SOUTH CAROLINA'S STATE WILDLIFE ACTION PLAN (SWAP) SUPPLEMENTAL VOLUME: PRIORITY SPECIES AND GUILD ACCOUNTS 2025

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FINAL
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INTRODUCTION TO THE SUPPLEMENTAL VOLUME OF SPECIES AND GUILD ACCOUNTS

This Supplemental Volume: Priority Species and Habitat Accounts is a compilation of written accounts, each following a standardized format to make sure Required Elements 1-6 are included. Authors describe the species, their status, population size and distribution, habitat requirements, challenges faced, conservation accomplishments thus far, conservation recommendations for future action, and how to measure success.

This supplemental volume can also be found on the South Carolina Department of Natural Resources' (SCDNR) State Wildlife Action Plan (SWAP) website. In the main SWAP document, Chapter 6, the last column in Table 6-2 references how each individual Species of Greatest Conservation Need (SGCN) was incorporated into the Supplemental Volume—either individually or as part of a guild. However, the last column in the Plants taxa section references an Excel spreadsheet in the Supplemental Volume. It details each species' priority habitat associations as determined by the taxa committee and presented in a format reminiscent of those of Hamel (1992), Trani et al. (2007), and Wilson (1995) in which X's appear in rows and columns. The Insects and Allies taxa's last column contains generalized location and habitat associations if know. These alternative SGCN representations serve as the plant and insect alternative to the species/guild narrative approach as many of these species are so data deficient that there is not enough information to discuss. Although habitat needs and life history traits are not expounded upon for insects and plants, they are still viable portions of this SWAP as threats and action items are addressed for them in Chapter 4 of the SWAP.

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American oystercatcher
Haematopus palliatus

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Photograph by Felicia Sanders

DESCRIPTION

Taxonomy and Basic Description

The American Oystercatcher (*Haematopus palliatus*) is a large shorebird found only in coastal habitats. Five races are distributed in North, Central and South America on the Atlantic, Pacific and Gulf Coasts. On the Atlantic Coast of the United States, the eastern race of the American Oystercatcher (*Haematopus palliatus palliatus*) breeds from Massachusetts to Florida, with highest concentrations of wintering birds from Virginia to Florida (Humphrey 1990).

Oystercatchers have a long orange bill, specialized for prying open bivalves (oysters, mussels, clams, etc.). Yellow eyes and an orange eye ring contrast with a black head and dark brown back and wings. The abdomen and portions of the wings and tail are white while the legs are light pink. The juvenile oystercatcher's head and back are speckled brown and the tip of its bill is brown.

Status


Photograph of oystercatcher chick by Felicia Sanders

The eastern race of the American Oystercatcher has been identified as an extremely high priority shorebird in the US Shorebird Conservation Plan (Brown et al. 2001). The rationale for this designation is based on population estimates that total less than 25,000 birds and on threats to the race posed by the degradation of beach nesting habitat.

POPULATION SIZE AND DISTRIBUTION

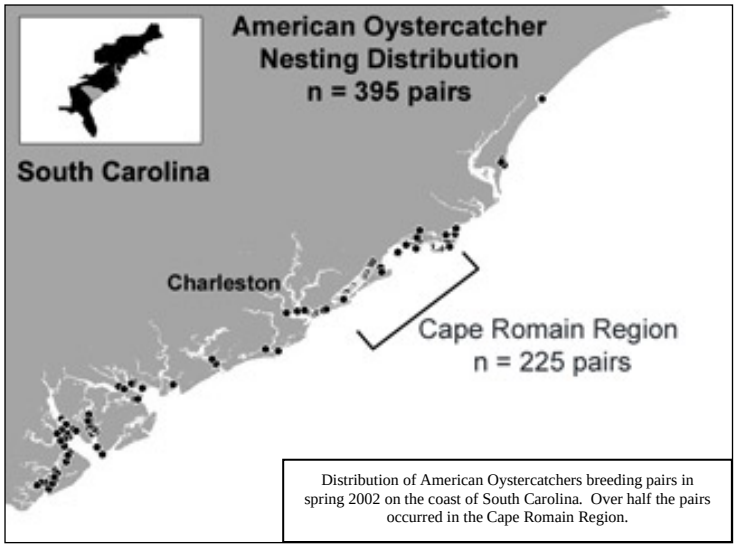
South Carolina supports just over one third (3,536) of the estimated oystercatcher population that winters on the Atlantic and Gulf Coasts of the United States (approximately 10,000; Brown et al. 2003; Sanders et al. 2004). The most recent winter census conducted by Manomet in 2023 recorded 3,545 oystercatchers in South Carolina during February (S. Schulte personal communication, February 20, 2024). This late February survey did not cover most of the nesting habitat but focused on shell rakes with large wintering flocks. Many resident oystercatchers were already on their nesting territories in late February; thus the 2023 count may have underestimated

the number of wintering oystercatchers. These surveys suggest that during the last two decades, the American Oystercatcher population is stable to increasing.

Statewide surveys by SCDNR in 2002 and 2003 averaged 394 breeding pairs (Sanders 2008). A statewide survey in 2008 documented 453 pairs, but this increase may be a result of increased effort. Additionally, South Carolina has nonbreeding flocks during the summer. In 2002, 378 nonbreeding Oystercatchers and 383 in 2003 were recorded during statewide breeding season surveys (Sanders et al 2008). The Cape Romain Region of the South Carolina coast includes the Cape Romain National Wildlife Refuge (CRNWR) south to Dewees Inlet. Between 50 and 60% of South Carolina's wintering Oystercatchers are in this region. Censuses in the winter of 1988 and 1989 and again in 2001, suggest a 21% decline in Oystercatchers in the Cape Romain region over these 14 years (Marsh and Wilkinson 1991; Sanders et al. 2004).

In 2002, SCDNR estimated immature to adult ratios at all oystercatcher roost sites in South Carolina. Of the birds examined, 9% had immature bill coloration. This suggests that breeding success may not have been sufficient to maintain the population.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS



Distribution of American Oystercatchers breeding pairs in spring 2002 on the coast of South Carolina. Over half the pairs occurred in the Cape Romain Region.

Oystercatchers nest in coastal habitats with little vegetative cover. They lay their eggs in a shallow depression on sandy beaches, shell mounds and spoil islands. Although historically oystercatchers may have nested primarily on front beaches in South Carolina, statewide surveys documented only 28% of the breeding pairs on barrier island beaches, 27% on estuarine islands, and 45% on edge shell mounds. Out of all the pairs in South Carolina, 24% were on edge shell mounds adjacent to the Atlantic Intracoastal Waterway (AIWW) (Sanders et al. 2008). Oystercatchers are territorial and solitary or semi-colonial nesters. Nesting territory size is variable, but frequently only a few pairs will occupy a mile of beach or shell rake. Therefore, extensive coastal habitat is required to maintain the present nesting population.

During the winter, outer beaches are not used as much as in the breeding season. Statewide surveys during the winter documented 89% roosted at high tide on washed shell rakes, 6% on docks, 4% on barrier island beaches, and 1% on estuarine islands (Sanders et al 2004).

Oystercatchers feed on oyster bars, intertidal mud flats and sandbars. A study conducted in the Cape Romain Region during the winter found Eastern oysters comprised 95.4% of the items consumed by frequency while ribbed mussels and unidentifiable items comprised 3.8% and 0.8%

of consumed prey, respectively (Hand et al. 2010). During the nesting season, they utilize a more diverse range of bivalves, mollusks and other invertebrates near their nest site.

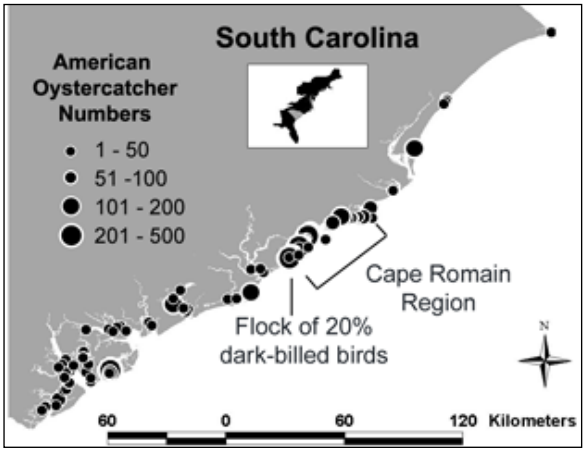
CHALLENGES

Oystercatchers are present in South Carolina during both the breeding and wintering seasons and are susceptible to catastrophic events such as hurricanes, oil spills, and harmful algal blooms.

Increased development of the South Carolina coast continues to reduce suitable oystercatcher nesting habitat and may force breeding pairs into less suitable sites. Although actual nesting sites are rarely destroyed, suitability of the sites is greatly reduced when nearby development increases disturbance of nesting birds. Disturbance from sources such as humans, dogs and boats negatively affects reproductive success by causing threatened oystercatchers to leave eggs and/or chicks unattended.

Oystercatcher nests are also at risk from native avian and mammalian predators. Recent studies in Cape Romain Region found chicks are also vulnerable to predation, and increases in American mink appear to be the primary cause of low chick survival. Human disturbance increases vulnerability to predation and can cause adults to abandon eggs. Nesting Oystercatchers are absent from areas with even moderate human disturbance.

Nests can also be destroyed by high tides and boat wakes; climate change is increasing the risk of nest wash-over. Barrier beaches, islands and shell rakes where Oystercatchers nest experience tidal inundation and the frequency and amplitude of coastal flooding has increased in the Charleston area with an average of 57 flood events a year since 2020 (Coastal Flooding Database: https://www.weather.gov/chs/coastal flood). During a 2-year study in the Cape Romain Region, overwash was the most frequently identified cause of nest loss of 200 oystercatcher nesting attempts (Thibault 2008).



Distribution of wintering American oystercatchers for 2002

In South Carolina, most wintering Oystercatchers roost in flocks of over 100 birds on shell rakes along heavily traveled waterways. In the Cape Romain Region, 75% of the wintering birds roost along the Atlantic Intracoastal Waterway. Increased boat traffic will increase the frequency at which birds are flushed from roost sites.

Because Oystercatchers feed primarily on shellfish, degradation of this resource through either disease or over-harvesting negatively affects oystercatchers. Healthy oyster reefs adjacent to nesting sites may be important for successful reproduction. Oystercatcher parents which had shellfish reefs adjacent to nest sites, spent more time at the nest site and fledged more chicks compared to parent oystercatchers nesting where shellfish reefs were not commonly adjacent to nest sites (Thibault et al. 2010).

CONSERVATION ACCOMPLISHMENTS

South Carolina over-winters the largest concentration of Oystercatchers on the Atlantic Coast of the United States. The winter population includes resident breeding birds as well as a large numbers of migratory Oystercatchers from all areas north. Statewide winter censuses have provided data on the abundance, age class partitioning, and distribution of Oystercatchers. Multi-year breeding season censuses provide data on abundance of nesting pairs and identify important nesting habitats. These surveys provide baseline numbers that are important for trend analysis. An American Oystercatcher working group was formed in 2001 to coordinate banding and survey efforts, prioritize conservation needs, and communicate evolving research techniques (American Oystercatcher Working Group, Nol & Humphrey, 2020). The working group's web site is an important tool to disseminate information on the status, management, and natural history of Oystercatchers (http://amoywg.org). The working group wrote a conservation plan for the species, and this plan is a guide for managers and researchers. Some important nesting areas, primarily on federal and state lands, are regularly closed to the public to allow Oystercatchers to nest undisturbed. Private coastal communities are also protecting select nesting sites and the number of communities willing to close portions of their beach for nesting birds continues to grow. Information about adult and juvenile survival rates, migratory patterns, and nest site fidelity has been collected from the color banding project. State wildlife grants funded research investigating nest success and causes and timing of nest loss in South Carolina (Thibault 2008). This research also piloted a head-starting program to test methods of increasing hatching success; research in this area is ongoing. Research on wintering foraging ecology identified prey items that are important for overwinter survival. A health assessment of Oystercatchers in the Cape Romain Region will serve as a baseline for future assessments (Carlson-Bremer et al 2010).

CONSERVATION RECOMMENDATIONS

- Protect American Oystercatchers during the nesting season, concentrating on public land. Adequate and timely posting and law enforcement may be required.
- Identify and protect important roost sites statewide. Identify important sites for protection during the permit review process.
- Continue cooperative efforts with the US Fish and Wildlife Service to census and manage nesting sites within Cape Romain National Wildlife Refuge (CRNWR). Control predators (especially raccoon and American mink) on important nesting areas and prioritize beaches that will benefit both sea turtles and shorebirds.
- Cannon net wintering Oystercatchers at high tide roosts to document the natal source of wintering birds and to color band resident breeding birds.
- Document adult mortality rates by annually monitoring color-banded adults on breeding territories. Adult mortality rates are required to evaluate the status of the species.
- Color band pre-flight chicks and monitor non-natal banded juveniles to determine movement and survivorship of juvenile Oystercatchers.
- Continue regionwide cooperative studies such as banding of wintering birds and resighting of color marked migratory birds.

- Develop standardized techniques to document nesting success and annual chick production because current estimates suggest that low reproductive success may be a limiting factor.
- Document important foraging areas and nocturnal roost locations using GPS and/or satellite tags. Protect these identified sites from disturbance.
- Evaluate possible state listing of the species to provide additional legal protection.
- Support research and conservation efforts to maintain a healthy marine environment, free of pollutants, and maintain or enhance shellfish populations.
- Conduct low tide observations of foraging oystercatchers to identify and quantify prey items taken during the nesting season.

MEASURES OF SUCCESS

As research and management needs are identified, we will initiate projects to address those needs. Factors leading to declines in oystercatcher populations are poorly understood and the rate of decline is poorly documented. As current population trends are documented and limiting factors are identified, appropriate research and management actions will be initiated.

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Peregrine Falcon

Falco peregrinus anatum



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DESCRIPTION

Taxonomy and Basic Description

The Peregrine Falcon is a crow-sized raptor in the family Falconidae (Order: Falconiformes). *F. p. anatum* adults have slate-gray upperparts, pale to buffy underparts with dark bars and spots, and a dark facial stripe from the eye down the side of the cheek (White et al. 2020). Immature birds are similar to adults, but with pale to brown upperparts and dark streaks on buffy underparts. Male Peregrines measure 36 to 49 cm (14 to 19 in.) while females measure 44 to 58 cm (17 to 23 in.).

Status

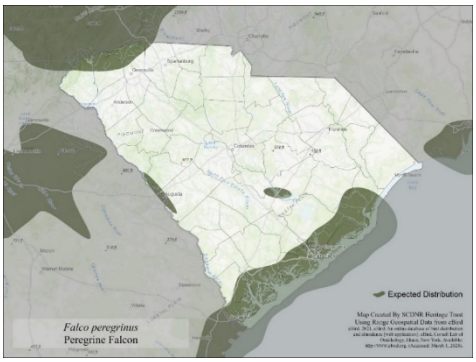
The Peregrine Falcon was listed as Federally Endangered in 1970 and transferred to the 1973 Endangered Species Act because of large-scale population declines from the 1950s to mid-1970s. The species saw total extirpation in the US east of the Rocky Mountains, and an overall reduction in North America to 324 nesting pairs in that time. Population declines were caused mainly by effects of synthetic organic chemicals, like DDT, on nesting success. After listing, Peregrine Falcon populations rebounded, largely due to captive breeding programs and reductions in DDT and other organic chemicals in the environment. By 1998, the species had returned to much of its former range and continental populations were viable. Therefore, the species was federally de-listed in 1999 (USFWS 2003).

As of 2003, the Peregrine Falcon was listed as endangered on the South Carolina Rare, Threatened and Endangered Species Inventory. In addition, the Peregrine Falcon and other birds of prey are protected by South Carolina state wildlife law section 50-11-852 which states that it is: “unlawful to molest or kill birds of prey.” Federal law protects the Peregrine Falcon under the Migratory Bird Treaty Act, while internationally, the Peregrine Falcon is protected under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 1975).

POPULATION SIZE AND DISTRIBUTION

Peregrine Falcons have a worldwide distribution. In the United States, the species breeds in western, northern, midwestern and eastern states. Partners in Flight estimates a population of 72,000 birds in the US and Canada in 2023 (pif.birdconservancy.org).

In South Carolina, Peregrine Falcons have successfully bred at Table Rock State Park in Pickens County since 1990. The Table Rock nesting pair has produced on average at least 2 young each year through 2019 (Scott Stegenga, per. comm.) The state's second nesting pair of Peregrine Falcons appeared at Jocassee Gorges in 2008, and nesting activity continues to the present with an observation of 1 juvenile in 2023 (Ken Forrester, pers. comm.).



Distribution of Peregrine Falcon in SC

Most other Peregrine Falcon observations in South Carolina occur during the winter or migration. Post and Gauthreaux (1989) note the peregrine as an uncommon winter visitor on South Carolina's coast and a rare winter visitor to the coast, interior, or Piedmont of South Carolina. Monthly beachfront shorebird surveys conducted in Cape Romain National Wildlife Refuge from 2007 through 2016 observe the presence of Peregrine Falcons on barrier islands every month except for June, July, and August (CRNWR, USFWS, shorebird data). Research indicates that Peregrine Falcons from Greenland and eastern Canada migrate southward along South Carolina's coast, and some birds may remain through the winter (Fuller et al. 1998).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Peregrines breed in most North American terrestrial biomes, although occupied habitats usually contain cliffs for nesting with open gulfs of air for foraging (White et al. 2020). The species historically nested on ledges along cliffs 8 to 400 m (26 to 1,312 ft.) high. However, they will also use nest boxes and artificial structures like towers and buildings, as well as abandoned stick nests such as those previously built and occupied by Osprey, Red-tailed Hawk, Bald Eagle and Common Raven (White et al. 2020). Peregrine Falcon density is limited by availability of suitable nest locations and by territorial spacing (White et al. 2020).
Peregrine Falcons mainly prey upon birds (77 to 99% by frequency), ranging in size from Hummingbirds (2.5 to 3.5 g or 0.08 to 0.12 oz.) to small Canada Geese (1,400 g or 49 oz.). They also occasionally eat mammals, and rarely, amphibians, fish and insects. In North America, Peregrines eat more than 429 avian species and 23 mammal species, 10 of which are bats. Prey is usually captured in the air while the falcon is in flight, but also from the surface of the water or ground. The Peregrine Falcon generally captures prey with its feet and kills by dislocating the cervical vertebra. Surplus prey is cached (White et al. 2020).

During migration and the wintering period, peregrine falcons prefer wetland areas that have concentrations of waterfowl and shorebirds (White et. al. 2002).

CHALLENGES

Peregrines are sensitive to loss or modification of nest sites, though they can switch among alternate sites if more than one exists in a territory (White et al. 2020). They are also sensitive to human presence above a nest cliff (Cely, pers. comm.). Loss or degradation of wetlands may negatively impact non-breeding Peregrines. Continued conservation of this species will require more precise knowledge of breeding and potential breeding sites as well as information regarding winter distributions.

CONSERVATION ACCOMPLISHMENTS

By 1998, most North American populations had stabilized due to intensive captive breeding programs and reductions in DDT and other organic chemicals in the environment. The species was federally de-listed in 1999. In 2003 the "Monitoring Plan of the American Peregrine Falcon" was implemented by the USFWS. South Carolina's Peregrine Falcon nesting territories are within the Southeastern region, and reports are annually submitted on the status of nesting and number of fledged young. Annual closure of climbing areas in Table Rock State Park to prevent disturbance to Peregrine Falcon nesting sites occurs in coordination with the Carolina Climbers Coalition, state park staff, and SCDNR (carolinaclimbers.org).

CONSERVATION RECOMMENDATIONS

- Conduct statewide surveys to identify areas used by breeding and migrating Peregrine Falcons; especially survey state and federally owned coastal properties for migrating and wintering peregrine falcons.
- Protect existing and potential Peregrine Falcon nest sites from destruction, physical alteration and excessive human disturbances.
- Conserve barrier islands, inland lagoons and other coastal and inland wetlands that support abundant prey for migrating peregrines.
- Monitor nesting Peregrine Falcons and breeding productivity in coordination with USFWS personnel at the Table Rock and the Jocassee Gorges nesting sites.
- Conduct banding of juveniles and assessment of prey items at the present nesting locations to determine migration and foraging needs.

MEASURES OF SUCCESS

The protection of nesting and foraging sites should result in a net increase in South Carolina's Peregrine Falcon population and in an increase in use during migration. Peregrine population trends and distributions in South Carolina should be monitored over time to assess potential changes.

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American Woodcock

Scolopax minor



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DESCRIPTION

Taxonomy and Basic Description

The commonly accepted scientific name of the American Woodcock is *Scolopax minor* (ITIS 2011) as described by Gmelin in 1789. Common names for Woodcock include “timberdoodle”, “bogsucker” and “wood snipe”. They are alternately characterized as marsh birds, shore birds or upland ground birds.

The Woodcock is a mottled brown bird, weighing from 125 to 240 g (4.4 to 8.5 oz.) (Owen and Krohn 1973) and averaging approximately 28 cm (11 in.) in total length (eNature 2012). The unusual physical appearance of the Woodcock is characterized by the bird’s buff-colored body, long beak, bulging eyes, and short wings. The diet of Woodcock consists primarily of earthworms, although other invertebrates and some vegetative matter are also consumed. Woodcock foraging for earthworms is aided by a prehensile beak, which allows Woodcock to grasp earthworms and extract them from below the soil surface (Krementz and Jackson 1999).

Status

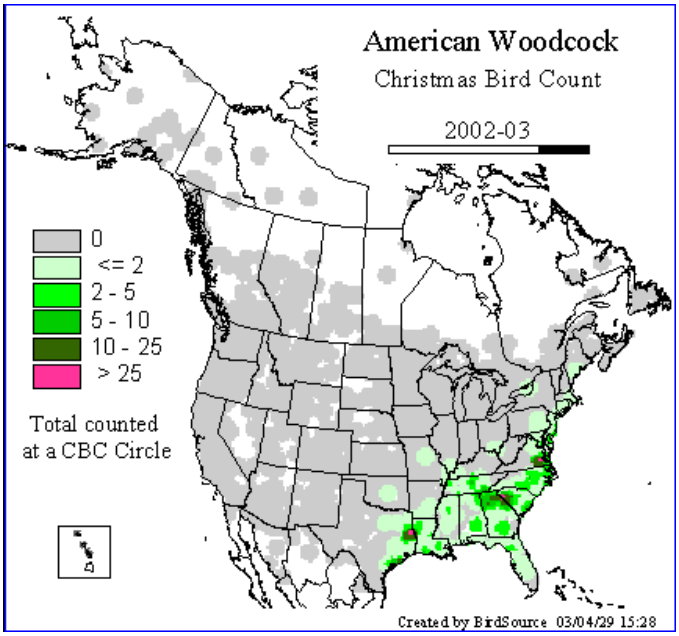
The US Shorebird Conservation Plan (USSCP) lists Woodcock as a Species of High Concern and as a species known or thought to be declining (Brown et al. 2004). Woodcock are listed by the US Fish and Wildlife Service as a Game Bird Below Desired Condition (USFWS 2004). They are listed on the Audubon Watchlist “yellow list” of those species that are in slow decline and of national conservation concern (National Audubon Society 2004). Woodcock are identified as apparently secure (S4) in South Carolina and as secure (G5) globally and (NatureServe 2011).

POPULATION SIZE AND DISTRIBUTION

Woodcock are managed on the basis of two regions or populations, eastern and central, as recommended by Owen et al. (1977). Singing ground surveys from the US Fish and Wildlife Service indicate a significant long-term decline of 1.0% annually for Woodcock in the Eastern region (Cooper and Parker 2011).

The range of American Woodcock extends from the Maritime Provinces in southern Canada westward to southeastern Manitoba and southward into eastern Texas. All states east of this line are within the species' range. The principal breeding range includes New England and the Lake States, although limited breeding occurs throughout almost the entire range (Roberts 1989). The estimated population of Woodcock in North America is approximately 5 million individuals (Brown et al. 2004). North American Breeding Bird Survey (BBS) data indicate a 1.5 percent annual declining trend in the U.S. between the years 1966 and 2009 (Sauer et al. 2011). Christmas Bird Count data indicate no significant declining trend for South Carolina and North America (National Audubon Society 2012). Christmas Bird Count data also reveal higher wintering populations of Woodcock in the Lower Coastal Plain and Piedmont than in the Upper Coastal Plain of the State. Wintering Woodcock numbers peak between mid-December and mid-February in South Carolina Coastal Plain habitats (Pace and Wood 1979).





HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Unlike most other shorebirds and marsh birds, Woodcock are a forest-dwelling species. Woodcock are often associated with forested wetlands. In the Southeast, alluvial floodplains with a brushy forest understory are apparently a preferred habitat type. Swamp privet (*Forestiera acuminata*), holly (*Ilex* spp.), switch cane (*Arundinaria gigantea*), honeysuckle (*Lonicera japonica*), peppervine (*Ampelopsis arborea*), trumpet creeper (*Campsus radicans*), greenbriar (*Smilax* spp.), and grapes (*Vitis* spp.) have been identified as important understory species (Owen et al. 1977; Roberts 1989). The composition of the tree overstory appears unimportant (Owen et al. 1977).

Old fields, croplands, pasturelands, wet seeps, and damp thickets also provide important habitat for Woodcock on wintering grounds. Old fields and other early successional habitat types are

often used as nocturnal habitat and should be located within 230 m (251 yds.) of diurnal habitats (Berdeen and Krementz 1998). While a high density of plant stems is preferred by Woodcock, open ground underneath the canopy is a necessity to provide easy access to worms and other invertebrates in the ground litter (Roberts 1989; Krementz and Jackson 1999).

CHALLENGES

Declines in Woodcock populations are currently unexplained, but may be linked to natural forest succession within the breeding range of the species. Bottomland hardwood loss due to reservoir construction, drainage and clearing for agricultural uses and urbanization has negatively impacted the availability of winter habitat for Woodcock in the Southeast (Straw et al. 1994; Krementz and Jackson 1999).

CONSERVATION ACCOMPLISHMENTS

Although little research on Woodcock has been conducted in the past 35 years in South Carolina, research projects have been completed on Woodcock habitat selection, food habitat and migration chronology. Woodcock hunter surveys were conducted in 1983 and 1985 to provide information on hunter effort, harvest, and Woodcock age ratios. The Harvest Information Program (HIP) has been fully implemented nationwide and allows a better assessment of Woodcock hunter numbers and harvest in South Carolina. Comprehensive hunter harvest surveys were conducted for all species in South Carolina, including Woodcock, in 2000, 2003, and 2005. Since 1997, Woodcock flushing rates and harvest by South Carolina quail hunters have been tracked through annual quail and rabbit hunter surveys. Several large land acquisitions in South Carolina, notably Wee Tee State Forest, Bonneau Ferry Wildlife Management Area, Woodbury WMA, and Marsh WMA have preserved significant acreages of prime Woodcock wintering habitat. Forestry Best Management Practices (BMPs) now strongly encourage the conservation of Streamside Management Zones (SMZs), which persist as Woodcock wintering habitat following timber harvest operations.

A draft *Interim American Woodcock Harvest Strategy*, which sets regulatory packages and thresholds for regulatory changes, has been developed and implemented (USFWS 2010). Additionally, a strategy which prioritized research and information needs for improving habitat and harvest management decisions for American Woodcock has been developed (Case 2010). Finally, the *American Woodcock Conservation Plan* which identifies Woodcock habitat needs and sets goals for the restoration of breeding and wintering habitat across the range of the species was completed in 2008 (Kelley et al. 2008).

CONSERVATION RECOMMENDATIONS

- Focus habitat protection efforts (acquisition and easements) on significant tracts of bottomland hardwoods and isolated forested wetlands to preserve Woodcock wintering areas in South Carolina.
- Implement management practices that promote habitat diversity, like timber harvest and prescribed burning, on SCDNR lands with high potential to provide wintering habitat for Woodcock.

- Maintain early successional upland habitat associated with wetlands conservation efforts (acquisition, easements) to provide roosting habitat for Woodcock. Early-successional habitats can be maintained through prescribed burning.
- Using remote imagery, identify potential areas of Woodcock wintering habitat to guide habitat conservation efforts.
- Identify winter microhabitat requirements for Woodcock in South Carolina.
- Assess population densities of Woodcock on wintering grounds in South Carolina and the state's contribution to range-wide wintering populations.
- Increase the number of yearly Christmas Bird Count (CBC) routes.
- Monitor habitat loss through mapping of landscape-level habitat changes.
- Continue hunter surveys as an assessment of Woodcock hunting effort and harvest.
- Insure that upland buffers are included in the Wetlands Reserve Program (WRP) and similar programs, and that proper management practices are recommended and implemented to provide quality Woodcock habitat.
- Provide Woodcock habitat recommendations to natural resource agencies with management responsibility for extensive acreages of Woodcock habitat.
- Provide Woodcock habitat recommendations to private landowners through on-site technical assistance, fact sheets, management bulletins, and websites.
- Work with USFWS to identify Woodcock hunters in South Carolina and increase hunter participation in the Woodcock parts collection survey.
- Partner with other agencies and organizations such as the US Forest Service, US Fish and Wildlife Service, Clemson University and National Audubon Society (South Carolina Chapter) in order to conduct surveys for Woodcock.
- Provide DNR representation to the Association of Fish and Wildlife Agencies Migratory Shore and Upland Game Bird Working Group Woodcock Task Force to assist in setting rangewide priorities for Woodcock management, research and monitoring.
- Establish a dedicated funding source for management, research and monitoring of webless migratory game birds (including Woodcock) by combining the Migratory Game Bird (HIP) permit with the Migratory Waterfowl Permit.

MEASURES OF SUCCESS

Following identification of Woodcock winter habitat requirements in South Carolina, experimental habitat manipulations should be conducted to test habitat models. Woodcock flushing rates by rabbit hunters and quail hunters should continue to be monitored through the statewide Rabbit Hunter Survey and Quail Hunter Survey. Christmas Bird Count data should be utilized as a statewide index of wintering Woodcock populations and trends evaluated periodically to determine changes in winter population status. As opportunities arise, directed research should examine changes in wintering Woodcock densities, which occur as a result of incidental or intentional habitat manipulation. Woodcock winter habitat changes should be monitored through remote imagery and mapping.

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Black-capped Petrel

Pterodroma hasitata

Contributors (2024): Cami Duquet (SCDNR), Yvan Satgé



Black-capped Petrel, Photo credit: USFWS

DESCRIPTION

Taxonomy and Basic Description

The Black-capped Petrel is a long-winged black and white seabird, in the gadfly (*Pterodroma*) petrel genus. It has a clearly defined black cap that is separated from the dark mantle by a white collar. The white upper tail which forms a 'U' shape on the upper tail coverts, differentiates it from other gadfly petrels in its range. In flight, it shows a white-black-white pattern, with mostly dark upperparts and light underneath. Varying amounts of dark and white plumage exist, with two distinct forms within the nominate subspecies, although the differences between the two forms are not well understood (Satgé et al. 2024).

Black-capped Petrels are highly pelagic species and occur in tropical and sub-tropical waters in the western North Atlantic and adjacent basins of the Caribbean Sea and Gulf of Mexico (Simons et al. 2013). The South Atlantic Bight, the U.S. Coast from Cape Canaveral, Florida to Outer Banks of North Carolina, serves as the primary foraging region for the Black-capped Petrel during the nonbreeding season (Wheeler et al. 2021). During the breeding season, Black-capped Petrels come to land in the Caribbean region and nest in burrows in mountainous areas.

Status

In 2018, BirdLife International confirmed the endangered status of the bird on the IUCN red list due to its very small, fragmented, and declining breeding range and population. It stated that "declines are likely to continue as a result of habitat loss and degradation, hunting and invasive predators" (BirdLife International 2024).

In 2024, the Black-capped Petrel was listed as endangered under the U.S Endangered Species Act and considered in danger of extinction.

POPULATION SIZE AND DISTRIBUTION

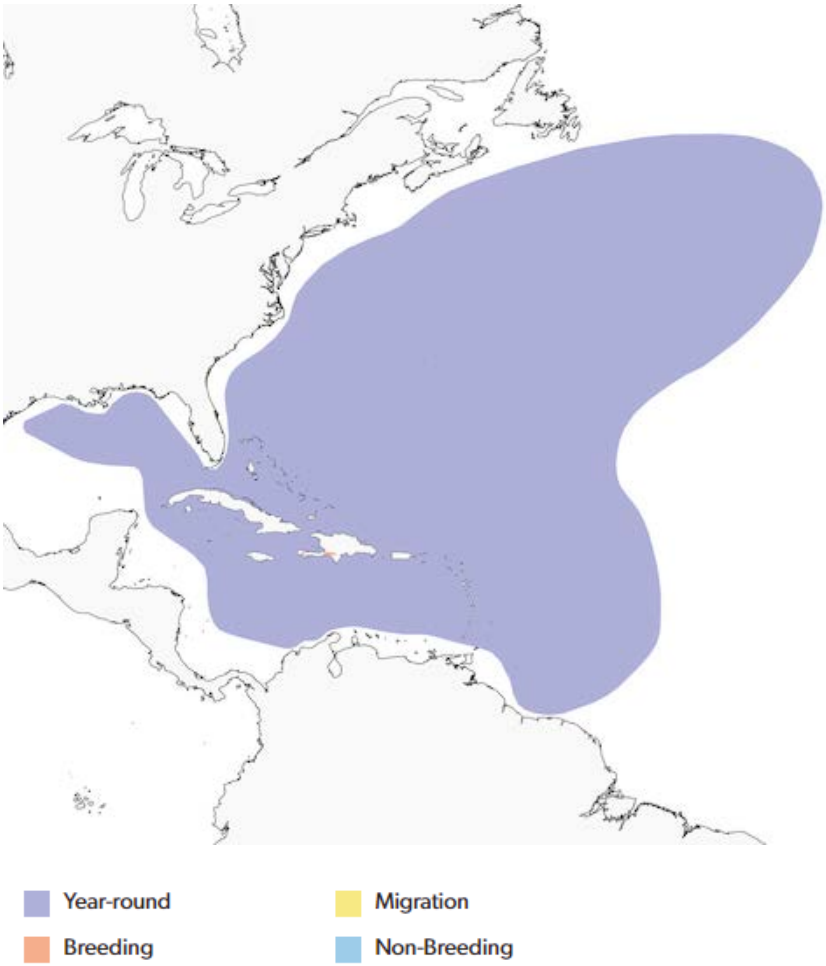
Population estimates of the Black-capped Petrel are highly uncertain due to the difficulty in using conventional survey techniques by field researchers. Recent estimates cite 5000 individuals (Howell and Patterson 2008), others estimate 2000 breeding pairs (Ramos et al. 2017), while additional research offers ranges from 1000-2000 breeding pairs (Lee 2000) to 500-1000 breeding pairs (Simons et al. 2013).

Only a handful of breeding sites of Black-capped Petrels have been found and confirmed, located on Hispaniola. Additional islands in the Greater and Lesser Antilles may also provide breeding sites as suggested by historical records and recent evidence (Wheeler at al. 2021).

The South Atlantic Bight, the U.S. Coast from Cape Canaveral, Florida to Outer Banks of North Carolina, serves as the primary foraging region for the Black-capped Petrel during the nonbreeding season.

Concentrations of birds can be found along the Gulf Stream in southeastern US waters, including South Carolina, throughout the year, but are particularly common in mid-July to mid-October, during the nonbreeding season. Concentrations of adult birds during winter, when peak breeding activity is underway, also suggest that breeding birds forage along the Gulf Stream while commuting to and from breeding colonies (Simons et al. 2013).

Recent research tracking individual Black-capped Petrels outfitted with satellite tags confirmed their use of shelf waters west of the Gulf Stream offshore of Cape Hatteras, North Carolina and within the South Atlantic Bight post breeding season (Jodice et al. 2015, Satgé et al. 2023).



Distribution of Black-capped Petrel on land and at sea. Satgé et al. 2024 (reproduced with permission from the authors).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

At sea, the Black-capped Petrel is considered highly pelagic and associated with oceanographic features like the eddies and detached rings of the highly dynamic Gulf Stream and Loop Current. They make use of oceanographic fronts and the area used by petrels in the Atlantic outer continental shelf of the U.S. is also characterized by the mixing of Gulf Stream and upwelling waters associated with Cape Hatteras, North Carolina, and the Blake escarpment off South Carolina and Georgia. (Haney 1987, Jodice et al. 2015, Satgé et al. 2023). Abundance in Black-capped Petrels correlates with more significant upwelling caused by amplitudes in the Gulf Stream as it increases biomass of marine organisms that petrels feed on, specifically in the South Atlantic Bight and notably in Northern Georgia and Southern South Carolina (Haney 1987).

CHALLENGES

Potential threats and challenges faced by the Black-capped Petrels include introduced predators, human encroachment on breeding and foraging habitats, and offshore oil, gas, and wind energy development (Simons et al. 2013, Wheeler et al. 2021).

While the Black-capped Petrels' most significant threats occur on their breeding grounds, their declining numbers necessitate protection along their entire range including nonbreeding and foraging grounds, notably along the South Atlantic Bight including the South Carolina coast.

The increased pressure of offshore wind energy development could pose challenges for Black-capped Petrels as negative impacts of offshore wind energy for marine birds have proven to cause displacement due to avoidance or direct mortality from collision of turbines (Goodale and Milman, 2016). Already, offshore wind energy development in nearby North Carolina has caused concerns as the proposed development area directly overlaps with nutrient-rich waters where the species is known to forage.

Increase severity of storms and storm events will negatively impact Black-capped Petrels as they naturally aggregate in areas along the South Atlantic Bight in the direct path of likely future storms. Simulated models show a loss of 437 petrels over the next century from direct mortality of hurricanes (Hass 2012).

CONSERVATION ACCOMPLISHMENTS

No conservation initiatives have been set specifically for the Black-capped Petrel in South Carolina. Reports of sightings through eBird as well as from tracked individuals through GPS transmitters has provided data showing their presence in South Carolina waters.

Other groups and research initiatives outside of South Carolina have contributed to further protection and understanding of the species, including:

- Creation of the international Black-capped Petrel conservation group in 2008
- Production of the Conservation Action Plan for the Black-capped Petrel in 2010 and updated in 2021 (Goetz et al. 2012, Wheeler et al. 2021)
- Increased understanding of range and movements through tracking individuals with GPS/satellite transmitters (Jodice et al. 2015, Satgé et al. 2019 Satgé et al. 2023)

- Expanded monitoring efforts at known breeding sites to identify and reduce terrestrial threats (Wheeler et al. 2021)
  Increased public awareness and involvement of local communities to improve environmental conditions at breeding sites (Wheeler et al. 2021)

CONSERVATION RECOMMENDATIONS

- Protect foraging habitat for nonbreeding Black-capped Petrels feeding in South Carolina waters
- Establish systematic pelagic seabird surveys to monitor activity, movements, and quantity of Black-capped Petrels in South Carolina
- Get involved with the international Black-capped Petrel conservation group
- Review proposed offshore wind developments along the coast of South Carolina to include mitigations to counterbalance impacts on Black-capped Petrels

MEASURE OF SUCCESS:

As the above-mentioned action items are accomplished and yield valuable information, adaptive management procedures will be evaluated and implemented for this species.

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Black Rail

Laterallus jamaicensis


Pair of Black Rails during courtship. Christy Hand, SCDNR.

Contributor (2013): Christine Hand (SCDNR)
Reviewed and Edited (2024): Christine Hand and Mikayla Thistle (SCDNR)

DESCRIPTION

Taxonomy and Basic Descriptions

The Black Rail is the smallest North American rail measuring 10-15 cm (4 -6 in.) in length and 35 g (1.2 oz.) in weight (Eddleman *et al*. 1994). Adult rails have strikingly red irises, a dark gray to blackish head, gray neck and breast, rufous nape, and a black-and-white patterned back. Adult males have darker chins and breasts compared to females but are comparable in size (Eddleman *et al.* 1994). Chicks have dense black down, dark grey legs, brown eyes, and black beaks with a light pinkish band at the base. Juveniles are similar in appearance to adults but are duller overall (Sibley 2003). There are 5 subspecies, two of which nest in North America: the Eastern Black Rail (*L. jamaicensis jamaicensis*) and the California Black Rail (*L. jamaicensis coturniculus*). The Eastern Black Rail subspecies is found in along the Atlantic Coast, Gulf Coast, Colorado, and Midwestern region of the US (Eddleman *et al.* 1994).

Status

The Black Rail (Eastern subspecies) was federally listed as Threatened under the Endangered Species Act in 2020 (U.S. Fish & Wildlife Service (USFWS) 2020). In South Carolina, the Black Rail is a state "species of concern." The rail species present challenges in determining statuses due to a difficulty in detection as a result of their secretive nature and a general lack of information. IUCN lists Black Rails as Endangered, considers the Black Rail to be Tipping Point species, and placed the species on their Red Watch Lists due to their level of population threats (2024). Globally, the Black Rail is ranked as Vulnerable (G3) and the Eastern subspecies is ranked as Critically Imperiled (T1). In South Carolina, the Black Rail is ranked as Critically Imperiled (S1) and the Eastern subspecies has no ranking (NatureServe 2024). Breeding Bird Survey data are insufficient to estimate Black Rail population trends.

POPULATION SIZE AND DISTRIBUTION

The historical breeding range of the Eastern Black Rail encompassed the Atlantic Coast from Connecticut to south Florida, the coastal plain of Texas, and inland states including Colorado, Kansas, Oklahoma, Minnesota, and Michigan (USFWS 2019). The Chesapeake Bay in the Mid-Atlantic region formerly was one of the most important strongholds for the species (Watts 2016). Particularly high and reliable numbers were consistently found in Maryland, Delaware, and New Jersey (Watts 2016, USFWS 2019). The Eastern Black Rail has experienced large population declines (by over 90% in the Mid-Atlantic since the early 1900s; Watts 2016) and range contractions. USFWS estimates that only 355-815 breeding pairs remain on the Atlantic Coast and approximately 1,299 individuals remained on the upper Texas coast prior to Hurricane

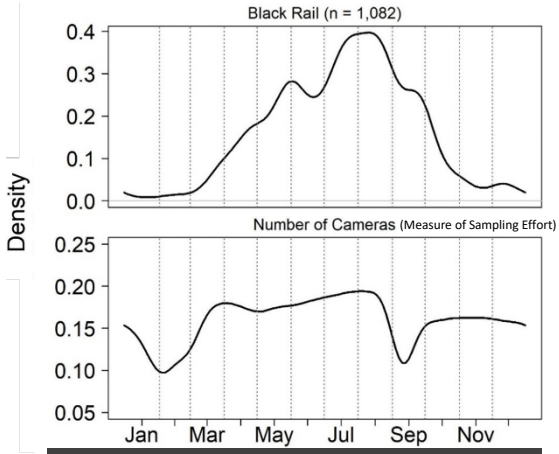
Harvey and other recent hurricanes (USFWS 2019). Without intervention to support population growth, USFWS predicts extirpation in 2068 (USFWS 2019). In South Carolina, USFWS (2019) and species experts estimated only 50 – 100 pairs persisted in 2016, prior to the recent storms and extreme flooding events that have occurred during vulnerable periods. Recent survey data suggest current numbers may be fewer than 50 pairs (C. Hand, personal observation).

Historically in South Carolina, Black Rails were considered to be a rare summer resident over much of the state (Sprunt and Chamberlain 1970). They have been observed in marshes in the coastal plain and in marshy meadows in scattered inland locations in South Carolina during the breeding season (LeGrand 1976, Watts 2016). Inland locations include an extensive marsh in Anderson County along Little Beaverdam Creek near its junction with Lake Hartwell, where a Black Rail was heard throughout the 1975 breeding season (LeGrand 1976). Mark Purcell reported seeing a Black Rail at Santee National Wildlife Refuge during the 2000's but details are unavailable. Declines in inland breeders were noted in 1976 in comparison to the beginning of the century (LeGrand 1976). No Black Rails were found in inland locations during surveys in 1991-1992 despite a concerted effort to find them (Cely *et al*. 1993). Historical and current records in the coastal plain are more numerous but also uncommon.

During statewide marsh bird surveys conducted by SCDNR during the 1991 and 1992 breeding seasons, Black Rails were detected 38 times at the following sites: Bear Island WMA (31), the Tom Yawkey Wildlife Center (5) and at the Santee Coastal Reserve (2). Extensive call-response surveys were conducted in South Carolina during 2014-2016 (Roach and Barrett 2015, Hand 2015, Hand 2016) and during 2024 (SCDNR, unpublished data). South Carolina breeding season surveys repeated 3–7 times per point per year produced detections at 32 of 283 points in 2015, 15 of 246 points in 2016, 13 of 48 points in 2017, 9 of 42 points in 2018, 9 of 54 points in 2019, 14 of 31 points in 2020, 8 of 51 points in 2021, 15 of 61 points in 2022, 13 of 88 points in 2023, and 12 of 149 points in 2024. The two SCDNR properties hosting the majority of the Black Rails detected during surveys from 1991 - 2024 have been resurveyed annually from 2017-2023 (Hand 2017a, Hand 2018a, Hand 2019, Hand 2020, Hand and Weitzel 2021, Hand 2022, and Hand 2023). All detections during 2024 occurred on these two properties.

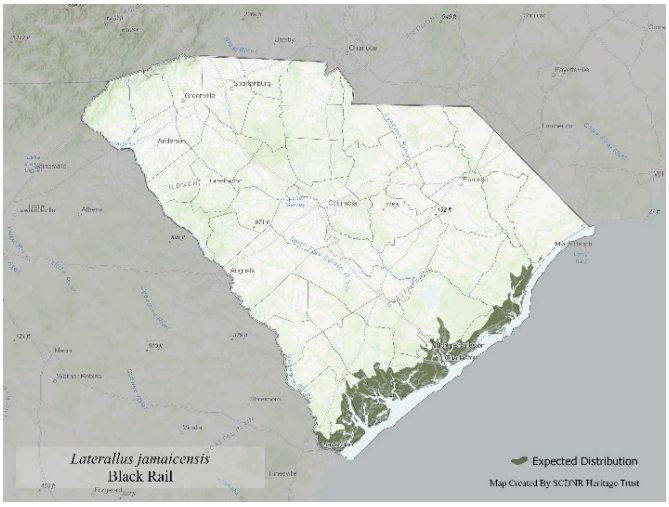
South Carolina is recognized as one of four states with important remaining population centers in the Atlantic Coast Joint Venture geographic area (ACJV 2020). Small breeding populations are known to persist in the ACE Basin region and Santee Delta region, primarily on lands managed by the South Carolina Department of Natural Resources (Hand 2023). There was only one definitive nesting record prior to 2015, which occurred in 1903 (Wayne 1905, Post and Gauthreaux 1989). From 2015 – 2023, 72 broods of chicks have been documented (Hand 2023).

During the non-breeding season, Eastern Black Rails are generally thought to migrate to the southern portion of their breeding range (USFWS 2019). South Carolina provides habitat for Black Rails throughout the year (Sanders *et al*. 2021), but it is unclear if the Black Rails present during the winter are year-round residents, migrants from more northern areas of their range, or a combination of residents and migrants (C. Hand, personal observation). Currently, detections in South Carolina are substantially lower during the nonbreeding season. Previous high counts for the state (including 12 in Mount Pleasant on September 30, 1913, and 15-25 at Rochelle Plantation along the North Santee River on November 25, 1982 during a rice harvest; LeGrand 1983, Post and Gauthreaux 1989) occurred during the nonbreeding season when Black Rails were flushed as fields were cut during the harvest of hay, rice, or other grains. Rarely, Black Rails are still seen during the post-breeding season when vegetation is cut during the preparation of ponds and fields for wintering waterfowl.



Seasonality of detections of Eastern Black Rails (*Laterallus jamaicensis jamaicensis*) in Colleton County, South Carolina during 2018 – 2020. Density is based on the number of independent detections (detection events separated by 30 minutes) captured by camera traps and their respective time of year. Sanders *et al.* 2021

HABITAT AND NATURAL COMMUNITY REQUIREMENTS



As the smallest rail species in North America, with a tarsus (i.e., lower leg) length of less than an inch and particularly secretive habits, the Black Rail has very specific habitat requirements. Suitable habitat for Black Rails has four key habitat characteristics: 1) gently sloping or slightly uneven terrain that promotes a matrix of subtle depressions for forage (i.e., invertebrates and seeds) and ridges for nesting and refuge from flooding, 2) dense, clumping herbaceous vegetation providing both a canopy of overhead cover and openings or tunnels at the ground level allowing movement through the marsh without emerging into the open, 3) shallow brackish or fresh water that promotes moist soil conditions and depression pools (< 1 inch) at relatively consistent levels, but not stagnant, and 4) hydric wetland soil rich in organic material that retains moisture and supports desired plant communities and invertebrates (text excerpted from Hand *et al*. 2024).

In South Carolina, a handful of managed tidal impoundments in the coastal plain, as well as a few unimpounded tidal marshes, have consistently supported breeding Black Rails for decades (Hand 2023). The impoundments typically occupied by Black Rails were built using “dragline”

excavators to construct dikes around tidal marshes during the 20th century following the end of the rice era until the Clean Water Act of 1972 (Hand *et al*. 2024). This construction technique resulted in fields with uneven elevations including shallow depressions, subtle high areas, and elevational gradients adjacent to uplands. These impoundments are far less prevalent than the historical rice fields built by enslaved Africans during the 18th and 19th centuries (Hanks *et al*. 2021), which were relatively level to facilitate commodity-scale rice production. Tidal and inland historical rice fields are abundant throughout coastal South Carolina but rarely offer suitable physical characteristics for black rails unless topography is altered to create necessary elevational variations (Hand *et al*. 2024). Inland, Black Rails once were found in fields of hay or oats rather than the low, wet marshes and swamps preferred by other rail species (Sprunt and Chamberlain 1970).

Dominant vegetation in Black Rail habitat in South Carolina typically includes bunch grasses, sedges, rushes, and cattails. In particular, Black Rails are typically found in grasses such as sand cordgrass (*Spartina bakeri*) and saltmarsh cordgrass (*Spartina patens*) intermixed with species such as marsh fimbry (*Fimbristylis castanea*), chairmakers bulrush (*Schoenoplectus robustus*), black needlerush (*Juncus roemerianus)*, soft rush (*Juncus effusus*) and cattails (*Typha spp*.; Hand *et al*. 2020). Vegetation structure is more important than species composition and Black Rails will use diverse habitats across their range that meet water level, overhead cover, and food requirements. Vegetation composition provides clues about the microtopography and hydrology of the wetland. While non-clumping species can indicate high quality habitat when interspersed in small patches with clumping grasses, monocultures typically indicate water levels have been too deep and/or topography is too uniform.



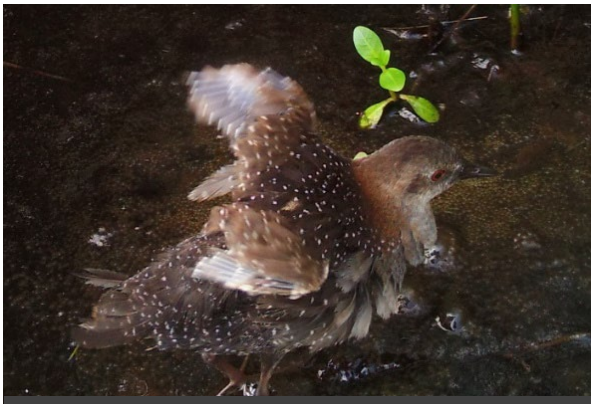
Adult male Black Rail caring for three downy chicks (<1 week old). Young chicks are wobbly and have shorter legs compared to adults, so very shallow water depths are important. Photos: Christy Hand, SCDNR.

Cryptic nests are typically built in clumps of vegetation in elevated areas surrounded by a mix of small pools of very shallow water (1-3 cm; USFWS 2019) and areas with moist soil (Eddleman *et al.* 1994). Foraging habitat near nests sites is necessary because chicks begin foraging with assistance from their parents within a few days of hatching (Hand *et al.* 2021). Black Rails are believed to feed primarily on small invertebrates and seeds (Eddleman *et al.* 1994).

CHALLENGES

Decreasing habitat availability and quality likely plays a large role in population decline (Eddleman *et al*. 1994). Wetlands in the Southeastern United States represented 89% of the total wetland lost in the United States in the mid-1980s (Hefner *et al*. 1994). Rapid and expansive coastal development has created many challenges for Black Rails and other coastal species. In addition to direct habitat loss, development also alters the ways that remaining Black Rail habitat is managed.

Sea level rise and climate change are expected to be particularly detrimental to high marsh habitat. In addition to causing flooding during extreme high tides, higher low tides resulting from sea level rise prevent managers from letting out water from impoundments occupied by Black Rails. Increases in storm frequency and intensity may lower productivity if nests or foraging habitat are flooded. Flightless molt coincides with hurricane season (Hand *et al*. 2021) and the increasing severity and frequency of extreme rainfall events and period of drought are likely to reduce survival and productivity.



A flightless female Black Rail documented in a managed tidal impoundment in South Carolina. Christy Hand, SCDNR

Woody vegetation encroaches and shades out stands of desirable vegetation and clumping wetland plants become too dense over time and require a setback to reestablish ground-level tunnels. A variety of tools are available depending on the physical characteristics of the wetlands, time and funding, and overall management objectives for the property. Prescribed fire is an important tool but can result in the death of adults and chicks if precautions are not taken. Slow-burning (backing and flanking) fires that leave a mosaic of burned and unburned areas maintain suitable habitat for Black Rails. Ideally, prescribed burns should occur in late winter or early spring and be immediately followed by flooding to moist soil conditions. Maintaining saturated soil during prescribed fires may minimize the loss of desirable organic material, minimize detrimental effects on invertebrates, and ensure clumping grasses can regrow quickly. Best Management Practices for prescribed fire are provided in the U.S. Fish & Wildlife Service final listing published in the Federal Register (https://www.fws.gov/species-publication-action/threatened-species-status-eastern-black-rail-section-4d-rule-0) and South Carolina-specific details are available in Hand *et al*. (2024). Deep flooding during the nonbreeding season within impoundments also can be an effective tool to eliminate shrubs if the necessary infrastructure is in place (Hand and Weitzel 2021). In small areas, hand clearing and applying herbicide to cut stumps can be effective (Hand 2022).

Managed tidal impoundments provide essential habitat for a variety of waterbirds along the South Carolina coast. These impoundments also significantly contribute to the state's biodiversity. Traditional impoundment management practices prioritize management for wintering waterfowl and other species that benefit from deeper water and substantial fluctuations in water levels. With the exception of a few dragline impoundments where Black Rails have persisted under traditional management due to their unusual elevations and microtopography, traditional management rarely creates suitable nesting conditions for Black Rails. To optimize survival and productivity, it is necessary to prioritize management for Black Rails rather than attempting to manage for a variety of species simultaneously.

Ethical birding practices are particularly critical when seeking an observation of a rare species such as the Black Rail. As interest in birding and nature photography continues to increase, disturbance at popular birding spots has become a threat. Playback of Black Rail calls should not

be used to attempt to lure rails into view and the public should not walk into vegetation where Black Rails may be present. These actions have the potential to disturb birds, alter nest care, increase nest abandonment, trample nests or eggs, and may lead to increased predation (USFWS 2019).

Despite the many challenges faced by the species, some aspects of their ecology are encouraging. For example, SCDNR documented Black Rails successfully raising multiple broods within a breeding season (Hand 2020), and Black Rails can lay 6-8 eggs per clutch, which suggests the species has high reproductive potential if conditions are optimal throughout the breeding season. In addition, Black Rails are primarily found in managed wetlands in South Carolina, which offers more opportunities for habitat management compared to undeveloped tidal marshes.

CONSERVATION ACCOMPLISHMENTS


Color banded adult male Black Rail followed by a brood of chicks, Christy Hand, SCDNR

During the past decade, substantial conservation accomplishments have been made for the Eastern Black Rail in South Carolina and throughout their range. The USFWS has published a Species Status Assessment (USFWS 2019), which provides the basis for listing the species as Threatened under the federal Endangered Species Act (USFWS 2020). An updated Species Status Assessment incorporating new data will be published during 2026.

SCDNR, USFWS, and partners have implemented population monitoring using call-response surveys annually from 2014-2024 and participated in developing the range-wide Eastern Black Rail Call-Response Survey Protocol (Hand *et al*. 2023) to monitor for changes in distribution, status, and trends. Based on these survey data, SCDNR determined Black Rails primarily are breeding in dragline impoundments (Hand *et al*. 2024) and are very rarely found in historical rice fields during the breeding season, as was commonly believed (Roach and Barrett 2015).

Building upon research by a collaborator from Australia (Znidersic 2017), SCDNR adapted the use of motion-triggered camera traps (camera traps) to detect Black Rails, determine breeding phenology and breeding status (based on estimated hatch dates from 72 broods, Hand 2023), and determine flightless molt phenology and duration (Hand *et al.* 2019, Hand *et al.* 2021). SCDNR is now able to provide the following definition for these important periods: SCDNR defines the nesting and brooding period in South Carolina from April 1 to September 30 and the flightless molt period from August 1 to October 31 (Hand and Weitzel 2021; Hand *et al*. 2021). Black Rails have limited mobility and high food requirements during these periods; therefore, maintaining suitable habitat conditions increases their survival and reproductive success. These two periods of vulnerability offer the greatest opportunities to positively influence chick and adult survival. Land managers and regulators now prioritize water level management during these periods of elevated vulnerability with the goal of reducing adult mortality and increasing the survival of nests, chicks, and fledglings. Data collected by SCDNR using camera traps from 2015-2024 provided a new window into previously unknown aspects of Black Rail ecology and

vocalizations and will help to inform an update to the Cornell Lab of Ornithology's Birds of the World account for Black Rails (current edition: Eddleman *et al*. 1994). Using camera trap data, SCDNR determined Black Rails vocalize throughout the day and night and set crepuscular survey periods to coincide with peaks in activity. By conducting additional call-response surveys throughout the breeding and nonbreeding seasons, SCDNR determined Black Rails are present throughout the year in areas used for breeding, but numbers appear to be substantially lower during the winter (Sanders *et al*. 2021).

Autonomous recording units (ARUs) have the potential to increase detection probabilities and to allow intensive monitoring in areas of high management interest while reducing disturbance to Black Rails and their habitat and reducing personnel time. Beginning in 2015, SCDNR has been collecting acoustic recordings each year using ARUs. SCDNR co-leads the Eastern Black Rail Bioacoustics Team, a group of researchers from throughout the species range working to develop effective sampling techniques and processing workflows. SCDNR's dataset from wetlands occupied by Black Rails has been used to test and improve the capabilities of BirdNET (Kahl *et al*. 2021), a research platform using computer learning to identify bird calls within large acoustic datasets. BirdNET is now being used to identify Black Rail calls in past and current SCDNR ARU datasets to determine site occupancy and diel vocalization patterns.

SCDNR has researched habitat characteristics such as water depth/fluctuations and vegetation species and structure throughout the past decade using a variety of techniques. In collaboration with the Atlantic Coast Joint Venture (ACJV), the Conservation Media Team at the Cornell Lab of Ornithology, and SCDNR, Whiteout Solutions (https://whiteoutsolutions.com/) collected topobathymetric LiDAR & hyperspectral imagery data via unoccupied aerial systems (UAS) for the purpose of characterizing the microtopography and developing a method for modeling hydrology within Black Rail habitat using UAS-collected data and minimal field sampling. The ACJV is pursuing funding for a larger scale multi-state project.

Several resources providing guidance of habitat management for Black Rails have recently been published. USFWS released their *Eastern Black Rail Recovery Outline* (USFWS 2021) in 2021 and the full USFWS Recovery Plan is anticipated during 2024. The ACJV, which brings together public and private agencies, conservation groups, and other partners focused on the conservation of habitat for native birds, selected the Black Rail as one of their three flagship species in 2016. SCDNR collaborated throughout several years of work, and the ACJV finalized their *Black Rail Conservation Plan* (ACJV 2020) in 2020. SCDNR completed version 1.0 of the *Management Considerations and Recommendations for the Eastern Black Rail in South Carolina* during 2022 (Hand 2022) and worked with partners (USFWS, Nemours Wildlife Foundation, and Folk Land Management) to refine this document as a chapter in a booklet titled *Rice fields for wildlife: history, management recommendations and regulatory guidelines for South Carolina's managed tidal impoundments* (Folk *et al.* 2024) published by Nemours Wildlife Foundation and distributed to local property managers and landowners with managed tidal impoundments. In 2022, the Center for Conservation Biology published a report titled *Eastern Black Rail: Management Guidance* (Watts 2022) focused on management strategies for each population center in the Atlantic Coast Joint Venture geographic area.

To increase quantity and quality of habitat, SCDNR, the USFWS ACE Basin National Wildlife

Refuge, the U.S. Forest Service, and private landowners including the Nemours Wildlife Foundation have dedicated management units (impoundments) and begun intensively managing habitat specifically for Black Rails. In addition to implementing intensive water level management in dragline impoundments, South Carolina was the first state along the Atlantic coast to deploy irrigation systems with the goal of enhancing breeding habitat for Black Rails. Biologists in South Carolina began participating in ACJV Adaptive Management Project in 2022 after SCDNR received a Multi-state Competitive State Wildlife Grant focused on habitat creation through irrigation at the Tom Yawkey Wildlife Center and a grant through State of the Birds focused on optimizing reproductive success of Black Rails through habitat creation and management. Data from these projects will be used to inform future habitat management and creation projects throughout the subspecies range. To remove woody vegetation without temporarily making habitat unsuitable for the rails during the breeding season, Daniel Barrineau (SCDNR Wildlife Biologist) successfully deep flooded key impoundments during the winter. SCDNR also removed shrubs from nesting habitat using hand-cleared and very targeted herbicide treatments during the nonbreeding season.

Numerous outreach and public education activities have been conducted to raise awareness about the conservation needs and opportunities for Black Rails in South Carolina. During 2023, the South Carolina Black Rails working group was established with the mission of implementing "habitat management strategies relevant to South Carolina to advance Black Rail conservation by increasing habitat quantity and quality" (https://www.southcarolinablackrails.org/; Hand and Thistle 2023). During 2023, the Conservation Media Team at the Cornell Lab of Ornithology visited South Carolina to collect footage to create a short film to promote habitat management for Black Rails in the state (https://www.youtube.com/watch?v=e4m6xIl7ds8).



South Carolina Black Rails website.

The Post and Courier newspaper accompanied SCDNR in the field and featured a long-form story about Black Rail research and conservation on the front page of their September 10, 2020 edition ("Ghost Bird", https://www.postandcourier.com/longform/few-will-ever-see-scs-elusive-black-rail-will-climate-change-make-it-vanish-forever/article_fef70ae8-c1ea-11ea-a6dc-c795a69e5e82.html). SCDNR followed up with a blog post providing more detailed information about research and monitoring in South Carolina (Behind "Ghost Bird": Key Discoveries about the Elusive Black Rail https://www.southcarolinawild.org/2020/10/01/2020-9-28-behind-ghost-bird-key-discoveries-about-the-elusive-black-rail/).

Presentations about Black Rail ecology, management, and conservation were given for professional and public audiences including the Waterbird Society, ACE Basin Task Force, South Carolina Interagency Workshop, The Wildlife Society, South Carolina National Wildlife Refuges, Florida and North Carolina Black Rail Working Groups, Carolina Bird Club, and private landowner groups. In addition, USFWS and SCDNR participated in numerous site visits

and informal consultations with landowners and managers who are considering managing wetlands for Black Rails.

CONSERVATION RECOMMENDATIONS

- Overall
    - Implement Recovery Actions established by the *USFWS Recovery Outline for the Eastern Black Rail* (USFWS 2021) and future USFWS Recovery Plans as appropriate for South Carolina.

- Conduct Research to Inform Management Decisions
    - Continue to monitor the status of the Black Rail in South Carolina using standardized protocols provided by USFWS when available. Establish a long-term monitoring framework (e.g., frequency and extent of call-response surveys and sampling utilizing additional methods).
    - Identify potential inland habitat based on historical detections and current land use. Conduct sampling to determine if Black Rails are present and to quantify habitat characteristics. Determine if there are high potential opportunities to manage potential habitat for Black Rails farther from the coast.
    - Continue to collaborate with agencies throughout the range of the Eastern Black Rail to evaluate and improve monitoring methods and to establish standardized range-wide monitoring protocols. Ensure standardized protocols are appropriate for South Carolina by participating in protocol development teams. Standardized protocols for sampling habitat characteristics such as water depth and fluctuations, plant composition and structure, soil firmness, and soil composition are under development. Upcoming priorities include establishing standardized protocols for the use of autonomous acoustic recording units (ARUs), camera traps and evaluating the effectiveness of surveying for rails using thermal imaging from unoccupied aerial systems (UAS; Olsen *et al*. 2024) in South Carolina and determining optimal water depths and vegetation management schedules using data collected with UAS-based LiDAR.
    - Develop effective methods for sampling prey and seed abundance and availability to Black Rails.
    - Identify factors limiting productivity. Factors that should be considered include predation, invasive species (fire ants, feral cats, phragmites, etc.), prey availability, and nest flooding/unstable water levels.
    - Identify factors limiting adult survival and recruitment.

- Develop and Refine Habitat Management Strategies
    - Collaborate with biologists throughout the range of the Eastern Black Rail to develop and test habitat management strategies. Ensure South Carolina is represented in regional and national teams developing conservation and management plans.
    - Test and implement habitat management strategies including the strategies described in the *ACJV Black Rail Conservation Plan* (ACJV 2020) as appropriate. Contribute to the development of future conservation planning documents and

ensure recommendations relevant to South Carolina are included.
    - Develop, assess (through pilot studies), and refine habitat management strategies for dragline impoundments with suitable hydrology and topography.
    - Develop, assess (through pilot studies), and refine habitat management strategies for habitat creation strategies. Determine which site characteristics are necessary for successful habitat creation and management. Determine which techniques are effective for creating suitable conditions (e.g., re-grading and/or adding berms with machinery, irrigation from well or pond, soil amendments, and planting/seeding native plants with suitable structure.

- Implement Habitat Management Actions
    - Implement habitat management recommendations from *Management Considerations and Recommendations for the Eastern Black Rail in South Carolina* (Hand 2022, Hand *et al*. 2024). Excerpts from Hand *et al*. (2024) are included below. These recommendations apply specifically to South Carolina and are based on local knowledge and research. This information is also available through the South Carolina Black Rails working group website, which will be updated as our knowledge increases and we continue testing the recommended strategies (https://www.southcarolinablackrails.org/).
    - Targeted Impoundment Management: Dragline impoundments in coastal South Carolina provide the most immediate opportunities to rapidly incorporate management for Black Rails into existing management plans. A high level of personal commitment from individuals managing these wetlands is critical. The management of impoundments for Black Rails is difficult and time consuming because the rails require much narrower ranges of conditions compared to waterfowl, shorebirds, and wading birds. In wetlands where only a small amount of habitat is likely to be suitable and/or where management for other species is the priority, the incorporation of Black Rail-friendly management practices can still benefit rail conservation. Recommendations include 1) minimizing the magnitude of flooding during vulnerable periods (i.e., flightless molt and nesting and brood-rearing periods), 2) minimizing the duration of flooding during vulnerable periods, 3) minimizing or avoiding burning during vulnerable periods—especially during flightless molt, and 4) maintaining suitable grassy vegetation in high elevation areas of wetlands and in connected uplands. Clearing trees and shrubs from islands within wetlands may be sufficient to provide breeding habitat in wetlands that otherwise would be too deep.
    - Irrigation: Frequent, moderate rainfall often is necessary to create and maintain suitable conditions in both high tidal marsh and impounded habitat, however, rainfall is increasingly unpredictable (i.e., too much or too little). Electric and solar-powered irrigation can be used to supplement rainfall in grassy high marsh habitats such as dragline impoundments or former pastures that otherwise would frequently be too dry to provide suitable habitat. Irrigating this wet meadow habitat facilitates moist soil conditions by maintaining shallow pools of water in depressions while promoting water circulation.
    - Altering Topography and Hydrology: It may be possible to alter the topography and hydrology in wetlands or meadows that do not currently have compatible

characteristics. For example, material dug during quarter drain/canal cleanouts within historical rice fields may be used to create ridges or islands within impoundments that otherwise would be too deep during portions of the breeding season. Alternatively, cross-dikes can be installed to subdivide expansive impoundments to isolate areas with suitable topography and hydrology. New habitat should encompass a minimum of 2.5 continuous acres per breeding pair. Management of woody vegetation will be necessary to maintain newly created habitat and should be considered prior to construction.

- Vegetation Management: Managers should strive to maintain wet meadow conditions that favor clumping wetland plants (i.e., moist soil grasses, sedges, and forbs) while controlling for woody plant encroachment. To maintain suitable vegetation structure, it is necessary to actively manage for early successional habitat. Overly dry conditions can promote woody shrubs, particularly groundsel bush. Conversely, prolonged flooding may eliminate desirable clumping wetland plants (e.g., clump cordgrass, marsh fimbry) and establish monocultures of non-clumping wetland species (e.g., cattails, bulrushes, giant cordgrass). Black Rail management strategies require periodic vegetation management which should be conducted during nonbreeding seasons to maximize the amount of time habitat is available and minimize disturbance during breeding seasons
- Winter Flooding: Flooding during early November–February can be an effective method to kill shrubs and enrich the soil and associated invertebrate community. Due to infrastructure limitations (e.g., dike height), this method is not feasible in all impoundments. Traditionally, flooding during the spring and summer has been used to control vegetation; but flooding during these seasons diminishes or eliminates habitat when Black Rails are breeding. Care should be taken to avoid killing desirable vegetation with prolonged flooding. Managing water levels lower during March–October supports the growth of desirable vegetation (i.e., clump cordgrass and saltmarsh hay) while preventing monocultures of non-clumping species from forming.
- Mechanical Removal and/or Herbicide: When feasible, mechanical removal can be effective for managing small patches of habitat. This practice is most effective when followed-up by treating stumps with a wetland-approved broadleaf herbicide.
- Prescribed Fire: Stands of desirable vegetation may become too dense over time and require a setback to reestablish ground-level tunnels. Fire is an important tool for maintaining early successional grassland habitat but can result in the death of adults and chicks if precautions are not taken. Prescribed burns typically should occur in late winter or early spring and be immediately followed by flooding to moist soil conditions to promote desired plant growth and re-establish invertebrate communities. Maintaining saturated soil during prescribed fires may minimize the loss of desirable organic material, minimize detrimental effects on invertebrates, and ensure clumping grasses can regrow quickly. In addition, saturated soil may promote patchier burns, which are safer for Black Rails. Best Management Practices for prescribed fire must be followed and are provided in the U.S. Fish & Wildlife Service final listing published in the Federal Register (https://www.fws.gov/species-publication-action/threatened-species-status-

eastern-black-rail-section-4d-rule-0) and detailed below under Regulatory Information.
    - Wetland-Upland Interface Refugia: In addition to creating and maintaining breeding habitat, managing similar vegetation structure in adjacent higher elevation areas and connectivity between these habitats (i.e., the wetland-upland transition zone) can also benefit Black Rails as refugia during tropical storms and hurricanes.

- Support Outreach and Public Education
    - Continue and increase collaborations among partners within South Carolina and throughout the range of the Eastern Black Rail to effectively communicate about conservations opportunities to professional and public audiences, with a focus on providing information to landowners and managers with land with potential for management to benefit Black Rails. Coordinate with the ACE Basin Task Force.
    - Support the South Carolina Black Rails working group, which is a coalition of public and private organizations and individuals dedicated to promoting conservation for Black Rails in South Carolina by increasing habitat quantity and quality. As of 2024, working group members include wildlife management and conservation professionals from the South Carolina Department of Natural Resources, Nemours Wildlife Foundation, U.S. Fish & Wildlife Service (Charleston Ecological Services Office, Coastal Program, Partners for Fish and Wildlife Program, and Ernest F. Hollings ACE Basin National Wildlife Refuge), U.S. Forest Service, Atlantic Coast Joint Venture, Ducks Unlimited, American Bird Conservancy, Folk Land Management, and Audubon South Carolina.
    - Create accessible resources with impoundment management recommendations and recommendations for creating new non-tidal wet meadow habitat in pastures and other agricultural land.
    - Raise public awareness about status and conservation needs of the Black Rail.
    - When appropriate, advocate for Black Rail-friendly management on public and private properties. Assist property owners in securing cost-share funding for projects with high potential to contribute to the recovery of Black Rails.

MEASURES OF SUCCESS

The first measure of success would be to continue to implement long-term population monitoring studies which would yield information about distribution, population status, and trends. The next step is to increase quantity and quality of habitat by implementing the above-mentioned conservation recommendations. The ultimate measure of success is to increase populations to a sustainable level.

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Black-throated Green Warbler (Wayne's race)

Setophaga virens wayneii



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DESCRIPTION

Taxonomy and Basic Description

The Wayne's race of the Black-throated Green Warbler is recognized as highest priority in the SWAP. The more widespread nominate race was described by Gmelin in 1789, and is found in the Blue Ridge Ecoregion of South Carolina, whereas the subspecies known as "Wayne's" is confined to the Coastal Plain.



Black-throated Green Warbler males of all forms have a black throat with a bright yellow face while the females are duller in color (Morse and Poole 2020). The typical size of the nominate race is 11 to 12 cm (4.3-4.7 in.) (Morse and Poole 2020). Wayne's Black-throated Green Warbler is slightly smaller with a smaller bill (Morse and Poole 2020). Male Wayne's Black-throated Green Warblers also have slightly less extensive black bibs (Dias, pers. comm.). The coloration is olive on the back and crown with yellow on the head (Sauer et al. 2000). Black streaks are present on the sides while the wings have white bars (Sauer et al. 2000). The male has an additional black throat patch (Sauer et al. 2000). The breeding range, separated from the nominate race by more than 321.8 km (200 mi.) and a 609.6 m (2,000 ft.) elevational difference, consists of a narrow band of Atlantic white cedar (*Chamaecyparis thyoides*) stands, cypress (*Taxodium*) swamps, and other forested wetlands of the Outer Coastal Plain from southern Virginia to South Carolina.

Watts and Paxton (2002) noted that peak singing activity for Wayne's is around the end of April with a notable decrease after mid-May. This corresponds to its early spring arrival, usually the last 7 to 10 days of March in South Carolina.

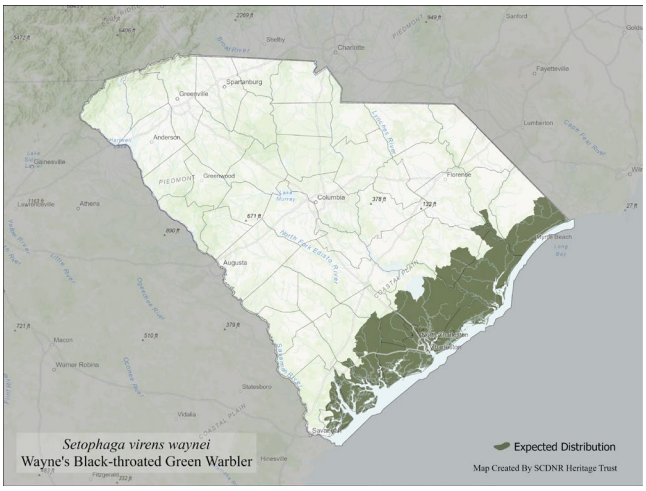
Status

The Wayne's Black-throated Green Warbler is protected under the Migratory Bird Treaty Act. It is listed as a "species of special concern" by the South Carolina Department of Natural Resources (SCDNR). In addition, it and the nominate race are considered high priority landbirds by Partners in Flight (Partners in Flight Science Committee 2013). Wayne's is locally distributed

within a narrow belt of forested wetlands of the Outer Coastal Plain from southern Virginia to the Edisto River in South Carolina. Even within this narrow range, it is absent from some areas. The South Carolina Heritage Trust Program identifies the Wayne's race as imperiled to critically imperiled (S1S2B) in South Carolina. The nominate race is considered secure but the Wayne's race is considered critically imperiled (G5T1) globally. Population estimates and trends are not available for Wayne's Black-throated Green Warbler, but the nominate species has experienced a -4.58% population decrease from 1970 to 2014, and a -21.29% decrease from 2004 to 2014 (Panjabi et al. 2021).

The second-largest colony of Wayne's Black-throated Green Warblers in SC has dwindled to a few sporadic sightings. Other colonies have disappeared entirely since the mid-to-late 1990's (Dias, pers. comm.). Population levels in the Francis Marion National Forest and other areas that received heavy damage from Hurricane Hugo in 1989 did not begin a steep or noticeable decline until the mid to late 1990's. For example, the population in the drainage between the Wambaw Wilderness and the Little Wambaw Wilderness was South Carolina's second-largest population until 2000. Point counts conducted from mid-March to April of 1998 consistently yielded multiple singing males with a low count of 5 and a high count of 10. During surveys conducted between 2010 to 2014, a maximum of one or two singing males were counted; many surveys failed to identify any birds (Dias pers. comm.).

POPULATION SIZE AND DISTRIBUTION



The nominate race has a wide distribution which extends into Canada. The population is thought to be approximately 11,000 birds in South Carolina (Partners in Flight 2020). However, Wayne's race has one of the most restricted breeding distributions of any warbler in South Carolina or the Southeastern United States. It is rarely found further than 40 to 48 km (25 to 30 miles) inland from the coast. Prior to Hurricane Hugo, the habitat of the Francis Marion National Forest in Berkeley and Charleston Counties could have supported the largest population in South Carolina (Cely, pers. obs.). Even there, it was probably not common, based on 82-point counts conducted in the late 1970's. In these counts, Black-throated Green Warblers ranked 8th out of 12 breeding warblers (Hamel 1981). The Wayne's Black-throated Green Warbler has a spotty, and perhaps clumped, distribution within its limited range in the state. It is not known to occur in Horry County and much of northern Georgetown County. A population of unknown size and status occurs southwest of Charleston extending up, but not within, the Edisto River floodplain. Black-throated Green Warblers are not known to occur within the ACE Basin west of the Edisto. Population size and trends are unknown, although it is suspected of disappearing or declining from southeastern Virginia and parts of North Carolina (Watts and Paxton 2002) as well as areas devastated by Hurricane Hugo in South Carolina in 1989 (Cely pers. obs.). Wayne's Black-throated Green Warbler appear to winter in the Caribbean

Basin where additional threats to their populations may be occurring, but are unknown (NatureServe Explorer 2024).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The nominate race is typically found in coniferous stands of white pine/hemlock in the Blue Ridge Ecoregion of South Carolina with an apparent attraction for stage 3 to stage 4 oak-hickory stands that graded into coves that were devoid of hemlocks or white pines Huckabee pers. obs.). In contrast to the nominate Black-throated Green Warbler, the Wayne's race occurs along the Coastal Plain and prefers stands of deciduous or cypress trees.

In coastal South Carolina, Wayne's Black-throated Green Warblers avoid the big blackwater rivers, except for a stretch of Wambaw Creek near the South Santee River. They remain in areas around the slow-moving headwaters of blackwater creeks and the swamps and swamp borders that feed blackwater rivers and their tributaries. South Carolina colonies sometimes occur in isolated Cypress-Tupelo swamps amidst drier pine-hardwoods habitat.

In southern Virginia and coastal North Carolina, Wayne's Black-throated Green Warblers are closely associated with Atlantic white cedar. Where cedar is scarce or absent, such as coastal South Carolina, these birds are found primarily in non-alluvial forested wetlands or transitional zones between upland and wetland, where, as a canopy or subcanopy species, it uses blackgum (*Nyssa sylvatica*), laurel oak (*Quercus laurifolia*), sweetgum (*Liquidamber styraciflua*), bald cypress (*T. distichum*), "wet" loblolly pine (*Pinus taeda*), and red maple (*Acer rubrum*). It is rare to see this species without the presence of pond cypress, sweet gum, and black gum, and they are almost always located near water tupelo (*Nyssa aquatica*) (N. Dias, pers. comm.). Wayne's Black-throated Green Warblers are sometimes found in small or headwater riparian forests, but most observers suggest an association with forest stands growing in non-alluvial muck swamp. In Virginia and North Carolina, Watts and Paxton (2002) found higher than expected warbler use in survey plots containing loblolly pine, Atlantic white cedar, and bald cypress and less than expected use in those plots with pond pine *(P.serotina*) and hardwoods. This may help to explain the bird's absence in pond pine-dominated Carolina bays in Horry County. However, a 2021 study in NC found Wayne's Black-throated Green Warbler nests in loblolly bay, loblolly pine, red maple, and pond pine trees, all within swampy sites (Worm and Carpenter 2021). Wayne's Black-throated Green Warblers are not known to occur in large and medium outer coastal plain floodplain forests such as those associated with the Waccamaw, Great Pee Dee, Black, and Santee Rivers.

In the Francis Marion National Forest, Hamel (1981) noted most foraging and behavioral observations occurred between 10 and 17 m (32.8 and 55.7 ft.), similar to that of the pine warbler (*D. pinus*) and yellow-throated warbler (*D. dominica*). More than 50% of behavioral observations were made in laurel oak, blackgum, sweetgum, and water oak (*Q. nigra*). Red maple was used sparingly, and a subjective impression was that the species was found in forest stands with a high site index (Hamel 1981). Male Wayne's Black-throated Green Warblers favor sweet gum trees for singing perches, even with taller cypress or tupelo trees nearby (Dias pers comm.).

CHALLENGES

Based on its very restricted breeding range, apparent decline in parts of this range, and the fact that almost nothing is known about its breeding biology, status, and habitat use, the Wayne's Black-throated Green Warbler should be considered a high priority landbird species for research and survey efforts in South Carolina.

As a canopy/subcanopy species, short timber rotations may negatively affect the nominate race and subspecies (Cely pers. obs.; Sprunt 1953; Morse and Poole 2020). Alterations of hydrology and wetland drainage also pose potential problems. Additionally, Hurricane Hugo opened up many habitats to Brown-headed Cowbirds. The I'On Swamp Road in the Francis Marion National Forest used to have breeding Wayne's warblers without sightings of Brown-headed Cowbirds. Currently, the opposite is true—Brown-headed Cowbirds are often seen while very few Wayne's warblers are noted. However, effects of nest predation have not been studied in depth.

Like most Neotropical migrants, the Black-throated Green Warbler is probably area-sensitive and may require thousands of acres of suitable habitat in large blocks to sustain long-term population viability. No information is available on wintering grounds habitat use.

CONSERVATION ACCOMPLISHMENTS

Past surveys for Wayne's Black-throated Green Warbler were coordinated through the Cape Romain Bird Observatory (Dias pers. comm.). These studies have confirmed that Wayne's Black-throated Green Warbler is declining precipitously in South Carolina. Researchers tried to plot all known present breeding locations, develop a plant index at each site, and document the locations of suitable habitat on private lands, especially plantations.

Some private lands, especially those with easements or long timber rotations, may offer some protection as well. The protected Francis Marion National Forest probably has the main concentration of the species in South Carolina.

CONSERVATION RECOMMENDATIONS

- Investigate the possible benefits of Streamside Management Zones and buffers to Wayne's Black-throated Green Warblers, with particular attention to characterization of width, extent, and configuration.
- Complete intensive surveys to locate as many potential breeding populations of Wayne's Black-throated Green Warblers within the State as possible.
- Support adoption of Brown-headed Cowbird control measures near identified breeding locations of Wayne's Black-throated Green Warblers.
- Conduct in-depth investigations of Wayne's Black-throated Green Warbler breeding biology and habitat use once breeding populations have been identified. Locate nests and determine nesting success and nesting habitat, site fidelity, foraging behavior, and habitat use. At least two such study areas should be established, if possible, for comparative purposes.

- Develop a statistically valid monitoring protocol for Wayne's Black-throated Green Warblers.
- Determine wintering locations, migration corridors, and stopover sites for Wayne's Black-throated Green Warblers.
- Issue news releases and information to the public, constituent groups and conservation organizations. Biologists and researchers should work closely with landowners and the forest products industry to provide management data as it becomes available.
- Establish habitat protection measures for Wayne's Black-throated Green Warbler, including easements, Best Management Practices, and acquisition where feasible.

MEASURES OF SUCCESS

After determining habitat use, management guidelines should be provided to landowners and agencies. Adaptive management techniques should be utilized when opportunities arise. The development of a valid monitoring protocol for the Wayne's race will facilitate the periodic evaluation of population health and allow for appropriate corrective measures when declines occur.

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Colonial Nesting Seabird Guild

Black Skimmer *Rynchops nigra*
Brown Pelican *Pelecanus occidentalis*
Common Tern *Sterna hirundo*
Forster's Tern *Sterna forsteri*
Gull-billed Tern *Gelochelidon nilotica*
Least Tern *Sternula antillarum*
Royal Tern *Thalasseus maximus*
Sandwich Tern *Thalasseus sandvicensis*

Contributors (2005): Thomas M. Murphy, Sally R. Murphy, and DuBose Griffin (SCDNR); Reviewed and Edited (2012): Felicia Sanders (SCDNR); Reviewed and Edited (2024): Mary-Catherine Martin (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

This guild ranges from the diminutive Least Tern (wingspan of 50.8 cm or 20 in.) to the sizeable Brown Pelican (wingspan of 228.6 cm or 90 in.). Members represent 2 families and are grouped into a guild because they nest on small coastal islands in mixed colonies. The 2 families are: Pelecanidae (pelicans) and Laridae (gulls and terns).

Smallest of the North American terns, the Least Tern measures 21 to 23 cm (8.3 to 9.1 in.). This tern has a black cap with a white forehead. Least Terns are grey above and white below with two black outer primaries. The bill is yellow with a dark tip (Thompson et al. 2020).



Least Tern, Photo by USFWS

The Sandwich Tern is intermediate in size between the Royal and Common Terns. Sandwich Terns are sized 34 to 45 cm (13.4 to 17.7 in.) and weigh between 180 and 300 g (6.3 to 10.6 oz.). This tern is the only crested tern with a black bill, the tip of which is yellow. They are uniformly gray above, darker on their outer primaries, and have a white rump and tail. Underneath, Sandwich Terns are white with dark grayish edges under the primaries. The cap is entirely black with a spiky crest (Shealer et al. 2020).



Sandwich Tern, Photo by Erin Weeks/SCDNR

The Gull-billed Tern is another medium-sized tern measuring 33 to 38 cm (13 to 15 in.) (Molina et al. 2023). The Gull-billed Tern has a black bill and is similar in size to the Sandwich but has a stockier, gull-like build, longer legs, and a thicker, shorter bill. The upper wing of the Gull-billed Tern is uniform with a black line on the edge of the primaries, a gray rump, and a similar tail. Gull-billed Terns have black ear patches during the nonbreeding season (Molina et al.2023).



Gull-billed Tern, Photo by Felicia Sanders/SCDNR

Common Terns are medium-sized terns with a length of 31 to 35 cm (12.2 to 13.8 in.), including elongated outer tail feathers forming a 6 to 9 cm (2.4 to 3.5 in.) fork. These terns weigh between 110 and 145 g (43 to 57oz.). Adult breeding Common Terns are light gray above and below with a black cap, orangish-red legs, and an orange-red bill with black tip. There is extensive black on outer primaries that is obvious on the closed wing (Arnold et al. 2020)



Common Tern: Photo by USFWS

Forster's Terns are typically 33 to 36 cm (13 to 14 in.) long and weigh 130 to 190 g (4.6 to 7.0 oz.). Both sexes are mostly white during the breeding season with a black cap, pale gray wings, and a deeply forked tail. These terns have orange legs and variably black-tipped orange bills (McNicholl et al. 2020).

The Royal Tern is the largest crested tern with a length of 45 to 50 cm (18 to 20 in.) and a weight of 350 to 450 g (12 to 16 oz.). Both sexes of the Royal Tern have long, orange bills and forked tails. The breeding plumage of the Royal Tern is gray above and white below with a full black cap and shaggy crest. The rump is very pale gray with a white tail. The legs and feet are black and the eyes dark brown (Buckley et al. 2021).



Royal Terns: Photo by Felicia Sanders/SCDNR

The Black Skimmer is a slim bird with a black back and white belly. Males and females vary greatly in size with lengths between 40 and 50 cm (16 to 20 in.). Weight for females averages 265 g (9.3 oz.) while male weights average 365 g (12.9 oz.). The bill of the Black Skimmer is unique: half red and half black, long, and laterally flattened. The bill of the male Black Skimmer is larger than the bill of the female Black Skimmer (Gochfield et al. 2020).



Black Skimmers: Photo by Felicia Sanders/SCDNR

The Brown Pelican is one of two North American pelican species and is easily distinguished from its counterpart, the American White Pelican. American White Pelicans are larger with white bodies and black primaries. Brown Pelicans are gray to gray-brown with a black-brown belly. This coastal seabird is very large, measuring 100 to 137 cm (3.3 to 4.5 ft.) with a long bill (25 to 38 cm, 9.8 to 14.9 in.) and extensible gular pouch (Shields 2020).



Brown Pelicans: Photo by Felicia Sanders/SCDNR

Status

Least Terns are listed as South Carolina state threatened. Coastal populations have no official federal designation since they are common along the Gulf and Atlantic Coasts. Nevertheless, Least Terns are classified as threatened, endangered or a species of concern for most states because of the loss of nesting habitat (Thompson et al. 2020).

Brown Pelicans were formally listed as endangered throughout their range in 1970, but were removed from the list in Alabama, Florida, Georgia, South Carolina, North Carolina, and other areas of the Atlantic coast in 1985as both numbers and reproductive success recovered (Shields 2020). Gull-billed Terns and Black Skimmers are listed as South Carolina state species of concern.

POPULATION SIZE AND DISTRIBUTION

This guild of birds supports populations with thousands of nesting pairs. All of these birds are subject to loss of suitable nesting habitat, which can cause abrupt changes in numbers. Members of this guild are probably at much lower population levels than they were historically. Common and Forster's Terns are peripheral and occur in low numbers. Figures 1 through 6 show the minimum number of nests recorded for each species as part of the statewide seabird census, running from 1989 to present day. A more detailed status review through 1996 can be found in Wilkinson (1997) with Royal Tern, Sandwich Tern, and Brown Pelican trends found in Jodice et al. (2007) in figure 7.

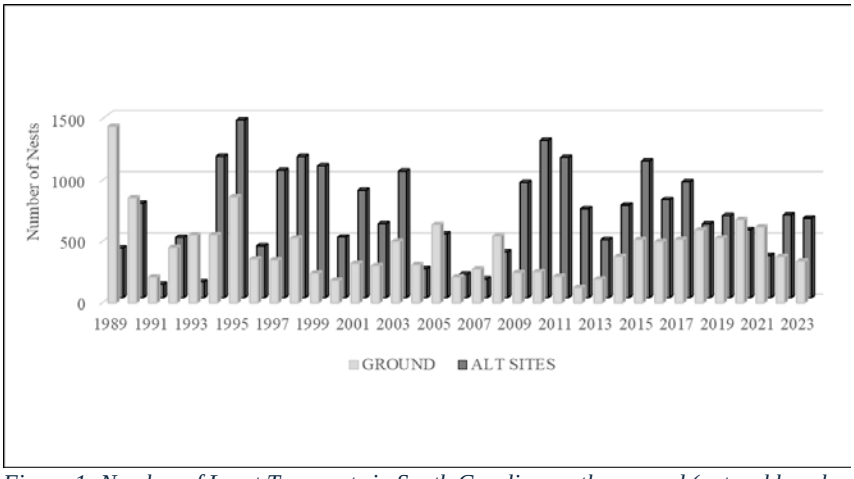


Figure 1: Number of Least Tern nests in South Carolina on the ground (natural beaches) and on alternative sites including dredge spoil sites and graveled roof tops. Use of graveled roof tops and other alternative sites started in 1975 in South Carolina.

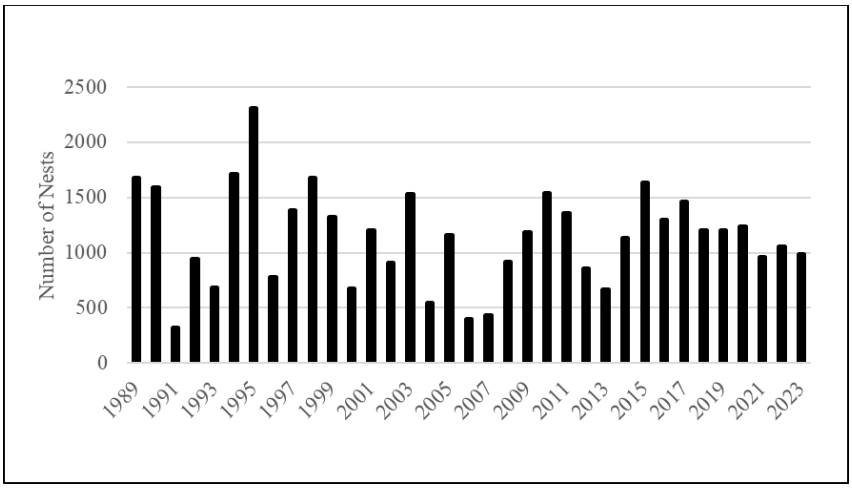


Figure 2: Number of Least Tern nests in South Carolina

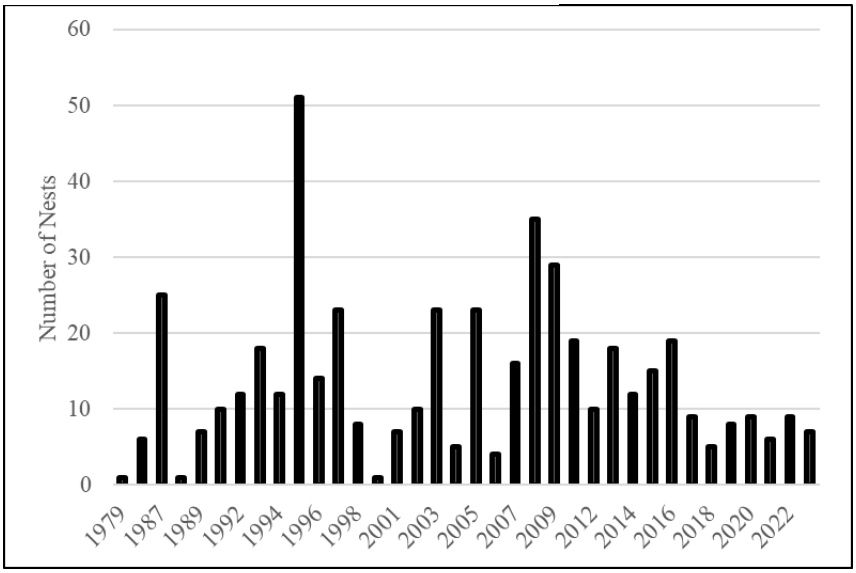


Figure 3: Number of Common Tern nests in South Carolina

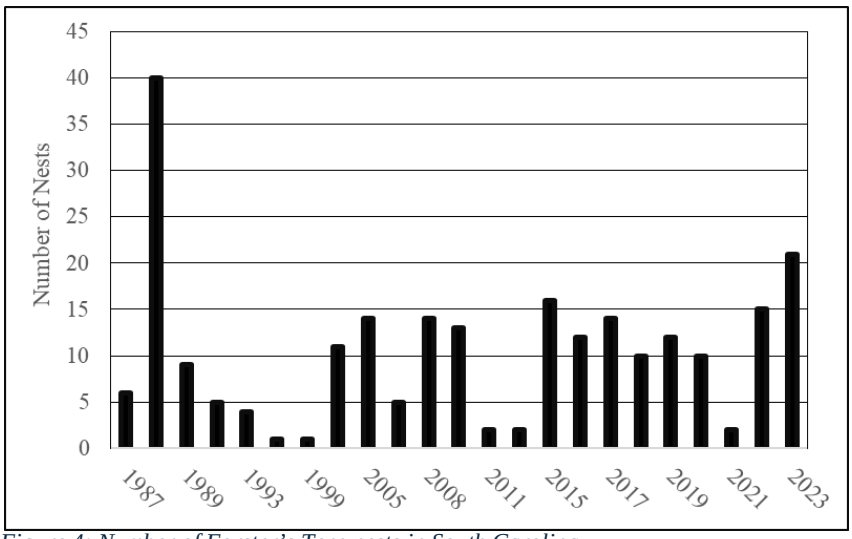


Figure 4: Number of Forster's Tern nests in South Carolina.

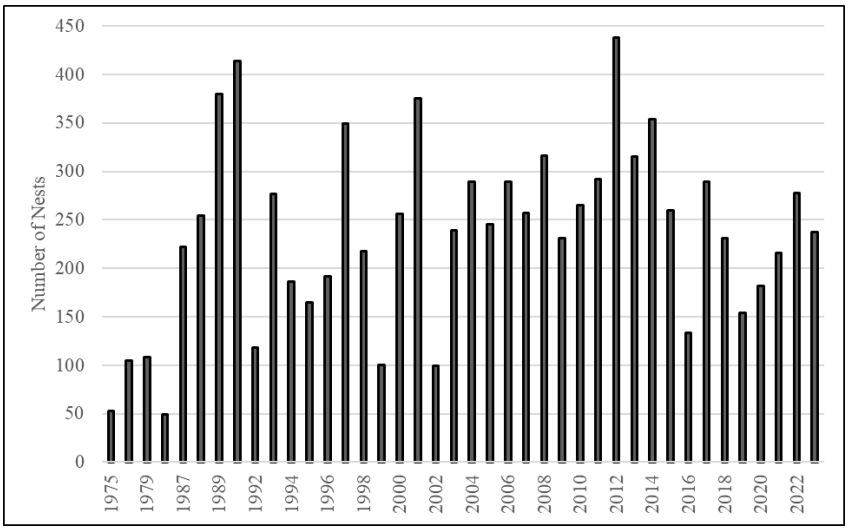


Figure 5: Number of Gull-billed Tern in South Carolina

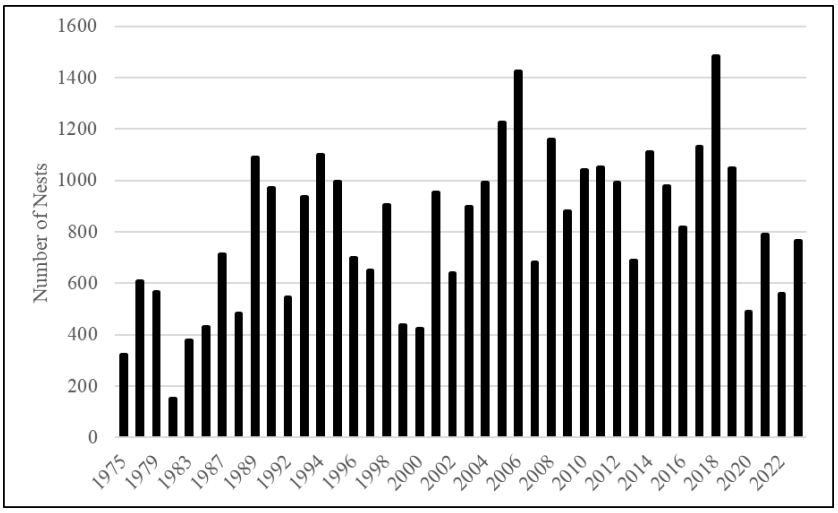
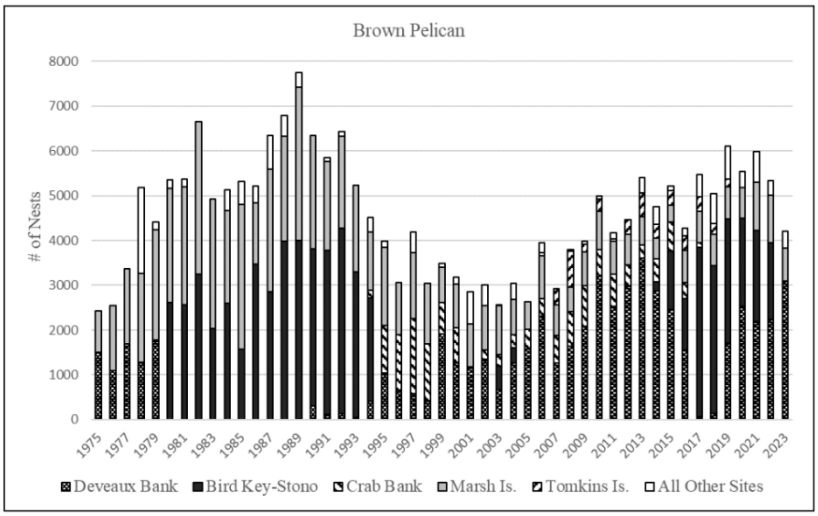
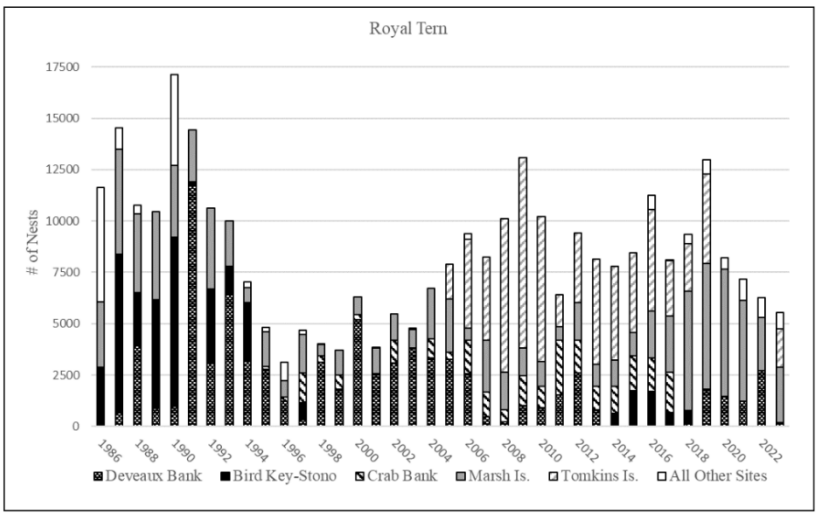


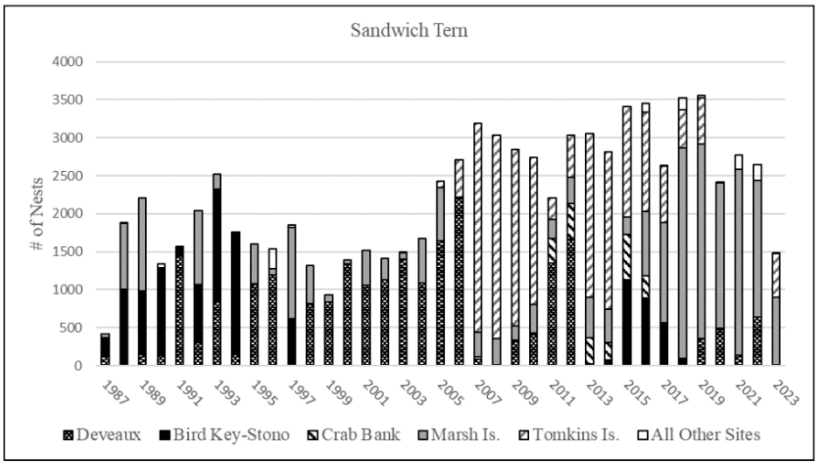
Figure 6: Number of Black Skimmer nests in South Carolina.



(a)

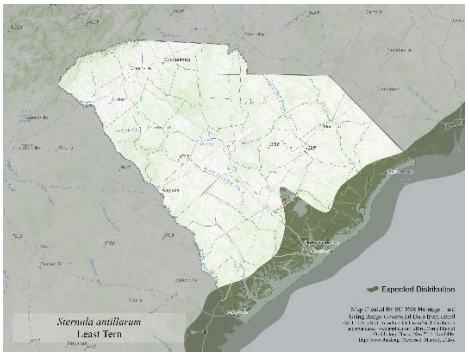


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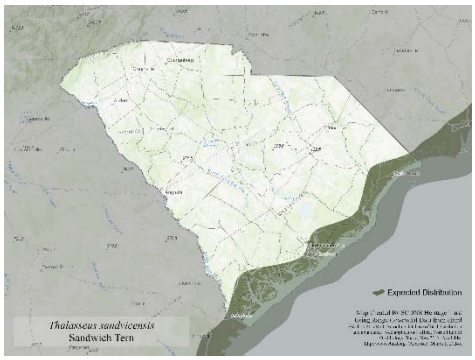


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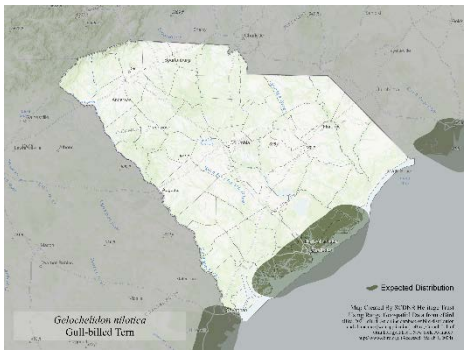
Figure 7: Brown Pelican (a), Royal Tern (b), and Sandwich Tern (c) nest numbers by year at 6 different sites in South Carolina. Adapted from Jodice et al. (2007).



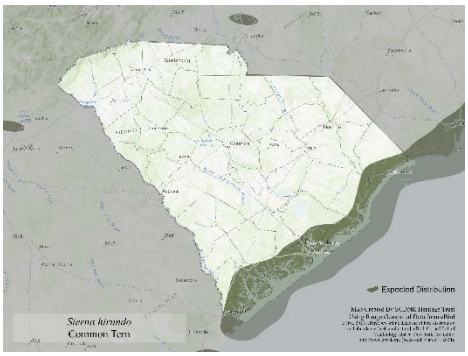
Least Tern distribution.



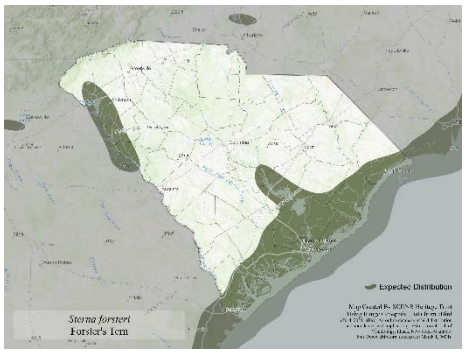
Sandwich Tern distribution



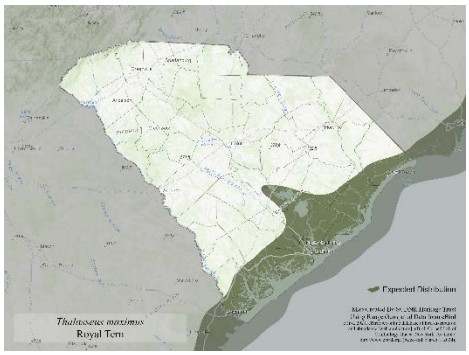
Gull-billed Tern distribution



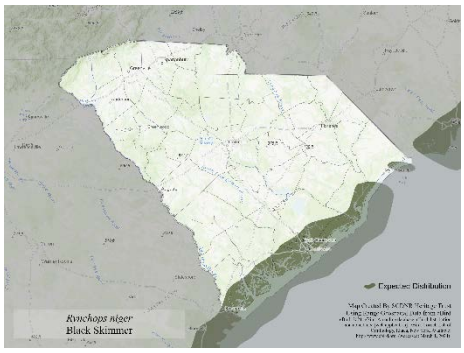
Common Tern distribution



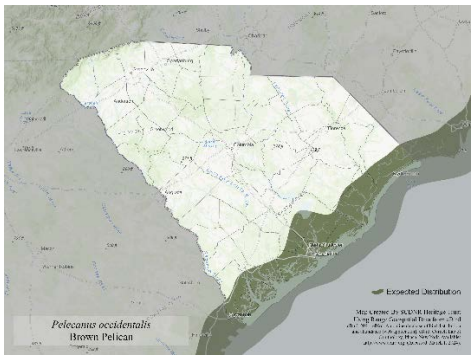
Forster's Tern distribution



Royal Tern distribution



Black Skimmer distribution



Brown Pelican distribution

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Seabirds usually nest on isolated coastal islands that are high enough to avoid over-washing and too small to support mammalian predators. Most active nesting sites in the state are in Charleston County. Three of the islands with the multiple species of nesting seabirds are made from or augmented with dredge material. Due to erosion of natural sites from extreme high tides and storms these types of islands may be more common in the future. Nesting occurs in habitats ranging from bare sand and shell to low grass or shrub vegetation. The ends of larger barrier islands are used by several species. Nesting colonies serve as information exchange centers to facilitate location of prey that has a patchy and changing distribution

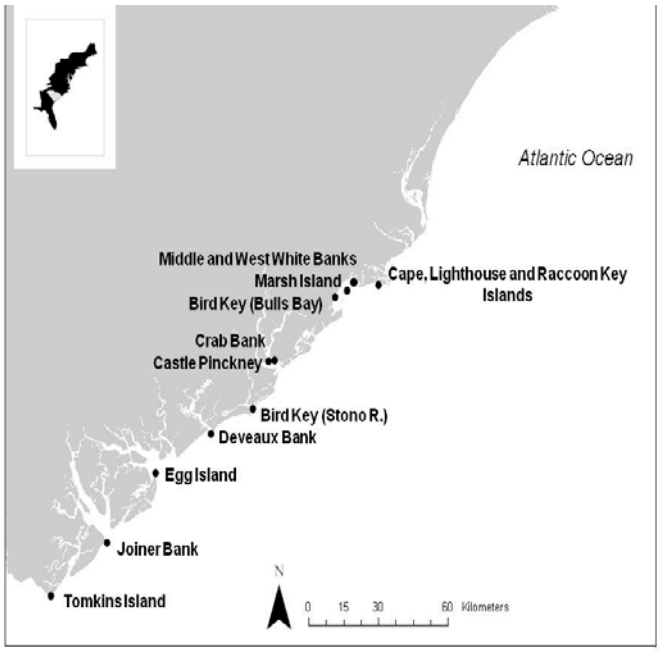


Figure 8: Locations of seabird colonies in South Carolina. These locations include sites that are currently active and sites that have had use in the past.

This guild is principally piscivorous and feeds in nearshore and estuarine waters of the state. During the nesting season, foraging is limited to areas within 16 to 24 km (10 to 15 mi.) of nesting sites. Terns typically plunge dive for food, while pelicans and skimmers have specialized foraging strategies. This guild also utilizes shrimp trawler by-catch.

CHALLENGES

Members of this guild share both nesting and foraging sites and are usually impacted by the following factors: loss of suitable nesting habitat; disturbance at nest and roost sites; predation, especially during nesting; soft tick infestation; loss of suitable roof nesting sites; oil spills; and loss of prey base.

Seabirds nest at sites that are prone to sudden and dramatic changes. Storms and hurricanes can alter or destroy nesting islands at any time. Loss of a single colony site can result in major, lasting impacts to statewide populations. Many of the islands currently in use by seabird colonies are owned by state or federal government agencies.



Soft tick infestation of a pelican nest. Photo by SCDNR

With ever increasing coastal development and associated boat use, protection of seabird colonies has become increasingly difficult. During the nesting season, several thousand nests can be negatively impacted by a single disturbance event such as a person entering a nesting colony during the heat of the day. Egg temperatures are significantly altered when the brooding parent is forced from the nest. Dogs that often

accompany their owners are a particular problem as they run through the colonies destroying eggs, killing or injuring chicks, and causing parent birds to leave chicks unattended and therefore vulnerable to aerial predators.

Predation by avian and mammalian predators significantly lowers nest success and can cause complete colony abandonment. Mammalian predators such as American mink, coyote and raccoon are frequently found on barrier islands, and trapping of these predators may be necessary to decrease loss of seabird, shorebird, and sea turtle nests. Great Horned Owls can cause colony abandonment and will prey on seabird adults and chicks. Nest abandonment associated with tick infestations has frequently affected Pelican rookeries in the state. These ticks (*Ornithodoros* spp.) feed mostly at night and complete a blood meal in a matter of hours; therefore, they are infrequently seen on the birds. Close examination of nests and chicks is required to detect the presence of ticks except when they are present in high densities. Infestations can involve thousands of ticks per nest and result in nest abandonment.

Least Terns have been able to maintain their nesting population by utilizing roofs with a pea-gravel substrate for nesting. A large proportion of the current population was hatched and has nested exclusively on roofs. In 2012 building codes changed in South Carolina to prohibit construction of gravel-covered flat roofs in hurricane prone coastal areas. The majority of gravel-covered roofs are old and have been refurbished with a poly-membrane resulting in a loss of 50% of suitable nesting roofs. Furthermore, although roof nesting sites can be productive, they frequently flood during thunderstorms, and may receive excessive disturbance from HVAC repair activities, and are susceptible to avian and rat predation.

CONSERVATION ACCOMPLISHMENTS

- South Carolina has the longest running seabird nesting trends dataset in the Southeast.

- Annually, 25 nesting sites on private and public lands are identified and posted with closed signs to minimize disturbance to colonial seabirds.

- Four SCDNR owned islands, with large colonies of nesting seabirds, continue to have Sanctuary Status as initially described and established by the SC Budget and Control Board on March 21, 2006. This Sanctuary Status allows management of the intertidal zone to benefit birds. Crab Bank and Bird Key-Stono are closed to boat landings and public access from March 15 – October 15. Deveaux Bank has closures to protect nesting and migratory birds. Tomkins Island is closed to public access year-round. Dogs and camping are prohibited year-round on these Sanctuary islands.

- Crab Bank Seabird Sanctuary was rebuilt in late 2021 with material taken from the Charleston Harbor Post 45 Deepening Project. The island is approximately a 32-acre sand bar at the mouth of Shem Creek. The first nesting season, in 2022, was successful for numerous seabird species including Black Skimmers and Least Terns.

- To avoid detrimental disturbance of walking through large colonies of Brown Pelicans, Royal Terns, and Sandwich Terns to obtain nest census data, aerial photos are obtained

from fixed-wing aircraft and/or drones. Nest counts are made from digital images using Image J software.

- New dog and camping restrictions on SCDNR owned barrier islands were passed. In 2023 an educational campaign, to make the public aware of the importance of undeveloped barrier islands to nesting birds, accompanied new signage with the beach rules and regulations.

- Beach stewarding programs were organized at several nesting sites with high probability of public disturbance. Beach stewards, consisting of volunteers and SCDNR staff, educate the public about nesting birds and facilitate reproductive success by minimizing disturbance.

- Created and implemented a web site with information on the status, management and natural history of seabirds in South Carolina. Additionally, the website promotes conservation of seabirds through partnerships and volunteer opportunities.

CONSERVATION RECOMMENDATIONS

- Protect birds during the nesting season with adequate and timely posting, stewarding and effective law enforcement.
- Establish or maintain suitable nesting islands at 48 km (30 mi.) intervals along the coast to maximize use of foraging habitat during the nesting season.
- Evaluate management actions and determine population trends using annual monitoring with complete ground or aerial counts.
- Continue cooperative efforts with the US Fish and Wildlife Service to census and manage nesting sites within Cape Romain National Wildlife Refuge.
- Monitor soft tick infestations and provide suitable treatment as needed.
- Conduct cooperative projects with the US Army Corps of Engineers to construct and maintain seabird-nesting sites under the authority of Section 204 of the Water Resources Development Act of 1992.
- Continue public education programs and partnerships on private and federal lands to promote conservation of seabirds.
- Develop oil spill contingency plans to protect nesting sites and provide rehabilitation of oiled birds.
- Maintain the fish prey-base for long-term success of these species.
- Continue to investigate management techniques that will improve reproductive success of these species.
- Continue to band seabirds to gather additional information on recruitment, dispersal, and migratory patterns.
- Participate in the development of monitoring protocol and data storage that can be used by the entire Southeast region. Support development of a Southeast Seabird Working Group.

MEASURES OF SUCCESS

This guild of birds is subject to rapid shifts in distribution and abundance and will require adaptive management to respond to these changes. Maintaining stable or increasing seabird populations regionally will represent a measure of success.

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Colonial Nesting Wading Birds and Allies Guild

Green Heron *Butorides virescens*
Little Blue Heron *Egretta caerulea*
Reddish Egret *Egretta rufescens*
Roseate Spoonbill *Platalea ajaja*
Snowy Egret *Egretta thula*
Yellow-crowned Night Heron *Nyctanassa violacea*

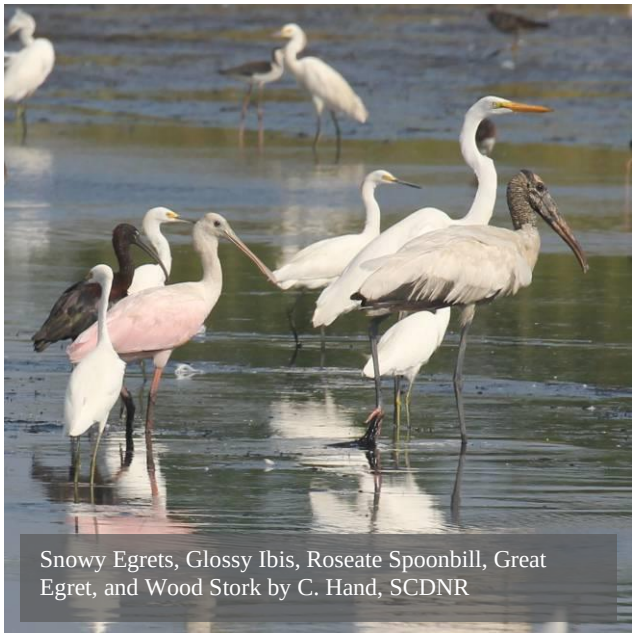
ALLIES
Double-crested Cormorant *Nannopterum auritum* – Breeding population

NOTE: The Wood Stork is described in a separate species account.

Contributors (2005): Elizabeth A. Ciuzio (KYDNR) and Thomas M. Murphy (SCDNR)
Reviewed and Edited (2012): Christine E. Hand (SCDNR)
Reviewed and Edited (2024): Amy Tegeler (SCDNR) and Mikayla Thistle (SCDNR)

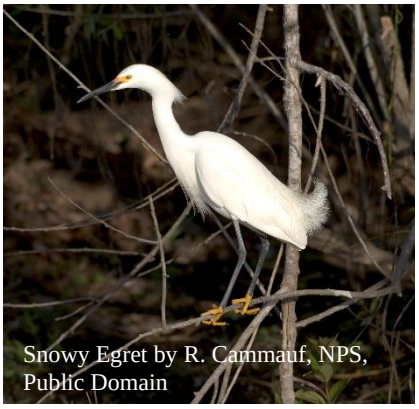
DESCRIPTION

Taxonomy and Basic Descriptions


Snowy Egrets, Glossy Ibis, Roseate Spoonbill, Great Egret, and Wood Stork by C. Hand, SCDNR

As the name suggests, colonial nesting wading birds nest in aggregations called colonies and feed by capturing prey while wading through or standing in shallow water. Colonial nesting wading birds are a taxonomically diverse group. Members of this guild belong to two orders: Pelecaniformes and Ciconiiformes. Pelecaniformes includes three families: Ardeidae (herons, bitterns and egrets), Threskiornithidae (ibises and spoonbills), and Pelecanidae (pelicans). Ciconiiformes includes one family: Ciconiidae (storks). Prior to the reclassification that occurred during 2010, all wading birds were classified as Ciconiiformes. Wading birds are medium to large birds that have long legs, necks and bills. Males and females look similar to each other. Immature birds often have different plumages than adults. These species typically nest and feed in wetland habitats. The double-crested Cormorant is a waterbird in the order Suliformes and the family Phalacrocoracidae that shares some habitat associations with wading birds and thus are included with this guild.

The Snowy Egret is a medium-sized heron that is approximately 56-66 cm (22-26 in) long and has a wingspan of about 100 cm (39 in). The Snowy Egret has white plumage, a thin black bill, black legs, yellow feet, and yellow bare skin around the lores. Breeding adults develop long flumes off the breast and back. The lores become red, pink, or orange during the early breeding season (Parsons and Master 2020).


Snowy Egret by R. Cammauf, NPS, Public Domain


Reddish Egret by Kristie Killam, USFWS, Public Domain

The Reddish Egret is also a medium-sized heron and is approximately 70-80 cm (28-31 in) long. The species has both a white and a dark color morph. Dark morph adults are gray with cinnamon-colored heads and necks. The bill is pink at the base and black towards the tip. The legs are blue on the sides and back and black on the front. Immature Reddish Egrets are gray to grayish tan. The white morph adults look similar to dark morph adults except their plumage is entirely white (Koczur et al. 2020).

The Little Blue Heron is similar in size to the Snowy Egret (length: 56-74 cm [22-29 in], wingspan: 100-105 cm [39-41 in]). Adults are slate blue with a purplish head and neck. The bill is dark gray with a black tip. The base of the bill can turn bright blue when breeding. The legs are gray to grayish green and turn black when breeding. Little Blue Heron chicks are white by day 7, and immature birds are white (Rodgers Jr. and Smith 2020).


Little Blue Heron by David Youngblood


Green Heron by David Youngblood

The Green Heron is small and compact (length 41- 46 cm [16-18 in]) with a relatively short neck and legs. It has a greenish black cap, dark grayish back and wings, reddish neck, and gray under-parts. The legs are yellow to orange-yellow, turning orange in the breeding season. The bill is dark with a yellow lower mandible (Davis Jr. and Kushlan 2020).


Yellow-crowned Night Heron by David Youngblood

The Yellow-crowned Night Heron is a medium-sized heron and is 55-70 cm (22-28 in) long. It is an overall gray with a yellow crown and white on its head and cheeks. Its legs are yellow-green and turn pink to scarlet during courtship. Juvenile Yellow-crowned Night Herons are mottled brown (Watts 2020).


Roseate Spoonbills by David Youngblood

The Roseate Spoonbill is a medium-sized pink wading bird that stands about 80 cm (31 in) tall and has a wingspan of 1.2 to 1.3 m (3.9-4.3 ft, Dumas 2020). The bill is long and flattens towards the tip, giving it a spoon-like appearance. The body is pale to light pink while the shoulders are a brighter pink-red. The legs are pink with some black and the feet are blackish. In adults, the bare head is a yellowish green. Juveniles have a feathered head and are pale pink.


Double-crested Cormorant, Wikimedia Commons

The Double-crested Cormorant is a large waterbird (length 70 to 90 cm [28-35 in], mass 1.2 to 2.5 kg [2.6-5.5 lbs]) with a small head on a long, kinked neck (Dorr et al. 2021). The beak is thin with a noticeable hook on the end. Adults of both sexes are dark brown-black, with a dull glossy sheen. The face and throat have a yellow-orange skin patch. During the breeding season adults develop a crest of black or white feathers behind the eye. Immatures are browner overall, with a paler upper breast and darker belly. Lesson first described the Double-crested Cormorant in 1831 (NatureServe 2024).

The terminology used to describe wading birds can be confusing. In North America, the term “wading bird” is used to refer to storks, herons, and egrets. In other areas of the world, shorebirds, such as oystercatchers and sandpipers, are often referred to as wading birds. The sites where groups of wading birds nest are referred to as colonies or rookeries. Sites where groups of wading birds rest during the day or overnight are called roosts, and groups of feeding wading birds are referred to as flocks or feeding aggregations.

Status

Members of this guild are of conservation concern because their reproductive strategy leaves them especially vulnerable to habitat degradation. Many wading bird species nest in large colonies; dozens of birds can nest in a single tree. Although this strategy affords benefits in terms of predator avoidance, it makes them especially vulnerable to habitat loss because the degradation of a small area (colony) can affect hundreds of breeding pairs of several different species. Food availability may be the limiting factor for many colonies in South Carolina. The loss of feeding habitat near a colony site can make the colony unsuitable even if the colony site itself is unaltered.

In addition to this vulnerability to habitat alterations, several members of this guild are of special concern due to declining population trends (Sauer et al. 2019). The Reddish Egret is listed as a Bird of Conservation Concern across the United States, while the Little Blue Heron is listed for other regions of the United States (USFWS 2021). The North American Waterbird Conservation Plan (Waterbird Conservation for the Americas) listed the Little Blue Heron and Snowy Egret as species of high concern; and the Reddish Egret, Roseate Spoonbill, and Yellow-crowned Night

Heron are listed as species of moderate concern (Kushlan et al. 2002). The Green Heron is listed as a species of low concern (Kushlan et al. 2002).

The Green Heron is considered a species of Least Concern by the International Union for the Conservation of Nature (IUCN, 2024). Globally, the Green Heron is ranked as Secure (G5) and in South Carolina, it is ranked as Apparently Secure (S4) (NatureServe 2024). However, Partners in Flight (PIF) considers the Green Heron to be a Common Bird in Steep Decline and a Species of Regional Concern for the Southeastern Coastal Plain, Piedmont, and Appalachian Mountain regions (2024). According to the North American Breeding Bird Survey (BBS) results from 1966-2019, Green Heron populations are declining by 1.35% each year in the United States and 1.30% in South Carolina (Sauer et al. 2019).

The Little Blue Heron is considered a species of Least Concern by the IUCN (2024). Globally, the Little Blue Heron is ranked as Secure (G5) and in South Carolina, it is ranked as Imperiled/Vulnerable (S2S3) (NatureServe 2024). PIF considers the Little Blue Heron to be a Common Bird in Steep Decline and a Species of Regional Concern for the Southeastern Coastal Plain (2024). According to the BBS results from 1966-2019, Little Blue Heron populations are declining by 1.25% each year in the United States and 3.39% in South Carolina (Sauer et al. 2019).

The Yellow-crowned Night Heron, Snowy Egret, and Roseate Spoonbill are considered species of Least Concern by the IUCN (2024). Globally, these species are ranked as Secure (G5) and in South Carolina, they are ranked as Imperiled (S2) (NatureServe 2024). PIF considers the Yellow-crowned Night Heron to be a Species of Regional Concern for the Southeastern Coastal Plain (2024). According to the BBS results from 1966-2019, Yellow-crowned Night Heron populations are declining by 0.23% each year in the United States and by 1.01% in the Southeastern Coastal Plain but are increasing by 1.51% in South Carolina (Sauer et al. 2019). Snowy Egret populations are increasing by 0.87% each year in the United States but are decreasing by 4.86% in South Carolina (Sauer et al. 2019). Roseate Spoonbill populations are increasing by 4.08% each year in the United States (Sauer et al. 2019). There is insufficient data to estimate population trends for Roseate Spoonbills in South Carolina.

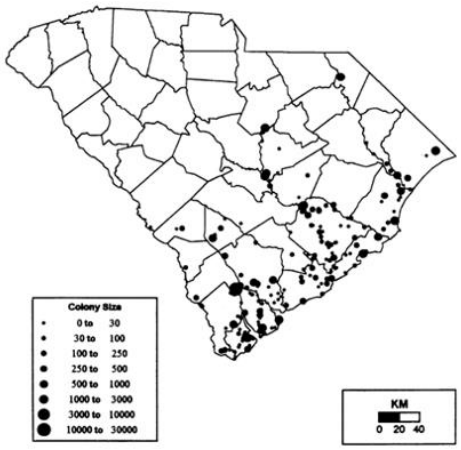
The Reddish Egret is considered by the IUCN to be Near Threatened (2024). Globally, the Reddish Egret is ranked as Apparently Secure (G4) and in South Carolina, it is ranked as Critically Imperiled (S1) (NatureServe 2024). PIF considers the Reddish Egret to be a Tipping Point Species and is on the Yellow Watch List, meaning the species has experienced “large long-term population loss but improved recent status (may be responding to current conservation efforts but still require recovery to healthier population levels)” (2024).

The Double-crested Cormorant is considered a species of Least Concern by the IUCN (2024). Globally, the Double-crested Cormorant is ranked as Secure (G5). In South Carolina, the breeding population is ranked as Critically Imperiled/Imperiled (S1S2B) and the nonbreeding population is ranked as Apparently Secure/Secure (S4S5N) (NatureServe 2024). According to the BBS results from 1966-2019, Double-crested Cormorant populations are increasing by 2.52% each year in the United States and 1.24% in South Carolina (Sauer et al. 2019). Double-crested Cormorants, like the wading birds listed in this account, are protected under the federal

Migratory Bird Treaty Act. However, the U.S. Fish and Wildlife Service also provides depredation and special permits for take of Double-crested Cormorants under certain circumstances.

POPULATION SIZE AND DISTRIBUTION

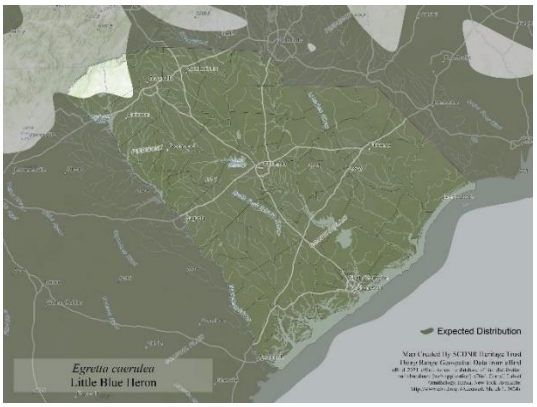
Complete ground censuses of nests in wading bird colonies in the Coastal Plain and Coastal Zone were conducted in 1988, 1989, 1994 and 1996. Counts of the total number of wading bird nests fluctuated among years, but high counts of 59,483 and 52,587 in 1989 and 1996 were representative of the population (Dodd and Murphy 1997). The fluctuations were primarily a result of one species: White Ibis. Nesting populations of members of this guild appeared to be stable between 1988 and 1996. Since that time, aerial estimates indicate the number of wading birds nesting in South Carolina has declined precipitously. This was particularly apparent during years of extended drought from 1999 through 2003.



Distribution of wading bird nesting locations (n=180) in South Carolina, 1996. (Figure from Dodd and Murphy 1997.)

The Green Heron is distributed throughout the eastern and parts of the southwestern United States, the Pacific coast of the United States, southeast and southwestern Canada, Central America, and northern South America. The winter distribution tends to be more coastal. The range avoids dry areas and areas of high latitude and altitude (Davis Jr. et al. 2020). In South Carolina, the Green Heron can be found statewide during the breeding season but is restricted to the Coastal Plain and Coastal Zone in the non-breeding season (Davis Jr. et al. 2020). PIF estimates the global population size of Green Herons to be 1,200,000 individuals, with 770,000 in the United States and Canada (2024).

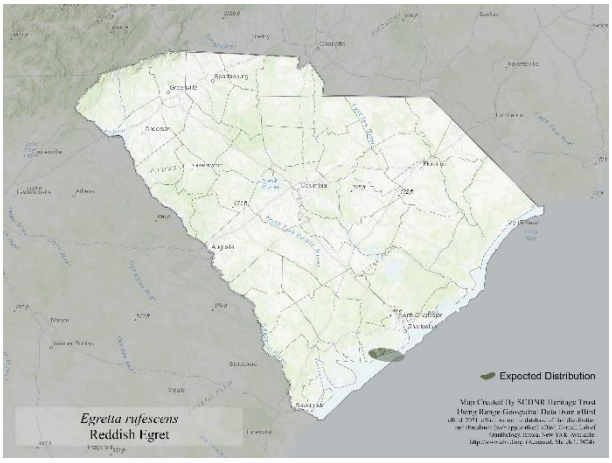


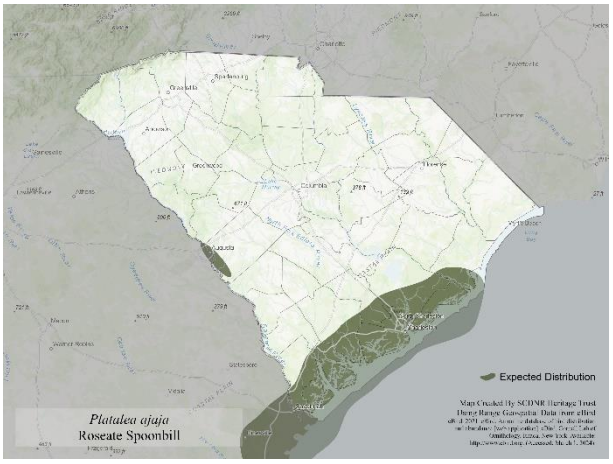


The Little Blue Heron breeds throughout Atlantic and Gulf Coast states, occasionally breeding further inland, the west coast of Mexico, the West Indies, and northern and central South America. Their nonbreeding range extends into Baja California and southern Central America. They can be found through the southeastern and south-central United States during migration (Rodgers Jr. and Smith 2020). The Little Blue Heron is distributed throughout all ecoregions of South Carolina except

for the Blue Ridge. PIF estimates the global population size of Little Blue Herons to be 1,100,000 individuals, with 270,000 in the United States (2024).

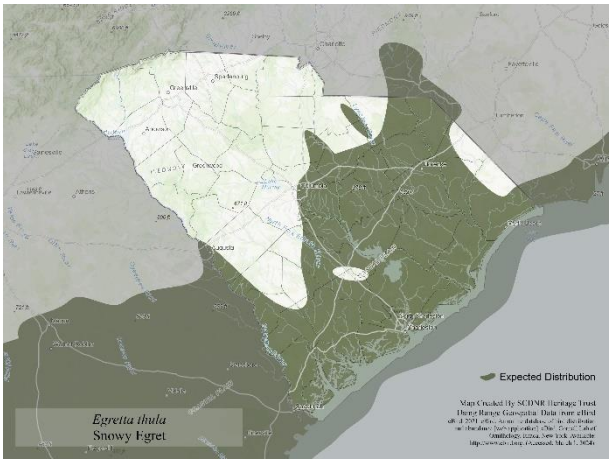
The Reddish Egret is distributed along coastal habitat in Florida and Gulf states, Central America, the Caribbean islands, and the northern coast of South America (Koczur et al. 2020). The Reddish Egret is regularly observed but uncommon in South Carolina. They are likely not regular breeders in the state. The first nesting activity in South Carolina was observed at Cape Romain National Wildlife Refuge in 2004 (Ferguson et al. 2005). PIF estimates the global population size of Reddish Egrets to be 15,000 individuals, with 2,400 in the United States (2024).

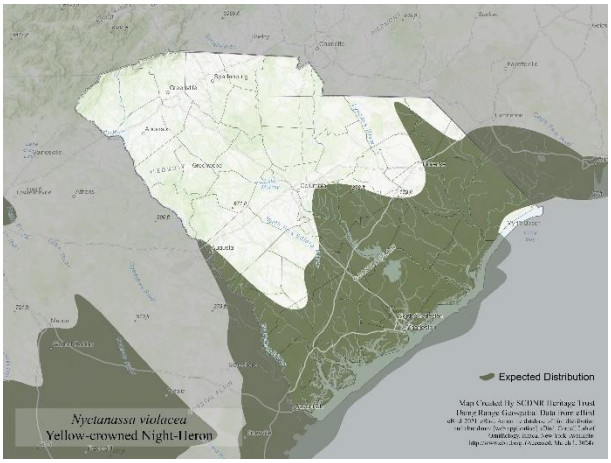




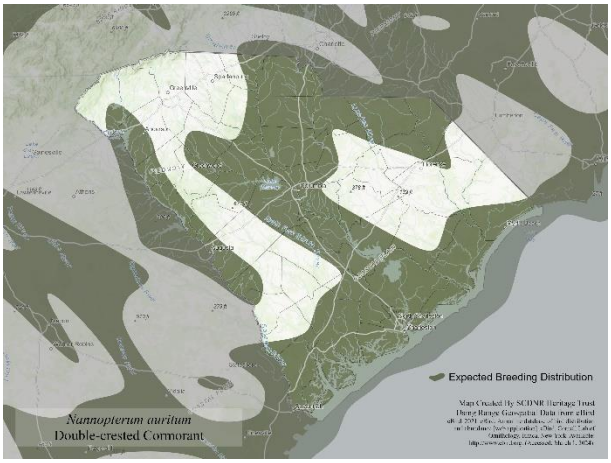
The Roseate Spoonbill is distributed from the southeastern United States, Central America, the West Indies, and South America, especially east of the Andes Mountains. In the United States, the Roseate Spoonbill primarily breeds and winters in coastal Texas, Louisiana, and South Florida (Dumas 2020). Occurrences elsewhere in the Southeast, including South Carolina, are generally immature individuals. In South Carolina, Roseate Spoonbills can be found in coastal wetlands south of Winyah Bay and occasionally inland along the Savannah River. PIF estimates the global population size of Roseate Spoonbills to be 170,000 individuals, with 11,000 in the United States (2024).

The Snowy Egret is distributed through much of South America, Central America, the United States, and into Nova Scotia, Canada. In the United States, Snowy Egrets breed along the Atlantic, Pacific, and Gulf Coasts. Breeding ranges extend inland in the South and Southwest, especially near rivers. Breeding populations can be disjunct (Parsons and Master 2020). PIF estimates the global population size of Snowy Egrets to be 2,100,000 individuals, with 220,000 in the United States and Canada (2024).





Yellow-crowned Night Herons feed primarily on crustaceans and their distribution is based on prey availability (Watts 2020). They range along the East Coast from Massachusetts to Florida, the Gulf Coast and up the Mississippi River and its tributaries, the Caribbean Islands, coastal Central America, and much of coastal South America. In the Unites States, there are also scattered breeding populations in the Appalachians and Midwest (Watts 2020). In South Carolina, Yellow-crowned Night Herons are found primarily in the Coastal Zone and Coastal Plain. PIF estimates the global population size of Yellow-crowned Night Herons to be 400,000 individuals, with 130,000 in the United States (2024).

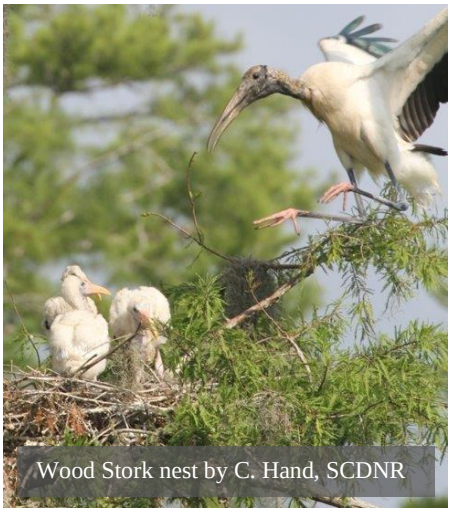


Double-crested Cormorant populations have had large fluctuations in size during the 19th and 20th centuries, largely due to human-related processes including decreases due to contaminant residues (Weseloh et al. 1983) and direct mortality (Vermeer and Rankin 1984) and increases due to increases in fish prey (Hobson et al. 1989) and availability of suitable habitat on man-made lakes (Post 1988). The first confirmed nesting colony of Double-crested Cormorants in South Carolina were found on Lake Marion in 1985 (Seriff and Beirregaard 2018). Two additional sites were confirmed by the late 1990's (Seriff and Beirregaard 2018). The South Carolina breeding population was 60 pairs in 1986 and 186 pairs in 1989 (Post and Seals 1991). In 2017, the South Carolina Department of Natural Resources (SCDNR) documented 220 nesting pairs in the state. The Atlantic Coast is estimated to have 96,000 breeding pairs (Dorr et al. 2021).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Nesting sites are found in a variety of habitats. Colony sites for most guild members are found on islands in fresh and brackish water ponds. Water surrounding a nesting site deters mammalian predators while alligators frequently provide an additional deterrent. When suitable island sites are lacking, guild members may use vegetation around the edge of a pond for nesting. These sites are generally unsuccessful as a result of predation except for ponds in residential areas that are not affected by predators. Colonies are also sustained on estuarine islands that are free of

mammalian predators. Larger species prefer mature trees with large lateral limb structures while smaller species nest lower and prefer shrubby habitat.


Wood Stork nest by C. Hand, SCDNR

Double-crested Cormorants create nesting colonies in trees in or near water or on small rocky or sandy islands on waterways including ponds, lakes, managed impoundments, estuaries and open coastlines (Dorr et al. 2021). Colonies are established at locations that are safe from ground predators and close to feeding areas. Double-crested Cormorants may shift to ground nesting at those islands once the trees die (Dorr et al. 2021). They can also nest on mats of emergent vegetation in marshes (Dorr et al. 2021).

Wading birds feed primarily on fish, crabs, crayfish, insects, and amphibians and can be found feeding in a wide variety of aquatic habitats. Some species also feed opportunistically on small birds and mammals. Gradually receding water levels concentrate prey and facilitate feeding. Wading birds can be observed in large numbers foraging in managed impoundments during drawdown.


Wood Stork feeling for prey while egrets and herons search visually by C. Hand, SCDNR

Each species has its own feeding style. Roseate Spoonbills have specialized sensitive bills and are tactile feeders, which means that they use touch to locate prey. They require high prey densities in shallow water to feed efficiently. These species can feed even when visibility is low, such as in murky water and at night. They can feed efficiently in large groups, even when the water is stirred up, which allows them to take advantage of ephemeral food sources. Roseate Spoonbills wade through shallow water, while sweeping their bills back and forth through the water, to locate and capture prey. When their lower bill comes into contact with a fish, the individual reflexively snaps its bill shut to capture the prey. Most egrets and herons are visual hunters, which means that they locate prey visually before striking. They can capture a variety of types of prey in various situations but cannot forage efficiently when visibility is poor. These species perch at the edge of the water or wade out into shallow water to search for prey. Snowy Egrets and Reddish Egrets are very active feeders and pursue their prey.


Wading birds feeding in an impounded wetland by C. Hand, SCDNR

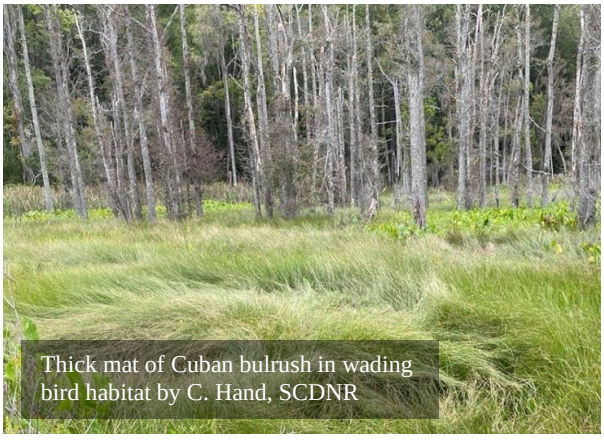
CHALLENGES

Loss of feeding, roosting, and breeding habitat is the biggest threat to colonial wading birds (Dodd and Murphy 1998). Over 50% of the wetlands in the contiguous United States were drained or converted to other uses between the 1780s and 1980s (Dahl 1990). Since the 1970s, the rate of wetland loss in the United States has been greatest in the Southeast. While South Carolina has been relatively successful in protecting its wetlands, significant losses have occurred in freshwater non-tidal wetlands. Some types of wetlands created to mitigate the loss of natural wetlands may be of lower ecological value to wading bird compared to diverse natural wetlands. The amount and quality of foraging habitat will ultimately determine the status of colonial wading bird populations.

Suitable nesting and roosting habitat is reduced by removal of vegetation during timber harvest and residential and commercial development. Shrub-type nesting and roosting habitat is lost through the removal of vegetation, mainly for aesthetic reasons, along the edge of ponds and impoundments.

Human disturbance is a problem for nesting colonial wading birds. Short-term disturbances such as airplanes, boats, vehicles, and human presence may cause the birds to fly from their nests, and can result in nest abandonment. Unattended eggs and chicks are vulnerable to depredation and to overheating. Disturbance at feeding areas can reduce the amount of prey that wading birds are able to consume and to feed to their young. Docks result in disturbance to feeding birds because of the increased boat traffic. The docks themselves are frequently used by the birds for foraging because fish concentrate in the shade of the docks.

Several types of environmental contaminants are problems for colonial wading birds. Petroleum from oil spills damages bird feathers and causes mortality. Chemicals such as DDT and PCBs are not currently widespread; however they do cause reduced reproductive success. Metals such as mercury and lead can concentrate and lead to reduced survivorship and reproductive success. Environmental contaminants also reduce availability of prey items. Nonpoint sources of pollution can reduce productivity of coastal marshes. Diseases such as cholera and botulism are particularly problematic for colonial wading birds. In the event of an outbreak of these diseases, they spread easily because the birds nest in such high densities.



Thick mat of Cuban bulrush in wading bird habitat by C. Hand, SCDNR

Other human-related causes of mortality include collisions with power lines and entanglement in fishing lines, gill nets, drift nets, and various forms of plastics (Dodd and Murphy 1998). Bird-flight diverters that make power lines more visible can be effective at reducing collisions by wading birds (Savereno *et al.* 1996).

The presence of invasive Cuban bulrush in rookeries is an emerging threat to wading bird colonies that warrants future study. Cuban

bulrush forms thick, buoyant mats that outcompete native aquatic plants and allow terrestrial predators such as racoons to access nesting sites. Thick mats of Cuban bulrush may also restrict alligator movement. Alligator presence attracts wading birds to nesting colonies (Burtner and Frederick 2017) as they reduce the number of mammalian predators. In turn, alligators benefit from consuming nestling carcasses (Nell and Frederick 2015).

CONSERVATION ACCOMPLISHMENTS

The Lacey Act of 1900 was the first major step toward protecting wading birds. The Lacey Act was passed, in part, in response to the millinery trade to regulate interstate and international trade of bird parts. Hundreds of thousands of herons and egrets, among other birds, were killed for their nuptial plumes, used in ladies hats and fashionable clothing (Ogden 1978). The Migratory Bird Treaty Act of 1918 made it illegal for a person to possess any migratory bird or part, with the exception of game birds during the proper season, as well as the possession of nests and eggs. Prior to these Acts, market hunting was responsible for population declines in many bird species.

SCDNR collected baseline data during statewide ground census counts in 1988, 1989, 1994 and 1996. Aerial surveys have been conducted annually since 1988 (with the exception of 2009 and 2010 when SCDNR did not employ a biologist to fill this role and in 2020 due to the COVID19 pandemic) to estimate the number of breeding individuals, breeding success, and distribution of wading bird colonies in South Carolina. SCDNR has documented over 300 wading bird nesting colonies since 1998, although not all colonies are active each year.

Surveys for breeding Double-crested Cormorant at historic breeding locations were completed in 2016 and 2017. They indicate the breeding population is small, but potentially increasing. Additionally, two dissertations were completed on Double-crested Cormorants in South Carolina (Kelley 2008, Sheehan 2013).

SCDNR has partnered with the USFWS Coastal Program, SCE&G, private landowners and other partners to improve habitat for wading birds. Collaborative projects include managing aquatic vegetation at rookeries using herbicide applications and the installation of bird-flight diverters on the power line adjacent to a rookery at Donnelley Wildlife Management Area to reduce the likelihood of collisions.

CONSERVATION RECOMMENDATIONS

- Conduct Research and Inform Permitting Agencies
    - Annually survey colonies containing federally listed birds.
    - Continue aerial surveys of nesting colonies to estimate the number of breeding individuals, breeding success, and distribution of wading bird in South Carolina.
    - Coordinate with biologists in the Southeastern Coastal Plain to develop plans to monitor wading birds on a regional scale.
    - Monitor individual nests at a subset of colonies to determine productivity.
    - Identify important foraging areas near nesting colonies, and determine how far from the colonies different species travel to forage.

  - Determine the effects of human activity on wading bird foraging efficiencies as well as the importance of roost sites and their relationship to available foraging habitat.
  - Monitor the effects of invasive Cuban bulrush and Cuban bulrush removal on wading bird nesting success
  - Complete intensive surveys to locate breeding Double-crested Cormorant colonies to better estimate the number of breeding pairs.
  - Determine distribution and survival of breeding Double-crested Cormorants during the nonbreeding season.
- Partner with Industry, Developers, Permitting Agencies and Private Property Owners/Managers to Protect Nesting and Feeding Habitat
  - Provide technical assistance and/or financial incentives to property owners for projects that will significantly benefit wading bird conservation. Control aquatic vegetation in large rookeries to ensure that alligators can move through the nesting area and deter mammalian predators from depredating eggs and chicks.
  - Determine Best Management Practices for multi-species management of impounded marsh habitat. Integrate management for colonial wading birds into traditional waterfowl management of currently impounded wetlands by timing draw-downs during key feeding periods (post-fledging).
  - Partner with industry and permitting agencies to prevent the destruction of important wading bird breeding, feeding, and roosting sites.
  - Work with permitting agencies to encouraged the creation of wetlands that are appropriate for wading birds when wetland mitigation is required. To create wetland habitat for waterbirds, water depth, water level fluctuation, vegetation, salinity, topography, food type, food accessibility should be considered (Ma et al. 2010). Short hydroperiod wetlands are important for tactile foragers. Deeper wetlands with islands and/or trees surrounded by water provide nesting habitat. Nesting and feeding habitat should be created in close proximity.
  - Determine and encourage the use of Best Management Practices for residential and commercial development activities near nesting and feeding sites.
    - Maintain vegetated visual buffers around nesting colonies and feeding areas to protect birds from human disturbance.
    - Include islands with suitable nesting habitat when constructing new ponds.
    - Leave shrubs around the edges of ponds to provide nesting and foraging habitat and for bank stabilization.
    - Minimize fertilizer, herbicide, and pesticide runoff into wetlands.
  - Document water quality issues at colony sites, and partner with appropriate permitting agencies to reduce the input of chemical contaminants and untreated wastewater into wetlands.
  - Place landfills, power lines, and towers away from colonies and wetland areas. Install bird-flight diverters and space power lines widely at sites used by wading birds where it is not feasible to bury lines.
  - Acquire, or assist conservation organizations to acquire, and manage important nesting and feeding sites to benefit wading birds.
- Support Outreach and Public Education

- Provide information about wading birds in South Carolina to the public via the SCDNR website and news releases.
- Provide increased opportunities for the public to view and appreciate wading birds while preventing disturbance to nesting and foraging birds (i.e. the overlook at Pinckney Island National Wildlife Refuge).
- Install educational kiosks and signs at sites where the public can view wading birds.

MEASURES OF SUCCESS

Protecting important habitat as outlined above should provide stable resources and enable populations to rebound. Wading bird nesting colonies should be distributed widely across Coastal Plain counties. The ultimate measure of success would be to document stable to increasing population trends of colonial wading birds.

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Cory's Shearwater

Calonectris Diomedea borealis



Photo by Irvin Pitts.

Contributor (2024): Cami Duquet (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

The Cory's Shearwater is a large pelagic seabird in the Shearwater *procellariidae* family. They have a distinguishable tube shape bill that is a pale pinkish yellow in color with irregular black coloring near the tip. They have a mostly gray-brown upper body with clean white underparts (del Hoyo et al. 2020). It has a long glide flight with bowed wings that are angled back slightly.

Historically, three subspecies of Cory's Shearwater were listed; *C. d. borealis, C. d. scopolis,* and *C.d. diomedea,* however, although closely related, the three were deemed to be different species based on genetic, morphological, and ecological differences. The Cory's Shearwater name was transferred to *Calonectris borealis* while the other two are now classified as Scopoli's Shearwater, (*C. Diomedea*), the nominate species, and Cape Verde Shearwater (*C. edwardsii*).

Status

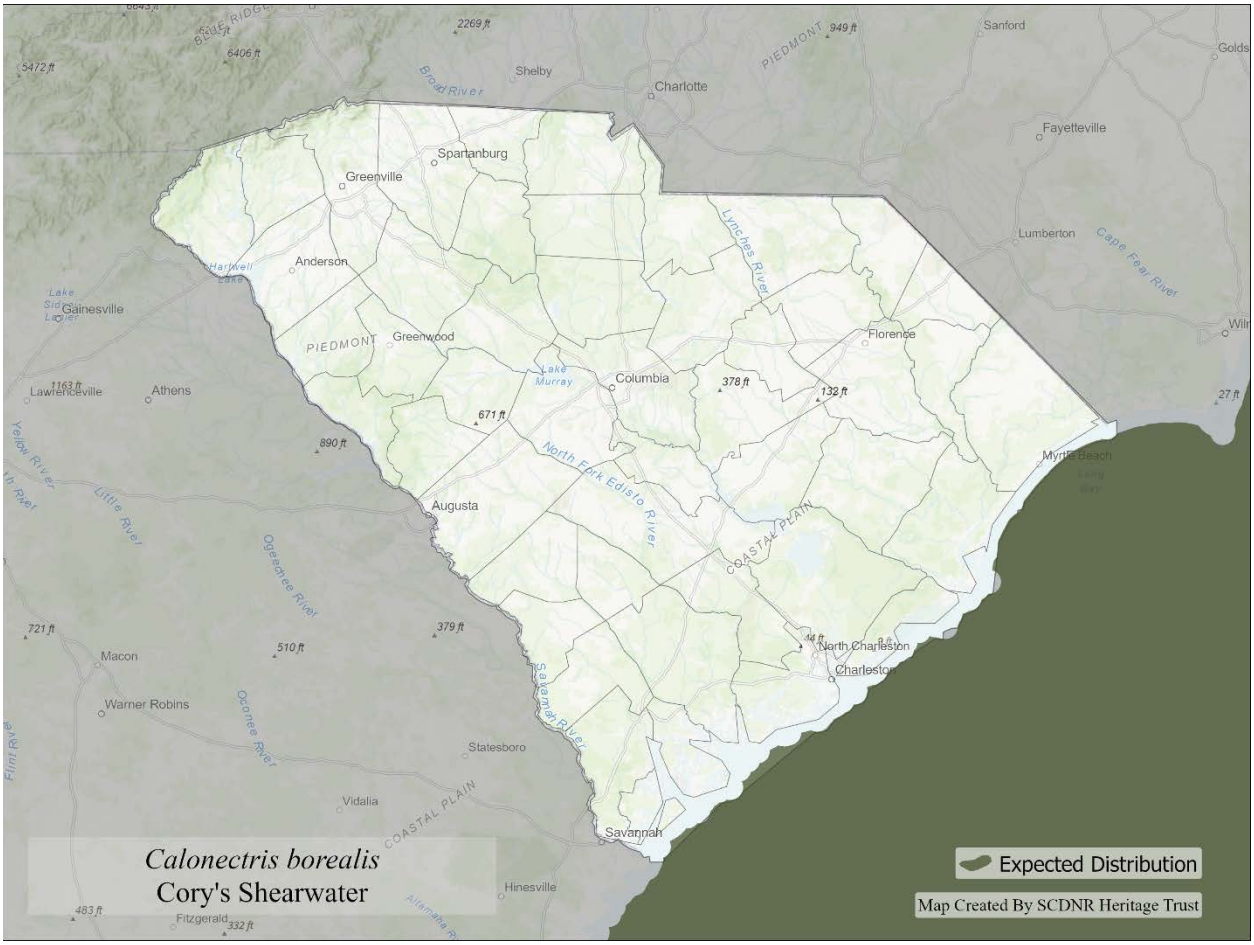
The Cory's Shearwater was most recently assessed for the IUCN Red List of Threatened Species in 2018 and is currently listed as *Least Concern*. Although the population trend is somewhat unknown, it does not meet the threshold for *Vulnerable* due to its extremely large range and large population size (BirdLife International 2024).

POPULATION SIZE AND DISTRIBUTION

Total population is estimated around 600,000 birds (Brooke 2004) with a single survey recording 365,729 in 1996 around the Azores (Monteiro et al. 1998). Recent studies suggest that the population may be declining due to mortality events of young birds from introduced mammals, poachers, and urban lights (Fontaine et al. 2011).

The Cory's Shearwater is a trans-equatorial migrant and therefore has a wide range over the Atlantic Ocean as well as into the Southwest Indian Ocean. Its wintering sites include the Eastern Atlantic off both North America and South America, as well as the south-western Atlantic off the coast of South Africa (del Hoyo et al. 2020). The largest numbers of Cory's Shearwater cross the Atlantic in mid-summer post breeding, then move up the Northeastern United States coast in the fall and congregate off the New England and Canadian Maritime region. A recent study shows that more birds may be increasingly using waters of Nova Scotia with high numbers reported in 2016 and 2017 (Gjerdrum, C et al. 2018).

As a pelagic species, it is rare to uncommon to observe Cory's Shearwater on land in South Carolina and if so, they are usually associated with a strong storm or a hurricane blowing them off their course. The first recorded sighting of the species in South Carolina from land was of a deceased bird found on Isle of Palms, post tropical hurricane in August of 1940 (Dingle 1941). Most recently a live Cory's Shearwater was found on Hilton Head Island, post hurricane-Irma in 2017 (High 2017). Live sightings in South Carolina waters have been observed as early as the 1970s. In July 1973, Dennis Forsythe observed 2 Cory's Shearwater 15km east of Charleston and suggested that the species may be more widely distributed in the western Atlantic than previously thought (Forsythe 1980). Ebird shows 251 reported sightings in South Carolina waters to date, all occurring between the months of March and November.



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

During the nonbreeding season (May to November) when Cory's Shearwaters are known to forage off South Carolina waters, they are often observed in groups with other Shearwaters and pelagic birds. Sightings and surveys show they are mostly associated with areas over the continental shelf as well as areas with abundant sargassum, where their primary food source small pelagic fish, tend to populate (Moser and Lee, 2012). Stomach content of Cory's Shearwater off the coast of Brazil during non-breeding season showed cephalopods present in 97% of cases and fish in 33% of cases (Kruger et al. 2009).

CHALLENGES

The pelagic nature of these birds makes them difficult to study. Research of Cory's Shearwaters has not been undertaken in South Carolina; therefore trends, movements, and numbers of the species frequenting South Carolina waters are not well understood.

However, research in other parts of their range may inform how the species will respond to similar threats they may face on the South Carolina coast. Such identified threats include incidental catch from fisheries, offshore developments such as wind farms, and climate change.

Shearwaters were found to be one of the most captured seabirds in Newfoundland and Labrador fisheries in Canada, primarily from gillnet fishery and bottom-set long lines. As a result, migrating Shearwater populations, including Cory's Shearwater, will likely experience sequential mortality in numerous fisheries due to their extensive migrations exposing them to fisheries interactions (Kulka et al. 2008).

Numerous studies have found clear evidence of Shearwaters and other seabirds being attracted to offshore structures, due to the abundance in prey items as caused by the structures acting as artificial reefs. Foundations of offshore wind turbines may similarly act as artificial reefs attracting pelagic seabirds, including Cory's Shearwaters, to feed on the fish populating in and around the structures which can result in collision (Baird 1990).

Additionally, Cory's Shearwaters are sensitive to climatic factors affecting the sea surface temperatures which affects food availability and therefore negatively impacts survival on nonbreeding grounds. These changes in sea surface temperatures are expected to worsen with climate change (Ramos et al. 2012).

CONSERVATION ACCOMPLISHMENTS

No conservation initiatives have been set specifically for the Cory's Shearwater in South Carolina. Reports of sightings through Ebird have provided data showing their presence in South Carolina waters.

CONSERVATION RECOMMENDATIONS

- Conduct systematic surveys of pelagic seabirds in South Carolina waters, including Cory's Shearwater, to gain better understanding of range, seasonality, movements, and numbers present
- Implement reporting of bycatch of pelagic seabird species from fisheries operating in South Carolina
- Protect foraging habitat where Cory's Shearwater feed from offshore development

MEASURE OF SUCCESS

As the above-mentioned action items are accomplished and yield valuable information, adaptive management procedures will be evaluated and implemented for this bird species.

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Forested Wetlands Birds Guild

Prothonotary Warbler *Protonotaria citrea*
Rusty Blackbird *Euphagus carolinus*

NOTE: The Swallow-tailed Kite is discussed in its own species account.

Contributor (2005): Craig Watson (USFWS)
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DESCRIPTION

Taxonomy and Basic Descriptions

These birds are grouped together because they either nest or winter primarily in forested wetlands in South Carolina.



The Prothonotary Warbler is a striking bird averaging 14 cm (5.5 in.) in length and 15 g (0.56 oz.) in weight. Adult male Prothonotary Warblers are bright yellow on their head, throat, breast, and nape; they have gray wings and an olive back. Females are similar to males but more muted in color, with more olive-green on the head and nape. Immature birds are similar to adult females.

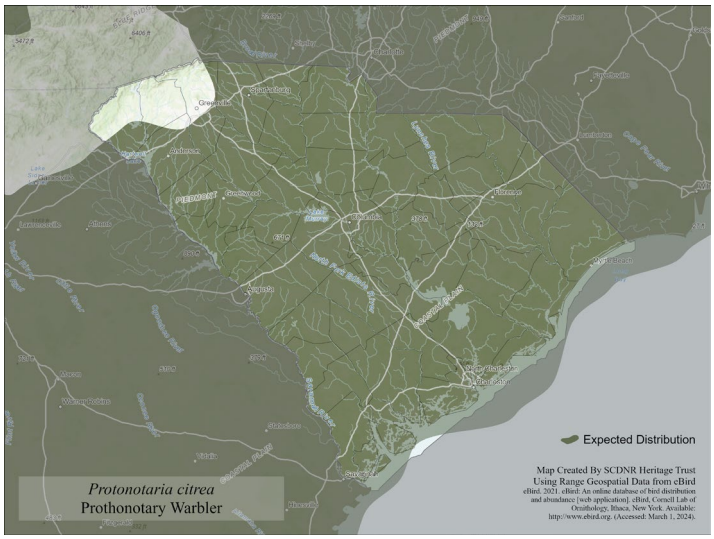


The Rusty Blackbird is brown to black overall with a length of 23 to 25 cm (9.1 to 9.8 in.). Its bill is narrow and shorter than its head with a slightly rounded tail nearly as long as its wing. During the breeding season, the males gain a bluish-green gloss to its upper feathers (Avery 1995). Its fall and early winter plumage is characterized by fringe of rusty brown coloring on their otherwise dark feathers.

Status

None of these species are officially recognized as threatened or endangered, but all are either experiencing declines or declines are suspected. The Prothonotary Warbler is recognized by Partners in Flight (PIF) as a Watch List species that is declining and have moderate to high threats (Rosenberg et al. 2016). These same species are also listed as a species of conservation concern by the U.S. Fish & Wildlife Service (CITE). The Prothonotary Warbler are the highest ranked species in the southeastern Coastal Plain. The Prothonotary Warbler is considered a moderate priority species in forested wetlands by PIF and is in need of conservation attention (Hunter et al. 2001). The Prothonotary Warbler is ranked vulnerable (S3S4; NatureServe 2005). The Global IUCN status for Rusty Blackbirds is Red List (Vulnerable). It is not listed by the U.S. Fish and Wildlife Service. Partners in Flight (2024) rank this as a Conservation Concern as a Common Bird in Steep Decline. The Rusty Blackbird is ranked as S3N in the State (NatureServe 2005).

POPULATION SIZE AND DISTRIBUTION



The Prothonotary Warbler is a common breeder throughout most of South Carolina in forested wetlands, though density is higher in the coastal plain than the midlands and piedmont. This species is a very rare breeder in the Blue Ridge escarpment. The Breeding Bird Survey (BBS) indicates a 0.1% rate of decline per year for South Carolina, and a decline of 0.9% survey-wide from 1966-2010 (Sauer et al. 2012).



Rusty Blackbird populations have declined by 89% overall in recent decades (Partners in Flight, 2024). In South Carolina, the Rusty Blackbird is a fairly common winter visitor to the Piedmont and Coastal Plain, with lesser numbers occurring in the Mountains. Rusty Blackbirds breed in northern forests and migrate southward in mid-September, arriving in southeastern wintering grounds in late November. They will remain on wintering grounds until late March or early April when they begin their northward migration.

Rusty Blackbirds were commonly encountered on the Christmas Bird Count routes until approximately 1970 when the species started a decline that has not ended (National Audubon 2002). It is speculated that the steep population declines observed in the 1970's may be due to blackbird control programs. Obtaining detailed knowledge of the species has been complicated due to difficulty in navigating or accessing their preferred forested wetland habitat.

Table 1: US and Canada, and Bird Conservation Region population estimates (PIF 2020) expressed as individual number of birds. Estimated years until another 50% of the North America population is lost (Rosenberg et al. 2016).

Species	US/Canada Population Estimate	Years Until 50% Population Loss Estimate	SE Coastal Plain BCR	Appalachian Mountain BCR	Piedmont BCR
Prothonotary Warbler	2,100,000	> 50	47,000	Unknown	1,900
Rusty Blackbird	Unknown	19	Unknown	Unknown	Unknown

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Prothonotary Warbler requires the presence of water in wooded areas. This is the only species of warbler in the eastern United States that nests in cavities, so appropriate habitat must contain suitable cavity nest sites. Nest cavities are usually placed over or near large, slow-moving water bodies, including seasonally flooded bottomland hardwood forest, bald cypress swamps, and large rivers or lakes. Nests are usually located close to water height, usually within five meters (Petit 2020). Nests are usually placed in secondary cavities or in hollow branches or cypress knees. Prothonotary Warblers readily use artificial cavities, including a variety of different next box types (Petit 2020).

The Rusty Blackbird is a wetland obligate for its entire life history. In South Carolina, the rusty blackbird is found wintering in swamps and bottomland hardwoods, sometimes associated with other blackbird species such as Red-winged Blackbirds and Common Grackles (Cornell Lab of Ornithology, 2024) This species is primarily found in damp, wooded places, such as swamps and wet thickets but will forage in croplands and lawns with other blackbirds (Hamel 1992). Rusty Blackbirds can spend over a quarter of their annual life cycle migrating. Habitat types such as dogwood-willow swamp, low-lying forest patches, and area of habitat complexity were found to be preferred for foraging in fall and spring. Spring migrants selected habitat edges with this habitat while fall migrants avoided areas with dense grass, forbs, and herbaceous shrub cover. Migrating Rusty Blackbirds have also been found to roost in dense stands of emergent *Phragmites* or *Typha* marsh, suggesting that the best stopover or staging sites include a mixture of different wetland habitat types (Wright et al., 2020). [5] Rusty Blackbirds have also been described in suburban landscapes within the Georgia and South Carolina Piedmont Plateau in the winter, with flocks observed in suburban areas that provide forested or wetland habitats (Wohner et al., 2018).

CHALLENGES

By far, the loss and fragmentation of forested wetlands on both the breeding and wintering grounds are the most significant challenges to successful conservation of these species. These impacts stem from urbanization, residential and commercial development, power lines, agricultural practices, forest management practices, and surface water management (Audubon

2024). Forested wetlands have been extensively drained and converted throughout the United States; most of the remaining intact-forested wetlands outside of the Mississippi Alluvial Valley occur in the Southeastern United States. Conservation of these remaining forested wetlands should be a top priority for any conservation entity. In some cases, a fragmented landscape will not be able to support minimum viable populations. Additionally, while available habitat in South Carolina for many of these species could be maintained under climate vulnerability scenarios of 1.5 – 2.0-degree warming (Wilsey et al., 2019),[9] concerted efforts to maintain and restore suitable habitat on wintering grounds found in the state are important for species recovery.

CONSERVATION ACCOMPLISHMENTS

A primary objective of the South Atlantic Migratory Bird Initiative has been to delineate focus areas in which public lands serve as the anchors. These focus areas have been important in garnering North American Waterfowl Conservation Act (NAWCA) grants for significant land acquisition and enhancement projects in the state with an emphasis on wetlands (Watson and McWilliams 2005). An international working group was formed to shed light on the Rusty Blackbird, in order to coordinate efforts including sponsoring workshops, symposium, and bioblitzs. The Wildlife Society Conference held in 2020 included presentations on research associated with the species (The Wildlife Society, 2020)[10] and a 2020 Management Plan has been developed for Rusty Blackbirds in Newfoundland and Labrador focused on the breeding territory (Wildlife Division, 2020).[11] Prothonotary Warbler Accomplishments include

- The Prothonotary Warbler Working Group formed in 2014 with the goal of using research-based methodologies to better understand gaps in knowledge around the full life cycle conservation of this species (https://prowwg.wixsite.com/home).
- Since the formation of this working group, papers looking at migratory connectivity (Wolfe and Johnson, 2015, Tonra et al., 2019) and stable isotope analysis (Reese et al, 2019).
- More research is needed using advanced tracing technologies to provide more refined information on migratory stopover sites and wintering ground locations.

CONSERVATION RECOMMENDATIONS

- Continue conservation and restoration of forested wetland habitats including pocosins and Carolina bays. Care should be taken to increase block/patch sizes in order to decrease the amount of small, isolated forest patches across the landscape so that minimum viable populations are sustained.
- Promote conservation easements on private lands, specifically developing and pursuing reforestation programs.
- Reduce the effects of habitat fragmentation by minimizing the frequency that roads and power line rights-of-way bisect contiguous forested tracts.
- Develop and implement forest management practices that produce large, mature forests with tall, closed canopies and high tree density with a mosaic of understories.
- Develop Best Management Practices to balance the habitat needs of priority forested wetland species. Identify silvicultural activities that mimic the historical mosaic of young and old forests created by catastrophic events.

- Protect Streamside Management Zones and identify optimal sizes.
- Restore canebrake habitats in the understory of forested wetlands.
- Preserve and improve water quality to ensure aquatic insect biomass and diversity.
- Conduct surveys and studies to collect information on the distribution and life history characteristics of Rusty Blackbirds in South Carolina.
- Follow green tree reservoir management guidelines to ensure timber survival and production of desired food.
- Develop and implement monitoring programs to better assess breeding and wintering bird population sizes. Management and surveillance monitoring techniques will need to be assessed to quantify short- and long-term population responses in order to answer specific monitoring questions. Measures will need to be developed to integrate state monitoring results into regional- and national-level databases in order to identify if continental goals are being reached.
- Continue use of the Breeding Bird Survey as a surveillance monitoring technique and consider modifications to make the survey more robust across the state.
- Continue use of the Christmas Bird Count to identify population trends of wintering species.

MEASURES OF SUCCESS

Conserving and restoring forested wetland acreages throughout the state will greatly benefit a wide range of taxa. Collecting monitoring data based on habitat restoration and management objectives should result in measurable population responses at the local level. Other bird species that are likely to be positively affected by forested wetland management and restoration include: Swallow-tailed Kite (*Elanoides forficatus*), Cerulean Warbler (*Dendroica cerulea*), Black-throated Green Warbler (*Dendroica virens*), Black-billed and Yellow-billed Cuckoos (*Coccyzus erythropthalmus* and *americanus*), Worm-eating Warbler (*Helmitheros vermivorus*), Hooded Warbler (*Wilsonia citrina*), White-eyed Vireo (*Vireo griseus*), Carolina Wren (*Thryothorus ludovicianus*), Red-bellied Woodpecker (*Melanerpes erythrocephalus*), and Yellow-throated Vireo (*Vireo flavifrons*; Rich et al. 2004).

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Grassland Birds Guild

Bobolink *Dolichonyx oryzivorus*
Common Ground Dove *Columbina passerina*
Dickcissel *Spiza americana*
Eastern Meadowlark *Sturnella magna*
Field Sparrow *Spizella pusilla*
Grasshopper Sparrow *Ammodramus savannarum*
Horned Lark *Eremophila alpestris*
Loggerhead Shrike *Lanius ludovicianus*

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Reviewed and Edited (2024): Amy Tegeler (SCDNR)

DESCRIPTION

Taxonomy and Basic Description





The Bobolink is medium-sized with a length of 15.2 to 20.5 cm and males weigh 34 to 56 g while females weigh 29-49 g (Renfrew et al. 2020). Breeding males have a black breast and black and white back. The head is black with a noticeable yellowish tan patch on the back of the neck (Sibley 2000). Nonbreeding males and females have a brown breast with faint streaking on the flanks. They have a dark eyeline and a pink bill (Sibley 2000). Linnaeus first described the Bobolink in 1758 (NatureServe 2014).



The Common Ground Dove is one of the smallest doves, measuring roughly 17 cm (0.39 in.) and weighing 30 g (1.06 oz.) (Sibley 2000). Typically, this is a stocky dove with a scaled effect on its head and breast and a short tail. Bright chestnut primaries and wing linings are visible in flight (NGS 1999). Linnaeus first described the Common Ground Dove in 1758 (NatureServe 2014).



The Dickcissel is sparrow-like. Breeding males have a yellow breast with a black V on the throat, and reddish-brown wings (Sibley 2000). Females have a pale yellow breast and lack the black V (Sibley 2000). They weigh 23 to 29 g and have a total length of 14 to 16 cm (Sousa et al. 2022). The Dickcissel was first described by Gmelin in 1789 (NatureServe 2014).



Linnaeus, in 1758, first described the Eastern Meadowlark (NatureServe 2014). This distinctive species has a black, V-shaped breast band on yellow underparts. The upperparts are dark brown with dusky brown feather tips (NGS 1999). This species is 24 cm (9.45 in.) in length and 90 g (3.17 oz.) in weight (Sibley 2000).



The Field Sparrow is in the genus *Spizella* which represents small, long-tailed sparrows. Field Sparrows have a gray face with a reddish crown, a distinct whitish eye ring, and a bright pink bill (NGS 1999). The overall size of field sparrows is 15 cm (5.9 in.) in length and 12.5 g (0.44 oz.) in weight (Sibley 2000). Wilson first described Field Sparrows in 1810 (NatureServe 2014).



Gmelin first described the Grasshopper sparrow in 1789 (NatureServe 2014). This ground-dwelling species is very secretive. It has a buff-colored breast and sides, usually without streaking; a white eye-ring; and a dark crown with a pale central stripe (NGS 1999). Overall, this sparrow is small and chunky with a length of 13 cm (5.1 in.) and weight of 13 g (0.46 oz.). Grasshopper Sparrows have short tails, long bills and a flat head (Sibley 2000).



The Horned Lark is sparrow-like. Males have a brown back and pale brown breast. They have a black chest band and mask with some yellow on the head and throat (Sibley 2000). Females are paler than males and lack the black mask (Sibley 2000). The Horned Lark was first described by Linnaeus in 1758 (NatureServe 2014).



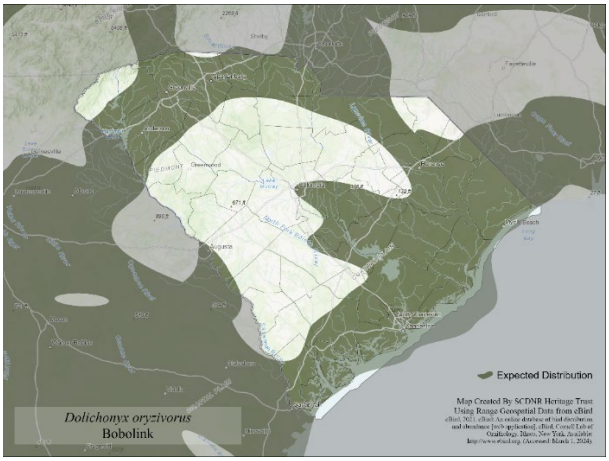
The Loggerhead Shrike is a predatory songbird with a strong, hooked bill used to kill and dismember prey (Sibley 2000). Its head and back are bluish-gray with underparts that are white with faint barring. A broad mask of black extends above the eye and thinly across the top of the bill (NGS 1999). This species is approximately 23 cm (9.1 in.) long and weighs 48 g (1.69 oz.) (Sibley 2003). Linnaeus first described the Loggerhead Shrike in 1766 (NatureServe 2014).

Status

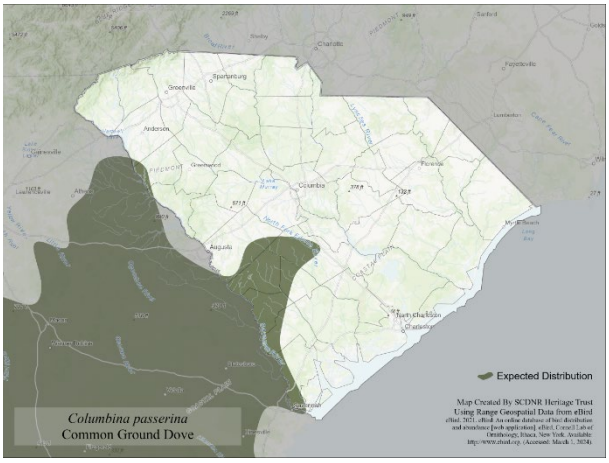
Birds that use grasslands have shown some of the steepest population declines of any bird group in North America (North American Bird Conservation Initiative 2022). Loggerhead Shrike and Field Sparrow are endemic to North America and were listed among the common birds in steep decline, having lost an estimated 74% and 62% of their populations, respectively, over the last 40 years. Although not endemic to North America Horned Lark has experienced a 65% population loss, Grasshopper Sparrow a 68% loss, Dickcissel a 14% loss, Bobolink a 60% loss and Eastern Meadowlark a 77% loss over the last 40 years (Rosenberg et al. 2016). Estimates for number of years until another 50% of each species North American populations are lost are in Table 1 (Rosenberg et al. 2016). Bobolink is included in the PIF Orange Watch List, while Field

Sparrow, Loggerhead Shrike, and Eastern Meadowlark are important to consider for conservation within the bird conservation regions in South Carolina (Rosenberg et al. 2016). The PIF Watch List is comprised of species that have multiple reasons for conservation concern across their entire range and species are selected according to the PIF scoring process. At the state level, the Common Ground Dove is listed as a threatened species in need of management.

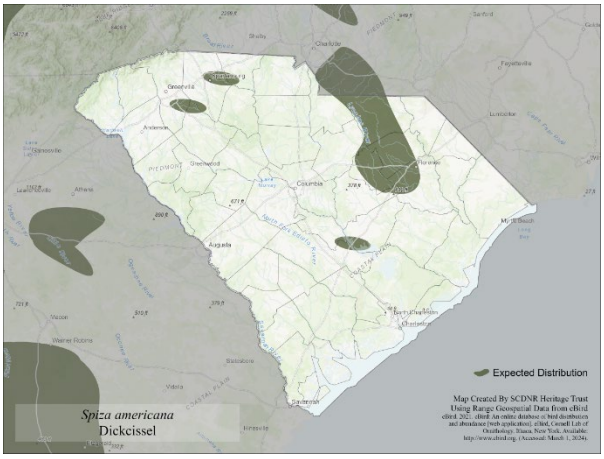
POPULATION SIZE AND DISTRIBUTION



The Bobolink is a passage migrant through South Carolina. Generally, spring migration occurs from mid-April to mid-May and fall migration from late August to mid-October (Seriff and Beirregaard 2018). Bobolinks nest in northern U.S. states and Canada and winter in South America (Renfrew et al. 2020). During the 1800's and early 1900's Bobolink were abundant, and often considered a pest (Seriff and Beirregaard 2018). They were often called "Ricebirds" due to large numbers foraging in rice fields (Seriff and Beirregaard 2018). They were also used as food (Seriff and Beirregaard 2018). However, the population has continued to decline (Renfrew et al. 2020).



The Common Ground Dove is a state resident of South Carolina; most individuals are concentrated along the Outer Coastal Plain. This bird is present in smaller numbers as far inland as the Fall Line within the Sandhills Ecoregion. Data for South Carolina indicates a decrease of 0.3% in the population of Common Ground Doves from 1966 to 2022 (Sauer et al. 2021).



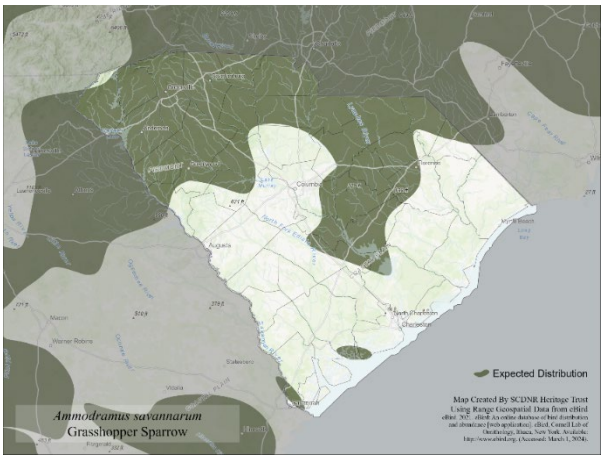
The Dickcissel is a sporadic breeder in South Carolina with very rare winter occurrences (Seriff and Beirregaard 2018). In the 1800's it is believed to have been more abundant along the Atlantic states, but by the early 1900's it had become a rare breeder (Seriff and Beirregaard 2018). South Carolina has experienced an annual rate of decline of 0.6% from 1966 through 2022 (Sauer et al. 2021).



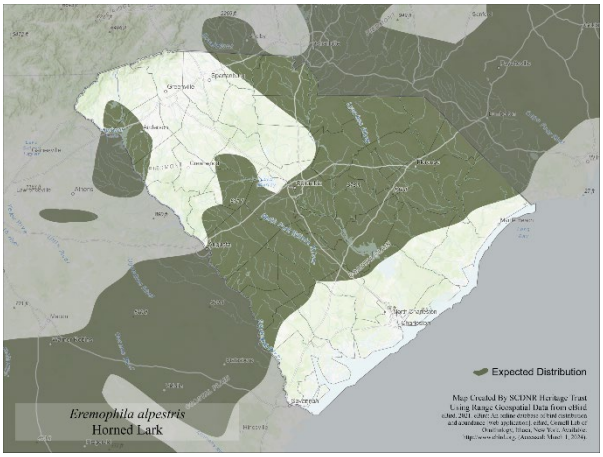
The Eastern Meadowlark is another permanent resident of South Carolina. Most individuals of this species are concentrated in the Piedmont BCR. The Eastern Meadowlark is also exhibiting long-term population declines throughout much of its range; in South Carolina, it has experienced a 4.1% annual rate of decrease from 1966 through 2022 (Sauer et al. 2021).



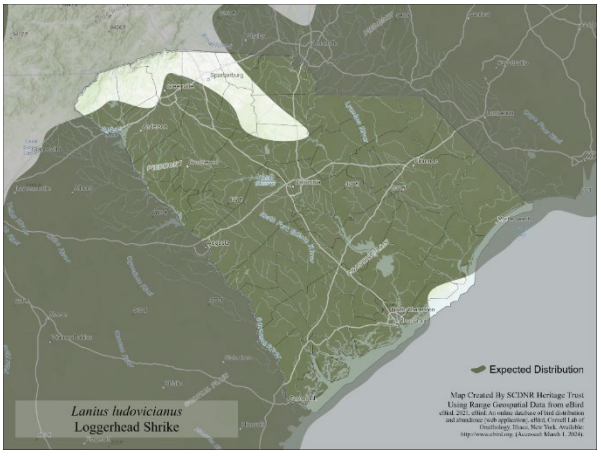
The Field Sparrow has a similar distribution to that of the Grasshopper Sparrow, but it is more abundant in South Carolina. However, data from the Breeding Bird Survey indicates a long-term decline of 4.6% in South Carolina for the period from 1966 through 2022 (Sauer et al. 2021).



The Grasshopper Sparrow is a summer resident of South Carolina; it also winters in this state, but in fewer numbers. Although breeding occurs throughout the Piedmont and within the Southeastern Coastal Plain, most breeding Grasshopper Sparrows are located in the "orchard-pasture belt" of the Upper Piedmont (Cely 2003). Breeding Bird Survey data indicates a long-term decline of 4.7% in South Carolina for the period from 1966 through 2022 (Sauer et al. 2021).



The Horned Lark is a resident in South Carolina. It is believed to be more common in the winter as birds come down from more northern states (Seriff and Beirregaard 2018). The first confirmed breeding record in South Carolina was in 1950 (Seriff and Beirregaard 2018). The winter population has noticeably decreased (Seriff and Beirregaard 2018). However, the small South Carolina breeding population has experienced an annual rate of increase of 1.7% from 1966 through 2022 (Sauer et al. 2021).



The Loggerhead Shrike is a resident found statewide, except at higher elevations. It is most abundant in the Coastal Plain, especially within the "farm belt" of the Inner Coastal Plain. Breeding Bird Survey data has demonstrated declines over significant portions of its range in the East, especially within the Piedmont Bird Conservation Region (BCR). South Carolina has experienced an annual rate of decline of 4.2% from 1966 through 2022 (Sauer et al. 2021).

Population sizes were estimated for South Carolina and (PIF 2020) and North America (Panjabi 2021, Table 1).

Species	South Carolina Population Estimate	US/Canada Population Estimate	Years Until 50% Population Loss Estimate
Bobolink		10,000,000	48
Common Ground Dove	12,000	2,000,000	>50
Dickcissel	2,500	28,000,000	>50
Loggerhead shrike	43,000	4,600,000	24
Grasshopper Sparrow	67,000	33,000,000	>50
Horned Lark	11,000	100,000,000	40
Field Sparrow	140,000	9,300,000	36
Eastern Meadowlark	170,000	24,000,000	23

Table 1: South Carolina population estimates, and US and Canada population estimates (PIF 2020) expressed as individual number of birds. Estimated years until another 50% of the North America population is lost (Rosenberg et al. 2016).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Bobolink use large open fields with a mixture of grasses and legumes, including hayfields and meadows, for breeding. After breeding they also use freshwater marshes and coastal areas to molt before migrating (Renfrew et al. 2020). Bobolink are passage migrants through South Carolina. Historically they fed on cultivated rice, corn, small grains and hay fields during migration, and it is believed to be similar today (Renfrew et al. 2020).

Common Ground Doves are found at greatest densities within coastal scrub/dune fields. This bird feeds heavily on weed seeds and requires a mix of bare ground and grassy areas for foraging but favors sandy soil. Common Ground Doves will nest on the ground; however, they more typically use shrubs or small trees along a woodland edge for nesting sites (Hamel 1992). These doves have also been seen nesting in the crowns of palmettos (*Sabal* spp.). Inner Coastal Plain habitats utilized by ground doves consist of recent clearcuts, peach orchards and farmland (Hamel 1992).

Dickcissel is an obligate grassland specialist. They nest in grasslands with 90-100% cover, vegetation that is 25-150cm tall, 5-15cm letter depth, and elevated song perches (Sousa et al. 2022). This habitat is typically found in native prairies, restored grasslands, hayfields, fallow fields, lightly grazed pastures, no-till crop fields, and linear grassy strips such as fencerows, stream sides, and roadsides (Sousa et al. 2022). A high proportion of forbes, especially legumes, is important because it provides song perches, nesting cover, nest support and invertebrate prey (Sousa et al. 2022). Proximity to wooded areas reduces habitat suitability (Sousa et al. 2022). During nonbreeding use agricultural fields, open grasslands, and fallow fields near water (Sousa et al. 2022).

Eastern Meadowlarks create well-concealed nests on the ground in clumps of grass 0.6 m (1.97 ft.) in height (Hamel 1992). Typically, this species nests and forages for insects or seeds in fields, orchards, pastures, roadsides and golf course roughs. Eastern Meadowlarks may require

landscapes dominated by agriculture and grasslands to maintain long-term population viability (Lanyon 1995).

The Field Sparrow is more tolerant of brush, hedgerows, briar tangles, plum thickets, and generally thicker stands of grass and herbaceous material than the Grasshopper Sparrow. Field sparrow nests are typically placed on the ground, but shrubs and small trees will also sometimes be used. This species forages by gleaning seeds from the ground, but its diet can also include insects (Hamel 1992). Field Sparrows benefit from management of grasslands and scrub/shrub habitats.

The Grasshopper Sparrow favors grassy fields for nesting; it is less numerous in weedy fields, pastures, and grain fields (Hamel 1992). Nest sites are usually found in vegetation approximately 0.3 m (0.98 ft.) high (Hamel 1992). Grasshopper Sparrow wintering habitat is composed of broomsedge (*Andropogon* spp*.)* fields, other open fields, and open Pine Savannas. The diet of this bird consists of primarily insects but can include seeds.

Horned Lark use open areas, and prefer bare ground to grasses taller than a few centimeters (Beason 2020). In agricultural areas they use bare ground, row crop stubble and heavily grazed areas. They also utilize mowed areas such as airport airstrips and sand beaches and dunes (Beason 2020). During nonbreeding they use similar habitats, but with increased use of areas such as feedlots and dunes (Beason 2020).

Loggerhead Shrikes use open lands consisting of expanses of short grass, old fields, orchards, grassy roadsides, cultivated fields, and pasture. This bird nests in hedgerows, shrubs, and trees—notably red cedar (*Juniperus virginiana*)—but also loblolly pine (*Pinus taeda*) and live oak (*Quercus virginiana*). Nest trees and shrubs are typically in the open. Loggerhead Shrikes hunt from powerlines, exposed tree limbs, fence posts, and other conspicuous perches. Thorn trees, barbwire, or other sharp objects are necessary within the habitat as the Loggerhead Shrike uses these to impale and cache prey. The Loggerhead Shrike feeds mainly on large insects and small rodents though it will, at times, take smaller birds.

The following species are PIF species on the continental watchlist and/or of regional concern that will benefit from increased amounts of grassland habitat on the landscape: Short-eared Owl (*Asio flammeus*), Eastern Kingbird (*Tyrannus tyrannus*), Henslow's Sparrow (*Ammodramus henslowii*), and Le Conte's Sparrow (*Ammodramus leconteii*)

CHALLENGES

Vegetative succession and permanent loss of early-successional habitat through urban development and intensified agriculture are primary factors resulting in the long-term population declines experienced by these species (Lanyon 1995; Ehrlich 1992; Colvin 1985). Although habitat protection will assist in protecting these early-successional species, that alone is not expected to increase populations of the birds included in the grassland guild. In order to increase populations, active management of early-successional habitat, such as burning, grazing, mowing, disking, and other means to retard plant succession, must be emphasized.

In general, intensive agricultural practices may reduce habitat suitability for grassland bird species. Mowing and haying, as well as the timing of these activities, undoubtedly destroy many nests. The use of pesticides may result in lower insect and rodent availability, thereby reducing foraging opportunities for these birds. Also, in some cases, existing Farm Bill programs may create sinks for wildlife. For example, planting sod-farming grass can preclude nesting and foraging activities for these species, as well as Northern Bobwhite quail. Active management for early-successional habitat is necessary to reverse population declines for grassland birds. The positive side of this problem is that early-successional management is straightforward; it can be accomplished in a short period compared to growing a 60-year old forest from seed; and the response time for grassland bird populations should be short. Monitoring and documenting the response of grassland birds to Farm Bill programs will allow for improving landowner recommendations (Hunter et al. 2001). Additionally, Dickcissel are targeted by illegal poisoning on their wintering grounds because they are considered a pest on grain crops (Sousa et al. 2022).

The decline of Common Ground Doves could be due to several factors in addition to habitat alteration and loss, especially excess predation by cats, raccoons, and other predators on developed barrier islands and inland habitats (NatureServe 2005). In some states, declines are also attributed to loss of birds due to misidentification during Mourning Dove (*Zenaida macroura*) hunting seasons (NatureServe 2005)

There are other, apparently less significant problems for grassland bird species. Birds are killed by flying into communication towers and turbines on wind farms. In a report reviewing studies of bird mortality at communication towers in the eastern portion of the US, 230 species of birds (184,797 individuals) were killed. Of these, 17.8% were warblers, 10% were sparrows, and 9.5% were waterfowl (Shire et al. 2000). Also, nest parasitism by Brown-headed Cowbirds is common; rates for this type of predation vary geographically. However, nest predation is a major cause of grassland bird population declines (NatureServe 2005; Carey et al. 1994). In some areas, roadsides may represent the best quality and highest quantity of nesting habitat, but the potential for vehicle collisions and invasion by exotic plant species may be high. For example, kudzu (*Pueraria lobota)* grows at an average rate of one foot per day (18 m or 60 ft. during a growing season) enveloping and eventually killing all vegetation in its path, thus destroying nest and foraging sites (Mississippi State University 2005)

Additionally, lack of survey and monitoring programs to supplement Breeding Bird Surveys and other existing programs can result in inaccurate population estimates and trends. A number of specific protocols need to be developed for individuals in this suite of species in order to adequately determine population declines. Additional monitoring efforts and coordination will increase the efficacy of management actions in the future (Coordinated Bird Monitoring 1).

CONSERVATION ACCOMPLISHMENTS

The development and implementation of agricultural incentive programs with focused environmental benefits for wildlife have provided significant benefits to said wildlife in the State and Nation. In fiscal year 2004, NRCS and its partners invested $2.8 billion in conservation nationally (Knight 2005). Implementation of conservation and monitoring objectives developed for the popular Northern Bobwhite quail (*Colinus virginianus*) will positively impact the suite of

grassland species (Dimmick et al. 2002). [NOTE: See the species account for the Northern Bobwhite for specific details of the NBCI's guidance document.]

A number of contributions have occurred at the state and species level: A two-year study of Loggerhead Shrike habitat and nesting productivity was conducted in the Coastal Plain (Cely and Corontzes 1988) and SCDNR funded 2 graduate projects exploring Loggerhead Shrike habitat, nesting success and survivorship (Froehly et al. 2019, Froehly et al. 2020, Krauser and Hill 2023). Also, a one-season survey to determine locations of significant Common Ground Dove populations was conducted in the State (Cely and Glover 2000) and SCDNR staff are in the process of trying to create Common Ground Dove habitat models using eBird data.

CONSERVATION RECOMMENDATIONS

- Research the possible creation of cost-share or incentive-based programs to promote the retention of early-successional habitats. Identify potential partners such as the Natural Resources Conservation Service to help assess the efficacy of such measures.
- Continue to participate in existing efforts to develop and implement agricultural incentives that are beneficial for wildlife. Integrate monitoring objectives and funding mechanisms to support such programs where appropriate. Also, continue to develop program delivery mechanisms.
- Develop partnerships and infrastructure to integrate bird conservation efforts into private land management activities. Pursue private and federal grant programs to implement management objectives.
- Establish Loggerhead Shrike posts in locations where perch sites are limited.
- In grassland bird habitat devoid of site-appropriate herbaceous species or with depauperate seed banks, establish seed sources through propagation from local sources.
- Prevent the spread of existing invasive and non-native grasses in wild areas, eliminating them, where possible.
- Acquire more complete information on the habitat needs of each grassland bird species to determine the best management guidelines. Promote the development and dissemination of best management practices for grassland species utilizing agricultural lands.
- Educate landowners about the use of seed mixtures that benefit wildlife in early succession habitats.
- Identify habitat requirements and dispersal rates for Common Ground Doves.
- Develop and implement monitoring programs to better assess breeding and wintering bird population sizes. Assess management and surveillance monitoring techniques to quantify short- and long-term population responses. Develop measures to integrate state monitoring results into regional and national level databases.
- Continue using the Breeding Bird Survey as a surveillance monitoring technique, and consider modifications to make the survey more robust across the state.
- Derive quantitative population-based habitat objectives for priority grassland birds, and test assumptions (identify habitat-specific densities, limiting factors) in order to model habitat requirements necessary to meet population objectives.
- Continue participation in the Atlantic Coast Joint Venture at the management board and science committee levels.

- Continue participation in Partner's In Flight, other bird initiatives, and the North American Bird Conservation Initiative.
- Promote the participation of volunteers and employees to collect survey and monitoring data for grassland bird species.
- Reduce communication tower collisions through design modifications.
- Reduce loss of grassland habitat through solar farm development by encouraging use of wildlife friendly solar BMP's.

MEASURES OF SUCCESS

The landbirds featured here are high-priority representatives of this group for South Carolina and populations should respond positively to focused management practices. The recovery of priority species, primarily through habitat restoration and management, should benefit the many other lesser priority birds that also use grasslands. Monitoring programs with specific objectives should indicate if populations are responding to an increase in the quantity and quality of grassland habitat across the state.

Calculation of habitat objectives will indicate if population objectives determined at the continental level are attainable for the State, and if changes in objectives are necessary. In some cases, it may be unrealistic to achieve PIF continental population objectives due to significant and permanent habitat loss. In other cases, South Carolina will be a source for some populations and will contribute to overall continental population goals.

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Seaside Sparrow (MacGillivray's)

Ammospiza maritimus macgillivraii

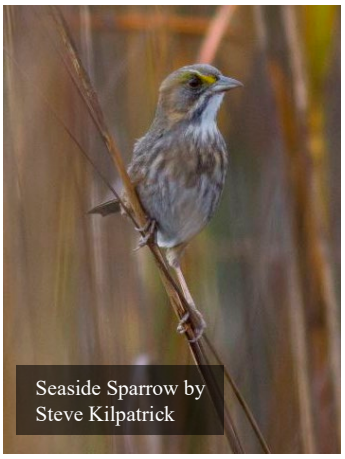
Contributors (2005): John E. Cely (SCDNR) and Dennis M. Forsythe (The Citadel)
Reviewed and Edited (2012): Chris Hill (Coastal Carolina Univ.)
Reviewed and Edited (2024): Mikayla Thistle (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

The Seaside Sparrow (*Ammospiza maritimus*, formerly *Ammodramus maritimus*) is a small passerine whose range extends along the Atlantic coast and Gulf of Mexico. There are seven extant subspecies of the Seaside Sparrow. Although other migratory subspecies, such as *Ammospiza maritimus maritimus,* may winter in South Carolina, the MacGillivray's Seaside Sparrow (*Ammospiza maritimus macgillivraii*) is the only species believed to breed in the state.

The Seaside Sparrow is olive-gray to olive-brown, has a relatively long conical bill and a short, sharp tail. The back and breast are streaked, but the streaking is not always visible. The Seaside Sparrow has a unique facial pattern. It has a yellow supraloral spot that blends to olive-green over the eye, a gray supercilium, crown stripe, and moustachial stripe, and a white chin and throat. The malar stripe is pale and buffy. Coloration is similar between the sexes. Seaside Sparrows are about 13 to 15 cm (5 to 6 in.) in length (Greenlaw et al. 2022). Males (22.8 ± 1.2 g [0.80 ± 0.04 oz]) are on average slightly larger than females (22.2 ± 1.6 g [0.78 ± 0.06 oz], Hunter 2016).



Seaside Sparrow by Steve Kilpatrick

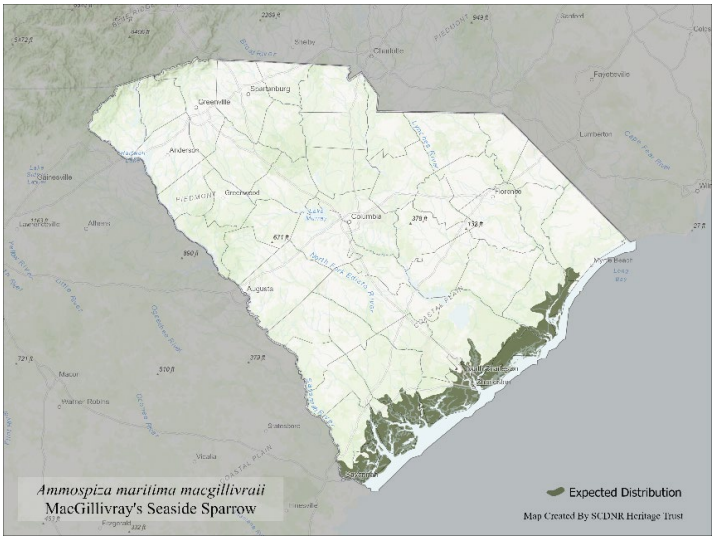
Status

The Seaside Sparrow is considered a species of Least Concern by the IUCN (2024). Globally, the Seaside Sparrow is ranked as Secure (G5) but the MacGillivray's subspecies is ranked as Vulnerable (T3). In South Carolina, MacGillivray's Seaside Sparrow is ranked as Imperiled (S2) (NatureServe 2024). Partners in Flight considers the Seaside Sparrow to be a Yellow Watch List species range-wide and a Species of Regional Concern and Regional Stewardship species for the Southeastern Coastal Plain (2024). Although not specific to the MacGillivray's subspecies, Breeding Bird Survey results from 1966-2019 indicate that Seaside Sparrow populations are increasing by 0.70% each year in the United States; however, populations in the Southeastern Coastal Plain are declining by 1.86% (Sauer et al. 2019). The Seaside Sparrow is designated as a high priority species by South Atlantic Migratory Bird Initiative. In 2010, the USFWS received a petition to list the MacGillivray's Seaside Sparrow as endangered or threatened under the Endangered Species Act. However, after review of a 12-month finding in 2018, known stressors to the subspecies were not considered sufficient for listing. Populations in South Carolina were found to be likely stable (USFWS 2018). A Florida subspecies, the Dusky Seaside Sparrow (*A.*

m. nigrescens) is now extinct, while the Cape Sable Seaside Sparrow (*A. m. mirabilis*) is critically endangered.

POPULATION SIZE AND DISTRIBUTION

The MacGillivray's Seaside Sparrow range included in the 2018 Species Status Assessment includes coastal counties from Georgetown, SC to Duval, FL. During the 20th century, the accepted northern boundary for the MacGillivray's Seaside Sparrow was Dare County, NC. However, recent genetic analysis suggests that this range may need to be revised. Sampled Seaside Sparrows in a Charleston, SC population were found to be genetically different from populations spanning from Florida to Georgia and northern South Carolina to Connecticut, with admixture evident in South Carolina populations north and south of Charleston (Roeder et al. 2021). Additional genetic analysis by Davis et al. identified a transition in the Atlantic Coast Seaside Sparrows genetic structure occurring near northern South Carolina; however, their analysis showed stronger support for only two intergrading groups (northern and southern) with some support for a third genetic group (Charleston, 2021).



The MacGillivray's Seaside Sparrow occupies a very narrow strip of salt and brackish marsh along the Outer Coastal Plain "tidewater region". In South Carolina, the species has also been found nesting in coastal marshes as far inland as the town of Hanahan near Goose Creek. Although they are non-migratory, MacGillivray's Seaside Sparrows will move locally between breeding and non-breeding seasons (USFWS 2018). Little is known about winter distribution. Winter numbers are augmented by migrants from northern populations. Typically, the breeding birds belong to the dark subspecies *A. m. macgillivraii* while additional wintering birds belong to the lighter subspecies *A. m. maritimus.*

The population size of MacGillivray's Seaside Sparrow is estimated to be 32,800 individuals (USFWS 2018). The 2018 USFWS Species Status Assessment outlines four populations for the subspecies, three of which are in South Carolina – North Inlet-Bulls Island, Headquarters Island, Ace Basin, and Georgia-Florida. The species is thought to be extirpated from Volusia, Flagler, St. Johns, and part of Duval Counties in Florida.

SCDNR and collaborators at Coastal Carolina University completed a study in 2014-2015 in order to understand the breeding distribution of MacGillivray's Seaside Sparrow in South Carolina. Tidal marshes throughout the state as well as historically occupied marshes were surveyed. At Yawkey Wildlife Center, Santee Coastal Reserve, and Cape Romain NWR, MacGillivray's Seaside Sparrows were found to be widespread but they were only found at dense concentrations at a few sites (Tegeler et al. 2015, Hill and Laskaris 2015). Results from

this study were used to inform the MacGillivray's Seaside Sparrow Species Status Assessment in 2018.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS


Melanie Gaddy, iNaturalist, Public Domain

The Seaside Sparrow is found exclusively in salt and brackish marshes. Low marsh habitat is dominated by smooth cordgrass and black needlerush and high marsh habitat is dominated by black needlerush, saltgrass, and glasswort (USFWS 2018). In South Carolina, MacGillivray's Seaside Sparrow breed in areas of lower elevation within high marsh that are flooded only twice a month. They also use managed impoundments (Tegeler et al. 2015, USFWS 2018). Significant populations occur in black needle-rush marshes at the Tom Yawkey Wildlife Center, Cape Romain National Wildlife Refuge, and other areas featuring extensive coastal marsh. In Georgia and Florida, MacGillivray's Seaside Sparrow breed in areas of higher elevation within low marsh (USFWS 2018). In order to avoid extreme tidal fluctuations, Seaside Sparrows move up the estuaries to nest (Post and Gauthreaux 1989). In South Carolina, birds breed in marshes upriver and move to saltier coastal marshes in the wintertime (Hill & Laskaris 2015). Predation is the leading cause of nest failure. MacGillivray's Seaside Sparrows use habitat far from upland to avoid areas with higher predator density (USFWS 2018). Nest placement must balance the risk of tidal flooding and predation (Hunter et al. 2016). Vegetation must be dense to prevent nest predation yet must allow movement.

MacGillivray's Seaside Sparrows forage in open stands of vegetation, shallow pools, pannes, and edges of tidal creeks (Greenlaw et al. 2022). Most commonly they probe and glean from the ground so maintaining open ground is important for foraging habitat. Their diet consists of small invertebrates and seeds (Greenlaw et al. 2022).

CHALLENGES

While the Seaside Sparrow has one of the most restricted breeding ranges of any passerine, its habitat has one of the most stringent regulatory protections of any type in the country. Prior to the enactment of tidelands protection such as the Clean Water Act, some Seaside Sparrow populations had been severely impacted by salt marsh ditching for mosquito control and impoundment creation for rice cultivation and wildlife management, particularly for waterfowl. These changes greatly alter the natural hydrology and vegetation of the marshes, often making them unsuitable for Seaside Sparrows. Although MacGillivray's Seaside Sparrow will use some impounded habitat, especially impoundments large enough to have sufficient topographic variability so that patches of suitable habitat remain, the creation of impoundments largely reduced habitat availability in South Carolina.

Major threats to MacGillivray's Seaside Sparrow include predation, flooding, and extreme weather (USFWS 2018). The largest challenge to Seaside Sparrow populations over the next

century may come from impacts of sea level rise on salt marsh habitat. Saltmarsh habitat will likely decline with sea-level rise, as accretion may not keep up with the rate of sea-level rise and coastal development may prevent marsh migration inland (Mitsch and Gosselink 2015, Crosby et al. 2016). In addition, increased severity of tidal flooding is expected to increase rates of nest failure. Nest loss due to sea-level rise and storm surge is likely affect the viability of Seaside Sparrow and other salt marsh species (USFWS 2018). Although MacGillivray's Seaside Sparrows accommodate for tidal fluctuation in nest placement, nests placed higher experience higher rates of predation (USFWS 2018).

CONSERVATION ACCOMPLISHMENTS

Many protected lands in South Carolina, including National Wildlife Refuges and Wildlife Management Areas, provide habitat for MacGillivray's Seaside Sparrow. Almost all marsh in the North-Inlet-Bulls Island Population is protected. The ACE Basin remains largely undeveloped and MacGillivray's Seaside Sparrow habitat is within the 38,292 ha ACE Basin National Estuarine Reserve. Management of marshes and impoundments on these properties can improve habitat for MacGillivray's Seaside Sparrow. Prescribed fire is often used to mimic historic fire regimes and reset vegetation structure. Seaside Sparrow use generally increases 3-4 years after burning.

Research completed in the past decade has clarified the distribution, habitat use, and breeding ecology of MacGillivray's Seaside Sparrow in South Carolina. Although there is still much to be learned about this species, this research can inform conservation activities. For example, because it is now known that MacGillivray's Seaside Sparrows tend to breed in dense clusters in South Carolina, marshes being used for breeding can be targeted for protection and management.

CONSERVATION RECOMMENDATIONS

- Maintain current regulations and statutes protecting tidal wetlands.
- Where possible, restore ditched and altered marshes.
- Control predators, such as rice rats, in areas experiencing high rates of MacGillivray's Seaside Sparrow nest predation.
- Support efforts to collect basic information on demographics, nesting, habitat, site fidelity, predation, and other biological parameters. Initiate a range-wide monitoring program.
- Inform the public and constituents about research, survey results, and habitat needs, as this species is little known to the general public.
- Acquire lands that are suitable for facilitated marsh migration.
- Manage select impoundments near natural marsh and MacGillivray's Seaside Sparrow hotspots specifically for the species. Mimic hydrology and restore low elevation high marsh vegetation.
- Initiate research project to determine wintering grounds of MacGillivray's Seaside Sparrow in South Carolina.

MEASURES OF SUCCESS

Stabilization or increases in populations would be considered successes, as well as preventing extirpation from high density clusters. This may be accomplished through establishing a state-wide monitoring program and habitat protection.

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Marsh Birds Guild

King Rail *Rallus elegans*
Least Bittern *Ixobrychus exilis*
Nelson's Sparrow *Ammospiza nelson*
Saltmarsh Sparrow *Ammospiza caudacuta*
Worthington's Marsh Wren *Cistothorus palustris griseus*
Yellow Rail *Coturnicops noveboracensis*

NOTE: The Black Rail, MacGillivray's Seaside Sparrow, and Whooping Crane are described in in separate species accounts.

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DESCRIPTION

Taxonomy and Basic Descriptions

The members of the marsh birds guild vary widely in appearance, size, and habits. Guild members included in this account are in three orders, although other orders not included in this account may use marsh habitat during some or all life history stages. The order Gruiformes includes the families Rallidae (rails) and Gruidae (cranes). The family Ardeidae (herons, egrets, and bitterns) is included in the order Pelicaniformes. The order Passeriformes includes all perching birds, including those of the families Passerellidae (new world sparrows) and Troglodytidae (wrens) included in this account.


Yellow Rail by USFWS

The Yellow Rail is a small marsh bird averaging 18.4 cm (7.2 in) in length and 50 g (1.8 oz) in weight. The adult has a short yellow bill, short tail, buffy yellow chest and face, dark crown and eye stripe, and a yellow and black streaked back. The juvenile is similar to the adult but has a darker bill and more speckling, especially on the neck and head (Sibley 2003).


King Rail by David Youngblood

The King Rail is the largest North American rail. It averages 38.1 cm (15.0 in) in length and 360 g (13 oz) in weight. The adult male has a brown streaked back, deep orange neck and breast, and a black and white striped flank. The adult female is smaller and drabber than the male. The juvenile is similar to the adult but has a whitish breast with dark speckling (Sibley 2003).

The Least Bittern is the smallest heron in the Americas, averaging 33 cm (13 in) in length and 80 g (2.8 oz) in weight.

The adult has a dark brown to blackish back and crown, an orange-brown neck and sides, and a white and orange striped neck and chest. The juvenile is similar to the adult but is paler with a brown crown (Sibley 2003).


Least Bittern by David Youngblood


Nelson's Sparrow by Kimberly Emerson, USFWS, Public Domain

The Nelson's Sparrow is a small short-tailed sparrow averaging 11 to 13 cm (4.3 to 5.1 in.) long and weighing 17 to 21 g (0.6 to 0.7 oz.). It has a dark brown to olive back that has four grayish or white stripes. The underparts are white or pale yellow and the breast and flanks have faint streaking. Nelson's Sparrows are typically identified by their bright yellow-orange supercilium stripe that batches the breast color, gray check patch, and brownish post-ocular stripe (Shriver et al. 2020). Juveniles are similar to adults but have a blackish crown with a broad orange-buff median strip, a broad supercilium, a chestnut or rust-colored nape, and a streaky rump (Shriver et al. 2020).


Saltmarsh Sparrow by Peter Paton, USFWS, Public Domain

The Saltmarsh Sparrow is slightly larger than the Nelson's Sparrow averaging 12 to 13 cm (4.7 to 5.1 in) long and weighing 17 to 24 g (0.6 to 0.8 oz.). Males and females appear similar. Saltmarsh Sparrows appear similar to Nelson's Sparrows; however, Saltmarsh Sparrows have a longer bill and more defined streaking on the chest. Nelson's Sparrow and Saltmarsh Sparrow will hybridize (Greenlaw et al. 2020).


Worthington's Marsh Wren by Roxan Chicalo, FWC, CC BY-ND 2.0

The Worthington's Marsh Wren is a small wren reaching up to 12 cm (4.7 in) in length. Male Marsh Wrens are larger than the female but otherwise appear similar. The upperparts of the Worthington's Marsh Wren are grayish-brown and its belly is light gray. It has a white eyebrow and a dark triangular patch with pale streaking on the back (FWC 2013).

Status

Except for the Black Rail and the Whooping Crane which are detailed in separate accounts, none of the marsh bird species in South Carolina are officially recognized as threatened or endangered. However, all are experiencing documented or suspected declines. All species are being negatively affected by the loss and degradation of wetland habitat through drainage, dredging, filling, impounding, and pollutant discharge. The most serious limiting factor to these species is the availability of wetland habitat (NatureServe 2024). Wetlands in the Southeastern United States represented 89% of the total wetland lost in the United States in the mid-1980s

(Hefner et al. 1994).

The rail species present challenges in determining statuses due to a difficulty in detection as a result of their secretive nature and a general lack of information. The International Union for the Conservation of Nature (IUCN) lists King Rails as Near Threatened and Yellow Rails as Least Concern (2024). Partners in Flight (PIF) considers the King Rail and Yellow Rail to be Tipping Point species and are placed on their Orange and Yellow Watch Lists, respectively, due to their level of population threats (2024). The King Rail is also a Species of Regional Concern for the Southeastern Coastal Plain (PIF 2024). The King Rail and Yellow Rail are ranked globally as Apparently Secure (G4) and, in South Carolina, the King Rail is ranked as Imperiled (S2) and the Yellow Rail is ranked as Vulnerable (S3) (NatureServe 2024). According to the North American Breeding Bird Survey (BBS) results from 1966-2019, King Rail populations are declining by 3.69% each year in the United States and 2.28% specifically in the Southeastern Coastal Plain (Sauer et al. 2019). BBS data is insufficient to estimate Yellow Rail population trends.

Many of the rail species are categorized as game birds and are hunted in South Carolina. The following species and daily bag limits (in parentheses) are listed in the 2023-2024 Migratory Bird Regulations: King and Clapper Rails (15), Sora and Virginia Rail (25), Common and Purple Gallinules (15), and Wilson's Snipe (8) (SCDNR 2024). The hunting seasons for marsh birds are during the winter, when both resident and migrant birds are likely to be present in South Carolina.

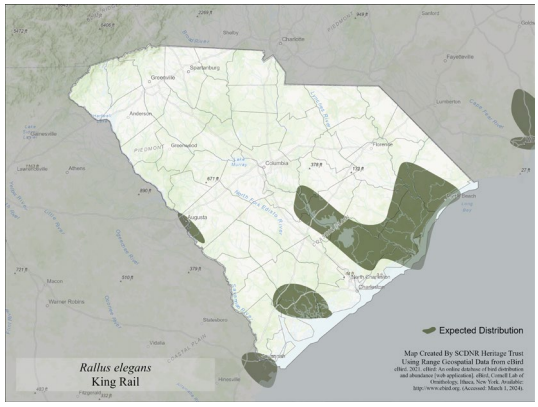
The Least Bittern is considered a species of Least Concern by the IUCN (2024). Globally, the Least Bittern is ranked as Apparently Secure (G4) and in South Carolina, it is ranked as Vulnerable (S3) (NatureServe 2024). PIF considers the Least Bittern to be a Yellow Watch List species range-wide and a Species of Regional Concern and Regional Stewardship species for the Southeastern Coastal Plain (2024). According to BBS results from 1966-2019, Least Bittern populations are declining by 0.14% each year in the United States and 1.30% specifically in the Southeastern Coastal Plain (Sauer et al. 2019).

The Nelson's Sparrow is considered a species of Least Concern by the IUCN and the Saltmarsh Sparrow is considered Endangered (2024). Globally, the Nelson's Sparrow is ranked as Apparently Secure (G5) and in South Carolina, the it is ranked as Vulnerable (S3) (NatureServe 2024). Globally, the Saltmarsh Sparrow is ranked as Imperiled (G2) and in South Carolina, it is ranked as Vulnerable (S3) (NatureServe 2024). PIF considers both sparrow species to be Watch List Species (Red: Saltmarsh Sparrow, Yellow: Nelson's Sparrow) range-wide and a Species of Regional Concern and Regional Stewardship species for the Southeastern Coastal Plain (2024). Saltmarsh Sparrows are also listed as a Tipping Point Species (PIF 2024). BBS results from 1966-2019 show that Nelson's Sparrow populations are increasing by 0.68% each year in the United States. BBS data is currently insufficient to estimate Saltmarsh Sparrow population trends.

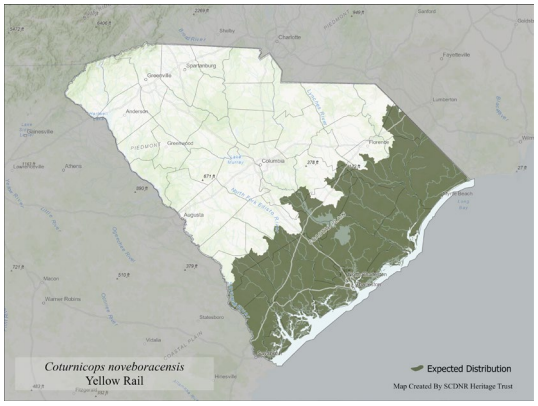
Very little is known about Worthington's Marsh Wren in South Carolina. Research will be needed to understand the population status of the subspecies in the state. The Worthington's Marsh Wren is state listed as threatened in Florida where the species has seen a 80% range contraction (Kale 1996). Globally, the Marsh Wren (nominate race) is ranked as Secure (G5) and

in South Carolina, it is ranked as Apparently Secure (S4) (NatureServe 2024). The Worthington's subspecies is ranked as Vulnerable (T3) throughout its range; however, there is no status rank for South Carolina. Although not specific to the Worthington's subspecies, BBS results from 1966-2019 indicate that Marsh Wren populations are increasing by 2.03% each year in the United States; however, populations in the Southeastern Coastal Plain are declining by 1.85% (Sauer et al. 2019).

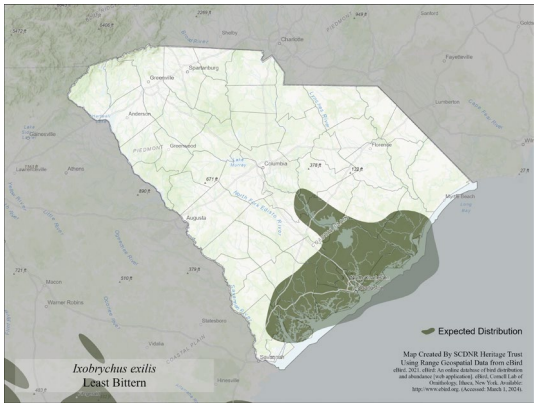
POPULATION SIZE AND DISTRIBUTION



King Rails are found year-round in freshwater to brackish marshes along the Gulf Coast, Florida, the Altantic Coast from Florida to Maryland, and the Greater Antilles. The breeding range also extends up the East Coast to Massachusetts. King Rails breed in inland Texas, Louisiana, and Mississippi. They are rare and localized throughout the eastern United States (Pickens and Meanly 2020). In South Carolina, the King Rail is primarily found in the Coastal Zone, but can be found in the Coastal Plain and Sandhills Ecoregions. It was formerly found statewide, but few, if any, Piedmont locations are currently known (Cely et al. 1993). PIF estimates the global population size of King Rails to be 69,000 individuals with 63,000 in the United States and Canada (2024).

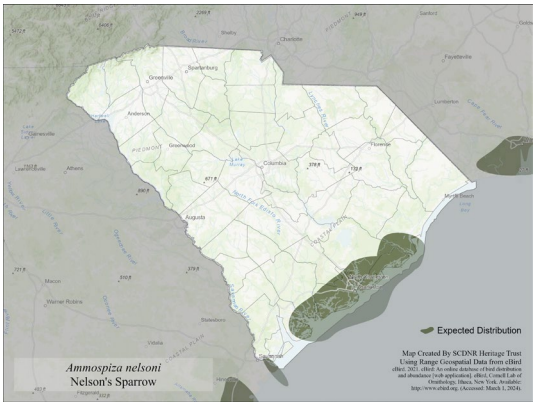


Yellow Rails primarily breed in south-central and southeast Canada. The breeding range extends into the United States near the Canadian border in Montana, North Dakota, Minnesota, Michigan, and Maine (Leston and Bookhout 2020). Breeding is very localized. Yellow Rails primarily winter along the Gulf Coast and Southeastern Coast from North Carolina to Texas. Little is known about the Yellow Rail's distribution and habitat requirements in South Carolina. They are expected to use brackish and fresh marshes, managed impoundments, and wet fields with very shallow standing water. PIF estimates the global population size of Yellow Rails to be less than 12,000 individuals with all populations existing within the United States and Canada (2024), although accurate abundance estimation is difficult due to low detection rates.

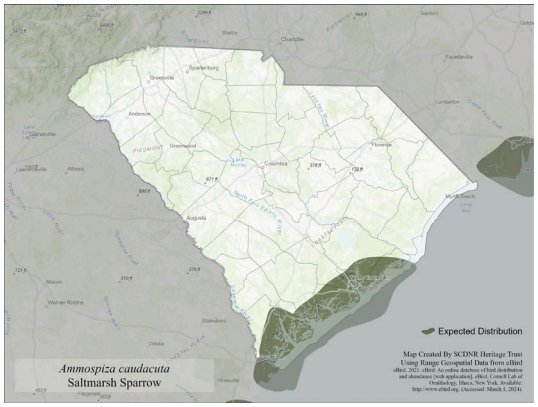


Least Bitterns breed in low-lying wetlands across much of the eastern United States, isolated areas in the western United States and southern Canada, the Greater Antilles, Mexico, Costa Rica, and South America. They winter where there is no frost through south Florida, Central America, the Greater Antilles,

and South America (Poole et al. 2020). In South Carolina, the Least Bittern is most abundant in the Coastal Zone. PIF estimates the global population size of Least Bitterns to be 310,000 individuals with 130,000 in the United States and Canada (2024).

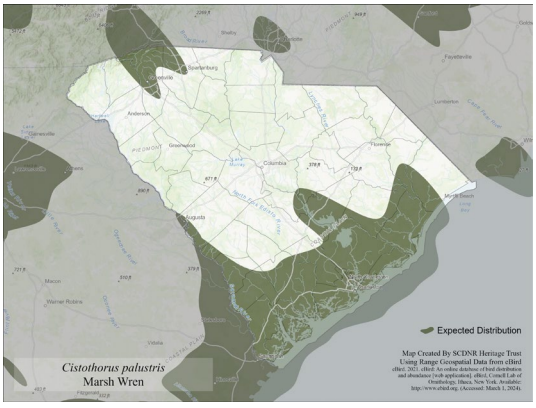


The Nelson's Sparrow has three breeding populations. The first breeds in marshes in central Canada and into the Dakotas and Minnesota. The second breeds around James and Hudson Bay in Canada. The third breeds along the St. Lawrence estuaries and the marshes of the Canadian Maritimes and northern New England. Nelson's Sparrows primarily winter on the Atlantic and Gulf Coasts from North Carolina to Texas, although they also occur in California (Shriver et al. 2020). In South Carolina, Nelson's Sparrows generally are detected in marshes in coastal counties from Charleston County to Jasper County. PIF estimates the global population size of Nelson's Sparrows to be 1,000,000 individuals with all residing in the United States and Canada (2024).



The Saltmarsh Sparrow only occupies tidal saltmarsh. The species breeds from Maine to Virginia and winters primarily from Maryland and Virginia to Florida, although in mild years they will winter in North Carolina and Virginia (Greenlaw et al. 2020). In South Carolina, Saltmarsh Sparrows generally are detected in tidal marshes in coastal counties from Charleston County to Jasper County. PIF estimates the global population size of Saltmarsh Sparrows to be 60,000 individuals with all residing in the United States (2024).

The Worthington's Marsh Wren is nonmigratory and can be found in coastal marshes from northeast South Carolina to the northeast coast of Florida year-round (Kroodsma and Verner 2020). Research is needed to better understand the distribution and population size of Worthington's Marsh Wren in South Carolina. The range map for the nominate race is included.



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The King Rail habitat includes freshwater to brackish marshes (both tidal and non-tidal), impoundments, early successional marsh-shrub swamp, and rice fields (Pickens and Meanly

2020). King Rails use habitat with dense vegetation and shallow open water interspersed within their home range that provide foraging opportunities (Pickens and King 2013, Pickens and Meanly 2020). Selection for specific vegetation types likely varies with water level and may be more indicative of the water level conditions due to precipitation and flooding at the time of use (Pickens and King 2013). King Rails feed primarily on crustaceans (crayfish, fiddler crabs) and forage under vegetation cover or close to the vegetation edge (Pickens and Meanly 2020).

The Yellow Rail uses the drier areas of coastal marsh, freshwater marsh, "wet" or low-lying fields and pastures, grassy Carolina bays, damp grassy power line right-of-ways, and ditch banks. Due to the bird's small size, it does not use marshes and impoundments with deep water. It is sometimes found in recent clearcuts with scattered puddles of standing water and bunched grasses. Tall or moderate-height grasses seem important for cover. Some woody trees and shrubs are acceptable features in the habitat, but based on personal observations (Cely) at a Yellow Rail site in lower Richland County, SC over an 8 to 9 year period, succession to woody shrubs and trees seemed detrimental. Fire, mowing, and other successional retardants are probably needed to maintain suitable habitat conditions. Yellow Rails forage in shallow water covered by dense vegetation and feed primarily on invertebrates (small snails, insects, spiders, crustaceans) and some seeds (Leston and Bookhout 2020).

The Least Bittern uses freshwater and brackish marsh with tall vegetation, such as cattails, and open water. In addition, pond and lake margins with emergent vegetation and managed impoundments are frequented. As with most members of the Ardeidae family, the Least Bittern may need deeper water for nesting security purposes. Least Bitterns primarily forage from dense stands of emergent vegetation on the edge of open water and feed on small fish and other small vertebrates, insects, and crustaceans (Poole et al. 2020).

Overwintering Nelson's Sparrows use tidal marshes and occasionally cattail marsh. Nelson's Sparrows forage for small invertebrates and seeds beneath the grass and along the edges of pools (Shriver et al. 2020). The Saltmarsh Sparrow similarly uses tidal marsh, usually those dominated by *Spartina* grasses. Saltmarsh Sparrows often forage along muddy edges and can be seen during high tides when they move upslope to the marsh periphery (Greenlaw et al. 2020).

The Worthington's Marsh Wren occupies tidal marshes dominated by *Spartina alterniflora*. They usually nest within colonies in the tall grass along tidal creeks (FWC 2011). Further study is needed to understand Worthington's Marsh Wren habitat use specifically in South Carolina.

CHALLENGES

Loss of wetland habitat is the most obvious problem, but for some species, adequate habitat seems available in South Carolina. Declines may be related to other reasons as yet undefined such as pollutants and/or predators. A marsh bird survey conducted by the SCDNR (Cely et al. 1993) noted that the majority of recorded marsh birds were associated with coastal waterfowl impoundments and managed wetlands. The future of these species in South Carolina could, therefore, be tied to active waterfowl management programs in the State and any threats to those habitats managed for waterfowl. As most marsh bird management is incidental to waterfowl management, more information is needed on how to effectively integrate marsh bird management with waterfowl management. In addition, little is known about the basic nesting

biology of the species in this guild that breed in South Carolina. Black Rails face many of the challenges identified for other species in the Marsh Birds guild, but also face unique challenges due to their specific habitat requirements.

Fire suppression causes habitat loss because plant succession reduces the suitability of wetland habitats. Shrub growth will reduce grass cover preferred by most marsh birds. Prescribed burning is an important tool for managing marsh bird habitat. As development increases along the coasts, managers are more reluctant to use fire as a management tool, and regulations restricting burning have increased. Slow-burning (backing and flanking) fires that leave a mosaic of burned and unburned areas maintain refugia and suitable habitat. Most wetlands should not be burned every year because it takes a couple of years for suitable vegetation to re-grow. Fast-moving and multipoint fires can result in marsh bird mortality (USFWS 2019). Burning during the nesting season can result in the loss of adults and young. The use of aerial ignition to burn huge areas quickly and "clean burns" in which no patches of vegetation are left are probably particularly dangerous practices for rails and other wetland species.

Effects of climate change and sea level rise are currently being studied, with some models being produced to demonstrate loss of marshes and the inundation of managed wetlands, where these species are generally found. The ability of these marshes to accrete soil and migrate inland will be important to the long-term survival of the species that utilize marshes and the estuarine systems. Some long-term projections show that some of the more inland managed wetlands will retain their infrastructure, while those closer to the ocean will likely be inundated. The ability to restore some of these degraded managed wetlands in more inland areas could be very important to the sustainability of these marsh bird populations.

CONSERVATION ACCOMPLISHMENTS

The continued preservation of wetland habitats, including freshwater and saltwater marshes, is beneficial to these species. The Atlantic Coast Joint Venture has published a Salt Marsh Bird Conservation Plan which highlights strategies and actions for supporting salt marsh bird populations experiencing declines, highlighting Black Rails and Saltmarsh Sparrows and flagship species (ACJV 2019). Preservation of areas such as the ACE Basin with extensive protected wetland complexes has provided excellent resources for these species. Some of the best habitats for these species include existing managed impoundments along the coast. Additionally, Conway (2004) has initiated standardized monitoring protocols for these species.

SCDNR is researching ways to maximize useable habitat for marsh birds, especially for rails, through prescriptive impoundment management. Often, traditional impoundment management does not allow for fine-scale water level control. By frequently monitoring water levels and adjusting water level control structures as needed, target water levels are maintained in high-priority breeding and foraging areas. Additionally, SCDNR is researching how experimental irrigation can be used to maximize usable habitat for marsh birds within impoundments as well as create novel habitat that is mindful of future climate scenarios. Some rail species, such as Black Rails and Yellow Rails, will use wet meadow habitat. As impoundment infrastructure becomes increasingly vulnerable to sea level rise and increased storm intensity, wet meadows may provide habitat that is less susceptible to climate stressors.

CONSERVATION RECOMMENDATIONS

- Protect and manage wetlands. This includes retarding plant succession through burning, disking, mowing, herbicide, seasonal flooding and other measures that restore natural disturbance regimes. This can be accomplished, in part, by increasing the utilization of federal incentive programs that compensate private landowners for wetland restoration activities and practices that reduce erosion and increase water quality.
- Control the spread of invasive species such as *Phragmites australis* and *Triadica sebifera* which outcompete native species and have negative wildlife value.
- Research basic life history and management needs for the species in this guild in South Carolina's wetland habitats.
- Survey appropriate habitat to gather distributional data for these species.
- Establish a monitoring initiative to determine current species distributions and evaluate population trends.
- Investigate the role of microtopography on habitat use by marsh birds, especially those that require extremely shallow water levels such as Black Rails and Yellow Rails.
- Acquire lands that are suitable for facilitated marsh migration.
- Create novel wet meadow habitat using irrigation or other land management practices to benefit marsh species, especially Black Rails and Yellow Rails, that rely on very shallow water levels.
- Create and distribute best management practices for guild species, especially rails, and disseminate to local landowners and land managers.

MEASURES OF SUCCESS

The first measure of success would be to implement long-term population monitoring studies which would yield information about distribution, population status, and trends for this group. The next step is to increase quantity and quality of habitat by implementing the above-mentioned conservation recommendations. The ultimate measure of success is to document stable population trends for declining species and to increase populations for species in which research suggests it is warranted.

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Migratory Shorebird Guild

Black-bellied Plover (*Pluvialis squatarola)*
Dunlin (*Calidris alpina***)**
Lesser Yellowlegs (*Tringa flavipes*)
Long-billed Curlew (*Numenius americanus*)
Marbled Godwit (*Limosa fedoa*)
Piping Plover (*Charadrius melodus*)
Red Knot (*Calidris canutus*)
Ruddy Turnstone (*Aenaria interpres*)
Sanderling (*Calidris alba*)
Semipalmated Sandpiper (*Calidris pusilla*)
Short-billed Dowitcher (*Limnodromus griseus*)
Whimbrel (*Numenius phaeopus*)

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Reviewed and Edited (2012): Felicia Sanders (SCDNR)
Reviewed and Edited (2024): Felicia Sanders (SCDNR)

DESCRIPTION

Taxonomy and Basic Description


Mixed shorebird flock by Felicia Sanders

The shorebird guild is composed of birds in the Charadrii suborder. Migratory shorebirds in the SWAP list in South Carolina are in the 2 families: Scolopacidae (sandpipers) and Charadriidae (plovers). Sandpipers are the most diverse family of shorebirds. Their tactile foraging strategy encompasses probing in soft mud or sand for invertebrates. Plovers are medium-size birds, with relatively short, thick bills and employ a distinctive foraging strategy. They stand, looking for prey, and then run to feed on detected invertebrates.

Shorebirds are characterized by long legs for wading and wings designed for quick flight and transcontinental migrations. Migrations can span continents; for example, some Red Knots migrate from the Canadian arctic to the southern tip of South America. Less frequently, shorebirds may migrate from the Northeastern to Southeastern US, as is the case for the Piping Plover. Migratory shorebirds in South Carolina may be transient birds on a northbound flight in the spring, a southbound flight in the fall, or wintering birds.

Plumage can be strikingly different between summer and winter. Although nesting habitat includes inland tundra and prairies, during the non-breeding season, they forage and roost in mixed species flocks primarily on the coast. Thus, they are aptly named shorebirds.

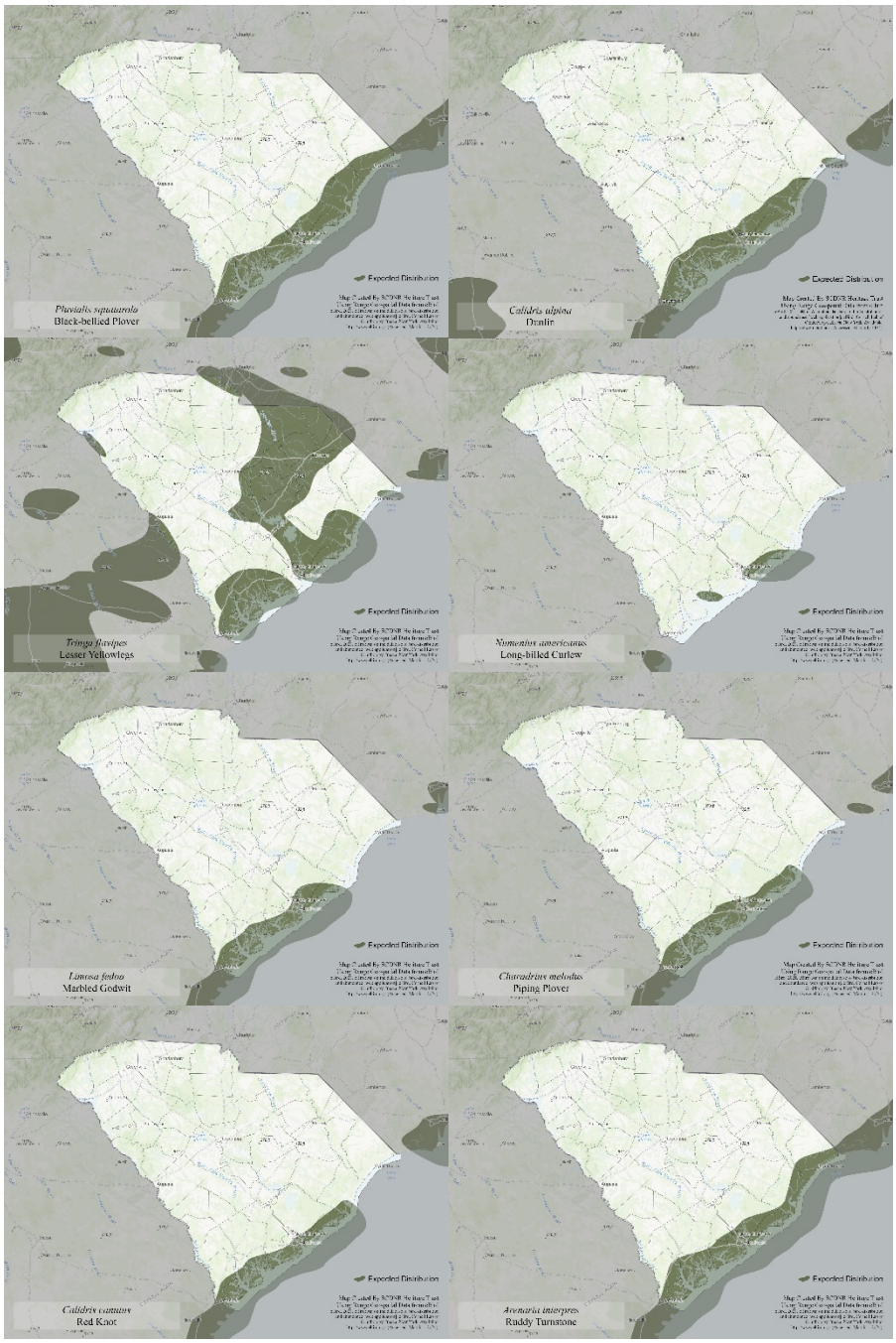
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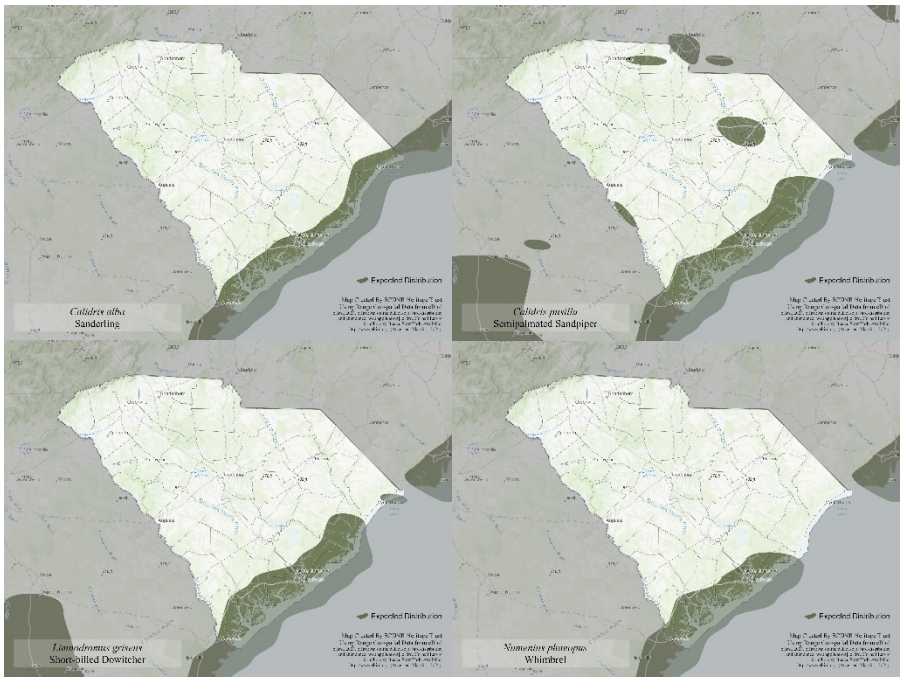

Whimbrel by USFWS

Despite challenges with low precision associated with migration count data, population trends between 1980 and 2019 for 28 shorebird species found in North America were analyzed by a team of experts from the Canadian Wildlife Service, USFWS and Manomet, a scientific research organization. This published study found that 26 of the 28 (93%) shorebird species were found to be declining with more than half of the species losing more than half of their abundance. The greatest declines were along the Atlantic coast from Nova Scotia to North Carolina and the declines are worsening in recent years (Smith et al. 2023). Many shorebird species are in need of protection afforded by federal listing, but Piping Plovers and Red Knots are the only listed shorebird in South Carolina; these species are federally threatened.

POPULATION SIZE AND DISTRIBUTION

Population sizes of most species are not known because shorebird migration can span continents and breeding grounds are mostly inaccessible arctic and sub-arctic habitats. Censuses at stopover areas are useful for estimating minimum population size. Most migrant species are present year-round but are less abundant during short arctic summers. Spring migration along the Atlantic Coast is from March to May while fall migration is from July to October (Helmers 1992). Peak shorebird counts occurred in late March in the Cape Romain Region, the area from Cape Romain National Wildlife Refuge south to Dewees Inlet, while minimum counts were in late June (Dodd and Spinks 2001). Dunlins consist of over half of all shorebirds present with a peak abundance in February (Wallover et al. 2015).


Pluvialis squatarola
Black-bellied Plover
Expected Distribution
Calidris alpina
Dunlin
Expected Distribution
Tringa flavipes
Lesser Yellowlegs
Expected Distribution
Numenius americanus
Long-billed Curlew
Expected Distribution
Limosa fedoa
Marbled Godwit
Expected Distribution
Charadrius melodus
Piping Plover
Expected Distribution
Calidris canutus
Red Knot
Expected Distribution
Arenaria interpres
Ruddy Turnstone
Expected Distribution



In 1974 Manomet Center for Conservation Sciences (http://www.manomet.org) began coordinating International Shorebird Surveys (ISS) to monitor shorebird numbers at important stopover sites. Surveys can be conducted all year, but most counts are conducted during fall and spring migrations. ISS are conducted by government biologists, staff from partner organizations and volunteers and data are used to identify important areas to individual species, valuable habitat types, and population trends. The most consistently surveyed sites in South Carolina from 2020 to 2023 are: Huntington Beach State Park, Yawkey Wildlife Center, North Inlet, Cape Romain NWR, Capers Island, Dewees Island, Headquarters Plantation Drive on Johns Island, Folly Beach, Bird Key Seabird Sanctuary, Kiawah Island, Seabrook Island, Hunting Island State Park, Harbor Island, Pinckney Retreat and Battery Creek West Basin in Beaufort, Hilton Head Island, and Turtle Island Wildlife Management Area (https://www.manomet.org/iss)


Black-bellied Plover by USFWS

The Western Hemisphere Shorebird Reserve Network (http://www.whsrn.org/) identified essential migratory sites for the western hemisphere using ISS data. The Network in 2024 has 120 sites in 20 countries, from Alaska to Tierra del Fuego in southern South America. In 2018, the Cape Romain NWR Western Hemispheric Shorebird Reserve Network Site (Site) was expanded. The Cape Romain-Santee Delta Region Site of International Importance now stretches for 50 miles of coastline, covering 119,440 acres (48,336 hectares) from the Yawkey Wildlife Center south to Dewees Island. ISS data confirm that the Cape Romain – Santee Delta Region site is a rest stop for 100,000 migratory shorebirds every year. The Site hosts 15% of the U.S. East and Gulf Coast population of American Oystercatchers, and 11% of Short-billed Dowitchers and likely supports more than 10% of the Semipalmated Plover and Red Knot populations. The expansion unites

seven sub-sites managed by three different partners – the federally run Cape Romain National Wildlife Refuge, the South Carolina Department of Natural Resources, and the privately run Dewees Island Property Owners Association. The Yawkey Wildlife Center, Santee Coastal Reserve Wildlife Management Area, and Cape Romain National Wildlife Refuge are additionally recognized by BirdLife International and National Audubon Society as Important Bird Areas (https://whsrn.org/whsrn_sites/cape-romain-santee-delta-region).

Piping Plovers nest in more southern latitudes compared to most migratory shorebirds. Piping Plovers nesting in the Great Lakes region are federally endangered with approximately 70 pairs. During the last range wide census, the 2016 International Piping Plover Census, the number of wintering piping plovers in South Carolina was 126 individuals. The largest proportion of Piping Plovers nesting in the Great Lakes appears to winter in South Carolina and Georgia, thus making South Carolina important for Piping Plovers. Research conducted on Piping Plovers in South Carolina found that plovers wintering on disturbed sites were 7% lighter than those in less disturbed sites and annual survival was lower in more disturbed areas. Movements away from specific areas were uncommon (Gibson et al. 2018). This research emphasizes the need for management of human disturbance for recovery of the species.

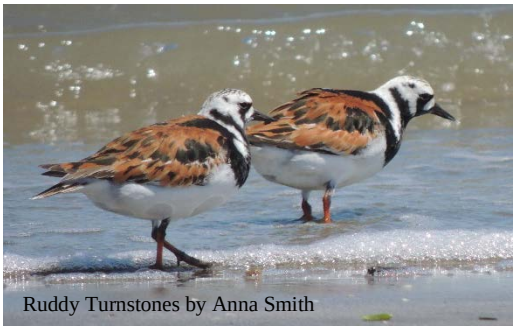
Piping Plover by USFWS



The *rufa* subspecies of the Red Knot, breeds in the Canadian Arctic and winters in four distinct areas: the Southeast United States/Caribbean, the north coast of South America, the western Gulf of Mexico/Central America, and in southern South America (Niles et al. 2008, U.S. Fish and Wildlife Service 2020). The Southeast United States/Caribbean hosts one quarter of the total estimated wintering knot population (U.S. Fish and Wildlife Service 2020) and is a critical region for knots as a stopover during north and southbound migration (Schwarzer et al. 2012, Lyons et al. 2017, Pelton et al. 2022). The most recent U.S. Fish and Wildlife Service estimate for the Red Knot population is 63,600 (U.S. Fish and Wildlife Service 2020). The southbound passage population utilizing the Georgia coast was estimated to be approximately 23,400 knots, (Andres et al. 2012, Lyons et al. 2017) while the Kiawah Island, Seabrook Island and Deveaux Bank area of South Carolina, supports a minimum spring passage population of more than 17,000 individuals (Pelton et al. 2022). This suggests the Southeast United States supports upwards of a third of the knot population during migration each year. Most Red Knots that are migrating north from South Carolina in the spring skip Delaware Bay (73%) while 27% of the knots stop in Delaware Bay for at least 1 day. Some knots use an Atlantic Coast strategy that does not include Delaware Bay, relying instead on the areas around Chesapeake Bay or New York Bay for stopovers. Most knots travel north from South Carolina through the eastern Great Lake Basin, without stopping, thus making the Southeast United States the last terminal stopover for some knots before reaching boreal or Arctic stopover sites.

Nocturnal roosts are an essential, yet often overlooked component of shorebird habitat due to their inaccessibility and use at night. South Carolina is an important staging area for Atlantic coast Whimbrel during spring migration, with the largest known Whimbrel nocturnal roost in the Western Hemisphere at Deveaux Bank Seabird Sanctuary. The peak count during spring surveys in 2019 and 2020 at Deveaux Bank was 19,485 roosting Whimbrel, which represents approximately 49% of the estimated eastern population of Whimbrel and 24% of the entire North American population (Sanders et al. 2021).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS


Ruddy Turnstones by Anna Smith

Shorebirds roost and forage in coastal wetland habitats as well as inland. They feed on invertebrates found in mudflats, sparsely vegetated shallow water, and on beaches and oyster reefs. They also regularly feed on horseshoe crab eggs in the spring. Additionally, the Ruddy Turnstones use rocky, intertidal habitats such as jetties. Different bill lengths and feeding strategies allow mixed species flocks to forage in the same area while exploiting different food resources. Along the coast, tides influence both diurnal and nocturnal foraging. Foraging activity occurs primarily during falling and rising tides and at low tide. At high tide, when foraging grounds are covered, birds roost in flocks on high shell rakes, beaches, estuarine islands, and occasionally on docks. Shorebirds may require different habitats for daytime and nighttime roosting. Roosting sites may contain thousands of shorebirds. Dunlin, Sanderlings, Red Knots, small sandpipers, and plovers primarily use beaches. Short-billed Dowitchers and Marbled Godwits are also found on oyster reefs and docks. Ruddy Turnstones use a variety of habitats (Dodd and Spinks 2001).


Red Knot by USFWS

South Carolina contains many managed coastal wetlands (30,000 hectares) that were historically used for rice production. These managed tidal impoundments are currently used for waterfowl habitat (Miglarese and Sandifer 1982). Managing for spring shorebird migrations requires specific manipulation of water levels. Additionally, shallow water can be periodically maintained in wetlands during August to October for fall shorebird migration (Williams et al. 2002). Management of wetlands for shorebirds and waterfowl provides supplemental habitat that may be preferred to natural mudflats (Weber and Haig 1996).

CHALLENGES

Members of this guild share both roosting and foraging sites and are usually impacted by the same factors. Shorebirds are especially vulnerable to habitat degradation because they congregate in large flocks at key stopover sites to replenish fat during long migrations (Myers et al. 1987).


Semipalmated Sandpiper by USFWS

Due to the complicated life history associated with birds of this guild, there are many challenges in conserving these species. Disturbance by humans and boat traffic at foraging areas reduces feeding efficiency, thereby reducing the fat available for migration or winter survival. Disturbance at roosting sites results in an expenditure of energy each time the birds are flushed and may have a cumulative effect of depleting fat reserves, particularly at key stopover areas. There has also been a decline in invertebrates available (for foraging) due to beach renourishment. Overharvests of horseshoe crabs for pharmaceutical use may also impact available forage. Finally, oil spills that degrade marine environments can have potentially major impacts on migrating shorebirds, both by disrupting feeding patterns and by leading to the direct mortality of food sources.

CONSERVATION ACCOMPLISHMENTS

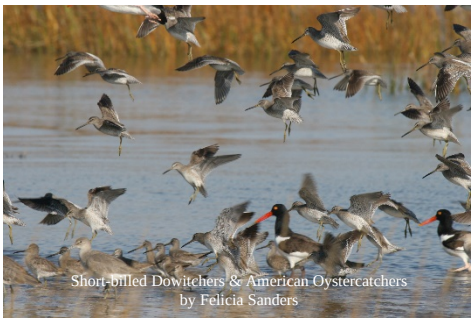

Long-billed Curlew by USFWS

SCDNR organized multiple workshops including a 3-day workshop for managers of impoundments. Topics covered during workshops included: brackish and moist-soil management for multiple species (waterfowl, wading birds and shorebirds), timing of shorebird migration, invertebrate identification, technical and cost-share assistance available to private landowners, and field identification of shorebirds.

SCDNR staff completed important research on shorebirds which was reported in scientific publications. Publications included topics such as: spring migration patterns of Red Knots and Ruddy Turnstones using the Motus Wildlife Tracking System; abundance and distribution of shorebirds in cape Romain National Wildlife Refuge; a population estimate of Red Knots using Kiawah and Seabrook islands; Red Knot migration tracking across the hemisphere using geolocators; spatial and temporal overlap between foraging shorebirds and spawning horseshoe crabs (*Limulus polyphemus*) in the Cape Romain National Wildlife Refuge; the world's largest nocturnal roost of Whimbrel at Deveaux Bank; and migratory shorebird movements to guide wind energy placements.

The SCDNR coordinated or conducted several surveys, including a coast-wide survey of large shorebird roosts. SCDNR conducted 2 statewide shorebird surveys that were not reported in the 2015 SC's SWAP. 38,235 shorebirds (28 species) were counted Jan 31, 2013 - Feb 7, 2014, at 54 sites. The Cape Romain Region had 16,031 (42% of the total) shorebirds. Only one shell rake boating route was covered. The shell rakes along the Intracoastal Waterway in the Cape Romain Region had 7,759 (20% of the total). South Carolina has miles of shell rakes that were not covered so this survey is a minimum count of shorebirds that use South Carolina coastal areas. 47,287 shorebirds (28 species) were counted Jan 22 to Jan 31, 2015. Dunlin (27,087) were over half the total shorebirds. The survey included 122 participant days, 57 sites, 149 miles of habitat and 175 hours. Like the previous year, the highest count was on the Intracoastal Waterway shell rakes in The Cape Romain Region which had 8,895 (19% of total) shorebirds. Kiawah (the east end) had the highest count for a beach with 5,177 shorebirds.

SCDNR partnered with multiple agencies and organizations, especially US Fish and Wildlife Service and the South Carolina Audubon to expand the South Carolina Shorebird Project, a partnership created to promote shorebird conservation in South Carolina. A component of the Shorebird Project is an annual meeting, hosted by SCDNR, to promote collaborative management of shorebirds.


Short-billed Dowitchers & American Oystercatchers by Felicia Sanders

The first shorebird festival in South Carolina was held in 2023. SCDNR and many organizations coordinated the 2-day Sea Islands Shorebird Festival, that consisted of speaking events, bird walks, and family friendly activities to celebrate shorebirds and the islands they depend on. The goal was to educate community members and visitors and raise awareness to protect these magnificent birds and places. After the success of the festival in 2023, in 2024, the Southeast Shorebird Festival will be held. The festival expanded in length and range to include the entirety of the South Carolina-Georgia coast for a full week of festivities. This decentralized model is inspired by the interconnectedness and importance of the entire region's coastal habitats for our shared shorebirds that depend on it for survival.

CONSERVATION RECOMMENDATIONS

- Conduct statewide surveys of large shorebird concentrations to document important areas or habitats and document annual variability and trends.
- Participate in Piping Plover and Red Knot surveys and color band resighting.
- Continue to research shorebird, especially Red Knot and Piping Plovers, migration patterns and prey items.
- Participate in International Shorebird Surveys organized by Manomet.
- Expand the number of sites in South Carolina that are included in the WHSRN.

- Reduce disturbance at foraging and roosting areas, including nocturnal roosts, by educating the public as to the effects of disturbance and the status of shorebirds. Place educational signage where applicable.
- Work with government and private land managers to manage important shorebird roosts and foraging sites.
- Disseminate information on and encourage use of integrated management of wetlands typically managed solely for waterfowl. Host workshops for land managers that encourage management for shorebirds.
- Expand the SC Shorebird Project to include additional partners, a network of volunteers and build a web site with resources for land managers, volunteers and partners.
- Work with the U.S. Army Corps of Engineers to enhance and create shorebird habitat with dredged sediments though the Corps' beneficial use of dredge material programs.
- Work with partners to understand the reasons for the decline in the Southeast wintering Long-billed Curlew.

MEASURES OF SUCCESS

This guild of birds is subject to rapid shifts in distribution and abundance and will require adaptive management to respond to these changes. Management priorities may shift if the severity of species' declines is further documented.

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Miscellaneous Bird Guild

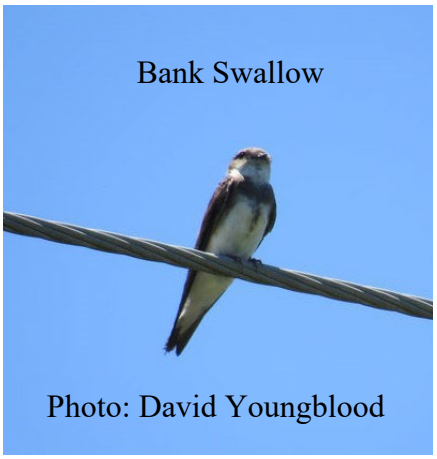
Bank Swallow (*Riparia riparia*)
Chimney Swift (*Chaetura pelagica*)
Evening Grosbeak (*Coccothraustes vespertinus*)

Contributor (2013): Paige Koon (SCDNR)
Reviewed and Edited (2024): Amy Tegeler (SCDNR) and Sarah Stewart (SCDNR)

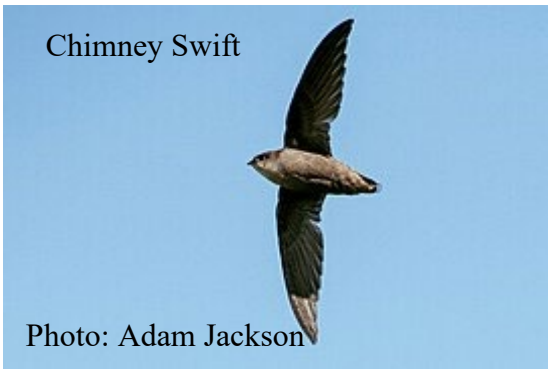
DESCRIPTION

Taxonomy and Basic Description

The Bank Swallow is a small swallow (length 12 cm and mass 10.2 to 18.8 g; Garrison and Turner 2020). Adults have a brown back, and white chest with a brown breast band. The tail is slightly notched (Garrison and Turner 2020). Both sexes are similar in appearance. One subspecies occures in North America, although another is a vagrant (Garrison and Turner 2020). The North American subspecies was first described in 1758 by Linnaeus (Garrison and Turner 2020).



The Chimney Swift is dark sooty olive or brown above and plain gray-brown below, with a paler chin and throat. The plumage is slightly glossy. The tail is short and rounded, sometimes with noticable spiny tips. Their flight is agile and fast, with rapid wing beats (Steeves et al. 2020). This species is 13.9 cm long with a 17.0 to 29.8 g mass (Steeves et al. 2020). Both sexes are similar. The Chimney Swift was first described by Linnaeus in 1758 (NatureServe 2014).



The Evening Grosbeak is a large finch species with an average length of 17 cm (6.7 in) and a weight between 53 – 74 g (1.9-2.6 oz). This species has a robust bill used for crushing small berries and seeds (Gillihan and Byers 2020). Males are identified by their distinctive coloring, with a brown-black crown and nape, bright yellow forehead, yellow scapulars and breast, and black wings with white wing bars.



Females are drabber in coloring and lack the yellow forehead of males. Three subspecies are recognized and are distinguished by their breeding ranges, following Howell (1968).

Status

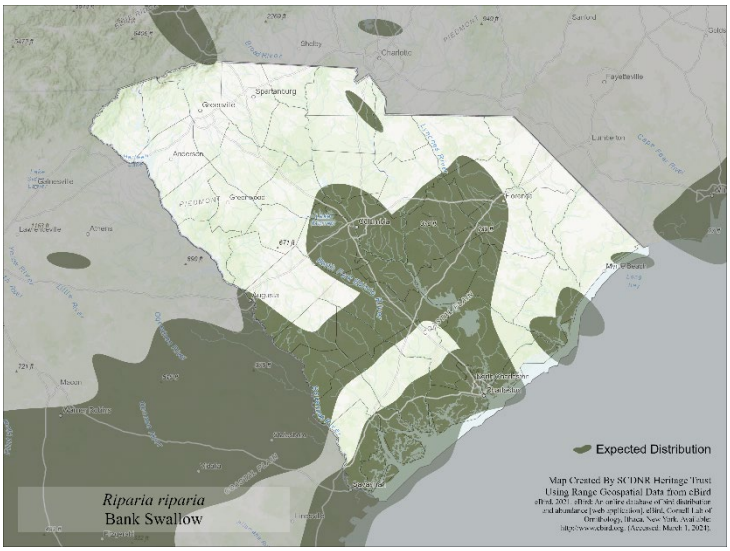
The Bank Swallow is considered a common bird in steep according to Partners in Flight (2016). The species has experienced a 89% population loss between 1970 to 2014 (Partners in Flight 2016).

The Chimney Swift is considered a common bird in steep decline and has experienced a 67% population loss between 1970 to 2014 (Partners in Flight 2016). The IUCN has the species listed as Vulnerable (2023).

The Evening Grosbeak is listed as Vulnerable by IUCN (2023) and included on PIF's Yellow Watch List, which identifies priority species for reversing population decline. The species is also listed as having regional importance for the Atlantic Coast Joint Venture (PIF 2023).

POPULATION SIZE AND DISTRIBUTION

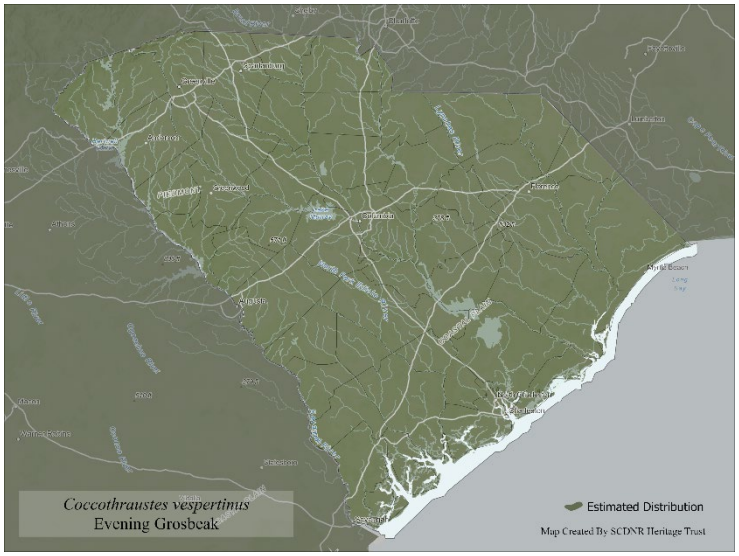
The Bank Swallow is a passage migrant through South Carolina. The species typically migrates in mixed-species flocks during the day (Barrett and Turner 2020). They are more common during spring migration than fall (Seriff and Beirregaard 2018). Most Bank Swallows migrate in spring from early April to the end of May (Seriff and Beirregaard 2018). The species breeds in portions of Canada and the northern U.S. and winters mainly in South America (Barrett and Turner 2020). The U.S. and Canada population estimate is 7,900,000 individuals (Partners in Flight 2020).



The Chimney Swift is found in the spring and summer months throughout the Eastern US and into the southern extremes of Eastern Canada; it winters in the upper Amazon River Basin in northern South America (Cink and Collins 2002). Chimney Swifts are common throughout South Carolina in spring and summer months. They generally arrive in early April and leave in mid-October (Seriff and Beirregaard 2018). Before



migrating south, Chimney Swifts form large roosting flocks, of sometimes thousands of birds (Seriff and Beirregaard 2018). Historically they were considered common, but are currently in steep decline (Seriff and Beirregaard 2018). The current South Carolina population estimate is 290,000 individuals (Partners in Flight 2020). South Carolina has experienced an annual rate of decline of 2.6 from 1966-2022 (Sauer et al. 2021).



The Evening Grosbeak is associated with northern coniferous forests, with resident populations across southern, central Canada and in mountainous regions of the western US. This species migrates irruptively, with large numbers of individuals wintering in southern or low-elevation regions in response to low food availability (Gillihan and Byers 2020). The first Evening Grosbeak observation in South Carolina was at Paris Mountain State Park in Greenville County in 1951 (Seriff and Beirregaard 2018). Irruptive winter populations have been recorded throughout the state and were fairly common in the second half of the 20th century, with a decline in observations since the turn of the millennia (Bonter and Harvey 2008; Seriff and Beirregaard 2018; eBird 2024). Because occurrence records are sparse, and their habitat use during migration and winter can be generalized, the species' distribution in South Carolina is not known. Rangewide, the species' current population estimate is 3.8 million individuals (PIF 2023). However, the Evening Grosbeak has experienced steep declines, with an approximately 94% decline since 1970 (Rosenburg et al. 2016), and an annual rate of decline of 1.5% between 1966 and 2021 (Ziolkowski et al. 2022).

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

During migration they utilize a variety of open and water-associated habitats including wetlands, agricultural areas, marshes and prairies that provide sources of food (Garrison and Turner 2020). Bank Swallow haven't been confirmed to nest in South Carolina (Seriff and Beirregaard 2018), but the species nest in vertical banks, cliffs and bluffs in alluvial, friable soils (Garrison and Turner 2020). Breeding sites are typically in lowland areas along ocean coasts, rivers, streams, lakes, wetlands and man-made sites such as quarries and road cuts (Garrison and Turner 2020). Suitability of sites depends on erosion, which both creates and reduces nesting sites. Rivers and streams with nesting habitat are typically low-gradient, meandering waterways with eroding banks. Waves, tidal action, and wind create vertical faces in coastal areas and along lakeshores (Garrison and Turner 2020).

Chimney Swifts use a variety of habitats. They forage over forested, open and urban areas. It appears that access to suitable nest and roosting sites tend to be more important (Steeves et al. 2020). Chimney Swifts are cavity nesters. Historically they nested in hollow trees, but currently almost exclusively nest on man-made structures, most often chimneys (Seriff and Beirregaard 2018) but can also utilize air vents, open wells, man-made Chimney Swift nesting towers and similar structures.

The Evening Grosbeak uses a range of habitats in its overwintering range, including suburban neighborhoods and woodlots, mid-elevation coniferous forests, and mixed hardwood-pine forests (Gillihan and Byers 2020). When observed in South Carolina, the species is most often seen at backyard feeders, though there have been historical winter sightings at Congaree Swamp in Congaree National Park, in mixed forest at Croft and Chester State Parks, and high elevation forest at Caesars Head State Park (Seriff and Beirregaard 2018; eBird 2024). They also appear to use mixed hardwood-pine forests and pine flatwoods in Florida (Gillihan and Byers 2020). While there have not been quantitative winter diet analyses for the species, Evening Grosbeaks appear to have varied diets of invertebrates, fruits, and seeds in the breeding season, and will exploit supplemented food at backyard feeders outside the breeding season (Gillihan and Byers 2020).

CHALLENGES

Loss of suitable nesting locations for Bank Swallow have likely contributed to population declines. Nest sites are eliminated due to flood and erosion control projects, declines in mining sand and gravel pit operations, and other activities that exacerbate erosion (Garrison and Turner 2020). There have also been reports of Bank Swallows colliding with vehicles and windows. Shooting on the wintering grounds has also been documented (Garrison and Turner 2020).

With the arrival of European settlers, Chimney Swifts likely went from being a somewhat uncommon bird to an abundant bird as chimneys and other human-made structures became available for nesting sites. In recent years however, the destruction of old chimneys and the subsequent construction of new chimneys less suitable as nest sites have contributed to the species' decline (Steeves et al. 2020). The species can also succumb to gas or suffocate in soot while in chimneys (Steeves et al. 2020). Collisions with communication towers and vehicles has also been noted (Steeves et al. 2020). It is also possible that declines in insect populations have led to declines in Chimney Swift populations (Steeves et al. 2020).

Despite the Evening Grosbeak's conspicuous flocking behavior during the winter, the species is generally understudied, and the primary drivers of their decline are poorly understood. With concurrent declines of other boreal forest breeders (Ralston et al. 2015), loss or degradation of mature, spruce-pine forests appears to play notable a role in Evening Grosbeak declines (Bonter and Harvey 2008; Gillihan and Byers 2020). Collisions with windows and vehicles, as well as outbreaks of diseases like Salmonellosis, may also negatively influence population dynamics (Bonter and Harvey 2008).

CONSERVATION ACCOMPLISHMENTS

No specific conservation accomplishments have been noted for these species.

CONSERVATION RECOMMENDATIONS

- Develop and implement monitoring programs to better assess breeding and nonnbreeding bird population sizes. Assess habitat management and surveillance monitoring techniques to quantify short- and long-term population responses. Develop measures to integrate state monitoring results into regional and national level databases.
- Reduce communication tower collisions through design modifications.
- Promote construction of Chimney Swift nesting towers at suitable locations.
- Locate and monitor Chimney Swift roosting sites.
- Continue monitoring potential irruptions of Evening Grosbeaks during Christmas Bird Counts and the Great Backyard Bird Count. Encourage greater participation by volunteers and provide information and ID guidance on irruptive species.
- Elucidate factors leading to the Evening Grosbeak's range expansion into South Carolina in the 1950's and eventual contraction at the end of the century. Determine historical timber or land use practices that may have contributed to changes in distribution.

MEASURES OF SUCCESS

As results from current research or surveys on these species are completed, projects will be initiated to address specific needs in South Carolina that arise from these results. Stable or increasing observations of the species will be a measure of success.

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Mountain Guild

Cerulean Warbler *Setophaga cerulea*
Golden-winged Warbler *Vermivora chrysoptera*

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DESCRIPTION

Taxonomy and Basic Description

The species in this guild belong to the taxonomic order Passeriformes (perching birds) and are in the family Parulidae (the wood warblers). Wood warblers are small and colorful with sharp, pointed beaks for gleaning insects.


Cerulean Warbler
photo from Wikimedia Commons

The Cerulean Warbler male is a deep cerulean blue with white underparts and a narrow dark band across the throat. The female Cerulean is bluish green with yellowish underparts and a pale line above the eye. Both male and female have white wing bars. The average length is 11.5 cm (4.5 in.), and the weight is 8 - 10 g (0.3 - 0.4 oz.) (Buehler et al. 2020).

The Golden-winged Warbler is a small, striking songbird averaging 12.1 cm (4.75 in.) in length and 8.8 g (0.31 oz.) in weight. Adult males have a yellow crown, a black mask, and a black throat. This bird has a white belly, gray back, and a yellow wing patch. Adult females and juveniles appear similar to the males but have a duller overall appearance and a greenish-yellow crown (Sibley 2003).

Status

The Cerulean Warbler is one of the most vulnerable Neotropical migrants (Hunter 2001). It is considered critically imperiled in South Carolina (NatureServe 2013). Between 1966-1993, the BBS indicated a 49.5% decline in the species in Eastern North America (Sauer et. al. 2012). This warbler is listed as Vulnerable by IUCN Red List (2011), and a National Species of Conservation Concern by U.S. Fish and Wildlife Service (USFWS 2007).

Golden-winged Warblers are currently facing declines from habitat loss, hybridization, and competition. Golden-winged Warblers are disturbance-dependent birds. Birds in this type of habitat are experiencing precipitous population declines (Askins 2000 and 2001; Hunter et al. 2001). These warblers nest in disturbed sites such as abandoned farmland, clearcuts, and burned

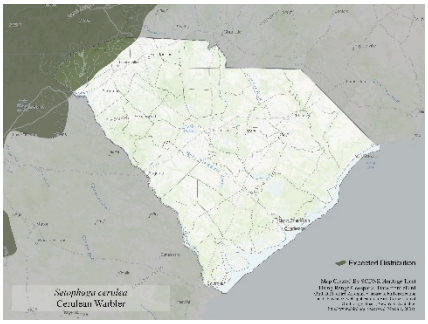
forest stands that are currently in decline in the face of urban sprawl, reforestation, and the succession of grassland and shrubby habitats (Confer et al. 2020, NatureServe 2013).



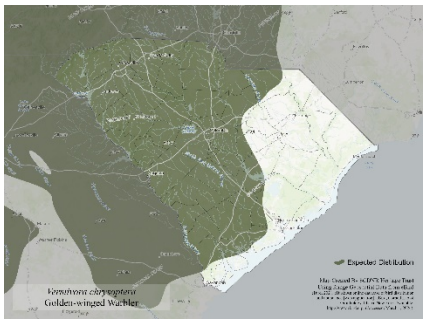
Golden-winged Warblers frequently become extirpated in areas with Blue-winged Warblers. Blue-winged Warblers are expanding their range northward and out-compete Golden-Winged Warblers for resources such as territories, nesting material, and food. Blue-winged Warblers also hybridize with golden-winged warblers, producing viable offspring. This causes a genetic decline for Golden-winged Warblers (Confer et al. 2020). While the Golden-winged Warbler is not currently ranked in South Carolina, it is ranked at the federal level as a Species of Concern (NatureServe 2013).

POPULATION SIZE AND DISTRIBUTION

The population status of the Cerulean warbler in South Carolina is unknown. Cerulean Warblers have experienced a long-term population decline. Cerulean Warbler numbers have declined at the steepest rate of any North American warbler species monitored by the North American Breeding Bird Survey (Sauer et al. 2005). Analysis of North American Breeding Bird Survey (BBS) data indicate that over the last 40 years, the decline has been steep and steady at a rate of about -3.0% per year (USFWS 2007). It winters in low to medium elevation broadleaf and evergreen forests of northern South America in Venezuela, Colombia and Peru. The Cerulean Warbler is sensitive to habitat changes and modifications. Habitat degradation in its breeding, migrating and wintering ranges over the last decades are suspected of having caused a decline of 72% since the 1970s. Its half-life is estimated at 26 years for a population of approximately 570,000 individuals (PIF 2024).



The Golden-winged Warbler is a northern breeding bird found in Southern Canada, the Northeastern United States and extending south into the Appalachians. South Carolina composes the southern-most extent of the range where these birds occur in small numbers in the extreme northwestern part of the State. The Golden-winged Warbler overwinters in Central America and northern South America (NatureServe 2013). According to BBS trend data (1966-2010), Golden-winged Warblers are declining at a rate of 2.6% per year in the Eastern BBS region. Population trends for the



Southern region cannot be accurately calculated since populations are so small (Sauer et al. 2012).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Mountains of South Carolina refers to the Blue Ridge Mountains, part of the larger Appalachian Mountains, that stretches from Maine to Alabama. It is the smallest geographical region in the whole state. The highest point in the South Carolina mountains is Sassafras Mountain, at an elevation of around 3,533 ft (1,078 m), which is located on the border with North Carolina. The Blue Ridge Region is mountainous and has many hardwood forests, streams, and waterfalls. Many rivers flow out of the Blue Ridge.

The Golden-winged Warbler is an early-successional specialist species. They require shrubby habitat in upland or wetland areas, with sporadic tree cover and an understory of grass and forbs. Early successional habitats are short-lived and turn into mature forests, forcing these warblers out of the habitat (Confer et al. 2020). Golden-winged warblers nest in habitat with dense herbaceous cover and patches of shrubs, often adjacent to a forest edge, usually at moderate elevations. Natural disturbance habitats include beaver glades and openings from natural fires. It also occurs in a variety of anthropogenic disturbance sites such as clearcuts, abandoned farmlands, and power line rights-of-ways. Golden-winged Warblers most commonly occur in clearcuts < 20 yr old (Confer et al. 2020).

The Cerulean Warbler prefers a mature forest with an open understory in large unfragmented tracts of forest (Buehler et al. 2020). Its distribution is not uniform throughout its range, and it can be widespread in some areas and localized in others. It prefers white oaks (*Quercus alba*) and bitternut hickories (*Carya cordiformis*) for nesting, foraging and as singing perches. Forests where red maples (*Acer rubrum*) and red oaks (*Quercus rubrum*) are dominant are avoided (PIF 2024).

CHALLENGES

Loss of mature deciduous forest, especially along stream valleys, has negatively affected Cerulean Warblers. This is the most serious long-term problem facing the species on its breeding grounds. Large areas of potential breeding terrain are uninhabitable by this warbler because they lie in urban areas or because they have been converted to agricultural land uses. Perhaps more than most North American birds, the Cerulean Warbler is sensitive to landscape-level changes in habitat (Buehler et al. 2020). Forest fragmentation is the biggest problem for all deciduous forest interior birds, including Cerulean Warblers. Roads into forests bring native and non-native predators such as rodents and feral cats. Nest parasites, such as the brown-headed cowbird (*Molothrus ater*) can also move into the forest interior (Kilgo and Moorman 2003). As forest habitat shrinks, bird species that are area-sensitive may abandon smaller woodlots altogether.

Local declines of Golden-winged Warblers correlate with both loss of habitat and with expansion of the Blue-winged Warbler into the range of the Golden-wing. Disturbed sites, such as abandoned farmland and aspen clearcuts and fire managed forest stands provide regionally important nesting habitat. Declines of these habitat types owing to reforestation, fire suppression,

reduced timber harvest, urban sprawl, and reduced acreage of recently abandoned farmland are associated with population declines throughout most of the Golden-wing range (Confer et al. 2020). Early successional habitats are short-lived and turn into mature forests, forcing these warblers out of the habitat (Buehler et al. 2006).

Disturbance-dependent birds have suffered steep population declines throughout the Eastern US (Hunter et al. 2001). Historically fire, floods, windstorms, and herbivores maintained habitat conditions conducive to disturbance-dependent species (Askins 2001). Fire suppression, the loss of large canopy tress such as the American chestnut (*Castanaea dentata*), and the extirpation of beaver (*Castor canadensis*) and mega herbivores such as elk (*Cervus elaphus*) and bison (*Bison bison*) following European settlement, reduced the availability of early-successional habitat throughout the Eastern US (Askins 2000).

Communication towers are a significant source of mortality for migratory birds. Nocturnal migrants often become confused by the red lights of communication towers and hit the guy wires or the towers themselves. (Shire et al. 2000),

Additionally, an over-population of white-tailed deer (*Odocoileus virginianus*) can be detrimental to bird habitat. In areas of high densities (greater than 7.9 deer/km2), herbivores browse the understory such that nesting and foraging substrates are greatly reduced (NatureServe 2004).

Although not a problem specific to South Carolina, habitat destruction on the birds' wintering grounds (Central and South America and the Caribbean) is causing a decline in populations.

CONSERVATION ACCOMPLISHMENTS

The purchase by the State and subsequent management of the Jocassee Gorges in 1997 resulted in habitat protection for these and other bird species. The Jocassee Gorges includes at least 1,200 acres of forest 60 years and older; some patches are older than 80 years (M. Hall, SCDNR, pers. comm.). Most stands, however, are still maturing. Completion of PIF plans for Physiographic Area #03: South Atlantic Coastal Plain and Physiographic Area #23: Southern Blue Ridge serve as good sources of continued management interaction. Finally, preliminary (Huckabee 2001) and continued (Boyle et al. 2003) research on forest interior species in the Jocassee Gorges and surrounds have provided—and will continue to provide—important information for these species.

In addition, a new guidance document has been prepared by the ACJV and its partners: The Piedmont Bird Conservation Region (BCR 29) Implementation Plan, Version 1.0, 2013. This Plan will be utilized when reviewing priority bird species in this ecoregion.

No conservation initiatives have been set specifically for members of this guild. South Carolina has many properties under ownership by state and federal agencies which protect habitat that could potentially host the species. These include State Heritage Preserves, Wildlife Management Areas, and National Forests.

Long-term monitoring programs, such as the Breeding Bird Survey (Sauer et al. 2005), have provided population trend data that enables biologists and land managers to prioritize management decisions based on the knowledge of population trends.

National initiatives such as the Partners in Flight (PIF) Landbird Conservation Plan (Rich et al. 2004) and the North American Bird Conservation Initiative (NABCI 2005) have provided a method by which interested parties can coordinate conservation activities. These initiatives have provided guidelines for priority species, population and habitat objectives, and recommendations for conservation actions. State and federal agencies have implemented habitat improvement projects based on guidelines outlined in PIF and NABCI.

CONSERVATION RECOMMENDATIONS

- Utilize GIS and land type associations to determine total area and distribution of available habitat. Modeling will enable SCDNR to prioritize land acquisition and habitat improvement projects.
- Partner with other land management agencies and make recommendations about habitat improvement projects that benefit these species.
- Expand the use of Farm Bill and other cost-share programs to implement activities that integrate habitat objectives for early-succession birds.
- Expand participation in the Landowner Incentive Program (LIP) to create or enhance habitat on private lands.
- Promote the use of Best Management Practices that support providing buffer zones and that increase structural diversity (such as providing small clearcuts).
- Partner with appropriate agencies to encourage prescribed burning activities on public and private lands.
- Work with international partners to identify problems on wintering grounds. Where feasible, provide financial incentives to conserve habitat.
- Breeding Bird Survey routes should continue annually; increase the number of routes in under-sampled areas of South Carolina.
- Initiate agency supported monitoring programs, such as Partners In Flight (PIF) point counts.
- Expand monitoring programs to areas not adequately sampled.
- Monitor bird response to management activities both pre- and post-treatment.
- Continue to strengthen partnerships with regional and national initiatives such as the Atlantic Coast Joint Venture, Appalachian Mountains Bird Conservation Region (BCR), PIF and NABCI.
- Pursue opportunities for funding for land acquisition or management activities through partnerships with regional agencies and NGOs.
- Develop partnerships with recreational bird watching organizations in the State.
- Research effects of bird strikes on migratory bird populations and partner with the communications industry to work toward solutions in SC.
- Identify and protect forest interior and unbroken large tracts of deciduous forest habitat. Determine the best sites for conservation and/or restoration projects by conducting a landscape-level spatial analysis. Utilize GIS-based models as a basis for land acquisition

and delivery of private lands programs to locate areas where opportunities for conservation are the greatest.

- Develop corridors to link forested tracts.
- Continue to promote partnerships to implement forest health measures to prevent, detect, and suppress outbreaks of sudden oak death (SOD) and hemlock woolly adelgid (*Adelges tsugae*) on public and private lands.
- Reduce communication tower collisions. The following recommendations set forth by Shire (2000) may assist in that effort:
    - No aviation lights should be placed on towers that are less than 199 ft. tall.
    - Remove old towers that are no longer in operation. Recycle old communication towers for additional purposes instead of building new ones.
    - Environmental Assessments should be conducted to determine the impact a new tower's construction will have on birds if built in a migratory route.
- If found to be causing an impact in certain areas, the removal of feral cats (*Felis catus*) from public lands through live trapping should be implemented.
- Conduct studies to determine the minimum area requirements for forest birds.
- Investigate the effects of deer on breeding bird habitat.
- Develop and implement monitoring programs to better assess breeding, migrating, and wintering bird population sizes. Management and surveillance monitoring techniques will need to be assessed to quantify short and long-term population responses in order to answer specific monitoring questions. Measures will need to be developed to integrate state monitoring results into regional- and national-level databases.
- Radar ornithology should be continued in order to monitor bird-habitat associations at migration stopover sites.
- Partner with other states and countries to gather data on migratory stop-over sites, wintering ground usage, and the threats faced at each.
- Promote existing and develop new partnerships to facilitate increased land acquisition.
- Promote the participation of volunteers and agency personnel to collect survey and monitoring data.

MEASURES OF SUCCESS

The first measure of success will be to implement monitoring programs that will allow SCDNR to document population trends and avian response to management in the State. Habitat improvement and restoration projects should result in higher breeding populations and nesting success rates. One measure of success is to halt population declines and support population sizes similar to the goals outlined by Rosenberg (2004).

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Nesting Shorebird Guild

Willet (*Catoptrophorus semipalmatus*)
Wilson's Plover (*Anarhynchus wilsonia*)

Contributors (2024): Janet Thibault and Felicia Sanders (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

The nesting shorebird guild is composed of birds in the Families *Haematopodidae, Scolopacidae* and *Charadridae.* American Oystercatchers (*Haematopodidae*) are covered in a separate SWAP species profile. Species in the nesting shorebird group breed in coastal ecosystems commonly on barrier beaches, islands, and inlets and migrate south to winter in the Caribbean or South America.

Willet Photograph by USFWS

The Willet has two distinct subgroups of breeding populations: *Tringa semipalmata semipalmata* and *Tringa semipalmata inornata* or Eastern and Western Willet, respectively (Lowther et al. 2020). Eastern Willets nest in South Carolina, whereas Western Willets winter in and migrate through South Carolina. Many aspects of the habitat requirements, challenges and conservation recommendations covered in the Migratory Shorebird Guild SWAP account are also applicable to the Nesting Shorebird Guild, especially for the Western Willet that nests in freshwater habitats of western states and provinces. Hereafter "Willet" will mostly refer to the Eastern subspecies, although the Eastern and Western Willets are often indistinguishable in the field, thus data such as survey results may include both subspecies.


Willet Photograph by USFWS

The Willet is a long-legged shorebird with a striking black and white pattern on its wings revealed in flight, a long bill, and gray to brown plumage.

The Wilson's Plover (*Anarhynchus wilsonia*) is a medium sized, belted plover with a heavy bill. Females have a brown breast band and males have a black band which is more pronounced during the breeding season. Both sexes have white underparts, a white forecrown, and pinkish-gray legs. Males and females are similarly structured with a mean wing length of 118 mm for females and 119 mm for males. Mean mass for males (69 grams) and females (68 grams) is similar (Zdravkovic et al. 2023).

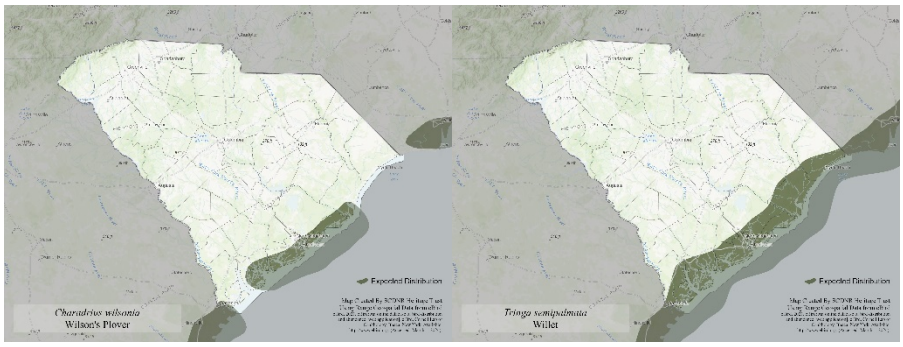

Male Wilson's Plover Photograph by Bess Kellett

Status

Willets have a large geographical range nesting along the Atlantic Coast from Canada to Florida and along all Gulf Coast states. Willets are listed as Moderate Concern according to the US Shorebird Conservation Plan Conservation Plan (Brown et al. 2001) but have no specific protections.

Wilson's Plovers once nested as far north as New Jersey but have not been recorded in that state since 1955 (Zdravkovic et al. 2023). Currently, Wilson's Plovers nest from Virginia to Southern Florida and along the Gulf Coast from Florida to Texas. They are listed as state endangered in Virginia and Maryland, a species of special concern in North Carolina, and state threatened in South Carolina. Wilson's Plovers are listed as High Concern in US Shorebird Conservation Plan Conservation Plan (Brown et al. 2001).

POPULATION SIZE AND DISTRIBUTION



The Eastern Willet has an estimated population of 90,000 birds (Lowther et al. 2001) but there are no estimates for South Carolina. While Willets are observed year-round in South Carolina, the Eastern Willet is only observed from March through July (Tomkins 1965) with the Western Willet present through most of the year. Peak counts of Willets (Eastern and Western are not distinguished) during monthly International Shorebird Surveys from 2013 – 2019 at Deveaux Bank, South Carolina occurred in Apil and June most years. The highest numbers recorded during these surveys were in April 2014 (85), April 2015 (94), June 2015 (166), June 2016 (91), April 2017 (94), and April 2018 (184). Monthly shorebird counts in Cape Romain National Wildlife Refuge also reported peak counts of Willets in April and June but the highest counts were in July (Figure 1 from Wallover et. al 2015).

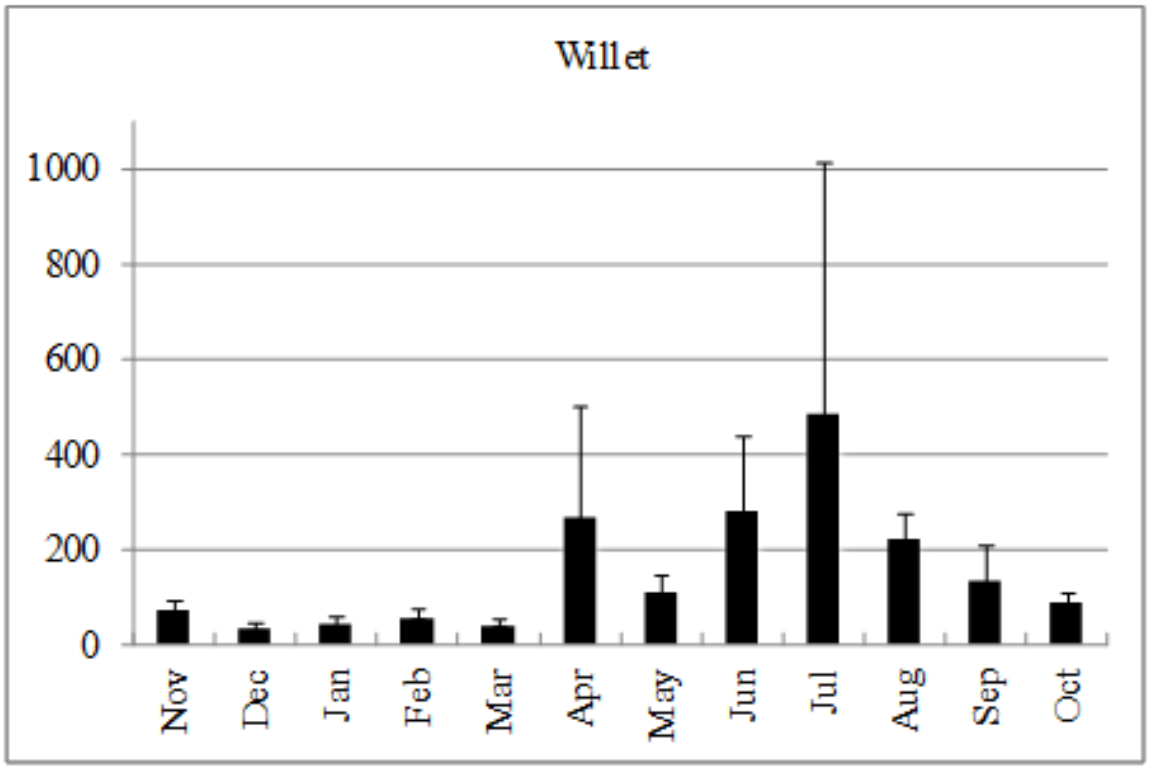


Figure 1. Mean monthly abundance and 95% confidence intervals of Willets censused monthly in Cape Romain National Wildlife Refuge, South Carolina, for three years from November 2007 to October 2010.

In South Carolina, Willets nest in the secondary dune systems of barrier beaches, islands and inlets along the coast often near saltmarsh. Willets make a nest on a raised clump of American beach grass (*Ammophila breviligulata*) or sea ox-eye (*Borrichia fruescens*) and lay 4 speckled eggs in a cup lined with finer grasses. Nests and chicks are at risk of mammalian and avian predation, and even in secondary dune habitat nests can be over washed from tidal inundation due to wind and storms.


Willet on nest Photograph by Janet Thibault

From breeding pair counts from Virginia to Georgia, the Atlantic coast population of Wilson's Plover is estimated to be 1,000-1,100 breeding pairs, although surveys have not been conducted in Florida (Zdravkovic 2013). A state census of Wilson's Plovers was conducted in South Carolina during 2009-2012 and a mean of 376 breeding pairs was recorded (Sanders et al. 2012). Wilson's Plovers nest directly on the ground in open areas of sandy or shell beaches near inlets often in remote areas (Dikun 2008). Harrington (2008) found from analyzing International Shorebird Surveys conducted in the Southeastern US, that

Wilson’s Plovers were found in significantly higher numbers around inlets than in non-inlet coastal locations.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Nesting habitat for Willets and Wilson’s Plovers is primarily on beaches and dune systems. Willets breed near coastal marshes in South Carolina and make their nests behind barrier dunes in vegetation. Wilson's Plovers nest in open areas of sandy islands and inlets, often near dune edges or clumps of vegetation. The nesting season of this group is from March through July. Both parents share incubation duties and chicks are precocial and mobile after hatching. To distract predators from its nest or chicks, Wilson's Plover parents will sometimes exhibit a "broken wing display."

Nesting shorebirds feed on invertebrates found in mudflats, sparsely vegetated shallow water, and on beaches and oyster reefs. Some may feed on horseshoe crab eggs in the spring. Both species feed on fiddler crabs (*Uca pugnax*) in mudflats near nesting sites. Along the coast, tides influence both diurnal and nocturnal foraging. Foraging activity is focused around the time of low tide.


Wilson’s Plover nest Photograph by Janet Thibault

CHALLENGES

Increased development of the South Carolina coast continues to reduce suitable shorebird nesting habitat and may force breeding pairs into less suitable sites. Although actual nesting sites are rarely destroyed, suitability of the sites is greatly reduced when nearby development increases disturbance of nesting birds. Disturbance from sources such as humans, dogs, and boats negatively affects reproductive success by causing threatened adults to leave eggs and/or chicks unattended. Nests are also at risk from native avian and mammalian predators. Flooding and predation were the most common causes of nest failure during a study of Wilson’s Plover nesting at the Yawkey Wildlife Center (Zinsser et al. 2017).

In addition, climate change continues to threaten this guild as sea level rise inundates nesting and foraging sites during the breeding season. Hurricanes and tidal flooding erode beaches and barrier islands and higher tidal amplitudes may flood nests that have been laid during the breeding season. Climate change will also affect coastal habitats where these species over winter in Central and South America where land surface is lost from subsidence (Galbraith et al. 2014). A study of Wilson’s Plovers in South Carolina found that daily survival rates of nests were most strongly related to maximum tide height,

which suggests that flooding and over wash may be common causes of nest loss (Zinsser et a. 2017).

Birds in this guild are also long-distance migrants, therefore, understanding and identifying stopover and wintering locations is crucial to conservation of birds that cross geopolitical and national borders. Shorebirds have historically experienced predation and direct mortality along stopover and wintering areas in Central and South America, where shorebird hunting has recently been identified (Watts and Turrin 2016).

Because of the complicated life history associated with birds of this guild, there are many challenges in conserving these species. Disturbance by humans and boat traffic at nesting areas reduces nest success, thereby reducing chick survival and recruitment. Overharvest of horseshoe crabs for pharmaceutical use may also impact available forage. Finally, oil spills that degrade marine environments can have potentially major impacts on nesting shorebirds, both by disrupting feeding patterns and by leading to the direct mortality of food sources.


Wilson's Plover "Broken Wing" display Photograph by Janet Thibault

CONSERVATION ACCOMPLISHMENTS

To protect nesting habitat, SCDNR maintains seasonal closures of important nesting islands, posts temporary closures of dunes and areas above high tide where these species nest. Approximately 30 properties in South Carolina have nesting shorebirds and are posted during the breeding season.

A geolocator tagging study of nesting Willets was conducted on Deveaux Bank in 2016-2019 to determine when Eastern Willets are present in South Carolina, to determine migration departure and arrival dates, and to identify overwintering and stopover locations (SCDNR unpublished data). Two geolocators were recovered and revealed wintering areas in Sao Luis, Brazil and French Guiana (Figures 2 and 3 respectively). Geolocator tracks were interpreted by Ron Porter of the Delaware Shorebird Project. These Willets departed South Carolina after the nesting season, one bird on 6 July and the other on 17 July. Willet 207 was banded on 8 June 2016 and recaptured on 18 May 2017. The geolocator of this bird failed in February so the return flight to South Carolina was not recorded. Willet 120 was banded on 7 June 2018, returned to South Carolina on 25 March 2019 and was recaptured on 24 May 2019.

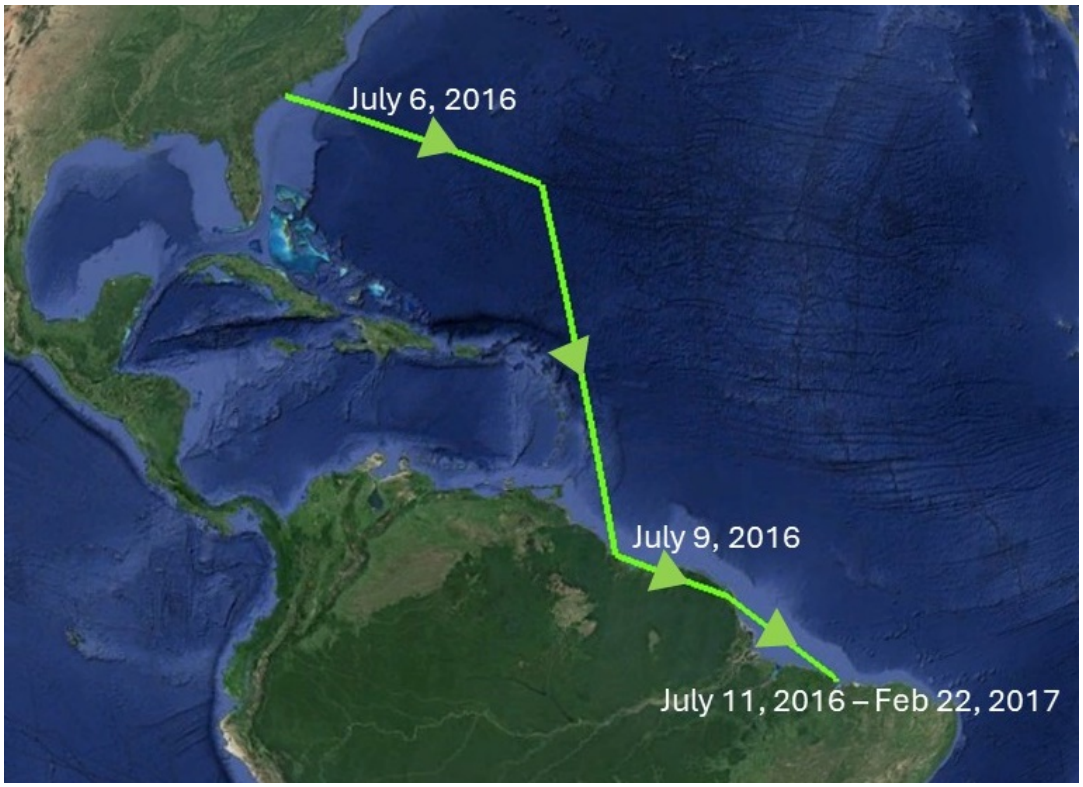


Figure 3. Geolocator track of Willet 207 from South Carolina to South America, July 2016 - February 2017. The geolocator failed in February and did not record the northbound track back to South Carolina.

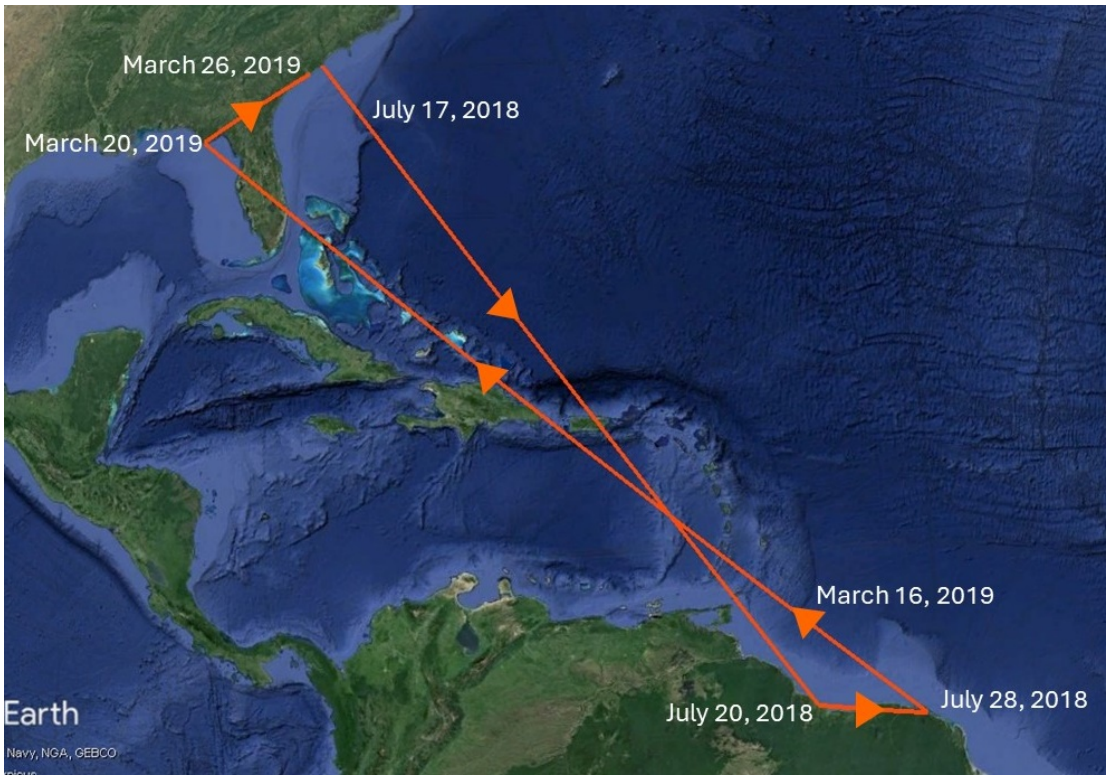


Figure 4. Geolocator tracks of Willet 120 southbound from South Carolina and northbound from French Guiana, 2018-2019.

SCDNR conducted a statewide census of nesting Wilson's Plovers in 2009-2012 to determine abundance and distribution of nesting pairs in the state which prior to 2009 was unknown in South Carolina. All suitable habitats were surveyed, and a mean of 376 pairs were recorded providing a baseline for the state that can be used to analyze population trends. In South Carolina, 29% of the pairs were present on private land and 71% were found on public land (Sanders et al. 2012). This census helped to identify priority areas for seasonal closures and important beaches to engage with public communities to increase awareness of beach nesting species. Graduate students at Coastal Carolina University and Clemson University conducted research projects on nest site selection and nest success of Wilson's Plovers in South Carolina (Dikun 2008; Zissner 2013).

SCDNR partners with multiple agencies and organizations, especially US Fish and Wildlife Service and Audubon South Carolina to develop community engagement, shorebird stewardship and conservation through the South Carolina Shorebird Project. This project organizes workshops and training sessions to promote shorebird conservation as well as educational materials and resources to increase awareness of shorebird conservation. Nesting and roosting site protection has increased due to partnerships and volunteers helping to install and maintain educational signs at important sites.

CONSERVATION RECOMMENDATIONS

- Conduct statewide surveys of nesting shorebirds.
- Reduce disturbance at foraging, roosting, and nesting areas by educating the public about the effects of disturbance and the conservation status of shorebirds.
- Work with government and private land managers to manage important shorebird roost and nest sites.
- Continue cooperative efforts with the US Fish and Wildlife Service to census and manage important shorebird nesting and foraging sites within Cape Romain National Wildlife Refuge.
- Support Shorebird Stewardship programs in beach communities and volunteer engagement activities.
- Expand the SC Shorebird Project to include additional partners, a network of volunteers and build a web site with resources for land managers, volunteers and partners.
- Research shorebird nesting ecology and migration patterns.

MEASURES OF SUCCESS

This guild of birds is subject to rapid shifts in distribution and abundance and will require adaptive management to respond to these changes. Management priorities may shift if the severity of species' declines is further documented.

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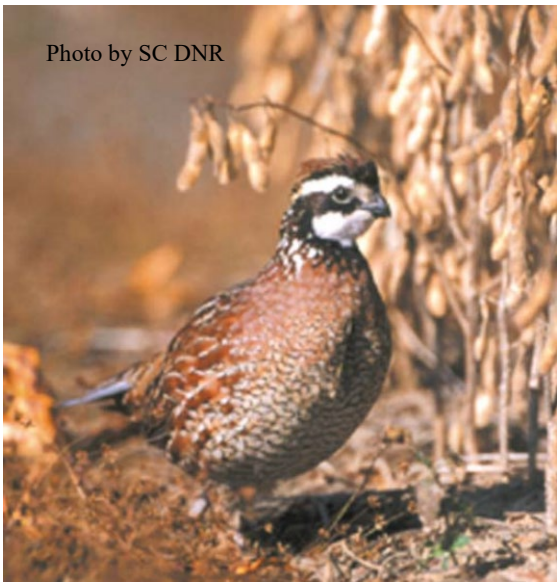
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Northern Bobwhite

Colinus virginianus



Contributor (2005): Billy Dukes (SCDNR)
Reviewed and Edited (2012): Billy Dukes (SCDNR)
Reviewed and Edited (2024): Billy Dukes (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

In 1748, Catesby gave the Bobwhite quail the name *Perdix sylvestris virginiana*. In 1758, Linnaeus dropped the generic name *Perdix* and substituted *Tetrao*. The generic name *Colinus* was first used by Goldfuss in 1820 and, despite several ensuing name changes, became the accepted nomenclature (Rosene 1984). Bobwhite quail are members of the family Odontophoridae, the New World quail.

Bobwhite quail are predominantly reddish-brown, with lesser amounts of white, brown, gray and black throughout. Both sexes have a dark stripe that originates at the beak and runs through the eye to the base of the skull. In males, the stripe above and below the eye is white, as is the throat patch. In females, this stripe and throat patch are light brown or tan. Typical weights for Bobwhites in South Carolina range from 160 to 180 g (5.6 to 6.3 oz.). Overall length throughout the range of the species is between 240 and 275 mm (9.5 and 10.8 in.) (Rosene 1984).

Status

Bobwhite quail are still widely distributed throughout their historic range. However, North American Breeding Bird Survey data indicate a significant range-wide decline of 3.8% annually between the years 1966 and 2009 (Sauer et al. 2004). In South Carolina, quail populations have declined at a rate of 6.1% annually since 1966 (Sauer et al. 2011).

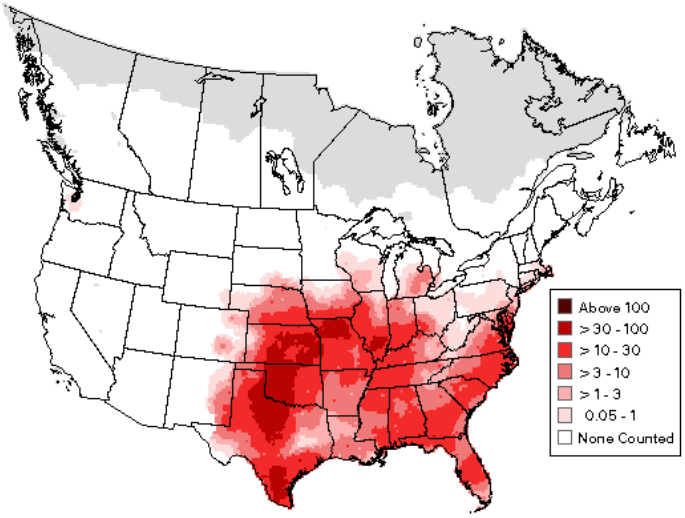
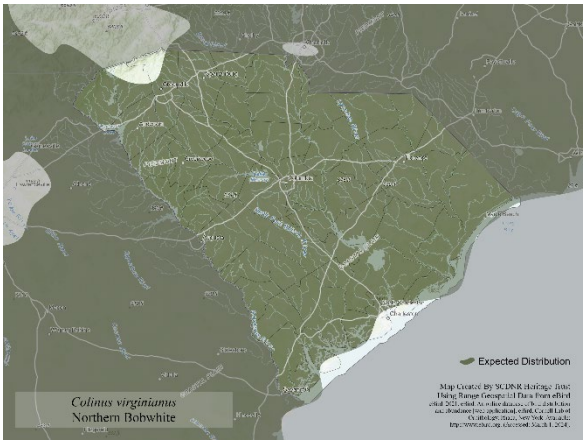


Figure 1: Average summer distribution of northern bobwhite quail 1994-2003. From Sauer et al. (2004).

While not on the Partners in Flight Watch List, the concern for Northern Bobwhite is specifically mentioned due to significant population declines over the past 35 years (Rich et al.

2004). Despite rangewide declines, high densities of quail (6.6 to 7.6 birds/ha) are often maintained on lands where intensive habitat management occurs or conditions are otherwise suitable (Brennan 1999).

POPULATION SIZE AND DISTRIBUTION



Bobwhite quail occur throughout South Carolina, with higher densities found in the Coastal Plain than the Piedmont (SCDNR unpublished data). Within the Coastal Plain of South Carolina, quail population densities are higher in the Inner Coastal Plain than in the Outer Coastal Plain and Coastal Zone. Greater concentrations and more wide-spread distribution of row-crop agriculture in the Inner Coastal Plain creates habitat conditions more favorable for quail than are found in heavily forested landscapes typical of the Outer Coastal Plain and Piedmont.

Quail populations exhibit dramatic seasonal and annual fluctuations, making accurate population estimates difficult. Estimated autumn and breeding populations of Bobwhites in 1999 were 20.1 million and 6.7 million, respectively (Dimmick et al. 2002). Partners in Flight put the estimated global breeding population at 9.2 million, with 82% (7.5 million) occurring in the continental US (Rich et al. 2004).

Quail habitat quality and population levels vary widely across the landscape, resulting in tremendous uncertainty related to extrapolation of population densities to the statewide level. Using assumptions contained in the National Bobwhite Conservation Initiative (NBCI) the estimated quail population for South Carolina in autumn of 2010 was 306,148 individuals (NBTC 2011).

An assumed autumn population of 306,148 individuals translates into a statewide density estimate of 3.9 individuals/km^2 (10.1 individuals/mi.^{2}). Autumn population estimates conducted at select areas in South Carolina where timber density and fire regimes favor quail have documented populations estimated at 98.9 individuals/km^2 (256 individuals/mi.^{2}) (SCDNR unpublished data). Some forested landscapes on which minimal management for quail has occurred have been documented to support autumn densities of 27.2 individuals/km^2 (70.4 individuals/mi.^{2}) (SCDNR unpublished data).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Bobwhite quail use a variety of cover types throughout their broad geographic range. Early successional habitats such as croplands, grasslands, fallow fields, open pinelands and open mixed pine-hardwood forests that have diverse groundcover vegetation are particularly important in the South (Brennan 1999). Perennial warm-season bunchgrasses are the preferred nesting substrate throughout much of the range of the species. Preferred brood-rearing cover consists of

diverse communities of erect annual forbs with abundant insects, bare ground between stems, and a foliage canopy.

Eastern Towhee, Blue Grosbeak, Yellow-breasted Chat, Indigo Bunting, Northern Cardinal, Gray Catbird, Brown Thrasher, and Carolina Wren are among the many species that have habitat requirements similar to Northern Bobwhite such as shrub/scrubland. Many of these species are discussed in more detail in the Early- to Mid-Succession Birds Guild. Those species found in more of an open grassland habitat, which is also frequented by the Northern Bobwhite, include Barn Owl, Loggerhead Shrike, Eastern Meadowlark, Grasshopper Sparrow, Field Sparrow, and Common Ground-dove. All of these species are subject to the same threats as Northern Bobwhite, and will likewise benefit from habitat enhancement practices aimed at restoring populations of Northern Bobwhites. They are discussed in more detail in the Grassland Birds Guild.

CHALLENGES

Habitat loss due to the effects of urbanization, modern agricultural and silvicultural practices, fire suppression, and the introduction of exotic pasture grasses is widely recognized as the primary problem for Bobwhite quail populations (Stoddard 1931; Rosene 1984; Barnes 1995; Brennan 1991; Brennan 1999; Thackston and Whitney 2001).

A lack of nesting and brood-rearing cover is believed to be the major limiting factor over much of the range of the species (Rosene 1984; Dimmick et al. 2002). For a more complete discussion of the effects of habitat changes on Bobwhite populations and habitat suitability, see the Northern Bobwhite Conservation Initiative (Dimmick et al. 2002) and the National Bobwhite Conservation Initiative (NBTC 2011).

Lack of qualified personnel for delivery of technical assistance to private landowners continues to be a limiting factor for state and federal natural resources agencies.

CONSERVATION ACCOMPLISHMENTS

The SCDNR Small Game Program was established in 1978 for the primary purpose of addressing declining populations of traditional small game species, including Bobwhite quail, through technical assistance to private landowners. Since that time, biologists in the Small Game Program have completed over 500 site visits and written management plans for private landowners, potentially affecting over 500,000 acres of habitat. Over the same time period, biologists have developed numerous technical publications and conducted countless seminars, workshops and public presentations on Bobwhite quail life history, habitat requirements, and habitat enhancement techniques. In the past 25 years, over 1,300 landowners, land managers, and natural resources professionals have received instruction on proper quail habitat management techniques through the Small Game Program's annual Quail Management Seminar series. Recently, Program staff have begun to rely more heavily on web-based delivery of technical materials, and have developed a website for dissemination of information on quail habitat management and population status.

Bobwhite population trends in South Carolina are monitored through various surveys which include a summer census of whistling males, a summer brood survey, an annual survey of avid quail hunters, fall covey counts on select Wildlife Management Areas (WMA), and a periodic statewide harvest survey. The Bobwhite Quail Whistling Cock Census, comprised of over 70 routes statewide, was begun in 1979 to provide broad-scale population trend data for Bobwhites. The Summer Bobwhite Quail Brood Survey has been conducted annually since 1994 in order to provide an index to recruitment for Bobwhites. The annual Quail Hunter Survey, conducted since 1987, tracks hunting success as a measure of the quail population at the county, physiographic region, and state levels. Fall covey counts have been utilized since 2001 on discrete WMAs as a measure of fall population and to assess effects of habitat management, and extrinsic factors such as weather, on Bobwhite quail reproduction and survival.

A multi-agency partnership led by SCDNR has established the Indian Creek Wildlife Habitat Restoration Initiative in Newberry County. Bobwhites are a focal species for habitat restoration efforts though the Initiative, and over 3,000 acres of early-successional habitat have been restored and maintained throughout the project area. Habitat restoration efforts through the Initiative are continuing, and relationships established through the formation of the Initiative have resulted in greater cooperation between state and federal agencies for management of early-successional habitat on public and private lands statewide. While not specifically identified as quail focal areas, efforts to restore and maintain early-successional habitat are underway at numerous WMAs across the state including Webb WMA and Hamilton Ridge WMA in Hampton County, Crackerneck WMA in Aiken County, Draper WMA in York County, Canal WMA and Bonneau Ferry WMA in Berkeley County, and Marsh WMA in Marion County.

Over the past decade, relationships have been established between DNR Small Game Program staff and staff of the USDA Farm Service Agency (FSA) and USDA Natural Resources Conservation Service (NRCS), resulting in a higher level of coordination in integrating wildlife objectives into USDA conservation programs. As a result of these relationships, as well as improved relationships between Bobwhite advocates and USDA staff at the regional and national levels, several beneficial programs and practices have been added or implemented to the benefit of Bobwhites and associated early-successional species. Within the Conservation Reserve Program (CRP), South Carolina received an allotment of 10,000 acres under the Habitat Buffers for Upland Birds practice (CP 33) and an additional 2,300-acre allotment under the State Acres for Wildlife Enhancement (CP38E) practice. Both of these practices have been implemented in South Carolina and have the ability to increase quail populations in agricultural landscapes. For years 2006-2008, DNR staff coordinated and participated in a coordinated monitoring effort to determine the effect of CP33 implementation on populations of Bobwhites and select songbird species. This effort indicated that Bobwhites were approximately 2- to 3- times more abundant on agricultural fields with herbaceous field borders than on similar fields with no herbaceous borders (Evans et al. 2009).

Several regional and national developments over the past 20 years have advanced the cause of Bobwhite conservation at the state, regional and national levels. In 1995, the Southeast Quail Study Group (SEQSG) was formed to identify causes of regional Bobwhite population declines and to devise solutions to reverse declining trends at state and regional levels. In 2002, the Northern Bobwhite Conservation Initiative (NBCI) was published (Dimmick et al. 2002). This

range-wide recovery plan for Bobwhites identified specific habitat and population recovery goals at the state and Bird Conservation Region (BCR) levels. In 2009, the SEQSG was expanded to encompass all states in the historic range of Bobwhites nationwide and renamed the National Bobwhite Technical Committee (NBTC). The NBCI was revised and renamed the National Bobwhite Conservation Initiative in 2011 (NBTC 2011). This revision provides a spatially-explicit habitat suitability ranking for all landscapes in South Carolina, which will allow geographic prioritization of future habitat enhancement efforts across the state. The NBCI revision also includes major constraints and opportunities for Bobwhite habitat management and contains estimated and projected densities of Bobwhites under a variety of management scenarios. NBCI was revised and renamed again the National Bobwhite and Grassland Initiative in 2022 (NBGI 2022) to include other associated species and their native habitats.

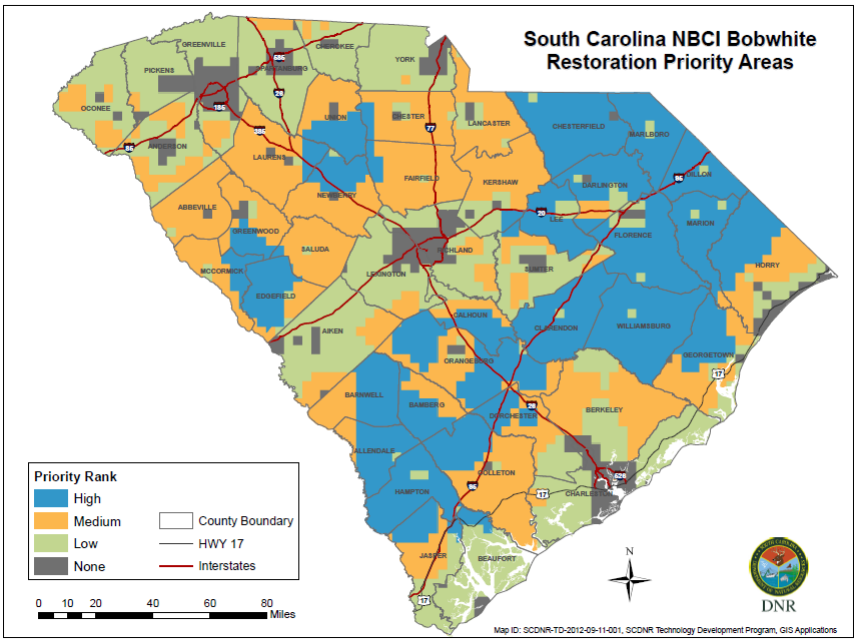


Figure 2: Northern Bobwhite habitat restoration potential as delineated through the NBCI's Biologist Ranking Information process. The BRI ranking process identified 9,150,594 acres as having medium or high potential as Bobwhite habitat in the State (NBCI 2013). (Ranking criteria and the plan in its entirely can be found online.)

CONSERVATION RECOMMENDATIONS

- Increase acreage of volunteer early succession vegetation or native warm season grasses on agricultural landscapes in South Carolina.
- Apply appropriate site preparation techniques, selective thinning regimes, and prescribed fire rotations to forest lands in South Carolina.
- Include protection of farmland and other potential early successional habitat as a priority in land acquisition and habitat protection programs.
- Maximize wildlife benefits in USDA Farm Bill programs through regional and national involvement in planning processes and through direct involvement with local and farm-level conservation planning.

- Identify funding sources for state-level cost-share programs to assist landowners with implementation of beneficial management practices for quail and other early-successional species.
- Identify focal areas for quail habitat enhancement within the state based upon existing land cover and quail populations; strive to focus private lands technical assistance and encourage USDA conservation programs in those areas where habitat enhancement would be most beneficial. Also focus on areas where the potential for positive population response would be greatest utilizing guidance provided by the NBGI.
- Identify public lands with high potential for quail habitat enhancement and assist responsible agencies with planning efforts for habitat enhancement.
- Identify SCDNR lands with high potential for quail habitat enhancement; establish population goals based on "managed density" estimates in the NBGI; and implement management practices necessary to achieve the population goal.
- Develop predictive models of Bobwhite quail occurrence and density based on land cover types from remote imagery.
- Evaluate Bobwhite quail colonization rate and population response to habitat enhancement, particularly in forested landscapes.
- Evaluate effect of geographic isolation on Bobwhite quail population viability and persistence.
- Evaluate effects of patch size and configuration on Bobwhite quail nest success and brood survival.
- Develop improved census techniques for low to moderate densities of quail
- Identify limiting factors for quail populations in agricultural and forested landscapes in South Carolina.
- Increase number of survey routes in spring call count survey for better statewide coverage and to allow regional trend comparisons.
- Increase number of cooperators in statewide quail hunter survey.
- Document habitat enhancement accomplishments that occur as a result of USDA Farm Bill programs, private lands technical assistance, or quail focus area initiatives.
- Establish a statistically-valid, density-based monitoring program for Bobwhites at appropriate scales to evaluate effects of management and monitor annual population fluctuations.
- Train additional observers in the fall covey count technique and expand the technique to additional sites in the State.
- Complete a statewide quail management and recovery plan which incorporates population and habitat objectives of the NBGI.
- Expand existing partnerships and establish new partnerships to advance the cause of Bobwhite habitat restoration.
- Continue annual quail management seminars for private landowners and agency personnel.
- Develop additional technical literature on beneficial quail management practices.
- Utilize agency outlets and cooperative efforts to promote benefits of prescribed burning.
- Provide Bobwhite habitat recommendations and population status updates to private landowners through on-site technical assistance, fact sheets, management bulletins, and websites.

- Establish demonstration areas that illustrate successful quail management practices on public or cooperative private lands within each DNR Wildlife Region.
- Increase capacity for private lands technical assistance and increased coordination and participation in federal Farm Bill program delivery at the state level.
- Support the National Bobwhite Technical Committee through participation of staff in annual meetings, committee involvement, support of the NBGI Director position, and agency participation on the NBGI Management Board.
- Support efforts of non-governmental organizations in South Carolina that promote conservation of Bobwhites through directed management and research.
- Publicize successful quail management efforts on public or private lands through Agency outlets and the popular press.

MEASURES OF SUCCESS

Development, implementation, and refinement of a statistically-valid, density-based monitoring technique will allow an assessment of Bobwhite population response to habitat management at various spatial scales. Managed density estimates, as provided in the NBGI, should be used as population targets in managed landscapes. Effects of landscape-level changes will be monitored using Breeding Bird Survey data and spring call count survey data. Management-oriented research projects will address emerging questions related to Bobwhite population dynamics and habitat enhancement techniques. SCDNR will strive to continue to respond to new data and adapt management actions once assumptions have been further tested.

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Painted Bunting (Eastern)

Passerina ciris ciris


Photo by Wayne Irvin

Contributor (2005): William C. Hunter (USFWS)
Reviewed and Edited (2012): Dean Demarest (USFWS)
Reviewed and Edited (2024): Jen Tyrrell (Audubon SC)

DESCRIPTION

Taxonomy and Basic Description

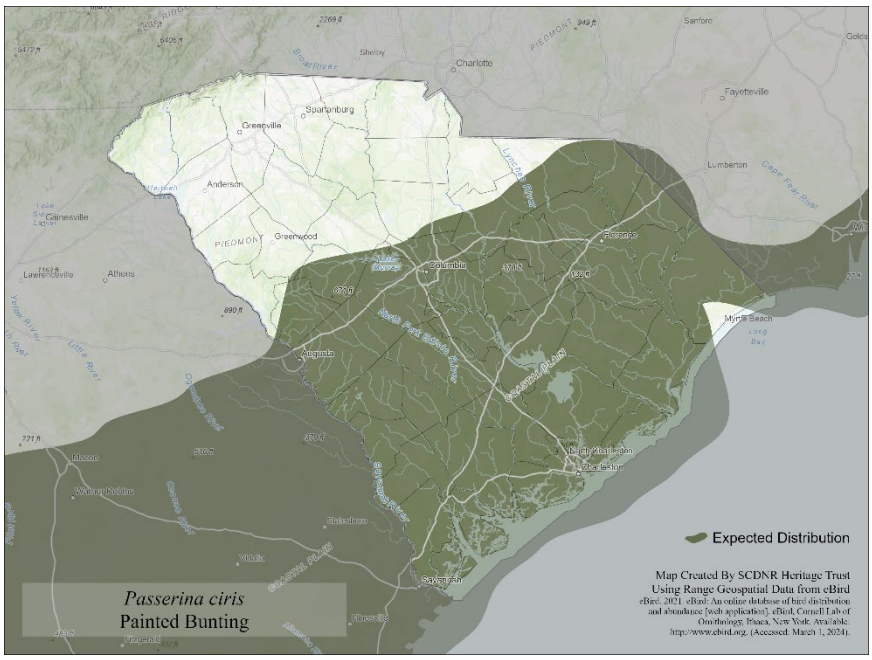
Buntings are small, New World finches with conical bills. The Painted Bunting is a small finch, typically 12 to 13 cm (4.7 to 5.1 in.) long and 13 to 19 g (0.46 to 0.67 oz.) (Lowther et al. 1999). The male Painted Bunting is among the most colorful birds in North America but is often hard to see as it usually stays close to thickets and dense cover. Males have a blue head and nape with bronze-green back, red rump and underparts, and dark wings and tail (Lowther et al. 1999). Even when in full view, male Painted Buntings may appear dark unless seen close and in good light. Females and immatures of both sexes are almost entirely dull green and are even more rarely seen except when at feeders (Lowther et al. 1999).

Painted Buntings breeding in South Carolina belong to the Eastern subspecies, *Passerina ciris ciris* (Thompson 1991; AOU 1998). During the breeding season, this subspecies is restricted to four states along the Atlantic Coast: North Carolina, South Carolina, Georgia and Florida. They winter exclusively in south Florida and the West Indies (mostly Bahamas and Cuba) (Lowther et al. 1999). Eastern Painted Buntings breed relatively late in the season (Duncan 1999; Springborn 1999).

Status

Formerly, Breeding Bird Survey (BBS) and Christmas Bird Count (CBC) data suggested steep long-term declines in Painted Bunting populations (Cox 1996). Although trend estimation within smaller geographies can be confounded by small sample sizes, more recent BBS analyses suggest the Eastern subspecies may not be declining as steeply as once thought. BBS trends from 1966-2010 for South Carolina are deemed to be moderately precise, and estimate a decline of 0.8% per year (Sauer et al 2011). While not particularly "steep" relative to other declining species, if accurate, this trend still equates to a loss of 55% of present populations in 100 years. The Painted Bunting is identified as a Watch List species by Partners in Flight (Rich et al. 2004), and is also identified by the US Fish and Wildlife Service as a Bird of Conservation Concern throughout the Southeast (USFWS 2008). Considering also that South Carolina supports one-third to one-half of the total breeding population of the Eastern subspecies, and that breeding habitats are disappearing or under increasing threat, it is clear that pro-active efforts will be required to ensure the future conservation of this popular species in the State and throughout its eastern range.

POPULATION SIZE AND DISTRIBUTION



Eastern Painted Buntings occur in highest densities around the sea islands of Georgia and South Carolina, occurring commonly but in lower densities in the adjacent mainland that is roughly parallel to U.S. Highway 17 and eastward. Their range extends north into coastal North Carolina and south into northeastern coastal Florida. These Buntings become uncommon, occurring sporadically farther inland along some river systems, most notably the Savannah River. More recently, Breeding Bird Atlas work in South Carolina and Georgia has documented Eastern Painted Buntings as more numerous than previously thought in fallow fields, woodland edges, and hedgerow habitat of the Upper Coastal Plain when looking north and east to the Santee River and on both sides of the Savannah River (Cely 2003). Although densities are lower in suitable habitats inland, these areas by far support the largest number of birds overall by virtue of their much larger geographic extent.

The vast majority of wintering Eastern Painted Buntings are concentrated in south Florida, Cuba, and the Bahamas (Lowther et al. 1999). Geolocation studies showed that an inland painted bunting from South Carolina wintered in South Florida, while a tracked bird from the Dewees Island, a barrier island North of Charleston, wintered in Cuba (Sharp, 2023). However, there does not seem to be any one reliable place where large numbers of Eastern Painted Buntings can be located during winter, at least in recent years, which may be cause for serious concern. Sykes and Holzman (2005a,b) provide a detailed state-by-state and site-by-site account of the breeding and non-breeding distributions of the Eastern Painted Bunting.

The total population size for Eastern Painted Bunting was estimated previously at well below 500,000 breeding adults (Sauer et al. 1997). Later, Partners in Flight (Rich et al. 2004) provided populations estimates at the continental level using BBS, and estimates at smaller geographic scales could be developed through application of similar methodologies (Rosenberg and Blancher 2005). Hence, South Carolina's population could be estimated at 50,354 (± 18,704) breeding adults using the Rosenberg and Blancher (2005) approach. According to this estimate, South Carolina supported 54% of the total Eastern population of breeding adults. Most recently, a "range-wide" survey effort for the Eastern population, competed in 2009, yielded data for a more robust assessment of the status of the Eastern population at ~1.2 million (C. Watson, pers.

comm.). There are several caveats that need to be considered with this estimate. First, sea and barrier islands, where the largest populations now occur, are not well represented in the BBS data and additional survey work may raise our estimate of total breeding adults. Second, if we decrease the statistical rigor of the estimate, then the maximum population estimate may be as large as 165,112 breeding-aged birds. Third, the ability to detect all individual Buntings (or at least all singing males) and make adjustments for estimating all breeding adults needs to be evaluated. If coastal sea and barrier islands were fully incorporated, then it is presumed that Georgia, with a larger quantity of quality coastal habitat, would have a higher proportion of the total population than South Carolina. However, it is clear by any of these estimates that both South Carolina and Georgia habitats are extremely important for the majority of breeding Eastern Painted Buntings (Meyers 2004). As of 2024, the PIF estimate for the species in South Carolina is 140,000, far more than Georgia (51,000), North Carolina (9,400), and Florida has decreased dramatically from 5,316 in 2013 to 640 (2024 Partners in Flight Database).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Eastern Painted Buntings are associated with maritime shrub-scrub and grassy habitats mixed in a woodland setting. The species is mostly absent from forests with no understory development and from large patches of scrub-shrub habitat separated from large woodland patches. Nearby grassy fields are also important for post-breeding foraging adults and fledglings (Lowther et al. 1999). High quality habitat is defined as largely forested areas with substantial edge and grassy forest openings and stands exhibiting structural diversity and large amounts of fleshy fruit (Lowther et al. 1999). On barrier islands the dominant habitat type utilized by Painted Buntings was maritime forest and scrub / shrub habitat. (Latshaw, 2011)

Research on annual survival and other demographic characteristics will lead to a more definitive understanding of the habitat requirements of the Painted Bunting. Current research indicates the defended territory of Buntings as ranging from 0.81 to 4.0 ha (2 to 10 ac.) with isolated males holding larger territories from one year to the next; there is also about a 95% breeding ground site fidelity for males. Annual survival estimates have yet to be calculated. The longevity record for the species was recorded in June of 2023 at a horse farm in St. Matthews South Carolina with an adult male who reached 14 years old. Adults use grassy areas for seeds and marshes for arthropod foraging near nest sites in scrub habitat.

Additional research has shown that Buntings will use Spanish moss as nest building material, especially in nests found higher in the canopy. Nests found 3 m (10 ft.) or higher in the canopy had higher productivity than nests found lower (Garcia 1994). In general, researches also observed that a greater number of nests were located in medium category trees/shrubs. On barrier islands, the primary substrates Painted Buntings were observed using were Live Oak, Wax Myrtle, Slash Pine, Redbay, Yaupon Holly, and Eastern Red Cedar (Latshaw, 2011). Additionally, successful nests were located in taller plants with greater distances from the trunk of the tree, greater canopy cover, and fewer small limbs. Cely and Glover (unpublished SCDNR data) concluded that early-successional habitat associated with fields and field-edges seem to consistently support Eastern Painted Buntings. However, while this research reported a high abundance of Eastern Painted Buntings in these habitats, the potential for nest predation and

parasites also increases in such environments, and effects on Bunting reproductive output has not been studied.

Finally, additional research by Duncan (1999) and Springborn (1999) was conducted on Sapelo Island Wildlife Management Area in Georgia from 1996 to 2000. These studies further described habitats found past the primary dune line where shrubs appear (maritime shrub habitat) as optimal for Painted Buntings. Pinelands with open canopy had Bunting densities at about 50% of those in optimum shrub-scrub habitat. Buntings preferred open freshwater wetlands to salt marsh. Data on telemetry of Buntings on Sapelo Island indicate home ranges of 2.8 to 7.3 ha (7 to 18 ac.) and ASY males on Kiawah Island had home ranges from 5.9 to 6.2 ha (Latshaw, 2011). Males had larger home ranges compared to females, and Buntings had significantly smaller home ranges in shrub-scrub habitat with high grass cover when compared to open pine forest habitat. With these data, it is estimated that areas between 486 and 1,012 ha (1,200 and 2,500 ac.) are required to support 100 to 200 breeding pairs of Eastern Painted Buntings.

CHALLENGES

Because the Eastern Painted Bunting is a true edge species, populations may be particularly vulnerable to increased nest parasitism by Brown-headed Cowbirds (*Molothrus ater*) and increased nest depredation. Although actual causes for Eastern Painted Bunting declines remain unclear, continued changes in landscape in inland areas are correlated with documented population declines (Hunter et al. 1993). During the BBS of inland sites in Georgia and South Carolina, landscape changes have included a doubling in developed land from 4 to 9%, an increase in pine plantation from 25 to 35%, while agriculture has declined from 18 to 9% (Meyers 2004). During this same time period, no change in emergent wetlands has been documented. Assuming that we have a correct understanding of Eastern Painted Bunting habitat characteristics, 35 to 45% of the variation in Eastern Painted Bunting population change is accounted for through changes in landscapes (Meyers 2004).

There appears to be a delicate balance between a landscape with enough fields to support larger populations of Eastern Painted Buntings, but with enough forest to keep predators and cowbirds at a low enough level to maintain high reproductive success. However, the landscape context of the Inner Coastal Plain of South Carolina is changing to the point where conditions are becoming less suitable overall for supporting Eastern Painted Bunting populations. Converting agriculture areas to hard edges, residential areas or pine plantations results in less suitable habitat for Eastern Painted Buntings. Overall landscape conditions may become less favorable for Eastern Painted Buntings with continued land conversion outside of public lands like Santee National Wildlife Refuge in the Inner Coastal Plain (Hunter pers. obs.). From 2001-2016 South Carolina lost 280,700 acres of agricultural land, and it is one of the top ten states most threatened with agricultural land loss (Martinson, 2023).

Because Eastern Painted Buntings breed late in the season, these birds could be prone to global climate change (Duncan 1999; Springborn 1999). Audubon's Survival by Degrees study suggests that Painted Buntings may expand their breeding range Northward over time. Mature habitat disturbance from hurricanes and tropical systems may provide maritime shrub and scrubland establishment.

Preliminary results from sea islands indicate few problems with nest predators or cowbirds in these protected areas; however, future coastline development may contribute to higher levels of nest parasitism and nest predation on these otherwise secure sites. On sea and barrier islands, development pressure is increasing at many privately owned sites. Development is expected to adversely affect island populations in the same manner as those on the mainland. In 2024 South Carolina has the fastest population growth of any state. Development pressure on the coast is increasing resulting in habitat loss and fragmentation. Sea level rise has increased 1 inch every two years, exceeding previous estimates. This has resulted in the loss of maritime forest and scrub / shrubland habitat, turning them into “ghost forests”. The combination of sea level rise and human development pressure results in a phenomenon called “the coastal squeeze” that threatens the Eastern Coastal population of Painted Buntings.

Also, on sea and barrier islands, feral horses and hogs severely damage and destroy forests by trampling and uprooting understory shrubs, as well as overgrazing grassy habitats. Where feral horses and hogs are established, Eastern Painted Buntings are not expected to thrive.

Management of public lands through the use of prescribed burning may affect Eastern Painted Bunting populations. In many areas, prescribed fire is an essential management tool for providing and maintaining appropriate conditions for Eastern Painted Buntings. However, fire at high frequency return intervals may eliminate the shrub layer, while fire at low frequency return intervals also may eliminate the shrub layer as well as the grassy conditions over time. Present experience suggests an average return interval between 3 to 6 years in maritime habitats is adequate to maintain the mosaic of structure Eastern Painted Buntings prefer, while not allowing succession to proceed too far. Of course, once a burn occurs, there will be a temporary reduction in habitat quality (Hunter, pers. obs.).

Golf courses may provide marginal habitat for Eastern Painted Buntings under certain circumstances, especially when all native vegetation is removed and there is a high reliance on pesticide and herbicide use. However, an increasing number of golf courses are modifying their practices to accommodate native birds in general and Eastern Painted Buntings specifically in coastal South Carolina. The US Fish and Wildlife Service is working with golf course managers in South Carolina with the objective of maintaining Eastern Painted Bunting populations in what is otherwise a rapidly developing landscape (Gordon et al. 2003).

Threats on the wintering grounds include trapping for the pet trade. Males wintering in Cuba had 20% less chance of returning from the wintering grounds (Rushing, 2020). Trapping has been banned in the United States where and has been banned since the early 1900’s, in Mexico the trade was banned from 1982 to 1999, but the ban was lifted and trapping continued. In Cuba there has been variable reports on the commonality of wintering Painted Buntings, but the most important wintering regions appear to be (1) The keys within the Archipiélago de Sabana-Camagüey along the northern coasts in the provinces of Matanzas, Villa Clara, Sancti Spiritus, Ciego de Ávila, and Camagüey (this region is rapidly being developed for the growing tourist trade); (2) From the north- eastern coast of Las Tunas Province, eastward along the northern coast of Holguín Province to Bahía de Naranjo, to include areas in and around the village of

Gibara, City of Holguín, Bahía de Nipe, and from Mayarí and Nipe eastward to Bahía Sagua de Tá-namo (Nils Navarro, pers. comm.); (3) The Península de Guanahacabibes; (4) Mil Cumbres in Pinar Del Río Province; (5) The northern coast of La Habana Province; and (6) The Península de Zapata in Matanzas Province, including the Zapata Swamp, the area from Jagüey Grande southward to Pálpite (Nils Navarro, pers. comm.), and near-by areas in the southern part of the province. (Sykes 2007). In a personal observation documented by Iñigo-Elias, in May 2003 an estimated 700 buntings were trapped for the pet trade near the capital Havana. (Sykes, 2007).

Historically, John James Audubon observed thousands of Painted Buntings exported to Europe through New Orleans ports for the pet trade in 1841.

CONSERVATION ACCOMPLISHMENTS

The Eastern Painted Bunting enjoys relative popularity as a species garnering conservation attention in the Southeast. The future security of the Eastern subspecies is particularly dependent on proactive conservation attention in South Carolina and Georgia, where a large percentage of the Eastern population breeds. Agencies and industrial landowners are incorporating the needs of this species into conservation strategies and management practices. There is increasing interest in linking the needs of Painted Buntings into other conservation efforts and initiatives where compatible objectives exist, such as with the Northern Bobwhite Conservation Initiative. The "Eastern Painted Bunting Working Group" successfully collaborated to complete a 3-year, range-wide population assessment for the Eastern taxon. Analyses have been conducted, and reports and publications are being prepared that will present results and conclusions to all appropriate conservation interests. A listserve exists to increase communication among managers and researchers.

CONSERVATION RECOMMENDATIONS

- Protect and maintain existing high-quality maritime woodland, shrub-scrub, and grassy habitats through easements/purchase.
- Determine more specific habitat objectives as research reveals a better understanding of present status for breeding populations.
- Target programs for both public land mangers and private landowners to encourage provision of adequate cover, food and habitat that presents minimal nest parasitism and depredation.
- Continue to conduct and support research on habitat selection, reproductive success and taxonomy of Eastern Painted Buntings.
- Conduct and support public outreach programs to solicit observations of Buntings and cowbirds from feeder watchers throughout the range of the species.
- Establish a network of sites for monitoring the population trends of Eastern Painted Buntings and address responses to local management and landscape conditions. Among generalized habitats used by Eastern Painted Bunting, there are 4 that merit treatment at the macro-scale, as follows:

  - Sea Islands/Barrier Islands – evaluate habitat management practices and suitability over the long term.
  - Coastal Mainland – evaluate development pressures on Buntings.
  - Agricultural Interior – evaluate farming and forestry practices on Buntings and determine how to implement conservation practices.
  - River Corridor – evaluate forestry practices and flood plain dynamics.
- Provide news releases when appropriate to announce key events or findings involving Eastern Painted Buntings that would allow opportunities to highlight general conservation goals and needs for the public.

MEASURES OF SUCCESS

Of particular importance in measuring success of conservation actions for this species is the demonstrated stability for Eastern Painted Bunting populations on sea islands. Measures of reproductive success should be used to gauge population health and habitat quality.

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Pine Savanna Bird Guild

American Kestrel (*Falco sparverius paulus*) – Southeastern subspecies
Bachman's Sparrow (*Peucaea aestivalis*)
Henslow's Sparrow (*Centronyx henslowii*) **–** winter population
Pine Siskin (*Spinus pinus*) **–** winter population
Red-headed Woodpecker (*Melanerpes erythrocephalus*)

NOTE: The Red-cockaded Woodpecker is discussed in its own species account.

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American Kestrel / Steve Kilpatrick

DESCRIPTION

Taxonomy and Basic Description

The American Kestrel is the smallest falcon in North America with an average length of 27 cm (10.6 in.), wingspan of 58 cm (22.8 in.), and weight of 117 g (4.13 oz.). Adults are identified by a russet back and tail, two black stripes on a white face, and blue-gray wings. Howe and King first described the Southeastern subspecies in 1902; this subspecies is nonmigratory and resides primarily in the Piedmont and Coastal Plain of South Carolina (Smallwood and Bird 2020). The male of the Southeastern subspecies is smaller and less spotted on the breast than males of northern subspecies. However, the northern subspecies are migratory and may coexist with the Southeastern subspecies outside of the breeding season.


Bachman's Sparrow / Steve Kilpatrick

The Bachman's Sparrow is a large songbird, averaging 15 cm (5.91 in) in length and 21 g (0.74 oz.) in weight. Known for their inconspicuous nature, these sparrows are often identified in the field by their two note-trill song (Dunning et al. 2020). This species has a large bill, fairly flat forehead and a long, rounded dark tail. Adults are gray above and heavily streaked with chestnut or dark brown. Their breast and sides are buff or gray with an off-white belly and a thin, dark eye line. Three subspecies are recognized, but the taxonomic record is complex, and more research is needed to parse out their geophysical distributions (Dunning et al. 2020).


Henslow's Sparrow / Andy Reago & Chrissy McClarren

The Henslow's Sparrow is a mid-sized,


Pine Siskin / Cephas

insectivore-granivore songbird averaging 13 cm (5.11 in) in length and 13 g (0.46 oz) in weight. This species has a large flat head, gray bill, and short tail. Adults are greenish on the head, nape, and central crown strip with dark chestnut wings (Herkert et al. 2020). Although they tend to be very quiet outside the breeding season, they may be identified by their sharp "*tsip*" call. Two subspecies of Henslow's Sparrows are recognized and both winter (or wintered) in South Carolina, though the eastern subspecies (*C. henslowii susurrans*) may be extinct. The Pine Siskin is a small finch species averaging 12 – 13 cm (4.7 – 5.1 in) in length and 12 – 18 g (0.42 – 0.63 oz) in weight (Dawson 2020). There is little sexual dimorphism in plumage; both sexes and juveniles have heavy brown streaking over a gray or light brown background with a brown-black wing and tail. A yellow wash on the remiges and base of rectrices is visible in flight. Three subspecies are recognized and distinguished by morphological characteristics such as body size, degree of yellow plumage, and presence-absence of an eyeline (Dawson 2020).


Red-headed Woodpecker / David Youngblood

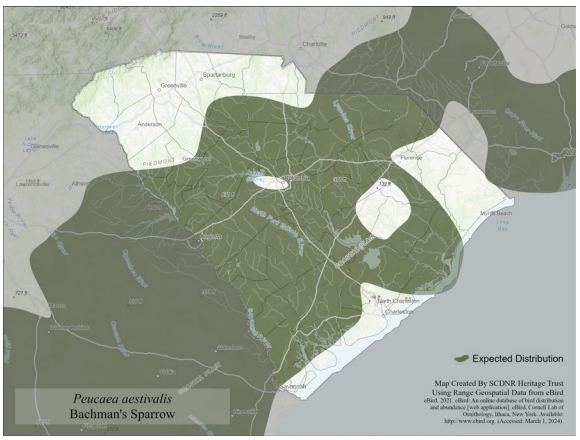
The Red-headed Woodpecker is a mid-sized woodpecker averaging 19 – 24 cm (7.5 – 9.4 in) in length and 56 – 91 g (2 – 3.2 oz) in weight. It is one of the most recognizable North American woodpeckers, with a bright red head and collar, light gray bill, white breast and underparts, and black wings with a white outer rectrices. Adult males and females have identical plumage, while juveniles are primarily gray until their definitive molt (Frei et al. 2020). No subspecies have been described, but Red-headed Woodpeckers in western and northern regions tend to average larger than those in the Southeast.

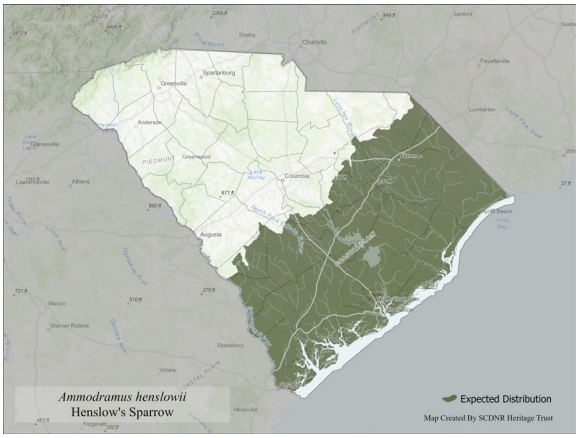
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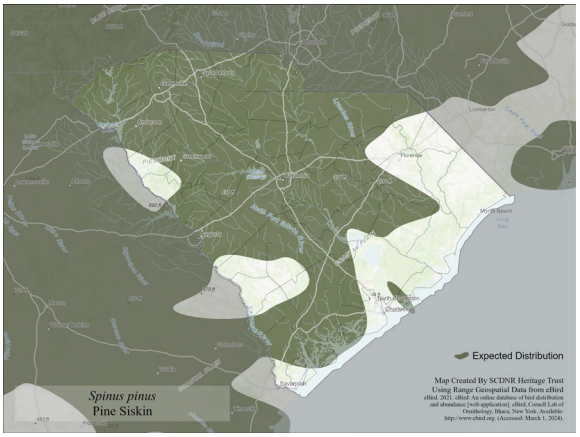
Of the species included in this guild, the Bachman's Sparrow has the highest levels of conservation status. The Bachman's Sparrow is listed as Near Threatened on the IUCN Red List (2023) and is included on Partners in Flight's (PIF) Red Watch List, indicating that the species' recovery should be prioritized due to the species' sharp population decline and small population size and distribution (PIF 2023). The species is also listed as having regional importance for the Atlantic Coast Joint Venture, with the region accounting for approximately 63% of the Bachman's Sparrow's breeding population (Rosenberg et al. 2016).

The American Kestrel, Henslow's Sparrow, Pine Siskin, and Red-headed Woodpecker are listed as species of Least Concern by the IUCN (2023). The Southeastern subspecies of American Kestrel does not have any state protections in South Carolina but is listed as state threatened in Florida. The Henslow's Sparrow is included on PIF's Yellow Watch List, while the Pine Siskin and the Red-headed Woodpecker are considered Common Birds in Steep Decline by PIF (PIF 2023).

POPULATION SIZE AND DISTRIBUTION









The Southeastern American Kestrel, Bachman's Sparrow, and Red-headed Woodpecker are resident species in South Carolina. Historically, the core distribution of each of their ranges coincided closely with the distribution of the Red-cockaded Woodpecker (*Dryobates borealis*), longleaf pine (*Pinus palustris*), and short leaf pine (*Pinus echinata*) (Hunter et al. 2001). Breeding Bird Atlas records for Bachman's Sparrows exist for the Piedmont and Coastal Plain while records for American Kestrels and Red-headed Woodpeckers are scattered throughout the State (Cely 2003). The American Kestrel is ubiquitous across North America, while the range of the Southeastern subspecies extends from the Atlantic coast to Louisiana, and north into South Carolina. Multiple subspecies can be found during the winter due to regional migration, but the Southeastern subspecies is a year-round resident (Hamel 1992). The species' rangewide population estimate is 2.8 million individuals (PIF 2023), which has declined approximately 48% since 1970 (Rosenberg et al. 2016). In South Carolina, the current population estimate in 1,100 individuals (PIF 2023). Based on Breeding Bird Survey (BBS) data, the species has experienced a 1.2% annual decline in South Carolina between 1966 and 2021, with higher rates of annual decline in the Piedmont conservation region (2.5%) compared to the Southeastern Coastal Plain conservation region (1.6%) (Ziolkowski et al. 2022). Caution should be exercised when extrapolating these data to the state or conservation region level due to consideration of various subspecies. The Florida Fish and Wildlife Conservation Commission estimates that Southeastern American Kestrels have declined by 82% over the last 70 years in Florida (FFWCC 2024), but it is not known whether declines have been as severe in South Carolina.

The Bachman's Sparrow can be found in localized populations throughout the Southeastern Coastal Plain and Piedmont, with isolated groups in central states like Tennessee, Kentucky, and Missouri. The

current rangewide population estimate for the species is 170,000 individuals, which is an estimated 73% decline since 1970 (Rosenberg et al. 2016). In South Carolina, the Bachman's Sparrow has an estimated population size of 6,000 individuals (PIF 2023) and has experienced a 0.6% annual decline between 1966 and 2021, with higher rates of annual decline in the Piedmont conservation region (3.6%) compared to the Southeastern Coastal Plain conservation region (1.1%) (Ziolkowski et al. 2022). This may reflect a noted range contraction along the northern and western peripheries of their range (Dunning et al. 2020). Bachman's Sparrows are often reported in low abundance by traditional survey methods (e.g. BBS), so estimates of population size and the degree of decline should be interpreted with caution.



The Red-headed Woodpecker is present locally throughout the eastern US. They can be found year-round in the Southeast, with breeding and wintering populations in the upper Midwest and Texas, respectively. However, Red-headed Woodpeckers are best described as facultative migrants, as their winter movements appear to be partially driven by availability of hard mast. Depending on the year, populations may only partially migrate or not migrate at all (Vukovich and Kilgo 2013; Frei et al. 2020). The current rangewide population estimate is 1,800,000 individuals (PIF 2023), reflecting an approximately 67% decline since 1970 (Rosenberg et al. 2016). However, the species appears to be stable in South Carolina, with a population size of 39,000 individuals (PIF 2023) and an 0.6% annual rate of increase between 1966 and 2021, with much higher rates in the Piedmont conservation region (2.1%) compared to the Southeastern Coastal Plain conservation region (0.1%) (Ziolkowski et al. 2022).

The Henslow's Sparrow and Pine Siskin are overwintering species in South Carolina that occur in and rely on resources found in pine savannas. Due to the lack of BBS data for these species in the state, only rangewide population trends are reported. The Henslow's Sparrow is found locally in the eastern US, breeding from eastern Kansas to central Pennsylvania, and north into Wisconsin and Minnesota. Its winter range is similarly localized but the species has been observed in the Southeastern coastal plain from east Texas to North Carolina (Herkert et al. 2020). In South Carolina, Henslow's Sparrows winter throughout the Coastal Plain, extending inland from the coast and throughout the Sandhills (Cely 2003; Seriff and Beirregaard 2018). Although the species is inconspicuous and not often reported on BBS routes, long-term declines are evident for this species both within South Carolina (McNair and Post 2000) and across its range. The rangewide population estimate is 410,000 individuals (PIF 2023) with a 10% estimated decline between 1970 and 2014 (Rosenberg et al. 2016).

The Pine Siskin can be found across North America, with resident populations in the western US and Canada. This species is an irruptive migrant and winters in large flocks throughout the Midwest and eastern US in response to poor food availability in their breeding range (Dawson 2020). In South Carolina, Pine Siskins are a common winter visitor in irruption years throughout the state and are often observed at backyard feeders; Root (1988) also indicated the species uses xeric pine forests throughout the Southeast. Although the rangewide population estimate for the

species is still quite high (46 million individuals; PIF 2023), BBS data report a concerning 2.2% annual rate of decline between 1966 and 2021 (Ziolkowski et al. 2022).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Each of these species is dependent upon southern pine-dominated landscapes for all or part of their life cycles. The American Kestrel is a secondary cavity nesting species and habitat generalist, though they prefer semi-open habitats. The Southeastern subspecies' historical range was closely associated with longleaf pine savannas (Hunter et al. 2001; FFWCC 2024), which provide the open structure preferred for foraging as well as an abundance of pine snags for nesting or perching (Smallwood and Bird 2020). Kestrels are "sit-and-wait" predators and will locate insects and small mammals in natural or artificial habitat openings, such as agricultural fields, roadsides, savannas, and woodland margins (Hamel 1992). As with other obligate cavity nesters, the species is often limited by the availability of suitable cavities; currently, few birds nest in natural cavities due to a lack of standing snags in open pinewoods and agricultural areas (Hunter et al. 2001). Nest box installation programs have allowed Kestrels to breed in previously unoccupied habitats (Smallwood and Bird 2020) and led to an increase in occupancy in the midlands of South Carolina (Cely and Sorrow 1988) and north-central Florida (Smallwood and Collopy 2009). Given that suitable cavities are available, preferred nest sites are located in open sites with minimal woody cover.

Bachman's Sparrows are found in open pine forests and grassland habitats and appear to occur at higher densities in areas also managed for Red-cockaded Woodpeckers (Dunning et al. 2020). They are ground nesters, constructing domed cup nests in patches of grasses and forbs. In addition to nesting on the ground, Bachman's Sparrows also forage primarily on the ground for grass seeds and invertebrates. The species is associated with habitat that possesses a relatively dense grass and forb layer and few tall shrubs or understory trees, with young (1- to 5-year-old clearcuts or powerline rights-of-way) and mature pine stands (≥80 years old) most frequently occupied (Dunning and Watts 1990a; 1990b). Generally, one of the strongest predictors of Bachman's Sparrow occupancy is the frequency of fire in a landscape; the species has been shown to abandon areas that go longer than 3 years without burning (Engstrom et al. 1984; Tucker et al. 2004; Dunning, personal observations). Landscape connectivity is also an important aspect of habitat suitability for Bachman's Sparrows, as they appear to be intolerant of habitat fragmentation and isolation (Taillie et al. 2015; Jones et al. 2017).

Red-headed woodpeckers are strongly associated with open forest, savanna habitats that have snags and decaying trees available for cavity excavation. The species has a varied diet of flying insects, seeds, nuts, and berries, and often captures insect prey by flycatching (Frei et al. 2020). In the Southeast, Red-headed Woodpeckers are found in the variety of habitat types, including pine flatwoods and savannas, mixed-pine hardwood forests, or urban areas, though disturbances that create snags or reduce midstory presence (e.g. prescribed fire, weather events) appear to have a positive effect on species density (Steen et al. 2013; Rose and Simons 2016; Frei et al. 2020).

The winter habitat requirements of Henslow's Sparrows are generally understudied, though open areas with dense, moist ground cover are likely important (Hunter et al. 2001; Herkert et al. 2020). In the Gulf Coastal Plain, wintering individuals have been observed in moist grassy areas or pitcher plant bogs under open pinewoods (Plentovitch et al. 1999). In the Coastal Plain of South Carolina, Henslow's Sparrows winter in grassy, non-inundated Carolina bays and in utility rights-of-way maintained in grasses (Champlin 2007). Soil moisture may not be as important further inland, where xeric upland rights-of-way supported more sparrows than Carolina bays (Champlin and Kilgo, unpublished data). Overall, the species appears to benefit on wintering grounds from pine savanna habitat that is frequently burned and has dense groundcover with high seed and insect availability for foraging (Thatcher et al. 2006; Johnson et al. 2011; Herkert et al. 2020).

The Pine Siskin primarily moves and forages in groups during the winter. They are seed eaters and feed in the canopies of conifer and hardwood trees but are also common visitors at artificial bird feeders in South Carolina (Dawson 2020). As their name suggests, Pine Siskins select for open, coniferous habitats on their breeding and wintering ranges. However, their winter habitat use tends to be more generalized to areas with high food availability (Dawson 2020), with sightings of Pine Siskins in South Carolina ranging from mature pine savanna, river bottoms, maritime forests, and suburban to urban habitats (Seriff and Beirregaard 2018; eBird 2024).

CHALLENGES

The greatest challenge to viability of these species is directly related to the availability and condition of their optimal habitat: the pine savanna. Prior to European settlement, the greater longleaf savanna ecosystem spanned over 92 million acres of the southeastern US and was maintained through frequent wildfires and indigenous land management. However, by the 1930s, the majority of these pines had been harvested; approximately 3% of the original longleaf forests remain standing today (Frost 1993). The loss of longleaf pine stands, especially those with intact understory, is particularly devastating to plant and animal species that depend upon a fire-maintained ecosystem. Although longleaf pine is ecologically the most important species of pine found in South Carolina, other species, such as loblolly (P. taeda) and slash pine (P. elliottii) have become more important economically and can also be managed to create savanna habitat in the absence of longleaf. Direct loss of habitat occurs when mature pine stands are converted for urban development, agricultural purposes, or timber production, while fire suppression leads to indirect habitat loss. For existing pine savanna habitat, intensive management is required to restore and maintain its historic condition. Prescribed fire on a 2-3-year rotation is the most effective tool for managing pine savannas, as this prevents midstory encroachment and maintains groundcover conditions, but Outcalt (2000) estimated that only half of available longleaf stands were burned within the previous 5 years. Additionally, former agricultural areas restored to longleaf may no longer provide the appropriate herbaceous groundcover due to deficiencies in the seed bank (Imm and McLeod 2005).

Species-specific challenges for the three resident species in this guild include low availability of suitable natural nest cavities for the Southeastern American Kestrel (Smallwood and Bird 2020) and Red-headed Woodpecker, as well as the negative effects of pine habitat fragmentation and

isolation on Bachman's Sparrow populations (Dunning et al. 2020). Dead and dying trees in suitable habitat are often removed because they are believed to be safety hazards, a refuge for pests, or are undesirable from a timber revenue or aesthetic standpoint, resulting in decreased nesting opportunities for obligate cavity nesters. Additionally, the current lack of state survey or monitoring programs outside of the BBS poses a barrier to understanding the ecology of wintering species. Standardized winter monitoring efforts may improve data on the distribution and habitat associations of Henslow's Sparrows and Pine Siskins in South Carolina.

CONSERVATION ACCOMPLISHMENTS

Continued restoration of the longleaf pine ecosystem in South Carolina is the most notable accomplishment to date for conservation of the pine savanna guild. Multiple public and private partners lead initiatives to reintroduce and restore longleaf pine habitat, as well as educate the public on the importance of the longleaf ecosystem. The federal Natural Resources Conservation Service (NRCS) introduced the Longleaf Pine Initiative in 2010 to encourage longleaf restoration on private forest and agricultural lands via financial and technical assistance. Since its formation, approximately 870,000 private acres have been restored to longleaf forest (NRCS 2024). Private organizations, such as Longleaf Alliance and the American Forest Foundation have also contributed to the effort of restoring longleaf ecosystems. For example, the American Forest Foundation has supported the publication of the *Forest Ecosystem Conservation Handbook for Birds in Georgia: A Guide for Family Forest Owners* (DeBerry 2005). Longleaf Alliance is a frequent partner with public and private stakeholders and provides cost share and grant opportunities for projects aimed at restoring the longleaf pine ecosystem in the Southeast. Additionally, state and federal agencies in South Carolina prioritize the acquisition and protection of land with remnant longleaf or pine savanna habitat and manage it to maintain its historic condition and benefit wildlife resources.

Red-cockaded Woodpecker (RCW) conservation has a symbiotic relationship with longleaf and pine savanna conservation, where both directly advance the other. A landmark benefit to the longleaf ecosystem was the completion and implementation of the updated RCW Recovery Plan in 2003 (USFWS 2003). Management requirements for RCW outlined in the Recovery Plan promote an open stand structure, reduced hardwood midstory, and improved groundcover condition, thus benefitting ecosystem health and conservation goals for other species which benefit from pine savannas. The RCW Safe Harbor Program has played a notable role in promoting management of pine savanna habitat on private lands. The program was developed by USFWS in 1998 to address land-use restrictions incurred under the Endangered Species Act. Those enrolled in the program do not incur additional regulatory restrictions for RCWs nesting on their land, thus removing the disincentives for managing pine forests in a manner that benefits pine savanna species.

Finally, measuring accomplishments for these species depends on the continued participation by state employees and volunteers in the Breeding Bird Survey and other avian surveys established in South Carolina, such as the Christmas Bird Count, International Migratory Bird Day, and the Great Backyard Bird Count. In the last decade, eBird has also become an important means of

crowdsourcing data on avian abundance, range limits, and habitat use, and will likely play a large role in assessing population status for species of concern (eBird 2024).

CONSERVATION RECOMMENDATIONS

Landscape-Level

- Continue the restoration and reintroduction of the longleaf pine ecosystem across South Carolina.
- In areas devoid of site-appropriate savanna species or with depauperate seed banks, establish wiregrass (*Aristida stricta, A. beyrichiana*) and other herbaceous species through propagation from local seed sources.
- Conduct landscape level spatial analyses on the geographic distribution and patch sizes of pine forest types in South Carolina to identify priority reintroduction or management areas and assess potential for land acquisition.
- Increase state and federally owned acreage through strategic acquisition to reduce forest fragmentation and create dispersal corridors, while protecting and managing existing areas that support pine savannas.
- Continue involvement in and delivery of private, state, and federal conservation programs aiding pine savanna restoration and management in South Carolina (NRCS Longleaf Pine Initiative, SCDNR Safe Harbor Program, USFWS Partners for Fish and Wildlife, Longleaf Alliance plantings and cost share program, etc.)
- Promote the use of best management practices (BMPs) for all pine species in Forest Stewardship Plans, including increased rotation length, decreased stocking densities, promotion of site prep burning, decreased use of chemicals, increased use of growing and dormant season prescribed fire, increased width of Streamside Management Zones, and selection of site-appropriate species.
- Derive quantitative habitat objectives for priority pine savanna species and test assumptions (identify habitat-specific densities, limiting factors) in order to model habitat requirements necessary to meet population objectives.
- Develop and implement monitoring programs to better assess breeding and wintering bird abundance and to quantify short- and long-term population trends in pine savannas (e.g. species response to fire reintroduction, etc.). Monitoring will need to be more frequent and tailored to better detect cryptic species such as Bachman's and Henslow's Sparrows. Develop training workshops or establish a bird counting team for volunteers, or utilize publicly-available eBird data.
- Continue to use the Breeding Bird Survey as a surveillance monitoring technique for pine savanna residents.
- Continue participation in the Atlantic Coast Joint Venture at the management board and science committee levels.

Species-Level

- Encourage the retention of standing pine snags on public and private land to provide nesting structures for Southeastern American Kestrels and Red-headed Woodpeckers.

- Provide artificial nest boxes for Southeastern American Kestrels in cavity-limited areas.
- Maintain a 1-2 -year fire rotation and intensive midstory management in areas that currently, or have the potential to, support Bachman's Sparrow populations.
- Investigate overwintering habitat preferences of Henslow's Sparrows and Pine Siskins through increased winter survey efforts and eBird data.

MEASURES OF SUCCESS

Reintroduction and restoration of the longleaf pine ecosystem and other pine savanna habitats in significant acreages across South Carolina provides benefits to a wide range of taxa. The continued use of prescribed fire at 1-3 year intervals, mechanical or chemical midstory treatments, and improvement of understory characteristics will improve ecological function of these habitat types. The resulting increase in plant species richness should expand food web complexity and plant-pollinator relationships, thus improving resource availability for priority bird species. Strategic land acquisition and protection of existing pine savanna by public agencies and other conservation programs will improve habitat connectivity, thus reducing impacts of isolation or small patch size on resident source populations.

Priority species occurrence and/or density increases within pine savanna habitats through a combination of habitat and monitoring improvements. Quantifying species-specific habitat objectives will indicate if PIF population goals are attainable for South Carolina and whether changes to these objectives are necessary. In some cases, it may be unrealistic to achieve PIF continental population goals due to irreparable habitat loss. However, South Carolina may provide essential source populations or habitats for some species, so measures will need to be developed to integrate monitoring results into regional- and national-level databases.

Other bird species that are likely to be positively affected by pine savanna management and restoration include: Brown-headed Nuthatch (*Sitta pusilla*), Carolina Wren (*Thryothorus ludovicianus*), Eastern Towhee (*Pipilo erythrophthalmus*), Northern Bobwhite (*Colinus virginianus*), Prairie Warbler (*Setophaga discolor*), Red-bellied Woodpecker (*Melanerpes carolinus*), Red-shouldered Hawk (*Buteo lineatus*), White-eyed Vireo (*Vireo griseus*), Wood Thrush (*Hylocichla mustelina*), Yellow-throated Vireo (*Vireo flavifrons*), and Yellow-throated Warbler (*Setophaga dominica*) (Rich et al. 2004). Management efforts for bird species in this guild should also positively impact other state priority species including the fox squirrel (*Sciurus niger*), gopher frog (*Lithobates capito*), flatwoods salamander (*Ambystoma cingulatum*), gopher tortoise (*Gopherus polyphemus*), and indigo snake (*Drymarchon couperi*).

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Prairie Warbler

Setophaga discolor

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DESCRIPTION

Taxonomy and Basic Description

The Prairie Warbler is a small songbird averaging 12.1 cm (4.75 in.) in length and 7.7 g (0.27 oz.) in weight (Sibley 2003). Male and female Prairie Warblers look similar. This bird has yellow underparts, black stripes on the sides of the body, a brownish green back, and two black face marks. Males can be distinguished from females by darker coloration and the presence of chestnut-colored streaks on the back. This species can also be identified by its propensity to bob its tail. Juvenile birds appear quite differently, but also bob their tails (Peterson and Peterson 2002).


Prairie Warbler by USFWS

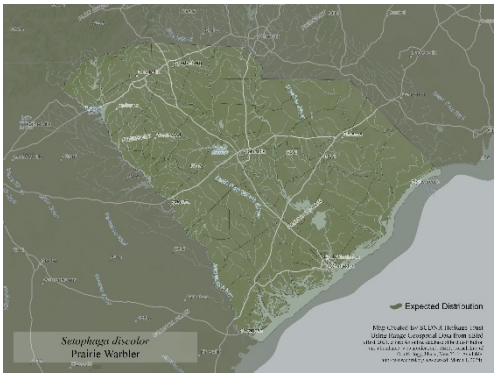
Two subspecies occur distinguished by rectrix pattern, plumage color, and body size. *S. d. discolor* is the smaller of the subspecies and is found in South Carolina. It breeds across the southeastern United States to northern Florida. *S. d. discolor* winters primarily in the Caribbean Basin, particularly on the Greater Antilles, with some occurring south along the eastern edge of the Yucatan Peninsula (Nolan et al. 2020).

Status

Prairie Warblers nest in shrubby habitat without a closed canopy. This habitat occurs in disturbed sites such as abandoned farmland and burned forest stands. These habitats are currently in decline in the face of urban sprawl and reforestation thus Prairie Warblers are experiencing population declines (Askins and Zickefoose 2000 and 2001, Hunter et al. 2001). Prairie Warblers are not state or federally listed but were listed as “Birds of Conservation Concern” by the U.S. Fish and Wildlife Service in 2021 (USFWS 2021). The 2021 Birds of Conservation Concern was an effort to identify those bird taxa (beyond those already designated as federally threatened or endangered) that represent the highest conservation priorities of the USFWS. Partners in Flight rate the species a 14 out of 20 on the Continental Concern Score, placing it on the Yellow Watch List for species with declining populations.

POPULATION SIZE AND DISTRIBUTION

Prairie Warblers nest in South Carolina and winter in Florida and islands south of Florida. Although rare, they regularly winter in coastal South Carolina. Partners in Flight estimates a global breeding population of 3.6 million individuals (Partners in Flight 2024). The North American Breeding Bird Survey estimates a loss of almost 2% per year between 1966 and 2015, resulting in a cumulative decline of 63% during that time. The Prairie Warbler has experienced long-term (1966 through 2010) population declines of 0.8% in South Carolina with the steepest declines (6.3%) occurring from 1966 through 1979 (Sauer et al. 2012). Recently (2011 through 2021), population trends in South Carolina have continued downward (USGS 2024).



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Prairie Warbler's name is a bit of a misnomer because open prairie is not the preferred habitat. This bird requires a shrubby component to its habitat. The Prairie Warbler can be found breeding in southern pine forests with a well-developed shrub layer, dunes along the Atlantic Coast, scrub oak forests, pine and scrub oak forests, and abandoned pastureland or fields (Nolan et al. 2020). Historically fire, floods, windstorms, and herbivores maintained habitat conditions conducive to disturbance-dependent species, such as Prairie Warblers (Askins 2001). Fire suppression, the loss of large canopy tress such as the American chestnut (*Castanaea dentata*), and the extirpation of beaver (*Castor canadensis*) and mega herbivores such as elk (*Cervus elaphus*) and bison (*Bison bison*) following European settlement, reduced the availability of early-successional habitat throughout the Eastern US (Askins and Zickefoose 2000). In Eastern North Carolina, minimum patch size of suitable shrubland habitat for Prairie Warblers is estimated to be 1.1 ha (Shake et al. 2012). Prairie Warblers place their nests in trees and shrubs, 1-2 meters from the ground.

CHALLENGES

Habitat loss and suppression of disturbance regimes are the main challenges to Prairie Warblers. The loss of the American chestnut (*Castanea dentata*) resulted in reduced availability of larger tree-fall gaps that create early-successional habitat within a forested landscape. The extirpation of elk and bison, large animals that drive successional processes through herbivory, has also reduced the ecological forces that maintain early-succession habitat. Additionally, fire suppression and a less abundant population of beavers have reduced available habitat for disturbance-dependent birds.

Even-aged timber management reduces the structural complexity of forested landscapes upon which the Prairie Warbler depends. Urban development and the conversion of agricultural land

to monoculture plantations has reduced the available habitat for the Prairie Warbler. Other causes of population decline in members of this guild may be attributed to bird strikes at communication towers and wind turbines, brood parasitism by the Brown-headed Cowbird (*Molothrus ater*) (another disturbance-dependent species), and habitat loss on wintering grounds. Although brood parasitism of Prairie Warbler nests in South Carolina is low (14%), Prairie Warblers are among the 4 most frequently parasitized species in the region (Kilgo and Moorman 2003).

CONSERVATION ACCOMPLISHMENTS

No conservation initiatives have been set specifically for Prairie Warblers.

Long-term monitoring programs, such as the Breeding Bird Survey have provided population trend data that enables biologists and land managers to prioritize management decisions based on the knowledge of population trends.

National initiatives such as the Partners in Flight (PIF) Landbird Conservation Plan (Rich et al. 2004) and the North American Bird Conservation Initiative (NABCI 2005) have provided a method by which interested parties can coordinate conservation activities. These initiatives have provided guidelines for priority species, population and habitat objectives, and recommendations for conservation actions. State and federal agencies have implemented habitat improvement projects based on guidelines outlined in PIF and NABCI.

CONSERVATION RECOMMENDATIONS

- Utilize GIS and land type associations to determine total area and distribution of available habitat. Modeling will enable SCDNR to prioritize land acquisition and habitat improvement projects.
- Partner with other land management agencies and make recommendations about habitat improvement projects that benefit early-succession species.
- Expand the use of Farm Bill and other cost-share programs to implement activities that integrate habitat objectives for early-succession birds.
- Expand participation in the Landowner Incentive Program (LIP) to create or enhance habitat on private lands.
- Promote the use of Best Management Practices that support providing buffer zones and that increase structural diversity (such as providing small clearcuts).
- Partner with appropriate agencies to encourage prescribed burning activities on public and private lands.
- Work with international partners to identify problems on wintering grounds. Where feasible, provide financial incentives to conserve habitat.
- Continue to monitor populations of early-succession birds through participation in the Breeding Bird Survey (BBS).
- Initiate agency supported monitoring programs, such as Partners In Flight (PIF) point counts.
- Expand monitoring programs to areas not adequately sampled.
- Monitor bird response to management activities both pre- and post-treatment.

- Continue to strengthen partnerships with regional and national initiatives such as the Atlantic Coast Joint Venture, PIF and NABCI.
- Pursue opportunities for funding for land acquisition or management activities through partnerships with regional agencies and NGOs.
- Develop partnerships with recreational bird watching organizations in the State.
- Research effects of bird strikes on migratory bird populations and partner with the communications industry to work toward solutions in SC.

MEASURES OF SUCCESS

The first measure of success will be to implement monitoring programs that will allow SCDNR to document population trends and avian response to management in South Carolina. The next goal will be to determine population and habitat objectives for this species. Finally, implementing the above-mentioned recommendations to provide the appropriate quantity of habitat to support target populations will be important.

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Red-cockaded Woodpecker

Dryobates borealis


Photo by SCDNR

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TAXONOMY & BASIC DESCRIPTION

Red-cockaded Woodpeckers were first described by the amateur naturalist Vieillot (1807) and named *Picus borealis*. In 1810, Alexander Wilson, unaware of Vieillot's previous description, described the species as *Picus querulus* because of its distinctive vocalizations (Wilson 1810). The species had been known as *Picoides borealis* until 2018 when the name was changed to *Dryobates borealis* after overwhelming scientific consensus found the genus *Picoides* to be polyphyletic; they share common characteristics with the *Picoides* woodpeckers, but do not share an immediate common ancestor (American Ornithological Society, 2018). The common name used today, Red-cockaded Woodpecker, was given to the species by AlexanderWilson. During Wilson's time, cockade was a commonly used term for a ribbon or other ornament worn on a hat to indicate rank or membership, and refers to the small patch of red feathers on the head of adult males, located between the black crown and white cheek patch.

Red-cockaded Woodpeckers are relatively small; adults measure 20 to 23 cm (7.8 to 9 in.) and weigh 40 to 55 g (1.4 to 1.9 oz.) (Jackson 1994; Conner et al. 2001). They are smaller than other southern woodpeckers except the Downy Woodpecker (*Picoides pubescens*) and are similar in size to Yellow-bellied Sapsuckers (*Sphyrapicus varius*). Red-cockaded Woodpecker size varies geographically, with larger birds to the north (Mengel and Jackson 1977).

Red-cockaded Woodpeckers are relatively slender, long-tailed and small-billed woodpeckers. They are black and white with a coarsely barred back, white cheek patch and black crown. Their breasts and bellies are white to grayish-white with spots on the sides changing to bars on the flanks. Outer tail feathers are white with black barring and central tail feathers are black. Adult plumage is nearly identical between sexes and generally indistinguishable in the field without optics. The only difference between adult males and females is the presence of the red cockade at the upper edge of the white auriculars, which is virtually invisible in field situations (Jackson 1994). Juveniles appear similar to adults but may be distinguished in the field by duller plumage, white flecks often present just above the bill on the forehead, and diffuse black shading in the white cheek patch. Juvenile males have a distinctive red patch on the crown and may be distinguished from juvenile females in this way (Jackson 1994). A juvenile's head plumage is generally molted and replaced with adult plumage by early Fall of their birth year.

STATUS

The Red-cockaded Woodpecker was among the first species to be listed as endangered in 1970 and received federal protection under the Endangered Species Act of 1973. Once a common bird, historical population estimates range from 1-1.6 million family groups (Conner et al. 2001). However, by 1970, the species had declined to no more than 4,000 family groups in widely scattered, isolated and declining populations (Jackson 1978). Due to advances in knowledge of Red-cockaded Woodpecker population dynamics and the use of highly effective management tools, such as artificial cavities and translocations, most public land populations of Red-cockaded The Partners in Flight Watch List has classified Red-cockaded Woodpecker as "tipping point yellow;" species that are range restricted and occur in small populations in need of constant care (Panjabi et al, 2020). The South Carolina Department of Natural Resources Heritage Trust program describes the species as imperiled state-wide because of rarity or factor(s) making it vulnerable (S2) while globally the species is ranked as vulnerable (G3). In November 2024, USFWS made a final ruling downlisting the species from Endangered to Threatened. Although this determination was made based on a number of important recovery milestones and stable to increasing population numbers across the species' range, Red-cockaded Woodpecker population viability is still threatened by the small, scattered, and isolated nature of most populations. Thus, the species continues to receive similar levels of protection, with some exceptions concerning incidental take from beneficial management practices, under Section 4(d) of the Endangered Species Act.

POPULATION SIZE AND DISTRIBUTION

Red-cockaded Woodpeckers are monitored based on the number of groups (a breeding pair with 0 to 7 helpers or a solitary male) and the clusters on which they depend (the actual physical cavity trees and acreage surrounding those trees). In 2020, there were an estimated 7,794 known active clusters across 11 states and distributed among 124 demographic populations; this number represents a small fraction of the estimated Red-cockaded Woodpecker abundance at the time of European settlement (USFWS 2020). In 2024 South Carolina, there were 278 groups on state-owned lands and another 921 groups on federal properties. Private properties enrolled in the SCDNR Safe Harbor program held another 479 groups. Based on these numbers, there were 1,678 known red-cockaded woodpecker groups in South Carolina in 2024, representing approximately 21.5% of all known Red-cockaded Woodpecker groups range-wide.

Populations of Red-cockaded Woodpeckers are distributed across the Southeastern United States and managed by distinct recovery units, across which recovery criteria must be met for the species to be removed from the Endangered Species List. In South Carolina, there are recovery populations in 4 of the 13 recovery units. These recovery units are the South Atlantic Coastal Plain, Mid-Atlantic Coastal Plain, Sandhills and Piedmont. No public lands RCW populations existed within the South Carolina Piedmont when the 2003 RCW Recovery Plan was published so these populations were not included in the recovery criteria.

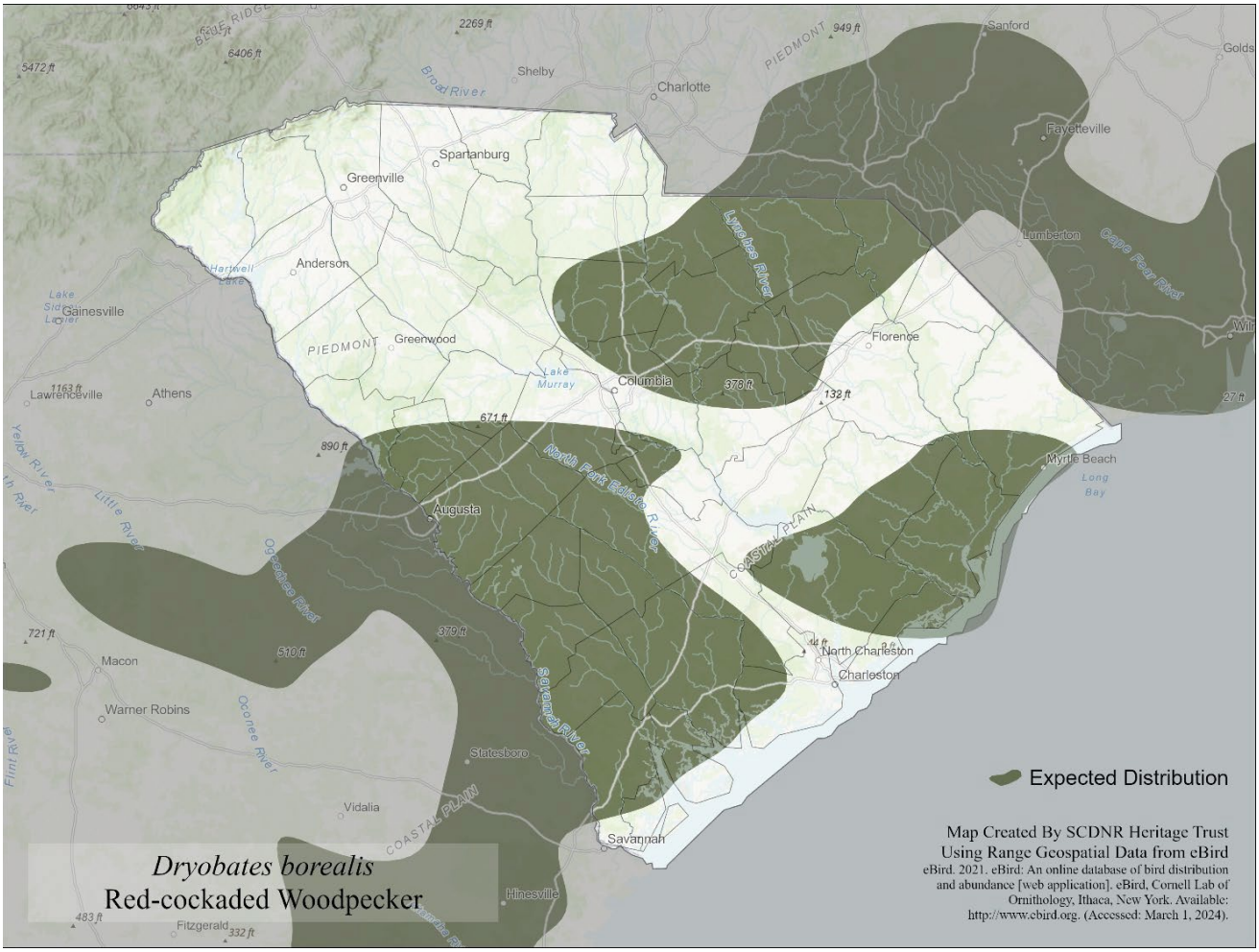


Figure 1. Current range of Red-cockaded Woodpeckers in South Carolina.

Recovery Unit Population	Agency	Type	Current Status	Population Goal
Mid Atlantic Coastal Plain				
Francis Marion National Forest	USFS	Primary	533**	350**
Lewis Ocean Bay Heritage Preserve	SCDNR	Significant	13	10
Longleaf Pine Heritage Preserve	SCDNR	Important	6	4
Sandy Island	TNC	Significant	32	35
Santee Coastal Reserve	SCDNR	Significant	20	16
Wedge Plantation	Private	Important	2	2
Yawkey Wildlife Center	SCDNR	Significant	13	15
Sandhills				
Carolina Sandhills National Wildlife Refuge	USFWS	Secondary	159**	250**^
Sand Hills State Forest	SCFC	Secondary	126**	250**^
Cheraw State Fish Hatchery	SCDNR	Important	1	1
Cheraw State Park	SCPRT	Significant	22	25
Fort Jackson	DOD	Significant	69	126
Manchester State Forest	SCFC	Important	5	3
Poinsett Weapons Range	DOD	Significant	37	30
South Atlantic Coastal Plain				
Savannah River Site	DOE	Secondary	151**	250**
Charleston Naval Weapons Station	DOD	Significant	0	12
Persanti Island	SC	Important	0	3
Santee State Park	SCPRT	Important	0	7
Webb Wildlife Center	SCDNR	Significant	25	30

**Number of Potential Breeding Groups (PBGs)
^ Number represents the combined Recovery Goal for the SC Sandhills Secondary Core, which includes Carolina Sandhills National Wildlife Refuge and Sandhills Sate Forest.

Figure 2: Red-cockaded Woodpecker populations on public lands in South Carolina by recovery unit. Each population has a designated role in recovery. Also listed are the property ownership, the type of recovery population, the current status of Red-cockaded Woodpecker groups (represented as number of active clusters unless otherwise noted), and the population goal for the property. Primary core (Primary) populations are those that will have at least 350 potential breeding groups (PBGs) at recovery; secondary core (Secondary) populations are those that will have at least 250 PBGs at recovery; significant support (Significant) are those populations that have a population goal of 10 or more active clusters; and important support (Important) are those populations that have a population goal of less than 10 active groups.

Recovery Unit Population	Agency	Type	Current Status	Population Goal
Mid-Atlantic Coastal Plain				
Bonneau Ferry WMA*	SCDNR	Significant	23	20
Hampton Plantation State Historic Site	SCPRT	Important	1	1
Lynchburg Savanna Heritage Preserve	SCDNR	Important	1	2
Ramsey Grove Plantation	SCPRT	Important	2	-
Samworth WMA	SCDNR	Important	1	1
Sandhills				
Aiken Gopher Tortoise Heritage Preserve	SCDNR	Important	3	3
Aiken State Park	SCPRT	Important	3	3
Piedmont	USFS	Important	10	18
Sumter National Forest – Long Cane District	USFS	Important	1	-
Sumter National Forest – Enoree District				
South Atlantic Coastal Plain				
Donnelley WMA	SCDNR	Significant	10	10
Tillman Sand Ridge Heritage Preserve	SCDNR	Important	3	3

Figure 3: Red-cockaded Woodpecker populations that have been established since 2003 or were not included* in the USFWS 2003 Recovery Plan.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Red-cockaded Woodpeckers depend on open, “park-like” mature pine woodlands and savannahs with large, old pines for nesting and foraging habitat. Large old pines are required because these birds excavate roost and nest cavities in living pine trees. The cavities are excavated completely within the heartwood; therefore, the trees must be old and large enough to have room for the cavity chamber. Additionally, old trees are more likely to have heartwood decay, which greatly facilitates cavity excavation. The cavity trees must be in open stands with little or no hardwood midstory and little or no hardwood in the canopy. Once the midstory reaches cavity height, Red-cockaded Woodpeckers typically abandon the cluster. Red-cockaded Woodpeckers will use nearly all of the southern yellow pines for cavity trees, including loblolly pine (*Pinus taeda*), shortleaf pine (*Pinus echinata*), pond pine (*Pinus serotina*), slash pine (*Pinus elliottii*) and longleaf pine (*Pinus palustris*), but prefer longleaf pine (Jackson 1994).

Red-cockaded Woodpeckers have very large foraging territories requiring vast areas of open pine habitat. Suitable foraging habitat consists of large mature pines, little or no midstory, and abundant herbaceous ground cover including native bunchgrasses and forbs. Red-cockaded Woodpeckers require 30 to 81 contiguous hectares (75 to 200 acres) of this foraging habitat, depending on the habitat quality. Red-cockaded Woodpeckers prefer to forage on mature longleaf pine trees, but will forage on younger trees and other pine species and the occasional hardwood tree. High-quality foraging habitat that results in the highest Red-cockaded Woodpecker productivity is contiguous open stands of mature longleaf pine with an herbaceous ground cover (Jackson 1994).

Red-cockaded Woodpeckers evolved in a fire-dominated ecosystem. The history of fire in the Southeast has both natural and human components. Fires were ignited naturally due to frequent lightning strikes. Both Native Americans and European settlers used fire to clear land and improve hunting grounds. Frequent fires resulted in an open forest with large pines, little to no midstory, and diverse herbaceous ground cover; this represents the ideal habitat for Red-cockaded Woodpeckers and other species of the longleaf pine ecosystem. However, much of the currently available habitat has been subjected to fire suppression and has become unsuitable for Red-cockaded Woodpecker use due to the presence of a dense hardwood midstory and/or canopy. Fire is essential to maintaining and restoring southern pine ecosystems, particularly the longleaf pine ecosystem, and is essential to Red-cockaded Woodpecker habitat maintenance and restoration (USFWS 2003).

CHALLENGES

Lack of suitable habitat is the underlying cause for all the primary threats to Red-cockaded Woodpecker species viability. First, there is very little of the open mature pine habitat remaining. The majority of the longleaf pine habitat that once covered the southeast has been destroyed. Of the remaining habitat, only a small amount is thought to be in pristine condition.

The serious threats from this lack of habitat fall into 4 basic categories (USFWS 2003):

(1) insufficient number of existing suitable cavities and the continued net loss of cavity trees in the environment (Costa and Escano 1989; James 1995; Hardesty et al. 1995);
(2) habitat fragmentation and the resulting impacts on genetic variation, dispersal, and demography (Conner and Rudolph 1991);
(3) lack of sufficient amounts of quality foraging habitat (Walters et al. 2000, 2002; James et al. 2001); and
(4) risks of extinction inherent to critically small populations (Shaffer 1981, 1987).

Red-cockaded Woodpeckers depend on mature pine trees for both cavity excavation and foraging substrate. Lack of mature pine trees in suitable habitat because of past and present fire suppression and silvicultural practices resulted in a severe shortage of these trees in the landscape. Red-cockaded Woodpecker groups that lack sufficient cavities for the group have been shown to decrease reproductive output. Decreased reproductive output has also been linked to an insufficient amount of quality foraging habitat. Habitat fragmentation reduces the ability for Red-cockaded Woodpeckers to disperse between clusters. This reduces the ability of individuals to find breeding vacancies, which influences both the genetic variation of populations

and overall demographic stability. Most critically, small populations face an inherent set of risks related to the size of the population. These risks include extirpation due to random environmental, demographic, genetic, and catastrophic events (Shaffer 1981, 1987).

In South Carolina, there are two primary threats that affect the availability of habitat, and, ultimately, Red-cockaded Woodpecker recovery now and in the future. The first is a lack of prescribed fire in existing and potential habitat. It has become increasingly difficult for private landowners and government agencies to burn their properties for wildlife management because of liability issues. Until this problem is solved, more and more landowners will opt not to conduct prescribed burning activities. The ultimate result will be less suitable habitat for Red-cockaded Woodpeckers and other wildlife.

The second major threat to Red-cockaded Woodpeckers in South Carolina is the risk of natural catastrophes, specifically hurricanes. The majority of Red-cockaded Woodpeckers in South Carolina are present in the Coastal Plain and face significant risks from hurricanes. Cavity trees are particularly susceptible from winds associated with tropical weather systems while foraging habitat can be devastated from hurricane force winds (Conner et al. 2001).

Red-cockaded Woodpecker surveys on SCDNR lands are ongoing; complete surveys should be conducted at least once every 10 years. Further, the last update to Red-cockaded Woodpecker status on private lands in South Carolina was conducted in the late 1980s to early 1990s. Private lands status should be updated periodically by field surveys and questionnaires to determine the current trend and management needs on private lands. This goal can largely be achieved by annual reports completed by Safe Harbor enrollees.

Avian Keratin Disorder

Avian keratin disorder (AKD), also called hyperkeratosis, is a disorder seen in several avian species often resulting in a dramatic elongation of the beak. Research with Black-capped Chickadees points toward Poecivirus, a rapidly mutating RNA-virus that is able to move between species, as the culprit, though this has yet to be confirmed with RCW (Zylberberg et al. 2018). Infected individuals can have significantly elongated bills that impair their ability to forage effectively. Birds suffering from AKD often experience beak elongation, increase in brittleness of beak, elongation/curvature of claws, deterioration of feather and body condition and skin ulcers or tumors (Handel et al. 2010). RCW's with AKD have been observed in multiple populations throughout the state of South Carolina. Recommendations to prevent spread include standard disinfection measures on any equipment used while capturing or handling RCW. Research regarding AKD in RCW is ongoing.

CONSERVATION ACCOMPLISHMENTS

Conservation accomplishments can be divided into 3 major categories. The first relates to advances in understanding population dynamics and advances in management techniques related to stabilizing and increasing populations of Red-cockaded Woodpeckers. The second category results directly from the recovery plan for Red-cockaded Woodpeckers (USFWS 2003). The

third category of accomplishments relates to the successful development and implementation of the Safe Harbor program in South Carolina.

Population Dynamics/Management

- Increased knowledge of population dynamics due to extensive research in South Carolina and across the Southeast has led to better translocation procedures which facilitates Red-cockaded Woodpecker population growth range-wide.
- Advancements in artificial cavity installation technique have allowed for unprecedented growth of existing populations and the creation of new populations through a combination of cavity creation and translocations.
- Due to these practices, most populations of Red-cockaded Woodpeckers on public lands were stabilized to increasing by the mid-1990s. Prior to these advances, nearly all populations were declining.

Red-cockaded Woodpecker Recovery Plan

- Drafts of the USFWS Red-cockaded Woodpecker Recovery Plan established required population goals for all federal properties and for one state property, Sandhills State Forest, and suggested goals for all other public properties in South Carolina (Figure 2). These established goals have resulted in population growth across all federal properties and most state properties. The most recent draft of the Recovery Plan was published in 2003. Many new populations have been established since that time that are not included in the plan (Figure 3).
- Recovery Plan guidelines established standard practices for management and reporting, resulting in a consistent recovery effort range-wide, including South Carolina.
- Recovery Plan guidelines call for annual average growth rates of 5% on all recovery populations. These goals have been met on most properties, resulting in overall growth on public lands in South Carolina.
- Translocation, intensive habitat management, and creation of recruitment clusters have yielded marked increases in many populations and creation of new populations in recent years.
- Efforts to establish RCW populations on suitable SCDNR properties have resulted in the creation 17 new colonies on 4 different properties since 2015. Donnelley WMA has a population of 10 active clusters, Aiken Gopher Tortoise HP has 3 active clusters, Lynchburg Savanna HP has 1 active cluster and Tillman Sandridge HP has 3 active clusters.

Safe Harbor Program

Since its introduction in 1998, the South Carolina Red-cockaded Woodpecker (RCW) Safe Harbor Program has grown to include 198 enrollees and 479 RCW groups, with enrolled properties stretching from Jasper County north to Horry County on the coast and inland from Aiken County north to Chesterfield County. These properties total over 360,000 acres. The Program's success stems from the flexibility the Endangered Species Act (ESA) offers: in exchange for voluntary habitat maintenance and enhancement, landowners are exempted from

ESA restrictions for any RCW groups that move onto their property in the future as a result of those habitat improvements. Though the November 2024 USFWS ruling to down-list RCW from Endangered to Threatened under the Endangered Species Act will affect neither the Safe Harbor program nor benefits to enrollees, agreements signed after that date will be referred to as Conservation Benefit Agreements.

Key conservation accomplishments related to this program include the following:

- The program has ensured habitat maintenance and enhancement for nearly 500 groups of Red-cockaded Woodpeckers on private lands across 24 South Carolina counties.
- As of 2024, 332 baseline groups and 147 above-baseline groups were known to exist on Safe Harbor properties. These 147 above-baseline groups represent a 44.2% growth in private lands RCW populations after enrollment in the program.
- The use of prescribed fire is a requirement for Safe Harbor enrollment; the program has helped facilitate widespread reintroduction and maintenance of fire on the landscape, thus maintaining and restoring critically imperiled longleaf pine habitat.
- Longleaf restoration is often included as part of a landowner's agreed-upon management activities in a Safe Harbor Agreement, resulting in the creation of higher quality habitat.
- The program continues to create and foster positive working relationships between the private sector, government organizations and private landowners, producing a cooperative effort toward conservation. These relationships provide open communication between RCW biologists, consultants, and landowners who have RCW colonies or habitat, resulting in more favorable management for RCW and other species.

CONSERVATION RECOMMENDATIONS

- According to the 2020 USFWS Species Status Assessment Report for the Red-cockaded Woodpecker, all RCW populatons under 30 breeding groups are considered to have "very low" resiliency and are grouped with those populations most vulnerable to extirpation (USFWS 2020). All SCDNR RCW populations fall within this grouping. Continued growth of the smallest, least resilient public lands populations through provisioning of recruitment clusters and targeted property acquisition will be essential to their long-term persistence.
- Continued annual monitoring of all public lands RCW populations including:
    - Number of active cavities
    - Number of potential breeding groups
    - Number of actual nests including clutch size, number of chicks, number successfully fledged, and sex of all individuals.
- Catastrophic weather events present the greatest immediate threat to RCW populations throughout South Carolina. Rapid post-storm assessment and insert provisioning are essential to reducing population losses. Public lands agencies should make efforts to maintain small teams of individuals who are properly trained to complete this work. In the case of a catastrophic weather event, these teams could work quickly to provision RCW clusters with needed cavities to avoid population declines. As the threat of catastrophic weather is perennial, a continued effort to maintain trained staff should be sustained indefinitely.
- As artificial cavities have allowed for rapid growth and expansion of RCW populations, many RCW groups throughout South Carolina are currently reliant on these cavities. The

goal for all RCW groups that are reliant on artificial cavities should be to provide assistance through maintenance and replacement of these artificial cavities until the group has completed and is roosting and nesting in natural cavities. Kleptoparasite removal will be necessary in the smallest populations (10 groups or less) until cavities are abundant enough within a cluster to reduce cavity competition.

- With the apparent high prevalence of color-band-related injuries in RCW, it is recommended that color banding should only be used if the following conditions are met:
    - Bird health is prioritized and banding/monitoring protocols are closely followed.
    - Banded birds are being closely monitored via resighting for potential band-related injuries, preferably multiple times throughout the year.
    - Any noted injuries are immediately addressed.
    - Banding data is being actively used to further our scientific understanding of RCW.
    - Beginning in 2020, with concurrence from USFWS, SCDNR ceased all color banding activities on SCDNR properties. Banding may be used in the future, as needed, to meet project objectives or requirements.
- Manage Red-cockaded Woodpecker habitat by adhering to the management objectives of the Recovery Plan for this species prepared by the USFWS (2003) including:
    - Application of frequent fire to foraging and cluster habitat.
    - Protection and development of large mature pines throughout the landscape.
    - Protection of existing cavities and provisioning of artificial cavities as necessary to facilitate population growth or to stabilize existing populations.
    - Creation of recruitment clusters to promote population growth.
    - Restoration of sufficient habitat quality and quantity to support species recovery.
- Monitor any birds translocated to or from state-owned properties to determine translocation success.
- Monitor any populations on state-owned properties donating birds for translocation to determine the effect on the donor population.
- Continue administration of the Safe Harbor Program by enrolling properties with Red-cockaded Woodpecker populations and/or longleaf pine habitat and offering technical/management support to landowners.
- Regularly discuss with Safe Harbor enrollees the potential for establishing recruitment or translocation clusters. Public opinion regarding RCW's has shifted dramatically since the 1990's and many of those enrolled in Safe Harbor would like to have birds. Maintain a list of potential recipient properties.
- Provide technical support to private landowners and other public land managers on issues of Red-cockaded Woodpecker management and recovery in cooperation with representatives of the USFWS.
- Continue a focused effort to disseminate RCW and Safe Harbor information to the public. Increased public knowledge of RCW is beneficial to the birds and their recovery.
- Produce annual informational RCW Safe Harbor updates for distribution to Safe Harbor participants, foresters and environmental consultants. Working to celebrate program successes and provide this information to enrollees will make them feel more involved and connected to the goals of the program.

MEASURES OF SUCCESS

If management and conservation recommendations are followed, we should expect to see the following:

- Continued work in expanding public land RCW populations through recruitment, translocation and land acquisition should result in increased population resiliency over time. It is expected that some of SCDNR's larger populations, such as Webb Wildlife Center and Bonneau Ferry WMA, will move from "very low" to "low" resiliency as defined in the USFWS RCW Species Status Assessment.
- Continued enrollment into the Safe Harbor program with no net loss in number of baseline clusters. Though the program is only intended to prevent population decline on private land, we expect to see a continued increase in the number of above-baseline clusters as groups bud and dispersing birds pioneer new clusters.
- Recovery goals for Red-cockaded Woodpeckers will be met on all state-owned lands by the time of de-listing.
- Adequate monitoring and surveys will result in an accurate measure of Red-cockaded Woodpecker status and trends on public and private lands facilitating management decisions to make recovery goals.
- Outreach efforts will educate the public about issues relating to Red-cockaded Woodpecker management and legal responsibilities.

On November 25th, 2024, the USFWS announced the down-listing of Red-cockaded Woodpecker from Endangered to Threatened status under the Endangered Species Act, marking a significant milestone in the species' recovery. Though RCW populations are likely to require active management indefinitely in order to prevent future declines, we believe that populations will continue to expand and become increasingly resilient as long as recovery efforts continue.

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Ruffed Grouse

Bonasa umbellus



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DESCRIPTION

Taxonomy and Basic Description

Linnaeus first described the Ruffed Grouse in 1776, and since then, many subspecies have been named. Johnsgard (1983) distinguishes 11 subspecies; Atwater and Schnell (1989) list 12; and del Hoyo et al. (1994) recognizes 14 subspecies. The Ruffed Grouse is a gallinaceous bird in the Order Galliformes and the Family Phasianidae, which includes grouse, quail, turkey, and pheasants.

The Ruffed Grouse is a chicken-like bird that weighs about 500 g (1.1 lbs.). The genus *Bonasa* is translated as “good when roasted” and the specific epithet *umbellus* means “sunshade” referring to the long, shiny, black or chocolate colored neck feathers most prominent on the male. Males tend to be slightly larger than females and have a large tail that it fans to attract a mate or defend its territory. The female’s tail is similar but smaller and usually is the best external basis for determining sex (Gough 1998). Across most of its range, a fully-grown tail feather of over 14.9 cm (5.87 in.) in length usually belongs to a male; less than 14 cm (5.5 in.), a hen. Ruffed Grouse have two or more color phases ranging from a grayish to a reddish-brown color. Red-phased grouse become more prevalent in milder climates while gray birds are more abundant where winter climates are more severe. Male Ruffed Grouse are aggressively territorial throughout their adult lives and proclaim their area with a “drumming” display. The male usually stands on a log, stone or mound of dirt and beats his wings against the air to create a vacuum, creating a drumming sound. The substrate, often called a “drumming log,” is used strictly for a stage; the bird does not strike the “log” to make the sound (Rusch et al. 2000).

Chicks are precocial and are not much larger than a man’s thumb when they leave the nest. They are very mobile and begin flying when about 5 days old. The hen may lead her brood as far as four miles from the nest to a summer brood range during their first 10 days of life. By 17 weeks of life, the chicks have reached their adult weight and usually disperse to find their own home range at 18 weeks.

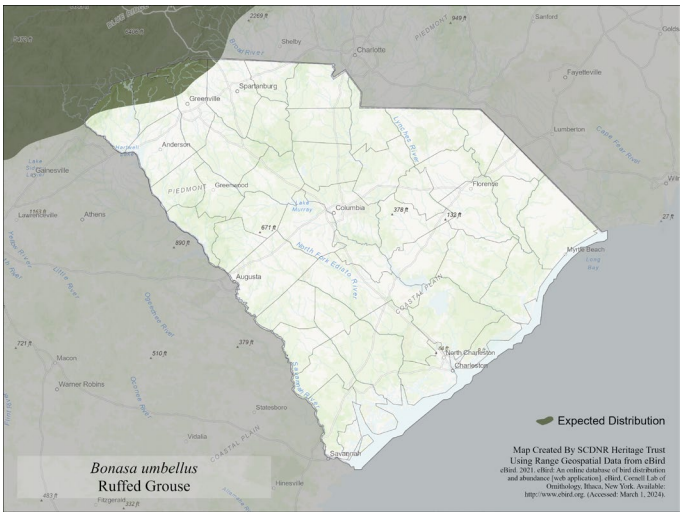
Status

According to the North American Breeding Bird Survey (BBS), Ruffed Grouse populations have been in a slow decline throughout the Appalachian region over the past 45 years (Sauer et al. 2011). Except for localized declines, Ruffed Grouse generally appear to be stable and secure in Canada and the Western United States, but numbers appear to be declining in the Eastern United

States (Atwater and Schnell 1989; Rusch et al. 2000). Ruffed Grouse have a state rank of apparently secure (S4) in South Carolina and a global rank of G5, indicating that they are considered secure globally (NatureServe 2011).

Though the Ruffed Grouse is considered peripheral in South Carolina's southern Appalachian ecoregion, eggs and young have been found in the vicinity of the Foothills Trail in Pickens County (Huckabee 2000). The species is included as a species of concern because South Carolina could provide more suitable habitat for Ruffed Grouse if disturbance regimes such as prescribed fire are used and early successional habitats are created within its mountain range.

POPULATION SIZE AND DISTRIBUTION



Ruffed Grouse is the most widely distributed upland game bird in North America (Gullion 1977). Its range spans from northern Georgia north through Labrador in the east, and west throughout northern California into Alaska. In the central portion of the United States, Ruffed Grouse are found in the Great Lakes states north into Canada to the tree line (Gullion 1977). Trippensee (1948) described the range of Ruffed Grouse; according to his range map, Ruffed Grouse did not occur in South Carolina. However, he reported that isolated populations of the species still maintained themselves outside the indicated range. Nesbitt (1966) reported that though the literature did not disclose information regarding population levels and distribution, Ruffed Grouse did occur in the northwest mountain counties of Greenville, Pickens, and Oconee in South Carolina. Population numbers are relatively low in the southern and southwestern parts of its range. The Ruffed Grouse breeding population density was estimated at about 1.9 drumming males per km^2 (5 males per $mi.^2$) in 2005 (Dessecker et al. 2006). Northern populations show approximately 10-year cycles. Other populations can exhibit significant year-to-year variation, largely dependent upon spring weather and its effects on brood production.

Densities vary between forest types. Throughout their range, Ruffed Grouse find most of their habitat needs in mixed age, upland hardwoods. In more northern reaches of their range, Ruffed Grouse are associated with aspen (*Populus tremuloides*) stands that meet all of their food and cover requirements (McDonald et al. 1998). In southern portions where aspen is sparse to absent, Ruffed Grouse are typically associated with upland oak (*Quercus* spp.) stands (Cole and Dimmick 1991).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Ruffed Grouse have 4 main habitat requirements: nesting cover, a "drumming log" for males, brood cover for females and fall/winter cover (Atwater and Schnell 1989). Proctor (2003)

indicated that in the southern portions of their range where long-term snow cover is absent, Ruffed Grouse utilize other methods of winter cover for protection from predation and thermal insulation. During winter in the southern Appalachians, Ruffed Grouse can be found using evergreen thickets in the form of rhododendron (*Rhododendron* spp.) and mountain laurel (*Kalmia latifolia*). Not only do Ruffed Grouse seek refuge in such evergreen habitats, but also in the southern Appalachians, Ruffed Grouse often forage on the leaves and buds of mountain laurel where the largely popular aspen trees of the north are absent (Stafford and Dimmick 1979). Ruffed Grouse in Tennessee were found to utilize evergreen thickets comprised mainly of mountain laurel where desirable higher stem density stands were lacking (White and Dimmick 1978). Young clear-cuts that provide tall and dense stands of sapling age trees, also provide excellent year round cover where Ruffed Grouse can find adequate food and protection from aerial predators. Literature concerning home range sizes of Ruffed Grouse varies widely, with differing tendencies in males and females. Densities of Ruffed Grouse and habitat quality also play a large role in determining average home range size for a particular area.

The Appalachian region is classified as oak-hickory or mixed-mesophytic forest associations; this classification is based on literature review, canopy tree composition, and abundance data collected as part of the Appalachian Cooperative Grouse Research Project (ACGRP) (Tirpak, 2002 unpublished data) and a Relative Phenology Index. Oak-hickory forests are dominated by chestnut (*Quercus prinus*), white (*Q. alba*), northern red (*Q. rubra*), scarlet (*Q. coccinea*), and black (*Q. velutina*) oaks and shagbark (*Carya ovata*), pignut (*C. glabra*), mockernut (*C. tomentosa*) and bitternut (*C. cordiformis*) hickories. Mountain laurel and great rhododendron are important understory species. Dominant species on mixed-mesophytic sites are sugar (*Acer saccharum*) and red (*A. rubrum*) maple, yellow birch (*Betula alleghaniensis*), basswood (*Tilia Americana*), black (*Prunus serotina*) and pin (*P. pensylvanica*) cherry, yellow poplar (*Liriodendron tulipifera*), white pine (*Pinus strobus*), beech (*Fagus grandifolia*), northern red oak (*Q. rubra*), and Eastern hemlock (*Tsuga canadensis*).

The ACGRP (2004) reports the nutritional quality of Ruffed Grouse diet differs markedly between the core range and the Appalachian region. Throughout most of their range, Ruffed Grouse depend on aspen buds, twigs and catkins to meet their nutritional requirements. In contrast, Ruffed Grouse diets in the Appalachian region consist of the leaves and seeds of herbaceous plants, buds of beech, birch and cherry trees, acorns and the fruits of grape, greenbrier, and numerous other soft mast producers. In the Appalachian region, diets of grouse tend to be higher in tannin and phenol levels, which serve as potential toxins. Additionally, Appalachian diets tend to have lower protein levels than the diets of grouse in the Northern United States and Canada. The poor nutritional quality of grouse diets in the Appalachian region may result in increased foraging time and predation risk, as well as decreased body condition, reproductive potential, and chick survival.

CHALLENGES

In the Appalachian region, habitat loss and degradation are the principle causes for Ruffed Grouse population declines. Fire suppression, maturing eastern deciduous forests, and lack of management practices involving timber harvest are major causes of habitat degradation and loss.

The quantity and quality of Ruffed Grouse habitat has declined in recent decades in the Appalachian region (ACGRP 2004).

Although the Ruffed Grouse is still a popular game species, hunting mortality is considered compensatory to some extent and is not thought of as a major factor controlling grouse populations. In a recent study, it was reported that, on average, hunting accounted for only 12% of all mortality and ranged from 0 to 35% across sites and years. This study did not conclude or infer that hunting would be compensatory at higher harvest rates (ACGRP 2004).

CONSERVATION ACCOMPLISHMENTS

Prior to 1996, Ruffed Grouse management in the Appalachian region was based on research conducted in the Northern United States and Canada. ACGRP was established in 1996 by state natural resource agencies to investigate potential factors limiting Ruffed Grouse populations in this region. Data were collected on twelve study sites in eight states over a 6-year period. Partners in this project were varied and provided funding and personnel as well as study sites. Partners consisted of state wildlife agencies, universities and various foundations and conservation organizations.

The objectives of the ACGRP were to:

1. Estimate survival rates and identify limiting factors,
2. Estimate reproductive rates and identify limiting factors,
3. Determine if harvest mortality is compensatory or additive, and
4. Evaluate habitat selection and quality.

This enormous undertaking has provided much needed information for management of Ruffed Grouse habitat in the Appalachian region. State wildlife agencies now have critical information to develop management strategies to slow or stop the decline of Ruffed Grouse in the Appalachian region.

Another accomplishment was the purchase of the Jocassee Gorges and creation of the Franklin Gravely Wildlife Management Area, a core area of South Carolina’s grouse range.

Throughout the Appalachian region, land ownership varies and includes National Forest land, state public land and industrial land. In South Carolina, land ownership is similar and a majority of potential grouse habitat will be protected by virtue of being within National Forests and state public land.

Finally, the *Ruffed Grouse Conservation Plan* (RGCP) which identifies Ruffed Grouse habitat needs and sets population and habitat restoration goals for each Bird Conservation Region (BCR) across the range of the species was completed in 2006 (Dessecker et al. 2006).

CONSERVATION RECOMMENDATIONS

- Implement management practices developed through the ACGRP (2004) on DNR lands and encourage implementation of these practices on National Forests and other public lands within the state. Action items include:
  - Maintain current Ruffed Grouse harvest levels and season; the current level of hunting pressure does not limit populations in South Carolina.
  - In mixed-mesophytic areas, employ "traditional" early-successional habitat management techniques that emphasize timber harvest techniques that provide a diversity of younger aged stands interspersed among mature forests.
  - In oak-hickory dominated sites, forest management should strive to provide both food (acorns) and cover (early successional habitat) needs of grouse in close proximity. Clearcutting, shelterwood, two-age and group selection silviculture offers managers alternatives to create these contrasting needs of acorns from mature oak trees in association with cover from young stands.
  - Manage roads by gating and planting preferred herbaceous foods to supplement existing natural foods.
  - Utilize prescribed fire as appropriate within Ruffed Grouse range in South Carolina to restore, enhance, and maintain habitat.
- Conduct surveys as appropriate to evaluate Ruffed Grouse population response to habitat management.
- Partner with private landowners and interested constituents to publicize and implement the recommendations of the ACGRP and the RGCP.
- Provide Ruffed Grouse habitat management recommendations to private landowners through on-site technical assistance, fact sheets, management bulletins and websites.

MEASURES OF SUCCESS

Existing bird surveys are insufficient to detect changes in the population of Ruffed Grouse in South Carolina. However, increased sightings of Ruffed Grouse by DNR personnel and members of the public would be considered one measure of success. Likewise, increased interest in management of Ruffed Grouse by the general public, as demonstrated by increased phone calls or e-mails related to Ruffed Grouse management and hunting, would be considered a measure of success of outreach and public awareness efforts.

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Swallow-tailed Kite

Elanoides forficatus

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DESCRIPTION

Taxonomy and Basic Description


Photo by Harry D Sell

The Swallow-tailed Kite is unmistakable with its long, pointed wings (wingspan of 1.2 m or 4.0 ft.) and long forked tail (32 cm or 12.6 in.). The dorsal coloration is black while the head and underparts are white. Average weight for adults is 440 to 480 g (1 lb.), with females being slightly heavier than males. Swallow-tailed Kites capture most of their food and eat, drink, and bathe on the wing. This bird spends much of the day in flight and feeds year-round on insects (particularly airborne; Meyer 1995, Baird 2011). However, they provision their young mainly with small vertebrates, including anoles, tree frogs, small arboreal snakes, nestling birds, and (roosting) bats (Meyer et al. 2004), all of which they glean from vegetation while in flight.

Status

The Swallow-tailed Kite is listed by the South Carolina Department of Natural Resources as a state endangered species, and is considered a high-priority species of concern by the other states in which it occurs, the United States Fish and Wildlife Service, Partners in Flight, and national conservation organizations. There are 3 distinct genetic populations that nest from the Southeastern United States to south-central South America (Washburn 2007). The degree of difference between the United States population and the two in Latin America equals or exceeds differences found between taxonomically-recognized species (Washburn 2007).

POPULATION SIZE AND DISTRIBUTION

Historically, the United States range included at least 21 states as far north as Minnesota (Cely 1979). The Swallow-tailed Kite is presently found in floodplain forests and other large tracts of forested wetlands and mixed pine habitats (Meyer et al., *in prep)* of the Outer Coastal Plain (OCP) from South Carolina to east Texas, with most of this remnant breeding range occurring in 6 Southeastern states: South Carolina, Georgia, Florida, Alabama, Mississippi, and Louisiana. The disappearance of the Swallow-tailed Kite from three-fourths of its US breeding range between 1880 and 1910 was one of the most dramatic range contractions of any bird before the post-World War II decline of the peregrine falcon. Since about 1940, populations have apparently stabilized with some evidence of a possible reoccupation of former habitat, including parts of South Carolina and small areas in eastern Texas; southeastern North Carolina, where

limited nesting may have begun around 2003; and southeastern Arkansas, where a few unsuccessful nesting attempts were documented in the early 2000s in Arkansas's White River bottoms, over 320 km (200 mi.) north of the nearest nesting population (J. Bednarz, pers. comm.).

Because Swallow-tailed Kites are so distinctive, noteworthy, and able to range widely in the United States prior to and following nesting, their unexpected or repeated appearance often leads people to believe that they are increasing in number. There are no clear indications from the limited samples of Breeding Bird Survey data or annual counts at large pre-migration roosts (Meyer and Zimmerman 2006; K. Meyer, unpublished data) that the population is presently changing substantially in number or distribution. Until recently, the estimated population for the entire United States was about 800 to 1,150 pairs (Cely and Sorrow 1990), or about 2,500 to 5,000 individuals allowing for sub-adults and juveniles at the end of the nesting season (Meyer 1995). About two-thirds of these birds are thought to reside in Florida (Meyer 1995). However, systematic, synchronized counts at large, pre-migration communal roosts in peninsular Florida since 2004, which have peaked at about 7,000 individuals each year, indicate that the United States population may include as many as 10,000 individuals, or 2,000 to 2,500 pairs (Meyer and Zimmerman 2006; K. Meyer, unpublished data).

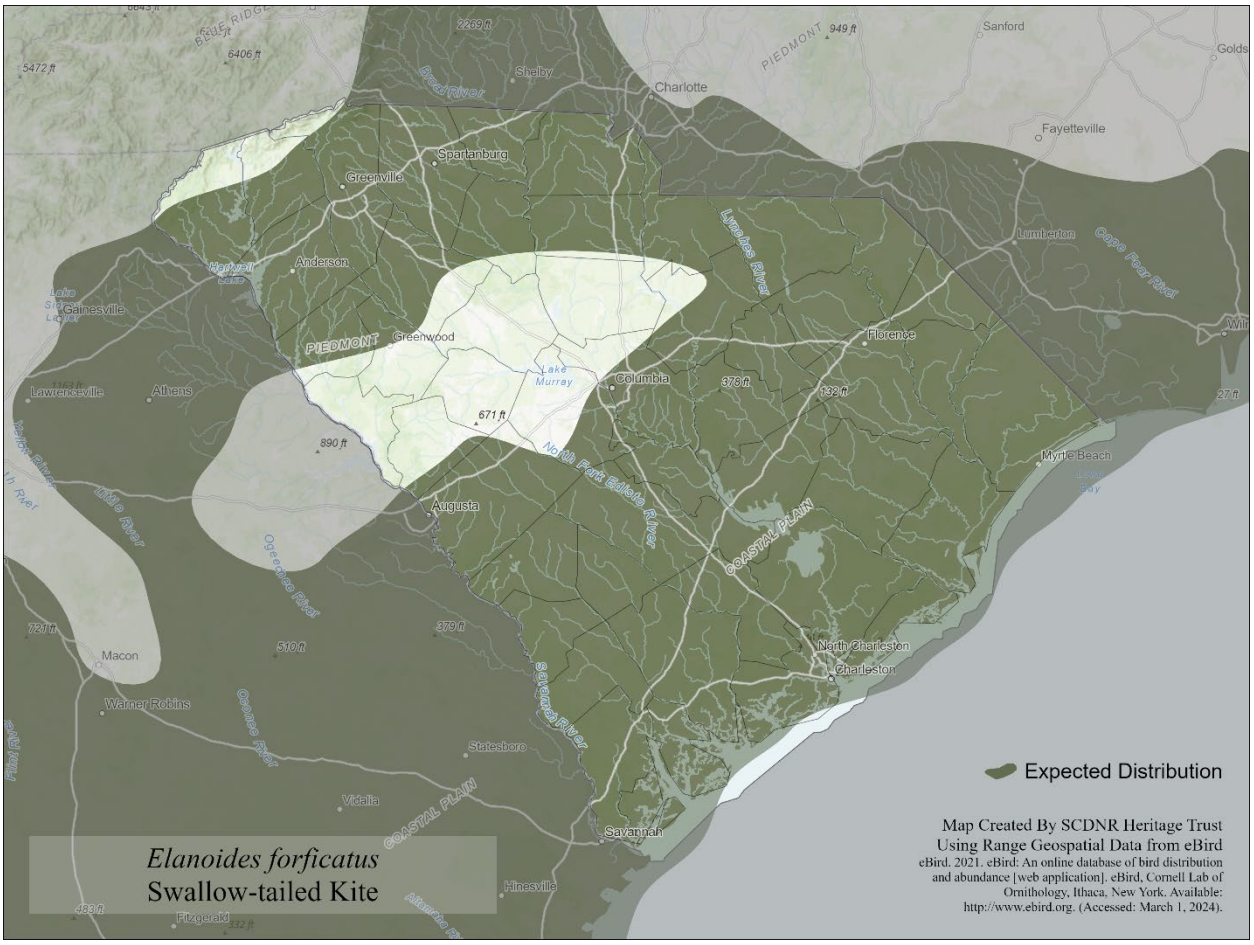
The estimated number of breeding pairs in South Carolina is 120 to 170; these are primarily found in large floodplain forests and swamps of the OCP, with significant populations occurring on the lower Great Pee Dee, Santee, Black, Edisto, and Savannah Rivers (and their tributaries), and in the Francis Marion National Forest.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

In South Carolina, the Swallow-tailed Kite is closely associated with large tracts of forested wetlands of the Outer Coastal Plain, such as those found in the Francis Marion National Forest and along the lower Savannah, Edisto, Santee, Black, and Great Pee Dee Rivers. It shows a strong preference for nesting in dominant or co-dominant loblolly pines (*Pinus taeda*) growing within or on the edges of wetland forests. However, kites will regularly use bald cypress (*Taxodium distichum*) when pines are unavailable. Swallow-tailed Kites have also been recorded nesting in water tupelo (*Nyssa aquatica*), sweetgum (*Liquidamber styraciflua*), and willow oak (*Quercus phellos*).

The average dimensions of loblolly pine nest trees in the Francis Marion National Forest were 32 m (104 ft.) tall and 49 cm (19 in.) diameter breast height. Pines were located within stands averaging 13.5 m^2/ha (60 $ft.^2$/ac.) basal area and 61 years of age (Cely and Sorrow 1990). Dimensions for cypress nest trees were similar to the pines; these trees had an average height of 29 m (96 ft.), with a diameter above the swell of 50.5 cm (20 in.) and a basal area of 13.5 m^2/ha (60 $ft.^2$/ac.). Smith, 2023, found a positive correlation between nest success and large DBH of the nest tree. Cypress ages were not determined but all were at least second, if not third, growth and probably no more than 75 years of age (J. Cely, unpublished data). Nest trees were only slightly larger than surrounding trees. The average distance to a waterway for kite nests in South Carolina was 135 m (455 ft.), but this distance ranged from 25 to 544 m (82 to 1,795 ft.) (J. Cely

and A. Day, unpublished data). As Spanish moss (*Tillandsia usenoides*) is a key component of nest construction, this epiphyte may be a necessary ecological requirement (Meyer 1995). In addition to nest tree DBH, nests initiated earlier in the season were three times more likely to be successful compared to nests started mid season, May, in the Corkscrew Regional Ecosystem Watershed Wildlife and Environmental Area (Smith, 2023). Old growth forests with large mature trees in bottomland forests provide superior nesting locations compared to other habitat types.



Based on VHF telemetry research, Swallow-tailed Kites have a large home range that encompasses thousands of acres (Cely and Sorrow 1990; Meyer and Collopy 1995). Foraging birds use a variety of stand types and ages and will often commute long distances, up to 24 km (15 mi.), from the nest site, to feed on various prey (Meyer 2004b). Once nestlings have fledged and are becoming independent, foraging kites gather to prey on beetles, dragonflies and grasshoppers associated with upland fields, pastures and freshwater marshes (Baird 2011). Other Swallow-tailed Kites are attracted to “hot spots” of insect abundance; feeding aggregations sometimes consist of more than 50 birds.

CHALLENGES

Swallow-tail Kites are highly social in all seasons, foraging, roosting, and migrating in flocks and nesting in loose aggregations (neighborhoods) within sight of each other, often only 60 to 100 m (197-328 ft.) apart. Their social behavior, undoubtedly adaptive, makes them conspicuous, relatively easy to count, and fascinating to observe. Predictably, Swallow-tailed Kites show strong site fidelity when joining in large roosts (Meyer 1998; Meyer and Zimmerman 2006) and especially when nesting, most likely because returning to previously used sites helps ensure that they will encounter conspecifics (Meyer 1995). This provides opportunities for resource managers to focus their attention and protection more efficiently.

Unfortunately, it also means that specific locations become very important to Swallow-tailed Kites. Because most of the United States' breeding population nests on unprotected, private lands, particularly commercial timberlands, human activities that alter or destroy natural habitats or create repeated disturbance will displace not just a single pair or roosting individual, but large numbers of kites (Meyer 2004b). Social bonds, and the benefits that accrue, may be lost, especially if the scale of the intrusion and the subsequent displacement are large. This creates one of the biggest challenges for conserving Swallow-tailed Kites, from local to landscape scales.

There appears to be substantial suitable-but-unoccupied habitat range-wide, including in South Carolina. This can be misleading. Because social needs and attractions result in clumped distributions, they intensify the use of some patches of suitable habitat while leaving other patches vacant. The Swallow-tailed Kite’s demography also may contribute to this incomplete use of suitable habitat. Adult survival is relatively low for a bird of this size and general ecology (Meyer 2005). This may stem, at least in part, from the risks of long-distance migration, which also may contribute to the low survival of first-year kites (Meyer 2004a, Meyer and Kent 2012).

Thus, the loss of habitat *is* a serious threat to Swallow-tailed Kites when it is *occupied* habitat. The loss of unoccupied habitat, furthermore, represents a threat when suitable habitat is relatively limited locally, forcing the associated groups of kites to move long distances and, therefore, to risk dissolution. This explains the recommendation that the size of clear-cuts on industrial forests occupied by Swallow-tailed Kites should be limited to allow for relocation of displaced birds within a reasonable distance (Meyer and Kent 2010a, 2011a). It also relates to the recommendation (Meyer and Kent 2011a) that forest managers should maintain a minimum total area of suitable nest trees (mature pines or cypress with open crowns within stands of uneven height and structure) within a specified areas of the landscape at all times. This would allow for flexibility in harvest planning while still accommodating the kites’ needs for attractive nest trees within a sufficiently small area to ensure that the social nesting neighborhood can move cohesively when they return to find the previous year’s nest trees gone.

Non-sustainable timber management (including short rotations), altered wetland hydroperiods, uncontrolled invasive species, budgetary limitations, or landowner restrictions that preclude appropriate land management, etc. are all forms of habitat loss. Additional factors limiting swallow-tailed kite recovery include shooting (which may have played a role in the decline of the early 1900s; Cely 1979); predation (e.g. where anthropogenic habitat alterations, such as

fragmentation, promote unnatural increases in key predators such as Great Horned Owls); and the loss of essential habitats combined with unexpectedly high mortality on the South American winter range, perhaps due to agricultural contaminants.

The Louisiana-Mississippi subpopulation (Coulson 2006; Coulson et al. 2008) appears to be limited by predation. Raptors, particularly great horned owls (*Bubo virginianus*), kill kites of all ages, but especially adult females attending nests, possibly limiting breeding-aged females. During monitoring of 290 nests, recently fledged young, and radio-tagged birds (90 fledglings, 13 adults), such predation accounted for 51 to 57% of mortality. Predation of nestlings and attending adults appears to be increasing in the Eastern portion of the breeding range, particularly in Florida and Georgia on industrial timberlands experiencing increased harvest rates, and high predation rates by Great Horned Owls have recently been observed in coastal kite neighborhoods (Meyer and Kent 2011b, 2011c). Little is known about the regional ecology of great horned owls, particularly abundance, breeding density, habitat associations, and range sizes. This predator, in particular, also is known to have high impacts on water bird colonies in South Carolina (Goyette et al. 2011).

CONSERVATION ACCOMPLISHMENTS

Following the example of South Carolina's initial research in the late 1980s, additional efforts have been directed towards the species during the past 15 to 24 years in Florida, Louisiana, Mississippi, and Georgia. Finding and monitoring active nests has yielded data on breeding biology, vegetation features of nest sites, philopatry, group sizes, prey species and feeding rates, estimates of nesting success and productivity, and causes of nest failures (see various references). In South Carolina, research by Cely and colleagues centered mainly on the Francis Marion National Forest from the mid-1980s into the 1990s (Cely and Sorrow 1990; J. Cely and A. Day, unpublished data). Later studies focused more on the Waccamaw National Wildlife Refuge and adjacent areas of the Winyah Bay watershed (Meyer and Kent 2009, 2010b, 2011d).

Long-term studies in Florida, Georgia, and South Carolina have investigated survivorship for large samples of adults tracked by satellite (Meyer 2005) and individuals tagged as nestlings with VHF transmitters, for which first-breeding age, breeding dispersal, and recruitment also were examined (Meyer 2004a; Meyer and Kent 2009, 2010b, 2011d, 2012).

Quantitative descriptions of selected habitats at the forest-stand and landscape scales have been derived from large sets of accumulated nest locations (Meyer et al. *in prep*). These results, in turn, are now being combined with spatially-explicit demographic and land-ownership data to produce a model that will prioritize land protection and management strategies across the Southeast (K. Meyer, G. Kent, S. Beyeler, and J. Cely, unpublished data).

Post-breeding / pre-migration communal roosts of Swallow-tailed Kites probably facilitate foraging efficiency in preparation for migration (Meyer 1995 and 1998). These aggregations, numbering from a few to 100 or more along rivers of the Atlantic and Gulf Coastal Plains and 2,000 to 3,000 at the largest roosts in peninsular Florida, may be used habitually year after year and are sensitive to human disturbance. Communal roosts offer unusually good opportunities for population monitoring (Meyer 2004a; Zimmerman and Meyer 2006). Systematic, synchronized

aerial counts were conducted in 2009, 2010, and 2011 in South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas with funding from the United States Fish and Wildlife Service and matching support from cooperating partners (South Carolina Nature Conservancy, Georgia Department of Natural Resources, Avian Research and Conservation Institute, Alabama Department of Conservation and Natural Resources, and The Orleans Audubon Society). The goal of this collaborative project was to refine and recommend population monitoring methods and, combined with concurrent location data from satellite/GPS telemetry (K. Meyer and J. Coulson, unpublished data), to identify previously unknown roost sites and apply occupancy data to systematically estimating national population size. Knowing the locations of pre-migration communal roosts, especially the larger, repeatedly used sites, is the first step toward land protection, habitat management, and prevention of human disturbance (Meyer 1998; Zimmerman and Meyer 2006). Annually the public is encouraged to report roost sightings through a web form to locate and count pre-migratory roost sites from July 15 through August 10.

The long-distance migration pathways (over 17,000 km or 10,563 mi. round trip) and wintering destinations of the United States population of swallow-tailed kites, described from satellite and VHF telemetry from 1996 to 2004 (Meyer 2004a; Meyer 2005; Zimmerman 2004; Zimmerman and Meyer 2004) and recent GPS tagging efforts, present international threats, challenges, and opportunities for year-round management and conservation. Particular portions of the migration route appear to pose greater risks based on associated mortality (Meyer 2004a and 2005). In some cases, the causes are natural and unmanageable (e.g. long over-water flights north- and southbound between the United States and Mexico/Central America; and when crossing the Andes Mountains in northwestern South America). Increased storm frequency and strength from climate change could increase the impacts of migration route mortality associated with water crossings during Fall migration. However, greater-than-expected mortality (inferred from loss of telemetry signals) on the winter range in central South America may be linked to rapid conversion of traditionally used ranchland habitats to intensive, highly-treated industrial agriculture (Meyer 2004a and 2005). A satellite/GPS telemetry study (see previous paragraph; K. Meyer and J. Coulson, unpublished data), including adults tagged in South Carolina, Georgia, Florida, Mississippi, and Louisiana, has produced much finer-scaled location data over several years and may reveal likely causes of death on the winter range. Wintering range of this species is highly concentrated with the majority of tracked individuals wintering in an area of Matto Grasso State of Brazil in a mixed-use landscape of agriculture and grazing near the Paraná River. Altering or use change in this landscape would have large impacts on the population and affect the Spring return rates. It is estimated that from 2001 to 2018 in Mato Grasso, more than 4.5 million ha of natural cerrado vegetation has been removed (Simoes, 2020). Much of this lost vegetation has been converted to agricultural use for corn, soybean, and cotton production, as well as increased cattle grazing (Simoes, 2020).

In 2007, a partnership, the Swallow-tailed Kite Conservation Alliance, was established to determine priorities for research, monitoring, management, and public education; to share information; and to advance conservation for the species (Zimmerman 2009). The Alliance has functioned mainly through the collaborations and cooperative efforts of sub-groups within the organization, depending on the goals and geographic scope of the respective activities.

In some instances in South Carolina, nest site information has increased land acquisition incentives and protection efforts, such as at the Waccamaw National Wildlife Refuge and the lower Santee/FMNF. Because of the species' large home range, it could serve as an umbrella species for the conservation of other area-sensitive wetland wildlife including neotropical migrants, Barred Owls, Red-shouldered Hawks, Pileated Woodpeckers, river otters, and black bears. South Carolina maintains an unusually active, collaborative approach to Swallow-tailed Kite conservation that is based on the combined interests and efforts of agencies and organizations devoted to land management, land acquisition, research, and public education.

One of the most important endeavors for researchers has been to produce management recommendations, particularly for breeding habitats on both public and private lands. Combined results of studies in 5 states point to favorable silvicultural practices at the nest-site, forest, and landscape levels. This is particularly important given the large proportion of Swallow-tailed Kite nesting territories on corporate and private lands. *Appendix 1* in Meyer and Kent (2010a), *Management recommendations for swallow-tailed kite nesting habitat in Florida*, lists actions that include thinning of even-aged pine plantations, establishment of Streamside Management Zones (SMZs), and maintaining mature pine and cypress stands of uneven age and structure within heterogeneous wetland landscapes. A recent study found nestling success correlated with nest tree DBH, suggesting Swallow-tailed Kites benefit from larger mature trees left in forest stands (Smith 2023). The *Synthesis* section, however, describes an encompassing approach:

> *"...our most important recommendation, based on 23 years of direct observation and integration of all available information from over 1,200 nesting attempts, is deceptively simple: Protect nesting swallow-tailed kites where they choose to be. This species, mainly due to its pervasive social nature, is exceptionally persistent in its attachment to place. This affinity, which transcends the short-term behavior of individuals within their relatively brief lifespan, is expressed by a continually shifting succession of pairs (and turnover within the pairs) and their collective return and adherence to locations where they can expect to find other swallow-tailed kites. 'Occupied habitat' is not a static, within-year physical condition exploited by a breeding pair. It is set of natural features, some essential, associated with a location that has taken on cultural and traditional importance. There is no question that many of the swallow-tailed kites in our study populations continue to nest where they do – despite local habitat alteration and loss that is often severe – due to this over-riding attachment to location. We do not know if their nesting success, productivity, and survival are compromised as a result… Protecting occupied swallow-tailed kite habitat where we find it is vitally important. This simple expression, however, masks the challenges this concept poses for implementing swallow-tailed kite conservation. The necessary, over-arching strategy will require communication and coordination among public, corporate, and private conservationists and land managers at all levels. The required effort will not be sustained without the active engagement of attentive conservationists from many disciplines. Critical-species leads in state and federal wildlife agencies will be in the best positions to monitor and guide this concerted effort. Favoring success is the unqualified allure of this spectacular bird and the public's keen interest in its persistence."*

CONSERVATION RECOMMENDATIONS

While most of the following recommendations also apply to management of the continental population of Swallow-tailed Kites, we have focused on the highest priority needs for South Carolina's breeding population.

- Incorporate Swallow-tailed Kite nest locations into management and protection efforts by ensuring that conservation agencies and organizations are aware of this database.

- Continue to participate in the national pre-migration monitoring surveys of Swallow-tailed Kites to protect critical pre-migration communal roost areas and detect population changes.

- Document and mitigate the impacts of avian predators on Swallow-tailed Kite nesting success, particularly for Great Horned Owls, which also are a threat to water bird breeding colonies in coastal South Carolina.

- Document present Swallow-tailed Kite habitat associations and reproduction in the Francis Marion National Forest (FMNF) and compare with 1980s and 1990s data (Cely 1979; Cely and Sorrow 1990) to inform current forest management in and beyond FMNF.

- Document nesting, land ownership, and management potential southwest of Charleston, (particularly the ACE Basin and lower Savannah River drainage), and compare with better-studied areas to the northeast.

- Work with the public, NGOs, volunteers, agencies, timber companies, private landowners, and the Swallow-tailed Kite Conservation Alliance to increase partnerships for the protection of Swallow-tailed Kites.

- Continue to maintain the citizen-science efforts to report Swallow-tailed Kites; increase applications of this information to address priority management needs.

- Instruct timber managers in practices that increase Swallow-tailed Kite reproduction and promote long-term forest stewardship, with a strong emphasis on conserving presently-occupied Swallow-tailed Kite nesting, foraging, and roosting habitat.

MEASURES OF SUCCESS

A recovery goal of roughly doubling the United States population has been established, which would require approximately 100 birds per river drainage range-wide (C. Hunter, personal communication). South Carolina's portion of this goal is approximately 400 nesting pairs, or at least twice the present breeding population.

A realistic, but still challenging, goal is to at least maintain the various subpopulations at their present levels by protecting suitable nesting and surrounding foraging habitats that breeding

Swallow-tailed Kites have already selected and are using repeatedly. This challenge is compounded by the relatively large portion of nests on private and corporate lands.

Identifying the cause(s), and thereby reducing mortality on the winter range along with establishing long-term protection of privately-owned traditional ranch and farm lands selected by wintering kites from the United States, should increase annual survival. This would thus help to offset, rather than add to, some of the natural mortality associated with long-distance migration and relatively low reproductive rates.

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Deciduous Forest Interior Birds Guild

Black-billed Cuckoo *Coccyzus erythropthalmus*
Blackpoll Warbler *Setophaga striata*
Wood Thrush *Hylocichla mustelina*
Yellow-billed Cuckoo *Coccyzus americanus*

NOTE: The Wayne's Black-throated Green Warbler is covered in more detail in its own species account.

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DESCRIPTION

Taxonomy and Basic Description

The species described in this report are in the perching bird order, Passeriformes, and represent 3 families: Cuculidae (cuckoos), Parulidae (wood warblers), and Turdidae (thrushes). Alexander Wilson first described the Black-billed Cuckoo in 1811, and the Yellow-billed Cuckoo was described by Linnaeus in 1758 (Hughes 2020). The accepted name for the Wood Thrush is from Gmelin (1789; Evans et al. 2020), while the Blackpoll Warbler was first described by Johann Forster in 1772 (AOU 2011).


Black-billed Cuckoo / Wikimedia Commons


Yellow-billed Cuckoo / Flickr

The Black-billed Cuckoo and the Yellow-billed Cuckoo are members of the Family Cuculidae. Both are similar in appearance and behavior, each slender birds with a long tail, gray-brown plumage and light underparts, a curved bill, and zygodactyl feet. The Black-billed Cuckoo has a black bill and a bright red eye ring during the breeding season. The Yellow-billed Cuckoo is distinguished by a bright yellow lower mandible, a rufous patch on the outer primaries, and distinctive white tips on the outer rectrices. Black-billed and Yellow-billed Cuckoos are similar in size, with the former having an average length of 28-31 cm (11-12 in) and weight of 45-55 g (1.5-1.0 oz), and the latter having an average length is 26-30 cm (12 in.) and weight of 55-65 g (2.3 oz.) (Hughes 2020).



The Family Parulidae includes the Blackpoll Warbler. Birds in this family are small and colorful with sharp, pointed beaks for gleaning insects. The Blackpoll Warbler is a large *Setophaga* warbler, measuring 14 cm (5.5 in) in average length and 12-13 g (0.4-0.45 oz) lean body mass. Some individuals reach nearly double this mass prior to fall migration (DeLuca et al 2020). Breeding male Blackpoll Warblers have a distinctive black cap, or "poll." The rest of the head is white with black malar stripes. The breast and underside are white, with black bars lining the flank and back. Wings are dark brown to yellow-green with two white wing bars. Breeding females have comparable but more subtle coloration; the cap is streaked rather than solid and flank streaking is paler. Females have a broken white eye ring. Basic, juvenile plumage is usually washed with yellow. Orange legs and feet are diagnostic in differentiating from similar warblers (DeLuca et al 2020).



The Wood Thrush is a member of the Family Turdidae, a group of cryptically colored birds known for their beautiful songs. Basic coloration of the Wood Thrush is rusty brown with white underparts punctuated by dark brown spots. A white eye ring is also present. The Wood Thrush is a medium-sized thrush, measuring 19-21 cm (7.5-8.25 in.) in length and weighing 40 to 50 g (1.4 to1.8 oz.) (Evans et al. 2020).

Status

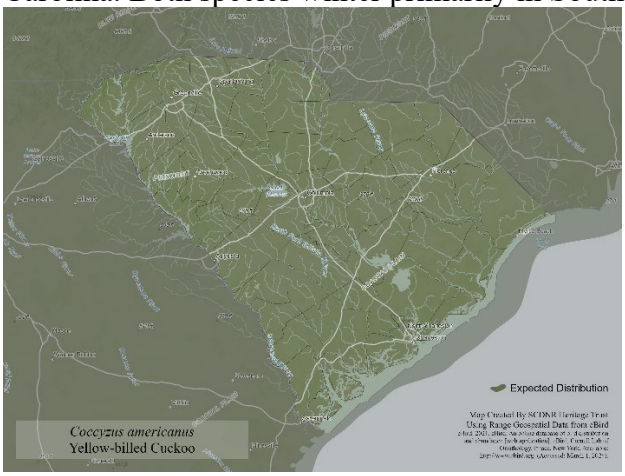
The Black-billed and Yellow-billed Cuckoo are considered species of Least Concern by the IUCN (2023) but are both included on Partners in Flight's (PIF) list of Common Birds in Steep Decline List (PIF 2023). Both species are listed as having regional importance for the Atlantic Coast Joint Venture (Rosenberg et al. 2016). In South Carolina, the Black-billed Cuckoo has a Vulnerable (S3) ranking and the yellow-billed Cuckoo has an Apparently Secure (S4) ranking (NatureServe 2024).

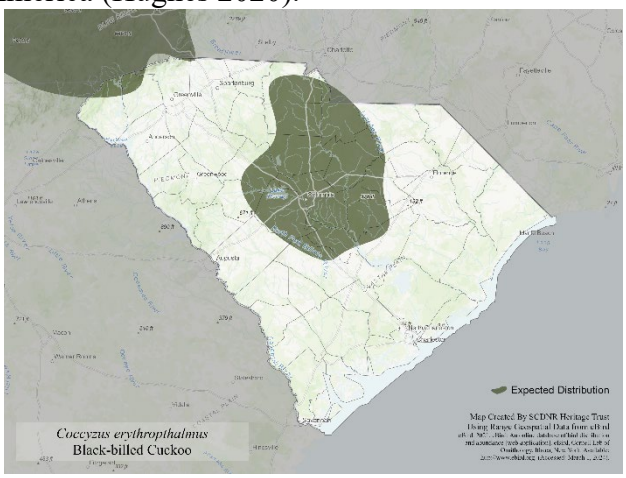
The Blackpoll Warbler is considered Near Threatened by the IUCN (2023) and, having declined by 92% since the 1970's, is included on the Partners in Flight list of Common Birds in Steep Decline (PIF 2023). In South Carolina, NatureServe ranks Blackpoll Warbler as Apparently Secure Migrant (S4M), though dramatic declines have been observed in some of the breeding range (NatureServe 2024). Birds of the World states that, though declines have been observed, the sampling effort only covers a very small part of the breeding range (DeLuca et al 2020).

The Wood Thrush is considered a species of Least Concern by IUCN (2023), but with decreasing populations. It is estimated that Wood Thrush populations have declined 1.92% per year from 1970 to 2017. Breeding Bird Survey (BBS) data has shown a slow in the decline in recent years (Partners in Flight 2019). Partners in Flight considers Wood Thrush a "D" Yellow Watch List species; "species with population declines and moderate to high threats" (2023). NatureServe considers Wood Thrush to be S3/S4, Apparently Secure/Vulnerable in South Carolina (2024).

POPULATION SIZE AND DISTRIBUTION

Black-billed and Yellow-billed Cuckoos breed throughout much of eastern North American, though there are rare and localized populations of Yellow-billed Cuckoos west of the Rocky Mountains (Hughes 2020). The breeding range of Yellow-billed Cuckoos extends southward into the Caribbean and northern Mexico, while Black-billed Cuckoos breed only as far south as South Carolina. Both species winter primarily in South America (Hughes 2020).





The current rangewide population estimate for the Black-billed Cuckoo is 880,000 individuals (PIF 2023), but no estimates exist for South Carolina, as the species is rarely recorded during breeding bird surveys. In the South Carolina Breeding Bird Atlas (1988-1995; Cely 2003), the Black-Billed Cuckoo is not documented. However, more recent sources, including NatureServe (2024) and the Carolina Bird Club (2024), confirm that Black-billed Cuckoos breed statewide. The species is in steep decline, with an estimated annual decline of 1.3% in the US between 1966 and 2021 (Ziolkowski et al. 2022). The Yellow-billed Cuckoo has a rangewide population estimate of 8.4 million individuals (PIF 2023) that is declining at an annual rate of 0.9% in the US (Ziolkowski et al. 2022). In South Carolina, the species appears to breed statewide (Cely 2003) and has an estimated state population of 240,000 individuals (PIF 2023). Between 1966 and 2021, the Yellow-billed Cuckoo has an average annual growth rate of 0.1% in South Carolina, though it appears to be declining in most other states where it breeds (Ziolkowski et al. 2022).



The Blackpoll Warbler breeds throughout Canada, inland Alaska and, in much smaller numbers, high elevation sites in the northeastern USA (PIF 2023). The Partners in Flight range-wide population estimate is 60,000,000 individuals (2023). During southward migration, individuals generally move southeast and congregate along the Atlantic Coast from Nova Scotia to Cape Hatteras, North Carolina before heading further south (DeLuca et al 2020). It has long been hypothesized that Blackpoll Warblers fly non-stop over the Atlantic Ocean during migration. Research by DeLuca et al. in confirmed this hypothesis by tracking five migrating individuals using light-level geolocators; the birds averaged 2540 km (1578 mi) of non-stop flight over three to four days before a short stopover in the Greater Antilles or Northeastern coast of South America before moving further south into their wintering range (2015). Blackpoll Warblers spend the non-breeding season throughout the Amazon Basin in Bolivia, Brazil, Colombia, Ecuador, Peru, and Venezuela (NatureServe 2024). Northward migration occurs at a more leisurely pace with movement occurring over land after shorter overwater flights from South America (DeLuca et al. 2015). It is during this spring migration that Blackpoll Warblers most often occur in South Carolina.



The Wood Thrush is distributed statewide in South Carolina with higher concentrations of breeding in the Piedmont and Mountain regions (Cely 2003). Partners in Flight estimates the current range-wide population to be 12,000,000 individuals (2023). Wood Thrush breed throughout the Eastern United States and Southeastern Canada from New Brunswick to Ontario south to Texas and north Florida. During August and September, individuals leave their northern breeding grounds to fly southward. Overwintering occurs in central America from southeastern Mexico to western Colombia. Northward migration occurs in April and May and is 2-6 times faster than the move south. Migrants generally cross the Gulf of Mexico while moving in both directions (Evans et al. 2020).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Black-billed and Yellow-billed Cuckoo are both strongly associated with deciduous riparian corridors and can be found in forest edges or forests fragmented by fallow agricultural field, hedgerows, and shrublands (Hughes 2020a and 2020b). While both species can occupy similar habitats, Yellow-billed Cuckoos are thought to prefer more open woodlands and lower elevation areas than Black-billed Cuckoos (Hughes 2020a). In the Florida coastal plain, Yellow-billed Cuckoos are present in hardwood hammocks and other moist forested habitats (Stevenson and Anderson 1994b). North American cuckoos are occasional intra- and interspecific brood parasites but often build a nest and raise their own young. Nest sites are usually located in deciduous forest groves, but Black-billed Cuckoos tend to nest in areas with greater forest cover and often in coniferous trees (Hughes 2020a and 2020b).

Blackpoll Warblers breed throughout Canadian and Alaskan boreal spruce forests in riparian areas or transitional zones between taiga and tundra. Overwintering habitat in South America consists of deciduous forest, rainforest, cloud forest, mangrove forest, and galley forests. Migratory stopover habitats are highly diverse, covering a vast latitudinal range. Blackpoll Warblers can be found in nearly any forested habitat during migration (DeLuca et al 2020).

Wood Thrush breeding habitat consists of edge and interior of mature deciduous or mixed forests, with preference for mesic, upland habitat. Ideal Wood Thrush nesting habitat contains diverse deciduous tree species, with a developed midstory that creates a shaded, open forest floor covered in leaf litter. Nest site selection favors larger tracts, but nesting does occur in smaller fragments and in residential areas or parks. Overwintering occurs in closed-canopy, semi-evergreen tropical forests. Migration habitat use for Wood Thrush is not well understood (Evans et al. 2020).

CHALLENGES

Forest fragmentation is one of the biggest problems for area-sensitive deciduous forest birds, such as the Wood Thrush, which may have reduced breeding success or abandon areas in response to shrinking patch sizes (Evans et al. 2020). Roads and edges which split or isolate forest fragments may also attract native and non-native predators, such as rodents and feral cats, or the Brown-headed Cowbird (*Molothrus ater*), a common nest parasite, into the forest interior (Lowther 2020). While Wood Thrush often select nest sites that contain edge or early successional habitat, this disproportionately exposes them to disturbance or nest parasitism by Brown-headed Cowbirds (Evans et al. 2020). Both Black- and Yellow-headed Cuckoos may also be sensitive to fragmentation, degradation or damming of water sources, and land use changes associated with removal of forest or ground cover (Hughes 2020a and 2020b).

The species included in this guild are neotropical migrants, and thus susceptible to collisions with stationary objects on migration routes (DeLuca et al 2020; Evans et al. 2020; Hughes 2020a; Hughes 2020b). Communication towers, wind turbines, cars, and buildings all pose a threat to migrating birds, with up to 900 million killed annually by window collisions alone (Elmore et al. 2021). The Wood Thrush has been noted by multiple studies as being particularly vulnerable within this guild to window collision mortality (Loss et al. 2014; Elmore et al. 2021). Flocks of Blackpoll Warblers are sometimes killed in at towers, lighthouses and wind turbines,

though this is not believed to be a significant source of population decline since Blackpolls are widespread and often have high population density (DeLuca et al. 2020).

However, Blackpoll Warblers have complex life histories involving long migrations to and from expansive and remote breeding and overwintering grounds. They are widespread and often occur in high population densities. Research is often focused within specific areas, making it difficult to gain a holistic view of the factors contributing to their decline. More widespread research is needed to fully understand Blackpoll Warbler population dynamics (DeLuca et al 2020).

As previously mentioned, Black- and Yellow-billed Cuckoos can be difficult to detect using traditional survey methods such as BBS, due to their secretive and highly mobile nature. Though Johnson and Benson (2022) found in Illinois that broadcast surveys in warm conditions increased the probability that a Cuckoo would be detected, both species exhibited high rates of territory movement during the breeding season, making occupancy estimation difficult.

Additional challenges to deciduous forest species management include introduced fugal diseases or parasites, such as sudden oak death (SOD; *Phytophthora ramorum*) and the Hemlock Woolly Adelgid (*Adelges tsugae*), which negatively impact the health of forested ecosystems.

CONSERVATION ACCOMPLISHMENTS

Deciduous forest types, including upland oak-hickory and bottomland oak-gum cypress, account for approximately 33% of total forest cover in South Carolina (South Carolina Forestry Commission 2021). In the northwest region of the state, SCDNR manages the approximately 43,000-acre Jocassee Gorges Wilderness Area, which contains critical tracts of uninterrupted mature hardwood. As of 2015, Jocassee Gorges included at least 1,200 acres of hardwood forest 60 years and older, with some patches older than 80 years (M. Hall, SCDNR, pers. comm.). The purchase of this tract of land by the state in 1997 ensures protection and management of habitat that benefits interior forest bird species.

Completion of Partners in Flight plans for Physiographic Area #03: South Atlantic Coastal Plain, Physiographic Area #23: Southern Blue Ridge, and Physiographic Area #29: Piedmont serve as helpful sources when reviewing priority bird species in these ecoregions, as well as for guiding population and habitat improvement objectives.

CONSERVATION RECOMMENDATIONS

- Identify and protect forest interior and unbroken large tracts of deciduous forest habitat.
- Determine the best sites for conservation and/or restoration projects by conducting a landscape-level spatial analysis. Utilize spatial models as a basis for land acquisition and delivery of private lands programs in order to locate areas where opportunities for conservation are the greatest.
- Promote existing and develop new partnerships to facilitate increased land acquisition.

- Maintain migratory stopover habitat in coastal areas and river bottoms for Wood Thrush and other Neotropical migrants.
- Continue to promote partnerships to implement forest health measures to prevent, detect, and suppress outbreaks of SOD and hemlock woolly adelgid on public and private lands.
- Reduce communication tower collisions. These measures will be particularly beneficial to species that are common subjects of tower mortality during migration, such as the Blackpoll Warbler (DeLuca et al 2020). Recommendations set forth by Shire (2000) include removing aviation lights on towers that are less than 199 ft tall, removing old towers that are no longer in operation, and conducting environmental assessments to determine the impact a new tower will have if placed within a migratory pathway.
- Introduce policy that seeks to reduce bird-building collisions in South Carolina. Improved building design and window placement in new structures, the addition of window deterrents in existing buildings, conscientious tree and shrub placement, and stricter urban light usage are all measures that should collectively decrease the number of building collisions in urban and suburban areas (Loss et al. 2019; Van Doren et al 2021). Wood Thrush, which are particularly vulnerable to window strikes (Evans et al. 2020), and other neotropical migrants will benefit from these measures.
- If found to be causing an impact in certain areas, the removal of feral cats (*Felis catus*) from public lands through live trapping should be implemented.
- Develop and implement monitoring programs to better assess population dynamics, breeding success, minimum habitat area requirements, and migratory behavior of deciduous forest species. Measures will need to be developed to integrate state monitoring results into regional- and national-level databases.
- Breeding Bird Survey routes should continue annually. The number of routes in under-sampled areas of South Carolina should increase, and new research on improving detection of cryptic species (such as Black- and Yellow-bellied Cuckoos) should be incorporated into survey protocol.
- Promote the participation of volunteers and agency personnel to collect survey and monitoring data.
- Radar ornithology should be continued in order to monitor bird-habitat associations at migration stopover sites. Understanding migratory stopover use of habitat in South Carolina would allow for more targeted projects that would benefit migrants like the Blackpoll Warbler.
- Continue participation in the Atlantic Coast Joint Venture at the management board and science committee levels.

MEASURES OF SUCCESS

Habitat improvement and restoration projects should result in higher breeding populations and nesting success rates. Objectives outlined in Partners in Flight Physiographic Region plans should help guide these measures.

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Eagle Guild

Bald Eagle (*Haliaeetus leucocephalus*)
Golden Eagle (*Aquila chrysaetos*)

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DESCRIPTION

Taxonomy and Basic Description

The family *Accipitridae* contains 59 species of eagles worldwide (Grossman and Hamlet 1964). Sea and fish eagles account for 11 species comprising 3 genera, of which 8 are in the genus *Haliaeetus*. The Bald Eagle is the only species of sea eagle to regularly occur on the North American continent. Two subspecies of *leucocephalus* are described based on size and weight. These are of questionable merit because of a continuous gradient in size from north to south throughout the range (Buehler 2022); therefore, the subspecies *leucocephalus* and *alascanus* are not recognized in this report.





Adult Bald Eagles are large raptors with a distinctive white head and tail that contrasts with the dark brown body. They also possess a bright yellow bill and feet with unfeathered lower legs. Their eyes are large and yellow. Juveniles have a dark head and tail in addition to the dark body. The eyes and bill are dark but the feet and legs are like those of the adults. As the juvenile ages, its body plumage becomes mottled with white and in 4-5 years will reach adult plumage.

South Carolina's nesting population of Bald Eagles is smaller in stature than their northern counterparts with a mean wingspan of 188 cm (6 ft., 2 in.) and a mean weight of 3.27 kg (7.14 lbs.). Bald Eagles from the northern portion of their range can be twice as heavy. Bald Eagle chicks are full grown when they leave the nest and frequently weigh more than adults.


Golden Eagle / Tom Koerner - USFWS

The Golden Eagle is a large, dark brown raptor with a wingspan of 185 – 222 cm (6 - 7 ft.) and a dark bill that fades to yellow at the cere. Females tend to be larger by weight than males (3,000 – 6,000 g (6.61-13.23 lbs.) vs. 2,400 – 4,500 g (5.29-9.92 lbs.). The sexes share plumage characteristics as adults (Katzner et al. 2020). Plumage differs in younger birds, which tend to have white on their inner primary remiges and rectrices, though the amount of white present differs between individuals and decreases with age. Subadult Golden Eagles and Bald Eagles can be difficult to distinguish, but the Golden Eagle can be identified by its head and bill, which are smaller and slimmer than those of a Bald Eagle. Because this species' range extends across the Northern Hemisphere, 6 geographically distinct subspecies are recognized (Katzner et al. 2020).

Status

Bald Eagles and Golden Eagles are protected under the Eagle Protection Act (16 U.S.C. 668-668d) of June 8, 1940, as amended on October 23, 1972. Bald Eagles below the 40th parallel were listed as endangered on March 11, 1967, and subsequently received protection under the Endangered Species Act of 1973 (16 U.S.C.1531-1543). On February 14, 1978, listing status was changed to endangered throughout the contiguous United States except for Washington, Oregon, Minnesota, Wisconsin and Michigan, where the Bald Eagle was designated as threatened. Bald Eagles were reclassified as threatened in all lower 48 states on July 12, 1995 (50CGR Part17). The Bald Eagle was removed from the Endangered Species list in June of 2007 and receives protection by the Eagle Protection Act under the Office of Migratory Birds at the US Fish and Wildlife Service. It continues to be listed under the South Carolina Nongame and Endangered Species Conservation Act as a state endangered species. In South Carolina, the Bald Eagle is considered a vulnerable species (S3B,S3N) and the Golden Eagle is considered critically imperiled (S1N; Nature Serve 2024). On September 11, 2009, a final rule was published in the Federal Register on two permit regulations that allow for take of Bald Eagles and their nests during the course of conducting otherwise lawful activities to protect human safety (74 FR 46836). The current management guidelines and conservation measures can be found at this website: National bald eagle management guidelines | FWS.gov.

POPULATION SIZE AND DISTRIBUTION

During the early 1960s, the nesting Bald Eagle population was estimated at about 412 pairs in the 48 contiguous states (Sprunt and Ligas 1963). In 1982, the number of nesting pairs was up to 1,482 (Green 1985). By the early 2000's there are 7,066 nesting pairs of Bald Eagles in the lower 48 states. The current population estimate for the US and Canada is 200,000 individuals (Panjabi



et al. 2021). The population has both a long-term and short-term increasing population trend, 784.80% and 261.64% respectively (Panjabi et al. 2021). Bald Eagles nest in every state except Hawaii and Vermont. In 1977, there were 13 occupied nesting territories in South Carolina, and by 2009 the State's population had increased to 251 pairs (Figure 1). In 2023, there were at least 350 nesting pairs in South Carolina.

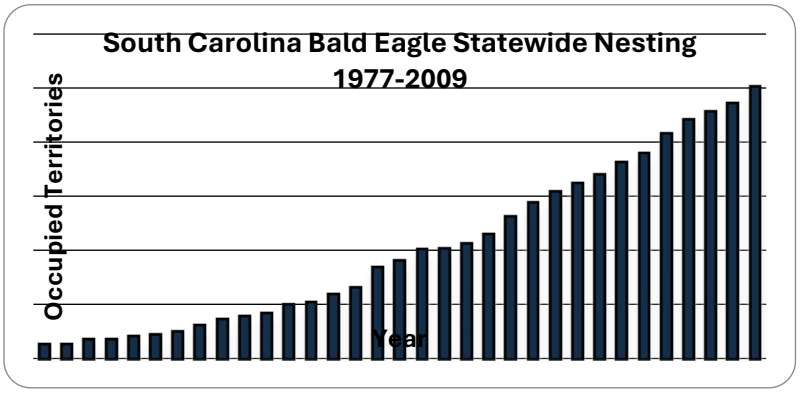


Figure 1: Nesting

Since 1979, mid-winter surveys of adult and juvenile Eagles in South Carolina have been conducted as part of a national effort. The 2009 survey resulted in 652 Eagles counted during mid-winter (Figure 2), up from 36 during the first survey.

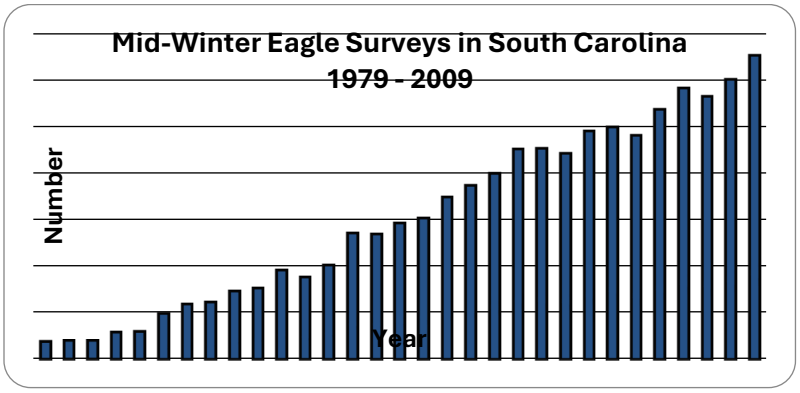
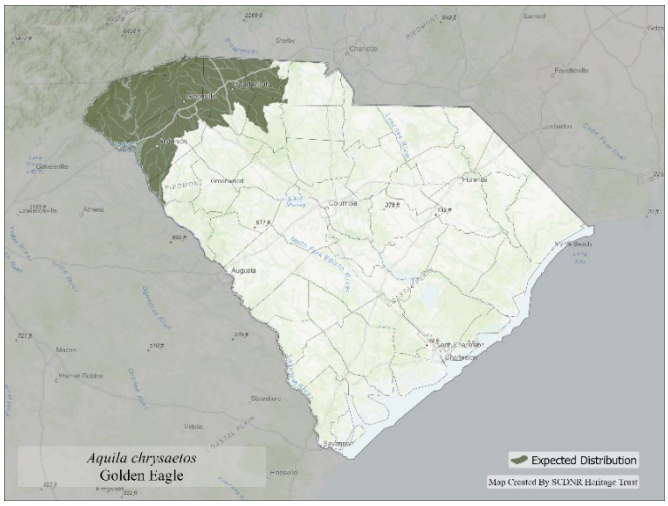


Figure 2: Surveys

The Golden Eagle is found globally, with resident populations in the western US and Canada. The species is a winter migrant to the southeast and has historically been recorded in South Carolina in the Appalachian foothills, with increasing frequency in the coastal plain (Vukovich et al. 2015). Golden Eagles appear to be increasing in number. The US population estimate for the species is 40,000 individuals (PIF 2023), with an approximately 6% increase in population size between 1970 and 2014 (Rosenberg et al. 2016). Based on Breeding Bird Survey data, the annual growth rate in the US is 0.2% (Ziolkowski et al. 2022).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Bald Eagles require large trees with an open limb structure for nesting and are usually located on the forest/marsh ecotone within 1 km (0.62 mi.) of open water. Large trees allow for large nests that can support nesting for many years without falling. The large size may also reduce fratricide or premature fledging. The open limb structure provides easy access and a clear view of foraging habitat. Nesting habitats initially selected by Bald Eagles usually have limited disturbance, although Bald Eagles show remarkable adaptability when confronted with moderate habitat alterations, often due to development in established territories. Trees suitable for perching and future nesting sites are also important components of stable nesting territories. Nonbreeding habitat includes large canopy trees suitable for resting and roosting near foraging sites (Buehler 2022).



Fresh, brackish, and marine habitats provide suitable foraging sites and include open water, marsh, and riverine types. Prime habitats are characterized by having shallow, slow moving water with abundant fish and bird prey. Preferred sites have suitable perches and roosts with minimal disturbance. Large manmade reservoirs in South Carolina have provided 240,000 ha (592,800 ac.) of new inland Bald Eagle foraging habitat. Concentrations of Bald Eagles may be found below hydroelectric dams where they forage on injured fish. Impounded marsh managed for waterfowl is preferred foraging and nesting habitat.

In eastern North America, wintering Golden Eagles are associated with areas of minimal human disturbance and higher forest cover compared with their breeding range in the western US (Katzner et al. 2020). There is evidence that migratory Golden Eagles return to the same wintering areas over consecutive years (McKinley and Mattox 2010; Katzner et al. 2020). This species hunts in flight and will primarily target small and mesomammals for live prey, but eating carrion is also common in the winter. Golden Eagles can be found in the Appalachian Plateau in the very northwest corner of South Carolina, but they are also observed occasionally in the Coastal Plain using forested habitat and managed coastal wetlands (Millsap and Vana 1984).

Eight individual eagles were observed over a 3-year period via carrion-baited camera traps at Savannah River Site in Aiken County (Vukovich et al. 2015). The authors suggested there are likely more eagles wintering in the Southeastern Coastal Plain than originally thought, and that longleaf pine savannas and feral pig carcasses may be important winter resources for them.

CHALLENGES

Shooting has historically been the most significant cause of mortality for Bald Eagles and Golden Eagles. Between 1961 and 1965, 62% of Bald Eagles found dead were shot. More recently, the percentage of Bald Eagles that died as a result of illegal shooting has declined to under 20%. This is undoubtedly one major reason for Bald Eagle recovery. Illegal take is also a concern for Golden Eagles, which are trafficked for their feathers or killed incidentally in mammal traps (Katzner et al. 2020).

Chemical contamination of eagle habitat has long been a problem for these top carnivores. Bald Eagles have been shown to be sensitive to a variety of toxins, particularly persistent organo-chlorine pesticides, such as DDT. Pesticide poisoning has been greatly reduced and is another reason for recovery of the species. However, even with many new products on the market, contamination problems persists. Lead poisoning in Bald and Golden Eagles has been identified as a significant problem (Pattee 1981; Katzner et al. 2020) and there is a chronic issue with barbiturate poisoning of Bald Eagles at landfills where they feed on euthanized animals. Deposition of mercury in foraging habitat also poses a potential threat to the health of Bald and Golden Eagle populations. Currently, the primary diseases affecting Bald Eagles are West Nile virus (WNV), Avian Vacuolar Myelinopathy (AVM), and High Pathogenic Avian Influenza (HPAI) have been identified as notable sources of mortality. Recovery of the Bald Eagle population will result in higher population density and less fit individuals as a result of competition, which may lead to an increased risk of disease.

Since Bald Eagles have been removed from the Endangered Species list, they lost some of the habitat protection previously afforded to the species and their nesting territories no longer require annual monitoring. These factors may lead to habitat degradation and decreased compliance with land management recommendations, which may make current and future nesting habitat unsuitable. Finally, other sources of mortality in Bald and Golden Eagles include electrocution at power lines and trauma sustained from collisions with wind turbines, cars, and other structures.

CONSERVATION ACCOMPLISHMENTS

Conservation accomplishments directly and indirectly affecting the Bald and Golden Eagle are varied. Through public education and effective law enforcement, shooting mortality in Bald Eagles has declined from 62% (Mulhern 1970) to less than 20% of diagnosed mortalities (Locke 1982). A ban on widespread use of DDT was implemented in 1972 and non-toxic shot has been required for waterfowl hunting. Additionally, an array of effective pesticides has been developed that have limited impacts on non-target species. A variety of raptor-safe powerline

configurations have been developed and implemented, and wind turbine collisions have decreased in frequency due to changes in turbine design (Katzner et al. 2020).

Bald Eagle management guidelines for nesting territories have been developed, with reproductive effort and fledgling success of South Carolina nesting Bald Eagles have been documented on an annual basis for 33 years. Adult mortality rates of 12% per year have been calculated based on banded Bald Eagles at nesting territories between 1977 and 2009. Currently, SCDNR surveys Bald Eagle nests by dividing the state into three sections and surveying one section each year so that the entire state is surveyed every three years.

CONSERVATION RECOMMENDATIONS

- Periodic monitoring to evaluate the effects of habitat alterations on the long-term viability of Bald Eagle nesting territories.
- Monitor a different portion of the state annually to keep an index of known Bald Eagle territories so SC can participate in the federal delisting monitoring plan.
- Monitor the causes of injury and mortality of Bald Eagles to document effects of delisting.
- Continue to work with DHEC, veterinarians, and landfill operators to eliminate barbiturate poisonings of Bald Eagles at landfills.
- Work with the Clemson Institute of Environmental Toxicology, Southeastern Cooperative Wildlife Study group (UGA), and the USFWS Wildlife Health Laboratory to monitor contaminants in Bald Eagles.
- Determine the etiology of AVM; document the current extent of the disease; evaluate the potential for future disease; and develop management strategies to minimize impacts. Conduct postmortem examination of fresh dead Bald Eagles to evaluate impacts of AVM, WNV, and HPAI.
- Identify important overwintering areas for Golden Eagles using baited camera traps, following methods in Vukovich et al. (2015).
- Continue monitoring the level of shooting mortality and react with increased active and proactive law enforcement in the event of an increase.
- Continue to implement raptor-safe powerline configurations with a variety of power companies and cooperatives.
- Continue to partner with the International Center for Birds of Prey to provide public education, raptor rehabilitation, and to document the causes of injury and death of Bald and Golden Eagles.
- Continue to ship suitable carcasses to the National Feather Repository for distribution to Native Americans.

MEASURES OF SUCCESS

The Bald and Golden Eagle are species with deferred maturity, low annual reproductive potential, and sensitivity to environmental contaminants. Therefore, utilizing adaptive management to implement conservation actions is important. An indicator of success for both

species is high annual survivorship. Maintaining annual survivorship greater than 85% can best be accomplished by minimizing anthropogenic sources of mortality such as shooting, barbiturate poisoning, and AVM disease. Management of Bald Eagle nesting territories should maintain 1.0 young per occupied territory by minimizing human disturbance and providing adequate perch and nest trees. Bald Eagle mortality and reduced reproduction by contaminants should be prevented by reducing environmental contamination of territories and important prey base species. A better understanding of Golden Eagle distribution in South Carolina will help facilitate protection of suitable habitat and contaminant reduction in key overwintering areas.

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Nightjar Bird Guild

Chuck-Will's-Widow *Antrostomus carolinensis*
Common Nighthawk *Chordeiles minor*
Eastern Whip-Poor-Will *Antrostomus vociferus*

Contributor (2013): Janet Thibault (SCDNR)
Reviewed and edited (2024): Sarah Stewart (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

The nightjar family (*Caprimulgidae*) is a group of insectivorous birds characterized by their nocturnal or crepuscular (dusk and dawn) activity patterns and cryptic appearance. Three nightjar species, the Chuck-will's-widow, Common Nighthawk, and Eastern Whip-poor-will, are known to breed in South Carolina.

All species have mottled brown plumage and share morphological features such as large eyes, wide mouths, and short bills with long rictal bristles around their gapes. Chuck-will's-widows are the largest nightjar in North America with an overall length of 28-32 cm (11-13 in.) and a mass of 110 g (3.9 oz.). They are a reddish-brown color with black patterning on the breast (Straight and Cooper 2020). Common Nighthawks are smaller (22–24 cm or 8.5-9.5 in; 65–98 g or 2.3-3.5 oz) with distinct barring on the abdomen and underside of wing, as well as bright white patches on the primary feathers (Brigham 2020). The Eastern Whip-poor-will is a similar length to the Common Nighthawk (22-26 cm or 8.5-10 in) but is the smallest in body mass of the three (43-64 g or 1.5-2.3 oz) and has more gray and brown patterning with a dark throat contrasted with a white necklace and pale underparts (Cink 2020).

Because of their cryptic appearance and nocturnality, nightjars are typically identified by their vocalizations. The Chuck-wills-widow and Eastern Whip-poor-will are distinguished by their onomatopoetic songs. Chuck-will's-widow songs begin with a low first note followed by 3 notes in which the middle syllable is emphasized ('chuck-wills-WID-ow'), while Eastern Whip-poor-will songs







Top to bottom: Chuck-will's-widow (Tony Castro), Common Nighthawk (David Youngblood), and Eastern Whip-poor-will (Mykola Swarnyk).

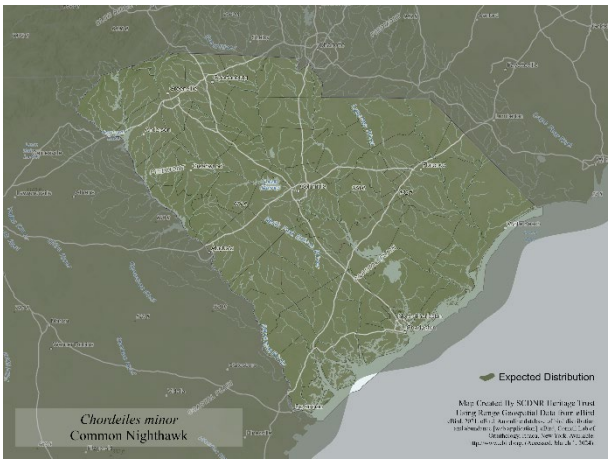
are 3-noted with the first and last notes accented ('WHIP-poor-WEEL'). Common Nighthawks do not have a distinct song, but often make a nasal '*Peent'* call in flight. Additionally, breeding males perform diving displays that produce a loud booming sound (Brigham 2020).

Status

The Chuck-will's-widow, Common Nighthawk, and Eastern Whip-poor-will are each in steep decline across their ranges (Rosenberg et al. 2016; Ziolkowski et al. 2022). Population declines within other aerial insectivore guilds indicate this may be influenced by long-term changes in the quality and availability of insect prey (Spiller and Detmers 2019); however, specific factors leading to nightjar declines are unclear. Estimated range-wide population change between 1970 and 2014 is -63% for Chuck-will's-widows, -58% for Common Nighthawks, and -69% for Eastern Whip-poor-wills (Rosenburg et al. 2016). In South Carolina, the annual rate of decline is 0.5% for Chuck-wills-widows, 6% for Common Nighthawks, and 1.6% for Eastern Whip-poor-wills (Ziolkowski et al. 2021).

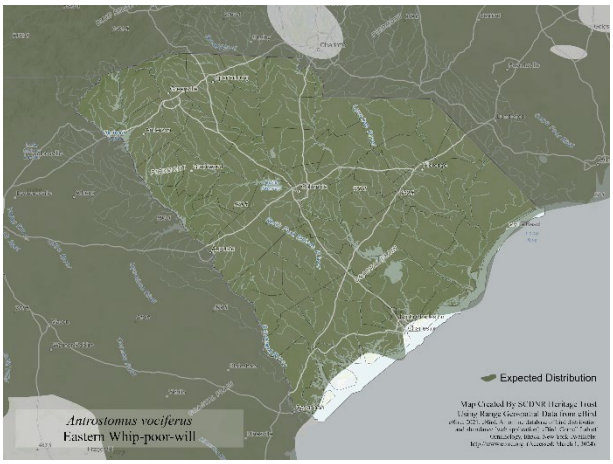
All three species are protected under the Migratory Bird Treaty Act, though none receive special federal status. The Chuck-will's-widow and Common Nighthawk are considered common birds in steep decline by Partners in Flight (PIF), while the Eastern Whip-poor-will is on the PIF Yellow Watch List, specifying greater urgency for the species (Rosenberg et al. 2016; PIF 2023). Regionally, PIF lists the Chuck-will's-widow and Eastern Whip-poor-will as conservation priority species for forests of the Atlantic Coast.





POPULATION SIZE AND DISTRIBUTION

Although there are limitations which increase uncertainty in surveying these species, global estimates of population size are roughly 5.4 million for Chuck-will's-widow, 16 million for Common Nighthawk, and 1.8 million for Eastern Whip-poor-will (Rosenberg et al. 2016). In South Carolina, population estimates are 330 thousand, 8.2 thousand, and 210 thousand, respectively (PIF 2023). The Chuck-will's-widow and Eastern Whip-poor-will have overlapping distributions throughout the Eastern United States and parts of the Midwest. The Chuck-will's-widow's breeding range extends north to Virginia, west to Iowa and Texas, and south to Florida (Straight and Cooper 2020). Eastern Whip-poor-wills breeding range is more northward, extending north to Ontario and New England, west to the Mississippi River, and south to northern Georgia and Alabama (Cink 2020). Both species winter in the



Caribbean and Central America, though the Eastern Whip-poor-will is also a frequent winter resident along the southeast and gulf coasts. Common Nighthawks are a more broadly distributed species and can be found breeding throughout North America, from northern Canada to central Mexico and the Caribbean, and wintering in South America (Brigham 2020).

In South Carolina, the Chuck-will's widow is a summer resident, and confirmed breeding records exist for Barnwell, Charleston, Edgefield, Greenville, Georgetown, Saluda, and Williamsburg counties (Cely 2003) as well as Lexington County (A. Huckabee Smith, pers. comm.). Common Nighthawks are also summer residents, with confirmed breeding records for Chesterfield, Hampton, Jasper, Lexington, and Spartanburg counties. While the Eastern Whip-poorwill is a winter resident along the South Carolina coast, it migrates northwest in April (Sprunt and Chamberlain 1970). Breeding records have been confirmed in Chesterfield, Lee, Spartanburg, and Union counties. There is evidence that Eastern Whip-poor-wills are expanding their breeding range to lower parts of the state; Hamel et al. (1980) reported hearing vocalizations of both species in the Coastal Plain at Beidler Forest in Dorchester County and Congaree Swamp in Richland County during May and June.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Nightjars are insectivorous and forage primarily at night, dusk, and dawn. The Chuck-will's-widow feeds aerially, flying just above the ground and capturing moths and flying beetles with sensory aid from its rictal bristles. They have also been documented consuming small birds and bats opportunistically (Straight and Cooper 2020). The Eastern Whip-poor-will forages at dusk and dawn and during times of bright moon phases, utilizing moonlight to improve prey detection. It often captures insects by sallying from perches and can capture large moths in its enormous gape (Cink 2020). Based upon a selection of qualitative and quantitative diet analyses, Chuck-will’s-widows and Eastern Whip-poor-wills seem to select for moths and flying beetles while foraging (Straight and Cooper 2020; Souza-Cole et al. 2022). Common Nighthawks exhibit more diversity in foraging times and prey selection; while they typically forage at dusk and dawn, they will also opportunistically forage during the day. Their diet encompasses a wide variety of flying insects, including moths, beetles, ants, wasps, mayflies, and caddisflies (Brigham 2020).

The Chuck-will’s-widow and Eastern Whip-poor-will are both considered forest species, but Chuck-will’s-widows appear to use forest gaps, riparian areas, and pastures at a greater rate than Eastern Whip-poor-wills, which prefer areas with more forest cover (Straight and Cooper 2020). Chuck-will's-widows can occur in mixed, pine, and oak-hickory forests while Eastern Whip-poor-wills prefer dry deciduous or mixed forests, open pine, or scrub oak with little or no underbrush. These species are never found in dense forests. Common Nighthawks are considered habitat generalists, though they are typically found in open habitats, including coastal sand

dunes, grasslands, pine savannas, and even urban areas if there are gravel rooftops available for nest sites. Water sources may also play a role in habitat suitability, as Common Nighthawks will exploit them for their insect abundance (Brigham 2020).

Nightjars are ground-nesters but do not create a nest structure, opting to lay their eggs directly on the ground. All three species tend to lay 2-egg clutches. Adults are attentive incubators, with their cryptic plumage serving as nest concealment against the selected ground cover (often deciduous leaf litter for Chuck-will's-widow and Eastern Whip-poor-will). Nightjar young are considered semi precocial and have open eyes and the ability to walk within a day of hatching but are still reliant on adults for physical protection and provisioning for multiple weeks.

CHALLENGES

Nightjars' nocturnal nature and cryptic appearance make these species difficult to detect and survey. Thus, there are knowledge gaps in the life history of Chuck-will's-widows, Common Nighthawks, and Eastern Whip-poor-wills that need to be filled before adaptive management is possible. A significant barrier to understanding nightjar declines is the lack of empirical research on the relationship between industrial pesticide use and abundance of preferred insect prey. While there is anecdotal evidence that indiscriminate mosquito control reduced Common Nighthawk populations in Saskatchewan (Wedgwood 1991), further analysis is needed to understand the influence of pesticides on nightjar ecology. Land use changes over the last century, particularly industrial agriculture, urbanization, and forest succession, likely play a role in loss of breeding habitat for Chuck-will's-widows and Eastern Whip-poor-wills. Collisions with automobiles on gravel roads and along forest edges may also negatively affect adult survival of all three species (Brigham 2020; Cink 2020; Straight and Cooper 2020).

CONSERVATION ACCOMPLISHMENTS

No specific conservation accomplishments have been noted for Chuck-will's-widows, Common Nighthawks, or Eastern Whip-poor-wills. However, significant strides have been made to fill knowledge gaps on the ecology of all three species; a plethora of studies focusing on their migration pathways, nest survival, habitat use, and diet have been published in the last 10 years. Additionally, the Nightjar Survey Network (www.nightjars.org), a U.S.-based network of nightjar survey routes and volunteers, has compiled a database of nightjar occurrence in 40 states since 2007. These data may help identify changes in population status or areas of high conservation priority.

CONSERVATION RECOMMENDATIONS

Priorities for continuing and future research on Chuck-will's-widows, Common Nighthawks, and Eastern Whip-poor-wills include:

- Conduct species-specific surveys for each within their ranges utilizing the United States Nightjar Survey Network to determine breeding distribution and density.

- Determine breeding habitat preferences of each species in South Carolina, as well as winter habitat preferences for the Eastern Whip-poor-will.
- Conduct insect and soil sampling where nightjars are present to assess how pesticide use may impact nightjar's preferred prey species.
- Investigate nest survival and juvenile dispersal patterns for each species.

MEASURES OF SUCCESS

Basic habitat characteristics, population surveys, and nest survival data should be collected before any adaptive management occurs for these species. Success parameters will be outlined pending research findings.

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Whooping Crane

Grus americana


Ryan Hagerty/USFWS, Public Domain

Contributors (2024): Mikayla Thistle (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

The Whooping Crane (*Grus americana*) is a large crane (Family *Gruidae*, Order *Gruiformes*), native to North America. The Whooping Crane and the Sandhill Crane, with which it sometimes forms mixed flocks, are the only crane species in continental North America. Whooping Crane populations can be migratory or non-migratory. Standing almost 1.5 m (4.9 ft), it is also the tallest bird in North America. Males (7.3 kg [16.1 lbs]) are on average larger than females (6.4 kg [14.1 lbs]). Males and females appear similar. Adults have white plumage except for black primary feathers that are only visible when the wings are outstretched. They also have a dark gray-black patch on the nape and sparse bristly black feathers on a red cap and moustache. Adults have a yellow iris. Their long legs are gray-black and bill is olive-gray, lightening during the breeding season. Hatchlings are cinnamon in color. Juveniles begin to develop white feathers at approximately 120 days.

Whooping Cranes are a long-lived species. In the wild, Whooping Cranes on average live to be 22-24 years old (Binkley and Miller 1983) and potentially reach a maximum of 30 years (Mirande et al. 1993). In captivity, they can reach an age of 35-40 years (Moody 1931, McNulty 1966). However, they are slow to reach maturity which contributes to recovery challenges. On average, Whooping Cranes do not produce an egg until 5 years of age (Kuyt and Goossen 1987) and captive birds often are not productive for at least ten years (USFWS 2012).

Status

In 1941, only 21 Whooping Cranes remained in the wild and two in captivity. The Whooping Crane was determined to be threatened with extinction in 1967 and endangered in 1970 under that Endangered Species Preservation Act of 1966. The Whooping Crane maintained its endangered status under the Endangered Species Act of 1973 and critical habitat for the species was designated in 1978. In Canada where the only self-sustaining population breeds, the Whooping Crane was listed as endangered in 1978 by the Committee on the Status of Endangered Wildlife in Canada and listed as endangered under the Species at Risk Act in 2003. NatureServe ranks Whooping Crane as a G1 (Critically Imperiled) Global Status due to only having one self-sustaining population and two reintroduced populations, decreased distribution, low population numbers, habitat degradation, and problems due to collisions with man-made objects such as power lines. Nature Serve also ranks Whooping Crane as a S1 (Critically Imperiled) State Conservation Status for South Carolina. Whooping Crane is not listed on the official State List of Endangered Wildlife Species of South Carolina.

With ESA protection and successes with captive rearing, Whooping Crane populations are increasing. However, only one self-sustaining population that breeds at Wood Buffalo National Park in Canada and winters at Aransas National Wildlife Refuge in Texas remains. As of 2023, the long-term growth rate of this population averaged 4.34% (McAbee and Conkin 2024). Today, Whooping Crane maintains its endangered listing. As of 2024, Whooping Crane is undergoing a 5-year status review by the USFWS.

The first objective listed in the species International Recovery Plan is to "establish and maintain self-sustaining populations of whooping cranes in the wild that are genetically stable and resilient to stochastic environmental events," with the goal of downlisting Whooping Crane from endangered to threatened status (CWS and USFWS 2007). In addition to the one self-sustaining Aransas-Wood Buffalo Population (AWP), there have been four efforts to establish new self-sustaining populations starting in 1975, 1993, 2001, and 2011. These experimental reintroduction populations include a migratory population in the Rocky Mountains for which management was discontinued in 1997 and the last crane disappeared in 2002, a non-migratory population in central Florida (Florida Population [FP]), a population that breeds in Wisconsin and winters between Indiana and Florida (Easten Migratory Population [EMP]), and a non-migratory population in Louisiana (Louisiana Population [LP]). However, success with these programs has been limited.

The second objective listed in the species recovery plan is to "maintain a genetically stable captive population to ensure against extinction of the species" (CWS and USFWS 2007). If self-sustaining populations cannot be established elsewhere through captive rearing and reintroduction, it is estimated that the AWBP must reach a size of 1,000 individuals to be genetically stable and meet criteria for downlisting to threatened.

POPULATION SIZE AND DISTRIBUTION

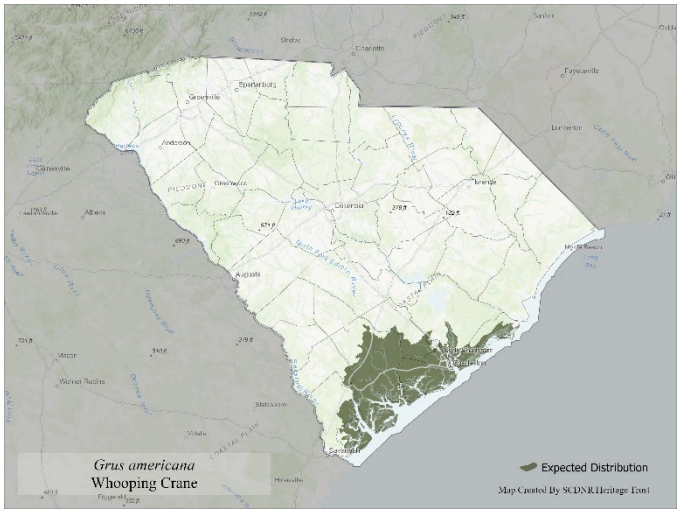
It is estimated that Whooping Crane populations historically reached over 10,000 individuals (USFWS 2012). This declined to about 1,400 individuals by the mid-1800s (USFWS 2012). After reaching a low of 15 or 16 Whooping Cranes wintering at Aransas National Wildlife Refuge in 1941, populations have increased due to conservation efforts (CWS and USFWS 2007). In the winter of 2023, it was estimated that 699 individuals, of which there are 139 breeding pairs, exist in the wild whooping crane populations. As of March 31, 2023, there are 134 individuals in captivity (McAbee and Conkin 2024).

The AWBP breeds primarily in Wood Buffalo National Park and surrounding areas in Canada. This population migrates through Alberta, Saskatchewan, eastern Manitoba, eastern Montana, North Dakota, South Dakota, Nebraska, Kansas, and Oklahoma before reaching wintering grounds in a roughly 50 km stretch of the Texas coast. The AWBP winters primarily at Aransas National Wildlife Refuge and surrounding areas including San Jose and Matagorda Islands. The spring migration corridor is the same as the fall migration corridor. Aerial surveys conducted on wintering grounds in January 2023 were used to estimate the population size at 536 individuals (McAbee and Conkin 2024). The non-migratory FP generally resides at and around Kissimmee Prairie in Osceola and Polk Counties. At the time that the Florida Fish and Wildlife Conservation Commission ended intensive monitoring of the reintroduced Whooping Cranes in June 2012,

there were 18 individuals. Opportunistic monitoring continues and there has been observed breeding success after the intensive monitoring period (McAbee and Conkin 2024). The population estimate as of June 2023 is 5 individuals. The EMP breeds in central Wisconsin at and around Necedah National Wildlife Refuge. The EMP migrates through and winters in various wetland and agricultural areas between Indiana and Florida. Originally, the EMP wintered primarily along the Gulf Coast of Florida; however, wintering grounds have shifted northwards. As of March 1, 2024, the population size of the EMP is 72 individuals (Thompson 2024). Whooping Cranes were reintroduced to White Lake Wetlands Conservation Area, Louisiana. The LP ranges through southwestern Louisiana and occasionally into Texas. As of 2023, there were 85 birds in the LP (McAbee and Conkin 2024). On March 31, 2023, there were 134 Whooping Cranes held in captivity in breeding centers and zoos as part of the American Zoological Association Saving Animals From Extinction program (McAbee and Conkin 2024).

Whooping Cranes were historically present in South Carolina. Fossil evidence demonstrated that Whooping Cranes ranged from the Arctic south to central Mexico, extending from Utah in the west and New Jersey, South Carolina, Georgia, and Florida in the east (Allen 1952). Until 1950, the Waccamaw River served as a wintering ground for Whooping Cranes (Allen 1952, CWS and USFWS 2007). Within the last few decades, Whooping Cranes that have appeared in South Carolina during the winters have been part of the experimental EMP. This wild population is part of a reintroduction effort by the Whooping Crane Eastern Partnership. Starting in 2001, eggs from the breeding population were hand reared at breeding facilities. The chicks are then brought to Necedah NWR in central Wisconsin in the summer. In the fall, the chicks, guided by an ultralight aircraft, migrate to wintering grounds at Chassahowitzka National Wildlife Refuge in west-central Florida. Some birds from this population wintered at the Hiawassee Wildlife Refuge in central Tennessee, Wheeler NWR in northern Alabama, and the ACE Basin in coastal South Carolina (USFWS 2012) although wintering grounds have been shifting northward during the past decade.

In the winter of 2004-2005, seven Whooping Cranes from the experimental EMP wintered in South Carolina. In May 2005, five subadult cranes were detected in South Carolina. These birds were part of the experimental FP and were likely dispersing from drought conditions. Two to four cranes wintered in South Carolina from 2006-2012 (Urbanek et al. 2014b, Thompson et al. 2022). Whooping Cranes were last detected in South Carolina in 2014 when a pair wintered in the ACE Basin (Thompson et al. 2022). Starting in the winter of 2007-2008 and continuing to the present, Whooping Cranes in the EMP have been wintering further north, from Florida up to Indiana. Suspected causes for this shift include warmer winter temperatures, information about norther wintering grounds being passed from older to younger individuals, fewer cranes being guided by aircraft, and use of crops as a



food source on northern agricultural lands (Urbanek et al. 2014a, Teitelbaum et al. 2016, Mengden et al. 2023).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Whooping Cranes generally spend all life history stages in wetland habitat, including coastal marshes and estuaries, inland marshes, lakes, ponds, wet meadows and prairie, rivers, and sometimes agricultural fields (CWS and USFWS 2007, Urbanek and Lewis 2020). The AWBP typically nests in and around Wood Buffalo National Park in Canada in shallow diatom ponds dominated by bulrush, but also use depressions with cattail, sedge, musk-grass, and other aquatic plants (Timoney 1999, CWS and USFWS 2007, Urbanek and Lewis 2020). On wintering grounds at Aransas National Wildlife Refuge in Texas, Whooping Crane typically use salt marshes and tidal flats dominated by salt grass, saltwort, smooth cordgrass, glasswort, and sea ox-eye daisy (CWS and USFWS 2007).

The EMP breeds in central Wisconsin in and near Necedah National Wildlife Refuge. The EMP winters between Indiana and Florida. Wintering sites include wetland complexes with shallow water (brackish marshes, moist soil management units, restored wetlands), riverine systems, flooded agricultural river bottoms, and wetlands on cattle ranches (Thompson 2018, Urbanek and Lewis 2020). The EMP also use agricultural lands, such as cornfields, while overwintering. However, this is more common at northern overwintering sites (Urbanek 2014a, Thompson 2018). Whooping Cranes generally select areas with short vegetation (Thompson 2018). In South Carolina, Whooping Cranes have been documented using managed wetlands such as those common in the ACE Basin.

The FP breeds and winters in central Florida, primarily in or around Kissimmee Prairie. This area is a floodplain to the Kissimmee River and contains freshwater marsh, natural grasslands, and livestock pasture used by the FP (CWS and USFWS 2007). The LP breeds and winters in southwestern Louisiana. Historically, Whooping Cranes in Louisiana used coastal tallgrass prairie. However, this region has experienced drastic land use conversion. The reintroduced population now primarily uses natural shallow freshwater wetlands and working wetlands including fields in rice and crawfish agriculture (Pickens et al. 2017, Vasseur et al. 2023).

Whooping Cranes are omnivores and forage by probing and gleaning food items in the water, soil, and vegetation (Urbanek and Lewis 2020). Their diet is fairly opportunistic, consisting of small aquatic animals, (e.g. fish, frogs, crabs, clams, shrimp, and insects), tubers, acorns, and berries. Migratory individuals often consume waste grain on migratory routes and northern wintering grounds (Urbanek and Lewis 2020).


Stan Bousson/USFWS, Public Domain

CHALLENGES

Range-wide, population declines were originally caused by hunting, egg collection, wetland drainage, and loss of habitat due to agricultural use (CWS and USFWS 2007). Today, Whooping Cranes are still occasionally killed by gunshot when they are mistaken for Sandhill Cranes or through acts of vandalism. Power line collisions and collisions with other manmade objects are threats are additional causes of direct mortality. Every three years, Whooping Cranes undergo a flightless molt period. During this time, adults experience a higher risk of predation.

In captivity, Whooping Cranes face threats such as disease outbreaks and loss of genetic diversity. As Whooping Cranes are slow to mature and typically average fewer than one chick per year, populations are slow to recover (CWS and USFWS 2007). Low reproductive success is a challenge in all populations, but especially in experimental populations where older individuals often fail to breed naturally. In captive populations, many fertile eggs often fail to hatch.

Climate change poses challenges to Whooping Crane conservation, particularly in the wintering grounds. Sea level rise poses a threat to populations wintering in coastal habitat. Whooping Cranes typically use wetlands with water levels <20 in (51cm) deep and sea level rise could limit the availability of suitable wetlands (USFWS 2012). The EMP faces additional threats due to increased drought frequency. Droughts change salinity levels and reduce food sources in wintering grounds, particularly in Florida (Spalding et al. 2009).

The EMP experiences multiple challenges to population growth. One of the largest challenges in the EMP is biting insects. Black flies on the breeding grounds are a large cause of nest abandonment and failure (Urbanek et al. 2010). To help solve this problem, eggs are being collected to encourage renesting after black flies have subsided (McAbee and Conkin 2024). Additionally, cranes are now being released at wetlands in the Eastern Rectangle of Wisconsin where black flies are less of a threat (Thompson et al. 2022). In recent years, the population size of the EMP has started to decline as management objectives shifted from releasing captive reared cranes (Thompson et al. 2022). Reproduction does occur in the wild but natural recruitment in this population remains low (Thompson et al. 2022).

CONSERVATION ACCOMPLISHMENTS

Due to intensive management and captive breeding efforts, total population numbers have increased from a low of 21 individuals to approximately 699 individuals in the wild (CWS and USFWS 2007, McAbee and Conkin 2024). Three additional experimental populations are currently being managed or still have cranes remaining from the management programs. Still, Whooping Cranes, particularly those in experimental populations, are highly dependent on human intervention for population growth. Although no reintroduced population has become self-sustaining, lessons have been learned from each attempt which are applied to improving rearing and release strategies.


Matt Strausser/USFWS, Public Domain

There have been limited direct conservation actions for Whooping Cranes taken in South Carolina as Whooping Cranes have only been an occasional visitor since reintroduction to eastern North America and have not been present in the state for ten years (Thompson et al. 2022). However, multiple partnerships and organizations are working towards rebuilding Whooping Crane populations throughout their range. The reintroduction of the EMP is supported by work from over 9 agencies and private organizations that form the Whooping Crane Eastern Partnership. In 2006, the first wild chick fledged in the EMP (Urbanek et al. 2014b). Initially, chicks were hatched in captivity and reared by staff in costume. The young were then either led by ultralight plane to wintering grounds in Florida or released directly into the population of adult cranes (direct autumn release) in Wisconsin. The ultralight program ended in 2015 as more natural direct autumn release and parent rearing strategies became favored (Thompson et al. 2022). Since the reintroduction program started, 167 ultralight-led, 92 direct autumn release, 52 parent reared, and 37 wild hatched Whooping Cranes have been added to the EMP (Thompson et al. 2022).

Researchers studying the EMP are currently investigating ways to improve management for reintroduced Whooping Cranes. Current goals include refining habitat management, particularly on breeding grounds, to increase reproductive success and better understanding the effects of rearing strategies on behavior, such as parenting abilities and predator aversion, in order to increase survival. Color bands, VHF transmitters, and GPS transmitters are also placed on Whooping Cranes in the EMP in order to monitor the species' movements, breeding ecology, and survivorship (Thompson et al. 2022).

CONSERVATION RECOMMENDATIONS

- Support work being conducted by the Whooping Crane Eastern Partnership to continue growing the EMP to where it is self-sustaining.
- Continue preserving and managing vast, largely undisturbed wetland complexes, such as those found in the ACE Basin. Maintain or increase the acreage and quality of available habitat for Whooping Crane.
- Maintain health of coastal wetlands and managed tidal impoundments. Maintain native vegetation.
- Monitor and protect Whooping Cranes that do arrive in South Carolina. Protect individuals from disturbance by controlling visitation in areas used by Whooping Cranes.
- Research resource use in South Carolina wintering areas if Whooping Cranes repopulate.
- Maintain functional managed tidal impoundments. Wetlands with increased water level control may protect food resources in times of drought.
- Start a public outreach campaign if Whooping Cranes reinhabit South Carolina.

MEASURES OF SUCCESS

Whooping Cranes are likely not dependent on habitat in South Carolina for population growth. Recent shifts in winter ranges are likely not driven by the amount quality habitat for Whooping Crane in the state. Success could be measured by maintaining or increasing the amount of quality habitat for Whooping Cranes in South Carolina if wintering ranges shift back into South Carolina. If Whooping Cranes do winter in the state again, success would be measured in low overwinter mortality rates, successful migration from wintering grounds, and breeding success in reproductive individuals in the following summer. Increased occupancy would only be considered a success if it were due to abundant resources in the state and not due to a decrease in quality habitat elsewhere in their range.

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Wood Stork

Mycteria americana

Contributors (2005): Thomas M. Murphy (SCDNR)
Reviewed and Edited (2012): Christine E. Hand (SCDNR)
Reviewed and Edited (2024): Mikayla Thistle

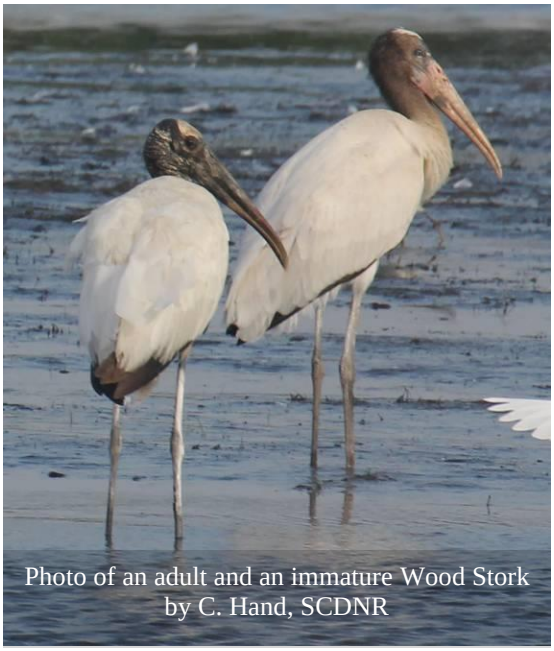


Photo of an adult and an immature Wood Stork by C. Hand, SCDNR

DESCRIPTION

Taxonomy and Basic Description

The Wood Stork is the only stork species that breeds in the United States. Worldwide, there are 19 species of storks in the family Ciconiidae, 4 of which belong to the genus *Mycteria*. Wood Storks are morphologically indistinguishable across their range, and no subspecies have been proposed (Coulter et al. 2020).

Wood Storks have a wingspan of 150 to 165 cm (59 to 65 in) and a head-to-tail length of 85 to 115 cm (33 to 45 in) (Coulter et al. 2020). They are the largest wading birds that breed in South Carolina. Unlike herons and egrets, storks fly with their neck and legs extended. Wood Storks are mostly white, but their primary and secondary wing feathers and their tail feathers are glossy black with a greenish tinge. Adults have dark, unfeathered necks and heads and long, dark bills. At the onset of the breeding season, adults have pinkish feathers under their wings, fluffy feathers under their tails, dark legs, and pink feet. Their legs and feet fade to gray during the nonbreeding season. Immature Wood Storks look similar to adults but have grayish feathers on their necks and heads as well as yellow bills. Storks gradually lose their neck feathers as they mature. They reach maturity at 3 to 4 years of age (Coulter et al. 2020).

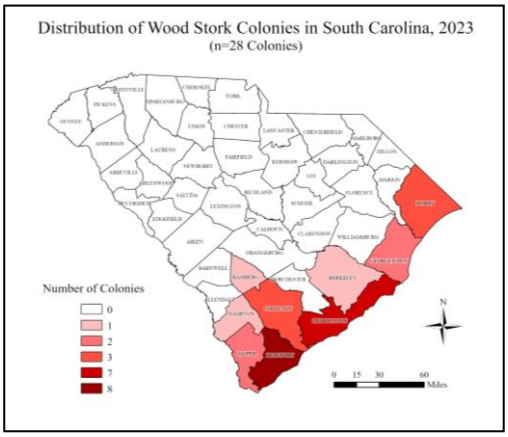
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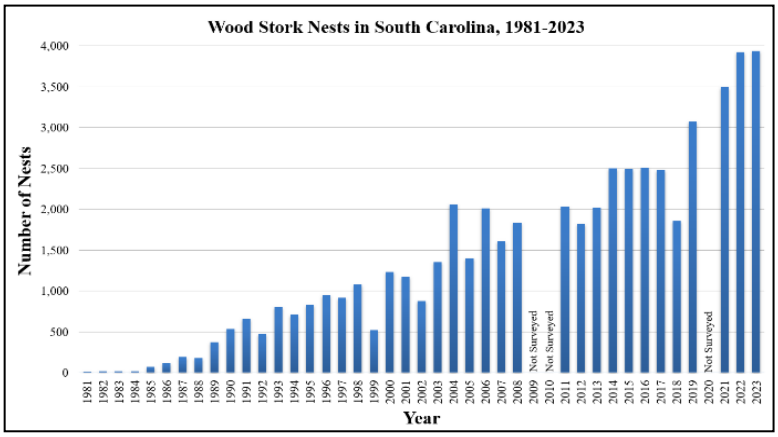
Wood Storks were listed as Endangered on February 28, 1984, pursuant to the Endangered Species Act of 1973, as amended (USFWS 1984). The status of the Wood Stork was reviewed by the U.S. Fish and Wildlife Service (USFWS) in 2007, and in 2010, a petition was filed to reclassify Wood Storks as Threatened rather than Endangered (USFWS 2010). A decision on the reclassification was announced in June 2014 and the bird was down-listed to Threatened. A reclassification to Threatened does not alter any of the protections Wood Storks receive under the Endangered Species Act, but it is a step toward delisting the species. In 2023, a petition was filed to delist the Southeast U.S. distinct population segment of the Wood Stork due to recovery and threats being sufficiently managed (USFWS 2023). After delisting, Wood Stork populations will be monitored for at least five years to ensure that they remain stable or continue to increase. Wood Storks are listed as endangered under the South Carolina Nongame and Endangered Species Conservation Act. The Wood Stork is considered a species of Least Concern by the International Union for the Conservation of Nature (2024). Globally, the Wood Stork is ranked

as Apparently Secure (G4). In South Carolina, it is ranked as Imperiled (S2) (NatureServe 2024). The North American Waterbird Conservation Plan (Waterbird Conservation for the Americas, Version 1) listed the Wood Stork as a species of high concern (Kushlan et al. 2002).

POPULATION SIZE AND DISTRIBUTION

The breeding range of the Wood Stork extends from the southeastern part of the United States through Mexico, Central America and the Caribbean, to central South America. In the United States, storks breed in Florida, Georgia, South Carolina, and North Carolina. The breeding population of Wood Storks in the United States was initially listed as Endangered after nesting pairs declined from between 15,000 and 20,000 in the 1930s to 2,500 pairs by 1978. The low number in 1978 was a combination of a decrease in the regional population and poor conditions for nesting that particular year (USFWS 1996).





Historically, Wood Storks have used South Carolina as a post-nesting foraging area during the summer and fall (Murphy 1995). In 1981, the first successful Wood Stork nests were documented in South Carolina. SCDNR estimates that the number of nests in South Carolina have increased from 11 in 1981 to 3,935 nests over 28 colonies in 2023. The highest counts of Wood Stork nests were recorded over the past five years, omitting 2020 due to survey constraints, and nest counts have nearly doubled over the past decade. This is likely due to increased habitat management and a trend of nesting colonies moving northward. Partners in Flight estimate the global population size of Wood Storks to be 450,000 individuals, with 16,000 in the United States.


Photo by C. Hand, SCDNR

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Wood Storks typically nest in the upper branches of black gum (*Nyssa biflora*) or cypress (*Taxodium distichum*) trees that are in standing water. Standing water deters mammalian predators and is an essential element of colony sites. Storks require open access to nest trees and are frequently found in trees adjacent to

open water areas. Range-wide, there has been a trend towards the use of manmade wetlands as colony sites in recent years as these sites are not totally dependent on rainfall for water (Rodgers 1996). In South Carolina, colony sites are typically surrounded by extensive wetlands, in particular palustrine forested wetlands (Mitchell 2002).

Wood Stork chicks are altricial, which means that they are completely dependent on their parents for temperature regulation and food when they hatch. At least one parent is usually at the nest caring for the chicks during the first three weeks after they hatch. Wood Stork chicks require parental care for a long period of time (over two months) before they can depart from their nests and feed themselves. In order for Wood Storks to nest successfully, prey must be abundant and available throughout their nesting season. A small colony of Wood Storks (100 pairs) requires over 15,000 kg (33,070 lbs) of food during the nesting season (Coulter et al. 2020). Storks time their nesting activity so that chick rearing coincides with receding water levels in wetlands, which allow them to capture prey more efficiently. In South Carolina, storks typically nest from March through August. When adequate food is not available throughout the entire nesting season, adult storks abandon the colony and the remaining eggs and chicks do not survive.


Photo by C. Hand, SCDNR

Unlike herons and egrets, which hunt visually, Wood Storks use tactolocation, which means that they hunt by feeling for fish, crustaceans, and other prey. Storks wade through the water with their bills open, and when their sensitive lower mandible comes into contact with prey, their bill snaps shut. A snapping reflex is used to close their bills in as little as 1/40th of a second (Coulter et al. 2020). Storks sweep their bills back and forth through the water and pump their feet up and down to startle prey. This feeding strategy requires high concentrations of prey in water that is shallow enough (less than 50 cm or 20 in) (Coulter et al. 2020) for storks to wade through it. Storks can feed in the dark and in water that is murky since they do not rely on visual cues to locate prey. Tactolocation also allows storks to feed in large aggregations that stir up sediment into the water. Forested riverine floodplains, diked marsh impoundments, ponds, ditches, and tidal creeks are important feeding habitats. Use of these habitats is enhanced by receding water which concentrates prey items.


Photo by C. Hand, SCDNR

CHALLENGES

Wood Storks are particularly vulnerable to habitat degradation and to unpredictable weather conditions because of their specialized feeding behavior and because their chicks require care for a long period of time before becoming independent. Loss of feeding habitat from alteration of natural hydroperiods in the Everglades has resulted in abandonment of nesting colonies or widespread nesting failures in south Florida. Development, lowered water tables, and disturbance also degrade nesting sites. As habitat in their historic breeding range has become degraded, South Carolina has become an important breeding area as well as an important feeding area during the nonbreeding season. The impounded backwaters and managed impoundments of South Carolina likely provide more stable habitat and food resources for Wood Storks while in other areas of their range, such as south Florida, resources may be more unstable. However, these impoundments are at risk because sea level rise and increasing storm intensity may damage impoundment infrastructure.



Thick mat of Cuban bulrush in wading bird habitat by C. Hand, SCDNR

The presence of invasive Cuban bulrush (*Oxycaryum cubense*) in rookeries is an emerging threat to wading bird colonies that warrants future study. Cuban bulrush forms thick, buoyant mats that outcompete native aquatic plants, reduce water quality, and allow terrestrial predators such as racoons to access nesting sites. Thick mats of Cuban bulrush may also restrict alligator movement. Alligator presence attracts wading birds to nesting colonies (Burtner and Frederick 2017) as they reduce the number of mammalian predators. In turn, alligators benefit from consuming nestling carcasses (Nell and Frederick 2015). SCDNR is developing strategies to manage Cuban Bulrush from Donnelley Wildlife Management Area and other ACE Basin properties used by colonial nesting wading birds.

CONSERVATION ACCOMPLISHMENTS

A regional Wood Stork working group has been organized to facilitate information exchange and to set research and management priorities. Regional management guidelines for Wood Stork nesting, feeding, and roosting habitats have been developed. Standardized surveys of nesting efforts have been completed for the Southeastern United States. A revised Wood Stork Recovery Plan was completed in 1997 which has informed management guidance in South Carolina. In 2001, a brochure to inform landowners of conservation and management needs of storks was completed as a joint production of the USFWS and the University of Georgia Savannah River Ecology Laboratory. This brochure can be found at: https://www.dnr.sc.gov/wildlife/species/wadingbirds/docs/WOST_Management_Landowners_brochure.pdf (Accessible as of August 30, 2024).

SCDNR has been monitoring Wood Stork populations in the state since 1981. In 2014, SCDNR banded 100 Wood Stork chicks as part of a research effort throughout the southeast to understand Wood Stork movement, demography, and longevity. Satellite transmitters were also placed on nine Wood Storks in South Carolina to identify foraging and roosting habitat, monitor productivity, and monitor survivorship. Monitoring currently includes on the ground nesting surveys at index colonies (to best estimate nesting success) and statewide aerial surveys. Nest success exceeded the recovery criteria of 1.5 fledglings per nest during 12 of the 13 years when monitoring has been completed. South Carolina has seen nest counts in South Carolina climb from 11 in 1981 to 3,935 nests in 2023. This increase reflects a commitment to management that supports Wood Storks by private and public land managers in South Carolina as well as a northward shift in the Wood Stork breeding range. Additionally, updated colony location and species composition data from surveys are added to the SCDNR Heritage Trust Database which is used by permit reviewers, land use planners, conservation easement advocates, landowners, consultants, and other agencies and individuals who are interested in considering wading bird conservation in their land use decisions.

At a few sites, intensive efforts have been made to create habitat for Wood Storks. Techniques for management of fresh water ponds to enhance stork use have been developed and implemented at the National Audubon Society's Silver Bluff Plantation Sanctuary in Jackson, South Carolina. At Harris Neck National Wildlife Refuge (NWR), artificial nesting platforms have been developed to enhance stork nesting at colony sites with limited vegetation for nest construction. In recent years, the storks at Harris Neck NWR have moved from the artificial platforms to trees that were grown to provide nesting habitat.

CONSERVATION RECOMMENDATIONS

- Conduct aerial surveys annually to locate new Wood Stork nesting colonies and to determine which colonies should be visited from the ground.
- Conduct complete ground counts of Wood Stork nests at colony sites in South Carolina each year.
- Provide permitting agencies with current information on Wood Stork colonies by updating distribution maps every year.
- Monitor a sample of nests each year to quantify nesting success.
- Determine survivorship of fledgling, immature, and adult Wood Storks using mark and recapture (band resighting) and satellite telemetry.
- Document important habitat for Wood Storks during the nonbreeding season.
- Determine if the amount of foraging habitat limits species recovery. Study foraging ecology and habitat use in South Carolina.
- Participate in and contribute to the regional Wood Stork working group.
- Integrate management for Wood Storks into traditional waterfowl management of currently impounded wetlands by timing draw downs during key feeding periods (post fledging).
- Provide technical guidance and assistance to owners and managers of land where storks nest, feed, and roost.
- Develop a fund that can be used by SCDNR to manage habitat for storks on private lands (with the consent and cooperation of the private landowners). SCDNR manages aquatic

vegetation in colonies on public land, but funding is not currently available for SCDNR to purchase herbicide and apply it on private land.

- Acquire, or assist conservation organizations to acquire, and manage important nesting and feeding sites to benefit Wood Storks.
- Continue maintaining a SCDNR web page on Wood Storks and other wading birds for public outreach and information exchange with existing and potential management partners.
- Develop management strategies to eradicate and prevent the spread of Cuban bulrush.
- Monitor the effects of invasive Cuban bulrush and Cuban bulrush removal on wading bird nesting success

MEASURES OF SUCCESS

During the past several decades, Wood Stork nesting has shifted northward and is significantly changing management of the species. Efforts to restore wetlands in south Florida may significantly affect wintering and nesting Wood Storks in the future. The USFWS recovery goal for the Wood Stork is a minimum of 10,000 breeding pairs with annual regional productivity greater than 1.5 chicks per nest/year (USFWS 1996). This goal has been met in all breeding regions except for the South Breeding Region which has had lower productivity (USFWS 2021). However, the Northeast, Northwest, and Central Breeding Regions have all met the productivity goal and the increased importance of the northern breeding regions in population recovery provide support for delisting. In South Carolina, management for Wood Storks will be considered successful if the distribution of nesting colonies in the state expands, number of nests continue to increase across years, and annual regional productivity is maintained at greater than 1.5 chicks per nest/year.

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Acuminate Crayfish

Cambarus acuminatus



Contributor (2024): Michael Kendrick (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

Cambarus acuminatus was described from the Saluda River but is known to be part of a species complex, known as the *Cambarus* sp. C. complex that ranges from South Carolina to Pennsylvania. *Cambarus acuminatus sensu stricto* appears to be restricted to the Saluda River basin in SC (Williams et al. 2019).

Status

Cambarus acuminatus appears to be stable, but development and land use change threaten this species. Populations in the South and North Fork of the Saluda River within the Enoree District of the Sumter National Forest appear to be robust.

POPULATION SIZE AND DISTRIBUTION

The Broad River Spiny Crayfish is restricted to the Broad River Basin, see Williams et al. 2019 for a map of its distribution. It is rare at sites where it is found (Eversole 1995, Loughman and Williams 2020). Simmons and Fraley (2010) completed surveys in the Broad River basin and found *C. spicatus* at 4 of 27 sampled sites. Russ and Fraley (2014) documented *C. spicatus* at eight of 43 sites in the Broad River basins. The historic distribution is the Broad, Little, Pacolet, Saluda and Tyger River basins in South Carolina. Survey efforts from 2017 to 2018 found *C. spicatus* from the Little River and Cedar Creek in lower portions of the Broad River, and in Obed Creek in the Pacolet River basin. No animals were collected from historical locations in the Tyger River system, indicating that these populations are likely extirpated.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

This species is often collected from third, or higher, order streams throughout the upper Saluda River basin at or above the fall line. Substrate of cobbles, slab boulders, and boulder clusters, as well as leaf packs, root wads, and undercut banks (Williams et al. 2019).

CHALLENGES

The presence of invasive crayfish, stream degradation and sedimentation, and lack of connectivity all represent significant challenges to this crayfish that is known to be locally rare when it is present. The spread of *P. clarkii*, in particular, within the Saluda River drainage poses a serious threat to long term existence of *C. acuminatus*.

CONSERVATION ACCOMPLISHMENTS

Surveys by Williams et al. (2019) provided critical information on the status of this species.

CONSERVATION RECOMMENDATIONS

- Additional surveys throughout the entire study area for undocumented populations as well as documenting the spread of invasive *F. rusticus* and *P. clarkii* populations is needed.
- Given the disjunct nature of the known populations, population genetics would be warranted to better understand population connectivity and genetic structure.

MEASURES OF SUCCESS

An increase or no net decrease in numbers of individuals collected in future surveys would be considered a sign of success.

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Black Mottled Crayfish

Procambarus enoplosternum

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Zanethia Barnett (USFS)

DESCRIPTION

Taxonomy and Basic Description

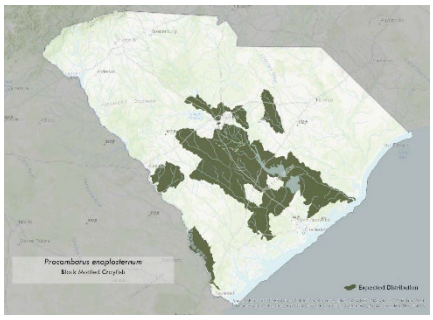
There is a great deal of geographic variation in the coloration of *P. enoplosternum*. Patterns vary and may be charcoal or black and orange, cream, or yellowish-cream. Sometimes, it may have black stripes or cream-colored tubercles. The antennae may be cream or have pinkish irregular spots. The chelae are olive tan or cream to orange-tan with black tubercles (Hobbs 1981). This species may be confused with the Cedar Creek crayfish, *P. chacei*. Therefore, questions have been raised regarding the taxonomic distinctness between these two species (Hobbs 1981, 1989).

Status

NatureServe (2024) currently identifies *P. enoplosternum* as vulnerable (S3) in South Carolina, while it is listed as apparently secure/secure in Georgia (S4/S5) and globally (G4/G5). Taylor et al. (2007) listed the species as currently stable in Georgia and South Carolina.

POPULATION SIZE AND DISTRIBUTION

P. enoplosternum occurs in South Carolina counties below the fall line from the Santee River basin in Berkely County to the Savannah River basin into eastern Georgia's Ogeechee, Altamaha, and Oconee River Basins (Eversole and Jones 2004; Skelton 2010; Z. Barnett, USFS, pers. comm. 2024). It is believed to be fairly widespread in South Carolina, but due to taxonomic confusion between *P. enoplosternum* and *P. chacei*, the exact range is difficult to determine (Hobbs 1981).



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

P. enoplosternum occurs in a variety of habitats including slow to moderately flowing streams and impoundments (Hobbs 1958). It can be found in shaded streams often in dense beds of macrophytes or occasionally in shallow lentic habitats such as roadside ditches (Hobbs 1981). Little is known of its specific habitat requirements.

CHALLENGES

Because little is known of the specific habitat requirements specifically for *P. enoplosternum*, surveys should be conducted to determine these requirements. Additionally, taxonomic work is necessary to clarify the relationship between this species and *P. chacei*. Until more information is available, it is difficult to identify specific challenges to *P. enoplosternum*.

CONSERVATION ACCOMPLISHMENTS

Stream surveys from 2022-2024 on the Francis Marion National Forest collected 106 *P. enoplosternum* from 5 sites in Berkely County (Z. Barnett, USFS, pers. comm.).

CONSERVATION RECOMMENDATIONS

- Conduct research to determine the range, population densities, and habitat requirements for *P. enoplosternum*.
- Conduct taxonomic studies to determine the relationship between *P. enoplosternum* and *P. chacei*.

MEASURES OF SUCCESS

The collection of data that better describes the habitat requirements, distribution, and population densities for *P. enoplosternum* may be considered a measure of success. Additionally, completion of taxonomic studies to determine the relationship between *P. enoplosternum* and *P. chacei* would be considered a sign of success.

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Broad River Spiny Crayfish

Cambarus spicatus



Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Michael Kendrick (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

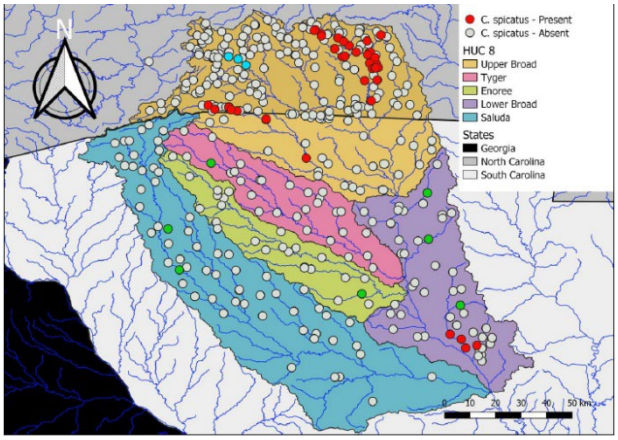
The Broad River Spiny Crayfish is a moderate-sized tertiary burrowing crayfish with cream, pink, purple, and brown highlights. The chelae are green with orange tips and a double row of tubercles (NCWRC 2005) with spination in the hepatic region of the carapace, and along the ventral and dorsolateral region of the carpus and merus and with prominent hepatic spines. The rostrum has marginal spines and two prominent rostral tubercles, and the chelae are broad with long fingers. The holotypic, allotypic and morphotypic specimens ranged from about 60-78 mm (2.4-3.1 in.) in length (Hobbs 1956a).

Status

Taylor et al. (2007) recommended that the Broad River Spiny Crayfish be listed as vulnerable in both North and South Carolina. The National Museum of Natural History considers it to be of special concern. NatureServe (2011) currently identifies this crayfish with a ranking of imperiled (S2) in North Carolina and vulnerable (S3) in South Carolina. Recently, the Broad River Spiny Crayfish was included on a list of 404 species being petitioned for consideration as candidates for federal protection (United States Fish and Wildlife Service 2011). The IUCN classifies *C. spicatus* as data deficient (IUCN, 2010).

POPULATION SIZE AND DISTRIBUTION

The Broad River Spiny Crayfish is restricted to the Broad River Basin. It is rare at sites where it is found (Eversole 1995, Loughman and Williams 2020). Simmons and Fraley (2010) completed surveys in the Broad River basin and found *C. spicatus* at 4 of 27 sampled sites. Russ and Fraley (2014) documented *C. spicatus* at eight of 43 sites in the Broad River basins. The historic distribution is the Broad, Little, Pacolet, Saluda and Tyger River basins in South Carolina. Survey efforts from 2017 to 2018 found *C. spicatus* from the Little River and Cedar Creek in lower portions of the Broad River, and in Obed Creek in the Pacolet River basin. No animals were collected from historical locations in the Tyger River system, indicating that these populations are likely extirpated.



Loughman and Williams (2019): SEAFWA SEARS Grant #2016-02. *C. spicatus* locations are documented in red points.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The streams in which the Broad River Spiny Crayfish has been found exhibit signs of flash flooding, including sand deposits and log jams. This species is usually found in leaf packs/debris, artificial cover, and associated with undercut banks (Eversole 1995; Loughman & Williams 2020). Siltation limits suitable habitat (Simmons and Fraley 2010; Russ and Fraley 2014).

CHALLENGES

The presence of invasive crayfish, stream degradation and sedimentation, and lack of connectivity all represent significant challenges to this crayfish that is known to be locally rare when it is present.

CONSERVATION ACCOMPLISHMENTS

Surveys by Loughman & Williams (2020) provided critical information on the status of this species.

CONSERVATION RECOMMENDATIONS

- Additional surveys throughout the entire study area for undocumented populations as well as documenting the spread of invasive *F. rusticus* and *P. clarkii* populations is needed.
- Given the disjunct nature of the known populations, population genetics would be warranted to better understand population connectivity and genetic structure.

MEASURES OF SUCCESS

An increase or no net decrease in numbers of individuals collected in future surveys would be considered a sign of success.

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United States Fish and Wildlife Service (USFWS). 2011. Endangered and threatened wildlife and plants; partial 90-day finding on a petition to list 404 species in the southeastern United States as endangered or threatened with critical habitat. *Federal Register* 76: 59836–59862.

Brushnose Crayfish
Procambarus pubescens



Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Graham Wagner and Michael Kendrick (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

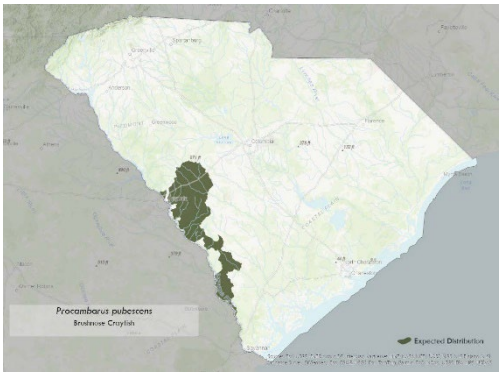
Procambarus pubescens is found in two color phases. One is predominantly blue, grey and black; and the other is brown, tan, orange, and black with a median longitudinal orange-tan stripe and black spots. The rostrum has marginal spines, and the chelipeds have tubercles (Hobbs 1981).

Status

NatureServe (2024) currently identifies this species as ranked of apparently secure (S4/S5) in Georgia and vulnerable (S3?) in South Carolina. It has a global rank of apparently secure (G4). Taylor et al. (2007) listed the Brushnose Crayfish as currently stable in Georgia and South Carolina.

POPULATION SIZE AND DISTRIBUTION

The Brushnose Crayfish is found in the Coastal Plain and the eastern edge of the Piedmont Plateau in the Savannah River Basin of South Carolina and Georgia. In South Carolina, it is documented in Edgefield, Aiken, and Barnwell counties and is expected to occur at least as far south as Hampton County (A. Eversole pers. comm., SCDNR data). This species is abundant in aquatic plant beds in Stevens Creek Reservoir (W. Poly pers. obs.). It is a peripheral species in South Carolina.



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

P. pubescens has been found in a variety of streams in the Coastal Plain, ranging from very small, shallow streams to small rivers. It can be found in both densely vegetated streams and well-shaded streams lacking in vegetation. Some of the streams in which it has been found are slow-flowing with muddy bottoms, while others have sandy or rocky substrates and are rapidly flowing (Hobbs 1947b).

CHALLENGES

Little is known about the Brushnose Crayfish. Survey work and research on its habitat association and life history are needed.

CONSERVATION ACCOMPLISHMENTS

Surveys were conducted with positive records of this species confirmed, but there are no other significant conservation accomplishments specifically for *P. pubescens* at this time.

CONSERVATION RECOMMENDATIONS

- Conduct research to determine the habitat requirements and life history for *P. pubescens.*

MEASURES OF SUCCESS

The collection of data that better describes the habitat requirements and life history of *P. pubescens* may be considered a measure of success.

LITERATURE CITED

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Chattahoochie Crayfish (*Cambarus* sp. "A" cf. *howardi*)

Cambarus howardi

Contributors (2024): Eric Ng and Kathryn Schulz
(West Liberty University) and Michael Kendrick (SCDNR)

DESCRIPTION

Taxonomy and basic description

Cambarus howardi was described by Hobbs and Hall in 1969 from Cobb County, Georgia. However, the species has more recently been reported to occur in South Carolina as *Cambarus* species "A" (*C. cf. howardi*), due to characteristics this species shares with the description of *C. howardi*. Both Eversole and Jones (2004) and Alderman (2005) identified the species occurring in South Carolina tentatively as *Cambarus howardi*. To address this issue, Eversole (2014), and Poly and Eversole (2015) recommended a taxonomic revision of *C. cf. howardi* as a research objective.

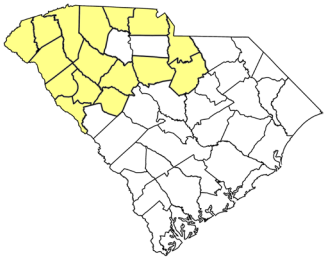
According to Eversole (2014), *Cambarus* species "A" resembles the description of *C. howardi*. *C. howardi* is an olive-green base color with scarlet-red rostral margins, suborbital and postorbital ridges. The abdomen is a greenish tan and possesses a scarlet band on the caudal portion of each segment. Eyes are large and well-developed. Chelae have alternating patches of tan and green with scarlet-red accenting on each segment. The mesial margin of the palm has a single row of tubercles and the fingers of the chelae have developed longitudinal ridges. The cervical groove of the carapace has small tubercles, but no spines. The total carapace length of mature, form I males can range between 27.6mm (1.09 inches) to 31.8mm (1.25 inches), while females can reach 34mm (1.34 inches) maximum (Hobbs & Hall, 1969).

Status

Because of the systematic concerns of *Cambarus cf. howardi* in South Carolina, there is no status rank for *Cambarus* species "A" in the state. A formal taxonomic review of *C. cf. howardi* needs to occur in order to establish a status rank for the species in South Carolina (Poly & Eversole, 2015). Under NatureServe (2024), the type Chattahoochee Crayfish (*C. howardi*) is ranked imperiled (S2) in Georgia and Alabama and vulnerable (G3) globally.

POPULATION SIZE AND DISTRIBUTION

The range of *Cambarus* sp. "A" consists of 16 counties located within the upper piedmont region of South Carolina. They are restricted to the Savannah, Saluda, Broad and Catawba river basins (Eversole, 2014). Individuals have been found in North Carolina as well under the name of *Cambarus sp. cf. howardi*, and are found within the Broad, Catawba, and Yadkin-Pee Dee River basins (LeGrand, 2022).



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Chattahoochee Crayfish typically inhabits water with moderate to fast flowing currents that contain a high dissolved oxygen rate. They prefer streams and rivers with gravel and rocky

substrate where they can seek shelter in interstitial burrows among the rocks (Hobbs & Hall, 1969).

CHALLENGES

Due to the limited information pertaining to *Cambarus* species "A" in South Carolina, future surveys are recommended to discern the exact range, threats, and life history of the species. Eversole (2014), lists this species in 16 counties across South Carolina, not placing it currently in a need for conservation concern. However, due to their sensitivity to low oxygenated water systems (Hobbs & Hall, 1969), habitat loss is still a concern for this species.

CONSERVATION ACCOMPLISHMENTS

There are no significant conservation accomplishments specifically for the *Cambarus* species "A" at this time.

CONSERVATION RECOMMENDATIONS

- Initiate the process to refine the taxonomy of *Cambarus* sp. "A" in South and North Carolina.
- Continue to conduct surveys to monitor the abundance of *Cambarus* sp. "A".
- Based on surveys, establish a conservation rank for *Cambarus cf. howardi* in South Carolina.

MEASURES OF SUCCESS

The collection of data that better describes the natural history and population status of the *Cambarus* sp. "A" may be considered a measure of success. An updated taxonomic revision of the species would also be considered a sign of success.

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Carolina Needlenose Crayfish

Cambarus aldermanorum



Credit: Michael Perkins/NCWRC

Contributor (2024): Graham Wagner (SCDNR) and Bronwyn Williams (NCMNS)

DESCRIPTION

Taxonomy and Basic Description

The Carolina needlenose crayfish is olive colored or green-gray with bluish highlights. The rostrum is long and narrow, not delineated by tubercles or spines (Cooper and Price 2010). The tips of the chelae are a yellowish-cream color. There is a strong longitudinal ridge on the dorsal surface of both fingers, and a double row of tubercles on the mesial margin of the palm. Individuals may or may not display hepatic spines.

Status

NatureServe (2024) identifies the rank as Vulnerable (S3) in South Carolina, but there is no global status rank.

POPULATION SIZE AND DISTRIBUTION

The Carolina Needlenose Crayfish occurs in the Catawba basin in South Carolina, with an apparently disjunct population in the Saluda River basin; the species also occurs in North Carolina in the Catawba basin. There are no current estimates of population size.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Little is known about the preferred habitat and environmental requirements of the Carolina Needlenose Crayfish. There have been no studies of the life history of this species (Cooper and Russ 2013).

CHALLENGES

Little is known about the life history of this species (Cooper and Russ 2013). Additionally, it has a relatively small range, and is therefore at risk of impacts from anthropogenic habitat alterations as well as nonnative species.

CONSERVATION ACCOMPLISHMENTS

There are no significant conservation accomplishments specifically for the Carolina Needlenose Crayfish at this time.

CONSERVATION RECOMMENDATIONS

Conduct thorough surveys to determine the range and distribution of the Carolina Needlenose Crayfish, as well as its habitat preferences and abundances.

MEASURES OF SUCCESS

An increased understanding of the distribution and population status of the Carolina Needlenose Crayfish would be considered a measure of success.

LITERATURE CITED

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Carolina Sandhills Crayfish

Procambarus pearsei



Credit: Kendrick/SCDNR

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Michael Kendrick (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

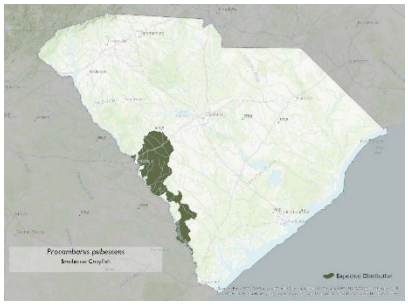
The Carolina Sandhills Crayfish is a small species, cylindrical in shape, and light brown in color with pastel highlights and often with dark speckles. The chelae are large but not robust (NCWRC 2005). Adult specimens examined in the process of writing the original description of the Carolina Sandhills Crayfish ranged from approximately 48-58 mm (1.9-2.3 in.) in length (Creaser 1934). A re-description of the Carolina Sandhills Crayfish was published (Cooper 2011b).

Status

NatureServe (2011) currently identifies the ranking of the Carolina Sandhills Crayfish as vulnerable (S3) in South Carolina and apparently stable (S4) in North Carolina. Taylor et al. (2007) listed the species as currently stable in North and South Carolina.

POPULATION SIZE AND DISTRIBUTION

The majority of the range of the Carolina Sandhills Crayfish is in North Carolina, but it does extend into the Waccamaw and Lumber-Little Pee Dee River Basins of South Carolina (Cooper 2011). It has been found in 5 counties in South Carolina and also might be expected to occur in other nearby counties (SCDNR stream data, Cooper 2011).



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Generally, the Carolina Sandhills Crayfish is found in lentic waters and subterranean burrows. It is a secondary burrower (NCWRC 2005). Hobbs (1989) listed it as being found in streams, so it may be able to inhabit a wide variety of habitats.

CHALLENGES

Our experts recommend that the Carolina Sandhills Crayfish be designated as a species of special concern in South Carolina due to an apparently restricted distribution. More research is needed on the habitat associations and distribution of this species before it can be determined if this ranking is appropriate.

CONSERVATION ACCOMPLISHMENTS

A re-description of the species, update of its distribution, and limited life history information was recently published (Cooper 2011b).

CONSERVATION RECOMMENDATIONS

- Conduct research on the life history and habitat requirements of the Carolina Sandhills Crayfish.
- Investigate the need to initiate the process to achieve special concern status for the Carolina Sandhills Crayfish in South Carolina.

MEASURES OF SUCCESS

The collection of data that better describes the life history and habitat requirements for the Carolina Sandhills Crayfish may be considered a measure of success.

LITERATURE CITED

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Creaser, E.P. 1934. A new crayfish from North Carolina. Occasional papers of the museum of Zoology, University of Michigan. 285, 4 pages, figures 1-3.

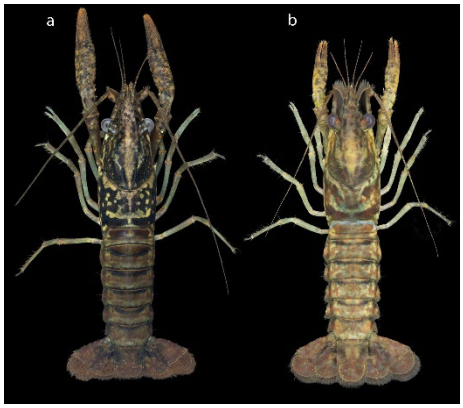
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North Carolina Wildlife Resources Commission (NCWRC). The Crayfishes of North Carolina. Accessed March 2005. http://www.ncwildlife.org/pg07_wildlifeSpeciesCon/nccrayfishes/nc_crayfishes.html.

Taylor, C.A., G.A. Schuster, J.E. Cooper, R.J. DiStefano, A.G. Eversole, P. Hamr, H.H. Hobbs III, H.W. Robison, C.E. Skelton, and R.F. Thoma 2007. Reassessment of the Conservation Status of Crayfishes of the United States and Canada after 10+ Years of Increased Awareness. Fisheries. 32(8):372–389.

Cedar Creek Crayfish
Procambarus chacei



Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Michael Kendrick (SCDNR)

DESCRIPTION

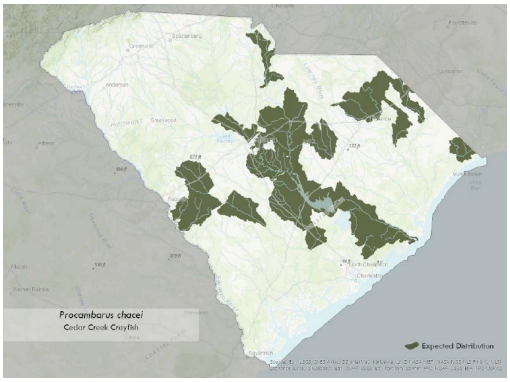
Taxonomy and Basic Description

This species has been synonymized with the Waccamaw Crayfish (*Procambarus braswelli*; Kendrick and Williams (In Review)). *Procambarus chacei* is also similar to the Black Mottled Crayfish (*Procambarus enoplosternum*) and there is concern that the two species may also be synonymous (Hobbs 1981, 1989).

The chelae of *P. chacei* are slender and elongate and covered in tubercles. The fingers of the chelae are not gaping and have well-developed longitudinal ridges on the upper and lower surfaces. Intensity of color markings can vary, but color patterns are fairly consistent. This species is greenish-tan in color with darker specks on the rostrum and black saddle-like markings. The chelae are greenish tan with dark and light spots and reddish fingers, while the legs are pale greenish-cream (Hobbs 1958). Body pigmented, eyes well developed, strong postorbital ridge, strong marginal spines, strong postorbital ridge spine; lacks median carina. Fingers without gape, without dense setae at opposable bases. Mesial margin of palm with or without serrate tubercles (Kendrick and Williams *In Review*).

Status

NatureServe (2024) has identified *P. chacei* as imperiled (S3) and apparently secure (G4) globally. The Cedar Creek Crayfish was considered to be currently stable in Georgia and South Carolina by Taylor et al. (2007), but has not been recognized by GADNR due to its taxonomic similarity uncertainty regarding *P. enoplosternum*.



POPULATION SIZE AND DISTRIBUTION

P. chacei is found in streams from all major drainage Basins in South Carolina to the Ogeechee and Canoochee River Basins in eastern Georgia.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

This species is found in Coastal Plain streams (Hobbs 1989). *P. chacei* frequents swamps, ponds, lakes, roadside ditches, springs and streams, including lentic and lotic habitats and burrows (Kendrick and Williams In Review).

CHALLENGES

Procambarus clarkii is spreading across much of South Carolina's coastal plain, with potential impacts on native crayfishes such as *P. chacei* (Kenderick et al. 2024). Additional morphological

and genetic work are needed to understand how *P. chacei* relates to *P. enoplosternum* (Hobbs 1981, 1989; Kendrick and Williams In Review).

CONSERVATION ACCOMPLISHMENTS

Significant distribution records of *P. chacei* have been gathered from the South Carolina Stream Assessment (2006–2011) and recent morphological and genetic data have led to the synonymy of the Waccamaw Crayfish *Procambarus braswelli* with the Cedar Creek Crayfish *Procambarus chacei*. This information has considerably expanded the species' known range in South Carolina and clarified important taxonomic questions.

CONSERVATION RECOMMENDATIONS

- Conduct taxonomic studies to determine the relationship between *P. enoplosternum*.
- Determine how the non-native *P. clarkii* may be impacting *P. chacei*.

MEASURES OF SUCCESS

Describing the range, population densities, and habitat associations for *P. chacei* may be considered a measure of success. Additionally, completion of taxonomic studies to determine the relationship between *P. enoplosternum* and *P. chacei* would be considered a sign of success.

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NatureServe. 2011. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer..

Taylor, C.A., G.A. Schuster, J.E. Cooper, R.J. DiStefano, A.G. Eversole, P. Hamr, H.H. Hobbs III, H.W. Robison, C.E. Skelton, and R.F. Thoma 2007. Reassessment of the Conservation Status of Crayfishes of the United States and Canada after 10+ Years of Increased Awareness. Fisheries. 32(8):372–389.

Chauga Crayfish
Cambarus chaugaensis



Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2024): Eric Ng and Kathryn Schulz (West Liberty University) and Michael Kendrick (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

Cambarus chaugaensis was described by Prins and Hobbs in 1972. Upon description, the Chauga Crayfish was designated to the former subgenus Punticambarus. However, after subsequent phylogenetic revision of the subgenera of the genus *Cambarus*, the designation to Punticambarus was eliminated (Breinholt et al., 2012; Crandall & De Grave, 2017).

The Chauga Crayfish is olive-green with dark olive-brown mottling, orangish or yellowish to red fingertips, and robust, well-developed chelae. It has large, well-developed eyes. The chelae have two rows of tubercles along the mesial surface of the palm and the fingers have well-defined longitudinal ridges. Mature males range in size from approximately 50-78 mm (2-3.1 in.), while females range from 50 mm (2 inches) to 70 mm (2.8 inches) in total length (Hobbs 1981).

Status

NatureServe (2024) currently designates the Chauga Crayfish an imperiled in both South Carolina (S2S3) and North Carolina (S2) and a vulnerable (G3) global ranking. However, Simmons and Fraley, 2010 suggest an imperiled (G2) global status for the Chauga Crayfish. In 2011, it was petitioned among 404 species for consideration as a candidate for federal protection (United States Fish and Wildlife Service 2011). The species has shown an apparent decline of approximately 50%, although it remains uncertain whether this decline is genuine or a result of insufficient surveying efforts (NatureServe, 2024).

POPULATION SIZE AND DISTRIBUTION

In South Carolina, the Chauga Crayfish is restricted to the upper Savannah River Basin, particularly the Chauga and Chattooga River Basins in Oconee County. They can be found in 3 counties in North Carolina. NatureServe (2024) reports that it has been found across 22 localities across South Carolina and North Carolina, using a 2km separation distance between sites. Most of its range in South Carolina lies within Sumter National Forest. The reduced range of the Chauga Crayfish no longer places them in Georgia. (Eversole et al. 2002, NCSM records, NatureServe, 2024).



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Chauga Crayfish is found at sites with medium to large cobble and boulders as substrate and little sediment accumulation. The Chauga Crayfish is found in both high and low order streams, but it is more abundant in higher order streams (Eversole et al. 2002). These crayfish are particularly prevalent in high-gradient streams within the Blue Ridge ecological zone (Eversole, 2014).

CHALLENGES

Because of its extremely restricted distribution, the Chauga Crayfish is in need of protection. Even though the Chauga River population appears to be fairly stable, this very small distribution is cause for great concern. Although the river basin in which this species occurs is within the Sumter National Forest and is currently relatively pristine, the Chauga Crayfish seems particularly sensitive to sedimentation, since it inhabits rocky sites free of sediment accumulation (Eversole et al. 2002). This species faces threats from industrial pollution along and upstream of the Savannah River, as well as industrial development operations in the surrounding region (Cordeiro et al., 2010).

CONSERVATION ACCOMPLISHMENTS

The majority of the distribution of the Chauga Crayfish lies within Sumter National Forest land, and the US Forest Service has funded survey efforts for this species (Eversole et al. 2002). In addition, the Chauga Crayfish has achieved 'species of concern' status in the state and is now indicated to be a species of highest priority for South Carolina's SWAP.

CONSERVATION RECOMMENDATIONS

- Continue to conduct surveys to monitor the abundance of the Chauga Crayfish.
- Continue to work with the US Forest Service to ensure that operations on Sumter National Forest do not negatively impact habitat for the Chauga Crayfish.

MEASURES OF SUCCESS

An increase or no net decrease in numbers of individuals collected in future surveys in the Sumter National Forest would be considered a sign of success.

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Cinnamon River Shrimp

Macrobrachium acanthurus



Credit: Torati et al 2011

Contributor (2024): Graham Wagner (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

The cinnamon river shrimp can be differentiated from other *Macrobrachium* species by its long and slender claws and carpus with felt-like setae. It also has only two teeth on its rostrum behind the eye. It is generally an olive green color with some blue coloration on the abdominal pleura and uropods. A brown-orange stripe runs down the middle of the dorsal surface of the abdomen. They can be fairly large, measuring 120-150 mm, and the chelipeds themselves can measure 180-225 mm, meaning an adult specimen can measure approximately 380 mm including chelipeds (Hedgepeth 1949).

Status

NatureServe (2024) identifies the global rank for the cinnamon river shrimp to be secure (G5); however, at the state level, it has not been assigned a rank.

POPULATION SIZE AND DISTRIBUTION

The cinnamon river shrimp occurs along the western Atlantic from North Carolina to Brazil, including the Gulf of Mexico and the Caribbean (Holthuis 1980). There are no estimates of population size.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The cinnamon river shrimp uses rivers, estuaries, and small lagoons during its life cycle, including moving up to ~300km inland (Coelho 1963). It has a migratory lifecycle in which it can move between fresh and salt water. They tend to seek out structure such as rocks, fallen trees and aquatic vegetation (Coelho 1963).

CHALLENGES

We are unaware of specific challenges to the cinnamon river shrimp. It is considered a species of concern because there is little information regarding its life history, and the contemporary distributions of this species are incomplete. In theory, its migratory life cycle make it susceptible to dams and other human-induced modifications to waterways. Due to its large size, this species has aquaculture potential (Kutty et al 2000), but a lack of understanding of reproductive biology and life history prevents large-scale aquaculture.

CONSERVATION ACCOMPLISHMENTS

No conservation accomplishments are currently known for the cinnamon river shrimp in South Carolina.

CONSERVATION RECOMMENDATIONS

Compile records of the cinnamon river shrimp in South Carolina to determine its range and habitat requirements.

MEASURES OF SUCCESS

The completion of a thorough survey of the systems where the cinnamon river shrimp has been found and the determination of its habitat requirements will be indicative of success.

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Coastal Plain Crayfish

Procambarus ancylus



Credit: B. Williams

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR): Michael Kendrick (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

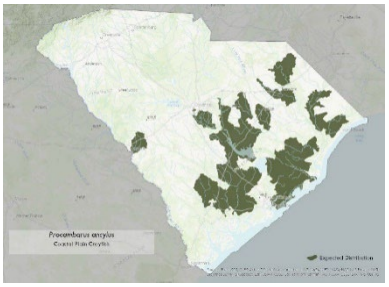
The Coastal Plain Crayfish is a small and cylindrical in shape. It is reddish-brown or chocolate in color with a narrow red-orange dorsal stripe and slender chelae (NCWRC 2005).

Status

NatureServe (2011) currently identifies the Coastal Plain Crayfish as vulnerable (S3) in North Carolina and apparently secure/secure (S4/S5) in South Carolina. The Coastal Plain Crayfish was listed as currently stable by Taylor et al. (2007).

POPULATION SIZE AND DISTRIBUTION

The Coastal Plain Crayfish is only found in the Coastal Plain of the Carolinas. In South Carolina, it is found in 13 Coastal Plain counties. It is less widespread in North Carolina.



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Coastal Plain Crayfish is found in both lentic and lotic waters and burrows (Hobbs 1989).

CHALLENGES

Because so little is known about the Coastal Plain Crayfish, this species is in need of surveys, research on habitat associations, and taxonomic investigations. The taxonomic status of this species across its currently understood range is unclear.

CONSERVATION ACCOMPLISHMENTS

Limited life history observations on egg number and size were reported by Poly (2007).

CONSERVATION RECOMMENDATIONS

- Conduct targeted surveys to determine the range and distribution of the Coastal Plain Crayfish. During these surveys, collect data about habitat requirements.
- Cooperate with the North Carolina Museum of Natural Sciences to determine whether additional taxonomic studies are necessary.

MEASURES OF SUCCESS

Collection of data that better describes the range and distribution of the Coastal Plain Crayfish may be considered a measure of success.

LITERATURE CITED

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Digger Crayfish

Creaserinus fodiens



Contributor (2024): Graham Wagner (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

The Digger Crayfish has a cylindrical body shape, short antennae with very small spines on the second and third segments, a moderate length rostrum that is broadly triangular, and no lateral spines.

Status

NatureServe (2024) identifies the rank for the Digger Crayfish as secure (S5) in South Carolina and secure (G5) globally. Taylor et al. (2007) considered the species to be currently stable.

POPULATION SIZE AND DISTRIBUTION

The digger crayfish has a relatively large distribution in eastern and central North America, stretching from Ontario down through the midwestern states, and east from Pennsylvania to Florida. Its range excludes much of the Appalachian Mountains (Hobbs 1989, Guiasu 2007, Taylor et al. 2007, Loughman and Simon 2011, Loughman et al. 2018, Guiasu 2021). The western extent of its range is Oklahoma. Occurrences in Texas, however, are no longer ascribed to this species (Johnson et al 2021). In South Carolina, it occurs in all river drainages in the eastern portion of the state in the coastal plain, including Bamberg, Lexington, Marion, Sumter, and Williamsburg counties (Eversole and Jones 2004).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The digger crayfish is a secondary burrowing species, meaning it spends much of its life in a burrow. This species requires clay soils in order to dig their burrows. They can sometimes be found in small streams, but even modest currents can wash them downstream (Bouchard 1974, Maude and Willimas 1983). Often, burrows are made in roadside ditches, and can be identified by vertical mud “chimneys.” These burrows can be several meters deep.

CHALLENGES

The digger crayfish is an obligate burrower; as such, collecting specimens and *in situ* studies of its biology are difficult. It is susceptible to anthropogenic impacts such as habitat loss and pollution (Guiasu 2007). Additionally, due to its wide distribution, the digger crayfish could be impacted by interspecific competition with nonnative crayfishes (Guiasu 2007).

CONSERVATION ACCOMPLISHMENTS

No conservation accomplishments are currently known for digger crayfish in South Carolina.

CONSERVATION RECOMMENDATIONS

Surveys to determine the distribution of digger crayfish would benefit the understanding of this species. Studies of the impacts of pollutants and habitat degradation and loss would improve the conservation of this species.

MEASURES OF SUCCESS

A contemporary understanding of the distribution and microscale habitat preferences of this species in South Carolina would be considered successful. Additionally, an understanding of how this species is impacted by nonnative *Procambarus clarkii* would be a success.

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Ditch Fencing Crayfish
Faxonella clypeata

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Michael Kendrick (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

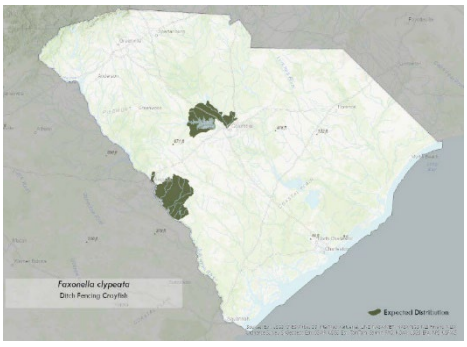


The Ditch Fencing Crayfish is very small and occurs in 2 distinctive color patterns: the first is olive tan to reddish brown with a pale creamy-tan stripe extending from rostrum to rear the margin of carapace; the second pattern lacks the stripe and is pinkish-brown. There are substantial differences in size between populations, but adults are generally 27 to 50 mm (1.1 to 2 in.) in total length (Hobbs 1981).

Status

NatureServe (2011) currently lists the Ditch Fencing Crayfish with a ranking of imperiled (S2). It is more common in other states and has a global ranking of secure (G5). It was listed as currently stable by Taylor et al. (2007).

POPULATION SIZE AND DISTRIBUTION



The Ditch Fencing Crayfish is found appears to have two disjunct population centers in SC. A cluster of occurrences is apparent in the coastal plain of Aiken and Barnwell Counties along tributaries to the Savannah River. Another cluster of occurrences appears in the Piedmont at the northern ends of Lexington and Richland Counties.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Ditch Fencing Crayfish is reported to inhabit slow moving streams, ditches, cypress ponds, and vegetation in clear, sandy-bottom streams (Hobbs 1981).

CHALLENGES

We are unaware of specific challenges to the Ditch Fencing Crayfish. We have included it as a species of concern because there is little information on its abundance and distribution in South Carolina.

CONSERVATION ACCOMPLISHMENTS

There are no significant conservation accomplishments specifically for the Ditch Fencing Crayfish at this time.

CONSERVATION RECOMMENDATIONS

- Conduct surveys to determine the range and habitat requirements of the Ditch Fencing Crayfish.

MEASURES OF SUCCESS

The completion of a thorough survey of the drainages where the Ditch Fencing Crayfish has been found and the determination of its habitat requirements will be indicative of success.

LITERATURE CITED

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Eastern Red Swamp Crayfish

Procambarus troglodytes



Credit: Kendrick/SCDNR

Contributor (2024): Gregory Rothman (SCDNR)
and Michael Kendrick (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

LeConte (1856) made the original description of *Procambarus troglodytes* from specimens collected in rice fields in Georgia, describing individuals as having: a slightly concave rostrum with a small, blunt, acumen; a coarse and sparsely punctate cephalothorax; and a narrow areola. Additionally, the chelae of *P. troglodytes* are described as being broad and tuberculate with a toothed inner margin. Specimens can vary in coloration, but typically are of a reddish-brown coloration, with an occasional dark lateral line. Specimens of *P. troglodytes* can often be confused with individuals of their sister taxa, *P. clarkii,* due to their close resemblance morphologically. A few key differences when identifying individuals of *P. troglodytes* include a downward curvature of the rostrum, and, as a more definitive feature in males, having the caudal margin of the cephalic process of first pleopod being rounded, instead of angled as featured in *P. clarkii* (Eversole & Jones, 2004).

Status

NatureServe (2024) identifies the rank of *P. troglodytes* as apparently secure/secure (S3/S4) in both South Carolina and Georgia. The species was listed as currently stable by Taylor *et al*. (2007) and assessed as secure by Simon (2011).

POPULATION SIZE AND DISTRIBUTION

The known distribution of *P. troglodytes* occurs from the Altamaha River in Georgia to the Pee Dee rivers in South Carolina, primarily being found along the coastal plain of both states (Hobbs, 1989). Spawning of *P. troglodytes* is thought to primarily occur in the fall, coinciding with increases in rainfall along the coastal plain (SCDNR, climatology data). This fall spawn is represented in collection data from 2017 – 2023, that shows the highest proportion of reproductively active male *P. troglodytes* caught in the fall, while in the winter, the majority of individuals caught are juveniles (SCDNR, unpublished data).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Procambarus troglodytes can be found in both lotic and lentic environments, and has been considered a tertiary burrower (Hobbs, 1989). Originally described specimens were collected from ditches and rice fields in Georgia; however, *P. troglodytes* has been collected in several different environments from streams to seasonally flooded wetlands, and typically in high abundances where present (Price & Welch, 2009).

CHALLENGES

The introduction of the sister species to *P. troglodytes,* the non-native crayfish *P. clarkii*, may pose threats to the population status of *P. troglodytes*. These species often occur within the same habitat (SCDNR unpublished data), and *P. clarkii* has been known to alter native crayfish species

richness and abundance in areas of South Carolina in which they are present (Kendrick *et al.,* in press). Additionally, the genetic relatedness of these two species presents a concern for introgression between these species, lessening genetic diversity.

CONSERVATION ACCOMPLISHMENTS

Opportunistic sampling over the last decade along the coastal plain of SC has shown that *P. troglodytes* is widespread in its distribution, and apparently high in abundance where present (SCDNR, unpublished data); however, much about the life history of this crayfish or its place within ecosystems is still unknown. An examination on the impacts of the non-native *P. clarkii* on native crayfish populations including *P. troglodytes* in the Lower Pee Dee, Waccamaw and Winyah watersheds was completed, highlighting the concerns for the introduction of this non-native species (Kendrick *et al.,* in press). Additionally, recent work has been completed comparing both the genetic relatedness of, as well as parasite communities, between *P. clarkii* and *P. troglodytes* living in sympatry. These efforts hope to identify how *P. clarkii* may be directly impacting populations of *P. troglodytes* in areas of which they are known to coexist (SCDNR, unpublished data).

CONSERVATION RECOMMENDATIONS

- Conduct research to determine current distributions, abundances, and population densities of *P. troglodytes*.
- Investigate the life history of *P. troglodytes*, particularly in regards to how this may be impacted by the introduction of non-native crayfish, like *P. clarkii*.

MEASURES OF SUCCESS

The collection of data to better understand any aspects of the life history of *P. troglodytes*, as well as threats to populations may be considered a measure of success.

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Edisto Crayfish
Procambarus echinatus

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Greg Rothman and Michael Kendrick (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

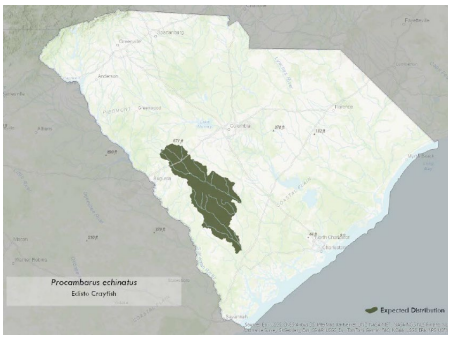
This is a large species with the holotypic male measuring 64 cm in carapace length, which is roughly equal to 128 mm (5.1 inches) in total length. The carapace of *Procambarus echinatus* Hobbs 1956, is olive-green dorsally, fading ventrally to creamy-white with ridges edged in black. The abdomen is greenish with a bright blue caudal section bearing red and reddish-purple markings. The chelae are reddish-black with white tubercles. There are well-developed spines on the carapace and chelae. This species exhibits large amounts of variation between individuals in the number of spines and the size ratios of various body parts (Hobbs 1956b).

Status

NatureServe (2024) identifies the rank of *P. echinatus* as vulnerable (S3) in South Carolina. The species was listed as vulnerable by Taylor *et al*. (2007) and conferred by Simon (2011).

POPULATION SIZE AND DISTRIBUTION

P. echinatus is endemic to South Carolina and known only from the headwaters of the Edisto and the Salkahatchie/Combahee River drainages. It has been recorded in at least five Coastal Plain counties (Eversole 1995, Poly 2009). In an extensive survey during 1988 and 1989, Eversole (1995) found that the species had a restricted distribution but was abundant at some sites. It is often abundant where it occurs based on recent surveys (Poly 2009).



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

P. echinatus is known to inhabit good quality, fast-flowing, dark water streams, usually with sandy substrates. It is often found in grass beds dominated by *Sparganium* and *Saururus* or in submerged rootwads along stream banks (Eversole 1995, Poly 2009).

CHALLENGES

The restricted distribution of *P. echinatus* and its apparent dependence on good water quality streams warrant considerable protection both for the species and its habitat, particularly with increases in urban development and impacts of climate change. Current surveys indicate that this species has a very limited distribution. Therefore, updated surveys are necessary to better determine its status. Additionally, the rarity of *P. echinatus* indicates that its status should be reviewed in South Carolina. The introduction of non-native species, like *Procambarus clarkii*, may also pose threats to the population status of *P. echinatus*, as distributions of the species may overlap (SCDNR unpublished data). Species like *P. clarkii* have been known to alter native

crayfish species richness and abundance in areas of South Carolina in which they are present (Kendrick *et al.,* in press).

CONSERVATION ACCOMPLISHMENTS

Distribution, abundance, and life history of this species have been studied recently, resulting in a slight extension of the known range into two other counties.

CONSERVATION RECOMMENDATIONS

- Conduct research to determine the range, population densities, and habitat associations for *P. echinatus*.
- Based on surveys, investigate the need to assign special concern status for *P. echinatus* in South Carolina.

MEASURES OF SUCCESS

The collection of data that better describes the range, population densities, and habitat associations for *P. echinatus* may be considered a measure of success.

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Eastern Grass Shrimp

Contributor (2024): Michael Kendrick (SCDNR)



Credit: Aguilar, Wikimedia Commons

DESCRIPTION

Taxonomy and Basic Description

The eastern grass shrimp *Palaemon paludosus* a member of the family Palaemonidae. The eastern grass shrimp is characterized by not having a hepatic spine present (as compared with members of the genus *Macrobrachium*). The eastern grass shrimp may grow up to 2.5 cm (1 in.) long.

Status

The eastern grass shrimp *Palaemon paludosus* is S4 in SC and G5 (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

The eastern grass shrimp is native to the Atlantic coastal plain from southern New Jersey to Florida (Thorp and Covich 2010), but the population size in SC is unknown.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The eastern grass shrimp has been identified as a keystone species with some vertical migration patterns that prefers aquatic vegetation, presumably due to the protection it provides from predators (Wessell et al. 2001).

CHALLENGES

The population size of the eastern grass shrimp in SC is unknown and deserves additional attention.

CONSERVATION ACCOMPLISHMENTS

Increasing attention on this potentially important species in South Carolina will aid in gathering additional information on how the importance of this species to native environments in SC.

CONSERVATION RECOMMENDATIONS

- Examine the ecological role of the eastern grass shrimp in riverine systems in South Carolina.
- Establish baseline data on population size, distribution, and habitat requirements of the eastern grass shrimp in South Carolina waters.
- Examine how anthropogenic river modifications and reduced floodplain connectivity may impact the eastern grass shrimp as well as other riverine species.

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Hummock Crayfish

Procambarus lunzi



Credit: Kendrick/SCDNR

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Graham Wagner and Michael Kendrick (SCDNR)

DESCRIPTION

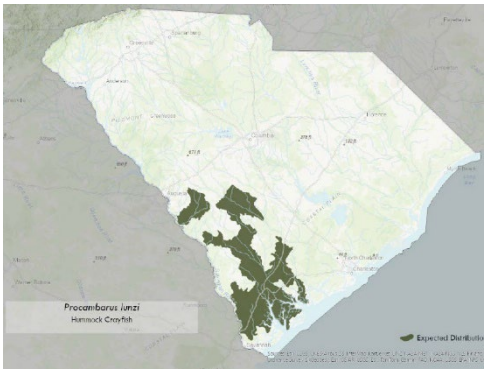
Taxonomy and Basic Description

Procambarus lunzi is reddish-brown with orange, tan, and black markings. The thoracic and abdominal sections have longitudinal stripes flanked by lighter pink stripes while the ventral surface is cream. The chelae are greenish cream to olive color with tubercles (Hobbs 1981).

Status

NatureServe (2024) identifies this species with a rank of vulnerable (S3) in Georgia and critically imperiled (S1) in South Carolina. Globally, it is apparently secure (G4). The Hummock Crayfish was considered to be currently stable in Georgia and South Carolina by Taylor et al. (2007).

POPULATION SIZE AND DISTRIBUTION



The Hummock Crayfish is found primarily in lentic waters within the Coastal Plain of South Carolina and Georgia (Hobbs 1989). In South Carolina, it has been collected in Beaufort, Colleton, Hampton and Jasper Counties. This is the only crayfish species that has been found in a survey of South Carolina hammock/hummock islands (McCord et al. 2004). Hobbs (1989) also lists Aiken and Bamberg counties as part of the range of *P. lunzi*, but these locations have not been confirmed by recent collections. This species is common at some sites including those in the Francis Marion National Forest.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

P. lunzi is found in lentic and sluggish lotic environments and sometimes burrows (Hobbs 1989). According to Hobbs (1981) this is a secondary or tertiary burrower.

CHALLENGES

The Hummock Crayfish should be considered a research priority because little is known about its distribution and habitat requirements. Additionally, as an inhabitant of low-lying hammock/hummock islands in South Carolina and Georgia, it is critically affected by the impacts of climate change, such as sea level rise and increased storminess. Development and urbanization of these same habitats also presents a threat to *P. lunzi* in the form of habitat loss.

CONSERVATION ACCOMPLISHMENTS

The hammock island where *P. lunzi* is found is protected as a South Carolina Heritage Preserve (McCord et al. 2004). A survey of North and South Williman Islands in South Carolina in 2024 recorded only *P. lunzi* and no non-native crayfish species (SCDNR unpub. data).

CONSERVATION RECOMMENDATIONS

- Conduct research to determine the range, distribution, and habitat requirements for *P. lunzi*.

MEASURES OF SUCCESS

The collection of data that better describes the range, distribution, and habitat requirements for *P. lunzi* may be considered a measure of success.

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Keeowee Crayfish

Cambarus sp. nov. "B" cf. *longirostris*



Credit: Sartore/National Geographic

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Michael Kendrick (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

Cambarus sp. nov. "B" appears to be a new species that was formerly misidentified as *Cambarus longirostris*. Although *C. longirostris* was previously thought to have been introduced to South Carolina, further examination of specimens indicates that *C. longirostris* does not occur in the state (D. Jones, pers. comm., 2004). However, the species was included as an invasive species (as C. longirostris) in South Carolina by McLaughlin et al. (2005) and Taylor et al. (2007), although the latter source indicated that *C. longirostris* was a species complex under investigation. Adults of this species average about 58 mm (2.3 in.) in total length. The body of this species is buckskin to dark tan with the tips of the chelae white and the joints of the legs pale blue. The posterior terga of the abdomen bears a thin, transverse, burgundy line, and there is usually a dark brown or black saddle following the cervical groove. The fingers of the chelae are very long and form a noticeable gap when closed (D. Jones, Clemson University, pers. comm. via e-mail message on March 10, 2005).

Status

Because this is possibly a new species of crayfish, no status information exists for Cambarus sp. nov. "B."

POPULATION SIZE AND DISTRIBUTION

Cambarus sp. nov. "B" has been collected in medium-sized rivers in the Savannah drainage in Pickens and Oconee Counties in South Carolina. Efforts to locate the species in Georgia have been unsuccessful; it appears to be endemic to South Carolina. It has only been found recently at 3 sites, 2 on Flat Shoals River and 1 on Oconee Creek. The site on Oconee Creek appears highly affected by sedimentation and is the site where the species is least abundant (D. Jones, pers. comm., 2004).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Cambarus sp. nov. "B" prefers riffles and fast flowing sections of streams and rivers with coarse gravel and cobble overlaying fractured bedrock. Females carrying juveniles can be found under boulders in deeper pools of water downstream from the riffles. Specimens are primarily found in crevices in boulders and under rocks 45 cm (18 in.) or more in diameter (D. Jones pers. comm. 2004).

CHALLENGES

The case of the Keeowee crayfish Cambarus sp. nov. "B" cf. longirostris, which was mistaken for an introduced species, is an excellent example. It has previously been treated as an introduced population of C. longirostris in South Carolina (McLaughlin et al. 2005; Taylor et al. 2007), and as of October 2023 this species remains undescribed. Formal description of this species is sorely needed to ensure its conservation status.

Cambarus sp. nov. "B" appears to be highly sensitive to sedimentation due to its need for coarse substrates. Therefore, development or forestry activities in the vicinity of this species' habitat could adversely impact *Cambarus* sp. nov. "B." Oconee Creek, one of the three locations from which this species is documented, appears to have been negatively affected by a high sediment loading and supports the smallest population. Additionally, much of the suitable habitat for this species has been inundated by reservoirs. *Cambarus* sp. nov. "B" is no longer found at several sites where specimens were once taken prior to inundation by Lake Jocassee (D. Jones pers. comm. 2004).

CONSERVATION ACCOMPLISHMENTS

There are no significant conservation accomplishments specifically for the *Cambarus* sp. nov. "B" crayfish at this time.

CONSERVATION RECOMMENDATIONS

- Complete the taxonomic description of *Cambarus* sp. nov. "B."
- Develop a landowner education program to promote sound land stewardship practices that result in the reduction of sedimentation in waterbodies.
- Conduct a stream restoration project at Oconee Creek to stabilize streambanks and reduce sediment loads. Revisit the site and conduct additional surveys to determine the affect of the restoration project on the population of *Cambarus* sp. nov. "B."
- Conduct additional surveys to determine the range for the *Cambarus* sp. nov. "B" crayfish.
- Based on surveys, determine the need to obtain special concern status for the *Cambarus* sp. nov. "B" crayfish.
- Review any new proposals for dam construction to determine whether habitat for *Cambarus* sp. nov. "B" is not affected by inundation. Work with appropriate

MEASURES OF SUCCESS

An increase or no net decrease in numbers of individuals collected in future surveys would be considered a sign of success. An increase in the numbers of individuals identified in surveys at the location of stream restoration would also be considered to be a success. Monitor the number of individuals that are reached through the landowner education program and survey those individuals to determine whether they implement stewardship practices conveyed in that program.

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Knotty Burrowing Crayfish
Cambarus nodosus

Contributors (2024): Kathryn Schulz and Eric Ng (West Liberty University) and Michael Kendrick (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

Cambarus nodosus was described by Bouchard and Hobbs in 1976. The Knotty Burrowing Crayfish was initially described under the subgenus Jugicambarus. However, after phylogenetic revision of the subgenera of the genus *Cambarus*, the designation to Jugicambarus was eliminated (Breinholt et al., 2012; Crandall & De Grave, 2017). The closest relative of *C. nodosus* is *Cambarus carolinus* and can be separated by multiple morphological traits.

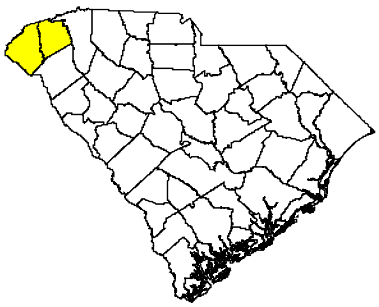
The Knotty Burrowing Crayfish is mainly blue grey on the body and abdomen. Dark brown stripes can sometimes be present on the abdomen of adults but are more prominent in juveniles. The chelae are blue grey with orange to yellow on the distal portion of the fingers. The eyes are reduced and pigmented. The rostrum is blunt and truncated, lacking spines or tubercles on the rostral margins. The chelae have a single row of cristiform tubercles on the mesial margin of the palm with a second row of reduced tubercles. Mature males can grow to be larger than 26.8mm (1.06 inches), with females also being a very similar size (Bouchard & Hobbs, 1976).

Status

In South Carolina, NatureServe (2024) designates the Knotty Burrowing Crayfish as critically imperiled to imperiled (S1/S2), critically imperiled (S1) in North Carolina, imperiled (S2) in Georgia, apparently secure in Tennessee, and secure (G4) globally. Threats to the species in the state are minimal, however the range in South Carolina is narrow (Eversole & Jones, 2004). Taylor et al., 2007 suggested *C. nodosus* to be currently stable (CS) and apparently secure globally (G4).

POPULATION SIZE AND DISTRIBUTION

In South Carolina, the Knotty Burrowing Crayfish is restricted to a single river system in the upper Savannah River Basin, particularly the Keowee River Basin in both Oconee and Pickens Counties (Eversole and Jones, 2004). There are 7 known populations of *Cambrus nodusus* in South Carolina, with a majority of them belonging in Pickens County (Eversole and Jones, 2004). NatureServe (2024) reports that the species can also be found in seepage areas and head water tributaries within Georgia, Tennessee, and North Carolina.



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Knotty Burrowing Crayfish is a primary burrowing crayfish and is considered a generalist in terms of habitat preference. They tend to reside in pools, seepage areas, roadside ditches and occasionally in the riffle areas of streams (NatureServe, 2024). They can be found near the headwaters and tributaries of the Savannah River basin (Eversole and Jones, 2004)

CHALLENGES

The Knotty Burrowing Crayfish faces no significant threats and demonstrates resilience in challenging habitats (NatureServe, 2024). However, due to the lack of recent surveying for the Knotty Burrowing Crayfish, future surveys are recommended to identify any localized threats to this species. Although the Savannah River population appears to be stable, its restricted range is cause for great concern. If the distribution of *Cambarus nodosus* is as restricted as it appears, any developmental project in the vicinity of its range could result in localized extirpation of this species.

CONSERVATION ACCOMPLISHMENTS

There are no significant conservation accomplishments specifically for the Knotty Burrowing Crayfish at this time.

CONSERVATION RECOMMENDATIONS

- Conduct more surveys to establish the full extent of the range in South Carolina.
- Create a contemporary map of the updated area of occurrence in the state.
- Monitor the response of the crayfish to local, fine-scale threats to ensure the security of persisting populations.

MEASURES OF SUCCESS

Data collection that better defines the distribution, population, and threat status of *C. nodosus* in South Carolina would be considered a measure of success. Gaining protection in areas where *C. nodosus* is found would also be considered a measure of success.

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Lean Crayfish

Cambarus strigosus

Contributor (2024): Zanethia Barnett (USFS)



Credit: Zachary Graham/West Liberty University

DESCRIPTION

Taxonomy and Basic Description

Cambarus strigosus is mostly olive to dark bluish green fading to pale orange tan with dark brownish to dark olive and orange markings. The eyes are small but well-developed. There are 5 to 8 tubercles on the mesial margin of palm on chela, and cervical tubercles on the carapace. There is also a single spine on both sides of the telson (Hobbs 1981).

Status

NatureServe (2024) currently ranks *C. strigosus* as critically imperiled in South Carolina (S1) and imperiled in Georgia (S2) and globally (G2). Taylor et al. (2007) recommended listing it as a threatened species, but at the time its known distribution was only in Georgia.

POPULATION SIZE AND DISTRIBUTION

Cambarus strigosus is a primary burrowing crayfish that is endemic to the Piedmont region of the Savannah River Drainage in South Carolina and Georgia (Barnett et al. 2024). It has a limited range, but has been collected from McCormick, Edgefield, Abbeville, and Aiken counties in South Carolina (Barnett et al. 2024), as well as Wilkes, Oglethorpe, and Elbert counties in Georgia (Skelton 2016).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Cambarus strigosus is a habitat specialist found in low-elevation terrestrial habitats associated with infrequently managed open fields and riparian forests, as well as ecotones between these two habitats (M. Stubbs, WLU, unpublished data). It has also been collected from roadside ditches and adjacent to spring-runs in Georgia (Hobbs 1981). *Cambarus strigosus* has been collected in sandy-clay to clay-loam soils (Hobbs 1981; M. Stubbs, WLU, unpublished data).

CHALLENGES

Little is known about the distribution, population size and microhabitat requirements of *C. strigosus.* It's association with infrequently managed open fields may indicate that it used to utilize prairie habitats and forest succession may threaten these populations. We are currently unsure if *C. strigosus* in South Carolina use roadside ditch or spring habitats as they do in Georgia.

CONSERVATION ACCOMPLISHMENTS

Crayfish surveys on the Long Cane Ranger District of the Sumter National Forest from 2020-2023 identified 6 new locations for *C. strigosus*, with over 90 individuals encountered (Barnett et al. 2024). These encounters of *C. strigosus* led to the investigation of the species presence in South Carolina and uncovered two historical records in the state from the 1980s.

The US Forest Service may be able to maintain suitable habitat for *C. strigosus* by managing wildlife openings, protecting riparian zones, as well as, reducing ditch maintenance during winter and spring months when *C. strigosus* are active within them.

CONSERVATION RECOMMENDATIONS

- Conduct additional surveys for *C. strigosus* throughout the Piedmont region of the Savannah River Drainage to assess its distribution.
- Conduct additional surveys to assess *C. strigosus* habitat requirements and population size.
- Continue to work with the US Forest Service to ensure that operations on Sumter National Forest maintain suitable habitats.

MEASURES OF SUCCESS

Collection of data that better describes the distribution and habitat requirements for *C. strigosus* may be considered a measure of success. Conservation of suitable habitats may be considered a success.

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Freshwater, Marine and Terrestrial Leeches Guild

New England Medicinal Leech *Macrobdella sestertia*
"A terrestrial leech" *Haemopis septagon*
Appalachian Leech *Placobdella biannulata*
Nuchal Leech *Placobdella nuchalis*
Translucent Leech *Placobdella translucens*
"A marine leech" *Branchellion ravenelii*

Contributors (2024): Bronwyn W. Williams (NC Museum of Natural Sciences), William E. Moser (Smithsonian Institution National Museum of Natural History)

New England Medicinal Leech
Macrobdella sestertia

The New England Medicinal Leech was described in 1886 from eastern Massachusetts. It took nearly a century, in 1976, to be collected a second time (Smith 1977), and nearly two decades more to be collected a third time (Smith and Hanlon 1997), in Maine. In 2008, 9 specimens of *M. sestertia* were collected in southwestern South Carolina (Poly 2011), representing a significant expansion of its historically reported New England distribution. Two additional specimens of the species from South Carolina were found in the collections of the Charleston Museum and North Carolina Museum of Natural Sciences (NCSM) (Poly 2018); these specimens are currently housed in the NCSM Non-molluscan Invertebrates (NMI) Collection. Carlson and Phillips (2020) presented an extinction model for *M. sestertia* throughout its patchy and disparate range, concluding that the species may have gone extinct, but urging for surveys and a focus more generally on leech conservation. Ironically, this paper was in press when Dr. Bronwyn Williams, joined by Dr. Anna Phillips, collected several *M. sestertia* specimens in southern New Hampshire; Dr. Williams had also collected a handful of *M. sestertia* specimens in South Carolina the previous year. In South Carolina, the New England Medicinal Leech is known to occur only in Edgefield County. *Macrobdella sestertia* has a Global Status of imperiled (G2) and is currently considered Possibly Extirpated in Massachusetts. It has no current status rank in South Carolina (NatureServe 2024). Nearly nothing is known about the local and range-wide distribution of this species or any aspect of its natural history; fewer than 30 individuals have been collected since its description over 140 years ago.

"A terrestrial leech"
Haemopis septagon

The terrestrial leech, *Haemopis septagon*, was described in 1976 from Durham County, North Carolina. Its known distribution ranges from New Jersey south into Georgia throughout coastal plain and lower Piedmont habitats. While it is truly a terrestrial species, *H. septagon* occupies damp riparian areas and microhabitats containing an abundance of earthworms, its primary prey. A substantial amount of information about the natural history of this species has been recently gleaned through collecting and husbandry efforts by a handful of herpetologists in the southeast. That said, *H. septagon* remains poorly documented in South Carolina, reported only from Georgetown, Charleston, and Lee Counties (Sawyer and Shelley 1976, NCSM NMI Collection

database). Basic surveys, ideally coincident with efforts focused on amphibians, are needed to assess the distribution and abundance of this species in South Carolina (Sawyer 1979). It was recommended for Special Concern status by Sawyer (1979). This species is currently unranked (NatureServe 2024).

Appalachian Leech
Placobdella biannulata

This species is found free-living and as a parasite on salamanders of the genus *Desmognathus*. Formerly known by the name *Oligobdella biannulate*, it is known to occur in South Carolina only in the Blue Ridge Ecoregion in Oconee, Pickens, and Greenville Counties (Sawyer and Shelley 1976; Moser et al. 2005). Sawyer (1979) recommended Special Concern status for the species. In its entirety, the species occurs in a relatively small area encompassing mountainous portions of Georgia, North Carolina, South Carolina, and Tennessee (Moser et al. 2005). This species has no current status rank in South Carolina (NatureServe 2024).

Nuchal Leech
Placobdella nuchalis

The nuchal leech was originally described by Sawyer and Shelley (1976) from one site in South Carolina (Orangeburg County) and a few localities in North Carolina. Little is known about the natural history of this species except it being reported as a temporary parasite of fishes (Shelley and Braswell 1981; Klemm, 1982). *Placobdella nuchalis* has been rarely collected since its description. Moser et al. (2017) added new information on its anatomy and a molecular characterization. Poly (2018) discovered individuals of this species to be hitchhikers of a collection of *M. sestertia* in South Carolina. The nature of this association is unknown but warrants further study. This species does not have any conservation rank currently assigned to it, but basic surveys are needed to assess its distribution and abundance.

Translucent Leech
Placobdella translucens

The translucent leech was originally described by Sawyer and Shelley (1976) from Georgetown and Berkeley Counties, South Carolina and from a site in Louisiana. *Placobdella translucens* is infrequently encountered and its range is Alabama, Florida, Georgia, Louisiana, North Carolina, and South Carolina (Sawyer and Shelley 1976; Klemm 1982, 1991). It is most likely a blood feeding leech, but there are no reported hosts for this species. Basic surveys are needed to assess its distribution and abundance of *P. translucens*. It has no current status rank in South Carolina (NatureServe 2024).

"A marine leech"
Branchellion ravenelii

This marine leech was described by Girard in 1850 from Charleston, South Carolina. It is parasitic on rays and skates and occurs along the southeastern Atlantic Coast to the Gulf of Mexico, although reports in South Carolina are exceedingly rare (Sawyer et al. 1975, Sawyer 1979). In 2024, a staff member of the Charleston Aquarium contacted Megan McCuller,

Collections Manager of NMI at the NCSM reporting a *B. ravenelii* on a batoid housed at the facility. If confirmed – and the leech specimen may end up in the NCSM NMI Collection – this would be a welcome recent finding. Sawyer (1979) recommended state endangered status for the species; such a status in turn reflects a conservation focus on the hosts of this leech. *Branchellion ravenelii* is likely present in nearshore areas of South Carolina but may be rare, or appear rare, given this region is the northern extent of its range. Typically, little attention is paid to ectoparasites of marine vertebrates, particularly if the parasites occur in small numbers. As such, this species may be relatively common, but just not reported. *Branchellion ravenelii* has no current status rank in South Carolina (NatureServe 2024).

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Mimic Crayfish

Distocambarus carlsoni


Photo by Dr. Zackary Graham

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2024): Kathryn Schulz and Eric Ng (West Liberty University)

DESCRIPTION

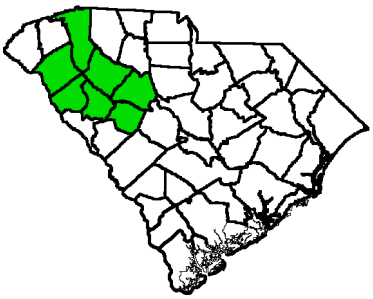
Taxonomy and Basic Description

Distocambarus carlsoni was described by Hobbs in 1983, shortly after the subgenus Distocambarus was elevated to generic status. The genus was formerly a subgenus of the more basal genus *Procambarus*. The most closely related species are the other members of the retained subgenus *Fitzcambarus*; *Distocambarus youngineri* and *D. hunteri* (Crandall & De Grave, 2017; H. Hobbs, 1983; H. H. Hobbs, 1981). Recent surveys suggest *D. carlsoni to* be a species complex. Outside of the known range, there are populations of a similar species that share physical characters, but also exhibit phenotypic variation. Due to taxonomic complexity within this species, further taxonomic revision is recommended.

The Mimic Crayfish exhibits amazing color variation across its range. The dorsal surface of the carapace is reddish to green or can present as a dark electric blue to grey-blue. The dorsal surface of the thoracic region is also dark, but the ventral surface is a lighter lavender-cream color. The tail is tan and pinkish to dark blue, and the chelae are lavender with a dark brown dorsal stripe and 5 to 7 tubercles on the mesial surface. The rostrum is very broad, lacking tubercles and spines on the margins. The gonopod anatomy of the form 1 male is unlike the other members of the genus, having a blade-like central projection curved to about 90 degrees. The first few adult specimens collected ranged from about 50-62 mm (2-2.5 in.) in total length (Hobbs 1983).

Status

NatureServe (2024) currently identifies the Mimic Crayfish as both globally imperiled (G2) and state imperiled (S2). The Mimic Crayfish was included on a list of 404 species being petitioned for consideration as candidates for federal protection (USFWS 2011).



POPULATION SIZE AND DISTRIBUTION

The Mimic Crayfish is a terrestrial obligate burrower endemic to South Carolina and is known only from 7 counties in the western Piedmont (Hobbs 1989, USNM records). Recent surveys suggest that the Mimic Crayfish may have an expanded range within the Piedmont Region of South Carolina.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Distocambarus carlsoni is a primary burrowing crayfish that can be found residing in a wide variety of habitat types. Hobbs (1983) described the habitat at the type locality as a swampy area with a water table fluctuating from the surface to 0.8 m (31.5 in.) below. The soil was described as sandy clay, with areas rich in hummus and leaf litter. This species has a strong association with swamp-seepages and can be found in occurrence with *Cambarus carolinus*. The two species

have been known to partition the habitat by *D. carlsoni* occupying static water and *C. carolinus* occupying sites with flowing water (Hobbs, 1983).

CHALLENGES

More research is needed to determine more specifically the distribution and habitat associations of the Mimic Crayfish within this region. The only published paper on *Distocambarus carlsoni* is its original description paper in 1983, making it difficult to discern the exact range and relevant threats this species obtains.

CONSERVATION ACCOMPLISHMENTS

South Carolina Department of Natural Resources is currently undergoing a three-year study to obtain more information on this species. The distribution of the Mimic Crayfish also crosses over into Sumter National Forest, which helps conserve its preferred habitat type. In addition, the Mimic Crayfish has achieved 'species of concern' status in the state and is now indicated to be a species of highest priority for South Carolina's SWAP.

CONSERVATION RECOMMENDATIONS

- Conduct research to determine the distribution, habitat associations, and population status of the Mimic Crayfish.
- Develop and conduct landowner and general education programs that stress the unique nature of terrestrial burrowing crayfish and their importance in South Carolina.
- Initiate the process to refine the taxonomic standing of *Distocambarus carlsoni* in South Carolina.

MEASURES OF SUCCESS

The collection of data that better describes the distribution, habitat associations, and population status of the Mimic Crayfish may be considered a measure of success. Assessing participation in education programs would assist in measuring success of the programs. An updated taxonomic revision of the species would also be considered a sign of success.

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Newberry Burrowing Crayfish

Distocambarus youngineri


Photo by Dr. Zackary Graham

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2024): Kathryn Schulz and Eric Ng (West Liberty University)

DESCRIPTION

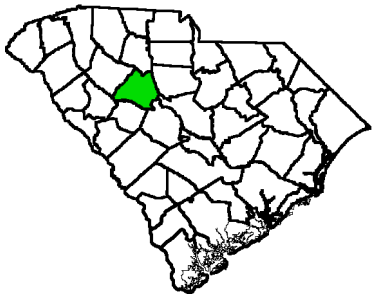
Taxonomy and Basic Description

Distocambarus youngineri was described by Hobbs and Carlson in 1985. Before being elevated to full generic status, the genus *Distocambarus* was formerly a subgenus of *Procambarus*. The most closely related species are the other members of the retained subgenus *Fitzcambarus*; *Distocambarus carlsoni* and *D. hunteri* (Crandall & De Grave, 2017; Hobbs & Carlson, 1985; H. H. Hobbs, 1981). Recent surveys suggest *D.* (*F.*) *youngineri* to be a potential species complex. Further taxonomic revision is suggested in order to resolve taxonomic complexity.

The Newberry Burrowing Crayfish is pale blueish to lavender in color uniformly throughout its body. The ventral surfaces are more pinkish cream. There is also some phenotypic variation, with some individuals being blue dorsally and pinkish cream ventrally. The abdomen is greatly reduced in size. The merus of the chelae uniquely has a more tuberculate ventral surface. The rostrum is broad and triangular in shape. The gonopod anatomy of the form 1 males features a blade-like central projection that is short and not bent to 90 degrees. *Distocambarus youngineri* mature males range in size from 12.1mm (0.47 inches) to 29.2mm (1.15 inches), a relatively small species (Hobbs & Carlson, 1985).

Status

NatureServe (2024) identifies *D. youngineri* as critically endangered in South Carolina (S1) and globally (G1), which seems appropriate for such a rare species. Taylor et al. (1996, 2007) recommended listing the species as endangered. The Newberry Burrowing Crayfish was included on a list of 404 species being petitioned for consideration as candidates for federal protection (USFWS 2011).



POPULATION SIZE AND DISTRIBUTION

D. (F.) youngineri is a very rare obligate burrower, endemic to South Carolina. Historically it has only been found in Newberry County, but recent surveys suggest it may also occur in Laurens county. They are primarily found within a portion of the Saluda River Basin and a few sites within the Broad River Basin. One location where this species was found was in Sumter National Forest; however, the majority of its occurrences are found on private land (Eversole 1995; Eversole and Welch 2010). Recent surveys suggest that they may occupy more than one location within Sumter National Forest.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

D. youngineri is found in moist, terrestrial areas with leaf litter and a mixed-hardwood overstory, usually near stream headwaters or intermittent streams (Eversole 1995). Recent studies suggest that it can be found within and near streambanks, having a positive association with water bodies. In areas where *D. youngineri* is found, the soil becomes saturated and may be covered with shallow water during periods of precipitation in the winter, spring, and sometimes into the early summer. Eversole (2010) found them often to occur in soil types that supported a seasonally perched water table. This species appears to have been extirpated from its type locality following a clearcut in the area during 1989 (Eversole 1995). Most of the sites where *D. youngineri* has been recorded are in moist, wooded areas, but it has also been found in a selectively logged pine stand and in grass lawn areas.

CHALLENGES

There is concern that *D. youngineri* may be in decline. Eversole (1995) found the species at only 6 sites despite intensive survey efforts; it now appears to be extirpated from one of those sites. Given the extremely restricted distribution and low population numbers of *D. youngineri*, protections should be put in place. The Newberry Burrowing Crayfish also appears to be more sensitive to habitat disturbance/destruction, raising concerns of range reduction.

CONSERVATION ACCOMPLISHMENTS

D. youngineri is also a species of federal concern, and status surveys funded by the US Fish and Wildlife Service have been conducted for this species. In addition, the Newberry Crayfish has achieved 'species of concern' status in the state and is now indicated to be a species of highest priority for South Carolina's SWAP.

CONSERVATION RECOMMENDATIONS

- Conduct research to determine the distribution and population status of *D. youngineri.*
- Collaborate with land trusts as well as other federal, state, and local agencies and private conservation groups to protect areas where *D. youngineri* is located. Protection methods used by SCDNR and/or other groups can include conservation easements or fee-simple land purchases.
- Determine the importance of alterations to the groundwater table to population stability of *D. youngineri*.
- Initiate the process to refine the taxonomy of *D. youngineri* in South Carolina.

MEASURES OF SUCCESS

Collection of data that better determines the distribution and population status of *D. youngineri* may be considered a measure of success. Achieving protection for areas *D. youngineri* is located would also be considered a measurement of success. Completion of groundwater investigations and determination of recommendations to protect this species would also be considered a sign of success. An updated taxonomic revision of the species would also be considered a sign of success.

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Ohio river shrimp

Macrobrachium ohione



Credit: Clinton & Charles Robertson

Contributor (2005): Elizabeth Wenner (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Michael Kendrick (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

The Ohio river Shrimp *Macrobrachium ohione* is a member of the family Palaemonidae, characterized by having the first two pairs of legs chelate, the second pair larger than the first, and the carpus of the second leg not subdivided. The Ohio Shrimp is characterized by having a hepatic spine present (as do several other *Macrobrachium*) and enlarged, elongate second pereiopods (though not as large as in other *Macrobrachium*). The rostrum has up to 13 teeth and is upturned with a toothless, daggerlike tip. The Ohio Shrimp may grow up to 10 cm (4 in.) long. Females, which are larger than males, can reach 110 mm in total length and are gray to green in color with light blue spots.

Status

The population of Ohio River Shrimp in South Carolina is not listed as threatened or endangered; however, in parts of its range, the Ohio Shrimp is listed as rare and of long-term concern (Missouri Natural Heritage Program 2004). In some parts of its range, such as Louisiana, the population is abundant enough to provide a fishery. The Ohio River Shrimp has a global rank of apparently stable (G4) but has no state rankings (NatureServe 2011).

POPULATION SIZE AND DISTRIBUTION

This river shrimp occurs in lower salinity and tidal freshwater areas and coastal plain rivers in South Carolina (Cooper 2011a). Its range on the Atlantic Coast extends from Virginia into Florida. The Ohio Shrimp was once common in the Mississippi River below St. Louis, and commercial fisheries for this species previously existed near Chester and Cairo, Illinois. However, Ohio Shrimp have declined dramatically in the Mississippi, most likely due to channelization of the river (Barko and Hrabik 2004). Two specimens collected in 2001 from the Ohio River of Illinois were the first records from the river in over 50 years (Poly and Wetzel 2002). The size of the population in South Carolina is unknown.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Ohio River shrimp is amphidromous such that larvae drift down rivers until they reach high salinity waters and move back to fresh water as adults. Females carrying eggs may also migrate downstream before releasing the larvae to reduce drift times. Ohio Shrimp apparently prefer low velocity water (Conaway and Hrabik 1997); however, open side channels, a preferred habitat of Ohio Shrimp, have flow during normal river elevations (Barko and Herzog 2003). Ohio Shrimp prefer borders of the main channel, especially when the borders are flooded and plant and animal material are available for foraging (Truesdale and Mermilliod 1979). Ohio River Shrimp have been reported to have greater abundance in areas with suspended particulate matter, which may be a predator avoidance response. Ohio River Shrimp occupy low visibility physical habitats that are also occupied by predatory fishes, such as flathead catfish, a species that is not native to South

Carolina (Barko and Herzog 2003). Little is known about the life history of the Ohio Shrimp in South Carolina. In other areas, it has been reported to receive reproductive cues from spring floods and uses flooded terrestrial habitat for reproduction (Hobbs 2001). Aspects of the reproductive biology of Ohio Shrimp in the lower Mississippi and Atchafalaya Rivers were studied recently (Olivier and Bauer 2011). According to Ortmann (1902), the genus Macrobrachium has probably only recently evolved migratory behavior into fresh water. Biological characteristics indicative of this relatively recent adaptation include high hemolymph osmo-ionic concentrations, tolerance of high salinities, dependence on saline water for larval development with many larval stages, and migratory behavior (McNamara 1987).

CHALLENGES

Ohio River Shrimp may have declined as a result of waterway channelization and habitat loss in parts of its range. Changes in river physiography that fragment main channel borders and isolate side channels during moderate to low river elevation can reduce Ohio Shrimp populations (Logsdon 1993; Hobbs 2001; Barko and Herzog 2003). In parts of its range, reduced connectivity with the floodplain—because of levees, closing structures, and wing dikes—has also contributed to Ohio Shrimp declines.

CONSERVATION RECOMMENDATIONS

- Examine the ecological role of Ohio River Shrimp in riverine systems in South Carolina.
- Establish baseline data on population size, distribution, and habitat requirements of Ohio River Shrimp in South Carolina waters.
- Examine how anthropogenic river modifications and reduced floodplain connectivity may impact Ohio River Shrimp as well as other riverine species.
- Protect tidal freshwater habitats in South Carolina from development and modifications to natural freshwater flow regimes by partnering with the appropriate permitting agency to provide better technical information about the potential negative effects of development on aquatic ecosystems.
- Encourage citizens to donate wetland areas to a land trust that will protect it in perpetuity.
- Consider water flow impacts on Ohio River Shrimp when renewing licenses for river dams.

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Pee Dee Lotic Crayfish

Procambarus lepidodactylus

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Zanethia Barnett (USFS)

DESCRIPTION

Taxonomy and Basic Description

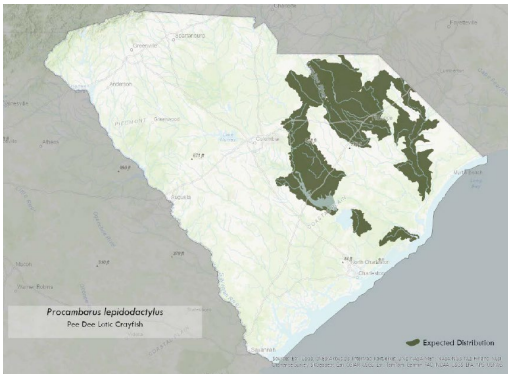
The Pee Dee Lotic Crayfish is a medium-sized crayfish, approximately 55 mm (2.1 in.) in total length with angulate shoulders covered with acute spines. The body is laterally compressed. The chelae are elongate and the palms studded with squamous tubercles (Hobbs 1947).

Status

NatureServe (2024) ranks the Pee Dee Lotic Crayfish as apparently secure in South Carolina (S4) and globally (G4). Taylor et al. (2007) listed the species as currently stable.

POPULATION SIZE AND DISTRIBUTION

The Pee Dee Lotic Crayfish is endemic to South Carolina (NatureServe 2024). It has been found in the Pee Dee River Basin in Chesterfield, Clarendon, Florence, Darlington, Dillon, Georgetown, Sumter, Kershaw, and Marion counties (Smithsonian Museum of Natural History data set) and in abundance in the Cooper River Drainage in Berkeley County (J. Bulak, SCDNR and Z. Barnett, USFS pers. comm.). However, more research on its distribution, population numbers, and habitat associations are needed to determine if this ranking is accurate.



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Pee Dee Lotic Crayfish tends to occur in clear, sandy-bottomed creeks of moderate gradient flowing through swampy areas, often among tree roots along stream banks (NatureServe 2024).

CHALLENGES

It appears that the Pee Dee Lotic Crayfish has a limited and spotty distribution (A. Eversole, pers. comm.). Taylor et al. (2007) listed the Pee Dee Lotic Crayfish as a species complex that is under study.

CONSERVATION ACCOMPLISHMENTS

In a 2006-2011 Stream Survey, 14 occurrences of this crayfish species were found at 9 sites in Sumter and Kershaw counties (A. Eversole, pers. comm.). Additionally, surveys from 2022-2024 on the Francis Marion National Forest collected 40 Pee Dee Lotic Crayfish from 3 sites in Berkely County (Z. Barnett, USFS, pers. comm.).

CONSERVATION RECOMMENDATIONS

- Conduct research to determine the range, distribution, and habitat requirements for the Pee Dee Lotic Crayfish.
- Conduct research to clarify the taxonomy of the Pee Dee Lotic Crayfish.

MEASURES OF SUCCESS

Collection of data that better describes the range, distribution, and habitat requirements for the Pee Dee Lotic Crayfish may be considered a measure of success. Conducting taxonomic research to understand if this species is a species complex may also be considered a measure of success.

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Piedmont Prairie Burrowing Crayfish

Distocambarus crockeri



by Gregory Myers, West Liberty University

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Zanethia Barnett (USFS)

DESCRIPTION

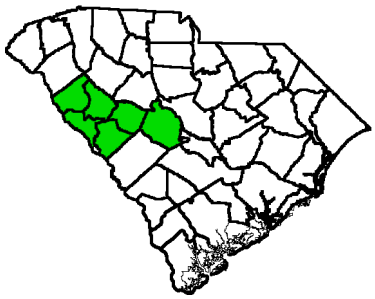
Taxonomy and Basic Description

Distocambarus crockeri is typically dark brown to grayish brown in color with stripes or patterns sometimes present. The chelae are dark tan with brown tubercles. Leucistic (Stubbs et al. 2023) and purple color morphs have been collected (G. Myers, WLU, pers. comm.). The eyes are small but well-developed, and the carapace may have one or several tubercles (Hobbs and Carlson 1983).

Status

NatureServe (2024) currently ranks *D. crockeri* as vulnerable both in South Carolina (S3) and globally (G3). This may be appropriate given that it is moderately abundant but with a restricted distribution. Given the restricted endemic distribution of *D. crockeri*, Taylor et al. (2007) recommended listing it as a threatened species.

POPULATION SIZE AND DISTRIBUTION



D. crockeri is a primary burrowing crayfish that is endemic to South Carolina. It appears to be the most abundant of the *Distocambarus* species. However, none of the species in this genus are particularly widespread. It is found in Abbeville, Edgefield, McCormick, Greenwood and Saluda Counties (Hobbs and Carlson 1983). This species can be found throughout the Carolina Slate Belt between the Savannah and Saluda River Drainage (Eversole and Foltz 2015). Its distribution lies primarily within the Long Cane Ranger District of the Sumter National Forest (S. Welch and Z. Barnett, pers. comm.).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

In the Long Cane Ranger District of the Sumter National Forest, *D. crockeri* is abundant in wildlife openings within the forests. These wildlife openings are grassy fields that were maintained by mowing or disking and resemble Piedmont prairies, which were present throughout much of the Piedmont at the time of European settlement (S. Welch, unpublished manuscript). This species has also been collected in low lying forested areas adjacent to wildlife openings, as well as along the banks of ephemeral streams (Z. Barnett, USFS, pers. comm.). Additionally, during winter and spring months, this species is abundant in roadside ditches and vernal pool habitats (Z. Barnett, USFS, pers. comm.).

Distocambarus crockeri is found primarily on ridgetops and saddles in upland Piedmont areas where there is a perched water table of less than 2 m (6.6 ft.) during the winter and spring. The soils in which *D. crockeri* is found also undergo seasonal drying during the summer and fall (S. Welch, pers. comm.). In the northwestern portion of its range, it is only found near plutonic geologies, which are large, flat, erosion resistant areas that retain fine sediments during rain events and hold water during dry periods (G. Myers, WLU, pers. comm.).

CHALLENGES

The dependence of *D. crockeri* on a perched water table makes it vulnerable to alterations in soil hydrology such as digging a large number of wells or severe drought. Forest succession in prairie areas may also threaten the survival of *D. crockeri* since large populations inhabit these areas (S. Welch, unpublished manuscript). Preliminary taxonomic assessments of the genus suggest that taxonomic clarification of the species may be needed (M. Kendrick, SCDNR, pers. comm.)

CONSERVATION ACCOMPLISHMENTS

The majority of the distribution of *D. crockeri* lies within the Sumter National Forest. The US Forest Service may be able to maintain suitable habitat for *D. crockeri* by managing wildlife openings, restoring prairies, or creating other prairie like environments, as well as, reducing ditch maintenance during winter and spring months when *D. crockeri* are active within them.

Surveys of *D. crockeri* from 2020-2024 has identified over 30 new locations within the Sumter National Forests with over 1,000 individuals encountered.

CONSERVATION RECOMMENDATIONS

- Conduct additional surveys for *D. crockeri* to assess its microhabitat requirements and use of areas outside of prairie-like habitats.
- Taxonomic clarification of species.
- Continue to work with the US Forest Service to ensure that operations on Sumter National Forest maintain suitable habitat for *D. crockeri*.
- Develop and conduct landowner and general education programs that stress the unique nature of terrestrial burrowing crayfish and their importance in South Carolina.

MEASURES OF SUCCESS

Collection of data that better describes the microhabitat requirements (outside of prairie-like habitat) for *D. crockeri* may be considered a measure of success. An update on the taxonomic status of the species would also be considered a measure of success. Assessing participation in education programs would assist in measuring the success of these programs.

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Pine Savannah Crayfish

Cambarus reflexus



Credit: Sarah Chinn (CC BY-NC

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Michael Kendrick(SCDNR)

DESCRIPTION

Taxonomy and Basic Description

Cambarus reflexus has a reddish-orange-tan carapace, a dark first abdominal segment, and progressively lighter segments approaching the pinkish tail. It has broad, triangular, orange-brown chelae and small eyes (Hobbs 1981).

Status

NatureServe (2024) currently identifies *C. reflexus* as imperiled (S2) in Georgia and vulnerable (S3) in South Carolina. The global ranking of apparently secure (G4) may need to be updated to reflect its rarity in those two states. The species was considered to be currently stable in Georgia and South Carolina by Taylor et al. (2007). According to Welch (2007), the species' current global status of "currently stable" and "vulnerable" in South Carolina likely underestimates its level of imperilment.

POPULATION SIZE AND DISTRIBUTION

Hobbs (1989) lists the distribution as extending to the Santee Basin, but its presence in this basin has not been confirmed by recent collections and there could be some misidentified specimens associated with some of these records or the species may be extirpated from portions of its historical range (Welch 2007).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

C. reflexus is a primary burrower and is restricted to flatwoods longleaf pine forests of the Savannah and Ogeechee River Basins of the Coastal Plain in South Carolina and Georgia (A. Eversole, pers. comm.). In addition to open pine forests, this species can occur underneath logs in low-lying seepage and boggy areas characterized by black soil, and it can be found in mixed hardwood and swamp forests (Hobbs et al. 1976, Hobbs 1981.).

CHALLENGES

Further survey work is needed for *C. reflexus*. This species appears to be rare; with its limited distribution, *C. reflexus* warrants significant habitat protection. However, the species occurs in an area of South Carolina that has a low human population that has decreased, unlike in other areas undergoing urbanization.

CONSERVATION ACCOMPLISHMENTS

A habitat modeling study was done on this species by Welch (2007). The presence of wiregrass was the most important habitat component measured in the study. The importance of wiregrass and stand age indicated that *C. reflexus* was associated with "high quality" fire-maintained pine savannah habitats. Furthermore, the study suggested that *C. reflexus* was limited to these sites and thus could

be included as an invertebrate component used to identify "high quality" pine savanna habitats for conservation and restoration. The species appears to be limited to the Coastal Plain in South Carolina and sensitive to soil surface disturbances.

CONSERVATION RECOMMENDATIONS

- Conduct surveys to determine the extent of the range of *C. reflexus*.
- Conduct research to determine the natural history and population status of *C. reflexus.*
- Determine the importance of alterations to the groundwater table to the population stability of *C. reflexus*.
- Investigate the need to initiate the process of achieving South Carolina special concern status for *C. reflexus*.
- Maintain remnant pine savannah stands containing *C. reflexus* with prescribed burns. Restoration efforts should focus on stands adjacent to *C. reflexus* colonies and restore savannah vegetation structure.
- Develop and conduct landowner and general education programs that stress the unique nature of burrowing crayfish and their importance in South Carolina.

MEASURES OF SUCCESS

The collection of data that better describes the natural history and population status of *C. reflexus* may be considered a measure of success. Completion of groundwater investigations and the determination of recommendations to protect Pine Savannah Crayfish would also be considered a sign of success. Assessing participation in education programs would assist in measuring the success of these programs.

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Red Burrowing Crayfish

Cambarus carolinus



Credit: iNaturalist/cporternc

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Michael Kendrick (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

The Red Burrowing Crayfish has a cylindrical body shape and is brick-reddish in color. The chelae have a large row of tubercles on the mesial surface of the palm (NCWRC 2005).

Status

NatureServe (2024) identifies the rank for the Red Burrowing Crayfish as imperiled (S2?) in South Carolina and apparently secure (G4). Taylor et al. (2007) considered the species to be currently stable.

POPULATION SIZE AND DISTRIBUTION

The Red Burrowing Crayfish is an obligate burrower found in the upper Broad, Saluda, and Savannah River Basins (Hobbs et al. 1973; Hobbs 1989, USNM records). Its distribution in South Carolina is spotty and restricted to a few wetlands, seeps, and bogs in the western Piedmont (A. Eversole, pers. comm.). This species is also found in western North Carolina and eastern Tennessee (Hobbs 1989).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Although the Red Burrowing Crayfish is a primary burrower, it is often found in surface waters including springs, seeps, and bogs (NCWRC 2005).

CHALLENGES

Very little is known about its natural history or population status. This species is hard to survey because of its burrowing habit and its colonies are small. It has a limited distribution and small population size (A. Eversole, pers. comm.). It is suspected that any activities likely to alter the water table, such as major road construction or tapping into groundwater for dense suburban development, would threaten this species.

CONSERVATION ACCOMPLISHMENTS

There are no significant conservation accomplishments for the Red Burrowing Crayfish at this time.

CONSERVATION RECOMMENDATIONS

- Conduct research to determine the natural history and population status of the Red Burrowing Crayfish.
- Determine the importance of alterations to the groundwater table to population stability of the Red Burrowing Crayfish.

- Develop and conduct landowner and general education programs that stress the unique nature of terrestrial burrowing crayfish and their importance in South Carolina.

MEASURES OF SUCCESS

The collection of data that better describes the natural history and population status of the Red Burrowing Crayfish may be considered a measure of success. Completion of groundwater investigations and determination of recommendations to protect Red Burrowing Crayfish would also be considered a sign of success. Assessing participation in education programs would assist in measuring success of the programs.

LITERATURE CITED

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Rocky River Crayfish

Cambarus hobbsorum


Credit: Kevin Metcalf

Contributor (2024): Graham Wagner (SCDNR) and Bronwyn Williams (NCMNS)

DESCRIPTION

Taxonomy and Basic Description

The body of the Rocky River Crayfish is dorsoventrally flattened. The thoracic section has punctations and granulations dorsally and cobbled tubercles laterally. Its color is variable but is generally in shades of deep brown, olive, green, blue-green, and black and is highlighted with tan, white, or orangish tubercles. The tips of fingers are orange, tan, or yellowish; the palms of its chelae are inflated and the dorsal surfaces of palms have tubercles (NCWRC 2005). It differs from other members of its subgenus by having a narrow areola, sometimes with long plumose setae on the opposable surface of the fixed finger of the chela of adults, and a disklike caudal knob on the gonopod of form I males (Cooper 2001).

Status

NatureServe (2024) identifies the rank as Vulnerable (S3) in North Carolina and South Carolina, and Vulnerable (G3) globally. Taylor et al. (2007) considered the species to be currently stable.

POPULATION SIZE AND DISTRIBUTION

The Rocky River Crayfish has been reported from the Catawba River basin in South Carolina, and from the middle Yadkin-Pee Dee, and upper Cape Fear and Neuse River basins in North Carolina; Cooper (2001) stated that this species likely has an even wider distribution. However, recent field surveys, coupled with extensive genetic analyses, indicate that the Rocky River Crayfish is restricted to a narrow stretch of the Pee Dee River basin, including the Rocky River, Little River, and Big Mountain Creek drainages (B.W. Williams, NCMNS, unpublished). As such, the species occurs in South Carolina only in Brown Creek, Chesterfield County, north of Pageland. It's presence from this creek has been confirmed (NCSM NMI Collection data)

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Rocky River Crayfish inhabits permanent freshwater creeks and streams (Cooper 2001). Little is known about specific habitat requirements and environmental tolerances of this species.

CHALLENGES

The highly limited distribution of this species in South Carolina makes it vulnerable to impacts from anthropogenic habitat alteration and spread of nonnative species from downstream areas.

CONSERVATION ACCOMPLISHMENTS

An increased understanding of the life history of this species, and assessment of potential threats to Brown Creek, and the species range-wide, would be an important accomplishment.

CONSERVATION RECOMMENDATIONS

Conduct surveys to establish an improved understanding of the entirety of the distribution of this species. Additionally, a study of the life history and microhabitat preferences of the Rocky River Crayfish would benefit the conservation of this species.

MEASURES OF SUCCESS

An increased understanding of the overall distribution and biology of the Rocky River Crayfish would be considered a success.

LITERATURE CITED

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Saluda Burrowing Crayfish

Distocambarus hunteri


Photo by Dr. Zackary Graham

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2024): Eric Ng and Kathryn Schulz (West Liberty University)

DESCRIPTION

Taxonomy and Basic Description

Distocambarus hunteri was described by Fitzpatrick and Eversole in 1997. The genus was formerly a subgenus of *Procambarus*. The most closely allied species are the other members of the retained subgenus *Fitzcambarus*; *Distocambarus* (*F.*) *youngineri* and *D.* (*F.*) *carlsoni* (Crandall & De Grave, 2017; Fitzpatrick & Eversole, 1997; H. H. Hobbs, 1981). Efforts to delimit this species in the field have proven to be difficult, as the Saluda Burrowing Crayfish closely resembles the Piedmont Prairie Burrowing Crayfish [*Distocambarus* (*Distocambarus*) *crockeri* (H.H. Hobbs, 1983)], despite being more closely related to *D.* (*F.*) *youngineri*. Due to taxonomic complexity within this species and difficulties with morphological delimitation, phylogenetic revision is recommended.

The color of the Saluda Burrowing Crayfish is variable, from lighter brown in recently molted individuals to darker brown in older intermolts with purple occurring on some individuals. The thoracic sections are mottled and fade to reddish-brown posteriorly. The chelae are strongly depressed, and the palm is comparatively long, with the mesial margin of the palm being almost 45% the length of entire chela. The coloring of the chelae is ash-brown with dark brown tubercles and reddish tips. The species has small, pigmented eyes and can rarely have one spine or tubercle on the cervical groove of the carapace. Adult individuals examined in the process of describing this species ranged from approximately 35-58 mm (1.4-2.3 in.) in length (Fitzpatrick and Eversole 1997).

Status

NatureServe (2024) currently lists the Saluda Burrowing Crayfish as both globally endangered (G1) and state endangered (S1). Endangered status was recommended for this species by Taylor et al. (2007).

POPULATION SIZE AND DISTRIBUTION

The Saluda Burrowing Crayfish is a very rare, obligate burrower that is endemic to South Carolina. Historically, there are only 2 populations known, both of which are in the Saluda River Basin in Saluda County (Fitzpatrick and Eversole 1997). However, recent surveys suggest additional populations may occur within Saluda County, South Carolina. The few documented populations occur between the town of Saluda, SC and Lake Murray.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Fitpatrick and Eversole (1997) found both populations of *D.* (*F.*) *hunteri* in roadside drainage habitats with wet, sandy soils that support a high-water table. The dominate forest of the type

locality was an overstory of loblolly pine, red maple, willow oak, and American elm. This species is also known to dig burrows among root mats (Fitpatrick and Eversole 1997). Recent surveys suggest that they can be found in association with juncus, sedge, low-lying depressions and seepage areas.

CHALLENGES

Given its restricted distribution, *D.* (*F.*) *hunteri* should be protected. If the distribution of *D.* (*F.*) *hunteri* is as restricted as it appears, any developmental project in the vicinity of its range could result in localized extirpation of this species. The only published article concerning *D.* (*F.*) *hunteri* is the original description paper from 1997, making it difficult to discern the exact range and relevant threats this species obtains.

CONSERVATION ACCOMPLISHMENTS

South Carolina Department of Natural Resources is currently undergoing a three-year study to obtain more information on this species. In addition, the Saluda Burrowing Crayfish has achieved 'species of concern' status in the state and is now indicated to be a species of highest priority for South Carolina's SWAP.

CONSERVATION RECOMMENDATIONS

- Conduct surveys in the Saluda drainage to look for additional populations of *D.* (*F.*) *hunteri.*
- Investigate the need to initiate the process to achieve South Carolina special concern status for *D.* (*F.*) *hunteri*, based on survey results.
- Initiate the process to refine the taxonomy of *D. (F.) hunteri* in South Carolina.
- Preserve habitat where *D.* (*F.*) *hunteri* is found through conservation easements or land acquisition.

MEASURES OF SUCCESS

An updated taxonomic revision of the species would also be considered a sign of success. In addition, finding more populations of the species with no population losses would be considered a sign of success.

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Santee Crayfish
Procambarus blandingii

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Greg Rothman and Michael Kendrick (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

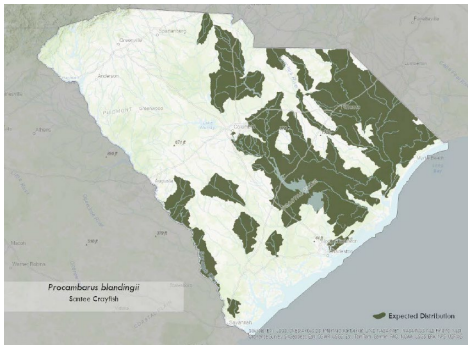
The Santee Crayfish is large and cylindrical in shape. It is tan, brown, and/or green with dark speckles or light mottling and slender chelae (NCWRC 2005).

Status

NatureServe (2024) currently identifies the Santee Crayfish with a ranking of vulnerable/ apparently secure (S3/S4) in North Carolina and apparently secure (S4) in South Carolina. The Santee Crayfish is considered apparently secure in North and South Carolina (Taylor *et al*. 2007; Simon, 2011).

POPULATION SIZE AND DISTRIBUTION

The Santee Crayfish is restricted to the Carolinas and found primarily in lentic waters of the Coastal Plain. Its range extends from the Lumber-Little Pee Dee River Basin in North Carolina to the Wateree-Santee River Basin in South Carolina. It is difficult to determine a detailed range map for this species, because *Procambarus blandingii* (Harlan, 1830) has often been confused with *P. acutus* and it is not known which records are identified correctly.



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Santee Crayfish can be found in lentic and slow moving sections of lotic streams. It is usually associated with vegetation or woody debris when found in swamps (NCWRC 2005).

CHALLENGES

The taxonomic status of the Santee Crayfish, primarily in regards to the similarities with *P. acutus*, is one of the larger challenges surrounding this species, leading to little being known about its distribution or life history. Further research is needed on its range, population densities, and habitat associations. Additionally, the introduction of non-native species, such as the Louisiana Red Swamp Crayfish, *Procambarus clarkii*, have been shown to reduce *P. blandingii* abundance in areas of which *P. clarkii* are present (Kendrick *et al.,* in press). This alteration in population status highlights the need to understand how these introductions may impact native crayfish species like *P. blandingii*.

CONSERVATION ACCOMPLISHMENTS

Collections made during the South Carolina Stream Assessment (2006–2011) indicate that the Santee Crayfish is fairly common in the Coastal Plain, but little is known about its life history. Work was also completed examining impacts of the non-native *P. clarkii* on native crayfish

populations including *P. blandingii* in the Lower Pee Dee, Waccamaw and Winyah watersheds (Kendrick *et al.,* in press).

CONSERVATION RECOMMENDATIONS

- Conduct research to determine the range, population densities, and habitat associations for the Santee Crayfish.
- Conduct taxonomic and genetic research comparing *P. blandingii* and the more common *P. acutus*.
- Identify threats posed (*i.e.* disease, resource competition) by the introduction of non-native species, like *P. clarkii*, to the Santee Crayfish.

MEASURES OF SUCCESS

The collection of data that better describes the range, population densities, habitat associations, genetic relatedness to other species of Procambarid crayfish and/or identifies threats to the Santee Crayfish may be considered measures of success.

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Shaggy Crayfish
Procambarus hirsutus

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Greg Rothman and Michael Kendrick (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

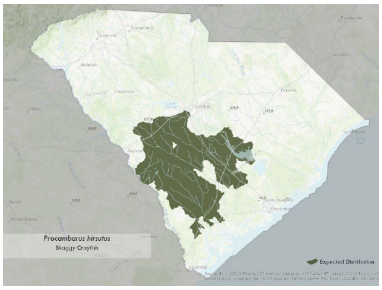
The body of *Procambarus hirsutus* is dark brown with bright orange mottlings. The chelae are brownish-orange with black tubercles on the upper surface, and lighter tubercles on the lower surface. The rostrum of this species has marginal spines and is covered in the dense hairs at the base of the acumen that give the species its name: "hirsutus" means "shaggy" in Latin. The holotypic male measured 68.4 mm (2.7 in.) in length, while the allotypic female and morphotypic male are slightly smaller (Hobbs 1958). Specimens of *P. hirsutus* share many charateristics to specimens of its sister taxa, *P. pubescens*, a tribute to their genetic relatedness, who are often found together in the same environments (Brown, 1981).

Status

NatureServe (2024) identifies *P. hirsutus* with a rank of apparently secure (S4) in South Carolina, but more information is needed to determine if this ranking is appropriate. Taylor *et al.* (2007) and Simon (2011) considered the species to be currently stable in South Carolina.

POPULATION SIZE AND DISTRIBUTION

P. hirsutus is endemic to South Carolina and has been found in the Santee, Edisto, Salkahatchie and Savannah River Basins in Aiken, Allendale, Bamberg, Barnwell, Calhoun, Lexington, Colleton, Orangeburg, and Hampton Counties (Hobbs 1958, SCDNR stream assessment data). During stream surveys (2006–2011) it was abundant at about half of the sites where it occurred.



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Procambarus hirsutus is found in clear streams with good flow (Hobbs 1989, W. Poly pers. obs.). Little else is known about its habitat requirements.

CHALLENGES

Little is known about *P. hirsutus*, and research is needed on all aspects of its biology before its conservation status can be determined. The restricted range of this species is cause for some concern, particularly with the potential overlap with non-native species, such as *P. clarkii*. Additionally, development in areas of which *P. hirsutus* are known to occur could alter population status.

CONSERVATION ACCOMPLISHMENTS

Collections of Shaggy Crayfish were made during the South Carolina Stream Assessment (2006–2011), but the known distribution was extended into only one additional county.

CONSERVATION RECOMMENDATIONS

- Conduct research to determine the range, distribution and habitat requirements for *P. hirsutus*.
- Identify threats to population status of *P. hirsutus* due to the introduction of non-native species, like *P. clarkii*, habitat alteration, and climate change.

MEASURES OF SUCCESS

The collection of data that better describes the range, distribution, and habitat requirements for *P. hirsutus* may be considered a measure of success.

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Wandering Crayfish
Procambarus barbatus



Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Greg Rothman and Michael Kendrick (SCDNR)

DESCRIPTION

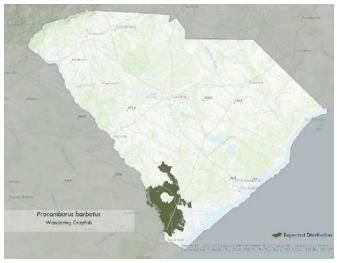
Taxonomy and Basic Description

Two color patterns have been observed for *Procambarus barbatus*. The "striped phase" has a dorsomedian longitudinal light stripe and a background color of light olive, olive-tan, pinkish-tan, or brown. The "speckled phase" has small irregular dark spots scattered over the carapace and dorsum of the abdomen and a background color similar to that of the striped phase. During the breeding season, males have a hairy tuft of setae on the mesial surface of the palm of the chelae (Hobbs 1981). Faxon (1890) examined several specimens that averaged 60 mm (2.4 in.) in length.

Status

NatureServe (2024) currently identifies the species with a ranking of apparently secure (S4) in South Carolina and secure (S5) in Georgia. The species was considered currently stable in Georgia and South Carolina (Taylor et al. 2007; Simon, 2011).

POPULATION SIZE AND DISTRIBUTION



P. barbatus is found in the Lower Coastal Plain from the lower Savannah River Basin in South Carolina to the Altamaha River basin in Georgia (Hobbs 1989). It has been collected in Hampton, Jasper, and Beaufort counties in South Carolina.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

P. barbatus is found in a fairly restricted habitat type: seasonal ponds and ditches in flatwoods. It lives in these lentic waters and will burrow to reach the water table when water levels become low (Hobbs 1981).

CHALLENGES

P. barbatus is fairly common in its preferred habitat but is restricted to ponds in flatwoods, which may be a threatened habitat. The hydrology of these seasonal ponds must remain intact with seasonal saturation of the area with open ground surrounding the pond, not dense vegetation. Anything that alters the hydrology of the soil could adversely affect the habitat of this species. It is possible that an appropriate fire regime is important to maintaining suitable habitat for this species. More research is needed to determine conclusively the soil and vegetation properties needed for this species' habitat and the effects of potential impacts. Based upon the restricted distribution and potential threats to its habitat, this species deserves some protection and should be considered a species of special concern.

CONSERVATION ACCOMPLISHMENTS

There are no significant conservation accomplishments specifically for *P. barbatus* at this time.

CONSERVATION RECOMMENDATIONS

- Conduct research to determine the necessary soil and vegetation properties of the habitat required by *P. barbatus*. Once these properties have been investigated, determine whether their habitat will be adversely impacted by activities in the vicinity of the habitat.
- Conduct additional surveys to determine the distribution and abundance of *P. barbatus*.
- Based on surveys, investigate the need to update the state ranking for *P. barbatus*.

MEASURES OF SUCCESS

Collection of data that better describes the habitat requirements for *P. barbatus* may be considered a measure of success.

LITERATURE CITED

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Alosines Guild

American Shad *Alosa sapidissima*
Hickory Shad *Alosa mediocris*
Blueback Herring *Alosa aestivalis*

Contributors:
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Revised 2015:
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DESCRIPTION

Taxonomy and Basic Description



The American Shad, Alosa sapidissima belongs to the herring family, Alosidae (Page et al. 2023). It is the largest Atlantic Coast member of the family, with females in South Carolina reaching about 66 cm (26 in.) in total length (TL). Sexually mature female American Shad, often called “roe shad” because of the large, highly prized ovaries, rarely attain more than 3 kg (7 lbs.). Mature male shad, or bucks, are generally smaller than females, rarely exceeding 2 kg (4.5 lbs.). American Shad, like other alosines and most members of the Alosidae, are laterally compressed, with relatively large scales. Scales on the midline of the underside form sharp scutes that produce a saw-toothed ridge. Coloration is dark bluish, greenish, or bronze on the back; silvery on the sides; and white below, and varies depending on color and turbidity of water. The mouth is near the midline of the snout, and a series of several dark spots usually extends backward to below the dorsal fin from near the operculum and pectoral fin. The fins are dark and without spines while the tail is deeply forked.

Most spawning shad in South Carolina are between 3 and 6 years old, with males averaging about a year less than females. Shad migrate several hundred miles or kilometers inland in large river basins and arrive in South Carolina from mid-January through mid-May. Peak spawning activity is water temperature-dependent, but generally occurs during March and April. Shad are sequential or batch spawners, with groups of eggs released as the fish move upriver. Eggs are semi-buoyant and drift in the water column when flows and depth are appropriate. Eggs usually hatch within a few days into tiny larvae that soon transform into small juveniles. Juveniles closely resemble adults but are generally have a more silver color, typically reaching only 10 to 12 cm (4 to 5 in.) TL before they move toward the ocean to complete growth and maturation, usually after about one year of development in the rivers, sounds and bays. However, some

juveniles remain within the Santee-Cooper Lakes at least until the summer of their second year. This is presumably because of difficulties in using out-migration options, some of which are not functional when outflows are limited due to low lake levels (D. Cooke, SCDNR, pers. comm., 2005;USFWS 2017).

Juvenile American Shad feed primarily on small invertebrates, including insect larvae and zooplankton. Adult shad prefer larger zooplankton and rarely feed while in freshwater as they are thought to die after their initial spawning run. Both out-migrating juveniles and adults that survive spawning generally move into the Atlantic and migrate into coastal areas of Maine and southern Canada where they mingle with shad from all Atlantic populations and prey primarily on abundant zooplankton. By fall, the vast conglomerate population migrates south and overwinters off the Mid-Atlantic States. Sexually mature fish then disperse up or down the coast to their respective rivers as late winter and spring water temperatures moderate and become ideal for spawning (Neves and Depres 1979; McCord et al. 1987; Greene et al. 2009).



The Hickory Shad, *Alosa mediocris* (Mitchill 1814), also belongs to the herring family, Alosidae (Page et al. 2023). It is smaller than the American Shad, with females in South Carolina reaching about 55 cm (22 in.) TL. Sexually mature female Hickory Shad, often called “roe jacks”, also carry highly prized ovaries, but rarely attain more than 2 kg (4.5 lbs.). Adult male Hickory Shad are usually smaller than females, rarely exceeding 1 kg (2.2 lbs.). Hickory Shad are shaped much like American Shad and also have large scales. General coloration is greenish or bronze on the back, silvery on the sides, and white below. A small, indistinct spot can usually be seen beneath each lateral scale. The mouth is nearer the top of the snout than in American Shad. Several dark spots usually extend backward to below the dorsal fin from near the operculum and pectoral fins. The fins are dark and spineless while the tail is deeply forked. Juvenile Hickory Shad resemble adults, but are less distinctively marked. Juveniles usually emigrate from inland habitats by early winter at approximately 15 cm (6 in.) TL. Larval and smaller juvenile fishes are primary dietary items for juvenile Hickory Shad.

Adult Hickory Shad migrate and spawn earlier than American Shad and Blueback Herring; Hickory Shad move inland from December through mid-April. Peak spawning for Hickory Shad in South Carolina is during February and early March. Hickory Shad typically spawn along channel edges of tidally influenced freshwater river reaches, usually within 80 km (50 mi.) of the ocean. Otherwise, the general life cycle is similar to the American Shad with a few exceptions. Most Hickory Shad are believed to survive after spawning, presumably because they feed primarily on small fishes that are generally available in inland habitats. Hickory Shad apparently concentrate farther south, principally from Delaware Bay to New England coastal inlets, where they feed primarily on small fishes (ASMFC 1999, Greene et al. 2009).



The Blueback Herring, *Alosa aestivalis* (Mitchill 1814), is the smallest alosine in the Southeast. Adult female Blueback Herring in South Carolina reach about 31 cm (12 in.) TL and weigh 0.3 kg (0.7 lbs.); while the slightly smaller mature males approach 28 cm (11 in.) TL and weighs 0.27 kg (0.6 lbs.). Adult Blueback Herring are shaped and marked much like American Shad. Juveniles, which usually emigrate to the ocean by mid-winter, resemble tiny adults and are about 10 cm (4 in.) TL.

Timing of inland migration, spawning and development of Blueback Herring closely follows patterns for American Shad. However, Blueback Herring typically spawn in freshwater marshlands or small tributaries. Small zooplankton constitute much of the juvenile diet. Post-spawning survival rates are not well known for Blueback Herring, but probably exceed those for American Shad. Migratory routes and timing of Blueback Herring are similar to those for American Shad. During the spawning migration, Herring move inland at distances intermediate to characteristics described for Hickory and American Shad. The distance that Herring move upriver may be partly dependent upon the availability of habitats with suitable substrates for egg adhesion nearer the coast (Loesch and Lund 1977).

During all life stages, alosines contribute greatly to the dynamics of food chains in freshwater, estuarine or marine habitats (Facey et al. 1986; MacKenzie et al. 1985; Weiss-Glanz et al. 1986). While at sea, alosines are prey for many species including sharks, tunas, mackerel and marine mammals, including porpoises and dolphin (Weiss-Glanz et al. 1986; ASMFC 1999). In fresh and brackish waters, both adult and juvenile alosines are consumed by American Eel and Striped Bass (Facey et al. 1896; Mansueti and Kolb 1953; Savoy and Crecco 1995; Walburg and Nichols 1967). Juvenile Herring are high quality prey for Largemouth Bass (Micropterus salmoides); accelerated growth of young bass occurs when Herring consumption is high (Yako et al. 2000). Tissues taken from predatory fish in tidal freshwaters following the residency of migrating alosines had between 35 and 84% of their carbon-biomass derived from marine sources (Garman and Macko 1998; MacAvoy et al. 2000). East Coast alosines, particularly populations in the Southeast where post-spawning mortality is highest, likely provide nutrients and carbon into riverine systems, similar to nutrient dynamics provided by salmon in the Pacific Northwest (Freeman et al. 2003). For example, the James River in Virginia may have received annual biomass input from alosines of 155 kg/ha (138 lbs./ac.) before dams blocked migrations above the fall line (Garman 1992).

More than 40 species of birds and mammals congregate to feed on migrating anadromous fish in southeastern Alaska (Willson and Halupka 1995; Willson et al. 1998). Similar relationships likely occur between East Coast alosines and birds and mammals. Fish-eating birds like Osprey (Pandion haliaetus) and Bald Eagle (Haliaeetus leucocephalus) prey upon alosines (J. W. McCord, pers. obs.) and may have evolved their late winter and spring nesting strategies in response to the availability of food resources supplied by pre and post-spawning alosines. In

addition, nutrients released from carcasses of post-spawning alosines can substantially subsidize aquatic food webs by stimulating productivity of bacteria and aquatic vegetation (Kline et al. 1993; Richey et al. 1975), thereby stimulating the assimilation of marine-derived nutrients into aquatic invertebrates and fish (Bilby et al. 1996).

Status

American Shad, Hickory Shad and Blueback Herring are experiencing coast-wide reductions in all stocks compared to historical populations (ASMFC 2020; ASMFC 2024). Current spawning runs of East Coast North American shad populations have been reduced to 10% of historical sizes and have been extirpated from over 4,000 km (2,500 mi.) of riverine habitat (Limburg et al. 2003). Several alosine stocks (riverine populations) are of unknown status because no directed studies have been conducted. Hickory Shad population status is very poorly known for South Carolina and historical data are virtually absent. The species is apparently not plentiful anywhere within South Carolina. Populations of Blueback Herring in the Waccamaw-Pee Dee and Santee-Cooper are presumably secure, though undoubtedly reduced from historical levels predating dams. Blueback Herring populations for other drainages are perceived to be of poorer status, and perhaps absent. Because of these declines in current stocks, the Atlantic States Marine Fisheries Commission (ASMFC) made the additions of Amendments 2 and 3 to the Shad and River Herring Fishery Management Plan. These amendments state, among other things, that participating states must submit and have approved river-specific sustainability fishing management plans (SMFP) for American Shad and Blueback Herring. These plans must demonstrate, by using targets, how fisheries are sustainable. If sustainability targets are not met or states cannot demonstrate a given river is sustainable, then fisheries on that river must be closed. South Carolina submitted both SFMPs (shad and herring) in 2010 and 2011, and updates for both species again in 2020. Plans and updates have both been accepted by the ASMFC Shad and Herring Board. Sustainability targets, using 75% of the mean in most cases, were set for all rivers where fisheries occur, and those systems where no fishing occur or no data were available have been closed. In addition, on August 5, 2011, the Natural Resources Defense Council submitted a petition to NOAA requesting that the agency consider river herring (Alewife and Blueback Herring) for listing under the Endangered Species Act. In response, NOAA made a determination in 2019 that Alewife and Blueback Herring did not warrant listing under the Endangered Species Act.

POPULATION SIZE AND DISTRIBUTION

American Shad occurs along the Atlantic coast from the Bay of Fundy in Canada to the St. Johns River in Florida. The historical range of Hickory Shad is very similar, from the Bay of Fundy in Canada to the Tacoma River in Florida, but current distribution is uncertain with known occurrence as far north as Connecticut (ASMFC 1999). Blueback Herring are distributed from Nova Scotia to northern Florida, though they are most abundant from the Chesapeake Bay and south (Scott and Scott 1988). In South Carolina, all three species are presumed to occur as unique populations by coastal river system with a minimum of eight populations (presumably for all three species): Waccamaw-Pee Dee, Santee-Cooper, Ashley, Edisto, Ashepoo, Combahee, Coosawhatchie, and Savannah drainage Basins. Relatively unique populations likely occur in the

major tributaries within the Waccamaw–Pee Dee Basin, including Waccamaw, Little Pee Dee, Great Pee Dee, Lynches, Black, and Sampit Rivers.

Historical population estimates are nonexistent, but historical distribution records (USFWS 2001) and anecdotal information on abundance strongly indicates that all populations of alosines in South Carolina are reduced compared to historical levels (early 20th century and before). American Shad and, to a lesser extent Blueback Herring, historically ascended large river basins of the State (Waccamaw-Pee Dee, Santee, and Savannah) well inland of the Fall Line and into North Carolina and Georgia (USFWS 2001).

Trends in American Shad stocks have been primarily monitored by observations in commercial gill-net fishery catch rates since 1979. Based on these trends, American Shad populations in the Waccamaw-Pee Dee Basin and Savannah River have remained relatively stable and healthy over the past 25 years, though almost certainly below levels of a century past and showing some signs of decline within the last 5 years (McCord 2003, Post and Waldrop 2023).

Fortunately, the lowermost dams on both Savannah and Waccamaw–Pee Dee Basins are approximately 300-river km (200 mi.) from the ocean, so spawning habitat is available below primary barriers. However, historical alosine spawning migrations in these basins extended beyond the point of these dams (USFWS 2001). Anecdotal information indicates that both Blueback Herring and Hickory Shad occur in the Savannah in small populations. Dam-locked populations of Blueback Herring now occur in several reservoirs, including Lakes Thurmond, Russell, and Hartwell. Hickory Shad may have also become dam-locked in Savannah Basin reservoirs, but spawning has not been recorded (D. Cooke, SCDNR, pers. comm. 2005).

The Santee-Copper American Shad population has grown substantially since 1985 and is among the largest on the Atlantic coast, with the population likely approaching one million adults annually (McCord 2003). The Blueback Herring population was estimated to average over 6 million in the 5 years following the rediversion of flows (Cooke and Leach 2003), and may be larger now following almost 20 years of increased flows and fish passage. Both American Shad and Blueback Herring populations in the Santee-Cooper Basin have responded well to existing fish passage protocols and increased flows.

Hickory Shad population status is poorly understood; however, based on anecdotal observations, the Santee-Cooper population is among the largest in the State, despite very low passage numbers recorded at St. Stephen Dam (Cooke and Leach 2001).

Among the ACE Basin rivers, Edisto River's shad populations apparently declined dramatically through the early 1990s, with overfishing indicated as a primary cause (McCord and Ulrich 1991). Directed management through restrictive commercial fishery regulations enacted in 1993 and a decline in the number commercial fishers has apparently promoted an increased population as indicated by improved catch rates for gill-net fishers (McCord 2003). However, this stock is considered to be in guarded condition until additional monitoring can better indicate stock status (McCord 2003; Post and Waldrop 2023). The Combahee River shad population was categorized as substantially declined in the late 1990s, presumably from an extended period of overfishing (McCord and Ulrich 1994; McCord 2003). Restrictive commercial fishery guidelines were

established in 2000 and should allow for growth of this stock. The status of the American Shad population in the Ashepoo River, the smallest of the ACE Basin rivers, is unknown. Relatively few records exist for either Hickory Shad or Blueback Herring in the ACE Basin. Both species are presumed to occur in very small populations.

Both Ashley and Coosawhatchie Rivers are small, Coastal Plain drainages that historically supported limited commercial American Shad fisheries. The current status of these populations is also unknown. Commercial fishing activity was restricted substantially for the Ashley and banned for the Coosawhatchie since fishery laws were revised in 2000 in accordance with Act #245 of the 2000 South Carolina General Assembly. Further restrictions to these fisheries occurred as part of requirements in the SC's SFMP for the species (SCDNR 2020). The status of alosine stocks in these small rivers, including whether any Hickory Shad and Blueback Herring are present, is unknown.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Because of the highly migratory nature of alosines, these fishes require access to an expansive variety of high-quality freshwater and marine habitats. Within state waters, adults migrate through nearshore Atlantic shelf waters and enter coastal sounds, bays and inlets to access the river basins in which they spawn. Eggs of American Shad and Hickory Shad require adequate flows (generally 0.15 to 0.9 m/sec. or 0.5 to 3.0 ft./sec.) and sufficiently low sediment loads to keep eggs adrift until hatching (ASMFC 1985; Mansueti 1962; Williams and Bruger 1972). In river reaches where flows and/or water depth are not sufficient to keep eggs suspended, the semi-buoyant eggs sink to the bottom and roll or bounce on hard substrates, but may be suffocated in areas with siltation (Massmann 1951; Williams and Bruger 1972). Successful spawning of Blueback Herring is partly dependent upon the availability of relatively clean vegetation and other substrates outside and at the periphery of river channels for egg adhesion and development with relatively low turbidity or suspended sediments (Christie et al. 1981). Christie et al. (1981) found high utilization of tidal, freshwater breached impoundments, or relict rice-fields as Blueback Herring spawning habitat in the Cooper River Basin.

American Shad require high, but stable flows of high-quality water for spawning and early nursery habitats (Crecco and Savoy 1987). Nursery habitats for American and Hickory Shad include all channel and adjacent out-of-channel submerged habitats from a few kilometers or miles seaward to estuarine sounds and bays of river basin deltas. Larval and early juvenile Blueback Herring are associated more with the floodplain small tributaries and marshlands where spawning occurs, but older juveniles move into the same riverine and estuarine habitats used by American and Hickory Shad (Greene et al. 2009). Where fish passage venues provide access into reservoirs, juveniles of all three species apparently successfully utilize artificial lake and tributary habitats as nursery areas as development continues (D. Cooke, SCDNR, pers. comm. 2005, Post et al. 2023).

Abundant sloughs and flats with submerged vegetation are generally available in reservoirs, providing excellent spawning habitat for Blueback Herring. During fall and winter, juvenile American Shad and Blueback Herring tend to co-occur predominantly in deeper, channel habitats of estuarine systems, while Hickory Shad juveniles are more frequently encountered in shallow

expanses of sounds and bays (J. W. McCord, pers. obs., Post et al. 2023). These variant distributions are likely reflective of differences in food preferences, as small crustaceans used by American Shad and Blueback Herring are generally abundant near the bottom in estuarine channels, and small fishes preferred by Hickory Shad are likely more numerous in shallower habitats adjacent to marshlands.

CHALLENGES

Obstructed access to a diversity of habitats may limit basin-specific alosine populations. Dams prevent upstream migration of alosines and other species (ASMFC 1985; ASMFC 1999; USFWS 2001; USFWS 2017). Atlantic streams from Maine to Florida have undergone a restriction or loss of access for migratory fishes to about 84% of stream habitat within historic ranges from dams alone (Busch et al. 1998;USFWS 2001). The Waccamaw-Pee Dee, Santee-Cooper and Savannah Basins in South Carolina are impacted by dams that restrict migrations of alosines into historical habitats (USFWS 2001). Dams and other impediments to migration have eliminated alosines from many historical habitats in South Carolina (USFWS 2001); the result being a general reduction in alosine populations even in currently accessible river reaches. The ecosystem effects of this loss are difficult to identify (Power et al. 1996), but ecological roles for alosines may be greatly diminished (Garman and Macko 1998). For example, many freshwater mussels are dependent upon migratory fishes as hosts for their parasitic larvae and are presently among the most imperiled freshwater fauna (Neves et al. 1997; Vaughn and Taylor 1999), with about 29 species of conservation concern in South Carolina.

The Santee Basin has the second largest drainage area and total discharge (only the Susquehanna is larger) of all river systems on the East Coast of the US (Hughes 1994). However, this large watershed has been adversely affected by damming to a greater extent than most basins on the Atlantic Coast of North America, with nearly 45 dams in the South Carolina portions of the Basin alone (USFWS 2001). The original Santee-Cooper diversion project, completed in 1942, shifted approximately 88% of the historical Santee River flow into the Cooper River, changing the average Cooper River flow rate from 2 cubic meters per second (cms) or approximately 7 cubic feet per second (cfs) to 442 cms (1,560 cfs) (Kjerfve 1976). Prior to rediversion in 1985, water releases at Pinopolis Dam on the Cooper River were generally continuous. A weekly average flow of 122 cms (430 cfs) has been maintained in the Cooper River since rediversion to protect water supplies (Orlando et al. 1994), but generation time has been restricted to as little as 10 hours per day. Tidal freshwater marshes along the Cooper River (many of which are relic rice impoundments with breached or eroded dikes), which were used extensively as spawning habitat by Blueback Herring prior to rediversion of flows into the Santee River (Christie et al. 1981), are less extensive under reduced flows. Many are now partly dewatered or influenced by brackish water. Available fish passage and commercial fishery data indicate that the Herring population has declined dramatically since flows were rediverted, presumably because of a reduction in the amount, and perhaps quality, of spawning and nursery habitat (Cooke and Eversole 1994).

The original diversion of Santee River historical flows into the Cooper River caused average freshwater flow in the Santee River seaward of Wilson Dam to drop from 525 to 74 cms (1,850 to 260 cfs), and allowed saltwater intrusion (Kjerfve and Greer 1978). The Santee-Cooper Rediversion Project returned about 70% of the Cooper River flow to the Santee, increasing average flow to approximately 367 cms (1,290 cfs) and reducing salinity in the lower Santee (Orlando et al. 1994). However, there is no minimum flow requirement at St. Stephen Dam on the Rediversion Canal (D. Cooke, SCDNR, per. comm., 2005) and the average daily flow from Wilson Dam is only about 18 cms (63 cfs) (Orlando et al. 1994).

During periods of low inflow into the Santee-Cooper Lakes, water releases can be discontinued at St. Stephen Dam (D. Cooke, SCDNR, per. comm., 2005). In contrast, the average daily discharge from Wilson Dam can approximate 500 cms (1760 cfs) during flood-control releases (Orlando et al. 1994). The resulting flow regimens in both the Cooper and Santee Rivers is typically in highs and lows (with more abrupt changes from peaked power generation and flood releases) than are characteristic of more gradual river flow changes that occur in open rivers where waters expand into, and withdraw from, floodplains.

With the construction of the Santee-Cooper Lakes (Moultrie and Marion) in the 1940s, the vast majority of the Santee was closed to migratory fishes (USFWS 2001). Both the Pinopolis navigational lock and St. Stephen fish passage facility are currently used for alosine passage. Passageways at both facilities provide passage for Blueback Herring and American Shad (Timko et al. 2003). The efficiency of passage at St. Stephen Dam for Blueback Herring and American Shad is low (Cooke and Leach 2001;Post and Waldrop 2023).

Fish passage designs and flow protocols currently used at dams on the lower Santee-Cooper Basin were initially designed for passing Blueback Herring into the lakes for forage and do not maximize passage efficiency for alosines in either direction (Cooke and Leach 2001; D. Cooke, SCDNR, pers. comm. 2005). Dams on the Santee-Cooper Basin, that currently incorporate passage for alosines, do not employ methodologies that accommodate timely outmigration and maximized survival of post-spawning adults or emigrating juveniles. Delayed outmigration of juvenile alosines, as occurs in the Santee-Cooper Lakes, may result in increased mortality of juveniles from artificially high predation and from potential capture for bait since fish become concentrated near dams for an extended period of up to several months. In open rivers, juveniles gradually move seaward in groups that are likely spaced according to the spatial separation of spawning and nursery grounds (Limburg 1996; J.W. McCord, SCDNR, pers. obs.;Post and Waldrop 2023). Delayed outmigration not only concentrates juvenile alosines, but extends their stay in freshwater areas until moderating water temperatures of late spring and early summer induce more active feeding behavior for many freshwater piscivores. Delayed outmigration may also increase vulnerability of juveniles to marine predators that would otherwise be absent from coastal waters if juveniles were able to adhere to natural migration patterns. According to the ASMFC Interstate Fishery Management Plan (IFMP) and Amendment 1 to the IFMP, a fish passage program for alosines is only legitimate if downstream passage is an integral part of such operations (ASMFC 1985, 1999).

Dams, and in particular hydropower dams, often produce flow regimens that are not reflective of natural seasonal flows. Pulse flows used for peaking hydropower production can disrupt natural productivity and availability of zooplankton needed for larval and early juvenile forage (Crecco and Savoy 1987; Limburg 1996), can displace eggs and/or larvae from otherwise highly productive habitats, and can disrupt both upstream and downstream migration patterns for adult and juvenile alosines (ASMFC 1985; ASMFC 1999; Limburg 1996; USFWS 2001). Dams may also reduce minimum flows, potentially dewatering otherwise productive habitats, thus causing increased water temperature, or contributing to or exacerbating poor water quality such as reduced dissolved oxygen (ASMFC 1985; ASMFC 1999; NMFS 1998; USFWS 2001). Water releases from deep reservoirs may be poorly oxygenated and/or of below normal seasonal water temperature, thereby causing loss of suitable spawning or nursery habitat in otherwise suitable river reaches (ASMFC 1985; NMFS 1998; ASMFC 1999; USFWS 2001). Further, impounded marshlands in freshwater river reaches prevent access of Blueback Herring to potential spawning and early nursery habitat.

Large concentrations of Double-crested Cormorants (*Phalacrocorax auritus*) and White Pelicans (*Pelecanus erythrorhynchos*) occur immediately below some dams, particularly below those with fish passage and during the winter-spring season of alosine passage (J.W. McCord, SCDNR, pers. obs.; Post and Waldrop 2023). The cormorant population has increased dramatically over the past decade (Wires et al. 2001), and these birds have been shown to feed heavily on alosines (Johnson et al. 1999). Small alosines can comprise up to 64.5% of the cormorant's diet (Johnson et al. 2000). Although the impact of cormorant predation on alosine populations has not been quantified, it appears that cormorants have the potential to negatively impact both upstream passage success for Blueback Herring and out-of-lake passage for all juvenile alosines.

Competition and predation from non-native species, in particular Flathead Catfish (*Pylodictis olivaris*) and Blue Catfish (*Ictalurus furcatus*), may be additive to 'more natural' sources of mortality and may be particularly problematic below dams where catfish density is often high (J.W. McCord, SCDNR, pers. obs). Even adult American Shad have been observed in the diet of large flathead catfish (D. Allen, SCDNR, pers. comm.), and both non-native catfishes are presumed to be problematic to alosines as both competitors and predators (NMFS 1998).

Dredging can also negatively affect alosine populations by producing suspended sediments (Reine et al. 1998). Behaviorally, chronic turbidity from frequent or prolonged dredging can also affect fish migration, spawning, conspecific interactions, and foraging (Coen 1995). Migrating alosines are known to avoid waters of high sediment load (ASMFC 1985; Reine et al. 1998). Suspended sediments have been linked to a variety of lethal and sublethal responses in juvenile and adult fishes that are consistent with oxygen deprivation due to gill clogging (Sherk et al. 1975; Sherk et al. 1974). Filter-feeding fishes such as alosines are particularly susceptible to negative impacts of suspended sediments on gill tissues (Cronin et al. 1970). Siltation from dredging and from agricultural, silvicultural, and other land use practices can reduce spawning success by causing mortality of eggs or by coating substrates needed for attachment of adhesive eggs (NMFS 1998). Suspended sediments, whether caused by dredging or by erosion from land use practices, can also cause reduced feeding success in larval or juvenile fishes that rely on

visual cues for plankton feeding (Kortschal et al. 1991). Larval striped bass (Morone saxatilis) consumed 40 percent less prey when suspended solids exceeded 200 milligrams per liter (mg/L) (Breitburg 1988). Survival of larval alosines decreases as turbidity or suspended sediments increases above 50 mg/L (Auld and Schubel 1978).

Dredging may negatively impact prey availability by removing benthic invertebrates within sediments, by increasing suspended sediments, or by producing changes in salinity or dissolved oxygen regimens (ASMFC 1990). Sediment resuspension from dredging can cause increased turbidity and localized depletion of dissolved oxygen, as well as increased bioavailability of any contaminants that may be bound to these sediments (Clarke and Wilber 2000). The eggs and larvae of estuarine and coastal fishes appear to be among the most sensitive to suspended sediment exposures of all the taxa and life history stages for which data are available (Clarke and Wilber 2000). High concentrations of suspended sediments, as well as relatively low concentrations sustained for several days, have been shown to cause direct mortality, impaired hatching success, reduced larval feeding, and diminished larval growth in several species of estuarine and anadromous fishes (Clarke and Wilber 2000). Waters with high suspended sediment are unproductive for primary and secondary portions of the food pyramid on which juvenile alosines feed, and changes in salinity regimens can dramatically impact prey distribution (ASMFC 1990).

Pollution from point and non-point sources is a primary cause of reduced habitat quality and aquatic species viability in tidal systems. Land use practices such as agriculture and logging, as well as residential, commercial and industrial development, greatly influence the input of chemicals and nutrients into waterways and are the primary sources of increased siltation. All of these factors contribute to eutrophication and a general decline in water quality, including a reduction in dissolved oxygen as previously mentioned. Sediments and pesticides most commonly enter coastal waters in run-off from agricultural and silvicultural lands, and discharges into coastal habitats, thereby causing drastic adverse impacts on aquatic life (Butler 1968). In addition to sediments, run-off from uplands includes nitrates, phosphates, herbicides, pesticides, silt and other chemicals, any of which either acting alone or in combination with other pollutants can be lethal to aquatic life, and particularly to larval forms (Matthews et al. 1980). Chemicals and heavy metals from industrial and other sources that do not cause acute toxicity can be assimilated through the food-chain and can produce sub-lethal effects including behavioral and reproductive abnormalities (Matthews et al. 1980). Pollution from contaminants such as pesticides can directly produce mortality, can lower pH that may reduce egg and larval survival (Klauda 1994), and can contribute to reduced oxygen levels. All of the potential impacts of sediment resuspension and increased turbidity due to dredging (described in detail above) would also apply to sediments derived from upland sources.

Deforestation of swamps potentially leads initially to increased soil and water temperature (Aust and Lea 1991; Perison et al. 1993), siltation from increased erosion and runoff (Aust et al. 1997), decreased dissolved oxygen (DO) (Lockaby et al. 1997), and disturbance of food-web relationships in adjacent and downstream waterways (Batzer et al. 2005). Forestry BMPs for bottomland forests are voluntary. When BMPs are not used, braided streams may be obstructed

by plant material and disturbed soils while excessive ruts may channel eroded sediments into streams. Partially stagnated waters may become nutrient-rich and promote algal growth that can die under extended periods of cloud-cover (J.W. McCord, SCDNR, pers. obs.). Siltation from agricultural, silvicultural, and other land use practices can reduce spawning success by causing entrapment and mortality of semi-buoyant eggs (Mansueti 1961). Siltation also causes increased water temperature and reduced DO, and can result in reduced productivity beginning at lower levels of food-chain relationships on which juvenile alosines are dependent (Mansueti 1961).

Siltation, from erosion due to land use practices or from dredging, physically covers and kills some aquatic life, including submerged aquatic vegetation (SAV) and thereby increases biological oxygen demand (BOD). SAV provides important ecological functions in freshwater habitats. SAV improves water quality (Rybicki and Hammerschlag) and provides habitat for predator avoidance, foraging, and nursery development for many macro-invertebrates and resident and migratory fishes (Maldeis 1970; Killgore et al. 1989; Monk 1988). SAV can also provide important spawning habitat or substrate for Blueback Herring (Christie et al. 1981). SAV is adversely affected by suspended sediments less than 15 mg/L (Funderburk et al. 1991) and by deposition of excessive sediments (Valdes-Murtha and Price 1998).

Dewatering of freshwater streams from irrigation and other water removal projects decreases instream flows and decreases the quantity of both spawning and nursery habitat. Dewatering can also result in reduced water quality from the impacts of more concentrated pollutants and/or increased water temperature (ASMFC 1985). Density-dependent impacts such as predation and competition may also increase. Further, mortality of eggs, larvae, and/or juvenile alosines can occur due to impingement and entrainment in water intakes at water removal projects and in turbines in dams (ASMFC 1985).

By-catch from ‘non-game’ gill-nets may exert excessive mortality on Hickory Shad. Participants in this late winter fishery have reported that numerous Hickory Shad are caught in these nets (J.W. McCord, SCDNR, pers. obs.). Further, Hickory Shad are not generally segregated from American Shad in commercial catches nor are they easily differentiated in fish passage counts. These factors prevent the collection of reliable fishery-dependent and fishery-independent data collection as needed to properly manage Hickory Shad populations. Mortality from directed fisheries and/or from by-catch in other fisheries outside of the State’s jurisdiction may negatively impact South Carolina stocks of alosines, including fisheries within the Exclusive Economic Zone (that portion of the Atlantic Ocean under federal jurisdiction from 3 to 200 mi. offshore) and within Canadian waters (ASMFC 1985; ASMFC 1999).

CONSERVATION ACCOMPLISHMENTS

The first river-specific, restrictive, commercial gill-net fishery regulations (Act # 343 of the 1992 South Carolina General Assembly) were enacted in 1993 for the Edisto River after SCDNR studies indicated overfishing was a major contributor to a perceived trend of population decline (McCord and Ulrich 1991). In 2000, laws and regulations were revised to be more responsive to individual perceived population status by drainage basin or river system (Act #245 of the 2000 South Carolina General Assembly). The Coosawhatchie River shad population received the most

protection, as the river was closed to commercial gill-nets (Act #245 of the 2000 South Carolina General Assembly). The amount of potential gill-net fishery effort was substantially reduced for other small, more imperiled stocks, including those in the Combahee, Ashepoo and Ashley Rivers (Act #245 of the 2000 South Carolina General Assembly).

Coast wide IFMPs has been developed for the alosines under the auspices of the Atlantic States Marine Fisheries Commission (ASMFC 1998). The original ASMFC IFMP for Shad and River Herring was completed in 1985 and was amended in 1999. The 1999 Amendment 1 to the ASMFC IFMP required all member states to close directed fisheries for American Shad in coastal Atlantic Ocean waters by 2005 through a phase-out process initiated in 2000 (ASMFC 1999). Addenda to the IFMP were also approved in 2000 and 2002 (ASMFC 2000; ASMFC 2002). The Atlantic Coastal Fisheries Cooperative Management Act (ACFCMA) of 1993 requires states to adopt management guidelines as mandated by approved ASMFC IFMPs, including the conduct of surveys in selected South Carolina rivers and the monitoring of catch and effort for commercial and recreational fisheries for alosines (ASMFC 1999).

The ASMFC IFMP also required that by the year 2000, states were to limit recreational harvest through the establishment of a possession limit not to exceed an aggregate of 10 American and Hickory Shad per angler per day. Through legislative action, South Carolina established a 10-fish limit in 2000 for all State waters, except for the Santee River and Rediversion Canal, where a 20-fish limit was allowed under a conservation equivalency adjustment.

Additionally, as mentioned above, ASMFC required states' to develop and submit SFMPs for both American Shad and Blueback Herring. Implementation of these plans led to a 50% reduction of allowable fishing gear in all waters of the state and up to a 90% reduction for specific rivers. Legal fishing days during the season were also adjusted earlier to account for and reduce by-catch of sturgeon. This change led to a noticeable reduction in effort later in the season, when water temperatures rise and post release delayed mortality increases.

Passage at all types of dams and other barriers to migration is strongly recommended by the ASMFC IFMP. Many dams in South Carolina are currently, or soon will be, undergoing Federal Energy Regulatory Commission (ERC) re-licensing processes; these processes will include considerations for improved access and migration of aquatic species. Existing passage systems and Herring populations in the Santee River.

CONSERVATION RECCOMENDATIONS

- Conduct statewide surveys of alosine distribution and population size, particularly for small rivers where stock status is unknown or perceived as poor, in order to make prioritized decisions for restoration and passage.
- Determine passage and outmigration efficiency for all alosines at existing facilities so potential changes in protocols or designs can be identified.

- Inventory sources of mortality, including existing outlets providing outmigration through dams and bycatch in commercial fisheries; formulate remedies where practical.
- Improve quality and scope of coverage for mandatory catch and effort records, for both recreational and commercial fisheries.
- Determine how often Hickory Shad is misidentified as American Shad or Blueback Herring.
- Investigate impacts of logging in swamp forests on water quality and habitat, especially as related to Blueback Herring.
- Determine impacts of dewatering of freshwater streams on aquatic species.
- Conduct studies on the energetics and nutrient dynamics related to food-chain relationships and spawning migrations of alosines.
- Determine genetic relationships, or extent of homing, of alosines relative to tributary streams (particularly in the Waccamaw-Pee Dee Basin).
- Determine impacts of competition and predation from non-native species, particularly below dams where alosines passing through existing outmigration routes may become stunned or disoriented, exacerbating predation impacts. To the extent possible, control and prevent further distribution of non-native Blue and Flathead Catfish populations.
- Partner with federal authorities to create on-board observer programs to investigate by-catch of alosines by out-of-state jurisdictional fisheries.
- Partner with appropriate agencies to evaluate State water quality standards and Best Management Practices (BMP) that may impact wetlands to ensure that guidelines are stringent enough to protect alosine habitat.
- Determine impacts of pollution and siltation on life history stages of alosines.
- Determine biotic effects of alosine stocking in habitats where access was previously restricted or absent.
- Determine the relationships of alosines to freshwater mussels on the South Carolina Species of Concern list.
- Determine impacts of biotic and abiotic factors on egg, larval, and juvenile survival and development and how such factors relate to spawning stock recruitment.
- Survey non-gamefish winter gill-net fisheries to determine potential impacts on alosines, particularly on Hickory Shad.
- Determine potential impacts of double-crested cormorant predation on passage of adult Blueback Herring and on all juvenile alosines, particularly at St. Stephen Dam.
- Participate in FERC-relicensing evaluations and partner with appropriate agencies to ensure that cost-effective and efficient designs for providing both upstream and downstream passage of alosines are installed in dams blocking access to suitable spawning and nursery habitats.
- Partner with appropriate entities to improve access to a full diversity of habitats by including fish passage designs, or improving existing designs, at facilities not under FERC jurisdiction.

- Impediments to migration, such as nonfunctional dams, dikes, or causeways should be identified. Investigate the feasibility for these structures to ultimately be removed, breeched, or bypassed through partnerships with the appropriate authorities.
- Build partnerships with NGOs, permitting authorities, and county and local governments to improve and/or implement the use of BMPs in agriculture, silviculture, and urban development activities to reduce siltation and contamination.
- Partner with the appropriate agencies to determine water removal guidelines for agricultural, civil, or industrial purposes that include considerations for migratory fishes.
- Partner with appropriate entities to limit deforestation of river floodplains and swamp forests.
- Partner with appropriate permitting authorities to design dredging protocols that consider the timing of alosine migration.
- Partner with other coastal states to promote protection of the alosines in the Exclusive Economic Zone (EEZ) and in Canadian coastal waters.
- Form an alliance with other state and federal agencies as well as NGOs to implement range-wide conservation and management of alosines as described in the ASMFC IFMP.
- Build partnerships with natural resource agencies in Georgia and North Carolina to manage alosine populations that transcend individual state jurisdictions, specifically populations in the Savannah River and Waccamaw-Pee Dee Basin, respectively.
- Partner with NGOs and other state and/or federal agencies to promote changes in water release protocols for dams that will restore or approximate natural flow regimens and increase minimum flows.
- Partner with appropriate agencies and NGOs to develop or revise river basin plans to identify habitat areas of particular concern (HAPCs), to identify degraded or threatened habitats, and to identify preventative or mitigation actions.
- Partner with appropriate agencies to designate critical coastal areas.
- Develop Memoranda of Understanding (MOUs) with other state agencies for joint review of projects and planning activities to ensure that habitats, particularly HAPCs, are sufficiently protected.
- Develop education and outreach programs that distribute information to governments, civic groups, educational systems and NGOs about critical habitat needs, threats, and potential conservation actions related to alosines.

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American Eel
Anguilla rostrata

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DESCRIPTION

Taxonomy and Basic Description

The American eel, *Anguilla rostrata* (Lesueur 1817), belongs to the freshwater eel family, Anguillidae. Related species occur throughout the world, but the American eel is the only North American anguillid eel. Eels are snake-shaped and covered with a mucous layer that renders them slimy to the touch despite the presence of minute scales. A continuous, low fin runs from the middle of the back, around the tail, and ends behind the vent. Relatively small pectoral fins originate near the midline and immediately posterior to the head and gill-covers. Coloration varies with stage of maturity and habitat, but eels are generally dark olive, yellowish, or slate-gray above and light below. Eels from dark, tannic acid streams are darker while those from clear streams and estuaries are lighter (J. W. McCord, pers. obs.).

The American eel is catadromous; it spawns in oceanic waters but uses freshwater, brackish, and estuarine systems for most of its developmental life. Sexually mature adults, called silver eels, migrate from freshwater to the sea in fall. Their destination for spawning is the Sargasso Sea, an expansive portion of the central North Atlantic Ocean, east of the Bahamas and south of Bermuda. Adults are thought to die after spawning. The largest females produce nearly 20 million eggs (Barbin and McCleave 1997). Mature females in the southern portion of the eel's range are generally smaller and carry as few as 400,000 eggs (Wenner and Musick 1974). Eggs hatch into a brief pre-larval stage before transformation into the active leptocephalus stage.

Leptocephali primarily drift with ocean currents for about a year before metamorphosing into the glass eel stage (Sheldon 1974). Glass eels are shaped like adults, but are transparent and smaller, reaching lengths of 5 to 7 cm (2 to 3 in.) (Hardy 1978). Glass eels actively migrate across the

continental shelf and move into estuaries and tidal river reaches in late winter and early spring, apparently by detecting temperature gradients and the scents associated with freshwater (Facey and Van Den Avyle 1987). Glass eels feed little or not at all, but within weeks of entering estuaries and tidal rivers, the small eels begin to feed and become pigmented, at which time they are called elvers and resemble miniature adults in coloration and other physical features.

While some elvers move far into inland habitats, others remain in brackish and estuarine areas. Both glass eels and elvers migrate primarily at night and are able to move beyond obstacles that prevent passage of most aquatic species. Small eels can climb vertical walls, including low dams, as long as surfaces are damp and textured.

The final inland resident stage is called the yellow eel and includes all eels greater than 10 cm (4 in.). Yellow eels may gradually move upstream over many years, with most movement occurring during spring and fall when water temperatures are moderate. However, larger yellow eels may settle in specific areas and have been found to occupy distinct home ranges (Gunning and Shoop 1962). Adult females are larger than males and may grow to lengths of nearly 1.0 m (40 in.), but most adults are 0.6 m (24 in.) or less. Maturation occurs from 3 to 24 years of age (ASMFC 2000), with males generally maturing at a younger age and remaining smaller in size than females. Eels as old as age 15 have been recorded in South Carolina (SCDNR SWG 2020).

American eels are opportunistic carnivores, feeding on a vast array of animal life, depending on the size of the eel and the availability of prey within a given habitat. Larger eels feed primarily on small fishes and benthic invertebrates, including crustaceans, aquatic insects, worms, and mollusks. Elvers and small yellow eels feed primarily on aquatic insects, small crustaceans and worms. Elvers collected from the Cooper River consumed mostly midge larvae, cladocerans (zooplankton), amphipods (small crustaceans) and fish parts (McCord 1977). Adults taken from the same study area fed primarily on fish parts, elvers (eels can be highly cannibalistic), and terrestrial isopods (McCord 1977). In estuaries, eels often feed on blue crab (*Callinectes sapidus*) and polychaete worms (Wenner and Musick 1975). Both blue crab and horseshoe crab (*Limulus polyphemus*) are used as bait in trap fisheries for American eel in the Chesapeake Bay and elsewhere.

Elvers are not only preyed upon by larger eels but are also eaten by many fishes, both game and non-game species. Small yellow eels up to 46 cm (18 in.) in length are used as bait for striped bass and cobia. Eels are also consumed by other predatory fishes such as Largemouth Bass (*Micropterus salmoides*) and Bowfin (*Amia calva*) (J. W. McCord, pers. obs.) and are likely preyed upon by opportunistic predatory fish like non-native Flathead Catfish (*Pylodictis olivaris*). American eels are also included in the diets of fish-eating birds and mammals, such as mink (*Mustela vison*) (Sinha and Jones 1967, Seymour 1974). American eels are a valuable part of the many ecosystems they inhabit during various growth stages. Dams and other impediments to migration have eliminated the American eel from many historical habitats in South Carolina (USFWS 2001). The effects of the loss of American eels from aquatic food webs, though not quantified, may be substantial (Freeman et al. 2003).

Status

At a population level, American eels have been on the International Union for the Conservation of Nature's (IUCN) red list since 2014, meaning they are considered globally endangered. The IUCN cited decreased US stocks along with increased commercial fishing on eels in the US, so in 2015 the US Fish and Wildlife Service evaluated the species and announced that despite their historically depleted status, the US American eel stock is stable and does not need protection under the Endangered Species Act. The global status was reassessed by the IUCN in 2017 and again in 2020, with all published results retaining their endangered status. The classification within the red listing is "A2bd" which indicates endangered status based upon "past observations of population decline", and the most recent assessment indicates that the global population trend is still "stable" (Pike et al. 2023).

American eels are managed by the Atlantic States Marine Fisheries Commission (ASMFC) along the Atlantic coast from Maine to Florida. The American eel interstate fishery management plan (IFMP) was implemented in 2000, and has since been modified through seven addenda. The goal of the IFMP is to conserve and protect the American eel resource to ensure ecological stability while providing for sustainable fisheries. Each state is responsible for implementing management measures within its jurisdiction to ensure the sustainability of the American eel population that resides within state boundaries (ASMFC 2023).

Critical to our concerns for the American eel population in the state of South Carolina are the findings of the 2017 assessment report (ASMFC 2017). The only young of the year (YOY) index from South Carolina, a YOY index based on fyke net catches in Goose Creek Reservoir, suggested a significant downward trend in relative abundance (ASMFC 2017). Similarly, the only index of the yellow eel life stage in South Carolina – a statewide upper estuary electrofishing survey – suggested a downward trend in the abundance of yellow eels across the state (Fig. 1 & 2; ASMFC 2017). When combined with other relative abundance data from Florida, Georgia, and North Carolina, there was a clear decline in YOY and yellow eel stage American eels across the four states since 2001 (ASMFC 2017). These results suggested at the meta-population scale, there is even greater concern for the status of American eel in the state of South Carolina and an increasing probability the population is approaching imperiled status.

The most recent stock assessment was an ASMFC benchmark conducted in 2023. The assessment was evaluated and endorsed by an independent panel of scientific experts through the ASMFC external peer review process. The 2023 assessment is the latest and best information available on the status of the coastwide American eel. The 2023 assessment concludes that the stock is depleted, meaning it is at or near historically low levels due to a combination of historical overfishing, habitat loss, food web alterations, predation, turbine mortality, environmental changes, toxins and contaminants, and disease. Based on trend analyses, the stock was also considered depleted in the 2012 and 2017 assessments. The 2023 stock assessment found that the yellow eel population was at lower levels than the previous assessment, and yellow eel harvest should be decreased (Fig. 3; ASMFC 2023).

POPULATION SIZE AND DISTRIBUTION

One genetically similar population of eels is thought to occur along the Atlantic Coast (Williams and Koehn 1984). However, eels become resident as sub-populations in drainage basins throughout the range of the species until they become sexually mature. Accordingly, many sub-populations by drainage basin and region collectively comprise the North American population. The complex life cycle contributes to the difficulty in determining the population status of this species. Furthermore, the American eel has been poorly studied through much of its range. Historical data are scant for most areas of the Atlantic coast; no such information exists for South Carolina. Long-term data sets collected in the northeastern United States and southeastern Canada indicate declines in both recruitment of juveniles and in adult populations (ASMFC 2000). Directed fisheries for silver eels have shown precipitous declines in catch per unit of effort (ASMFC 2000). Long-term data for elvers at Conowingo Dam fish lift on the Susquehanna River, Maryland indicate a declining trend from 1974 through 1996 (ASMFC 2000). Eel migration data from 1984 to 1995 indicates significant negative trends for yellow and/or silver eels in Ontario, Quebec, New York, and Virginia (Richkus and Whalen 2000). Since there is likely a single genetic stock throughout the range, sub-population declines in any region or drainage basin can impact the entire population. The largest declines have been indicated over the past two decades. Dramatic declines in the northern portion of the American eel's range are important since sub-populations in this region carry the highest reproductive potential (Casselman 2003).

The American eel occurs along the Atlantic coast from Canada to Central and South America. Within South Carolina, eels occur from estuaries to the headwaters of coastal streams and at least as far inland as the Fall Line in longer river basins, including the Savannah, Santee and Pee Dee. Although the American eel is capable of traversing obstacles that may completely restrict dispersal of other fishes, both eel distribution and population size may be limited by dams and other impediments to migration. Historical records show that American eels occur in the Santee basin well inland of the fall line and into North Carolina (USFWS 2001). Similar historical distributions occurred for the Waccamaw-Pee Dee Basin and are likely to be present in the Savannah River Basin.

American eel populations within the Santee-Cooper River watershed inland of Pinopolis, St. Stephen, and Wilson Dams are likely well below numbers present prior to impoundment of the Santee-Cooper lakes in the 1940s. Observations from St. Stephen Dam and a eel ramp below the Goose Creek Reservoir indicate rather poor passage success for the American eel (Post and Waldrop 2023). Fish passage at Pinopolis Dam on the Cooper River is provided by navigational lock. Such passage systems are not considered to be particularly effective for American eels because of great fluctuations in water flow that occur during lock operations (Lary and Busch 1997). Dams on the Savannah and Waccamaw-Pee Dee drainages are well inland and probably do not significantly restrict eel distribution.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The American eel is widely distributed in many aquatic habitats including estuarine, brackish and freshwater tidal channels; tidal creeks; coastal impoundments; ponds; lakes; and nearly all accessible freshwater habitats associated within river basins as far inland as the Fall Line and beyond. Males are generally restricted to estuarine and brackish habitats while females are more often found in freshwaters. Among freshwater habitats, eels seem to be most abundant in streams, but occupy all habitats having sufficient food resources and well-oxygenated water. A high density of yellow eels has been observed in the upper South Edisto River, where single channels branch into a braided or intertwined network of small creeks within swamp forest. Yellow eels are also present in high densities in the middle Savannah River in relatively shallow, non-navigable reaches characterized by riffles and pools with rocks and submerged aquatic vegetation (J. W. McCord, pers. obs.). American eels are dependent upon access to such diverse habitats for growth and maturation, as well as free downstream passage for spawning migration. Sexually mature adults are dependent upon the vast expanses of the North Atlantic Ocean and the Sargasso Sea.

CHALLENGES

Because of its complicated life cycle, the American eel population faces a broad range of challenges, some of which are specific to a particular growth stage. Since males and females largely utilize separate habitats, impacts in a given region may affect the sex ratio of the eel population. Dams and causeways obstruct access to a diversity of habitats, which may limit basin-specific and statewide populations. The Pee Dee, Edisto, and Santee coastal drainages have suffered an 83% reduction in unobstructed stream habitat (Busch et al. 1998). Impingement (entrapment in) and entrainment (being carried through) water intakes and turbines are sources of mortality on seaward-migrating eels.

The American eel is sensitive to low dissolved oxygen levels (Hill 1969, Sheldon 1974) in water typically found below dams. Logging in swamp forests may also cause lowered dissolved oxygen by increasing siltation and water temperature. Contaminants such as heavy metals, dioxin, chlordane and polychlorinated biphenyls (PCBs) can bioaccumulate and cause acute toxicity or reduced productivity (Hodson et al. 1994).

Dredging can result in many negative effects to American eels. Physical injury or mortality may result from entrainment of seaward-migrating adults. Increased turbidity or suspended sediments may negatively affect migration of adults, glass eels and elvers. Dredging may also cause changes in salinity regimens that could impact eel distribution and prey availability.
Spawning habitat may be adversely affected due to seaweed (*Sargassum* sp.) harvest in the Sargasso Sea. Spawning habitat and success is also likely to be affected by pollution like oil spills.

Dewatering freshwater streams for irrigation and other water removal projects decreases habitat availability for American eels and exacerbates any existing areas of poor water quality.

Nonpoint source runoff from residential areas, roads, and golf courses can have a negative impact on floodplain ecosystems and impact water quality. Potential overfishing or excessive harvest of juveniles (glass eels and elvers) could negatively impact localized populations. Competition and predation from non-native species, particularly Flathead Catfish (*Pylodictis olivaris*) and Blue Catfish (*Ictalurus furcatus*), is also a problem for American eels. Both of these catfish are piscivorous and opportunistic; they will feed on any fish that can fit in their mouths. Because both species are found in habitats frequented by elvers (J. W. McCord, pers. obs.), predation on eels by these catfish is a concern. Additionally, non-indigenous pathogens or parasites such as the Asian swimbladder nematode (*Anguillicola crassus*), has been shown to have significant negative impacts on the European Eel (*Anguilla anguilla*) and on captive American eels in South Carolina and Texas (ASMFC 2000).

Changes in oceanographic conditions may alter oceanic currents, thereby potentially altering larval transport and recruitment of juveniles across the continental shelf. The cause of these changes is unknown, but global warming may play a part (ASMFC 2000).

CONSERVATION ACCOMPLISHMENTS

An interstate fisheries management plan (IFMP) has been developed for the American eel under the auspices of the ASMFC. The original IFMP for the American eel was completed in 2000 and include five Addenda with another in process. The plan and all Addenda are available at https://asmfc.org/species/american-eel and were established as a framework of recommendations for protecting or enhancing eel sub-populations by state and region.

The IFMP and Addenda require states to control and limit directed effort in both bait and commercial eel fisheries in South Carolina. Beginning in 2001, states were required to collect and monitor catch and effort statistics for American eel commercial fisheries and to limit effort at levels achieved in 2000. As a result, SCDNR capped participation at 10 license holders and capped gear use as well. The permitting system that emerged from the IFMP mandate has greatly enhanced SCDNR’s ability to initiate proactive controls over American eel fisheries. In addition, the plan requires states to limit recreational harvest through the establishment of several regulations: the possession limit is not to exceed 25 eels; the minimum size limit is 15 cm (6 in.); and sale of American eels is prohibited without a license.

SCDNR and Duke Energy partnered to study American eel movement and growth throughout the Santee Basin beginning in 2009. Other partners include SCANA, NWRC, and USFWS. Analysis of annual glass eel migrations in Goose Creek, elver use of the St. Stephen eel ramps, and eel occurrence at a trap in the Wateree Dam provided incentive to gather more detailed data on eel movement rates. As part of this effort, 7,469 eels have been marked.

The question was whether eels passing St. Stephen in April make it through the Santee-Cooper lakes and arrive at the Wateree Dam in the subsequent month of May, or does it take longer periods. The only real way to verify movement speed was to implant uniquely colored elastomer tags under the skin of elvers at St.Stephen, release them upstream into Lake Moultrie, and look for their arrival at the Wateree Dam. Elvers marked with yellow (2010), blue (2011), orange (2012), and white (2013) elastomer tags have been released annually into Lake Moultrie. For

example, in April and June of 2012, SCDNR, along with the USFWS, Duke Energy, and others, tagged 3,377 elvers (young eels) with orange elastomer.

On May 24, 2013, the first tag from the elastomer tagging effort was recovered at the Wateree Hydro eel trap. The elver was 132 mm (5.2 in.). Notes indicate the average length of these 2012 eels was 93 mm (3.7 in.) at tagging so that's almost 40 mm (1.2 in.) of growth. A second orange VIE tagged eel was caught on June 6, 2013 that measured 175 mm (6.9 in.) in length.

Many dams in South Carolina are currently, or are soon to be, undergoing Federal Energy Regulatory Commission (FERC) re-licensing, which includes considerations for improved access by and migration of aquatic species. Therefore, increasing opportunities for passage are possible in the future. After almost 30 years, Santee Cooper received their long-awaited license in 2023. Requirements in the 40-year license include eel monitoring and construction of passage facilities at both the Pinopolis and Santee Dams. Duke Energy also received their license for the Yadkin Pee Dee in 2015. As part of requirements in this license, a eel ladder was installed at Blewett Falls Dam and begun passing fish in 2022. Lastly, Duke Energy received a license for the Catawba Wateree System in 2015. Requirements in this license continued monitoring of an already constructed eel ladder at the Wateree Dam in Lugoff, SC.

Prior to the 2023 ASMFC benchmark stock assessment, a South Carolina State Wildlife Grant (SC-T-F18AF00965) was obtained to improve understanding of American eel populations in the state (SCDNR SWG 2020). The research recommendations put forth by the previous 2017 stock assessment were the driving force in securing this grant. The overall goal was to leverage an existing collection of histological and otolith samples to address critical data gaps identified in 2017. Eel datasets were used to assess life history parameters such as age structure, sex ratio, size-at-maturity, and age-at-maturity of American eels in South Carolina. Other objectives included the evaluation of infection by the swimbladder nematode *Anguillicola crassus*, as well as a comparison of otolith processing methods to assess the precision of age determinations for eels. This last objective was pursued as the outcome of an in-person workshop hosted by SCDNR and conducted by the ASMFC in 2018 including representatives from 11 Atlantic and Gulf coast states, 4 of which regularly age American eel. Analysis of the two predominant aging methods (whole otoliths versus thin sectioned otoliths) showed that the methods were not statistically comparable to each other, and that South Carolina’s method of thin sectioned otolith aging produced less biased and more precise data. Recommendations were then made at the federal level for all states to use the thin sectioned method for aging American eel in the future.

As mentioned previously, following the acceptance of the 2023 stock assessment, there were 2 addenda proposed to the IFMP; one to modify the coastwide yellow eel harvest cap, and the other to address the quota for Maine’s glass eel fishery. Both these addenda were approved, which represents a significant effort to help the rangewide depleted stock status of American eels.

CONSERVATION RECOMMENDATIONS

- Conduct statewide eel distribution and population surveys to make prioritized decisions for restoration and passage.
- Inventory sources of American eel mortality and formulate remedies where practical.
- Determine contaminant levels in eel tissues and relate those to mortality and reproductive success.
- Investigate impacts of logging in swamp forests on water quality and habitat. Work with municipalities and landowners to direct forestry activities away from floodplain areas.
- Determine impacts to American eel populations of dewatering freshwater streams.
- Determine size, sex, and age structures for each sub-population of American eels.
- Determine potential presence and distribution of the Asian swimbladder nematode (*Anguillicola crassus*).
- Determine potential impacts to American eels from competition and predation by non-native species and, to the extent possible, control and prevent further distribution of non-native blue and flathead catfish populations.
- Determine the scope and impact of American eel harvest on sub-populations, and revise South Carolina eel regulations to limit harvest of any eel life stage or sub-population.
- Conduct genetics studies to document sub-populations by region or river basin.
- Investigate opportunities to provide passage at dams and other obstructions that are not under FERC authority, and to develop more cost-effective and efficient techniques for providing both upstream and downstream passage of American eels at migration barriers. Partner with NMFS, USFWS, United States Army Corps of Engineers (USACE) and non-governmental organizations (NGOs) to promote the inclusion of fish passage designs, wherever prescribed, that can successfully provide two-way passage of American eels.
- Build partnerships with NGOs, permitting authorities and county and local governments to improve and implement the use of Best Management Practices (BMPs) in agriculture and urban development activities to reduce siltation and contaminant input.
- Partner with the Department of Health and Environmental Control to develop or improve water removal guidelines for agricultural, civil, or industrial purposes that protect American eels.
- Work with the USACE to identify dredging protocols that consider the timing of eel migration.
- Form an alliance with other state and federal agencies as well as NGOs to implement range-wide conservation and management of the American eel as described in the ASMFC IFMP.
- Partner with the South Atlantic Fishery Management Council (SAFMC) to promote implementation of the Fishery Management Plan for Pelagic Sargassum Habitat of the South Atlantic Region.
- Promote changes in water release protocols for dams that will restore or approximate natural flow regimens and increase minimum flows.
- Institute permitting protocols for aquaculture and pet fish industries that require certification of the absence of diseases and parasites for all *Anguilla* species.
- Participate in interstate research examining the effects of oceanic changes on distribution of larval American eel and how these changes may be related to global warming.

Figures:

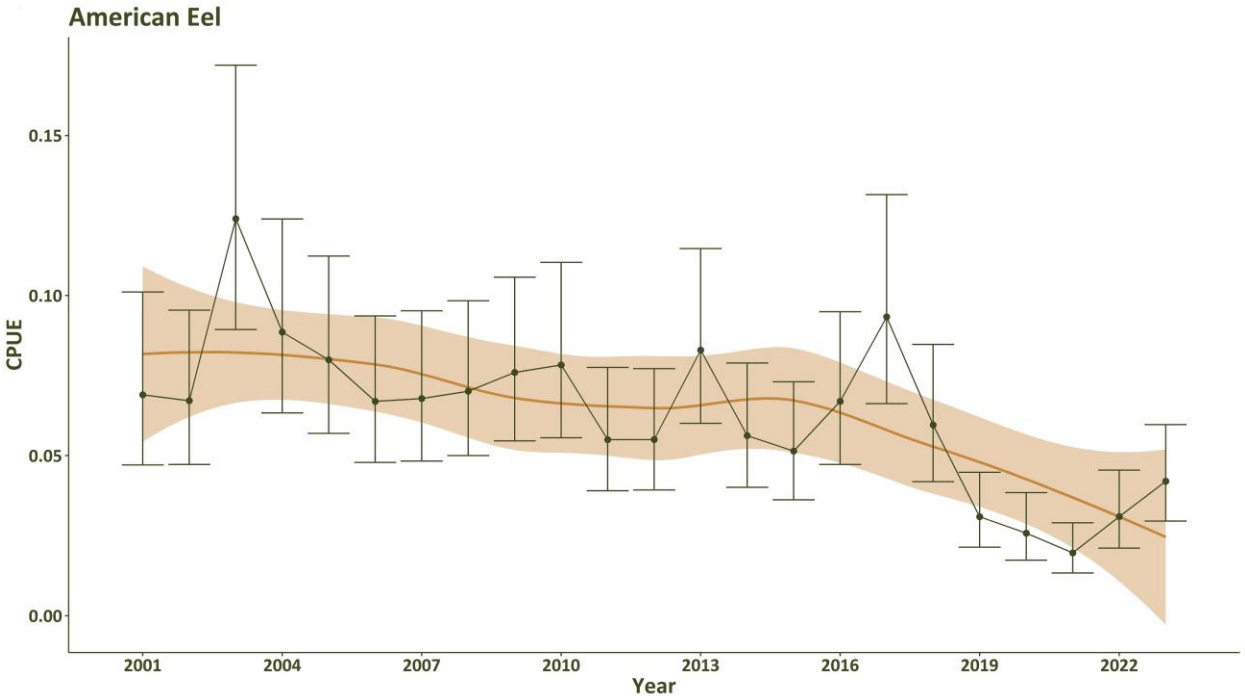


Figure 1: American Eel Smoothed Annual CPUE from SCDNR Electrofishing Survey (2001-2023)

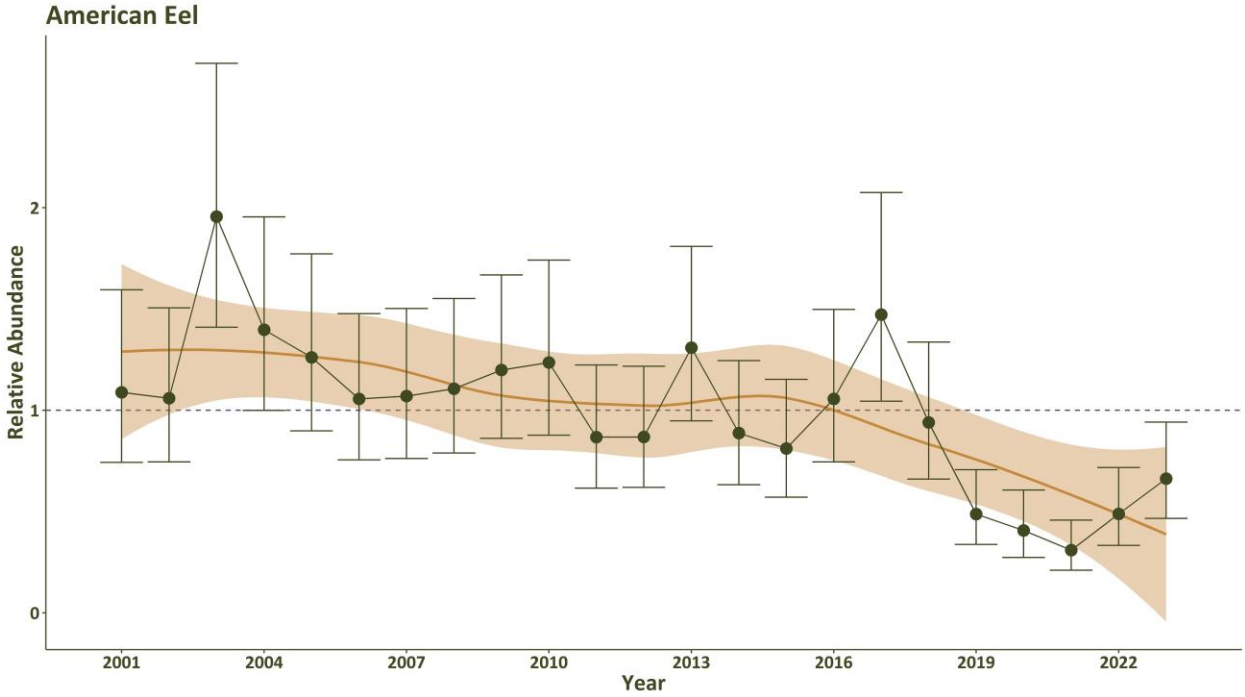


Figure 2: American Eel Smoothed Annual Relative Abundance from SCDNR Electrofishing Survey (2001-2023)

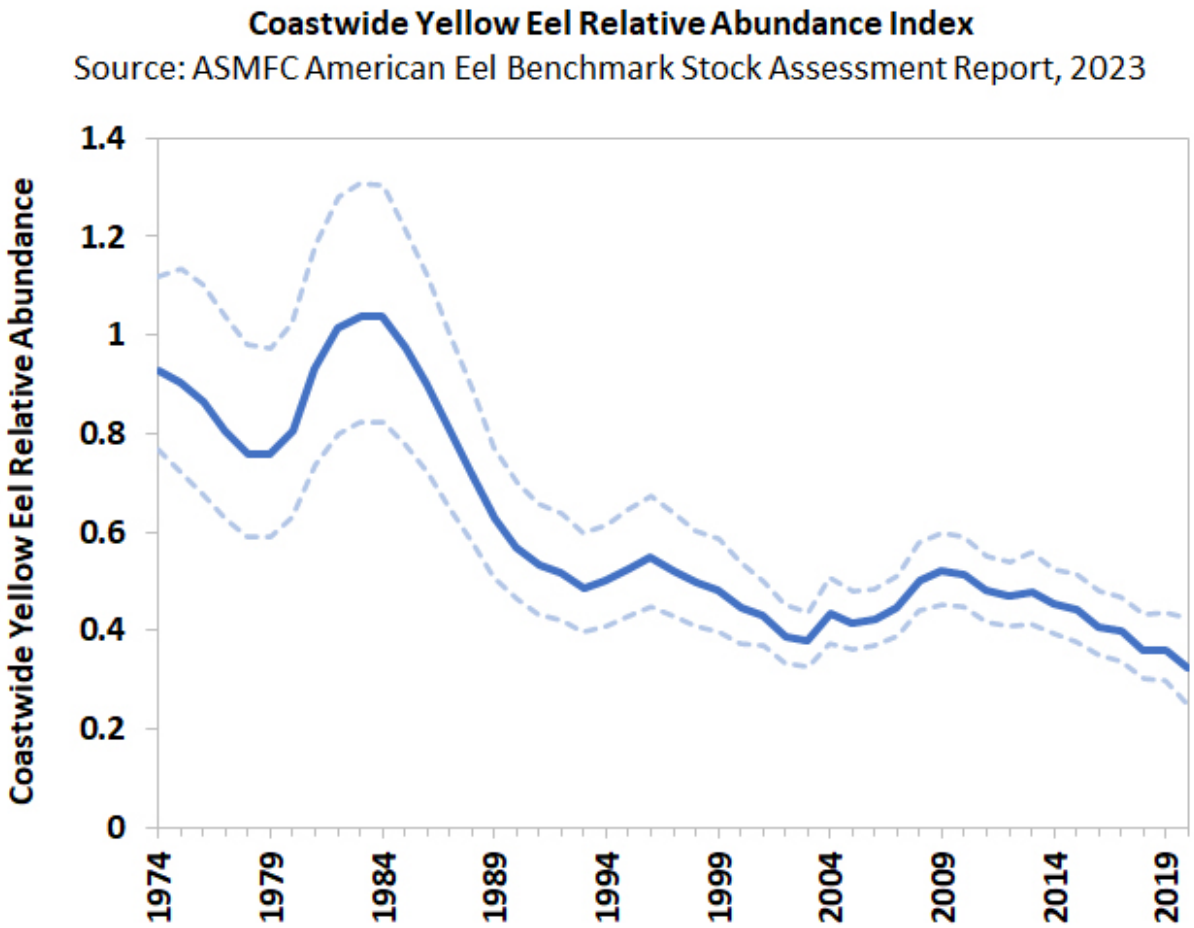


Figure 3: ASMFC Coastwide Yellow Eel Relative Abundance Index (1974-2020)

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Sturgeons Guild

Atlantic Sturgeon *Acipenser oxyrinchus oxyrinchus*
Shortnose Sturgeon *Acipenser brevirostrum*

Contributors 2005: John W. McCord (SCDNR)
Revised 2015: Bill Post, Chad Holbrook, Corbett Norwood, and Elizabeth Miller (SCDNR)
Revised 2025: Ellen Waldrop, Bill Post (SCDNR)

DESCRIPTION

Taxonomy and Basic Description



The Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus* (Mitchell 1815) belongs to the sturgeon family, Acipenseridae. Atlantic sturgeon are among the longest-lived fish, with a life span approaching 50 years or greater in the northern part of their range and 35 to 40 years in the southern part of their range. Sexual maturity is not obtained until 8 to 20 years old, with males maturing younger than females (ASMFC 1990; ASMFC 1998). The Atlantic sturgeon is also the largest fish inhabiting freshwaters on the Atlantic Coast, with females in South Carolina reaching about 2.5 m (8 feet) Total Length (TL). There is little sexual dimorphism, although females reach a larger size than males. Sexually mature female Atlantic sturgeon, often called "cows," may weigh several hundred kilograms or pounds. Mature male Atlantic sturgeons, or "bucks," are generally smaller than females, rarely exceeding 1.8 m (6 feet) TL and 45 kg (100 pounds).

Atlantic sturgeon, like other sturgeon, are shaped like sharks and have a deeply forked tail in which the upper lobe is longer than the lower. A single, small dorsal fin is located far back toward the tail and a single anal fin is directly beneath the underside. Paired pectoral and pelvic fins originate immediately rear of the bony operculum and vent, respectively. The head extends forward into a snout that is pointed in juveniles and blunt and rounded in adults. The ventral protrusible mouth is at the rear of the snout and is preceded by a row of four barbels similar to catfishes. The mouth, the width of which is about one half the distance between the eyes, does not bear teeth, but bony plates in the throat are used to crush food items if necessary (Vladykov and Greeley 1963; Gilbert 1989). The skeleton is partly cartilaginous, with the skull and leading edges of the pectoral fins among the boniest structures. Structural support and protection are provided by thick, tough skin with five rows of bony plates or scutes. Dermal ossifications are well developed on the skin between the dorsal and lateral row while the rest of the body surface appears naked but has patches of smaller denticles (Vladykov and Greeley 1963). The skin is generally rough, and gritty, not unlike that of a shark. Coloration is dark bronze to brownish above, lighter on the sides and white below (Gilbert 1989).



The shortnose sturgeon, *Acipenser brevirostrum* (Lesueur 1818) is also classified in the Acipenseridae family. Adults are much smaller than adult Atlantic sturgeon, with "cows" reaching 1.2 m (47 inches) TL and reaching a maximum weight of perhaps 18 kg (40 pounds). Mature "bucks" are generally smaller than females, rarely exceeding 0.8 m (32 inches) TL and 7 kg (15 pounds). The shortnose sturgeon is similar in shape and physical characteristics to the Atlantic sturgeon. The snout is pointed only in young juveniles, and is broad, blunt and rounded in adults. The ventral protrusible mouth is nearly as wide (70%) as is the distance between the eyes, and wider than for Atlantic sturgeon of similar size (Gilbert 1989).The body is also protected by five rows of scutes, but compared to those of Atlantic sturgeon, the bony plates collectively cover less surface area and denticles are small and sparse. The skin, though thick and tough, is less rigid than that of Atlantic sturgeon and is much smoother and often slimy or mucous-covered (J.W. McCord, SCDNR, pers. obs.). Coloration is generally brownish above with pinkish or salmon tones, lighter on the sides, and white below. Because of this coloration, commercial fishers often refer to this species as "salmon sturgeon." Shortnose sturgeon are also long-lived fish, reaching age 67 in the northern part of their range (e.g., Canada, Dadswell 1979), while southern populations likely have shorter lifespans. Shortnose sturgeon reach sexual maturity at an earlier age than Atlantic sturgeon and in southern rivers males may mature as soon as 2 years old and females at 6 years old (Dadswell et al. 1984).

As indicated by the ventral mouth, both species of sturgeon are benthic feeders that primarily prey on invertebrates. Aquatic insects such as mayfly and midge larvae and small crustaceans predominate the juvenile shortnose sturgeon diets (Dadswell et al. 1984; Carlson and Simpson 1987), whereas mayfly larvae, amphipods and earthworms are most frequently consumed by juvenile Atlantic sturgeon. Adults of both species consume mollusks, snails and amphipods (Van Den Avyle 1984; Dadswell et al. 1984; Haley 1998). Amphipods are particularly abundant in the lower Edisto River near the fresh-brackish interface (J.W. McCord, SCDNR, pers. obs.); preliminary evidence indicates amphipods and polychaetes as prevalent dietary items for sturgeons in similar habitat in the Savannah River (B. Post, SCDNR, pers. comm., 2005).

Status

Both the Atlantic and shortnose sturgeons are identified with rankings of G3 and S3 (NatureServe 2005), meaning that populations for both species are "vulnerable," both globally and in South Carolina. In general, populations of both species of sturgeon along the entire Atlantic Coast are reduced from historical levels for at least the past half-century (ASMFC 1990; ASMFC 1998; NMFS 1998). The Atlantic sturgeon was considered for listing under the Endangered Species Act (ESA) in 1998, but the National Marine Fisheries Service (NMFS) determined that listing was unwarranted. On October 6, 2009, NMFS received a petition from the Natural Resources Defense Council to list Atlantic sturgeon throughout its range as endangered under the Endangered Species Act. In January 2010, NMFS announced the petition had merit and it would formally consider whether to list the species under the Endangered

Species Act. In October 2010, NMFS proposed listing the species and sought public comment. NMFS received comments from 119 individuals or agencies, which were submitted in writing or during the six public meetings. In 2012, NMFS listed the New York Bight, Chesapeake Bay, Carolina, and South Atlantic distinct population segments of Atlantic sturgeon as endangered, while the Gulf of Maine population was listed as threatened. The ESA listing provides tools for greater protection and prohibits unauthorized "take" of the species. Additionally, it has been illegal to fish for, catch, or keep Atlantic sturgeon in South Carolina since the 1985 state moratorium. Furthermore, in 1998 the Atlantic States Marine Fisheries Commission implemented a long-term coast wide moratorium on all U.S. Atlantic sturgeon fisheries (Collins et al. 2000). However, the gulf sturgeon (*Acipenser oxyrinchus desotoi*), a subspecies of the Atlantic sturgeon restricted to rivers and adjacent waters of the Gulf of Mexico, remains on the candidate list and is currently listed as "threatened" under the ESA. The shortnose sturgeon has been listed as "endangered" under the ESA since 1967.

POPULATION DISTRIBUTION AND SIZE

Atlantic sturgeon historically ranged along the Atlantic coast from Labrador, Canada to the St. Lucie River, Florida (ASMFC 1990). The historical range of the shortnose sturgeon is very similar, from the St. John River, Canada to the St. Johns River, Florida (Vladykov and Greeley 1963). Currently, both species are thought to be either very rare or extirpated from the extreme southern portion of their ranges.

In South Carolina, Atlantic sturgeon and shortnose sturgeon both occur as relatively distinct populations by river system, as typical for anadromous fishes (Wirgin et al. 2000; Quattro et al. 2002). There are a minimum of four populations (presumably for both species) in South Carolina: the Pee Dee, Santee, Edisto, and Savannah River drainage basins. A dam locked population of shortnose sturgeon exists in the Santee Cooper Lake System (Collins et al. 2003). Since historical data relative to individual stock status are absent and current information is incomplete, the status of all stocks is still not well understood.

In general, shortnose sturgeon stocks are more genetically isolated and dissimilar than are Atlantic sturgeon stocks, presumably because shortnose sturgeon are freshwater amphidromous, (Kynard 1997; NMFS 1998; Wirgin et al. 2009) while Atlantic sturgeon are truly anadromous and different stocks regularly intermingle (Quattro et al. 2002; Kazyak et al. 2021; White et al. 2021a).

Historical data that relate directly to population size for South Carolina stocks are nonexistent, but historical distribution records and anecdotal information on abundance strongly indicate that all populations of sturgeons in South Carolina are reduced from early 20th century and previous levels (USFWS 2001). The current status and trends in stock status over the past 35 years for both sturgeons in South Carolina are based primarily on anecdotal information and short-term datasets. Collectively, stock status of Atlantic sturgeon throughout the state was considered in decline based on trends of commercial landings in the early 1980s (Smith et al. 1984).

Pee Dee Basin: The Pee Dee basin extends from the North Carolina border southeast to the Atlantic Ocean. It covers approximately 7,860 square miles and is the largest basin in the State. The main stem of the Great Pee Dee River is the dominant hydrologic feature of the basin. Major tributary streams include the Lynches, Little Pee Dee, Black, Sampit, and Waccamaw Rivers. The Lynches and Little Pee Dee Rivers drain into the Great Pee Dee River, while the Black, Sampit, Waccamaw, and Great Pee Dee Rivers drain into Winyah Bay (SCDNR 2013). Historically, South Carolina hosted a substantial sturgeon fishery with Winyah Bay supporting the primary fishing activity in the state. Laws and regulations concerning potential sturgeon overexploitation were created as early as 1906 (Smith et al. 1984) and led to full closure in 1985. Currently, this large basin provides sturgeon access to the vast majority of their historical range of spawning and early nursery habitat, which was identified by Mills (1826); low falls near the fall-line may have prevented further inland access except under high flows. Spawning of both Atlantic and shortnose sturgeon presently occurs over more than 200 km (100 mi) of river mainstem in suitable channel habitats.

Efforts to better understand the ecology and life history of sturgeons in this system, primarily in response to bycatch in the American shad fishery, began in 1994. Both species were collected in Winyah bay during the study (Collins and Smith 1996a). From 2002 to 2003, sampling was conducted to determine which of the several rivers in the system might support a population of shortnose sturgeon, identify spawning sites, and describe seasonal movements. A total of 26 shortnose sturgeon were captured and subsequent telemetry data revealed a spawning location in the Great Pee Dee River confirmed by the collection of fertilized eggs (Collins and Post 2003). From 2006 to 2009, sampling was conducted to monitor the movements and inter-basin transfer of shortnose sturgeon between the Santee River and Winyah Bay System. A total of 13 shortnose sturgeon and 10 Atlantic sturgeon were captured and transmitted. Telemetry data demonstrated that shortnose sturgeon residing in the Winyah Bay System have a larger range than previously published, with fish moving into the Black River, Sampit River, and inter-basin transfer between the Winyah Bay and the adjacent Santee River. Data also indicated that multiple spawning sites likely exist in the system (Gibbons and Post 2009).

The next period of sampling occurred from 2011 to 2013 as part of the National Marine Fisheries Service funded multistate study examining riverine movements of shortnose and Atlantic sturgeon in the Southeast. A total of 100 Atlantic sturgeon and 73 shortnose sturgeon were transmitted during the study. Telemetry data confirmed spawning runs occurred for both species (fall spawning run confirmed for Atlantic sturgeon) in the Great pee Dee River. Data also confirmed both species tagged in other systems inhabited tributaries of the Pee Dee River Basin for extended periods of time, confirming its importance as an aggregation area (Post et al. 2014). Around the same time, advancements in side scan sonar technology provided a new way to enumerate adult sturgeon and paddlefish that have been used to estimate abundance in several species (Thomas and Haas 2002; Hale et al. 2003; English et al. 2014). Researchers from North Carolina State University developed an approach to estimate numbers of spawning adult sturgeon using this technology (Flowers and Hightower 2013). Abundance estimates were determined during spawning runs using N-mixture and distance models for several rivers in South Carolina. The abundance estimate of riverine Atlantic Sturgeon >1 m TL in the Great Pee Dee River was 1,944 (95% CI: 1,036–3,646) (Flowers and Hightower 2015).

In 2015, FERC-relicensing was completed for Blewett Falls Dam on the Great Pee Dee River, as part of the Yadkin-Pee Dee River Hydroelectric Project. The Project Biological Opinion required long-term monitoring of adult shortnose and Atlantic sturgeon in the system. The first 10 years of monitoring (the Baseline) resulted in the capture of 72 shortnose sturgeon and 518 Atlantic sturgeon. Of those captures, 68 shortnose and 145 Atlantic sturgeon received internal acoustic transmitters. Movement data have shown spawning runs during the spring and fall annually for Atlantic sturgeon, and nearly annually for shortnose sturgeon. These data have also been used to evaluate environmental cues associated with spawning migration behavior in Atlantic sturgeon in both the spring and fall cohorts (Denison et al. 2021). In 2021, a range-wide analysis of population genetics for North American Atlantic sturgeon led to an updated and substantially improved genetic baseline (White et al. 2021). Results from this analysis confirmed the spring and fall spawning runs are genetically distinct in the Great Pee Dee River (also known as dual spawning). Future genetic analysis will potentially calculate additional genetic metrics such as estimate of effective population size and estimate of numbers of breeders.

In 2019 funding was received from NMFS to conduct a 3-year study to (1) estimate annual abundance for age 1 Atlantic sturgeon in the Winyah Bay System, and (2) develop, test, and implement side scan sonar techniques to estimate the annual abundance of spawning adult Atlantic sturgeon in the Winyah Bay System. For objective 1, over the course of the study period, sampling targeting juvenile sturgeon resulted in the capture of 1,253 sturgeon (1,247 Atlantic and six shortnose). Sturgeon were captured in the Black River, Sampit River, Waccamaw River, and Winyah Bay indicting wide ranging use of all system tributaries which was further validated through acoustic telemetry via 40 acoustically transmitted juvenile Atlantic sturgeon (Post and Waldrop 2024). Preliminary abundance estimates of juvenile Atlantic sturgeon (≤ 1,000 mm FL) were calculated using the Jolly-Seber POPAN Mark open population model in RMark. POPAN model comparisons based on AICc selected constant survival, constant capture probability, and variance in probability of re-entry as model parameters [Phi(~1)p(~1)pent(~time)N(~1)]. The POPAN model produced a comparable estimate of 3,060 individuals from 2021–2023 (1,997–5,001). For comparison to previous sturgeon population estimates, the Huggins closed capture model in RMark was also used. The Huggins model produced a superpopulation estimate of 3,001 individuals from 2021–2023 (95% CI = 2,013–6,583).

For objective 2, side-scan sonar surveys were conducted along a 70 km section of the Great PeeDee from RKM 52 to RKM 122. The entire study area was surveyed twice weekly over three sample days from March 1 – May 15, 2021 (spring run), and again from August 10 – November 7, 2021(fall run). Side-scan sonar imagery was reviewed in SonarWiz and only marks clearly identified as Atlantic Sturgeon were used in the analysis. N-mixture models were then used to estimate daily abundance of Atlantic Sturgeon and to identify environmental covariates associated with Atlantic Sturgeon abundance and detection in the study area. A total of 1,392 Atlantic Sturgeon were confidently identified from the sonar imagery. Over twice as many Atlantic Sturgeon were detected from the fall run (n = 966) as opposed to the spring run (n= 426). Estimated maximum weekly abundance of adult Atlantic Sturgeon in the study area was 587 (95% CI = 328–1085) and 875 (95% CI = 511–1607) individuals during the spring and fall spawning runs, respectively (Denison et al. submitted).

Santee Basin: The Santee Basin, originating in the Blue Ridge Mountains of North Carolina, is the second largest watershed on the East Coast (Hughes 1994), with the Santee River having the fourth largest average flow of any river on the Atlantic coast of the United States (SCDNR 2013). This large watershed has been impacted by damming to a greater extent than most basins on the Atlantic coast of North America. With the completion of the Santee Cooper Diversion Project in 1942, two large reservoirs (Lakes Moultrie and Marion), two dams (Santee and Pinopolis Dams), and a diversion canal linked the Cooper River to the Santee Basin, diverting approximately 88 percent of the Santee River's annual flow into the Cooper River (Kjerfve and Greer 1978). In 1985, to reduce shoaling downstream in Charleston Harbor, flows were re-diverted back into the Santee River near St. Stephen, South Carolina. This project created the "Rediversion Canal" between Lake Moultrie and the Santee River, and a new hydroelectric power generation facility (St. Stephen Dam) (NMFS 2019).

The Santee-Cooper Lakes: With the construction of the Santee-Cooper Lakes (Moultrie and Marion) in the 1940s, the majority of the Santee River was closed to migratory fishes. In the 1990s and early 2000s, several studies were conducted investigating the exchange of individuals between the Cooper River the reservoirs and any consequences of interactions with the dams. Results showed that the navigational lock at Pinopolis Dam is generally ineffective at passing shortnose sturgeon (Cooke et al. 2002; Collins et al. 2003; Timko et al. 2003). Since 2011, seven transmitted sturgeon (five shortnose and two Atlantic sturgeon) have passed though Pinopolis Lock into Lake Moultrie (E. Waldrop, SCDNR, pers. comm., 2024). Fish passed from the Santee River at St. Stephen Dam are recorded, and only six sturgeons have been passed at the St. Stephen Dam since 1985 (B. Post, SCDNR, pers. comm., 2011). During the approximately 80 years since the impoundment of the Santee River, average flows in the Santee River seaward of Santee Dam have been greatly reduced from historical levels (Kjerfve and Greer 1978). Stocks of both sturgeons may have been severely impacted over the decades of generally low flows. Surveys have recorded both adult shortnose sturgeon and juvenile Atlantic sturgeon in rather low numbers through 2023 (Collins and Smith 1996b; Cooke and Leach 2004a; Post et al. 2014; Post and Holbrook 2018; Post and Waldrop 2023).

A dam-locked population of shortnose sturgeon is present in the Santee-Cooper Lakes (primarily Lake Marion) with spawning occurring in the Congaree River below Columbia, SC (Collins et al. 2003; Post 2008). Fish passage observations indicate that this population may receive little genetic influx from either river (see above), although it is still unclear how frequently sturgeon are able to use the Pinopolis Lock. The sustainability of the population within the lakes is unknown, but the dam-locked shortnose sturgeon population tends to be in poorer conditions than the open river populations (Collins et al. 2003). More recent genetic analyses of shortnose sturgeon haplotype frequencies in the remnant Santee River population in Lake Marion did not differ significantly from those in the Cooper River. This suggests that the Cooper River harbors descendants of the Santee River population that are unable to access their historical spawning locales (Wirgin et al. 2010).

In 2020, Santee-Cooper Public Service Authority was issued a new FERC License including specific requirements for shortnose and Atlantic sturgeon monitoring and spawning habitat restoration. Potential passage of both sturgeon species into the Santee Cooper Lakes System at the Santee Dam on the Santee River and Pinopolis Dam on the Cooper River is also included in

the License (Santee Cooper Hydroelectric Project, FERC Project No. 199). Dedicated studies focusing on all life stages of shortnose sturgeon will begin in 2025.

The Santee River: In 1991 two significant fish kills occurred in the Rediversion Canal in the Santee River. Both were the result of low dissolved oxygen that developed following a shutdown of the St. Stephen Hydro Facility. A total of 20 shortnose sturgeon were collected and documented (White and Lamprecht 1991). No Atlantic sturgeon were collected. In general, there has been limited documentation of sturgeon in the Santee River by SCDNR personnel. Efforts during several of the previously mentioned studies resulted in few if any sturgeon collections (Collins and Smith 1996a; Collins and Smith 1996b; Collins et al. 2003; Gibbons and Post 2006). Sampling during the NMFS multistate study (2011 to 2013) only resulted in the capture of 18 sturgeon (2 shortnose and 16 Atlantic) and four were transmitted. Telemetry data showed no detectable patterns of movement and no spawning migrations in the Santee River (Post et al. 2014). As mentioned in Pee Dee Basin section, researchers from North Carolina State University developed an approach to estimate numbers of spawning adult sturgeon using side scan sonar technology (Flowers and Hightower 2013). Unfortunately, the researchers did not observe sturgeon in the surveyed portion of the Santee River, resulting in no population estimate (Flowers and Hightower 2015).

The most dedicated sampling in the Santee River to date took place from 2014 to 2018. In that time two shortnose and 84 Atlantic sturgeon were captured. Of those Atlantic sturgeon, ten were considered young of year (<350 mm FL) and all were captured in 2016. Unfortunately, no other young of year were captured and it is possible that these fish emigrated from the Winyah Bay via the Intracoastal Waterway during periods of high flow (Post and Holbrook 2018). Over the last decade, several shortnose sturgeon (originally transmitted in Lake Marion or the Cooper River) entered the Santee River via the Santee Dam or St. Stephen Dam. However, exchange between the three populations is considered rare (Post and Waldrop 2023).

In 2020, Santee-Cooper Public Service Authority was issued a new FERC License including specific requirements for shortnose and Atlantic sturgeon monitoring and spawning habitat restoration (Santee Cooper Hydroelectric Project, FERC Project No. 199). Dedicated studies focusing on all life stages of shortnose and Atlantic sturgeon began in 2024.

The Cooper River: As mentioned above, the Cooper River was heavily impacted by damming beginning in the 1940s. While historic data are lacking, prior to the construction sturgeon were not thought to inhabit the Cooper River since it was historically a small tidal river (ASMFC 2017). Shortnose sturgeon were first documented in the Cooper River in 1992 (Cooke and Leach 2004b). Since 1995, the SCDNR Diadromous Fishes Program has conducted sampling for adults below the Pinopolis Dam (rkm 77). Results have indicated that adult shortnose sturgeon still reside in the Cooper River, albeit it at low levels (approximately 230 annually over the last decade) (Post and Waldrop 2023). Fertilized eggs have been collected below Pinopolis Dam as recently as 2017 (Cooke and Leach 2002; Duncan et al. 2004; Post and Holbrook 2017). However, neither larvae nor juveniles have been collected and successful reproduction has not been confirmed (Cooke and Leach 2004b).

From 2015 to 2018, dedicated sampling occurred throughout the Cooper River. Adult shortnose sturgeon were collected, but no larvae, young of year, or juveniles. Juvenile Atlantic sturgeon were also collected. Sampling included netting below Pinopolis Dam in the fall months (which has continued) to target adult Atlantic sturgeon. Sampling resulted in the capture of 21 adults including 19 males and two females (Post and Waldrop 2023). Telemetry movement data from these fish, water temperature, seasonal capture, and physiological stage of maturity of captured fish all provide evidence of fall and potentially spring spawning behavior for Atlantic sturgeon in the Cooper River (see Balazik et al. 2012; Farrae et al. 2017), however further verification is required before final conclusions can be drawn. Overall, the status and viability of sturgeon populations in the Cooper River remains poorly understood, particularly for Atlantic sturgeon. Long-term studies will continue as part of the Santee-Cooper Public Service Authority license requirements listed above (Santee Cooper Hydroelectric Project, FERC Project No. 199).

Ashley River: The Ashley River is a small, coastal plain drainage. Several juvenile Atlantic sturgeon have been taken in the Ashley River during shrimp trawl surveys (Collins and Smith 1996b). Several transmitted Atlantic sturgeon and one shortnose sturgeon have been detected in the lower Ashley River over the last decade, but detections represent only brief visits. The status of both the Atlantic and shortnose sturgeon is not well known for this small river.

Edisto Basin : The Edisto River Basin is drained by four major streams: South Fork Edisto River, North Fork Edisto River, Edisto River, and Four Hole Swamp. The Edisto River is the longest and largest river system completely contained within the borders of South Carolina (SCDNR 2013). The rivers that make up this largely pristine basin remain unimpounded.

Prior to 1994, there were very few authenticated records of shortnose sturgeon in the Edisto Basin (Collins and Smith 1996b; McCord 2003). Shortnose sturgeon captures are still rare 30 years later and spawning has not been observed in the Edisto River, however several young of year have been captured (Post and Waldrop 2023). The current status of shortnose sturgeon stocks in the Edisto Basin is poorly understood, however a new study focused on confirming the existence of a native shortnose sturgeon population in the system should provide more information (Post and Waldrop 2023).

Atlantic sturgeon were commercially harvested in the Edisto River in the late 1970s and early 1980s (Smith et al. 1984). In 1994, a sampling program was initiated by SCDNR that was originally intended to tag American shad, (*Alosa sapidissima)*, in the Edisto River, but also captured juvenile Atlantic sturgeon (McCord et al. 2007). Since then, SCDNR has conducted a sturgeon mark and recapture study in a portion of the Edisto River, resulting in the longest continuing data set for Atlantic sturgeon in South Carolina (1994–present). The primary objectives of this study are to assist in the development and implementation of FMP activities through fishery independent sturgeon mark and recapture studies, and to focus on a series of special studies directed at critical fisheries where data collection needs to be concentrated in South Carolina. Annual results of this long-term study are used to produce abundance and recruitment data for ASMFC benchmark stock assessments (ASMFC 2017) and stock assessment updates (ASMFC 2024) and ASMFC compliance reports and that will assist in correctly assessing management needs of sturgeon in Edisto River. A 2022 analysis of these data (1994–2022) provided a current juvenile (≤1050 millimeters total length) abundance average of

837 individuals (range = 333–1,343, 95% CI = 677–997) based on the average of daily and monthly encounter history population estimates (Takacs et al. in prep.).

Atlantic sturgeon are confirmed to spawn in both the spring and fall in the Edisto River (dual spawning), (Collins et al. 1999; 2000; Post et al. 2014), with the two populations considered genetically distinct with little gene flow or admixture between them (Farrae et al. 2017; White et al. 2021). Genetic characterization also showed a moderate effective population size estimate compared to published estimates for other Atlantic sturgeon populations (Farrae et al. 2017). Sampling during the NMFS multistate study (2013 to 2013) resulted in the capture of 90 individual Atlantic sturgeon and 5 shortnose sturgeon. Telemetry data from transmitted fish highlighted the distinct seasonal spawning runs and the differences between them (maximum river kilometer and spawning run duration) (Post et al. 2014). As mentioned in sections above, researchers from North Carolina State University developed an approach to estimate numbers of spawning adult sturgeon using side scan sonar technology (Flowers and Hightower 2013). Abundance estimates were determined during spawning runs using N-mixture and distance models for several rivers in South Carolina. The abundance estimate of riverine Atlantic Sturgeon >1 m TL in the Edisto River was 343.5 (95% CI: 150–788) (Flowers and Hightower 2015).

Salkehatchie Basin: The Salkehatchie River basin is in the southern Coastal Plain region of the State, with an area of approximately 2,870 square miles. The major streams draining this mostly middle and lower Coastal Plain basin are the Salkehatchie River, Coosawhatchie River, and Ashepoo River. The Salkehatchie and Little Salkehatchie Rivers join to form the tidally influenced Combahee River. The Coosawhatchie River discharges into the Broad River, a tidal saltwater river that also receives drainage from surrounding marshlands. The coastal area of this basin contains the most extensive estuarine water bodies in the State. These coastal water bodies are dominated by St. Helena Sound and Port Royal Sound and include numerous, often interconnecting, tidal creeks and rivers (SCDNR 2013).

All rivers in this basin are small, coastal plain drainages. Atlantic sturgeon were harvested commercially in the Coosawhatchie and Combahee Rivers in the early 1980s (Smith et al. 1984). There are a few records of juvenile Atlantic sturgeon taken by shrimp trawls in lower Port Royal Sound. Prior to 1994, there were very few authenticated records of shortnose sturgeon in the basin and only one record in the lower Ashepoo River (Collins and Smith 1996b; McCord 2003). Starting in 1998, attempts were made to capture adult shortnose sturgeon for a telemetry study to identify movements and habitat use (Collins, unpubl. data), these were largely unsuccessful. Atlantic sturgeon may spawn in the Combahee Rivers (Collins et al. 1999; 2000), however no records exist for adult Atlantic sturgeon in Ashepoo River. During the NMFS multistate study (2010 to 2011), seven Atlantic sturgeon were captured in the Combahee River (Post et al. 2014). Additional Atlantic sturgeon tagged in other river systems were also detected in the Combahee River, as well as several shortnose sturgeon. In general, the status of both the Atlantic and shortnose sturgeon is not well known for these small rivers.

Savannah Basin: The Savannah basin is located in western South Carolina and extends 265 miles southeast from the North Carolina state line to the coast. It shares its western border with Georgia and is the second largest in the State, encompassing an area of approximately 4,900

square miles. The Savannah River is the major watercourse in the basin (SCDNR 2013) and the only tributary known to contain sturgeon.

According to historical distribution records much of the historically available spawning and nursery habitat for sturgeons in the Savannah River remains accessible (USFWS 2001; ASSRT 2007). SCDNR has conducted dedicated sturgeon monitoring studies in the Savannah River since the 1980s. Most research was directed toward shortnose sturgeon, but information on Atlantic sturgeon (especially juveniles) was also acquired (Collins et al. 2000). From 1985 through 1992, and 1997 to 2000, sturgeons were captured by directed sampling and acquired from the by-catch of a network of commercial American shad (*Alosa sapidissima*) gill-net fishermen (Hall et al. 1991; Smith et al. 1993, unpubl. data). Radio and acoustic telemetry studies were conducted on shortnose sturgeon during 1985 to 1991 (Hall et al. 1991; Collins and Smith 1993). Detection data helped to determine seasonal movements (including the identification of two probable spawning sites), spawning frequency, adult sex ratios, and preferred habitats for both life stages (e.g., a nursery area for juveniles and use of freshwater versus saltwater or brackish habitats) (Hall et al. 1991; Collins and Smith 1993). Some of these shortnose sturgeon were also used as brood fish as part of a pilot stock enhancement program in the Savannah River (Smith and Collins 1996). About 92,000 progeny of various ages were released into the river at several locations. In addition to the stock-enhancement work, cultured juveniles were used in other studies, such as delineation of environmental tolerances (salinity, temperature, and DO; Jenkins et al. 1993) and identification of optimal tagging techniques (Smith et al. 1990; Collins et al. 1994). Spawning and culture research on Savannah River strain shortnose sturgeon has been conducted since the mid-1980s at several locations, including U.S. Fish and Wildlife Service facilities (e.g., Orangeburg National Fish Hatchery, Bears Bluff National Fish Hatchery) and South Carolina Department of Natural Resources facilities (e.g., Marine Resources Research Institute, Waddell Mariculture Center) (Collins et al. 2000).

A collaborative study (including Nature Conservancy, NOAA National Marine Fisheries Service, Georgia Department of Natural Resources, Georgia Ports Authority, and the Southeastern Natural Sciences Academy), was conducted from 2007 to 2009. The study focused on shortnose sturgeon essential fish habitat and resulted in the capture of 115 shortnose and 180 Atlantic sturgeon (SCDNR unpubl. data). During the NMFS multistate study (2011 to 2013), 47 Atlantic sturgeon and 33 shortnose sturgeon were captured (Post et al. 2014). Telemetry data from transmitted fish highlighted the spawning behavior of shortnose sturgeon as well as potential dual spawning runs of Atlantic sturgeon (Post et al. 2014).

Beginning in 2013, SCDNR has conducted sturgeon telemetry studies for the U.S. Army Corps of Engineers (USACE)-Savannah District as part of the Savannah Harbor Expansion Project. The study is ongoing and includes acoustically transmitting adults and juveniles of both species while maintaining the acoustic receiver array established in the Post et al. (2014) study. Telemetry data have been used to improve the understanding of seasonal nursery and foraging habitats for both species and to monitor annual spawning migrations of both species. These data have also identified potentially separate spring- and fall-spawning runs for Atlantic sturgeon however further validation is needed (Vine et al. 2019a).

Telemetry data from 2013 to 2018 were also used in a study to identify environmental cues of spawning migration behavior for both species. Results showed that cues for the initiation of migration and upriver movement were species-specific, but water temperature was the primary predictor of sturgeon migrations, and discharge also played a significant secondary role (Vine et al. 2019a). Another study conducted in the fall of 2017 used side scan sonar surveys to estimate Atlantic Sturgeon spawning migration abundance in the Savanah River. Results from Bayesian N-mixture modeling estimated a maximum daily spawner abundance between 35 and 55 individuals (95% credible interval) (Vine et al. 2019b).

Since the Savannah River forms the east–west border separating the states of South Carolina and Georgia, the University of Georgia has also conducted sturgeon research in the Savannah River and has conducted multiple population estimates in recent years. A study conducted from 2013 to 2015 used Huggins closed capture models to estimate that the Savannah River contained 528 (95% CI = 402–726) age-1 juvenile Atlantic sturgeon in 2013, 589 (478–742) in 2014, and 597 (437–852) in 2015 (Bahr and Peterson 2016). During the same study (2013 to 2015), shortnose sturgeon were also collect. Analyses estimated that the Savannah River contained 81 (95% CI = 27–264) age-1 juvenile shortnose sturgeon in 2013, 270 (162–468) in 2014, and 245 (104–691) in 2015. Huggins closed-capture models also estimated the river to contain 486 (198–1,273) age-2+ juveniles in 2013, 123 (69–235) in 2014, and 187 (81–526) in 2015. Similarly, the adult population was estimated to be 1,865 (784–4,694) individuals in 2013, 1,564 (1,005–2,513) in 2014, and 940 (535–1,753) in 2015. These data suggest that the Savannah River may contain the second largest population of Shortnose Sturgeon in the southeast (Bahr and Peterson 2017). An updated analysis of the Atlantic sturgeon data set to include the 2 subsequent years indicate greater numbers of age-1 Atlantic sturgeon (973 [95% CI = 786–1233], fish in 2016 and 639 [449–953] fish in 2017), implying abundance of age-1 recruits may be increasing in the Savannah River, however more data are needed to confirm this trend (Fox et al. 2023).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Because of the highly migratory nature of sturgeons, particularly the Atlantic sturgeon, these fishes require access to an expansive variety of high quality freshwater and marine habitats. Within state waters, adult Atlantic sturgeon migrate through nearshore Atlantic shelf waters and enter coastal sounds, bays and inlets to access the river basins in which they spawn. Shortnose sturgeon move primarily from tidal estuarine or brackish channels into freshwater reaches to spawn, however use of nearshore Atlantic shelf waters does occur (Post et al. 2014). Both species spawn in freshwater channel habitats from tidal river reaches to at least as far inland as the fall line in large, unobstructed river basins. Eggs of both species are adhesive and successful spawning is dependent upon the availability of relatively clean, hard substrates within river channels for egg adhesion and development. Both spawning and egg survival to hatching are dependent upon habitats with low to moderate flows and limited sedimentation. Shortnose sturgeon and, presumably, Atlantic sturgeon generally spawn where flow rate is 0.2 to 1.8 meters per second (0.7 to 6.0 feet per second) (Kynard 1997). Nursery and foraging habitats for both sturgeons (including adults within rivers) include all channel and adjacent out-of channel submerged habitats from a few kilometers seaward to estuarine sounds and bays of river basin deltas. During the fall and winter, sturgeon move seaward into brackish and estuarine channels. The Atlantic sturgeon over winters in deep channels and holes within coastal sounds and bays. It

is during such seaward migrations that Atlantic sturgeon may transfer into other river basins by traversing coastal Atlantic continental shelf waters (McCord 2003). Atlantic sturgeon tagged in South Carolina have been found as far south as northern Florida and as far north as New York.

CHALLENGES

Dams prevent upstream migration of sturgeons and other species (ASMFC 1990; NMFS 1998; USFWS 2001). Atlantic streams from Maine to Florida have undergone a restriction or loss of access for migratory fishes to about 84 percent of stream habitat within historic ranges from dams alone (Busch et al. 1998). Obstructed access to a diversity of habitats may limit basin-specific populations of both Atlantic and shortnose sturgeon. The Pee Dee, Santee, and Savannah basins in South Carolina are impacted by dams that restrict migrations of sturgeons into historical habitats (USFWS 2001). Dams can block spawning migrations and severely restrict the availability of spawning and nursery habitat, particularly in large river systems when dams are near the coast (ASMFC 1990), as in the Santee and Cooper Rivers. Dams and other impediments to migration have eliminated sturgeons from many historical habitats in South Carolina (USFWS 2001); the result being a general reduction in sturgeon populations in even currently accessible river reaches.

The Santee Basin has the second largest drainage area and total discharge (only the Susquehanna is larger) of all river systems on the east coast of the U.S. (Hughes 1994). However, this large watershed has been impacted by damming to a greater extent that most basins on the Atlantic Coast of North America, with nearly 45 dams in the South Carolina portions of the basin alone (USFWS 2001). The original Santee-Cooper diversion project, completed in 1942, shifted approximately 88 percent of the historical Santee River flow into the Cooper River, changing the average Cooper River flow rate from 2 cms (cubic meters per second) or 7 cfs (cubic feet per second) to 442 cms (1560 cfs) (Kjerfve 1976). Prior to rediversion in 1985, water releases at Pinopolis Dam on the Cooper River were generally continuous. A weekly average flow of 122 cms (430 cfs) has been maintained in the Cooper River since rediversion to protect water supplies (Orlando et al. 1994), but generation time has been restricted to as little as 10 hours per day. The original diversion of Santee River historical flows into the Cooper River caused average freshwater flow in the Santee River seaward of Wilson Dam to drop from 525 to 74 cms (1850 to 260 cfs) and allowed saltwater intrusion (Kjerfve and Greer 1978). The Santee-Cooper Rediversion Project returned about 70 percent of the Cooper River flow to the Santee, increasing average flow to approximately 367 cms (1,290 cfs) and reducing salinity in the lower Santee (Orlando et al. 1994). However, there is no minimum flow requirement at St. Stephen Dam on the Rediversion Canal (D. Cooke, SCDNR, per. comm., 2005) and the average daily flow from Wilson Dam is only 18 cms (63 cfs) higher (Orlando et al. 1994). During periods of low inflow into the Santee-Cooper Lakes, water releases can be discontinued at St. Stephen Dam (D. Cooke, SCDNR, per. comm., 2005). In contrast, the average daily discharge from Wilson Dam can approximate 500 cms (1,760 cfs) higher during flood-control releases (Orlando et al. 1994). The net result of flow regimens in both the Cooper and Santee Rivers is flows that are typically in highs and lows with more abrupt changes in flows from peaked power generation and flood releases than are characteristic of more gradual river flow changes that occur in open rivers where waters expand into, and withdraw from, floodplains. Dams, and particularly hydropower dams, often produce flow regimens that are not reflective of natural seasonal flows. Dams may

reduce minimum flows, thereby potentially dewatering otherwise productive habitats and increasing water temperature (NMFS 1998; USFWS 2001). Pulse flows used for peaking hydropower production can disrupt natural productivity and prey availability for larval and early juvenile fishes (Crecco and Savoy 1987; Limburg 1996), can displace eggs and/or larvae from otherwise highly productive habitats (USFWS 2001), and can disrupt both upstream and downstream migration patterns for adult and juvenile anadromous fishes (ASMFC 1985; ASMFC 1999; Limburg 1996; USFWS 2001). As part of dam relicensing through the Federal Energy Regulatory Commission (FERC), prescribed flows through the Santee Dam and St. Stephen Dam will be changed and increased to benefit sturgeon in the coming years (Santee Cooper Hydroelectric Project, FERC Project No. 199).

Atlantic sturgeon prefer moderate water temperatures, 12 to 24°C (54 to 75°F); body weight is negatively impacted at higher temperatures (McCord 2003). Reduced flows caused by dams can reduce dissolved oxygen (DO) to levels unsuitable for sturgeon (Secor and Niklitschek 2001). For example, DO within the Santee River Rediversion Canal can reach less than 3.0 mg/L (milligrams per liter) and more frequently reaches less than 4.0 mg/L during summer periods with low or no flows from St. Stephen Dam (Cooke and Leach 2004a). At least 20 adult shortnose sturgeon were killed in the Rediversion Canal following a DO crash related to decaying submerged vegetation that had been trapped on trash racks associated with turbines in St. Stephen Dam (Cooke and Leach 2004a). However, dissolved oxygen sensors have since been installed downstream and upstream of that dam and sensors are regularly monitored regularly. If the dissolved oxygen drops below a certain level, water is released from the dam. Water releases from deep reservoirs may be poorly oxygenated and/or of below normal seasonal water temperature, thereby causing loss of suitable spawning or nursery habitat in otherwise suitable river reaches. Deepwater releases in late winter through early spring (season of spawning) are often below the required temperatures: 13.3 to 17.8ºC for Atlantic (Borodin 1925), 8.0 to 15.0ºC for shortnose (Dadswell et al. 1984; Buckley and Kynard 1985).

Dredging and bridge construction may negatively impact sturgeons in several ways (ASMFC 1990). Deepened channels can allow saltwater to intrude further inland, and changes in salinity regimens can dramatically impact prey distribution (ASMFC 1990). Prey availability can also be reduced by the removal of benthic invertebrates within sediments (ASMFC 1990). Dredging can also negatively affect fish populations by producing suspended sediments (Reine et al. 1998). Sediment resuspension from dredging can cause increased turbidity and localized depletion of dissolved oxygen, as well as increased bioavailability of any contaminants that may be bound to the sediments (Clarke and Wilber 2000). High concentrations of suspended sediments, as well as relatively low concentrations sustained for several days, have been shown to cause direct mortality, impaired hatching success, reduced larval feeding, and diminished larval growth in several species of estuarine and anadromous fishes (Clarke and Wilber 2000). Suspended sediments have been linked to a variety of lethal and sublethal responses in juvenile and adult fishes that are consistent with oxygen deprivation due to gill clogging (Sherk et al. 1975; Sherk et al. 1974). Behaviorally, chronic turbidity from frequent or prolonged dredging can affect fish migration, spawning, conspecific interactions, and foraging (Coen 1995). Some fishes avoid waters of high sediment load, even during spawning migrations (ASMFC 1985; Reine et al. 1998). Water quality impacts and/or the reduction or elimination of prey may also disturb sturgeon concentration areas near the freshwater-brackish interface. Dredges, primarily hydraulic

or hopper dredges may damage or kill sturgeons by entrainment or impingement in drag-arms or impellers (ASMFC 1990; NMFS 1998).

Siltation from dredging and from agricultural, silvicultural, and other land use practices can also reduce spawning success by causing mortality of eggs or by coating substrates needed for attachment of adhesive eggs (NMFS 1998). Pollution, runoff and siltation input contaminants and pollutants into sturgeon habitat that can cause lowered pH or lowered DO, which can reduce survival of eggs, larvae, or juveniles (Rogers and Weber 1995; NMFS 1998; USFWS 1998). Bioaccumulation of contaminants, such as dioxin in parts of Winyah Bay, may reduce productivity or increase susceptibility to diseases or stress (Cooper 1989; Varanasi 1992; Sindermann 1994; NMFS 1998).

Erosion from agriculture and silviculture (logging) can significantly lower water quality and cause drastic adverse reactions in aquatic life (Butler 1968). Runoff carries silt, chemicals and nutrients into wetlands that, acting alone or in combination, can be lethal to aquatic life, and particularly to larval forms (Matthews et al. 1980; Aust et al. 1997). Runoff can cause sedimentation and nutrients can encourage algal blooms, both leading to eutrophication and possible dissolved oxygen (DO) depletion (Matthews et al. 1980; Lockaby et al. 1997). Siltation can also cause increased water temperature (Aust and Lea 1991; Perison et al. 1993). Further, siltation results in reduced productivity beginning at lower levels of food-chain relationships upon which juvenile sturgeons are dependent and disturbance of food-web relationships in adjacent and downstream waterways (Batzer et al. 2005). Forestry BMPs for bottomland forests are recommendations to landowners in order to conserve site productivity, primarily for silviculture, and are voluntary (South Carolina Forestry Commission 1998). When BMPs are not used, braided streams may be obstructed by plant material and disturbed soils, excessive ruts may channel eroded sediments into streams, partially stagnated waters may become nutrient-rich and promote algal growth that can die under extended periods of cloud-cover (J.W. McCord, SCDNR, pers. comm.). These factors contribute to increased water temperature and reduced DO.

Siltation, from erosion due to land use practices or from dredging, physically covers and kills some aquatic life, including submerged aquatic vegetation and thereby increases BOD (biological oxygen demand) (Funderburk et al. 1991; Valdes-Murtha and Price 1998). Submerged aquatic vegetation provides important ecological functions in freshwater habitats. Submerged aquatic vegetation improves water quality (Rybicki and Hammerschlag) and provides habitat for predator avoidance, foraging and nursery development for many macro-invertebrates and resident and migratory fishes (Maldeis 1970; Killgore et al. 1989; Monk 1988). Submerged aquatic vegetation is adversely affected by suspended sediments greater than 15 mg/l (Funderburk et al. 1991) and by deposition of excessive sediments (Valdes-Murtha and Price 1998).

Dewatering of freshwater streams from irrigation and other water removal projects decreases habitat availability and contributes to reduced water quality by concentrating non-point source pollution and increasing water temperature (ASMFC 1985). Density dependent impacts such as predation and competition may also increase. Sturgeons of various sizes can become impinged or entrained by intakes for power plants or by municipal, industrial or agricultural water intakes (Hoff and Klauda 1979; NMFS 1998).

Sturgeon also have been affected by commercial and recreational fishing operations. By-catch from gill nets, trawls, or trotlines may cause excessive mortality on adult shortnose sturgeon and on adult and juvenile Atlantic sturgeon (NMFS 1998). By-catch mortality for Atlantic sturgeon occurs in fisheries within the Exclusive Economic Zone (EEZ) (the Atlantic Ocean from 3 to 200 miles offshore). There is currently no management plan for sturgeon in the EEZ. (ASMFC 1998; Kahnle et al. 1998). Evidence of impingement in crab traps has been observed for juvenile Atlantic sturgeon (J.W. McCord, SCDNR, pers. comm.) and abandoned or lost traps may be problematic as potential sources of injury or mortality for both species of sturgeon. Illegal harvest of both species is likely, particularly for animals captured incidentally in American shad and shrimp trawl fisheries, but also from directed effort (NMFS 1998). Allowable take of sturgeons, as permitted under the ESA, may allow excessive mortality, particularly for adults in small populations (NMFS 1998). However, in 2010, NMFS required the state of South Carolina to account for and reduce by-catch of both species of sturgeon in fisheries. In response, SCDNR has made several changes to their shad fisheries and sent required documentation to NMFS.

Predation and competition between sturgeon and non-native species, such as flathead catfish (*Pylodictis olivaris*) and blue catfish (*Ictalurus furcatus*), may be additive to "more natural" sources of mortality. Both of these non-native catfishes are presumed to be problematic to sturgeons as both competitors and predators (NMFS 1998).

CONSERVATION ACCOMPLISHMENTS

The shortnose sturgeon was listed as an endangered species in 1967, the Atlantic sturgeon in 2012. In addition, both Atlantic and shortnose sturgeon received a high level of protection with the closure of the directed Atlantic sturgeon gill-net fishery in 1985, which made the possession of any sturgeon illegal in the South Carolina.

Both sturgeon species were incidentally caught in the ocean shad fishery (J.W. McCord, SCDNR, pers. comm.). The ASMFC's Amendment 1 to the Interstate Fisheries Management Plan (IFMP) for shad and river herring mandated closure by 2005, preceded by an effort phase-out period. Any reduction in shad fishery effort reduces the potential for by-catch and associated mortality. Participation in South Carolina's American shad gill-net fishery has gradually declined over at least the past 30 years.

An IFMP was developed for the Atlantic sturgeon under the auspices of the Atlantic States Marine Fisheries Commission (ASMFC 1990; 1998). In addition to numerous management recommendations, the sturgeon amendment also includes requirements for states to monitor by-catch in all fisheries and to control levels of by-catch if necessary. More importantly, the 1998 amendment required all states to implement a moratorium on sturgeon harvest for 20 to 40 years. Despite the earlier closure of directed Atlantic sturgeon fisheries in South Carolina, the coast wide moratorium is important for management of populations in South Carolina because of the migratory behavior of Atlantic sturgeon.

Additional protection from bycatch mortality was afforded to both Atlantic and shortnose sturgeon with the initiation of bycatch reduction devices (BRDs) and turtle excluder devices

(TEDs) in shrimp trawl nets, as required by the NMFS. In 1990, TEDs were required and BRDs were required in 1996. According to commercial shrimp trawler captains interviewed by the author in 1995, sturgeon bycatch has been substantially reduced by these devices.

The Santee-Cooper Rediversion Project completed in 1985 also enhanced year-around flows and average late winter and spring water levels in the Santee River, primarily seaward of the Rediversion Canal. These improved flow regimens have presumably produced increases in the quantity and quality of spawning and nursery habitat for both sturgeons seaward of St. Stephen Dam and the Rediversion Canal. Accordingly, both Atlantic and shortnose sturgeon may have been positively influenced.

CONSERVATION RECOMMENDATIONS

- Conduct statewide surveys of Atlantic and shortnose sturgeon populations, particularly for small rivers where stock status is poor or unknown, to determine abundance (or presence/absence), age structure, and recruitment indices of juveniles into spawning populations. Develop standardized sampling protocols for inventorying life stages for both species.
- Expand sturgeon tagging programs to other South Carolina rivers to gather additional information on movements of both species within and between river basins.
- Validate aging techniques for South Carolina sturgeons by analyzing archived hardened fin-rays collected from sturgeons and comparing growth rings with seasonal growth (in length) of recaptured sturgeon.
- Explore the application of alternative ageing approaches and techniques for South Carolina sturgeons such as chemical marking (e.g., calcein or alizarin red S), DNA methylation, Near-infrared spectroscopy, and scanning electron microscopes.
- Compare the genetic relationship of shortnose sturgeon between all South Carolina Rivers.
- Determine genetic relationships for spring and fall spawning Atlantic sturgeon within all individual drainage basins.
- Prioritize the genetic assignment of tagged fish, including the processing of archived samples, to improve the estimates of Z at the DPS-level.
- Develop standardized methods that can be used to create reliable indices of abundance
- for adults and young juveniles (age 0–1) to reflect the status of individual DPSs.
- Determine the minimum viable populations for both Atlantic and shortnose sturgeon, below which stocking should be considered.
- Develop breeding and stocking protocols for both species of sturgeon that protect the genetic integrity of unique populations.
- Document seasonal distribution of both sturgeons throughout the state to identify and map essential habitat.
- Inventory existing sources of mortality for sturgeons and formulate remedies where practical.
- Improve quality and scope of coverage for sturgeon by-catch records received from mandatory catch and effort records collected from shad and herring fisheries and expand the program to include non-gamefish gill-nets. Additionally, create a survey to collect

sturgeon by-catch information from gill-net fisheries and to determine the reliability of mandatory reports. Require sturgeon by-catch reporting for all trawl fisheries.

- Investigate impacts of logging in swamp forests on water quality and habitat, especially as related to sturgeon spawning and nursery habitat.
- Determine impacts of dewatering of freshwater streams from irrigation and other water supply withdrawal projects. Determine the relation of river discharge rates to sturgeon spawning success.
- Characterize the degree to which vessel strikes in specific rivers and estuaries may be impacting populations which spawn in other locations.
- Evaluate strategies to reduce or mitigate mortalities from ship strikes. Improve understanding of how dredging may concentrate Atlantic sturgeon within high-traffic shipping channels and elevate risk of adverse interactions.
- Investigate potential need for fish passage at various dams by evaluating upstream spawning and nursery habitat.
- Investigate the potential for improving spawning success of both species by deployment of rock to supplement natural spawning substrate or to create new spawning habitat.
- Conduct an interview survey of past sturgeon fishery participants for the purpose of gathering invaluable information on productive fishing techniques and gear, on most productive sites, and on seasonality of sturgeon spawning runs.
- Determine potential impacts of predation and competition from non-native species on sturgeons and, to the extent possible, control and prevent further distribution of non-native blue and flathead catfish populations.
- Evaluate state water quality standards and BMPs that may impact wetlands to ensure that these practices adequately protect sturgeon habitat.
- Determine minimum flows below dams that are necessary to maintain appropriate dissolved oxygen levels for sturgeons and the response of sturgeons to low dissolved oxygen, particularly within preferred habitats.
- Determine impacts of pollution, contaminants, and siltation on all life history stages of sturgeons.
- Evaluate utilization and effectiveness of existing fish passage structures and protocols for Atlantic and shortnose sturgeon.
- Determine impacts of biotic and abiotic factors on egg, larval, and juvenile survival and development and how such factors relate to spawning stock recruitment.
- Assess the impacts of dredging, open water disposal of sediments, and blasting on sturgeons and on their habitat and prey base.
- Determine food habits by habitat type and life stage for both species of sturgeon and the relationships of food habits to availability and density of potential prey.
- Determine contaminant loads in sediments of areas frequented by either sturgeon species, determine contaminant loads in sturgeon tissues, and determine the impacts of contaminants on sturgeon health.
- Participate in FERC-relicensing exercises and partner with USFWS, NMFS and NGOs (non-governmental organizations) to ensure that cost-effective and efficient designs for providing both upstream and downstream passage of sturgeons are installed in dams that are currently blocking access to suitable spawning and nursery habitats.

- Partner with NMFS, USFWS, USACE, NGOs, and local governments to improve access to a full diversity of habitats by including fish passage designs wherever appropriate and by removing, breeching, or bypassing impediments to migration such as nonfunctional dams, dikes, or causeways.
- Build partnerships with NGOs, permitting authorities, and county and local governments to improve and/or implement the use of Best Management Practices (BMPs) in agriculture, silviculture, and urban development activities to reduce siltation and contaminant input.
- Partner with the South Carolina Department of Environmental Services to develop water removal guidelines for agricultural, civil or industrial purposes that include considerations for the needs of migratory fishes.
- Continue and expand partnerships with UGA and GADNR to study and manage sturgeon populations in the Savannah River.
- Continue and expand partnerships with UNCW and North Carolina natural resource agencies to study and manage Atlantic and shortnose sturgeon populations in the Pee Dee Basin.
- Continue and expand partnerships with NMFS and regional universities (Clemson University, University of Georgia, University of North Carolina Wilmington, and Coastal Carolina University) to study sturgeon populations throughout the southeast.
- Partner with GADNR, USACE, USFWS, NMFS, and local governments to provide sturgeon passage at New Savannah Bluff Lock and Dam and at dams inland of this point, should passage be deemed appropriate at other barriers.
- Partner with NGOs state and federal agencies, and industry to discourage deforestation of river floodplains and swamp forests.
- Partner with appropriate permitting authorities, including the USACE, to design dredging protocols that consider the timing of sturgeon migration and that protect freshwater-brackish interface zones.
- Partner with other coastal states, possibly through the ASMFC, to promote protection of the Atlantic sturgeon in the EEZ.
- Form an alliance with other state and federal agencies as well as NGOs to implement range wide conservation and management of sturgeons as described in the ASMFC IFMP for Atlantic sturgeon and the NMFS FRP for shortnose sturgeon.
- Partner with NGOs and other state and/or federal agencies to promote changes in water release protocols for dams that will restore or approximate natural flow regimens, increase minimum flows and improve water quality below dams.
- Partner with South Carolina Department of Environmental Services, federal agencies and NGOs to develop or revise river basin plans to identify habitats areas of particular concern (HAPCs), to identify degraded or threatened habitats and to identify preventative or mitigation actions.
- Partner with South Carolina Department of Environmental Services to designate critical coastal areas, such as freshwater-brackish interface zones.
- Partner with other state agencies to regionally review and manage projects and planning activities that protect sturgeon habitat.

- Partner with the NMFS, USFWS, and other groups to confine allowable take of sturgeons by water intake facilities to levels that do not limit population growth, particularly for small stocks.
- Critical habitats and migration patterns for Atlantic and shortnose sturgeon should be included in Coastal Zone Management Plans, in BMPs for non-point source pollution, and in State Pollution Discharge Elimination Systems permits. Develop education and outreach programs that distribute information to governments, civic groups, educational systems and NGOs regarding critical habitat needs, threats and potential conservation actions for sturgeons.
- Improve understanding of offshore habitat use, particularly in areas where offshore energy development and mineral removal may be planned.
- Leverage species distribution models and acoustic telemetry data to identify key areas of occupancy along the coast throughout the year (for the species overall, and specific to each spawning population and DPS).
- Develop education programs to specifically address by-catch of sturgeons in American shad and other gill-net fisheries, trawl fisheries and various trap and trot-line fisheries.

MEASURES OF SUCCESS

By improving aquatic ecosystem health and access to and from suitable spawning and nursery habitats, and by monitoring population responses to conservation actions as suggested above, SCDNR will be able to promote and document rebounding populations of both Atlantic and shortnose sturgeons.

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“Atlantic” Highfin Carpsucker

Carpiodes velifer

Contributors (2005): Scott D. Lamprecht and Jason Bettinger [SCDNR]
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Photo: NCFishes.com

DESCRIPTION

Taxonomy and Basic Description

The “Atlantic” Highfin Carpsucker (*Carpiodes* sp. cf. *velifer*) is a member of the sucker family (Catostomidae), which is represented by 78 described species in North America (Page et al. 2023). Suckers comprise about 8% of the continent’s freshwater ichthyofauna, behind only minnows (Leuciscidae) and perches and darters (Percidae) in number of species (Warren and Burr 2014). There are currently three described species of *Carpiodes* suckers (Page et al. 2023), which are primitive, deep bodied, silver-colored fishes with a long dorsal fin (Jenkins and Burkhead 1994). The form of the Highfin Carpsucker on the Atlantic slope has long been recognized as distinct from populations in the Mississippi and eastern Gulf drainages (Lee et al. 1980; Rohde et al. 2009; Tracy et al. 2024) but awaits full description.

This family is characterized by soft-rayed fins, a mouth located on the underside of the head, thick, fleshy, distensible lips, and paired fins attached low on the body (Rohde et al. 1994). “Atlantic” Highfin Carpsuckers can reach lengths of 50 cm (19.7 in.; Rohde et al. 1994). In South Carolina, the “Atlantic” Highfin Carpsucker most closely resembles the “Carolina” Quillback (*Carpiodes* sp. cf. *cyprinus)*, but the former has a steeper forehead and shorter snout, a nipplelike projection on the lower lip, and usually has fewer lateral scales and dorsal fin rays.

Status

The “Atlantic” Highfin Carpsucker is currently listed globally as apparently secure (G4) to secure (G5) (NatureServe 2024). It is listed as vulnerable (S3) in South Carolina and is considered imperiled to vulnerable (S2S3) in Georgia. This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of moderate concern.

POPULATION SIZE AND DISTRIBUTION

The “Atlantic” Highfin Carpsucker occurs on the Atlantic Slope from the Cape Fear River in North Carolina to the Altamaha River in Georgia (Rohde et al. 2009). In South Carolina, the Highfin Carpsucker occurs in the Santee basin (known from the Tyger, Broad and Congaree Rivers and Lake Marion) and the Savannah River. SCDNR staff collected this species in lower

Twelvemile Creek, a tributary of Lake Hartwell in the upper Savannah River basin, in 2012 and subsequent years, representing a population there. Despite being known from relatively few, now decades-old records in the North Carolina section of the Great Pee Dee River below Blewett Falls Dam (Tracy et al. 2024), there are no records from the South Carolina portion of the river (Rohde et al. 2009).

In South Carolina, this species was observed in 0.1% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023. There appear to be healthy populations with recruitment in the Broad River, Congaree River, and Savannah River, although it is still relatively uncommon compared with most other catostomids in these rivers. Based on recent work in North Carolina, the "Atlantic" Highfin Carpsucker is presumed to have been extirpated from the Great Pee Dee River (or exists at nearly undetectable levels and is extremely close to extirpation) (Tracy et al. 2020; B. Jones, NCWRC, pers. comm. 2024). Extensive sampling for suckers in the section of the Great Pee Dee River downstream of Blewett Falls Dam in recent years has failed to yield this species (B. Jones, NCWRC, pers. comm. 2024). In the Cape Fear River, North Carolina, this species was last recorded in the mid-1990s despite targeted sampling in recent decades; it is also presumed to be extirpated from this river (B. Jones, NCWRC, pers. comm. 2024). Preservation of populations in the Santee and Savannah River basins is extremely important to the global preservation of the species given its likely extirpation from the Cape Fear and Pee Dee rivers.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The "Atlantic" Highfin Carpsucker inhabits small to large rivers in areas with moderate or swift current over firm sand and gravel substrate (Robison and Buchanan 1988; Etnier and Starnes 1993; Pflieger 1997; Rohde et al. 2009). In standardized sampling covering streams to small rivers of South Carolina, this species exhibited its highest frequency of occurrence (5.6%) and highest average relative abundance (0.03%) in upland small rivers (watershed area 300 – 2,000 km^2) of the Santee River basin, and it is also found in larger rivers (for which standardized data was not available). *Carpiodes* suckers spawn in slow current and pools, with eggs deposited on firm gravel (Warren and Burr 2014 and sources therein).

CHALLENGES

This species is susceptible to the same pervasive types of anthropogenic habitat alteration and fragmentation affecting other large riverine catostomids (Cooke et al. 2005), including the construction and operation of dams and impoundments, sedimentation of important foraging and spawning habitats, alteration of hydrologic regimes, and introduction of non-native species. Among the *Carpiodes* suckers, the Highfin Carpsucker has been regarded as the most sensitive to anthropogenic alteration and impoundment of riverine habitats (Robison and Buchanan 1988; Etnier and Starnes 1993; Pflieger 1997; Marcy et al. 2005), with associated effects implicated in its decline in portions of the range (Smith 2002; Boschung and Mayden 2004). During unsuccessful searches for "Atlantic" Highfin Carpsuckers in the Cape Fear River, North Carolina, abundant non-native Flathead Catfish and Blue Catfish were documented in the habitats being targeted for this carpsucker (B. Jones, NCWRC, pers. comm. 2024).

CONSERVATION ACCOMPLISHMENTS

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

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- Epstein, J.M., W.E. Pine III, C.M. Romagosa, M.C. Scott, C.T. Phillips, C.A. Marion, and B. Baiser. 2018. State- and Regional-Scale Patterns and Drivers of Freshwater Fish Functional Diversity in the Southeastern USA. Transactions of the American Fisheries Society. 147:1179-1198. https://doi.org/10.1002/tafs.10110

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna.

CONSERVATION RECOMMENDATIONS

- Complete work on genetic relationships of existing wild populations of the Highfin Carpsucker.
- Identify and protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this and other species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Banded Killifish

Fundulus diaphanus



Photo: NCFishes.com

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DESCRIPTION

Taxonomy and Basic Description

The Banded Killifish is a member of the topminnow family (Fundulidae) and one of 38 described species of the genus *Fundulus* (Page et al. 2023), many of which occur predominantly in brackish or estuarine waters. As of 2024, genetic investigations are in progress and suggest the form occurring in the Waccamaw River in South Carolina may be distinct from other populations along the Atlantic drainages and other portions of its range (F. Rohde, pers. comm. 2024). It is closely related to and probably evolved from the Waccamaw Killifish (*F. waccamensis*), endemic to Lake Waccamaw in southeastern North Carolina (Rohde et al. 2009).

The Banded Killifish reaches a length of 130 mm (5.1 in.). The fundulids are commonly used as bait (Jenkins and Burkhead 1994) and are important for mosquito control (Rosen 1973). Hobbyists also keep many members of the family in aquaria. The Banded Killifish is distinguished from others in the genus by a more elongate body, longer and more flattened snout, small scales and numerous narrow bars. Bars are darker than the background color in females and silvery in males (Rohde et al. 1994).

Status

The Banded Killifish is considered secure or apparently secure (G5) throughout most of its global range (NatureServe 2024). In locations on the fringes of its range, it is classified as critically imperiled (S1) in South Carolina and South Dakota, and imperiled (S2) in Iowa and Manitoba (NatureServe 2024). The Banded Killifish is considered apparently secure (S4) in North Carolina.

POPULATION SIZE AND DISTRIBUTION

Broadly, the Banded Killifish is widely distributed along the Atlantic Slope from the Waccamaw River in South Carolina to the Canadian Maritime Provinces and Newfoundland; St. Lawrence, Great Lakes, and Mississippi River Basins from Quebec to Manitoba; and south to southern Pennsylvania, northern Illinois, and northeastern Nebraska (Page and Burr 1991). However, the subspecies *F. d. diaphanus* dominates in Atlantic slope drainages and *F. d. menona* in the remainder of its range, with the exception of the St. Lawrence and Lake Erie drainages where the

two subspecies integrate. In South Carolina, the Banded Killifish occurs only in the Waccamaw and Sampit Rivers (Rohde et al. 2009). This species is common to abundant throughout much of its range; however, on the southern fringe of its global range in the Waccamaw River drainage, it is by all indications relatively uncommon. This species was not observed in any SCDNR standardized stream and river sampling over the past 20 years, and four individuals collected in the Waccamaw River by a Coastal Carolina University ichthyology class (D. Crane, Coastal Carolina University, pers. comm.) represent the only known recent observations of this species in its native range in the state.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Banded Killifish can survive in a wide range of salinities, from fresh water to estuaries with salinity as high as 20 ppt but reside almost exclusively in fresh water (Warren and Burr 2020). It inhabits quiet waters of lakes, ponds, and sluggish streams, usually over a sand, gravel, or detritus-covered bottom where there are patches of submerged aquatic plants. Schools of these fish tend to stay in shallows in the summer (NatureServe 2024).

CHALLENGES

Challenges to this species are similar to those for other aquatic fauna and include alterations in channel morphology and flow, point and nonpoint source pollution and sedimentation. Based on the indications that the Waccamaw River form of this species may be genetically distinct from other populations, this form represents an endemic and highly unique component of the state's aquatic biodiversity. Its apparently low abundance and elusiveness represent a fundamental challenge in establishing a baseline for evaluating abundance and monitoring trends. The restricted range in a coastal river furthermore places this species in an area of rapid development and habitat alteration. For example, flow control measures are commonly employed to facilitate development along coastal river corridors, which can alter the natural flow regime of littoral habitats, both reducing habitat availability/suitability as well as the fitness of inhabitant species (Farly et al. 2021).

CONSERVATION ACCOMPLISHMENTS

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

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restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Identify lotic and lentic habitats with healthy populations and intact critical habitat in the Waccamaw and Sampit River systems. Protect these areas, once identified.

- Protect critical habitats from future development and further habitat degradation by following Best Management Practices (BMPs) as well as protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators on the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Banded Sunfish

Enneacanthus obesus

Contributors (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]



Photo: NCFishes.com

DESCRIPTION

Taxonomy and Basic Description

The Banded Sunfish is a member of the sunfish family (Centrarchidae), which is currently represented by 41 described North American species including many popular sport fishes (Page et al. 2023). *Enneacanthus* sunfishes, all three of which are found in South Carolina, are small, laterally compressed sunfishes collectively distributed on the Atlantic and Gulf coastal plains from New Hampshire to Mississippi (Sweeney 1972; Darden 2008). Among the *Enneacanthus* species, the Banded Sunfish is most closely related to the Bluespotted Sunfish (*E. gloriosus*) and studies have shown evidence of a relatively recent divergence from *E. gloriosus* (Darden 2008; Kie 2011).

Adult Banded Sunfishes are small and stocky, ranging in total length from 50 to 95 mm (2.0 to 3.8 in.) (Rohde et al. 2009). The body is olive-brown to olive-green, with 5 to 8 dark vertical bars on the side and many small, irregularly-placed iridescent spots on the side and fins. Typically, there is a continuous iridescent bluish crescent under the eye and a large black spot (larger than the pupil) on the operculum (Rohde et al. 2009).

Status

The Banded Sunfish is considered secure (G5) on a global scale and is currently ranked vulnerable (S3) in South Carolina (NatureServe 2024). This species is considered vulnerable (S3) or more highly imperiled (S2 or S1) in all states within its range except Georgia (S4), Maryland (S3S4), Massachusetts (S4) and New Jersey (S4) (NatureServe 2024). It is considered State Significantly Rare in North Carolina (Tracy et al. 2020) and was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of moderate concern.

POPULATION SIZE AND DISTRIBUTION

The Banded Sunfish is found on the Atlantic Coastal Plain from southern New Hampshire to north-central Florida and along the Gulf Slope to eastern Alabama (Rohde et al. 2009). It is found across all of South Carolina's Coastal Plain drainages, occurring most widely in the mid to outer (lower-elevation) coastal plain (compared with Blackbanded Sunfish, which associates primarily with the inner coastal plain) (Rohde et al. 2009; Marion et al. 2015; SCDNR data). This species is relatively uncommon (Rohde et al. 2009); based on standardized sampling in

South Carolina, frequency of occurrence and relative abundance of Banded Sunfish are both almost five times lower than those of its congener on the outer coastal plain, the Bluespotted Sunfish (*E. gloriosus*). In South Carolina, this species was observed in 3.8% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

Banded Sunfish occur primarily in sluggish Coastal Plain streams and swamps as well as vegetated backwaters of lakes and ponds, often over silt or sand (Rohde et al. 2009). It is most strongly associated with streams exhibiting low current velocity (Marion et al. 2015) and, like the other *Enneacanthus*, is most often found near aquatic vegetation (Ciccotto 2011). This species has also been collected in tidally-influenced coastal rivers (SCDNR data). Natural watershed forest and wetland cover is important in maintaining the dependent water chemistry required by this species, which is characterized by low pH and high dissolved organic carbon (Ciccotto 2011). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (13.7%) and average relative abundance (0.8%) in small streams (watershed area 0-15 km^2) of the outer coastal plain.

CHALLENGES

Although it appears to have a wide range across the Coastal Plain of South Carolina, the Banded Sunfish generally occurs in low abundance where it is found. Anthropogenic alteration of natural landscapes for development or agriculture, siltation, and hydrologic alterations such as channelization and construction of impoundments threaten this species. The conversion of native forest and wetland cover in the watershed and riparian zone for development or poorly planned agriculture reduces in numerous ways the suitability of low-gradient coastal plain habitats for this species and its ecological associates. The physicochemical habitat template for which this species and other lowland coastal plain specialists are evolved is dependent on intact forested watersheds with functional wetlands (Ciccotto 2011). Mature forest and riparian vegetation are important sources of large woody debris in Coastal Plain streams, which provides critical habitat for many endemic southern Atlantic coastal plain species including the Banded Sunfish (Marion 2008). Alteration of naturally sluggish lowland swamps and streams into channelized, shallow drainage ditches with unnaturally high current velocities greatly reduces the suitability of habitat this species and other “non-fluvial” specialists (Marion et al. 2015). Furthermore, the introduction of contaminants from agricultural runoff (exacerbated by removal of riparian vegetation) can disrupt physiological function in such settings and biological assemblages (Breitmeyer et al. 2022).

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

    - Marion, C.A., M.C. Scott, and K.M. Kubach. 2015. Multiscale environmental influences on fish assemblage structure of South Atlantic coastal plain streams. Transactions of the American Fisheries Society. 144(5):1040-1057.

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    - Mruzek, J.L, L.M. Bower, M.C. Scott, K. Kubach, and B.K. Peoples. *In review* 2024. Relative influence of flow regime, natural and anthropogenic environment on dimensions of local fish diversity. Hydrobiologia.

- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) as well as protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Bannerfin Shiner
Cyprinella leedsi

Contributors (2005): David Allen, Chris Thomason, and Jason Bettinger [SCDNR]
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Photo: Fred Rohde

DESCRIPTION

Taxonomy and Basic Description

The Bannerfin Shiner belongs to the minnow family (Leuciscidae), the most speciose family of freshwater fishes in North America with at least 323 described taxa of predominantly small (<150 mm) and slender fishes (Warren and Burr 2014; Page et al. 2023). Following the recent revision of the formerly large genus *Notropis* (Stout et al. 2022), *Cyprinella* is currently the most diverse genus of North American minnows, with 29 described species (Page et al. 2023). The Bannerfin Shiner is one of eight described plus one undescribed (as of 2024) species of *Cyprinella* in South Carolina.

Members of the genus *Cyprinella* are distinguished from other leuciscids by their diamond-shaped scales and black pigmentation in the dorsal fin membranes (Rohde et al. 1994). Bannerfin Shiner can be distinguished from other *Cyprinella* by the position of the black blotch, which occurs on the anterior portion of the dorsal fin. Bannerfin Shiners are deep-bodied, slender fish with a flattened underside and long, rounded snout. The back is olive-tan with a dark middorsal stripe; the belly is white and the flanks are silvery gray (with a purplish iridescence in breeding males). Bannerfin Shiners reach lengths of 100 mm (3.9 in.; Rohde et al. 1994).

Status

The Bannerfin Shiner is considered apparently secure (G4) globally but is considered vulnerable (S3) in South Carolina (NatureServe 2024). Bannerfin Shiner populations appear to be stable (Warren et al. 2000; NatureServe 2024), although it is uncommon and sometimes rare (Page and Burr 1991; NatureServe 2024). Collections have been made at numerous sites throughout its limited range. The Bannerfin Shiner is considered vulnerable (S3) in Georgia and Florida.

POPULATION SIZE AND DISTRIBUTION

The Bannerfin Shiner occurs in Atlantic slope drainages from the Edisto River, South Carolina to the Altamaha River, Georgia (NatureServe 2024). It also occurs in the gulf slope drainages of the Ochlockonee and Suwanee Rivers in Georgia and Florida (Marcy et al. 2005). In South Carolina, the species is restricted to the coastal plain ecoregion in the Edisto and Savannah River drainages

(Rohde et al. 2009). This species was observed in 0.3% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Bannerfin Shiner inhabits channels of medium- to large-sized, sand-bottomed, coastal plain rivers. Schools often gather in eddies behind woody debris or other structure. They rarely enter tributary streams farther upstream than the modern floodplain (Marcy et al. 2005). As with other non-barbeled *Cyprinella* species, the Bannerfin Shiner is a crevice spawner, depositing eggs in crevices of logs and rocks in a territory defended by the male over an extended spring-summer breeding period (Gale and Buynak 1978; Rohde et al 1994; Rohde et al. 2009). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (15.4%) and average relative abundance (0.1%) in small coastal plain rivers (watershed area 300-2000 km^2) of Sand Hills (fluvial) character.

CHALLENGES

The Bannerfin Shiner, like many other specialized stream fishes, is susceptible to an array of acute and cumulative impacts from anthropogenic alterations to the watershed, riparian zone and streams and rivers directly. These include deforestation and conversion of natural land cover for development and agriculture with resulting sedimentation and non-point source pollution, hydrologic alterations, and habitat fragmentation from dams and reservoirs. The breeding behavior of the non-barbeled *Cyprinella* makes this group particularly vulnerable to impacts from both suspended and deposited sediment. Because the breeding process is dependent on visual cues (extended display and territorial defense period) as well as clean crevices for egg deposition and larval development, suspended sediment (increased turbidity) and deposited sediment has been shown to delay or inhibit spawning success in fishes of this genus (Hubbs and Echelle 1972; Burkhead and Jelks 2001; Warren and Burr 2014).

CONSERVATION ACCOMPLISHMENTS

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

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and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.

- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Identify streams and rivers with healthy Bannerfin Shiner populations and intact critical habitat in the Savannah River drainage below the Fall Line, the Edisto River System, and the ACE basin. Protect these areas, once identified.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices as well as protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.

- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Educate aquarists as to the adverse impacts of removing fish from the wild.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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“Bartram’s” Bass

Micropterus sp. cf. *coosae*



Photo: NCFishes.com

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DESCRIPTION

Taxonomy and Basic Description

Bartram’s Bass is a member of the family Centrarchidae. Bartram’s Bass represents one of only 3 native black basses in South Carolina; both Smallmouth and Alabama Bass (*Micropterus dolomieu* and *M. henshalli*, respectively) are introduced in this state. The closest relative of the Bartram’s Bass is the Redeye Bass (*M. coosae*), which is endemic to the Mobile River system (Lee et al. 1980). Historically, Bartram’s Bass was considered as another population of Redeye Bass and was referred to under that name, until taxonomic revisions of this complex recognized new species across the Mobile River basin and the Chattahoochee drainage, from what was part of the original *M. coosae* range (Baker et al. 2013). The Savannah River basin represents a distinct genetic lineage as well, indicating separate species status with the suggested common name of “Bartram’s Bass” (Freeman et al. 2015). Further, Oswald et al. (2015) found significant genetic diversity within the Savannah and identified multiple management units. The species has yet to be formally described, but final work is now being performed to describe South Carolina populations as “Bartram’s” Bass.

Bartram’s Bass are similar in structural features and more closely related to Alabama Bass than to Smallmouth Bass. However, Bartram’s Bass are known to hybridize with both species (Turner and Bulow 1989; Pierce and Van Den Avyle 1997; Philipp et al. 2002). In native stream habitat, Bartram’s Bass range in length from 144 to 381 mm (5.6 to 15 in.; Rohde et al. 2009); however, where found in the Savannah River impoundments, Bartram’s Bass often exceed this size range. Bartram’s Bass are typically olivaceous to bronze dorsally with black blotching or mottling. The jaw extends even with the back of the eye. Laterally, Bartram’s Bass have black vertical bars or blotches, which are not connected. Bartram’s Bass typically have eleven or fewer lateral bars or blotches, whereas Alabama Bass generally have a more or less continuous lateral stripe, or it is broken up into more than eleven bars or blotches. Bartram’s Bass have ventro-lateral streaks that are typically darker and more irregular than those in Spotted or Alabama Basses. A white margin on the upper and lower tips of the caudal fin and often along the margin of the anal fin is a key characteristic. This margin may be less obvious in older specimens. The anal fin typically has dark pigmentation. About 60% of Bartram’s Bass from the upper Savannah River basin possess a tooth patch on the tongue (SCDNR unpublished data).

Status

The Bartram's Bass was listed as stable in Warren et al. (2000), before the risk of introgressive hybridization was recognized, and is currently globally unranked (GNR; NatureServe 2024). The Bartram's Bass is ranked critically imperiled (S1) in South Carolina (NatureServe 2024); studies have shown that South Carolina populations are imperiled due to introgressive hybridization with nonnative black bass species, primarily Alabama bass (Bangs et al. 2018, Peoples et al. 2021). Hybrids have also been collected from stream and river populations throughout the upper and middle Savannah Basin though their impact is not yet fully understood (Leitner et al. 2015, Peoples et al. 2021). In Georgia, Bartram's Bass are considered vulnerable (S3) while in North Carolina they are considered critically imperiled (S1), largely due to their limited range (NatureServe 2024). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of very high concern.

POPULATION SIZE AND DISTRIBUTION

The native range of the originally described Redeye Bass includes the Mobile Basin above the Fall Line and the upper Chattahoochee, Altamaha and Savannah drainages (Etnier 1993; Rohde et al. 2009; Lee et al. 1980), although—as noted above—populations outside of the Mobile including the Savannah system have been shown to be distinct. The Bartram's Bass is native to the Savannah River basin of Georgia, South Carolina and a small portion of North Carolina. It is primarily found in the uplands, or the upper half of the Savannah River basin, but is also present at and just below the Fall Line in the main stem Savannah River (Rohde et al. 2009). The Chattooga River, once being a tributary to the Chattahoochee system (Ross 1970), likely explains the presence of Bartram's Bass in the Savannah drainage. Ramsey (1973) considered all populations outside this range to be a result of stocking. Redeye Bass have also been introduced in Tennessee, Kentucky, California and Puerto Rico (Lee et al. 1980; Etnier and Starnes 1993).

The Bartram's Bass occurs in the Santee drainage in South Carolina as well. In the Saluda River it is found primarily in the river's mainstem and tributaries below the Saluda Dam, with records dating to the 1960s (SCDNR unpublished data). One report of Bartram's Bass from a tributary upstream of Saluda Dam is documented in the Clemson University's museum collection. The species also occurs in the Broad River, including the Enoree and Pacolet Rivers. Their patchy distribution and apparently recent spread would tend to support taxonomists' opinions that Bartram's Bass are not native to the Santee River system, but this is debatable and currently under study.

Bartram's Bass are sensitive to habitat alterations in their native flowing-water systems, and this is exacerbated by presence of nonnative bass (Peoples et al. 2021). Bartram's Bass can be locally common in their upper Savannah range (Peoples et al. 2021; SCDNR unpublished data) but concern remains over unknown dynamics of nonnative invasion and hybridization throughout the system. The research over the last decade has included a National Fish & Wildlife Foundation (NFWF) grant through the Southeast Aquatic Resources Partnership and a Competitive State Wildlife Grant (with GADNR and Clemson University as partners). Results from 2017-2018

collections documented an expansion of the Alabama Bass genome widely into lotic habitats across the upper Savannah range, with 45% of sites where bass were collected being occupied by Alabama Bass or their hybrids, and the discovery of hybrid nesting and progeny production *in situ* (Judson et al. 2021, Peoples et al. 2021).

Even in some tributaries where non-native bass are not yet known, the persistence of Bartram's Bass may be uncertain. In several drainages in which historical records of Bartram's Bass exist, recent sampling efforts in what seem outwardly suitable habitats have not been successful in relocating any individuals. For example, in the upper Stevens Creek/Turkey Creek system in which numerous collection localities date to the 1970s, recent sampling efforts have failed to yield Bartram's Bass in this portion of the drainage. Similarly, in the Little River system (South Carolina) draining to Lake Thurmond, sampling of the lone historic collection locality were unproductive; numerous samples throughout the system over the past 18 years have also been unsuccessful in confirming its persistence. Searches of the best remaining large shoal habitats in many tributaries have not been successful in locating the species. It remains to be determined whether the lack of detection in such cases reflects actual extirpation or very low densities. Nevertheless, numerous populations of pure or nearly pure Bartram's Bass continue to persist in largely disjunct tributaries across the basin, with nearly 60% of sites sampled in 2017-2018 harboring pure Bartram's (Peoples et al. 2021).

Although Redeye Bass reportedly perform poorly in impoundments within their native range, Bartram's Bass thrived in the large oligotrophic and mesotrophic reservoirs of the upper Savannah River system prior to the introduction of Alabama Bass (Barwick and Moore 1983; Barwick et al. 2006; Oswald et al. 2015). However, recent studies show the Bartram's Bass has since likely been eliminated from Lakes Keowee and Russell via introgressive hybridization. The species also declined by more than 60% in Lakes Jocassee and Hartwell over the 6-year period from 2004 –2010 (Bangs et al. 2018). Recent collections in 2021-22 have failed to document presence of genetically pure Bartram's Bass in Lakes Hartwell and Jocassee (SCDNR unpublished data).

Current work continues to focus on what effects introduced black bass will have on Bartram's Bass in their native running-water habitats – mainstem Savannah and tributary streams. Many of the tributaries to the lakes do have barriers to upstream fish movement, which may protect stream populations of Bartram's Bass from invasion of Alabama Bass or their hybrids to some extent, although angler-assisted movement of nonnative bass remains a serious issue. Tagging and telemetry work on Eastatoee Creek showed limited movement upstream by Alabama Bass and their hybrids from their Lake Keowee source population, with refugia for pure Bartram's Bass in the upper reaches of the creek (Zumwalt 2023). The dynamics of this situation in terms of active invasion versus segregation remains to be seen. This species was observed in 3.9% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

Bartram's Bass occur in a variety of habitats in South Carolina from fast flowing, high-gradient streams of the Blue Ridge and Upper Piedmont Ecoregions to lower-gradient streams and the Savannah River just below the Fall Line. It is found in mid-sized streams to large rivers and

reservoirs; the Savannah River mainstem below Stevens Creek Dam to Augusta Shoals may be one of the strongest populations extant, and robust populations also occur in the Chattooga and Chauga Rivers. This species exhibits its highest densities in large, high-gradient shoal habitats characterized by bedrock and boulders producing heterogeneous pockets and pools. Outside of rocky shoals, in lower-gradient reaches, woody debris is particularly important in creating habitat heterogeneity and providing cover for this species. In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (45.5%) in upland large streams (watershed area 100-300 km²) and highest average relative abundance (1.5%) in upland small rivers (watershed area 300-2000 km²) of the Savannah River basin.

CHALLENGES

Bartram's Bass is primarily threatened by the introduction and spread of nonnative Alabama Bass (and to a lesser extent Smallmouth Bass) as well as habitat alteration. Recent results suggest that persistence of Bartram's Bass is at serious risk, with populations in most river systems being affected by hybridization and others being potentially on the verge of colonization by nonnative species. Hybridization between endemic Bartram's Bass and invasive Alabama Bass is widespread throughout the upper Savannah basin with models indicating that prevalence of hybridization is related to habitat disturbance and distance from the reservoirs which serve as source pools for Alabama Bass (Bangs et al. 2018; Peoples et al. 2021). Evidence suggests that maintaining natural land cover (forest, in this context) at both the watershed and local scales will be important for maintaining integrity of Bartram's Bass populations, as model results suggest occurrence of pure Bartram's Bass is sensitive to even low levels of local development (Peoples et al. 2021). As such, working with local authorities and stakeholders (e.g. counties, municipalities, and landowners) to preserve and restore natural riparian land cover in developing regions may help maintain existing populations of pure Bartram's Bass. In addition, it will be important to work with resource managers, land trusts, mitigation banks, and other nongovernmental organizations to preserve and enhance natural land cover across the landscape regardless of proximity to reservoirs.

CONSERVATION ACCOMPLISHMENTS

Since the 2015 SWAP the Bartram's Bass has been the subject of some of the most intensive research and conservation efforts of any freshwater fish in SC, save perhaps the Robust Redhorse. The filling of information gaps with regard to the extent of hybridization in the Savannah Basin allows the informed use of resources to further the conservation of this species. Funding from NFWF and the U.S. Fish & Wildlife Service has been secured to formally describe the species, establish more in-depth baseline genetic, distributional, and habitat data on tributaries in the upper Savannah, to identify genetically pure populations, characterize movement, and assess protections provided headwater populations by in-place barriers. Results will guide prioritization of sub-watersheds for further conservation actions.

A microsatellite panel to determine genetic integrity of Bartram's Bass was developed by the SCDNR Population Genetics Laboratory in Ft. Johnson that utilizes a Beckman Coulter CEQ Genetic Analysis System at 16 loci (*Msaf27, Msaf05, Msaf08, Msaf22, Msaf32, Msaf17, Msaf24, Msaf09, Msaf13, Msaf25, Msaf31, Msaf06, Msaf10, Msaf29, Msaf12, Msaf28*). All tissue

samples are genetically analyzed for species identification and degree of hybridization following a standardized protocol for the clustering program STRUCTURE. This protocol involves comparing unknown sample genotypes to the genotypes of known black bass species referred to as a reference set. Reference set samples were identified and provided by Florida FWC, except for Bartram's Redeye Bass samples which were provided and verified by SCDNR Freshwater Fisheries staff during protocol optimization in the SCDNR Population Genetics Laboratory. Detailed information on this procedure and the reference set are included in Judson et al. (2021). A thorough population genetic health analysis from tissues across the range is scheduled to be completed in 2024, which will give information on genetic structure and indicate sub-population diversity which must be managed for.

Efforts to establish methods to culture Bartram's Bass were initiated in 2020, when wild broodstock were collected from Stevens Creek (n=23). Genetic analysis indicated that all fish were genetically pure, but that the population suffered from inbreeding due to its location between downstream and upstream dams on the creek which severely limited geneflow beyond that reach. The individuals had good survival and growth over two years but no successful reproduction ensued. In 2022 there was a total mortality event in which an external predator is suspected of accessing the holding area. Plans are to secure additional wild broodstock from a healthy population and continue with developing culture methods prior to consideration of potential conservation stocking strategies.

Outreach and education efforts have included media engagement in the Augusta-Central Savannah River Area local news (Hale 2021) and through partnership with Clemson University (Bradley 2018) to highlight the existence and conservation challenges facing this species. Numerous angling-centered postings on social media and the Internet have cropped up since the last SWAP, indicating that awareness of this endemic fish is on the rise.

Bartram's Bass habitat is primarily protected by land ownership patterns in some key habitats including the Chattooga River, Chauga River, Eastatoee River, and Stevens Creek. However, the amount of unprotected habitat for this species far exceeds protected habitat.

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and "ecobasin" (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

In addition to the targeted collections for Bartram's Bass, following and building upon the dataset amassed from the South Carolina Stream Assessment SWG study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating

future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- Formal description of Bartram's Bass is expected to be published in 2024 or 2025.
- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use available data to populate decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity
- Assess spatial and temporal patterns of introgression of nonnative genes in lotic populations.
- Identify genetically pure tributary populations of Bartram's bass.
- Consider identified management units and strive to protect the full complement of genetic diversity among Bartram's Bass populations within the Savannah Basin.
- Describe life history and habitat requirements of Bartram's Bass.
- Inventory and monitor water quality and habitat in Bartram's Bass streams to identify water quality threats as well as habitat needs and deficiencies.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices (BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Monitor the success of Bartram's Bass habitat protection and advocate for additional protection through the environmental permit review process.
- Conduct an education and outreach campaign to raise awareness of the impacts of illegal introductions of nonnative species.
- Promote Bartram's Bass as a sport fishery in larger streams to raise awareness of the species.

MEASURES OF SUCCESS

Formal description of the species will significantly enhance the awareness of the existence and conservation challenges facing Bartram's Bass. Identification of genetically pure populations that can benefit from conservation measures will be a key component in the protection of this species. Establishing refugia for pure Bartram's Bass populations above barriers that may deter immigration of nonnative black basses would be a benefit. Determining the distribution, life history, habitat needs, and population structure and trends would represent a measure of success for this species. Methods that protect water quality and aquatic habitats, such as maintenance and restoration of native forest cover, are also protective of this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the

effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Blackbanded Sunfish

Enneacanthus chaetodon



Photo: NCFishes.com

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DESCRIPTION

Taxonomy and Basic Description

The Blackbanded Sunfish is a member of the sunfish family (Centrarchidae), which is currently represented by 41 described North American species including many popular sport fishes (Page et al. 2023). *Enneacanthus* sunfishes, all three of which are found in South Carolina, are small, laterally compressed sunfishes collectively distributed on the Atlantic and Gulf coastal plains from New Hampshire to Mississippi (Sweeney 1972; Darden 2008).

This species is a small, deep-bodied, extremely compressed fish with a small mouth and 6 black bars on a silvery body. The caudal fin is rounded. The anterior edges of the pelvic fins are pink to red (Rohde et al. 1994, 2009). It reaches an adult size of 50 to 82 mm (2 to 3.2 inches) (Rohde et al. 1994).

Status

The Blackbanded Sunfish is considered apparently secure to vulnerable (G3G4) globally. It is ranked imperiled to vulnerable (S2S3) in South Carolina but is considered critically imperiled (S1) or imperiled (S2) in the majority of other jurisdictions (NatureServe 2024). This species is presumed extirpated (SX) from Pennsylvania and is considered critically imperiled (S1) in Georgia, Virginia and Maryland (NatureServe 2024), where only one known, isolated population remains in the entire Chesapeake basin (Cessna et al. 2023). It is a State Significantly Rare species in North Carolina (Tracy et al. 2020). Additionally, the Blackbanded Sunfish was considered vulnerable in a recent assessment of North American freshwater fishes (Jelks et al. 2008) and was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of high concern. The imperilment of this species represents documented decline rather than a naturally disjunct and isolated distribution (Kilian et al. 2009; Cessna et al. 2023). In many areas such as Maryland, it has declined to a level warranting the development of captive propagation efforts to support reintroduction or augmentation strategies (Cessna et al. 2023; Murray et al. 2023).

POPULATION SIZE AND DISTRIBUTION

The Blackbanded Sunfish has a relatively wide but patchy distribution along the Atlantic coastal plain from New Jersey to Florida, as well as some Gulf slope drainages in Georgia and Florida (Lee et al. 1980; Darden 2008; Rohde et al. 2009). Its range is unusually fragmented; the species is often missing from areas where appropriate habitat is seemingly present (Rohde et al. 1994).

In South Carolina, the Blackbanded Sunfish is found predominantly in the inner coastal plain (especially the Sand Hills) across all of the state's river basins (Rohde et al. 2009). Interestingly, despite being found in the South Carolina portion of the Savannah River basin, at this time it is not known to occur on the Georgia side of the basin or elsewhere in the Sand Hills ecoregion of Georgia. By comparison with its status in most other states, the Blackbanded Sunfish appears to be relatively secure in South Carolina in appropriate habitat. Results from environmental DNA (eDNA) sample concentrations and traditional sampling catch per unit effort indicated that Blackbanded Sunfish populations in South Carolina were both more widespread and abundant where present than those in Georgia (Darden et al. 2019). This species was observed in 1.0% of over 900 standardized statewide stream and river assessment samples across South Carolina between 2006 and 2023; however, these studies did not include swamps, backwaters and beaver impoundments, which represent primary habitats for this species.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Blackbanded Sunfish is found in quiet, densely vegetated margins of tannin-stained swamps, sloughs, backwaters, streams and rivers with sand or mud bottoms (Shute et al. 1981; Jenkins and Burkhead 1994; Rohde et al. 2009). It is often abundant in artificial mill ponds in the Sand Hills with dense aquatic vegetation. Blackbanded Sunfish habitats in South Carolina are typically very acidic, often exhibiting pH values below 5.0 and sometimes below 4.0 (Darden et al. 2019). This species associates with areas of low current velocity and high aquatic vegetation coverage (Cessna et al. 2022); in a recent study in South Carolina, sites in which Blackbanded Sunfish was present had higher mean percent coverage of floating/emergent (5.9%) and submerged (45.2%) aquatic vegetation than those in which the species was not detected (3.7% and 27.3%, respectively) (Darden et al. 2019). Although most abundant in swamps and backwater areas in association with dense aquatic vegetation, it has been found in low numbers near filamentous root matter and similar cover along the banks of streams and rivers. In the lotic systems of the Middle Savannah River Basin, adults seasonally migrate into beaver ponds to spawn (Marcy et al. 2005); these habitats are also important nursery areas (Snodgrass and Meffe 1999). The estimated lifespan is 3-4 years (Rohde et al. 2009; Cessna et al. 2024). In standardized sampling covering streams to small rivers of South Carolina, this species exhibited its highest frequency of occurrence (7.1%) in medium streams (watershed area 15-100 km^2) of the Sand Hills and highest average relative abundance (0.1%) in large streams (watershed area 100-300 km^2) of the Sand Hills.

CHALLENGES

By comparison with its status in most other parts of its range, the Blackbanded Sunfish in South Carolina appears to be relatively widespread in appropriate habitat and, in certain places, abundant. However, the range-wide trend of decline and imperilment for this species is concerning and signals risk for the integrity of its populations in the state. In the adjacent and

ecologically similar coastal plain of North Carolina, the Blackbanded Sunfish is considered State Significantly Rare (Tracy et al. 2020).

The conversion of native forest and wetland cover in the watershed and riparian zone for development or poorly planned agriculture reduces in numerous ways the suitability of inner coastal plain habitats for this species and its ecological associates. Its narrow habitat requirements make it susceptible to physical and chemical changes in habitat resulting from the alteration of natural land cover. The presence of sensitive *Enneacanthus* sunfishes has been shown to be related to high amounts of forest and wetland cover in the watershed (Ciccotto 2011). This species is adversely affected by the practice of draining swamps as well as by pesticide contamination (Burkhead and Jenkins 1991).

Decline, fragmentation and isolation of Blackbanded Sunfish populations has contributed to low population genetic diversity and associated complications such as inbreeding (Kercher 2005; Darden et al. 2019; Cessna et al. 2022). The relatively low genetic diversity exhibited by South Carolina populations (Darden et al. 2019), which by all indications represent a stronghold for the species compared with most other states, suggests that fragmentation may already be occurring. This species inherently exhibits low movement and dispersal with resulting low population genetic diversity (Darden et al. 2019), placing it at heightened risk for crossing the threshold of genetic decline due to fragmentation by physical barriers as well as habitat degradation. Additionally, the potential for this species to be collected for the aquaria trade could result in adverse impacts to isolated populations (Burkhead and Jenkins 1991).

The elusiveness of this species and resulting data deficiency represent a fundamental challenge in its conservation. As illustrated in Georgia (Darden et al. 2019), especially where Blackbanded Sunfish densities are low, the species can be extremely difficult to detect using traditional sampling methods, confounding efforts to identify and protect critical areas.

CONSERVATION ACCOMPLISHMENTS

The development and implementation of an environmental (eDNA) tool (Darden et al. 2019) has enabled more effective detection and conservation of Blackbanded Sunfish. This tool is useful for detecting previously unknown populations, confirming the persistence of populations difficult to detect using traditional sampling methods, and evaluating habitat factors important in supporting Blackbanded Sunfish. For example, in Georgia, where only three localized populations were known as of 2015, this eDNA tool led to the discovery of Blackbanded Sunfish at four new sites and confirmed the existence of another population that was thought to have been extirpated. In South Carolina, the eDNA tool was used to provide a survey of Blackbanded Sunfish status across its range in the state and evaluate habitat and landscape factors influencing its presence, thereby enhancing our understanding of its distribution and abundance to serve as a baseline for future monitoring (given its nearly universal decline elsewhere). Environmental DNA is also being used to identify and monitor Blackbanded Sunfish populations in Virginia (K. Chestnut-Faull and J. Hallacher, pers. comm. 2025).

Results of the State Wildlife Grants collaborative study with Georgia (Darden et al. 2019) were presented at local, regional, and national scientific meetings – including meetings of the

Southern Division of the American Fisheries Society, Southeastern Fishes Council, South Carolina Chapter of the American Fisheries Society, and SC DNR Marine Resources Research Conference. A total of 13 presentations have been shared to date by the project team. Additionally, a project press release was developed and released through both the SCDNR and GADNR media centers. Although we have not published the results from the project yet, we have three manuscripts in preparation including 1) eDNA tool development and optimization, 2) Distribution of *E. chaetodon* in Georgia and South Carolina using both eDNA and traditional survey methods, and 3) Genetic population characterization of *E. chaetodon* in the southeastern US.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.

- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

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- Mruzek, J.L., L.M. Bower, M.C. Scott, K. Kubach, and B.K. Peoples. *In review* 2024. Relative influence of flow regime, natural and anthropogenic environment on dimensions of local fish diversity. Hydrobiologia.

- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

Our project team recommends the following general measures to protect *E. chaetodon* populations:

- Management for native aquatic plant communities by preventing the spread of invasive plant species (e.g., http://stopaquatichitchhikers.org/), preventing run-off of fertilizers that can lead to eutrophication and algae blooms, and avoiding the use of aquatic herbicides in *E. chaetodon* habitat.
- Protection and restoration of water quality through general watershed protection measures, including protection of wetland habitats and riparian buffers and best management practices for forestry and agriculture.
- Protection of water quantity and natural hydrology through water conservation efforts, protection of instream flows, and maintenance of aquatic connectivity. Factors that could negatively affect aquatic connectivity include dams and poorly designed culverts that impede dispersal of aquatic species as well development (i.e., roadways, housing, etc.) that interferes with the inundation of floodplain habitats and wetlands.
- Management for native fish communities by protecting water quality and habitat (see previous three bullets) and preventing the spread of non-native species. Although native sport fishes often co-occur with *E. chaetodon*, we do not recommend stocking sport fishes in the few known populations. Fishing with live fishes or crayfishes as bait should be avoided or carried out using legally harvested native bait species from the local watershed.
- Protection of habitats with yet unknown but potential populations of *E. chaetodon*. Our eDNA tool can be utilized to assess areas with potential populations of *E. chaetodon* as part of the environmental review of projects that could negatively impact habitat, such as large developments and road construction projects.

Conservation recommendations have been provided to State managers in both Georgia and South Carolina. We have also developed an online species profile to share these management recommendations with the general public through the Georgia Biodiversity Portal. The website (link) also includes photographs, a range map, and other biological information. We have also created an online conservation status map (link) that categorizes all occurrences of *E. chaetodon* in South Carolina and Georgia by date of last observation at different spatial scales such as watersheds or stream reaches. This tool also allows users with a password access to fine scale data that is not available to the general public. Additionally, we have created a conservation and management brochure for private landowners near *E. chaetodon* project sites to help promote the awareness of the species and its biology, our project results, and incorporation of the recommendations above into their land management practices (Appendix C). Due to differences in land ownership near project and known locations of *E. chaetodon* between Georgia and South Carolina, we focused the brochure to target South Carolina private landowners. With the reduced number of known *E. chaetodon* locations in Georgia, all landowners are known, and the most significant one is USFWS (OSNWR) who is already managing the swamp for natural ecosystems. The project team has been in direct contact with all private Georgia landowners who have been informed in person about the project and the online data portal.

In addition to the *E. chaetodon*-specific recommendations above, the following general recommendations are beneficial to conservation of aquatic resources.

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop other educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Educate aquarists as to the adverse impacts of removing fish from the wild.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species and others. In the event that more protective BMPs

are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Bluebarred Pygmy Sunfish

Elassoma okatie

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Photo: Fred Rohde

DESCRIPTION

Taxonomy and Basic Description

The Bluebarred Pygmy Sunfish is a member of the small, secretive family Elassomatidae, of which all 7 known species are placed in the genus *Elassoma* (Page et al. 2023). Four species of elassomatids occur in South Carolina. This species and its close relative, the Carolina Pygmy Sunfish (*E. boehlkei*), were not described until 1987 (Rohde and Arndt 1987). Bluebarred Pygmy Sunfish range in length from 24 to 35 mm (0.9 to 1.4 in.). As with other members of the genus *Elassoma,* the Bluebarred Pygmy Sunfish lacks a lateral line, has a relatively large eye, an upturned mouth and a rounded caudal fin. This colorful fish is very similar and closely related to the Carolina Pygmy Sunfish (Sandel et al. 2014), with an alternating series of bright blue and black bars, but the black bars of the Bluebarred Pygmy Sunfish are about three times wider than the blue bars (Rohde et al. 1994), and black bars number 8 to 14 (mode 11) (Rohde et al. 2009). The taxonomic placement of the *Elassoma* remains somewhat uncertain, with some studies suggesting they belong in Centrarchidae rather than a separate family (Near et al. 2012).

Status

Globally, it is considered imperiled (G2) to vulnerable (G3) (NatureServe 2024). While this small sunfish is considered vulnerable to imperilment throughout its range (Warren et al. 2000), it is considered critically imperiled in Georgia (S1) and is critically imperiled to imperiled (S1S2) in South Carolina (NatureServe 2024). In a recent assessment of North American freshwater fishes, the Bluebarred Pygmy Sunfish was considered vulnerable to imperilment (Jelks et al. 2008). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of very high concern.

POPULATION SIZE AND DISTRIBUTION

Bluebarred Pygmy Sunfish are restricted to the lower Savannah River drainage in Georgia and South Carolina and the lower Combahee and Edisto Rivers in South Carolina. The populations within South Carolina are restricted to the coastal plain, occurring most frequently in the Middle

Atlantic Coastal Plain ecoregion. Quattro et al. (2001) observed genetic differences between the Edisto basin populations and those in the New and Savannah basins (Rohde et al. 2009).

Bluebarred Pygmy Sunfish populations are generally uncommon and localized in South Carolina but can be abundant in favorable settings (Page and Burr 1991). Locally, populations experience frequent fluctuations with hydrologic conditions (see HABITAT OR NATURAL COMMUNITY REQUIREMENTS). In spite of this, these populations overall are currently considered stable. Owing to its patchy distribution and preference for other habitat types, this species was only observed in 0.1% of over 900 standardized statewide stream and river assessment samples throughout South Carolina between 2006 and 2023. The species co-occurs in a few watersheds with the Everglades Pygmy Sunfish, but individuals do not tend to share space in close proximity (Sandel & Harris 2007, Rohde et al. 2009). The Bluebarred Pygmy Sunfish has no known coexistence with its closest relative, the Carolina Pygmy Sunfish, in South Carolina (Sandel & Harris 2007, Rohde et al. 2009).

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Bluebarred Pygmy Sunfish inhabits shallow backwaters of streams and rivers, as well as other watercourses with appropriate habitat. It is found in shallow water with abundant submerged and/or emergent vegetation that is rooted in soft, detritus-rich substrate (Rohde and Arndt 1987) and can apparently tolerate certain altered habitats such as drainage ditches and backwaters adjacent to boat landings (Rohde and Arndt 1987). This species is very short-lived, spawning at age one and dying shortly thereafter (Snelson 1989). Bluebarred Pygmy Sunfish populations fluctuate widely with predominant hydrologic conditions and stability of water levels (Rohde and Arndt 1987; Snelson 1989; Sandel & Harris 2007), proliferating during wet periods supporting sufficient aquatic vegetation and becoming locally extirpated during droughts. Direct observations of the spawning behavior for these elusive fish and its relatives are sparse; some accounts exist for the relatives from captivity among aquarists (Bohlen & Nolte 2012). As such, survey efforts may yield drastically different successive catch rates at a given site, with the species being undetectable or extirpated one year and abundant the next (Snelson 1989). Hydrologic pulses appear to be beneficial to the Bluebarred Pygmy Sunfish, with Lee et al. (2016) noting that it was caught in the Savannah River floodplains only in years with flood events connecting the floodplains to the river channels. In standardized sampling covering streams to small rivers across South Carolina, this species exhibited its highest frequency of occurrence (7.7%) and average relative abundance (0.1%) in small rivers (watershed area 300-2000 km^2) of the coastal plain.

CHALLENGES

Primary threats to the Bluebarred Pygmy Sunfish include loss of natural/forested land cover and especially the removal of riparian cover along coastal plain streams. Fish assemblage integrity of coastal plain streams increases with natural land cover, whereas integrity decreases as the amount of agricultural land increases (SCDNR 2023). Mature forest and riparian vegetation are important sources of large woody debris in Coastal Plain streams, which provides critical habitat for many endemic Southern Atlantic Coastal Plain species including the Bluebarred Pygmy

Sunfish (Marion et al. 2015). Land development, siltation, and hydrologic alterations such as channelization and construction of impoundments also threaten this species.

Although Bluebarred Pygmy Sunfish can occur in anthropogenically altered environments such as drainage ditches, the high variability of populations and low dispersal capability render this species susceptible to acute disturbances and habitat fragmentation (Snelson 1989). Furthermore, the extreme variability in abundance and corresponding detection difficulties confound efforts to monitor its distribution and overall population trends (Cannister & Bechler 2019).

CONSERVATION ACCOMPLISHMENTS

Riverbanks Zoo currently has a propagation and maintenance program of representative populations of Bluebarred Pygmy Sunfish.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.

- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Identify critical habitats and areas with healthy populations for the Bluebarred Pygmy Sunfish.
- Describe life history and habitat requirements for the Bluebarred Pygmy Sunfish.
- Conduct genetic assessments to determine appropriate taxonomy for the Bluebarred Pygmy Sunfish.
- Protect critical habitats for the Bluebarred Pygmy Sunfish from future development and further habitat degradation by following Best Management Practices (BMPs) as well as protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Bluebarred Pygmy Sunfish.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame fish species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate off-road motor vehicle operators on the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species and others. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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“Brassy” Jumprock

Moxostoma sp.

Contributors (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]



Photo: NCFishes.com

DESCRIPTION

Taxonomy and Basic Description

The “Brassy” Jumprock is an undescribed member of the sucker family (Catostomidae), which is represented by 78 described species in North America (Page et al. 2023). Suckers comprise about 8% of the continent’s freshwater ichthyofauna, behind only minnows (Leuciscidae) and perches and darters (Percidae) in number of species (Warren and Burr 2014). The genus *Moxostoma* includes 23 described species (Page et al. 2023), about one third of which are considered imperiled at some level (Jelks et al. 2008; Warren and Burr 2014).

Due to being mis-assigned by Robins and Raney (1956) as what is now known as *Moxostoma robustum* (Robust Redhorse), this species did not receive further taxonomic investigation until the error was discovered by Robert E. Jenkins in 1992 (Rohde et al. 2009; Tracy et al. 2020), and a full description has yet to be completed. Among suckers found in South Carolina, the “Brassy” Jumprock is most closely related to the Striped Jumprock (*Moxostoma rupiscartes*).

The Brassy Jumprock grows to moderately large size, with adults reaching 240 to 456 mm total length and having an elongate yet stout and slightly laterally compressed body (Rohde et al. 2009). Overall coloration ranges from tan to olive, with increasing brassy coloration in larger and mature individuals. Fins are typically dusky (dorsal and caudal) or pale orange (paired ventral fins). Younger individuals usually have alternating longitudinal light and dark stripes; below the lateral line, the light stripes are wider than or equal to the width of the dark stripes (conversely for the Striped Jumprock) (Rohde et al. 2009; Tracy et al. 2024). Dorsal fin rays usually total 12-13 (sometimes 11). The lower lip is plicate, lacks or has few transverse grooves, and has a relatively straight posterior margin (i.e., not deeply notched) (Tracy et al. 2024).

Status

The “Brassy” Jumprock is currently considered to be apparently secure globally (G4; NatureServe; accessed 2024) but is listed as vulnerable (S3) in South Carolina. This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of moderate concern. Although it can be relatively abundant in optimal habitat of larger streams and rivers, it is also patchy and uncommon in certain river basins and many of its native habitats have been highly altered by the construction of large reservoirs and numerous dams as well as land uses contributing to sedimentation of shoals.

POPULATION SIZE AND DISTRIBUTION

The “Brassy” Jumprock occurs on the Atlantic Slope from the Cape Fear River basin in North Carolina to the Altamaha River basin in Georgia. In South Carolina, the species is predominantly found above the fall line. This species was observed in 7.8% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023. It is particularly abundant in the Broad River, where population measures indicated relatively stable status (Bettinger and Crane 2011).

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The “Brassy” Jumprock primarily inhabits rocky shoals, runs and pools with sandy to rocky substrate in moderate to large streams and rivers, where it feeds on benthic invertebrates (Rohde et al. 2009). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (100.0%) in upland small rivers (watershed area 300-2000 km²) of the Savannah River basin and highest average relative abundance (1.2%) in upland small rivers (watershed area 300-2000 km²) of the Santee/Pee Dee River basins.

CHALLENGES

Although the “Brassy” Jumprock appears relatively wide-ranging across the uplands of South Carolina and was found to be apparently stable in the Broad River in the early 2000s (Bettinger and Crane 2011), its habitat requirements for larger streams and rivers place it within some of the most altered aquatic habitats in the state. Much of its range, such as the upper Savannah River basin, has been impounded by the construction of numerous large reservoirs, and many similar reservoirs exist across the Saluda, Broad and Catawba-Wateree basins. Furthermore, many additional dams limit movement throughout river networks and alter hydrologic and temperature regimes to which this species has adapted. Both the frequency of occurrence and mean relative abundance of this species were several times higher in rivers (watershed area > 300 km²) than smaller streams (SCDNR 2023); because larger rivers make up a proportionally small amount of aquatic habitat by length, its core populations are more vulnerable to the effects of cumulative and acute disturbances in these locations. This species is susceptible to the same pervasive types of anthropogenic habitat alteration and fragmentation affecting other large riverine catostomids (Cooke et al. 2005), including the construction and operation of dams and impoundments, sedimentation of important foraging and spawning habitats, alteration of hydrologic regimes, and introduction of non-native species.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion and “ecobasin” (ecoregion x river basin). These estimates for the first time provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements of the "Brassy" Jumprock.
- Identify critical habitats and areas with healthy populations of "Brassy" Jumprock, and protect these areas once identified.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices (BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. If more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling

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Bridle Shiner

Notropis bifrenatus



Photo: NCFishes.com

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Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Bridle Shiner belongs to the minnow family (Leuciscidae) and remained classified within *Notropis* based on a recent investigation of shiner taxonomy (Stout et al. 2022; Page et al. 2023), joining Comely Shiner (*N. amoenus*), Taillight Shiner (*N. maculatus*) and Sandbar Shiner (*N. scepticus*) as the only *Notropis* minnows in South Carolina following this taxonomic revision. Minnows represent the most speciose family of freshwater fishes in North America (about 27% of the continental fauna), with at least 323 described taxa of predominantly small (<150 mm) and slender fishes (Warren and Burr 2014; Page et al. 2023).

Bridle Shiners are relatively small, reaching a maximum total length of 48-66 mm (1.9-2.6 in.) (Rohde et al. 2009). A prominent black lateral stripe extends from the tip of the snout to the tail fin. The back is straw-colored and the sides of the fish are silver with blue-green iridescence. Breeding males develop light yellow to bright yellow-gold color on the lower sides of their bodies and faint yellow fins (Jenkins and Burkhead 1994).

Status

Globally, the Bridle Shiner is considered vulnerable (G3) (NatureServe 2024). In South Carolina, the Bridle shiner is currently considered possibly extinct (SH), and critically imperiled (S1) in North Carolina (NatureServe 2024). Widely regarded as at-risk across the majority of jurisdictions (Margolis 2003), the Bridle Shiner is listed as critically imperiled (S1), imperiled (S2), or possibly extinct (SH) in 11 of the 15 states that comprise its historic range (NatureServe 2024). In a recent assessment of North American fishes, the Bridle Shiner was identified as a species vulnerable to imperilment (Jelks et al. 2008). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of high concern.

POPULATION SIZE AND DISTRIBUTION

The Bridle Shiner has a widespread but patchy distribution in eastern North America, occurring in Atlantic basins from western Lake Ontario-St. Lawrence drainages east to Maine and south to South Carolina. Bridle Shiner populations are highly disjunct, with gaps in excess of 200 km

(124 mi) between known localities. Furthermore, populations are declining throughout the range (NatureServe 2024). Once common in Pennsylvania (Cooper 1983), it has been reduced to a single known extant population in one small drainage (Criswell 1998; Finger 2001; Leckvarcik 2005; Hanson 2013). The Bridle Shiner is rare or declining in Maine, Vermont (Shervinskie 1998), Massachusetts (Chandler et al. 1998), Rhode Island, Connecticut, New York, Delaware, Virginia (Starnes et al. 2025), North Carolina, and South Carolina. In Virginia, the Bridle Shiner is extant in the James River basin but is likely extirpated from most other basins in which it was known or believed to have occurred (Jenkins and Burkhead 1994; Starnes et al. 2025). Recognition of its possible extirpation from North Carolina began in the 1960s, but it was rediscovered in 2000 and subsequent decades from a few localities (Tracy et al. 2020; Tracy et al. 2024).

Within South Carolina, the only known collection sites are in Lakes Marion (1954) and Moultrie (1981) (Jenkins and Burkhead 1994; Rohde et al. 2009). Targeted searches in and around the known collection localities in recent decades have been unsuccessful (W. Starnes, North Carolina State Museum [retired], pers. comm. 2024) yet also inconsistent. Despite the South Carolina records being from large reservoirs and approximately 330 km (204 mi) from the nearest known populations (lower Neuse River, NC), they are not believed to be the result of introduction by humans (Rohde et al. 2009). The determination of its persistence in South Carolina is confounded by its probable elusiveness and specific habitat and sampling requirements (Jensen 2012; Jensen and Vokoun 2013; Pregler et al. 2015; Pregler et al. 2019).

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

Due to nearly universal decline across its large range, the Bridle Shiner has received a relatively high amount of research attention in recent years. The Bridle Shiner inhabits the quiet areas of warmwater streams (slower-flowing sections), swamps, and lakes with clear water and is usually associated with abundant aquatic vegetation (Finger 2001; Henning 2012; Jensen and Vokoun 2013; Hanson 2013; Starnes et al. 2025), as these areas are used for feeding and breeding. This species is generally found over sand, mud (Henning 2012; Hanson 2013), or gravel substrates and broadcasts eggs over submerged aquatic vegetation (Harrington 1947). The Bridle Shiner can be found in tidal and slightly brackish water in the southern portion of its range (Burkhead and Jenkins 1991). In South Carolina, it has only been found in the shallow lacustrine areas of Lakes Marion and Moultrie (Rohde et al. 2009). This species has been shown to benefit from floodplain connectivity and natural flooding regimes (Farly et al. 2021).

CHALLENGES

With only two known localities and a span of over 40 years since the last observation of this species in South Carolina, its persistence in the state is very uncertain. The apparently universal decline of this species across a wide range of ecological settings and types of habitat alteration suggest it is sensitive to a spectrum of anthropogenic factors (Finger 2001; Leckvarcik 2001; Hanson 2013). Its susceptibility to cumulative degradation is exemplified by its remaining distribution in Connecticut, which was positively associated with high levels of forest cover and low amounts of impervious land cover (Pregler et al. 2019). This species is particularly sensitive to increased turbidity, which can both directly affect its feeding efficiency and behavior (Gray et

al. 2014) and physiological function (Gray et al. 2016) as well as indirectly affect this fish by altering the growth of submerged aquatic vegetation on which the species is dependent ecologically (Jenkins and Burkhead 1994; Henning 2012). Agricultural runoff may also negatively impact its habitat (Burkhead and Jenkins 1991), which could be particularly problematic since its only known localities in South Carolina lie in a region of widespread agriculture. Species with disjunct or isolated populations are typically at greater risk of detrimental effects from low genetic diversity. Northeastern disjunct populations of Bridle Shiners were found to exhibit low within-population genetic diversity, which can lead to additional problems associated with inbreeding depression (Geneva et al. 2018).

The apparent elusiveness of this species and resulting data deficiency represent a fundamental challenge in its conservation. In South Carolina, the physicochemical template that supports this species may represent a moving target in an expansive and anthropogenically changing landscape. However, the perceived absence or possible extirpation are difficult to interpret due to the recognized challenges associated with its apparent elusiveness coupled with the lack of dedicated sampling efforts using appropriate species- and habitat-specific methods (Jensen and Vokoun 2013; Pregler et al. 2015; Pregler et al. 2019; Katz 2023; Starnes et al. 2025). If the Bridle Shiner is still extant in South Carolina, a specialized and standardized sampling approach will be necessary to quantify the probability of its persistence in the state and enable informed conservation efforts (Jensen and Vokoun 2013; Pregler et al. 2015; Pregler et al. 2019; Katz 2023; Starnes et al. 2025). For example, employing multiple and/or targeted methods led to the rediscovery of multiple Bridle Shiner populations in Connecticut (Pregler et al. 2019) and Maine (Katz 2023).

CONSERVATION ACCOMPLISHMENTS

Bridle Shiner populations are currently protected as part of the Santee Wildlife Refuge.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by

numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.

- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
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- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

    - Marion, C.A., M.C. Scott, and K.M. Kubach. 2015. Multiscale environmental influences on fish assemblage structure of South Atlantic coastal plain streams. Transactions of the American Fisheries Society. 144(5):1040-1057.

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Describe the life history and habitat requirements for Bridle Shiner.
- Determine the statewide distribution and population status for Bridle Shiner with targeted surveys.
- Survey Lake Marion and its tributary streams to identify the presence of additional Bridle Shiner populations and verify its existence in Lake Marion.
- Conduct genetic assessments to determine the appropriate taxonomy for Bridle Shiners.
- Explore reasons for the decline of Bridle Shiners in South Carolina.
- Protect critical habitats for Bridle Shiner from future development and further habitat degradation by following Best Management Practices (BMPs) and protecting and purchasing riparian areas.

- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for Bridle Shiner.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame fish species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate off-road motor vehicle operators on the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species and others. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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“Broadtail” Madtom

Noturus sp. cf. *insignis*

Contributor (2005): Jason Bettinger (SCDNR)
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]



Photo: Fred Rohde

DESCRIPTION

Taxonomy and Basic Description

The “Broadtail” Madtom is an undescribed member of the family Ictaluridae (bullhead catfishes), the most diverse family of freshwater fishes indigenous entirely to North America (Warren et el. 2020; Page et al. 2023). The genus *Noturus*, which includes small catfishes known as madtoms, includes 29 described species and is the most diverse genus in the family (Rohde et al. 1994; Page et al. 2023). The “Broadtail” Madtom was first documented in the 1960s and 1970s in most of the river basins in which it is known to occur (Tracy et al. 2020); Jenkins and Palmer (1978) published the first recognition of the new species. More recently, investigations continue into the taxonomy of this group and indicate distinctiveness by river basins; among described species, the “Broadtail” Madtoms are most closely related to the Margined Madtom (*N. insignis*) (Bennetts et al. 1999; Hardman and Hardman 2008; Burr et al. 2020; F. Rohde, pers. comm. 2024). Tracy et al. (2020; 2024) recognize three forms in North Carolina—the “Cape Fear,” “Lake Waccamaw” and “Pee Dee” (the latter also occurring in South Carolina); the Edisto River form may also be distinct.

Madtoms are small and can be distinguished from other catfish by their long adipose fin, which is continuous with the caudal fin. The “Broadtail” Madtom is a slender-bodied fish with fine black speckling on an otherwise pale body and a dark blotch at the base of its caudal fin (Rohde et al. 2009). It has a “banjo-shaped” body when viewed from above (Rohde et al. 2009). Although there is not much known about this fish, it probably reaches lengths similar to the Speckled Madtom (*N. leptacanthus*), which has a maximum total length of 94 mm (3.7 in.) (Rohde et al. 1994).

Status

The “Broadtail” Madtom has received legal status and is listed as State Threatened in South Carolina. In North Carolina, the only other state in which it occurs, it is of Special Concern and is considered critically imperiled (S1). Tracy et al. (2020) noted that the range of the “Cape Fear Broadtail” Madtom has contracted in recent decades, and it may be extirpated from that basin. This species is critically imperiled (S1) in South Carolina (NatureServe 2024) and is considered

vulnerable to imperilment throughout its range (Warren et al. 2000). The "Broadtail" Madtom is globally considered to be imperiled (G2) (NatureServe 2024). It was also considered vulnerable in a recent assessment of North American freshwater fishes (Jelks et al. 2008). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of very high concern.

POPULATION SIZE AND DISTRIBUTION

The "Broadtail" Madtom is only known from coastal plain rivers in the Carolinas, including the Cape Fear, Lumber, Little Pee Dee, Waccamaw (including Lake Waccamaw), Lynches and Edisto rivers (Rohde et al. 2009; Tracy et al. 2020). Within South Carolina, it is known from the South Fork Edisto, Lynches, and Little Pee Dee Rivers (Rohde et al. 2009). The "Pee Dee Broadtail" Madtom is known from the Waccamaw River in North Carolina and within close proximity to South Carolina (Tracy et al. 2020; Tracy et al. 2024); it may therefore occur in the South Carolina portion of the Waccamaw River, although this has not been documented. Due to its elusiveness and apparent habitat preference for deep portions of coastal plain rivers, very little is known about its population sizes, but it is most likely more widely distributed along these rivers than collection records indicate (Rohde et al. 2009). Monitoring by the North Carolina Wildlife Resources Commission from 2019 to 2024 has confirmed the presence of the "Broadtail" Madtom in multiple tributaries of the Lumber River just upstream of South Carolina (Omerberg and Jones 2025).

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The "Broadtail" Madtom generally occupies the middle of narrow and deep coastal plain rivers with sand and gravel substrates (Page and Burr 1991; Rohde et al. 2009). However, the recent detection of this species by the North Carolina Wildlife Resources Commission (Omerberg and Jones 2025) in small artificial habitat structures deployed in moderate depths suggests habitat use may not be restricted to the deepest areas. The specific habitats of this fish are poorly known, but "Broadtail" Madtoms are often associated with woody debris (F. Rohde, pers. comm.). Spawning apparently takes place from May to June (Rohde et al. 2009).

CHALLENGES

The "Broadtail" Madtom is susceptible to the many forms of anthropogenic habitat alteration reducing the integrity of coastal plain rivers. Clearing of watershed and riparian forest and natural land cover for poorly planned agriculture or development can cause an array of impacts to streams and rivers, including runoff and non-point source pollution, disruption of natural hydrologic and sediment regimes, reduction in habitat heterogeneity including the input of wood to stream systems, and habitat fragmentation. The apparent dependence of this species on habitat structure in deep coastal plain channels makes it particularly vulnerable to alterations reducing the amount of wood and organic matter entering rivers (i.e., deforestation and poor riparian management). Furthermore, the "Broadtail" Madtom, like other small ictalurids, is adversely affected by the nonnative Flathead Catfish (*Pylodictis olivaris*) and Blue Catfish (*Ictalurus furcatus*), both of which are known to be expanding in coastal plain rivers and occupy similar

deeper sections of rivers. These large catfish are voracious predators that have decimated ictalurid and other native fish populations throughout the southeastern United States (Guire et al. 1984; Jenkins and Burkhead 1994; Bart et al. 1994). The apparent decline and possible extirpation of the “Cape Fear Broadtail” Madtom (Tracy et al. 2020) suggest the “Broadtail” Madtoms are sensitive to a range of disturbances.

CONSERVATION ACCOMPLISHMENTS

Efforts by the North Carolina Wildlife Resources Commission to document “Broadtail” Madtoms using small, deployed artificial habitat structures known as “madtom motels” have been successful (Omerberg and Jones 2025), representing a promising method for detecting this species in South Carolina. These structures are inexpensive and function as a passive method for attracting the fish, affording a relatively low-effort technique to increase sampling coverage and efficiency.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina’s freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

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    - Marion, C.A., M.C. Scott, and K.M. Kubach. 2015. Multiscale environmental influences on fish assemblage structure of South Atlantic coastal plain streams. Transactions of the American Fisheries Society. 144(5):1040-1057.

    - Epstein, J.M., W.E. Pine III, C.M. Romagosa, M.C. Scott, C.T. Phillips, C.A. Marion, and B. Baiser. 2018. State- and Regional-Scale Patterns and Drivers of Freshwater Fish Functional Diversity in the Southeastern USA. Transactions of the American Fisheries Society. 147:1179-1198. https://doi.org/10.1002/tafs.10110

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Continue to determine statewide distribution and population status for the "Broadtail" Madtom through assessment surveys as well as targeted sampling using methods such as the deployment of "madtom motels" (Omerberg and Jones 2025).
- Describe life history and habitat requirements for the "Broadtail" Madtom.
- Identify critical habitats and areas with healthy populations for the "Broadtail" Madtom.
- Conduct genetic assessments to determine appropriate taxonomy for the "Broadtail" Madtom.
- Formally describe the "Broadtail" Madtom and examine morphological and genetic differences among the populations in the Edisto, Pee Dee, Lynches, and Lumber Rivers.
- Protect critical habitats for the "Broadtail" Madtom from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the "Broadtail" Madtom.
- Encourage responsible land use planning.
- Consider species needs when participating in the environmental permit review process.
- Continue development of educational materials in order to raise public awareness of nongame fish species and their ecological importance to the natural history of South Carolina's aquatic habitats.

- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect most of this species and others. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Carolina Darter

Etheostoma collis

Contributor (2005): Gene Hayes and Jason Bettinger [SCDNR]
Reviewed and Edited (2013): Mark Scott, Andrew R. Gelder, and M. Troy Cribb [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]



Photo: NCFishes.com

DESCRIPTION

Taxonomy and Basic Description

The Carolina Darter is a member of the perch and darter family (Percidae), an extremely diverse group of predominantly small, bottom-dwelling fishes currently represented by 224 described species comprising more than 20% of the North American freshwater ichthyofauna (Page 1983; Kuehne and Barbour 1983; Near et al. 2011; Page et al. 2023). With 138 described species, *Etheostoma* is the most diverse genus of North American freshwater fishes (Page et al. 2023). The Carolina Darter, along with the Swamp Darter (*E. fusiforme*) and Sawcheek Darter (*E. serrifer*) in South Carolina, is placed in the darter subgenus *Hololepis* (Rohde et al. 1994). This species was originally described by Hubbs and Cannon (1935) as *Hololepis collis* along with another species, the Saluda Darter (*Hololepis saludae*); the species were distinguished by differences in the number of anal spines and interorbital pores (Page 1983; Kuehne and Barbour 1983; Rohde et al. 2009). The distinctiveness of these species, which both occur in the Santee River basin, was eventually investigated further (Collette 1962; Jenkins and Burkhead 1994) and genetic results indicated that they were not sufficiently distinct to warrant separate species; thus, these species were synonymized as *Etheostoma collis* (Jenkins and Burkhead 1994; Rohde et al. 2009; Oswald et al. 2009).

Carolina Darters reach a length of 60 mm (2.4 in.) (Rohde et al. 1994). The fish has a small head and mouth with a highly arched, incomplete lateral line characteristic of the subgenus *Hololepis* (Kuehne and Barbour 1983). The brown-spotted sides are marked with a median dark stripe that breaks into blotches on the peduncle (Eddy and Underhill 1979). A primary basicaudal spot has two spots of lesser intensity above and below (Rohde et al. 1994). Breeding males do not develop bright colors but may have breeding tubercles on the pelvic fin spine and rays as well as on all anal fin rays (Kuehne and Barbour 1983).

Status

The Carolina Darter is considered vulnerable (G3) globally (NatureServe 2024). The species is considered vulnerable (S3) in North Carolina (State Special Concern), imperiled (S2) in Virginia, and vulnerable (S3) in South Carolina (NatureServe 2024). The Carolina Darter was identified as a species vulnerable to imperilment in recent assessments of the southeastern (Warren et al.

2000) and North American (Jelks et al. 2008) freshwater fish faunas. This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of high concern.

POPULATION SIZE AND DISTRIBUTION

The Carolina Darter occurs in the Piedmont ecoregion from the Roanoke River basin of south-central Virginia to the Saluda (Santee) River basin of South Carolina (Rohde et al. 2009). In South Carolina, it is found predominantly in the Carolina Slate Belt and outer Piedmont ecoregions in the lower Saluda and Broad basins (i.e., the range of *E. saludae* before it was synonymized with *E. collis*) as well as the mid to upper Broad and Catawba/Wateree basins (Rohde et al. 2009). This species is most abundant in the Carolina Slate Belt and far outer Piedmont portions of the lower Saluda and Broad River basins. The Carolina Darter was observed in 6.3% of over 900 standardized statewide stream and river assessment samples across South Carolina between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Carolina Darter inhabits small to large streams in areas of low to moderately low current velocity and a wide range of substrate types (Collette 1962; Kuehne and Barbour 1983; Rohde et al. 2009). In the core area of its distribution in South Carolina—the Carolina Slate Belt streams of the lower Saluda and Broad River basins—the species is closely associated with streams exhibiting long, sluggish reaches interspersed with short riffles of bedrock, rubble and gravel. In this regard, the Carolina Darter appears to share a close ecological association with the Highfin Shiner (*Hudsonius altipinnis*) where their ranges overlap. During periods of seasonal or extended drought, these streams often reduce to long, stagnant, nearly broken to broken pools; Carolina Darters have been collected in abundance during such conditions and appear somewhat tolerant of this high variability in water level and temperature, provided they are not stressed by additional anthropogenic habitat alteration. Outside of this region, in more typical Piedmont streams, it is often found in slower areas with sand and gravel. Interestingly, it has been deemed somewhat tolerant of fine sediment (Kuehne and Barbour 1983; Rohde et al. 1994). In standardized sampling covering streams to small rivers of South Carolina, this species exhibited its highest frequency of occurrence (21.0%) in upland medium streams (15-100 km^2) of the Santee River basin and highest average relative abundance (1.5%) in upland small streams (watershed area 0-15 km^2) of the Santee River basin. Spawning occurs in March to April, and the lifespan appears to be 2 years (Kuehne and Barbour 1983; Rohde et al. 2009).

CHALLENGES

Geographic isolation of the Carolina Darter makes it extremely vulnerable to development, pollution and habitat alterations. Although *E. saludae* was synonymized with *E. collis*, sufficient genetic variation across its range still exists (Oswald et al. 2009) and may represent local adaptations at the level of individual sub-basins. Fragmentation and isolation of populations has already occurred over a large portion of the core range of this species in South Carolina due to the creation of large reservoirs in the lower Saluda River basin in the 1920s and 1930s; tributary populations have been isolated to gene flow, potentially impacting the genetic fitness of these

populations and reducing their resistance and resilience to disturbance. Additional fragmentation and or barriers to movement within these localized drainages could furthermore disturb its natural ability to handle acute disturbances including the high seasonal variability in flow and connectivity characteristic of the outer Piedmont and Carolina Slate Belt ecoregions. Conservation efforts within South Carolina are critical to the global conservation of this species.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina’s freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT’s second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting’s pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.

- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

    - Marion, C.A., M.C. Scott, and K.M. Kubach. 2015. Multiscale environmental influences on fish assemblage structure of South Atlantic coastal plain streams. Transactions of the American Fisheries Society. 144(5):1040-1057.

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species and others. Methods that protect water

quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Carolina Fantail Darter

Etheostoma brevispinum



Photo: NCFishes.com

Contributor (2005): Mark Scott and Jason Bettinger [SCDNR]
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Carolina Fantail Darter is a member of the perch and darter family (Percidae), an extremely diverse group of predominantly small, bottom-dwelling fishes currently represented by 224 described species comprising more than 20% of the North American freshwater ichthyofauna (Page 1983; Kuehne and Barbour 1983; Near et al. 2011; Page et al. 2023). With 138 described species, *Etheostoma* is the most diverse genus of North American freshwater fishes (Page et al. 2023). It is placed in the subgenus *Catonotus* (Near et al. 2011). The Carolina Fantail Darter was recently elevated as a species (Blanton and Schuster 2008) from its previous status as a subspecies of the Fantail Darter, *E. flabellare.*

The adult Carolina Fantail Darter ranges from 45 to 95 mm (1.8 to 3.7 in.) in total length (Jenkins and Burkhead 1994). As is typical of other members of the subgenus *Catonotus*, the Carolina Fantail Darter has a deep caudal peduncle, frenum, closely set pelvic fins, and broadly joined gill membranes. Additionally, this fish is characterized by a spiny dorsal fin comprised of 7 short spines with enlarged golden knobs on both males and females, a characteristic of the *Richiella* clade (Near et al. 2011). The Carolina Fantail Darter usually has 7 dark bars on the side set against a light body coloration (Page and Burr 1991; Rohde et al. 1994).

Status

The Carolina Fantail Darter is globally considered apparently secure (G4) but imperiled (S2) in South Carolina (NatureServe 2024). Warren et al. (2000) listed the global status of Carolina Fantail Darter as currently stable within its range. The Carolina Fantail Darter is considered apparently secure (S4) in North Carolina and critically imperiled (S1) in Virginia. This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of high concern.

POPULATION SIZE AND DISTRIBUTION

Broadly, the Carolina Fantail Darter occurs in the Savannah, Santee and Pee Dee River basins of North and South Carolina (Blanton and Schuster 2008; Tracy et al. 2020). Although the Carolina

Fantail Darter occurs over a relatively wide range spanning multiple river basins, its distribution in South Carolina is oddly disjunct, with apparently isolated populations scattered across a range of elevations (Rohde et al. 2009). In the Santee River basin in South Carolina, it occurs in several streams and rivers of the upper Saluda and upper Broad drainages as well as one tributary of the Wateree River near the fall line. It is only known from one stream system in the far upper Savannah River basin. In the Pee Dee River basin of South Carolina, it is only known from one tributary of the Great Pee Dee River near the fall line. Interestingly, the streams in which it occurs in the Wateree and Pee Dee basins in South Carolina are apparently separated by considerable river network distance from the nearest respective populations in these basins in North Carolina (Tracy et al. 2020; Tracy et al. 2024). The Carolina Fantail Darter was observed in 1.5% of over 900 standardized statewide stream and river assessment samples in South Carolina between 2006 and 2023. In high-gradient streams and rivers with continuous suitable habitat it can be moderately abundant, but due to the siltation of many Piedmont streams and the localized nature of appropriate coarse riffles in lower-gradient Piedmont streams, it is often limited in abundance.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Carolina Fantail Darter inhabits gravel or rubble riffles in creeks and small to medium rivers where stronger currents exist (Rohde et al. 2009). Rocky substrates are important to its benthic feeding habits and spawning behavior, in which nests are excavated and guarded under rocks (Jenkins and Burkhead 1994; Rohde et al. 2009). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (14.3%) and highest average relative abundance (0.3%) in upland large streams (watershed area 100-300 km^2) of the Santee River basin.

CHALLENGES

The limited and extremely patchy distribution of this species within South Carolina makes it vulnerable to extirpation. Several of its populations in South Carolina are restricted to one stream within a given river basin, representing a very high risk of basin-level extirpation within the state. The Carolina Fantail Darter, like many other specialized stream fishes, is susceptible to an array of acute and cumulative impacts from anthropogenic alterations to the watershed, riparian zone and streams and rivers directly. These include deforestation and conversion of natural land cover for development and agriculture with resulting sedimentation and non-point source pollution, hydrologic alterations, and habitat fragmentation from dams and reservoirs. The lithophilic requirements of this species make it particularly susceptible to impacts from both suspended and deposited sediment.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment (2006-2011) data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will

serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Describe life history and habitat requirements for Carolina Fantail Darters.
- Identify and protect areas with healthy populations and intact critical habitat for the Carolina Fantail Darter.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Consider this species' needs when participating in the environmental permit review process.
- Encourage responsible land use planning.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species and others. Genetic resolution of the status of this species will allow for more specific management protocols. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast

Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Carolina Pygmy Sunfish

Elassoma boehlkei



Photo: NCFishes.com

Contributor (2005): Jason Bettinger (SCDNR)
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

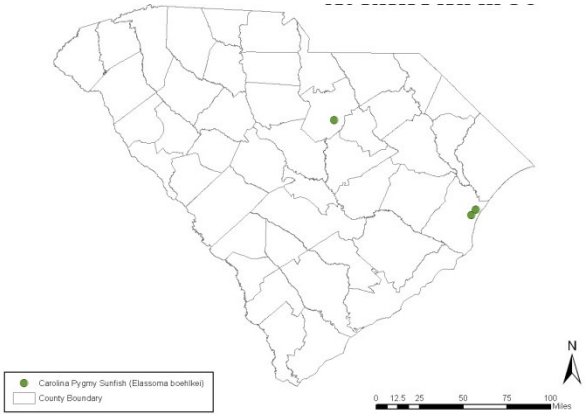
Taxonomy and Basic Description

The Carolina Pygmy Sunfish is a member of the family Elassomatidae; this family of small secretive fishes contains 7 known species, all of which are placed in the genus *Elassoma* (Page et al. 2023). Four species of elassomatids occur in South Carolina. This species and its close relative, the Bluebarred Pygmy Sunfish (*E. okatie*), were not described until 1987 (Rohde and Arndt 1987). The elassomatids are found only in the southeastern United States (Rohde et al. 1994). Carolina Pygmy Sunfish range in length from 20 to 32 mm (0.8 to 1.3 in.) (Tracy et al. 2024). As with other members of the genus *Elassoma,* the Carolina Pygmy Sunfish lacks a lateral line, has a relatively large eye, an upturned mouth, and a rounded caudal fin. This species is identifiable by the series of 10 to 16 dark bars along its side (Rohde et al. 2009); males of the species display alternating blue and black bars along their sides, with the bars on the females alternate between dark brown and light brown (Rohde et al. 1994). The Carolina Pygmy Sunfish is most closely related to the Bluebarred Pygmy Sunfish (Sandel et al. 2014). The taxonomic placement of the *Elassoma* remains somewhat uncertain, with some studies suggesting they belong in Centrarchidae rather than a separate family (Near et al. 2012; Tracy et al. 2024).

Status

The Carolina Pygmy Sunfish is listed as State Threatened in both South Carolina and North Carolina, the only two states in which it occurs and recommended as a threatened status in Threatened fishes of the world (Sandel & Harris 2007). It is listed as imperiled on the global scale (G2), critically imperiled (S1) in South Carolina and imperiled (S2) in North Carolina (NatureServe 2024, Tracy et al. 2024). The species was identified as vulnerable to imperilment in a recent assessment of southeastern freshwater fishes (Warren et al. 2000). The Carolina Pygmy Sunfish was considered threatened in a recent assessment of North American freshwater fishes (Jelks et al. 2008). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of very high concern.

POPULATION SIZE AND DISTRIBUTION



The Carolina Pygmy Sunfish is only known from the Waccamaw River drainage (Pee Dee basin) and Wateree/Congaree drainages (Santee basin) of North and South Carolina. In South Carolina, it is known from about 11 localities, three of which were recently discovered in 2013 and 2018 whereas two or three others may no longer support the species (Jones and Ewing 2019). Populations are known from scattered sites in the upper (Horry County) and lower (Georgetown County) Waccamaw River drainage near the confluence with the Great Pee Dee River. In addition, and rather disjunct from the Waccamaw River system, populations occur in several tributaries of the Wateree and Congaree Rivers in the central Santee River basin. These Santee basin populations were determined to be genetically distinct from those of the Waccamaw basin (Quattro et al. 2001).

Overall, especially in the North Carolina portion of the Waccamaw River drainage, this species is considered relatively stable, and it is likely that additional populations await discovery (F. Rohde, pers. comm.; Jones and Ewing 2019). Although its populations can fluctuate dramatically due to the variable hydrology characteristic of its habitats, in more stable habitats or under prolonged favorable wet periods, it can be very abundant (Jones and Ewing 2019). Owing to its patchy distribution and preference for other habitat types, this species was not collected during any SCDNR standardized stream and river assessment sampling from 2006 through 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Carolina Pygmy Sunfish inhabits slow-moving acidic waters with dense cover in swamps, streams, river backwaters and ditches in the coastal plain (Rohde and Arndt 1987). This species is generally associated with abundant aquatic vegetation and often occurs in the shallow (<15 cm) margins of these habitats (Rohde et al. 1994; Rohde et al. 2009). Spawning occurs mainly from February to May, and this short-lived species is mature at and rarely persists beyond one year; the maximum known age in the wild is 22 months (Rohde et al. 2009). The geographic range of the Carolina Pygmy Sunfish overlaps with that of the Banded Pygmy Sunfish (*E. zonatum*) and probably the Everglades Pygmy Sunfish (*E. evergladei*), but there is no known coexistence of this species with its closest relative, the Bluebarred Pygmy Sunfish (*E. okatie*) (Rohde et al. 2009).

CHALLENGES

Although the Carolina Pygmy Sunfish is often locally abundant and believed to be currently stable, its limited distribution is cause for concern. The isolation of this species makes it extremely vulnerable to development, pollution, and habitat alterations. Primary threats to the Carolina Pygmy Sunfish include loss of natural/forested land cover and especially the removal of riparian cover along coastal plain streams. Fish assemblage integrity of coastal plain streams increases with natural land cover, whereas integrity decreases as the amount of agricultural land

increases (SCDNR 2023). Mature forest and riparian vegetation are important sources of large woody debris in Coastal Plain streams, which provides critical habitat for many endemic Southern Atlantic Coastal Plain species including the Carolina Pygmy Sunfish (Marion et al. 2015). Land development, siltation, and hydrologic alterations such as channelization and construction of impoundments also threaten this species. The conversion of naturally stagnant lowland swamps and streams into channelized, shallow drainage ditches with consistently high current velocities represents a principal threat to Carolina Pygmy Sunfish habitat. In contrast to many of the North Carolina populations, those in South Carolina predominantly occur on private (unprotected) lands and in relatively close proximity to rapidly developing areas (Jones and Ewing 2019). The Waccamaw drainage in South Carolina is squarely within the coastal development corridor encroaching from cities including Conway, Myrtle Beach and North Myrtle Beach; a legitimate possibility exists for populations to be extirpated before they are discovered. Similarly, the central Santee basin populations are located within the growing footprints of Columbia, Camden and Sumter, which represent principal sources of habitat alteration. The high variability of populations and low dispersal capability render pygmy sunfishes susceptible to acute disturbances and habitat fragmentation (Snelson 1989). Furthermore, the extreme variability in abundance and corresponding detection difficulties confound efforts to monitor their distribution and overall population trends. Conservation efforts within South Carolina are critical to the global conservation of the species.

CONSERVATION ACCOMPLISHMENTS

Riverbanks Zoo currently has a propagation and maintenance program of representative populations of Carolina Pygmy Sunfish.

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

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- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements for the Carolina Pygmy Sunfish.

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- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame fish species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species and others. In the event that more protective BMPs are implemented, population studies of this species could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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"Carolina" Redhorse

Moxostoma sp. cf. *erythrurum*



Photo: NCFishes.com

Contributors (2005): Scott D. Lamprecht and Jason Bettinger [SCDNR]
Editors (2013): Scott D. Lamprecht and Mark C. Scott [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The "Carolina" Redhorse (*M.* sp. cf. *erythrurum*) is an undescribed member of the sucker family (Catostomidae), which is represented by 78 described species in North America (Page et al. 2023). Suckers comprise about 8% of the continent's freshwater ichthyofauna, behind only minnows (Leuciscidae) and perches and darters (Percidae) in number of species (Warren and Burr 2014). The genus *Moxostoma* includes 23 described species (Page et al. 2023), about one third of which are considered imperiled at some level (Jelks et al. 2008; Warren and Burr 2014).

Although vouchered specimens of this species date to the early 1960s, due to confusion and misidentification, the recognition of this undescribed species did not occur until 1995 (Rohde et al. 2009; Jenkins 2011). It is presumed to be most closely related to the Golden Redhorse, *M. erythrurum* (Rohde et al. 2009; Jenkins 2011).

This species is characterized by a stout body with an overall olive to gold coloration and one to three golden to brassy stripes of variable length on the flanks. The lips are deeply plicate, and the posterior margin of the lower lip is U-shaped (bottom of the U pointing anteriorly) and thinned at the corners. Fins are generally dusky to gray (caudal fin probably orange in young); the dorsal fin usually has 14-15 rays, and its distal margin is straight to slightly concave. Adults range from 390 to 560 mm total length (Rohde et al. 2009).

Status

The "Carolina" Redhorse is listed as threatened in North Carolina (NCWRC 2013). NatureServe (2024) lists the status as globally critically imperiled (G1Q) to imperiled (G2Q), though the taxonomy is currently questionable or uncertain. It is listed as critically imperiled (S1) in South Carolina and imperiled (S2) in North Carolina. This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of very high concern.

POPULATION SIZE AND DISTRIBUTION

The “Carolina” Redhorse is currently only known from the Pee Dee River and Cape Fear River basins in North and South Carolina (Rohde et al. 2009; Jenkins 2011; Tracy et al. 2020). Jenkins (2011) proposed that this species may have also been native to the Santee River basin, possibly having been extirpated there as is presumed to have occurred with Robust Redhorse (*M. robustum*) (Tracy et al. 2020; Tracy et al. 2024). In South Carolina, this species has only been found in the Great Pee Dee River downstream to about 63 air km (40 miles) from the North Carolina state line (Rohde et al. 2009) and is probably recruiting from upstream sections of the river in North Carolina (W. Starnes, pers. comm.). Most recently in South Carolina, a specimen was collected and photographed on the Great Pee Dee River near Cheraw in October 2017 (S. Holbrook, pers. comm.). The “Carolina” Redhorse has likely declined considerably from its historic distribution based on the disjunct nature of currently known populations, which could represent remnants of a formerly broad range extending much higher into the Piedmont portions of the Pee Dee and Cape Fear basins (Jenkins 2011). However, it does seem to be locally stable in some isolated river reaches in the Pee Dee and Cape Fear drainages (W. Starnes, pers. comm.).

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The elusiveness and only recent recognition of this species have confounded characterization of its habitat use and biology. It has been collected from cool to warm, moderate gradient streams (juveniles) to large rivers, small run-of-river reservoirs, and a large reservoir (Jenkins 2011). In rivers with moderate gradient, it prefers the deep pool areas along the shore that contain woody debris but moves into shoal areas to spawn in late April to May (W. Starnes, pers. comm.). Lackmann et al. (2023) reported a maximum age for the closely related Golden Redhorse (*M. erythrurum*) of 17 years, which exceeds previously published values and represents an expansion of knowledge regarding longevity of this species and its close relatives.

CHALLENGES

The population of “Carolina” Redhorse is limited to one short section of the Great Pee Dee River in South Carolina. Even small alterations to this river section or to the upstream reaches in North Carolina that probably serve as the primary population source could lead to the extirpation of the species from South Carolina. This species is susceptible to the same pervasive types of anthropogenic habitat alteration and fragmentation affecting other large riverine catostomids (Cooke et al. 2005), including the construction and operation of dams and impoundments, sedimentation of important foraging and spawning habitats, alteration of hydrologic regimes, and introduction of non-native species.

CONSERVATION ACCOMPLISHMENTS

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina’s freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and

developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
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- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Continue to define “Carolina” Redhorse habitat in the upper reaches of the Pee Dee River.
- Continue to advocate for responsible development and the adoption of Best Management Practices (BMPs) in timber and agricultural land use, especially in the upper Pee Dee system.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species’ needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina’s aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species and others. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership’s 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Central Stoneroller

Campostoma anomalum



Photo: NCFishes.com

Contributor (2005): Dan Rankin and Jason Bettinger (SCDNR)
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
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DESCRIPTION

Taxonomy and Basic Description

The Central Stoneroller is a member of the minnow family (Leuciscidae) and one of five to six recognized species of *Campostoma* (Warren and Burr 2014; Page et al. 2023). *C. anomalum* is widespread in central and eastern North America; variation across its range has long been known and several subspecies recognized (Rohde et al. 2009 and sources therein). Recent investigations indicate that the form occurring in southern Atlantic (including South Carolina) and adjacent drainages, currently considered *C. anomalum michauxi* (Fowler, 1945; Burr and Cashner 1983), is probably distinct at the species level (Blum et al. 2008). Minnows represent the most speciose family of freshwater fishes in North America (about 27% of the continental fauna), with at least 323 described taxa of predominantly small (<150 mm) and slender fishes (Warren and Burr 2014; Page et al. 2023).

Adult Central Stonerollers range in length from 122 to 239 mm (4.8 to 9.4 in.) (Rohde et al. 1994). The species is a round-bodied, chub-like minnow with a ventral mouth, hard ridge along the lower jaw, and a rounded snout. The back is brown to olive with a brassy sheen. The belly and fins are typically light colored (Jenkins and Burkhead 1994). Breeding males develop orange and black on the fins. Though primarily considered herbivores grazing on algae, the Central Stoneroller consumes considerable amounts of detritus and invertebrates and should instead be considered omnivorous (Evans-White et al. 2003).

Status

NatureServe (2024) lists the status as secure globally (G5). The Central Stoneroller is currently stable within its native range (Warren et al. 2000). Its current state ranking for South Carolina is vulnerable (S3) and is also listed as vulnerable in several states on the fringes of its native range, including North Dakota and New Mexico (NatureServe 2024). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of moderate concern.

POPULATION SIZE AND DISTRIBUTION

Broadly (including all recognized subspecies), the Central Stoneroller is found throughout much of the Eastern and Central US in the Atlantic, Great Lakes, Mississippi River, and Hudson Bay (Red River) basins from New York and southern Ontario west to North Dakota and Wyoming, and south to South Carolina and Texas; Thames River system, Ontario; Gulf Slope drainages from Galveston Bay, Texas to Rio Grande, Mexico; and isolated populations in Southwestern Mississippi and Eastern Louisiana (Page and Burr 1991). Blum et al. (2008) found the southeastern form of *C. a. michauxi* to show sufficient distinctiveness to be classified as a unique species once the taxonomy of related forms is resolved; the range of this species would include the Savannah and Santee basins in addition to adjacent Atlantic drainages and portions of the Green and Tennessee basins. In South Carolina, the Central Stoneroller is found in the Blue Ridge and upper Piedmont ecoregions of the upper Savannah River, Saluda River, and Broad River drainages (SCDNR unpublished data). This species was observed in 1.1% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Central Stoneroller is found in small to medium rivers with cool, clear water, moderate or sometimes rapid current, and gravel or rubble substrates. It commonly occurs in pools with a current and in riffles of small rocky streams. Occasionally Central Stonerollers are found in slow-moving turbid water (NatureServe 2024). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (16.7%) and average relative abundance (0.6%) in upland small rivers (watershed area 300-2000 km^2) of the Savannah River basin. It is particularly abundant in the Chattooga River.

CHALLENGES

The Central Stoneroller may be somewhat vulnerable in South Carolina due to its limited distribution that is apparently associated with unique zoogeographic events (Ross 1970). Primary threats to the Central Stoneroller include loss of forested land and especially the removal of riparian cover along upland streams. Fish assemblage integrity of upland streams increases with natural land cover, whereas integrity decreases as the amount of developed and agricultural land increases (SCDNR 2023). Mature forest and riparian vegetation are important sources of large woody debris in upland streams, which contributes to beneficial habitat diversity and channel stability. Land development, siltation, and hydrologic alterations such as channelization and construction of impoundments also threaten this species. Although many of the Central Stoneroller populations in the upper Savannah and Saluda basins occur in protected, forested watersheds on federal and state lands, other populations in South Carolina and on the edge of the range of this species are vulnerable to development, such as those in certain portions of the Saluda and Broad basins. Further, regardless of land protection status, the limited range of this species in South Carolina in a limited elevational band places it at heightened risk from broader climatic change associated with human activity.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river

basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina’s freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements for the Central Stoneroller.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop of educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species and others. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures. An increase in native Eastern Brook Trout populations within the State would also indicate that restoration and habitat protections were successful. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008

Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Christmas Darter

Etheostoma hopkinsi



Photo: Fred Rhode

Contributor (2005): Dan Rankin and Jason Bettinger [SCDNR]
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Christmas Darter is a member of the perch and darter family (Percidae), an extremely diverse group of predominantly small, bottom-dwelling fishes currently represented by 224 described species comprising more than 20% of the North American freshwater ichthyofauna (Page 1983; Kuehne and Barbour 1983; Near et al. 2011; Page et al. 2023). With 138 described species, *Etheostoma* is the most diverse genus of North American freshwater fishes (Page et al. 2023). Bailey and Richards (1963) recognized *E. hopkinsi* as polytypic and described two subspecies based primarily on differences in scale counts and coverage: *E. h. hopkinsi* in the Altamaha River basin and *E. h. binotatum* in the Savannah River basin. Subsequent authors have suggested (Kuehne and Barbour 1983) or published results supporting elevation to species level (Near et al. 2011) of *E. binotatum* in the Savannah basin, garnering the common name of Hanukkah Darter or sometimes Christmas Eve Darter. Although *E. binotatum* is not yet formally recognized by the American Fisheries Society (Page et al. 2023), the distinction of *E. binotatum* as the Savannah basin form and *E. hopkinsi* as the Altamaha form is widely acknowledged among the ichthyological community for conservation purposes. *E. binotatum* is most closely related to the sister species pair of *E. hopkinsi* and *E. fricksium* (Savannah Darter) (Near et al. 2011), the latter of which also occurs in South Carolina.

The colorful Christmas Darter ranges in length from 41 to 71 mm (1.6 to 2.8 in.). It has a small conical head, broad frenum, and two anal spines. Breeding males have a blue marginal and a red sub-marginal band on the spiny dorsal fin (Kuehne and Barbour 1983). This darter has 10 to 12 dark green bars on its side, separated by a red bar in a mature male and a yellow bar in the female. Its greenish back has eight dark saddles while its belly is light green.

Status

The Christmas Darter is considered stable within its range (Warren et al. 2000). NatureServe (2024) lists the status as secure to apparently secure both globally (G4G5) and in Georgia (S4S5). In South Carolina, the fish is considered to be imperiled (S2). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and

Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of very high concern.

POPULATION SIZE AND DISTRIBUTION

The Christmas Darter (*E. binotatum* form) is restricted to the Savannah River basin at and above the fall line. It is generally absent from the higher elevations of the inner Piedmont and Blue Ridge and occurs mainly through the Southern Outer Piedmont and Carolina Slate Belt ecoregions. Its distribution within this range is patchy and it is not always present nor abundant in apparently suitable habitat. This species was observed in 5.0% of over 900 standardized statewide stream and river assessment samples in South Carolina between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Christmas Darter inhabits gravel or rubble riffles in cool water springs, creeks, and small- to medium-sized rivers with current and coarse substrate (Page 1983; Kuehne and Barbour 1983). It sometimes occurs in slower moving waters with submerged vegetation and in springs (Rohde et al. 1994, 2009). In high quality watersheds with intact habitat, this species is often found in association with Bartram's Bass (*Micropterus* sp. cf. *coosae*). In standardized sampling covering streams to small rivers across South Carolina, this species exhibited its highest frequency of occurrence (66.7%) and average relative abundance (2.0%) in upland small rivers (watershed area 300-2000 km^2) of the Savannah River basin. Gravid females and tuberculate males have been observed in March and April (Page 1983; Kuehne and Barbour 1983), and the lifespan is 2 years (Rohde et al. 2009).

CHALLENGES

The Savannah basin Christmas Darter (*E. binotatum*) appears to be fairly stable in suitable habitat; however, the disjunct distribution of intact habitats and robust populations warrants concern. Given its close ecological association with Bartram's Bass, it faces similar threats from habitat alteration and fragmentation throughout its core range. Much of its preferred larger, fluvial habitat in the upper Savannah River basin has already been lost to major reservoirs collectively spanning hundreds of thousands of acres. Fish assemblage integrity of upland streams increases with natural land cover, whereas integrity decreases as the amount of developed and agricultural land increases (SCDNR 2023). Mature forest and riparian vegetation are important sources of large woody debris in upland streams, which contributes to beneficial habitat diversity and channel stability. The patchy and limited distributions of remaining intact habitats and populations are vulnerable to development, deforestation, loss of riparian cover and siltation of suitable rocky habitats.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and "ecobasin" (ecoregion x river basin). These estimates, for the first

time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements of the Christmas Darter.
- Conduct a genetic survey to determine the relationship between the Christmas and Savannah darters.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices (BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Conduct an education and outreach campaign to raise awareness of the impacts of illegal introductions of non-native species.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best

accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Eastern Brook Trout

Salvelinus fontinalis

Contributor (2005): Dan Rankin and Jason Bettinger [SCDNR]
Reviewed and Edited (2013): Dan Rankin and Mark Scott [SCDNR]
Reviewed and Edited (2024): Dan Rankin, Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]



Photo: NCFishes.com

DESCRIPTION

Taxonomy and Basic Description

The Eastern Brook Trout is a member of the family Salmonidae and the genus *Salvelinus*, which includes five described species of chars (Page et al. 2023) and as many as 7-10 recognized forms (Behnke 1980; Cavendar 1980; Kendall and Behnke 1984). However, it has been suggested that this genus may contain as many as 16 species (Behnke 1990). The Eastern Brook Trout is the lone living member of the subgenus *Baione*, as its only other member, the Silver Char (*Salvelinus agassizi*), has become extinct (Jenkins and Burkhead 1994). Genetic variation of Brook Trout across its native range is consistent with geographic expansion from Mississippian, mid-Atlantic, and Acadian glacial refugia (Kazyak et al. 2021). Mississippian or southern Appalachian populations are typically found south of the New River in Virginia and are genetically distinct from northern populations at subspecific levels (Stoneking et al. 1981; McCracken et al. 1993; Danzmann et al. 1998; Guffey et al. 1999, Kazyak et al. 2021). In South Carolina, 12 of 18 patches (populations) of Brook Trout tested genetically were found to be of a pure or near-pure genotype and were highly differentiated across the two major river drainages with maximum pair-wise Fst=0.773 (Pregler et al 2018).

The brilliantly marked char range in adult length from 130 to 508 mm (5.1 to 10.0 in.) (Rohde et al. 1994); however, in the Southern Appalachians, Eastern Brook Trout rarely exceed 250 mm (9.8 in.) (Jenkins and Burkhead 1994). This char is identified by a white leading margin on a black sub-margin or streak on the ventral fins; yellow and olive pale spots and red spots with a pale blue halo on an olive background along the side; and a vermiculate (wormlike) back. The belly is brilliant orange-red bordered by black at the ventrolateral margin, especially in breeding males. Larger breeding males develop a distinct kype (hook) on the lower jaw.

Status

Eastern Brook Trout are considered currently stable by Warren et al. (2000) and globally secure (G5) (NatureServe 2024). NatureServe (2024) lists Eastern Brook Trout in South Carolina as critically imperiled to imperiled (S1S2). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of high concern.

POPULATION SIZE AND DISTRIBUTION

The native range for Eastern Brook Trout extends from Canada south and east to Hudson Bay, and southward through the northern states from Eastern Minnesota and Northeastern Iowa eastward to Pennsylvania. The native range also includes the Appalachian uplands—particularly the Blue Ridge—south to Georgia. Drainage changes in the region, stream captures and piracies (Ross 1970) likely explain the occurrence of Eastern Brook Trout in Atlantic slope drainages of the Southern Appalachians, south of the New River, Virginia. These drainage changes in headwaters of the Savannah River drainage and Saluda River system in South Carolina, coupled with the occurrence of pure or near-pure native genotypes in both systems (Guffey 1995), are indicative of native heritage for South Carolina brook trout. The Eastern Brook Trout has been widely introduced outside its native range in North America and is established on all continents except Antarctica (Jenkins and Burkhead 1994).

The Eastern Brook Trout is widespread and seemingly stable across much of its range; however, a troubling decline in miles of stream occupied in the Southern Appalachians has occurred over the last century (Etnier and Starnes 1993). The range for Eastern Brook Trout in Great Smoky Mountains National Park (Moore et al. 1981) was estimated to have declined approximately 70 percent since monitoring efforts began. Factors resulting in this decline are deforestation (King 1937; Jenkins and Burkhead 1994) which causes excessive siltation and water warming, acidification, competition from non-native introductions, and global warming (Etnier and Starnes 1993; Larson and Moore 1985; Moore et al. 1986). A similar level of decline appears to have taken place in South Carolina and likely other regions of the southern Appalachians. The Brook Trout has been collected in 24 patches in SC including approximately 90 km of stream. SCDNR has expanded Brook Trout distribution through restoration and enhancement efforts in 12 streams including 30 km of additional stream.

Wild Brook Trout inhabit over 3,000 km (1,864 mi.) of streams across the Southern Appalachian region (Habera and Moore 2005). Mississippian or southern Appalachian Brook Trout populations are distributed from the New River drainage in Virginia southward into Tennessee, North Carolina, South Carolina and Georgia. The Southern Appalachian genotype (subspecies) comprises only about 17% of these streams. Most populations are located in the upper Tennessee River (Mississippi River) system; however, a few also occur in 3 Atlantic Coast and 2 Gulf Coast drainages. About 50% of Brook Trout streams in the Tennessee River system are the pure Southern genotype, while only about 5-10% of stream populations in the Atlantic Slope are pure. Of the 70% known Brook Trout resources in the Southern Appalachians, 88% occur on public lands (Habera and Moore 2005). This species was observed in 0.42% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Eastern Brook Trout inhabits rocky, often high-gradient, well-shaded, pristine coldwater mountain creeks (Rohde et al. 1994), generally above 600 m (1,969 ft.) in elevation but also occasionally down to 490 m (1,608 ft.) in streams with north-facing aspects (Etnier and Starnes 1993). Brook Trout require high dissolved oxygen levels and cannot tolerate temperatures

regularly above 20°C (68°F). Brook Trout are the most tolerant of the salmonids with regard to acidity, tolerating pHs from 4.5 to 9.5 (Jenkins and Burkhead 1994).

CHALLENGES

The Eastern Brook Trout is challenged by deforestation; specifically, the associated water temperature rises as shade trees are removed, and siltation from timber harvesting practices (King 1937; Jenkins and Burkhead 1994). Additionally, impoundments, acid deposition and displacement by non-native salmonids adversely affect this species (Etnier and Starnes 1993; Larson and Moore 1985; Moore et al. 1986). Climate change threatens the species in southern portions of its range (Meisner 1990). Contemporary genetics studies (Pregler et al. 2018) of Brook Trout in SC indicate the lowest local genetic diversity and highest genetic differentiation reported for the species to date. This creates great challenges for management, as is evidenced through occasional loss of populations.

CONSERVATION ACCOMPLISHMENTS

Many conservation practices have been accomplished for the Eastern Brook Trout. Range and population levels have been monitored across the species' range, and taxonomic characterization of the Eastern Brook Trout is well advanced. Further, water quality designations designed to protect the species have been implemented. The American Fisheries Society–Trout Committee's Position Paper (Habera and Moore 2005) is a valuable tool for management of the Southern Appalachian Brook Trout. This position paper is currently being updated to reflect new findings from contemporary genetics studies.

Additionally, the recent development of a state, federal and non-governmental organizations (NGOs) "Eastern Brook Trout Joint Venture" is focusing on protection and restoration of Eastern Brook Trout across its range in the US. To assist in this restoration, successful biological restoration techniques have been developed for this species. For the past 20 years, the South Carolina Department of Natural Resources has partnered with the USFWS, USFS, Trout Unlimited, and others to restore or enhance Eastern Brook Trout populations in 12 streams totaling approximately 30 km in South Carolina. SCDNR also completed a comprehensive assessment of in-stream habitat, water quality, and longitudinal fish distribution in several candidate streams for restoration. Recent successful restoration efforts include restoration of Brook Trout in Howard Creek (>2 miles) by removal of non-native rainbow trout and in-stream habitat enhancement. This project was funded through SARP Grant. SCDNR with partners also just completed restoration of Brook Trout in Pig Pen Branch (3.5 miles), including dam removal, non-native removal using Antimycin, and reintroduction of native strain Brook Trout.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and

mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Continue to monitor the distribution and population status with stream surveys for Eastern Brook Trout.
- Describe life history and habitat requirements for Eastern Brook Trout.
- Refine distribution information for Eastern Brook Trout, primarily on privately owned lands.
- Continue to assess water quality and habitat in Brook Trout streams to identify threats and deficiencies; establish long-term water quality and habitat monitoring programs in those streams.
- Protect critical habitats from future development and further habitat degradation by following best management practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Aggressively seek protection of Brook Trout habitat through land acquisition, conservation easements, agreements and other methods.
- Where feasible and appropriate, implement Brook Trout restoration in headwater streams.
- Conduct water quality monitoring and habitat enhancement in Brook Trout streams where habitat is determined to be impaired.

MEASURES OF SUCCESS

Monitoring the distribution, life history, and habitat needs would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species and others. In the event that more protective BMPs are implemented, population studies for this fish could assist in determining the effectiveness of those measures. An increase in native Brook Trout populations within the State would also indicate that restoration and habitat protections were successful. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Everglades Pygmy Sunfish

Elassoma evergladei

Contributors (2013): Kevin Kubach and Mark Scott [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

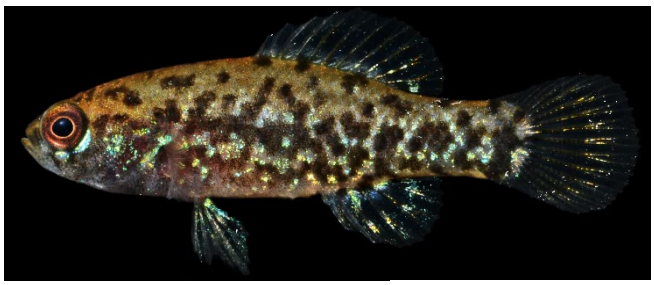


Photo: NCFishes.com

DESCRIPTION

Taxonomy and Basic Description

The Everglades Pygmy Sunfish is one of seven known species in the family Elassomatidae (Pygmy Sunfishes), all of which are placed in the genus *Elassoma and* are restricted entirely to the Southeastern United States (Rohde et al. 2009; Page et al. 2023). In addition to the Everglades Pygmy Sunfish, three other elassomatids occur in South Carolina: the Banded Pygmy Sunfish (*E. zonatum*), Bluebarred Pygmy Sunfish (*E. okatie*) and Carolina Pygmy Sunfish (*E. boehlkei*).

Everglades Pygmy Sunfish reach an adult size of only 0.9 to 1.3 in. total length (23 to 32 mm) (Rohde et al. 2009). They lack a lateral line and have a rounded caudal fin. Overall coloration varies and may be plain, mottled, or streaked with indistinct bars posteriorly and scattered blue flecks on the body and head. The breeding male is black with a bright blue spot behind and below the eye (Tracy et al. 2024). The Everglades Pygmy Sunfish and the Banded Pygmy Sunfish usually have four pores in the preopercular branch of the cephalic lateral-line canal (Snelson et al. 2009). Unlike the other three species of *Elassoma* in South Carolina, the Everglades Pygmy Sunfish has scales on the top of its head, which are often embedded (Rohde et al. 2009). Everglades Pygmy Sunfish is related to the Carolina and Bluebarred Pygmy Sunfishes, but not as closely as the latter are to each other (Sandel et al. 2014). The taxonomic placement of the *Elassoma* remains somewhat uncertain, with some studies suggesting they belong in Centrarchidae rather than a separate family (Near et al. 2012).

Status

The Everglades Pygmy Sunfish is considered secure (G5) on a global scale and is currently ranked as apparently secure in South Carolina (S4) (NatureServe 2024). It is currently stable according to Warren et al. (2000). In North Carolina and Alabama, the Everglades Pygmy Sunfish is considered vulnerable (S3), while in Georgia it is considered secure (S5) (NatureServe 2024, Tracy et al. 2024).

POPULATION SIZE AND DISTRIBUTION

The Everglades Pygmy Sunfish is distributed along the southern Atlantic Coastal Plain from the Cape Fear River Basin in North Carolina south to the Florida Everglades and west to Mobile Bay, Alabama (Rohde et al. 2009). It has been collected at scattered localities on the coastal plain across all of South Carolina's river drainages, although the highest concentration of records appears to be in the southern corner of the State (Rohde et al. 2009). This species was observed in only 0.1% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023; however, this likely reflects its preference for swamps and other densely vegetated backwaters, which were not among the habitat types targeted by these studies. In South Carolina, the ranges of this species and the Banded Pygmy Sunfish overlap across all river basins, and it also overlaps with the Bluebarred Pygmy Sunfish and Carolina Pygmy Sunfish in the smaller areas in which those species occur (Rohde et al. 2009).

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Everglades Pygmy Sunfish prefers quiet backwaters of creeks, sloughs and swamps with abundant aquatic vegetation (Rohde et al. 2009, Bohlen & Nolte 2012). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (1.1%) and average relative abundance (0.03%) in small streams (watershed area 0-15 km^2) of the coastal plain. Individuals are most often found in or near dense vegetation. The species is more motile and active at night based upon capture in traps in the Florida Everglades region (Obaza et al. 2011). However, observed mating behavior indicates the male flashes its fins in a visual signal to females, which occurs during the day, as observed in captivity. Information on the life history aspects of this species is sparse, as direct observations are mostly of captive individuals documented by aquarium hobbyists (Bohlen & Nolte 2012).

CHALLENGES

Primary threats to the Everglades Pygmy Sunfish include loss of forested land and especially the removal of riparian cover along Coastal Plain streams. Mature forest and riparian vegetation are an important source of large woody debris in Coastal Plain streams, which provides critical habitat for many endemic southern Atlantic Coastal Plain species including the Everglades Pygmy Sunfish (Marion 2008). Land development, siltation, and hydrologic alterations such as channelization and construction of impoundments also threaten this species. The conversion of naturally stagnant lowland swamps and streams into channelized, shallow drainage ditches with consistently high current velocities represents a principal threat to Everglades Pygmy Sunfish habitat. High variability of populations and low dispersal capability render pygmy sunfishes susceptible to acute disturbances and habitat fragmentation (Snelson 1989). The species is understudied, and the full extent of its distribution is unknown. Recent Georgia sampling efforts revealed new sites where the species is present, and a previously unknown site where the Everglades and Gulf Coast Pygmy Sunfishes coexist (Cannister & Bechler 2019).

CONSERVATION ACCOMPLISHMENTS

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's

freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Identify and protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Successful conservation of Everglades Pygmy Sunfish habitats would produce expected population densities comparable to or exceeding those observed in the South Carolina Stream Assessment (2006 – 2011) for given ecoregions, river basins and ecobasins. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Fieryblack Shiner
Cyprinella pyrrhomelas



Photo: NCFishes.com

Contributor (2005): Jason Bettinger (SCDNR)
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Fieryblack Shiner belongs to the minnow family (Leuciscidae), the most speciose family of freshwater fishes in North America with at least 323 described taxa of predominantly small (<150 mm) and slender fishes (Warren and Burr 2014; Page et al. 2023). Following the recent revision of the formerly large genus *Notropis* (Stout et al. 2022), *Cyprinella* is currently the most diverse genus of North American minnows, with 29 described species (Page et al. 2023). The Fieryblack Shiner is one of eight described plus one undescribed species of *Cyprinella* in South Carolina.

Members of the genus *Cyprinella* are distinguished from other leuciscids by their diamond-shaped scales and black pigmentation in the dorsal fin membranes (Rohde et al. 1994). Adult Fieryblack Shiners range in length from 47 to 110 mm (1.8 to 4.4 in.). This attractive species has a red snout, a black bar behind the opercle and a black margin on the caudal fin (Rohde et al. 1994). Breeding males display bright red and white bands on the caudal fin (Rohde et al. 1994).

Status

The Fieryblack Shiner is considered apparently secure globally (G4) (NatureServe 2024); however, there is some concern for their long-term status based on their limited distributions. The Fieryblack Shiner is considered vulnerable (S3) in South Carolina and apparently secure (S4) in North Carolina (NatureServe 2024). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of moderate concern.

POPULATION SIZE AND DISTRIBUTION

The Fieryblack Shiner occurs in the Santee and Pee Dee River systems predominantly above the fall line in North Carolina and South Carolina. In South Carolina, it is most common and abundant in the moderate to higher elevations of the Saluda and Broad River drainages; it occurs less frequently and generally in lower abundance in the Pee Dee basin and areas in which it ranges into the inner coastal plain. Outside of certain high-quality watersheds supporting stronghold populations in the upper Saluda River drainage, the Fieryblack Shiner is usually

vastly outnumbered by its congeners the Whitefin Shiner (*C. nivea*) and Greenfin Shiner (*C. chloristia*) in most locations in the Piedmont and especially in disturbed watersheds. This species was observed in 3.5% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Fieryblack Shiner requires cool, clear water in creeks and small to moderate-sized rivers. The species is generally associated with rocky runs and pools below riffles (Page and Burr 1991; Rohde et al 1994). Where it occurs (in lower abundance) in the inner coastal plain, the streams are characterized by steady flow over sand and fine gravel (SCDNR data). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (33.3%) in upland small rivers (watershed area 300-2000 km^2) of the Santee River basin. As with other non-barbeled *Cyprinella* species, the Fieryblack Shiner is a crevice spawner, depositing eggs in crevices of logs and rocks in a territory defended by the male over an extended spring-summer breeding period (Gale and Buynak 1978; Rohde et al 1994; Rohde et al. 2009).

CHALLENGES

Although the distribution of the Fieryblack Shiner spans a relatively large portion of the South Carolina uplands, abundant populations are patchy and are typically restricted to undisturbed watersheds and habitats. Approximately half of the global distribution of the Fieryblack Shiner occurs in South Carolina. Therefore, conservation efforts within South Carolina are critical to the global preservation of this species. The Fieryblack Shiner, like many other specialized stream fishes, is susceptible to an array of acute and cumulative impacts from anthropogenic alterations to the watershed, riparian zone and streams and rivers directly. These include deforestation and conversion of natural land cover for development and agriculture with resulting sedimentation and non-point source pollution, hydrologic alterations, and habitat fragmentation from dams and reservoirs. The breeding behavior of the non-barbeled *Cyprinella* makes this group particularly vulnerable to impacts from both suspended and deposited sediment. Because the breeding process is dependent on visual cues (extended display and territorial defense period) as well as clean crevices for egg deposition and larval development, suspended sediment (increased turbidity) and deposited sediment has been shown to delay or inhibit spawning success in fishes of this genus (Hubbs and Echelle 1972; Burkhead and Jelks 2001; Warren and Burr 2014). The rapidly developing Greenville-Spartanburg and Interstates 85 and 385 corridors are situated directly within the range of this species. Furthermore, the introduction and establishment of the highly invasive Red Shiner (*Cyprinella lutrensis*) in the North Carolina portion of the Pee Dee River basin (Poulos et al. 2012; Glotzbecker et al. 2016; Tracy et al. 2020; Tracy et al. 2024) represents a potential threat to native *Cyprinella*, including the Fieryblack Shiner. *C. lutrensis* has been shown to impact native *Cyprinella* through competition and hybridization (Walters et al. 2008; Ward et al. 2012), both of which can be exacerbated with additional stressors such as elevated turbidity resulting from alteration of natural land cover (Glotzbecker et al. 2015) and broader influences of climate change (Poulos and Chernoff 2014).

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina’s freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT’s second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting’s pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.

- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

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    - Epstein, J.M., W.E. Pine III, C.M. Romagosa, M.C. Scott, C.T. Phillips, C.A. Marion, and B. Baiser. 2018. State- and Regional-Scale Patterns and Drivers of Freshwater Fish Functional Diversity in the Southeastern USA. Transactions of the American Fisheries Society. 147:1179-1198. https://doi.org/10.1002/tafs.10110

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    - Denison, C.D., M.C. Scott, K.M. Kubach, and B.K. Peoples. 2021. Incorporating network connectivity into stream classification frameworks. Environmental Management. 67:291-307.

    - Denison, C.D., M.C. Scott, K.M. Kubach, and B.K. Peoples. 2021. Integrating regional frameworks and local variability for riverine bioassessment. Environmental Management. 68(1):126-145.

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements of the Fieryblack Shiner.
- Identify critical habitats and areas with healthy populations of the Fieryblack Shiner.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the

Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Flat Bullhead

Ameiurus platycephalus



Photo: NCFishes.com

Contributor (2005): Jason Bettinger (SCDNR)
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
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DESCRIPTION

Taxonomy and Basic Description

The Flat Bullhead is a member of the family Ictaluridae. The ictalurids, with approximately 51 species, represent the largest family of fishes indigenous to only North America (Warren et al. 2020; Page et al. 2023). The genus *Ameiurus* contains the moderately-sized (reaching only a few pounds) catfish collectively known as the "bullheads." Flat Bullheads have a large flat head, a relatively straight snout profile, a bi-colored maxillary barbel that has a white leading edge, short rounded anal fin (though usually several rays longer than that of the Snail Bullhead), emarginate tail, gold-yellow to dark brown colored back, dark mottling along the sides, and a cream-colored belly. In their natural habitats (rivers and streams), Flat Bullheads typically reach maximum adult sizes of 294 mm (11.4 in.) (Rohde et al. 1994). However, in impounded river reaches and reservoirs, they reach substantially greater sizes (443 mm, 17.6 in.) (SCDNR unpublished data).

Status

The Flat Bullhead is considered apparently secure (G4) globally (NatureServe 2024). However, in a recent assessment of North American fishes, this species was considered vulnerable to imperilment (Jelks et al. 2008). The Flat Bullhead is considered vulnerable to apparently secure (S3S4) in South Carolina and Virginia. In North Carolina this species is considered apparently secure (S4), while in Georgia it is considered apparently secure to secure (S4S5) (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

The Flat Bullhead occurs in the Piedmont and coastal plain of the Atlantic slope from the Roanoke River basin in Virginia south to the Altamaha River basin in Georgia. In South Carolina, the Flat Bullhead is found in all river basins and ecoregions, although it is most widespread and abundant in the uplands. Flat Bullheads appear to be relatively stable in South Carolina streams; however, their fate in the larger rivers is uncertain due to the presence of the nonnative Flathead Catfish. Flat Bullheads are common to abundant in the upper Santee basin but decreasing trends have been noted in many coastal rivers like the Edisto River and lower

Savannah River following the introduction of Flathead Catfish (C. Thomason, SCDNR, pers. comm.). The largest populations of Flat Bullhead are probably located in the Broad River system; however, both the Flathead Catfish and Blue Catfish have been documented in the system in recent decades, and their impact has yet to be determined. This species was observed in 22.9% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Flat Bullhead is typically found in streams, rivers, and impoundments occupying areas with mud, sand, or rock bottoms, with slow-flowing water along the banks and in pool areas (Jenkins and Burkhead 1994; Rohde et al. 1994, 2009; NatureServe 2024). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (82.9%) and average relative abundance (1.0%) in upland large streams (watershed area 100-300 km²) of the Santee River basin.

CHALLENGES

The Flat Bullhead is adversely affected by the same myriad of challenges for all aquatic species, such as sedimentation, hydrologic modification, impoundments, non-point source pollution, and development. Other threats to the Flat Bullhead include loss of forested land and especially the removal of riparian cover along upland streams. Fish assemblage integrity of upland streams increases with natural land cover, whereas integrity decreases as the amount of developed and agricultural land increases (SCDNR 2023). Mature forest and riparian vegetation are important sources of large woody debris in upland streams, which contributes to beneficial habitat diversity and channel stability. Additionally, this species is also threatened by the introduction of nonnative ictalurids like the Flathead Catfish and the Blue Catfish; both of these non-native species displace and prey on the smaller bullheads (Guire et al. 1984; Ashley and Buff 1986; Quinn 1988; Bart et al. 1994, Rohde et al. 2009).

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment (2006-2011) data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

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- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land-use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Develop a Non-Game Fishes of South Carolina poster and other educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Prevent the spread of Flathead Catfish and other non-indigenous aquatic species.
- Educate the public as to the discontents of stocking nonnative species.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Florida Gar

Lepisosteus platyrhincus



Contributor (2005): Jason Bettinger (SCDNR)
Reviewed and Edited (2013): Kevin Kubach and Mark Scott [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Florida Gar is a member of the ancient family *Lepisosteidae*, which arose at least 100 million years ago (Warren and Burr 2014). Along with the Longnose Gar (*L. osseus*), it is one of two species of gars in South Carolina. *Lepisosteidae* is a small family with seven currently described species, five of which occur in eastern North America, one in Cuba and one in Central America (Warren and Burr 2014), though the Cuban Gar (*Atractosteus tristoechus*) is not currently recognized by the American fisheries society (Page et al. 2023).

Gars are distinctive, with a heavy armor of diamond-shaped scales and a long, beak-like mouth equipped with needle-sharp conical teeth. The Florida Gar can be distinguished from the Longnose gar by its broader and shorter snout, which has spots on top (absent in Longnose). The Florida Gar can attain lengths of 132 cm (52 in.) (Page and Burr 1991).

Status

The Florida Gar is considered globally secure and stable (G5) (Warren et al. 2000) but is listed as critically imperiled to imperiled (S1S2) in South Carolina (NatureServe 2024). In Georgia, this species is thought to be vulnerable (S3) (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

The Florida Gar occurs from portions of the Savannah River Basin in South Carolina and Georgia into peninsular Florida and west to the Ochlockonee River drainage of Florida and Georgia (Rohde et al. 2009). In South Carolina, it was previously known only from the lower Savannah River near the mouth of Steel Creek and a handful of tributaries in Barnwell County near the Savannah River Site (Rohde et al. 2009). In 2020, SCDNR staff studying the state's small rivers collected the species in two additional localities: Boggy Branch, a tributary of the lower Savannah River in Hampton County, and the New River, a small coastal river just east of the Savannah River in Jasper County. The New River now represents the global easternmost known occurrence for the species. This species was observed in 0.3% of over 900 standardized statewide stream and river assessment samples throughout South Carolina between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Florida Gar inhabits sluggish pools of quiet streams, rivers, sloughs and oxbow lakes, usually near vegetation (Rohde et al. 2009). In standardized sampling covering streams to small rivers across the state, this species exhibited its highest frequency of occurrence (7.7%) and average relative abundance (0.3%) in small rivers (watershed area 300-2000 km^2) of the coastal plain.

CHALLENGES

Primary threats to the Florida Gar include anthropogenic habitat alteration near its limited range in the lower Savannah and New River basins. Although certain tributaries within its range in South Carolina are protected under management of the Savannah River Site (US Department of Energy), impacts to the Savannah River and its tributaries may affect habitat for the Florida Gar, including flow alterations and channelization of swamps and sluggish streams. Currently, the recently discovered population in Boggy Branch of the lower Savannah River basin in Hampton County is located in a watershed largely established as state-managed (SCDNR) Wildlife Management Area land and therefore maintained for the benefit of native species. However, the headwaters of this system should be monitored in order to reduce potential impacts on Florida Gar habitat for this potentially isolated population. The recently discovered Florida Gar population in the New River in Jasper County is at a relatively high risk of habitat alteration from development along the Interstate 95 and U.S. Highway 278 corridors and adjacent coastal communities experiencing rapid growth. Draining of floodplains for development and channelization of tributaries represent immediate threats on the global edge of the Florida Gar's range.

CONSERVATION ACCOMPLISHMENTS

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online

tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.

- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.

- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Highback Chub

Hybopsis hypsinotus



Photo: NCFishes.com

Contributor (2005): Jason Bettinger (SCDNR)
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Highback Chub is a member of the minnow family (Leuciscidae) and is one of two species of *Hybopsis* in South Carolina, along with Rosyface Chub (*H. rubrifrons*). Minnows represent the most speciose family of freshwater fishes in North America, with at least 323 described taxa of predominantly small (<150 mm) and slender fishes including six described species of *Hybopsis* (Warren and Burr 2014; Page et al. 2023).

This fish looks similar to numerous shiners but often has a small barbel in the corner of its inferior mouth, a long snout, and upward-looking eyes (Rohde et al. 1994). The Highback Chub has a strongly arched dark olive body with a black lateral stripe that extends onto the snout—it resembles a deeper-bodied version of its congener, the Rosyface Chub. During the breeding season, males display red fins. The adult size range is 43 to 84 mm (1.7 to 3.3 in) (Rohde et al. 2009).

Status

The Highback Chub is apparently secure globally (G4) (NatureServe 2024); however, there is some concern for their long-term status based on their limited distributions. The Highback Chub is considered vulnerable (S3) in South Carolina, apparently secure (S4) in North Carolina, and imperiled (S2) in Virginia (NatureServe 2024). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of moderate concern.

POPULATION SIZE AND DISTRIBUTION

The Highback Chub is found in the Blue Ridge foothills and Piedmont ecoregions of the Santee and Pee Dee River drainages. Its core densities occur in the Broad River drainage of the Santee basin (Rohde et al. 2009). Although this species currently appears to be stable in South Carolina, it has a patchy distribution and is typically among the least abundant species in the fish assemblage where present, rarely exhibiting the levels of abundance often shown by the closely related Rosyface Chub (*H. rubrifrons*). This species was observed in 7.0% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Highback Chub is found in cool to warm water streams and small rivers, generally in riffles and runs with sand, gravel, and rock bottoms (Page and Burr 1991; Jenkins and Burkhead 1994). Lemly (1985) mentions finding them only in first-order streams in the Piedmont region of North Carolina. In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (21.8%) and highest average relative abundance (0.9%) in upland small streams (watershed area 0-15 km²) of the Santee River basin. The Highback Chub spawns in May-June, using nests constructed by *Nocomis* chubs (Rohde et al. 2009).

CHALLENGES

The Highback Chub is currently stable with relatively large distributions throughout the State. They are of conservation concern because they are only found within a few major drainages. Approximately 50% of the global range of the Highback Chub occurs in South Carolina. Therefore, conservation efforts within South Carolina are critical to the global preservation of this species. Challenges to this species are similar to those faced by other aquatic fauna and include point and nonpoint source pollution, deforestation and loss of riparian corridors, impoundment development, siltation from poor land use practices, and unplanned or poorly planned urban and suburban development. Midway et al. (2014) modeled a positive occurrence response of Highback Chub with increasing forest land cover, indicating that preservation of natural land cover would be beneficial to the species. Introduction of non-native species is also a conservation concern; for example, Lemly (1985) only observed Highback Chubs in small first-order streams in which non-native Green Sunfish (*Lepomis cyanellus*) were absent.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina’s freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

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CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements of the Highback Chub.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Highfin Shiner

Hudsonius altipinnis



Photo: NCFishes.com

Contributors (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Highfin Shiner belongs to the minnow family (Leuciscidae) and was recently moved to the genus *Hudsonius* from the polyphyletic *Notropis* (Stout et al. 2022 and sources therein), joining the Spottail Shiner (*H. hudsonius*) as the only current members of this genus in South Carolina and North America (Page et al. 2023). Minnows represent the most speciose family of freshwater fishes in North America, with at least 323 described taxa of predominantly small (<150 mm) and slender fishes (Warren and Burr 2014; Page et al. 2023).

Adult Highfin Shiners are small, ranging in total length from 36 to 63 mm (1.4 to 2.5 in.) (Rohde et al. 2009). This species has a diffuse, black lateral stripe extending from less than halfway onto the caudal fin to, and occasionally over, the eye and around the nostril. The lateral stripe does not extend below the lowest part of the lateral line, and it is bordered above by a light (mostly unpigmented) stripe. The scales on the back are outlined in black. The lateral line is often incomplete. The mouth is oblique and there is a U-shaped smudge of pigment between the nostrils when viewed from above. Little or no pigment is present along the anal fin base (Rohde et al. 2009). Highfin shiners have been found to be efficient larval hosts of the federally endangered Carolina Heelsplitter (*Lasmigona decorata*), a freshwater mussel found in North and South Carolina (Eads et al. 2010).

Status

The Highfin Shiner is considered secure (G5) on a global scale and is currently considered vulnerable to apparently secure in South Carolina (S3S4; NatureServe 2024). It is currently stable according to Warren et al. (2000). The Highfin Shiner is considered secure (S5) in North Carolina and vulnerable (S3) in Virginia (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

The Highfin Shiner occurs primarily in the Piedmont region of drainages from the Chowan River, Virginia to the Savannah River, Georgia/South Carolina (Rohde et al. 2009). It is found in all of South Carolina's river basins, predominantly in the outer Piedmont and especially the Carolina Slate Belt Ecoregion. This species was observed in 5.2% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Highfin Shiner occurs in pools and runs of small to large streams with substrata ranging from sand to rocks (Rohde et al. 2009). It is particularly abundant in relatively slow-flowing streams of the Carolina Slate Belt ecoregion exhibiting long, sluggish reaches interspersed with short riffles of bedrock, rubble and gravel. In this regard, the Highfin Shiner appears to share a close ecological association with the Carolina Darter (*Etheostoma collis*) where their ranges overlap. During periods of seasonal or extended drought, these streams often reduce to long, stagnant, nearly broken to broken pools; Highfin Shiners have been collected in abundance during such conditions and appear somewhat tolerant of this high variability in water level and temperature, provided they are not stressed by additional anthropogenic habitat alteration. In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (22.9%) in large streams (watershed area 100-300 km^2) and highest average relative abundance (1.7%) in medium streams (watershed area 15-100 km^2) of the Outer Piedmont and Carolina Slate Belt of the Santee River basin.

CHALLENGES

Primary threats to the Highfin Shiner include loss of forested land and especially the removal of riparian cover along Piedmont and Carolina Slate Belt streams. Fish assemblage integrity of upland streams increases with natural land cover, whereas integrity decreases as the amount of developed and agricultural land increases (SCDNR 2023). Mature forest and riparian vegetation are important sources of large woody debris in upland streams, which contributes to beneficial habitat diversity and channel stability. Land development, siltation, and hydrologic alterations such as channelization and construction of impoundments also threaten this species. The conversion of upland streams into channelized ditches with little in-stream habitat represents a principal threat to Highfin Shiner habitat. Fragmentation caused by road crossings or other anthropogenic barriers may be particularly detrimental in the Carolina Slate Belt ecoregion, reducing the ability of native species to locate suitable habitat during periods of drying and disconnection.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina’s freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning

the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Ironcolor Shiner

Alburnops chalybaeus



Photo: NCFishes.com

Contributors (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Ironcolor Shiner belongs to the minnow family (Leuciscidae) and was recently moved to the genus *Alburnops* from the polyphyletic *Notropis* (Stout et al. 2022 and sources therein), joining the reclassified Coastal Shiner (*A. petersoni*) as the only members of this genus in South Carolina (Page et al. 2023). Minnows represent the most speciose family of freshwater fishes in North America (about 27% of the continental fauna), with at least 323 described taxa of predominantly small (<150 mm) and fusiform fishes including 18 recognized species of *Alburnops* (Warren and Burr 2014; Page et al. 2023).

Adult Ironcolor Shiners are relatively small, ranging in total length from 45 to 65 mm (1.8 to 2.6 in.) (Rohde et al. 2009). The sides and back are yellowish and there is a well-defined black lateral stripe extending from the caudal fin base to the snout with pigment present on the chin and lips. Its snout is shorter than the width of the eye and its mouth is small with a black roof. Breeding males have a bright orange stripe above the black lateral stripe and often have orange spots above and below the black caudal spot. The lateral line is usually incomplete (Rohde et al. 2009).

Status

The Ironcolor Shiner is considered apparently secure (G4) on a global scale and is currently considered vulnerable (S3) in South Carolina (NatureServe 2024). Although it occupies a relatively wide distribution, populations are disjunct (Lee et al. 1980) and it is considered rare or declining in many portions of its range. This species was regarded as vulnerable in a recent assessment of North American fishes due to present or threatened destruction and modification of its habitat (Jelks et al. 2008). Accordingly, it has received varying degrees of state conservation status as high as critically imperiled (S1) in Alabama, Delaware, Maryland, Michigan, Missouri, New York, Oklahoma, and Pennsylvania (NatureServe 2024). After being rediscovered in Pennsylvania, the species is confined to one stream system and its persistence there may depend on reintroduction and augmentation efforts (Leckvarcik 2005; Hanson 2013). In Georgia the Ironcolor Shiner is considered vulnerable (S3), while in North Carolina it is considered imperiled to vulnerable (S2S3) as its range there has apparently contracted over the past 30 years (Tracy et al. 2020). This species was selected as a Regional Species of Greatest

Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of high concern.

POPULATION SIZE AND DISTRIBUTION

The Ironcolor Shiner occupies a large but somewhat disconnected range that includes the coastal plain of the Atlantic and Gulf Slopes from Maine to Texas and northward in the Mississippi River Basin to Wisconsin (Rohde et al. 2009). Although it is found in all of South Carolina's river basins on the coastal plain, populations appear to be patchy based on standardized statewide assessment sampling. This species was observed in 4.3% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

In South Carolina, the Ironcolor Shiner generally inhabits low-velocity blackwater streams and swamps (Rohde et al. 2009), including a wide range of sizes from small streams to large swamp channels and blackwater rivers. In standardized sampling covering streams to small rivers across the state, this species exhibited its highest frequency of occurrence (38.5%) and average relative abundance (2.9%) in small rivers (watershed area 300-2000 km^2) of the outer coastal plain. It was particularly abundant in the streams of the Francis Marion National Forest as well as the Coosawhatchie River. In South Carolina, the Ironcolor Shiner is most often collected in habitats with a large amount of organic substrate (≥48% of channel substrate), consistent with the finding of swamps and blackwater streams being a primary habitat per Rohde et al. (2009) (SCDNR unpublished data). The Ironcolor Shiner is a broadcast spawner, releasing eggs into sand- and gravel-bottomed pools (Becker 1983; Rohde et al. 2009).

CHALLENGES

By comparison with its status in most other parts of its range, the Ironcolor Shiner in South Carolina appears to be relatively widespread and, in certain places, abundant. However, the range-wide trend of decline and imperilment for this species is concerning and signals risk for the integrity of its populations in the state. In the adjacent and ecologically similar coastal plain of North Carolina, the range of the Ironcolor Shiner has contracted over the past 30 years, and its frequency of occurrence and relative abundance also appeared to be lower in surveys of the southeastern basins in 2010-2016 than those observed in the same basins in the 1960s (Tracy et al. 2020). Its sensitivity to the spectrum of anthropogenic habitat alteration, which has been attributed to its decline elsewhere (Leckvarcik 2001), is notable. In South Carolina, much of the range of this species is in relatively rural or least-disturbed landscapes, but the high rate of human population growth outward from the state's major coastal plain cities and associated conversion of natural land to developed areas represents a principal threat. Fish assemblage integrity of coastal plain streams increases with natural land cover, whereas integrity decreases as the amount of agricultural land increases (SCDNR 2023).

Primary threats to the Ironcolor Shiner include loss of forested land and especially the removal of riparian cover along Coastal Plain streams. Mature forest and riparian vegetation are important sources of large woody debris in Coastal Plain streams which provides critical habitat for many

endemic southern Atlantic coastal plain species including Ironcolor Shiner (Marion 2008). Land development, siltation, and hydrologic alterations such as channelization and construction of impoundments also threaten this species. The conversion of lowland swamps and streams into channelized, shallow drainage ditches with unnaturally high current velocities represents a principal threat to Ironcolor Shiner habitat.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment (2006-2011) data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

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Mirror Shiner

Paranotropis spectrunculus



Photo: NCFishes.com

Contributor (2005): Jason Bettinger (SCDNR)
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Mirror Shiner belongs to the minnow family (Leuciscidae) and was recently moved to the resurrected genus *Paranotropis* from the polyphyletic *Notropis* (Stout et al. 2022 and sources therein), joining the reclassified Tennessee Shiner (*P. leuciodus*) as the only members of this genus in South Carolina (Page et al. 2023). Minnows represent the most speciose family of freshwater fishes in North America (about 27% of the continental fauna), with at least 323 described taxa of predominantly small (<150 mm) and slender fishes including eight recognized species of *Paranotropis* (Warren and Burr 2014; Page et al. 2023).

This species is identified by its slender body, broad head, small subterminal mouth, and upward-directed eyes (Rohde et al. 1994). There is a prominent dark, triangular spot at the caudal fin base. During breeding season, males display red-orange fins with white margins. Adults range in length from 43 to 75 mm (1.7 to 3.0 in.) (Rohde et al. 1994).

Status

Globally, the Mirror Shiner is considered to be stable (Warren et al. 2000) and apparently secure (G4) (NatureServe 2024). It is considered vulnerable (S3) in South Carolina and Georgia (NatureServe 2024). In Virginia this species is considered imperiled (S2) and is considered apparently secure (S4) in both North Carolina and Tennessee (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

The Mirror Shiner mainly occurs in upland drainages in the upper Tennessee River basin of western Virginia, western North Carolina, eastern and southern Tennessee, and northern Georgia, along with small portions of the upper Savannah River basin and upper Broad River drainage (Santee basin) in North Carolina (Rohde et al. 2009). In South Carolina, it is only known from several locations in the upper Savannah River basin, with the bulk of its occurrences coming from the Chattooga River (Rohde et al. 2009). Its presence in the upper Savannah basin of the Atlantic slope is probably a result of stream capture with the Tennessee basin (Ramsey 1965; Ross 1970; Rohde et al. 2009), similar to other taxa in this volume with predominantly Mississippi drainage distributions. The Broad (Santee) population may have resulted from

human-mediated introduction (Tracy et al. 2020). It is considerably more abundant in the Chattooga River than its congener, the Tennessee Shiner (*P. leuciodus*). On a statewide scale, this species was observed in only 0.1% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Mirror Shiner inhabits clear, coolwater streams and rivers with moderate to high gradients (Jenkins and Burkhead 1994) and gravel and rubble substrates (Rohde et al. 2009). This species is generally found in the slower moving areas associated with pools, slow runs, and riffle margins (Rohde et al. 2009; Olson and Martin 2016). Spawning in western North Carolina occurred from April to July (Olson and Martin 2016). In standardized sampling covering streams to small rivers across South Carolina, this species exhibited its highest frequency of occurrence (16.7%) and average relative abundance (0.6%) in upland small rivers (watershed area 300-2000 km^2) of the Savannah River basin.

CHALLENGES

While the Mirror Shiner is currently stable throughout the majority of its range, its limited distribution in South Carolina make it vulnerable to imperilment within the state. Although much of the Chattooga River drainage is officially designated as wilderness area and therefore protected from development, other anthropogenic actions such as the introduction of non-native species (both aquatic and terrestrial) or long-term environmental change represent potential threats to this species. For example, non-native organisms such as the hemlock woolly adelgid (*Adelges tsugae*) or other tree pathogens could cause widespread loss of major forest constituent tree species and therefore alter the natural thermal and other ecological regimes to which aquatic fauna have adapted. As with other freshwater fishes, anthropogenic landscape alteration can result in cumulative degradation of dependent aquatic ecosystems. The Mirror Shiner may be sensitive to changes in water quality as indicated by its failure to reestablish in a restored river section in which reintroductions of many other species were successful (Olson and Martin 2016).

CONSERVATION ACCOMPLISHMENTS

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and

restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.

- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- • Use South Carolina Stream Assessment decision-support GIS modeling tools to identify
- levels and spatial distributions of critical habitat factors to sustain the species in
- geographic areas of interest.

- • Use South Carolina Stream Assessment decision-support GIS modeling tools to identify
- priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements of the Mirror Shiner.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices (BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Mottled Sculpin

Cottus bairdii



Photo: NCFishes.com

Contributor (2005): Mark Scott and Jason Bettinger [SCDNR]
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Mottled Sculpin is a member of the family Cottidae, which includes 36 species of predominantly freshwater fishes across North America (Page et al. 2023). Taxonomic relationships, geographic delimitations and species descriptions within this family have proven particularly challenging to resolve and have received considerable attention in recent decades (Page et al. 2023 and sources therein). Despite the recommendation of or use by some authors of *Cottopsis* and *Uranidea* in place of *Cottus* (Kinziger et al. 2005; e.g., Smith and Busby 2014; Robison and Buchanan 2020), the American Fisheries Society continues to recognize *Cottus* based on the confounding results of recent investigations (Page et al. 2023 and sources therein). *Cottus bairdii* in a broad sense occurs throughout eastern North America and on both sides of the western Continental Divide; variation across this large range has long been recognized (Robins 1954; Robins 1961; Jenkins and Burkhead 1994) and remains largely unresolved (Rohde et al. 2009; Tracy et al. 2020; Tracy et al. 2024). The form occurring in South Carolina and adjacent drainages, often referred to as the "Smoky Sculpin," probably represents a distinct species (Jenkins and Burkhead 1994; Warren et al. 2000; Rohde et al. 2009).

The adult Mottled Sculpin ranges in total length from 58 to 114 mm (2.3 to 4.5 in.). As is typical of other members of the genus *Cottus*, the Mottled Sculpin has a large head and mouth, 2 dorsal fins (the first is spiny and the second is soft-rayed) and three reduced preopercular spines. This sculpin has a complete lateral line—or nearly so—and well-developed palatine teeth. Red marginal and black basal bands in the spinous dorsal fin are found on males. Pigmentation is highly variable, with body background color ranging from coppery brown to slate gray, approaching black in nuptial males, with dark brown to black mottling on sides and back (Robins 1961; Page and Burr 1991; Jenkins and Burkhead 1994).

Status

Warren et al. (2000) listed the global status of the Mottled Sculpin as currently stable within its range, and it is considered secure (G5) by NatureServe (2024). The Mottled Sculpin is Considered imperiled to vulnerable (S2S3) in South Carolina (NatureServe 2024). In Georgia

this species is considered apparently secure (S4), while in North Carolina they are considered secure (S5). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of high concern.

POPULATION SIZE AND DISTRIBUTION

The South Carolina form of the Mottled Sculpin is endemic to the southern portion of the Blue Ridge physiographic region (Warren et al. 2000). In South Carolina, it is found in the high elevations of the upper Savannah River drainage, primarily in the Blue Ridge ecoregion and in scattered locations of the Inner Piedmont (to as low as about 700 feet). The Savannah populations are thought to have colonized the basin due to stream capture of Tennessee drainages, similar to other taxa in this volume with predominantly Mississippi drainage distributions (Jenkins et al. 1971, Ramsey 1965; Ross 1970; Rohde et al. 2009); this may also explain its absence from the sufficiently high elevations of the upper Saluda River basin. Outside of South Carolina, the species occurs in the Blue Ridge portions of north Georgia and western North Carolina (Jenkins and Burkhead 1994).

This species can be abundant in high-elevation, high-gradient streams and rivers draining well-forested watersheds. It is extremely abundant in the upper Chattooga River, where its population appears stable based on annual fish population sampling (SCDNR unpublished data). Future population viability is likely in the high-elevation rivers draining protected lands of the Blue Ridge, particularly in light of the protected status afforded the Chattooga as a Wild and Scenic River. This species was observed in 1.0% of over 900 standardized statewide stream and river assessment samples across the state between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Mottled Sculpin inhabits clear, cold to cool headwaters, creeks, springs and small montane rivers of high to moderate gradient. Substrates are rubble and gravel, which are important to its benthic feeding habits and crevice spawning behavior. In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (12.1%) and average relative abundance (1.1%) in upland small streams (watershed area 0-15 km^2) of the Savannah River basin.

CHALLENGES

The Mottled Sculpin is currently stable throughout its range. However, the limited distribution of this species within South Carolina makes it vulnerable to impacts from land development, deforestation, loss of riparian cover, siltation (McGinley et al. 2013), and hydrologic alterations (channelization and impoundment construction). Populations outside of the protected lands of the Blue Ridge escarpment, and especially those in relatively low elevations of the Inner Piedmont, are particularly susceptible to anthropogenic habitat alteration. Habitat alteration in the lower elevations of its range, where it is already closer to its thermal limits, is particularly detrimental. In addition, this species is among those in South Carolina most likely to be impacted by longer-term decline in habitat suitability associated with climate change.

CONSERVATION ACCOMPLISHMENTS

The core area of “Smoky” Sculpin abundance is protected by the Wild and Scenic Chattooga River.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina’s freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements for the "Smoky" Sculpin.
- Conduct genetic studies of the "Smoky" Sculpin to resolve taxonomic questions regarding differentiation of Savannah populations.
- Identify and protect areas with healthy populations and intact critical habitat for the "Smoky" Sculpin.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Consider this species' needs when participating in the environmental permit review process.
- Encourage responsible land use planning.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species and others. Genetic resolution of the status of the species will allow for more specific management protocols. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of

natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Piedmont Darter

Percina crassa



Photo: NCFishes.com

Contributor (2005): Gene Hayes and Jason Bettinger [SCDNR]
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Piedmont Darter is a member of the family Percidae (perches and darters) and one of two species of *Percina* found in South Carolina, along with *P. westfalli* (Sooty-banded Darter) (Page et al. 2023). Percids represent the second-most diverse family of freshwater fishes in North America (behind Leuciscidae, minnows) with 224 currently recognized species and many forms awaiting full description (Page et al. 2023). The darters, predominantly small, bottom-dwelling fishes, comprise the vast majority of species in this family.

This is a moderate-sized darter ranging in adult length from 68 to 90 mm (2.7 to 3.5 in.) (Rohde et al. 1994, 2009). It is generally brown in color with 7 to 9 vertically elongated oval blotches joined by a mid-lateral band. A caudal spot is usually diffuse and vertically elongated (Kuehne and Barbour 1983). The Piedmont Darter has a black chin bar, black breast spot, and a large black teardrop below the eye. The first dorsal fin has a black edge, a tan band below, a yellow interior, and vertical black markings below the lower portion of each spine (Rohde et al. 1994). Chin, throat, and breast are lightly stippled in females and more heavily so in males.

Status

Globally, the Piedmont Darter is considered apparently secure (G4) (NatureServe 2024). Warren et al. (2000) classified the Piedmont Darter as currently stable. The Piedmont Darter is considered vulnerable (S3) in South Carolina (NatureServe 2024). In North Carolina it is considered apparently secure (S4) but is critically imperiled (S1) in Virginia (NatureServe 2024). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of moderate concern.

POPULATION SIZE AND DISTRIBUTION

The Piedmont Darter occurs in the Santee, Pee Dee (a small portion of Virginia, through North Carolina and into South Carolina) and Cape Fear River basins of the Carolinas. In South

Carolina, it is most common and abundant in the Piedmont and foothills of the mountains, with additional populations occurring at generally lower densities on the inner coastal plain where topography supports flowing streams. This species was observed in 8.1% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Piedmont Darter is found in clean, moderate to large streams with a sand to cobble substrate. Though a riffle dweller, this darter does not seem to favor extremely strong currents (Kuehne and Barbour 1983; Rohde et al. 1994) and is often observed in moderately deeper and slower habitats adjacent to the main flow with woody debris. Where it occurs (in lower abundance) in the inner coastal plain, the streams are characterized by steady flow over sand and fine gravel, and wood plays an important role as cover and in creating habitat heterogeneity (SCDNR data). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (94.4%) and highest average relative abundance (1.4%) in upland small rivers (watershed area 300-2000 km^2) of the Santee River basin.

CHALLENGES

Although the Piedmont Darter is currently considered stable, conservation efforts within South Carolina are critical to its global conservation. Approximately one third of the global range of the Piedmont Darters occurs in South Carolina. Within the state, destruction of stream riffle habitat caused by land development, deforestation, loss of riparian cover, siltation, and hydrologic alterations like channelization and impoundments could jeopardize this species. Mature forest and riparian vegetation are important sources of large woody debris in coastal plain streams, which provides critical habitat for many endemic Southern Atlantic Coastal Plain species including the Piedmont Darter (Marion et al. 2015). Deforestation and clearing of riparian cover may be particularly detrimental to this species in the coastal plain portion of its range, where it is already near the limits of its thermal tolerance and in which wood may play a larger role as habitat in the absence of rock.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment (2006-2011) data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina’s freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and

developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

    - Marion, C.A., M.C. Scott, and K.M. Kubach. 2015. Multiscale environmental influences on fish assemblage structure of South Atlantic coastal plain streams. Transactions of the American Fisheries Society. 144(5):1040-1057.

    - Epstein, J.M., W.E. Pine III, C.M. Romagosa, M.C. Scott, C.T. Phillips, C.A. Marion, and B. Baiser. 2018. State- and Regional-Scale Patterns and Drivers of Freshwater Fish Functional Diversity in the Southeastern USA. Transactions of the American Fisheries Society. 147:1179-1198. https://doi.org/10.1002/tafs.10110

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity. Describe life history and habitat requirements of Piedmont Darters.
- Identify streams with healthy Piedmont Darter populations and intact critical habitat in the upper Santee and Pee Dee drainages. Protect these areas, once identified.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices (BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Pinewoods Darter

Etheostoma mariae



Photo: NCFishes.com

Contributor (2005): Scott Lamprecht and Jason Bettinger [SCDNR]
Reviewed and Edited (2013): Kevin Kubach, Mark Scott, Andrew R. Gelder, and M. Troy Cribb [SCDNR]
Contributors (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Pinewoods Darter is a member of the perch and darter family (Percidae), an extremely diverse group of predominantly small, bottom-dwelling fishes currently represented by 224 described species comprising more than 20% of the North American freshwater ichthyofauna (Page 1983; Kuehne and Barbour 1983; Near et al. 2011; Page et al. 2023). With 138 described species, *Etheostoma* is the most diverse genus of North American freshwater fishes (Page et al. 2023).

The Pinewoods Darter is a member of the subgenus *Belophlox*, which can be separated from most other darters by the presence of a broad dark stripe on its side and a contrasting light lateral line (Rohde et al. 1994). The Pinewoods Darter has roughly 10 elongate dark blotches on its side and a red marginal or submarginal band in its first dorsal fin. Pinewoods Darters reach a maximum length of about 74 mm (2.9 in.) (Page and Burr 1991).

Status

The Pinewoods Darter has received recognition as State Endangered in South Carolina and of Special Concern in North Carolina, the only other state in which it occurs. It is considered imperiled (S2) in North Carolina and possibly extirpated (SH) in South Carolina while globally vulnerable (G3) (NatureServe 2024). The Pinewoods Darter was considered vulnerable in a recent assessment of North American freshwater fishes (Jelks et al. 2008) and was listed as a regional species of greatest conservation need (Rice et al. 2019), receiving a designation of high concern.

Although the Pinewoods Darter has not been confirmed in South Carolina since 1949 (Rohde et al. 2009), the isolated and complex habitats in which the species occurs coupled with comparatively few dedicated searches suggest it may still be extant in the state's waters. The discovery or rediscovery of several elusive fish species in North Carolina and Georgia in recent decades (Darden et al. 2019; Tracy et al. 2020; Tracy et al. 2024) illustrates the potential for this species to persist in South Carolina.

POPULATION SIZE AND DISTRIBUTION

The Pinewoods Darter is extremely restricted, occurring only in the Sand Hills ecoregion of the Lumber/Little Pee Dee River system in North and South Carolina. Although it is not extremely uncommon in appropriate habitat in its limited range within North Carolina, the species has not been documented in South Carolina since 1949 and is therefore considered possibly extirpated from the state (Rohde et al. 2009). The only records from South Carolina are from Panther and Beaverdam Creeks near the town of McColl, SC (Rohde et al. 2009).

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Pinewoods Darter inhabits small, cool, flowing headwater streams with sand to gravel substrate and abundant aquatic vegetation (Rohde and Arndt 1991). Where their ranges overlap, the Pinewoods Darter shares a strong similarity in habitat requirements with the regionally endemic Sandhills Chub (*Semotilus lumbee*) (Rohde and Arndt 1991). Rooted aquatic vegetation is particularly important; Rohde and Arndt (1991) noted the highest abundances of this species in aquatic vegetation and rarely observed the species in streams lacking this habitat type. Young inhabit pools with vegetation and sand or silt substrates with little flow (NatureServe 2004).

CHALLENGES

Highly restricted in both range and habitat requirements, the Pinewoods Darter is extremely vulnerable to habitat alteration. Anthropogenic alterations within its range include agriculture and suburban development (primarily in North Carolina). Clearing of forest and riparian cover, channelization of streams for agricultural drainage, and improper or unregulated use of pesticides and fertilizers all disrupt the natural hydrology, water chemistry and habitat heterogeneity to which this species is adapted (Marion 2008). Further, both dam construction on streams to create ponds for golf courses and golf course irrigation has led to a direct loss of habitat and favor competitive and often highly predacious species like the Redbreast Sunfish, Bluegill, and Largemouth Bass (NatureServe 2004).

The elusiveness of the Pinewoods Darter in South Carolina and resulting data deficiency represent a fundamental challenge in its conservation. In South Carolina, the physicochemical template that supports this species may represent a moving target in a complex and dynamic landscape. Coastal plain streams are highly variable in space and time, often changing dramatically in physical characteristics on the scale of just kilometers due to both natural hydrologic variability as well as biotic factors such as beaver activity. The perceived absence or possible extirpation of this species are difficult to interpret due to the uncertainty in the amount and type of sampling effort required to yield a reasonable probability of detection. A specialized and standardized sampling approach will be necessary to quantify the probability of its persistence in the state and enable informed conservation efforts such as the strategies employed in the rediscovery of other elusive fishes including the Bridle Shiner (Jensen and Vokoun 2013; Pregler et al. 2015; Pregler et al. 2019; Katz 2023), Blackbanded Sunfish (Darden et al. 2019) and other darters (Bajo-Walker et al. 2024).

CONSERVATION ACCOMPLISHMENTS

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Determine the statewide distribution, population status, life history and habitat requirements for the Pinewoods Darter with statewide stream surveys.
- Survey streams in the Sandhills Ecoregion of the Little Pee Dee River system to determine the existence or extirpation of Pinewoods Darter. Previous positive locations in Panther Creek and Beaver Dam Creek should be re-surveyed. Protect any identified areas.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices (BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Educate aquarists as to the adverse impacts of removing fish from the wild.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of

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“Carolina” Quillback

Carpiodes cyprinus

Contributors (2005): Scott D. Lamprecht and Jason Bettinger [SCDNR]
Editors (2013): Scott D. Lamprecht and Mark C. Scott (SCDNR)
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Photo: NCFishes.com

DESCRIPTION

Taxonomy and Basic Description

The “Carolina” Quillback (*Carpiodes* sp. cf. *cyprinus*) is a member of the sucker family (Catostomidae), which is represented by at least 78 described species in North America (Page et al. 2023). Suckers comprise about 8% of the continent’s freshwater ichthyofauna, behind only minnows (Leuciscidae) and perches and darters (Percidae) in number of species (Warren and Burr 2014). There are currently three described species of *Carpiodes* suckers (Page et al. 2023), which are primitive, deep bodied, silver-colored fishes with a long dorsal fin (Jenkins and Burkhead 1994). Variation across the range of this species has long been recognized with multiple subspecies (Rohde et al. 2009); the form of the Quillback on the southern Atlantic slope is distinct from those to the north and west (Tracy et al. 2024) but awaits full species description.

This family is characterized by soft-rayed fins, a mouth located on the underside of the head, thick, fleshy, distensible lips, and paired fins attached low on the body (Rohde et al. 1994). Quillback are high bodied, laterally compressed fish that range in length up to 66 cm (26.0 in.) (Rohde et al. 2009). In South Carolina, the “Carolina” Quillback most closely resembles the “Atlantic” Highfin Carpsucker (*Carpiodes* sp. cf. *velifer)*, but the former has a shallower forehead and longer snout, lacks a nipplelike projection on the lower lip, and usually has more lateral scales and dorsal fin rays. Furthermore, the Quillback’s first long dorsal ray does not usually reach the full length of the dorsal fin base, while the first dorsal ray of the Highfin Carpsucker typically is as long as the fin (Rohde et al. 1994; Jenkins and Burkhead 1994).

Status

Quillback populations are considered to be stable by Warren et al. (2000) and common, widespread, and abundant by NatureServe (2024). It is currently considered secure globally (G5) and vulnerable to imperiled (S2S3) in South Carolina (NatureServe 2024). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of high concern.

POPULATION SIZE AND DISTRIBUTION

The “Carolina” Quillback occurs on the southern Atlantic Slope from the Pee Dee River basin in North Carolina to the Altamaha River basin in Georgia (Tracy et al. 2024). In South Carolina, it is found in the Savannah, Santee and Pee Dee River basins (Rohde et al. 2009). This species was not observed in any of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

The Quillback is commonly encountered during non-directed sampling efforts. Populations with abundant numbers are observed in the upper Santee and Savannah River drainages while Quillback are rare in the Pee Dee (SCDNR unpublished data). Population declines in the Pee Dee River may be related to introduced, non-native species like Buffalo.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Quillback is found in warm, low- to moderate-gradient reaches of most major rivers, including upper portions of associated reservoirs (Rohde et al. 1994; Jenkins and Burkhead 1994). It occurs over varied substrates in rivers, but seldom over mud. They tend to occupy calm water; however, Quillback may shift to swifter and deeper depths during times of low water. Quillback reportedly spawn in spring in riffles, calm stream reaches, and in floodplain bayous, laying eggs on gravel, sand, mud, and organic matter (Scott and Crossman 1973; Jenkins and Burkhead 1994). Quillback feed on insect larvae and other benthic organisms. Studies of Quillback (from outside the “Carolina” form range) have reported estimated ages of sexual maturity ranging from about 4 to 9 years (Parker 1987; Lackmann et al. 2022), with males generally maturing earlier than females, and maximum ages as high as 30 in Florida (Grabowski et al. 2012) to 44 years in Minnesota (Lackmann et al. 2022).

CHALLENGES

Quillback populations are likely stable throughout their range. However, habitat degradation from deforestation and urbanization remains as much a challenge to this native species as it does to most other riverine animal species. This species is susceptible to the same pervasive types of anthropogenic habitat alteration and fragmentation affecting other large riverine catostomids (Cooke et al. 2005), including the construction and operation of dams and impoundments, sedimentation of important foraging and spawning habitats, alteration of hydrologic regimes, and introduction of non-native species.

CONSERVATION ACCOMPLISHMENTS

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina’s freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and

mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Identify the distribution of Quillback throughout South Carolina.
- Resolve taxonomic relationships of Atlantic Slope, Interior Basin and Gulf Slope Quillback populations.
- Identify and protect critical habitats from future development and further habitat degradation by following Best Management Practices (BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species and others. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Redlip Shiner

Hydrophlox chiliticus



Photo: NCFishes.com

Contributor (2005): Ross Self and Jason Bettinger [SCDNR]
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Redlip Shiner is a member of the minnow family (Leuciscidae) and the genus *Hydrophlox*, which was recently elevated from within *Notropis* (Stout et al. 2022 and sources therein; Page et al. 2023). It is currently one of three described species of *Hydrophlox* in South Carolina along with the Yellowfin Shiner (*H. lutipinnis*) and Greenhead Shiner (*H. chlorocephalus*) (Page et al. 2023), but variation and intergradation in this group has long been recognized (Rohde et al. 2009 and sources therein) and additional forms have been treated as distinct in taxonomic keys (Tracy et al. 2024). Minnows represent the most speciose family of freshwater fishes in North America, with at least 323 described taxa of predominantly small (<150 mm) and slender fishes including five currently recognized species of *Hydrophlox* (Warren and Burr 2014; Page et al. 2023).

This species is characterized by bright red lips with red coloration in the dorsal, anal, and caudal fins and black blotches on the sides (Rohde et al. 1994). The lateral line is complete (Jenkins and Burkhead 1994). Members of this genus are known to exhibit strong sexual dimorphism, in particular with breeding males developing bright red coloration over most of the body. Male Redlip Shiners attain a scarlet-red body and eye coloration with yellow fins (Rohde et al. 1994). Adults range in length from 38 to 72 mm (1.5 to 2.8 in.) (Rohde et al. 2009).

Status

The Redlip Shiner is considered apparently secure (G4) globally (NatureServe 2024). It is considered imperiled to vulnerable (S2S3) in South Carolina (NatureServe 2024). In North Carolina this species is considered apparently secure (S4), while it is considered vulnerable (S3) in Virginia (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

The Redlip Shiner is native to the Pee Dee River basin and the Dan River system of the Roanoke River basin in North Carolina and Virginia (Tracy et al. 2024). In South Carolina, the southern edge of its range, the Redlip Shiner is restricted to a small portion of the Pee Dee River drainage in the Carolina Slate Belt and Sand Hills ecoregions, with a population in the Thompson Creek

system and a couple collection localities in the Great Pee Dee River. This species was observed in 0.1% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Redlip Shiner occupies flowing pools of clear headwaters, creeks, and small rivers of the Piedmont and (outside of South Carolina) mountains; it prefers areas with sand-gravel to rubble substrate. Spawning takes place in May-June on gravel nests constructed by the Bluehead Chub (*Nocomis leptocephalus*), as is the case with other *Hydrophlox* minnows (Johnson 1991; Jenkins and Burkhead 1994; Rohde et al. 2009; NatureServe 2024). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (2.9%) and highest average relative abundance (0.4%) in upland large streams (watershed area 300-2000 km^2) of the Pee Dee River basin.

CHALLENGES

The occurrence of the Redlip Shiner in only one stream system in South Carolina, and on the southern fringe of its global range, makes it vulnerable to decline in the state. Cumulative or acute disturbances to Thompson Creek could cause extirpation of this species from South Carolina. Challenges to this species are similar to those of other aquatic fauna and include point and non-point source pollution, deforestation and loss of riparian corridors, impoundment development, channelization and siltation from poor land use practices, and unplanned or poorly planned urban and suburban development. Fish assemblage integrity of upland streams increases with natural land cover, whereas integrity decreases as the amount of developed and agricultural land increases (SCDNR 2023). Mature forest and riparian vegetation are important sources of large woody debris in upland streams, which contributes to beneficial habitat diversity and channel stability. Because of its limited distribution, it is also vulnerable to habitat losses due to anthropogenic influences such as water withdrawals or environmental disturbances such as drought. Introduction of non-native species is also a conservation concern; for example, Lemly (1985) only observed Redlip Shiners in small first-order streams in which non-native Green Sunfish (*Lepomis cyanellus*) were absent.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment (2006-2011) data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina’s freshwater habitats and understand the relationships between aquatic resource integrity and a

rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.

- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements of the Redlip Shiner.
- Survey Thompson Creek and surrounding areas in Chesterfield County to determine the status of the Redlip Shiner as this stream likely houses the strongest populations of this species and may have been severely impacted by the drought of 2002. Protect these areas, once identified.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices (BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Robust Redhorse

Moxostoma robustum



Photo: NCFishes.com

Photo: NCFishes.com
Contributors (2005): Scott D. Lamprecht and Jason Bettinger [SCDNR]
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Reviewed and Edited (2024): Tanya Darden, Jason Marsik, Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Robust Redhorse is a large, heavy-bodied sucker that can reach lengths greater than 70 cm (28 in.) and weights up to 8 kg (17.6 lbs.). The Robust Redhorse has large, molar-like pharyngeal teeth specialized for crushing hard-bodied prey like native mussels. It resembles the River Redhorse, *M. carinatum,* but has 10 pelvic rays instead of 9 (Rohde et al. 1994). The fish is bronze on the back and sides, and adults are faintly striped on the lower sides. Juveniles have intense red in the caudal fin, which becomes less obvious in adults. Breeding males develop prominent tubercles on the snout, head, and anal and caudal fins (GADNR 1999).

After specimens of a large redhorse collected in Georgia and North Carolina in the 1980s and early 1990s were determined to be the fish described by Cope (1870) as *M. robustum*, major revisions of sucker taxonomy were initiated. Jenkins and Burkhead (1994, in a footnote) applied the name *M. robustum* to the large, rediscovered redhorse and called it Robust Redhorse. Smallfin Redhorse was moved to the newly elevated genus *Scartomyzon* and proposed the common name “Brassy” Jumprock. Its taxonomic status has still not been completely resolved (NatureServe 2024).

With 78 described species in North America (Page et al. 2023), suckers comprise about 8% of the continent’s freshwater ichthyofauna, behind only minnows (Leuciscidae) and perches and darters (Percidae) in number of species (Warren and Burr 2014). The genus *Moxostoma* includes 23 described species (Page et al. 2023), about one third of which are considered imperiled at some level (Jelks et al. 2008; Warren and Burr 2014).

Status

The Robust Redhorse is listed as Endangered in Georgia and North Carolina, the only other states in which it occurs (NatureServe 2024). It is critically imperiled (G1) globally and in all three states (S1) (NatureServe 2024). In July 2024, a law went into effect in South Carolina prohibiting the taking, harming or killing of Robust Redhorse (scstatehouse.gov; accessed 3 August 2024). In the 2000 assessment of southeastern fishes, the Robust Redhorse was considered in danger of extinction throughout all or part of its range (Warren et al. 2000). Over

the past decade, much has been learned about existing populations, and four experimental populations have been stocked. While this progress has reduced the danger of extinction, regional drought and habitat limitations continue to be impediments to reaching the goals of population stability in all parts of its range (S. Lamprecht, pers. obs.). The Robust Redhorse was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of very high concern.

POPULATION SIZE AND DISTRIBUTION

Wild populations of Robust Redhorse are now known to exist in the Ocmulgee and Oconee rivers (Georgia), the Savannah River (Georgia/South Carolina), and the Pee Dee River (North Carolina/South Carolina). In addition, small *stocked populations* have been established in Georgia by introducing Oconee River progeny in the Ocmulgee, Ogeechee, and Broad Rivers; and in South Carolina by introducing Savannah River progeny in the Broad and Wateree Rivers. Mature individuals have been collected and spawning behavior observed in all systems at some point, but detection of natural recruitment into these populations has been limited (SCDNR). Spawning runs of Robust Redhorse remain regularly detectable in the Georgia Broad and South Carolina Broad and Wateree rivers. Field surveys have not observed Robust Redhorse in the Ogeechee River since 2011; however, a recent eDNA survey confirmed their continued presence in that system (Farrae and Darden 2023).

Robust Redhorse population size in the Oconee River was originally estimated as approximately 1,000 to 3,000 adults in an 80 km (50 mi.) section of river. Annual sampling currently suggests that the Oconee population may not be reproducing at levels sufficient to sustain the population. Further, this population is vulnerable to catastrophic events (NatureServe 2024). The latest population estimate for the Oconee River could not be made because the population has decreased to the point where the available detection effort was unable to observe any fish in the spring of 2011 (RRCC 2011).

The Savannah River appears to be supporting a substantial population of Robust Redhorse (RRCC 2004). However, no estimates of the size of the Savannah population have been made to date. Repeated spawning efforts have recaptured adults at an average of about 30%. New individuals continue to be encountered, indicating relatively steady recruitment into the Savannah River population. While the Savannah population has not been studied as extensively as the Oconee and Pee Dee, a decade broodstock collection indicates that it is likely the most stable of the known wild populations (S. Lamprecht, pers. obs.).

In the Yadkin-Pee Dee drainage, Robust Redhorse are only found downstream of Blewett Falls Dam, the most downstream dam on the system. Initial collections were scant, but with the use of telemetry, two spawning shoals were identified, and collection numbers increased to the point where over 20 individuals were actively tracked in 2010 (RRCC 2010). Beginning in 2014 a stocking program was initiated and to date (2023) 67,343 individuals among eight year classes have been stocked across SC and NC portions of the Pee Dee River. In early 2024, SCDNR staff collected seven unmarked (possibly wild) individuals ranging from 285 mm to 540 mm total length from the lower Pee Dee River basin near the confluence of the Great Pee Dee and

Waccamaw Rivers (J. Marsik, SCDNR, pers. comm.). These collections represent the lowermost records of this species in the Pee Dee River basin and may suggest possible downstream dispersal of juveniles as part of the life history of this species. Researchers are currently studying the possible reintroduction of Robust Redhorse in the Tillery reach of the system by looking for eDNA in water samples.

Wirgin et al. (2001) examined mitochondrial DNA (mtDNA) variation in *M. robustum* and concluded that the Oconee/Ocmulgee River and Savannah River populations should be treated as evolutionarily significant units (ESU). These results were confirmed in 2011 by Tanya Darden (RRCC 2011), who also examined a larger Pee Dee population data set and confirmed the preliminary assessment that it too should be considered a distinct ESU (Darden and Tarpey 2014). Both the Pee Dee and Savannah populations show high within-population diversity as well as low levels of inbreeding as compared to the average genetic diversity measured for freshwater fishes, despite relatively low effective population size estimates (RRCC 2011; Darden and Tarpey 2014).

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

Robust Redhorse is known only from habitats in mainstream rivers where it has been collected in riffles, runs, and pools. Adults are usually found in association with tree snags, often in deep water near shore. Spawning occurs in course gravel habitats (GADNR 1999). Stocked juvenile Robust Redhorse have been collected in Thurmond Reservoir and in slower Coastal Plain river runs; however, young wild juveniles have remained largely elusive, and little is known about their habitat use. Despite hundreds of full fish assemblage samples conducted by SCDNR on direct tributaries of South Carolina rivers with known Robust Redhorse populations since the early 2000s, this species has never been detected in these tributary habitats. One wild spawn juvenile was collected in Savannah River tidal freshwater. Adults in Georgia's Broad River utilize the downstream reservoir outside of spawning season. These reservoir collections tend to indicate a tolerance of, or a preference for, lentic habitat during a portion of the life cycle (RRCC 2000). Recent telemetry observations in both the Santee River drainage and Georgia's Broad River support the hypothesis that adults select cooler water temperatures during the summer.

CHALLENGES

The Robust Redhorse is susceptible to the same pervasive types of anthropogenic habitat alteration and fragmentation affecting other large riverine catostomids (Cooke et al. 2005), including the construction and operation of dams and impoundments, sedimentation of important foraging and spawning habitats, alteration of hydrologic regimes, and introduction of non-native species. Habitat loss and disruption of spawning migrations resulting from dams and impoundments; predation and competition by introduced non-native species like buffalos, Flathead Catfish and Blue Catfish; and significant deterioration of water quality due to sedimentation and pollution are believed to have contributed to the decline of the Robust Redhorse. Additionally, the limited range of known populations and low rates of recruitment to the adult population represent challenges to the species' future (RRCC 2004).

CONSERVATION ACCOMPLISHMENTS

The Robust Redhorse Conservation Committee (RRCC) was established in 1995 under a Memorandum of Understanding (MOU) between state and federal resource agencies, private industry, and the conservation community to work proactively to recover the population across its historic range. The RRCC was formed in lieu of listing the species under the Endangered Species Act. Partners include 13 signatory members to the MOU, two cooperating members under the MOU, and a variety of university research and resource management facilities as affiliate members.

A plan entitled *Conservation Strategy for the Robust Redhorse*, which provides overall conservation guidance to assure the continued survival of the species, was adopted by the RRCC in 1998 and updated in 2003. It establishes short- and long-term conservation goals, describes the status and distribution of the species, discusses problems facing the species, and presents conservation actions that should be implemented to accomplish short- and long-term goals (RRCC 2004). The recovery goal established by the RRCC is six self-sustaining populations of Robust Redhorse across its former range (Nichols 2003).

Efforts to restore Robust Redhorse to the Santee River drainage began in 2004 with Phase I fingerling stockings in the Broad River above and Below Parr Reservoir. Entering 2011 a total of 50,500 Phase I fingerlings were released in the 2 Broad River restoration sites. The Wateree River site has received 12,601 Phase I fingerlings, 2,400 Phase II juveniles (age 1+), and 400 Phase III juveniles (age 2+). Stocking efforts in these sites are to continue until progeny from 100 parental crossings are produced. To date, mature males and females have been collected and spawning behavior has been observed. Fish of all sizes have been collected, but no wild spawn recruitment has been detected. Telemetry study has shown long distance movement between spawning shoals in the spring and summer residence areas. Telemetry studies on the Pee Dee River have shown that some Robust Redhorse use the South Carolina portion of the river during the summer, fall, and winter, while critical spawning shoals occur in North Carolina.

See the SWAP chapter on SWG grants, particularly those pertaining to the Robust Redhorse.

The Robust Redhorse received legal protection in South Carolina in July 2024, when a law went into effect prohibiting the taking, harming or killing of this species (scstatehouse.gov; accessed 3 August 2024).

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Continue work on habitat preference and utilization for various life stages for the Robust Redhorse.

- Continue refining our understanding of the life history of the Robust Redhorse.
- Maintain the MOU that formed the RRCC and continue working with partners to achieve the goals set forth in the conservation strategy developed by the RRCC.
- Complete the reintroduction of the Robust Redhorse to the Santee River Drainage and confirm natural recruitment.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.

MEASURES OF SUCCESS

Since 2005, work on all of the initial recommendations have been initiated or are nearly completed for Robust Redhorse (RRH). Present occurrence of adult RRH is well defined, as well as habitat preferences of adults, but collection of juveniles continues to be problematic across its range. The genetic work done on RRH has lent insight into existing population health and what to consider as we move forward in efforts to enhance existing populations. The RRCC MOU has been renewed and partners continue to meet and cooperatively address current issues and questions. The importance of RRH has been elevated so that it has been considered in recent FERC relicensing and water flow recommendations that affect critical spawning habitat. South Carolina's Santee drainage reintroduction program is also nearing completion; the ultimate measure of success, natural recruitment, has yet to be observed. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Rosyface Chub

Hybopsis rubrifrons



Photo: NCFishes.com

Contributor (2005): Jason Bettinger (SCDNR)
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Rosyface Chub is a member of the minnow family (Leuciscidae) and is one of two species of *Hybopsis* in South Carolina, along with Highback Chub (*H. hypsinotus*). Minnows represent the most speciose family of freshwater fishes in North America, with at least 323 described taxa of predominantly small (<150 mm) and slender fishes including six described species of *Hybopsis* (Warren and Burr 2014; Page et al. 2023).

The Rosyface Chub has the typical chub body, somewhat elongate with a long snout, upward-looking eyes, and a small barbel in the corner of its inferior mouth. It resembles a more elongate version of its congener, the Highback Chub. Breeding males can be distinguished from other members of *Hybopsis* by the strong rosy-red coloration that develops on the anterior third of the body. Rosyface Chubs can attain a length of 90 mm (3.50 in.) (Rohde et al. 1994, 2009).

Status

The Rosyface Chub is considered apparently secure globally (G4) (NatureServe 2024); however, there is some concern for their long-term status based on their limited distributions. The Rosyface Chub is considered critically imperiled (S1) in North Carolina largely due to its limited distribution within the State; Georgia has listed the Rosyface Chub as vulnerable to apparently secure (S3S4) while it is ranked vulnerable (S3) in South Carolina (NatureServe 2024). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of moderate concern.

POPULATION SIZE AND DISTRIBUTION

The Rosyface Chub is found in the Altamaha, Savannah, Saluda and extreme upper Edisto drainages of Georgia, North Carolina and South Carolina, predominantly above the fall line. Although it can be locally abundant in appropriate habitat, its distribution is somewhat patchy. In South Carolina, the Rosyface Chub is most common and abundant in the upper Savannah River

basin. This species was observed in 13.7% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Rosyface Chub inhabits runs and pools of small to large streams and small rivers, generally over sand and gravel (Rohde et al. 2009). It spawns in moderately fast riffles and has also been observed aggregating over *Nocomis* nests (Maurakis and Loos 1986; Rohde et al. 2009). The Rosyface Chub primarily consumes aquatic invertebrates but will also feed on terrestrial and aquatic plant matter to a lesser degree (Rybczynski et al. 2008; Rohde et al. 2009). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (100%) in upland small rivers (watershed area 300-2000 km²) of the Savannah River basin and highest average relative abundance (7.6%) in upland large streams (watershed area 100-300 km²) of the same basin.

CHALLENGES

The relatively narrow range of the Rosyface Chub (much of which has been fragmented by large reservoirs) along with its habitat requirements place it at risk of decline from anthropogenic habitat alteration. Challenges to this species are similar to those faced by other aquatic fauna and include point and non-point source pollution, deforestation and loss of riparian corridors, impoundment development, siltation from poor land use practices, and unplanned or poorly planned urban and suburban development. Fish assemblage integrity of upland streams increases with natural land cover, whereas integrity decreases as the amount of developed and agricultural land increases (SCDNR 2023). Mature forest and riparian vegetation are important sources of large woody debris in upland streams, which contributes to beneficial habitat diversity and channel stability. The conversion of upland streams into channelized ditches with little in-stream habitat represents a principal threat to Rosyface Chub habitat. Approximately 50% of the global range of the Rosyface Chub occurs in South Carolina. Conservation efforts within South Carolina are critical to the global preservation of this species.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina’s freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and

developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

    - Marion, C.A., M.C. Scott, and K.M. Kubach. 2015. Multiscale environmental influences on fish assemblage structure of South Atlantic coastal plain streams. Transactions of the American Fisheries Society. 144(5):1040-1057.

    - Epstein, J.M., W.E. Pine III, C.M. Romagosa, M.C. Scott, C.T. Phillips, C.A. Marion, and B. Baiser. 2018, State- and Regional-Scale Patterns and Drivers of Freshwater Fish Functional Diversity in the Southeastern USA. Transactions of the American Fisheries Society. 147:1179-1198. https://doi.org/10.1002/tafs.10110

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements of the Rosyface Chub.
- Identify critical habitats and areas with healthy populations of the Rosyface Chub.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Rosyside Dace
Clinostomus funduloides



Photo: NCFishes.com

Contributors (2013): Kevin Kubach and Mark Scott [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Rosyside Dace belongs to the minnow family (Leuciscidae) and is the only member of the genus *Clinostomus* in South Carolina. Minnows represent the most speciose family of freshwater fishes in North America (about 27% of the continental fauna), with at least 323 described taxa of predominantly small (<150 mm) and slender fishes (Warren and Burr 2014; Page et al. 2023). Although there are currently only two described species in this genus (Page et al. 2023), variation across the wide range of *C. funduloides* has long been recognized (Deubler 1955; Warren et al. 2000; Tracy et al. 2024). Recently, Weyand and Piller (2019) found *C. funduloides* to be paraphyletic and noted evidence of multiple distinctive lineages likely representing additional unique forms.

Adult Rosyside Dace reach a total length of 56 to 109 mm (2.2 to 4.3 in.) (Rohde et al. 1994, 2009). Overall coloration is olive with a diffuse, dark lateral stripe and usually a red bar or slash behind the opercle. The lower sides of breeding males are bright red. The body is laterally compressed and covered with small scales. The snout is pointed and features a large, oblique mouth (Rohde et al. 2009).

Status

The Rosyside Dace is considered secure (G5) on a global scale and is currently ranked apparently secure (S4) in South Carolina (NatureServe 2024). It is currently stable according to Warren et al. (2000). In Georgia this species is considered apparently secure (S4), while in North Carolina this species is considered secure (S5).

POPULATION SIZE AND DISTRIBUTION

The Rosyside Dace occurs on the Atlantic Slope from the Delaware River drainage, Pennsylvania to the Savannah River drainage, South Carolina and in portions of the upper Tennessee River drainage as well as the upper Ohio River drainage (Rohde et al. 2009). Further resolution of genetically distinctive forms (Weyand and Piller 2019) will probably lead to geographic range revisions involving the species found in South Carolina. In South Carolina, the Rosyside Dace is found in all river basins, primarily in the Piedmont and Blue Ridge, with some records from the inner Coastal Plain. This species was observed in 6.8% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Rosyside Dace is most abundant in flowing pools of clear headwater streams and occasionally larger streams (Rohde et al. 2009). This species is specialized for the cooler, clearer headwater drainages of stream systems and has relatively narrow thermal tolerances (Nelson et al. 2021). Being sight-based drift feeders, the Rosyside Dace requires clear water to feed effectively. Increased turbidity has been shown to be detrimental to the foraging behavior of this species and can negatively affect feeding success even at low levels (Zamor and Grossman 2007). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (28.2%) and average relative abundance (2.2%) in upland small streams (watershed area <15 km^2) of the Santee River basin; it is particularly abundant in higher elevations of the Saluda River basin.

CHALLENGES

Primary threats to the Rosyside Dace include loss of forested land and especially the removal of riparian cover along Piedmont and Blue Ridge streams. Fish assemblage integrity of upland streams increases with natural land cover, whereas integrity decreases as the amount of developed and agricultural land increases (SCDNR 2023). Mature forest and riparian vegetation are important sources of large woody debris in upland streams, which contributes to beneficial habitat diversity and channel stability. Land development, siltation, and hydrologic alterations such as channelization and construction of impoundments also threaten this species. The conversion of upland streams into channelized ditches with little in-stream habitat represents a principal threat to Rosyside Dace habitat. The specialization of this species for higher, cooler headwater drainages places it at heightened risk of local extirpation from anthropogenic habitat alteration (Zamor and Grossman 2007; Nelson et al. 2021) as well as longer-term effects of climatic change on flow and thermal regimes (Grossman et al. 2016; Nelson et al. 2021).

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina’s freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

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- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
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- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Sandhills Chub

Semotilus lumbee



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DESCRIPTION

Taxonomy and Basic Description

The Sandhills Chub is a member of the minnow family (Leuciscidae) and the most recently described (Snelson and Suttkus 1978) of four species of the genus *Semotilus*, two of which occur in South Carolina (*S. lumbee* and *S. atromaculatus* Creek Chub) (Page et al. 2023). Minnows represent the most speciose family of freshwater fishes in North America (about 27% of the continental fauna), with at least 323 described taxa of predominantly small (<150 mm) and fusiform fishes (Warren and Burr 2014; Page et al. 2023).

Fish in the genus *Semotilus* are large minnows characterized by a robust body and large head. The Sandhills Chub typically ranges from 45−140 mm total length (Phelps 2025; Ramsey 2025) with a maximum reported total length of 240 mm (Rohde et al. 1994). The species appears to be reproductively mature by age-1, and males tend to be larger than mature females (Phelps 2025; Ramsey 2025), which may be a function of the need for males to have a large enough mouth gape to pick up gravel for building pit-ridge nests. There is a very small barbel in a groove above the upper lip near the corner of the mouth. The Sandhills Chub has relatively fine scales, a diffuse black lateral stripe, and a pinkish wash to the body in breeding season. This species can be distinguished from the similar Creek Chub (*S. atromaculatus*) by the absence of a dark spot in the dorsal fin near the anterior base in *S. lumbee* (present in *S. atromaculatus*) and a typical dorsal fin ray count of 9 (8 in *S. atromaculatus*).

Status

Globally, the Sandhills Chub is ranked as vulnerable to apparently secure (G3G4) (NatureServe 2024). It is considered imperiled (S2) in North Carolina and South Carolina, the only two states in which it occurs (NatureServe 2024). The Sandhills Chub was listed as vulnerable in fauna-wide assessments of the southeastern (Warren et al. 2000) and North American (Jelks et al. 2008) freshwater fishes and was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of high concern.

POPULATION SIZE AND DISTRIBUTION

The Sandhills Chub occupies a narrow strip of the Sand Hills ecoregion (Griffith et al. 2002) of the inner coastal plain in south-central North Carolina and eastern South Carolina, from the Wateree (Santee) River basin eastward to the Cape Fear River basin (Snelson and Suttkus 1978; Rohde and Arndt 1991; Rohde et al. 2009; Tracy et al. 2020; Tracy et al. 2024). At the time of its description in 1978, the Sandhills Chub was only known from the Pee Dee (including Lynches) and Cape Fear River basins, and its presence in tributaries of the Wateree River (Santee basin) to the west was documented later (Rohde and Arndt 1991). In South Carolina, it is almost wholly restricted to the Sand Hills portions of the Wateree, Lynches, and Pee Dee River drainages. This species was observed in 1.4% of over 900 standardized statewide stream and river assessment samples across South Carolina between 2006 and 2023, but it can be relatively abundant in appropriate habitat within its narrow range (Rohde and Arndt 1991). Populations in the Lynches and Lumber (North Carolina) drainages are strongholds and exhibit higher genetic diversity than those in other drainages (Phelps 2025; Ramsey 2025). Abundance estimates in two representative populations were 218 per km in Aberdeen Creek (Pee Dee basin) and 137 per km in Gum Branch Creek (Cape Fear basin) (Ramsey 2025). Conversely, populations in the Wateree basin in the western portion of its range occur in comparatively low densities (SCDNR data; Rohde and Arndt 1991; Phelps 2025; Ramsey 2025).

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Sandhills Chub is almost exclusively associated with small, flowing, often tannin-stained and acidic streams of the Sand Hills ecoregion (Snelson and Suttkus 1978; Rohde and Arndt 1991). Accordingly, in standardized sampling covering streams to small rivers of South Carolina, the Sandhills Chub exhibited its highest frequency of occurrence (14.3%) and average relative abundance (2.9%) in small streams (watershed area 0-15 km^2) of the Sand Hills. It is usually found in streams dominated by sand substrates with some gravel (Rohde and Arndt 1991; Rohde et al. 1994). This species is dependent on relatively cool, flowing, well-oxygenated headwaters with sufficient structure (i.e., wood); higher dissolved oxygen concentrations and greater amounts of cover in the stream section were both positively related to Sandhills Chub presence (Herigan et al. 2023). The Sandhills Chub shares its narrow Sand Hills-specific distribution with the Pinewoods Darter (*Etheostoma mariae*) and, in North Carolina where the latter is still known to occur, these species are often found in the same stream systems (Rohde and Arndt 1991).

Spawning primarily occurs in April and May, with the former month yielding the largest proportion of ripe individuals (Phelps 2025; Ramsey 2025). Males construct a pit-ridge nest characteristic of the genus (Woolcott and Maurakis 1988) using gravel in the 6 mm to 11 mm diameter range (Maurakis et al. 1990). Substrate composition is therefore important, and the amount of gravel in the 6-11 mm size range at the scale of the stream reach was a strong predictor of Sandhills Chub presence (Herigan et al. 2023).

Home range size in the Sandhills Chub is extremely small, with movement generally limited to relatively short stream reaches. In two North Carolina streams, 82% of almost 900 tagged individuals moved less than 200 m from their initial capture section, and only four individuals (<1%) moved distances greater than 1 km (Phelps 2025; Ramsey 2025). This limited movement

has probably contributed to the high degree of genetic structuring observed across populations (Phelps 2025; Ramsey 2025).

CHALLENGES

A narrow range coupled with low mobility and specific habitat and life history requirements in headwater streams render the Sandhills Chub vulnerable to many anthropogenic threats. Its nearly exclusive association with small drainages places it at greater risk of extirpation from a given system due to acute or cumulative disturbances. The small headwater streams occupied by Sandhills Chub can be easily altered or fragmented, and this is compounded by the fact that headwater streams are afforded less regulatory protection than larger streams and rivers. Populations in small stream drainages flowing directly into considerably larger streams or rivers may be at heightened risk of extirpation (Sheldon 1987), since the larger downstream waterbodies could represent a physicochemical or behavioral barrier to emigration and subsequent recolonization, particularly given the low rates of movement exhibited by this species. The few known populations in tributaries of the Wateree (Santee) basin are inherently at higher risk of extirpation from this river basin due to their lower abundance and close proximity to areas of rapid human population growth such as the Columbia-Camden corridor.

Stable hydrology and associated physicochemical regimes are a defining feature of the Sand Hills ecoregion and serve as the template for the life history strategies of many regionally endemic species such as the Sandhills Chub. Even minor alterations to the natural hydrologic, thermal and sediment regimes, such as those typically associated with anthropogenic conversion of natural forested land cover to developed or impervious surfaces, have the potential to disrupt critical life history and ecological processes. Poor agricultural, silvicultural, and road construction practices often lead to stream siltation and non-point source water pollution (Waters 1995). For example, the reduction of natural forest and riparian cover in the watershed would be expected to increase water temperature (decrease dissolved oxygen), reduce wood loading for in-stream habitat and bank cover, and increase fine sediment inputs, all of which would decrease the probability of supporting Sandhills Chub (Marion 2008; Herigan et al. 2023). Unregulated use of motor vehicles in the stream bottoms also results in stream siltation and destruction of fish habitat.

Human-constructed impoundments cause additional impairment of Sandhills Chub habitat. Damming headwater streams to create ponds for golf courses eliminates important lotic habitats; the new lentic environments favor competing and often predatory species such as Largemouth Bass in unnaturally high densities. Impoundments also fragment habitat and can affect dispersal, prevent recolonization of streams after drought or other disturbances, and alter hydrology and sediment transport. Although impoundments are the most visible form of habitat fragmentation, culverts can also function as barriers if they are perched or if water velocity in a culvert prevents movement. The small streams occupied by Sandhills Chub are inherently more likely to be passed under roads by culvert rather than bridge, making full or partial barriers due to culverts a widespread factor affecting dispersal of this species.

CONSERVATION ACCOMPLISHMENTS

The Sandhills Chub has been the focus of two recent State Wildlife Grant investigations by Dr. Derek Crane and his graduate students at Coastal Carolina University since 2019 (Herigan et al. 2023; Phelps 2025; Ramsey 2025):

- 2019-2020: Identification of environmental and biological factors limiting occurrence of the Sandhills Chub (*Semotilus lumbee*) in South Carolina.

- 2022-2025: Conservation planning for a geographically restricted headwater species, the Sandhills Chub.

These investigations have produced important information on Sandhills Chub ecology and habitat requirements, allowing the development and refinement of conservation strategies for this species. Furthermore, this work yielded estimates of abundance, density and survival from two high-integrity populations that can serve as references for the evaluation of other populations.

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and "ecobasin" (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the

Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.

- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

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    - Epstein, J.M., W.E. Pine III, C.M. Romagosa, M.C. Scott, C.T. Phillips, C.A. Marion, and B. Baiser. 2018, State- and Regional-Scale Patterns and Drivers of Freshwater Fish Functional Diversity in the Southeastern USA. Transactions of the American Fisheries Society. 147:1179-1198. https://doi.org/10.1002/tafs.10110

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe additional life history and habitat requirements for the Sandhills Chub.
- Resample known locations to determine the population status of the Sandhills Chub and expand monitoring efforts within the Carolina Sandhills National Wildlife Refuge (NWR) in order to quantify the population within the refuge.
- Protect critical habitats for the Sandhills Chub from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Sandhills Chub.
- Encourage responsible land use planning.

- Consider species needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame fish species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Santee Chub

Cyprinella zanema



Photo: NCFishes.com

Contributor (2005): Gene Hayes and Jason Bettinger [SCDNR]
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Santee Chub belongs to the minnow family (Leuciscidae), the most speciose family of freshwater fishes in North America with at least 323 described taxa of predominantly small (<150 mm) and slender fishes (Warren and Burr 2014; Page et al. 2023). It is sister to the Siouan Thinlip Chub (*C. leptocheilus*) of the Pee Dee and Cape Fear River basins (Tracy et al. 2024). Following the recent revision of the formerly large genus *Notropis* (Stout et al. 2022), *Cyprinella* is currently the most diverse genus of North American minnows, with 29 described species (Page et al. 2023). The Santee Chub is one of eight species of *Cyprinella* in South Carolina.

Along with the Siouan Thinlip Chub (*C. leptocheilus*) and Thicklip Chub (*C. labrosa*), this species is unique among *Cyprinella* in possessing barbels in the corner of its mouth. These three species furthermore have a different shape than other members of the genus, with a slender, ventrally flattened profile, relatively long snout and inferior mouth. In the Santee and Siouan Thinlip Chubs, the dorsal fin origin is positioned posteriorly to that of the pelvic fin origin, whereas in the Thicklip Chub the dorsal fin origin sits directly over the origin of the pelvic fin (Rohde et al. 2009). The Santee Chub is distinguished from the Siouan Thinlip Chub by the position of the dorsal fin origin modally 2.5 scales posterior to the pelvic fin origin versus modally 1.5 scales posterior to the pelvic fin origin, respectively; mean upper lip width at midpoint modally 3.5% of head length versus modally 2.1% of head length; mean upper lip width at midline modally 4.1% of head length versus modally 2.9% of head length; and mean maxillary barbel length modally 8.0% of head length versus modally 3.5% of head length (Tracy et al. 2024). The Santee Chub can reach a length of 75 mm (3 in.) (Page and Burr 1991). This species exhibits dark cross-hatching on the back and sides; breeding males are silvery with yellow fins and black streaks on the dorsal and caudal fins (Rohde et al. 1994).

Status

The Santee Chub is currently stable (Warren et al. 2000) and apparently secure (G4) throughout its range, though it is ranked vulnerable (S3) in South Carolina and North Carolina (NatureServe 2024). This species was selected as a Regional Species of Greatest Conservation Need in the

Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of high concern.

POPULATION SIZE AND DISTRIBUTION

The Santee Chub is endemic to the Santee River basin of North and South Carolina, primarily in the Piedmont and Blue Ridge foothills (Rohde et al. 1994). It can be locally abundant in appropriate habitat but is typically among the least abundant members of its genus in streams and rivers in which it occurs. This species was observed in 5.3% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Santee Chub inhabits streams to rivers with sand and rocky runs or current-swept pools (Rohde et al. 1994). It is usually more abundant on finer substrate (e.g., sand and fine gravel) than the sympatric Thicklip Chub (*C. labrosa*) (SCDNR unpublished data; Rohde et al. 2009), resulting in some degree of habitat segregation with *C. zanema* in more uniformly sandy runs and *C. labrosa* in rockier areas. In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (55.6%) in upland small rivers (watershed area 300-2000 km²) of the Santee River basin and highest average relative abundance (2.4%) in upland large streams (watershed area 100-300 km²) of the Santee River basin.

CHALLENGES

Although the Santee Chub can be locally abundant in appropriate habitat of Piedmont streams, its limited distribution is cause for concern. The Santee Chub, like many other specialized stream fishes, is susceptible to an array of acute and cumulative impacts from anthropogenic alterations to the watershed, riparian zone and streams and rivers directly. These include deforestation and conversion of natural land cover for development and agriculture with resulting sedimentation and non-point source pollution, hydrologic alterations, and habitat fragmentation from dams and reservoirs. Fish assemblage integrity of upland streams increases with natural land cover, whereas integrity decreases as the amount of developed and agricultural land increases (SCDNR 2023). Mature forest and riparian vegetation are important sources of large woody debris in upland streams, which contributes to beneficial habitat diversity and channel stability. The conversion of upland streams into channelized ditches with little in-stream habitat represents a principal threat to Santee Chub habitat. One of the fastest-growing areas of human population pressure and land development in the United States, the Interstate 85 corridor between Greenville, South Carolina and Charlotte, North Carolina, runs directly through the range of this species. The vast majority of its populations occur on private (unprotected) lands. Approximately 75% of the global range of the Santee Chub occurs in South Carolina; conservation efforts within the state are critical to the preservation of this species.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment (2006-2011) data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including

statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices (BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the

critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Satinfin Shiner
Cyprinella analostana



Photo: NCFishes.com

Contributor (2005): Ross L. Self and Jason Bettinger [SCDNR]
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Satinfin Shiner belongs to the minnow family (Leuciscidae), the most speciose family of freshwater fishes in North America (about 27% of the continental fauna) with at least 323 described taxa of predominantly small (<150 mm) and slender fishes (Warren and Burr 2014; Page et al. 2023). Following the recent revision of the formerly large genus *Notropis* (Stout et al. 2022), *Cyprinella* is currently the most diverse genus of North American minnows, with 29 described species (Page et al. 2023). The Satinfin Shiner is one of eight described plus one undescribed (as of 2024) species of *Cyprinella* in South Carolina.

Fishes of the genus *Cyprinella* are characterized by large, vertical, diamond shaped scales and a dark blotch on the dorsal fin. The Satinfin Shiner is extremely similar to the Greenfin Shiner (*C. chloristia*), which was once considered its subspecies (Rohde et al. 2009), but the former usually has 9 anal fin rays whereas the latter typically has 8. The dorsal fin of the Satinfin Shiner exhibits black speckles on all membranes with a distinct black blotch on its rear half (Rohde et al. 1994). Breeding males appear gray-blue with yellow fins (Rohde et al. 1994). Adults range in size from 47 to 110 mm (1.9 to 4.3 in.) (Rohde et al. 1994).

Status

Globally, the Satinfin Shiner is considered secure (G5) (NatureServe 2024). The Satinfin Shiner is currently considered vulnerable (S3) in South Carolina (NatureServe 2024). In North Carolina this species is considered to be secure (S5). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of moderate concern.

POPULATION SIZE AND DISTRIBUTION

The Satinfin Shiner is found on the Atlantic slope from the Hudson River and southern Lake Ontario drainages in New York south to the Pee Dee River drainage in North and South Carolina (Page and Burr 1991). In South Carolina, the southern fringe of its global range, the Satinfin Shiner is restricted to tributary streams of the upper Pee Dee River drainage in the Slate Belt and Sandhills Ecoregions (SCDNR, unpublished data), with a notable population in Thompson

Creek. This species was observed in 0.1% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Satinfin Shiner occupies pools and runs of creeks and small to medium rivers with substrate ranging from sand to gravel and rubble. Occasionally, this species is found in headwaters and tidal portions of some large rivers elsewhere in its range. In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (2.9%) and average relative abundance (0.05%) in upland large streams (watershed area 100-300 km²) of the Santee River basin.

As with other non-barbeled *Cyprinella* species, the Satinfin Shiner is a crevice spawner, depositing eggs in crevices of logs and rocks in a territory defended by the male over an extended spring-summer breeding period (Gale and Buynak 1978; Rohde et al 1994; Rohde et al. 2009). Eggs are attached to branches, stumps and logs and may be deposited in cracks in rocks, in crevices under loose submerged bark, between exposed tree roots, and/or under flat rocks (NatureServe 2024). Due to the limited habitat available for this species in South Carolina if it is to be maintained as part of South Carolina's fauna, then it is essential that the habitat requirements for these fishes be better understood, and actions taken to protect and preserve appropriate sites for the survival of this species.

CHALLENGES

This species is vulnerable in South Carolina due to its very limited distribution but is currently stable throughout much of its range. The Satinfin Shiner, like many other specialized stream fishes, is susceptible to an array of acute and cumulative impacts from anthropogenic alterations to the watershed, riparian zone and streams and rivers directly. These include deforestation and conversion of natural land cover for development and agriculture with resulting sedimentation and non-point source pollution, hydrologic alterations, and habitat fragmentation from dams and reservoirs. The breeding behavior of the non-barbeled *Cyprinella* makes this group particularly vulnerable to impacts from both suspended and deposited sediment. Because the breeding process is dependent on visual cues (extended display and territorial defense period) as well as clean crevices for egg deposition and larval development, suspended sediment (increased turbidity) and deposited sediment has been shown to delay or inhibit spawning success in fishes of this genus (Hubbs and Echelle 1972; Burkhead and Jelks 2001; Warren and Burr 2014). Furthermore, the introduction and establishment of the highly invasive Red Shiner (*Cyprinella lutrensis*) in the North Carolina portion of the Pee Dee River basin (Poulos et al. 2012; Glotzbecker et al. 2016; Tracy et al. 2020; Tracy et al. 2024) represents a potential threat to native *Cyprinella*, including the Satinfin Shiner. *C. lutrensis* has been shown to impact native *Cyprinella* through competition and hybridization (Walters et al. 2008; Ward et al. 2012), both of which can be exacerbated with additional stressors such as elevated turbidity resulting from alteration of natural land cover (Glotzbecker et al. 2015) and broader influences of climate change (Poulos and Chernoff 2014). The limited distribution of the Satinfin Shiner in South Carolina—the southern fringe of its global range—makes it particularly susceptible to

extirpation from the state should the Red Shiner expand downstream into the South Carolina waters of the Pee Dee basin.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment (2006-2011) data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and "ecobasin" (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.

- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements of the Satinfin Shiner.
- Survey Thompson Creek and surrounding areas in Chesterfield County to determine the status of the Satinfin Shiner as this stream likely houses the strongest populations of this species and may have been severely impacted by the drought of 2002. Protect these areas, once identified.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices (BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Savannah Darter

Etheostoma fricksium



Photo: Fred Rohde

Contributor (2005): Jason Bettinger (SCDNR)
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Savannah Darter is a member of the perch and darter family (Percidae), an extremely diverse group of predominantly small, bottom-dwelling fishes currently represented by 224 described species comprising more than 20% of the North American freshwater ichthyofauna (Page 1983; Kuehne and Barbour 1983; Near et al. 2011; Page et al. 2023). With 138 described species, *Etheostoma* is the most diverse genus of North American freshwater fishes (Page et al. 2023). The Savannah Darter is sister to the Christmas Darter (*E. hopkinsi*) and closely related to the form of the Christmas Darter occurring in the Savannah River basin, the "Hanukkah" Darter (*E. binotatum*) (Near et al. 2011).

The Savannah Darter is characterized by a broad dark stripe on its side and a red marginal or submarginal band on its first dorsal fin. The dorsum is pale. This colorful darter also displays alternating green and orange bars on its lower side as well as orange on its belly. Savannah Darters reach a length of 74 mm (2.9 in.) (Rohde et al. 1994).

Status

Globally, the Savannah Darter is considered apparently secure (G4), but it is considered vulnerable in South Carolina (S3) and imperiled (S2) in Georgia (NatureServe 2024). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of high concern.

POPULATION SIZE AND DISTRIBUTION

The Savannah Darter is only found in the mid to lower Savannah River basin of Georgia and South Carolina and the mid to upper Edisto and Combahee River drainages in South Carolina. It is restricted to the mid to upper elevations of the coastal plain, predominantly occurring in the Southeastern Plains ecoregion where topography supports flowing streams and rivers. In appropriate habitat of the Sand Hills and Atlantic Southern Loam Plains, it occurs regularly and

can be somewhat abundant. This species was observed in 4.5% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Savannah Darter inhabits clear or tannin-stained creeks and small rivers with steady current and sand or gravel substrates (Rohde et al. 2009). It is generally found in or near aquatic vegetation or woody debris (Layman 1993; Rohde et al. 1994). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (34.5%) and average relative abundance (1.7%) in large streams (watershed area 100-300 km^2) of the Sand Hills.

CHALLENGES

Although the Savannah Darter is currently considered stable (Warren et al. 2000), its limited distribution is cause for concern. Of the Savannah Darter's global range, 75% occurs in South Carolina. Loss of habitat in South Carolina from development, point and non-point source pollution, and poor land management practices would threaten its global existence. This species is dependent on the habitat heterogeneity supported by intact watershed forest cover and riparian floodplains and wetlands, which supply woody material and maintain channel morphology and substrate composition encouraging the growth of aquatic vegetation (Layman 1993; Marion 2008). Destruction of forest cover and especially the alteration or draining of forested riparian wetlands and floodplains represents a principal threat to the Savannah Darter. Channelization of streams for agricultural drainage further alters flow regimes and reduces the habitat complexity required by this species.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and "ecobasin" (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

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- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage

SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.

- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements for the Savannah Darter.
- Conduct genetic assessments to determine appropriate taxonomy for the Savannah Darter.
- Protect critical habitats for the Savannah Darter from future development and further habitat degradation by following Best Management Practices (BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Savannah Darter.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame fish species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species and others. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Sawcheek Darter

Etheostoma serrifer

Contributors (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]



Photo: NCFishes.com

DESCRIPTION

Taxonomy and Basic Description

The Sawcheek Darter is a member of the perch and darter family (Percidae), an extremely diverse group of predominantly small, bottom-dwelling fishes currently represented by 224 described species comprising more than 20% of the North American freshwater ichthyofauna (Page 1983; Kuehne and Barbour 1983; Near et al. 2011; Page et al. 2023). With 138 described species, *Etheostoma* is the most diverse genus of North American freshwater fishes (Page et al. 2023). This species is a member of the subgenus *Hololepis*, which is also represented in South Carolina by the Swamp Darter (*E. fusiforme*) and Carolina Darter (*E. collis*) (Rohde et al. 2009).

Adult Sawcheek Darters range in size from 40 to 68 mm total length (1.6 to 2.7 in.) (Rohde et al. 2009). Overall coloration is tan with dark mottling on the side and a greenish venter. It has a highly arched and incomplete lateral line and a serrated edge on its preopercle. Two vertically aligned dark spots, usually outlined in orange or red, are present at the base of the caudal fin. The cheek, opercle, breast, and belly are fully scaled (Rohde et al. 1994, 2009).

Status

The Sawcheek Darter is considered secure (G5) on a global scale (NatureServe 2024) and currently stable according to Warren et al. (2000). It has received varying degrees of state status including imperiled (S2) in Georgia, vulnerable (S3) in Virginia, secure (S5) in North Carolina, and apparently secure (S4) in South Carolina (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

The Sawcheek Darter is distributed primarily on the Atlantic coastal plain from the Chowan River basin of southeastern Virginia to the Altamaha River basin, Georgia (Rohde et al. 2009). In South Carolina, it is found across all river basins, primarily in the coastal plain and occasionally in the outer Piedmont. This species was observed in 5.7% of over 900 standardized statewide stream and river assessment samples across South Carolina between 2006 and 2023. It is typically not abundant; where collected, the mean sample catch was 3.1 individuals, and the highest two sample catches were 21 and 11 (SCDNR data).

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Sawcheek Darter typically occur in small to moderate Coastal Plain streams with mud, sand, and organic substrates, often in association with flow and aquatic vegetation (Hoover and Killgore 1999; Rohde et al. 2009). In South Carolina, this species is predominantly found in streams of the inner coastal plain characterized by stable baseflow; in standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (19.1%) and average relative abundance (0.2%) in medium streams (watershed area 15-100 km^2) of the Sand Hills ecoregion. Spawning occurs in March and April (Kuehne and Barbour 1983; Rohde et al. 2009).

CHALLENGES

Although it has a relatively wide range across South Carolina, the Sawcheek Darter generally occurs in low abundance where it is found. Primary threats to the Sawcheek Darter include loss of forested land and especially the removal of riparian cover along coastal plain streams. Mature forest and riparian vegetation are important sources of large woody debris in coastal plain streams which provides critical habitat for many endemic southern Atlantic coastal plain species including the Sawcheek Darter (Marion 2008). In addition to providing direct habitat, wood is important in creating and maintaining overall habitat heterogeneity and stability of stream channels. Land development, siltation, and hydrologic alterations such as channelization and construction of impoundments also threaten this species.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina’s freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use

and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.

- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
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- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
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- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species and others. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Seagreen Darter

Etheostoma thalassinum



Photo: NCFishes.com

Contributor (2005): Gene Hayes and Jason Bettinger [SCDNR]
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Seagreen Darter is a member of the perch and darter family (Percidae), an extremely diverse group of predominantly small, bottom-dwelling fishes currently represented by 224 described species comprising more than 20% of the North American freshwater ichthyofauna (Page 1983; Kuehne and Barbour 1983; Near et al. 2011; Page et al. 2023). With 138 described species, *Etheostoma* is the most diverse genus of North American freshwater fishes (Page et al. 2023). It is sister to the Turquoise Darter (*E. inscriptum*) of the Altamaha, Savannah and Edisto River basins (Richards 1966; Near et al. 2011).

The Seagreen Darter is a moderate-sized darter ranging in adult length from 66 to 78 mm (2.6 to 3.1 in.) (Rohde et al. 1994). This species has seven to eight dark brown saddles and a similar number of small dark brown blotches on the sides, the posterior three or four of which usually form vertical bars (Tracy et al. 2024). The first dorsal fin has a red edge with a dusky black base and the second dorsal fin is reddish-orange. Pelvic and anal fins are blue (Rohde et al. 1994). Breeding males are brilliantly colored and develop tubercles on the mid-ventral scales just anterior to the anus and also on the caudal peduncle (Kuehne and Barbour 1983).

Status

The Seagreen Darter is listed as stable throughout its range (Warren et al. 2000) and apparently secure (G4) globally but considered vulnerable (S3) in South Carolina and North Carolina, the only two states in which it occurs (NatureServe 2024). North Carolina also designates the Seagreen Darter as State Significantly Rare (Tracy et al. 2020). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of moderate concern.

POPULATION SIZE AND DISTRIBUTION

The Seagreen Darter is restricted to the Santee River drainage of the Carolinas. In South Carolina, it is predominantly an upland fish and sees its highest abundance in swift-flowing streams and rivers, but it also occurs in lower numbers in scattered localities on the inner coastal

plain of the Congaree and Wateree drainages where topography supports steady flow. In high-gradient streams and rivers with continuous suitable habitat it can be moderately abundant, but due to the siltation of many Piedmont streams and the localized nature of appropriate coarse riffles in lower-gradient Piedmont streams, it is often limited in abundance. This species was observed in 10.9% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

In the Piedmont and Blue Ridge portions of its range, the Seagreen Darter occurs in streams to large rivers in higher-velocity areas with coarse substrates ranging from gravel to cobble and bedrock (Page 1983; Kuehne and Barbour 1983; Rohde et al. 2009). Where it occurs (in lower abundance) in the inner coastal plain, the streams are characterized by steady flow over sand and fine gravel (SCDNR data, unpublished). Life history characteristics are not well known but are presumably similar to those of the sister Turquoise Darter (*E. inscriptum*). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (44.4%) and average relative abundance (1.8%) in upland small rivers (watershed area 300-2000 km²) of the Santee River basin.

CHALLENGES

Although the Seagreen Darter is currently considered stable, conservation efforts within South Carolina are critical to their global conservation. More than half the global range of the Seagreen Darter occurs in South Carolina. Within the State, destruction of stream riffle habitat caused by land development, deforestation, loss of riparian cover, siltation, and hydrologic alterations like channelization and impoundments could jeopardize these species. The distribution of this species overlaps with three of the most populated and rapidly growing metropolitan areas of South Carolina—Greenville-Spartanburg, Rock Hill-Charlotte, and Columbia—placing it in the path of unprecedented anthropogenic habitat alteration. Inner coastal plain populations of Seagreen Darters in particular, with lower abundance, may be especially vulnerable to extirpation due to their proximity to Columbia. Further, in extreme headwaters of their range, Seagreen Darters may be adversely affected by Brown and Rainbow Trout introductions.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements of Seagreen Darters.
- Study the potential predator/prey relationship between darters (Turquoise and Seagreen Darters) and introduced trout (Brown and Rainbow Trout) and the impact of this relationship on the native darters.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices (BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Siouan Thinlip Chub
Cyprinella leptocheilus



Photo: NCFishes.com

Contributor (2005): Jason Bettinger (SCDNR)
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Siouan Thinlip Chub is a recently described (Tracy et al. 2024) member of the minnow family (Leuciscidae), the most speciose family of freshwater fishes in North America with at least 323 described taxa of predominantly small (<150 mm) and slender fishes (Warren and Burr 2014; Page et al. 2023). The earliest recognized specimens date from the early 1960s in North Carolina, and this species is sister to the Santee Chub (*C. zanema*) of the Santee River basin (Tracy et al. 2020; Tracy et al. 2024). Tracy et al. (2024) detected genetic distinctiveness between *C. leptocheilus* in the Pee Dee and Cape Fear basins and recommended recognition of these clades as evolutionarily significant units. Following the recent revision of the formerly large genus *Notropis* (Stout et al. 2022), *Cyprinella* is currently the most diverse genus of North American minnows, with 29 described species (Page et al. 2023). There are eight additional species of *Cyprinella* in South Carolina.

Along with the Santee Chub (*C. zanema*) and Thicklip Chub (*C. labrosa*), this species is unique among *Cyprinella* in possessing barbels in the corner of its mouth (Tracy et al. 2024). These three species furthermore have a different shape than other members of the genus, with a slender, ventrally flattened profile, relatively long snout and inferior mouth. In the Siouan Thinlip Chub and Santee Chubs, the dorsal fin origin is positioned posteriorly to that of the pelvic fin origin, whereas in the Thicklip Chub the dorsal fin origin sits directly over the origin of the pelvic fin (Rohde et al. 2009; Tracy et al. 2024). The Siouan Thinlip Chub is distinguished from the Santee Chub by the position of the dorsal fin origin modally 1.5 scales posterior to the pelvic fin origin versus modally 2.5 scales posterior to the pelvic fin origin, respectively; mean upper lip width at midpoint modally 2.1% of head length versus modally 3.5% of head length; mean upper lip width at midline modally 2.9% of head length versus modally 4.1% of head length; and mean maxillary barbel length modally 3.5% of head length versus modally 8.0% of head length (Tracy et al. 2024). A light yellow-green stripe is present above the dark lateral stripe. Siouan Thinlip Chubs attain sizes similar to Santee Chubs, about 75 mm (3 in.).

Status

The Siouan Thinlip Chub is listed as imperiled (G2Q) globally and imperiled to critically imperiled (S1S2) in South Carolina (NatureServe 2024). It is also considered a species of Special Concern in North Carolina and is considered imperiled (S2) there (NatureServe 2024). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of high concern.

POPULATION SIZE AND DISTRIBUTION

The Siouan Thinlip Chub is endemic to the Carolinas, occurring primarily on the inner coastal plain of the Cape Fear River and Pee Dee River basins. In South Carolina, it is known from scattered localities in the Lumber, Little Pee Dee, Great Pee Dee, and Lynches drainages (Rohde et al. 2009; Tracy et al. 2024).

Due to its small range and infrequent occurrence, Siouan Thinlip Chub population size and trends are not well known. It is not commonly encountered within its known range (F. Rohde, pers. comm.) and, when detected, is generally among the least abundant species in the fish community. This species was observed in 0.4% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Siouan Thinlip Chub inhabits small to large rivers of the inner coastal plain over sand and gravel substrate (Rohde et al. 2009). It occurs in some typical flowing blackwater rivers as well as rivers exhibiting transitional characteristics between those of the Piedmont and Coastal Plain. Although its occurrence in deeper river sections is difficult to infer due to challenges of effectively sampling these habitats, the Siouan Thinlip Chub has been observed in association with schools of mixed leuciscids on inside river bends over sand and gravel in shallow to intermediate depths (SCDNR unpublished data). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (15.4%) and average relative abundance (0.8%) in small rivers (watershed area 300-2000 km^2) of the Sand Hills in the Lynches and Pee Dee basins. The Siouan Thinlip Chub probably spawns in mid to late summer (Rohde et al. 2009).

CHALLENGES

The Siouan Thinlip Chub is threatened by the same anthropogenic disturbances that challenge all aquatic fauna. However, due to its limited distribution, it is especially vulnerable to development as the Sandhills ecoregion of South Carolina is under constant development pressure. Habitat modifications in this region that impact the Siouan Thinlip Chub include agriculture, residential development, and tourism. Damming headwater streams to create ponds for golf courses eliminates important lotic habitats; the new lentic environments favor competing—and often predatory—species such as Bluegill and Largemouth Bass. Poor agricultural, silvicultural, and road construction practices often lead to stream siltation and non-point source water pollution (Waters 1995). Unregulated use of motor vehicles in stream bottoms also results in stream siltation and destruction of fish habitat. The elusiveness of this species also represents a

fundamental challenge in its conservation, confounding efforts to monitor its status and habitat requirements.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina’s freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT’s second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting’s pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.

- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

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    - Denison, C.D., M.C. Scott, K.M. Kubach, and B.K. Peoples. 2021. Integrating regional frameworks and local variability for riverine bioassessment. Environmental Management. 68(1):126-145.

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- Mruzek, J.L, L.M. Bower, M.C. Scott, K. Kubach, and B.K. Peoples. *In review* 2024. Relative influence of flow regime, natural and anthropogenic environment on dimensions of local fish diversity. Hydrobiologia.

- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements for Siouan Thinlip Chub.
- Protect critical habitats for Siouan Thinlip Chub from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat for Siouan Thinlip Chub.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame fish species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are

implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Snail Bullhead

Ameiurus brunneus



Photo: NCFishes.com

Contributor (2005): Jason Bettinger (SCDNR)
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Snail Bullhead is a member of the family Ictaluridae. The ictalurids, with approximately 51 species, represent the largest family of fishes indigenous to only North America (Warren et al. 2020; Page et al. 2023). The genus *Ameiurus* contains the moderately-sized (reaching only a few pounds) catfish collectively known as the "bullheads." Snail Bullheads have a large, flat head, a decurved snout profile, uniformly colored maxillary barbel, short rounded anal fin, emarginate tail and a large dusky blotch at the base of the dorsal fin. Snail Bullheads vary greatly in color and pattern, but in general they have a brown or yellow-green back, mottled sides of the same colors, and a white belly. In their natural habitats (rivers and streams), Snail Bullheads typically reach maximum adult sizes of 294 mm (11.4 in.) (Rohde et al. 1994); however, in impounded river reaches and reservoirs, they reach substantially greater sizes (443 mm or 17.6 in.) (SCDNR unpublished data).

Status

The Snail Bullhead is apparently secure (G4) over its range; however, in a recent assessment of southeastern fishes, this species was considered vulnerable to imperilment (V) (Warren et al. 2000; Jelks et al. 2008). It is considered vulnerable to apparently secure (S3S4) in South Carolina (NatureServe 2024). The Snail Bullhead is considered at least vulnerable to imperilment in 3 of the 6 states where it occurs. It is considered imperiled (S2) in Virginia, vulnerable (S3) to imperilment in Alabama, and apparently secure (S4) in Florida, Georgia and North Carolina (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

Snail Bullheads occur along the Atlantic Slope from the Dan River system in Virginia and North Carolina south to the Altamaha River system in Georgia and the Saint Johns River drainage in Florida (NatureServe 2024). They also occur in Gulf Slope drainages of the Apalachicola River system in Georgia, Alabama, and Florida and in the upper Coosa River system in northern Georgia (Page and Burr 1991).

The Snail Bullhead is found in all of South Carolina's river basins and ecoregions, although it is most widespread and abundant in the uplands. Snail Bullheads appear to be relatively stable in South Carolina streams; however, their fate in the larger rivers is uncertain due to the presence of the non-native Flathead Catfish and Blue Catfish. They are common to abundant in the upper Santee basin but decreasing trends have been noted in many coastal rivers like the Edisto River and lower Savannah River following the introduction of Flathead Catfish (C. Thomason, SCDNR, pers. comm.). The largest populations of Snail Bullhead are probably located in the Broad River system; however, both the Flathead Catfish and Blue Catfish have been documented in the system in recent decades, and their impact has yet to be determined. This species was observed in 11.7% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Snail Bullhead is found in rocky riffles, shoals, runs, and pools in streams and rivers. (Jenkins and Burkhead 1994; Rohde et al. 1994; NatureServe 2024). It has also been found in small streams and rivers in the Blue Ridge (Rohde et al. 2009). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (83.3%) in small upland rivers (watershed area 300-2000 km²) of the Savannah River basin and highest average relative abundance (3.0%) in upland small rivers (watershed area 300-2000 km²) of the Santee River basin.

CHALLENGES

The Snail Bullhead is adversely affected by the same myriad of challenges plaguing all aquatic species such as sedimentation, hydrologic modification, impoundments, non-point source pollution, and development. Other threats to the Snail Bullhead include loss of forested land and especially the removal of riparian cover along upland streams. Fish assemblage integrity of upland streams increases with natural land cover, whereas integrity decreases as the amount of developed and agricultural land increases (SCDNR 2023). Mature forest and riparian vegetation are important sources of large woody debris in upland streams, which contributes to beneficial habitat diversity and channel stability. Additionally, this species is threatened by the introduction of non-native ictalurids like the Flathead Catfish and Blue Catfish; both non-native species displace and prey on the smaller bullheads (Guire et al. 1984; Ashley and Buff 1986; Quinn 1988; Bart et al. 1994).

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment (2006-2011) data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and "ecobasin" (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
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- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

    - Marion, C.A., M.C. Scott, and K.M. Kubach. 2015. Multiscale environmental influences on fish assemblage structure of South Atlantic coastal plain streams. Transactions of the American Fisheries Society. 144(5):1040-1057.

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements of the Snail Bullhead.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices (BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Develop a Non-Game Fishes of South Carolina poster and other educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Prevent the spread of Flathead Catfish and other non-indigenous aquatic species.
- Educate the public as to the discontents of stocking nonnative species.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the

Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Striped Bass

Morone saxatilis

Contributor (2005): Forest Sessions, Scott Lamprecht, and Jason Bettinger [SCDNR]
Reviewed and Edited (2013): James Bulak and Mark Scott [SCDNR]
Reviewed and Edited (2024): Jason Bettinger, Tanya Darden, Jason Marsik, Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]



Photo: NCFishes.com

DESCRIPTION

Taxonomy and Basic Description

The Striped Bass is a member of the family Moronidae, which contains four North American species that are known as the temperate basses (Jenkins and Burkhead 1994; Page et al. 2023). The Striped Bass, commonly called "rockfish" or "lineside," has a compressed, moderately deep body covered with ctenoid scales. Striped Bass have an olive-green back, a silvery flank with several thin, dark lines and silvery-white belly. Striped Bass are large, robust fish that attain adult sizes of up to 198 cm (78 in.), but most individuals in freshwater systems are much smaller, measuring less than 99 cm (39 in.).

Status

Although the Striped Bass is currently considered stable (Warren et al. 2000) and secure (G5) overall across its native range, it is considered critically imperiled (S1) in South Carolina (NatureServe 2024). Although the species currently appears stable, there are populations of concern in South Carolina. South Carolina is home to small reproductively isolated populations of Striped Bass that exhibit minimal anadromy and are generally restricted to their natal coastal rivers (Bulak et al. 2004). It is those small, unique populations that warrant conservation concern in South Carolina.

POPULATION SIZE AND DISTRIBUTION

The Striped Bass's native range includes coastal rivers on the Atlantic Slope from the St. Lawrence River, Canada, to the St. Johns River, Florida, and in Gulf Slope drainages from western Florida to Lake Pontchartrain, Louisiana (NatureServe 2024). The Striped Bass has been introduced into rivers and reservoirs throughout the United States as it provides a valuable recreational fishery. The populations of conservation concern within South Carolina inhabit coastal rivers in the Lower Coastal Plain including the Savannah River, New River, Combahee River, Ashepoo River, Edisto River, Santee-Cooper Rivers, Black River, Lynches River, Great Pee Dee River, Little Pee Dee River and Waccamaw River.

Striped Bass population trends within the coastal rivers are not well known. However, based on anecdotal evidence it appears that the coastal Striped Bass populations have declined. Coastal Striped Bass populations appear to be relatively small. A recent study of the Combahee River estimated the population of Striped Bass greater than 30 cm (12 in.) to be only 406 individuals (Bulak et al. 2004). This species was observed in only 0.6% of over 900 standardized statewide stream and small river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

Striped Bass inhabit medium to large rivers; they are also found in impoundments where they have been introduced but are often unable to complete their life cycle. They prefer to occupy areas with clean, sandy bottoms with fine gravel and rock (NatureServe 2004). Adult Striped Bass have a thermal tolerance of 6 to 27°C (43-81°F) (Merriman 1941) but seek temperatures between 18 to 25°C (64-77°F) when available (Coutant and Carroll 1980; Crance 1984). During spawning, Striped Bass occupy shallow rocky and gravely areas with strong, turbulent water flow. Striped Bass eggs are semi-buoyant; they drift and sink slowly requiring moderate current to keep the eggs from settling to the bottom and dying before they are hatched in 1 to 3 days (Scruggs 1955, Etnier and Starnes 1993). Hassler et al. (1981) observed that optimum water temperatures for successful Striped Bass egg hatching and survival in North Carolina was 17 to 18°C (63-64°F).

CHALLENGES

The major challenges to South Carolina's coastal Striped Bass populations include siltation, increased river water temperatures, oxygen depletion associated with nutrient enrichment, hydrologic modification, and over-exploitation. Clearing forests and riparian areas along coastal rivers and their tributaries has led to increased siltation and potentially warmer water temperatures. Increased water withdrawals for agricultural and municipal purposes may also pose a threat to habitat quality and quantity by reducing river flows and potentially increasing water temperatures. Warmer water temperatures may decrease the amount of summertime refuge habitat for Striped Bass and negatively impact reproduction. In the Combahee and Edisto rivers, Striped Bass used upstream areas with greater riparian overstory and associated cooler water temperatures as summertime thermal refuges (Bjorgo et al. 2000). Dams negatively impact Striped Bass populations by disrupting migrations and altering thermal and hydrologic regimes. The presence of impoundments along the Savannah and Pee Dee Rivers may partially account for limited reproduction in those systems. Additionally, stocking non-endemic Striped Bass into coastal rivers may compromise the genetic integrity of these small, isolated populations (Bulak et al. 2004). Escapement of hybrid Striped Bass into coastal systems containing reproducing populations of Striped Bass may also pose a threat to the genetic integrity of those populations.

CONSERVATION ACCOMPLISHMENTS

Striped Bass fishing regulations on coastal river systems were implemented in 2012 to reduced harvest and summer mortality of Striped Bass due to angling. The 2012 regulations made it unlawful to take, attempt to take, or to possess Striped Bass from the State's coastal river

systems from June 1st to September 30th, decreasing the potential for angling-related summer mortality. In 2018, those regulations were amended and made it unlawful to take, attempt to take, or to possess Striped Bass from June 16th to September 30th. During the remainder of the year, Striped Bass must be at least 66 cm (26 in.) in length, protecting female Striped Bass from harvest prior to spawning. Hybrid Striped Bass are not stocked in the Santee-Cooper, Pee Dee, Ashepoo, Combahee or Edisto drainages in order to protect those spawning stocks. The genetic integrity of small isolated Striped Bass populations is protected thanks to the current South Carolina Department of Natural Resources (SCDNR) stocking policy which allows only endemic stocks to be used to augment small coastal river Striped Bass populations. Spawning flows for Striped Bass have been identified for several hydroelectric facilities in South Carolina that are currently in the relicensing process.

The genetic structure of Striped Bass populations within South Carolina's major coastal rivers has been evaluated to determine genetic diversity within and among populations to guide future efforts to restore and/or enhance coastal Striped Bass populations (Anderson et al. 2014). Restoration stocking of Striped Bass was conducted for eight years (2006 – 2014) in the Ashley River (SCSWG 2014). While the effort did not successfully restore Striped Bass to the Ashley River, methods were developed for stocking Striped Bass into coastal systems and stocked fish survived to adulthood, demonstrating that stocking may be a viable tool to maintain coastal river populations.

Two efforts were conducted to determine if habitat (i.e., temperature and dissolved oxygen) were causal factors for limiting or extirpating the Striped Bass population from the Ashely River. Johnson (2015) validated the existing Striped Bass bioenergetics model (Hartman and Brandt 1995) for use in a southeastern river and used it to evaluate Striped Bass Habitat quality in the Ashley River. The study emphasized the importance of summer-time thermal refuges in upstream portions of the river and demonstrated the potential for the Ashely River to support a self-sustaining Striped Bass population; however, additional perturbances (e.g., increased water temperatures or decreased dissolved oxygen) to the system could have serious consequences to available suitable habitat and the sustainability of the population. The effects of temperature and hypoxia on the metabolic performance of a southern stock of juvenile Striped Bass were also evaluated (Anweiler et al. 2019). The two studies demonstrated how bioenergetic approaches could be used to assess habitat suitability in coastal rivers and used as a tool to select and prioritize appropriate restoration habitats.

The Pee Dee River population has undergone a population assessment in recent years including genetic genotyping, adult telemetry tracking, juvenile telemetry tracking, and stocking augmentation. Through genetic assessment, the population was determined to include wild spawned fish, SCDNR stocked fish and NCWRC stocked fish from upriver reservoirs. A telemetry study of adult Striped Bass determined spawning areas, summer refugia, and resting areas (Doll and Marsik 2023). A juvenile telemetry study of stocked Phase II fish was conducted to determine movement patterns and identify the best stocking locations. Since 2019, nearly 150,000 Phase II Striped Bass have been stocked over four year classes, using Santee-Cooper Striped Bass progeny, into the Great Pee Dee River. A standardized electrofishing study design has been implemented to determine hatchery contribution as well as population trends.

In 2019, a study was initiated to document the seasonal movements of adult Striped Bass in the Edisto River, assess the genetic structure of the Striped Bass population, and identify summer-time thermal refuges. Between 2019 and 2023, 28 adult Striped Bass were implanted with acoustic transmitters and fin clips for genetic analysis were collected from 161 individuals. Annually adult Striped Bass follow similar seasonal patterns occupying the downstream tidally influenced portion of the river during cool weather months (October to March) and the upper reaches of the mainstem and the forks of the river during warm weather months (April to September). The vast majority (98%) of the population is comprised of naturally spawned Edisto "strain" Striped Bass.

In 2023, a study (SWG F22AF03676) was initiated to quantify the effect of mean daily flow on summertime water temperatures in the Edisto River, model summertime water temperature under current and future climate and water withdrawal scenarios and determine if thermal tolerances of SWAP fishes (e.g., Striped Bass) are exceeded.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.

- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

    - Marion, C.A., M.C. Scott, and K.M. Kubach. 2015. Multiscale environmental influences on fish assemblage structure of South Atlantic coastal plain streams. Transactions of the American Fisheries Society. 144(5):1040-1057.

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna.

CONSERVATION RECOMMENDATIONS

- Describe life history and habitat requirements of the Striped Bass.
- Identify critical habitats and areas with healthy populations of the Striped Bass. Protect these areas, once identified.
- Identify and monitor key Striped Bass habitats like thermal refuges and spawning sites.
- Assess Striped Bass reproductive potential in the coastal rivers.
- Continue to monitor genetic stock structure of Striped Bass in coastal rivers.
- Determine reasons for lack of Striped Bass recruitment in coastal populations.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices (BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider species needs when participating in the environmental permit review process.
- Augment coastal Striped Bass populations with endemic strains, as needed.
- Use hatchery practices that will either maintain or enhance effective population size in a particular drainage.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for these species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of these fish could assist in determining the effectiveness of those measures. An increase in coastal Striped Bass populations within the State would also indicate that restoration and habitat protections were successful. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Swallowtail Shiner

Miniellus procne



Photo: NCFishes.com

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DESCRIPTION

Taxonomy and Basic Description

The Swallowtail Shiner belongs to the minnow family (Leuciscidae) and was recently moved to the genus *Miniellus* from the polyphyletic *Notropis* (Stout et al. 2022 and sources therein; Page et al. 2023), joining the reclassified Whitemouth Shiner (*M. alborus*) as the only *Miniellus* in South Carolina. Minnows represent the most speciose family of freshwater fishes in North America (about 27% of the continental fauna), with at least 323 described taxa of predominantly small (<150 mm) and slender fishes including 21 recognized species of *Miniellus* (Warren and Burr 2014; Page et al. 2023).

Adult Swallowtail Shiners range from 46 to 78 mm in total length (1.8 to 3.1 in.) (Rohde et al. 2009). The overall coloration is a somewhat translucent straw-yellow with a dark lateral stripe extending onto but not encircling the snout. It has a predorsal stripe, a dash of black pigment at the base of the dorsal fin and two light dashes along the back, just anterior and posterior to the dorsal fin. The breast is usually unscaled (Rohde et al. 2009). This species can be distinguished from the Whitemouth Shiner by the presence in Swallowtail of a predorsal stripe, a black stripe not completely encircling the snout, and moderate pigmentation on the upper lip (absent in Whitemouth).

Status

The Swallowtail Shiner is considered secure (G5) on a global scale (NatureServe 2024) and is currently stable according to Warren et al. (2000). It is listed as vulnerable (S3) in South Carolina, imperiled (S2) in New York, and critically imperiled (S1) in West Virginia. Other states within its range list it as secure (S5), including North Carolina and Virginia, or apparently secure (S4) as in Delaware, Maryland, New Jersey, and Pennsylvania (NatureServe 2024). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of moderate concern.

POPULATION SIZE AND DISTRIBUTION

The Swallowtail Shiner is distributed along the Atlantic Slope from the Delaware and Susquehanna River basins in New York to the Santee River basin in South Carolina (Rohde et al. 2009). In South Carolina, it is found in the Pee Dee and Santee River basins primarily in the Piedmont, with fewer records from the inner coastal plain. Although it can be locally abundant in certain areas such as the upper Catawba and Lynches River drainages, it is patchy across much of its range in South Carolina. This species was observed in 6.1% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Swallowtail Shiner occurs in sandy pools of streams and small rivers (Jenkins and Burkhead 1994; Rohde et al. 2009). In standardized sampling covering streams to small rivers of South Carolina, this species exhibited its highest frequency of occurrence (34.3%) in upland large streams (watershed area 100-300 km^2) of the Santee River basin and average relative abundance (6.8%) in upland small rivers (watershed area 300-2000 km^2) of the Santee River basin. It spawns from May to July in moderate current over sand or in the nests of sunfish or other minnows (Jenkins and Burkhead 1994; Warren and Burr 2014).

CHALLENGES

The Swallowtail Shiner is susceptible to an array of acute and cumulative impacts from anthropogenic alterations to the watershed, riparian zone and streams and rivers directly. These include deforestation and conversion of natural land cover for development and agriculture with resulting sedimentation and non-point source pollution, hydrologic alterations, and habitat fragmentation from dams and reservoirs. Fish assemblage integrity of upland streams increases with natural land cover, whereas integrity decreases as the amount of developed and agricultural land increases (SCDNR 2023). Mature forest and riparian vegetation are important sources of large woody cover in upland streams, which contributes to beneficial habitat diversity and channel stability. Land development, siltation, and hydrologic alterations such as channelization and construction of impoundments also threaten this species. The conversion of upland streams into channelized ditches with little in-stream habitat represents a principal threat to Swallowtail Shiner habitat.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion and “ecobasin” (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina’s freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning

the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

    - Marion, C.A., M.C. Scott, and K.M. Kubach. 2015. Multiscale environmental influences on fish assemblage structure of South Atlantic coastal plain streams. Transactions of the American Fisheries Society. 144(5):1040-1057.

    - Epstein, J.M., W.E. Pine III, C.M. Romagosa, M.C. Scott, C.T. Phillips, C.A. Marion, and B. Baiser. 2018. State- and Regional-Scale Patterns and Drivers of Freshwater Fish Functional Diversity in the Southeastern USA. Transactions of the American Fisheries Society. 147:1179-1198. https://doi.org/10.1002/tafs.10110

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Swampfish

Chologaster cornuta



Photo: NCFishes.com

Contributors (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Swampfish is one of nine known species of cavefishes (Amblyopsidae) (Page et al. 2023), and the lone representative in South Carolina (Rohde et al. 2009). Although taxonomically a cavefish, the Swampfish is a strictly epigean (surface water-dwelling) member of the family and is placed in its own genus, *Chologaster* (Warren and Burr 2020; Page et al. 2023). The cavefishes are considered sister to the Pirate Perches (Aphredoderidae) (Betancur-R et al. 2017).

Adult Swampfish are small, ranging in total length from 23 to 68 mm (0.9 to 2.7 in.) (Rohde et al. 2009). This is one of the only pigmented members of the cavefish family (Warren and Burr 2020). The Swampfish has a very unique appearance: coloration contrasts sharply from brown dorsally to creamy white–yellow ventrally, with 3 dark longitudinal stripes on each side. The scales are cycloid and are absent from the head. It is dorso-ventrally compressed anteriorly and laterally compressed posteriorly. It has very small eyes, a supraterminal mouth, and lacks pelvic fins. The caudal fin is clear along its base and black in its center. In adults, the anus is located in a jugular position and is usually covered by the branchiostegal membranes. Short rows of neuromasts—small protruding papillae—are present on the head, body, and caudal fin (Rohde et al. 2009).

Status

The Swampfish is considered secure (G5) on a global scale and vulnerable (S3) in South Carolina (NatureServe 2024). The species in currently listed as imperiled to vulnerable (S2S3) in Georgia (NatureServe 2024). Otherwise, it is currently stable according to Warren et al. (2000). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of moderate concern.

POPULATION SIZE AND DISTRIBUTION

The Swampfish occurs along the southern Atlantic coastal plain from the Chickahominy River, Virginia to the Altamaha River, Georgia (Warren et al. 2000; Rohde et al. 2009). It is found across the coastal plain of South Carolina in all river basins. Although it may be locally common

in some locations, it is not widely encountered due in part to its nocturnal behavior and the heavily vegetated habitats in which it resides (Rohde et al. 1994). It can be categorized as a species that is widespread but not abundant (as detected by most standardized electrofishing methods, largely because it occurs in complex habitats and heavy cover). This species was observed in 3.4% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Swampfish occurs primarily in calm, acidic blackwater swamps, sloughs and streams in association with organic matter and aquatic vegetation (Rohde et al. 2009). Accordingly, it possesses various physiological and behavioral adaptations for these settings, including nocturnal activity and generally sedentary behavior with low metabolic rates (Warren and Burr 2020). Aquatic vegetation and complex structure are important as diurnal cover for light and predator avoidance (Warren and Burr 2020). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (30.8%) and average relative abundance (0.4%) in small rivers (watershed area 300-2000 km^2) of the outer coastal plain.

CHALLENGES

Primary threats to the Swampfish include loss of forested land and especially the removal of riparian cover along Coastal Plain streams. Fish assemblage integrity of coastal plain streams increases with natural land cover, whereas integrity decreases as the amount of agricultural land increases (SCDNR 2023). Mature forest and riparian vegetation are important sources of large woody debris in Coastal Plain streams, which provides critical habitat for many endemic Southern Atlantic Coastal Plain species including the Swampfish (Marion 2008). Land development, siltation, and hydrologic alterations such as channelization and construction of impoundments also threaten this species. The conversion of naturally stagnant lowland swamps and streams into channelized, shallow drainage ditches with consistently high current velocities represents a principal threat to Swampfish habitat.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). These estimates for the first time provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

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- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Tennessee Shiner
Paranotropis leuciodus

Contributor (2005): Jason Bettinger (SCDNR)
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]



Photo: NCFishes.com

DESCRIPTION

Taxonomy and Basic Description

The Tennessee Shiner belongs to the minnow family (Leuciscidae) and was recently moved to the resurrected genus *Paranotropis* from the polyphyletic *Notropis* (Stout et al. 2022 and sources therein), joining the reclassified Mirror Shiner (*P. spectrunculus*) as the only members of this genus in South Carolina (Page et al. 2023). Minnows represent the most speciose family of freshwater fishes in North America (about 27% of the continental fauna), with at least 323 described taxa of predominantly small (<150 mm) and slender fishes including eight recognized species of *Paranotropis* (Warren and Burr 2014; Page et al. 2023).

The Tennessee Shiner is slender with a prominent midlateral stripe and a lateral line set off by dashes terminating in a small rectangular spot at the base of the caudal fin. During the breeding season, the bodies and fins of males take on a red hue and they display a lime green stripe on their upper side. Adult Tennessee Shiners range in length from 43 to 82 mm (1.7 to 3.2 in.) (Rohde et al. 1994).

Status

The Tennessee Shiner is listed globally as currently stable (Warren et al. 2000), secure (G5), and is considered vulnerable (S3) in South Carolina (NatureServe 2024). It is also considered vulnerable (S3) in Georgia and critically imperiled in Alabama (S1) (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

Overall, the Tennessee Shiner primarily occurs in upland drainages in the Tennessee, Cumberland and Green River basins of Alabama, Georgia, Kentucky, North Carolina, and Tennessee, as well as small portions of the upper Savannah, Linville (Santee), and New River basins (Rohde et al. 2009). In South Carolina, it is only known from several locations in the upper Savannah River basin, with the bulk of its occurrences coming from the Chattooga River (Rohde et al. 2009). Its presence in the upper Savannah and Linville basins of the Atlantic Slope is probably a result of stream capture with the Tennessee basin (Ramsey 1965; Ross 1970; Rohde et al. 2009; Tracy et al. 2020), similar to other taxa in this volume with predominantly Mississippi drainage distributions.

Information on population size and status is limited for this species. Based on samples of the South Carolina/Georgia section of the Chattooga River over the past several decades, the abundance of Tennessee Shiner is very low compared with most other leuciscids in the river; usually only one or two are collected in a typical community sample. Its congener the Mirror Shiner is considerably more abundant in the Chattooga River. On a statewide scale, this species was observed in only 0.1% of over 900 standardized statewide stream and river assessment samples across South Carolina between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Tennessee Shiner inhabits the mid-water areas of riffles, runs and pools adjacent to moderate and swift currents in streams to medium rivers (Jenkins and Burkhead 1994; Rohde et al. 2009). This species spawns in May to June and has been observed using the nests of stonerollers (*Campostoma* spp.) and River Chubs (Etnier and Starnes 1993; Rohde et al. 2009), but it is also known to spawn in shallow gravel runs without nests (Jenkins and Burkhead 1994).

In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (16.7%) and average relative abundance (0.1%) in upland small rivers (watershed area 300-2000 km^2) of the Savannah River basin.

CHALLENGES

While the Tennessee Shiner is currently stable throughout the majority of its range, its limited distribution and apparently low abundance in South Carolina make it vulnerable to imperilment within the state. Although much of the Chattooga River drainage is officially designated as wilderness area and therefore protected from development, other anthropogenic actions such as the introduction of non-native species (both aquatic and terrestrial) or long-term environmental change represent potential threats to this species. For example, non-native organisms such as the hemlock woolly adelgid (*Adelges tsugae*) or other tree pathogens could cause widespread loss of major forest constituent tree species and therefore alter the natural thermal and other ecological regimes to which aquatic fauna have adapted. As with other freshwater fishes, anthropogenic landscape alteration can result in cumulative degradation of dependent aquatic ecosystems.

CONSERVATION ACCOMPLISHMENTS

The core area of Tennessee Shiner abundance is protected by the Wild and Scenic Chattooga River.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and

mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
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- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
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- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
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Micropterus sp. *cf. coosae*: Disturbance and proximity to invasion source increase hybridization with invasive Alabama Bass. North American Journal of Fisheries Management. 41:1309-1321. https://doi.org/10.1002/nafm.10637

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements of the Tennessee Shiner.
- Identify critical habitats and areas with healthy populations of the Tennessee Shiner and protect these areas once identified.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Thicklip Chub
Cyprinella labrosa

Contributor (2005): Jason Bettinger (SCDNR)
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]



Photo: NCFishes.com

DESCRIPTION

Taxonomy and Basic Description

The Thicklip Chub belongs to the minnow family (Leuciscidae), the most speciose family of freshwater fishes in North America with at least 323 described taxa of predominantly small (<150 mm) and slender fishes (Warren and Burr 2014; Page et al. 2023). It is closely related to the sister pair of Santee Chub (*C. zanema*) and Siouan Thinlip Chub (*C. leptocheilus*) (Tracy et al. 2024). Following the recent revision of the formerly large genus *Notropis* (Stout et al. 2022), *Cyprinella* is currently the most diverse genus of North American minnows, with 29 described species (Page et al. 2023). The Thicklip Chub is one of eight described plus one undescribed (as of 2024) species of *Cyprinella* in South Carolina.

Along with the Santee Chub (*C. zanema*) and Siouan Thinlip Chub (*C. leptocheilus*), this species is unique among *Cyprinella* in possessing barbels in the corner of its mouth. These three species furthermore have a different shape than other members of the genus, with a slender, ventrally flattened profile, relatively long snout and inferior mouth. In the Thicklip Chub, the dorsal fin origin is positioned directly over the pelvic fin origin, whereas in the Santee and Siouan Thinlip Chubs the dorsal fin origin sits posterior to that of the pelvic fins (Rohde et al. 2009). The back of the fish is marked with prominent cross-hatching and ranges in color from dark olive (juveniles and females) to steel blue (breeding males). All fins have cream-colored edges; males develop straw to red colored fins during the breeding season. Adults range in length from 46 to 75 mm (1.8 to 3 in.) (Rohde et al. 1994).

Status

The Thicklip Chub is considered apparently secure (G4); however, there is some concern for their long-term status based on their limited distributions (NatureServe 2024). In South Carolina, the Thicklip Chub is considered imperiled to vulnerable (S2S3), is considered vulnerable (S3) in North Carolina, and possibly extirpated (SH) in Virginia (NatureServe 2024). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of moderate concern.

POPULATION SIZE AND DISTRIBUTION

The Thicklip Chub is largely restricted to the Santee and Pee Dee River basins of the Carolinas; however, there was one record for the Thicklip Chub in the Pee Dee drainage of Virginia (Jenkins and Burkhead 1994). In South Carolina, the Thicklip Chub is known from the Broad and Saluda drainages of the Santee River system above the Fall Line. In North Carolina, it is found both in the upper Pee Dee and upper Santee drainages. It can be locally abundant in appropriate habitat but is typically among the least abundant members of its genus in streams and rivers in which it occurs. This species was observed in 1.1% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Thicklip Chub is found in cool- to warmwater streams and rivers, generally in riffles and runs with sand, gravel and rock bottoms (Page and Burr 1991; Jenkins and Burkhead 1994; Rohde et al. 2009). It usually inhabits coarser substrate (e.g., gravel to cobble) than the sympatric Santee Chub (*C. zanema*) (SCDNR unpublished data), resulting in some degree of habitat segregation with *C. labrosa* in rockier areas and *C. zanema* in more uniformly sandy runs (Rohde et al. 2009). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (16.7%) and average relative abundance (0.5%) in upland small rivers (watershed area 300-2000 km^2) of the Santee River basin.

CHALLENGES

The Thicklip Chub, like many other specialized stream fishes, is susceptible to an array of acute and cumulative impacts from anthropogenic alterations to the watershed, riparian zone and streams and rivers directly. These include deforestation and conversion of natural land cover for development and agriculture with resulting sedimentation and non-point source pollution, hydrologic alterations, and habitat fragmentation from dams and reservoirs. Fish assemblage integrity of upland streams increases with natural land cover, whereas integrity decreases as the amount of developed and agricultural land increases (SCDNR 2023). Mature forest and riparian vegetation are important sources of large woody debris in upland streams, which contributes to beneficial habitat diversity and channel stability. The conversion of upland streams into channelized ditches with little in-stream habitat represents a principal threat to Thicklip Chub habitat. The apparent preference of this species for coarser substrate than that occupied by the sympatric Santee Chub may suggest it is more sensitive to runoff and increased fine sediment loading in streams. One of the fastest-growing areas of human population pressure and land development in the United States, the Interstate 85 corridor between Greenville, South Carolina and Charlotte, North Carolina, runs directly through the range of this species. The vast majority of its populations occur on private (unprotected) lands. Approximately 50% of the global range of the Thicklip Chub occurs in South Carolina; conservation efforts within the state are critical to the preservation of this species.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and "ecobasin" (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

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- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a

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Turquoise Darter

Etheostoma inscriptum



Photo: NCFishes.com

Contributor (2005): Gene Hayes and Jason Bettinger [SCDNR]
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Turquoise Darter is a member of the perch and darter family (Percidae), an extremely diverse group of predominantly small, bottom-dwelling fishes currently represented by 224 described species comprising more than 20% of the North American freshwater ichthyofauna (Page 1983; Kuehne and Barbour 1983; Near et al. 2011; Page et al. 2023). With 138 described species, *Etheostoma* is the most diverse genus of North American freshwater fishes (Page et al. 2023). It is sister to the Seagreen Darter (*Etheostoma thalassinum*) of the Santee River basin (Richards 1966; Near et al. 2011).

The Turquoise Darter is a moderate-sized darter, ranging in adult length from 66 to 78 mm (2.6 to 3.1 inches) (Rohde et al. 1994). Adults of both sexes have 5 to 6 dark dorsal saddles and 6 blotches on the side (Kuehne and Barbour 1983). The male Turquoise Darter is brown with several horizontal rows of small red spots, whereas the sides of the female are yellow-brown with brown saddles and blotches. Breeding males take on a pinkish body color with dark green bars on the side. The lower portion of the head becomes blue, as do the pelvic fins, anal fins, and outer edges of the caudal fin. The dorsal fin of the male becomes blue-green with a red upper edge during the spawning period (Rohde et al. 1994).

Status

Globally, the Turquoise Darter is listed as apparently secure (G4) (NatureServe 2024). The Turquoise Darter is considered imperiled to vulnerable (S2S3) in South Carolina and apparently secure (S4) in Georgia, but is a fish of special concern in North Carolina, where it is considered critically imperiled (S1) (NatureServe 2024) due to its very restricted range in that state. In an assessment of Southeastern fishes, the Turquoise Darter was considered currently stable (Warren et al. 2000). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of moderate concern.

POPULATION SIZE AND DISTRIBUTION

The Turquoise Darter is native to the Altamaha, Savannah and Edisto River basins of the southern Atlantic slope. In South Carolina, it is predominantly an upland fish and sees its highest abundance in swift-flowing streams and rivers, but it also occurs in lower numbers in scattered localities on the inner coastal plain of the Savannah and Edisto River basins where topography supports steady flow. In high-gradient streams and rivers with continuous suitable habitat it can be moderately abundant, but due to the siltation of many Piedmont streams and the localized nature of appropriate coarse riffles in lower-gradient Piedmont streams, it is often limited in abundance. This species was observed in 4.5% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

In the Piedmont and Blue Ridge portions of its range, the Turquoise Darter occurs in streams to large rivers and almost exclusively in swift riffle habitats with coarse substrates ranging from gravel to cobble and bedrock (Page 1983; Kuehne and Barbour 1983; Rohde et al. 2009; K. Lusk and B. Peoples, unpublished data). In an Inner Piedmont stream during spring-summer, Turquoise Darter density was highest in depths of 5-20 cm, velocities of 55-65 cm per second, and substrate of boulder/bedrock (DeLong 1991). Where it occurs (in lower abundance) in the inner coastal plain, the streams are characterized by steady flow over sand and fine gravel (SCDNR data). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (50%) and average relative abundance (3.3%) in upland small rivers (watershed area 300-2000 km^2) of the Savannah River basin. Spawning occurs from late March to early June with a peak in April (Richards 1966; Irwin 2009). Following the first spawn of a reintroduced Turquoise Darter population in the upper Savannah River basin, juveniles were found exclusively downstream of and on finer (gravel) substrate than the adults (Kubach 2003), suggesting age-specific differences in habitat use as well as probable downstream drift of pelagic larvae as a dispersal method, which has been observed in other darters (Rakes 1999; Muller 2000). Other aspects of its biology are not well studied but are probably similar to those of the related and wider-ranging Greenside Darter, *E. blennioides*.

CHALLENGES

Although the Turquoise Darter is currently considered stable, conservation efforts within South Carolina are critical to its global conservation. Approximately one-third of the global distribution of Turquoise Darter occurs in South Carolina. Within the state, destruction of stream riffle habitat caused by land development, deforestation, loss of riparian cover, siltation, and hydrologic alterations like channelization and impoundments could jeopardize this species. Much of its preferred larger, fluvial habitat in the upper Savannah River basin has already been lost to major reservoirs collectively spanning hundreds of thousands of acres. The patchy and limited distributions of remaining intact habitats and populations are vulnerable to habitat alteration. Coastal plain populations of the Turquoise Darter are of concern due to increased development pressures in that region and smaller darter population sizes. Further, in extreme headwaters of their range, Turquoise Darters may be adversely affected by Brown and Rainbow Trout introductions.

CONSERVATION ACCOMPLISHMENTS

Populations of Turquoise Darters occurring in Howard Creek are protected through land purchase and/or conservation easements. A successful reintroduction of Turquoise Darters was conducted on Six Mile Creek in 2003.

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and "ecobasin" (ecoregion x river basin). These estimates, for the first time, provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements of Turquoise Darters.
- Study the potential predator/prey relationship between darters (Turquoise and Seagreen Darters) and introduced trout (Brown and Rainbow Trout) and the impact of this relationship on the native darters.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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V-lip Redhorse

Moxostoma pappillosum



Photo: NCFishes.com

Contributor (2005): Forest Sessions, Scott Lamprecht, and Jason Bettinger [SCDNR]
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The V-lip Redhorse is a member of the sucker family (Catostomidae), which is represented by 78 described species in North America (Page et al. 2023). Suckers comprise about 8% of the continent's freshwater ichthyofauna, behind only minnows (Leuciscidae) and perches and darters (Percidae) in number of species (Warren and Burr 2014). The genus *Moxostoma* includes 23 described species (Page et al. 2023), about one third of which are considered imperiled at some level (Jelks et al. 2008; Warren and Burr 2014).

This family is characterized by soft-rayed fins, a mouth located on the underside of the head, thick, fleshy, distensible lips, and paired fins attached low on the body (Rohde et al. 1994). Adult V-lip Redhorse range in total length from 252 to 420 mm (10 to 16.5 in.) (Rohde et al. 2009). The V-lip Redhorse is elongate and slender, with a tan-olive back and silver to gold or brassy sides with dark scale bases. Lips are papillose, and the lower lip has a deeply V-shaped posterior margin. The dorsal fin is concave and usually has 12 or 13 rays. Caudal and anal fins may have faint reddish edges, and paired fins are orange or pale red (Jenkins and Burkhead 1994).

Status

The V-lip Redhorse is currently considered stable (Warren et al. 2000) and apparently secure (G4) (NatureServe 2024). However, there is some concern about the long-term outlook for the species due to declines and other factors and is considered vulnerable in South Carolina (S3) (NatureServe 2024). Though it may be uncommon in certain areas like within South Carolina, it is not considered rare and is listed as apparently secure (S4) in both North Carolina and Virginia (NatureServe 2024). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of moderate concern.

POPULATION SIZE AND DISTRIBUTION

The V-lip Redhorse occurs on the Atlantic slope from the Roanoke–Chowan basin in Virginia to the Santee River basin in South Carolina (Rohde et al. 2009). In South Carolina, the species is

only known from the Broad and Saluda River drainages of the Santee River basin (Rohde et al. 2009), where it is uncommon. Despite being known from many localities in the upper Catawba River basin in North Carolina (Tracy et al. 2020; 2024) and most of the other Piedmont drainages of the Santee basin in South Carolina, the V-lip Redhorse has not been observed in the Catawba-Wateree basin in South Carolina; this apparent absence may represent extirpation or occurrence in very low densities. This species was observed in 1.4% of over 900 standardized statewide stream and river assessment samples throughout South Carolina between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The V-lip Redhorse inhabits rocky runs and silty to firm-bottomed pools within warm, medium-sized streams to large rivers of moderate or gentle gradient (Jenkins and Burkhead 1994; Rohde et al. 2009). Juveniles have been collected in the lower reaches of larger streams that join the rivers supporting its primary populations. This species is a benthic feeder and has been observed feeding in slow current, gravel-bottomed areas (NatureServe 2024). In standardized sampling covering streams to small rivers in South Carolina, this species exhibited its highest frequency of occurrence (16.7%) and average relative abundance (0.03%) in upland small rivers (watershed area 300-2000 km^2) of the Santee River basin.

CHALLENGES

The V-lip Redhorse has a very limited distribution in South Carolina; any major disturbances or cumulative impacts to these rivers could have a substantial influence on its populations. This species may experience impacts from non-native catfish species such as Blue and Flathead Catfish that likely prey on juvenile and adult redhorses (Guire et al. 1984; Bart et al. 1994), both of which are expanding in the Santee River basin. The V-lip Redhorse is susceptible to the same pervasive types of anthropogenic habitat alteration and fragmentation affecting other large riverine catostomids (Cooke et al. 2005), including the construction and operation of dams and impoundments, sedimentation of important foraging and spawning habitats, alteration of hydrologic regimes, and introduction of non-native species.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion and “ecobasin” (ecoregion x river basin). These estimates for the first time provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

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- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements of the V-lip Redhorse.
- Identify critical habitats and areas with healthy populations of V-lip Redhorse, and protect these areas once identified.
- Investigate the existence of the V-lip Redhorse in the Pee Dee River.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Warpaint Shiner

Coccotis coccogenis



Photo: NCFishes.com

Contributor (2005): Jason Bettinger (SCDNR)
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Warpaint Shiner is a member of the minnow family (Leuciscidae) and was recently moved to the resurrected genus *Coccotis* from its former classification in *Luxilus* (Stout et al. 2022 and sources therein; Page et al. 2023). It is the only species of *Coccotis* in South Carolina, and its only current North American congener is the Bandfin Shiner, *C. zonistius*. Minnows represent the most speciose family of freshwater fishes in North America (about 27% of the continental fauna), with at least 323 described taxa of predominantly small (<150 mm) and slender fishes (Warren and Burr 2014; Page et al. 2023).

Fishes within the genus *Coccotis*, like those of *Luxilus*, are characterized by deep, strongly compressed bodies and large lateral scales which are much higher than wide (Jenkins and Burkhead 1994; Rohde et al. 1994). Warpaint Shiners range in length from 76 to 120 mm (3.0 to 4.7 in) (Rohde et al. 2009). This attractive species displays a dark submarginal band in the dorsal and caudal fins and a prominent red slash on the opercle behind the eye. Breeding males display red on the upper lip and snout (Rohde et al. 1994).

Status

Globally, this species is considered currently stable (Warren et al. 2000) and secure (G5) but is considered vulnerable (S3) in South Carolina (NatureServe 2024). Along with South Carolina, Georgia and Virginia consider the Warpaint Shiner to be vulnerable (S3) (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

The presence of the Warpaint Shiner in the Savannah River of the southern Atlantic slope is likely due to a stream capture from the Tennessee River, similar to other taxa in this volume with predominantly Mississippi drainage distributions (Ramsey 1965; Ross 1970; Rohde et al. 2009). In South Carolina, the Warpaint Shiner is restricted to upland drainages in the Chattooga and Seneca River systems in the upper Savannah River drainage. Outside of South Carolina, the Warpaint Shiner occurs in upland drainages in the upper Tennessee River drainage of western Virginia, western North Carolina, eastern and southern Tennessee, northern Georgia and

northern Alabama. This species was observed in 0.7% of over 900 standardized statewide stream and river assessment samples in South Carolina between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Warpaint Shiner inhabits clear coolwater streams and rivers with moderate to high gradients (Jenkins and Burkhead 1994) and gravel and rubble substrates. It is often observed spawning over mounds built by nest-building *Nocomis* species in late May through mid-July (Rohde et al. 2009). This species is generally found in the slower moving areas associated with pools, slow runs, and riffle margins. In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (16.7%) and average relative abundance (1.5%) in upland small rivers (watershed area 300-2000 km^2) of the Savannah River basin.

CHALLENGES

Although the Warpaint Shiner is currently stable throughout the majority of its range, its limited distribution in South Carolina makes it vulnerable to imperilment within the state. It is especially vulnerable to development within the Chattooga and Seneca River systems. The major challenges to this species include loss of forested land and especially the removal of riparian cover along upland streams. Fish assemblage integrity of upland streams increases with natural land cover, whereas integrity decreases as the amount of developed and agricultural land increases (SCDNR 2023). Mature forest and riparian vegetation are important sources of large woody debris in upland streams, which contributes to beneficial habitat diversity and channel stability. Land development, siltation, and hydrologic alterations such as channelization and construction of impoundments also threaten this species. The conversion of upland streams into channelized ditches with little in-stream habitat represents a principal threat to Warpaint Shiner habitat. The habitat requirements of the Warpaint Shiner for colder and higher-gradient streams and the limited availability of this habitat in South Carolina also make it susceptible to competition from non-native species such as introduced trout (Elkins and Grossman 2014; Elkins et al. 2018). Although the Warpaint Shiner appears to be secure where it overlaps with introduced trout in South Carolina streams that exhibit high habitat quality on protected lands (SCDNR unpublished data), such competition could represent a greater threat in streams in which anthropogenic habitat alteration places additional stresses on native species.

CONSERVATION ACCOMPLISHMENTS

South Carolina Stream Assessment data have facilitated the calculation of standardized abundance (density) estimates for this species at multiple spatial strata including statewide, river basin, level-IV ecoregion, and “ecobasin” (ecoregion x river basin). For the first time, these estimates provide an objective measure of current population status that will serve as a baseline for following future population trends and gauging the effectiveness of conservation actions.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina’s freshwater habitats and understand the relationships between aquatic resource integrity and a

rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.

- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna.

CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify levels and spatial distributions of critical habitat factors to sustain the species in geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements of the Warpaint Shiner.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Warren, M.L., Jr., and B.M. Burr, editors. 2014. Freshwater fishes of North America: Volume 1: Petromyzontidae to Catostomidae. John Hopkins University Press. Baltimore, Maryland. 644 pp.

Western Blacknose Dace

Rhinichthys obtusus



Photo: NCFishes.com

Contributor (2005): Dan Rankin and Jason Bettinger [SCDNR]
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Western Blacknose Dace is a member of the minnow family (Leuciscidae) and one of six currently recognized North American species of the genus *Rhinichthys* (Page et al. 2023), two of which occur in South Carolina (*R. obtusus* and *R. cataractae* Longnose Dace). Minnows represent the most speciose family of freshwater fishes in North America (about 27% of the continental fauna), with at least 323 described taxa of predominantly small (<150 mm) and slender fishes (Warren and Burr 2014; Page et al. 2023).

Genetic and morphological variation across the large range of the Blacknose Dace in eastern North America (all of which were formerly known as *R. atratulus*) has long been recognized and varying proposed subspecific and/or specific geographic delineations have arisen (Etnier and Starnes 1993 and sources therein; Jenkins and Burkhead 1994; Nelson et al. 2004; Kraczkowski and Chernoff 2014). Most recently, a genetic analysis by Kraczkowski and Chernoff (2014), in alignment with previous distributional works (Boschung 1992; Jenkins and Burkhead 1994; Rohde et al. 2009; Straight et al. 2009), supported the occurrence of *R. atratulus* (Blacknose Dace) in Atlantic drainages from Nova Scotia south to and including the Roanoke River basin as well as southeastern Lake Ontario drainages, whereas *R. obtusus* was determined to occur in the St. Lawrence and Great Lakes basins (except southeastern Lake Ontario tributaries), upper Mississippi basin, southern Atlantic basins from the James to the Savannah (i.e., in South Carolina, including the upper Savannah and Santee basins), and portions of the Mobile River basin. The zoogeographic dynamics responsible for the distribution of *R. obtusus* in the upper portions of southern Atlantic basins (e.g., potential capture of adjacent Tennessee/Ohio drainages) warrant additional investigation (Kraczkowski and Chernoff 2014).

Adult Western Blacknose Dace range in length from 44 to 100 mm (1.7 to 3.9 in.) (Rohde et al. 1994, 2009). The species has small scales, a frenum, a subterminal mouth with a small barbel in each corner, a moderate-sized head, small eyes, a moderate-sized mouth and fleshy lips. The breast and belly are fully scaled. There is a black lateral stripe extending from the snout through the eye to the caudal area, separating a brownish back from a whitish belly (Jenkins and Burkhead 1994).

Status

The Blacknose Dace is considered currently stable within its range (Warren et al. 2000) and globally secure (G5) (NatureServe 2024). The Blacknose Dace is considered imperiled (S2) in South Carolina primarily on the basis of its extremely limited range and available habitat in the state. In surrounding states including more of its range, the species is listed as vulnerable to secure (S3S5) in Georgia and secure (G5) in North Carolina (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

Based on the most recent analysis (Kraczkowski and Chernoff 2014), the Western Blacknose Dace occurs in the St. Lawrence and Great Lakes basins (except southeastern Lake Ontario tributaries), upper Mississippi basin, southern Atlantic basins from the James to the Savannah (i.e., in South Carolina, including the upper Savannah and Santee basins), and portions of the Mobile River basin. In South Carolina, Blacknose Dace are found in the upper Savannah and Saluda River drainages, almost exclusively in the Blue Ridge ecoregion. This species was observed in 0.3% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

Blacknose Dace are common throughout their range (Page and Burr 1991; Rohde et al. 1994; Etnier and Starnes 1993). Healthy populations are known to occur in Howard Creek (Savannah drainage), Matthews Creek and Big Falls Creek (Saluda drainage). Blacknose Dace also occur in lower abundance in the Chattooga (where it is considerably lower in abundance than the congeneric Longnose Dace, *R. cataractae*), Whitewater, Eastatoee, Middle Saluda, and South Saluda Rivers (SCDNR unpublished data).

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Western Blacknose Dace occurs in small to medium coldwater streams and rivers with slow to rapid current and a diverse substrate of sand, gravel, and rock (Rohde et al. 1994). Observations of this species indicate seasonal colonization of headwaters of small intermittent and perennial streams (Goettel et al 2015) and a tendency to move upstream in lotic systems (Trail et al. 1983). In South Carolina, the Western Blacknose Dace is one of few species known to occur sympatrically with native Brook Trout in small headwater streams of the Blue Ridge (SCDNR unpublished data). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (3.0%) and average relative abundance (2.7%) in upland small streams (watershed area 0-15 km^2) of the Savannah River basin.

CHALLENGES

While the Blacknose Dace is currently stable throughout the majority of its range, its limited distribution in South Carolina makes it vulnerable to imperilment within the state. Although much of its range in the Blue Ridge of South Carolina is officially designated as wilderness area and therefore protected from development, other anthropogenic actions such as the introduction of non-native species (both aquatic and terrestrial) or long-term environmental change represent potential threats to this species. For example, non-native organisms such as the hemlock woolly

adelgid (*Adelges tsugae*) or other tree pathogens could cause widespread loss of major forest constituent tree species and therefore alter the natural thermal and other ecological regimes to which aquatic fauna have adapted. As with other freshwater fishes, anthropogenic landscape alteration such as development, deforestation, loss of riparian cover, siltation, and impoundments can result in cumulative degradation of dependent aquatic ecosystems. The occurrence of Western Blacknose Dace in predominantly smaller and shorter headwater streams in South Carolina places it in a position vulnerable to extirpation from such streams due to acute disturbances.

CONSERVATION ACCOMPLISHMENTS

Populations of Blacknose Dace found in Matthews Creek, Big Falls Creek, and Howard Creek have been protected through fee simple land purchases and/or conservation easements in those areas.

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

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CONSERVATION RECOMMENDATIONS

- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify
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- geographic areas of interest.
- Use South Carolina Stream Assessment decision-support GIS modeling tools to identify
- priority regions and watersheds at greatest risk of decline in stream integrity.
- Describe life history and habitat requirements for the Blacknose Dace.
- Identify streams with healthy populations and intact critical habitat in the upper Savannah River drainage, and Saluda River System for Blacknose Dace. Protect these areas, once identified.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop other educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.

- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for these species. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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White Catfish

Ameiurus catus



Photo: NCFishes.com

Contributor (2005): Forrest Sessions, Scott Lamprecht, and Jason Bettinger [SCDNR]
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The White Catfish is one of 51 recognized species comprising the family Ictaluridae (Page et al. 2023; Warren and Burr 2020). It is within the genus *Ameiurus*, which contains medium-sized catfish often referred to as "bullheads." Of the seven species of *Ameiurus*, five occur in South Carolina. This genus is characterized by a lack of scales, four pairs of barbels, one stout spine supporting dorsal and pectoral fins, an upper jaw protruding over the lower, cardiform teeth on jaws, and an adipose fin (Jenkins and Burkhead 1994). The White Catfish is bluish-gray to olive above and white on the belly with unmarked sides. The tail is slightly forked with rounded tips. Maximum length is 620 mm (24.4 in.), making them among the largest of the *Ameiurus* bullhead species (Rohde et al. 2009); however, White Catfish are typically less than 500 mm (20 in.) long. The anal fin is convex with a ray count ranging between 19 and 23.

Status

Overall, the White Catfish is currently considered to be stable (Warren et al. 2000) and common as well as widespread and secure (G5) (NatureServe 2024). It is considered vulnerable to apparently secure (S3S4) in South Carolina and vulnerable (S3) in Alabama (NatureServe 2024). Populations have greatly declined in the Neuse River, Cape Fear River, Pee Dee River (W. Starnes, pers. comm.) and Edisto River (W. McCord, pers. comm.) since the introductions of Flathead Catfish and Blue Catfish. This declining trend has also been observed in other small coastal plain rivers of South Carolina that were former strongholds for the White Catfish (C. Thomason, pers. comm.).

POPULATION SIZE AND DISTRIBUTION

The White Catfish is native to the major Atlantic Slope drainages from Delaware to Florida as well as the eastern Gulf Slope in Alabama, Florida and Georgia. This species has been observed in all of South Carolina's river basins and ecoregions (Rohde et al. 2009; Nature Serve 2024). White Catfish populations in North Carolina and South Carolina coastal rivers have declined

since the introduction of non-native Blue Catfish and Flathead Catfish, (*Ictalurus furcatus* and *Pylodictis olivaris*, respectively) (W. Starnes, pers. comm.; SCDNR unpublished data). This species was observed in 1.3% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

White Catfish primarily inhabit small to large rivers in freshwater and brackish water habitats, venturing into the lower reaches of tidally influenced rivers (Jenkins and Burkhead 1994, Rohde et al. 2009). This species also shows a tolerance for reservoirs, probably owing to its occurrence in large, deep river sections among its native habitats. It spawns in early summer, with both parents exhibiting parental care until the young hatch (Rohde et al. 1994). These catfish are relatively long-lived, reaching a maximum of 14 years (Rohde et al. 1994; Jenkins and Burkhead 1994). White Catfish feed on plants, insects, and other fish. In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (15.4%) and average relative abundance (0.8%) in small rivers (watershed area 300-2000 km^2) of the coastal plain.

CHALLENGES

This species is threatened by the introduction of non-native ictalurids like the Flathead Catfish and the Blue Catfish; both of these non-native species displace and prey on the smaller bullheads (Guire et al. 1984; Ashley and Buff 1986; Quinn 1988; Bart et al. 1994). Predation by and competition with introduced Flathead Catfish and Blue Catfish may negatively affect abundance of the White Catfish and limit its distributions in portions of its range. Other threats to the White Catfish include loss of forested land and especially the removal of riparian cover. Fish assemblage integrity increases with natural land cover, whereas integrity decreases as the amount of developed and agricultural land increases (SCDNR 2023). Mature forest and riparian vegetation are important sources of large woody debris in coastal plain streams, which provides critical habitat for many native southern Atlantic coastal plain species including the White Catfish (Marion et al. 2015). Land development, siltation, and hydrologic alterations such as channelization and construction of impoundments also threaten this species. The conversion of naturally stagnant lowland swamps and streams into channelized, shallow drainage ditches with consistently high current velocities represents a principal threat to White Catfish habitat.

CONSERVATION ACCOMPLISHMENTS

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and

mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

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- Compilation of information and photographs for the development of nongame fish description web pages currently in development.
- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Control exotic catfish species, like Blue and Flathead Catfish, through eradication efforts and by educating landowners, fishermen, and the general public to the discontents of stocking non-native species.
- Describe life history and habitat requirements of the White Catfish.
- Identify critical habitats and areas with healthy populations of the White Catfish; protect these areas, once identified.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Whitemouth Shiner

Miniellus alborus



Photo: NCFishes.com

Contributor (2005): Ross L. Self and Jason Bettinger [SCDNR]
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Whitemouth Shiner belongs to the minnow family (Leuciscidae) and was recently moved to the genus *Miniellus* from the polyphyletic *Notropis* (Stout et al. 2022 and sources therein; Page et al. 2023), joining the reclassified Swallowtail Shiner (*M. procne*) as the only *Miniellus* in South Carolina. Minnows represent the most speciose family of freshwater fishes in North America (about 27% of the continental fauna), with at least 323 described taxa of predominantly small (<150 mm) and slender fishes including 21 recognized species of *Miniellus* (Warren and Burr 2014; Page et al. 2023).

Adult Whitemouth Shiners range from 36 to 61 mm in total length (1.4 to 2.2 in.) (Rohde et al. 2009). Its straw-colored upper half and white lower half are bisected by a thin, dark, jagged-edged lateral stripe terminating in a small, triangular caudal spot (Rohde et al. 1994). This species can be distinguished from the Swallowtail Shiner by the absence in Whitemouth of a predorsal stripe, a black stripe completely encircling the snout, and lack of pigmentation on the upper lip (present in Swallowtail) (Rohde et al. 2009).

Status

The Whitemouth Shiner is considered apparently secure globally (G4) (NatureServe 2024). Its status, however, does vary from apparently secure to critically imperiled as one moves across its range. In South Carolina, the status of the Whitemouth Shiner is imperiled to vulnerable (S2S3) (NatureServe 2024). This species was selected as a Regional Species of Greatest Conservation Need in the Southeastern Association of Fish and Wildlife Agencies regional effort (Rice et al. 2019), receiving a designation of moderate concern.

POPULATION SIZE AND DISTRIBUTION

The native range of the Whitemouth Shiner includes the Chowan, Roanoke, Cape Fear, and Pee Dee basins in Virginia, North Carolina and South Carolina (Jenkins and Burkhead 1994). It is believed to have been extirpated from the Chowan basin (Jenkins and Burkhead 1994) and is apparently absent from intervening Tar and Neuse drainages (Jenkins and Burkhead 1994;

NatureServe 2004). This species has also been collected in the Catawba River system of the Santee basin in North Carolina, presumably as a result of introduction (Hocutt et al. 1986; Jenkins and Burkhead 1994; Tracy et al. 2020; Tracy et al. 2024).

The Whitemouth Shiner occurs predominantly on the outer Piedmont, where it is fairly common in some drainages (Tracy et al. 2020; Tracy et al. 2024). In South Carolina, it is only known from Thompson Creek and its confluence with the Pee Dee River (Rohde et al. 2009); these localities represent the southern edge of the global range of this species. This species was observed in 0.1% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Whitemouth Shiner occurs in streams and small rivers that typically exhibit riffle-pool sequences with sand, rubble and bedrock (Rohde et al. 2009; NatureServe 2024). Like its congener the Swallowtail Shiner (*M. procne*), this species presumably spawns in spring to early summer over sand or in the nests of sunfish or other minnows (Jenkins and Burkhead 1994; Warren and Burr 2014). In standardized sampling covering streams to small rivers of South Carolina, this species exhibited its highest frequency of occurrence (2.9%) and average relative abundance (0.4%) in upland large streams (watershed area 100-300 km²) of the Pee Dee River basin.

CHALLENGES

The occurrence of the Whitemouth Shiner in only one stream system in South Carolina, and on the southern fringe of its global range, makes it vulnerable to decline in the state. Cumulative or acute disturbances to Thompson Creek could cause extirpation of this species from South Carolina. Challenges to this species are similar to those of other aquatic fauna and include point and non-point source pollution, deforestation, and loss of riparian corridors, impoundment development, channelization and siltation from poor land use practices, and unplanned or poorly planned urban and suburban development. Fish assemblage integrity of upland streams increases with natural land cover, whereas integrity decreases as the amount of developed and agricultural land increases (SCDNR 2023). Mature forest and riparian vegetation are important sources of large woody debris in upland streams, which contributes to beneficial habitat diversity and channel stability. The conversion of upland streams into channelized ditches with little in-stream habitat represents a principal threat to Whitemouth Shiner habitat. Because of its limited distribution, it is also vulnerable to habitat losses due to anthropogenic influences such as water withdrawals or environmental disturbances such as drought.

CONSERVATION ACCOMPLISHMENTS

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning

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- Collaboration with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Survey Thompson Creek and surrounding areas in Chesterfield County to determine the status of the Whitemouth Shiner as this stream likely houses the strongest populations of this species and may have been severely impacted by the drought of 2002. Protect these areas, once identified.
- Describe life history and habitat requirements of the Whitemouth Shiner
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Whitetail Shiner

Cyprinella galactura



Photo: NCFishes.com

Contributor (2005): Jason Bettinger (SCDNR)
Reviewed and Edited (2013): Mark Scott, Kevin Kubach, M. Troy Cribb, and Andrew Gelder [SCDNR]
Reviewed and Edited (2024): Kevin Kubach, Andrew Gelder, Rachel Moore, Clint Burton, Andrew Peel, and Mark Scott [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

The Whitetail Shiner belongs to the minnow family (Leuciscidae), the most speciose family of freshwater fishes in North America with at least 323 described taxa of predominantly small (<150 mm) and slender fishes (Warren and Burr 2014; Page et al. 2023). Following the recent revision of the formerly large genus *Notropis* (Stout et al. 2022), *Cyprinella* is currently the most diverse genus of North American minnows, with 29 described species (Page et al. 2023). The Whitetail Shiner is one of eight described plus one undescribed (as of 2024) species of *Cyprinella* in South Carolina.

Members of the genus *Cyprinella* are distinguished from other leuciscids by their large, vertically-elongated, diamond-shaped scales and a black blotch in the dorsal fin (Rohde et al. 1994). As with the other *Cyprinella* species, the Whitetail Shiner is a crevice spawner (Jenkins and Burkhead 1994). Whitetail Shiners have moderately deep and compressed bodies. Two large creamy white spots at the base of the caudal fin separate the Whitetail Shiner from other similar *Cyprinella* species (Rohde et al. 1994). During the breeding season, males often display a red tint to the pectoral, dorsal, and caudal fins (Rohde et al. 2009). Adults range in size from 44 to 150 mm (1.7 to 5.9 in.) (Rohde et al. 1994).

Status

Globally, this species is currently considered to be stable (Warren et al. 2000) and secure (G5). The Whitetail Shiner is considered vulnerable (S3) in South Carolina, apparently secure (S4) in North Carolina, and Georgia has the species listed between vulnerable and apparently secure (S3S4) (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

The presence of the Whitetail Shiner in the upper Savannah River basin of the southern Atlantic slope is likely due to a stream capture from the Tennessee River basin, similar to other taxa in this volume with predominantly Mississippi drainage distributions (Ramsey 1965; Ross 1970; Rohde et al. 2009). In South Carolina, this species occurs only in the Chattooga and Seneca River systems of the upper Savannah River drainage. Interestingly, in the Chattooga River it

appears to be absent upstream of Big Bend Falls. This species was observed in 0.1% of over 900 standardized statewide stream and river assessment samples between 2006 and 2023.

The Whitetail Shiner occurs in upland drainages both east and west of the former Mississippi Embayment. It occurs in the Cumberland and Tennessee drainages of Virginia, Kentucky, North Carolina, Tennessee, Georgia, Alabama, and Mississippi. It also occurs in the upper Santee drainage in North Carolina. West of the Mississippi River, the Whitetail Shiner occurs in the St. Frances and White River drainages of Missouri and Arkansas (Page and Burr 1991).

HABITAT OR NATURAL COMMUNITY REQUIREMENTS

The Whitetail Shiner inhabits clear, coolwater streams and rivers with moderate to high gradients (Jenkins and Burkhead 1994) and gravel and rubble substrates. This species is common in deep pools near riffles and is often associated with large boulders and rocky banks (Mayden 1989). In standardized sampling covering streams to small rivers, this species exhibited its highest frequency of occurrence (16.7%) and average relative abundance (1.1%) in upland small rivers (watershed area 300-2000 km^2) of the Savannah River basin. As with other non-barbeled *Cyprinella* species, the Whitetail Shiner is a crevice spawner, depositing eggs in crevices of logs and rocks in a territory defended by the male over an extended spring-summer breeding period (Gale and Buynak 1978; Rohde et al 1994; Rohde et al. 2009).

CHALLENGES

Although the Whitetail Shiner is currently stable throughout the majority of its range, its limited distribution in South Carolina makes it vulnerable to imperilment within the State. The Whitetail Shiner, like many other specialized stream fishes, is susceptible to an array of acute and cumulative impacts from anthropogenic alterations to the watershed, riparian zone and streams and rivers directly. These include deforestation and conversion of natural land cover for development and agriculture with resulting sedimentation and non-point source pollution, hydrologic alterations, and habitat fragmentation from dams and reservoirs. The breeding behavior of the non-barbeled *Cyprinella* makes this group particularly vulnerable to impacts from both suspended and deposited sediment. Because the breeding process is dependent on visual cues (extended display and territorial defense period) as well as clean crevices for egg deposition and larval development, suspended sediment (increased turbidity) and deposited sediment has been shown to delay or inhibit spawning success in fishes of this genus (Hubbs and Echelle 1972; Burkhead and Jelks 2001; Warren and Burr 2014).

CONSERVATION ACCOMPLISHMENTS

Following and building upon the dataset amassed from the South Carolina Stream Assessment study (2006-2011), additional standardized river and stream assessment efforts have enhanced the ability to assess the status of freshwater fishes across the majority of South Carolina's freshwater habitats and understand the relationships between aquatic resource integrity and a rapidly changing landscape. The dataset now includes over 1,000 standardized samples spanning the past 20 years, providing the framework for modeling impacts to aquatic ecosystems and developing conservation tools aimed at preserving or restoring species status to former levels and

mitigating future impacts on them. Aquatic resource conservation products and efforts completed or initiated since the previous SWAP include:

- The development and revision (C-SWG collaboration with North Carolina) of a web-based Aquatic Planning Tool (APT). This tool will allow practitioners to better manage SGCNs by providing predictive maps of the effects of proposed future development and restoration. The APT will have two primary functions, the first being an application to visualize current occurrence probabilities of SGCNs and their relationships with land use and climate across the Carolinas. The APT's second function will be an interactive online tool allowing users to explore predicted impacts of future land management and climate scenarios on SGCNs at any stream segment in the Carolinas. This tool will be used by numerous and diverse conservation practitioners to guide future SGCN prioritization and surveys, restoration and reintroduction, and 'smart' city development to prevent the worst impacts of urbanization on freshwater fish SGCNs.
- Development of the first fish-based biotic index covering all freshwater stream regions in the state. The index provides a measure of stream biological (fish assemblage) integrity based on the relative abundance of region-specific and basin-specific indicator species. Current uses involve incorporating the index with fish vouchering and reporting into the Office of Environmental Permitting's pipeline for wetland mitigation in an effort to assess success of mitigation and restoration projects.
- We conduct analysis of stream integrity based on the biotic index versus the watershed land use categories in an effort to determine thresholds of land-use-based disturbance and how fish communities respond.
- Provide collaborative input to the Office of Environmental Programs review of projects and permitting.
- Review fish collection permits for validity and ethics in regard to species and number of fish taken and the proposed purpose therein.
- We work closely with Aquatic Information Staff to promote awareness of SC aquatic resources and biodiversity.
- We collaborate with university researchers and graduate students to analyze relationships between aquatic species and environmental change.
- We produced eleven publications and manuscripts analyzing South Carolina stream and river resource response to environmental gradients and disturbances:

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- We compiled information and photographs for the development of nongame fish description web pages which are currently in development.
- Collaborated with SC Education Television in the filming and production of informative nature programs highlighting the diversity and status of South Carolina's aquatic fauna

CONSERVATION RECOMMENDATIONS

- Describe life history and habitat requirements of the Whitetail Shiner.
- Identify critical habitats and areas with healthy populations of the Whitetail Shiner and protect these areas, once identified.
- Conduct targeted surveys of the Seneca River Basin to assess the existence or extirpation of the Whitetail Shiner. Surveys should be concentrated on the Toxaway River and the tributaries of Lake Jocassee. Once identified, these areas should be protected.
- Protect critical habitats from future development and further habitat degradation by following Best Management Practices(BMPs) and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Continue to develop educational materials in order to raise public awareness of nongame species and their ecological importance to the natural history of South Carolina's aquatic habitats.
- Educate motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and Southeastern population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect this species. In the event that more protective BMPs are implemented, population studies of this fish could assist in determining the effectiveness of those measures. Successful conservation of South Carolina's native aquatic species is best accomplished proactively by maintaining natural land cover, which supports aquatic habitat integrity and dependent species assemblages. For example, achieving the foremost goal of the Southeastern Aquatic Resource Partnership's 2008 Southeast Aquatic Habitat Plan that 85% of lands within 30 m (100 ft.) of streams or rivers be maintained in natural vegetation would be a significant measure of success. Maintenance or recovery of natural land cover levels above the critical thresholds identified quantitatively using aquatic conservation planning tool modeling applications represents a foremost, highly-defensible measure of success in supporting species of greatest conservation need. At the species level, an indicator of effective conservation implementation could include a stable or increasing distribution and/or abundance relative to current levels as measured by statewide assessment data.

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Altamaha Arcmussel

Alasmidonta arcula (Lea, 1838)

Contributor (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason and Morgan Kern (SCDNR)



Figure 1. Image of *Alasmidonta arcula* courtesy of the North Carolina State Museum of Natural Sciences, Jamie Smith, and Dr. Art Bogan. The NCSM catalog number of the specimen photographed is 56179.

DESCRIPTION

Taxonomy and Basic Description

Like many other freshwater mussel species in South Carolina, taxonomy in the genus *Alasmidonta* is still under revision. A recent study of the genus performed by Whelan et al. (2023) maintained *Alasmidonta arcula* as a separate species due to conflicting results. Future studies using additional nuclear models may support synonymy of *Alasmidonta arcula*, *Alasmidonta undulata*, and *Alasmidonta triangulata* (Whelan et al. 2023).

The Altamaha Arcmussel is a small-shelled mussel that can grow to around 3 inches in length (Figure 1). The umbo, or beak, is high above the hinge line near the center of the shell. The umbo or beak cavity is relatively shallow. The posterior ridge is sharp and straight. Pseudocardinal teeth are present. Lateral teeth are reduced or absent in the left valve. The outer surface is generally smooth except on the posterior slope which can have defined ridges corresponding with growth lines. The shell is inflated with a rounded anterior end and ventral margin with a truncated posterior end. The shell is considered triangular in shape. The coloration is brown to greenish-yellow with green rays, becoming darker in mature individuals. The nacre, inner shell surface, is bluish-white or white. (Johnson 1970; Wisniewski 2018).

As with many of our native freshwater mussels, Altamaha Arcmussel can be misidentified as other South Carolina species. The height of the umbo/beak and the severity of the posterior ridge will distinguish it from most forms of Triangle Floater (*Alasmidonta undulata*) which has lateral teeth that are absent or vestigial, and the more compressed Carolina Slabshell (*Elliptio congaraea*).

Status

NatureServe (2024) lists the current global status for the Altamaha Arcmussel as imperiled (G2). In South Carolina it is critically imperiled (S1) and in Georgia it is vulnerable (S3).

This species has been a candidate for listing as Threatened or Endangered under the endangered species act since the publishing of the Partial 90-Day Finding on a Petition to List 404 Species in the Southeastern United States as Endangered or Threatened with Critical Habitat in 2011 to the federal register (USFWS 2011). No species status assessment has been completed to determine the need to list this species.

POPULATION SIZE AND DISTRIBUTION

The Altamaha Arcmussel is an endemic species to Georgia in the Altamaha, Ocmulgee, Oconee, Ogeechee

and the Savannah River Basins. This species has only been found in the Savannah River and attached Thurmond Lake in South Carolina (Figure 2). Altamaha Arcmussel was once thought to be restricted to the Altamaha River system in Georgia (Johnson 1970). Now it is known from several rivers of the Altamaha River system in Georgia, including the Ocmulgee, Little Ocmulgee, Ohoopee, and Altamaha Rivers to the Ogeechee and Savannah River which is the border for Georgia and South Carolina. It was found in the Savannah River downstream of Augusta in 2006 (NatureServe 2024). Live individuals have been identified in the lower Savannah River as recently as 2011 (personal communication, Morgan Wolf USFWS). Individuals have also been found in Thurmond Lake (Clarks Hill Lake in GA) in 2007 and the lower Ogeechee River as recently as 2018 in surveys performed by Georgia DNR (Wisniewski 2018).

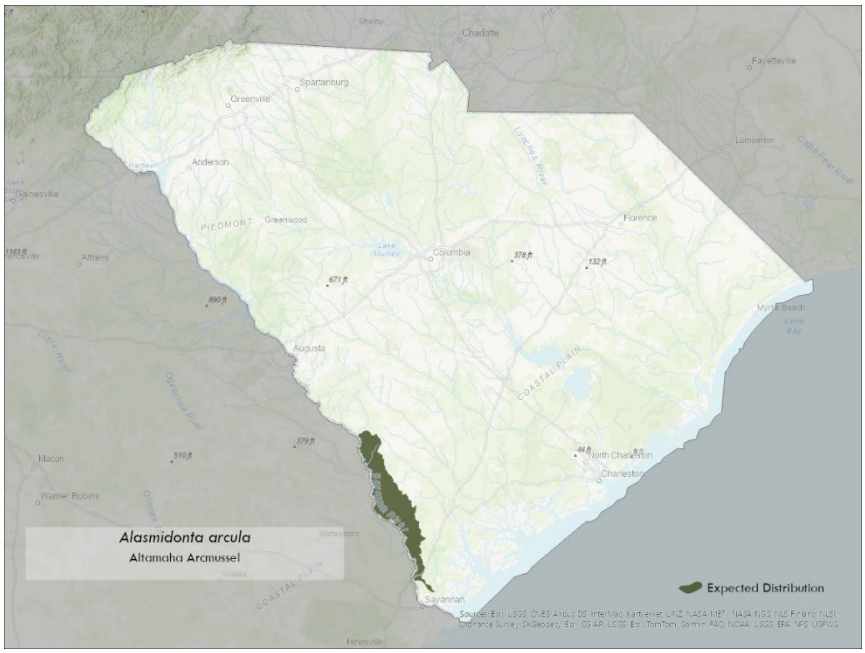


Figure 2. Expected distribution of *Alasmidonta arcula* based on reported observations at a HUC 10 watershed level and designated ecoregion.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Altamaha Archmussel is typically found in sloughs, oxbows, or depositional areas in large creeks, large rivers and reservoirs with silt, mud, and/or sand substrates. This species is often found in shallow areas near the water's edge and occasionally in pools with coarse sand and gravel from 6-9ft in depth in Georgia (Wisniewski 2018).

In South Carolina, the Altamaha Arcmussel has only been found in the Savannah River and connected lakes, and not in the surveyed tributaries in the Savannah Basin. No targeted efforts to survey this species in South Carolina have been made. Reported hosts include Eastern Mosquitofish (*Gambusia holbrooki*), Robust Redhorse (*Moxostoma robustum*), and Striped Jumprock (*Moxostoma rupiscartes*). More host fish research is needed for this species as both Robust Redhorse and Striped Jumprock showed low metamorphosis percentages in lab testing (Johnson et al. 2012). Testing of Eastern Mosquitofish reported only numbers of juveniles recovered and did not report transformation success; the life history of this surface-dwelling fish is unlikely to put them in contact with Altamaha Arcmussel in the wild (O'Brien 2002).

Johnson et al. (2012) report collecting gravid females in November at a temperature of 16°C. The reproductive cycle, brooding behavior, and glochidia release of *A. arcula* are understudied and attention is needed. Like other species in the Anodontini tribe, glochidia of the Altamaha Arcmussel are hooked and triangular, images can be seen in Johnson et al. (2012).

CHALLENGES

As it has only been documented in South Carolina recently, little is known about the habitat preferences, abundance, and population range of the Altamaha Arcmussel in South Carolina. Without opening its shell, Altamaha Arcmussel can resemble some forms of the Triangle Floater and may be misidentified during surveys. The Altamaha Arcmussel appears rare in South Carolina, but little work has been done to survey the Savannah River and non-wadable habitat in the larger Savannah Basin where this species can be found. Little is known about the reproductive and brooding behaviors of *A. arcula* and wild host fish(es) are unknown.

Like other freshwater mussels, the Altamaha Arcmussel is sensitive to changes in water quality, habitat, and access to host fish(es), although the degree of sensitivity to these changes is understudied. The host fish(es) for the Altamaha Arcmussel are unknown, but like other freshwater mussels, the Altamaha Arcmussel must have adequate access to species-specific hosts and relies on host fish(es) for reproduction and distribution. Maintaining stream connectivity for host fish(es) is important to allow distribution of juveniles and gene flow between populations. Environmental stressors that lead to degradation of water quality, habitat, and stream connectivity include development, agriculture, and incompatible forestry management; additionally, systemic changes that have negative effects include climate change, invasive species, and dams and barriers (USFWS 2021).

In South Carolina, practices such as mining, clearcutting for timber production, and recreational vehicle use in streams are observed to result in degradation of habitat. Preservation of a riparian buffer is needed for the continued existence of suitable habitat for most native freshwater mussels. A riparian buffer is the land area adjoining a stream, lake or wetland characterized by a cover of naturally occurring vegetation consisting of trees, shrubs, grasses, and forbs where development is restricted or prohibited.

CONSERVATION ACCOMPLISHMENTS

There are no significant conservation accomplishments for the species currently.

CONSERVATION RECOMMENDATIONS

- Conduct surveys to document the extent of distribution and population size and range of the Altamaha Arcmussel.
- Complete comprehensive, range-wide genetic analysis to determine the validity of the species alongside other species in the genus *Alasmidonta*.
- Determine habitats that are critical for this species in South Carolina.
- Perform host fish trials to determine natural hosts for native populations.
- Study interactions of laboratory host fish(es) in the wild.
- Conserve populations of host fish(es) to insure reproduction of the Altamaha Arcmussel in the wild.
- Protect critical habitats for the Altamaha Arcmussel from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Altamaha Arcmussel.
- Consider this species' needs when participating in the environmental permit review process.
- Encourage responsible land use planning.
- Work to improve minimum flows and restoration of more natural hydrologic regimes in the Savannah River.
- Research the reproductive and brooding behavior of the species.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Conduct further research to determine the degree of sensitivity of the Altamaha Arcmussel to various point and non-point sources of pollution and land use impacts.

MEASURES OF SUCCESS

- Completion of targeted surveys in areas of historic occupancy and similar habitat types in the Savannah Basin.
- Determine the host fish(es) and complete surveys in suitable habitat for host fish(es).
- Collection of genetic swabs of Altamaha Arcmussel and Triangle Floater to ensure successful identification of species range and distribution.

- Work to reduce or halt further disturbance to the habitat and natural hydrology of the Savannah River.
- Determine the effects of channel modification, such as dams, on the Altamaha Arcmussel.
- Perform outreach to relevant landowners about the importance of freshwater mussels and their habitats.
- Determination of environmental and toxicological tolerances and endpoints.

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Triangle Floater

Alasmidonta undulata (Say, 1817)

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason and Morgan Kern (SCDNR)



Figure 1. Image of *Alasmidonta undulata* photographed by Briana Cairco, SCDNR.

DESCRIPTION

Taxonomy and Basic Description

Like many other freshwater mussel species in South Carolina, taxonomy in the genus *Alasmidonta* is still under revision. A recent study of the genus performed by Whelan et al. (2023) maintained *Alasmidonta undulata* as a separate species due to conflicting results. Future studies using additional nuclear models may support synonymy of *Alasmidonta arcula*, *Alasmidonta undulata*, and *Alasmidonta triangulata* (Whelan et al. 2023). Clarke (1981) notes that although there are morphological differences, the beak sculpturing, posterior slope sculpturing, and relative height are too irregular to suggest *A. undulata* and *A. triangulata* are separate species. Additionally, internal anatomy and glochidia of northern and southern populations were compared and no differences attributable to genetic divergence were evident (Clarke 1981). More studies are needed to determine the validity of *A. arcula*, *A. undulata*, and *A. triangulata*.

The Triangle Floater (Figure 1) is a small-shelled mussel that can grow to around 3 inches in length (Bogan and Alderman 2004, 2008). The umbo or beak is prominent and raised above the hingline (Figure 1). A posterior ridge is present and distinct. The Triangle Floater has prominent, triangular shaped pseudocardinal teeth, but lacks lateral teeth. The exterior shell surface is smooth and shiny, yellowish/greenish with broad green or blackish rays, becoming black with age. The shell has strong ridges that run parallel with the growth lines. The shell of the Triangle Floater is subtriangular to ovate. The shell is thicker at the anterior end than at the posterior. The interior shell surface is white but includes salmon pink or red anteriorly and becomes iridescent posteriorly (Bogan and Alderman 2004, 2008; Nedeau 2008; Clarke 1981).

As with many of our native freshwater mussels, Triangle Floater can be easily misidentified especially when the individual is still living. They can closely resemble the sister species, the Altamaha Arcmussel. The shell of the Triangle floater has varying morphology, the subtriangular morphology closely resembles Altamaha Arcmussel, but lacks lateral teeth.

Status

The current global status for the Triangle Floater is apparently secure (G4) due to the wide range of this species (NatureServe 2024). In North Carolina and Virginia, it is ranked as vulnerable (S3) and in West Virginia it is ranked as critically imperiled (S1). It is ranked as critically imperiled (S1?) in South Carolina with a conservation priority ranking of data deficient because of insufficient data collection and targeted surveys. Most reported observations of the species are from surveys in the Savannah River which were completed by Georgia. The Savannah River, and other non-wadeable streams and reservoirs have historically not been thoroughly surveyed by South Carolina state partners.

POPULATION SIZE AND DISTRIBUTION

The range of the Triangle Floater extends from the St. Lawrence River Basin in Ontario and Quebec to the Ogeechee Basin in Florida (Bogan and Alderman 2004, 2008). Throughout its range it is found in a variety of habitat types from small creeks to large rivers and lakes, with sand, fine gravel, sandy mud, or silt as a substrate. It is found in the Neuse River Basin, Tar River Basin, Roanoke River Basin, Chowan River Basin, and PeeDee Basin in North Carolina and has not been reported in Georgia. In South Carolina, a shell of Triangle Floater was found in Turkey Creek in a 2005 survey conducted by Alderman Environmental. A live specimen was found in the Savannah River in 2006 by Tim Savidge in Jasper County. The Triangle Floater has not been reported in South Carolina since 2006. Expected distribution of the species can be seen in Figure 2. Bogan and Alderman (2004, 2008) identify the Santee-Cooper drainage as part of the Triangle Floater's historic range. Targeted survey efforts for this species in South Carolina have not occurred.

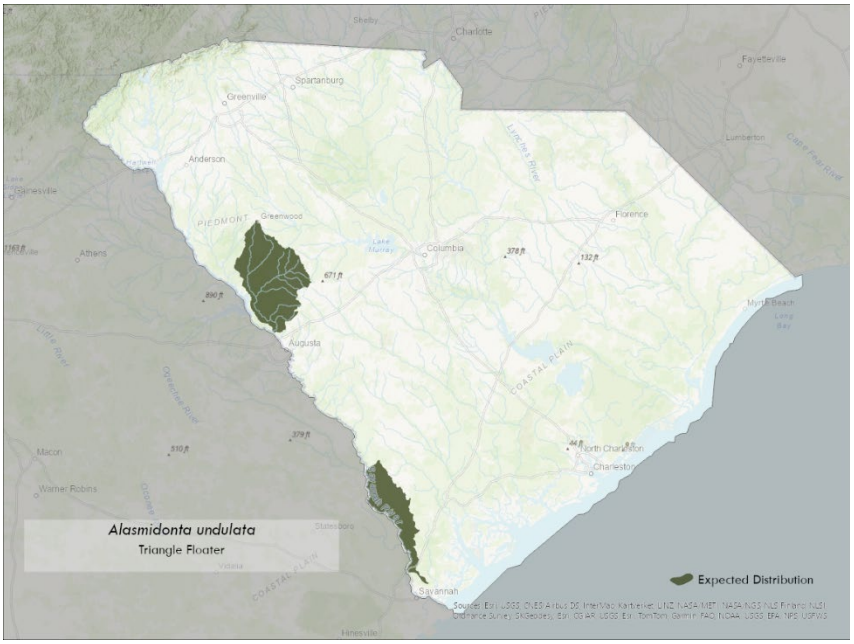


Figure 2. Expected distribution of *Alasmidonta undulata* based on reported observations at a HUC 8 watershed level and designated ecoregion.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Triangle floater is reported to show little habitat preference in North Carolina being collected from silt/sand in slower waters, gravel/sand in riffles and runs, and crevices in bedrock (NCWRC 2024). Historically, it was reported to be common in sections of moderate flow in small rivers and headwater streams (Bogan and Alderman 2004). Ortmann (1919) and Clarke (1981) note that the species is not typically found in large waters and prefers smaller, headwater streams or outlet streams just below lakes. Host fish trials have occurred in the grey literature for this species from the work of Barry Wicklow and Tom Watters' lab at Ohio State. Blacknose Dace, Slimy Sculpin, Common Shiner, Central Stoneroller, Rosyface Shiner, Northern Hogsucker, Pumpkinseed, Largemouth Bass, Fantail Darter, Fallfish, and Longnose Dace produced animals (Fichtel and Smith 1995; Watters 1999; Maine 2000; Nedeau et al. 2000). No metamorphosis percentage was reported on the fish species tested.

Clarke (1981) noted gravid females being collected from August-October; however, glochidia from the gravid female collected in August possessed short, blunt stylets and soft, pliable microstylets which was likely due to being immature. Ortmann (1912) described the breeding season being from July until June of the following year. Of the specimens found, he reported animals found in July having eggs and animals (only 2) found in June having mature glochidia. North Carolina reports only finding gravid females during cooler months of the year (NCWRC

2024). Ortmann (1912) describes the outer demibranchs of female *A. undulata* being pale yellow when containing eggs and brownish when containing glochidia. The reproductive cycle, brooding behavior, and glochidia release of *A. undulata* are understudied and attention is needed. Like other species in the Anodontini tribe, glochidia of the Triangle Floater are hooked and triangular; images can be seen in Clarke (1981).

CHALLENGES

Without opening its shell, Triangle Floater can resemble some forms of the Altamaha Arcmussel. and may be misidentified during surveys. Unsettled taxonomy also makes determining short- and long-term population trends difficult. The Triangle Floater appears rare in South Carolina, but little work has been done to survey the Savannah River and non-wadable habitats in the larger Savannah, PeeDee and Santee-Cooper basin where this species may be found.

Like other freshwater mussels, the Triangle Floater is sensitive to changes in water quality, habitat, and access to host fishes, although the degree of sensitivity to these changes is understudied. The Triangle Floater must have adequate access to species-specific hosts, like other native freshwater mussel species, and relies on host fishes for reproduction and distribution. Maintaining stream connectivity for host fishes is important to allow distribution of juveniles and gene flow between populations. Environmental stressors that lead to degradation of water quality, habitat, and stream connectivity include development, agriculture, and incompatible forestry management; additionally, systemic changes that have negative effects include climate change, invasive species, and dams and barriers (USFWS 2021).

In South Carolina, practices such as mining, clearcutting for timber production, and recreational vehicle use in streams are observed to result in degradation of habitat. Preservation of a riparian buffer is needed for the continued existence of suitable habitat for most native freshwater mussels. A riparian buffer is the land area adjoining a stream, lake or wetland characterized by a cover of naturally occurring vegetation consisting of trees, shrubs, grasses, and forbs where development is restricted or prohibited.

CONSERVATION ACCOMPLISHMENTS

There are no significant conservation accomplishments for the species currently.

CONSERVATION RECCOMENDATIONS

- Conduct additional surveys in reservoirs in the Pee Dee Basin, Savannah Basin, and Santee-Cooper collecting genetic swabs to determine Triangle Floater presence and abundance in this state.
- Complete comprehensive, range-wide genetic analysis to determine the validity of the species alongside other species in the genus *Alasmidonta*.
- Explore the need to determine special concern status for the Triangle Floater based on survey results.
- Protect critical habitats for the Triangle Floater from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Triangle Floater.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Work to improve minimum flows and restoration of more natural hydrologic regimes in river systems with suitable habitat for Triangle Floater.
- Perform host fish trials to determine natural hosts for native populations.
- Research the reproductive and brooding behavior of the species.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Conduct further research to determine the degree of sensitivity of the Triangle Floater to various point and non-point sources of pollution and land use impacts.

MEASURES OF SUCCESS

- Completion of targeted surveys in areas of historic occupancy and similar habitat types in the PeeDee Basin, Savannah Basin, and Santee-Cooper.
- Collection of genetic swabs of Triangle Floater and Altamaha Arcmussel to ensure successful identification of species range and distribution.
- Work to reduce or halt further disturbance to the habitat and natural hydrology in river systems with suitable habitat for Triangle Floater.
- Perform outreach to relevant landowners about the importance of freshwater mussels and their habitats.
- Determine the effects of channel modification, such as dams, on the Triangle Floater
- Determination of environmental and toxicological tolerances and endpoints.

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Brook Floater

Alasmidonta varicosa
(Lamark, 1819)

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason and Morgan Kern (SCDNR)



Figure 1. Image of hatchery produced *Alasmidonta varicosa* photographed by Briana Carico, SCDNR.

DESCRIPTION

Taxonomy and Basic Description

The Brook Floater (Figure 1 and Figure 2) is a small mussel that rarely exceeds 3 inches in length. The Brook Floater has a series of corrugations (or raised ridges) along the upper posterior slope, perpendicular to the growth lines. These corrugations may be difficult to see on young, eroded, stained individuals or mussels that are covered with algae. The pseudocardinal teeth are poorly developed and lateral teeth are absent. The outer surface is generally smooth except on the posterior slope; the anterior margin is abruptly curved, the ventral margin long, and shells are gently concave centrally. The color of the shell is yellowish, greenish, turquoise, or covered with dark greenish rays in juveniles. The outer surface becomes brownish with rays partially obscured or almost black in some adults. The shell of the Brook Floater is oblong, long, and rhomboid. The inner shell surface is whitish or bluish-white often with salmon, pink or purple in the beak cavity. Maximum shell length for this species is 70 mm (2.8 in.) (Bogan and Alderman 2004, 2008; Nedeau 2008).

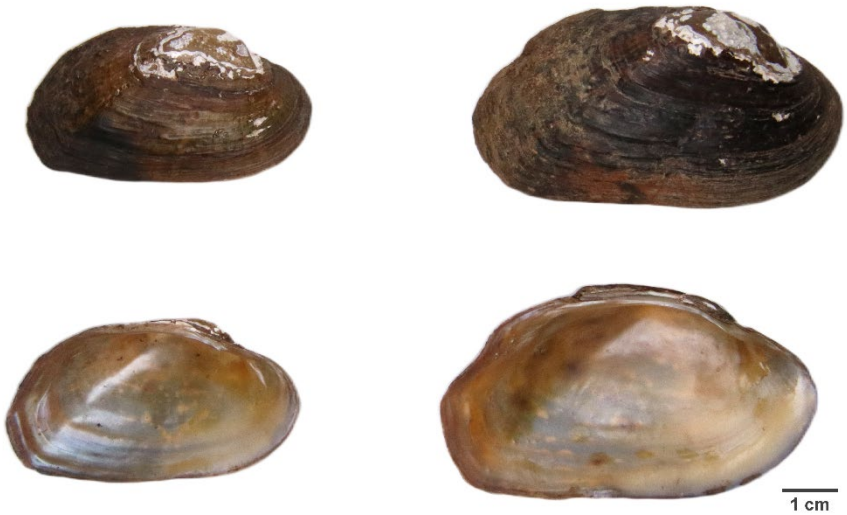


Figure 2. Image of wild *Alasmidonta varicosa* photographed by Briana Cairco, SCDNR.

Brook Floaters are distinct but can be confused with Creeper (*Strophitus undulata*) which has a similar shape with poorly developed pseudocardinal teeth. Creeper mussels lack corrugations and are boxier in appearance.

Status

The current global status for the Brook Floater is vulnerable (G3); it is ranked critically imperiled to imperiled (S1S2) in South Carolina (NatureServe 2024). This species has been a candidate for listing as Threatened or Endangered under the endangered species act since the publishing of the Partial 90-Day Finding on a Petition to List 404 Species in the Southeastern United States as Endangered or Threatened with Critical Habitat in 2011 to the federal register. A species status assessment was completed and a finding of not warranted for listing as endangered or threatened was published to the federal register in 2019 (USFWS 2019).

POPULATION SIZE AND DISTRIBUTION

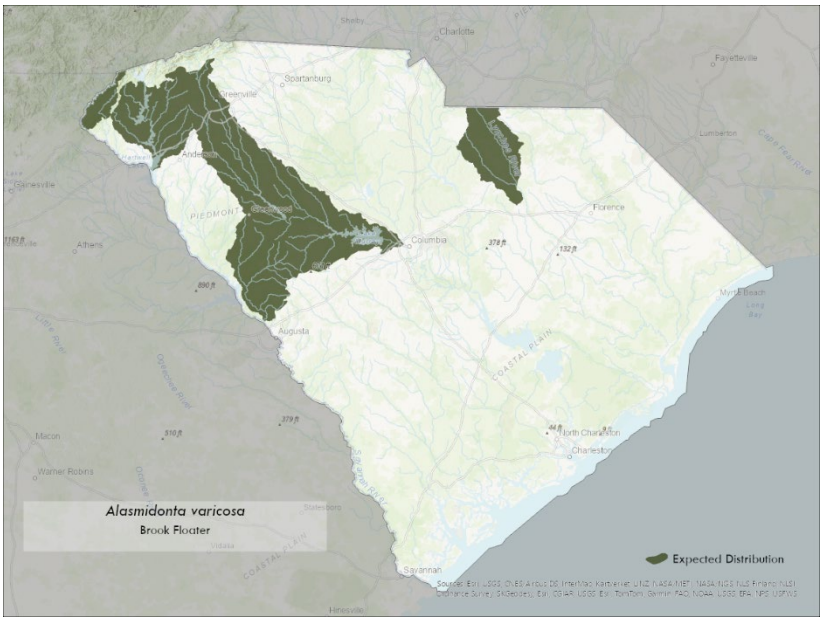


Figure 2. Expected distribution of *Alasmidonta varicosa* based on reported observations at a HUC 8 level and designated ecoregion.

The Brook Floater is found along the East Coast from eastern Canada to the Savannah River basin in South Carolina and Georgia. In South Carolina, it also occurs in Flat Creek and the Lynches River; however, this species is becoming increasingly rare in this system (Figure 2). No live animals were found in the Lynches during recent surveys. In the Savannah basin it is found in several streams in the Steven's Creek watershed but is often rare, with only one or two animals recovered at a site. While the historic range in the Savannah basin included more of the piedmont and blue ridge regions in South Carolina, recent surveys were unable to locate living animals in the upper Savannah basin outside of the Chattooga River. The Brook Floater population in the Chattooga River on the South Carolina/Georgia state line is possibly the second largest on the Atlantic Slope and appears stable.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The main population of Brook Floater in South Carolina is found in the Chattooga River that borders South Carolina and Georgia. The Chattooga is a high relief stream where Brook Floater can be found among boulders in sand or along the banks. In smaller streams Brook Floater has been found in riffles in mixed cobble or boulders in South Carolina. In the North Atlantic slope, this species inhabits streams and rivers of varying sizes, but ones that usually have low to moderate flow velocities and stable substrates. While absent from reservoirs or lakes, this species may inhabit the upstream end of small impoundments created by run-of-river dams.

In South Carolina, gravid females have been collected in February and March. Reported hosts include Golden Shiner, Longnose Dace, Margined Madtom, Yellow Perch, Slimy Sculpin, Pumpkinseed, Blacknose Dace, Tessellated Darter, and Bluegill. No studies have confirmed how well laboratory results relate to the availability of hosts or parasitism under natural conditions. (Schulz and Marbain 1998; Fichtel and Smith 1995; Nedeau 2008).

CHALLENGES

While a strong population of Brook Floater exists in the Chattooga River with habitat on US Forest Service owned land, we have seen a recent reduction in populations in the Pee Dee and lower Savannah Basin.

Like other freshwater mussels, the Brook Floater is sensitive to changes in water quality, habitat, and access to host fishes, although the degree of sensitivity to these changes is understudied. Like other freshwater mussels, the Brook Floater must have adequate access to species-specific hosts and relies on host fishes for reproduction and distribution. Maintaining stream connectivity for host fishes is important to allow

distribution of juveniles and gene flow between populations. Environmental stressors that lead to degradation of water quality, habitat, and stream connectivity include development, agriculture, and incompatible forestry management; additionally, systemic changes that have negative effects include climate change, invasive species, and dams and barriers (USFWS 2021).

In South Carolina, practices such as mining, clearcutting for timber production, and recreational vehicle use in streams are observed to result in degradation of habitat. Preservation of a riparian buffer is needed for the continued existence of suitable habitat for most native freshwater mussels. A riparian buffer is the land area adjoining a stream, lake or wetland characterized by a cover of naturally occurring vegetation consisting of trees, shrubs, grasses, and forbs where development is restricted or prohibited.

CONSERVATION ACCOMPLISHMENTS

The Brook Floater is a species of federal concern and has been included in a petition for listing as a Federally Threatened or Endangered species (USFWS 2011). As such, the US Fish and Wildlife Service may conduct a status survey to determine its range and abundance to evaluate its status as a potential candidate for federal listing.

Propagation of this species using brood stock collected from the Chattooga River has been attempted in South Carolina resulting in 12 animals being stocked into Turkey Creek in October 2019. SCDNR completed propagation of the species in 2023 and examined a 21.6% metamorphosis success on Bluegill fish.

South Carolina has partnered with other states in the species range to aid in the conservation of Brook Floater in the Competitive State Wildlife Grants Grant: Advancing Conservation and Restoration of Brook Floater and Associated Freshwater Mussels.

CONSERVATION RECOMMENDATIONS

- Continue monitoring populations of Brook Floater in South Carolina.
- Continue conducting genetic investigations, particularly to compare Brook Floater populations in the Lynches River and Steven's Creek Basins if possible.
- Protect Brook Floater habitat, critical for their survival from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas, especially those portions along Flat Creek in the Lynches River drainage.
- Conserve populations of host fish to insure propagation of the Brook Floater in the wild.
- Consider propagation efforts to augment declining populations.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Brook Floater.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Conduct further research to determine the degree of sensitivity of the Brook Floater to various point and non-point sources of pollution and land use impacts.
- Study interactions of laboratory host fishes in the wild.

MEASURES OF SUCCESS

- Protecting land and maintaining healthy riparian habitat adjacent to streams with populations of Brook Floaters will indicate some success.
- Outreach to relevant landowners about the importance of freshwater mussels and their habitats.
- Development of species-specific restoration plan based on the results of routine monitoring and the implementation of that plan for augmentation.

- Monitoring of wild populations of the species that show stabilization or an increase in the size of South Carolina's populations of the Brook Floater.
- Determine the effects of channel modification, such as dams, on the Brook Floater.
- Determination of environmental and toxicological tolerances and endpoints.

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Tidewater Mucket

Atlanticoncha ochracea

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason (SCDNR)



Figure 1. Image of male (top) and female (bottom) *Atlanticoncha ochracea* photographed by Briana Cairco, SCDNR.

DESCRIPTION

Taxonomy and Basic Description

The Tidewater Mucket (*Atlanticoncha ochracea*) was reassigned into the genus *Atlanticoncha* in Smith et al. (2020). The Freshwater Mussel Conservation Society recognized this name change in the 2023 Freshwater Mussel Name List. The scientific name was changed from Leptodea ochracea as it appeared in the 2015 SWAP.

The Tidewater Mucket is usually small but can reach up to about 4 inches in length (Bogan and Alderman 2004, 2008). The shell is elliptical to ovate with a rounded anterior margin and an evenly rounded ventral margin. The posterior ridge is well developed and ends in a blunt point about halfway up from the base (Figure 1). The species is sexually dimorphic. Shells of males are more elliptical with the posterior margin somewhat pointed; shells of females are more ovate with a truncated posterior margin. The outer surface of the shell is a dull and yellowish/grayish/greenish- or brownish-olive, sometimes with fine grayish or greenish rays. The inner surface of the shell is white to reddish pink.

The Tidewater Mucket is fairly distinct; however, it can sometimes be confused with Lampsilis cariosa, especially when handling live specimens. The Yellow Lampmussel has a waxier periostracum and does not get thin rays on the entirety of the shell. The Tidewater Mucket is also an overall thinner shelled species and internally has thin and elongated pseudocardinal teeth. Atlanticoncha ochracea pseudocardinal teeth are situated far forwards of the umbo versus almost directly under the umbo in L. cariosa.

Status

The Tidewater Mucket is currently assigned a global ranking of vulnerable to apparently secure (G3/G4) (NatureServe 2024). This mussel is ranked as critically imperiled (S1) in some of its northern ranges but ranked imperiled (S2) in North Carolina and vulnerable (S3) in Georgia (NatureServe 2024). It is currently ranked imperiled to vulnerable (S2S3) in South Carolina.

POPULATION SIZE AND DISTRIBUTION

The Tidewater Mucket is found in coastal rivers, lakes, ponds, and shallow-moving sections of rivers from Nova Scotia to the Savannah River in Georgia. Historically, it has been found in the Waccamaw and Savannah Rivers in South Carolina (Bogan and Alderman 2004, 2008). In 2004 it was found in the Pee Dee River in North Carolina just above the South Carolina State Line and in the lower Little Pee

Dee River in South Carolina (Figure 2). We have a total of 19 reported observations of the species from 2004-2019. Targeted surveys in the coastal plains with suitable habitat are needed for this species.

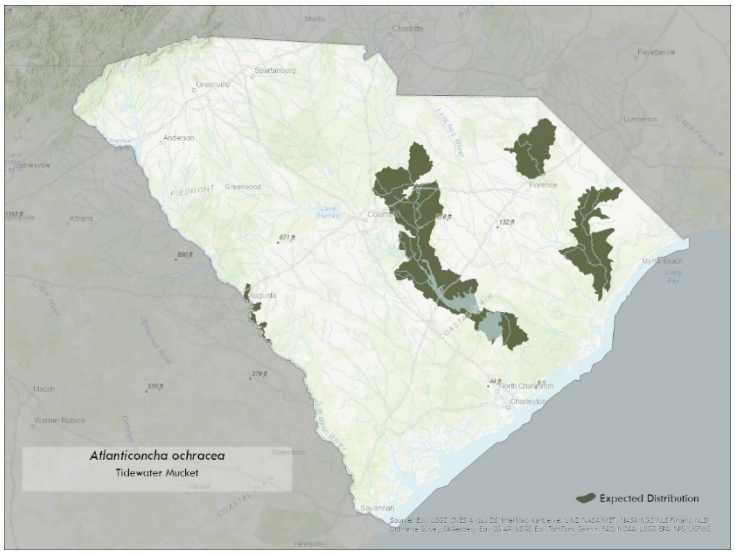


Figure 2. Expected distribution of *Atlanticoncha ochracea* based on reported observations at a HUC 10 watershed level and designated ecoregions.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Tidewater Mucket tends to be found on the lower coastal plain, often in water with tidal influence, but always in freshwater. It has been typically found in pristine rivers.

Tidewater Mucket are presumed long-term brooders, spawning in the fall and releasing glochidia the following spring (Nedeau et al. 2000). Reported host fishes in laboratory conditions include Banded Killifish, White Perch, and Yellow Perch (Kneeland 2006; Wick 2006). In 2008, Kneeland and Rhymer confirmed glochidia of A. ochracea on all three host species mentioned previously in wild populations with White Perch being most heavily infested with glochidia.

CHALLENGES

Like other freshwater mussels, this species is sensitive to channel modification, agriculture and urban pollution, sedimentation, and saltwater intrusion. Additionally, A. ochracea uses a semi-anadromous species of fish as its host, the white perch, (Kneeland 2006, 2008). White perch that are not locked by reservoirs migrate from estuaries to freshwater to spawn. This movement inland allows the Tidewater Mucket to maintain native ranges. Channel modifications and fragmented habitats directly impact the only method of dispersal by the species.

Environmental stressors that lead to degradation of water quality, habitat, and stream connectivity include development, agriculture, and incompatible forestry management; additionally, systemic changes that have negative effects include climate change, invasive species, and dams and barriers (USFWS 2021).

In South Carolina, practices such as mining, clearcutting for timber production, and recreational vehicle use in streams are observed to result in degradation of habitat. Preservation of a riparian buffer is needed for the continued existence of suitable habitat for most native freshwater mussels. A riparian buffer is the land area adjoining a stream, lake or wetland characterized by a cover of naturally occurring vegetation consisting of trees, shrubs, grasses, and forbs where development is restricted or prohibited.

CONSERVATION ACCOMPLISHMENTS

There are no significant conservation accomplishments specifically for the Tidewater Mucket currently.

CONSERVATION RECOMMENDATIONS

- Conduct surveys to document the extent of distribution and population size and range of the Tidewater Mucket.
- Explore the need to upgrade the listing of the Tidewater Mucket in South Carolina,

based on survey results.
- Determine habitats that are critical for this species in South Carolina.
- Perform host fish trials to determine natural hosts for native populations.
- Conserve populations of host fish to insure reproduction of the Tidewater Mucket in the wild.
- Protect critical habitats for the Tidewater Mucket from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Tidewater Mucket.
- Encourage responsible land use planning.
- Determine the effects of saltwater intrusion.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Conduct further research to determine the degree of sensitivity of the Tidewater Mucket to various point and non-point sources of pollution and land use impacts.
- Conduct a thorough search of museum records for the Tidewater Mucket and determine if there are any additional historical records for this species.
- Conserve populations of host fish to insure reproduction of the Tidewater Mucket in the wild.
- Develop a restoration plan that considers the need for augmentation or reintroduction.
- Consider species needs when participating in the environmental permit review process.

MEASURES OF SUCCESS

- Completion of targeted surveys in areas of historic occupancy and similar habitat types.
- Work to reduce or halt further disturbance to the habitat and natural hydrology of occupied rivers.
- Perform outreach to relevant landowners about the importance of freshwater mussels and their habitats.
- Comprehensive, range-wide genetic analysis of the species.
- Completion of thorough, standardized surveys in presumed range and habitat of the species.
- Determination of host fishes used for reproduction of the Tidewater Mucket.
- Monitoring of wild populations of the species that show stabilization or an increase in the size of South Carolina's populations of the Tidewater Mucket.
- Determine the effects of channel modification, such as dams, on the Tidewater Mucket.
- Determination of environmental and toxicological tolerances and endpoints.

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Carolina Slabshell

Elliptio congaraea
(Lea 1831)

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Morgan Kern and Ericah Beason (SCDNR)



Figure 1. Images of *Elliptio congaraea* photographed by Briana Cairco, SCDNR.

DESCRIPTION

Taxonomy and Basic Description

The Carolina Slabshell belongs to one of the largest genera in the Unionidae family in North America with 31 species recognized in North America, Canada, and Mexico as of 2023 (FMCS 2023). The overlapping morphological variations between species and limited comprehensive genetic and morphological analysis make it difficult to tease apart valid *Elliptio* species and their ranges. Large synonymies of Elliptio species without adequate, range-wide genetic confirmation also make conservation recommendations difficult.

Oftentimes, *Elliptio* species in South Carolina fall under 3 "groups" that are characterized by generalizations of overall morphological traits. These groups are not based on comprehensive genetic and morphological research, but years of observation of morphological traits and are simply a means to aid in the understanding of morphological types seen through the *Elliptio* genus. A working list of the *Elliptio* of South Carolina can be found in Bogan and Alderman (2008).

The three groups are the lanceolata, the complanata, and icterina. The lanceolates group is comprised of species that have a greater length to heigh ratio than the complanates and include species such as *Elliptio angustata*, *Elliptio producta,* and *Elliptio folliculata*. The complanates group is comprised of species that are rather rectangular to subrhomboidal in shell outline and usually compressed; species in this group include those such as *Elliptio complanata*, *Elliptio roanokensis*, *E. fraterna*, *E. congaraea,* and *Elliptio hopetonensis*. Lastly, species in the icterina group are typically smaller in overall size, inflated, and have a waxy, dark exterior with a prominent posterior ridge; species in this group recognized to occur in South Carolina include *Elliptio icterina* and species that were synonymized by Johnson (1970).

The Carolina Slabshell, like other species of *Elliptio,* has taxonomic difficulties and challenges have been ongoing with *E. congaraea, E. waccamawensis, E. complanata* and *E. fraterna*. In (2017), Williams et al. consider *E. congaraea* a valid taxa and *E. waccamawensis* a synonym for *E. congaraea* with supporting molecular evidence from McCarty et al (2016). The results of the genetic analysis did not provide enough evidence to separate individuals between the lake form once called Waccamaw Spike and the river morphologies found downstream. Williams et al. (2017) recognizes the common name Carolina Slabshell and not Carolina Elephantear as the species appears in the 2015 SWAP. There are ongoing concerns with *E. congaraea* and whether it is distinct from *E. fraterna* and *E. complanata,* but comprehensive genetic analysis has not occurred.

The shell of the Carolina Slabshell (Figure 1) has two described morphologies. The river morphology is more compressed with an umbo or beak that is slightly elevated above the hinge line with sculpturing of parallel undulations or wrinkles on the posterior slope. The pseudocardinal and lateral teeth are present. The umbo or

beak cavity is not deep. The posterior ridge is high and angled. The outer surface of the shell is greenish-yellow or tawny and is usually rayed. The shape of the shell is rhomboid. The inner surface of the shell is purplish (Bogan and Alderman 2004, 2008). The lake morphology is inflated with a prominent umbo or beak and angular posterior ridge. The ventral margin is straight. The pseudocardinal and lateral teeth are present. The shell is elliptical in shape. The outer surface of the shell is light to dark brown and smooth; the inner surface is white to bluish (Bogan and Alderman 2004, 2008).

Status

NatureServe (2024) currently identifies the species having a global ranking of vulnerable (G3). In North Carolina and Georgia, the species is ranked vulnerable (S3) and in South Carolina, the species is ranked apparently secure (S4).

POPULATION SIZE AND DISTRIBUTION

This species ranges from the Ogeechee Basin in Georgia to the Chowan River Basin in Virginia (Bogan and Alderman 2004, 2008). Carolina Slabshell is found in most river basins in South Carolina and can be recovered in low to moderate numbers at sites it is present (Figure 2).

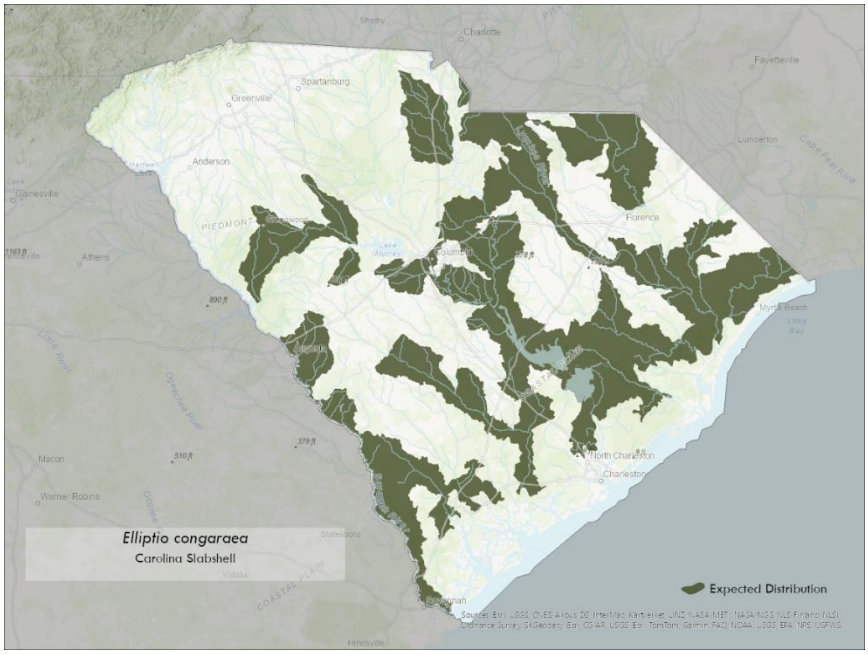


Figure 2. Expected distribution of *Elliptio congaraea* based on reported observations at a HUC 10 watershed level and designated ecoregion.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Carolina Slabshell species is found in a variety of habitats, including rivers, lakes, and small streams. Johnson (1970) notes the species in sandy substrates in swift water of medium sized rivers to smaller creeks. This species can be found in many substrates, preferring sandy substrate (Bogan and Alderman 2008). The Carolina Slabshell (*Elliptio congaraea*) does not tolerate silt substrates and prefers slow-moving velocities, hydrology that is often lost due to impoundments and stream channelization (Pandolfo et al. 2016).

Gravid females have been observed brooding from May to July in Lake Waccamaw (Bogan and Alderman 2008). The host fish(es) for this species are unknown.

CHALLENGES

There is still much taxonomic uncertainty in the *Elliptio* genus which exhibits highly variable shell morphology. While the *Elliptio* genus is largely recognized as monophyletic, many species designations within the genus have yet to be tested and are based only on morphology. While the relationship of Carolina Slabshell and the formerly recognized Waccamaw Spike has been evaluated, the relationship of the species to the rest of the genus remains unclear (Williams et al. 2017). Classifications in this genus will require genetic testing that includes representative specimens of all *Elliptio* species from across their ranges.

Little is known about the reproductive and brooding behaviors of *E. congaraea,* and wild host fish(es) are unknown.

Like other freshwater mussels, the Carolina Slabshell is sensitive to changes in water quality, habitat, and access to host fishes, although the degree of sensitivity to these changes is understudied. The host fish(es) for the Carolina Slabshell are unknown, but like other freshwater mussels, the Carolina Slabshell must have adequate access to species-specific hosts and relies on host fish(es) for reproduction and distribution. Maintaining stream connectivity for host fish(es) is important to allow distribution of juveniles and gene flow between populations. Environmental stressors that lead to degradation of water quality, habitat, and stream connectivity include development, agriculture, and incompatible forestry management; additionally, systemic changes that have negative effects include climate change, invasive species, and dams and barriers (USFWS 2021).

In South Carolina, practices such as mining, clearcutting for timber production, and recreational vehicle use in streams are observed to result in degradation of habitat. Preservation of a riparian buffer is needed for the continued existence of suitable habitat for most native freshwater mussels. A riparian buffer is the land area adjoining a stream, lake or wetland characterized by a cover of naturally occurring vegetation consisting of trees, shrubs, grasses, and forbs where development is restricted or prohibited.

CONSERVATION ACCOMPLISHMENTS

There are currently no significant conservation accomplishments specifically for the Carolina Slabshell.

CONSERVATION RECOMMENDATIONS

- Continue monitoring populations of Carolina Slabshell in South Carolina.
- Conduct genetic analyses to determine the relationship between the Carolina Slabshell and other species in the genus *Elliptio*.
- Perform host fish trials to determine natural hosts for native populations.
- Conserve populations of host fish to insure propagation of the Carolina Slabshell in the wild.
- Protect critical habitats for the Carolina Slabshell from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Carolina Slabshell.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Determine the life history of the Carolina Slabshell including time of spawning and brooding.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

- Determine the effects of channel modification, such as dams, on the Carolina Slabshell.
- Determine the environmental and toxicological tolerances and endpoints.

MEASUREMENTS OF SUCCESS

- Completion of targeted surveys where historic occupancy or suitable habitat for host fish.
- Collection of genetic swabs of Carolina Slabshell to ensure successful identification of species range and distribution.
- Development of a list of habitats where populations of Carolina Slabshell exist in South Carolina.
- Determining or confirming host species of Carolina Slabshell in South Carolina.
- Outreach to relevant landowners about the importance of freshwater mussels and their habitats.
- Determination of the effects of channel modification, such as dams, on the Carolina Slabshell.
- Determination of environmental and toxicological tolerances and endpoints.
- Determination of life history of the Carolina Slabshell including time of spawning and brooding.

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Pod Lance

Elliptio folliculata (Lea, 1838)

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason (SCDNR)



Figure 1. Image of *Elliptio folliculata* photographed by Briana Cairco, SCDNR.

DESCRIPTION

Taxonomy and Basic Description

The Pod Lance belongs to one of the largest genera in the Unionidae family in North America with 31 species recognized in North America, Canada, and Mexico as of 2023 (FMCS 2023). The overlapping morphological variations between species and limited comprehensive genetic and morphological analysis make it difficult to tease apart valid *Elliptio* species and their ranges. Large synonymies of Elliptio species without adequate, range-wide genetic confirmation also make conservation recommendations difficult.

Oftentimes, *Elliptio* species in South Carolina fall under 3 “groups” that are characterized by generalizations of overall morphological traits. These groups are not based on comprehensive genetic and morphological research, but years of observation of morphological traits and are simply a means to aid in the understanding of morphological types seen through the *Elliptio* genus. A working list of the *Elliptio* of South Carolina can be found in Bogan and Alderman (2008).

The three groups are the lanceolata, the complanata, and icterina. The lanceolates group is comprised of species that have a greater length to heigh ratio than the complanates and include species such as *Elliptio angustata*, *Elliptio producta,* and *Elliptio folliculata*. The complanates group is comprised of species that are rather rectangular to subrhomboidal in shell outline and usually compressed; species in this group include those such as *Elliptio complanata*, *Elliptio roanokensis*, *E. fraterna*, *E. congaraea*, and *Elliptio hopetonensis*. Lastly, species in the icterina group are typically smaller in overall size, inflated, and have a waxy, dark exterior with a prominent posterior ridge; species in this group recognized to occur in South Carolina include *Elliptio icterina* and species that were synonymized by Johnson (1970).

The Pod Lance, like other species of *Elliptio*, has taxonomic difficulties and challenges have been ongoing with *E. lanceolata*, *E. angustata*, *E. fisheriana*, and *E. folliculata*. In (1970), Johnson considered *E. folliculata* a synonym of *E. lanceolata*, but Turgeon et al. (1998) consider *E. folliculata* a valid taxon distinct from *E. lanceolata*. A master’s thesis by Lohmeyer (2020)

found a high degree of haplotype sharing between *E. ahenea*, *E. angustata*, *E. producta*, *E. shepardiana,* and *E. folliculata* in the southern Atlantic slope (St. John River Drainage, FL to Neuse drainage, NC) and support synonymizing of the above species with *E. angustata* but this research has not been peer reviewed or published. Although the species is currently recognized as valid and distinct, future research may reveal synonymy with another lanceolate *Elliptio*.

The Pod Lance's shell is narrow and uninflated, resembling a straight-edged razor (Figure 1). The dorsal and ventral margins are parallel to one another. The outer surface of the shell is rough; the inner surface varies from bluish to pink (Bogan and Alderman 2004, 2008). The shell can vary in color from pale yellowish brown to dark brown, almost black. The umbo is at or below the hinge; a posterior wing may be present.

Like other freshwater mussels, *E. folliculata* can be confused with other *Elliptio* species such as *Elliptio angustata* and *Elliptio producta*, especially when alive or young. Animals of *Elliptio folliculata* are far more compressed and have a greater length to height ratio than *E. angustata* or *E. producta*; *E. folliculata* dorsal and ventral margins are parallel.

Status

NatureServe (2024) identifies the Pod Lance as having a ranking of imperiled to vulnerable globally (G2/G3). In North Carolina and Georgia, the species is ranked as imperiled (S2) and in South Carolina the species is ranked as critically imperiled to vulnerable (S1S3).

POPULATION SIZE AND DISTRIBUTION

The Pod Lance ranges from the Ogeechee River in Georgia to the Waccamaw and Cape Fear Basins in North Carolina. The Pod Lance has been reported in all the major river basins in South Carolina (Bogan and Alderman 2004, 2008). This species is found alongside other lanceolate *Elliptio* species and stands out due to its extremely compressed shell and blade-like appearance. It is not found often in South Carolina and when it is found, it is found in relatively low abundance (Figure 2).

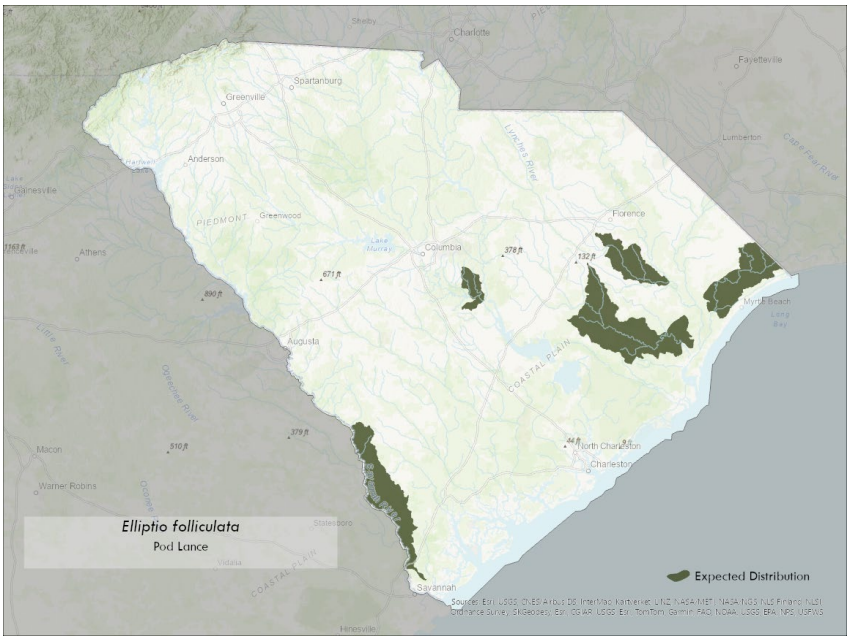


Figure 2. Expected distribution of *Elliptio folliculata* based on reported observations at a HUC 10 watershed level and designated ecoregions.

Like other *Elliptio* species, it is likely that overlapping morphology has skewed population distribution data. In South Carolina, the Pod Lance has been reported across the Pee Dee and Savannah watersheds in the coastal plain. There is one reported observation of the species in the Congaree River (Santee watershed), but it is noted that the species identification is in question and cannot be confirmed. In the Savannah watershed, the species has only been reported in the main stem Savannah River.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Pod Lance has been found on sandy or clay substrates in water generally greater than 1 m (3.3 ft.) in depth. It has been found in both rapidly flowing rivers as well as slow flowing areas (Bogan and Alderman 2004, 2008). Like other *Elliptio* species, research for the Pod Lance is minimal. There are no known host fishes.

CHALLENGES

The greatest challenge with the Pod Lance is the uncertainty of taxonomy and the validity of the species against other lanceolate *Elliptio* species across the southern Atlantic slope. Like other species in the genus, comprehensive, range-wide genetic analysis is needed. Determining population ranges in South Carolina is also difficult due to a high likelihood of misidentifications. There are no known host fishes for the Pod Lance, but the species may use an anadromous fish like other species of *Elliptio*. Little is known about the reproductive and brooding behaviors of *E. folliculata,* and wild host fish(es) are unknown.

Like other freshwater mussels, the Pod Lance is sensitive to changes in water quality, habitat, and access to host fishes, although the degree of sensitivity to these changes is understudied. The host fish(es) for the Pod Lance are unknown, but like other freshwater mussels, the Pod Lance must have adequate access to species-specific hosts and relies on host fish(es) for reproduction and distribution. Maintaining stream connectivity for host fish(es) is important to allow distribution of juveniles and gene flow between populations. Environmental stressors that lead to degradation of water quality, habitat, and stream connectivity include development, agriculture, and incompatible forestry management; additionally, systemic changes that have negative effects include climate change, invasive species, and dams and barriers (USFWS 2021).

In South Carolina, practices such as mining, clearcutting for timber production, and recreational vehicle use in streams are observed to result in degradation of habitat. Preservation of a riparian buffer is needed for the continued existence of suitable habitat for most native freshwater mussels. A riparian buffer is the land area adjoining a stream, lake or wetland characterized by a cover of naturally occurring vegetation consisting of trees, shrubs, grasses, and forbs where development is restricted or prohibited.

CONSERVATION ACCOMPLISHMENTS

There are no significant conservation accomplishments specifically for the Pod Lance currently.

CONSERVATION RECOMMENDATIONS

- Conduct genetic analyses across the range of the Pod Lance to determine its relationship with other lanceolate *Elliptio* species.
- Conduct surveys, especially deep water, to determine the current range and status of the Pod Lance.
- Explore the need to list the Pod Lance within South Carolina based on survey results.
- Protect critical habitats for the Pod Lance from future development and further habitat degradation by following Best Management Practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Pod Lance.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Conduct further research to determine the degree of sensitivity of the Pod Lance to various point and non-point sources of pollution and land use impacts.

MEASURES OF SUCCESS

- Resolving taxonomic questions regarding the relationship between the Pod Lance and other *Elliptio* species.
- Determination of host fish species in laboratory and wild.
- Determination of environmental and toxicological tolerances and endpoints.
- Determination of habitat preferences.
- Determination of species range in South Carolina and target deep water habitats.

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Brother Spike

Elliptio fraterna (Lea, 1852)

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason (SCDNR)



Figure 1. Image of *Elliptio fraterna* courtesy of the North Carolina Museum of Natural Sciences, Jamie Smith, and Dr. Art Bogan. The NCSM catalog number of the photographed specimen is 62778.



from Bogan and Alderman (2008)

Figure 2. Image of *Elliptio fraterna* from Bogan and Alderman 2008.

DESCRIPTION

Taxonomy and Basic Description

The shell of the Brother Spike (Figure 1 and 2) is elongate, rather thin, and subrhomboid; the anterior end is regularly rounded, the posterior end blunt, the ventral margin is mostly straight, and the dorsal margin straight or slightly curved. There is a well-developed posterior dorsal ridge that becomes double near the posterior margin. The posterior slope is covered with corrugations, or ridges that extend from near the umbo to the posterior margin. The outer surface of the shell is smooth and shiny, reddish-brown to yellowish, often with fine green rays that become obscured with age. The inner surface varies from white to pink, salmon, and purple. Bogan and Alderman (2004, 2008) note the Brother Spike reaching 65 mm (2.6 in.) in length; however, Johnson (1970) plated *Unio fraternus* from the Chattahoochee River in Georgia being 69 mm in length.

Like other animals in the *Elliptio* genus, there are taxonomic challenges. In 1970, Johnson lumped many taxa under a single name, but current genetic research suggests some synonymized species are valid. Johnson (1970) considered *E. mcmichaeli* a synonym of E. fraterna but Fuller and Bereza (1975) and Brim Box and Williams (2000) consider *E. fraterna* and *E. mcmichaeli* distinct species. Comprehensive, range-wide genetic analysis is needed to determine the validity of *E. fraterna* as a distinct species.

Like other native freshwater mussels, the Brother Spike can be confused with other species such as *Elliptio congaraea* and *Elliptio complanata*, especially when living. The Brother Spike closely resembles the Carolina Slabshell but the Brother Spike is consistently much thinner and more compressed (Johnson 1970). The Brother Spike could also be confused with the Eastern Elliptio; however, the Eastern Elliptio does not have corrugations on the posterior slope like the Brother Spike.

Status

The Brother Spike is listed as a state endangered species in South Carolina and is declining in abundance and distribution. NatureServe (2024) notes the species as having a global ranking of critically imperiled (S1). In Alabama, it has a ranking of presumed extirpated (SX), and in North Carolina, Florida, and Georgia, it has a ranking of critically imperiled (S1) (NatureServe 2024). In South Carolina it has a ranking of critically imperiled (S1?). The Brother Spike was included on a list of 374 species being petitioned for consideration as candidates for federal protection (USFWS 2011); however, a finding has not been made.

POPULATION SIZE AND DISTRIBUTION

This species appears to be endemic to the Savannah River Basin and occupies two disjunct river systems, the Savannah, draining to the Atlantic, and the Apalachicola, draining to the Gulf of Mexico. The animal is rare wherever it is found. There is at least one historic occurrence from the Chattahoochee River but may be extirpated from the river now. Specimens have been reported from the Chattahoochee, Flint, Apalachicola, and Savannah rivers. Britton and Fuller (1979) noted that *Elliptio fraterna* was naturally rare in the Savannah River system and reported observations suggest that the species is rare in all inhabited systems.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Not much is known about the habitat preferences of the Brother Spike, but Johnson (1970) reported the species to inhabit sand bars in swift flowing sections of streams and rivers (Johnson 1970). In (1979), Britton and Fuller document the species as only being found on sand bars. The species may be a deep-water species, but confirmation is needed (NatureServe 2024).

There are no known host fish for the species and no life history research has been completed.

CHALLENGES

Specific challenges are difficult to determine due to the lack of data associated with the species. Due to the rarity of occurrences, it is likely that populations of Brother Spike are being impacted by decreased reproduction and genetic variation due to fragmented occurrences and disjointed populations. The Brother Spike is presumed to be a deep-water mussel and if accurate, damming, dredging, low water levels, and water withdrawal would pose direct threats to the presumed habitats. Additionally, sedimentation and shifts in substrates due to development and sedimentation are likely to directly interfere with the Brother Spike as it seems to prefer sand bars. Additionally, like other freshwater mussels, the Brother Spike faces challenges due to anthropogenic pollutants, poor land management, channel modification, and clearing of riparian buffers. Changes to the habitat that do not directly affect the mussels may affect their host fishes and without adequate access to species-specific hosts, reproduction cannot occur.

CONSERVATION ACCOMPLISHMENTS

The Brother Spike has been listed as an endangered species in South Carolina.

CONSERVATION RECOMMENDATIONS

- Conduct genetic analyses to determine the relationship between the Brother Spike and other *Elliptio* species.
- Conduct targeted, comprehensive surveys to determine the current range and status of the Brother Spike.
- If populations are found, research is needed to determine the habitat preferences and host fishes needed for reproduction of the Brother Spike.
- Protect critical habitats for the Brother Spike from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Brother Spike.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Conduct further research to determine the degree of sensitivity of the Brother Spike to various point and non-point sources of pollution and land use impacts.

MEASURES OF SUCCESS

- Resolving taxonomic questions regarding the relationship between the Brother Spike and other *Elliptio* species.
- Completion of targeted, comprehensive surveys.
- Persistence of any identified populations and an increase in population size.
- Determination of host fishes.
- Determination of ecological and toxicological endpoints.

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Altamaha Slabshell

Elliptio hopetonensis (Lea, 1838)

Contributor (2024): Ericah Beason (SCDNR)



Figure 1. Image of *Elliptio hopetonensis* courtesy of the North Carolina State Museum of Natural Sciences, Jamie Smith, and Dr. Art Bogan. The NCSM catalog number of the specimen photographed is 46026.2.

Taxonomy and Basic Description

The Altamaha Slabshell belongs to one of the largest genera in the Unionidae family in North America with 31 species recognized in North America, Canada, and Mexico as of 2023 (FMCS 2023). The overlapping morphological variations between species and limited comprehensive genetic analysis make it difficult to tease apart valid *Elliptio* species and their ranges. Large synonymies of Elliptio species without adequate, range-wide genetic confirmation also make conservation recommendations difficult.

Oftentimes, *Elliptio* species in South Carolina fall under 3 “groups” that are characterized by generalizations of overall morphological traits. These groups are not based on comprehensive genetic and morphological research, but years of observation of morphological traits and are simply a means to aid in the understanding of morphological types seen through the *Elliptio* genus.

The three groups are the lanceolata, the complanata, and icterina. The lanceolates group is comprised of species that have a greater length to heigh ratio than the complanates and include species such as *Elliptio angustata*, *Elliptio producta,* and *Elliptio folliculata*. The complanates group is comprised of species that are rather rectangular in shell outline and usually compressed, species in this group include those such as *Elliptio complanata*, *Elliptio roanokensis*, and *Elliptio hopetonensis*. *Elliptio hopetonensis* is in the complanates group because it has a rather rectangular shell appearance, but animals may get inflated in soft substrates. Lastly, species in the icterina group are typically smaller in overall size, inflated, and have a waxy, dark exterior with a prominent posterior ridge; species in this group recognized to occur in South Carolina include *Elliptio icterina* and species that were synonymized by Johnson (1970).

The Altamaha Slabshell is somewhat oblong, compressed to inflated, with somewhat thick valves (Figure 1). The umbo is scarcely prominent and undulated at the tip. The posterior is broad and bi-angulated. The outer surface of the shell is smooth, except near shell margins, and varies in color from greenish with yellow hues in younger individuals to deep brown in older individuals. Narrow green rays may be present but darken with age. The inner surface of the shell is noted as purple and iridescent (Lea 1838). The lateral teeth are long and curved.

Because of the varying degree of morphological overlap in the *Elliptio* genus, the Altamaha Slabshell can be easily confused with several species, especially when alive. Animals of *Elliptio hopetonensis* can easily be misidentified with some animals of *Elliptio complanata* and *Elliptio roanokensis*. *Elliptio hoptonensis* is mostly identified by its large bi-angulated posterior, that extends into somewhat of a wing at the dorsal margin. It also has a very noticeable posterior ridge.

A study trying to determine if glochidia could aid in or be used for identification of *Elliptio* species described the glochidia as depressed and subelliptical with a length of 206 ± 5.8 µm (197-215µm), a height of 226 ± 3.9 µm (222-231µm), and a hinge length of 137 + 5.0 µm (130-145 µm) (O'brien et al. 2003). They describe the anterior and posterior margins as equal and more rounded towards the ventral margin (O'brien et al. 2003). Additionally, they describe a broad flange, covered in vertical rows of microstylets, extending from the ventral margin (O'brien et al. 2003). Lastly, the dorsal margin is long and straight with the hinge ligament located closer to the posterior margin; the surface of the valve is covered with loose-looped exterior valve sculpturing (O'brien et al. 2003).

Status

NatureServe (2024) currently identifies the global ranking for this species as apparently secure (G4). The Altamaha Slabshell is ranked as apparently secure (G4) in Georgia and not ranked (SU) in South Carolina due to insufficient data on the species.

POPULATION SIZE AND DISTRIBUTION

The Altamaha Slabshell is endemic to Georgia and historically only found in the Altamaha River system where it remains one of the most common native mussels collected. Additional surveys placed the species in the Ogeechee and Savannah River systems as of 2009 (NatureServe 2024). Until 2024, South Carolina did not recognize the species having occupancy in the state, despite having a reported observation of the species by Tim Savidge in the Savannah River in 2006 and in Turkey Creek in 2013 which was presumed to be a misidentification due to the observation being outside of

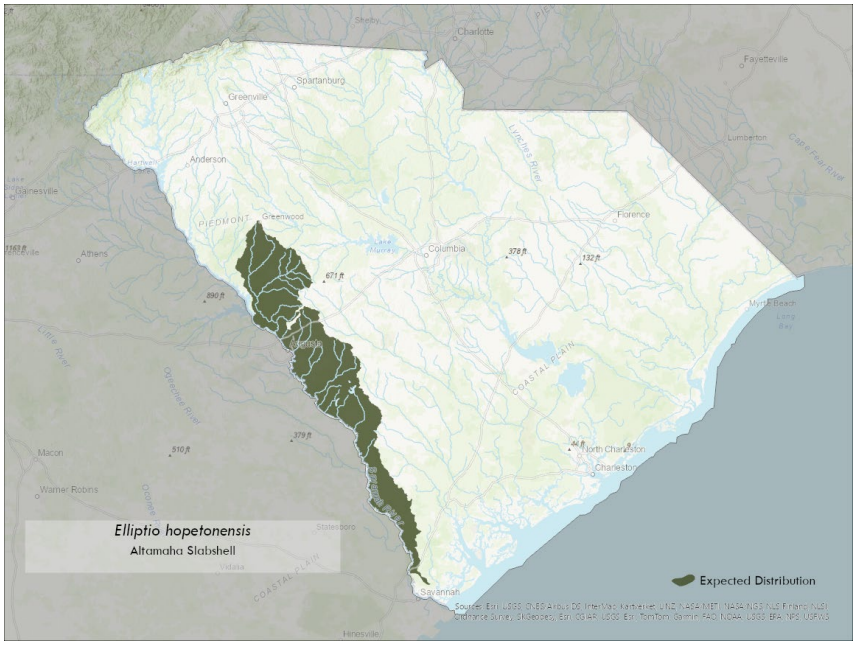


Figure 2. Expected distribution of *Elliptio hopetonensis* based on reported observations at a HUC 8 watershed level and designated ecoregion.

its recognized range (Figure 2). Targeted sampling in the Savannah River and associated tributaries is needed to determine the range of *E. hopetonensis* in South Carolina.

In 2024, SCDNR and partners in Georgia sampled a historic site in the Savannah River and documented live individuals of *E. hopetonensis*, which is the first reported observation of *E. hopetonensis* by South Carolina state entities. Although individuals of the species have been identified, genetic analysis is needed to confirm if indeed, *E. hopetonensis* is a distinct species.

Animals have been reported mostly in Georgia, including the Ocmulgee River drainage, Little Ocmulgee River tributary, Oconee River, Ohoopee River, Altamaha River drainage; however, it has also been documented in the Savannah River and potentially Turkey Creek in South Carolina.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Johnson (1970) and Heard (1975) note the species being found in sand, mud, and sandy mud and Heard (1975) note them in moderate to slack current. The individuals found in the Savannah River in 2024 were found in stable, sandy mud with clay mixed throughout.

Genetic analysis conducted on *E. hopetonensis* in upper, more urbanized, and lower reaches of the Altamaha, which are separated by some discontinuities in appropriate habitat, showed no significant structure of mitochondrial data suggesting that uniform management may be beneficial across the range of the species (Small et al. 2012).

A laboratory trial identified Eastern Mosquitofish (*Gambusia holbrooki*) and Bluegill (*Lepomis macrochirus*) as potential hosts, but no metamorphosis success was reported (O'brein et al. 2003). An additional study identified Bluegill, Fathead Minnow (*Pimephales promelas*), and Largemouth Bass (*Micropterus salmoides*) as hosts, but reported very low (<5%) metamorphosis success on all tested species (Johnson et al. 2012). Host fish interactions in the wild are unknown but the species may use an anadromous fish like other species of *Elliptio*.

O'brein et al. (2003) reported finding gravid females in the Altamaha River in April and Johnson et al. (2012) reported finding gravid females in June.

CHALLENGES

Taxonomy of this species as well as other *Elliptio* species in South Carolina need comprehensive, range-wide genetic analysis to determine which species are valid and to be recognized in the state.

As it has only been documented in South Carolina recently, little is known about the habitat preferences, abundance, and population range of the Altamaha Slabshell in South Carolina. The Altamaha Slabshell can easily be misidentified with other *Elliptio* species which make determination of the species range difficult. The Altamaha Slabshell appears rare in South Carolina, likely only occurring in the Savannah River, but little work has been done to survey the Savannah River and non-wadeable habitat in the larger Savannah Basin where this species can be

found. Little is known about the reproductive and brooding behaviors of *E. hopetonensis* and wild host fishes are unknown.

Like other freshwater mussels, the Altamaha Slabshell is sensitive to changes in water quality, habitat, and access to host fishes, although the degree of sensitivity to these changes is understudied. The natural host fishes for the Altamaha Slabshell are unknown, but like other freshwater mussels, the Altamaha Slabshell must have adequate access to species-specific hosts and relies on host fishes for reproduction and distribution. Maintaining stream connectivity for host fishes is important to allow distribution of juveniles and gene flow between populations. Environmental stressors that lead to degradation of water quality, habitat, and stream connectivity include development, agriculture, and incompatible forestry management; additionally, systemic changes that have negative effects include climate change, invasive species, and dams and barriers (USFWS 2021).

In South Carolina, practices such as mining, clearcutting for timber production, and recreational vehicle use in streams are observed to result in degradation of habitat. Preservation of a riparian buffer is needed for the continued existence of suitable habitat for most native freshwater mussels. A riparian buffer is the land area adjoining a stream, lake or wetland characterized by a cover of naturally occurring vegetation consisting of trees, shrubs, grasses, and forbs where development is restricted or prohibited.

CONSERVATION ACCOMPLISHMENTS

Listing the mussel on the 2025 South Carolina State Wildlife Action Plan.

CONSERVATION RECOMMENDATIONS

- Conduct targeted surveys in the Savannah River and tributaries to determine the range of the species in South Carolina.
- Determine the validity of the species alongside overlapping morphologies of *Elliptios.*
- Explore the need to list the Altamaha Slabshell within South Carolina.
- Determine adequate host fishes for the Altamaha Slabshell.
- Study interactions of laboratory host fishes in the wild.
- Protect critical habitats for the Altamaha Slabshell from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Altamaha Slabshell.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Research the reproductive and brooding behavior of the species.

- Conduct further research to determine the degree of sensitivity of the Altamaha Slabshell to various point and non-point sources of pollution and land use impacts.

MEASURES OF SUCCESS

- Completion of thorough, standardized surveys in presumed range and habitat of the species.
- Determination of host fishes used for reproduction of the Altamaha Slabshell.
- Determination of life history of the Altamaha Slabshell including time of spawning and brooding.
- Monitoring of wild populations of the species that show stabilization or an increase in the size of South Carolina's populations of the Altamaha Slabshell.
- Comprehensive, range-wide genetic analysis of the species alongside other overlapping *Elliptio* mussels.
- Determine the effects of channel modification, such as dams, on the Altamaha Slabshell.
- Perform outreach to relevant landowners about the importance of freshwater mussels and their habitats.
- Determination of environmental and toxicological tolerances and endpoints.

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Atlantic Spike

Elliptio producta (Conrad, 1836)

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason (SCDNR)



Figure 1. Image of *Elliptio producta* photographed by Briana Carico, SCDNR.

DESCRIPTION

Taxonomy and Basic Description

The Atlantic Spike belongs to one of the largest genera in the Unionidae family in North America with 31 species recognized in North America, Canada, and Mexico as of 2023 (FMCS 2023). The overlapping morphological variations between species and limited comprehensive genetic and morphological analysis make it difficult to tease apart valid *Elliptio* species and their ranges. Large synonymies of Elliptio species without adequate, range-wide genetic confirmation also make conservation recommendations difficult.

Oftentimes, *Elliptio* species in South Carolina fall under 3 “groups” that are characterized by generalizations of overall morphological traits. These groups are not based on comprehensive genetic and morphological research, but years of observation of morphological traits and are simply a means to aid in the understanding of morphological types seen through the *Elliptio* genus. A working list of the *Elliptio* of South Carolina can be found in Bogan and Alderman (2008).

The three groups are the lanceolata, the complanata, and icterina. The lanceolates group is comprised of species that have a greater length to heigh ratio than the complanates and include species such as *Elliptio angustata*, *Elliptio producta,* and *Elliptio folliculata*. The complanates group is comprised of species that are rather rectangular to subrhomboidal in shell outline and usually compressed; species in this group include those such as *Elliptio complanata*, *Elliptio roanokensis*, *E. fraterna*, *E. congaraea*, and *Elliptio hopetonensis*. Lastly, species in the icterina group are typically smaller in overall size, inflated, and have a waxy, dark exterior with a prominent posterior ridge; species in this group recognized to occur in South Carolina include *Elliptio icterina* and species that were synonymized by Johnson (1970).

The Atlantic Spike, like other species of *Elliptio*, has taxonomic difficulties and challenges have been ongoing with *E. lanceolata*, *E. angustata*, *E. fisheriana*, and *E. folliculata*. In (1970), Johnson considered *E. producta* a synonym of *E. lanceolata*, but Williams et al. (2017) consider *E. producta* a valid taxon distinct from *E. lanceolata*. A master’s thesis by Lohmeyer (2020)

found a high degree of haplotype sharing between *E. ahenea*, *E. angustata*, *E. producta*, *E. shepardiana,* and *E. folliculata* in the southern Atlantic slope (St. John River Drainage, FL to Neuse drainage, NC) and support synonymizing of the above species with *E. angustata* but this research has not been peer reviewed or published.

Although the species is currently recognized as valid and distinct, personal communication with biologists in agencies across the southern Atlantic slope drainage found that agencies tend to synonymize *E. angustata* and *E. producta* and refer to them as either *E. angustata* or *E. producta* and this varies across agencies in the same state and across states. For example, currently, The South Carolina Department of Natural Resources recognizes both taxa based on the Freshwater Mollusk Conservation Society (2023) names list but some independent agencies that sample within South Carolina only recognize *E. angustata* while others only recognize *E. producta*. The synonymy comes from the overwhelming overlap in the morphological characteristics of the two species and the morphological differences between lentic and lotic animals. Because of this, it is difficult to determine short- and long-term trends of the population.

The shell of the Atlantic Spike (Figure 1) is somewhat compressed and solid with a maximum length of nearly 140 mm (5.6 inches). The anterior margin is rounded and the posterior margin roundly pointed, with a low posterior ridge. The outer surface of the shell is slightly shiny, dark reddish-brown or greenish-brown in color. The inner surface may be purple (Bogan and Alderman 2004, 2008). The ventral margin sweeps upwards towards the posterior of the shell and the posterior point is typically at or above the midline of the shell.

Like other freshwater mussels, *E. producta* can be confused with other *Elliptio* species such as *Elliptio angustata* and *Elliptio folliculata*, especially when alive or young. *Elliptio producta* can be distinguished from *E. angustata* because of ventral margin sweeping up towards the midline. Animals of *E. angustata* have a posterior point towards the ventral margin, not the midline of the shell. Animals of *Elliptio folliculata* are far more compressed and have a greater length to height ratio than *E. angustata* or *E. producta*; *E. folliculata* umbo are at or below the hinge.

Status

NatureServe (2024) shows the Atlantic Spike of having a global ranking of vulnerable (G3). The species is ranked as imperiled (S2) in Pennsylvania, imperiled to vulnerable (S2S3) in Maryland, vulnerable (S3) in South Carolina, and not ranked in North Carolina or Georgia.

POPULATION SIZE AND DISTRIBUTION

The Atlantic Spike ranges from the Savannah River in Georgia to the Potomac River Basin in Maryland and Pennsylvania. Because of the overlapping morphology and the commonality of lanceolate *Elliptios* when compared to higher conservation priority species, minimal research has been completed on *E. producta* populations. In South Carolina, the species has been found across the state, but most reported observations have been in the Santee and Savannah watersheds in the piedmont regions (Figure 2).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Johnson (1970) noted that the species was found in streams or rivers with sandy, rocky, and/or muddy bottoms in sections where the current is not too rapid. Observational collections have been made in most substrate types and in different lentic and lotic environments. Like other freshwater mussels, *Elliptio producta* need stable habitat and adequate access to host fishes.

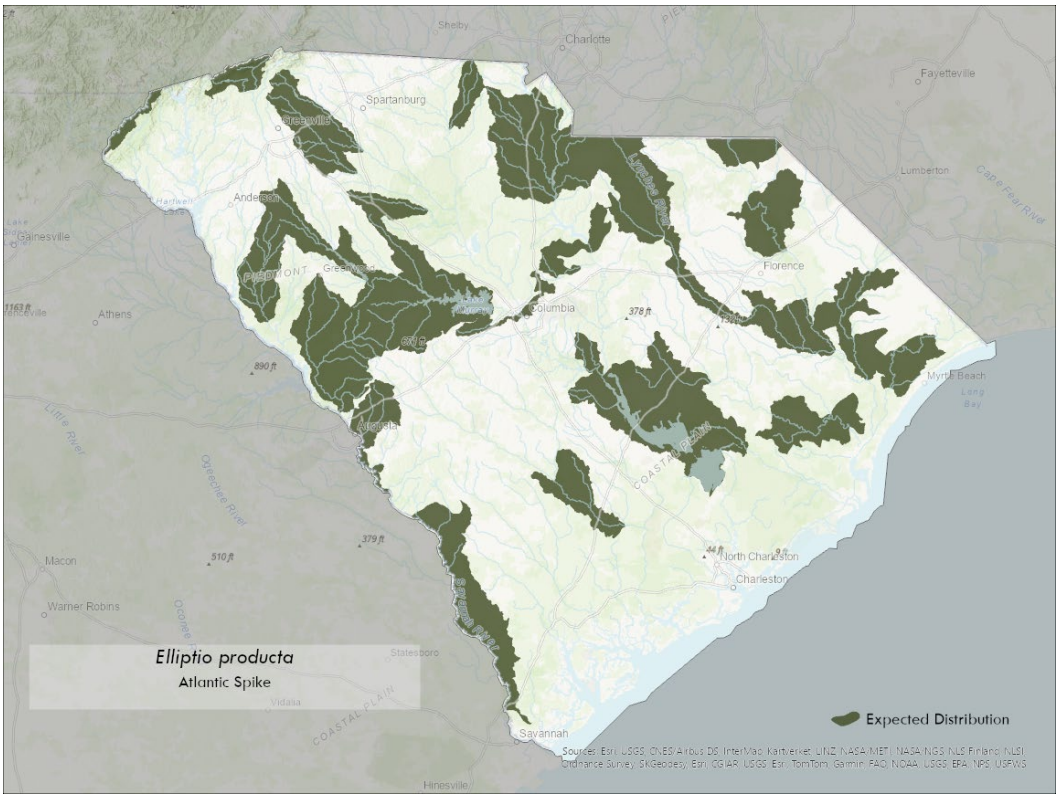


Figure 2. Expected distribution of *Elliptio producta* based on reported observations at a HUC 10 watershed level and designated ecoregion.

There are no known host fishes for the Atlantic Spike.

CHALLENGES

The greatest challenge with the Atlantic Spike is the uncertainty of taxonomy and the validity of the species against other lanceolate *Elliptio* species across the southern Atlantic slope. Like other species in the genus, comprehensive, range-wide genetic analysis is needed. There are no known host fishes for the Atlantic Spike, but the species may use an anadromous fish species like other species of *Elliptio*.

Like other freshwater mussels, the Atlantic Spike is sensitive to changes in water quality, habitat, and access to host fishes, although the degree of sensitivity to these changes is understudied. The host fish(es) for the Atlantic Spike are unknown, but like other freshwater mussels, the Atlantic Spike must have adequate access to species-specific hosts and relies on host fish(es) for reproduction and distribution. Maintaining stream connectivity for host fish(es) is important to allow distribution of juveniles and gene flow between populations. Environmental stressors that lead to degradation of water quality, habitat, and stream connectivity include development, agriculture, and incompatible forestry management; additionally, systemic changes that have negative effects include climate change, invasive species, and dams and barriers (USFWS 2021).

In South Carolina, practices such as mining, clearcutting for timber production, and recreational vehicle use in streams are observed to result in degradation of habitat. Preservation of a riparian buffer is needed for the continued existence of suitable habitat for most native freshwater mussels. A riparian buffer is the land area adjoining a stream, lake or wetland characterized by a cover of naturally occurring vegetation consisting of trees, shrubs, grasses, and forbs where development is restricted or prohibited.

CONSERVATION ACCOMPLISHMENTS

There are no significant conservation accomplishments for the Atlantic Spike currently.

CONSERVATION RECOMMENDATIONS

- Conduct comprehensive, range-wide genetic analyses of the Atlantic Spike to determine its relationship with other lanceolate species of *Elliptio*.
- Explore the need to list the Atlantic Spike within South Carolina based on survey results.
- Protect critical habitats for the Atlantic Spike from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Conduct surveys to determine habitat preferences of the species.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Atlantic Spike.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Conduct further research to determine the degree of sensitivity of the Atlantic Spike to various point and non-point sources of pollution and land use impacts.

MEASURES OF SUCCESS

- Resolving taxonomic questions regarding the relationship between the Atlantic Spike and other *Elliptio* species.
- Determination of host fish species in laboratory and wild.
- Determination of environmental and toxicological tolerances and endpoints.
- Determination of habitat preferences.
- Determination of life history of the Atlantic Spike including time of spawning and brooding.
- Perform outreach to relevant landowners about the importance of freshwater mussels and their habitats.

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Roanoke Slabshell

Elliptio roanokensis
(Lea, 1838)

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason (SCDNR).



Figure 1. Image of *Elliptio roanokensis* photographed by Briana Cairco, SCDNR.

DESCRIPTION

Taxonomy and Basic Description

The Roanoke Slabshell belongs to one of the largest genera in the Unionidae family in North America with 31 species recognized in North America, Canada, and Mexico as of 2023 (FMCS 2023). The overlapping morphological variations between species and limited comprehensive genetic and morphological analysis make it difficult to tease apart valid *Elliptio* species and their ranges. Large synonymies of Elliptio species without adequate, range-wide genetic confirmation also make conservation recommendations difficult.

Oftentimes, *Elliptio* species in South Carolina fall under 3 “groups” that are characterized by generalizations of overall morphological traits. These groups are not based on comprehensive genetic and morphological research, but years of observation of morphological traits and are simply a means to aid in the understanding of morphological types seen through the *Elliptio* genus. A working list of the *Elliptio* of South Carolina can be found in Bogan and Alderman (2008).

The three groups are the lanceolata, the complanata, and icterina. The lanceolates group is comprised of species that have a greater length to heigh ratio than the complanates and include species such as *Elliptio angustata*, *Elliptio producta,* and *Elliptio folliculata*. The complanates group is comprised of species that are rather rectangular to subrhomboidal in shell outline and usually compressed except for *E. hopetonensis*; species in this group include those such as *Elliptio complanata*, *Elliptio roanokensis*, *E. fraterna*, *E. congaraea*, and *Elliptio hopetonensis*. Lastly, species in the icterina group are typically smaller in overall size, inflated, and have a waxy, dark exterior with a prominent posterior ridge; species in this group recognized to occur in South Carolina include *Elliptio icterina* and species that were synonymized by Johnson (1970).

The Roanoke Slabshell, like other species of *Elliptio*, has taxonomic difficulties and challenges have been ongoing with *E. roanokensis, E. judithae,* and *E. complanata*. In (1970), Johnson considered *E. roanokensis* a synonym of *E. complanata*, but Williams et al. (2017) consider E. roanokensis a valid taxa and *E. judithae* a synonym for *E. roanokensis*. Clark (1986) described *E. judithae* from the Neuse River but North Carolina only recognized *E. roanokensis* in the Neuse, Tar, Roanoke, Cape Fearm and Yadkin-Pee Dee drainages. *Elliptio judithae* is not a recognized species as of the (2019) Freshwater Mollusk Conservation Society names list.

The Roanoke Slabshell is a thin, rectangular, thick shelled mussel that can grow to a length of greater than 150 mm (6 inches) (Bogan and Alderman 2004, 2008). The posterior ridge of the Roanoke Slabshell varies from well-defined to uniformly round. The outer surface of the shell is smooth, except near shell margins, and is generally yellowish/reddish-brown. The color of the Roanoke Slabshell darkens with age; narrow greenish rays are often present but are less distinct in larger individuals. The inner surface of the shell is usually purple.

Like other freshwater mussels, the Roanoke Slabshell can be confused with other *Elliptio* species such as *Elliptio complanata*, especially when alive or young. The Roanoke Slabshell can be distinguished from the Eastern Elliptio due to the thick, rectangular, compressed shell of the Roanoke Slabshell. The Roanoke Slabshell also gets larger than the Eastern Elliptio.

Status

NatureServe (2024) currently identifies the global ranking for this species as vulnerable (G3). The Roanoke Slabshell is ranked imperiled in Georgia and Virginia (S2), imperiled to vulnerable in South Carolina (S2S3), and vulnerable in North Carolina (S3).

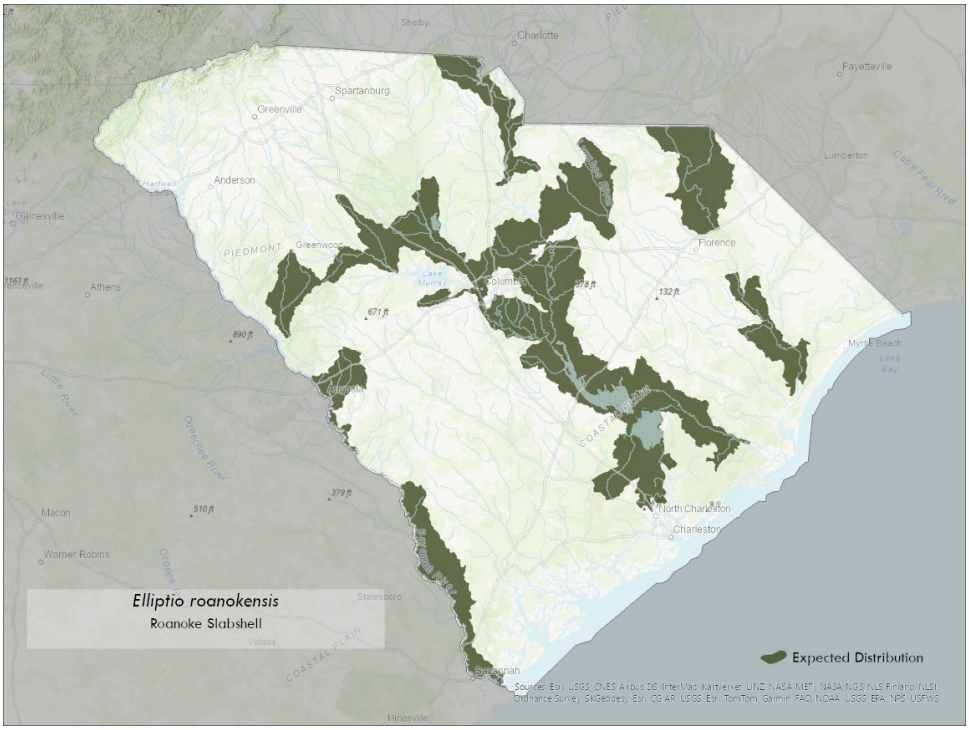


Figure 2. Expected distribution of *Elliptio roanokensis* based on reported observations at a HUC 10 watershed level and designated ecoregion.

POPULATION SIZE AND DISTRIBUTION

Walter (1954) considered the range of the Roanoke Slabshell to be from the Connecticut River in Massachusetts to the Altamaha River in Georgia.

The species is currently recognized in Georgia, South Carolina, North Carolina, and Virginia. In South Carolina, it is found in the main stem of the Pee Dee River and in the Catawba, Congaree, and Savannah River drainages (Figure 2). In South Carolina, the Roanoke Slabshell is relatively common in several sites in the Pee Dee, Savannah and Congaree Rivers.

NatureServe (2024) identifies the Roanoke and Chowan populations as nearly extirpated and the Tar, Neuse, Cape Fear, Savannah, and Pee Dee populations as significantly reduced; however, there have been no definitive population studies conducted for the species. The Catena Group (2006) notes collecting individuals from the Great Pee Dee River, but collections are dominated by large, older individuals suggesting low recruitment of the species.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Roanoke Slabshell is found in large rivers but can occasionally be found in small creeks. The Catena Croup (2006) notes the species being found in deep run habitats dominated by coarse sand/pea gravel with swift flow in the Pee Dee River drainage. Through modeling, Pandolfo et al. (2016) found *E. roanokensis* suited to coarse gravel habitats with deeper and swifter waters. The Roanoke Slabshell may be able to tolerate large variations in flow levels and higher water temperatures, making it able to survive in some locations near dams and hydroelectric plants, but specific endpoints and tolerances are unknown. The species has experienced large die-offs when the plants generate extremely low flows and cause levels of oxygen to drop (Taxonomic Expertise Committee 2004).

The Roanoke Slabshell, like the Eastern Elliptio, is capable of at least 2 broods during one season and the brood cycle may be as short as 18 days (Price and Eads 2011). Brooding *E. roanokensis* were collected from late March to late June and water temperatures were 14.5°C when *E. roanokensis* were collected already gravid (Price and Eads 2011).

Laboratory trials found Blueback Herring, Gizzard Shad, and White Perch served as hosts for the Roanoke Slabshell; encystment lasted 10-16 days (Eads et al. 2015). Price and Eads (2011) found that brooding periods of Roanoke Slabshell are associated with temperatures of 14-18°C, and Eads et al. (2015) suggests that the timing of Blueback Herring and American Shad spawning makes them the most likely natural hosts. Additional work by Wardell and Eads found American Shad to be a confirmed host in laboratory trials (Eads person. Comm. 2024).

CHALLENGES

Like other *Elliptio*, there are taxonomic challenges that need to be sorted through comprehensive, range-wide genetic analysis.

The Roanoke Slabshell, like many freshwater mussel species, is vulnerable to water fluctuations caused by channel modifications such as dams. Not only do the dams directly affect the Roanoke Slabshell by altering flow and habitat, but they act as a barrier for host fishes which is the only means of dispersal for the Roanoke Slabshell. Dams create physically isolated mussel populations in the same river reach and without fish passage, upstream populations could be extirpated due to the lack of anadromous fish, the hosts needed for Roanoke Slabshell

reproduction. Juveniles are rarely found above dams that prohibit fish passage, but Roanoke Slabshell mussels often return to these areas following efforts to facilitate fish passage.

Additionally, shifts in substrates due to development and sedimentation are likely to directly interfere with the Roanoke Slabshell as it seems to prefer coarse gravel. The Roanoke Slabshell, and many other mussels, face challenges due to anthropogenic pollutants, poor land management, channel modification, and clearing of riparian buffers. Changes to the habitat that do not directly affect the mussels may affect their host fishes and without adequate access to species-specific hosts, reproduction cannot occur.

CONSERVATION ACCOMPLISHMENTS

The brooding season of *E. roanokensis* has been studied in the Broad River (Price and Eads 2011).

CONSERVATION RECOMMENDATIONS

- Comprehensive, range-wide genetic analysis.
- Explore the need to list the Roanoke Slabshell within South Carolina.
- Closely monitor Roanoke Slabshell populations near dams for changes in population density.
- Work with other state agencies (DHEC) to determine appropriate minimum flows to protect the Roanoke Slabshell.
- Recommend minimum flows during the FERC relicensing process.
- Facilitate the travel of anadromous fishes by keeping rivers and streams free of artificial obstructions or by using fish ladders at dams.
- Monitor areas upstream of fish ladders or locations where obstructions have been removed to determine if the Roanoke Slabshell has extended its range upstream.
- Protect critical habitats for the Roanoke Slabshell from future development and further habitat degradation by following Best Management Practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Roanoke Slabshell.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Conduct further research to determine the degree of sensitivity of the Roanoke Slabshell to various point and non-point sources of pollution and land use impacts.
- Verify wild host fishes.

MEASURES OF SUCCESS

- Persistence of identified populations of the Roanoke Slabshell.

- Increases in populations or population size of Roanoke Slabshell.
- Achieving minimum flows from dams.
- Achieving fish passage through in-stream obstacles and dams.
- Determination of ecological and toxicological tolerances and endpoints.
- Verification of host fishes in the wild.

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Atlantic Pigtoe

Fusconaia masoni

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason (SCDNR)



Figure 1. Image of *Fusconaia masoni* courtesy of the North Carolina Museum of Natural Sciences, Jamie Smith, and Dr. Art Bogan. The NCMNS catalog number of the specimen photographed is 12275.

DESCRIPTION

Taxonomy and Basic Description

The shell of the Atlantic Pigtoe is subrhomboidal in shape, but individuals from headwater areas are more elongate. There is a distinct posterior ridge. The outer surface of the shell is yellow to dark brown and parchment like, while the inner surface is iridescent blue to salmon, white, or orange. Its small shell is generally less than 50 mm (2.2 in.) in length (Bogan and Alderman 2004, 2008).

The Atlantic Pigtoe, like many other native freshwater mussels, can easily be confused with other species such as *Elliptio congaraea*, especially when alive. The Atlantic Pigtoe mussel does not get as large as the Carolina Slabshell and is more triangular in appearance than the Carolina Slabshell. The Carolina Slabshell also usually has noticeable plications on the posterior slope.

Status

The Atlantic Pigtoe is a state endangered species in South Carolina. NatureServe (2024) currently identifies the Atlantic Pigtoe as having a global status of critically imperiled (G1). It is listed as possibly extirpated (SH) in South Carolina and ranked as critically imperiled (S1) in Georgia. In North Carolina it is ranked vulnerable (S3) and in Virginia it is ranked as imperiled (S2). In November 2021, the Atlantic Pigtoe was federally listed as threatened. Additionally, roughly 563 river miles (906 river kilometers) were designated and fall within 17 units of critical habitat (USFWS 2021).

POPULATION SIZE AND DISTRIBUTION

This species originally ranged from the James River Basin in Virginia to the Ogeechee River basin in Georgia, but its range has been steadily declining. In South Carolina, it was once found in the Savannah River drainage, but had not been collected in the State for over 100 years (Bogan and Alderman 2004, 2008). It is difficult to determine the timing of the decline, since few surveys were conducted for the Atlantic Pigtoe throughout the 1900s. This species was probably historically widespread in South Carolina; it is currently found in the Pee Dee River and Goose Creek in North Carolina. There are only historical records or shell material of the species in South Carolina, and it is possible that this species has been extirpated from the state.

Remnant populations could still exist in the state but targeted, comprehensive surveys in historical and suitable habitat are needed.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The preferred habitat of the Atlantic Pigtoe is coarse sand and gravel at the downstream edge of riffles. It is less common in sand, cobble, and mixtures of sand, silt, and detritus (Bogan and Alderman 2004, 2008). The Atlantic Pigtoe requires fast-flowing, well oxygenated streams and is typically found in medium to large rivers. Pandolfo et al. (2016) found through modeling that *V. constricta* and *F. masoni* had similar suitable habitat including moderately penetrable gravels and cobble with boulders and woody debris providing most suitable cover for the species; it was noted that *F. masoni* suitable habitat was slightly deeper and faster flowing that *V. constricta*.

The Atlantic Pigtoe mussel is a short-term brooder, brooding larvae (glochidia) for roughly 30-60 days before releasing them and fecundity can vary greatly (Rash and Neeves 2005). The Atlantic Pigtoe does not do well with environmental and water quality changes which make studying life history difficult. It has been noted that brooding females will abort glochidia due to environmental changes and transport and glochidia are not viable after 24 hours, making laboratory trials difficult (Black 2001). Brooding Atlantic Pigtoe mussels have been collected from mid-May and early-June (Wolf 2012). Conglutinates are semi-buoyant, pinkish, and average ~5mm in length (Wolf 2012)

Laboratory trials show transformation of juveniles on Bluegill, Shield Darters, Whitefin Shiner, and Satinfin Shiner but transformation success for all species was low (Watters and O'Dee 1997; O'Dee and Watters 2000; Rash and Neeves 2005). Higher transformation success was seen with Longnose Dace, Creek Chub, and Rosefin Shiner (Wolf and Emrick 2011). It is likely that the Atlantic Pigtoe utilizes the feeding behavior of minnows to reproduce and further research into host fish interactions in the wild are needed.

CHALLENGES

The Atlantic Pigtoe is a species of mussel that is vulnerable to local extirpation and without conservation measures, will be vulnerable to extinction. Data collection from 2005-2019 indicate only 7 viable populations of the species in Virginia and North Carolina, presumably occupying only 40% of its historic range (USFWS 2021). Only 3 of the 7 viable populations have documented multiple occurrences from 2005-2019.

With small, fragmented populations, successful wild reproduction is of concern; but due to the life history of the species, assisted propagation of the species is also a challenge. The Atlantic Pigtoe is a short-term brooder and only broods for a period of roughly 30-60 days before expelling larvae. This short window of time makes laboratory propagation of the species more difficult than species that have a longer window of larvae viability.

The Atlantic Pigtoe seems to be extremely vulnerable to changes in water quality, in-stream substrate, and habitat connectivity (USFWS 2021). Environmental stressors that lead to degradation of water quality, habitat, and stream connectivity include development, agriculture,

and incompatible forestry management; additionally, systemic changes that have negative effects include climate change, invasive species, and dams and barriers (USFWS 2021).

One of the healthiest, most viable populations of this species was recently lost in Virginia and the populations in North Carolina are not doing well (Taxonomic Expertise Committee 2004). A recent study determined that the glochidia (larvae) of the Atlantic Pigtoe are extremely sensitive to pollution. Levels of ammonia far below USEPA criteria maximum concentrations caused the death of glochidia (Augspurger et al. 2003).

CONSERVATION ACCOMPLISHMENTS

In November 2021, the Atlantic Pigtoe was federally listed as threatened and roughly 563 river miles (906 river kilometers) were designated and fall within 17 units of critical habitat (USFWS 2021). The species is listed as state endangered in South Carolina.

CONSERVATION RECOMMENDATIONS

- Conduct targeted, comprehensive surveys in historical and suitable habitats to see if remnant populations are in South Carolina.
- If South Carolina populations are rediscovered, protect land near these populations and upstream from where they are found should be protected through land acquisition and conservation easements.
- If populations are rediscovered, completing population genetics to determine population size and genetic variation is needed.
- Consider reintroduction of the Atlantic Pigtoe in relatively pristine, high-quality habitat in South Carolina. Partner with North Carolina and or Georgia in these efforts.
- Protect critical habitats for the Atlantic Pigtoe from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Atlantic Pigtoe.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process and conduct surveys to determine if it is present prior to major projects.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

- Completion of targeted sampling efforts in the historical ranges and at sites with suitable habitat.
- If populations are found, completion of population genetics.
- If augmentation or reintroduction efforts are established, survival of the species would be success.
- Successful propagation of the species.

- Research into the life history of the species and their interactions with hosts in the wild.

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Yellow Lampmussel

Lampsilis cariosa

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason (SCDNR)



Figure 1. Images of male (top) and female (bottom) *Lampsilis cariosa* photographed by Briana Cairco, SCDNR.

DESCRIPTION

Taxonomy and Basic Description

The shell of the Yellow Lampmussel (Figure 1) is obovate (egg-shaped) in shape and moderately inflated with the anterior margin rounded, the ventral margin slightly curved, and the posterior margin bluntly rounded. The posterior ridge is poorly developed and rounded. Males have a gently curved ventral margin; the females have a distinct posterior swelling. The outer surface of the shell is waxy, shiny, and yellow but can become stained brown in certain habitats. Some shells may exhibit a trace of green. Thin dark rays are absent from the shell or restricted to the posterior slope. Older specimens are brownish and not as shiny. The inner surface of the shell is bluish-white and may be tinged with cream or salmon. The shell length of adults is approximately 120 mm (4.8 in.) (Bogan and Alderman 2004, 2008).

Female *L. cariosa* produce a modified mantle lure that mimics a small prey item to attract host fishes. Most lures have an eyespot but can range in complexity. Lures have mimicked shiners, minnows, and sunfish. Yellow Lampmussel females are long term brooders and have been found gravid from March-October, but gravidity is likely temperature dependent (Martell 2020).

This species is fairly distinct but small individuals can sometimes be mistaken with Atlanticoncha ochracea when living.

Status

NatureServe (2024) currently identifies the Yellow Lampmussel as having a global ranking of vulnerable (G3). It is ranked as vulnerable (S3) in North Carolina and Georgia and (S3?) in South Carolina. The species is presumed extirpated and critically imperiled in several northeastern states. The Yellow Lampmussel is a species of special concern.

POPULATION SIZE AND DISTRIBUTION

The Yellow Lampmussel ranges from the Ogeechee River Basin in Georgia to Nova Scotia, Canada. In South Carolina (Figure 2), it is found in the Steven's Creek sub-basin, and the Savannah, Wateree, Congaree, and Pee Dee River Basins (Bogan and Alderman 2004, 2008). The Congaree and Pee Dee Rivers may contain the best populations in the State. In South Carolina, there have been 114 total reported observations of the species with most reports from the Savannah River basin.

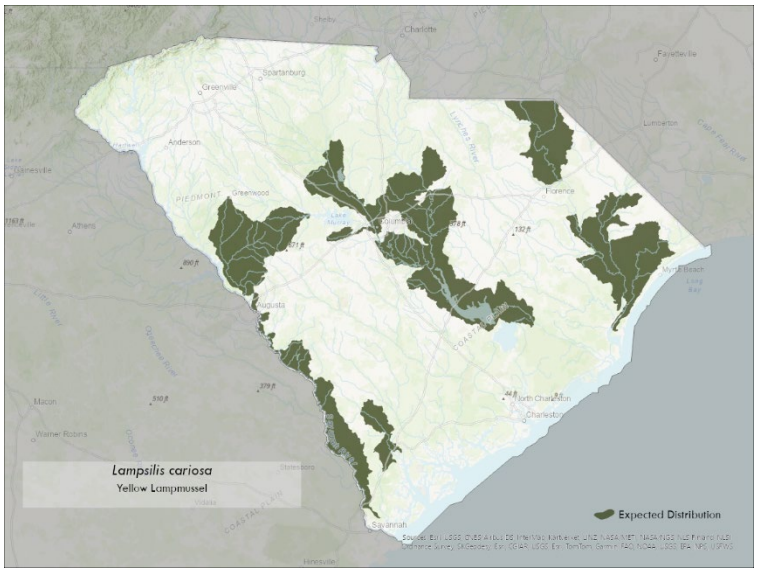


Figure 2. Expected distribution of *Lampsilis cariosa* based on reported observations at a HUC 10 watershed level and designated ecoregions.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Yellow Lampmussel can be found in gravel bars and stable sandbanks (Sabine et al. 2004) in the margins of the flowing portions of water bodies, and in cracks in bedrock in moderate to large rivers. Most observations of the Yellow Lampmussel in South Carolina have been in large rivers which have been under surveyed by state agencies.
Laboratory trials show successful transformation on largemouth bass, black crappie, white bass, striped bass, white perch, and yellow perch (Eads et al. 2007, 2015; Martell 2020) White perch and yellow perch were confirmed host fishes in the wild (Kneeland and Rhymer 2008).

CHALLENGES

This species is known to have rapid decreases in population sizes across its historic ranges. The specific challenges for the species are not well understood but are associated with pollution from industry, agriculture, and energy production and invasive species (Williams et al. 1993; Nedeau et al. 2000; Sabine et al. 2004; Kelly and Rhymer 2005; Bogan and Woolnough 2017). The species is often found in large rivers and the impacts of impoundments on the species is not documented in South Carolina.

Like other freshwater mussels, the Yellow Lampmussel is sensitive to changes in water quality, habitat, and access to host fishes, although the degree of sensitivity to these changes is understudied. Yellow Lampmussel must have adequate access to species-specific hosts and relies on host fishes for reproduction and distribution. Maintaining stream connectivity for host fishes is important to allow distribution of juveniles and gene flow between populations. Impoundments can lead to disjunct populations which have reduced genetic variation which could cause localized extirpation (Kelly and Rhymer 2005). Environmental stressors that lead to degradation of water quality, habitat, and stream connectivity include development, agriculture, and incompatible forestry management; additionally, systemic changes that have negative effects include climate change, invasive species, and dams and barriers (USFWS 2021).

In South Carolina, practices such as mining, clearcutting for timber production, and recreational vehicle use in streams are observed to result in degradation of habitat. Preservation of a riparian buffer is needed for the continued existence of suitable habitat for most native freshwater mussels. A riparian buffer is the land area adjoining a stream, lake or wetland characterized by a cover of naturally occurring vegetation consisting of trees, shrubs, grasses, and forbs where development is restricted or prohibited.

CONSERVATION ACCOMPLISHMENTS

In 2023, a working group involving state and federal agencies and other stakeholders throughout the species range was created and opens communication across the range for conservation and management of the species moving forward. In 2024, SCDNR provided genetic material to other agencies for analysis and also provided wild collected gills of presumed host fishes for analysis to a different agency.

CONSERVATION RECOMMENDATIONS

- Conduct surveys to document the extent of distribution and population size and range of the Yellow Lampmussel.
- Explore the need to upgrade the listing of the Yellow Lampmussel in South Carolina, based on survey results.
- Determine habitats that are critical for this species in South Carolina.
- Perform host fish trials to determine natural hosts for native populations.
- Conserve populations of host fish to insure reproduction of the Yellow Lampmussel in the wild.
- Protect critical habitats for the Yellow Lampmussel from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Yellow Lampmussel.
- Encourage responsible land use planning.
- Work to improve minimum flows and restoration of more natural hydrologic regimes in the Savannah River.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Conduct further research to determine the degree of sensitivity of the Yellow Lampmussel to various point and non-point sources of pollution and land use impacts.
- Conduct a thorough search of museum records for the Yellow Lampmussel and determine if there are any additional historical records for this species.
- Conserve populations of host fish to insure reproduction of the Yellow Lampmussel in the wild.
- Develop a restoration plan that considers the need for augmentation or reintroduction.
- Consider species needs when participating in the environmental permit review process.

MEASURES OF SUCCESS

- Completion of targeted surveys in areas of historic occupancy and similar habitat types in the Savannah Basin.
- Work to reduce or halt further disturbance to the habitat and natural hydrology of the Savannah River.
- Perform outreach to relevant landowners about the importance of freshwater mussels and their habitats.
- Comprehensive, range-wide genetic analysis of the species.
- Completion of thorough, standardized surveys in presumed range and habitat of the species.
- Determination of host fishes used for reproduction of the Yellow Lampmussel.

- Monitoring of wild populations of the species that show stabilization or an increase in the size of South Carolina's populations of the Yellow Lampmussel
- Determine the effects of channel modification, such as dams, on the Yellow Lampmussel.
- Determination of environmental and toxicological tolerances and endpoints.

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Rayed Pink Fatmucket
Lampsilis splendida (Lea 1838)

Eastern Lampmussel
Lampsilis radiata (Gmelin 1791)

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason and Morgan Kern (SCDNR)



Figure 1. Images of male (top) and female (bottom) *Lampsilis splendida* photographed by Briana Cairco, SCDNR.

Taxonomy and Basic Description

These two species are discussed together in this document due to taxonomic uncertainty. These species may represent geographical variation and phenotypic plasticity of a single species. Phenotypic plasticity, in this document, refers to non-heritable variation of size, shape, and coloration of individuals due to environmental parameters such as, but not limited to, substrate, shear stress, stream size, water chemistry, etc., that the individuals interact with during life.



Figure 2. Images of male (top) and female (bottom) *Lampsilis radiata* photographed by Briana Cairco, SCDNR.

In (1998), Turgeon et al. recognized nominal *L. radiata* and a single subspecies, *L. r. conspicua* but (Stiven and Alderman 1992) point to molecular and morphological data not supporting *L. r. conspicua* as distinct. Williams et al. (2017) placed both *L. r. conspicua* and *L. fullerkati* into synonymy with *L. radiata* based on molecular data from McCartney et al. (2016); this was a change from Turgeon et al. (1998) which recognized *L. fullerkati* as distinct. As of (2023), the Freshwater Mollusk Conservation Society does not recognize *L. r. conspicua* or *L. fullerkati* but does recognize *L. splendida* and *L. radiata*.

A Nei genetic identity value is a measure used in population genetics to quantify genetic similarity between populations and is calculated based on the proportion of shared alleles; the index ranges from 0 (no shared alleles) to 1 (identical). Kat (1983) calculated a Nei genetic

identity value based on electrophoresis of *L. splendida* and *L. radiata* found that *L. splendida* resembles *L. radiata* at a level of 0.805 ± 0.003 but maintained *L. radiata* and *L. splendida* as distinct species (Kat 1983). Additionally, Kat (1983) found that the stomach anatomy of L. splendida and L. radiata was 67% similar.

Comprehensive, range-wide genetic analysis is needed to determine if L. radiata and L. splendida are both valid taxa.

Individuals identified as *Lampsilis splendida* (Figure 1) have an elongate shell that is oval and greatly inflated. The anterior end is rounded. The posterior end of the shell is sexually dimorphic; in the male, this area is bluntly pointed, and in the female, it is more broadly rounded. There is a sharp posterior ridge and sometimes a secondary ridge on the shell of these species. The outer surface of the shell is wrinkled with a fuzzy appearance and is yellowish-green to reddish-brown in color. Further, the outer surface of the shell has numerous green rays that may become dark brown and obscured in older specimens. The inner surface of the shell varies from bluish-white to pinkish or purple and is iridescent. Rayed Pink Fatmucket mussels attain lengths of approximately 110mm (4.4 in.) (Bogan and Alderman 2004, 2008).

Individuals identified as the *Lampsilis radiata* (Figure 2) have shells that are subelliptical to subovate in shape, with the anterior end rounded. The shells of the male are elongated and not expanded posteriorly, while the shells of females are expanded in the postbasal area. The posterior ridge is low to absent. The outer surface of the Eastern Lampmussel shell is yellowish- or brownish-green with poorly defined dark green or black rays over the entire surface. The inner surface is white, pink, or salmon-colored. The shell may be greater than 120 mm (4.8 in.) in length (Bogan and Alderman 2004, 2008).

Observations of museum specimens show that mussels identified as *L. splendida* had thinner shells and a more prominent posterior ridge than those identified as *L. radiata*, but these morphological differences could be a result of geographical variation and phenotypic plasticity.

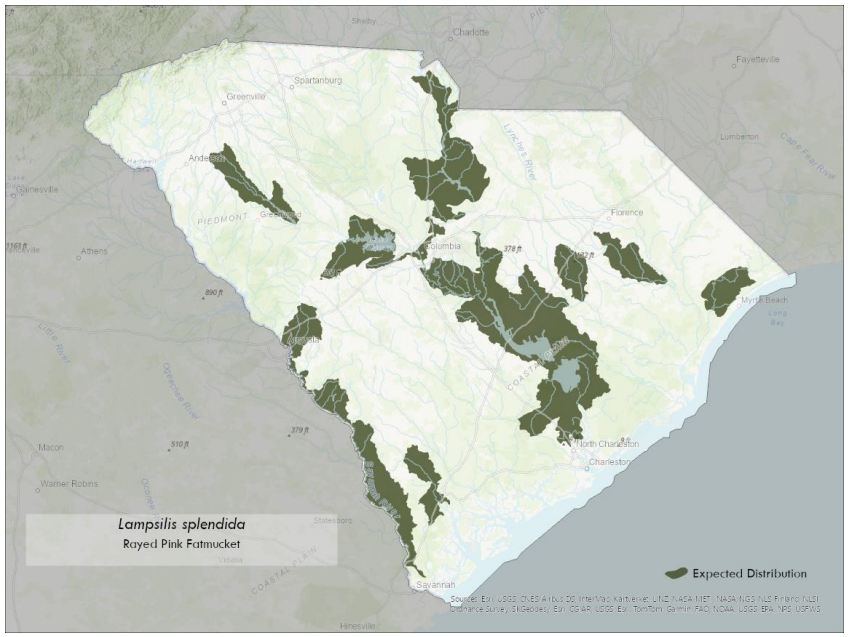


Figure 3. Expected distribution of *Lampsilis splendida* based on reported observations at a HUC 10 watershed level and designated ecoregions.

Status

The Rayed Pink Fatmucket is currently considered a species of special concern in South Carolina. NatureServe (2024) currently identifies *L. splendida* with a global status of vulnerable

(G3). In North Carolina, the species is ranked critically imperiled (S1), in South Carolina the species is ranked imperiled (S2?), and in Georgia the species is ranked vulnerable (S3).

NatureServe (2024) currently identifies the Eastern Lampmussel as secure globally (G5). In West Virginia the species is ranked critically imperiled (S1), in Virginia it is ranked as imperiled to vulnerable (S2S3), in North Carolina it is ranked vulnerable (S3), and in South Carolina it is ranked imperiled (S2?).

POPULATION SIZE AND DISTRIBUTION

Mussels currently classified as *L. splendida* are found from the Altamaha and Ogeechee Rivers in Georgia to the Cape Fear River Basin in North Carolina. In South Carolina, the species has been reported in the piedmont, sandhills, and coastal plain regions in all four major watersheds (Figure 3). Most reported observations come from the coastal plain region in and around Lake Marion and Lake Moultrie. There are also several reported observations throughout the Savannah River. Other observations have been made in Lake Greenwood, Lake Murray, and the Congaree and Wateree Rivers.

The Eastern Lampmussel (*L. radiata*), is globally more widespread and has a more northern distribution, reaching its southern limit in the Santee-Cooper basin South Carolina. In South Carolina, there are fewer reported observations of this species which have only been reported in the Santee and Pee Dee watersheds (Figure 4). Observations have been reported in the piedmont, sandhills, and coastal plain regions. Most observations of *L. radiata* were around Lake Greenwood and Lake Marion. A single observation has also been reported in the Waccamaw River.

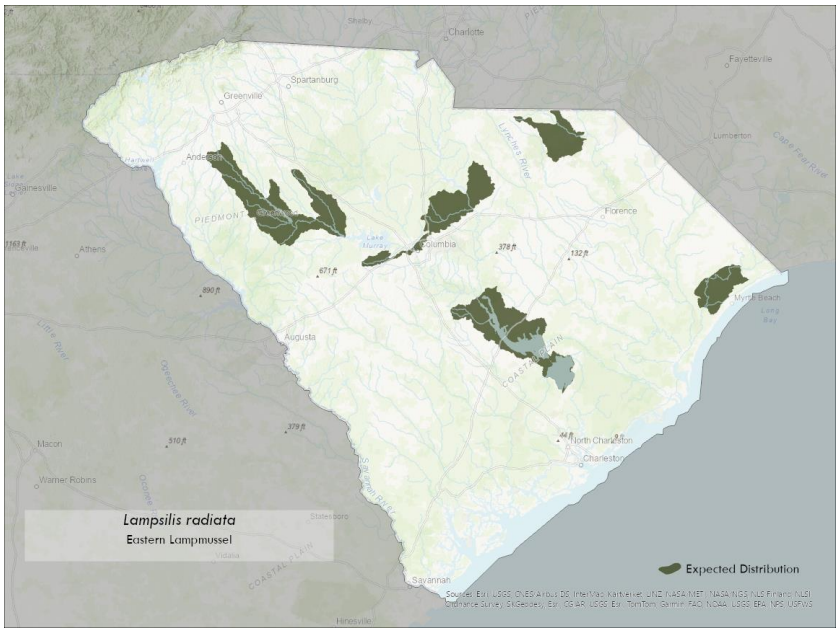


Figure 4. Expected distribution of *Lampsilis radiata* based on reported observations at a HUC 10 watershed level and designated ecoregions.

A gradient of phenotypes of both species are found in South Carolina and some individuals collected are difficult to give an ID to because they resemble both *L. radiata* and *L. splendida*. Overlapping morphology and misidentification make it difficult to determine population ranges.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Both the Rayed Pink Fatmucket and the Eastern Lampmussel are found in swift waters of large rivers on sand bars and gravelly areas as well as muddy and sandy areas in streams, and blackwater swamps. Meador et al. (2011) reported a catch per unit effort range of 7.0-15.0 individuals per person hour in slack water depending on sampling season in the Altamaha River. Through modeling, and the assumption that mussel abundance is an indicator of habitat preference, *L. splendida* preferred slack water and pool habitats in the Altamaha River (Meador et al. 2011).

Johnson et al. (2012) report collecting gravid *Lampsilis splendida* in the Altamaha River in October with a water temperature of 26°C. Meador et al. (2011) report collecting gravid females (15% of all *L. splendida* collected) during autumn, defined as (15°C < t < 25°C with decreasing temperature from the previous time period).

The Largemouth Bass was found as a suitable host fish in laboratory trials with a reported metamorphosis success (%) of 43.0 ± 5.5 (Johnson et al. 2012). Glochidia of Eastern Lampmussel have been found attached to Yellow Perch, Black Crappie, Smallmouth Bass, Largemouth Bass (Telda and Fernando 1969).

CHALLENGES

Eastern Lampmussel in South Carolina represent the southern edge of this species range. Because it is a more northern species, rising water temperatures may lead to local extirpation but research is needed to determine thermal tolerances of the species. Similarities in morphology between Eastern Lampmussel and Rayed Pink Fatmucket lead to difficulties in field ID which make it difficult to determine population ranges in South Carolina. The Eastern Lampmussel appears less abundant than Rayed Pink Fatmucket in South Carolina based on reported observations, but little work has been done to survey non-wadeable habitat where both species can be found. Due to overlapping morphologies, comprehensive genetic analysis is needed to determine if *L. radiata* and *L. splendida* are distinct species. Little is known about the reproductive and brooding behaviors of *L. splendida and L. radiata* and wild host interactions have not been studied.

Like other freshwater mussels, both the Rayed Pink Fatmucket and Eastern Lampmussel are sensitive to changes in water quality, habitat, and access to host fishes, although the degree of sensitivity to these changes is understudied. The Rayed Pink Fatmucket and Eastern Lampmussel must have adequate access to species-specific hosts and relies on host fishes for reproduction and distribution. Maintaining stream connectivity for host fishes is important to allow distribution of juveniles and gene flow between populations. Environmental stressors that lead to degradation of water quality, habitat, and stream connectivity include development, agriculture, and incompatible forestry management; additionally, systemic changes that have negative effects include climate change, invasive species, and dams and barriers (USFWS 2021).

In South Carolina, practices such as mining, clearcutting for timber production, and recreational vehicle use in streams are observed to result in degradation of habitat. Preservation of a riparian buffer is needed for the continued existence of suitable habitat for most native freshwater mussels. A riparian buffer is the land area adjoining a stream, lake or wetland characterized by a

cover of naturally occurring vegetation consisting of trees, shrubs, grasses, and forbs where development is restricted or prohibited.

CONSERVATION ACCOMPLISHMENTS

A small number of individuals of Eastern Lampmussel were reared in captivity, and 11 tagged mussels were released in the lower Broad River in 2010 (C. Eads, pers. comm.).

CONSERVATION RECOMMENDATIONS

- Conduct comprehensive genetic analyses across the known ranges of both the Rayed Pink Fatmucket and Eastern Lampmussel and determine validity of species and range of species.
- Monitor population trends of the Rayed Pink Fatmucket and Eastern Lampmussel.
- Protect critical habitats for the Rayed Pink Fatmucket and Eastern Lampmussel from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Rayed Pink Fatmucket and Eastern Lampmussel.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Perform host fish trials to determine natural hosts for native populations of Rayed Pink Fatmucket and Eastern Lampmussel.
- Study interactions of laboratory host fishes in the wild with Rayed Pink Fatmucket and Eastern Lampmussel.
- Conserve populations of host fish to insure reproduction of the Rayed Pink Fatmucket and Eastern Lampmussel in the wild.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Conduct further research to determine the degree of sensitivity of the Rayed Pink Fatmucket and Eastern Lampmussel to various point and non-point sources of pollution and land use impacts.
- Work to improve minimum flows and restoration of more natural hydrologic regimes in river systems with suitable habitat for Rayed Pink Fatmucket and Eastern Lampmussel.

MEASURES OF SUCCESS

- Completion of targeted surveys in areas of historic occupancy and similar habitat types in the PeeDee Basin, Savannah Basin, and Santee-Cooper.
- Determine the host fish(es).
- Collection of genetic swabs of and Rayed Pink Fatmucket and Eastern Lampmussel to ensure successful identification of species range and distribution.
- Determine the effects of channel modification, such as dams, on the Rayed Pink Fatmucket and Eastern Lampmussel.

- Perform outreach to relevant landowners about the importance of freshwater mussels and their habitats.
- Determination of environmental and toxicological tolerances and endpoints.
- Determination of life history of the Rayed Pink Fatmucket and Eastern Lampmussel including time of spawning and brooding.

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Carolina Heelsplitter

Lasmigona decorata (Lea 1852)



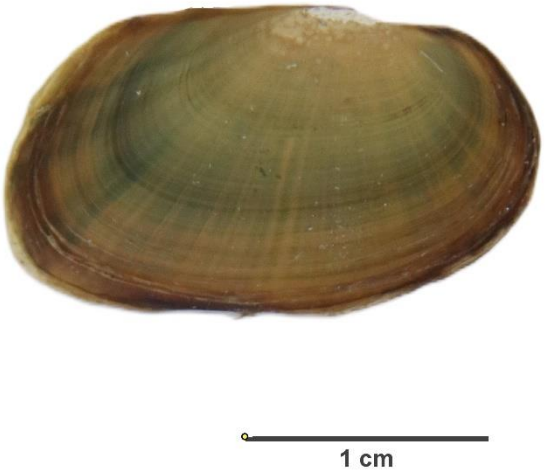
Figure 1. Images of wild *Lasmigona decorata* photographed by Briana Cairco, SCDNR.

Taxonomy and Basic Description

The shape of the Carolina Heelsplitter's shell is an ovate trapezoid with a straight dorsal margin that may end with a slight wing (Figures 1-3). The ventral margin is straight. The umbo is above the hinge. The outer surface of the shell is yellowish, greenish, or brownish and may have greenish or blackish rays. The inner shell surface ranges from iridescent white to mottled pale orange. The Carolina Heelsplitter shell can reach up to 118 mm (4.7 in.) in length; the mean shell length for this species is 78mm (3.1 in.) (Bogan and Alderman 2004, 2008).

Status

This is currently the only mussel species in South Carolina that is federally listed as endangered. NatureServe (2024) identifies the Carolina Heelsplitter as critically imperiled globally (G1) and critically imperiled in North and South Carolina (S1).



POPULATION SIZE AND DISTRIBUTION

The Carolina Heelsplitter is endemic to North and South Carolina. In 1993, Carolina Heelsplitter was listed as federally endangered with six critical habitat units designated in 2002. Five of these critical habitat units are in South Carolina. There are 11 surviving populations and all, but one, population can be found in South Carolina (USFWS 2019).



Figure 2. Image of hatchery produced *Lasmigona decorata* photographed by Briana Cairco, SCDNR. The specimen is from cohort 2302LdA-C.

The Pee Dee River System is home to two populations: Goose Creek/Duck Creek population found in Union County, North Carolina and Flat Creek/Lynches River in Lancaster, Kershaw, and Chesterfield Counties, South Carolina. The Catawba River System has 5 populations. Waxhaw Creek population found in Union County, North Carolina, and Lancaster County, South Carolina. Sixmile Creek population, found in Union and Mecklenburg Counties, North Carolina, and Lancaster County, South Carolina. Gills Creek/Cane Creek population in Lancaster County, South Carolina. Fishing Creek/South Fork Fishing Creek population found in Chester County, South Carolina and Bull Run Creek/unnamed tributary to Bull Run Creek/Beaverdam Creek/Hooper Branch (Rocky Creek population) found in Chester County of South Carolina. The Saluda River System has two populations, the Red Bank Creek population and the Halfway Swamp Creek populations found in Saluda County, South Carolina. The Savannah River System has two

populations, Turkey Creek/Mountain Creek/Beaverdam Creek/Sleepy Creek/Little Stevens Creek/Rocky Creek/Log Creek (Turkey Creek population) found in Edgefield and McCormick Counties of South Carolina and the Cuffytown Creek population found in Greenwood and McCormick Counties of South Carolina.

The entire extent of the Heelsplitter's historic range is not known, but evidence indicates that it was once more widely distributed in the Catawba, Pee Dee, Savannah, and Saluda River systems (USFWS 1997). The Carolina Heelsplitter has a spotty distribution where it is found (Figure 4) due to restrictions in suitable habitat (USFWS 1997). Where the Carolina Heelsplitter is found, it is no longer abundant; typically, only 1 to 3 individuals are discovered during a survey at any one site. In the 5-year review published by the US Fish and Wildlife Service in 2019, 4 of the 11 populations (Sixmile Creek, Gills/Crane Creek, Rocky Creek, and Turkey Creek) were considered declining. Recent surveys by SCDNR in Red Bank Creek and Halfway Swamp Creek, and the Lynches River did not recover any live Carolina Heelsplitter. All 11 of the surviving populations remain highly susceptible to extirpation from a single event or chronic conditions such as drought, chemical spills, stormwater runoff, sedimentation and bank instability etc.



Figure 3. Image of hatchery produced *Lasmigona decorata* photographed by Briana Cairco, SCDNR. Specimen photographed is from cohort 1502LdA-O.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Although it was once found in large rivers and streams, the Carolina Heelsplitter is now restricted to cool, clean, shallow, heavily shaded streams of moderate gradient. Stable streambanks and channels, with pool, riffle and run sequences, little or no fine sediment, and periodic natural flooding, appear to be required for the Carolina Heelsplitter (USFWS 2002). This species still exists in some degraded streams in pockets of viable habitats. Eads et al. (2010) performed laboratory host fish trials and reported metamorphosis of glochidia on Pirate perch (Aphredoderus sayanus), Largemouth Bass (Micropterus salmoides), Bluegill (Lepomis macrochirus), Satinfin Shiner (Cyprinella analostana), Bluehaead Chub (Nocomis leptocephalus), Golden Shiner (Notemigonus crysoleucas), Whitemouth Shiner (Notropis alborus), Highfin Shiner (Notropis altipinnis), Redlip Shiner (Notropis chiliticus), Spottail Shiner (Notropis hudsonius), Yellow Bullhead (Ameriurus natalis, Fantail darter (Etheostoma flabellare), and Tessalated Darter (Etheostoma olmstedi). Out of these, Satinfin Shiner (Cyprinella analostana), Bluehaead Chub (Nocomis leptocephalus), Golden Shiner (Notemigonus crysoleucas), Highfin Shiner (Notropis altipinnis), and Spottail Shiner (Notropis hudsonius) had mean

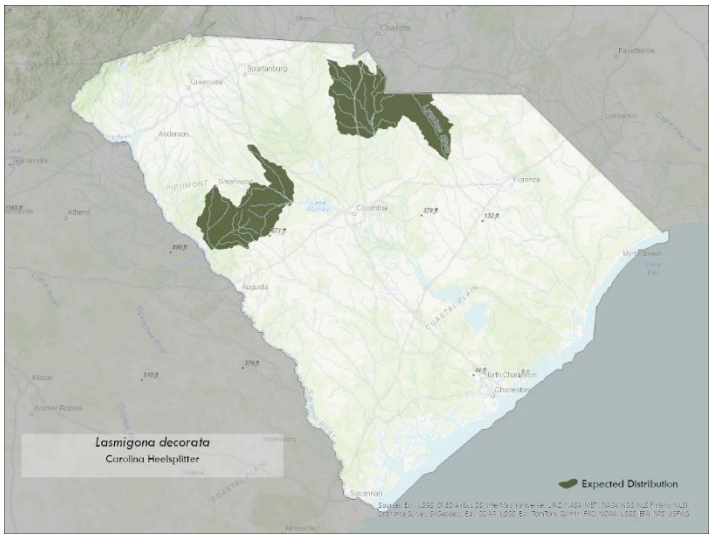


Figure 4. Expected distribution of *Lasmigona decorata* based on reported observations at a HUC 10 watershed level and designated ecoregions.

percentage of metamorphosis above 30% and have been targeted for propagation efforts. Bluehead Chub (Nocomis leptocephalus), Golden Shiner (Notemigonus crysoleucas), and Spottail Shiner (Notropis hudsonius) are more common and have been the primary hosts used in propagation. No information is available about infestation of hosts in the wild. Carolina Heelsplitter mussels are presumed to be long-term brooders, but research is needed to determine the reproductive cycle of *L. decorata*.

CHALLENGES

The Carolina Heelsplitter is vulnerable to a variety of threats related to human disturbance. Polluted wastewater from sewage treatment plants and industrial discharges are a threat. Storm water runoff carrying silt, fertilizer, pesticides, and other pollutants threatens the Carolina Heelsplitter, especially when erosion and stormwater control is inadequate (USFWS 2002).

Habitat alteration including impoundments, channelization, dredging, and streambank scouring by stormwater runoff have also contributed to the decline of the Carolina Heelsplitter and adversely affect remaining populations (USFWS 2002). Activities such as agriculture, forestry, road construction, mining, urban development, and other land use activities that do not adequately control stormwater runoff and soil erosion are likely to destroy Carolina Heelsplitter habitat (USFWS 2002). Current and potential land uses within the watersheds of streams supporting Carolina Heelsplitter results in increased discharge and runoff of silt, sediments, and organic and chemical pollutants that threaten habitat and water quality this species requires. Past and on-going agriculture and timbering operations negatively affect several of the populations due to the continued loss of riparian buffers which results in increased runoff of silt and other sediments as well as fertilizer, insecticide, and herbicide drift, and contamination of groundwater entering the streams. The loss of riparian buffers and livestock entering streams also contributes to the destabilization of streambanks and substrate that provide habitat for Carolina Heelsplitter (USFWS 2019).

A study on the natural host for Carolina Heelsplitter was attempted, (Polemen 2023) however no Carolina Heelsplitter glochidia were recovered attached to host fish. This type of study may be difficult to accomplish while the density of Carolina Heelsplitter at a site remains low.

CONSERVATION ACCOMPLISHMENTS

The United State Fish and Wildlife Service (USFWS) (1997) has created a Recovery Plan for the species that includes objectives such as research and monitoring of existing populations, reintroduction programs, and public education. They have also designated stretches of streams where the Carolina Heelsplitter is found as critical habitat (USFWS 2002) and have proposed that the establishment of sanctuaries, stream buffer zones and other protective measures should be encouraged.

SCDNR has been working cooperatively with the USFWS to develop standardized, routine surveys of populations in South Carolina that began in 2019. Genetic swabs collected in these efforts have been held for a planned population genetics study for the species.

Propagation efforts have been attempted and animals grown from Orangeburg National Fish Hatchery since 2015 and SCDNR Cohen Campbell Fisheries Center since 2021 have been stocked in the wild in South Carolina.

USFWS Programs including Recovery, Refuges, and Fisheries and Lancaster County, South Carolina have initiated work restoring fish passage and natural flows at road crossing structures, replacing undersized, round culverts with appropriately sized bottomless arch culverts. Three projects have been completed (Happy Trail, Langley Road, and Gills Creek Drive), reopening the entire length, approximately 6 miles of Critical Habitat Unit 3 to fish passage (USFWS 2019).

The Forest Service has also taken strides to retrofit and replace nonfunctioning culverts on their system of roads in the Long Cane Ranger District of the Sumter National Forest.

SCDNR is also incorporating fish passage restoration into much of their work, including Clean Water Act compensatory mitigation recommendations and state-wide property management plans. Hundreds of acres and thousands of linear feet of critical habitat in the Flat Creek watershed have been protected through conservation easements (Carolina Heelsplitter Conservation Bank) and fee simple transfer of property to the State of South Carolina. SCDNR has also contracted stream restoration to reduce sedimentation in a tributary of Flat Creek.

CONSERVATION RECOMMENDATIONS

- Partner with United States Fish and Wildlife Service to carefully evaluate the impact of all potential development projects proposed in the watersheds where the Carolina Heelsplitter is found.
- Partner with United States Fish and Wildlife Service to ensure implementation of the recovery plan and continue augmentation and reestablishment of populations through propagation and culture.
- Conduct population genetics analysis to guide recovery efforts.
- Encourage careful land use planning in the Charlotte metropolitan area to protect the upper Lynches River and Catawba River watersheds. Land protection through conservation easements and fee simple purchases should be a high priority, especially in the vicinity of Fishing Creek and the headwater streams in the upper Lynches River drainage. Land protection is also necessary in the Steven's Creek Basin, particularly around headwater streams. Careful land use planning is necessary in the Augusta and Aiken developing areas that are beginning to encroach upon this watershed. Such protection may be accomplished through conservation easements or fee simple purchase.
- Protect critical habitats for the Carolina Heelsplitter from future development and further habitat degradation by following Best Management Practices.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Carolina Heelsplitter.
- Consider this species' needs when participating in the environmental permit review process.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Determine ecological and toxicological endpoints for the species.

MEASURES OF SUCCESS

- Completion of continued population monitoring of the populations of Carolina Heelsplitter in South Carolina.
- Successfully stocking of propagated animals to augment or restore populations in stable habitat.
- Completion of surveys to monitor the success of stocking propagated animals.
- Completion of population genetic analysis to determine the health of populations and guide recovery efforts.
- Continue outreach to relevant landowners about the importance of freshwater mussels and their habitats.

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Eastern Pondmussel

Sagittunio nasutus (Say 1817)

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason



Figure 1. Image of *Sagittunio nasutus* courtesy of the North Carolina Museum of Natural Sciences, Jamie Smith, and Dr. Art Bogan. The NCSM catalog number of the specimen photographed is 30040.2.

DESCRIPTION

Taxonomy and Basic Description

The Eastern Pondmussel (Figure 1) was petitioned to be reassigned to the genus *Sagittunio* in 2021 based on Watters (2018) and supplemental genetic work from Kuehnl (2009), Zanatta and Murphy (2006), and Raley et al. (2007). The petition was accepted and the scientific name *Sagittunio nasutus* was assigned (FMCS 2023), which differs from *Ligumia nasuta*, as seen in the 2015 SWAP.

The shell of the Eastern Pondmussel is elongated and sub-elliptical with a rounded anterior margin and a broadly curved ventral margin. The posterior margin is rounded and drawn out into a posterior angle or blunt point near the midline of the shell, and the posterior ridge is well developed and angular. The ventral margin of the female's shell is expanded in the postbasal region. The outer surface of the Eastern Pondmussel shell is dark olive green to brownish, often with faint, dark green straight and narrow rays, especially in juveniles. The shell also has irregular growth lines; sometimes a few ribs are present below the posterior ridge. The inner surface of the shell is bluish white, sometimes with salmon in the beak area, and is iridescent posteriorly. The shell can reach a maximum length of 102 mm (4.1 in.) (Bogan and Alderman 2004, 2008).

The Eastern Pondmussel is sexually dimorphic, and females have been documented displaying marginal papillae to attract hosts fishes when brooding. Corey et al. (2006) found that gravid *S. nasutus* papillae move rapidly and synchronously, allowing the striking white of the marsupial gills to be seen moving up and down the mantle margin, mimicking a copepod. A video produced by the Aquatic Epidemiology and Conservation Laboratory at NC State University shows that a small portion of the mantle is folded outward, and the fold varies in direction and speed up and down the mantle margin (Eads 2009). The displaying behavior attracts fish, and naïve fish readily attack the mussel, triggering the release of mussel larvae, glochidia. The display behavior slows in low light and stops in high turbidity or in the dark, regardless of time or day (Corey et al. 2006). When fish attack the mantle tissue, female *S. nasutus* release free glochidia; however, when probed by a pipette in laboratory conditions, mussels simply stopped displaying, closed their shells, and then resumed displaying after a few seconds (Corey et al. 2006). Fish that attacked and were exposed to glochidia were not likely to attack a second time. During the study, two captive *S. nasutus* ejected conglutinates at night when no fish were present then buried themselves and did not display any longer (Corey et al. 2006). Conglutinates were ~10mm long, elongated, and cream colored. Additionally, it was noted that displaying females

were very active at night, suggesting nocturnal movement before daytime displaying, potentially seeking new, naïve fish (Corey et al. 2006).
Sagittunio nasutus are reportedly long-term brooders, with the breeding season from August until the following June (Ortmann 1919). Corey et al. (2006) collected gravid females in May and June. North Carolina reports finding gravid females during the cooler months of the year (NCWRC). In Eads et al. (2015), gravid *S. nasutus* were collected in the spring.

Reported host fishes include Yellow Perch, Largemouth Bass, Bluegill, and Pumpkinseed based on laboratory trials (Eads et al. 2015).

Status

NatureServe (2024) currently identifies the Eastern Pondmussel's global status as vulnerable (G3). The species is ranked as imperiled (S2) in North Carolina, Vulnerable (S3) in Virginia, and imperiled to vulnerable (S2S3) in South Carolina. The Committee on the Status of Endangered Wildlife in Canada designated the species as endangered in April of 2007 but re-examined and designated the species as special concern in April 2017 (COSEWIC 2007; COSEWIC 2017).

POPULATION SIZE AND DISTRIBUTION

This historic range of the Eastern Pondmussel extends from the Savannah River Basin in Georgia north to Maine and Ontario and as far west as Michigan. In South Carolina, it was historically documented in the Savannah, Santee-Cooper, and Pee Dee Basins (Johnson 1970). Although the species has a larger range, it is considered critically imperiled and imperiled throughout the northern ranges largely due to invasive dreissenid mussels and habitat destruction in the 20th century (NatureServe2024; Scott et al 2016). In South Carolina, there have been a total of 62 reported observations of the species from 2002-2019 across the Pee Dee, Santee, and ACE watersheds (Figure 2). The species has been observed in the piedmont, sandhills, and coastal plain regions with an overwhelming majority of observations being around the shorelines of Lake Marion and Lake Moultrie. The species can be abundant when found, but extant populations are quite rare (Taxonomic Expertise Committee 2004).

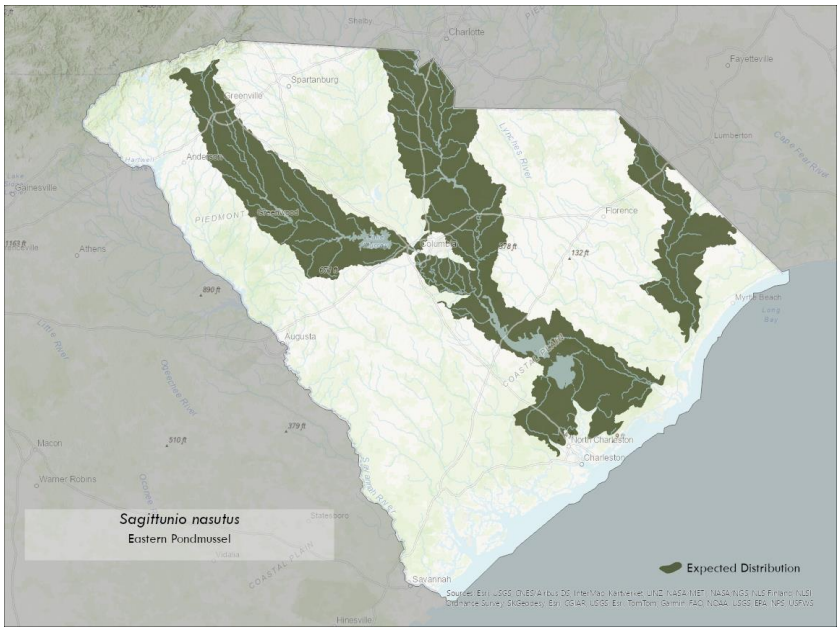


Figure 2. Expected distribution of *Sagittunio nasutus* based on reported observations at a HUC 8 watershed level and designated ecoregions.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Eastern Pondmussel can be found in lakes, ponds, streams, and rivers of variable depths with muddy, sandy, or gravelly substrates. Often, it is found in very shallow water near the banks of rivers (Taxonomic Expertise Committee 2004). The Eastern Pondmussel is not known to be found in areas where saltwater intrusion is present and has a documented 24-hour EC50 of 1.7 ppt of sea salt for glochidia and 5.8 ppt 96-hour EC50 for juveniles (McIver et al. 2023).

CHALLENGES

Observations suggest that this species is sensitive to channel modification, pollution, salinity, sedimentation, and low oxygen conditions, but we do not know how the relative sensitivity of this species to these threats compares to other species. The tendency for the Eastern Pondmussel to inhabit shallow water near riverbanks may make it especially sensitive to sudden drops in water levels (Taxonomic Expertise Committee 2004).

CONSERVATION ACCOMPLISHMENTS

Additional populations have been located in Lake Greenwood and the lower Broad River (Savidge 2006; Price and Eads 2011). Two hundred individuals of Eastern Pondmussel were reared in captivity, and tagged individuals were released in the lower Broad River in 2010 (C. Eads, pers. comm.). Genetic analysis has placed the species, and others in a distinctive clade and microsatellite markers were developed and characterized for the species (Scott et al. 2016).

CONSERVATION RECOMMENDATIONS

- Conduct additional surveys to determine the status and distribution of the Eastern Pondmussel.
- Evaluate the need to list the Eastern Pondmussel based upon survey results.
- Examine museum specimens to determine the historic range of the Eastern Pondmussel; compare its present and historic distributions.
- Protect critical habitats for the Eastern Pondmussel from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Eastern Pondmussel.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Conduct research into the reproduction of the Eastern Pondmussel.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Conduct further research to determine the degree of sensitivity of the Eastern Pondmussel to various point and non-point sources of pollution and land use impacts.

MEASURES OF SUCCESS

- Once the distribution of the Eastern Pondmussel is thoroughly evaluated, persistence of populations and increases in numbers where rare will indicate successful conservation efforts.
- Determination of environmental and chemical tolerances.
- Determination of gravidity time frame and environmental parameters that affect this.

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Carolina Creekshell

Sagittunio vaughanianus
(Leas, 1838)

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason and Morgan Kern (SCDNR)

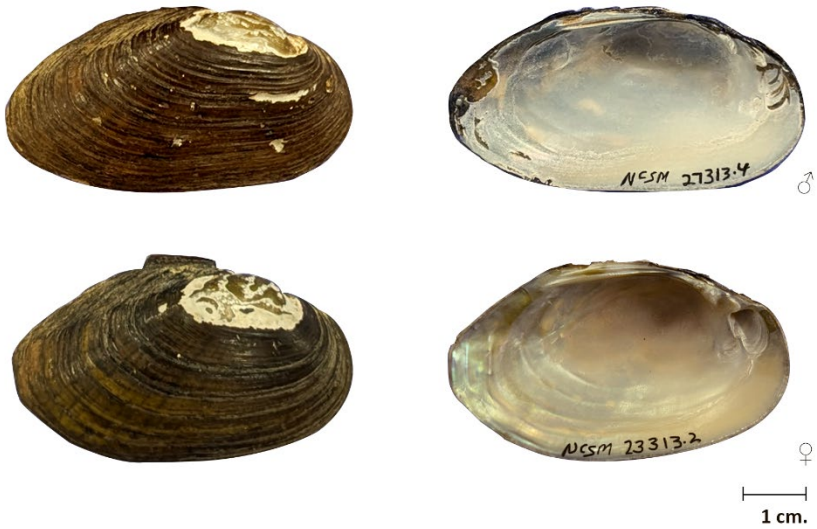


Figure 1. Images of male (top) and female (bottom) *Sagittunio vaughanianus* courtesy of the North Carolina State Museum of Natural Sciences, Jamie Smith, and Dr. Art Bogan. The NCSM catalog number of the male and female specimens are 27313.4 and 23313.2 respectively.

DESCRIPTION

Taxonomy and Basic Description

Carolina Creekshell was reassigned into the genus *Sagittunio* by the Freshwater Mollusk Conservation society in (2023) based on the work in Watters (2018) which established the genus *Sagittunio* with type species *Sagittunio nasutus* (Say, 1817). Several other unpublished studies (Kuehnl 2009; Raley et al. 2007) support the separation of the genus and the placement of Eastern Pondmussel and Carolina Creekshell in a distinct genus. The scientific name was changed from *Villosa vaughaniana* as it appeared in the 2015 SWAP.

Carolina Creekshell is a small mussel that rarely exceeds 2.5 inches in length and is sexually dimorphic (Figure 1). Females exhibit an expanded posterior end that accommodates the expanded marsupial gills when brooding. Carolina Creekshell has well developed pseudocardinal and lateral teeth. The anterior margin is rounded in both sexes. The posterior end is pointed about two-thirds of the way from the ventral margin. Males have a gently curved ventral margin, elliptical in shape; the female has a distinct posterior basal swelling and a straight ventral margin making them more ovate in shape. The outer surface of the Carolina Creekshell is moderately shiny and greenish-yellow to dark brownish-yellow with numerous continuous green rays. The inner surface is shiny, iridescent white or bluish-white. (Bogan and Alderman 2004, 2008; NCWRC 2024).

As with many of our native freshwater mussels, Carolina Creekshell can be easily misidentified especially when the individual is still living. Carolina Creekshell can be confused with the Eastern Creekshell, *Villosa delumbis*. Eastern Creekshell often have wide broken rays rather than complete rays as seen on Carolina Creekshell. The marsupium of Eastern Creekshell has a dark margin while it is ivory colored in Carolina Creekshell.

Status

NatureServe (2024) currently identifies the Carolina Creekshell as having a global ranking of imperiled (G2). This mussel is considered critically imperiled (S1) in South Carolina. The Carolina Creekshell has been historically found in several South Carolina streams but was only recovered from one historic site during a 2022 survey.

POPULATION SIZE AND DISTRIBUTION

The Carolina Creekshell is endemic to North Carolina and South Carolina and has been found in the Cape Fear River, Catawba River, Neuse River, Pee Dee River, and Santee-Cooper River Basins (Figure 2). In South Carolina, one individual was found at a historic site during recent survey efforts. The Carolina Creekshell was first described in 1838 from specimens found at Sawney's Creek in Kershaw County, South Carolina. In recent years, targeted surveys have been completed in and around Sawney's Creek and no animals have been located.

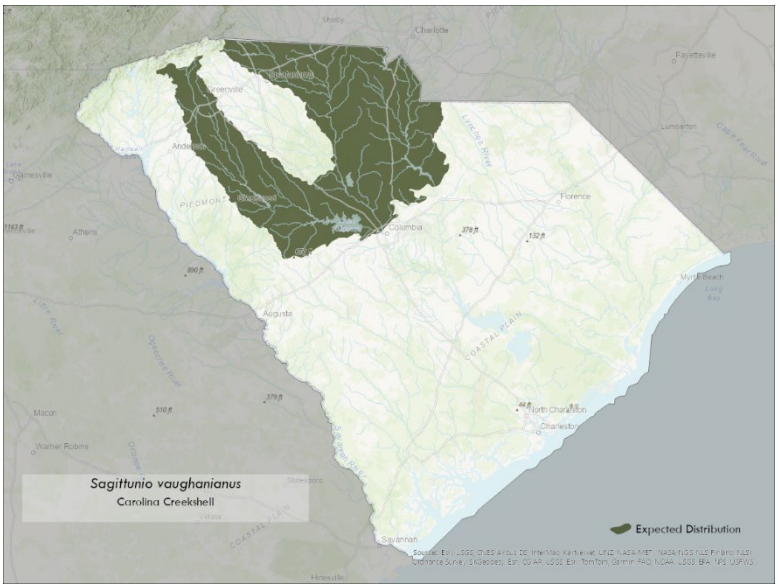


Figure 2. Expected distribution of *Sagittunio vaughanianus* based on reported observations at the HUC 8 watershed level and designated ecoregion.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Carolina Creekshell tends to be found in mud or sand near stream banks. Occasionally, this mussel is found in gravelly sand in the main channel of streams and medium-sized rivers. Regardless of the substrate, this species needs to be able to burrow.

The reproductive cycle, brooding behavior, and glochidia release by the Carolina Creekshell are understudied. Although not formally documented, a video produced by Chris Eads (2009) with the Aquatic Epidemiology and Conservation Laboratory at NC State University show that gravid females produce a mantle lure towards the ventral portion of the shell and the lure is similar to that of *S. nasutus*, moving papillae to expose white coloration. There are no known host fish(es) for *S. vaughanianus* although host fishes for *S. nasutus* may also act as hosts for *S. vaughanianus* but research is needed.

CHALLENGES

The Carolina Creekshell can easily be misidentified as Eastern Creekshell which makes determining population ranges and historic sites difficult. Surveys across the historic range of the species in South Carolina suggest that the species is becoming increasingly rare in South Carolina. Historic habitats such as the Lynches River appear unstable and may no longer be able to support this species. Little is known about the reproductive and brooding behaviors of *S. vaughanianus* and wild hosts are unknown. Work to recover this species through propagation would be difficult without access to broodstock in North Carolina.

Like other freshwater mussels, the Carolina Creekshell is sensitive to changes in water quality, habitat, and access to host fishes, although the degree of sensitivity to these changes is understudied. The hosts for the Carolina Creekshell are unknown, but like other freshwater mussels, the Carolina Creekshell must have adequate access to species-specific hosts and relies on host fish(es) for reproduction and distribution. Maintaining stream connectivity for host fish(es) is important to allow distribution of juveniles and gene flow between populations. Environmental stressors that lead to degradation of water quality, habitat, and stream connectivity include development, agriculture, and incompatible forestry management; additionally, systemic changes that have negative effects include climate change, invasive species, and dams and barriers (USFWS 2021).

In South Carolina, practices such as mining, clearcutting for timber production, and recreational vehicle use in streams are observed to result in degradation of habitat. Preservation of a riparian buffer is needed for the continued existence of suitable habitat for most native freshwater mussels. A riparian buffer is the land area adjoining a stream, lake or wetland characterized by a cover of naturally occurring vegetation consisting of trees, shrubs, grasses, and forbs where development is restricted or prohibited.

CONSERVATION ACCOMPLISHMENTS

Efforts were made to survey for this species at sites of historic occupancy as part of a SWG Grant from 2022-2024. Genetic swabs from five presumed *S. vaughanianus* collected from this effort were provided to aid in a study being performed in North Carolina.

CONSERVATION RECOMMENDATIONS

- Conduct a thorough search of museum records for the Carolina Creekshell and determine if there are any additional historical records for this species.
- Conduct surveys to closely monitor population trends for the Carolina Creekshell and to look for populations near the type locality to determine if any other populations remain.
- Determine habitats that are critical for this species in South Carolina.
- Research the reproductive and brooding behavior of the species.
- Perform host fish trials to determine natural hosts for native populations.
- Study interactions of laboratory host fishes in the wild.
- Conserve populations of host fish to insure reproduction of the Carolina Creekshell in the wild.
- Develop a restoration plan that considers the need for augmentation or reintroduction.
- Encourage responsible land use planning.
- Protection of land by encouraging the use of best management practices, conservation easements, and land purchases.
- Prioritize the purchase and protection of land in the vicinity of Fishing Creek and other known habitats.
- Consider species needs when participating in the environmental permit review process.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Carolina Creekshell.
- Conduct further research to determine the degree of sensitivity of the Carolina Creekshell to various point and non-point sources of pollution and land use impacts.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

- Completion of targeted surveys where historic occupancy or suitable habitat are found.
- Determination of life history of the Carolina Creekshell including time of spawning and brooding.
- Determine the host fish(es) and complete surveys in suitable habitat for host fish(es).
- Collection of genetic swabs of Carolina Creekshell when found.
- Development of a restoration plan that may include propagation and culture to reintroduce the species in suitable habitat within its historic range.
- Perform outreach to relevant landowners about the importance of freshwater mussels and their habitats.
- Work to reduce or halt further disturbance to the habitat and natural hydrology of historic habitats.
- Determination of environmental and toxicological tolerances and endpoints.
- Monitoring of wild populations of the species that show stabilization or an increase in the size of South Carolina's populations of the Carolina Creekshell.

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Creeper

Strophitus undulatus (Say, 1817)

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason



Figure 1. Images of *Strophitus undulatus* photographed by Briana Cairco, SCDNR.

DESCRIPTION

Taxonomy and Basic Description

Taxonomy for the species in the northern and eastern ranges of the species does not currently seem to be in question. There are taxonomy concerns in the western Gulf coast drainages (Texas, Louisianna, Alabama) regarding *Pseudodontoideus subvexus, P. connasaugensis, Strophitus undulatus, S. pascagoulaensis, S. radiatus,* and *S. williamsi*. Smith et al (2018) found polyphyly in *Strophitus* and resurrected the genus *Pseudodontoideus* for *S. connasaugaensis* and *S. subvexus.* They also found up to 4 evolutionary divergent clades within S. radiatus and formally describe 2 new species, *S. pascagoulaenis*, and *S. williamsi* (Smith et al. 2018). In (2023), Freshwater Mollusk Conservation Society recognized 4 species of *Strophitus.* Future, comprehensive, range-wide research may reveal that *S. undulatus* has a narrower range than previously thought.

The shell of the Creeper (Figure 1) is elliptical and somewhat rhomboid; the anterior end is rounded and the posterior end is bluntly pointed and often obliquely truncated. The posterior ridge is broadly rounded and may be compressed or quite pronounced. The outer surface of young individuals is yellowish or greenish and may have greenish, often wavy rays. Older individuals are dark brown, dark green, or black and usually without rays. The inner surface is white or bluish white and iridescent around the margins and center. The shell is usually less than 110 mm (4.4 in.) in length (Parmalee and Bogan 1998).

Status

NatureServe (2024) currently lists the Creeper as globally secure (G5) due to its wide range. In Alabama the species is ranked critically imperiled (S1), in Georgia the species is not ranked (SNR), in South Carolina the species is ranked imperiled to vulnerable (S2S3), in North Carolina the species is ranked vulnerable (S3), and in Virginia the species is ranked vulnerable to apparently secure (S3S4).

POPULATION SIZE AND DISTRIBUTION

The Creeper is widespread throughout the eastern and central United States and Canada including population in Ohio and Mississippi Rivers, Great Lakes systems, northern and southern Atlantic slope drainages, and part of the Canadian Interior basin. The southern and southeastern states seem to be along the periphery of the species range. In South Carolina the Creeper is found across the piedmont and sandhills region with most reported observations being in the Lynches River, Catawba River, and Turkey Creek and its tributaries (Figure 2). The Creeper, when found, is usually found in small numbers.

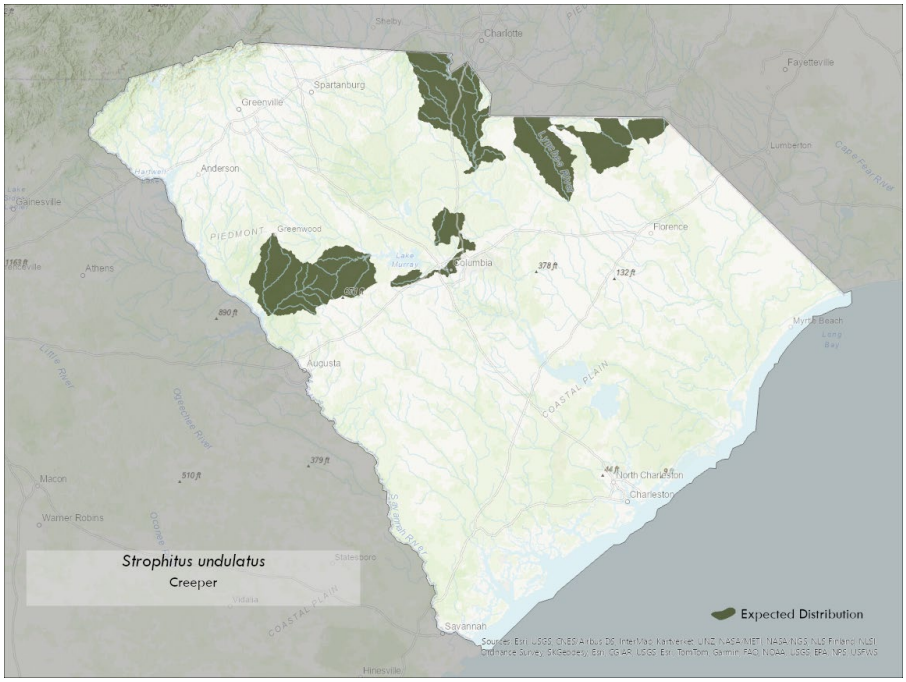


Figure 2. Expected distribution of *Strophitus undulatus* based on reported observations at a HUC 10 watershed level and designated ecoregions.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Creeper can be found in shallow water in both small streams and large rivers, although it is not typically found in high gradient or mountain streams. It inhabits a variety of substrates, from silt and mud to boulder fields. In South Carolina, Creeper mussels are not usually found in lotic environments and are typically found in substrates of mixed mud, sand, gravel, and cobble. Research into the tolerances to habitat alterations, pollution, and environmental changes are needed.

The Creeper has a large distribution across Canada and the United States, and this is likely, in part, due to the species being a host generalist. Laboratory trials show Creeper mussels being able to transform on many host species including fish from the following families, Cyprinidae, Cottidae, Percidae, Ictaluridae, Centrarchidae, Acipenseridae, Salmonidae, Fundulidae, Gadidae, Gasterosteidae, and Umbridae; laboratory trials also show transformation on the Eastern Newt. Adequate access to host fishes do not seem to be a challenge for the Creeper mussel and because all native freshwater mussels rely on host fishes for distribution, it is understandable that the mussel species has a wide distribution. Lefevre and Curtis (1912) document that *Strophitus undulatus* larvae, glochidia, can transform in the marsupia, receiving nutrients from the parent mussel, but more research is needed to determine how, why, and how often this method of reproduction occurs. Research is needed to determine interactions between mussels and host species in the wild.

The Creeper uses a conglutinate to distribute glochidia. Watters (2002) found that the conglutinate was made of a homogenous, spongy material and that each glochidium was contained within its egg membrane and tethered by a glochidial thread. Glochidia remain inside of the membrane in the conglutinate until they are forced out from a pore in the membrane via osmotic pressure (Watters 2002). Watters (2002) suggests that when the conglutinate is being brooded in the marsupium it is bathed in a hypertonic solution and only after expulsion into the hypotonic water column does the spongy material of the conglutinate swell, forcing the glochidia out. The brief period of innate motion may attract host fishes and the connection of each glochidium to the conglutinate allows for a higher chance of attachment on host fishes if the conglutinate is ingested. Glochidia of the Creeper are hooked, having a stout, hinged hook at the ventral margin of each triangular valve (Coker at al. 1921).

Coker et al. (1921) note that the marsupium occupied the entire outer gills and egg masses lie transversely in the gills. The Creeper is presumed to be a long-term brooder, having eggs fertilized in the summer, and glochidia released the following spring. Coker et al. (1921) report finding females with glochidia from March to November; however, it is unclear the locality of these reports and the developmental stage of the glochidia.

In South Carolina, gravid females are generally sought out in March and April; however more research is needed to determine the reproductive cycle.

CHALLENGES

In South Carolina, Creeper mussels are not often found in lotic environments or in streams with high gradients or high velocities. Channel modifications including dredging and damming are likely to create environments that create unsuitable habitat for *Strophitus undulatus*. Like other freshwater mussels, the Creeper mussel is sensitive to changes in water quality and habitat degradation, although the degree of sensitivity is understudied. Even though *S. undulatus* is a host generalist, maintaining stream connectivity is important to allow distribution of juveniles and gene flow between populations. Environmental stressors that lead to degradation of water quality, habitat, and stream connectivity include development, agriculture, and incompatible forestry management; additionally, systemic changes that have negative effects include climate change, invasive species, and dams and barriers (USFWS 2021).

The Creeper has an unusually wide range for a freshwater mussel, and there is some concern that mussels currently classified as the Creeper in different parts of its range may be other species which would result in a more restrictive range. Comprehensive, range-wide genetic analysis is needed to determine the effective range of *S. undulatus* and to determine if *S. undulatus* is the only species of the genera in South Carolina.

CONSERVATION ACCOMPLISHMENTS

As a part of a SWG grant, 4 sites with historic observation of the species were visited; one animal was collected from one of the survey sites.

CONSERVATION RECOMMENDATIONS

- Conduct additional surveys to look for new populations of the Creeper and closely monitor existing populations.
- Conduct research to determine if channel modifications are directly influencing populations of Creeper.
- Conduct genetic analysis on the Creeper throughout its range.
- Explore the need to elevate the listing of the Creeper based on survey results.
- Determine methods for impounded habitat restoration that will benefit the species, if warranted.
- Protect critical habitats for the Creeper from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Creeper.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Conduct further research to determine the degree of sensitivity of the Creeper to various point and non-point sources of pollution and land use impacts.

MEASURES OF SUCCESS

- Research showing the effects, if any, of channel modification on population distribution.
- Determination of the reproductive cycle of the species and their interactions with hosts in the wild.
- Completion of research into the ability of the species to reproduce without a host.
- Determination of environmental and toxicological tolerances and endpoints.

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Savannah Lilliput

Toxolasma pullus (Conrad, 1838)

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason and Morgan Kern (SCDNR)

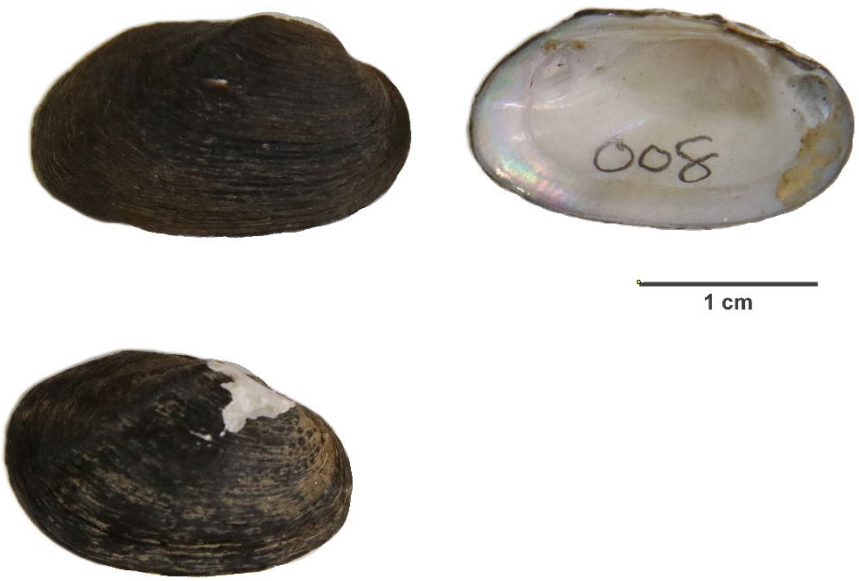


Figure 1. Images of male (top) and female (bottom) *Toxolasma pullus* photographed by Briana Carico, SCDNR.

DESCRIPTION

Taxonomy and Basic Description

Savannah Lilliput from the lower Savannah River exhibit slightly different shell morphology: they have a more extensive beak sculpture than members of this species found elsewhere. They were once described as a separate species, *Carunculina patrickae* (Bates 1966), but *C. patrickae* was synonymized with *C. pulla* by Johnson (1970) and is now known as *Toxolasma pullus*.

The Savannah Lilliput (Figure 1) is a small mussel with an oval or elliptical shell and a double posterior ridge. This ridge is usually angular but is sometimes broadly rounded. Females have a broader, more truncated posterior end; males have a narrower, rounded posterior end. The outer surface of the shell is usually blackish, but sometimes brownish, greenish, or olive with very fine, obscure green rays. The inner surface of the shell is bluish-white with pink to purplish iridescence at the posterior end. Large specimens range from 30 to 35 mm (1.2 to 1.4 in.) in length (Bogan and Alderman 2004, 2008).

Status

NatureServe (2024) currently identifies the Savannah Lilliput as having a global status of vulnerable (G2). This mussel is ranked as critically imperiled to vulnerable (S1/S3) in South Carolina. This species has been a candidate for listing as Threatened or Endangered under the endangered species act since the publishing of the Partial 90-Day Finding on a Petition to List 404 Species in the Southeastern United States as Endangered or Threatened With Critical Habitat in 2011 to the federal register. No species status assessment has been completed to determine the need to list this species.

POPULATION SIZE AND DISTRIBUTION

The Savannah Lilliput once ranged from the Neuse River Basin in North Carolina to the Altamaha basin in Georgia (Bogan and Alderman 2004). This species is presently considered extirpated from the Neuse and

Waccamaw river basins in North Carolina (NCWRC 2024). Savannah Lilliput is found in the Savannah, Ogeechee, and Altamaha River systems in Georgia. It has been lost from the Neuse Basin and is declining rapidly throughout its range. In South Carolina, it has been found in the Saluda and Savannah River Basins (Figure 2). The species was originally described from the Wateree River in South Carolina. Found in Lake Marion, the Congaree River and Halfway Swamp Creek in recent surveys in South Carolina and was reported by GADNR in the Savannah River as recently as 2021. This species was found in Lake Greenwood and Cloud's Creek in the past. Two specimens were found in Crab Tree Swamp (Waccamaw River drainage) in 2007.

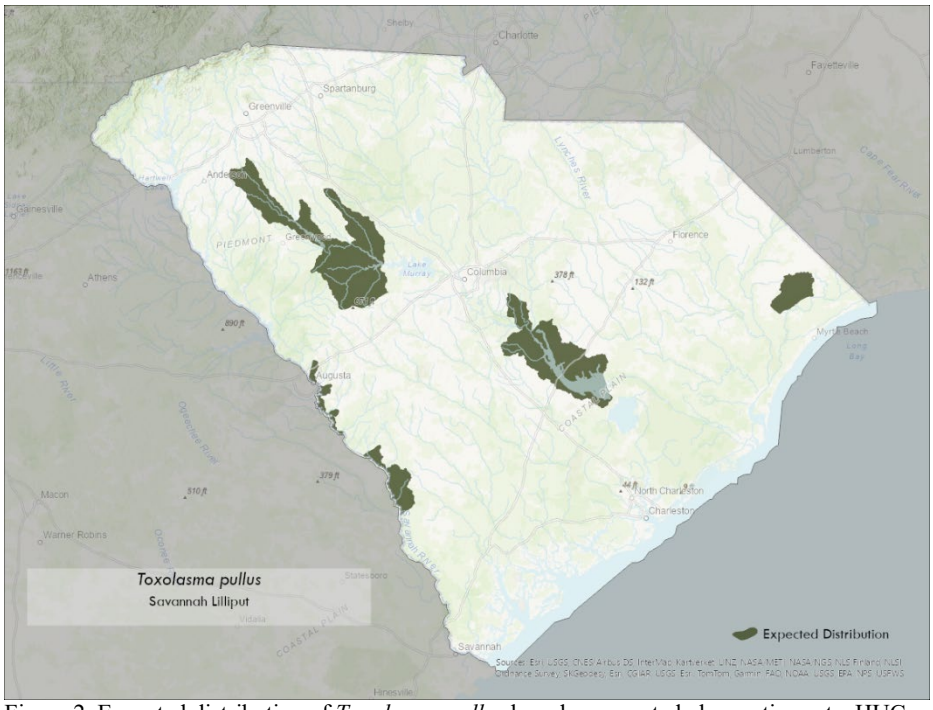


Figure 2. Expected distribution of *Toxolasma pullus* based on reported observations at a HUC 10 watershed level and designated ecoregions.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Savannah Lilliput tends to inhabit shallow water, usually at the edges of streams, rivers and lakes; it may also be found in backwaters. This mussel is rarely found in deeper lake waters and tends to be found in mud or silty sand typically found in backwaters, sloughs, and oxbows (Johnson 1970).

Gravid females have been observed between late April through early August; gravid females collected in April had fully developed, active glochidia while gravid females collected in late July and August had only partially inflated marsupia which held mostly embryos and few glochidia (Hanlon and Levine 2004). Hanlon and Levine (2004) notes that gravid females brood in the outer demibranchs and fully charged marsupial gills were milky-white and inflated.

Hybrid Bluegill-Green Sunfish (*Lepomis macrochirus* x *L. cyanellus*) served as suitable host for glochidia of Savannah Lilliput from University Lake in North Carolina, suggesting that other *Lepomis* spp. might also be hosts (Hanlon and Levine 2004).

CHALLENGES

The Savannah Lilliput's primarily shallow water distribution makes it particularly susceptible to off-road motor vehicle traffic, droughts, and water draw-downs in reservoirs. Similarly, water level fluctuations in the Savannah River may affect this species. This species can be hard to detect in traditional stream bed surveys, often requiring intensive surveys of bank habitat and grubbing with low visibility.

Hanlon and Levine (2004) note that a total of 181 pairs of shells of *T. pullus* were collected from muskrat middens along the shoreline; predation of the species may be of concern due to inhabiting shallow areas of streams.

Like other freshwater mussels, the Savannah Lilliput is sensitive to changes in water quality, habitat, and access to host fishes, although the degree of sensitivity to these changes is understudied. Like other freshwater

mussels, the Savannah Lilliput must have adequate access to species-specific hosts and relies on host fishes for reproduction and distribution. Maintaining stream connectivity for host fishes is important to allow distribution of juveniles and gene flow between populations. Environmental stressors that lead to degradation of water quality, habitat, and stream connectivity include development, agriculture, and incompatible forestry management; additionally, systemic changes that have negative effects include climate change, invasive species, and dams and barriers (USFWS 2021).

In South Carolina, practices such as mining, clearcutting for timber production, and recreational vehicle use in streams are observed to result in degradation of habitat. Preservation of a riparian buffer is needed for the continued existence of suitable habitat for most native freshwater mussels. A riparian buffer is the land area adjoining a stream, lake or wetland characterized by a cover of naturally occurring vegetation consisting of trees, shrubs, grasses, and forbs where development is restricted or prohibited.

CONSERVATION ACCOMPLISHMENTS

Work on the propagation of this species has been ongoing at Bears Bluff National Fish Hatchery.

CONSERVATION RECOMMENDATIONS

- Conduct additional surveys for the Savannah Lilliput, in Lake Greenwood and Lake Marion. Additional surveys are needed in areas where the Savannah Lilliput was historically found to determine if populations are extant.
- Conduct genetic analyses across the range of the Savannah Lilliput to determine if populations in the Savannah River described as *Carunculina patrickae* (Bates 1966) are genetically distinct from other populations and if they warrant classification as a separate species.
- Closely monitor water levels and discourage shallow water activities at sites where the Savannah Lilliput is found.
- Study the effects of water draw-downs and low flows and propose new flow regimes if needed to protect the species from stranding, predation, or isolation from suitable habitats in both lotic and lentic habitats.
- Work with other state agencies (DHEC) to determine appropriate minimum flows to protect the Savannah Lilliput. Also, recommend minimum flows during the FERC relicensing process.
- Protect critical habitats for the Savannah Lilliput from future development and further habitat degradation by following Best Management Practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Savannah Lilliput.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Conduct further research to determine the degree of sensitivity of the Savannah Lilliput to various point and non-point sources of pollution and land use impacts.

MEASURES OF SUCCESS

- Development of a list of habitats where populations of Savannah Lilliput exist in South Carolina.
- Completion of targeted surveys where historic occupancy or suitable habitat for host fish. collecting genetic swabs to study the relationships between populations will be a measure of success.
- Achieving minimum flows from dams that are effective in reducing or eliminating mussel strandings.
- Outreach to relevant landowners about the importance of freshwater mussels and their habitats.
- Determine the effects of channel modification, such as dams, on the Savannah Lilliput.
- Determination of environmental and toxicological tolerances and endpoints.

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Barrel Floater

Utterbackiana couperiana (Lea, 1840)

Contributor (2005): Jennifer Price (SCDNR)

Reviewed and Edited (2012): William Poly (SCDNR)

Reviewed and Edited (2024): Ericah Beason (SCDNR)



Figure 1. Image of *Utterbackiana couperiana* courtesy of the North Carolina Museum of Natural Sciences, Jamie Smith, and Dr. Art Bogan. The NCSM catalog number of the specimen photographed is 48715.2.

DESCRIPTION

Taxonomy and Basic Description

Research from Mock et al. (2004) and Zanatta et al. (2007) found the genus *Anadonta* to be polyphyletic, with eastern North American species forming a monophyletic clade that is distinct from the clade that includes the type species (*Anadonta cygnea*, occurring in Eurasia) and western North American *Anadonta*. The knowledge of this distinctive clade led to the Barrel floater being reassigned into the genus *Utterbackia* by Graf and Cummings (2007) and Cummings and Graf (2010) but no discussion or supporting evidence was provided which led to the reassignment not being recognized. Because of this, the next available genus for the eastern North American clade (including *A. couperiana, A. heardim A. suborbiculata,* and *A. implicata*) was *Utterbackiana* (Frierson, 1927), the senior available name for the monophyletic clade, with the type species being *Anadonta suborbiculata.* The Barrel Floater (*Utterbackina couperiana*) name has been recognized by the Freshwater Mollusk Conservation Society based on the discussion in Williams et al. (2017). The name differs from *Anadonta couperiana* found in the 2015 SWAP.

The Barrel Floater (Figure 1) is laterally flattened (wide) and ranges in color from pale greyish yellow to yellowish brown. The ventral margin of the shell is broadly rounded while the dorsal margin is straight. The shell is thin and lacks pseudocardinal and lateral teeth. The length to height ratio of this species is approximately 1.5. The outer surface of the shell has fine green rays. Barrel floaters may reach over 100 mm (4 in.) in length (Bogan and Alderman 2004, 2008).

The Barrel Floater, like many native freshwater mussels, can be misidentified with other species. The Barrel Floater may be confused with the Paper Pondshell (*Utterbackia imbecillis*) or the Eastern Floater (*Pyganadon cataracta*), especially when alive. The Paper Pondshell umbo is never above the dorsal margin, whereas in the Barrel Floater, it can barely extend above the hinge margin. The Eastern Floater umbo is always above the hinge margin and is typically inflated.

Status

NatureServe (2024) currently identifies the Barrel Floater as having a global rank of apparently secure (G4). This species is ranked as critically imperiled to imperiled (S1S2) in South Carolina and is a species of special concern. The Barrel Floater is critically imperiled (S1) in North Carolina and apparently secure (S4) in Georgia.

POPULATION SIZE AND DISTRIBUTION

The Barrel Floater was once found from the Apalachicola region in Florida to the Cape Fear River Basin in North Carolina (Bogan and Alderman 2004, 2008). However, most records of the species in North and South Carolina are not recent, and it may have been extirpated from much of its former range (Taxonomic Expertise Committee 2004). A few populations are known in the Savannah River (Figure 2) and its tributaries, and there are a few old records from the Little Pee Dee and Edisto Rivers. It is not clear if some of these populations persist, since a recent survey of the Little Pee Dee failed to locate any Barrel Floaters (T. Savidge pers. comm., Jan. 25, 2005). It is quite rare when it is found (Taxonomic Expertise Committee 2004). There have been a total of 16 reported observations of the species in South Carolina from 1978-2006, mostly in the coastal plain region. Fuller (1979) stated that the Barrel Floater was found in much of peninsular Florida and not usually populous in the Atlantic drainages to the North, with South Carolina being on the periphery of its range.

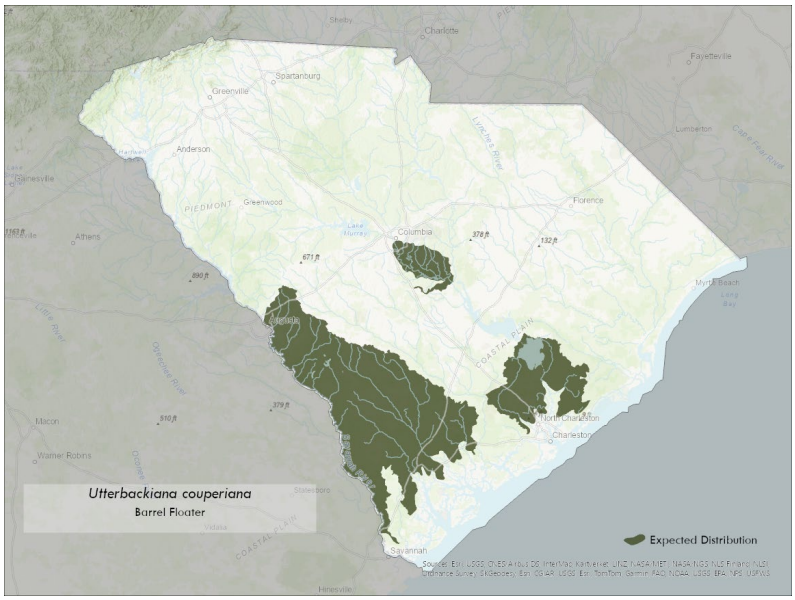


Figure 2. Expected distribution of *Utterbackiana couperiana* based on reported observations at a HUC 8 watershed level and designated ecoregions.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Barrel Floater is found in ponds or slow flowing streams with soft, sandy or muddy bottoms (Fuller 1979). Often those bottoms are very deep with soft, unstable mud (Taxonomic Expertise Committee 2004). Although the Barrel Floater can tolerate softer sediments, like all South Carolina native mussels, it must be able to remain stabilized during high flow events. Although increased development from anthropogenic sources and stream modifications may provide more suitable substrate types for the Barrel Floater (Fuller 1979), it may result in higher flow during precipitation events due to increased runoff, making habitats undesirable because of the increased velocity and shear stress.

There are no reported host fish for the Barrel Floater. Host fish for species in the same genus include Alewife (Alosa pseudoharengus), Blueback Herring (Alosa aestivalis), and Striped Bass (*Morone saxatilis*) (Kneeland and Rhymer 2008). White Sucker (Catostomus commersoni), Pumpkinseed (Lepomis gibbosus), White Perch (Morone americana), and Threespine Stickleback (*Gasterosteus aculeatus*) are suspected hosts (Davenport and Warmuth 1965; Wiles 1975).

One report of the Barrel Floater notes an observation of a singular population in Florida containing gravis females in midwinter (Heard 1979).

CHALLENGES

Research into the life history and habitat preferences of the Barrel Floater is minimal. Observational data suggest that the species, unlike most native freshwater mussels, is tolerant of siltation but sensitive to toxicants (Taxonomic Expertise Committee 2004). The biggest challenge to this species is the sharp decline from its previous historic range and the extreme rarity with which it is encountered. Little is known about specific challenges to this species and the causes of its decline are not understood. No known ecological or toxicological endpoints for the species exist. The life history and host fish preferences are undetermined which are needed prior to producing animals for potential augmentation of populations.

CONSERVATION ACCOMPLISHMENTS

There are no significant conservation accomplishments for the Barrel Floater at this time.

CONSERVATION RECOMMENDATIONS

- Conduct surveys to determine the current status of the Barrel Floater.
- Determine host fishes used by the Barrel Floater.
- Explore the need to list the Barrel Floater within South Carolina, based on survey results.
- Closely monitor the presence of various pollutants in present and historic parts of the Barrel Floater's range.
- Evaluate the species' sensitivity to pollutants and address any point source pollutants that are found.
- Consider reintroduction of the Barrel Floater to parts of its historic range, where and when conditions seem to have improved.
- Protect critical habitats for the Barrel Floater from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Barrel Floater.

MEASURES OF SUCCESS

- Thorough, standardized surveys in historical ranges of the species which aid in a comprehensive status assessment of the species.
- Determination of host fishes used for reproduction of the Barrel Floater.
- Determination of life history of the Barrel Floater including time of spawning and brooding.
- Monitoring of wild populations of the species that show stabilization or an increase in the size of South Carolina's populations of the Barrel Floater.
- Collecting swabs, genetic material, or vouchers when needed to determine population genetics.

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Alewife Floater
Utterbackiana implicata

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason and Morgan Kern (SCDNR)



Figure 1. Image of *Utterbackiana implicata* photographed by Briana Cairco, SCDNR.

DESCRIPTION

Taxonomy and Basic Description

Alewife Floater (*Utterbackiana implicata)* was reassigned into the genus *Utterbackiana* in Williams et al. (2017). The scientific name was changed from *Anodonta implicata* (Say, 1829) as it appeared in the 2015 SWAP.

The shell of the Alewife Floater is a medium- to large-bodied mussel that can grow to around 6 inches in length (Figure 1). The umbo or beak of the shell is raised above the hinge line, which is straight or slightly curved. The majority of the shell is thin but thickens on the ventral margin moving from the posterior to anterior of the shell. This thickening is more pronounced in larger individuals. Shells lack pseudocardinal and lateral teeth. The shell surface is smooth and varies from almost shiny to rough. The shell surface may have irregular growth lines which can form ridges. The anterior margin of the shell is narrowly rounded; the posterior margin is bluntly pointed below the midline. The ventral margins are generally straight. The shell is elliptical and oblong to ovate. The color of the periostracum varies. Observed colors include yellowish-brown, greenish-brown, and reddish-brown; individuals often become dark brown to black with age. Shells of young Alewife Floaters may have fine green rays. The inner surface, nacre, of the shell varies from white, salmon, or purple and is generally darker in the beak



Figure 2. Images of *Utterbackiana implicata* courtesy of Tim Savidge, Three Oaks Engineering.

cavity (Smith 1991; Bogan and Alderman 2004, 2008; Nedeau 2008).

As with many of our native freshwater mussels, Alewife Floater can be easily misidentified especially when the individual is still living. They can closely resemble Easter Floater (*Pyganadon cataracta*) in shape, color, umbo or beak height. Both species lack pseudocardinal and lateral teeth. The main differentiating feature is the thickening of the shell which is absent in Eastern Floater.

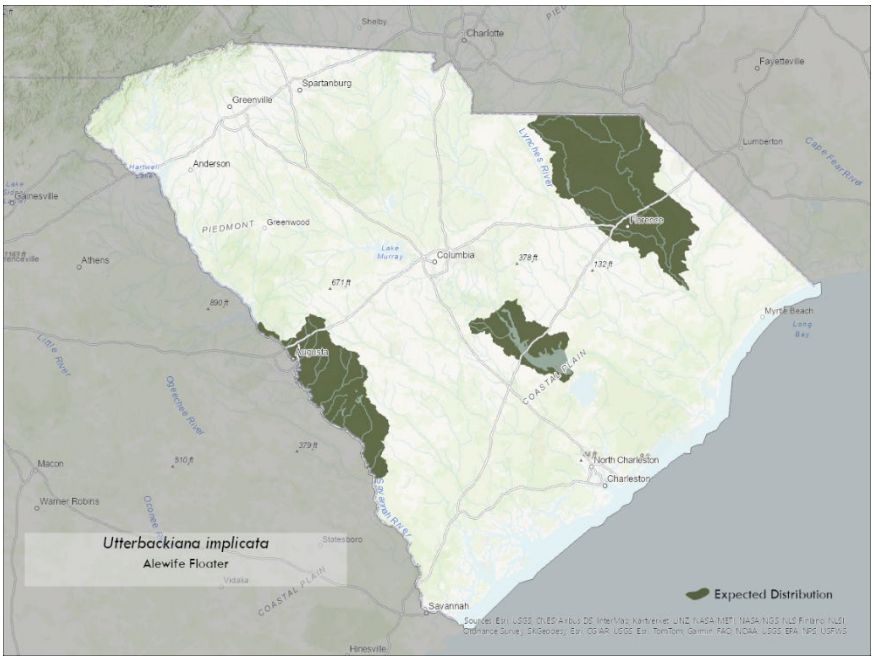


Figure 3. Expected distribution of *Utterbackiana implicata* based on reported observations at a HUC 8 watershed level and designated ecoregions.

Status

Nature Serve (2024) currently identifies this species as globally secure (G5). It is currently ranked as SU in South Carolina as no targeted efforts to survey for this species in SC have been made. Some shells have been identified by morphology as recently as 2023 but have not been confirmed genetically.

POPULATION SIZE AND DISTRIBUTION

The Alewife Floater is mainly a northern species with a primary range extending from Maryland to Canada, with disjunct populations in the Chowan and Pee Dee River basins in North Carolina. Shells have been found in the Santee River Basin of South Carolina (Alderman 2005) and in lake Wateree in 2023. This species may be found in deeper water which has been historically under surveyed in South Carolina and is similar in morphology to other native species which may cause this species to be misidentified when found alive. Its host fish are mainly anadromous species that travel through South Carolina to reach established populations found in North Carolina in the Pee Dee basin (Bogan and Alderman 2004, 2008). If carrying Alewife Floater glochidia during travel, the species could be throughout the Pee Dee basin. Fuller (1978) thought the species might be found eventually in the Outer Coastal Plain of South Carolina, particularly in the lower portions of rivers. Specimens have not been confirmed in South Carolina genetically.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Alewife Floater is found in streams, rivers, and pools and in a variety of substrates including silt, sand, and gravel across its range. Its distribution appears to be controlled by the distribution of its host fish, mainly clupeids such as the alewife (*Alosa pseudoharengus)* and other migratory fish such as Striped Bass (*Morone saxatilis*).

Reported hosts include Alewife (Alosa pseudoharengus), Blueback Herring (Alosa aestivalis), and Striped Bass (*Morone saxatilis*) (Kneeland and Rhymer 2008). White Sucker (Catostomus commersoni), Pumpkinseed (Lepomis gibbosus), White Perch (Morone americana), and Threespine Stickleback (*Gasterosteus aculeatus*) are suspected hosts (Davenport and Warmuth 1965; Wiles 1975).

CHALLENGES

Without opening its shell, the Alewife Floater can resemble the Eastern Floater and may be misidentified during surveys. Alewife Floater continues to be rare in the rivers of South Carolina and little work has been done surveying the state's reservoirs for freshwater mussels. Due to the lack of direct survey effort, this species is considered data deficient in South Carolina.

Like other freshwater mussels, this species is sensitive to channel modification, agriculture and urban pollution, sedimentation, and saltwater intrusion. Additionally, the Alewife Floater appears to be dependent on migratory fishes for reproduction. Impoundments obstructing migratory fish through the Pee Dee watershed are likely to threaten the Alewife Floater. Channel modifications and fragmented habitats directly impact the only method of dispersal by the species.

Environmental stressors that lead to degradation of water quality, habitat, and stream connectivity include development, agriculture, and incompatible forestry management; additionally, systemic changes that have negative effects include climate change, invasive species, and dams and barriers (USFWS 2021).

In South Carolina, practices such as mining, clearcutting for timber production, and recreational vehicle use in streams are observed to result in degradation of habitat. Preservation of a riparian buffer is needed for the continued existence of suitable habitat for most native freshwater mussels. A riparian buffer is the land area adjoining a stream, lake or wetland characterized by a cover of naturally occurring vegetation consisting of trees, shrubs, grasses, and forbs where development is restricted or prohibited.

CONSERVATION ACCOMPLISHMENTS

There are no significant conservation accomplishments specifically for the Alewife Floater currently.

CONSERVATION RECOMMENDATIONS

- Conduct additional surveys in reservoirs in the Pee Dee Basin, collecting genetic swabs to determine Alewife Floater presence and abundance in this state.
- Complete genetic analysis to determine if individuals collected in South Carolina are Alewife Floater.
- Determine habitats that are critical for this species in South Carolina.
- Perform host fish trials to determine natural hosts for native populations.
- Facilitate the travel of anadromous fishes such as the alewife by keeping rivers and streams free of artificial obstructions or by using fish ladders at dams.
- Conserve populations of host fish to insure propagation of the Alewife Floater in the wild.
- Protect critical habitats for the Alewife Floater from future development and further habitat degradation by following Best Management Practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Alewife Floater.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.

- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.

MEASURES OF SUCCESS

- Completion of targeted surveys in areas of historic occupancy and similar habitat types to determine the species range and distribution.
- Collection of genetic material of Alewife Floater and Eastern Floater to ensure successful identification of species range and distribution.
- Perform outreach to relevant landowners about the importance of freshwater mussels and their habitats.
- Comprehensive, range-wide genetic analysis of the species.
- Completion of thorough, standardized surveys in presumed range and habitat of the species.
- Determination of host fishes used for reproduction of the Alewife Floater in South Carolina.
- Monitoring of wild populations of the species that show stabilization or an increase in the size of South Carolina's populations of the Alewife Floater.
- Determine the effects of channel modification, such as dams, on the Alewife Floater.
- Determination of environmental and toxicological tolerances and endpoints.

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Notched Rainbow

Venustaconcha constricta (Conrad, 1838)

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason and Morgan Kern (SCDNR)

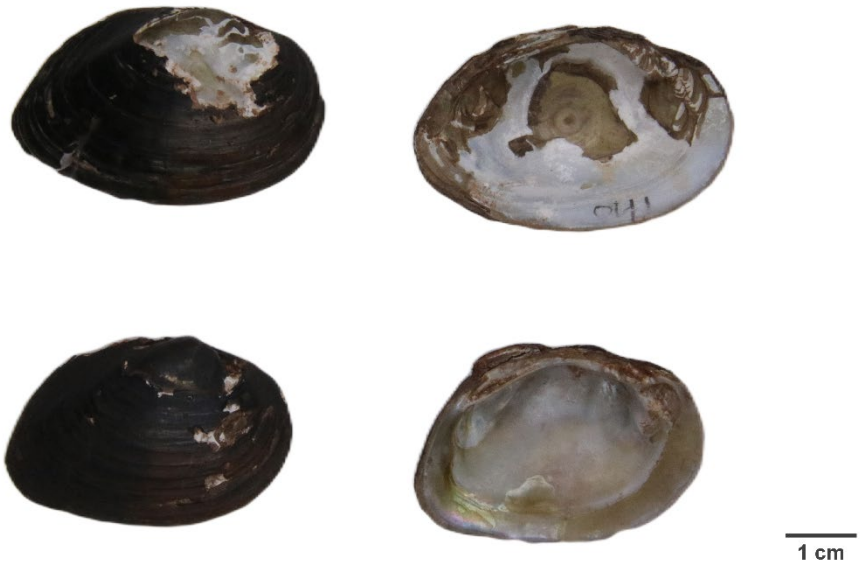


Figure 1. Images of *Venustaconcha constricta* photographed by Briana Cairco, SCDNR. Both specimens are presumed male based on shell morphology.

DESCRIPTION

Taxonomy and Basic Description

The Notched Rainbow was reassigned into the genus *Venustaconcha* by the Freshwater Mollusk Conservation society in (2023) based on the work in Watters (2018) and supporting evidence from Kuehnl (2009). The scientific name was changed from *Villosa constricta* (Conrad, 1838) as it appeared in the 2015 SWAP.

The shell of the Notched Rainbow (Figure 1) is rather small and short and is sub-elliptical in shape. The shell of the female has a posterior point a little more than midway up from the base with a small swelling along the outline. The shell of the male is often sub-rhomboid with the posterior point generally less than midway up from the base. The outer surface of the Notched Rainbow's shell is yellowish-green or green and has indistinct rays. The inner surface of the shell is bluish, sometimes purplish in the center and sometimes thicker in front (Bogan and Alderman 2004, 2008).

Status

NatureServe (2024) currently identifies the Notched Rainbow as vulnerable (G3) globally. This species is ranked critically imperiled (S1) in South Carolina and vulnerable in North Carolina and Georgia (S3).

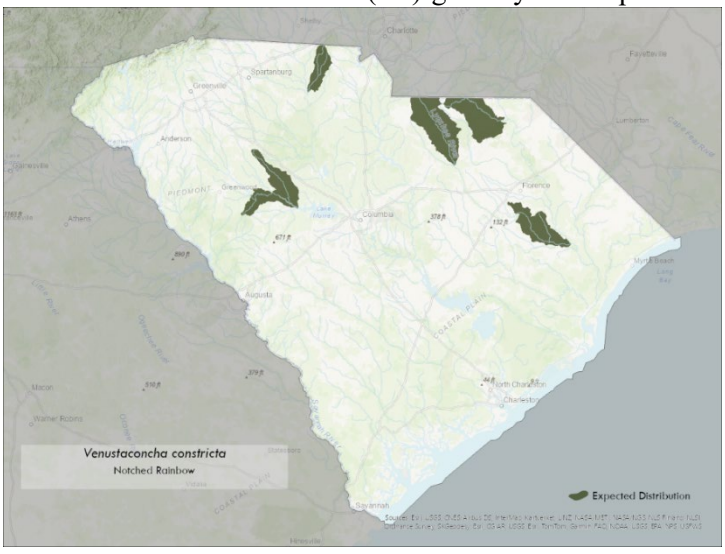


Figure 2. Expected distribution of *Venustaconcha constricta* based on reported observations at a HUC 10 watershed level and designated ecoregions.

POPULATION SIZE AND DISTRIBUTION

The Notched Rainbow ranges from the Rappahannock River Basin in Virginia to the Santee-Cooper Basin in South Carolina (Johnson 1970). In South Carolina, it has been found in the headwaters of the Lynches River, Hills Creek, Black Creek, and Deep Creek in the Pee Dee drainage as well as in the Little Sandy River in the Broad River Basin. It has declined in many portions of its range, especially in the larger rivers. In

recent, targeted surveys at historic sites have resulted in no animals of the species found. In 2024, a shell of *V. constricta* was collected in Thompson Creek in the Pee Dee watershed.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

This species is found in riffles, runs, and pools of streams and large rivers. It prefers sandy or sand and gravel substrates only in very clean, high-quality habitats.

This species has been found gravid March-May in North Carolina. Eads et al. (2006) reported Fantail darter as a possible host in a laboratory setting. Green Sunfish also produced a small number of juvenile Notched Rainbow but was not recommended as a host in that study (Eads et al 2006). Watters et al. (1999) reported small numbers of juveniles produced from infesting Smallmouth Bass, Central Stoneroller, Goldfish, Siamese Fighting Fish, Blackside Darter, Tessellated Darter, Logperch, Yellow Perch, Redbreast Sunfish, Longear Sunfish, Smallmouth Bass, Rockbass and a Bullfrog Tadpole in laboratory infestations. No work has been done to determine hosts in the wild and additional laboratory testing is still needed for fish species with overlapping ranges.

CHALLENGES

This species is becoming increasingly rare in South Carolina, historic habitats such as the headwaters of the Lynches River may no longer be able to support this species. Work to recover this species through propagation would be difficult without access to broodstock from North Carolina or Virginia. Little is known about the reproductive and brooding behaviors of *V. constricta,* and wild host fish(es) are unknown.

Like other freshwater mussels, the Notches Rainbow is sensitive to changes in water quality, habitat, and access to host fishes, although the degree of sensitivity to these changes is understudied. Like other freshwater mussels, the Notched Rainbow must have adequate access to species-specific hosts and relies on host fishes for reproduction and distribution. Maintaining stream connectivity for host fishes is important to allow distribution of juveniles and gene flow between populations. Environmental stressors that lead to degradation of water quality, habitat, and stream connectivity include development, agriculture, and incompatible forestry management; additionally, systemic changes that have negative effects include climate change, invasive species, and dams and barriers (USFWS 2021).

In South Carolina, practices such as mining, clearcutting for timber production, and recreational vehicle use in streams are observed to result in degradation of habitat. Preservation of a riparian buffer is needed for the continued existence of suitable habitat for most native freshwater mussels. A riparian buffer is the land area adjoining a stream, lake or wetland characterized by a cover of naturally occurring vegetation consisting of trees, shrubs, grasses, and forbs where development is restricted or prohibited.

CONSERVATION ACCOMPLISHMENTS

As a part of a SWG grant, 5 sites with historic observation of the species were visited; however, no live animals were collected during survey efforts.

CONSERVATION RECOMMENDATIONS

- Conduct surveys to determine population status and distribution of the Notched Rainbow. Closely monitor known populations and any additional populations discovered in the surveys.
- Determine habitats that are critical for this species in South Carolina.
- Develop a restoration plan that considers the need for augmentation or reintroduction.
- Protect critical habitats for the Notched Rainbow from future development and further habitat

degradation by following best management practices and protecting and purchasing riparian areas.

- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Notched Rainbow.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Conduct further research to determine the degree of sensitivity of the Notched Rainbow to various point and non-point sources of pollution and land use impacts.
- Research the reproductive and brooding behavior of the species.

MEASURES OF SUCCESS

- Completion of targeted surveys where historic occupancy or suitable habitat for host fish.
- Collection of genetic swabs of Notched Rainbow when found.
- Development of a restoration plan that may include propagation and culture to reintroduce the species in suitable habitat within its historic range.
- Outreach to relevant landowners about the importance of freshwater mussels and their habitats.
- Determination of environmental and toxicological tolerances and endpoints.
- Determination of life history of the Notched Rainbow including time of spawning and brooding.
- Determination of wild host fishes used for reproduction of the Notched Rainbow.

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Southern Rainbow

Villosa vibex
(Conrad, 1834)

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason (SCDNR)



Figure 1. Images of male (top) and female (bottom) *Villosa vibex* photographed by Briana Cairco, SCDNR.

DESCRIPTION

Taxonomy and Basic Description

In the 2015 SWAP, this mussel species was represented as the Eastern Rainbow (*Villosa modioliformis*) but has since been synonymized with the Southern Rainbow (*Villosa vibex*) based on review of the *Villosa* genus by Watters (2018), but attention was drawn to the uncertainty of the Atlantic Slope species differing from that found in the Gulf of Mexico drainages. *Villosa modioliformis* was first synonymized with *V. vibex* in (1970) by Johnson who examined shell specimens from across its range. The synonymizing of *V. modioliformis* into *V. vibex* was recognized by the Freshwater Mollusk Conservation Society in (2019) but there remains uncertainty in Atlantic Slope specimens. Comprehensive genetic analysis is needed to determine if individuals in South Carolina are *V. vibex* or *V. modioliformis*.

The shell of the Eastern Rainbow (Figure 1) is elliptical to an elongate egg-shape with the anterior and posterior margins evenly rounded and the dorsal margin straight. The ventral margin is straight to slightly curved in males and often more strongly curved in females towards the posterior. The posterior ridge is broadly rounded. The outer surface of the Eastern Rainbow's shell is greenish-yellow to olive brown with broad unbroken to slightly wavy dark green rays. These rays are occasionally absent or restricted to the posterior portion of the shell. The umbo is wide, very low, and sculptured with a few coarse, double-looped ridges. The inner surface of the shell is bluish-white and often iridescent posteriorly. The shell length averages 60 mm (2.4 in.) but may be up to 100 mm (4 in.).

This species can easily be mistaken for *Villosa delumbis and Sagittunio vaughanianus* when alive. *Villosa delumbis* females are more obviously sexually dimorphic than those of *Villosa vibex* and have broken rays. Individuals of *Sagittunio vaughanianus* are darker in color and have a more pointed posterior.

Status

NatureServe (2024) currently identifies the Southern Rainbow as having a global ranking of secure (G5). In Tennessee and Louisiana, the species is ranked as imperiled (S2) and in South Carolina the species is ranked as imperiled (S2?). Georgia has the species ranked as secure (S5) and Alabama and Mississippi have the species ranked as apparently secure (S4) and (S4?) respectively.

POPULATION SIZE AND DISTRIBUTION

The Southern Rainbow is found primarily in the Gulf Coast area and ranges from the Cape Fear Basin in North Carolina, south to peninsular Florida and west to the Pearl River in the Mississippi drainage. In South Carolina, there have been a total of 57 reported observations to date. This species has been most frequently observed in the Steven's Creek sub-basin of the Savannah River (Figure 2). Outside of this, observations are sparse and scattered throughout the following sub-basins: Salkehatchie, Upper Savannah, Middle Savannah, Broad-St. Helena, Lower Catawba, Black, Lynches, Lower Pee Dee, Lake Marion, Cooper, Saluda, Enoree, and South Fork Edisto. Even when found in South Carolina, the Southern Rainbow is never abundant. Although the Southern Rainbow is more abundant in Georgia, the individuals collected have a different appearance, which, to some researchers, indicates that the South Carolina and Georgia populations are actually different species (Taxonomic Expertise Committee 2004).

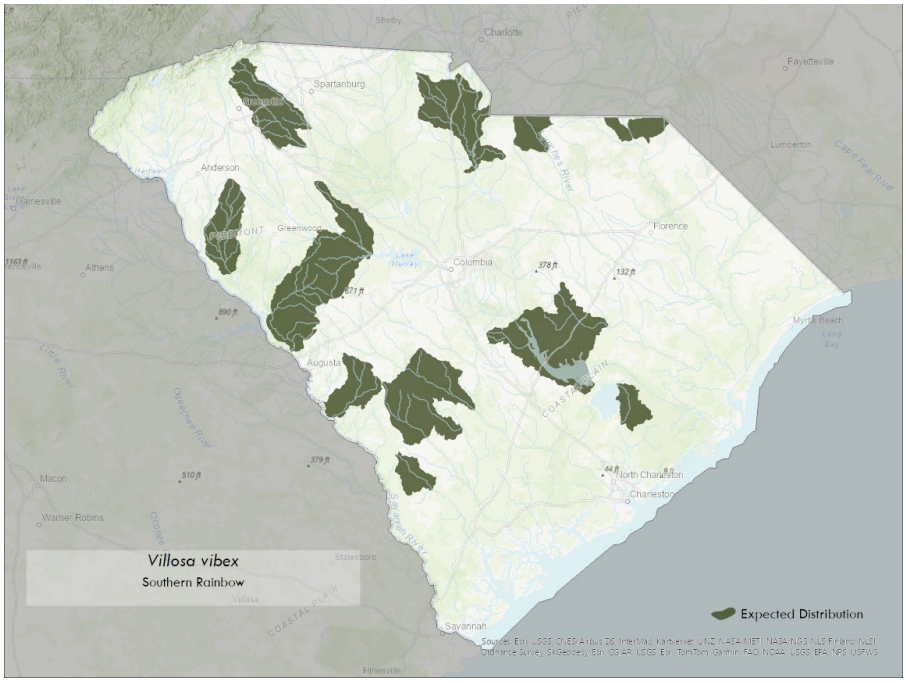


Figure 2. Expected distribution of *Villosa vibex* based on reported observations at a HUC 10 watershed level and designated ecoregions.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Southern Rainbow is found in sandy runs of small to medium-sized creeks and small rivers. This mussel is sometimes found in rocky portions of the same types of rivers (Taxonomic Expertise Committee 2004). In the Conasauga River in Tennessee, the Eastern Rainbow has been reported to live in stretches with moderate current at depths of less than 0.9 m (3 ft.) (Bogan and Alderman 2004, 2008). Johnson (1970) notes the species being found in mud and soft sand, particularly with rich vegetable detritus.

Laboratory trials show that host fishes include Green Sunfish, Blackspotted Topminnow, Redeye Bass, Largemouth Bass, Spotted Bass, and Longear Sunfish, with Spotted Bass producing the most juveniles in the trial (Haag et al. 1999). During the study, 10 of the 13 gravid adult females collected from Shoal Creek in Alabama were observed displaying a mantle margin lure in March (Haag et al. 1999). Seven of the females were observed lying on their sides, completely exposed on top of the substrate and 3 females were exposed but near rocks; male *Villosa vibex* were mostly observed buried with only siphons exposed, with 1 exception that was found exposed. Haag et al. (1999) describe the modified female mantle as extending "…from a point immediately anterior to the incurrent siphon to a point directly ventral and opposite to the posterior-most end of the hinge ligament." Additionally, the observed mantle margins were "…ornamented with approximately 15 pairs of unbranched tentacle-like papillae about 15 mm in length that were thick at the base but tapered to a fine point." (Haag et al. 1999). Coloration of the papillae, the outer sheath, and inner surface of the sheath varied but had some variation of inky black, rusty orange, and fine black spots (Haag et al. 1999). All females observed had fully gravid gills visible just below the shell margin and the papillae were pulsated rapidly and actively (Haag et al. 1999).

Additional work shows that *V. vibex* mostly display during the day and require physical interaction before releasing large amounts of glochidia (Haag and Warren 2000). Watters (2018) noted seeing gravid females from June to the following February.

CHALLENGES

A comprehensive approach is needed to determine if animals of *Villosa vibex* being collected in South Carolina are the same species as those collected in Alabama and Mississippi. Drought conditions from 1999-2001 resulted in species decline in the Flint River drainage in Georgia as seen in surveys (Chastain et al. 2005).

Like other freshwater mussels, the Southern Rainbow is sensitive to changes in water quality, habitat, and access to host fishes, although the degree of sensitivity to these changes is understudied. Like other mussels, the Southern Rainbow must have adequate access to species-specific hosts and relies on host fishes for reproduction and distribution. Maintaining stream connectivity for host fishes is important to allow distribution of juveniles and gene flow between populations. Environmental stressors that lead to degradation of water quality, habitat, and stream connectivity include development, agriculture, and incompatible forestry management; additionally, systemic changes that have negative effects include climate change, invasive species, and dams and barriers (USFWS 2021).

In South Carolina, practices such as mining, clearcutting for timber production, and recreational vehicle use in streams are observed to result in degradation of habitat. Preservation of a riparian buffer is needed for the continued existence of suitable habitat for most native freshwater mussels. A riparian buffer is the land area adjoining a stream, lake or wetland characterized by a cover of naturally occurring vegetation consisting of trees, shrubs, grasses, and forbs where development is restricted or prohibited.

CONSERVATION ACCOMPLISHMENTS

Preliminary genetic analyses have been conducted on some populations of the Southern Rainbow. However, comprehensive genetic analysis is needed to determine if populations from different parts of its range represent distinct species.

CONSERVATION RECOMMENDATIONS

- Conduct additional, comprehensive genetic analyses across the range of the Southern Rainbow.
- Conduct additional surveys for the Southern Rainbow across SC and target areas where fragmented occurrences have been reported.
- Explore the need to list the Southern Rainbow within South Carolina, based on survey results.
- Protect critical habitats for the Southern Rainbow from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Southern Rainbow.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Educate off-road motor vehicle operators of the negative effects of crossing streams at multiple locations and using stream bottoms as trails.
- Conduct further research to determine the degree of sensitivity of the Southern Rainbow to various point and non-point sources of pollution and land use impacts.
- Determine habitats that are critical for this species in South Carolina.

MEASURES OF SUCCESS

- Resolving genetic issues across the range of the Southern Rainbow.
- Persistence of known populations and an increase in numbers of rare species will indicate the success of management activities.
- Verification of laboratory tested host fishes in the wild.
- Completion of targeted surveys in areas of historic occupancy and similar habitat types across SC.
- Determine the effects of channel modification, such as dams, on the Southern Rainbow.
- Determination of environmental and toxicological tolerances and endpoints.

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Rotund Mysterysnail

Callinina intertexta (Say, 1829)

Contributor (2024): Ericah Beason and Jeff Smola (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

Originally described by Say (1829) as *Paludina intertexta*, but over time has had many names synonymized to its current name. North American species of *Viviparus* were reassigned to genus *Callinina* by Stelbrink et al. (2020) where they determined the genus *Viviparus* is polyphyletic. In the 2023 Freshwater Gastropod list released by the Freshwater Mollusk Conservation Society, this change was recognized for *C. intertexta* (FMCS 2023).



Figure 1. Image of *Callinina intertexta* labelled *Viviparus intertextus* on web-based Freshwater Gastropods of North America. Image courtesy of Dillon et al. (2019).

Its shell is sub globose, yellowish-green or brownish, wrinkled, and with many thin, revolving lines. There are nearly four volutions and the suture is rather deeply indented (Figure 1). It is remarkable for its globular form and for the numerous obsolete lines. *Callinina* can be distinguished from *Viviparus* and the other genera with a concentric inverted-comma-shaped operculum by the following combination of characters: a thin marginal region that obviously differs in color from the enamel region; a shiny, smooth and relatively small nuclear region; and a narrow inner enamel region (Zhang and Rintelen 2021).

Callinina intertexta could be misidentified with *C. georgiana*, but *C. intertexta* has a relatively darker and thicker operculum in comparison to *C. georgiana* (Say 1829). Additionally, *C. georgiana* tends to have thick, dark bands attributing to its common name the "Banded Mysterysnail." Although, in tannic waters, it could be hard to see the bands due to shell staining.

Status

The species is globally ranked as apparently secure (G4) but is ranked as imperiled (S2) in North Carolina and ranked as imperiled to vulnerable in South Carolina (S2S3) (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

The Rotund Mysterysnail is primarily found in the American interior basins but has many occurrences throughout the Atlantic drainages, ranging from Georgia to southern North Carolina; however, the presence of the species in these states seem peripheral. There have been a total of 41 reported occurrences of the species in South Carolina from 1965-2012 (Figure 2). More than half

of the observations were reported by Dillon and team. All observations have been in the coastal plain region or right on the boundary of the coastal plain and coastal zone. Animals have been found in all 4 major watersheds in South Carolina including the Pee Dee, Santee, ACE, and Savannah. Although we have observations of this species, we do not have a comprehensive understanding of their range, relative densities, habitat preferences, or population dynamics. The last reported occurrence of this species was in 2012, even though work within their presumed distribution was occurring.

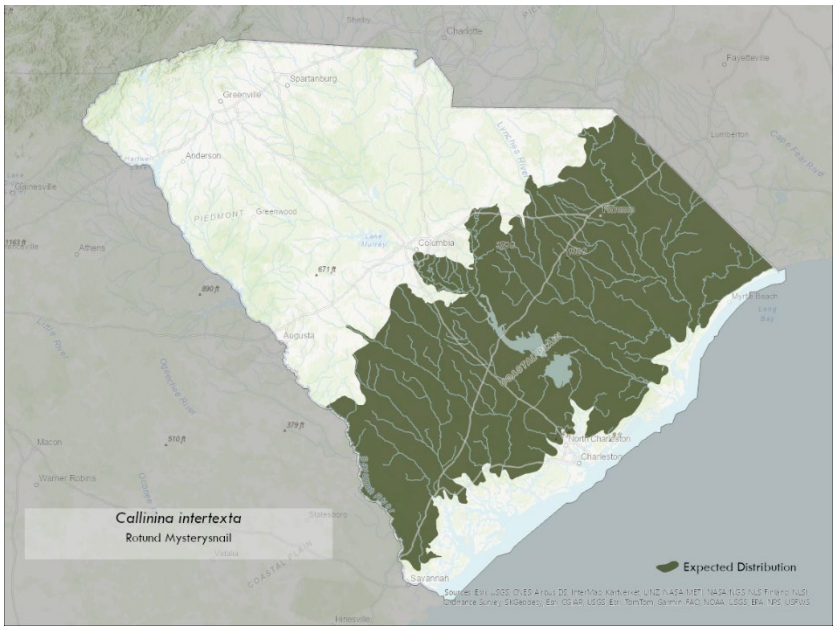


Figure 2. Expected distribution of *Callinina intertexta* in South Carolina based on reported observations at a HUC 6 watershed level and designated ecoregions.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Dillon et al. (2019) report that individuals found in Atlantic drainages are typically in swamps and slow-moving rivers within the Coastal Plain. They note that individuals are often in shallow, isolated, or temporary habitats. Additionally, despite the dark tannic waters they inhabit, it has been observed that they are not overly acidic (Dillon et al. 2019). Nothing is known regarding the life cycle of *V. intertexta*, targeted surveys and research is needed. Cook (1949) has recorded the process of filter feeding in European *V. viviparus*. The stationary, burrowing habits observed in the European species closely resemble those exhibited by *C. intertexta* in the swamps of the US interior and coastal plain (Dillon et al. 2019).

CHALLENGES

The greatest challenge with the Rotund Mysterysnail in SC seems to lie in the unfavorable survey conditions of its preferred habitat. This species is often found in swamps which are difficult to navigate and pose additional challenges due to mosquitos, alligators, and deep, soft mud that is difficult to traverse. Additionally, not much is known about environmental and toxicological tolerances of the species and at present, there is not a standardized survey protocol for snails in South Carolina. The development of a standardized survey is needed to ensure accurate and insightful data collection to aid in our understanding of population dynamics of the species.

CONSERVATION ACCOMPLISHMENTS

There are currently no known conservation accomplishments specifically for the Rotund Mysterysnail.

CONSERVATION RECOMMENDATIONS

- Develop a standardized survey protocol for snails in the coastal plain and coastal zone.
- Collect voucher specimens to aid in the genetic confirmation of the species and family which it belongs
- Explore the need to list the Rotund Mysterysnail within South Carolina based on survey results.
- Conduct standardized surveys in coastal plain and coastal zone to determine the population range and life history requirements for the Rotund Mysterysnail.
- Carefully monitor existing populations of the Rotund Mysterysnail
- Determine habitat restoration methods that will benefit the Rotund Mysterysnail.
- Protect critical habitats for the Rotund Mysterysnail from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Conduct further research to determine the degree of sensitivity of the Rotund Mysterysnail to various point and non-point sources of pollution and land use impacts.

MEASURES OF SUCCESS

- Performing standardized surveys across the range of the species.
- Protecting land and maintaining healthy riparian habitat adjacent to habitats with populations of Panhandle Pebblesnails.
- Outreach to relevant landowners about the importance of freshwater mussels and their habitats.
- Development of a species-specific restoration plan based on the results of routine monitoring and the implementation of that plan for augmentation.

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Data Deficient Freshwater Snails Guild

Family Planorbidae
- Flexed Gyro *Gyraulus deflectus* (Say, 1824)
- Thicklip Rams-horn *Planorbula armigera* (Say, 1821)

Family Lymnaeidae
- Golden Fossaria *Galba obrussa* (Say, 1825)
- Marsh Fossaria *Galba humilis* (Say, 1822)

Family Amnicolidae
- Indented Duskysnail *Lyogyrus retromargo* (Thompson, 1968)

Family Physidae
- Tadpole Physa *Physella gyrina* (Say, 1821)

Family Pomatopsidae
- Slender Walker *Pomatiopsis lapidaria* (Say, 1817)

Family Valvatidae
- Threeridge Valvata *Valvata tricarinata* (Say, 1817)

Contributor (2024): Ericah Beason (SCDNR)

OVERVIEW

Freshwater snails are a diverse group of animals within the class Gastropoda (phylum Mollusca) and are broadly distributed worldwide. North America is of global importance, having one of the highest numbers of freshwater snail species recognized. In 2013, Johnson et al. completed a conservation assessment of 703 species of native freshwater snails from Canada and the United States representing 16 families and 93 genera. Here they described that freshwater gastropods have 67 species (10%) considered likely extinct, 278 (40%) endangered, 102 (15%), threatened, 73 (10%) vulnerable, and 26 (4%) have uncertain taxonomic status. This makes 74% of the entire fauna imperiled, exceeding levels of fishes (39%), crayfishes (48%), and even bivalves (72%) by a small margin. The remaining 157, only 26%, of North American species are considered stable. Freshwater gastropods are an important component in their aquatic ecosystems; most feed on periphytic and epiphytic algae and biofilms. In some habitats, freshwater gastropods may be the principal grazers and are capable of significantly influencing algal primary production. Others are suspension or deposit feeders, capturing and resuspending nutrients in the water column.

Like other aquatic organisms, freshwater gastropods are largely threatened by rapid habitat changes due to anthropogenic development, inputs, degradation, or modifications. Johnson et al. (2013) point to habitat destruction in medium and large rivers as the primary cause for most extinctions of highly endemic species (those occurring in a single lake, stream, or spring), citing damming and channelization (45 species, 67% of total), drainage or diversions of lakes (8 species, 12%), alteration of springs (4 species, 6%), and potential effects of exotic fish introduction (2 species, 3%).

In South Carolina, a total of 45 species are recognized to potentially occur in the state; however, 8 are non-native to SC and 2 need to be genetically confirmed. No recent standardized surveys have been completed across the state of South Carolina. The bulk of observations which lead to species

recognition in South Carolina came from Burch and Tottenham (1980) placing the species in SC, or Dillon et al. (2019) reporting observations from 1952-2019. Nomenclature and uncertain taxonomy pose a specific challenge when placing observation records in South Carolina, which can be seen in some species profiles below. The State Wildlife Action Plan aims to provide a framework for the conservation of species with the greatest need for conservation in the state; however, it proves difficult to place a conservation ranking on species with minimal data. Because of this, 9 species, representing 6 families are given a data deficient conservation ranking, highlighting the need to prioritize collection of baseline data.

FAMILY PLANORBIDAE

Family Planorbidae, the "Rams-horn Snails" is a family of air breathing, freshwater aquatic, pulmonated gastropods. There are a total of 16 genera and 52 species of Planorbidae recognized in the US, Canada, and Mexico by the Freshwater Mollusk Conservation Society as of 2023. Animals in this family can range in size from 1mm to over 30mm and in most cases are discoidal or coiled in a singular plain (Burch 1982), see Figure 1. In general, animals in the Planorbidae family have lost their gill, leaving respiration to occur across the entire mantle cavity. Planorbids are monoecious and able to cross- or self-fertilize and the egg masses are gelatinous, transparent, colorless, and sausage-shaped with numerous yellow eggs (Clarke 1981). Many species produce multiple generations in a year, and others may take a year to reach maturity (Burch 1989).

South Carolina recognizes 9 genera and 10 species of freshwater snails in the family Planorbidae, 2 of which are data deficient, the Flexed Gyro (*Gyraulus deflectus*) and the Thicklip Rams-horn (*Planorbula armigera*) of which are described below.

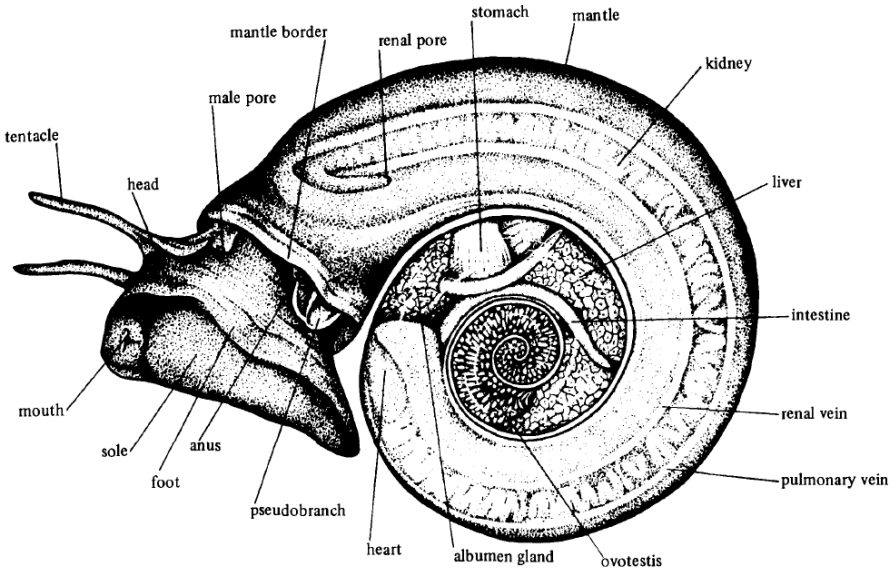


Figure 1. Planorbid (*Biomphalaria*) with shell removed to show aspects of anatomy (left side) pulled from Burch 1982 but originally seen in Barbosa et al. 1968, after Demian.

Flexed Gyro
Gyraulus deflectus (Say, 1824)

The Flexed Gyro was originally described as *Planorbis deflectus* by Say in 1824 and has a dextral shell with five whorls that are flattened and slightly rounded. The spire is not impressed, and the suture is indented but not profoundly. The shells are pale white to flat yellow in color and may exhibit some green.



Figure 1. Image of *Gyraulus deflectus* courtesy of the North Carolina Museum of Natural Sciences, Jamie Smith, and Dr. Art Bogan.

The Flexed Gyro populations are widely distributed across the northern ranges of the US, throughout Canada, and into the central Arctic. The Flexed Gyro has a global ranking of secure (G5); however, the species does not seem secure at the periphery of its southern range, receiving a conservation ranking of vulnerable (S3) in Virginia and imperiled (S2) in North Carolina (NatureServe 2024). In South Carolina, the species has a ranking of SU because of insufficient data on the species. Individuals are observed in several habitats including wetlands, marshes, ponds, lakes, and the shores of rivers, found in both perennial and intermittent waters, usually in mud or on vegetation where inhabiting (Clarke 1981, Burch 1989). Egg masses are small, containing only 2-5 eggs, and gelatinous (Clarke 1981). Although no individuals of *Gyraulus decflectus* have been observed in South Carolina, Burch and Tottenham (1980) placed the species in Virginia and later populations were found in North Carolina. Because no targeted efforts have been completed in South Carolina, the Flexed Gyro distribution cannot be confirmed or denied and therefore, a presumed species distribution map could not be generated.

To accurately determine a conservation priority for this species, presence/absence surveys must be conducted throughout the potential range, collecting voucher specimens or genetic material to confirm the species. Presence/absence surveys could be completed simultaneously with catch-per-unit-effort surveys to determine the relative abundance of the species at specific sites. A thorough study into the reproductive behavior and life cycle could give biologists a better understanding of their population dynamics.

Thicklip Rams-horn
Planorbula armigera (Say, 1821)

The Thicklip Rams-horn was originally described as *Planorbis armigerus* by Say in 1821 and has a dextral shell with a perfectly regular spire that is slightly concave. The suture is well impressed and there are four whorls with a profound umbilicus. The shell is often brownish in color but may exhibit some greenish-brown hues.



Figure 2. Image of *Planorbula armigera* courtesy of the North Carolina Museum of Natural Sciences, Jamie Smith, and Dr. Art Bogan.

Thicklip Rams-horn has a global ranking of secure (G5) and a South Carolina state ranking of SU due to insufficient data on the species (NatureServe 2024). Thicklip Rams-horn are widespread across the United States with scattered populations from Florida to Maine and as far west as Nebraska. Populations of this species seem to tolerate a multitude of habitat types including sluggish water, small order streams, large rivers, swamps, marshes, intermittent pools, and ponds. Although widespread throughout the US west of the Rocky Mountains, no individuals of *P. armigera* have been reported in South Carolina since Burch and Tottenham (1980) placed them in the state. This may be due to a lack of targeted sampling in the coastal plain region where fragmented populations may occur. Dillon and team collected individuals in the coastal plain region in North Carolina, but specimens were found closer to the VA border rather than SC border (Dillon et al. 2019). Because we are unable to confirm the presence of the species at this time, a presumed distribution map could not be generated.

To accurately determine a conservation priority, preliminary presence/absence surveys must be conducted throughout the potential range of the species, collecting voucher specimens or genetic material to confirm the identity of presumed individuals. Presence/absence surveys could be completed simultaneously with a catch-per-unit-effort survey to determine the relative abundance of the species at specific sites. Additionally, not much is known about the specific life history of the species outside of the generalized reproduction history of the family which it belongs. A thorough study into the reproductive behavior and life cycle of the species could give biologists a better understanding of their population dynamics.

FAMILY LYMNAEIDAE

The family Lymnaeidae, the “Pond Snails” is the most diverse family of freshwater gastropods and has a global distribution, being most diverse in the northern US and Canada. There are 13 genera and 61 species of Lymnaeids recognized in the US, Canada, and Mexico by the Freshwater Mollusk Conservation Society as of 2023. Lymnaeids are described by Clarke (1981) as dextrally coiled, mainly thin-shelled, with an elevated spire, with or without an umbilicus, and without an operculum. No Lymnaeids have planispiral shells like those of Planorbidae (Burch 1982). Species in the family Lymnaeidae primarily reproduce through self-fertilization but sexual fertilization can occur. Egg masses are gelatinous, transparent, colorless, and sausage-shaped with few to many eggs (Clarke 1981) and juveniles grow quickly, often with multiple generations produced in a

single year (Burch 1989). Additionally, animals in the Lymnaeidae family are well known for their capability of serving as intermediate hosts for trematodes, or flukes.

South Carolina recognizes 2 genera and 4 species of freshwater snails in the family Lymnaeidae, 2 of which are data deficient, the Golden Fossaria (*Galba obrussa*) and the Marsh Fossaria (*Galba humilis*), which are described below.

Golden Fossaria and Marsh Fossaria
Galba obrussa (Say, 1825) and *Galba humilis* (Say, 1822)

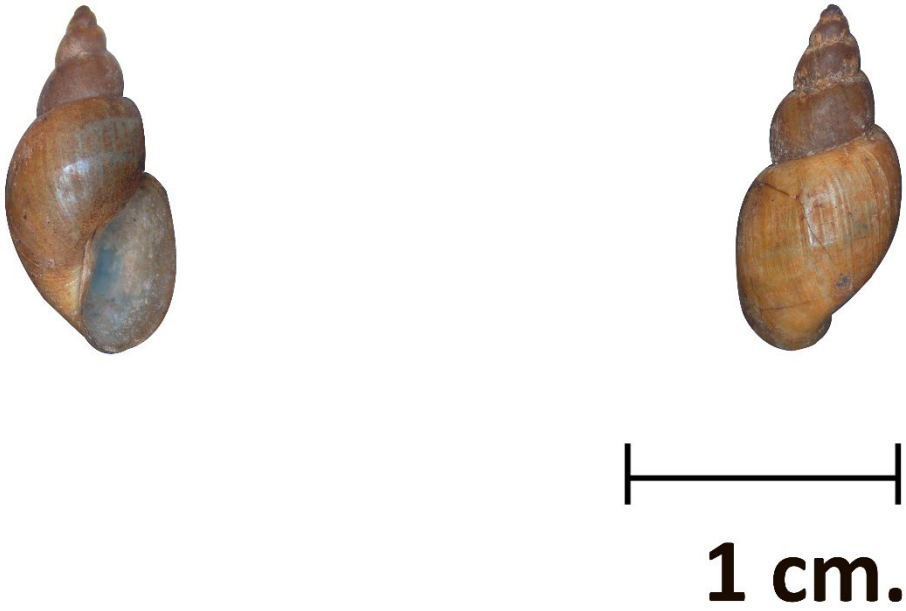


Figure 3. Image of *Galba obrussa* courtesy of the North Carolina State Museum of Natural Sciences, Jamie Smith, and Dr. Art Bogan.

The Golden Fossaria was originally described as *Lymneus obrussus* by Say in 1825 and is a pulmonated aquatic snail where respiration occurs across the entire mantle. It is a "left-handed snail," having the coils of the shell on the left side when viewed from the opening. The shell is oblong and rather slender having 5 whorls which are slightly rounded. The shells are yellow to a pale rust in color. Burch (1982) recognized this species as *Fossaria obrussa* prior to the genera change by Johnson et al. 2013. Alda et al. 2021 recommend *G. obrussa* as a junior synonym of *G. humilis*, however this has not been recognized by the Freshwater Mollusk Conservation Society, which the agency follows for nomenclature of species present in SC.

The Marsh Fossaria was originally described as *Lymneus humilis* by Say in 1822 and is a pulmonated aquatic snail where respiration occurs across the entire mantle. Like *G. obrussa*, *G. humilis* is a "left-handed snail", exhibiting nearly 6 whorls on the left side of the openings. The shell is ovate-conic, thin, and transparent. The labium has an obvious calcium deposit and shells are pale-reddish or yellowish-white in color.

Although minimal work has been completed on the life history of *G. obrussa* or *G. humilis*, Mattice (1975) suggests that temperatures above 15°C may negatively affect reproduction of *G. obrussa*. Animals in the Lymnaeidae family are well known for their capability of serving as intermediate hosts for trematodes, or flukes. *Galba humilis* is a known intermediate host of *Fascioloides magna*, a fluke that can infect deer, bovids, pigs, and horses (Davidson 1981). Additionally, in 2018, a

parasitic blood fluke found in dogs, *Heterobilharzia americana*, was reportedly found using *G. humilis* as an intermediate host (Loker et al. 2021).

The Golden Fossaria has a global ranking of secure (G5) and a South Carolina state ranking of SU due to insufficient data on the species (NatureServe 2024). The Golden Fossaria is widely distributed throughout the US, having populations in almost all the continental states and Canada.

The Marsh Fossaria has a global ranking of secure (G5) and a South Carolina state ranking of SU due to insufficient data on the species (NatureServe2024). The Marsh Fossaria has a more limited range than the Golden Fossaria and is mostly found in the Eastern US with scattered populations towards the west. Like the Carib Fossaria, the Golden and Marsh Fossaria snails are amphibious and prone to leave the water to graze. Individuals are typically found in muddy soils at or around the water line, in streams, marshes, ponds, and lakes regularly found attached to aquatic vegetation (Clarke 1981; Stewart and Dillon 2004).

Dillon et al. (2019) reported 12 observations of *Lymnaea (Galba) humilis* in South Carolina; however, Dillon includes Fossaria *or Galba humilis, obrussa, modicella, parva*, etc. under the *Lymnaea (Galba) humilis* name. The Freshwater Mollusks Conservation Society still recognizes *G. obrussa* and *G. humilis* as two distinct species and because of this, there are no known observations of *G. obrussa* or *G. humilis* in SC. Due to a lack of confirmed occurrences, a presumed distribution map could not be generated for either species. Additionally, not much is known about the specific life history of either species outside of the generalized reproduction history of the family which they belong.

To accurately determine a conservation priority for these two species, presence/absence surveys must be conducted throughout the potential range of the two species, collecting voucher specimens or genetic material to confirm whether both species are present in the state. Comprehensive genetic testing that includes animals from the entire range is needed. Presence/absence surveys could be completed simultaneously with catch-per-unit-effort surveys to determine the relative abundance of either species at specific sites. A thorough study into the reproductive behavior and life cycle of both species could give biologists a better understanding of their population dynamics. Research into the potential for them to be intermediate hosts for trematodes could aid in the understanding of their ecological impacts in SC.

FAMILY AMNICOLIDAE

Family Amnicolidae, the “Dusky Pebblesnails” is a family of freshwater aquatic, operculate gastropods. There are a total of 4 genera and 19 species of Amnicolidae recognized in the US, Canada, and Mexico by the Freshwater Mollusk Conservation Society as of 2023. In general, animals in the family Amnicolidae are unicolored, small (<5mm), higher than wide, and have few whorls with the environment playing significant roles in variation of shell (Berry 1943, Johnson et al. 2013). Amnicolids are dioecious and males have an external copulatory organ (verge) projecting from the side of the neck (Berry 1943). Eggs are laid singly or in clusters throughout the year attached to vegetation or other firm surfaces if temperatures are suitable (Davis 1961); females can store sperm from previous breeding cycles (Berry 1943). The family is of ecological importance, acting as a food source for freshwater fishes because of their small size (Berry 1943).

Species identification can be challenging, and the radula and verge should be examined (Hershler and Ponder 1998; Berry 1943).

South Carolina recognizes 2 genera and 3 species of freshwater snails in the family Amnicolidae, 1 of which is data deficient, the Indented Duskysnail, described below.

Indented Duskysnail
Lyogyrus retromargo (Thompson, 1968)

The Indented Duskysnail is a relatively new species, originally described as *Amnicola (Lyogyrus) retromargo* by Thompson in 1968 who placed the species in South Carolina. *Lyogyrus retromargo* is sub-globose in shape and pale yellow to brownish in color. It is dextral in shell morphology and has about 4 rounded whorls. The genus *Lyogyrus* is distinguished from other genera by having an operculum that is initially multispiral, becoming paucispiral in adult individuals (Dillon et al. 2019) but attention must be given to the male sex organ (verge) for identification.

The Indented Duskysnail has a global ranking of no status rank (GU). In Florida, it has a ranking of apparently secure (S4), and in South Carolina it has a ranking of SU due to insufficient data on the species (NatureServe 2024). The Indented Duskysnail is historically found in the southern United States including HUCs in Florida, Georgia, and South Carolina. Dillon et al. (2019) have documented ~35 observations of *Lyogyrus granum*, but in his description, lists *G. retromargo* a synonym of *L. granum* and does not recognize *L. retromargo* as a species in SC. Outside of Thompson placing the species in SC, there are no known occurrences of the species. Due to the limited information on its range and habitat preferences, a presumed distribution map could not be generated.

To accurately determine a conservation priority, preliminary presence/absence surveys must be conducted throughout the potential range of the species, collecting voucher specimens or genetic material to confirm presence of *L. retromargo* in SC. Presence/absence surveys could be completed simultaneously with a catch-per-unit-effort survey to determine the relative abundance of the species at specific sites. Additionally, not much is known about the life history of the species outside of the generalized reproduction history of the family which it belongs. A thorough study into the reproductive behavior and life cycle of the species could give biologists a better understanding of their population dynamics.

FAMILY PHYSIDAE

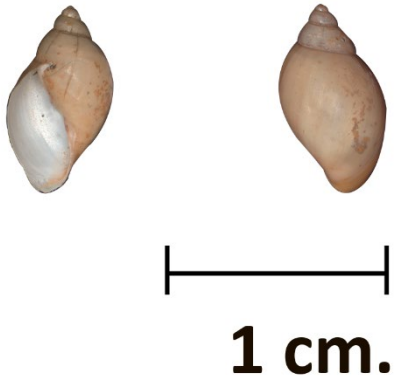
Family Physidae, the “Tadpole Pondsnails” is a family of freshwater aquatic, pulmonated gastropods which has been subject to numerous taxonomic revisions (Johnson et al. 2013).
There are a total of 5 genera and 48 species of Physidae recognized in the US, Canada, and Mexico by the Freshwater Mollusk Conservation Society as of 2023. In general, animals in the family Physidae are found in lentic environments and are sinistral (coiled to the left), have an elevated spire, and no operculum (Clarke 1981; Johnson et al. 2013). The mantle in Physidae animals has numerous digitate (finger-like) mantle lobes that project from the aperture over both sides of the shell (Clarke 1981; Burch 1989). Physa are monoecious and capable of cross- or self-fertilization. Egg masses are large, gelatinous, transparent, whitish, and crescent-shaped typically laid during

warmer months; multiple generations can be produced in a single year (Burch 1989; Clarke 1981; Johnson et al. 2013).

South Carolina recognizes 1 genus and 5 species of freshwater snails in the family Physidae, 1 of which is data deficient, the Tadpole Physa, described below.

Tadpole Physa
Physella gyrina (Say, 1821)

The Tadpole Physa was originally described as *Physa gyrina* by Say 1821 and the taxonomy of the genus which it belongs is long and complicated. The species contains many synonymies, recently including *Physella ancillaria, Physella johnsoni*, *Physella parkeri*, *Physella wrighti*, *Utahphysa microstriata* (FMCS 2023). Animals have a sinistral shell that is oblong with 5 or 6 whorls and an acute apex. The labrum is a little thickened on the inner margin, the aperture is 60-80% of the shell height, and the shell is pale yellowish brown to greyish brown in color. Tadpole Physa are monoecious and egg laying begins when morphological and physiological development has been reached. Dillon et al. 2004 found that (*Physa*) *gyrina* reproduced at a median age of 11-12 weeks. DeWitt (1954) points to reproduction being directly related to temperature.



The Tadpole Physa is historically abundant throughout Canada and all the US. Individuals are found occurring in many perennial habitats, intermittent pools of water, swamps, and mildly organic polluted water sources; where they are often occupying mud, sand, gravel, rock and plants (Clarke 1981; Turner and Montgomery 2009; Dillon et al. 2019). The Tadpole Physa has ecological importance, feeding on a multitude of organic sources including detritus, diatoms, fungi, algae, and vascular plants (Newman et al. 1996) which affects algal and macrophyte biomass (Hunter 1980). They are also a food source for many crayfish, fish, and other vertebrates. DeWitt et al. (2000) found that in habitats where crayfish regularly consumed snails, some Physa had narrowed apertures which may aid in animal protection from crayfish.

The Tadpole Physa has a global ranking of secure (G5) and a South Carolina ranking of SU due to insufficient data on the species (NatureServe 2024). While abundant throughout the US, no records of *P. gyrina* have been documented in SC; however, animals are found in NC and GA, suggesting that SC should be within its range. Due to a lack of observations in SC, an expected distribution map could not be generated.

To accurately determine a conservation priority, preliminary presence/absence surveys must be conducted throughout the potential range of the species, collecting voucher specimens or genetic material to confirm the species. Presence/absence surveys could be completed simultaneously with a catch-per-unit-effort survey to determine the relative abundance of the species at specific sites.

Toxicological studies could aid in the understanding of the species preferred habitat types and potential threats.

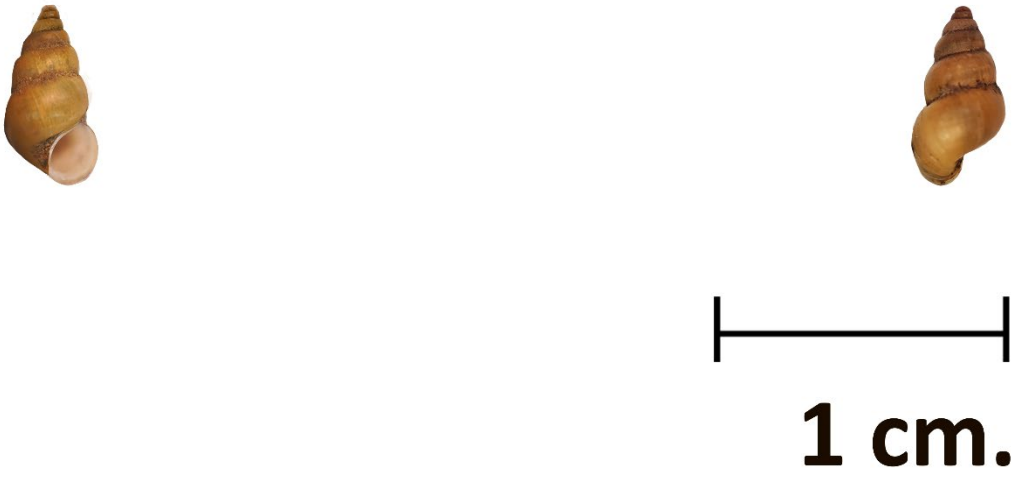
FAMILY POMATOPSIDAE

The family Pomatopsidae, the "Amphibious Walkers," is a family of small, dextral, operculated, amphibious gastropods with a loping mode of transportation. Animals are dioecious and males have a large external male organ located dorsally behind the head (Burch 1989).

There are 6 species of 1 genus in the US, Canada, and Mexico recognized by the Freshwater Mollusk Conservation Society as of 2023. Animals in this family can be found in freshwater or brackish water.

South Carolina recognizes 1 species in the family Pomatiopsidae which is data deficient, the Slender Walker, described below.

Slender Walker
Pomatiopsis lapidaria
(Say, 1817)



The Slender Walker was originally described as *Cyclostoma lapidaria* by Say 1817 and is a small (usually <5.5mm) operculated snail that is slender and has 6-7 flatly rounded whorls which are separated by incised sutures. The aperture is ovate and barely touches the penultimate whorl. The shell is reddish-brown to brown in color, sometimes having a greenish hue. It may exhibit small wrinkles on the periostracum (Say 1817; Clarke 1981). Sexes are separate (dioecious); eggs are laid singly in mud or soil during ideal temperatures (Clarke 1981). Males have a distinctive penis. This species can serve as the intermediate host of the oriental blood fluke, *Schistosoma japonicum* (Abbott 1948).

The Slender Walker is historically abundant throughout the eastern US and Canada. Individuals are amphibious, oftentimes being found along the edges of streams, seeps, in flowing water, and lakes (Burch 1989). It was once considered terrestrial or semiamphibious due to species occurrences always being near, not in, water (Walker 1918).

The Slender Walker has a global ranking of secure (G5) (NatureServe 2024). Burch and Tottenham (1980) placed this taxon as "widely distributed in the eastern US"; however, we currently do not have any known observations of this species in South Carolina. Therefore, the Slender Walker has

a ranking of SU until distribution can be confirmed. A presumed distribution map could not be generated for the species.

To accurately determine a conservation priority, preliminary presence/absence surveys must be conducted throughout the potential range of the species, collecting voucher specimens or genetic material to confirm the species. Presence/absence surveys could be completed simultaneously with a catch-per-unit-effort survey to determine the relative abundance of the species at specific sites. Further research into the species' ability to act as intermediate hosts for trematodes could aid in the understanding of their ecological importance.

FAMILY VALVATIDAE

Family Valvatidae, the "Gilled Flatsnails" is a family of freshwater, Holarctic snails, occurring in large lakes and rivers (Burch 1989). Animals in this family are usually small (<8mm) and have an operculum; they are dextral in shape. There are 11 species from 1 genus of Valvatidae recognized in the US, Canada, and Mexico by the Freshwater Mollusk Conservation Society as of 2023.
In general, animals in the family Valvatidae have a shell that is wider than high and a nearly circular aperture. Snails in this family can be distinguished from others by a gill protrusion (feather-like) to the exterior from the mantle cavity and a mantle tentacular appendage (Burch 1989; Clarke 1981). Because of the gill protrusion, animals may tolerate low DO (Burch 1989). Valvatids are hermaphroditic; egg capsules are spherical and contain 1-60 eggs; developing embryos are green in color (Burch 1989; Clarke 1981).

South Carolina recognizes 1 genus and 2 species of freshwater snails in the family Valvatidae, 1 of which is data deficient, the Threeridge Valvata, described below.

Threeridge Valvata
Valvata tricarinata (Say, 1817)

The Threeridge Valvata was originally described as *Cyclostoma tricarinata* by Say in 1817 and is a small (usually <5mm high and <6mm wide), operculated snail that is solid with 4 whorls. It is dextral and usually has 3 prominent spiral cords on the body whorl; the species has a round aperture, see figure 4. The operculum is horny, round, and multispiraled. Animals are uniformly white to whitish-pink, and shells are green to brown in color but may have greyish overtones.

Individuals often occur among vegetation and in perennial habitats such as lakes, rivers, and streams, they are rarely in ponds (Burch and Tottenham 1980; Clarke 1981). There seems to be a correlation between deep water with abundant vegetation and *V. tricarinata* (Moyle and Bacon 1968; Yang et al. 2001). Egg masses are gelatinous and found on aquatic vegetation, substrate, and other smooth surfaces during spring and summer (Clarke 1981; Jokinen 1992). Juveniles can emerge 12-15 days after eggs are laid.

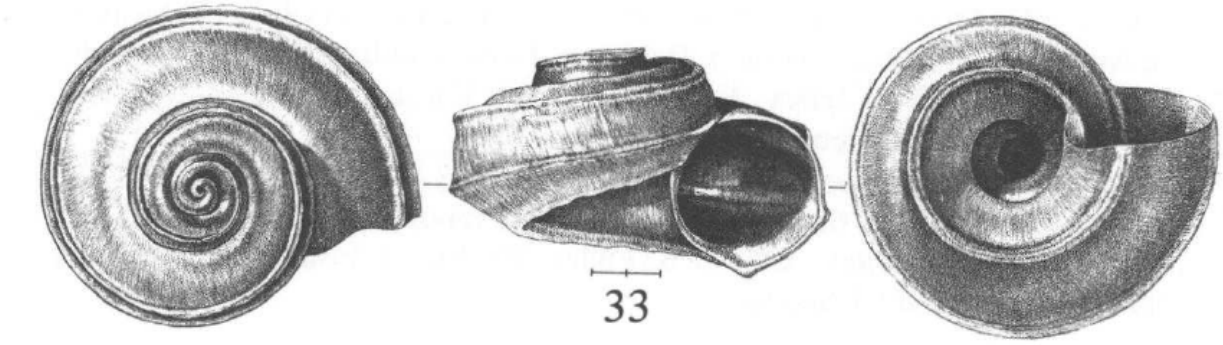


Figure 4. *Valvata tricarinata* spire, apertural, and umbilical views (left to right) as seen in Burch and Tottenham 1980.

The Threeridge Valvata is historically found throughout Canada and the US, being most abundant in the northern lakes and less common further south. The species has a global ranking of secure (G5) and a South Carolina ranking of SH, suggesting the species is likely extirpated from the state (NatureServe 2024). There has been only 1 observation of the species in South Carolina which was in the Savannah River in 1977 (Dillon et al. 2019). To our knowledge, SC is the southernmost observation of the species and with only 1 individual represented, it is likely that populations were either not able to establish or remain established in warmer temperatures.

To accurately determine a conservation priority, preliminary presence/absence surveys must be conducted throughout the potential range of the species, collecting voucher specimens or genetic material to confirm the species. Presence/absence surveys could be completed simultaneously with a catch-per-unit-effort survey to determine the relative abundance of the species at specific sites. Further research into the species' ideal temperature range could aid in the understanding of their native ranges.

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Lapped Elimia

Elimia dislocata (Reeve, 1861)

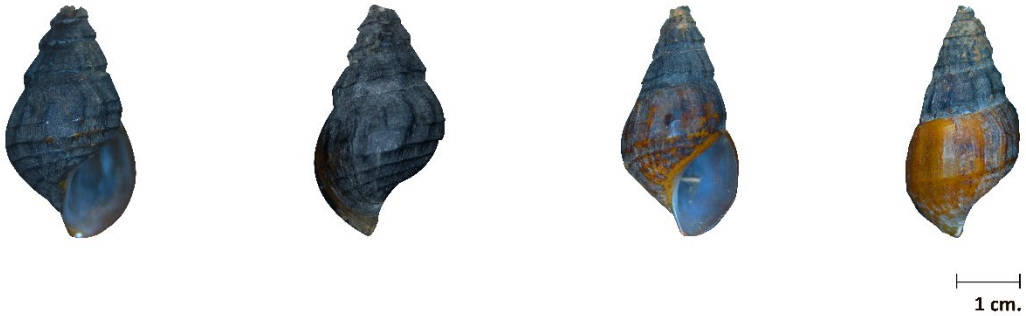


Figure 1. Images of *Elimia dislocata* showing shell morphology variation courtesy of the North Carolina Museum of Natural Sciences, Jamie Smith, and Dr. Art Bogan.

Contributor (2024): Ericah Beason (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

The Lapped Elimia was originally described as *Melania dislocata* by Reeve in (1861) and belongs to the family Pleuroceridae which historically has complex taxonomic difficulties (Johnson et al. 2013). In 2023, the Freshwater Mollusk Conservation Society recognized 8 genera and 173 species in the family, 3 of which are recognized to occur in South Carolina (FMCS 2023). In the 2013 Conservation Status of Freshwater Gastropods of Canada and the United States summary, attention is drawn to the need for substantial revision of taxonomy to accurately reflect evolutionary history within the family (Johnson et al. 2013). The family is the second highest in diversity but also one of the most imperiled (79%) (Johnson et al. 2013).

The Lapped Elimia (Figure 1) is a larger snail (~20mm in length), and its shell is yellowish to brown in color. The shell is ovately turreted with convex whorls. It is longitudinally plicately ribbed, and the ribs are obsolete towards the base. The aperture is ovate, rather small, and is a little effused at the base (Reeve 1861).

Status

The species is globally ranked as apparently secure (G4), ranked apparently secure (S4) in North Carolina, and ranked vulnerable to secure (S3S5) in South Carolina (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

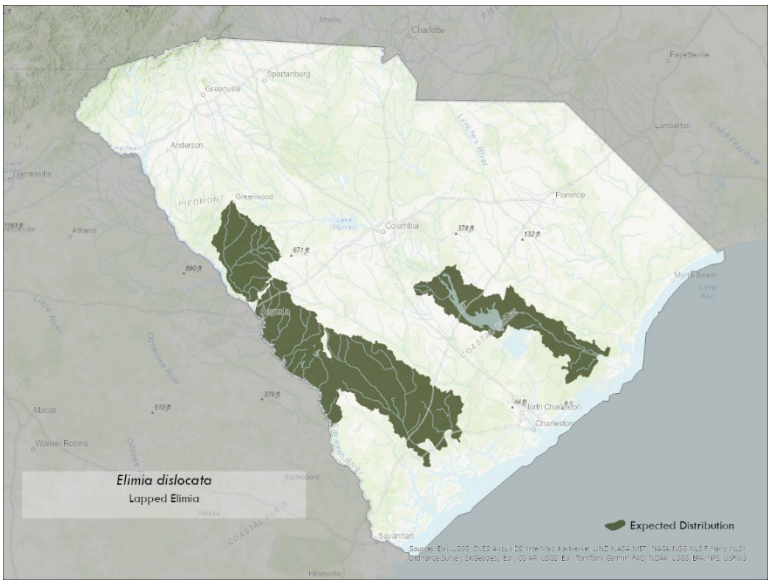


Figure 2. Expected distribution of *Elimia dislocata* in South Carolina based on reported observations at a HUC 8 level and designated ecoregions.

The Lapped Elimia has a fairly small distribution, being recognized in Virginia, North Carolina, and South Carolina by Burch (1989) and the Freshwater Mollusk Conservation Society (2023); however, Dillon et al. (2019) also places the species, which is referred to as "*Pleurocera catenaria dislocata*" as far south as tributaries to the Ogeechee River in Georgia. In South Carolina, there have been 20 reported observations across the Santee, ACE, and Savannah watersheds (Figure 2). Most observations have been in the upper coastal plain region and 2 have been in the piedmont regions. Some Pleurocerids can reach high densities (Johnson and Brown 1997), and high densities have been observed in cave springs that flow east into Lake Marion (Dillon et al. 2019).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Dillon et al. (2019) report that individuals of Elimia dislocata, which he refers to as "*Pleurocera catenaria dislocata*" are found in areas with limestone or marl outcroppings and typically not in acidic waters. Additionally, it is reported that the species may not be as strict as other species on the requirement of rocky substrates as they have been found on the bottoms of firm sand and woody debris (Dillon et al. 2019).

Not much is known about the life history of the Lapped Elimia, but based on generalized life history of the family, it is likely that the Lapped Elimia reach maturity around 2 years and have several years of reproduction, having a presumes maximum lifespan of 2-6 years (Dazo 1965; Brown et al. 2008; Johnson et al. 2013; Dillon et al. 2019). Generally, males lack a penis, and females attach egg capsules to firm substrate singly, in lines, or well-defined clutches (seen in Johnson et al. 2013 from Whelan et al. 2012a, 2012b).

CHALLENGES

The greatest challenge with the Lapped Elimia is unresolved taxonomy of the family. The Lapped Elimia was raised to the species level and placed in Pleuroceridae by Turgeon et al. (1998) but in (2011), Dillon and Robinson placed the genus *Goniobasis* and *Elimia* under *Pleurocera*. In the gastropod review by Johnson et al. (2013) attention is drawn to interim taxonomy arrangements being likely inadequate and recommends that classifications remain those of Turgeon et al. (1998) until comprehensive taxonomy is constructed. In South Carolina, species names follow those of

the Freshwater Mollusk Conservation Society (FMCS) and in (2023), the name recognized for the Lapped Elimia was *Elimia dislocata*, which is how we will refer to the species until changes are petitioned and accepted by FMCS.

Little is known about the reproductive cycle of the species. Additionally, not much is known about environmental and toxicological tolerances of the species and no standardized surveys have been completed in South Carolina, making it difficult to properly assess short- and long-term population trends. There is a challenge alone in establishing standardized freshwater snail surveys as many species have patchy distribution and very specific, microhabitat requirements that can be overlooked when sampling at a large scale. Attention is needed to establish a standardized survey protocol that takes these concerns into consideration.

CONSERVATION ACCOMPLISHMENTS

There are currently no known conservation accomplishments specifically for the Lapped Elimia.

CONSERVATION RECOMMENDATIONS

- Develop a standardized survey protocol for snails.
- Collect voucher specimens to aid in the genetic confirmation of the species and family which it belongs.
- Explore the need to list the Lapped Elimia within South Carolina based on survey results.
- Conduct standardized surveys in the ranges of the Lapped Elimia to determine the population range and life history requirements.
- Carefully monitor existing populations of the Lapped Elimia.
- Determine habitat restoration methods that will benefit the Lapped Elimia.
- Protect critical habitats for the Lapped Elimia from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Conduct further research to determine the degree of sensitivity of the Lapped Elimia to various point and non-point sources of pollution and land use impacts.

MEASURES OF SUCCESS

- Performing standardized surveys across the range of the species.
- Collecting vouchers of the species.
- Protecting land and maintaining healthy riparian habitat adjacent to habitats with populations of Lapped Elimia.
- Outreach to relevant landowners about the importance of freshwater mussels and their habitats.

- Development of a species-specific restoration plan based on the results of routine monitoring and the implementation of that plan for augmentation.

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Carib Fossaria

Galba cubensis (Pfeiffer, 1839)

Contributor (2024): Ericah Beason (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

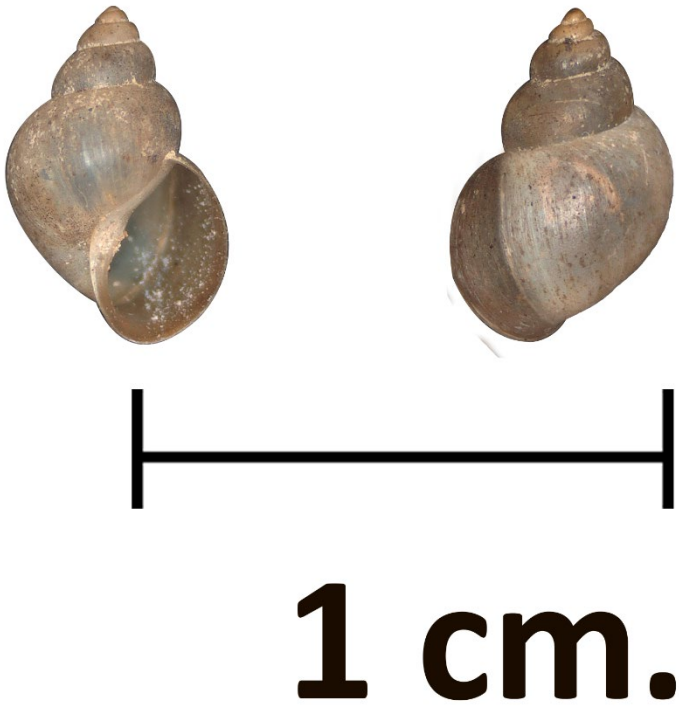


Figure 1. Image of *Galba cubensis* courtesy of the North Carolina Museum of Natural Sciences, Jamie Smith, and Dr. Art Bogan.

The Carib Fossaria was originally described as *Limnaeus cubensis* by Pfeiffer in 1839 and is a pulmonated aquatic snail (Figure 1). It is a "left-handed snail," having the coils of the shell on the left side when viewed from the opening which is ovate to oblong in shape. It is typically yellow to brown in color and the shell is formed by rounded spirals. The genus has been reassigned numerous times until settling into the *Galba* genus following Johnson et al. (2013).

The taxonomy of this species is largely intertwined with *G. humilis* and *G. viator* and the genus *Galba* has many redundancies in nomenclature with regular revisions. In 1989, Burch originally recognized 55 species in 7 genera, but Hubendick (1951) recognized 13 species and placed them in a singular genus, *Lymnaea*. Standley et al. (2013) cited the need to combine molecular, morphological, and ecological variables to develop a solid taxonomic framework based on 3 species of *Galba* analyzed in Argentina. More recent work in 2021 suggests that *Galba* comprises 5 species or species complexes by using an integrative approach using both phenotypic and molecular approaches (Alda et al. 2021). Here they confirm the suggestions of Correa et al. (2011) and Lounnas et al. (2017) that *G. neotropica* (Bargues et al. 2007, 2011) be considered synonyms of *G. cubensis/viator*. Alda et al. (2021) discuss the difficulties of *G. viator* and the uncertainty of it being considered a clade within *G. cubensis*, or a species on its own; however, *G. viator* is not recognized in the US, Canada, or Mexico by FMCS (2023). Researchers suggest a cautious position be considered; the two species may constitute a species complex or a species with wide diversity, as has been found in other freshwater snails from the *Hygrophila* family (Alda et al. 2021).

Work in Cuba has shown that *G. cubensis* is an intermediate host for the common liver fluke *Fasciola hepatica* (Vazquez et al. 2014) which has distribution throughout the Americas (Mas-Coma et al. 2009). More recently, Baniya et al. (2024) found a parasitic schistosome, a blood fluke, He*terobilharzia americana*, using *G. cubensis* as an intermediate host in California.

Status

The Carib Fossaria has a global ranking of secure (G5), a national ranking of secure (N5), and a SC state ranking of imperiled to vulnerable (S2S3) (NatureServe 2024). Carib Fossaria have populations across the southern United States, but most populations seem to have settled in the southeastern region with individuals in AL, FL, GA, SC and NC.

POPULATION SIZE AND DISTRIBUTION

There are a total of 21 observations across the piedmont, coastal plain, and coastal zone regions in South Carolina ranging in collection dates from 1958-2004. Figure 2 provides an expected distribution of the species based on these reported observations. Although we have observations of this species, we do not have a comprehensive understanding of their range, relative densities, habitat preferences, or population dynamics. The last reported occurrence of this species was in 2004, even though work within their presumed distribution was occurring. Additionally, not much is known about the specific life history of the species outside of the generalized reproduction history of the family which it belongs.

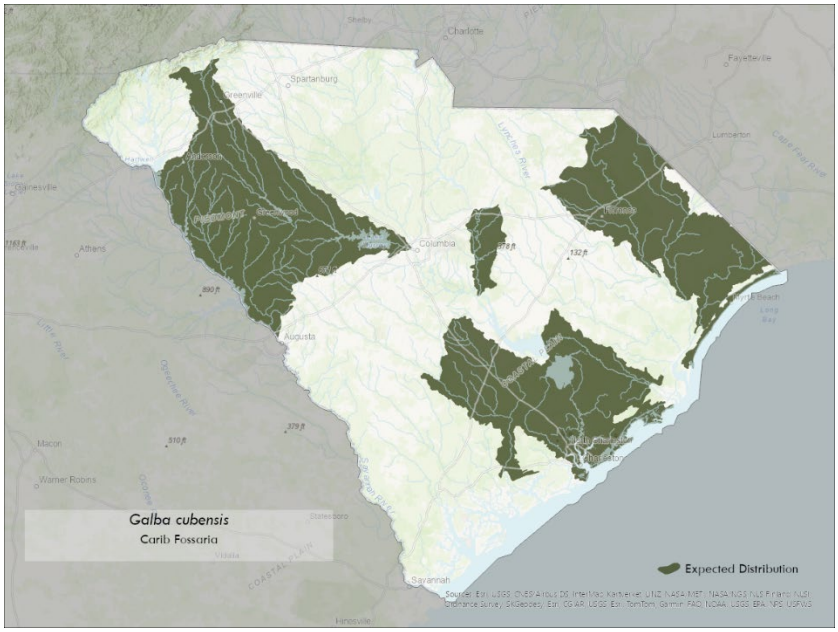


Figure 2. Expected distribution of *Galba cubensis* in South Carolina based on reported observations at a HUC 8 watershed level and designated ecoregions.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Galba cubensis is an amphibious species typically found in muddy soils, attached to aquatic vegetation or other solid surfaces. Dillon et al. (2019) stated that the species (which he refers to as *Lymnaea cubensis/viator*) apparently spend a substantial fraction of their lives grazing on mud above the water level, noting that populations typically colonize ditches, vernal ponds, and the muddy margins of larger coastal plain rivers.

CHALLENGES

Taxonomy of the species is in question and may need some revision due to one of the suggested synonyms only occurring in South America. Additionally, the species is amphibious and may not

be detected if survey approaches are fully aquatic. Like other snails, degradation of habitat and a loss of nutritious food sources are of concern. Little is known about the species specific life history.

Not much is known about environmental and toxicological tolerances of the species and no standardized surveys have been completed in South Carolina, making it difficult to properly assess short- and long-term population trends. There is a challenge alone in establishing standardized freshwater snail surveys as many species have patchy distribution and very specific, microhabitat requirements that can be overlooked when sampling at a large scale. Attention is needed to establish a standardized survey protocol that takes these concerns into consideration.

CONSERVATION ACCOMPLISHMENTS

There are currently no known conservation accomplishments specifically for the Carib Fossaria.

CONSERVATION RECOMMENDATIONS

- Develop and conduct standardized surveys specific for amphibious snail species to better determine the population range.
- Collect voucher specimens throughout its range for genetic analysis.
- Explore the need to list the Lapped Elimia within South Carolina based on survey results.
- Study the life history strategy of the species.
- Carefully monitor existing populations of the Carib Fossaria.
- Discourage structural alteration of rivers such as damming, channelization, and dredging.
- Determine habitat restoration methods that will benefit the Carib Fossaria.
- Protect critical habitats for the Carib Fossaria from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Carib Fossaria.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Conduct further research to determine the degree of sensitivity of the Carib Fossaria to various point and non-point sources of pollution and land use impacts.
- Research their potential to be intermediate hosts for trematodes to aid in the understanding of their ecological impacts in SC.

MEASURES OF SUCCESS

- Performing standardized surveys across the range of the species.
- Protecting land and maintaining healthy riparian habitat adjacent to habitats with populations of Carib Fossaria.
- Outreach to relevant landowners about the importance of freshwater mussels and their habitats.
- Development of a species-specific restoration plan based on the results of routine monitoring and the implementation of that plan for augmentation.

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Henscomb Hydrobe

Littoridinops tenuipes (Couper, 1844)

Contributor (2024): Ericah Beason (SCDNR)

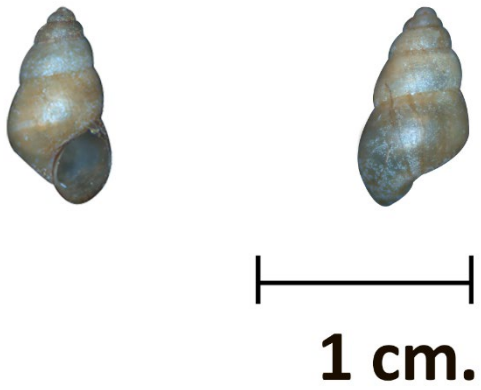


Figure 1. Image of *Littoridinops tenuipes* courtesy of the North Carolina Museum of Natural Sciences, Jamie Smith, and Dr. Art Bogan.

DESCRIPTION

Taxonomy and Basic Description

The Henscomb Hydrobe was originally described as *Amnicola tenuipes* by Couper in (Haldeman 1844) and belongs to the family Cochliopidae which was previously a subfamily of Hydrobiidae before evolution to the family level (Wilke et al. 2001). Animals in the family are small-sized (<5mm adult shell length) and taxonomically remained unknown in the 19th century (Johnson et al. 2013). Members of the family are highly localized and have a high imperilment rate (91%) (Johnson et al. 2013).

The Henscomb Hydrobe is a small snail that has a pale yellowish to light brown shell. Couper describes the shell as subumbilicated, oblong-ovate, turreted, thin, and smooth (Halderman 1844). The growth lines are slightly marked, and shells have 5 volutions. The suture is slightly impressed, and the aperture is ovate, oblong, angulated above and rounded at the base. The labrum is simple and sharp. Males possess a distinct penis on the side of their neck that is fringed with numerous papillae (Hershler and Thompson 1992).

Status

The species is globally ranked as secure (G5) but ranked critically imperiled to vulnerable in South Carolina (S1S3). In North Carolina, Virginia, Maryland, New Jersey, and Delaware the species is not ranked. In Georgia and Florida, the species is ranked as secure (G5) but in Connecticut the species is ranked as critically imperiled to imperiled (S1S2) and in Massachusetts the species is ranked as critically imperiled (S1) (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

The Henscomb Hydrobe is primarily found in eastern states that border the Atlantic coast but seems to have more secure populations in southeastern states. There have been a total of 12 reported observations of the species in South Carolina in the coastal plain and coastal zone regions. Animals have been found in all 4 major watersheds in South Carolina including the Pee Dee, Santee, ACE, and Savannah. The last reported observation was in 2015, and the animal was found in a pond in Hilton Head Island, SC.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Dillon et al. (2019) report that individuals found in Atlantic drainages are typically in coastal rivers, estuaries, and freshwater tidal marshes. Furthermore, samples are associated with blades of emergent vegetation, specifically *Typha*, and other organic debris on the water's surface (Dillon et al. 2019). Although there are no species-specific life history studies, it is presumed that the Henscomb Hydrobe, like other hydrobiids, have a lifespan of less than two years (Johnson et al. 2013).

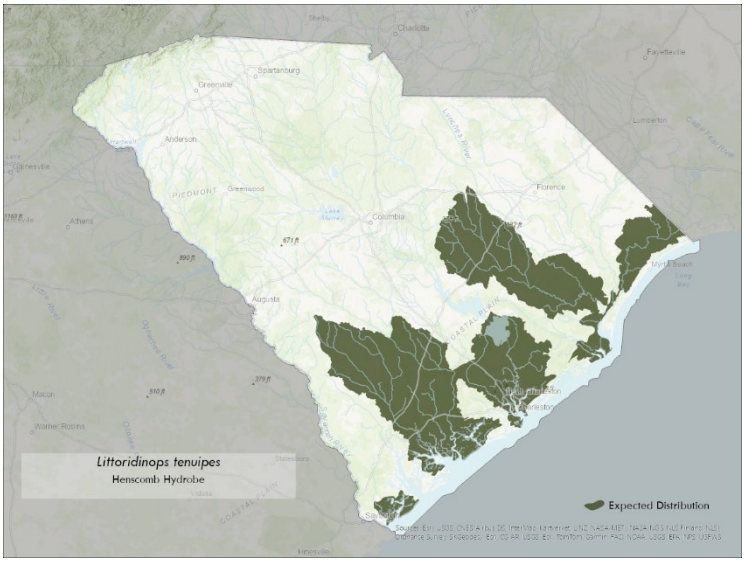


Figure 2. Expected distribution of *Littoridinops tenuipes* based on reported observations at a HUC 8 watershed level and designated ecoregions.

CHALLENGES

Like the Rotund Mysterysnail, one of the greatest challenges with the Henscomb Hydrobe in SC seems to lie in the unfavorable survey conditions of its preferred habitat. This species is often found in coastal rivers, estuaries, and freshwater tidal marshes. Nothing is known about the specific reproduction of the species. Additionally, not much is known about environmental and toxicological tolerances of the species and no standardized surveys have been completed in South Carolina, making it difficult to properly assess short- and long-term population trends. There is a challenge alone in establishing standardized freshwater snail surveys as many species have patchy distribution and very specific, microhabitat requirements that can be overlooked when sampling at a large scale. Attention is needed to establish a standardized survey protocol that takes these concerns into consideration.

CONSERVATION ACCOMPLISHMENTS

There are currently no known conservation accomplishments specifically for the Henscomb Hydrobe.

CONSERVATION RECOMMENDATIONS

- Develop a standardized survey protocol for snails.
- Collect voucher specimens to aid in the genetic confirmation of the species and family which it belongs.
- Explore the need to list the Henscomb Hydrobe within South Carolina based on survey results.
- Conduct standardized surveys in coastal plain and coastal zone to determine the population range and life history requirements for the Henscomb Hydrobe.
- Carefully monitor existing populations of the Henscomb Hydrobe.
- Determine habitat restoration methods that will benefit the Henscomb Hydrobe.

- Protect critical habitats for the Henscomb Hydrobe from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Conduct further research to determine the degree of sensitivity of the Henscomb Hydrobe to various point and non-point sources of pollution and land use impacts.

MEASURES OF SUCCESS

- Performing standardized surveys across the range of the species.
- Protecting land and maintaining healthy riparian habitat adjacent to habitats with populations of Henscomb Hydrobe.
- Outreach to relevant landowners about the importance of freshwater mussels and their habitats.
- Development of a species-specific restoration plan based on the results of routine monitoring and the implementation of that plan for augmentation.

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Carolina Physa

Physella carolinae (Wethington, Dillon, and Wise, 2009)

Contributor (2024): Ericah Beason (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

The Carolina Physa (Figure 1) is a relatively new species described by Wethington, Dillon, and Wise in 2009 as *Physa carolinae*. In 2023, the Freshwater Mollusk Conservation Society recognized the recommendation that the species be reassigned to the genus *Physella* based on the findings of Young et al. (2021). The full description can be found in Wethington et al. (2009) but in summary, the shell is sinistral, narrowly elongate-ovate, high spired, thin, and translucent with faint spiral growth lines. The body whorl is roughly 85% of the shell length and there are 4-5 whorls as an adult. Individuals have a moderately auricular aperture, approximately 70% of the shell length, and have a thin outer lip.



Figure 1. Image of *Physella carolinae* labelled *Physa carolinae* on web-based Freshwater Gastropods of North America. Image courtesy of Dillon et al. (2019).

Physella carolinae can be confused with *P. acuta, P. hendersoni,* and *P. pomilia*; however, the Carolina Physa animal is distinctly dark, and shells are slender. Dillon found through breeding experiments, *P. carolinae* freely hybridize with *P. acuta* but F1 hybrids are sterile (Dillon et al. 2019).

Status

The Carolina Physa does not have a global status rank, likely due to limited data associated with the distribution of the species. It is ranked as vulnerable to secure in South Carolina (S3S5) (NatureServe 2024). Targeted, standardized surveys are needed to determine a more accurate ranking.

POPULATION SIZE AND DISTRIBUTION

The Carolina Physa is recognized to have distributions in the southeast from Virginia to Florida (FMCS 2023). In South Carolina, there are a total of 37 reported observations, all of which have been in the coastal plain or coastal zone regions. Three observations have been on the cusp of the sand hills region, but none have been found in or above the region. Individuals are reported to be in all four of the major river basins in South Carolina including the Pee Dee, Santee, ACE, and Savannah. The last reported observation of the species was in the Charleston area in 2014.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Carolina Physa is reportedly found in shallow waters, ditches, or temporary water sources in forested lands throughout the coastal plain, but their abundance may be seasonal; however, due to habitat alterations and degradation, more individuals are being found in manmade drainage ditches nearby roads (Wethington et. al 2009). They seem to graze on organic debris and detritus when in water sources and burrow as water becomes scarce (Wethington et al. 2009). Dillon and team (2019) report that laboratory cultures of the species reach maturity around 7-9 weeks post hatch which is about a week later than other *Physella* species and they reach a greater maximum size.

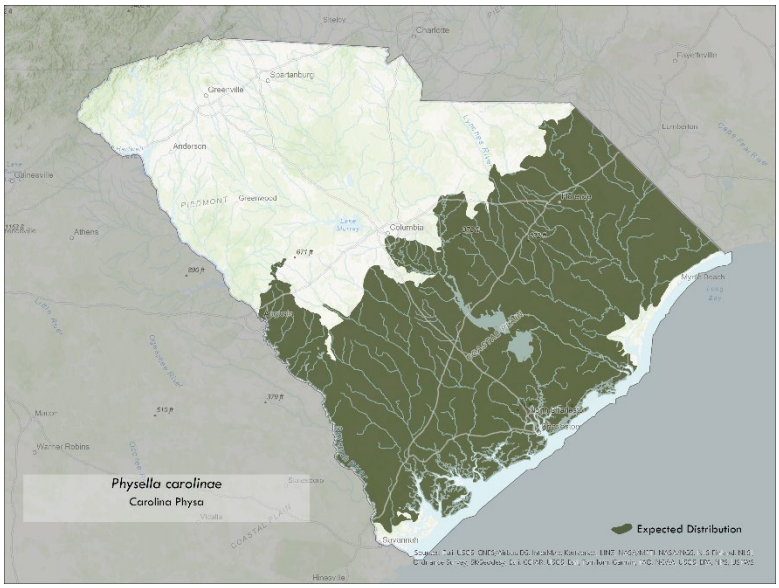


Figure 2. Expected distribution of *Physella carolinae* in South Carolina based on reported observations at a HUC 6 watershed level and designated ecoregions.

CHALLENGES

Challenges associated with the Carolina Physa are largely associated with the shift from individuals occupying natural habitat types to inhabiting manmade habitats which may not be ecologically sound. Additionally, due to climate change, weather events are becoming more severe, and drought conditions are likely to reduce the number of the currently occupied habitats by the species.

Not much is known about environmental and toxicological tolerances of the species and no standardized surveys have been completed in South Carolina, making it difficult to properly assess short and long- term population trends. There is a challenge alone in establishing standardized freshwater snail surveys as many species have patchy distribution and very specific, microhabitat requirements that can be overlooked when sampling at a large scale. Attention is needed to establish a standardized survey protocol that takes these concerns into consideration.

CONSERVATION ACCOMPLISHMENTS

There are currently no known conservation accomplishments specifically for the Carolina Physa.

CONSERVATION RECOMMENDATIONS

- Develop a standardized survey protocol for snails in the coastal plain and coastal zone.

- Collect voucher specimens to aid in the genetic confirmation of the species and family which it belongs.
- Explore the need to list the Carolina Physa within South Carolina based on survey results.
- Conduct standardized surveys in coastal plain and coastal zone to determine the population range and life history requirements for the Carolina Physa.
- Carefully monitor existing populations of the Carolina Physa
- Determine habitat restoration methods that will benefit the Carolina Physa.
- Protect critical habitats for the Carolina Physa from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Conduct further research to determine the degree of sensitivity of the Carolina Physa to various point and non-point sources of pollution and land use impacts.

MEASURES OF SUCCESS

- Performing standardized surveys across the range of the species.
- Protecting land and maintaining healthy riparian habitat adjacent to habitats with populations of Carolina Physa.
- Outreach to relevant landowners about the importance of freshwater mussels and their habitats.
- Development of a species-specific restoration plan based on the results of routine monitoring and the implementation of that plan for augmentation.

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Sharp Sprite

Promenetus exacuosus (Say, 1821)

Contributor (2024): Ericah Beason and Briana Cairco (SCDNR)



Figure 1. Image of *Promenetus exacuosus* on web-based Freshwater Gastropods of North America. Image courtesy of Dillon et al. (2019).

DESCRIPTION

Taxonomy and Basic Description

Originally described as *Planorbis exacuosus* by Say in 1821, *Promenetus exacuosus* is a small, up to 7mm wide snail in the family Planorbidae, the Rams-horn snails. Snails in this family are distinguished by their round, flat, compressed appearance. The name "Sharp Sprite" may seem rather unfitting at first glance, but a defining characteristic of *Promenetus exacuosus* is the "sides obliquely descending to an acute lateral edge, below the middle" (Say 1821). The Sharp Sprite shell has almost 4 whorls, is biconvex, and dextral. The spire is low, convex, or flattened.

This animal is easily distinguishable from other species by its biconex, flattened form, and rapidly expanding whorls (Clarke 1981).

Status

The species is globally ranked as secure (G5) but is ranked as imperiled (S2) in North Carolina, vulnerable (S3) in Virginia, and critically imperiled to vulnerable in South Carolina (S1S3) (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

The Sharp Sprite ranges from Atlantic to Pacific coasts, and from the boreal zones of Canada to northern Texas. Although widespread in distribution, populations may be patchy, especially so in the Atlantic slope. There have been 9 reported observations of *P. exacuous* in South Carolina, ranging in report dates from 2003-2013. Most observations (8) were in the coastal plain region. The remaining account was reported in the piedmont region in a tributary to West Creek. Dillon and team (2019) note that this species is among the less-commonly encountered of the planorbids in the Eastern US. It has been nearly a decade since the last reported observation of the species even though survey work has been conducted in their presumed range.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Dillon et al. (2019) report that individuals found in Atlantic drainages are sparsely distributed in ponds and sluggish waters. The species has been reported to inhabit shallow waters, marshes, ponds, small lakes, roadside ditches, swamps and intermittent ponds (Baker 1928; Burch and Tottenham 1980; Clarke 1981). This species is found where submersed vegetation is present, and animals are typically found in mud substrate (Clarke 1981; Jokinen 1983). The Sharp Sprite are hermaphroditic and capable of self-fertilization, adults lay egg masses armed with a thick outer coating and die shortly after reproducing (Colton 1918; Dillon 2011). These short-lived snails reach adulthood and reproduction in a matter of months, and populations may often go through two generations through the course of a year (Jokinen 1985).

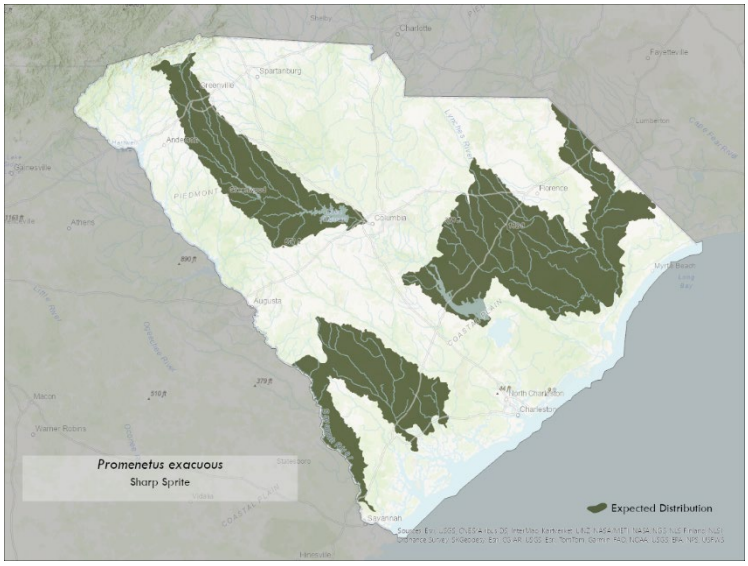


Figure 2. Expected distribution of *Promenetus exacuosus* in South Carolina based on reported observations at a HUC 8 watershed level and designated ecoregions.

CHALLENGES

Like many mollusks, the Sharp Sprite are sensitive to environmental degradation. In southern Manitoba, a rapid decline in occurrence was observed between 1978 and 1998 when agriculture and anthropogenic impacts increased (Pip 2000). Not much is known about toxin tolerances of the species and no standardized surveys have been completed in South Carolina, making it difficult to properly assess short and long- term population trends. There is a challenge alone in establishing standardized freshwater snail surveys as many species have patchy distribution and very specific, microhabitat requirements that can be overlooked when sampling at a large scale. Attention is needed to establish a standardized survey protocol that takes these concerns into consideration.

CONSERVATION ACCOMPLISHMENTS

There are currently no known conservation accomplishments specifically for the Sharp Sprite.

CONSERVATION RECOMMENDATIONS

- Develop a standardized survey protocol for snails, accounting for different habitat requirements.
- Explore the need to list the Sharp Sprite within South Carolina based on survey results.
- Conduct standardized surveys in the piedmont and coastal plain to determine the population range and life history requirements for the Sharp Sprite.
- Carefully monitor existing populations of the Sharp Sprite.

- Determine habitat restoration methods that will benefit the Sharp Sprite.
- Protect critical habitats for the Sharp Sprite from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Collect voucher material that can be used to aid in identification of the species and be used for future genetic analysis.
- Conduct further research to determine the degree of sensitivity of the Sharp Sprite to various point and non-point sources of pollution and land use impacts.

MEASURES OF SUCCESS

- Performing standardized surveys across the range of the species.
- Protecting land and maintaining healthy riparian habitat adjacent to habitats with populations of Sharp Sprite.
- Conduct outreach to relevant landowners about the importance of freshwater snails and their habitats.
- Development of a species-specific restoration plan based on the results of routine monitoring and the implementation of that plan for augmentation.

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Panhandle Pebblesnail

Somatogyrus virginicus
(Walker, 1904)

Contributor (2005): Jennifer Price (SCDNR)
Reviewed and Edited (2012): William Poly (SCDNR)
Reviewed and Edited (2024): Ericah Beason and Briana Cairco (SCDNR)

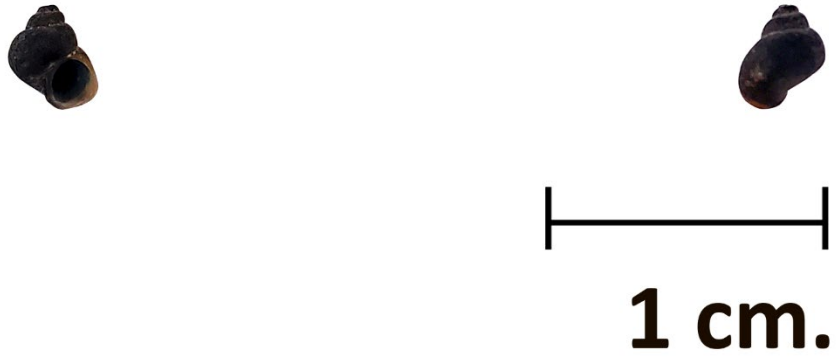


Figure 1. Image of *Somatogyrus virginicus* courtesy of the North Carolina Museum of Natural Sciences, Jamie Smith, and Dr. Art Bogan.

DESCRIPTION

Taxonomy and Basic Description

Somatogyrus virginicus was first described by Walker in 1904. It is a small snail, 3-5mm, with a globosely conic shell and paucispiral operculum (Figure 1). Shells are light greenish-yellow, smooth, and have very fine growth lines; there are about four whorls. Two forms are known for this species, one being slenderer than the other (Walker 1904). Little is known about the life history of *S. virginicus*, but it is thought to be like other *Somatogyrus* species in that individuals are typically dioecious (either male or female), the lifecycle is annual with females lay eggs singly in the spring, and adults dying shortly after reproducing (Johnson et al 2013).

This species could resemble *S. pennsylvanicus* and *S. hinkleyi* however it is smaller in size with a more convex body whorl.

Status

The status of the Panhandle Pebblesnail is not easy to discern. From the time of its original description by Walker in 1904, until the early 2000s it was believed to be endemic to the Rapadan River in Virginia and in 2000 the IUCN Redlist status assessment classified it as endangered due to declines in habitat within the narrow range it was believed to occur (Hilton-Taylor and Brackett 2000). Subsequent surveys outside of Virginia recorded snails matching its description in North Carolina, South Carolina, and Georgia. In 2012 the IUCN evaluated the Panhandle Pebblesnail and listed it as least concern, owing to the incorporation of several populations in North and South Carolina (Cordiero and Perez 2012). Despite the vast increase in known range and observed populations, threats to its populations remain prevalent across the entire range. As of 2024, the Pandhandle Pebblesnail has a global ranking of imperiled (G2G3) and a state ranking of S2S4 with a conservation priority ranking of high (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

Panhandle Pebblesnail populations are patchy but widespread across the Atlantic piedmont. Within South Carolina, observations have been reported in the Savannah, Santee, and PeeDee watersheds. There have been 46 reported observations of the species in SC from 1987-2016. No observations of the species have been reported since 2016. Of the 46 observations, 40 have been in the piedmont region, 2 have been in the sandhills that are on the cusp of the piedmont, 3 have been in the sand hills, and only 1 has been in the coastal plain region, observed in 2011 (Figure 2).

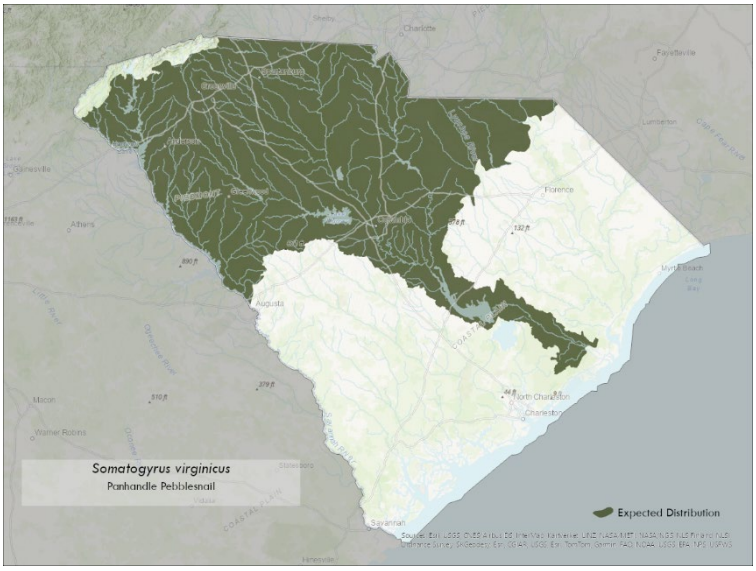


Figure 2. Expected distribution of *Somatogyrus virginucus* based on reported observations.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Across their range, Panhandle Pebblesnails are associated with solid substrate, especially rocky riffles in moderately productive water bodies. They inhabit medium to large rivers with moderate to high gradient (Dillon et al. 2019). The emergent macrophyte *Podostemum* often co-occurs with populations that have been observed (Dillon et al. 2019). Interestingly, in 2005 Morse and Lenat discovered a rare species of caddisfly, *Ceraclea joannae,* that feeds on *Somatogyrus virginicus*; however, this caddisfly is apparently restricted to a small segment of the Little River downstream of Asheboro, NC.

CHALLENGES

Siltation of streams and rivers through agricultural runoff and erosion of unstable stream banks appear to be the main challenge to *Somatogyrus virginicus*. Historically, siltation has occurred due to land clearing for farming, residential development, forestry practices, mining operations, and construction of dams. Absence of sufficient riparian buffers significantly contributes to siltation (Moglen 2000). Clear-cutting a substantial part of a watershed can also contribute to siltation, even if a riparian buffer is maintained. Livestock and feral pigs degrade stream banks and bottoms as they drink and search for food. Impervious surfaces, such as roads, buildings, and parking lots, increase erosion in adjacent areas and contribute to flooding (NCWRC 2002). Use of motor vehicles in streams and along banks can also disturb stream flow and increase siltation. All these factors that contribute to siltation can also alter the topography of streams and rivers by changing the slope of the bank and eliminating heterogeneity in the channel. The patchy

occurrence of this species seems to indicate that historically, they had a more robust presence across their range, prior to habitat loss (Archambault and Cope 2016; Dillon et al. 2019). Additionally, certain herbicides used to manage invasive aquatic plants such as *Hydrilla*, can negatively impact hatching success of *S. virginicus* eggs and adult stages (Archambault and Cope 2016). Not much is known about environmental and toxicological tolerances of the species and no standardized surveys have been completed in South Carolina, making it difficult to properly assess short and long- term population trends. There is a challenge alone in establishing standardized freshwater snail surveys as many species have patchy distribution and very specific, microhabitat requirements that can be overlooked when sampling at a large scale. Attention is needed to establish a standardized survey protocol that takes these concerns into consideration.

CONSERVATION ACCOMPLISHMENTS

Aside from several survey efforts that have revealed a wider distribution, there have not been any significant conservation achievements for the Panhandle Pebblesnail.

CONSERVATION RECOMMENDATIONS

- Develop a standardized survey protocol for snails.
- Collect voucher specimens to aid in the genetic confirmation of the species and family which it belongs.
- Conduct standardized surveys in the piedmont, sand hill, and coastal plain ecobasin to better determine the population range and life history requirements for the Panhandle Pebblesnail.
- Explore the need to list the Panhandle Pebblesnail within South Carolina based on survey results.
- Carefully monitor existing populations of the Panhandle Pebblesnail.
- Discourage structural alteration of rivers such as damming, channelization, and dredging.
- Determine habitat restoration methods that will benefit the Panhandle Pebblesnail.
- Protect critical habitats for the Panhandle Pebblesnail from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat for the Panhandle Pebblesnails.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Conduct further research to determine the degree of sensitivity of the Panhandle Pebblesnail to various point and non-point sources of pollution and land use impacts.

MEASURES OF SUCCESS

- Performing standardized surveys across the range of the species.
- Protecting land and maintaining healthy riparian habitat adjacent to habitats with

populations of Pandhandle Pebblesnails.

- Outreach to relevant landowners about the importance of freshwater mussels and their habitats.
- Development of a species-specific restoration plan based on the results of routine monitoring and the implementation of that plan for augmentation.

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Two-Ridge Valvata

Valvata bicarinata (Lea, 1841)

Contributor (2024): Ericah Beason and Jeff Smola (SCDNR)

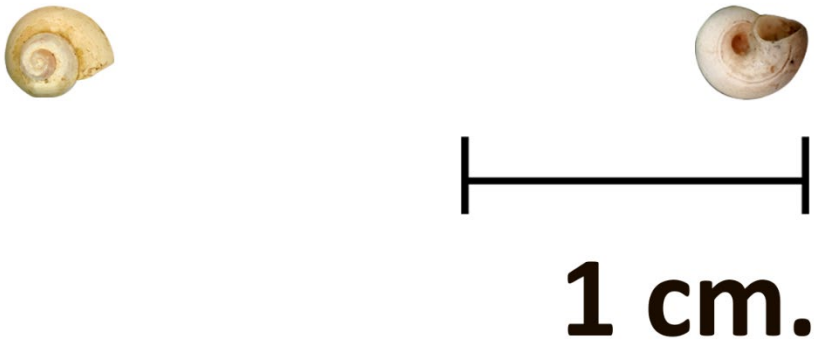


Figure 1. Image of *Valvata bicarinata* courtesy of the North Carolina Museum of Natural Sciences, Jamie Smith, and Dr. Art Bogan.

DESCRIPTION

Taxonomy and Basic Description

Valvata bicarinata was originally described by Lea in 1841 and it is similar to *Valvata tricarinata* but differs in the number of carinae (Figure 1); however, the *Valvata* species are polymorphic, and one population can contain several morphological variations (Burch 1989). Additionally, both *V. bicarinata* and *V. tricarinata* can produce polymorphs which closely resemble the other species (Burch 1989).

The Two-Ridge Valvata belongs to the family Valvatidae, the "Gilled Flatsnails" which is a family of freshwater, Holarctic snails, occurring in large lakes and rivers (Burch 1989). Animals in this family are usually small (<8mm) and have an operculum; they are dextral in shape. In general, animals in the family Valvatidae have a shell that is wider than high and a nearly circular aperture. Snails in this family can be distinguished from others by a gill protrusion (feather-like) to the exterior from the mantle cavity and a mantle tentacular appendage (Burch 1989; Clarke 1981). Because of the gill protrusion, animals may tolerate low DO (Burch 1989). Valvatids are hermaphroditic; egg capsules are spherical and contain 1-60 eggs; developing embryos are green in color (Burch 1989; Clarke 1981).

Status

The Two-Ridge Valvata is globally secure (G5) but is considered vulnerable (S3) in Georgia and Alabama and is critically imperiled to imperiled in South Carolina (S1S2) due limited observations across its range in SC (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

This species is endemic to North America and can be found throughout the southeast and into the Midwest. This is a rare species in southern Atlantic drainages. We have 4 reported observations in the coastal plain region of South Carolina. Animals have been reported in the Santee and Savannah River basins. Two of the collections were from larger rivers and 1 was from a PONAR sample collected at a depth of 3.2 m from Lake Marion, SC, in 2009. This species, like *Valvata tricarinata* may be associated with deep waters and surveys that target those deep habitats are needed. See Figure 2 for an expected species range map which was rendered using the reported observations in South Carolina.

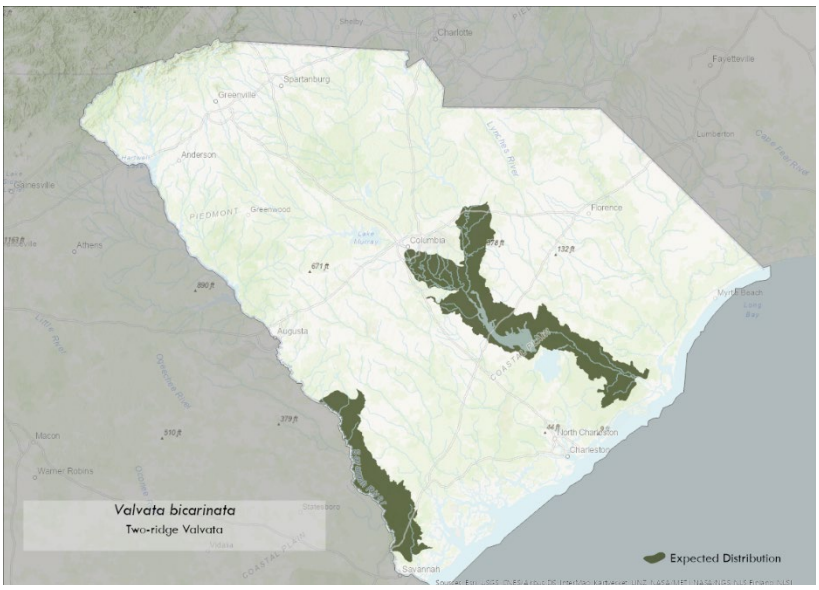


Figure 2. Expected distribution of *Valvata bicarinata* based on reported observations.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Not much is known about the specific habitat requirements of the species; however, if it is like *V. tricarinata*, individuals of *V. bicarinata* may occur among vegetation and in perennial habitats such as lakes, rivers, and streams (Burch and Tottenhan 1980; Clarke 1981). Survey efforts are needed to determine specific habitat requirements of the species. Based on our most recent record in SC, there is a need to thoroughly sample large impoundments.

CHALLENGES

The polymorphism of this species and *V. tricarinata* make it difficult to accurately determine species presence without further species confirmation. Although this species is widespread, South Carolina is part of the peripheral southern Atlantic slope range where animals are rare.

Additionally, not much is known about environmental and toxicological tolerances of the species and no standardized surveys have been completed in South Carolina, making it difficult to properly assess short and long- term population trends. There is a challenge alone in establishing standardized freshwater snail surveys as many species have patchy distribution and very specific, microhabitat requirements that can be overlooked when sampling at a large scale. Attention is needed to establish a standardized survey protocol that takes these concerns into consideration.

CONSERVATION ACCOMPLISHMENTS

There are currently no known conservation accomplishments specifically for the Two-Ridge Valvata.

CONSERVATION RECOMMENDATIONS

- Develop and conduct standardized surveys in the native ranges coupled with specific surveys for deep water snail species to better determine the population range.
- Study the life history strategy of the species.
- Carefully monitor existing populations of the Two-Ridge Valvata.
- Determine habitat restoration methods that will benefit the Two Ridge Valvata.
- Protect critical habitats for the Two-Ridge Valvata from future development and further habitat degradation by following best management practices and protecting and purchasing riparian areas.
- Promote land stewardship practices through educational programs both within critical habitats with healthy populations and in other areas that contain available habitat.
- Encourage responsible land use planning.
- Consider this species' needs when participating in the environmental permit review process.
- Conduct further research to determine the degree of sensitivity of the Two-Ridge Valvata to various point and non-point sources of pollution and land use impacts.
- Collect voucher specimens throughout its range for genetic analysis.

MEASURES OF SUCCESS

- Performing standardized surveys across the range of the species.
- Protecting land and maintaining healthy riparian habitat adjacent to habitats with populations of Two-Ridge Valvata.
- Outreach to relevant landowners about the importance of freshwater mussels and their habitats.

- Development of a species-specific restoration plan based on the results of routine monitoring and the implementation of that plan for augmentation.

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Freshwater Sponges

Species:

Corvospongilla becki
Corvospongilla novaterrae
Corvospongilla sp. 1
Ephydatia fluviatilis
Eunapius fragilis
Heteromeyenia baileyi
Heteromeyenia latitenta
Heteromeyenia longistylis
Racekiela ryderi
Racekiela sp. 1
Radiospongilla cerebellata
Radiospongilla sp. 1
Spongilla lacustris
Trochospongilla horrida
Trochospongilla latouchiana
Trochospongilla leidyi
Trochospongilla pennsylvanica

Contributors (2024): Christopher Freeman (College of Charleston), Josie Shostak (College of Charleston), Alexander Parry (College of Charleston)

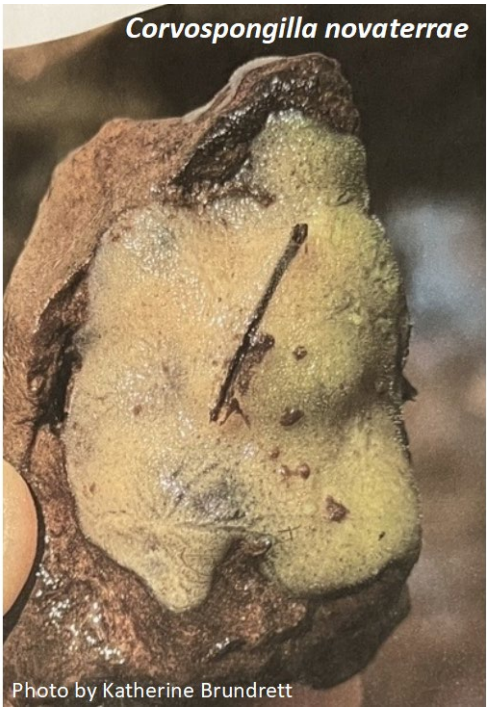
DESCRIPTION

Taxonomy and Basic Descriptions

This guild includes 14 species and three individual sponges that are identified to genus. All sponges are in the family Spongillidae. These species are typically small (<6 cm long) but can reach up to 24 cm long on some floating docks. Species are identified by their skeletal elements (silicious spicules) after digesting tissue in bleach. Species are also identified based on spicules within gemmules (asexual buds found embedded in or under sponge tissue). All species adopt encrusting or cushion growth forms, and many have obvious pores and canal structures that are part of their water filtration system.



Corvospongilla becki- encrusting on 3D substrates like moss and vegetation attached to a dock, tan-brown, 5-7 mm thick, pores are obvious, spicules protruding from surface can be easily seen



Corvospongilla novaterrae- tan to green (the green color is likely from algal symbionts), thin to medium (5-10 mm) thickness, cushion-like appearance, obvious canal structures, found on rock in shallow stream

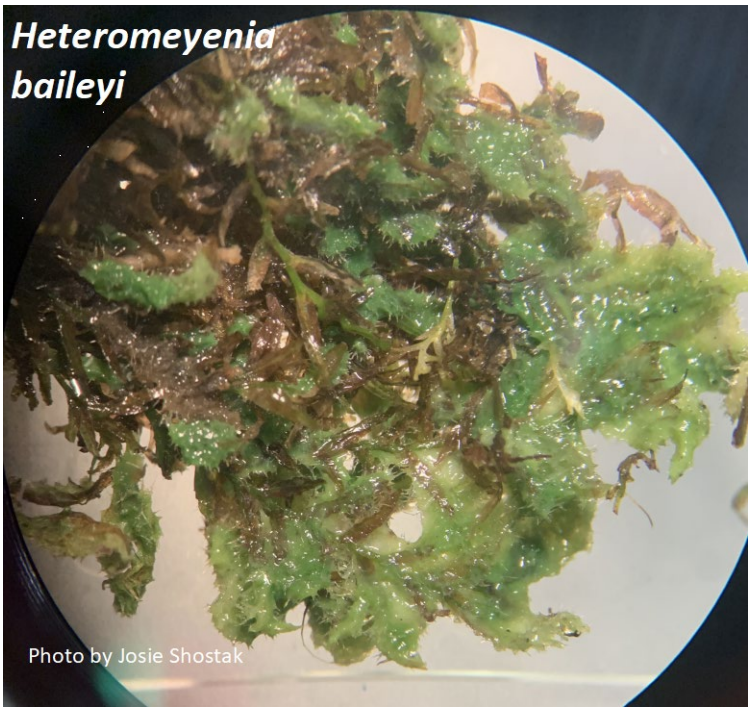
Corvospongilla sp.-no photo available; thin to thickly encrusting, pipe-shaped, growing on and associated with moss, pale, no visible pores, soft and cushion-like



Ephydatia fluviatilis- tan, thin to thickly (3-10 mm) encrusting, found on floating log, obvious canal structures



Eunapius fragilis- thinly (1-3 mm) encrusting, growing on and surrounded by moss, pale green, visually porous with a soft and fragile texture



Heteromeyenia baileyi- Bright green with obvious spicules protruding from tissue, soft cushion-like texture, growing on and surrounded by moss.

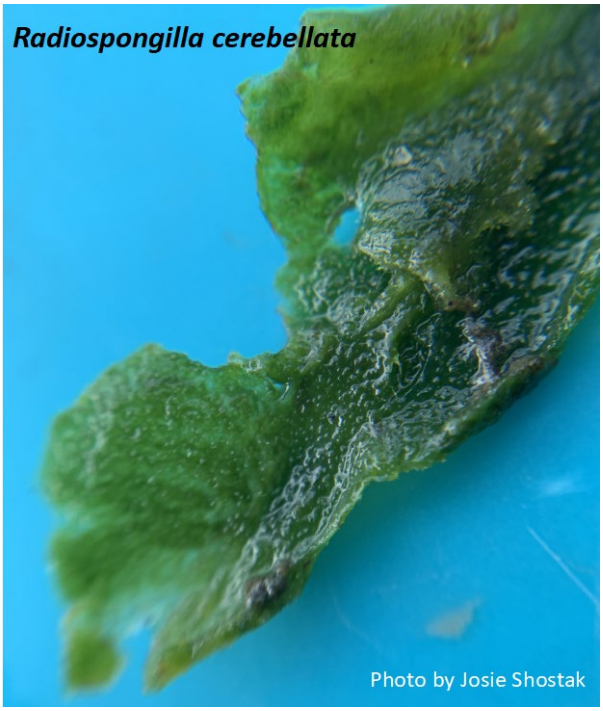
Heteromeyenia latitenta - no photo available; found associated with moss, pale green

Heteromeyenia longistylis- no photo available; tissue was dead on collection, tan in color, thinly (3-5 mm) encrusting



Racekiela ryderi- tan with a strong earthy smell, thin to thick (5-15 mm) encrusting, cushion-like texture, not associated with moss or plants, no obvious canal structure.

Racekiela sp.- no photo available; large (about 10 cm long), thickly encrusting (up 1 cm), dark brown and green, very porous, strong earthy smell



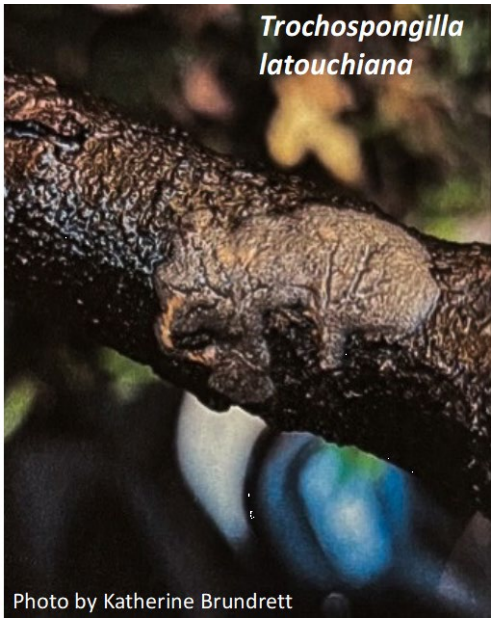
Radiospongilla cerebellata- thinly encrusting (2-5 mm), bright green, no visible pores, canal structures visible, spicules sometimes protrude from surface

Radiospongilla sp. no photo available; thinly (2-5 mm) encrusting, pale green, clear canal structures, found on rock, porous with cushion-like texture

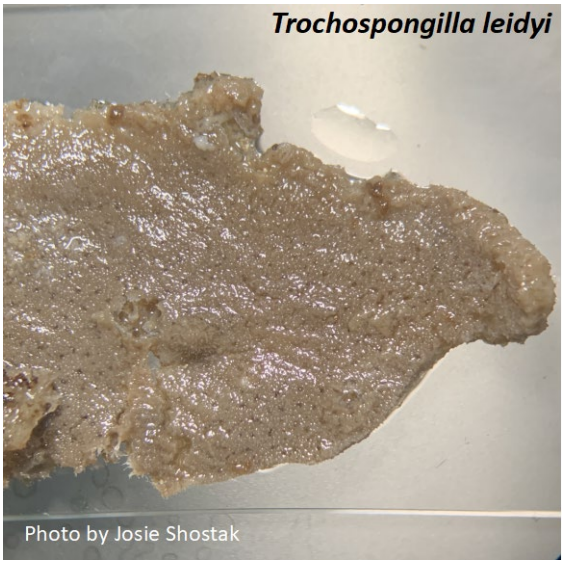
Spongilla lacustris- no photo available; green-brown sponge, thin to thick (3-10 mm) encrusting, found on plastic dock



Trochospongilla horrida- thin to thickly (3-10 mm) encrusting, tan-pale green, obvious canal structures visible, found on both rock and docks, soft and compressible.



Trochospongilla latouchiana- small and thinly (<5 mm) encrusting, pale green or tan color, soft tissue with visible canals



Trochospongilla leidyi- brown-tan, thinly (3-5 mm) encrusting, found deeper on dock piling, strong smell, pores visible on surface, flexible and brittle tissue



Trochospongilla pennsylvanica- tan, thin (<5 mm) encrusting, found on floating log with obvious canal structure

Status

These populations of freshwater sponges in South Carolina are not listed as threatened or endangered. Species are given Natural Heritage ranks as follows: *Corvospongilla becki*: S4, *Corvospongilla novaterrae*: S3S4, *Corvospongilla* sp. 1: S3S4, *Ephydatia fluviatilis*: S3, *Eunapius fragilis*: S3S4, *Heteromeyenia baileyi*: S3S4, *Heteromeyenia latitenta*: S*3*, *Heteromeyenia longistylis*: S3, *Racekiela ryderi*: S3S4, *Racekiela* sp. 1: S3S4, *Radiospongilla cerebellata*: S3, *Radiospongilla* sp. 1: S3S4, *Spongilla lacustris*: S3, *Trochospongilla horrida*: S3S4, *Trochospongilla latouchiana*: S3S4, *Trochospongilla leidyi*: S3S4, *Trochospongilla pennsylvanica*: S3S4.

POPULATION SIZE AND DISTRIBUTION

Historically, freshwater sponges were reported from a single location near Columbia, South Carolina in Adams Pond (Harrison, 1977; Brisbee, 1992) where five sponges were found: *Corvomeyenia carolinensis, Heteromeyenia baileyi, Anheteromeyenia (Racekiela) ryderi, Spongilla lacustris*, and *Trochospongilla pennsylvanica.* Recent records indicate widespread distribution of this guild with species present at diverse sites within both the Coastal Plain and Coastal Zone Ecobasins.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The species in this guild are found in diverse environments including fast flowing and deep rivers and shallow (<3 cm deep) streams, as well as slow flowing ponds and ephemeral wetlands. Species grow on both natural (rock, vegetation roots and stems, live and dead wood) and artificial (plastic and wooden docks and pilings) substrates. Sponges are found near the surface and down to a depth of ~ 10 cm. Species are generally found in clear water but have been identified at sites both distant from and near human development and pollution, as well as in turbid waters (but this is rare).

CHALLENGES

Sponges as a group are not threatened globally, but freshwater sponges may be at increased risk due to pollution and temperature fluctuations (Bell et al., 2015), as well as habitat destruction.

CONSERVATION ACCOMPLISHMENTS

There are no known conservation accomplishments pertaining to freshwater sponges, but any initiatives that protect wetlands and maintain water quality are likely to protect habitat for these organisms.

CONSERVATION RECOMMENDATIONS

- Determine the role of freshwater sponges in nutrient and organic matter cycling in freshwater systems in South Carolina.
- Establish baseline growth rates for dominant species.
- Assess the use of freshwater sponges by aquatic insects (particularly the use of sponges by insect larvae).
- Examine reproductive cycles and seasonality of freshwater sponges and their use of gemmules to survive high or low temperatures or other disturbances
- Protect wetlands from human development or other anthropogenic impacts that might destroy sponge habitat or contribute to pollution

MEASURES OF SUCCESS

Current surveys are providing critical information on the distribution of these species, but more work is needed to study the ecology (growth rates, diet, contribution to organic matter and nutrient cycling, and reproduction) of freshwater sponges. This research should also evaluate seasonal variation in freshwater sponge populations and their use of gemmules to survive environmental fluctuations and promote dispersal. Recurring populations in ephemeral wetlands distant from humans, rivers or streams near human development, and after seasonal die-offs due to temperature extremes is a measure of success for this group.

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Freshwater, Marine and Terrestrial Leeches Guild

New England Medicinal Leech *Macrobdella sestertia*
"A terrestrial leech" *Haemopis septagon*
Appalachian Leech *Placobdella biannulata*
Nuchal Leech *Placobdella nuchalis*
Translucent Leech *Placobdella translucens*
"A marine leech" *Branchellion ravenelii*

Contributors (2024): Bronwyn W. Williams (NC Museum of Natural Sciences), William E. Moser (Smithsonian Institution National Museum of Natural History)

New England Medicinal Leech
Macrobdella sestertia

The New England Medicinal Leech was described in 1886 from eastern Massachusetts. It took nearly a century, in 1976, to be collected a second time (Smith 1977), and nearly two decades more to be collected a third time (Smith and Hanlon 1997), in Maine. In 2008, 9 specimens of *M. sestertia* were collected in southwestern South Carolina (Poly 2011), representing a significant expansion of its historically reported New England distribution. Two additional specimens of the species from South Carolina were found in the collections of the Charleston Museum and North Carolina Museum of Natural Sciences (NCSM) (Poly 2018); these specimens are currently housed in the NCSM Non-molluscan Invertebrates (NMI) Collection. Carlson and Phillips (2020) presented an extinction model for *M. sestertia* throughout its patchy and disparate range, concluding that the species may have gone extinct, but urging for surveys and a focus more generally on leech conservation. Ironically, this paper was in press when Dr. Bronwyn Williams, joined by Dr. Anna Phillips, collected several *M. sestertia* specimens in southern New Hampshire; Dr. Williams had also collected a handful of *M. sestertia* specimens in South Carolina the previous year. In South Carolina, the New England Medicinal Leech is known to occur only in Edgefield County. *Macrobdella sestertia* has a Global Status of imperiled (G2) and is currently considered Possibly Extirpated in Massachusetts. It has no current status rank in South Carolina (NatureServe 2024). Nearly nothing is known about the local and range-wide distribution of this species or any aspect of its natural history; fewer than 30 individuals have been collected since its description over 140 years ago.

"A terrestrial leech"
Haemopis septagon

The terrestrial leech, *Haemopis septagon*, was described in 1976 from Durham County, North Carolina. Its known distribution ranges from New Jersey south into Georgia throughout coastal plain and lower Piedmont habitats. While it is truly a terrestrial species, *H. septagon* occupies damp riparian areas and microhabitats containing an abundance of earthworms, its primary prey. A substantial amount of information about the natural history of this species has been recently gleaned through collecting and husbandry efforts by a handful of herpetologists in the southeast. That said, *H. septagon* remains poorly documented in South Carolina, reported only from Georgetown, Charleston, and Lee Counties (Sawyer and Shelley 1976, NCSM NMI Collection

database). Basic surveys, ideally coincident with efforts focused on amphibians, are needed to assess the distribution and abundance of this species in South Carolina (Sawyer 1979). It was recommended for Special Concern status by Sawyer (1979). This species is currently unranked (NatureServe 2024).

Appalachian Leech
Placobdella biannulata

This species is found free-living and as a parasite on salamanders of the genus *Desmognathus*. Formerly known by the name *Oligobdella biannulate*, it is known to occur in South Carolina only in the Blue Ridge Ecoregion in Oconee, Pickens, and Greenville Counties (Sawyer and Shelley 1976; Moser et al. 2005). Sawyer (1979) recommended Special Concern status for the species. In its entirety, the species occurs in a relatively small area encompassing mountainous portions of Georgia, North Carolina, South Carolina, and Tennessee (Moser et al. 2005). This species has no current status rank in South Carolina (NatureServe 2024).

Nuchal Leech
Placobdella nuchalis

The nuchal leech was originally described by Sawyer and Shelley (1976) from one site in South Carolina (Orangeburg County) and a few localities in North Carolina. Little is known about the natural history of this species except it being reported as a temporary parasite of fishes (Shelley and Braswell 1981; Klemm, 1982). *Placobdella nuchalis* has been rarely collected since its description. Moser et al. (2017) added new information on its anatomy and a molecular characterization. Poly (2018) discovered individuals of this species to be hitchhikers of a collection of *M. sestertia* in South Carolina. The nature of this association is unknown but warrants further study. This species does not have any conservation rank currently assigned to it, but basic surveys are needed to assess its distribution and abundance.

Translucent Leech
Placobdella translucens

The translucent leech was originally described by Sawyer and Shelley (1976) from Georgetown and Berkeley Counties, South Carolina and from a site in Louisiana. *Placobdella translucens* is infrequently encountered and its range is Alabama, Florida, Georgia, Louisiana, North Carolina, and South Carolina (Sawyer and Shelley 1976; Klemm 1982, 1991). It is most likely a blood feeding leech, but there are no reported hosts for this species. Basic surveys are needed to assess its distribution and abundance of *P. translucens*. It has no current status rank in South Carolina (NatureServe 2024).

"A marine leech"
Branchellion ravenelii

This marine leech was described by Girard in 1850 from Charleston, South Carolina. It is parasitic on rays and skates and occurs along the southeastern Atlantic Coast to the Gulf of Mexico, although reports in South Carolina are exceedingly rare (Sawyer et al. 1975, Sawyer 1979). In 2024, a staff member of the Charleston Aquarium contacted Megan McCuller,

Collections Manager of NMI at the NCSM reporting a *B. ravenelii* on a batoid housed at the facility. If confirmed – and the leech specimen may end up in the NCSM NMI Collection – this would be a welcome recent finding. Sawyer (1979) recommended state endangered status for the species; such a status in turn reflects a conservation focus on the hosts of this leech. *Branchellion ravenelii* is likely present in nearshore areas of South Carolina but may be rare, or appear rare, given this region is the northern extent of its range. Typically, little attention is paid to ectoparasites of marine vertebrates, particularly if the parasites occur in small numbers. As such, this species may be relatively common, but just not reported. *Branchellion ravenelii* has no current status rank in South Carolina (NatureServe 2024).

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Common bottlenose dolphin (offshore)

Tursiops truncatus

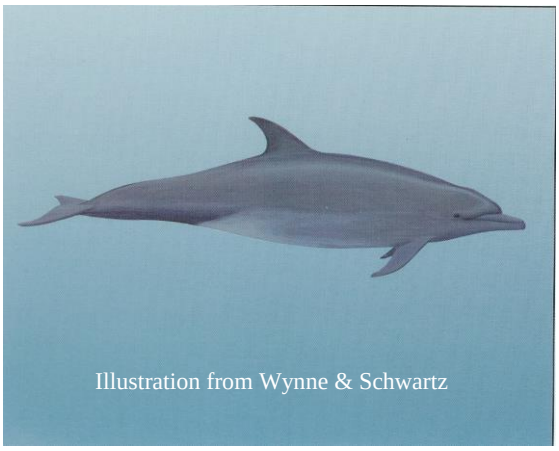


Illustration from Wynne & Schwartz

Contributors (2005): David Cupka and Margaret Murphy [SCDNR]
Reviewed and Edited (2013): Wayne McFee (NOAA); Updated (2024): Wayne McFee (NOAA) and Todd Speakman (NMMF)

DESCRIPTION

Taxonomy and Basic Description

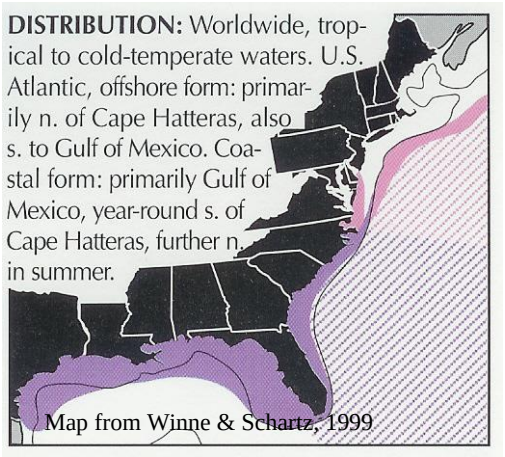
The bottlenose dolphin, *Tursiops truncatus*, was first described by Montagu in 1821. The body and head are robust with a short, thick, well-defined beak. Based on distribution, genetics, morphology, parasites and prey items, two distinct species are now recognized; the "coastal form" (*Tursiops erebennus*) is shorter and slimmer than the larger "offshore form", *Tursiops truncatus* (Costa et al., 2022). The flippers are pointed with deeply notched flukes. The teeth are small and conical and number between 40 to 52 in the upper row and 36 to 48 in the lower row. The dorsal fin, located mid-back, is tall and falcate with a broad base. Adult size varies considerably, ranging from 1.9 to 3.6 m (6 to 12 ft.) (Wynne & Schwartz 1999). The bottlenose has been reported to weigh up to 650 kg (1,432 lb) (Minasian et al. 1984).

Status

The bottlenose dolphin is not listed as threatened or endangered under the Endangered Species Act (ESA). In 1993, the National Oceanic and Atmospheric Administration (NOAA) Fisheries Service (National Marine Fisheries Service or NMFS), treating the coastal population as a single migratory stock, designated the stock as "strategic" under the Marine Mammal Protection Act (MMPA). The action was due to a massive die-off of coastal bottlenose dolphins between 1987 and 1988 (Waring et al. 2002). From 1995 through 2001, the NMFS recognized only a single migratory stock of coastal bottlenose dolphins in the western North Atlantic; therefore, the entire stock was listed as depleted. Current stock assessments have identified 5 coastal stocks of bottlenose dolphins based on genetic studies (Rosel et al. 2009), photo-id (Zolman 2002), strandings (McLellan et al. 2003), and satellite telemetry data (Southeast Fisheries Science Center, NMFS, unpublished data): the Northern Migratory and Southern Migratory stocks, South Carolina/Georgia Coastal stock, Northern Florida Coastal stock, and the Central Florida Coastal stock (Hayes et al. 2022). Further, there are at least 10 recognized Estuarine Stocks on the east coast of the US: a Northern NC Estuarine System stock, a Southern NC Estuarine System stock, a Northern South Carolina Estuarine System stock, a Charleston Estuarine System stock, a Northern Georgia/Southern SC Estuarine System stock, a Central Georgia Estuarine System stock, a Southern Georgia Estuarine System stock, a Jacksonville Estuarine System stock, an Indian River Lagoon Estuarine System stock, and a Biscayne Bay Estuarine System stock (Hayes et al. 2022). Because one or more of the stocks may be depleted, all stocks retain the depleted designation.

The western North Atlantic offshore bottlenose dolphin (offshore ecotype) is also not listed as threatened or endangered under the ESA. Potential Biological Removal level or PBR is an estimate of the maximum number of animals, not including natural mortalities, which may be removed from a marine mammal stock while allowing that stock to reach or maintain its Optimum Sustainable Population (OSP). PBR's are established under the MMPA. The average annual fishery-related mortality and serious injury for western North Atlantic offshore bottlenose dolphin from 1996 to 2000 is unknown and the PBR is 519 animals; therefore, the status of this stock is unknown (Hayes et al. 2022).

POPULATION SIZE AND DISTRIBUTION



Two bottlenose dolphin ecotypes inhabit waters in the western North Atlantic Ocean: a shallow water or nearshore/coastal ecotype and a deep water or offshore ecotype (Curry and Smith 1997). Based on work to date, it appears that the western North Atlantic offshore stock consists primarily of the offshore ecotype. Relatively little is known about the distribution of the offshore ecotype except that it is typically concentrated along the continental shelf break in deeper waters and can, in lower concentrations, extend beyond the continental shelf into continental slope waters (Kenney 1990). However, the offshore ecotype has been documented to occur close to shore near Cape Hatteras, NC and points south. Although the ranges of the coastal and offshore ecotypes overlap to some degree, Torres et al. (2003) found a statistically significant break in the distribution of the two ecotypes at 34 km (18 nautical miles) from shore. Torres reports that the offshore ecotype is found seaward of 34 km and in waters deeper than 34 m (112 ft.), and the coastal ecotype is found within 7.5 km (4 nautical miles) offshore. The best available abundance for the offshore stock of bottlenose dolphins in <40 m (131 ft.) depth is 26,849 and in >50 m (164 ft.) water depth is 44,953. Data are insufficient to determine current population trends for the offshore stock (Waring et al. 2009a). The most recent and best available estimate for the entire offshore stock of common bottlenose dolphins in the western North Atlantic is 62,851 with a minimum population estimate of 51,914 (Hayes et al. 2022).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Bottlenose dolphins are both a coastal and an oceanic species, with the coastal ecotype preferring waters of less than 30 m (98 ft.) in depth. The offshore ecotype seems to be adapted for cooler, deeper waters. Certain characteristics of their blood indicate that this form may be better suited for deep diving. They typically occur in deep waters of the continental shelf and inner continental slope (Hersh and Duffield 1990).

CHALLENGES

A variety of factors, both natural and human-related, can affect bottlenose dolphins. Natural factors include predation by large sharks, disease, parasites, exposure to naturally occurring biotoxins, changes in prey availability, and reduction or loss of habitat due to environmental variation. Human-related causes of mortality and injury to this species include loss of habitat due to coastal development, exposure to pollutants, vessel strikes, entanglement in debris, as well as noise and pollution related to oil and gas development. Bottlenose dolphins have also increasingly become the target of dolphin watching and wild dolphin interaction programs. There is growing concern that these activities may result in altered behavioral patterns, especially where people enter the water with dolphins and where they are fed. In the latter case, behavioral patterns are altered significantly and increased aggression may occur (Bryant 1994).

In addition, recreational and commercial fisheries directly and indirectly affect bottlenose dolphins. Coastal bottlenose dolphins are taken as bycatch in various kinds of fishing gear including gillnets, seines, longlines, shrimp trawls and crab pots (Waring et al. 2002). Bycatch of offshore bottlenose dolphins has been observed in the pelagic drift gillnet, pelagic pair trawl, New England multispecies sink gillnet, North Atlantic bottom trawl, mid-Atlantic coastal gillnet and pelagic longline fisheries. The pelagic drift gillnets and pelagic pair trawl fisheries no longer exist. Mortalities of bottlenose dolphins due to ingestion of hooks and/or line have also been documented (Gorzelany 1998; Well et al. 1998). The gear most likely had been discarded or was consumed by the dolphin by eating a fish that had been hooked then broke away with the gear. Estimates of fishery-attributed interactions suggest that mortality exceeds the PBR of several coastal stocks considered depleted by the 1987 through 1988 die-off and, thus, may be impeding their recovery.

CONSERVATION ACCOMPLISHMENTS

SCDNR and South Atlantic Fishery Management Council (SAFMC) personnel serve as members of the Bottlenose Dolphin Take Reduction Team (BDTRT), which was convened in 2001. The BDTRT works with NOAA Fisheries to develop the Bottlenose Dolphin Take Reduction Plan (BDTRP) for coastal stocks. The short term goal of the plan is to reduce, within 6 months of its implementation, the incidental mortality or serious injury of western North Atlantic coastal bottlenose dolphins incidentally taken in commercial fishing operations to levels less than the potential biological removal (PBR) level. The long term goal of the take reduction plan is to reduce, within five years of plan implementation, incidental mortality and serious injury of coastal bottlenose dolphins incidentally taken in the course of commercial fishing operations to insignificant levels approaching a zero mortality rate goal (ZMRG). The BDTRT has developed a number of recommendations to achieve these goals and to be incorporated into the BDTRP. The BDTRP was amended in December of 2008 (73 FR 77531) with an effective date of January 20, 2009.

The BDTRT has made a number of recommendations to be incorporated into the BDTRP for coastal stocks including regulatory suggestions, based on management units, which apply to specific fisheries. Generally, these recommendations seek to reduce soak times, the amount of fishing gear in the water at any given time, or to modify practices in order to limit interactions with and the take of bottlenose dolphins. The BDTRT also adopted non-regulatory recommendations for all management units including education and outreach, as well as

improved research, monitoring, collection of strandings data, and observer coverage. The finalized specific recommendations were published on April 26, 2006 (FR 50CFR Parts 223 and 229) and SCDNR will continue to explore avenues to implement these recommendations, working together with members of the BDTRT as funding opportunities become available.

SCDNR conducted a marine mammal stranding program from 1991 to 2005 in order to obtain data on marine mammals that strand along the South Carolina coast. Data from the program are used to further our knowledge regarding these animals and the extent to which anthropogenic factors are responsible for or contribute to their stranding. From 2006-2008, the NOAA National Centers for Coastal Ocean Science in Charleston, SC assumed responsibility of the network, Coastal Carolina University administered the program from 2009-2021, and the Lowcountry Marine Mammal Network has assumed responsibility of the Network since 2021, having received grant awards from the Prescott Grant.

CONSERVATION RECOMMENDATIONS

- Improve understanding of stock structure and population trends in order to assess the greatest threats to bottlenose dolphins.
- Determine the significance of periodic die-offs, especially to relatively small, isolated populations of bottlenose dolphins.
- Assess the impact of contaminants on marine mammals, particularly the repercussions of high contaminant loads in individual bottlenose dolphins as well as their offspring.
- Measure the effects of interactions between humans and dolphins in the wild, including behavioral disruption, habituation, injury and death.
- Mitigate threats to bottlenose dolphins posed by entanglement in fishing gear through support of methods proposed by the BDTRT.
- Continue to explore avenues to partner in implementation of recommendations to be published by the BDTRT.

MEASURES OF SUCCESS

A take reduction plan has been developed for coastal bottlenose dolphins to reduce the incidental take of animals in commercial fishing operations to below the Potential Biological Removal (PBR) level. SCDNR personnel will continue to serve on the BDTRT in order to help develop and implement programs and activities designed to reduce bottlenose dolphin non-natural mortalities to insignificant levels approaching a zero mortality and serious injury rate (the Zero Mortality Rate Goal or ZMRG).

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Florida Manatee

Trichechus manatus latirostris

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Reviewed and Edited (2012): Clay George (GADNR) and Wayne McFee (NOAA)
Reviewed and Edited (2024): Michelle Pate and Melanie Olds (USFWS)

DESCRIPTION


SCDNR

Taxonomy and Basic Description

Manatees are aquatic mammals in the order Sirenia. The order includes manatees, dugongs and the extinct Steller's sea cow. The West Indian manatee is one of three species in the family Trichechidae. Linnaeus named the single genus *Trichechus* in 1758. Two subspecies of West Indian manatee are now recognized: the Florida manatee, *T. manatus latirostris*, which occurs in the southeastern United States, and the Antillian manatee, *T. manatus manatus* that is found throughout the remainder of species' range (USFWS 2001).

Manatees are large, robust marine mammals with short, paired flippers and a distinct paddle-shaped tail. On average, manatees reach lengths of 3.5 m (11.5 ft.) with females tending to be larger than males. Average weight is approximately 1000 kg (2200 lbs.). In the murky waters of South Carolina, only the small head is sometimes seen as the animal surfaces for air. The head is rounded and indistinct from the body with no neck area apparent. Stiff vibrissae (tactile hairs) are present around the small mouth, and two circular-valved nostrils are situated on the top of the muzzle. The eyes are small with a small lid and nictitating membrane, a clear inner eyelid that protects the eye. External ear flaps are absent. Manatee pectoral flippers are flexible and aid in moving over the substrate, maneuvering in the water column, scratching, manipulating food, and embracing other manatees. The large tail is rounded and horizontally flattened for locomotion and steering. The tail is used to propel the manatee forward with a strong up-and-down pumping motion, which creates circular swirls on the surface of the water known as "footprints."


Monica Ross, Clearwater Aquarium

Manatees are semi-social and can be found alone or in small groups. They are not territorial. Ranges of individuals often overlap, with male ranges ("circuits") being larger and encompassing several female ranges. Manatees see well and are sensitive to audible and tactile cues. They

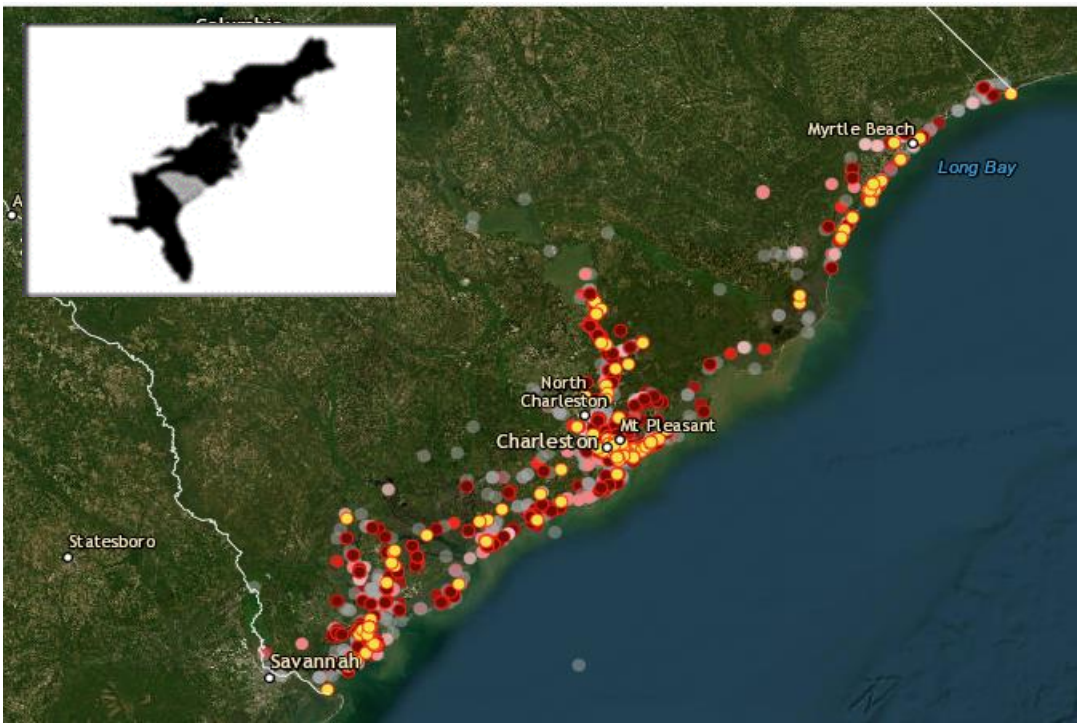
communicate with a variety of high-pitched squeaks and chirps. Manatees often return to the same wintering and summering habitats year after year. Females reach sexual maturity by 5 years of age and males by age 3 - 4 years. Lifespan can exceed 50 years. Breeding usually takes place in mating herds, which form when several males are attracted to a female in estrus. Mating herds may remain together for a few days to over a month, during which as many as 20 males may compete intensely for access to the focal female. Manatees mate and calve year-round. Female manatees usually give birth to a single calf, but twins are born on rare occasions. Calves remain with their mothers for 1 - 2 years after birth. Newborns average 1.2 to 1.4 m (4 to 4.5 ft.) in length and weigh about 30 kg (66 lbs.) (Odell 1981). Manatees have slow metabolic rates which makes them intolerant of water colder than 20°C (68°F).

Conservation Status

The West Indian manatee is listed as threatened throughout its range under the Endangered Species Act of 1973 as amended (16 U.S.C. 1531 *et seq.*) having been downlisted from endangered in 2017 (82 FR 16668). The manatee is listed as "vulnerable" under the International Union for Conservation of Nature (IUCN). It is also protected under the South Carolina Nongame and Endangered Wildlife Species Act (§§ 50-15-10-50-10-90) and the Marine Mammal Protection Act (MMPA) of 1972 as amended (16 U.S.C. 1461 *et seq.*). Manatees in South Carolina have state rankings of S2/S3 indicating the species is of high conservation concern. Critical habitat for the Florida subspecies was designated in 1976 (50 CFR Part 17.95(a)), the first for an endangered marine mammal. The largest population of manatees is found in the southeastern United States. Outside the United States, manatees occur in the Greater Antilles, on the east coast of Mexico and Central America, along the north and northeast coast of South America, and in Trinidad and Tobago (Lefebvre et al. 1989). A petition to reclassify the West Indian manatee, including its subspecies the Antillean manatee and Florida manatee, as endangered species under the Act has been filed (88 FR70634) prompting the initiation of a status review to determine if the petition actions are warranted. That review is ongoing as of 2024.

POPULATION SIZE AND DISTRIBUTION

Commercial and subsistence harvests in the 1800's probably significantly reduced the population. Minimum population size has been based on counts of manatees at all known winter refuges in Florida and Georgia. Aerial and ground counts at winter refuges are highly variable depending on weather, water clarity, manatee behavior and other factors (Packard et al. 1985). It is estimated that 9,790 manatees live between Florida's east and west coasts as of 2022 (Gowan, T.A. *et al.* 2023).



Manatee Sightings in South Carolina: 1850 to 2023.

Between 1850 and 1981, a total of 23 records of manatees in South Carolina were documented (Rathbun et al. 1982). Four additional records were reported by O'Shea (1988) from 1981 through 1986. Between 1986 and 1992, an additional 25 records were recorded by SCDNR (unpublished data). Therefore, only 52 records of manatees were documented in South Carolina over a period of 142 years, suggesting that manatees are rare visitors. In 1998, a record 190 sightings were made of manatees in SC. The farthest inland a manatee has traveled in South Carolina is to Santee State Park along the shores of Lake Marion in Orangeburg County in November of 2012. The individual died due to cold stress. Since active surveillance was initiated in 1993, more than 2,300 manatee sightings have been reported in South Carolina.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

In the Southeast, manatees are found in rivers, bays, or estuaries with submerged aquatic vegetation from which they forage. Manatees migrate to SC during the spring when water temperatures are approximately 68F or higher and stay through the warm summer months and then migrate back to Florida in the winter. Sightings in SC are highest from June-September than other times of the year. Any manatees sighted in SC during December-March would be outliers; possibly animals attracted to industrial warm water outfalls associated with industrial sites. Such individuals would likely be in imminent danger of mortality from cold stress given the low ambient water temperature in SC during winter. In South Carolina, manatees occupy fresh, brackish, and marine habitats and move freely between salinity extremes. Because of our high tidal amplitude, manatees feed on abundant *Spartina alternaflora* grasses at high tide and frequently move to submerged *Ulva sp*. beds at low tide. Manatees will move up rivers until the water is too shallow for passage or is blocked by a dam. South Carolina sightings indicate that manatees are frequently reported in areas where food resources exist including occurring near locations of *Hydrilla verticillate* available on the upper Cooper River. This area is the only site

with extensive stands of the introduced exotic plant *Hydrilla verticillata* accessible to manatees in the state and analysis of sightings records suggests they are utilizing it to a lesser extent for forage as well (Leslie 2017).

CHALLENGES

The greatest known human-related cause of manatee mortality in the southeastern United States is collisions with watercraft. There is limited documented collision-mortality in South Carolina and few of the many manatees sighted are reported to have fresh wounds. However, the lack of extensive collision mortality may be a result of the low number of animals present. It is likely that manatees are prone to being struck by fast moving boats when foraging in shallow areas; however, most boat operators avoid shallow water hazards in South Carolina. The high tidal amplitude and abundant oyster beds present in this state reduce the frequency of collisions.

Cold stress may have a significant effect on manatees in South Carolina because the state is in the northern range of manatees. The threat of cold stress is complicated by use of heated water discharges at a variety of industrial sites in the fall. Unlike power plants and paper mills, many of these smaller discharge sites are not in continuous operation and do not provide a predictable source of warm water. Many are being eliminated as alternative treatments for heated effluent are being adopted. Although based on a limited sample, several manatee mortalities in South Carolina were related to low water temperature exposure.


USFWS

Manatee mortality by trauma or drowning can be associated with the operation of locks and water control gates. One such site in South Carolina is the Pinopolis Lock on the upper Cooper River that transports boats between the river and Lake Moultrie. Manatee mortality has occurred in two ways at lock sites. Several manatees have died from exposure to cold-water temperatures after they failed to navigate back to the lock in the fall during its limited operation. The other source of mortality is from drowning or being crushed during in the lock during operation. Several of these locks sites have a lock operation plan that is aimed at preventing passage of manatee and to prevent injury if the manatee gets into the lock.

Although documented in Florida (O'Shea et al. 1991), harmful algal blooms have not been documented as a source of manatee mortality in South Carolina. However, documentation of the state's first large-scale marine algal bloom (*Heterosigma akashiwo*) in the spring of 2003 increases the likelihood of future blooms.

An unusual mortality event (UME) is ongoing in Florida associated with the lack of available food resources such as seagrass. A record number of 841 manatee deaths were documented over a six-month period in 2021. This UME is the first due to starvation. This type of event has not

been documented in South Carolina, but individuals may utilize available foraging areas outside of their Florida range when resources are limiting, prompting more individuals to travel to places like South Carolina.

Several manatee mortalities have been associated with the shrimp trawl fishery, though not in South Carolina. The interaction between shrimp trawlers and manatees appears to be rare because manatees should be able to outswim the approaching nets or surface to avoid them.

A changing climate may have effects on foraging, distribution, and habitat use of manatees. Sea water temperature data recorded for Charleston Harbor indicates relatively constant water temperatures between 1970 to 1985. As of 1985, data recorded indicates a warming trend for this area (SCDNR). During recent years manatees have been observed earlier in South Carolina waters, the earliest yet occurred in February 2022 (SCDNR unpublished data). Changing water temperatures may also have effects on available forage and timing of availability.

CONSERVATION ACCOMPLISHMENTS

Geographic distribution of and seasonal use by manatees in South Carolina continues to be documented through reports from the public. A manatee web site has been maintained since 2003 to inform the public about manatees in South Carolina and to provide an online form for reporting manatee sightings. The online reporting system has been upgraded to GIS platform utilizing the ArcGIS Survey123 form.

New signage was created and installed at marinas in coastal and riverine areas that directs the public to the online reporting form. This signage also reminds boaters of manatee's presence in our waters.

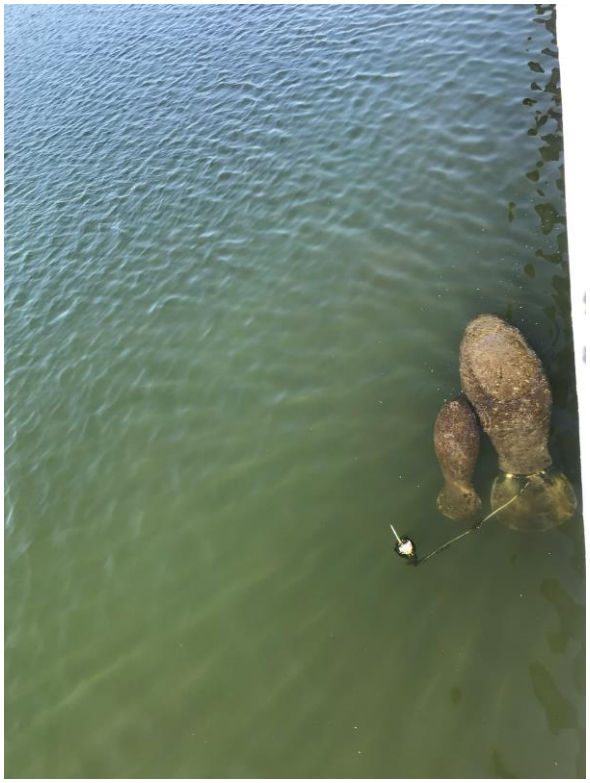
The approval of a new Manatee Protection Plan for Santee Cooper's Pinopolis Lock on the Cooper River. The plan was mandated by the Federal Energy Regulatory Commission to receive a new license to operate. The plan outlines continued efforts to reduce the likelihood that manatees will enter Lake Moultrie from the Tailrace Canal, and "avoid and minimize project-related effects on the West Indian Manatee" (order issuing new License, 2023).

Installation of a diffuser on the WestRock plant to disperse heated effluent and reduce use of the area by manatees when water temperatures drop and subsequent mortality during fall and winter season. Though WestRock has since shut down operations as of 2023. Other warm-water discharge sites have changed operations to include two-cycle cooling and more monitoring for adverse impacts to manatees.

CONSERVATION RECOMMENDATIONS

- Document seasonal use and evaluate the relationship between manatee reports and actual population size.
- Continue cooperation with Clearwater Marine Aquarium Research Institute in monitoring manatees tagged with radio instruments to determine manatee use areas in the northern portion of the range.

- Attempt to identify individual manatees to better understand patterns of use.
- Continue to document the relationship between use of heated effluent by manatees and distribution of these animals in northern waters as well as any associated manatee mortality.
- Protect the quality of wetlands in South Carolina by preventing the rise of harmful algal blooms. This can be accomplished by reducing nutrient loading of coastal water bodies through best management practices and land use planning.
- Collaborate with port and shipping operation authorities to develop contingency plans for oil spill events that will result in protection to manatees.
- Collaborate with port and shipping operations authorities for the installation of manatee bumpers to prevent large container ships "crushing" manatees.
- Continue to solicit and summarize sightings of manatees from the public to determine habitat use.
- Monitor the causes of manatee injury and mortality.
- Monitor water uptake and discharge areas at industrial sites for manatee use and evaluate the potential for conflicts involving entrainment and cold-stress mortality.
- Monitor the effectiveness of Turtle Excluder Devices in preventing drowning of manatees in trawl nests.
- Maintain an updated, interactive manatee web site at https://www.dnr.sc.gov/manatee/ to increase public awareness of manatee threats while continuing to solicit sightings information from the public.



Tagged manatee and calf observed along the concrete wall of the Hugh Leatherman terminal, Charleston, South Carolina. Tagged by Clearwater Marine Aquarium Research Institute in 2022.

MEASURES OF SUCCESS

Since low visibility in coastal waters limits the utility of aerial surveys for manatees unless they are at the surface, other means, mentioned above, will allow monitoring of manatees in South Carolina. As additional data on manatees in South Carolina are accumulated and a better understanding of the distribution and habitat use of state waters, further management recommendations can be developed. Data collected will continue to be used in stock assessments and the permit review process.

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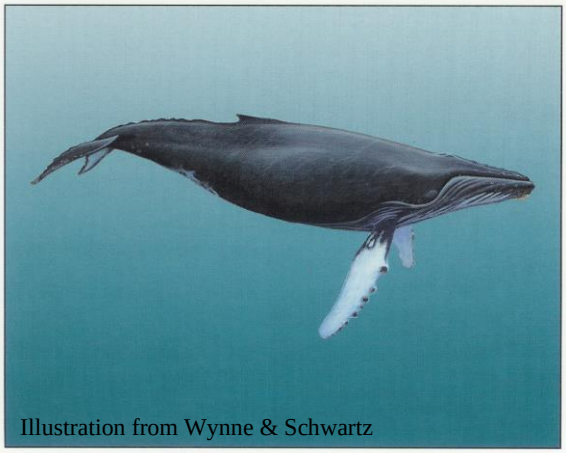
Humpback Whale

Megaptera novaeangliae

Contributors (2005): David Cupka (SCDNR) and Margaret Murphy (SCDNR)
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Reviewed and Edited (2024): Wayne McFee (NOAA)

DESCRIPTION

Taxonomy and Basic Description


Illustration from Wynne & Schwartz

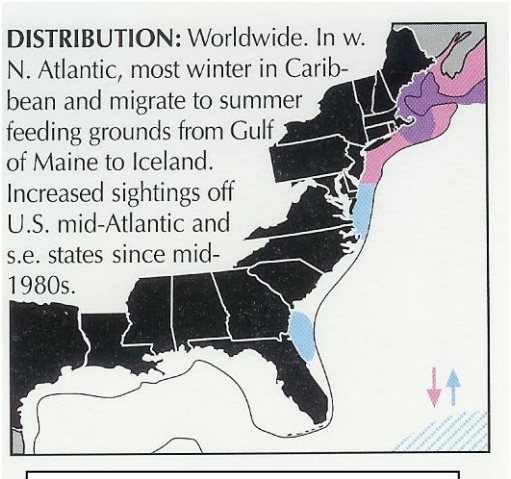
The humpback whale is a moderately large baleen whale. First described by Borowski (1781), the humpback's most distinguishable features include: a robust body with a broad, rounded head; a series of fleshy knobs on the rostrum and lower lip; long flippers (one-third of the body length); broad flukes with an irregular trailing edge; ventral throat grooves (12 to 36) extending to the navel; black with white coloring on the throat and belly with variable amounts of white on the undersides of flukes and both sides of the flippers; and a broad and bushy blow hole. Adults reach 11 to 16 m (36 to 52 ft.) in length and a weight of 36 metric tons (40 tons); females are slightly larger than males (Wynne & Schwartz 1999).

Status

All humpback whale populations are federally listed as endangered under the Endangered Species Act. However, The US Atlantic stock (Gulf of Maine stock) is defined as "not-depleted" because it does not coincide with any ESA-listed Distinct Population Segments (DPS) under the Marine Mammal Protection Act and because the average annual fishery-related mortality and serious injury did not exceed its Potential Biological Removal (PBR) level of 22 whales (Hayes et al. 2020).

POPULATION SIZE AND DISTRIBUTION

The humpback whale is worldwide in its distribution. In the western North Atlantic, most winter in the West Indies, where they mate and calve. These whales then migrate to summer feeding grounds from the Gulf of Maine to Iceland. However, a notable number of humpbacks do not undertake this extensive seasonal migration but instead overwinter in mid- and high-latitude regions (Clapham et al. 1993; Swingle et al. 1993). There have been increased sightings of this species off the US mid-Atlantic and southeastern



Map from Wynne and Schwartz, 1999

states since the mid-1980s (Swingle et al. 1993; Wiley et al. 1995). In this region, sightings have been reported in all seasons but are more predominant from January to March (Barco et al. 2002). Whether these increased sightings represent a distributional change or are simply due to an increase in sighting effort and/or whale abundance, is currently unknown (Waring et al. 2004).

The best available estimate of the population size for the US Atlantic waters (Gulf of Maine stock) is 1,396 (Hayes et al. 2020). The most recent estimates indicate continued population growth; however, the size of the humpback stock in the US Atlantic Exclusive Economic Zone (EEZ) may be below its Optimum Sustainable Population (OSP).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The humpback is considered a pelagic and coastal species. These whales are typically encountered over shallow banks and in shelf waters while feeding or breeding but may traverse open ocean during migration (Leatherwood and Reeves 1983; Wynne and Schwartz 1999). Feeding occurs in the cold, nutrient-rich waters of high latitudes. In the western North Atlantic, several discrete feeding grounds exist extending from the Gulf of Maine to off Iceland and northern Norway. Humpbacks exhibit strong fidelity to a particular feeding ground. Calves will typically return to the same feeding ground as their mother. Off the U.S. Atlantic coast, the primary feeding ground for humpbacks is the Gulf of Maine. Humpbacks begin to arrive in the waters off New England in early spring and remain through the fall. Their distribution in this area has been largely correlated to prey species and abundance, although behavior and bottom topography are also factors in foraging strategy (Payne et al. 1986, 1990). Humpbacks are generally piscivorus but krill are also frequently taken in the northern Gulf of Maine (Paquet et al. 1997).

Humpbacks fast while on breeding and calving grounds. During this time, these whales live off their vast reserve of blubber. Individuals from different feeding grounds mix while on the breeding grounds. Such mixing is also recorded within the group of humpback whales that winter off the U.S. mid-Atlantic coast. Most identified individuals from this group belong to the Gulf of Maine stock, but a few animals from stocks off Newfoundland and in the Gulf of St. Lawrence have been identified on the US mid-Atlantic coast wintering grounds as well (Barco et al. 2001). This population, composed of mostly first-year animals and a smaller number of juveniles and adults, is thought to use the mid-Atlantic/southeast region as a supplemental winter feeding ground. Some individuals have been observed over multiple years indicating repeated use of this area.

CHALLENGES

Although hunting previously caused a major decline in all humpback whale populations, these animals are no longer endangered by that activity. Ship collisions and entanglements in fixed fishing gear are the greatest causes of non-natural mortality in humpback whales. Other factors that may affect the recovery of humpback whales include disturbance or displacement caused by noise and other activities associated with shipping, recreational boating, whale watching or air traffic; pollutants from waste disposal; activities associated with mineral exploration and

extraction; habitat degradation associated with coastal development; and competition with fisheries for prey species. These factors could affect reproductive success in individual whales, alter survival, and impact habitat (NMFS 1991).

CONSERVATION ACCOMPLISHMENTS

SCDNR and SAFMC (South Atlantic Fishery Management Council) personnel serve as members of the Atlantic Large Whale Take Reduction Team (ALWTRT). The ALWTRT works with National Oceanic and Atmospheric Administration (NOAA) Fisheries to develop and amend the Atlantic Large Whale Take Reduction Plan. The goal of the plan is to reduce the incidental take of finback, humpback and right whales in commercial fishing operations so that they can reach or maintain their optimum sustainable population size.

To reduce the incidence of ship strikes, especially in the area of shipping lanes, NOAA Fisheries, in collaboration with other Federal agencies, state agencies including SCDNR, environmental groups, citizen groups and the shipping industry have been working to develop ship strike reduction measures along the US Atlantic coast. Currently, the focus of this effort is on the northern right whale given its highly endangered status; however, such measures are also expected to benefit the humpback.

SCDNR conducted a marine mammals stranding program from 1991 to 2005 to obtain data on marine mammals that strand along the South Carolina coast. NOAA National Ocean Service in Charleston managed the stranding network from 2006-2007. From 2008-2018, Coastal Carolina University managed the volunteer SC Marine Mammal Stranding Network in collaboration with NOAA National Ocean Service in Charleston, SC. Since 2018, the non-profit Lowcountry Marine Mammal Network has assumed stranding response activities. SCDNR continues to provide logistical support to the stranding program. Sightings of humpback whales are fairly common in SC waters. Since 1993 there have been seven humpback whale strandings in SC: one in 1993; one in Myrtle Beach in 2001; three in 2006 on Myrtle Beach, Cape Island, and off of Hilton Head Island; one off of Myrtle Beach in 2009; and one on North Island in 2016.

A take reduction plan has been developed for Atlantic large whales, including the humpback whale, to reduce the incidental take of animals in commercial fishing operations to below the Potential Biological Removal (PBR) level. PBR is an estimate of the maximum number of animals, not including natural mortalities, which may be removed from a marine mammal stock while allowing that stock to reach or maintain its Optimum Sustainable Population (OSP). The minimum annual rate of human-caused mortality and serious injury to the Gulf of Maine stock from 2013-2017 averaged 12.5 whales (Hayes et al. 2020). Therefore, despite efforts of the plan to reduce large whale entanglements and other activities to reduce ship strikes, annual mortalities are still exceeding PBR for this stock (22 whales) (Hayes et al. 2020). SCDNR personnel will continue to serve on the ALWTRT in order to help develop and implement programs and activities designed to reduce humpback whale non-natural mortalities to insignificant levels approaching the Zero Mortality Rate Goal (ZMRG). The ZMRG (currently defined as 10% of PBR) for humpback whales is 0.37 animals.

Numerous individuals from scientific, management and conservation communities have been working for some time to improve the status of the humpback whale. One of the outcomes of these efforts has been development of the humpback whale recovery plan. Another was a major research initiative known as the Years of the North Atlantic Humpback (YONAH) (Smith et al. 1999) conducted from 1992 through 1993. This project was a large-scale intensive study of humpback whales throughout most of their entire North Atlantic range, from the West Indies to the Arctic. It addressed large-scale issues, such as size and structure of the population, vital population rates, migratory movement, and structure of the mating system. Information resulting from this study will serve a baseline against which to evaluate, among other things, whether the population is increasing or decreasing over time.

CONSERVATION RECOMMENDATIONS

- Identify essential/critical humpback whale habitat in US waters.
- Identify and minimize possible adverse impacts of human activities and pollution on important habitat by commenting on such things as proposed offshore drilling activities and other energy development activities which could impact important humpback habitat such as offshore wind farms or proposed changes to ocean dumping laws.
- Reduce mortality and injury from entanglement in fishing gear and ship strikes by working with commercial fishermen and the maritime industry to modify fishing gear and harbor approach routes, vessel operational procedures and speeds, and by improving early warning systems to notify vessel traffic of whales in the area.
- Within South Carolina's waters, identify and implement seasonal and/or geographic regulations for fishing gear that may kill or injure humpback whales. Collaborate with other jurisdictions to implement similar fishing gear recommendations.
- Evaluate cumulative impacts of vessel collisions on humpback whale populations.
- Continue photo-identification studies of humpback whales.
- Continue biological studies on stranded humpback whales.
- Develop a standardized protocol for sampling tissues of humpback whales using strandings and biopsies.
- Identify and evaluate feeding competition between humpback whales and fish species and the impacts of prey abundance on whale populations.
- Employ radio tags, underwater listening stations and genetic techniques to define migration routes and transit times for humpback whales.
- Continue assessment of mortality levels and population structure of the wintering aggregation of humpback whales in the mid-Atlantic/southeast region.
- Develop a protocol for monitoring physical and chemical factors that could decrease habitat suitability for humpback whales.
- Assist in defining measurable criteria for monitoring the success of implemented management measures within the ALWTRP.
- Educate fishermen on the importance of reporting entangled whales to improve such counts.
- Improve coordination with federal, state and non-governmental agencies/groups involved in education, outreach and cooperative efforts by supporting regional meetings and workshops to facilitate the exchange of information on whale strandings and ship strikes and to develop and implement procedures to reduce fishing gear entanglements and ship

strikes. Examples would include such things as educational brochures for fishermen and maritime interests informing them about regulatory changes in regards to fishing gear modifications or vessel operating procedures in critical whale habitat areas.
- Develop educational materials in support of humpback whale recovery plan objectives.
- Collaborate with other research, monitoring, and outreach groups to combine efforts to protect the humpback whale.

MEASURES OF SUCCESS

SCDNR personnel will continue to serve on the ALWTRT in order to help develop and implement programs and activities designed to reduce humpback whale non-natural mortalities to insignificant levels approaching the Zero Mortality Rate Goal (ZMRG). The ZMRG (currently defined as 10 percent of PBR) for humpback whales is 0.37 animals. Success of any individual program will be measured according to its apparent contribution toward this goal. Additionally, information resulting from the YONAH study will serve a baseline against which to evaluate whether the population is increasing or decreasing over time.

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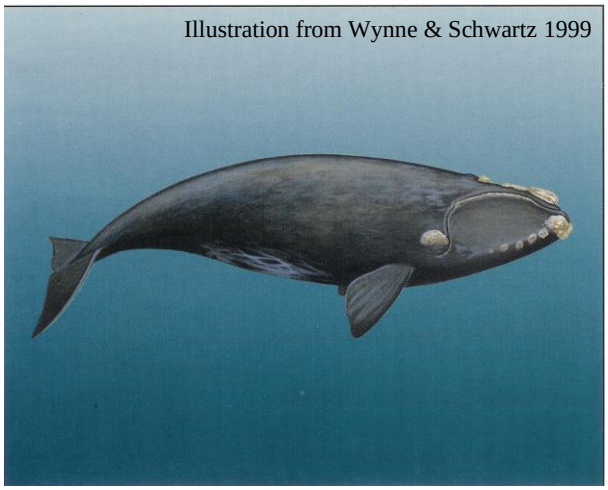
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North Atlantic Right Whale

Eubalaena glacialis

Contributors (2005): David Cupka (SCDNR) and Margaret Murphy (SCDNR)
Reviewed and Edited (2024): Wayne McFee (NOAA)

DESCRIPTION


Illustration from Wynne & Schwartz 1999

Taxonomy and Basic Description

The North Atlantic right whale was first described by Müller (1776). Not built for speed, the northern right whale has a rotund body with a large head (one-third of its total body length) and a narrow, arching rostrum. Its baleen can reach up to 3 m (8 ft.) with the fringe along the inside edge fine enough to allow right whales to filter very small food items from the water. Right whales have a broad, smooth back absent a dorsal fin. Callus-like patches of skin are found on the rostrum, lower lip, and around the eyes. These patches are called callosities and offer a secure holding place for cyamids, (whale lice) which give the callosities an orange or whitish-yellow color. Right whales also have broad, paddle-like flippers and large flukes with smooth concave margins. These whales are predominately black in color, are often mottled, and have a variable amount of white on the belly. Their spout is V-shaped. Adults reach 13 to 18 m (43 to 59 ft.) in length and a weight of 55 metric tons (60 tons) (Wynne & Schwartz 1999).

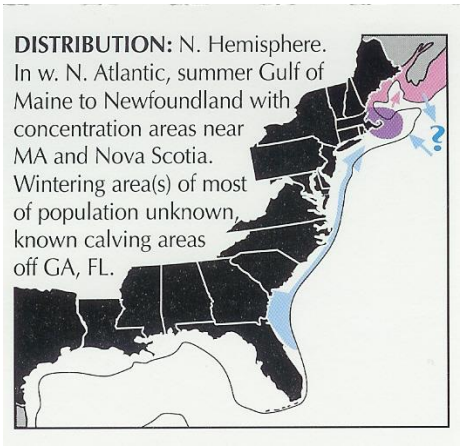
Status

The North Atlantic right whale is federally listed as an endangered species. It is among the rarest of all large whale species and, indeed, of all marine mammal species. Population size is at a critical level with an estimated 338 animals remaining in western North Atlantic waters as of 2022 (Hayes et al. 2023). The North Atlantic right whale is defined as Endangered under the Endangered Species Act (ESA) due to its endangered status and because the average annual fishery-related mortality and serious injury exceeds its Potential Biological Removal (PBR) level, which is 0.7 individuals (Hayes et al. 2023).

POPULATION SIZE AND DISTRIBUTION

The seasonal movements of the North Atlantic right whale are still poorly understood. Individuals in the western North Atlantic population range from winter calving and nursery areas off the southeastern United States to summer feeding grounds off New England and north to the Bay of Fundy and Scotian Shelf. These northern waters are also important mating and nursery habitats. Analyses based on both genetics and sighting histories of photographically identified individuals suggest that not all reproductively active females return to calving and nursery

grounds each year (Waring et al. 2004). In addition, other than calving females and a few juveniles that winter off the coasts of Georgia and Florida, the wintering location of the remaining individuals in the population is unknown. Therefore, it appears that one or more additional wintering and summering grounds may exist in unsurveyed locations. However, it is possible that the "missing" animals simply disperse over a wide area at these times (Waring et al. 2004).



Map from Wynne & Schwartz, 1999

The right whale was routinely harvested in U.S. waters from 1650 through 1924, with a peak in the early 1700s (Wynne & Schwartz 1999). An estimate of pre-exploitation population size is not available. Population trajectories, based on historical data and estimated present population size, indicate that there may have been 1,000 right whales in the population during the mid 1600s (Waring et al. 2004). During this time period, the population size has been greatly reduced to the point where today there are an estimated 361 animals remaining. It is currently unclear whether the population is stationary, undergoing modest growth, or in decline. Recent examination of the minimum number alive population index suggests a decline in population size with a decline of 23.5% estimated from 2011-2020 (Hayes et al. 2023). The size of this stock is considered to be extremely low relative to its Optimum Sustainable Population (OSP) level in the U.S. Atlantic Exclusive Economic Zone (EEZ).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

There are five well-known habitats used annually by western North Atlantic right whales: 1) coastal Florida and Georgia, 2) Great South Channel east of Cape Cod, 3) Cape Cod and Massachusetts Bays, 4) the Bay of Fundy, and 5) Browns and Baccaro Banks south of Nova Scotia (NMFS 2005). Movements within and between these habitats are believed to be more extensive than originally considered (Waring et al. 2004).

Important feeding areas occur in the Bay of Fundy, Cape Cod Bay, Great South Channel and the Scotian Shelf. Right whales are frequently found in coastal and shelf waters and, for much of the year, their distribution is strongly correlated to the distribution of their prey, calanoid copepods (NMFS 2005). Individuals are generally found in Cape Cod Bay and adjacent waters from January through early May. In late spring, mothers with their newborn calves appear. In summer, right whales make their way northward to feeding grounds off Maine, New Brunswick, and Nova Scotia. As mentioned earlier, these northern waters are also important mating and nursery habitats. In October, a portion of the population—mostly pregnant females—migrates southward to waters off southern Georgia and northern Florida to calve. At present, the southeastern United States is the only known calving ground for the western North Atlantic right whale.

Depending on the time of the year, right whales will spend much of their time near bays and peninsulas and in shallow, coastal waters. These areas provide shelter, food abundance, and security for females rearing young or avoiding the mating efforts of males. Four important habitat areas, used as both feeding and nursery grounds for northern right whales, are the

Browns-Baccaro Bank, Bay of Fundy, Great South Channel and the Cape Cod Bay. Each of these areas is distinguished by high densities of copepod populations. The first three have deep basins (150 m) flanked by relatively shallow water. Copepods are concentrated here because of convergences and upwellings driven by tidal currents. This also occurs in the Cape Cod Bay even though a deep basin isn't present (Cummings 1985; Katona 1999). A fifth important habitat area is found off southern Georgia and northern Florida in nearshore waters; this area serves as a nursery ground and is characterized by large shallow embayments that provide safe areas for females to calve in the winter.

Right whales are known to occur in waters off South Carolina during the winter but the duration of their residency and the extent to which they utilize this area of habitat is currently unknown. There have been three strandings reported: one off Murrels Inlet in 2001, one off Charleston in 2011, and one on Cape Island in March of 2011; the latter two died (Wayne McFee, NOAA, pers. comm.).

Four areas have been designated under the Endangered Species Act as critical habitat for this species (81 FR 4837, 26 February 2016). Three include feeding and nursery areas off the northeastern United States in the Gulf of Maine, Cape Cod/Massachusetts Bay and the Great South Channel; the fourth is the winter calving and nursery area in waters off the southeastern United States south of Cape Fear, North Carolina.

CHALLENGES

The two most common anthropogenic causes of right whale mortalities in the western North Atlantic are ship strikes and entanglement in fishing gear. While entanglements were more common during the period 2016-2020 (n=30), less incidents resulted in documented mortality (36.7%) than did ship strikes (91.7%; 11/12) (Hayes et al. 2023). In the instances where mortality from entanglement does not initially occur, such events probably weaken the entangled individuals making them more susceptible to other direct causes of mortality (Kenney and Kraus 1993). Entanglement-related stress may also decrease reproductive success or reduce the life span of an individual and may adversely affect the growth of the population. Fishing gear commonly implicated in right whale entanglements are gillnets, lobster pots, seine nets and fish weirs (NMFS 1991). Based on scarification, Moore et al. (2021) found that between 1980-2017, 86.1% individual whales identified had evidence of entanglement, some multiple times, suggesting that whales were able to shed gear over time in a number of cases.

The relatively low incidence of photographically identified whales showing scars/wounds attributed to ship propellers when compared to the high rate of such wounds on stranded carcasses indicates that a high proportion of ship/whale interactions are fatal to the whale (Kraus 1990). Ship speed has been argued as an important factor regarding the frequency of ship strike occurrence in large whale species including the right whale (Laist et al. 2001).

Other potential challenges include habitat degradation, noise, contaminants and climate and ecosystem change (NMFS 2005). A continued impact to the coastal habitat of the right whale in the North Atlantic is the undersea exploration and extraction of mineral deposits, as well as

dredging of major shipping channels. Offshore wind turbines could also be a threat as they influence primary production and copepod distribution, as well as increase noise (Hayes et al. 2023). Right whales also frequent coastal waters where dredging and its associated disposal operations occur on a regular basis, such as along the southeastern U.S. It is unknown to what extent mineral extraction and dredging activities may impact right whales.

CONSERVATION ACCOMPLISHMENTS

SCDNR and South Atlantic Fishery Management Council (SAFMC) personnel serve as members of the Atlantic Large Whale Take Reduction Team (ALWTRT). National Oceanic and Atmospheric Administration (NOAA) Fisheries established the ALWTRT, comprised of stakeholder groups, to determine ways to reduce serious injury and mortality of northern right, fin and humpback stocks that interact with Category I or II fisheries. Category I Fisheries are those that have a serious injury/mortality rate of 50 percent or more of a marine mammal stock's PBR. Category II Fisheries are those that are expected to have a serious injury/mortality rate of more than 1 percent but less than 50 percent of a marine mammal stock's PBR. The final plan was implemented in 1999; however, despite the measures put forth in the plan, annual mortalities and serious injury are still exceeding PBR for right whales (0.7 whales). Consequently, the ALWTRT is currently working with NOAA Fisheries to amend the Atlantic Large Whale Take Reduction Plan in order to meet the goals of the MMPA which mandate reducing incidental mortality or serious injury to below each stock's PBR level within six months of the plan's implementation. The long-term goal is to reduce serious injuries and mortality to an insignificant level approaching a Zero Mortality Rate Goal (ZMRG) in order that they can reach or maintain their optimum sustainable population size. To date, despite efforts of the plan to reduce large whale entanglements and other activities to reduce ship strikes, annual mortalities attributed to fishery interactions and ship strikes are still exceeding PBR for right whales (PBR = 0.7 whales, from 2016 – 2020 the minimum rate of annual human-caused mortality and serious injury averaged 8.1 per year). SCDNR personnel will continue to serve on the ALWTRT in order to help develop and implement programs and activities designed to reduce North Atlantic right whale non-natural mortalities to insignificant levels approaching the ZMRG, which is 0.07 right whales.

South Carolina also has representatives on the Southeastern Right Whale Recovery Plan Implementation Team (SEIT). Since its inception in August 1993, the SEIT has met regularly and has been active in a number of areas. Among other things, the SEIT has coordinated a number of efforts to educate mariners about the threat of ship strikes in right whale habitat. Particularly, the SEIT has been instrumental in developing a system of aircraft surveys and communication systems that alert mariners to the presence of right whales in the southeastern US on a real time basis. In addition, the team has addressed and/or provided recommendations to NOAA Fisheries regarding right whale research in the southeastern US, additional measures to reduce the possibility of ship strikes, development of safe operating procedures for large vessels transiting right whale habitat, minimum vessel approach distances, and restrictions on hazardous fishing gear in right whale calving areas (NMFS 2005).

SCDNR conducted a marine mammals stranding program from 1991 to 2005 to obtain data on marine mammals that strand along the South Carolina coast. NOAA National Ocean Service in

Charleston managed the stranding network from 2006-2007. Coastal Carolina University managed the volunteer SC marine mammal stranding network in collaboration with NOAA National Ocean Service in Charleston, SC from 2008-2018. The non-profit Lowcountry Marine Mammal Network has managed stranding response since 2018. SCDNR continues to provide logistical support to the stranding program.

CONSERVATION RECOMMENDATIONS

- Analyze available data and collect additional whale sighting data to assess expanding or modifying the critical habitat boundaries.
- Assess the utility and feasibility of voluntary and mandatory ship routing measures and vessel speed restrictions in right whale habitat.
- Develop and implement programs and regulations to incorporate gear modifications and fishing practices that reduce entanglements of right whales in South Carolina waters.
- Conduct studies of gear modifications that result in reduced right whale entanglements.
- Assess right whale population size, survival rate, and trends on a regular basis. Determine right whale foraging ecology.
- Continue and expand annual winter surveys for right whales off the southeastern US coast.
- Compile or collect relevant physical, chemical, biological, oceanographic, fishery, and other data to characterize features of important right whale habitats and potential sources of anthropogenic destruction and degradation of critical right whale habitats.
- Use acoustic detection technology to monitor right whale occurrence and distribution.
- Continue to maintain a database of right whale sightings and photo-identifications.
- Conduct studies to determine the direct and indirect effects of coastal development, mineral extraction, and dredging activities on the distribution, behavior, and productivity of right whales.
- Continue and improve seasonal aircraft surveillance of right whale habitats and other elements of the “Sighting Advisory System.”
- Continue and improve the mandatory ship reporting system for right-whale sightings.
- Continue and improve the stranding network for right whales.
- Continue and expand efforts to educate mariners and the shipping industry, and fishermen and the fishing industry, about right whale vulnerability to ship strikes and fishing gear entanglements.
- Provide right whale sighting locations to mariners through broadcasts and other appropriate media.
- Encourage reports of right whale entanglements to the disentanglement network.

MEASURES OF SUCCESS

SCDNR personnel will continue to serve on the ALWTRT and the SEIT in order to help develop and implement programs and activities designed to reduce North Atlantic right whale non-natural mortalities to insignificant levels approaching the ZMRG.

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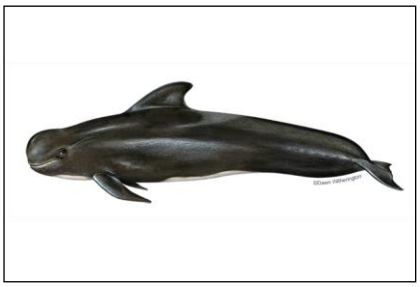
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Short-finned Pilot Whale

Globicephala macrorhynchus



Contributor (2024): Wayne McFee (NOAA)

DESCRIPTION

Taxonomy and Basic Description

The short-finned pilot whale was first described by Gray in 1846. It is one of two species in the *Globicephala* genus, the other being *G. melas* (long-finned pilot whale). Both are in the family Delphinidae.

At sea, these two species are virtually indistinguishable and overlap geographically along the continental shelf break from Delaware and southern Georges Bank (Rone and Pace 2012), with most sightings of short-finned pilot whales occurring south of Cape Hatteras, NC through the greater Caribbean and into the northern Gulf of Mexico (Maze-Foley and Mullin 2006). Both species are black dorsally with a bulbous head and broad falcate dorsal fin. As the name suggest, short-finned pilot whales have shorter fins that measure about 1/6th of the body length, than long-finned pilot whales, and short-finned pilot whales have fewer teeth (7-9 in reach row) and a shorter and broader rostrum (Olson 2008).

Short-finned pilot whales can attain lengths up to 7.2 m (24 ft.) and weigh upwards of 4,000 kg (8,800 lbs.) (Wursig et al. 2017). Newborns are between 1.4 m to 1.9 m (4’7”ft to 6’3”ft) in length weighing 60 kg (130 lb). Females mature at 7-12 years of age and produce a calf every five to eight years. They can live between 40-60 years.

Short-finned pilot whales are highly social living in large groups of 10-30 animals though sightings and mass strandings of groups of several hundred have been noted. They are deep divers and feed primarily on squid, but will also feed on fish species and octopus (Mintzer at al. 2008).

Status

The status for short-finned pilot whales is neither listed as threatened or endangered under the Endangered Species Act and is not a Strategic Stock under the MMPA (Hayes et al. 2022). Potential Biological Removal (PBR) is 236 animals.

POPULATION SIZE AND DISTRIBUTION

The best population estimate of short-finned pilot whales in the western North Atlantic 28,924 (Hayes et al. 2022). Short-finned pilot whales appear to occur worldwide in tropical and temperate latitudes. They tend to occur over the continental shelf break primarily south of Cape Hatteras, NC through the greater Caribbean and into the norther Gulf of Mexico.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Based on ship-board surveys and genetic analysis through biopsy sampling short-finned pilot whales live in deep water on the continental shelf break and deeper offshore waters of the Gulf Stream east of Cape Hatteras, feeding on cephalopods (squid) and, less frequently, crustaceans and fish (Thorne et al. 2017).

CHALLENGES

The greatest challenge to short-finned pilot whales appears to be fisheries interactions, in particular the pelagic longline fisheries. The estimated mean annual fishery-related mortality and serious injury between 2015-2019 due to the pelagic longline fishery was 136 animals (Hayes et al. 2022). Other threats include marine debris ingestion (plastics, bags, etc.), hook and line fisheries, contaminants (PCBs, DDT, DDE, toxic metals), and increased anthropogenic sound.

From 2013-2023 there have been 9 short-finned pilot whales stranded in South Carolina, five of which stranded alive during a mass stranding event in 2019.

CONSERVATION ACCOMPLISHMENTS

A Prescott Grant through the NMFS to Coastal Carolina University (2008-2020) and the Lowcountry Marine Mammal Network (2021-2024) has funded responses to marine mammal strandings, data collection, training of volunteers, and timely collection of tissues for research since 2008. These funds have allowed the recovery and collection of tissues by the National Ocean Services (NOS), Hollings Marine laboratory (HML) for research on short-finned pilot whales and the supply of tissues to the National Institute of Standards and Technology National Marine Mammal Tissue Bank (Charleston, SC).

CONSERVATION RECOMMENDATIONS

- Continue monitoring short-finned pilot whale strandings to:
    - develop predictive models of stranding rates, especially seasonally, to better prepare network volunteers for increased strandings of these species;
    - increase information on mortality rates and cause of mortalities to obtain a better understanding on the stressors these species face; and
    - develop a better understanding of the distribution of this species.
- Develop outreach material to educate the public about the harm plastics and other marine debris can cause to marine life.
- Engage SC pelagic longline fishers on the potential interaction with long-finned pilot whales
- Conduct collaborative research with partners to determine the cause(s) mortality in short-finned pilot whales. Basic life history parameters such as age analysis using teeth and reproductive status are also essential in determining longevity, population status, and fecundity.

MEASURES OF SUCCESS

As more data are accumulated and a better understanding of the status and life history of short-finned pilot whale species emerges, further management recommendations will be developed. Reduction of interactions with the pelagic longline fisheries and marine debris could have a substantial impact on the survival of this species.

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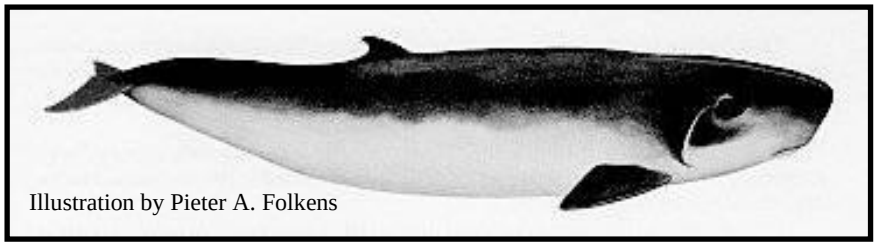
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Sperm Whales Guild

Dwarf sperm whale (*Kogia sima*)
Pygmy sperm whale (*Kogia breviceps*)


Illustration by Pieter A. Folkens

Contributor (2005): Wayne McFee (NOAA)
Reviewed and Edited (2012; 2024): Wayne McFee (NOAA)

DESCRIPTION

Taxonomy and Basic Description

The pygmy sperm whale was first described by de Blainville in 1838. The dwarf sperm whale was first described by Owen in 1866. Both were considered a single species until 1966. These are the only two species in the family Kogiidae. The species name for the dwarf sperm whale was changed in 1998 from '*simus'* to '*sima*.' Neither the pygmy nor dwarf sperm whale are kin to the true sperm whale (*Physeter macrocephalus*).

At sea, these two species are virtually indistinguishable. Both species are black dorsally with a white underside. They possess a shark-like head with a narrow under-slung lower jaw and a light colored "false gill" that runs between the eye and the flipper. Small flippers are positioned far forward on the body.

Pygmy sperm whales generally have between 12 and 16 (occasionally 10 to 11) pairs of needle-like teeth in the lower jaw. They can attain lengths up to 3.5 m (11.5 ft.) and weigh upwards of 410 kg (904 lbs.). A diagnostic character of this species is the low, falcate dorsal fin (less than 5% of the body length) positioned behind the midpoint on the back.

Dwarf sperm whales generally have 8 to 11 (rarely up to 13) pairs of teeth in the lower jaw and can have up to 3 pairs of teeth in the upper jaw. They can attain lengths up to 2.7 m (8.9 ft.) and weigh upwards of 210 kg (463 lbs.). A diagnostic character of this species is the high, dolphin-like dorsal fin (greater than 5% of the body length) positioned in the middle of the back. This species usually has a pair of short grooves on the throat.

Status

The status for both species is unknown; and neither is listed as threatened or endangered under the Endangered Species Act (Hayes et al. 2020). The western North Atlantic stock of *Kogia* sp. is not strategic under the MMPA. Potential Biological Removal (PBR) is 46 animals. An unusual mortality event (UME) of pygmy sperm whales in the southeastern United States was declared in 2003 by NMFS, prompting the need for more research on mortality of both species.

POPULATION SIZE AND DISTRIBUTION

Because both species are difficult to distinguish apart from ship board surveys, the population in the western North Atlantic of 7,750 is a combined estimate of both *Kogia* species (Hayes et al. 2020). Both species appear to occur worldwide in tropical and temperate latitudes. They tend to occur over the continental slope with the pygmy sperm whale possibly venturing over the limits of the continental shelf more often than the dwarf sperm whale. Stable isotope research suggests that the species may be separated by vertical niche partitioning, occurring in similar locations (Barros et al. 1998).

Because of their shy behavior and avoidance of research vessels at sea, population estimates in the Western North Atlantic Ocean are unreliable. Nearly all the information obtained on either of these species is from stranded animals.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Based largely on stomach content analyses from stranded specimens, pygmy and dwarf sperm whales live in deep water on the continental slope and occasionally the continental shelf, feeding on cephalopods (squid) and, less frequently, crustaceans and fish. The species of squid found in stomachs suggests that these animals require deep water up to 1,500 m (4,921 ft.). Benthic fish and crabs found in stomachs also suggest that these species forage on the ocean bottom (Reeves et al. 2002).

CHALLENGES

The greatest challenge to both species appears to be marine debris (plastics, bags, balloons). Numerous stranded specimens have been documented with plastic bags and other marine debris in the stomachs. The reasons for this remain speculative but could be the result of mistaking the debris for a potential food source. NMFS observer programs have not documented any mortality in fisheries operations except for one take in the pelagic longline fishery in 2000 (Waring et al. 2002; Hayes et al. 2020).

Cardiomyopathy (enlargement of the heart muscle) appears to be very common in pygmy sperm whales. The etiology of this disease to the heart is unknown, but is observed in nearly 50% of the stranded animals (Bossart et al. 2007). Research on this disease has occurred at a few institutions in the southeastern US (Bryan et al. 2012; Viricel and Rosel 2017). From 2013-2023 there have been 33 *K. breviceps*, 8 *K. sima*, and 3 *Kogia* spp. stranded in South Carolina.

CONSERVATION ACCOMPLISHMENTS

A Prescott Grant through the NMFS to Coastal Carolina University (2008-2020) and the Lowcountry Marine Mammal Network (2021-2024) has funded responses to marine mammal strandings, data collection, training of volunteers, and timely collection of tissues for research since 2008. These funds have allowed the recovery and collection of tissues by the National Ocean Services (NOS), Hollings Marine laboratory (HML) for research on pygmy and dwarf sperm whales.

CONSERVATION RECOMMENDATIONS

- Continue monitoring sperm whale strandings to:
  - develop predictive models of stranding rates, especially seasonally, to better prepare network volunteers for increased strandings of these species;
  - increase information on mortality rates and cause of mortalities to obtain a better understanding on the stressors these species face; and
  - develop a better understanding of the distribution of these species.
- Develop outreach material to educate the public about the harm plastics and other marine debris can cause to marine life.
- Conduct collaborative research with partners to determine the cause(s) of cardiomyopathy in sperm whales. Basic life history parameters such as age analysis using teeth and reproductive status are also essential in determining longevity, population status, and fecundity.

MEASURES OF SUCCESS

As more data are accumulated and a better understanding of the status and life history of the two sperm whale species emerges, further management recommendations will be developed. Reduction of marine debris could have a substantial impact on the survival of these species.

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Tamanend's bottlenose dolphin (coastal)

Tursiops erebennus

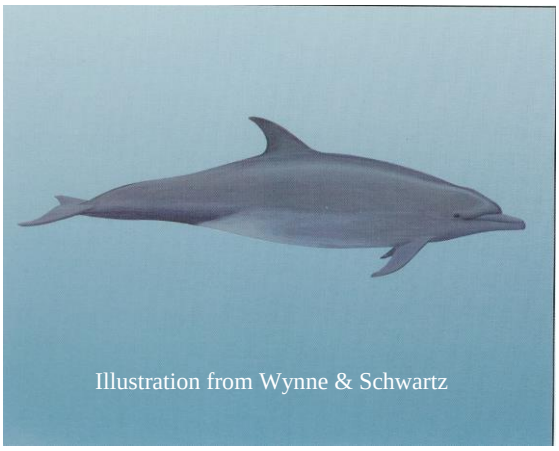


Illustration from Wynne & Schwartz

Contributors (2024): Wayne McFee (NOAA) and Todd Speakman (NMMF)

DESCRIPTION

Taxonomy and Basic Description

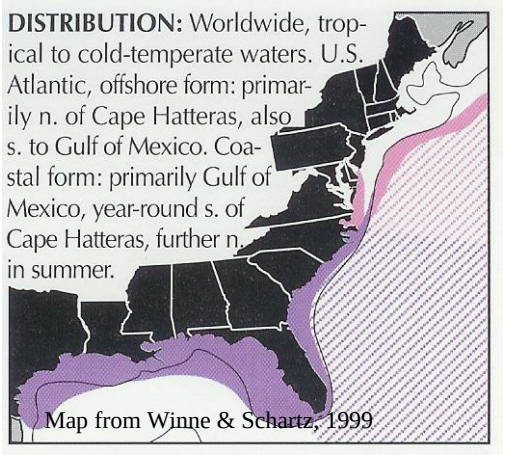
The bottlenose dolphin, *Tursiops truncatus*, was first described by Montagu in 1821. The body and head are robust with a short, thick, well-defined beak. Based on distribution, genetics, morphology, parasites and prey items, two distinct species are now recognized; the "coastal form" (*Tursiops erebennus*) is shorter and slimmer than the larger "offshore form", *Tursiops truncatus* (Costa et al. 2022). The flippers are pointed with deeply notched flukes. The teeth are small and conical and number between 40 to 52 in the upper jaw and 36 to 48 in the lower jaw. The dorsal fin, located mid-back, is tall and falcate with a broad base. Adult size varies considerably, ranging from 1.9 to 3.6 m (6 to 12 ft.) (Wynne & Schwartz 1999). The bottlenose dolphin has been reported to weigh up to 650 kg (1,432 lb) (Minasian et al. 1984).

Status

The bottlenose dolphin is not listed as threatened or endangered under the Endangered Species Act (ESA). In 1993, the National Oceanic and Atmospheric Administration (NOAA) Fisheries Service (National Marine Fisheries Service or NMFS), treating the coastal population as a single migratory stock, designated the stock as "strategic" under the Marine Mammal Protection Act (MMPA). The action was due to a massive die-off of coastal bottlenose dolphins between 1987 and 1988 (Waring et al. 2002). From 1995 through 2001, the NMFS recognized only a single migratory stock of coastal bottlenose dolphins in the western North Atlantic; therefore, the entire stock was listed as depleted. Current stock assessments have identified 5 coastal stocks of bottlenose dolphins based on genetic studies (Rosel et al. 2009), photo-id (Zolman 2002), strandings (McLellan et al. 2003), and satellite telemetry data (Southeast Fisheries Science Center, NMFS, unpublished data): the Northern Migratory and Southern Migratory stocks, South Carolina/Georgia Coastal stock, Northern Florida Coastal stock, and the Central Florida Coastal stock (Hayes et al. 2022). A second UME from 2013-15 occurred along the Atlantic coast from New York to Florida resulting in over 1,600 bottlenose dolphins stranded (Morris et al. 2015; Hayes et al. 2022). Further, there are at least 10 recognized Estuarine Stocks on the east coast of the US: a Northern NC Estuarine System stock, a Southern NC Estuarine System stock, a Northern South Carolina Estuarine System stock, a Charleston Estuarine System stock, a Northern Georgia/Southern SC Estuarine System stock, a Central Georgia Estuarine System stock, a Southern Georgia Estuarine System stock, a Jacksonville Estuarine System stock, an Indian River Lagoon Estuarine System stock, and a Biscayne Bay Estuarine System stock (Hayes et al. 2022). Because one or more of the stocks may be depleted, all stocks retain the depleted designation.

The western North Atlantic offshore bottlenose dolphin (offshore ecotype; *T. truncatus*) is also not listed as threatened or endangered under the ESA. Potential Biological Removal level or PBR is an estimate of the maximum number of animals, not including natural mortalities, which may be removed from a marine mammal stock while allowing that stock to reach or maintain its Optimum Sustainable Population (OSP). PBR's are established under the MMPA. The average annual fishery-related mortality and serious injury for western North Atlantic offshore bottlenose dolphin from 1996 to 2000 is unknown and the PBR is 519 animals; therefore, the status of this stock is unknown (Hayes et al. 2022).

POPULATION SIZE AND DISTRIBUTION



Two bottlenose dolphin ecotypes inhabit waters in the western North Atlantic Ocean: a shallow water or nearshore/coastal ecotype and a deep water or offshore ecotype (Curry and Smith 1997).

The coastal ecotype is continuously distributed along the Atlantic coast south of Long Island, around peninsula Florida, and along the Gulf of Mexico coast. However, based on genetic studies, Curry (1997) concluded that the nearshore animals in the northern Gulf of Mexico and the western North Atlantic are separate stocks. Within the western North Atlantic, the stock structure of coastal bottlenose dolphins is complex. Efforts to distinguish stocks are complicated by the fact that animals from different stocks cannot be separated on the basis of appearance and by the fact that different stocks sometimes have geographic ranges that overlap temporally and spatially (MMC 2004). Preliminary results from studies involving genetics, photo-identification, telemetry and stable isotopes suggest the existence of at least 5 coastal ecotype stocks in the western North Atlantic and ten estuarine ecotype stocks (Harris et al. 2022). Estimates of abundance for each stock of western North Atlantic coastal bottlenose dolphins are as follows: Northern migratory (6,639); Southern Migratory (3,751); SC/GA (6,027); Northern Florida (877); and Central Florida (1,218). Estimates of abundance for the Estuarine stocks are: Northern NC Estuarine System stock (823); Southern NC Estuarine System stock (unknown); Northern SC Estuarine System stock (453), Indian River Lagoon (1,032). Estimates are unknown (because estimates are greater than 8 years old) for the Charleston, Northern GA/Southern SC, Central Georgia, Southern Georgia, Jacksonville, and Biscayne Bay Estuarine System Stocks.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Bottlenose dolphins are both a coastal and an oceanic species, with the coastal ecotype preferring waters of less than 30 m (98 ft.) in depth. The habitats they occupy are diverse, ranging from rocky reefs to calm lagoons and open waters. The coastal ecotype is adapted for warm shallow waters. Its smaller body and larger flippers suggest increased maneuverability and heat dissipation. These dolphins occur along the outer coastline and in bays, sounds, inlets, estuaries and other inland waters (Hersh and Duffield 1990).

CHALLENGES

A variety of factors, both natural and human-related, can affect bottlenose dolphins. Natural factors include predation by large sharks, disease, parasites, exposure to naturally occurring biotoxins, changes in prey availability, and reduction or loss of habitat due to environmental variation. Human-related causes of mortality and injury to this species include loss of habitat due to coastal development, exposure to pollutants, vessel strikes, entanglement in debris, as well as noise and pollution related to oil and gas development. Bottlenose dolphins have also increasingly become the target of dolphin watching and wild dolphin interaction programs. There is growing concern that these activities may result in altered behavioral patterns, especially where people enter the water with dolphins and where they are fed. In the latter case, behavioral patterns are altered significantly and increased aggression may occur (Bryant 1994).

In addition, recreational and commercial fisheries directly and indirectly affect bottlenose dolphins. Coastal bottlenose dolphins are taken as bycatch in various kinds of fishing gear including gillnets, seines, longlines, shrimp trawls and crab pots (Waring et al. 2002). In South Carolina, the commercial Atlantic blue crab fishery is the most common cause of fishery-related mortality of *T. erebennus* (Krzewinski et al. 2024). Bycatch of offshore bottlenose dolphins has been observed in the pelagic drift gillnet, pelagic pair trawl, New England multispecies sink gillnet, North Atlantic bottom trawl, mid-Atlantic coastal gillnet and pelagic longline fisheries. The pelagic drift gillnets and pelagic pair trawl fisheries no longer exist. Mortalities of bottlenose dolphins due to ingestion of hooks and/or line have also been documented (Gorzelany 1998; Well et al. 1998). The gear most likely had been discarded or was consumed by the dolphin by eating a fish that had been hooked then broke away with the gear. Estimates of fishery-attributed interactions suggest that mortality exceeds the PBR of several coastal stocks considered depleted by the 1987-1988 and 2013-15 die-offs and, thus, may be impeding their recovery.

CONSERVATION ACCOMPLISHMENTS

SCDNR and South Atlantic Fishery Management Council (SAFMC) personnel serve as members of the Bottlenose Dolphin Take Reduction Team (BDTRT), which was convened in 2001. The BDTRT works with NOAA Fisheries to develop the Bottlenose Dolphin Take Reduction Plan (BDTRP) for coastal stocks. The short-term goal of the plan is to reduce, within 6 months of its implementation, the incidental mortality or serious injury of western North Atlantic coastal bottlenose dolphins incidentally taken in commercial fishing operations to levels less than the potential biological removal (PBR) level. The long-term goal of the take reduction plan is to reduce, within five years of plan implementation, incidental mortality and serious injury of coastal bottlenose dolphins incidentally taken in the course of commercial fishing operations to insignificant levels approaching a zero mortality rate goal (ZMRG). The BDTRT has developed a number of recommendations to achieve these goals and to be incorporated into the BDTRP. The BDTRP was amended in December of 2008 (73 FR 77531) with an effective date of January 20, 2009.

The BDTRT has made a number of recommendations to be incorporated into the BDTRP for coastal stocks including regulatory suggestions, based on management units, which apply to specific fisheries. Generally, these recommendations seek to reduce soak times, the amount of

fishing gear in the water at any given time, or to modify practices in order to limit interactions with and the take of bottlenose dolphins. The BDTRT also adopted non-regulatory recommendations for all management units including education and outreach, as well as improved research, monitoring, collection of strandings data, and observer coverage. The finalized specific recommendations were published on April 26, 2006 (FR 50CFR Parts 223 and 229) and SCDNR will continue to explore avenues to implement these recommendations, working together with members of the BDTRT as funding opportunities become available.

SCDNR conducted a marine mammal stranding program from 1991 to 2005 in order to obtain data on marine mammals that strand along the South Carolina coast. Data from the program are used to further our knowledge regarding these animals and the extent to which anthropogenic factors are responsible for or contribute to their stranding. From 2006-2008, the NOAA National Centers for Coastal Ocean Science in Charleston, SC assumed responsibility of the network, Coastal Carolina University administered the program from 2009-2021, and the Lowcountry Marine Mammal Network has assumed responsibility of the Network since 2021, having received grant awards from the Prescott Grant.

CONSERVATION RECOMMENDATIONS

- Improve understanding of stock structure and population trends in order to assess the greatest threats to bottlenose dolphins.
- Determine the significance of periodic die-offs, especially to relatively small, isolated populations of bottlenose dolphins.
- Assess the impact of contaminants on marine mammals, particularly the repercussions of high contaminant loads in individual bottlenose dolphins as well as their offspring.
- Measure the effects of interactions between humans and dolphins in the wild, including behavioral disruption, habituation, injury and death.
- Mitigate threats to bottlenose dolphins posed by entanglement in fishing gear through support of methods proposed by the BDTRT.
- Continue to explore avenues to partner in implementation of recommendations to be published by the BDTRT.

MEASURES OF SUCCESS

A take reduction plan has been developed for coastal bottlenose dolphins to reduce the incidental take of animals in commercial fishing operations to below the Potential Biological Removal (PBR) level. SCDNR personnel will continue to serve on the BDTRT in order to help develop and implement programs and activities designed to reduce bottlenose dolphin non-natural mortalities to insignificant levels approaching a zero mortality and serious injury rate (the Zero Mortality Rate Goal or ZMRG).

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American Mink

Mustela vison


Photo by Phillip Jones, SCDNR

Contributors (2005): Jay Butfiloski and Buddy Baker [SCDNR]
Reviewed and Edited (2013): Jay Butfiloski (SCDNR)

DESCRIPTION

Taxonomy and basic description

The American mink, *Mustela vison* was first described by Schreber in 1777. Mink are classified in the order Carnivora, family Mustelidae, and further categorized into the subfamily Mustelinae.

The mink is characteristic of other members of the weasel family with its short legs and long cylindrical body. Body mass ranges from 0.55 - 1.25 kg (1.2 - 2.75 lbs.) with an overall length of 470 - 700 mm (18.5 - 27.5 in.). Males are approximately 10% larger than females. Pelage is typically dark brown with white markings on the throat, chest, and belly. The tip of the tail is markedly darker than the rest of the body (Jackson 1961).

Mink have two anal glands that produce a strong odor. When stressed, mink can release secretions from these glands, potentially as a defense mechanism (Brinck et al. 1978). Feces are usually deposited in prominent places as territorial markers.

Mink are polygamous, and thus courtship and mating in mink can often be aggressive. Mating usually occurs from January through March, and because of delayed implantation, the gestation period ranges from 40 - 75 days. Birth of the young occurs 30 days after implantation. Young are typically born from April to June. Weaning occurs at 8 - 9 weeks, though the young may remain with the female as a family group until fall.

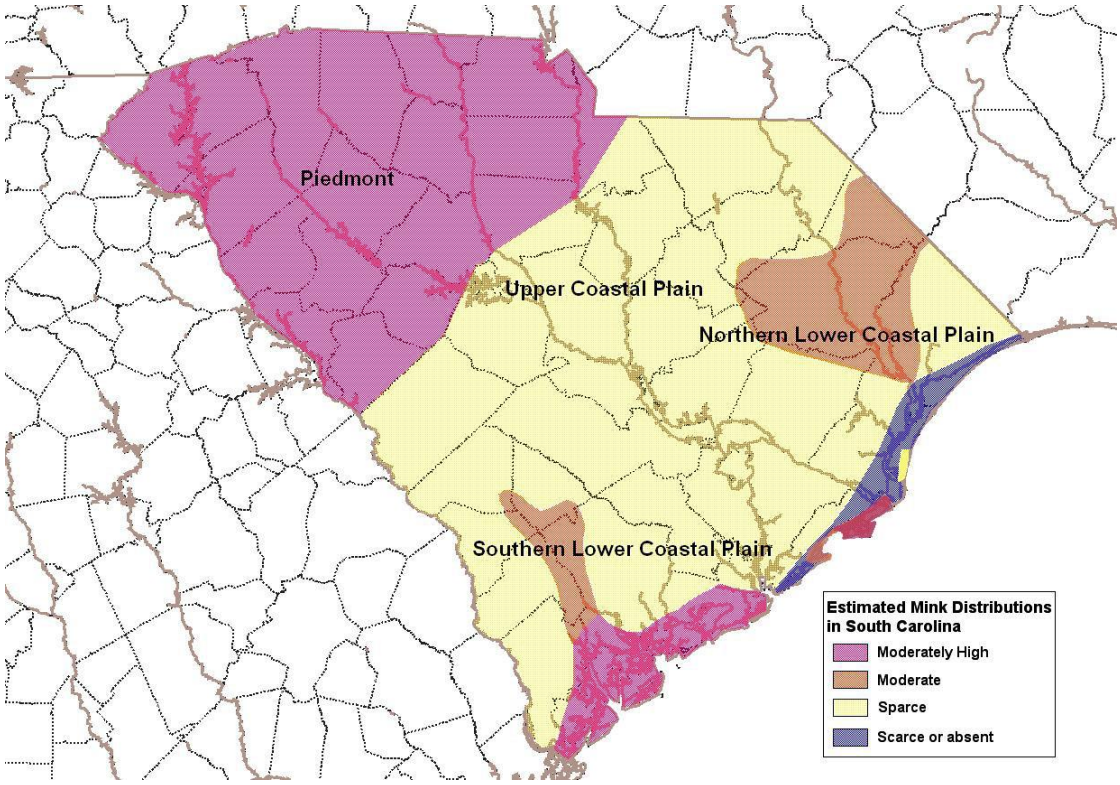
Status

In South Carolina, the rank for American mink is S3, and the population is considered to be in decline statewide. The global status is listed as secure (G5) (NatureServe 2025).

POPULATION SIZE AND DISTRIBUTION

The mink's range extends throughout Canada and much of the United States except the southwest and a great deal of the northwest. Historically, mink occurred throughout South Carolina. Mink occur in varying densities; the Piedmont region and southern coastal marsh areas have had relatively abundant populations while much of the Upper and Lower Coastal Plain regions have sparse densities, with moderately higher concentrations in the Lynches/Pee Dee and Salkahatchie/Combahee River corridors. Mink are scarce or absent in the northern coastal marshes. Survey data, however,

indicates mink are essentially absent in the northern coastal marshes where population restoration by SCDNR has not taken place, and possibly declining throughout the remainder of the State (Baker 1999). Annual commercial fur harvest data indicated a 38-year average harvest of 86 animals per year by commercial trappers and hunters. However, this average does not adequately reveal the decline in harvest data. From the 1974 - 75 season to 1988 - 89, the average mink harvest was 197. Since the 1989 - 1990 fur harvest season, the average take was only 14 mink (SCDNR 2004 unpublished data).



Map by Jay Butfiloski, SCDNR; modified from Baker 1999.

A considerable amount of anecdotal information has been received from older trappers have reported declining mink numbers. Numerous experienced mink trappers have noted that the species is rare or absent from areas of former abundance, although the habitat is seemingly intact. One trapper from Lancaster County reported that he had not caught a mink in over 20 years from a trap line that once produced as many as 30 mink per year. Furbearer biologists from the Georgia Department of Natural Resources and the North Carolina Wildlife Resources Commission reported similar comments from trappers about declines in mink numbers in their states (Greg Waters, GADNR; Perry Sumner, NCWRC, pers. comm.).

In a mail survey of South Carolina sportsmen who caught mink during the 1987 - 88 trapping season, over 40% of the respondents perceived the mink population to be declining (SC Wildlife and Marine Resources Department, unpublished data).

HABITAT / NATURAL COMMUNITY REQUIREMENTS

Mink are typically associated with habitats that have some type of water component. These areas include swamps, rivers, streams, ponds, and saltwater marshes. Mink typically live in dens located in rock piles, under tree roots, bridge crossings, and stream bank holes. Mink in saltwater marsh habitat may rarely utilize dens because of tidal fluctuations. Instead, young are often birthed on tide rack rafts.

Mink are carnivorous and their diet often reflects prey availability, opportunity, and location. Statewide, fish may make up 40% of the mink's diet. However, mink will also consume small rodents, rabbits, muskrats, squirrels, crabs, crayfish, insects, snails, frogs, snakes, and waterfowl (Baker 1999).

CHALLENGES

A. Habitat Degradation

Because of the lack of historic data on habitat conditions in South Carolina, it is difficult to evaluate quantitatively how mink habitat has changed over time. While the integrity of some streams has clearly been altered, others appear reasonably pristine. There has been no attempt thus far to correlate mink densities with habitat alteration. Future studies should compare mink densities with existing habitat suitability index models.

While habitat alterations may be a contributing factor in South Carolina mink population declines, it is doubtful that habitat conditions alone are responsible. Elsewhere throughout the mink's range, the species is reported to be adaptable in its use of habitats, tolerating both human activity and habitat changes (Allen 1984). Additionally, some of the areas in South Carolina where mink have declined are in stream drainages, which appear to be intact.

B. Environmental Contaminants

Environmental pollution has long been recognized as a biological hazard to wildlife and to man. Industrial pollutants, pesticides, and heavy metals are known to exhibit biomagnification as they pass up the food chain. The mink occupies a niche at or near the top of the food chain and would therefore be especially vulnerable to these environmental contaminants. Mink population declines in other regions of North America, most notably in the Great Lakes Region, have been associated with environmental contaminants. Numerous studies have demonstrated the mink's high level of sensitivity to pollutants, particularly organic mercury compounds (Aulerich et al. 1974; Woberser et al. 1976) and polychlorinated biphenyl (PCBs) (Platonow and Karastad 1973; O'Shea et al. 1981).

In 1987 the Furbearer Project initiated studies to evaluate contaminant levels in trapper - harvested mink carcasses from South Carolina (Carmichael and Baker 1989). The University of Georgia Riverbend Research Center performed chemical analyses under

contract. Mink samples were screened for a total of 21 chlorinated hydrocarbon pesticides plus PCBs. Tests for 10 heavy metals were also conducted.

Residues of DDE, PCBs and mercury were detected in mink tissue samples from South Carolina. Residue levels were generally lower than those reported for other wild mustelid populations and did not approach levels published for mink that suffered mortality in laboratory studies. However, the effect of low levels of these contaminants on reproduction and survivability in wild mink is still questionable. Ringer (1981) stated that reproduction in mink would normally not be impaired by chlorinated hydrocarbon pesticides such as DDT at levels typically encountered in the environment. However, small doses of PCBs and mercury, singly or in combination, are of concern. Fish in most rivers and lakes throughout the country are now contaminated with PCBs (Jacknow et al. 1986), and dietary levels as low as 0.64 ppm have been shown to seriously impair reproduction (Platonow and Karstad 1973). In our studies, 43% of the mink sampled had detectible residues of PCBs with a mean level of 0.56 ppm. Likewise, mercury is widespread in the environment due to man's activities as well as natural processes, and 1 ppm mercury in the mink diet for as little as 2 months is known to be lethal (Kirk 1971). Smaller doses would likely have sublethal effects on reproduction and behavior.

Health advisories posted by the South Carolina Department of Health and Environmental Control in January of 1995 indicated that mercury contamination of fish in 18 rivers and 9 lakes in South Carolina were high enough to prompt warnings about human consumption of fish. The advisory covered all of the stream drainages of the Coastal Plain and reported mercury levels in many drainages which are above the levels known to be lethal to mink. Mercury levels for some fish species in the Black River and Pee Dee River were nearly 3 times higher than known lethal dietary levels for mink.

While the mean levels of mercury detected in mink from the Piedmont Ecoregion of South Carolina (0.53 ppm) were below levels expected to cause direct mortality, a small sample of Coastal Plain mink (n = 3) exhibited levels considered to be greater than normal background levels (mean = 6.01 ppm).

The current Environmental Protection Agency (EPA) limit for fish deemed safe to consume by humans is 2 ppm for PCBs and 1 ppm for mercury. Wild mink eating fish containing PCBs or mercury at these levels, or even less, are at risk. The situation becomes very complex when synergistic or combined effects of environmental contaminants are considered. Lab studies with mink have shown reduced survival in kits born to mink that received both PCBs and mercury simultaneously (Wren et al. 1987). Over 40% of mink sampled in South Carolina contained residues of both PCBs and mercury. If other conditions such as food shortages, extreme climatic conditions such as cold weather or drought, or parasite burdens are added, tolerance levels for these contaminants may be very low for a species like the mink (Wren et al. 1986; Wren et al. 1987).

In 1990 the Furbearer Project continued its investigations into the impact of environmental toxicants on mink by expanding the sample in the Coastal Plain (Osowski et al. 1995). This study was expanded further to include samples from Georgia and North

Carolina because of similar concerns of mink population declines by the wildlife agencies in those states. The Clemson University Institute of Wildlife and Environmental Toxicology conducted chemical analyses for the tri-state study.

Of the organochlorine pesticides tested, only dieldrin was detected at significantly higher levels in South Carolina's Coastal Plain than in the Piedmont. Liver PCB concentrations were also found to be significantly higher than the Piedmont reference group, and many samples were higher than those known to cause mink reproductive dysfunctions.

This study also revealed mercury concentrations from mink kidney tissue to be elevated in the Georgia, North Carolina, and South Carolina Coastal Plain compared to the Piedmont reference. The concentrations detected were high enough, according to Wren et al. (1986), to cause sub-lethal effects on most physiological functions, including reproduction, growth, and behavior. Of the 3 states, South Carolina had the highest mean level of detectable mercury (3.51 ppm).

CONSERVATION ACCOMPLISHMENTS

The Furbearer Project spent a number of years determining the status of mink populations in South Carolina and the causes of their decline. Our research revealed that one of the areas where mink populations had been lost entirely was the tidal marshes from Charleston Harbor north to the SC/NC line. Beginning in 1999, the Furbearer project initiated restoration efforts with South Carolina's coastal mink population. Fortunately, mink remain abundant in the marshes along our state's southern coast. The marshes in the North Edisto River, the ACE Basin, and in the vicinity of Hilton Head Island have served as mink population sources for our capture efforts. Our first restoration effort in the Cape Romain NWR in 1999 and 2000 was hugely successful, thanks in part to the hard work of then Clemson graduate student Jason Peeples and to Dr. Tim Fendley of Clemson University. Based upon the success of our first effort, we moved up the coast with our mink restoration project.

2002 Restoration

In 2002, our goal was to complete a stocking of mink at North Inlet in Georgetown County. Thanks to many of our cooperators, our trapping efficiency was so good in 2002 that we were able to complete stocking efforts in North Inlet and move on to our next target area which was Murrells Inlet. All totaled, we stocked 17 adults and 35 kits in North Inlet and 25 adults in Murrells Inlet.

Population Indexing

In 2002 we were also able to test a new mink indexing technique for measuring marsh mink populations. The work was conducted by Lisa Vandiver who was working with us on a work study contract with the College of Charleston. The Kiawah Island Natural Habitat Conservancy provided funding for the studies. We are very grateful to Barbara Winslow of Kiawah Island for getting the project off of the ground and for her willingness to get her hands dirty with marsh mud throughout the project. Lisa's research focused on the testing of a floating track board design. Overall visitation rates by mink

were 42%, revealing this technique to have great value as a population monitoring device. Our current technique of monitoring marsh mink involves spotlight flood tide surveys. The shortcoming of the flood tide surveys is that we are limited to employing this technique to several days per season. Additionally, these are the same days (during flood tides) that we need to be trapping mink. The track board technique could allow us greater latitude in population monitoring. No flood tide surveys are currently being done.

Population Health Check
We were fortunate to have the cooperation of the Southeastern Cooperative Wildlife Disease Study in performing a population health check on mink from the ACE Basin. A final report is forthcoming, but preliminary reports reveal some surprising virus antibodies.

Toxicology
Because earlier research suggested that the decline in mink populations from South Carolina's northern coastal region was related to environmental contaminants, we wanted to determine if similar problems exist in mink populations of the southern coastal areas. SCDNR partnered with the Clemson University Department of Environmental Toxicology to answer this question. While this research did reveal concentrations of mercury, organochlorine pesticides, PCBs, dioxins, and furans in tissues of mink at levels that may have some adverse effect on individual animals, the overall levels were not considered to be high enough to have adverse effects on the mink population.

Age Structure
Age structure work on ACE Basin mink suggests good survival rates and good recruitment rates within this population.

Food Habits
The Furbearer Project was able to enlist the assistance of Marine Division scientist David Knott to conduct food habits studies of mink in the ACE Basin. We utilized David's expertise to identify marine organisms in mink scats and stomach contents collected throughout other studies. This data allows us to evaluate prey abundance in prospective restoration sites to test for environmental contaminant uptake in prey without sacrificing mink. It also allows us to better explain mink population fluctuations, which may be tied to changes in food availability. Results of the studies revealed that mink are very opportunistic. Some general observations of the common food items in their diet include; small fish, blue crabs, fiddler crabs, insects, mud minnows, marsh hens, and marsh rice rats.

2002 Restoration Evaluation
During the May flood tides in 2003, we conducted follow-up surveys in North Inlet and in Murrells Inlet to evaluate the success of the 2002 stockings. Our observations in North Inlet were very encouraging. In the course of a 2-hour flood tide we counted 5 adult mink. Three of these were females with young. For mink to survive the stress of relocation and still be fit enough to reproduce the first year indicates good environmental conditions. Results from the Murrells Inlet surveys were disappointing. We conducted 2

evening surveys without spotting any mink. Conditions were less than ideal, as the survey crew made it into the marsh late on the first night and it rained on the second night. While we failed to document survival of the released mink, two incomplete surveys are not sufficient to demonstrate absence of mink. A mink sighting report from staff from Huntington Beach State Park in the Summer of 2004 does give some encouragement that the released mink may still be present in the area.

2003 Restoration
Pre-release surveys in the vicinity of Dewees and Capers Islands support our belief that mink are absent in that area. This area of marsh was enrolled as our next restoration site. Assisting us with the logistics of that release were Arla Jessen, Environmental Education Coordinator at Dewees Island, and SCDNR Law Enforcement officers from District 9.

2004 Restoration
A total of 12 mink (females with young) were released into the marshes of Dewees Island during the June flood tides. One of the adult females was predated by a marsh hawk which was witnessed by staff. The remaining young were taken to a rehabilitator, and one survived and was released later that year. We also plan to supplement the number of released animals in the future at Murrells Inlet unless surveys indicate that it is not warranted.

2008 - 2009 Survey Work
Clemson Graduate Student Michael Waller worked to implement track board surveys in an effort to reduce survey manpower. However, many of the same issues that plagued track board work previously—such as tidal fluctuations and other environmental factors—again hampered track board implementation. Thus, emphasis was placed on perfecting spotlight survey work in an effort to evaluate which environmental factors were most significant in surveying mink. Waller's work determined that tide heights 6.05' above Mean Lower Low Water (MLLW) level as measured at the Charleston station and adjusted for local areas was the best predictor for when to use spotlight surveys (Waller 2010).

2010-2011 Mink Impacts and Ecology Study
As the reintroduced mink into Cape Romain National Wildlife Refuge (CRNWR) began to thrive, concerns from staff at the refuge centered on the impacts mink may be having on nesting shorebirds. Clemson Graduate Student Caroline Gorga began looking at that potential impact (Gorga 2012). Refuge staff have implemented a mink removal program along Cape Island in conjunction with other predator removal prior to nesting seasons. Diet analysis from mink taken from the CRNWR in an effort to increase shorebird nesting success found that out of 45 mink stomachs collected, 7.4 % contained avian material of unknown species. A bioenergetics model developed from this estimated that an individual mink consumed 8.5 avian prey items per month based on the sampled diet. Unfortunately mink are being blamed for much of the lack of nesting success of several species of nesting shorebirds for which only anecdotal or isolated data exists. Previous studies in the area have shown that habitat loss from erosion and overwash from tides and boat wakes to be significant factors in loss of coastal nesting birds (Thibault 2008, Brooks 2011). Because the natural loss of habitat and overwash is not controllable,

predator control remains one of the management strategies of the refuge. In fact, the CRNWR Comprehensive Conservation Plan states one of the goals is to "remove mink from the refuge" (USFWS 2010).

CONSERVATION RECOMMENDATIONS

- The protection of river corridors, streams, and marsh habitat are necessary for reestablishment of mink populations. Any efforts to improve water quality attributes would benefit mink. Large-scale conservation easements and focus areas such as those in the ACE Basin area, as well as outright purchases of important riparian properties, should benefit mink populations. Such areas would need to be identified and prioritized.

- Continued monitoring through the use of flood tide surveys are needed to assess the success of reintroduction projects in the northern coastal marshes of South Carolina.

- Further research will be needed to fully support the contention that environmental contaminants are associated with the decline in mink populations in South Carolina. From the results of the studies conducted thus far, the list of suspected contaminants can be narrowed to mercury, PCBs, DDE, and dieldrin, with the greatest level of concern assigned to mercury.

- Assess the impacts of predation on nesting shorebirds. Find strategies to limit mink predation where necessary yet discourage prophylactic trapping and shooting of mink where it isn’t warranted.

- Surveys should be run in the northern coastal marshes to assess the ability of mink to persist in reintroduced areas.

MEASURES OF SUCCESS

A definitive determination of what has caused mink declines in the State would be considered a measure of success with the ultimate goal being to correct the problem(s) and bring mink levels back up to the 1970s or 1980s population count.

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Silver-haired Bat

Lasionycteris noctivagans

Contributors (2012): Mary Bunch (SCDNR), Susan Loeb (US Forest Service), Mary K. Clark (Private consultant), Austin Trousdale (Lander University), Travis Perry (Furman University), and Jeff Magniez (US Forest Service)
Revised and Updated (2025): Jennifer Kindel (SCDNR)

DESCRIPTION

Taxonomy and basic description

The silver-haired bat was described by Le Conte in 1831. It is monotypic. A medium sized insectivorous bat, the silver-haired bat weighs 8.1 - 11 g (0.28 - 0.38 oz.) as an adult and has a total length of 92 - 115 mm (3.62 - 4.53 in.). The forearm measures 42 - 44 mm (1.65 - 1.73 in.) and the foot measures 7 - 11 mm (0.27 - 0.43 in.). The fur is dark brown or black with distinct white or silver tips. Older bats have a less frosted appearance. The ears are rounded and the tragus is broad. Litter size is 1 - 2 young in a single birth per year, with 2 being typical.



Silver-haired bat

This bat is often grouped as a tree bat because roosting habitat includes tree features such as foliage, lightening scars and loose bark and they are frequently found roosting alone. Other times it is lumped with colonial cavity or crevice-roosting bat species because they have been found in small groups in tree features and man-made structures. The silver-haired bat is best described as a migratory, often solitary, crevice-roosting bat, with exceptions to each.

Status

In South Carolina the silver-haired bat is ranked as Vulnerable (S3). They are ranked Apparently Secure (S4) in North Carolina and Tennessee, and Secure (S5) in Georgia. Silver-haired bats are not ranked in Alabama and Florida (they are not typically found in Florida), and their designation in West Virginia is Imperiled (S2). The silver-haired bat has a global status of Vulnerable (G3).

POPULATION SIZE AND DISTRIBUTION

The distribution of the silver-haired bat is thought to be widespread in the United States. It is migratory, although in some regions, such as British Columbia, they can be found year-round. They migrate south in the fall, where they overwinter, and north in the spring

where they give birth and raise their young. The silver-haired bat is a long-distance migrant, traveling distances of more than 1600 km (994 mi.) between winter sites and summer sites. Evidence suggests that females of the species migrate farther than males. Summer records for silver-haired bats in South Carolina are lacking. Density estimates are likewise not available. When found in groups, the groups tend to be of a dozen individuals or less. However, they are often found as singles. Nothing is known about their social structure or why they sometimes form small colonies that tend to re-form when the group changes roosts. When small colonies switch summer (maternity) roosts, they do not all switch at the same time but do switch roosts the same night so as to remain together. Studies of relatedness of individuals in summer and winter colonies have not been done.

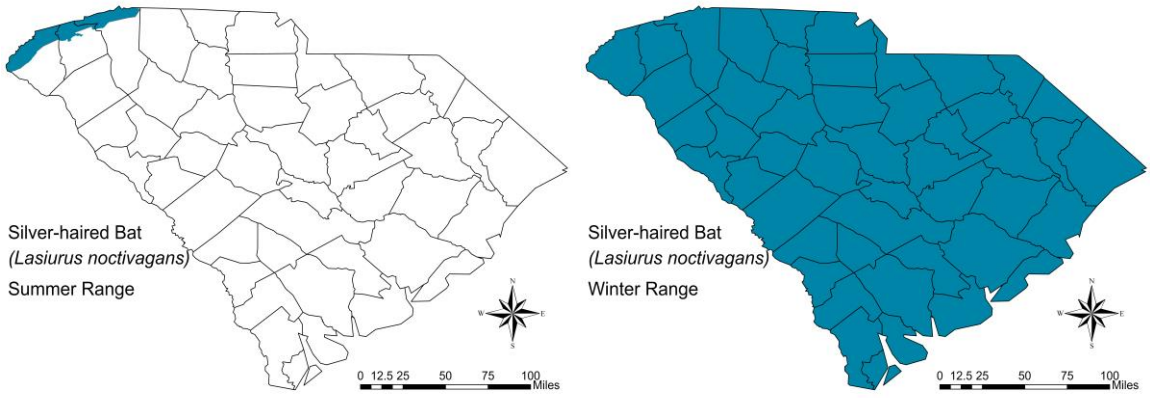


Figure 1: Summer and winter distribution of the silver-haired bat in South Carolina

The silver-haired bat is distributed statewide in South Carolina in the winter; they are not typically found outside of the Blue Ridge ecoregion in the summer. During a study from 1996-2001, silver-haired bats were not detected at the Savannah River Site in the Inner Coastal Plain of South Carolina during summer. Acoustic survey of sites along the shores of Keowee and Jocassee Lakes in 2012 did detect silver-haired bats in July. Significant silver-haired bat mortality has been documented at wind energy facilities in the eastern United States, particularly during fall migration.

Human deaths from rabies have been linked to tri-colored bat (*Perimyotis subflavus*) and silver-haired bat strains of the rabies virus at a greater rate than the bats' abundance would suggest. The silver-haired bat strain is more virulent than other bat strains, but it is not known if silver-haired bats succumb to rabies at a higher rate than other North American bats.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

In summer, silver-haired bats are often captured over or near water. Documented summer roosts include tree cavities, under loose bark, under tree foliage, and occasionally in buildings. They engage in frequent roost site switching when using trees. The average distance recorded for summer roost switching noted in British Columbia is 194 m (636 ft.).

Winter roosts include rock crevices, stacks of firewood, caves, tree crevices created by lightning strikes, under loose bark, buildings, bird nest boxes, and in tree cavities, including those created by woodpeckers. In Arkansas, winter roosts are frequently on canopy trees, most often shortleaf pines (under loose bark) and less frequently in cavities in white oak (*Quercus alba*), northern red oak (*Quercus rubra*) and black gum (*Nyssa sylvatica*). However, they are also found in rock crevices (reused over multiple years), and during colder weather, under a tree root or in a hole at the base of a tree. Winter roosts in Arkansas are most often on the south-facing aspect of terrain, and the average height in trees is slightly over 5 m (16.4 ft.). Spring migratory season roosts in Canada are typically 2.5-3 m (8.2-9.8 ft.) above ground in trees. The optimal temperature for hibernating silver-haired bats in Missouri is 5°C (41°F) and is consistent with that for red bats (*Lasiurus borealis*) in the same area.

The silver-haired bat may forage above a cluttered environment. They do not avoid gaps in canopy cover and seem to select larger woodland seasonal pools, in open canopy, over small pools, and in closed canopy. Most foraging is done in openings, but they have been documented using low (near 5 meters above ground) open areas below very high canopy trees with little vertical structure below the canopy. They often use pine or mixed pine-hardwood forests for foraging and roosting. Their flight speed has been described as slow, 4 - 8 m/sec (10.7 - 11.2 mph). Prey consists of Lepidopterans, Homopterans, Dipterans, Hymenopterans, Hemipterans, Coleopterans and Neuropterans. In the southeast some foraging activity of silver-haired bats has been noted in winter during warm spells.

Silver-haired bats may delay foraging periods, when big brown bats (*Eptesicus fuscus*) are abundant in the same area, and forage earlier when the big brown bat is not prevalent.

CHALLENGES

- Loss of roost habitat due to development and forestry practices (man-made alterations and anthropogenic changes).
- Loss of habitat and direct mortality from natural causes such as hurricanes.
- Collisions with wind turbines or injury from active turbines (currently not in SC).
- Collisions with towers.
- Possible vulnerability to heavy metal contamination because they often forage over water.
- It is not known if white-nose syndrome, a fungal disease of hibernating bats, will afflict silver-haired bats.

CONSERVATION ACCOMPLISHMENTS

None of the experts contacted in the mammal review process had knowledge of any funded projects dealing specifically with the silver-haired bat in South Carolina. These bats are detected sporadically but are poorly understood.

CONSERVATION RECOMMENDATIONS

Management

- In timber harvest projects, retain a snag density of >21 snags/hectare.
- Work with wind energy development companies to mitigate impacts of wind turbines (e.g. increasing the cut-in speed of turbines to reduce mortalities).
- Only flashing lights should be used on towers, rather than constant on lights; this is now regarded as acceptable by the FAA and can reduce bird and bat mortality.

Priority research and survey needs

- Research the migration routes, timing and patterns of the silver-haired bat.
- Determine where South Carolina's over-wintering population goes for the summer (perhaps by using stable isotopes from hair or nail samples).
- Study potential impacts from wind farms and develop strategies to reduce silver-bat mortality.
- Determine winter roost site and habitat requirements.
- Determine if silver-haired bats are threatened by pesticide and/or heavy metal contamination.
- Examine the impacts of winter burns during cold weather on silver-haired bats (particularly on south-facing burn units).

Monitoring

- Maintain capture and location information for silver-haired bats.
- Use vehicular acoustic surveys to monitor silver-haired bats occupancy rates on a seasonal and annual basis.

MEASURES OF SUCCESS

As research and management needs are identified, projects should be proposed and prioritized by those with the greatest conservation applicability. Surveys and density estimates in the southern region should provide some population estimations that will be used to more accurately rank the species and prioritize future management needs. It is important to determine important roost site locations to provide long-term habitat for the species. Currently, very little is known about silver-haired bats in South Carolina.

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Colonial Cavity Roosting Bats Guild

Big Brown Bat (*Eptesicus fuscus*)
Eastern Small-footed Myotis (*Myotis leibii*)
Gray Bat (*Myotis grisescens*)
Little Brown Bat (*Myotis lucifugus*)
Northern Long-eared Bat (*Myotis septentrionalis*)
Rafinesque's Big-eared Bat (*Corynorhinus rafinesquii*)
Southeastern Myotis (*Myotis austroriparius*)
Tricolored Bat (*Perimyotis subflavus*)

Contributors (2013): Mary Bunch (SCDNR), Susan Loeb (US Forest Service), Austin Trousdale (Lander University), Mary K. Clark (Private bat consultant), Jonathon Storm (University of South Carolina-Upstate), Jeff Magniez (US Forest Service), and Travis Perry (Furman University).
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DESCRIPTION

Taxonomy and basic description

Colonial bats are those which gather in groups, forming maternity and/or hibernation colonies. The colony size can vary from 3 to 4 individuals to thousands. Cavity roosting bats use cavities or crevices for shelter. Most species of South Carolina bats are colonial cavity or crevice roosting. They include big brown bat (*Eptescicus fuscus*), brazilian free-tailed bat (*Tadarida brasiliensis*), eastern small-footed myotis (*Myotis leibii*), evening bat (*Nycticeius humeralis*), gray bat (*Myotis grisescens*), little brown bat (*Myotis lucifugus*), northern long-eared bat (*Myotis septentrionalis*), Rafinesque's big-eared bat (*Corynorhinus rafinesquii*), southeastern myotis (*Myotis austroriparius*), and tricolored bat (*Perimyotis subflavus)*. Eight of these species are of conservation concern and are discussed in this SWAP Plan; big brown, eastern small-footed, gray, little brown, northern long-eared, Rafinesque's big-eared, southeastern, and tricolored bat.

All South Carolina bats are nocturnal, feed on insects, and navigate or locate prey by ultrasonic echolocation. Echolocation is the use of reflected sound waves to locate objects. Ultrasonic echolocation means the sound waves used are typically above the human hearing range. Fecundity in these species is low, with bats producing 1-2 young (pups) annually in the summer. Eastern small-footed, gray, little brown, northern long-eared and Rafinesque's big eared bats produce only a single pup while southeastern, big brown, and tricolored bats typically give birth to up to 2 young per year.



Big brown bats

Big brown bats are large bats weighing 13-18 g (0.4 - 0.6 oz.) with a body length of 10.3 -13.0 cm (4.1 - 5.1 in) and a forearm measurement of 4 cm (1.57 in) or more. They have dark brown glossy fur, with a dark muzzle that has an inflated appearance. This species was first described in 1796 by Palisot de Beauvois.



Eastern small-footed myotis © MerlinTuttle.org

The eastern small-footed myotis (*Myotis leibii*) is a monotypic species and is South Carolina's smallest bat. Adults typically weigh only 3 - 6 g (0.1 - 0.2 oz) and have a wingspan of 21 - 25 cm (8.3 - 9.7 in). They have distinctively small feet only 6 - 8 mm (0.2 - 0.3 in) long, a dark mask at the eyes, and black ears. Their fur is shiny brown on back and whitish or buff on the belly. Wing and tail membranes as well as the muzzle, are a dark chocolate color. The eastern small-footed myotis was first described by Audubon and Bachman in 1842.



Gray bat © MerlinTuttle.org

The gray bat (*Myotis grisescens*) is the largest *Myotis* species in the eastern United States weighing ~7 - 10 g (0.25 - 0.35 oz) with a wingspan of 22 - 27 cm (10 - 12 in). While many southeastern bat species have bi- or tri-colored hairs, gray bats are known for their monochromic smoky brown or mouse gray dorsal fur colored from base to tip, though the belly may have whitish or buff tipped hairs. Unlike most other *Myotis* species, the plagiopatagium of the gray bat attaches at the ankle or base of the foot rather than at the base of the toes. The southeastern myotis may present a similar attachment, but gray bats are further distinguished by the unique presence of a notch in the thumb claw. The gray bat was first described by A.H. Howell in 1909.



Little brown bat ©MerlinTuttle.org

Little brown bats can be difficult to tell from northern long-eared bats. Both are small bats with brown fur. Little brown bats tend to have dark brown fur on the back that appears glossy. The little brown bat typically weighs 7 - 14 g (0.24 - 0.49 oz) and is 8 - 9.5 cm (3.1 - 3.7 in) long. The hairs on the feet of the little brown bat extend beyond the nail, unlike those of the northern long-eared bat. Northern long-eared bats are also 8 - 9.5 cm (3.1 - 3.7 in) long and their average weight is 7.4 g (0.26 oz).

The tragus (a structure within the ear) is straight on both the little brown bat and the northern long-eared bat, but it is more pointed in the northern long-eared bat. The ears of a northern long-eared bat, if folded toward the nose, would extend slightly beyond the tip of the nose. The little brown bat was first described in 1831 by LeConte, and the northern long-eared bat by Trouessart in 1897.



Northern long-eared bat



Rafinesque's big-eared bats

Rafinesque's big-eared bats (*Corynorhinus rafinesquii*) have enormous ears, 27 - 37 mm (1.1 - 1.5 in) which they fold up (deflate) while resting or hibernating. These bats have hairy toes, relatively large feet (9 - 13 mm or 0.4 - 0.5 in), and two distinct fleshy protuberances, on either side of the nose. They weigh 7 - 10 g (0.24 - 0.35 oz). Fur color in adults is a dark brown on back with dark rooted whitish hairs on the underside of the animal. Juveniles appear dark gray. The first upper incisor tooth has two cusps or points. The Rafinesque's big-eared bat was first described by Lesson in 1827.

Previously accepted designations for this species were *Corynorhinus macrotis* and *Plecotus rafinesquii*. The current accepted scientific name, *Corynorhinus rafinesquii*, is based on chromosomal variation and morphometric measurements. Two subspecies of Rafinesque's big-eared bats are recognized within South Carolina. *Corynorhinus rafinesquii rafinesquii* is the subspecies found in the mountains of South Carolina and into North Carolina, Georgia and beyond along the Appalachian Mountains. The disjunct Coastal Plain populations are recognized as *C. r. macrotis*.

Southeastern myotis (*Myotis austroriparius*) have a pinkish face or muzzle. The fur of the southeastern myotis has a wooly texture and is generally a dull-grayish brown. Fur color may vary with season, with some individuals having a bright reddish-orange appearance in the summer. These bats weigh 5 - 12 g (0.17 - 0.42 oz). The hindfoot is hairy and averages 10 mm (0.39 in) long. The southeastern myotis was first described by Rhoads in 1897.



Southeastern myotis (red phase)



The tricolored bat is small, weighing an average of 6 g (0.2 oz). For their size they have large feet, 7.3 - 9.9 mm (0.29 - 0.39 in). They are not as colorful as the term “tricolored” implies. Tricolor refers to the banding on the hairs; from the base to tip each hair appears dark, light and dark. Most tricolored bats are buff-yellowish but can appear brown. The radius bone visible through the skin appears pink. The face and ears also have a pinkish color. The tricolored bat was described by F. Cuvier in 1832 and renamed to their current Genus in 2006 by Hooper, Van Den Bussche and Horacek.

Tricolored bat

Status

In South Carolina, the big brown bat is considered Apparently Secure (S4) and globally ranked as Secure (G5). Most surrounding states rank this species as Secure (S5), but big brown bats are known to suffer from White-nose Syndrome (WNS).

Eastern small-footed myotis have a global rank of Apparently Secure (G4). In South Carolina small-footed myotis are Imperiled (S2) and are designated as “in need of management” which equates to State Threatened. North Carolina, Georgia, Virginia, Tennessee, and Kentucky also rank this species as Imperiled (S2). In North Carolina, the eastern small-footed bat is considered a species of state special concern. In 2013, USFWS determined that the eastern small-footed myotis did not warrant listing under the ESA.

The gray bat is Critically Imperiled (S1) in South Carolina, as well as in Georgia, Florida, North Carolina, and Virginia. It is considered Imperiled (S2) in Alabama, Tennessee, and Kentucky. The rounded global status of the gray bat is considered Vulnerable (G3) and has been federally endangered since 1976. This species is vulnerable due to being highly sensitive to human disturbance and having large numbers limited to a small number of caves across their range.

Little brown bats are globally ranked as Vulnerable (G3). In South Carolina, they are considered Imperiled (S2). North Carolina, Virginia, West Virginia, and Kentucky share the Imperiled rank for little brown bats. In Georgia they’re considered Critically Imperiled (S1) while in Alabama and Tennessee they are ranked as Vulnerable (S3). In North Carolina, this species is considered state endangered. The little brown bat is currently under review by the US Fish and Wildlife Service for listing on the Endangered Species Act due to threats from WNS.

Northern long-eared bats in South Carolina are considered Critically Imperiled (S1). They are ranked as Critically Imperiled in Georgia, Tennessee, and Kentucky, and as Imperiled (S2) in North Carolina, Alabama, and Virginia. In North Carolina, this species

is considered state endangered. The US Fish and Wildlife Service listed northern long-eared bats as endangered under the ESA in 2024 due to threats from WNS. This species has global rounded rank of Imperiled (G2).

The Rafinesque's big-eared bat is Imperiled (S2) in South Carolina and is listed as State Endangered. In North Carolina, *C. r. rafinesquii* is state threatened and *C. r. macrotis* is of state special concern. Georgia, Tennessee, and Kentucky rank Rafinesque's as Vulnerable (S3), while Virginia and Alabama rank them as Imperiled (S2). West Virginia and Florida consider the species to be Critically Imperiled (S1). This species has a rounded global status of Vulnerable (G3).

The southeastern myotis is Vulnerable in South Carolina (S3) and is designated as "in need of management." It has the same designation in Georgia, Florida, and Tennessee. In Virginia, North Carolina and Alabama the species is ranked as Imperiled (S2). In North Carolina, this is a state special concern species. The global status of southeastern myotis is ranked as Apparently Secure (G4).

In South Carolina, tricolored bats are ranked as Vulnerable (S3) as they are in North Carolina and Alabama as well. However, Florida, Georgia, Tennessee, Kentucky, West Virginia and Virginia rank this species a Imperiled (S2). In North Carolina, this species is considered state endangered. Globally, the tricolored bat has a rounded rank of Vulnerable (G3).

WNS is a fungal disease of hibernating bats. The fungus, *Pseudogymnoascus destructans*, attacks the dermis of bats while their immune systems are not active during hibernation. The fungus prefers cool, humid conditions such as those bats seek for winter hibernation in caves and mines. The fungus is difficult to detect on bats during the warm summer months when their body temperature is high and their immune systems launch effective attacks on the fungus. However an individual's past affliction with WNS may manifest as damage to wing membranes post-hibernation. By summer much of the damage from the previous winter is not evident. Over 7 million bats are estimated to have been killed by WNS in the Northeast since the discovery of WNS in 2006.

Although winters in South Carolina are warmer and shorter than those in the northeast, hibernaculum temperatures in the northeastern section are in the optimal growth range of the fungus. Consequently, WNS has had a significant impact on tricolored bat, northern long-eared bat, and little brown bat populations in the northwestern part of the state. However, big brown bat populations do not appear to have been significantly impacted by WNS.

In February 2013, a tricolored bat was found dead at Table Rock State Park. Testing by the Southeastern Cooperative Wildlife Disease Study in Athens, GA confirmed that the bat had WNS, the first case in SC. Since then, there have been three confirmed counties with bats found to suffer from WNS (Oconee, Pickens and Richland counties) and seven others confirmed with fungus *Pseudogymnoascus destructans* (Cherokee, Greenville, Lancaster, Laurens, Spartanburg, Union, and York). Unfortunately, tricolored bat

populations in two major Upstate hibernacula had declined at an alarming rate (up to 97 percent) since WNS arrived in South Carolina. However, tricolored bats populations in those hibernacula have stopped declining and begun to slowly increase in recent years.

POPULATION SIZE AND DISTRIBUTION

Big brown bats are common in South Carolina and occur throughout the state. These bats will use T-beam bridges, buildings, mines, tunnels, caves, and hollow trees for roosts. They are sometimes deemed a nuisance by homeowners. These bats use T-beam bridges, buildings, mines, tunnels, caves, and hollow trees for roosts. They are sometimes deemed a nuisance by homeowners. Tricolored bats also occur throughout the state. While populations have declined precipitously in the northwestern part of the state, they are still relatively common in the lower part of the state.

The range of the eastern small-footed myotis extends from the mountains of South Carolina (Figure 1) and Georgia, northward along the Appalachian Mountains into Virginia, West Virginia, Pennsylvania and southern New England and Canada. Populations extend westward into Kentucky, Tennessee, Alabama, and into Oklahoma. Population trends for this species are largely unknown and this species has never been regarded as abundant anywhere.

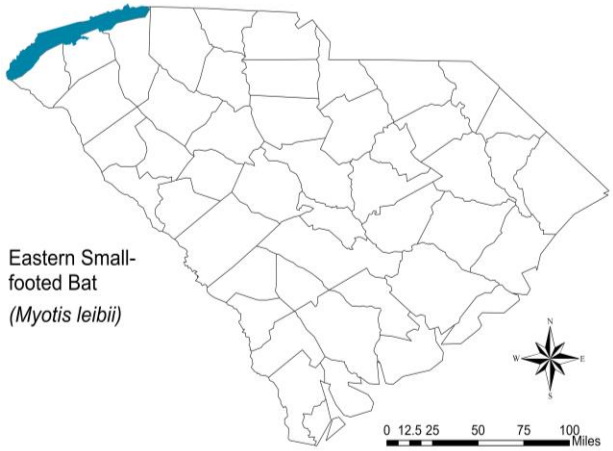


Figure 1. Distribution of the eastern small-footed bat in South Carolina

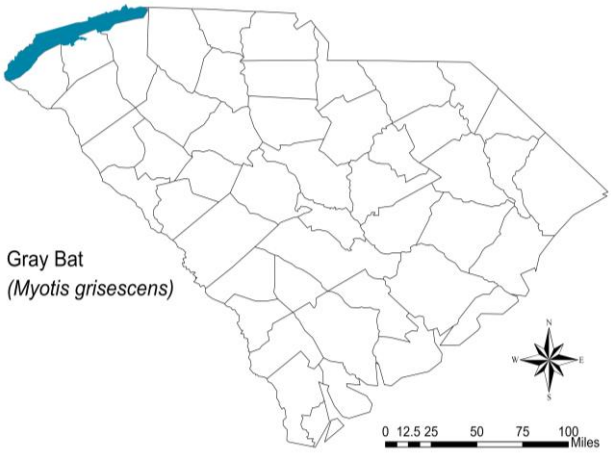


Figure 2. Distribution of the gray bat in South Carolina

Gray bats are restricted to cave regions of the midwestern and southeastern parts of the United States. Ninety-five percent of all gray bats hibernate in nine main winter caves located in Tennessee, Missouri, Kentucky, Alabama, Arkansas, and North Carolina. In August 2023, four gray bats were first recorded in South Carolina in Greenville and Oconee counties in crevices of bridges. Thus, we anticipate the range of this species to be in the Blue Ridge ecoregion of South Carolina (Figure 2).

Historically, both little brown and northern long-eared bats were found primarily in the mountains of South Carolina. However, their populations have declined significantly in this part of the state. Little brown bats range from central Alaska and southern Canada into the southeastern and southwestern US and are widely distributed. The southern limit of this species is in northern portions of South Carolina, Georgia, Alabama, and Mississippi, and little brown bats have been found in every ecoregion of South Carolina. In summer, little brown bats are found primarily in the Blue Ridge mountains, though there have also been infrequent reports of this species in the Piedmont, Sandhills and Coastal Plain regions (Figure 3). However, it is unknown where most of South Carolina's summer populations overwinter.

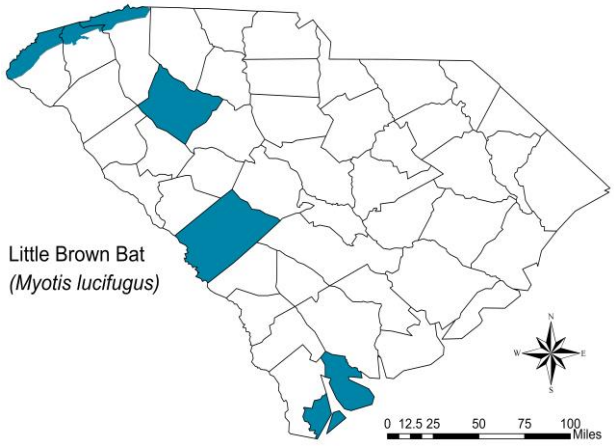


Figure 3. Distribution of the little brown bat in South Carolina.

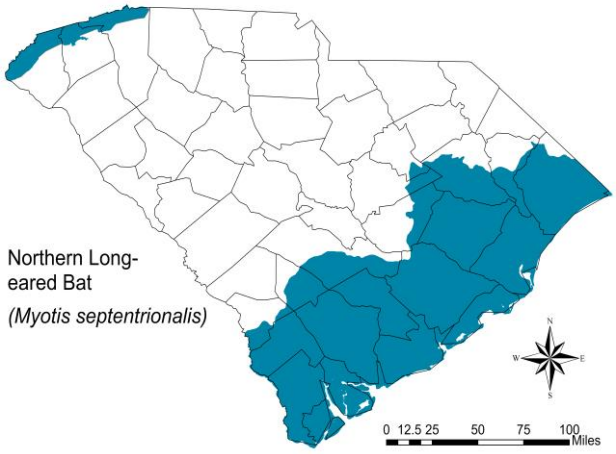


Figure 4. Distribution of the northern long-eared bat in South Carolina.

Northern long-eared bats are widely but patchily distributed across eastern North America ranging from southern Canada and the central and eastern US, northwest to the Dakotas, west through the central states, and south to northern Florida. No individuals from the SC mountain populations of this species have been captured in recent years. However, northern long-eared bats have been found in the Coastal Plain in many areas, although their numbers do not appear to be high (Figure 4).

Rafinesque's big-eared bats are found in all SC ecoregions except the Piedmont (Figure 5). *C. r. rafinesquii* are distributed within the Southern Appalachian Ecoregion from West Virginia southward into South Carolina, Georgia, and into Alabama. *C. r. macrotis* range from North Carolina, southward along the entire coastal plain and into the Sandhills of South Carolina. They extend southward through Georgia and into Florida. Rafinesque's big-eared bats have never been considered abundant. Colony sizes are larger in the northern end of their range where the species often inhabits caves and

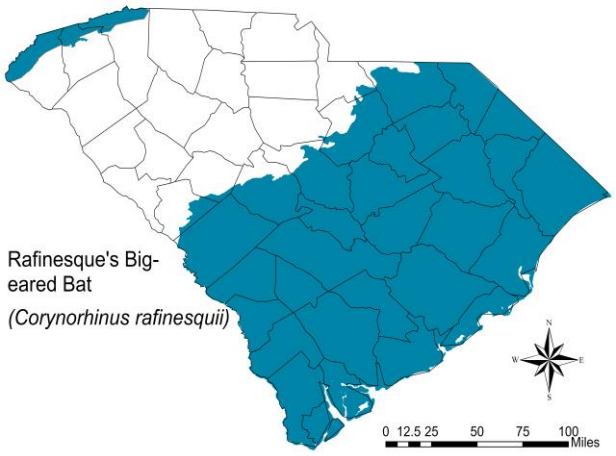


Figure 5. Distribution of the Rafinesque's big-eared bat in South Carolina.

mines but tend to be smaller in the southern portions of the range where caves and mines are less abundant. Southern roosts tend to be in tree cavities and man-made structures. Colony sizes are often less than 30 (usually 5-12) and seldom over 100. Population trend information is sparse, but most states suspect declines. Size of home range varies, averaging 93.2 ha (230.3 acres) in the Inner Coastal Plain Ecoregion, and ranges from 64-89 ha (158-220 acres) in a forested old growth swamp on the Outer Coastal Plain.

The southeastern myotis occurs from Florida northward mostly in the Coastal Plain through South Carolina (Figure 6), North Carolina and into the Southern Coastal Plain of Virginia. The distribution extends westward along the Coastal Plain of Georgia, Alabama, Louisiana, and Mississippi and northward along the Mississippi River into western Tennessee, Kentucky, southern Illinois and Indiana. Individuals have recently been documented in Piedmont counties in South Carolina, but state population trends are not known.

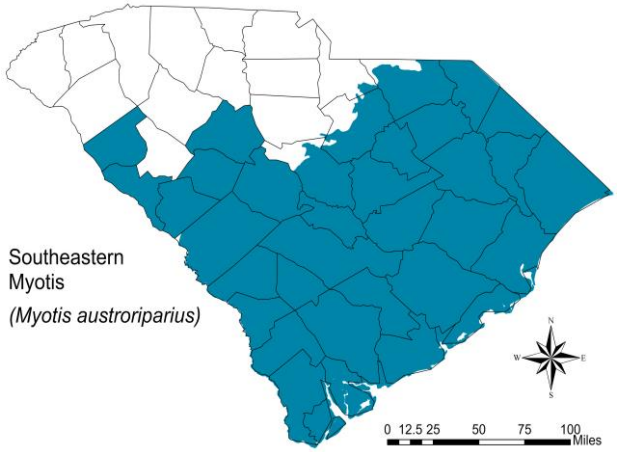


Figure 6. Distribution of the southeastern myotis in South Carolina.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Big Brown Bat

Big brown bats are ubiquitous. They are frequently found in buildings, cavity trees, under bridges and in bat boxes. They are infrequently found in tunnels and caves. Typically, they do not move to underground structures until extremely cold temperatures arrive and they are often the first species to leave the hibernaculum. They are frequently excluded from homes by wildlife control operators.

Big brown bats usually forage in open areas such as fields and wildlife openings or large gaps within forests. In the eastern United States, their diet consists primarily of Coleoptera. Lepidoptera are also an important part of their diet in some areas.

Eastern Small-footed Myotis

These small bats are known to use caves, mines, abandoned buildings, rock crevices and shelters, and crevices within bridges in wooded areas of the Southern Appalachian Ecoregion. In South Carolina, only few eastern small-footed myotis roosts have been found. They included a crevice in a rock outcrop in mature hardwoods (also suitable for green salamanders, *Aneides aeneus*), loose tarpaper on an abandoned log cabin, a wood pile on a porch, a fish hatchery building, and a picnic shelter.

Hardwood and evergreen forests, mixed hardwood-conifer stands, bottomland, and floodplains are reported as important habitat for the eastern small-footed myotis. They appear to prefer to forage over streams and ponds. For example, in South Carolina, they have been observed foraging over Reedy Cove Creek >100 m (328 ft.) downstream from the waterfalls. These bats are slow fliers with a fluttery flight pattern. It is likely they require forested corridors between roosts and foraging areas. The winter and summer roosting requirements and foraging habitats are poorly understood for this species.

Several species of colonial bats are sometimes nuisances or unwanted residents of homes, businesses, stadiums, and other man-made structures. Most often, nuisance colonies in South Carolina can be attributed to four species: big brown, free-tailed, evening bats, and tricolored bats. While all three colonial species of conservation concern do sometimes use buildings, those buildings are usually unoccupied; it is very uncommon for them to use sites frequented by humans.

Gray Bat

Although gray bats are nearly exclusively cave dwellers, they have been found using storm sewers/box culverts, abandoned mines, and bridges during the summer. Maternity caves have high humidity, are often wet, and have high domed rooms that serve as heat traps. Gray bats have been observed roosting with southeastern bats in Florida and Indiana bats in Arkansas and Missouri. At maternity sites farther from water, females and juveniles sometimes move to alternative caves closer to water post-volancy. In the winter, 95% of all gray bats hibernate in nine main winter caves located in Tennessee, Missouri, Kentucky, Alabama, Arkansas, and North Carolina. Gray bats were only recently discovered in South Carolina, but four separate individuals found were roosting in expansion joint crevices on bridges over water in Oconee and Greenville counties in August 2023. Gray bat calls have also been detected in those counties in mid-July as part of South Carolina's North American Bat Monitoring Program (NABat).

Little Brown Bat

In South Carolina, maternity colonies are known to use buildings and picnic shelters. They also are likely to use cavity trees. Only one hibernaculum is known from a single cave in Pickens County, South Carolina. It is unknown where most of South Carolina's little brown bats overwinter.

Northern Long-eared Bat

Habitat requirements of northern long-eared bats are still not well known in South Carolina. A northern long-eared bat was tracked to a dead pine; the bat was under loose

bark on National Forest land near Oconee State Park. In the Coastal Plain of South Carolina, northern long-eared bats primarily use longleaf pines (*Pinus palustris*). Studies of their roosting habits in North Carolina, Kentucky, Arkansas, and West Virginia show they use a variety of tree species. Oaks were the primary roost in one study in North Carolina, where pines were the primary roost in another. Shortleaf pine (*Pinus echinata*) has been shown to be used in Arkansas and Kentucky, and in West Virginia black locust was used for roosting. Northern long-eared bats tend to prefer crevices and cavities in dead or live-damaged trees, but they sometimes roost between loose bark and the bole of dead trees. Females prefer larger diameter trees than those used by males.

Northern long-eared bats are clutter-adapted species; meaning that they often forage in densely forested areas. In South Carolina, they are most likely to forage in mature stands. Northern long-eared bats often glean their prey from the surface of vegetation although they also forage by aerial hawking.

Rafinesque's Big-eared Bat

In South Carolina, some Coastal Plains' and Sandhills' populations use T-beam and I-beam bridges, abandoned buildings, old bunkers and tunnels, and cavity trees. The mountain populations apparently do not use bridges for roosts but use cavity trees, typically large hollow tulip poplars (*Liriodendron tulipifera*), abandoned buildings, cave or cave-like structures called rock shelters, and abandoned mines and tunnels. Rafinesque's big-eared bats are non-migratory. Movement is described as localized, not far-ranging from the roost; and distribution is patchy.

Habitat in the Blue Ridge Mountains for *C. r. rafinesquii* includes rock outcrops (for roosting), mesic and cove hardwood forests, forested bottomlands, bottomland agricultural fields, dry deciduous forest, pine woodlands, and forested riparian areas. Coastal Zone and Sandhills habitat of *C. r. macrotis* for roosting and foraging include black gum (*Nyssa sylvatica*) and water tupelo (*Nyssa aquatic*) stands, bald cypress (*Taxodium distichum*) swamp forests, maritime forests, and mature forested bottomlands (hardwood or mixed). They require very large tree cavities, frequently found in gum (*Nyssa sp*.) trees. Foraging was documented in a young pine plantation in a study with a small sample size. The best way to locate colonies is to examine cavities of large trees in appropriate areas.

Rafinesque's big-eared bats are reported to be moth specialists, although other insects are also consumed. Studies have shown that consumption of moths varied, with 48-100% of samples containing moths (Lepidoptera).

Southeastern Myotis

Caves (including limestone sinks), mines, abandoned buildings, log piles, and large hollow trees are used for roosting, maternity colonies and hibernation sites. In addition, they use forested bottomlands, forested swamps, Carolina bays, mesic deciduous and mixed forests. This bat forages and prefers to roost over or near water.

In Florida studies show that food habits vary with season. In summer Coleoptera and Lepidoptera were primary prey. Winter consumption included Coleoptera, Lipidoptera, Diptera, and especially Culicidae.

Tricolored Bat

The small-bodied tricolored bat is often one of the first species to move into a mine or cave for hibernation and is often the last to leave in the spring. In winter these bats often use abandoned mines and caves in the northwestern part of the state. Although considered colonial bats, individuals are often not physically clumped together. While hibernating in these caves, mines, and tunnels, tricolored bats hang singly but can be near conspecifics. Frequently they are covered in condensation while hibernating. In the lower part of the state, tricolored use a variety of structures including culverts, bridges, tree hollows, and tree foliage. During cold periods they go into deep torpor with torpor bouts lasting as long as 15 days. However, during warm periods they often switch roosts and possibly forage.

During summer tricolored bats can be found under certain bridges and in buildings in the summer. They are sometimes regarded as a nuisance by homeowners. In South Carolina and Indiana, females often form small maternity colonies (3-5 individuals) in clusters of live or dead leaves in trees. Male tricolored bats in North Carolina use large diameter oaks and hickories for roosts. In the Coastal Plain of South Carolina they use hardwood trees and often roost in Spanish moss (*Tilandsia usneoides*). Tricolored bats switch roost sites frequently in summer but their roosts are typically close together.

South Carolina data shows that tricolored bat activity does not seem to be influenced by thinning forest stands or by conducting controlled burns. In Illinois the diet of tricolored bats consisted mainly of Trichopterans (caddisflies) and consist of Coleoptera and Hymenoptera and in bottomland forests of east Texas it consists mainly of Coleoptera, Diptera, and Lepidoptera.

CHALLENGES

Threats to these bat species are summarized as follows:

All colonial bats in South Carolina[1]:

White-nose syndrome threatens all these species, although Rafinesque's big-eared bats have not suffered mortality due to WNS. An eastern small-footed myotis and a tricolored bat were discovered at Table Rock in 2013 suffering from WNS. The population of tricolored bats in Stumphouse Main Tunnel dropped 90 percent between 2014 (321 individuals) and 2018 (31 individuals) but has slowly begun to recover with 123 individuals detected in 2024. As of March 2024, there have been three confirmed counties with bats found to suffer from WNS (Oconee, Pickens and Richland) and seven others confirmed with the fungus that causes WNS, *Pseudogymnoascus destructans* (Cherokee, Greenville, Lancaster, Laurens, Spartanburg, Union, and York).

- Disturbance/destruction of natural roost structures (caves, rock shelters, trees).
- Global climate change may make southern hibernation sites unsuitable (too warm).

- Increased development and urbanization reduces habitat and forces bats into direct contact with humans.
- Increased predation by natural predators due to habitat alterations that either make the bats more vulnerable to predation or increase the density of predators.
- Destruction and disturbance of artificial roost structures (girder type bridges, abandoned houses and barns, mines, and tunnels).

Rafinesque's big-eared bat and Southeastern myotis:

- Destruction of natural roosts, particularly large hollow trees in the Coastal Plain.
- Destruction and fragmentation of bottomland hardwood forests that are used for roosting and foraging.
- Pesticide and heavy metal contamination.
- Unnatural predation at roosts by feral cats.
- Alteration of natural flood regimes may affect the regeneration of important forest community types such as cypress-gum, thus preventing recruitment of future roost trees.
- Alteration of local hydrology can increase flooding of natural roosts.
- Genetic isolation of populations.
- Abundant invasive exotic vegetation, such as some privet species, may prevent regeneration of forest species and impair recruitment of suitable roost trees.

Rafinesque's big-eared bat:

- Destruction and fragmentation of mature forests in the mountains and Coastal Plain.

Southeastern myotis:

- Flooding / inundation of natural roost sites.

Other threats (not species-specific) on the horizon:

- Wind turbines erected near roosts, and colony sites, and along migratory routes kill bats. Significant mortality of tricolored bats was noted at one wind power facility.

CONSERVATION ACCOMPLISHMENTS

Currently nearly 80,000 ha (197,684 ac.) of mountain habitat in South Carolina is protected by state, federal, or nonprofit conservation organizations. Many of those tracts protect Rafinesque's big-eared bat and eastern small-footed myotis roosts or foraging areas. Examples are Ashmore Heritage Preserve, the Greenville Water System's South Saluda watershed that is held in a conservation easement, and the Andrew Pickens District of the Sumter National Forest.

Several important roost and/or foraging sites in the Coastal Plain are in public ownership. An excellent example of old growth forest with Rafinesque's big-eared bats and Southeastern myotis is the Francis Beidler Swamp, also known as Four Holes Swamp, owned by the Audubon Society. Congaree National Park, which is the largest intact expanse of old growth bottomland hardwood forest remaining in the southeast and is

10,802 ha (26,692 ac), provides important roosting and foraging habitat for big-eared bats and southeastern myotis.

These activities have benefited bats:

- Surveys of mines, tunnels, bunkers and rock shelters/caves and trees along the Savannah River floodplain have located some colonies of Rafinesque's big-eared bats, Southeastern myotis, tricolored bats and occasional records of the other colonial species listed here.
- Contribution to poster, "Bats of the Eastern United States" used for educational outreach and provided free to the public.
- Completed a survey of Pest Control and Wildlife Control Operators in 1991 to evaluate the use of chemicals / pesticides vs. exclusion on nuisance bat colonies and reported findings at the South Carolina 33rd Annual Pest Control Operators School (38% had been using pesticides/chemicals on bats).
- Provided several training sessions on exclusion techniques and bat identification to Wildlife Control operators (WCOs) and Clemson University students.
- Posted WNS information and important links on the SCDNR website.
- Conducted numerous information and education programs on South Carolina's bats.
- Gated 12 tunnels to reduce human disturbance to Rafinesque's big-eared bat and tricolored bat colonies and modified 5 to improve air traps for Rafinesque's big-eared bats and big browns.
- Completed state-wide survey of bridges (2002-2003) to determine distribution of Rafinesque's big-eared bats; 52 bridges were used by Rafinesque's big-eared bats and of those 24 were used by maternity colonies. That work also located several big brown colonies and one tricolored bat colony.
- Completed studies of tricolored bats roosting and foraging habitat use throughout the state and throughout the year and conducted annual censuses of Stumphouse Main Tunnel 2014-2024.
- Good baseline data on the use of natural roosts and foraging areas by Rafinesque's big eared bat and the southeastern myotis are available for the Francis Beidler Forest in the Outer Coastal Plain, Congaree National Park in the Inner Coastal Plain, the Savannah River Site, Webb Wildlife Center and Groton Plantation.
- Some baseline data on the use of natural roosts by coastal northern long-eared bat populations are available for Francis Marion National Forest and Santee Coastal Reserve Wildlife Management area.
- Various agencies and NGOs have erected artificial roost structures (concrete bat towers and/or wooden bat boxes) at Silver Bluff Audubon Sanctuary, Hamilton Ridge WMA, Oconee, Devils Fork, Kings Mountain, and Table Rock State Park, Clemson Experimental Forest, Sumter National Forest, South Carolina National Guard McCrady Training Site, Jocassee Gorges, Ashmore Heritage Preserve and Hampton Plantation State Historic Site.
- WNS information was posted at the main Stumphouse Tunnel owned by Clemson University.
- Acoustic survey routes have provided baseline population and diversity information within the Andrew Pickens and Long Cane and Enoree Districts of the Sumter

National Forest, the Savannah River Site, and Carolina Sandhills National Wildlife Refuge.
- Statewide acoustic surveys (stationary and mobile) following the North American Bat Monitoring (NABat) protocol have been running annually since 2015, providing over 10 years of long-term bat data across South Carolina.
- A citizen science project and online form called SC Bat Watch! was created to monitor bat roost sites across the state and can be found here: https://www.dnr.sc.gov/wildlife/bats/batwatch.html

CONSERVATION RECOMMENDATIONS

Habitat protection
- Efforts should be made to protect foraging areas and migration corridors in addition to protecting known roosts. Protections could vary including landowner incentive programs, conservation easements, lease agreements, or purchases.
- Some formal agreement, such as a Memorandum of Understanding, between SCDNR and SCDOT regarding adaptations to new, long bridges over water in the Sandhills and Inner and Outer Coastal Plain is desirable. Currently, some of this work is handled though discussions with environmental consultants working on bridge projects with wetlands impacts.
- The protection of mature bottomland hardwood forests and connecting corridors in the Inner and Outer Coastal Plain is important for *C. rafinesquii* and *M. austroriparius*. Recruitment of younger stages of high-quality bottomland habitat for growth into future roost trees is needed.

Management
- Control human access to important mines, tunnels, caves, and rock shelter formations by signage or other restrictions, and do not create trails or roads to these sites.
- Designate buffers (no-cut zones) around known roosts.
- Provide forested corridors between any harvested units and retain large snags.
- Retain and recruit cypress-gum swamp forests containing large cavity trees.
- Regarding roosts in buildings: Measures should be taken to provide alternate roost structures at each significant site, or repairs should be made to the structure to ensure roost longevity. Typical bat box structures will not suffice for species that prefer large open cavities (Rafinesque's big-eared bats), not crevices. Structures which mimic large hollow trees may be suitable alternative roosts (similar to artificial chimney structures now used for chimney swifts) for Rafinesque's big-eared bats and southeastern myotis. Multi-chamber nursery boxes should be erected for significant little brown bat, northern long-eared, and small-footed myotis colonies. Alternatively, large bat towers for Rafinesque's big-eared bats can be modified to accommodate these species.

Priority research and survey needs
These research and survey needs are not restricted to South Carolina and could involve partnerships with other states in the respective ecoregions.

All colonial bats:

- Because we are at the southernmost range to find bats hibernating, evaluation of roost availability along with roost temperature and the availability of appropriate food (insects high in polyunsaturated fats) should be compared to winter survival.

Eastern small-footed and southeastern myotis:

- Determine summer and winter roost site requirements.

Gray bat:

- Determine seasonal distribution in South Carolina through capture and tracking surveys.
- Continue surveys of transportation structures where gray bats are likely to roost.
- Determine roosting habitat requirements including landscape factors that influence roost habitat quality.

Rafinesque's big-eared bat and eastern small-footed myotis and southeastern myotis:

- Determine if prescribed fire represents any threat, and what the acceptable distance of fire, smoke and fire lines from roosts.

Rafinesque's big-eared bat and southeastern myotis:

- Determine the genetic structure of selected colonies and test whether populations are experiencing adverse genetic consequences from isolation and fragmentation.
- Survey and map mines, tunnels, wells and cave-like structures not surveyed in previous efforts.
- Obtain long-term demographic data including reproductive success, sex ratios, survival, immigration and emigration facilitated by dispersal, and determine the effects of biotic and abiotic factors on these parameters.
- Determine if unnatural predation at roosts by feral cats is occurring. The study sites should include the southeastern myotis roost at Orangeburg State Park.
- Develop suitable man-made roosts specific to these species.
- Use existing data on habitat preferences to identify the availability of natural roost habitat and to determine the amount of protected versus unprotected habitat.

Rafinesque's big-eared bat:

- Determine alternate roost sites for bridge roosting individuals.
- Locate and map roost trees by physical searches where possible.
- Determine foraging habitat requirements (habitat types, size, and distance from roosts).
- Determine the effects of habitat fragmentation and roads on foraging behavior of Rafinesque's big-eared bats.
- Study the feeding ecology requirements in the mountains and coastal plain.

Southeastern myotis:

- Determine roosting habitat requirements including landscape factors that influence roost habitat quality.
- Obtain basic information on colony size, composition, dynamics, and how these vary with roost site characteristics.
- Little brown, northern long-eared bat:
- Locate any hibernacula of South Carolina bats.
- Conduct demographic studies on little brown bats to measure the effects of WNS if it occurs.

Monitoring

- Identify colonies of eastern small-footed myotis and southeastern myotis and begin long-term monitoring on colony size, persistence, and roost sites.
- Identify more of gray bat locations and monitor those individuals or colonies.
- Monitor any winter colonies of little brown bats, if found and continue monitoring of hibernacula of other species where access is permitted.
- Monitor the little brown bat maternity colony at the SCDNR Fish Hatchery in Oconee County.
- Continue long-term monitoring of bridges in the Coastal Plain for Rafinesque's big-eared bats.
- Continue long-term monitoring of Rafinesque's big-eared bat roosts in the mountains.

Education, public outreach and cooperative efforts

- Currently, bats are gaining recognition and popularity largely due to efforts of conservation organizations such as Bat Conservation International. Development of brochures, interactive websites and study plans should benefit the public and the species.
- Incorporate bats, particularly those of conservation concern, into forest plans, and other land management plans.
- Require certification of WCOs that includes exclusion training, restrictions or recommendations on appropriate timing of exclusion, and mandatory notification of SCDNR if any of the bat species in this document are involved. Clemson University's Pesticide Regulation and Control, Clemson Extension, and SCDNR could partner in training and administering this program.
- If suitable designs for man-made alternate roosts prove effective, those plans should become mainstreamed by making the plans and placement guides available as a pdf document to be shared with organizations such as the South Carolina Wildlife Federation (SCWF).

MEASURES OF SUCCESS

Initiating, funding, managing, and continuing to run a long-term statewide acoustic bat project has been an efficient use of grant funds and hugely successful for providing data to determine bat species distribution and abundance across South Carolina. Statewide bat monitoring through winter hibernacula counts and summer mist-netting and tracking have

provided critical information such as survivorship from WNS, northern long-eared bat maternity roosts, and pup season timing. Any significant bat roost that is protected or created from these actions can be interpreted as success. Not all threats can be abated, though, such as flooding of natural roosts. Surveys and density estimates in the southern region should provide some population estimations, which will be used to more accurately rank the species and prioritize future management needs. It is important to determine important roost site locations to provide long-term habitat for the species.

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[1] Threats to eastern small footed bats are not known in South Carolina. At best, they are poorly understood throughout their range.

Foliage Roosting Bats Guild

Hoary Bat (*Lasiurus cinereus*)
Northern yellow Bat (*Lasiurus intermedius*)
Eastern Red bat (*Lasiurus borealis*)
Seminole Bat (*Lasiurus seminolus)*

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Revised and Updated (2025): Jennifer Kindel (SCDNR), Katherine Etchison (NC Wildlife Resources Commission), and Susan Loeb (US Forest Service).

DESCRIPTION

Taxonomy and basic description

Foliage roosting bats (also called tree bats) roost by hanging under leaves and branches, or often in the case of northern yellow bats (*Lasiurus intermedius*), under Spanish moss (*Tillandsia usneoides*). Tree bats rarely, if ever, roost in caves although they have sometimes been captured with colonial bats during fall swarming at cave entrances. These species have been documented roosting on the outside of buildings and behind shutters. The Genus name Lasiurus refers to the fact that these bats have hairy tail membranes (the membrane between the hind legs encompassing the tail). These are South Carolina's more colorful bat species. In addition to the northern yellow bat, South Carolina has the eastern red bat (*Lasiurus borealis*), the Seminole (*Lasiurus seminolus*) bat and the hoary bat (*Lasiurus cinereus*). These latter three species have fur to the tip of the tail membrane. The northern yellow bat tail membrane is not well furred entirely to the tip and the ears are somewhat pointed, not rounded like those of eastern red, Seminole and hoary bats. All these bats typically have 2-4 young in a single birth per year. These bats exhibit sexual dimorphism; the females are larger than the males, and females tend to have a frosted appearance to their fur.

The northern yellow bat was described by H. Allen in 1862, and the subspecies recognized in South Carolina is *Lasiurus intermedius floridanus*. The eastern red bat was described by Gray in 1831, and the closely related Seminole bat was first described in 1895 by Rhoads. Palisot de Beauvois described the hoary bat in 1796.


Northern yellow bat

The second largest bat in South Carolina, the northern yellow bat weighs 14 - 20 g (0.49 - 0.7 oz.) and has a total length of 127.6 mm (5 in.). The forearm measures 51 - 53 mm (2 - 2.1 in.) and foot measures 8 - 12 mm (0.3 - 0.47 in.). The fur is a silky yellow-orange with a faint wash of brown or gray on the tips.

Female eastern red bats have a light red base color with hairs frosted at the tips so their general appearance is lighter and have a more chestnut appearance than that of males who tend to be a brick red color. Both sexes have a crisp white patch at the wrist and shoulder. Individuals have an average weight of 15 g (0.53 oz.), and a body length of 13 cm (5.1 in). Ears are rounded and furred. The coloration of eastern red bats and Seminole bats gives them the appearance of dead leaves.



Eastern red bat, female



Seminole bat

Male Seminole bats are a rich mahogany and the larger females also have a mahogany base color but with frosted hairs. Like eastern red bats they have distinct white patches at the wrist and shoulder. Sizes vary from 8.8 - 12.1 cm (3.5 - 4.8 in.) body length and weighing 9 - 14 g (0.3 - 0.5 oz.). They have furry rounded ears.

Hoary bats are the largest bat in South Carolina weighing 25 g (0.9 oz.) on average, and their wingspan approaches 40 cm (16 in.). They are very attractive with distinct black ear margins and a dark muzzle, contrasted by yellow on the head and under the chin. The rest of the bat is a rich mahogany base color with light frosted tips. Females are larger than males but are not colored differently. This coloration allows a hoary bat to visually blend in with tree bark. The species is the most well-furred bat in South Carolina. Like the red and the Seminole bat, the hoary bat has white wrist and shoulder patches.



Hoary bat © MerlinTuttle.org

Status

The status of the northern yellow bat in South Carolina and Georgia is Vulnerable (S3). Mississippi regards the species as Imperiled (S2). Alabama and North Carolina rank the northern yellow bat as Critically Imperiled (S1) and of state special concern. The species has a global status of Apparently Secure (G5).

Eastern red, Seminole, and hoary bats are ranked as Vulnerable to Apparently Secure (G3G4). However, recent models suggest that hoary bat populations may become endangered due to mortality associated with wind energy developments. In South Carolina the state rank for hoary bats is Imperiled (S2). Georgia ranks hoary bats as Apparently Secure (S4), whereas North Carolina lists them as Vulnerable to Apparently Secure (S3S4). Seminole bats are ranked as Vulnerable (S3) in South Carolina and North Carolina, whereas in Georgia they are ranked Secure (S5). Eastern red bats are ranked as Vulnerable (S3) in South Carolina, but Secure (S5) in Georgia, Alabama, and North Carolina.

POPULATION SIZE AND DISTRIBUTION

The distribution of northern yellow bats is poorly known. They have been found in coastal New Jersey and Virginia, but the accepted range is typically farther south. They occur in the Outer Coastal Plain of South Carolina and into the Inner Coastal Plain along the Savannah River, and southward in the Coastal Plain of Georgia and Alabama and into Florida (Figure 1). North Carolina reports two records near South Carolina from New Hanover and Brunswick Counties.

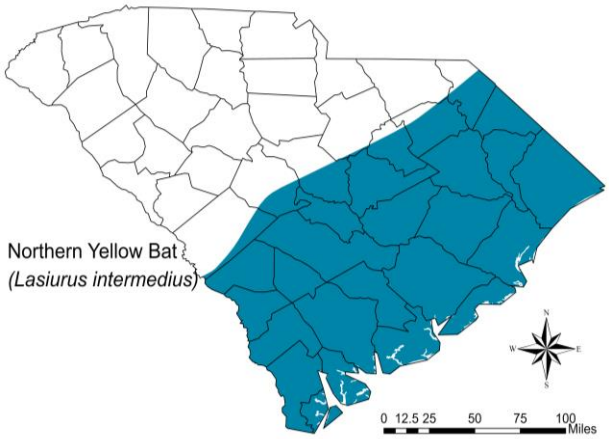


Figure 1. Distribution of the northern yellow bat in South Carolina.

Northern yellow bat density estimates are not available. In some locations in Florida, the northern yellow bat is the predominant species. There, feeding aggregations of more than 100 individuals, (mostly females) have been reported in mid to late summer. Males may congregate in the winter in Florida; the behavior in the Carolinas is unknown. The home range of an individual northern yellow bat in Georgia was reported as 10.5 ha (25.9 acres) in oak and pine habitat. The species is not known to be migratory.

Eastern red bats are distributed statewide and are considered year-round residents, but their numbers increase in the late fall and winter due to the arrival of winter migrants from the north. Hoary bats are distributed statewide in winter, but they are probably rare in the state during summer due to their likely migratory patterns. Hoary bats are more difficult to detect than eastern red bats because they typically forage higher than most net

and harp trap sets, but they have been detected in breeding condition in summer in the mountains. An adult hoary bat was found in the Piedmont, July 3, 2012. Little is known about eastern red bat and hoary bat migration. High mortality is seen in eastern red and hoary bats at wind energy facilities, particularly in spring and fall in forested regions of the Eastern United States.

Seminole bats have been found statewide, though only a few summer and fall records of Seminole bats in the upper Piedmont and Blueridge ecoregion exist. Seminole bats are more common in South Carolina's pine-dominated Inner and Outer Coastal Plains and lower Piedmont. They are non-migratory. Like northern yellow bats, Seminole bats will roost in clumps of Spanish moss. These bats can also roost behind loose bark. Roosts are typically 1- 4.5 meters above the ground.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Northern yellow bats are one of the least understood mammalian species in South Carolina. They occur in the Coastal Plains of South Carolina. Most of what is known about the species was derived from Florida. These bats forage over open areas such as fields, pastures, golf courses, marshes, and along lake and forest edges. Roosting habitat includes oak forests, long-leaf pine stands (*Pinus palustris*) in Florida sandhills, and live oak (*Quercus virginiana*) hammocks. Roosting sites are usually in clumps of Spanish moss or under old palm fronds. In South Carolina they roost in dead fronds of the Sabal palm (*Sabal palmetto*) or Spanish moss in hardwood forests. During summer they forage in open areas near water such as salt marshes, ponds, and fields but in winter they forage in bottomland hardwood forests, fields, and ponds.

Seminole and eastern red bat calls are too similar to differentiate using acoustic detectors so it is difficult to estimate relative abundance or habitat use where the species overlap without using radio telemetry. Eastern red bats prefer foraging in uncluttered stands (those which have been thinned). They roost on smaller branches or twigs, often in the hardwood tree canopy. Eastern red bats often prefer the dominant or co-dominant live hardwoods, and they may not use trees near forest margins. However, in North Carolina, males select roosts that are close to forest roads. Eastern red bats sometimes roost in the leaf litter, particularly during very cold periods, with their furry tail membrane pulled around their body up to their face. Thus, they may be vulnerable to predation and any activity involving disturbance of the leaf litter during winter periods.

Seminole bats roost in pine-dominated stands in summer. Preferred roost trees tend to be large pines located near forested corridors. Reproductive females choose the largest trees. Non-reproductive bats will use smaller trees (they are not limited to use of large pines only). During winter, Seminole bats are more likely to use both hardwood and pine stands for roosting. Like eastern red bats, Seminole bats use the leaf litter of the forest floor for winter roosting as well as overstory and understory trees.

Both Seminole and eastern red bats exhibit low roost site fidelity (i.e. they frequently switch trees) but have high site fidelity (they roost among different trees located within the same general area).

Seminole bats typically do not use hardwood forested streamside corridors for foraging but use upland forested corridors which typically have a pine component. Eastern red bats in managed forests in Mississippi show no preference for habitat types. Although eastern red bats are often in urban areas, at the landscape level they avoid areas with greater development.

Hoary bats typically roost 3-5 m (10 - 16 ft.) above the ground and will use tree cavities, trunks, tree foliage, squirrel nests, and Spanish moss. They inhabit coniferous and deciduous forests near clearings.

Studies on habitat use of these bats have not been abundant and evenly spread among physiographic regions or habitat types. Therefore, one cannot presume the information herein to be comprehensive and typical to all areas.

CHALLENGES

- Loss of habitat due to development (man-made alterations and anthropogenic changes).
- Loss of roost sites in the form of removal of old palm fronds (for cosmetic reasons) and harvest of Spanish moss.
- Loss of habitat and direct mortality from natural causes such as hurricanes.
- Collisions with wind turbines or injury from active turbines.
- Collisions with towers.

CONSERVATION ACCOMPLISHMENTS

A two-year study of northern yellow bat foraging ecology during summer and winter and summer roosting ecology was conducted at the Palmetto Bluff Conservancy, Pinckey Island National Wildlife Refuge, and Victoria Bluff Heritage Preserve. They were not detected in several bat surveys on coastal military installations but have been detected at Waccamaw National Wildlife Refuge and in several Coastal Plain counties through SC NABat acoustic surveys.

CONSERVATION RECOMMENDATIONS

Management

- Retain Spanish moss and old palm fronds on public lands to benefit northern yellow bats.
- Encourage retention of Spanish moss and old palm fronds on private lands to benefit northern yellow bats.
- Retain upland forest corridors to prevent isolation of Seminole bats.

- In the Piedmont region, timber management that creates uncluttered forest, such as pine thinning or controlled burns may benefit foraging bats.
- Work with wind energy development companies to mitigate impacts of wind turbines (e.g. increasing the cut-in speed of turbines to reduce mortalities).
- Advise forestry professionals to conduct controlled burns when minimum night temperatures are >4°C (39°F) and temperatures at the time of ignition are >10°C (50°F).

Priority research and survey needs

- Identify priority areas for field surveys for northern yellow bats.
- Determine northern yellow bat distribution, via surveys, in the Carolinas.
- Determine summer and winter roost site and habitat requirements for all lasiurine species.
- Gather migration information for red and hoary bats.
- Determine the extent of off-shore foraging and commuting and its seasonality to assess vulnerability of lasiurine bats to off-shore wind development.
- Determine vulnerability of lasiurine bats to coastal wind energy development, particularly during fall migration.
- Conduct molecular research to determine the validity of the yellow bat subspecies designation and the variation within the species across its known distribution.
- Determine if northern yellow bats are threatened by pesticide and / or heavy metal contamination.

Monitoring

- Monitor significant northern yellow bat roost sites, located by survey efforts, for continued usage.
- Maintain capture and location information for all lasiurine bats.
- Use NABat surveys to monitor lasiurine bats occupancy rates on a seasonal and annual basis.

Education, public outreach and cooperative efforts

- Educate home and landowners about the importance of northern yellow and other bats and discourage the practice of removing roosting habitat such as old palm fronds and large amounts of Spanish moss from trees.
- Create demonstration areas on publicly owned site(s), leaving old fronds uncut on palms in a highly visible area with prominent signage explaining that old fronds provide important roosting habitat for northern yellow bats.

MEASURES OF SUCCESS

As research and management needs are identified, projects should be proposed and prioritized by those with the greatest conservation applicability. Surveys and density

estimates in the southern region should provide some population estimations that will be used to more accurately rank the species and prioritize future management needs. It is imperative to determine important roost site locations to provide long-term habitat for the species. Currently, very little is known about northern yellow bats in South Carolina.

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Moles Guild

Hairy-tailed Mole (*Parascalops breweri*)
Star-nosed Mole (*Condylura cristata*)

Contributors (2005): Mary Bunch (SCDNR), Mark Ford (VA Tech),
and David Webster (UNC-W)
Reviewed and Edited (2012): Steve Fields (Culture and Heritage Museums)
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TAXONOMY AND BASIC DESCRIPTION

Three species of moles occur in South Carolina. These include the eastern mole (*Scalopus aquaticus*), which is widely distributed and common. The other 2 species, the star-nosed mole (*Condylura cristata*) and hairy-tailed mole (*Parascalops breweri*), are less commonly encountered in South Carolina. All 3 possess velvety fur; eyes that are small and concealed in the fur; and large well-developed forelimbs with backward facing palms and long claws. They also lack external ear structures.


Star-nosed Mole Photo courtesy of ATBI

The star-nosed mole was first described by Linnaeus in 1758. Two subspecies are recognized for the star-nosed mole: *Condylura cristata cristata* and *Condylura cristata parva*. Star-nosed moles in South Carolina are considered to be *C. c. parva* (Peterson and Yates 1980). As the name implies, the rostrum of the star-nosed mole is star-like and consists of 22 fleshy appendages. Total length of this species ranges from 153 to 238 mm (6.24 to 9.3 in.). The moderately haired tail is approximately one-third to one-half the body length. The fur is black or a black-brown on the back (Peterson and Yates 1980; Webster et al. 1985; Laerm et al. 2005a).


Hairy-tailed Mole Photo by E.B. Pivorun

The hairy-tailed mole, first described by Bachman in 1842, is the smallest of South Carolina's moles, ranging from 139 to 174 mm (5.4 to 6.8 in.). The name suggests its identifying attribute, a densely furred tail. The tail is less than one-quarter of the body length. The fur is black to a gray-black on top and slightly paler underneath (Hallett 1978; Laerm et al. 2005b). Both mole species use their tail for fat storage; therefore, tail width varies with season and condition.

STATUS

Both species are of special concern in South Carolina. The state rank for the hairy-tailed mole is imperiled (S2) (NatureServe 2024). The star-nosed mole is ranked state-wide as vulnerable (S3) (NatureServe 2024). Both species have a global rank of secure (G5) (NatureServe 2024). The hairy-tailed mole is common in Pennsylvania (Merritt 1987) and appears to be secure (S5) in Virginia and apparently secure (S4) in Kentucky and North Carolina but is considered vulnerable (S3) in Tennessee and critically imperiled in Georgia (S1) (Lamer et al. 2005b; NatureServe 2024). The star-nosed mole, ranked as uncommon in South Carolina, is imperiled (S2) in Georgia and Tennessee and is considered apparently secure (S4) in North Carolina and Virginia (Laerm et al. 2005a; NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

There are no population estimates available in the southern end of the range (Southern Appalachians) for either the hairy-tailed or star-nosed moles. Laerm et al. (2005a, 2005b) reports both species as "uncommon" and the hairy-tailed mole as "rarely reported in appropriate habitat."

The hairy-tailed mole is restricted to the high elevation mountains of South Carolina within the Southern Appalachian Ecoregion (Figure 1).

The range for hairy-tailed moles extends from the mountains in South Carolina northward into southern Maine and extreme southern Canada (Hallett 1978).

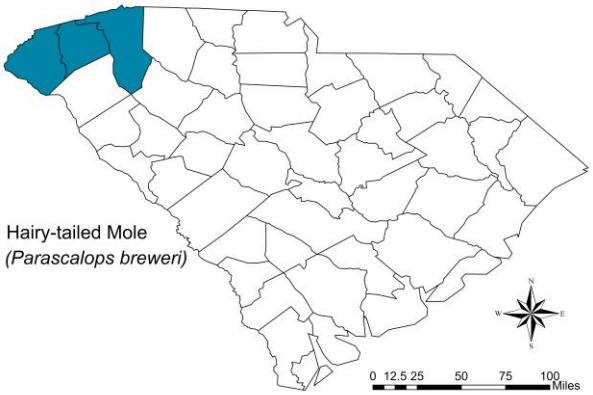


Figure 1. Distribution of the hairy-tailed mole in South Carolina.

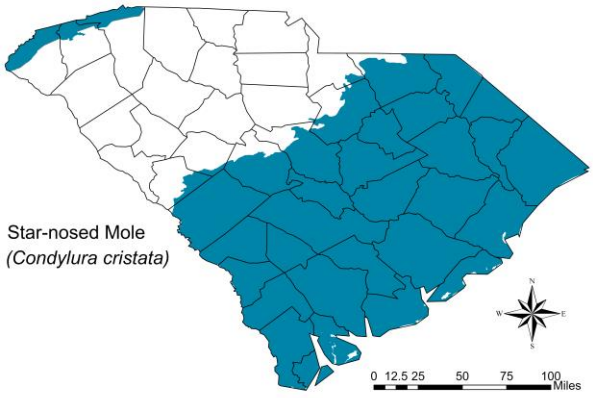


Figure 2. Distribution of the star-nosed mole in South Carolina.

The star-nosed mole extends both into South Carolina's mountains and the Outer and Inner Coastal Plains and Sandhills Ecoregions (Figure 2). There appears to be a gap in the distribution of star-nosed moles in the piedmont of South Carolina and most of the piedmont of North Carolina (Beane 1995).

The North American distribution for the star-nosed mole extends from Canada, down to and across New England and the Great Lakes states, southward along the Appalachians into Georgia and South Carolina. Additionally, it is found coastally through Georgia and extreme northern Florida (Peterson and Yates 1980).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Both the star-nosed and hairy-tailed moles are found in the southern Appalachian Mountains. Within that ecoregion, they show some overlap in habitat; both species use mesic mixed forest, mesic deciduous hardwood, and bottomland or floodplain forests. The latter habitat is extremely uncommon in the mountain ecoregion in South Carolina (Griffith et al. 2002).

Hairy-tailed moles are usually found in areas with elevations above 427 m (1400 ft.). Habitats for this species include fields and pastures, deciduous (including dry deciduous) needle-leaved evergreen forest, and mixed evergreen-hardwood forest. Often the habitat includes loose, easily drained, and excavated soil with cover. Soils are not typically wet or of high clay content. In the southern Appalachians, associated species that can occur in the same habitats as the hairy-tailed mole include several other South Carolina species of concern: the southern red-backed vole (*Myodes gapperi*), woodland jumping mouse (*Napaeozapus insignis*), star-nosed mole (*Condylura cristata*) and masked shrew (*Sorex cinereus*).

Star-nosed moles in the Southern Appalachian Ecoregion tend to be found in wetter sites than hairy-tailed moles, often found in sites such as swamps, marshes and bogs. Star-nosed moles are the most aquatic of our moles and construct tunnels that sometimes lead into water (Webster et al. 1985). Forested floodplains, forested and early successional bottomlands, mesic hardwood sites, and streamside areas typify habitats used by this species in the mountains. Additionally, star-nosed moles are found in sites with dense leaf litter.

The coastal and sandhills habitats for star-nosed moles include pocosins, wetlands, saturated bottomlands, and long-leaf pine habitat. Neither forest age nor successional stage has been reported as a critical factor determining habitat suitability for the star-nosed mole (Laerm et al. 2005a).

Both the star-nosed mole and the hairy-tailed mole burrow and will create both underground tunnels and surface tunnels. Nests are constructed underground. All moles are vulnerable to inundation; therefore, nests are built above the typical high-water level.

CHALLENGES

Scientists agree that additional surveys for star-nosed moles and hairy-tailed moles are necessary to better understand the distribution and abundance of these species. Additionally, in order to better understand the association with wet soils preferred by star-nosed moles, soil requirements should also be investigated for this species.

Cats, dogs, owls, foxes and snakes can all prey upon both species. Presumably, coyotes will also use star-nosed moles and hairy-tailed moles as a food source. Currently, none of these predators are reported to be major threats to the species' survival (Hallett 1978; Peterson and Yates 1980). Increased predation from cats and dogs is expected as residential development increases.

Increases in eradication from humans that view these species as nuisances can be expected. However, landscaping techniques exist that may reduce problems that result due to mole activity.

One of these techniques is to limit the use of mulch. Mulch favors water retention, which in turn attracts soil invertebrates, the food source for moles. By removing the habitat of these invertebrates, the area becomes inhospitable to moles. Exclusion techniques, such as mole fences or underground barriers, may also limit mole damage (Henderson 1994).

As the urban interface grows, increased impacts from development will occur. Development impacts can be measured by quantifying creation of impermeable surfaces, such as roads, buildings and parking lots (Laerm et al. 2005a). Direct loss of habitat is a threat, as are changes in hydrology associated with development. Laerm et al. (2005a) suggest that activities that permanently saturate the soil in sites occupied by star-nosed moles and hairy-tailed moles are detrimental. Neither the hairy-tailed nor star-nosed mole seems to be sensitive to seral stage; however, effects of timber harvests on localized, temporal water levels could cause nests to be flooded with ground water.

The recent range expansion of the nine-banded armadillo into the South Carolina Coastal Plain may represent a threat to the star-nosed mole due to competition for food resources. Predation by feral hogs may also present a threat to moles throughout their range.

CONSERVATION ACCOMPLISHMENTS

In South Carolina, the Andrew Pickens Ranger District of the Sumter National Forest, several mountain Heritage Preserves, Jocassee Gorges, several state parks, and some tracts owned or held in easement by various land trusts contain habitat for star-nosed moles and hairy-tailed moles. For example, over 12,141 ha (30,000 ac.) of mountain land is under conservation easement held by The Nature Conservancy. None of those properties were purchased specifically to protect either the star-nosed or hairy-tailed moles; however, both benefit from these acquisitions and the protection offered for their habitat.

SSURGO (Soil Survey Geographic database) level soils have been completed for the State in 2002. The Geological Survey is mapping structural geology for various areas of the state at 1:24,000-scale including the mountains and upper Piedmont (J. Scurry, pers. comm.). This new data may assist in defining mole habitat.

CONSERVATION RECOMMENDATIONS

- Discourage the construction of ponds in known star-nosed mole and hairy-tailed mole habitat and prevent increases in storm water run-off associated with development in known and potential habitats.
- Re-examine current South Carolina state rankings for these mole species as required under the Nongame and Endangered Species Conservation Act, in Chapter 15 under Title 50 of the Code of Law of South Carolina.
- Conduct ecoregion-wide surveys for distribution and density of both the star-nosed mole and the hairy-tailed mole in order to better understand their conservation status. Survey techniques should be standardized throughout the southeast so that results and data are readily comparable. All capture data should be made available to the most current

statewide Heritage Trust database. That information should also be shared with neighboring states.
- Complete a thorough identification of mountain bogs and seeps and their interface with upland sites to prioritize site surveys for the star-nosed mole and the hairy-tailed mole.
- Investigate specific limiting factors associated with habitats for both the star-nosed mole and the hairy-tailed mole.
- Investigate the effects of timber harvest on temporal water table levels and associated impacts to star-nosed mole distribution.
- Educate landowners and other members of the public about the ecological role and benefits of star-nosed moles and hairy-tailed moles.

MEASURES OF SUCCESS

As research and management needs are identified, projects should be proposed and prioritized by those with the greatest conservation applicability. Surveys and density estimates in the southern region should provide some population estimations, which will be used to more accurately rank the species and prioritize future management needs.

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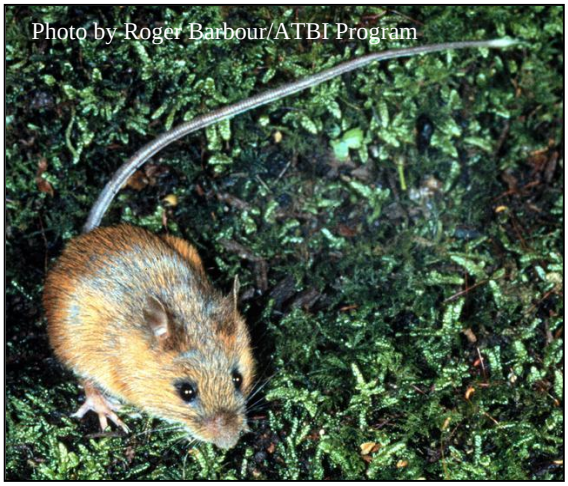
Woodland Jumping Mouse

Napaeozapus insignis

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DESCRIPTION

Taxonomy and basic description



The woodland jumping mouse (*Napaeozapus insignis*) was first named by Miller in 1891. The subspecies recognized in the southern Appalachians, based entirely on morphometric measurements, is *Napaeozapus insignis roanensis* (Whitaker and Wrigley 1972). Adults of this subspecies are 204 to 256 mm (8.0 to 10.1 in.) long, including the tail. The tail, which is longer than the body, is often white-tipped and bicolored; it is brown-gray on the top and whitish underneath and ranges in length from 115 to 160 mm (4.5 to 6.3 in.). Woodland jumping mice have large hind feet, 28 to 34 mm (1.1 to 1.3 in.), which are appropriate for jumping. The woodland jumping mouse is a colorful mammal: the fur on the sides is a yellow-orange and a dark wide stripe down the back is a red-orange-brown hue. The belly is white. Adults weigh 15 to 30 g (0.53 to 1.06 oz.) (Whitaker and Wrigley 1972; Webster et al. 1985).

Status

Woodland jumping mice are ranked as imperiled (S2) in South Carolina, as secure (S5) in Virginia, as apparently secure (S4) in North Carolina, Tennessee, and Kentucky, and as vulnerable (S3) in Georgia (NatureServe 2024). Their global rank is secure (G5) (NatureServe 2024). They are not listed on the IUCN Red list as a species of concern and their populations are considered stable (Cassola 2016).

POPULATION SIZE AND DISTRIBUTION

Woodland jumping mice range from Manitoba, Canada, eastward through Ontario, Quebec, Labrador, Nova Scotia and New Brunswick, and south through the Great Lakes region, New England, and the Mid Atlantic. As the range extends southward, it narrows to the confines of the Appalachian Mountains, ending in northern Georgia and northwestern South Carolina (Linzey 1995; Whitaker and Wrigley 1972; Webster et al. 1985; NatureServe 2024). See Figure 1.

Density estimates from the north vary at 0.64, 5.2, and 6.7 animals per hectare (0.26, 2.7, and 5.2 per acre, respectively), and home ranges are about 0.4 to 3.6 hectares (1 to 9 acres) (Whitaker and Wrigley 1972). It is not considered abnormal to have widely varying densities due to short life expectancies, high reproductive outputs, and a life cycle prone to fluctuation with seasons, weather, and predation cycles. No density estimates are available for the Southeast.

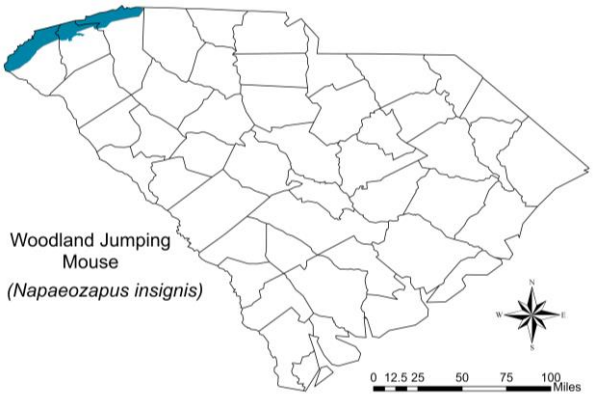


Figure 1. Distribution of the woodland jumping mouse in South Carolina.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Within the Southern Appalachian Ecoregion, woodland jumping mice are restricted to high elevation sites in cool moist habitats such as hemlock stands, sheltered cove hardwood stands with northern species, and Rhododendron draped streamside zones (Ford et al. 1994). In South Carolina, these animals have been found at elevations of 427 m (1,400 ft.) and above. Woodland jumping mice are true hibernators in the north (Merritt 1987); however, this behavior has not been studied or confirmed in the southeast. Hibernation requires reliably cold temperatures; this fact might explain their range restriction in the southeast.

The effects of logging or canopy removal on the habitat selection of woodland jumping mice is not clearly understood, but there are indications that these mice prefer moist habitats with abundant herbaceous cover rather than thick woody regeneration (Ford et al. 2000). South Carolina priority listed species that are sometimes associated with these same habitat characteristics in the southern Appalachians include the southern red-backed vole (*Clethrionomys gapperi*), eastern pygmy shrew (*Sorex hoyi*), star-nosed mole (*Condylura cristata*), and masked shrew (*Sorex cinereus*).

Woodland jumping mice have a varying diet of fungi, insect larvae, berries, seeds, nuts, and vegetation (Whitaker and Wrigley 1972). Studies indicate that woodland jumping mice consume significant amounts of the *Endogone* spp. and *Glomus* spp. fungi in both mixed mesic forest and eastern hemlock habitats (Williams and Finney 1964; Orrock et al. 2003). The presence or abundance of deer mice (*Peromyscus maniculatus*) is negatively correlated with consumption of the *Endogone* spp. fungi; in those situations, the jumping mice consume other fungal species (Orrock et al. 2003).

CHALLENGES

Challenges to the woodland jumping mouse include habitat fragmentation due to development and barriers created by associated structures such as 4-lane divided highways (NatureServe 2024). Additionally, hemlock wooly adelgids (*Adelgas tsugae*), an invasive pest, may threaten some suitable habitat sites if the hemlocks and associated fungi are killed or reduced (Evans

2004). Finally, global warming could shift suitable habitat farther north and into higher elevations not found in South Carolina (W. Mark Ford, pers. comm.).

CONSERVATION ACCOMPLISHMENTS

Some woodland jumping mouse habitat is protected on public lands such as the Jocassee Gorges and Caesars Head State Park.

CONSERVATION RECOMMENDATIONS

- Consider land acquisitions or conservation easements that provide linkage of appropriate habitat within the Southern Appalachian Ecoregion. Investigate the possibility of promoting or participating in regional efforts to establish such linkages.
- Encourage land managers to avoid canopy removal of mesic, high elevation sites and provide corridors linking appropriate habitat.
- Estimate woodland jumping mouse density for habitats in the southern part of the species' range.
- Conduct genetic research to determine if southern woodland jumping mice are distinct from northern conspecifics.
- Designate permanent monitoring sites on public land including a high elevation hardwood cove and a hemlock site.
- Work with partners to make information about the woodland jumping mouse available to the general public.

MEASURES OF SUCCESS

As research and management needs are identified, projects should be proposed and prioritized for the greatest conservation applicability. Surveys and density estimates in the southern region should provide some population estimations, which will be used to more accurately rank the species and prioritize future management needs. Analysis of DNA and mtDNA will reveal the relatedness and genetic diversity of the northern versus southern woodland jumping mice.

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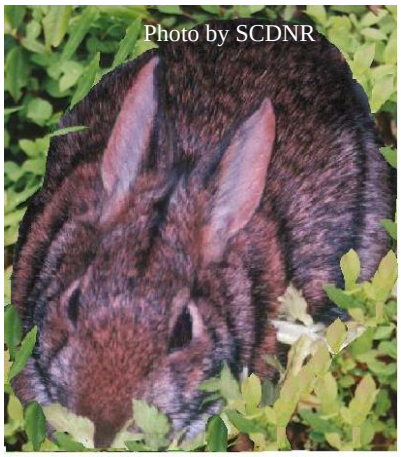
Appalachian Cottontail

Sylvilagus obscurus

Contributors (2005): Mary Bunch (SCDNR), Rickie Davis (Clemson University), Stanlee Miller (Campbell Museum, Clemson University), and Rob Harrison (SCDNR)
Reviewed and Edited (2012): Steve Fields (Culture and Heritage Museums)

DESCRIPTION

Taxonomy and Basic Description


Photo by SCDNR

Appalachian cottontails were recently described by Chapman, Cramer, Deppenaar, and Robinson in 1992. The species was previously known as New England cottontail (*Sylvilagus transitionalis*) but was reclassified to Appalachian cottontail (*Sylvilagus obscurus*) based on chromosome number and exacting skull measurements. Ruedas et al. (1989) described the southern cytotype, now known as the Appalachian cottontail (Chapman et al. 1992), as having a smaller diploid chromosome compliment than the northern cytotype (the New England cottontail) (46 and 52, respectively). Although analysis of a region of mitochondrial DNA does not support the new species designation (Litvaitis et al. 1997), the Integrated Taxonomic Information System (USDA 2005) recognizes the new designation.

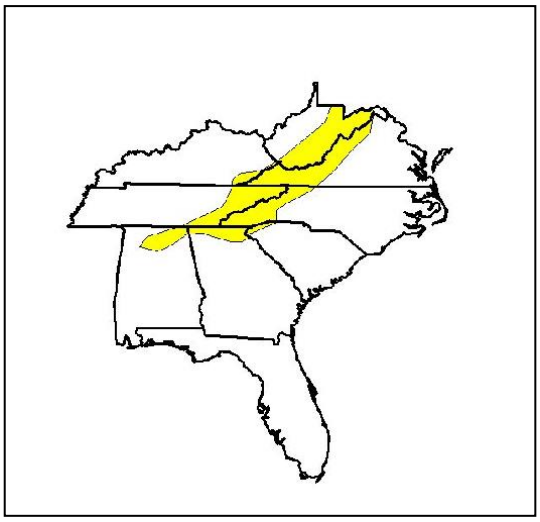
New England and Appalachian cottontails are indistinguishable without cranial examination or karyotyping (Chapman et al. 1992). The two are distinguished in the field by geographical location rather than by external features; those that occur south or west of the Hudson River in New York are Appalachian cottontails.

As with all "cottontails," including the sympatric Eastern cottontail (*Sylvilagus floridanus*), the underside of the Appalachian's tail is white. The fur is rusty-brown with black hairs. There are seldom any white hairs on the forehead and the ears are somewhat rounded (Chapman 1975) and less 'mulish' in appearance than Eastern cottontails. Sometimes the anterior ear margin is black or very dark in sharp contrast to the white hairs inside. Eastern cottontails have a rusty orange patch at the nape of the neck and often have the appearance of a dark saddle across their backs (Chapman 1975); the Appalachian cottontail has a reddish nape patch but is more uniformly dark. Live specimens have a very dark iris relative to Eastern cottontails (Bunch and Dye 1999). Appalachian cottontails have a diffuse gray cheek patch, lacking in the Eastern cottontail. The most reliable characteristic to distinguish Appalachian from Eastern cottontails is the presence of a dark patch between the ears in Appalachian cottontails (Litvaitis et al. 1991; Chapman et al. 1992). These differences between the Eastern and Appalachian cottontails are so subtle that identification usually requires handling of the animal. These two species are easily distinguished by skull characteristics (Chapman 1975).

The Appalachian cottontail is the smallest rabbit species in the southeast; adults weigh 0.8 to 1.1 kg (1.75 to 2.42 lbs.). They range in total length from 386 to 430 mm (15.5 to 17 in.), with an average ear length of about 58 mm (2.3 in.) (Chapman 1975). Weights of South Carolina specimens in the Campbell Museum of Natural History at Clemson University average 1.05 kg (2.32 pounds).

Status

In South Carolina, Appalachian cottontails are considered uncommon or rare and therefore vulnerable (S3). They are also considered rare in Georgia (Ozier 1999), Tennessee and North Carolina (NatureServe 2013). The Appalachian cottontail is still listed as apparently secure globally (G4). The fact that populations that occur in South Carolina are at the limit of the range of the species increases the responsibility of SCDNR to monitor the status of the population. Any changes to the viability of the species might likely occur on the periphery of its range.



POPULATION SIZE AND DISTRIBUTION

Appalachian cottontails occur in mountain habitat and range from the Hudson River in New York, southward through Pennsylvania and Maryland, and continue southward in the Appalachian Mountains into northwestern South Carolina, northern Georgia and Alabama. Appalachian cottontails are better adapted to colder climates than Eastern cottontails (Chapman et al. 1977). The Blue Ridge escarpment represents the extreme southeastern extent of the range for Appalachian cottontails.

The noncontiguous arrangement of Appalachian cottontails in the southeast is described as a mosaic distribution (Chapman et al. 1992). In South Carolina, the species is found only in the mountains of the three northwestern counties at elevations as low as 274 m (900 ft.), but more typically above 487 m (1600 ft.) (Bunch and Dye 1999). The Blue Ridge Mountain province in South Carolina has elevations between 365 and 1066 m (1,200 and 3,500 ft.) above sea level (Myers et al. 1986). Appalachian cottontails are restricted to the southern Appalachian ecoregion in South Carolina, which comprises only 1.7% of the state's total land area (Myers et al. 1986).

Distribution is patchy across the mountains of Oconee, Pickens and Greenville Counties. Suitable habitat is not uniform and continuous throughout the mountains. However, the Appalachian cottontail does not occur in all suitable mountain habitats. Some sites that appear suitable based on cover, forage, and elevation are occupied by Eastern cottontails, both Eastern and Appalachian cottontails, or no rabbits at all. Therefore, estimates of Appalachian cottontail populations cannot be extrapolated using remote sensing such as aerial photographs to identify habitat.

Density estimates have not been made for this rabbit in the southern end of their range; however, densities in South Carolina are expected to be similar to those found in other states. A density estimate from Virginia approximates one rabbit per two hectares in six to seven year-old clearcuts (Blymer 1976). Laseter (1999) estimated a density of 0.8 rabbits per hectare in eastern Tennessee. In western Maryland, home ranges are identified as 2 to 10 hectares (4.9 to 24.7 acres) for females and 4 to 9 hectares (9.9 to 22.2 acres) for males (Sommer 1997).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Ericaceous cover (heath-like plants) is a component of all sites occupied by Appalachian cottontails in the state (Bunch et al. 1997), which is consistent with previous reported requirements (Chapman et al. 1992). The cover varies and includes mountain laurel (*Kalmia latifolia*), blueberries (*Vaccinium* spp.), blackberry vines (*Rubus* spp.), greenbriar (*Smilax* spp.) and cane (*Arundinaria gigantea*). Sites with Appalachian cottontails range from ridgetops of pine-heath communities to mixed pine hardwoods and extend down slopes into riparian sites (Paul and Quay 1963). Forest or stand ages vary and include young clearcuts and pine plantations less than 4 years old; overstocked pine plantations approaching thinning age; and mature pine, pine-hardwood and hardwood forests (Bunch et al. 1997; Bunch and Dye 1999). Appalachian cottontails have not been noted in pastures, orchards or wildlife plots, but have been captured near the edges of linear food plots. Sole (1999) reported captures at reclaimed mine sites.

Good rabbit habitat is not thoroughly understood. Reproduction and rabbit health have been linked to salt availability (McCready and Weeks 1992), stem density and quality (Lochmiller et al. 1995) and availability of cover (Barbour and Litvaitis 1993; Smith and Litvaitis 2001). Appalachian cottontails require dense understory vegetation (Laseter, 1999). Appalachian cottontails consume more forbs and are less dependent on grasses than Eastern cottontails. However, both rabbits eat significant amounts of woody material in the winter (Spencer and Chapman 1986).

CHALLENGES

Due to regional differences between habitats in the southern Appalachian mountains and the New England area, management needs for the Appalachian cottontail are likely very different from management needs for the New England cottontail. Therefore, lack of species-specific makes it difficult to successfully manage for the Appalachian cottontail.

Small patch size (less than 2.5 hectares or 6.1 acres) and habitat fragmentation are known to lead to low survival rates of New England cottontails (Barbour and Litvaitis 1993). Habitat fragmentation, often due to development, may limit Appalachian cottontails to public lands with extensive private inholdings and to areas where large public tracts are separated by private holdings; such areas currently exist in northeastern Greenville County.

Indirect displacement by Eastern cottontails is a possible threat, particularly where both species are found sympatrically and permanent clearing takes place for pastures, lawns, orchards, golf courses and housing developments. Eastern cottontails benefit more from grasses (Spencer and

Chapman 1986) and large grassy areas than Appalachian cottontails; the latter needs more cover (Litvaitis et al. 1985; Barbour and Litvaitis 1993; Sommer 1997). Although Eastern cottontails are not capable of evicting New England cottontails from occupied habitats and vice versa (Probert and Litvaitis 1996), once habitats are modified to favor Eastern cottontails and they move into the site, it is unlikely that New England cottontails will displace them. Because Appalachian cottontails are similar to New England cottontails behaviorally and in cover and habitat requirements (Tefft and Chapman 1987; Probert and Litvaitis 1996), they are expected to respond similarly.

Hunting is not known to adversely affect the species in South Carolina; however, pregnant and lactating rabbits have been captured in February before the end of hunting season on March 1. Species-specific rabbit hunting data are not currently collected, and small game hunting pressure is believed to be light in the mountains. It is currently legal to possess and move all native rabbit species in the state of South Carolina. However, release of Eastern cottontails into habitat of Appalachian cottontails remains a threat of undetermined proportion or likelihood. Historically, moving and releasing rabbits was a common practice (Chapman and Fuller 1975). Once Eastern cottontails are established, they cannot be displaced via interspecific competition. Eastern cottontails can colonize neighboring disturbance patches more quickly than Appalachians because the latter requires dense cover in close proximity while Eastern cottontails are well adapted to foraging in open areas (Smith and Litvaitis 2000). Therefore, the Eastern cottontail more easily accesses new habitat (Probert and Livaitis 1996).

Cottontails are taken by a wide variety of predators including cats, dogs, coyotes, foxes, bobcats, mink, weasels, birds of prey and snakes. Any activity that increases the density of predators, or any changes in habitat that make Appalachian cottontails more vulnerable to predation (Litvaitis and Villafuerte 1996), are a threat.

CONSERVATION ACCOMPLISHMENTS

The species was first documented in South Carolina by a 1940 museum specimen collected by W. Perrygo and J. Hoyt. In the 1980's, the South Carolina Department of Natural Resources (SCDNR), initiated survey work with Check for Wildlife funds to verify the species' presence in South Carolina.

SCDNR tested a discriminate model developed by Litvaitis et al. (1991) for field identification of Appalachian (then known as New England) cottontails. Identifications were confirmed by mtDNA analysis and skull characteristics. The model was 77.7% accurate on southeastern specimens. One consistent external feature was the black spot or strip between the ears in Appalachian cottontails (Bunch and Dye 1999).

A study was conducted in the Sumter National Forest to assess whether Appalachian cottontails would be displaced after timber harvest in a mature pine-hardwood forest. This forest was adjacent to or near two habitats: a young clear cut and an orchard, which were occupied by Eastern cottontails. The mature pine-hardwood stand was cut and burned. Eastern cottontails used the site as it regenerated, and Appalachian cottontails did not reappear at the site until seven years after site regeneration (Bunch and Dye 1999).

In South Carolina, a significant amount of appropriate Appalachian cottontail habitat in the southern Appalachian ecoregion is on public land or is otherwise protected, including the Andrew Pickens Ranger District of the Sumter National Forest, ten Heritage Preserves, and the Jocassee Gorges; the latter is managed by SCDNR. Suitable habitat is also on several large state parks and some tracts owned or held in easement by various land trusts, including over 12,140 ha (30,000 acres) of mountain land under a conservation easement held by The Nature Conservancy. Over 65,559 ha (162,000 acres) of mountain lands are protected in some capacity.

CONSERVATION RECOMMENDATIONS

- Encourage land acquisitions or conservation easements which will provide mountain habitat linkage. Consider regional partnerships for habitat protection in the Blue Ridge Escarpment.
- Discourage or avoid creation of new, permanent, early successional habitat on mountain sites on public lands adjacent to existing populations of Eastern cottontails until the impact of Eastern cottontails on Appalachian cottontails is better understood.
- Evaluate the impact of hunting on Appalachian cottontails. Breeding condition should also be noted in harvested animals to evaluate seasons and bag limits. If rabbit identification by hunters is unreliable, heads and tissue samples can be collected and used to improve accuracy.
- Conduct an ecoregion-wide Appalachian cottontail distributional and density survey using mtDNA analysis of fresh fecal pellets.
- Partner with states throughout the entire range of both Appalachian and New England cottontails to provide materials and samples for expanded mtDNA analysis of these rabbit populations and support nuclear genome analysis for these species.
- Determine best management practices for Appalachian cottontails in the southeast through habitat measurements and manipulations.
- Measure the effectiveness of salt licks and fertilizing sites on Appalachian cottontail condition and reproduction.
- Evaluate prescribed burning as a tool for proper habitat management.
- Periodically survey selected sites for Appalachian and Eastern cottontails.
- Discourage moving and releasing Eastern cottontails.
- A demonstration area for Appalachian cottontails could be developed in the mountains in conjunction with efforts to highlight other species of conservation concern in South Carolina. This demonstration area would also provide research opportunities for new information on management and ecological needs of the species.
- Develop web links and educational materials to help educate the public about wildlife diversity, especially that of rabbits, in the mountain ecosystems.

MEASURES OF SUCCESS

Surveys of distribution and density, paired with long-term monitoring of harvests and use at specific sites will help assign status information to the species and set appropriate harvest limits and seasons. Researching the effects of controlled burns and supplemental salt will help public and private landowners know if those actions will benefit Appalachian cottontails.

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Swamp Rabbit

Sylvilagus aquaticus

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Reviewed & Edited (2012): Steve Fields (Culture and History Museums)
Reviewed & Edited (2024): Stephen Harris (Clemson University), David Jachowski (Clemson University), Michael Hook (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

The swamp rabbit, *Sylvilagus aquaticus*, was first described by Bachman in 1837. Swamp rabbits, or "cane-cutters", are the largest species of rabbit in the southeastern United States. These rabbits range in total length from 452 to 552 mm (17.8 to 21.7 in.) and range from 1900 to 2700 g (4.5 to 6 lbs.) in weight (Chapman and Feldhamer 1981; Webster et al. 1985). Weights of South Carolina specimens in the Campbell Museum of Natural History at Clemson University range from 1700 to 2300 g (3.74 to 5.07 lbs.).



Swamp rabbit, © Clayton Bownds (CC BY-NC)

The fur of swamp rabbits is rusty-brown with black hairs, giving the animals a grizzled appearance. Similar to the eastern cottontail (*Sylvilagus floridanus*) and the Appalachian cottontail (*Sylvilagus obscurus*), the underside of the tail is white. This differs from the bluish gray tail of the marsh rabbit (*Sylvilagus palustris*).

Status

In South Carolina, these rabbits are considered vulnerable (S3) due to habitat loss and limited habitat availability. In Alabama and neighboring Georgia, the swamp rabbit is ranked as secure (S5), while in Tennessee the species is apparently secure (S4; NatureServe 2024). The Global Heritage Rank is secure or G5 (NatureServe 2024), yet data from several states, including Arkansas, Missouri and Kentucky, indicate populations are imperiled due to loss of habitat (Platt and Bunch 2000) and range shrinkage (Sealander and Heidt 1990; Schwartz and Schwartz 1981; Sole 1994).

POPULATION SIZE AND DISTRIBUTION

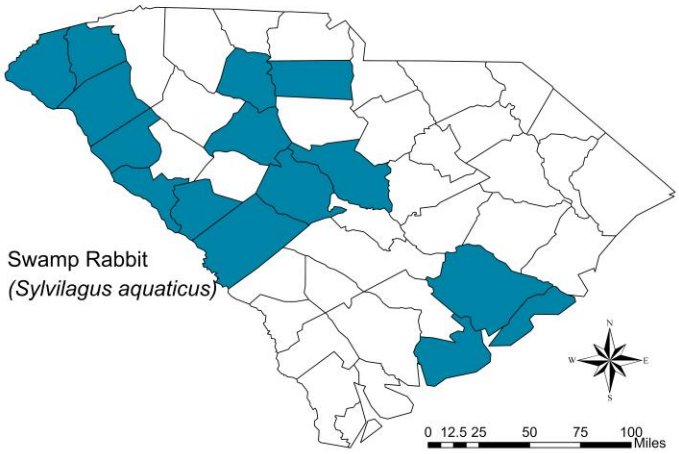


Figure 1: Distribution of the swamp rabbit in South Carolina

Swamp rabbits are distributed from the Gulf of Mexico, northward along the Mississippi River to Illinois and Indiana, eastward to the western Piedmont of South Carolina, and westward to east Texas and Oklahoma (Chapman and Feldhamer 1981). In South Carolina, most occurrences are in Anderson, Oconee, and Pickens Counties in the Savannah River drainage of the western Piedmont region (Platt and Bunch 2000). Recent surveys conducted from 2021–2023 documented swamp rabbits in Abbeville, Aiken, Anderson, Charleston, Edgefield, Lexington, McCormick, Newberry, Oconee, Pickens, Richland, and Union Counties (Figure 1), suggesting a more extensive distribution than previously thought (S.N. Harris, Clemson University, unpub. data, 2024). There is also one confirmed historical record from York County (Platt and Bunch 2000) and unverified reports from Chesterfield, Greenville, Kershaw, Marlboro, and Orangeburg Counties (Golley 1966); M. Hook, SCDNR, unpub. data, 2024). It is unclear whether disjunct records east and south of the bulk of confirmed records represent historically-occurring populations or more recent range expansions.

Swamp rabbit population size and density estimates are unavailable for South Carolina. In a Georgia floodplain, swamp rabbits had an average maximum home range of 7.6 hectares (18.9 acres) and a density of 0.14 animals per hectare (0.05 animals per acre) (Lowe 1958). Home ranges in Missouri average 1.82 to 2.43 hectares (4.5 to 6 acres) (Schwartz and Schwartz 1981). An occupancy probability at potential swamp rabbit locations derived from visual pellet surveys in South Carolina was 0.32 (S.N. Harris, Clemson University, unpub. data, 2024). Results from this study also indicated that swamp rabbits persisted at 83% of sites with previous swamp rabbit records that the researchers were able to visit.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

As indicated by their common name, swamp rabbits tend to be found in close proximity to water. In some parts of its range, the species is considered a bottomland hardwood forest specialist, and thus an indicator species for the quality of this ecosystem (Hilliard et al. 2017). The home range of swamp rabbits in Indiana is limited to within two kilometers (1.24 miles) of water (Terrel 1972); this is likely to hold true throughout the entire range for this species. In South Carolina, habitat varies from swamps and wet scrub/shrub land to forested bottomlands. Swamp rabbits are often associated with, but not restricted to canebrakes dominated by switchcane (*Arundinaria gigantea*) (Platt et al. 2001). A recent study in the state found that swamp rabbit occupancy was positively associated with proximity to emergent herbaceous or woody wetlands and lower percentages of tree canopy cover, the latter potentially highlighting the importance of open,

sunny areas with herbaceous vegetation to the species (S.N. Harris, Clemson University, unpub. data, 2024).

Korte and Fredrickson (1977) reported that viable swamp rabbit populations require contiguous habitat in areas exceeding 100 ha (247.1 acres); however, Sole (1994) suggests that this figure needs to be re-evaluated. Sole found that in Kentucky, about one third of the occupied habitat was in woodlots less than 100 ha in size that were sometimes isolated or connected by narrow bands to other suitable habitat.

Logs, stumps and tree falls are an important component of swamp rabbit habitat. These structures are used for latrine sites, resting cover, and nesting (Zollner et al. 2000a; Platt and Rainwater 2001). Like all of South Carolina's rabbits, swamp rabbits prefer dense thickets that provide suitable cover.

CHALLENGES

Hydrologic changes that result from flooding associated with dam construction and filling, channelization, ditching, and draining of wetlands are well-recognized challenges to swamp rabbit populations throughout their range. In South Carolina, a significant portion of swamp rabbit habitat was inundated by the construction of Lake Hartwell. Habitat is also lost as a result of pond construction, urban development, road construction and land clearing for agricultural activities. Two sites reported by Platt and Bunch (2000) along U.S. 123 have since been destroyed by urban development.

Because swamp rabbits inhabit floodplains and wetlands, they are vulnerable to flooding. Floods during the breeding season can be especially deleterious to populations. Although flooding is a natural phenomenon, urban development tends to alter natural floodplains, resulting in more frequent and, often, more severe flooding than is usually expected (C. Gawne and Lee Mitchell, personal communication, 2004). As stated above, hydrologic changes will result from urban development, and Upstate South Carolina, where the majority of swamp rabbit records come from, is currently experiencing rapid growth in human population (i.e., a 10.7% increase between 2010 and 2020; U.S. Census Bureau 2021). An unpublished study conducted by SCDNR demonstrated a four-fold increase in development for every one-fold increase in population between 1983-1998 (Richard Lacy, personal communication, 2004). For this study, development was measured by impermeable surfaces such as pavement and buildings. This increase in flow to rivers and streams often results in erosion of streambeds. Once this erosion begins, the streams and rivers become vulnerable to flash flooding.

The impact of hunting on swamp rabbits has not been determined. Swamp rabbit populations on small tracts of land and those isolated by development or well-traveled roads tend to preclude the use of hunting dogs, thereby reducing the threat of hunting. Current data collected from rabbit hunting does not require hunters to distinguish the rabbit species that was taken.

Most of the suitable swamp rabbit habitat in South Carolina is on private land. Therefore, the future of the species in South Carolina and throughout much of its range largely depends on the

stewardship of private lands (Sole 1994). It is important that the landscape and local flooding history be a consideration in site protection design (Zollner et al. 2000b).

There is some evidence that swamp rabbits at the periphery of their range occur in a metapopulation of smaller, isolated subpopulations (Roy Nielsen et al. 2008). As South Carolina represents the eastern extent for this species, it is possible that swamp rabbits in the state have a metapopulation structure, meaning naturally-disjunct subpopulations are at greater risk of localized extinction.

Rabbit haemorrhagic disease virus type 2 is an emerging pathogen with a high mortality rate (USDA-APHIS 2024) that has been documented in domestic rabbits and in wild lagomorphs in the western United States (Asin et al. 2022). However, no outbreaks in wild lagomorphs in the eastern United States have yet been reported.

CONSERVATION ACCOMPLISHMENTS

The U.S. Army Corps of Engineers designed and constructed Lake Hartwell. Because their boundary line follows the approximate 204 m (670 ft.) contour around Lake Hartwell, some swamp rabbit habitat along creeks and rivers flowing into the lake was protected during development of the lake. Other public lands that offer protection for the swamp rabbit include U.S. Forest Service, SCDNR, and Clemson University properties.

CONSERVATION RECOMMENDATIONS

- Partner with private and public landowners to maintain swamp rabbit habitat via whatever means are available, including but not limited to acquisitions, conservation easements, designations of green spaces, and encouragement of stewardship by private landowners.
- Partner with federal agencies, such as the Army Corps of Engineers, the Natural Resources Conservation Service, and the U.S. Fish and Wildlife Service, to protect more wetland habitat.
- Evaluate the impact of hunting on swamp rabbit populations and improve collection of harvest data from rabbit hunters.
- Partner with hunters to collect habitat information for the swamp rabbit.
- Estimate the amount of habitat necessary to sustain a viable population of swamp rabbits.
- Conduct surveys of suitable habitat in the Southeastern Plains and Middle Atlantic and Southern Coastal Plain ecoregions to determine how far east and south the swamp rabbit's range extends in the state.
- Determine swamp rabbit density within selected study populations and determine population size estimates based on available habitat.
- Evaluate the genetic makeup and health of swamp rabbit populations in the state (genetic diversity, gene flow, metapopulation status, etc.)
- Communicate with other agencies and engage with new scientific literature to monitor for pathogen outbreaks and epizootics that may adversely affect swamp rabbits in South Carolina.
- Monitor suitable swamp rabbit habitat by aerial photography over regular intervals.

- Produce brochures and web links to better educate South Carolinians on this unique species of rabbit.
- Where possible, restore wetlands that exist within the range of the swamp rabbit. The restoration work could be used for public outreach, giving school groups or community organizations hands-on experience in wetland restoration. A recent successful example of this was conducted at Rocky River Nature Park, a known swamp rabbit site (S.N. Harris, Clemson University, unpub. data, 2024), where a volunteer workday was carried out in March 2024 to remove invasive species. Part of the pretext for this work was that a population of the "rare swamp rabbit" inhabited the park (https://www.upstateforever.org/events/58/volunteer-workday-rocky-river-nature-park-invasives-removal, accessed 2024 May 30).

MEASURES OF SUCCESS

Density estimates, paired with habitat information, will allow evaluation of the amount of potential habitat and remote assessment of habitat levels. The effectiveness of partnerships protecting wetlands and other properties that contain swamp rabbits can be assessed when paired with the monitoring of those populations.

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Shrews Guild

Masked Shrew (*Sorex cinereus*)
Eastern Pygmy Shrew (*Sorex hoyi*)
Smoky Shrew (*Sorex fumeus*)

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DESCRIPTION

Taxonomy and Basic Description


Masked Shrew. Photo by E.B. Pivorun

All shrews have long pointed snouts, short dense fur, and small eyes. The ears blend in well with the surrounding fur. The masked shrew was first named by Kerr in 1792 (Laerm et al. 2007*a*), the eastern pygmy shrew by Baird in 1858, and the smoky shrew by Kerr in 1792 (Laerm et al. 2007*b*). The eastern pygmy shrew and the masked shrew closely resemble each other; both are small with gray-brown fur on the back and a more faded version underneath. Both have distinctly bicolored tails, dark above and pale underneath, that are more than half the head and body length (Webster et al. 1985). In the summer, the eastern pygmy shrew has a reddish hue to its pelage, whereas the masked shrew has a brown hue. In contrast, the smoky shrew is slightly larger with dark gray to blackish-gray fur in winter and brownish fur in summer with a lighter hue underneath for both coats (Owen 1984). Similar to its congenerics, the smoky shrew also has a bicolored tail more than half the length of its head and body which is dark above and pale underneath (Laerm et al. 2007*b*).


Eastern pygmy shrew. Photo by Roger Barbour/ ATBI Program

Only one subspecies of masked shrew, *Sorex cinereus cinereus*, is found in South Carolina. The total length of this animal ranges from 80 to 111 mm (3.1 to 4.3 in.), including a tail of 34 to 48 mm (1.34 to 1.9 in.). Masked shrews weigh 3 to 5 g (0.10 to 0.17 oz.).

Eastern pygmy shrews are the smallest mammal in South Carolina, weighing only 2 to 4 g (0.07 to 0.14 oz.), about the weight of a dime (Webster et al. 1985). They range in total length from 70 to 96 mm

(2.7 to 3.8 in.; Ford et al. 2007). Tail length is 25 to 34 mm (0.99 to 1.34 in.). The most reliable distinguishing feature is a third upper unicuspid tooth (one with only one point) that is reduced when compared to preceding unicuspids. In shrews found sympatrically with eastern pygmy shrews, such as the masked shrew or the southeastern shrew (*Sorex longirostris*), the third upper unicuspid is similar in size to other unicuspids (Long 1974). *Sorex hoyi winnemana* is the only subspecies of eastern pygmy shrew known from the extreme southern range, including from within South Carolina (Diersing 1980). The eastern pygmy shrew was originally classified as *Microsorex hoyi*. Diersing (1980) subsequently determined that the species was more appropriately classified in the genus *Sorex; microsorex* was reclassified to a subgenus. [Note: North Carolina's Wildlife Action Plan lists the eastern pygmy shrew by subspecies and Georgia's Comprehensive Wildlife Conservation Strategy does not list it at all.]

Relatively large for a shrew, the smoky shrew (*Sorex fumeus)* weighs 6 to 10 g (0.21 to 0.35 oz.) and ranges in total length from 104 to 130 mm (4.09 to 5.11 in.) with a tail length of 37 to 52 mm (1.45 to 2.04 in; Laerm et al. 2007*b*). Their fur in summer is dark gray to brownish, and in winter is blackish gray. Only one subspecies of smoky shrew, *S. f. fumeus*, occurs in South Carolina (Laerm et al. 2007*b*).



Photo by Phil Myers, Museum of Zoology, University of Michigan-Ann Arbor; accessible on Animal Diversity Web

Status

The masked shrew, eastern pygmy shrew, and smoky shrew all have a global rank of secure or G5 (NatureServe 2024). This species is considered secure (S5) in the northern part of its range from Virginia north through the continental United States, through Canada and into Alaska (NatureServe 2024). The state rank for the masked shrew is imperiled (S2) in South Carolina and Georgia, and the species is listed as vulnerable (S3) in Kentucky but considered apparently secure (S4) in North Carolina and Tennessee (NatureServe 2024).

The eastern pygmy shrew is ranked as imperiled (S2) in South Carolina, Georgia, and Tennessee, as vulnerable (S3) in North Carolina, and as apparently secure (S4) in Virginia and Kentucky but is designated as critically imperiled (S1) in Alabama (NatureServe 2024).

The smoky shrew is listed as vulnerable (S3) in South Carolina and Georgia, as apparently secure (S4) in North Carolina and Tennessee, and as secure (S5) in Virginia and Kentucky, but is ranked as critically imperiled (S1) in Alabama (NatureServe 2024).

These species are considered of conservation concern in interest of maintaining the biological diversity of the state of South Carolina. Each species is indicative of habitats that are uncommon in the state and, therefore, provides an index of proper management of such habitats.

POPULATION SIZE AND DISTRIBUTION

South Carolina's mountains represent the southeastern most extent of masked, eastern pygmy, and smoky shrew distribution. The masked shrew extends into Alaska and western Canada, ranging into the Rocky Mountains, while all three species occur in eastern Canada and across much of the Great Lakes region, New England, and down the Appalachians to northern Georgia and South Carolina (Figures 1 and 2). The eastern pygmy and smoky shrews' ranges extends

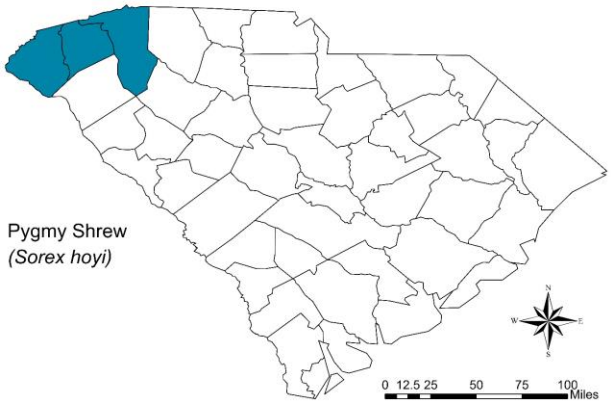


Figure 1. Distribution of the eastern pygmy shrew in South Carolina

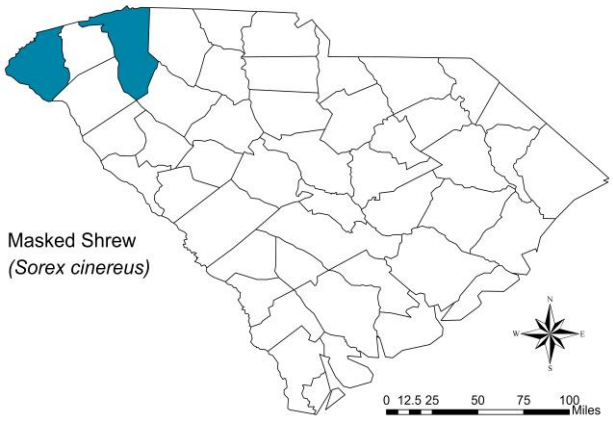


Figure 2. Distribution of the masked shrew in South Carolina

westward into Alabama (NatureServe 2024). Masked shrews are at the extreme edge of their range in Georgia and South Carolina. Here, they are uncommon and found only at high elevations or in sheltered coves (Ford et al. 1994; Laerm et al. 1995).

Though there are no recent records of the smoky shrew in South Carolina, historical records of this species exist in Oconee, Pickens and Greenville Counties (South Carolina Heritage Trust 2024).

There are no population estimates available in the southern Appalachians for the eastern pygmy, masked, or smoky shrew.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Masked, eastern pygmy, and smoky shrews are restricted to the southern Appalachian (Blue Ridge) Ecoregion in South Carolina. Within that ecoregion, masked and eastern pygmy shrews show some overlap in habitat; both species use mesic mixed forest, mesic deciduous hardwood, dry deciduous forest, and eastern hemlock ravine forests. The smoky shrew prefers mesic deciduous hardwood forests and moist coniferous or mixed forests (Laerm et al. 2007*b*). Masked and smoky shrews are more selective in their southern habitats and tend to use more northern-type communities like high elevation sites (Laerm et al. 2007*a*, 2007*b*). The eastern pygmy

shrew is rather prevalent throughout most mountain habitats (Ford et al. 2007; Laerm et al. 2007*c*). Masked shrews use sites with thick understory, high soil moisture, and high organic matter (Brannon 2000, Laerm et al. 2007*a*). Features like logs, stumps, rocks, and dense leaf litter are often components of masked and smoky shrew habitat (Laerm et al. 2007*a*, 2007*b*). Masked, eastern pygmy, and smoky shrews are not sensitive to timber harvest or prescribed burning in the central Appalachians provided that moist conditions with abundant ground structure remain (Ford et al. 2007; Laerm et al. 2007*b*).

Shrews are beneficial mammals in that they eat many grubs and larvae, which are often pest species (Merritt 1987). Predators of the masked, pygmy, and smoky shrew include domestic and feral cats and dogs, hawks, owls, foxes, coyotes, weasels and snakes. None of these predators are currently reported to be major threats to these species' survival.

CHALLENGES

In South Carolina, a large portion of the habitat in the Appalachian ecoregion that is appropriate for masked, eastern pygmy, and smoky shrews is on public land which includes National Forests, State Parks, Nature Conservancy properties, and DNR managed properties. None of these properties were purchased specifically to protect these shrews; however, these species benefited from acquisition and protection of habitat. While these protected areas provide needed habitat, populations on private lands are still threatened by land conversion. Land development in the southern Appalachians represents a major threat to masked, eastern pygmy, and smoky shrews. Land use in this region is rapidly changing from rural/agricultural to urban. An unpublished study conducted by SCDNR showed a 4-fold increase in development to every one-fold increase in population between 1983 and 1998 (Richard Lacy, personal communication). Increased predation from domestic cats and dogs, direct displacement from development, and limited movement across roads that form barriers are expected as development increases in the southern Blue Ridge Mountains.

Shrews and some other rodent species are readily found dead in discarded glass and plastic uncapped bottles; sometimes multiple animals are trapped in a single bottle. Therefore, unnecessary losses associated with refuse entrapment represent one of the challenges that litter poses to the ecosystem.

Destruction of hemlock forests by the exotic hemlock wooly adelgid (*Adelges tsugae*) may also impact local masked shrew populations (Laerm et al. 2007*a*). It is important that entire hemlock-associated communities be sampled and monitored at permanent plots in order to measure effects of hemlock wooly adelgid infestations and to evaluate the effectiveness of recent releases of exotic predatory beetles to control the infestation (Conway and Culin 2004).

CONSERVATION ACCOMPLISHMENTS

As previously mentioned, a large portion of the South Carolina habitat in the Blue Ridge ecoregion that is appropriate for masked, eastern pygmy, and smoky shrews is on public land which includes National Forests, State Parks, Nature Conservancy properties, and DNR managed properties.

CONSERVATION RECOMMENDATIONS

- Re-examine current state rankings for masked, eastern pygmy, and smoky shrews. Adjust those rankings based on any new surveys as appropriate.
- Conduct ecoregion-wide surveys to determine masked, eastern pygmy, and smoky shrew distribution and density. All capture data should be shared with neighboring states.
- Consider partnerships that can help educate the public that litter can be extremely harmful to native wildlife.
- Encourage various groups to increase litter removal.

MEASURES OF SUCCESS

As research and management needs are identified, projects should be proposed and prioritized by those with the greatest conservation applicability. Surveys and density estimates in the southern region should provide population estimations that will be used to more accurately rank the species and prioritize future management needs. The effectiveness of anti-litter campaigns can be readily verified by the amount of trash removed before and after the projects.

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Eastern Spotted Skunk
Spilogale putorius

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DESCRIPTION

Taxonomy and Basic Description



Photo by Roger Barbour (ATBI, Smoky Mountains National Park)

The eastern, or Alleghanian, spotted skunk is smaller than the more common striped skunk (*Mephitis mephitis*). The spotted skunk ranges from 0.5 to 1.8 kg (1 to 4 lbs.) in weight and from 250 to 688 mm (10 to 27 in.) in overall length (Crabb 1944; Hall and Kelson 1959; Walker 1964; Patton 1974). Males are approximately 10% larger than females (Van Gelder 1959). Pelage is typically dark black with 4 to 6 broken white stripes, which give the animal the appearance of being spotted. An inverted, white, triangle-shaped nose patch is usually present and is separate of the broken white stripes. The fur is denser and finer than that of the striped skunk (Zeiner 1975).

Spotted skunks breed in late winter or early spring and may delay implantation for up to two weeks. Gestation lasts 45 to 60 days. One litter per year generally produces one to six young. Young are born from April through July and are weaned by about 8 weeks of age; May and June are the peak breeding months for this species (Contantine 1961).

Like other members of the genus, eastern spotted skunks have well-developed scent glands that are often used for defense. The paired anal glands are located in nipples just inside the anus. Musk is discharged after the nipples protrude through the anus as the tail is elevated (Crabb 1948). One of the more curious behaviors displayed by the spotted skunk is a headstand that is used in defensive posturing. The skunk will move towards the threat, balance itself on its forelegs and direct the anal sacs towards the opponent (Johnson 1921).

Status

Eastern spotted skunk populations have declined since at least the mid-1900s (Gompper and Hackett 2005). State NatureServe rankings indicate that the species is not secure in the states it is known to occur in (NatureServe 2024). It is currently ranked as critically imperiled in Maryland and Mississippi (S1) and imperiled (S2) in Pennsylvania, South Carolina, and West Virginia. The species is considered vulnerable and/or imperiled (S2S3) in Alabama and Kentucky).

Additionally, the International Union for Conservation of Nature (IUCN) Red List status for the species is Vulnerable and a decreasing population trend is noted (Gompper and Jachowski 2016).

POPULATION SIZE AND DISTRIBUTION

The eastern spotted skunk's range extends from southern Pennsylvania, down the Appalachian Mountain range and into Florida, with a portion of the eastern edge of its range encompassing the western portion of South Carolina (Figure 1). Unlike the striped skunk, which has a more uniform distribution within its geographic range, the spotted skunk is typically more localized in its distribution (Perry et al. 2021).

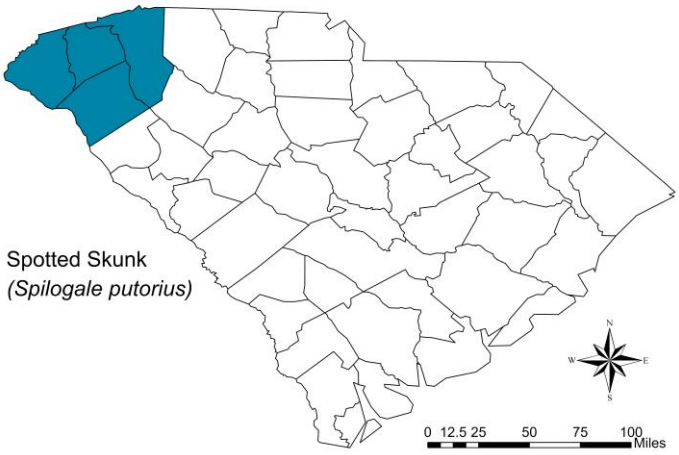


Figure 1: Distribution of the spotted skunk in South Carolina

The eastern spotted skunk is known primarily to persist in the Blue Ridge Mountains of Upstate South Carolina, with a majority of records within the past 10 years coming from Oconee, Pickens, and Greenville Counties. Little is known about its distribution throughout the Piedmont, though there is a recent observation from Anderson County. Historical records (>40 years ago) exist for Aiken, Edgefield, and Richland Counties. No recent observations have occurred in the Coastal Plain, despite the species commonly occurring in coastal environments in Florida (Kinlaw et al. 1995). Little is known about the population size and extent of the spotted skunk's distribution in South Carolina, although the infrequent rates of detection in structured camera surveys suggest they occur at low densities relative to other furbearers.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

In the Appalachian Mountains, eastern spotted skunks are found in both young/early-successional forest stands (Eastern Spotted Skunk Cooperative Study Group 2020) as well as mature forest stands at higher elevations (Thorne et al. 2017). Regardless of stand age, they prefer dense understory cover and coarse woody debris (Reed and Kennedy 2000, Diggins et al. 2015, Wilson et al. 2016, Thorne et al. 2017, Eng and Jachowski 2019*a*). A study in the Blue Ridge Mountains of South Carolina showed spotted skunk occupancy probability decreased with increasing elevation, suggesting that lower elevation habitats in the Upstate could be occupied by this species (Eng and Jachowski 2019*a*).

Dens are important requirements for eastern spotted skunks as they are used as protection from weather and predators (Crabb 1948). Multiple studies have demonstrated that cover (e.g., canopy cover, understory cover) and coarse woody debris are important factors in den site selection in the Appalachian Mountains (Sprayberry and Edelman 2018, Eng and Jachowski 2019*b*, Hassler et al. 2021, Thorne and Ford 2022, Siegfried et al. 2023). The presence of rocks (e.g., rock

outcrops; Hassler et al. 2021, Thorne and Ford 2022) and proximity to drainage channels (Eng and Jachowski 2019*b*) have also been positively correlated with skunk den site selection in the Appalachian Mountains.

CHALLENGES

A diverse suite of threats likely limit eastern spotted skunks in South Carolina. Upstate South Carolina is one of the fastest-growing regions in a state that that is currently outpacing the percent change seen in resident human population of the United States as a whole (U.S. Census Bureau), so habitat for spotted skunks will likely continue to be fragmented or entirely lost. As natural areas are transformed to developed areas, skunk populations are expected to decline. Because skunks prefer dense cover and such areas are generally not found in developed areas, habitat loss will lead to these population declines.

Conversion of small-scale farms to larger industrial operations and refinement of agricultural practices have had a negative effect on eastern spotted skunks (Gompper and Hackett 2005, Eastern Spotted Skunk Cooperative Study Group 2019). Similarly, the maturation of early-successional forests has likely led to the species' decline as it loses the dense woody cover associated with these forest stands (Eastern Spotted Skunk Cooperative Study Group 2020). In fact, a 37% decline in suitable area for the species since its decline in the mid-1900s has been suggested (Cheeseman et al. 2021).

Spotted skunks, as one of the smallest carnivores, are also sensitive to the presence of other carnivores in the systems they occupy (Jachowski et al. 2024). As human development changes the abundance of larger carnivores in these systems, it is likely these processes have cascading effects on spotted skunks and deserve future research attention.

Further, humans tend to be very intolerant of skunks due to the animals' defensive behaviors. Skunks that do not attempt to relocate as development occurs are likely to be considered nuisance wildlife and may be removed or destroyed as development continues.

An outbreak of canine distemper that killed half of the study population of eastern spotted skunks in a recent study in western North Carolina (Harris et al. 2021) highlights the possible detrimental effects of cyclical or novel epizootics on small or isolated populations. Spotted skunks are also known to be sensitive to a diversity of other diseases, although the population-level impacts of these diseases is poorly understood (Eastern Spotted Skunk Cooperative Study Group 2020).

Also, anticoagulant rodenticide exposure has not been documented in spotted skunks thus far, but morbidity or mortality due to exposure has been documented in imperiled carnivore species in North America and globally (Keating et al. 2024). More information is needed on the potential threat rodenticides may pose to eastern spotted skunks as rodents are known to be an important food item (Crabb 1941).

CONSERVATION ACCOMPLISHMENTS

In South Carolina, considerable portions of the Blue Ridge ecoregion have been protected for conservation by federal and state agencies including SCDNR and the U.S. Forest Service. While these areas were not designated to further conservation of this species, they are largely dense forest areas that are used by spotted skunks.

The reporting requirements of the annual commercial fur harvest were modified so that trappers were asked to differentiate between striped and spotted skunks. It was hoped that this data would be utilized to evaluate long-term trends, but no one has yet to report spotted skunks in their harvests.

CONSERVATION RECOMMENDATIONS

- Manage forested lands for silvicultural treatments that retain understory vegetation and coarse woody debris.
- Determine population size and viability of resident spotted skunk populations in the Upstate.
- Determine the distribution, abundance, and habitat requirements of spotted skunks in the Piedmont and Coastal Plain of South Carolina.
- Continue camera trap-based monitoring of spotted skunk populations in the Upstate to determine long-term trends in occupancy, colonization and extinction.
- Educate residents that there are 2 different skunk species in South Carolina and there are beneficial aspects of spotted skunks; these animals are not killing poultry, getting into garbage cans, and are indicators of healthy and biodiverse ecosystems.

MEASURES OF SUCCESS

As research and management needs are identified, projects should be proposed and prioritized by those with the greatest conservation applicability. Within the upstate, research is needed on the abundance and population viability of resident spotted skunks. State-wide surveys and density estimates are needed to provide information on the current distribution of the species and prioritize future management needs.

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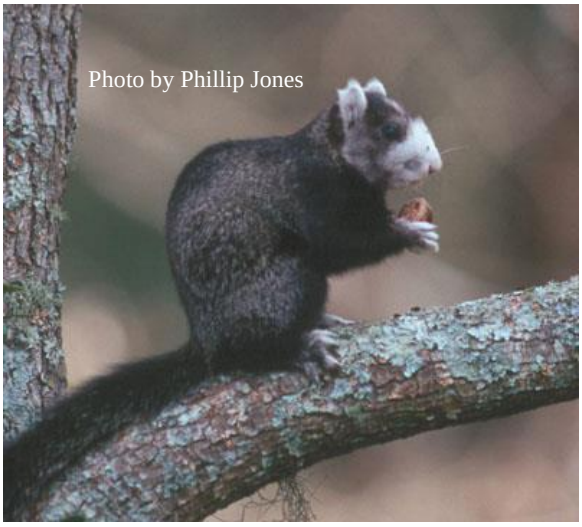
Southern Fox Squirrel

Sciurus niger niger

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DESCRIPTION

Taxonomy and Basic Description


Photo by Phillip Jones

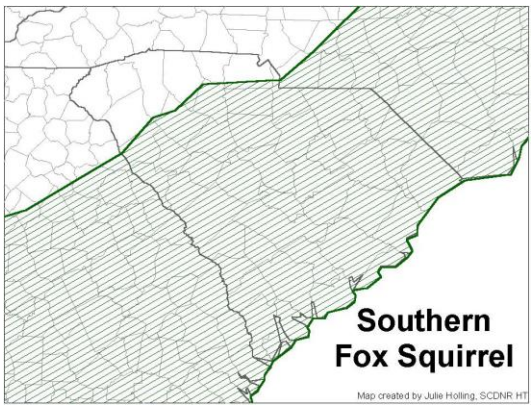
Fox squirrels (*Sciurus niger*) were first described by Linnaeus (1758); ten recognized subspecies exist throughout the United States. These arboreal mammals range in length from 450 to 698 mm (17 to 27.5 in.) and weigh 0.5 to 1.2 kg (17.6 to 42.3 oz.). Coloration varies greatly, both locally and regionally; this variation has resulted in subdivision into numerous subspecies (Hall 1981). Fox squirrel subspecies can be divided into two distinctive but intergrading coloration groups (Weigl et al. 1989). Six subspecies (*S. n. vulpinus*, *S. n. cinereus*, *S. n. niger*, *S. n. shermani*, *S. n. avicennia* and *S. n. bachmani*) have silver, gray, agouti (grizzled) and/or melanistic (black) pelage with tan, gold or reddish undersides. In this coloration group, animals have black head markings, white or gray noses, and white ears and feet. The other coloration group contains four subspecies (*S. n. vulpinus, S. n. subauratus, S. n. ludovicianus*, and *S. n. limitis*) that are characterized by a distinctly reddish, orange, or tan agouti (grizzled) pelage, a grizzled or black nose, and no white markings on the head or feet. Melanism is common in the southern portions of the range (Lowery 1974; Kiltie 1989; Roe 1994). However, Turner and Laerm (1993) concluded that pelage characteristics are too varied and subjective to permit consistent determination or subspecies in the southeastern portions of the range. The fox squirrel is readily distinguished from the smaller gray squirrel (*S. carolinensis*) by its larger size and presence of only a single pair of premolars in the upper and lower jaws.

Status

The eastern fox squirrel has state rank of apparently secure (S3S4) in South Carolina and a global rank of secure G5 (NatureServe 2024). However, it is listed as vulnerable (S3) in North Carolina and Alabama, as apparently secure (S4) in Virginia, and as secure (S5) in Arkansa, Florida, Georgia, Kentucky, Louisana, Mississippi, Oklahoma, Tennessee, and Texas. The Delmarva Peninsula fox squirrel (*S. n. cinereus*) is federally listed as endangered (US Department of Interior 2003). The fox squirrel is considered a game animal and its harvest seasons are regulated in all states in the southeast (Edwards et al. 2003). Concerns for the

conservation status of the southern fox squirrel are due to the lack of information on the distribution, abundance and ecology of the species.

POPULATION SIZE AND DISTRIBUTION



The southern fox squirrel (*Sciurus niger niger*) is the only fox squirrel native to South Carolina (Edwards et al. 2003). Populations are scattered across the South Carolina Coastal Plain, occur less often in the Piedmont (Wood and Davis 1981; Harrigal 1993), and are rare to absent in the Blue Ridge (Harrigal 1993). According to the 2024 SCDNR Biennial Fox Squirrel Survey Report Southern fox squirrels have been documented in every county in SC except Greenville and York counties. (Hook 2024) In Georgia the species is most common in the Coastal Plain and Piedmont and rare to absent in the Blue Ridge (Hilliard 1979; Turner 1988; Turner and Laerm 1993). Fox squirrels in North Carolina are restricted to the southeastern Coastal Plain south of the Pamlico River (Weigl 1987); although historical records indicate its former occurrence in the Piedmont and Blue Ridge (Lee et al. 1982), the fox squirrel is now rare to absent (Weigl 1987).

Fox squirrel populations east of the Appalachians and along the eastern Gulf Coast have been declining dramatically over the past 100 years (Doutt et al. 1977; Webster et al. 1985; Loeb and Lennartz 1989; Weigl et al. 1989; Humphrey and Jodice 1992, Loeb and Moncrief 1993; Conner et al. 1999). Density estimates in the southeast range from 0.1 to 75 per square km (0.2 to 185 per square acre) (Moore 1957; Hilliard 1979; Humphrey et al. 1985; Weigl et al. 1989; Tappe 1991; Tappe et al.1993; Lee 1999).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Southeastern fox squirrels select more pine-dominated habitats compared to the deciduous habitats selected by the midwestern subspecies (Weigl et al. 1989). In southern Florida, they occur in cypress swamps, tropical hardwood forests, live oak (*Q. virginiana*) forests, and mangrove forests (Humphrey and Jodice 1992). Throughout the lower Coastal Plain, fox squirrels occur in fire-maintained longleaf pine (*P. palustris*) turkey oak (*Q. laevis*) sand hills, pine flatwoods and associated bottomland habitat (Moore 1957; Williams and Humphrey 1979; Kantola 1992; Wooding 1997; Conner et al. 1999). The preferred habitat of fox squirrels in the sandhills and piedmont of the Carolinas, Georgia and elsewhere is mixed stands of longleaf, loblolly (*P. taeda*) and shortleaf pine (*P. echinata*), hardwoods and bottomlands (Taylor 1973; Hilliard 1979; Dueser et al. 1988; Edwards et al. 1989; Loeb and Lennartz 1989; Weigl et al. 1989; Loeb and Moncrief 1993). Throughout its range, parks, golf courses and residential areas may support substantial fox squirrel populations (Jodice and Humphrey 1992).

Fox squirrels use tree cavities and leaf nests both as refugia and for rearing young. Leaf nests occur in a variety of tree species including both hardwoods and pines. Fox squirrels use cavities

in a variety of tree species. Cavity use is greatest during winter and spring (Nixon and Hansen 1987; Edwards et al. 1989; Edwards and Guynn 1995). Hilliard (1979) and Weigl et al. (1989) suggested that the absence of suitable cavity trees might be a critical factor in litter survival and subsequent recruitment of fox squirrels in Georgia and North Carolina. However, others have found no evidence that an absence of cavities was limiting fox squirrels in Florida or Georgia (Kantola 1986; Edwards and Guynn 1995).

Throughout their range, fox squirrels produce two litters per year; breeding is concentrated in late winter/early spring and, to a lesser extent, in summer (Moore 1957; Hoffman and Kirkpatrick 1959; Harnishfeger et al. 1978; Weigl et al. 1989; Larson 1990). Reproductive success is highly variable and dependent on demographic and environmental factors such as availability and timing of food sources, availability of cavities, and weather (Nixon and McClain 1969).

The diet of the fox squirrel is diverse and varies seasonally and by region (Flyger and Gates 1982). Nuts, seeds, buds, and flowers of pines (*Pinus* spp.), oaks (*Quercus* spp.), hickories (*Carya* spp.), beech (*Fagus grandifolia*), walnut (*Juglans* spp.) and other available hardwood species like maple (*Acer* spp.) are major components of the squirrel's diet. Soft mast, such as dogwood (*Cornus* spp.), grape (*Vitis* spp.), persimmon (*Diospyros virginiana*) and cherry (*Prunus* spp.), various fruits, fungi, and insects are also eaten.

CHALLENGES

The widespread loss of preferred habitat, including mature, open pine-oak forests and associated bottomland and swamps is detrimental to fox squirrels throughout the southeast. Practices that have contributed to habitat loss include large-scale monocultural replacement of longleaf pine by loblolly pine, shortened stand rotation, loss of hardwoods, and fire suppression (Weigl 1987; Loeb and Lennartz 1989; Weigl et al. 1989; Dueser and Handley 1991; Humphrey and Jodice 1992; Kantola 1992).

Habitat improvement practices for fox squirrels generally target forest structure and tree species composition. Changes in forest structure affect overstory and understory densities and tree cavity availability. Tree species composition markedly affects mast production. Specific management practices vary among regions. The primary factor in maintaining fox squirrel populations in forest stands after harvest is sustaining adequate levels of winter-storable tree seeds (Nixon et al. 1975). Chamberlain et al. (1999) and Yarrow and Yarrow (1999) provide management guidelines specific to Mississippi and Alabama, respectively. Streamside management zones offer an option for providing high-quality habitat and travel corridors for fox squirrels in areas affected by even-aged forest management. Studies in the southeast suggest that forest management practices that reduce dense understory vegetation and promote retention of mature mast-producing hardwoods will benefit fox squirrels. Such practices include the use of prescribed fire, mowing and retention of hardwood stringers in pine-dominated habitats (Kantola 1986; Edwards et al. 1989; Lee 1999; Chamberlain et al. 1999; Conner et al. 1999).

Fox squirrels also benefit from the promotion and retention of cavity trees. Although cavity trees benefit both fox and gray squirrels, cavities are a more important habitat component for gray squirrels (Sanderson et al. 1980; Flyger and Gates 1982; Edwards and Guynn 1995).

The fox squirrel is a popular small game animal. Hunting mortality is considered compensatory to some extent, and is generally not thought of as a major factor controlling squirrel populations (Conner 2001). However, intensively hunted populations may be particularly vulnerable to overharvest depending on their level of isolation and potential for recolonization from nearby refuges or other lightly hunted areas (Allen 1943; Nixon et al. 1974; Herkert et al. 1992). In South Carolina, no distinction is made between hunting regulations for fox and gray squirrels on private lands, which contain the bulk of suitable fox squirrel habitats. Tappe and Guynn (1998) suggested that it might be more appropriate to manage southern fox squirrels differently than the gray squirrel because the former requires large home ranges and has a lower reproductive rate. Hunting fox squirrels is prohibited on many wildlife management areas in South Carolina.

CONSERVATION ACCOMPLISHMENTS

Fox squirrels have been protected from hunting mortality on over 61% Wildlife Management Areas within South Carolina. Additionally, a sighting survey to determine fox squirrel distribution in South Carolina was performed in 1989 and became a biennial event beginning in 1994. Statewide distribution of fox squirrels appears to be stable based on county distribution of sightings in the fox squirrel sighting survey. The data are not appropriate for estimating abundance as the number of personnel and sighting effort vary greatly between survey periods. A restoration project on St. Phillips and Hall Islands, South Carolina suggests translocation of fox squirrels may be a useful tool in restoring and augmenting fox squirrel populations throughout the Southeast (Senecal 2001). Fifty-two fox squirrels were released on the islands in 1999 and 2000. Annual survival of translocated fox squirrels was similar to reported rates in native populations and reproduction was documented.

Since 2004, successful restoration projects for southern fox squirrels have taken place on Yeamans Hall, Bailey Island, Clemson Sandhills Research and Education Center and Botany Bay Plantation Heritage Preserve and Wildlife Management Area in Charleston County. All squirrels translocated in these projects came from within South Carolina.

CONSERVATION RECOMMENDATIONS

- Consider southern fox squirrel habitat requirements when managing for red-cockaded woodpeckers (*Picoides borealis*) as these two species often occur sympatrically.
- Consider southern fox squirrel habitat when restoring longleaf pine/wiregrass ecosystems.
- Encourage landowners and developers to consider southern fox squirrels when planning and constructing developed areas such as golf courses, parks and residential communities.
- Encourage maintenance of mature (greater than 50 years) loblolly and longleaf pine stands that have open canopies and sparse midstories. When possible, encourage landowners to maintain mature stands on their properties.

- Use prescribed burning to maintain sparse midstories in pine and mixed pine/hardwood stands on SCDNR properties. Encourage other landowners to also use prescribed burning to provide habitat for southern fox squirrels.
- Utilize fox squirrel translocation as a population restoration and conservation tool when suitable unoccupied habitat is identified and fox squirrel donors are available.
- Document the distribution and population status of southern fox squirrels in South Carolina, particularly in the piedmont.
- Conduct studies of dispersal patterns, feeding habits, translocation success, hunting mortality and population dynamics for southern fox squirrels.
- Conduct landscape-scale research studies to determine the effects of anthropogenic-induced habitat fragmentation and loss.
- Establish a survey protocol to periodically monitor southern fox squirrel population trends on WMAs and large SCDNR land holdings.
- Estimate harvest of fox squirrels on game harvest surveys.
- Continue the biennial fox squirrel sighting survey.

MEASUREMENTS OF SUCCESS

The ongoing biennial survey has shown population fluctuations from year to year. At this point, there is not enough data to determine if this is a cyclical pattern of a stable population. Over time, biologists hope that the population in South Carolina can be stabilized or increased. As research and management needs are identified, projects will be initiated to address those needs.

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Meadow Vole

Microtus pennsylvanicus

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Reviewed and Edited (2024): Ben Cooper (SCDNR) and Jennifer Kindel (SCDNR)

DESCRIPTION

Taxonomy and Basic Description


Photo by John White©

The meadow vole was originally described by George Ord in 1815 (*in* Guthrie 1815) from specimens collected "in meadows below Philadelphia" and was named *Microtus pennsylvanicus* (Wilson and Reeder 1993). A single subspecies, *Microtus pennsylvanicus pennsylvanicus*, occurs in South Carolina.

The meadow vole is a small to medium sized rodent and is characterized by relatively small eyes, inconspicuous ears, and a short tail. Meadow voles range in total length from 140 to 196 mm (5.5 to 7.7 in.) and in weight from 33 to 65 g (1.2 to 2.3 oz.) (Hall 1981; Tamarin 1999). The pelage is dark brown above and silvery gray beneath (Brown 1997). Meadow voles are best distinguished from South Carolina's other vole species, the pine or woodland vole (*Microtus pinetorum),* by 4 characteristics: (1) pine vole tails are barely longer than the hind foot whereas meadow vole tails are 2 to 3 times the length of the hind foot; (2) pine voles have elongate fore-claws relative to meadow voles; (3) pine voles (25 to 33 g; 0.88 to 1.16 oz.) are typically much smaller than meadow voles; and (4) the second upper molar in pine voles has four dentine islands; there are five to six dentine islands in the meadow vole.

Status

The meadow vole is a globally secure (G5) species (NatureServe 2024); however, the IUCN states that at least five of 26 subspecies are of conservation concern (MacDonald et al. 1998). The species *M. pennsylvanicus* is listed as vulnerable (S3) in South Carolina where it is at the edge of its geographic range (NatureServe 2024). An apparent isolated population of meadow voles in the Charleston area may be of particular concern. In Georgia, the species is vulnerable (S3) while in North Carolina it is considered secure (S5) (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

Meadow voles purportedly range throughout the upper piedmont of South Carolina with an isolated population(s) in Charleston (Sanders 1978) and southern Georgetown County (Figure 1). Meadow vole populations fluctuate, sometimes dramatically from several to several hundred per hectare, within a period of 2 to 5 years (Krebs and Myers 1974).

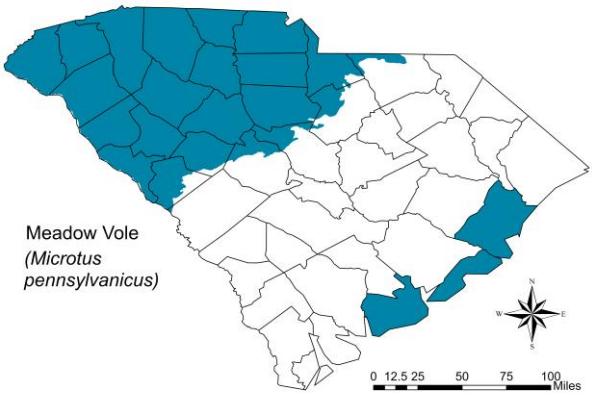


Figure 1. Distribution of the meadow vole in South Carolina.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Meadow voles depend on grassland habitat. Apparently, density and height of grass cover are more important than food quality in determining the suitability of habitats in maintaining high, stable vole populations. In a 25-year study, Getz et al. (2001) found that meadow vole populations exhibited the highest densities and lowest fluctuations in tall grass prairie habitats as compared to bluegrass and alfalfa habitats, which had successively lower cover and increased food quality.

Meadow voles coexist with numerous other small mammal species. In the southern Appalachians, meadow voles generally coexist with star-nosed moles (*Condylura cristata*), southern bog lemmings (*Synaptomys cooperi*), and meadow jumping mice (*Zapus hudsonius*). However, there is some evidence to suggest that meadow voles avoid areas where short-tailed shrews (*Blarina brevicauda*) are present (Fulk 1972), and previous studies indicate that there may be competitive avoidance between meadow voles and other vole species (Klatt 1986 and Blatzi et al. 1999). Evidence of this phenomenon has not been investigated in South Carolina meadow and woodland voles.

CHALLENGES

The major challenge to meadow vole populations is most likely habitat loss. Dense grassland habitats are lost through at least three mechanisms: agricultural development via cultivation or grazing, urban development, and the natural process of community succession whereby fields and meadows revert to pine or hardwood forest in the absence of disturbances such as fire. An additional problem may be displacement of native grasses by those favored for livestock production.

CONSERVATION ACCOMPLISHMENTS

To date, very little work has been done on the status or management of the meadow vole in South Carolina. However, from 2001 to 2003, researchers at Furman University worked closely with SCDNR biologists to assess the effects of vegetation type, fire and mowing on meadow vole populations in an old field on the Bunched Arrowhead Heritage Preserve in Greenville County. The results of these studies indicated that mowing is the preferred means of maintaining early successional habitats as voles moved back into mowed habitats sooner than burned habitats. Further, meadow voles preferred dense stands of planted switchgrass (*Panicum virgatum*) to naturally regenerated stands of broomsedge (*Andropogon virginicus*) and blackberry briar (*Rubus* spp.) or planted stands of deer tongue (*Panicum clandestinum)*.

CONSERVATION RECOMMENDATIONS

- Conduct a multi-year live-trapping survey of suitable habitats throughout the historical range. As meadow vole populations are known to fluctuate dramatically within periods of two to five years, areas will need to be surveyed over successive years to ensure that populations cycling through low density are not overlooked. Use Sherman live traps to survey known populations and suitable habitats annually during mid to late summer when densities should be highest. A standard trapping protocol should be used to enable reliable comparisons across years and sites. A trap density of 50 per 1/20 hectare (0.5 acre) in a grid formation should be sufficient.
- Investigate the apparently disjunct populations in the Charleston area with molecular techniques to determine if this isolate is unique and deserving of more serious independent conservation concern.
- Consider purchase of lands where meadow voles are documented on large areas of pasture or old-field habitat that can be easily maintained in an early succession grassland community.
- To the extent feasible, plant switchgrass (*P. virgatum*) and other tall, dense, native grassland species in open areas on existing SCDNR lands and mow on a two-year cycle to ensure tall dense stands and prevent conversion of grassland areas to brush and woodland.
- Partner with local colleges to complete initial survey work for meadow voles through educational field exercises.

MEASURES OF SUCCESS

Surveys and monitoring will allow the re-evaluation of the status of the species in South Carolina. The molecular study of the coastal versus piedmont animals will allow researchers to discern the appropriate taxonomic designation of the coastal animals.

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Southern Red-backed Vole

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DESCRIPTION

Taxonomy and basic description



The southern red-backed vole was first described by Vigors in 1830 (Gapper 1930) and is a member of the group of rodents termed microtine or arvicoline rodents. This species is readily distinguished from the other voles in South Carolina by the presence of a reddish dorsal pelage, with grayish sides and a silvery white to pale yellow underside pelage. The reddish color is usually present as a broad band running from the forehead to the rump. The tail is bicolored. The ears are relatively prominent and extend above the fur. Females possess eight mammae. Young voles are gray until their post-juvenile molt, which occurs at approximately 30 days of age. There is no sexual dimorphism. Adult length is 116 to 172 mm (4.57 to 6.77 in.) with a tail length of 30 to 50 mm (1.18 to 1.98 in.). Adult weight varies from 14 to 42 g (0.49 to 1.48 oz.). In general, the animals from the Appalachians are larger than their northern counterparts (Whitaker and Hamilton 1998). The skull has a short rostrum, large auditory bullae, and the palate ends posteriorly as a straight, transverse shelf in contrast to the structure of the palate of other microtines.



The subspecies of southern red-backed vole that occurs in South Carolina is the Carolina red-backed vole, *Clethrionomys gapperi carolinensis* (formerly *Myodes gapperi carolinensis*. This subspecies is present in the Appalachian Mountains from northern Georgia north through eastern Tennessee, western North Carolina, the northwest corner of South Carolina, western Virginia and West Virginia. The separation line between *Clethrionomys gapperi carolinensis* and *Clethrionomys gapperi gapperi* is farther to the north in Virginia and West Virginia (Whitaker and Hamilton 1998).

Status

This species is tracked by the South Carolina Department of Natural Resources (SCDNR) Heritage Trust database and is of special concern in South Carolina. The state rank for the southern red-backed vole is imperiled (S2) (NatureServe 2024), which indicates it is rare;

the factor that makes the species vulnerable is the limitation of suitable habitat within South Carolina. This species has a global rank of secure (G5) (NatureServe 2024). The southern red-backed vole is listed as apparently secure (S4) in West Virginia and Tennessee, as secure (S5) in Virginia and North Carolina, and as vulnerable (S3) in Georgia (NatureServe 2024). The species currently has no status rank in Kentucky (NatureServe 2024). Southern red-backed voles are included on the IUCN Red List as a species at lower risk/least concern (Cook and Kirkland, Jr. 1998; Lizney and NatureServe 2008; Cassola 2016), because the species is widespread, common, and no major threats have been noted across most of its range.

POPULATION SIZE AND DISTRIBUTION

The southern red-backed vole is distributed throughout Canada and the northern tier of states in the US. The range of this species extends south in the Appalachian Mountains to northern Georgia (Wharton and White 1967; Merritt 1981).

There are no population estimates available in the southern Appalachian Mountains, which represent the southern end of the southern red-backed vole's range. However, trapping records from collections in Highlands, North Carolina and the Smoky Mountains National Park indicate that this species can attain high densities and maintain viable populations in suitable habitats (Pivorun, pers. obs.). In addition, the population was observed to cycle over 5 to 8 year intervals in the Highlands, North Carolina National Forest lands (Pivorun, pers. obs.); 6 to 10 year cycles (Patric 1962; Grant 1976) and 4.4 year cycles (Elias et al. 2006) have been observed in other localities. There is such a paucity of trapping records from South Carolina that no data are available on population cycles.

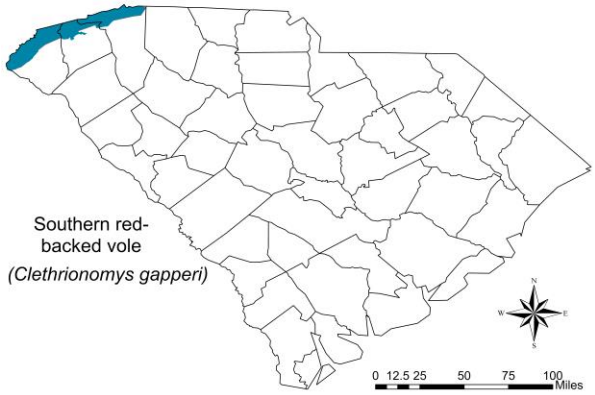


Figure 1. Distribution of the southern red-backed vole in South Carolina.

The southern red-backed vole is restricted to the higher elevation habitats of South Carolina within the Southern Appalachians Ecoregion. Currently, the only published records for this species are from Oconee (Pivorun et al. 1984) and Pickens Counties (Laerm et al. 1995). Suitable habitat for the Carolina red-backed vole is present in Greenville County. This species was one of the most abundant mammals on the summit of Mt. Rogers in western Virginia (Linzey 1998); the higher density populations are usually located at altitudes above 610 to 915 m (2,000 to 3,000 ft.) in the Southern Appalachians. In the eastern states, population size ranged from 24-65 individuals/hectare (or per 2.5 acres) in New York (Fisher 1968) to 0-37 per hectare in Connecticut and Vermont (Miller and Getz 1977a). The majority of suitable habitat in South Carolina is limited and one would expect smaller population numbers in this state. The presence of

voles in South Carolina may also be dependent upon immigration of voles to South Carolina from higher altitudes in the North Carolina mountains when population cycles result in high densities there. Current population studies are not being conducted on the distribution and abundance of this species in South Carolina.

A recent study has shown that since many Southern Appalachian populations of this species are located on "sky islands", or high altitude locations separated by lower altitude valleys or "oceans" of unsuitable habitat, a relatively low genetic variability and a high degree of inbreeding is occurring in these isolated populations (Browne and Ferree 2007). Comparable situations have been noted for the boreal habitat-dependent Southern Appalachian *Desmognathus wrighti*, the dwarf salamander (Crespi et al. 2003) and *Glaucomys sabrinus*, the northern flying squirrel (Arbogast et al. 2005). This results in limited gene flow between various insular populations. The effect of this bottlenecking could result in the loss of local populations due to stochastic fluctuations in climatic conditions or resource availability (Bonnell and Selander 1974; Hartl and Clark 1997).

Predators of southern red-backed voles include snakes, owls, foxes, bobcats, coyote and weasels. Although these voles are prey for several species, survival of the southern red-backed vole population is usually not threatened by these predators.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The southern red-backed vole is found in the Southern Appalachians Ecoregion. Within that ecoregion, the vole can be found in habitat with mesic mixed forests, mesic deciduous hardwood, and high altitude coniferous forests and beech gaps. A mesic environment with an abundance of litter, rotting logs, moss covered rocks, exposed roots and rock crevices would be considered an ideal habitat (Miller and Getz 1977b; Merritt 1981). This species has also been observed on mountain balds and in rhododendron thickets (Pivorun, pers. obs.). Generally, the presence of a bog area or streambed at altitudes above 762 m (2,500 ft.) offers an appropriate habitat (Webster et al. 1985). Neither forest age nor successional stage has been reported as critical factors in determining habitat preference (Merritt 1981). Southern red-backed voles do not colonize post burn communities as readily as other species (Martell and Radvanyi 1977) but will inhabit clear cuts (Kirkland 1990; Schloyer 1977; Martell 1983; Monthey and Soutiere 1985). One study in Wyoming demonstrated that *C. gapperi* clearly preferred forest to harvested stands on all study sites and avoided crossing boundaries between those stands (Keinath and Hayward 2003).

In South Carolina, red-backed voles have only been found in Oconee and Pickens County at altitudes above 915 m (3,000 ft.) in mixed deciduous forests associated with boggy and stream bed habitats that contain rhododendron. In the Southern Appalachians, associated species include the woodland jumping mouse (*Napaeozapus insignis*), star-nosed mole (*Condylura cristata*), the hairy-tailed mole (*Parscalops breweri*), smoky shrew (*Sorex fumeus*) and masked shrew (*Sorex cinereus*) (Watts 1970). Home range varies from 0.25 to 3.5 acres (Merritt and Merritt 1978). Experimentation by Gillis and Nams (1998) suggests that populations separated by an inter-patch distance of 60-70 m (197-230 ft.)

would likely be considered isolated from one another.
The red-backed vole is semifossorial and utilizes the underground tunnels of other species such as shrews and moles for den and nest sites; they also use crevices among exposed roots and rocks for these purposes. These voles forage along the ground and around downed trees. This species is omnivorous and opportunistic, consuming nuts, berries, mosses, lichens, ferns, fungi, arthropods and seeds (Merritt 1981). There is very little known about the use of subterranean fungi by this species in the Southern Appalachians. One study in Virginia demonstrated the consistent presence of spores in fecal pellets suggesting that fungi are an important food item and that *C. gapperi* may be an important disperser of fungal spores. This work supports the notion that *C. gapperi* is a fungal generalist since spores from the genera *Melanogaster, Coprinus, Elaphomyces* and *Glomalean* were present in fecal pellets. In addition, fungi are considered a primary food source for populations inhabiting forests in New York (Fisher 1968). Up to 20-40% of the total food consumed was the fungus *Endogone* and related hypogeous species during the fall and summer; during the winter, some individuals were found to have stomach contents that were 100% fungal. Bark and roots are also an important food source during the winter months.

CHALLENGES

Since this vole is located on a multitude of protected areas across its range in North America and since no widespread declines in populations have been noted, this species is generally not considered of conservation concern (Lizney and NatureServe 2008). However, in South Carolina, it is rare and considered worthy of inclusion in the State Wildlife Action Plan (SWAP). Luckily, a large portion of the habitat in the Blue Ridge Ecoregion that is appropriate for southern red-backed voles is on public land, including National Forests, State Parks, and SCDNR managed properties. Additionally, some lands that contain southern red-backed vole habitat are owned or held in easement by various land trusts. None of these properties were purchased specifically to protect the southern red-backed vole; however, the species benefits from acquisition and protection of its habitat. While these protected areas provide needed habitat, populations on private lands are still impacted by land conversion.

Land development in the Southern Appalachians represents a major challenge to the southern red-backed vole. Land use in this region is rapidly changing from rural/agricultural to urban/retirement or vacation homes. An unpublished study conducted by SCDNR showed a 4-fold increase in development to every one-fold increase in population between 1983 and 1998 (Richard Lacy, pers. comm.). As these conversions occur, habitat for this species is being lost. Even when development proceeds in close proximity to existing southern red-backed vole habitat, the species may be adversely affected as these animals require relatively undisturbed habitats. Additionally, the changes in hydrology that result from urbanization will affect habitat for this species. This species require wet areas like bogs; these areas are expected to diminish as development continues.

The appropriate habitat for this species in South Carolina is limited and a concern that

needs to be addressed is the impact of climate change, elevated temperatures, and drought in the state. In addition, the loss of hemlock forests to the invasive hemlock woolly adelgid (*Adelges tsugae*) may have significant impacts on populations. These factors all adversely impact the montane habitats, thereby contracting the ideal habitat that this species requires.

CONSERVATION ACCOMPLISHMENTS

Terrestrial small mammal surveys that have been conducted in the South Carolina mountains have provided data to better understand habitat requirements and population dynamics of the various rodent and insectivore species. These studies were possible as a result of partnerships between several interested parties including the University of Georgia, the US Forest Service, Clemson University, and SCDNR.

CONSERVATION RECOMMENDATIONS

- Discourage major developments in known southern red-backed vole habitat in the Blue Ridge Ecoregion
- Complete ecoregion-wide surveys for southern red-backed vole distribution and density. Surveys and survey techniques should be standardized throughout the Southeast so that results and data are readily comparable. All capture data should be made available through the statewide Heritage Trust database as well as shared with neighboring states.
- These surveys need to be conducted over a period of at least ten years. The impact of climate change, elevated temperatures, drought in the state, and the loss of hemlock forests need to be addressed.
- Concurrent with surveys, the subspecies designation and distribution needs to be resolved for Carolina red-backed voles (*M. c. carolinensis*) using molecular data and intensive morphometric analysis. This will require cooperation or partnerships with neighboring states. Genetic analyses are needed to determine if a relatively low genetic variability and a high degree of inbreeding is occurring in the isolated populations distributed across the northwestern montane regions of the state. One would expect bottlenecking which could result in the loss of local populations due to fluctuations in climatic conditions or resource availability.
- Provide information on the ecological role and benefits of southern red-backed voles. This species is not considered a nuisance species. This information would allow for better management of private, state, and federal lands in the montane regions of the state; management would be partially based on consideration of the impact on mammalian species that are major prey items for predators such as fox, bobcat, and birds of prey.

MEASURES OF SUCCESS

As research and management needs are identified, projects should be proposed and prioritized by those with the greatest conservation applicability. Surveys and density estimates in the Southern region should provide some population estimations which will

be used to more accurately rank the species and prioritize future management needs.

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Weasels Guild

Least Weasel (*Mustela nivalis*)
Long-tailed Weasel (*Neogale frenata*)

Contributors (2024): Stephen Harris (Clemson University) and David Jachowski (Clemson University)

DESCRIPTION

Taxonomy and Basic Description

Two weasel species occur in South Carolina, the diminutive least weasel (*Mustela nivalis*) and the larger long-tailed weasel (*Neogale frenata*). A third weasel species, known as the short-tailed weasel or American ermine (*Mustela richardsonii*), also occurs in the contiguous United States but is not found in South Carolina. Weasels are in the family Mustelidae (badgers, otters, wolverine, etc.) in the order Carnivora. These weasels are well-known for their elongated, cylindrical bodies, narrow heads, short legs, and their movements that appear serpentine at times. They are also known to be formidable predators despite their small size.



Least weasel. © Hennadii Tarasenko (CC BY-NC), cropped from original

The least weasel is the smallest mammalian carnivore in the world (Sheffield and King 1994). Head and body length for the species is 4.75–6.75 in. (12–17 cm) and body mass ranges from 1–2 oz. (31–57 g; Reid 2006). Females are usually smaller in size than males (i.e., sexually dimorphic; King 1989). The tail is relatively short—less than 25% of the head and body length (approximately 0.75-1.375 in. or 2–4 cm) and lacks a black tip unlike the short- and long-tailed weasel (Hall 1951, Reid 2006). Colors and patterns can vary some, but generally the dorsal pelage can range from tan to a chocolate or rusty-brown color (Sheffield and King 1994). The ventral pelage ranges from yellow to white and may have brown. In northern locales, the coat turns completely white in winter.

The long-tailed weasel is considerably larger than the least weasel, with a head and body length of 7–11.5 in. (18–29 cm) and a body mass of 3–10 oz. (85–284 g; Reid 2006). As its name indicates, it has a longer tail than the least or short-tailed weasel, ranging from 3–6.625 in. (7–17 cm) and more than half of the head and body length. Like the least weasel, females are generally



Long-tailed weasel. © Michael Donahue (CC BY-NC)

smaller than males. The tip of the tail is black. In eastern North America, its dorsal pelage in summer is medium to dark brown and its ventral pelage is light yellow to white (Reid 2006). Northern populations turn white in winter, but southern populations remain brown. The long-tailed weasel can be discerned from the American mink (*Neogale vison*), which also occurs in South Carolina, by the mink's larger size and completely dark brown coat excepting a white chin patch.

Status

The least weasel is globally secure (G5), but within North America the species is of current conservation concern in 53% of range states and provinces (Jachowski et al. 2021). Over the past century, Cheeseman et al. (2024) predicted a 54% loss of suitable habitat. It is critically imperiled (S1) in Georgia and New York, critically imperiled/imperiled (S1S2) in Wyoming, imperiled (S2) in North Carolina, South Carolina, and Tennessee, possibly imperiled (S2?) in Indiana, and has an elevated status in other states as well (NatureServe 2024). It is considered Least Concern with a stable global population trend by the International Union for Conservation of Nature (IUCN; McDonald et al. 2019)

The long-tailed weasel is globally secure (G5). The species is ranked as imperiled (S2) in Nebraska, Oklahoma, and South Carolina, imperiled/vulnerable (S2S3) in Kansas, and has an elevated status in other states as well (NatureServe 2024). The long-tailed weasel is ranked as Least Concern with a stable global population trend by the IUCN (Helgen and Reid 2016).

Recent research has provided evidence that weasel observations and harvest levels in North America have declined in the last century and likely reflect a real decline in weasel numbers during that period (Jachowski et al. 2021). In particular, there is a recent lack of records for the long-tailed weasel in non-mountainous portions of its southern range, which includes South Carolina.

In South Carolina, weasels are considered a furbearer and can be trapped from 1 December–1 March with a valid Commercial Fur Harvester's License. A limit of 5 weasels can also be trapped for non-commercial purposes (with a valid hunting license) from Thanksgiving–March 1 (https://www.eregulations.com/southcarolina/hunting/trapping-commercial-fur-harvesting).

POPULATION SIZE AND DISTRIBUTION

The least weasel is a species found in the northern (circumboreal) region of the Northern Hemisphere worldwide, as well as having been introduced outside of its native range in New Zealand and on other islands (Sheffield and King 1994). It reaches the southern limit of its range in North America in the Southern Appalachian/Blue Ridge Mountains, as far south as Georgia. In South Carolina, the species has only been recorded in Cherokee County (Figure 1), but records come from bordering Henderson and Jackson Counties in North Carolina, including one record 16 km from the South Carolina border (Barkalow 1967, Linzey and Hamed 2016). Suitable habitat for the least weasel across North America appears to be declining, driven by habitat fragmentation or loss and climate change (Cheeseman et al. 2024).

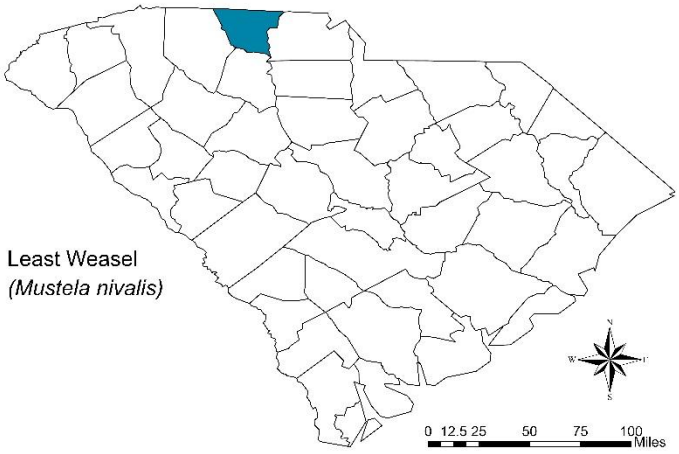


Figure 1. Distribution of the least weasel in South Carolina.

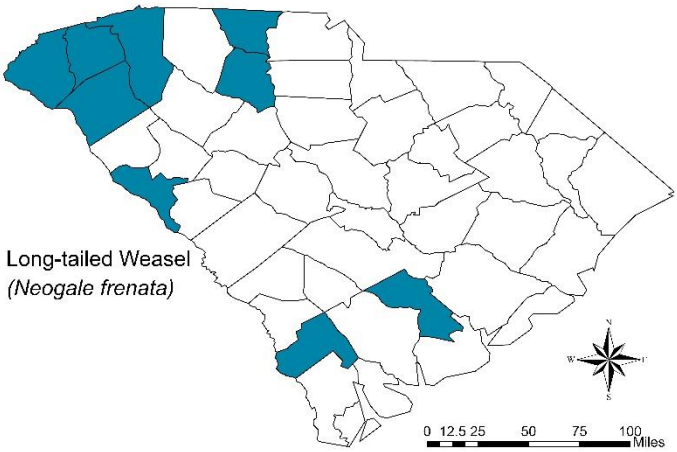


Figure 2. Distribution of the long-tailed weasel in South Carolina.

The long-tailed weasel occurs throughout most of the United States, in southern Canada, throughout most of Mexico and Central America, and into parts of northern and central South America (Sheffield and Thomas 1997). Records in South Carolina come from Anderson, Cherokee, Dorchester, Greenville, Hampton, McCormick, Oconee, Pickens, and Union counties (Figure 2). The species also occurs in the adjacent states of Georgia, Florida, and North Carolina.

Due to the dearth of records for the least and long-tailed weasel in South Carolina, nothing populations in the state. Least weasels are thought to be naturally rare (i.e., occurring in low densities) in North America (Sheffield and King 1994). Long-tailed weasel populations can fluctuate greatly, and local populations can go extinct when prey availability decreases (King 1989).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The least weasel is considered a habitat generalist. It has been documented in a variety of forest types, fields, meadows, prairies, cultivated farmlands, hedgerows, steppe, scrub, semi-deserts,

and coastal dunes (Sheffield and King 1994). Least weasel habitat selection may be influenced on a local scale by the distribution of their rodent prey. The species may be restricted to the mountainous northwestern corner of South Carolina due to incompatibly high minimum temperatures outside of this region (Cheeseman et al. 2024).

Like the least weasel, the long-tailed weasel is a habitat generalist. Throughout its range, it inhabits most habitat types besides desert (Sheffield and Thomas 1997). It can be found in forests, fields, meadows, marshes, and pastures (DeVan 1982, Reid 2006). Long-tailed weasels are often found in and near riparian areas with dense vegetation, and these riparian areas act as corridors for movement and dispersal (Fagerstone 1987, Sheffield and Thomas 1997, Reid 2006).

CHALLENGES

Land use change is a threat to many imperiled species, and weasels in South Carolina are likely negatively impacted as well. As previously noted, habitat loss and fragmentation, paired with climate change, have likely led to declines in suitable habitat for least weasels (Cheeseman et al. 2024). South Carolina's human population rapidly increased 10.7% from 2010 to 2020 (U.S. Census Bureau 2021) and will continue to grow, increasing the risk that weasel habitat will be destroyed by human development.

Establishing solid estimates of weasel population size and status and determining if weasels occur in an area of interest are difficult, as weasels may occur at low densities (Sheffield and King 1994) and are hard to detect (Jachowski et al. 2024).

Epizootic diseases such as canine distemper virus are known to have devastating effects on mustelids, with mortality rates near 100% recorded for some outbreaks (Budd 1981, Davidson 1986, Perpiñán et al. 2008). It is currently unknown how impactful or prevalent diseases are to weasel populations in South Carolina. However, a canine distemper outbreak in nearby DuPont State Recreational Forest, North Carolina (a site where long-tailed weasels are known to occur), killed at least 50% of a study population of eastern spotted skunks (*Spilogale putorius*) at the site (Harris et al. 2021), highlighting the potential effects diseases can have on low-density populations of small carnivores in the region.

Least and long-tailed weasels' primary prey are small mammals, especially rodents (Sheffield and King 1994, Sheffield and Thomas 1997). Therefore, they are at risk from poisoning through secondary exposure (i.e., eating poisoned rodents) to anticoagulant rodenticides (Townsend et al. 1984). Anticoagulant rodenticide exposure, and associated morbidity or mortality, have been documented in many carnivore families and species worldwide, but most frequently in mustelids (Keating et al. 2024).

CONSERVATION ACCOMPLISHMENTS

Locations where long-tailed weasels have been recorded in South Carolina are protected and managed by the U.S. Forest Service (e.g., Andrew Pickens District, Sumter National Forest) and Clemson University (e.g., Clemson Experimental Forest). Recent camera trap surveys in the Piedmont ecoregion and Upstate South Carolina have increased the number of recent records of

the long-tailed weasel in the state (S.N. Harris, 2024, pers. comm.) Clemson University and SCDNR researchers have actively participated in the North American Weasel Working Group, which works collaboratively to improve knowledge of weasel ecology, status, distribution in North America.

CONSERVATION RECOMMENDATIONS

- Partner with private and public landowners to maintain known weasel habitat via whatever means are available, including but not limited to acquisitions, conservation easements, designations of green spaces, and encouragement of stewardship by private landowners.
- Engagement of the public to bolster verifiable records of weasels in the state. Examples include pushes for observation submissions through social media, directing the public to record their observations in a new or established database (e.g., iNaturalist), or sending out surveys and calls for observations to hunters and trappers that frequent weasel habitat.
- Surveys in areas with old historical observations (e.g., >40 years ago) to determine whether weasels still inhabit these areas.
- Systematic surveys throughout the purported ranges of both species' in South Carolina to improve understanding of distribution and allow for population estimates. There are a number of non-invasive methods that have been effectively used to monitor weasels, each with their own advantages and disadvantages. Regardless of the method(s) used, a commitment to sustained monitoring over a long period of time is essential to collect population trend data for weasels (Jachowski et al. 2024).
- Investigate the level of current weasel harvest and what effect it may have on weasel populations in the state.
- Further research into the effects of diseases and rodenticides on weasels will aid in determining if these pose a serious threat to populations in the state.

MEASURES OF SUCCESS

Obtaining new observations of the least weasel and long-tailed weasel would be beneficial in updating our current understanding of both species' distribution in South Carolina. New records may inform researchers as to sites where further, more in-depth studies of weasels could be conducted. Finally, observations obtained from systematic surveys throughout the state would be instrumental in establishing baseline density or population size estimates for these species.

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Eastern Woodrat
Neotoma floridana

Contributors (2005): Mary Bunch (SCDNR), Stanlee Miller (Clemson University), and David Webster (UNC-W)
Revised & Edited (2012): Steve Fields (Culture and Heritage Museums) and David Webster (UNC-W)


Photo by D. Webster

DESCRIPTION

Taxonomy and Basic Description

The Eastern woodrat was first described by Ord in 1818. Woodrats build extensive stick nests in which they larder bright, shiny objects, hence the nickname "packrats." The Eastern woodrat (*Neotoma floridana*), the only woodrat species in South Carolina, has gray-brown or rusty brown fur on the back with darker hairs down the center of the back, a white belly and whitish paws. The white extends to the underside of the jaw. The well-furred tail is nearly as long as the body. It has short hairs and is bi-colored (dark on top and light underneath). Woodrats have long whiskers and large, unfurred ears. They are easily distinguished from black rats (*Rattus rattus*) and Norway rats (*Rattus norvegicus*) because woodrats have relatively large eyes, four white feet, well-furred tails and rather blunt snouts. Both black and Norway rats, introduced invasive species, have scaly tails and pointy snouts (Webster et al. 1985).

Males are slightly larger than females (Wiley 1980). Specimen weights from South Carolina at the Campbell Museum of Natural History range from 119.5 to 306.4 grams (4.1 to 10.7 ounces) for males and 104 to 268.8 g (3.6 to 9.4 oz.) for females. The average weight of woodrats captured at mountain sites in South Carolina during winter were 264 g (9.2 oz.) in males and 207.5 g (7.3 oz.) in females (Bunch and Dye 1999c).

The woodrats in South Carolina were formerly recognized as two distinct subspecies. The mountain or Appalachian population was referred to as the southern Appalachian Eastern woodrat (*Neotoma floridana haematoreia*). Coastal populations were assigned *Neotoma floridana floridana* (Hall and Kelson 1959; Wiley 1980). They are now considered to be the same subspecies, *Neotoma floridana haematoreia,* based on molecular genetic comparisons (Hayes and Harrison 1992; Ray 2000).

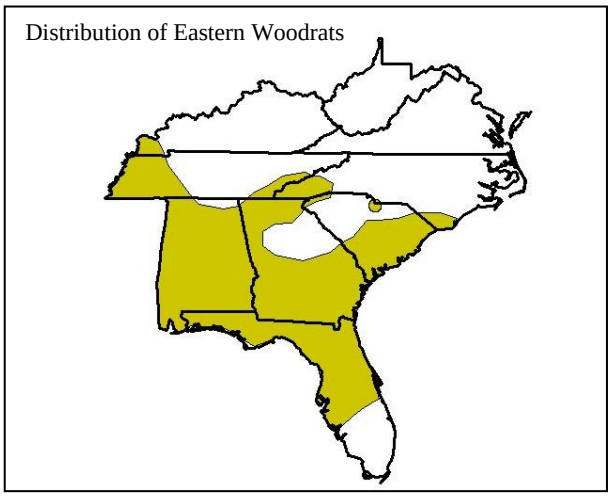
Farther to the north and west, ranges of both the Eastern woodrat and the less common Allegheny woodrat (*Neotoma magister*) almost overlap. Allegheny woodrats were once recognized as a subspecies of *Neotoma floridana* but are now recognized as a discrete species (Hayes and Harrison 1992; Hayes and Richmond 1993; Ray 2000; Edwards and Bradley 2001). The differences between the two species are subtle. Woodrats in the mountains tend to have longer whiskers than their coastal counterparts (Ray 2000), and their tails are more distinctly bi-colored and hairier. In this regard, Eastern woodrats from the southern Appalachians more closely resemble Allegheny woodrats; those from the coastal plain of North and South Carolina more closely resemble Eastern woodrats from Florida.

Status

In South Carolina, the species is apparently secure (S3/S4). Currently, coastal and mountain populations are not ranked separately in South Carolina. North Carolina ranks coastal populations of Eastern woodrats as critically imperiled and mountain populations as rare or uncommon. Georgia and Florida rank *N. floridana* as secure (S5), and the global rank is secure (G5) (NatureServe 2004, 2013). Eastern woodrats are on the IUCN Red List in the "lower risk, least concern" category (Yensen and Kirkland, Jr. 1998).

POPULATION SIZE AND DISTRIBUTION

Woodrats range along the coast from Pender County in southeastern North Carolina (Webster et al. 1985), southward along the entire Coastal Plain and into the Sandhills of South Carolina. The distribution broadens westward into Piedmont habitat as it continues southward into Georgia. The mountain populations of Eastern woodrats are restricted to the southwestern mountains of North Carolina and northwestern South Carolina, ranging west and southward in Georgia.



A record of an Eastern woodrat from York County, South Carolina (Dowda et al. 1981) in the Upper Piedmont suggests that the distribution in the Midlands and Upper Piedmont of South and North Carolina is not well understood.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Woodrats use a wide variety of habitats in South Carolina. In the Southern Appalachian Ecoregion, they can be found in dry or mesic deciduous or mixed deciduous forests including coves, bottomlands and swamps. They also occur in pine-heath communities and early successional stands such as old fields and clear cuts. Woodrats will use harvested woodlands prepared mechanically if piles of woody debris are present, but do not use sites that have been treated with herbicides within the previous five years (O'Connell and Miller 1994). They are often found in, but are not limited to, rock outcrops, boulder fields and cliffs.

In the Coastal Plain, woodrats use floodplain and swamp forests, wet scrub thickets, logged areas, dry and mesic deciduous forests, and hardwood-pine forests. At the Naval Weapons Station near Charleston, woodrats were captured in natural pine regeneration areas that were approximately 12 years old; these areas were affected by Hurricane Hugo and contained abundant coarse woody debris. Woodrats were also captured in mature hardwood pine forest habitat and mixed stand edge with an adjoining field at the Naval Weapons Station (Louie et al. 2001). At coastal North Carolina sites, Webster et al. (1987) reported an apparent association of

woodrat prevalence in deciduous forest with dense dwarf palmetto (*Sabal minor)* cover and circum-neutral soils.

Woodrats are opportunistic; they forage on a variety of items including berries, stems, buds, leaves, seeds, fruit, bark, fungi, insects, acorns and other nuts (McMurry et al. 1993; Monty and Feldhamer 2002; Schwartz and Schwartz 1981; Wiley 1980). Hard mast, such as acorns, may be an important food source in winter.

Two obvious items can be found to indicate the presence of woodrats: large, bulky nests and latrines. Nests for woodrats are built inside a large house constructed of sticks, leaves, branches, and scavenged litter such as vinyl flagging, bottle caps, and Mylar balloon remnants. The bulky houses are continually maintained. Several nests can be found in one large house or den structure. Often these structures are in or under rock outcroppings, large cavity trees, large slash piles or in abandoned buildings. Latrines are often found on rock ledge sites where large piles of droppings accumulate.


Photo of woodrat nest by SC DNR

CHALLENGES

Coastal populations of Eastern woodrats in South Carolina are impacted by habitat loss and isolation due to development. Although some habitat for this species is protected on public lands, barriers of intense development isolate many preserved sites, particularly in the coastal plain. Much of the suitable habitat found in the midlands needs additional protection, and many suitable areas found in the Inner and Outer Coastal Plain are not protected at all.

Predation (Monty and Feldhamer 2002), and factors that increase predator density or woodrat detection by predators, also represent challenges to this species. Additionally, placement of recreational trails near suitable bolder or rock outcrop nest sites may adversely affect Eastern woodrats by resulting in increased access to and, therefore, increased predation of nests.

Raccoons and their associated parasite, the raccoon roundworm (*Baylisascaris procyonis*) may also pose a threat to Eastern woodrats (Monty and Feldhamer 2002). Although this parasite is not common outside of the Southern Appalachians, the potential exists for parasite transmission to woodrats. Once transmission occurs, raccoon roundworm larvae migrate to the brain and death can occur. Such mortality has been documented in the rare Allegheny woodrat (*Neotoma magister*). As raccoon populations increase, an observable decrease in the woodrat population has been noted; transference of the roundworm is believed the cause (NatureServe 2004). Recent research indicates that the parasite is experiencing a range expansion and has been documented in isolated regions of Florida and Georgia (SCWDS 2013). Raccoons are a cosmopolitan species that often coexist and benefit from human activity, readily foraging in garbage, gardens, agriculture fields, aquaculture areas, koi ponds, pet food and bird feeders. Anything that causes an increase of raccoons within woodrat habitat can therefore increase the likelihood of raccoon parasite transfers to woodrats.

The exotic gypsy moth (*Lymantria dispar*) may pose a threat to populations of woodrats. Gypsy moth caterpillars prefer oak trees, but will defoliate most hardwoods when present in large numbers. This defoliation reduces mast production; repeated defoliations lead to tree mortality (McManus et al. 1992; Pearson 2002). Gypsy moths were first reported in South Carolina in 1998 (Pete Bischoff personal communication 2005). To date, no significant outbreaks of gypsy moth caterpillars have occurred in this state; however, should such an outbreak occur, it could result in significant impacts to woodrat food sources.

Sudden Oak Death (SOD) results from an introduced fungus (*Phytophthora ramorum*) that recently arrived in South Carolina via nursery stock. The impacts of this fungus on our forests could be devastating as it attacks many species of shrubs and trees (O'Brien et al. 2002). Specific impacts to the many types of oak trees (*Quercus* spp.) in the southeast are not yet known. If the blight is not contained, serious losses of oak trees can be expected. Red, northern pin and black oaks have been shown to be susceptible to the fungus in experimental exposures (Tooley and Kyde 2003). The warm, humid climate in the southeast is conducive to the spread of the fungus. Unfortunately, SOD is believed to be distributed by air borne spores; such distribution makes it very difficult to control this fungus. Infected nursery stock has been shipped to several southeastern states, and was documented in South Carolina for the first time in 2005 by Clemson University (Kent 2005). Woodrats use acorns, as do many other species of wildlife. Losing a significant proportion of our mature oaks could create a forage bottleneck that could decimate woodrat populations.

Currently, very few people are aware of woodrats or packrats in South Carolina, except for the perception that they are a nuisance species. This perception contributes to the assumption that this species is responsible for nuisance rat infestations. However, this species is generally not found living in areas populated by humans. Lack of knowledge of the Eastern woodrat and its relevance in the ecosystem can represent a challenge for protection of this species.

CONSERVATION ACCOMPLISHMENTS

Extensive holdings in various public ownerships and nonprofit conservation organizations or conservation easements have protected over 162,000 acres of land in the mountains of South Carolina. Most, if not all of the tracts, have woodrats (Bunch et al. 1999 a,b,c). Some habitat preservation exists in the midlands and lower coastal plain on sites such as the Congaree National Monument and the Silver Bluff Audubon Sanctuary. Significant tracts, such as the SCDNR's system of Heritage Preserves, the Francis Marion National Forest, the multi-partnered ACE Basin project and the various National Wildlife Refuges also protect some coastal populations.

CONSERVATION RECOMMENDATIONS

- Conserve woodrat habitat linkages between sites that are already under protection through acquisition and/or conservation easement and encourage stewardship by private landowners.

- Encourage landowners and foresters to avoid use of herbicides as a site preparation technique in areas with woodrats.
- Survey the upper piedmont region in York County and surrounding counties to determine the distribution of woodrats in that region.
- Determine if trails by-passing outcrops and boulder fields lead to increased predation of woodrats.
- Acquire Eastern woodrat density estimates for each ecoregion and designate selected sites for long-term monitoring in each of the following geographical area: Southern Appalachians, Inner and Outer Coastal Plains, and Piedmont.
- Educate the public about the relevance of the Eastern woodrat in the ecosystem. Such education could occur at a demonstration site that illustrates important habitat and species in the mountain region of South Carolina.
- Continue to monitor the spread of raccoon roundworm, gypsy moths, and SOD in South Carolina and develop an action plan in the event these threats adversely affect wildlife species within this state.

MEASURES OF SUCCESS

Surveys and density estimates in the southern region should provide some population estimations that will be used to more accurately rank the species and prioritize future management needs.

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Atlantic Billfishes – Family *Istiophoridae* and *Xiphiidae*

Blue Marlin, *Makaira nigricans*
White Marlin, *Kajikia albida*
Sailfish, *Istiophorus albicans*
Longbill Spearfish, *Tetrapturus pfluegeri,*
Swordfish, Xiphias gladius

Contributors:
Amy Dukes (SCDNR), Elizabeth Gooding (SCDNR), & Sydney Bates (SCDNR)

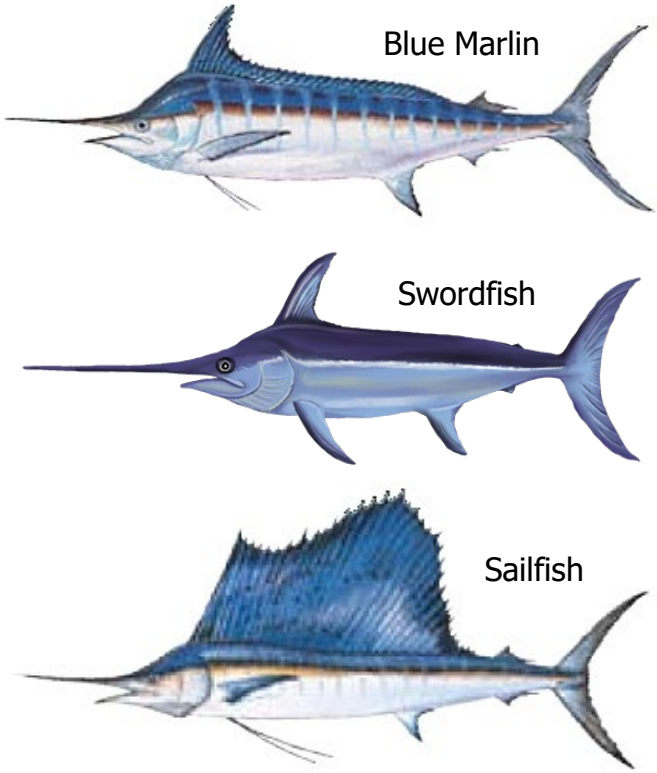


Photo Credit: FishBase

DESCRIPTION

Taxonomy and Basic Description

Istiophoridae and xiphiidae family species, found within the order Carangiformes (Page et al. 2023), hereafter referred to collectively as billfishes, are highly migratory pelagic marine predatorial fish characterized by their protruding upper jaw pointed bills that appear sword or spear-like (Nakamura 1985). The species of billfishes that inhabit the waters off the South Carolina coast include sailfish, blue marlin, white marlin, longbill spearfish , roundscale spearfish, and swordfish (Collette 2006). These fish species vary in total length, with some species demonstrating sexual dimorphism; females typically grow larger than males. Sailfish, white marlin and spearfish reach a maximum size of approximately 200 cm total length (TL), while swordfish grow to 400 cm TL. The blue marlin is the largest of the group with a maximum length of 500 cm TL for females and 290 cm for males (FishBase). They are considered apex predators, noted for their fast speeds, and feed on a wide variety of fish, crustaceans and cephalopods using their long rough bills when swimming through bait fish, slashing their head/bills back and forth to stun, injure or kill prey.

Status

Billfishes are both ecologically significant and economically valuable pelagic fishes, existing in every ocean (Nakamura 1985). With a high exploitation rate in some areas of the world, for food consumption and revenue, billfish stock status can be difficult to determine and varies from healthy to severely depleted or rebuilding (Pons 2017). Billfishes, excluding swordfish, are often caught as bycatch in other large-scale fisheries for tunas and swordfish. Not surprisingly, many of the populations of these species show signs of overfishing (ICCAT 2021). Additionally, preferred open ocean habitat hinders large scale research activities, resulting in limited information about their movements and life histories further complicating management, especially if only locally applied (Collette 2011).

In the western North Atlantic, swordfish are the only species targeted commercially, with federal restrictions on the harvest and sale of the other billfishes; however, all the billfishes are considered an economically important recreational fishery off the U.S. East coasts (Ditton 2003). Commercial swordfish landings and bycatch of other billfishes are tracked under strict federal quota monitoring efforts, and recreational landings for all these billfishes are relatively low with several species being prohibited. Documentation of these recreational landings are self-reported to NOAA Highly Migratory Species Division (NOAA-HMS). In SC, conservation measures began in the early 1970s. As these concerns about population declines of billfishes ramped up in 1989, the South Carolina Governor's Cup Billfishing Series, a SCDNR-administered program, was initiated (SCDNR Series). The program promotes research, education and conservation of a suit of these species through efforts to encourage catch and release fishing practices.

POPULATION SIZE AND DISTRIBUTION

SCDNR has not conducted any directed fishery independent studies on billfishes. The South Carolina Governor's Cup Billfishing Series does collect fishery dependent data and limited biological data from tournament focused fishing activities. These data have varied over the timeframe of the program and are collected through interviews with participants post fishing activities to determine catch rates and both estimated and measured billfish lengths, sex and weights. Limited otoliths have been collected in more recent years but have not yet been processed. Specialized equipment is needed to read these extremely tiny and delicate structures.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Billfishes prefer tropical and subtropical waters, specifically clear-blue waters of the Gulf Stream near the outer continental shelf and are more concentrated during the spring through fall months; however, smaller sailfish and spearfish will stray into nearshore waters during the summer (SCDNR Sea Science).

CHALLENGES

As a highly migratory species occurring in every ocean, billfishes are subject to a variety of fishing pressures and vastly different regulations regarding harvest, bycatch and reporting requirements. This does limit the ability to conduct a comprehensive stock assessment and collect sufficient data. Understanding the hurtles to management of some billfishes has allowed conservation and management strategy evaluations to be developed.

CONSERVATION ACCOMPLISHMENTS

NOAA-HMS has an Advisory Panel that consists of fishermen from all sectors, non-governmental representatives from scientific and environmental groups and state agency personnel to share perspectives and gain insight of each billfish species to aid in the development and implementation of management strategies for these species.

Additionally, the South Carolina Governor's Cup Billfishing Series encourages catch and release of billfish species, and the program has a 99% release rate averaged between the participating fishing tournaments since 1989. In recent years, the program has assisted with small scale scientific studies, using popoff satellite archival tags to enhance the understanding of basic patterns of the species' daily and seasonal movements, which may aid in fisheries management (Walter 2020).

CONSERVATION RECOMMENDATIONS

- Characterize stock status in Atlantic waters compared to globally
- Determine potential spatial and temporal shifts in distribution
- Further investigate migration patterns
- Expand research and monitoring of fishery-independent surveys and better utilize and expand fishery-dependent data
- Improve data of bycatch or incidental catch and better documentation of fish encounters

MEASURE OF SUCCESS

The highly migratory nature of billfishes and occurrence in all oceans with varied regulations complicates the measure of success. Additionally, not all species have been assessed nor are managed similarly, which further makes ensuring the sustainability of these fish more difficult. The continuation and expansion of regional fisheries management organizations, such as the International Commission for the Conservation of Atlantic Tunas, will increase the success of cohesive internationally approached future management measures.

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Atlantic Croaker

Micropogonias undulatus

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DESCRIPTION

Taxonomy and Basic Description

Atlantic croaker, members of the order Perciformes and family Scienidae, is the only representative of the genus *Micropogonias* occurring on the US Atlantic coast; the other *Micropogonias* species, *M.* furnieri, occurring in North America occurs along the far southern coast of Mexico (Page et al. 2023). This species gets its name from the deep croaking sounds created by muscular action on the air bladder. It is one of 23 members of the family Sciaenidae found along the Atlantic and Gulf of Mexico coasts (Mercer 1987). The species has a typical fusiform shape, although it is somewhat vertically compressed. The fish is silvery overall with a faint pinkish-bronze cast. The back and upper sides are grayish, with brassy or brown spots forming wavy lines on the side (Manooch 1988). The gill cover has 3 to 5 prominent spines, and there are 3 to 5 small chin barbels. It has a slightly convex caudal fin.

Atlantic croaker south of Cape Hatteras reach maturity after one year at lengths of 140-180 mm (5.5-7″) total length (TL) and have previously been thought to not survive longer than one or two years (Diaz and Onuf 1985). More recent data, however, has expanded the age range with ages as high as 7 in South Carolina (ASMFC 2010). North of Cape Hatteras, they mature a year later at lengths greater than 200 mm (8″) TL. The age range in the mid-Atlantic region for croaker is greater with age-12 fish landed in Virginia and North Carolina in 2001 (Bobko et al. 2003) and 15 to 17-year-old fish landed by the Chesapeake Bay Multispecies Monitoring and Assessment Program (ChesMMAP). The Atlantic Croaker reaches a maximum length of 500 mm (20″) TL (Hildebrand and Schroeder 1927). Catches of large Atlantic croaker appear to be relatively common in Chesapeake Bay, but large individuals are rare in South Carolina.

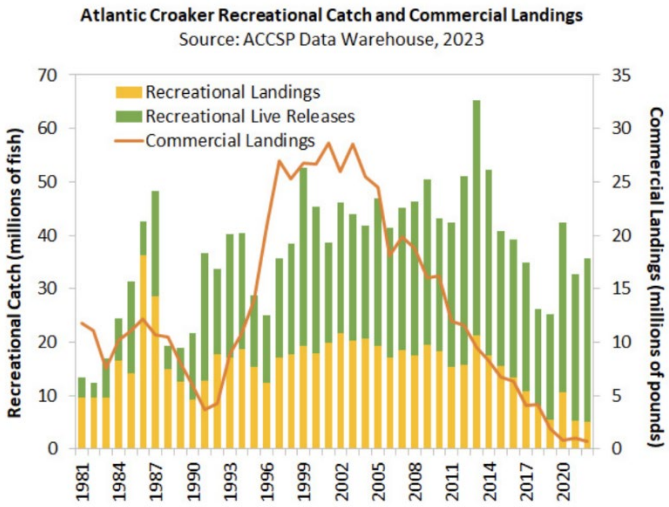


Figure 1: Atlantic croaker recreational and commercial harvest and recreational discards from 1981-2022 (Source: ASMFC 2024).

Status

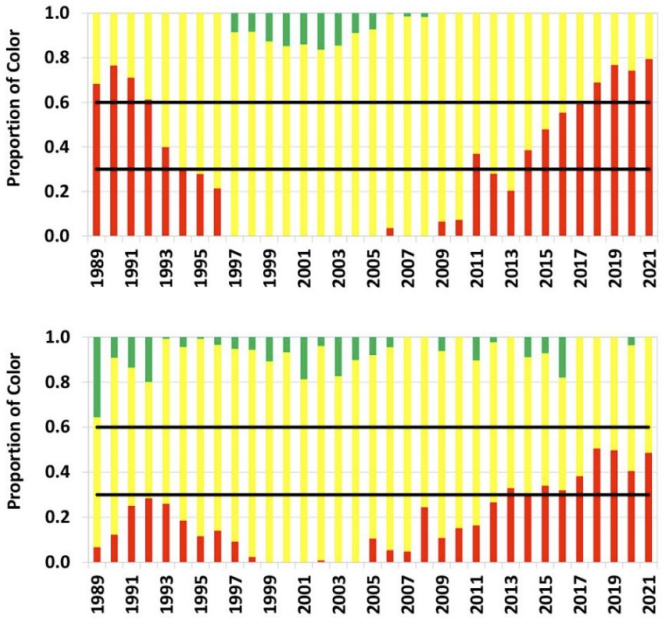
Sought by recreational and commercial fishermen alike, coastwide an estimated 2.8 million pounds of croaker were landed in 2022, 25% and 75% from the commercial and recreational fisheries, respectively (ASMFC 2024). Atlantic croaker have been part of a mixed-stock commercial fishery on the Atlantic coast since the 1800s, contemporarily being caught commercially with a wide variety of gear. The dominant types include gill nets, pound nets, haul seines, and trawls. Coastwide commercial landings, dominated by harvest in North Carolina, exhibit a cyclical pattern with low landings in the 1960s to early01970s and the 198-s to early-1990s and high landings in the mid- to late-1970s and the mid-1990s to 2011 (Figure 1; ASMFC 2024).

Two other, potentially unaccounted for "commercial" fisheries land Atlantic croaker. First, Atlantic croaker are a major component of "scrap fisheries," or fisheries in which fish species that are unmarketable as food, due to size or palatability, are sold unsorted, usually as bait. Second, small Atlantic croaker have also been a major part of the bycatch in the Southeastern Atlantic shrimp trawl fishery (Hoar et al. 1992; Nance 1998), and while the use of turtle excluder devices (TEDs) and by-catch reduction devices (BRDs) has reduced this bycatch, the overall impact of the trawl fishery on the Atlantic Croaker population and the magnitude of the reduction through the use of TED's and BRD's is difficult to quantify. Currently, there are limited to no monitoring efforts for by-catch composition of the shrimp trawl fishery along the Southeastern Atlantic Coast of the US.

Recreationally, coastwide landings from New Jersey through Florida have varied between 5.1 million fish in 2022 to 36.2 million fish in 1986 (Figure 1; ASMFC 2024). Landings generally increased until 2001, and held stable from 2001-2006 before exhibiting a declining trend from 2007 though 2022. However, recreational discards have generally increased throughout the time series, with 85.5% of croaker captured recreationally released in 2022 (Figure 1; ASMFC 2024). The rise in catch-and-release fishing, as with many other coastal species, means a large component of contemporary annual removals is now comprised of dead discards due to post-release mortality.

The Atlantic Croaker is not a federally or state listed species. The Atlantic States Marine Fisheries Commission (ASMFC) oversees the management plan, with limited

management recommendations for the Southeastern US Atlantic. While a 2017 benchmark stock assessment was completed, conflicting trends in abundance and harvest, as well as other uncertainties, led to the assessment not being recommended for management use (ASMFC 2017; ASMFC 2024). The 2010 stock assessment, the last approved for management use, for Atlantic croaker determined that the Atlantic stock (including South Carolina) was not overfished and is not currently undergoing overfishing (ASFMC 2010).



Independent of stock assessments, each year a traffic light analysis (TLA) is performed to analyze trends in the fishery and implement state-specific management actions if necessary (ASMFC 2024). However, recent TLA analyses have also shown conflicting trends in abundance (adult and juvenile) and harvest of Atlantic croaker, with significant decreases in overall harvest but increases in adult abundance and some juvenile abundance (ASMFC 2024). The 2020 TLA showed significant declines in abundance and harvest of Atlantic croaker in the mid-Atlantic which triggered management actions be put in place for the entire region (ASMFC 2024). Overall status could not be determined in the 2022 TLA due to limited data availability from fishery independent surveys and the TLA was not run in 2023 due to an ongoing stock assessment (ASMFC 2024). An updated benchmark stock assessment for Atlantic Croaker will be completed in 2024. Results of the most recent TLA, for fishing year 2021, is found in Figure 2.

Figure 2: Atlantic croaker traffic light analysis harvest metrics for mid-Atlantic (NJ-VA; top) and south Atlantic (NC-FL; bottom) regions. Management response is triggered when the proportion of red exceeds either the 30% (moderate management response) or 60% (higher management response) threshold level for 3 out of 4 of the most recent years in both harvest and abundance metrics. (Source: ASMFC 2022)

POPULATION SIZE AND DISTRIBUTION

Atlantic Croaker are a very common species in the waters of South Carolina. Globally, they occur in coastal waters from Cape Cod, Massachusetts to Campeche Bank, Mexico, and possibly from southern Brazil to Argentina (Mercer 1987). The species has an extended spawning season— depending on the coastal area—that can range from October through April (ASMFC 2010). Adults in spawning condition have been found in depths of 7-131 m (23-430 ft.) north of Cape Hatteras, and from 5-50 km (3-31 mi.) offshore of South Carolina in depths of 40-91 m (131-298 ft.; Bearden 1964).

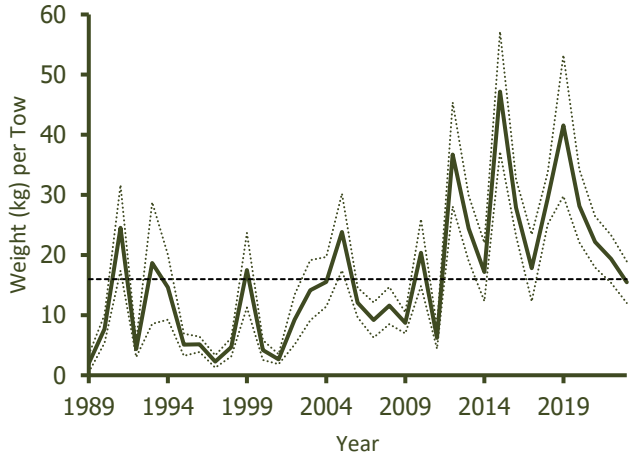


Figure 3: Stratified mean annual CPUE (kg/tow) for Atlantic croaker for fall months across for the SEAMAP-SA coastal trawl survey. The blue line represents the long-term mean and the dashed lines represent the 95% confidence intervals.

Joseph (1972) examined historical landings and catch-per-unit-effort data for Atlantic croaker stocks in the mid-Atlantic states and Chesapeake Bay and concluded fluctuations in abundance over the previous 80 years were largely attributable to the natural environment, namely temperature. He noted unusually cold winters could decimate larval and juvenile fish. More recent evidence indicates year-class strength is decoupled from larval supply and is determined by temperature-linked, overwinter survival of juveniles (Hare and Abel 2007). Hare and Abel (2007) hypothesized the environment drives the large-scale variability in Atlantic Croaker abundance and distribution, but fishing and habitat loss decrease the resiliency of the population to periods of poor environmental conditions and subsequent weak year classes.

Additionally, there is archeological evidence for changes in the population age structure of Atlantic croaker in the south Atlantic region. Hales and Reitz (1992) examined Native American middens and Spanish colonial sites in Florida for Atlantic croaker otoliths and found large fish (12-46 cm (5-18") TL) that were present from 2000 BC to the mid-16th century. They concluded there has been a severe reduction in size and age of Atlantic croaker in the southeast within historic times due to overfishing or habitat degradation. This reduction could be related to mechanized commercial shrimp trawl bycatch since the early 20th century.

Several contemporary South Carolina Department of Natural Resources (SCDNR) long-term fishery independent monitoring programs encounter Atlantic croaker in sufficient numbers for the development of relative abundance indices. First, the Southeast Area Monitoring and Assessment Program – South Atlantic (SEAMAP-SA) coastal trawl survey (CTS) is a shallow water, fishery independent trawl survey that monitors status and trends of numerous coastal species within the coastal zone in Atlantic waters off the southeastern United States between Cape Canaveral, FL to Cape Hatteras, NC. The stratified annual mean catch per unit effort (CPUE) in kilograms per tow for fall months for Atlantic Croaker from the CTS has been highly variable since 1989. The general trend has been increasing abundance since 2007, although the index value has been declining for the last four years of the series (Figure 3).

SCDNR Inshore Fisheries runs three additional long-term fishery independent indices in estuarine waters that encounter Atlantic croaker regularly, namely the trammel net,

electrofishing and estuarine trawl surveys. In the trammel net survey, relative abundance of Atlantic croaker has increased since the early-2000s, particularly since a recent low in 2018 (Figure 4). Of note, evident is the impacts of marine cold spells during the winters of 1993-1994, 2000-2001, and 2017-2018, which affected the abundance of spotted seatrout in coastal waters but also apparently affected the abundance of Atlantic croaker in subsequent years. This supports the finding that Atlantic croaker recruitment is environmentally, and likely temperature linked as suggested by previous research (Hare and Abel 2007; Joseph 1972). The relative abundance trend in the electrofishing survey, in contrast, suggests a stable to declining population through time, with recent years near all-time lows (Figure 4). Finally, the estuarine trawl survey suggests increasing relative abundance through the late-2010s, with potential recent declines (Figure 4). Of note, the estuarine trawl and electrofishing survey encounters similar sized young-of-the-year croaker, while the trammel net survey due to the nature of the gear selects for larger individuals (Figure 5). This suggests local environmental conditions are leading to driving different trends in Atlantic croaker abundance between the electrofishing and estuarine trawl surveys.

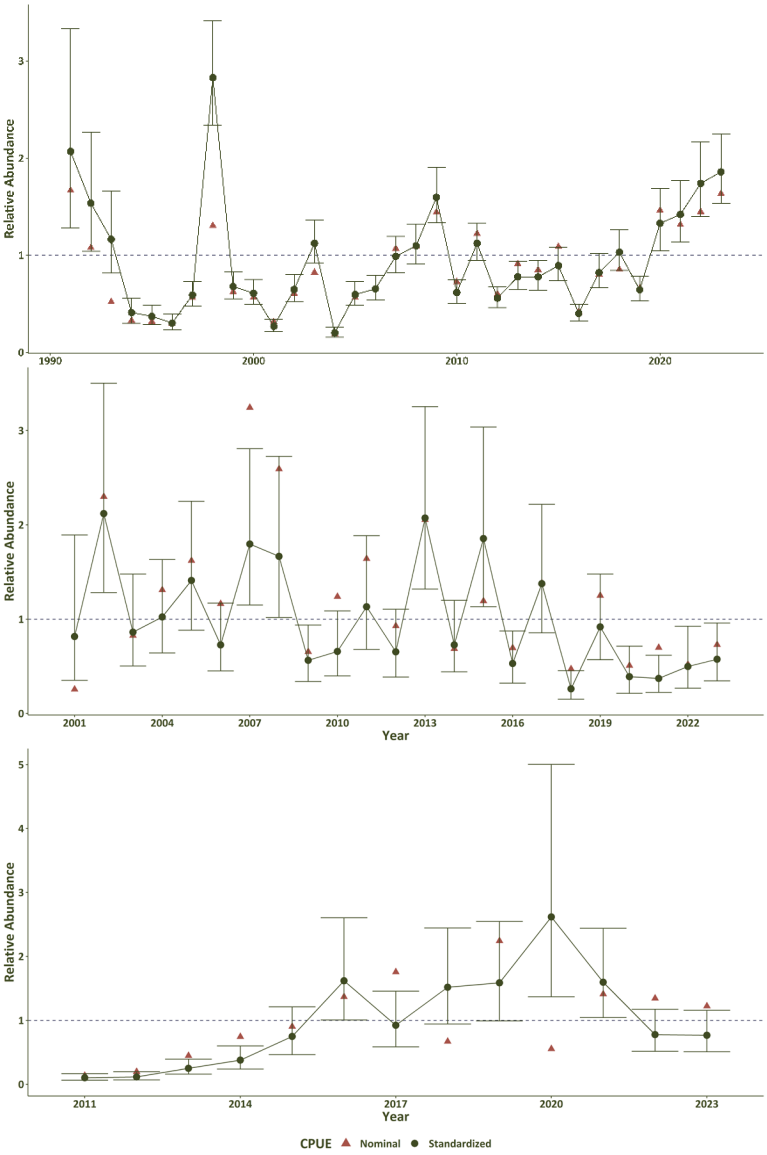


Figure 4: Atlantic croaker standardized catch per unit effort in SCDNR's Inshore Fisheries trammel net (top), electrofishing (middle) and estuarine trawl (bottom) surveys by year. Shown is the standardized index of abundance (green line and circles) with a 95% CI (error bars) as well as nominal catch per unit effort (red triangles). Both the standardized and nominal indices are normalized to average catches from 2010-2023 (trammel net) or time-series average catches (electrofishing and estuarine trawl; dashed lines), such that if annual estimates are greater than 1, catch was above average and vice versa if below.

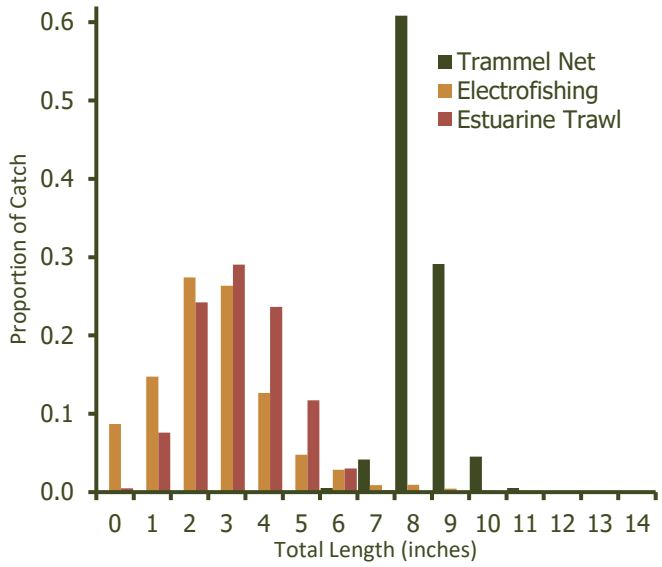


Figure 5: Length frequency of Atlantic croaker captured in the trammel net (green), electrofishing (gold), and estuarine trawl (red) surveys.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Atlantic croaker has a down-turned mouth, making it well-suited for its bottom-feeding life style. Adults spawn offshore, producing larvae that are carried into the coastal inlets by tidal currents. Larvae ride the "salt wedge" which moves along the bottom into estuaries (Bearden 1964). Larvae have a day-night (diel) distribution in the water column that is opposite of that for most planktonic animals (Comyns and Lyczkowksi-Shultz 2004). This "reverse diel vertical migration" means they are more common in deeper water during daylight compared to night. Optimal habitat for post-settlement juveniles are the low salinity zone in the upper portion of the estuary. Peterson et al. (1999) demonstrated in controlled laboratory experiments Atlantic croaker grew considerably faster in salinities of 5 parts per thousand (ppt) than those growing in 20 ppt or a variable salinity (5 to 20 ppt). Young Atlantic croaker first recruit to the upper estuarine areas and gradually move seaward toward higher salinities as they become larger (Bearden 1964). Lower salinity estuaries typically had larger numbers of Atlantic Croaker compared to higher salinity estuaries, indicating survival and growth are enhanced by lower salinities and/or other factors that might be related to salinity (Bearden 1964). Miglarese et al. (1982), also working in South Carolina estuaries, found salinity affects size distribution, and Chao and Musick (1977) found croakers were most abundant in lower salinities in the York River, Virginia. However, others have suggested depth and food preference may be related to size distribution (Miglarese et al. 1982).

Rogers et al. (1984) found seasonal freshets of river flow were important to estuarine-dependent species including Atlantic croaker. They noted it was striking that low salinity and freshwater areas serve as primary zones of recruitment and peak recruitment and utilization periods occur during the period of maximum riverine influence, temporarily creating "a much larger proportion of the preferred habitat." Ross (2003) concluded oligohaline habitats (low salinity: 0.5-5.0 ppt) provided better habitats for spot and Atlantic croaker because mortality rates are lower there. There are several explanations of why mortality rates are lower in the lower salinity areas including: reduced predation, lower respiration rates (compared to high salinity), and higher growth rates.

Parker (1971) noted that the "large concentrations of Croaker were always observed in shallow waters less than 1.2 m (4 ft.) deep and in close proximity to a source of fresh or brackish water." Parker also noted these habitats were generally soft mud bottoms with large quantities of detritus, suggesting these shallow areas provide abundant food and protection from predators. Bearden (1964) also found young Atlantic croaker were most often found in small tidal creeks where bottoms are composed of soft mud and decomposing organic matter. He noted larger Atlantic croaker were found on a great variety of bottom types, but were most abundant on "bottoms composed of mud and sand mixture, particularly near the mouths of tidal sounds and several miles offshore." Miller and Able (2002), working in Delaware Bay, found young Atlantic croaker used the entire range of marsh creek habitats. When found in deeper waters of the bay, croaker were most abundant over the mud bottoms.

In summary, it appears that the lower-salinity upper reaches of estuaries are optimal habitat in South Carolina for young Atlantic croaker. Survival and growth rates appear to be higher in low salinity areas although the reason(s) is unknown. Atlantic croaker move seaward as they become larger, using the deeper channels to migrate. Mud bottom habitats throughout the estuary appear to be important to the species regardless of depth. Atlantic croaker are a significant and ubiquitous component of the near-shore and inshore benthic fish community and as such, this species is a valuable indicator species of the relative health of estuarine benthic finfish and their associated habitat.

CHALLENGES

Atlantic croaker along coastal South Carolina face a number of challenges, including increased fishing pressure, changing and increasingly stressful environmental conditions, loss and degradation of critical habitats, and other anthropogenic stressors such as contaminants and pollutants. Further, major data gaps still exist including the size composition of recreationally released fish, and hence the sizes and ages subject to post release mortality and fishery selectivity. Since colonial times, size- and age-structure of Atlantic croaker populations appears to have changed drastically in ways consistent with heavy fishing pressure (Hales and Reitz 1992).

Emerging challenges facing Atlantic croaker, and many other estuarine species, included the impact of warming estuarine waters and marine heat waves during critical life history stages, phenological changes in weather patterns and food web dynamics, and increased variability in the climate. Further, adequate freshwater flow into the coastal zone appears to be very important to the species with inadequate freshwater flow into estuaries when juveniles are on the nursery grounds negatively impacting the species due to changing estuarine salinity profiles. Loss of shallow saltmarsh habitats through construction of seawalls in the upper reaches of tidal creeks could also be detrimental. Additionally, compromised water quality resulting from nutrients and

chemicals associated with untreated storm water from coastal development could negatively affect the species, particularly the juveniles while in the nursery habitats

The potential impacts of chemical pollutants on Atlantic Croaker and other fishes are just now coming to light. Emerging contaminants of concern, including per- and polyfluoroalkyl substances and microplastics among others, on the productivity of the population still needs investigation, particularly given recruitment appears closely tied to environmental conditions. The impact of other endocrine disrupting chemicals (EDCs) such as organo-chlorines, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and alkylphenols are being investigated in fishes. Thomas (1990) found female Atlantic croaker exposed to cadmium had elevated levels of reproductive hormones resulting in precocious ovarian growth; exposure to lead, benzene(a)pyrene, and the PCB Aroclor 1254 each caused a decline in circulating steroid hormone levels and ovarian growth. McCarthy et al. (2003) demonstrated environmentally realistic loadings of a PCB (Aroclor 1254) in eggs of Atlantic Croaker through dietary exposure and maternal transfer can have significant effects on survival and growth rates of larvae. In a separate study, Khan and Thomas (1996) showed that Aroclor 1254 significantly blocks testicular growth in Atlantic Croaker.

CONSERVATION ACCOMPLISHMENTS

Actions taken by the South Atlantic Fishery Management Council in Amendment 2 to Shrimp Management Plan (SAFMC 1996) and by the Atlantic States Marine Fisheries Commission in the Weakfish Management Plan (ASMFC 1994) have resulted in the mandatory use of by-catch reduction devices in shrimp trawl nets. Studies have shown that these devices are useful in reducing by-catch-related fishing mortality of fishes including Atlantic Croaker. Additionally, the South Carolina General Assembly closed most of the area in the State's sounds and bays to shrimp trawling in 1986, thus reducing fishing mortality and providing greater survival of juveniles. Another legislative action by South Carolina eliminated small mesh gill nets in the state's estuaries and significantly reduced the length of recreational gill nets to 30.5 m (100 ft.). Beginning in 2014, Atlantic Croaker are regulated in the recreational fishery by an aggregate bag limit along with other Sciaenids, spot (*Leiostomus xanthurus*) and southern kingfish (*Menticirrhus americanus*), where any combination of the three species can sum to 50 fish per person.

Regionally, Atlantic croaker are managed under Amendment 1 to the Interstate Fishery Management Plan for Atlantic Croaker (ASMFC 2005) and Addenda I, II, and III (ASMFC 2011, ASMFC 2014, ASMFC 2020). The Amendment did not require any specific measures restricting harvest but encouraged states with conservative measures to maintain them while also implementing a set of management triggers to respond to changes in the fishery or resource.

CONSERVATION RECOMMENDATIONS

Regional assessments have identified numerous research recommendations conducive to the effective assessment and management of Atlantic croaker (ASMFC 2010). Added to this list are some state specific priorities. Combined, identified research priorities include:

- Continue fisheries-independent surveys throughout the species range and subsample for individual weights and ages, particularly in the southern range.
- Encourage fishery-dependent biological sampling of Atlantic croaker from the southern region. Collect age samples from the recreational fishery when the length distribution of the recreational fishery is not adequately represented by the fisheries from which the age-length keys are developed.
- Conduct post-release mortality studies for recreational and commercial fisheries, including investigation of sub-lethal effects of landings, particularly as impacted by fishing depth, fish size, fishing season, and the type of terminal tackle used.
- Better characterize the reproductive potential of the population, particularly in the southern region, through investigations of batch fecundity, lengths- and age-at-maturity, sex ratios, spawning seasons, and spawning frequencies. Investigate who these values change with size and/or age.
- Evaluate drivers of recruitment success and other environmental covariates affecting population dynamics.
- Develop a coast-wide tagging program to evaluate migration and movement and continue any coast-wide studies (e.g., genetic, otolith microchemistry) designed to improve understanding of stock definition.
- Quantify the level of Atlantic croaker bycatch from the South Carolina commercial shrimp trawling fishery and associated mortality levels.
- Determine the level of contaminants (organics, pesticides, heavy metals, per- and polyfluoroalkyl substances) found in Atlantic croaker as well as the sediments/waters in the areas in which they are caught. Relate that to the potential effects of bioaccumulation.
- Examine ecological interactions between Atlantic croaker and other species, including red drum.
- Protect water quality in marine ecosystems by encouraging municipalities to use Best Management Practices (BMPs) to reduce runoff from highways, agricultural fields, and housing developments.
- Plan development based on sound terrestrial and estuarine ecology that takes into consideration all factors affecting the long-term health of the estuary ecosystem.
- Partner with other state agencies to improve resource management at the whole estuary or drainage basin level using a more holistic ecological approach. Such

restructuring should provide for greater regulatory authority in implementing migratory fish management plans.

- Work with partner agencies and municipalities to minimize the loss of salt marsh habitat to construction projects in the Coastal Zone.
- Along with OCRM and other partners, work with municipal and county planners to work toward reducing the negative impacts of urban development to sensitive areas in coastal marshes.

MEASURE OF SUCCESS

The fishery-independent programs conducted by the SCDNR annually monitors the relative abundance, population demographics (size- and age-compositions) and reproductive potential of estuarine and nearshore demersal finfish, such as Atlantic croaker. These surveys can detect changes in those parameters, providing critical data for the assessment of stock status and early detection of change (positive or negative) in abundance or population demographics. Although there appears to be much variability in relative abundance year to year, the ultimate measure of success will be to document stable to increasing population trends over long-term periods.

Further, work identifying abiotic and biotic drivers of population fluctuations, in particular concerning recruitment, remain critical for projecting the response of Atlantic croaker to future climate change, climate variability, and emerging contaminants of concern.

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Atlantic Menhaden

Brevoortia tyrannus



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DESCRIPTION

Atlantic menhaden, a Clupeoid fish of interest to fisheries, is one of the most common forage fish species encountered in South Carolina estuarine and coastal waters. It is estuarine-dependent with juveniles utilizing estuarine nursery areas (Whitehead 1985).

Taxonomy and Basic Description

Atlantic menhaden, *Brevoortia tyrannus* (Latrobe 1802), belong to the order Clupeiformes and the shad family, Alosidae (Page et al. 2023), and are similar in appearance to the alewife and shad. They belong to the subfamily Alosinae (a.k.a. the shads), which includes 7 genera, 2 of which (*Brevoortia* and *Alosa*) have representatives in the western Atlantic (Whitehead 1985). The genus *Brevoortia* includes 6 species: *B. aurea*, *B. gunteri*, *B. patronus*, *B. pectinata*, *B. smithi*, and *B. tyrannus*. *B. tyrannus* and *B. smithi* (yellowfin menhaden) overlap in distribution off the East coast of the United States, particularly off Florida (Whitehead 1985). In areas of overlap, *B. tyrannus* and *B. smithi* commonly will hybridize (Dahlberg 1970).

Atlantic menhaden have a bluish body above with silvery sides possessing a reddish luster and fins tinged with pale yellow and edged in black (ASMFC 1981). They are distinguished from other Alosidae by a large head, an upper jaw with distinct median notch, no teeth, pectinated scales, the location of the dorsal fin over the interval between the pelvic and anal fins, the pelvic fin with a rounded hind margin, modified pre-dorsal scales, and a compressed body with bony scutes along the belly (ASMFC 1981; Whitehead 1985). Atlantic menhaden posses long gill rakers and a muscular pyloric stomach or gizzard (ASMFC 1981). The lateral line scales above the base of the anal fin and at the base of the tail are much smaller and irregularly spaced (Whitehead 1985). There is a conspicuous black spot behind the gill opening that is usually followed along the flank by a variable number of smaller spots (or blotches) forming up to 6 approximate lines (ASMFC 1981; Whitehead 1985). Atlantic menhaden are readily distinguished from yellowfin menhaden due to the difference in lateral line scale number (40 to 58 (usually 45-52) versus 54 to 80 (usually 60-70) in *B. tyrannus* and *B. smithi*, respectively) and a lack of lines of spots on flank in *B. smithi* (Whitehead 1985). Other *Brevoortia* species do not overlap in range while other alosids lack the modified pre-dorsal scales (Whitehead 1985).

Status

Currently, the Atlantic menhaden population is managed by the Atlantic States Marine Fisheries Commission (ASMFC) as a unit stock along the east coast of the United States. In February 2020, the ASFMC Atlantic Menhaden Board accepted the results of the Atlantic Menhaden Single-Species and Ecological Reference Point (ERP) Assessments and Peer Review Reports (ASMFC 2020; SEDAR 2020) for management use. Of note, the ERP assessment evaluates the health of the stock in an ecosystem context using an ecosystem model focused on four key predator species (striped bass, bluefish, weakfish, and spiny dogfish) and three key prey species (Atlantic menhaden, Atlantic herring, and bay anchovy; ASMFC 2020). The ERP assessment indicated lower fishing mortality (F) reference points for menhaden, relative to the single-species model, to account for menhaden's role as a forage fish were necessary. This lead to the development of ERP reference points directly accounting for the menhaden needed to sustain Atlantic striped bass at their biomass target (or threshold) when striped bass are fished at their target (or threshold; ASMFC 2020). An update of the Atlantic menhaden single-species model was performed in 2022 (ASMFC 2022), with stock status determined relative to the defined ERP reference points accepted following the benchmark assessments (ASMFC 2020).

The recent update assessment determined the stock was not overfished nor experiencing overfishing in the terminal year (ASMFC 2022). The assessment suggested that while overfishing had occurred only briefly throughout the assessment time series (1972-1973 & 1985), F exceeded target levels most years from 1955- 1998 (Figure 1; ASMFC 2022). Since the late-1990s, F has hovered around the target F (ASMFC 2022). The last extended period when the stock was overfished was from 1971-1990, with the stock being approximately at the target fecundity since the early-1990s (Figure 2; ASMFC 2022).

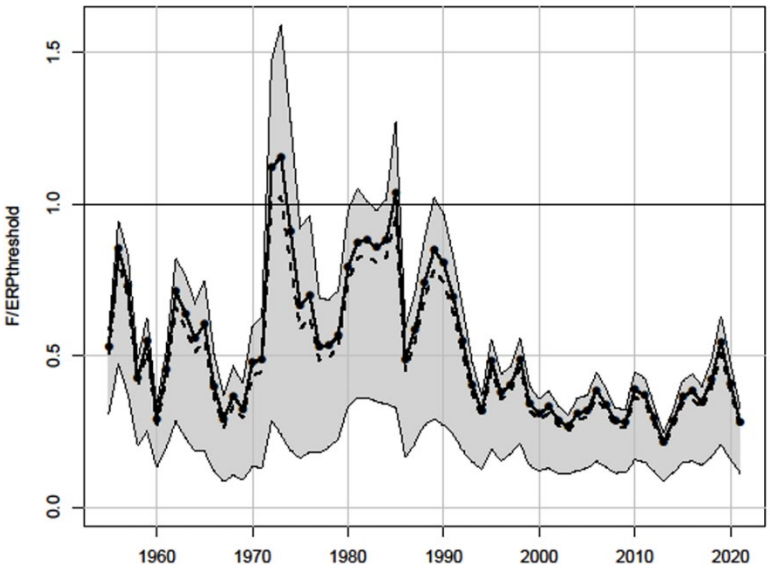


Figure 1: Annual F relative to threshold F (F_{ERP} of F=0.28; Source: ASMFC 2022). The grey represents the 5th and 95th percentiles across Monte-Carlo Bootstrap (MCB) iterations, while the black line with closed black circles represents the base run. The dashed line represents the median of the MCB analysis.

POPULATON SIZE AND DISTRIBUTION

Atlantic menhaden are distributed from Nova Scotia, Canada, southward to Indian River, Florida. Throughout this range, they are a euryhaline species that occurs in the Atlantic Ocean and inland tidal waters (Hildebrand 1948;

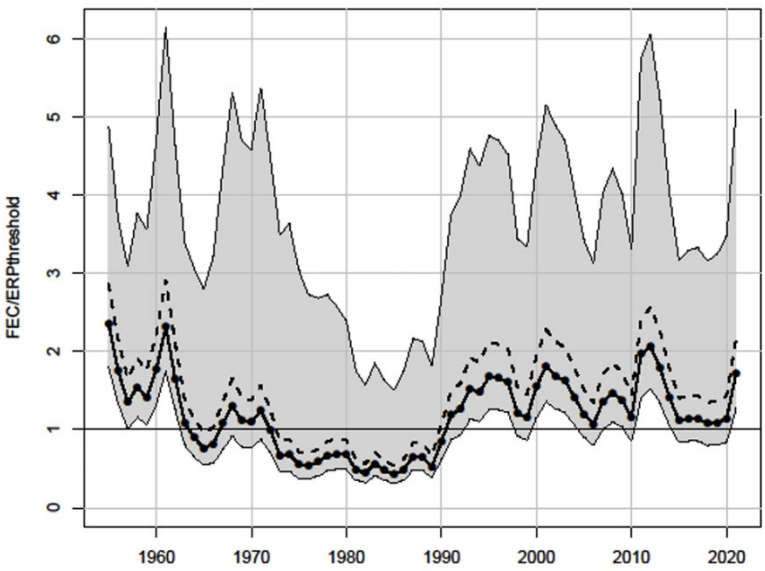


Figure 2: Annual population fecundity relative to threshold fecundity (Source: ASMFC 2022). The grey represents the 5th and 95th percentiles across Monte-Carlo Bootstrap (MCB) iterations, while the black line with closed black circles represents the base run. The dashed line represents the median of the MCB analysis.

Hildebrand 1964; Reintjes 1960; Reintjes 1964). Juveniles and adults occupy bays, sounds, and estuaries to the uppermost limits of brackish water (ASMFC 1981). In coastal ocean waters, they are confined to waters of the Continental Shelf and are never observed far from land (ASMFC 1981). Seaward, the farthest from land an Atlantic menhaden has been captured was approximately 130 km (81 mi.) south of Cape Cod by a Soviet trawler (Gusev 1964). Historically, this distance from shore is about the maximum distance from land schools have been sighted by scouting aircraft, and further offshore than the seaward limit of the purse seine fishery (ASMFC 1981).

Generally, Atlantic menhaden are found inshore during summer months, but at least some move into deeper waters in winter. It is thought this offshore movement during winter months is less pronounced in the southern part of their range (Whitehead 1985). Adults are found in near surface waters (June 1961), most commonly in continental shelf water, in greatest abundance immediately adjacent to major estuaries (Jones et al. 1978). Juveniles are generally found in shallower, potentially lower salinity waters, with the smallest size groups being found farthest upriver (June and Chamberlain 1959).

Menhaden are pelagic, forming large and compact schools (Whitehead 1985). The majority appear to be migratory in nature, with northward migrations occurring during the spring/summer and southward migrations occurring during the fall (Figure 3; ASMFC 1981; Whitehead 1985). More specifically, different size/age menhaden appear to undergo migrations of different degrees, with larger/older individuals migrating

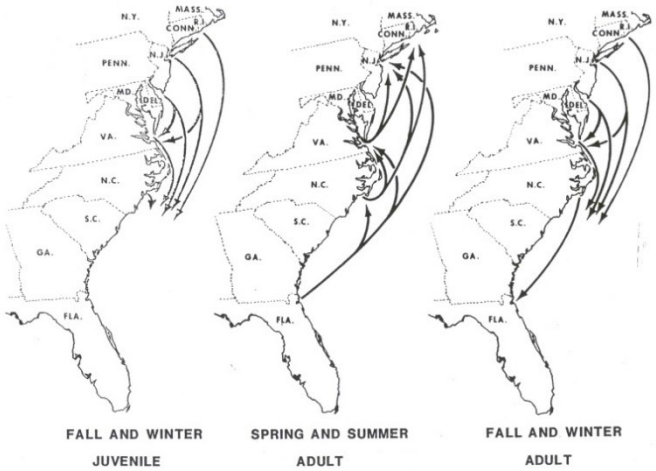


Figure 3: Juvenile and adult migrations of Atlantic menhaden (Source: ASMFC 1981).

further distances (Dryfoos et al. 1973; Nicholson 1978). Menhaden typically school with individuals of a similar size and age in a locality, with schools remaining distinct from those of overlapping sizes and ages in adjacent localities. The net effect is a north-south gradient in size and age becoming established during summer months, with larger and older fish found farther northward (Dryfoos et al. 1973; June and Reintjes 1959; McHugh et al. 1959; Nicholson 1978; Whitehead 1985). In the fall, there is once again a southward withdrawal of fish from the summer grounds, with fish congregating in large schools (sometimes covering a surface area of many square kilometers) for the southward migration (ASMFC 1981). These large, migrating schools are last seen off the North Carolina coast in December and January (June 1961; Roithmayr 1963; Reintjes 1969; Nicholson 1971; Nicholson 1972; Dryfoos et al. 1973; Kroger and Guthrie 1973). Kroger and Guthrie (1973) found juvenile Atlantic menhaden also exhibit a seasonal north-south movement. From tag recoveries, they report juveniles (age-0's) migrate as far south as Florida in fall and winter, then redistribute northward along the coast by size as age-1 fish during the following spring and summer. Due to the redistribution by size, the smaller age-1 fish tend to remain along the south Atlantic coast.

In South Carolina, juvenile and adult Atlantic menhaden are present in estuaries and coastal ocean waters throughout the year. Unfortunately, there is not an estimate available of their absolute population size off South Carolina. However, several SCDNR fishery-independent surveys encounter menhaden in low to moderate numbers, including the SCDNR trammel net, SCDNR electrofishing, SCDNR estuarine trawl, and SCDNR coastal trawl surveys. The three inshore surveys (trammel net, electrofishing, and estuarine trawl) primarily encounter age-0 (electrofishing and estuarine trawl) and age-1 (trammel net) individuals. The 2022 benchmark assessments considered and, in the case of the electrofishing survey, included these indices in the coastwide assessment (ASMFC 2022). The SCDNR coastal trawl survey primarily encounters age-1+ Atlantic menhaden, and this survey was incorporated in the 2022 assessment as an adult abundance index for the southern region (ASMFC 2022). The recruitment indices suggest generally low recruitment interspersed with periodic strong recruitment in coastal South Carolina (e.g., 2001, 2003, 2012, 2023) which is typical for recruitment surveys where recruitment success is environmentally driven (Figure 4). The trammel net survey suggests higher relative abundances were observed in the early-1990s through mid-2000s, before an extended period of low abundance from the late-2000s through 2014, followed by a general increase since with peaks in abundance in 2017 and 2021 (Figure 5). Catches of Atlantic menhaden adults in the SEAMAP-SA coastal trawl survey indicate low relative abundance in general, though with a period of higher abundance in the late 2000s (Figure 5).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Being euryhaline, Atlantic menhaden can tolerate a wide range of salinities. As such, both juveniles and adults can be found in a wide array of nearshore habitats, including bays, sounds, and estuaries to the uppermost limits of brackish water (ASMFC 1981). In general, the smallest size groups are found farthest upriver (June and Chamberlain 1959), as attested by the catch of very small young-of-the-year in the SCDNR electrofishing survey. Regardless of size, Atlantic menhaden are pelagic in nature, feeding by filtering phytoplankton and zooplankton (Whitehead 1985; Scott and Scott 1988). As adults they are obligate filter-feeders, while larvae and pre-juvenile fish (smaller than 4.0 cm or 1.6 in. TL) are particulate feeders (Lazzaro 1987; James 1988). In the ecosystems where menhaden are found in South Carolina, they are a significant forage fish for a host of predators, including striped bass, bluefish, spotted seatrout, red drum, and various sharks and rays.

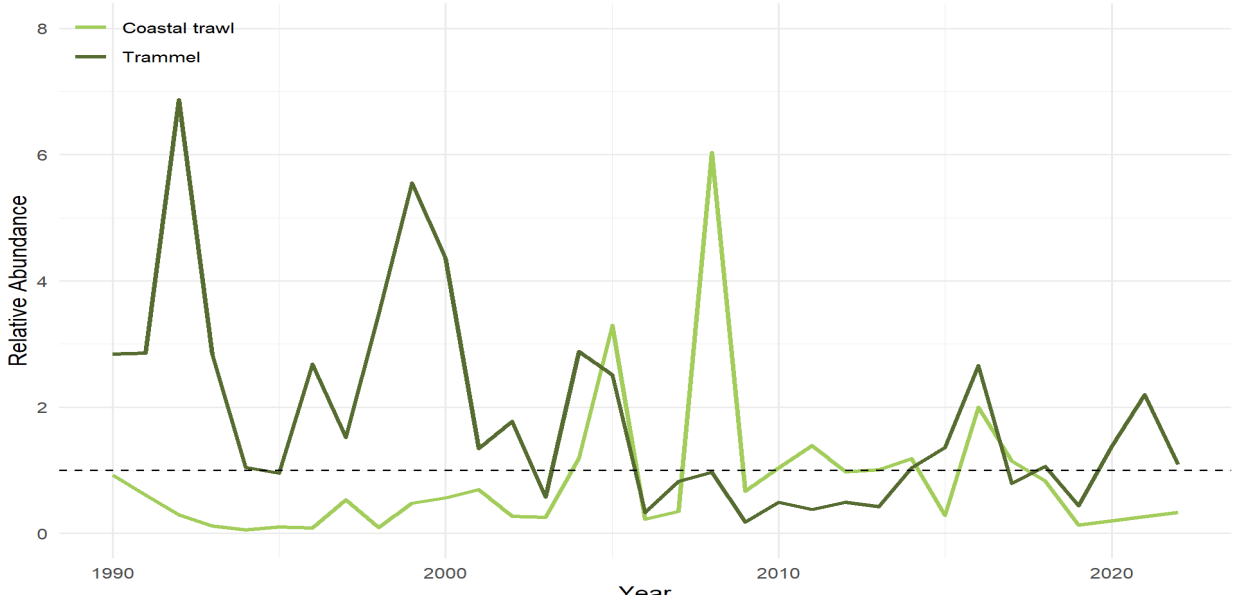


Figure 5: Standardized indices of abundance of Atlantic menhaden as developed from the SCDNR fishery-independent trammel net (dar green line) and coastal trawl (light green line) surveys.

Spawning likely occurs year-round, though there is evidence that the breeding season in specific locales is limited by high water temperatures (Higham and Nicholson 1964; Whitehead 1985). This limits spawning to certain seasons along the entire coast: spawning during the spring (April/May) in New England waters, autumn (October/November) in the mid-Atlantic, and winter (December to March) in the South Atlantic (Whitehead 1985). It is thought the major spawning season occurs off the Carolinas during December-February (ASMFC 2011), with the majority of ovigerous

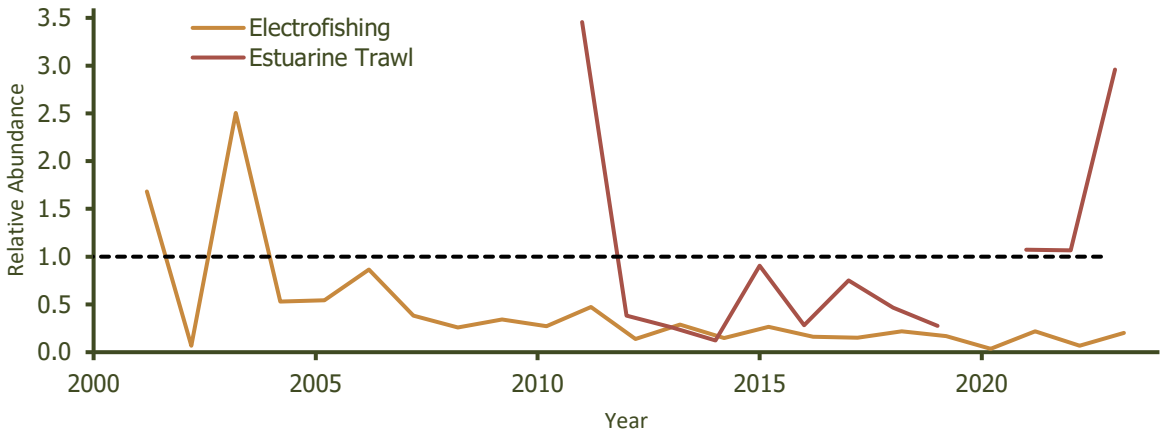


Figure 4: Standardized indices of abundance of Atlantic menhaden as developed from the SCDNR fishery-independent electrofishing (gold line) and estuarine trawl (red line) surveys.

females being observed in the South Atlantic (Nelson et al. 1977). The temperature, depth, and salinity at presumed spawning locations varies widely depending on latitude and distance from shore (Kendall and Reintjes 1975; Bourne and Govoni 1988; Berrien and Sibunka 1999; Checkley et al. 1999). Reported water temperatures are typically in the range of 55-77ºF (13 to 25ºC). Spawning occurs at depths <33-66 ft. (<10-20 m). Salinity at spawning sites has been reported to be 29-36 ppt at offshore mid-Atlantic sites and 35.8-36.6 ppt at South Atlantic sites. Eggs have been found at 18-28 ppt in Long Island Sound (Wheatland and Lewis 1956) and 10-22 ppt in Chesapeake Bay (Dovel 1971). Post hatching, larvae are pelagic (Massman et al. 1962), probably spending approximately a month in waters over the Continental Shelf (McKenney 1969), prior to entering estuarine waters at about 0.39 in. (10 mm) and larger (Reintjes 1969).

In the mid- and south-Atlantic nursery areas, bottom composition is "unconsolidated," consisting of sand-mud, and organic material which may be important to juvenile consumption (Lewis and Peters 1984; Peters and Schaaf 1991). Juvenile menhaden remain in their estuarine nursery areas throughout the summer. In fall, most juveniles emigrate southward, though some overwinter in the Chesapeake Bay and south-Atlantic region estuaries. Immature adult menhaden are most abundant in inshore and estuarine areas from Chesapeake Bay southward (Nicholson 1978). Older, larger adults are typically found in colder, rockier northerly habitats during summer, while they overwinter off North Carolina and further south (Nicholson 1978). Adults appear to prefer temperatures of about 64ºF (18ºC; ASMFC 2011).

CHALLENGES

As menhaden of different life stages use a diverse array of habitats, almost all estuarine and nearshore waters along the Atlantic coast from Florida to Nova Scotia serve as an important habitat for some life stage. As such, pollution and habitat degradation of any estuarine and nearshore habitat could be expected to threaten the coastal menhaden

population. Such habitat degradation concerns are especially acute in estuarine waters due to the residency of larvae and juveniles in these habitats (ASMFC 2011). An indication of the threat habitat degradation poses to menhaden is the concern that the outbreaks of ulcerative mycosis in the 1980s may have been symptomatic of deteriorating water quality in estuarine waters along the East coast (Ahrenholz et al. 1987). As coastal development increases, we expect estuarine water quality to further deteriorate unless steps are taken to ameliorate their effect on the environment (Cross et al. 1985). Estuarine and coastal habitats have been significantly affected by dredging, filling, coastal construction, energy plant development, pollution, waste disposal, and other human-related activities (ASMFC 1999a). Other potential threats in coastal waters include the offshore dumping of sewage. High concentrations of DDT have been reported in menhaden due to their feeding on plankton and detritus (Warlen et al. 1977). Directly applicable to Atlantic menhaden is the concern regarding microplastic pollution, with a study in Charleston Harbor finding the highest concentration of microplastics per gram of fish reported to date in Atlantic menhaden digestive tracts captured from the system, suggesting potential impacts of this emerging contaminant of concern (Parker et al. 2020).

An additional challenge to the Atlantic menhaden population is the large-scale fisheries that operate on the population. At present, two large-scale fisheries target Atlantic menhaden: a commercial reduction fishery and a commercial bait fishery (Figure 6; ASMFC 2022). Combined landings from the fleets peaked during the late-1950s (>600,000 metric tons), and then declined to lower levels during the 1960s. The stock rebuilt some during the 1970s, with landings rising before leveling off in the 1980s through mid-1990s as decreases in commercial reduction landings were offset by increases in commercial bait landings. Since the mid-1980s coastwide bait landings have gradually increased as reduction landings decreased, resulting in a relatively stable harvest of just over 200,000 mt annually since the early-2000s. Though landings off the coast of South Carolina have generally been small, due to the migratory nature of the stock, any overharvest of the stock in other regions can have an adverse effect on the sub-population located off the coast of South Carolina.

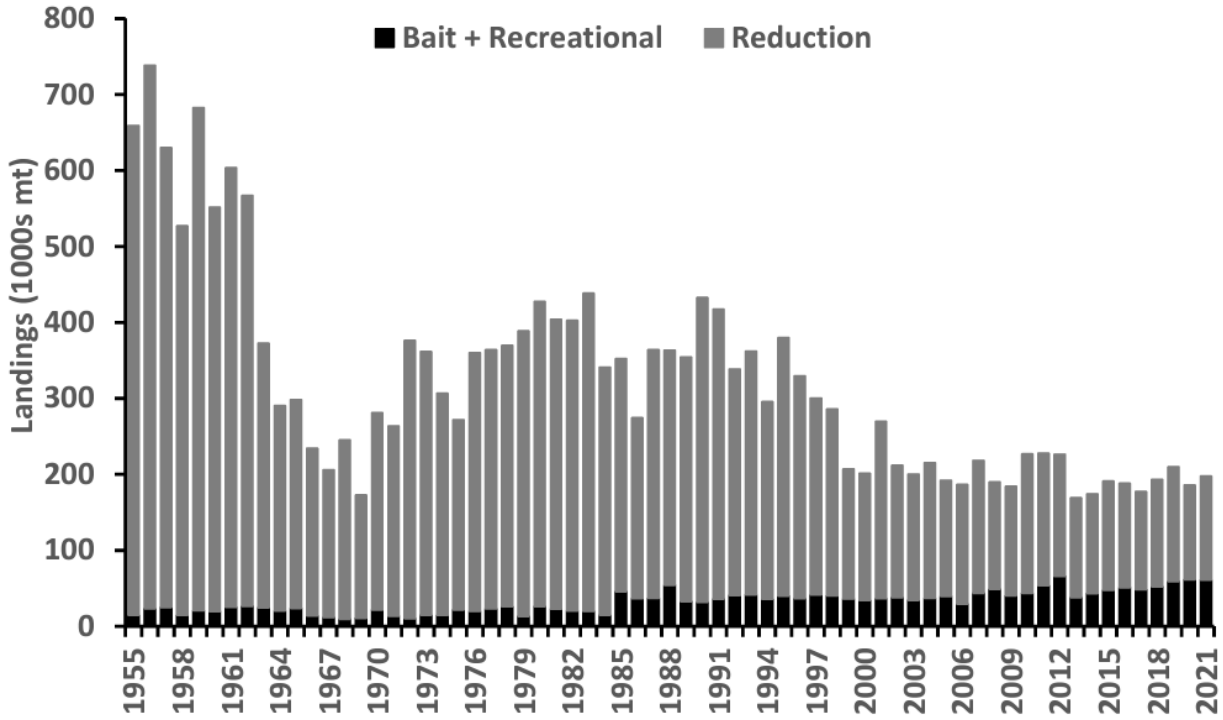


Figure 6: Coastwide Atlantic menhaden landings for the reduction and bait fisheries (1955-2021; Source: ASMFC 2022).

CONSERVATION ACCOMPLISHMENTS

Atlantic menhaden are currently managed under Addendum I to Amendment 3 to the Interstate Fishery Management Plan (FMP) for Atlantic Menhaden established via the Atlantic States Marine Fisheries Commission (ASMFC 2023). This Addendum includes provisions for setting annual total allowable catches (TAC; 2023-2025 = 233,550 mt), allocated percentages of the TAC to individual states, sets aside 1% of the TAC for episodic events, and prohibits purse seines as a permitted small-scale directed gear, thereby prohibiting them from harvesting the incidental catch/small-scale fishery provision. The addendum also continues to prohibit the rollover of unused quota, maintains the 6,000 pounds trip limit for applicable gear types following the closure of a directed fishery, and keeps the current Chesapeake Bay Cap, which was first implemented in 2006 to limit the amount of reduction harvest within the Bay, at 51,000 mt. This recognizes the Chesapeake Bay as nursery grounds for many species by capping reduction landings from the Bay to current harvest levels.

Further, the ASMFC Atlantic Menhaden Board continues to place a high priority on advancing the development of ecosystem-based reference points using a multispecies modeling approach (ASMFC 2020). This is because of the realization that Atlantic menhaden constitute a major component of the diet of coastal water piscivores. Ecosystem reference points are expected to address the forage needs of menhaden's predator species. The current single-species stock assessment is scheduled to complete

another update assessment in 2025, while the next benchmark ecological reference point assessment is also scheduled for completion in 2025.

CONSERVATION RECOMMENDATIONS

At the state level, conservation recommendations include:

- Continue to evaluate the effects of fishing and management plans on the South Carolina sub-population of Atlantic menhaden
- Initiate studies to investigate the within-year age composition variability of Atlantic menhaden in South Carolina coastal waters,
- Explore the trophic assemblages involving menhaden,
- Monitor trends in Atlantic menhaden young-of-the-year and adult relative abundance by continuing to collect data about this species during ongoing fishery-independent monitoring programs,
- Initiate additional work to understand the local and regional movement patterns of menhaden occurring in South Carolina waters,
- Protect water quality in marine ecosystems by encouraging municipalities to use Best Management Practices (BMPs) to reduce runoff from highways, agricultural fields, and housing developments. Improve BMPs in areas already affected by non-point source pollution.
- Plan development based on sound terrestrial and estuarine ecology that takes into consideration all factors that will affect the long-term health of the estuary ecosystem.
- Identify the origin of non-point source pollution and specific point source pollution and develop a plan of action to mitigate any negative impacts to the affected aquatic systems.
- Monitor the impact of contaminants of emerging concern in estuarine environments, such as per- and polyfluoroalkyl substances and microplastics.

The most recent benchmark assessment (single-species and ecological reference points; ASMFC 2020; SEDAR 2020) identified the following research recommendations for the coastwide stock applicable to South Carolina:

- Develop and implement a menhaden-specific, multi-year coastwide fishery-independent index of adult abundance-at-age with ground truthing for biological information (e.g., size- and age-compositions).
- Continue age-specific studies on spatial and temporal dynamics of spawning

- Conduct an ageing validation study, making sure to sample older age classes
- Continue to investigate environmental covariates related to productivity and recruitment on a temporal and spatial scale
- Consider other ageing methods for the future, such as the use of Fourier transform near infrared spectroscopy (FT-NIRS)
- Expand collection of diet and condition data along the Atlantic coast to provide seasonally and regionally stratified annual, year-round monitoring of key predator diets to provide information on prey abundance and predator consumption
- Improve monitoring of population trends and diet data in non-finfish predators (e.g., birds, marine mammals) and data-poor species (e.g., bay anchovy, sand eels, benthic invertebrates, zooplankton, and phytoplankton) to better characterize the importance of Atlantic menhaden and other forage species to the ecosystem dynamics

MEASURE OF SUCCESS

The SCDNR fishery-independent programs that annually monitor the relative abundance and length frequency of inshore fish species are already in place to monitor for changes in size distribution and relative abundance as a result of regional management efforts. The measurement of success will be to see an increasing trend in catch of Atlantic menhaden in these surveys.

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Atlantic Tripletail

Lobotes surinamensis

Contributors:
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Illustration by Duane Raver, Jr.

DESCRIPTION

Taxonomy and Basic Description

The Atlantic tripletail, *Lobotes surinamensis*, is a compressed, deep-bodied fish recognizable as an adult by its three rounded fins and a concave head (Gudger 1931). Found in warm coastal waters around the globe, this fish can reach up to 1100 mm (43 in.) in total length (TL) and 19.2 kg in weight (Baughman 1941; IGFA 2001). Atlantic tripletail are relatively short-lived, with an average lifespan of 5-10 years (Merriner and Foster 1974; Armstrong 1996; Strelcheck et al. 2004). As a result, juveniles reach maturity around age 1, growing the most during their first year of life (up to 600 mm TL; Merriner and Foster 1974; Franks et al. 2001; Jefferson et al. 2021). Juveniles are often brown to dark brown or black and yellowish in coloration, while adults may vary from brown to red or greyish mottling (Baughman 1941). Both are known to prefer shaded areas, where they often float on their sides to camouflage as drifting mangrove leaves or debris (Baughman 1941). Tripletail are gonochoristic, meaning males and females remain separate sexes throughout their entire lifespan. This species is one of the two members in the family Lobotidae, found within the order Acanthuriformes, and the only member found in the Atlantic Ocean (Page et al. 2023).

Status

Atlantic tripletail were previously managed by the Gulf of Mexico Fishery Management Council (GMFMC). However, due to variability or a lack of data, the GMFMC decided to remove Atlantic tripletail from inclusion in federal management practices. As a result, this species is managed on a state-by-state basis. In 2020, South Carolina implemented catch (3 per person per day or 9 per boat per day) and size (at least 18 inches TL) limit regulations. There is currently no stock status information available for this species. Based on a 2012 IUCN assessment, the Atlantic tripletail is listed as a species of 'Least Concern'. However, this assessment dates from over a decade ago and is noted as 'needs updating'.

POPULATION SIZE AND DISTRIBUTION

Along the eastern seaboard, Atlantic tripletail are distributed from Massachusetts to Argentina, throughout the Gulf of Mexico, and the Caribbean Sea (Gudger 1931; Hoese and Moore 1998), though the densest populations are found southward of the

Chesapeake Bay (Gudger 1931). This species is commonly found in association with structure (e.g., *Sargassum*, pilings, buoys, platforms, etc.) and shade, both in nearshore and offshore coastal regions (Gudger 1931; Baughman 1941; Caldwell 1955). Atlantic tripletail are migratory fish (Merriner and Foster 1974; Streich 2013), yet these patterns are not very well understood. This species has become more commonly encountered in our fishery-independent trammel net survey since the early-2010s, in which we sample randomly selected sites along salt-marsh edges within five estuaries statewide (Winyah Bay, Cape Romain, Charleston Harbor, ACE Basin, and Port Royal Sound), with 9 of 12 (75%) years since 2102 encountering 10 or more individuals while 10 individuals or more were only encountered during five of 21 years (24%) from 1991-2011. However catch rates are currently not high enough for the development of indices of abundance.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

In the summer, Atlantic tripletail occupy inshore and nearshore areas such as bays, basins, and lagoons (Gudger 1931; Baughman 1941; Merriner and Foster 1974). This species prefers structured habitat including wrecks, pilings, buoys, jetties, and patches of *Sargassum* for juveniles (Gudger 1931; Baughman 1941; Caldwell 1955). Adults may be found in open waters or passes such as the mouths of estuarine systems (Baughman 1941). Outside of seasonal occurrences (typically April-October), estuarine habitat-use of the Atlantic tripletail is not very well known (Streich 2013). These fish are opportunistic feeders eating both small finfish and invertebrate species, a few of these prey items including menhaden, blue crabs, and shrimp (Gudger 1931; Baughman 1941).

CHALLENGES

The population status of Atlantic tripletail in South Carolina is difficult to assess due to a lack of data in the region. Little is known about the species' habitat-use and life history, particularly in South Carolina, and therefore fishing pressures and climate change consequences are challenging to gauge. However, as South Carolina is near the northern extent of their current range, warming estuaries may allow larger populations of Atlantic tripletail to develop in South Carolina, which may be what the SCDNR trammel net survey is currently observing.

CONSERVATION ACCOMPLISHMENTS

The Atlantic tripletail fishery in South Carolina is managed by the state, with recent implementation of catch (3 per person per day or 9 per boat) and size (at least 18 in.) limits in 2020. Prior, no size limits existed for this species. South Carolina was the last state within the northern species range to enact regulations due to growing recreational and commercial fisheries over the last decade.

CONSERVATION RECOMMENDATIONS

- Performing a formal stock assessment for Atlantic tripletail in the Southeastern US coastal waters would allow for a better understanding of their stock status, fishing pressure, and best future direction for the sustainable management of this species, however more robust input data for the assessment is needed.
- Continue to monitor Atlantic tripletail populations via fishery-independent sampling programs such as the SCDNR trammel net survey.
- Initiate studies of the life history, juvenile habitat preference, and spawning locations.

MEASURE OF SUCCESS

Measurement of management success is difficult given the lack of population assessments and fishery-dependent and -independent data. However, the SCDNR Inshore Fisheries (IF) group monitors relative abundance, population demographics, and reproductive status of estuarine finfishes through monthly trammel netting, electrofishing, and longline surveys and can detect changes in those parameters that result from management efforts. Increases in recruitment, abundance, and size- and/or age-compositions would indicate positive trends in the population.

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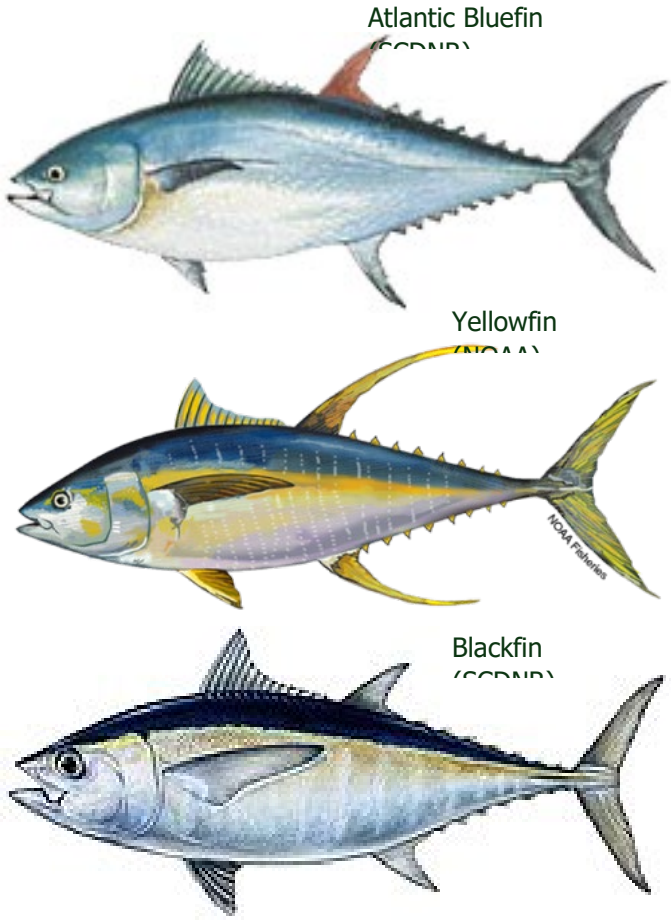
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Tuna

Atlantic Bluefin *Thunnus thynnus*, Yellowfin *Thunnus albacares,* Blackfin *Thunnus atlanticus*

Contributors:
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DESCRIPTION

Taxonomy and Basic Description

These tunas, all members of the order Scombriformes and family Scombridae (Page et al. 2023) are further subgrouped into the tribe Thunnini. Tunas within this tribe become sexually mature near 20 pounds and can reach weights of 1,500 pounds (SCDNR Sea Science). Size and age differ among species of tunas; smaller species tend to have shorter lifespans, while other species grow larger and have relatively longer lifespans. Size also varies among tuna between male and female. Male tuna will grow larger and faster than females. The largest tuna, Atlantic bluefin tuna, reach lengths over 13 feet and 1,500 pounds. This species has a suggested lifespan of over 35 years, which is substantially longer than the two to 18 year estimated lifespan of the yellowfin tuna (Murua 2017, Andrews 2020). Blackfin tuna are much smaller, weighing 15 pounds at age five. Blackfins average weight nears 42 pounds suggesting this species lifespan is near 10 years (De Sylva 1987). Tunas have a fusiform body shape with a lunate caudal fin that allows them to move at high speeds through the water column via thunniform swimming (Graham 2004). Tunas have two dorsal fins, the first with 11 to 14 spines, separated by an interspace and the second with 12 to 16 rays. Posterior to the second dorsal fin are seven to 10 distinguished finlets. They have relatively small scales and small, sharp teeth.

Tunas mostly remain in oceanic waters, ranging from epipelagic to mid-water ranges. They remain out of polar regions; however, they have a distinctive trait that allows them to swim in colder waters. These fish have a high metabolic rate which allows them to maintain a body temperature that is much higher than the surrounding water. This, in turn, also creates a high growth pattern for these specific fish. Because they retain warmth in the muscles, they have more power allowing strong swimming to enable high gas exchange providing ample oxygen to support their high metabolism (Collete 1983). Because tunas occur in pelagic waters, they feed in open ocean systems and are considered opportunistic predators with other fishes as their primary diet (Ménard 2006). Tuna species swim in schools, which provides various advantages for protection, energy saving, and foraging (Stocker 1999).

Even though their sexual differences are not visible externally, they are a dioecious species. Once tunas reach maturity, about two years for blackfin, they are reproductive (De Sylva 1987). Tunas spawn via releasing buoyant eggs and sperm into the open water. Egg fertilization will occur there, and larvae will begin to develop (Schaefer 2001). Tunas are considered highly migratory species, where spawning migrations differ between species. The Atlantic bluefin tuna migrates a long distance from feeding to spawning grounds, whereas yellowfin tunas spawn year-round without a long migration to spawning grounds (Muhling 2017).

Status

The Atlantic bluefin tuna and the yellowfin tuna are both considered not to be overfished (NOAA 2024). Many other tuna species have reached endangered status from being overfished. Now, population sizes have rebounded, but ineffective regulation of commercial and recreational landings is a challenge that can easily reappear (Miller 2007).

POPULATION SIZE AND DISTRIBUTION

Tunas are found worldwide in high abundances. Atlantic bluefin tuna are found in the Atlantic Ocean, with higher densities in the northern area. Yellowfin tuna populations are found worldwide but are heavily located in equatorial areas staying in tropical and subtropical waters (Erauskin-Extramiana 2019). Blackfin tuna have a more confined geographical distribution remaining within the western Atlantic Ocean (Collete 1983). Because of these large populations and wide distribution of tunas, they are significant in commercial and recreational fisheries. In 2012, the estimated end value of tuna reached $41.6 billion. Because they hold such high value in commercial fishing, they are more susceptible to overfishing. This creates an increased need for fisheries management to help conserve the tuna resources by enforcing sustainable fishing guidelines (Galland 2016).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

As highly migratory species, the duration of tunas' lifespan is spent travelling long distances in the water column in the open ocean. Habitat preference differs between species. Blackfin tuna are only found in the very clear waters in the Western Atlantic. They also vary in water temperature, where bluefin tuna are found in colder water compared to blackfin (De Sylva 1987). They are found closer to the surface, but often make vertical migrations to depths between 500 and 1,000 meters. Tuna species swim in large schools to provide better advantages to the species for protection and foraging (NOAA 2024).

CHALLENGES

Challenges easily arise in research of tuna, because of their highly migratory patterns. Organizations have struggled in efforts to study climate sensitive tuna species. Effective and efficient management of tuna species is also a challenge. Migrations of tuna causes higher fishing pressures in multiple regions and reduces the ability to properly manage the fishery. Some of the regions tunas move through are not in cooperation with fishing agreements putting certain species at higher risk to overfishing (Miller 2007).

CONSERVATION ACCOMPLISHMENTS

A wide range of amendments have been made to protect tuna species under the 2006 Consolidated Atlantic Highly Migratory Species Fishery Management Plan. These amendments help control fishing pressures by implementing gear restrictions, size limits, time/area closures, and permit requirements.

The International Commission for the Conservation of Atlantic Tunas (ICCAT) is an organization that helps manage tuna fisheries on a global scale. New yellowfin tuna management policies were put in place along West Africa to reduce undersized catch in 2011. Further, in 2013, reporting requirements were broadened to improve data collection on fishing efforts around fish aggregating devices.

Within commercial fishing, specific types of gear are approved and required for fishing to prevent damage to habitat and limit bycatch. One example is fishers are required to use circle hooks to prevent injury when hooking a non-target species and increase the chance of a healthy release (NOAA 2024).

CONSERVATION RECOMMENDATIONS

- Characterize stock status in Atlantic waters
- Determine potential shifts in distribution and driving factors
- Investigate migration patterns
- Expand research and monitoring in fishery-independent surveys

- Research early life stages and develop better understanding of complete life history

MEASURE OF SUCCESS

A successful species can be viewed by measuring a strong population size. Difficulties in assessing population size occur due to the highly migratory nature of tuna and their recent distribution movements. Due to climate change, some species of tuna, like the Atlantic bluefin tuna, have shifted in habitat distribution northward (Erauskin-Extramiana 2019). Another way to measure the success of a healthy population is to use independent or dependent data from recreational and commercial fishing effort and catch to determine population sizes. Successful populations can be suggested from successful management (NOAA).

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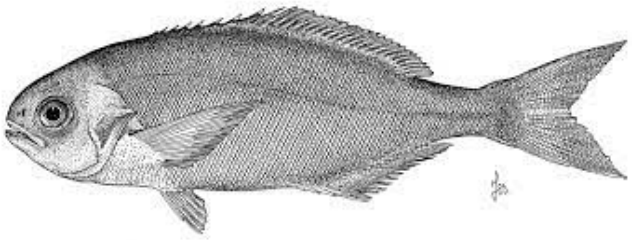
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Barrelfish

Hyperoglyphe perciformis



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DESCRIPTION

Taxonomy and Basic Description

The Barrelfish, *Hyperoglyphe perciformis*, is a member of the family Centrolophidae in the order Scombriformes (Page et al. 2023). The species has an elongate but deep body. The snout is blunt and the caudal fin is broad, not deeply forked. Small cycloid scales cover the body except for the head. Color is uniform dark green to gray or brownish with indistinct striping (either vertical or horizontal). The eye is often golden (Haedrich 2002). Juveniles commonly associate with floating objects such as barrels giving the species its common name. The species can grow to over 100 cm in length and is commonly encountered up to 80 cm. Barrelfish are long-lived, at up to 85 years of age. Sexual maturity occurs by 70 cm and 6 years of age (Filer and Sedberry 2008). Adults can be found in deep submarine canyons (Haedrich 2002). The species is gonochoristic with fish remaining male or female throughout their lifetime. Peak spawning occurs November through February (Filer and Sedberry 2008).

Status

Barrelfish is unassessed in southeastern U.S. waters and sustains no targeted fishery in the region. Therefore, little is known about their stock status. However, the species is listed under IUCN as a species of least concern as of February 2009.

POPULATION SIZE AND DISTRIBUTION

The species is landed as bycatch in the wreckfish commercial fishery. Juveniles are found in surface waters around the North Atlantic Ocean in loose schools associated with floating debris such as barrels. Adults are found at > 200 m depth associated with large topographic features such as the Charleston Bump in the western North Atlantic (Filer & Sedberry 2008). Commercial fisheries have recorded between 679 and 54,000 pounds landed off the southeast coast since 1991 with large fluctuations in annual harvest (NOAA 2024).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Adult Barrelfish are top predators found in temperate pelagic and deep-water continental slope habitats throughout the North Atlantic Ocean. A study of stomach content found the species feeds primarily on splendid alfonsino (*Beryx splendens*) and other mesopelagic fishes as well as squids (Goldman & Sedberry 2011). As juveniles,

the species congregate around floating debris in the open ocean, often congregating in large groups and is hypothesized to feed on organisms encrusting this debris, such as barnacles (Filer & Sedberry 2008).

CHALLENGES

Slow-growing, long-lived species are not as resilient to disturbances compared to others in their community. This leads to more opportunities for removal from the ecological system, whether natural or fisheries-related, before their first reproductive contribution to the fishery. Barrelfish are also a deepwater species and they can be highly susceptible to post-release mortality (e.g. barotrauma).

Because the species currently has no targeted fishery and there are no effective methods of fishery-independent monitoring available, it is difficult to know the status or needs of sustainable practices.

CONSERVATION ACCOMPLISHMENTS

SCDNR convened a study of the age, growth, reproduction, and food habits of the species prior to the development of a targeted fishery. This action has provided a baseline for understanding the age, growth, and reproductive parameters of an unfished stock if a fishery were to develop for the species.

CONSERVATION RECOMMENDATIONS

- Increase fishery-independent information to develop reliable indices of abundance
- Partner with commercial fishers for updated life history information, genetic analyses, and reproductive parameter assessments
- Complete research studies of pelagic juvenile movements, settlement requirements, and other factors associated with habitat needs

MEASURE OF SUCCESS

Because there is currently no fishery-independent measure of population size or trends, and no targeted fishery, information for the species is very sparse. In recent years landings have fluctuated. If a fishery-independent or hybrid fishery-independent/fishery-dependent survey can be initiated, a stock level will be able to be estimated, with a measure of success being a stable population and size distribution through time.

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Black Drum

Pogonias cromis



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Revised 2025:
Zoe Golden (SCDNR/College of Charleston) & Joseph C. Ballenger (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

Black drum (*Pogonias cromis*) are the largest members of the family Sciaenidae, who are members of the order Perciformes (Page et al. 2023), weighing up to 66 kg (145 lbs.). It is an estuarine-dependent saltwater fish found in the western Atlantic and Gulf of Mexico from the Bay of Fundy to Argentina (Welsh and Breder 1923; Bleakney 1963; Sutter et al. 1986). Throughout its range, black drum supports both recreational and commercial fisheries, with most commercial landings occurring in the Gulf of Mexico (Sutter et al. 1986; ASMFC 2012).

Black drum typically have 11 dorsal spines with 19-22 dorsal soft rays, 2 anal spines, and 5-7 anal soft rays. Colors range from silvery grey to very dark in juveniles with 4 or 5 black vertical bars on their sides which tend to disappear with growth. Pelvic and anal fins are usually dark. The chin has 5 pores and 10 to 13 pairs of small barbels along the median edges of the lower jaws and subopercles, increasing in length posteriorly (Chao 2003).

Along the US East coast, Jones and Wells (1998) reported a maximum age of 59 years in Virginia waters, while a maximum age of only 43 years has been observed in the northern Gulf of Mexico (Beckman et al. 1990). Long-lived adults exhibit group-synchronous maturation of oocytes and batch spawning (Fitzhugh et al. 1993) that occurs annually from sexual maturation to death (Pearson 1929). Annual fecundity of a mature female in the northern Gulf of Mexico has been estimated at 32-37 million eggs (Fitzhugh et al. 1993; Nieland and Wilson 1993). Early studies reported black drum reaching sexual maturity by the end of their second year in the Gulf of Mexico (Pearson 1929; Simmons and Breuer 1962; Sutter et al. 1986), but more recent investigations have presented evidence for later maturation. In northeast Florida, Murphy and Taylor (1989) found black drum to mature between 4-6 years, agreeing with findings from other studies in the northern Gulf of Mexico (Fitzhugh et al. 1993; Nieland and Wilson 1993; Olsen et al. 2018).

Black drum form large schools and move inshore for spawning during late winter into spring. In the Gulf of Mexico and northeast Florida, spawning occurs from January to May (Pearson 1929; Murphy and Taylor 1989; Nieland and Wilson 1993) but takes place in later months (April to June) at more northern latitudes, like the Chesapeake and Delaware Bays (Richards 1973; Thomas and Smith 1973). Young black drum recruit to shallow, muddy waters, such as tidal creeks, moving to deeper waters as they grow, until they reach sexual maturity and join the spawning stock (Pearson 1929; Richards 1973). Adults move offshore in the late fall and exhibit the potential for long-range migration along the Atlantic coast, especially along the coasts of southeast states (Jones and Wells 1998).

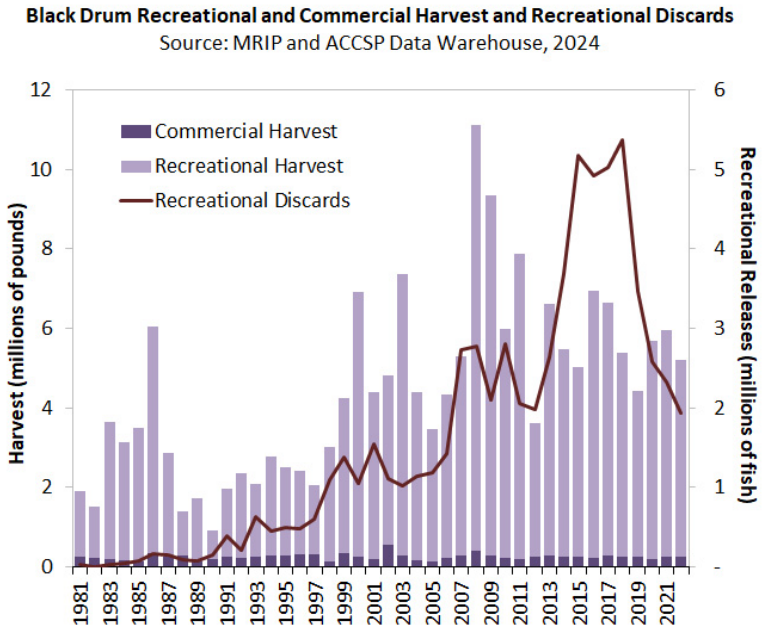


Figure 1: Black drum recreational and commercial harvest and recreational discards from 1980 to 2022 (Source: ASMFC 2023).

Status

Black drum are not listed as either an endangered or protected species in South Carolina or the US. They support a popular recreational fishery along both the Atlantic coast and Gulf of Mexico in the United States. Recreational and commercial landings have remained relatively constant since 2000 besides a considerable peak in 2008 (Figure 1; ASMFC 2023). Compared to commercial landings, recreational landings are typically 20-30 times greater by weight (ASMFC 2023).

In 2022, recreational harvest was 4.9 million pounds, or 849,000 fish, making up about 31% of all black drum caught by the recreational fishery (ASMFC 2023). The other 69%, or 1.9 million, recreationally caught black drum were released alive as a result of the Fishery Management Plan that was put into place in 2013 (ASMFC 2023). However, a portion of fish caught and released in the recreational fishery die to the stress of capture, with the most recent assessment assuming an 8% discard mortality rate (ASMFC 2023). Application of this rate to the 2022 live releases results in an additional 152,000 removals due to the recreational fishery as a result of discard mortality. Florida, followed by North Carolina and Georgia were responsible for the majority of recreational landings (ASMFC 2023). Also in 2022, the commercial fishery landed 244,198 pounds of black drum with North Carolina and Virginia fisheries contributing most to the commercial harvest (ASMFC 2023).

The most recent stock assessment was conducted through 2020 and was accepted in 2023 for black drum management purposes. Based on the most recent stock assessment, black drum are not overfished or experiencing overfishing (Figure 2; ASFMC 2023). Therefore, amendments to the fishery management plan were not deemed necessary. Although management action was not taken, data limitations and assessment uncertainties exist. Several indices of abundance, range, and fishery characteristics will be monitored annually to determine any troubling trends in the stock (ASMFC 2023).

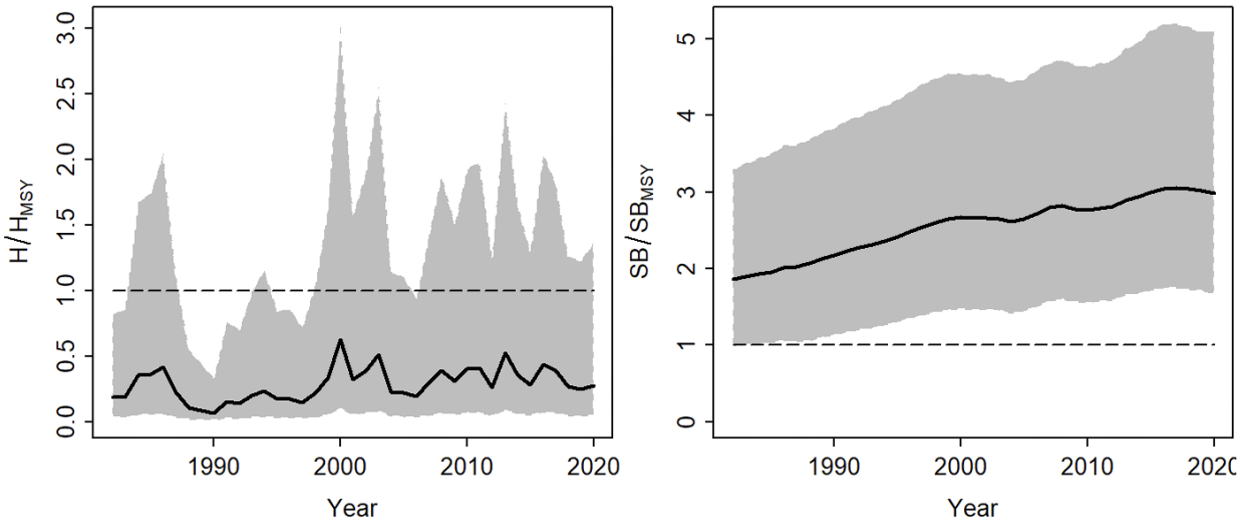


Figure 3:Exploitation (left) and spawning biomass (right) relative to threshold reference points. The solid line is the median and the shaded regions is the 95% credible interval. The dashed line indicates the estimate at its respective threshold. (Source: ASMFC 2023).

POPULATION SIZE AND DISTRIBUTION

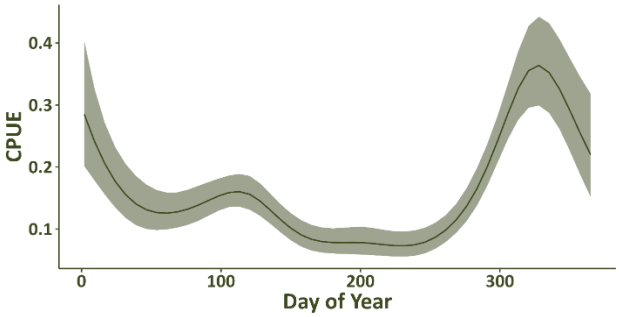


Figure 2: Black drum catch per unit effort in the SCDNR's Inshore Fisheries trammel net survey by day of the year.

Black drum are found throughout South Carolina estuarine marsh and coastal habitats, depending on life stage. While no specific sampling programs conducted by the South Carolina Department of Natural Resources (SCDNR) target black drum, they have been present in multiple estuarine fishery-independent monitoring surveys over the years. Most black drum caught in these surveys are sexually immature juveniles, typically less than 40 cm (16 in.) in total length. Black drum are present in South Carolina estuaries year round but are more abundant during the fall months (Figure 2).

The SCDNR fishery independent trammel net survey (1991-present) has caught black drum at a relatively stable, if cyclical, rate over the last 33 years (Figure 3). Catches were somewhat above 2010-2023 average catches in 1991-1993, 1999-2000 and 2016, indicating strong year classes entering the population. Conversely, catches were below average in 1995-1998, 2004-2005, and 2010-2011, indicative of weak year classes.

Most black drum captured in the trammel net survey are immature fish (ages 0-3). There is much less known above adult black drum in South Carolina, and no long-term fishery-independent indices of abundance exist for adults in South Carolina. As black drum age and become sexually mature, they move to deeper channel habitat within estuaries and eventually move to deep areas with bottom structure both inside and

outside the estuary. This makes them difficult to capture except with recreational hook-and-line gear. Most adult specimens available to SCDNR come from recreational anglers through either

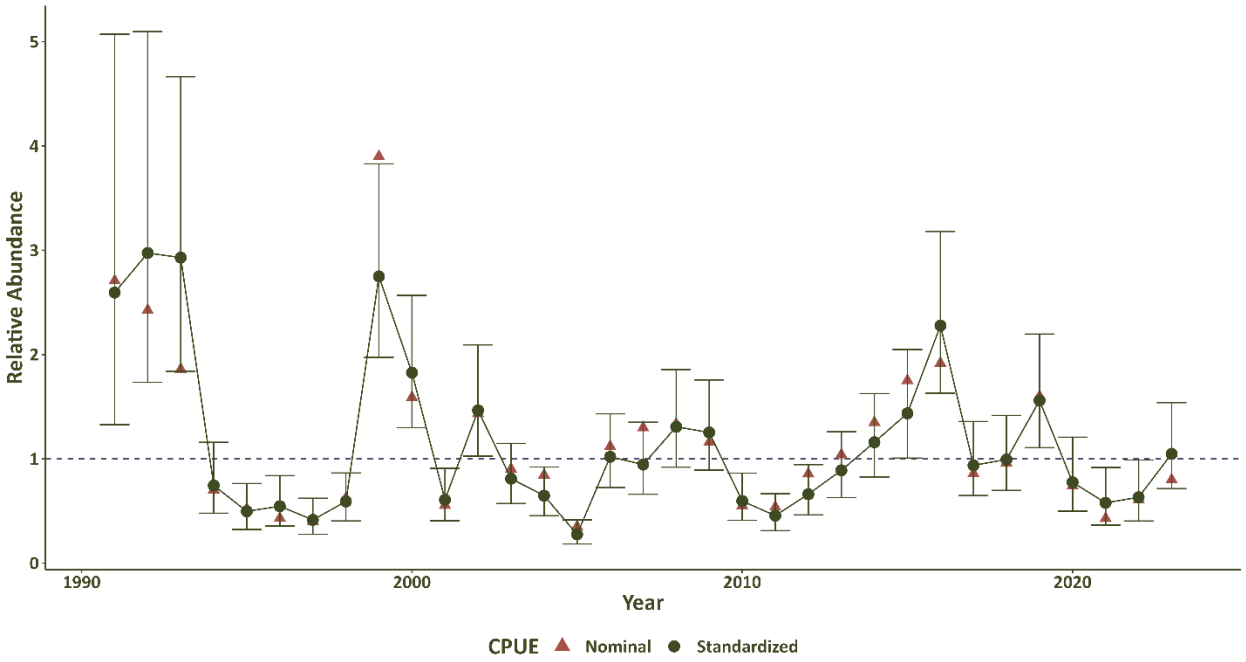


Figure 3: Black drum standardized catch per unit effort in SCDNR's Inshore Fisheries trammel net survey by year from 1991 to 2023. Shown is the standardized index of abundance (green line and circles) with a 95% CI (error bars) as well as nominal catch per trammel net (red triangles). Both the standardized and nominal indices are normalized to average catches from 2010-2023 (dashed line), such that if annual estimates are greater than 1, catch was above the 2010-2023 average and vice versa if below.

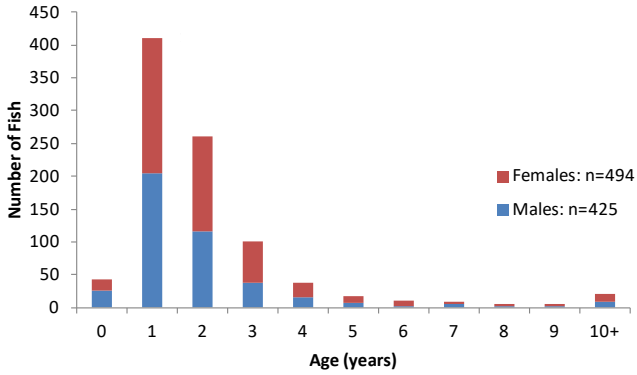


Figure 4: Age frequency distribution by sex for black drum from all SCDNR sampling efforts: 1985-2012.

fishing tournaments or SCDNR's fish wrack recycling program. The age distribution for black drum in South Carolina ranges from 0 - 46 with all fish older than 6 years being mature adults (Figure 4). Overall, however, the age distribution of SCDNR black drum samples are representative of shallow water, estuarine habitats. Figure 4 uses a truncated age distribution for older fish (ages 10+) because this group only represented 2.3% of aged black drum.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Black drum are found in estuaries throughout South Carolina, typically in habitats with vertical complexity such as oyster bars, salt marsh grass, natural rock outcroppings and reefs, and piling structures around docks, piers and bridges. Black drum in South

Carolina are usually found in salinities greater than 18 parts per thousand (ppt), near the mouths of estuaries, although juveniles less than 40 mm (1.5 in.) total length may also occur at lower salinities. As black drum grow during their first few years of life, they move into deeper channels and eventually into deep waters around natural ledges, bridges, and piling structures, both offshore and in higher salinity estuarine habitats.

CHALLENGES

There is currently a lack of information on the population size of black drum in South Carolina, although the coast-wide stock assessment (ASMFC 2023) indicated the regional population is neither overfished nor experiencing overfishing. Black drum feed primarily on fish, mollusks, and crustaceans, and therefore, may be adversely affected by contaminants (organics, pesticides, and heavy metals) that bioaccumulate in these organisms. Further, as with other estuarine species using estuaries for nursery habitats, there is a risk to the population due to habitat loss and degradation as a result of coastal development, coastal hydrography changes, and system eutrophication. Finally, little is known about the role of the environment in successful recruitment, though given the cyclical nature of year classes observed in the trammel net survey there likely is a strong environmental component to successful recruitment. As such, climate change, extreme thermal events (e.g., marine heat waves and marine cold spells) and shifts in phenology of ecological events (e.g., phytoplankton blooms) relative to black drum spawning could impact recruitment success.

CONSERVATION ACCOMPLISHMENTS

Commercial landings in South Carolina reported by the National Marine Fisheries Service (NMFS) are generally low and indicative of reported by-catch rather than a targeted fishery. Section 50-5-360 of the South Carolina Code requires that anyone who buys, receives or handles any live or fresh saltwater fish or any saltwater fishery products taken or landed in the State for sale, must obtain a wholesale dealers license. Prior to 2007, there were no recreational management regulations for black drum in South Carolina. In 2007 the South Carolina legislature amended section 50-5-1705 of the South Carolina Code creating a slot limit of 36-69 cm (14 to 27 in.) total length and a daily bag limit of 5 fish per person for black drum that applies to both commercial and recreational fisheries.

In 2013, the Interstate Fishery Management Plan for black drum was established that requires all states to have a maximum possession limit, a minimum size limit of 14 inches total length, and a continuation of all previous regulations (ASMFC 2023). In 2017, a report was released that included black drum habitat information at each life stage, essential fish habitat, habitat areas of particular concern, habitat threats, and habitat management recommendations (ASMFC 2023). In 2018, there was an addendum to the Interstate Fishery Management Plan that allowed for Maryland to

reopen its black drum commercial fishery in the Chesapeake Bay with a daily limit of 10 fish per vessel and a minimum size of 28 inches (ASMFC 2023).

CONSERVATION RECOMMENDATIONS

- Study basic biological aspects of black drum ecology such as population size, age structure, and reproduction (especially for the adult population).
- Develop length- and/or age-composition estimates for the discarded component of the recreational fishery and better characterize post-release mortality across sizes, age, and environmental conditions.
- Determine the level of contaminants (organics, pesticides, heavy metals, per- and polyfluoroalkyl substances) found in black drum as well as the sediments/wates in the areas in which they are caught. Relate that to the potential effects of bioaccumulation.
- Protect water quality in marine ecosystems by encouraging municipalities to use Best Management Practices (BMPs) to reduce runoff from highways, agricultural fields, and housing developments.
- Plan development based on sound terrestrial and estuarine ecology that takes into consideration all factors affecting the long-term health of the estuary ecosystem.
- Identify the origin of non-point source pollution and specific point source pollution and develop a plan of action to mitigate any negative effects to the affected aquatic systems.
- Improve BMPs in areas already impacted by non-point source pollution.
- Identify important or essential habitat types for different life stages of black drum and partner with other regulatory agencies to reduce impacts of development on these fish habitats.
- Partner with other state agencies to improve resource management at the whole estuary or drainage basin level using a more holistic ecological approach. Such restructuring should provide for greater regulatory authority in implementing migratory fish management plans.
- Evaluate environmental drivers of recruitment success.
- Identify habitat threats and habitat uncertainties for black drum.

MEASURE OF SUCCESS

Currently, the abundance of juvenile black drum appears to be stable, as indicated by the SCDNR trammel net survey. However, very little is known about the size and stability of the adult population. By learning more about this species and protecting the habitat upon which it depends, we can ensure this important recreational game fish remains abundant. In addition, by monitoring black drum populations in response to environmental contaminants, South Carolina will be better able to detect problems and work to correct them more quickly.

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Blacknose Shark
Carcharhinus acronotus

Contributor (2025):
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DESCRIPTION

Taxonomy and Basic Description



The blacknose shark, *Carcharhinus acronotus* is a member of the family Carcharhinidae, residing in the genus *Carcharhinus* (32 species). The blacknose shark is a placentally viviparous shark (bears live young with a maternal connection). Blacknose sharks are moderately small sized sharks reaching maximum reported total lengths (TL) of 150 cm (Castro 2011). They have a pale greenish, or yellowish color to their skin with a dusky gray to dark gray blotch at the tip of their nose. They have moderate life histories with males maturing at 4.3 years old (111 cm TL), and females maturing at 4.5 years old at around 119 cm TL (Driggers et al. 2004). The reproductive periodicity of blacknose sharks appears to be based on energetics of females with blacknose sharks presenting both an annual and biennial reproductive cycle (Frazier unpublished). Brood size ranges from one to eight with an average of five pups (Driggers et al. 2004). The maximum observed age for the blacknose shark is 22.8 years old (Frazier et al. 2015).

Status

The blacknose shark is classified as a small coastal shark (SCS) and it is managed separately by the National Marine Fisheries Service (NMFS). The blacknose shark was last assessed in 2011 and the results of that assessment indicated that the US Atlantic stock was overfished and overfishing was occurring (SEDAR 21). This resulted in a separate blacknose shark-specific quota that was linked to the small coastal shark quota, triggering a closure of both fisheries when the blacknose quote was reached (NMFS 2023) The International Union for Conservation of Nature (IUCN) Red List considers blacknose sharks as "Endangered" with a decreasing population trend; however, that is largely based on threats to the populations in Central and South America (Carlson et al. 2021). In South Carolina blacknose sharks are primarily sampled by the SCDNR Coastal Longline; abundances trends vary widely but suggest a moderate increase in blacknose sharks over the time-series (Figure 1).

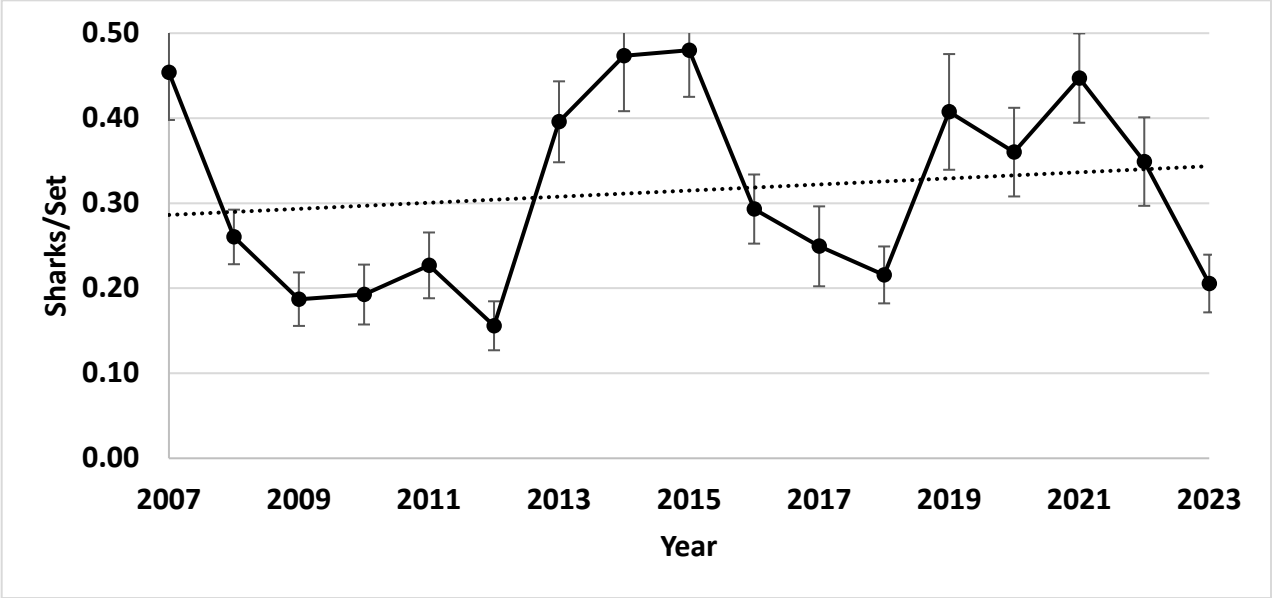


Figure 1. Catch per unit effort (sharks per set) of blacknose sharks from 2007 to 2023 in the South Carolina Coastal Longline Survey. Standard error is denoted by error bars.

POPULATION SIZE AND DISTRIBUTION

Blacknose sharks are restricted to the Western Atlantic Ocean and are distributed from North Carolina south through the Gulf of Mexico and Caribbean to southern Brazil. In the southeastern US they are found are rare north of Cape Hatteras and common off of South Carolina and Georgia. In South Carolina waters, young of the year are rarely encountered although they are thought to reside in nearshore waters, they are primarily captured as juveniles and adults.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

In South Carolina, blacknose sharks are commonly found in high salinity waters (>30 ppt) over sandy bottoms in nearshore coastal waters (Ulrich et al. 2007). They appear to have a limited distribution, occurring from front beaches and the mouths of sounds and bays out to nearshore waters with maximum depths of 15 m. While diet hasn't been formally described for this region, they are thought to primarily feed primarily on benthic fishes with a smaller component of their diet being invertebrates.

CHALLENGES

The stock status of blacknose sharks has not been assessed in almost 15 years, while the results suggested overfishing and overfishing occurring species-specific data and life history data were limiting factors. Given the small coastal shark quote is linked to the blacknose shark population it is imperative that the stock status of this species is reevaluated. As there is a limited shark fishery, the primary threat to blacknose sharks is as bycatch in other fisheries, primarily shrimp otter trawls. Blacknose sharks are caught recreationally; however, they do not reach the minimum size limit for harvesting, therefore the primary concern is post-release mortality (Knotek et al. 2021)

CONSERVATION ACCOMPLISHMENTS

There are no conservation accomplishments specific to this species at this time.

CONSERVATION RECOMMENDATIONS

- Continue to monitor the stock status of blacknose sharks within SC waters through fishery-independent methods, primarily the Coastal Longline Survey.
- Increase collection of species-specific data to allow for future species-specific stock assessments.
- Initiate genomic studies of blacknose sharks including using close-kin mark recapture studies to estimate population size.
- Conduct studies using electronic monitoring tags (i.e. PSATs, acoustic tags, and SPOT tags to understand blacknose shark migratory behavior and essential habitat.
- Investigate non-lethal ways of obtaining life history data from blacknose sharks (e.g. epigenetic age estimation)
- Continue to study the reproductive periodicity of blacknose sharks to better understand why both annual and biennial reproductive cycles are observed in this species.
- Improve the public's understanding of the importance of sharks in the ecosystem through outreach activities such as school programs, providing story opportunities for media, and educational brochures.
- Continue to educate the public on the importance of species identification of sharks to ensure undersized and prohibited sharks are not landed.
- The primary action at the state level via law enforcement partnering is to ensure adequate compliance with regulatory actions implemented through the federal management plan and subsequent amendments.

MEASURE OF SUCCESS

One of the most important measures of success will be reassessing the stock status of blacknose sharks in US waters. Regional management efforts to maintain healthy, sustainable populations of blacknose sharks will require active participation from South Carolina due to its importance as habitat for the species. Expanding our knowledge on the life history of blacknose sharks, in particular the occurrence of young of year and reproductive periodicity, is of high importance. Maintaining ongoing monitoring programs to continue indices of abundance and trends over time is critical to the success of future stock assessments.

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Black Sea Bass

Centropristis striata



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DESCRIPTION

Taxonomy and Basic Description

Black Sea Bass are a relatively small member of the family Serranidae, found within the order Perciformes (Page et al. 2023). The larger individuals are black, sometimes with a blue wash of color. The smaller individuals can be dusky brown in color. The exposed parts of scales are paler than the margins, giving the fish the appearance of being barred with a series of longitudinal dots. The belly is only slightly lighter in color than the sides. The fins are dark, and the dorsal is marked with a series of white spots and bands. The upper portion of the caudal fin ends as a filament. During spawning, males may have a conspicuous blue nuchal hump (SAFMC).

Black sea bass are protogynous hermaphrodites, changing sex with size. Large individuals are males, and smaller individuals are female. Females reach sexual maturity by approximately their first birthday with the age at 50% transition to male estimated to be 3.83 years (SEDAR 76). The spawning season is February through May in the Southeast U.S. Atlantic Ocean (SEUSA). Black sea bass may live up to 20 years, although fish older than 9 years are rare. The maximum size attained is 24 inches and 6 pounds. (SAFMC).

Status

The most recent stock assessment was completed in 2023 (with 2021 as the last year of data included), and results indicated that the stock off the coast of the Southeastern US was overfished, and that overfishing was occurring (SEDAR 2023). However, IUCN lists Black Sea Bass as a species of least concern worldwide and the species has been documented increasing at the far northern extent of the species range.

POPULATION SIZE AND DISTRIBUTION

Black Sea Bass occur along the US coast from the Gulf of Maine to Cape Canaveral, Florida, and in the Gulf of Mexico, though the Gulf of Mexico individuals are considered a separate subspecies, and thus, managed as its own stock (Bowen and Avise 1990, McBride 2018). Traditionally, US Atlantic coast Black Sea Bass have been managed as two separate stocks – Mid-Atlantic and South Atlantic – with the stocks being split at Cape Hatteras, NC. Genetic and preliminary otolith microchemistry data supports these two separate stocks (Roy et al 2011). Tagging studies suggest minimal movement of

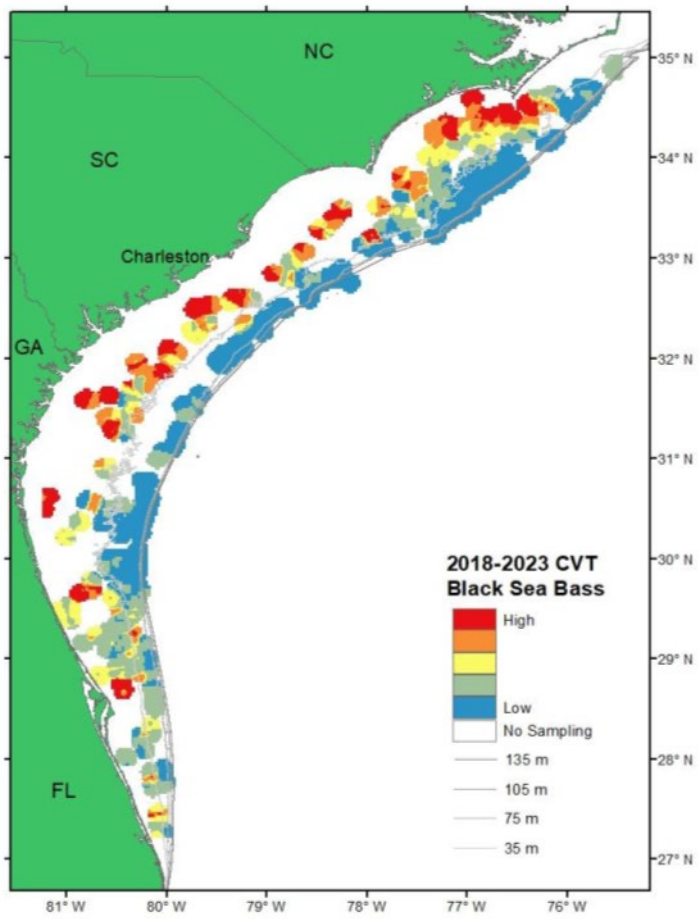


Figure 1: Distribution of Black Sea Bass catches from SERFS Chevron Trap survey in 2018-2023 (excluding 2020).

adult Black Sea Bass in the South Atlantic region (Rudershausen et al. 2010). The species is a major component of the fishery independent chevron trap catches of the Southeast Reef Fish Survey (SERFS) off the coast of Cape Hatteras, NC to St. Lucie Inlet, FL. Highest densities are observed in shallower trap stations at the northern extent of the survey near the SC/NC border and in NC waters (Figure 1).

As represented by SERFS data, the Black Sea Bass population in the Southeast U.S. Atlantic hovered around the long-term average until 2008, when the species went through a period of very high recruitment until 2011. The population has declined steadily since that time reaching a value lower than the long term average in 2014 and remaining below this level for a decade (Figure 2).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Black Sea Bass are a temperate marine species that inhabits irregular hard-bottom areas, such as wrecks or reefs. Larval Black Sea Bass settle in coastal and estuarine waters often near structure (Steimle et al. 1999), subsequently migrating to offshore reefs as they get larger. Once they get to offshore reefs, site fidelity is very high (Rudershausen et al. 2010). Those found in the Southeast U.S. Atlantic usually occur inshore of

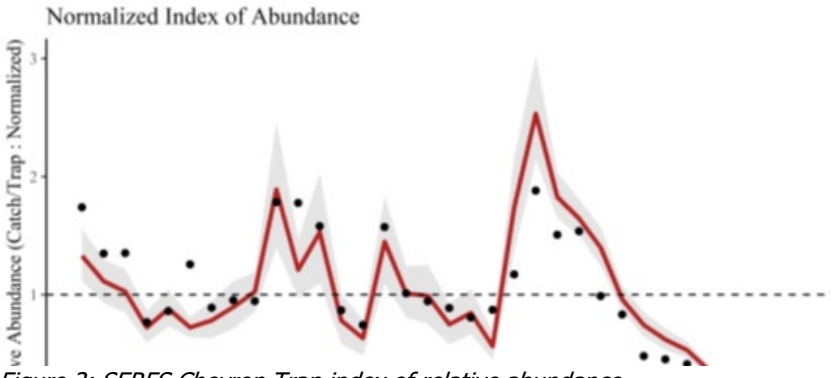


Figure 2: SERFS Chevron Trap index of relative abundance for Black Sea Bass for the Southeast U.S. Atlantic region. Nominal values are black dots. Red line is modeled index value. Gray shading is standard error. Dotted horizontal line is long-term average value.

some other popular reef fish species such as snappers, groupers, porgies and grunts. Black sea bass are opportunistic feeders eating whatever is available, preferring crabs, shrimp, worms, small fish and clams (Schmidtke 2024).

CHALLENGES

The species is currently overfished and undergoing overfishing in the SEUSA. The decreasing biomass trend seems to reflect decreased recruitment since 2014. No mechanism for the recent low recruitment has been identified, but the duration (since 2014) has exceeded a single generation time. Determining the cause of this apparent decline in recruitment will be critical for management decisions. Because Black Sea Bass are sequential hermaphrodites, there is also disproportionate targeting of the larger sex (males) that has the potential to skew population demographics. As with many other reef fish species which have substantial overlap in habitat use, there is potential for mortality even when they are not targeted in this multi-species fishery.

There is currently no effective mechanism for surveying black sea bass in their first year of life. The SERFS chevron trap survey does not effectively capture black sea bass < 50 mm TL, and the coastal trawl survey only infrequently encounters the species. Therefore, it would be beneficial to initiate a survey mechanism that could effectively capture young of year for this species as well as others. The pattern of low recruitment at the end of the time series raises the question of whether there has been a regime shift. More research is needed to determine if this is the case. As of now there is not sufficient evidence to support the regime shift hypothesis (SEADR 76). However, research indicates the most extreme depletion of the stock appears to be in the southern extent of the range (Vecchio et al., *in review*).

CONSERVATION ACCOMPLISHMENTS

The Black Sea Bass fishery off South Carolina is managed in federal waters by the South Atlantic Fishery Management Council (SAFMC 2013). The total annual catch limit (ACL) has been reduced multiple times since 2019 in both the commercial and recreational fishery. The size limits for Black Sea Bass were increased in 2013 (commercial to 11”/recreational to 13”). The recreational retention limit was increased to 7/person/day in 2016. As of July 2020, all recreational fishing boats were required to have a descender device rigged and ready to help mitigate discard mortality.

CONSERVATION RECOMMENDATIONS

- Protogynous life history: 1) investigate possible effects of hermaphroditism on recent low recruitment; 2) investigate the sexual transition for temporal patterns, considering possible mechanistic explanations if any patterns are identified, and 3) investigate methods for incorporating the dynamics of sexual transition in assessment models.

- Initiation of an effective survey for young-of-year in multiple reef fish species, including Black Sea Bass, to produce predictions of population available to the fishery in future years.
- Mark-recapture approaches (conventional, telemetry, close-kin) might make it possible to obtain direct estimates of natural mortality specific to Black Sea Bass in the SEUSA.
- Additional experiments to estimate discard mortality in greater ranges of depths, locations, angler experience related to barotrauma mitigation techniques (venting and descender devices), and times of year to match fishing within the SEUSA.
- More research is needed on the cause(s) of low recruitment in several South Atlantic reef-fish stocks, including Black Sea Bass.
- Direct observation of fishing practices by observers or video are needed to determine reliable estimates of these sources of mortality to fish in the SEUSA.
- Establish a more comprehensive sampling program for ages and lengths of fish captured by the recreational fleet in all regions of the SEUSA.

MEASURE OF SUCCESS

The fishery independent SERFS program annually monitors relative abundance, length frequency, size and age at maturity of reef fishes and can detect changes in those parameters that result from management efforts.

A new survey of juveniles could provide an indicator of recruitment success over time.

Increases in recruitment, abundance, size, size and age at maturity would indicate positive trends in the population.

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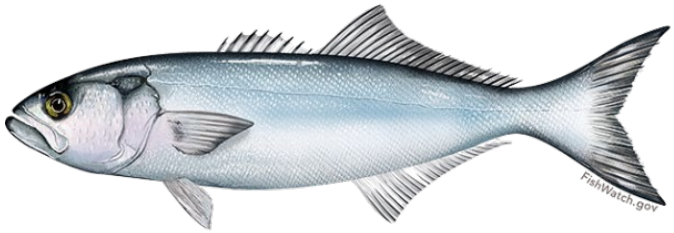
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Bluefish

Pomatomus saltatrix



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DESCRIPTION

Taxonomy and Basic Description

Bluefish, *Pomatomus saltatrix* (Linnaeus 1766), are a migratory, coastal, pelagic species encountered in South Carolina estuarine and coastal waters. They are the only member of the family Pomatomidae (bluefishes), within the order Scombriformes (Collette 2002; Nelson 2006; Page et al. 2023).

Bluefish have a sturdy, compressed body and a large head with prominent, sharp, compressed teeth in a single series; the jaw is terminal, with the lower jaw sometimes slightly projecting (Collette 2002). Bluefish possess two dorsal fins, the first being short and composed of 7 to 8 weak spines connected by a membrane and the second long, with one spine and 23-28 soft rays (Collette 2002). The pectoral fins are short, not reaching the origin of the soft dorsal fin (Collette 2002). Bluefish possess small scales that cover the head, body, and bases of vertical fins; the lateral line is almost straight (Collette 2002). Bluefish have a greenish-blue back, silvery sides and belly, dorsal and anal fins that are pale green tinged with yellow, pectoral fins that are bluish at the base, and a caudal fin that is dull greenish tinged with yellow (Collette 2002).

Bluefish are fast-growing, reaching lengths of 115 cm and weights of 12 kg (27 lbs; Shepherd and Packer 2006). They can live up to 12 years (Shepherd and Packer 2006), and they reach sexual maturity at 2 years old and 48 cm total length (Robillard et al. 2008). They are gonochorists (separate sexes) that exhibit indeterminate fecundity and spawn multiple times per season (Robillard et al. 2008), with two main spawning cohorts represented: a spring-spawned cohort south of Cape Hatteras, NC, and a summer-spawned cohort north of Cape Hatteras, NC (Kendall and Walford 1979; Norcross et al. 1974; Fahay 1999). A fall-spawned cohort has also been identified south of Cape Hatteras, NC (Kendall and Walford 1979; McBride et al. 1993).

Status

Currently, the bluefish population off the East Coast of the United States is managed as a single stock (NEFSC 1997; Fahay et al. 1999) under the joint management authority of the Atlantic States Marine Fisheries Commission (ASMFC) and Mid-Atlantic Fisheries

Management Council (MAFMC). A 2019 assessment found the stock to be overfished yet not undergoing overfishing, and a rebuilding plan was established to get the stock to a target Spawning Stock Biomass (SSB) by 2028 (ASMFC 2021). Later, in both the 2022 and 2023 assessments, the stock was found to not be overfished and not experiencing overfishing, yet the rebuilding plan will remain in place until the target SSB is met (Figure 1, NEFSC 2020, NEFSC 2023). These last two assessments showed an increase in SSB above SSB Threshold, with a continuing increasing trend (Figure 1), and it is now estimated to be at 60% of the SSB Target (NEFSC 2023). The IUCN last assessed Bluefish in 2014 and found the worldwide population showed a declining trend, and although there is to be an update by the end of 2024, Bluefish are currently listed as Vulnerable (IUCN 2024).

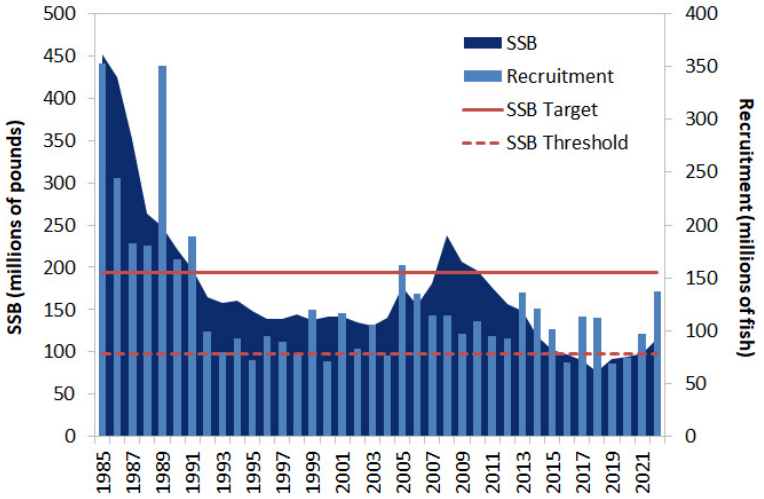


Figure 1. Bluefish Spawning Stock Biomass (SSB) and recruitment in the US Western Atlantic (Source: ASMFC 2024).

POPULATION SIZE AND DISTRIBUTION

Bluefish are found in coastal temperate and subtropical waters around the world, but are absent from the eastern Pacific and the Indo-West Pacific north of the equator (Collette 2002). In the western North Atlantic, they range from Nova Scotia along the East Coast of the Americas (including Bermuda) to Argentina, though they are rare between southern Florida and northern South America (Figure 2; Robins et al. 1986; Collette 2002).

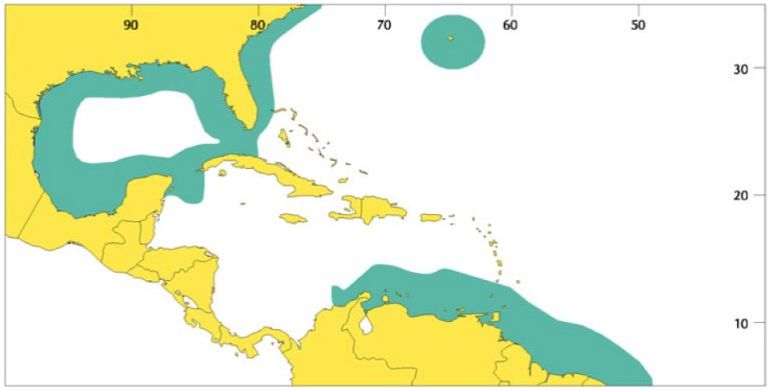


Figure 2. Bluefish native range in the US South Atlantic region through northern South America. (Source: Collette 2002).

Bluefish tend to travel in schools of like-sized individuals while undertaking seasonal migrations following waters between 14 and 16°C (57-61°F): traveling north along the East Coast of the US during spring, and south or farther offshore during fall (Bigelow and Schroeder 1953; Fahay 1999; Shepherd et al. 2006). In South Carolina, juvenile and adult Bluefish are present in estuarine and coastal ocean waters, and they are encountered in some SCDNR fishery-independent surveys. The Coastal Trawl Survey

and the SCDNR Trammel Net Survey encounter bluefish often enough to develop indices of abundance (Figure 3 and Figure 4). The Coastal Trawl Survey primarily indexes juveniles, which have been below the long-term average in recent years (Figure 3). The SCDNR trammel net survey, which also primarily indexes juveniles, shows a

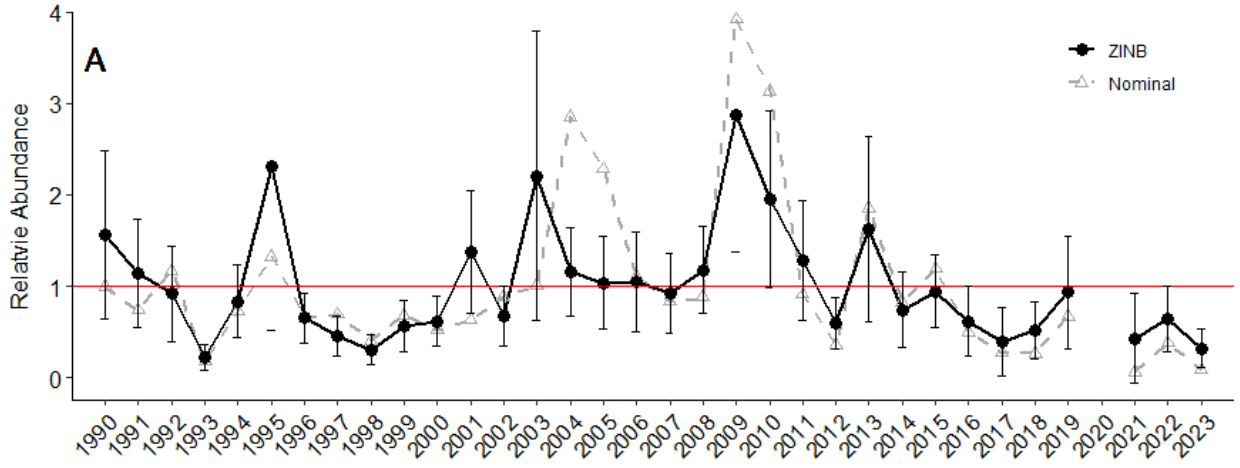


Figure 3. Annual relative abundance of bluefish, *Pomatomus saltatrix*, in U.S. South Atlantic waters based on SCDNR SEAMAP-SA coastal trawl survey catches. Nominal abundance and zero-inflated negative binomial modeled abundance are shown, with the red line representing the time-series mean. (Source: SEAMAP-SA 2024).

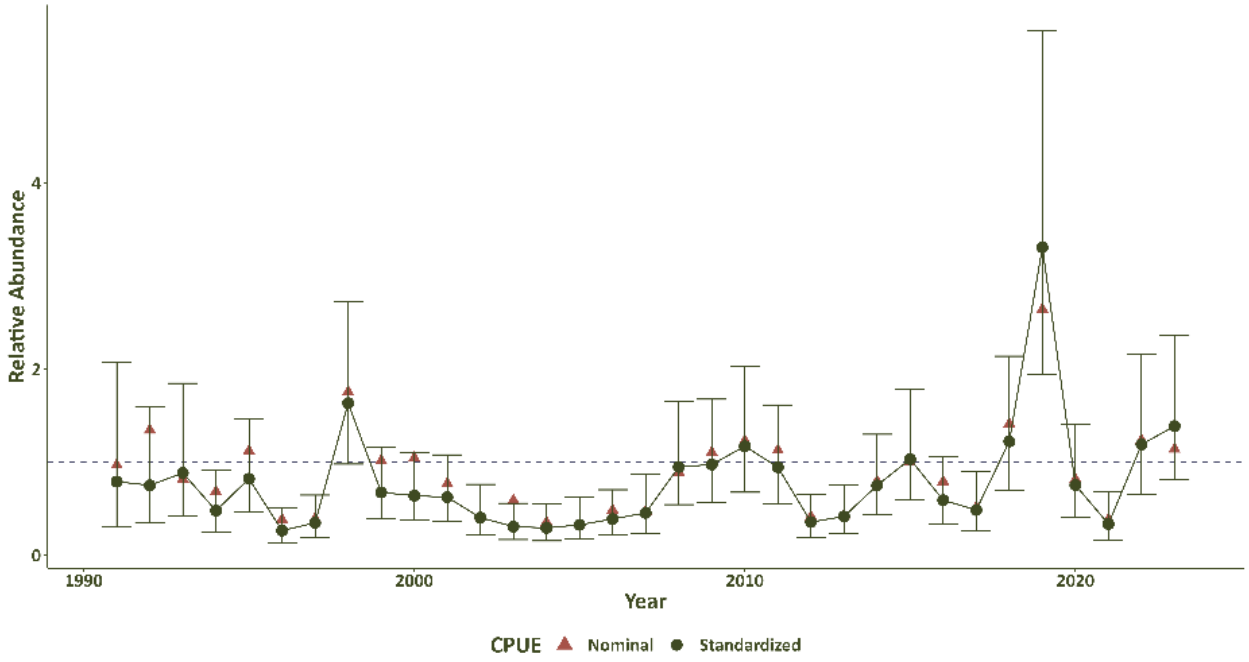


Figure 4. Annual relative abundance of bluefish, *Pomatomus saltatrix*, in South Carolina estuaries based on SCDNR trammel net survey catches. Nominal and standardized abundance shown, with the dashed line representing the time-series mean. (Source: Joseph Ballenger, SCDNR, unpublished data)

recent uptick in abundance in SC estuaries not reflected in the coastal trawl survey (Figure 4).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The habitat used by bluefish tends to vary by size and cohort. The following is a description of the habitat used by bluefish at various life stages.

Eggs

Bluefish eggs are found in the open ocean at temperatures between 18 and 22°C (64-90°F) and salinities >31.0 ppt (Fahay 1999). Egg distribution varies by month, with eggs being spawned either in the South Atlantic Bight (SAB; in spring) or the Mid Atlantic Bight (MAB; in summer), and rapidly expanding further northward during the summer (Fahay 1999). Most eggs are collected over depths of 30 to 70 m (98-230 ft; Norcross et al. 1974).

Larvae and Pelagic-Juveniles

Larvae occur in open oceanic waters near the edge of the Continental Shelf in the southern MAB and over mid-shelf depths farther north (Norcross et al. 1974; Kendall and Walford 1979). Most larvae occur in temperatures of 18-24°C (64-75°F) and salinities of 30-32 ppt. Bluefish larvae migrate vertically in the water column, occurring near the surface at night but centered at about 4 m (12 ft.) during daylight (Kendall and Naplin 1981). Larvae spawned in the SAB are advected north via the Gulf Stream (Hare and Cowen 1996; Kendall and Walford 1979), although some recruit successfully to local estuaries (Collins and Stender 1987; McBride et al. 1993).

Many pelagic-juveniles are found in the vicinity of Cape Hatteras as early as April (Fahay 1999). In May, several have been collected on the shelf of the SAB (Fahay 1975; Kendall and Walford 1979). By June, pelagic-juveniles occur in the MAB between the shore and the shelf/slope front, actively crossing the shelf (Hare and Cowen 1996). In both the SAB and MAB, there is a strong negative correlation between fish size and depth, indicating an offshore origin and onshore migration with growth (Fahay 1999).

Juveniles

The following description of bluefish juvenile habitats derives from the works of Lund and Maltezos (1970), Olla et al. (1975), Milstein et al. (1977), Nyman and Conover (1988), Rountree and Able (1992), McBride et al. (1995), Able et al. (1996), and Buckel and Conover (1997).

Juveniles occur in estuaries, bays, and the coastal ocean of the MAB and SAB, where they are less common. They are found in many habitats, though they do not use the marsh surface. Juveniles migrate south in October to spend the winter months south of Cape Hatteras. They arrive in estuaries, bays, and coastal ocean waters once water temperature exceeds 20°C (68°F) and subsequently remain in these waters throughout the summer until water temperature declines to 15°C (59°F). Data suggests juveniles cannot survive at temperatures less than 10°C (50°F) or above 34°C (93°F). As they do

occur in estuaries, juveniles can tolerate a wide range of salinities (as low as 3.0 ppt), though they are generally found in salinities of 23.0-33.0 ppt.

Adults

Adults are generally oceanic, distributed nearshore to well offshore over the Continental Shelf, preferring waters warmer than 14-16°C (57-61°F; Bigelow and Schroeder 1953; Olla and Studholme 1971). Bluefish can tolerate water temperatures between 11.8 and 30.4°C (53.2-86.7°F), though there is physiological stress at either extreme (Fahay 1999). Although generally found in waters of oceanic salinity, adults are not uncommon in bays, larger estuaries, and coastal waters (Bigelow and Schroeder 1953; Olla and Studholme 1971) and have been found in most estuarine systems within their range (Fahay 1999).

CHALLENGES

As bluefish of different life stages use a diverse array of habitats, almost all the estuarine and nearshore waters along the Atlantic Coast from Florida to Nova Scotia serve as an important habitat for some life stage. Pollution and habitat degradation of any estuarine and nearshore habitat could be expected to threaten the bluefish population. As coastal development increases, estuarine water quality is expected to further deteriorate unless steps are taken to ameliorate their effect on the environment (Cross et al. 1985). Estuarine and coastal habitats have been significantly affected by dredging, filling, coastal construction, energy plant development, pollution, waste disposal, and other human-related activities. The offshore dumping of sewage is also a threat.

Additional challenges to the bluefish population are the large-scale fisheries that operate on the population, both commercial and recreational. Landings peaked in the 1980s and have since declined (Figure 5). Although there is a catch and release portion of the recreational fishery, dead discards make up 22% of the recreational removals of bluefish (ASMFC 2021). The multi-state nature of the population also creates jurisdictional and management challenges.

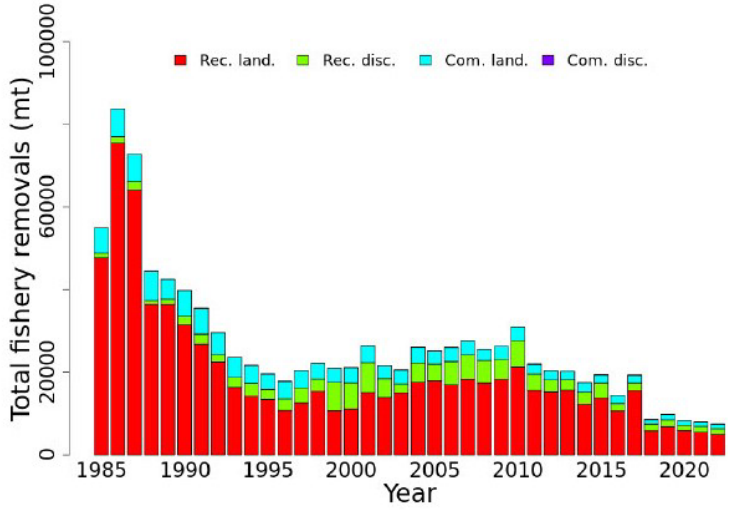


Figure 5. Time series of bluefish total removals (mt; recreational and commercial landings and discards) along the Atlantic coast between 1985 and 2022. (Source: NEFSC 2023).

CONSERVATION ACCOMPLISHMENTS

The current Interstate Fishery Management Plan (FMP) for bluefish, and subsequent amendments, institute the following management practices:

- Allocates fisheries landings between sectors (86% recreational and 14% commercial).
- Establishes that a portion (less than 10% of the Acceptable Biological Catch (ABC)) of each sector can be transferred to the other (ASMFC 2021).
- Establishes a state-by-state commercial quota system based on historic landings, allocating 0.10% of the Annual Catch Limit (ACL) to South Carolina.
- Since 2012, it establishes a coast-wide biological sampling program to improve the quality of information available for use in the age-structured stock assessment models (ASMFC 2012b).
- Since 2021, it puts in motion a 7-year rebuilding plan to get the bluefish population to target SSB. As part of this, it establishes a coastwide recreational limit of 3 fish per person for private fishermen, and a 5-fish bag limit for for-hire fishing.

Finally, the East Coast bluefish population has played a central role in the development of a multi-species stock assessment model developed by the ASMFC to move fisheries management away from individual species assessments to ecosystem-based fishery management. This model explores predator-prey interactions among key ASMFC-managed species, including Atlantic menhaden as the primary forage fish and striped bass, bluefish, and weakfish as predators (Garrison et al. 2010). While this model has yet to be used to manage the bluefish population directly, it has been used to produce annual estimates of natural mortality (M) at age for Atlantic menhaden, which were subsequently included in assessments to help manage that species (ASMFC 2012a). In addition, an Ecological Reference Points (ERP) stock assessment was recently conducted on menhaden, utilizing this multi-species model to provide fisheries managers guidance on how much menhaden biomass is required to meet the forage needs of the primary predators mentioned above (SEDAR 2020). An additional ERP stock assessment is currently being conducted on Atlantic menhaden as well.

CONSERVATION RECOMMENDATIONS

The following are research recommendations taken from the bluefish 2022 research track stock assessment, in addition to other conservation recommendations.

- Improve collection of recreational efforts, landings, and release and determine recreational demand.
- Establish monitoring programs to better characterize dynamics of larger, older bluefish.

- Continue the coastwide collection of biological samples from fishery-independent and -dependent sources to monitor trends in bluefish young-of-the-year and adult relative abundance.
- Develop and refine ecosystem-based modeling approaches that include bluefish (and collect needed trophic data to support).
- Evaluate the effects of fishing and management plans on the South Carolina sub-population of bluefish.
- Understand the local and regional movement patterns of bluefish occurring in South Carolina waters.
- Identify the source of bluefish recruits.
- Protect estuarine habitats through responsible development and minimization of pollution and disturbance.

MEASURE OF SUCCESS

The SCDNR fishery-independent programs that annually monitor bluefish, the coastal trawl survey and the inshore trammel net survey, are already in place to track changes in size distribution, age, maturity, and relative abundance as a result of regional management efforts. The measurement of success will be to see an increasing trend in catch of bluefish in these surveys. Furthermore, as mentioned above, in the past 5 years the bluefish stock has seen an increase in SSB and recruitment (Figure 1), along with a decrease in fishing mortality that is likely due to implementation of regulations as part of the rebuilding plan established in 2021 (NEFSC 2023). These changes in mortality and abundance, and their current trends towards a more balanced population, exemplify a measure of success in management.

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Blueline Tilefish

Caulolatilus microps



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DESCRIPTION

Taxonomy and Basic Description

The Blueline Tilefish, *Caulolatilus microps*, is a member of the family Malacanthidae (tilefishes), themselves a member of the order Perciformes (Page et al. 2023). They are a medium-sized fish that are dull olive-gray overall and white below. The lack of fleshy protuberance behind the head distinguishes it from the Golden Tilefish, *Lopholatilus chamaeleonticeps*. Blueline Tilefish have elongate, continuous dorsal and anal fins more than half the length of the body, long snout, narrow gold stripe underlined in blue from snout to the tip of the eye and a strong, flat spine on the gill cover.

Blueline tilefish live to a maximum age of 43 years and reach a maximum size of 626 mm total length (TL). Maturity of 50% of fish is reached by age 3, at a length of 326-350 mm TL (Harris et al., 2004). Blueline Tilefish exhibit sexually dimorphic growth, with males attaining larger size-at-age than females. Blueline Tilefish are gonochorists and have an extended spawning season from February to October, peaking between March and September.

Status

Blueline Tilefish support commercial and recreational fisheries in South Carolina. The most recent stock assessment determined that Blueline Tilefish are not overfished, and no overfishing occurring (SEDAR 50 2017a).

POPULATION SIZE AND DISTRIBUTION

Blueline Tilefish are patchily distributed along the outer continental shelf of North America from Cape Lookout, NC, to Campeche Bank, Mexico (Dooley 1978). Adults appear to move little, inhabiting areas along the outer continental shelf, shelf break, and upper slope on irregular bottom (Harris et al. 2004). The distribution of early juveniles is not well known. Atlantic Blueline Tilefish are considered a single genetic stock (O'Donnell and Darden 2016).

Blueline Tilefish are encountered by the Southeast Reef Fish Survey chevron trap survey, however not in sufficient numbers or consistency to develop indices of abundance. Blueline Tilefish were more commonly encountered using Short Bottom longline (SBLL) gear by the Marine Resources Monitoring and Prediction Program (MARMAP) to sample snapper-grouper species in habiting hard-bottom areas with

considerable vertical relief in depths greater than 75 m, from 1996 to 2022. However, SBLL sampling was not conducted consistently enough to develop reliable indices of abundance.

In 2020 a coastwide longline survey, the South Atlantic Deepwater Longline Survey (SADL), was developed which aims to consistently sample deepwater species including Blueline Tilefish. However, at least 5 years of survey data should be available before an index of relative abundance should be considered for use in a stock assessment. The distribution of catches confirmed the patchy distribution throughout the region, including SC, but showed areas of increased abundance in NC and VA and to a lesser extent the Florida Keys (Figure 1).

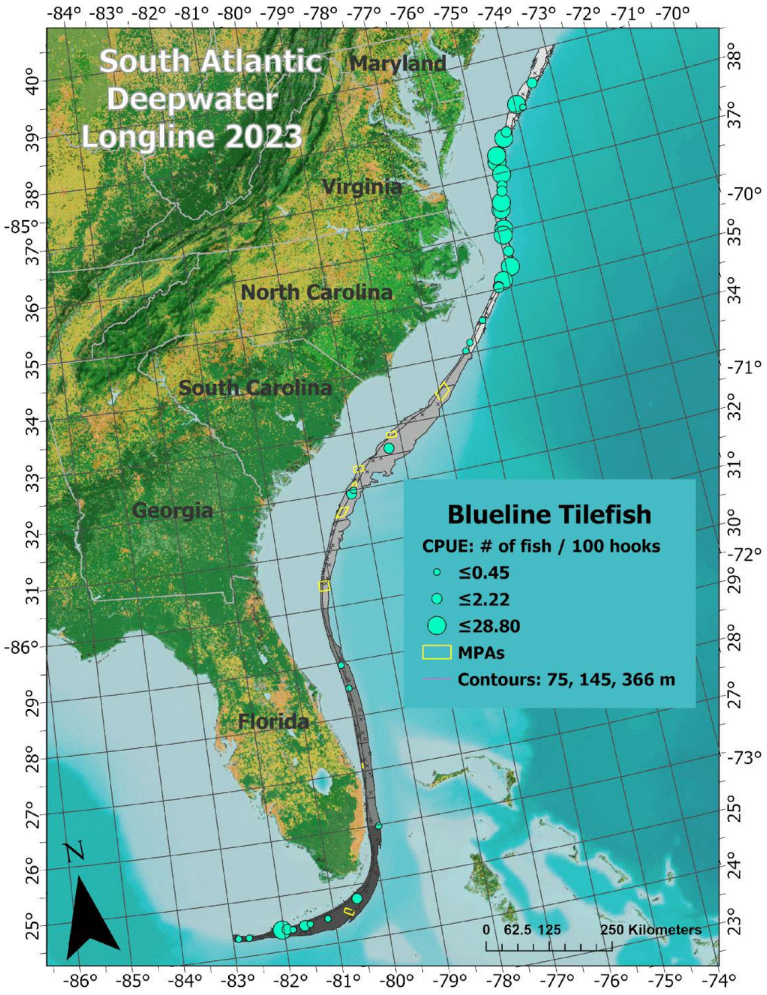


Figure 1. Distribution and magnitude of Blueline Tilefish catches from the South Atlantic Deepwater Longline Survey in 2023.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Usual adult habitats include ledges or crevices and around boulders or rubble piles at depths of 48-236 m, where temperatures are 15-23°C (Struhsaker 1969; Ross 1978; Ross and Huntsman 1982). Individuals have been observed hovering near or entering burrows under rocks (Parker and Ross 1986), a characteristic associated with many malacanthids (Able et al. 1982; Able et al. 1987; Baird and Baird 1992). Blueline Tilefish prey on a variety of fishes and macroinvertebrates closely associated with the substrate, primarily decapod crustaceans (Ross 1982).

CHALLENGES

Blueline Tilefish and other deepwater fisheries have become increasingly important because of their economic value and because they provide an alternate resource when

shallow-water stocks are depleted or access is restricted by management (Large et al. 2013). Deepwater stocks are difficult to monitor, as the depths and distance from shore at which these species occur are often cost-prohibitive for traditional surveys to adequately collect samples for life history analyses, estimation of population demographics, and development of relative abundance trends. As a result, stock assessments for Blueline Tilefish have historically been data-limited. SADL was developed to more effectively sample deepwater species throughout their range and will be a critical data source for stock assessment in the future. Because deepwater species, including Blueline Tilefish, tend to be slower growing and long-lived species they are not as resilient to disturbances compared to others in their community. This leads to more opportunities for removal from the ecological system, whether natural or fisheries-related, before their first reproductive contribution to the fishery. As with many other reef fish species which have substantial overlap in habitat use, there is potential for mortality even when they are not targeted in this multi-species fishery. Because they are a deepwater species (≥30 m), they can be highly susceptible to post-release mortality (e.g. barotrauma) during these encounters.

CONSERVATION ACCOMPLISHMENTS

The Blueline Tilefish fishery off South Carolina is managed in federal waters by the South Atlantic Fishery Management Council. Several management measures to reduce fishing mortality and dead discards have been implemented including the requirement of descending devices, dehooking tools, and non-stainless steel circle hooks.

CONSERVATION RECOMMENDATIONS

- Increased sampling of young fish to improve maturity ogive
- Movement and migration of juvenile and adults
- Identification of larvae as well as location, duration, and dispersal mechanisms of egg and larval stages
- Document the distribution of early life stages
- Determine thermal tolerance and likelihood of climate change induced range expansion
- Characterize and quantify relationships between catch and habitat

MEASURE OF SUCCESS

Management success for Blueline Tilefish is difficult to measure since fishery-independent sampling has not been consistent historically and offshore species recreational catch is more difficult to monitor. SADL was developed to more effectively sample deepwater species throughout their range and will be a critical data source for stock assessments in the future.

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Cobia
Rachycentron canadum



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DESCRIPTION

Taxonomy and Basic Description

Cobia, *Rachycentron canadum* (Linnaeus, 1766) are the sole representative of the family Rachycentridae. Adults are characterized by having a depressed head with an elongate body and a lunate caudal fin. The mouth is terminal with a protruding lower jaw. The first dorsal fin is comprised of 7 to 9 short, stout isolated spines with the second dorsal fin long with anterior rays forming a raised lobe in adults. The anal fin is similar to the second dorsal and both are covered in thick skin. Adults are typically chocolate brown on their back and sides with a white to cream-colored belly with small, embedded scales. Juvenile fish have a more rounded caudal fin with lateral white stripes that run the length of their body, fading as the fish grows older.

The South Carolina State Record Marine Gamefish Program, operated by the Marine Resources Division, recognizes a 42.0 kg (92.6 lbs.) Cobia caught offshore of Port Royal Sound in June 2009 as the largest Cobia caught in the state. Franks et al. (1999) reported a female Cobia taken from the Gulf of Mexico that measured 165 cm (63 in.) in fork length and weighed 62.2 kg (137 lbs.). The IGFA recognizes a 61.5 kg (135.6 lbs.) specimen caught off Australia as its all tackle record. Maximum recorded ages are 16 years in the Atlantic and 11 years in the Gulf of Mexico.

Sexual maturity for male Cobia in the South Atlantic appears to occur at a very small size. Because of the paucity of samples of Cobia smaller than 200 mm (7.9 in.) FL, it is not possible to determine the smallest size at which male Cobia reach sexual maturity, but this appears to occur well before they reach age one. Female Cobia appear to reach sexual maturity later than males. Results by SCDNR (unpublished) and Smith (1995) suggest that females typically reach sexual maturity between 2 and 3 years old, with 100% maturity for 3 year-old fish.

Status

In 2017, cooperative management of Atlantic cobia began between the South Atlantic and Gulf of Mexico Fishery Management Councils following approval of the Interstate Fishery Management Plan (FMP) for Atlantic Migratory Group Cobia by the Commission. Subsequently, in 2019, Amendment 1 to the FMP was approved, marking a shift from joint management with the Councils to exclusive management under the Commission's jurisdiction. This Amendment outlined a framework for the Commission to establish harvest quotas, allocate quotas among sectors, define criteria for stock status, and propose management actions for adoption by NOAA Fisheries in federal waters. Additionally, Amendment 1 transferred responsibility for monitoring and potential closure of commercial harvests to the Commission. It also introduced a de minimis status for states with minimal commercial cobia harvests, exempting them from certain in-season monitoring requirements. States were mandated to implement the provisions of Amendment 1 by July 1, 2020.

There are two distinct populations of cobia along the U.S. Atlantic coast: Atlantic cobia and Gulf of Mexico Migratory Group, known as Gulf cobia. Gulf cobia are distributed throughout the Gulf of Mexico and extend to the east coast of Florida, whereas Atlantic cobia are found from Georgia northward. These boundaries were established during a Stock Identification Workshop in 2018. Ongoing tagging and genetic studies are further exploring the structure of these stocks to identify potential subgroups within each population.

According to the 2020 Atlantic Cobia Benchmark Stock Assessment, the Atlantic cobia stock is currently not considered overfished nor subject to overfishing (SEDAR, 2020). This determination was based on comparing spawning stock biomass (SSB) and fishing mortality rate (F) against reference points derived from F40%, which is the fishing mortality rate resulting in 40% of the stock’s maximum reproductive potential in the absence of fishing (SEDAR, 2020).

The biomass of Atlantic cobia has exhibited a trend of significant increase during years of strong recruitment, followed by periods of decline. Despite these fluctuations since the 1980s, the stock has remained above the overfished threshold due to robust year classes, including notable occurrences in 2010 as identified in the assessment.

The next assessment of the Atlantic cobia stock is scheduled for 2025.

POPULATION SIZE AND DISTRIBUTION

Cobia have a world-wide distribution, occurring in all tropical and subtropical seas except for the eastern Pacific (Shaffer and Nakamura 1989). The Marine Recreational Fisheries Statistical Survey (MRFSS), conducted by the National Marine Fisheries Service (NMFS), has recorded recreational Cobia landings from Texas to New York.

There is some evidence of at least 2 migratory groups in the Gulf of Mexico: a north/south migratory group that overwinters in southern Florida and moves west and north throughout the Gulf during the spring and summer; and an inshore/offshore migratory group that overwinters in deeper waters and moves into shallower coastal waters during spring and summer (Franks et al. 1991; Burns and Neidig 1992). Tagging studies in the Atlantic have shown a similar pattern as well with a seasonal northward movement of fish from Cape Canaveral to North Carolina and Virginia. Cobia may also be present in deep (>31 m or 100 ft.) live bottom areas in the winter off the East Coast, suggesting some east-west migration as well. In South Carolina, the vast majority (90%) of recaptures from fish tagged during annual spring aggregations in Port Royal and St. Helena sounds have occurred in those same estuaries in subsequent years, suggesting a high degree of site fidelity. Recent population genetics work indicates that inshore Cobia aggregations in South Carolina and the Chesapeake Bay represent distinct population segments that are genetically different from those found offshore of those locations along the East Coast (Darden et al. 2014). In general, Gulf cobia are found across the Gulf of Mexico and along Florida's eastern coast, whereas Atlantic cobia inhabit waters from Georgia northward. These delineations were verified during a Stock Identification Workshop in 2018. Ongoing research involving tagging and genetic studies aims to delve deeper into the stock structure, seeking to uncover potential subgroups within each population.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Cobia normally occur singularly or in small pods. They commonly associate with any structure in the water (buoys, trash, shipwrecks, and artificial reefs) or large animals (sharks, turtles and stingrays) (Hammond et al. 1977; Shaffer and Nakamura 1989). They are opportunistic feeders, conducting most of their feeding near the bottom where they target crabs, shrimp, squid, and benthic fish (Smith 1995).

Cobia are asynchronous batch spawners with spawning reported for the Gulf stock from April to September (Burns et al. 1998) and peak spawning occurring in the Atlantic from May to July (Brown-Peterson et al. 2001; SCDNR, unpublished data). Spawning frequency for Atlantic Cobia has been estimated at 4-6 days by Hunter and Macewicz (2005), and the application of their histological techniques to data reported in Lefebvre and Denson (2012) produced an estimate of spawning frequency of 6.1 days in South Carolina. Spawning has been shown to occur in the mouth of bays and sounds (Joseph et al. 1964; Richards 1967; Smith 1995). In South Carolina, the presence of eggs and larvae and the collection of gravid females from within Port Royal and St. Helena Sounds suggest that spawning is occurring during these inshore aggregations (Lefebvre and Denson 2012). Based on gonadosomatic indices, peak spawning occurs in May, June, and July in South Carolina, North Carolina, and Virginia, respectively. Migration into these inshore spawning grounds appears to be closely related to temperature, with seasonal appearances of Cobia aggregations beginning as water temperatures approach 20°C (68°F).

CHALLENGES

Their large size, strong fighting ability, and excellent culinary qualities make Cobia a very popular recreational species. In South Carolina, fishing pressure on inshore aggregations in the southern portion of the State has increased steadily in recent years. Uncertainty about population size and pressure on spawning grounds of a genetically distinct population segment during the spawning season are two challenges to maintaining a sustainable fishery for Cobia in South Carolina. Additionally, life history work conducted by SCDNR suggests that recruitment success varies strongly from year to year, and intermittent strong year classes may make up a large proportion of the population structure.

CONSERVATION ACCOMPLISHMENTS

The coastal migratory pelagics FMP, a joint effort by the South Atlantic and Gulf of Mexico Fishery Management Councils, established an 84 cm (33 in.) FL minimum size for Cobia in 1985 and added a 2 fish/person/day bag limit in 1990. In South Carolina, extensive life history and genetic sampling has led to a greater understanding of Cobia population genetics, age structure, and critical spawning habitat of concern. This research has identified critical spawning grounds and contributes important data to the SEDAR stock assessment process.

Additionally, the implementation of a cooperative angler fin clipping program and development of microsatellite markers for Cobia allows catch and release by recreational anglers to contribute non-lethal genetic samples to program biologists and become stakeholders in the research process.

CONSERVATION RECOMMENDATIONS

- Develop fishery-independent sampling program to better understand overall abundance and relative changes in population(s) through time.
- Coordination and expansion of tagging efforts, to improve estimates of mortality rates and growth parameters.
- Determine tag retention and reporting rates.
- Hold workshops to aid in consistent tagging methods across states.
- Expand creel sampling in Beaufort County during April, May, and June to better capture catch and effort data on the inshore Cobia fishery.
- Expand the genetic sampling program throughout the Cobia's range to increase understanding of its population structure, stock boundaries, and to identify additional genetically distinct population segments along the Atlantic Coast.
- Promote sustainable fishing practices by recreational anglers targeting seasonal Cobia aggregations in South Carolina, including catch and release and proper handling of undersized fish.
- Collect fecundity data on fish collected during tournaments and through carcass

collection programs targeted at recreational anglers.

MEASURE OF SUCCESS

Measures of success will include an increased understanding of Cobia life history and genetic structure as well as stable or increasing population trends as determined by further sampling efforts. Furthermore, increases in tagging efforts across states (number of tags released and recaptured), will lead to better estimates of mortality, growth parameter, and understanding of long-term movement patterns.

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Common Snook
Centropomus undecimalis

Contributors 2025: Michelle Taliercio and Jimmy Kilfoil (SCDNR)



Photo courtesy of Floridasportsman.com

DESCRIPTION

Taxonomy and Basic Description

Snook have long, concave snouts with a large mouth, and jutting underjaws. The lateral line is pigmented and distinct, extending well into the tail. Pelvic fins are typically yellow in color. Coloration ranges from dark brown on the back to silvery on the sides and white below depending on the habitat. The two dorsal fins are well separated. Common snook are moderately long-lived and fast-growing fish. Females live about 21 years and can grow to lengths of 48 inches. Males live about 15 years and can reach 39 inches. Females attain legal minimum length (current snook regulations in Florida) in about four years, whereas males require five to six years to reach that length. Fifty percent of male snook reach maturity at about 18 inches total length (TL) and about two years of age, whereas 50 percent of females are mature at about 30 inches TL and five years of age. Snook are protandric hermaphrodites: meaning the males reverse sex and change into females. This reversal occurs during the fall after the spawning season, sometimes in a short span of ninety days.

Status

There was no legal commercial fishery of common snook in Florida after the Florida Legislature declared snook a gamefish in 1957 and prohibited the sale of snook. Currently, there are no regulations in place for commercial or recreational regulations in South Carolina. For historical perspective, commercial landings of snook during 1918–1957 can be found in Muller et al. (2015). The recreational fishery on the gulf coast in Southwest Florida (Pasco through Lee counties, and Collier county north of Gordon's Pass) has been restricted to catch and release fishing only since August 30, 2018 due to red tides. However, that has changed with updated catch data. New regulations for snook in state and adjacent federal waters have gone into effect beginning Jan. 1, 2024. These regulation changes will establish nine snook management regions in Florida, and will establish closed seasons as well as bag and slot limits for each management region throughout Florida.

In Texas, from the late 1800s to the early 1940s, commercial snook landings were quite large and even reached 230,000 lbs landed in Port Isabel in 1928. Since the early 1940s, commercial landings dropped to token levels with no landings reported after 1961. In 1987, regulations were passed that limited the catch of snook to rod and reel only. This bag limit remains to be one snook per person per day, adopted in 1995.

The most recent assessment by the International Union for Conservation of Nature (IUCN) conducted in 2019 found the common snook to be of "Least Concern" status across their global range, with a population status of "unknown" (Mendonca et al 2019).

POPULATION SIZE AND DISTRIBUTION

Common snook are found in estuaries, adjacent rivers, and in nearshore waters of the tropical and subtropical western Atlantic (Gilmore et al. 1983; Rivas 1986). Fishes in the genus Centropomus occur in coastal waters bounded by the August 24°C water isotherm in the North Atlantic and the February 24°C water isotherm in the South Atlantic (Rivas 1986). Common snook are the most widely distributed species within the genus. Common Snook have been reported from as far north as New York along the Atlantic seaboard (Schaefer 1972), and throughout the Gulf of Mexico. Common snook are most abundant on the Atlantic coast of Florida from Cape Canaveral south through the Florida Keys and on the Gulf coast from Cedar Key south to the Dry Tortugas. Common snook occur infrequently along the rest of the gulf coast until Galveston, Texas where they again become abundant through Rio de Janeiro, Brazil (Gilmore et al. 1983; Rivas 1986).

Rather than a resident species, common snook are considered seasonal migrants in South Carolina, with infrequent encounters in estuarine waters of the state by recreational anglers and SCDNR sampling projects such as trammel netting and electrofishing. The vast majority of snook encountered are believed to be young of year juveniles that will be very unlikely to survive the next winter unless individuals find thermal refugia such as golf course ponds or impoundments.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Snook are euryhaline, meaning they spend time in both fresh and saltwater. They live in a wide variety of habitats, including river mouths, nearshore reefs, salt marshes, seagrass meadows, and along Gulf beaches, but they have a preference for mangrove-fringed estuaries. Snook are tropical fish. They cannot tolerate cold water, not even for a couple days. The lower lethal limit for adults is 6 to 12°C, though they become lethargic once temperatures fall to 18°C and can begin to die at 15.5°C. Unsurprisingly, temperature is a large factor in distribution. The common snook is by far the most abundant and wide-ranging of all snook species. Adults inhabit coastal waters, estuaries and lagoons, penetrating into freshwater; usually at depths less than 20 m. They feed on fishes (Gobiidae, Gerreidae, Engraulidae) and crustaceans (shrimps and crabs) (Keith et al. 2000). Mature individuals congregate at mouths of passes and rivers during the spawning season, from May through September. Seasonal movements into freshwater occur but are poorly understood. Marketed fresh, it is also a valued game fish and an excellent food fish.

CHALLENGES

Several reasons have been suggested for the decline of snook in Texas and Florida that involve range limitations due to cold temperature, high pesticide levels, disease, overfishing, and reduced freshwater inflows to bays and estuaries; however, the actual reason for the demise remains unknown. (Munyandorero et al.2020)
The population status of common snook in South Carolina is difficult to assess due to a lack of data in the region. Little is known about the species' habitat use and life history in South Carolina, and therefore fishing pressures and climate change consequences are challenging to gauge. However, as South Carolina is near the northern extent of their current range, warming estuaries may allow larger populations of common snook to develop in South Carolina, which may be what the SCDNR trammel net survey is currently observing.

CONSERVATION ACCOMPLISHMENTS

The management history of common snook was described extensively in the 2015 stock assessment (Muller et al. 2015). Snook are managed under Chapter 68B-21 of the Florida Administrative Code. There are variations in open and closed fishing seasons that have been historically established in the recreational fishery of common snook on the Atlantic and gulf coasts during 1957–2019. Recent data provided an account of the evolution of common snook regulations about the size limits, allowance of fish specifically above 34 inches TL, and the daily bag limits. (Munyandorero et al 2020)

Future research on common snook in South Carolina will be aided by the library of genetic fin clip samples and associated capture locations and fish lengths that the Inshore Fisheries section has been collecting from every specimen encountered since 2020.

CONSERVATION RECOMMENDATIONS

- To collect ages and lengths for young fish, especially the young-of-the year and age-1 individuals.
- To continue the collections of the reproductive data on the spawning periodicity, fecundity, sex-ratio, maturation, male-to-female transition, and skipped spawning, etc.
- To monitor and directly estimate the mortality rates or the extent of fish kills subsequent to episodic environmental events.

MEASURE OF SUCCESS

Measurement of management success is difficult given the lack of population assessments and impact fishing pressure on the common snook. However, the SCDNR Inshore Fisheries group monitors relative abundance, length frequency, size and age at maturity of estuarine finfishes through monthly trammel netting, electrofishing, and trawl surveys and can detect changes in those parameters that result from management efforts. Increases in recruitment, abundance, size, size and age at maturity would indicate positive trends in the population.

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Dolphinfish

Coryphaena hippurus

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Source: SAFMC

DESCRIPTION

Taxonomy and Basic Description

Dolphinfish (*Coryphaena hippurus*, Linneaus 1758) are a highly migratory pelagic species in the family Coryphaenidae within the order Carangiformes (Page et al. 2023). Dolphinfish are identified by bright green-blue coloration dorsally and silvery-yellow ventrally. Darker spots are usually visible along their sides. Dolphinfish are characterized by a long dorsal fin and deeply forked tail. Males are distinguished by their more straight-edged head compared to a more rounded head on females. Males also grow larger in size than females. Compared to the closely related Pompano dolphinfish (*Coryphaena equiselis*, Linneaus 1758), the anal fins of dolphinfish are pointed and notched anteriorly, while the Pompano dolphinfish have a convex anal fin. Additionally, dolphinfish have slightly more dorsal fin rays (58-66) than Pompano dolphinfish (52-59).

Dolphinfish are fast-growing and highly prolific, reaching sexual maturity around four to five months and spawning hundreds of thousands to several million eggs per female, with larger females producing more eggs, in the open ocean as water temperatures begin to rise (SAFMC 2022). They are relatively short-lived for a highly migratory species, living to a maximum age of three or four years (Schwenke & Buckel 2008). The average fork lengths of dolphinfish range from 34 to 55 inches (SAFMC 2022). The current South Carolina (SC) state record dolphinfish, which was caught offshore of Seabrook Island, SC in 2008, was 77.5 pounds (SCDNR 2024).

Status

Dolphinfish are economically important as a primary target species for both recreational and commercial fishers worldwide. In the United States exclusive economic zone for the Atlantic and Gulf of Mexico, recreational and commercial landings have consistently been in the tens of millions of pounds since 1990, with the recreational sector representing the majority of the landings (NOAA Fisheries 2024). A recent study analyzing data from five southeastern U.S. tournaments in the western North Atlantic found declines in dolphinfish sizes over the past 15-30 years (Rudershausen *et al.* 2023).

NOAA Fisheries is currently in the process of developing a management strategy evaluation to examine possible management plans to determine how effective they might be under varying circumstances. The overarching goals for the evaluation include guaranteeing access to the fishery and opportunities to fish, avoiding closures, promoting an overall increase in size of fish caught, keeping regulations consistent, and balancing different stakeholder needs (NOAA Fisheries 2024).

POPULATION SIZE AND DISTRIBUTION

SCDNR has not conducted any directed fishery independent studies on dolphinfish; however, several surveys intercept the fish and relevant data are recorded.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Dolphinfish are distributed throughout tropical and subtropical waters around the world and are primarily influenced by temperature with an optimal range of 21-30°C (Gibbs and Collette 1959, Maguire 2006). They typically reside and feed in surface waters and can be found in waters up to 200 meters (Maguire 2006). They are generalist consumers with a diet consisting primarily of small fish, swimming crabs and other pelagic crustaceans, cephalopods, and conspecifics (Rudershausen 2010, Teffer 2015) Dolphinfish are pelagic but often associated with *Sargassum* sp., a genus of large, orange-brown algae, and prey on smaller species using the algae as habitat (Rudershausen 2010).

CHALLENGES

Typically, shorter-lived, fecund species can tolerate more fishing pressure; however, dolphinfish distribution and reproduction are highly dependent on environmental factors, specifically temperature. Additionally, due to their migration patterns, dolphinfish are harvested internationally, which can include areas with more lenient regulations and fewer or no reporting requirements thus limiting the ability to conduct a comprehensive stock assessment (NOAA Fisheries 2024).

Additionally, pollution poses a threat to dolphinfish, specifically man-made floating garbage. Dolphinfish live and feed around *Sargassum* sp. floating in the open ocean, making it easy for fish to misidentify and consume trash. Researchers have found plastic wrappers, light bulbs, rope, and string in the stomachs of dolphinfish (SAFMC 2022).

The South Atlantic Fishery Management Council has received concerns from the public about regional declines in the dolphinfish stock and availability of fish in certain areas, which are being considered for the management strategy evaluation.

CONSERVATION ACCOMPLISHMENTS

In January 2021, NOAA Fisheries implemented the Southeast For-Hire Integrated Electronic Reporting Program (SEFHIER). The SEFHIER program required that all charter vessel operators federally permitted through the NOAA Fisheries Southeast Regional Office (SERO) must report trip-level information electronically, and a SERO permit is required to target or retain dolphinfish in federal waters. In May 2022, the SAFMC lowered the recreational vessel limit of dolphinfish from 60 to 54 fish, excluding headboats (Amendment 10).

CONSERVATION RECOMMENDATIONS

- Characterize stock status in Atlantic waters
- Determine potential shifts in distribution and driving factors
- Investigate migration patterns
- Expand research and monitoring in fishery-independent surveys
- Research early life stages and develop better understanding of complete life history

MEASURE OF SUCCESS

The highly migratory nature, short lifespan, distribution changes, and variability in environmental condition complicates the measure of success; however, completing a baseline stock assessment in the Atlantic waters is critical for monitoring the population.

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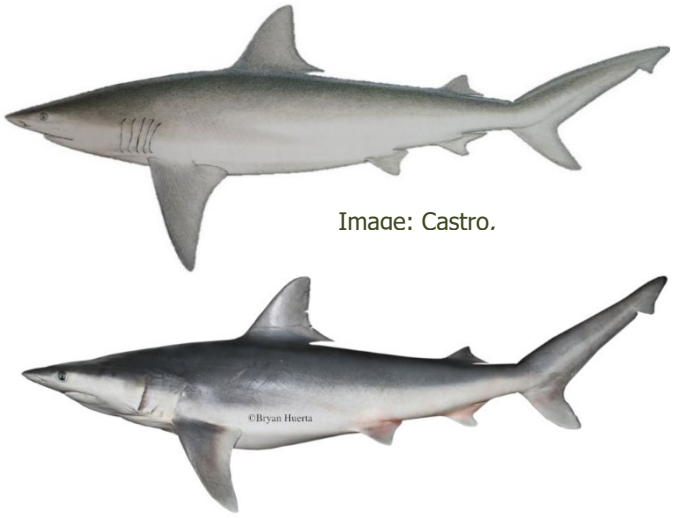
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Finetooth Shark

Carcharhinus isodon

Contributors:
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DESCRIPTION

Taxonomy and Basic Description

Finetooth sharks, members of the order Carchariniformes and family Carcharinidae (Page et al. 2023), are a slender, medium-sized shark which lacks an interdorsal ridge. Body color is a distinctive light blueish gray with a metallic sheen which transitions to a white underside. The color may change to a brownish gray during the winter months or after death. The snout is shorter than the mouth width, the gills are proportionally large and delicate, the fins lack any distinctive markings, and the first dorsal fin originates over the free rear tips of the pectoral fins. The species gets its common name from the fine, smooth-edged teeth which are similar in size and shape in both jaws (Castro, 2011). Finetooth sharks are sometimes mistaken with juvenile Spinner or Blacktip sharks but are easily distinguished by the unique coloration, lack of fin markings, large gill slits, and fine, smooth teeth.

Most sharks encountered are under 160 cm total length (TL) although prior studies suggested they may reach up to 200 cm TL (Compagno, 1984). Observed maximum ages determined by vertebral counts ranged from 8.2 to 21.9 years for males and 8.1 to 22.3 years for females in the Gulf of Mexico and Northwest Atlantic Ocean, respectively (Carlson et al., 2007; Vinyard et al., 2019). Age and growth studies suggest intermediate life history parameters with moderate growth rates which may differ between regions (Vinyard et al., 2019).

Females are thought to mature between 4.2 to 6.8 years which varies based on geographic location and size at maturity likely falls between 990-1043 mm FL (Carlson et al., 2007; Vinyard et al., 2019). Males are thought to reach maturity around 3.5 to 6.6 years and slightly smaller lengths between 935-1010 mm FL (Carlson et al., 2007; Vinyard et al., 2019).

Like many Carcharhinids, they are placental viviparous, giving birth to live young. Reproductive periodicity also differs between regions with annual reproduction reported in the Gulf of Mexico while biennial reproduction has been observed in the Northwest Atlantic (Driggers and Hoffmayer, 2009; Brown et al., 2020). Litters average 4 pups and

typically range from 2 to 6 pups (Castro, 1993). Size at birth has been reported in each region based on umbilical scaring and varies from 374-414 mm fork length (FL) in the Gulf of Mexico to 389-482 mm FL in the Atlantic (Carlson et al., 2003; Vinyard et al., 2019).

In addition to observed differences in life history parameters and reproductive periodicity, a genetic assessment concluded distinct regional populations exist in the Gulf of Mexico and Northwest Atlantic Ocean (Portnoy et al., 2016).

Status

Finetooth sharks have an IUCN Red List status of near threatened. Where they are well-managed in the Northwest Atlantic Ocean, the relative abundance time series suggest an increasing population rate of approximately 3.5% annually. Conversely, intense, unregulated fishing in the Southwest Atlantic has driven population declines in excess of 80%, and in 2012, they were considered regionally extinct by the Brazilian government (Carlson et al., 2021).

The most recent stock assessment was a Benchmark assessment in 2007, and it concluded finetooth were not overfished and not experiencing overfishing (Carlson et al., 2007).

POPULATION SIZE AND DISTRIBUTION

Finetooth sharks inhabit coastal waters in the Northwestern Atlantic from North Carolina to Florida and throughout the Gulf of Mexico. In the Southwestern Atlantic, they are found down to Brazil. Other reported occurrences outside of this range are likely misidentifications (Castro, 2011). Genetic, reproduction, and life history studies suggest two distinct stocks split between the Gulf of Mexico and Western North Atlantic.

In 2023, Finetooth were the most common species captured in the SCDNR Cooperative Atlantic States Shark Pupping and Nursery Habitat (COASTSPAN) survey. This survey acts as a recruitment index as well as an index of abundance. Long-term trends show populations of finetooth sharks have continued to recover from overfishing (Figure 1). Finetooth sharks are the third most common species captured in the SCDNR adult red drum and shark longline. This survey primarily tracks abundance of

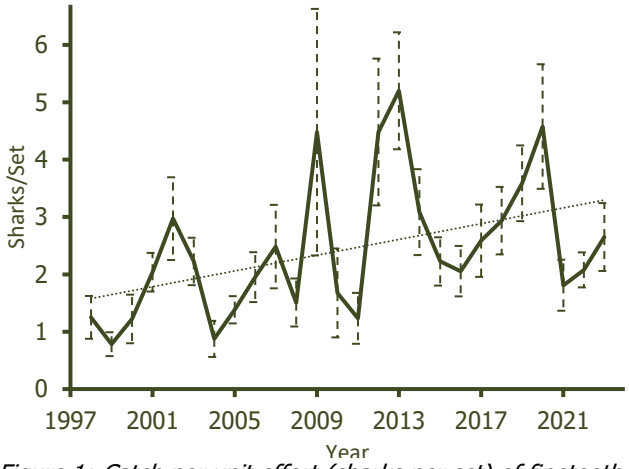


Figure 1: Catch per unit effort (sharks per set) of finetooth sharks from 1998 to 2023 in the South Carolina COASTSPAN Survey. Standard error is denoted by error bars. This survey primarily monitors recruitment of young of year finetooth sharks.

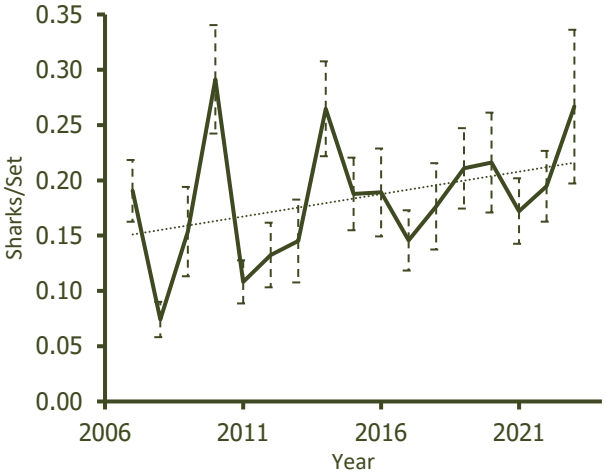


Figure 2: Catch per unit effort (sharks per set) of finetooth sharks from 2007 to 2023 in the adult red drum and shark longline survey. Standard error is denoted by error bars.

large juvenile and adult finetooth sharks. The trends in this survey mirror those of the COASTSPAN survey showing increases in population abundance over the duration of the survey (Figure 2).

Tag recapture reports of finetooth have increased over the past decade with several known time at liberty to 5.8 years (E. Vinyard, pers. comm.).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Finetooth sharks are migratory, utilizing high salinity estuaries and nearshore waters from North Carolina to Florida. They are most often found in shallow coastal waters less than 20 m deep.

South Carolina, Bull's Bay in particular, is a well-known nursery habitat for finetooth and many other coastal shark species. Juveniles typically begin to arrive in late April, just ahead of the adults, who will mate and pup off South Carolina from May to early June. Young of Year (YOY) and juvenile sharks spend more time in the estuaries and rivers, while adults tend to inhabit nearshore waters. As water temperatures drop below 20^{o}C, finetooth migrate south and overwinter off the east coast of Florida.

Diet studies suggest they are specialists, focusing primarily on oil-rich menhaden, however they are known to consume other estuarine teleosts as well as shrimp, squid and other small sharks (Bethea et al., 2004; E. Vinyard, pers. comm.).

CHALLENGES

Population growth along the coast as well as restrictions in other species has increased recreational angler pressure on coastal sharks, including for finetooth sharks. Little is known about post-release mortality rates in this species.

Finetooth are targeted for meat by commercial fishing vessels, and their fins have been identified overseas in the fin trade (Fields et al., 2018; Cardenosa et al., 2020). They are also taken as bycatch in gillnet, longline and trawl fisheries and are thought to be extirpated from the southern extent of their range off Brazil. Several life stages of finetooth sharks are highly dependent on menhaden so proper management and conservation of prey species is vital to their overall success. Further, given their reproductive strategy, as is the case with many shark species, rebuilding populations

from overexploitation that led to declines in biomass and numbers is slow given the low productivity of the species relative to most bonyfish.

CONSERVATION ACCOMPLISHMENTS

There are no conservation accomplishments specific to this species at this time.

Finetooth sharks are managed under NOAA's Atlantic Highly Migratory Species (HMS) Fisheries Management Plan. In recreational fisheries, there is currently a minimum size of 54" FL and a bag limit of 1 per vessel per trip. For commercial fisheries, the Atlantic Shark Directed fishery has no size limit but a retention limit of 55 sharks per vessel per trip while the Atlantic Incidental Permit lists a maximum of 16 combined small coastal and pelagic sharks per vessel per trip. The HMS Commercial Caribbean Small Boat Permit reduces the retention limit to 3 combined sharks per vessel per trip which includes specific large and small coastal sharks (including Finetooth).

CONSERVATION RECOMMENDATIONS

- Continue to monitor the stock status of finetooth sharks within SC waters through fishery-independent methods, including COSTSPAN and the adult red drum and shark longline surveys.
- Initiate genomic studies of finetooth sharks including using close-kin mark recapture studies to estimate population size.
- Conduct studies using electronic monitoring tags (i.e. PSATs, acoustic tags, and SPOT tags) to understand finetooth shark migratory behavior and essential habitat.
- Investigate non-lethal ways of obtaining life history data from finetooth sharks (e.g. epigenetic age estimation)
- Obtain post-release mortality estimates of finetooth sharks in recreational fisheries.
- Continue to educate the public on the importance of species identification of sharks to ensure undersized and prohibited sharks are not landed.
- The primary action at the state level via law enforcement partnering is to ensure adequate compliance with regulatory actions implemented through the federal management plan and subsequent amendments.

MEASURE OF SUCCESS

Continued increases in abundance of finetooth sharks. Continue to increase our understanding including knowledge of finetooth shark's life history and movement ecology.

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Large-Tooth Flounders Guild

Summer Flounder *(Paralichthys dentatus)*
Gulf Flounder *(Paralichthys albigutta)*

Contributors:
Brock Renkas (SCDNR), Luke Troha (SCDNR), & Hayden Bessette (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

Summer flounder (*Paralichthys dentatus*) and gulf flounder (*P. albigutta*) are members of the order Carangiformes and family Paralichthyidae, or left-eyed flounders (Page et al. 2023). Members of this family possess both eyes on the left side of a dorsoventrally flattened body. When larvae develop into the juvenile form, the right eye migrates to the left side of the fish. There are no spines in the pectoral and pelvic fins, and the dorsal fin originates at the anterior portion of the eye. The dorsal and anal fins are not joined to the caudal fin (Carpenter 2002). They possess small, cycloid scales. These species are often confused with the southern flounder (*P. lethostigma*) and each other, from which they can be differentiated by comparing counts of vertebrae, fin elements, gill rakers, and body pigmentation (Wenner and Archambault, 2005).

Summer Flounder (NC Sea Grant)



The left side of summer flounder possesses five prominent ocellated spots on the posterior portion of their body forming a double triangular pattern. The dorsal fin contains 80-96 rays, and the anal fin contains 61-73 rays. The pectoral fins are on both sides of the body with 10-12 branched rays. The ocular side varies from brown to gray, depending on the substrate color and texture (Smithsonian 2023a), while the blind side is white. The Summer Flounder have been reported to have a maximum size of 94 cm total length but is more commonly found at an average size of 14.7 cm in South Carolina coastal waters (SCDNR 2020, Carpenter 2002). Males typically live to a maximum age of 7 years, while females live 12-20 years (SCDNR 2020). Summer flounder are demersal fish occurring to depths of 185 m, but are generally found at depths of 40 m or less. Spawning occurs on the continental shelf from September-January, with salt marsh and tidal flat habitats in the lower estuary serving as nursery grounds. Summer flounders typically mature at 2-3 years of age and near 10 inches in total length (ASMFC 2024). As juveniles, they forage on invertebrates;

as adults, they forage primarily on fish, squid, crabs, shrimp, and mollusks (Carpenter 2002).

Gulf Flounder (USGS)



The left side of gulf flounder possesses three prominent ocellated dark spots forming a triangle. The dorsal fin contains 71-86 rays, and the anal fin contains 53-63. The pectoral fins are on both sides of the body with 10-12 branched rays. The ocular side is brown but varies in tone depending on the substrate, and the blind side is white. The gulf flounder have been reported to have a maximum size of 71 cm but are most common up to 35 cm in South Carolina waters. Males have a reported longevity of 8-11 years but have commonly been cited in collections as 2 years maximum age. Females have a reported longevity of 7 years but have commonly been cited in collections as 2 years maximum age (Fitzhugh et al. 2008). These demersal fish inhabit hard, sandy substrate at depths of 19-130 m. They spawn in late autumn and winter offshore with the highest spawning frequency observed during late-October to mid-December (Carpenter 2002). Gulf Flounder are carnivores, feeding on bony fish and mobile benthic crustaceans (Smithsonian 2023b).

Status

Summer flounder are managed by the Atlantic States Marine Fisheries Commission (ASMFC), and are one of the most targeted commercial and recreational species along the Atlantic Coast, with total landings estimated at 21.2 million pounds in 2022 (ASMFC 2024). Recreational harvest limits for summer flounder were first implemented in 1993. According to a 2023 stock assessment, they are not overfished but are experiencing overfishing. Though total fishery removals have generally decreased over recent decades, recruitment has also shown gradual declines (ASMFC 2023).

Gulf flounder are not managed by the ASMFC nor the Gulf States Marine Fisheries Commission (GSMFC) but are instead managed by individual states. As such, little information exists on the population status of this species. The majority of flounder research in the southeastern United States (US) focuses on the southern flounder and summer flounder.

POPULATION SIZE AND DISTRIBUTION

Despite being estuarine-dependent fishes, neither summer nor gulf flounder are encountered frequently in the South Carolina Department of Natural Resources (SCDNR) fishery-independent inshore monitoring program surveys. Although catches are low in the estuarine trawl survey, the catch-per-unit-effort (CPUE) of summer flounder has remained relatively stable (Figure 1). Gulf flounder are not encountered in significant numbers in any of the SCDNR inshore monitoring program surveys. The rarity of capture of any life stage of summer or gulf flounder in inshore surveys such as

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the trammel net survey or the electrofishing survey indicate that there is likely not a significant population of either of these species in the South Carolina inshore environment. If there were significant populations of these species, they would likely be caught more frequently as SCDNR samples habitats that would serve as vital nursery grounds for juveniles, as we see with the southern flounder.

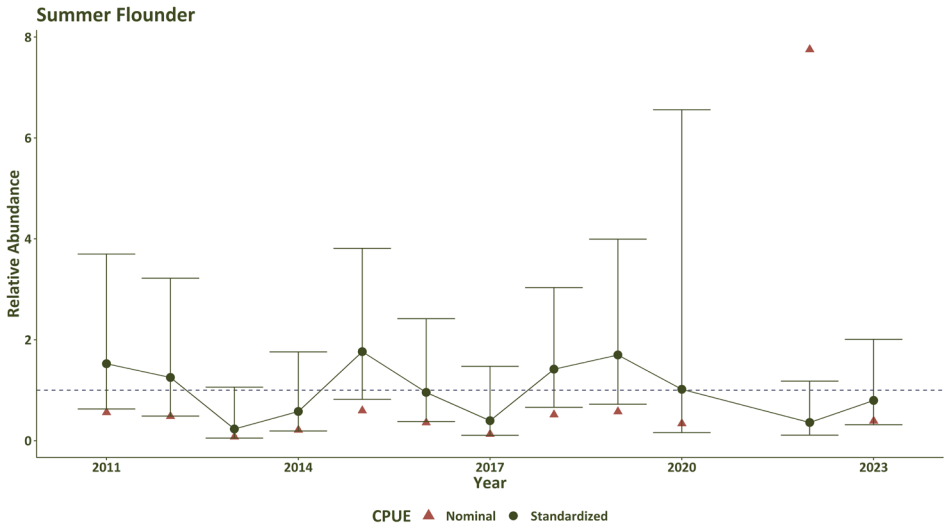


Figure 1: Summer flounder standardized catch per unit effort in SCDNR's estuarine trawl survey by year from 2011 to 2023. Shown is the standardized index of abundance (green line and circles) with a 95% CI (error bars) as well as nominal catch per trammel net (red triangles). Both the standardized and nominal indices are normalized to average catches from 2011-2023 (dashed line), such that if annual estimates are greater than 1, catch was above the 2011-2023 average and vice versa if below.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Both summer and gulf flounder are estuarine-dependent species, as they spawn offshore during their emigration out of the estuary to their wintering grounds (Able et al. 1990, Packer et al. 1999, Fitzhugh et al. 2008, ASMFC 2024). The timing of emigration may be related to several environmental variables such as water temperature, dissolved oxygen levels, and storm intensity (Sackett et al. 2007). After the adults spawn offshore, the larvae immigrate to the shallow inshore waters from October to May to continue development in a more sheltered environment. They spend their life in the estuary until maturation, when they join the adult offshore migration, though some juveniles partake in this emigration as well (ASMFC 2024).

CHALLENGES

As flounder are demersal fishes, both the summer and gulf flounder may be affected by any habitat modification of the seafloor, such as dredging and trawling (Santos et al. 2016), both of which are frequent occurrences in South Carolina waters. It may be difficult to parse out removals of summer and gulf flounder from the recreational fishing data due to the aggregate regulations where southern flounder are also included. Additionally, neither summer nor gulf flounder are common in South Carolina waters according to SCDNR fishery-independent surveys, and there is limited data available for the local populations of these species. Unlike summer flounder, gulf flounder are not formally assessed by any organization, so its overall population status is largely unknown and they are the lesser-studied species of the flounder guild in the southeastern US.

CONSERVATION ACCOMPLISHMENTS

In 2022, the fisheries management program for summer flounder was changed to adjust how recreational limits are set based on harvest estimates (ASMFC 2024).

In South Carolina, southern, summer, and gulf flounder are treated collectively as "flounder," where a fisher may keep five fish per day at a minimum of 16 inches total length. These same aggregate limits for flounder species are applied throughout the states of the southeastern US with variable length limits. South Carolina anglers primarily catch the southern flounder, and individual summer and gulf flounder in excess of 16 inches are relatively uncommon in South Carolina, especially in the inshore environment.

CONSERVATION RECOMMENDATIONS

- Examine long-term trends in summer and gulf flounder population size, abundance and relative distribution; relate these dynamics to fishing pressure, climate variation, pollution affects, and parasite load and disease.
- Monitor the effects of recreational fishing on summer and gulf flounder reproduction, growth, and longevity.
- Develop a management plan for gulf flounder in the southeastern US.
- Characterize the gulf and summer flounder population dynamics in South Carolina, including exploring environmental drivers of recruitment success, particularly in the context of projected climate changes impacts along coastal South Carolina.
- Decrease fishing mortality of summer flounder with well-executed fishery management plans and reduce overfishing levels.
- Test for benthic contaminants. Acquiring this knowledge could benefit a great number of species that associate closely with the estuarine bottoms in addition to summer and gulf flounders.

MEASURE OF SUCCESS

Assess the population status of summer and gulf flounders in South Carolina waters. Neither species has been formally assessed in South Carolina, and in order to detect changes in populations, we first must investigate the local population size and dynamics.

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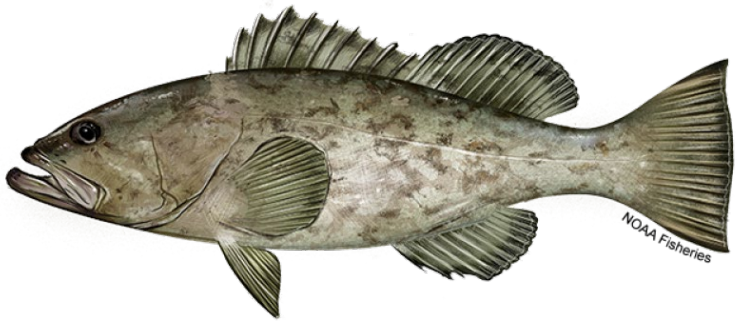
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Gag

Mycteroperca microlepis



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DESCRIPTION

Taxonomy and Basic Description

The Gag, *Mycteroperca microlepis*, is a common, medium-sized grouper occurring in commercial and recreational fishery landings in South Carolina. The Gag is a member of the family Epinephelidae (groupers), a family found within the order Perciformes (Page et al. 2023).

Gag are a slender grouper with body depth distinctly less than head length. The body is elongate and the head is pointed. The mouth is large with 2 canine teeth present anteriorly in each jaw. The scales are very small and number from 128 to 146 in the lateral line series. The dorsal fin is continuous with 16 to 18 soft rays and 11 slender spines (rarely 10 or 12) without fleshy tips. The pelvic fin inserts perpendicular to the pectoral fin which has 16 to 18 fin rays. The anal fin has 3 spines and 10 to 12 soft rays. The dorsal and anal fins are rounded, and the caudal fin is emarginated without extended rays (Murdy and Musick 2013, Heemstra et al. 2002). The maximum adult total length (TL) for Gag is at least 1.2 m (4 ft.) and the maximum weight is around 39 kg (86 lbs.; Murdy and Musick 2013, Heemstra et al. 2002).

Gag are protogynous hermaphrodites, which means they are born as females and change sex from female to male at a certain size and age. Females reach sexual maturity at around 75 cm TL or 4.6 years old. Sexual transition from female to male occurs when the fish are around 104 cm, and roughly 10.7 years of age (Gamboa-Salazar et al. 2020; SEDAR 2021). Off South Carolina's coast, Gag spawning occurs on reefs along the continental shelf and shelf edge from January through May, peaking in March and April (McGovern et al. 1998; Gamboa-Salazar et a. 2020).

Gag color is variable with the predominant color pattern for adults being an olive-brown with darker leopard spot-like markings on the side. Adult Gag may also be seen with dark brown and white bars below the dorsal fin or as a black-belly morph with the

ventral part of the body black above the anal fin (Heemstra et al. 2002; Murdy and Musick 2013).

Status

The stock of Gag off the southeast Atlantic coast was listed in 2023 as undergoing overfishing and overfished based on a stock assessment completed in 2021 (with 2019 as the last year of data included; SEDAR 2021). Gag are listed as Vulnerable by the IUCN.

POPULATION SIZE AND DISTRIBUTION

Gag are found in the western Atlantic, primarily from North Carolina to the Yucatan Peninsula, Mexico with juveniles reported as far north as Massachusetts and spotty reports as far south as Brazil. Juveniles are estuarine-dependent, using oyster and sea grass beds, while adults are found offshore (Heemstra and Randall 1993; McGovern et al. 1998; Heemstra et al. 2002). On the continental shelf, including off South Carolina, Gag have been collected at depths from 17 to 95 m (56 to 312 ft.) by the fishery-independent Southeast Reef Fish Survey (SERFS, Figure 1).

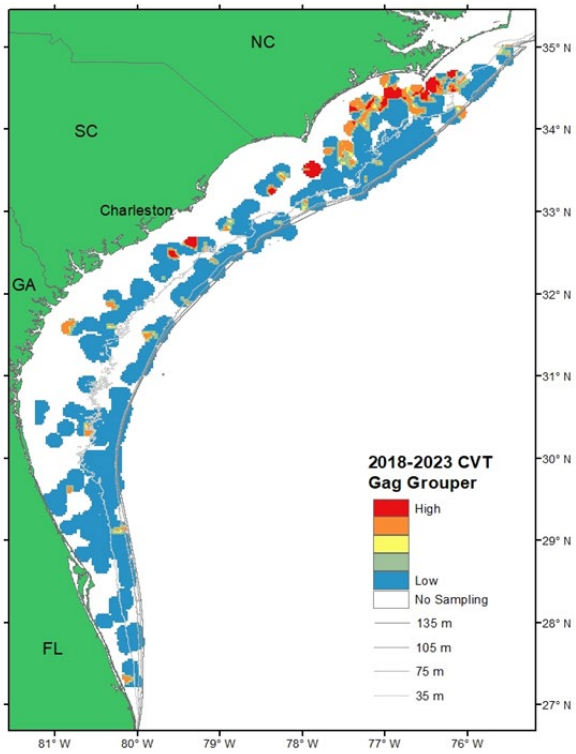


Figure 1: Distribution map of Gag catches from SERFS Chevron Traps from 2018-2023 (excluding 2020; Vecchio et al. 2024).

Two data sources independently support the decline in the Gag population off the U.S. southeast Atlantic coast and were used in the most recent assessment. Fishery-independent data collected by SCDNR during the Marine Resources Monitoring, Assessment and Prediction Program (MARMAP; 1990-2009) and the Southeast Reef Fish Survey (SERFS: 2010-present and includes MARMAP) indicates an overall decline in relative abundance since 1990 (Vecchio et al. 2024; Figure 2). South Carolina commercial fishery landings have averaged 221,170 lbs per year from 1980 to 2022 with an overall declining trend (NOAA Fisheries 2024b; Figure 3), while recreational landings in South Carolina averaged 22,217 lbs per year from 1984 to 2022 with no trend (NOAA Fisheries 2024b; Figure 3). An estimate of absolute Gag population size in South Carolina is not available.

HABITAT AND NATURL COMMUNITY REQUIREMENTS

Juvenile Gag occupy high-salinity estuaries and are found in habitats with natural or artificial structure such as seagrass beds, salt marsh edges, oyster reefs, wrecks, pilings, and dredged canals (Keener et al. 1988; Adamski et al. 2011). Oyster reefs are a favored habitat for juveniles in South Carolina. Post-larvae recruit to inlets, harbors, and saltmarsh creeks in March through June (peak in April) and remain in the estuary until waters cool in October and then they move offshore (Keener et al. 1988; Adamski et al. 2011). In offshore waters, Gag occupy natural and artificial reefs, including wrecks, hard bottom, live bottom, shelf-edge scarps, ledges, sponge/coral habitat, and other habitats that provide vertical relief above the bottom. Small juveniles feed on crustaceans while adults are piscivorous (Mullaney 1994; Spanik 2018).

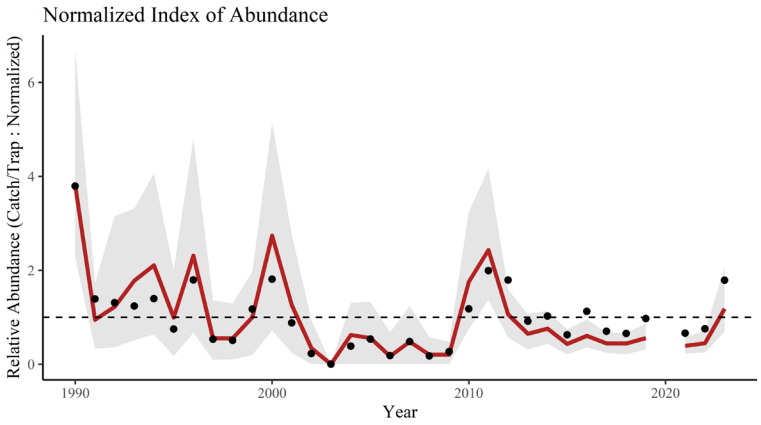


Figure 2: SERFS Chevron Trap index of relative abundance for Gag for the Southeast U.S. Atlantic region. Nominal values are black dots. Red line is modeled index value. Gray shading is standard error. Dotted horizontal line is long-term average value.

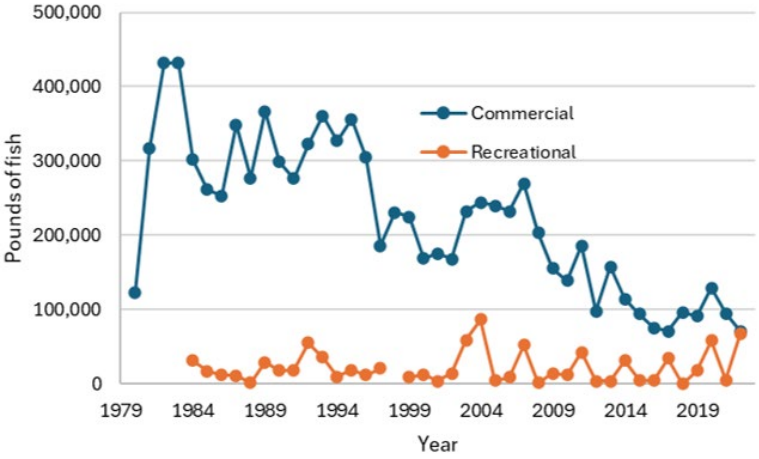


Figure 3: Commercial and recreational landings (in lbs) of Gag in South Carolina.

CHALLENGES

Coastal development adversely affects salt marsh availability and increased harvesting can impact oyster reef availability, both of which are essential habitats for juvenile Gag. Because Gag are long-lived, slow growing and late maturing, overfishing is a primary concern as such activity is likely to reduce the number of fish, skew age compositions, and impact reproductive output (McGovern et al. 1998; Coleman et al. 2000; Harris and Collins 2000; Musick et al. 2000). Additionally, Gag undergo sex transition, which further results in skewed sex ratios under heavy fishing pressure; the largest fish are males and are selectively removed by the fishery (Huntsman et al. 1999; McGovern et al. 1998; Coleman 2000). Gag can be found in deep water (50 to 100 m or 164 to 328

ft; McGovern et al. 1998) where post-release mortality is high due to pressure changes and barotrauma impacts. In addition, Gag are larger in deep water and tend to be more sedentary with increasing depth, further increasing the vulnerability of males to fishing pressure (McGovern et al. 2005). Gag have a minimum size limit and a spawning season closure in place to reduce fishing mortality. However, Gag are also part of a multi-species fishery (snappers, other groupers, etc.), and so they are caught when not being targeted which increases the likelihood of regulatory discards and post-release mortality.

CONSERVATION ACCOMPLISHMENTS

The Gag fishery off of South Carolina is managed in federal waters by the South Atlantic Fishery Management Council, which enacted several management measures to reduce fishing mortality. In the commercial fishery, a limited access snapper-grouper permit is required and there is a 300 lb gutted weight trip limit. There is a commercial and recreational 61 cm (24 in) total length minimum size limit. Between January 1 and May 1, there is a prohibition on recreational and commercial harvest and possession of Gag and other shallow water groupers during their peak spawning period. Outside of the spawning season closure, longline use in areas shallower than 50 fathoms is prohibited and traps and trawls are banned for commercial use for Gag. The recreational fisherman is limited to 3 groupers (mixed species) per person, although no more than one may be a Gag or a Black Grouper. Vessels fishing for snapper-grouper species must have a descending device on board to reduce post-release mortality. Gag must be landed with the heads and fins intact to facilitate enforcement of regulations. In addition, the SAFMC established Marine Protected Areas (MPA) in the region in 2009 that are closed to bottom fishing year-round to product grouper spawning areas (SAFMC 2024).

CONSERVATION RECOMMENDATIONS

- Evaluate the effects of fishing and management plans, such as closures and MPAs, on Gag stocks.
- Investigate the potential for male limitation in the Gag population and its impact on reproductive output and recruitment.
- Investigate drivers of recent low recruitment for Gag.
- Establish a pre-recruit index of abundance by monitoring the abundance of juvenile Gag in South Carolina estuaries. Such an index could be used to evaluate recruitment success and predict trends in adult population size.
- Determine key saltmarsh and oyster reef habitat utilized by juvenile Gag to protect those areas from degradation, either permanently or seasonally.

MEASURES OF SUCCESS

Measurement of management success is difficult in the absence of long-term historical data that precede expansion of the fishery in the 1970s; however, the SCDNR MARMAP and SERFS programs have monitored relative abundance, size structure, age structure, and reproduction of reef fish, including Gag, since 1990. These data have shown an increase in average size of Gag following implementation of size regulations, suggesting small fish have been preserved from fishing mortality. This survey can serve as an early warning sign of population recovery based on abundance and size structure well before a full assessment can be conducted.

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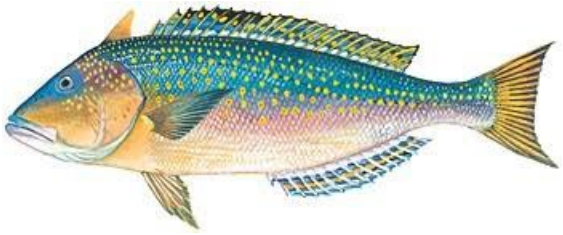
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Tilefish (Golden Tilefish)

Lopholatilus chamaeleonticeps



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DESCRIPTION

Taxonomy and Basic Description

Golden Tilefish, *Lopholatilus chamaeleonticeps*, are members of the family Malacanthidae (tilefishes) found within the order Perciformes (Page et al. 2023). They are a medium-sized fish easily distinguishable from other members of the family Malacanthidae by their large adipose flap, or crest, on the head. The species is blue-green and iridescent on the back, with numerous spots of bright yellow and gold. The belly is white and the head is rosy, with blue under the eyes. The pectoral fins are sepia-colored, and the margin of the anal fin is purplish-blue.

Golden Tilefish live to a maximum age of 40 years and reach a maximum size of 855 mm. Maturity of 50% of fish is reached by age 3. Golden Tilefish are gonochorists and have an extended spawning season from March to November, peaking between April and June (SEDAR 2021).

Status

Golden Tilefish support commercial and recreational fisheries in South Carolina. The most recent stock assessment determined that Golden Tilefish are not overfished, and no overfishing is occurring (SEDAR 2021).

POPULATION SIZE AND DISTRIBUTION

Golden Tilefish are distributed along the outer continental shelf of North America from Nova Scotia to Key West, FL; in the Gulf of Mexico from the northern shoreline to Campeche Bank, Mexico, and off South America from Venezuela to Surinam (Able et al. 1982; Dooley 1978; Grimes et al. 1988; Hightower and Grossman 1988; Turner et al. 1983). Adults move little in depths of 100-400 m and water temperatures of about 9-14°C (Erickson et al. 1985; Grimes et al. 1986; Grimes et al. 1982; Grimes et al. 1988; Hightower and Grossman 1988; Low and Ulrich 1983).

Golden Tilefish were encountered occasionally using Short Bottom longline (SBLL) gear by the Marine Resources Monitoring and Prediction Program (MARMAP) to sample snapper-grouper species in habiting hard-bottom areas with considerable vertical relief in depths greater than 75 m, from 1996 to 2022. However, SBLL sampling was not conducted consistently enough to develop reliable indices of abundance.

In 2020 a coastwide longline survey, South Atlantic Deepwater Longline Survey (SADL) was developed which aims to consistently sample deepwater species including Golden Tilefish. However, at least 5 years of survey data should be available before an index of relative abundance should be considered for use in a stock assessment. The distribution of catches confirmed the patchy distribution throughout the region, including SC, but showed areas of increased abundance in FL (Figure 1).

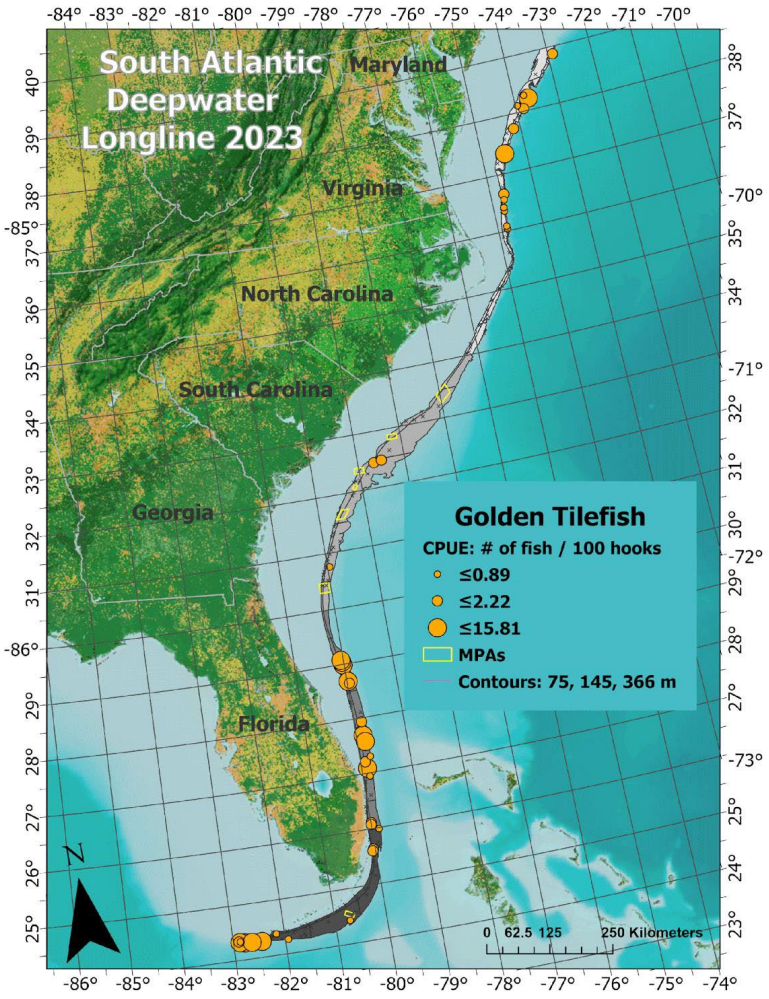


Figure 1: Distribution and magnitude of Golden Tilefish catches from the South Atlantic Deepwater Longline Survey in 2023.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Golden Tilefish occupy burrows within clay bottoms or scour depressions around boulders or rubble piles in depths of 100-400 m and water temperatures of 9-14°C (Erickson et al. 1985; Grimes et al. 1986; Grimes et al. 1982; Grimes et al. 1988; Hightower and Grossman 1988; Low and Ulrich 1983). Golden Tilefish are opportunistic feeders that prey on benthic-associated crustaceans, annelids, mollusks, echinoderms, and fishes (Freeman and Turner 1977).

CHALLENGES

Golden Tilefish and other deepwater fisheries have become increasingly important because of their economic value and because they provide an alternate resource when shallow-water stocks are depleted or access is restricted by management (Large et al. 2013). Deepwater stocks are difficult to monitor, as the depths and distance from shore at which these species occur are often cost-prohibitive for traditional surveys to adequately collect samples for life history analyses, estimation of population demographics, and development of relative abundance trends. As a result, stock assessments for Golden Tilefish have historically been data-limited. SADL was

developed to more effectively sample deepwater species throughout their range and will be a critical data source for stock assessments in the future. Because deepwater species, including Golden Tilefish, tend to be slower growing and long-lived, they are not as resilient to disturbances compared to others in their community. This leads to more opportunities for removal from the ecological system, whether natural or fisheries-related, before their first reproductive contribution to the fishery. As with many other reef fish species which have substantial overlap in habitat use, there is potential for mortality even when they are not targeted in this multi-species fishery. Because they are a deepwater species (≥30 m), they can be highly susceptible to post-release mortality (e.g. barotrauma) during these encounters.

CONSERVATION ACCOMPLISHMENTS

The Golden Tilefish fishery off South Carolina is managed in federal waters by the South Atlantic Fishery Management Council. Several management measures to reduce fishing mortality and dead discards have been implemented including the requirement of descending devices, dehooking tools, and non-stainless steel circle hooks.

CONSERVATION RECOMMENDATIONS

- Reconsider evidence of stock structure
- Investigate effects of weather/oceanographic patterns on catchability
- Characterize and quantify relationships between catch and habitat

MEASURE OF SUCCESS

Management success for Golden Tilefish is difficult to measure since fishery-independent sampling has not been consistent historically and offshore species recreational catch is more difficult to monitor. SADL was developed to more effectively sample deepwater species throughout their range and will be a critical data source for stock assessment in the future.

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Gray Snapper

Lutjanus griseus

Contributors:
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DESCRIPTION

Taxonomy and Basic Description

The gray snapper also known as the "mangrove snapper" is a member of the Lutjanidae (Snapper) family and order Perciformes (Page et al. 2023) with a maximum reported age of 32 years (SEDAR 2018) and a world record total weight of ~8.45 kg (IGFA 2024). The gray snapper has a relatively slender body with a pointed snout. Starck and Schroeder (1971) described the gray snapper as generally gray dorsally with white countershading but with variable shades and color patterns based on the size of the fish and their environment, ranging from pale gray to dark reddish brown. In most cases, there is a dark stripe running obliquely from the snout through the eye, ending ahead of the first dorsal spine. The gray snapper reaches sexual maturity around ages 2 to 3 (175 to 198 mm standard length) with a general male to female sex ratio of 50:50 (Starck and Schroeder 1971; Domeier et al. 1996). From May to September, adult gray snapper form spawning aggregations offshore; spawning is thought to occur during new or full moons (Starck and Schroeder 1971; Domeier et al. 1996).

Status

Results of the SEDAR 51 assessment (2018) suggest the Gulf of Mexico stock is experiencing overfishing and has been for decades but is not currently overfished. The stock status for the gray snapper population along the southeastern United States (SEUS) Atlantic coast has not been formally analyzed since the early 1990s (Bacheler et al. 2020). The gray snapper is listed as Least Concern by the IUCN (Lindeman et al. 2016).

POPULATION SIZE AND DISTRIBUTION

The gray snapper is found in tropical, subtropical, and warm temperate waters along the United States Atlantic coast to Brazil, Bermuda, and throughout the Gulf of Mexico and the Caribbean (Starck and Schroeder 1971; Denit and Sponaugle 2004; Lindeman et al. 2016; Andrade and Santos 2019; Bacheler et al. 2020). The Southeast Reef Fish Survey (SERFS) uses traps and video cameras to monitor species composition and abundance from Cape Hatteras, NC, to St. Lucie Inlet, FL, with video counts of particular use for gray snapper (Figure 1). The gray snapper is common along the

eastern Florida coast but generally decreases in abundance northward (Starck and Schroeder 1971; Chester et al. 1984; Bacheler et al. 2020). However, there has been evidence of recruitment in South Carolina estuaries since the early-2000s, with individuals captured annually every year since 2001 in the SCDNR Inshore Fisheries fishery-independent electrofishing survey and several years in the trammel net survey; particular pulses occurred from 2002-2006 and 2015-2018 (Joseph C. Ballenger, pers. comm.).

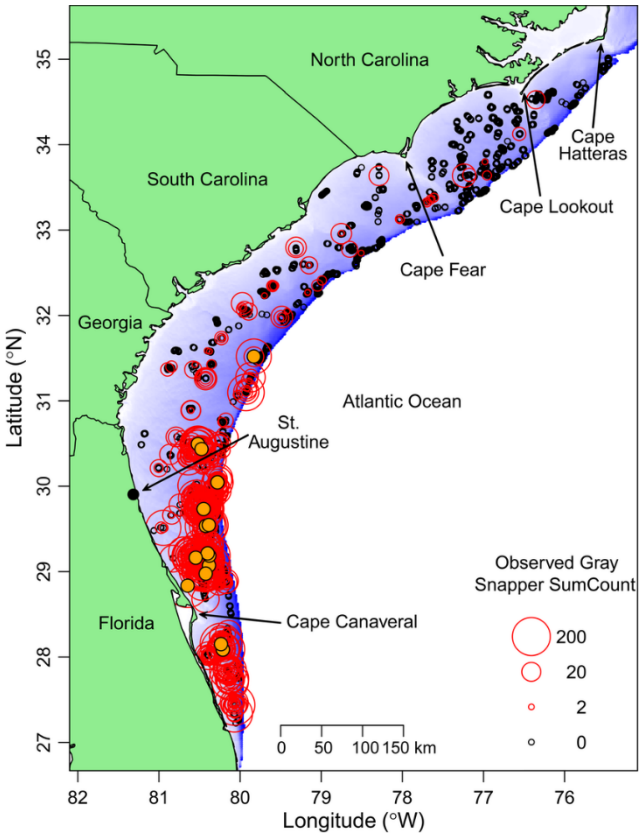


Figure 1: Figure from Bacheler et al. (2020) displaying Southeast Reef Fish Survey (SERFS) distribution of gray snapper from video counts from 2011-2017. The scaled red bubbles indicate the number of observed gray snapper. The orange circles indicate gray snapper aggregations (i.e., >20 individuals). Note that bubbles often overlap. The depth range is from 5 m (light blue) to 100 m (dark blue).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The habitats occupied by gray snapper vary widely and generally with life stage. Juveniles inhabit estuarine seagrass beds, mangroves, and oyster reefs (Starck and Schroeder 1971; Flaherty et al. 2014; Bacheler et al. 2020), subadults move into channels, and adults tend to occupy deeper channels or offshore waters associated with coral reef, rocky reef, or hard-bottom habitats (Starck and Schroeder 1971; Bacheler et al. 2020). Along the southeast US continental shelf, Bacheler et al. (2020) found adult gray snapper were more common in warmer waters (>22 °C) at depths less than 50 m (Fig 1) and in high-relief hardbottom habitats. Schools of adult gray snapper form during the day before dispersing at night to forage, feeding largely on shrimp, crab, and fish (Starck and Shroeder 1971).

CHALLENGES

The gray snapper is susceptible to fishing pressure as an easily accessed coastal species. Latitudinal demographic differences (e.g., size and age) have been noted in gray snapper in Florida waters, with a lack of older and larger fish in south Florida where there is greater fishing pressure (Burton 2001; Allman and Goetz 2009; SEDAR 2018). Although the South Atlantic Fishery Management Council (SAFMC) manages gray snapper, there are limited data available for the southeast US Atlantic population because the species is minimally susceptible to common survey gears due to location

and ecology. The long-term population trend is unknown, and information is limited on adult gray snapper temporal and spatial movements, with no spawning aggregation sites identified in the southeast US (Bacheler et al. 2020). The general lack of information on the gray snapper population in this region creates challenges for fisheries managers, especially considering gray snapper are part of a multi-species fishery, and as coastal development can adversely affect nursery habitats.

CONSERVATION ACCOMPLISHMENTS

The SAFMC manages the gray snapper fishery in federal waters off South Carolina. Commercial fishery regulations include a minimum total length of 12 in. Recreational fishery regulations include a minimum total length of 12 in, a 10 fish bag limit, and a 10 fish aggregate bag limit (10 snapper combined). Recreational fishing vessels are required to have a descending device on board when fishing for species in the snapper-grouper complex.

CONSERVATION RECOMMENDATIONS

- Continue to monitor gray snapper abundance via fishery-dependent and fishery-independent surveys, particularly watching for range expansions in to South Carolina waters.
- Increase biological sampling efforts.
- Conduct discard mortality studies for gray snapper.
- Initiate tagging studies to identify spatial and temporal movement patterns.
- Identify spawning aggregation locations.

MEASURE OF SUCCESS

Data collected by the SERFS, particularly counts of individuals via the video survey, can be used to observe long-term trends in total abundance. Stability or increases in total abundance can indicate a healthy population, suggesting successful management measures. Further, if abundances of juveniles in estuarine waters increases, the SCDNR fishery-independent electrofishing and trammel net surveys may continue to encounter Gray Snapper, offering another avenue to monitor their status in South Carolina.

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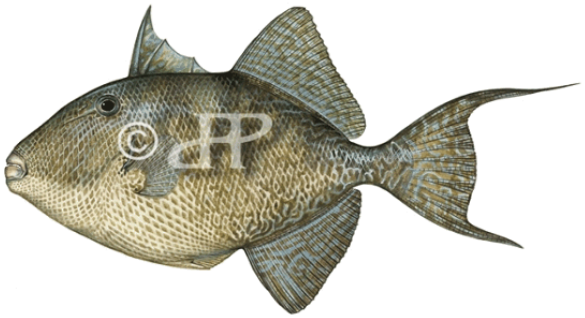
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Gray Triggerfish

Balistes capriscus

Contributors:
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DESCRIPTION

Taxonomy and Basic Description

Gray triggerfish, *Balistes capriscus*, is a marine species in the family Balistidae found within the order Tetraodontiformes (Robins and Ray 1986; Bernardes 2002; Page et al. 2023). Their name accurately describes their coloration (gray with blue or purple spots or shading) and can easily distinguish them from their cousins, the queen triggerfish, which are brightly colored. Gray triggerfish have a laterally compressed body with large incisor teeth and a large dorsal spine that remains erect, for protection, until a smaller second spine is deflexed, triggering the first.

Gray triggerfish are gonochoristic (separate sexes) and demonstrate sexual dimorphic growth where males obtain larger sizes than females. Males build demersal nests and perform courtship behaviors to attract multiple females into a harem-like group (Simmons and Szedlmayer 2012). Both parents will then protect the demersal eggs in the nest until they hatch. Females in the southeastern US can be reproductively mature within the first year but are fully mature by age 4, have a max age of 15 years, and max size of 453 mm (~18 inches) total length (TL; SEDAR 82). Additionally, they spawn from April-September (Kelly-Stormer et al. 2017).

Status

Gray triggerfish in the Atlantic off the U.S. southeast coast (SEUSA) are managed as a single stock based on genetics (Antoni et al 2011). The only completed assessment for this stock characterized Atlantic gray triggerfish as not overfished and overfishing not occurring (SEDAR 2024). IUCN characterizes gray triggerfish as Vulnerable.

POPULATION SIZE AND DISTRIBUTION

Gray triggerfish occur in coastal waters of the western Atlantic from Nova Scotia (Canada) to Argentina, including the Gulf of Mexico and Bermuda (Robins and Ray 1986; Bernardes 2002). Throughout this distribution, they are found at depths to 100 m (Harmelin-Vivien and Quéro 1990). In the SEUSA, the species is regularly encountered by the fishery-independent Southeast Reef Fish Survey (SERFS) chevron trap survey. The species is most abundant on hard-bottom habitats off the coasts of North and South Carolina (Figure 1). Despite their not overfished status, SEDAR 82 used fishery-independent and dependent data, which showed a decreasing trend in biomass in the

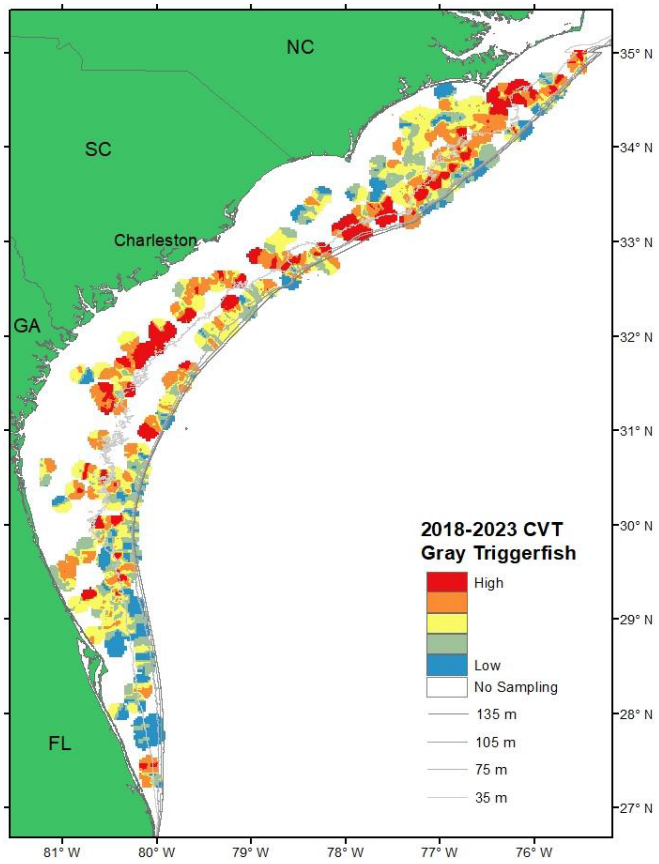


Figure 2: Distribution map of Gray Triggerfish from Southeast Reef Fish Survey chevron traps.

region. Data from the fishery-independent Southeast Reef Fish Survey showed a decline in relative abundance recently compared to the 1990s (Vecchio et al. 2024; Figure 2).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Gray triggerfish have a unique life history strategy where juveniles associate with *Sargassum* spp. in the water column (Ingram 2001; Wells and Rooker 2004; Casazza and Ross 2008) and eventually settle into the benthos and are most associated with natural and artificial reefs, rocky outcroppings/hard bottom, and wrecks as adults. Adults feed diurnally on invertebrate prey, such as mollusks, crustaceans, and echinoderms (Frazer et al. 1991; Vose and Nelson 1994; Blitch 2000). Off the coast of South Carolina, they are found from the mid-shelf out to about 100 m in depth.

CHALLENGES

Gray triggerfish are part of a multi-species reef fish fishery off the U.S. southeast Atlantic coast managed by the South Atlantic Fisheries Management Council (SAFMC). In 2024, gray triggerfish were managed through minimum size limits, bag and trip limits, and annual catch limits. When the fishery is closed for gray triggerfish, they may co-occur with other open species and are therefore subject to bycatch and potentially post-release mortality when released due to

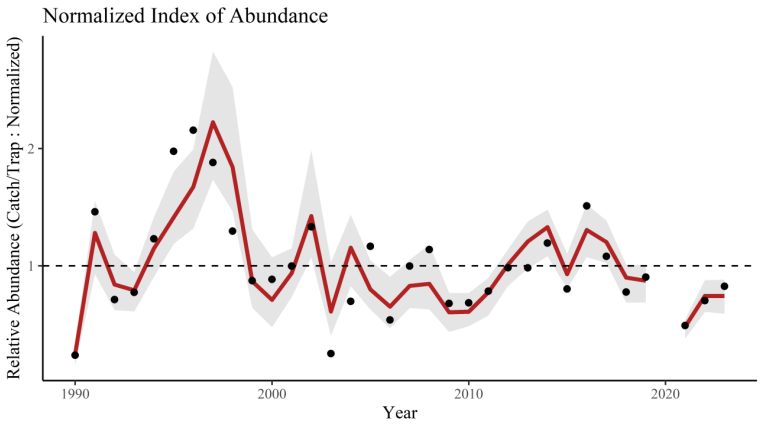


Figure 1: Estimated index of abundance for gray triggerfish off the SEUSA coast as captured by the SERFS chevron trap survey from 1990 to 2023.

regulations. Additionally, they occur in deeper waters (>30 m), which makes them prone to barotrauma during capture, which can also increase rates of post-release mortality.

Gray triggerfish life history also proves challenging for understanding their populations. Capturing juvenile specimens is difficult due to their early association with the sargassum habitat, meaning we lack information about recruitment and early growth and reproduction. Further, age determination in gray triggerfish is notoriously difficult. Because females lay demersal eggs and their eggs may not fully hydrate like other pelagic egg layers, estimating fecundity (reproductive output) is difficult. They also guard nests and may not forage during the short time they are guarding the nest, making it difficult to capture individuals in spawning condition to develop needed parameters for assessments.

CONSERVATION ACCOMPLISHMENTS

SAFMC regulations for gray triggerfish since the first bag limit in 1999 (Amendment #9) have proven to be sufficient to maintain them in acceptable stock status.

CONSERVATION RECOMMENDATIONS

- Age-structure validation
- Research movement and migration in Atlantic waters
- Evaluate their reproductive strategy, including investigations of spawning location, spawning season, effects of nesting behavior on reproductive output, and fecundity type
- Determine early life history parameters, specifically on 4-7 month pelagic stage
- Determine recruitment patterns, including availability of Sargassum as essential juvenile habitat
- Determine the impact of climate change on reproduction, recruitment, and mortality

MEASURES OF SUCCESS

The SERFS program annually monitors relative abundance, population demographics and reproductive status of reef fishes can detect changes in the Atlantic gray triggerfish population that result from management efforts or require management efforts. Further, tracking changes in relative abundance and population demographics from the SERFS survey is faster and more responsive than traditional stock assessments, though only stock assessments can integrate all available data to determine stock status.

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Hammerhead Sharks Guild

Bonnethead *Sphyrna tiburo*
Carolina Hammerhead *Sphyrna gilberti*
Great Hammerhead *Sphyrna mokarran*
Scalloped Hammerhead *Sphyrna lewini*
Smooth Hammerhead *Sphyrna zygaena*

Contributors:
Bryan Frazier (SCDNR) & Liz Vinyard (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

The bonnethead, great, Carolina, scalloped, and smooth hammerheads are members of the family Sphyrnidae and reside in the genus *Sphyrna* (9 species). They have a distinct head, known as a cephalofoil, which is laterally expanded and dorso-ventrally flattened.


Bonnethead Shark

The bonnethead is a relatively small shark reaching a maximum reported total length (TL) of 140 cm (Castro 2011). Its head is semicircular in outline. Among sharks in general, they are considered rapidly maturing with females reaching maturity around 6 years of age (106 cm TL) and males reaching maturity around 4 years of age (80 cm TL) (Frazier 2014). Bonnetheads are placentally viviparous and have a 4.5 month gestation period with parturition occurring in September. The short gestation period and month of parturition are both unique among sharks inhabiting coastal waters of the US. Mature bonnetheads reproduce annually with an average litter size of 8-9 pups (Gonzales de Acevado et al. 2020). The maximum observed age for bonnetheads is 18 years old (Frazier 2014)


Scalloped/Carolina Hammerhead Shark

The scalloped hammerhead is a large hammerhead reaching a maximum reported size of 430 cm TL, although total lengths of 360 are more common. The head has a median notch at its center and a slight arch that is more prominent

in young of the year and juveniles. They are relatively slow to mature with males maturing at around 12.4 years of age (158 cm FL) and females maturing around 16.2 years old (188 cm FL) (Piercy et al. 2007; Moncrief-Cox et al. 2021). Scalloped hammerheads are placentally viviparous with a 9-to-12-month gestation period and parturition occurring in late spring. Reported litter sizes range from 12-41 pups with an annual reproductive cycle. The maximum reported age for scalloped hammerheads is 39.5 years old (Frazier et al. 2021).

The Carolina hammerhead has only recently been described (Quattro et al. 2013). It is morphologically similar to the scalloped hammerhead, with x-ray counts of pre-caudal vertebrae being the only conclusive characteristic. Carolina hammerheads have less than 92 pre-caudal vertebrae (range of 83-91) while scalloped hammerheads have greater than 91 pre-caudal vertebrae (range of 92-99). Although some external morphological features differ on average between the two species, their ranges overlap, so there is currently no definitive field method of distinguishing one species from the other. Instead, either genetic analysis or x-ray pre-caudal vertebrae counts are required. The Carolina hammerhead was described based on neonate and juvenile stages, and limited data are available regarding life history and ecology. Life history characteristics are thought to be similar to the scalloped hammerhead, but it is likely that existing knowledge of scalloped hammerhead life history included mixed information from both species. The current maximum estimated age of Carolina hammerheads is 22 years; however, only a couple adults have been aged to date.



The great hammerhead is the largest hammerhead species in the family with a maximum reported length of 466 cm TL. They have a head with nearly straight anterior margins, a prominent high first dorsal fin and pelvic fins with curved rear margins. Maturity data are lacking due to relatively low sample availability of juveniles, however the available data suggest they mature at a younger age, but greater length than scalloped hammerheads with males maturing at around 7.8 years of age (201 cm FL) and females maturing around 8.1 years old (207 cm FL) (Moncrief-Cox et al. 2021). Great hammerheads are placentally viviparous with a 11 to 12 month gestation period and parturition occurring in early summer. Reported litter sizes range from 13-56 pups with an annual reproductive cycle. The maximum reported age for scalloped hammerheads is 44 years old (Piercy et al. 2010).



The smooth hammerhead obtains similar lengths to the scalloped hammerhead and has a rounded anterior margin to the cephalofoil similar to Carolina and scalloped hammerheads, but it can be readily distinguished by the lack of a central indentation. Smooth hammerheads are generally found in more northerly latitudes compared to other hammerhead species, and regional abundance is also lower. Given the low abundance, regional life history data are lacking with no studies on age and growth or reproduction in this region. From studies of other populations, it appears that the life history of smooth hammerheads (length, reproduction and maximum age) is most similar to that of the scalloped hammerhead.

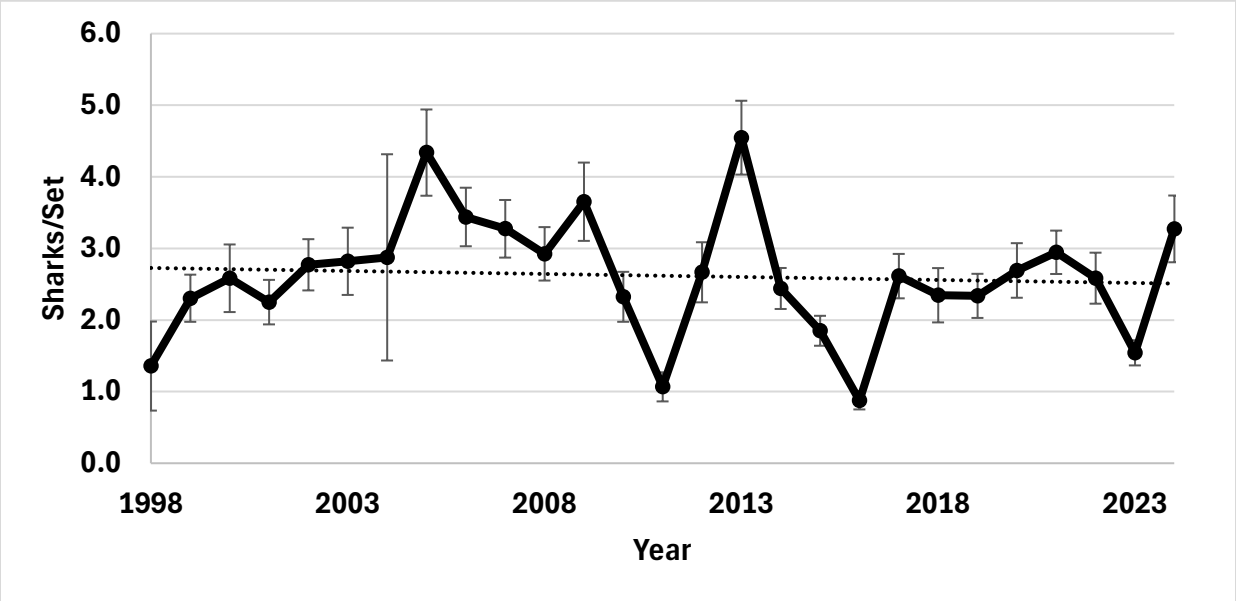


Figure 1. Catch per unit effort of bonnetheads (sharks per set) from 1998 to 2023 in the South Carolina Cooperative Atlantic States Shark Pupping and Nursery Habitat gillnet survey. Standard error is denoted by error bars.

Status

The status of the bonnethead in the US Atlantic Ocean is currently considered unknown. The species was last assessed in 2013; however, the Gulf of Mexico (GOM) and US Atlantic (Atlantic) populations were assessed as a single stock, despite substantial evidence showing multiple stocks (tagging, genetic and life history data) the combination of the stocks confound the assessment results leading external reviewers to reject the assessment for management purposes. The International Union for Conservation of Nature (IUCN) Red List currently considers the bonnethead as an "Endangered" species, although this assessment is largely based on status in countries outside of the US where bonnethead populations are in decline. Data from the South

Carolina Department of Natural Resources (SCDNR) gillnet survey suggest a general decrease in bonnethead abundance since the survey began (Figure 1).

Given the limited availability of Carolina hammerhead specific fishery independent data, commercial and recreational data, as well as life history data, they were most recently assessed as a combined species assessment with scalloped hammerheads. Ultimately the stock assessment determined there was no overfishing occurring, and the combined stocks were not overfished in US waters (SEDAR 77). That said, the stock assessment noted the difficult nature in dealing with the cryptic Carolina hammerhead. A 2012 petition to list the scalloped hammerhead as an endangered species was found to not have merit in the Northwestern Atlantic Ocean and Gulf of Mexico. However, the National Marine Fisheries Service did find populations in the eastern Atlantic Ocean and eastern Pacific Ocean were at high risk of extinction, and the population in the Central and Southwest Atlantic were listed as threatened (NMFS 2013). The IUCN Red List currently considers the scalloped hammerhead to be critically endangered, the Carolina hammerhead is considered data deficient. Data from the SCDNR shark gillnet survey suggest an increase in abundance of young of year scalloped and Carolina hammerhead sharks in SC waters (Figure 2), indicating increasing recruitment.

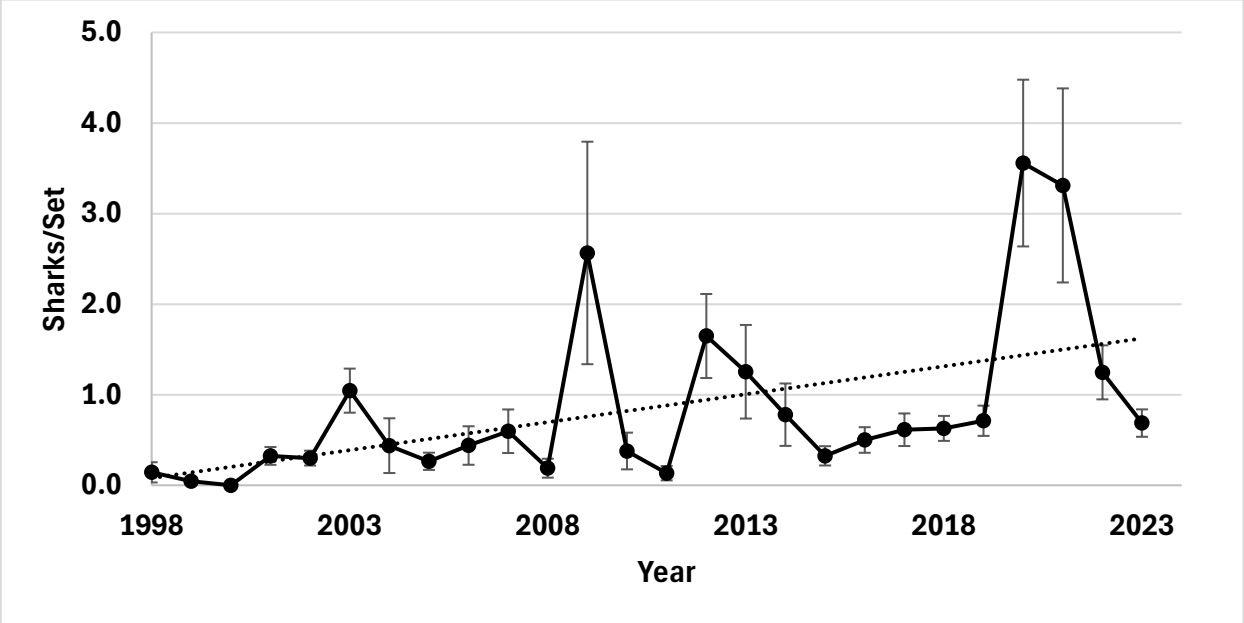


Figure 2. Catch per unit effort of young of year scalloped and Carolina hammerheads (sharks per set) from 1998 to 2023 in the South Carolina Cooperative Atlantic States Shark Pupping and Nursery Habitat gillnet survey. Standard error is denoted by error bars.

Data are comparatively lacking on great hammerhead abundance, especially in young of year and juvenile life stages, that said sufficient data were present to conduct a stock assessment with results showing the population is overfished, but no overfishing was occurring at the time of the assessment (SEDAR 77). Globally, there is significant concern for the great hammerhead with the IUCN Red List currently considering the great hammerhead critically endangered.

Data were acknowledged to be lacking in the assessment of the status of the smooth hammerhead and while robust recommendations could not be generated, the assessment indicated that the stock had been depleted in the past, reduced fishing pressure over the last 20 years had allowed the stock to begin rebuilding, and that rebuilding would likely continue to occur with the current management. Globally, the smooth hammerhead is considered vulnerable by the IUCN Red List, although their assessment notes that populations are declining.

POPULATION SIZE AND DISTRIBUTION

Bonnetheads are distributed in coastal and estuarine waters from North Carolina south through the Gulf of Mexico, Caribbean, and to Brazil (Compagno 1984). Within South Carolina waters, bonnetheads are found in high to moderate salinity estuarine waters (17-34 ppt) in the late spring through early fall (Ulrich et al. 2007). Females and males spatially segregated with females found primarily in estuarine waters, and males mostly found in coastal waters. A high degree of site fidelity by female bonnetheads has been observed through tagging studies, with individuals returning to the same estuary year after year (Driggers et al. 2013). This observed site fidelity could lead to localized exploitation of bonnetheads, resulting in a potential loss of genetic diversity. Recent research by Keller et al. (2021) found that bonnetheads are likely using geomagnetic features to migrate to and from Spring-Fall habitat.

Scalloped hammerheads are globally distributed in coastal warm temperate and tropical seas. Genetic evidence indicates 6 distinct population segments (Northwest Atlantic & Gulf of Mexico, Central & Southwest Atlantic, Eastern Atlantic, Indo-West Pacific, Central Pacific, and Eastern Pacific). Within South Carolina waters, adult and juvenile scalloped hammerheads are found primarily in coastal waters with estuaries, particularly Bulls Bay, serving as primary nursery areas for young of the year scalloped hammerheads. Juveniles and adults are found in nearshore and offshore waters year-round.

Recent research has shown Carolina hammerhead distribution is limited compared to the globally distributed scalloped hammerhead with Carolina hammerheads being limited to the western Atlantic Ocean (Barker et al. 2021). The center of abundance of young of year and early juveniles occurs in Bulls Bay, SC with decreasing abundance to the north and south. The species has been detected in waters off Brazil as well as in Trinidad and Tobago; however, it appears to be completely absent from the Gulf of Mexico (Pinhal et al. 2012). While estimates are preliminary, recent genomic work suggests the number of breeding Carolina hammerheads contributing to US East Coast nurseries is half that of scalloped hammerheads. Additional sampling is needed to fully assess the species range with samples needed from the Caribbean and eastern Atlantic to confirm presence/absence. Ongoing research is examining relative contributions of nursery areas to the adult population.

Great hammerheads are a circumtropical globally distributed species, in US waters they range from NC south through the Gulf of Mexico, primarily inhabiting coastal and nearshore waters, although they are known to make forays into deeper waters. Nurseries areas remain enigmatic, several neonates were captured alongside Carolina and scalloped hammerheads in Bulls Bay, and in scalloped hammerhead nurseries off the Big Bend of Florida (Barker et al. 2017); however, these are only a handful of encounters. More recently, a nursery area has been proposed for Biscayne Bay, FL; however, the great hammerheads captured there may be early juveniles (Macdonald et al. 2021).

The smooth hammerhead is distributed globally in temperate waters and is rarely encountered in tropical waters. In the western north Atlantic it is most commonly found from the Bay of Fundy to North Carolina and is infrequently countered off of South Carolina to Florida. Those animals that are encountered off South Carolina are typically mature and are found in nearshore waters. Juveniles and young of year smooth hammerheads are generally found in cooler waters off the mid-Atlantic bight.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

In SC bonnetheads are commonly found on sandy and muddy bottoms in shallow estuarine and coastal waters, often aggregating in areas associated with oyster reefs or along sandy beach fronts. These areas are important foraging areas since the primary component of bonnetheads diet is blue crabs, comprising >95% of their diet. Females are more commonly found in estuarine habitats while males are more common nearshore (Ulrich et al. 2007)

Adult and juvenile scalloped hammerheads prefer nearshore coastal and oceanic waters, with adult hammerheads often associated with the gulf stream edge; however, they may make limited movements into the mouths of sounds and estuaries. Young of the year scalloped hammerhead and Carolina hammerheads are found in high salinity estuaries in areas with depths ranging from 1 to 10 m (3-33 ft.). They are often found over muddy bottoms in areas with high concentrations of prey items. Work by Galloway et al. (2024) suggests scalloped and Carolina hammerheads have a generalist diet with no resource partitioning between species. That said, stable isotope analysis (SIA) of neonate tissue suggests that there is either spatial or resources partitioning between mature female Carolina and scalloped hammerheads. These results have also been confirmed using trace elements, and SIA of eye lens and suggest that while nursery areas are shared, habitats in older life stages may not be shared.

Great hammerheads are mostly commonly captured in sounds and nearshore waters off South Carolina, their preferred prey is tarpon, blacktip sharks, and stingrays, and they are commonly found in areas where these prey species are dense. The majority of great hammerheads encountered in SC are mature, however small juveniles have been captured in high salinity sounds in Port Royal Sound and St Helena Sound, often associated with waters off of sandbars.

Smooth hammerhead habitat requirements in SC are poorly understood, catches have been historically low, but when encountered they were often in association with nearshore live bottom habitats.

CHALLENGES

The bonnethead is regularly captured as by-catch in commercial shrimp trawls, likely leading to a large source of mortality. Additionally, bonnethead are increasingly being targeted by recreational anglers and fishing guides as a sport fish. While the majority of these interactions are catch and release, some are harvested for consumption. The effects of increases in fishing pressure are unknown as limited data exist for catch and release mortality of bonnetheads. The capture of bonnetheads in August and September could have negative consequences for pregnant females with near full-term pups, as the stress of capture could lead to premature birth. Declines in abundance of their primary prey, blue crabs, have been observed. As this species represents >95% of bonnethead's diet, further declines in this important forage species could be detrimental to bonnetheads.

The scalloped hammerhead is facing severe population declines worldwide and is considered at risk for extinction in multiple distinct population segments. Multiple fishery independent surveys have reported large declines in abundance of scalloped hammerheads within the western North Atlantic and Gulf of Mexico segment, that said, populations appear to be recovering (Hayes et al. 2009; SEDAR 77). Complicating matters is that an unknown portion of these declines are Carolina hammerheads. Further, Carolina hammerheads may be experiencing declines in abundance through hybridization. Research by Barker et al. (2019) found unidirectional hybridization (scalloped hammerhead males mating with Carolina hammerhead females) which could eventually lead to reductions in the number of pure Carolina hammerheads; that said, to date there is no evidence of that occurring. Hammerheads experience significant mortality in commercial fisheries, primarily bottom and pelagic longlines (Branstetter 1987). Recently, the National Marine Fisheries Service reduced commercial quotas as well as increased recreational size limits; however, hammerheads may continue to have high mortality within these fisheries as they have high at-vessel and post-release mortality. Given the unknown distribution of Carolina hammerheads, it is possible that one species may be experiencing proportionally higher mortality due to fisheries interactions. There are no estimates of natural or catch and release mortality of young of the year scalloped hammerheads in the estuaries. Their natural mortality is thought to be relatively high, given the large brood sizes of female hammerheads.

CONSERVATION ACCOMPLISHMENTS

Recent funded C-SWG, and SWG research has led to increased knowledge on the distribution and trophic ecology of Carolina and scalloped hammerheads (Barker et al. 2017, Barker et al. 2019, Barker et al. 2021, Galloway et al. 2024) with additional

manuscripts in prep, but significant work remains.

CONSERVATION RECOMMENDATIONS

- Continue to monitor stock status of hammerhead sharks within SC waters through fishery-independent methods, primarily COASTSPAN, the Adult Red Drum and Coastal Sharks longline survey, and Trammel Survey.
- Monitor the community composition of scalloped and Carolina hammerheads utilizing SC estuaries as a primary nursery to track population stability.
- Investigate genetic variation of bonnethead sharks to determine if observed site fidelity has led to fine-scale genetic structure.
- Determine fine-scale movements of bonnetheads within South Carolina estuaries to investigate environmental drivers of movement within individual estuaries.
- Determine vertical and horizontal habitat use of Carolina and scalloped hammerheads across their range in the western North Atlantic.
- Collect and genotype tissue from hammerheads in the eastern Atlantic, Caribbean, and southwestern Atlantic to determine the geographic range of the Carolina hammerhead as well as to attempt to determine ancestral origins of scalloped and Carolina hammerheads.
- Conduct Close-Kin Mark Recapture studies to estimate population sizes of hammerheads.
- Generate species-specific life history data for Carolina and scalloped hammerheads.
- Determine vertical and horizontal movement patterns of smooth and great hammerheads.
- Investigate ecological processes that could have led to speciation in the scalloped and Carolina hammerheads.
- Improve the public's understanding of the importance of sharks in the ecosystem through outreach activities such as school programs, providing story opportunities for media, and educational brochures.
- The primary action at the State level is to ensure that overfishing is eliminated.
- Partner with law enforcement to ensure adequate compliance with regulatory actions implemented through the Federal management plan and subsequent amendments.

MEASURE OF SUCCESS

One of the most important measures moving forward will be determining the stock status of the population of bonnetheads residing in the US Atlantic. Within SC waters, tagging studies have documented that bonnetheads have a high degree of site fidelity. It will be important to document fine-scale movement within these systems as well as examine genetics to determine if populations are at risk for localized exploitation and loss of genetic variation. Success criteria would be an increase in our knowledge of utilization of habitat within South Carolina estuaries as well as knowledge of the genetic structure of this species.

Regional management efforts to maintain healthy, sustainable populations of hammerheads will require active participation from South Carolina due to its importance as primary and secondary nursery habitat for hammerheads. Expanding our knowledge of the importance of SC waters for hammerhead sharks is of the utmost importance. Currently, the primary nursery area for Carolina hammerhead sharks resides in SC (Bulls Bay). Moving forward, it will be important to document the relative importance of SC waters for the scalloped and Carolina hammerheads as well as the ecological processes that define these two species. A measure of success would be to increase our understanding of the relationship between these two species in juvenile and adult age classes, as most of what we know comes from young of year sharks. An integral component of measuring success will be the continued monitoring of SC sharks through fishery-independent surveys. The ultimate measure of success will be a stock status determination of not overfished with no overfishing occurring for all hammerhead sharks. Until then, particular attention should be paid to hammerhead sharks within SC waters.

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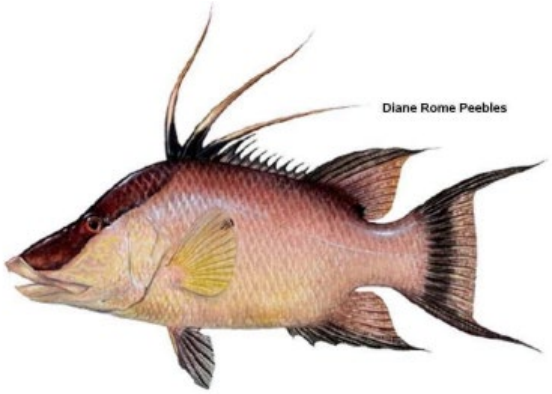
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Hogfish

Lachnolaimus maximus



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DESCRIPTION

Taxonomy and Basic Description

The hogfish commonly known as the "hog-snapper" is a member of the Labridae (Wrasse) family and order Labriformes (Page et al. 2023) with a maximum total length of ~82 cm (McBride and Murphy 2003), maximum observed age of 23 years (McBride and Richardson 2007), and world record total weight of ~9.95 kg (IGFA 2024). Hogfish possess a deep, compressed body and a long, pig-like snout. The first three spines of the dorsal fin are elongated, and a black spot is present at the base of the dorsal fin (Colin 1982). Hogfish coloration is variable depending on size, sex, and habitat, ranging from a mottled rusty brown, solid reddish orange, or whitish to pale pink (McBride and Johnson 2007). Mature male hogfish have a distinctive dark reddish-brown band from the tip of their snout to the top of their head (Colin 1982; McBride and Johnson 2007). The hogfish is a protogynous hermaphrodite starting life as a female (Colin 1982; McBride and Murphy 2003; McBride and Johnson 2007; Collins and McBride 2011; Seyoum et al. 2014; Towne et al. 2021), generally reaching maturity by age 3 (McBride and Johnson 2007; Towne et al. 2021) and transitioning to a male at age 3-5 (300-400 mm FL) after one or more spawning seasons (McBride and Johnson 2007).

Status

Two genetically distinct stocks exist along the southeastern United States Atlantic coast: the Florida Keys/East Florida stock and the Georgia to North Carolina stock (Seyoum et al. 2014, Cooper et al. 2014). A third stock exists in the eastern Gulf of Mexico (Seyoum et al. 2014). Results of the SEDAR 37 assessment (Cooper et al. 2014) suggest the Florida Keys/Eastern Florida stock is currently overfished and experiencing overfishing and the Georgia to North Carolina stock has been experiencing overfishing in recent years. The eastern Gulf of Mexico stock in not overfished or experiencing overfishing (Cooper et al. 2014). The hogfish is listed as Vulnerable by the IUCN (Choat et al. 2010).

POPULATION SIZE AND DISTRIBUTION

Hogfish are found in tropical, subtropical, and warm temperate waters along the United States Atlantic coast to the northern coast of South America and throughout the Gulf of

Mexico and Caribbean (McBride and Murphy 2003; Choat et al. 2010; Collins and McBride 2011; Cooper et al. 2014; Seyoum et al 2014; Towne et al. 2021).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Hogfish are associated with hard bottom and reef habitats (McBride and Murphy 2003; Choat et al. 2010; Collins and McBride 2011; Cooper et al. 2014; Seyoum et al 2014; Towne et al. 2021) from 3 to 40 m depth (Choat et al. 2010) and observed as deep as 69 m (Collins and McBride 2011). Juveniles inhabit nearshore environments including estuaries, seagrass beds, and shallow reef habitats (Colin 1982; McBride and Johnson 2007; Choat et al. 2010; Cooper et al. 2014). The hogfish diet is primarily benthic invertebrates (McBride and Murphy 2003; Cooper et al. 2014). One male has a harem of as many as 15 females (Colin 1982; McBride and Murphy 2003; McBride and Johnson 2007). Hogfish spawning occurs primarily during winter and spring (Davis 1976; Colin 1982; McBride and Johnson 2007; Cooper et al. 2014).

CHALLENGES

Hogfish are susceptible to size-selective fishing pressure (McBride and Richardson 2007; McBride et al. 2008; Towne et al. 2021). Demographic differences (e.g., size, age, fecundity, size and age at sex change) have been noted in hogfish between stocks with larger, older fish in the eastern Gulf of Mexico stock compared to the Florida Keys/East Florida stock (McBride and Murphy 2003; Collins and McBride 2011; Cooper et al. 2014; Seyoum et al. 2014), as well as, when comparing nearshore vs offshore habitats within the same region (Collins and McBride 2011, Seyoum et al. 2014; Collins and McBride 2015). There is a disproportionate higher removal of hogfish in areas with high human populations and/or relative accessibility (McBride and Richardson 2003) with larger and older hogfish in areas with less fishing pressure or in less accessible habitats (Seyoum et al. 2014; Collins and McBride 2015). Removal of males is particularly problematic because it could interrupt harems and reduce reproductive output (McBride and Murphy 2003; McBride and Johnson 2007; Towne et al 2021). Information on the Georgia to North Carolina hogfish stock is limited due to the species tendency to avoid trapping and hooked gears, which are the primary gears used for fishery-independent data collections. Data available from this stock are from fishery-dependent sources that catch larger, older males (Cooper et al. 2014).

CONSERVATION ACCOMPLISHMENTS

The South Atlantic Fishery Management Council (SAFMC) manages the hogfish fishery in federal waters off South Carolina. Commercial fishery regulations include a minimum fork length of 17 inches and a trip limit of 500 lbs whole weight. Recreational fishery regulations include a minimum fork length of 17 in and a 2 fish bag limit. There is no spawning season closure for the Georgia to North Carolina stock. Recreational fishing

vessels are required to have a descending device on board when fishing for species in the snapper-grouper complex, which includes hogfish.

CONSERVATION RECOMMENDATIONS

- Conduct life history studies across a range of sizes, ages, and stocks to test for differences between hogfish stocks.
- Investigate the contribution of males to spawning reproductive potential.
- Continue to monitor hogfish via fishery-dependent and fishery-independent surveys. Make improvements to existing fishery-independent surveys or develop new surveys to estimate hogfish abundance.
- Obtain length frequency and age samples via a consistent approach that are representative of each fishery and stock.
- Investigate spatial effects (nearshore vs offshore) on hogfish populations (Collins and McBride 2015).

MEASURE OF SUCCESS

The South Carolina Department of Natural Resources Southeast Reef Fish Survey (SERFS) collects data on the relative abundance, population demographics, and reproductive state of reef fish species collected in waters of the continental shelf and shelf edge between Cape Hatteras, North Carolina and St. Lucie, Florida. The SERFS detects hogfish primarily in video camera footage, providing an index of abundance. However, very few physical specimens are brought aboard research vessels, so population demographics and reproductive state are not currently assessed for the species. A measure of success would be for the video index of abundance to remain stable or increase in the region.

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King Mackerel

Scomberomorus cavalla


Source: SAFMC

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Revised 2025:
Elizabeth Bullard and Tracey Smart [SCDNR]

DESCRIPTION

Taxonomy and Basic Description

King mackerel, *Scomberomorus cavalla* (Cuvier 1829), are members of the Scombridae family, which includes a variety of mackerel, tuna, wahoo, and bonito, and the order Scombriformes (Page et al. 2023). The King mackerel is one of the three species in the Scomberomorini tribe (in addition to Atlantic Spanish mackerel and wahoo) that is frequently encountered off the coast of South Carolina (SC; Collette and Nauen 1983).

King mackerel have muscular, laterally compressed, fusiform bodies. Their body is tapered posteriorly, ending in a thin caudal peduncle, and they bare a powerful lunate tail. Two dorsal fins are followed by 7 to 10 small finlets, and the ventral side shows 7 to 10 small finlets also following the anal fin (Collette 2002). The body color is typically a dark blue to black dorsally with iridescent spots of a blue/green and a silver ventral side. Juveniles have yellow spots which fade as the fish ages, disappearing completely by maturity. These spots can cause juveniles to be mistaken for Spanish mackerel. However, the lateral line of king mackerel drops sharply towards the abdomen under the second dorsal fin jaw (Collette 2002), which allows for easy identification from Spanish mackerel who have a more gradual drop in the lateral line. King mackerel reach sexual maturity at 3-4 years, are gonochoristic (separate sexes), and can live more than 20 years. Maximum sizes can reach 6 ft and near 100 pounds (Finucane et al. 1986).

Status

The International Union for the Conservation of Nature (IUCN) lists king mackerel as a species of Least Concern. King mackerel had their last full assessment through the SouthEast Data, Assessment and Review (SEDAR) process in 2014, and SEDAR 38 was then updated in 2019. At that time, king mackerels were found to be not overfished nor undergoing overfishing.

POPULATION SIZE AND DISTRIBUTION

In the northwest Atlantic, king mackerel range along the US Atlantic coast, throughout the Gulf of Mexico and the Caribbean, and extend south into the coastal waters of Brazil (Godcharles and Murphy 1983). Large aggregations can be found off the coast of North

and South Carolina beginning in the late spring and continuing through the fall (Collette and Nauen 1983) as they typically occupy areas north of Florida during the warmer months of the year. Two separate migratory stocks are recognized between the Atlantic and Gulf of Mexico (GOM, Figure 1; SEDAR 2020). Although these migratory groups are managed separately, there is evidence of a winter mixing zone off Florida of these two stocks (Banks 2024).

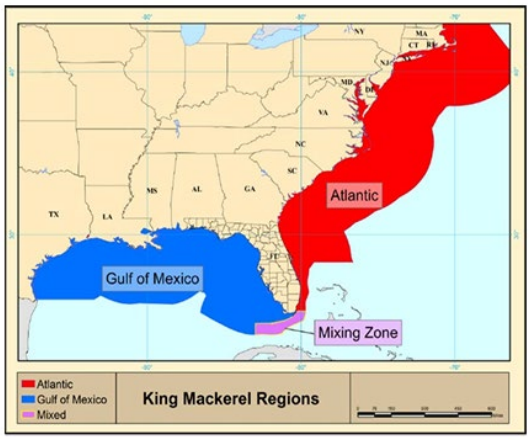


Figure 1: Map of king mackerel distribution through the stock boundaries, separating the Gulf of Mexico and Atlantic stocks while denoting a mixing zone between the two regions.

An estimate of absolute king mackerel population size in South Carolina waters is not currently available, but data reported from recreational and commercial fishing efforts on the Atlantic migratory group show a decrease in the number of pounds of king mackerel landed over the last decade commercially and recreationally (Figures 2 and 3; SAFMC 2018), continuing a decline that began in 1990 (NMFS 2014). The Coastal Trawl Survey (CTS) for the South Carolina Department of Natural Resources (SCDNR), a fishery-independent survey, encounters juvenile mackerel. The survey exhibits a high degree of interannual variability in abundance with a drop in catch per unit effort over the last 8 years (Figure 4).

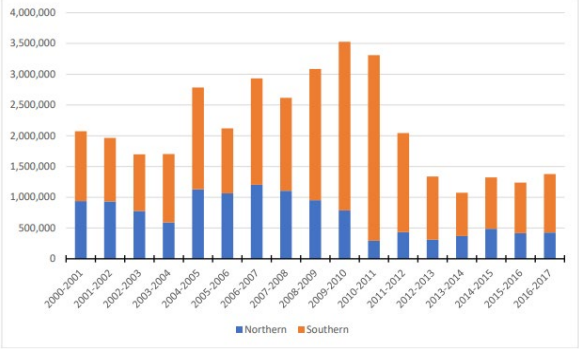


Figure 2: Commercial landings (pounds) of king mackerel from 2000-2017 separated by the northern and southern zone of the Atlantic migratory group (SAFMC 2018).

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HABITAT AND NATURAL COMMUNITY REQUIREMENTS

King mackerel are epipelagic carnivores that inhabit offshore waters out to the continental shelf, but have been noted occurring closer to shore near inlets as well (Berrien and Finan 1977). They most often occupy waters with temperatures of 79-88°F. They prey on schooling finfish such as menhaden and anchovies, as well as invertebrates (Godcharles and Murphy 1986).

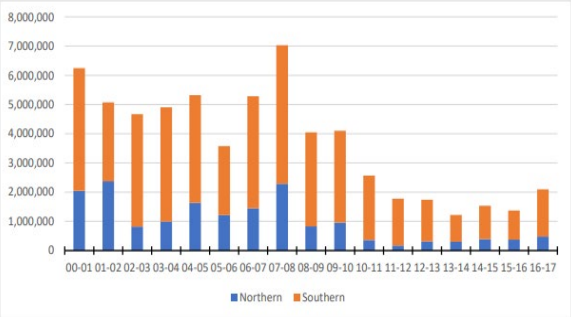


Figure 3: Recreational landings (pounds) of king mackerel from 2000-2017 separated by the northern and southern zone of the Atlantic migratory group (SAFMC 2018).

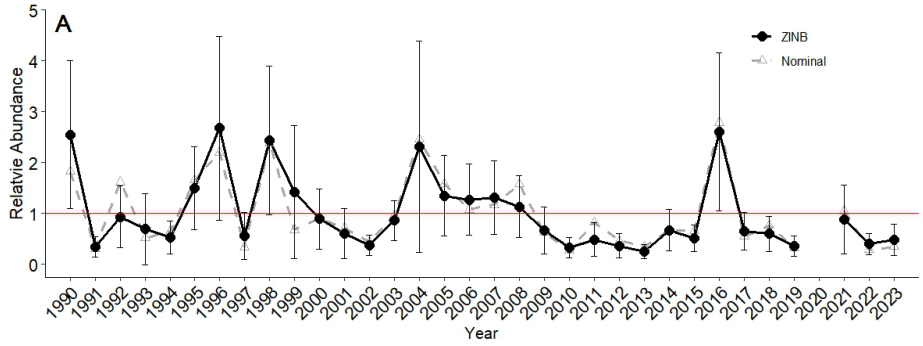


Figure 4: Nominal and ZINB standardized relative abundance of king mackerel normalized to the time series mean of the SEAMAP-SA Coastal Trawl Survey. Errors bars are representative of standard error.

Spawning occurs in coastal waters of the Southeast Atlantic and Gulf, with larvae being pelagic and found in the outer shelf region at depths of 41-200 meters (Finucane, et al. 1986). A concentration of larvae has been observed in the 32-33 degree latitudes in the vicinity of the Charleston Bump, suggesting the upwelling created by this geologic feature provides an important spawning and nursery habit for these fish (Collins and Stender 1987).

CHALLENGES

King mackerel remains a popular commercial and recreational fish and subsequently are certain to experience continued fishing pressure from both sources. SAMFC does not currently consider the Atlantic population to be overfished. However, the council also acknowledged the absence of fishery-independent monitoring data for adults of this species as a substantial challenge not only to determine appropriate management practices, but also to establish meaningful future population benchmarks for stock assessment (SEDAR 2009). Lucena-Frédou et al. (2021) expanded upon these gaps in information and knowledge for the species, discussing that more quantitative data is needed to evaluate populations successfully. It is thought that in recent years the number of recreational landings reported are severely underestimated in the Atlantic (Pons et al. 2019) and applying more quantitative data (such as length-based methods)

as a proxy for king mackerel stock status (ICCAT Manual 2021) could help to increase confidence in stock numbers.

With a separation of migratory groups, it is also vital to denote that the priorities of one group may not match that of another. Historically, the GOM population had been exploited at a higher rate than the Atlantic population with catch routinely exceeding limits (Banks 2024). Further evaluation of how these stocks function separately, and how certain environmental conditions may influence them individually and within the mixing zone, must be considered. Climatic conditions can result in these stocks increasing their overlap within the mixing zone or change the seasonality of mixing and therefore result in greater competition for resources and consequently enhanced competitive pressure on both stocks.

CONSERVATION ACCOMPLISHMENTS

The Fishery Management Plan for Coastal Migratory Pelagic Resources has developed substantially throughout its history and has been amended many times since its introduction in 1982 (FMP 1983). The introduction of permits for fishing, quota limits, size restrictions, landing limits, and mandatory reporting of commercial catches have all contributed to the beneficial management of king mackerel. Allowable Catch Limits (ACLs) have been set for both commercial and recreational sectors, and seasonal restrictions reduces potential impacts on mating and spawning fish. Geographic management boundaries have also been expanding to include as many members of the stock in management efforts as possible. Conservation efforts have also focused on the identification and protection of essential fish habitat throughout the coast with the goal of enhancing recruitment of juvenile fish into the stock.

CONSERVATION RECOMMENDATIONS

- Continue monitoring of commercial and recreational catches of king mackerel coupled with appropriately set ACLs that are maintained through enforceable regulation.
- Evaluate and update the effects of fishing and management plans on king mackerel stocks collectively and separately to determine where focus should be prioritized.
- Expand research and life history data collection from fishery-independent sources, particularly for adult fish which are rarely caught in current fishery-independent monitoring efforts and continue recruitment monitoring, which can be variable from year to year.
- Enhance research efforts focused on king mackerel diet.
- Further investigation of migratory patterns through tagging and otolith micro-chemistry to better define Atlantic and Gulf stock boundaries as well as the area of seasonal overlap.

MEASURE OF SUCCESS

The SEAMAP-SA Coastal Trawl Survey program monitors the relative abundance, population demographics, and reproductive characteristics of the Atlantic population of king mackerel, though they primarily encounter juveniles. Studying these metrics can help to detect when changes in these parameters occur relative to fishing pressures or current management efforts and can serve as early indicators of issues with the Atlantic stock. Utilizing sufficient fishery-independent data can help to generate stock estimates with more confidence. Increases in recruitment and abundance, expansion of size and age structures, and increases in spawning stock biomass (SSB) would indicate positive trends in the population. Ideally, stock structure would improve to a point where calculations of maximum sustainable yield (*MSY*) result in total allowable catch (*TAC*) levels that can accommodate demand for commercial and recreational harvest.

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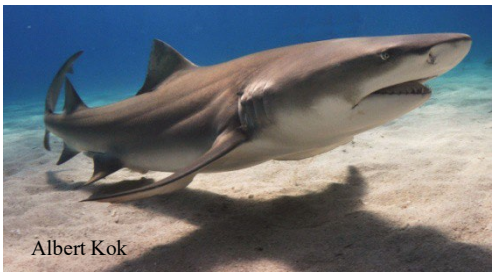
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Lemon Shark

Negaprion brevirostris



Contributor (2025):
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DESCRIPTION

Taxonomy and Basic Description

The lemon shark, *Negaprion brevirostris* is a member of the family Carcharhinidae and resides in the genus *Negaprion* (2 species). The lemon shark is a placentally viviparous shark (bears live young with a maternal connection). They are relatively large sharks reaching a reported maximum length of 284 cm TL (Castro 2011). The lemon shark is recognized by its pale yellow to olive gray coloring, blunt snout, equal sized first and second dorsal fins, and no inter-dorsal ridge. Life history information is lacking for lemon sharks, but they are generally thought to be slow growing and long lived. Male and female lemon sharks are thought to reach maturity around 12 to 13 years old at a length of 225 to 235 cm (89-93 in.) TL (Brown and Gruber 1988). Once mature, lemon sharks give birth to litters of 4-17 pups every 2 years (Gruber and Stout 1983; Feldheim et al. 2002). Maximum age is estimated as 20+ years old, however genetic data suggest a maximum age of 37 years (Brooks et al. 2016).

Status

Lemon sharks are classified as large coastal sharks (LCS) and are managed as a complex by the National Marine Fisheries Service (NMFS). Status determination for LCS is hampered by a lack of species specific data. The population of lemon sharks in the southeastern US were assessed independently (apart from the SEDAR process) by Hansell et al. (2021). Results of that assessment suggested there had been prior population depletion, but that the stock had been relatively stable since the mid-1990's. In early years, there had been overfishing occurring, but the conclusion was that in the most recent years the stock was not undergoing overfishing and was not overfished. The International Union for Conservation of Nature (IUCN) lists lemon sharks as "Near Threatened" listing evidence of decreasing populations. Lemon sharks are rarely captured in traditional longline gear, however they are seen in SCDNR trammel nets (primarily young of year), and on drumlines (large juveniles and mature lemon sharks), these catches suggest there are gear biases with traditional shark sampling gear (gillnets and longlines). Catch per unit effort data from the South Carolina Department of Natural Resources Coastal Longline survey suggest stable abundance of lemon sharks in estuarine waters (Figure 1); that said, catches of lemon sharks are low in this survey.

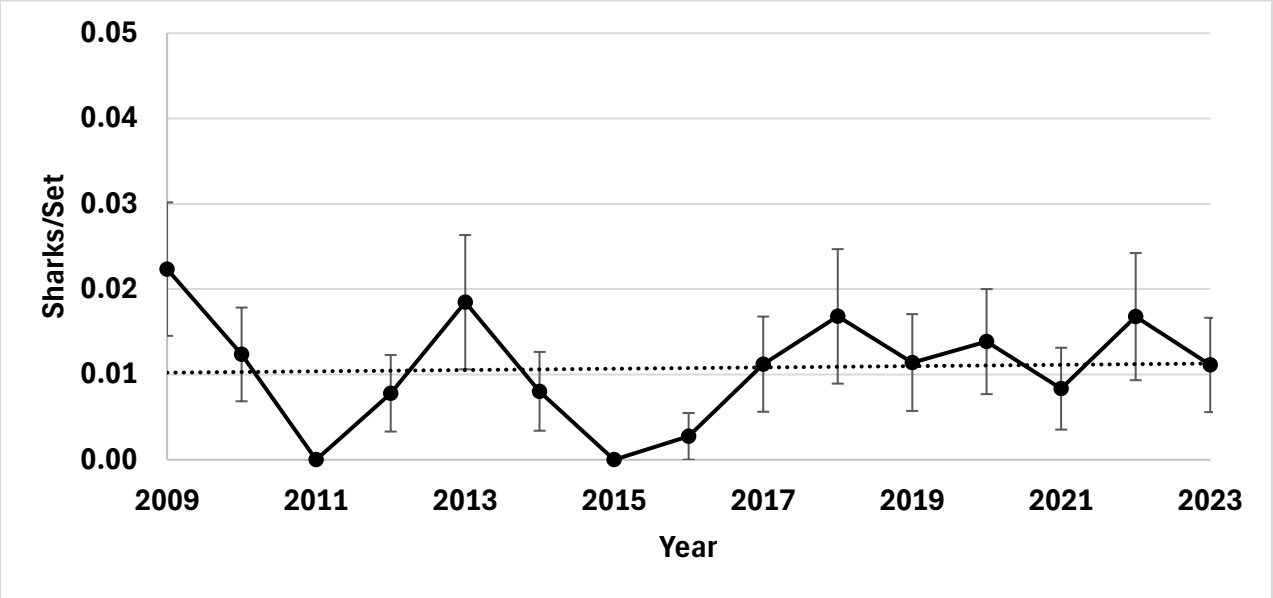


Figure 1. Catch per unit effort (sharks per set) of blacktip sharks from 2009 to 2023 in the South Carolina Coastal Longline Survey. Standard error is denoted by error bars.

POPULATION SIZE AND DISTRIBUTION

Lemon sharks are primarily found in the western Atlantic Ocean, although populations also exist in the eastern Pacific Ocean and the west coast of Africa. It is a coastal species, primarily occurring in shallow water. In US Atlantic waters, they are found from New Jersey south through the Gulf of Mexico with overwintering occurring in south Florida and the Bahamas. South Carolina waters may serve as nursery habitat for lemon sharks; however, young of year are found in lower abundance in South Carolina compared to nurseries in Florida, Georgia, and the Bahamas. All life stages of lemon sharks have been documented and they generally occur in salinities from 20-34 ppt (Ulrich et al. 2007).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Little is known about habitat requirements for lemon sharks as there is significant gear bias that prevents their capture in the numbers that are likely present. That said, young of year and juvenile lemon sharks are often see in shallow water over oyster reefs as well as along sandy front beaches. Large juvenile and adult lemon sharks are found in deeper estuarine waters, as well as at the mouths of sounds and bays. They are infrequently captured in nearshore waters, preferring to stick close to shore. Limited diet data suggest young of year and early juveniles prefer bony fish, while large juveniles and adults switch to a diet of bony fish and elasmobranchs including smaller sharks and stingrays.

CHALLENGES

The primary threat facing lemon sharks is development in critical habitat areas. In core nursery areas, lemon sharks are reliant on mangrove habitat for foraging and shelter from larger predators, In many parts of their range, these habitats are threatened by coastal development. While populations of lemon sharks appear stable threats to these nursery areas could impact these species. Lemon sharks display high site fidelity including natal philopatry, meaning it is pertinent to protect these nursery areas as future generations will return to use them. Management of lemon sharks is also hampered by a lack of life history data, despite being one of the most studied species of sharks in the world, there is a lack of data on reproduction and age and growth of the species, this lack of information undoubtedly hampers management.

CONSERVATION ACCOMPLISHMENTS

There are no conservation accomplishments specific to this species at this time.

CONSERVATION RECOMMENDATIONS

- Continue to monitor the stock status of lemon sharks within SC waters through fishery-independent methods, primarily trammel netting, drumlines and the Coastal Longline Survey.
- Investigate gear biases that may hamper monitoring of lemon shark populations.
- Partner with external collaborators to increase understanding of the life history of species lacking data.
- Use genomic methods to better understand site fidelity of lemon sharks to SC habitats as well as better understand the importance of SC as a nursery for lemon sharks.
- Use genomic methods such as Close Kin Mark Recapture to estimate population size.
- Investigate the use of non-lethal methods to age lemon sharks.
- Improve the public's understanding of the importance of sharks in the ecosystem through outreach activities such as school programs, providing story opportunities for media, and educational brochures.
- Continue to educate the public on the importance of species identification of sharks to ensure undersized and prohibited sharks are not landed.
- The primary action at the state level via law enforcement partnering is to insure adequate compliance with regulatory actions implemented through the federal management plan and subsequent amendments.

MEASURE OF SUCCESS

Regional management efforts to maintain healthy, sustainable populations of lemon sharks will require active participation from South Carolina due to its importance as habitat for all life stages. Expanding our knowledge on the life history and importance of SC waters for lemon sharks is important given potential impacts to nursery areas (especially in the Bahamas). Current population trends appear to be stable, but it is critical to maintain ongoing monitoring programs to generate indices of abundance to allow accurate regional stock assessments.

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Marine Catfishes Guild

Hardhead Catfish *Ariopsis felis*
Gafftopsail Catfish *Bagre marinus*

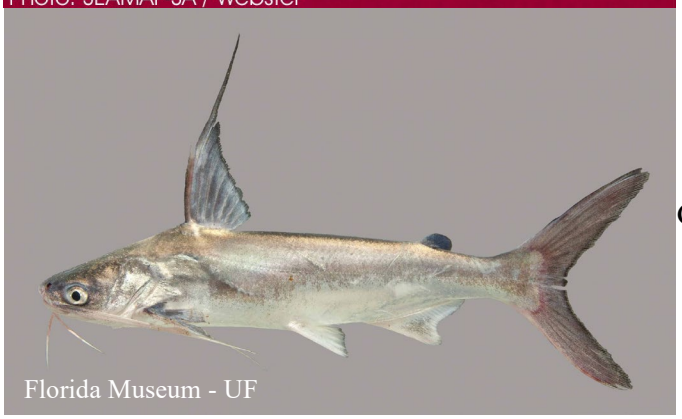
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Hardhead



Gafftopsail

DESCRIPTION

Taxonomy and Basic Description

The marine catfishes, *Ariopsis felis* and *Bagre marinus*, belong to the family Ariidae. They lack scales but possess a forked caudal fin (tail), have an adipose fin anterior of the caudal peduncle, and have large, serrated spines on the three forward-most fins (two pectoral and the first dorsal). The spines can induce a painful injury and are covered in a slime that is mildly venomous (Halstead et al. 1990).

The common name for hardhead catfish is derived from the presence of a hard, bony plate extending rearward toward the dorsal fin from a line between the catfish's eyes.

The head is moderately flattened with the upper jaw forming a broad arc. One thread-like barbel is located on either side of the mouth just above the rear corners, and two pairs of white barbels are located on the chin. The rear dorsal (adipose) fin is fleshy and black, unlike the other fins which are membranous and translucent. The back of the fish is generally silvery with blue, green, or brownish tones, while the belly is generally white. The hardhead catfish has been reported at sizes up to 70 cm (27 inches; Acero 2002) and reaching 24 years of age in the Gulf of Mexico (Flinn et al. 2019), but it is more commonly found at sizes up to 36 cm (14 in.) in South Carolina's coastal waters (P. Webster, pers. obs.).

The gafftopsail catfish, *Bagre marinus*, is readily distinguished from the hardhead by long, thread-like extensions from its dorsal and pectoral fins and more strap-like, rather than rounded, barbels extending from the upper jaw. It has 22-28 anal fin rays and 11-14 pectoral fin rays, compared with 18-20 and 6-10, respectively, in the hardhead catfish. Gafftopsail catfish generally may reach greater lengths than hardhead catfish across both sexes (Flinn et al. 2019).

Status

On occasion, mass mortalities of marine catfish have been observed along the Gulf Coast. There have been no known directed fisheries for marine catfish in South Carolina, but both species have undergone a dramatic decline in numbers since the mid-1990s, and state regulations stipulate that any caught fish must be released alive immediately.

POPULATION SIZE AND DISTRIBUTION

South Carolina is well within the northern limits for the hardhead catfish and the gafftopsail catfish. *A. felis* has a coastal range from North Carolina to Florida and throughout the Gulf of Mexico to the Yucatán Peninsula (Acero, 2002); other sources indicate that the species may range as far north as Cape Cod at times (Jones et al. 1978). *B. marinus* ranges from Cape Cod, Massachusetts south through coastal Florida and the Gulf of Mexico to Panama (Muncy and Wingo 1983). Portnoy et al. 2024 suggests four genetically differentiated groups of the gafftopsail catfish, where three of these groups reside in the Gulf of Mexico and the remaining group represents the Atlantic population.

Hardhead catfish have been prominent in a number of mass mortality incidents in the Gulf of Mexico and appear to be in decline along the Southeastern Atlantic Coast (Wardle et al. 1998; SEAMAP unpub. data). As suggested by trawl surveys, abundance of the hardhead catfish in South Carolina experienced two drastic drops during the 1990s. Additional sampling along the Atlantic Coast of the Southeastern United States indicates that abundance remains depressed from North Carolina to Florida (SEAMAP unpub. data). However, since the decline occurred, sampling of coastal waters from Cape Hatteras, North Carolina, to Cape Canaveral, Florida, indicates that the decline in

abundance is most pronounced in the northern portion of this range. Gafftopsail catfish are generally less abundant than hardhead catfish, but they too have experienced a sharp and persistent decline in abundance (SEAMAP unpublished data). Contrary to the South Carolina population, the Gulf of Mexico population of gafftopsail catfish may be increasing in some areas (Cates et al. 2024).

Despite reduced abundance over the shallow coastal shelf, marine catfish may be encountered by anglers in estuaries, through the surf zone, and into near-coastal waters of the shelf. A true estimate of population size, considering abundance through all of these habitats, has not been calculated.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Marine catfishes are generalists, tolerating a wide range of salinities from open ocean to fresh water; however, their occurrence in fresh waters is less common. They are generally found over muddy bottoms, or at least in murky waters (Acero 2002).

Marine catfishes are mouth-brooders. Once spawning has occurred, the male will carry the eggs in his mouth until they hatch into larvae in about a month. He may then carry the young for a few more weeks until they are larger and stronger (Jones et al. 1978). Marine catfishes produce relatively large eggs and exhibit low fecundity (Merriman 1940; Ward 1957; Jones et al. 1978).

CHALLENGES

Mass mortalities of marine catfish have generally been ascribed to one of three causes: disease (R. Overstreet, USM, pers. comm., June 7, 2005), harmful algal blooms, and/or extremely low levels of dissolved oxygen (hypoxia; Wardle et al. 1998). It is unclear which, if any, of these agents is the cause of the recent declines of hardhead and gafftopsail catfish observed in South Carolina. A simple decline in abundance, as generally seen for these species in the Atlantic, does not tend to garner the immediate attention elicited by the mass mortalities witnessed along the Gulf Coast and in Indian River Lagoon, Florida.

Chemical contamination in the catfishes' environment provides two very different possible threats. Non-point source pollution may contribute to the occurrence of algal blooms, which, depending on the algal variety, may simply cause hypoxic events (Wardle et al. 1998) or may result in the release of deadly toxins (Steidinger et al. 1998). The second threat comes from contaminants accumulated in the muddy sediments with which this fish is associated. Metals, polycyclic aromatic hydrocarbons (PAHs), and pesticides all accumulate in muddy sediments (Sanger et al. 1999a,b) and have been shown to have detrimental effects on benthic creatures exposed to them.

While limited studies have been conducted on the effects of certain compounds on hardhead catfish (Steele 1983a,b), the effects of other pollutants and combination effects are not known. Catfish both live and feed primarily along the bottom, which increases their exposure to contaminants. This challenge is not unique to catfish. Bioaccumulation is a threat to the entire food chain, including humans.

CONSERVATION ACCOMPLISHMENTS

South Carolina state law prohibits the taking of marine catfish in an effort to preserve their declining populations.

CONSERVATION RECOMMENDATIONS

- Examine long-term trends in marine catfish population size and distribution and relate, where possible, to environmental variation.
- Identify causative factors in future marine catfish mortality events.
- Determine if latent pathogens exist in the marine catfish populations. Monitor the population to determine pathogen temporal prevalence and determine whether mortality events are triggered by pathogens themselves or by some other stressor.
- Investigate whether wild saltwater catfish are plagued by similar diseases to their captive freshwater relatives such as: visceral toxicosis, proliferative gill disease and enteric septicemia. If so, determine if effluent from aquaculture operations is a significant threat to the marine catfish.
- Develop the capacity to properly investigate possible harmful algal blooms and monitor for such blooms.
- Determine effects of pollutants on marine catfish reproduction, growth, and longevity.
- Determine marine catfish spawning seasons, spawning locations, and recruitment mechanism for the Atlantic Coast.
- Determine marine catfish predator/prey relationships and examine contaminant loads across these relationships.
- Monitor the effectiveness of existing Best Management Practices (BMPs) such as setbacks, retention ponds, and vegetated buffers for preventing nutrient and contaminant runoff into coastal waters.
- Apply and enforce BMPs, such as those utilized by proactive communities.
- Educate the public about the importance of the marine catfish in terms of ecological value. While these species are not commonly utilized as a food fish and it is generally maligned due to its pain-inducing spines, it does have a role to play in coastal ecosystems.

MEASURE OF SUCCESS

If stressors depressing abundance of marine catfish are identified, it may be possible to halt and reverse the downward trend. One indication of this would be a move toward abundance or density values at least approaching those seen in 1993 through 1995 by the SEAMAP trawl survey off of South Carolina. Future actions proposed to remove stresses on marine catfish will likely benefit other benthic organisms as well and thus could be quite valuable from an ecological and even a human health perspective.

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Mobulid Guild

Giant Oceanic Manta Ray *Mobula birostris*
Lesser Devil Ray *Mobula hypostoma*
Devish Fish *Mobula mobular*

Contributors:
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DESCRIPTION

Taxonomy and Basic Description

The giant oceanic manta ray (*Mobula birostris*), lesser devil ray (*Mobula hypostoma*), and devil fish (*Mobula mobular*) are members of the mobulidae family and reside in the genus *Mobula* (11 species), encompassing both manta and devil rays, and consists mostly of large species living in the open ocean rather than on the sea bottom.

Manta rays are easily recognized by their large, diamond-shaped bodies, elongated wing-like pectoral fins, gill slits positioned on their ventral sides, eyes on their lateral sides, and broad, terminal mouths. Unique among vertebrates, they have cephalic lobes located in front of their mouths that help channel water during feeding.


Giant oceanic manta ray

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The giant oceanic manta ray is potentially the largest ray species, reaching a disc width (DW) of up to 700 cm, with some anecdotal evidence suggesting sizes up to 910 cm (Compagno, 1999; Alava et al., 2002). These rays are typically larger than their reef counterparts, characterized by a caudal thorn, rough skin, and distinct coloration patterns. Male giant oceanic manta rays mature at a disc width of 350–400 cm, while females mature at 380–500 cm (White et al., 2006; Last et al., 2016; Stevens et al., 2018). Their reproductive method is aplacental viviparous, meaning they give birth to a single large pup measuring 122–200 cm DW (White et al., 2006; Rambahiniarison et al., 2018). Though the exact reproductive cycle is unknown, it is estimated to be 4–5 years, similar to the closely related reef manta ray (*M. alfredi*). Females reach maturity around 8.6 years of age, but their first pregnancy might be delayed until 12 years due to food availability (Rambahiniarison et al., 2018). With a potential lifespan of up to 45 years, giant

oceanic manta rays have a generation length of approximately 29 years. They have a notably low reproductive rate, producing only 4–7 pups over their lifetime, which hinders their population recovery from over-exploitation and other threats (Dulvy et al., 2014).



Lesser devil ray

The lesser devil ray can grow up to 120 cm in disc width (DW), with some reports indicating sizes up to 230 cm DW in Venezuela (Ehemann et al., 2017). Males reach maturity at 114 cm DW, while females mature at 111 cm DW (McEachran and Carvalho, 2002). Their reproductive process is aplacental viviparous, typically producing a single pup ranging from 55 to 97 cm DW at birth (McEachran and Carvalho, 2002; Ehemann et al., 2017). Similar to other species in the mobulid family, lesser devil rays may have resting periods of 1–3 years between pregnancies (Marshall and Bennett, 2010; Deakos, 2011; Stevens, 2016). Although the precise age-at-maturity and maximum lifespan for lesser devil rays are not well-documented, they are estimated based on the spinetail devil ray (Mobula mobular), which matures at 5–6 years and can live up to 20 years (Cuevas-Zimbron et al., 2013; Pardo et al., 2016). This leads to a presumed generation length of about 12.8 years. However, since the spinetail devil ray grows considerably larger (520 cm DW) than the lesser devil ray (120 cm DW), this generation length may be overestimated.


Devil fish

The devil fish (Mobula mobular) is a large pelagic species, reaching up to 350 cm disc width (DW), and inhabits tropical and subtropical waters globally, from the surface to depths of 1,112 meters. This species is found in temperate and tropical waters across all oceans, with notable presence in the Mediterranean Sea, though it is absent from the Red Sea (Notarbartolo-di-Sciara, 1987; Notarbartolo di Sciara et al., 2017). Its distribution is sporadic, with patchy occurrences throughout its range (Lawson et al., 2017).

The devil fish grows to a maximum size of 350 cm DW, with significant geographical size variations (Notarbartolo di Sciara et al., 2020). Males reach maturity at 200–220 cm DW, while females mature at 215–240 cm DW. They reproduce aplacental matrotrophically, with a gestation period of 12 months, typically birthing a single large pup, though occasionally two pups per litter are born. The pups measure 90–160 cm DW at birth. The reproductive cycle ranges from 1 to 3 years, with some resting periods between pregnancies (White et al., 2006; Last et al., 2016; Rambahiniarison et al., 2018; Stevens et al., 2018). Females reach maturity at approximately 5–6 years of age, with a maximum lifespan estimated at 20 years, leading to a generation length of about 12.8 years (Cuevas-Zimbron et al., 2013; Pardo et al., 2016)

Status

Global status for three species are listed as "Endangered" by the IUCN Redlist, with population trends in decline. In 2018 NOAA Fisheries listed the giant oceanic manta ray as threatened.

POPULATION SIZE AND DISTRIBUTION

The giant oceanic manta ray is found circumglobally in tropical and temperate waters, inhabiting depths from the surface down to 1,000 meters (Last et al., 2016). They are distributed throughout the Pacific, Indian, and Atlantic Oceans in both coastal and pelagic waters. The global population size of the giant oceanic manta ray is not well-known, but local and regional populations have been estimated, generally numbering fewer than 500 individuals, with the exception of Ecuador, where the population is estimated to exceed 2,000 individuals. Population trends for the giant oceanic manta ray vary significantly across their range. In regions where they are protected, such as Hawaii (Ward-Paige et al., 2013) and Ecuador (Holmberg and Marshall, 2018), populations appear stable. However, in Ecuador, these rays migrate seasonally to Peru, where they face directed fishing pressures (Heinrichs et al., 2011). In areas where the species is frequently targeted or caught as bycatch, populations are likely declining. Globally, it is estimated that the population has decreased by 50–79% over three generations (approximately 87 years), with further declines anticipated over the next three generations (2018–2105) due to ongoing threats, exploitation, and reductions in their area of occupancy. In areas where manta rays are protected, their populations remain stable (Marshall et al. 2022a).

The lesser devil ray is endemic to the Atlantic Ocean, displaying a patchy distribution. In the Western Atlantic, it is found from North Carolina in the United States down to Argentina, while in the Eastern Atlantic, its range extends from Western Sahara to Angola (Mas et al., 2015; Last et al., 2016; Stevens et al., 2018).

This species is now absent from many areas that were once part of its historical range, with notably few sightings in countries such as Brazil. Genus-wide data indicate that populations of devil rays, including the lesser devil ray, have experienced significant declines of 51 to 94% over 10- to 15-year periods (~one generation length) in areas with intense fishing pressure. Similar declines are likely in West Africa due to comparable fishing pressures. An exception to these declines is observed along the east coast of the United States. From 1989 to 2005, the Southeast Area Monitoring and Assessment Program research trawl surveys recorded the lesser devil ray in 15 out of 17 survey years (n = 113). This suggests an estimated instantaneous rate of change of 0.105 (95% CI: 0.037–0.173), indicating a population increase in this region (Bizzarro et al., 2009).

The devil fish inhabits temperate and tropical waters globally, present in the Mediterranean Sea but notably absent from the Red Sea (Notarbartolo-di-Sciara, 1987; Notarbartolo di Sciara et al., 2017). Its distribution is uneven across its range (Lawson et al., 2017). There are no comprehensive estimates of the global population of the devil fish. Despite its extensive distribution, populations are sporadically distributed and vary greatly, likely influenced by food availability and fishing pressures (Marshall et al. 2022c). This species is often solitary but can gather in large groups for feeding or reproduction. In some regions, such as the northwest Mediterranean Sea, aerial surveys have estimated populations of up to 12,700 individuals (Fortuna et al., 2014; Notarbartolo di Sciara et al., 2015). In most areas, devil fish populations are declining due to targeted fishing and bycatch. These declines are inferred from decreased landings or sightings despite increased fishing efforts (Couturier et al., 2012; Ward-Paige et al., 2013; Croll et al., 2016). Reports from fishers and traders suggest that devil ray gill plates are becoming scarcer, driving up prices as supplies dwindle (O'Malley et al., 2017). Regional extinctions are suspected in areas with high fishing pressures (Lewis et al., 2015). However, in regions such as Australia, New Zealand, and some Pacific countries, the threat level is likely lower due to reduced fishing pressure and effective fisheries management in the former two countries (Marshall et al. 2022c)

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Although the giant oceanic manta ray is typically solitary, it congregates at cleaning stations and during feeding and mating events. Their diet mainly consists of planktonic organisms like euphausiids, copepods, mysids, decapod larvae, and shrimp, though they have also been observed consuming small to moderately sized fish. The giant oceanic manta ray demonstrates significant flexibility in its use of habitat depths. While they often feed in shallow waters less than 10 meters deep, tagging studies have shown that they can dive between 200 and 450 meters, and occasionally even deeper than 1,000 meters. This diving behavior is thought to be influenced by seasonal changes and shifts in prey location associated with the thermocline. These rays are found worldwide in tropical, subtropical, and temperate waters. They typically inhabit offshore oceanic regions and productive coastal areas but can also be seen in estuaries,

oceanic inlets, bays, and intercoastal waterways. They can tolerate cooler waters down to 19°C, with regional temperature preferences. For example, off the U.S. East Coast, they are frequently found in waters ranging from 19 to 22°C, while in regions like the Yucatan Peninsula and Indonesia, they prefer warmer waters between 25 and 30°C

The lesser devil ray is a pelagic species that inhabits coastal and oceanic waters, typically found from the surface to depths of 100 meters (Robbins et al., 1986; McEachran and Carvalho, 2002; Wiegmann, 2016). These rays often form schools, which can include up to 40 individuals, though they more commonly occur in smaller groups of 2 to 10. They primarily feed on zooplankton, including small crustaceans, but may occasionally consume schooling fish. They use their cephalic lobes to funnel prey into their mouth (source needed for feeding behavior details).

The devil fish is a pelagic species that primarily inhabits coastal and continental shelf waters. While it spends most of its time in waters shallower than 50 meters, it occasionally dives to depths of up to 1,112 meters (Canese et al., 2011; Croll et al., 2012; Holcer et al., 2013; Francis and Jones, 2017). This species demonstrates extensive movements, traveling up to 1,800 kilometers at minimum speeds of 63 kilometers per day, likely driven by seasonal prey availability (Freund et al., 2000; Canese et al., 2011; Croll et al., 2012; Francis and Jones, 2017).

CHALLENGES

Mobulids face significant threats from both targeted and incidental capture in various types of fisheries, including both industrial and artisanal operations (Couturier et al., 2012; Croll et al., 2016; Stewart et al., 2018). They are caught using an array of fishing gear, such as harpoons, drift nets, purse seines, gill nets, traps, trawls, and longlines. Their wide-ranging coastal and offshore habitats, combined with their tendency to form aggregations, make them highly susceptible to bycatch in purse seine and longline fisheries, as well as targeted capture in artisanal fisheries (Croll et al., 2016; Duffy and Griffiths, 2017). Their large size, slow swimming speed, and predictable patterns of habitat use further increase their vulnerability. These fisheries often meet the demand for gill plates in international markets, though some still focus on local use (White et al., 2006; Essumang, 2010; Rohner et al., 2017).

In addition to targeted capture, Mobulids are also caught incidentally as bycatch in at least 21 small-scale fisheries across 15 countries and nine large-scale fisheries in 11 countries (Croll et al., 2016). Even when caught unintentionally, their high market value often leads to them being retained. Those that are released alive frequently suffer from injuries and have high post-release mortality rates (Tremblay-Boyer and Brouwer, 2016; Francis and Jones, 2017).

While fishing remains the primary cause of population declines, other threats exist including entanglement in fishing gear, accidental hooking by recreational fishers, vessel strikes, and potential impacts from climate change, ocean acidification, oil spills, and pollution (Marshall and Bennett, 2010; Deakos et al., 2011; Couturier et al., 2012; Stewart et al., 2018). Additionally, the loss and degradation of shallow water lagoon habitats pose risks to juvenile rays (Stewart et al., 2018).

CONSERVATION ACCOMPLISHMENTS

In 2018, NOAA Fisheries listed giant oceanic manta rays under the Endangered Species Act. This species is further protected in over a dozen countries and territories (Lawson et al., 2017; Lawson and Fordham, 2018; Booth et al., 2020). All three species have been listed on Appendix I and II of Convention for the Conservation of Migrator species of Wild Animals (CMS). Mobula Species were listed on Appedix II of the Convetional on International Trade in Endageared Species (CITES) in 2016. In 2015, the Inter-American Tropical Tuna Commission prohibited Mobula species caught by large-scale fisheries in their Conventional Area form being retained or sold (whole or in part), requiring them to be released alive (Lawson et al., 2017; Lawson and Fordham, 2018).

CONSERVATION RECOMMENDATIONS

To facilitate the recovery of mobulid populations, it is recommended that landings of these species be banned, in accordance with various international agreements, for as long as their global numbers remain under threat. Furthermore, it is essential to enhance the collection and reporting of data on catches and discards. Additionally, implementing regional and national catch limits based on scientific recommendations or the precautionary principle, reducing bycatch mortality, establishing protocols for the safe release of caught individuals, and adopting codes of conduct for responsible tourism are crucial. Furthermore, it is important to fully enforce commitments made through international treaties. For more comprehensive guidance on priority conservation actions, refer to the IUCN SSG Global Devil and Manta Ray Conservation Strategy (Lawson et al., 2017).

MEASURE OF SUCCESS

- Reduced bycatch with and unwanted interactions with fisheries
- Reducing post-release mortality through gear modifications and establishment of safe handling and release practices
- Establishing population estimates and monitoring programs throughout distribution
- Understanding drivers of spatiotemporal patterns to reduce bycatch and identify critical habitat areas

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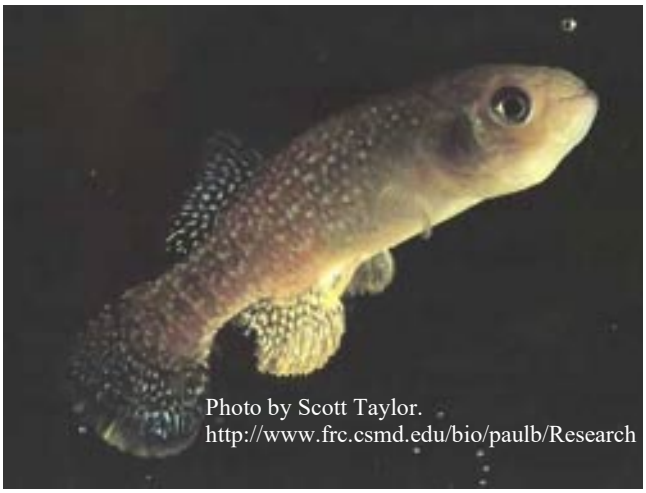
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Mummichog

Fundulus heteroclitus


Photo by Scott Taylor.
http://www.frc.csmd.edu/bio/paulb/Research

Contributor (2005):
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Revised (2013): Erin Levesque

Revised (2025: Erin Levesque and Sabrina Cobb (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

The mummichog belongs to a group of fishes known as killifish, which are members of the family Cyprinodontidae. The mummichog was described by Linnaeus in 1766 as *Corbitis heteroclita*. He soon after created a new name for the species, *Fundulus heteroclitius*, which remains as the accepted nomenclature today. It is also thought that different "forms" of this species may exist. For example, *Fundulus heteroclitus macrolepidotus* is considered by some to be a northern form of the species that is distinguished from *F. heteroclitius heteroclitius* by egg structure and spawning behavior. The word "mummichog" comes from a Native American word meaning "going in crowds" and refers to its common schooling behavior.

The mummichog is a sexually dimorphic fish. Breeding males are easily distinguished from females by their more brilliant, intense pigmentation. Males also display vertical bars along the sides which the females lack. Females, in general, tend to be much paler than males. Very small fish of both sexes show dark transverse bars on their sides which are later lost. This species can vary in shade based on background surroundings (Bigelow and Schroeder 1953).

The mummichog is an omnivore, feeding on plant matter, small crustaceans, small mollusks, and fish. Adults are reported to reach sizes as large as 17.8 cm (7 in) with females growing larger than males. The mummichog is oviparous. Spawning takes place during the summer months during the new and full moon. Eggs are sticky, about 2 mm (0.08 in) in diameter, and sink after being spawned. Eggs then cling to the insides of mussel shells, oyster shells, and on vegetation. The eggs can develop out of water and typically hatch in 9 to 18 days after being submerged again in water during the following high tide. At 20 mm (0.8 in) the fry are fully developed and resemble adults (Bigelow and Schroeder 1953).

Status

The mummichog is not a state or federally listed species; however, is an extremely important food source for many larger fish as well as wading and sea birds. It is harvested commercially as bait and, because of its hardiness, is a favorite for biological experimentation and education. The species is also used as an indicator species in severely polluted systems and is sometimes the only species found in these areas. Significant levels of cancer and precancerous lesions have been found in the livers of small mummichogs. Scientists have correlated these to high levels of PAH in the mud associated with the wood preservative creosote (The Elizabeth River Project). Mummichogs have been known to consume as many as 2,000 mosquito larvae a day and can be used as a natural mosquito control in ponds and ditches.

POPULATION SIZE AND DISTRIBUTION

Mummichogs occur from the Gulf of St. Lawrence along the Atlantic Coast south to the Gulf coast of Texas. The mummichog has reportedly been introduced into Hawaii, the Philippines, Portugal, and Spain. It was also introduced to ponds in New Hampshire via bait bucket release and was later collected from the upper Ohio and Beaver River systems in far western Pennsylvania (Froese and Pauly 2004; Richart and Incze 2004; Fuller 2004).

The species is present year-round in South Carolina and is abundant in the state's estuaries and tidal creeks. One of the earliest records of the mummichog in South Carolina was collected on January 11, 1891, from the Ashley River (Anonymous 2001). Very little scientific information exists on abundance and distribution; however, it is assumed to be an abundant species. Cain and Dean (1976) sampled a high salinity creek in South Carolina and found mummichogs to be the most abundant (29.7%) species in their samples. The SCDNR electrofishing survey, that began in 2001 and continues to the present, has captured mummichogs in low salinity waters (<10 ppt) in each of the estuaries sampled along the coast (Winyah Bay system, Charleston Harbor system, ACE Basin system), with mummichogs representing the 6th most abundant species.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The mummichog is a benthopelagic, eurohaline species. They are commonly found in saltwater marshes, tidal creeks and in sheltered shores. The fish's upper salinity limit is reported to be 106 to 120.3 parts per thousand (ppt) (Abraham 1985). However, it is also reported that mummichogs living in Chesapeake Bay prefer to live in freshwater. This is an extremely tolerant species that can survive at very low oxygen levels and in heavily polluted ecosystems. It can also withstand temperatures as warm as 34^{o}C (93°F) and temperature fluctuations from 6^{o}C to 35^{o}C (43°F to 95°F). Because of the

hardiness of the mummichog, no specific critical habitats have been established. During cold weather months, mummichogs burrow into the mud to depths up to 20.3 cm (8 in.) to avoid freezing temperatures. In other cases, they may move to deep channels (Bigelow and Schroeder 1953).

CHALLENGES

In South Carolina, there is a commercial bait fishery that targets mummichogs. For a license fee of $25, an individual may have up to 50 pots with the option to pay $1 extra for each pot over 50. Another $25 license is required for the sale of mummichogs as bait. As of January 2010, commercial minnow trap license holders are also required to report monthly to the SCDNR on their catch and fishing effort. In January 2013, there had been 15 minnow trap licenses purchased for the 2013 fiscal year. Since reporting began in 2010, between 9,979-10,750 kg (22,000-23,700 lbs.) of mummichogs have been harvested; over half of this catch has come from creeks between James Island and Folly Beach (Charleston County) (Brad Floyd pers. Comm.). The gregarious nature of the mummichog makes it vulnerable to localized population depletion if heavily fished repeatedly in the same areas. More information on the impacts of localized population depletions due to harvest would be beneficial in describing potential ecological implications of mummichog removal (SCDNR final report).

CONSERVATION ACCOMPLISHMENTS

The mummichog bait industry is currently regulated through license sales and reporting requirements in South Carolina.

CONSERVATION RECOMMENDATIONS

- Continue to examine the mummichog bait fishery in South Carolina to collect fishery dependent data on catch and effort.
- Examine ways to use mummichog as an indicator species for water quality in South Carolina.
- Determine mummichog relative abundance and distribution in coastal waters.
- Track mummichog population trends including localized depletions related to harvesting for bait.

MEASURES OF SUCCESS

By implementing a monitoring protocol for mummichog in South Carolina, SCDNR will be able to infer water quality which, in turn, will benefit all marine life. Another measurement of success would be to document whether localized depletions of mummichog occur due to bait harvest.

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Mutton Snapper

Lutjanus analis

Contributors:
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DESCRIPTION

Taxonomy and Basic Description

Mutton Snapper are a large member of the family Lutjanidae found within the order Perciformes (Page et al. 2023). Their bright, distinctive coloration makes the species easy to identify. The back and upper half of their deep, laterally compressed body is olive green, while the body and fins on the lower half is red. A bright blue line is beneath the eye and other blue lines might be visible on the face. A distinct, small black spot can be seen under the dorsal fin and above the lateral line about midway down the body.

Mutton Snapper are gonochoristic, remaining the same sex from birth to end of life which may extend to 40 years of age. Little is understood about their reproductive strategy, but the species has been reported to congregate in large (tens of thousands) spawning aggregations, specifically in the Dry Tortugas National Park at Riley's Hump (Feeley, 2018; Domeier, 2004; O'Hop et al., 2015). While spawning may occur throughout the year, the primary spawning season for Mutton Snapper is between April and July. At approximately 15 inches total length (TL) and 2.85 years old, 50% of females are mature (SEDAR, 2023).

Status

Currently, the species is managed by the South Atlantic Fishery Management Council for the southeastern U.S. region (SAFMC 2023). As of the last SEDAR stock assessment, which included data through 2013, Mutton Snapper was not overfished nor was it undergoing overfishing (SEDAR 2015). A new stock assessment is under way, but results are not finalized as of this writing. Small numbers of Mutton Snapper are landed in South Carolina each year. Currently this species is not managed with any seasonal spawning closures, however fishing on some known spawning grounds is prohibited inside a special management zone (SMZ).

Worldwide, the species is listed as Near Threatened by ICUN as of October 2015.

POPULATION SIZE AND DISTRIBUTION

Mutton Snapper can be found in the western Atlantic Ocean from Massachusetts to southeastern Brazil, and in the Caribbean (Carson et al. 2011). Historically,

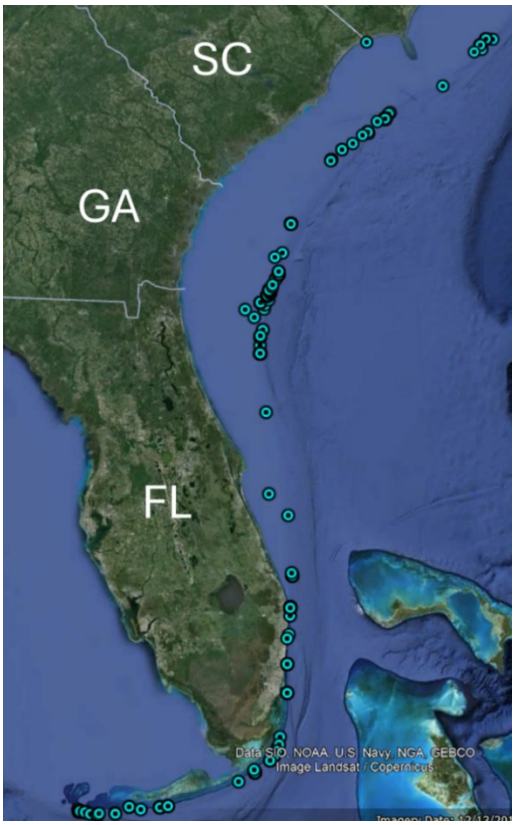


Figure 1: Mutton Snapper catch locations by SERFS and SADLS surveys from 1995-2023.

concentrations have been most dense off the eastern coast of Florida at Cape Canaveral and the Florida Keys, as seen in recreational landings data (Burton, 2002). Population size off South Carolina is unknown, however hook-and-line or longline efforts associated with the Southeast Reef Fish Survey (SERFS) and the cooperative South Atlantic Deepwater Longline Survey (SADLS) regularly encounter the species (Figure 1).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Mutton Snapper, like most reef fish, spend the first few weeks of life as planktonic larvae where challenges include starvation, predation, and movement away from appropriate settlement habitat (Houde, 1987, D'Alessandro et al., 2010). In the post-larval phase, juvenile Mutton Snapper settle onto seagrass beds and mangroves in Florida, but there is little published on juvenile settlement and habitat off the South Carolina coast (Burton, 2002). As they grow, Mutton Snapper move offshore and dwell on hard bottom habitats, coral reefs, ledges and rocky outcrops (Burton, 2002). In these environments, they serve as top predators, consuming smaller fish and invertebrates.

CHALLENGES

The challenges to achieving a sustainable Mutton Snapper population that support the commercial and recreational industries are similar to those of other reef fish species. Lack of data in the northern reaches of their distribution range makes it difficult to understand the status of the population. Slow growth and long lifespan make the species less resilient to disturbances than other community members. The species is also part of a reef fish complex that inhabits similar areas as other reef fishes and is pursued by multi-species fisheries. This means that post-release mortality, including barotrauma, may be an issue for the species.

CONSERVATION ACCOMPLISHMENTS

The SEDAR 15A update in 2015 determined the stock was not overfished or undergoing overfishing. However, analysts noted the stock was likely to be sensitive to fishing

pressure in the future. SEDAR 79 is currently ongoing and results of the assessment were not available at the time this document was compiled.

CONSERVATION RECOMMENDATIONS

Like other species in the snapper-grouper management complex, more data is the greatest need when considering best approach for species conservation.

Specific recommendations include:

- data collection focused on smaller individuals/juveniles in the population and primary habitat used in early life stages,
- focused effort on understanding seasonal migration patterns,
- increased dockside sampling and monitoring to improve data for areas and depths fished, as well as fishing effort employed, and
- focused effort on obtaining data about discard rates and discard mortality in both recreational and commercial sectors.

MEASURE OF SUCCESS

Because there is currently no fishery-independent measure of population size or trends off the South Carolina coast, fishery catch is the only available measure of success. If the hybrid SADLS project continues to produce the highest consistent abundance of Mutton Snapper for the region, then a stable population size and age structure would be a measure of success for fisheries management in the region.

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Night Shark

Carcharhinus signatus



Photo: shark-references.com

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Photo: Ashley Galloway

DESCRIPTION

Taxonomy and Basic Description

Night sharks are a slender, medium-sized species with an interdorsal ridge and distinctive large, green eyes. The first dorsal fin is small and originates over or behind the free rear tip of the pectoral fins. Body color is brownish to blueish gray above which fades to grayish white below, and the nose is long and pointed. The common name is thought to be a translation of the name Cuban fishermen gave the shark, *tiburon de noche*, which references the tendency to only catch them at night (Castro, 2011).


Photo: Ashley Galloway

Most sharks encountered are under 275 cm total length (TL), and maximum length is likely around 300 cm TL (Castro, 2011). While observed maximum ages determined by vertebral counts was 17 years old, back calculated ages using catch data indicated night sharks may live 31+ years (Santana and Lessa, 2004). Currently age and growth has only be studied in the southwestern Atlantic which reports life history parameters corresponding to slow to moderate growth rates (Santana and Lessa, 2004).

Females are thought to mature around 10 years old and size at maturity likely falls between 200 – 205 cm TL (Hazin et al., 2000; Santana and Lessa, 2004). Males are thought to reach maturity slightly younger at 8 years, corresponding to a size at maturity between 185 – 190 cm TL (Hazin et al., 2000; Santana and Lessa, 2004).

Like many Carcharhinids, they are viviparous placental giving birth to live young with a biennial reproductive cycle and a gestation period around 12 months. Gonadosomatic index values suggest copulation occurs during summer, and due to remarkable variability in embryo sizes collected from February to June, it is possible they have a

protracted parturition period lasting several months (Hazin et al., 2000; Santana and Lessa, 2004). Size at birth is presumed to be 60 – 67 cm TL (Compagno, 1984; Santana and Lessa, 2004) with litter sizes ranging from 4 to 18 pups (Hazin et al., 2000; Compagno et al., 2005).

Status

Due to declining abundance throughout their range, night sharks have an IUCN Red List status of Endangered. Night sharks are managed under the Atlantic Highly Migratory Species Fisheries Management Plan and retention has been prohibited in both recreational and commercial fisheries since 1999. An analysis of available abundance trends data produced conflicting results, warranting the continuation on the prohibited list as a precaution until sufficient data is collected to conduct a thorough stock assessment (Carlson et al., 2008).

POPULATION SIZE AND DISTRIBUTION

Night sharks are found in warm temperate and tropical waters of the western Atlantic ocean from Delaware to Argentina including the Gulf of Mexico, Bahamas, Caribbean, and Central America. In the eastern Atlantic, they occur from Senegal to northwestern Namibia (IUCN, 2021).

Information on demographics and movement patterns in night sharks is limited. Available evidence suggests significant declines due to high fishing mortality, with populations estimated to have declined 50-70% over the past three generations (IUCN, 2021). Several studies used marked recapture with conventional tags to document large scale movements upwards of 2,669 km and maximum reported time at liberty of 13.8 years, suggesting susceptibility to large scale pelagic longlining as well as regional artisanal fisheries (Kohler and Turner, 2001; Baremore et al., 2019).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Night sharks are a deepwater coastal or oceanic species residing offshore or along the outer continental and insular shelves in waters 50 to 100 m or deeper (Bigelow and Schroeder, 1948). They actively school and are known to conduct vertical diel migrations at night consuming a diet primarily of small active teleosts, squid, and shrimp (Compagno et al., 2005).

CHALLENGES

The night shark makes up a significant proportion of shark bycatch in pelagic longline fisheries off the southeastern U.S. Historically, they comprised a significant proportion of the artisanal shark fishery in Cuba; however, they are now rarely caught (Carlson et al., 2008). Despite being on the prohibited species list and are hence not targeted, some are likely retained by fisheries due to species identification issues as well as

lucrative demand for shark fins (Carlson et al., 2008). To monitor impacts of the demand for shark fins, genetic testing for prohibited species was conducted in fin markets in Hong Kong and Guangzhou; unlike many of the other prohibited pelagic species, they failed to identify any night shark fins (Fields et al., 2018; Cardenosa et al., 2020).

A study describing the demographics of night sharks captured in the longline fishery in the southwestern Atlantic ocean found the stock being targeted was over 89% juveniles. Recruitment to the fishery occurred around 5 years of age, however, age at maturity is not until 10 years for females. The high mortality rate of this fishery on individuals prior to reaching sexual maturity suggests significant reductions in the population is likely and unsustainable (Santana et al., 2009).

Life history information in the northwestern Atlantic is not available and very little is known about population size, productivity, or demographics. While significant declines in CPUE are reported to have occurred throughout the western Atlantic, it is unknown if observed changes are due to species identification, fishing tactics, market value or actual population declines (Carlson et al., 2008). Additionally, based on observer data, the average size of night sharks captured in pelagic longline fisheries has decreased approximately 40 cm TL since the 1980s. Whether this is due to changes in leader types and catchability, or a true decrease, requires additional research (Carlson et al., 2008)

CONSERVATION ACCOMPLISHMENTS

Some conservation sites have been identified over part of their range (IUCN, 2021).

While lacking comprehensive data for stock assessment, fishing has been restricted as a proactive management tool.

CONSERVATION RECOMMENDATIONS

- Explore ways to decrease fisheries bycatch and mortality in commercial and artisanal fisheries
- Improve monitoring and reporting in commercial and artisanal fisheries by international organizations and individual countries to improve estimates of catch and discards
- Improve knowledge and understanding of life history and demographics
- Improve knowledge and understanding of population status, abundance trends, and genetic structure

MEASURE OF SUCCESS

Removal from IUCN Endangered designation and an increase in abundance throughout their range. A first goal should be to collect sufficient data to conduct a thorough stock assessment.

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Oceanic Whitetip Shark

Carcharhinus longimanus



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DESCRIPTION

Taxonomy and Basic Description

Oceanic whitetip sharks, members of the order Carchariniformes and family Carcharinidae (Page et al. 2023) are a large-bodied, stocky pelagic species with a distinctive pattern of mottled white on the tips of their dorsal, pectoral, and caudal fins. The first dorsal fin is broadly rounded while their pectoral fins are long and paddle-like (Compagno, 1984). It has black tips on the ventral surface of the pelvic and anal fins and the anal fin has a free rear tip that almost reaches the base of the caudal fin (Compagno, 1984). The nose is bluntly rounded, the eyes small and circular, and they may have a weak or occasionally absent interdorsal ridge (Castro, 2011). Body color can vary based on habitat but is generally olive gray to brown while their undersides are white to yellow tinged (Compagno, 1984). Small juveniles may have black blotched or black tips on their fins and black saddle marks on the dorsal surface between fins (Castro, 2011).

Most sharks encountered are under 300 cm total length (TL), and maximum length is likely around 325 cm TL (Lessa et al., 1999). While observed maximum ages determined by vertebral counts ranged from 12-18 years in the Pacific and from 13-19 years in the South Atlantic (Seki et al., 1998; Lessa et al., 1999), oceanic whitetip sharks are estimated to live up to 25 years with the potential that individuals may be considerably older, up to 36 years (NOAA, 2024). Studies conducted in the Northwest Atlantic and eastern Pacific indicate intermediate life history parameters with generally slow to moderate growth rates which may vary slightly between regions (Backus et al., 1956; Strasburg, 1958).

Females are thought to mature between 6 to 9 years which varies based on geographic location, and size at maturity likely falls between 180 – 200 cm TL (Lessa et al. 1999, Joung et al., 2016). Males are thought to reach maturity around the same ages and slightly smaller lengths between 175 – 189 cm TL (Seki et al. 1998, Joung et al., 2016). In a study from the equatorial Atlantic off North-Eastern Brazil, no difference in morphometrics or weights were observed between the sexes and the size at maturity ranged from 180-190 cm TL for both sexes (Lessa et al., 1999)

Like many Carcharhinids, they are placentally viviparous giving birth to live young with a biennial reproductive cycle and a gestation period of 10 to 12 months. Litters average 6 pups but can range from 1 to 14 pups with larger females producing more offspring. Size at birth is estimated between 65-70 cm PCL (Lessa et al., 1999; Castro, 2011).

Status

Due to declining global abundances, oceanic whitetip sharks have an IUCN Red List status of Critically Endangered and are currently listed under Annex II of the Protocol Concerning Specially Protected Areas and Wildlife of the Cartagena Convention (SPAW Protocol), Annex I of the Sharks Memorandum of Understanding on the Convention on Migratory Species (CMS), and effective September 2014, they were added to Appendix II of the Convention on International Trade in Endangered Species (CITES).

Stock assessments are only available in the Western and Central Pacific Ocean which conclude they are overfished and overfishing is occurring. While a formal stock assessment hasn't been completed in the US, management actions were implemented in 1993 as part of the Federal Fishery Management Plan for Sharks and subsequent regulations have been passed to further reduce fishing mortality (NOAA, 2006).

In 2018, NOAA Fisheries listed the species as threatened under the Endangered Species Act. They are currently managed under the Atlantic Highly Migratory Species Fisheries Management Plan, and retention is prohibited in both recreational and commercial fisheries in all U.S. Federal waters in the Atlantic, Gulf of Mexico, and Caribbean. In July 2024, the final Oceanic Whitetip Shark Recovery Plan was adopted by NOAA.

POPULATION SIZE AND DISTRIBUTION

Oceanic whitetip sharks are a circum-global, highly migratory species found in tropical and warm temperate waters. In the Atlantic Ocean, oceanic whitetip sharks are distributed from Maine to Argentina, including the Gulf of Mexico and Caribbean Sea but are uncommon in the U.S. Atlantic EEZ. In the Pacific Ocean, they are found from California to the tropics.

Global population data is lacking for the oceanic whitetip shark. Available evidence indicates significant magnitude declines due to heavy fishing pressure. Since the mid-1990s, their populations have declined approximately 80-95% across the Pacific Ocean, 88% in the Gulf of Mexico, and substantial declines are estimated in the Atlantic Ocean (Young and Carlson, 2020).

With declining populations, focus was placed on gaining insight into movement through use of conventional as well as pop-up and satellite archival tags. Patterns were consistent between studies and regions with large scale movements as well as evidence of philopatry which suggests potential depletions in localized abundance and genetic diversity due to overfishing (Kohler et al., 1998; Howey-Jordan et al., 2013; Camargo et

al., 2016). Several lines of evidence show declining median sizes for both sexes and this pattern in females is particularly concerning due to correlation between maternal length and litter size (Young and Carlson, 2020).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Oceanic whitetip sharks reside offshore in deep waters of the open ocean but are thought to spend most of their time in depths shallower than 100 m, primarily utilizing the upper mixed layer of the pelagic zone. While they are considered a surface-dwelling shark and prefer warm waters above 20^{o} C, they have been recorded making deep dives down to 1,082 m (Howey-Johnson et al. 2013; Young and Carlson 2020).

Major prey species include large epipelagic teleosts and squid, but they are also known to be opportunistic and will consume sea birds, other sharks and rays, marine mammals, and even garbage. They are considered a top predator and a stable isotope study conducted in the Southwestern Indian Ocean found significant dietary overlap with pelagic thresher sharks (*A. pelagicus*) and scalloped hammerheads (*Sphyrna lewini*) (Kiszka et al, 2015).

According to NOAA, critical habitat designation under the ESA is not possible at this time based on a comprehensive review of the best available scientific data (as of 2020). They determined there are no identifiable physical or biological features essential to the conservation of oceanic whitetip sharks within areas under U.S. jurisdiction.

CHALLENGES

Oceanic whitetip sharks are one of the most common pelagic bycatch species in gillnet, longline, and purse seine fisheries. While purse seine fisheries have historically had low bycatch rates, the development of industrialized seine fisheries targeting larger pelagic species has increased the likelihood of shark bycatch. To increase catches, fish aggregating devices (FADs) are frequently used prior to encircling with seine nets, and consequently, oceanic whitetip sharks are one of the predominant species associated with bycatch in these fisheries (Eddy et al., 2016). They are also the third most dominant shark bycatch species globally in pelagic longline fisheries and are frequently reported as being discarded alive (Abel and Grubbs, 2020).

Post-release mortality estimates for pelagic longline fisheries range from 5-20% (Abel and Grubbs, 2020), however, seine and FAD associated mortality rates are likely much greater and may be similar to their congener, *C. falciformis,* which has a seine mortality rate upwards of 85% (Filmalter et al., 2013; Poisson et al., 2014). Adding to concerns about fishing mortality rates, a recent study investigated the accuracy of shark bycatch estimations by onboard observers and found shark counts were underestimated for 50-100 percent of the sets with a mean underestimation at trip level ranging from 9 to 40

percent for onboard observers in the Pacific and Atlantic Oceans and 65 percent for electronic monitoring systems in the Indian Ocean (Forget et al. 2021).

In addition to concerns about fishing mortality, oceanic whitetip shark fins are in high demand in the global shark fin trade due to their large size. They are highly valuable and can sell for $45 to $85 USD per kg (CITES 2013). While retention of oceanic whitetip sharks has been prohibited by major tuna regional fisheries management organizations, genetic testing of fins in the Hong Kong fin market continued to detect their presence (Cardenosa et al. 2018).

Since oceanic whitetip shark abundance data is heavily reliant on fishery-dependent methods, variability in gear configurations and tactics has made the standardization of abundance trends for population assessments difficult (Young and Carlson, 2020). Additionally, vital information on location and timing of breeding, pupping, and nursery habitats are lacking. Identifying these areas and implementing protection measures could ensure increases in abundance and population recovery (Young and Carlson, 2020). Other emerging concerns include pollution with recent studies finding methylmercury levels in oceanic whitetips notably increased with fork length and were in high enough concentrations to have adverse health effects (Kiszka et al., 2015).

CONSERVATION ACCOMPLISHMENTS

While much work needs to be accomplished to allow the recovery of the oceanic whitetip shark, the recent adoption of the Oceanic Whitetip Shark Recovery Plan by NOAA is a strong step forward.

CONSERVATION RECOMMENDATIONS

- Explore ways to reduce bycatch mortality and assess post release mortality in longline fisheries in the Atlantic and Pacific Oceans.
- Develop methodology to quantify the percentage of fins in shark fin markets that can be assigned to oceanic whitetips with the goal of assigning fin samples to the basin of origin. This would allow for a better understanding of where IUU fishing is occurring.
- Improve knowledge and understanding of population status, abundance trends, and genetic structure.
- Improve knowledge and understanding of distribution, movement, and habitat use.
- Improve knowledge and understanding of demographics and life history.
- Minimize fisheries bycatch and mortality by determining frequency of capture and severity of interactions in commercial, artisanal, and recreational fisheries.

- Minimize fisheries bycatch and mortality in international fisheries and trade through enhanced coordination and collaboration with relevant international organizations.
- Determine effects of international shark fin trade on populations in all management units and take management actions to minimize or eliminate the quantity of fins in trade.
- Improve species-specific monitoring and reporting in commercial and artisanal fisheries by international organizations and individual countries to provide a better understanding of the effects of illegal, unreported, and unregulated (IUU) fishing, improve estimates of catch and discards, and measure progress towards recovery.
- Minimize fishing mortality through effective development, implementation, and enforcement of internation and domestic measures such as legislation and regulation.
- Develop and implement outreach and education strategies and programs to increase public and stakeholder awareness on status and recovery needs.

MEASURE OF SUCCESS

Increase population abundance to the level of removal from listing under the Endangered Species Act. Meet criteria listed in NOAA's Oceanic Whitetip Recovery Plan.

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Pigfish

Orthopristis chrysoptera

Contributor (2025):
Sabrina Cobb (SCDNR)



Photo courtesy of Don Flescher and FishBase.org

DESCRIPTION

Taxonomy and Basic Description

Orthopristis chrysoptera, commonly known as the pigfish, is a member of the grunt family, Haemulidae. Haemulids encompass 17 genera and 150 species. They are distributed throughout the Atlantic, Indian, and Pacific Oceans and although most species are found in marine waters, some can be observed in brackish and freshwater (Ohs, Cortney L., et al. 2011). Haemulids are referred to as grunts because of the "grunting" or "chattering" sound that is produced when they rub their pharyngeal teeth together.

Key characteristics of the pigfish that help distinguish the species from others throughout their range include: a dorsal fin comprised of 12 to 13 spines followed by 15 to 16 soft rays, an anal fin with three spines and 12 to 13 soft rays. Both the dorsal and anal fin spines are covered by a scaly layer that is absent on the soft rays.

Pigfish have 53 to 58 lateral-line scales oriented in ten longitudinal rows above the lateral line and 15 to 19 rows below (Ohs, Cortney L., et al. 2011). Their body is elliptical in shape and significantly compressed, resulting in a body depth that is approximately 30 to 40 percent of their standard length (SL). Pigfish can grow up to 482 mm and weigh upwards of 10 kg (NCDEQ).

The overall coloration of the pigfish is greenish blue with iridescent highlights that gradually shade into silver ventrally. They have dark orange spots and irregular lines that cover the head and body. In addition, the upper body can have pale to dark grey bars and their fins are a yellow to bronze color with dusky margins.

Status

Pigfish are not a state or federally listed species; however, they are an important food source for Atlantic sharpnose *(Rhizoprionodon terraenovae)*, spotted seatrout

(Cynoscion nebulosus), and weakfish *(Cynoscion regalis)* (Radcliffe 1916; Hastings 1972; Darcy 1983).

POPULATION SIZE AND DISTRIBUTION

Pigfish occur predominately in the Gulf of Mexico from Florida to the Yucatan peninsula and along the Atlantic coast of the United States from the northern Bahamas to as far as New York, however they are uncommon north of Virgina.

The species is present year-round in South Carolina and is most abundant in the state's estuaries. Pigfish are often caught in SCDNR's estuarine based trammel net survey. Data collected from the survey shows year to year variability in abundances based on differences in recruitment and environmental variables (Figure 1). Overall, pigfish abundance appears consistent over the last few decades.

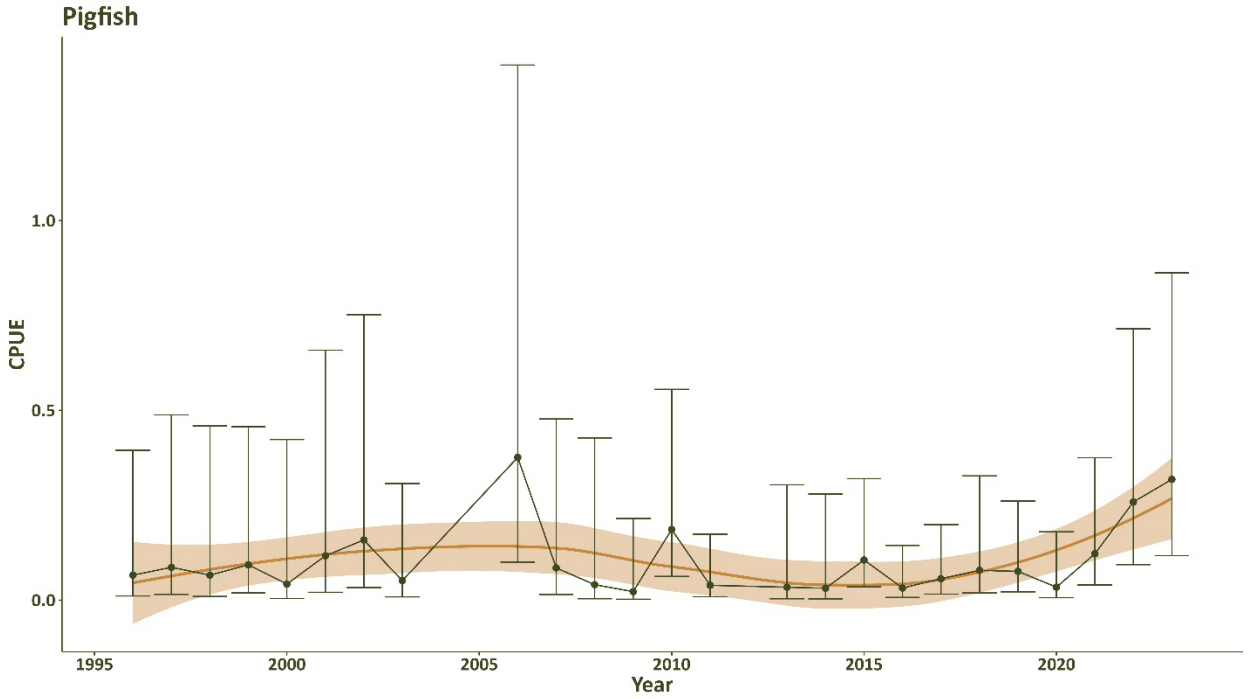


Figure 1. Pigfish mean annual standardized CPUE from SCDNR's trammel net survey.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Like many other species of grunts, juveniles will typically inhabit shallow waters near shore, often near vegetation, making South Carolina estuarian systems the perfect habitat to observe them. Adults can be observed over deep soft bottom flats, sandy and sparsely vegetated areas, and near mid-shelf reefs.

Pigfish can be found in water temperatures from 13.7 to 36.0 C but tend to prefer 23.9 to 26.7 C (Ohs, Cortney L., et al. 2011). This species is tolerant of salinities from 0 to 44.1 g/L however they tend to avoid waters with a salinity of 15 ppt or less (Ohs, Cortney L., et al. 2011). Pigfish have been historically collected from waters with a dissolved oxygen concentration of 2.1 to 11.8 mg/L (Schwartz et al. 1982).

Adult pigfish are primarily benthic carnivores, feeding on marine invertebrates, such as benthic worms, crabs and a variety of shrimp species; whereas young fish are planktivorous (Carr and Adams 1973; Darcy 1983). A shift in diet relative to increasing lengths was first documented from samples collected from Crystal River, Florida by Reid (1954). Reid's research showed pigfish between 25-50 mm total length (TL) consumed mostly copepods, while larger fish preyed upon amphipods, shrimps, and other benthic organisms. Juvenile pigfish diet in the Crystal River was also studied by Carr and Adams (1973). They observed fish 16-80 mm SL had two distinct feeding phases, planktivorous (consuming only copepods, mysids, and post larval shrimp), followed by a two-phase carnivorous stage in which marine invertebrates were the primary food target. Documented diet transition in the study began at approximately 26 mm SL and completed by 41-45 mm SL (Sutter and McIlwain 1987).

CHALLENGES

Some of the anthropogenic and environmental challenges pigfish are being faced with include increased fishing pressure and depletion of favorable habitat availability driven by climate change. As fishing efforts along our coast increase, the species becomes more susceptible to becoming bycatch which inadvertently could deplete local populations. Pigfish are caught by a variety of gear types including trawls, traps, and handlines, and currently have no commercial value in South Carolina. Along the Gulf of Mexico where the species is more prevalent, some are marketed as live bait but have little economic value (Darcy 1983). Commercial fishery statistics are not specifically reported for the species; however, overall catch data have been combined with other grunt species by the National Marine Fisheries Service and the Bureau of Commercial Fisheries (Sutter and McIlwain 1987).

Climate change poses a threat for pigfish by pushing their range north with increasing water temperatures and changing the macro habitat with increased, more intense tropical storms. This ultimately could decrease the preferred available habitat for the species and negatively impact their reproductive success.

CONSERVATION RECOMMENDATIONS

- Determine pigfish relative abundance and distribution in coastal waters.

- Track pigfish population trends in South Carolina including local depletions related to bycatch in fisheries.
- Explore the use of pigfish as bait in South Carolina after assessing population trends.

MEASURE OF SUCCESS

By implementing monitoring protocols for pigfish in South Carolina, SCDNR will be able to gain a better understanding of the species' life history, and their ecological role along the coast. In return, this will benefit targeted inshore fisheries such as spotted seatrout, that rely on the pigfish as a food source. Monitoring pigfish along our coast would also allow us to gain further insight to how climate change is affecting inshore fisheries and the implications it will have to our dynamic estuarine systems.

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Red Drum

Sciaenops ocellatus



Contributors:
Joseph C. Ballenger (SCDNR)

DESCRIPTION

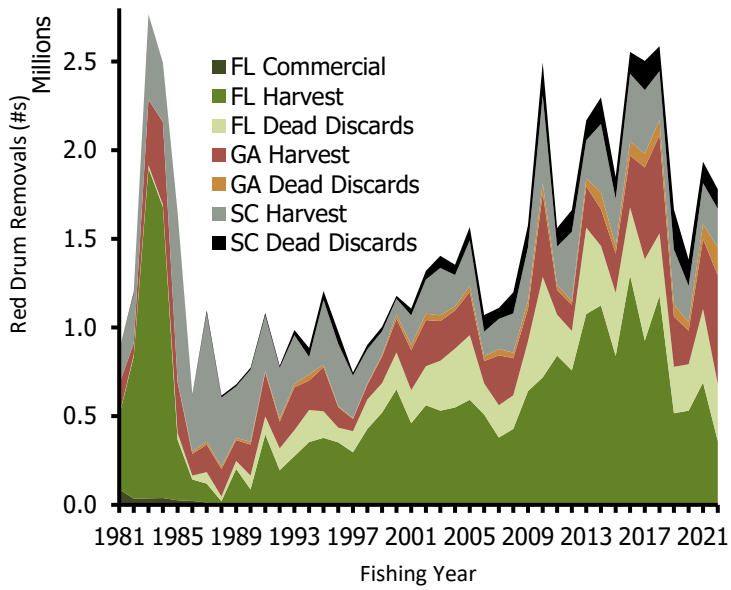
Taxonomy and Basic Description

Red drum are a large member of the order Perciformes and family Sciaenidae (Boschung & Mayden 2004; Carpenter 2002; Page et al. 2023) that are similar in body shape to Atlantic croaker but are not easily confused as they are the only local sciaenid possessing a conspicuous spot(s) on the caudal peduncle (Boschung & Mayden 2004). Their body is elongate, rather robust, with an inferior, horizontal mouth with chins not possessing any barbels (Boschung & Mayden 2004; Carpenter 2002). Their dorsal fin is long with two distinct sections: a spinous dorsal fin (15 spines) with a second dorsal fin (1 spine & 23-25 soft rays) separated by a very deep notch (Boschung & Mayden 2004; Carpenter 2002). Caudal fin shape changes with ontogeny, being rounded in young and becoming truncate to slightly concave in adults (Boschung & Mayden 2004; Carpenter 2002). Their coloration is distinct in the estuarine environment, with their body being iridescent silvery with a copper cast, being darker above and with age, with one to several black oscillated spots about eye size under the soft portion of dorsal fin to base of caudal fin (Boschung & Mayden 2004).

Red drum inhabit nearshore and estuarine waters of the U.S. Atlantic coast from Massachusetts (rare north of Chesapeake Bay) to Florida and the Gulf of Mexico from Florida to northern Mexico (Lux & Mahoney 1969; Mercer 1984). Management divides their population into two distinct stocks along the U.S. Atlantic coast (east coast FL to the north), one from the North Carolina/South Carolina (NC/SC) border north and the other from the NC/SC border south through the east coast of Florida, based on differences in life history (ASMFC 2022; SEDAR 2015), movement (ASMFC 2022; Bacheler et al. 2009; SEDAR 2015), and genetics (ASMFC 2022; Cushman et al. 2014; SEDAR 2015). South Carolina red drum belong to the southern population, which exhibit maximum observed sizes and ages of approximately 47 inches (120 cm) total length (TL) and 41 years old (SEDAR 2015). Red drum from the northern population reach slightly larger maximum sizes (55 inches (140 cm) TL) and older ages (62 years old; SEDAR 2015). In both areas, red drum exhibit extremely fast, strongly seasonal growth through ages 4-5 with evidence of changes in rates of approach to asymptotic sizes with age making their growth difficult to model with traditional growth models (e.g., von Bertalanffy growth model; ASMFC 2022; Cadigan 2009; Porch et al. 2002).

However, fast growth means harvest of red drum, which are managed through slot limits throughout their range, is primarily restricted to sub-adults between 1 and 3 years of age, though post-release mortality of catch-and-release fish occurs throughout their size and age range.

Despite their long life, southern population red drum mature early with 50% of females mature by 4.2 years old and 30 inches (76.6 cm) TL; similar ages- and sizes-at-maturity are observed for the northern population (3.5 years and 33 inches (83.6 cm) TL), keeping in mind the differences in size-at-age (J. Ballenger, pers. comm.). Spawning occurs in nearshore areas adjacent to channels and passes (Lowerre-Barbieri et al. 2008; Murphy & Taylor 1990; Wenner 2000) or near the mouths of high salinity estuaries along the coast (Beckwith et al. 2006; Johnson & Funicelli 1991; Luczkovich et al. 1999; Murphy & Taylor 1990; Nicholson & Jordan 1994; Woodward 1994) where adults form spawning aggregations during the late summer and early-fall months (August – mid-October; Lowerre-Barbieri et al. 2008; Luczkovich et al. 1999; Murphy & Taylor 1990; Ross et al. 1995). There is a slight latitudinal cline, with a 45-60 day spawning season shifted slightly later further south, with peak spawning in South Carolina from mid-August to September (J. Ballenger, pers. comm.). While adult fish participating in these spawning aggregations are protected from direct harvest due to slot limits, large-scale catch-and-release fisheries occur on and near aggregation sites resulting in post-release mortality of adult fish and potential sub-lethal effects affecting reproductive output.



There is growing literature that environmental factors affect the recruitment success of red drum (SEDAR 2015). In support, Goldberg et al. (2020) found a relationship between year class strength and ocean wind conditions promoting onshore movement of larvae during and after the peak spawning season. Similar environmental drivers are being identified for other species (e.g., Southern Flounder (Erickson et al. 2021)). Further exploration will likely result in the identification of other correlations between year class strength and environmental variables, though the relationship is likely complex making predictions difficult.

Status

The Atlantic coast southern population of red drum supports large scale recreational fisheries (Figure 1), though historic commercial fisheries were phased out in the region during the mid- to late-1980s when assessments indicated the stock was experiencing overfishing and in need of management protection (SEDAR 2015). The most recent regional assessment (ASMFC 2017; SEDAR 2015) of the southern population had high uncertainty in overfishing status, though point estimates suggested overfishing was not occurring during the terminal year, and additional concerns identified made use of the assessment for management purposes difficult. A subsequent state assessment in Florida found red drum in neither the northeast or southeast region of Florida were overfished nor experiencing overfishing (Addis 2020). In contrast, a state assessment in South Carolina suggested recruitment declined rapidly in the state after 2008 with abundance of sub-adults and adults following suit after 2010 with terminal year estimates indicating the population was experiencing overfishing (Murphy 2017).

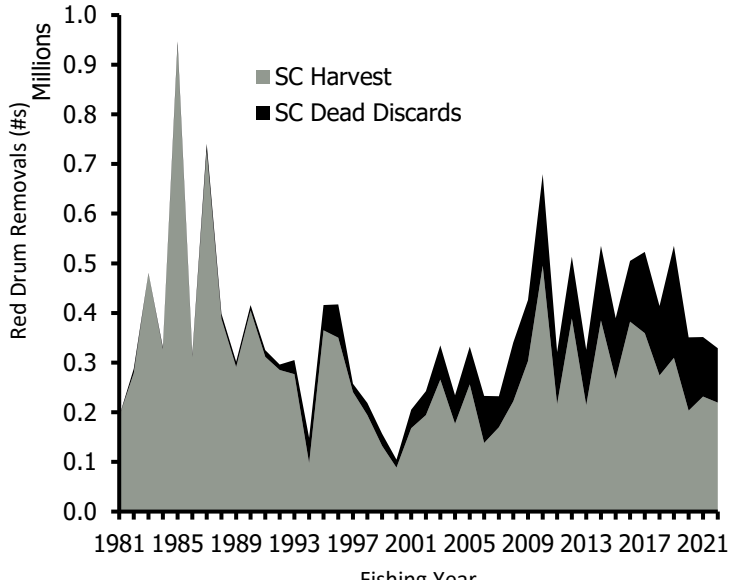


Figure 1: Red drum recreational (and commercial) removals from the southern population (top) and South Carolina specifically (bottom) for the 1981-2022 fishing years (Sept. 1 - Aug. 31). Shown are removals based on direct harvest and dead discards assuming an 8% discard mortality rate (ASMFC 2017; SEDAR 2015). Recreational harvest and discard data by state obtained from a Marine Recreational Information Program Query (NMFS. pers. comm.).

Currently, a new regional assessment of the southern population is being conducted through the SouthEast Data Assessment and Review (SEDAR) process by representatives of the Atlantic States Marine Fisheries Commission and Atlantic coast states. This assessment is scheduled for peer review in August 2024, with assessment results released for use by fisheries managers in late 2024. Data provided to the assessment suggests removals

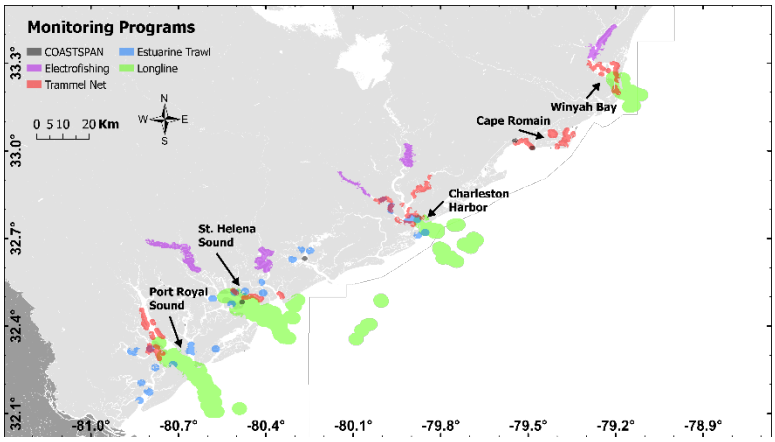


Figure 2: SCDNR Inshore Fisheries fishery-independent monitoring program survey areas.

in South Carolina and across the population have increased in recent years to levels observed in the early- to mid-1980s (Figure 1).

POPULATION SIZE AND DISTRIBUTION

Red drum are encountered by three SCDNR fishery-independent surveys operating in estuarine and coastal South Carolina waters, the SCDNR electrofishing survey, SCDNR trammel net survey, and SCDNR coastal longline survey. These surveys sample different habitats used by and life stages of red drum in South Carolina, with the electrofishing survey encountering primarily sub-adult (age-0 to age-3) red drum using upper estuary, low salinity (0-5 ppt), riverbank habitats during all months of the year (Figure 2). The trammel net survey also encounters sub-adults (age-0 to age-5) during all months of the year, though it samples lower estuary, salt marsh edge and oyster reef habitats (Figure 2). Adult red drum (ages 3+) are captured in the seasonal longline survey near the mouths of estuaries and in coastal ocean channel edge and live bottom/artificial reef habitats from mid-August through early-December.

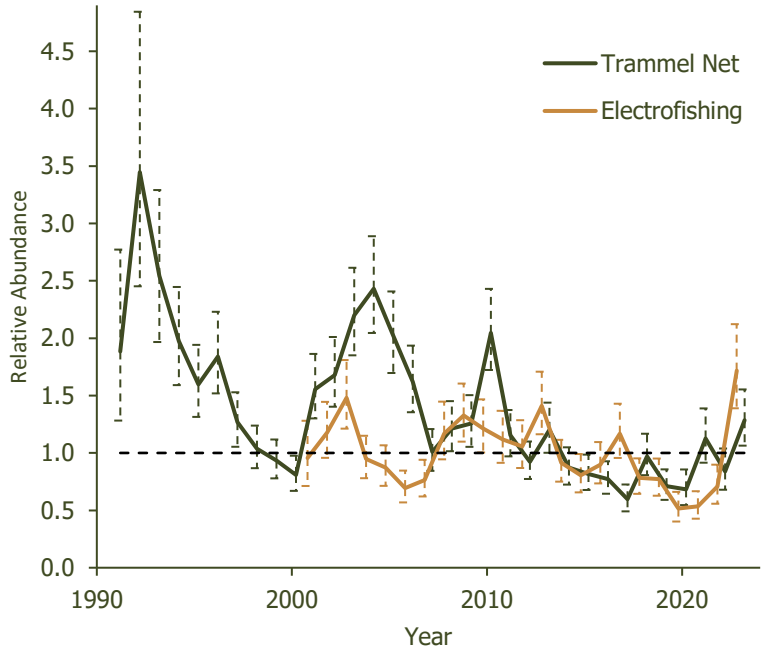


Figure 3: SCDNR Inshore Fisheries sub-adult (top) standardized indices of abundance for red drum. Provided are indices from the trammel net (green), electrofishing (gold). Error bars represent 95% CIs.

The two sub-adult surveys both indicate long term declines in abundance of sub-adult red drum across coastal South Carolina through the early-2020s, followed by a slight increase in recent years (Figure 3). For the trammel net survey, which has the longest time series, we observe a much larger decrease in relative abundance through time from highs in the early-1990s. The adult index has been much more stable through time, though there are indications of decreases in the last two years (Figure

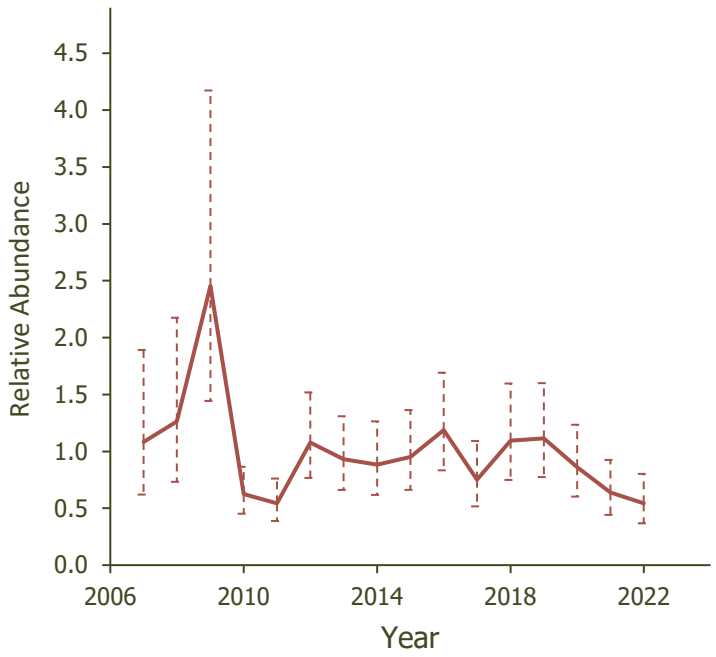


Figure 4: SCDNR Inshore Fisheries Coastal longline survey standardized index of abundance for adult red drum. Error bars represent 95% CIs.

4). This is expected given the integration of many year classes in the adult index, making it less responsive to population change.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Red drum can be found in most estuarine and coastal aquatic habitats found along coastal South Carolina, ranging from tidally influenced, oligohaline (0-5 ppt) riverine habitats to nearshore artificial reefs. While widely distributed, there are ontogenetic shifts in habitat use through time, resulting in different critical habitats throughout their life (ASMFC 2024; Odell et al. 2017). Adult red drum aggregate to spawn in a range of habitats, including estuaries, near inlets, and bay mouths, from late summer to late fall (Peters and McMichael 1987). Post-spawning, eggs and larvae are transported throughout estuarine environments, initially being found in high salinity (>25 ppt) waters adjacent to adult spawning habitats (Nelson et al. 1991; Reyier & Shenker 2007; Renkas 2010) but being found throughout estuaries, including low salinity nursery areas upon settlement where they tend to remain throughout early and late juvenile stages (Holt et al. 1983; Pattillo et al. 1997; Rooker & Holt 1997; Rooker et al. 1998; Stunz et al. 2002). Wenner (1992) indicated red drum juvenile habitats vary slightly seasonally in South Carolina; most often between August and early October red drum reside in main channels of rivers ranging in depths from 10 to 50 ft (3-15 m). Studies show red drum inhabiting non-vegetated sand bottoms exhibit the greatest vulnerability to natural predators (Minello and Stunz 2001). As juveniles transition to sub-adults (~200 mm+ TL), the distribution within estuaries varies seasonally as individuals grow and disperse. It is in the sub-adult stage red drum are most vulnerable to contemporary fisheries. Tagging studies indicate these fish remain in the vicinity of a given area (Beaumarriage 1969; Wenner et al. 1990; Troha 2023), with movements observed typically linked to changes in temperature and food availability (Pafford et al. 1990; Woodward 1994), increasing the risk of localized depletion.

CHALLENGES

Red drum along coastal South Carolina face a number of challenges, including increased fishing pressure, changing and increasingly stressful environmental conditions, loss and degradation of habitats critical to juvenile and sub-adult red drum, and other anthropogenic stressors such as contaminants and pollutants. In combination, these challenges are leading to long-term declines in sub-adult abundance (Figure 2) and recruitment (Murphy 2017; SEDAR 2015), evidence of size- and age-truncation and decreases in adult abundance (Figure 4) and documented overfishing conditions (Murphy 2017). Further, while population abundance trends and life history of red drum is well studied in South Carolina, major data gaps still exist, including the size composition of recreationally released fish (ASMFC 2022; SEDAR 2015); hence, the sizes and ages subject to post-release mortality and fishery selectivity, and the impact (lethal and sublethal) of catch-and-release fishing on adult red drum prior to , during and after the spawning season. Emerging challenges facing red drum, and many other estuarine species, include the impact of warming estuarine waters and marine heat waves during critical life history stages, phenological changes in weather patterns and food web dynamics, and increased variability in the climate. Finally, the impact of contaminants of emerging concern, such as per- and polyfluoroalkyl substances and microplastics among others, on the productivity of the population still needs investigation, particularly given recruitment appears closely tide to environmental conditions (Goldberg et al. 2020; SEDAR 2015).

CONSERVATION ACCOMPLISHMENTS

Red drum management in South Carolina began in the late-1980s as regional assessments (Vaughan and Helser 1990; Vaughan 1992; Vaughan 1993) suggested high fishing mortality and low escapement of red drum throughout the 1980s and into the early-1990s. This led to the adoption of fishery management plans by the Atlantic States Marine Fisheries Commission (ASMFC 1984) and the South Atlantic Fisheries Management Council, and the adoption of minimum size limits and a complete banning of commercial harvest in South Carolina by 1990. Later assessments (Vaughan 1996, Vaughan & Carmichael 2000), indicated overfishing continued on the regional population, leading to further management changes in South Carolina and other states intended to restrain harvest to sustainable levels. This led to a 15-24” TL slot limit and a 2 fish per person per day bag limit in South Carolina by 2001. Despite a short term increase in sub-adult abundance in the early-2000s, abundance trends in South Carolina (Figure 3) and state (Murphy 2017) and regional (ASMFC 2017;SEDAR 2015) assessments suggested continued overexploitation of the population, leading to management action resulting in our current regulations in South Carolina (15-23” TL slot limit, 2 fish per person per day bag limit, 6 fish per boat per day boat limit, and a prohibition on commercial harvest) which went into effect in 2018. Further, given the restrictive nature of the fishery and rise in population of catch-and-release fishing,

SCDNR has promoted the use of handling techniques and terminal tackle conducive to lower post release mortalities.

CONSERVATION RECOMMENDATIONS

Regional assessments have identified numerous research recommendations conducive to the effective assessment and management of the southern population of red drum, including the short term priorities:

- development of methods to estimate recreational discard catch length compositions coastwide,
- greater intensity of age sampling of adults to better characterize year class strength when size-at-age overlaps considerably,
- collect data to estimate movement rates of sub-adults in inshore waters to the adult population in offshore/nearshore waters for development of a multi-area assessment model,
- expand biostatistical sampling to better cover all statistical strata and collect more otolith ages proportion to lengths to support development of seasonal models,
- determine batch fecundity estimates of red drum to support fecundity-based assessment of reproductive potential,
- further study of post release mortality and sub-lethal effects of landings, particularly as impacted by fishing depth, fish size, fishing season, and the type of terminal tackle used,
- determine the contribution of stocked fish to wild populations and their impacts on stock status, and
- investigate appropriateness of reference points used for red drum management.

Longer term, research priorities identified in assessments include:

- expanding tag-recapture analyses to develop direct estimates of exploitation rates and apparent survival,
- incorporate tag-recapture data directly into integrated assessments for stock status determination, and
- identify impacts of water quality, environmental, ecosystem, and habitat changes on red drum stock dynamics and incorporate into our assessment of population dynamics.

MEASURE OF SUCCESS

The fishery-independent programs conducted by the SCDNR Inshore Fisheries research group annually monitors the relative abundance, population demographics (size- and age-compositions) and reproductive potential of estuarine finfish, such as red drum. These surveys can detect changes in those parameters, providing critical data for the

assessment of stock status and early detection of change (positive or negative) in abundance or population demographics. A sustained reversal of the twenty plus year decline in red drum sub-adult abundance and several years of above average recruitment would provide a tangible measure of management success.

Further, work identifying abiotic and biotic drivers of population fluctuations, in particular concerning recruitment, remain critical for projecting the response of red drum to future climate change, climate variability, and emerging contaminants of concern.

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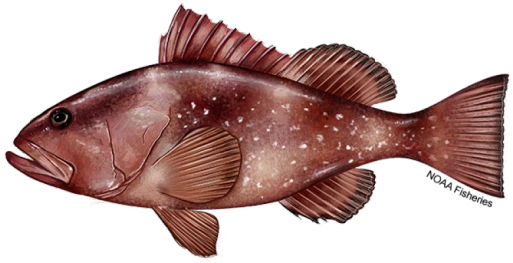
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Red Grouper

Epinephelus morio



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DESCRIPTION

Taxonomy and Basic Description

The Red Grouper, *Epinephelus morio*, is a medium-sized grouper of commercial and recreational importance in South Carolina. Adults are found on offshore reefs and man-made structures where they are top-level predators (Heemstra et al. 2002; Spanik 2018). The Red Grouper is a member of the family Epinephelidae (groupers) within the order Perciformes (Page et al. 2023).

The Red Grouper is a robust reddish-brown colored fish with body depth distinctly less than head length. The body is elongate and the head is pointed. The mouth is large and bright reddish orange in color with several fixed canine teeth. The scales are small and number from 112 to 128 in the lateral line series. The dorsal fin is continuous with 16 or 17 soft rays and 11 spines with the second or third spine being longer than the first. The anal fin has 3 spines and 8 to 10 soft rays. The caudal fin is convex in small fish (standard length less than 15 cm) but becomes truncate or slightly concave in larger individuals (Heemstra et al. 2002). The maximum adult total length (TL) for Red Grouper is at least 90 cm (35 in.) and the maximum weight is around 20 kg (45 lbs.; Heemstra et al. 2002).

Red Grouper color is a dark reddish-brown on the head and body and becomes lighter pinkish-red ventrally. The dorsal, caudal, and anal fins are dark on the edges with a thin white border. Red Grouper usually have dark spots on the nose or cheeks and the body has asymmetrical white spots and/or large pale patches (Heemstra et al. 2002).

Red Grouper are protogynous hermaphrodites, which means that they are born as females, subsequently changing sex from female to male. Females reach sexual maturity at around 48 cm TL and 2.8 years old. Sexual transition from female to male occurs when the fish are around 79 cm TL and roughly 7.7 years of age (Burgos et al. 2007; SEDAR 2010; SEDAR 2017).

Status

The most recent stock assessment was completed in 2017 (with 2015 as the last year of data included) and results indicated the stock off the coast of the Southeastern US is overfished and that overfishing is occurring (SEDAR 2017). The stock of Red Grouper off the southeast Atlantic coast was listed in 2023 as overfished but not currently

undergoing overfishing under the Sustainable Fisheries Act (SFA) standards (NOAA Fisheries 2024a). Red Grouper are listed as Vulnerable by the IUCN.

POPULATION SIZE AND DISTRIBUTION

Red Grouper are found in the western Atlantic, primarily from North Carolina to Southern Brazil including Bermuda, the Gulf of Mexico, and the Caribbean, with juveniles occasionally reported as far north as Massachusetts. Red Grouper off the continental U.S. are managed as two separate stocks, the Gulf of Mexico stock managed by the Gulf of Mexico Fishery Management Council and the South Atlantic stock managed by the South Atlantic Fishery Management Council (SAFMC). However, there is evidence the two populations are genetically related via larval recruitment and gene flow (Bernard et al. 2020). Red Grouper off the Atlantic coast have a disjunct distribution, and are commonly captured off North Carolina, northern South Carolina and southern Florida, but are rare from southern South Carolina to northern Florida (McGovern et al. 2002; Figure 1). On the continental shelf off South Carolina, Red Grouper have been collected at depths from 22-101 m (72-331 ft.) by the Southeast Reef Fish Survey chevron traps (SERFS, see Figure 1).

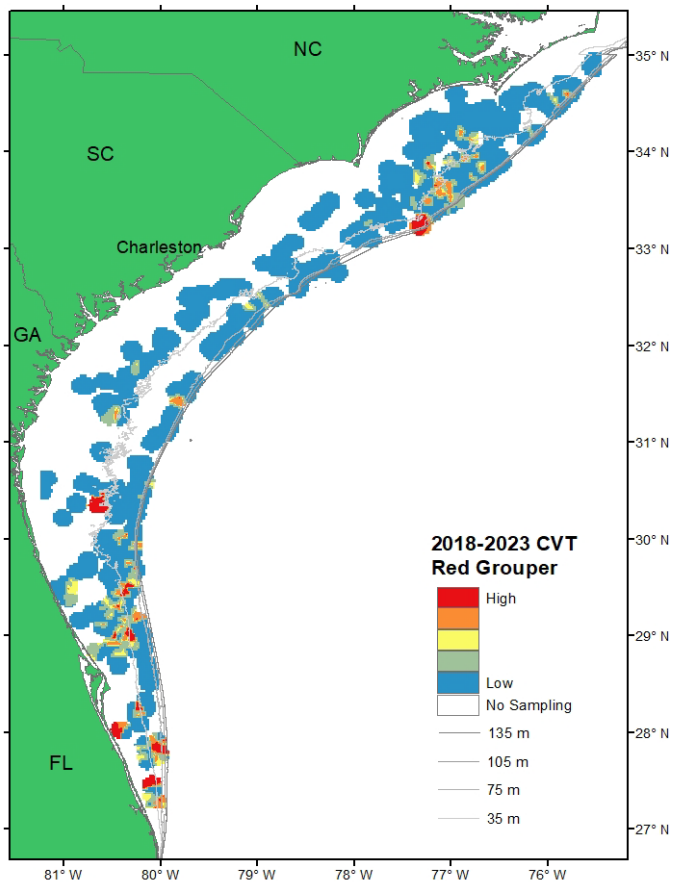
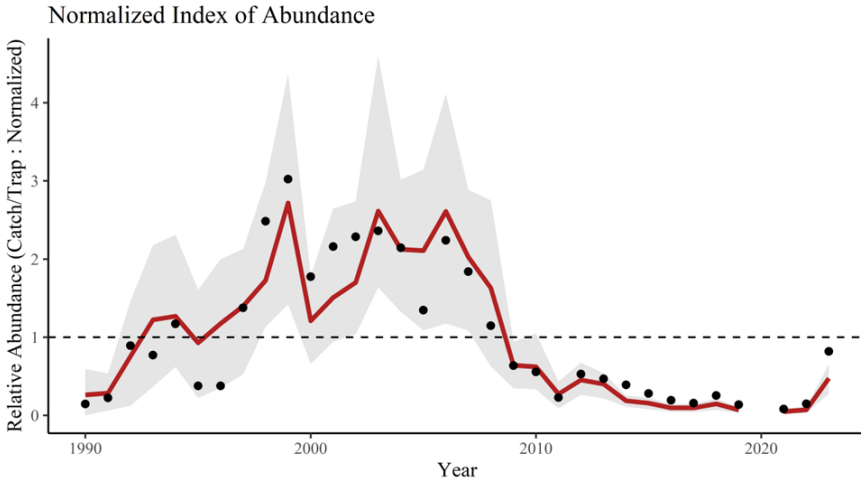


Figure 1: Distribution map of Red Grouper catches from SERFS Chevron Traps in 2018-2023 (Vecchio et al. 2024).



Two data sources suggest a decline in Red Grouper population off the Southeast U.S. Atlantic coast and were used in the most recent assessment. Fishery-independent data collected by SERFS (1990-present) indicates an overall decline in relative abundance since 2007 (Vecchio et al. 2024; Figure 2). A small uptick in the relative population estimate was seen in the 2023 data, but this increase does not rise to the level of the long-term average for the species. Southeast U.S. Atlantic coast commercial and recreational fisheries landings have also been in decline since around 2007 (NOAA Fisheries 2024b, ACCSP 2024; Figure 3).

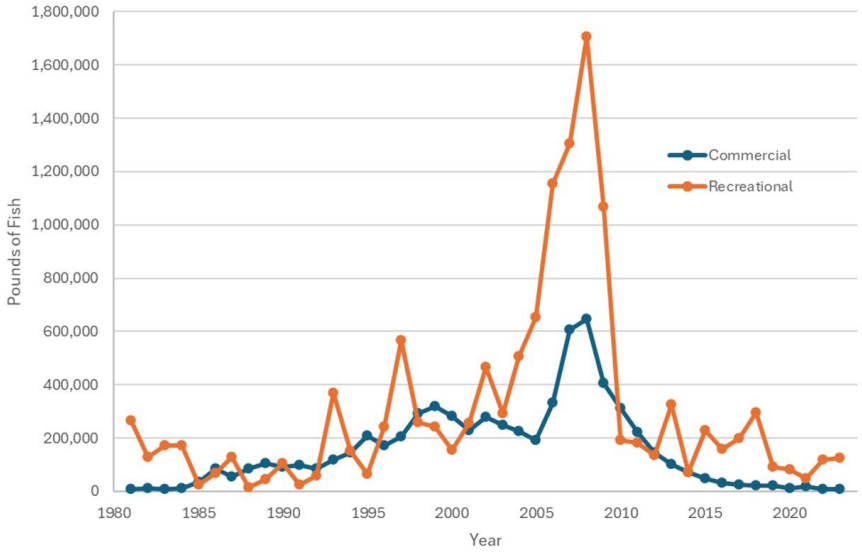


Figure 3: Commercial and recreational landings (in lbs) of Red Grouper for the South Atlantic Coast.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Red Grouper occupy offshore waters with rocky ledges/crevices and other live-bottom habitats with sponges, corals, algae, etc. (Heemstra et al. 2002). Red Grouper are known to create habitat for themselves and other marine species, both fish and invertebrates, by removing sand from rocky structures (Coleman et al. 2010; Ellis et al. 2017). It has been found that juvenile Red Grouper stay in shallower waters (< 40 m) until reaching maturity at which point they move into deeper waters for spawning. Transitioning and male Red Grouper have been found to inhabit deeper water (> 40 m) year round while females may move to shallower waters after the spawning season (Sedberry et al. 2006; Burgos et al. 2007). Off the southeast Atlantic coast, Red Grouper spawning occurs in deeper water (> 40 m) from February to June, peaking in April (Sedberry et al. 2006; Burgos et al. 2007; SEDAR 2010). Red Grouper exhibit an ontogenetic shift in diet with juveniles having a primarily benthic diet of crabs and other invertebrates while larger adults primarily feed on fishes (Spanik 2018; Vecchio and Peebles 2022).

CHALLENGES

Figure 2: Relative abundance of Red Grouper based on SERFS chevron trap catches. Red line is the modeled index of abundance. Gray shading is standard error Dotted line is the long term average value.

Red Grouper are vulnerable to heavy fishing pressure (Coleman et al. 2000; Sadovy de Mitcheson et al. 2020) and are considered to be overfished (SEDAR 2017). Because Red Grouper are long-lived (26 years), slow growing and late maturing (it takes 2.8 years for 50% of the female

population to become mature; Burgos et al. 2007; SEDAR 2010; SEDAR 2017), overfishing is a primary concern as such activity is likely to skew population demographics (size- and age-compositions) and reproductive ability of the population. Additionally, Red Grouper undergo sex reversal, which further results in skewed sex ratios under heavy fishing pressure; the largest fish are males and are selectively removed by the fishery (Huntsman et al. 1999; Coleman et al. 2000; Heppell et al. 2005). Red Grouper spawn in deep water (> 40 m; Sedberry et al. 2006; Burgos et al. 2007); if caught from these depths and subsequently released, mortality is high due to barotrauma from the resultant pressure changes. In addition, Red Grouper are larger in deep water and tend to be more sedentary with increasing depth, further increasing the vulnerability of males to fishing pressure (Burgos et al. 2007). Red Grouper have a minimum size limit and a spawning season closure in place to reduce fishing mortality. However, Red Grouper are also part of a multi-species fishery (snappers, other groupers, etc.), and so they are caught when not being targeted which increases the likelihood of regulatory discards and post-release mortality.

CONSERVATION ACCOMPLISHMENTS

The Red Grouper fishery off South Carolina is managed in federal waters by the SAFMC, which enacted several management measures to reduce fishing mortality. In the commercial fishery, a limited access snapper-grouper permit is required and there is a 200 lb gutted weight trip limit. There is a commercial and recreational minimum size limit of 20 inches (51 cm) T:. Red Grouper must be landed with the heads and fins intact to facilitate enforcement of regulations. Between January 1 and May 1, during the peak spawning period, there is a prohibition on recreational and commercial harvest and possession of Red Grouper and other shallow water groupers. Red Grouper harvest off the coast of North Carolina and South Carolina stays closed until June 1 while the fishery reopens May 1 off Georgia and Florida. Outside of the spawning season closure, longline use in areas shallower than 50 fathoms is prohibited and traps and trawls are banned for commercial use for Red Grouper. The recreational fishery is limited to 3 groupers (mixed species) per person per day including Gag, Black Grouper, Red Grouper, Scamp, Red Hind, Rock Hind, Coney, Graysby, Yellowfin Grouper, and Yellowmouth Grouper. Vessels fishing for snapper grouper species must have a descending device on board. In addition, the SAFMC established Marine Protected Areas (MPA) in the region in 2009 that are closed to bottom fishing year-round (SAFMC 2024).

CONSERVATION RECOMMENDATIONS

- Continue to evaluate the effects of fishing and management plans, especially MPA's that prohibit bottom fishing, on Red Grouper stocks.
- Initiate studies of the behavior, genetics and physiology of sex reversal, maturation and migration, timing of sex reversal, and movement of fish to spawning sites for Red Grouper.

- Establish a pre-recruit index of abundance by monitoring the abundance of juvenile Red Grouper off the southeast U.S. Atlantic Coast. Such an index could be used to evaluate recruitment success and predict trends in adult population size.
- More research on discard mortality, particularly the use and effect of descender devices, would benefit stock assessments of South Atlantic reef fishes.
- Evaluate the spatial structure of the stock along the southeast U.S. Atlantic coast to determine how to best assess and management Red Grouper since they display a disjunct distribution from North Carolina to Florida.

MEASURE OF SUCCESS

Measurement of management success is difficult in the absence of long-term historical data that precede expansion of the fishery in the 1970s; however, the SERFS program has monitored relative abundance, population demographics, and reproductive behavior of reef fish, including Red Grouper, since 1990. This survey can serve as an early warning sign of population recovery based on changes in abundance, size structure and sex ratio well before a full assessment can be conducted.

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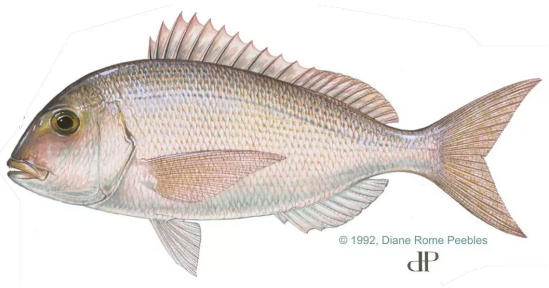
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Red Porgy

Pagrus pagrus



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DESCRIPTION

Taxonomy and Basic Description

Red porgy, informally known as "Pinky" and commercially advertised as Pink Snapper, is a member of the family Sparidae within the order Perciformes (Page et al. 2023). They possess a known maximum total length (TL) of approximately 91 cm, maximum age of 25 years old, and world record weight of approximately 7.7 kg (SEDAR 2020, Carpenter 2002, IGFA 2024). Red porgy coloration is reddish silver, with yellow and blue hues, and a yellow pigmented eye (Carpenter 2002). Adult red porgy possess an oblong, compressed body with 11 to 12 spines and 10 soft rays along their dorsal fin, an anal fin with 3 spines and 8 soft rays, and a forked caudal fin (Carpenter 2002). They have molariform teeth and a rounded posterior nostril (Goldman et al. 2016, Manooch and Hassler 1978). Red porgy are protogynous hermaphrodites, starting life as female and transitioning to male at 3.7 years of age (377 mm TL; Daniel 2003). Spawning red porgy off the southeast U.S. Atlantic coast (i.e. NC, SC, GA, and FL) have been observed from January to April, although there is some variability among regional studies (Daniel 2003, Sedberry et al. 2006).

Status

Recreational and commercial landings of red porgy in the SEUS Atlantic peaked in the 1970s and 1980s, followed by a decline (NOAA Fisheries 2024). An assessment in the early 2000s determined the stock was overfished with overfishing occurring (SEDAR 2002). Subsequent updates and assessments continued to characterize red porgy as overfished and overfishing occurring through 2017 (SEDAR 2020). Despite these findings, IUCN characterizes Red Porgy as Least Concern.

POPULATION SIZE AND DISTRIBUTION

Red porgy are found from New York to Argentina, including the Gulf of Mexico and excluding Bermuda and the Caribbean, along the mid-to-outer continental shelf in hard bottom habitats (Carpenter 2002, Bubley et al. 2023). They occur at depths of 9-280 m worldwide (Carpenter 2002, Manooch 1976). Genetic data supports the distinction of a red porgy stock in the southeast US (SEUS) Atlantic (Ball et al. 2003, Ball et al. 2007). Red porgy off the SEUS inhabit hard bottom habitats along the mid-to-outer continental

shelf and shelf-break and are more recently concentrated in the middle to northern portion of the region (Figure 1; Grimes et al. 1982, Bacheler et al. 2016, Smart et al. 2020, Vecchio et al. 2024). A fishery-independent trap survey supports a continued decline of abundance in the region for all life stages encountered (Figure 2; Vecchio et al. 2024) and more specifically a reduction in recruitment of young fish in the region (Smart et al. 2020).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

SEUS Atlantic red porgy occupy natural and artificial reefs including wrecks, hard bottom, live bottom (e.g. sponges, corals), and habitats that provide bathymetric relief (e.g. rocky outcrops, rocky ledges), in temperatures of 57-77° F (Grimes et al. 1982, Harris and McGovern 1997, Manooch and Hassler

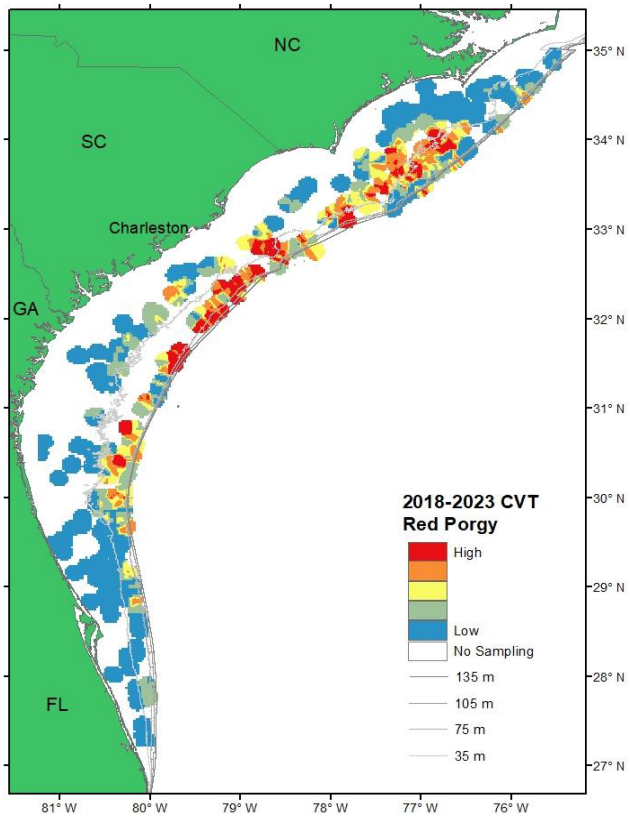


Figure 1: Figure from Vecchio et al. (2024) displaying Southeast Reef Fish Survey (SERFS) distribution of Red Porgy catches in Chevron Video Traps (CVTs) from 2018-2019 and 2021-2023, where red indicates the highest catches and blue to lowest.

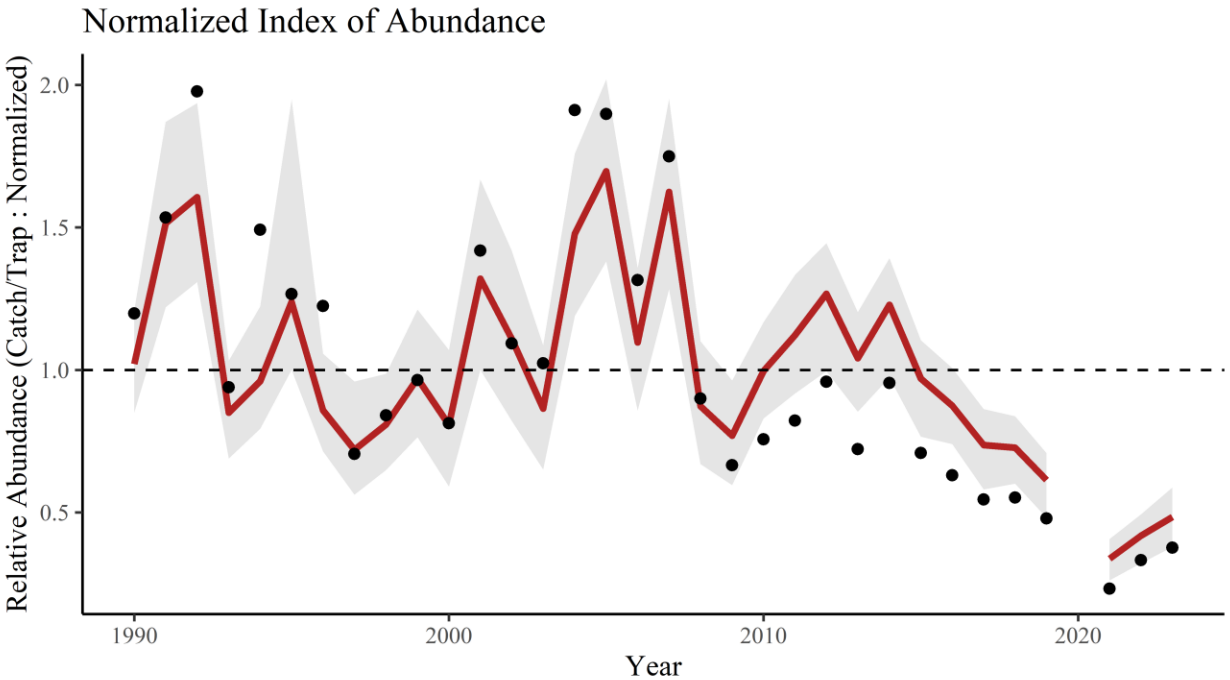


Figure 2: Figure from Vecchio et al. (2024) displaying index of abundance of Red Porgy over time from Southeast Reef Fish Survey (SERFS) Chevron Video Traps (CVTs).

1978). Juvenile Red Porgy are found in shallower depths, while mature Red Porgy are more frequently encountered in deeper water (Harris and McGovern 1997, Smart et al. 2020). Red Porgy are a relatively sedentary or non-migratory species and have a wide-ranging diet (Daniel 2003, Goldman et al. 2016, Harris and McGovern 1997, Manooch and Huntsman 1977).

CHALLENGES

Red porgy are part of a multi-species fishery, both recreationally and commercially. There is currently a spawning season closure, minimum size limits, bag and trip limits, and an annual catch limit for this species to reduce fishing mortality. However, the population continues to decline and has shown poor recruitment in the last decade. Because of the multi-species nature of the fishery, red porgy may still be caught and discarded during closures or because of size, which may lead to post-release mortality. Additionally, as protogynous hermaphrodites, red porgy males may be preferentially removed from the population due to their larger size, potentially leading to sperm limitation and reduced reproductive output. The drivers of low recruitment are currently unknown.

Red porgy in the SEUS Atlantic have been considered overfished since the mid-1990s and additionally, undergoing overfishing since 2000 (SEDAR 2020). This is a concern, as regardless of numerous regulation measures, the fishing pressure it has historically sustained has had a lasting effect (i.e. age composition bias and altering the reproductive ability of the population). Furthermore, at this time, no positive effect has been observed of the SAFMC Marine Protected Areas (MPAs) effectiveness on red porgy abundance (Pickens et al. 2021).

CONSERVATION ACCOMPLISHMENTS

The South Atlantic Fishery Management Council (SAFMC), which manages the stock, established a rebuilding timeframe in 2000. In the commercial fishery, a limited access snapper-grouper permit is required and there is a 15 fish trip limit. There is a commercial and recreational 14 in total length minimum size limit. Between January 1 and May 1, there is a prohibition on recreational and commercial harvest during their peak spawning period. Outside of the spawning season closure, longline use in areas shallower than 50 fathoms is prohibited and traps and trawls are banned for commercial use for Red Porgy. Recreational fisherman are limited to 1 fish per person per day. Vessels fishing for snapper-grouper species must have a descending device on board to reduce post-release mortality. In addition, the SAFMC established Marine Protected Areas (MPA) in the region in 2009 that are closed to bottom fishing year-round, however no positive effect has been observed for red porgy abundance (Pickens et al. 2021).

CONSERVATION RECOMMENDATIONS

- Initiate stock assessment update(s) by 2030.
- Re-assess the effectiveness of MPAs, as needed.
- Continue to monitor via fishery-dependent and fishery-independent surveys.
- Pursue non-lethal methods of determining age or reproductive condition
- Conduct a discard mortality study in conjunction with ongoing surveys.
- Investigate drivers of recruitment, including possibility of sperm limitation

MEASURES OF SUCCESS

The SCDNR Coastal Research Section monitors the economically important Snapper and Grouper fisheries off the SEUS Atlantic through the Southeast Reef Fish Survey (SERFS). The Survey, along with Federal partners, collects data on the relative abundance, population demographics, and reproductive state of these fish. With the information collected, the program can observe long-term trends and provide data needed by decision-makers for management regulations. The SERFS data can also serve as an early warning system for if management is leading to recovery or if there is a change in recruitment.

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Red Snapper

Lutjanus campechanus

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Revised 2025:
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DESCRIPTION

Taxonomy and Basic Description

Red snapper, *Lutjanus campechanus*, is a large, fast-growing, early maturing, and long-lived member of the family Lutjanidae, themselves a member of the order Perciformes (Page et al. 2023). Maximum adult total length (TL) is 1.0 m (Smith 1997) with a maximum weight of 22.8 kg (IGFA 2001). The species has been aged to 51 years in the region of the Atlantic Ocean off the coast of the Southeastern U.S (SEDAR 2021). The species is gonochoristic, with separate males and females that remain the same sex throughout their life. The age at 50% maturity is 1.3 years (SEDAR 2021).

The Red snapper's body has a sloped profile, medium-to-large scales, a spiny dorsal fin, and a laterally compressed body. Red snapper have short, sharp, needle-like teeth. Coloration is light red, with more intense pigment on the back with a red eye iris. Individuals possesss 10 dorsal spines, 14 dorsal soft rays, 3 anal spines, and 8-9 anal soft rays. Red snapper under 30 to 35 cm TL frequently have a large, dark spot on the upper sides, located below the anterior soft dorsal rays.

Status

The latest stock assessment for Red Snapper off the Southeastern United States Atlantic (SEUSA) coast indicated the stock continued to be overfished and overfishing was occurring through 2019 (SEDAR 2021). In addition, IUCN lists the species as Vulnerable throughout the species range.

POPULATION SIZE AND DISTRIBUTION

Red snapper occur from North Carolina to the Yucatan Peninsula, including the Gulf of Mexico (Nelson and Manooch 1982; Manooch and Potts 1997) where they are commonly found near reef habitats consisting of limestone outcroppings, live-bottom habitat (Powles and Barans 1980), gas and oil platforms, and artificial reefs. Red snapper occur in depths ranging from a few meters as juveniles to 210 m as adults (Camber 1955; Bradley and Bryan 1975). On the continental shelf off South Carolina, they have been collected at depths from 7-74 m (Figure 1). The species is regularly encountered in the Southeast Reef Fish Survey (SERFS) using chevron trap gear, and total abundance has increased since the beginning of the time series (Figure 2).

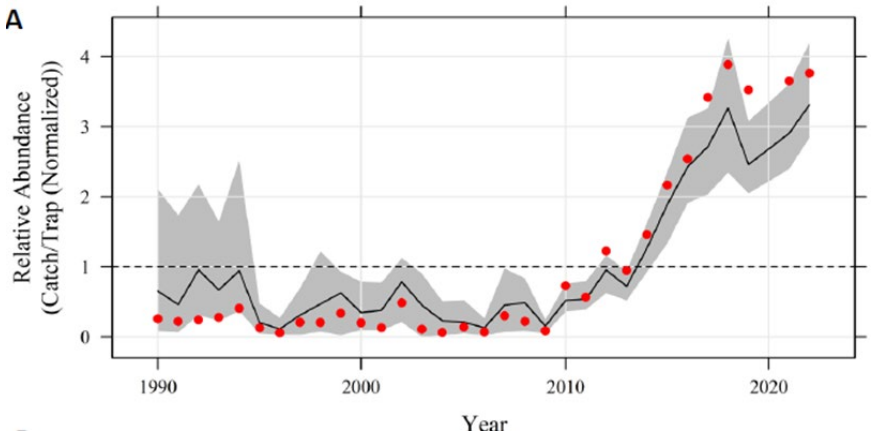
HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Adult red snapper occupy natural and artificial reefs including wrecks, hard bottom, live bottom, shelf-edge scarps, ledges, sponge/coral habitat, and other habitats that provide vertical relief above the bottom. Juvenile red snapper under one year can be found on mud or sand flats in shallow coastal waters (Stender and Barans 1994; SEAMAP 2000). In the Gulf of Mexico, red snapper juveniles are frequently taken as by-catch in shrimp trawls, but are rarely encountered by these gears in the waters of the SEUSA (Bradley and Bryan 1975; Gutherz and Pellegrin 1988).

CHALLENGES

Red snapper are considered to be overfished and are experiencing overfishing in the SEUSA (SEDAR 2021). The primary driver of overfishing in recent years has been recreational discards because of high recreational fishing effort, a recovering (but not yet recovered) population, and the aggressive nature of the species when found on mixed-species reefs. Red snapper are frequently caught in deep water, 30+ m (98+ ft.); if caught from these depths and subsequently released, mortality can be > 20% due to barotrauma associated with pressure changes. In 2022 the South Carolina General Assembly passed legislation that allows for year-round harvest of up to two red snapper per person per day with a minimum size of 20 inches total length in state waters (SC Bill -S.980). However, due to the relative low numbers of large fish in state waters and sparse enforcement ability, it can be difficult to discern whether a fish is being landed legally.

Figure 1: Distribution map of Red Snapper catch from Chevron Traps in 2018-2023.



CONSERVATION ACCOMPLISHMENTS

The red snapper fishery off South Carolina is managed in federal waters by the South Atlantic Fishery Management Council (SAFMC 2013). In the commercial fishery, a limited access permit is required. There is currently a prohibition on recreational and commercial harvest and possession of Red Snapper in federal waters, except a brief open season that is announced annually by SAFMC. In addition, the SAFMC established Marine Protected Areas (MPA) in the region in 2009 that are closed to bottom fishing year-round (SAFMC 2013). As of July 2020, all recreational fishing boats were required to have a descender device rigged and ready to help mitigate discard mortality. The SEDAR73 stock assessment for red snapper in 2021 provided updated information as to the status of the population in the region. This assessment estimated that, since 2010, total abundance and spawning stock have been increasing at a relatively rapid rate, showing substantial progress toward rebuilding (Figure 3). Despite overfishing, this increase in abundance has been stimulated by higher-than-average recruitment.

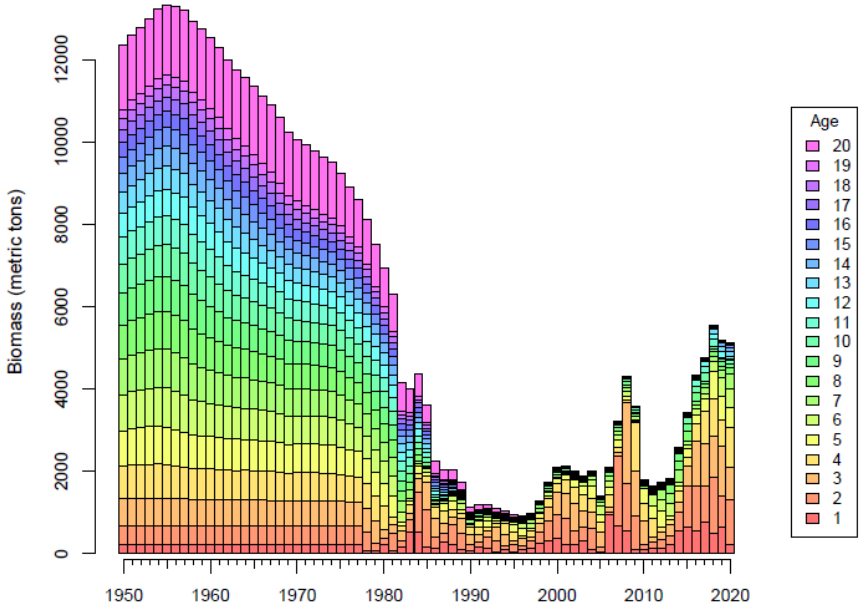


Figure3: Estimated biomass at age at start of year (SEDAR 2021).

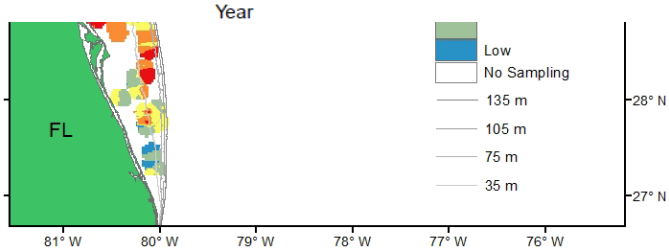


Figure 2: Chevron trap index of abundance for Red Snapper

CONSERVATION RECOMMENDATIONS

- Continue to evaluate the effects of management plans, including MPA's, on red snapper stocks.
- Continue to monitor red snapper populations via fishery-independent sampling.
- Initiate studies of the early life history, juvenile habitat preference, and spawning locations.
- More research on discard mortality, particularly the use and effect of descender devices, will improve estimates of discard mortality.

MEASURES OF SUCCESS

The SERFS program that annually monitors relative abundance, population demographics and reproductive status of reef fishes can detect changes in those parameters that result from management efforts. Measurement of management success is difficult in the absence of long-term historical data that precede expansion of the fishery in the 1970s; however, SERFS monitoring can detect changes in relative abundance and population demographics that respond to fishing pressure or management regulations. Increases in abundance, and size- and/or age-expansion in the population would indicate positive trends in the population.

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Ridge-back Shark Guild

Sandbar Shark *Carcharhinus plumbeus*
Dusky Shark *Carcharhinus obscurus*
Bignose Shark *Carcharhinus altimus*

Contributors (2025):
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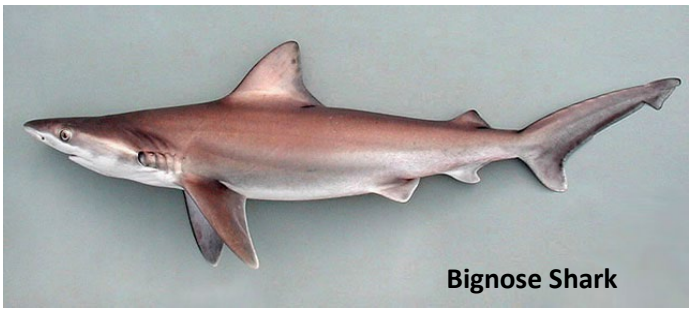
DESCRIPTION

Taxonomy and Basic Description

The sandbar, dusky, and bignose sharks are morphologically similar members of the family Carcharhinidae. All three species have a ridge between the first and second dorsal fin which is used for management purposes to define species that may not be taken recreationally. All are placentally viviparous (bear live young with a maternal connection) and are thought to be more sensitive to commercial and recreational harvest than other Carcharhinids. Sandbar sharks can be distinguished from dusky and bignose sharks using several characteristics. The dorsal fin on a dusky shark is smaller than bignose and sandbar sharks and originates behind the free rear tips of the pectoral fins, whereas the origin is over the pectoral fins in sandbar and bignose sharks. The sandbar shark has a shorter snout than a bignose, with bignose snouts being equal and greater than their mouth width; further, the dorsal fin on bignose sharks is smaller than found on sandbars.


Sandbar Shark

The sandbar shark is the most common member of the group and is a moderate sized shark reaching a maximum reported total length (TL) of 234 cm (Castro 2011). There is considerable debate on the reproductive periodicity of sandbar sharks with research indicating a biennial or triennial reproductive periodicity with an average brood size of 8 pups born in May to June at ~ 60 cm TL (Driggers et al. 2017). It is possible that both reproductive periodicities are present within the population as energy stores may control whether a female has a litter every two or three years. Maximum estimated age is 31 years with 50% maturity estimated at 13.1 for males and 14.1 for females (Hale and Baremore 2013). Tag and recapture data suggest sandbar sharks likely live longer than the reported maximum estimated age.


Bignose Shark

Bignose sharks reach slightly larger lengths than sandbar sharks, with a maximum reported length of 282 cm TL. The life history of this species is poorly understood; to date, no peer reviewed studies of age and growth or reproduction of this species in the western North Atlantic exist. Castro

(2011) reported a size at birth of 75 cm TL, with an average brood size of 7.


Dusky Shark

The dusky shark is the largest of these three species and is the largest member of the genus *Carcharhinus* with maximum reported lengths of 384 cm TL. Dusky sharks have a triennial reproductive cycle with an 18 month gestation period. Dusky shark pups are much larger than sandbar and bignose shark pups with an average size at birth of 95 cm TL (average brood size of 7.1) (Castro 2011). The maximum estimate age of dusky sharks is 39 years (Natanson et al. 2014).

Status

The above-mentioned species are classified as large coastal sharks (LCS) and are managed as a complex by the National Marine Fisheries Service (NMFS). Due to their similar appearance, they are managed as a subgroup of "ridgeback sharks" and recreational retention of all species are prohibited. Commercial retention of sandbar sharks is allowed; however, only be commercial fisherman participating in a highly controlled research fishery. Commercial retention of dusky sharks and bignose sharks is prohibited. All three species were heavily fished both recreationally and commercially prior to the implementation of management. This fishing pressure led to significant declines in abundance for all three due to the relatively low reproductive output of these species. The sandbar shark stock status has been assessed several times with the most recent assessment finding the stock is overfished, but overfishing is not occurring (SEDAR 54). Dusky sharks have also been assessed several times with the most recent stock assessment indicating dusky sharks are experiencing overfishing, and the stock is overfished. Dusky sharks suffer from high at-vessel and post-release mortality when captured as bycatch, and despite the ban on landings, the post-release mortality experienced by the population may be of large enough magnitude to keep the population in an overfishing occurring stock status (SEDAR 21). The International Union for Conservation of Nature (IUCN) Red List lists both sandbar and dusky sharks as endangered with decreasing populations (Rigby et al. 2019; Rigby et al. 2021). Bignose sharks have never undergone a stock assessment, they are primarily captured as bycatch within the commercial pelagic longline fishery, and there are no estimates of at vessel or post-release mortality rates for the species. The IUCN considers bignose sharks threatened with decreasing populations (Rigby et al. 2020).

POPULATION SIZE AND DISTRIBUTION

All three species have a circumglobal distribution although bignose sharks have a patchy distribution (Ebert et al. 2013). In US waters sandbar sharks are common from New England to Texas, with individuals commonly migrating between the Gulf of Mexico and the US Atlantic. All life stages of sandbar sharks are found in SC waters with SC estuarine waters serving as a nursery are for sandbar sharks (Ulrich et al. 2007). While SCDNR surveys generate ample data on young of year sandbar shark recruitment (Figure 1) and abundance of all life stages (Figure 2), dusky sharks are rarely captured. Dusky sharks have a similar distribution to sandbar sharks in US waters; however, they are not typically

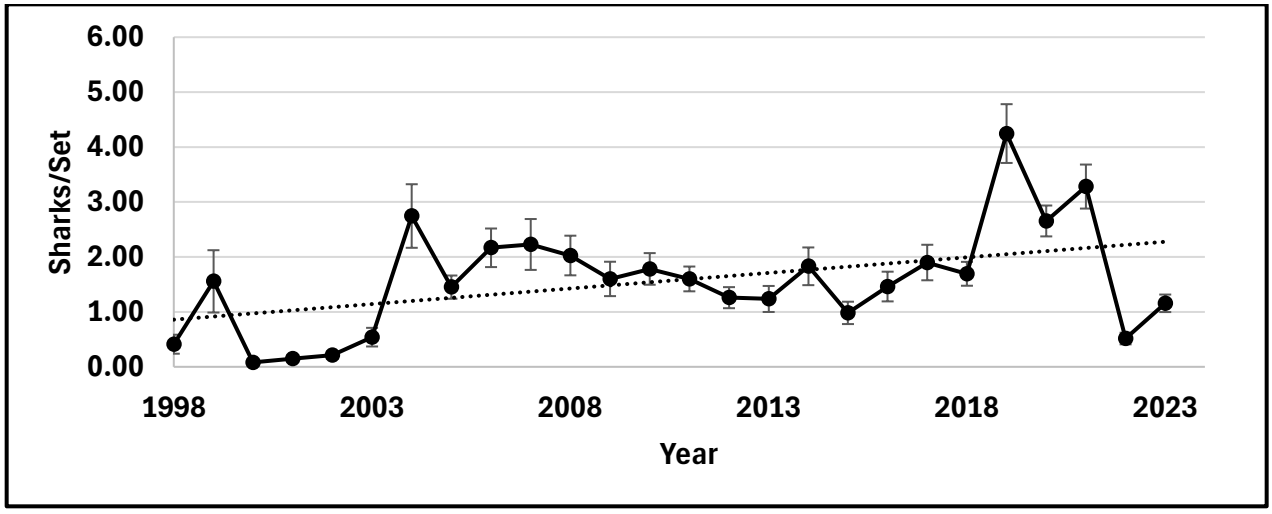


Figure 1. Catch per unit effort (sharks per set) of sandbar sharks from 1998 to 2023 in the South Carolina Cooperative Atlantic States Shark Pupping and Nursery Habitat Survey. Standard error is denoted by error bars. This survey primarily monitors recruitment of young of year sandbar sharks.

found in estuarine waters with young of year and juveniles preferring nearshore waters. Dusky sharks were more frequently observed in the early years of SCDNR monitoring; however, as the population was exploited, the populations center of abundance may have also shifted northward with most young of year and juvenile dusky sharks now found off of Maryland to North Carolina. Young of year dusky sharks are infrequently captured in SC waters, mature individuals are more commonly encountered in depths from 50 to 500 m. Off the US Bignose sharks are though to inhabit waters to a maximum depth of 840 m from Delaware to Florida, however they are rarely captured in fishery independent surveys and are considered data poor.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

In South Carolina, young of year and juvenile sandbar sharks are commonly found in deeper sandy and muddy bottoms habitat in estuarine and coastal waters (Ulrich et al. 2007). While sandbar shark diet hasn't been formally quantified in South Carolina they are known to actively feed on a variety of bony fish (mostly benthic) before switching to larger teleosts and smaller elasmobranchs as large juveniles and adults (Shiffman et al. 2014). Adult sandbar sharks are primarily found in nearshore waters out to 100 m although they can be found in large abundance near the mouths of rivers and sounds. Port Royal Sound, St. Helena Sound, and Bulls Bay have been documented as primary nurseries for sandbar sharks.

Dusky sharks primarily utilize coastal to offshore waters. Young of year dusky sharks are infrequently observed in coastal SC waters; juveniles are rare. Adult dusky sharks can be found in coastal waters from 50m out to 500+ m, often associating with the shelf edge or live bottom habitats and gulf stream eddies. Little is known about habitat requirements for bignose sharks, as most catches are associated with pelagic longlines targeting swordfish.

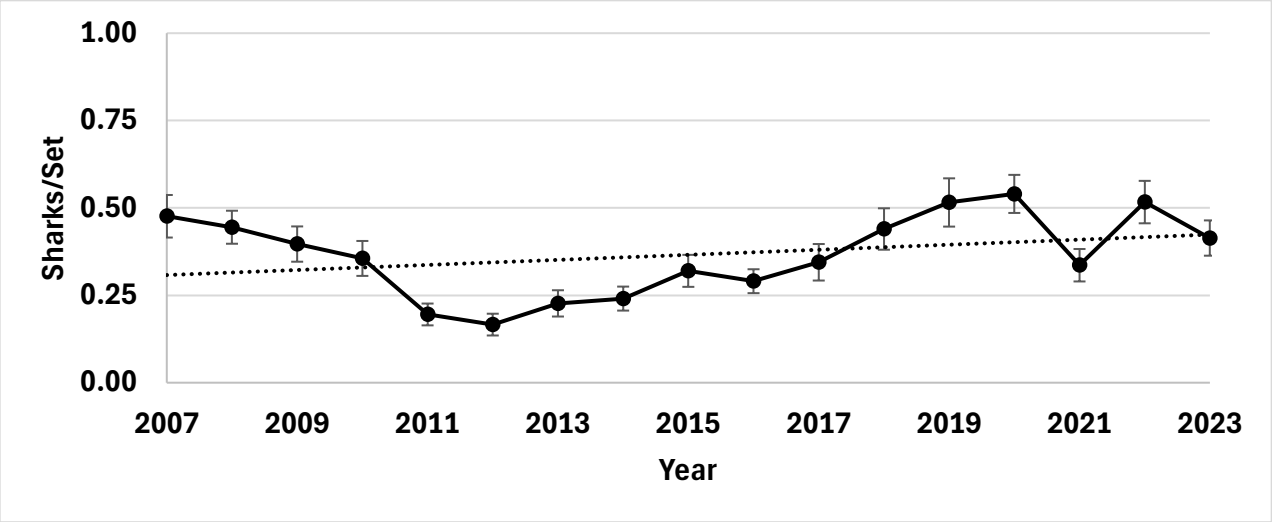


Figure 2. Catch per unit effort (sharks per set) of sandbar sharks from 2007 to 2023 in the South Carolina Coastal Longline Survey. Standard error is denoted by error bars. This survey monitors abundance of juvenile and adult sandbar sharks.

CHALLENGES

Large coastal sharks, specifically ridgeback sharks, have been shown to be the most affected species by the overfishing that occurred prior to implementation of a federal fishery plan for sharks. As such, these species are continuing to recover as their life histories only allow slow population growth. As such, they are particularly susceptible to fisheries interactions (i.e. bycatch and post-release mortality). As these species are easily confused it is imperative to promote safe handling and release of ridgeback sharks. In recent years, interactions between humans and sharks (in the form of depredation) has increased. These negative interactions have caused negative sentiment towards coastal sharks (in particular, sandbar sharks) potentially hampering recovery efforts of these species. Moving forward, it will be important to document as well as attempt to mitigate depredation of recreational and commercial catch by sharks.

CONSERVATION ACCOMPLISHMENTS

There are no conservation accomplishments specific to this species at this time.

CONSERVATION RECOMMENDATIONS

- Continue to monitor the stock status of ridgeback sharks within SC waters through fishery-independent methods, primarily COASTSPAN, and the Coastal Longline Survey.
- Increase collection of species specific-data to allow for future species-specific stock assessments.
- Implement genomic studies using Close-Kin Mark Recapture methods to estimate population sizes of ridgeback sharks (sandbar sharks in particular).
- Assess philopatry and fine-scale population structure in sandbar sharks
- Continue to study reproduction in sandbar sharks to define reproductive periodicity.
- Conduct large scale tagging of sandbar sharks throughout their range to better understand migration patterns of juveniles and adults.

- Develop methods of mitigating or preventing depredation or damage to recreational and commercial catch and gear.
- Partner with other federal, university and other southeastern states to increase understanding of the life history of species lacking data.
- Improve the public's understanding of the importance of sharks in the ecosystem through outreach activities such as school programs, providing story opportunities for media, and educational brochures.
- Continue to educate the public on the importance of species identification of sharks to ensure undersized and prohibited sharks are not landed.
- The primary action at the state level via law enforcement partnering is to insure adequate compliance with regulatory actions implemented through the federal management plan and subsequent amendments.

MEASURE OF SUCCESS

One of the most important measures of success will be the continued recovery of sandbar sharks and the recovery of dusky sharks, which seem to be lagging behind other coastal shark populations who are fully recovered or recovering (SEDAR 21). Regional management efforts to maintain healthy, sustainable populations of ridgeback sharks will require active participation from South Carolina due to its importance as nursery habitat. Maintaining ongoing monitoring programs to continue indices of abundance and trends over time is critical to the success of accurate stock assessments.

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Sand tiger

Carcharias taurus



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DESCRIPTION

Taxonomy and Basic Description

The sand tiger shark (*Carcharias taurus*), also known as the grey nurse shark or spotted raggedtooth shark, is a globally distributed species, occurring in all oceans except for the eastern Pacific (White et al. 2006, Ebert et al. 2013, SEAFDEC 2016, NFRDI 2017, White et al. 2017, Psomadakis et al. 2019, Tyabji et al. 2020). Characterized by a robust and bulky body, sand tigers reach a maximum length of approximately 325 cm (10.4 feet) total length (TL). It is distinguished by its two dorsal fins of nearly equal size, with the first dorsal fin situated just in front of the pelvic fin bases. Its caudal fin is short and asymmetrical, featuring a pronounced subterminal notch and a strong ventral lobe. The shark has five medium-sized gill slits positioned in front of the pectoral fin bases, lacks gill rakers, and possesses a short snout with small eyes that lack nictitating membranes.

The sand tiger shark's coloration includes a light grey-brown dorsal side with pale, yellowish blotches and a white underside. It has long, pointed teeth with small spine-like cusps on either side, and its body is typically adorned with reddish-brown spots, primarily on the posterior portion. The species' mouth extends beyond its eyes, and its caudal fin exhibits a long upper lobe, contributing to its strong heterocercal structure.

Sexual maturity in sand tiger sharks occurs at different sizes and ages for males and females. Males typically reach maturity at 190–200 cm TL, around 6 to 7 years of age, while females mature at 220–235 cm TL, between 9 and 10 years of age (Gilmore et al., 1993; Lucifora, 2003; Ebert et al., 2013; Weigmann, 2016). Reproduction in sand tiger sharks is adelphophagic viviparous. Females produce an average litter of 1–2 pups (due to intrauterine cannibalism), with a biennial reproductive cycle, although some studies suggest the cycle could be annual or triennial in certain regions (Cliff, 1989; Branstetter and Musick, 1994; Henningsen et al., 2004; Dicken et al., 2006; Gilmore et al., 2005; Bansemer and Bennett, 2009). The size at birth ranges from 85 to 105 cm TL. Age data for sand tigers have been validated to at least 40 years, and has an estimated 24.8 year generation length (Lucifora, 2003; Passerotti et al., 2014; Jakobs and Braccini, 2019).

Both juvenile and adult sand tiger sharks are generalist predators. Their diet includes a variety of prey such as bony fish, crustaceans, squids, skates, and small sharks. Common prey items are summer flounder, monkfish, sea robins, scup, spot, bluefish, butterfish, and tautog (Branstetter, 2002). Due in part to their size and demersal nature, sand tigers have few natural predators, though cannibalism has been observed (Branstetter, 2002).

Status

The sand tiger shark is globally recognized as Critically Endangered on the IUCN Red List (Rigby et al., 2021). The species has experienced a dramatic decline across much of its range, with populations in the southwest Atlantic and Mediterranean having decreased by over 80% over the past century, and in some areas, few or no individuals remain. In the western North Atlantic Ocean, estimates suggest a decline of 30–49% (Musick et al., 1993; Ha, 2006; Rigby et al., 2021). Conversely, in regions such as eastern Australia and South Africa, there are signs of population recovery following the implementation of management measures aimed at reducing fishing mortality. Overall, the sand tiger shark is thought to have experienced a global population reduction exceeding 80% over the past 74 years, which corresponds to three generation lengths. This severe decline underscores its critical conservation status.

POPULATION SIZE AND DISTRIBUTION

Sand tiger sharks are widely distributed and not restricted to any specific area, making them cosmopolitan. They are found across the Indian and Pacific Oceans and in the western North Atlantic Ocean, stretching from the Gulf of Maine to Florida and the northern Gulf of Mexico (Bigelow & Schroeder, 1948). In the western North Atlantic Ocean, sand tiger sharks are more abundant in warmer months, particularly in Delaware Bay, off North Carolina, and along Florida's east coast throughout the year. Adult sharks are commonly associated with wrecks off North Carolina, while juveniles are found from Massachusetts to North Carolina, predominantly in estuarine and coastal nursery habitats from late spring through October, with peak numbers in June (Bigelow & Schroeder, 1948; McCandless et al., 2007).

Adult sand tigers are present off Florida and in the Gulf of Mexico year-round, and they migrate as far north as the Gulf of Maine during the summer and fall (Branstetter, 2002; Carlson et al., 2009). Genetic research identified at least five distinct subpopulations of sand tiger sharks: western North Atlantic Ocean, Japan, west Australia, east Australia, and South Africa, with the latter possibly overlapping with Brazil and the Mediterranean (Stow et al., 2006; Ahonen et al., 2009; Fioravanti et al., 2019). These populations show low migration rates between regions and are genetically discrete from one another (Ahonen et al., 2009; Fioravanti et al., 2019).

The most comprehensive and recent population status assessment of sand tigers was conducted by Rigby et al. (2021), as a part of their IUCN Red Llist Assessment. The results of this assessment are summarized below.

In the IUCN Red List Assessment used data from three major sources: 1) western North Atlantic Ocean (Carlson et al. 2009, J. Carlson and C. McCandless unpubl. data 2020); (2) Western Indian Ocean (M. Dicken and H. Winker unpubl. data 2020); and, (3) east Australia (Reid et al. 2011). Trends in each data stream were analyzed covering three generations lengths within a Bayesian state-space framework (Sherley et al. 2020; Winker et al., 2020). Using this technique, Rigby et al., (2021) quantified the annual rate of change, a median change over three generation lengths, and the probability of the most likely IUCN Red List category percent change over three generation lengths. Based on these analyses, sand tiger sharks seem to be experiencing a decline throughout their entire range due to exploitation, with the exception of Western Australia. However, in areas where management measures that restrict retention or reduce fishing mortality have been implemented for some time—such as in the western North Atlantic Ocean, South Africa, and Eastern Australia—there are signs of potential recovery. The Eastern Australian subpopulation is estimated to have decreased by over 80% over the past three generations (74 years), while the western North Atlantic Ocean and South African subpopulations are believed to have declined by 30–49% over the same period. The species is suspected to be Critically Endangered in the western South Atlantic Ocean, Mediterranean, and Arabian Seas regions, with reductions exceeding 80% over the past three generations. In Southeast Asia and West Africa, where fishing pressure is high throughout their spatial and depth range, similar severe declines are suspected. Overall, it is believed that the sand tiger shark has experienced a population reduction of over 80% over the last three generations (74 years) due to exploitation levels.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Sand tiger sharks are primarily coastal and are typically found in waters from the surf zone down to approximately 23 meters deep. Their global range includes warm and temperate seas, excluding the eastern Pacific. They can also inhabit shallow bays, coral reefs, and extend to depths of 183 meters on the continental shelf. While they generally reside near the ocean floor, they have been observed throughout the water column.

In the western North Atlantic Ocean, sand tiger sharks occupy a variety of coastal habitats, including estuaries, nearshore areas, natural hard bottoms, artificial reefs such as shipwrecks, and the continental shelf. Their habitat preferences can vary based on factors like life stage, sex, and seasonal changes, making it crucial to understand the role of each habitat type.

Recent studies suggest that sand tiger sharks give birth along the Southeastern U.S. coast, with continental shelf waters off North Carolina playing a significant role in mating, gestation, and possibly pupping (Marens, 2021; Wyffels et al., 2022). They are reported to be present year-round in North and South Carolina coastal waters, frequently associating with artificial reefs and shipwrecks (Farmer, 2004; Schwartz et al., 2013; Paxton et al., 2019, 2020; Marens, 2021).

On the U.S. East Coast, certain areas are vital for various stages of sand tiger shark development, with some individuals demonstrating notable site fidelity. Kneebone et al. (2012) pinpointed key summer nursery sites for juvenile sand tigers in Plymouth, Kingston, and Duxbury Bay, Massachusetts. Their telemetry study from 2008 to 2011 showed that juveniles remained in these regions as late as October (Kneebone et al., 2013, 2014). Additionally, tagged sharks were tracked from the Gulf of Maine to Cape Canaveral throughout the year. While summer residency (May–October) was prevalent among these sharks in New England, juveniles were also observed off North Carolina and Florida during the winter months (November–April). Both juvenile and adult sand tigers have been known to return consistently to Delaware Bay, where they form aggregations based on maturity and show distinct habitat preferences within the bay and nearby coastal areas (Teter et al., 2015; Haulsee et al., 2016; Kilfoil et al., 2017; Haulsee et al., 2018; Roose et al., 2022).

CHALLENGES

The sand tiger shark's life history traits—such as slow growth, delayed sexual maturity, and low reproductive rates—render it particularly vulnerable to population declines (Goldman et al., 2006; Ha, 2006; Rigby et al., 2021). These characteristics, combined with ongoing bycatch and targeted catch-and-release fishing pressures in the U.S. (Kneebone et al., 2013; Kilfoil et al., 2017) and globally (Dicken et al., 2006; Lucifora et al., 2009), exacerbate the species' risk of decline (Carlson et al., 2009).

Sand tiger sharks face fishing pressure throughout their range, being caught as both target and bycatch in artisanal, recreational, and industrial fisheries using various methods such as longlines, gillnets, and trawls. They are often retained for their meat and fins, unless regulations prevent this. However, at-vessel mortality is reported as zero for demersal longlines, and the species shows high survival rates when released from longlines and rod-and-reel gear (Carlson et al., 2009; Kneebone et al., 2013; Ellis et al., 2017; Kilfoil et al., 2017). A recent vulnerability assessment rated sand tiger sharks as "High" in terms of biological sensitivity, climate exposure, and overall vulnerability (Hare et al., 2016). Additionally, their preference for inshore coastal environments makes them susceptible to habitat loss and degradation due to pollution, coastal development, and climate change.

CONSERVATION ACCOMPLISHMENTS

Species-specific protections for sand tiger sharks have been implemented in various countries and regions. In the United States, the species was listed as prohibited under the Fishery Management Plan for Atlantic Sharks in 1997 (Carlson et al., 2009). Several states have since adopted similar regulations. Additionally, the National Marine Fisheries Service (NMFS) identified the sand tiger as a candidate for listing under the Endangered Species Act (ESA) due to concerns over its low productivity and declines in abundance attributed to fishing pressures. On April 15, 2004, NMFS introduced a Species of Concern list, which included the sand tiger shark among other species, outlining factors considered for such designations (69 FR 19976). Although this status highlighted conservation concerns, it did not confer legal protection under the ESA and has since been discontinued. Other U.S. management strategies aimed at reversing the decline of sand tiger sharks include designating certain areas as Essential Fish Habitat (EFH) and Habitat Areas of Particular Concern (HAPC) within their range (NMFS, 2009, 2017).

CONSERVATION RECOMMENDATIONS

- Enacted species-specific legislative protections throughout range
- Increase studies of movement and habitat utilization to identify potential additional Habitat Areas of Particular Concern
- Explore gear modification to reduce bycatch and deleterious aspects of landing (e.g., gut hooking due to gulp-feeding mechanism)
- Increased capacity building throughout range and ongoing training to increase enforcement of existing protections
- Increased catch-monitoring to improve understanding of population trends
- Use new methods to determine census size such as close-kin mark recapture studies.
- Determine fine-scale population structure of sand tiger sharks in US waters.
- Explore non-lethal methods of age estimation to allow modeling of growth for the population.

MEASURE OF SUCCESS

- Decreased uncertainty in population trend estimates
- Reduced levels of bycatch and unwanted interactions with fisheries
- Potential increases in protected areas (Essential Fish Habitat, nurseries, spawning aggregations)

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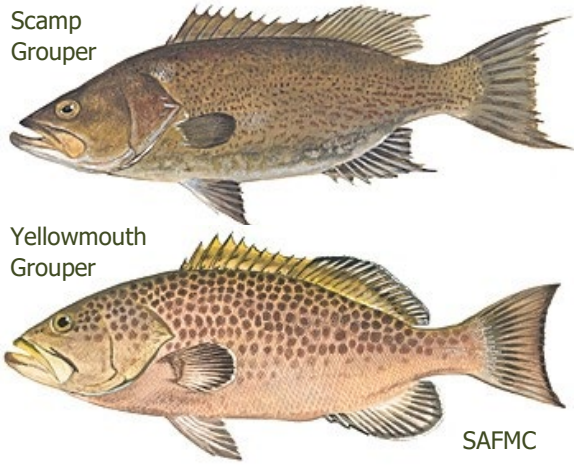
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Scamp Grouper and Yellowmouth Grouper

Mycteroperca phenax & *M. interstitialis*

Contributors:
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DESCRIPTION

Taxonomy and Basic Description

Scamp and yellowmouth grouper are part of the family Epinephelidae, themselves a part of the order Perciformes (Page et al. 2023) These species share a similar appearance that can be difficult to distinguish and along with the overlapping range throughout the Southeast United States (SEUS) presents a significant potential for misidentification (Burton et al. 2014). The high risk of misidentification in commercial and recreational landings compelled the SEDAR 68 Stock ID Workshop Participants and the Snapper Grouper Advisory Panel to recommend evaluating the two in a single stock assessment (SEDAR 2020). Following this logic, the two are combined here.

Both scamp and yellowmouth grouper are considered small to medium sized groupers. Yellowmouth grouper generally do not get as large as scamp, with a maximum size of approximately 30 inches and 20 lbs (SAFMC 2023). Scamp reach a maximum size of approximately 43 inches and 36 lbs (SAFMC 2023). Scamp are grayish brown in color with darker spots that appear blotched (sometimes described as "cat's paw" pattern) or lined. The corners of the mouth may appear slightly yellow, while the "broom-like" or raggedy appearance of the tail is different than that of other groupers (SEDAR 2020). Yellowmouth grouper are tan to brown with dark spots on the head and body. Like scamp, the corners of the mouth are yellow and there may also be yellow coloration around the eyes and at outer edges of the fins. The caudal fin has a similar filamentous appearance as scamp, but with minor differences that can be difficult to distinguish. Another indicator between species is the anal fin of adult yellowmouth grouper are typically more rounded than adult Scamp.

Their diets are similar, eating mainly fish and crustaceans. Both display behavioral color changes and are protogynous hermaphrodites (Burge et al., 2012; Gilmore and Jones, 1992). Scamp spawn from February to August with a peak from March to April, with spawning parameters having a dome-shaped relationship with age and size (Gamboa-Salazar et al., 2020). Yellowmouth Grouper are thought to spawn throughout the year, with peak from April to May (Bullock and Murphy, 1994). Results from the combined assessment indicate at least 50% of females from these species achieve reproductive maturity when they are close to 3 years of age (~15 inches total length), they transition

to males at about 10 years of age, and these species can reach a maximum age of 34 years (SEDAR 68, 2020).

Status

The combined assessment of these two species in the Atlantic waters off the southeastern U.S. determined the population in the South Atlantic region was overfished, but that overfishing was not occurring (SEDAR 2022). There is currently a commercial and recreational fishery for these species, with landings declining in both since the early 2000's (NOAA Fisheries 2024; pers. comm. from the National Marine Fisheries Service, Fisheries Statistics Division).

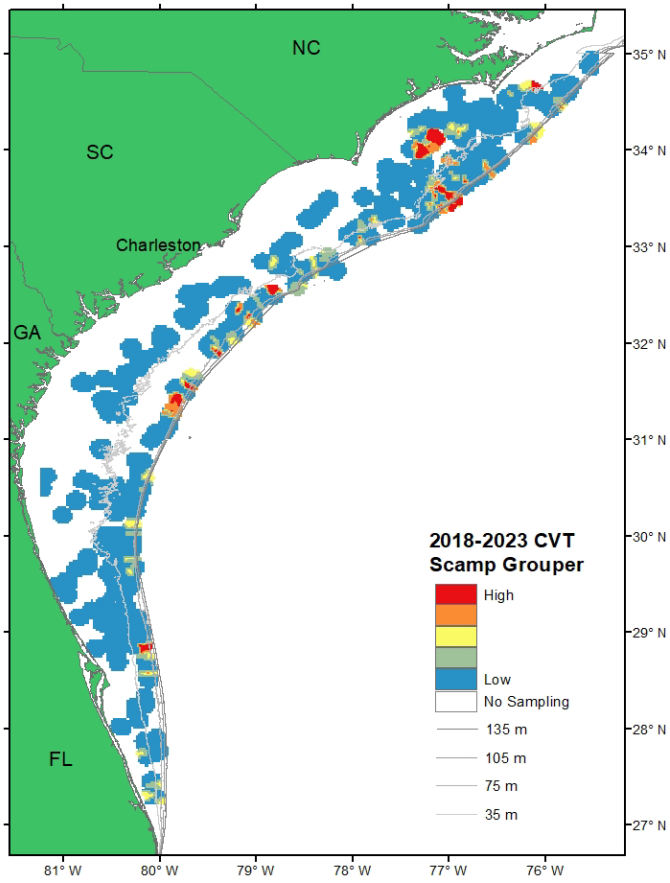
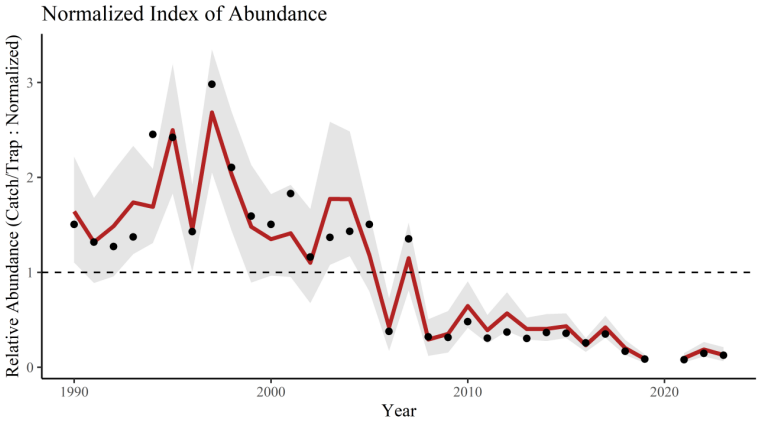


Figure 1: Distribution map of scamp catch from SERFS from 2018-2023 (excluding 2020).

POPULATION SIZE AND DISTRIBUTION

Scamp and yellowmouth grouper can be found along the Atlantic Coast of the US from North Carolina to Key West, FL, and throughout the Caribbean. Scamp's range further extends into the Gulf of Mexico to the Campeche Banks, while yellowmouth grouper's range extends further south to Brazil (Burton et al., 2014; Heemstra and Randall, 1993; Smith, 1978). The spatial distribution of scamp and yellowmouth grouper catches for the Southeast Reef Fish Survey (SERFS) is highest in the central to northern portion of the survey's sampling region (Fig. 1), which is also the northern end of geographical distribution for these species (Vecchio et al., 2024). Yellowmouth Grouper are seen by the survey but far less frequently.



Like many species in the region, scamp and yellowmouth grouper appear to be experiencing a decline in abundance and catch rates. Indices of abundance prepared annually by the SERFS using Chevron Traps indicate declining catch since 2007 (Fig. 2; Vecchio et al., 2024). Yellowmouth grouper catches are not high enough to create an independent index of abundance.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Scamp and yellowmouth grouper can be found in depths up to approximately 300 feet. They inhabit low-profile, hard-bottom areas within their geographic range. These live bottom areas are covered with hard and/or soft corals, sponges, and patches of macroalgae. While low profile habitat is generally the preferred habitat type, they also utilize ledges and high-relief rocky bottoms comprised of rocky outcroppings and ledges, or wrecks (Manooch et al., 1998; SAFMC, 2023).

CHALLENGES

Scamp, yellowmouth grouper, and other grouper species in the South Atlantic are experiencing similar challenges as other apex predators. Slower growing, long-lived species are not as resilient to disturbances compared to others in their community. This leads to more opportunities for removal from the ecological system, whether natural or fisheries-related, before their first reproductive contribution to the fishery. Because both species are also sequential hermaphrodites, there is also disproportionate targeting of the larger sex (males) which has the potential to skew population demographics. As with many other reef fish species which have substantial overlap in habitat use, there is potential for mortality even when they are not targeted in this multi-species fishery. Additionally, changing climate, warming ocean temperatures, and habitat destruction might be contributing to low recruitment and a declining population.

CONSERVATION ACCOMPLISHMENTS

Because scamp and yellowmouth grouper are highly prized by both commercial and recreational fishers (Manooch et al. 1998), both species have undergone several management actions as a result. Historically, they have been managed in the South Atlantic under the Shallow Water Grouper Complex (SASWG). Under the SASWG, both species are currently subject to an aggregate grouper bag limit of 3 per angler per day, with a minimum size of 20 inches (508-mm) total length. There is also a spawning season closure from January 1 – April 30. Since 1992, permits were required to harvest them commercially. Hook use requirements and annual catch limits (ACL) have been enacted throughout the years to accompany bag/size limits and seasonal closures (SEDAR 68, 2020). In March 2024, the SAFMC's Amendment 55 moved scamp and

Figure 2: Chevron trap index of abundance for Scamp. Normalized nominal (black dots) and standardized abundance (red line) with 95% CI.

yellowmouth grouper to their own complex so that they might be managed independently of other shallow water groupers.

CONSERVATION RECOMMENDATIONS

The greatest need when considering effective conservation metrics for these species is more data. Stock assessment analysts are required to use proxies or less robust data to make decisions about natural mortality, reproductive biology, and juvenile cohorts within the population.

Specific recommendations include:

- practical applications for addressing data inadequacies identified in assessment modeling (SEDAR 2020),
- data collection focused on smaller individuals/juveniles in the population,
- development of artificial intelligence to automate the tools used in life history evaluation and underwater video analysis that can contribute to future stock assessments (SEDAR 2020),
- investigation into taxonomic status of yellowmouth grouper,
- incorporation of ecosystem considerations in management strategies, and
- more research into nonlethal opportunities for life history data collection.

MEASURE OF SUCCESS

A direct measure of success would be a steady increase in catch rates by fishery-independent surveys and/or expansions of population size- and age-structure.

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Sheepshead

Archosargus probatocephalus

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DESCRIPTION

by Dianne Rome Peebles

Taxonomy and Basic Description

The sheepshead, *Archosargus probatocephalus* (Walbaum 1792), is a relatively large representative of the porgy family (Sparidae), most commonly found around hard bottom and structure occurring in South Carolinas estuarine and coastal waters.

The sheepshead is greenish-gray to silvery in color, with five to seven distinct vertical black bars and an oval shaped, laterally compressed, deep body (Manooch 1984; Smith 1997). The black bars remain very distinctive throughout the life of the fish. The mouth is of medium size, with prominent incisor-like teeth in the front and molars and grinding teeth in the rear. There are no barbels on the lower jaw. The posterior nostril is slit-like in appearance and the pectoral fins are long, extending beyond the anal opening when pressed close to the body (Böhlke and Chaplin 1993). The caudal fin is shallowly forked. The dorsal and anal fins possess strong spines, with the second spine of the anal fin being prominently enlarged (Robins and Ray 1986). Juvenile sheepshead are sometimes confused with young Atlantic spadefish (*Chaetodipterus faber*) or black drum (*Pogonias cromis*) when encountered in estuarine waters.

Adult sheepshead can attain a length of 76 cm (30 in.), and typically weigh from 2.3-6.8 kg (5-15 lbs.), though growth parameters vary by state (Adams et al. 2018). Fish in the 9-11.3 kg (20-25 lbs.) range are occasionally landed (Manooch 1984). The current recreationally landed record sheepshead in South Carolina is 7.4 kg (16 lbs., 6 oz.) (SCDNR 2012).

Sheepshead can have a total lifespan of 20 to 25 years, and can begin to sexually mature as early as age 1 (McDonough et al. 2011). Through fishery-independent and fishery-dependent collection of 509 sheepshead sampled for age-growth analysis in Georgia (Woodward et al. 2000), the maximum age through otoliths analysis was determined to be 17 years. In a similar effort conducted in South Carolina, the oldest individual sheepshead captured and aged by examination of otoliths was 26 years of age (Wenner 2004). Age-length data acquired by Wenner (2004) and McDonough et al.

(2011) for sheepshead in South Carolina show that fish on average reach about 25 cm (10 in.) fork length (FL) at the end of their first year, where about half of the fish remain sexually immature. Nearly all of the members of the population are mature at about 35 cm (14 in.) in length (FL), or 3 to 5 years in age (Wenner 2004; McDonough et al 2011). Sheepshead display a relatively rapid growth rate up to about age 6; size increases slowly thereafter with age.

Sheepshead are serial spawners; they spawn multiple times within a season. Females in South Carolina have been found to be capable of producing anywhere from 18,400 to 738,500 eggs per spawning event, depending on age and location (McDonough et al. 2011). This is much higher than the 1,100 to 250,000 per spawning event estimated in the Gulf of Mexico (Render and Wilson 1992; Tucker and Barbera 1987). Spawning has been documented to occur in coastal waters from late winter through early spring through the mid-Atlantic and Gulf of Mexico, with hatching of eggs occurring within 28 to 40 hours from time of fertilization, depending on water temperature. Estimates of spawning frequency determined by the presence of post-ovulatory follicles for sheepshead in South Carolina ranged from 2.5 to 20 days with an average of 7 days or once a week. With an approximate spawning season of 14 weeks (February-early May), total annual fecundity could range from 250,000 to 10,339,000 eggs per female per year (McDonough et al. 2011).

Sheepshead are an omnivorous species, feeding on a wide range of items including invertebrates, small vertebrates, and some plant material. Large juveniles and adults have been known to prey on small crustaceans, oysters, clams, and even smaller finfish (Bester and Robins 2005). Sedberry's 1987 analysis of the stomach contents of sheepshead taken from offshore hard bottom areas in the South Atlantic Bight demonstrated the importance of sessile invertebrates as an important dietary component for this species. Smaller sheepshead were found to have been feeding heavily on bryozoans, while larger specimens also included bivalves, echinoderms and ascidians in their diet. Both large and small sheepshead also feed to a lesser extent on barnacles, decapods, foraminiferans, cnidarians, polychaetes, gastropods and small arthropods as well.

The sheepshead's ability to maintain such a wide-ranging diet is supported by its rather unique dentition, as well as physical changes that can occur developmentally within its oral-jaw crushing musculature (Hernandez and Motta 1997; Cutwa and Turnigan 2000). Older fish, or fish that are in an environment where hard-shelled prey items are abundant have a much better developed feeding apparatus, capable of significant crushing power.

Sheepshead are most frequently encountered near some type of structure like pilings, jetties, oyster reefs, artificial reefs and coastal live bottom. Their close association with manmade reefs in South Carolina is documented as far back as the mid-1800s (Holbrook 1860). As a consistently popular species sought after by serious recreational

anglers, their year-round presence in South Carolina waters can be documented over time through various methods, including creel surveys (Table 1) and SCDNR's trammel net survey (Fig. 1). Creel surveys reveal the increase in catch-and-release fishing of Sheepshead over time, and the trammel net survey indicates fairly stable and consistent catches of Sheepshead since the early 1990's, though overall catches of Sheepshead in this survey are relatively low.

Table 1: Estimated number of Sheepshead harvested and released (in thousands of fish) in South Carolina by year, courtesy of the National Marine Fisheries Service (NMFS 2023).

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Harvested	458	128	66	169	141	136	204	118	164	135
Released	203	163	315	421	368	391	436	421	533	411

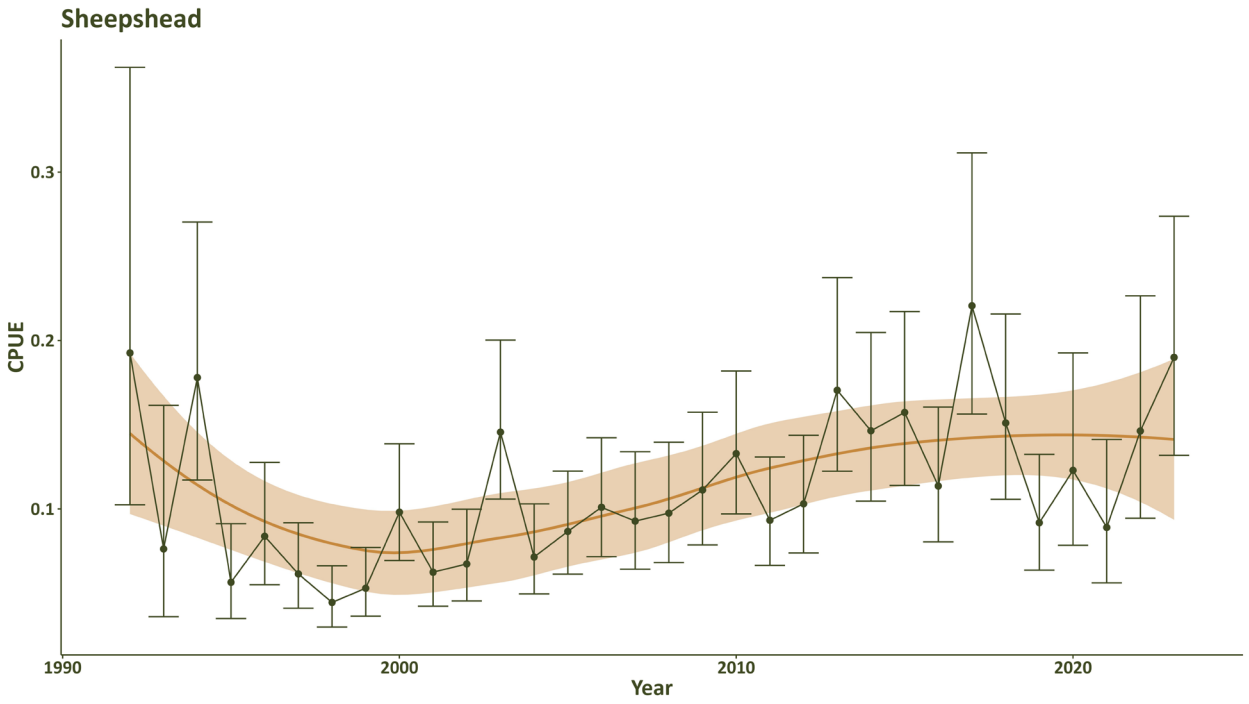


Figure 1. Sheepshead catch-per-unit-effort (CPUE) in SCDNR's trammel net survey.

While fish are present in the fishery every month of the year, there are peaks in landings in the spring and fall months. Examination of National Marine Fisheries Service (NMFS) Marine Recreational Fisheries Statistics Survey (MRFSS) data for the South Carolina sheepshead fishery shows clearly that the fishery is made up primarily of private boat anglers targeting the fish in inland and nearshore waters (NMFS 2005).

Status

The exact status and health of sheepshead populations in South Carolina's coastal waters is uncertain at this time. The species used to be federally managed as part of the South Atlantic Fishery Management Council's (SAFMC) Snapper Grouper Fishery Management Unit, but it was removed from this unit in April 2012 and is now managed by individual states. Of the states in the southeastern U.S., South Carolina has the most temporally expansive dataset on sheepshead catches with sampling dating back to 1985, whereas the next closest state (Florida) began collecting data in 2000 (Adams et al. 2018).

While sheepshead are targeted commercially to a limited degree in some areas, this species is typically recognized for its popularity among recreational anglers in coastal waters along the mid-Atlantic through Gulf of Mexico. In creel/angler surveys conducted by the South Carolina Department of Natural Resources (SCDNR) of saltwater recreational fishermen encountered at boat landings, sheepshead is the fifth most sought after species mentioned and ranks sixth in occurrence in the creels examined among this group (SC SRFSS data, 1991 through 2011). SCDNR's Marine Game Fish Tagging Program shows that sheepshead have averaged as the third most-tagged fish species by anglers in recent years (SCDNR 2024).

POPULATION SIZE AND DISTRIBUTION

Sheepshead are found in waters ranging from Nova Scotia to the Gulf of Mexico, and southward to Brazil (Manooch 1984). Populations of sheepshead occurring in South America and in parts of the Gulf of Mexico are regarded as two separate subspecies. Sheepshead are year-round residents from about South Carolina through the Gulf of Mexico, and most abundant to the north between April through November. They are found in coastal waters, bays and estuaries, and are tolerant of low salinity brackish waters as well.

Sheepshead are found in South Carolina's estuarine, nearshore and offshore waters throughout the year. Juveniles, and sub-adults are commonly found in the state's estuaries, bays, brackish rivers and creeks, and adults are typically encountered in nearshore and coastal waters, associated with hard-bottom habitat of some type. Spawning occurs in the early spring in offshore waters (Moore and Barkley 2005; McDonough et al. 2011). Adults and sub-adults of the species are commonly found around the State's marine artificial reefs out to depths of 30 m (100 ft.) (M. Bell, pers. obs.).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Sheepshead commonly occur in estuarine, nearshore, and coastal waters throughout the southeastern United States (Jennings 1985). They are encountered throughout a diverse range of ecosystems including brackish mangroves, salt marshes and nearshore waters, particularly around pilings, jetties and other structures. Recreational anglers fishing on manmade and naturally occurring reefs in nearshore and offshore waters

frequently target this species (Stanley and Wilson 2000). Juveniles are found predominately in estuaries and adults in offshore waters.

Sheepshead are taken in trawls, traps and other fishing gear used in tidal harbors, rivers and creeks in South Carolina waters. Their presence has been documented on subtidal and intertidal oyster reef habitats and on intertidal flats in the southeastern United States (SAFMC 1998). Adults are found in nearshore and offshore waters along the entire coast where suitable bottom habitat and structure exists. Grimes et al. (1982) noted their presence on shallow water live bottom habitats off North Carolina and South Carolina where limited vertical relief and a rich invertebrate community often exist.

Sheepshead readily recruit to South Carolina's marine artificial reefs, from 5 to 56 km (3 to 35 miles) offshore, but are most commonly noted by divers on reefs in the 9-18 m (30-60 ft.) range. Larger fish seem to move offshore as water temperatures drop in the fall and winter months and remain closely associated with reef structure (M. Bell, pers. obs.). It is not uncommon for divers to encounter very large sheepshead taking refuge or resting inside openings found in various reef structures.

CHALLENGES

Challenges for this species would most likely occur in the form of over-fishing, loss or degradation of essential fish habitat, degradation of estuarine water quality, or a combination of factors. Any of these problems, if materialized, could be initiated by multiple causative factors introduced in specific locales along the South Carolina coast, coast-wide, or even along larger spans of coast within the South Atlantic region.

While no directed commercial fishery for sheepshead currently exists in South Carolina, the species is popular with skilled recreational fishermen in inland and nearshore waters. Although the fishery is somewhat specialized and technique-dependent, anglers who know where and how to target the species may be very successful. Over-harvest of sheepshead that have yet to reach maturity in state waters could result in population problems for this species if the current harvest practices remain unchecked.

South Carolina NMFS-MRIP catch data for sheepshead from 2000 through 2011 indicate that 92% of the catch occurs in state waters, with an overall catch and release rate of only about 28% (NMFS 2012). However, the catch-and-release rate of sheepshead has increased since 2011, with every year since 2011 reporting significantly more releases than harvests (release rate of 73% post-2011; NMFS 2023). With removal of sheepshead from the snapper-grouper complex in 2012, new state regulations are currently relied upon to protect the species from overharvesting.

Any impacts to the health of South Carolina's estuarine habitats, or degradation of water quality in these areas, could also have negative consequences for the success of larval recruitment and settlement from coastal spawning populations of sheepshead or the health of juveniles and sub-adults inhabiting estuarine waters and bottoms.

Alterations to water quality parameters can impact the health of many marine-spawning species like sheepshead that can only be successful if they are physiologically, thermally and salinity adapted (Sea Grant 1976). Introduction of toxins and pollutants such as PCBs into coastal waters can also have a disruptive effect on juvenile fishes with potentially long-term impacts on life cycles (Thomas 1990).

CONSERVATION ACCOMPLISHMENTS

Sheepshead rely on a wide range of habitats throughout their life history, including estuarine oyster reefs, tidal flats, nearshore and offshore hard bottom reefs, manmade reefs, and other structure. In developing a comprehensive habitat plan essential to the health and success of all managed marine fishery species within the entire South Atlantic region, the South Atlantic Fishery Management Council (SAFMC) has characterized and documented the importance of the various habitat types essential to all managed finfish species within the region, including sheepshead (SAFMC 1998). In 2012, new size and bag limits were implemented in response to the removal of sheepshead from the snapper/grouper complex regulations. Currently, sheepshead must be a minimum of 14 inches total length to land, and there is a bag limit of 10/person/day, not to exceed 30/boat/day.

CONSERVATION RECOMMENDATIONS

- Quantify fishing mortality and catch per unit effort for the recreational sheepshead fishery off South Carolina.
- Determine age frequency, population trends, and significance of spawning activities of sheepshead occurring within the State's fishery.
- Examine the extent to which sheepshead occur as by-catch in commercial gear.
- Examine larval distribution, settlement and recruitment of sheepshead to estuarine systems and the importance of estuarine habitats in supporting sheepshead populations in South Carolinas coastal waters.
- Better define seasonal movement patterns and habitat utilization of sheepshead adults.
- Examine ability to use juvenile sheepshead as a finfish indicator species in monitoring the health of estuarine habitat.
- Examine possible impacts of degraded estuarine water quality on sheepshead.
- Determine emigration patterns of young sheepshead adults and recruitment to near/offshore habitats.
- Understand environmental factors that affect abundance and health of sheepshead stocks.
- Work with appropriate federal, state and local partners and stakeholders to better protect water quality by implementing better coastal planning policies, assessing current policies/regulations involving the introduction of various biocides and other potentially harmful chemicals into estuarine and coastal waters and requiring stricter monitoring and tighter restrictions on storm water runoff and wastewater treatment effluents.

- Work with appropriate federal agencies and others to develop realistic strategies, plans and policies to protect limited areas of essential fish habitat (EFH) as designated by the SAFMC Essential Fish Habitat Management Plan.
- Manage the use of marine artificial reefs in South Carolina's coastal and offshore waters to provide additional EFH where most appropriate to improve the chances of reaching fishery management and conservation goals established for applicable finfish species.

MEASURE OF SUCCESS

By protecting habitat, improving water quality, and actively managing the effects of recreational angler harvest on sheepshead populations, SCDNR will be able to encourage stable sheepshead populations within in the State's coastal waters, which will be documented by continuing current fishery-dependent and fishery-independent monitoring programs

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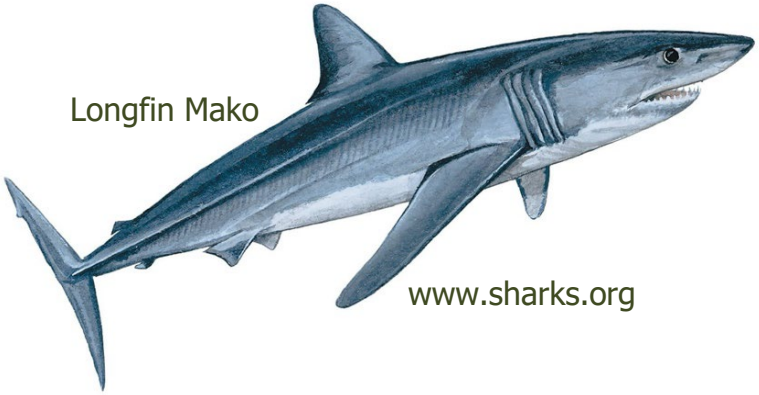
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Shortfin Mako and Longfin Mako

Isurus oxyrinchus & I. paucus

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DESCRIPTION

Taxonomy and Basic Description

Shortfin Mako

The shortfin mako and longfin mako are members of the order Lamniformes and family Lamnidae (Page et al. 2023). These highly migratory, pelagic species are found in the Atlantic, Pacific, and Southern oceans (Compagno, 2001). Sharks of the family Lamnidae are predicted to be less resilient than other shark species in situations of high mortality rates due to their high longevity, late maturity and extremely low fertility and productivity rates (Stevens, 2008; Smith, 2008; Cortés et al. 2010, 2015).

The shortfin mako is considered the fastest shark in the world, able to reach max burst swimming speeds of 43 mph (69.2 kph; Diez et al. 2015). They have a bluntly pointed snout, large black eyes, and long gill slits. They are recognized by their metallic blue side coloring and white undersides with a distinct color break down its side. The tail has a high aspect ratio (ratio of height to length), which produces maximum thrust with minimum drag and provides almost all of the propulsion for the shark. The mouth is distinctly U-shaped (Compagno et al. 2005).

Shortfin mako sharks are a slow growing species. The average adult size is about 260-270 cm and 330 cm total length (TL) for males and females, respectively, with a reported maximum size of about 380 cm (13 ft) TL (Castro 2011). Size at birth is 60-70 cm TL. Age at maturity is between 7 and 9 years for males and 18 to 21 years for females (Cailliet et al. 2009). Shortfin makos are estimated to live 29-32 years (Bishop et al. 2006). Their slow growth and late maturity, along with a three-year reproductive cycle, renders makos vulnerable to overfishing.

Longfin Mako

Longfin mako have slimmer bodies and longer pectoral fins than the shortfin mako. The longfin mako has a slender, torpedo-shaped body with a moderately long conical snout. Like their congenger, they have elongated gill slits for more efficient gas exchange. The

mouth is shorter than it is wide with the lower teeth extruding. The eyes are large, and the pectoral fins are wide with a round tip. The pelvic fins are short with concave posterior margins. The first dorsal fin is large with a light free rear tip. Both anal and the second dorsal fins are small. There are strong keels on the caudal peduncle and short secondary keels on the caudal base. The caudal fin is semi-lunate, and the upper lobe is not much larger than the lower one. The terminal caudal lobe is not prominent, and the subterminal notch is well distinguished (Compagno, 2001; Castro, 2011).

The maximum size is believed to be 427 cm TL (168 inches; Castro et al. 1999, Compagno 2001, Castro, 2011). While age at maturity is not known, females have been reported mature at > 300 cm (>118 inches) TL and males at 229 cm (90 inches) TL (Castro, 2011). Longevity has not been studied to date. The longfin mako is ovoviviparous and fetuses are larger than those of the shortfin mako. Fetuses are believed to be cannibalistic in utero, consuming other eggs in the womb (Oophagy; Compagno, 2001). Females give birth to 2-8 pups measuring 122-135 cm (48-53 inches; Castro, 2011; Compagno, 2001; Manday, 1975). Reproductive periodicity and gestation times are currently unknown.

Status

Worldwide, the shortfin mako is considered overharvested due to direct targeted fishing and as by-catch associated with tuna and swordfish fisheries. The U.S. National Marine Fisheries Service (NMFS) includes the shortfin mako on their list of managed pelagic sharks. This species is also listed under the 1995 UN Agreement on the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UNFSA), which requires all fishing states implement measures to conserve the species. Unfortunately, a lack of scientific data, underreported catch data and the large-scale nature of their movement patterns, has made it challenging to collect accurate information about the status of their populations globally. Genetic work has identified three distinct subpopulations of the shortfin mako. These are assessed separately under the IUCN (Cailliet et al. 2009).

Most information available on the population status and trends consists of fisheries catch data and is therefore either not species-specific or focuses primarily on shortfin mako. The population structure of the longfin mako is widely unknown due to a paucity of data. However, it is suspected populations in the Atlantic Ocean and the Indo-Pacific could be isolated (Reardon et al. 2006). ICCAT assessed the status of shortfin mako in the North Atlantic and South Atlantic. Stock units have not been defined in the Pacific Ocean. The current IUCN Red List status for the global population of shortfin mako and longfin mako is 'Endangered' (Rigby et al. 2019). More details of the population status and trends can be found in the IUCN assessment.

The conservation status of the longfin mako is uncertain. Longfin mako are thought to have a very low, minimum population with a doubling time of more than 14 years. The ICUN lists longfin makos as "Vulnerable" due to their increasing rarity due to fisheries bycatch and the shark fin trade (Amorim et al., 1998; Compagno, 2001).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The shortfin mako is a pelagic species with a worldwide distribution. They are primarily resident in oceanic waters but can also be found near the coast where the continental shelf is short. They occur from the surface to about 500 m (1640 ft) and usually inhabit waters that are above 16°C (60°F; Calliet et al. 2009, Compagno et al. 2005).

There is little data available on the habitat and range of the longfin mako but they are most often seen in tropical and temperate waters. As in other Lamnids, the longfin mako has counter current vascular heat exchange, allowing the musculature, eyes, brain and viscera to be heated. They are often observed at the surface, but specimen's stomach contents include deepwater squids suggesting a broad range of habitable depths for the species (Compagno, 2001; Castro, 2010).

CHALLENGES

In terms of fisheries, both species are caught in pelagic longlines, drifting or set gill nets and in hook-and line fisheries (Stevens 2008). Shortfin mako constitute a larger proportion of bycatch in longline fleets than the longfin (Reardon et al. 2006).

There are also challenges related to the international trade of shark meat and fins. The shortfin mako is a higher value shark species for meat products. Clarke et al. (2006) found fins of shortfin mako entered the international fin trade, where they account for approximately 2.7% of the fins traded. Longfin mako are mostly sold in the same category with shortfin mako or thresher fins due to a similarity of appearance and market value. Challenges for the longfin mako include the rarity of this shark, limited knowledge of its biology, slow life history, and occurrence as a limited but complementary bycatch of high-intensity oceanic fisheries targeting shortfin makos, other sharks, and pelagic scombroid fishes.

Other challenges exist with a general lack of management actions for makos that have been implemented by regional fishery management organizations. National fishery or conservation measures have been limited. Full stock assessments have only been conducted for the two Atlantic shortfin mako stocks, excluding the Mediterranean. The assessment for the south Atlantic stock was considered to be highly uncertain. Finally, critical habitats have not been identified and delineated and fishery data (landings, discards, size frequency, catch and effort) are lacking in some areas.

CONSERVATION ACCOMPLISHMENTS

Currently, there are no species-specific conservation measures in place.

CONSERVATION RECOMMENDATIONS

There is a need to improve the understanding of mako sharks through research, monitoring and data exchange, including data collection of biological and distributional data and population status. Steps towards accomplishing this include:

- Identifying critical sites of mako shark abundance and seasonality.
- Filling data gaps in life history parameters of shortfin mako.
- Investigating life history of longfin mako.
- Improve understanding of post-release survivorship of mako sharks to enable improved handling and release protocols.
- Initiate necessary collection of fishery data (including landings, discards, size frequency, catch and effort where needed).
- Research into ways to reduce bycatch and improve survivorship of makos, including gear modifications and fishing practices (soak time and safe release handling guidelines).

MEASURE OF SUCCESS

Mako sharks are heavily overfished in the Atlantic. As such, the primary measure of success would be the rebuilding of populations and implementations of international fisheries management measures allowing the stock to be sustainably fished once recovered.

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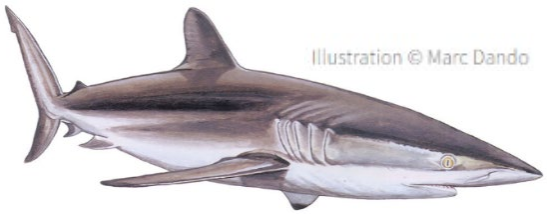
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Silky Shark

Carcharhinus falciformis



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DESCRIPTION

Taxonomy and Basic Description

The silky shark is large and slender, deriving its common name from the smooth appearance of its skin relative to other shark species. Body color is usually bronze-brown to grey-brown with an inconspicuous pale flank band and white underside. The nose is blunted and shorter than the mouth width. The first dorsal fin is low and sloping and originates behind the free rear tips of the elongated pectoral fins. It has an interdorsal ridge and the second dorsal fin is small with a very long free rear tip approximately 2.5 times the vertical height of the fin (Castro, 2011).

The species was originally thought to be two separate species, *C. falciformis* based on a description of one embryo, and *C. floridanus* based on morphometrics from two adults. The two species were determined to be the same by Garrick et al. (1964) and combined. Frequent confusion with night sharks (*C. signatus*) and dusky sharks (*C. obscurus*) contributed to misidentification for decades (Castro, 2011).

Most sharks encountered are under 250 cm total length (TL), and maximum length is likely around 332 cm TL (Joung et al., 2008). Observed maximum ages determined by vertebral counts ranged from 11 to 16 years for females (Indian and eastern Pacific oceans, respectively) and 14 years for males in both regions (Clarke et al., 2015). Observed maximum ages from studies in the Gulf of Mexico and Atlantic were slightly older and varied from 13 years to 22 years (Branstetter, 1987; Bonfil et al., 1993). Silky sharks are estimated to live up to 32 years with the potential individuals may be considerably older (Clarke et al., 2015). Age and growth studies conducted throughout their range suggest intermediate life history parameters with slow to moderate growth rates which may vary slightly between regions (Joung et al., 2008; Clarke et al., 2015; Santander-Neto et al., 2021).

Females are thought to mature between 9 to 15 years which varies based on geographic location and size at maturity likely falls between 190-220 cm TL (Bonfil, 2008; Joung et al., 2008; Clarke et al., 2015; Santander-Neto et al., 2021). Males are thought to reach maturity around 9 to 13 years and slightly smaller lengths between 180 to 212 cm TL (Bonfil, 2008; Joung et al., 2008; Clarke et al.,2015; Santander-Neto et al., 2021).

Like many members of the Carcharinidae, themselves members of the order Carcharhiniformes (Page et al. 2023), they are placental viviparous giving birth to live young and likely have a biennial reproductive cycle with a gestation period around 12 months although it may vary between regions (Castro, 2011). Litters average six pups and can range from 2 to 18 pups. Size at birth has been reported to vary between regions as well and ranges from 65-85 cm TL (Bonfil, 2008; Joung et al., 2008).

Status

Due to declining global abundances, silky sharks have an IUCN Red List status of vulnerable and are currently listed under Appendix II of the Convention on the Conservation of Migratory Species (CMS) of Wild Animals, and Appendix II of the Convention on International Trade in Endangered Species (CITES) as of 2016 (NMFS, 2022).

The first stock assessment on silky sharks was conducted in the western and central Pacific Ocean in 2012; however, it was rejected by the scientific committee who recommended further modeling. In 2013, the assessment was again attempted with additional data sets and longer time series, and due to consistent declines in size composition data, increased fishing mortality, and declining CPUEs, they conclude silky sharks are likely overfished and experiencing overfishing although there was still a great deal of uncertainty in the models (WCPO, 2013).

A stock assessment in the Indian Ocean also contained a great deal of uncertainty about the relationship of abundance to nominal CPUE series but an ecological risk assessment determined they were highly vulnerable due to their low productivity and high susceptibility to longline and purse seine fisheries. Therefore, the IUCN status was changed to a Near Threatened status in the western and eastern Indian Oceans (FAO, 2022).

Silky sharks have not been assessed in the U.S. but are managed under the 2006 Consolidated Highly Migratory Species (HMS) Fisheries Management Plan (NMFS, 2006; NMFS, 2022). Retention is prohibited in recreational fisheries and by the commercial Caribbean Small Boat permit. However, they are allowed to be landed by the Atlantic directed commercial shark fishery which has no limit on pelagic sharks (other than shortfin makos) and the Atlantic Incidental Permit which has a limit of 16 combined pelagic and small coastal sharks/vessel/trip (excluding shortfin mako). Several states within the U.S. have regulations allowing some landings of silky sharks within their waters, but most follow the federal guidelines prohibiting recreational landings.

Sharks captured domestically in association with the International Commission for the Conservation of Atlantic Tunas (ICCAT) fisheries using pelagic longline gear are required to follow ICCAT recommendations. Since 2012, these include prohibiting retaining, transshipping or landing silky sharks.

POPULATION SIZE AND DISTRIBUTION

Silky sharks have a circum-global distribution in tropical waters and are found in both oceanic and coastal-pelagic zones. In the western Atlantic, they are distributed from Massachusetts to southern Brazil, including the Caribbean Sea and Gulf of Mexico. They are also found in the central Atlantic, eastern Atlantic from Spain to northern Angola, the Indian Ocean, and throughout the equatorial regions of the Pacific Ocean.

Their population structure is not fully understood, but there is evidence of multiple stocks. Initial work in the Indo Pacific suggested there were potentially up to three groups within the region while a later study using larger sample sizes concluded there were at least five genetically distinct populations globally: western and eastern Pacific Oceans, Indian Ocean, Red Sea, and the western Atlantic Ocean (Aires da Silva et al., 2014; Clarke et al., 2015). Clarke et al. (2015) found the greatest divergence between the western Atlantic Ocean and the Indo-Pacific specimens. The Indo-Pacific had significantly less genetic diversity relative to the western Atlantic but still showed evidence of genetic differentiation, suggesting less connectivity among regional populations than expected (Clarke et al., 2015). Interestingly, the opposite was observed in the western Atlantic samples which suggests gene flow and a lack of female philopatry between the western North Atlantic and western South Atlantic (Clarke et al., 2015).

Although catch data in all regions have been too variable to conduct stock assessments, declines in CPUE were observed and estimates of fishing mortality exceeded estimates of sustainable yields (IOTC, 2013; WCPO, 2013; Aires da Silva et al., 2014). In the Gulf of Mexico, research surveys and observer data suggested their abundance declined 91% since the 1950's and declines in CPUE in the Atlantic regions were between 46-50% from 1992-2005 (Cortes et al., 2007). Cortes et al. (2007) estimated over three generations, silky populations in the Atlantic were reduced by 95-98%. Assuming evenly distributed silky populations, authors estimated global population declines over three generations of 47-54% (Cortes et al., 2007; WCPO, 2013; Lennert-Cody et al., 2016).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Silky sharks are most often found near the edge of continental and insular shelves at depths 200 m or more or offshore in the epipelagic zone from the surface to 500 m (Last and Stevens, 2009). They are also associated with deepwater reefs and insular slopes near islands and prefer warmer waters above 23°C.

Their diet consists of large squid, pelagic fish and pelagic crabs (Kiszka et al., 2015). While they are commonly observed following schools of tuna, they were found to occupy the lowest trophic position relative to several other commonly encountered pelagic shark species (Kiszka et al., 2015).

Ontogenetic shifts in habitat usage have been observed in the western Atlantic with neonates and early juveniles occupying coastal waters on the continental shelf, which suggests the potential for localized nursery grounds (Yokota and Lessa, 2006; Bonfil, 2008). Adults and older juveniles are more likely to be found in deeper water off the continental shelf or open ocean waters (Bonfil, 2008). Unlike some other species of pelagic sharks, silky sharks are known to aggregate in mixed sex and size groups, frequently around floating aggregation devices (FADs) and following schools of tuna (Castro, 2011; Filmalter et al., 2013).

CHALLENGES

Silky sharks are one of the most common pelagic bycatch species in gillnet, longline, and purse seine fisheries. While purse seine fisheries have historically had low bycatch rates, the development of industrialized seine fisheries targeting larger pelagic species has increased the likelihood of shark bycatch. To increase catches, FADs are frequently used to increase catches prior to encircling with seine nets, and consequently, silky sharks are one of the predominant species associated with bycatch in these fisheries (Eddy et al., 2016). They are the second most dominant shark bycatch species globally in pelagic longline fisheries and are frequently reported as being discarded alive (Abel and Grubbs, 2020).

Post release mortality estimates for longline fisheries range from 5-20% (Abel and Grubbs, 2020), however, seine and FAD associated mortality rates are much greater and may be upwards of 85% (Filmalter et al., 2013; Poisson et al., 2014). In many instances drifting FADs may have old nets attached to them and silky shark entanglement and associated mortality in the combined structure has been estimated to be five to 10 times the actual bycatch associated with the seine fishery (Filmalter et al., 2013).

Adding to concerns about fishing mortality rates, a recent study investigated the accuracy of shark bycatch estimations by onboard observers and found shark counts were underestimated for 50-100 percent of the sets with a mean underestimation at trip level ranging from 9 to 40 percent for onboard observers in the Pacific and Atlantic Oceans and 65 percent for electronic monitoring systems in the Indian Ocean (Forget et al. 2021)

Consequently, pelagic species like silky sharks are one of the most predominant in the global shark fin trade and as such, are listed under CITES Appendix II to ensure international trade does not threaten their survival. Despite this designation, genetic testing of fins in the Hong Kong fin market found silky shark fins were the second most traded species (Cardenosa, 2018).

Accurate estimates of population sizes, demographic structure, and fishery data is severely lacking and urgently needed to generate data necessary for regional stock

assessments so that sustainable levels of fishing pressure and spawning stock biomass can be determined (CMS, 2018).

CONSERVATION ACCOMPLISHMENTS

Bycatch rates by depth were investigated in pelagic longline fisheries targeting multiple species. Comparisons between global pelagic longline fisheries suggested shark bycatch was lowest while targeting tuna at deeper depths and highest in fisheries targeting species in shallower depths or closer to shore (Abel and Grubbs, 2020). Increasing hook depth to 150 m or more has been shown to significantly reduce the bycatch rate of Silky sharks.

Following recommendations adopted in the North Atlantic Ocean, the Indian Ocean Tuna Commission passed a resolution to fully utilize entire shark catches by restricting finning at sea for fresh landed sharks, limiting the proportion of fins by weight of frozen sharks, encouraging the release of live sharks (particularly juveniles and pregnant females), and improving collection of accurate data while setting a firm date for annual reporting of landings (IOTC, 2022).

CONSERVATION RECOMMENDATIONS

Improve knowledge of population sizes and demographics

Improve knowledge and understanding of critical habitat use areas outside of seamounts

Improve knowledge on key biological and ecological parameters, life history and behavioral traits, and migration patterns

Identify shark mating, pupping, and nursery areas

Identify effective approaches to reduce bycatch including gear modifications and handling practices to maximize post release survival

Enhance and develop collection of fishery data (landings, discards, size frequency, catch and effort)

Support increased multilateral cooperation, management plans, and conservation measures

MEASURE OF SUCCESS

Gather enough information to effectively conduct stock assessments by region

Increase population abundance

Reduce bycatch mortality

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Smalltooth Sawfish

Pristis pectinata



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DESCRIPTION

Taxonomy and Basic Description

Smalltooth sawfish are a chondrichthyan species belonging to the sub-class *Elasmobranchii*, the order *Rhinopristiformes* and the family *Pristidae* (Page et al. 2023). Within this family, there are two genera, *Pristis* and *Anoxypristis*, which contain the 6 extant species of sawfish. These species are most closely related to the order *Rajiformes*, which is composed of skates and rays.

The smalltooth sawfish shares a distinguishing characteristic with the other sawfish species, a long snout-like protrusion lined with teeth, called the rostrum. This rostrum contains 22-29 teeth along its edges, which are unique from many elasmobranch teeth, given they are not replaced after falling out. Smalltooth sawfish differ from other *Pristidae* through several features. They have longer, narrower rostra with smaller, more numerous teeth. Their caudal fin lacks a lower lobe, and the front of the dorsal fin is located in line with the posterior end of the pectoral fins. The smalltooth sawfish has an olive-brown dorsal coloration and a white ventral coloration.

Smalltooth sawfish reproduce via internal fertilization and are ovoviviparous. They are born in broods of 7-14, with stretched total lengths (STL) of 64-81 cm at birth (Brame et al., 2019). Sexual maturity is reached at 7-11 years old, at lengths of 340 cm STL in males and 370 cm STL in females. They can reach lengths of 700 cm STL with a longevity of approximately 36 years in the wild (Kyne et al., 2021).

Status

Smalltooth sawfish are currently listed as an endangered species under the Endangered Species Act. They were the first marine fish to receive federal protection under this act. The International Union for the Conservation of Nature Red List lists them as critically endangered (Carlson et al. 2022). It is estimated populations have declined by up to 95%, with their geographic range declining by greater than 80% (Norton et al., 2012; Dulvy et al., 2014). Few data exist that describe total abundance levels in either stock.

POPULATION SIZE AND DISTRIBUTION

Historically, smalltooth sawfish occupied neritic environments from the Gulf of Mexico to North Carolina. There are generally believed to be two distinct populations, with one in south Florida and the other in The Bahamas. The core of the current population resides in south Florida, although in recent years, as the population has slowly increased, sawfish have been observed as far up the east coast as South Carolina, and as far as Mississippi in the Gulf of Mexico.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Young of year and juvenile sawfish inhabit riverine and estuarine areas, with several critical habitats established in Florida (Norton et al., 2012). Density in these environments has been associated with habitat structure, including correlations with mangrove density (Guttridge et al., 2015). Habitat utilization expands as smalltooth sawfish develop, with adults occupying areas composed of seagrass beds and reef structures further offshore (Hollensead et al., 2018). However, typical distributions remain nearshore, and individuals demonstrate high site fidelity (Carlson et al., 2014). Their general diet consists mainly of teleost and elasmobranch fishes throughout all life history stages (Poulakis et al., 2017). Behavior and morphology suggest most of prey items occupy benthic or epibenthic areas. Smalltooth sawfish rely on the rostrum to stun or immobilize prey items. Ampullae of Lorenzini allow sawfish to locate buried prey items through the emission of electrical impulses.

CHALLENGES

Traditional threats to the smalltooth sawfish include bycatch through non-discriminate fisheries such as gill netting, shrimp otter trawls, and longlining due to increased vulnerability based on morphology and distribution relative to these types of fisheries. Responses to physiological stressors vary over ontogeny, with young of year individuals demonstrating the highest sensitivity. However, resilience is relatively high across all life history stages (Prohaska et al., 2018). Smalltooth sawfish are also vulnerable due to habitat loss, as development continues to threaten nursery areas such as red mangrove forests. There is currently a large-scale mortality of smalltooth sawfish occurring in the Florida Keys, research into the cause is ongoing with initial results pointing towards ciguatoxins (Poulakis pers comm).

CONSERVATION ACCOMPLISHMENTS

Numerous regulations have been put in place across several US states, including a ban on gillnet fishing in Florida waters. Information on safe-handling practices for both commercial and recreational fisheries is available from multiple agencies. A recovery

plan implemented by NOAA Fisheries under the Endangered Species Act was published in 2009 and is currently being adapted as information develops. The main goals of this recovery plan were to

1. minimize human interactions and associated injury and mortality,
2. Protect and/or restore smalltooth sawfish habitats, and
3. ensure smalltooth sawfish abundance increases and the species reoccupies areas from which it had previously been extirpated (NOAA Fisheries).

In addition to this recovery plan, several areas of critical habitat have been established. Smalltooth sawfish, along with the other Pristis species, were listed in Appendix I of the Convention on International Trade in Endangered Species (CITES: 2007, The Hague, Netherlands). This restricts the commercial trade of the species. In addition, all five species were listed under Appendices I and II of the Convention on Migratory Species (CMS: 2014, Quito, Ecuador). Smalltooth sawfish are also listed as endangered under the Endangered Species Act (NMFS, 2003, ESA Listing Rule for the U.S.A. DPS, Federal Register 68 FR 15674).

CONSERVATION RECOMMENDATIONS

- Continued research on life history including investigations into non-lethal methods of age determination
- Use genomic methods to estimate population size using Close Kin Mark-Recapture methods
- Increased observer coverage to document sawfish interactions in the shrimp otter trawl fishery
- Protection of sawfish in the Bahamas
- Continued electronic tagging and monitoring of sawfish to monitor habitat expansion and continue defining critical habitats.
- Protection of habitats most important to the recovery of the smalltooth sawfish

MEASURES OF SUCCESS

The ultimate measure of success for this species would be recovery of the population allowing removal from ESA protections, that said, this measure is in the distant future. More achievable measures would be the protection of critical habitats, recovery of the species from the ongoing unusual mortality event, and protection of sawfish populations in the Caribbean (including the Bahamas).

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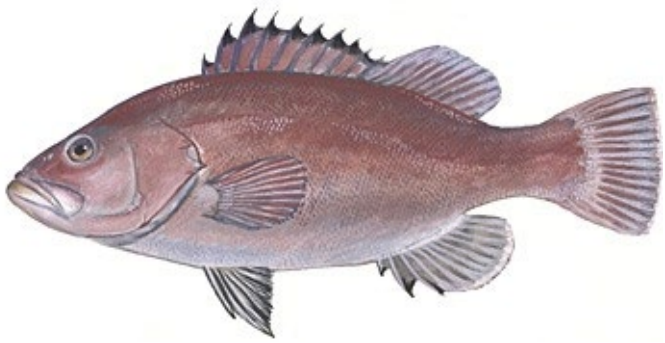
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Snowy Grouper

Hyporthodus niveatus



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DESCRIPTION

Taxonomy and Basic Description

Snowy grouper, *Hyporthodus niveatus*, are a commercially valuable deepwater grouper species in the family Epinephelidae, themselves members of the order Perciformes (Page et al. 2023). Their coloration changes with the size of the fish. Juveniles have brownish coloration with coin-sized white spots along their sides, giving them their "snowy" look and name. A black saddle shape is present on the caudal peduncle and extends below the lateral line. Larger individuals usually lose their white spots with the top of the dorsal fins having a black margin. Snowy grouper have 11 dorsal spines and 3 anal spines.

Snowy grouper are a relatively long-lived, protogynous hermaphrodite whose spawning season spans late January – October, with a peak in May – August (Kolmos et al. 2019). Kolmos et al. (2019) found max ages of males and females in the South Atlantic (SA) to be 32 and 35 years, respectively, with a max length of 1137 mm total length (TL). Spawning events vary by size, increasing as the individuals grew (Table 1).

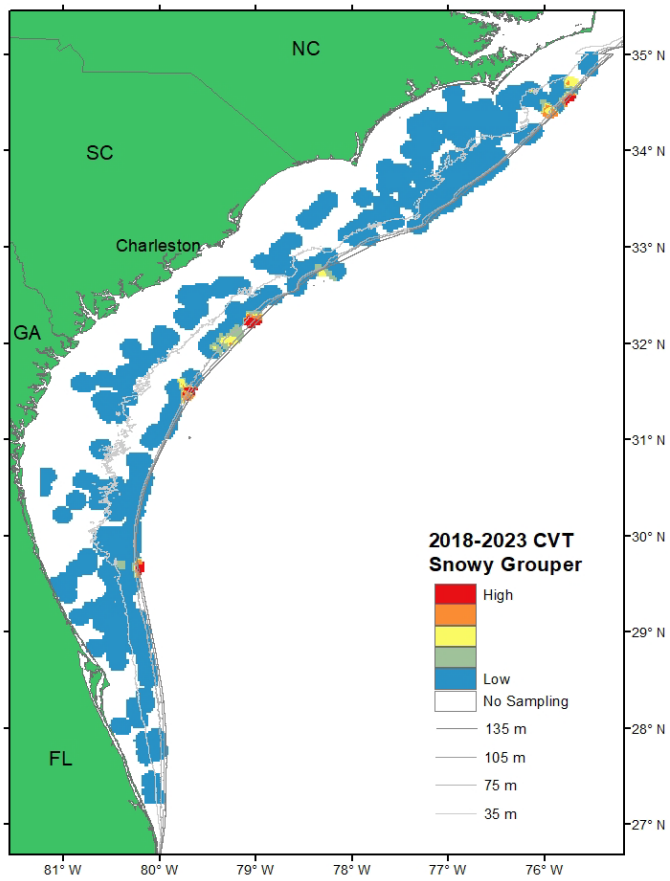
Table 1: Proportion of adult female (active and inactive) snowy grouper that were spawning daily, by 100 mm TL bin. Specimens were collected during spawning season (April – September) off North and South Carolina in 1979-2012. Spawners had at least one indicator of imminent spawning (i.e., oocyte maturation, ovulated eggs, or postovulatory complexes). Sampling period is the time (in days) from which representative samples of data were taken. Values of spawning proportion have been proportionally reduced to a 24-h period. (Table 6 in Kolmos et al. 2019).

Total Length (mm)	Adult Females (*n*)	Spawning Proportion (24 h)	Sampling period (d)	Spawning season duration (d)	Spawning interval (d)	No. of batches
501–600	130	0.06	178	139	17.1	8
601–700	326	0.13	178	153	8.0	19
701–800	325	0.14	178	177	7.0	25
801–900	94	0.17	175	163	6.0	27
≥901	26	0.18	171	129	5.4	24
Total	**901**	**0.13**		**152**	**7.8**	**19**

The length and age at 50% female maturity in the SA was 596 mm TL and 5.8 years, respectively (Kolmos et al. 2019). Snowy Grouper are a protogynous hermaphrodite where individuals start off as female and transition to male around the age of 17 years old or 900 mm TL (Kolmos et al. 2019). Very few males have been captured less than 800 mm TL.

Status

Snowy grouper in the U.S. are managed as two stocks within different jurisdictions, a Gulf of Mexico stock and a SA stock, which is supported by recent otolith microchemistry research that suggests little mixing between the two regions (Sanchez et al. 2022). The SEDAR 36 Update completed in 2020 confirmed SA snowy grouper were both overfished and experiencing overfishing.



POPULATION SIZE AND DISTRIBUTION

Snowy grouper occur in the western Atlantic from Massachusetts to Brazil, including Bermuda, Cuba, the Bahamas, and the Gulf of Mexico with some occurrences off the cost of Canada (Scott and Scott 1988; Heemstra et al. 2002). Along the coast of the southeast United States, adult snowy grouper are found predominantly on the upper continental slope (> 75 m) at depths of 116-302 m (Figure 1; Low and Ulrich 1983; Moore and Labisky 1984; Parker and Ross 1986; Kolmos et al. 2019) whereas juveniles are more common at shallower depths (Moore and Labisky 1984, Wyanski et al. 2000).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Snowy Grouper are found on the continental slope out to 300+ m depths along rocky outcroppings, ledges, and cliffs (Matheson and Huntsman 1984). Juveniles can typically be found in shallower waters than adults.

Figure 1: Regional distribution of snowy grouper from the SERFS chevron traps from 2018-2023 (excluding 2020).

CHALLENGES

Deepwater species are usually harder to monitor based on the logistical challenges associated with weather, gear, currents, and depth in capturing these individuals. Slower growing, long-lived species are not as resilient to disturbances compared to others in their community. This leads to more opportunities for removal from the ecological system, whether natural or fisheries-related, before their first reproductive contribution to the fishery. Because snowy grouper are sequential hermaphrodites,

there is also disproportionate targeting of the larger sex (males) potentially skewing population demographics. As with many other reef fish species which have substantial overlap in habitat use, there is fisheries related mortality even when they are not targeted in this multi-species fishery. As a deepwater species (≥30 m), snowy grouper are highly susceptible to post-release mortality (e.g. barotrauma). Fishery-dependent data is minimal, sporadic, and/or confidential (NOAA Fisheries 2024) due to regulations and limited participants in both the commercial and recreational fisheries. Overall gear encounters with snowy grouper by the fishery-independent SERFS chevron traps is relatively low, with catches not significant enough to create an index of relative abundance (Bubley et al 2023). Because snowy grouper continue to be overfished and overfishing is occurring, this necessitates monitoring on a consistent basis crucial to properly managing this stock, which can be challenging for the reasons stated above.

CONSERVATION ACCOMPLISHMENTS

There are seasonal closures for snowy grouper from July 1-April 30 as well as a 3-bag aggregate limit per vessel during the open season. There have been periodic decreases in the total allowable catch for Snowy Grouper since 2006 with additional deepwater MPAs established off the southeast coast of the US. After the results of the SEDAR 36 Update, Amendment 51 was proposed and is still going through the review process to determine the best course of action to sustainable manage the snowy grouper stock. Kolmos et al. (2019) indicated the population off NC and SC has started a slow recovery from an overfished status with age and growth, sex composition, and maturity all indicating a positive response to regulations to reduce fishing effort.

CONSERVATION RECOMMENDATIONS

- Increase fishery independent information to develop reliable indices of abundance
- Collect more age samples from the recreational sector with more spatial coverage
- Creating finer scale spatial structures to better assess the population
- Investigate sexual transition for temporal patterns as well as incorporating the dynamics of sexual transition in assessment models
- Use the updated information from Kolmos et al. (2019) to better estimate spawning potential

MEASURE OF SUCCESS

The South Atlantic Deepwater Longline Survey (SADLS) continued in 2023. SADLS was recently developed to address data deficiencies for deepwater species such as golden tilefish, blueline tilefish, and snowy grouper in the region. Protocols and locations were developed based on a workshop held in February 2020 and sampling commenced in

August 2020. Sampling is primarily conducted through cooperative efforts with commercial fishers and onboard observers. These collaborations are vital to the continued monitoring of our valuable deepwater species.

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Southern Flounder

Paralichthys lethostigma



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Revised 2015:
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Revised 2025:
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DESCRIPTION

Taxonomy and Basic Description

The southern flounder, *Paralichthys lethostigma* (Jordan and Gilbert, 1884), is a member of the order Carangiformes and family Paralichthyidae, or left-eyed flounders (Page et al. 2023). Diagnostic characters of this bottom dwelling predator include a rather large mouth with large, sheathed teeth, an arch in the lateral line over the pectoral fin, and no ocellated spots on the pigmented side. The southern flounder is the most abundant of the four species of the *Paralichthys* genus found in South Carolina estuarine and near shore waters, occurring from freshwater-tidal riverine systems to higher salinity seawater (Wenner et al. 1990). This species is often confused with the summer flounder (*P. dentatus*) or the gulf flounder (*P. albigutta*), from which it can be differentiated by comparing counts of vertebrae, fin elements, gill rakers, and body pigmentation (Wenner and Archambault, 2005). The fourth species, the large-tooth flounder *P. squamilentus*, is found on South Carolina beachfronts only as juveniles (Anderson et al. 1977). Although the South Carolina state record southern flounder weighed 8 kg (17 lbs., 6 oz.; SCDNR 2024a), this species occurs much more abundantly up to about 2.3 kg (5 lbs.) in local waters.

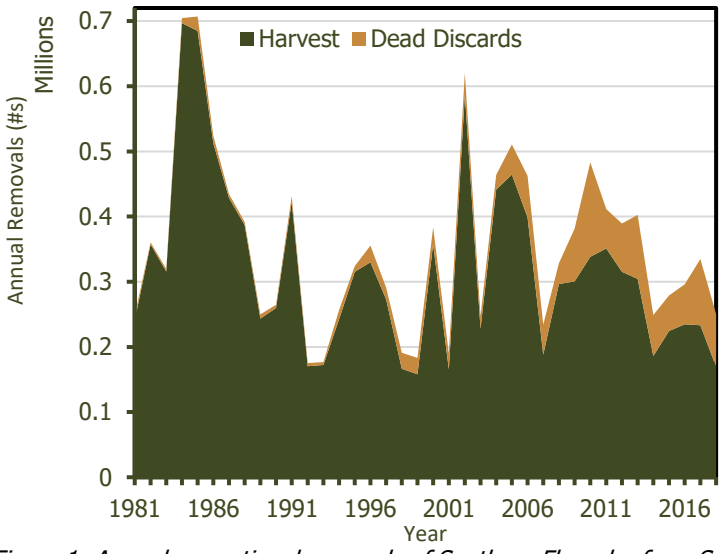


Figure 1: Annual recreational removals of Southern Flounder from South Carolina based on Marine Recreational Information Program estimates from 1981-2018. Removals represent direct harvest (green area) plus dead discards assuming a 9% post-release mortality rate (orange area).

Status

Annual removals of southern flounder in South Carolina have remained relatively stable since the mid-early 2000s, though

annually a greater share of removals is comprised of dead discards due to post-release mortality (Figure 1; NOAA, Office of Fisheries Statistics, pers. comm.)

A regional stock assessment of southern flounder, finalized in 2019, integrated available data from the east coast of Florida, Georgia, South Carolina and North Carolina to assess the status of the stock across the region (Flowers et al. 2019). The assessment suggested long-term declines in recruitment, chronic overfishing of the stock since the late-1980s, and spawning stock biomasses (SSB) below threshold levels (i.e., overfished) throughout the assessment time series with further rapid declines since the mid-2000s (Figure 2), and to end overfishing and allow the stock to rebuild to the target SSB in ten years a 72% coastwide reduction in annual removals was necessary.

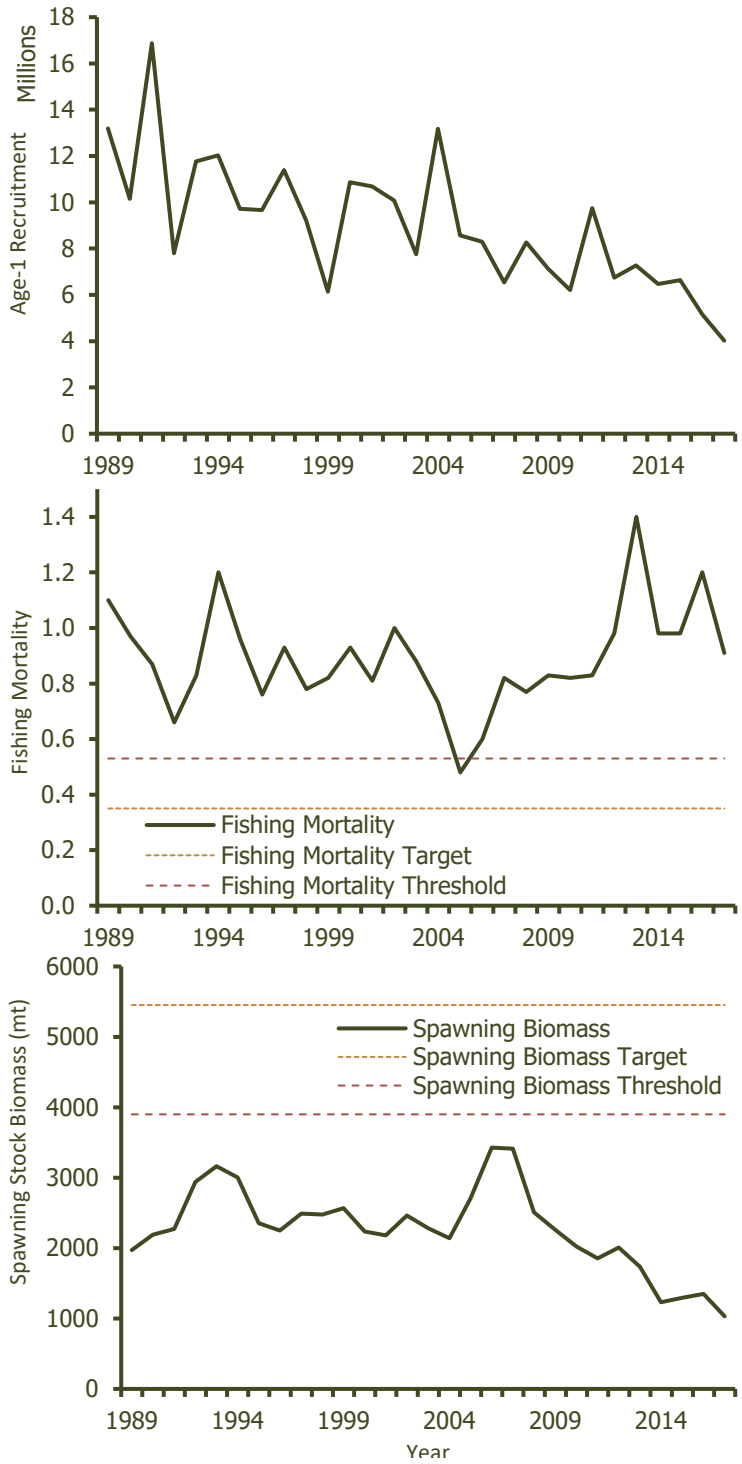


Figure 2: Time series of recruitment (top), fishing mortality (F; middle) and spawning stock biomass (SSB; bottom) as estimated in the regional assessment (Source: Flowers et al. 2019).

Currently, a second update to the regional assessment is being finalized with data through a 2022 terminal year. Results of the update assessment are expected to be available for management use in the fall of 2024.

POPULATION SIZE AND DISTRIBUTION

South Carolina falls within the northern limits for this species, which has a range from North Carolina to eastern Florida on

the Atlantic coast, and from southwestern Florida through the Gulf of Mexico to the Yucatan peninsula (Munroe 2002).

Tagging efforts have been conducted in South Carolina estuarine waters (Hart 2018; Wenner 1990), with the resultant data indicating limited movement and perhaps residence of southern flounder in estuarine systems, promoting the possibility of localized depletion. Three South Carolina Department of Natural Resources (SCDNR) fishery-independent monitoring programs routinely encounter southern flounder in South Carolina estuaries, namely the trammel net, electrofishing, and estuarine trawl surveys (Figure 3). The electrofishing and trammel net surveys both suggest steep declines in abundance through the late-2010s, with the decline more apparent in the longer trammel net time series which suggests declines of approximately 75% across coastal South Carolina since the early-1990s (Figure 3). The short estuarine trawl survey suggests generally increasing abundances from the early-2010s through 2020, followed by a rapid decline the last couple of years (Figure 3). These surveys also allow for a tracking of changes in population demographics through time using size- and age-compositions (Figure 4).



Figure 3: Standardized relative abundance of southern flounder as observed in the SCDNR trammel net (green line), electrofishing (gold line) and estuarine trawl (red line) surveys. Trammel net catches are normalized to average catches from 2010-2023, while electrofishing and estuarine trawl catches are normalized to their entire time series. The horizontal line represents average catch over the respective normalization period (survey specific) with points above the line indicating above average catch in that year and vice versa if below.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Immature southern flounders remain in the estuaries throughout the year. Adults migrate from estuaries during colder months to spawn offshore, though growing evidence suggests some adults may overwinter and spawn in estuarine waters (Midway

et al. 2024). Larvae are transported by ocean currents into the estuaries, finally reaching their

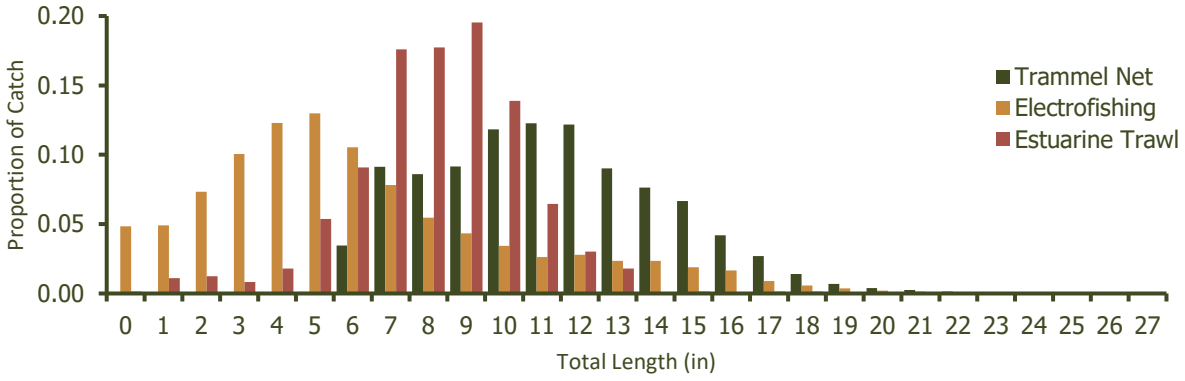


Figure 4: Percent frequency, across all years, of southern flounder by length captured in the SCDNR trammel net (green bars), electrofishing (gold bars), and estuarine trawl (red bars) surveys.

nursery habitat as small juveniles (1.3 cm or 0.5 inches) in the upper reaches of South Carolina estuaries. It is believed the majority of both sexes reach maturity by age-2, though females are much larger than males at that time (Midway et al. 2024). In South Carolina, at age 2, males are approximately 20 cm or 8 in. while females measure approximately 33 cm or 14 in. Females not only grow faster than males, but also live longer (Midway et al. 2024; Wenner et al. 1990), with maximum age of males and females in South Carolina waters of 3 and 6 years old, respectively.

Diet information for the southern flounder was investigated by Wenner et al. (1990) for adults and by Fernandez (1991) for juveniles. Prey items reflected the habitat location of this species during growth. Small flounders fed on copepods and opossum shrimp found in the upper reaches of the estuaries (Fernandez 1991). As the flounders grew and moved down the estuaries into higher salinities, their diet changed to include larger crustaceans and small fishes (Wenner et al. 1990). Larger southern flounders primarily consumed fishes and small blue crabs found in the shallow waters near the marsh edge in the higher salinity/lower reaches of South Carolina estuaries (Wenner et al. 1990).

CHALLENGES

The increase in the human population along the coast of South Carolina is disproportionate to the general demographics of the nation as a whole, and a concomitant increase in fishing pressure on flounder stocks in local estuaries has resulted (Flowers et al. 2019). The regional assessment suggested regionally the flounder population had been overfished and experiencing overfishing since at least the late-1980s (Flowers et al. 2019), with evidence of large declines in relative abundance along coastal South Carolina. Further, the potential for more limited movements of juvenile and adults across state boundaries (Midway et al. 2024), enhances the risk of

localized depletion due to fishing and habitat degradation. There is also mounting evidence of broadscale impediments to recruitment due to climate change (Erickson et al. 2020) or other factors (Midway et al. 2024).

Chemical contaminants and other emerging contaminants of concern, especially those that precipitate and incorporate into the sediment, pose a great threat to this species because of its close and persistent contact with the estuary bottom. Metals, polycyclic aromatic hydrocarbons (PAHs) and pesticides were shown to accumulate in the muddy sediments with which this fish is closely associated (Sanger 1998); these were shown to be detrimental to the benthic creatures exposed to it. Similar concerns are now arising regarding per- and polyfluoroalkyl substances (Fair et al. 2019; Thornton 2024) and microplastics (Parker et al. 2020) There is presently no routine testing of southern flounders for any of the above contaminants, except for the heavy metal mercury. Fortunately, samples of southern flounder fillets regularly examined since 2001 have not indicated any harmful build-up of the highly toxic methyl-mercury that can be found in South Carolina waters (SCDHEC 2024).

Preliminary investigations have shown various amounts of naturally occurring southern flounder parasites in different South Carolina estuarine systems. Since there is a history of industrial discharge in the Winyah Bay and Charleston Harbor estuarine systems, the potential of a positive correlation with parasite loads and pollution needs to be further investigated, especially in these two areas. Understanding the affects of parasite loads on natural populations of southern flounders, especially in reference to contaminants in the estuaries, could assist in circumventing future population problems.

CONSERVATION ACCOMPLISHMENTS

Because southern flounder are such a highly sought-after species, the State of South Carolina instituted harvest restriction on both the commercial and recreational fishery. Harvest of this important species is currently regulated by law with a 16-inch total length minimum size and 5 fish per angler per day, not to exceed 10 fish per boat per day for both the commercial and recreational fishery. The southern flounder does not enjoy gam fish status, so there are no restrictions on commercial capture except harvest must abide to the minimum size and possession limits for the recreational fishery. Further, the recent regional assessment led to changes in flounder regulations in North Carolina and Florida to work towards reducing coastwide removals by 72%.

CONSERVATION RECOMMENDATIONS

- Examine long-term trends in southern flounder population size, abundance and relative distribution; relate these dynamics to fishing pressure, climate variation, pollution affects, and parasite load and disease.

- Determine effects of pollutants on southern flounder reproduction, growth, and longevity.
- Determine the seasonality and potential estuarine hotspots of parasitic infections on southern flounder; relate these to growth and reproductive dynamics.
- Monitor the effects of recreational fishing stress on the existing population of southern flounders.
- Monitor the effects of marine pollutants on fish.
- Test for benthic contaminants. Acquiring this knowledge could benefit a great number of species that associate closely with the estuarine bottoms in addition to southern flounders.
- Continue exploring environmental drivers of recruitment success, particularly in the context of projected climate change impacts along coastal South Carolina.
- Further work is needed to elucidate the rates of coastal mixing of juvenile and adult flounder throughout the region.

MEASURE OF SUCCESS

By monitoring and reacting to a potential decline of this species due to increased angler harvest, parasite load, or environmental contaminants, SCDNR will be able to maintain adequate stocks. A measure of success would be to see sustained improvements in relative abundance as observed in various SCDNR fishery-independent surveys and future assessments showing rebuilding of the regional population to target levels and an ending of overfishing.

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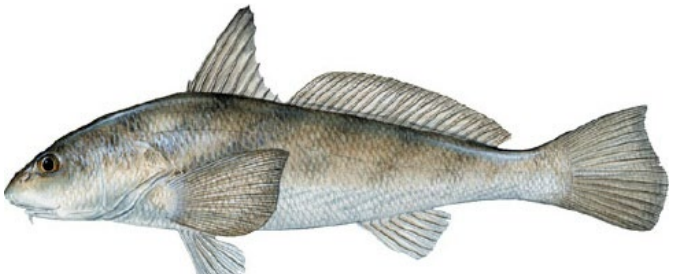
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Southern Kingfish
Menticirrhus americanus

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Southern Kingfish by Diane Peoples for Florida Department of Wildlife and Conservation.

DESCRIPTION

Taxonomy and Basic Description

Kingfishes are members of the drum family of fishes and are related to such species as spotted sea trout (*Cynoscion nebulosus*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulates*), red drum (*Sciaenops ocellatus*), black drum (*Pogonias cromis*), and others. In South Carolina's waters, there are three different species of kingfishes: the Gulf kingfish (*Menticirrhus littoralis*), the southern kingfish (*Menticirrhus americanus*), and the northern kingfish (*Menticirrhus saxatilis*); however, only the southern kingfish is encountered with any regularity. On occasion, all three species will be found together. Along the East Coast of the United States, the common name for the kingfishes varies by location. In South Carolina, they are called "whiting" whereas in North Carolina they are "sea-mullet."

The southern kingfish can be distinguished from the other two species by pale angular bands and a short first dorsal spine. The northern kingfish has dark, angular bands along the sides of their body and a long first dorsal spine. The Gulf kingfish has a silvery color as well as a darker area on the tail fin (mainly on the dorsal lobe or the top portion), and much smaller scales than the southern kingfish.

Both commercial and recreational fishers harvest the southern kingfish throughout this species' range. It is difficult to obtain reliable estimates of the landings because neither group of fishermen separates landings by species. For example, all three kingfishes are listed as "king whiting" in the commercial statistics of the National Marine Fisheries Service (NMFS Commercial Fisheries Statistics 2005) for the East Coast. The recreational statistics are also problematic due to confusion of the species by port samplers and creel clerks. Port samplers view the commercial catch and obtain catch statistics (amount of catch, species, and individual fish size). Creel clerks interview recreational anglers at boat landings, piers, beaches, and marinas to obtain information on recreational catch. Additional training for individual samplers has minimized this problem in the recreational fishery; however, data from the early years of the survey are suspect (NMFS Marine Recreational Fisheries Statistics Survey 2024). Figure 1 represents the collective recreational catch (# of fish) of southern kingfish in South

Carolina, which has experienced a downward trend after peaking in 2006.

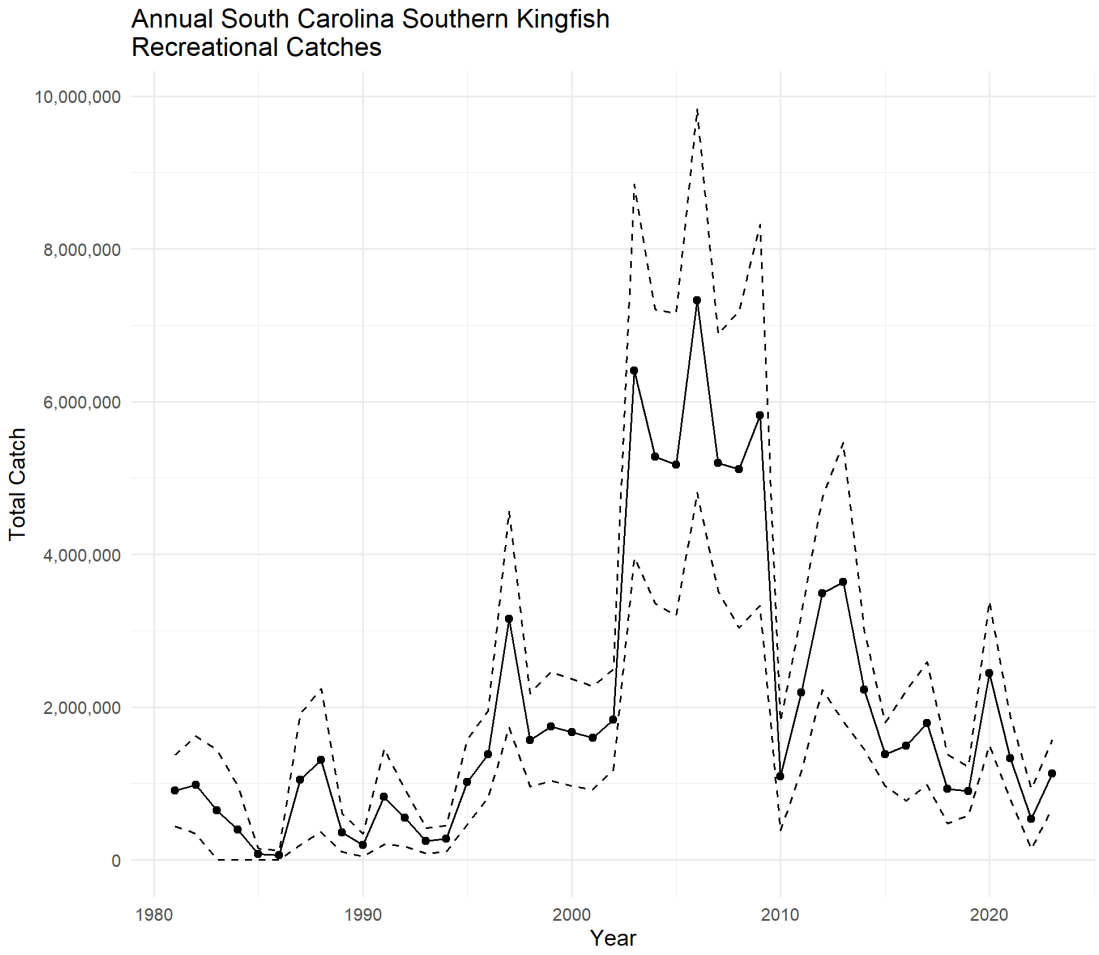


Figure. 1: Recreational catch (number of fish) of southern kingfish in South Carolina (NMFS 2024). Black solid line represents total catches, and grey dashed line represents the 95% confidence interval around those catch estimates.

Status

None of the kingfishes are considered threatened or endangered; however, there are concerns in South Carolina regarding by-catch mortality. Although the population status of kingfish in general appears to be stable in South Carolina, the difficulty in separating these three species in order to detect population trends for each is a cause for concern.

The prevalence of kingfish in near shore, shallow, coastal waters make these species excellent indicators of the health of this ecosystem. In addition, kingfish are a forage item in the near-shore oceanic waters for another species of conservation concern, the bottlenose dolphin.

Southern Kingfish are present in South Carolina estuaries year round but are more abundant during June-September (Fig. 2).

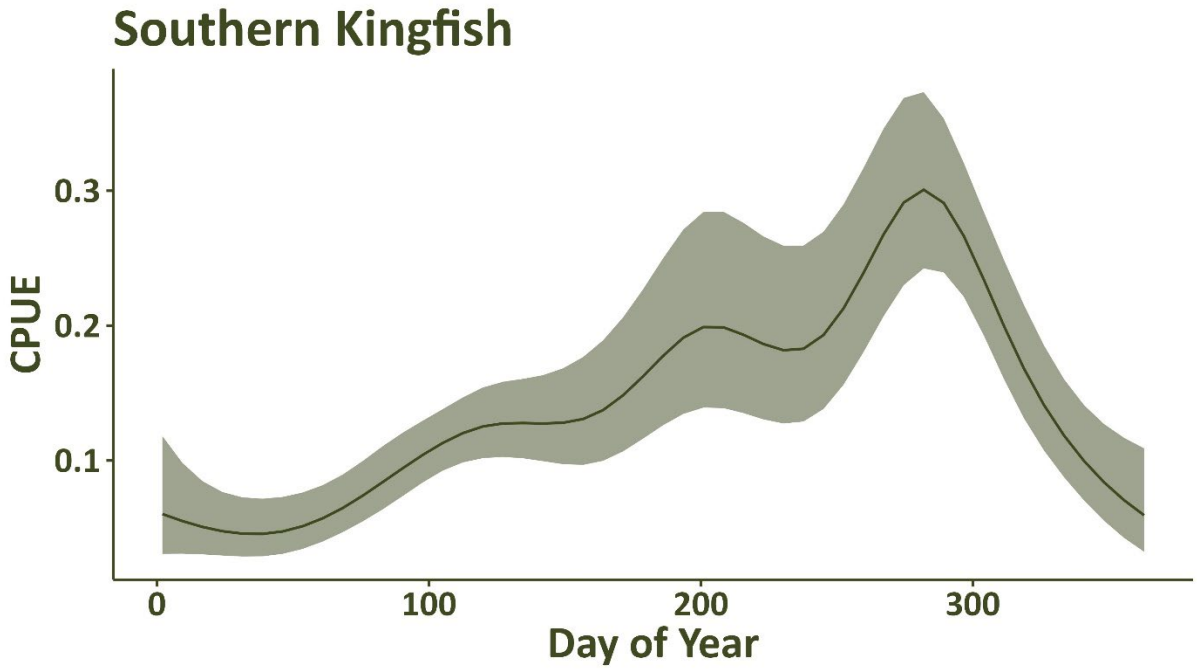


Figure 2. Southern Kingfish catch per unit effort in the SCDNR's Inshore Fisheries trammel net survey by day of the year.

The SCDNR fishery independent trammel net survey (1990-present) has caught southern kingfish at steadily increasing numbers over the last 34 years (Fig. 3), though declines have been observed since 2021.

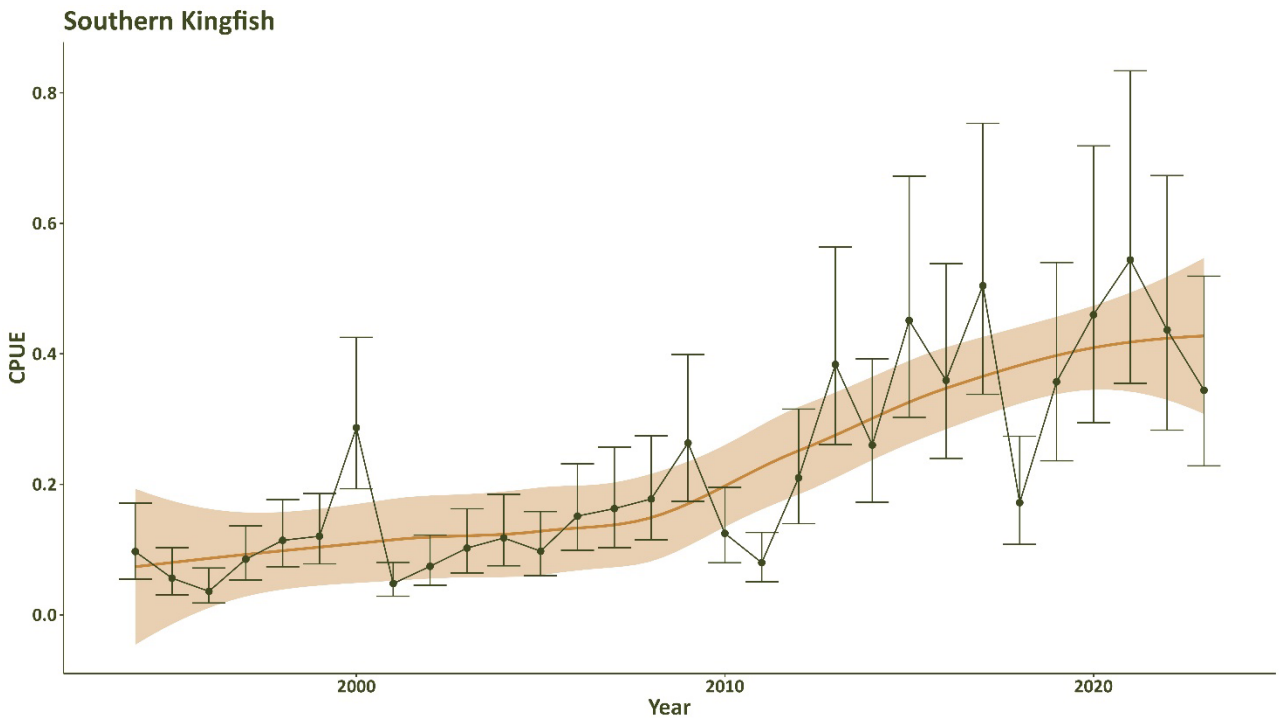


Figure 3. Southern Kingfish catch per unit effort in SCDNR's Inshore Fisheries trammel net survey by year from 1990 to 2023.

POPULATION SIZE AND DISTRIBUTION

The southern kingfish is found from Cape Cod to northern Argentina. The southern range of the northern king fish extends to northern Mexico in the Gulf; the two other species extend to southern Brazil. In waters of the United States, kingfish are relatively common from Chesapeake Bay, Virginia to southern Florida and throughout the Gulf of Mexico (Chao 2002). In South Carolina, southern kingfishes are commonly encountered in near-shore, ocean waters along the coast, and in higher salinity bays and estuaries like Calibogue Sound. Large southern kingfish are over 35 cm (13.8 in.) in total length; however, most individuals are smaller.

The population status of kingfishes along the Southeastern coast is unknown. The Southeast Area Monitoring and Assessment Program (SEAMAP) within the South Carolina Department of Natural Resources (SCDNR) is responsible for monitoring coastal waters. Cruises are undertaken during spring, summer, and fall from Cape Hatteras, North Carolina south to Cape Canaveral, Florida. These surveys provide estimates of relative abundance for a variety of species. Relative abundance is the average catch of a given species for all trawls made during a survey cruise. SEAMAP catch per tow values (CPUE) for South Carolina waters varies between years.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Southern kingfish prefer near-shore, shallow coastal waters with a muddy-sand bottom as well as high salinity bays and estuaries along the coast. Kingfish can also be found in areas that have sufficient benthic infauna. These animals that live in the sediment, such as polychaetes (sea worms), mollusks (clams and snails), and crustaceans (amphipods, sea-lice) represent an important food source to kingfish. Southern kingfish appear to move south in the winter to areas with warmer water temperatures. They return to South Carolina's waters in the spring as temperatures moderate (Wenner and Sedberry 1989).

CHALLENGES

Kingfish are consistently found in penaeid shrimp fishery by-catch along the Southeastern coast (unpub. data); this incidental catch can result in death for many kingfish juveniles. The mesh of a shrimp trawl is able to retain all but the very smallest kingfish juveniles. Any fishes that reside in the same area as the targeted shrimp will be caught by nets during shrimp trawls. Since the nets are pulled for a relatively long time (one or more hours), most fish caught by the net are dead by the time the catch reaches the boat (pers. obs.). Deckhands remove shrimp from the catch, then cull the remaining by-catch of fish and crab. Fish large enough for consumption are retained and the remainder is discarded over the side. Larger southern kingfish are placed in boxes, iced, and brought to the dock for sale (pers. obs.). Kingfishes are prized for their mild and firm flesh and can bring a fair price. In some kingfish habitat, shrimp fishing is not conducted, either because of rough bottom or an absence of shrimp. These areas provide a refuge for kingfish from the shrimp trawl nets (unpub. data).

Poor water quality from increased nutrient runoff and sewage discharges can cause oxygen depletion in kingfish habitat. Dredging offshore sandbars could eliminate some habitat as well as stir up sediments. Elimination of sandbars impacts the benthic infauna that forms the diet of the southern kingfish. During dredging activities, sediments and sediment-bound chemical toxicants become suspended in the water column. Turbidity that accompanies dredging activities may impact the respiratory lamellae in the gills of the fishes, resulting in affects similar to terrestrial animals breathing dust.

CONSERVATION ACCOMPLISHMENTS

Regulations require that shrimp nets be equipped with TEDs (turtle excluder devices) and BRDs (by-catch reduction devices). TEDs prevent large kingfish and marine turtles from being trapped in the nets and drowned. BRDs allow many fish to escape the nets that would otherwise be included in the catch. By-catch reduction devices have mitigated some of the by-catch mortality for kingfishes and other species. However, with increased fuel prices combined with soft markets due to competition from farm-raised, imported shrimp, the use of BRDs in the penaeid shrimp fishery has declined over the years—a pattern that may continue.

CONSERVATION RECOMMENDATIONS

- Continue to monitor southern kingfish distribution, relative abundance, maturity and age composition in the SEAMAP survey and through recreational fisher surveys.
- Develop ways to obtain better data from the recreational and commercial fisheries.
- Develop a management plan for kingfish in South Carolina.
- Work with municipalities to encourage the use of Best Management Practices (BMP) to reduce nutrient and sewage runoff.
- Identify key offshore habitat (sandbars) and work with the appropriate agency to deter dredging in these areas.
- Partner with federal agencies and NGOs to establish incentive programs that promote continued use of BRDs in the shrimp trawl industry.

MEASURE OF SUCCESS

The ability to estimate population trends for each species of kingfish is one measure of success. Stable population trends for all three species of kingfish, as documented during annual surveys, would represent another measure of success.

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Atlantic Spanish Mackerel

Scomberomorus maculatus


Source: SAFMC

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Revised 2025:
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DESCRIPTION

Taxonomy and Basic Description

Atlantic Spanish mackerel, *Scomberomorus maculatus* (Mitchell 1815), is a smaller member of the Scombridae family which includes a variety of mackerel, tuna, wahoo, and bonito, and the order Scombriformes (Page et al. 2023). This is a migratory species with two distinct populations, one of which is found off the Atlantic coast of the United States and another throughout the Gulf of Mexico (GOM). The Spanish mackerel is one of the three species in the Scomberomorini tribe (in addition to King mackerel and wahoo) that is frequently encountered off the coast of South Carolina (SC; Collette and Nauen 1983).

Spanish mackerel have laterally compressed, elongate, fusiform bodies. Along the dorsal surface is a forward dorsal fin, which fades from black to translucent, that is narrowly separated from a second dorsal fin with green coloration and a concave shape to the trailing edge. These fins are followed by 7 to 10 small finlets (Collette 2002). The lateral line of the Spanish mackerel begins to slope slightly downwards below the second dorsal fin. With the lateral line apparent at most sizes, it is a key feature to distinguish the species from smaller king mackerel which have a lateral line that drops abruptly below the second dorsal fin (Collette 2002). Spanish mackerel are gonochoristic, females reach sexual maturity by age two, and both sexes can live as long as 12 years, reach maximum lengths of 12 to 15 inches, and may weigh several pounds (Powell 1975; Schmidt et al. 1993).

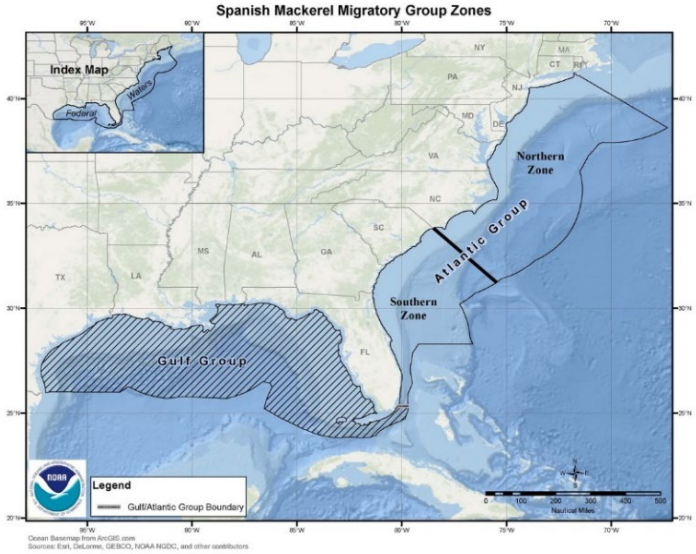


Figure 1: Map of Spanish mackerel distribution through migratory group zones management areas (noaa.gov)

Status

The International Union for the Conservation of Nature (IUCN) lists

Spanish mackerel as a species of Least Concern. While Spanish mackerel experienced low biomass and increased fishing pressure during the 1980s and 1990s, cooperative management by the Atlantic States Marine Fisheries Commission (ASMFC) and the South Atlantic Fishery Management Council (SAFMC) helped to rebuild stocks. In 2022, an operational assessment with data through 2020 through the SouthEast Data, Assessment and Review (SEDAR) process found the Atlantic Spanish mackerel stock was not overfished nor experiencing overfishing.

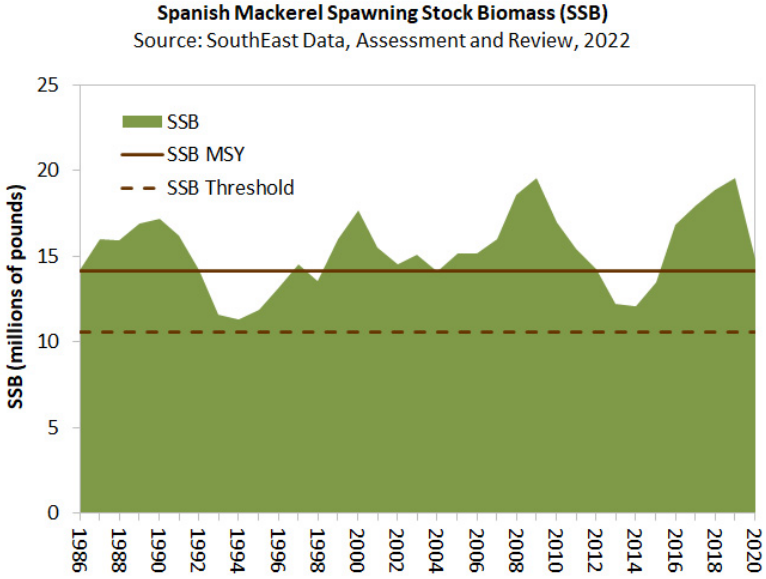


Figure2: Spawning stock biomass of Atlantic Spanish mackerel from 1986 to 2020 (SEDAR 78).

POPULATION SIZE AND DISTRIBUTION

Spanish mackerel ranges along the US Atlantic coast, around the Florida peninsula, and throughout the Gulf of Mexico predominantly in continental shelf waters (Figure 1; Collette 2002). For management purposes, this species is split into two separate stocks at the Florida Keys into an Atlantic and a Gulf of Mexico stock. There is little direct evidence of mixing between the two migratory groups around the Florida peninsula, however it is not known how closely these management units come to representing actual genetically defined stocks.

It was shown through SEDAR 78 that spawning stock biomass (SSB) had been increasing in recent years, but current fishing pressures are causing a decrease that

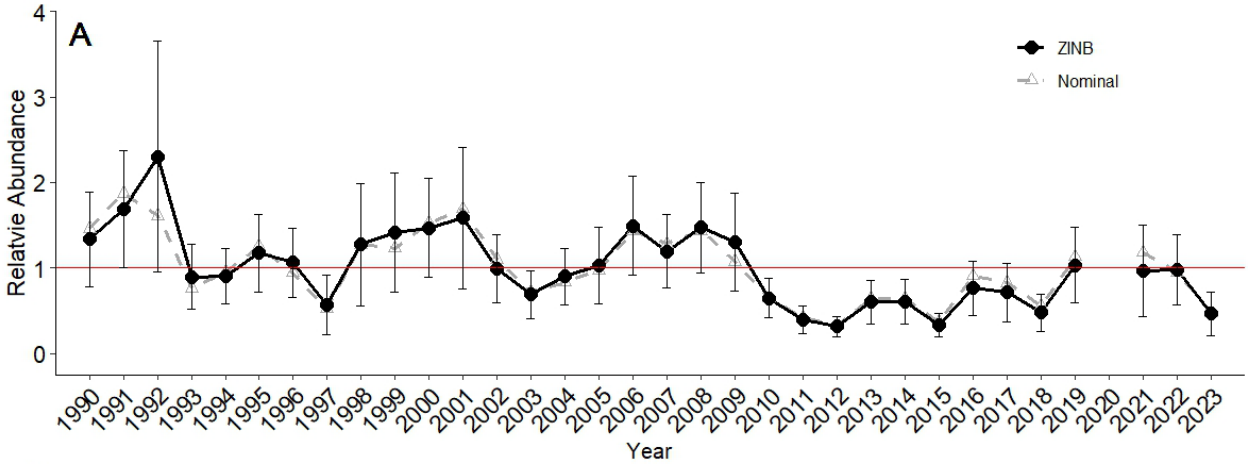


Figure 3: Nominal and ZINB standardized relative abundance of Spanish mackerel normalized to the time series mean of the SEAMAP-SA Coastal Trawl Survey. Error bars are representative of standard error.

could lead to decreased population numbers (Figure 2). The Coastal Trawl Survey (CTS) for the South Carolina Department of Natural Resources (SCDNR) has seen yearly variability in Spanish mackerel catches, with a general decrease in relative abundance per trawl sustained over the last 10 years (Figure 3).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Spanish mackerel is primarily a piscivorous pelagic occupant of coastal shelf waters. It is an opportunistic feeder encountered in a variety of habitats ranging from areas of structure (e.g., reefs, jetties) to grassy beds to open water in temperatures ranging from 65-80˚F (Earll 1883), with some occurrence observed outside of this range as well. All life stages from egg to adult appear to occur in near-shore ocean waters off South Carolina (Berrien and Finan 1977). Occasionally, individuals have been observed in estuarine waters as well.

CHALLENGES

The most recent Atlantic assessment showed recent fishing mortality was above the maximum fishing mortality threshold (MFMT), leading to a potential for the stock to be considered experiencing overfishing if current fishing rates continue (ASFMC; SEDAR 2022). Currently, no fishery-independent survey exists in the Atlantic for adult Spanish mackerel, leading to the assessment relying on landings data streams and a juvenile fishery-independent survey (SEAMAP-SA Coastal Trawl Survey). Spanish mackerel exhibit reduced movement and mixing compared to other migratory pelagics, which raises concerns about localized depletion from fishing pressures (Schrandt et al. 2015). More research is needed to determine movement patterns of adult fish to understand connectivity within the stock. Additionally, few studies have investigated spawning of Atlantic Spanish mackerel. This adds to the uncertainty of fish stock projections on a long-term basis (SEDAR 2022). Secondary challenges arise relating to bycatch of Spanish mackerel by the commercial shrimp trawl industry. Current bycatch numbers are thought to be inaccurate and underestimated (SEDAR 2012; SEDAR 2022).

CONSERVATION ACCOMPLISHMENTS

The original fishery management plan (FMP), effective in 1983, set a maximum sustainable yield (MSY) and size limit for the harvest of Spanish mackerel within the U.S. Exclusive Economic Zone (EEZ). Further expansion of Spanish mackerel management was implemented throughout the 1990s and 2000s as the stock was maintained through a variety of commercial trip limits, recreational bag limits, size limits, seasonal fishing restrictions, gear restrictions, and extensive monitoring of landings (SEDAR 2022). To date, these management efforts have supported a stock that is not overfished or undergoing overfishing.

CONSERVATION RECOMMENDATIONS

- Further investigation of migratory patterns, through tagging, otolith micro-chemistry, or genetics, to better define Atlantic and Gulf stocks and set biologically meaningful management boundaries.
- Expand research and monitoring of adults via fishery-independent surveys.
- Assess migratory spawning migrations and behavior to better determine stock projections, recruitment, and spatial scale of Spanish mackerel at all life stages.
- Investigate new methods to determine point estimates for natural mortality which can better inform stock assessments.
- Increase observer coverage of the shrimp trawl fishery along the SE Atlantic coast, quantifying bycatch estimates and discard mortality.

MEASURE OF SUCCESS

The SEAMAP-SA Coastal Trawl Survey program monitors the relative abundance, population demographics, and reproductive state of primarily juvenile Atlantic Spanish mackerel. Studying these metrics can help to detect when changes in these parameters occur relative to fishing pressures or current management efforts and can serve as early indicators of issues within the stock. Utilizing sufficient fishery-independent data can help to generate stock estimates with more confidence. Increases in recruitment, abundance, size- and age-composition, and spawning stock biomass (SSB) would indicate positive trends in the population. Ideally, stock structure would improve to a point that calculations of maximum sustainable yield (*MSY*) result in total allowable catch (*TAC*) levels that can accommodate demand for commercial and recreational harvest.

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Speckled Hind

Epinephelus drummondhayi



Contributors:
Stephen Long (SCDNR)

DESCRIPTION

Speckled hind, a once abundant subtropical-tropical, deep-water grouper of economic importance, is found along the mid-continental shelf to shelf-edge at areas of vertical relief, including wrecks, from North Carolina to the Gulf of Mexico and Bermuda, and potentially the Caribbean (Farmer and Karnauskas 2013, Ross 1988). Presently, encounters with speckled hind are low in comparison to other Snapper-Grouper species in the southeastern U.S. Atlantic, and a rarity with juveniles (Bubley et al 2023).

Taxonomy and Basic Description

Speckled hind, colloquially known as *Kitty Mitchell* grouper, is found in the order Perciformes and family Epinephelidae (Page et al. 2023), with a maximum total length (TL) and weight of 1,096 mm and approximately 29 kg, respectively (Matheson and Huntsman 2011, SAFMC 2024). Speckled hind larvae (<20 mm TL) are reported as morphologically indistinguishable from related western Atlantic groupers (e.g. *E. morio*), while juveniles (20 to ~340 mm TL) exhibit a distinctly yellow pigmentation with white spots before transitioning to a red-brown coloration, also with white spots, by 2 years of age. (Johnson and Keener 1984, Ross 1988). Adult speckled hind have a deep body, with 11 spines and up to 16 soft rays on the dorsal fin, an anal fin with 3 spines and 9 soft rays, pectoral fins with 18 rays, and a caudal fin with no fork (Carpenter 2002). Speckled hind are protogynous hermaphrodites, starting life as female and transitioning to male as early as 3 years of age, shortly after maturity at 2 to 13 years (~360 to 730 mm TL; Brule et al 2000, Ziskin 2008, Ziskin et al 2011). Spawning in the Southeast U.S. (SEUS) Atlantic has been noted from May to October, although some observations have occurred outside this range (Ziskin et al 2011). A regional life history study found a maximum age of 35 years, while an age-validation of samples from adjacent waters indicate under-ageing and estimate true longevity at 45 to 80 years (Andrews et al 2013, Ziskin et al 2011).

Status

Speckled hind in the SEUS Atlantic (i.e. NC, SC, GA, and FL East) have not undergone a formal stock assessment, and no Southeast Data, Assessment, and Review (SEDAR) assessment is scheduled. The Gulf of Mexico (GOM) assumes a separate stock structure, due to a lack of information on population mixing with the Atlantic, but available genetic studies have not revealed a distinction (SEDAR 2016). A SEDAR

evaluation of GOM speckled hind in 2016 was inconclusive, due to issues with available data.

POPULATION SIZE AND DISTRIBUTION

Speckled hind occur from Cape Hatteras to the Florida Keys, Bermuda, and in the Gulf of Mexico, and possibly the Caribbean at depths of 25-183 m (Ross 1988). They are strongly associated with continuous hardbottom, distributed along the mid-continental shelf to the shelf edge, with probability of presence in the SEUS increasing with latitude (Farmer and Karnauskas 2013). This agrees with Southeast Reef Fish Survey (SERFS) video observations (Figure 1; Bacheler et al 2016). An estimate of absolute Speckled Hind population size off South Carolina is not available. Commercial landings for Speckled Hind off the SEUS peaked in 1986 (NOAA Fisheries 2024). Commercial and recreational landings of Speckled Hind throughout the southeast have been in a general decline since, and prior, resulting in strict regulation and eventual closure (NOAA Fisheries 2024).

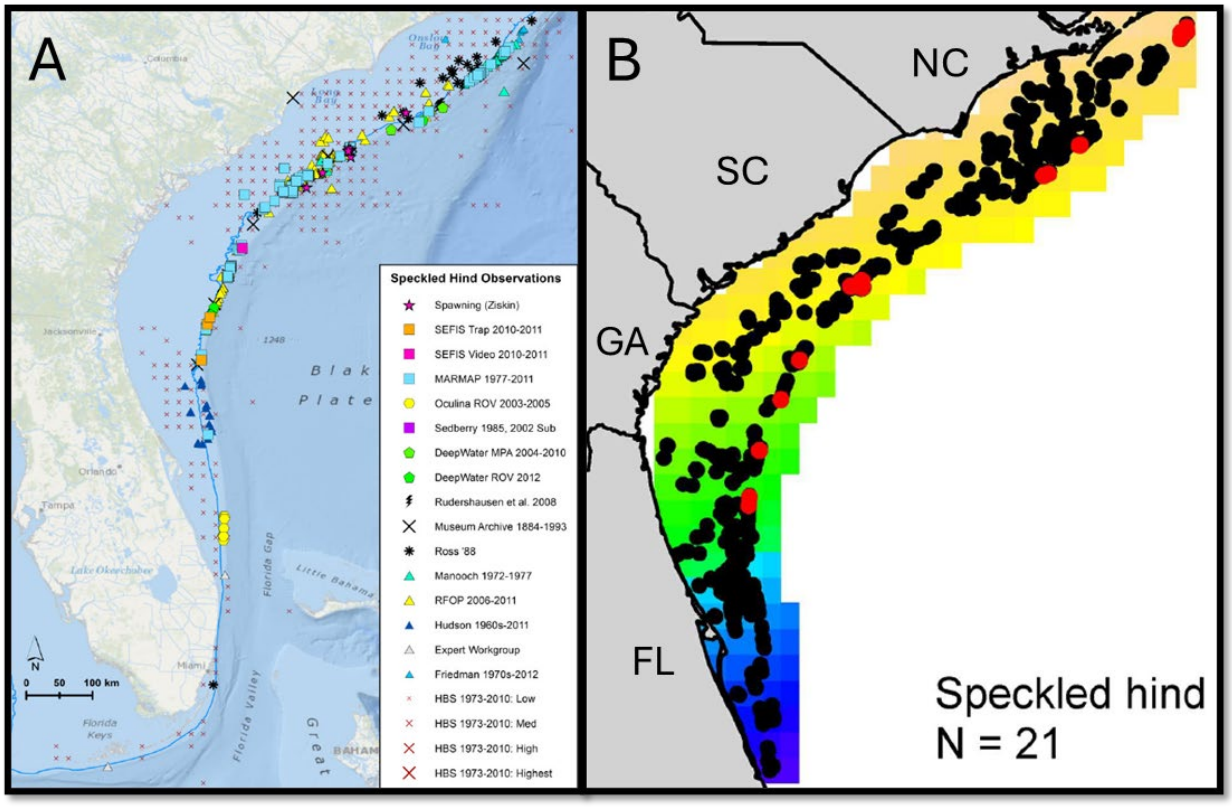


Figure 1: Modified figures from Farmer and Karnauskas (2013) displaying comprehensive reporting of Speckled Hind in SEUS Atlantic waters to 2011, and Bacheler et al (2016) showing the presence and absence of the Speckled Hind on videos. (A) Reliability of specific data sources (i.e. HBS) is noted as questionable. (B) Red indicates presence and gray points indicate absence from the Southeast Reef Fish Survey, 2011–2014. The "N" shows the number of videos samples in which the species was present.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Juveniles are concentrated in shallower depths (i.e. ~30-60 m), while mature adults are concentrated deeper (i.e. ~60-120 m), in temperatures of 60-85°F (SAFMC 2024, Ziskin et al 2011). Speckled hind occupy natural and artificial reef including wrecks, hard bottom, live bottom, and generally habitats that provide bathymetric relief (e.g. steep cliffs, rocky ledges; Ziskin et al 2011).

CHALLENGES

Speckled hind in the SEUS Atlantic has not undergone a formal stock assessment, but is considered overexploited (Ziskin et al 2011). Slower growing, long-lived species are not as resilient to disturbances compared to others in their community. This leads to more opportunities for removal from the ecological system, whether natural or fisheries-related, before their first reproductive contribution to the fishery. Because they are sequential hermaphrodites, there is also disproportionate targeting of the larger sex (males) which can skew population demographics. As a deepwater species (≥30 m), they are highly susceptible to post-release mortality (e.g. barotrauma). Although harvest is prohibited, bycatch of speckled hind is difficult to reduce as there is potential for mortality even when they are not targeted in this multi-species fishery. Since harvest closure, fishery-dependent data is minimal, sporadic, and/or confidential (NOAA Fisheries 2024). Overall gear encounters by the fishery-independent SERFS is relatively low, with catches not significant enough to create an index of relative abundance (Bubley et al 2023). As a data-limited species, life history information (e.g. peak spawning) and distribution knowledge is incomplete and current stock status difficult to assess.

CONSERVATION ACCOMPLISHMENTS

Speckled hind in the SEUS Atlantic are managed by the South Atlantic Fishery Management Council (SAFMC). After various regulation increases to commercial and recreational harvest, beginning in 1992, a complete prohibition of harvest was enacted in 2011. In addition, the SAFMC established Marine Protected Areas (MPA) throughout the region in 2009. Although effectiveness is yet to be determined, these spatial reserves are closed to bottom fishing year-round, protecting known habitat of speckled hind, and providing a valuable data source and potential tool for rebuilding the stock. To mitigate bycatch release mortality of Snapper-Grouper species in the SEUS Atlantic, NOAA National Marine Fisheries Service (NMFS) has implemented various gear requirements onboard all vessels (e.g. non-offset circle hooks), including descending devices as recent as 2020 (NOAA NMFS 2020).

CONSERVATION RECOMMENDATIONS

- Initiate a formal stock assessment of speckled hind, specific to SEUS Atlantic.

- Assess and alter MPAs, as needed, for maximum effectiveness.
- Continue to monitor via fishery-dependent and -independent surveys.
- Continue pursuit of non-lethal methods of determining abundance estimates.
- Conduct discard mortality studies in conjunction with ongoing surveys.
- Assess/address data gaps for speckled hind (e.g. oceanographic variables, spawning locations/patterns).
- Initiate an age-validation study of SEUS speckled hind.
- Perform high-resolution mapping, where not present, of assumed preferred habitat.

MEASURE OF SUCCESS

The SCDNR Marine Resources, Monitoring, Assessment, and Prediction (MARMAP) Program historically monitored the economically important Snapper and Grouper fisheries off the SEUS Atlantic. MARMAP, along with the Southeast Area Monitoring and Assessment Program – South Atlantic (SEAMAP-SA), and the Southeast Fishery Independent Survey (SEFIS), collectively known as SERFS, use a variety of survey platforms, designs, and methods to collect data on the relative abundance, population demographics, and reproductive state of these fish. With the information collected, the program can observe long-term trends and provide data needed by decision-makers for management regulations. An increase in relative abundance would suggest an increase in the numbers of speckled hind.

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Spinner Shark

Carcharhinus brevipinna



Contributor:
Bryan Frazier (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

The spinner shark, *Carcharhinus brevipinna* is a member of the family Carcharhinidae and reside in the genus *Carcharhinus* (32 species). The spinner is a placentally viviparous shark (bears live young with a maternal connection). Spinners are moderate sized sharks reaching maximum reported total lengths (TL) of 242 cm (Castro 2011). Spinner sharks are frequently confused with blacktip sharks, both species are recognizable by a prominent "Z" line along their sides; however, spinner sharks can be differentiated by their pointy snout, less robust body, shorter dorsal fin, and a black tipped anal fin. They have moderate life histories with males maturing at 4.5 years old (127 cm fork length, FL), and females maturing at 6.6 years old at around 142 cm FL (Palmrose unpublished). Once mature, spinner sharks reproduce every other year (biennial) and produce an average of 5 pups (Palmrose unpublished). The maximum observed age for the spinner shark is 23.5 years old (Vinyard unpublished).

Status

The spinner shark is classified as a large coastal shark (LCS) and is managed as a complex by the National Marine Fisheries Service (NMFS). Status determination for LCS is hampered by a lack of species specific data. The large coastal shark complex was last assessed in 2006, and the results of that assessment prompted a 50% reduction in available commercial quota. Spinner sharks have never had a species-specific stock assessment due to a lack of critical data including life history, catch, and fishery-independent data. The International Union for Conservation of Nature (IUCN) Red List considers spinner sharks as "Vulnerable" (Rigby et al. 2020). In South Carolina spinner shark catches vary from year to year as some years they appear in greater frequency then other, that said, abundance trends suggest a moderate increase in spinner sharks over the time-series (Figure 1).

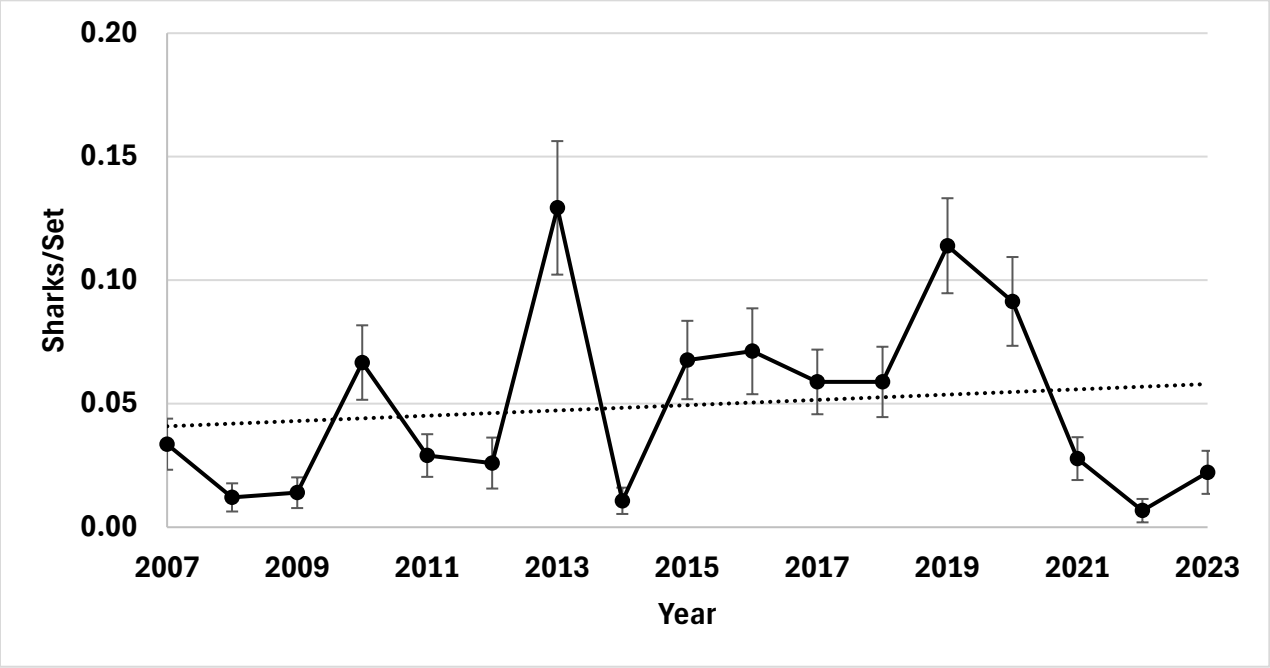


Figure 1. Catch per unit effort (sharks per set) of spinner sharks from 2007 to 2023 in the South Carolina Coastal Longline Survey. Standard error is denoted by error bars.

POPULATION SIZE AND DISTRIBUTION

Spinner sharks have a circumtropical distribution with the exception of the eastern Pacific Ocean (Castro 2011); however, records are spotty as they are often confused with blacktip sharks. In the US Atlantic Ocean, they are found from the mouth of the Chesapeake Bay (Virginia), south through the Gulf of Mexico. In South Carolina waters, they are primarily found as young of the year, with juveniles and adults occurring further offshore. Young of the year have been documented to be in estuarine waters. They are most abundant in late fall when other shark species have migrated out of SC waters.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

In South Carolina, spinner sharks are commonly found over sandy and muddy bottoms in estuarine and coastal waters. They are known to actively feed on schooling fish and can often be found mixed in with larger schools of blacktip sharks. While young of year sharks are infrequently captured, the extent of their use of South Carolina waters is unclear, as some years young of year spinner sharks are not encountered at all in South Carolina, whereas in other years they can be abundant. It appears there may be plasticity to their use of estuarine habitat. Larger juvenile and adult spinner sharks are primarily found in nearshore coastal waters. Little is known about habitat requirements for spinner sharks, but they seem to prefer high salinity waters (>32 ppt) (Ulrich et al. 2007).

CHALLENGES

Large coastal sharks, including spinner sharks, were generally shown to be in decline in US Atlantic waters; however, in recent years, the majority of populations have been increasing (Peterson et al. 2017). Recent efforts have focused on gathering critical life history data including age and growth, reproduction, and stock structure (multiple publications expected in 2025). These data should allow for a species-specific assessment has for spinner sharks. That said, difficulties in separating catches of spinner sharks and blacktips sharks may hamper assessing the stock status of the spinner shark. The life history of these species (slow growing, late maturity, and few offspring) means they are highly susceptible to overfishing. Spinner sharks are harvested both commercially and recreationally and are bycatch in a variety of fisheries; therefore, it is imperative that the stock status of spinner sharks is assessed.

CONSERVATION ACCOMPLISHMENTS

There are no conservation accomplishments specific to this species at this time.

CONSERVATION RECOMMENDATIONS

- Continue to monitor the stock status of spinner sharks within SC waters through fishery-independent methods, primarily COASTSPAN, and the Coastal Longline Survey.
- Increase monitoring of spinner sharks within coastal waters to determine habitat utilization.
- Increase collection of species specific-data to allow for future species-specific stock assessments.
- Continue genomic studies of spinner sharks including using close-kin mark recapture studies to estimate population size.
- Conduct studies using electronic monitoring tags (i.e. PSATs, acoustic tags, and SPOT tags to understand spinner shark migratory behavior and essential habitat.
- Improve the public's understanding of the importance of sharks in the ecosystem through outreach activities such as school programs, providing story opportunities for media, and educational brochures.
- Continue to educate the public on the importance of species identification of sharks to ensure undersized and prohibited sharks are not landed.
- The primary action at the state level via law enforcement partnering is to ensure adequate compliance with regulatory actions implemented through the federal management plan and subsequent amendments.

MEASURE OF SUCCESS

One of the most important measures of success will be determining species-specific stock statuses for spinner sharks in US waters. Regional management efforts to maintain healthy, sustainable populations of spinner sharks will require active participation from South Carolina due to its importance as habitat for the species. Expanding our knowledge on the life history and importance of SC waters for spinner sharks as well as the drivers of their movements and essential fish habitat for the species is of high importance. Maintaining ongoing monitoring programs to continue indices of abundance and trends over time is critical to the success of stock assessments.

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Spot

Leiostomus xanthurus

Contributor: (2005): Phil Maier (SCDNR)

Revised and Edited (2012): Phil Maier (SCDNR)

Revised and Edited (2025): James Kilfoil and Michelle Taliercio (SCDNR)

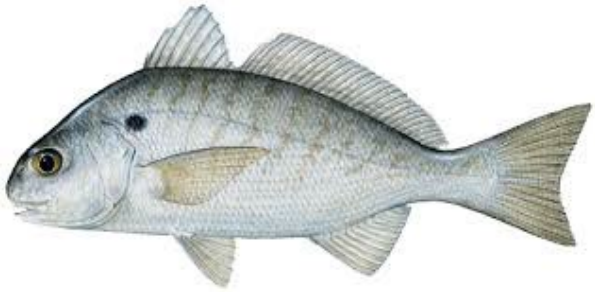


Photo courtesy of Maryland Fish Facts

DESCRIPTION

Taxonomy and Basic Description

Spot is a common member of the family Sciaenidae that was first described by Lacepede (1802). Johnson (1978) provided the following description of morphology: the body of the Spot is deep and compressed laterally; the back is strongly elevated; the head is obtuse and short with the small mouth positioned ventrally. Spot are bluish-gray above and somewhat golden below. They have 12 to 15 oblique dark streaks that may become indistinct in larger specimens. A single large black spot is located above the gill cover. Their average size is 8 inches, 0.5 pounds, and maximum age is approximately 5 years.

Status

Spot provide important recreational and commercial fisheries in the South Atlantic, although year-to-year fluctuations in landings are common. This is because spot are short-lived and the catch in most years consists of a single year-class, the strength of which is variable (partly due to environmental conditions prevalent in the spawning and nursery areas). In 2017, the first coastwide benchmark stock assessment was completed for Spot. The assessment used a catch survey model to estimate population parameters (e.g., stock status, natural mortality, discard rates, and mortality) and biological reference points. However, due to conflicting trends in abundance and harvest, as well as other uncertainties, this assessment was not recommended to be used for management advice. Independent of stock assessments, each year a traffic light analysis (TLA) is performed to analyze trends in the fishery and implement state-specific management actions if necessary. However, recent TLA analyses have also shown conflicting trends in abundance and harvest of Spot. The 2020 TLA showed significant declines in harvest of Spot in the mid-Atlantic and South Atlantic and declines in adult abundance in the mid-Atlantic which triggered management actions be put in place for the entire region. Overall status could not be determined in the 2022 TLA due to limited data availability from fishery independent surveys and the TLA was not run in 2023 due to an ongoing stock assessment. An updated benchmark stock assessment for Atlantic Croaker will be completed in 2024. Based on a 2019 IUCN assessment, Spot is listed as a species of 'Least Concern'. However, this assessment dates from over a decade ago and is noted as 'needs updating'.

POPULATION SIZE AND DISTRIBUTION

Spot are commonly found within estuarine and coastal waters from Cape Cod to the Bay of Campeche in Mexico (Phillips et al. 1989). In South Carolina they are found in estuaries throughout the state's coastline. With adults inhabiting estuaries, tidal creeks, and shallow coastal waters; generally over muddy or sand-mud bottoms; also over oyster reefs and along beaches, and juveniles utilizing lower salinity tidal creeks; yearlings progress to deeper water of lower estuaries and inlets; most common over mud or detritus-laden bottoms and seagrass beds.

The Southeast Area Monitoring and Assessment Program – South Atlantic (SEAMAP-SA) Coastal Trawl Survey (CTS) is a fishery independent survey conducted by SCDNR. This shallow water trawl survey monitors status and trends of numerous coastal species within the coastal zone in Atlantic waters off the southeastern United States between Cape Canaveral, FL to Cape Hatteras, NC. The stratified annual mean catch per unit effort (CPUE) in kilograms per tow per hectare for all months for Spot from the CTS has been highly variable since 1989. The general trend has been increasing abundance since 2007 (Figure 1).

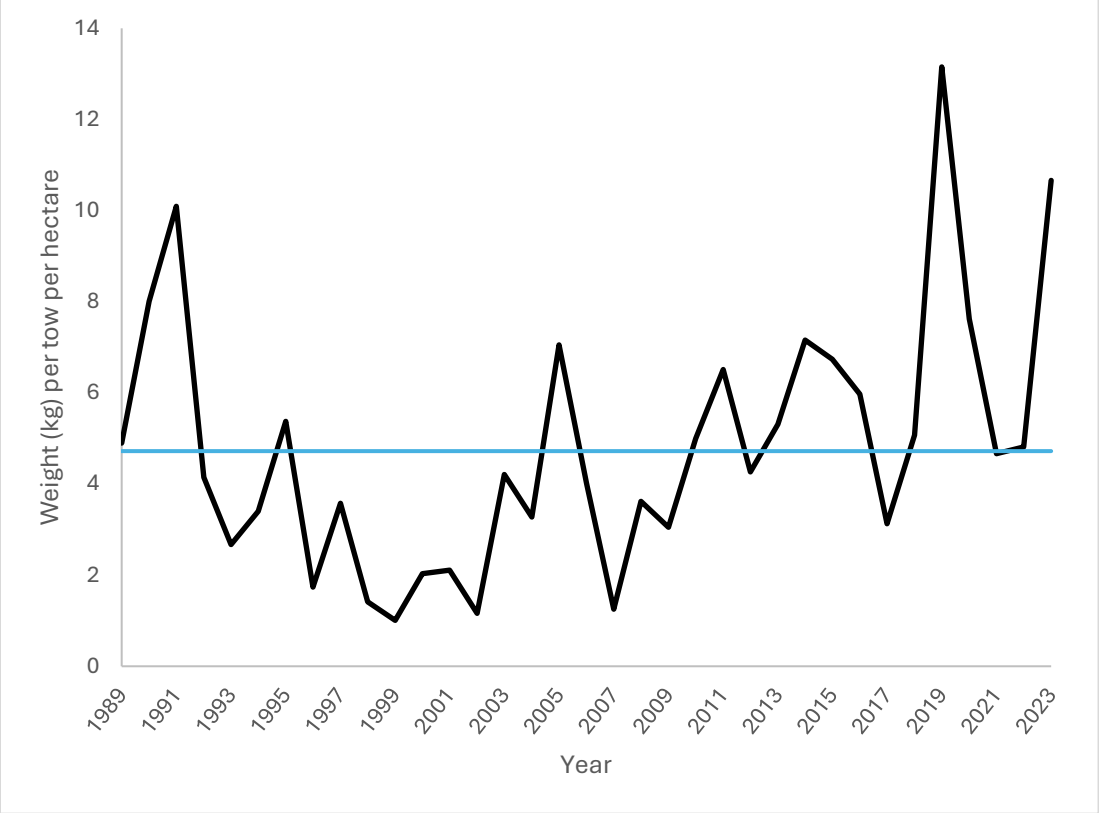


Figure 1. Stratified mean annual CPUE (kg/tow/hectare) for Spot from SEAMAP CTS from all months and strata. Blue line represents the long-term mean.

This species is commonly encountered in our fishery independent surveys; however, the population has decreased over the past few decades in the SCDNR Trammel Net Survey. (Figure 2), in which randomly selected sites along salt marsh edges amongst five estuaries along the South Carolina coast are sampled monthly. A similar trend is seen in the SCDNR Electrofishing survey over the past decade (Figure 3).

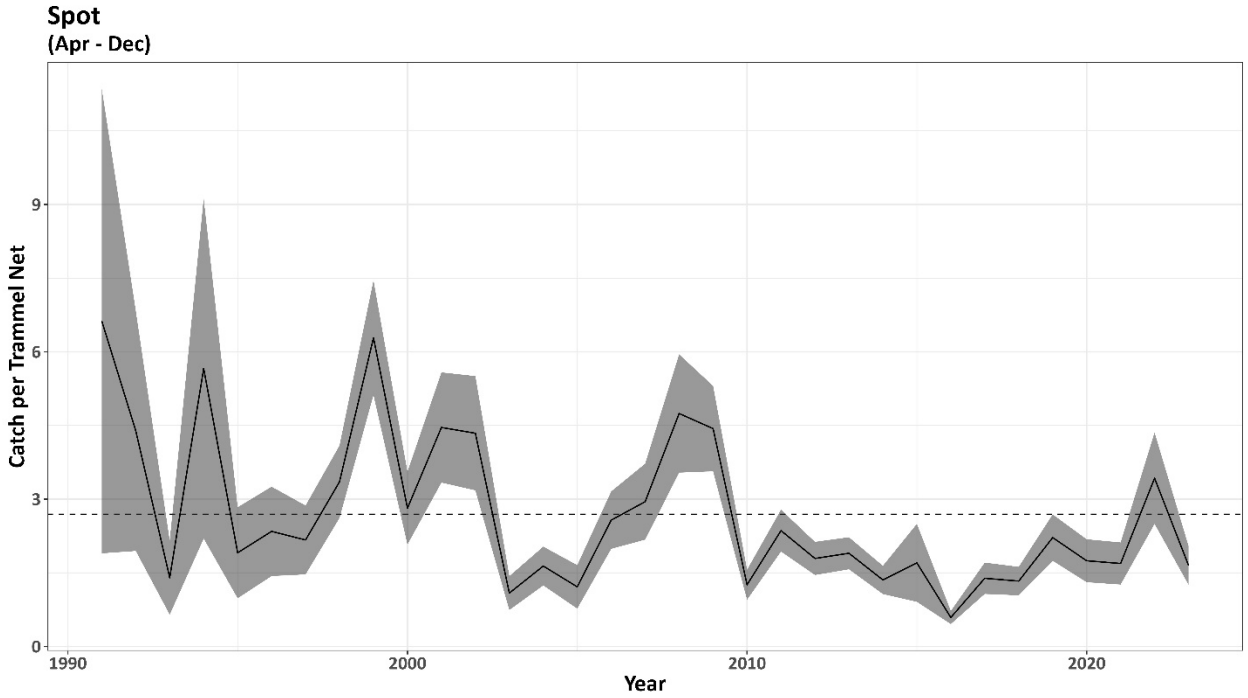


Figure 2. Trammel net index of Spot statewide normalized catch per unit effort (CPUE).

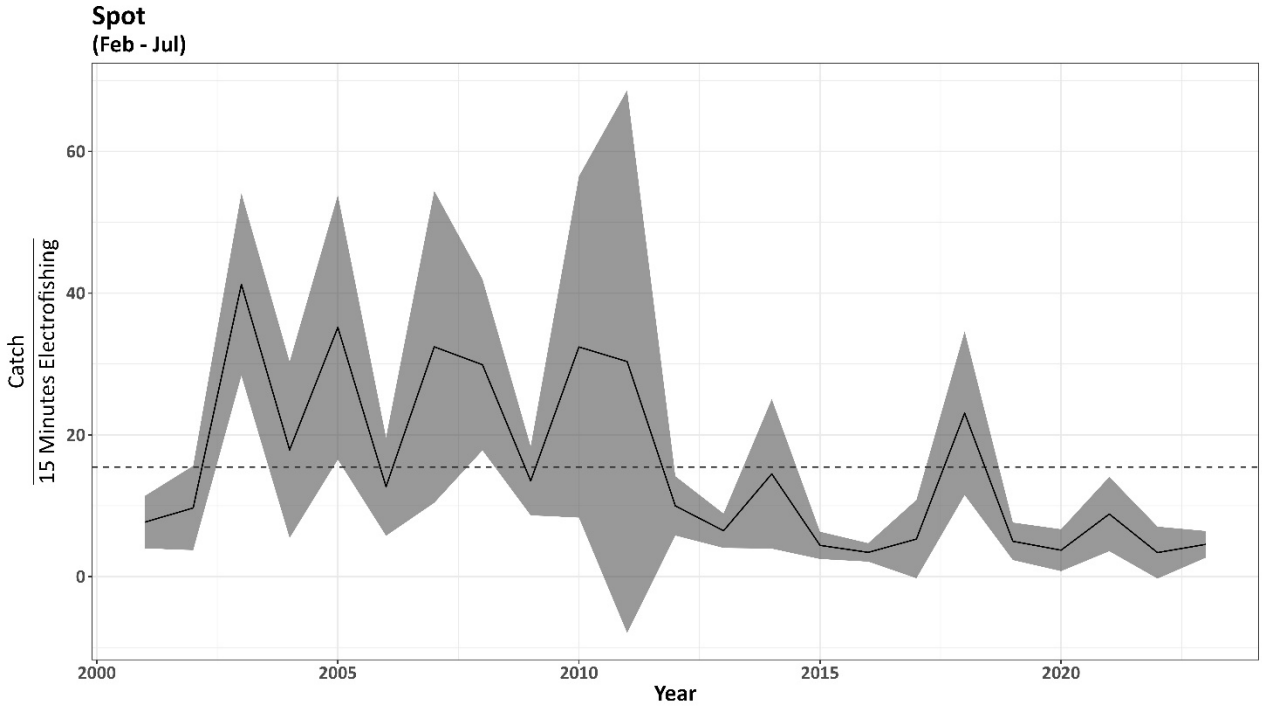


Figure 3. Electrofishing index of Spot statewide normalized catch per unit effort (CPUE).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Following entry to the estuary, Spot associate with shallow habitats, particularly tidal creeks. Due to its high productivity, this habitat provides ample prey for Spot, where they feed on locally available invertebrates including polychaete worms, amphipods, copepods, small mollusks and detritus. Adults gulp sediments and sort out invertebrate prey; juveniles graze on bottom-dwelling invertebrates. Larvae consume zooplankton.

The habitat is shallow and structurally complex, providing a physical refuge from predators. In addition, Spot are well adapted to live in the physiologically stressful, low dissolved oxygen/high carbon dioxide environment of small tidal creeks (Cochran 1994). Research in Rose Bay, North Carolina suggests that during their first summer, Spot grow and disperse from shallow edges of the bay to all depths (Currin 1984).

While offshore, Spot inhabit sandy or muddy bottoms in depths up to 60 m (197 ft.). Both sexes mature by 2 years of age; approx. size at maturity: 7 – 8 inches. Following spawning, larvae may take advantage of tidal mechanisms such as tidal bores and internal waves to migrate inshore (Williams 1993). Spot larvae are most dense in midwater and near the bottom during the day and migrate into surface waters at night. Nearshore, they are most dense on the bottom both day and night, possibly utilizing the salt wedge to enter the estuary.

Spot are strongly associated with the bottom as juveniles and adults and are seasonally dependent on the estuary. Along the east coast of the United States, spawning takes

place on the outer continental shelf from October through March. Peak spawning occurs during December and January off the North Carolina coast. As larvae mature, they are passively transported toward shore by currents (Warlen and Chester 1985). Near inlets, the larvae begin to metamorphose into juveniles (Phillips et al. 1989). In South Carolina, peak movement into the estuary occurs during late March (Williams 1993). Young-of-the-year Spot typically move first into the upper reaches of the estuary and then disperse to the lower reaches as they mature through their first season. In South Carolina, tidal creeks are important nursery habitats for post larval and juvenile spot (Cochran 1994). Young-of-the-year may remain in the estuary during their first winter, while older fish migrate offshore to spawn.

CHALLENGES

Conservation concerns: degradation and loss of estuarine habitat; pollution and compromised water quality; potential for significant recreational harvest; potential for significant commercial harvest and mortality as by-catch in southeast U.S. shrimp trawl fishery.

CONSERVATION ACCOMPLISHMENTS

Actions by the South Atlantic Fishery Management Council (SAFMC) led to the mandatory use of bycatch reduction devices (BRD) in shrimp trawl nets. Studies have shown that BRDs are effective at reducing mortality of fish such as spot. Also, since 1986 shrimp fishing in South Carolina is not allowed in the bays and sounds, thereby reducing exposure to trawls. Additionally, the South Carolina General Assembly closed most of the area in the State's sounds and bays to shrimp trawling in 1986, thus reducing fishing mortality and providing greater survival of juveniles. Another legislative action by South Carolina eliminated small mesh gill nets in the state's estuaries and significantly reduced the length of recreational gill nets to 30.5 m (100 ft.). Beginning in 2014, Spot are regulated in the recreational fishery by an aggregate bag limit along with other Sciaenids, Atlantic Croaker *(Micropogonias undulatus*) and Southern Kingfish (*Menticirrhus americanus*), where any combination of the three species can sum to 50 fish per person.

CONSERVATION RECOMMENDATIONS

- Continue fishery-independent surveys of Spot populations and identify factors affecting their abundance and recruitment.
- Investigate effects of chemical pollutants on spot populations and abundance.
- Continue to monitor long-term changes in Spot catch and effort statistics from the commercial and recreational fisheries to determine population trends.
- Protect water quality and important estuary habitat by working with municipalities to include best management practices (BMPs) in soil and water

conservation plans. Such plans should include installation of retention ponds, modified septic systems, and stream bank protection measures.

MEASURE OF SUCCESS

The measurement of success will be healthy estuarine habitat and a stable or increasing population trend for Spot. SCDNR has several fishery independent surveys that annually monitor trends in relative abundance, length frequency, size and age at maturity of estuarine finfishes including Spot, through monthly trammel netting, electrofishing, and the coastal trawl survey and can detect changes in those parameters that result from management efforts. Increases in recruitment, abundance, size, size and age at maturity would indicate positive trends in the population.

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Spotted Eagle Ray

Aetobatus narinari

Contributors:
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DESCRIPTION

Taxonomy and Basic Description

The spotted eagle ray (*Aetobatus narinari*), members of the order Myliobatiformes and family Aetobatidae (Page et al. 2023), sometimes referred to as the whitespotted eagle ray, are a distinctive marine ray speices widely distributed across the Atlantic Ocean in tropical to warm-temperate waters (Sellas et al. 2015). Characterized by its broad, round, flat snout reminiscent of a duck's bill, the species also has large spiracles located just behind its eyes and pointed pectoral fins. Its body displays a unique pattern of white spots across its back, which is typically black, dark gray, or blue, while its underside is white.

They can reach a maximum size of approximately 230 cm disc width (DW). Males mature at 127–129 cm DW, while females mature at 134.9 cm DW (Tagliafico et al. 2012; Last et al. 2016). Spotted eagle rays have a single row of broad, flat teeth in each jaw, forming upper and lower plates for crushing shelled prey. The skin of this species is smooth and lacks significant denticles or thorns. Spotted eagle rays can weigh up to 507 pounds and achieve a length of up to 8.2 ft (2.5 m).

The species primarily inhabits the neritic zone, which extends from the low-tide mark to the edge of the continental shelf, in tropical to warm-temperate waters (Dulvy et al. 2021; H. Asmus & R. Asmus 2011). They are commonly found in lagoons and estuaries and are closely associated with coral reef ecosystems (Dulvy et al. 2021). Spotted eagle rays are benthopelagic, residing over the continental shelf from the surface to depths of 60 m. Their preferred habitat, often considered "Hard Bottom" habitat, includes mixed communities of algae, sponges, octocorals, and stony corals, occurring in subtidal, intertidal, and supratidal zones.

Spotted eagle rays are matrotrophic viviparous, with females producing litters of 1–5 pups, averaging three, after a 12-month gestation period (Tagliafico et al. 2012; Last et al. 2016). Pups are born at a size of 18–36 cm DW. The species has a relatively low reproductive rate and a lifespan of 15 to 20 years (Boyd 2017). The inferred generation length is about 10 years, slightly shorter than the 12-year generation length of the larger *Aetobatus ocellatus* (Kyne et al. 2016).

Spotted eagle rays play a crucial role in the marine food web as both predators and prey. They primarily consume bivalve and gastropod mollusks, but their diet also includes cephalopods, crustaceans, and teleost fishes, helping to maintain the population balance of these species (Tagliafico et al. 2012; Flowers et al. 2021; Ajemian et al. 2012). Predators of spotted eagle rays include other teleosts, mammals, and other elasmobranchs (Flowers et al. 2021).

Status

The spotted eagle ray was assessed by the International Union for Conservation of Nature's (IUCN) Redlist in 2020 and was listed as Endangered globally with current population trends being in decline (Dulvy et al., 2021). The major justifications were overall suspected declines of 50-79% over the last 30 years due to fishing levels (both actual and potential; Dulvy et al, 2021). Regionally, the IUCN list spotted eagle rays as Critically Endangered in the Eastern and Southeast Atlantic, Endangered in the Southwest Atlantic, Least Concern in US water and Caribbean Islands, Near Threatened in central and northern South America (Dulvy et al., 2021). In addition, the Defend Them All Foundation petitioned NOAA-NMFS to list the species under the Endangered Species Act in 2023. However, NOAA-NMFS did not find substantial scientific or commercial information indicating the petitioned action may be warranted.

The spotted eagle ray is often captured in both industrial and artisanal fisheries, primarily through the use of demersal trawls, shrimp trawls, demersal set gillnets, and beach seine nets. Its swimming behavior makes it highly vulnerable to a variety of fishing gear throughout the water column, particularly to inshore gillnets, which are extensively used across its range. This species is frequently targeted in artisanal gillnet fisheries and caught as bycatch in industrial shrimp trawls. The rays are typically retained and sold fresh for local consumption (Dulvy et al., 2021).

POPULATION SIZE AND DISTRIBUTION

The spotted eagle ray was initially limited to the Western Central and Southwest Atlantic (Sales et al., 2019) but has since expanded to the eastern Atlantic (Fricke et al., 2020). This species primarily inhabits shallow nearshore waters such as estuaries, lagoons, and bays, but can also be found in coral reef ecosystems up to 200 ft deep (Dulvy et al., 2021; Desgarnier et al., 2022). The ray's range in the Western Central and Southwest Atlantic extends from Cape Hatteras, North Carolina, USA, to Rio de Janeiro, Brazil, including the Gulf of Mexico, the Bahamas, and the Caribbean Islands (Last et al., 2016; Sales et al., 2019). In the Eastern Central and Southeast Atlantic, its range is believed to extend from Mauritania south to Angola, and possibly South Africa (Sales et al., 2019; Fricke et al., 2020).

This species is native to and resident in numerous countries, including Angola, Anguilla, Antigua and Barbuda, Aruba, the Bahamas, Barbados, Belize, Benin, Bermuda, Bonaire,

Sint Eustatius and Saba, Brazil, Cameroon, the Cayman Islands, Colombia, the Republic of Congo, the Democratic Republic of the Congo, Costa Rica, Cuba, Curacao, Côte d'Ivoire, Dominica, the Dominican Republic, El Salvador, Equatorial Guinea, French Guiana, Gabon, Gambia, Ghana, Grenada, Guadeloupe, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Jamaica, Liberia, Martinique, Mauritania, Mexico, Montserrat, Nicaragua, Nigeria, Panama, Puerto Rico, Saint Barthelemy, Saint Kitts and Nevis, Saint Lucia, Saint Martin (French part), Saint Vincent and the Grenadines, Sao Tome and Principe, Senegal, Sierra Leone, Sint Maarten (Dutch part), South Africa, Suriname, Togo, Trinidad and Tobago, Turks and Caicos Islands, the United States (Alabama, Florida, Georgia, Hawaiian Islands, Louisiana, Mississippi, North Carolina, South Carolina, Texas), Venezuela, and the Virgin Islands (both British and U.S.; Dulvy et al., 2021).

In Belize, population trend data collected via baited remote underwater videos (BRUVs) from 2009 to 2018 showed an annual increase in abundance at a rate of 7.5% (G. Clementi and D. Chapman, unpublished data, 2019). Conversely, in Mexico, data from 2000 to 2014 indicated an annual decline of 0.95% (J.C. Perez Jimenez, unpublished data, 2019). When these datasets are combined, they suggest an overall annual increase of 1.32% over 30 years, placing the population primarily in the Least Concern category with a 72% probability (Sherley et al., 2020; Winker et al., 2019).

In the Western Central Atlantic, artisanal fisheries targeting spotted eagle rays are known in Mexico (Cuevas-Zimbron et al., 2011), Cuba (Cuba NPOA-Sharks, 2015) and Venezuela (Tagliafico et al., 2012). Declining annual catch rates have been observed in these fisheries. For example, fisher interviews in the southern Gulf of Mexico report a decline from 30-40 rays per trip in the 1990s to about 10-15 rays per trip more recently (Cuevas-Zimbron et al., 2011; J.C. Perez Jimenez, unpublished data, 2019). In Venezuela, unmanaged artisanal gillnet fisheries continue to target this species, contributing to population declines reported since the early 1970s (Gines et al., 1972, cited in Tagliafico et al., 2012). Data from the Guianas is sparse, but similar reductions are suspected due to the level of artisanal and commercial fishing pressure. While populations may be stable in U.S. waters and the Caribbean Islands, declines are suspected in central and northern South America, suggesting a Near Threatened status in these regions (Dulvy et al., 2021).

In the Southwest Atlantic, intense and unmanaged commercial and artisanal fisheries have led to significant declines in this and other species. For instance, in Pernambuco, Brazil, gillnet landings have decreased by about 80% since 1995 (F.M. Santana, personal communication, 2018 cited in Dulvy et al., 2021). Monitoring in São Paulo between 1996 and 2002 recorded only five individuals, with fishers reporting further declines (S. Montealegre-Quijano, personal communication, 2018 cited in Dulvy et al., 2021). It is suspected that the population in the Atlantic South American range has

decreased by 50-79% over the past three generations due to exploitation by widespread artisanal and some commercial fisheries, which lack adequate management (Dulvy et al., 2021).

In the Eastern Central and Southeast Atlantic, the largest reported elasmobranch fisheries in Africa are in Nigeria, Senegal, and Ghana, but actual landings are likely higher due to underreporting (Dulvy et al. 2021). From 1970 to 2015, the average elasmobranch catch per unit effort (CPUE) in West Africa decreased by 71%, while the average catch increased by over 250% (Pauly et al., 2020). In Mauritania, shark, ray, and skate landings increased by 246% from 1992 to 2015. In Senegal, reconstructed landings showed a decline of at least 30% over 15 years from 2001 to 2016. Guinea-Bissau experienced a 22% decline from 2012 to 2016, while Cameroon saw a 96% decline from 2007 to 2016 (Pauly et al., 2020). These declines in landings are indicative of population reductions, as fishing effort increased during the periods of declining landings (Dulvy et al., 2021).

There have been few records of the spotted eagle ray in the Eastern Central and Southeast Atlantic over the past decade. In the Republic of Congo, only a single specimen was caught in a pilot project, despite regular catches of similar species (P. Doherty, unpublished data, 2020). In Cameroon and Angola, landing site surveys have recorded very few instances of this species (A. Tamo, unpublished data, 2020; A.-L. Soares, unpublished data, 2020). The lack of recent sightings suggests that the species may have largely disappeared from West Africa, with an estimated population reduction of over 80% in the past three generations (Dulvy et al., 2021).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The spotted eagle ray is a benthopelagic species found over the continental shelf, ranging from the surface down to 60 m (Last et al., 2016). It commonly inhabits lagoons and estuaries and is often associated with coral reef ecosystems (Ajemian et al., 2012; Bassos-Hull et al., 2014).

Spotted eagle rays prey mainly on bivalves, crabs, whelks, and other benthic infauna. They also feed on mollusks, such as the queen conch (Dulvy et al., 2021), and crustaceans, particularly malacostracans (Richards et al., 2009), as well as echinoderms, polychaete worms (Schluessel et al., 2010), hermit crabs (Schluessel et al., 2010), shrimp, octopuses, and some small fish.

The spotted eagle ray's specialized chevron-shaped tooth structure helps it to crush the hard shells of mollusks (Froese and Pauly, 2024). The jaws of these rays have developed calcified struts to support them and prevent dents from hard prey (Summers, 2001). These rays exhibit a unique behavior of digging with their snouts in the sand of the ocean floor. While doing this, a cloud of sand surrounds the ray, and sand spews from its gills.

CHALLENGES

Spotted eagle rays inhabit coastal inshore waters where fishing pressure is significant, particularly in regions such as the Gulf of Mexico, Caribbean Sea, and Eastern Central and Southeast Atlantic Ocean along the African coast. These rays often enter estuarine waters, increasing their exposure to fishing activities. Their swimming behavior makes them vulnerable to various fishing gears throughout the water column, particularly inshore gillnet fisheries, which are prevalent across their range. They are commonly caught in both artisanal gillnet fisheries and industrial shrimp trawl fisheries (Dulvy et al., 2021).

In the Northwest and Western Central Atlantic, there is limited documentation of artisanal directed fisheries for spotted eagle rays, but they are known to exist in Mexico (Cuevas-Zimbrón et al., 2011), Cuba (Cuba NPOA-Sharks, 2015) and Venezuela (Tagliafico et al., 2012). In Caribbean Colombia, widespread artisanal fisheries lack proper management, and there is a collapsed shallow-water shrimp trawl fishery. The ray is caught using gillnet, longline, and trawl gears (P. Mejía-Falla and A. Navia, unpublished data, 2018). Venezuela experiences intense commercial and artisanal fisheries, which also lack management and have shown peaks followed by declines, indicating sequential overfishing. This ray species is targeted in artisanal fisheries (Tagliafico et al., 2012), and declining annual catch rates have been observed in both Mexico and Venezuela (Cuevas-Zimbrón et al., 2011; Tagliafico et al., 2012).

In the Southwest Atlantic, intense artisanal fisheries operate along much of the coastal regions of South America. Many areas have largely unmanaged commercial trawl and longline fisheries. By 2000, groundfish fisheries on the Brazil-Guianas shelf were fully over-exploited. These fisheries are multi-gear, multi-species, and multinational, with vessels crossing national maritime borders (Booth et al., 2001). Despite some closures and total allowable catch limits, the number of operating vessels has decreased (Diop et al., 2015). In northwestern Brazil, high artisanal fisheries pressure led to 44% of target stocks being overfished by the end of the 2000s (Vasconcellos et al., 2011). The intense and unmanaged fishing has resulted in the disappearance of several elasmobranch species in the region, including Largetooth Sawfish (Pristis pristis), Smalltooth Sawfish (Pristis pectinata), Daggernose Shark (Isogomphodon oxyrhynchus), and Smalltail Shark (Carcharhinus porosus) (Charvet and Faria, 2014; Lessa et al., 2016; Reis-Filho et al., 2016; Santana et al., 2020). In northeastern and eastern Brazil, artisanal fisheries are intense, predominantly using gillnets, and fishers report overexploited stocks and depleted shark populations (Guebert-Bartholo et al., 2011; Reis-Filho et al., 2016). The southern Brazilian trawl fishery expanded rapidly in the 1990s and 2000s, with over 650 vessels fishing at depths of 20–1,000 meters (Port et al., 2016). Artisanal fisheries are intense, with 58% of targeted stocks overexploited and half having collapsed (Vasconcellos et al., 2011).

In the Eastern Central Atlantic, sharks and rays have been exploited by semi-industrial fisheries since the 1950s, but these fisheries have gradually collapsed. The demand for dried salted shark meat (for export to Ghana) and shark fins in the 1980s spurred the development of artisanal targeted shark fishing across the region (Diop and Dossa, 2011; CCLME, 2016; Seto et al., 2017; Moore et al., 2019). This has expanded into targeted shark and ray fisheries across many countries, increasing fishing pressure on this species (Walker et al., 2005; Diop and Dossa, 2011). The result has been population reductions of many shark and ray species, including the local extinction of sawfishes (family Pristidae) from West African coastal waters and several species of wedgefishes from their northern range in Mauritania and Senegal (Walker et al., 2005; Kyne et al., 2020). Sharks and rays continue to be targeted in many countries, with artisanal fishers using drift gillnets and demersal set gillnets with large mesh sizes (M. Diop, I. Seidu, A. Tamo, and A.B. Williams, unpublished data, 2020).

Overall, fishing effort and the number of fishers have increased in recent decades across most of this species' range. For instance, in West Africa, there has been a marked decline in the diversity and average body size of many important commercial coastal, demersal, and pelagic fishery species, with many stocks now overexploited (FAO, 2002; Srinivasan et al., 2012; Polidoro et al., 2016; CCLME, 2016). Trawl surveys conducted across the Gulf of Guinea from 1977 to 2000 showed a 50% decline in fish biomass (Brashares et al., 2004), and the total demersal biomass of inshore stocks is estimated to have declined by 75% since 1982 (Meissa and Gascuel, 2015). The primary cause of this decline has been overcapacity within both industrial and artisanal fisheries and destructive fishing practices (GCLME, 2006; CCLME, 2016). From 1950 to 2010, artisanal fishing effort increased tenfold, with an estimated 252,000 unregulated artisanal vessels and 3,300 industrial vessels (mainly distant water fleets from Europe and East Asia operating under 'access agreements') operating in the region by 2010 (Walker et al., 2005; Diop and Dossa, 2011; Belhabib et al., 2018).

Due to their diet primarily consisting of mollusks, Whitespotted Eagle Rays sometimes negatively interact with shellfish farming, with episodic and anecdotal reports of such interactions in the Northwest Atlantic (McEachran and Carvalho, 2002). Confirmed interactions often involve molluscan culture operations in the Indo-Pacific, such as those reported for conspecifics like A. narutobiei in Japan (Yamaguchi et al., 2005). While predator culling programs have not been implemented for Whitespotted Eagle Rays in the USA, similar programs have been considered for other myliobatid species, such as the Bat Ray (Myliobatis californicus) off California (Gray et al., 1997) and the Cownose Ray (Rhinoptera bonasus) in Chesapeake Bay and other areas in the USA (Grubbs et al., 2016).

The quality of neritic marine habitats that the Whitespotted Eagle Ray occupies has deteriorated and is anticipated to worsen due to pollution and coastal development

affecting Atlantic coastlines (Dulvy et al., 2021). This species is particularly susceptible to habitat alterations because it inhabits, breeds, and feeds in shallow coastal areas such as lagoons, estuaries, and coral reefs (Dulvy et al., 2021). In addition, these concerns are likely exacerbated by the effects of warming ocean temperatures, as temperature fluctuations can influence spotted eagle ray behavior and migration patterns (Osgood et al., 2021)

CONSERVATION ACCOMPLISHMENTS

Certain countries, such as Cuba, have initiated National Plans of Action (NPOAs) to conserve sharks and rays and manage their fisheries sustainably, comprehensive management plans are essential for the conservation of elasmobranch species such as the spotted eagle ray. These plans can be local, regional, national, or international, such as the FAO International Plan of Action for the Conservation and Management of Sharks (IPOA-Sharks).

In West Africa, several countries have adopted a Regional Plan of Action for the Conservation of Sharks (including Sub-Regional Fisheries Commission countries from Mauritania to Sierra Leone, and Cape Verde) or are working on National Plans of Action (e.g., Liberia) under the FAO IPOA-Sharks to conserve sharks and rays and manage their fisheries sustainably.

The Regional Marine Protected Areas Network in West Africa (RAMPAO), established in 2007 across six countries from Mauritania to Sierra Leone, aims to conserve critical habitats and protect threatened species. However, many of these protected areas suffer from a lack of capacity, funding, infrastructure, and governance, undermining effective enforcement and conservation (Polidoro et al., 2016). Other countries, such as Gabon, the Republic of the Congo, and Côte d'Ivoire, are expanding their marine protected areas, but they will need financial and technical support to ensure effective enforcement and to promote connectivity and protection of key life history stages (K. Metcalfe, unpublished data, 2020).

In Florida state waters, the spotted eagle ray is protected under the Florida Administrative Code. The species cannot be harvested, possessed, landed, purchased, sold, or exchanged in Florida. In Bermuda, a small recreational fishery was quickly curtailed when protection was enacted in 2010.

CONSERVATION RECOMMENDATIONS

- Expand legislative protections to other US States within species range
- Continue monitoring of elasmobranchs within coastal waters
- Increase collection of species-specific data to allow for future species-specific stock assessment

- Investigate fine-scale movement to determine habitat utilization and potential influence of future habitat loss/degradation and/or climate change
- Conduct studies to investigate post-release mortality rates from targeted fisheries and bycatch
- Investigate potential gear-modifications and time-area closures to reduce unwanted interactions with fisheries

MEASURE OF SUCCESS

- Gather enough information to effectively monitor population trends by region
- Decreased bycatch and unwanted interactions in fisheries
- Species-specific legislative protections

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Spotted Seatrout

Cynoscion nebulosus



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DESCRIPTION

Taxonomy and Basic Description

Spotted seatrout are medium sized member of the order Perciformes and family Sciaenidae (Page et al. 2023). Individuals are dark gray above with a bluish reflection and silvery below, with numerous dark spots scattered along the upper sides of the body and on the dorsal and caudal fins (Carpenter 2002; Lorio & Perret 1978). Dorsal fin meristics include 9-10 spines located in the anterior dorsal fin and one spine located in the second dorsal with 25-28 rays (Carpenter 2002). The soft part of the dorsal fins do not have scales, which distinguishes it from their congener weakfish (*C. regalis*; Carpenter 2002). Weakfish also possess a snout with 1 marginal pore, compared to two in spotted seatrout, and an anal fin with 2 weak spines and 11-13 soft rays (Carpenter 2002). Spotted seatrout possess two large canine-like teeth at the tip of the upper jaw, while the remainder of the teeth are small and increase with size posteriorly on the lower jaw (Carpenter 2002). Unlike some other members of the family Sciaenidae, they do not have barbels or pores located on the chin (Carpenter 2002).

Spotted seatrout are found throughout the estuaries and coastal waters of South Carolina. On the Atlantic coast, they can be found from Cape Cod, Massachusetts to the Florida Keys, but are most commonly found south of Chesapeake Bay. Spotted seatrout are also found along the Gulf coast from Florida to northern Mexico. Throughout much of their range, they are considered non-migratory and spend their entire life within 5-10 miles of their natal estuary (ASMFC 2024b). However, in the northernmost estuaries, they exhibit some migratory behavior (ASMFC 2024b).

Spotted seatrout mature at about one year of age, when males and females are approximately 10 and 11 inches total length (TL), respectively (ASFMC 2024). The sexes exhibit dimorphic growth, with females being significantly larger than males at all life stages and reach greater maximum ages. Spotted seatrout have been documented to live up to 18 years, but individuals over 5 years of age are rare. The oldest individuals caught by the Inshore Fisheries Research Section were 10 years of age (J. Ballenger, pers. comm.).

Spotted seatrout spawn in the evenings, like many other Sciaenids, from April to September in the lower reaches of estuaries and around inlets (Roumillat & Brouwer 2004). Spotted seatrout are group-synchronous spawners with indeterminate fecundity (Roumillat & Brouwer 2004). Male spotted seatrout have the capacity to produce drumming sounds by contracting the swim bladder; this sound plays an integral role in spawning events (Roumillat & Brouwer 2004). Spotted seatrout exhibit external fertilization with the number of eggs released by a female during a spawning event correlated with body size.

Status

A coastwide stock assessment has not been conducted due to the non-migratory nature of the species (ASFMC 2024). Instead, age-structured analyses of stocks have been conducted in North Carolina, South Carolina, Georgia, and Florida. South Carolina and Georgia have adopted the goal of 20 percent spawning potential ratio, while North Carolina and Florida have adopted a goal of 30 percent and 25 percent SPR, respectively (ASFMC 2024).

A stock assessment was conducted for spotted seatrout in Florida in 2016 with results indicating stocks in northeast and southeast Florida are above the biomass threshold, but below the biomass target and overfishing is likely not occurring (Addis et al., 2018). An assessment of spotted seatrout in Virginia and North Carolina was completed in 2022, with data from 1991-2019, suggesting spotted seatrout were experiencing overfishing but not overfished (NCDMF 2022). The model suggested a shift in population dynamics around the year 2004, with lower fishing mortality and higher spawning stock biomass and recruitment with greater variation predicted since 2004 (NCDMF 2022).

The South Carolina population of spotted seatrout supports large scale recreational fisheries, with annual removals (harvest plus dead discards) generally increasing from lows in the early 1980's of less than 0.5 million fish to highs in recent years at greater than 3 million fish, peaking in 2021 at 5.2 million fish (Figure 1). Since the late-2000s, in most years greater than 50% of annual recreational removals is the result of dead discards (Figure 2), assuming 30% of catch-and-release spotted seatrout suffer post-release mortality as reported in Nelson et al. (2021). The South Carolina

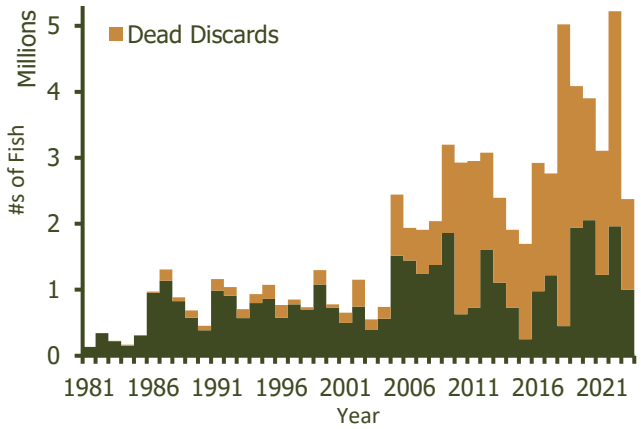


Figure 1: Recreational harvest (green) and dead discards (gold) of spotted seatrout in South Carolina (Source: NMFS, Office of Fisheries Statistics, pers. comm.). Dead discards calculated by applying a 30% post-release mortality rate to dead discards as estimated in Nelson et al. (2021).



Figure 2: Percent of annual removals represented by direct harvest (green) and dead discards (gold) for the South Carolian spotted seatrout fishery (Source: NMFS, Office of Fisheries Statistics, pers. comm.). Dead discards calculated by applying a 30% post-release mortality rate to dead discards as estimated in Nelson et al. (2021).

Department of Natural Resources (SCDNR) included several state-specific assessments into a report in 2001, though these were not peer reviewed. The initial assessment covering 1986-1992 indicated female SPR was just above the 20% goal in the terminal year leading to a minimum size limit increase and a creel limit reduction (Zhao and Wenner 1995). While an assessment has not been conducted recently, the coastwide increase in recreational harvest is concerning.

POPULATION SIZE AND DISTRIBUTION

The SCDNR Inshore Fisheries trammel net survey routinely captures spotted seatrout, with spotted seatrout being the second most encountered species in the survey. The trammel net survey conducts a monthly survey of coastal South Carolina salt-marsh edge habitats, with the survey encountering spotted seatrout year-round, though more frequently during the latter half of the year (Figure 3) as individuals born in the spring recruit to the gear as they grow to larger sizes. Throughout the time series of the survey, we see a cyclical pattern of spotted seatrout relative abundance with particularly high relative abundances in 1999-2000, 2006-2009, and 2020 (Figure 4). In contrast, particularly low abundances occurred in 1991-1996, 2001-2005, 2010-2011 and 2018. Note these generally followed marine cold spells during winters producing estuarine water temperatures known to lead to spotted seatrout mortality, with documented events during the winters of 1989-1990, 1993-1994, 2000-2001, 2010-2011, and 2017-2018 (J. Ballenger, pers. comm.). Spotted seatrout begin recruiting to the survey once 10” (254 mm) TL, with the largest individual encountered in the survey being greater than 27” (685 mm) TL (Figure 5).

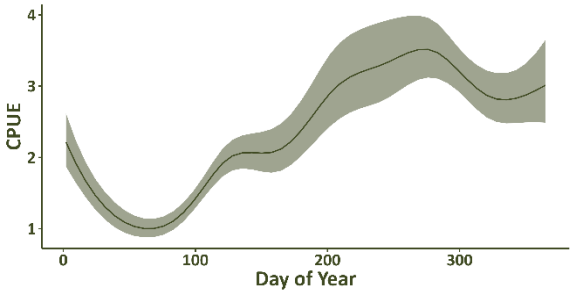


Figure 3: Predicted catch per trammel net of spotted seatrout as a function of day of year based on standardized relative abundance index.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Submerged aquatic vegetation, salt marsh, and oyster reefs, especially where submerged aquatic vegetation is not available, are fish habitats of concern for spotted seatrout (ASMFC 2024a). Seagrass beds provide important habitat for both juvenile and

adult spotted seatrout, but are in decline along much of the Atlantic coast (Orth et al. 2006; Waycott et al. 2009; Adams et al. 2019; Morris et al. 2022), though never present due to estuarine turbidity in South Carolina. In South Carolina, saltmarsh and oyster reef habitats provide fish habitat of concern for juvenile and adult spotted seatrout (ASMFC 2024a). Spotted seatrout prefer depths less than 10 ft and temperatures 60-80°F (15°-27° C). In South Carolina, and other areas, spotted seatrout are vulnerable to mortality in winter when water temperature decreases rapidly. Anweiler et al. (2014) found temperatures below 41°F (5° C) are cause for concern for this species, though the

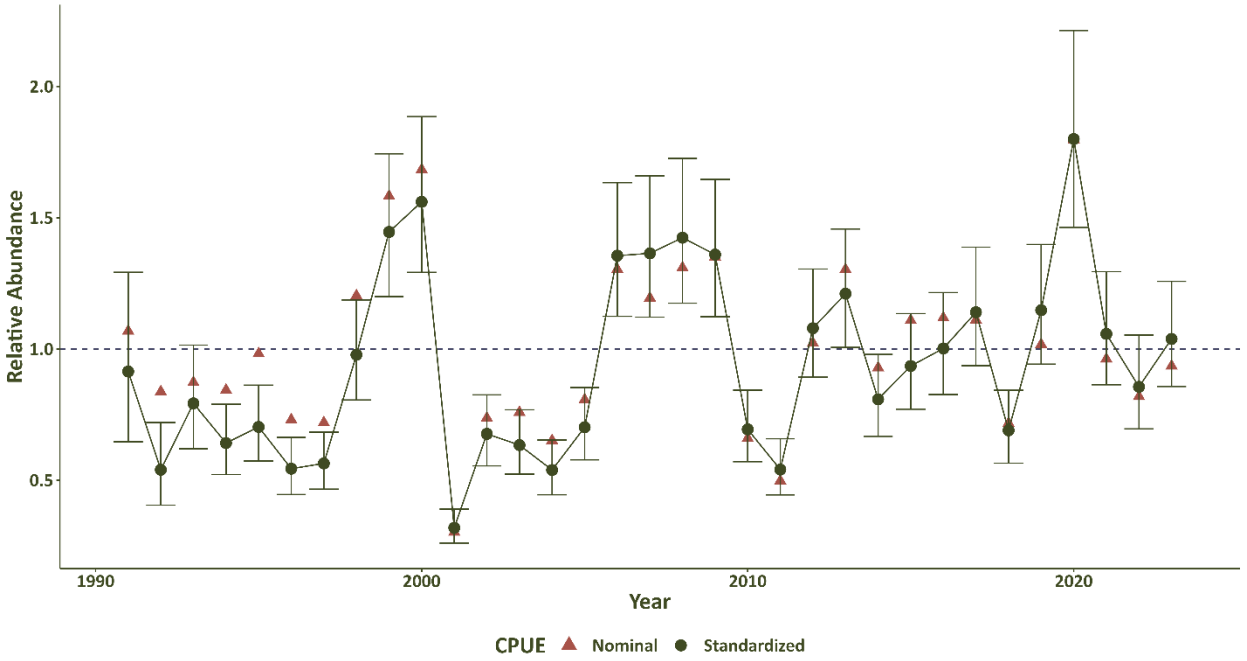


Figure 4: Spotted seatrout standardized catch per unit effort in SCDNR's Inshore Fisheries trammel net survey by year from 1991 to 2023. Shown is the standardized index of abundance (green line and circles) with a 95% CI (error bars) as well as nominal catch per trammel net (red triangles). Both the standardized and nominal indices are normalized to average catches from 2010-2023 (dashed line), such that if annual estimates are greater than 1, catch was above the 2010-2023 average and vice versa if below.

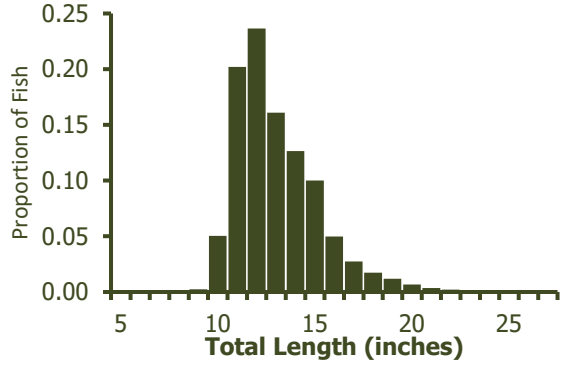


Figure 3: Length frequency distribution of spotted seatrout encountered by the SCDNR trammel net survey.

duration of cold temperatures and the spatial distribution of temperature conditions will determine the severity of a winter mortality event.

CHALLENGES

Spotted seatrout along coastal South Carolina face a number of challenges, including increased fishing pressure, changing and increasingly stressful environmental conditions, loss and degradation of habitats critical to juvenile and adult spotted seatrout due to coastal development, and other anthropogenic stressors such as contaminants and pollutants. To date these challenges have not apparently led to long-term declines in abundance, but additional study is warranted to predict changes in population demographics and abundance under future conditions. Further, major data gaps still exist, including the size composition of recreationally released fish, and hence the sizes and ages subject to post-release mortality and fishery selectivity, and the impact (lethal and sublethal) of catch-and-release fishing on spotted seatrout. Emerging challenges facing spotted seatrout, and many other estuarine species, include the impact of warming estuarine waters and

marine heat waves during critical life history stages, phenological changes in weather patterns and food web dynamics, and increased variability in the climate. Finally, the impact of contaminants of emerging concern, such as per- and polyfuoroalkyl substances and microplastics among others, on the productivity of the population still needs investigation.

CONSERVATION ACCOMPLISHMENTS

The South Atlantic Board approved the Omnibus Amendment for spotted seatrout in 2011, which included recommended efforts to protect the spawning stock (ASMFC 2024b). The Omnibus Amendment also required a coastwide minimum size limits of 12" TL for spotted seatrout. A report on fish habitat of concern designations for fish and shellfish species was released in 2024 1that included habitat information for spotted seatrout (ASMFC 2024a), drawing attention to habitats warranting protection. In South Carolina, there is currently a minimum size of 14" total length and a bag limit of 10 fish per angler per day (SCDNR 2007).

SCDNR's Inshore Fisheries group monitors the health of spotted seatrout populations through two long-term monthly fish surveys. These surveys collect critical long-term data sets on the relative abundance, population demographics, and reproductive status of spotted seatrout throughout coastal South Carolina. Further, Anweiler et al. (2014) investigated the minimum thermal tolerances of spotted seatrout during the winter, providing valuable information on impacts marine cold spells may have on the relative abundance of spotted seatrout. Since publication, when marine cold spells have occurred (e.g., winter of 2017-2018) information in Anweiler et al. (2014) has been used by managers to predict the impact on South Carolina spotted seatrout populations.

CONSERVATION RECOMMENDATIONS

To aid conservation of this important estuarine species, we propose the following research recommendations:

- Development of methods to estimate recreational discard length- and age-compositions and better characterize post-release mortality across size, age, and environmental conditions. In addition to direct post-release mortality, investigate the potential for sublethal effects of catch-and-release fishing on individuals.
- Expand biostatistical sampling to collect more otolith ages to provide robust age-length data for development of seasonal growth models necessary to support development of seasonal assessment models.
- Better characterize the reproductive potential of the population through investigations of batch fecundity, lengths- and ages-at-maturity, sex ratios, spawning seasons, and spawning frequencies. Investigate how these values change with size and/or age.

- Investigate the appropriateness of reference points used for spotted seatrout management.
- Identify impacts of water quality, environment, ecosystem, and habitat changes on spotted seatrout stock dynamics and incorporate into our assessment of population dynamics.
- Determine the level of contaminants (organics, pesticides, heavy metals, per- and polyfluoroalkyl substances) found in spotted seatrout as well as the sediments/waters in the areas in which they are caught. Relate that to the potential effects of bioaccumulation.
- Protect water quality in marine ecosystems by encouraging municipalities to use Best Management Practices (BMPs) to reduce runoff from highways, agricultural fields, and housing developments.
- Plan development based on sound terrestrial and estuarine ecology that takes into consideration all factors affecting the long-term health of the estuary ecosystem.
- Identify the origin of non-point source pollution and specific point source pollution and develop a plan of action to mitigate any negative effects to the affected aquatic systems.
- Improve BMPs in areas already impacted by non-point source pollution.
- Identify important or essential habitat types for different life stages of black drum and partner with other regulatory agencies to reduce impacts of development on these fish habitats.

MEASURE OF SUCCESS

The fishery-independent programs conducted by the SCDNR Inshore Fisheries research group annually monitors the relative abundance, population demographics (size- and age-compositions) and reproductive potential of estuarine finfish, such as spotted seatrout. These surveys can detect changes in those parameters, providing critical data for the assessment of stock status and early detection of change (positive or negative) in abundance or population demographics. Currently, the abundance of spotted seatrout throughout coastal South Carolina has remained stable, if cyclical, since the early-1990s

Further, work identifying abiotic and biotic drivers of population fluctuations, in particular concerning recruitment, remain critical for projecting the response of red drum to future climate change, climate variability, and emerging contaminants of concern. By learning more about this species and protecting the habitat upon which it depends, we can ensure this important recreational game fish remains abundant. In addition, by monitoring spotted seatrout populations in response to environmental

contaminants, South Carolina will be better able to detect problems and work to correct them more quickly.

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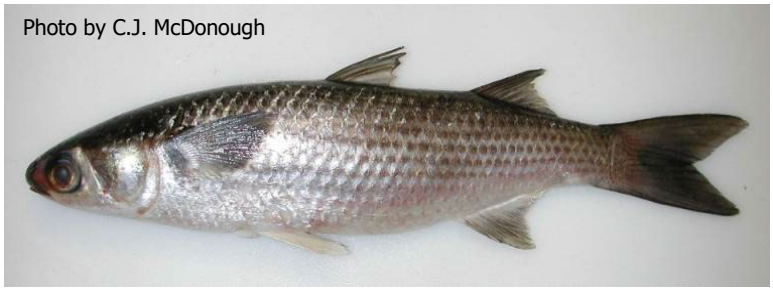
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Striped Mullet

Mugil Cephalus

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Revised 2013: Christopher J. McDonough (SCDNR)
Revised 2025: Jimmy Kilfoil and Michelle Taliercio (SCDNR)


Photo by C.J. McDonough

DESCRIPTION

Taxonomy and Basic Description

The striped mullet is in the order Mugiliformes, family Mugilidae. There are 9 species of mullet found in the western central Atlantic, the most common being the striped mullet (*Mugil cephalus* Linnaeus, 1758). There are two species of mullet found in South Carolina territorial waters: the striped (*M. cephalus*) and white mullet (*M. curema*). The remaining species within this family are found mostly in the Caribbean and Central/South America.

Striped mullet are dark above (blue to green with some brown) and silvery on the sides. Conspicuous stripes on the sides are formed from dark spots at the base of scales. Dorsal and anal fins are unscaled. The second dorsal fin begins directly above the point where the anal fin begins. The anal fin has 3 spines and 8 soft rays; juveniles have 2 spines and 9 soft rays (Robins et al. 1986). Maximum recorded size for this species from the eastern Atlantic is 1,500 mm (59 in.) total length (TL) (Harrison 2002); however, the most common sizes in South Carolina range from 250 to 350 mm (10 to 14 in.) TL (McDonough et al. 2003).

Striped mullet spawn offshore, and their offshore migrations in large schools have been well documented historically in South Carolina (Ravenel 1887; Jacot 1920; Anderson 1958; Arnold and Thompson 1958). Striped mullet are considered isochronal spawning fishes; they have synchronous gamete development, and individuals spawn all of their reproductive material at once or in batches over a very short period of time (days as opposed to weeks) (Greeley et al. 1987; Render et al. 1987). Collins and Stender (1989) concluded that striped mullet spawn in and around the edge of the Continental Shelf off the coasts of North Carolina, South Carolina, Georgia and the east coast of Florida. These areas make up a larger area often referred to as the South Atlantic Bight. There is a protracted spawning season from October to April, with most spawning occurring from December through February (McDonough and Wenner 2003; McDonough et al. 2003). Most striped mullet in South Carolina recruit to estuarine nursery grounds from January through May and range in size from 18 to 30 mm (0.5 to 0.7 in.) TL (Anderson 1958; McDonough and Wenner 2003). Females mature at 3 years of age and at a size from 300 to 400 mm (12 to 16 in.) TL (Thomson 1963; Greeley et

al. 1987; McDonough unpub. data). Male striped mullet begin to mature at 2 years of age and approximately 250 mm (10 in.) TL (Stenger 1959; McDonough et al., 2005). Juvenile striped mullet are omnivorous and feed on zooplankton and phytoplankton. Adults are herbivorous and feed primarily on diatoms and algae siphoned from soft bottom mud, except in areas of submergent vegetation where they often feed on attached algae (Collins, unpub. data).

Status

The striped mullet is not listed as either an endangered or threatened species in any state in the Southeastern United States. Striped mullet are a commercially important fish throughout the world for both fisheries and aquaculture purposes. In the Southeastern United States, there are significant commercial fisheries for striped mullet in North Carolina and Florida, and in all of the Gulf Coast states (a wholesale landings value of over $20 million for 2012 to 2022). Recreational harvest and discard data by state obtained from a Marine Recreational Information Program Query (NMFS. pers. comm.).

Striped mullet are also one of the most important forage fishes in the estuaries of the Southeast and represent a significant food source to upper level piscivores (Wenner et al. 1990). Because striped mullet are ubiquitous throughout the estuaries of South Carolina and provide an important food resource for many recreationally important finfish species, the species is an excellent candidate as an indicator species for the relative health of finfish in South Carolina's estuaries.

Based on the 2018 IUCN assessment, the striped mullet is listed as a species of "Least Concern" with a global population status of "stable" (Camara et al. 2018).

POPULATION SIZE AND DISTRIBUTION

The striped mullet is distributed worldwide between latitudes 51^{o} N and 42^{o} S, although it is less abundant in the tropics (Thompson 1963; Rossi et al. 1998; Harrison 2002). Striped mullet are euryhaline; they are able to tolerate the entire range of salinities from freshwater to oceanic water. As such, they can be found year-round throughout the full range of estuarine salinities as well as freshwater in South Carolina (Jacot 1920; Anderson 1958). In many river basins, striped mullet have been documented hundreds of miles from marine habitats with their only apparent limitation being physical barriers such as dams (Gunter 1938; Johnson and McClendon 1969).

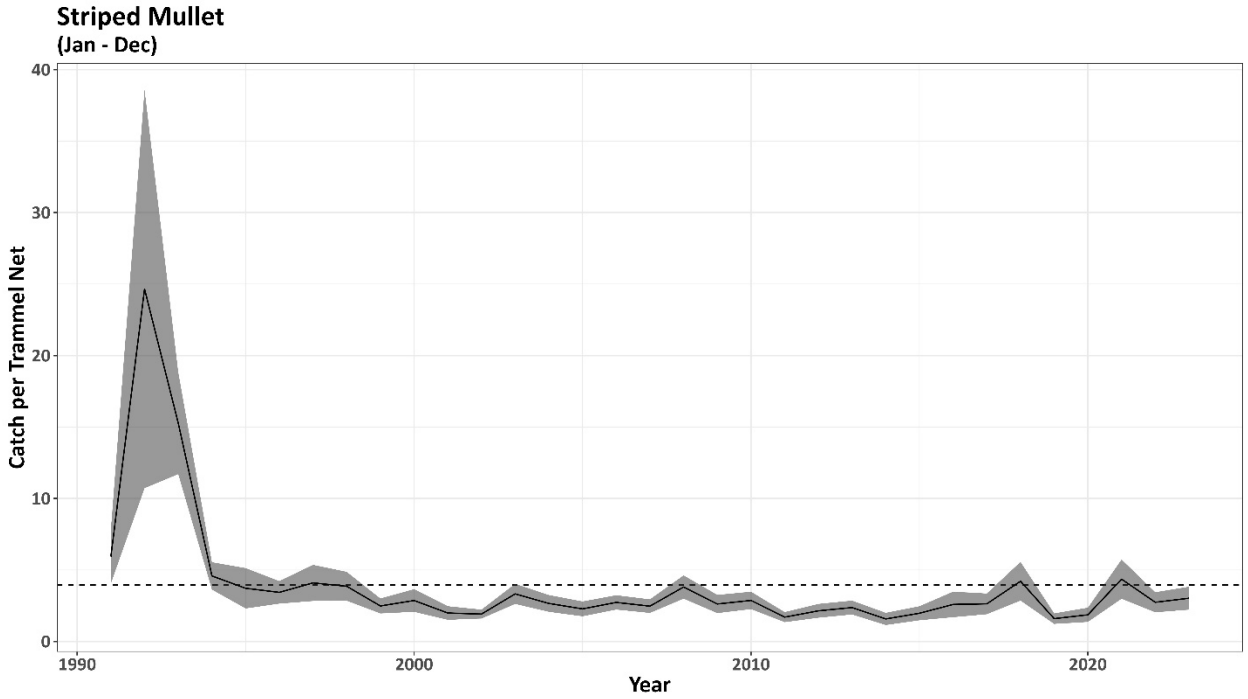


Figure 1. SCDNR Trammel net index of the CPUE of striped mullet statewide

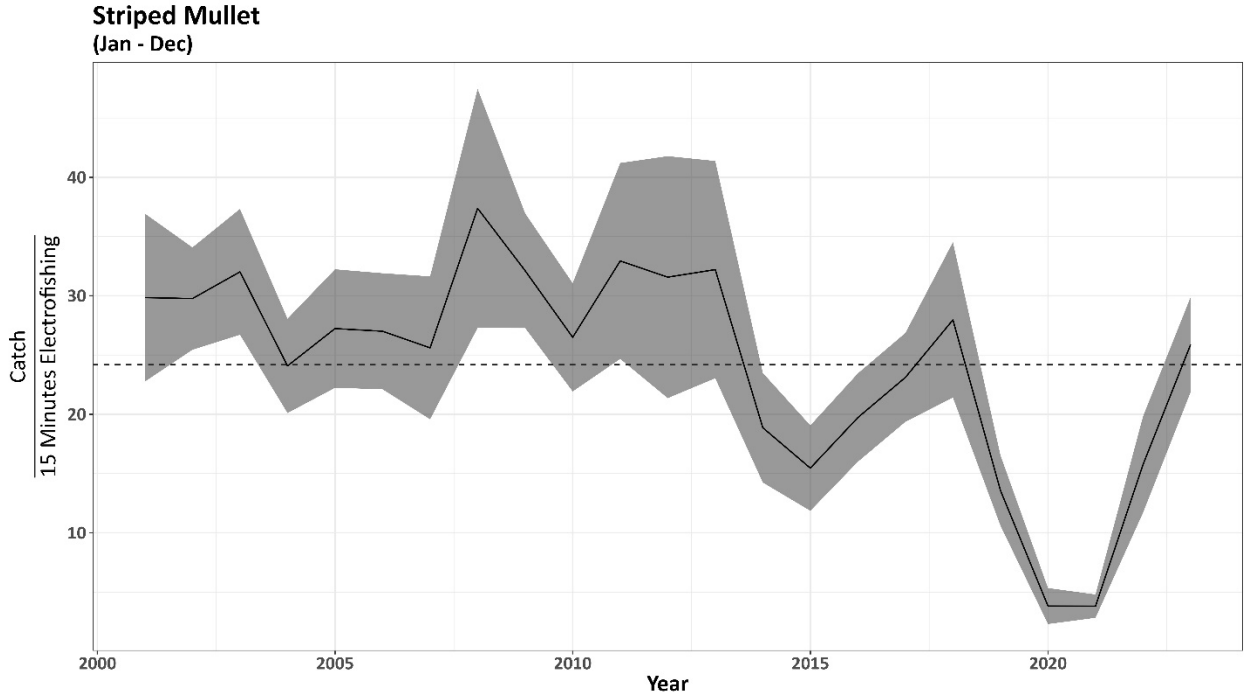


Figure 2. SCDNR Electrofishing survey CPUE of striped mullet statewide

SCDNR Inshore Fisheries (IF) group monitors relative abundance, length frequency, size and age at maturity of estuarine finfishes through monthly trammel netting,

electrofishing, and longline surveys and can detect changes in those parameters that result from management efforts.

Striped mullet are found in most habitats throughout South Carolina estuaries including mud flats, oyster bars, salt marshes, submerged aquatic vegetation beds, reservoirs, and tidal freshwater and riverine environments. Striped mullet in South Carolina prefer salinities less than 18 parts per thousand (ppt), but are commonly found throughout the entire estuarine salinity range (McDonough and Wenner 2003; McDonough et al. 2003). Juveniles less than 40 mm (1.5 inches) TL prefer salinities greater than 18.0 ppt, while juveniles and adults greater than this size can be found throughout the entire estuarine salinity range (McDonough and Wenner 2003). Larger striped mullet (greater than 350 mm or 14 in. TL) are frequently found in low salinity brackish water (less than 5.0 ppt) and freshwater, but this is more likely due to capture methods rather than the actual distribution of larger striped mullet. Striped mullet may stratify by depth according to size with the larger individuals moving into deeper water habitats, particularly in winter (Whitfield and Blaber 1978; Chubb et al. 1981). However, during the spawning migration—particularly in November and December—larger, reproductively developing striped mullet are seen in greater numbers closer to the mouth of most estuaries in high salinity habitats (McDonough et al. 2003; McDonough et al. 2005).

CHALLENGES

Striped mullet feed primarily on soft mud and other detritus, and therefore may be adversely affected by contaminants (organics, pesticides, and heavy metals) that settle out from the water column or become bound to sediment since their feeding strategy offers a vector for these contaminants to enter the food chain. While these types of contaminants are not currently considered a direct threat to striped mullet as a species, they could pose a threat in highly contaminated areas where bioaccumulation up the food chain may have an effect on gamefish, birds, and human health through direct consumption.

CONSERVATION ACCOMPLISHMENTS

South Carolina currently has no significant commercial striped mullet fishery, primarily due to gear restrictions and a lack of interest by commercial fishermen. Long term commercial catch statistics show a significant decrease in the commercial landings of striped mullet in South Carolina since 1982. Although limited inshore net bans were instituted in the 1950s, these regulations primarily targeted the trawl fishery, and the use of seines, gill nets, and stop nets accounted for most of the commercial catch up until the complete inshore net ban in 1986.

CONSERVATION RECOMMENDATIONS

- Determine seasonal movement and distribution of striped mullet in tidal freshwater systems by initiating a tagging project.
- Determine the level of contaminants (organics, pesticides, and heavy metals) found in striped mullet as well as the sediments in the areas in which they are caught. Relate that to the potential effects of bioaccumulation in predators.
- Protect water quality in marine ecosystems by encouraging municipalities to use Best Management Practices (BMPs) to reduce runoff from highways, agricultural fields, and housing developments.
- Plan development based on sound terrestrial and estuarine ecology that takes into consideration all factors that will affect the long-term health of the estuary ecosystem.
- Identify the origin of non-point source pollution and specific point source pollution and develop a plan of action to mitigate any negative effects to the affected aquatic systems.
- Improve BMPs in areas already impacted by non-point source pollution.
- Identify important or essential habitat types for different life stages of striped mullet and partner with other regulatory agencies (e.g. DHEC) to reduce impacts of development on these fish habitats.
- Partner with other state agencies in order to improve resource management at the whole estuary or drainage basin level using a more holistic ecological approach. Such restructuring should provide for greater regulatory authority in implementing migratory fish management plans.

MEASURE OF SUCCESS

Increases in recruitment, abundance, size, size and age at maturity would indicate positive trends in the population. In addition, by monitoring striped mullet populations in response to environmental contaminants, South Carolina will be better able to detect problems and work to correct them more quickly.

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Tarpon

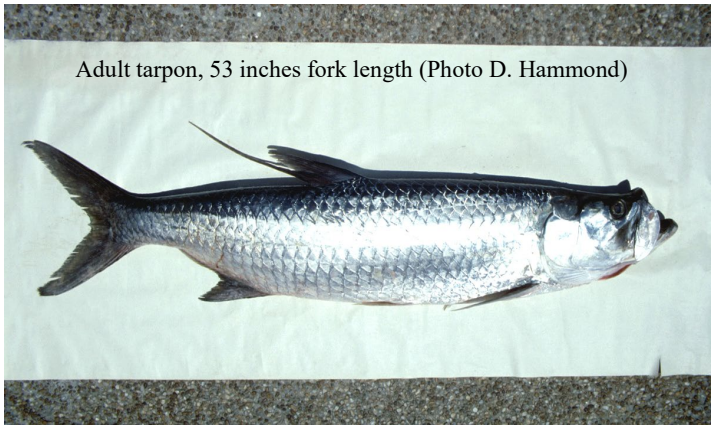
Megalops atlanticus

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DESCRIPTION


Adult tarpon, 53 inches fork length (Photo D. Hammond)

The Atlantic tarpon (*Megalops atlanticus*) is recognized throughout its range as a very highly prized recreational species due in part to its fight strength and tendency to breach the water's surface while hooked. It is not utilized for food in the United States. While this species is reserved for recreational fishermen, only a small segment of the state's saltwater fishermen actually target this species. Little research has been done on this species on the east coast of the US north of Florida. State law bans the commercial harvest of this species in state waters.

Taxonomy and Basic Description

Tarpon belong to the family Megalopidae, which is represented by only one species in the eastern and southern United States. Members of this family are noted for their silvery herring appearance with large scales and a compressed, moderately deep body. Tarpon pass through an eel-like leptocephalus stage as young.

The sides of the fish are flat, virtually vertical in profile. The sides and belly are silvery and covered by very large scales; there are 40 to 48 scales present along the lateral line. The mouth is superior in position with the lower mandible extending far beyond the upper jaw. The fins are composed completely of soft rays. The dorsal fin has a high anterior lobe with a sharp downward slope posterior ending with the last ray greatly elongated into a heavy filament. The fin contains 13 to 16 soft rays. The caudal fin is deeply forked with the lobes equal in length. The anal fin is inserted behind the dorsal fin base and has a high anterior lobe; the remainder of the fin is long and low, ending in an elongated ray that is shorter than that in the dorsal fin. The anal fin has 22 to 25

soft rays. The pelvic fins are positioned in front of the origin of the dorsal fin and contain 13 to 14 soft rays (Whitehead and Vergara 1978).

Tarpon usually appear dark blue to greenish-black on the back. However, this color may be muted on individuals inhabiting inland waters. The sides and belly are bright silver in color. The dorsal and caudal fins have charcoal tipped margins.

Tarpon are reported to reach sizes of 250 cm (98 in.) (Whitehead and Vergara 1978) and weights of 161 kg (355 lbs.) (Claro 1994). Crabtree et al. (1995) reported that females grow more quickly than males and may live longer. Males are reported to reach 43 years of age while females can reach ages of at least 55 years (Crabtree et al. 1995). Sexual maturity for tarpon taken in Florida is reached by 117 cm (70 in.) in males and 128 cm (50 in.) in females (Crabtree et al 1997). By 10 years of age, all females were found to be sexually mature (Crabtree et al. 1997).

Tarpon are a schooling fish. They are usually found in small groups of 12 or fewer individuals but will form large schools comprised of over 100 fish.

Status

Tarpon are apex predators in South Carolina's coastal and estuarine waters. As such, they represent an excellent indicator of the condition of coastal waters for this trophic level.

Tarpon are considered one of the premier recreational species in the Western North Atlantic and support economically important fisheries in areas where they occur in high abundance. No stock assessment has been conducted on tarpon to determine whether the stock is being over-fished. With no regional or national fishery management plan in place for tarpon, management of this species rests with each coastal state.

Tarpon are infrequently caught in SCDNR's inshore fisheries' trammel net and electrofishing surveys. From 2013-2018, there were 26 tarpon caught in the trammel net survey (42nd most abundant species in this survey) and 30 tarpon captured in the electrofishing survey (53rd most abundant species; SCDNR 2018). However, currently there is virtually no data beyond creel occurrence for the species in South Carolina State waters. Subsequently, their population status is unknown.

POPULATION SIZE AND DISTRIBUTION

Tarpon inhabit a large range of warm temperate to tropical waters on both sides of the Atlantic Ocean (Whitehead and Vergara 1978). In the Western Atlantic, the fish are primarily found in warmer coastal waters with the largest populations found in the Gulf of Mexico off of Florida and in the West Indies (Smith 1997). However, they have been noted from Nova Scotia south to Argentina and eastward to Bermuda. Tarpon are also noted to enter freshwater (Boseman 1960).

Tarpon found in state waters are presumed to have migrated from points south, probably Florida. This is supported by a recovery of a tagged tarpon released in August 1996 at Hilton Head Island, South Carolina and recovered in June 1997 at Tavernier Key, Florida (R. Wiggers, SCDNR, pers. comm.). They have been captured from the three-mile state territorial limit in coastal waters westward into the estuaries and rivers along the entire coast of South Carolina (D. Hammond, pers. obs.). Tarpon will enter the estuaries at all ocean inlets in South Carolina. These fish follow tidal flow moving offshore as much as three miles from the inlets and bays during the ebb tide, and move inland as much as seven to ten miles on the flooding tide (D. Hammond, pers. obs.). They will occasionally stray up freshwater rivers; one specimen was captured approximately one mile below the Pinopolis Dam at Moncks Corner on the Cooper River (D. Hammond, pers. obs.). Recreational anglers have tagged tarpon for the Marine Game Fish Tagging Program from April to December. Tarpon begin to appear in state waters as early as April; peak abundance occurs in late summer (Hammond 1988; Elmo et al. 2021). They usually depart coastal waters in late October through early November, presumably due to declining water temperature (Mace et al. 2017).

The majority of current research on tarpon in South Carolina focuses on the larval and juvenile stages, and no work has been done to assess the population size of tarpon along the southeastern coast of the United States or in South Carolina. Subsequently, no information is presently available on the health of the east coast population.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Tarpon occur from near shore ocean waters to estuaries and up into freshwater rivers (Boseman 1960). They are primarily found in coastal waters, bays and estuaries, within tropical, subtropical and temperate climates (45° N to 30° S). Although a marine fish, tarpon can tolerate euryhaline environments and often enter river mouths and bays and travel upstream into fresh water (Boseman 1960). In addition, tarpon can also tolerate oxygen-poor environments due to a modified air bladder that allows them to inhale atmospheric oxygen (Bone et al. 1995; Geiger et al. 2000).

Spawning in Puerto Rico occurs in nearshore waters with tarpon leptocephali larvae arriving in the estuaries in their second stage of metamorphosis (Zerbi et al. 2001). Florida tarpon were reported to spawn from April through July (Crabtree et al. 1997). A similar spawning scenario may occur in South Carolina. Juvenile tarpon are common members of the ichthyofauna found in brackish water impoundments in the early fall (D. Hammond, pers. obs.; Mace et al. 2017). However, tarpon are not present in these impoundments in the spring, presumably due to escapement and/or die-off related to low water temperatures. Tarpon probably enter these impoundments during their annual flooding in late spring as leptocephali larvae. They become trapped in these bodies of water when the floodgate connections to the estuaries are closed.

CHALLENGES

Catch and release fishing by recreational anglers may be a source of adult tarpon mortality. However, Edwards (1998) found a high survival rate, 26 of 27 fish studied, for recreationally caught and released fish in Florida. This would indicate a small latent mortality for the recreational catch and release fishery. Recent studies estimate tarpon post-release mortality to be at least 5%, though researchers also recognize that the maximum realistic mortality rate could be 13-18% based on shark predation and tagging data (Guindon 2011; Horowitz et al. 2023).

Habitat and water quality are recognized as especially important in the early life stage of marine fish found in estuaries. Any degradation to the estuarine ecosystems could impact the survival, growth, and later life of juvenile tarpon that utilize these estuaries as a nursery ground. The impact that many pollutants have on marine fish life cycles are just now being discovered. Thomas (1990) found that four known mammalian reproductive toxins also altered the reproductive endocrine function in female Atlantic croaker, *Micropogonias undulatus,* impairing reproduction. These toxins could have a similar impact on tarpon.

Industrial and municipal sewage discharge along with runoff from agriculture, golf courses and suburban developments negatively affect tarpon and other estuarine fishes. Because of its prevalence in estuaries, tarpon are considered an indicator of the overall health of this ecosystem.

CONSERVATION ACCOMPLISHMENTS

The tarpon was declared a game fish in South Carolina by state law in 1991. This law banned the sale of tarpon and limited recreational anglers to a possession limit of one fish per person per day.

CONSERVATION RECOMMENDATIONS

- Identify the origin(s) of adult tarpon found in South Carolina and determine length of residence in state waters.
- Information on the temporal/spatial incursion of larval tarpon into South Carolina estuaries is needed to aid in defining spawning activity and larval recruitment.
- Determine essential habitat and water quality needed by tarpon at their various life stages and identify the corresponding areas found in South Carolina.
- Identify primary food sources at the various stages in their life.
- Educate fishermen to employ circle hooks and careful handling practices when releasing this fish. This can be accomplished, in part, by partnering with fishing clubs and conservation groups to push for stronger conservation ethics among their members. Community avocation and awareness will therefore help guide and direct the future of this fishery.

MEASURE OF SUCCESS

Because there are currently no known estimates of population size or trends, it is impossible to identify a measurement of success. However, once monitoring establishes baseline data, the measurement of success will be a stable tarpon population year to year.

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Vermilion Snapper

Rhomboplites aurorubens



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DESCRIPTION

Taxonomy and Basic Description

Vermilion snapper, Rhomboplites aurorubens, is a small member of the order Perciformes and family Lutjanidae (Page et al. 2023) reaching a maximum length and weight of approximately 24 inches (600 mm) and 6 pounds (2.8 kg), respectively (Grimes, 1978; Schmidtke, 2024). The species has a streamlined body with a vermilion/red coloration dorsally and a silvery-white coloration ventrally. Narrow, yellow-gold streaks occur below the lateral line, either horizontal or diagonal. The moderately forked caudal fin appears red with a subtle black margin, while the dorsal fin appears red with a yellow margin. Individuals have a short snout, a slightly projecting lower jaw, and lack canine teeth (Allen, 1985; NOAA Fisheries, 2024; Schmidtke, 2024).

Vermilion snapper are gonochoristic, meaning sexes are separate, and indeterminate spawners with a spawning frequency of around 35 times per year, increasing with age (Bagley et al., 1999; Cuellar et al., 1996; SEDAR, 2018). The spawning season begins in April and continues through September, with a peak between June and August in the southeast U.S. Atlantic Ocean (SEUSA). Sexual maturity occurs early in this species with 0.85 years as the estimated age at 50% maturity for females, and 100% of individuals are mature by age 2. Males and females have not been shown to exhibit sexual dimorphism, however, 68% of individuals within the SEUSA stock of vermilion snapper are female (SEDAR, 2018; Zhao et al., 1997). The current oldest observed age for the stock is 19 years (SEDAR, 2018).

Status

The last stock assessment, conducted in 2018 through SEDAR 55, determined the stock is not experiencing overfishing and is not overfished using fishery data through 2016 (SEDAR, 2018). However, the IUCN Red List currently lists the species as vulnerable.

POPULATION SIZE AND DISTRIBUTION

Vermilion snapper occur from North Carolina and Bermuda, throughout the Caribbean Sea and Gulf of Mexico to southeastern Brazil (Grimes & Huntsman, 1980; Potts et al., 1997). In U.S. waters, the species has traditionally been managed as two separate and distinct stocks – South Atlantic and Gulf of Mexico (GOM). This species represents a significant component of the fishery-independent catches obtained using chevron traps by the Southeast Reef Fish Survey (SERFS: joint program between SCDNR and NOAA),

spanning from Cape Hatteras, NC, to Cape Canaveral, FL (i.e., SEUSA). High densities of vermilion snapper can be found in the waters off the states of South Carolina and southern North Carolina, but remain prevalent across the entire range of the survey, spanning various depths (Figure 1).

The most recent estimate of population size for the South Atlantic stock was ~16.8 million as of 2017. The SERFS chevron trap index indicates that the stock is above the long-term average value after approximately ten years of relatively low population levels (Figure 2).

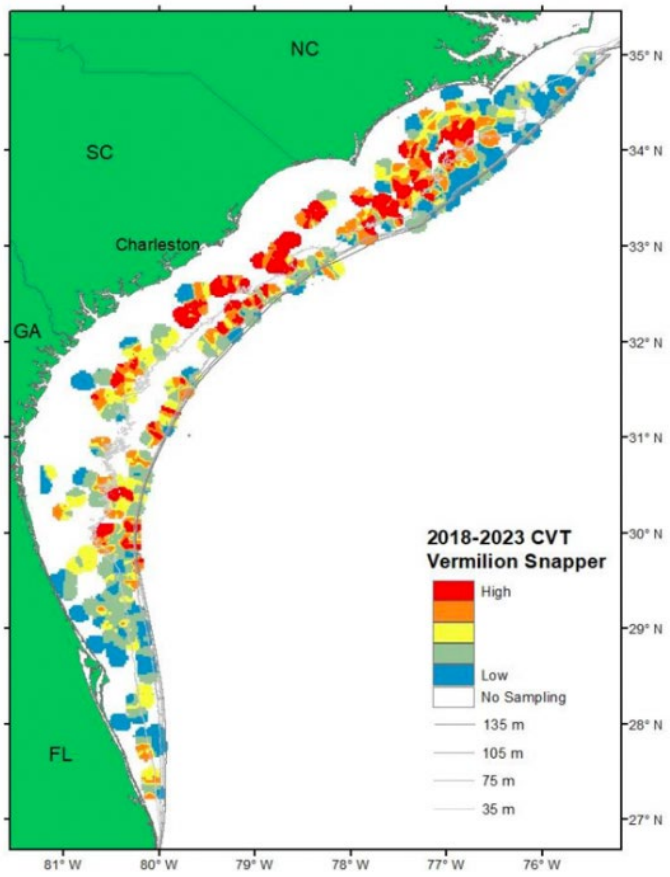


Figure 1: Density of vermilion snapper catches from SERFS Chevron Trap survey: 2018 – 2019 and 2021 – 2023.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

This schooling species is associated with high and low relief live bottom habitat encompassing sponge/coral, rocky outcrops, and rocky ledges (Davis et al., 2015; Grimes et al., 1982). They can be found throughout the continental shelf and shelf break (26-56 m) and upper slope reef habitats (64-183 m; Cuellar et al., 1996; Grimes, 1978; Grimes et al., 1982). They will often utilize the upper water column and show patterns of diel vertical migration, with data suggesting individuals feed in the late afternoon and evening (Grimes, 1979; Grimes et al., 1982; SEDAR, 2018). Within these habitats vermilion snapper can often be found feeding on fishes, shrimps, crabs, polychaetes, other benthic invertebrates, cephalopods and planktonic

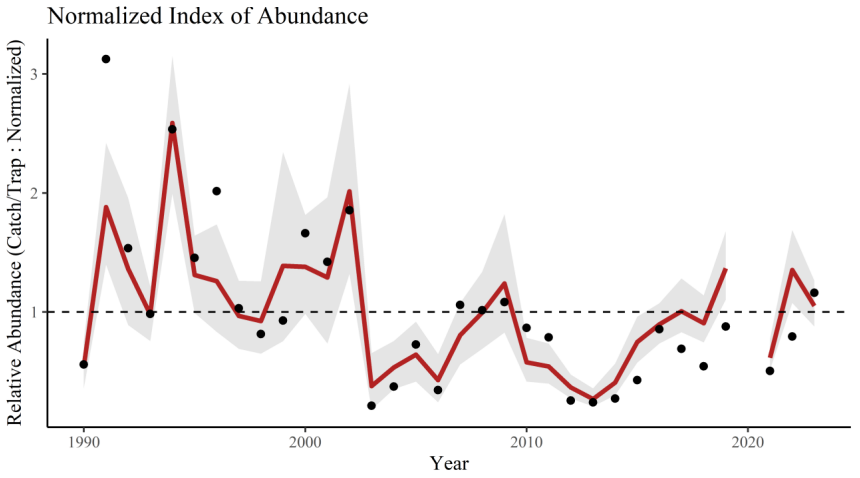


Figure 2: Chevron trap index of abundance and length compositions for vermilion snapper from the SERFS. Red line is the modeled value through time, gray shading represents the 95% confidence interval for the model, and black dots are nominal values.

organisms (Allen, 1985). Copepods are the primary prey for juvenile vermilion snapper, while adults shift their diet to predominantly consume fish (Grimes, 1979).

CHALLENGES

Among reef fish species in the SEUSA, vermilion snapper provide important economic contributions to both recreational and commercial fisheries (Bagley et al., 1999). As part of a multi-species fishery (snappers, groupers, etc.), the species is susceptible to elevated rates of discard mortality. Presently, the commercial discard mortality rate is estimated at 0.41 and the recreational rate at 0.38 (SEDAR, 2018). Given the depths vermilion snapper often inhabit, barotrauma poses a threat to individuals if proper descending practices are not carried out, potentially contributing to the rates of discard mortality. In addition, as fishing regulations become more restrictive for other snapper/grouper species, vermilion snapper could see an increase in fishing pressure and mortality.

Climate change has led to warming waters all around the world that could affect vermilion snapper species distribution. This trend has already been observed in other stocks, such as Black Sea Bass (*Centropristis striata*), in the SEUSA (ASMFC, 2024). Should South Atlantic waters continue to warm, we could see a potential shift northward of the SEUSA vermilion snapper stock. This may, in turn, affect other aspects of the species' life history such as growth rates and reproduction.

CONSERVATION ACCOMPLISHMENTS

The SEUSA stock of vermilion snapper is managed by the South Atlantic Fishery Management Council (SAFMC). The first benchmark assessment of vermilion snapper was completed in 2003 and found the stock was not overfished but experiencing overfishing (SEDAR, 2003). It was not until SEDAR 17 Update Assessment that the stock was no longer experiencing overfishing (SEDAR, 2012), which continues today. Throughout the species' assessment history, the stock has never been overfished. The minimum size limit for the stock has remained relatively constant throughout its history, with the current limit set at 12" total length for both the recreational and commercial fisheries. A bag limit of 5 individuals is set for the recreational fishery, while a trip limit of 1000 lbs gutted weight is set for the commercial fishery. Allowable gear for fishing this species includes vertical hook-and-line (hand line and bandit gear) and spearfishing gear without rebreathers. In federal waters north of 28°N latitude non-offset, non-stainless steel circle hooks are required. Fish must be landed with fins and head intact, and a descending device is required aboard all vessels and readily available for use (Schmidtke, 2024).

CONSERVATION RECOMMENDATIONS

- Continue monitoring via fishery-dependent and -independent sampling programs
- Investigate discrepancies between age compositions and indices of abundance

- Develop methods to standardize and combine SERFS chevron trap and video gears for creating indices of abundance
- Investigate the optimal level of spatial structure to model in an assessment of snapper-grouper species such as vermilion snapper.
- Investigate the genetic stock connectivity between the Gulf of Mexico and South Atlantic stocks

MEASURE OF SUCCESS

The SERFS program works to monitor various stock parameters for vermilion snapper, including relative abundance, population demographics and reproductive status. This program can detect changes in those parameters as a result of changes in fishing pressure and/or management efforts. SERFS can then inform fishery managers and scientists of these changes to take the appropriate action. Increases in abundance, size- and/or age-compositions, and spawning stock biomass would indicate positive trends in the population.

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Wahoo
Acanthocybium solandri



NOAA

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DESCRIPTION

Taxonomy and Basic Description

Wahoo are part of the family Scombridae, in the order Scombriformes, connecting them to Spanish mackerels (Page et al. 2023). They share an elongate body form that is cylindrical enabling them to be one of the fastest fish in the ocean. Wahoo have distinct coloration with dark blue, iridescent vertical streaks along the body sides. Beyond these bands, the base color of the wahoo begins dorsally as metallic blue and fades to a silvery ventral side. With a streamlined body, they have an infamously prolonged snout and serrated, razor-sharp teeth (SCDNR Sea Science). Identifiable features of the wahoo include a first and second dorsal fin with spines ranging between 23 and 27 and rays between 12 and 16. In addition to the dorsal fins, there are eight to nine finlets present posterior to these fins (Zischke 2012).

It is hard to measure the ages of individual wahoo, because the scales, otoliths, and vertebrae do not provide an accurate record of age. Instead, scientists use their growth rate to estimate age. Research in North Carolina has shown maturity is typically reached in one year of life. At this age, male wahoo are 860 mm total length (TL), while females are often slightly larger at 1010 mm TL (Hogarth 1976). In these age estimations, it is also found that wahoo live five to six years.

Wahoo are gonochoristic; each fish develops as either male or female. When both sexes reach sexual maturity, the fish can reproduce via spawning. Females release buoyant eggs and males release sperm into the water column to disperse. The sperm will fertilize the egg, form larvae, and continue to develop (Triay-Portella 2023).

Wahoo have great importance toward commercial and recreational fisheries. They are a targeted species due to their size and high-quality meat, as well as an incidentally caught species (Zischke 2012). For this reason, fisheries management and conservation are critical to prevent the depletion of the resource and protect the populations. Understanding the life history of wahoo can allow for informed decisions for size and catch limits that can enable sustainable marine fisheries for future generations (SCDNR Sea Science).

Status

The four stocks of wahoo have not been assessed and the status of this species is unknown. Based on catch data, fishing pressures are not causing overfishing and catch limits are in place for the South Atlantic and Gulf of Mexico stocks (NOAA 2024).

POPULATION SIZE AND DISTRIBUTION

Wahoo remain in the tropical and subtropical waters of the Atlantic, Pacific, and Indian Ocean year-round. However, in the warmer months, this species is present at a higher distribution in northern waters of the Atlantic (Oxenford 2003).

Several studies have demonstrated differences in sex ratios. Values near 1:1 have been reported in most studies (Brown-Peterson *et al.,* 2000; Oxenford *et al.,* 2003; Jenkins and McBride, 2009). Meanwhile, research from Hogarth (1976) found a sex ratio of 3:1 with the higher abundance being female.

A recent risk assessment resulted in low vulnerability for northern Atlantic wahoo and high vulnerability for southern Atlantic wahoo. (Lucena-Frédou *et al.,* 2017a). Using length-based data, a stock assessment was conducted for these stocks and determined that the population was being overfished in the Northwest Atlantic. Results pertaining to the Northeast Atlantic also determined slight overfishing, however, the methods of these two assessments were different (Pons *et al*., 2019).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Wahoo are found in offshore waters of the Carolinas more prevalently in the warmer months. The distribution of wahoo has been reported as very wide. They are found worldwide and in a variety of ocean features. Because they are aggressive piscivores, habitat usage is possibly driven by competition for resources (Theisen 2012). They have been reported near objects floating on the water, including *Sargassum* or naturally occurring fish attracting devices. They are solitary apex predators with a diet that consists of 70% finfish species. Wahoo search for food sources in open water, primarily feeding on fast-swimming pelagic prey, including small tunas, flying fish, herring, squids, and several additional species. It has also been suggested this species forages below floating material due to occurrence of such within their diet (Oxenford 2003).

CHALLENGES

Wahoo have not been formally assessed which poses a challenge for management. Without having the best available information regarding this species, resources cannot be properly allocated to help support its conservation. In addition to lack of assessment, because wahoo are commercially and recreationally important, the species faces increased fishing pressure which can negatively impact the population status (NOAA 2024).

CONSERVATION ACCOMPLISHMENTS

Atlantic wahoo are managed through several organizations including NOAA Fisheries, the Caribbean Council, and the South Atlantic Fishery Management Council (SAFMC). Under the SAFMC Dolphin and Wahoo Fishery Management Plan, there are fishing regulations to help manage the Atlantic wahoo population. These regulations include different levels of permits (i.e., vessel, dealer, charter), annual and daily catch limits, and size limits (NOAA 2024).

CONSERVATION RECOMMENDATIONS

- Characterize stock status in Atlantic waters
- Determine potential shifts in distribution and driving factors
- Investigate migration patterns
- Expand research and monitoring in fishery-independent surveys
- Research early life stages and develop better understanding of complete life history
- Enforce restrictions to minimize overfishing

MEASURE OF SUCCESS

A successful species can be viewed by measuring a strong and healthy population size. The use of fishery independent and dependent data from recreational and commercial fishing effort and catch can aid in this determination (NOAA 2024). However, few studies prioritize wahoo for data collection. Without reliable research it is hard to measure the health of the Atlantic wahoo population. Wahoo have been identified as a critical species needing assessment and actions toward proper management. Wahoo have been categorized as high risk, but no assessments are available to provide data in this fishery (Pons et al. 2019).

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Warsaw Grouper

Hyporthodus nigritus

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Illustration by Duane Raver, Jr.

DESCRIPTION

Taxonomy and Basic Description

The Warsaw grouper (*Hyporthodus nigritus*) is a large-bodied fish belonging to the Epinephelidae family within the order Perciformes (Page et al. 2023). It is characterized by a robust body, typically dark reddish brown to gray in coloration, juveniles may have a yellow caudal fin with irregular lighter spots and blotches (FAO 2002). Warsaw grouper are characterized by having 10 spines and 13-15 soft rays on their caudal fin, with the second spine being distinctly elongated and the interspinous membranes deeply incised (FAO 2002) Warsaw grouper diet consists of a variety of crabs, shrimp, lobster, and fishes. It is a long lived, slow growing species that reaches a maximum age of 59 with annulus formation occurring between April and May (Manooch and Mason 1987) and can reach lengths exceeding 6 feet and weights over 400 pounds (FAO 2002; Sanchez 2019). Reproductively, Warsaw groupers are slow-growing and late-maturing, with individuals reaching reproductive age around 7-9 years old. They exhibit protogynous hermaphroditism where females can transition into males as they mature. Spawning typically occurs in aggregations during specific seasons, but exact timing and locations can vary. The Warsaw grouper spawns during August, September, and October in the Gulf of Mexico (SAFMC 2010), and during April and May off Cuba (Naranjo 1956).

Status

Warsaw grouper are an important sport fish for bottom fishers due to their large size, but historically have contributed to less than 1% of commercial grouper landings on the southeast Atlantic Coast (FAO 2002). They were first identified as a species of concern by the NOAA National Marine Fisheries Service in 1997 and are also listed as near threatened across their range on the International Union for Conservation of Nature (IUCN) Red List which was last assessed in 2016 (IUCN 2018; NOAA 2009). In the United States, including South Carolina, regulations are in place to prohibit the possession of Warsaw groupers to aid in population recovery. Warsaw grouper was listed as having ongoing overfishing status up until 2021 due to concern about monitoring discards from incidental catch of Warsaw grouper when fisherman targeted co-occurring snapper-grouper species (Farmer 2014; SAFMC 2010). The current Warsaw grouper stock status, however, has been changed to an unknown overfishing status and an unknown overfished status due to a lack of data (Farmer 2014; NOAA 2023; SAFMC 2010).

POPULATION SIZE AND DISTRIBUTION

Warsaw groupers are distributed in the western Atlantic Ocean from North Carolina to the Florida Keys and throughout much of the Caribbean and Gulf of Mexico to the northern coast of South America, occurring along the continental shelf break in deep waters ranging from 180 to 1,000 feet (FAO 2002; Manooch and Mason 1987). Juveniles can occasionally occur on shallow water reefs and jetties (Heemstra and Randall 1993). Warsaw Grouper have been rarely encountered in any survey covering their reported habitat that SCDNR has been involved in, including the historic short bottom longlining survey conducted by SCDNR or the ongoing cooperative South Atlantic Deepwater Longline Survey (SADLS) conducted jointly by commercial fisherman, NOAA Fisheries and SCDNR (less than 75 individuals since 1978). Commercial catches peaked in 1973 at 34,0005 lbs. landed and steadily declined throughout the 1970's, 80's, and 90's, reaching a low of 1,393 lbs. in 1995 (Figure 1; Parker and Mays 1998). Due to data deficiencies, little is known about Warsaw grouper sex ratio or population demographics (size- and age-composition) in the region.

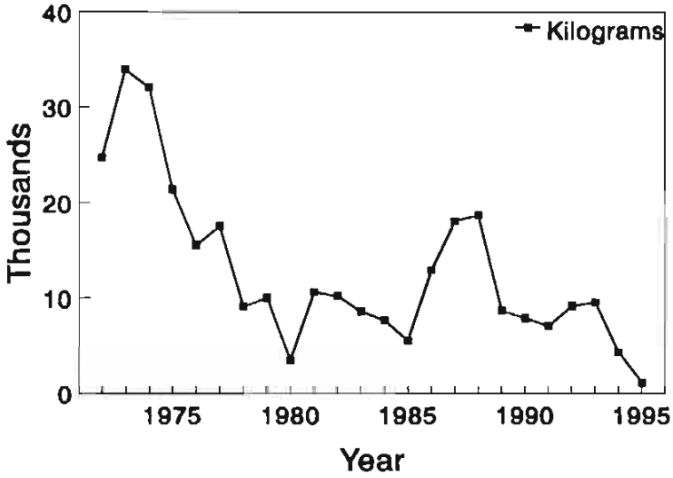


Figure 1: Warsaw Grouper commercial fishery catch (kg) from 1972-1995.

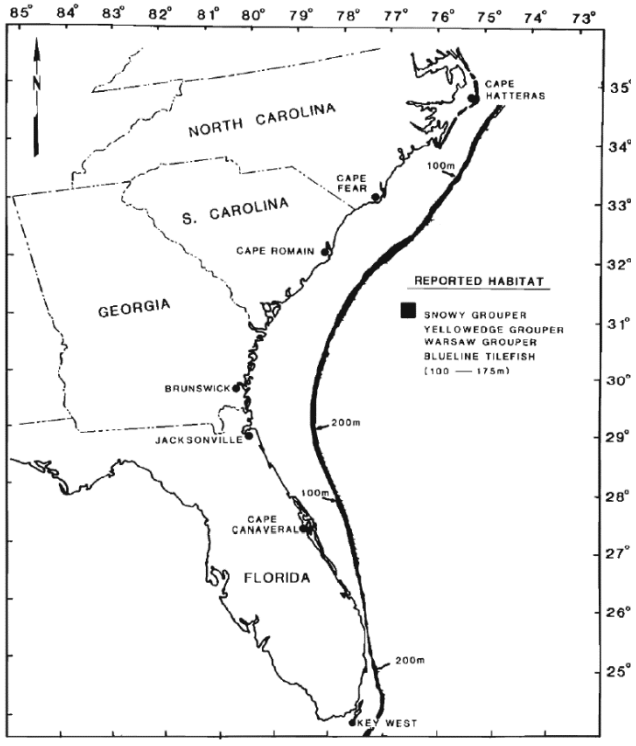


Figure 2: Reported habitat for deep water species in the Atlantic along the Southeastern US.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Warsaw grouper inhabit rough irregular bottom, notches, valleys, seamounts and drop-offs, occurring along the continental shelf break, in waters ranging from 180 to 1,000 feet. (FAO 2002) This habitat is characterized by steep cliffs, rocky ledges, and swift currents and is the same habitat where snowy grouper, yellowedge grouper and blueline tilefish are found (Figure 2; Manooch and Mason 1987; Parker and Mays 1998; Robins and Ray 1986).

CHALLENGES

Slower growing, long-lived species are not as resilient to disturbances compared to others in their community. This leads to more opportunities for removal from the ecological system, whether natural or fisheries-related, before their first reproductive contribution to the fishery. Because Warsaw grouper are sequential hermaphrodites, there can be disproportionate targeting of the larger sex (males) which skews population demographics. As with many other reef fish species which have substantial overlap in habitat use, there is potential for mortality even when they are not targeted in this multi-species fishery which is further compounded in deepwater species (≥30 m), as they can be highly susceptible to post-release mortality (e.g. barotrauma). Deeper reef species, such as Warsaw grouper, may also be especially vulnerable because of their limited geographic ranges (Parker and Mays 1998). Small impacts to their preferred habitat due to climate change or anthropogenic effects could have large consequences. Data deficiencies due to low population size or lack of reporting discards of these fish makes it difficult to assess the health of the population leading to continued stringent restrictions.

CONSERVATION ACCOMPLISHMENTS

In 1994, a recreational and commercial bag limit of 1 Warsaw grouper per vessel per trip and no sale was put in place by the SAFMC to try to limit fishing mortality. In 2008, fishery-independent projects indicated they were conspicuously absent from historical areas of catch. Because the overfishing limit could not be determined, the incredibly small biomass and the high degree of uncertainty associated with these species, any catch was thought to result in overfishing of this stock and therefore the acceptable biological catch (ABC) and annual catch limits (ACL) were set to zero (SAFMC 2011). In 2011, SAFMC prohibited the harvest and possession of the remaining six deepwater species that co-occur with Warsaw grouper to reduce bycatch of Warsaw grouper in water deeper than 240-ft (40-fathoms) where release mortality is very high (SAFMC 2011). This act of prohibiting the harvest of deep-water species is thought to protect spawning aggregations of Warsaw grouper, as well (SAFMC 2011). Existing Marine Protected Areas (MPAs) in 2013 covered 10% of probable shelf-edge habitats for Warsaw Grouper, protecting 8% of Warsaw grouper stocks. Proposed additional MPAs could add 24% more probable shelf-edge habitat and protect an additional 20% of Warsaw grouper stocks (Farmer and Karnauskas 2013).

CONSERVATION RECOMMENDATIONS

- Harvest restrictions for Warsaw grouper are currently as strong as they can with an annual catch limit = 0, however increasing enforcement of these regulations could result in the quicker recover of this species.
- Increasing the size and quantity of MPAs in areas likely to be inhabited by Warsaw grouper would benefit the population.

- Increasing funding for research studying fisheries population dynamics in preferred habitats.
- Educating stakeholders on sustainable fishing practices and conservation needs.

MEASURE OF SUCCESS

The SADLS monitors relative abundance, population demographics and reproductive state of deep-water fishes and can detect changes in those parameters that result from management efforts. Increases in recruitment, abundance, size- and/or age-compositions would indicate positive trends in the population.

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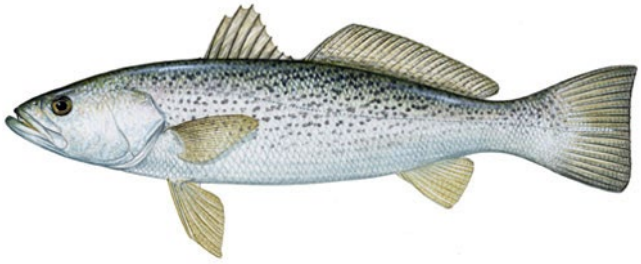
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Weakfish

Cynoscion regalis



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Revised 2025:
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DESCRIPTION

Taxonomy and Basic Description

Weakfish, *Cynoscion regalis* (Bloch and Schneider 1801), are members of the order Perciformes and the family Sciaenidae (drums; Page et al. 2023). Diagnostic characters include a rather large mouth with a pair of large canine teeth in the upper jaw, a silvery body with dark speckles along the dorsal surface, and yellowish pelvic and anal fins. In South Carolina, weakfish are found predominantly in estuaries as juveniles and in shallow coastal waters as adults. The species may be confused with the closely related spotted seatrout (*C. nebulosus*), silver seatrout (*C. nothus*), and sand seatrout (*C. arenarius*). Weakfish can be clearly differentiated by the presence of only one marginal pore on the snout, while the three other species have two pores. However, hybridization between species may sometimes occur (Tringali et al. 2011).

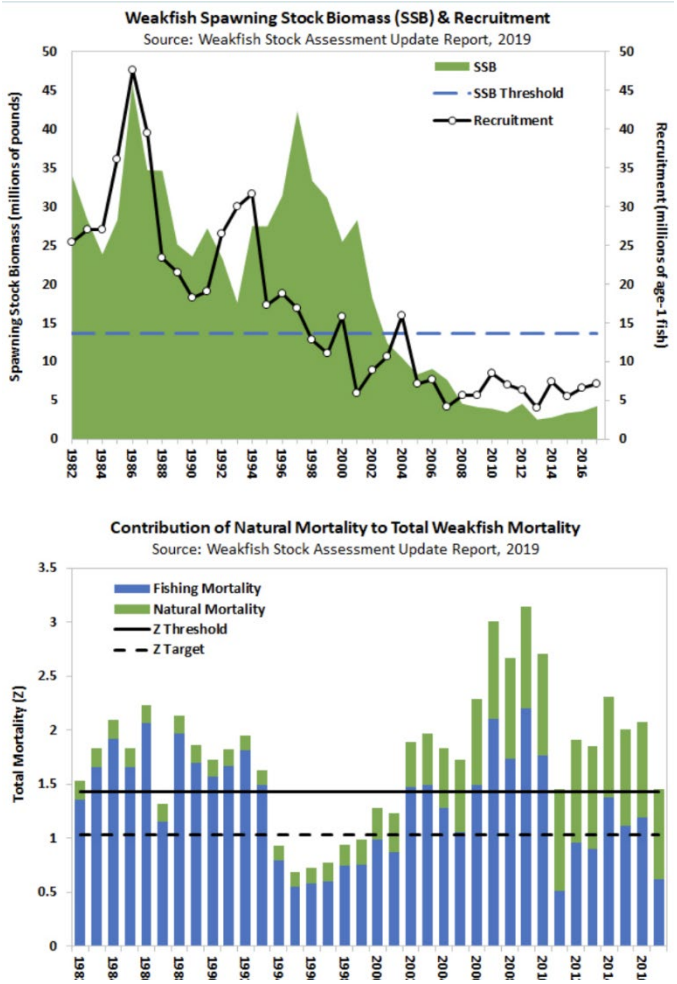


Figure 1: Top: Time series of weakfish spawning stock biomass (SSB; green area) and recruitment (black line). Also shown is the SSB threshold. Bottom: Time series of total mortality (Z) broken down by components: fishing mortality (blue bar) and natural mortality (green bar). Also shown is the Z target (dashed line) and threshold (solid line; Source: ASMFC 2019).

Status

Currently, the weakfish population is managed as a unit stock along the east coast of the United States and managed by the Atlantic States Marine Fisheries Commission (ASMFC). The

most recent assessment, finalized in 2019, concluded weakfish were depleted and total mortality exceeded threshold levels in the terminal year (2017; ASMFC 2019). Coastwide estimates of recruitment, spawning stock biomass, and total abundance remained low in recent years with moderately high, though not near time-series highs, fishing mortality (Figure 1). Natural mortality remained high in the terminal year, averaging 0.92 in the most recent 10 years, compared to 0.16 over the first 10 years of the time series (Figure 1). Therefore, even though harvest has been at low levels in recent years (Figure 2), the weakfish population has been experiencing very high levels of total mortality, preventing the stock from recovering. In support of assessment findings, the 2019 IUCN assessment lists weakfish as "Endangered" under criteria A2b and noted a decreasing population trend as measured by the number of mature individuals (Barbieri & Barbieri 2020).

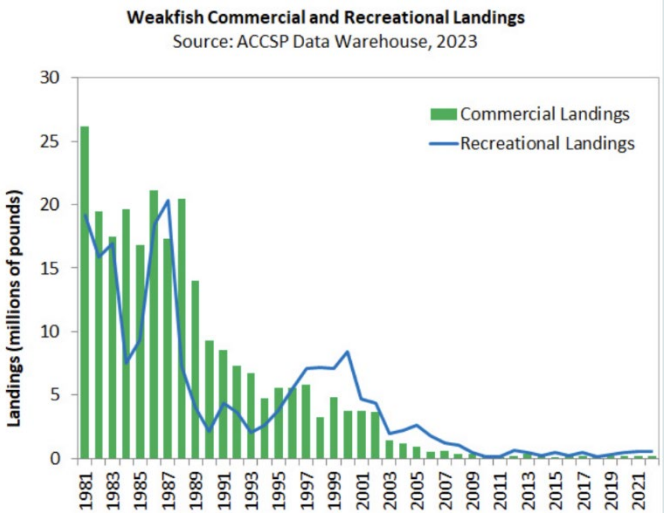


Figure 2: Time series of coastwide weakfish commercial and recreational landings (Source: ASMFC 2024)

POPULATION SIZE AND DISTRIBUTION

Weakfish are found along the Atlantic Coast from southern New England to Florida, occuring in highest numbers in the mid-Atlantic area (New York to North Carolina; Wilk 1979). Historically, weakfish were one of the most important components of a mixed-stock fishgery on the Alantic coast since the 1800s (ASMFC 2024). However, landings in the weakfish fishery have generally declined sinc ethe late-1980s as weakfish biomass began to decline, natural mortality rates increased, and fisheries management regulations were put into place (ASMFC 2019). Commercial landings have dramatically declined since the early 1980s, dropping from over 19 million pounds landed in 1982, still below the peak in 1980 at 36 million pounds, to 190,176 pounds in 2022 (Figure 2; ASMFC 2024). The majority of landings occurred in New York, North Carolina, and Virginia. Commercial fishermen have been known to discard weakfish, especially in the mixed species trawl fishery, and the discard mortality is assumed to be 100%. Discards peaked in the 1990s but have since declined as the result of management measures and a decline in stock abundance.

Coastwide, recreational catches followed similar trends to that of commercial landings (Figure 2; ASMFC 2024). After harvests above 10 million pounds in the early-1980s, landings decreased to two million pounds by 1989, and hovered between one and two million pounds through the early 1990s. Harvest then increased to over four million

pounds by the late 1990s, before exhibiting a decline like that in the commercial fishery. Recreational harvest has been dominated by New York, North Carolina, and South Carolina (ASMFC 2024). Recreational landings in 2023 were 468,618 fish (46,264 pounds) and recreational releases were estimated at 2.87 million fish. Recreational harvest in South Carolina in 2023 was 176,118 fish (215,795 pounds; 37.6% of the Atlantic catch by fish number and 33.4% by pound), the most of any individual state, followed by Florida and North Carolina (NMFS, Office of Fisheries Statistics, pers. comm.).

Several SCDNR fishery-independent surveys encounter weakfish in low to moderate numbers, including the estuarine trawl and the SEAMAP-SA coastal trawl surveys. The SCDNR estuarine trawl survey primarily encounters age-0 weakfish, providing an index of annual recruitment along coastal South Carolina. This index suggests a general increasing trend in weakfish recruitment in South Carolina estuaries since the early-2010s, though there is high uncertainty in this trend (Figure 3). Unfortunately this index was not available for consideration during the benchmark assessment (ASMFC 2016) due to its short time series, but may be included in future regional assessments. In the regional SEAMAP-SA coastal trawl survey, weakfish abundance has gradually increased over time, generally above the long-term average since 2003 (Figure 4). This survey also encounters smaller, younger weakfish (primarily age-0 and age-1), though in different habitats than surveyed by the estuarine trawl survey.

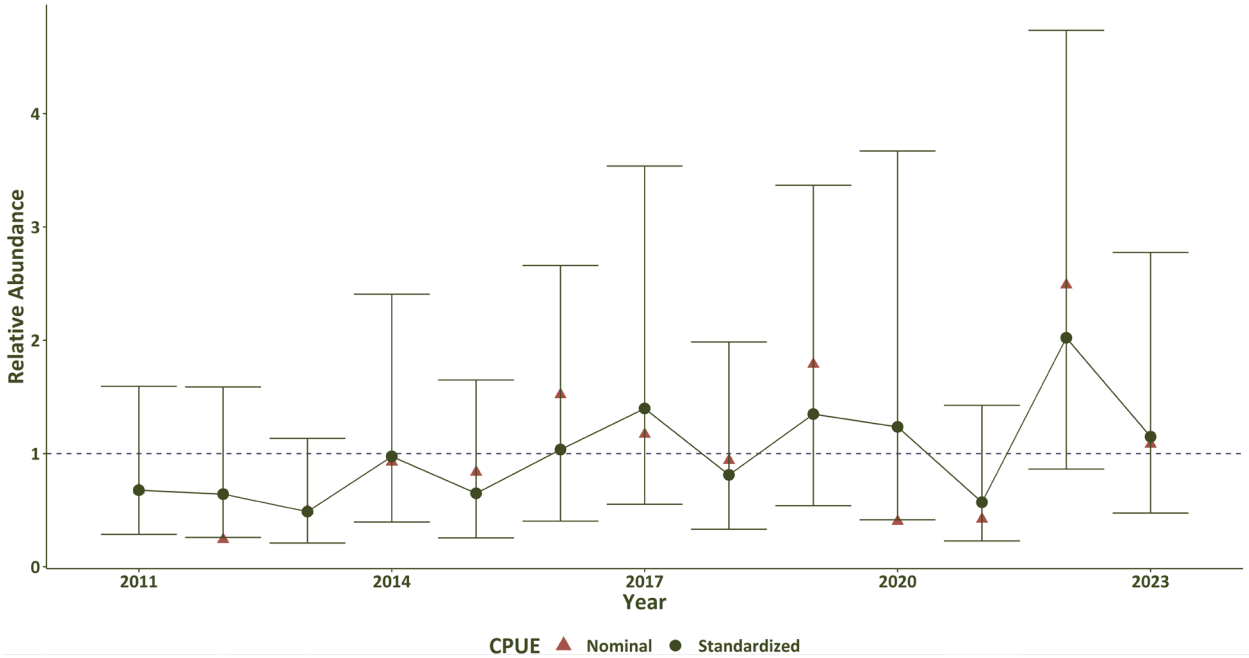


Figure 3: Annual relative abundance of weakfish in South Carolina estuaries based on SCDNR estuarine trawl survey catches. Nominal and standardized abundance shown, with the dashed line representing the time-series mean. (Source: Joseph Ballenger, SCDNR, unpublished data)

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

During warmer months of the year, weakfish adults live in nearshore coastal waters and inside bays and estuaries. In the winter, they aggregate and move farther offshore and possibly south to warmer, more stable water temperatures (Bigelow and Schroeder 1953; Mercer 1985; Wilk 1979). In South Carolina, the recreational fishery for weakfish begins in the late fall and continues through winter and early spring, taking advantage of the large schools that form offshore, often associated with live-bottom.

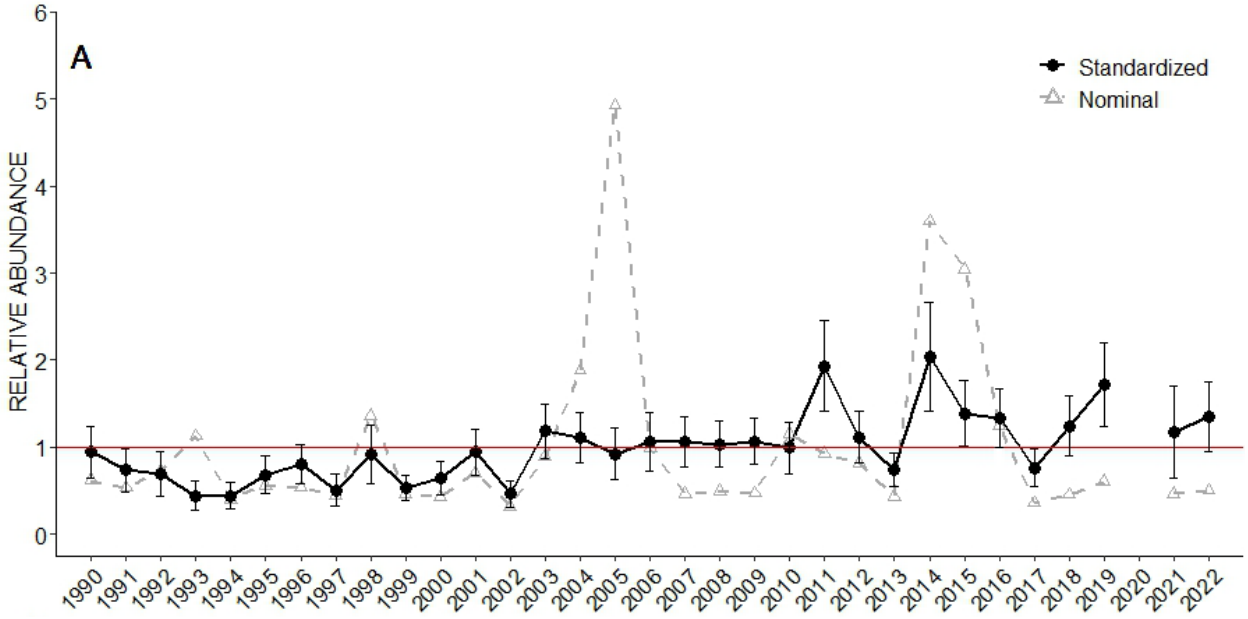


Figure 4: Annual relative abundance of weakfish as observed in the regional SEAMAP-SA coastal trawl survey. Nominal (gray line + triangles) and delta-GLM standardized (black line + circles) CPUE normalized to the time series mean (red line) are provided. Error bars represent the annual standard error estimate for the standardized index.

Weakfish have a protracted spawning season from spring through late summer. Males attract females with sounds produced by vibrating their swim bladder using adjacent musculature. Larval and juvenile weakfish make their way from nearshore spawning grounds to shallower, lower salinity nursery habitats inside of estuaries. Weakfish mature at approximately one-year old, the first spring/summer after they are spawned (Lowerre-Barbieri et al. 1996).

Diet of juvenile weakfish consists mostly of shrimp and anchovies and shifts in adults to larger fish including clupeids, sciaenids, carangids, and other locally abundant fishes that inhabit the mid-water column where weakfish tend to feed (Merriner 1975; Wilk 1979; Bowman et al. 2000).

CHALLENGES

Recreational harvests of weakfish have been in a precipitous decline along the entire Atlantic Coast. The South Carolina harvest typically makes up a very small proportion of the entire harvest and has declined at a slower rate than areas further north. As a

result, however, the South Carolina weakfish fishery now comprises a larger portion of the total Atlantic Coast harvest. As such, South Carolina now is one of the top three recreational harvesters of weakfish along the Atlantic coast (ASMFC 2024), suggesting the state is contributing to the continue moderate to high exploitation rates of the speices (Figure 1).

Since weakfish use waters off the coast of South Carolina as winter habitat, any dredging activity that adversely affects water quality or live bottom habitat where weakfish aggregate could negatively impact adults. Dredging activity that increases suspended sediment and reduces oxygen levels in shallow estuarine habitats could aso impact the survival of larval and juvenile stages.

South Carolina is also near the southern extent of the native weakfish range, suggesting the thermal conditions of South Carolina estuaries and coastal waters were historically near upper limits. As such climate change, whethe represented by increses in annual mean temperatures or, perhaps more likely, a higher frequency and intensity of marine heatwaves could have a negative impact on weakfish along our coast. Such an impact would affect weakfish natural mortality rates, either on certain sizes and ages or across all ages, which is already acknowledged as a primary factor restricting their range wide recovery. Further, even without changes to the thermal profile of our estuarine and marine waters, climate change may impact the phenology of events along coastal South Carolina, leading to poorer recruitment. Such impacts have already been observed for southern flounder (Erickson et al. 2021) and red drum (Goldberg et al. 2021) in our region.

CONSERVATION ACCOMPLISHMENTS

Regionally, weakfish are currently managed under Amendment 4 to the Interstate Fishery Management Plan and its subsequent addenda (Addendum I-IV), with the most recent addendum requiring states to implement a one fish recreational creel limit, 100 pound commercial trip limit, 100 pound commercial bycatch limit during closes seasons, and 100 undersized fish per trip allowance for the finfish trawl fishery (ASMFC 2024). The Addendum's measures are intended to reduce the level of harvest withou creating a large amount of discards and to poise the stock for recovery should natural mortality decrease in the future. The State of South Carolina lost its *de minimis* management status for weakfish in 2009 because its combined recreational and commercial catch exceeded 1% of the total Atlantic Coast catch. Therefore, the State is now subject to the ASMFC Weakfish Management Plan regulations of 1 fish per angler per day with a 12 inch total length limit (reduced from 10 fish per angler per day prior to 2010).

CONSERVATION RECOMMENDATIONS

The recent update assessment (ASMFC 2019) supported the research recommendations from the benchmark assessment, identifying seven high priority research avenues:

- Increase observer coverage to identify the magnitude of discards for all commercial gear types from both directed and non-directed fisheries.
- Evaluate predation of weakfish with a more advanced multispecies model.
- Develop a bioenergetics model that encompasses a broader range of ages than Hartman and Brandt (1995) and use it to evaluate diet and growth data.
- Analyze the spawner-recruit relationship and examine the effects of the relationship between adult stock size and environmental factors on year class strength.
- Develop a coastwide tagging program to identify stocks and determine migration, stock mixing, and characteristics of stocks in overwintering grounds. Determine the relationship between migratory aspects and the observed trend in weight at age.
- Monitor weakfish diets over a broad regional and spatial scale.
- Continue to investigate the geographical extent of weakfish hybridization.

Beyond these assessment recommendation, we identify these additional conservation priorities:

- Collect catch and effort data including size and age composition of the catch (harvested and released).
- Derive alternative estimates of discard mortality rates and the magnitude of discards; in particular, quantify trawl by-catch and refine estimates of mortality for below minimum size fish.
- Identify stocks and determine coastal movements and the extent of stock mixing, including characterization of stocks in over-wintering grounds.
- Develop latitudinal/seasonal/geo-specific age length keys for the Atlantic Coast. Increase sample sizes to consider gear specific keys.
- Compile data on larval and juvenile distribution from existing databases in order to obtain preliminary indications of spawning and nursery habitat location and extent.
- Conduct hydrophonic studies to delineate weakfish spawning habitat locations and environmental preferences (temperature, depth, substrate, etc.) and enable quantification of spawning habitat.
- Investigate the lethal and sub-lethal effects of marine heatwaves on weakfish, in particular focusing on impacts to recruitment.

MEASURE OF SUCCESS

Currently, SCDNR fishery-independent programs monitors the relative abundance, population demographics and reproductive status of estuarine and nearshore demersal species through a variety of long-term monitoring programs, including the estuarine and coastal trawl surveys. These programs can detect changes in those parameters that result from management efforts. Increases in recruitment, abundance, and population

demographics would indicate positive trends in the population. Furthermore, investigations of discard mortality, migration habits, identification of predators and competitors in South Carolina, and juvenile recruitment will greatly benefit the future success of the species.

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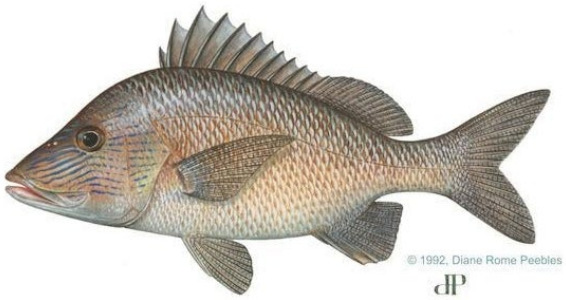
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White Grunt

Haemulon plumierii

Contributors:
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DESCRIPTION

Taxonomy and Basic Description

The White grunt, *Haemulon plumierii*, is a demersal marine reef fish belonging to the order Perciformes and family Haemulidae, commonly known as grunts (Page et al. 2023). They are found in temperate and tropical waters of the western Atlantic from Virginia to Brazil, including Bermuda, the Caribbean and the Gulf of Mexico (Böhlke and Chaplin 1993; FAO 2002). White grunt are characterized by a silver-gray body, with numerous blue and yellow horizontal stripes on the head and anterior portion of the body. The fins are typically brown-grey with the dorsal fin having 12 spines and 15 to 17 soft rays, and the anal fin having 3 spines and 8-9 soft rays. Its underbelly is white when out of the water or can take on a dark hue when underwater. White grunt have large mouths with bright orange lips, typical of the Haemulidae family. The lining of the body cavity, or peritoneum, is black (FAO 2002). White grunt have a maximum age of 27 in the South Atlantic, a maximum size of 20 inches, a maximum weight of 5.6 lbs., and on average reach sexual maturity by 2 – 3 years of age and at about 6 inches total length (SCDNR 2009; White et al. 2006). White grunt are a gonochoristic species, having separate males and females within the population.

Status

White grunt are managed in the snapper-grouper species complex by the South Atlantic Fisheries Management Council (SAFMC); however, no stock assessment has been performed on this species. While they may not be a commercially important species, only using 26% of the 2023 commercial annual catch limit (landings of all grunts: 58,707 pounds), they are a commonly caught hook and line recreational game fish (NOAA 2024). There is no minimum size limit for white grunt and recreational fisheries have a 10 fish bag limit that is part of the 20 fish aggregate limit for "All Other Snapper-Grouper Complex Species". According to the IUCN, White Grunt is a species of least concern throughout the range.

POPULATION SIZE AND DISTRIBUTION

White Grunt are encountered in chevron traps by the Southeastern Reef Fish Survey (SERFS) conducted jointly between NOAA and SCDNR from mid-April through mid-October surveying from Cape Hatteras, NC to Port St. Lucie, FL. White Grunt have a disjunct distribution off the Southeastern United States, as it typically occurs

infrequently off Georgia and northeast Florida (Potts and Manooch 2001). The genetic differentiation, along with regional growth studies, warrant the management of White Grunt as three separate stocks in the Atlantic Ocean bordering the continental USA: the Carolinas, southeast Florida and Florida Keys, and the eastern Gulf of Mexico, with at least one other separate stock in the Caribbean Sea (O'Donnell et al., 2019). In SERFS, the spatial distribution of White Grunt catch is centered mainly in the shallower waters off the northern portion of the region, with highest abundances off North Carolina in recent years (Vecchio et al. 2024; Figure 1).

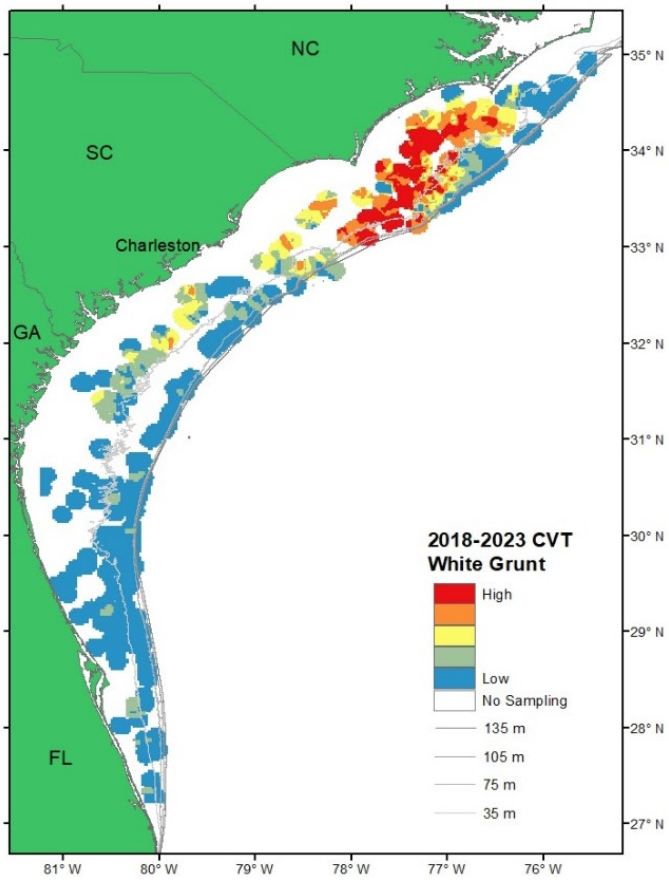


Figure 1: Distribution map of white grunt catch from chevron-video traps (CVT) from 2018-2023 (excluding 2020).

Relative abundance has fluctuated above and below the time series mean over the past two decades. In recent years both the nominal and the standardized index for white grunt decreased falling below the time series mean (Figure 2; Vecchio et al. 2024). The survey samples nearly the entire size range, however juvenile life stages are difficult to survey due to the traps mesh size not typically capturing fish below 150 mm TL. The sex ratio is significantly different from 1:1, favoring females (Padgett al. 1997). No sexual dimorphism occurs in body shape or color, however males attain larger sizes than females (Billings and Munro 1974). White grunt spawn from May to September with peak spawning occurring inshore of the shelf edge in 24.7–26.2°C waters during the waxing half-moon from May to June (Farmer et al., 2017).

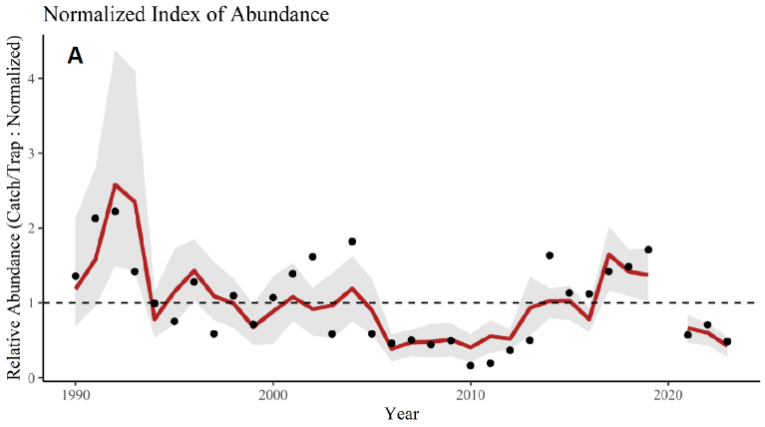


Figure 2: Chevron trap index of abundance and length compositions for white grunt. Chevron trap normalized nominal and ZINB standardized abundance with 95% Confidence Intervals.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

This species inhabits nearshore sponge-coral live-bottom habitats or offshore rocky outcrop habitats on the continental shelf along the southeastern coast of the United States and the Gulf of Mexico (Powles and Barans 1980; Darcy 1983) in depths ranging from 18-55 m (Huntsman 1976). They have a widespread diet that includes amphipods, bivalves, bony fishes, bryozoans, crabs, decapods, echinoderms, gastropods, isopods, ostracods, plants, shrimp, sponges, stomatopods, tunicates and worms (Babrowicz 2015).

CHALLENGES

While white grunt are not currently considered threatened, there are several challenges that could impact the population. White grunt are a target species for recreational and commercial fisheries in some regions, but currently has not been formally assessed. As harvest of other, more popular, reef fish species become increasingly restricted, white grunt may see increased fishing mortality. The mean annual South Atlantic recreational discards and landings data for White Grunt from 2014-2016 shows the private sector having a high discard ratio which could result in high discard mortality for this species (SAFMC 2019). High fishing mortality could lead to population declines if not managed sustainably. Degradation of coastal ecosystems, such as coral reefs and seagrass beds can reduce their food availability and suitable spawning grounds. Rising sea temperatures associated with climate change could negatively impact their populations by altering their distribution, growth rates, and reproduction.

CONSERVATION ACCOMPLISHMENTS

Snapper Grouper Regulatory Amendment 26 by SAMFC set the first bag limit for white grunt when it specified that no more than 10 fish of any one species can be retained in the 20-fish aggregate (SAMFC 2019). Outreach programs by SCDNR and SAMFC educate anglers, divers, and the public about responsible fishing practices and the importance of marine conservation. Fishers targeting white grunt and other reef fish are required to have a descending device on board and required to use non-stainless steel, non-offset circle hooks north of 28°N to reduce discard mortality due to barotrauma and excessive handling (SAFMC 2010; SAFMC 2020). White grunt must be landed with the heads and fins intact to facilitate enforcement of regulations. The establishment of artificial reefs and Marine Protected Areas may have benefited white grunt populations as they have increased suitable habitat and protected a section of the population against harvest.

CONSERVATION RECOMMENDATIONS

- Performing a formal stock assessment in the Southeastern US Atlantic waters would greatly benefit the species, allowing for a better understanding of the

stock status, fishing pressure, and best future direction for the sustainable management of this species.
- Continue to monitor populations via fishery-independent sampling programs such as SERFS.
- Initiate studies of the early life history, juvenile habitat preference, and spawning locations for White Grunt, including environmental drivers.

MEASURE OF SUCCESS

SERFS annually monitors relative abundance, population demographics, and reproductive status of reef fishes and can detect changes in those parameters that result from management efforts. Increases in recruitment, abundance, size- and/or age-compositions would indicate positive trends in the population.

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White Mullet

Mugil curema

Contributors 2025:
Michelle Taliercio and Jimmy Kilfoil (SCDNR)



Photo courtesy of the Florida Museum

DESCRIPTION

Taxonomy and Basic Description

Bluish green or olive dorsally, flanks silvery and abdomen off-white; yellowish blotch between eye and upper edge of opercle (Harrison, I.J. 2008). Dorsal fins translucid with numerous, fine, black speckles on and between rays, second dorsal fin sometimes slightly darker than first. Caudal fin yellowish at base, with fine black speckles on and between rays and blackish distal margin. Anal and pelvic fins are paler than dorsal fins and may be yellowish. Pectoral fin speckled with fine black spots, but paler than dorsal fins. Dark spot dorsally at origin of pectoral fin. Maximum size is around 910 mm total length (TL) for western Central Atlantic specimens, eastern Central Atlantic specimens may reach 350 mm TL and commonly reach 250 mm TL.

Status

POPULATION SIZE AND DISTRIBUTION

White mullet is a widespread coastal pelagic fish with its distribution ranging from Massachusetts to southern Brazil. They can be found from the Western Atlantic from Nova Scotia, but uncommon north of Cape Cod (Harrison, 2008.) to Argentina. In the Eastern Atlantic, they can be found from the Senegal River outlet southward to Namibia, the Eastern Pacific, and in addition from the Gulf of California to Chile.

The white mullet possibly uses temperature or other signals associated with upwelling to synchronize its spawning with upwelling events. The variations in the timing of recruitment of white mullet in different geographical regions may be the result of variation in the timing of favorable conditions that enhance survival.

The most recent assessment by the International Union for Conservation of Nature (IUCN) conducted in 2019 found the white mullet to be of "Least Concern" status across their global range, with a population status of "unknown" (Castro et al. 2018).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

wis a widespread coastal pelagic fish, inhibiting sandy coasts and littoral pools but also occurs in muddy bottoms of brackish lagoons and estuaries. Sometimes penetrate rivers. May also be found on coral reefs. Juveniles are common in coastal waters and

are known to find their way to estuaries and coastal lagoons. Growth in juveniles is moderate (30-40 cm in 4 years). Adults form schools. Mullet feed on microscopic or filamentous algae and small juveniles of planktonic organisms. Reproduction occurs between March and August. It is considered a catadromous fish, with juvenile fish recruit to lagoons and estuaries following a period of spawning offshore. Spawn several million eggs provided with a notable yolk. Oviparous, eggs are pelagic and non-adhesive. An important foodfish, it is marketed fresh, smoked, and salted.

CHALLENGES

The periodicity of white mullet reproduction may be related to environmental variability that may signal periods of early growth and survival. Stability of the water column and suitable food in coastal lagoons, river deltas, and estuarine areas have been identified as important factors influencing the recruitment of juvenile Mugilidae (Yañez-Arancibia, 1976; Blaber and Blaber, 1980; Blaber, 1987; Vieira, 1991).

CONSERVATION ACCOMPLISHMENTS

White mullet have a very wide range and are important ecologically as food fish as well as recreationally to anglers as bait and food. South Carolina currently has no significant commercial mullet fishery, primarily due to gear restrictions and a lack of interest by commercial fishermen. Long term commercial catch statistics show a significant decrease in the commercial landings of mullet in South Carolina since 1982. White mullet are not considered at risk of significant population depletion by humans in South Carolina. If there ever were a concern regarding population size, regulations could be put in place to establish a recreational bag limit in a similar fashion to Florida's laws (FWC 2024).

CONSERVATION RECOMMENDATIONS

- Performing a formal stock assessment for white mullet in the Southeastern US coastal waters would allow for a better understanding of the stock status, fishing pressure, and the best future direction for the sustainable management of this species.
- Continue to monitor white mullet populations via fishery independent sampling programs such as our SCDNR trammeling, electrofishing, and trawl surveys.
- Initiate studies of the early life history, juvenile habitat preference, and spawning locations for white mullet.

MEASURE OF SUCCESS

Measurement of management success is difficult given the lack of population assessments for white mullet in SC. However, the SCDNR Inshore Fisheries group monitors relative abundance, length frequency, size and age at maturity of estuarine finfishes through monthly trammel netting, electrofishing, and longline surveys and can detect changes in those parameters that result from management efforts. Increases in recruitment, abundance, size, size and age at maturity would indicate positive trends in the population.

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White Shark

Carcharodon carcharias

Contributors:
Claire Benson (SCDNR) & Bryan Frazier (SCDNR)



DESCRIPTION

Taxonomy and Basic Description



White sharks are one of the largest sharks with a maximum size estimated at 600 cm total length (TL; Fergusson et al. 2009). Males mature at about 350-410 cm TL and females at about 450-500 cm TL (Castro 2011). Size at birth is between 109-165 cm TL (Fergusson et al. 2009). White sharks have viviparous, oophagous reproduction, meaning embryos hatch in uteri and are nourished through ingestion of unfertilized eggs until the female gives birth to a live pup (Sato et al., 2016).

The white shark is an apex predator preying on items including marine mammals and fishes, including other sharks and rays, and the occasional sea turtle. Few animals prey on white sharks. Killer whales (*Orcinus orca*) pose the main threat for an adult white shark. Larger shark species may also prey on juvenile white sharks.

White sharks are classically shaped with a triangular dorsal fin, pointed snout, lunate tail, and crescent shaped caudal fin. They are identifiable by a sudden color change on their flanks which transitions from greyish black on top to a pale, almost white, underside. They can often have a black spot on the underside of pectoral fins. This species appears to be intelligent and inquisitive and exhibits complex social behaviors (Compagno et al. 2005).

Status

White sharks are listed as globally vulnerable on the IUCN Red List. In 2002, the Convention on International Trade in Endangered Species (CITES) placed white sharks on its Appendix II list, which demands tighter regulations and requires permits to monitor trade in white shark products (Fergusson et al., 2009).

Stock status in U.S. waters is unknown and no stock assessments have been completed to date. White sharks are a prohibited species in U.S. waters and fisheries. They are occasionally caught by recreational and commercial fishermen but must be released immediately. In the Atlantic, the white shark is managed under the 2006 Consolidated Atlantic Highly Migratory Species (HMS) Fishery Management Plan. In the Pacific, it is managed by the Pacific Fishery Management Council under the West Coast HMS Fishery

Management Plan. There are complementary management measures protecting the white shark in state waters along both the east and west coasts. The white shark is further protected in some of NOAA's National Marine Sanctuaries.

POPULATION SIZE AND DISTRIBUTION

White sharks occur worldwide in temperate, subtropical and tropical waters, often migrating seasonally to follow their preferred temperature range (approximately 10-26° C). In the North Atlantic, they range from Nova Scotia down to the Gulf of Mexico and U.S. Caribbean. In the U.S. Pacific, they range from Alaska down to California and Hawaii.

Globally, white sharks range in the western Atlantic as far north as Newfoundland and as far south as Argentina. In the eastern Atlantic, they are found from France to South Africa, including the Mediterranean Sea. In the Indian Ocean they occur from the Red Sea, to South Africa, the Seychelles, Reunion and Mauritius. In the western Pacific, they range from Siberia to New Zealand and the Marshall Islands, and down to Panama and Chile in the Eastern Pacific. Young-of-the-year (YOY) and juvenile white sharks are thought to prefer shallow coastal waters (Weng et al., 2007) with waters off New York considered a nursery area (Curtis et al., 2018). Global population size estimates for this species are unknown. Regional estimates conducted to date have been considered unreliable.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

White sharks spend most of their time in the upper part of the water column in nearshore waters. However, they range from the surf line to the open ocean and from the surface to depths of over 1300 m (Compagno et al. 2005). White sharks commonly patrol small coastal archipelagos inhabited by pinnipeds, offshore reefs, banks and shoals, and rocky headlands where deepwater drop-offs come close to the shoreline. White sharks usually cruise in a purposeful manner, either just off the bottom or near the surface, but spend relatively little time at midwater depths

CHALLENGES

As with most sharks, white sharks are slow-growing, producing few young, and are therefore highly vulnerable to overfishing. Fortunately, the threat of habitat loss is not significant for white sharks. They are adaptable predators capable of shifting diet as conditions dictate and may simply move away from an area with little food.

The most significant challenge for effectively managing white shark populations stems from the lack of accurate data associated with fecundity, age, growth, and population numbers. Research indicates shark populations, including those of the white shark, will dwindle unless measures for their protection are implemented.

CONSERVATION ACCOMPLISHMENTS

No conservation accomplishments specific to this species are reported.

CONSERVATION RECOMMENDATIONS

- Determine stock size & status of white sharks in Atlantic waters
- Use techniques (e.g. Close-Kin Mark Recapture genomics techniques) to develop estimates of population size
- Determine usage of habitat from white sharks migrating near SC waters
- Generate life history information (age, growth and reproduction) using non-lethal techniques
- Determine driving forces of distribution & movements

MEASURE OF SUCCESS

An important measure moving forward would be to determine the stock status of the population residing in the western North Atlantic.

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Wreckfish

Polyprion americanus



Contributors:
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DESCRIPTION

Taxonomy and Basic Description

Wreckfish, *Polyprion americanus*, is a member of the order Acropomatiformes and family Polyprionidae (Page et al. 2023). The species can grow quite large with a maximum recorded total length (TL) of 210 cm and commonly recorded catches around 80 cm TL (Bauchot 1987). Adults are bluish-gray above and paler below with a silvery sheen. Fins are blackish-brown. Juveniles have black blotches on head and body (Heemstra 1986). The body is laterally compressed with a large head, large mouth, and a rough bony ridge across the upper operculum. The species is long-lived and late-maturing with aged fish up to 80 years and 50% maturity at 790 mm TL (Lytton et al. 2015, Wyanski & Meister 2002). The species is gonochoristic having separate males and females within the population (Wyanski & Meister 2002).

Status

The latest stock assessment for the U.S. South Atlantic region, completed in 2014, indicates the stock is not overfished nor is it undergoing overfishing (Rademeyer and Butterworth 2014). IUCN Red List status is data deficient. Because the species lives in relatively deep water and constrained habitats there exists a possibility of overexploitation, but data is limited so no world-wide determination can be made.

In 2022, the last year with commercial landings data available, 22,000 lbs of Wreckfish were reported as landed and sold in the U.S. South Atlantic region (NOAA Fisheries, 2024).

POPULATION SIZE AND DISTRIBUTION

Pelagic juveniles for this species are widely distributed throughout the north Atlantic Ocean, more commonly found in the eastern Atlantic Ocean. Adults are associated with high-relief hard-bottom environments in deep water. In the Atlantic Ocean off the Southeastern U.S., the Charleston Bump is a well-known habitat (Sedberry et al. 1999).

Repeated genetic analyses have indicated northern and southern hemisphere stocks are genetically distinct but that significant mixing occurs within hemispheres and ocean basins (Ball et al. 2000).

Wreckfish are not regularly encountered by any long-term survey efforts in the region. All life stages are difficult to survey due to their diverse ontogenetic habitat preferences as well as wide distribution with low density.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The species is known to spend their juvenile period in pelagic waters in the North Atlantic basin. Length of settlement to the benthos is 56-65 cm TL, occurring around 3-4 years of age (Michias et al. 2003). Post-settlement individuals are associated with the benthos and found in isolated areas of high relief in depths of at least 150 m (Sedberry et al. 1999).

CHALLENGES

Deepwater species are very difficult to monitor based on the logistical challenges associated with weather, gear, currents, and depth in capturing these individuals. The distinct habitat requirements of each major life-phase and the isolated nature of populations make the species especially challenging to monitor. In addition, slower growing, long-lived species are not as resilient to disturbances compared to others in their community. This leads to more opportunities for removal from the ecological system, whether natural or fisheries-related, before their first reproductive contribution to the fishery. This is exacerbated in deepwater species as they can be highly susceptible to post-release mortality (e.g. barotrauma).

CONSERVATION ACCOMPLISHMENTS

The commercial wreckfish fishery in the Southeastern U.S. is managed under an ITQ (Individual Transferable Quota) program for the region and is closed during the spawning season of January 15 to April 15 each year. The recreational fishery is allocated a small proportion (5%) of catch and is currently open during June and July with a 1 fish per vessel bag limit (SAFMC, 2024).

Despite challenges, the Wreckfish fishery off the Southeastern U.S. has been developed in a relatively responsible and conservation-minded way. The ITQ program has kept the commercial fishery relatively contained and modernization efforts have kept the monitoring of the species up-to-date. Due to distance from shore, the recreational fishery is also quite limited. Seafood Watch rates the fishery as sustainable within the region.

CONSERVATION RECOMMENDATIONS

- Increase fishery independent information to develop reliable indices of abundance

- Partner with commercial fishers for updated life history information, genetic analyses, and reproductive parameter assessments
- Complete research studies of pelagic juvenile movements, settlement requirements, and other factors associated with habitat needs

MEASURE OF SUCCESS

Because there is currently no fishery-independent measure of population size or trends, fishery catch is the only available measure of success. In recent years landings have fluctuated. Total landings have been considered confidential in seven of the past ten years due to the small size of the fleet. If a fishery-independent or hybrid fishery-independent/fishery-dependent survey can be initiated, a stock level will be able to be estimated, with a measure of success being a stable population and size distribution through time.

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American Horseshoe Crab

Limulus polyphemus



Contributors: Elizabeth Wenner (SCDNR, (2005); Larry Delancey and Peter Kingsley-Smith (SCDNR, 2013); Daniel Sasson and Peter Kingsley-Smith (SCDNR, 2023)

DESCRIPTION

Taxonomy and Basic Description

Despite their name, horseshoe crabs are not true crabs. Horseshoe crabs are more closely related to spiders and scorpions than they are to other crabs; in fact, recent molecular analyses now place horseshoe crabs within the arachnid lineage (Ballesteros *et al.,* 2022). Unlike true crabs, horseshoe crabs lack antennae and jaws and have 6 pairs of appendages, including a pair of chelicerae. Chelicerae are appendages similar to those used by spiders and scorpions for grasping and crushing. Their carapace is divided into three sections: the anterior portion is the prosoma; the middle section is the opithosoma; and the "tail" is called the telson. Horseshoe crabs have two pairs of eyes located on the prosoma, one anterior set of simple eyes, and one set of lateral compound eyes similar to those of insects. In addition, they possess a series of photoreceptors on the opithosoma and telson (Shuster, 1982). Horseshoe crabs are the only living group that have book gills, which are related to the book lungs found in many arachnids. The American horseshoe crab, *Limulus polyphemus*, is the only member of the Arthropoda subclass Xiphosura found in the Atlantic Ocean.

Status

The American horseshoe crab, *Limulus polyphemus,* is not currently listed as threatened or endangered (although on December 21, 2023, NOAA's National Marine Fisheries Service received a petition from the Friends of Animals to list *Limulus polyphemus* as threatened or endangered under the Endangered Species Act of 1973). The status of the American horseshoe crab differs across populations. For instance, while population health is considered "good" in the southeastern United States, populations in the New York region are declining (ASMFC, 2019). Continued assessments of horseshoe crab populations are crucial as American horseshoe crabs are an important species, both commercially and ecologically. Ecologically, horseshoe crabs are an important component of coastal food webs and have been shown to be a controlling factor in benthic communities through their feeding activities.

POPULATION SIZE AND DISTRIBUTION

The range of the American horseshoe crab (hereafter simply horseshoe crabs for the purposes of this account) extends from northern Maine to the Yucatan Peninsula, but this species is particularly abundant in Delaware Bay, the center of its distribution, and in coastal areas between Virginia and New Jersey. Horseshoe crabs are thought to inhabit every major estuary along the Atlantic Coast. Across this range are multiple genetically distinct populations (King *et al.,* 2015).

In South Carolina, horseshoe crabs can be found in shallow estuarine areas and offshore habitats near the continental shelf and are relatively common in trawls in South Carolina. Trawl collections can be used to obtain a measure of relative abundance, although there is no current estimate of population size. Research has indicated that the horseshoe crab population in South Carolina is genetically diverse with little evidence of inbreeding (Cushman *et al.,* 2019).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Horseshoe crabs are long-lived, benthic animals. Like other arthropods, horseshoe crabs must molt in order to grow. As the horseshoe crab ages, more and more time passes between molts, with 16 to 19 molts occurring before a horseshoe crab becomes mature, stops growing, and switches energy expenditure to reproduction (Shuster & Sekiguchi, 2003). They obtain sexual maturity between 9 to 12 years of age and may live for another 10 years or more as adults, although there is no way to directly measure the age of a horseshoe crab.

Adult horseshoe crabs feed on a variety of bottom-dwelling organisms including marine worms, shellfish, and decaying animal matter. The larvae and juvenile stages are preyed upon by many species of fish and birds, while adult horseshoe crabs are known to be an important food item for the threatened loggerhead sea turtle, *Caretta caretta* (Keinath *et al.,* 1987). Horseshoe crab eggs are also the primary source of fat for at least 20 species of migratory shore birds (Harrington, 2001). There has been great concern about how the harvest of horseshoe crabs in the mid-Atlantic affects the red knot, *Calidris canutus*, an imperiled species of migratory shorebird (Piersma & Barker, 2000).

Early each spring in SC, as estuarine water temperature approaches 16°C (60.8°F), adult horseshoe crabs move inshore to seek suitable spawning habitat. Throughout the spring, females with males attached to their carapace follow flooding tides high onto the beaches and marshes where they excavate nests and deposit thousands of eggs. In South Carolina, mating and nesting activities coincide with high tides; spawning activity is especially abundant during night-time spring tides. During mating, the male grasps the carapace of the female and fertilizes her eggs externally as she deposits them in the nest cavity. Oftentimes, other unattached “satellite” males may also fertilize some of these eggs. Nests are excavated by the female and eggs are laid in clusters. Females nest several times per season, usually returning to deposit more eggs on subsequent high tides. After approximately 2 – 4 weeks, depending on temperature, moisture, and oxygen levels, larval horseshoe crabs emerge from the nest. Larval horseshoe crabs are semi-planktonic for about 3 weeks before their transition to a benthic existence. They then settle to the bottom and assume a benthic existence, typically spending their first 2 years in intertidal sand flat habitats near beaches where they were spawned. Adults return to deeper estuary bays and continental shelf waters after the breeding season (Thompson, 1999).

While beaches were often considered the primary spawning habitat for horseshoe crabs, recent work has found that horseshoe crabs also spawn with regularity in salt marshes (Kendrick *et al.,* 2021, Sasson *et al.,* in press); however, more work needs to be done to understand the extent and the ecological impacts of marsh spawning in South Carolina and other regions.

CHALLENGES

Horseshoe crabs are harvested for a number of uses. They are the primary bait used in the whelk and eel fisheries along the Atlantic coast (ASMFC, 1998). The ASMFC places yearly state harvest quotas on the collection of horseshoe crab for bait (ASMFC 2019) and, since 2013, those quotas have allowed for the harvesting of only males for Delaware Bay-origin horseshoe crabs (ASMFC 2012). Horseshoe crabs are also harvested for use in biomedicine. A clotting agent in horseshoe crab blood (or hemolymph), known as *Limulus* Amoebocyte Lysate (LAL), is used to detect microbial toxins in medical intravenous fluids, injectable drugs, and supplies (Rudloe, 1983). Biomedical companies purchase adult horseshoe crabs which are harvested by hand from spawning areas in SC or by trawlers in some other regions. The crabs are transported to the LAL production facility, bled, and then transported back to the general harvest vicinity and released alive. LAL is currently used as the standard (FDA required) test for microbial contamination in injectable pharmaceutical products in the United States (Walls & Berkson, 2000), although a synthetic version of LAL has been developed (Maloney *et al.,* 2018). Horseshoe crabs have also been used in eye research and the development of wound dressings and surgical sutures. [Note: The horseshoe crab is also discussed in the Intertidal Marine Invertebrates Guild.]

Resource managers are concerned that the health of horseshoe crab populations along the northeastern coast of the United States is impacted by overharvesting (Widener & Barlow, 1999; ASMFC, 2001). Fishery regulations are set by individual states and the Atlantic States Marine Fishery Commission (ASMFC) fishery management plan for the Atlantic Coast (ASMFC, 1998). In South Carolina, the harvest of horseshoe crabs is limited to the LAL industry, and a permit has been required since 1991. The ASMFC estimates that 15% of horseshoe crabs harvested for LAL production do not survive (ASMFC 2019). Dredging practices may also result in horseshoe crab mortality, but the impacts of dredging on horseshoe crabs have not been well studied (ASMFC, 2019). The main challenge to conservation in South Carolina is providing high quality habitat for juvenile and spawning horseshoe crabs.

COMMENTS ON ASIAN HORSESHOE CRAB IMPORTATION

In 2013, prompted by recent importations of Asian horseshoe crab as bait in northern states (*e.g.,* New York), the ASMFC passed a resolution intended to curtail this practice. Several concerns were listed, including the potential introduction of parasites and diseases into the native *Limulus* populations, potential toxic effects from one species if ingested, and threats to the populations in Asia which are thought to be in serious decline. In addition, South Carolina prohibits the importation of the giant Asian horseshoe crab, *Tachypleus gigas*, the Asian horseshoe crab *Tachypleus tridentatus*, and the mangrove horsehoe crab, *Carcinoscorpius rotundicata*, along with other marine and estuarine species not already found in the wild or native to South Carolina. (For more information, see South Carolina Codes of Laws Sections 50-5-45 and 50-16-20).

CONSERVATION ACCOMPLISHMENTS

A fishery management plan is now in place for horseshoe crabs through the ASMFC. States must comply with the goals of the plan and provide updates on their horseshoe crab status. In states that allow the harvest of horseshoe crabs for bait, restrictions have lowered the allowable harvest

from the high levels seen in the late 1990s. Crabs in the ACE Basin were once harvested for bait in small numbers; however, South Carolina prohibited this activity in 1991. Increased funding has led to the establishment of a long-term trawl survey (*e.g.,* the Virginia Tech Trawl Survey conducted in the Delaware bay) and standardized methodology for spawning and egg surveys. Basic research has increased in recent years, and public awareness has been heightened to support conservation measures.

CONSERVATION RECOMMENDATIONS

- Determine the long-term trends in horseshoe crab spawning stocks and investigate how these trends relate to environmental and other factors such as harvesting and LAL bleeding practices.
- Determine the relative importance of marsh spawning vs beach spawning in population recruitment.
- Determine the nutritional importance of horseshoe crab eggs and larvae for shorebirds and how this is influenced by habitat change.
- Quantify the impacts of dredging on horseshoe crabs
- Avoid beach renourishment activities during the horseshoe crab spawning season due to the importance of low energy beachfront as spawning and juvenile nursery habitat for horseshoe crabs.

MEASURES OF SUCCESS

Success will be reflected as stable population trends for horseshoe crabs in South Carolina.

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Atlantic Brief Squid

Lolliguncula brevis Blainville 1823



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DESCRIPTION

Taxonomy and Basic Description

The brief squid, *Lolliguncula brevis* (Cephalopoda, Myopsida, Loliginidae) was first identified by Blainville (1823) from specimens collected in Brazil. This squid is relatively small, rarely exceeding 120 mm in mantle length. Having rounded fins, the body is less streamlined than most oceanic squids, such as the northern shortfin squid, *Illex illecebrosus*. Within the order Myopsida, the family Loliginidae contains over 40 species of squid that vary widely in their distribution (Jereb & Roper, 2010). Loliginid squid inhabit all shallow continental shelf habitats of the world, with the exception of the polar ocean regions (Jereb & Roper, 2010), and contribute significantly to coastal fisheries (Arkhipkin *et al.,* 2015). Loliginid squid lay large clutches of eggs that yield high numbers of paralarvae, facilitating life history studies that can begin with early life stages (*e.g.,* Jackson, 2004; Guarneros-Narváez *et al*., 2022). The sexes are separate in this species, with males and females in South Carolina reported to reach reproductive maturity at mantle lengths of 50.2 mm and 59.2 mm, respectively (Good *et al*., 2023). Through the utilization of statolith-based age assessments, Jackson *et al.* (1997) showed that brief squid in the northern Gulf of Mexico have an estimated life span of between 100 and 200 days, whereas Good (2022) deduced that this species collected in South Carolina reached 128.7 ± 3.38 days.

Status

As a common component of the nearshore and estuarine nektonic community of South Carolina, this species represents a considerable portion of the estuarine biomass and therefore likely occupies a critical role in the estuarine food web. That being said, there are no long-term fisheries independent surveys for this species that document trends in abundance and the species has not been the target of any rigorous assessments to determine its status in relation to fisheries pressure or conservation efforts.

POPULATION SIZE AND DISTRIBUTION

Brief squid inhabit protected shallow water habitats along the continental shelf of the Atlantic Ocean from Argentina to the Bay of Fundy (Voss, 1956; Jereb & Roper, 2010) and are common throughout the coastal waters of South Carolina, with all age classes, from small juveniles to adults, having been collected in trawl samples throughout the coastal zone. The presence of both small and large brief squid throughout the year in stations spanning a broad salinity range supports a pattern of overlapping cohorts, whereas the continual presence of immature brief squid suggests asynchronous recruitment dynamics (Good *et al*., 2023).

While precise information on spawning locations is lacking, egg strings have been found in trawl samples taken in Charleston Harbor (Whitaker, pers. obs.). Cephalopods typically attach egg strings to solid objects such as oyster shells, clam shells, or other bare, solid objects. Brief squid egg strings have been observed on shallow mud flats in South Carolina, presumably attached to molluscan shells (M. Maddox, SCDNR, pers. comm., 18 March 1980). Given the planktonic development of paralarvae in this species, it is assumed that there is a single population distributed along the South Carolina coast; however, this has not been specifically investigated and field observations suggest that there may be different temporal patterns of reproduction among estuaries along the coast (Kingsley-Smith, pers. observation).

In the study by Good *et al.* (2023), season and sampling station were significantly related to brief squid abundance, which was greater for all sexes (*i.e.*, indistinct individuals, males, and females) in spring, summer, and fall than in winter, and generally greater at higher salinity stations than more upstream, lower salinity stations. In this same study, excluding sexually indistinct squid, and across all seasons, significantly more male squid were collected than female squid. In addition, mean brief squid size tended to be larger in May than in several other months of the year, largely due to the lower abundance of small squid in that month. Furthermore, catches were numerically dominated by immature squid compared to mature squid and both temperature and salinity were significant predictors of the occurrence of brief squid.

Although the brief squid is relatively common in trawl and seine samples collected in South Carolina, there is no estimate of population size or trend. Additionally, the factors that may negatively affect brief squid populations and the principle aspects of its life history are still largely unknown.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The brief squid is one of the few cephalopod species that is able to osmoconform to salinities ranging from 17.0 ppt to 35.5 ppt (Hendrix *et al.,* 1981; Laughlin & Livingston, 1982; Mangum 1991, Bartol *et al*., 2002). The study by Laughlin & Livingston (1982) demonstrated that brief squid can even tolerate salinities as low as 8.5 ppt. This physiological adaptation allows brief squid to occupy an extended habitat range from marine environment to fluvial, tidal creeks (Voss, 1956), including estuaries that present abiotic stressors, such as rapid changes in salinity, temperature, nutrient flow, and dissolved oxygen (Islam *et al*., 2005). For example, brief squid tolerate waters with low dissolved oxygen by increasing their rates of oxygen uptake, and their paralarvae tolerate hypoxic waters of < 2 mg O_2 L^{-1} (Wells *et al.*, 1988; Vecchione, 1991).

No specific critical habitats have been established for the brief squid. Vecchione (1991) found catch rates of brief squid paralarvae (a planktonic form that is anatomically identical to the adult) to be higher in bottom samples compared to samples taken in the upper portion of the water column. Ogburn-Mathews & Allen (1993) found brief squid to be more abundant over mud bottoms versus sand bottoms within inlets. Bartol *et al.* (2002) noted that in Chesapeake Bay, brief squid were more common in central channels, at depths of 10 m to 15 m (33 to 49 ft.), than in deeper waters.

The Atlantic brief squid plays an important role in the food webs of estuarine ecosystems, such as North Inlet, SC where it can comprise up to 5.5% of the faunal biomass (Ogburn-Matthews & Allen, 1993). Furthermore, brief squid are important prey for many recreationally- and commercially-important species, such as the black sea bass (*Centropristis striata*, Sedberry 1988). In addition, the diets of endangered shark species that use estuaries as juvenile nurseries, specifically the scalloped hammerhead (*Sphyrna lewini*) and the Carolina hammerhead (*Sphyrna gilberti*), can comprise up to 16.6% brief squid (Bornatowski *et al.,* 2014). Brief squid are also the most abundant prey items in the guts of lactating female bottlenose dolphins, *Tursiops truncatus*, a species of high conservation concern (Pate & McFee, 2012). In turn, based on experimental trials, brief squid prey upon white shrimp (*P. setiferus,* Hanlon *et al.,* 1983), a commercially important species that supports an approximately $7M fishery annually in South Carolina (Liddel *et al*., 2017).

CHALLENGES

Shrimp trawlers occasionally catch brief squid (D. Whitaker, pers. obs.); however, they are not likely captured by this fishery in quantities that would be likely to threaten the sustainability of the species. The vast majority of squid utilized as bait and food in South Carolina are of the genus *Loligo* that are imported from California due to their larger size and preferred texture. Reported commercial landings of *L. brevis* in South Carolina average < 454 kg (< 1,000 lbs.) annually, most if not all of which is derived from by-catch from the shrimp trawl fishery. Brief squid have been part of the shrimp fishery bycatch for over 50 years and there appear to be no negative impacts upon the population due to trawling; however, population trends are not specifically monitored.

Brief squid probably rely on relatively clean water and appear to be linked to mud bottom habitats that are common in South Carolina. Hard structures for attachment of egg strings are important for the species, and oyster and clam shell are abundant on estuarine bottoms. Substantial alteration to intertidal and subtidal mud flats, particularly resulting in siltation covering shell and hard structure, could reduce optimal substrate for egg string attachment.

Reductions or alterations in river flow rates through out-of-basin transfers or diversions may negatively impact brief squid. Presuming brief squid are estuarine-dependent, adequate quantities of fresh water flowing into estuaries may be necessary to maintain viable populations, although the species is common in North Inlet, which is a small system with very little freshwater inflow. Pollutants associated with terrestrial runoff are likely to be problematic for brief squid populations.

CONSERVATION ACCOMPLISHMENTS

In the 1950s, South Carolina closed most of its estuarine waters to shrimp trawling. Additionally, the State's sounds and bays, which were periodically opened on a limited basis, were permanently closed to trawling in 1986. Shrimp trawling is known to produce bycatch of brief squid such that these closures may have contributed to some level of conservation of stocks. The State has also prohibited the use of small mesh gill nets and "stop nets" (nylon mesh nets used to

entrap fish) in most estuarine waters. It is presumed that these gear types could have contributed to the mortality of brief squid when they were in use.

CONSERVATION RECOMMENDATIONS

- Explore estuary-scale and regional geographic differences in life history patterns and apply genetic and molecular tools to investigate population structure (see Zaleski *et al*. (2012) and Sales *et al*. (2014) for discussion of cryptic sister species of brief squid).
- Examine long-term trends in brief squid population size, as well as the influence of natural environmental and anthropogenic factors, including physical factors such as depth and tidal currents (see Pinckney & Dustan 2006) on temporal and spatial patterns of life history.
- Improve our understanding of predator/prey relationships through the application of gut content analyses and diet studies, including the application of stable isotope analyses.
- Determine spawning locations, overwintering habitats, and recruitment mechanisms.
- Improve our understanding of recruitment dynamics in brief squid through statolith-based assessments.
- Conduct tag-recapture studies to determine the degrees to which migration and local environmental conditions influence these spatial patterns in brief squid size.
- Determine effects of pollutants on distribution, reproduction, growth, maturation, and longevity of brief squid.
- Examine regional water use plans to assure that adequate quantities of water are provided to coastal estuaries during the appropriate seasons.
- Work with municipalities and counties to include Best Management Practices (BMPs) in development plans throughout the Coastal Zone. Such plans should include installation of retention ponds, modified septic systems, and stream bank protection measures. Poorly designed, existing storm water systems should be retrofitted to updated designs.

MEASURES OF SUCCESS

Once threats and conservation actions are better identified by addressing the above-mentioned survey and research needs, a management plan for brief squid could be developed. This plan would represent a measure of success for this species. Furthermore, improved water quality will benefit many sensitive marine and estuarine species.

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Atlantic Ghost Crab
Ocypode quadrata

Contributor (2005): David Knott (SCDNR)
Reviewed and Edited (2013, 2023): Peter Kingsley-Smith, Joseph Cowan (SCDNR)



Ocypode quadrata
Photo by Michael Frick

DESCRIPTION

Taxonomy and Basic Description

In 1787, J.C. Fabricius formally described the Atlantic ghost crab from specimens collected in Jamaica, originally calling it *Cancer quadrata*. Following Linnaeus' development of the modern scientific method of naming organisms, the name '*Cancer*' was commonly applied to a variety of crustacean taxa, not just crabs, by taxonomists and carcinologists. *Ocypode quadrata*, also known for some time as *O. albicans* or the "fleet-footed one of white," was characterized by Phillips (1940) as "an occult, secretive alien from the ancient depths of the sea." Since the time he wrote that romanticized description, much has been learned about this conspicuous inhabitant of the ocean beach community.

A true crab, or brachyuran, the ghost crab belongs to the family Ocypodidae, which also includes the fiddler crabs. Worldwide, there are approximately 20 species of ghost crabs, but *O. quadrata* is the only one found on the East Coast of the United States. The species is a small, straw-colored or grayish-white crab, measuring about 5 cm across the carapace at maturity. *Ocypode quadrata* has the greatest terrestrial adaptation of any crab in South Carolina, returning only occasionally to the water to wet its gills. It can also moisten its gills by extracting water from damp sand, using fine hairs near the base of its walking legs to wick ground water up onto the gills through capillary action (Ruppert & Fox, 1988). Despite this semi-terrestrial existence, the ghost crab's link to the sea is a critical one that provides not only moisture for its gills, but also the necessary means for development of larvae that are hatched from eggs that the females release at the water's edge.

Status

The ghost crab is not presently included in federal lists of threatened or endangered species, and there is no present-day human exploitation of this species. Having few terrestrial predators or competitors, a flexible feeding behavior, and the ability to endure starvation for long periods, *Ocypode quadrata* is an ideal top carnivore in a simple, filter feeding-based food chain of the dune and fore-beach ecotone (Wolcott, 1978). As such, it may prove to be a useful indicator of the health of that environment.

POPULATION SIZE AND DISTRIBUTION

Williams (1984) reported a range for *Ocypode quadrata* that extends from Block Island, Rhode Island to Santa Catarina, Brazil, including the Gulf of Mexico, the Caribbean, and Fernando de Noronha, 322 km (200 mi.) off the Brazilian mainland. It is also found in Bermuda, and populations are known to exist as far north as Martha's Vineyard, Massachusetts (Luanne

Johnson, Edgartown, MA, pers. comm.). Although rarely seen in the winter, during the rest of the year *O. quadrata* is common or abundant on outer beaches and on more protected harbor beaches near coastal inlets along the coast of South Carolina (Fox & Ruppert, 1985). Rarely has the species been the target of quantitative study in South Carolina, and despite its abundance, nothing is known of trends in its population status here. Quantitative measures of the population size in South Carolina are non-existent, although estimates based on burrow counts or nocturnal transect counts could provide a good measure of abundance (Wolcott, 1978). Such efforts have not been undertaken across a wide geographic area within the State.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The ecology of ghost crabs was recently reviewed by Lucrezi & Schlacher (2014). While they have long been considered beach scavengers, a careful study of ghost crab behavior showed that on oceanfront beaches they are more likely to subsist on a diet of the common filter-feeding inhabitants of the swash zone, like the coquina clam, *Donax variabilis,* and the Atlantic sand crab, *Emerita talpoida* (Wolcott, 1978). There is evidence, however, that they may be effective scavengers of organic matter; on more protected beaches, their prey is believed to include eggs and nestlings of the loggerhead turtle, *Caretta caretta* (Dodd, 1988).

Ghost crabs are largely nocturnal in nature and it is rare to catch a glimpse of them during daylight hours. Most feeding activity occurs at night, which reduces predation by visual predators like shorebirds and gulls that might otherwise be capable of exerting considerable pressure on populations of this species. In the event that they do leave their burrows during daylight, their ability to change color to match the sand where they live lessens their chances of being seen on such a foray.

The burrows dug by ghost crabs may be up to 1.3 m deep (4 ft.). Their habits of periodically closing the burrow opening with sand during the hottest part of the day and of remaining within the burrow through the colder months provide sufficient protection from the climatic extremes that fully aquatic species rarely encounter. These burrows, which take different shapes beneath the sand, are found from near the high tide line to a distance as great as 400 m (0.25 mi.) from the ocean. A distributional gradient based on crab age is typical for this species, with younger crabs generally burrowing closer to the shore than older individuals (Williams, 1984).

CHALLENGES

Berry (1976) reported that because of their burrowing and scavenging habits, ghost crabs might be adversely affected by increased oil tanker traffic and the resultant increase in the amount of stranded oil on ocean beaches. Contact with the oil, although it appears not to be acutely toxic to the crabs, may cause a reduction in the breeding rate and increased mortality at molting.

The decline in undeveloped beachfront habitat may represent the greatest threat to the ghost crab. In South Carolina, coastal regions claim a significant portion of the State's tourism. For example, in 1996 these coastal areas accounted for 56% of the State's visitors (SCDNR and NOAA 2000). Spending time at the beach is a highly popular activity among tourists during their visit to the coast. Alterations to the upper intertidal zone caused by residential or commercial development of coastal areas and other beach construction may eliminate *Ocypode* from its natural habitat,

either by direct mortality or by displacement to less optimal habitat. Such development, undertaken to accommodate increased recreational uses of the beaches, has been cited as the cause of the elimination of the ghost crab *O. stimpsoni* from the coastal Chinese region of Rizhao (Gao & Xu, 2002).

In North Carolina, Peterson *et al.* (2000) found significant deleterious effects on ghost crab populations resulting from beach nourishment and bulldozing activities on eroding beaches. Although these short-term responses to erosion are considered to be preferable to "hardening" the shoreline by constructing of seawalls and groins, Peterson *et al.* (2000) demonstrated a clear impact, not only on ghost crabs but also on the abundance of their principal prey items. These erosion control measures are readily permitted and widely practiced on barrier islands in southeastern U.S. states (Leonard *et al.,* 1990; Peterson *et al.,* 2000); for that reason, erosion control measures present a potential but undefined threat to the well-being of ghost crab populations in South Carolina.

Even well-meaning conservation efforts targeting other species may present a threat to ghost crabs. Previous turtle protection efforts, for example, have included measures to destroy ghost crabs when its burrows were found in close proximity to loggerhead turtle nests (*Caretta caretta*), based upon widespread reports of predation. The true impact of such predation on the loggerhead population, however, has not been adequately assessed; there is recent evidence that this level of predation is insignificant (Thompson, 1995; Von Harten *et al.,* 2002).

CONSERVATION ACCOMPLISHMENTS

Mathews *et al.* (1980) previously recognized the importance of protecting the beach/dune ecosystem in South Carolina. Five of the top 14 areas in South Carolina identified by the U.S. Fish and Wildlife Service as needing preservation measures included barrier islands with pristine dune habitat.

Although not directed specifically at the conservation of ghost crabs, a 2004 judicial ruling will keep 30 ha (75 ac.) of oceanfront property in Georgetown County uninhabited, which will ensure the preservation of that critical habitat for the Atlantic ghost crab. The ruling serves to maintain the suitability of this pristine acreage as prime habitat for sea turtles and numerous species of shorebirds, as well as ghost crabs.

Acquisition and conservation easements on undeveloped uplands and coastal islands in the ACE Basin drainage area have previously resulted in the protection of roughly 56,656 to 64,750 ha (140,000 to 160,000 ac.) though conservation measures on public and private land (Mike McKenzie, ACE Basin Committee Chairman, pers. comm., 2004). The ACE Basin National Estuarine Research Reserve includes four barrier islands, assuring protection of significant ghost crab habitat on Otter, Pine, Edisto and Morgan Islands. Some additional protection is afforded by state ownership of 4 oceanfront parks (Hunting Island, Edisto Beach, Huntington Beach, and Myrtle Beach) that include substantial amounts of suitable ghost crab habitat, although beach maintenance efforts at some of them may have the negative impacts noted above.

Although numerous beach nourishment studies conducted in the past failed to include an assessment of impacts on ghost crabs, this oversight has recently been recognized; measures are

underway to include such evaluations at several sites in South Carolina in the near future (Pam Jutte, SCDNR, pers. comm., 2005). Peterson *et al.* (2000) recently conducted such a study of nourished and bulldozed beaches in North Carolina.

CONSERVATION RECOMMENDATIONS

- Assess impacts of beach nourishment projects on Atlantic ghost crab populations in South Carolina.
- Investigate the impact, if any, that ghost crab predation may have on loggerhead turtle populations.
- Establish estimates of population size and determine trends for ghost crabs in South Carolina by widespread and long-term monitoring of ghost crab abundance, incorporating both unaltered and developed areas along the entire coastline.
- Work with municipalities and private landowners to schedule beach renourishment activity so that it is completed prior to the warm season, when *Donax variabilis* and *Emerita talpoida* (two primary food sources for ghost crabs) return in large numbers to intertidal beaches.
- To mitigate impacts to ghost crabs associated with beach bulldozing practices, encourage municipalities and private landowners to implement dune stabilizing techniques such as planting grasses.
- Develop either a state or federal management plan for the Atlantic ghost crab.
- Continue SCDNR participation in Emergency Response training programs to ensure that the Department has the most current information on planning logistics and technology for dealing with coastal oil and hazardous material releases, as well as the most effective design of aftermath shoreline assessments.

MEASURES OF SUCCESS

If the burrow-counting census methods of Wolcott (1978) were used in conjunction with other periodic beach monitoring efforts (*e.g.* horseshoe crab surveys), a cost-effective program of data collection could be undertaken that would initially provide a baseline assessment of the ghost crab population size. Ultimately, this could be used to follow population trends, provide data necessary for determining what conservation measures, if any, are needed, and enable managers to make informed decisions on how useful this species might be as an indicator of the overall "health" of the dune and fore-beach ecotone. The measurement of success will be stable population trends for the Atlantic ghost crab and increased conservation of front beach habitat in South Carolina.

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Atlantic Mud Crab

Panopeus herbstii (H. Milne Edwards, 1834)

Contributors: Amy E. Fowler (2013) and Peter Kingsley-Smith (2013, 2023)



DESCRIPTION

Taxonomy and Basic Description

The Atlantic mud crab or black-fingered mud crab, *Panopeus herbstii* (H. Milne Edwards, 1834), belongs to the super family Xanthidae (family Panopeidae) and is the largest of mud crab species, with the exception of the stone crab, *Menippe mercenaria* (Ruppert & Fox, 1988). *Panopeus herbstii* is a true crab, growing to a maximum carapace width of 6.4 cm (Ruppert & Fox, 1988) and is distinguished from other mud crab species by its robust black or dark brown fingers (top and bottom portion of the claw) that fade into a pale white along the interior portion of the base of the claw. The outsides of the claws are often mottled. The claws themselves are dissimilar in size, with the larger one having a curved upper finger and an enlarged white tooth at the base and the smaller one exhibiting a nearly straight lower finger (Williams, 1984). The brownish green, slightly granular carapace of *P. herbstii* is approximately ⅔ as long as it is wide and has five teeth on the anterolateral margins of which the first two are mostly fused (Williams, 1984). Ryan (1956) found a red spot to be present on the third maxilliped (feeding appendage) of males and some females (Williams, 1984).

Status

Panopeus herbstii is currently not included on any Federal lists of threatened or endangered species and there is no human exploitation of this species. As the dominant mud crab species in salt marshes along the Mid-Atlantic coast of the United States (Daiber, 1982; Williams, 1984), however, *P. herbstii* plays a key role in the food web structure of this ecosystem on a regional scale (Silliman *et al*., 2004) and may be a potential indicator of the heath of that particular ecosystem.

POPULATION SIZE AND DISTRIBUTION

Panopeus herbstii inhabits oyster reefs, mangrove swamps, and salt marshes along the Atlantic Coast of North America, from Massachusetts to Brazil and on Bermuda (Williams, 1984). While the maximum age of *P. herbstii* is unknown, it is thought to vary between populations along the latitudinal gradient and to be driven by differences in temperature and food availability. The population density of *P. herbstii* can vary over small spatial scales; in a survey of salt marshes from Delaware to North Carolina, densities ranged from 0 to 82 individuals m^{-2}, with individuals

positively associated with the height of the associated cord grass, *Spartina alterniflora,* and the availability of bivalve prey (Silliman *et al.,* 2004). Like other crustaceans, the timing of *P. herbstii* reproduction is seasonally dependent on water temperature and food availability and therefore can vary between populations along the coast (Williams, 1984). After hatching, the planktonic larva stays within the estuary (Dittel & Epifanio, 1982) and molts through four zoeal stages and a megalopa stage before metamorphosing into the juvenile stage (Williams, 1984).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The type localities for *Panopeus herbstii* are oyster beds and mangrove swamps from the intertidal zone to 22 meters in depth (Williams, 1984). Both adults and juveniles can be found on muddy bottoms or areas covered with shells and/or stones or in shallow burrows (4-10 cm) along the edges of the higher marsh (Williams, 1984; Dittel *et al.,* 1996). While little empirical work has been conducted on the temperature and salinity tolerances of this species, the broad latitudinal gradient that it encompasses suggests that it has the potential to withstand wide ranges of environmental conditions. Individuals have been kept in the laboratory at temperatures between 5°C and 30°C (Dame & Vernberg, 1978) and have been observed in brackish water estuaries above 10 ppt (Gosner, 1978; Rodriguez & Epifanio, 2000).

Primarily carnivorous, adult and juvenile *P. herbstii* have been documented to consume oysters, barnacles, clams, crustaceans, annelid worms, fish, and snails (McDermott, 1960; Castagna & Kraeuter. 1977; Whetstone & Eversole, 1981; Silliman & Bertness, 2002; Silliman *et al*., 2004; Tolley & Volety, 200; Whitefleet-Smith & Harding, 2014) and play an important role as prey items for a variety of birds, fish, and larger crustaceans (Grabowski, 2004). Silliman *et al.* (2004) showed that predation by *P. herbstii* on the marsh periwinkle (*Littoraria irrorata*) population had a positive effect on salt marsh vegetation growth. The megalopae of *P. herbstii* prey upon other zooplankton (Harvey & Epifanio, 1997) but are also prey for blue crabs, shrimp, and fish species (Dittel *et al.,* 1996).

CHALLENGES

As one of the most important habitats for *Panopeus herbstii* is oyster reef, the declining populations of oysters, especially the Eastern oyster, *Crassostrea virginica*, could be detrimental to *P. herbstii* populations. Populations of *C. virginica* have declined along much of the mid-Atlantic Coast of the United States during the last century due to a combination of over-harvesting (Gross & Smyth, 1946), habitat degradation (Rothschild *et al.,* 1994), reduced water quality (Seliger *et al.,* 1985), disease (Ford & Tripp, 1996; Lenihan *et al.,* 1999), the interactions among these factors (Lenihan & Peterson, 1998), and ecosystem shifts (see Rothschild *et al.,* 1994; Luckenbach *et al.,* 1999; Dame *et al.,* 2002). Wild populations of *C. virginica* are harvested both commercially and recreationally in South Carolina, and aquaculture on leased grounds (culture and mariculture permit areas) is increasing. Although *C. virginica* in South Carolina have not been as extensively exploited as the *C. virginica* populations in the mid-Atlantic states, the rapid pace of coastal development has created numerous threats to tidal creek habitats with inevitable undesirable impacts (e.g., Lerberg *et al.* 2000, Van Dolah *et al*., 2004, Holland *et al.,* 2004). Threats involve increased runoff from upland clearing and associated non-pervious surfaces; contaminants (particularly detrimental to larval stages) such as pesticides and

heavy metals (see Capuzzo, 1996 and Roesijadi, 1996, respectively, for reviews); water quality closures resulting in concentrated harvest pressure on open, harvestable beds; impacts from dredging and other channel manipulations; and boat-related impacts. The potential impacts on *P. herbstii* of ocean acidification also warrant consideration (Dodd et al., 2015). Furthermore, despite a relative focus on filter-feeding species when it comes to microplastic studies, P. herbstii may be particularly susceptible to this emerging threat (Waite *et al.,* 2018).

CONSERVATION ACCOMPLISHMENTS

Due to their importance as habitat for several species of conservation concern in South Carolina, including *Panopeus herbstii*, oyster reefs are also considered critical habitats of concern in both the State Conservation Plan and this State Wildlife Action Plan. As such, the South Carolina Department of Natural Resources (SCDNR) and others are actively involved in the restoration and enhancement of oyster reef habitat. Newly created oyster reefs provide the foundation for the settlement of oyster larvae that will eventually develop into natural oyster habitat. These new oyster reefs will benefit *Panopeus herbstii* and all of the associated marine species that utilize this habitat. To ensure that populations of *C. virginica* in South Carolina remain abundant, extensive efforts at the SCDNR Marine Resources Division, both by the Office of Fisheries Management and the Marine Resources Research Institute Shellfish Research Section, continue to be directed towards assessments of the distribution of *C. virginica* statewide to monitor changes in the acreage and condition of intertidal oyster reef habitat using ground-, boat-, and helicopter-based survey techniques.

CONSERVATION RECOMMENDATIONS

- Assess the impacts of oyster reef restoration projects on *Panopeus herbstii* populations in South Carolina.
- Establish estimates of population size and determine population trends for *Panopeus herbstii* in South Carolina by widespread and long-term monitoring of their abundance, both in oyster reef habitats as well as alternative habitats.
- Understand the importance of *Panopeus herbstii* in the overall marine species community structure on oyster reef habitats in South Carolina.
- Develop a state or federal management plan for *Panopeus herbstii* based on population assessments.
- Continue SCDNR and others' oyster reef restoration and enhancement projects to ensure viable habitat exists for *Panopeus herbstii* and other marine species that rely on this important ecosystem engineer.

MEASURES OF SUCCESS

If measures of abundance and population demographics of *Panopeus herbstii* are conducted as part of regular monitoring efforts that are currently established to monitor macroinvertebrates associated with oyster reefs, this could be a cost-effective way to collect data to provide baseline information. If continued over a longer period, these data would be able to follow population trends, which will allow managers to make decisions regarding possible conservation measures for this species. The overall measure of success for *Panopeus herbstii* will be stable population

trends along the entire coast, as part of the increased conservation and restoration of oyster reef habitat in South Carolina.

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Atlantic sand crab
Emerita talpoida



Contributor: Peter Kingsley-Smith (SCDNR)

DESCRIPTION

Taxonomy and basic description:

Also referred to as the common mole crab, *Emerita taploida* (Say, 1817) is a member of the family Hippidae (Malacostraca: Decapoda: Anomura). Mole crabs have no pincers and the shape of their body is modified for rapidly digging in wet sand. *Emerita talpoida* is an oval-shaped, beige, or purplish crab, that is subcylindrical, ridged, longer than broad, and that measures less than 2" in total length. Its pointed abdomen is fairly well developed and is usually folded beneath its ovoid body. The antennae are short and fuzzy and are used for filtering food particles out of the water of spent waves as it flows in thin sheets back to the sea (Ruppert & Fox, 1988). This specialized method of feeding is arguably unique among the arthropods (Snodgrass, 1952). A second species, *E. benedicti*, is less common and is reported from shelly bottoms in shallow water. The last segment of the first leg of *E. benedicti* is sharply pointed while that of *E. talpoida* is bluntly pointed. A detailed description of the anatomy of *E. talpoida* and some of its relatives can found in Snodgrass (1952).

Status

The status of this species in South Carolina is known as it is not the target of any standardized surveys, does not support a directed fishery, and is not listed on any recognized Federal or state conservation list. That being said, published data on this species, particularly from North Carolina, indicate that its numbers are subject to both natural and anthropogenically-driven fluctuations that warrant an improved understanding in coastal South Carolina habitats.

POPULATION DISTRIBUTION AND SIZE

Emerita talpoida occurs from Harwick, Massachusetts, USA to the Progreso, Yucatan, Mexico (Efford, 1976; Williams, 1965, 1984). The size of the population of *E. talpoida* in South Carolina is unknown because this species is data deficient. While the general habitat requirements of *E. talpoida* in the region have been explored, and it is known to be a specialist of the swash zone, details of its distribution in South Carolina are lacking.

HABITAT / NATURAL COMMUNITY REQUIREMENTS

Emerita talpoida is a successful, specialized colonizer of the intertidal zone of sandy beaches to depths of 11 ft (3½ m, (Diaz, 1980). These crabs are renowned for their ability to move rapidly in order to maintain their position with the changing tide. While several other uncrablike burrowing crustacean are collectively referred to as mole crabs, *Emerita* is by far the most familiar and is a characteristic inhabitant of the swash zone of ocean beaches, burrowing backwards into the sand facing the sea (Ruppert & Fox, 1988).

The distribution of *E. talpoida* on the foreshore is strongly influenced by inshore processes and the grain size and morphology of the beach deposit, with a preference shown for finer grain sizes into which they can more easily burrow (Bowman & Dolan, 1985). It can occur in large aggregations (*e.g.,* Diaz, 1980) that move up the beach on the rising tide and down the beach on the falling tide, with smaller crabs generally distributed higher intertidally than larger crabs (White, 1976). Tidal rhythms of activity (*e.g.,* Enright, 1963, 1972) that underly such movements up and down the beach can be entrained by tidal cycles in temperature, salinity, hydrostatic pressure, inundation, and mechanical agitation (Palmer, 1995). Such tidal rhythms of behavior of different life stages of *E. talpoida* were investigated by Forward *et al.* (2005) and all stages were found to have a circatidal rhythm in vertical swimming and activity peaks shortly after the time of high tide. Increased activity during ebb tide implies that animals are moving with the waves and feeding at this time (Forward *et al.,* 2005).

Emerita talpoida is an important component of the diet of the SWAP-listed ghost crab, *Ocypode quadrata*, which despite previous reports that it primarily scavenges (*e.g.,* Philips, 1940; Crane, 1941) has been shown to spend little time in areas where drifted material accumulates, and have a diet comprised almost entirely (90%) of live prey, namely *E. talpoida* and *Donax variabilis* (Wolcott, 1978). Predators such as wading birds, ghost crabs (*Ocypode quadrata*) and planktivorous fishes, have also been suggested to prey heavily on *E. talpoida* such that their populations may be regulated by predation (Nelson, 2012). Long-term population stability of ghost crabs, *O. quadrata*, therefore, may also be a function of the production of *E. talpoida* and *D. variabilis*, whereas populations of these prey items are unlikely to be controlled by predation by *O. quadrata*, but rather by aspects of their K-selected life history characteristics of rapid growth and reproduction, pelagic larvae, and short life cycles (Wolcott, 1978).

In North Carolina, there are two breeding pulses for *E. talpoida*, the first of which begins in the spring and ends in June, and the second of which begins after June and ends in September when most recruitment has been observed (Diaz, 1980). Larvae are released near sunset (T. Ziegler, unpubl.) and undergo a series of zoeal stages (Rees, 1959; Diaz & Costlow, 1983) in coastal areas before returning to sandy beaches as megalopae where they metamorphose and settle out as juveniles. Bowman & Dolan (1985) observed a temporal pattern in the abundance of *E. talpoida* in North Carolina, with numbers increasing through the spring and summer to a seasonal maximum in late summer and early fall. Superimposed on these seasonal patterns can be large and rapid fluctuations in numbers related to variations in wave energy and tide level, reflecting onshore and offshore migration in response to energy conditions and feeding requirements (Bowman & Dolan, 1985). Populations of *E. talpoida* are believed to overwinter offshore along the

mid-Atlantic coast, with onshore migration beginning in the early spring (Diaz, 1980; Bowman & Dolan, 1985). Females have been observed to be more abundant in summer and to produce several clutches (Diaz, 1980). A greater proportion of females has been observed in the spring as a result of the death of larger males, and another peak in the abundance of females observed in the fall due to a large recruitment of females (63%, Diaz, 1980). A higher mortality rate for males than females results in a shorter life expectancy for the former.

CHALLENGES

The spatial distribution of *E. talpoida* is strongly affected by inshore processes and the grain size and morphology of sandy beaches such that it is perhaps not surprising that the distribution of this species has been shown to be altered by the installation of a research pier in North Carolina (Bowman & Dolan, 1982) and to be affected by beach nourishment activities (Hayden & Dolan, 1974), in both cases resulting more in the redistribution of this species than in an increase in mortality. More specifically in the case of renourishment, reductions in population densities at and immediately adjacent to the downcurrent side of the point of discharge have been observed (Hayden & Dolan, 1974). Population numbers further away from the point of renourishment down the beach in the direction of the longshore current increased, indicating a migration of mole crabs in response to nourishment (Hayden & Dolan, 1974). Tidal, wave, and current motions were found to play an essential role in reducing the mortality of the mole crabs and permitting migrations associated with beach nourishment. Population numbers at the discharge site recovered within a few tidal cycles (Hayden & Dolan, 1974). Anecdotally, in South Carolina, however, there have been reports that beach renourishment activities lead to reductions in observations of *E. talpoida*. It seems plausible therefore that *E. talpoida* is a viable indicator species for assessing the environmental impacts of large-scale coastal engineering projects and renourishment events (Hayden & Dolan, 1974).

Freshwater discharge has also been shown to influence the distribution, abundance, and life history traits (*i.e.,* size, sex, maturity, fecundity) of another closely related species within the genus *Emerita* (*E. brasiliensis*) in Uruguay (Lercari & Defeo, 1999), raising the possibility that freshwater discharges from “swashes” in South Carolina could be a potential cause of disturbance to *E. talpoida*. This species also appears to be negatively affected by hurricanes, as evidenced by their recovery from such an event in North Carolina in the fall of 1971 as documented by Diaz (1980).

CONSERVATION ACCOMPLISHMENTS

Emerita talpoida has received little or no attention in terms of past conservation efforts, likely due to the data deficient nature of this species to indicate that its number have been in decline, either as a result of natural or anthropogenic factors.

CONSERVATION RECOMMENDATIONS

A first step in the conservation of this species would be to gain a better understanding of the spatial distribution of this species in coastal South Carolina and to define essential habitat characteristics for this species. In addition, gathering baseline data on temporal variation in life history and demographic parameters (*i.e.,* size, sex, abundance, recruitment patterns) would help to inform the impacts of future disturbances (*e.g.,* hurricanes, coastal engineering projects, freshwater inputs). Additional research is also needed to understand the importance of *E. talpoida* as a prey item for wading birds, ghost crabs, and planktivorous fishes in sandy beaches habitats for which they are specialized.

MEASUREMENT OF SUCCESS

A better understanding of the spatial distribution and baseline life history of *E. talpoida* would be first order measures of conservation success. Such an understanding would enable the impacts of disturbances to be conceptualized but also provide protection to critical habitats, including at key points in their life history. Healthy populations of *E. talpoida* have important implications for the species that rely upon them as prey items, during both their larval and post-settlement life stages.

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Cannonball Jellyfish

Stomolophus meleagris



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DESCRIPTION

Taxonomy and Basic Description

Cannonball jellyfish (*Stomolophus meleagris*) (L. Agassiz 1860), also known as jellyballs, belong to the class Scyphozoa and order Rhizostomeae. Agassiz (1860) described and illustrated the medusa of cannonballs using specimens collected from Wassaw Island, Georgia and Charleston, South Carolina. The hemisperical bell reaches 20 to 25 cm in size and is bordered with brown pigment. It has short, protruding oral arms with secondary mouth folds (scapulets) at the base of the bell covered with mucus for trapping small prey. *Stomolophus meleagris* means "many mouthed hunter." The mucus is also thought to be a response to disturbance rather than for feeding (Phillips *et al*., 1969; Larson, 1976).

Status

The cannonball jellyfish is not a state or federally listed species; however, cannonballs are ecologically-important because they are the major prey base for Atlantic spadefish (*Chaetodipterus faber*), butterfish (*Peprilus triacanthus*) and the endangered leatherback sea turtle (*Dermochelys coriacea*) and therefore warrant conservation (Phillips *et al.,* 1969; Hayse, 1990; Page, 2015). In addition to its ecological importance, the cannonball jellyfish is economically important as an estimated 3000 tonnes of cannonball jellyfish are harvested in the southeastern United States annually (Atlantic Coastal Cooperative Statistics Program [ACCSP] 2022) to contribute to the commercial fishery for the species.

POPULATION SIZE AND DISTRIBUTION

Cannonball jellyfish have been reported in the western Atlantic from New England to Brazil (Kramp, 1961; Larson, 1976), in the eastern Pacific from southern California to Ecuador, and in the western Pacific from the Sea of Japan to the South China Sea (Kramp, 1961; Omori, 1978). They are one of the most abundant scyphomedusae along the southeastern and Gulf coasts of the United States (Mayer, 1910; Kraeuter & Setzler, 1975; Burke, 1976; Calder & Hester, 1978). Their success is based in part on their ability to grow rapidly and take advantage of ephemeral secondary production (Larson, 1986).

Current distributions of most populations are undocumented; however, numerous reports of their occurrence in the southeastern U.S exist. Mayer (1910) reported them as abundant during the winter and spring off the coast of Florida north to South Carolina. Brooks (1882) and Gutsell

(1928) reported them in North Carolina as very abundant in June and July and common throughout the summer in the sounds and ocean. In South Carolina and Georgia, they are reported as the most common scyphomedusae, occurring sporadically year-round (Kraeuter & Setzler, 1975; Calder & Hester, 1978).

The seasonal cycle of cannonball jellyfish is described by Rountree (1983) as the following:

> *"Small populations of large adults appear offshore in the spring and move inshore by early summer. The origin of these populations of adults has not been determined, but it seems likely that they are survivors from the previous season (Kraeuter & Setzler 1975). It is also possible that they are early spawned medusae from more southern waters which are carried north by prevailing spring ocean currents…Kraeuter & Setzler (1975) found the young medusae move out from estuarine waters into more saline waters as they grow. Two concurrent events are therefore hypothesized: 1) first generation populations move from offshore in the spring to inshore waters in the summer and finally into brackish waters in the fall; 2) second generation populations move out from estuarine waters beginning in the mid-summer and continuing through the fall."*

The South Carolina Department of Natural Resources (SCDNR) has been conducting surveys in the South Atlantic Bight since 1986 through a program called the Southeast Area Monitoring and Assessment Program – South Atlantic Shallow Water Trawl Survey (SEAMAP-SA). Tows were conducted each year in spring (April to May), summer (July to August), and fall (October to November) in shallow coastal waters from Cape Hatteras, North Carolina to Cape Canaveral, Florida. From 1989 to 2000, only the presence or absence of cannonball jellyfish was recorded on each individual tow. During this time, cannonballs were present in 43% of the tows during all three survey seasons.

Beginning in 2001, total numbers of cannonballs per hectare were counted for each year (102 tows per season; J. Boylan and P. Webster, SCDNR, pers. Comm.). From 2001 to 2019, cannonball jellyfish were present in 39% of the tows. These data are presented in the following graph (Figure 1 below; Zimney & Gut, 2020). Since 2001, there has been an apparent steady decline in the relative abundance of cannonballs with very low catch rates observed in 2004 and 2009. The reasons for this decline are unknown; however, anomalously low summer water temperatures in the coastal waters in summer 2003 may be related to the low numbers in 2004. In recent years, the relative abundance has increased and was 1.5 times greater than the mean of the time series (Zimney & Gut, 2020). The highest biomass (kg per tow) of cannonball jellyfish was observed in the portion of the sampling region that includes the coastal waters of Georgia and the southern portion of South Carolina (south of Charleston) with the largest jellyfish occurring in the spring sampling season (Faulk *et al.,* 2023). The lowest biomass (kg per tow) was observed in the summer sampling months, which could be a result of decreased biomass or inshore transport into estuaries and inlets outside of the SEAMAP sampling region (Faulk *et al.,* 2023). This supports the seasonal movement observed by Kraeuter & Setzler (1975) and Rountree (1983) described above. The spatial and temporal variability observed does not appear to be linearly related to salinity or temperature (Faulk *et al.,* 2023).

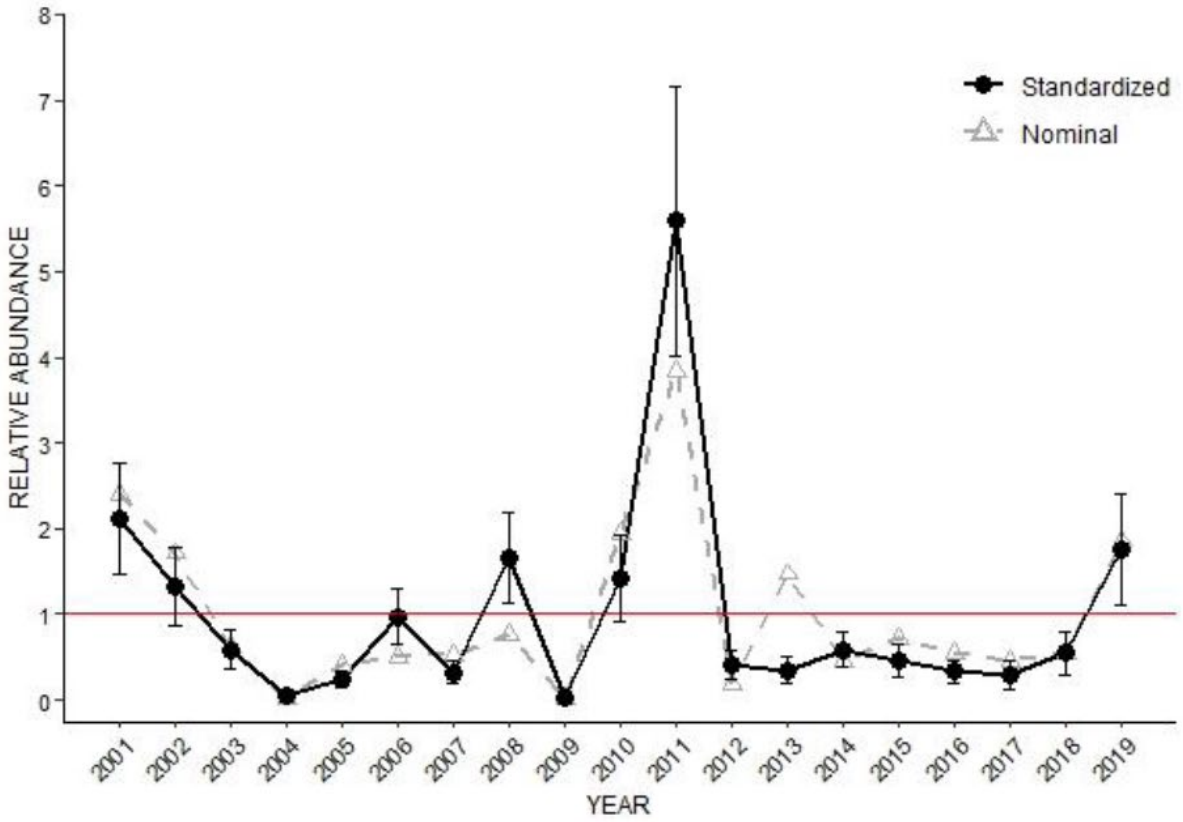


Figure 1: Nominal (grey dashed line) and delta-GLM standardized (black solid line) catch per unit effort (number of cannonball jellyfish per hectare) each year from 2001-2019. Errors bars represent the corresponding standard error.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Cannonball jellyfish are found in estuarine and saline waters. Temperature and salinity measured during the SCDNR SEAMAP-SA tows (unpub. data) indicate they are found in waters with an average temperature of 23.1°C (74°F) and in salinities from 17.7 to 36.5 parts per thousand (ppt) with an average of 33.8 ppt. Cannonballs feed on zooplankton, primarily bivalve veligers (Larson, 1991), have also been shown to prey on all stages of red drum larvae (Duffy *et al.,* 1997) but do not sting humans (Calder & Pridgen, 1977). Cannonballs are strong horizontal and directional swimmers (Shanks & Graham, 1987). They are known for their symbiotic relationships with other marine species, specifically 10 species of fishes as well as juvenile longnosed spider crabs (*Libinia dubia*). These symbionts feed on both the zooplankton taken in by the jellyfish and on the host's medusae. Symbionts may also use the bell for protection (Corrington, 1927; Gutsell, 1928; Phillips *et al.,* 1969; Rountree, 1983).

CHALLENGES

Since cannonball jellyfish are dependent on the abundance of zooplankton in nearshore waters, any activity, marine or terrestrial, that could affect water quality, should be considered a

detriment to this species. Such problems include harmful algal blooms, oil spills, and nonpoint source pollution. Also, the level of dependence of cannonball jellyfish on bivalve veligers suggests a relationship with the health of bivalves.

The potential exists for cannonball jellyfish to be adversely affected by commercial fishing. Currently, South Carolina does not regulate a commercial cannonball jellyfish fishery; however, this fishery does exist in other portions of the cannonball's range. Japan imports 5,400 to 10,000 tons of jellyfish products valued at $25.5 million annually (Omori & Nakano, 2001). Currently, Asian countries are developing fisheries management plans to conserve jellyfish because populations are unstable or declining due to pollution, overfishing, or climate change. Consequently, dealers are looking for new sources of jellyfish (Hsieh *et al.,* 2001). Interest in cannonball jellyfish from the United States increased recently because of high consumer demand in Asia (Hsieh *et al.,* 2001). A fishery in Florida has processed cannonball jellyfish since 1992 (Rudloe, 1992), and a commercial trawl fishery for cannonball jellyfish in Georgia exists (M. Dodd, GADNR pers. comm.). Rising demand in Japan and southeast Asia may create an international market for cannonball jellyfish from South Carolina coastal waters. Any development of commercial fisheries for cannonballs must consider its affect on this species' role in the food web of coastal ecosystems, as well as the effects on endangered leatherback sea turtles through incidental mortality in trawls and reduction of their food resources. Life cycles of cannonball jellyfish involve federal and state waters; therefore, cannonballs should be managed on a regional scale (Murphy *et al.,* 2006).

CONSERVATION ACCOMPLISHMENTS

In 1989, SCDNR began surveying cannonball jellyfish during SEAMAP-SA tows. These surveys have provided an index of relative abundance of cannonball jellyfish in coastal waters along the southeastern United States, which has led to a better understanding of this species. In addition, current regulations requiring the use of turtle excluder devices (TEDs) in shrimp trawling nets have also provided protection to cannonball jellyfish. Although required to reduce incidental catch of turtles, TEDs also exclude cannonballs > 10 cm, thus increasing survival. TEDs have been required for shrimp trawls since 1990.

CONSERVATION RECOMMENDATIONS

- Determine the distribution of cannonball jellyfish in state waters and how this species affects the distribution of leatherback sea turtles.
- Examine the basic life history and determine the source of the spring recruitment of cannonball jellyfish.
- Determine the effect of temperature, salinity, and rainfall on spring reproduction.
- Determine the effect of distance from estuarine habitat and wind direction on the spatial and temporal variability of cannonballs.
- Determine the southeastern U.S. population genetic structure through genetic analysis of cannonballs.
- Continue to monitor population trends through SCDNR SEAMAP-SA sampling of cannonballs.
- Determine the maximum sustainable yield for a harvest fishery.

- More fully examine the species' role in predator-prey dynamics.
- Encourage municipalities to adopt Best Management Practices (BMPs) that protect water quality and bivalve health by reducing nonpoint source runoff from highways, agricultural fields, and housing developments.
- Monitor the effectiveness of existing BMPs such as setbacks, retention ponds, and vegetated buffers for preventing nutrient and contaminant runoff into coastal waters.
- Examine the relationship between bivalve populations and cannonball reproduction.
- If a fishery develops in South Carolina for cannonball jellyfish, it should be monitored and regulated to avoid overexploitation, and appropriate harvest techniques should be identified that are protective of other marine species.
- Facilitate the development of a regional management plan for cannonballs.
- Develop an education program that stresses the importance of cannonball jellyfish to coastal ecosystems and that they are harmless to humans.

MEASURES OF SUCCESS

Determining the distribution, life history, habitat needs, and southeastern U.S. population structure and trends would represent a measure of success for this species. Methods that protect water quality are also likely to protect cannonball jellyfish and associated predator/prey relationships. In the event that more protective BMPs are implemented, SEAMAP data can be used to indicate whether these measures have affected cannonball jellyfish populations. Producing a regional management plan for this species would greatly benefit the cannonball jellyfish throughout the southeastern U.S. coastal area.

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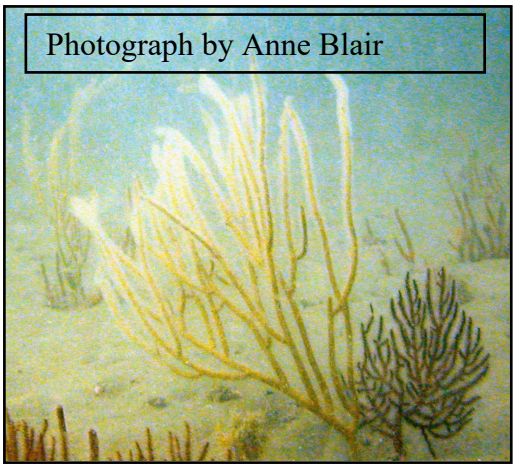
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Colorful Sea Whip

Leptogorgia virgulata



Contributors (2005): Stacie Crowe (SCDNR), Anne Blair (NOAA), Pam Jutte (SCDNR)
Reviewed and Edited (2013, 2023): Peter Kingsley-Smith (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

The colorful sea whip was first described by Lamarck (1815) and named *Leptogorgia virgulata*. Gorgonians, or soft corals, such as the sea whip, belong to the suborder Holaxonia. These colonial cnidarians are so named because they lack the permanent, rigid skeleton of scleractinian hard corals. As octocorallians, they possess 8 tentacles. Branches in gorgonians are arranged around a central axis. *Leptogorgia virgulata* colonies are moderately branching into whip-like stalks. Polyps alternate in rows along two sides of each branch; rows are separated by distinct grooves on older main branches. The color of the colony is variable and may range from shades of purple, red, orange, yellow or white. Sea whip polyps are translucent to white. The typical adult size of the colorful sea whip is 15 to 60 cm (Ruppert & Fox, 1988).

Status

Gorgonians are important benthic suspension feeders in sublittoral benthic communities and are present in tropical, subtropical, temperate and polar regions (*e.g.,* Weinberg, 1976; White, 1984; Dahlgren, 1989; Linares *et al*., 2008). The colorful sea whip is one of many coral species that commonly colonizes hard bottom substratum in high salinity areas of South Carolina estuaries and coastal shelf habitats. It serves as an indicator species that is representative of the sessile epifauna that form essential reef habitats utilized by many economically valuable or ecologically important species. These include snappers (*Lutjanus* spp.), groupers (*Epinephelus* spp.) and the black sea bass (*Centropristis striata*) (Van Dolah *et al.,* 1987). The colorful sea whip was selected over other fauna as a SWAP indicator species because it is one of the most pervasive and abundant species inhabiting hard bottom substratum. The colorful sea whip also serves as the home or prey for several specialized associates including the Atlantic wing oyster (*Pteria colymbus*), brown barnacles (*Conopea galeata*), a tissue-feeding nudibranch (*Tritonia wellsi*), and the shrimp, *Neopontonides beaufortensis* (Patton, 1972; Ruppert & Fox, 1988). No long-term studies have been completed, however, to assess the population status of the colorful sea whip.

POPULATION SIZE AND DISTRIBUTION

The colorful sea whip is a common shallow water gorgonian species that occurs over a latitudinal range that extends from Brazil to the Chesapeake Bay and perhaps as far north as the “Bay of New York” (Bayer, 1961). This species inhabits estuaries and coastal sites up to 20 m (66 ft) or more in depth (Van Dolah *et al.,* 1987; Blair, 2003).

Research indicates that the colorful sea whip is a dominant octocoral in the coastal shelf areas off the southeastern United States (Van Dolah *et al*., 1987). It is commonly found in high salinity estuarine habitats where tidal scour has exposed hard substrata (Van Dolah, unpubl. data).

The colorful whip coral is relatively common in estuarine, coastal, and offshore habitats in South Carolina. There are, however, no known estimates of population size or population trends. Additionally, factors that may limit the population are unknown.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Gorgonians are important for structuring benthic communities and driving diversity (Gili & Coma, 1998), and yet data on their trophic ecology in nature are relatively limited. This is due to the difficulties of studying feeding in organisms with such a wide spectrum of prey types. Gorgonians are capable of consuming prey and food particles ranging in size from nanometres to millimetres (Ribes *et al*., 1998, 2003). Furthermore, temporal shifts have been documented for L. virgulate in terms of diet composition, suggesting that this species may be an opportunistic feeder utilizing seasonal shifts in food availability (Leal *et al*., 2014).

Sea whips grow abundantly on shell live bottoms in sounds and tidal creeks but can also be found on floating docks, rock jetties, and oyster reefs (Ruppert & Fox, 1988) as well as on artificial reefs (Schweitzer & Stevens, 2019). They are also familiar constituents of hard-bottom reefs, which are a common topographic feature of the continental shelf off the southeastern United States. Sea whips are also found on artificial reefs constructed in this region. Furthermore, the presence of *L. virgulata* has been shown to influence mesocosm habitat selection by fish species encountering intercoastal jetties during migration, in particular the fish commonly called the ‘sergeant major’, *Abudefduf saxatilis* (Squiers & Strychar, 2021).

Unlike many gorgonian species, the colorful sea whip does not reproduce asexually through cloning or fragmentation. Fertilization is external and larvae spend 3 to 20 days in the plankton before settlement and metamorphosis. All recruits are derived from the successful settlement and survival of planktonic larvae, which require adequate substrata such as low-relief rocky outcrops or extensive hard bottom (Gottelli, 1991).

CHALLENGES

Occasionally, the colorful sea whip is damaged by shrimp trawl nets; studies have found that the overall effects were a loss of 3.9% to 38% during respective census periods (Van Dolah *et al*., 1987; Tilmant, 1979).

Another potential threat to sea whip populations is offshore disposal of dredged material. A study investigating changes in sponge and coral communities at select hard bottom reef sites adjacent to the Charleston Ocean Dredged Material Disposal Site (ODMDS) found that sessile invertebrates, including the colorful sea whip, experienced natural fluctuations in community structure and suffered limited, if any, impacts from the large-scale disposal operations occurring at the ODMDS (SCDNR, unpubl. data). Coral populations that are located closer to disposal

activities in other areas, however, could be negatively impacted by burial or decreases in the aerial extent or damage to the coral beds.

A study of the physiological effects of dredged material disposal on the oxygen metabolism of a related gorgonian octocoral, *Leptogorgia hebes*, was completed in 1992 by the EPA in conjunction with the University of Georgia's Department of Ecology. The results of that study suggested that while coral recovery from single episodes of low-level sediment exposure is likely, recovery is more difficult following repeated low-level exposures or single episodes of high-level exposure. Both long-term responsiveness and immediate short-term productivity rates were inhibited by exposure to sediment concentrations above 100 mg L-*1* [15 NTU (nephelometric turbidity units)] (Porter, 1993). Since dredging occurs frequently in the Charleston area, the potential exists for this activity to adversely affect the population size or reproductive ability of whip corals.

Populations of the colorful sea whip that inhabit sounds and tidal creeks may be subjected to increased sedimentation rates, nutrient levels (eutrophication), or contaminants due to terrestrial runoff from suburban, urban, industrial, and agricultural areas. The physiological impacts from exposure to elevated sediment concentrations in nearshore populations are described in the previous section. The possible effects of exposure to eutrophication could include impacted growth rates, reproductive ability, or mortality (Jones & Endean, 1976). Other threats to gorgonian corals include those from oil spills (*e.g.,* Frometa & Etnoyer, 2023) and potential negative impacts associated with climate change-driven increases in water temperatures.

CONSERVATION ACCOMPLISHMENTS

Inshore state waters that were historically open, including the sounds and Bulls Bay, were closed to shrimp trawling in 1986. Sea whips are common in these high salinity estuaries. Since 1978, SCDNR has monitored offshore dredge material disposal in Charleston in an effort to minimize the effects of dumping on hard bottom reef communities. Likewise, the South Carolina Estuarine and Coastal Assessment Program (SCECAP) monitors habitat quality of estuarine waters statewide and identifies specific sites with degraded water or sediment quality conditions as well as provides estimates of the overall condition of State waters (*e.g.,* Sanger *et al.,* 2022).

CONSERVATION RECOMMENDATIONS

- Conduct mapping studies of bottom habitats to better define the location of hard bottom reef areas that include sea whips.
- Examine the long-term population trends of sea whips.
- Further investigate the relationships between sea whips and commensal or cryptic species that live in association with sea whips.
- Establish detailed baseline monitoring data to allow for a better understanding of the impacts of offshore dumping on hard bottom reef habitats.
- Conduct studies on the impacts of increased sedimentation rates, nutrient levels, and contaminant levels on estuarine populations.

- Educate commercial trawl fishermen on the damage trawling causes to hard bottom reef species and collaborate with the shrimp industry to avoid trawling near sea whip communities.
- Cooperate with the United State Army Corps of Engineers to reduce sedimentation and burial of coral assemblages near disposal sites.
- Work with communities and municipalities to reduce runoff by improving and implementing Best Management Practices (BMPs).
- Work with partners to develop ways to reduce nutrient runoff that exacerbates the effects of eutrophication.
- Develop and enforce a management plan for protecting live bottom communities in South Carolina State waters.

MEASURES OF SUCCESS

Once the information regarding population distribution and trends in State waters has been documented, development of both population models for live bottom communities and a conservation plan for sea whip in South Carolina would benefit this species. Documenting stable population trends for sea whips and other members of live bottom communities within South Carolina waters would be the ultimate measure of success for this community.

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Common mantis shrimp

Squilla empusa





Contributor: Peter Kingsley-Smith (SCDNR)

DESCRIPTION

Taxonomy and basic description:

Squilla empusa Say, 1818 (Subphylum Crustacea; Class Malacostraca; Order Stomatopoda; Family Squillidae) belongs to a group of predatory benthic crustaceans known collectively as the mantis shrimps due to their resemblance in appearance to praying mantises. Details of the stomatopod crustaceans found in the Carolinas and Georgia, including a key to their identification, and geographic records of their collection, can be found in Manning & Heard (1997).

Stomatopods are visually active animal with large, mobile compound eyes of unique design (Trevino & Larimer, 1969; Cronin *et al.,* 2010; Feller *et al.,* 2015). Stomatopods are very common in marine waters around the world with around 500 species described (Muller, 1994) and are both ecologically and economically important. These crustaceans are dorso-ventrally flattened and have a pair of large powerful claws (second maxillipeds) which they hold beneath their body as if they were praying. The motions of these claws when they strike is one of the fastest recorded animal movements, taking 4 to 8 milliseconds to complete and traveling at a velocity of 1,000 cm per second (Burrows, 1969). As such, a wide diversity of prey may fall victim to the strikes of this species, including fish, penaeid shrimp, crabs, annelids, clams, mussels, snails, squids, and echinoderms (Piccinetti & Manfrin, 1970; Camp, 1973; Caldwell & Dingle, 1976). As a group the stomatopods are divided into 'smashers' and 'spearers' (Caldwell & Dingle, 1976), for which *S. empusa* falls into the category of a spearer mantis shrimp.

Squilla empusa is a robust, prickly animal that reaches 15-20 cm in length and inhabits an irregular, branched U-shaped burrow 2 to 4 cm in diameter (Frey & Howard, 1969; Hertweck, 1972) which in the southeastern United States reaches a depth of approximately 51cm (Ruppert & Fox, 1988), compared to up to 4m in more northern parts of its range (Myers, 1979). Other species are known to occupy these burrows, e.g., the small snail, *Cyclostremiscus pentagonus* (family Tornidae) and the copepod *Goodingius* (formerly *Hemicyclops*) *adhaerens* (Ruppert & Fox, 1988).

This species has also been documented to have nocturnal patterns of activity, such that numbers caught in trawls are typically higher during nighttime hours (McCluskey, 1977; Rockett *et al.,* 1984). Furthermore, the burrowing activities of stomatopods oxygenate and release nutrients to the benthic habitat, such that they could be considered to be ecosystem engineers.

Status

The mantis shrimp, *Squilla empusa* is not presently included in federal lists of threatened or endangered species, and there is no present-day direct human exploitation of this species in South Carolina; however, its population is likely impacted by the commercial penaeid shrimp fishery (details provided in *Challenges* below). No targeted population assessments are conducted on this species, despite its ecological significance. Understanding of the life history on this species for the South Carolina coastal region is lacking compared to that available for the northern Gulf of Mexico (as presented below).

POPULATION DISTRIBUTION AND SIZE

Squilla empusa is found in the western Atlantic Ocean and ranges from Massachusetts, USA to northern South America, including Trinidad, Venezuela, Surinam, and French Guiana (Manning, 1969). The animals burrow in sandy and muddy substrates overlain by high salinity waters (Gunter, 1950; Manning, 1969; Franks *et al.,* 1972). The species is abundant throughout its range but is especially prevalent in commercial shrimp beds and is believed to be a significant predator of penaeid shrimp. For example, Hildebrand (1954) observed *S. empusa* to be the most abundant crustacean in the offshore trawl fishery of the Gulf of Mexico, except for *Penaeus* spp. and *Callinectes* spp. Similarly, Wenner & Wenner (1989) reported that *S. empusa* ranked second to *Achelous* (formerly *Portunus) gibbesii* in total catch and that it occurred in 78% of trawls conducted between Cape Fear, NC and Cape Canaveral, FL in depths between 4m and 20m. In biomass, *S. empusa* constituted 11% of the total catch and was outranked only by the blue crab, *Callinectes sapidus*.

For *S. empusa* in the northern Gulf of Mexico, individuals are larger in body length and wet weight in the winter, but abundances are higher in the summer, with the sex ratio of males and females nearly equal regardless of season (Wortham, 2009). No difference has been found in the carapace lengths of male and female *S. empusa* (Rockett *et al*., 1984;Wortham, 2009). Females may be less likely to be captured during the summer spawning season as they are more inclined to remain in their burrows to care for egg masses, while males are more actively searching for new burrows (Wortham, 2009). The distribution of male and female *S. empusa* in the Gulf of Mexico also do not appear to differ in relation to depth, temperature, and salinity (Wortham, 2009).

HABITAT / NATURAL COMMUNITY REQUIREMENTS

Stomatopod larvae can occur in swarms, particularly within tropical regions of their range, and can constitute a considerable portion of the diet of reef fishes and

commercially-important pelagic fishes such as the tunas, skipjack tuna, mackerel, herring, and snapper (Sunier, 1917; Fish, 1925, Reintjes & King, 1953; Randall, 1967; Dragovich, 1970). Conversely, similar to the adults, the larvae of *S. empusa* are voracious predators, able to capture zooplankton of a similar size to themselves. In addition, Dahlberg & Heard (1969) reported that *S. empusa* was found in the stomach contents of a southern stingray, *Hypanus* (formerly *Dasyatis) americanus* collected in Wassaw Sound, GA. That being said, little information has been published on their larval ecology and development, and among the stomatopods, species are difficult to differentiate at the larval stage and present challenges with rearing from hatching to metamorphosis (although see Morgan & Provenzano, 1977).

While *S. empusa* has been extensively studied, including larval descriptions (Morgan & Provanzano, ,1979), preliminary growth and distributional data (Chace 1954; Manning, 1969; Rockett *et al.*, 1984), burrow and habitat preference, reproductive morphology and grooming behavior (Wortham 2001; Wortham-Neal 2002a,b), as well as abundance, distribution, sizes, sex ratios and habitat (Wortham, 2009), the majority of studies on this species have been conducted in the Gulf of Mexico.

By comparison, equivalent information on *S. empusa* from the South Atlantic Bight, and South Carolina, more specifically, is lacking. Within the southeastern United States, Howard & Frey (1975) reported that the stomatopods *S. empusa* and *Gibbesia neglecta* were collected together at a station in Sapelo Sound, Georgia, but that more than 100 other specimens of *S. empusa* were collected by them at nine other stations in Georgia at salinities ranging from 11.7-34.1%, suggesting that *S. empusa* was the more widespread species within this region. These authors also indicated that while *S. empusa* was locally common in Georgia estuaries, it was less common in deeper estuarine channels. Fox & Ruppert (1985) considered *S. empusa* to be common all year along the South Carolina coast; however, this has not been re-evaluated more recently to determine whether this remains the case.

CHALLENGES

Stomatopods are fished for human consumption in most Mediterranean countries, Japan, and the tropical Pacific (Kaestner, 1970), and constitute a significant component of the bycatch of commercial shrimp fisheries (*e.g.,* Wenner & Wenner, 1989; Hendrickx & Sanchez-Vargas, 2005). Stomatopods are also exploited by humans for use in animal feed and pet food, and as biomonitors for heavy metal toxicity following environmental disasters and from industrial pollution (Blasco *et al*., 2002; Storelli & Marcotrigiano 2002). Indeed, the abundance, recruitment, and diversity of stomatopods have been shown to be negatively correlated with contaminated waters (Risk & Erdmann, 2000).

Although eminently edible, the fishery for this species in the U.S. is currently very small indeed. In the Adriatic, there is a substantial fishery for the abdominal meat of the closely related species, *Squilla mantis* (Manfrin & Piccinetti, 1970). Given the abundance of stomatopods as bycatch of commercial trawls, however, the possibility has been raised of these species supporting a commercial fishery in their own right (Rudloe, 1971).

CONSERVATION ACCOMPLISHMENTS

The mantis shrimp *S. empusa* has received little or no attention in terms of past conservation efforts, likely due to the lack of trends data for demographic information on this species, either from fisheries-independent or fisheries-dependent sources. The species is currently not listed as either threatened or endangered at either the state or Federal level, which also explains the lack of targeted conservation efforts.

CONSERVATION RECOMMENDATIONS

Understanding the life history of *S. empusa* in the South Atlantic Bight at a level equivalent to that available from research conducted in the Gulf of Mexico is an overarching conservation priority for this species to ensure its populations remain sustainable and healthy. Its important ecological role within coastal food webs, at multiple life stages, further support the need to conduct research to better understand these linkages for *S. empusa* in South Carolina.

While there is no current fishery or management in the United States for stomatopods, based on fisheries in other parts of the world the potential for one could exist, particularly as a bycatch fishery associated with commercial penaeid shrimp trawl fisheries. Given the common nature of their co-occurrence in trawl catches, harvesting both penaeid shrimp and mantis shrimp at the same time might yield optimal economic and ecological efficiency (Wortham, 2009). This suggests the need for baseline data on the abundance, distribution, and life history of this species in South Carolina waters.

There is also the potential to use *S. empusa* as an environmental indicator of coastal habitat health, with a precedent for its use as a bioindicator of heavy metal pollution and contamination from human sewage. Research to compare *S. empusa* abundances across a range of habitats ranging in environmental quality and contamination could shed light on the future potential to use *S. empusa* in South Carolina as an environmental indicator.

MEASUREMENT OF SUCCESS

A better understanding of the ecology and life history parameters for *S. empusa* would be one measure of success to enable researchers to determine whether or not declines in abundance were occurring and whether certain life stages of the species are susceptible to negative impacts from anthropogenic and environmental disturbances.

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Coquina clam

Donax variabilis



Contributor (2005): Larry DeLancey (SCDNR)
Reviewed and Edited (2013, 2023): Peter Kingsley-Smith (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

This small species of clam, described by Say in 1822 (Adamkewicz & Harasewych, 1996), is well known to visitors to sandy beaches where its shells are found in abundance. Live coquinas are often exposed by retreating waves on sandy oceanic beaches and seem to be more active in the warmer months. Coquina clams possess wedge-shaped shells, generally less than 2.5cm in length, and are characterized by variously colored bands radiating along the shells (Miner, 1950). This species is a member of the bivalve family Donacidae, with *D. variabilis* being larger and more abundant than *D. fossor* along sandy beaches in the southeastern U.S. [Note: The coquina is also discussed in the Intertidal Marine Invertebrates Guild.]

STATUS

The seemingly abundant coquina clam is considered an indicator species for the sandy beach-ocean front habitat. This filter feeder is an important link in food webs, feeding on small particles such as microalgae and detritus and, in turn, being consumed by fish such as Pompano, *Trachinotus carolinus* and "whiting", *Menticirrhus* spp. (Finucane, 1969), as well as shorebirds (Nelson, 1986; DeLancey, 1989; Wilson, 1999), including ruddy turnstones, *Arenaria interpres* (Schneider, 1982) and the Federally-threatened rufa red knot, *Calidris canutus rufa* (Cohen *et al*., 2010; Karpanty *et al.,* 2010; Heller *et al.,* 2022), as well as ghost crabs, *Ocypode quadrata* (*e.g.,* Wolcott, 1978; Lucrezi, & Schlacher, 2014). Coquina clams are also consumed by humans (Miner, 1950).

POPULATION SIZE AND DISTRIBUTION

The coquina clam ranges from Virginia south through the Gulf of Mexico to Texas (Ruppert & Fox, 1988) and is common on most ocean front beach types that occur in South Carolina. The prevalence of coquina clams in this habitat makes it an excellent indicator of the health of this ecosystem.

Although current population status for these species is unknown, it appears to be common or abundant on the beaches in South Carolina. Surveys in South Carolina and the southeastern U.S. have consistently documented the occurrence of coquinas since the 1940s and have found that it is among the most abundant macroinvertebrates present in the intertidal area during spring,

where numbers have been recorded as exceeding 1000 per m^2 (Pearse *et al.,* 1942; Shealy *et al.,* 1975; Knott *et al.,* 1983).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The coquina clam is among several taxa that are uniquely adapted to live and feed in the waves as the tides ebb and flow on sandy, ocean front beaches. Coquina clams can be seen rapidly burrowing, often in groups, as waves recede down the beach (Turner & Belding, 1957). This species migrates shoreward during rising tides and seaward during falling tides, spending most of their time in the sand but emerging several times per tidal cycle to ride waves (Ellers, 1995). Like most bivalves, coquinas are filter feeders, ingesting phytoplankton, bacteria, and other small suspended particles. The sandy beach ecosystem is one of the most familiar to the public and, like other littoral habitats, is extremely dynamic, being eroded or accreted (built up) often in a period of months. Although many organisms feed in the surf zone, this clam has unique adaptations to this habitat type, making the coquina clam a key habitat indicator species.

CHALLENGES

Rising sea levels, global warming, and beach erosion are the greatest challenges to the long-term sustainability of sandy beach habitat that is required for species such as the coquina clam. The natural supply of sand borne by rivers from sources in the mountains has been curtailed by the construction of dams and reservoirs throughout the 20th century (Komar, 1998). Although beach renourishment projects restore sand to eroded beaches, these activities can significantly negatively affect populations of coquina clams and other sand dwelling invertebrates as they are buried under tons of sediment. Populations may take at least one to two years to recover following beach renourishment activities (Reilly & Bellis, 1983; VanDolah *et al.,* 1994).

Rapid coastal development also poses a problem for coquinas and other beachfront dwelling species through its associated human activities in sensitive dune areas, potential increased erosion from groins and temporary seawalls, and the disruption of sand flow. Renourishment activities could also affect the availability of prey such as *D. variabilis* to shorebirds, ghost crabs, and surf fish. As mentioned earlier, harvest by humans could also negatively impact coquina clam populations (Velez *et al.,* 1985).

CONSERVATION ACCOMPLISHMENTS

Under South Carolina's Beach Front Management Act of 1990, activities such as groin and seawall construction that may accelerate erosion have been greatly curtailed. This Act and the current administrative policy have attempted to discourage beachfront development by denying building permits and reducing funds for renourishment. In addition, intertidal beach habitats are currently protected from most construction by municipal or state setback laws such as amendments under the South Carolina Beachfront Management Act first established in 1988 (http://www.scdhec.gov/environment/ocrm/beachfront_management.htm). There have been significant strides made in the education of the public concerning the need for the protection of dunes and stabilizing vegetation. In addition, many beaches in South Carolina do not permit

motor vehicles access because of the damage these vehicles can cause to the beaches and the dunes.

Most monitoring efforts for beach invertebrates have been conducted as part of environmental impact studies required by the US Army Corps of Engineers and SC Ocean and Coastal Resource Management (OCRM) for beach renourishment projects. Future research and monitoring activities will hopefully continue to provide at least short-term estimates of the abundances for coquinas and other oceanic sandy beach organisms that can be compared to previous studies.

CONSERVATION RECOMMENDATIONS

- Periodically conduct assessments of beach invertebrates and their communities to determine their condition.
- Prepare impact models of Coastal Zone dynamics on build-up and erosion of beaches.
- Work with coastal municipalities and communities to reduce future impacts of development on beach environments.
- Work with appropriate state, local, and non-governmental agencies to discourage development on beachfront properties.
- Educate the public as to the importance of beach and dune habitat and initiate participative projects such as dune vegetation plantings.
- Encourage planned development projects in coastal zones, particularly on barrier islands, to reduce associated impacts of development on the long-term health of sandy beach habitats in South Carolina.
- Continue to investigate and document the effects of rising sea levels and global warming on beach habitats.
- Discourage the building or repair of seas walls and groins on South Carolina's beaches to allow more natural movement of sand and, ultimately, more natural beach renourishment.
- When feasible, remove dams and reservoirs that block the flow of sand and sediment from upland areas to allow for more natural beach renourishment.

MEASURES OF SUCCESS

Normal surf zone dynamics will cause beaches to accrete, erode, and move up and down the coast over decadal timeframes. The most obvious sign of success for species such as the coquina clam is the continued presence of healthy beaches with adequate, natural supplies of sand.

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Crested Oyster

Ostrea stentina (= *O. equestris*)



Contributor: Nancy Hadley (SCDNR); reviewed by Peter Kingsley-Smith (2023).

DESCRIPTION

Taxonomy and Basic Description

First described by Say in 1834 as *Ostrea equestris*, the crested oyster is now considered to be *Ostrea stentina*, as described by Payraudeau in 1826 (Shilts, 2007; ITIS, 2013*)*. The new classification combines oysters previously known as *O. equestris* (Caribbean and North Atlantic), *O. spreta* (South America), and *O. auporia* (New Zealand) with the type species *Ostrea stentina* (Mediterranean). Thus, this species has a worldwide distribution in middle latitudes. In the Mediterranean ,this oyster is known as the dwarf oyster or Provence oyster.

Members of the genus *Ostrea* are brooding oysters and are usually confined to subtidal regions to avoid dessication during the brooding period. This species is small, rarely observed larger than 5 cm, and has no commercial value. Abbott (1974) described this oyster as "usually oval; lower valve has a high, vertical crenulated margin; muscle scar almost central; interior pearly-green to gray; edge of upper valve has a row of denticles." Although oysters fitting this description, with a ruffled edge due to the folds or crenulations on the lower valve, have been observed in South Carolina, crested oysters from oyster reefs in this state are often flat, with no obvious ruffles or folds (as in the picture above). The exterior of the shell may have light purple markings on the outer edges. The crested oyster is distinguished from juvenile Eastern oysters (*Crassostrea virginica*) by the presence of small denticles (teeth) on the interior of the upper valve (Abbott, 1974). These are indicated with arrows on the picture above and are the primary characteristic that SCDNR biologists use to distinguish this oyster from juvenile *C. virginica*.

Status

The crested oyster is not a listed species but has received attention as a potential host for *Bonamia* spp. which are microcell haplosporidian parasites that infect oyster hemocytes. *Bonamia* spp. are serious pathogens of oysters, causing high mortality in susceptible species, but represent no human health threat. Until recently, *Bonamia* spp. were not known to infect *Crassostrea spp.* The only harvestable oyster in South Carolina is *C. virginica*. In susceptible species, mortality from *Bonamia* infections can exceed 90%. The European oyster industry (*Ostrea edulis*) was devastated by *Bonamia* infections beginning in the late 1970s (Balouet *et al.,* 1983; Elston *et al.,* 1986), and the New Zealand oyster (*Ostrea chilensis*) suffered massive losses in the late 1980s (Hine, 1991; Hine *et al*., 2001). *Bonamia* spp. infections were reported in the non-native oyster *C. ariakensis* during experimental introductions in North Carolina in 2003 (Burreson *et al.,* 2004; Carnegie *et al.,* 2008). In 2005, *Bonamia* spp. were observed in native *O. stentina* in North Carolina (Carnegie *et al.,* 2005, 2006), leading to concern that *O. stentina* might be serving as a reservoir and vector for the parasite (Bishop *et al.,* 2006). In 2012 and 2013, *Bonamia* infections were reported for the first time in *C. virginica* from North Carolina

and Massachusetts (Carnegie & Bushek, 2013). The parasites were identified as *Bonamia exitiosa* (Carnegie & Bushek, 2013), the species responsible for mortalities of *O. chilensis* in New Zealand (Hine *et al.,* 2001). *Bonamia exitiosa* is included on the World Organization for Animal Health list of notifiable pathogens. Ballast water is thought to be the source of *Bonamia* spp. introductions (Bishop *et al*., 2006) but its proliferation and range expansion could be facilitated by *O. stentina* (Schott *et al.,* 2008; Bishop *et al.,* 2006). Thus, greater knowledge of the distribution of *O. stentina* and its infection with *Bonamia* spp. is needed in order to fully understand the implications for the oyster industry in the southeastern United States. The extensive geographic distribution of *B. exitiosa* parasites belonging to the cosmopolitan and Atlantic Coast groups described by Hill-Spanik *et al.* (2015) may relate to both natural and anthropogenic dispersal of a single host*, O. stentina*, which is distributed from the eastern Americas to the Mediterranean and African coast to New Zealand—that is, in most regions where *B. exitiosa* has been found to occur.

POPULATION SIZE AND DISTRIBUTION

Ostrea stentina is found in high salinity waters (> 20 ppt) from North Carolina to the West Indies and in the Gulf of Mexico (Wells, 1961; Galtsoff & Merrill, 1962), along the Mediterranean coastlines, and in New Zealand. Although earlier literature indicates that this species is confined to subtidal regions (Galtsoff & Merrill, 1962), a survey in North Carolina (Markwith, 2010) found this species in a wide range of habitats from the mid-intertidal down into the subtidal. It was most abundant on floating docks, low intertidal oyster reefs, and low intertidal shell hash with a patchy distribution, with patch densities ranging from 5 to 125 oysters/0.25m^2. On North Carolina oyster reefs, *O. stentina* was found to represent up to 10% of the population in sampled areas. It is thought to prefer higher salinity regimes than *C. virginica* and population shifts have been reported in relation to drought (Hoese, 1960; Galtsoff & Merrill, 1962), with *C. virginica* dominating in wet periods and *O. stentina* dominating in dry periods. In conjunction with oyster reef studies in South Carolina, crested oysters were observed on shells of *C. virginica* at 24 sites in 2006 (SCDNR unpublished data). Abundance was quantified on restored oyster reefs at one site near Charleston, SC. Distribution was patchy, with localized abundances as high as 400 m^{-2}, although overall abundances were much lower, ranging from 46 m^{-2} in the mid-intertidal to 134 m^{-2} in the low intertidal. *Ostrea stentina* represented 68% of the live oysters found in the lowest intertidal region but only 1% in the mid-intertidal region of the restored reefs. The largest crested oyster observed in that study was 36 mm in shell height. Due to the challenges of distinguishing *O. stentina* from *C. virginica* (described above), it may be easily overlooked and therefore more abundant than previously thought.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The crested oyster has been observed on low intertidal oyster reefs in NC, SC, and GA as well as on manmade structures (*e.g.*, pilings, floating docks, buoys) and subtidal hard bottom (*e.g.,* shell hash). It appears to be limited to higher salinities (Menzel, 1955; Markwith, 2010) and the lower intertidal or subtidal regions (Markwith, 2010; SCDNR unpublished data). In natural habitats, it attaches primarily to other shell material and appears to favor degraded oyster shells, although it will also settle on scallop shells and pen shells. This species does not form reefs.

CHALLENGES

Little is known about the distribution and abundance of *O. stentina* in South Carolina. The potential of this species to harbor *Bonamia* spp. parasites and the first ever report of *Bonamia exitiosa* in *C. virginica* are cause for concern and warrant further study of South Carolina populations of *O. stentina*, especially given that *Bonamia* spp. infections have decimated oyster populations in Europe and New Zealand. The recent revelation that these parasites can infect *C. virginica* makes vigilance in controlling importations from other geographic areas paramount. The SCDNR bans the introduction of non-native species (*e.g., C. ariakensis*) and requires importation permits for native species. These importation permits are contingent on negative results from disease diagnostic testing but it is important to update testing requirements frequently as new parasites such as *Bonamia exitiosa* are identified.

CONSERVATION ACCOMPLISHMENTS

The SCDNR has an indigenous species importation policy requiring negative disease tests for all importations. The SCDNR does not allow importation of non-indigenous species. Some preliminary data on the distribution and density of *O. stentina* has been gathered incidental to other studies on oyster reefs.

CONSERVATION RECOMMENDATIONS

- Cooperate with investigators from other institutions who are evaluating the presence of disease organisms in crested oysters and related issues.
- Continue to require disease testing for indigenous shellfish importations.
- Update disease diagnostic requirements for indigenous shellfish importations at least annually and whenever alerts are received.
- Collect information on the distribution and abundance of crested oysters in SC.

MEASURES OF SUCCESS

South Carolina's oyster populations have been largely unaffected by disease issues which have been problematic in other Atlantic states. A continuing absence of disease epizootics (which might in some cases be facilitated by *O. stentina*) would be considered a measure of success.

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Eastern Oyster

Crassostrea virginica (Gmelin, 1791)



Contributor: Peter Kingsley-Smith (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

The Eastern oyster, *Crassostrea virginica*, was first identified by Gmelin (1791) and over time has been shown to be synonymous with a number of other species. Harry (1985) recognized only 4 species in the genus *Crassostrea*, namely *C. angulata, C. virginica, C. columbiensis, and C. gigas*. Menzel (1987), observing ease of hybridization and chromosomal patterns in hybrids, suggested that *C. virginica, C. columbiensis* and *C. gigas* should be considered the same species with *C. columbiensis* and *C. rhizophorae* being subspecies of *C. virginica*. *Crassostrea v. guyensis* and *C. v. lacerate*—reported from Venezuela—are subspecies of *C. virginica* (Ahmed, 1975), and *C. crassa, C. brasiliana*, and *C. floridensis* are synonyms of *C. virginica* (Abbott, 1974; Quayle, 1980; Castillo-Rodriguez & García-Cubas, 1986). Ahmed (1971, 1975) believed *C. madrasensis* in India and Pakistan to be *C. virginica* based on their very close morphological similarities, while Lamy (1929-1930) reported many other synonyms of *C. virginica* (see also papers by Reece *et al.*, 2008, Cordes *et al.* 2008 and references therein).

The Eastern oyster, *Crassostrea virginica* (Phylum Mollusca; Class Pelecypoda or Bivalvia; Order Lamellibranchia; Family Ostreidae) is a monomyarian (anterior adductor muscle has been lost) lamellibranch with a pronounced bilateral asymmetry and restricted coelom typical of the class (Seed, 1983). The shell of *C. virginica* consists of two calcareous valves, joined by a resilient hinge ligament, and serves as an exoskeleton to support the soft internal organs and prevent the collapse of the mantle cavity. The left valve is almost always thicker and heavier than the right valve and more deeply cupped (Yonge, 1960; Galtsoff, 1964), while the post-settlement form is cemented to the substrate on the left valve. Shell hinge teeth are absent in *C. virginica*, although a buttress on the right valve fits into a depression on the left valve (Stanley & Sellers, 1986). The interior of the shell of *C. virginica* has a purple pigmented adductor muscle scar located slightly posteriorly and ventrally. This feature can be used to distinguish *C. virginica* from other similar species of *Crassostrea* (*e.g.*, lightly pigmented in *C. rhizophorae* and *C. gigas*; unpigmented in *C. rivularis*). A second muscle scar—of the Quenstedt's muscle—is situated ventral to and a short distance from the hinge (Stanley & Sellers, 1986). Species of *Crassostrea* are distinguishable from species of *Ostrea* by the promyal chamber which is well-developed in *Crassostrea* but not in *Ostrea*. The growth form of *C. virginica* is highly variable (McLean, 1941) and is strongly affected by environmental conditions.

The internal organs of bivalves are covered by a fleshy fold of tissue called the mantle that deposits the shell. The gills of *C. virginica* consist of four folds of tissue that are suspended from the visceral mass and occupy much of the mantle cavity. Together with the mantle, the gills are the main organs of respiration and create water currents that enable food particles to be captured

and sorted by the labial palps prior to ingestion at the mouth and digestion. Extensive communities of filter-feeding bivalves are capable of improving water clarity and quality through high filtration rates associated with feeding and the transfer of nutrients from the water column to the benthos (Ulanowicz & Tuttle, 1992; Dame, 1999; Dame *et al.*, 2001; Newell, 2004; Porter *et al.*, 2004). The most comprehensive work describing the anatomy and histology of *C. virginica* is that by Galtsoff (1964), with a thorough review of many aspects of the biology and ecology of this species having recently been compiled by Kennedy *et al.* (1996).

Crassostrea virginica is a protandric, gonochoristic or dioecious alternate hermaphrodite (Coe, 1943; Mackie, 1984) with an annual reproductive cycle that culminates in spawning and external fertilization in the water column. Reproduction is typically triggered by periods of higher water temperatures (*e.g.*, Loosanoff & Davis, 1963) that support abundant phytoplankton that enable larvae to grow rapidly. Adult oysters are responsive to macroscale environmental changes that stimulate gametogenesis and spawning when conditions are suitable for larval survival and gametogenesis. These processes are synchronized between the sexes such that eggs and sperm are released concurrently, maximizing the number of eggs that are successfully fertilized. Following fertilization, blastula and gastrula stages occur, and the first larval form (trochophore) hatches from the egg and begins to swim (Galtsoff, 1964). The trochophore persists for 24 to 48 hours, depending on water temperatures, before developing into the veliger (or D-shape) stage which is protected by the larval shell. The planktotrophic veliger stage, which typically lasts 2 to 3 weeks, takes its name from the 'velum'—a structure that enables the veliger to swim and feed and which is resorbed after settlement (Baker & Mann, 1994). Temperature and food supply affect the length of the larval period, with increases in time undoubtedly leading to decreased survival due to extended exposure to predators and disease (Underwood & Fairweather, 1989). Larvae that survive in the plankton to reach the "eyed" stage explore the substrate as pediveligers, searching for suitable locations to adopt the permanently benthic form whereupon cementation occurs. Early post-settlement and post-metamorphic stages in bivalves are referred to as "spat" which feed, grow, and mature into the adult form.

Status

Crassostrea virginica is not State or Federally listed, although this species plays a pivotal ecological role in the health of marine and estuarine ecosystems as an individual species and collectively as a priority habitat (reef). Populations of *C. virginica*, have declined along much of the mid-Atlantic coast of the United States during the last century due to a combination of over-harvesting (Gross & Smyth, 1946), habitat degradation (Rothschild *et al.*, 1994), reduced water quality (Seliger *et al.*, 1985), disease (Ford & Tripp, 1996; Lenihan *et al.*, 1999), the interactions among these factors (Lenihan & Peterson, 1998), and ecosystem shifts (see Rothschild *et al.*, 1994; Luckenbach *et al.*, 1999; Dame *et al.*, 2002). Newell (1988) estimated that the extant population of *C. virginica* in Chesapeake Bay was approximately 1% of the biomass present a century earlier. Furthermore, Beck *et al.* (2009) recently highlighted the imperiled status of shellfish habitats, with an estimated 85% loss of habitat on a global scale, placing them as the most threatened of marine habitats. Wild populations of *C. virginica* are harvested both commercially and recreationally in South Carolina, and aquaculture on leased grounds (culture and mariculture permit areas) is increasing. To ensure that populations of *C. virginica* in South Carolina remain abundant, extensive efforts at the SCDNR Marine Resources Division—both by

the Office of Fisheries Management and the Marine Resources Research Institute Shellfish Research Section—continue to be directed towards assessments of the distribution of *C. virginica* statewide to monitor changes in the acreage and condition of intertidal oyster reef habitat using ground-, boat-, and remote sensing survey techniques.

POPULATION SIZE AND DISTRIBUTION

The Eastern oyster, *Crassostrea virginica* is distributed in the Western Atlantic along the coasts of Brazil and Argentina northwards through the Caribbean and Gulf of Mexico to the St. Lawrence River estuary in eastern Canada, representing a range of some 8,000 km (4,971 mi.) (Buroker, 1983; Newball & Carriker, 1983; García-Cubas *et al.*, 1987; Andrews, 1991). *Crassostrea virginica* has also been introduced to a wide geographic range of localities, including the west coast of North America, Hawaii, Australia, England, Japan, and possibly other areas, but in general has not become established there (Quayle, 1988; Arakawa, 1990). A review of non-native oyster introductions and the ecological consequences and restoration implications of these actions was provided by Ruesink *et al.* (2005).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Crassostrea virginica is critically dependent on a mixture of saltwater with freshwater from land drainage (Butler, 1954) and therefore occurs commonly in estuaries and coastal areas of reduced salinity as extensive reefs on hard to firm bottoms, both intertidally and subtidally (Meyer & Townsend, 2000; Wilson *et al.*, 2005). *Crassostrea virginica* forms extensive, 3-dimensional reef habitat through the settlement of competent larvae on the shells of previous generations. The natural environmental factors governing the distribution of *Crassostrea virginica* were reviewed by Shumway (1996). Adult *C. virginica* are highly tolerant of broad ranges in salinity and temperature, making them well-suited to life in the estuary and, in South Carolina, to a predominantly intertidal distribution. Adult oysters are found in waters where the annual temperature range is from -2°C to 36°C (Butler, 1954; Gunter, 1954; Galtsoff, 1964). Galtsoff (1964) reported that oysters can survive intertidal temperatures of 46°C to 49°C when exposed at low tide. In terms of salinity, across its geographic range, *C. virginica* occurs from ~ 5 ppt to ~40 ppt (Galtsoff, 1964; Wallace, 1966). If left undisturbed in an optimal environment, oysters will continue to grow for many years. Galtsoff (1964), for example, reported a maximal shell height of *Crassostrea virginica* of 36 cm (14 in.), although the majority of oysters experience mortality prior to reaching this size.

More than 95% of the South Carolina oyster populations are intertidal (Bahr & Lanier 1981; Burrell 1986), consisting of 3-dimensional, multi-generational, vertical clusters of oysters. The vertical height of oyster reefs in an otherwise 2-dimensional sedimentary landscape and the interstitial space generated by these clusters are central to the ecosystem services that they support. Historically, both intertidal and subtidal populations of *C. virginica* were distributed widely throughout coastal South Carolina; however, reported landings of subtidal populations of *C. virginica* have seen a steep decline since the mid-1900s. Anecdotal information from SCDNR shellfish managers and commercial growers indicates that certain estuaries still support limited subtidal populations of *C. virginica*. A targeted habitat survey of subtidal oysters in South Carolina, however, has not been undertaken in more than 50 years (Keith and Cochran 1968).

Intertidal *C. virginica* populations (both natural and restored), unlike subtidal populations, form natural breakwaters that protect fringing salt marshes from erosion (*e.g.,* Meyer *et al.,* 1997; Coen & Luckenbach, 2000; Piazza *et al.,* 2005), and support the proliferation of new cordgrass (Spartina alterniflora) habitat (*e.g.,* Kingsley-Smith *et al.,* 2023). South Carolina has more acreage of salt marsh than any other Atlantic Coast state (Newell & Pearson, 2009), and much of it is protected by adjacent intertidal oyster reefs. Many of the species utilizing these habitats take advantage of their close proximity to one another as both nursery and foraging grounds.

CHALLENGES

Salinity affects the distribution of oysters directly through its physiological consequences on the oysters themselves and indirectly through its role in determining the relative incidence of predators (*e.g.,* fish, gastropods, crabs, and polyclad flatworms), pests (*e.g.,* boring sponges, mud worms, pea crabs), competitors (*e.g.,* barnacles, sponges, bryozoans, and other molluscs), and disease-causing protistan parasites, in particular those responsible for the endemic diseases MSX (*Haplosporidium nelsoni*) and Dermo (*Perkinsus marinus*). These challenges to oyster populations generally increase at higher salinities.

Crassostrea virginica has been heavily exploited and widely cultivated throughout much of its geographic range (Galtsoff, 1964; García-Cubas *et al.,* 1987; Quayle & Newkirk, 1989; Andrews, 1991; Menzel, 1991; Nascimento, 1991). Sustainable management of state and public shellfish grounds and Best Management Practice (BMP) approaches to aquaculture, are therefore important for the long-term viability of *C. virginica* populations in South Carolina. Although *C. virginica* in South Carolina has not been as extensively exploited as the *C. virginica* populations in the mid-Atlantic States, the rapid pace of coastal development has created numerous threats to tidal creek habitats with inevitable undesirable impacts (*e.g.,* Lerberg *et al.,* 2000; Holland *et al.,* 2004; Van Dolah *et al.,* 2004). Particularly, these involve increased runoff from upland clearing and associated non-pervious surfaces, contaminants (which are particularly detrimental to larval stages), such as pesticides and heavy metals, (see Capuzzo, 1996 and Roesijadi, 1996, respectively, for reviews), water quality closures resulting in concentrated harvest pressure on open, harvestable beds, impacts from dredging and other channel manipulations, and boat-related impacts. Boat wakes and intense harvesting can both easily damage intertidal reefs, and the vegetated marsh habitats protected by these reefs can rapidly erode when the reefs are compromised (*e.g.,* Kennish, 2002). Furthermore, several South Carolina estuaries including Charleston Harbor, Winyah Bay, and Port Royal Sound have been heavily impacted by industrial activities, shipping, chronic pollution, and habitat destruction related to urbanization. These threats to oyster reefs have prompted extensive efforts to protect, restore, and enhance these critical coastal habitats.

CONSERVATION ACCOMPLISHMENTS

Oyster reefs are now broadly recognized as “ecosystem engineers” (see Luckenbach *et al.,* 1999; Gutiérrez *et al.,* 2003; ASMFC, 2007) that form complex habitats utilized by numerous finfish, invertebrates, wading birds, and mammals (Coen *et al.,* 1999; Lehnert & Allen, 2002; ASMFC, 2007; Peterson *et al.,* 2003; Shervette & Gelwick, 2007, 2008). Within the Southeast Region, the South Atlantic Fishery Management Council (SAFMC) has designated estuarine marshes, oyster

reefs, associated estuarine water columns, intertidal flats, and areas of submerged aquatic vegetation (SAV) as essential fish habitat (EFH). In South Carolina, oyster reefs are also considered critical habitats of concern in both the State Conservation Plan and the State Wildlife Action Plan (formerly the CWCP), primarily due to their provision of habitat for a number of species of concern (*e.g.,* Atlantic blue crab, *Callinectes sapidus*; stone crab, *Menippe mercenaria*; southern flounder, *Paralichthys lethostigma*; and the American oystercatcher, *Haematopus palliatus*). Both the ACE Basin National Estuarine Research Reserve (NERR) and the North Inlet-Winyah Bay NERR list oyster reefs as important habitat, and The Nature Conservancy recently completed a biological assessment of the Carolinian Ecoregion that specifically identified oyster reefs as a priority conservation target (DeBlieu *et al.,* 2005).

Oyster reefs provide essential habitat for federally-managed (ASMFC) species such as red drum (*Sciaenops ocellatus*), southern flounder (*Paralichthys lethostigma*), Atlantic croaker (*Micropogonias undulatus*), spot (*Leiostomus xanthurus*), black sea bass (*Centropristis striata*), spotted sea trout (*Cynoscion nebulosus*), Atlantic menhaden (*Brevoortia tyrannus*), members of the snapper-grouper complex (managed by SAFMC), Atlantic blue crab (*Callinectes sapidus*), and penaeid shrimp species (Shervette & Gelwick, 2007, 2008). A number of prey species of the southern founder, *P. lethostigma*, a South Carolina priority species in the SWAP, for example, have been shown to be associated with edge habitats, including oyster reefs (Reagan, 1985). Many of these species depend on the inter-relationships of oyster reefs and adjacent marsh habitats for their survival during various life stages. In turn, these species provide prey for SAFMC-managed species such as Spanish mackerel (*Scomberomorus maculatus*), King mackerel (*Scomberomorus cavalla*), and cobia (*Rachycentron canadum*), as well as NOAA Fisheries-managed highly migratory species (HMS), such as sharks and billfishes.

Numerous species prey directly on oysters, including xanthid crabs, such as the stone crab, *M. mercenaria* and the Atlantic mud crab, *Panopeus herbstii* (Tolley & Volety, 2005), both species of concern in SC. In turn, several finfish species, including the naked goby (*Gobiosoma bosc*) and the striped blenny (*Chasmodes bosquianus*), are known to feed on these xanthid crabs, generating trophic complexity and the potential for the formation of trophic cascades (Grabowski, 2004). Mann & Harding (1998) investigated the trophic interactions among oysters, fishes, and benthic predators on restored oyster reefs and showed that small and intermediate sized fishes such as gobies (*e.g.,* seaboard goby, *Gobiosoma ginsburgi* and *G. bosc*) and blennies (*e.g.,* feather blenny *Hypsoblennius hentz* and *C. bosquianus*), were abundant in Chesapeake Bay oyster reef-dominated ecosystems. The presence of these species on reef structures is thought to attract larger pelagic predatory species such as southern flounder (*P. lethostigma*), striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), weakfish (*Cynoscion regalis*), sheepshead (*Archosargus probatocephalus*), and spotted seatrout (*C. nebulosus*). Other benthic predators, such as the Atlantic blue crab (*C. sapidus*)—another South Carolina priority species for conservation—have also been shown to be strongly associated with *C. virginica* reefs (Mann & Harding, 1998).

Several studies have shown that the 3-dimensional structure of oyster reefs attracts greater numbers of resident and transient nektonic species than sand- or mud-bottom habitats (Posey *et al.,* 1999; Harding & Mann, 2001; Lenihan *et al*., 2001; Plunket & Peyre, 2005; Coen *et al*., 2007; Kingsley-Smith *et al*., 2013). Breitburg (1999) defined 3 groups of nekton associated with

subtidal *C. virginica* reefs in the Chesapeake Bay: (1) reef residents whose primary habitat is the reef; (2) facultative residents generally associated with structured habitats; and (3) transient species which forage on or near the reef but are wide-ranging. Furthermore, a number of oyster reef resident fishes—including *G. bosc*, *C. bosquianus, H. hentz,* the freckled blenny (*Hypsoblennius ionthas*), skilletfish (*Gobiesox strumosus*), oyster toadfish *Opsanus tau,* and Gulf toadfish (*O. beta*) have been shown to be dependent on oysters for reproduction, depositing their eggs on or inside oyster shells (Breitburg, 1999; Coen *et al.,* 1999). In summary, it appears that the diverse range of organisms associated with oyster reefs creates complex food webs that sustain higher trophic levels than surrounding sediment or marsh habitats (Wrast, 2008; Quan *et al*., 2012). Additionally, oyster reefs serve as critical foraging habitat for the American oystercatcher, *Haematopus palliatus* (a Species of Concern of Highest Priority) and other shorebirds such as egrets, herons, sandpipers, plovers, and godwits, all of which are listed in the South Carolina SWAP as species of highest priority. The largest concentration of overwintering *H. palliatus* occurs in South Carolina, utilizing oyster reefs as foraging grounds (Tomkins, 1947; Sprunt & Chamberlain, 1949; Nol *et al.,* 2000). A recent study by Sanders *et al.* (2004) also highlighted the importance of washed shell rakes as roosting sites for *H. palliatus*.

In recognition of the value of oyster reefs as critical habitats, considerable efforts have been made to successfully secure Federal funding in support of research and community-based restoration and enhancement projects utilizing a variety of traditional (bagged and loose oyster shell) and alternative materials (*e.g.,* revitalized abandoned and unwanted crab traps, manufactured wire reefs) to increase the availability of oyster reefs as habitat for a diverse array of associated fauna, including a number of high priority conservation species. Furthermore, as protection for existing *C. virginica* populations, the South Carolina Department of Natural Resources regulates the importation of oysters for placements in its State waters, primarily for mariculture, requiring inspections for the presence of "hitch-hiker species" upon arrival in the State and restricting importation from areas of known diseases (such as Dermo and MSX). Disease testing is required prior to importation, with zero tolerance for the presence of known diseases. Hatchery certification is also available to permit the importation of oyster seed from other states, provided a number of criteria, protocols, and procedures related to water quality and disease are satisfied.

CONSERVATION RECOMMENDATIONS

- Apply both traditional and alternative approaches to oyster reef habitat restoration and enhancement activities, and engage the community in conservation and stewardship through volunteer opportunities.
- Conduct scientifically rigorous monitoring to evaluate the habitat value of oyster reefs to conservation priority species as well as commercially, recreationally, and ecologically-important species of finfish, invertebrates, and birds.
- Regularly update importation policies for cultured oysters to reflect changes in threats to native oysters and to make the best use of all available information and technology.
- Regulate recreational and commercial harvesting of wild oyster populations and mariculture activities in collaboration with SCDHEC in order to ensure sustainable harvesting and to protect human health.

- Monitor the population status of oysters statewide using on-the-ground efforts, aerial surveys and remote sensing techniques, and GIS applications.
- Collaborate with the appropriate agencies and municipalities to improve and implement Best Management Practices in terms of responsible urban planning to minimize and mitigate the effects of terrestrial freshwater inputs on oyster populations.

MEASURES OF SUCCESS

Determining that populations of *C. virginica* in South Carolina are remaining stable through the collection of annual fishery statistics and population monitoring would constitute a measure of success. An absence of human health problems would also be a measure of success in demonstrating the effectiveness of the collaborative resource management implemented by the SCDNR and SCDHEC. Continued monitoring of the fauna associated with natural, restored, and enhanced reef habitats—and in particular demonstrating their value to priority conservation species—would also be a measure of success.

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Estuarine Sensitive Taxa Guild

Contributor (2014): Stacie Crowe (SCDNR). Reviewed (2025) Joseph Cowan.

Amphipod Crustaceans
Ampelisca abdita
Neohaustorius schmitzi
Parahaustorius longimerus
Protohaustorius wigleyi
Rhepoxynius hudsoni
Isopod Crustaceans
Cyathura spp.
Bivalve Mollusks
Tellina spp.
Polychaete Worms
Aphelochaeta sp.
Caulleriella sp.
Mediomastus sp.
Monticellina sp.
Streblospio benedicti
Tharyx acutus
Tubificoides spp.



Estuarine habitat in South Carolina. Photo courtesy of SCDNR.

DESCRIPTION

The members of the Estuarine Sensitive Taxa Guild are benthic macrofauna commonly found in South Carolina estuaries that have been identified as pollution sensitive by a benthic index of biological integrity for assessing habitat quality in estuaries of the southeastern USA (Van Dolah *et al.,* 1999). Benthic macrofauna serve as ecologically important components of the food web by consuming detritus, plankton, and smaller organisms living in the sediments and in turn serve as prey for finfish, shrimp, and crabs. Benthic macrofauna are also relatively sedentary, and many species are sensitive to changes in environmental conditions. As a result, these organisms are important biological indicators of water and sediment quality and are valuable to monitoring programs that assess overall coastal and estuarine health (Hyland *et al.,* 1999; Van Dolah *et al.,* 1999).

Taxonomy and Basic Description

Amphipods are in the taxonomic order Amphipoda of malacostracan crustaceans which have no carapace and generally laterally compressed bodies. Amphipods in the family Ampeliscidae are distributed worldwide. Ampeliscid amphipods are often the dominant amphipod group in fine sediment areas where they live in infaunal tubes that they construct from 'amphipod silk' and sediment (Barnard, 1960, 1969). *Ampelisca* species have four eyes, each with a thickened lens (Ruppert & Fox, 1988). Members of the Ampeliscidae can be difficult to distinguish from one another. The common species in South Carolina estuaries, *Ampelisca abdita*, is characterized by subtle differences from other species in its epimeral plates and uropods.

Neohaustorius schmitzi, Parahaustorius longimerus and *Protohaustorius wigleyi* are burrowing amphipods of the family Haustoriidae. Haustorids are characterized by their white, barrel-shaped body, and the lack of a true rostrum and dactyls on pereopods 3-7.

The amphipod family Phoxocephalidae is a strictly marine group of abundant, free-living benthic amphipods that primarily inhabit soft substrates as burrowers. *Rhepoxinius hudsoni* is a common phoxocephalid amphipod in southeastern U.S. estuaries, differentiated from a similar species, *R. epistomus*, by a spine and the setal patterns of the uropods and epimera (Barnard & Barnard, 1982).

Cyathura spp. are members of the crustacean order Isopoda that are small (1") and often confused with amphipods. Unlike amphipods, isopods are dorsoventrally flattened (depressed) and have no carapace. *Cyathura* species commonly found in South Carolina, namely *C. polita* and *C. burbancki*, are distinguished by whether or not the sixth pleonal segment is fused to the telson.

Species of the genus *Tellina* are members of the bivalve family Tellinidae. Tellin clams are small (usually < 1"), laterally compressed, and usually have a slight twist at the posterior end (Abbott, 1974). Color can vary from iridescent white to pale pastels.

Aphelochaeta, *Caulleriella, Monticellina* and *Tharyx* are all genera belonging to the polychaete family Cirratulidae. Members of this family are cylindrical, elongate (up to 1"), and characterized by cone or wedge-shaped heads that have no antennae. Cirratulid bodies are generally cylindrical, tapering at both ends, and are characterized by a large number of long, simple, thread-like hairs along the body. Some of the "hairs" occur as clusters of tentacles on the head and are grooved to facilitate deposit-feeding. Species in the genus *Mediomastus* are members of the polychaete family Capitellidae. Capitellid worms are red or purple in color with thread-like, flexible bodies that grow up to 4" in length. They are characterized by their conical shaped head and reduced appendages.



The polychaete worm, *Streblospio benedicti*. Photo courtesy of Southeastern Regional Taxonomic Center (SERTC).

Streblospio benedicti is a member of the tube-dwelling polychaete family Spionidae. Spionids, or palp worms, are characterized by their small heads and two long grooved palps used for deposit or suspension feeding. Spionids are mostly small (<6"), but large species do exist.

Tubficoides wasselli and other *Tubificoides* species are worms in the class Oligochaeta. Oligochaete worms are distinguished from polychaete worms by their lack of parapodia and a reduced prostomium (head) which lacks appendages. Marine oligochaetes resemble earthworms in appearance although they are much smaller (~1", Ruppert & Fox, 1988).

Status

None of the species in this guild are officially recognized as threatened or endangered, but all are part of the benthic macrofaunal community in southeastern U.S. estuarine habitats. The benthic macrofaunal community serves as an important source of food for juvenile finfish such as spot (*Leiostomus xanthurus*) and weakfish (*Cynosion regalis*) and is also used as an early indicator of degraded habitats.

POPULATION SIZE AND DISTRIBUTION

The ampeliscid amphipod, *A. abdita*, is found in fine or silty sand in the protected waters of estuaries and bays from central Maine to the Indian River Lagoon system in Florida (Bousfield, 1973; LeCroy, 2000). Population size estimates are difficult to establish due to spatial and seasonal variation; however, the South Carolina Estuarine and Coastal Assessment Program (SCECAP) has recorded abundances as high as 25,000 individuals per m^2 in estuarine areas (Bergquist *et al.,* 2009, 2011; Van Dolah *et al.,* 2002a, 2004, 2006, 2013).

Haustorid amphipods are very abundant along the intertidal gradient of the US East Coast (Bliss *et al.,* 1983). The haustorid amphipods in this guild range from Saco Bay, ME through Cape Canaveral, FL (Bousfield, 1973; Grant & Lazo-Wasem, 1982). Although the distribution of this group is well documented, population size can vary considerably by location and season and would be difficult to quantify.

The phoxocephalid amphipod, *R. hudsoni*, is found burrowed in sandy areas from Maine to South Carolina at depths from 4 to 161 m. Abundances recorded from the SCECAP program range from 22-9,150 individuals per m^2 (Bergquist *et al.,* 2009, 2011; Van Dolah *et al.,* 2002a, 2004, 2006, 2013).

Isopods in the genus *Cyathura* range from Maine to Florida in the Eastern US. Abundances recorded from the SCECAP program range from 22-1,089 individuals per m^2 (Bergquist *et al.,* 2009, 2011; Van Dolah *et al.,* 2002a, 2004, 2006, 2013).

Members of the family Tellinidae, especially the genus *Tellina*, are very common on the South Carolina coast (Ruppert & Fox, 1988). Due to the numerous species within this genus, population size is difficult to estimate. Most of the species commonly found in the southeastern U.S. range from the Mid-Atlantic (Virginia/North Carolina) to Florida (Abbott, 1974).

Cirratulids in the genera *Aphelochaeta*, *Caulleriella, Monticellina* and *Tharyx* are found worldwide, and most species range from the Gulf of Maine through Florida on the East Coast of the US. Little information has been reported on population estimates of cirratulids; however, a benthic invertebrate survey in New York reported *T. acutus* abundances of 80 individuals m^{-2} (USACE, 2004).

Mediomastus sp. are very abundant on the East Coast of the US. Identifications to species level in the genus *Mediomastus* are often difficult due to the collection of incomplete worms, but there are several species that occur in high abundances on the U.S. Atlantic Coast.

The spionid polychaete, *Streblospio benedicti* occurs along the Atlantic US coast from Maine south to Florida. Studies on *S. benedicti* abundance on the East Coast have reported the species to be among the most abundant and characteristic taxa occurring in Gulf of Maine mud flats (Larsen & Dogget, 1991) and among four taxa dominating North Carolina saltmarsh macrofauna (Cammen, 1979). In South Carolina, *S. benedicti* is one of the most abundant invertebrates found in estuarine samples with abundances ranging from 25 to ~14,000 individuals per m^2 (Bergquist *et al.,* 2009, 2011; Van Dolah *et al.,* 2002a, 2004, 2006, 2013).

Members of the family Tubificidae (*T. wasselli*, *Tubificoides* sp.) found in the southeastern U.S. appear to be specific to the zoogeographic region from Cape Hatteras to Florida (Baker, 1984). SCECAP abundances from 1999-2010 range from 22 to 14,589 individuals per m^2 (Bergquist *et al.,* 2009, 2011; Van Dolah *et al.,* 2002a, 2004, 2006, 2013).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Members of the estuarine sensitive taxa guild are benthic macrofauna that live in estuarine habitats in South Carolina's Coastal Zone. The sheltered waters of estuaries provide habitat for many organisms that are specially adapted for life in a range of salinities. The macrofauna in this guild are found in the many types of habitats in and around estuaries, including shallow open waters, salt marshes, swamps, sandy beaches, mud and sand flats, rocky shores, and oyster reefs.

Ampeliscid amphipods are infaunal organisms that live in protected sand flats. They prefer muddy or sandy bottoms where they build lined tubes embedded with sediment grains. The tubes protrude above the surface of the sediment where the amphipods use water currents or their appendages for filter feeding.

Haustorid amphipods are free-swimming amphipods which are adapted for burrowing in sandy or silty substrate. They prefer a variety of intertidal areas including exposed and protected beaches, inlet entrances, and estuaries with fine sand or mud. They can be found from mean low water to a depth of 50 m, in salinities from 6 ppt to fully marine, depending on the species (Bousfield, 1973).

Phoxocephalids, such as *R. hudsoni*, are free-living benthic amphipods that primarily inhabit soft substrates as burrowers. They are omnivorous, detritivores, and opportunistic predators found in all oceans and at all depths.

Cyathura species of isopods burrow in mud and muddy sand and have a high tolerance for changes in physical factors such as salinity that occur commonly in shallow water estuarine habitats (Schultz, 1969).

Tellinid clams are mud or sand dwellers with a worldwide distribution. The tellinids are active infaunal burrowers in soft sediments, usually in the silty sand of protected beaches (Ruppert & Fox, 1988). Unlike other bivalves, tellinids are deposit feeders who burrow horizontally through the sediment to seek fresh deposits of particulate organic material.

Capitellid worms, such as *Mediomastus* sp., are sedentary deposit feeders that often occur in mud or muddy sand on the lower shore to sublittoral zone. They may be found under pebbles or small stones, with the burrows at or near the surface of the sediment where they feed on deposited organic material (Ruppert & Fox, 1988).

Members of the polychaete family Cirratulidae (*Aphelochaeta* sp., *Caulleriella* sp., *Monticellina* sp., *Tharyx acutus*) are sluggish-type worms that inhabit medium to fine sand or muddy sediments. Cirratulids mostly burrow in soft sediments, but some live in rock crevices. They can be found buried just below the surface of the sediment with only their feeding appendages exposed.

Streblospio benedicti prefers soft sediments in which it can form a mucoid tube just below the sediment-water interface that allows it to deposit feed. *Streblospio benedicti* is relatively tolerant of elevated levels of sediment organics (Reish, 1979), a trait that contributes to its success as an opportunistic species.

Tubificoides wasselli and other *Tubificoides* species are common in estuarine habitats in South Carolina, especially those habitats with a high organic content (Ruppert & Fox, 1988).

CHALLENGES

South Carolina's Coastal Zone includes a variety of sensitive habitats that serve as critical nursery grounds for most of the State's commercial and recreational fisheries resources. Rapid population growth and development along South Carolina's coastline threaten the vitality of our state's natural marine resources. In addition to their natural beauty and ecosystem functions, these resources support recreational and commercial fishing industries worth hundreds of millions of dollars and tourism that brings billions of dollars to the State annually. As with most coastal states, population growth in the coastal counties has been rapidly increasing in recent years, a trend that is expected to continue. The ongoing urbanization of our coast, combined with increased recreational utilization of our coastal waters, will result in an escalating potential for serious impacts on South Carolina's estuarine and coastal habitats.

CONSERVATION ACCOMPLISHMENTS

In South Carolina, the SCECAP program was established in 1999 to begin evaluating the overall health of the State's estuarine habitats. SCECAP represents an expansion of ongoing monitoring programs being conducted by both state and federal agencies and ranks among the first in the country to apply a comprehensive, ecosystem-based assessment approach for evaluating coastal habitat condition.

CONSERVATION RECOMMENDATIONS

Effective habitat management requires monitoring on a periodic basis to evaluate coastal habitat condition. SCECAP's goal is to monitor the conditions of the State's estuarine habitats and provide periodic reports to both coastal managers and the general public. The program monitors a suite of water quality, sediment quality, and biological condition parameters at a large number

of sites throughout the State's Coastal Zone each year and integrates these measurements into an overall assessment of estuarine habitat condition at individual sites and statewide. The program also expands historical monitoring activities that have primarily focused on open water habitats (*e.g.,* bays, sounds, tidal rivers) to include an assessment of environmental conditions in tidal creeks, which serve as important nursery habitats for most of the State's economically valuable species. Many of these tidal creeks are also the first point of entry for upland runoff and therefore provide an early indication of stress related to coastal development, agriculture, and industrial activities (Holland *et al.,* 1997; Sanger *et al.,* 1999a,b; Lerberg *et al.,* 2000; Van Dolah *et al.,* 2000b).

MEASURES OF SUCCESS

The members of this guild inhabit the estuarine areas of South Carolina's extensive Coastal Zone and are thereby directly affected by increased utilization of that area. Measures of success for this guild will directly correlate with continued efforts to protect our coastal habitats from degradation.

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Fiddler Crabs Guild

Mud Fiddler Crab, *Minuca pugnax* (Smith, 1870)
Atlantic Sand Fiddler Crab, *Leptuca pugilator* (Bosc, 1801)
Red-jointed Fiddler Crab, *Minuca minax* (Le Conte, 1855)

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DESCRIPTION

Taxonomy and Basic Description

Fiddler crabs are true crabs in the infraorder Brachyura. The Brachyura are the most advanced of the decapods. The crab body is generally short, wide, and flat, and is characterized by a reduced abdomen that lacks a tail fan and is flexed under the body. In all but a few small groups, all 5 pairs of walking legs are large and the first pair is always claws. The majority of brachyuran species pass through a number of planktonic larval stages, with the megalopal stage being the last larval stage before settlement to the crab form. The megalopa stage resembles the adult; however, the abdomen has yet to fold under the body. Fiddler crabs are in the family Ocypodidae that is characterized by eyes that are set close together at the end of long eye stalks.



Fiddler crabs are easily recognized by their square body and a marked difference in size between the right and left claws of males. As the male grows to maturity, the relative weight of its cheliped, or large claw, changes from approximately 2% to 65% of its total body weight. In most fiddler crab species, males can have either an enlarged left or right, with a typical handedness ratio of close to 50:50 in the population. In all fiddler crab species, fights between males of the same handedness are very different to those between opposite handed males. When facing each other, males with different handedness have their claws lined up on the same side, while males with the same handedness have their claws lined up on the opposite side. It may be easier for males of different handedness to judge each other's size, but it may be easier to interlock claws when their claws line up on the same side.

Mud fiddler crabs, *Minuca pugnax,* have an H-shaped depression in the middle of the carapace and their eyestalks are long and thin. They are brown in color, with the front of the shell and eyestalks ranging from blue to turquoise. The large claw of the male is usually yellowish-orange to yellowish-white, and its walking legs are dark and banded. The propodus of the large claw in males has an oblique ridge of small granules on the inner surface that extends from the lower margin to the junction with the dactyl (Williams, 1984; Crane, 1975).

The carapace of the sand fiddler crab, *Leptuca pugilator,* is typically a pinkish-purple color, with a bright patch of purple in the center of the carapace. The legs range in color from orange to brown. The inner surface of the large claw in males lacks the row of tubercles which can be used to distinguish sand fiddler crabs from other *Uca* species.


Sand Fiddler Crab

Red-jointed fiddler crabs (*Minuca minax)* are larger than the other two species. The joints of the large claws in males are red and possess a row of tubercles. The merus (fourth segment) of the second walking leg lacks dense pubescence (soft down or short hairs) on the ventral margin.


Red-jointed Fiddler

http://animaldiversity.ummz.umich.edu/site/accounts/information/Uca_minax.htm

Status

Although fiddler crabs have no directly quantifiable commercial value, they do occupy an important role in the ecology of salt marshes and are a good environmental indicator as they are sensitive to environmental contaminates, especially insecticides. Their population densities are an example of the high productivity of coastal marshes. Their burrowing activity can erode or undermine marsh banks and can affect the aeration of sediments, which increases the growth of marsh grasses. These activities stimulate the turnover and mineralization of important nutrients. Fiddler crabs are also important regulators of cordgrass-derived production and decomposition. Fiddler crabs are often used as fishing bait, especially for sheepshead (*Archosargus probatocephalus*) and black drum (*Pogonias cromis*) and are an important food source for many other estuarine species, such as blue crabs, clapper rails and other marsh birds (Grimes *et al*., 1989).

POPULATION SIZE AND DISTRIBUTION

Mud fiddler crabs range from Massachusetts to Florida and are common in marshes along the Southeastern coast. The sand fiddler crab occurs along the Atlantic and Gulf Coasts from Massachusetts to western Florida. Red-jointed fiddler crabs are found along the East and Gulf Coasts of the United States from Cape Cod to Texas. South Carolina is well within the natural range of all 3 species, and they can be found throughout the State's Coastal Zone (Ruppert & Fox, 1988).

Fiddler crabs are extremely abundant in South Carolina; however, assessments of fiddler crab populations are scarce. It would be extremely challenging to count these small creatures directly, in part due to their high mobility, and therefore surrogate measures of fiddler crab density can be made from counting burrows. Fiddler crab burrow density was measured along a transect from

the forest to the creek bank in North Inlet, SC. Burrow density ranged between 40 and 300 burrows m^{-2} with highest densities at the creek bank (McCraith *et al.,* 2003). Standing stock of the mud fiddler crab at North Inlet, SC was estimated at 29 g m^{-2} dry weight (Krebs *et al.,* 1974). In Georgia, the density of fiddler crab populations was reported as 27 crabs per m^2 (Teal, 1958).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Fiddler crabs are one of the most conspicuous inhabitants of the marsh surface and intertidal zone. They can often be seen foraging in large groups along creek banks at low tide.

Mud Fiddler Crab

The mud fiddler crab prefers a muddy marsh environment where the substrate is relatively free of heavy plant roots, yet stable enough to allow for the construction of its burrows, which can be up to 60 cm deep.

Male fiddler crabs wave their oversized claw up and down to attract the attention of females for mating and to intimidate potential male competitors. They also stomp their walking legs and make noises with them in an effort to attract mates. Such displays reach a peak during spring tides, and mating occurs thereafter inside the males' burrows. The females remain inside their burrows during the two-week incubation period and come out to release their eggs, which are swept out to sea by neap tides (*i.e.,* especially weak tides that occur during quarter moons).

After hatching, larvae go through several developmental stages (5 zoeae and a megalopal or first post-larval stage) over the two-week period that they are adrift in the ocean. Larvae are then transported back inside estuaries on the subsequent spring tide. Larvae are predatory and feed on zooplankton in the water column. They remain pelagic for some time after reaching the megalopal stage, gradually adopting a benthic existence.

Adult fiddler crabs feed on organic material extracted from mud, which is rolled into small balls after the food is removed and deposited back onto the substrate. They appear different from pellets formed during burrow excavation; excavated pellets are much larger than feeding pellets. Mud fiddlers are adept at regulating their metabolism over a wide range of temperatures, which may explain their widespread abundance.

Sand Fiddler Crab

The sand fiddler is an abundant species on sandy and muddy intertidal areas near salt marshes and banks of tidal creeks. Burrows are constructed along the edges of marshes; however, the sand fiddler crab may occur on the marsh surface when the substrate contains more sand than mud. Sand and mud fiddler crab populations may intermingle, and large populations can be seen feeding in the intertidal areas bordering marshes along tidal creeks in the southeastern United States. The sand fiddler crab burrow is unbranched and dug at an angle to the surface. The biology of the sand fiddler crab is similar to that already described for the mud fiddler crab above. Sand fiddler crabs have specialized spoon-shaped bristles on their maxillipeds (appendages used in feeding) that enable the crab to remove algae and other organic matter from

sandy sediments. Once the sediment has been “cleaned” by the fiddler crab, the mouthparts shape the inorganic matter into balls that are deposited around the openings of burrows (Williams, 1984; Heard, 1982).

Red-jointed Fiddler Crab

The red-jointed fiddler crab occurs in low salinity and freshwater tidal marshes. It is generally found on mud and sandy substrates with high organic content. This species can withstand low oxygen conditions. Red-jointed fiddler crabs may move near terrestrial areas away from the intertidal zone of marshes. Feeding habits and biology are similar to other fiddler crabs occurring in the Southeastern United States.

CHALLENGES

Contaminants, such as polychlorinated biphenyls (PCBs) and insecticide/fertilizer mixtures, will adversely affect the health of fiddler crab populations (Krebs *et al.*, 1974). Fiddler crabs apparently concentrate these toxins from seawater or food. Fiddler crabs accumulate PCBs from contaminated sediments and detritus and can transfer them to aquatic, avian, and terrestrial food webs when preyed upon by fishes, birds, and small mammals. When the insecticide, Dieldrin, is concentrated in crab tissues, it impairs locomotion, eventually killing crabs at higher concentrations (Krebs *et al*., 1974). Chemical contaminants can drastically reduce populations of fiddler crabs in the marsh (Krebs *et al*., 1974). Fiddler crabs have also been found to be sensitive to mercury (DeCoursey & Vernberg, 1972) and cadmium (O'Hara, 1973). Heavy metals such as mercury, copper, and zinc are toxic to fiddler-crab larvae, causing a significant delay in larval development as well as deformities.

Spraying marsh habitats with pesticides for mosquito control can also cause a significant decrease in the natural fiddler crab populations downwind of the pesticide application area (Rookery Bay NERR, 1996). Studies in Florida have shown that the mortality of fiddler crabs can be markedly reduced when high-pressure nozzles are used in combination with the mosquito adulticide, Dibrom. Methods that reduce the size of the pesticide droplets not only improve the effectiveness of a pesticide to kill mosquitoes but also significantly reduce the amount of pesticide needed (Rookery Bay NERR, 1996).

Nonpoint source runoff from residential areas, roads, and golf courses can have negative impacts on marsh creek ecosystems by impacting water quality. Any one discharge may involve only small amounts of chemicals that are diluted by the receiving streams, but when combined with other chemicals from multiple other discharges, significant concentrations of pollutants may result. Pollution may disrupt the food web in the salt marsh by killing off certain species and prompting others to greatly increase in abundance.

CONSERVATION ACCOMPLISHMENTS

Non-point source pollution is difficult to control. A remedy to the problem that has been adopted in many communities in South Carolina is the maintenance of buffer zones and retention ponds

(George *et al*., 2001). Studies have shown that fiddler crab populations respond in a positive way when wetlands are restored and good water quality is maintained (Knott et al. 1997).

CONSERVATION RECOMMENDATIONS

- Assess burrow density before and after impacts to marsh habitat to evaluate its recovery.
- Evaluate the effects of mosquito control on fiddler crab populations in South Carolina.
- Conduct studies to investigate the use of high-pressure nozzles in combination with the mosquito adulticide, Dibrom, to determine the effectiveness of this method in reducing the mortality of fiddler crabs.
- Encourage the continued use of Best Management Practices (BMPs) to reduce nonpoint source pollution runoff.

MEASURES OF SUCCESS

By evaluating the effect of mosquito adulticides and application technology on fiddler crab populations, South Carolina Department of Natural Resources (SCDNR) would be able to recommend changes in application techniques to the South Carolina Department of Health and Environmental Control (SCDHEC), resulting in more stable fiddler crab populations. In addition, by monitoring population trends in fiddler crabs, SCDNR will be better able to assess the health of and protect marsh habitat for all fish and wildlife species.

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Florida Stone Crab, *Menippe mercenaria*


Photo: Southeastern Regional Taxonomic Center

Contributors: Elizabeth Wenner (SCDNR, 2005); Peter Kingsley-Smith (SCDNR, 2013, 2023), Daniel Sasson (SCDNR, 2023)

DESCRIPTION

Taxonomy and Basic Description

There are two species of stone crab in the southeastern United States, namely the Florida stone crab, *Mercenaria mercenaria* and the Gulf stone crab, *M. adina*. While an active hybridization zone was long thought to occur in the eastern Gulf of Mexico and into parts of the South Carolina coast (*e.g.,* Bert & Harrison, 1988), recent genetic evidence suggests that hybridization of the two species has not occurred for thousands of years (Seyoum et al., 2021). This work also suggests that a strong barrier to gene flow between the two species occurs in Apalachicola Bay, Florida and thus that all the stone crabs found on the Atlantic Coast of the U.S. are of one species, *M. mercenaria* (Seyoum et al. 2021).

The Florida stone crab, *M. mercenaria* Say, 1818 is a true crab in the family Xanthidae. The xanthid family of crabs is commonly called the mud crabs. This is a highly diverse family whose members are characterized by having a body that is transversely oval or hexagonal, with a broad front, without a rostrum, and notched centrally. The last pair of legs is unmodified (Williams, 1984). The carapace of the stone crab is nearly smooth to the unaided eye.

The lateral margins of the carapace are divided into 4 lobes. The pincers are large and heavy, unequal in size and nearly smooth. The inside of the palm has a patch of fine, oblique and parallel striations. The walking legs are stout and hairy towards the ends (Williams, 1984). The claws of the stone crab are asymmetrical; there is a major or crusher claw and a minor or pincer claw. Only the claws of stone crab are harvested and a legal-size claw has a propodus base measurement of > 70 mm. In South Carolina, only the larger of the two claws may be taken.

The color of juveniles is generally dark purplish-blue, often with a white spot occurring on the inner carpus. Juveniles also exhibit three prominent white spots in the form of an inverted triangle on the carapace. Older individuals vary in color from brown to green on the anterior half of the carapace, with tan to cream coloration on the posterior half. The carapace is mottled with darker blotches. The fingers are dark and the walking legs are either entirely purple or brown, or with partial dark and light coloration (Caldwell, 1986).

Status

The stone crab is not a state or federally listed species; however, they are dependent upon coastal nursery grounds and thus may be a potential indicator species of the health of estuarine habitat. In addition, stone crab claws are harvested in South Carolina; it is not clear what impacts that activity may be having on the population.

POPULATION SIZE AND DISTRIBUTION

Stone crabs are found from North Carolina south, around peninsular Florida, to the Yucatan Peninsula and Belize, and throughout the Bahamas and Greater Antilles (FL FWC, 2003). In South Carolina, the stone crab is a conspicuous inhabitant of estuaries and inlets. They occur along the coast in high salinity areas, bays, sounds and along jetties (Wenner & Stokes, 1984). No long-term surveys exist to determine the population size of the stone crab in South Carolina or trends in its abundance. Adequate information to determine population abundance and health is not available.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Across its geographic range, stone crabs inhabit jetties, dead shell, mud and grass flats, and oyster reefs (Williams, 1984). Stone crabs occur in areas characterized by high salinities and live oyster beds. Although stone crabs may dwell on a variety of bottom types throughout their geographic range, the shell substrate of oyster reefs provides reinforcement for the creation of stable burrows, as well as protection from predators. Adult stone crabs live in burrows below the low tide mark around oyster bars and mud flats. The burrows provide protection for molting crabs and those females incubating eggs (Williams, 1984).

In South Carolina, the Eastern oyster, *Crassostrea virginica* is the principle food of the stone crab, which uses its major cheliped to crush the shell. Thus, stone crabs in South Carolina are generally found in proximity to intertidal oyster beds. Stone crabs may also eat other bivalves and crustaceans such as blue crab. Wenner & Stokes (1984) found that stone crabs were most abundant in areas immediately adjacent to the ocean and inlet areas with steep banks; fast current speeds yielded more stone crabs than did creek sites that had a gradual slope and slower current.

Few studies on the life history of the stone crab have been conducted in South Carolina. Egg bearing females occur from May to October with a peak from May to August. Females with mature ovaries occur during spring and summer. Juvenile stone crabs occurred throughout the year (Caldwell, 1986). Mating is similar to that of other crabs in that the male protects the female while copulation occurs. Individual females have been reported to spawn several times during a year (Porter, 1960). Once the eggs are extruded, larvae hatch as a larval form called zoea and develop through 5 zoeal stages, followed by a single more advanced larval stage called a megalopa before metamorphosis into the first crab stage. Juvenile crabs occur on shell bottom and consume a variety of foods including polychaete worms, small bivalves, oyster drills and occasionally other stone crabs (Bender, 1971). Crabs mature at around 2 years of age.

CHALLENGES

Stone crabs can be affected by water pollution. Urban contaminants such as heavy metals, polychlorinated biphenyls (PCBs), hydrocarbons, pesticides, and herbicides entering coastal waters via runoff from farmlands and suburban yards could negatively affect stone crab populations. Stone crab productivity is considered to be dependent on the maintenance of coastal nursery grounds, especially oyster reefs. Disease and pollution that affect oyster reefs could indirectly have a negative impact on stone crab populations. C. M. Bearden observed thousands

of dead stone crabs washing ashore on beaches just north of Charleston Harbor in the late 1960s, presumably because of a mass die off caused by disease (D. Whitaker, SCDNR, pers. comm., 2005).

Stone crab claws are harvested in South Carolina; however, there is no directed fishery for stone crabs (the major fishery for the stone crab is located in Florida). Stone crab claws are generally taken incidentally to the blue crab fishery in South Carolina, although there may be some individuals who directly target stone crab. Approximately 18,000 lbs of stone crab claws are landed annually in South Carolina. The stone crab fishery depends on the ability of crabs to regenerate a lost limb. This unique fishery lands only the large, meaty claw of these crabs. One claw is removed from each trapped crab and the animal is released alive. If carefully treated, adult stone crabs can regenerate their claws several times. Most of the stone crabs sampled in South Carolina had at least one legally harvestable claw. Of those captured with both claws, most possessed unregenerated claws (Wenner & Stokes, 1984). Estimates of the proportion of the harvest composed of claws regenerated after natural claw loss is around 10% for South Carolina. Survival depends partly upon the skill of the fisherman, who must separate the claw from the crab's body at the proper joint. If the joint is pierced or snapped quickly enough, the crabs own defense reflex contracts its muscles and sheds the claw cleanly. If a crab is de-clawed incorrectly (if, for example, part of the body is taken with the claw), the crab may bleed excessively or may be unable to regenerate a new claw, which significantly increases the likelihood that the crab will die (Wenner & Stokes, 1984, Duermit *et al.,* 2015); however, claw removal has been found to impact the ability of stone crabs to forage in that stone crabs with one claw removed ate fewer bivalves than stone crabs with both claws intact and stone crabs with both claws removed switched to a primarily fish based diet (Duermit *et al.,* 2015). Declawed stone crabs also exhibit reduced movement and likely higher rates of mortality than crabs without removed claws (Duermit *et al.,* 2017). Since molting and thus claw regeneration is a slow process in larger stone crabs, claw removal likely has long term consequences (Duermit *et al.,* 2015).

Landings of stone crab claws in South Carolina may increase because of added interest and awareness of the potential for a fishery. It is unlikely, however, that South Carolina stone crab populations could withstand the level of fishing effort found in the Florida fishery. Until data are available on effort and yield of claws from crabbing operations in South Carolina, it will not be possible to properly assess the impact of fishing on existing stocks of stone crab. In other parts of its range, scientists and fishers believe that the population is heavily fished, although landings have remained stable (FL FWC, 2003).

CONSERVATION ACCOMPLISHMENTS

At present, the minimum legal size of a harvestable claw is 70 mm, which allows most females to mature and reproduce in at least one season prior to attaining legal size. Although a declawed female can bear eggs and contribute to the spawning stock, mortality can result from incorrect claw removal or because the female is unable to adequately feed or protect herself. Although not yet studied in stone crabs, claw regeneration has been shown to impact female fecundity in other crabs (*e.g.,* Norman & Jones 1993). Protection of egg bearing females is a conservative measure that may be beneficial to the resource. Stone crabs have relatively high fecundity. A single

female may produce 4 to 6 egg masses or "sponges" during a single mating season with an average of 4.5 spawning events per molt (USFWS, 1984). Each egg sponge may contain between 160,000 and 1,000,000 eggs.

Declawing crabs immediately upon their capture is also a legal stipulation that represents a good conservation measure. If crabs are held for long periods before declawing, they are subjected to air exposure and desiccation.

The South Carolina Department of Natural Resources' Marine Resources Division, through both its research and fisheries management sections, is actively involved in the restoration of oyster habitat by planting shell and/or deploying suitable reef-building substrate in coastal waters, which provides a foundation for settlement of oyster larvae. Over time, these new reefs will collect oysters through natural larval settlement. Eventually, these areas should develop into natural oyster habitat. Maintenance, enhancement, and restoration of oyster reefs secondarily provide excellent habitat that benefits the stone crab and other marine species that use such habitat.

CONSERVATION RECOMMENDATIONS

- Determine the impact of stone crab bycatch in the blue crab fishery on reproductivity and survivorship of stone crab.
- Monitor stone crab populations in order to determine population status.
- Explore the impacts of declawing on reproductive output of female stone crabs.
- Educate fishers about the proper method to remove a stone crab claw to achieve higher survivorship following claw harvest.
- Continue SCDNR oyster habitat restoration and enhancement projects to ensure that essential habitat for stone crab populations is maintained in South Carolina waters.
- Work with municipalities to include Best Management Practices (BMPs) in development plans throughout the Coastal Zone. Such plans should include installation of retention ponds, modified septic systems, and stream bank protection measures.

MEASURES OF SUCCESS

In the event that municipalities implement BMPs along coastal waterways, improved water quality in marine ecosystems should result. In turn, the improved water quality will benefit many sensitive marine species, including the stone crab. Continuation of the oyster bed restoration project will provide habitat for the stone crab, which will result in stable to increasing population trends.

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Four-Handed Box Jellyfish

Chiropsalmus quadrumanus F. Muller, 1859



Contributor: Daniel Sasson (SCDNR, 2024)

DESCRIPTION

Taxonomy and basic description:

Chiropsalmus quadrumanus F. Muller, 1859 (Phylum: Cnidaria, Class: Cubozoa, Order: Chirodropida, Family: Chiropsalmidae) is a box jellyfish named for its four appendages hanging below the four corners of its gelatinous bell. From these appendages hang bundles of tentacles which *C. quadrumanus* uses to capture its prey. Their tentacles can be up to four meters in length and have a powerful sting, which, in rare cases or young children, can result in death (Bengston *et al.,* 1991).

Reproduction is believed to occur externally and histological evidence suggests that *C. quadrumanu*s is iteroparous (García-Rodríguez *et al.,* 2023). Sexual maturity likely occurs quickly as oocytes have been found in medusae of all sizes (Garcia-Rodriguez *et al.,* 2023).

In Brazil, the diet of *C. quadrumanus* consists primarily of crustaceans, although other prey items such as fish eggs were occasionally consumed (Nogueira Júnior & Haddad, 2008). To date, no such similar studiees of prey items of *C. quadrumanus* have been conducted in the Northern Hemisphere.

While *C. quadrumanus* is currently considered one species across its entire range, phenotypic comparisons of specimens from the Atlantic Coast of the United States and specimens from Brazil have led some researchers to suggest these may be multiple species (Gershwin, 2006).

Status

Chiropsalmus quadrumanus is not currently included in federal lists of threatened or endangered species and there is no present-day direct human exploitation of this species in South Carolina. No targeted population assessments are conducted on this species, despite its potential ecological significance as a predator. Relatively little is known about the presence or ecological impacts of *C. quadrumanus* in South Carolina.

POPULATION DISTRIBUTION AND SIZE

Chiropsalmus quadrumanus is distributed throughout the Eastern Atlantic Coast, ranging from Brazil to the Carolinas, in the Gulf of Mexico, and in the Caribbean. It has occasionally been observed in the Pacific Ocean as well, with reports from Hawaii and Australia; however, there is some question whether there is only one species across its range (see ‘Description’ section

above). It can be found both offshore in open waters and inshore, with occasional reports of large numbers washing ashore.

HABITAT / NATURAL COMMUNITY REQUIREMENTS

Little is known about the environmental conditions necessary for *C. quadrumanus*. Experimental work in other box jellyfish have found that salinities above 20 ppt are required (Mooney & Kingsford, 2016), but it is unclear whether that applies to all Cubazoa. As in some other Cnidaria, it may be that Cubazoa may be especially sensitive to environmental conditions when in the polyp stage (e.*g.,* Kingsford & Mooney 2014; Goldstein *et al.,* 2017).

CHALLENGES

Chiropsalmus quadrumanus is not used for any commercial purpose.

CONSERVATION ACCOMPLISHMENTS

Cubazoa in general have received little to no attention in terms of conservation efforts, likely due to a lack of demographic information. The species is currently not listed as either threatened or endangered at either the state or Federal level, which also explains the lack of targeted conservation efforts.

CONSERVATION RECOMMENDATIONS

Little is known about the abundance and ecological impacts of *Chiropsalmus quadrumanus* in South Carolina waters. It is also unclear whether *Chiropsalmus quadrumanus* consists of one species throughout its range.

MEASUREMENT OF SUCCESS

A better understanding of the ecology, distribution, and taxonomic classification of *Chiropsalmus quadrumanus* in South Carolina would improve our ability to recognize changes in abundance patterns that might result from shifts in environmental conditions.

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Grass Shrimps Guild

Daggerblade Grass Shrimp, *Palaemon pugio* (Holthuis, 1949)
Marsh Grass Shrimp, *P. vulgaris* Say, 1818
Brackish Grass Shrimp, *P. mundusnovus* (De Grave & Ashelby, 2013)

Contributors: Loren Coen (SCDNR, 2005, retired), Elizabeth Wenner (2005, SCDNR, retired) & Peter Kingsley-Smith (SCDNR, 2013 & 2023)

DESCRIPTION

Taxonomy and Basic Description



These small decapod shrimp are collectively known as ‘carideans.’ Common names include grass shrimp, jumpers, glass shrimp, popcorn shrimp, glass prawns, and hardbacks.

Grass shrimp have a well-developed 'horn' or ‘rostrum’ (hence the name of one of the species, daggerblade) with teeth along the dorsal and or ventral surfaces. The presence and position of these and other nearby teeth are used to separate out the species in the genus. Important distinguishing characteristics are a lack of claws on the third pair of walking legs and their diminutive size. They are rarely larger than 5 cm; this differentiates them from commercial shrimp. Because of their morphological similarities and the need of a dissecting scope to view key characteristics, the species are often misidentified. Grass shrimp are nearly transparent. Males can be separated from females by the presence of the ‘appendix masculina’ attached to the ‘appendix interna’ of the endopod of the second pair of pleopods. Also, the endopod of the first pleopod is larger in males versus females. A significant positive correlation between female length and egg number has been also observed as it has in many decapod crustaceans (Hines, 1982; Anger *et al*., 2002).

Spawning occurs from February through October, although this may vary with location. More than one brood may be produced during the spawning season. During mating, which occurs within 7 hours of molting, the male transfers a spermatophore to the female. The eggs are fertilized externally as they are extruded. The female attaches the eggs to her pleopods, where they remain until hatching 12 to 60 days after they are fertilized. Ovigerous females—those carrying eggs—are easy to recognize because the eggs are visible through the carapace. Egg incubation varies among species and is shorter in the southeastern United States. Females molt again after spawning, thereby producing a second brood. Grass shrimp larvae undergo a series of developmental stages: 10 zoeae and a postlarva. Juvenile grass shrimp mature when they are perhaps 1.5 to 2 months old or about 15 to 18 mm long; they live from 6 to 13 months. Older, overwintering individuals usually spawn early in the year and die by the following winter. Most young-of-the-year spawn late in the fall as adults. Post-larvae that survive fall and winter spawn the following spring. Since some grass shrimp populations reproduce two broods each year,

length-frequency distributions may be polymodal (two or more peaks), with growth rates difficult to characterize. Growth rates vary somewhat between species, sexes, habitats, and times of the year. In colder coastal waters, growth patterns are different with salinity also affecting growth (Anderson, 1985).

Grass shrimp eat a wide variety of foods but are considered by many to be primarily detritivores. Nevertheless, they can be quite carnivorous in captivity, where they are often also cannibalistic (E. Wenner, pers. obs.). Grass shrimp are also predators of meiofauna and small infaunal polychaetes, oligochaetes, and nematodes (Bell & Coull, 1978; Smith & Coull, 1987; Gregg & Fleeger, 1998).

Status

Grass shrimp are not state or federally listed; however, they are an important species from an ecological perspective because they serve as a link for energy transfer between trophic levels in the coastal food web. Their feeding on the epiphytic algae that occur on marsh grass assists with the mechanical breakdown of organic material (Orth *et al*., 1984). The fecal pellets from the unused part of their diet are rich in nutrients and, therefore, an important component of energy cycling in estuarine ecosystems. Marsh grass shrimp are hosts to several ectocommensals, including the bopyrid isopod *Probopyrus pandalicola*, as well as microsporidians, trematodes, coccidian, and leeches (Anderson, 1985). Marsh grass shrimp have been extensively documented as the prey of fishes and other carnivores. They are instrumental in transporting energy and nutrients between various estuarine trophic levels: primary producers, decomposers, carnivores, and detritivores (Haertel-Borera *et al*., 2004). Grass shrimp are consumed in large quantities by commercially important fishes and forage species, including spotted seatrout (*Cynoscion nebulosus*), red drum (*Sciaenops ocellatus*), and mummichogs (*Fundulus heteroclitus*) (Heck & Thoman, 1981; Anderson, 1985; Wenner, 1990; Posey & Hines, 1991; Wenner & Archambault, 1996).

POPULATION SIZE AND DISTRIBUTION

Grass shrimp are found in large numbers in estuarine waters along the Atlantic and Gulf Coasts, where they occur from Massachusetts to Texas. Although there are many freshwater members of the genus, the three species considered here are common in estuaries and tidal creeks in South Carolina waters.

Although there are no estimates of population sizes of grass shrimp in South Carolina, they are amongst the most widely distributed, abundant, and conspicuous of the shallow water benthic macroinvertebrates in our estuaries, often reaching hundreds to thousands per meter (Coen & Luckenbach, 2000; Leight *et al*., 2005).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Grass shrimp are very common estuarine species in southeastern U.S. marshes and tidal creeks where they are usually associated with beds of submerged or emergent vegetation, oyster reef habitats or structures such as oyster shell, fouling communities, woody debris (Ruiz *et al*., 1993),

docks, or pilings (Coen *et al*., 1981). The marsh grass shrimp (*P. vulgaris*) tolerates somewhat higher salinities than its congener, the daggerblade grass shrimp (*P. pugio*). This has led some to suggest a separation of the 2 species based on preferred habitat, although biotic interactions such as competition for food and space may be more important (Thorp, 1976; Coen *et al*., 1981). Grass shrimp are eurythermal. In estuarine waters, daggerblade grass shrimp can survive at temperatures from 5ºC to 38ºC; however, optimal temperatures range from 18 to 25ºC. Marsh grass shrimp are more tolerant of high salinity water and less tolerant of low salinity water than daggerblade grass shrimp. Although salinities as low as 3 ppt have been lethal to adult marsh grass shrimp, they have been collected in freshwater (Anderson, 1985). Although brackish grass shrimp are also considered euryhaline, they have typically been collected from waters with salinities of 5 ppt to 39 ppt.

Grass shrimp can inhabit very shallow areas near their margins but have been reported at depths as great as 15.2 m (50 ft). In winter during temperature lows, and in summer when water temperatures approach seasonal highs, daggerblade grass shrimp may move from shallow to relatively deeper water. The extent of the movement of grass shrimp among various depths often coincides with the distribution of oyster shell substrates, which, in some waters, are preferred by both daggerblade grass shrimp and marsh grass shrimp. They are abundant in these structured estuarine and marine habitats as they provide abundant food and protection from predators such as various fish species (Thorp, 1976; Coen *et al*., 1981; Heck & Thoman, 1981; Heck & Crowder, 1991).

CHALLENGES

The main challenge to conserving grass shrimp is the degradation of habitat associated with extensive anthropogenic development along the South Carolina coast. Estuaries and tidal creeks are increasingly being affected directly and indirectly through runoff and spraying, to name just a few impacts. As epibenthic predators and sediment disturbers, grass shrimp can significantly alter infaunal community structure. For example, in North Carolina, a sharp decline in the abundance of marsh grass shrimp due to predation by mummichogs *(Fundulus heteroclitus)* may have changed marsh infaunal composition (Anderson, 1985).

Since grass shrimp often rely on aquatic vegetation or other structured habitats (Boesch & Turner, 1984), activities that reduce structural complexity can negatively affect grass shrimp populations (Weaver & Holloway, 1974; Thorp, 1976; Coen *et al*., 1981; Heck & Thoman, 1981; Heck & Crowder, 1991). In West Bay, Texas, dredging, bulkheading, and filling of coastal marshes caused a permanent loss of intertidal vegetation (Trent *et al*., 1976). The reduction of detrital input into the adjoining aquatic systems caused a noticeable decrease in the abundance of grass shrimp. Coen *et al.* (1999 a,b) found that juvenile grass shrimp were collected in much higher numbers (20 to 60 times greater) over marsh than other adjacent estuarine habitats (mud or oyster reefs).

Changes to water regimes that alter salinity or dissolved oxygen through diversion or rediversion may also alter grass shrimp abundance patterns.

Grass shrimp have been used extensively by researchers in South Carolina and across the US as a bioassay organism for contaminant and toxicological research (*e.g.,* APHA, 1975Mayer, 1987); a great deal of information is available regarding mortality and sublethal effects. Researchers conducting toxicological work with the genus *Palaemon* have noted that grass shrimp adults are generally more sensitive than fish (Scott *et al*., 1994; Strozier, 1996; Van Dolah *et al*., 1997); however, this may vary greatly upon the toxicant (Scott *et al*., 1987). Grass shrimp larvae are also generally more sensitive to many organophosphates (Key & Fulton, 1993; Lund, 1997; Key et al., 1998b; Lund *et al*., 2000). Overall, grass shrimp appear to be more sensitive to organophosphate and pyrethroid insecticides and less sensitive to several organochlorine insecticides at high versus low salinities (Scott *et al*., 1989; Fulton & Scott, 1991; Key & Scott 1993). Concentrations of heavy metals (mercury, cadmium, and chromium) are acutely toxic to adult grass shrimp, usually in the order of 100 to 1,000 parts per billion. Work in Charleston by NOAA and other scientists at Fort Johnson have focused on grass shrimp as an invaluable model organism (Scott *et al*., 1992, 1994; Key & Fulton, 1993; Fulton 1993, 1997; Cochran & Burnett, 1996; Lund, 1997; Finley *et al*., 1999; Wirth *et al*., 2001; Bolton-Warberg, 2005; Leight *et al*., 2005).

CONSERVATION ACCOMPLISHMENTS

Extensive research on grass shrimp population dynamics has been conducted around sites with known pollution sources in South Carolina, including suburbanized Murrells Inlet, Charleston Harbor, North Inlet, the Broad and Okatee Rivers (Van Dolah *et al*., 1999), and the ACE Basin NERR. Thus, an extensive historical database exists for grass shrimp population dynamics within South Carolina. Egg number per female has also been compared among tidal creeks, rivers, and intertidal habitats to evaluate impacts.

CONSERVATION RECOMMENDATIONS

- Determine species' associations, critical habitats, and population abundance patterns for grass shrimp.
- Determine grass shrimp predator-prey relationships.
- Determine the effects of contaminants on the reproduction, growth, and longevity of grass shrimp.
- Protect important habitats, such as fringing marsh and oyster habitats, from the direct and indirect impacts of development, and increase our directed restoration efforts. Oyster habitats have only recently begun to be appreciated for their unique ecosystem services (see Oyster Habitat document and references therein).
- In order to conserve grass shrimp habitat, protect aquatic vegetation by directing dredge and fill operations away from intertidal marshes.
- Partner with NOAA-NOS to develop and implement ways to use grass shrimp as an indicator of ecosystem health.
- Work with municipalities to encourage the use of Best Management Practice (BMPs) that reduce non-point source runoff and reduce acute and chronic effects on grass shrimp.
- Encourage the use of conservation buffers that intercept pollutants to mitigate the movement of sediment, nutrients, and pesticides within non-point source pollution.

- Development and implementation of nutrient management plans (NMP) by farmers to help minimize nutrient loss while maintaining yield, decreasing the flow of nutrients into waterways, and reducing eutrophic effects.

MEASURES OF SUCCESS

By implementing the above recommendations, the SCDNR will be able to protect important marsh habitat and monitor water quality. The measurement of success will be to observe stable populations of grass shrimp (during annual surveys) that should result from this proactive management approach.

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Hard Clams Guild

Northern Quahog, *Mercenaria mercenaria*
Southern Quahog, *M. campechiensis*



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DESCRIPTION

Taxonomy and Basic Description

Members of the genus *Mercenaria* are bivalve mollusks in the family Veneridae. Common names for *Mercenaria mercenaria* (Linnaeus 1758) include the hard clam, quahog, quahaug, northern quahog, littleneck clam, and cherrystone clam, although the latter two are actually referring to commercial size classes. The sister species, *M. campechiensis*, is commonly known as the southern quahog.

The hard clam has two thick, equal-sized valves that are elliptical in shape and marked with conspicuous concentric rings (Eversole, 1987). The valves are joined dorsally by a dark brown external ligament just below the anteriorly-inclined umbo. Opposite the hinge is a distinct heart-shaped lunule. The external shell is generally tan-colored or off-white and may have reddish markings (*notata* form). The internal shell is white or pale yellow with a dark purple margin. The prominent adductor muscle scar may also be purple.

The body of the hard clam is surrounded by a mantle that secretes the shell. The clam filters through a pair of siphons fused at the bases. The incurrent siphon has sensory tentacles that are involved in food selection. The siphons are generally creamy white, but the margins may be colored in a range of yellows, browns, purples, or reds. The clam has a large hatchet-shaped foot that is used for digging.

Clams may live for up to 46 years (Peterson, 1986) and reach a size of 150 mm although the mean size is usually 60 to 70 mm (Stanley & Dewitt, 1983).

Status

Hard clams are not state or federally listed; however, clams and other filter feeders are ecologically very important in marine ecosystems. Filter feeders affect nutrient cycling in estuarine habitats and improve water quality by removing suspended particles along with phytoplankton (Officer *et al*., 1982; Dame, 1996; Dame *et al*., 2001; Newell, 2004). A large adult clam filters an average of 7 to 8 L hr^{-1}. Clams also readily ingest bacteria, viruses, and other water-borne pathogens that can cause human health problems. Although hard clam stocks

appear to be stable based on high densities observed in some locations, they are a high priority for conservation in marine ecosystems.

Hard clams are harvested both recreationally and commercially and are the most valuable commercially harvested clam species in the United States (Pritchard, 2004). In South Carolina, the hard clam fishery was at one time valued at $3 million but has decreased in recent years, both in volume and in value due to depressed market factors. Since the effort for harvesting wild clams is considerably greater than growing them in mariculture operations, a vast majority of the hard clam landings come from mariculture permits. There are approximately 20 hard clam mariculture permits currently active in South Carolina. The Southern Regional Aquaculture Center has two fact sheets on hard clam biology and aquaculture (Hadley & Whetstone, 2007; Whetstone *et al*., 2005).

POPULATION SIZE AND DISTRIBUTION

Mercenaria mercenaria is found from the Gulf of St. Lawrence to the Atlantic coast of Florida. This species has been introduced to other areas of the United States, notably Humboldt Bay, California (Murphy, 1985), Washington State, and Puerto Rico. It has also been introduced into Great Britain and Southern Brittany, where it is now well established, as well as the Mediterranean (France, Italy, Sicily, the Adriatic Sea) and China. A sister species, *M. campechiensis* (Gmelin 1791), is distributed primarily along the Atlantic Coast from North Carolina to Florida and in the Gulf of Mexico (Dillon & Manzi, 1989a). A subspecies, *M. mercenaria texana* (Dillon & Manzi, 1989b) is found primarily along the Gulf coasts of Texas and Louisiana. The two species *M. mercenaria* and *M. campechiensis* readily hybridize where their ranges overlap. Both *M. campechiensis* and hybrids have been reported in South Carolina (Dillon, 1992; Dillon & Manzi, 1992), but only represent small percentages of the overall population. Kraeuter & Castagna (2001) provide a review of the biology of the hard clam.

Hard clams are contagiously distributed (randomly clumped) in South Carolina estuarine waters at relatively low densities of 6 to 24 per m^2 (Dame, 1979; Rhodes *et al*., 1977; Anderson *et al*., 1978). A statewide survey in the 1970s (Anderson *et al*., 1978) estimated that 10% of estuarine waters in South Carolina contained hard clams, predominantly at low densities (< 4 per m^2). Most of the clams in this survey (68%) were in substrates composed of sand and shell; the fewest specimens were found in mud and sand mixtures. Small clams may be found in saltmarshes where the rhizomes provide protection from predators. Larger clams are often found in association with oyster reefs, burrowed under and adjacent to oyster clusters (Anderson *et al*., 1978). Larval clams (70 to 350 µm in length) are planktonic; they drift with the currents and may be distributed considerable distances from where they were spawned (Wood & Hargis, 1971).

HABITATS AND NATURAL COMMUNITY REQUIREMENTS

Hard clams occupy intertidal as well as subtidal habitats and burrow into the substrate to depths up to 20 cm, but more commonly to a depth of 1 to 2 cm (Roberts *et al*., 1989; Eversole, 1987). Hard clams are found in a variety of substrates including sand, mud, shell, and mixtures of these; however, studies have demonstrated a preference for coarser substrates that may relate to associated water currents (Stanley & Dewitt, 1983). They are often most abundant where there is

an overlying layer of shell or coarse sand (Anderson *et al.,* 1978) which provides predator protection. Although clams are infaunal, they can 'migrate' horizontally, as well as vertically (Toll *et al.,* 2003). Adult clams have been shown to repopulate a harvested area in a relatively short period of time (Toll *et al.,* 2003).

The hard clam is a moderately euryhaline osmoconformer. Although it has been found in salinities ranging from 4 to > 35 ppt (Eversole, 1987), growth is optimal at salinities between 24 and 28 ppt. Hard clams can tolerate long periods of reduced salinity by closing their valves (Eversole, 1987) and are tolerant of low dissolved oxygen, surviving up to 3 weeks at 1 mg L^{-1} (Stanley & Dewitt, 1983). Hard clams, especially larval and juvenile stages, are sensitive to pH outside the range of 7.0 to 8.75 (Calabrese & Davis, 1966).

Growth and reproduction in hard clams are largely controlled by temperature. Hard clams usually reach sexual maturity at a size of about 35 mm shell length. In South Carolina, hard clams usually spawn intermittently from May through October when water temperatures reach or exceed 24 °C (75 °F). The planktonic larval stage may last as long as 2 weeks during which time the larvae may be distributed widely by currents and winds. At the end of this stage, the clam metamorphoses to the adult form and rapidly burrows into the substrate (MacKenzie *et al*., 2002).

CHALLENGES

High turbidity—which can result from runoff, dredging, and boating activities, as well as natural causes, such as storm-induced flooding and winds—can negatively impact hard clams (reviewed in Ward *et al.*, 1994; Coen, 1995; Ward & Shumway, 2004). As with other filter-feeding bivalves, high turbidity may interfere with feeding by potentially clogging the gills or even limiting the time that hard clams attempt to feed (Stanley & Dewitt, 1983).

Hard clams, like other filter feeders, can be adversely affected by blooms of certain types of phytoplankton (Gainey & Shumway, 1988; Shumway & Cucci, 1987; Shumway, 1990; Bricelj & MacQuarrie, 2007). Most phytoplankton blooms result from a combination of physical, chemical, and biological mechanisms and interactions that are only partially understood. Some phytoplankton species produce toxins and, in a bloom situation, can adversely affect other organisms. Even when such blooms do not harm the filter-feeding organisms, the toxins can accumulate in the filter-feeders and reach levels that can endanger consumers, including humans. Harmful algal blooms have increased in frequency and become more widely distributed in the last few decades; this suggests that human activities may be affecting bloom occurrence or distribution (Hallegraeff, 1993; WHOI, 2004). A specific concern associated with hard clams occurs when healthy bivalves from 'open' approved areas that have experienced harmful algal blooms are transferred to other bays or creeks that have not experienced such blooms. Such transfer is of interest because many of the phytoplankton species that cause harmful algal blooms can survive digestion (Burkholder & Shumway, 2011).

Mariculture-related importations of clams or other bivalves could inadvertently introduce new predators or diseases into South Carolina waters. The SCDNR has documented 27 other species, including oyster drills and a number of crab species—at least one of which is not indigenous to

South Carolina—in hard clams transferred from Florida as part of a mariculture operation. Mariculture operations could also potentially modify local population genetic structure (Metzner-Roop, 1994; Arnold *et al*., 2003). Research has suggested that hard clam populations may differ in susceptibility to certain diseases (Ford *et al*., 2002; Ragone-Calvo & Burreson, 2002; Camara *et al*., 2004; Ragone-Calvo *et al*., 2003). Hard clams imported for mariculture in South Carolina could be of strains that are more susceptible to certain diseases. Interbreeding with local populations could then result in an increased susceptibility of native stocks to disease.

Relatively few diseases have been reported in *M. mercenaria*. The most notable is the parasite QPX (Quahog Pathogen Unknown), which was originally observed in the 1960s in New Brunswick, Canada, where it caused observable mortalities. Epizootics have since been observed in hard clam aquaculture plantings in parts of Atlantic Canada, Massachusetts, New Jersey, and Virginia (Whyte *et al*., 1994; Ragone-Calvo *et al*., 1998; Smolowitz *et al*., 1998; Ford, 2001) and in wild populations near Raritan Bay (Bobo *et al*., 2004; Lyons *et al*., 2007). Lyons *et al*. 2007 reviewed the epizootiology of QPX, which has not been reported south of Virginia. The parasite is more prevalent in intermediate size clams (25-55 mm) and in cultured populations. Research has found that southern (South Carolina and Florida) hard clam populations are more susceptible to QPX mortality than northern populations (Ford *et al*., 2002; Ragone-Calvo & Burreson, 2002; Calvo *et al*., 2007). QPX has not been reported in South Carolina, either in wild or aquacultured populations (Bobo *et al*., 2004). Importations for mariculture from areas of QPX infestation could spread this disease into local waters where it could be a threat to wild populations as well as cultured clams.

CONSERVATION ACCOMPLISHMENTS

The South Carolina Department of Health and Environmental Control (DHEC) restricts harvest of shellfish, including clams, in approximately 30% of estuarine waters in South Carolina for human health reasons. There have been no outbreaks of human disease related to hard clam consumption in South Carolina.

The South Carolina Department of Natural Resources (SCDNR) regulates importations of hard clams and other bivalves for placement in South Carolina waters, primarily for mariculture (SCDNR OFM, 2004). Importation from areas of known diseases, such as QPX, is restricted. Disease testing is required prior to importation, with zero tolerance for the presence of any known diseases. Shipments are also inspected by SCDNR staff for the presence of predators, non-native species, and other undesirable associated organisms.

The SCDNR regulates and monitors the commercial clam fishery, including annual compilation of fishery statistics. The SCDNR also makes limited assessments of oyster populations on State Shellfish Grounds on an annual basis to determine which State Grounds may need to be temporarily closed to allow populations to recover; however, a thorough fishery independent assessment of the resource status has not been conducted since 1978 and is long overdue.

CONSERVATION RECOMMENDATIONS

- Regularly update importation policies of cultured clams to reflect changes in threats to native clams.
- Continue to regulate and monitor mariculture activities given that these practices have the greatest potential for introducing diseases or non-indigenous predators and for affecting the native population genetic structure.
- Monitor for signs of the QPX disease in wild and cultured clam populations.
- Continue to monitor fishery trends.
- Conduct a thorough fishery independent assessment of the statewide hard clam population.
- Work with appropriate agencies to improve and implement Best Management Practices (BMP) in order to protect water quality and prevent turbidity caused by urban and agricultural runoff.

MEASURES OF SUCCESS

Determining that populations of hard clams are stable through annual fishery statistics and population monitoring within South Carolina would result in a measure of success. Another way to measure success is the absence of disease in native clam populations. Furthermore, the absence of human health problems associated with the consumption of hard clams would indicate successful conservation actions for this species.

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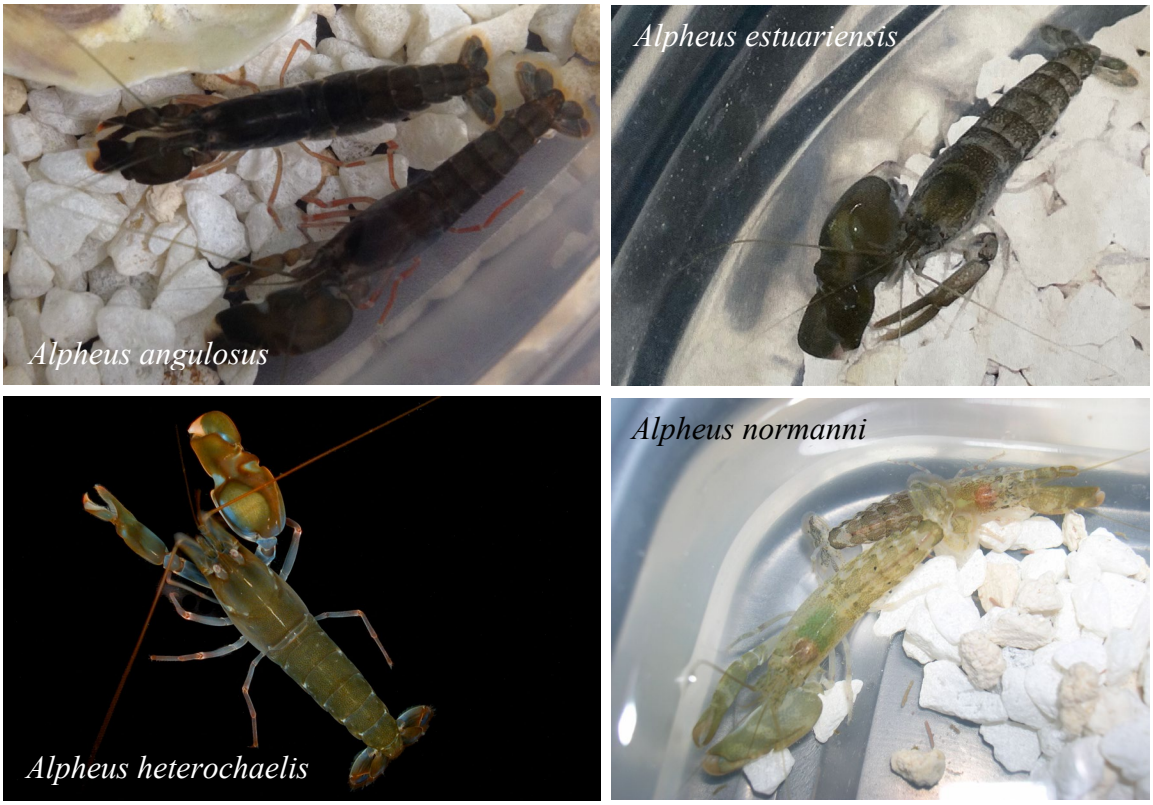
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Intertidal Alpheid Guild

- *Alpheus angulosus* McClure, 2002 (formerly *A. angulatus* McClure, 1995; no common name.)
- Estuarine snapping shrimp, *Alpheus estuariensis* Christoffersen, 1984
- Bigclaw snapping shrimp (*Alpheus heterochaelis)* Say, 1818
- Green snapping shrimp (*Alpheus normanni*) Kingsley, 1878

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DESCRIPTION

Taxonomy and basic description:

The genus *Alpheus* is found in tropical, subtropical and temperate oceans and represents the most speciose genus of Caridea, with approximately 250 described species (Chace, 1988). These relatively large caridean shrimp are common in the intertidal regions. The *Alpheus edwardsii* group is notoriously difficult to decipher systematically as two or more very similar and highly variable species usually occur in sympatry.

The bigclaw snapping shrimp, *Alpheus heterochaelis* Say, 1818 (Crustacea: Decapoda: Alpheidae) is the largest and most colorful of four species of snapping or pistol shrimp found in the southeastern United States. It is typically dark translucent green with orange

and blue tipped uropods (Nolan & Salmon, 1970; Spence & Knowlton, 2008). Detailed descriptions of *A. heterochaelis* are provided by Brooks & Herrick (1892) and Williams (1984). Ovigerous females can measure up to 54 mm in body length, while males reach 40 mm (Willliams, 1984). In addition to size and coloration differences, *A. heterochaelis* can also be differentiated from other alpheids in South Carolina in that its larger claw has a notch in both the upper and lower margins at the base of the fingers (Ruppert & Fox, 1988). Within *A. heterochaelis*, males collected near Beaufort, NC had a greater ratio of claw length to total body length than females (Schein, 1975), although the degree of sexual dimorphism in claw size varies seasonally (Dinh & Patek, 2023). Sexual dimorphism of the minor chela can be used to determine sex in this species, with the male having a curved dactyl ("balaeniceps" claw) bearing many more setae than the female's straight dactyl (Nolan & Salmon, 1970; McClure & Wicksten, 1997; Spence & Knowlton, 2008).

The green snapping shrimp, *A. normanni* reaches a maximum body size of 10 mm carapace length (Williams, 1984), but other than its smaller size morphologically is quite similar to *A. heterochaelis*. The minor claw of the male, as in *A. heterochaelis*, is balaeniceps in shape. It is not known if the major chela is also sexually dimorphic, as in *A. heterochaelis*; the shape of the major chela differs from *A. heterochaelis* and the other species here in tapering dramatically towards the distal end (Williams, 1984) There are also other characteristics that allow these two species to be differentiated. In *A. normanni*, the orbital hoods of the carapace form an anterior toothlike projection, which is lacking in *A. heterochaelis*. Additionally, only the outer margin on the large claw of *A. normanni* is notched compared to both margins being deeply notched in *A. heterochaelis* (Nolan & Salmon, 1970). Its color likely varies among localities with Williams (1984) compiling several color descriptions of *A. normanni*: body gray or dullish green, sometimes with median lateral whitish stripe, often mottled with dark green or brown; pale spot behind each eye; major chela darker green and usually banded with yellow or yellowish brown on inner surface, occasionally with 2 pale bands and blackish fixed finger. Color variants should be treated with caution as cryptic species that can be morphologically distinguished solely by color in living specimens may be common in this genus (Knowlton & Keller, 1983). In SC, *A. normanni* typically has distinct light brown bands on the abdominal segments and chelae.

The estuarine snapping shrimp, *A. estuariensis* was distinguished morphologically from *A. heterochaelis* and *A. angulosus (*formerly *A. angulatus)* by McClure & Wicksten (1997). In contrast with *A. heterochaelis* and *A. angulosus*, this species is not sexually dimorphic in its minor chela, *i.e.,* in both sexes, the fingers are straight and distinctly longer than in the other species. It is not known if the major chela is sexually dimorphic in size. In contrast with the other species, the major chela of *A. estuariensis* has a pronounced square tip (see McClure & Wicksten, 1997 for comparison of major and minor chelae of these species). Like *A. normanni*, the abdomen is typically banded, although darker in coloration.

Alpheus angulosus was first described in 1997 (originally *Alpheus angulatus*); this species has likely been confused in older collections with *A. heterochaelis*, *A.*

estuariensis, and *A. armillatus* (a species now considered to be restricted to the tropics; McClure & Wicksten, 1997). Both the major and minor chelae differ in shape from the other species considered here; see McClure & Wicksten, 1997, Fig. 4, for comparison. The minor chela is not sexually dimorphic and is shorter and stouter than the minor chelae of *A. estuariensis* or females of *A. heterochaelis* or *A. normanni* (McClure & Wicksten, 1997). The major chela is sexually dimorphic in both size (with the size of both male and female major chelae vary seasonally, Heuring & Hughes, 2019) and – unique among these species – shape; the distal tip of the male major chelae is broader than the distal tip of female major chelae (McClure & Wicksten, 1997). Body colors in *A. angulosus* range from green to brown and can be dark or light; darker individuals tend to be females. While individual captured further south on the Atlantic coast and in the Gulf are described as having blue antennae (Spence & Knowlton, 2008), in SC, antennae are greenish brown or orange. Genetic analyses confirm these color variations are not cryptic species (Heuring *et al.,* 2017).

Status

POPULATION DISTRIBUTION AND SIZE

The bigclaw snapping shrimp, *A. heterochaelis* occurs from the lower Chesapeake Bay (Van Engel & Sandifer, 1972) to Aransas County, Texas, Cuba, Curaçao, and Surinam (Chace, 1972), with other authors listing the range as extending as far as Sao Paulo, Brazil (Whitaker, 1984). These range limits should be treated with caution, however, as they may include cryptic species and/or more recently described species (e.g., *A. angulosus*, see below; McClure, 1995).

The green snapping shrimp, *A. normanni* occurs in Bermuda, around Cape Charles, Virginia and the lower Chesapeake Bay, through the Gulf of Mexico and West Indies to Brazil (Kingsley, 1878).

The estuarine snapping shrimp, *A. estuariensis* ranges from Florida and the Gulf of Mexico southward to Brazil (Christoffersen, 1984).

Alpheus angulosus occurs in the Gulf of Mexico (Mathews, 2002) and southern Atlantic coast through South Carolina (Hughes *et al.*, 2014), with some collections occurring as far north as Beaufort, NC. The full extent of their range is not known, given their relatively recent description.

HABITAT / NATURAL COMMUNITY REQUIREMENTS

The recently described *Alpheus angulosus* is the most commonly collected alpheid species intertidally in South Carolina (*e.g.,* Song *et al.,* 2021) and as it was not described until the late 1990s (McClure, 1995), it is likely confused with other species, including *A. heterochaelis* in prior collections of alpheids (Hughes, M., pers. obs.). By comparison, *A. estuariensis* and *A. normanni* are found less often, perhaps because they have different habitat requirements (Hughes, M., pers. obs.). Within South Carolina anecdotally and

based on collection (Hughes, M. unpubl. data), *A. heterochaelis* may be more common intertidally along more northern parts of the coast, and perhaps due to limited upper temperature tolerances may be more common intertidally in the winter than the summer, moving more subtidal when temperatures rise.

Intertidal alpheids, unlike their subtidal counterparts, all build their own burrows under hard substrate or take advantage of existing cavities. Similarly, unlike subtidal species, they are generally not associated with other species (although at least in the mid-Atlantic region, *A. heterochaelis* may sometimes form commensal relationships with mud crabs; Silliman *et al*., 2003). There is little information on the impacts that their burrowing activities have on other dwellers of intertidal habitats in South Carolina.

Members of the family Alpheidae are ubiquitous producers of sound (Johnson *et al*., 1947) and members of the genera *Alpheus* and *Synalpheus* (generally a more subtidal group) are capable of producing vigorous snaps (Johnson, 1944; Everest *et al.*, 1948; Kaji *et al*., 2018; Song *et al*., 2021). These snaps have been detected across a range of habitats, including estuaries of the southeastern United States (*e.g.,* Monczak *et al*., 2019, 2020; Mueller *et al*., 2020)

The snapping sounds produced by members of the genera *Alpheus* and *Synalpheus* have been the subject of considerable literature, reviewed by Knowlton & Moulton (1963). The snaps are produced by the rapid closure of the larger of the asymmetrical claws, resulting in the production of a rapid jet of water and pressure differential (Versluis *et al*., 2000). Consequently, small bubbles of dissolved gases grow in size and form a larger cavitation bubble, which then collapses creating a short-duration acoustic pulse, which operates over short distances (~ 9mm; Herberholz & Schmitz, 1999). The most well-known function of this snapping sound is as an agonistic communication behavior during intraspecific encounters (Nolan & Salmon, 1970; Schein, 1975, 1977). Competitors can also assess body size based on the signal of an open major chela (Hughes, 2000). The snaps may also function as a physical weapon to defend territory by stunning or killing prey (Schein, 1975, 1977; Schmitz & Herberholz, 1998; Schultz, 1998). Additionally, the lower frequencies of snaps may act as acoustic cues for larvae seeking appropriate settlement habitats (Simpson *et al*., 2005; Lillis *et al*., 2013, 2015) and have been documented to occur at higher rates around physically complex habitats of gregarious reef building organisms such as corals and oyster reefs (Spence & Knowlton, 2008). As such, soundscapes may present an indirect measure of habitat quality in the context of habitat enhancement and restoration (Butler *et al*., 2017; Monczak *et al*., 2020). Additionally, *A. heterochaelis* has been shown to be more abundant around oyster reefs than adjacent non-reef study plots (*e.g.,* Tolley & Volety, 2005; Kingsley-Smith *et al.,* 2012).

While the role of snapping shrimp in coastal SC food webs is not well known, in other ecosystems they have been identified as keystone species (Wu *et al*., 2020). Snapping shrimp are common prey items for a diverse assemblage of predators, ranging from teleost fishes (Morato *et al*., 2000; Šantić *et al*., 2009; Lopez-Lopez *et al*., 2011, Šantić *et al*., 2011; Jeyabaskaran *et al*., 2020; Chen *et al*., 2023) including flatfish (Dou, 1995;

Sartor & De Ranieri, 1996; Fanelli *et al*., 2009), sharks and rays (Lowe, 2002; Šantić *et al*., 2011, 2012; Queiroz *et al*., 2023), and octopus (Quetglas *et al*., 2009, Serrano-Tadeo *et al*., 2021) to terrestrial predators such as snakes (Jayne *et al*., 2018) and presumably wading birds and shorebirds that are regularly observed in their habitat at low tide (Hughes, pers. obs.).

The diets of these Alpheus species are not known, although most probably range from scavenging to attacking small prey. Under laboratory conditions, *A. angulosus* and *A. heterochaelis* will both attempt to depredate small hermit crabs by snapping directly on their shells (Hughes, pers. obs.). In the case of *A. heterochaelis*, this species will prey upon small bivalves by similarly crushing shells with their major chela (Beal, 1983).

THREATS

From a conservation perspective, the dominant threats to intertidal alpheids that may make them vulnerable on a local and regional scale to extirpation are likely to be related to habitat loss and degradation, particularly given the rapid rate of coastal development and its associated negative impacts (e.g., losses of intertidal oyster reef habitat and/or salt marsh habitat, pollutants and contaminations.

CONSERVATION ACCOMPLISHMENTS

Species in the genus *Alpheus* have received little or no attention in terms of past conservation efforts in South Carolina, likely due to the data deficient nature of this species to indicate that its number have been in decline, either as a result of natural or anthropogenic factors.

CONSERVATION RECOMMENDATIONS

Soundscape ecology, including that focused on snapping shrimps, can provide a long-term non-invasive approach to improving our understanding of animal movement and behavior patterns, assessments of habitat quality and community structure and species interactions over temporal and spatial scales. Furthermore, the comparison and interaction of biological and anthropogenic soundscapes can be used to determine the degree of human disturbance in relation to sound in coastal landscapes (*e.g.,* Transue *et al.*, 2023). Understanding the impacts of anthropogenic sound on coastal organisms directly and through its interference with biological soundscapes will be important for the conservation of species that rely on sound for communication, defense, prey capture, and other ecological functions.

More basic information is needed on the distribution, habitat associations, and basic life history for the species in the genera *Alpheus* in coastal South Carolina. Without such baseline data, it is impossible to detect whether or not these species abundances are in decline and species in need of targeted conservation actions. Furthermore, population sizes for all of these species are largely unknown (Hughes, M. pers. comm.). Additionally, there have been misidentifications and taxonomic confusion for these

species in the recent past, such that a robust field for these species in the South Atlantic Bight would be a valuable tool to aid in the collection of field data on these species to inform our knowledge on this important guild.

The array of functions and consequences of shrimp snaps are such that characterizing the parameters of the sounds of the different alpheid species inhabiting coastal South Carolina habitats is important to better understand their functions and to discern their signals within coastal soundscapes. The impacts of these sounds on other organisms also warrant further investigation. The snaps of *A. heterochaelis* and *A. angulosus* have been described by Song *et al.* (2021), but equivalent information for other members of the guild described here is lacking.

MEASUREMENT OF SUCCESS

Success would constitute a thorough understanding of the distributions and life histories of these species and a greater confidence in differentiating among species in the field. In addition, the application of distribution and abundance information as a metric of habitat quality would be informative within the broader disciplines of habitat conservation and restoration in coastal habitats of South Carolina.

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Intertidal Marine Invertebrates Guild
(Intertidal Foraging Habitat Guild for Shorebirds)

Contributors (2013): Stacie Crowe and Denise Sanger [SCDNR]. Andrew Tweel and Joseph Cowan [SCDNR] (2025).

Amphipod Crustaceans

Gammaridae

Gammarus palustris
Gammarus mucronatus

Haustoriidae

Acanthohaustorius intermedius
Acanthohaustorius millsi
Acanthohaustorius pansus
Acanthohaustorius shoemakeri
Acanthohaustorius similis
Haustorius canadensis
Haustorius jayneae
Lepidactylis dytiscus
Neohaustorius schmitzi
Parahaustorius longimerus
Parahaustorius holmesi
Protohaustorius bousfieldi
Protohaustorius deichmannae
Protohaustorius wigleyi
Pseudohaustorius caroliniensis



Haustorid amphipod. Photo courtesy of Southeastern Regional Taxonomic Center (SERTC)

Bivalve Mollusks

Coquina clam (*Donax variabilis*)
Dwarf Surf Clam (*Mulinia lateralis*)
Tellin clams; family Tellinidae
False Angel Wing (*Petricolaria pholadiformis)*
Scorched Mussel *(Brachidontes exustus)*

Polychaete Worms

Alitta succinea
Arabella mutans
Drilonereis longa
Capitella capitata
Glycera americana
Glycera dibranchiata
Laeonereis culveri
Mediomastus sp.
Paraonis fulgens
Scolelepis sp.
Streblospio benedicti
Tharyx acutus



Polychaete worm, *Nereis succinea*.
Photo courtesy of SERTC.

Chelicerate Arthropods

American Horseshoe Crab (*Limulus polyphemus*)

Nemertean Worms

Cerebratulus lacteus

Acorn Worms (Hemichordata)

Saccoglossus kowalevskii

Balanoglossus aurantiacus

Isopod Crustaceans

Exosphaeroma diminutum

Decapod Crustaceans

Pinnotheridae

Austinixa cristata

Dissodactylus mellitae

Pinnixa lunzi

Rathbunixa sayana

Tubicolixa chaetopterana

Tumidotheres maculatus

Zaops ostreum

DESCRIPTION

Species in the intertidal shorebird foraging habitat guild are critical food resources for many shorebirds including species of national concern, such as the piping plover (*Charadrius melodus*) and red knot (*Calidris canutus)*. Prey availability has been shown to be a critical factor affecting the distribution of shorebirds (Fraser *et al.,* 2005; Lyons, 2005; Spruzen *et al.,* 2008a, b), and therefore represents an important measure of habitat quality. Recent studies of overwintering habitat quality in South Carolina have investigated potential prey items found in sediment cores taken from known foraging areas of piping plover and red knot (Bergquist *et al.,* 2011; Thibault & Levisen, 2013; Coastal Eco-Group, Inc., 2013). Fecal samples have also been collected from overwintering locations in South Carolina to identify invertebrate taxa consumed by piping plover and red knot (USFWS, unpublished data; Thibault & Levisen, 2013). The dominant taxa from cores and fecal samples included amphipod crustaceans, polychaete worms, bivalve mollusks, and eggs of the American horseshoe crab *Limulus polyphemus* (subphylum Chelicerata) [a separate species account is afforded to this species], all of which comprise this guild.

Shoreline modification projects and other human disturbances of coastal habitats have been shown to reduce the foraging success and fitness of migratory shorebird populations (Verhulst *et al.,* 2004; Peterson *et al.,* 2006). Physical changes resulting from beach re-nourishment may be associated with changes in infaunal macroinvertebrate distributions and subsequent reductions in shorebird utilization of the affected habitat (Peterson *et al.,* 2006).



Red Knot (*Calidris canutus*) foraging on an intertidal flat at Kiawah Island, SC. Photo by Janet Thibault, SCDNR.

The invertebrates included in this guild become species of concern because disruption of the biological characteristics of overwintering areas, including reduced abundance of these available prey items, could have substantial and long-lasting impacts on migratory shorebird populations.

Taxonomy and Basic Description

Amphipods are in the taxonomic order Amphipoda of malacostracan crustaceans which have no carapace and generally have laterally compressed bodies. These inconspicuous crustaceans are prominent members of marine communities worldwide.

Species in the family Gammaridae that are represented in marine intertidal habitats include *Gammarus palustris* and *Gammarus mucronatus* both of which are estuarine species. These gammarid amphipods range in size from 6-14 mm as adults and have compressed, anteriorly smooth bodies.

Species in the family Haustoriidae are well represented in intertidal habitats, particularly in the sandy substrate of open beaches, but some species can also be found intertidally along salt marsh creeks and bars. Haustorids are burrowing amphipods that are characterized by their white barrel-shaped body the lack of a true rostrum and no dactyls on peraeopods 3-7 as well as fossorial appendages with numerous spines that assist in digging within sandy substrates. The species that occur in South Carolina are usually small (<0.5", 13 mm) and include species in the genera *Acanthohaustorius, Haustorius, Lepidactylus, Neohaustorius, Parahaustorius, Protohaustorius* and *Pseudohaustorius.*

The coquina clam, *Donax variabilis*, is a member of the bivalve family Donacidae. Coquina clams possess wedge-shaped shells, generally less than 0.8 in. (2 cm) in length, and are characterized by pastel colored bands radiating from the umbo to the margins of the valve (Ruppert & Fox, 1988). [A separate species account is afforded to this species.]

The dwarf surf clam, *Mulinia lateralis*, in the family Mactridae, is one of the smallest clams found on southeastern U.S. beaches, with lengths of only 0.6" (1.5 cm). *Mulinia lateralis* is characterized by its moderately inflated shape, solid strong valves and triangular hinge. The shell is pale cream-white in color with a radial ridge on each side of the posterior slope.

Tellin clams include species in the family Tellinidae and are small (usually < 1"), laterally compressed, and usually have a slight twist at the posterior end (Abbot, 1974). Shel color can vary from iridescent white to pale pastels.

The false angel wing, *Petricolaria pholadiformis*, is a small (2") bivalve in the family Petricolaridae that has a thin, white elongated shell marked by strong, scaly, radial ribs. It can superficially resemble the Angel wing, *Cryptopleura cosata*, but is much smaller.

The scorched mussel, *Brachidontes exustus*, is a small (1") fan shaped intertidal bivalve in the family Mytilidae that attaches to hard surfaces using a strong byssus. It has dark brown or yellowish values crossed by radial ribs.

Polychaete worms are in the taxonomic class Polychaeta which are segmented annelid worms. They are characterized by an elongated body bearing appendages called parapodia which bear many bristles, called chaetae. *Arabella mutans* and *Drilonereis longa* are both members of the family Oenonidae. Oenonids are typically large (as long as 12-14") earthworm-like worms which burrow in sand and mud on protected beaches. Species of Oenonidae can be distinguished using such characters as the shape of the head and the presence or absence of eyespots.

The bloodworms, *Glycera americana and Glycera dibranchiata,* are both members of the family Glyceridae. Glycerid worms are bright red, segmented worms that can reach up to 9" in length. Glycerids are ferocious epi- and infaunal polychaetes that prey upon small invertebrates. They are characterized by their pointy snout used for burrowing in sediment and their eversible pharynx containing 4 poisonous fangs used for capturing prey.

Laeonereis culveri and *Nereis succinea* are both members of the polychaete family Nereididae. Adult nereid worms can range from approximately 2.5-6" and are characterized by their conspicuous heads with 2 short antennae, 4 eyes, 2 bulbous palps, and 4 pairs of long tentacular cirri (Ruppert & Fox, 1988).

Tharyx acutus is a segmented worm of the polychaete family Cirratulidae. Members of this family are cylindrical, elongated, and characterized by reduced heads that lack appendages.

Capitella capitata and *Mediomastus* sp. are members of the polychaete family Capitellidae. Capitellid worms are red or purple in color with thread-like, flexible bodies that grow up to 4" in length. They are characterized by their conical shaped head and reduced appendages.

Paraonis fulgens is a segmented worm of the family Paraonidae. Paraonids are slender-bodied worms with many segments than can grow up to 1.3" in length. *Paraonis fulgens* is characterized by its lack of a median antenna on the head and hooked neurosetae on the postbranchial region of the body.

Scolelepis sp. and *Streblospio benedicti* are members of the tube-dwelling polychaete family, Spionidae. Spionids, also called palp worms, are characterized by their small heads and two long grooved palps used for deposit or suspension feeding. Spionids are mostly small (~6"), but large species do exist.

The American horseshoe crab, *Limulus polyphemus,* is the only member of the Arthropoda subclass Xiphosura found in the Atlantic Ocean. Horseshoe crabs are not true crabs as their name suggests, but members of the subphylum Chelicerata, which are more closely related to spiders, scorpions, and ticks. *Limulus polyphemus* are characterized by their lack of antennae and jaws and have 7 pairs of legs, including a pair of chelicerae.

Ribbon worms are non-segmented worms that belong to the phylum Nemertea and include the intertidal predator *Cerebratulus lacteus* which can reach 20" or more. It is smooth, milky white to pink and lacks external appendages.

Acorn worms are large non segmented worms belonging to phylum Hemichordata, a relatively advanced invertebrate taxa that includes a primitive nerve chord called a stomochord. The two common species in our region are *Saccoglossus kowalevskii* which grows to 15-20 cm and the much larger *Balanoglossus aurantiacus* which can reach up to 1 meter.

Exosphaeroma diminutum is a small (2 mm) marine isopod in the family Sphaeromatidae. It is characterized by a series of interlocking plates that allow it to fully curl itself into a sphere for protection which is the source of the family name.

Brachyuran crabs in the family Pinnotheridae are relatively small decapods with a membranous carapace that lacks lateral spines and ranges in width from 3.5-21 mm, however most species have a carapace width of less than 10 mm (Williams, 1984).

Status

None of the species in this guild are officially recognized as threatened or endangered, but all are part of the macroinvertebrate prey community in coastal habitats of the southeastern U.S. which serve as critical habitats within the overwintering/foraging range for threatened, endangered, and conservation priority shorebirds. There have been some concerns regarding reduced numbers of adult horseshoe crabs at some locations due to loss of habitat and overharvesting, which would result in fewer eggs and larvae available as prey items.

POPULATION SIZE AND DISTRIBUTION

Gammarus palustris and *Gammarus mucronatus* are distributed in estuaries from Northern Florida through the mid-Atlantic and north to the Cape Cod region and Piscataqua estuary with the range of *G. mucronatus* extending to the Gulf of St. Lawrence (Bousfield, 1973). Population size varies by location and season and has not been previously quantified.

Haustorid amphipods are very abundant along the intertidal gradient of the US East Coast (Bliss *et al.,* 1983). The haustorid amphipods in this guild range from Saco Bay, ME through Cape Canaveral, FL (Bousfield, 1973; Grant & Lazo-Wasem, 1982). Although the distribution of this group is well documented, population size could vary considerably by location and season and would be difficult to quantify.

Donax variabilis is a familiar species on sandy intertidal beaches in the southeastern U.S., where its shells are found in abundance. In the U.S., *D. variabilis* ranges from New Jersey to Florida and the Gulf of Mexico (DeVictor *et al.,* 2010). Surveys in the southeastern U.S. have found that it is among the most abundant macroinvertebrates present in the intertidal area during spring, where numbers have been recorded in excess of 1,000 per m^2 (93 per $ft.^2$; Pearse *et al.,* 1942; Shealy *et al.,* 1975; Knott *et al.,* 1983). [A separate species account is afforded to this species.]

The dwarf surf clam, *Mulinia lateralis*, can be an abundant species in shallow water sandy areas on the Atlantic Coast of the U.S. This species ranges from Maine to North Florida and has been found in abundances as high as 21,000 individuals per m^2 (Santos & Simon, 1980).

Tellinid clams are mud or sand dwellers found worldwide. Members of the family Tellinidae are very common on the South Carolina coast (Ruppert & Fox, 1988). Because there are many species in this genus, population size is difficult to estimate. Most of the species commonly found in the Southeast range from the Mid-Atlantic (Virginia/North Carolina) to Florida (Abbott, 1974).

The false angel wing, *Petricolaria pholadiformis* can be found along the Western Atlantic coast from Canada to Uruguary (Porter & Houser, 1997). Current population estimates are not available for this species but future monitoring may be necessary as it expands beyond its native range to both the west coast of North America and the Eastern Atlantic.

Brachidontes exustus occurs in the western Atlantic from North Carolina to Venezuela. This species can form dense mats in the low intertidal zone and is often one of the dominant mollusk species in estuaries (Barber *et al.,* 2005).

The glycerid worms, *Glycera americana* and *Glycera dibranchiata*, are very common in shallow water areas of South Carolina (Ruppert & Fox, 1988). In the eastern U.S., *G. americana* ranges from Massachusetts to Florida, while *G. dibranchiata* ranges from Maine to Florida (Day, 1973). Since these species can be epifaunal as well as infaunal, population size is difficult to estimate.

Polychaetes of the family Oenonidae (*A. mutans, D. longa*) are commonly found burrowed in sand and mud on protected intertidal beaches. In the eastern U.S., *A. mutans* ranges from South Carolina to Florida and *D. longa* ranges from Massachusetts to Georgia (Day, 1973). Although members of this family are more conspicuous than other polychaetes, population size is unknown.

Alitta succinea enjoys the widest distribution of any invertebrate species in the southeastern U.S., occurring in all benthic habitats except outer beaches (Ruppert & Fox, 1988). In the North Atlantic, *N. succinea* ranges from the Gulf of St. Lawrence to Florida, while *Laeonereis culveri* ranges from Connecticut to Florida (Gardiner, 1975). Studies in the Chesapeake Bay indicated that *N. succinea* may occur in considerable abundance, with densities of 400 individuals per m^2 in disturbed, partially anaerobic sediments (Hamilton, 1972).

Tharyx acutus ranges from the Gulf of Maine through North Florida on the East Coast of the U.S. Little has been reported on population estimates of *T. acutus*; however, a benthic invertebrate survey in New York reported abundances of 80 individuals per m^2 (USACE, 2004).

Capitella capitata and *Mediomastus* sp. are both very abundant on the East Coast of the U.S. *Capitella capitata* is a cosmopolitan species (occurring worldwide) that is often found in very high densities up to several thousand per m^2 in sediments that have been enriched with organic pollutants (Ruppert & Fox, 1988). Identifications to species level in the genus *Mediomastus* are often difficult due to the collection of incomplete worms, but there are several species that occur in high abundances on the U.S. Atlantic Coast.

Paraonis fulgens ranges from Maine to Florida in the Atlantic coastal waters of North America. Little is known regarding the population size of this species.

The spionid polychaete, *Streblospio benedicti* occurs along the US Atlantic coast from Maine south to Florida. Studies on *S. benedicti* abundance on the East Coast have reported the species to be among the most abundant and characteristic taxa occurring in Gulf of Maine mud flats (Larsen & Dogget, 1991) and among 4 taxa dominating North Carolina saltmarsh macrofauna (Cammen, 1979). The other spionid in this guild, *Scolelepis* sp., ranges from New England to Florida in the North Atlantic and has been found in abundances higher than 100 individuals per m^2 on the studied beach (Degraer *et al.,* 2003).

Horseshoe crabs range from northern Maine to the Yucatan Peninsula. Adult horseshoe crabs migrate from deep bay waters and the Atlantic continental shelf to spawn on intertidal sandy beaches as well as salt marshes in South Carolina (Kendrick *et al.,* 2021).

The geographic range of *Cerebratulus lacteus* in the western Atlantic begins in Florida and extends north to Prince Edward Island. It is a common inhabitant of sand and mud flats throughout its range; however, population size estimates are not currently available.

Saccoglossus kowalevskii and *Balanoglossus aurantiacus* can be found in the western Atlantic from Florida extending north to Newfoundland and have also been reported along the Gulf Coast. A study of *Saccoglossus* in Virginia estuaries found that this species can occur at densities of up to 500 m^2 (Schrage, 2021).

Exosphaeroma diminutum occurs from North Carolina through central South America intertidally on sandy beaches. A study of benthic infauna collected from a sand bar in the Charleston Harbor estimated the density of *Exosphaeroma diminutum* to be 24 individuals m^{-2} (Tweel & Sanger, 2016).

Numerous genera of pinnotherid crabs are found in the western Atlantic with most species ranging between central South America and extending north to Newfoundland. The small size and cryptic life history of these species makes population estimates difficult.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Marine invertebrate members of the shorebird foraging habitat guild live in the intertidal zone on sandy ocean beaches. The intertidal zone lies between the high tide line and the low tide line and is alternately submerged and exposed depending on the stage of the tide. As the tide moves up and down the beach, sand formations such as bars and runnels can form which border elongated tidal pools that run parallel to the waterline. These tidal pools are excellent habitat for the invertebrates in this guild.

Gammarus palustris and *Gammarus mucronatus* are free-swimming benthic estuarine amphipods that occur intertidally on muddy, grassy and stony beaches and marsh banks from about mid tide to mean high water. These species have an optimal salinity range of 5-20 ppt but can tolerate full short periods of fresh water, in cold winter conditions, or oceanic sea water (~36 ppt) in warmer summer months (Bousfield, 1973). Both species are important contributors to the breakdown of marsh grasses and the formation of detritus in salt marshes (Heard, 1982) as well as providing a food source for fish and birds (Thomas, 1976; Heard, 1982).

Haustorid amphipods are free-swimming amphipods which are adapted for burrowing in sandy or silty substrates. They prefer a variety of intertidal areas including exposed and protected beaches, inlet entrances, and estuaries with fine sand or mud. They can be found from mean low water to 50 m in depth and in salinities from 6 ppt to fully marine, depending on the species (Bousfield, 1973).

Donax variabilis is well-adapted to live and feed in the wave-washed swash zone of sandy, intertidal beaches. Coquina clams are shallow burrowers that have the ability to alternately emerge and burrow in the sand to move up and down the beach with the tide in order to filter feed on the phytoplankton and other small suspended particles.

Mulinia lateralis live shallowly buried in sand or mud on the lower ocean beach where, like other bivalves, they filter feed on suspended materials. They are tolerant of low salinities and are also found in estuaries and lagoons.

Tellinid clams include numerous genera which inhabit muddy or sandy bottoms in a range of depths and salinities. Two common species, *Ameritella agilis and Oudardia iris,* most often live in high-salinity estuaries but can also be found offshore in depths up to 75'. Tellin clams feed primarily on detritus and are consumed by fish and wading birds.

Petricolaria pholadiformis is an intertidal bivalve that bores into dense sediments such as clay or peat associated with marsh vegetation or on hard substrates intermingled with other bivalves such as mussels (Ruppert & Fox, 1988). This species has been observed in the marsh relic habitat of barrier islands. This unique habitat is characterized by dense clay and root mats that are the remnants of old marsh habitat on the estuarine side of the island that was covered over by sand as the island migrated landward and later exposed by erosion on the ocean facing side of the island. Marsh relic habitat has been identified as potentially important foraging grounds for wading birds such as piping plover and red knot which have been observed feeding on bivalves, including *Petricolaria*, on front facing beaches where marsh relic occurs.

Brachidontes exustus can tolerate a broad temperature range and spawning periods correlate with changes in water temperature with both spring and fall spawns triggered by changes in water temperature (Barber *et al.,* 2005). Adults can tolerate a range of salinity allowing them to colonize hard surfaces throughout estuaries as well as rocks and pilings on ocean facing beaches. Dense mats of *Brachidontes* can provide habitat for other invertebrates in much the same way as reef building oysters. Like the false angel wing, these mussels have been observed in marsh relic habitat where they are likely preyed on by wading birds.

Capitellid worms, such as *Capitella capitata* and *Mediomastus* sp., are sedentary deposit feeders that often occur in mud or muddy sand on the lower shore to sub-littoral zone. They may be found under pebbles or small stones, with the burrows at or near the surface of the sediment where they feed on deposited organic material (Ruppert & Fox, 1988).

Polychaete worms of the family Nereididae (formerly Nereidae) are commonly found in all water depths, hiding under rocks or burrowing in sand or mud. *Laeonereis culveri* constructs tubes in shoals of sand mixed with mud and shell fragments (Gardiner, 1975). *Nereis succinea* is

often found on pilings, oyster clumps, under rocks, and in shoals of sand mixed with some mud or shell fragments. They prefer estuarine and intertidal habitats to 40 m in depth (Day, 1973).

Tharyx acutus, of the polychaete family Cirratulidae, is a sluggish-type worm that inhabits medium to fine sand or muddy sediments. This species is usually found buried just below the surface of the sediment with only its feeding appendages visible.

Paraonis fulgens, like other members of the Paraonidae, are burrowers and deposit feeders that occur in the intertidal zone to depths of 10 m (Day, 1973). They prefer fine sands as the deeper portion of their burrows are spiraled to provide better anchorage in the sediment (Ruppert & Fox, 1988). *Paraonis fulgens* is often found in association with the spionid worms *Scolelepis* sp. and *Streblospio benedicti. Streblospio benedicti* prefers suitable soft sediments where they can form mucoid tubes just below the sediment-water interface that allow them to deposit feed. *Streblospio benedicti* is relatively tolerant to elevated levels of sediment organics (Reish, 1979), a trait that contributes to its success as an opportunistic species. *Scolelepis* sp., unlike other spionids, are not deposit feeders. They construct inconspicuous sandy tubes at the surface of the beach where they can catch suspended particles in the sticky mucus of their palps (Ruppert & Fox, 1988). *Scolelepis* sp. prefer a physically stressed habitat where there is rapid water movement.

Adult horseshoe crabs (*L. polyphemus*) mate in the spring and deposit up to 88,000 eggs in large bowl-like depressions in the intertidal region of quiet, sandy beaches, while also spawning in salt marshes (Kendrick *et al.,* 2021). Planktonic larvae hatch from the eggs within 2-4 weeks, although some larvae may overwinter within nests and hatch out the following spring (Botton *et al.,* 1992). Juvenile *L. polyphemus* remain in the intertidal flats, usually near breeding beaches.

Cerebratulus occurs in estuaries and on beaches where it burrows in the soft sediment of sand and mud flats preying upon bivalves and polychaetes. It swims in the water column at night and returns to the bottom during the day (Ruppert & Fox, 1988). *Cerebratulus* fragments itself voluntarily in response to predation, leaving behind a tail that moves vigorously to distract predators, allowing the head to escape and regenerate. The genetic signature of this species was identified in fecal samples collected from piping plover indicating it is a likely prey item.

Acorn worms are relatively large burrowing deposit feeders that live in the protected intertidal sand and mudflats of estuaries and beaches. Both *Saccoglossus kowalevskii* and *Balanoglossus aurantiacus* break apart easily when collected, making complete specimens rare. Large burrowing fauna such as acorn worms are potential prey items for wading birds.

Exosphaeroma diminutum is found intertidally on beaches associated with tide pools, under rocks or other debris or amongst encrusting communities that colonize pilings, rocks and other hard substrates. This species has been documented in waters ranging from 20-30°C with a salinity range of 20-36 ppt.

Pinnotherid crabs are small commensal or parasitic decapods that are most often associated with a bivalve, tunicate, polychaete or echinoderm host. Species from numerous genera are found intertidally each forming a symbiotic relationship with a specific host. *Zaops ostreum*, for

example, commonly live on the gills of oysters while *Austinixa cristata* is associated with callianassid decapod burrows. Adult pinnotherid crabs generally inhabit intertidal habitat and can tolerate a range of salinity and temperature. Spawning occurs only in the warmer months (May-September) in the northern portion of the range (New England and Canada) and becomes more protracted in the southern portion of the range with spawning of some species occurring year-round in Florida waters (McDermott, 2005).

CHALLENGES

Habitat loss and degradation from coastal development and rising sea levels are the main challenges to the beach invertebrate/shorebird feeding guild. Intertidal macroinvertebrate fauna play a key role in the sandy beach food chain, where filter feeders and deposit feeders turn over high amounts of particulate organic matter and meiofauna (McLachlan & Brown, 2006). In turn, they are an important food source for different kinds of predators such as shorebirds.

Although beach re-nourishment projects restore sand to eroded beaches, these activities can significantly negatively affect populations of sand-dwelling invertebrates as they are buried under a thick layer of sand. Re-nourishment may alter the physical environment of a beach by adding non-native sand, potentially resulting in a changed sediment composition and beach morphology. If these environmental changes are permanent, long-term changes in the macroinvertebrate community may occur.

CONSERVATION ACCOMPLISHMENTS

In South Carolina, critical habitats for the piping plover overwintering population have been designated by the U.S. Fish and Wildlife Service to help protect the species during its migratory period. Because of the official designation, standardized monitoring protocols which include assessing overwintering habitat quality (*i.e.,* identity and quantity of prey organisms included in this guild) are required in conjunction with shoreline modification projects.

CONSERVATION RECOMMENDATIONS

Effective habitat management requires a better understanding of the factors that determine habitat value to shorebirds. Piping plover conservation efforts continue to concentrate on increasing the population and on ensuring protection and maintenance of overwintering habitat for distinct populations (USFWS, 2009). The red knot is currently a candidate species for federal listing under the Endangered Species Act due to the rapid decline of this species in the last 15 years. It is theorized that population declines may be influenced by a lack of food availability, most notably horseshoe crab eggs, during migration. A fishery management plan is in place for horseshoe crabs on the East Coast through the Atlantic States Marine Fishery Commission (ASMFC) which implements regulations to limit the harvest of this species. Monitoring efforts to investigate potential impacts to the quality of overwintering piping plover and red knot habitat associated with shoreline construction projects is ongoing in South Carolina and will continue to provide estimates of the abundances of available prey items described in this guild.

MEASURES OF SUCCESS

Measures of success for this guild will directly correlate with conservation efforts to increase the populations of shorebirds such as the piping plover and red knot, as well as maintaining the quality of overwintering foraging habitats utilized for these distinct populations.

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Lettered olive
Oliva sayana

Contributor: Peter Kingsley-Smith (SCDNR)



DESCRIPTION

Taxonomy and basic description:

The lettered olive, *Oliva sayana* Ravenel, 1834 (Gastropoda: Neogastropoda: Olividae) as a member of the family of olive snails, is characterized by a long, narrow, streamlined shell with a very large body whorl. This last body whorl accounts for most of the of the shell and the spire is short, inconspicuous, and pointed (Ruppert & Fox, 1998). The shell length can measure up to 2½" (64 mm). The shell aperture is long and narrow, with the inner margin bearing numerous wrinkles or folds. The long axis of the shell is held parallel to the long axis of the animal as it crawls across the sand. Living in the sand, the shell is protected from abrasion by being surrounding by the large foot and mantle (Ruppert & Fox, 1988). The shell lacks an operculum, the siphonal canal is poorly developed, and the smooth, glossy shell is characterized by dark brown or purples letter-like markings (Ruppert & Fox).

Three previous subspecies of *O. sayana*, namely *O. sayana sarasotensis* Petuch & Sargent, 1986, *O. sayana texana* Petuch & Sargent, 1986, and *O. sayana sayana* Ravenel, 1834, have since all been recognized as *O. sayana* Ravenel, 1834, such that these subspecies names are no longer accepted according to the World Register of Marine Species (https://www.marinespecies.org/).

Status

This species in the South Carolina State Shell and received its common name because of the markings that look like writing. Another member of the Olividae found in South Carolina, *Olivella mutica*, is much smaller, has an operculum, and has a larger spire to shell length ratio (DeVictor *et al*., 2010). The species is currently not listed as threatened or endangered on any recognized state or Federal listing; however, this is likely in part explained by its data deficient nature.

POPULATION DISTRIBUTION AND SIZE

The geographic range of *O. sayana* extends from North Carolina to Florida, the Gulf states of North America, including Louisiana and Texas, and further south to the east

coast of Mexico, including Campeche State, Yucatan State and Quintana Roo, with the species reportedly collected live at depths of up to 27 m (Malacolog version 4.1.1).

HABITAT / NATURAL COMMUNITY REQUIREMENTS

The lettered olive is often found in the surf zone of outer beaches, on shallow sand flats near inlets, and offshore in sand (Ruppert & Fox, 1998). In the surf zone, it feeds on coquina clams (*Donax variabilis*) and Atlantic mole crab (*Emerita talpoida*), both of which are species included in the South Carolina State Wildlife Action Plan, which it asphyxiates with its foot. Details of spawning and a description of the egg capsules of O. sayana were described by Olsson & Crovo (1968) and briefly outlined later by D'Asaro (1970). The life history of this species includes the deposition of transparent, roughly spherical egg capsules of average diameter of 1.6 mm containing a large amount of albumen that forces the embryos against the inner surface of the capsule wall. Counts of embryos range from 14 to 48, with an average of 24, and the species has a long-term planktotrophic veliger (D'Asaro, 1970).

THREATS

This species is likely susceptible to disturbances to its natural habitat from the effects of coastal development and beach renourishment activities, as well as dredging and trawling activities in nearshore waters. Additionally, in a forecasting effort for how marine molluscan fauna might respond to environmental change over the remainder of the 21st Century, Saupe *et al.* (2014), *O. sayana* was among those species found to show reductions in suitable area of moth than 20% by 2080.

CONSERVATION ACCOMPLISHMENTS:

This species has not received any directed conservation actions, likely due to the lack of a fishery for this species, and the data deficient nature of this species. This species has been included in the State Wildlife Action Plan since at least 2015 in recognition of its probably importance as a predator of other SWAP-listed species and its status as the State Shell of South Carolina.

CONSERVATION RECOMMENDATIONS

Searching the literature and other information online yielded very little, both at a local and geographic range scale. While limited life history information is available from aquarium studies (see D'Asaro, 1970), studies of natural life history from South Carolina for this species are completely lacking. Baseline information on demographics, trophic interactions, and physiological tolerances would all serve to improve our understanding of the current status of this species and its future needs from a conservation perspective. Studies of the natural interactions between this and other SWAP-listed species (e.g., *Donax variabilis, Emerita talpoida*) could be conducted at a habitat level scale of study, perhaps focusing on the role of *O. sayana* within the surf zone.

MEASUREMENT OF SUCCESS

Success would constitute a better understanding of the distribution of this species in coastal habitats of South Carolina and therefore the prioritization of areas for monitoring and protection to ameliorate impacts from anthropogenic activities and the potential loss of habitat due to climate change.

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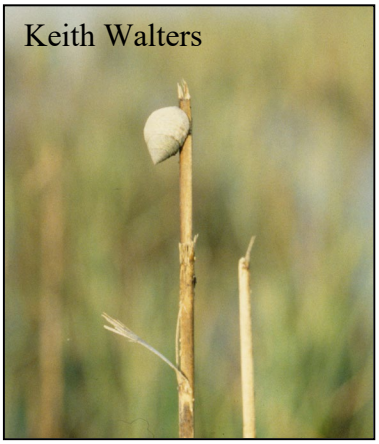
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Marsh Periwinkle

Littoraria irrorata


Keith Walters

Contributors (2005): Keith Walters (Coastal Carolina University) and Loren Coen (SCDNR). Reviewed and Edited (2013, 2023): Andrew Tweel and Peter Kingsley-Smith (SCDNR)

DESCRIPTION

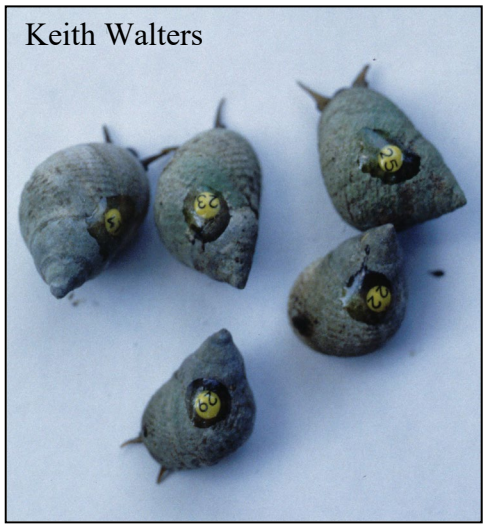
Taxonomy and Basic Description

The marsh periwinkle was first described in the United States by Say in 1822 from specimens collected along the Atlantic shoreline (Say 1822). This gastropod, in the order Mesogastropoda, belongs to an important genus of common marsh snails. They can reach a size of up to 30 mm in shell height. Individual snails are hermaphroditic and capable of reproduction throughout the summer. In South Carolina, maximum settlement of young typically occurs in early to late spring with shell growth to maximum length taking approximately 2 to 3 years. Adult snails can range in color from dark brown to an almost bleached white.

Status

Although the marsh periwinkle is not a threatened or endangered species, it is an important component of the intertidal salt marsh community. Periwinkles may be a major participant in the decomposition of cordgrass, *Spartina alterniflora*, leaves (Bärlocher & Newell, 1994; Silliman & Newell, 2003) through a mutualistic association with leaf fungi (Silliman & Newell, 2003). Marsh periwinkles can serve as an indicator species of the health of saltmarsh habitat, a type that is critical for many species of marine invertebrates and migratory birds.

POPULATION SIZE AND DISTRIBUTION


Keith Walters

The marsh periwinkle is distributed from New England to the Gulf Coast of Texas. In South Carolina, it can be found within vegetated landscapes, from the low water line up to the terrestrial scrub community in most estuarine saltmarshes, including those that contain *Spartina cynosuroides* as well as black needlerush, *Juncus roemerianus* (Failon *et al.,* 2020, Anderson *et al.,* 2022). Although it is an abundant and common species, little is known in South Carolina regarding long-term population trends and related information. Seasonal densities in the mid-marsh can range from 50 to 300 individuals per m^2 with greater densities observed during winter months.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The marsh periwinkle is an obligate saltmarsh resident in which cordgrass may be considered a critical habitat. Individuals can be found inhabiting high-marsh areas around freshwater seeps and low-marsh stems submerged in full strength seawater (> 25 ppt). Short-term studies (less than 2 years) indicate densities within the low marsh zone tend to be lower (less than 100 per m^2) compared to mid-marsh elevations (over 300 per m^2). In some cases, densities in excess of 1,000 per m^2 have been reported (Silliman & Bertness, 2002). Snails are also commonly found above the high water line on the stems of marsh plants; evidence suggests this climbing behavior is in response to blue crab predators (Hamilton, 1976; Vaughn & Fisher, 1992). Marsh periwinkles feed on microalgae and detritus; they may also garden and consume fungal decomposers found on the surface of marsh plants (Silliman & Newell, 2003).



Photo: Periwinkles occurring in very high densities as part of a “snail front” in a salt marsh near Charleston, SC.

CHALLENGES

Major challenges to the conservation of saltmarsh periwinkle populations include the loss of habitat and dramatic alterations to predator populations. The marsh periwinkle has been implicated as a critical consumer of cordgrass and increased snail densities may be responsible for observed declines in intertidal cordgrass, (*Spartina alterniflora*) coverage (Silliman & Bertness, 2002). marsh periwinkle densities have been attributed to reductions in predator pressure (Silliman & Bertness, 2002). Later research has demonstrated that these relationships are more complicated, with potential feedbacks and interactions between both top-down and bottom-up controls (*e.g.,* drought stress; Silliman *et al.,* 2005). Reductions in marsh acreage or quality will also affect snail foraging and survival. Periwinkles appear to have an obligatory relationship with *S. alterniflora*, and the loss of *S. alterniflora* habitat would suggest a negative

effect on snail populations. Periwinkles, however, also appear to have a reciprocal negative effect on *S. alterniflora* in the absence of "natural densities" of predators. The cause of what appears to be an out-of-balance predator-prey dynamic between blue crabs and the marsh periwinkle needs to be determined.

CONSERVATION ACCOMPLISHMENTS

The marsh periwinkle has received little or no attention in terms of past conservation efforts, likely in part because of the ubiquitous distribution of this species within coastal saltmarshes.

CONSERVATION RECOMMENDATIONS

- Further investigate the theory of top-down regulation of *Spartina alterniflora* biomass by the marsh periwinkle.
- Determine whether blue crab predation, in particular, is capable of regulating the distribution and abundance of periwinkles.
- Determine the preferred food(s) of marsh periwinkles.
- Determine whether recruitment is responsible for the initial distribution and abundance of marsh periwinkles.
- Determine the dispersal capabilities of the marsh periwinkle.
- Determine whether *Spartina alterniflora* characteristics and/or environmental conditions determine diet preferences of the marsh periwinkle.
- Determine the fraction of the overall productivity of a marsh that is processed by marsh periwinkles.
- Determine the role of the marsh periwinkle in observed declines of *Spartina alterniflora*, including interactions between drought, wrack depositional events, and periwinkle abundances.
- Determine factors other than predation and *Spartina alterniflora* quality that may account for the naturally patchy distribution of the marsh periwinkle, such as drought or wrack depositional events.

MEASURES OF SUCCESS

A better understanding of cordgrass-marsh periwinkle-predator dynamics is one measure of success. Conservation of predator populations, including blue crabs, may restore balance to the salt marsh systems which would be another measure of success.

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Penaeid Shrimp Guild



Contributors: Larry DeLancey (2015, retired), Michael Kendrick, Graham Wagner, and Greg Rothman (2024, SCDNR)

- **White Shrimp** *Penaeus setiferus* (Linnaeus 1767) (top)
- **Brown Shrimp**, *Penaeus aztecus* (Ives, 1891) (middle)
- **Pink Shrimp**, *Penaeus duorarum* (Burkenroad 1939) (bottom)

DESCRIPTION

Taxonomy and Basic Description

These penaeid shrimp species are among the most well-known shrimp due of their importance in fisheries along the southeastern US coast, including the Gulf of Mexico. They are members of the family Penaeidae, a large group that also contains smaller species common in this geographic area. White shrimp are most abundant in SC, and therefore make up more of the commercial catch, than brown shrimp, and finally pink shrimp. The giant tiger prawn, *Penaeus monodon* is also known from SC waters but is not native to the region.

Penaeid shrimp possess a prominent rostrum with small teeth on both upper and lower margins, and lack postorbital spines. The first three pairs of walking legs are chelate (pincer like). White shrimp can be distinguished from brown and pink shrimp by their lack of a groove along the dorsal midline of the carapace (shell) and last section of the tail (telson). The groove on brown shrimp is wider than on pink shrimp (it is difficult to insert a fingernail in the pink shrimp telson groove). Despite the common names, color is often not a distinguishing characteristic for these shrimp. Pink shrimp usually possess a dark spot on their abdomen, hence the alternative common name “spotted shrimp”. These species can grow to relatively large size, up to 19 cm (8 in.) total length or greater, and are generally harvested starting at about 10 cm total length.

Female penaeid shrimp possess a specialized structure composed of plates on the ventral surface near the last pair of walking legs (thelycum) that receives the spermatophore from male shrimp during mating, prior to releasing fertilized eggs. The male uses specialized appendages located on the first pair of swimming legs (petasma) to place spermatophores on the female (Williams, 1984) using direct fertilization, which differs from broadcast spawning used in some other shrimp.

The spawning season varies by species, but occurs from spring through fall in oceanic waters. White shrimp and pink shrimp have a protracted spawning season from late March to early September, whereas brown shrimp spawning peaks in spring and fall (Williams, 1955; Lindner & Anderson, 1956; Joyce, 1965). Fertilized eggs fall to the bottom where they hatch into a swimming nauplius stage in about 24 hours, which is different than the caridean shrimp that brood their eggs. The nauplius than passes through several protozoea and mysis stages before molting

into the postlarval stage (Pearson, 1939). This process takes several weeks, depending on water temperature and time of year (Lindner & Cook, 1970). Postlarvae move into estuarine areas through inlets, utilizing coastal winds and tidal currents (Bearden, 1961; Wenner *et al*., 2005). Pink shrimp postlarvae are the most abundant penaeid postlarvaal species despite being least abundant subadult and adult stages in SC waters (Wenner & Beatty, 1993).

Penaeid shrimp grow rapidly in shallow estuarine nursery areas in the warm months of the year, predominately in tidal creeks adjacent to salt and brackish water marshes (Williams, 1955; Zein-Elden & Renaud, 1986), then eventually move downstream to areas close to and into the ocean, where they are harvested by both recreational and commercial fishermen. They continue growing and developing as they make their way seaward, and eventually move out of estuarine waters to spawn (Figure 1 below). Commercial fishing involves trawling, which is generally not allowed within estuarine waters.

Penaeid shrimp are omnivorous, feeding on living and dead animal and plant material, including small benthic invertebrates (Hunter & Feller, 1987; McTigue & Zimmerman, 1991). They in turn, are consumed by numerous species, especially finfish, providing an important link between primary and secondary producers and larger predators (Minello & Zimmerman, 1983).

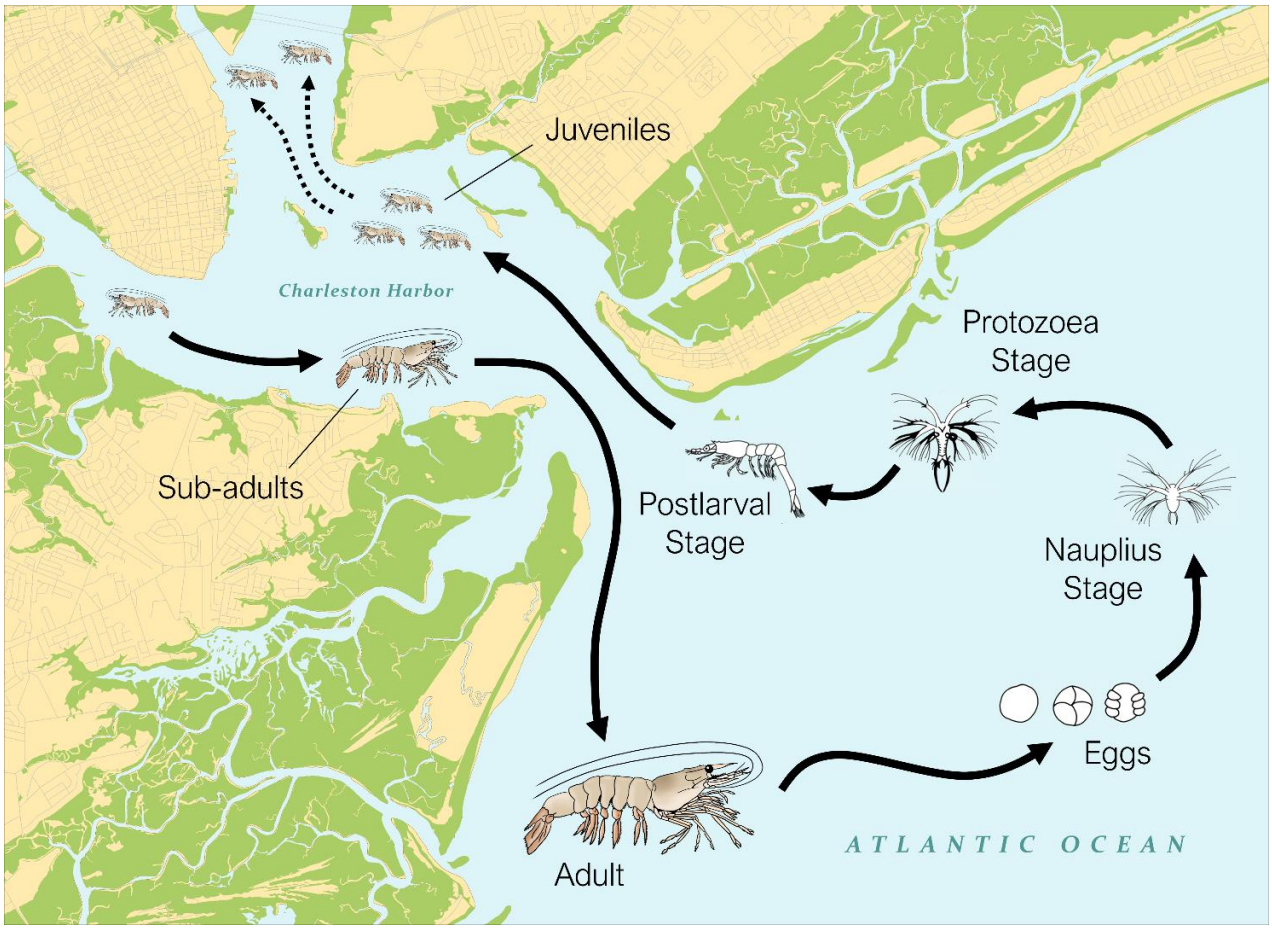


Figure 1: Penaeid shrimp stages of development.

Culturally, Penaeid shrimp are important in South Carolina, with a large emphasis on “boils”, where large amounts of shrimp are consumed at a gathering or event. Many local seafood restaurants also promote serving locally-sourced shrimp. In recent years, however, there has been an increase in Penaeid shrimp imports from overseas, which has negatively impacted the fishery, and caused the declarations of economic disasters in some localities.

Status

Penaeid shrimp have been intensively fished since the early part of the 20th Century leading to management and regulation of commercial and recreational harvests of penaeid shrimp at the state and Federal level in the US. In South Carolina, the Department of Natural Resources (SCDNR) sets openings for the shrimp seasons, and the closing of the commercial trawl season in state waters. In the Exclusive Economic Zone (EEZ), NOAA and the South Atlantic Fisheries Management Council (SAFMC) promulgate regulations through a management plan (http://safmc.net/resource-library/shrimp). The stocks of penaeid shrimp represent some of the most abundant nekton along the coast. Declines in landings in recent years may be driven by multiple factors, including reduced effort driven by high fuel prices and imported shrimp, and/or changes to shrimp population dynamics.

POPULATION SIZE AND DISTRIBUTION

Penaeid shrimp range from at least the mid-Atlantic coast down along the Atlantic and through the Gulf of Mexico (Williams, 1984). Although no population estimates of overall numbers exist off the Atlantic Coast, numbers of all three species are thought to exist in the billions in the Gulf of Mexico, where commercial landings exceed Atlantic landings by an order of magnitude (http://www.st.nmfs.noaa.gov/commercial-fisheries/index; Hart 2011a, b, c). In South Carolina, the commercial trawl fishery averaged over 500 licensees in the most recent decade and is the most valuable commercial fishery in the state in most years. Recreationally, penaeid shrimp are caught in the thousands by fishermen in South Carolina for consumption and bait for fishing by baiting for shrimp or using modified cast net for ‘deep holing’, the latter of which has become increasingly popular in recent years.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

White shrimp occur primarily in shallow waters less than 30 m in depth (Williams, 1984). This reflects some of the adaptations that differ from those of brown and pink shrimp (McMillen-Jackson & Burt, 2003). As year-round residents of shallow water, white shrimp are prone to periodic cold kills from winter cold fronts that generally do not severely impact brown shrimp, which reside in deeper waters in the winter (Williams, 1984), or pink shrimp which burrow into the sediment (Williams, 1955). Larval stages of the penaeids are planktonic in oceanic waters and are therefore influenced by factors such as currents, planktonic food supply, and abundance of various predators such as medusae and fish (Temple & Fisher, 1967; Wong *et al*., 1989; Mills, 1995; Lindquist & Hay, 1996). When penaeid shrimp enter estuaries as postlarvae, they are carried by tidal currents into suitable nursery habitats using cues such as optimal salinity regimes to settle out onto preferred bottom types (Zein-Elden & Renaud, 1986; Wenner & Beatty, 1993). All three species are found over soft bottoms (mud, sand, and clay) with varying levels of detritus, but

juvenile pink shrimp are most abundant in seagrass beds that exist in North Carolina and the Florida Keys (Williams, 1955; Murphey & Fonseca, 1995).

All three species can tolerate a wide range of physical factors, but generally water temperature that falls below 8°C is lethal for white shrimp, which are more tolerant of very low salinity waters (Zein-Eldin & Renaud, 1986; Lam *et al*., 1989).

CHALLENGES

The factors that drive trends in penaeid shrimp wild populations are primarily climatic in nature, whereas the shrimp fisheries have been strongly influenced by both climatic and economic factors. In the second decade of the 21st Century, the stocks and the fishery are in decline in South Carolina and in the neighboring states. Prolonged drought conditions can negatively impact white shrimp stocks and may approximate effects of future freshwater usage demands by a growing coastal human population (DeLancey *et al.,* 2008). Rising sea level, establishment of exotic species such as the tiger shrimp, *Penaeus monodon*, and the black gill are all factors that could be detrimental to penaeid shrimp stocks. Outbreaks of black gill are correlated with large-scale climate indices (Kendrick *et al.,* 2021), can lead to shifts in shrimp susceptibility to predation (Gooding *et al.,* 2019), and are related to infections by multiple parasites (Zuidema *et al.,* 2022). Viruses are another challenge to the penaeid shrimp, especially in South Carolina, particularly via the importation of infected commodity seafood as well as through non-native species. Some recent examples of viruses known to impact penaeid shrimp that have been reported from South Carolina include white spot syndrome virus (Sasson *et al.,* 2024) and infectious hypodermal and hematopoietic necrosis virus (Krol *et al.,* 2024).

A general trend observed over the last four decades of an apparent increase in the frequency of warmer-than-normal winters appears to be resulting in increased survival of white shrimp spawners. Mild winters may be interfering with brown shrimp recruitment mechanisms, however, potentially affecting populations of that species. Also, reduced annual rainfall and increasing salinities in the estuaries appear to be having negative impacts on both white and brown shrimp populations. [Whitaker 2012, SCDNR Climate Change Workshop presentation.]

Climate may be altering migratory and/or reproduction cues, leading to shifts in the timing of spawning. Since the white shrimp fishery is managed, in part, based on ovarian development, the timing of opening of the commercial white shrimp season may shift accordingly. This could have implications for management strategies related to female spawning status for white shrimp, and altered migration patterns could in turn shift estuarine community structure.

CONSERVATION ACCOMPLISHMENTS

Coastal Zone protection laws and regulations have been the most important factors in ensuring adequate and productive estuarine habitats for penaeid shrimp, with destructive activities such as dredging and filling marshland a thing of the past for the most part in South Carolina. More subtle impacts of increased human population growth in the Coastal Plain include increased freshwater usage and non-point source runoff that can degrade water quality. These factors can impact the

ability of the estuaries to produce sustainable shrimp crops (Holland *et al.*, 1996). Efforts to educate the public about resource protection and less impactful development practices have been fruitful and will hopefully continue to inform planning and management decisions affecting shrimp and all coastal resources in the years to come.

CONSERVATION RECOMMENDATIONS

- Continue support for long-term monitoring programs for penaeid shrimp stocks
- Continue research on environmental impacts on species life history and production, especially as it relates to management of the commercial fishery (*i.e.*, spawning)
- Develop population models and innovative disease diagnostic tools
- Improve our understanding of parasite and pathogen communities associated with shrimp, particularly regarding black gill
- Ensure that coastal habitat protection efforts continue
- Collectively pursue alternative energy strategies to lessen dependence on fossil fuels
- Continue to support conservation easements for land in estuarine watersheds

Additional information on penaeid shrimp can be found on the SCDNR website: http://www.dnr.sc.gov/marine/pub/seascience/shrimp.html.

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Plumed worm

Diopatra cuprea



Contributor: Peter Kingsley-Smith (SCDNR)

DESCRIPTION

Taxonomy and basic description:

Commonly referred to as the plumed worm, and also the decorator worm, or sometimes ornate worm, *Diopatra cuprea* (Bosc, 1802) is a species of polychaete worm in the family Onuphidae.

Onuphid polychaetes have captured the imagination of scientists for more than a century, with some of the earliest reports remarking on the size, beauty, and charismatic behavior of incorporating debris into an elaborate tube (Verrill & Smith, 1874; Saint-Joseph, 1898; Linville, 1903). The skin of *D. cuprea* is brilliantly iridescent and there are five long antennae protruding from the head beneath which are impressive, spiraled gills.

As its common name of the decorator worm suggests, *D. cuprea* builds conspicuous tubes that project a few inches above the sediment surface that are typically composed of plant fibers, shell fragments, seaweeds, sticks, and other debris bound together by a mucous polysaccharide material secreted from glands beginning at the sixth segment (Linville, 1903). The worm captures material for its tube by extending several centimeters from its tube, capturing material with its palps and its jaws, maneuvering materials into position, and integrating them into the tube wall using the mucous secretions. Myers (1972) reported that *D. cuprea* prefers 'tabular' materials and appears to use progressively smaller items along the axis from the tube opening towards the sediment surface.

The part of the tube beneath the sediment surface is comprised of a parchment material entirely secreted by the worm itself. It has the appearance off a smooth, collapsible, straight, grey tube, the upper end of which is turned downwards facing the substrate surface to prevent sediment from entering the tube (Ruppert & Fox, 1988). The tube of *D. cuprea* can reach deep (> 1 m) into the sediment (Berke, 2022), emerging above the surface in a decorated 'tube cap' (Hartman, 1959; Day, 1967).

Diopatra cuprea is an active omnivorous predator that feeds on its own gardens as well as those of other conspecifics. Algae and invertebrates found in the stomachs of *D. cuprea* suggest that 'gardening' plays a major role in explaining why this species decorates its tube (reviewed by Berke *et al*., 2006; Berke, 2012). In North Inlet, SC, *D. cuprea* has also been documented to scavenge on dead fish (Berke, 2022).

Status

The status of *D. cuprea* in South Carolina is currently known as it is not the target of any standardized surveys, does not support a directed fishery, and is not listed on any recognized Federal or state conservation list. That being said, its ecological importance is in little doubt, given its role as an ecosystem engineer and its facilitation of trophic connections to other species and increases in biodiversity of mudflat habitats, described in more detail in this account. It also faces a number of threats that support the need for its conservation status to be further explored.

POPULATION DISTRIBUTION AND SIZE

The plumed worm, *Diopatra cuprea* occurs from Massachusetts to Brazil on muddy tidal flats (Fauchald, 1977), with its northern limit set by cold temperature (Mangum, 1969; Mangum & Cox, 1971; Myers, 1972).

HABITAT / NATURAL COMMUNITY REQUIREMENTS

At cold temperatures, *D. cuprea* stops feeding between 5°C and 8°C (Mangum, 1969; Mangum & Cox, 1971) and stops maintaining its tube below 1.8°C (Myers, 1972). As is the case for most estuarine organisms, *Diopatra* spp. exhibit a wide salinity tolerance, from 15 to 40 ppt (Berke, 2022). Typical habitats of *D. cuprea* include protected intertidal and shallow subtidal flats of muddy sand or sandy mud, while generally avoiding areas of pure sand, pluff mud, or clay (Verrill & Smith, 1874; Mangum *et al*., 1968; Peckol & Baxter, 1986; Berke, 2012).

The ecosystem engineering effect of the tube-building behavior of *Diopatra* is one of the earliest examples of facilitation (Woodin, 1978; Wright & Jones, 2006; Cuddington *et al*., 2007; Berke, 2010), with biogeographic variation in this ecosystem engineering role described in Berke (2012). The tubes of *D. cuprea* stabilize the sediments and provide refuge for infauna (Woodin 1978, 1981) by physically excluding predators, such as epibenthic fish, skates, rays, crabs, shorebirds, and horseshoe crabs; these effects are summarized in Berke (2022). The tubes can also serve to increase recruitment by the entrainment of passively dispersed larvae (Eckman, 1983), although this effect varies with tube density (Woodin 1978, 1981). In the northwest Atlantic, juvenile fish have been shown to have a diel pattern of habitat use for *D. cuprea* tubes, spending daylight hours sheltering in beds of tubeworms but venturing out into open habitats to forage at night (Diaz *et al*., 2003). A summary of the ecological interactions involving *D. cuprea* was recently written and presented illustratively by Berke (2022), summarizing that *D. cuprea* increases the diversity and abundance of other organisms.

By actively attaching algae to its tube, *D. cuprea* can also create an algal canopy on intertidal flats that would otherwise lack stable, attached algal populations, thereby acting as a foundational species in a facilitation cascade (Thomsen & McGlathery, 2005; Thomsen *et al*., 2010; Gribben *et al*., 2019). The single tube of a *D. cuprea* worm can support > 300 mg of algal biomass representing multiple species (Berke, 2012), although

the degree of interaction with algae can vary spatially, particularly in relation to current velocity (Berke, 2022). The facilitation of algal communities by *D. cuprea* extends beyond that of native algal species; indeed, *D. cuprea* has been implicated in the facilitation of the non-native algal species, *Agarophyton vermiculophyllum* (formerly *Gracilaria vermiculophylla*) (Keller *et al*., 2019; Thomsen *et al*., 2005; Wright *et al*., 2014). While invasive, however, *A. vermiculophyllum* provides habitat to native species, including epibenthic invertebrates (Wright *et al*., 2014) and juvenile blue crabs (Johnston & Lipcius, 2012; Gribben et al., 2019), thereby potentially increasing secondary production in some habitats (Thomsen *et al*., 2018).

THREATS

Species of *Diopatra* are impacted by anthropogenic activities on multiple fronts, including climate change, harvesting for the bait trade, human-assisted transport, and interactions with invasive species. At least in terms of *D. cuprea*, as of 2022 (Berke, 2022), in relation to climate change-driven changes in geographic extent, its northern range limit appears to be stable. The extent to which *D. cuprea* will be impacted by higher temperatures in subtropical habitats, such as the coast of South Carolina, however, remains largely unexplored, according to Berke (2022). This includes an assessment of how intertidal vs subtidal populations may be differently affected by temperatures over the course of daily, seasonal, and annual timeframes in terms of the effects of both increased air and water temperatures.

Intertidal *Diopatra* are dug for use as fishing bait throughout western Europe, however the extent to which South Carolina populations of *D. cuprea* are affected by this human disturbance is currently unknown.

Superblooms of *A. vermiculophyllum* can lead to sediment anoxia and *D. cuprea* death such that under certain circumstances this invasive alga can present a threat to this important ecosystem engineer (Keller *et al*., 2019), potentially leading to long-term population declines. The conditions that lead to *A. vermiculophyllum* blooms, their frequency and effects on invertebrates, including D. cuprea, warrant investigation.

CONSERVATION ACCOMPLISHMENTS

The plumed worm, *Diopatra cuprea* has not been the subject of targeted conservation efforts likely due to the data deficient nature of this species to indicate that its number have been in decline, either as a result of natural or anthropogenic factors. The species is currently not listed as either threatened or endangered at either the state or Federal level, which also explains the lack of targeted conservation efforts.

CONSERVATION RECOMMENDATIONS

In general, there appears to be more information available on the effects of *D. cuprea* on other organisms than there is on the worm itself. More information is needed on the environmental tolerances of *D. cuprea*, as well as more research on its feeding biology,

reproductive cycles, and population dynamics, especially for populations subject to harvesting or close to geographic range limits. The potential impacts of climate change on *D. cuprea* populations in South Carolina are poorly understood, which is concerning given the important nature of the ecological interactions between this species and other native fauna on intertidal mudflats.

A better understanding of the spatial distribution and baseline life history of *D. cuprea* would be first order measures of conservation success. Such an understanding would enable the impacts of disturbances to be conceptualized but also provide protection to critical habitats for this species. The conservation of healthy populations of *D. cuprea* has important implications for the species that utilize it as prey directly, or that feed on fauna that comprise components of its 'gardens'.

Furthermore, there is a research need to compare the functionality of *D. cuprea* + *A. vermiculophyllum* and *D. cuprea* + native algae in terms of ecosystem services provided by these different facilitations.

Berke (2022) also commented that the taxonomy of the genus *Diopatra* is in a period of rapid revision and urges those working on this genus to stay apprised of taxonomic developments in their geographic region and recommends that retention of voucher specimens and tissue samples for genetic analyses whenever possible.

MEASUREMENT OF SUCCESS

More information is needed regarding population distribution and trends in State waters for *D. cuprea*, as well as a better understanding of the life history of the worm itself (as compared to studies on its provision of services to other species which by comparison has received more attention). A better understanding of the threats to this species, particularly in terms of pressures from climate change, could form part of a conservation plan for *D. cuprea* in South Carolina. Documenting stable population trends for *D. cuprea* within South Carolina waters would be the ultimate measure of success for this species and its associated communities.

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Portunid crab guild (selected species from the family Portunidae)

Contributors (2024): Michael Kendrick, Graham Wagner, and Greg Rothman (SCDNR)

- Blue crab *Callinectes sapidus* Rathbun, 1896



- Lesser blue crab *Callinectes similis* Williams, 1966



- Rugose swimming crab *Callinectes exasperatus* Gerstaecker, 1856



- Ornate swimming crab *Callinectes ornatus* Ordway, 1863



- Speckled swimming crab *Arenaeus cribrarius* (Lamarck, 1818)



- Iridescent swimming crab *Achelous gibbesii* (Stimpson, 1859)



- Blotched swimming crab *Achelous spinimanus* (Latreille, 1819)



DESCRIPTION

Taxonomy and Basic Description

The family Portunidae comprises the swimming crabs, whose final segment (dactyl) of the fifth walking leg is flattened to a paddle-like appearance to enhance swimming ability. This modified swimming appendage has allowed members of this family to be effective and aggressive predators. Additionally, portunid crabs are a food source for a number of commercially- and recreationally important finfish species. As such, it is thought that members of this family play an important role as a link in the food web between benthic primary consumers, and higher-order benthic and pelagic consumers. Two portunid crabs are non-native in SC, including the Indo-Pacific swimming crab *Charybdis hellerii* (A. Milne-Edwards, 1867) and Bocourt's swimming crab *Callinectes bocourti* A. Milne-Edwards, 1879, and present potential threats to native portunids. Many portunid crabs will also eat carrion and detritus, strengthening their position as links in marine and estuarine food webs.

The family Portunidae is of global economic importance, supporting large fisheries in the Americas and Asia. In South Carolina, there is representation from several genera within the family Portunidae; however, the Atlantic blue crab, *Callinectes sapidus*, being of commercial, recreational, ecological and cultural importance, has resulted in a greater focus to study its life history and biology when compared to the other species in this family. Therefore, our understanding of the ecological role of this family within marine and estuarine environments is often inferred from that of *C. sapidus*.

The genus *Callinectes* Stimpson 1860, is one of the more predominant genera of portunid crabs in South Carolina. This genus can be distinguished from other genera within the family by the absence of a mesiodistal spine along the carpus of the cheliped, as well as the abdomen of males being T-shaped. The Atlantic blue crab, *Callinectes sapidus*, can be distinguished from the closely related lesser blue crab, *C. similis*, by its larger adult size (> 13 cm carapace width), red coloration on the chelipeds (claws), and the presence of two interorbital teeth of the frontal margin of the carapace compared to the four interorbital teeth present in *C. similis*, *C. bocourti*, *C. ornatus*, and *C. exasperatus. Callinectes sapidus* also displays a more bluish-green color on the carapace, whereas *C. similis* is characterized by a more violet hue on the carapace and legs (Williams, 1984). *Callinectes bocourti* is olive green in color with prominent red markings, and red to brown chelipeds. These crabs are native to the Caribbean and South America but have been reported from commercial crab pots in South Carolina. *Callinectes ornatus* is olive to dark brown with a large roundish spot of orange on each side posteriorly. The chelipeds are spotted with blue or soft purple, and the walking legs are blue with a band of scarlet at each joint. *Callinectes exasperatus* has a purplish-red carapace, and the dorsal surface of all legs are purplish-red with intense orange-red on articulations.

Arenaeus cribrarius can be distinguished from other portunid crabs by a carapace that is more than twice as wide as it is long, light brown or gray in color, with many small rounded white or yellow spots.

Charybdis hellerii is native to the Indo-Pacific Ocean, but has been documented in the south Atlantic (Lemaitre, 1995), specifically in South Carolina. It has a more rounded carapace that is dark olive or brown, and dark purple tips of chelipeds. There are six prominent teeth on the front margin of the carapace. It is unknown how this non-native portunid affects the native portunids and the greater marine and estuarine systems in South Carolina.

Achelous spinimanus and *A. gibbesii* can be differentiated from other portunid crabs by their relatively long chelipeds, a spine on the upper propodus, and purple and/or red markings on the carapace. *Achelous spinimanus* has a carapace that is considerably less than twice as wide as it is long, and yellowish or reddish brown in color, as well as white blotches on the chelipeds. *Achelous gibbesii* has a carapace that is approximately twice as wide as it is long, brownish-red in color, purple walking and swimming legs, and considerable iridescence.

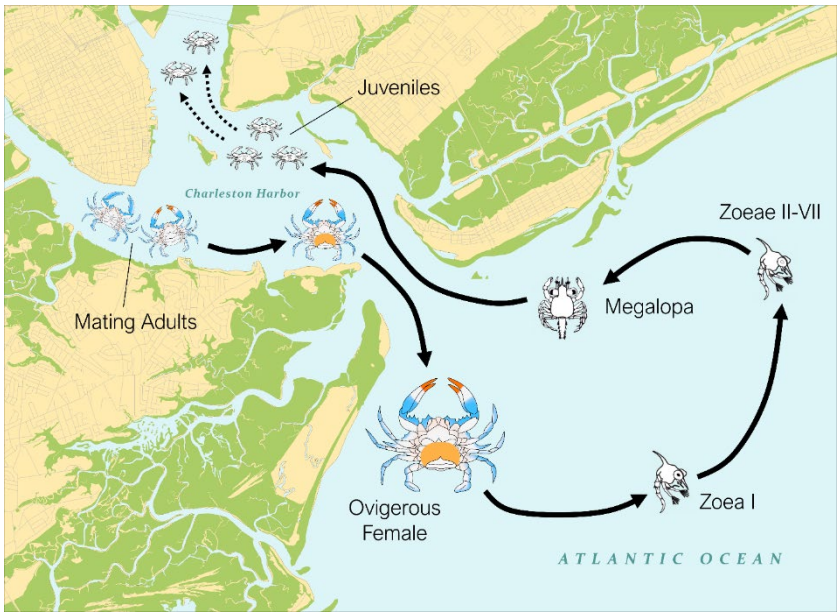


Figure 1: Atlantic blue crab *C. sapidus* development cycle.

Much of the life history information for portunid crabs as a family is inferred from that of the Atlantic blue crab, as its commercial and cultural importance have resulted in a greater research focus. Generally, spawning in *C. sapidus* occurs after the female undergoes a terminal molt and is impregnated by the male crab while she is in a "soft" state, prior to the exoskeleton hardening (Van Engel, 1958). Females will carry sperm internally until they deposit eggs that attach to setae on specialized pleopods, forming an egg mass (sponge). Several sponges can be produced from a single mating event (Hines *et al.*, 2003); however, there is evidence that the quality of the sperm, and therefore the resulting brood of eggs, degrades over time (Hines *et al* 2003). Figure 1 above represents the general life cycle of portunid crabs. Mature females migrate close to or into the ocean prior to eggs hatching; in South Carolina, this occurs from March through early fall for *C. sapidus* (Eldridge & Waltz, 1977). In the case of *C. similis,* summarized data on spawning of *C. similis* in areas including South Carolina, suggesting a spring and fall spawning season (Williams, 1984). Among the other genera, less is known about these periods of spawning, particularly in South Carolina; however, it is noted that ovigerous females of both *A. spinimanus* and *A. gibbesii* are known to occur in North Carolina from May – October and May – August, respectively (Williams, 1984). Much of the research related to the reproduction of *Arenaeus cribrarius* has taken place in Brazil, where mating occurs in the fall, and ovigerous females can be found year-round, with peaks in abundance occurring in spring and summer (Pinheiro & Fransozo, 2002).

Eggs hatch into a zoea stage and are carried offshore where they undergo development through several zoeal stages (Costlow & Bookhout, 1959; Epifanio, 1995). After a period of several weeks, the last zoea stage molts into the megalopa stage and returns to coastal waters from offshore, utilizing tidal and wind driven currents, and eventually entering the estuaries (Boylan & Wenner, 1993; Epifanio, 1995). Megalopae transform into juvenile crabs which gradually move upstream into nursery areas, such as tidal creeks in South Carolina, or seagrass beds in North Carolina and the Chesapeake Bay, as they pass through a series of molts (Orth & van Montfrans, 1987; Mense & Wenner, 1989; Whitaker *et al*., 1998; Etherington & Eggleston, 2000). Atlantic blue crabs mature in 6 months to two years, depending on geographic location, with crabs maturing faster in warmer climes (Tagatz, 1968).

Status

Since the late 1970s, SCDNR crustacean biologists have monitored the health of the *C. sapidus* population in South Carolina to manage the species for future generations. The team currently operates multiple surveys to study the status of *C. sapidus* status across the state. Data from these multiple surveys show that, beginning with a severe drought around 2000, *C. sapidus* has experienced two decades of decline.

The status of the other members of the family Portunidae in South Carolina is not known, but threats from climate change and non-native species, including congeners and confamilials, may threaten native portunid crabs.

POPULATION SIZE AND DISTRIBUTION

Callinectes sapidus ranges from Massachusetts, down the Atlantic Coast, through the Gulf of Mexico, and into South America (Williams, 1984). Recent stock assessments for the Chesapeake Bay estimate the number of blue crab to be approximately 500 million individuals in that area (http://dnr.maryland.gov/fisheries/crab/dredge.asp), with annual landings averaging approximately 50 million lbs (http://www.st.nmfs.noaa.gov/commercial-fisheries/index).

Most of South Carolina's *C. sapidus* harvest is commercial. Recreational crabbers are believed to represent a relatively small fraction of harvest pressure in South Carolina. Economic and environmental pressures elsewhere along the east coast of the United States strongly impact South Carolina's commercial blue crab fishery. Shortages of crabs in the mid-Atlantic United States, for example, have driven prices high coast-wide, subsequently increasing harvest pressure in South Carolina. Landings have declined in recent years, reaching a 50-year low in 2021. At the same time, because of soaring prices nationally, the total value of landings is near record levels. In recent years (2015-2022) the number of commercial crab licenses sold has ranged from 358-389 per fiscal year. In 2021 (fiscal year) there were 389 licensed crab harvesters with a total number of 36,242 licensed pots/traps. The number of pots per license holder ranged from 50 (the minimum) to 800, although most commercial harvesters (93%) fished 200 pots or fewer. Additionally, there were 35 licensed peeler (soft-shell) dealers and a single crab trawl permit issued in 2021 (SCDNR, 2023).

Callinectes similis ranges from Delaware Bay, down the Atlantic Coast, and through the Gulf of Mexico. *Callinectes exasperatus* ranges from the mid-Atlantic through the Gulf of Mexico and Central America and into Brazil. *Callinectes ornatus* ranges through the western Atlantic, from North Carolina down into the Gulf of Mexico and through the Caribbean. *Arenaeus cribrarius* ranges from Massachusetts, down the Atlantic coast of the US, through the Gulf of Mexico, and down into Brazil and Argentina in South America. Despite having a wide latitudinal distribution, much of the life history information regarding *A. cribrarius* results from work done in South America. *Achelous spinimanus* ranges from the coast of Virginia, through the south Atlantic and into the Gulf of Mexico. *Achelous gibbesii* ranges through the mid- and south-Atlantic regions of the US and into the Gulf of Mexico. It also reaches through Central America into the northern portions of South America.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Some *C. sapidus* inhabit oceanic waters as adults, but all undergo larval development in the ocean, relying on winds and ocean currents for distribution back to nearshore habitats before entering estuaries as megalopae (Epifanio, 1995). Recent changing climatic conditions could negatively influence many biological and physical factors that affect the survival and recruitment of larval crab (NEFSC, 2009). In the estuary, *C. sapidus* can be widely distributed across habitats from euryhaline to freshwater environments, depending on geographic location, season, and life stage (Williams, 1984). In South Carolina, small *C. sapidus* inhabit marsh-tidal creek habitats, mudflats, and oyster reefs (Mense & Wenner, 1989; Kingsley-Smith *et al.,* 2012) whereas larger *C. sapidus* move upriver in the warmer months (Archambault *et al.,* 1990; Childress, 2012). *Callinectes sapidus* feed opportunistically on a wide variety of live and dead food items but seem to prefer bivalve mollusks when available (Darnell, 1958; Hines *et al.,* 1980; Laughlin, 1982; Fitz & Weigert, 1991). Blue crabs are preyed on by many species, including sharks and sea turtles (Frazier, SCDNR, pers. comm.). Although tolerant of a wide range of conditions such as relatively low dissolved oxygen, drought, and high freshwater runoff, good water quality and undegraded estuarine habitats help to ensure the sustainability of the blue crab resource (Eldridge & Waltz, 1977; Engel & Thayer, 1998; Bell *et al.,* 2003; Bauer & Miller, 2010; Childress, 2012).

While *C. sapidus* and *C. similis* are known to co-occur, there may be differences in habitat preferences over small spatial scales. *Callinectes similis* has been documented to utilize more open water bay and estuarine waters as juveniles, whereas *C. sapidus* juveniles recruit to more shallow salt marsh systems in the Gulf of Mexico (Hsueh *et al.,* 1993). It is unknown if this habitat preference is retained in South Carolina.

CHALLENGES

As a heavily fished stock, *C. sapidus*—as is the case for most exploited species—is probably vulnerable to overharvesting, but that condition is difficult to document. Apparent population declines in the past have usually been followed by rapid recoveries (Sharov *et al.,* 2003). Efforts to cap the number of commercial licenses as a means of stabilizing fishing effort have been unsuccessful in South Carolina to date. Projected human population growth along the coast may be detrimental if development is not carefully planned to minimize runoff and non-point source pollution (Engel & Thayer, 1998). Increased water demands (Wilber, 1994) may alter estuarine salinity patterns. Educating the public and garnering support for lower impact development may

be the greatest challenge facing resource managers regarding blue crab and all species that utilize the estuaries. Derelict fishing gear in the environment can continue passively trapping portunid crabs in a process known as ghost fishing. There is currently no known estimate of the impacts of ghost fishing on portunid crabs as a collective group in South Carolina. Additionally, as climate changes, there is an expectation for the life history regimes of marine and estuarine organisms to shift. Many migratory and reproductive cues are environmental in nature, and therefore are susceptible to changing conditions. Furthermore, warming temperatures allow for the poleward expansion of marine organisms, which can create niche overlap and competition as species expand their ranges. There are several non-native portunid crabs in South Carolina, and it is unknown how their presence is affecting native portunids.

Predation by non-native blue catfish, *Ictalurus furcatus*, has been shown to be a source of mortality of portunid crabs, especially for juveniles that inhabit lower salinity waters (Fabrizio *et al.,* 2021). Other concerns include pathogens, such as viruses and parasites, that are known to infect and potentially impact populations of the Atlantic blue crab, and most likely other portunid crab species, including but not limited to: White spot syndrome virus (WSSV) (Powell *et al.,* 2015), *Callinectes sapidus* reovirus 1 (CsRV1) (Flowers *et al.,* 2018), and the dinoflagellate, *Hematodinium* sp. (Stentiford & Shields, 2005).

CONSERVATION ACCOMPLISHMENTS

Regulations on minimum size and prohibition of possession of egg-bearing females have ensured some protection of the *C. sapidus* stock in South Carolina. Protection of the Coastal Zone by legislation passed in the 1970s lessened the scale of destructive human activities such as dredging and filling of marshes and improved treatment of wastewater (Engel & Thayer, 1998). The protective stance and support of organized conservation groups such as the Coastal Conservation League and SC Wildlife Federation have promoted continued awareness of threats to the coastal environment in South Carolina. Genetic characterization of blue crab populations in SC suggests that the Charleston Harbor *C. sapidus* population is genetically 'healthy' (Cushman & Darden, 2017).

CONSERVATION RECOMMENDATIONS

- Investigate contemporary updates to our understanding of portunid crab life histories, given that much of the work to understand this is from decades ago. This is important in the context of climate change, anthropogenic impacts, and fishing pressures.
- Support efforts by SCDNR to manage the commercial blue crab fishery more actively by stabilizing effort and exploring short term closures or limits on harvest of female blue crab during times of low population abundance.
- Collect data, including survey information, to improve our understanding of the numbers of crabs removed from populations by the harvesting of blue crabs and the impacts of these practices on wild populations.
- Continue to support outreach and education and acquiring basic knowledge about the blue crab resource within an ecosystem context. Fishermen and interested members of the public should be involved in these efforts.
- Promote continuing monitoring and protection of critical habitats.

- Examine modeling techniques that have predictive value to assess how future human population growth and climate change will impact watersheds and blue crab stocks.
- Explore the reproductive biology of portunid crabs, given the short mating window following a female's terminal molt, and the possibility of sperm limitation
- Explore how changes in climate may be altering the movement and development patterns of portunid crabs in South Carolina.
- Empirically measure the impacts of derelict fishing gear on portunid crab populations.
- Establish reliable distributions and abundances of nonnative portunid species in South Carolina. This will help in understanding the impacts of nonnative species on native portunids.

Additional information on blue crab can be found on the SCDNR Website:
http://www.dnr.sc.gov/marine/species/bluecrab.html,
http://www.dnr.sc.gov/marine/pub/seascience/bluecrab.html

MEASURES OF SUCCESS

As the above-mentioned action items are accomplished and yield valuable information, adaptive management procedures will be evaluated and implemented for this crab species.

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Purple Marsh Crab

Sesarma reticulatum Say, 1817

Contributor: Andrew Tweel (SCDNR, 2024)



DESCRIPTION

Taxonomy and Basic Description

The purple marsh crab, *Sesarma reticulatum* Say, 1817 is a grapsid crab (family Grapsidae, shore or marsh crabs) characterized by scattered setae, a dark olive, black or purple carapace approximately 28 mm wide (Williams, 1984). This species is found in salt marshes, particularly the lower, muddier portions where it produces a burrow often found with a mud chimney (Ruppert & Fox, 1988).

Status

There are no population level estimates for this species, but it has been documented as playing a significant role in overall salt marsh ecology through the consumption of smooth cordgrass, *Spartina alterniflora* and the deposition of fecal pellets on the marsh surface (Day *et al.,* 1973; Williams, 1984). They also play a role in increasing the disturbance or turnover of salt marsh soils and decomposition processes.

POPULATION SIZE AND DISTRIBUTION

The purple marsh crab is found from Woods Hole, MA to Volusia County, FL, and in the Gulf of Mexico from Sarasota, FL to Calhoun County, TX. In South Carolina, *S. reticulatum* can be found in salt marshes, particularly the lower elevation, often muddier portions. The reported salinity preferences of this species range from 16 ppt to 20 ppt, but they are able to tolerate a much broader range.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Their habitat is the lower elevation portions of salt marshes, usually those that contain siltier sediments. In Georgia, this species has been found to be active when the marsh is flooded or during overcast conditions (Teal, 1959).

CHALLENGES

Recent research has highlighted the potential role that this species may play in shaping the morphology and evolution of salt marsh creeks in areas where they are highly abundant (Crotty *et al.,* 2020). Changes in sea level and inundation were reported to alter substrates and shift available habitat in favor of this species, which can trigger a cycle of excessive grazing, subsequent erosion, and altered channel morphology. Similarly, in high densities this species has

been associated with die off events or reduced productivity in southeastern US salt marshes (Angelini *et al.,* 2018).

CONSERVATION ACCOMPLISHMENTS

None known.

CONSERVATION RECOMMENDATIONS

Future research is needed to better understand how *S. reticulatum* may be affected by changes in sea level and inundation, and what impacts this might have on the greater salt marsh landscape and ecological cascades. These changes may also alter the cycling of nutrients and carbon through burrowing or decomposition processes (Wilson *et al.,* 2022). Conservation of salt marshes is critical toward preserving the landscape and ecology of the South Carolina coast, so a better understanding of predator-prey and other competitive relationships is important.

MEASURES OF SUCCESS

If measures of abundance and population demographics of *S. reticulatum* are conducted as part of regular monitoring efforts that are currently established to monitor macroinvertebrates associated with salt marsh habitats, this could be a cost-effective way to collect data to provide baseline information. If continued over a longer period, these data would be able to follow population trends, which will allow managers to make decisions regarding possible conservation measures for this species. The overall measure of success for *S. reticulatum* will be stable population trends along the entire coast, as part of the increased conservation and restoration of salt marsh habitat in South Carolina.

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Ribbed Mussel

Geukensia demissa (Dillwyn, 1817)



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DESCRIPTION

Taxonomy and Basic Description

The ribbed mussel, *Geukensia demissa*, Dillwyn 1817 is a member of the bivalve molluscan family Mytilidae, previously included in the genera *Modiolus* and *Brachidontes*. It is relatively large, in coastal South Carolina growing to approximately 100 mm in length (see models in Julien *et al*., 2020a). The surface is grooved with obvious ribs from which its name is derived. It has a glossy brown-black shell, often with some yellow to a bleached white color on the exterior surface; the inner surface is generally white. It has no external siphon; rather it draws water loosely over its gills.

The ribbed mussel is distinguished from other South Carolina intertidal mussels by its oblong shape, parallel dorsal and ventral margins, very close exterior ridges, and the lack of teeth on the hinge. The other common mussels in South Carolina, *Brachidontes exustus* (scorched mussel) and *Ischadium recurvum* (hooked mussel), differ in several aspects. Both of these species reach sizes as adults of no more than 2.5cm to 5 cm (1-2”). Furthermore, the scorched mussel has a higher divergent angle from the umbo than the ribbed mussel, small cardinal teeth on the hinge, and its shell is thicker and stouter than that of the ribbed mussel.

Ribbed mussels are not hermaphroditic, and their sexes can be determined by the color of the mantle tissue. The mantle tissue in females tends to be a medium brown whereas the mantle tissue in males tends to be a yellowish-cream color. Reproduction usually occurs in spring and peaks by midsummer. Mussels are not known to spawn more than once in a season.

Status

The ribbed mussel is not a Federally-listed species; however, it is an ecologically important species in coastal estuaries in South Carolina that is susceptible to threats from harvesting pressure and other anthropogenic disturbances to habitat quality. Ribbed mussels do not seem to be declining in South Carolina; however, comparatively little is known about their populations here compared to the northeastern United States (except see recent studies by Julien *et al.,* 2019, 2020a,b). There are currently no fishery regulations through the South Carolina Department of Natural Resources that are species-specific to ribbed mussels; rather this species falls under the same regulations in terms of seasons, size limits, etc. that apply to other shellfish species, such as oysters (*Crassostrea virginica*). For example, there is no commercial harvest limit for the ribbed mussel in South Carolina and there are no best management practices for this species.

POPULATION SIZE AND DISTRIBUTION

The ribbed mussel inhabits salt marshes along the eastern coast of North America from the Gulf of St. Lawrence to Florida, forming dense aggregations in the marsh substrate (Bertness, 1984; Bertness & Grosholz, 1985). It also occurs in the Gulf of Mexico from Florida to the Yucatan. Although the actual population size of ribbed mussels is unknown for South Carolina, this species is assumed to be very abundant and forms rather dense colonies (Franz, 2001)

The relationship between shell height and age has recently been described by Julien *et al.* (2020a), with age determined through counting the number of external growth bands in the shell (described by Brousseau, 1984, Bertness & Grosholz, 1985). From this study, ribbed mussels were estimated to reach market size (76mm shell height) in approximately 3 years. Individuals with more than 10 growth bands were not uncommon and the oldest aged individual had 17 growth bands. Patch densities of ribbed mussels in South Carolina have been recorded as ranging from 352.3 ± 20.0 to 566.8 ± 41.0 individuals m^{-2} (mean ± S.E., Julien *et al.,* 2020a) or even as high as over 1,500 per m^2 (Coen *et al*., 1999; Luckenbach *et al*., 2005). Natural recruitment rates of ribbed mussels have been found to be low, especially following the removal of conspecifics from manipulated study plots (see Julien *et al.,* 2020a), supporting the premise that settlement is gregarious in this species (Bertness & Grosholz, 1985). Although growth rates decline at higher shore levels, this is offset by increased survival at higher elevations (Bertness, 1980; Bertness & Grosholz, 1985; Stiven & Gardner, 1992; Franz, 2001).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS



The ribbed mussel is an important ecosystem engineer in salt marshes along the eastern coast of North America from Canada to Florida (Alteri *et al.,* 2007, Angelini *et al.,* 2015, Bertness, 1984) where it is most commonly found associated with the smooth cordgrass, *Spartina alterniflora*, but may also occur in association with *Juncus roemarianus* (A. R. Julien, pers. obs.) as well as amongst intertidal oyster (*Crassostrea virginica*) reefs. Ribbed mussels increase the structural complexity of the habitat, both as living and dead animals (Kuenzler, 1961; Bertness, 1980; Jordan & Valiela, 1982; Bertness & Grosholz, 1985; Borrero, 1987; Borrero & Hilbish, 1988; Kemp *et al*., 1990; Stiven & Gardner, 1992; Franz, 1993, 1997). Ribbed mussels attach by byssal threads to any hard substrate like oyster shells and cordgrass stems and protrude above the surface. In South Carolina, one can typically find ribbed mussels embedded in and amongst salt marsh sediments attached by byssal threads to each other and/or to *Spartina* stalks. Unlike oysters, and like other mussel species, ribbed mussels have the ability to reattach if dislodged using their byssal threads, providing them with more opportunities to respond to disturbance. That said, the ability of ribbed mussels to repopulate at a local scale following simulated harvest and removal has been shown to be limited (Julien *et al.,* 2020a).

The ribbed mussel is a common filter feeder within a range of intertidal South Carolina intertidal habitats including marshes, pilings (Lent, 1969), and oyster reefs (Coen *et al*., 1999, 2004; Coen & Luckenbach, 2000; Luckenbach *et al*., 2005). Filter feeders improve water quality and affect nutrient cycling in estuarine habitats, especially with regard to the water-column microbiota community structure. Ribbed mussels are one of the few bivalves able to forage on small-sized bacterioplankton (Newell & Kambeck, 1995; Kreeger *et al.,* 1990), with most bivalves only consuming larger phytoplankton. At low tide, in general, the valves typically remain tightly closed to conserve water. Lent (1967, 1969), however, showed that ribbed mussels exposed at low tide are capable of respiring by "air-gaping."

The distribution of ribbed mussels poses a regional scale ecological question, as it appears to vary in relation to latitude. At northern latitudes, such as in the northeastern United States, ribbed mussels are most abundant at the edge of the marsh, forming a dense, continuous band (Bertness, 1984; Bertness & Grosholz, 1985). In the high marsh platform, which is characterized by short-form *Spartina alterniflora* (Valiela *et al.,* 1978), ribbed mussel abundance is low (Bertness & Grosholz, 1985). At southern latitudes, including the southeastern United States region, ribbed mussels are not found at the edge of the salt marsh in a continuous band; instead, ribbed mussels forms discrete, dense patches in the high marsh platform and near the mouths of tidal creeks (Kuenzler, 1961; Lent, 1969; Stiven & Gardner, 1992). The driving mechanisms responsible for these two distinct distribution patterns are unclear, although the difference has been attributed to variation in predation intensity (Nielsen & Franz, 1995).

Previous studies attempting to characterize the distribution of ribbed mussels have mostly focused on their relationship with biological variables, with several studies concluding that ribbed mussel distribution differs depending on salt marsh vegetation characteristics and location within the salt marsh. For example, Kuenzler (1961) noted that at a site on Sapelo Island, GA, ribbed mussels were most abundant near the mouths of creeks that supported tall-form *Spartina alterniflora* (size morphologies of *S. alterniflora* are described by Valiela *et al*., 1978). Kuenzler (1961) also observed lower abundances of ribbed mussels at higher elevations associated with short-form *S. alterniflora*. Other studies (*e.g.*, Bertness & Grosholz, 1985; Stiven & Gardner, 1992; Franz, 2001) have focused on the importance of salt marsh vegetation to the distribution of ribbed mussels, noting that they tend to occur in association with tall-form *S. alterniflora*. These studies only focused on small-scale factors that influence the distribution of ribbed mussels (*e.g.,* the importance of a microhabitat because of its biological characteristics), however, and would be difficult to apply to landscape-scale habitat characterization efforts. Furthermore, although the upper and lower salinity tolerances of ribbed mussels have been previously described (Wells, 1961; Lent, 1969), until recently no studies explicitly examined the relationship between ribbed mussel distribution and salinity, an important environmental variable for sessile marine bivalves (Remane, 1934; Deaton & Greenberg, 1986).

Recently, Julien *et al.* (2019) investigated the distribution of ribbed mussels in South Carolina salt marshes in relation to both elevation and salinity, with the goal of creating a tool that could be used to predict the distribution of ribbed mussel habitat throughout South Carolina. This study also established a methodology for determining the inundation period for ribbed mussels across a range of elevations, providing temporal insights into opportunities for filter feeding and exposure to tidally migrating predators. Using logistic regression modeling, Julien *et al.* (2019) found that

ribbed mussels were most likely to occur high in the intertidal zone (0.17 m below mean high water) and at an intermediate salinity of 18 ppt. Furthermore, this study determined the inundation period for ribbed mussel at sites in South Carolina to range from 45 minutes to 6 hours, averaging 3.5 hours per high tide, highlighting the physiologically challenging nature of their lifestyle.

In the southeastern United States, salt marshes and their associated tidal creeks serve as important nursery grounds for the early life history stages of several fish and crustacean species (Weinstein, 1979; Rountree & Able, 2007), with even the high marsh platform acting as a nursery ground during high tide (Kneib, 1984; Talbot & Able, 1984). In South Carolina salt marshes, mummichogs (*Fundulus heteroclitus*), daggerblade grass shrimp (*Palaemon pugio*) and blue crabs (*Callinectes sapidus*) are often the most abundant nektonic species (Kneib, 1984; 1997; LaSalle *et al.,* 1991) with these species, among others, moving onto the high-marsh platform with the incoming tide (Kneib & Wagner, 1994) as part of the transient nekton assemblage. Within the salt marsh landscape, the ribbed mussel is an example of a secondary foundation species, as it provides additional habitat within the range of smooth cordgrass in a hierarchical manner (Altieri *et al.,* 2007; Angelini *et al.,* 2015). Ribbed mussel aggregations provide physical structure, accrete sediments, and facilitate smooth cordgrass growth, thereby providing habitat for salt marsh invertebrates, such as fiddler crabs and marsh periwinkles (Angelini *et al.,* 2015).

The coexistence of smooth cordgrass and ribbed mussels has previously been shown to augment diversity more than the presence of smooth cordgrass alone in both Narragansett Bay, Rhode Island, USA (Altieri *et al*., 2010), as well as on Sapelo Island, Georgia, USA (Angelini *et al*., 2015). Areas of smooth cordgrass associated with high densities of ribbed mussels support greater invertebrate species abundance, richness, and species diversity than smooth cordgrass patches associated with low densities of ribbed mussels (Angelini *et al*., 2015). By modifying the pre-existing conditions and providing habitat for other species, foundation species such as the ribbed mussel increase the number of trophic interactions in a community (van der Zee *et al*., 2016). Consequently, ribbed mussels indirectly enhance landscape-scale ecosystem functions such as infiltration, which is influenced by burrowing invertebrates, and decomposition rates, which are influenced by smooth cordgrass productivity (Angelini *et al*., 2015; Bertness, 1984). Ribbed mussels and smooth cordgrass also play important roles in nutrient cycling, as their mutualistic relationship enhances landscape-scale salt marsh nitrogen removal (Bilkovic *et al*., 2017; Jordan & Valiela, 1982). Through these functions, ribbed mussels recognized as an ecosystem engineer (*sensu* Jones *et al*., 1997) and constitute an integral part of the salt marsh community.

Additionally, the role that ribbed mussels play in promoting nekton diversity was recently investigated by Julien *et al.* (2020b). While this study did not find significant differences in nekton abundance or diversity between plots with and without mussels, nekton community composition did differ between plot type, and season and tidal height both influenced nekton assemblage abundance and diversity. Interestingly, this study also revealed a pulse of juvenile (< 50 mm carapace width) blue crabs, *Callinectes sapidus* utilizing the high marsh platform during the fall season.

THREATS

Habitat loss and the pollution associated with coastal development are the main challenges to conserving ribbed mussel populations. Coastal salt marshes have declined in area over the last 200 years in the conterminous United States and are currently being lost at a higher rate than any other wetland category (Dahl, 2011). In South Carolina, USA, a recent shoreline assessment classified over 57% of coastal shorelines as erosional, with an average long-term marsh erosion rate of 0.34 m yr-1 (Jackson, 2017). The loss of salt marsh habitats is of particular concern as they represent some of the most biologically productive and ecologically valuable habitats in the coastal region (*e.g.*, Whittaker & Likens, 1973; Odum, 1979; Day *et al*., 1989; Levin *et al*., 2001; Peterson *et al*., 2007; Barbier *et al*., 2011). These marsh habitats are at risk of degradation and loss through synergistic relationships between sea level rise, increased storm frequency, coastal development, and shoreline hardening (Peterson *et al*., 2008a,b; Titus *et al*., 2009; Mattheus *et al*., 2010; Nicholls & Cazenave, 2010; Rahmstorf, 2010; Grinsted *et al*., 2013). Such losses of salt marsh habitat will comprise declines in abundances of ribbed mussels and losses of the ecosystem services that they provide.

Mussels have frequently been used for pollution assessment studies (O'Connor, 2002; Hellou & Law, 2003). "Mussel Watch" programs, in which mussels (typically *Mytilus* spp.) and oysters are used as valuable bioindicators of pollutant exposures and effects, have been used by the National Oceanic and Atmospheric Association (NOAA) in the United States and in a variety of countries throughout the world. Mussels are regarded as especially valuable bioindicator organisms because they readily accumulate pollutants in their tissues, and a number of valuable cellular biomarker approaches have been developed for characterizing the adverse effects of these contaminants on these organisms. Comparative studies with oysters have demonstrated some similarities in mussel bioaccumulation and biomarker responses, but these studies also suggest that marsh mussels may be more sensitive to pollutants. Therefore, marsh mussels may be particularly important as bioindicators of pollutants in marsh grass habitats where oysters are less common. Moreover, since *Mytilus* spp. do not occur in the southeastern U.S., *Geukensia demissa* may be a valuable alternative mussel species. Research conducted in South Carolina (*e.g*., Ringwood, 1999) and elsewhere (*e.g*., Ford *et al*., 2005) suggests that the ribbed mussel is an excellent subject to evaluate sediment contamination impacts. The results in South Carolina for the ribbed mussel were very similar to those observed previously by Ringwood *et al.* (1998a; 1998b; 1999a; 1999b) for *Crassostrea virginica*. Cellular 'biomarkers' appear to be extremely useful in assessing contaminant sublethal exposures under both field and laboratory conditions.

In South Carolina, driven by demand from restaurants and retail outlets in response to local interest in the human consumption of ribbed mussels, estimated commercial harvest of this species increased markedly from under 10,000 lbs before 2011 to a peak of more than 30,000 lbs between 2014 and 2016 (SCDNR Office of Fisheries Management, unpubl. data; Julien *et al.,* 2020a). This species is also occasionally harvested recreationally. The removal of ribbed mussels via harvesting raised concerns as to the potential for negative impacts on the ecological health and functioning of the salt marsh community in which it serves as a foundation species (*sensu* Dayton 1972). This concern prompted the study by Julien *et al.* (2020a) that investigated the demographics of ribbed mussels and the effects of simulated harvest on salt marsh health.

CONSERVATION ACCOMPLISHMENTS

The SCDNR Marine Resources Division in collaboration with multiple partners is actively involved in habitat enhancement efforts through the creation of intertidal oyster reefs, achieved through the provision of hard substrate for settlement and recruitment. It is likely that the provision of this substrate has also benefitted ribbed mussel populations. In addition, the Marine Resources Division is becoming increasingly active in the realm of salt marsh research and conservation at the landscape scale, which is likely to benefit ribbed mussels through an improved understanding of the need for salt marsh management and conservation.

CONSERVATION RECOMMENDATIONS

- Improve our basic understanding of ribbed mussel life history in South Carolina to include studies related physiological tolerances, growth rates, size-at-age relationships, predator-prey interactions, and reproductive phenology.
- Develop and apply habitat characterization models for ribbed mussel to predict their current and future statewide distributions for use as a conservation tool to support habitat conservation and sustainable harvest practices.
- Evaluate interactions between ribbed mussels and oyster reef population dynamics and the role of ribbed mussels in oyster reef development.
- Enhance/expand SCDNR habitat restoration and enhancement programs to consider benefits to ribbed mussels.
- Explore the feasibility of restoration efforts primarily focused on increasing ribbed mussel populations within the salt marsh landscape.
- Evaluate ribbed mussel contributions to the nutrient dynamics of salt marshes and the possible role of ribbed mussels in the restoration of marsh habitats.
- Develop a fisheries management plan for ribbed mussels and promote sustainable fisheries practices for ribbed mussel harvesting that serve to reduce the negative impacts on salt marsh health and that promote ribbed mussel recovery.
- Develop applications of ribbed mussels as a bioassay for determining pollution and as a potential indicator of the functional health of communities (*e.g.,* oyster reefs, salt marshes).
- Partner with local governments and the SC Department of Environmental Health and Control (SCDHEC) to deter development in sensitive areas where development will have negative effects on ribbed mussel populations.
- Implement and improve Best Management Practices (BMPs) in future urban and commercial developments to protect water quality.

MEASURES OF SUCCESS

By implementing the conservation recommendations listed above, the SCDNR will be able to encourage stable, or even increasing, populations of ribbed mussels in South Carolina. It is clear that more studies of the specific nature of ribbed mussels in our state our warranted and much basic information on the biology of this species remains lacking. Equivalent attention to the ecosystem services provided by ribbed mussels and its associations with smooth cordgrass as those appreciated for intertidal oyster reefs is arguably warranted.

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Sea Walnut

Mnemiopsis leidyi Agassiz, 1865



Contributor: Daniel Sasson (SCDNR, 2023)

DESCRIPTION

Taxonomy and Basic Description

The sea walnut, *Mnemiopsis leidyi* Agassiz, 1865 (Phylum Ctenophora; Class Tentaculata; Order Lobata; Family Bolinidae) belongs to an order of ctenophores recognized by their pair of muscular lobes that project past the mouth. Along these lobes run eight ciliated comb rows. Small bumps sometimes seen on the lobes of *Mnemiopsis* are the basis for its other common name, the warty comb jelly.

Like most other ctenophores, *M. leidyi* is a simultaneous hermaphrodite with the ability to self-fertilize, although self-fertilization may come at a cost to embryonic viability (Sasson *et al.,* 2018). Spawning generally takes place at night and fertilization occurs externally. The number of eggs released is size dependent with larger *Mnemiopsis* releasing more eggs (Sasson & Ryan, 2016). They do not start spawning with regularity until reaching roughly 30 mm (Sasson & Ryan, 2016), but research has shown that they are capable of spawning at very small sizes (*e.g.,* 1 mm, Edgar *et al.,* 2022). *Mnemiopsis leidyi* can reach roughly 120 mm in length.

Mnemiopsis leidyi generally floats with water currents, although their ciliated comb rows can provide some directionality to their movement (Coonfield, 1934). Small and medium sized *M. leidyi* also have diel vertical migrations, perhaps to avoid predators or to follow the movement patterns of prey (Haraldsson *et al*., 2014). Lobate ctenophores generally feed on zooplankton, including fish eggs and larvae. To feed, beating cilia generate a current which pulls slow-swimming prey into oral tentacles covered in sticky colloblasts (Franc, 1978), which are then drawn into the mouth (Sutherland *et al.,* 2014). *Mnemiopsis leidyi* capture faster prey that would otherwise escape the current generated by altering their lobe positions in response to fluid disturbances made by the prey (Costello *et al.,* 1999).

Currently, all *Mnemiopsis* are considered a single species, but population genetic studies on this group suggest that *Mnemiopsis* above and below Cape Hatteras, NC are distinct either to the level of species or subspecies (Bayha *et al.,* 2015; Jaspers *et al.,* 2021). Given that the oldest description of *Mnemiopsis* was the species *gardeni* (L. Agassiz, 1860) from Charleston, SC (as compared to *leidyi* L. Agassiz, 1865 from Woods Hole, MA), it seems likely that eventually, the Charleston *Mnemiopsis* will either become *M. gardeni* or *M. gardeni* subspecies *gardeni*. There is also a chance that the genera will change (possibly to *Bolinopsis*, but there are other considerations based on precedence) since *Mnemiopsis* is paraphyletic within *Bolinopsis* (Christianson *et al.,* 2022).

While still in some dispute (*e.g.,* Redmond & McLysaght, 2021), the phylum Ctenophora is widely considered the sister species to all other animals (Dunn *et al.,* 2008; Whelan *et al.,* 2017, Schultz *et al.,* 2023). For this reason, ctenophores are often used as study organisms to understand early animal evolution (*e.g.,* Ryan *et al.,* 2013, Moroz *et al.,* 2014)

Status

Mnemiopsis leidyi is not currently included in federal lists of threatened or endangered species and there is no present-day direct human exploitation of this species in South Carolina. No targeted population assessments are conducted on this species, despite its ecological significance. Relatively little is known about the presence or ecological impacts of *Mnemiopsis* in South Carolina compared to areas where it has recently become established (see below).

POPULATION DISTRIBUTION AND SIZE

Mnemiopsis leidyi has been historically found in the western Atlantic Ocean ranging from New England to Argentina (GESAMP, 1997). It can be found in both offshore and inshore waters, including brackish estuaries.

In the 1980s, *M. leidyi* appeared in the Black Sea, likely brought over in the ballast water of ships, and has since been found in many European waters (Ghabooli *et al.,* 2011). In these regions, *M. leidyi* has been implicated in a reduction of zooplankton abundance (Roohi *et al*., 2008) and crashing fish stocks (Oguz *et al.,* 2008). Due to its potentially devastating effect on local ecosystems, *M. leidyi* is considered one of the 100 worst invasive species (Lowe *et al*., 2000).

HABITAT / NATURAL COMMUNITY REQUIREMENTS

Adult *M. leidyi* have wide tolerances to temperature and salinity (Haraldsson *et al.,* 2013), which allows them to thrive under many conditions, although reproduction may be reduced in lower salinity environments (Jaspers *et al.,* 2011). They are also tolerant of relatively low food environments and can continue spawning daily even after 12 days without food (Jaspers *et al.,* 2015). Their tolerance of wide-ranging conditions, high reproductive output, and ability to self-fertilize are likely key reasons why *M. leidyi* has been able to spread to, and become established in, areas outside of its native range.

CHALLENGES

Ctenophores are not used for any commercial purpose, but may be susceptible to changes in environmental conditions that lead to the degradation of their habitat, such as coastal development, pollutants and contaminants. This species may also be influenced by changes in environmental conditions associated with climate change-related shifts in temperature, pH and circulation patterns.

CONSERVATION ACCOMPLISHMENTS

Ctenophores in general have received little to no attention in terms of conservation efforts, likely due to a lack of demographic information. The species is currently not listed as either threatened or endangered at either the state or Federal level, which also explains the lack of targeted conservation efforts.

CONSERVATION RECOMMENDATIONS

Little is known about the abundance and ecological impacts of *Mnemiopsis leidyi* in South Carolina waters. As seen from areas where *M. leidyi* has recently become established, they can have profound impacts on zooplankton abundance and fish recruitment (Oguz *et al.,* 2008; Roohi *et al*., 2008). Quantifying the seasonal trends in abundance and the diet of *M. leidyi* would greatly expand our understanding of their role in the ecosystem of South Carolina.

The taxonomic classification of *M. leidyi* is currently in flux. Recent work suggests that those *Mnemiopsis* found north of Cape Hatteras are a separate species from those south of Cape Hatteras. Additional genetic sampling along the coast, especially in the Charleston area where *Mnemiopsis* was first described, would help to resolve this issue.

MEASUREMENT OF SUCCESS

A better understanding of the ecology, distribution, and taxonomic classification of *Mnemiopsis* in South Carolina would improve our ability to recognize changes in abundance patterns that might result from shifts in environmental conditions.

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Shark eye
Neverita duplicata



Contributor: Peter Kingsley-Smith (SCDNR)

DESCRIPTION

Taxonomy and Basic Description

Neverita duplicata Say, 1822 (formerly *Natica duplicata* and *Polinices duplicatus*), common name the shark eye, or the lobed moonsnail, is a predatory marine gastropod mollusc in the family Naticidae, collectively referred to as the moon snails (Rosenberg, 2010). It is one of the most familiar animals of the southeastern coast, recognizable in both its postlarval form as well as from its characteristic circular egg collars (3”-4” in diameter) which can be found on sandy beaches at lower tidal elevations, and further up the beach when washed ashore after storms.

Hülsken *et al.* (2006) reported the existence of a second, very similar species with a smaller range of distribution that occupies part of the range inhabited by *N. duplicata*. This second species had previously been considered to be simply a form of *N. duplicata*, but is now recognized as *Neverita delessertiana*.

Reaching approximately 2” in height, the shell of *N. duplicata* is smooth, generally flattened and rounded with a low spire, such that the shell is generally much wider than it is high (Abbott, 1974). The operculum is corneous and flexible. The shell color ranges from slate gray to tan, with the base of the shell often whitish (Abbott, 1974). The shell aperture is large and the deep umbilicus extends up into the columella, but the umbilicus is partially plugged by a large brown growth of shell (Abbott, 1954; Ruppert & Fox, 1988).

Naticid gastropods are characterized by an extremely large and broad foot relative to the size of the shell. The foot is employed both in locomotion and in the capture, subjugation, and manipulation of prey. The anterior part of the powerful, muscular foot, referred to as the propodium, is used for burrowing and can act as a plough at the sediment surface. The snail is able to inflate its foot by drawing in seawater through a series of small posterior pores (Fretter & Graham, 1994) such that the expanded foot can have up to four times the volume of the retracted foot (Ruppert & Fox, 1988). The large foot permits rapid locomotion over soft substratum. Naticids possess a well-developed gill which is housed within a large and effectively isolated mantle cavity. During locomotion, the propodium is extended and reflected anteriorly over the shell, thereby regulating the pallial stream and preventing all but the smallest particles from entering the mantle cavity. Furthermore, an extension of the opercular lobe of the metapodium is raised over the posterior part of the shell, concealing the operculum, such that the foot is virtually hidden during locomotion.

During the process of prey capture naticids ‘pick up’ the prey using the propodium and secrete large quantities of mucus that reduces the likelihood of the prey escaping. Once captured, the

prey is transferred to the posterior region of the foot and towed beneath the sediment until the predator comes to rest. The prey is then brought forward such that the apex of the prey lies at the anterior end of the propodium ready for drilling (Fretter & Graham, 1994). Although foraging may occur near the sediment surface, an immobilized prey is usually dragged down into the substrate before drilling is initiated (*e.g.,* Kitchell, 1986; Kabat, 1990; Reyment, 1999; Kelley & Hansen, 2003). Shell penetration is achieved by alternation of chemical etching, as a result of chemical secretions from the accessory boring organ, and physical abrasion, thought the action of the radula (Ziegelmeier, 1954; Fretter & Graham, 1962; Carriker, 1981; Kabat, 1990), after which the proboscis is inserted through the hole for consumption of prey. Naticid drill holes are countersunk, truncated, spherical paraboloids, which is to say that the enlarged outer margin is bevelled or tapered (Benton, 1986).

Status

The status of this species in South Carolina is known as it is not the target of any standardized surveys, does not support a directed fishery, and is not listed on any recognized Federal or state conservation list.

POPULATION SIZE AND DISTRIBUTION

Neverita duplicata is distributed from Cape Ann, Massachusetts, to Florida and the Gulf States (Abbott, 1974). Hanks (1953) demonstrated that feeding in *N. duplicata* ceased at temperatures below 5°C, which likely plays a role in determining the distribution of this species. The size of the population of *N. duplicata* in South Carolina is unknown because this species is data deficient. While the general habitat association of *N. duplicata* in the region is known, details of its distribution in South Carolina are lacking.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Neverita duplicata is typically found on silty sand beaches along protected stretches of coast and spends much of its time beneath the sand in search of its typical molluscan prey. Naticid gastropods are regular members of infaunal invertebrate communities across a broad range of latitudes (Taylor & Taylor, 1977) and are specialist predators of shelled prey, most commonly bivalve species. The diets of naticids comprise over 80 families of gastropods and bivalves, mainly restricted to those taxa inhabiting soft substrata, in particular *Donax*, *Tellina*, *Macoma*, and *Mactra*, but also *Mya*, *Abra*, *Spisula*, *Chamelea*, and *Nucula* (Piéron, 1933; Ziegelmeier, 1954; Fretter & Graham, 1994).

Naticid gastropods have been significant predators of benthic marine molluscs since the Cretaceous period (Sohl, 1969), with evidence of their consumptive behavior in nearshore habitats remaining in the form of stereotypic and characteristics countersunk boreholes in left behind in the shells of their molluscan prey (*e.g.,* Guerrero & Reyment 1988; Kabat, 1990; Kelley, 1991; Dietl & Alexander, 1997; Kelley & Hansen, 2003; Kingsley-Smith et al., 2003; Dietl & Kelley, 2006; Harper, 2006; Cintra-Buenrostro, 2012). Along northwest Atlantic coastlines, naticids consume a broad diversity of molluscan fauna, including commercially-important species (*e.g.,* Dietl & Alexander, 1995; Clements *et al.,* 2013), such as the surfclam

Spisula solidissima, with consequent effects on the spatial patterns and abundances of their prey (*e.g.,* Wiltse, 1980).
Although many naticids have broad diets (*e.g.,* Edwards, 1974; Edwards & Huebner, 1977; Ansell, 1983; Clements *et al.,* 2013), many are also capable of selective predation with respect to prey species, prey size, prey shell thickness, and borehole location. In such cases, larger predators tend to feed on larger prey items (*e.g.,* Rodrigues *et al.,* 1987; Kingsley-Smith *et al.,* 2003; Chiba & Sato, 2012), with the correlation coefficient of the relationship between predator size and prey size representing the strength of their selectivity (Dietl & Alexander, 1997). Interspecific prey selectivity has also been observed in naticid species associated with selection of prey species that, for a certain size class of prey and predator, offer a better energetic reward per unit handling time (*e.g.,* Kitchell et al., 1981; Kelley, 1991; Dietl & Alexander, 1995, 1997; Kelley & Hansen, 1996). Kitchell *et al.* (1981) reported a consistent rate of drilling in *N. duplicata* of 0.0223 mm hr^{-1}. Kitchell *et al.* (1986) found that *N. duplicata* would not feed on opened bivalves-only live, closed prey items were chosen. This suggests that the stereotypy of prey choice restricts naticids to fresh prey and rules out scavenging or carrion-feeding.

Members of the family Naticidae have traditionally been considered to be predators that drill distinctive, circular holes in the shells of their bivalve and gastropod prey to gain access to the soft tissues inside (Carriker, 1981; Kitchell *et al*., 1981). Laboratory experiments confirm that moon snails drill using a combination of radular scraping and the application of weak acid produced by an accessory boring organ (Kabat, 1990), and consume all or most prey tissue (Carriker, 1981; De Angelis *et al*., 1985; Kitchell *et al.,* 1986; Visaggi *et al*., 2013). Recent stable isotopic analyses—a powerful tool for determining dietary sources and complex trophic interactions (Post, 2002; Layman *et al*., 2012)—yielded realized trophic positions for *Neverita duplicata* between 2.3 and 2.5 in Long Island Sound (Casey *et al.,* 2014). The lower than expected trophic positions reported by Casey *et al.* (2014) resulted from a combination of unexpectedly high carbon signatures and lower than expected nitrogen signatures (Casey & Post, 2011; Casey *et al.,* 2014). The high C signatures indicate that *N. duplicata* relies heavily on littoral carbon sources *i.e.,* those that grow along the surface of the seashore (Casey *et al*., 2016).

CHALLENGES

The spatial distribution appears to be closely associated with silty sandy beaches along protected stretches of shorelines, such that alterations and disturbances to such habitats are likely to be a significant challenge to this species. Processes that alter the grain size and morphology (*e.g.,* installations of piers and land-based shoreline structures, beach renourishment activities) of sandy beaches where *N. duplicata* occurs are therefore likely represent threats to this species. This species is typically found in high salinity habitats, and not in brackish or estuarine habitats, such that alterations to the salinity of areas where this species occur are likely to have negative impacts on *N. duplicata*. Freshwater discharges may influence the distribution, abundance, and life history traits of this species, raising the possibility that freshwater discharges from "swashes" in South Carolina could be a potential cause of disturbance to *N. duplicata*. This species may also be negatively affected by coastal storms through physical disturbance, such that the increased frequency of tropical storms and hurricanes predicted under future scenarios of anthropogenically-driven climate change could be an additional challenge to this species.

CONSERVATION ACCOMPLISHMENTS

Neverita duplicata has received little or no attention in terms of past conservation efforts, likely due to the data deficient nature of this species to indicate that its number have been in decline, either as a result of natural or anthropogenic factors.

CONSERVATION RECOMMENDATIONS

- Periodically conduct assessments of beach invertebrate communities to determine their condition and better understand their temporal and spatial dynamics.
- Work with coastal municipalities and communities to reduce future impacts of development on sandy beach environments.
- Work with appropriate state, local, and non-governmental agencies to discourage development on beachfront properties.
- Educate the public as to the importance of sandy beach habitats and about some of the key fauna that rely on these coastal habitats.
- Encourage planned development projects in coastal zones to reduce associated impacts of development on the long-term health of sandy beach habitats in South Carolina.
- Continue to investigate and document the effects of rising sea levels and global warming on beach habitats.
- Discourage the building or repair of seas walls and groins on South Carolina's beaches to allow more natural movement of sand and, ultimately, more natural beach renourishment.

MEASURES OF SUCCESS

A better understanding of the spatial distribution and baseline life history of *N. duplicata* would be first order measures of conservation success. Such an understanding would enable the impacts of disturbances to be conceptualized but also provide protection to critical habitats, including at key points in their life history. An improved understanding of the trophic interactions between this naticid gastropod species and the molluscan prey community of sandy beach habitats will help to understand the role of this predator within such ecosystems in coastal South Carolina habitats, including its potential impacts on commercially-important and conservation priority bivalve species.

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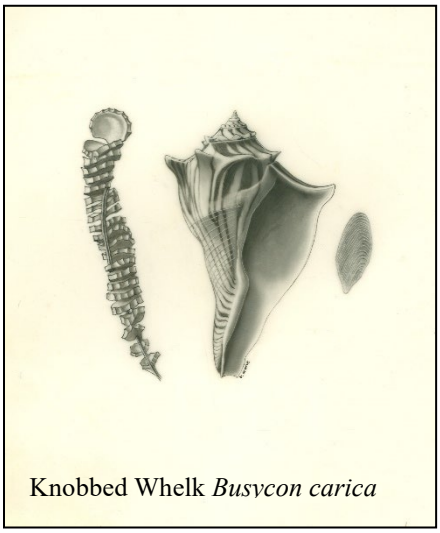
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Whelks Guild

Knobbed Whelk, *Busycon carica* (Gmelin 1791)
Channeled Whelk, *Busycotypus canaliculatus* (Linnaeus 1758)
Lightning Whelk, *Sinistrofulgur perversum* (Linnaeus 1758)
Pear Whelk, *Fulguropsis spirata* (Lamarck 1816)

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Illustrations by D. Bryan Stone


Knobbed Whelk *Busycon carica*

DESCRIPTION

Taxonomy and Basic Description

The knobbed whelk, *Busycon carica*, is the most common whelk in South Carolina, but three other species are found in State waters in the following order of abundance: the channeled whelk (*Busycotypus canaliculatus*); the lightning whelk (*Sinistrofulgur perversum*); and the pear whelk (*Fulguropsis spirata*). The only whelk in SC found in commercial quantities is the knobbed whelk and therefore it is the best studied.

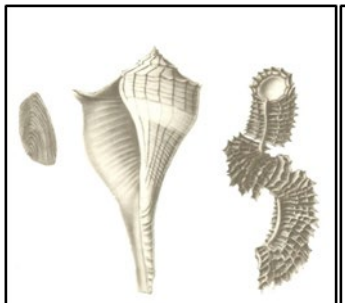
First described by Gmelin in 1791, the knobbed whelk, *Busycon carica,* is a member of the family Melongenidae. Whelks have flourished off of the South Carolina coast in the Atlantic for over 30 million years. Adult knobbed whelks are usually 5-9” in length and are characterized by low knobs on the shoulder of the whorl with the aperture on the right side. Aperture coloration ranges from light orange-yellow to brick red. The knobbed whelk is the state shell of both New Jersey and Georgia.

The structure and coloration of knobbed whelk shells vary greatly, not only over their geographical range, but also within a locality. It is not unusual to find whelks on South Carolina beaches with different knob lengths, knob directions, and aperture colors. Whelks grow by extending the shell around a central axis, producing turns or whorls as they evolve. The final whorl—and usually the largest—is the body whorl that terminates, providing the aperture into which the snail can withdraw. Whelks also have a separate hard, horny plate, called an operculum, which acts like a trap door when the snail withdraws into the shell. Sometimes called a “shoe,” the operculum is attached to the top of the foot and is seldom found with empty whelk shells (Magalhaes, 1948; Eversole & Anderson, 1985).

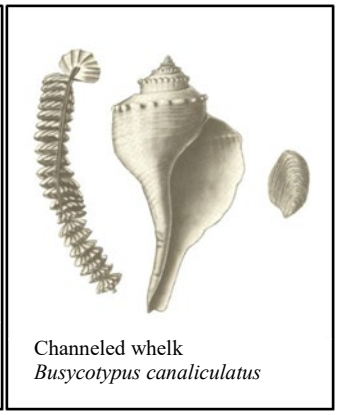
Knobbed whelks in South Carolina lay egg strings twice a year, usually from September through October and April through May. Egg strings start to appear at times when the water temperature approximates 20°C (68°F). Of the two egg-laying periods, fall appears to be the most productive. It is not known if an individual female whelk contributes to both of these egg-laying peaks or if a

female lays more than one string per season. Good estimates of the average number of eggs per capsule (34 to 35) and capsules per string (100 to 120) are available for this species. Spent egg strings often wash up on beaches and consist of a series of flattened capsules attached at one end to a tough cord or string-like structure. Some egg cases reach a length of over 0.3 m (1ft.) and contain up to 160 capsules. In all four whelk species, eggs complete their development within the egg capsule and, after hatching, small juvenile snails emerge through a predesigned exit. The first capsules in the string usually do not contain eggs and are buried in the ocean floor as an anchor. Knobbed whelk egg capsules are coin-shaped, 20 mm to 30 mm (0.8-1.2 in.) in diameter and are 3 mm to 6 mm (0.1-0.2 in.) thick with crenulations around the edges. Eggs develop slowly, hatching in about 3 to 13 months. Egg cases that wash up on beaches are usually empty, with open holes providing evidence of successful hatchings (Magalhaes, 1948; Eversole & Anderson, 1985).

If one finds a large knobbed whelk on the beach, chances are good it is a female. Male knobbed whelks rarely reach the large sizes of their opposite sex. Normally, female knobbed whelks have larger shells, weigh more, and possess a larger foot. Whelks are thought to be protandric hermaphrodites; this means that they start out as males when young, and then change into females as they grow older. This phenomenon may lead to a preponderance of females among the older and larger-sized individuals in the population (Eversole & Anderson, 1985).



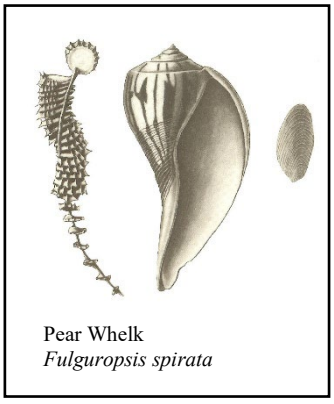
Lightning Whelk
Sinistrofulgur perversum



Channeled whelk
Busycotypus canaliculatus

Channeled whelks have a much thinner shell than knobbed whelks and may be covered with a fine hairy periostracum. The spire is characterized by flat shoulders with knobs that are reduced to fine beads.

Lightning whelks can reach a length of 16”, making them the largest whelk in South Carolina. It is, however, rare to see a lightning whelk in inshore waters. Chances increase in the fall when mature individuals may migrate inshore to breed. A lightning whelk is distinguished from the other whelks in South Carolina by the counter-clockwise coiling of the shell, giving it a “left-handed” shell.



Pear Whelk
Fulguropsis spirata

Pear whelks are smaller than the other species, seldom exceeding 6”. The species lacks knobs, beads, and periostracum and has a large flaring aperture. It is found in high salinity, subtidal areas and is nocturnal so live specimens are seldom seen in South Carolina, although shells may be found along the southern coastline.

Whelks are carnivorous gastropods, not to be confused with filter feeding conchs, such as the queen conch (*Strombus gigas*), found in the waters of southern Florida and the Caribbean.

Whelks feed by tearing off strips of tissue with their file-like radula. Knobbed whelks and lightning whelks feed on bivalves such as hard clams (*Mercenaria* spp.), oysters (*Crassostrea virginica*), and incongruous arks (*Anadara brasiliana*). These heavy whelks use the lip of their shell to chip and pry the valves of their prey apart, holding it with its foot so that the ventral edges of the prey valves are under the outer lip of the whelk shell. Slow chipping continues until an opening is generated that allows the whelk to wedge its shell between the prey valves and then enter its proboscis to begin feeding. Since the feeding process results in damage to the shell, limited growth sometimes occurs in adults as energy is used to repair their shells (Magalhaes, 1948; Carriker, 1951).

The thinner-shelled pear and channeled whelks feed on incompletely closed bivalves (*e.g.* razor clams) or wait for prey to open its valves and use the lip of their own shell as a wedge. Pear whelks also feed on mobile gastropods which they outrun and trap in their large siphonal canal.

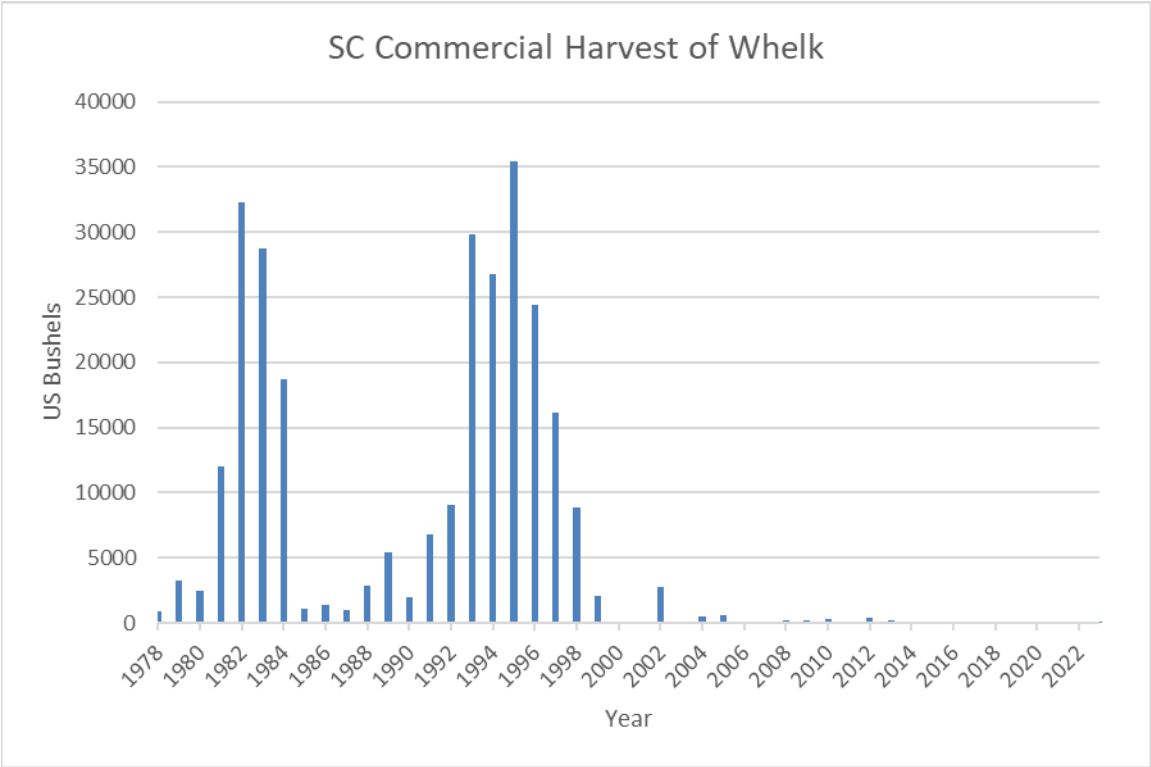
Status

The knobbed whelk is a common species of the shallow shelf ecosystem of the South Carolina coast. The prevalence of knobbed whelks in this habitat makes it an excellent indicator of the health of this ecosystem. Many people enjoy collecting whelk shells at the beach. Aside from its recreational and ecological value, the knobbed whelk is targeted in the offshore whelk trawl fishery in South Carolina. Although this species is harvested, there is limited information about population trends or how whelk populations recover from commercial harvests.

The commercial whelk trawl fishery off the South Carolina coast evolved in 1977-1978 as an alternative industry to provide cash flow during the periodic closure of the shrimp season. During the early 1980s, knobbed whelks were shipped alive to processing facilities in Mt. Pleasant and near Beaufort, South Carolina and cooked under pressure for approximately 20 minutes to break down the viscera that attaches the animal to its shell. Meats were extracted from the shell and transported on ice to New England or blast frozen in Savannah, Georgia for markets in the Far East. Whelk meats that arrived in New England were usually processed as canned scungilli (Anderson *et al.,* 1985).

Trawling occurs from 0.8 km to 4.8 km (0.5 to 3 mi.) offshore. Peak collections occur in the spring as the water temperature approaches 14°C (57°F); this is when whelks begin moving over the sediment surface after a dormant period of burial. Of the whelks collected in this trawl fishery, knobbed whelks average approximately 90% of the catch with the remainder being channeled whelks. In recent years, no more than three commercial fishermen have participated in the whelk trawl fishery with some years not having any participants. Peak whelk harvests occurred in 1982 and 1995 with landings of over 30,000 US bushels. This was followed by two years of declining catches and four consecutive years (1985-1988) of production below 3,000 US bushels as the fishery collapsed. Currently, whelk harvest in State waters is limited to a total of 13,000 US bushels per year (SCDNR Office of Fisheries Management, 2003), but harvests have not reached that level since 1997. Since 1998, annual harvests have been lower than 10,000 bushels, whereas the average annual harvest for 2013-2023 was only 43 bushels. The last two years of reported commercial harvest through the whelk trawl fishery were 2005 and 2010.

The cyclical nature of the offshore fishery suggests that overfishing is followed by fishery collapse and slow recovery. The offshore whelk fishery will likely remain cyclical based on market demand, cost of processing the whelk, and the capacity of fishermen to locate aggregations of whelk populations in offshore coastal waters. South Carolina has a highly regulated, short exploitation window for whelk (usually mid-February to mid-April) that is further limited by fishing gear restrictions, weather conditions, minimum whelk harvest size, and marketing opportunities.



South Carolina manages the whelk trawling fishery through the SC Whelk Fishery Management Plan. Although state law provides for a minimum size of 4" shell length (hand collection), the trawl fishery minimum size is currently 4.5". The Plan restricts trawling to early spring, with exact dates determined by the closing of shrimp trawling season and water temperature, and fishermen are required to report catches daily so that the fishery can be closed when the harvest approaches 13,000 bushels, which is considered to be the maximum sustainable yield.

POPULATION SIZE AND DISTRIBUTION

Knobbed whelks are found in US East Coast waters from the south shore of Cape Cod, Massachusetts to Cape Canaveral, Florida, with greater numbers occurring in more southern latitudes (Abbott, 1974). There is no estimate of the whelk population size or distribution in South Carolina. All existing data are fishery-dependent.

Channeled whelks have a similar distribution but are more common in northern latitudes.

Lightning whelks range from New Jersey to Florida and into the Gulf of Mexico but are more common in the southern portion of the range. Pear whelks are found from North Carolina to Mississippi and are more common in Florida and Georgia than in South Carolina.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The knobbed whelk lives in tidal estuarine waters and offshore in depths of up to 150 ft, although they are more commonly found in shallow shelf waters. In estuaries, knobbed whelks sometimes congregate on oyster reefs and clam beds as they feed on these species, along with other marine bivalves, such that these are key habitats for these gastropods (Magalhaes, 1948). Mating and spawning occurs in estuaries and offshore where egg cases are anchored to the bottom. Higher abundances of whelk in intertidal habitats in spring and fall have been assumed to reflect migrations to and from subtidal waters; however, Shalack *et al.* (2011b) suggest that intertidal populations probably remain localized year-round and are simply less visible in summer and winter when harsh intertidal conditions limit their ability to forage at low tide.

Results from mark-recapture studies indicate that whelks are very slow growing and exhibit little long-shore movement, migrating to and from estuaries only in the immediate area of their genesis (Anderson *et al.,* 1985; Eversole *et al.,* 2008). Similar results have been found in Georgia (Walker *et al.,* 2008) where male whelks have been shown to reach sexual maturity at 4 years old and 3.5", while females did not reach maturity until 3.9" and 6 years of age (Power *et al.,* 2009).

CHALLENGES

Currently, low levels of commercial harvest of whelks (predominately knobbed whelks but probably also channeled whelks) have been collected as by-catch in crab pots. Inshore populations have not been studied in South Carolina, but data from Georgia (Shalack *et al*. 2011a,b) suggest that inshore populations may be easily overfished. The SC Whelk Fishery Management Plan does not regulate the inshore fishery. Although this by-catch has made up most of the annual whelk harvest, it is a relatively modest total (< 50 bushels per year). If a targeted whelk fishery were to emerge, landings might increase substantially and represent a risk to inshore populations. Also, if whelk pots are utilized, these are likely to target channeled whelks more than knobbed whelks. Our knowledge of channeled whelk populations is less than that for knobbed whelk.

To provide whelks the opportunity to reach sexual maturity and spawn before entering the fishery, SCDNR requires a minimum size of 4.5" in shell length (apex to end of siphonal canal) for whelk harvest by trawl (hand harvest minimum size is 4:); however, as the siphonal canal frequently breaks during normal feeding, the minimum shell length may not always be indicative of sexual maturity. Furthermore, data from Georgia suggest that females have only recently reached sexual maturity at 4" (Walker *et al.,* 2008). Data from both South Carolina and Georgia suggest that this size limit will result in the selective harvest of females (Walker *et al.,* 2008; Eversole *et al.,* 2008).

Other anthropogenic activities that may negatively impact whelk populations include oil spills, beach renourishment, and dredging. Oil spills, depending upon their severity, could inhibit the

feeding and movement out of the affected area by whelk. Whelks can be entrained in the dredge cutter during beach renourishment, where sand is pumped from offshore or directly from a nearby tidal creek onto the front beach, causing mortality. Pumping substrate for projects such as maintenance dredging in South Carolina harbors or the Atlantic Intracoastal Waterway can also cause mortality in a manner similar to that described above (W. D. Anderson, pers. obs.).

Whelks are major predators on oysters and clams such that shellfish growers actively remove and destroy whelks preying on their culture grounds. While the presence of large numbers of whelks in these areas suggests an abundant population, the practice of destroying large quantities of these organisms could become problematic for the larger population.

CONSERVATION ACCOMPLISHMENTS

Since 1983, SCDNR has had regulatory authority over commercial whelk fisheries to set lawful fishing areas, minimum size requirements, net mesh size, and the opening / closing dates for the offshore whelk trawl fishery. Currently, whelk harvesting in state waters by trawl is limited to a total of 13,000 US bushels per year. The complete closure of inshore trawling areas in 1986 has conserved the resource by reducing incidental whelk by-catch during shrimp harvest. A management plan for South Carolina's offshore whelk trawl fishery was developed in 1999 to provide for a more balanced, less cyclical fishery. There has been virtually no fishery since the plan was enacted, although it is unclear whether this is due to a lack of fishing effort or reduced catch per unit of effort (CPUE). The management plan specifies closing the whelk season when water temperature reaches 20°C (68°F) to prevent trawling when sea turtles are present.

CONSERVATION RECOMMENDATIONS

- Develop reliable aging techniques for knobbed whelk.
- Determine sex specific growth rates for knobbed whelk.
- Further study the population dynamics of inshore whelk (both knobbed whelk and channeled whelk).
- Develop methods for and evaluate long-term population trends in both inshore and offshore populations of knobbed whelk.
- Evaluate the potential effects of an inshore fishery on whelk populations and determine the need for an inshore whelk fishery management plan.
- Utilize and continue to update the SCDNR Offshore Whelk Trawl Fishery Management Plan.
- Investigate the roles that knobbed whelk play in benthic communities, particularly as they pertain to oyster and clam populations.

MEASURES OF SUCCESS

There is currently a lack of biological information needed to effectively manage the whelk fishery for sustainability, particularly with regards to a growing inshore fishery. Development of

this knowledge base would be a measure of success. Consistent, less cyclical, whelk harvests in the offshore fishery and sustainable harvests in an inshore fishery would also be indicators of success.

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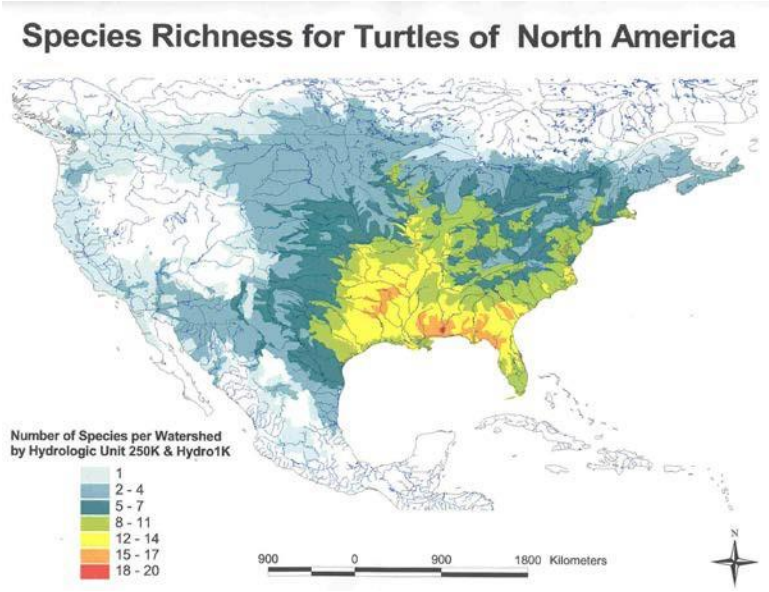
Freshwater Turtles Guild

Yellow-bellied Slider *Trachemys scripta*
Eastern River Cooter *Pseudemys concinna concinna*
Coastal Plain Cooter *Pseudemys concinna floridana*
Eastern Chicken Turtle *Deirochelys reticularia*
Florida Softshell Turtle *Apalone ferox*
Gulf Coast Spiny Softshell Turtle *Apalone spinifera aspera*
Snapping Turtle *Chelydra serpentina*
Eastern Painted Turtle *Chrysemys picta picta*
Striped Mud Turtle *Kinosternon baurii*
Eastern Mud Turtle *Kinosternon subrubrum*
Eastern Musk Turtle *Sternotherus odoratus*
Spotted Turtle *Clemmys guttata*

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GENERAL TURTLE DIVERSITY INTRODUCTION

The Southeastern United States includes one of the world's richest regions for freshwater turtle diversity. Freshwater turtles are under increasing levels of threat around the world. Two-thirds of the world's turtle species are listed as threatened by the IUCN, and many of the remaining third have not been evaluated (Turtle Conservation Fund 2002). Human exploitation of turtles has resulted in population declines, local extirpations, and even extinction of some species (Thorbjarnarson et al. 2000).



DESCRIPTION
Taxonomy and Basic Description

The yellow-bellied slider, eastern river cooter, coastal plain cooter, eastern chicken turtle, eastern painted turtle and spotted turtle are members of the family Emydidae, the semi-aquatic pond turtles (Ernst and Barbour 1989). These species all have hardened carapace (top) and plastron (bottom) shells.

The yellow-bellied slider is large, reaching lengths from 12.5 to 20.3 cm (4.9 to 7.9 in.). The maximum length for the yellow-bellied slider is approximately 29 cm (11.4 in.). Adults are sexually dimorphic; females reach greater lengths and overall body size than males (Ernst and Barbour 1998). Adults are typically dark with vertical yellow markings on their carapace. The most conspicuous marking is the yellow blotch on the side of the head just behind the eye (Conant and Collins 1991; Martof et al. 1980). The plastron of these turtles is yellow with round, dark markings along its edge. Older adult yellow-bellied sliders can become very dark, obscuring many of their distinguishing marks.



Photo by Andrew Grosse

The eastern river cooter and coastal plain cooter are both large turtles that can reach lengths between 23 and 33 cm (9 to 13 in.); approximately 39 cm (15.3 in.). Adults of both species have dark carapaces with yellow markings; however, markings on the coastal plain cooter tend to be



Photo by Andrew Grosse; *Eastern River Cooter (left) Coastal Plain Cooter (Right)*

vertical stripes while the eastern river cooter as a net-like pattern. The plastron of the coastal plain cooter is typically plain yellow (Conant and Collins 1991; Martof et al. 1980). The eastern river cooter has dark markings on its plastron. Both cooters have yellow stripes along the sides of their heads. These species are closely related and some taxonomists believe they might actually be the same species (Seidel 1994). They are typically found in different habitat types, but some overlap does occur and they may hybridize readily in these areas, producing individuals that share traits of both species.

The eastern chicken turtle is small to moderate in size. This turtle reaches lengths from 10 to 15 cm (3.9 to 5.9 in.); maximum length is approximately 25 cm (9.8 in.). This species has a dark black to brown carapace with a light, net-like pattern and a very long, striped neck (Conant and Collins 1991; Martof et al. 1980). The plastron is typically plain yellow, and patterning on the bridge varies among individuals. The bridge may have a black bar, one or two spots, or no markings at all. Very strong, vertical striping is present on the rear legs.



Photo by Andrew Grosse

The carapace is longer than it is wide and is widest toward the rear, appearing somewhat pear-shaped from above. The edges of all marginal scutes are smooth. The species differs from most other North American turtles because it has both a fall and spring nesting season as well as a long incubation period.

The eastern painted turtle is a medium-sized turtle, typically ranging in adult size from 11.5-15.2 cm (4.5-6 in.) (Conant and Collins 1991). The record size for an adult is 19.5 cm or just over 7 in. The large scutes of its smooth carapace are arranged in straight lines across the back, making it unique in that regard (Conant and Collins 1991). Eastern painted turtles are brightly marked with red on the marginal scutes, a yellow plastron, and red stripes on the head and neck. The adults are sexually dimorphic with males exhibiting very long nails on the front feet and thicker tails (Conant and Collins 1991). This turtle is found most often in shallow waters in the Piedmont of South Carolina though some do exist further south in Pee Dee River Drainage.



Photo by Andrew Grosse

The spotted turtle is a small turtle, reaching lengths of only 9 to 11 cm (3.5 to 4.3 in.); maximum size is approximately 12 cm (4.7 inches) (Conant and Collins 1991). The carapace is typically black in color sprinkled with numerous orange-yellow spots. However, the density and location of spots on the carapace vary and spotless individuals have been observed. Typically, hatchlings and juveniles have a single spot per scute. The head and neck of this species also has orange-yellow blotches. This species has no hinges on the plastron but typically the plastron is a red/orange or cream color with black blotches.



Photo by Andrew Grosse

The Florida softshell turtle and the Gulf coast spiny softshell turtle are both members of the Family Trionychidae (Ernst and Barbour 1989). Members of this family are semi-aquatic and have cartilaginous shells rather than hardened shells like other turtles and tortoises. The cartilaginous "shell" of these turtles covers a bony shell in much the same way the scutes of other turtles and tortoises cover a bony shell. Softshell turtles, in general, have very flattened, pancake-like shells.



Photo by Andrew Grosse

The Florida softshell turtle is a large species, reaching lengths between 28 and 62 cm (11 to 24 in.); females are significantly larger than males (Conant and Collins 1991; Martof et al. 1980). The shell of this species is typically dark brown to dark green and generally uniform in color. The Florida softshell has an oval-shaped shell with numerous bumps on the carapace just behind the head and neck.

The Gulf coast spiny softshell turtle is also a large species, reaching lengths between 18 and 45 cm (7 to 17.7 in.) (Conant and Collins 1991; Martof et al. 1980). Females of this species are significantly larger than males. The spiny softshell turtle has a more rounded shell than the Florida softshell, and there are usually two or more dark, broken lines that parallel the curve of the shell at its rear. The carapace of this species also has numerous small blotches or circular marks. The spiny softshell has two stripes along its neck. The Gulf coast spiny softshell has few to many small “spines” on the carapace just behind the head and neck. Both species have extremely long necks and elongated nostrils.



Photo by Andrew Grosse

The snapping turtle is a member of the Family Chelydridae which includes the snapping and alligator snapping turtles. Members of this family are semi-aquatic and are only found in North America. The snapping turtle is large, reaching lengths of 20 to 36 cm (7.8 to 14 in.). The maximum length for this species is approximately 50 cm (19.6 in.) (Conant and Collins 1991; Martof et al. 1980). This species has a "prehistoric" appearance because its long tail looks "saw-toothed" and its dark brown carapace has a jagged edge. The plastron of this species is greatly reduced and white. The head of the snapping turtle is very large and includes a sharp beak-like snout.



Photo by Andrew Grosse

Striped mud, eastern mud and eastern musk turtles are all members of the Family Kinosternidae (Ernst and Barbour 1989). These turtles are small (2-5 inches) semi-aquatic turtles with a hard carapace and plastron, though the plastron for all these species has varying levels of flexibility. While these species can and do swim, they are typically found walking the bottom of slow or non-moving aquatic habitats.

The striped mud turtle was first documented to occur in South Carolina in the late 1960s. Since that time, additional surveys have confirmed the occurrence of the species in this state and revealed that it is more widespread than previously believed. In the heart of its range (Florida and Georgia), the striped mud turtle has 3 stripes on its carapace and stripes on the side of its head. In South Carolina many individuals of this species lack the carapacial and head stripes, making it easy to confuse them with the more common Eastern mud turtle. Based on museum searches (Lamb and Lovich 1990), this species occurs throughout the Coastal Plain of South Carolina and may be relatively common. However, it seems to be most common in the floodplain swamps of rivers.



Photo by Parker Gibbons



Photo by Andrew Grosse

The eastern mud turtles are a small turtle (2-5 in.) found through most of SC. The carapace is dark in color and plastron is usually yellow or orange with two hinges allowing the turtle to close its shell. The head is usually mottled with yellow with no defined stripes like striped mud and eastern musk turtles.

The eastern musk turtle is a small species (2-5 in.) found throughout SC. The carapace is dark in color and usually covered in algal growth. The plastron has a slight, single hinge and is reduced exposing much of the turtle's soft underbelly. The head has a pair of solid yellow stripes above and below the eye.



Photo by Andrew Grosse

Status

Of this group, only the spotted turtle is listed as a species in Need of Management in South Carolina. The spotted turtle was listed as a species of concern until 2001 when its status was changed to Species in Need of Management (threatened). This change in status was based on the growing popularity and price of the spotted turtle in the pet trade and the fact that most of South Carolina's neighboring states already protected this species. Increasing the protection of this species in South Carolina helped strengthen protections for spotted turtles in South Carolina and the SE US. The South Carolina Department of Natural Resources ranks this species as vulnerable, at moderate risk of extirpation (S3) and it is ranked globally as secure (G5) (NatureServe 2023). Additionally, spotted turtles are listed as Endangered by the International Union for Conservation of Nature (IUCN; van Dijk, 2011), and are currently being evaluated for listing by the United States Fish and Wildlife Service.

Each of the other turtle species are currently considered relatively common to abundant in South Carolina. However, all native turtles in South Carolina continue to face increased threat of illegal collection to meet the growing domestic and international demand for food and pets. These species all occur in freshwater habitats in this state and are susceptible to over harvest.

Freshwater turtle populations cannot withstand the level of harvest to which they have been subjected to in South Carolina. Many of the "target" species are long-lived animals that may not reach sexual maturity until they are 15 years old. Further, these turtles exhibit low survivorship in both the egg and juvenile life stages. It could be possible for one trapper to eliminate a population of turtles at a given site within a matter of months.

Turtle Life Histories

Endangerment of many tortoise and freshwater turtles worldwide is directly related to their life history strategies. Turtles are long-lived organisms that can take years to mature; in some species,

sexual maturity is not reached until 20 years of age. Turtle life history traits sharply contrast with those of North American wildlife game species. Rabbits, squirrels, and white-tailed deer can reproduce at 6 to 12 months of age and may only live to be 2 or 3 years old. Even earlier maturing turtle species become reproductive later than do many shorter-lived birds and mammals: diamondback terrapins (*Malaclemys terrapin*) mature at age 6 (Lovich and Gibbons 1990), Florida cooters (*Pseudemys c. floridana*) at age 6 to 7 (Gibbons and Coker 1977), yellow-bellied slider (*T. scripta*) females at age 8 (Gibbons et al. 1981), and chicken turtles (*Deirochelys reticularia*) at 5 to 6 years of age (Buhlmann et al 2009). Thus, turtles grow slowly, mature later in life, and survive for many years. Consequently, management strategies for turtles should be very different from historical wildlife management approaches for most game species.

When turtles reach sexual maturity, they have a low annual fecundity. In general, few hatchling turtles survive; those that do must harvest resources, grow, and survive for years before they become adults. Thus, adult turtles must have high annual survivorship to maintain stable populations (Congdon et al. 1993, 1994). In some species, older females have higher survivorship and produce more offspring than do younger individuals (Gibbons 1990). Many animals eat turtle eggs, hatchlings, and juveniles, but adults of many turtle species have few natural enemies except humans (Gibbons 1990). Commercial harvests remove large numbers of adult turtles which are the most important individuals for population stability and persistence.

POPULATION SIZE AND DISTRIBUTION

Accurate population estimates do not exist for any of these species. The spotted turtle is not an abundant species in South Carolina, but it can be found in high densities in appropriate intact, contiguous habitat throughout the Coastal Plain. While data exists throughout the state, many of the elemental occurrences in the heritage database are of individuals moving through the landscape or crossing roads and almost no population level data has been compiled. However, this species is known to occur on several tracts of public land in South Carolina. Most of the remaining species are considered relatively common to abundant in South Carolina.



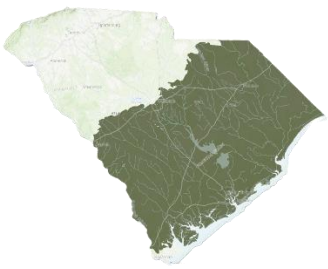
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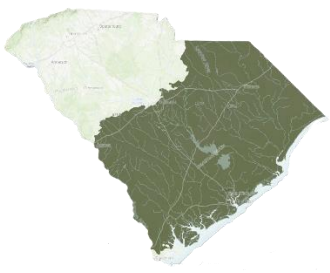
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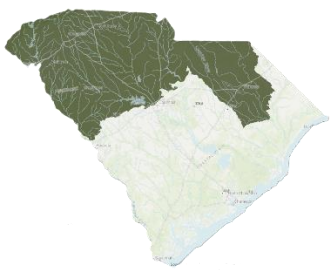
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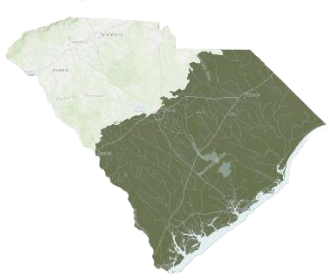
Eastern Chicken Turtle



Spotted Turtle



Eastern Painted Turtle



Striped Mud Turtle



Eastern Mud Turtle



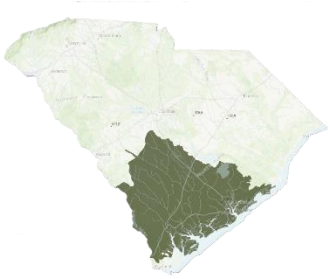
Eastern Musk Turtle



Snapping Turtle



Gulf Coast Spiny Softshell



Florida Softshell

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

All of the members of this group inhabit some type of freshwater and/or wetland system in South Carolina. The spotted turtle is a semi-aquatic species that inhabits a variety of wetland types including small, isolated wetlands, small streams, swamps, flooded forests and other shallow bodies of water (Conant and Collins 1991; Martof et al. 1980; Ernst and Barbour 1989). Spotted turtles are most active during early spring when they can occasionally be observed basking on logs and other objects. Individuals can wander some distance from wetlands when moving between isolated habitat patches, searching for mates, or during nesting movements. This species is difficult to find during the summer months and may undergo a period of summer dormancy (aestivation) in some areas (Litzgus and Mousseau, 2004).

Some species, such as the Gulf coast spiny softshell turtle and the river cooter, are restricted to reservoirs resulting from impounded rivers as well as the rivers themselves. The yellow-bellied slider, coastal plain cooter, mud and musk turtles and eastern painted turtle are most commonly associated with ponds, small lakes, and other non-flowing wetlands. The chicken turtle inhabits seasonally fluctuating, fish-free isolated wetlands. The Florida softshell turtle and the snapping turtle occur in ponds, lakes, and other wetland types.

Chicken turtles (and spotted turtles) also use surrounding upland habitats for refugia during periods when wetlands are dry (Buhlmann et al 2009). These turtles, predominantly juveniles and males but also several females, can spend September through March wintering 50 to 250 m (164 to 820 ft.) from a Carolina bay in South Carolina (Buhlmann and Gibbons 2001). Most often, chicken turtles chose an older live oak-pine forest for wintering habitat; fewer choose clearcut areas. Even the most stringent wetland protection laws do not protect more than 30 m (100 ft.) of adjacent uplands (Burke and Gibbons 1995).

In contrast to the Florida softshell, Gulf coast spiny softshell turtles live in riverine habitats where they often bask on sandbars and bury in clean sand in river bottoms.

CHALLENGES

Due to their life history characteristics, the primary challenge facing turtle populations in South Carolina is the intentional or unintentional, loss or removal of adults. Studies have shown that the loss of only a few individuals per year can result in drastic population declines or complete extirpation of turtle populations (Howell and Seigel 2019).

Alterations to freshwater habitats can result in impacts to all these species but especially eastern chicken turtles and spotted turtles. These alterations include draining and filling isolated wetlands. Additionally, a substantial increase in coastal plain development has resulted in increased wetland impacts, especially to non-jurisdictional freshwater wetlands that have little to no protection. These projects continue to clear-cut forests to edges of wetlands or leave insufficient buffers that eliminate the dry season habitat required by chicken turtles. Narrow buffers of forest habitat left to protect water quality are currently insufficient to provide the upland habitat component needed by chicken turtles. Water quality degradation in these wetlands can also adversely affect these turtles. Eastern chicken turtle populations appear most robust where clusters of seasonal wetlands exist in proximity in an unfragmented landscape. Roads that pass near seasonal wetlands contribute to eastern chicken turtle and spotted turtle population declines through automobile mortality; this mortality results when turtles are moving to nesting areas or upland forests during the dry period.

The primary threats facing the spotted turtle are collection for the illegal wildlife trade and habitat loss or alteration. Due to their colorful pattern and small size, spotted turtles remain highly collectible and can bring a large profit to illegal collectors. A skilled poacher can successfully capture spotted turtles at a rate that is not sustainable because populations depend on high adult survival for long-term stability, resulting in severe population declines or localized extirpation. Draining and filling isolated and/or forested wetlands, a preferred habitat of the spotted turtles, has reduced the number of populations and continues to impact this species. Small shallow ponds, Carolina bays, and other related wetlands receive little to no protection under the Clean Water Act and in many cases are drained and altered.

The loss of wetlands has likely reduced suitable habitat for coastal plain cooters. Mortality also occurs as roads and highways further fragment and isolate wetland habitats.

Population stability of yellow-bellied sliders is threatened by hybridization with red-eared sliders (*Trachemys scripta elegans*), a related subspecies from the Mississippi Valley. Red-eared sliders were sold in South Carolina pet stores for many years and continue to be sold through other venues such as flea markets and exotic animal trade shows. This non-native species is often released in South Carolina by well-meaning, but ill-informed people and can survive in our state. The primary issue here is one of genetic integrity as established red-eared sliders interbreed with yellow-bellied sliders, shifting the genetics of these local populations.

Florida softshell and Gulf coast spiny softshell turtles are often captured incidentally on hook and line and are either killed to retrieve the tackle, or later die due to complications from the ingested hook. Road mortality may be a factor as Florida softshells frequently move overland between lakes and wetlands.

Pollution of rivers and streams may adversely affect Gulf coast spiny softshell turtles at greater rates relative to hard-shelled turtles due to the permeability of the skin and shell. Sandbars used for nesting are also favorite sites for recreational boaters and campers during the summer months.

Whether the human use of the sandbars directly and significantly affects nesting and hatching success is unknown; however, raccoon predation likely increases where camping refuse is also found. Fire ants have been observed to colonize river sandbar habitats and likely affect hatchling survival (Buhlmann and Coffman 2001).

Alteration of rivers, through damming and dredging, adversely affects river fauna. Dams increase normal summer low flows and thus scour aquatic weed beds (Petts 1984); these abnormal flows may affect hatchling survival. Bottom-release dams reduce river water temperatures and may adversely affect river cooters. Reservoirs may also allow for hybridization between river cooters and Florida cooters as their habitats coincide.

Establishment of nonnative fire ants in the Southeastern US has had an adverse impact on freshwater turtles as they will predate nests and newly hatched turtles. These ants especially affect those species in which the hatchlings exhibit delayed emergence and have evolved to remain in the nest because it provided a safe refuge. Other nonnative species that likely negatively impact turtles and their nests include wild hogs and armadillos.

CONSERVATION ACCOMPLISHMENTS

The spotted turtle was listed as a species in need of management in 2001. As such, a set of regulations was adopted that controlled the take and possession of spotted turtles in South Carolina. Effective July 1, 2002, anyone that possessed spotted turtles in South Carolina was required to apply for a free possession permit prior to September 30, 2002. This regulation change limited wild-caught spotted turtles to nine individuals and anyone exceeding that was allowed to apply for a permit to retain all legally acquired turtles prior to the regulation change by September 30, 2002. Over the years following this regulation change, it was clear that permitted individuals had found a loophole and were taking advantage of it to illegally collect and export spotted turtles for profit. As such, in 2019, regulations pertaining to all native reptiles and amphibians were updated, adding protections for all native species from commercial exploitation. A major component of these regulation changes were increased protections for turtles, which prohibited export, transfer of possession, and added possession limits for individual species as well as in aggregate. For spotted turtles specifically, possession of spotted turtles without a permit was still prohibited and current permit holders with a legally acquired collection of spotted turtles were given an opportunity to apply for the new permit within 90 days of the new regulations. Additional changes included, no new turtles could be acquired, no unmarked turtles could be acquired, no reproduction allowed, all individuals permitted must be notched uniquely (with a SCDNR issued code that is unique to every permitted turtle) and photographed annually. Failure to do so results in denial of permit applications/renewals. Notching and annual permit renewals with photographs have addressed the identified loophole. Additionally, new possession permits for spotted turtles are only considered for education and research and justification must be provided.

As the new regulations and permitting requirements were put in place, SCDNR herpetology staff created a Freshwater Turtle and Tortoise identification guide for all South Carolina native turtles and tortoises, which included natural history, how to ID (with photos), and all the new regulations as they pertained to each species. This ID guide was specifically created as a tool for SCDNR Law Enforcement Officers to help assist with identification of native species and the corresponding regulations. Additional collaboration with our chiefs, permitting biologist, law enforcement, and herpetology staff has continued to foster healthy relationships and enforce the new regulations, resulting in greater compliance.

Since the last revision in 2015, we (SCDNR) have added a significant number of new records to the heritage database identifying new populations or areas of interest for many of our native turtles. In 2019, a US Fish and Wildlife Service grant funded The Orianne Society to survey multiple locations throughout SC, to identify presence of spotted turtles at new locations. This survey data was combined with data collected under a Competitive State Wildlife Grant in states across the eastern US and included in the recently published Status Assessment and Conservation Plan for the Spotted Turtle in the Eastern United States (Willey et al. 2022). Beginning in 2020, the Amphibian and Reptile Conservancy initiated an effort to identify important spotted turtle locations. Using telemetry and intensive trapping methodology, they have been successful identifying multiple new locations and population hotspots for this species, as well as gaining a better understanding of spotted turtle behavior and habitat use. In 2022, SCDNR began revisiting population previously studied in the late 1990's to the early 2000's (also surveyed by The Orianne Society in 2019). During the initial study, many individuals were uniquely marked, and some tracked using radio telemetry. Surveys by SCDNR in 2022 and 2023 identified three individual females that were originally marked in 1999 and 2000. Two of these individuals were adults when they were originally captured. Spotted turtles mature between 8-12 years of age, suggesting a minimum age of 30 years old, further supporting the importance of long-term habitat and population protection.

Surveys conducted by the Amphibian and Reptile Conservancy since 2015 in the Francis Marion National Forest have added a significant number of element occurrence records to the South Carolina Heritage Database for several species of this guild. These data have helped inform the status and distribution of several species in the Francis Marion National Forest, including chicken turtles, striped mud turtles and spotted turtles.

Recently, another Competitive State Wildlife Grant was funded to identify presence of spotted turtles in new locations and more intensively survey known populations to learn more about their life history, population viability, and habitat needs in South Carolina. This project is set to begin in January 2024 and continue through 2026. Data resulting from these surveys will continue to help SCDNR make more informed management decisions for spotted turtles in South Carolina.

CONSERVATION RECOMMENDATIONS

- Include the importance of protecting all freshwater turtles and their habitat in general in education materials.
- Consider habitat needs of freshwater turtles in river dredging and dam construction projects.
- Consider all spotted turtle habitat needs when managing Carolina bays and floodplain ecosystems.
- Work with partners on public and private lands to protect spotted turtle habitat and manage appropriately.
- Work with law enforcement to enforce regulations that protect native turtle populations.
- Identify locations of viable spotted turtle populations by conducting early spring surveys when basking turtles are easily seen.
- Continue research and surveys at known spotted turtle populations to learn more about the life history of this species in South Carolina.
- Monitor known spotted turtle sites and populations.
- Conduct research to better understand how relocation effects freshwater turtle species

- Determine locations of viable river cooter populations. Surveys can be conducted via basking surveys during the spring and early summer months. These surveys can form the baseline for long-term monitoring.
- Conduct research that determines effects of dams and reservoirs on the exclusively riverine river cooter.
- Conduct research to determine the ecological habitat niche overlap between Florida cooters and river cooters.
- Determine locations of viable Florida cooter populations.
- Include chicken turtles in protection plans for coastal plain wetlands.
- Consider chicken turtle habitat needs when managing Carolina bays and similar wetland ecosystems.
- Determine locations of viable chicken turtle populations and monitor those populations. Priority survey sites should be located in the vicinity of Carolina Bay clusters.
- Assess the probable impacts of fire ants on freshwater turtles, particularly on chicken turtles, which spend a greater amount of time in the ground as developing eggs, overwintering hatchlings, and terrestrially aestivating adults.
- Survey for Florida softshell turtles and identify possible sites for protection based on results of surveys.
- Consider Gulf coast spiny softshell turtle habitat needs in river dredging and dam construction projects.
- Monitor known spiny softshell turtle sites for water quality changes and determine whether changes in water quality adversely affect this species.
- Determine striped mud turtle distribution, locations of viable populations and collect data on its life history and demography in South Carolina.
- Monitor and conduct research on the impacts of nonnative species on freshwater turtles.
- Monitor changes in the demand for turtles and turtle products and the effectiveness of the new law.
- Work with the South Carolina Department of Transportation (SCDOT) and other partners to design wildlife crossings to reduce road mortality of reptiles and amphibians.
- Evaluate the impacts of disease on this guild.

MEASURES OF SUCCESS

As results from current research and surveys or future efforts are identified and analyzed, projects will be initiated to address specific needs that arise from these results. Stable or growing native turtle populations on protected lands will be considered a measure of success. Data from surveys and other research will be used to continue to determine the best means of conserving these species in South Carolina through habitat and species management and regulatory means.

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Aquatic Snakes Guild

Carolina Swampsnake *Liodytes pygaea paludis*
Florida Green Watersnake *Nerodia floridana*
Glossy Swampsnake *Liodytes rigida*
Queen Snake *Regina septemvittata*
Rainbow Snake *Farancia erytrogramma*
Red-belled Mudsnake *Farancia abacura*

Contributor (2005): Stephen H. Bennett (SCDNR)
Reviewed and Edited (2012): Stephen H. Bennett (SCDNR) and Will Dillman (SCDNR)
Reviewed and Edited (2024): Andrew Grosse (SCDNR)

The following snakes are a part of the aquatic snakes guild due to their dependence on aquatic environments. These vary from large lakes and ponds to isolated ephemeral wetlands. Most of these species have been under surveyed due to their cryptic nature and difficulty to capture or have a limited distribution in South Carolina. As such, all species are listed as data deficient except the Florida Green Watersnake which is a high priority species in the State Wildlife Action Plan.

DESCRIPTION

Taxonomy and basic description


Photo by J.D. Willson

The Carolina swampsnake is the smallest snake in this guild reaching lengths of only about 56 cm (22 in). Carolina swampsnakes have a dark, typically black background with iridescent scales and a red or orange belly. Females are longer and heavier than males but males have longer tails (Camper 2019).

The Florida green watersnake is a large to moderately sized snake that reaches lengths of between 76 to 140 cm (30-55 in.) with a maximum length of approximately 188 cm (74 in; Conant and Collins 1991). It is a heavy bodied snake with a row of subocular scales under each eye and pale, creamy unmarked belly. Florida green watersnakes have keeled scales and typically range from green to brown with short, wavy, bands or crossbars and small black spots (Camper 2019). Surveys at the Savannah River Site showed females are generally larger than males. Females averaged 83 cm (33 in) and males averaged 59 cm (23 in; Gibbons and Semlitsch, 1991).


Photo by Andrew Grosse



Photo by Parker Gibbons

The glossy swampsnake is a small snake with a light brown to olive green appearance. It can reach length of only about 80 cm (31 in). The belly is pale yellow or cream colored with two rows of dark “half moon” shaped markings on each scale. Females tend to larger and thicker than males overall but the males have longer and thicker tails than females (Camper 2019).

The queen snake is a small snake reaching up to about 92 cm (36 in). Queen snakes typically have a dark background color though can be light brown to olive-green in color. Their belly is pale in color but has four dark stripes that run the length of the body, though can fuse together as they near the tail. Females will grow larger and thicker than males but males have thicker and longer tails (Camper 2019).



Photo by Todd Pierson



Photo by Parker Gibbons

The rainbow snake can grow up to 1.7 m (66.5 in). Similar to red-bellied mud snakes, rainbow snakes have an iridescent dark skin with smooth scales however they have three red dorsal stripes. The belly is red with two or three rows of dark spots (Camper 2019). Females are larger and longer than males but have shorter tails.

The red-bellied mudsnake is a large snake that can reach length of up to 2 m (78 in.). They have dark iridescent skin with smooth scales and red ventral and lateral markings (Camper 2019). The belly has alternating red and black bars that extend onto the sides of the snake. Females tend to be larger and relatively longer than males but have shorter tails (Camper 2019).



Photo by Parker Gibbons

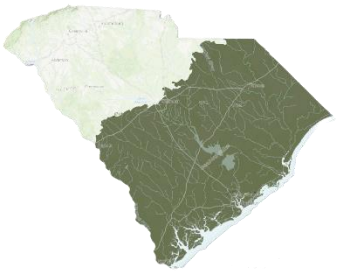
Status

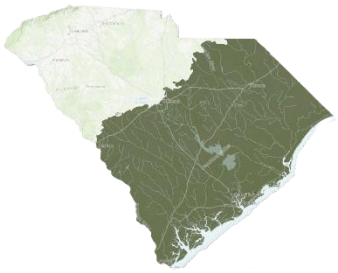
The Carolina Swampsnake is listed as vulnerable in South Carolina (S3) and apparently secure as a subspecies (T4). The Florida green water snake is listed as a Species of Concern in South Carolina and has a rank of S2/G5. The Glossy Swampsnake is listed as vulnerable in South Carolina (S3) and secure globally (G5). The queen snake is listed as apparently secure in South Carolina (S4) and secure globally (G5). The Rainbow snake is listed as listed as vulnerable in South Carolina (S3) and apparently secure globally (G4). The red-bellied mudsnake is listed as apparently secure in South Carolina (S4) and secure globally (G5; NatureServe 2024).

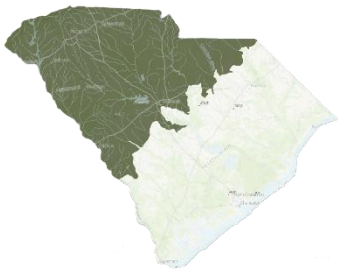
POPULATION SIZE AND DISTRIBUTION

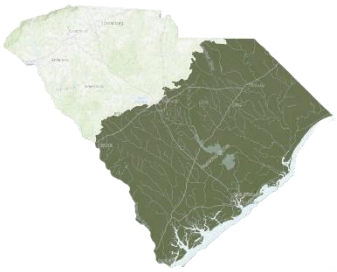
Little data exists concerning the population biology of each of these species in South Carolina. While some of these species have several records throughout the coastal plain of South Carolina, element occurrence data represent a single observation and no thorough population studies have been done. Other than queen snakes, which occur primarily above the fall line, these species largely occur in the coastal plain of South Carolina, with some having more extensive distributions than others depending on their preferred habitat.

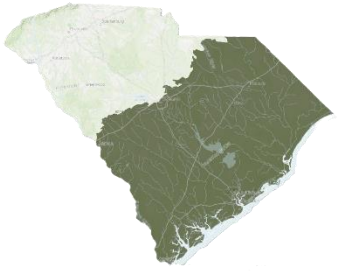
The Florida green watersnake is known from the Savannah River Site in Aiken, as well as Barnwell, Charleston and Berkeley Counties. There are also reports of this species from old rice fields in Georgetown County. There are no records from the counties between these two South Carolina population areas. The South Carolina population of the Florida green watersnake are disjunct from the primary range of this species, which is extreme South Georgia and Florida, by over 300 kilometers (200 miles).

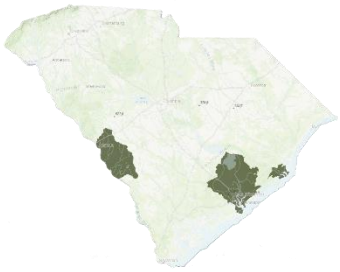

Red-Bellied Mudsnake


Rainbow Snake


Queen Snake


Carolina Swampsnake


Glossy Swampsnake


Florida Green Watersnake

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The Carolina swampsnake, glossy swampsnake and red-bellied mudsnake are semi-aquatic species that inhabit a variety of wetland types. These species are typically associated with wetlands that have abundant aquatic vegetation, including water lilies and other emergent species. Some of these habitats include Carolina bays, isolated wetlands, cypress swamps and slow moving streams and rivers. In South Carolina the Florida green watersnake has been reported from such wetland types as Carolina bays, lakes, rivers, old rice fields, and reserves. Sites where the Florida green watersnake has been typically reported have open water with little or no canopy of trees and an abundance of "pad plants" such as water lily, cow lily, lotus, and water shield. The queen snake is typically found in the piedmont and mountains around streams, creeks and rivers. The rainbow snake is found in the coastal plain of South Carolina and is more commonly found in blackwater streams, creeks and rivers, but has also been found using cypress swamps and occasionally, isolated wetlands and Carolina bays.

CHALLENGES

All of these species are dependent on aquatic systems for persistence. Habitat degradation, habitat loss, pollution and disease are the most common challenges for species persistence. Snake Fungal Disease (*Ophidiomyces ophidiicola)* has been documented on most species of this guild. Preliminary results from a study conducted by Viriginia Tech showed high prevalence of *Ophidiomyces ophidiicola*, on rainbow snakes and anecdotal data suggests rainbow snakes may be more susceptible and/or more negatively impacted than other species of this guild. Unfortunately, due to their cryptic nature, surveillance of the impacts of *Ophidiomyces ophidiicola* on this guild is challenging but remains an area that warrants further investigation.

Species such as the Florida green watersnake and Carolina swampsnake, have been shown to be poor overland dispersers and less drought tolerant than other snake species and may not easily become re-established if extirpated from wetlands due to ditching, draining, or drought (Seigel et al.1995, Winne et al. 2001).

CONSERVATION ACCOMPLISHMENTS

In 2019, the SCDNR passed new regulations that added significant protections for all reptiles and amphibians native to South Carolina. Specifically, as it pertains to these species, no native species can be exported from SC and transfer of possession (buy, sell, trade, etc.) is prohibited.

A State Wildlife Grant was funded from 2021-2026 to focus efforts on expanding the known distribution of Florida green watersnakes and Carolina swampsnakes. While the 2015 version of the State wildlife Action Plan only listed these two species, targeted surveys for them are conducted in the same habitats as the other species listed in the aquatic snakes guild. The only exception is the queen snake which occurs north of the fall line. This survey effort was an opportunity to add new EO records for several species. While these surveys are ongoing, several new EO records have already been added, on new properties, to our heritage database. These include: Eleven (11) new records of Carolina swampsnakes on two (2) different SCDNR properties, 24 new records for rainbow snakes on seven different properties, five (5) new records for glossy swampsnakes on two (2) different properties and three (3) new records for red-bellied mudsnakes on three (3) different properties. For Florida green watersnakes, surveys conducted on the Savannah River Site in 2019 successfully captured 10 individuals. Additionally, recent surveys, as part of the above State Wildlife Grant, conducted in 2021-2025 captured adults at four new locations expanding the range and number of properties where this species is known to occur. All data collected during all surveys have been compiled and included in the SCDNR Heritage Database.

CONSERVATION RECOMMENDATIONS

- Conduct surveys for these species on public and private properties—with appropriate permission—within the range of this species to identify new properties and watersheds/wetlands/river systems where these species occur to better understand abundance and distribution in South Carolina.
- Conduct life history research on these species, at selected sites, to determine habitat and management requirements.
- Monitor and conduct research on the impacts of nonnative species on this guild.
- Work with the South Carolina Department of Transportation (SCDOT) and other partners to design wildlife crossings to reduce road mortality of reptiles and amphibians.
- Evaluate the impacts of disease on this guild.

MEASURES OF SUCCESS

As results from current research and surveys or future efforts are identified and analyzed, projects will

be initiated to address specific needs that arise from these results. Identifying specific population parameters for these species would be beneficial for future management.

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Blue Ridge Reptiles and Amphibians Guild

Bog Turtle *Glyptemys muhlenbergi*
Eastern Milksnake *Lampropeltis Triangulum*
Timber Rattlesnake *Crotalus horridus* – mountain population
Northern Pinesnake *Pituophis melanoleucus melanoleucus*
Coal Skink *Plestiodon anthracinus*
Seepage Salamander *Desmognathus aeneus*
Shovel-Nosed Salamander *Desmognathus aureatus*
Green Salamander *Aneides aeneus*
Wood Frog *Lithobates sylvaticus*
Dwarf Black-Bellied Salamander *Desmognathus folkertsi*
Patch-Nosed Salamander *Urspelerpes brucei*

Contributors (2005): Stephen H. Bennett and Kurt Buhlmann [SCDNR]
Reviewed and Edited (2012): Stephen H. Bennett (SCDNR), Kurt Buhlmann (SREL), Jeff Camper (Frances Marion University), Eran Kilpatrick (USC-Salkehatchie), and Will Dillman (SCDNR)
Reviewed and Edited (2024): Andrew M. Grosse (SCDNR), Jill Newman (Clemson University)

GUILD DESCRIPTION

This grouping includes several amphibian and reptile species that are not necessarily related in terms of their life histories or habitat requirements. These species are restricted to or primarily occur in the Blue Ridge Physiographic Province (Southern Appalachian Ecoregion) and upper piedmont (foothills) of South Carolina; some are peripheral to our state. Several members of this group are, in fact, quite common in the core of their geographic ranges to the north of South Carolina. Several large public lands are located within the ranges of these species and those land managers will be responsible for management of these species. These land holdings include Sumter National Forest and the Jocassee Gorges Wildlife Management Area as well as several South Carolina State Parks. Thus, presenting these species together as a "guild" may help land managers develop a holistic, multiple species conservation plan and minimize management conflicts that may occur if the species are treated separately.

The Southern Appalachian Ecoregion (Blue Ridge Province) and upper piedmont of South Carolina support a diverse and rich herpetofaunal assemblage. Many species found in this region occur nowhere else in South Carolina with most of their geographic range lying to the north of the State. While several of the species represented in this grouping are relatively common outside of South Carolina, some, such as the bog turtle, are not. Other species, such as the green salamander and coal skink have disjunct ranges and are of conservation concern in other portions of their range.

Although most of these species are peripheral to South Carolina, we can make a case for their conservation in our state based on the overall rarity of some and the consideration that most species are most vulnerable at the edge of their geographic range. In addition, the edge of a species' range is often where it experiences the greatest possibility for some evolutionary change, making these populations of potential interest to evolutionary biologists as well as conservation biologists.

BOG TURTLE

DESCRIPTION


Photo by Todd Pierson

The bog turtle is a small, semi-aquatic turtle that can reach 7.5 to 9 cm (2.9 to 3.5 in.) in length; maximum is approximately 11 cm (4.3 inches). Bog turtle shells are typically dark brown with light yellow or red centers on the large scutes. The bog turtle has a distinctive orange or yellow blotch on the head located just behind the eye (Conant and Collins 1991).

Status

The bog turtle is currently listed as threatened in South Carolina with a state rank of S1, critically imperiled, and a global rank of G2, imperiled (NatureServe 2024). In the Southern Appalachians, bog turtles are listed as federally threatened, due to similarity of appearance to the northern populations. This species was discovered in South Carolina in the 1980s.

POPULATION SIZE AND DISTRIBUTION



The bog turtle was first documented in South Carolina in 1988 (SC Heritage Trust Program). To date no populations of bog turtles have been documented. In South Carolina, the bog turtle is not a truly mountain species. The occurrence records we have indicate they occur primarily in the foothills region of the state.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The bog turtle is typically found in streamside bogs, fens, seeps, beaver ponds and other wetlands. In South Carolina, the few specimens found have been discovered in streamside bogs or crossing roads adjacent to streams or beaver ponds. Bog turtle wetlands are generally characterized by wet meadow habitats described as open canopies with spring-fed water and deep silts (Palmer and Braswell 1995). In South Carolina, this habitat type is generally found in the upper piedmont and foothills in association with small streams, seeps, springs and rivers.

CHALLENGES

The wet meadow habitats in which bog turtles are found are typically associated with farming activities or in some cases beaver activity. As farming has declined, the wet meadow bogs have undergone natural succession to red maple swamps (Buhlmann et al. 1997; Herman and Tryon 1997). As succession occurs, the previously open canopy of a bog closes, limiting light to the ground layer. Canopy closure results in changes to the vegetative composition and the physical structure of the bog, resulting in degraded habitat for bog turtles. Over time, the loss of the vegetative composition and structure of the bog systems results in declines in survival, lack of

reproduction and overall population declines for this species. Bog turtles grow slowly, have delayed sexual maturity (4-10 years of age), low annual fecundity (~3 eggs) and require high survivorship of adults for populations to persist. Direct mortality of adults from road mortality, subsidized predators and illegal collection can have detrimental impacts to bog turtle populations and lead to population declines or extirpation.

EASTERN MILK SNAKE

DESCRIPTION



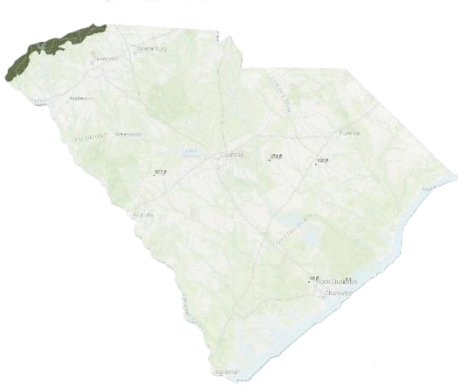
Photo by Todd Pierson

The eastern milk snake is a slender, strongly blotched snake that reaches lengths of 61 to 90 cm (24 to 35 in.); the maximum length is approximately 132 cm (52 in.) (Conant and Collins 1991; Martof et al. 1980). Milk snakes typically possess reddish-brown blotches or saddles that run the length of the snake's body. In South Carolina, though the exact delineation of their distribution is unclear, milksnakes are only found in the upstate. Previous studies suggested that milk snakes in South Carolina may be an "intergrade" between the eastern milk snake and the scarlet kingsnake. However, more recent genetic studies suggest that eastern milks snakes are a separate species from the more common and widespread scarlet kingsnake (Pyron and Burbrink 2009, Ruane et al. 2014 and Chambers and Hillis 2020). Additionally, Crother et al. 2017 list each as separate species.

Status

The South Carolina Department of Natural Resources (SCDNR) Heritage Trust Program assigns a state rank of S2 to the population of the eastern milk snake, classifying it as imperiled because of rarity and restricted range in South Carolina. The global rank of the species is secure (G5; NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION



Specimens of the eastern milk snake have been recorded from the several areas of the Blue Ridge region of South Carolina. Many of the element occurrence records in the Heritage Database are from protected National Forests, State Forests, State Parks and SCDNR state owned properties. Unfortunately, not many records exist in South Carolina and what is available does not provide information on population status and full distribution of this species in South Carolina.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Little is known about the specific habitat requirements of the milk snake. Specimens have been found in mountain valleys, along streams, and in rocky areas. This species is likely to be fossorial much of the year and can be found occasionally under cover objects such as rocks and fallen woody debris (Conant and Collins 1991).

CHALLENGES

Lack of data on the abundance and distribution of the milk snake in South Carolina makes conservation planning for this species problematic. Additionally, milk snakes are highly collectible in the pet trade and illegal collection can have negative impacts on populations.

TIMBER RATTLESNAKE – *Mountain population*

DESCRIPTION

The timber rattlesnake is a large bodied snake that can reach lengths between 90 and 152 cm (35 to 60 in.); maximum length is approximately 189 cm (74 in.) (Conant and Collins 1991; Martof et al. 1980). There are 2 forms, or phases, of the timber rattlesnake found in South Carolina: the coastal plain form, known colloquially as the canebrake rattlesnake, and the mountain form known as the timber rattlesnake. These 2 forms were formerly recognized as subspecies of the timber rattlesnake, but recent research has determined that no genetic evidence supports this classification (Pisani et al 1972). Despite the genetic similarity, there are morphological and ecological differences between the 2 forms (Brown and Ernst 1986).


Photo by Kiley Haberman

The canebrake rattlesnake is typically a tan to flesh-colored snake with black chevrons crossing the body and a dark red lateral stripe running the length of the body along the spine. A dark stripe runs diagonally through the eye (Conant and Collins 1991).

Two color phases are known for the timber rattlesnake. In the first color phase, the body is yellow; in the second color phase, the animal is almost solid black. In both phases, dark chevrons cross the body, and the dorsal stripe, if evident, is not red. This form does not typically have an eye stripe (Conant and Collins 1991).

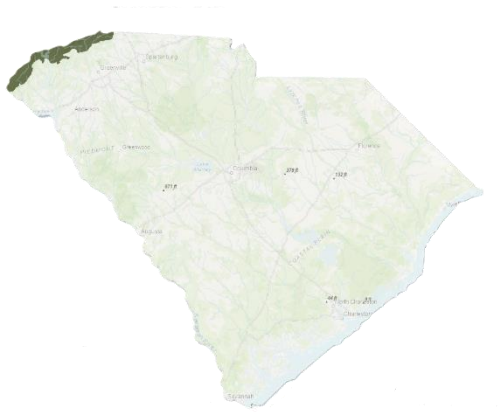
Status

The timber rattlesnake (both the Mountain and Coastal Plain forms) is listed as a species of concern by the South Carolina Heritage Program and although it is considered a single species, is

ranked separately by form/location in the state. Snakes found in the blue ridge region are referred to as Timber Rattlesnakes and are ranked as imperiled (S2) in South Carolina, while snakes found further south are ranked as apparently secure (S4) in South Carolina, with a ranking of apparently secure (G4) globally (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

To date no exhaustive population study exists for the timber rattlesnake and the canebrake rattlesnake in South Carolina, however, although rattlesnakes are widespread in South Carolina, they are most common in the Coastal Plain and Blue Ridge and tend to be uncommon or absent in much of the intervening Piedmont. In Upstate South Carolina, the distribution of the timber rattlesnake is not fully known. Timber rattlesnake specimens from the foothills and upper piedmont more closely resemble the canebrake form of this species. The distribution of the mountain form of the timber rattlesnake is not known, but it is assumed that this form is isolated to areas of higher elevation in our state.



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The mountain form of the timber rattlesnake is generally associated with dry, south-facing slopes at relatively high elevations. In these areas, the timber rattlesnake uses communal den sites in rock outcrops, particularly those with an open south face exposed to the sun. Timber rattlesnakes spend the winter months in these dens; pregnant females give birth to their young in the fall. During the warmer months, timber rattlesnakes may be found in several mountain habitats. This species is an ambush predator, feeding primarily on squirrels and other large rodents (Palmer and Braswell 1995).

CHALLENGES

Humans often fear rattlesnakes, so snake/human interactions often end with the death of the snake. Populations may be threatened by urban development as the timber rattlesnake's habitat becomes more fragmented. Additional development is also likely to result in increased road mortality. Emerging diseases, including snake fungal disease is known to have significant impacts on other rattlesnakes. Finally, illegal collection for the pet and venom trade can have profound negative impacts on populations since collectors target overwintering and birthing habitats where several snakes can be collected at one time.

NORTHERN PINESNAKE

DESCRIPTION



Photo by Bryan Hudson

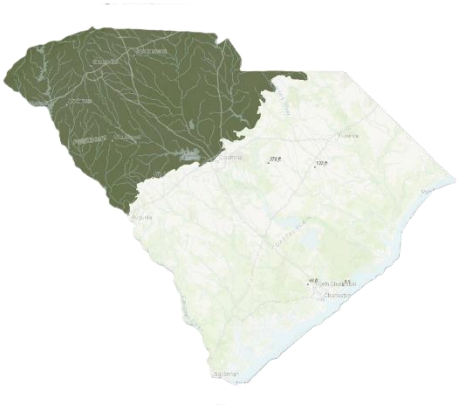
Northern pinesnakes are large, snakes that average 48-66 inches (122-168 cm). Northern pinesnakes tend to be a white, cream or yellow color with distinct, dark, square blotches on the sides and back. Typically, the blotches become more distinct closer to the tail. The belly is generally white with some dark spotting on the edges. Compared to other large snakes, pinesnakes have a smaller head and more of a pointy snout. Additionally, they have four prefrontal scales.

Status

The Northern pinesnake is ranked as imperiled (S2) in SC but apparently secure globally (G4, NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

There are two subspecies of pinesnakes in South Carolina the Northern (*P. m. melanoleucus*) and the Florida pinesnake (*P. m. mugitus*). It was once thought that both subspecies overlapped in South Carolina, creating a hybridization zone somewhere in the coastal plain. However, a recent genetic study suggests that northern pinesnakes may only be found in the upstate and mountains of South Carolina while the Florida pinesnake subspecies, is found further south throughout the coastal plain (Apodaca et al. 2021). To date, no exhaustive population study for the northern pine snakes exists in South Carolina and there are only four occurrence records in Oconee and Greenville counties.



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Pinesnake habitat is generally characterized as xeric, pine-dominated or pine-oak (50 to 80% pine) woodland with an open canopy and open understory of herbaceous vegetation established on sandy soils. In the coastal plain, longleaf pine sandhills appear to represent critical habitat over much of the southeastern United States. In the mountains, pinesnakes are found along the edges of open fields and dry mountain ridges.

CHALLENGES

The primary threat to northern pine snakes is likely habitat loss and degradation although illegal collection and human persecution likely have a negative impact on this species. Larger snakes are particularly vulnerable to habitat fragmentation. Pine snakes, are long-lived animals with large home ranges, whose life histories are not suitable for either harvest or additive mortality. Maintaining viable populations becomes more difficult when additive mortality from automobiles is factored into the equation.

COAL SKINK

DESCRIPTION



Photo by Todd Pierson

The coal skink is a small lizard that reaches lengths of 12 to 17 cm (4.7 to 6.6 in.). This skink has four dorsal lines with the light stripes extending onto the tail. A thick, dark stripe lies between the two light stripes on either side of the body. The body color is bronze to brown, sometimes with dark brown spots, dashes, or lines (Palmer and Braswell 1995). There are no light lines on the head in this species. The heads of males occasionally turn light red during mating season (Conant and Collins 1991; Martof et al. 1980).

Status



The coal skink is listed as endangered in South Carolina with ranking of critically imperiled (S1) in SC but secure globally (G5, NatureServe 2024). This species is split into two subspecies (northern and southern) however, it is unclear which subspecies occurs in South Carolina, especially since the coal skink has only been found at one site, Sassafras Mountain, in South Carolina. This skink is an enigmatic species; it is rarely seen and is never seen in large numbers (Palmer and Braswell 1995)

POPULATION SIZE AND DISTRIBUTION

To date, no exhaustive population study for the coal skink exists in South Carolina.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The coal skink occurs near small, forested streams. They are found in mesic environments under stones, logs and other sheltering debris (Palmer and Braswell 1995). Little is known about its habitat preferences in South Carolina. In the Appalachians, this species occurs most frequently in forests formerly dominated by chestnut, chestnut oak and yellow poplar (Braswell 1977).

CHALLENGES

Lack of data on the distribution of the coal skink in South Carolina makes conservation planning for this species problematic.

SEEPAGE SALAMANDER

DESCRIPTION



Photo by Todd Pierson

The seepage salamander belongs to the dusky salamander group. This salamander is small; it typically only reaches lengths from 4.4 to 5.7 cm (1.7 to 2.2 in.) and is very slender. Seepage salamanders typically have a wide dorsal stripe that varies in color from tan to yellow. Some individuals have a dorsal strip that terminates in a "Y" behind the head. The sides of the salamander are dark while the underbelly is pale (Conant and Collins 1991; Martof et al. 1980).

Status



The seepage salamander has only been found in the Sumter National Forest in Oconee County (Petranka 1998). The seepage salamander is ranked S2, Imperiled, in South Carolina, and has a global ranking of G3, vulnerable (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

To date, no exhaustive population study for the seepage salamander exists in South Carolina.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The seepage salamander is associated with small streams and wetlands where it may be found beneath leaf litter and debris, especially in seepage areas. The South Carolina population is disjunct from the main geographic range of this species (Petranka 1998).

CHALLENGES

Lack of data on the distribution of the seepage salamander in South Carolina makes conservation planning for this species problematic.

SHOVEL-NOSED SALAMANDER

DESCRIPTION



Photo by Todd Pierson

The shovel-nosed salamander is a totally aquatic relative of dusky salamanders. This species can reach lengths of 9 to 12.5 cm (3.5 to 4.9 in.) with a maximum length of approximately 14 cm (5.5 in.). The shovel-nosed salamander is variable in coloration, ranging from gray-brown to yellow. Typically, a paired row of lightly colored spots is found on the back (Conant and Collins 1991; Martof et al. 1980). The tail of the shovel-nosed salamander is compressed laterally, an adaptation to its aquatic lifestyle.

Status



The shovel-nose salamander is ranked vulnerable (S2) in the State of South Carolina and apparently secure (G4) globally (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

To date no exhaustive population study for the shovel-nose salamander exists in South Carolina.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The shovel-nosed salamander is a stream dweller, found in fast-flowing, rocky streams. The salamander is typically found under rocks, mostly in second and third order steams below elevations of 1,220 m (below 4,000 ft.) (Petranka 1998).

CHALLENGES

Lack of data on the distribution of the shovel-nosed salamander in South Carolina makes conservation planning for this species problematic.

GREEN SALAMANDER

DESCRIPTION



Photo by Todd Pierson

The green salamander is the only arboreal salamander in South Carolina. This species can reach lengths of between 8 and 12 cm (3.1 to 4.7 in.) with a maximum length of approximately 14 cm (5.5 in.). Green salamanders are perfectly adapted for life in and around rocky habitat. They are dorsoventrally flattened to fit in small rock crevices, has toe pads, much like those of a treefrog, to help it climb trees and rocky cliffs, and is green and black with a pattern that resembles the lichens and mosses found growing on rocks in the green salamander's habitat (Conant and Collins 1991; Martof et al. 1980).

Status

The green salamander is ranked critically imperiled (S1) in South Carolina and vulnerable (G3) globally and is listed as a Species of Concern. (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

Systematic and opportunistic surveys for green salamanders suggest their distribution in South Carolina is restricted to the blue ridge and some portions of the upper piedmont regions of the state.

From 2016-2019 a Competitive State Wildlife Grant (CSWG) project was funded for several Southeastern states to better understand the green salamander populations in their states. In South Carolina, Clemson University staff and students surveyed over 60 historic sites to document presence/absence. Results of those surveys indicated that green salamanders were present at about half of the sites surveyed. Additionally, a follow up project (2020-2022 State Wildlife Grant SWG), was funded for Clemson University to further investigate information gleaned from the previous CSWG. Photo capture-mark-recapture surveys at eleven sites produced abundance estimates between 3 and 27 individuals with high survival estimates.



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The green salamander is occasionally found in the same rocky areas that are used by the timber rattlesnake. This species is a "cliff dweller," residing in moist, but not wet, rocky sites with abundant crevices. Green salamanders are also found using arboreal habitat (i.e. Trees, downed logs, stumps, rhododendron, etc) that occur adjacent to rock outcrops (Waldron and Humphries 2005).

CHALLENGES

Detection of green salamanders is incredibly low and dependent on several factors. Habitat degradation on the macro and micro habitat level both have negative impacts on individual green salamander populations. At the micro level, damage to rock outcrops leading to reductions in suitable habitat can cause declines. At the macro level deforestation, clearcuts and other large forestry operations between inhabited rock outcrops can limit or eliminate gene flow between populations. Increases in epidemic disease, climate change and illegal collection are also concerns for current and future populations.

WOOD FROG

DESCRIPTION



Photo by Todd Pierson

The wood frog is a small member of the true frog family and so it is related to the bullfrog, leopard frog, and gopher frog. This species can attain a size of 3.5 to 7 cm (1.3 to 2.7 in.); the maximum size is approximately 8 cm (3.1 in.). The body color of the wood frog is highly variable ranging from pink to brown to almost black. The major distinguishing characteristic is the dark patch that extends backward from the eye (Conant and Collins 1991; Martof et al. 1980).

Status

The wood frog is ranked vulnerable (S3) in the State of South Carolina and secure globally (G5) (NatureServe 2024). This frog is also listed as Species of Concern.

POPULATION SIZE AND DISTRIBUTION



To date no exhaustive population study for the wood frog exists in South Carolina. However, surveys by Clemson University, researchers from the University of Connecticut and SCDNR biologists have documented several new breeding locations and incorporated historic locations in the Natural Heritage Database.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The wood frog breeds in small ponds, bogs and other wetlands during late winter and early spring in South Carolina. This species is typically associated with wet or moist areas, but it can be found some distance away from water during the non-breeding season (Palmer and Braswell 1995).

CHALLENGES

Lack of data on the distribution of the wood frogs in South Carolina makes conservation planning for this species problematic. Habitat loss of small breeding pools and wetlands that receive no protection negatively impact populations of wood frogs.

DWARF BLACK-BELLIED SALAMANDER

This species was formerly included in *Desmognathus amphileucus* (black-bellied salamander). It was recognized as a distinct species on the basis of adult size, body proportions, color pattern, and fixed differences at four allozyme loci (Camp et al. 2002).

DESCRIPTION



Photo by Todd Pierson

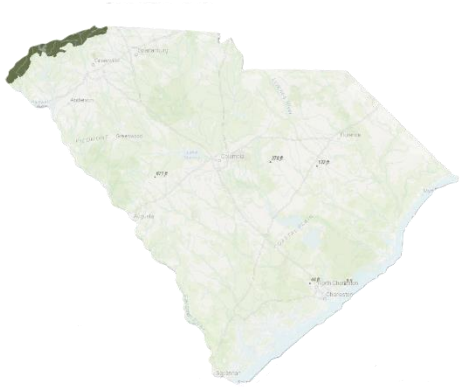
This is a large, semi-aquatic salamander that occurs in small streams. Adults of this species are not as large as the black-bellied salamander, ranging from 56 to 76 mm (2.2-3.0 in.) snout-vent length. The two species can be separated morphologically based on the dwarf black-bellied salamander attaining adult pattern and coloration, particularly on the venter, at a smaller size than the black-bellied salamander. This species has aquatic larvae.

Status

The dwarf black-bellied salamander is ranked as imperiled (S2) in the State of South Carolina and imperiled globally (G2, NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

To date this species has been documented from only two sites in South Carolina, one in Oconee County and the other in Greenville County. The species was originally described from populations in Georgia. Camp et al. 2002 indicate that the species is abundant where it occurs in Georgia and that is also true at the two sites in South Carolina. However, sites in South Carolina comprise a few small streams, located on public property, in the extreme western portion of Oconee County. A survey of several additional sites was conducted in 2015-2016 by Clemson University and while some individuals appeared to be dwarf black bellies, no new occurrence records were documented.



HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Adults have been collected in high-gradient, turbulent first- and second-order streams. They are most abundant in shallow areas of streams where they take cover under rocks. At night they are occasionally seen wandering away from cover; however, they usually remain with only their heads and/or anterior parts of their bodies protruding from cover sites. No differences in habitat have been noted between the sexes (Camp, personal observations).

CHALLENGES

Lack of data on the distribution of the dwarf blackbelly salamander in South Carolina makes conservation planning for this species problematic.

PATCH-NOSED SALAMANDER

Patch-nosed salamanders were first discovered in Georgia in 2007 and subsequently described as a new genus and species (Camp et al, 2009). This species was first described from populations in Georgia and documented to occur in South Carolina in 2009 (Bennett, personal observation).

DESCRIPTION

The patch-nosed salamander is a miniature species, with adults reaching a length of only 25 to 26 mms (0.98-1.0 in.). The species has aquatic larvae. Unlike other dwarf salamanders in the related genus Eurycea, which have four toes on their hind limbs, the patch-nosed salamander has five toes on its hind limbs. In addition, unlike any other known salamander species, the patch-nosed salamander is sexually dimorphic with regard to coloration and pattern. Adult males have a bright yellow dorsum with two darker pigmented dorsolateral stripes. Adult females have a more muted brownish yellow coloration due to a suffusion of numerous dark melanophores, and the dorsolateral stripes are absent. Adults have a distinctive saffron yellow patch on the snout; in larvae this patch is white. A thin dorsal stripe stretches down the center of the tail; this stripe is yellow in adults and white in larvae. The venter is yellow and without markings.

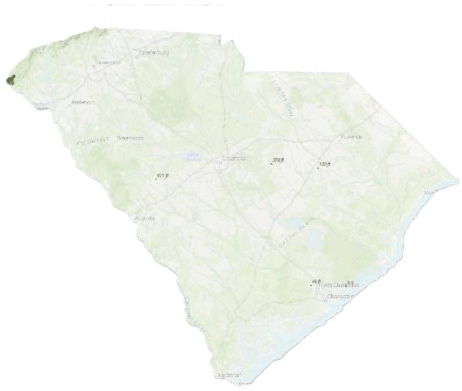


Photo by Todd Pierson

Status

The patch-nosed salamander is ranked as critically imperiled (S1) in the State of South Carolina and globally (G1, NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION



From 2020-2022 a State Wildlife Grant (SWG) project was funded for Clemson University to better understand the distribution of, and define suitable habitat for, the patch-nosed salamander in South Carolina. Using multiple survey techniques, Clemson researchers and students were able to identify 2 additional locations for patch-nosed salamanders in South Carolina, bringing the total known locations in the state up to three, with all three occurring on the same public land in western Oconee County. The particular life history of this species makes it

difficult to survey though a follow up State Wildlife Grant (SWG) project awarded to Clemson University will survey additional nearby streams and attempt to produce abundance estimates at each location using the information gleaned from the previous survey.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

The patch-nosed salamander has been found in or in association with headwater streams. Adults have been observed typically in the leaf litter adjacent to these streams. The aquatic larvae have been observed in portions of these streams lacking a steep gradient, with a bottom of mixed sand and cobble and ample rocks or woody debris to use as refugia.

CHALLENGES

Lack of data on the distribution of the patch-nosed salamander in South Carolina makes conservation planning for this species problematic. Impacts from nonnative species, especially wild hogs, continue to a be problem in the small tributaries where this species is found.

CONSERVATION ACCOMPLISHMENTS

Approximately 40,500 hectares (100,000 acres) of land is in public ownership in South Carolina's southern Appalachians and vicinity. The majority of this land is in the Sumter National Forest, Andrew Pickens District and the Jocassee Gorges Wildlife Management Area, the latter of these owned and managed by SCDNR. Several other smaller tracts, including Heritage Preserves and State Parks, are also protected in this region. Amphibians and reptiles are not the primary management targets on any of these sites, but these species do benefit from conservation management on most, if not all, of these public lands.

In 2015-2016, Clemson University surveyed for six reptile and amphibian species found in the Blue Ridge region of South Carolina. Their surveys resulted in wood frog detections in 15 wetlands, pickerel frog detections in 5 wetlands, Shovel-nosed salamander detections at four locations and milk snake detections as three locations. This survey added significant location data to our heritage and herpetological databases.

In 2019, regulations pertaining to all native reptiles and amphibians were updated, adding protections for all native species from commercial exploitation. A major component of these regulation changes were increased protections for turtles, added possession limits for individual species as well as in aggregate. Additionally, new regulations prohibit export and transfer of possession for all native reptiles and amphibians.

From 2016-2019 a Competitive State Wildlife Grant (CSWG) project was funded for several Southeastern states to better understand the green salamander populations in their states. In South Carolina, Clemson University staff and students were tasked with assessing presence/absence of over 60 historic sites, as well as swabbing individuals for disease prevalence in South Carolina. Results indicated that green salamanders were present at about half of the sites surveyed. Additionally, opportunistic swabs of green salamanders in South Carolina showed an incredibly low prevalence of disease; 2.4% for *Bd* – a single individual and no detections for *Bsal* or *Ranavirus.* Two manuscripts were produced as a result of this project.

Newman, J.C., K. Barrett and J.W. Dillman. 2018. Green salamander estimated abundance and

environmental associations in South Carolina. Journal of Herpetology, 52(4): 438-444.

Newman, J.C., J.L. Mota, R.H. Hardman, J.W. Dillman and K. Barrett. 2019. Pathogen detected in green salamanders (Aneides aeneus) in South Carolina, USA. Herpetological Review, 50(3): 503-505.

From 2020-2022 a State Wildlife Grant (SWG) project was funded for Clemson University to further investigate information gleaned from the previous CSWG. Specifically, they derived occupancy probability estimates for rock crevices, estimated population size across a gradient of forest disturbance and estimated population connectivity, inbreeding and likelihood of past bottlenecks across 15-30 sites. In addition to the results of these objectives Clemson University also provided SCDNR with Conservation and Management recommendations to help SCDNR make more informed decisions using this data as it pertains to green salamanders in South Carolina. The following manuscript was produced from this project.

Novak, M**.** and K. Barrett. 2023. Within-site microclimate and connectivity can help predict the presence of discrete patch inhabitants, *Aneides aeneus*. Herpetological Conservation and Biology 18:111-117.

In 2020-2021, the South Carolina Department of Natural Resources funded a project led by Clemson University to assess the use of salamanders as live fishing bait in South Carolina. This has been reported as a problem impacting salamander populations and we were interested in its current prevalence in the state. Surveys via mailed and emailed questionnaires, as well as physical visits to upstate bait shops suggested that salamanders haven't been sold in the last 5-12 years but that some individuals still use them and ask for them when purchasing bait. The overall survey suggested that anyone using salamanders as fishing bait, likely collect them themselves for personal use.

From 2020-2022 a State Wildlife Grant (SWG) project was funded for Clemson University to better understand the distribution of, and define suitable habitat for, the patch-nosed salamander in South Carolina. Using multiple survey techniques, Clemson researchers and students were able to identify 2 additional locations for patch-nosed salamanders in South Carolina, bringing the total known locations in the state up to three.

A follow-up State Wildlife Grant (SWG) was funded for Clemson University and Kennesaw State University to build upon the previous project and clarify the distribution and status of patch-nosed salamanders by surveying the "core" range in South Carolina (identified in the previous project) as well as to better characterize the population genetic structure and diversity for this species. This project began in late 2023 and will be completed in 2026.

A multi-state competitive State Wildlife Grant was funded to conduct bog turtle surveys at historic locations throughout the southern range of the species. As such SCDNR has visited four historic locations for bog turtles in South Carolina. Two of which no longer have suitable habitat. The other two will be surveyed, beginning in 2024, using multiple techniques, including bucket camera traps which have been shown to significantly increase detection for this incredibly cryptic species. Access to additional historic locations is ongoing.

A survey, partly funded by a State Wildlife Grant, began in 2023 to identify presence, habitat use, and seasonal activity patterns for timber rattlesnakes in South Carolina. Preliminary results have identified several important habitats for this species.

SCDNR staff continue to work with partners (State Parks, State Forests, National Forests, Conservation groups and private landowners) to disseminate information regarding important habitats, natural history, management techniques and how all of those things and compliment each other to better manage habitat for reptiles and amphibians.

Since the last revision in 2015, we (SCDNR) have added a significant number of new records to the heritage database identifying new areas of interest for many of our native reptiles and amphibians found in the blue ridge region.

CONSERVATION RECOMMENDATIONS

- Determine the current extent of bog turtles in South Carolina.
- Re-survey all known historical sites for bog turtles.
- Protect bog turtle habitat through acquisition or conservation easement at all known sites, based on the inventory work.
- Educate local landowners who have populations or suitable habitat for bog turtles on their properties about the ecological importance of this species.
- Work with private landowners to provide bog turtle habitat management recommendations through habitat management guidelines for Southeastern amphibians and reptiles currently being developed by Partners in Amphibian and Reptile Conservation (PARC).
- Implement management techniques for restoring bog turtle habitat. These include cutting shrubs and trees, diking streams, restoring sheet flow to wetlands, burning and use of livestock to mimic native herbivore grazing.
- Consider captive breeding and reintroduction programs if inventory results indicate that bog turtles have been extirpated in South Carolina.
- Conduct research to determine the effectiveness of bog turtle habitat management (scrub clearing and grazing) in South Carolina.
- Create or expand existing education programs for public and private land managers about the presence and ecological importance of eastern milk snakes and ways to protect this species.
- Determine the extent of the distribution of eastern milk snakes in South Carolina.
- Monitor known pet trade collection sites for eastern milk snakes.
- Work with US Forest Service and South Carolina State Park Service (SCSPS) to protect known timber rattlesnake (mountain race) den sites.
- Develop an education program promoting the ecological importance of venomous snakes, including timber rattlesnakes.
- Conduct surveys to identify denning sites of timber rattlesnake populations in the Blue Ridge Mountains.
- Monitor known timber rattlesnake denning sites in the Blue Ridge Mountains to assess any potential human impacts.
- Investigate life history requirements for timber rattlesnakes in South Carolina, including adult sex ratios, recruitment and mortality, habitat use, and seasonal activity patterns.
- Partner with the US Forest Service and the South Carolina Park Service to make recommendations regarding seepage salamander habitat requirements during preparation of forest plans.
- Conduct baseline research to identify seepage salamander distribution, abundance and specific habitat requirements.
- Work with land conservancy groups, the US Forest Service, and the SCSPS to protect watersheds that contain shovel-nose salamanders.

- Include the importance of protecting shovel-nose salamanders in general education materials.
- Survey the Andrew Pickens National Forest to determine the presence of shovel-nose salamanders on that property; monitor any populations discovered.
- Protect sandstone cliffs, the habitat of the green salamander, by eliminating or reducing timber activities that expose these cliffs to drying or allow fragmentation of connective forest habitat.
- Develop an education program highlighting the green salamander and their rock outcrop habitat as a unique species and structure that illustrates biodiversity in the Blue Ridge Mountains.
- Encourage the USFS to consider avoiding isolation of sandstone cliffs from the forest matrix as a result of timber cutting operations on Andrew Pickens National Forest.
- Survey appropriate habitat for the green salamander, including Andrew Pickens National Forest and South Carolina State Parks in the region; monitor any populations discovered.
- Conduct research to determine dispersal mechanisms for green salamanders through intervening forest habitat.
- Use LiDAR imagery to identify additional habitat for green salamanders and other rare and cryptic species that rely on similar habitats.
- Collaborate with public land managers to protect wood frog habitat.
- Include the importance of protecting wood frogs in general education materials.
- Work with USFS and consider the needs of wood frogs when creating wildlife watering ponds in the mountains.
- Inventory appropriate habitat in the Blue Ridge Mountains for presence of wood frogs; monitor any populations discovered.
- Conduct calling frog surveys to determine the presence of wood frogs.
- Monitor successful metamorphosis of larval wood frog tadpoles.
- Conduct surveys for the coal skink, dwarf black-bellied salamander, seepage salamander and northern pine snakes.
- Monitor and conduct research on the impacts of nonnative species on this guild.
- Work with the South Carolina Department of Transportation (SCDOT) and other partners to design wildlife crossings to reduce road mortality of reptiles and amphibians.
- Evaluate the impacts of disease on this guild.

MEASURES OF SUCCESS

For many of these species, the first measure of success will be to document basic life history requirements as well as population status and distribution. As results from current research and surveys or future efforts are identified and analyzed, projects will be initiated to address specific needs that arise from these results. Data from status surveys will be used to direct future research on life history, ecology, and limiting factors for the target species. Such data will also be used to direct future habitat acquisition and management projects. Stable or increasing populations of the primary target species on public lands will be the ultimate measure of success.

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Longleaf Pine Reptile Guild

Mimic Glass Lizard *Ophisaurus mimicus*
Florida Pinesnake *Pituophis melanoleucus mugitus*
Southern Hog-nosed Snake *Heterodon simus*
Eastern Diamond-backed Rattlesnake *Crotalus adamanteus*
Harlequin coralsnake *Micrurus fulvius*
Gopher Tortoise *Gopherus polyphemus*
Slender Glass Lizard *Ophisaurus attenuatus*
Pine Woods Littersnake *Rhadinea flavilata*

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GUILD DESCRIPTION

This guild comprises eight species. Five of the species are snakes and 2 are lizards and one is a tortoise. All the species are commonly associated with one or more of the natural communities that comprise the longleaf pine ecosystem.

All of the species in the Longleaf Pine Reptile Guild are associated with the longleaf pine ecosystem that was extensive across the Southeastern United States at the time of European settlement (Bartram 1791; Guyer and Bailey 1993). The longleaf pine ecosystem has declined to less than 10% of its original land area (Frost et al. 1986). Much of the previously forested lands are now urban or agricultural (Gibbons and Buhlmann 2001). Those lands that are forested have been planted in pine species other than longleaf and have been managed on shorter rotations, in many cases without prescribed fire and without concern for the diverse herbaceous plant species that once occurred with the longleaf pine. It is not surprising, therefore, that the reptiles associated with this ecosystem are also species of concern.

Taxonomy and basic description

The mimic glass lizard is a recently described species that reaches a maximum length of approximately 65 cm (25.6 in.). This is the smallest glass lizard and is generally similar in color and pattern to the slender and island glass lizards, making identification difficult. The mimic glass lizard is typically light brown with dark brown or black longitudinal stripes. A dark mid-dorsal stripe is typically present. All glass lizard species lack any limbs and are also known as legless lizards. (Conant and Collins, 1991; Martof et al. 1980)



Photo by Pierson Hill

There are two subspecies of pinesnakes in South Carolina the Northern (*P. m. melanoleucus*) and the Florida pinesnake (*P. m. mugitus*). It was once thought that both subspecies overlapped in South Carolina, creating a hybridization zone somewhere in the coastal plain. However, a recent genetic study suggests that northern pinesnakes may only be found in the upstate and mountains of South Carolina while the Florida pinesnake subspecies, is found further south throughout the coastal plain (Apodaca et al. 2021). The Florida pinesnake is a large snake with a maximum length of approximately 228 cm (11 in.). This species can be variable in pattern. The Florida pinesnake typically has a light brown to ivory background color with large brown or black blotches down the length of the body. In the Florida subspecies, the anterior blotches are typically not present, and the pattern is indistinct. Pinesnakes from different regions of South Carolina can be very different in coloration and pattern, ranging from light backgrounds with distinct, dark blotches to dark animals with indistinct patterns, and occasionally individuals occur that have red (erythristic) blotches or background colors (Conant and Collins 1991; Martof et al. 1980).



Photo by Andrew Grosse



Photo by Todd Pierson

The Southern hog-nosed snake is the smallest of the hog-nosed snakes, a group of snakes that possess a sharply upturned snout, believed to be an adaptation for burrowing. This species averages 36 to 51 cm (14-20 in.) in length. The Southern hog-nosed Snake is typically a tan-brown snake with darker blotches running down the back. The colors of this snake are typically less variable than its more common relative, the Eastern hog-nosed (Conant and Collins 1991).

Originally described by Palisot de Beauvois in 1799 (type-locality: Charleston, South Carolina; Schmidt, 1953) the Eastern diamond-backed rattlesnake is the largest venomous snake in the United States. The maximum reported length is 243 cm (96 in.), but most adult specimens in South Carolina are typically much smaller, averaging approximately 84 to 183 cm (33-72 in.). Typical of crotaline pitvipers, the Eastern diamond-backed rattlesnake is heavy-bodied, with keeled dorsal scales, a large head, and a tail rattle composed of avascular keratinized epidermis (Klauber, 1972; Ernst, 1992). Coloration ranges from olive green, yellow, tan, and light to dark brown, with 24-35 dark, diamond-shaped blotches running the length of the body (Means, 2017; Camper, 2019). These blotches are typically outlined by a single row of yellow-white scales but often become compressed and sandy-colored towards the snake's tail (Wright & Wright, 1957). There is a distinctive wide, dark stripe across the eye, surrounded on either side by a narrow, light stripe (Conant and Collins 1991; Martof et al. 1980). Adults express sexual size dimorphism such that males attain larger body sizes than females; males typically have larger heads and longer tails than females of the same age class (Means, 2017). Neonatal Eastern-diamondback rattlesnakes resemble adults in both pattern and coloration but are usually less than 48 cm (19 in.) in length and possess only one, singularly lobed rattle segment that is vascularized and thus dark in color. This "pre-button" segment emerges further following the snake's first post-natal shed and is avascular following the second post-natal shed (Means, 2017).



Photo by Wade Kalinowsky

EDBs exhibit juvenile biased dispersal, with adult EDBs having high spatial fidelity that makes them unlikely to redistribute at the landscape scale (Waldron et al. 2013a). EDBs exhibit a slow life history characterized by delayed maturation, high site fidelity, high longevity, and long birthing intervals. In SC, EDBs reach sexual maturity in 7 years (Waldron et al. 2013a); exhibit high adult survival (82%), and can live > 20 years. Juvenile EDB survival is low, reflecting susceptibility to predation and risks associated with dispersal.

The harlequin coralsnake is the only member of the Family Elapidae (cobras and relatives) found in South Carolina. This venomous snake is very different from all of South Carolina's other venomous snakes, which are all pit vipers. Instead, this species has short, fixed fangs.



Photo by J.D. Willson

The harlequin coralsnake is a brightly colored species with red, yellow and black annular rings running the length of the body. There are two species of non-venomous snakes, the scarlet kingsnake and the scarlet snake, which are similarly patterned. On the harlequin coralsnake, the red and black bands don't touch, whereas on the non-venomous species, the red and yellow bands never touch. In addition, the harlequin coralsnake has a black head and the non-venomous species have red heads. The harlequin coralsnake can reach a maximum length of 120 cm (47 in.); however most specimens are typically in the range of 51-76 cm (20-30 in.), (Conant and Collins 1991; Martof et al. 1980).



Photo by Andrew Grosse

The gopher tortoise was described by Daudin in 1791. This is the only species of tortoise found in the eastern United States and one of only four tortoise species found in North America. The gopher tortoise is a large, terrestrial turtle with front legs that are spade-like, an adaptation for digging and hind legs that are elephantine. The carapace of the gopher tortoise can vary from brown to dark gray. Carapace length averages 25.4 to 30.5 cm (10 to 12 in.) for adults; maximum length is approximately 38 cm (15 in.). The carapace of the adult tortoise is generally dull and unmarked. Adult tortoises can weigh up to 4.5 kg (10 lbs.). The head of a tortoise is square in profile with a flat, blunt nose (Conant and Collins 1991). Juvenile tortoises are typically lighter colored than adults, varying from yellow-brown to light gray. Juveniles may have light colored centers on their carapacial scutes, and visible growth annuli. As tortoises grow, their annuli become worn and are seldom apparent on adult specimens (Ernst et al. 1994). Tortoises are herbivorous, feeding primarily on grasses and plants, but they have also been documented to scavenge on carrion and other materials, as available (Conant and Collins 1991; Ernst et al. 1994). The gopher tortoise is a long-lived species, possibly reaching 50 to 60 years, or greater, in age. This species is believed to reach sexual maturity between 12 to 14 years of age and can be reproductively active until death. Tortoises mate in spring and nesting occurs during April though July. Clutch sizes typically number five to seven eggs. Hatchlings emerged in late summer to early autumn (Conant and Collins 1991; Ernst et al. 1994).

The slender glass lizard is a moderately large lizard that can reach lengths from 56 to 106 cm (22-42 in.) (Conant and Collins 1991). This species is typically brown with dark longitudinal markings that are similar to those of the mimic glass lizard. The slender glass lizard differs from the mimic glass lizard and the island glass lizard, another rare species, in that it has numerous dark markings (dark spots, dashes or lines) below the lateral fold (Palmer and Braswell 1995). There is sufficient variation in the glass lizard species to make casual identification problematic, and the use of a good dichotomous key is typically required for accurate identification.



Photo by Parker Gibbons

The pine woods littersnake is a small, secretive species that rarely exceeds 33 cm (13 in.) in length. This species varies from golden brown to light reddish-brown, becoming paler along the sides. There is a dark line through the eye, and the lip scales are white to yellowish in color (Conant and Collins 1991).



Photo by Todd Pierson

Status

The members of this guild are listed as Species of Concern in South Carolina with the Southern hog-nosed snake listed as state threatened and the gopher tortoise listed as state endangered. The Heritage Trust Program currently ranks the species as follows: mimic glass lizard (S1/G2), Florida pinesnake (S2/G4), Southern hog-nosed (S1/G2), Eastern diamond-backed rattlesnake (S2/G3), Harlequin coralsnake (S2/G5), slender glass lizard (S4/G5), gopher tortoise (S1/G3) and pine woods littersnake (S3/G4; NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

Little is known of the actual population status of any of these guild members other than the gopher tortoise. The mimic glass lizard, possibly the most rare guild member, has only been reported once in South Carolina. The slender glass lizard is more widespread and better represented in collections than the mimic glass lizard, but no data exists on its population status. Glass lizards as a group are not well known in terms of their population status, life history or demography.

The Florida pinesnake is widespread in South Carolina but appears to be restricted to several specific habitat types that are either subsets of the longleaf pine ecosystem, or share some of the characteristics of this system, primarily the relatively open canopy and xeric conditions. Pinesnakes are not abundant in any particular area of the state, even where they are found with some regularity. To date, no exhaustive population study for the Florida

pinesnake exists in South Carolina.

The Southern hog-nosed snake has been documented from several counties in South Carolina however this species is both fossorial and cryptic, making survey efforts difficult. As such, population estimates are not available for this species and observations are infrequent.

The Eastern diamond-backed rattlesnake is primarily restricted to the lower terraces of South Carolina's Coastal Plain. This species was once believed to be common and widespread but is now thought to be declining range-wide (Martin and Means 2000; Timmerman and Martin 2003). In South Carolina, the species is most abundant in the lower coastal plain and barrier or sea islands south of the Santee River.

The harlequin coralsnake is one of South Carolina's least known reptile species. This fossorial, secretive species appears to be colonial in distribution. No population data exists for this species, and its fossorial habits make it a very difficult species to survey.

In South Carolina, gopher tortoise populations currently occur in the Sandhills and Inner Coastal Plain ecoregions in three counties: Jasper, Hampton and Aiken. There are additional records of the tortoise in Colleton and Dorchester Counties and an anecdotal record for Bamberg County. Another additional record for the gopher tortoise came from Allendale County; this is believed to be an introduced population, although it is likely that Allendale County was in the historic range of the tortoise. The currently accepted (historic) range of the gopher tortoise in South Carolina includes the southern portion of the state. Additional records have added to the range of this tortoise in South Carolina. Based on all the records for the tortoise, it is reasonable to believe that the gopher tortoise once occurred throughout the southeastern portion of South Carolina. Native, extant, reproducing populations of the gopher tortoise are currently known from three different "metapopulation" areas: 1) the sandhills along the South Edisto River in Aiken County; 2) the sandhills along the Coosawhatchie River in both Jasper and Hampton Counties; and 3) The sandhills along the Savannah River in Jasper County.

A minimum viable population (MVP) is defined as “a species-specific abundance threshold below which stochastic threats pose an unacceptable risk to an isolated population” (Shaffer 1981; Shoemaker et al. 2014). The Gopher Tortoise Council defines a gopher tortoise MVP as a population of at least 250 adults with a density of no less than 0.4 tortoises/ha on a site that is at least 100 ha in size and of superb quality (Gopher Tortoise Council 2013). Anything less than that is considered a support population and Gopher Tortoise Council (2014) defined two such population types: A primary and secondary support population which were defined as:

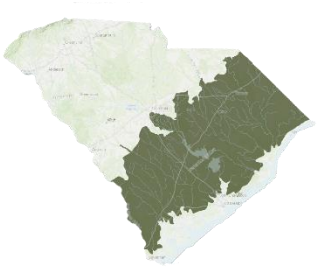
Primary Support Populations: Populations with between 50-250 adults which are candidates for population restoration by improving habitat to increase natural recruitment, or through population augmentation to attain MVP status. By definition, Primary Support Populations must occur on sites large enough to sustain a MVP.

Secondary Support Populations: Populations of <50 adults, some of which are constrained from reaching primary support status because of limited habitat or management options. Secondary Support Populations are important for education, community interest, or can be used for augmentation purposes. If sufficient potential habitat is present and managed, Secondary Support Populations are candidates for habitat restoration and/or population

augmentation to attain Primary Support Population or MVP status.

In South Carolina, a survey initiative to estimate abundance of gopher tortoise populations in South Carolina began in 2015 and continued through 2018. Surveys were done using Line Transect Distance Sampling methods (LTDS) and survey results suggest that South Carolina has two MVP's, four PSP's and 3-5 SSP's. While this survey was not exhaustive of all gopher tortoise habitat in the state, it does suggest that South Carolina likely has fewer than 1500 adult gopher tortoises. Based on survey results, the SCDNR and other conservation groups currently own the properties that hold the four largest gopher tortoise populations in South Carolina.

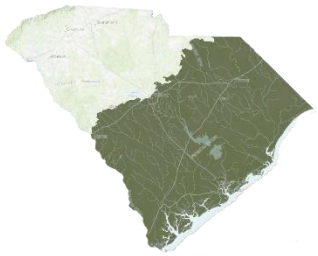
Little or no data on the distribution or status of the slender glass lizard and the pine woods littersnake exists for South Carolina. These species are not necessarily rare, but they are not frequently encountered.



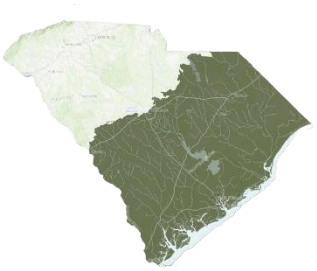
Mimic Glass Lizard



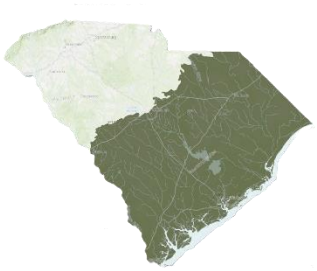
Slender Glass Lizard



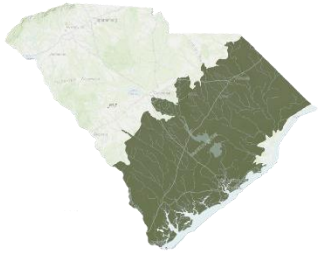
Pine Woods Littersnake



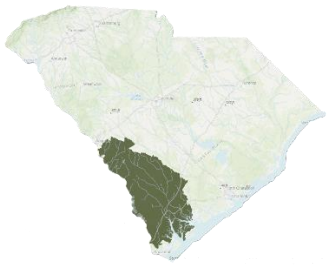
Florida Pinesnake



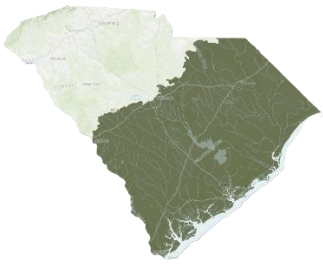
Southern Hog-nosed Snake



Eastern Diamond-backed Rattlesnake



Gopher Tortoise



Harlequin Coralsnake

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Members of this guild are closely associated with, but not necessarily endemic to, natural communities that are part of the Longleaf Pine Ecosystem. The Florida pinesnake, Southern hog-nosed snake and harlequin coralsnake are typically associated with the more xeric longleaf communities and can be found in the same habitat types that support gopher tortoise populations. The Eastern diamond-backed rattlesnake, mimic glass lizard and slender glass lizard are more commonly associated with the mesic longleaf communities, including longleaf pine flatwoods. All species show some overlap in their habitat preferences and can be found in habitats other than longleaf.

While closely associated with Longleaf pine habitats (e.g., sandhills, savannas, and flatwoods; Timmerman & Martin, 2003; Martin & Means, 2000; Means, 2006, 2017; Waldron et al., 2006; Waldron et al., 2008), Eastern diamond-backed rattlesnakes are also found in coastal maritime communities such as maritime grassland and maritime forests, particularly those on barrier or estuarine islands. Coastal habitats are probably hospitable in that they share some physiognomic similarities (e.g., open-canopies, low basal areas) with Longleaf pine savannas (Fill et al., 2015; Means, 2017). The occurrence of EDBs in coastal island habitats is patchy and poorly understood. Populations can reach high densities on barrier and sea islands, but island occupancy is difficult to predict based on current habitat structure. The occurrence of island EDB populations might coincide with the availability of inland (upstream), high-integrity pine savannas and woodlands. The EDB's propensity for swimming in coastal and tidal water bodies likely facilitates down-river dispersal influenced by extreme tidal events. EDBs rely on open-canopy pine savannas and woodlands at multiple spatial scales (Waldron et al. 2008, Waldron et al. 2006, Fill et al. 2015). At the microhabitat scale, EDB ambush site selection is influenced by mast availability, indicating a bottom-up trophic effect (Heres et al. 2018). Eastern diamond-backed rattlesnakes can be found in mixed forests, old fields, prairies, and edge habitats around agricultural land (Klauber, 1972; Means, 2017; Camper, 2019). They may also use closed-canopy hardwood hammocks in proximity to open pine woodlands (Timmerman, 1995; Means, 2017). Similarly, the harlequin coralsnake prefers Longleaf pine habitats but can also be found in maritime and hardwood forests within the Southeastern Coastal Plain.

The gopher tortoise is a fossorial, burrowing species that primarily inhabits xeric longleaf pine sandhills in South Carolina. The deep, droughty sands of such habitats provide the ideal substrate for the excavation of the tortoise's burrow. Adult tortoises may excavate a burrow that can be from 3 to 9 m (10 to 30 ft.) in length; at its deepest point the burrow may be 3 m (10 ft.) underground (Ernst et al. 1994). An individual tortoise may excavate several such burrows over its lifetime; it may also take over and utilize burrows excavated by other tortoises. Tortoises typically use more than one burrow during the active period of the year, but typically over-winter in only one burrow (Ernst et al. 1994). The burrow system within a tortoise colony may provide the organization and structure for these social animals. Courtship occurs at burrow mouths and egg deposition typically occurs within 4 m (12 ft.) of the burrow (Ernst et al. 1994). Tortoise burrows are not just important to the tortoises but are also a critical resource for many species that are found in sandhill habitats. Over 360 species of vertebrate and invertebrates have been documented to use tortoise burrows, whether active or abandoned. Longleaf pine sandhill habitat is fire adapted, that is, it requires periodic wildfire (historically) or prescribed burning (currently) for establishment, restoration, and maintenance of this vegetative community. This habitat type has declined

due to the suppression of fire in the southeast and the conversion of longleaf pine forests to commercial loblolly plantations. Historical tortoise habitat would consist of longleaf pine in an open, park-like stand with a lush ground cover dominated by wiregrass (*Aristida stricta*). Herbaceous plants such as gopher apple, goat's rue, lupine and other grass species would have also occurred. A sparse understory would have been composed of scrub oaks.

All members of this guild spend some portion of their life using underground shelters, such as stump holes, rodent burrows, root channels or gopher tortoise burrows. The Eastern diamond-backed rattlesnake is typically found underground during the colder months. EDBs rely on underground structures for reproduction (gestation and parturition), ecdysis, and overwintering. Selection of microhabitats for gestation and overwintering is driven by thermal conditions of the microsite, reflecting thermoregulatory and metabolic requirements specific to behaviors (e.g., access to basking opportunities during winter and access to shade/cool temperatures during gestation). This ambush predator can, however, be found on the surface during the active (warmer) season. The other species spend far greater amounts of time underground, coming to the surface for only short periods of time. Longleaf pine habitats provide open canopies with abundant stump holes. These are created when pine trees are blown over by storms or killed by lightning. In the case of lightning-killed trees, the root ball is typically burned out by periodic fire, creating underground chambers. In addition to stump holes, this habitat typically features friable, sandy-loam soils that are easily excavated by rodents and other animals. Many reptiles take advantage of these burrows, exploiting the food resource by eating the occupants and then using their burrows for refuge.

Numerous amphibian and reptile species are closely associated with some form of longleaf pine habitat. Several species of conservation concern in South Carolina, other than the primary guild members, would benefit from conservation efforts directed at this habitat type, including species that have been covered either individually or under another guild type. The following species are highly likely to benefit from such conservation efforts: Frosted flatwoods salamander (*Ambystoma cingulatum*), Mabee's salamander (*Ambytoma mabeei*), Eastern tiger salamander (*Ambystoma tigrinum*), gopher frog (*Lithobates capito*), oak toad (*Anaxyrus quercicus*), and ornate chorus frog (*Pseudacris ornata*). In addition, numerous species whose status is not fully understood or are relatively common would also benefit from longleaf pine habitat conservation. Examples of such species include the coachwhip (*Masticophis flagellum*), scarlet kingsnake (*Lampropeltis triangulum elapsoides*) and barking treefrog (*Hyla gratiosa*).

CHALLENGES

The primary threat confronting members of this guild is habitat loss and degradation. Longleaf pine habitat has been greatly reduced both in extent and in quality subsequent to European settlement of the Southeast (Noss 1989). Vast acreages of longleaf pine have been converted to agriculture and/or loblolly pine plantations in South Carolina. The loss, or degradation of longleaf pine habitat results in the loss of key components, such as stumpholes and open canopy conditions, required by the guild members.

Certain guild members, such as the Eastern diamond-backed rattlesnake and pinesnake, are under pressure from illegal collection for the pet trade and venom collection. Larger bodied snakes are particularly vulnerable to habitat fragmentation and an increasing road network. Additionally, persecution and direct killing of snakes by humans affects these populations. Negative attitudes and misguided risk perception are particularly harmful to rattlesnake

populations, challenging efforts to effectively mitigate human-rattlesnake conflicts (Dunn et al. 2024, Keener-Eck et al. 2019, Waldron et al. 2013b). Some of the large snakes, particularly pinesnakes and eastern diamond-backed rattlesnakes, are long-lived with large home ranges. Maintaining viable populations becomes more difficult when additive mortality from humans and automobiles occurs. Many species associated with the imperiled longleaf pine ecosystem have poor dispersal ability and cannot return to restored habitats, requiring repatriation efforts to restore populations.

The introduction of fire ants throughout the Southeastern United States has been implicated as a potential reason for the apparent decline of the Southern hog-nosed snake (Tuberville and Jensen 2008). Fire ants may also be having unknown/unseen population effects on other fossorial and egg-laying snakes. Additionally, intensive or chronic soil disturbance may also pose a threat to fossorial snake species (Tuberville and Jensen 2008). Fire suppression, stump removal, and short timber rotations may limit population numbers by reducing availability of nesting sites and large stump holes for refugia (Tuberville and Mason 2008).

Further, infectious disease (e.g., *Ophidiomyces ophiodiicola*; *Oo*) is an emergent threat to snakes across the eastern seaboard. *Oo may* cause abnormal shedding (dysecdysis) and epidermal disfigurement or systemic growths that can result in death (Lorch et al., 2016; Baker et al., 2019). Sublethal effects interfere with standard seasonal behaviors such as reproduction and brumation (Lind et al., 2019; McKenzie et al., 2021; Lind et al., 2023). Though there is little data on population-level impacts of *Oo* in southeastern snakes, recruitment rates could be negatively affected by truncated reproductive effort and by the potential for decreased offspring survival resulting from vertical (mother-to-progeny) transmission (Lind et al., 2019; Stengle et al., 2019). Additionally, *Oo* could reduce the number of mature, reproductive individuals within a population, thus altering demographic composition and impeding vital rates necessary for population stability. Recent findings suggest that *Oo* could pose a serious threat to vulnerable snake populations in South Carolina; 9 adult female Eastern diamond-backed rattlesnake mortalities within the state have been attributed to *Oo* between 2022-2024. Between 2022-2023, research conducted on the Marine Corps Recruit Depot at Parris Island, SC indicated that *Oo* infection severity was negatively associated with annual survival of mature female Eastern diamondback rattlesnakes; estimated annual survival (calculated using a known-fates framework) was 68% (Gray et al., unpbl. data), which is the lowest survival estimate available for the species of this age class.

Efforts to conserve coastal populations that are threatened by climate change are challenged by a limited ability to predict how populations will respond to temperature and precipitation changes. The southeastern US faces warming temperatures and an increasing frequency of extreme precipitation events, with climate models predicting that warming temperatures will continue through the 21st century. Climate change may not only result in ambient conditions that are unfavorable to wildlife, but indirectly challenge populations via habitat degradation and increase incidence of infectious disease and human-wildlife conflict (Gibbons et al., 2000; Acevedo-Whitehouse & Duffus, 2009; Newsom et al., 2023). The ability to identify vulnerable populations hinges on an improved understanding of how changing weather patterns will affect population demographics and population viability.

Tortoise populations have been historically adversely affected by take or harvest. The gopher tortoise was collected for food throughout the southeast prior to its range-wide

protection. Illegal take for food still occurs, especially on private lands where little or no management or protection occurs. Gopher tortoises have also been confiscated when found for sale as pets. It is often unknown from where these individuals originated. The primary challenge to the gopher tortoise is habitat loss, either through direct means, such as type conversion to loblolly plantations, agriculture or development; or through indirect means, such as fire suppression that results in successional changes that render the habitat unsuitable for tortoises. Direct threats to habitat may cause immediate mortality in tortoises or result in displacement of tortoises into unsuitable habitats. Heavy equipment can collapse burrows; this can result in additional tortoise mortality. Indirect threats to habitat may result in long-term population declines correlated to declines in available food and burrow sites and increases in predators. While adult tortoises have few predators, with the exception of man, juvenile tortoises are predated by a wide array of animals, including foxes, coyotes, domestic dogs, raccoons and snakes. Additionally, armadillos may pose a threat to the tortoise by modifying existing burrows and potentially predating tortoise eggs.

CONSERVATION ACCOMPLISHMENTS

Several members of this guild have been the focus of research and survey either conducted by SCDNR personnel or funded by SCDNR in the past decade. Surveys for the pinesnake, Southern hog-nosed snake, gopher tortoise, and mimic glass lizard have been ongoing at several SCDNR owned and managed preserves.

Documented occurrences of the Eastern diamond-backed rattlesnake, Southern hog-nosed snake, harlequin coralsnake and pinesnake are known from several publicly owned and managed sites and several new records for these species were added to the heritage database over the last decade resulting from survey and monitoring by SCDNR staff and collaborators.

A State Wildlife Grant (SWG) funded a survey from 2016-2020 to use camera traps to document upland snake species, specifically, southern hog-nosed snakes, pinesnakes and eastern diamond-backed rattlesnakes. While the funding ended in 2020, many of the fences that were originally constructed are still monitoring the same properties and additional fences have been constructed in new locations. In total, over 20 fences have been installed with some still in operation. In total, we were able to document presence of pinesnakes on seven properties, southern hog-nosed snakes on one property and eastern diamond-backed rattlesnakes on one property using this method. Full results can be found in the 2020 completion report to the USFWS.

Coastal Carolina students and staff used radio telemetry to track movements and habitat use of pine snakes in the coastal plain of South Carolina. Eight pine snakes were tracked between 2021 and 2023, and locations were documented every 1-2 days. Male straight-line movements averaged 373 m/move with the longest straight-line movement averaging 1811 m. Female straight line movements averaged 331 m with the longest straight-line movement averaging 1270 m. Male total home range averaged 185 ha while female total home range averaged 99 ha. Finally, males were underground for 94% of their observations and females were underground for 88% of their observations. The data from this study is currently being written into a manuscript for publication and will be useful for future management decisions that impact this species.

The Eastern diamond-backed rattlesnake is currently being evaluated for listing through the USFWS Species Status Assessment Process. A decision should be made in 2024.

SCDNR partnered with the Marine Corps Recruit Depot Parris Island (MCRDPI) and Marshall University to conduct an EDB translocation study. The project examined the utility of long-distance translocation for mitigating negative human-rattlesnake conflicts. Kelley et al. (2022) used pre- and post-translocation radio telemetry to examine the impact of long-distance translocation on EDB movement and survival. In 2018, they moved 12 adult EDBs from the MCRDPI to the James W. Webb Wildlife Center and Management area (WEBB). Using insight gained from the SCDNR's long-term monitoring of the WEBB EDB populations (i.e., Waldron et al. 2013, Waldron et al. 2008, Waldron et al. 2006), translocated EDBs were released in high-quality pine savannas known to be used by the WEBB EDB population. Post-translocation activity ranges were larger than pre-translocation ranges and daily movements were longer following translocation. Translocation did not significantly affect survival probability, and post-translocation movement patterns likely reflected the need to find suitable microsites. The study suggests that translocations may be a viable conservation and mitigation strategy for EDBs; however, more research is needed to identify correlates of post-translocation mortality.

Four areas that support gopher tortoise populations are protected in South Carolina, due to partnerships and collaborations of SCDNR and its conservation partners. Two areas, Tillman Sand Ridge Heritage Preserve (TSRHP) and Aiken County Gopher Tortoise Heritage Preserve (AGTHP), were already owned and managed by SCDNR. In 2020-2022, the Open Space Institute, Knobloch Foundation and Nature Conservancy purchased a total of ~12,000 acres of land in Jasper and Hampton counties separated by the headwaters of the Coosawhatchie River. The uplands on each side of the Coosawhatchie River Floodplain are longleaf pine habitat and represent a separate group of gopher tortoises. Based on Line Transect Distance Survey efforts in 2015-2018, these four properties represent the four largest gopher tortoise populations in the state and will eventually all be under the ownership of SCDNR.

TSRHP is one of the two MVP's in South Carolina and encompasses about 1400 acres with approximately 400 acres of suitable tortoise habitat. Beginning in 2015 and continuing through 2021, SCDNR partnered with several other state agencies and collaborators on a Competitive State Wildlife Grant (CSWG) to restore about 100 acres of potentially suitable habitat at TSRHP. Through a combination of timber harvest, thinning, hand removal and herbicide of recruiting hardwoods, prescribed fire, and replanting native ground cover, we've been able to significantly increase the quality and quantity of habitat for gopher tortoises at the TSRHP.

AGTHP is about 1600 acres in size, most of which is suitable tortoise habitat. SCDNR initiated a population augmentation project for the gopher tortoise at the Aiken Gopher Tortoise Heritage Preserve in 2005, funded initially by State Wildlife Grant dollars. Since then, significant improvements to habitat and the gopher tortoise population have been made, through collaboration with partners.

- Several hundred waif gopher tortoises were transported to the AGTHP through our agreement with the Florida Fish and Wildlife Commission and other partners. SCDNR staff have coordinated the transport of waifs to the AGTHP from sixteen different states in the US.

    - Funding from the USFWS helped support a 2017-2020 study done by the University of Georgia's Savannah River ecology Lab, which documented

long-term site fidelity, survivorship, and tested for disease at the AGTHP. Results indicated that >75% of penned gopher tortoises are present within 400 m of the original release pen, some of which have been on the preserve for over a decade. Additionally, adult survival was between 90-95%, similar or better than natural populations. Additionally, disease screening did show positive results of *M. agassizii* and M. testudineum. However, prevalence was similar to what is found in natural gopher tortoise populations. Full results can be found in the 2020 completion report to the USFWS. Additionally, this project produced a master's degree and resulted in the two below publications:

- McKee, R.K., K.A. Buhlmann, C.T. Moore, J. Hepinstall-Cymerman and T.D. Tuberville. 2021. Waif Gopher Tortoise Survival and Site Fidelity Following Translocation. The Journal of Wildlife Management 85(4):640-653.

- McKee, R.K., K.A. Buhlmann, C.T. Moore, M.C. Allender, N.L. Stacy and T.D. Tuberville. 2022. Island of Misfit Tortoises: Waif Gopher Tortoise Health Assessment Following Translocation. Conservation Physiology 10:1-18.

- All waif gopher tortoises transported to the AGTHP are penned in 1-hectare pens, in groups of 15-20 individuals for at least 12 months (Tuberville et al 2005) before the pen walls are removed and the tortoises can roam the preserve. To-date we've constructed 19 pens.

- Several hundred headstarted gopher tortoises have been raised and released by partners (Savannah River Ecology Lab and Longleaf Alliance). Headstarted gopher tortoises are first collected as eggs from natural reproduction at the AGTHP, raised for one or two years and released at AGTHP.

    - A State Wildlife Grant (SWG) project from 2016-2020 provided funding to radio track over 70, one- and two-year headstart gopher tortoises. Results from the study provided insight on habitat use, survival and movements of young gopher tortoises at AGTHP and allowed methodological shifts that will potentially improve survival. Results can be found in the 2020 completion report to the USFWS.

The first of the two properties purchased in 2020-2022 (Coosawhatchie WMA or CWMA) was transferred to SCDNR in the fall of 2023. Management and restoration activities have ensued.

SCDNR was a collaborator in a large multi-state grant with funds that will go directly toward restoration of both upland and wetland communities on CWMA, TSRHP and the Webb Wildlife Center and benefit several wildlife and plant species. This work will occur over the next three years.

In 2011, after a two-year review following a petition to list the gopher tortoise, the USFWS issued a finding that listing the gopher tortoise as endangered was warranted, but precluded at this time due to budgetary constraints, in effect adding the species to the candidate list. The Service reviewed the species through the Species Status Assessment Framework and in

2022 determined that a federal listing for gopher tortoises was not warranted. While this did not change its state endangered designation and protection in South Carolina it did have a ripple effect on the conservation of the species throughout its range. One impact is the future of the gopher tortoise Candidate Conservation Agreement (CCA) and the retention of its signatories. SCDNR is a partner in the Candidate Conservation Agreement (CCA) for the gopher tortoise in the non-listed (federal) portion of the species range. The CCA details the voluntary conservation measures to be undertaken on behalf of the tortoise by the CCA partners. Since the listing decision deemed gopher tortoise not warranted, the future of the CCA and retention of signatories is uncertain.

CONSERVATION RECOMMENDATIONS

- Continue presence/absence surveys for species of this guild
- Inventory known gopher tortoise populations and relict individual localities to determine the extent of the population.
- Protect all gopher tortoise sites identified in the inventory through land acquisition or conservation easement. Monitor these sites to determine the stability of known populations at minimum, every 10 years.
- Conduct landowner workshops to educate landowners about the importance of gopher tortoises and methods for protecting this species.
- Conduct fire management operations at known gopher tortoise locations on SCDNR properties.
- Continue life history research for species in this guild
- Continue gopher tortoise repatriation/relocation technology research.
- Monitor impacts to gopher tortoise burrows from species such as armadillos, domestic dogs and other nonnative species.
- Monitor and conduct research on the impacts of non native species on this guild.
- Work with the South Carolina Department of Transportation (SCDOT) and other partners to design wildlife crossings to reduce road mortality of reptiles and amphibians.
- Evaluate the impacts of disease on this guild.

MEASURES OF SUCCESS

As results from current research and surveys or future efforts are identified and analyzed, projects will be initiated to address specific needs that arise from these results. Habitat protection and management projects of the longleaf pine habitat will be considered successful steps to conservation of the habitat and species that depend on it. The maintenance and growth of existing gopher tortoise populations in South Carolina and recovery of the tortoise population at Aiken Gopher Tortoise Heritage Preserve will serve as two measures of success.

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Miscellaneous Reptiles Guild

Diamondback Terrapin *Malaclemys terrapin*
Eastern Box Turtle *Terrapene carolina*
Eastern Kingsnake *Lampropeltis getula*
Island Glass Lizard *Ophisaurus compressus*
Mole Kingsnake *Lampropeltis rhombomaculata*
Pygmy Rattlesnake *Sistrurus miliarius*

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The following reptile species do not fit logically into any guild or group but are a mix of species that have been studied intensively and species that we know little about in South Carolina. For some of these species, the primary conservation objective will be to determine their status through surveys in South Carolina.

DESCRIPTION
Taxonomy and Basic Description

The diamondback terrapin is a small, long-lived estuarine turtle endemic to coastal marshes, estuarine bays, lagoons and creeks ranging from Cape Cod, Massachusetts to the Gulf Coast of Texas. Currently, there are 7 (Ernst et al. 1994) subspecies. More recently, Hart (2004) identified six management units. The subspecies most common in South Carolina is the Carolina diamondback terrapin (*Malaclemys terrapin centrata*). Terrapins have varied coloration from black to spotted patterns on the soft tissue and dark or light-colored scutes with strong concentric layers on the carapace. The hind margin of the carapace curls up instead of flaring. Hind legs are large, and toes have extensive webs. These turtles are strong, fast swimmers that feed on a variety of mollusks, crustaceans and other invertebrates. In South Carolina, salt marsh periwinkles (*Littoraria irrorata*) and blue crabs (*Callinectes sapidus*) are among the terrapin's primary food sources (Tucker et al. 1995; Levesque 2000). Terrapins are sexually dimorphic. Females are much larger than males and reach 15 to 18 cm (6 to7 in.) in length; males reach 10 to 13 cm (4 to 5 in.) in length. Adult females also have enlarged heads. Terrapins mate in the spring. Eggs are laid from May through early August and clutches have 5 to 12 eggs (Pritchard 1979).


Photo by Andrew Grosse

Eastern box turtles are small, terrestrial turtles that can be found statewide in a variety of habitats, including mesic hardwood forests mixed with pine, open grassy habitats and wetlands. Some populations seem to be able to persist in developed suburban environments, provided there is some intact natural habitat (Camper 2019). Currently there are two or four subspecies of eastern box turtles but the only one native to South Carolina is *Terrapene carolina carolina* (NatureServe, 2024). However, three-toed box turtles *T. c. triunguis* are common in the pet trade and have been found in suburban areas. While these are likely released pets, the



Photo by Andrew Grosse

risk of breeding with naturally occurring populations of eastern box turtles *T. c. carolina* is a concern. Box turtles have a domed shell with a hinged plastron. When frightened, they can retract and completely close their shell, protecting them from many predators. Box turtles are omnivorous and have been documented eating various fungi, plants, fruits and invertebrates (Camper 2019). Adult eastern box turtles are around 10-15 cm (4-6 inches) in length. Males typically have a concave plastron and vibrant yellow to red eyes, while females tend to have a flatter plastron and brown eyes.

Eastern kingsnakes are a large nonvenomous snake found statewide. They are typically between 91-121 cm (36-48 in) in total length, though larger individuals are not uncommon. Eastern kingsnakes are usually dark black or brown with white or yellow markings that connect along the back and sides to give a chain-link appearance (Camper 2019). They inhabit a variety of habitats but are typically close to some form of aquatic habitat (streams, swamps, wetlands, bays, marshes and even man-made impoundments). Eastern kingsnakes will eat a variety of prey though they are best known for their propensity to eat other snakes.



Photo by Andrew Grosse



Photo by J.D. Willson

Island Glass Lizards are one of four species of glass lizards found in South Carolina. Island glass lizards grow to a max of about 60 cm (24 in) and are only found in coastal counties of South Carolina. Like other glass lizards the tail is typically twice the length of the body and there is a lateral fold on the sides that extends the length of the body. Island glass lizards have a single black stripe that extends down each side of the body above the lateral fold and typically a dark vertebral stripe on a dark brown or tan body. There are no markings below the lateral fold. This species is typically found in upland sandy, dry habitats and likely feeds on invertebrates (Camper 2019).

Mole kingsnakes are moderately sized nonvenomous snakes that are not commonly seen due to their fossorial nature. They are typically 60-121 cm (24-48 in) in total length. Mole kingsnakes can vary in color and pattern with a gray to brown background and brown to red blotches down their backs, usually outlined with dark borders. Their bellies are cream colored with small red, gray, or brown blotches. While this species has a large distribution in South Carolina it is much more common in the piedmont and few specimens found in the coastal plain (Camper 2019).



Photo by Alan Jones

Pygmy rattlesnakes are the smallest of the rattlesnakes native to South Carolina, averaging between 30-60 cm (12-24 in) as adults. Currently there are three subspecies, two of which are thought to occur in South Carolina, as well as integrades which have been found in the lower coastal plain. Pygmy rattlesnakes are typically found in well-drained soils in the sandhills, pine flatwoods and mixed hardwood forests, although they have also been documented in forested habitat near swamps. They have a tiny rattle that is difficult to hear compared to other native rattlesnake species. The dorsal pattern consists of a gray or brown background, with brown to red blotches and orange to red vertebral stripe that extends down the spine (Camper 2019).



Photo by Todd Pierson

Status

The Diamondback terrapin is listed as vulnerable in South Carolina (S3) and apparently secure globally (G4) (NatureServe 2024). The eastern box turtle is listed as vulnerable in South Carolina (S3) and secure globally (G5) (NatureServe 2024). The eastern kingsnake is listed as listed as apparently secure in South Carolina (S4) and secure globally (G5) (NatureServe 2024). The island glass lizard is listed as imperiled in South Carolina (S2) and vulnerable globally (G3) (NatureServe 2024). The mole kingsnake is listed as apparently secure in South Carolina (S4) and secure globally (G5) (NatureServe 2024). The pygmy rattlesnake is listed as vulnerable in South Carolina (S3) and secure globally (G5) (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

The current status of most populations of terrapins is unknown or declining (Seigel and Gibbons 1995). The species experienced near extinction in the early 1920s because of commercial over-harvest. Commercial harvest declined in the late 1920s, and terrapin populations increased (Gibbons et al. 2001). Mr. Robert Gault, the last terrapin harvester in the state, reported catches of nearly 500 turtles in two to three days of net fishing in the Beaufort area in the 1970s. Diamondback terrapins occur in all coastal counties, with Horry county being the last to confirm presence in 2016, through citizen-scientist documentation. Two decades of monitoring terrapins in four creeks adjacent to the Kiawah River has documented a decline since the early 1990s and local extirpation (Gibbons et al. 2001; Tucker et al. 2001). Along the South Carolina coast, incidental capture of diamondback terrapins in trammel net surveys have been documented each year from 1995 through 2023. Since about 2005 relative abundance of diamondback terrapins has shown a steady decline.

Genetic studies in North and South Carolina indicate that terrapin populations from these states are not significantly different (Hart 2004; Hauswaldt 2004) and should be treated as one management unit. A previous genetic study using a different genetic marker was unable to detect a difference between the Carolinas and Georgia (Lamb and Avise 1992). It should be noted that in 1947, several thousand diamondback terrapins were released into Cape Romain National Wildlife Refuge (CRNWR) waters from the North Carolina Beaufort Fishery Station (Anonymous 1947). The genetic stock of these terrapins is not known. This should be taken into consideration when determining the genetic stock of diamondback terrapins in South Carolina waters.

Eastern box turtles occur statewide in South Carolina however few population level studies have been done. Brisbin et al. (2008) show long term survival and habitat use of a box turtle population in a suburban setting. Naturally, box turtles can be abundant in appropriate habitat but several past and emerging threats to this species are a concern.

Eastern kingsnakes occur statewide and are generally considered a "common" species, however, some documented declines have occurred in portions of their range (Winne et al 2007). Overall, little population level data exists for this species in South Carolina, and the combination of isolated declines and several past and emerging threats are a concern.

The island glass lizard is virtually unknown in South Carolina, with less than ten records of occurrence for this state, all of which occur in coastal counties. This species was listed as a species of concern at the 1978 Endangered Species Symposium based on our lack of knowledge. Very little information or data exists for any glass lizard species in our state; this whole group deserves attention regarding taxonomy, distribution, and demography.

Mole kingsnakes are cryptic, fossorial snakes that are most commonly found in the piedmont and upstate but also occur in isolated locations in the coastal plain. While several element occurrence records exist for this species in South Carolina, very little information exists regarding distribution, demography, and other population level parameters, especially for coastal plain populations.

Element occurrence records for South Carolina suggest pygmy rattlesnakes occur statewide however, very little population level information exists for them in South Carolina and their absence in some areas of suitable habitat is concerning.



Island Glass Lizard



Eastern Box Turtle



Diamond-backed Terrapin



Pygmy Rattlesnake



Mole Kingsnake



Eastern Kingsnake

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Diamondback terrapins are endemic to estuarine habitats. They are the only emydid turtle that can survive in a high salinity environment without accessing a freshwater source. Terrapins nest on land and require access to dry, soft sand/soil to deposit their eggs. There is also evidence of high site fidelity and low recruitment and/or dispersal among tidal creeks. If a population were extirpated from a tidal creek, recruitment from other creeks would be very slow to repopulate the area (Gibbons et al. 2001).

Eastern box turtles can be found in a variety of habitats including mesic hardwood forests, mixed pine-hardwood forests, grasslands, old fields and pastures and some even persist in suburban landscapes (Camper 2019). Seasonal wetlands, marshes and bogs can be important micro habitats. Openings in the forest canopy and forest edges can be important nesting habitats.

Eastern kingsnakes can be found in a variety of habitats as they are widely distributed in South Carolina however they are mostly found in terrestrial habitats in proximity of aquatic habitat including streams, rivers, swamps, ponds and Carolina bays (Camper 2019), though they also can be found around managed impoundments.

As the name implies, island glass lizards are found on coastal islands in South Carolina typically inhabiting xeric habitats, such as sand dunes, pine and maritime forests and have been found under an accumulation of spartina and other debris in the wrack line (Camper 2019).

Mole kingsnakes can be found in a variety of habitats though they can be quite fossorial and cryptic. Mole kingsnakes can be found in open woodlands, old fields, meadows and prairies as well as sandhills, especially for coastal plain populations (Camper 2019)

Pygmy rattlesnakes are widespread in South Carolina; however, populations are not found everywhere. Suitable habitat can include longleaf pine-turkey oak sandhills, pine flatwoods, mixed hardwoods forests and some mesic forest habitats (Camper 2019).

CHALLENGES

Diamondback terrapins face several challenges. On land, the loss or degradation of nesting habitat resulting from coastal development continues to be a problem. Also, nests are destroyed by native (raccoons and mink) and non-native predators (fire ants) as well as erosion and storm events. Vehicle inflicted mortality of females during the nesting season is common where a highway separates nesting sites from tidal creeks. Mortality is also associated with the mowing of causeway shoulders (T. Murphy, SCDNR, pers. comm.). In the water, terrapins may be increasingly vulnerable to injury or mortality due to encounters with watercraft (Cecala et al. 2009). A major source of mortality in the marine environment is the presence of recreational, commercial and abandoned/ghost crab pots. In the Ashley and Wando Rivers, Bishop (1983) estimated that the mean daily terrapin catch per baited crab pot was 0.16 in April and May with 10 % mortality. A statewide survey in the fall of 2003 documented nearly 10,000 commercial hard crab pots (M. Maddox, SCDNR, pers. comm.). Grosse et al. (2011) found terrapin density in Georgia tidal creeks to be negatively correlated with crabbing intensity. In a Kiawah Island study, mean terrapin size increased in the presence of crabbing; these results were attributed to the greater survival of larger terrapins (females) too big to gain entry into pots (Dorcas et al. 2007). Other problems include destruction of food resources, environmental degradation and contamination (through increased sedimentation, nutrient enrichment, oil spills and filling/draining marshes), boat and propeller mortality, and the commercial pet trade (D. Owens,

College of Charleston, pers. obs.). Climate change is a potential threat to sea turtles as it may affect these species in three ways: (1) loss of dry sand beaches to sea level rise; (2) lethal high temperatures within the nest that would cause egg/hatchling mortality or decrease hatchling fitness; or (3) a female biased sex ratio of hatchlings due to increased nest temperatures. Terrapins, like many other turtles, have temperature-dependent sex determination (TDSD) with higher temperatures favoring the development of female terrapin offspring and lower temperatures favoring males (Roosenburg 1996; Jeyasuria and Place 1997; Jeyasuria et al. 1994). Additionally, diamondback terrapins are a species that is highly sought after in the "wild-caught" pet trade.

Box turtles are a long-lived species whose life history may not allow population recovery if large numbers of reproductively active members are removed from the population (Dodd et. al. 2006). Eastern box turtles are considered to be relatively common in SC but are a popular target for the "wild-caught" pet trade. In 2019, over 200 eastern box turtles were seized from a resident in South Carolina who was planning to ship them overseas for the illegal turtle trade. This case severity of illegal collection and further emphasized the importance of protecting this species in South Carolina. In 2020, regulations pertaining to all native reptiles and amphibians were updated, adding protection for all native species from commercial exploitation. A major component of these regulation changes was increased protections for turtles, which prohibited export, transfer of possession, and added possession limits for individual species as well as in aggregate. Other challenges or threats to box turtles include road mortality, habitat loss and fragmentation and disease.

Eastern kingsnakes, mole kingsnakes and pygmy rattlesnakes have a large distribution and are considered relatively common in some areas of South Carolina however they are a popular target for the "wild-caught" pet trade. In 2020, regulations pertaining to all native reptiles and amphibians were updated, adding protection for all native species from commercial exploitation and added prohibitions for export and transfer of possession (buy, sell, trade, etc). Other threats include road mortality, habitat loss and fragmentation and disease, specifically Snake Fungal Disease.

Due to the lack of data, challenges for Island glass lizard are unknown, however, given their preferred habitat and the elemental occurrence records we do have, climate change and its relationship with sea level rise could impact this species.

CONSERVATION ACCOMPLISHMENTS

In 2020, regulations pertaining to all native reptiles and amphibians were updated, adding protection for all native species from commercial exploitation (Code of laws, Title 50, Chapter 15). A major component of these regulation changes were increased protections for turtles, which prohibited export, transfer of possession, and added possession limits for individual species as well as in aggregate. For box turtles specifically, possession limits were limited to two individuals and any legally acquired collections of box turtles, prior to the regulation change, were given an opportunity to apply for a permit within 90 days of the new regulations. Additional changes included, all individuals permitted must be notched uniquely (with a SCDNR issued code that is unique to every permitted turtle) and photographed annually. Failure to do so results in denial of permit applications/renewals. Notching and annual permit renewals with photographs have addressed the identified loophole. Diamondback terrapin possession limits remained at two.

University of Georgia's Savannah River Ecology Laboratory (SREL), in collaboration with SCDNR and USFS-Savannah River, responded to a large confiscation of eastern box turtles and partnered to release them on the Savannah River Site in 2019. In 2020, they partnered to release former long-term captive turtles that had been surrendered to SCDNR to comply with new legislation. SREL researchers conducted post-release

monitoring of released confiscated and long-term captive turtles, as well as sympatric resident turtles. They evaluated health, survival, movement, and reproduction. Two master's theses and three publications resulted from the project to date.

Theses and Publications

Browning, E.A. 2022. Investigating the suitability of releasing confiscated eastern box turtles (*Terrapene carolina carolina*) back into the wild. M.S. Thesis. University of Georgia, Athens, GA. 112 pgs

Rimple, R.J. 2024. Evaluating the repatriation of long-term captive and confiscated eastern box turtles: movement, reproduction, and vertical transmission of ranavirus.

Tuberville, T.D., K.A. Buhlmann, J.W. Dillman, A.M. Grosse, E.A. Browning, P.A. McGovern, D.L. Haskins, C.E. Davis, M.K. Brown, and R.J. Rimple. *In press*. Anatomy of a turtle confiscation: what to expect when you're not expecting and recommendations for improving outcomes. To appear in: Chelonian Conservation and Biology.

Rimple, R.J., K.A. Buhlmann, and T.D. Tuberville. *In press*. A protocol to safely obtain viable eggs from free-ranging *Terrapene* in outdoor mesocosms in temporary captivity. To appear in: Herpetological Review.

Rimple, R.J., M.T. Kohl, K.A. Buhlmann, and T.D. Tuberville. *In press*. Translocation of long-term captive eastern box turtles and the efficacy of soft-release: implications for turtle confiscations. To appear in special issue of Northeastern Naturalist (*Biology and Conservation of Emydine Turtles*).

Since the last revision in 2015, SCDNR has added a significant number of new records to the heritage database identifying new populations or areas of interest for most of the species in this guild.

From 2014-2016, a State Wildlife Grant was funded to evaluate headstarting as a means to augment diamondback terrapin populations in South Carolina. Over the course of three nesting seasons 206 female diamondback terrapins were examined for eggs and 1,089 eggs were collected from 154 clutches. Overall hatching success was 88.2%. Eggs hatched more quickly at female producing temperatures though there was no statistical difference in hatching success between male and female producing temperatures. Further, no significant differences in hatching success were detected between gravid females collected in-water vs on land or between gravid females that were induced to lay eggs vs those that laid eggs naturally. Overall, during the course of this study 638 diamondback terrapins were produced (411 headstarts, 227 hatchlings) and released into the Charleston Harbor system, suggesting that a substantial number of diamondback terrapins could be collected and headstarted should population augmentation or establishment be warranted in the future.

In 2016, a thorough web page (https://www.dnr.sc.gov/wildlife/diamondbackterrapin/index.html) was launched which provided a centralized overview SCDNR research for this species. Shortly thereafter, an online citizen-scientist reporting form was also launched, with a direct link accessible from the home page of the terrapin website. In 2023 the online reporting platform switched from Survey Monkey to the ArcGIS-based Survey123. Through May 2024, nearly 900 entries were submitted by nearly 400 citizen-scientists, with >100 reports filed for the top participant. Report submission rate varies with season as well as outreach intensity. Two-thirds of sightings involve terrapins on land, including 19% of overall reports associated with nesting activity (i.e., nest deposition, observation of eggs and/or hatchlings). In-water sighting reports predominantly pertain to terrapins in natural habitats (23% overall); however, 10% of all reports either reflect terrapins in swimming pools (usually young-of-the-year in spring) or incidentally captured by fishing gear (hook-and-line, crab nets, and crab pots). These data are accessed by the SCDNR Office of Environmental Programs when making land-management policy and thus address prior CA's to "identify and protect" (a) nesting habitats and (b) mating aggregations.

Across habitats, 90% of reports filed by citizen-scientists reflect observation of live terrapins. The 2015 SWAP stipulated four CA's directed at quantifying and reducing mortality along roadways; thus, despite being relatively few, terrapin mortalities reported through the online tool provide a valuable starting point for informing future conservation actions. Through May 2024, the online reporting tool documents several consistent terrapin roadway mortality point-sources that can hopefully be better mitigated through (a) collaboration with the South Carolina Department of Transportation and (b) appropriate motorist alerting to terrapin crossings. Due to intra- and inter-agency considerations, addressing these later CA's received less attention than other CA's following the 2015 SWAP but remains a high focal area following the 2025 SWAP.

A terrapin population study in four tidal creeks adjacent to the Kiawah River has been ongoing since 1983; to date, there have been 1,821 individual terrapins captured and 2,015 recaptures (K. Cecala, pers. comm. 2024). Recreational crab pots have been shown to adversely affect diamondback terrapin populations in the Kiawah River (Hoyle and Gibbons 2000). Crab pots with BRDs showed an increase in the number of legal crabs caught in a Louisiana study (Guillory and Prejean 1998), and a significant decrease in terrapin capture without a change in number or size of blue crabs caught was shown in Florida (Butler et al. 2007) and Chesapeake Bay (Rook et al. 2010).

Progress for reducing terrapin mortality in crab traps was marked by the Arendt et al. (2018) publication of a 25-year synthesis of excluder design studies from Texas through New Jersey and subsequent validation of proper device sizing for target and non-target species. Following this publication, SCDNR enlisted the help of >30 commercial and >60 recreational crabbers to voluntarily test a new bycatch reduction device (BRD) designed to optimize blue crab catch while excluding the maximum number of terrapins by emphasizing the width of both species during entry through crab pot funnels. Subsequent measurement of commercially landed blue crabs across the South Carolina coastal plain (n = 328) substantiated slight morphological differences in the southern portion of the state that led to sub-optimal impression of catch among crabbers. From north to south, subsequent testing of this BRD by researchers has occurred in New Jersey (Wynek et al. 2019), Virginia (Grubbs et al. 2018), North Carolina (UNCW, unpublished data), Georgia (Howard 2022), and Florida (FWC, unpublished data). In May 2020, SCDNR BRD performance in North Carolina inspired seasonal fishery management action (NCDMF 2023). Favorable results have also been reported with respect to legal-sized blue crab capture and retention in all other studies; however, findings from those studies have not yet been translated into management action. Likewise, South Carolina does not also require BRDs in crab traps.

In addition to reducing terrapin mortality in actively fished traps, SCDNR researchers conducted several studies to (a) identify the root-causes and reduce the prevalence of abandoned crab traps and to (b) salvage abandoned crab traps and repurpose them for oyster reef substrate (SRFAC Report 2014). In 2023, findings from the former initiative continued to favorably reverberate among regional Marine Debris Removal funding initiatives, particularly with reducing the generation of derelict crab traps following vessel strikes. Although the collection of derelict traps for upcycling remains an active area of SCDNR research, investigation of biodegradable panels to reduce ghost trap fishing has not received as much attention as closely related CA's associated with derelict gear.

Crucial to population assessment, the 2015 SWAP stressed a need to "develop and implement long-term coastwide standardized surveys to estimate the abundance and distribution of South Carolina's terrapin population." However, during 2013-2016, a new acoustic telemetry study (Arendt et al 2016) that built on earlier efforts by Estep (2005) and Broyles (2010) validated the multi-decadal trammel net survey as a good source of temporal trend data for diamondback terrapins captured along the marsh-edge of larger waterbodies such as the Ashley River. Relative to other strata, the Ashley River also exhibits an outlier effect for diamondback terrapins, with >40% of all captures for this species

occurring there during 1995-2013. Specifically, proportionate distribution of terrapins in the Ashley River did not correspond to the number of creeks in the trammel net survey area whereas an inverse relationship between proportionate distribution and number of creeks was observed across the remaining seven trammel net survey strata.

Several funded and non-funded studies that provide insight into population parameters were also conducted following the 2015 SWAP. Nest temperatures and predators were monitored in known areas of terrapin nesting activity in Charleston, SC and at Botany Bay Heritage Preserve, Edisto Island, SC over a five-year period, 2017 – 2021 (Levesque and Grosse 2022). Study locations were either defined as natural (limited human activity) or disturbed (increased human activity) to assess differences between these areas and potential differential nest success. Predator identification was largely qualitative, however predators detected on natural nesting beaches were numerous, potentially because shorebirds and sea turtles used these areas to nest and predators optimized that season to feed on eggs and hatchlings. Predators included racoons, mink, bobcats, crows, armadillos and ghost crabs. In 2021, 18 clutches of eggs were buried at on open beach at Botany Bay (natural) and 9 clutches were buried in a landscaped residential neighborhood in Charleston (disturbed). Mean hatching success across 21 nests that endured the entire incubation period was 75.6% (Botany Bay 70.8% and Wappoo Creek 82.0%). A 100% hatch rate occurred in nests with mean daily temperatures between 27.3ºC – 29.9ºC, a mean maximum no greater than 35.2ºC and a mean daily range no greater than 9.2ºC. Hatching rate decreased significantly with increasing mean maximum daily temperatures and mean daily range in temperatures. The mean, maximum and range of daily temperatures were significantly higher at the open beach Botany Bay site and hatching success was significantly lower there. The mean temperatures, mean maximum temperature and mean temperature ranges recorded over the five year study period in vegetated/open habitats and natural/disturbed habitat in areas with documented terrapin nests fell within the limits that would produce successful hatching; however, there were some nesting areas that were significantly hotter than the nests that produced highest hatching success.

Following 28 diamondback terrapin encounters in the backyard of a marsh front property in 2016, SCDNR researchers began collaborating with a citizen-scientist to conventionally tag nesting females on the property beginning in 2017. Over the course of this novel pilot study, fewer than two dozen individual terrapins have accounted for annual nesting activity, with most females encountered in subsequent years (but rarely more than once per nesting season). This study entered its eight consecutive year in 2024 and has since expanded into a neighborhood awareness effort; however, tagging continues to be conducted by the original citizen-scientist.

CONSERVATION RECOMMENDATIONS

- Quantify anthropogenic sources of terrapin mortality, with focus on life stage and sex- specific mortality rates.
- Establish several intensive studies to determine population parameters required for evaluating the status of diamondback terrapins, such as mortality rates and nesting effort/success.
- Evaluate the need for predator control programs on critical diamondback terrapin nesting beaches.
- Develop terrapin culture program through salvage of eggs from road-killed females and collection of eggs from gravid females in critical areas with the intent of releasing head-started terrapins in areas where contribution of stocked terrapins can be determined in the future
- Evaluate the benefits of headstarting for population augmentation or reestablishment
- Identify and protect critical diamondback terrapin mating aggregations throughout the state.
- Collaborate with the South Carolina Department of Transportation (SCDOT) to negotiate restrictions of causeway mowing during the terrapin nesting season.

- Educate the public about how they can help conserve the diamondback terrapin and specifically emphasize responsible actions when using crab pots. Produce education materials to be distributed coastwide.
- Erect crossing signs along roadways alerting motorists about crossing diamondback terrapins during the breeding season. Signs should be theft proof or removed each year at the end of the breeding season.
- Work with the South Carolina Department of Transportation (SCDOT) and other partners to design wildlife crossings to reduce road mortality of reptiles and amphibians.
- Determine mole kingsnake, island glass lizard, and pygmy rattlesnake distribution, locations of viable populations and collect data on life history and demography in South Carolina.
- Monitor the impacts of habitat loss, disease, illegal collection and road mortality on box turtle populations.
- Monitor Eastern kingsnake populations.
- Monitor and conduct research on the impacts of nonnative species on this guild.
- Evaluate the impacts of disease on this guild.
- Monitor changes in the demand for turtles and turtle products and the effectiveness of the new law.

MEASURES OF SUCCESS

As results from current research and surveys are identified and analyzed, we will initiate projects to address specific needs that arise from these results.

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Miscellaneous Amphibians Guild

Baird's Dusky Salamander *Desmognathus bairdi*
Bird-voiced Treefrog *Dryophytes avivoca*
Chamberlain's Dwarf Salamander *Eurycea chamberlaini*
Dwarf Waterdog *Necturus punctatus*
Four-Toed Salamander *Hemidactylium scutatum*
Gulf Coast Mud Salamander *Pseudotriton montanus flavissimus*
Many-lined Salamander *Stereochilus marginatus*
Pickerel Frog *Rana palustris*
Pine Barrens Treefrog *Dryophytes andersonii*
River Frog *Lithobates heckscheri*
Webster's Salamander *Plethodon websteri*

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The following amphibian species do not fit logically into any guild or group but are a mix of state protected species and several species that we know little about in South Carolina. Many of these species are listed as data deficient but are listed here to avoid the potential risk of overlooking a species in need. For many of these species, the primary conservation objective will be to determine their status through surveys in South Carolina.

DESCRIPTION
Taxonomy and Basic Description


Photo by Todd Pierson

The Bairds dusky salamander was recently described in 2023 (Pyron and Beamer 2023). This is a moderately sized dusky salamander reaching lengths between 2.4-5.5 cm (SVL) and is described by Pyron and Beamer (2023) as having a heavily keeled tail and a distinct brown to yellow dorsal stripe with defined, yet irregular borders. Additionally, a 2nd row of "portholes" along the sides is usually present in this species (Pyron and Beamer 2023).

Bird-voiced treefrogs are a small frog in the treefrog family, Hylidae. This species reaches lengths of 2.8 to 4.4 cm (1.1-1.7 in.) with a maximum length of approximately 5 cm (1.9 in.) (Conant and Collins 1991). Bird-voiced treefrogs are similar in appearance to gray treefrogs though the latter tends to have brighter orange coloration on the inside of the thigh. Additionally, calls of the two species are unique and easily distinguishable. They have a very limited distribution in our state but can be common to abundant within their range.


Photo by Todd Pierson



Photo by Todd Pierson

Chamberlain's dwarf salamander was described in 2003 and recognized as distinct from the more common, dwarf salamander (*Eurycea quadridigittata*; Harrison and Guttman 2003). Chamberlain's dwarf salamander is lighter in color than the dwarf salamander, having a yellow underside that lacks any markings. Chamberlain's dwarf salamander is a very small salamander averaging approximately 2.5 cm (0.9 in.) in total length (Harrison and Guttman 2003).

Dwarf Waterdogs are a relatively large salamander species in South Carolina but represent the smallest species in the genus *Necturus*, reaching lengths from 11.5-15.9 cm (4.5-6.25 in; Conant and Collins 1991). They tend to be a uniform gray, brown or black color with a creamy belly. Dwarf waterdogs have red external gills and 4 toes on all feet.



Photo by Todd Pierson



Photo by Todd Pierson

Four-toed salamanders range in size between 5-10 cm (2-4 in). They are reddish to brown, with the appearance of chevrons extending down their backs. The belly is white with distinct, irregular black spots. The connection point of the tail to the body is constricted. Similar to a lizard, four-toed salamanders will drop their tail if needed to distract a predator and escape (Conant and Collin 1991).

The Gulf coast mud salamander is one of two subspecies of the more widely distributed mud salamander that occurs in South Carolina. The known range of this subspecies in South Carolina is small though more survey efforts are warranted. Gulf coast mud salamanders grow to about 12 cm (about 5 in) and have a dark brown to pinkish color on their backs with a lighter underside. They have brown eyes (Conant and Collins 1991).



Photo by Todd Pierson



Photo by Todd Pierson

The many lined salamander is a small salamander that ranges in size from 6-9.5 cm (2-4 in). They typically have a dark brown back with a lighter yellow to brown coloration down their sides with several small, thin black stripes or sometimes a series of very small dots. This species is mostly aquatic and not generally found far from water (Conat and Collins 1991).

The pickerel frog can grow to lengths between 4-8 cm (2-4 in) and can be identified by the two rows of dark spots that are usually in pairs, down its back. Pickeral frogs have dorsolateral folds running down their backs, stripes on their legs and a lighter colored belly with some dark blotches (Conant and Collins 1991).



Photo by Todd Pierson



Photo by Kiley Haberman

The pine barrens treefrog is a small member of the treefrog family, Hylidae. This species reaches lengths of 2.8 to 4.4 cm (1.1-1.7 in.) with a maximum length of approximately 5 cm (1.9 in.) (Conant and Collins 1991). The pine barrens treefrog is green with a broad lavender stripe on either side of the body. This stripe has a thin, white outline. The concealed portions of the legs and inner thigh are bright orange with numerous yellow dots (Martof et al. 1980).

River frogs are one of the larger Ranids, reaching size of 7-13 cm (3-5 in). Their skin has a bumpy appearance, they have no dorsolateral folds and usually some pattern of white spots on the lips. The belly is lighter in color, usually with some pattern consisting of spots or wavy lines. In young frogs and tadpoles, the eyes are usually red. River frog tadpoles are large, reaching lengths of up to five inches and can be found schooling, like fish, in the swamps and black water rivers and wetlands, where they live (Conant and Collins 1991).



Photo by Todd Pierson

Webster's salamander is a small member of the woodland salamander family. This species reaches lengths of 7 to 8.2 cm (2.7-3.2 in.; Conant and Collins 1991). Both striped and unstriped individuals of this species may be found. Striped individuals typically have a wavy yellowish brown to orange-red dorsal stripe extending from the head to the tail tip (Petranka 1998). Unstriped individuals are usually uniform in color, ranging from brown to reddish-orange. The belly of the salamander is mottled with black, white, and reddish-orange (Martof et al. 1980). This is a relatively non-descript salamander but is typically the only salamander of its size and coloration within its limited range in South Carolina.



Photo by Todd Pierson

Status

Bairds dusky salamander was recently described in 2023 (Pyron and Beamer 2023) and has a state ranking of S3 (vulnerable) due to the lack of information on its life history and apparent small distribution in South Carolina (NatureServe 2024). Bird-voiced treefrogs are listed as vulnerable (S3) in South Carolina and secure (G5) globally (NatureServe 2024). Chamberlain's Dwarf Salamanders are listed as vulnerable (S3) in South Carolina and apparently secure (G4) globally (NatureServe 2024). Dwarf waterdogs are listed as apparently secure (S4) in South Carolina and secure (G5) globally (NatureServe 2024). Four-toed salamanders are listed as vulnerable (S3) in South Carolin and secure (G5) globally (NatureServe 2024).Gulf coast mud salamanders are listed as vulnerable (S3) in South Carolina and apparently secure (G4) globally (NatureServe 2024). Many-lined salamanders are listed as vulnerable (S3) in South Carolina and secure (G5) globally (NatureServe 2024). Pickeral frogs are listed as vulnerable (S3) in South Carolina and secure (G5) globally (NatureServe 2024). Pine barrens treefrogs are listed as threatened in South Carolina with a state designation of imperiled (S2) and apparently secure (G4) globally (NatureServe 2024). River frogs are listed as apparently secure (S4) in South Carolina and secure (G5) globally (NatureServe 2024). Websters salamanders are listed as endangered in South Carolina with a state designation of imperiled (S2) and vulnerable (G3) globally (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

Baird's dusky salamander was recently described and is known to occur in the upper portion of the fall line sandhills and into the piedmont. This species population size and distribution in South Carolina is currently unknown, though it is not thought to have a very extensive range in the state.

In South Carolina, the bird-voiced treefrog has a very limited distribution, but it can be common to abundant within its range. Population sizes are currently unknown for this species. The primary conservation objectives for this species are to monitor the populations in South Carolina and collect data on the life history and demography.

Chamberlain's dwarf salamanders have an unusual distribution in South Carolina, occurring in the southwestern portion of the upper piedmont and coastal plain and extending the length of the fall line sandhill ecoregion. A survey is currently underway to determine the full distribution of this species in North and South Carolina. Population sizes are currently unknown.

Dwarf waterdogs are found throughout the coastal plain of South Carolina though more survey is needed to better understand their abundance, distribution, and population level parameters within different watersheds.

Four-toed salamanders are found north of the fall line in South Carolina. Very few populations are known for this species and even less is known about their natural history in South Carolina. A study is currently being conducted to better understand their natural history, abundance, nesting behavior, and longevity in South Carolina.

Gulf coast mud salamanders are known to occur in the southern portion of the coastal plain of South Carolina, but their full distribution is not fully known in the state.

Very little data exists for many-lined salamanders in South Carolina. Their distribution is thought to extend throughout the coastal plain though few records exist.

Pickerel frogs occur in the upper piedmont, mountains, lower coastal plain and have a spotty distribution near the fall line sandhills. They seem to be abundant in the northern portion of the state, but little abundance and population level data exists for this species.

The pine barrens treefrog is found in the upper (northern) portion of South Carolina's Coastal Plain in the Sandhills (Fall-line) Ecoregion. Between 1979 and 1982, Cely and Sorrow (1982) surveyed 222 potential treefrog sites, in this region, and found that approximately 50 (23%) supported pine barrens treefrog colonies. Colony sizes ranged from a few frogs to several dozen, but larger colonies were difficult to estimate. During this study, the researchers used a mark- recapture method to develop a population estimate for one large colony. The estimate for this colony of 159 frogs (95% C.I.= 91-637) was much higher than the 25 to 50 individuals originally estimated by call counts. The researchers concluded that estimates of pine barrens treefrog populations, based on call counts, will typically underestimate the actual population size. The pine barrens treefrog was found to be more widespread in South Carolina than previously believed. Based on their findings, Cely and Sorrow recommended that the status of the frog be changed from Endangered to Threatened and considered a Species in Need of Management in South Carolina. Currently, no valid estimate exists for the number of extant pine barrens treefrog colonies in South Carolina or estimates for population size at any colony. More recently, opportunistic surveys were conducted at 20 historic locations in 2021 and 2022 and pine barrens tree frogs were detected at 14 of those locations.

River frogs are distributed throughout the coastal plain of South Carolina. Recent survey efforts at several historic sites (2022-2023) have not detected this species. While fluctuations from year to year certainly have an impact on detectability, this species requires further monitoring to determine its status and distribution in South Carolina.

Webster's salamander occurs across the southeast in several disjunct populations. The majority of the species' range is in western Georgia and eastern Alabama in the lower Piedmont. In South Carolina the species is restricted to several counties along the Savannah River in the lower Piedmont. Semlitsch and West (1983) surveyed this region of the state and found several new populations of this species. Little data exists on the size of the Webster's salamander populations in South Carolina; however, the species is seemingly abundant where it occurs.

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Pyron and Beamer (2023) describe the Baird's dusky salamander's habitat as streamside habitats, usually under rocks, logs or leaf packs. It seems to be abundant in ravine habitats though has also been found in swampier habitats in some portions of its range.

Bird-voiced treefrogs are found in the forested floodplains and swamps of large river systems in

South Carolina.

Chamberlain's dwarf salamander is typically found in wet areas, particularly seepages near small streams, and other wetland types. This species is most typically found under leaf litter, sphagnum, and small debris in these habitats (Harrison and Guttman 2003).

Dwarf waterdogs are found in slow-moving black water streams and rivers in South Carolina. Leaf packs and other accumulated debris can be important structure for this species.

Four-toed salamanders are found in small seepages, bogs, other ephemeral, fishless wetland types and the forested uplands that surround these habitats. Sphagnum moss in these wetland habitats is important.

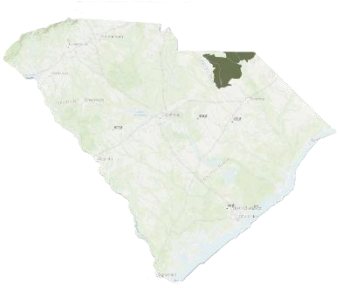
Many-lined salamanders and Gulf coast mud salamanders can be found using slow-moving swamps and streams with an abundance of mud and leaf packs.

Pickerel frogs are known to use a variety of habitats in South Carolina. They are often found in streams, seepages and other wetlands in the northern part of the state. They are also frequently found in entrances of caves and old mines. In the coastal plain they can be found using black water swamps and streams (Conant and Collins 1991).

The pine barrens treefrog, in South Carolina, occurs in herb shrub bogs, pocosins and other related communities in the Sandhills (Cely and Sorrow 1982; Conant and Collins 1991; Martof et al. 1980). Typical pine barrens treefrog habitat is found in transition zones on the down-slope of sandhills where water percolates out of the soil in some sort of seepage zone. These habitats would burn periodically—prior to European settlement of the Southeast and the exclusion of fire—and these fires would maintain an open character to the seepage bogs. Pitcher plants, sundews and terrestrial orchids are species that typify this habitat type and also require the acidic, open conditions of these bogs. Pine barrens treefrogs live in the thick, pocosin vegetation that often surrounds this habitat, but they also require the open, slow-flowing seeps as breeding habitat. Currently, several pine barrens treefrog colonies exist along power-line and gas line right-of-ways, where mechanical vegetation control (e.g. mowing) keeps the vegetation low, maintaining the open habitat required by the species.

River frogs have been documented using floodplain swamps, black water rivers and streams and man-made lakes, ponds and borrow pits in South Carolina. Man-made structures used by river frogs are typically located in close proximity of natural habitat. Water needs to be permanent to allow for the extended tadpole development period for this species.

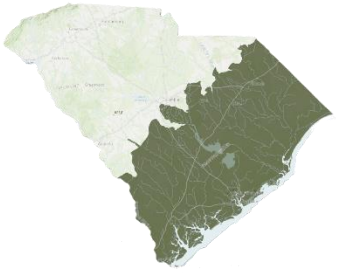
Webster's salamander is found in moist, mixed hardwood forests on steep north-facing slopes (Martof et al. 1980). Optimal habitat for this species has a rocky substrate with abundant coarse, woody debris (Petranka 1998). This species is typically associated with forests that have a relatively dense canopy that prevents drying of the forest floor substrate.



Baird's Dusky Salamander



Chamberlain's Dwarf Salamander



Many-lined Salamander



Gulf Coast Mud Salamander



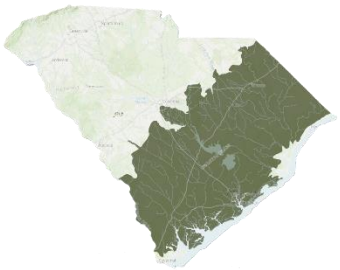
Four-toed Salamander



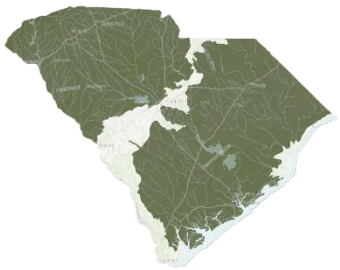
Webster's Salamander



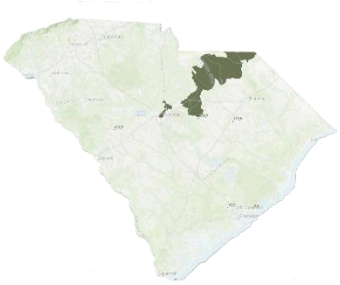
Dwarf Waterdog



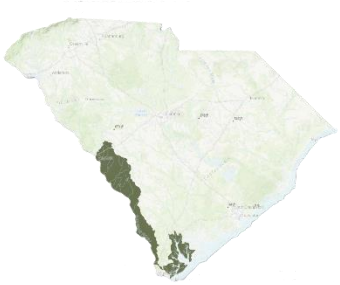
River Frog



Pickerel Frog



Pine Barrens Treefrog



Bird-voiced Treefrog

CHALLENGES

The primary challenges for all these species include habitat loss or alteration of both terrestrial and wetland habitats (depending on species), disease, illegal collection and impacts from nonnative species.

For Webster's salamanders habitat loss or alteration due to forestry practices, conversion to agriculture, or development could have detrimental impacts to persistence. Loss of the dense hardwood forest canopy this species prefers can lead to drying of the habitat and an elevation of soil temperatures, making the habitat unsuitable for the salamander.

The primary threat facing pine barrens treefrogs is habitat loss due to fire suppression, and other inappropriate management activities such as herbicide application in power-line rights of way, in the preferred herb-shrub bog habitat. Ditching and drainage of small, hillside wetlands or other alterations of these wetlands is a potential threat to pine barrens treefrog populations, especially since these important breeding habitats are non-jurisdictional wetlands and don't receive any protection from development.

CONSERVATION ACCOMPLISHMENTS

Since 2013, no formal surveys have taken place for Websters salamanders but known locations have been visited opportunistically, as recently as 2022, and presence of multiple Websters salamanders have been confirmed. All data collected during all surveys have been compiled and included in the SCDNR Heritage Database.

In 2019, the SCDNR passed new regulations that added significant protections for all reptiles and amphibians native to South Carolina. Specifically, no native species can be exported from SC and transfer of possession (buy, sell, trade, etc) is prohibited.

A State Wildlife Grant funded a survey of historic and new pine barrens treefrog sites in South Carolina from 2011-2016. At the onset of the survey, 31 historic sites were known for pine barrens treefrogs (Cely and Sorrow 1982). Over the course of the survey, 48 active locations were documented for this species, including several new occurrences. Most locations that detected pine barrens treefrogs in Cely and Sorrows 1983 surveys were still extant, or populations were in close proximity. Additionally, many of these sites were on public lands where managers expressed an interest in managing habitat for this species.

Opportunistic surveys were conducted at 20 historic pine barrens treefrog locations in 2021 and 2022. At least one calling individual was detected at 14 of those locations.

A recently funded survey effort, funded by the US Fish and Wildlife Service and conducted by Kennesaw State and the Savannah River Ecology Lab, is underway to determine the distribution of Chamberlain's dwarf salamander throughout their range in South Carolina and North Carolina. The results of this project will be important to help inform species status and management decisions for this species in South Carolina.

A survey, funded by a State Wildlife Grant, began in 2023 to identify presence, habitat use, and seasonal activity patterns for four-toed Salamanders in South Carolina. Preliminary results show sphagnum is important for nesting and that communal nesting is not uncommon. Additionally, habitat loss and degradation of important breeding/nesting sites from development, ditching, and nonnative, invasive species (hogs) likely has a negative impact on breeding, nesting, hatching success and population

persistence. Finally, protection of important breeding/nesting sites may be warranted and current wetland BMPs that suggest 50-foot buffers, are likely inadequate to protect this species.

CONSERVATION RECOMMENDATIONS

- Determine the distribution of Baird's dusky salamanders in South Carolina.
- Monitor the populations of bird-voiced treefrogs in South Carolina and collect data on abundance, life history and demography.
- Monitor the populations of Chamberlains dwarf salamanders in South Carolina and collect data on abundance, life history and demography.
- Determine the four-toed salamanders' distribution and collect data on abundance, life history and demography.
- Determine the pickerel frogs' distribution and collect data on abundance, life history and demography, especially in the coastal plain populations.
- Determine the dwarf waterdog's distribution and collect data on abundance, life history and demography.
- Determine the distribution of the Gulf coast mud salamander in South Carolina.
- Determine the many-lined salamanders' distribution and collect data on abundance, life history and demography.
- Ensure appropriate management is in place for pine barrens treefrog populations on public lands.
- Locate additional populations of pine barrens treefrogs and protect them.
- Monitor known populations of pine barrens treefrogs and develop accurate population estimates.
- Obtain life history data for pine barrens treefrogs which will inform our conservation and management efforts.
- Determine the river frog's current distribution and collect data on abundance, life history and demography.
- Ensure appropriate management is in place for websters salamander populations on public lands.
- Monitor known populations of websters salamanders and develop accurate population estimates.
- Obtain life history data for websters salamanders.
- Monitor and conduct research on the impacts of nonnative species on this guild.
- Evaluate the impacts of disease on this guild.

MEASURES OF SUCCESS

As results from current research and surveys are identified and analyzed, we will initiate projects to address specific needs that arise from these results. Measures of success for most of these species is to define distribution and population status in the state since most are data deficient.

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Isolated Wetland-breeding Amphibians Guild

Broad-Striped Dwarf Siren *Pseudobranchus striatus striatus*
Eastern Tiger Salamander *Ambystoma tigrinum*
Eastern Cricket Frog *Acris crepitans* -Coastal Plain only
Frosted Flatwoods Salamander *Ambystoma cingulatum*
Carolina Gopher Frog *Lithobates capito*
Oak Toad *Anaxyrus quercicus*
Ornate Chorus Frog *Pseudacris ornata*
Mabees Salamander *Ambystoma mabeei*
Upland Chorus Frog *Pseudacris feriarum* -Coastal Plain only

Contributors (2005): Stephen Bennett and Kurt A. Buhlmann [SCDNR]
Reviewed and Edited (2012): Stephen Bennett (SCDNR), Kurt A. Buhlmann (SREL), and Jeff Camper (Francis Marion University)
Reviewed and Edited (2024): Andrew Grosse (SCDNR), Ben Morrison (ARC) and Sydney Sheedy (ARC)

DESCRIPTION

Taxonomy and Basic Descriptions

This guild contains 9 species with differing levels of federal and state protections, as well as some where reports throughout their range indicate declines and still others that may be considered “common” but have disjunct populations in different ecoregions of South Carolina.

The frosted flatwoods salamander, tiger salamander and mabees salamander are members of the family Ambystomatidae, the mole salamanders. These species are large with the tiger salamander being the largest terrestrial salamander in the eastern United States.


Photo by Todd Pierson

The frosted flatwoods salamander can reach lengths of 9 to 12 cm (3.5 to 4.7 in.) as an adult. This species is dark, ranging from black to dark brown with silver-white reticulated markings (Conant and Collins 1991; Martof et al. 1980).

The tiger salamander can reach lengths of 18 to 20 cm (7.1 to 7.9 in.) as an adult; maximum size is approximately 30 cm (11.8 in.). This species has a dark background, typically black, with bright, yellow-orange irregular markings (Conant and Collins 1991; Martof et al. 1980).


Photo by Todd Pierson



Photo by Todd Pierson

The mabees salamander is the smallest of these three Ambystomatids, reaching lengths between 7-10 cm (3-4 in.) as an adult. Similar to the other two species, mabees salamanders typically have a dark brown or black background with pale/white speckling along the sides (Conant and Collins 1991).

The broad-striped dwarf siren is a member of the family Sirenidae, a family of salamanders that consists of both dwarf sirens and sirens. These are totally aquatic species that retain larval characteristics into adulthood. The dwarf siren is small, only reaching 10 to 15 cm (3.9-5.9 in.) in length and is an eel-like salamander that lacks hind limbs and has external gills. Dwarf sirens are typically brown in color with dark-brown longitudinal stripes flanking a broad, light brown stripe that runs the length of the animal's body (Conant and Collins 1991; Martof et al. 1980).



Photo by Todd Pierson

The Carolina gopher frog is a member of the family Ranidae, the true frogs. Its closest relatives include the bullfrog, leopard frog and bronze frog. This species can reach sizes of 6 to 9 cm (2.4 to 3.5 in.). It has the body shape of a typical frog but is more robust than other frogs with proportionately shorter legs. Gopher frogs are typically light to dark brown with heavy blotching and numerous warts (Conant and Collins 1991; Martof et al. 1980). In fact, while a true frog, the gopher frog does somewhat resemble a toad in appearance. This trait, as with the toad, is evidence of a more terrestrial lifestyle.



Photo by Andrew Grosse

The oak toad is a member of the family Bufonidae, the true toads. This is a small toad species only reaching lengths of 2-3 cm (.75-1.5 in.). The oak toad varies in color with a background of black to gray with a light, cream, yellow or orange mid dorsal stripe and warts that vary from orange to red (Conant and Collins 1991).



Photo by Andrew Grosse

The ornate chorus frog is in the family Hylidae and is a small frog, reaching lengths 2.5-3 cm (1-1.5 in). They can vary in color from reddish brown to silvery white to green but have a black mask-like stripe that runs through the eyes. They typically have dark spots on the sides and yellow in the groin (Conant and Collins 1991)



Photo by Todd Pierson

Four of these species, the flatwoods salamander, gopher frog, mabees salamander and tiger salamander spend their adult lives in terrestrial habitats as fossorial species, inhabiting crayfish holes, root channels, rodent burrows and other subterranean structures. Adults move to breeding ponds where they deposit eggs. Flatwoods salamanders move during autumn (Anderson and Williamson 1976) while tiger salamanders, mabees salamanders and gopher frogs move in late winter (Braswell 1993). Oaks toads and ornate chorus frogs spend their adult lives in the uplands surrounding wetland breeding habitat and move to wetlands during the breeding season. The aquatic larva of these species may spend several months in a pond before metamorphosing to the adult form. Newly metamorphosed individuals move away from breeding ponds; they only return to these ponds when they become reproductively mature adults (Petranka 1998).

The upland chorus frog and the eastern cricket frog are both small frogs; they reach lengths of 1 to 3 cm (0.3 to 1.2 in.). These frogs are in the family Hylidae and are related to treefrogs. The color pattern of the upland chorus frog can be variable; they are typically light brown with dorsal



Photos by Todd Pierson; *Upland Chorus frog (left), Eastern Cricket frog (right*)

striping that is broken at the posterior. The eastern cricket frog is also a highly variable species in terms of coloration; it ranges from red-brown to green (Conant and Collins 1991; Martof et al. 1980). Both species are common throughout most of their range, which, in South Carolina, is primarily the Southern Appalachian and piedmont ecoregions. These species both have populations in the coastal plain, disjunct from their typical range; it is these populations that are of conservation concern.

Status

The frosted flatwoods salamander is currently listed as endangered in South Carolina and is given a Natural Heritage rank of S1. With a federal ranking of G2, the flatwoods salamander is federally listed as a threatened. The Carolina gopher frog is currently listed as endangered in South Carolina with a natural heritage rank of S1. The gopher frog is considered a federal

candidate for listing and is currently considered a species of concern, G2. The dwarf siren is currently listed as threatened in South Carolina and ranked S1; it has a federal ranking of G5, secure. The tiger salamander is currently a species of concern in South Carolina and is ranked S2; it has a federal ranking of G5, secure globally (NatureServe 2024). The mabees salamander is a species of concern in South Carolina and ranked S3, with a federal ranking of G4. The oak toad is ranked as S3 in South Carolina has a global rank of G5. The ornate chorus is ranked S3 in South Carolina and has a global rank of G4 (NatureServe 2024).

The coastal plain populations of the upland chorus frog are ranked S5, secure, and G5, secure globally. The eastern cricket frog is considered secure, both federally and in South Carolina with rankings of G5/S5 (NatureServe 2024).

POPULATION SIZE AND DISTRIBUTION

Historically, the flatwoods salamander was known from Orangeburg, Jasper, Berkeley, and Charleston Counties. This species has been the object of intense survey efforts in South Carolina but has not been detected since 2010. The most recent records consisted of one or two individuals at breeding ponds. There has been no documentation of any significant reproduction for this species in South Carolina in over 20 years (Moulis and Seyle 1987; Harrison 2001; Bennett et al. 2002). While it's unlikely this species still occurs at historic locations on public land, there are significant private land holdings where this species may still occur.

The range of the Carolina gopher frog in South Carolina is generally believed to have included the entire Coastal Plain. Currently, the gopher frog is only known to occur in Aiken, Barnwell, and Berkeley Counties, although historic records include Aiken, Barnwell, Bamberg, Orangeburg, Dorchester, Hampton, Berkeley and Charleston Counties. Recent records indicate that gopher frogs are only present on large, public properties. Such properties include: the Savannah River Site, owned by the US Department of Energy and managed by the US Forest Service and the Francis Marion National Forest, owned and managed by the US Forest Service. Gopher frog breeding has been documented within the last decade and at multiple isolated wetlands at these sites, with evidence of successful reproduction at both the Savannah River Site and Francis Marion National Forest. The gopher frog has been the object of significant survey effort by the SCDNR in recent years. Efforts to relocate historic breeding ponds outside of the previously mentioned public lands have been met with little success. All of these historic ponds have been altered, drained or the surrounding habitat has been significantly altered.

Broad-striped dwarf sirens were last known to occur in Jasper, Hampton, Orangeburg, and Charleston counties in South Carolina. SCDNR documented this species from several new sites in Jasper and Hampton Counties in the early 1990s, however no records for this species at new or historic locations have been documented since. Extensive surveys for this species have not been conducted throughout the general range; it is likely that previously undocumented populations exist.

There are historic records for the tiger salamander from McCormick, Aiken, Barnwell, Bamberg, and Charleston Counties. Since the last revision, tiger salamanders have been documented in Allendale, Berkely, Chesterfield, Darlington, Aiken and Barnwell counties. The tiger salamander has not been the object of a range- wide survey in South Carolina. Little is known about the population biology of this species in this state.

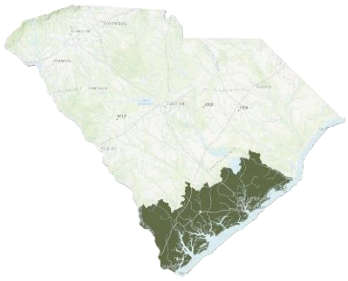
There are historic records for the mabees salamander from Jasper, Dorchester, Berkely, Charleston, Orangeburg, Bamberg, Marion and Sumter counties with the most recent records

occurring in Sumter, Charleston, Berkely and Hampton counties. The mabees salamander has not been the object of a range-wide survey in South Carolina. Little is known about the population biology of this species in this state.

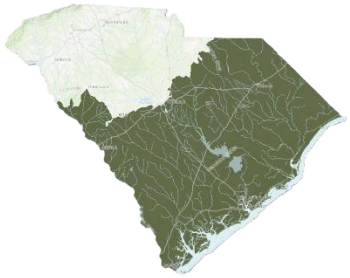
Oak toads occur throughout the coastal plain of South Carolina, however, they seem to be limited to large, well-managed, contiguous properties with well-managed isolated ephemeral wetlands and may be in decline due to habitat loss. The oak toad has not been the object of a range-wide survey in South Carolina. Little is known about the population biology of this species in this state.

Historic records of ornate chorus frogs show they occur throughout the coastal plain. However, most records north of the Santee River are over a decade old with most recent records occurring further south. Due to reports of recent declines in adjacent states, primarily due to habitat loss, and the lack of a range wide survey, this species may be declining in South Carolina. Local populations in the southern portion of the coastal plain seem to be robust where they occur.

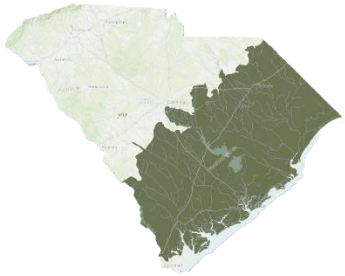
The coastal plain populations of the upland chorus frog and eastern cricket frog were previously believed to be restricted to areas near Charleston, South Carolina. Surveys by Dr. Emily Lemmon of Florida State University and Dr. Jeff Camper of Francis Marion University, indicate that both of these species are more widespread in the South Carolina Coastal Plain than previously thought. At this time, however, the actual distribution of these species in the Coastal Plain is not completely known. These two species are common to relatively abundant throughout the Piedmont and Southern Appalachian Ecoregions of South Carolina. The presence of these disjunct populations in the coastal plain is of scientific and conservation interest.



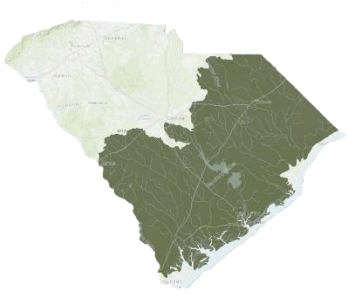
Frosted Flatwoods Salamander



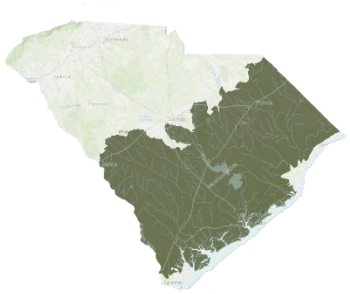
Eastern Tiger Salamander



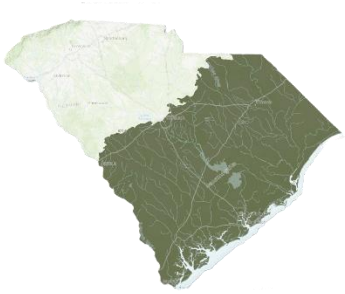
Mabee's Salamander



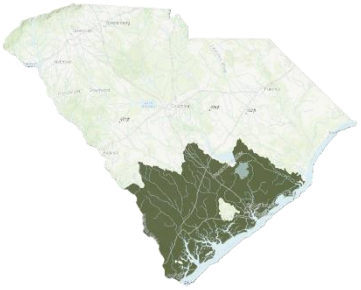
Carolina Gopher Frog



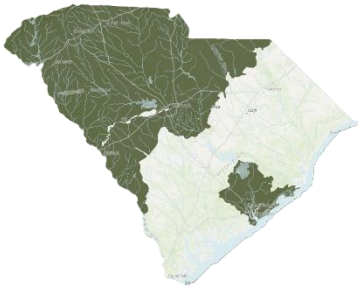
Ornate Chorus frog



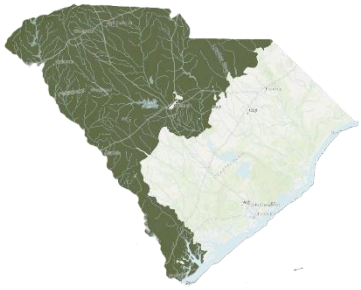
Oak Toad



Broad-striped Dwarf Siren



Upland Chorus Frog



Eastern Cricket frog

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Aquatic (Breeding) Habitat

The primary species in this guild typically breed or live in isolated, temporary freshwater wetlands. Examples of these naturally occurring wetlands include Carolina Bays, limesinks, flatwoods wetlands and other such related features. While these wetlands may differ in their geologic origin and geomorphology, they share certain characteristics. Typical breeding wetlands are isolated from flowing streams, particularly any inflows. Occasionally such wetlands will have an outflow "stream" that only flows when exceptionally heavy rains fill the pond above full pool (Bennett and Nelson 1991).

Due to the lack of stream-fed water, these wetlands typically fill and dry with rainfall cycles. Most, if not all, of these wetlands represent perched water tables, holding rainwater and runoff "perched" above the normal water table. The perching mechanism generally consists of an impermeable layer, such as clay, underlying the wetland basin. Typical breeding wetlands fill during the late autumn and winter and dry, due to evaporation and evapotranspiration, during the mid to late summer.

Breeding wetlands may exhibit a diversity of vegetative communities including open-shallow water, grass-sedge prairie (depression meadow), pond cypress savanna, and tupelo gum pond (non- alluvial swamp forest). The amphibian guild members tend to favor wetlands with an open canopy and abundant grasses and sedges. The clumped-bases of these plants provide refuge and habitat structure for many species of amphibian larvae. Hydroperiod, defined as the duration and seasonality in which a wetland holds water, ultimately determines the suitability of a wetland for specific amphibian species. Tiger salamanders and gopher frogs require wetlands that fill by mid- winter; further, they need to hold water continuously until May or June for successful larval metamorphosis to occur (Buhlmann et al. 1999; Mitchell and Buhlmann, 1999). Several wetlands with a variety of hydroperiods located in proximity within a landscape yields a high diversity of pond-breeding amphibian species.

Fish species, which may prey on amphibian larvae, are typically absent from these wetlands, due to their cyclical hydrology. Certain fish species, such as pigmy sunfish, do colonize wetlands in low- lying areas that have connection to other water bodies during flooding. Large, predatory fish such as pickerel and sunfish may invade these wetlands at times of abundant rainfall and high water, using deer trails, other natural channels, and man-made ditches and firebreaks to move from areas of permanent water into wetlands. However, in general, high quality amphibian breeding sites for members of this guild are free of fish.

Terrestrial (Non-breeding) Habitat

The species comprising this guild are typically found in the Coastal Plain in natural communities associated with the longleaf pine ecosystem, including longleaf pine flatwoods, longleaf pine savanna and xeric longleaf pine sandhills. Breeding wetlands are nested within the upland longleaf pine matrix of these communities.

In South Carolina, the flatwoods salamander is closely associated with the longleaf pine savannas of the lower coast. These communities typically exhibit a sparse canopy of longleaf pine with a rich herbaceous layer. The water table in such habitat is usually close to the surface and small, isolated wetlands may be numerous.

The tiger salamander, mabees salamander, oak toad, ornate chorus frog and gopher frog may occur in a wider array of longleaf pine habitats, including the savanna. These species also occur in longleaf pine flatwoods, which typically have a lower water table and a denser canopy, and xeric sandhills, which have a very low water table and deep, droughty sands. wetlands are generally less common in these two habitat types.

Other Habitats

The dwarf siren has been documented from small Coastal Plain streams that exhibit little or no flow and have muck bottoms. Such streams are typically too small to have established populations of predatory fish such as pickerel and sunfish. All of the members of this guild have been found to occasionally breed in man-made wetlands such as borrow-pits and ditches, when they occur within the appropriate terrestrial habitat. Long-term breeding success in these habitats is currently unknown; therefore, artificial habitats should not be considered as replacements for the destruction of natural wetlands.

CHALLENGES

The requirement for both suitable aquatic (breeding) habitat and terrestrial (non-breeding) habitat has made these species susceptible to alterations in either one of these habitats. The following activities have been suggested as reasons for the perceived decline of the species:

- Drainage of temporary wetlands
- Alteration of wetland hydroperiod
- Filling of wetlands
- Conversion of wetlands to other uses such as agriculture or development
- Exclusion of fire in longleaf pine forests
- Conversion of longleaf forest to loblolly pine plantations
- Commercial and residential development
- Conversion of longleaf forest to agriculture

Isolated wetland breeding amphibians are known to require adequate upland habitat around breeding wetlands. Populations of amphibians may be extirpated by the elimination of adequate upland habitat despite the protection of the breeding wetland. Conversely, the drainage or alteration of wetlands in an otherwise unaltered forest may result in the extirpation of local amphibian populations.

Many isolated wetlands that still exist are now unsuitable for breeding by amphibian species of

this guild because they have been left isolated in the landscape as a result of farming or timber operations. Such land management likely causes local extinctions of amphibian populations because the surrounding upland forests are removed, thus eliminating the terrestrial habitat required by these species when they are not breeding in the wetlands (Gibbons and Buhlmann 2001; Semlitsch 1998; Semlitsch and Bodie 1998).

Typically, isolated, ephemeral wetlands are non-jurisdictional and receive little protection, However, these wetland systems provide critical habitat for numerous amphibian and reptile species in addition to the species listed for this guild.

CONSERVATION ACCOMPLISHMENTS

Due to continued declines in gopher frog populations, headstart programs for the species began in 2019 with the goal of boosting gopher frog populations. This occurred in three distinct locations: The Francis Marion National Forest, the Savannah River Site and the Webb Wildlife Center. Partners from the US Fish and Wildlife Service, US Forest Service, Savannah River Ecology Lab, South Carolina Department of Natural Resources, Riverbanks Zoo and the Amphibian and Reptile Conservancy are all involved in this effort and have produced and released several thousand gopher frog metamorphs back into their natal wetlands.

Comprehensive surveys begin in 2015 at the lone wetland in the Francis Marion National Forest where headstarting occurred, the highest number of gopher frog egg masses were documented in 2023 and then again in 2024. Also, near the headstart area, egg masses were discovered at one wetland that had been surveyed since 2015, but never documented any breeding. This suggests that headstarting is likely having a positive impact on breeding numbers and that the headstarted wetland’s population is at least stable and possibly increasing and expanding to other nearby wetlands. Due to the positive response, in 2024, headstarting in the Francis Marion National Forest was expanded to allow headstarting at a second historic breeding wetland.

In the fall of 2021, as part of a Competitive State Wildlife Grant, three historic isolated, ephemeral wetlands were restored at the Webb Wildlife Center to aid in gopher frog population augmentation and re-establishment on the site. This effort was of benefit to a multitude of species, including oak toads and ornate chorus frogs (also SWAP species), who showed evidence of breeding within a few months of the restoration work.

A South Carolina gopher frog working group was created to improve communication among partners involved in gopher frog surveys, conservation, research, habitat restoration, and headstarting to benefit the species. This group includes partners from US Fish and Wildlife Service, US Forest Service, Savannah River Ecology Lab, South Carolina Department of Natural Resources, Riverbanks Zoo, The Longleaf Alliance and the Amphibian and Reptile Conservancy and officially meet annually to report on each year’s efforts.

The U.S. Forest Service and Amphibian and Reptile Conservancy gained approval to restore and enhance several significant isolated wetlands on the Francis Marion National Forest that will directly benefit gopher frogs, frosted flatwoods salamanders, oak toads and ornate chorus frogs, as well as a multitude of other species. Those efforts started in 2023 and significant progress has already been made. Similar to the restoration work at the Webb Wildlife Center, in just a few months following restoration of a portion of an isolated wetland in the Francis Marion, Gopher frog egg masses were detected for the first time.

Several new location records for Eastern tiger salamanders have been added to the SCDNR

heritage database. Since the last revision, tiger salamanders have been documented in Allendale, Berkely, Chesterfield, Darlington, Aiken, and Barnwell counties. The most significant finding was the population in Allendale County, which is located on a large, well-managed private property with several suitable isolated wetlands. This property is under a conservation easement and will be protected.

Research and survey efforts on pond breeding amphibians by SCDNR personnel, have been supported in the past by State Wildlife Grants. The primary focus of past work has been survey efforts to verify historic populations and document new populations. Little data exists on the demography, population dynamics, or conservation requirements for these species.

Since the last revision in 2015, we (SCDNR) have added a number of new records to the heritage database identifying new areas of interest for ornate chorus frogs, eastern tiger salamanders, mabees salamanders and oak toads. The Amphibian and Reptile Conservancy began comprehensive herpetofauna surveys in 2015 in the Francis Marion National Forest and have added many new records to the heritage database. These survey efforts have provided information on the status and distribution of several species in the National Forest, including mabee's salamanders, oak toads and ornate chorus frogs. Future surveys will continue to target these species as well as dwarf sirens, tiger salamanders and upland chorus frogs.

In 2019, the SCDNR passed new regulations that added significant protections for all reptiles and amphibians native to South Carolina. Specifically, no native species can be exported from SC and transfer of possession (buy, sell, trade, etc) is prohibited.

CONSERVATION RECOMMENDATIONS

- Inventory historic frosted flatwoods salamander breeding sites; Continue to monitor, protect and enhance these sites and surrounding uplands.
- Meet with public and private land managers to discuss the imperilment of the frosted flatwoods salamander and methods to ensure its protection.
- Survey potential new locations for frosted flatwoods salamanders in South Carolina
- Conduct habitat restoration or enhancement in wetlands of conservation importance for wetland breeding amphibians.
- Develop positive working relationships with key South Carolina landowners to allow inventory to proceed on private lands and plantations.
- Protect all known Carolina gopher frog population sites.
- Include the importance of protecting all isolated wetlands breeding amphibians and their habitat in general education materials.
- Survey and inventory new wetlands for all species of this guild with an emphasis on those that occur in intact, protected habitat and have connectivity to one another. Historic wetlands or those in close proximity to known breeding sites should be prioritized.
- Inventory sites that have historically contained Carolina gopher frogs. Monitor these sites for continued population by this species.
- Research the effects of fire management and wetland restoration on wetland breeding habitat for wetland breeding amphibians.
- Work with partners to establish a fire regime of late growing season or summer burns of dry wetland basins and surroundings uplands of important amphibian breeding wetlands.
- Work with partners to strategically thin timber stands that surround critical amphibian

breeding wetlands to create an open canopy forest with a diverse herbaceous and graminaceous understory. All stumps from any timber harvest should remain on the landscape to become future refugia.

- Investigate Carolina gopher frog life history to determine the status of "protected" populations and to address habitat requirements, seasonal activity, adult sex ratios, recruitment, mortality, and longevity.
- Evaluate the effectiveness of releasing headstarted members of this guild for population augmentation or re-establishment.
- Evaluate the success of gopher frog headstarting through the use of genetic analysis and monitoring.
- Evaluate the most effective release strategies for headstarted member of this guild.
- Investigate the feasibility of a captive breeding program or rearing of metamorphic frogs in semi-wild enclosures to help assure the availability of breeding adults.
- Consider broad-striped dwarf siren habitat needs when managing Carolina bays and similar wetland ecosystems.
- Inventory appropriate broad-striped dwarf siren habitat, primarily Carolina bays, for this poorly known species to determine actual distribution in South Carolina.
- Once identified, protect, and monitor habitat for broad-striped dwarf sirens.
- Collaborate with appropriate partners to identify, protect, and monitor sites that contain tiger salamanders.
- Determine distribution of the tiger salamander in South Carolina.
- Survey new and monitor known breeding sites of ornate chorus frogs, oak toads and mabees salamanders to determine presence and distribution in South Carolina.
- Conduct surveys for the upland chorus frog in the coastal plain, particularly in Francis Marion National Forest, to determine if the species is still present and if so, the status of this disjunct population.
- Monitor and conduct research on the impacts of nonnative species on this guild.
- Evaluate the need for invasive species control (fire ants, feral hogs, etc) in proximity of critical amphibian breeding wetlands and if done, evaluate the success of this management action.
- Work with the South Carolina Department of Transportation (SCDOT) and other partners to design wildlife crossings to reduce road mortality of reptiles and amphibians.
- Evaluate the impacts of disease on this guild.

MEASURES OF SUCCESS

As results from current research and surveys or future efforts are identified and analyzed, projects will be initiated to address specific needs that arise from these results. Data from surveys will be used to identify and develop appropriate life history and ecology research projects to detail causes of decline and limiting factors to population. Stable or growing populations of the target species, on protected lands, will be a measure of success.

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Leatherback turtle

Dermochelys coriacea

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Photo: Dr. Phil Schneider

DESCRIPTION

Taxonomy

The leatherback (*Dermochelys coriacea*) is the largest and most migratory of the living turtles, with the most extensive geographic range (Eckert et al. 2012). It is so distinctive that it is placed in a separate family, Dermochelyidae and is the only extant species remaining in this family. Blainville introduced the generic name *Dermochelys* in 1816. The binomial refers to the distinctive leathery, scaleless skin of the adult turtle. The specific name, *coriacea,* was first used by Vandelli in 1761 and adopted by Linneaus in 1766 (NMFS & USFWS 1992).

Basic Description

The carapace of the leatherback is distinguished by a rubber-like texture unlike hard-shell sea turtles. It is black with white spots and has seven prominent longitudinal ridges, which taper posteriorly to a blunt point. No sharp angle is formed between the carapace and the plastron, resulting in the animal being somewhat barrel-shaped; hence one common name was "trunkback". Adult leatherbacks possess a pink spot on the top of their heads (Eckert et al. 2012), associated with the pineal gland (Wyneken 2001). The undersurface is mottled, pinkish-white and black and is highly variable. They have long clawless front flippers, pointed tooth-like cusps for foraging on soft body prey, and keratinized spines in the mouth and throat to retain prey as water is expelled from their mouths (Pritchard 2015). Mean curved carapace length for adult



females nesting in the United States Caribbean is 155 cm (61 in.) with weights of 262 to 506 kg (578 to 1274 lbs.) (NMFS & USFWS 1992). Leatherback hatchlings are dorsally mostly black and covered with bead-like scales appearing as stripes along the length of the back. Their long flippers, reaching lengths as long as the carapace, are margined in white.

Conservation Status

The United States Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) share jurisdiction for sea turtles under the Endangered Species Act (ESA) with the USFWS's responsibility for turtles on the beach and NMFS's jurisdiction in the marine environment. The leatherback sea turtle was listed as Endangered throughout its global range on June 2, 1970, under the Endangered Species Conservation Act of 1969 (35 FR 8491), the precursor to the Endangered Species Act of 1973, as amended (ESA; 16 U.S.C. 1531 *et seq*). The leatherback is included on Appendix I of CITES (Convention on International Trade in Endangered Species) that recognizes the species is threatened with extinction and in need of the greatest level of protection. The leatherback is listed as Vulnerable globally under the IUCN (International Union for Conservation of Nature) Red List though separate subpopulations (also called populations in ESA reviews) have different listings. Leatherback subpopulations in the Pacific have declined and, overall, the Pacific subpopulations are listed as Critically Endangered (Wallace et al. 2013). The Northwest Atlantic Ocean subpopulation is listed as Endangered (Wallace et al. 2013, the Northwest Atlantic Working Leatherback Group 2019).

Critical habitat for the leatherback was designated by USFWS for a small area in US Virgin Islands on September 26, 1978 (43 FR 43688) and by NMFS in marine waters adjacent to Sandy Point Beach on March 23, 1979 (44 FR 17710). On January 5, 2010, the National Marine Fisheries Service proposed regulation to revise the critical habitat designation for the endangered leatherback sea turtle by designating additional areas of protection within the Pacific Ocean. The proposed addition measures approximately 70.6 $mi.^2$ and was designated in January 2012 (77 FR 4170).

Status review of the leatherback has determined there are seven leatherback populations that meet the requirements of discreteness for consideration as distinct population segments (DPSs). Discreteness determination is based on genetics, tagging, satellite telemetry data, and physical factors such as land masses, oceanographic features, and currents. Leatherbacks observed in South Carolina fall within the Northwest (NW) Atlantic DPS (NMFS and USFWS 2020).

POPULATION SIZE AND DISTRIBUTION

The estimated worldwide nesting population of leatherbacks in 1995 was about 34,500 females on 28 major surveyed beaches, with a lower limit of about 26,200 and an upper limit of about 42,900 (Spotila et al. 1996). This is less than one third of the 1980 estimate of 115,000 (Spotila et al. 1996). The largest female nesting aggregation was once located in Gabon (Southeast Atlantic DPS) (Witt *et al.* 2009) but recent analysis shows a steep decline in numbers (NMFS & USFWS 2020). The Northwest Atlantic DPS population now hosts the largest number of female leatherbacks with the largest nesting aggregations occurring in Trinidad, French Guiana, and Panama



(NMFS & USFWS 2020). Leatherback nesting beaches are distributed circumglobally on tropical or subtropical beaches but also on some temperate beaches (Pritchard and Mortimer 1999, NMFS & USFWS 2020). In North America, the northeast coast of Florida was considered the northern limit for leatherback nesting. Nesting in Florida was once considered extremely rare, but now nests number in the hundreds annually (Stewart et al. 2011). Leatherback nesting has been confirmed in South Carolina but is considered a rare occurrence as the state lies beyond the northern edge of nesting range and nests laid in South Carolina typically are not successful. Since 1996, 36 leatherback nests have been documented in South Carolina (SCDNR unpublished data, 2024). Despite expansion of nesting occurring north of historical beaches, evidence of a decreasing nest trend has been observed at nesting beaches with greatest known female abundance in the NW Atlantic DPS (NMFS & USFWS 2020).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Leatherbacks' highly migratory nature, with extensive geographic range, ensures they are rarely encountered except females during nesting and because of such less is known about their overall life history. They are unique among sea turtles in the ability to thermoregulate (maintain their core temperature) utilizing countercurrent heat exchange and due to large size can avoid overheating while nesting (Friar et al. 1972, Greer et al. 1973). Leatherback adaptations such as low metabolic rate, large oxygen storage capacity, ability to withstand crushing hydrostatic pressures at depth, and tolerate cold water temperatures allow them to reach deep depths in the water column over 1 km (Doyle et al. 2008, Robinson and Paladino, 2015)

Mating between adult males and females is thought to occur prior to or during migration from foraging areas before females arrive in waters off nesting beaches. On occasion mating has occurred just off nesting beaches before commencement of actual nesting (Rostal 2015).

Nesting females prefer high-energy beaches with deep, unobstructed access to nesting sites from soft-bottom, deep-water approaches (Pritchard and Mortimer 1999; Eckert et al. 2012, 2015) that occur most frequently along continental shorelines. Foraging areas are typically where zones of upwelling occur including where major currents converge such as continental edges. (Saba 2013).

Leatherback movements are likely in response to seasonal abundance of macroplanktonic prey, jellyfish, their major food item. An annual migration of adult and sub-adult leatherbacks from the

wider Caribbean to the northwestern Atlantic results in spring and fall concentrations of leatherbacks in South Carolina waters. Nearshore concentrations of leatherbacks can occur from April to June during the northward migration when cannonball jellyfish (*Stomolophus meleagris*) are abundant. Based on strandings reported and live in-water observations, there is a second, less apparent peak, during the southward migration in October and November. (Murphy et al. 2006, SCDNR unpublished data).

Information on habitat requirements for post-hatchling and juvenile leatherbacks is limited, with individuals smaller than 100 cm (39 in.) in carapace length confined to waters > 26°C (79°F) Eckert et al. 2012).

CHALLENGES

Loss or degradation of nesting habitat from coastal development and beach armoring results in adverse impacts to leatherbacks. Even if a suitable sandy beach is available, nesting can be aborted because of beach furniture and equipment blocking access to nest sites.

Artificial light pollution along the coast is disruptive to both nesting adult females and emerging hatchlings. The presence of humans using flashlights or cell phone lights at night can also disrupt nesting females. Artificial lighting that illuminates the beach causes females to avoid certain areas to nest and disorients hatchlings when direct and timely migration to the ocean is critical to their survival. (NMFS & USFWS 1992).

Climate change is a potential threat to sea turtles as it may affect these species in three ways: loss of dry sand beaches to sea level rise or inundation of existing nests (Daniels et al. 1993; Fish et al. 2005; Baker et al. 2006); lethal high temperatures within the nest that would cause egg/hatchling mortality or decreased hatchling fitness; or a female-biased sex ratio of hatchlings due to increased nest temperatures (Glen and Mrosovsky 2004, Binckley and Spotila, 2015, Seaman and Milton 2023). Sea turtles, like some other reptiles, have temperature-dependent sex determination (TDSD), with higher temperatures favoring the development of female offspring and lower temperatures favoring males (Spotila 2004). Foraging grounds in the marine environment may also be affected as increased sea water temperatures alter prey species availability, foraging success and reproductive success (Goudarzi, F et al 2024, Spotila, Saba et al. 2015).

Egg clutches on beaches are subject to expected natural predators such as raccoons, coyotes, ghost crabs (*Ocypode quadratus*) (SCDNR, unpublished data, NMFS & USFWS 1992) and yellow crown night herons (*Nyctanassa violacea*) on the beach at night (NMFS & USFWS 1992).

Because of their very large front flippers, leatherbacks become entangled often in longlines, float lines of crab and lobster pots, buoy anchor lines, and other vertical ropes and cables existing in the water column. This can lead to serious injuries and/or death by drowning (NMFS & USFWS 1992; SCDNR unpublished data). Leatherbacks apparently mistake floating plastic bags and sheets for jellyfish and consume these materials. This can cause direct obstruction of the gut or absorption of toxic byproducts and reduced absorption of nutrients across the gut wall.

Mrosovsky (1981) reviewed data from leatherback stomach content studies worldwide and concluded that approximately 44% of the adults examined had plastic in their stomachs.

The shrimp trawl fishery also captured leatherbacks until Turtle Excluder Devices (TEDs) were enlarged to allow their escape. They are also vulnerable to boat and ship collisions, particularly when inhabiting shallow, near-shore waters. Lewison et al. (2004) integrated catch data from over 40 nations and by-catch data from 13 international observer programs. They estimate that 50,000 leatherbacks were likely taken as pelagic longline by-catch in 2000. Eckert and Sarti (1997) reported that, "mortality associated with the swordfish gillnet fisheries in Peru and Chile represents the single largest source of mortality for Eastern Pacific leatherbacks." Incidental mortality in fisheries, implicated in the collapse of the Eastern Pacific population, is a largely unaddressed problem worldwide (Eckert et al. 2012).

Vessel strikes continue to be a threat (NMFS & USFWS 2020). In South Carolina, leatherbacks are vulnerable to vessel strikes where interaction with large propellers lead to direct mortality (SCDNR, unpublished data).

Leatherbacks are still occasionally killed for meat and oil in the Caribbean (NMFS & USFWS 1992). The theft of eggs for local consumption was once a problem in the US Virgin Islands but has been all but eliminated because of nightly patrols and nest protection programs (NMFS & USFWS 1992).

CONSERVATION ACCOMPLISHMENTS

Since 1981, intensive nest survey and protection efforts have been implemented at Sandy Point, St. Croix, US Virgin Islands. In 1984, the US Fish and Wildlife Service purchased the 2.4 km (1.49 mi.) long nesting beach at Sandy Point, which became a National Wildlife Refuge and designated as Critical Habitat under the Endangered Species Act of 1973. In South Carolina, nearshore aerial surveys have documented the spatial and temporal distribution of leatherbacks since 1993. The leatherback Conservation Zone was established as part of the Contingency Plan in 1995 (60 FR 25260, May 12, 1995; 60 FR 25663, May 12, 1995). Additionally, leatherback-sized TEDs were required in all shrimp trawls by the National Marine Fishery Service in 2003.

On January 5, 2010, the National Marine Fisheries Service proposed regulation to revise the critical habitat designation for the endangered leatherback sea turtle by designating additional areas of protection within the Pacific Ocean. The proposed addition measures approximately 70.6 $mi.^2$ and was designated in January 2012 (77 FR 4170).

SCDNR continues to partner with and permit the South Carolina Aquarium Sea Turtle Care Center™, which opened in 2000, to provide medical care for sea turtles in need from both South Carolina waters and surrounding states. To date only one leatherback has been successfully rescued off a barrier island by SCDNR staff and rehabilitated in South Carolina. Leatherbacks do not normally respond well to captivity, even brief stints for rehabilitation. SCDNR partners with the South Carolina Aquarium staff on educational outreach.

In 2020 changes were made to the NMFS South Atlantic Regional Biological Opinion for dredging

activities because of multiple entanglement events associated with a dredging project in South Carolina waters. Gear modification requirements ensured leatherback would not get flipper caught in cable loops of vertical lines used to mark submerged pipelines.

CONSERVATION RECOMMENDATIONS

- Protect areas of high leatherback concentration in water from activities that can have a negative impact on leatherbacks such as longlines, set nets and trawl fisheries that do not require effective TEDs.
- Continue to monitor use of vertical lines for fisheries, dredging projects and other projects that may present a possibility of interaction.
- Continue to monitor presence of leatherbacks in South Carolina waters or just offshore to learn more about migratory paths and ensure protection against vessel interactions.
- Conduct education programs that inform the public about the detrimental impacts of litter on aquatic organisms like the leatherback to assist in reducing the volume of plastics in the marine environment.
- Provide protection from predators and erosion for any nests that are laid on the beaches.
- Continue to work with partners to model sea level rise with leatherback nesting beaches in South Carolina.
- Increase education of boaters to raise awareness of sea turtles in our coastal waters.
- Ensure a continued food source for leatherbacks by protecting the cannonball jellyfish from commercial over-harvest.
- Monitor stranded leatherbacks to determine the number, size, and distribution of mortalities and the source of tagged individuals.
- Perform post-mortem examinations of stranded leatherbacks to document cause of death, food habits, sex ratio, reproductive condition, and extent of ingestion of plastics.
- Continue to gain more information on leatherback distribution from the public through the Marine Turtle Conservation Program web site.

MEASURES OF SUCCESS

While Pacific populations of leatherbacks are in sharp decline, nesting populations in the Atlantic appear to be either declining or stable though nesting areas have expanded. South Carolina research and monitoring efforts will be an important component to document future population trends in this endangered and unique animal. An increase in the number of nests and nesting females may be considered a sign of successful management actions.

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Loggerhead turtle

Caretta caretta



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DESCRIPTION

Taxonomy and Basic Description

The loggerhead was described by Linnaeus (1758) and named *Testudo caretta.* Over the next two centuries more than 35 names were applied to the species (Dodd 1988), but there is now general agreement on *Caretta caretta* as the valid name. The carapace, head scales, and dorsal scales of the flippers of adult and juvenile loggerheads are reddish-brown to brown in color. The plastron, neck, ventral surface of the flippers, and margins of the head scales are cream to yellow in color, but with some variation. Adult loggerheads in the southeastern United States have a mean straight carapace length (SCL) of 92 cm and weigh about 116 kg (NMFS & USFWS 2008).



Hatchlings vary from light to dark brownish to dark gray dorsally, lacking the reddish-brown coloration of adults. Both pairs of flippers are dark brownish to dark gray with distinct white margins. The plastron and other ventral surfaces are a dull tan. Hatchlings have three dorsal keels (prominent spines extending from their scutes) on their carapace and two plastral keels. At emergence their mean straight carapace length is about 45 mm (1.8 in), and they weigh approximately 20 g (0.7oz) (NMFS & USFWS 2008).

Conservation Status

The United States Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) share jurisdiction for sea turtles under the Endangered Species Act (ESA), with the USFWS's responsibility for turtles on the beach and NMFS's jurisdiction in the marine environment. The loggerhead sea turtle was listed as threatened on July 28, 1978 (43 FR 32800) under the ESA. In 2011, the listing was later revised from a single threatened population to nine distinct population segments (DPSs) designated as either threatened or endangered (76 FR 58868). These DPSs are isolated from each other, considered discrete

populations, based on tagging data, telemetry studies, demography, and genetic data (76 FR 58868).

Within the Northwest Atlantic Ocean DPS there are five recovery units because loggerheads are a wide-ranging species, have multiple populations and varying ecological pressures, and differing threats in different parts of their range. The five recovery units include the Northern Recovery Unit, Peninsula Florida Recovery Unit, Dry Tortugas Recovery Unit, Northern Gulf of Mexico Recovery Unit, and the Greater Caribbean Recovery Unit (NMFS & USFWS 2008). Loggerhead sea turtles that nest in southern Virginia, North Carolina, South Carolina, and Georgia fall within the Northern Recovery Unit.

POPULATION SIZE AND DISTRIBUTION

The Northern Recovery Unit is the second largest loggerhead nesting assemblage in the US. Annual nest totals from beaches north of Florida averaged 5,125 nests from 1989-2008, representing approximately 1,272 nesting females per year (NMFS & USFWS 2008). South Carolina loggerhead nesting effort represents over 65% of the Northern Recovery Unit. Historically, the Northern Recovery Unit nesting population showed a significant declining trend of 1.3% annually from 1983-2008 (NMFS & USFWS 2008). Recent data indicate that the overall nesting trend may be stable, neither increasing nor decreasing (NMFS & USFWS 2023).

Research by the South Carolina Department of Natural Resources (SCDNR) Marine Resources Division indicates that juvenile loggerheads in coastal waters off GA, SC, and northern Florida are more abundant by an order of magnitude than they were in the late 1970's and early 1980's (Maier et al. 2004).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Adult females inhabit temperate coastal waters during the nesting season, from mid-May to mid-August. During this time of egg laying, the females are not feeding. After nesting, females migrate to foraging areas both north and south of their nesting beaches. The predominate pattern for South Carolina females is to move to the Mid-Atlantic Bight until November and then return south of Cape Hatteras, North Carolina during winter. In spring, they return to their same foraging area as the previous season. They repeat this until it is time for their breeding migration back to the nesting beach (Hawkes et al. 2011; Griffin et al. 2013). Females nest every three years for a good portion of loggerheads in South Carolina.



The loggerhead sea turtle nests on ocean beaches within the continental US from Texas to Virginia. They are the predominant species nesting on South Carolina coastal islands and estuarine shorelines with

suitable sand (NMFS & USFWS 2008). Nests are typically made between the high tide line and the primary dune front in dry sand.

For early life stages of hatchlings through ages 10-12 years, loggerheads maintain a pelagic existence living amongst sargassum weed and drifting with ocean currents (NMFS & USFWS 2008). Current data suggests hatchlings exhibit swimming instead of passive drifting during the sea turtle "lost years" (Putnam and Mansfield 2015). At 10-12 years of age, loggerheads return to inhabit nearshore coastal waters to also include creeks and tidal rivers of South Carolina's salt marshes.

Juveniles from the various Recovery Units mix on foraging grounds, which include estuarine, neritic, and continental shelf waters in the Gulf of Mexico and the eastern seaboard (NMFS & USFWS 2008). Juvenile loggerheads 40 to 91 cm in carapace length are found in South Carolina on a seasonal basis from early April through November.

CHALLENGES

Because of their highly migratory behavior, with life stages that occupy different habitats, conservation efforts for loggerhead populations in one country and/or state may be offset by activities in another.

One major challenge faced by loggerheads includes the loss or degradation of nesting habitat from sea level rise, erosion, coastal development, and beach armoring, although beach armoring is no longer allowed in South Carolina (Beachfront Management Act 1988), previously built rock revetments and sea walls exist. Even if a suitable sandy beach is available, nesting can be aborted because of beach furniture and equipment left overnight that blocks access to these suitable nest sites. Beach vitex (*Vitex rotundifolia*), an exotic introduced plant, found historically in areas in northern Georgetown and Horry Counties still exists in other communities.

Climate change is a potential threat to sea turtles as it may affect these species in three ways: loss of dry sand beaches to sea level rise or inundation of existing nests (Daniels et al. 1993; Fish et al. 2005; Baker et al. 2006); lethal high temperatures within the nest that would cause egg/hatchling mortality or decreased hatchling fitness; or a female-biased sex ratio of hatchlings due to increased nest temperatures (Glen and Mrosovsky 2004). Sea turtles, like some other reptiles, have temperature-dependent sex determination (TDSD), with higher temperatures favoring the development of female offspring and lower temperatures favoring males (Spotila 2004; Wyneken and Lolavar 2015). Foraging grounds in the marine environment may also be affected as increased sea water temperatures and acidification alter prey species availability (Goudarzi, F et al 2024).

Artificial light pollution along the coast is disruptive to both nesting adult females and emerging hatchlings. The presence of humans using flashlights or cell phone lights at night can also disrupt nesting females. Artificial lighting that illuminates the beach causes females to avoid certain areas to nest and disorients hatchlings when direct and timely migration to the ocean is critical to their survival. Excessive predation by native and non-

native predators, as well as erosion and storm events, destroy nests. Coyotes, feral hogs, raccoons, foxes, and armadillos destroy loggerhead nests as well as negatively impact the maritime forest community on some coastal islands (NMFS & USFWS 2008). Killing of adult loggerheads on land is rare, but human poaching of turtle nests and clandestine markets for eggs may continue to be a problem (NMFS & USFWS 2008).

Another major impact on sea turtles can result from the incidental take in commercial fishing operations. Historically it was estimated that between 5,000 and 50,000 loggerheads were killed annually by the shrimping fleet in the southeastern Atlantic and Gulf of Mexico (National Research Council 1990) and this fishery was responsible for most adult loggerhead deaths at sea. All trawl fisheries operating in South Carolina now require the use of a turtle excluder device (TED) to prevent mortality of sea turtles and allow safe passage out of a net. The shark longline fishery, which operates all year long off the south Atlantic, may impact loggerheads in the neritic environment (Lewison et al. 2004). Loggerheads have been found entangled in a wide variety of materials including fishing line, crab pot lines, buoys associated with marking underwater equipment, rope, and discarded netting (NMFS & USFWS 2008; SCDNR unpublished data). They also ingest many types of marine pollution and debris, resulting in gut blockage (NMFS & USFWS 2008).

Vessel interaction (boat strikes) has become more prevalent and the predominant challenge for sea turtles occupying South Carolina waters. Upwards of one-third of the stranded sea turtles reported in South Carolina had wounds indicating some type of vessel interaction (SCDNR unpublished data).

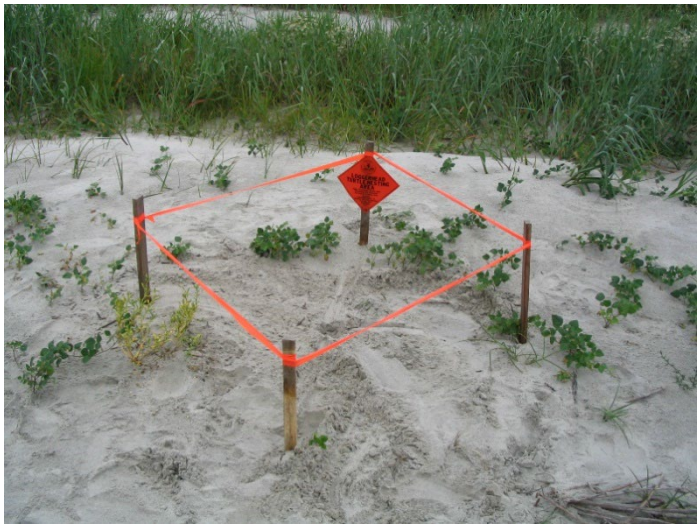
The use of hopper dredges to manage material in shipping channels and other areas continues to be a threat to sea turtles, especially when allowed to operate during time periods when sea turtles are known to occupy those coastal areas (Van Dolah and Maier 1993; Arendt et al. 2012; SCDNR unpublished data).

Natural mortality factors in-water include predation by large sharks, disease, and parasites (NMFS & USFWS 2008).

Degradation of foraging habitat by physical damage occurs when there is trawling over live bottoms. Clam dredges can cause similar damage in areas further offshore. Over-harvesting of prey species, such as horseshoe crabs and whelks, can deprive loggerheads of their food resource, resulting in longer remigration intervals between nesting (Bjorndal 1997). Data on the quantity and quality of foraging habitat is scarce. Continued protection of foraging habitat, where loggerheads spend most of their time, and migration corridors is necessary to ensure minimal interaction with fishing operations and dredging operations.

CONSERVATION ACCOMPLISHMENTS

Some conservation accomplishments achieved for this species span a regional scale by federal agencies while others were made locally in South Carolina. The Sea Turtle Stranding and Salvage Network (STSSN) was established in 1980 to document the number of sea turtle carcasses that wash ashore.



The loggerhead turtle was designated the State Reptile of South Carolina in 1988 (Act # 588, June 1, 1988).

South Carolina became the first state to enact Turtle Excluder Device (TED) regulations in 1988. Federal regulations requiring TEDs in all waters throughout the year came into effect in 1991.

In 1991, South Carolina also became the first state to require the US Army Corps of Engineers to restrict hopper dredge channel maintenance to the winter months. However, recent changes to the South Atlantic Regional Biological Opinion for dredging (2020) have seen a removal of the previous seasonal hopper dredging windows.

South Carolina became the first state to enlarge TED openings in 2002. Federal regulations requiring larger TED openings came into effect in 2003.

SCDNR in conjunction with local electric service providers continues to produce and distribute large “Lights Out” causeway signs that are erected on roadways leading to beaches. Volunteer turtle projects produce newspaper articles and social media content to inform beach residents and visitors about the necessity to have lights out during the nesting and hatching seasons as well as other conservation measures to aid sea turtles.

Nest protection projects and an associated volunteer network were established along the South Carolina coast from 1981 to the present to increase hatchling productivity. Over 70% of the nests laid in South Carolina are under nest protection management and achieve at least a 60% hatching success (Hopkins-Murphy et al. 1999). Statewide aerial beach surveys were carried out from 1980 to 2007 to provide a standard index for monitoring the nesting population (Hopkins-Murphy et al. 2001). Currently, statewide on the ground beach surveys have replaced the aerial surveys and include an index beach portion to monitor the nesting population that consists of six beach projects continuously operating since 1982 under the same methodology. Use of *Vitex rotundiflora* (Beach Vitex) has been banned in at least 12 municipalities in North and South Caorlina to limit its further spread.

Since 2010 SCDNR has participated in a regional loggerhead genetics research study conducted by state sea turtle coordinators in Georgia, North Carolina, and South Carolina in collaboration with the University of Georgia to answer critical reproductive biological questions.

SCDNR Marine Turtle Conservation Program produced and installed signage on piers to educate anglers what to do in case of an incidental take of a sea turtle while recreational

fishing. Signs were produced in both English and Spanish.

SCDNR Marine Turtle Conservation Program produced and installed signage at boat ramps and marinas alerting boaters to the presence of sea turtles in our inshore waters to avoid collisions. Additionally, a QR code on the sign provides access to our ArcGIS Survey 123 online form to report live healthy sea turtles observed in the water during their travels.

SCDNR continues to partner with and permit the South Carolina Aquarium Sea Turtle Care Center™, which opened in 2000, to provide medical care for sea turtles in need from both South Carolina waters and surrounding states. SCDNR partners with the South Carolina Aquarium staff on educational outreach.

Endangered Species Act Section 6 funding from both the US Fish and Wildlife Service and the National Marine Fisheries Service provide program support for the SCDNR Marine Turtle Conservation Program.

CONSERVATION RECOMMENDATIONS

- Protect any remaining significant loggerhead nesting beaches that are still threatened with development through fee simple purchase or conservation easement (i.e. Bay Point).
- Continue to work with partners to model sea level rise with loggerhead nesting beaches in South Carolina.
- Establish partnerships to determine the quantity and quality of foraging habitat.
- Ensure that important nesting beaches destroyed by storm events are restored. Collaborate with the US Army Corps of Engineers to complete beach restoration projects.
- Reduce coyote, armadillo, and feral hog populations on coastal islands.
- Ensure that predator control is conducted on important loggerhead nesting beaches.
- Continue to monitor effects of a changing climate on sex ratios.
- Consider establishing Marine Protected Areas based on satellite telemetry data of adult female loggerheads on resident foraging areas. This should be done in collaboration with the Atlantic States Marine Fisheries Commission, Fisheries Management Councils, and relevant states.
- Work with the US Army Corps of Engineers to address changes in the South Atlantic Regional Biological Opinion for dredging (2020) where seasonal hopper dredging windows have been removed.
- Increase education of boaters to raise awareness of sea turtles in our coastal waters.
- Increase education of anglers both on land (piers, shore-based) and on boats regarding sea turtles in our coastal waters.
- Collaborate with other states in the southeast on emerging issues affecting loggerheads as the needs are identified.
- Ensure existing surveys that are providing a standardized index to the population are adequately funded.
- Continue to publicize and promote the “Lights Out” efforts and enlist the

assistance of electric utility companies when necessary.
- Continue to work with partners to establish coastal lighting ordinances in coastal counties to reduce artificial illumination of nesting beaches.
- Maintain and improve the SCDNR Marine Turtle Conservation Program web page.

MEASURES OF SUCCESS

As research and management needs are identified, we will initiate projects to address those needs. This was done previously with TED opening sizes when they were found to be too small and with the management of beach vitex through the establishment of a Beach Vitex Task Force using funding from a National Fish and Wildlife Foundation grant.

Because there are multiple threats to loggerheads, both on the nesting beaches and at sea, there are likewise multiple management strategies being implemented to bring about their recovery. We may not know which ones have been responsible for recovery of the species, should population numbers on nesting beaches begin to increase. The state will work to implement any Loggerhead Recovery Plan Tasks where South Carolina is the Responsible Agency.

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Resident Juvenile Sea Turtles Guild

Kemp's Ridley Turtle *Lepidochelys kempii*
Green Turtle *Chelonia mydas*
Hawksbill Turtle *Eretmochelys imbricata*

Contributors (2005): DuBose Griffin and Sally Murphy, SCDNR
Reviewed and Edited (2013): DuBose Griffin, SCDNR
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DESCRIPTION

Taxonomy

Samuel Garman first described the Kemp's ridley sea turtle in 1880 as *Thalassochelys kempii*. It was named for Richard M. Kemp, a fisherman interested in natural history who submitted the type specimen from Key West, Florida (USFWS and NMFS 1992). Later *kempii* was allocated to the genus, *Lepidochelys*, when it was realized by Baur in 1890 that the Kemp's ridley and Indo-Pacific olive Ridley were congener. Others considered *L. kempii* as a sub-species of *L. olivacea*. A review by Pritchard justified their status as a full, separate species and this determination is accepted by most authors (USFWS and NMFS 1992).

Linnaeus described the green turtle in 1758 as *Testudo mydas*. Schweigger first applied the binomial, *Chelonia mydas,* in 1812. Although trinomials have been applied to various populations in the past, they are generally not in use today (NMFS and USFWS 1991).

The hawksbill was originally named *Testudo imbricata* by Linnaeus in 1766. Two subspecies (*Eretmochelys imbricata imbricata* in the Atlantic Ocean and *Eretmochelys imbricata bissa* in the Pacific and Indian oceans) are recognized. However, a complex pattern of phenotypic variation exists.

Basic Description

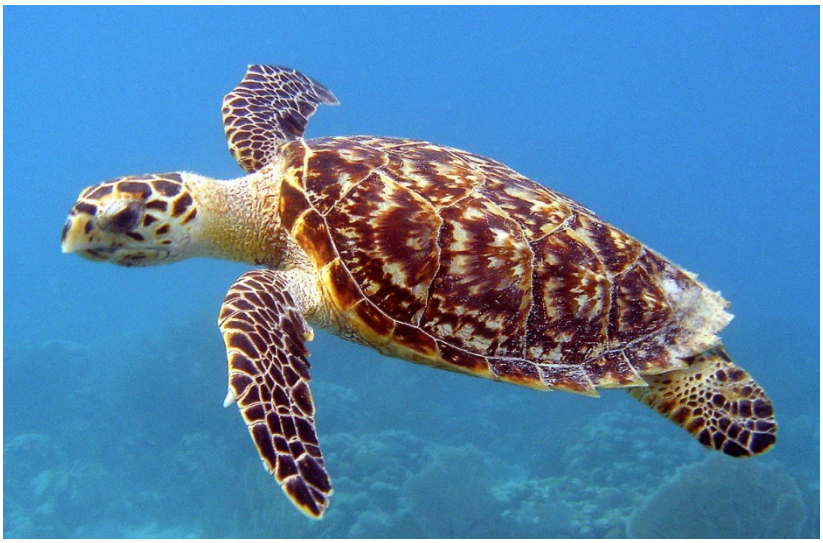
The Kemp's ridley turtle is one of the smallest and rarest of the seven sea turtle species; it has an adult straight carapace length of approximately 65 cm (26 in.) and weighs less than 45 kg (99 lbs.). Adults have an almost round carapace that is as wide as it is long. The coloration changes significantly during development from the almost black hatchlings to the lighter, grey-olive carapace and cream-white or yellowish plastron of adults. There are four inframarginal scutes, each of which contains a pore. Kemp's ridleys possess a hooked beak and almond shaped eyes. Hatchlings generally range from 42 to 48 mm (1.7 to 1.9 in.) straight carapace length and weigh between 15 and 20 g (0.5 and 0.7 oz.) (USFWS and NMFS 1992).




Green turtles are the largest of the hard-shelled sea turtles with adults reaching 1 m (3.3 ft.) in carapace length and 150 kg (330 lbs.) in weight as an adult. They have a smooth carapace with four pairs of lateral scutes and a single pair of elongated prefrontal scales between the eyes. The coloration changes significantly during development. The plastron remains a yellowish white, but the carapace changes color from solid black as a hatchling to a variety of shades of grey, green, brown and black in starburst or irregular patterns as juveniles and adults. Their name is derived from the green fat, or calipee, in their body due to their herbivorous diet. Different from loggerheads, green sea turtles have a significantly smaller head as compared to the rest of the body size as adults. They have a serrated lower jaw for tearing grass. Green turtle hatchlings are about 50 mm (2.0 in.) long and weight about 25 g (0.88 oz.).




Adult hawksbills shell length for nesting females varies between 62.5 and 95 cm (25.0 and 37.0 in.) in the Atlantic. Distinguishing features of hawksbills are four pairs of overlapping scutes, a long neck compared to other sea turtles, and beak-like mouth resembling a hawk that allows them to forage in hard-to-reach cracks and crevices. The adult shell is usually amber with streaks of red-brown, black-brown and/or yellow with the plastron whitish-yellow and may have black spots.



Status

Kemp's ridleys were listed as Endangered throughout their range on December 2, 1970, and are the most seriously endangered of the sea turtles (35 FR 18319). They are also listed as endangered by the International Union for the Conservation of Nature and Natural Resources (IUCN) and are listed in Appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) which prohibited all commercial international trade. The International Union for Conservation of Nature lists the Kemp's ridley as Critically Endangered.

Green turtles were listed as Threatened under the U.S. Endangered Species Act of 1973 on July 28, 1978. Breeding populations in Florida and on the Pacific coast of Mexico were listed as endangered (43 FR 32800). Critical habitat was designated to include waters surrounding Culebra Island, Puerto Rico and its outlying keys in 1998 (63 FR 46693). In 2016 the population was further recognized into eight distinct population segments (DPS) under the ESA with three DPSs listed as endangered and eight as threatened. The North Atlantic DPS, which includes greens nesting in South Carolina, is listed as Threatened (81 FR 20057).

Hawksbills were listed as Endangered in 1970 under the precursor to the Endangered Species Act (35 FR 8491). They are also listed as endangered by the International Union for the Conservation of Nature and Natural Resources (IUCN) and are listed in Appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Kemp's ridleys and green turtles use South Carolina waters as developmental foraging grounds. Hawksbills are rarely seen in South Carolina waters.

POPULATION SIZE AND DISTRIBUTION

<u>Kemp's Ridley</u>

Kemp's ridleys have a restricted distribution with nesting primarily occurring on beaches in

western Gulf of Mexico. In 1947, over 42,000 nesting Kemp's ridleys were estimated in a single day's arribada (mass nesting) (Hildebrand 1963). Their numbers precipitously declined since then. The nesting population produced a low of 702 nests in 1985 (Ross et al. 1989). This initial decline was brought about by decades of harvesting females and the exploitation of eggs. Exploitation was brought under control in 1976 when Mexican marines and biologists began protecting nesting females and their nests. In 1978, the program expanded into an international effort with the assistance of United States biologists where among other goals a secondary nesting colony was established at Padre Island National Seashore in Texas (Ross et al. 1989). Since the mid-1980s, the number of nests laid in a season has been increasing primarily due to bi-national nest protection efforts and the implementation of TED regulations for shrimp trawlers. The total annual number of nests recorded at Rancho Nuevo and adjacent camps in Mexico has exceeded 10,000 in recent years (NMFS et al. 2011).

Green

Green sea turtles are found throughout the world in tropical and subtropical waters. In United States Atlantic waters, green turtles are found around the Virgin Islands, Puerto Rico, and in the continental United States in inshore and nearshore waters from Texas to Maine. (USFWS and NMFS 1992). Historically they were exploited for their fat, meat and eggs resulting in a global population decline. Green turtles were an important source of protein for coastal dwellers, commercial exploitation from the 16th to 18th centuries decimated stocks (Mager 1985) and were fished commercially in Florida and Texas (Hildebrand 1982). Conservation efforts implemented over the decades have improved population numbers.

Hawksbill

Female hawksbills are solitary nesters with nests laid quickly and hidden under vegetation (NMFS and USFWS 1993). Therefore, the hawksbill is a difficult turtle to census by aerial surveys. They nest in small numbers on remote beaches. The largest populations are found in the Caribbean, Indian, and Indo-Pacific Oceans. The largest nesting populations occur in Australia and Solomon Islands. Because of the general lack of intensive effort needed to survey hawksbill populations, reliable estimates for the population size are available for only a few localities. Major nesting and foraging areas in the United State territories in the North Atlantic occur in Puerto Rico and US Virgin Islands. The main cause of depletion of hawksbill populations is the direct harvest (NMFS and USFWS 1993).

HABITAT AND NATURAL COMMUNITY REQUIREMENTS

Kemp's Ridleys

Kemp's ridleys nest primarily in the daytime on a beach near Rancho Nuevo in Tamaulipas, Mexico and require dry sand beaches for successful nesting. This locale is the only place in the world where large, synchronized nesting aggregations (arribadas) of the species are known to occur (TEWG 2000). Nesting has been documented along the coast of Texas (Shaver and Caillouet 1998) and occurs as a very rare event in the Carolinas and Florida (Bowen et Al. 1994).

Early life stages of hatchlings are assumed to be like other species of sea turtles where they maintain a pelagic existence drifting with ocean currents, either currents of the northern and western Gulf of Mexico or transported to the Gulf Stream of the Northwest Atlantic. The major

foraging habitat for Kemp's ridleys is the nearshore and inshore waters of the northern Gulf of Mexico as well as the Gulf of Campeche in the southern Gulf of Mexico. Kemp's ridleys are often found in salt marsh habitats. Though they do not typically nest in South Carolina, juveniles can be regularly found in South Carolina waters from April through November foraging in our salt marsh habitats and inshore waters. In recent years, the numbers of Kemp's ridley have increased significantly, indicating that the juvenile population in South Carolina's coastal waters is increasing (Duermit et al. 2017).

Green

Adult green sea turtles require dry sand beaches for successful nesting and are found in the Hawaiian Islands, Pacific Island territories, Puerto Rico, the Virgin Islands and Florida. The largest green nesting populations exist at Tortuguero (Costa Rica) and Raine Island (Australia). Nesting in Florida occurs from June through late September in almost every coastal county but is predominantly observed along the southeast coast. Nesting in Florida has been on the increase, although the annual nesting effort fluctuates from year to year. Between 2019 and 2023 green nest counts range between 26,656 to 77,040 (Florida Fish and Wildlife Conservation Commission). Nesting in significantly lower numbers occurs annually in North Carolina, South Carolina, Georgia and Texas.

Juvenile green sea turtles are herbivores but have also been found to consume small invertebrates and mollusks as well. As adults they are exclusively herbivores. Feeding grounds are relatively shallow, sheltered waters. Most commonly, these foraging habitats are pastures of seagrasses and/or algae. Hatchlings and post-hatchlings maintain a pelagic existence drifting with ocean currents. When they reach a carapace length of about 20 to 25 cm (7.9 to 9.8 in.), green turtles leave oceanic habitats and move into benthic habitats. Some feeding grounds only support certain size classes of green turtles; in South Carolina, juvenile green turtle size class ranging from 21 to 40 cm are the most common life stage found in coastal and estuarine waters of South Carolina. In recent years, the numbers of green turtle strandings have increased significantly, indicating that the juvenile population in South Carolina's coastal waters is increasing (Duermit et al. 2017) and that a fair number of juvenile greens may remain in South Carolina inshore waters over the winter.

Hawksbill

Hawksbills are a circumtropical species, preferring warm shallow water areas such as coral reefs, lagoons, shoals and bays. They are omnivorous (feeding on plants and animals) such as marine algae, sea grasses, soft corals, crustaceans and jellyfish, but sponges are the principal diet of hawksbills once they enter shallow coastal waters and begin feeding on the bottom (NMFS and USFWS 1993). The species has been recorded in the continental US from all the Gulf States and from along the eastern seaboard as far north as Massachusetts, but sightings north of Florida are rare (NMFS and USFWS 1993). Hawksbills are infrequent in South Carolina waters likely due to no coral reef habitat. No nesting of this species has occurred in South Carolina, although hybrid hawksbill/loggerhead nests were recorded in 2020, all laid by the same genetically identified female within the Cape Romain National Wildlife Refuge.

CHALLENGES

Coastal development and shoreline hardening and armoring could adversely affect nesting turtles resulting in loss or degradation of dry suitable nesting habitat. Even if a suitable sandy beach is available, nesting can be aborted because of beach furniture and equipment blocking access to nest sites. Beach vitex (*Vitex rotundifolia*), an exotic introduced plant, found historically in areas in northern Georgetown and Horry Counties. Its aggressive growth and impenetrable roots quickly cover the dunes, making them unsuitable for nesting.

Artificial light pollution along the coast is disruptive to both nesting adult females and emerging hatchlings. The presence of humans using flashlights or cell phone lights at night can also disrupt nesting females. Artificial lighting that illuminates the beach causes females to avoid certain areas to nest, misdirect females return to the ocean and disorients hatchlings when direct and timely migration to the ocean is critical to their survival. (NMFS & USFWS 1992).

Climate change is a potential threat to sea turtles as it may affect these species in three ways: (1) loss of dry sand beaches to sea level rise or inundation of existing nests (Daniels et al. 1993; Fish et al. 2005; Baker et al. 2006); (2) lethal high temperatures within the nest that would cause egg/hatchling mortality or decrease hatchling fitness; or (3) a female biased sex ratio of hatchlings due to increased nest temperatures (Glen and Mrosovsky 2004). Sea turtles, like some other reptiles, have temperature-dependent sex determination (TDSD) with higher temperatures favoring the development of female offspring and lower temperatures favoring males (Spotila 2004). Foraging grounds in the marine environment may also be affected as sea water temperatures increase. Warming waters can result in changes in the abundance and distribution of food resources, leading to shifts in migratory and or foraging ranges.

Loss or degradation of Foraging Habitat in the marine environment is another challenge. Anchors and anchor chains of cruise ships and yachts are destroying portions of the reefs, and some ships run aground, causing widespread damage (NMFS and USFWS 1993). Land-based runoff and coral bleaching events can damage coral reefs for which hawksbill rely on as a food resource. Bottom trawling can degrade live bottom habitat on the ocean floor. Sea turtles may ingest many types of marine pollution and debris which they mistake as food, resulting in gut blockage, disease and or death.

Egg clutches on beaches and emerging hatchlings are subject to native and non-native predators such as raccoons, coyotes, ghost crabs (*Ocypode quadratus*) especially in areas where nest management does not exist. Killing of adult greens is rare, but human poaching of turtle nests with clandestine markets for eggs continues to be a problem (NMFS and USFWS 1991). Sharks and other large fish predate on hatchlings and adults.

The main cause of depletion of hawksbill populations is direct harvest associated with the exploitation of eggs, meat, shell, and whole young animals that are stuffed and sold as curios to tourists (NMFS and USFWS 1993). However, the greatest challenge for this species is the continuing demand for “tortoise shell” or the carapace and plastral scutes of the animal. These are reworked to produce hairpins, broaches, fans, inlayed furniture, eyeglass frames and numerous other items (Mager 1985).

Vessel strikes continue to be a threat to sea turtles (NMFS & USFWS 1991; NMFS, USFWS &

SEMARNAT 2011). In South Carolina, greens and Kemp's ridley turtles are vulnerable to boat strikes where interaction with propellers and boat skegs lead to direct mortality and has become more prevalent over the years.

Challenges are associated with unintended captures especially larger juvenile and adult turtles from commercial fishing operations. Juvenile turtles appear to reside in the more sheltered estuarine creeks and marshes and are thus not typically exposed to the threat of incidental catch in shrimp trawlers. The shark longline fishery, which operates all year long off the south Atlantic, may impact sea turtles in the neritic environment.

Sea turtles can become entangled in a wide variety of fishing gear existing within the water column including fishing line, crab pot line, rope, onion sacks, and discarded netting. The unintended capture of sea turtles on fishing gear is an increasing challenge that can result in drowning or injuries that can lead to death or debilitation (swallowing hooks, flipper entanglement). The full scale of these unintended captures is not known as many are not reported or the carcass does not wash ashore. These types of events are typically observed with juvenile Kemp's ridleys and green sea turtles on hook and line fisheries and make up the largest cause of strandings for juvenile greens and Kemp's ridleys in South Carolina.



Cold Stunning is a condition where sea turtles become very weak and unable to swim when water temperatures fall below 50F (10C). Cold stun event regularly occurs in the northeast part of the United States (Massachusetts) from November through January with a small number of cases reported during the winter in South Carolina.

Green turtles develop lobulated tumors (fibropapilloma) on their skin, scales, scutes, eyes (including surrounding tissues), oral cavities, and viscera. The cause of this disease is unknown, but it has increased to epidemic proportions in areas as far apart as Florida and Hawaii (Balazs and Pooley 1991). Fibropapilloma was first positively confirmed on a sea turtle in South Carolina in 2014 and since then a few live captures or stranded carcasses in South Carolina have shown signs of this disease.



CONSERVATION ACCOMPLISHMENTS

Nest protection projects and an associated volunteer network were established along the South Carolina coast from 1981 to the present to monitor nesting activities and increase hatchling

productivity. Use of *Vitex rotundiflora* (Beach Vitex) has been banned in at least 12 municipalities in North and South Carolina to limit its further spread.

Kemp's ridley nesting beach protection at Rancho Nuevo has significantly increased over the past decades; there has also been an increase in the number of Kemp's ridley nests documented at Rancho Nuevo since 1985 (Márquez-M. et al. 2005). An increasing number of Kemp's ridley nests are being laid annually on the Texas coast, some of which are "head- started" turtles (Fontaine and Shaver 2005).

Green turtle nesting is increasing in Florida (Florida Fish and Wildlife Conservation Commission). Research into the cause of fibropapilloma in green turtles is progressing, and field studies have documented cases of natural remission of the disease (Hirama and Ehrhart 2002). This is encouraging since there was no known treatment or cure.

Japan ended import of hawksbill shell in 1993 and dropped its CITES reservation on sea turtles in 1994. Because Japan is the largest importer of hawksbill shells in the world, this should diminish the demand for the species (NMFS and USFWS 1993). The two most important hawksbill nesting beaches in the US Caribbean are now fully protected (NMFS and USFWS 1993).

The US ratified Optional Annex V of the MARPOL Protocol in 1987, which prohibits dumping of all plastics and fishing gear from all ships at sea (O'Hara et al. 1988).

SCDNR continues to partner with and permit the South Carolina Aquarium Sea Turtle Care Center™, which opened in 2000, to provide medical care for sea turtles in need from both South Carolina waters and surrounding states. Cases involving fibropapilloma are isolated from other turtles and tanks to ensure no spread of the disease while undergoing medical care. Removal of recreational fishing gear in a structured medical environment ensures a better outcome for turtles incidentally caught on hooks.

SCDNR Marine Turtle Conservation Program produced and installed signage on piers to educate anglers what to do in case of an incidental take of a sea turtle while recreational fishing. Signs were produced in both English and Spanish.

SCDNR Marine Turtle Conservation Program produced and installed signage at boat ramps and marinas alerting boaters to the presence of sea turtles in our inshore waters to avoid collisions. Additionally, a QR code on the sign provides access to our ArcGIS Survey 123 online form to report live healthy sea turtles observed in the water during their travels.

CONSERVATION RECOMMENDATIONS

- Ensure that live bottoms and marine algae habitats are protected from dredging and dredge spoil dumping through coordination with the US Army Corps of Engineers.
- Map the location of juvenile sea turtle foraging areas for inclusion in protected areas.
- Increase education of boaters to raise awareness of sea turtles in our coastal waters.
- Increase education of anglers both on land (piers, shore-based) and on boats regarding sea turtles in our coastal waters.

- Increase number of estuarine sample areas conducted by SCDNR's Marine Resources Division to discover new foraging areas for juvenile sea turtles.
- Monitor all known juvenile sea turtle foraging areas to document changes in habitat condition, species composition, abundance, and size classes in coordination with SCDNR's Marine Resources Division.
- Collaborate with other institutions, such as the South Carolina Aquarium and the College of Charleston, to protect juvenile sea turtles.

MEASURES OF SUCCESS

As new Recovery Plans are updated and Status Reviews are completed, we will review the needs of the species and implement research and/or management as indicated.

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