

The Charleston Deep Reef: Creating an Artificial Reef Marine Protected Area to Enhance Fisheries Resources

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Abstract.—In support of the Magnuson–Stevens Conservation and Management Reauthorization Act of 2006, which tasked regional fisheries management councils with ending overfishing of numerous marine finfish species, the South Atlantic Fisheries Management Council established 8 deepwater (90–150 m [300–500 ft]) type II marine protected areas (MPAs) along the coastline of the southeastern United States. At the request of the South Carolina Department of Natural Resources (SCDNR), one of these MPAs was established on an undeveloped sand-bottom area previously permitted by SCDNR for artificial reef development. After monitoring the production potential of unfished artificial reefs for several years on shallower experimental reef sites, SCDNR staff proposed that a deeper location had the potential to become a highly productive spawning site, particularly for deepwater grouper species. Development of this permitted site began in 2014 when two 79-m (260 ft) barges with nearly 30 m (100 ft) of added profile were deployed. Subsequent monitoring of the site through remotely operated underwater vehicle video revealed colonization by several target species, including Warsaw Grouper *Hyporthodus nigritus*, Snowy Grouper *H. niveatus*, and Misty Grouper *H. mystacinus*. Due in part to the success of this deepwater MPA, the SCDNR was also granted spawning special management zone designation for its two previously established, undisclosed experimental artificial reef sites in federal waters off South Carolina in 2017.

Introduction

The Magnuson–Stevens Fishery Conservation and Management Act, first enacted in 1976, is the primary law governing marine fisheries management in U.S. federal waters. This act established eight regional fishery management councils that are responsible for

developing fishery management plans to prevent overfishing and rebuild overfished stocks (U.S. Department of Commerce 2007). The act was strengthened with the passage of the Magnuson–Stevens Fishery Conservation and Management Reauthorization Act of 2006. This amendment added new requirements on regional councils to establish annual catch limits and accountability measures to achieve

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species-specific goals to eliminate overfishing. In 2007, to assist in meeting the management goals of these new requirements, the South Atlantic Fisheries Management Council (SAFMC) established eight deepwater type II marine protected areas (MPAs) in the Atlantic Ocean along the southeastern United States coast, specifically to protect populations and spawning sites of deepwater snapper and grouper species (Figure 1).

Designation as a type II MPA prohibits bottom fishing or the possession of snapper/grouper species while within the designated boundaries of the MPA; however, surface trolling for pelagic species such as dolphin or billfish is allowed. Most sites designated as MPAs encompassed areas of naturally occurring hard/live-bottom or rocky ledges inhabited by populations of snapper and grouper species of management interest. Consequently, the South Carolina Department of Natural Resources (SCDNR) requested that the

SAFMC designate an additional site consisting primarily of flat, featureless sand bottom as a type II MPA. This site, called the Charleston Deep Reef, was previously permitted for deepwater artificial reef development by the state. After monitoring the production potential of unfished artificial reefs for several years on shallower experimental artificial reefs, SCDNR staff believed that a deeper location had the potential to become a highly productive spawning site, particularly for deepwater snapper and grouper species of management interest. This belief was also supported by the experiences of numerous commercial fishermen over the years who have encountered large populations of grouper on newly discovered shipwrecks.

Background

South Carolina Department of Natural Resources staff began researching the potential benefits of developing artificial reefs as

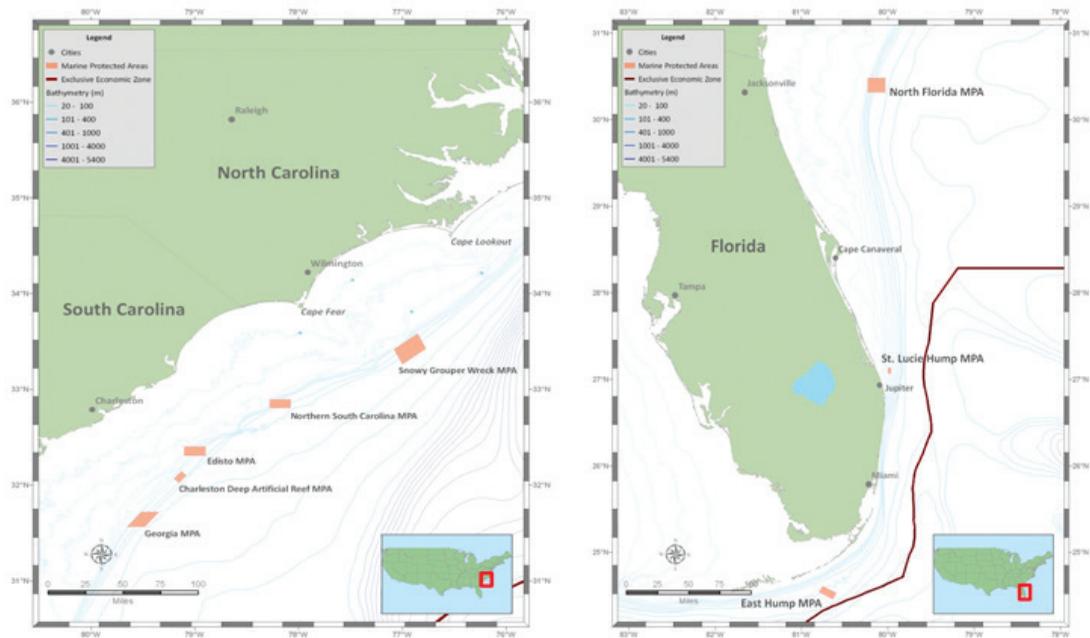


Figure 1. Deepwater marine protected areas (MPAs) established by the South Atlantic Fisheries Management Council in 2007.

marine reserves with the creation of an undisclosed research reef in 1998. The experimental artificial reef site, designated "Area 51," was initiated to investigate the feasibility of using artificial reefs as small-scale but potentially valuable MPAs. By monitoring and documenting the fish populations of an unfished artificial reef area over time and comparing their population parameters to those on regularly fished artificial reef areas of identical design, the potential value of nonexploited artificial reef MPAs as a supplement to traditional methods of utilizing artificial reefs could be evaluated. To more accurately measure the productivity potential of this newly created reef, it was necessary to eliminate unmeasured public fishing pressure on it by limiting public awareness and, consequently, public use of the site during the study period. The U.S. Army Corps of Engineers allowed SCDNR to utilize a special permitting process to bypass the standard public comment period normally required for artificial reef permitting. Several years of monitoring revealed that MPA reef sites indicated significantly higher abundances of commercially and recreationally important species (i.e., Black Sea Bass *Centropristis striata*, Gag *Mycteroperca microlepis*), recruitment of juveniles and subadults, spawning activity in several species, and minimal movement among nearby sites once populations became established (Gold 2001; Kauppert 2002).

Due in part to the results obtained from investigations at Area 51, the SAFMC provided funding in 2003 to replicate that study design in deeper water to specifically target other species of interest within the SAFMC's Snapper Grouper Management Unit. The permitting process and all reef parameters for the new site, designated "Area 53," were identical to those from Area 51 except that water depth for this site was 32 m (105 ft)

compared to 21 m (70 ft) for Area 51. In addition to dart tags used in Area 51 to track fish movement and site fidelity, acoustic tags were also implanted in numerous fish of several species on Area 53. Receiver arrays were established on all four corners of the experimental site to better monitor site fidelity on the reef over time.

Observations from Area 53 were similar to those from Area 51, indicating the total abundances of Black Sea Bass, Gag, Scamp *Mycteroperca phenax*, and Gray Triggerfish *Balistes capriscus*, were significantly greater at unfished sites. Also, spawning activity within the reef complex was observed as well as an indication of high site fidelity for some species. In addition, protected reef sites had significantly larger-sized individuals and faster growth rates for some species (Kolmos 2007). Both sites clearly demonstrated that artificial reefs could be designed, permitted, and deployed to function specifically as MPAs and that this concept could be particularly useful in increasing the reproductive potential of designated species of management concern.

While neither experimental reef site had governmental regulatory protection from fishing during the study periods, the general public was unaware of the reef sites or the ongoing research activities. Although exploitation of the areas was certainly possible, there were no indications of public discovery of the sites from normal indicators of fishing activity, as evidenced by unexpected decreases in fish abundance, lost fishing tackle, or fouled boat anchors.

The Charleston Deep Reef

Observations from the Area 51 and Area 53 research sites led SCDNR staff to conclude that much deeper artificial reefs that excluded fishing might successfully function as habitat

for large numbers of deepwater species and potentially serve as supplemental spawning locations to assist in the rebuilding of stocks deemed overfished. Additionally, there have been documented experiences of commercial fishermen harvesting large numbers of deepwater grouper species from previously undiscovered shipwrecks offshore. For example, a large shipwreck found 195 m (640 ft) deep off North Carolina was estimated to have an initial biomass of 31.3–32.9 metric tons (mt; 34.5–36.3 tons) whole weight of Snowy Grouper, with an estimated density of 11 kg/m² over the entire ship. Following its discovery by commercial fishermen, 17.2 mt (19 tons) of Snowy Grouper were harvested in approximately 3 months (Epperly and Dodrill 1995). This information suggested that there might be value in developing similar-scale artificial reefs specifically for the purpose of maintaining unexploited biomass of key species for spawning potential and stock enhancement.

From its inception, the objective of the Charleston Deep Reef was to be designated a special management zone (SMZ), and this objective was stated in the reef construction permit application to the U.S. Army Corps of Engineers. This objective was also made known to the SAFMC prior to the site selection process for the specific area to be permitted, and SAFMC staff assisted in selecting the actual deployment site. All previous bottom surveys of offshore South Carolina waters on file with SAFMC, along with those conducted by SCDNR, were reviewed to locate a suitable region devoid of hard- or live-bottom habitat. After selecting a site, side-scan sonar confirmed that substrate at the site was, in fact, flat sand bottom. The site selected was a 4 × 6 mi (6.4 × 9.7 km) region with water depths between 91 and 122 m (300–400 ft), located 83.7 km (52 mi)

off the central South Carolina coast (Figure 2). The construction permit was approved in March 2005.

The original permit application for the Charleston Deep Reef indicated that the reef construction materials would be the steel trusses of two major bridges that spanned Charleston Harbor. The Grace Memorial and Silas Pearman bridges were scheduled for demolition at this time, and the steel spans, each nearly 2 mi (3.2 km) long and more than 30.5 m (100 ft) high, were specifically recommended for offshore reef deployment in the bridge demolition study (Dial Cordy and Associates 2001).

As the time for actual bridge demolition neared, the South Carolina Department of Transportation (SCDOT) recouped as much funding as possible by selling the steel trusses for scrap metal rather than allowing their use as reef material. This left the Charleston Deep Reef project with a permitted site but no significant material with which to construct the reef. Still intending to eventually deploy on the site, SCDNR proceeded with its request to the SAFMC for MPA designation and the site was included in the SAFMC's Amendment 14 to the Snapper/Grouper Fishery Management Plan submitted to NOAA Fisheries in 2007 and established as federal regulation in 2009. South Carolina now had a legally established artificial reef MPA but no actual reef material for the site.

Attempts were made throughout subsequent years to procure a steel-hulled vessel large enough to provide significant profile at the reef site's depths. Because there was no dedicated funding for the Charleston Deep Reef project through the SCDNR, there were no available vessels within the scope of the South Carolina Marine Artificial Reef Program's budget. Around the same time frame,

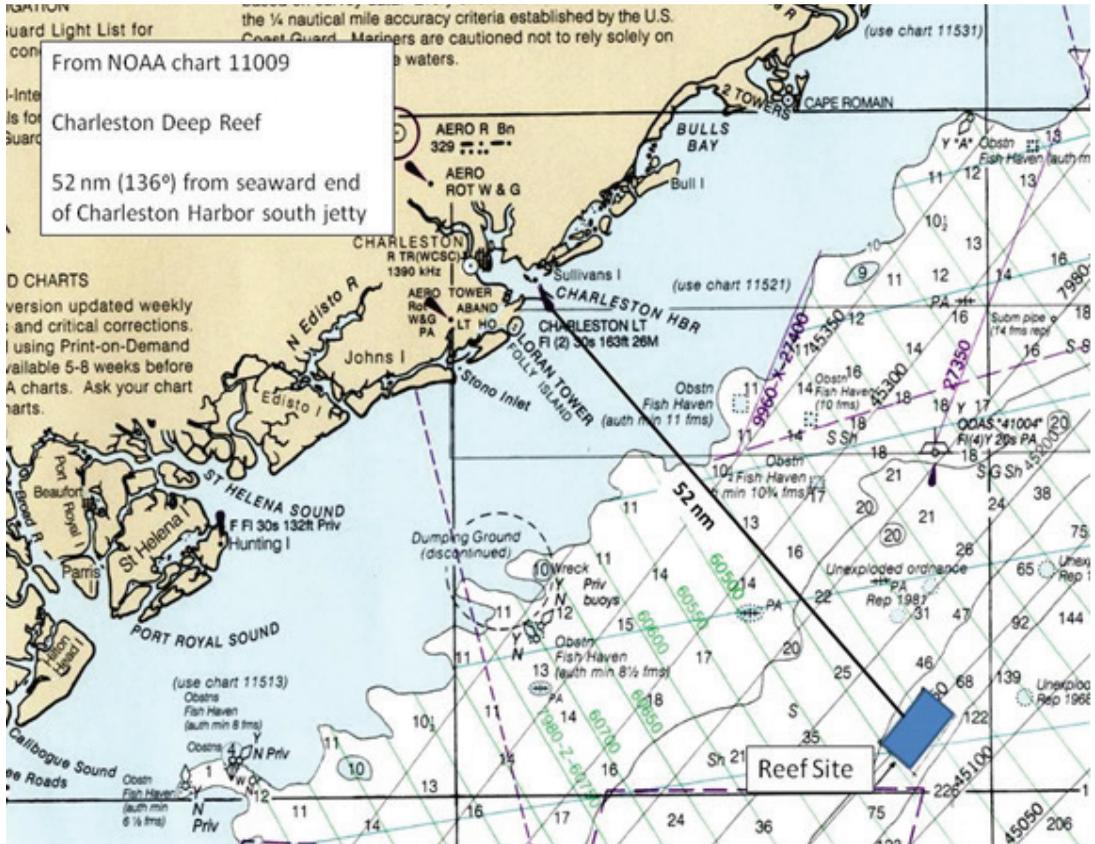


Figure 2. Location of the Charleston Deep Reef marine protected area.

a group of offshore fishermen approached SCDNR with the idea of raising funds to support a memorial reef to honor deceased offshore anglers. After numerous discussions, it was decided that the Charleston Deep Reef MPA would be an appropriate location for such a memorial. Consequently, an organization called the South Carolina Memorial Reef (www.scmemorialreef.com) was formed to raise funds to support the Charleston Deep Reef project. Donations of money and materials were received from individuals and businesses to support the project. Over several years, the South Carolina Memorial Reef conducted numerous fundraising activities that including fishing tournaments and auctions. Even with this newfound source of funding, most available larger vessels simply

remained too expensive to procure, clean, and deploy.

Eventually, a local marine transportation company offered two large but relatively low profile steel-hulled deck barges, 79 × 16 m (260 × 52 ft). These vessels were purchased and their vertical profile increased by adding various steel structures donated to the project by local individuals and businesses. Among the contributed steel structures were a derelict derrick crane, steel I-beams, 20- and 40-ft steel shipping containers, truck chassis, and radio and cell towers. Plans for the design of the modified barges were approved as per the permit requirements and all structures were welded into place, creating nearly 30.5 m (100 ft) of profile on each of the barges (Figure 3).



Figure 3. The Charleston Deep Reef barges with added profile.

The first barge was deployed on May 4, 2014 and the second 3 weeks later on May 25. One month later, June 25, 2014, the NOAA vessel R/V *Pisces*, on its first research cruise to examine each of the designated MPA areas, used multibeam sonar and remotely operated vehicle (ROV) video

to begin documentation of the newly created sites. Upon reviewing the data, it was noted that although both barges remained upright, the first barge had lost much of its added profile when it landed on the ocean bottom (Figure 4). The second barge remained intact. The only fish found on the



Figure 4. Multibeam image of barge 1 showing detached container boxes beside the upright barge.

barges at this time were amberjacks *Seriola* spp.

Two years later, June 13, 2016, a second survey of the Charleston Deep Reef was undertaken by the R/V *Pisces*. Video from one ROV dive on each of the barges revealed numerous species of interest on each, including Red Snapper *Lutjanus campechanus*, Scamp, and Yellowedge Grouper *Hyporthodus flavolimbatus* on barge 1 and Red Snapper, Scamp, Warsaw Grouper (Figure 5), Misty Grouper, Snowy Grouper, and Yellowedge Grouper on barge 2 (Table 1).

There was no indication of spawning activity during these surveys. However, colonization of the barges by multiple targeted species indicated that an artificial reef MPA

could, in fact, become inhabited and potentially utilized for reproduction just as any other naturally occurring substrate. It is anticipated that future site monitoring will continue to show increases in fish biomass with concomitant spawning activity.

Colonization on the deployed reef materials at the Charleston Deep Reef by grouper species designated as overfished, coupled with the fishing success experienced by recreational anglers trolling for pelagic and highly migratory species in the waters overhead, led all involved with the reef's creation to continue its expansion through the addition of more reef materials. The South Carolina Memorial Reef Fund and the South Carolina Governors Cup Billfishing Series provided a



Figure 5. Warsaw Grouper on the Charleston Deep Reef.

Table 1. Fish abundances of all species observed on the two barges comprising the Charleston Deep Reef marine protected area. (From Harter et. al. 2016.)

Species	Barge 1 abundance	Species	Barge 2 abundance
Anthiinae	50	Bank Sea Bass	
<i>Calamus</i> spp.	2	<i>Centropristis ocyurus</i>	2
Bank Sea Bass		Jackknife-fish <i>Equetus lanceolatus</i>	2
<i>Centropristis ocyurus</i>	3	Red Barbier <i>Baldwinella</i> (also <i>Hemanthias vivianus</i>)	350
<i>Halichoeres</i> spp.	7	Yellowedge Grouper <i>Hyporthodus flavolimbatus</i>	2
Graysby <i>Cephalopholis cruentata</i> (also <i>cruentatus</i>)	1	Misty Grouper <i>Hyporthodus mystacinus</i>	1
Reef Butterflyfish <i>Chaetodon sedentarius</i>	5	Warsaw Grouper <i>Hyporthodus nigritus</i>	5
<i>Halichoeres</i> spp.	10	Snowy Grouper <i>Hyporthodus niveatus</i>	26
Red Barbier <i>Baldwinella</i> (also <i>Hemanthias vivianus</i>)	150	Red Snapper <i>Lutjanus campechanus</i>	1
Blue Angelfish <i>Holacanthus bermudensis</i>	3	Scamp <i>Mycteroperca phenax</i>	15
Yellowedge Grouper <i>Hyporthodus flavolimbatus</i>	1	<i>Pareques</i> spp.	18
Wrasse Basslet <i>Liopropoma eukerines</i>	2	Roughtongue Bass <i>Pronotoqrammus martinicensis</i>	2
Red Snapper <i>Lutjanus campechanus</i>	6	Red Lionfish <i>Pterois volitans</i>	22
Scamp <i>Mycteroperca phenax</i>	16	Vermilion Snapper <i>Rhomboplites aurorubens</i>	30
<i>Mycteroperca</i> spp.	4	<i>Seriola</i> spp.	35
Cubby <i>Pareques umbrosus</i>	7	Saddle Bass <i>Serranus notospilus</i>	3
Bank Butterflyfish <i>Prognathodes aya</i>	1	Unknown	1
Red Lionfish <i>Pterois volitans</i>	52		
<i>Seriola</i> spp.	15		
Saddle Bass <i>Serranus notospilus</i>	3		
Unknown	1		

mechanism to initiate additional fund-raising activities if appropriate materials could be identified for the site. In late 2016, a potential source of materials was located when the SCDOT announced plans to replace a steel swing bridge over the Wando River near Charleston, South Carolina with a fixed span bridge. Discussions with the general contractor for the demolition of the bridge produced a plan to remove the entire steel truss

in one piece and place it on a barge at the bridge site. With the bridge welded into place on the barge, the entire structure, approximately 52 m (170 ft) long and 15 m (50 ft) tall, would be towed and sunk on the Charleston Deep Reef MPA site. The truss was removed in August 2017 and brought to the reef site in October (Figure 6). Underwater footage of this latest structure has not yet been obtained, but future ROV monitoring is planned.



Figure 6. A steel bridge truss welded to a deck barge deployed on the Charleston Deep Reef marine protected area.

Early indications were that the Charleston Deep Reef MPA would be successful in attracting deepwater species of management interest and that the site could be legally afforded protection through federal regulation. Consequently, SCDNR asked the SAFMC for similar protected status for its original two research reefs, Areas 51 and 53. This request was included in the council's Snapper Grouper Amendment 36, went through an extensive public review process, received final approval in March 2016, and was implemented as federal regulation in July 2017. These two research sites are now designated as spawning special management zones (SSMZs). Like the type II MPAs in deeper water, fishing for or possessing species from the Snapper Grouper Management Unit is prohibited within these areas while

trolling for other pelagic species is allowed. South Carolina is now the first state in the USA with three artificial reefs deployed and maintained exclusively for the protection and enhancement of its reef fish fisheries resources.

With the successful precedent of artificial reef deployment specifically to enhance fisheries, it is hoped that additional support can be obtained for long-term monitoring, research, and evaluation activities on these and new MPA and SSMZ reef sites. These artificial-reef-enabled MPAs and SSMZs are necessary to further explore the potential benefits from developing artificial reefs specifically for the purposes of fisheries stock enhancement and to rebuild and maintain healthy populations of reef fishes along the coast. The concept of using artificial reefs

primarily for stock enhancement and limiting or prohibiting fishing on them may seem somewhat alien to many anglers. Nevertheless, the very successful Charleston Deep Reef–South Carolina Memorial Reef partnership has resulted in a clearly beneficial situation for both fishery managers interested in conservation and rebuilding of deepwater grouper populations and blue water anglers interested in enhancing their pelagic and highly migratory fishing activities.

The ability to provide protection for artificial reef sites through the fishery management council process and federal regulation allows the biomass and spawning potential of deepwater grouper species to increase. These increases could potentially rise to the levels seen on newly discovered deep shipwrecks, such as the “snowy wreck” off North Carolina (Epperly and Dodrill 1995), and could allow a reef complex of strategically located and protected artificial reefs to serve in the rebuilding of overfished stocks of concern. To accomplish this, other states within the range of these species should also invest in and develop similar artificial reefs and seek appropriate regulatory protection for this purpose. Eventually, the development of a wider series of protected reef sites along the coast or around the nation may, in time, aid in the rebuilding of overfished stocks of many species.

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