FRESHWATER FISHERIES RESEARCH

ANNUAL PROGRESS REPORT

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January 1, 2006 – December 31, 2006

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Study Title: STATEWIDE RESEARCH

Job Title: Crayfish, Shrimp, and Copepod Identifications

Period Covered January 1, 2006 – December 31, 2006

Results and Discussion

Collections of crayfishes and shrimps from the Pee Dee Atlantic Southern Loam Plain (PDASLP) ecoregion were made at 19 of 22 sites between August and September 2006 during the stream team sampling (see report by Kubach, 2006; 3 sites did not yield any crayfishes or shrimps), and nineteen collections from regional offices and other miscellaneous collections from late 2005 and early 2006 were also examined. Species-level identifications of all these collections have been completed, except for some samples containing only form II males, females, or juveniles. Identifications of 60 collections from 2004 through 2006 were made by Dan Jones of Clemson University.

A total of 20 species of crayfishes and 2 species of shrimp have been identified so far from 98 localities (Table 1). During the PDASLP surveys, collections of the crayfish *Procambarus braswelli / chacei* were made in High Hill Creek and Back Swamp (both near Florence), which is an intermediate area from which neither *P. chacei* nor *P. braswelli* had been collected before. The taxonomic status of these two similar species is in question. A new locality, Goodland Creek in Orangeburg County, was found for *Procambarus echinatus*; although only a slight extension of the known range, it is important because the species occurs in only a few counties in southern South Carolina (Aiken, Bamberg, Barnwell, and now Orangeburg). A single specimen of the bristled river shrimp, *Macrobrachium olfersii*, was collected from the Edisto River in October 2005. This species is native to Central and South America and has been introduced into Florida, Louisiana, Mississippi,

Table 1. Crayfish and shrimp species collected during the period October 1, 2005 – September 30, 2006 (including other collections from 2004 and 2005). PDASLP stream surveys were made in August and September 2006.

Species name	Number of sites within the state	Number of sites within PDASLP	Total number of specimens	Conservation concern in SC
Procambarus acutus	8	0	66	
Procambarus ancylus	1	0	1	High
Procambarus blandingii	5	4	108	Moderate
Procambarus braswelli / *chacei*	3	2	29	Moderate / High
Procambarus clarkii	4	1	58	Invasive
Procambarus echinatus	1	0	4	Highest
Procambarus enoplosternum	1	0	9	Moderate
Procambarus hirsutus	1	0	4	Moderate
Procambarus lepidodactylus	1	1	6	High
Procambarus lunzi	3	0	33	Moderate
Procambarus pubescens	1	0	14	Moderate
Procambarus raneyi	1	0	9	
Procambarus spiculifer	15	0	94	
Procambarus troglodytes	10	3	114	
Procambarus zonangulus	1	0	1	Invasive
Procambarus spp.	17	7	29	
Cambarus asperimanus	1	0	3	
Cambarus diogenes	1	3	25	
Cambarus cf. *howardi*	1	0	1	
Cambarus latimanus	16	0	60	
Cambarus spicatus	2	0	4	High
Cambarus spp.	4	2	18	
Cambarus sp. *acuminatus* complex	18	0	115	
Palaemonetes sp[p].	4	4	21	
Macrobrachium olfersii	1	0	1	Invasive

North Carolina, and Texas (McLaughlin et al., 2005). The specimen from the Edisto River appears to represent the first record from South Carolina. Among the collections identified by Dan Jones was a form I male *Procambarus zonangulus* from Greenwood County. This is another non-native species often used in aquaculture (as is *P. clarkii*) and appears to be the first record for South Carolina. It is native to Texas, Louisiana, Mississippi, and Alabama, and has been introduced to Ohio (McLaughlin et al., 2005).

I have been assembling past records of non-native crustacean species in South Carolina, mostly from published literature, to provide a history of introductions for the state. There have been several decapods introduced for freshwater or marine aquaculture: *Cherax quadricarinatus* (Australian redclaw crayfish), *Procambarus clarkii* (red swamp crawfish), *Macrobrachium rosenbergii* (giant river prawn), *Penaeus monodon* (jumbo tiger shrimp), and *Litopenaeus vannamei* (Pacific white shrimp), several of which have escaped into the wild and survived (Smith et al., 1978; Wenner and Knott, 1992; Brummett and Alon, 1994; Eversole and Jones, 2004; McLaughlin et al., 2005). *Cambarus longirostris* has been introduced into headwaters of the Savannah River in South Carolina according to McLaughlin et al. (2005, p. 374).

I also have been examining available collections of *Procambarus clarkii* (non-native) and *P. troglodytes* (native) to look for differences that will enable the two species to be identified easily. Additional collections are being made to help determine the best characters for separating these two species. Besides the recent collections, museum specimens will be used to gather morphological data to increase the sample size.

The crayfish and shrimp collections mentioned above will be housed temporarily in collection cabinets at the Eastover Fisheries Research Lab and will be studied to learn more about the taxonomy of the various species. Eventually, most of the specimens, and especially those of greatest

significance (such as new distribution records) will be deposited in museum collections such as the North Carolina State Museum of Natural History (Raleigh) and the National Museum of Natural History (Washington, D.C.) for long-term storage. However, some specimens will be retained to form a synoptic reference collection of all species occurring in the state, both native and non-native, in order to facilitate future identifications, especially of non-native species.

Populations of striped bass in several states have been infested by a parasitic copepod, *Achtheres* (cf. *pimelodi*) in recent years (http://www.tnfish.org/Achtheres/Achtheres.htm#top). This copepod was identified on striped bass collected in the Saluda River, Lexington Co., South Carolina in August 2006. Five striped bass caught by fishermen had "moderate" infestations in the buccal cavity but otherwise appeared to be in good health. Specimens of the copepod from the Saluda River were preserved and are at the Fisheries Research Lab in Eastover.

Mussels and snails have been kept from sites within the PDASLP as well, but none of these collections have been identified yet.

Recommendations

Collecting

Continue to collect crayfishes and mollusks during ecobasin surveys and other fish surveys because valuable information about species distributions will accumulate, especially for rare and non-native ones, and the collections will provide data to allow better identifications of species.

Invasive species

The distributions of the recently-discovered invasive species, *Procambarus zonangulus* and *Macrobrachium olfersii*, should be checked immediately and measures taken to eliminate them from the locations, if possible, and to monitor success.

Specimen labeling

Request to all biologists that a specific set of data be included with each collection of crayfishes, mollusks, or other specimens in order to insure that complete data accompany each collection, which will help with curation of the collections and provide more complete data for the SCDNR database and for museum records of specimens deposited by SCDNR.

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Prepared By: William Poly Title: Aquatic Biologist

Job Title: Smallmouth Bass Stocking Assessment – Broad River and Lake Jocassee

Period Covered January 1, 2006 – December 31, 2006

Results and Discussion

Field Sampling

During fall 2005, prior to fall stocking, smallmouth bass were collected from 18 electrofishing transects in three sections of the Broad River (Table 1). Roughly 9.8 km of transects were sampled with a total electrofishing effort of 4.56 hours. Forty-eight smallmouth bass were collected, measured, weighed and aged. Otoliths of smallmouth bass from the 2002 and 2005 year-classes were reviewed for OTC marks. OTC marking of smallmouth bass was initiated in 2002 and smallmouth bass were not stocked during 2004 due to hatchery production shortages.

Catch per unit effort of all smallmouth bass was 10.5/hour (Table 2). While age-1 fish were the most abundant, even though no stocking occurred during 2004, their catch rates were low (4.6/hour). During 2003 limited numbers of smallmouth bass were stocked into the Broad River; however, we did not collect any age-2 fish. None of the otoliths from the 2002 year class fish were marked with OTC. Six of seven otoliths collected from age-0 smallmouth bass were successfully reviewed for marks. Only one of those fish was marked, indicating it was stocked during spring 2005; the other five fish were presumably wild. Based on the limited number of fish collected, smallmouth bass exhibit good growth in the Broad River.

During spring 2006 Region 1 personnel collected 107 smallmouth bass from Lake Jocassee with boat electrofishing equipment. Otoliths from those fish have not been aged or examined for OTC marks.

Marking Efficacy

During 2005 an estimated 8,200 smallmouth bass fry were stocked during spring and 2,800 smallmouth bass sub-adults were stocked during fall at four locations into the Broad River. Spring-stocked fish received a single OTC mark and fall-stocked fish received a double OTC mark at the Cheraw State Fish Hatchery prior to stocking. Fifteen fish from each of three rearing ponds for the spring and fall stockings were retained to evaluate marking efficacy. Unfortunately spring-stocked fish (single mark) were not grown-out long enough after marking to evaluate marking success. Marking efficacy of fall-stocked smallmouth bass was 100% with all 45 fish reviewed exhibiting clear double marks.

Table 1. Location of 18 Broad River transects sampled for smallmouth bass during fall 2005, by date. Sampling effort is given in both seconds of electrofishing and meters sampled.

Date	River Section	No. Transects	Latitude	Longitude	Effort (s)	Effort (m)
10/19/2005	Below 99-islands	1	35.0287	-81.4919	455	450
10/19/2005	Below 99-islands	3	35.0271	-81.4894	1156	534
10/19/2005	Below 99-islands	3	35.0253	-81.4873	2765	1230
10/20/2005	Below Gaston Shoals	3	35.1194	-81.5810	2696	1793
10/20/2005	Below Gaston Shoals	3	35.1041	-81.5754	2361	1123
11/8/2005	Below Neal Shoals	3	34.6289	-81.4180	4254	2279
11/8/2005	Below Neal Shoals	1	34.6072	-81.4180	1339	1247
11/8/2005	Below Neal Shoals	1	34.5955	-81.4208	1375	1117

Table 2. Estimated age, year class, total number collected, CPUE (N/h) and average length (mm) of smallmouth bass collected with boat electrofishing equipment from the Broad River during fall 2005.

Age	Year class	N	CPUE	TL (mm)
0	2005	7	1.54	113
1	2004	21	4.61	203
2	2003	0	0.00	
3	2002	10	2.20	322
4	2001	4	0.88	399
5	2000	4	0.88	382
6	1999	0	0.00	
7	1998	1	0.22	435
8	1997	1	0.22	416
Overall		48	10.54	324

Recommendations

A sample size of at least 80 age-1 smallmouth bass is needed to find a significant difference between survival of fry-stocked and sub-adult-stocked smallmouth bass, assuming there is a difference in survival of at least 10%. Based on 2005 catch rates of age-1 fish (4.6/hour), roughly 17 hours of electrofishing effort will be required during 2006 to collect the target sample of 80 age-1 smallmouth bass.

Prepared By: Jason Bettinger Title: Fisheries Biologist

Job Title: Seasonal Movements and Exploitation of Adult Striped Bass in the Santee Drainage

Period Covered January 1, 2006 – December 31, 2006

Results and Discussion

During April 30, adult striped bass (mean TL = 720 mm; range 663-860 mm) collected from the Congaree River were implanted with acoustic transmitters (Vemco LTD., Nova Scotia, Canada). Thirty-seven additional adult striped bass (mean TL = 765 mm; range 675-930 mm) collected from the lower Saluda River during May and on one day in June and July were implanted with acoustic transmitters. Overall tagging mortality of striped bass was low (7%). Five of 30 striped bass tagged in the Congaree River were assumed to have expired due to tagging and handling. No tagging mortality was observed in fish tagged from the Saluda River, presumably due to cool water temperatures during tagging.

Of the 62 fish successfully implanted, 10 were missing 49-180 d post implantation and 12 were harvested 4-89 d post implantation (Figure 1). Given the extensive receiver system within the Santee-Cooper system, the bulk of the missing fish are likely lost to the study (e.g., unreported harvest, mortality, or transmitter failure). Overall exploitation during the late spring and summer was 19%. Eleven fish were harvested from the Saluda River and one fish was harvested from the Congaree River. No fish have been reported as harvested since 22 August. Forty tagged striped bass are currently considered to be alive within the Santee-Cooper system.

After tagging, fifty-six percent of the fish successfully tagged in the Congaree River moved into the Saluda River between 21 April and 18 June (between 7 d and 73 d post implantation). The fish that moved into the Saluda River on 18 June first moved down into Lake Marion and then back up the Congaree and into the Saluda River. One fish was harvested from the upper Congaree River.

The other 10 fish tagged in the Congaree River moved down into the lower lakes, reaching Lake Marion between 5 and 24 d post implantation. Two of those fish moved through the lakes and Pinopolis Dam into the Cooper River within 14 and 33 d post implantation. These downstream movements following implantation may demonstrate a down-stream flight response to capture and handling.

Striped bass tagged in the Saluda River and the Congaree-tagged striped bass that moved into the lower Saluda River spent the spring and most of the summer in the Saluda River, then left the river and moved down to the lakes. Congaree River fish that moved into the Saluda River post implantation spent between 25 d and 158 d (mean = 113 d) in the Saluda River before heading for the lakes. Fish left the Saluda River between 13 July and 7 November; the median departure date was 25 September. After leaving the Saluda River striped bass spent between 0 d and 23 d (mean = 7.6 d) in the Congaree River before entering Lake Marion.

Preliminary data indicates that there is seasonal segregation of adult striped bass with roughly 50% of the fish occupying the lower Saluda River and 50 % occupying the Lakes during the late spring through early fall seasons. However, there does not appear to be annual segregation of the population or multiple spawning stocks. The lower Saluda River is an important thermal refuge for adult striped bass in the Santee-Cooper system where they are subjected to relatively high exploitation rates.

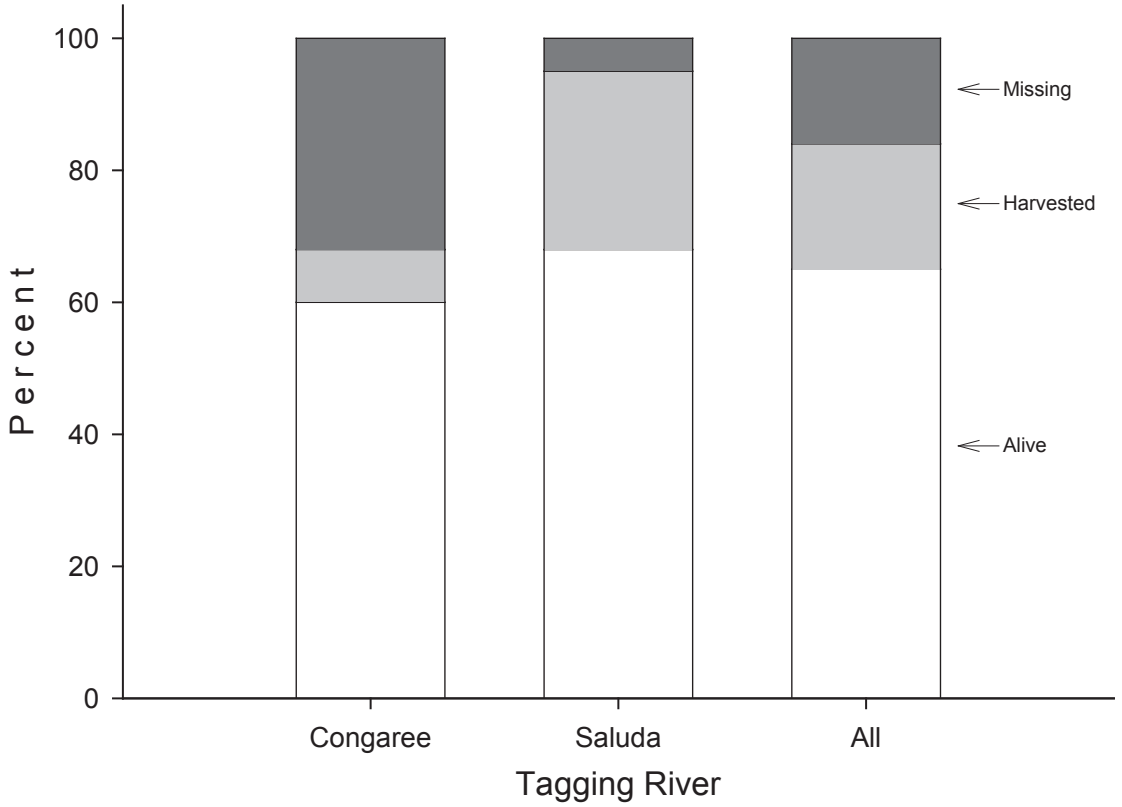

Figure 1. The fate of Congaree River and Saluda River striped bass successfully implanted with transmitters.

Recommendations

Data collection, management and analyses are ongoing and will continue through the spring of 2008. During winter 2006/2007 up to 20 additional striped bass collected from Lake Marion and/or Lake Moultrie will be implanted with transmitters, to determine the proportion of the Lake populations that utilize tributary rivers (i.e., Wateree, Congaree and Saluda).

Prepared By: Jason Bettinger Title: Fisheries Biologist

Job Title: Water Quality and Productivity Gradients in Lake Murray

Period Covered January 1, 2006 – December 31, 2006

Results and Discussion

A general limnological assessment of Lake Murray was performed in May and June, 2006. A similar survey was conducted in 2005. The objective of conducting this survey was to characterize productivity and water quality characteristics at various potential stocking locations for striped bass juveniles. The working hypothesis was that areas of relatively high productivity would be superior stocking sites.

Lake Murray was divided into an upper (8,204 hectares) and lower (9,105 hectares) zone of similar areas. Water quality samples were taken at five sites at two-meter intervals in both the upper and lower zones (Figure 1). Temperature and dissolved oxygen measurements were taken to the depth of the thermocline with a YSI model 58 meter. Incident light and measurements were taken with a Licor LI – 250A meter to the depth where light penetration was less than 1%. A 2.2 liter Van Dorn bottle was used to collect water samples from the surface to eight meters. Conductivity measurements were taken from the Van Dorn bottle using a YSI model 30 meter. A 250 ml subsample was extracted from each sample and put on ice for subsequent laboratory analysis of chlorophyll a. The remaining contents of each water sample were filtered through an 80 micron plankton net rinsed into a depth-integrated, common sample for zooplankton analysis. The zooplankton sample was preserved in a 250 ml glass sample bottle containing 4 g of sugar and .025 g of rose bengal stain.

For each site, mean temperature, dissolved oxygen and conductivity values were determined using measurements taken at the surface, two, four, six, and eight meters. From incident light data,

an exponential regression equation was calculated for each site to determine the extinction coefficient. Using the light extinction coefficient, I determined the depth of the photic zone, i.e. the depth that receives 1% of the incident light. Mean chlorophyll concentration was calculated from measurements from the surface to eight meters. If the photic zone was less than six meters, only chlorophyll measurements that were wholly or partly within the photic zone (i.e. if the photic zone extended to five meters and chlorophyll measurements were taken at four and six meters, both values would be included in the calculation) were used. To estimate the mass of chlorophyll in the photic zone per unit area of lake surface (mg/m^2), mean chlorophyll concentration (mg/m^3) was multiplied by the depth of the photic zone (m) for each site. The significance of differences between the mean values of temperature, dissolved oxygen, depth of photic zone, and chlorophyll concentration were evaluated between upper and lower lake stations using the two sample T-test for unequal variances at alpha = 0.05.

Figure 1. Limnological sampling sites for up and down lake zones of Lake Murray, SC, in 2006.

Within their respective photic zones, the upper zone of the lake had substantially different water quality and was more productive than the lower basin (Table 1). While mean temperature was slightly warmer in the upper zone, the difference was not significant. Dissolved oxygen was significantly lower in the upper zone. This statistical difference was generally due to shallower, more nutrient rich conditions in the upper zone, which caused hypoxic conditions in the hypolimnion during this time period. Mean chlorophyll concentrations within the photic zone were significantly higher in the upper zone, probably associated with higher nutrient concentrations generally observed in the upper end of reservoirs. The depth of the photic zone was significantly less in the upper lake, probably due to a combination of higher primary productivity and increased turbidity in the upper lake. The mean mass of chlorophyll in the photic zone per unit area of lake surface was 55.2 mg/m^3 and 25.0 mg/m^2 in the upper and lower lake zones, respectively. If survival of striped bass juveniles were directly correlated with productivity, this would suggest stocking 67% of the stocked fish in the upper lake and 33% in the lower lake. This suggestion assumes that predation potential is equal in each zone.

In the upper lake zone, there was a consistent decrease in the concentration and mass of chlophyll per unit area from the most upstream to the most downstream sites (Table 2); lower lake levels were very similar. This information suggested that three main chlorophyll production zones existed in 2006: a highly productive (59.8 mg chlorophyll/m^2) uplake zone of 2,578 hectares, a productive (45.2 mg chlorophyll/m^2) mid-lake region of 5,626 hectares, and a less productive (25.8 mg chlorophyll/m^2) down-lake region of 9,105 hectares (Figure 2). Calculation of chlorophyll production indicated 1542, 2543, and 2,349 kg were produced in uplake, mid-lake, and downlake zones, respectivley. If survival were directly related to total production of chlorophyll, we would stock 24, 40, and 37 percent of the fish in the uplake, mid-lake, and down-lake zones, respectively.

Table 1. Mean water quality measurements obtained from multiple sites within the upper and lower half of Lake Murray. Sampling was conducted during four separate sampling dates in May and June of 2006. Calculation methods are provided in text.

Zone	Number of sites	Temperature (C)	Dissolved Oxygen (mg/L)	Depth of photic zone (meters)	Chlorophyll (mg/m3)	Chlorophyll (mg/m2)
Lower	20	23.2	7.3	7.4	3.4	25.0
Upper	20	23.5	6.6	6.1	9.1	55.2

Table 2. Mean mass of chlorophyll within the photic zone at Lake Murray sites sampled in 2006. Sites are listed from the most upstream to the most downstream locations and are shown on Figure 1.

Site	Mean depth of photic zone (m)	Mean chlorophyll (mg/l)	Chlorophyll (mg/m2)
Upper L. Murray			
River Bend	3.6	17.7	63.3
Buffalo Gap	5.3	10.7	56.4
Hollow Creek	7.0	7.0	49.4
Rocky Point	7.0	5.9	40.9
Bear Creek	7.6	4.0	30.1
Lower L. Murray			
Turners	6.9	3.6	24.4
Hilton	6.5	3.5	22.5
Snelgroves	8.4	3.3	27.2
Susie Ebert	7.6	3.4	25.4
Pine Island	7.7	3.3	25.4

Figure 2. Map of three major productivity zones in Lake Murray, SC, 2006.

Recommendations

- Compare 2005 and 2006 study findings for completion report.
- Process 2006 zooplankton samples and incorporate this information into a completion report.
- Recommend an altered stocking strategy for 2007 and 2008 based on observed productivity gradients. If this recommendation is implemented, continue monitoring water quality during May and June, especially if either year is a high inflow year.

Prepared By: James Bulak Title: Research Coordinator – Freshwater Fisheries

Job Title: Statewide Stream Assessment – Random Site Selection Model

Period Covered January 1, 2006 – December 31, 2006

Results and Discussion

A new approach to stream assessments was implemented in 2006 to improve our ability to generate estimates of aquatic resource condition. The Stream Assessment Task Group decided to stratify the state according to unique combinations of river drainage and ecoregion, termed "ecobasins". The sampling units were watersheds of appropriate size (i.e., those that drain to wadeable streams), stratified by the 30 ecobasins in the state. The number of watersheds per ecobasin was proportional to ecobasin area. Watersheds were further stratified by stream size using three size classes of drainage area: 4-25 km^2, 26-75 km^2, 76-150 km^2. Two methods of watershed selection were employed, reference sites and randomly-selected sites. Data collection is identical in both designs, occurring at two spatial scales:

Watershed

Anthropogenic variables: point sources as measured by NPDES permits, nonpoint sources as measured by appropriate land use/land cover classes in entire basin and within riparian buffer, hydrological disruption as measured by impounded area; natural variables: climatic, geological, and topographic features;

Stream Reach

Selected measures of channel geomorphology and flow characteristics, water quality and contaminants, vertebrate and invertebrate community structure with particular interest in state priority conservation species.

The first site selection method called for establishing long-term annual monitoring sites on least-impacted, or reference, watersheds, identified by regional experts and management biologists familiar with aquatic resources within the respective ecobasins. The results of the assessments of reference streams will be reported here in the sections of the various regions. The reference approach is intended to provide expected resource condition as well as range due to temporal variability.

The second method employs a two-stage random design with a known selection probability of watersheds within ecobasin strata to allow statistically defensible estimates of statewide resource parameters from the sample data. The program will rotate the randomized sampling effort annually among ecobasins of the state to provide complete coverage every five years. The probabilistic design process involved construction of a statewide list frame of all streams meeting the size criteria outlined above, and development of a database query and user interface to randomly select watersheds and stream sites. A Geographic Information System (GIS) was developed using ESRI's ArcGIS version 9, ArcInfo software package and the Spatial Analyst extension. The Hydrology toolset within the Spatial Analyst extension was used for data preparation and stream delineation. Hydrologic GIS tools were used to create a stream layer from a statewide Digital Elevation Model. The statewide stream layer was then divided into 100 meter sections by converting the line file to points in ArcGIS using the extension "XTools" Pro version, with the downstream end of each stream section represented by a "point" with lat/long coordinates.

An Ecobasin GIS layer was prepared by intersecting a spatial layer of major river basins in South Carolina with a GIS layer containing level IV ecoregions. This divided the state into 30 ecobasins. The 100 m stream sections (points) layer was spatially joined with the ecobasins layer to assign an ecobasin to every point. The points layer was then intersected using Hawths tools to assign a total flow accumulation for each point that would represent the drainage area.

The final sample points layer was exported as a database and inserted into a database for the random selection. The table included a column of a unique ID for each sample point (FID_1). Two columns, the "From_Node" and "To_Node" columns are used in the database to identify which points are in the same stream, or network. A column called "EcoBasin" identifies which of the 30 ecobasins each point falls into. Finally, a column, "TotalArea" signifies the total area that drains into each individual point. Two columns are also added using the GIS to assign coordinate values to each point, so that these points may be replotted in the GIS after process to randomly select sample sites.

The second stage random selection takes place within the database of stream points in the state. The number of stream sections points selected for sampling per ecobasin is proportional to the area of each ecobasin. Within ecobasin, points were allocated among the three size classes of watershed as follows: 4-25 km^2 – 38%, 26-75 km^2 – 37%, 76-150 km^2 – 25%. The random site selection prodecure was created in Microsoft Access to eliminate the need for a GIS analyst to choose points in the future years. A form and script was programmed using Microsoft Visual Basic.

We also wanted to address a general problem with random site selections of streams. Because of the nature of hydrologic systems, points downstream can be dependent on selected points upstream. Two points may share much of a drainage area in common, leading to expected commonalities among variables such as water quality, habitat measures, and biotic assemblage composition. This means that data analysis may be plagued by a violation of the statistical assumption of independence of observations. Therefore, our model had to take into consideration the fact that potential sampling locations in stream may be correlated with selected upstream selected points. To address this problem, a script was written to check the delineated watershed of each point to evaluate the degree of "nestedness" with other points already selected. We determined that less than 50% of shared drainage area would preserve adequate independence among selected sites. The

"percent nested" value can be modified in the future via a dialog box on the user interface, if subsequent analysis suggests that 50% is too great/little a threshold.

Through the end of the reporting period in 2006, thirty-three randomly selected stream sites were sampled in four ecobasins: the Saluda – Sand Hills, Savannah – Sand Hills, Congaree/Lower Santee – Carolina Flatwoods, and Pee Dee – Atlantic Southern Loam Plains. The results of sampling these sites are tabulated elsewhere in this report.

Recommendations

In each of the next four years, a new selection of sites from remaining ecobasins should be made using the model described above such that all ecobasins in the state will be sampled proportionate to their area. This will allow estimates of mean conditions and their variances of all variables measured during the stream assessments for the entire state, by ecobasin, by drainage, by ecoregion, and by stream size as desired.

Prepared By: Mark Scott Title: Research Fisheries Biologist

Job Title: The Freshwater Mussels of Lake Greenwood, SC

Period Covered January 1, 2006-December 31, 2006

Results and Discussion

A total of 47 locations were searched mainly by Scuba divers including 11 water quality monitoring stations, and 36 additional locations. Seven species of Unionid mussels were located in the Lake and the tributaries examined in this study. One native snail, one invasive snail, and one invasive bivalve were also located in the lake. A description of sampling locations and catch by station is provided in Table 1. A brief description of collection highlights for unionid mussels is provided in the following paragraphs.

Table 1. Sampling locations and unionid species present in Lake Greenwood, SC.

Sampling Stations	date	Coordinates °W	Coordinates °N	Species collected	Number live	Number shells	Person hours	Catch/ Effort (live)
Water Quality Sampling Stations								
Forebay	7/27/06	34.17967	-81.91017	*Pyganodon cataracta* *Utterbackia imbecillis*	4 1	5 2	0.67	6.0 1.5
Greenwood State Park	7/27/06	34.19619	-81.94438	*Elliptio complanata* *Lampsilis radiata* *Pyganodon cataracta* *Utterbackia imbecillis*	1 3 2 3		0.83	1.2 3.6 2.4 3.6
Random Lake Site	7/27/06	34.2254	-81.9617	*Pyganodon cataracta* *Utterbackia imbecillis*	3 2	2 1	0.83	3.6 2.4
Irwin's Point	9/7/06	34.2375123	-82.0060211	*Pyganodon cataracta* *Utterbackia imbecillis*	10 1		1.0	10.0 1.0
Highway 72	7/28/06	34.27955	-82.05215	*Ligumia nasuta* *Pyganodon cataracta* *Uniomerus caroliniana* *Utterbackia imbecillis*	2 3 1 1	0 0 1 0	0.67	3.0 4.5 1.5 1.5
Hidden Lake	8/23/06	34.272564	-82.0138644	*Utterbackia imbecillis*	0	1	0.5	0
Lower Saluda	7/28/06	34.3049	-82.1067	*Pyganodon cataracta*	0	1	0.67	0
Upper Saluda	7/28/06	34.31927	-82.13328	No unionidae (but see additional search time at same location)			0.67	0
Lower Reedy	7/28/06	34.30877	-82.08523	No unionidae			0.83	0
Middle Reedy	8/24/06	34.326685	-82.0823056	No unionidae			0.5	0
Upper Reedy	8/24/06	34.34706	-82.10774	*Utterbackia imbecillis*	0	1	1.0	0

Table 1. Continued.

Sampling Stations	date	Coordinates °W	Coordinates °N	Species collected	Number live	Number shells	Person hours	Catch/ Effort (live)
Non-Water Quality Sampling stations (site description-if any)								
Greenwood State Park (Same site as WQ transect but additional effort concentrated near shore)	7/27/06	34.19619	-81.94438	*Lampsilis radiata* *Pyganodon cataracta* *Utterbackia imbecillis*	26 38 45		2.25	11.6 16.9 20.0
Forebay (Same site as WQ transect but additional effort concentrated near shore)	7/27/06	34.17967	-81.91017	*Pyganodon cataracta* *Utterbackia imbecillis*	3 3		0.33	9 9
Upper Saluda (Same site as WQ but additional effort concentrated near shore)	7/28/06	34.31927	-82.13328	*Pyganodon cataracta* *Utterbackia imbecillis*	0 3	1 0	0.75	0 4
Near SC 72	8/23/06	34.288223	-82.0304387	*Utterbackia imbecillis* *Toxolasma pullus*	5 2	0 0	1.85	2.7 1.1
Near SC 72	8/23/06	34.2891	-82.0313	*Utterbackia imbecillis*	0	1	1.0	0.0
Upstream of SC 72	8/23/06	34.291976	-82.0316269	No unionidae			1.8	0.0
Near SC 72	8/23/06	34.28318	-82.02991	*Utterbackia imbecillis*	0	1	0.5	0.0
Near SC 72	8/23/06	34.276746	-82.024444	*Utterbackia imbecillis*	0	1	1	0.0
Near SC 72	8/23/06	34.26514	-82.015183	*Pyganodon cataracta* *Utterbackia imbecillis*	1 2	7 6	2.5	0.4 0.8
Island near mouth of Reedy	8/24/06	34.349966	-82.1114547	*Utterbackia imbecillis*	1	3	1.75	0.6
Near SSR 307	8/24/06	34.35398	-82.1003	*Utterbackia imbecillis*	1	3	1.5	0.7
Near SSR 29	8/24/06	34.33082	-82.09245	*Utterbackia imbecillis*	0	1	1.25	0.0
	8/24/06	34.29086	-82.08098	*Ligumia nasuta* *Pyganodon cataracta* *Utterbackia imbecillis*	1 14 4	2 21 11	2.25	0.4 6.2 1.8

Table 1. Continued.

Sampling Stations	date	Coordinates °W	Coordinates °N	Species collected	Number live	Number shells	Person hours	Catch/ Effort (live)
	8/24/06	34.29725	-82.06162	*Ligumia nasuta* *Pyganodon cataracta* *Utterbackia imbecillis*	2 6 8	0 5 5	1.5	1.3 4.0 5.3
Mud flat near point of impoundment of Quarter Creek	8/25/06	34.27261	-82.07291	*Toxolasma pullus* *Pyganodon cataracta* *Utterbackia imbecillis*	0 2 19	1 0 5	2.0	0.0 1.0 9.5
	8/25/06	34.26064	-82.06314	*Ligumia nasuta* *Pyganodon cataracta* *Utterbackia imbecillis*	3 0 3	0 1 4	1.75	1.7 0.0 1.7
Near SSR 397	8/25/06	34.23265	-81.98612	*Lampsilis radiata* *Pyganodon cataracta* *Utterbackia imbecillis*	1 7 7	0 10 11	2.25	0.4 3.1 3.1
Near SSR 344	8/25/06	34.25808	-81.98994	*Pyganodon cataracta* *Utterbackia imbecillis*	6 5	5 6	1.0	6.0 5.0
	8/25/06	34.25616	-82.03059	*Ligumia nasuta* *Pyganodon cataracta* *Utterbackia imbecillis*	9 5 1	5 3 1	1.35	6.7 3.7 0.7
Cove of unnamed tributary near Irvin's Landing	9/7/06	34.240076	-82.02987	*Toxolasma pullus* *Pyganodon cataracta* *Utterbackia imbecillis*	1 4 9	0 0 0	3.0	0.3 1.3 3.0
Near Irvin's Landing	9/7/06	34.24022	-82.02352	*Pyganodon cataracta* *Utterbackia imbecillis*	5 4	0 0	1.5	3.3 2.7
	9/7/06	34.25307	-82.0275	*Elliptio complanata* *Lampsilis radiata* *Pyganodon cataracta* *Utterbackia imbecillis* *Uniomerus carolinianus*	0 1 15 6 1	1 0 0 0 1	2.5	0.0 0.4 6.0 2.4 0.4
Near SSR 535	9/7/06	34.22803	-82.01875	*Pyganodon cataracta* *Utterbackia imbecillis*	3 4	0 0	1.0	3.0 4.0
Near SSR 88	9/7/06	34.23058	-81.96127	*Pyganodon cataracta* *Utterbackia imbecillis*	15 3		1.5	10.0 2.0

Table 1. Continued.

Sampling Stations	date	Coordinates °W	Coordinates °N	Species collected	Number live	Number shells	Person hours	Catch/ Effort (live)
Near SSR 88	9/7/06	34.21947	-81.95196	*Pyganodon cataracta* *Utterbackia imbecillis*	5 5		1.25	4.0 4.0
	9/8/06	34.18924	-81.89732	*Pyganodon cataracta* *Utterbackia imbecillis*	6 3		1.67	3.6 1.8
	9/8/06	34.17422	-81.91335	*Pyganodon cataracta* *Utterbackia imbecillis*	12 3		2.0	6.0 1.5
Near SC 39	9/8/06	34.20912	-81.91863	*Pyganodon cataracta* *Utterbackia imbecillis*	3 2		0.67	4.5 3.0
Near SC 39	9/8/06	34.19254	-81.91746	*Pyganodon cataracta* *Utterbackia imbecillis*	3 0	4 5	1.0	3.0 0
Near SC 702	9/8/06	34.2004	-81.95827	*Lampsilis radiata* *Pyganodon cataracta* *Utterbackia imbecillis*	9 41 33		2.25	4.0 16.4 14.7
Near SC 702	9/8/06	34.19784	-81.96566	*Lampsilis radiata* *Pyganodon cataracta* *Utterbackia imbecillis*	11 12 13		2.5	4.4 4.8 5.2
Near SC 702	9/8/06	34.20107	-81.96994	*Lampsilis radiata* *Pyganodon cataracta* *Utterbackia imbecillis*	4 11 17		1.25	3.2 8.8 13.6
Near SSR 130	9/7/06	34.21598	-81.96318	*Lampsilis radiata* *Pyganodon cataracta* *Utterbackia imbecillis*	1 9 7		1.0	1.0 9.0 7.0
Near SSR 535	7/27/06	34.2375	-82.006	*Pyganodon cataracta* *Utterbackia imbecillis*	10 1		1.0	10.0 1.0
Near SSR 269	7/28/06	34.3194	-82.1328	*Utterbackia imbecillis*	2		0.83	2.4
Near SSR 269	7/28/06	34.31582	-82.12854	*Pyganodon cataracta*	1	0	1.0	1.0
Shoreline near water quality station HWY 72	7/28/06	34.2795	-82.05216	*Ligumia nasuta* *Pyganodon cataracta* *Uniomerus caroliniana* *Utterbackia imbecillis*	17 41 0 32	 4 	2.75	6.2 14.9 0 11.6

Elliptio complanata, Eastern Elliptio

This species is a large species complex widespread in the Eastern United States. Many previously described species have been synonomized under the name *Elliptio complanata* (Bogan and Alderman 2004). The potential distinctness of some of these is currently under investigation. Although members of the *Elliptio complanata* complex are commonly found in abundance in many parts of South Carolina, they were not abundant in the lake. Only a single live specimen was found during the study at the Greenwood State Park water quality site. One additional relict shell was found near the middle section of the lake (Table 1). The rarity of this species at the lake is not particularly surprising, because most *Elliptio* species are not particularly tolerant of impoundments (Lora Zimmerman, USFWS, personal communication).

Lampsilis radiata, Eastern Lampmussel

This species reaches the southern end of its distribution in South Carolina and is found along the east Coast into Canada (Nature Serve 2006). The morphology of specimens found in Lake Greenwood as well as in several other populations throughout South Carolina exhibit some morphological characteristics of both *L. radiata* and *L. splendida*, the Rayed Pink Fatmucket, which is endemic to North and South Carolina and Georgia (Nature Serve 2006). The morphological distinctness of these two species has been questioned and is currently under investigation by geneticists at North Carolina State University and the North Carolina Museum of Natural Sciences. We expect the voucher specimens collected and sent to the museum during this study to be valuable in assisting researchers to determine the taxonomic relationship between these two species. While *L. radiata* is considered to be globally stable, *L. splendida* is considered to be globally vulnerable (Nature Serve 2006). Both species are considered to be species of high conservation concern as designated in the South Carolina Comprehensive Wildlife Conservation Plan (SCDNR 2005).

Lampsilis radiata was found at the Greenwood State Park Water quality sampling station as well as seven other sites primarily concentrated around the lower section of the lake (Table 1). Typically, the species was found on sandy or silty substrates with some gravel or larger rocks present, at depths from five to 15 feet. They were found in the greatest abundance at about 10 feet in depth. Many of the *Lampsilis radiata* in the area around Greenwood State Park were gravid females actively displaying lures to attract fish, which would allow for the dispersal of their young. A wide variety of sizes of individuals were also observed, indicating that the populations are apparently healthy and reproducing despite limited distribution throughout the lake. The reason for its limited distribution within the lake is unknown, but further data analysis may suggest some reasons.

Ligumia nasuta, Eastern Pondmussel

This species ranges from the Savannah River basin in Georgia northward into the St. Lawrence River basin in Canada, and westward to Ohio, Pennsylvania, and Michigan (Bogan and Alderman 2004). Despite a moderately widespread distribution, its global status is uncertain, as it appears to be declining in many states and extirpated from several Midwestern basins due to Zebra mussel invasion (Nature Serve 2006). South Carolina considers this species to be of high conservation priority in the Comprehensive Wildlife Conservation Plan. In the Lake it was found at the water quality sampling station near Highway 72 and at four other locations relatively near this site (the middle section of the lake) (Table 1). Typically, the species was found on sandy or silty substrates with some gravel or rocks, at depths from five to 15 feet. The greatest abundances were encountered at about 10 feet. Although not widely distributed throughout the lake, multiple size classes were found, indicating a well-established population with signs of relatively recent reproduction.

Pyganodon cataracta, Eastern floater

This species is widespread along the East coast of the United States and Canada (Nature Serve 2006). It is relatively common in South Carolina in a variety of habitats, and was found in most of the locations searched at the lake including six water quality sampling stations and 27 additional sites (Table 1). The locations where this species was found, ranged widely in substrate and depths from two to greater than 20 feet in depth, (most commonly from three to 15 feet in depth) both in the open water of the lake and in coves. Its widespread distribution throughout the lake, with multiple size classes typically present, indicates a healthy, reproducing population.

Uniomerus carolinanus, Florida Pondhorn

This species is found in the Southeastern United States ranging from Virginia to Florida and west to Mississippi. It is considered globally stable and of no particular conservation status in South Carolina (Nature Serve 2006). At Lake Greenwood, it was found at the Highway 72 water quality sampling station, and at two additional sites in the vicinity of this station. As this species is typically widespread and tolerant of a range of water conditions, it is difficult to determine why this species was not more abundant or widespread in the lake.

Utterbackia imbecillis, Paper pondshell

This species is widespread throughout the Eastern and Midwestern United States (Nature Serve 2006). It is often found in impoundments and is relatively common in South Carolina. It was found throughout most of the Lake, and in many of the tributaries including seven water quality sampling sites and 35 additional locations (Table 1). The locations where this species was found, ranged widely in substrate and depths from two to greater than 20 feet in depth, (most commonly from three to 15 feet in depth) both in the open water of the lake and in coves. Its widespread

distribution throughout the lake, with multiple size classes typically present, indicates a healthy, reproducing population.

Toxolasma pullus, Savannah lilliput

This species, the smallest unionid native to South Carolina, historically ranges from the Altamaha basin in Georgia, to the Neuse River basin in North Carolina (Bogan and Alderman 2004), although it may have been extirpated from the Neuse (Bogan 2002). In recent years, it has become increasingly difficult to find in many sites of its historic range (SCDNR 2005). It is a species of federal concern as well as designated to be of highest conservation concern by South Carolina (SCDNR 2005). The global status of this species is considered somewhat uncertain ranging from imperiled to critically imperiled (Nature Serve 2006). This species was found alive at only two sites, the Cane Creek arm near the intersection of the tributary with highway 72 and a cove near Irvins landing. A relict shell was also found in a cove near the impounded point of Quarter Creek, indicating a high likely possibility that a live population still exists in the area. All of these sites shallow, muddy areas in coves fairly well protected from the wave action of activity on the lake.

Given the relatively few remaining populations of this rare species, it is not reasurring that *T. pullus* was not more abundant at any of the sites searched despite intensive effort to focus on habitats likely to harbor populations of this species. Both in Lake Greenwood and throughout its known range, *T. pullus* exhibits a preference for shallow habitats dominated by fine sandy or silty sediments. All sites where it was discovered at the Lake were less than or equal to 0.75 meters in depth. A species that inhabits only shallow water may be more severely affected by lake level draw downs such as those that take place on Lake Greenwood during the winters, although particularly sudden or deep draw downs are potentially detrimental to all freshwater mussels. Populations of *T. pullus* elsewhere in its range have been stranded on shore by rapidly declining lake levels (Tim Savidge and

Tom Dickinson, personal communication). The observation that the species was only observed in coves where tributaries connect to the lake, also supports this possibility, because the incoming water is less likely to allow the appropriate habitat for the species to dry out completely. The observation that the sites at which the species was found are all fairly well-protected from the wave action that is prevalent throughout most of the lake also suggests that this species may be intolerant of high levels of wave activity. This pattern of distribution for the species is also present in other parts of the range of *T. pullus*, where it has been found in the slower flowing sections and swampy backwater tributaries of the Savannah River and Lake Marion, suggesting that the species may have a strong preference for slow moving, shallow waters.

Other mollusks present

The presence of two invasive mollusks was noted. *Corbicula fluminea*, the Asian clam, was located at 100% of sites searched. This species is widespread throughout the Eastern United States and appears to be tolerant of a wide range of hydrologic conditions. A few studies have demonstrated a potential competitive effect of *Corbicula* on native mussels, though many others have not detected any significant interactions (reviewed in Dillon 2000).

The Asian mystery snail was first recorded in Lake Greenwood in the late 1980s and has now become widespread throughout the lake. There are numerous records of this species in North and South Carolina waters, particularly in large reservoirs. The snail was found in all parts of the lake searched except the Cane Creek arm.

One native snail, *Campeloma decisum*, the Pointed campeloma, was found at one site in the Rabon Creek arm of the Reedy River end of the lake, with coordinates 34.35398 ^{o}N and –82.1003 ^{o}W. The site contained a sandy silty substrate, with slightly turbid water. This species is common

throughout much of the eastern and Midwestern United States. It is considered globally stable, G5, and is not ranked with any particular conservation status in South Carolina (Nature Serve 2006).

Recommendations

- Conduct additional data analysis to determine the relationship between mussel distribution and water quality and habitat parameters
- Avoid actions, such as dredging or draw down, that will disturb the benthic environment in areas where rare mussels are known to occur
- Add data to Section database

Within the next six months, write a Completion Report.

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Prepared By: Jennifer Price Title: Biologist

Job Title: Randomized Stream Sampling

Period Covered January 1, 2006 – December 31, 2006

Results and Discussion

Thirty-three randomly selected stream sites from within four ecobasins—the Saluda – Sand Hills, Savannah – Sand Hills, Congaree/Lower Santee – Carolina Flatwoods, and Pee Dee – Atlantic Southern Loam Plains—were sampled for the randomized component of the Statewide Stream Assessment in 2006 (Table 1; Figure 1). Sites represented watersheds ranging from 4.1-129.7 km^2 in area. Sampling followed Statewide Stream Assessment procedures for aquatic community and habitat assessment (SCDNR 2006). Fifty-two freshwater fish species were collected altogether from the abovementioned ecobasins.

Saluda – Sand Hills

Twenty fish species were present among the three sample sites within the Saluda – Sand Hills ecobasin (Table 2). Fish species richness averaged 10.3 (range 8-14). Bluegill (*Lepomis macrochirus*) was the most abundant species on average and occurred at all three sites, followed by creek chub (*Semotilus atromaculatus*; one site), redbreast sunfish (*Lepomis auritus*; three sites), and yellowfin shiner (*Notropis lutipinnis*; two sites). Only one freshwater fish species of conservation priority (SCDNR 2005), seagreen darter (*Etheostoma thalassinum;* High Priority), was present among the sampled sites of this ecobasin (one individual at Site 216167).

Table 1. Randomly selected sample sites for the Statewide Stream Assessment in 2006, by watershed area within ecobasins. The number of sites per ecobasin is proportional to ecobasin area.

River Basin	Level-IV Ecoregion[1]	Site Number	Sample Date	Stream Name	Latitude	Longitude	Watershed Area (km^2)
Saluda	Sand Hills	207511	5/24/2006	Long Branch	33.99107	81.26844	5.29
		205370	5/30/2006	Double Branch	34.00502	81.09119	6.23
		216167	5/24/2006	Twelvemile Creek	33.94643	81.29340	59.74
Savannah	Sand Hills	346456	6/13/2006	Gantts Mill Creek	33.17216	81.45010	5.07
		289522	6/6/2006	Sand River	33.55402	81.80125	38.97
		287580	6/6/2006	Little Horse Creek	33.56462	81.87298	63.01
		309818	6/7/2006	Upper Three Runs	33.43627	81.60522	81.92
Lower Santee	Carolina Flatwoods	354455	6/22/2006	Trib. to Mechaw Creek	33.11570	79.53317	8.03
		322692	6/21/2006	Trib. to Cedar Creek	33.33989	79.62838	13.15
		316253	6/21/2006	Wee Tee Branch	33.38702	79.73762	35.03
		354133	6/20/2006	Mechaw Creek	33.13544	79.52372	80.55
Pee Dee	Atlantic S. Loam Plains	258489	8/1/2006	Home Branch	33.73895	80.31462	4.11
		89192	8/24/2006	Trib. to Martins Branch	34.58167	79.47741	4.31
		98871	9/13/2006	Trib. to Little Pee Dee R.	34.52654	79.38184	4.62
		87719	9/6/2006	Trib. to Muddy Creek	34.58005	79.69834	5.12
		142478	8/23/2006	Trib. to Little Pee Dee R.	34.30009	79.24415	5.17
		177533	8/9/2006	Cane Branch	34.13659	79.67572	5.35
		178408	8/9/2006	Trib. to Alligator Branch	34.12706	79.82150	6.52
		108484	9/7/2006	Rogers Creek Canal	34.47689	79.60016	6.55
		143880	8/15/2006	Trib. to Gully Run	34.30175	80.19142	7.03
		114174	9/13/2006	Trib. to Bear Swamp	34.44013	79.31690	8.89
		163545	8/23/2006	White Oak Creek	34.19163	79.23698	9.40
		155269	8/17/2006	High Hill Creek	34.26095	79.94437	16.78
		145731	8/16/2006	Gum Swamp	34.28217	79.52395	24.50
		132724	8/2/2006	Catfish Canal	34.35708	79.51189	26.65
		159553	8/16/2006	Trib. canal to Tobys Cr	34.22031	79.48608	30.76
		215668	8/22/2006	Mush Branch	33.94879	80.41985	32.79
		236192	8/3/2006	Nasty Branch	33.86467	80.39501	59.38
		125509	8/2/2006	Rogers Creek Canal	34.39219	79.67761	61.73
		100467	8/15/2006	Muddy Creek	34.51595	79.74564	72.09
		145650	9/27/2006	Back Swamp	34.28546	79.68657	78.56
		153122	8/8/2006	High Hill Creek	34.24792	79.76696	92.94
		231143	8/1/2006	Cane Savannah Creek	33.87917	80.41662	129.74

[1]Griffith et al. (2002)

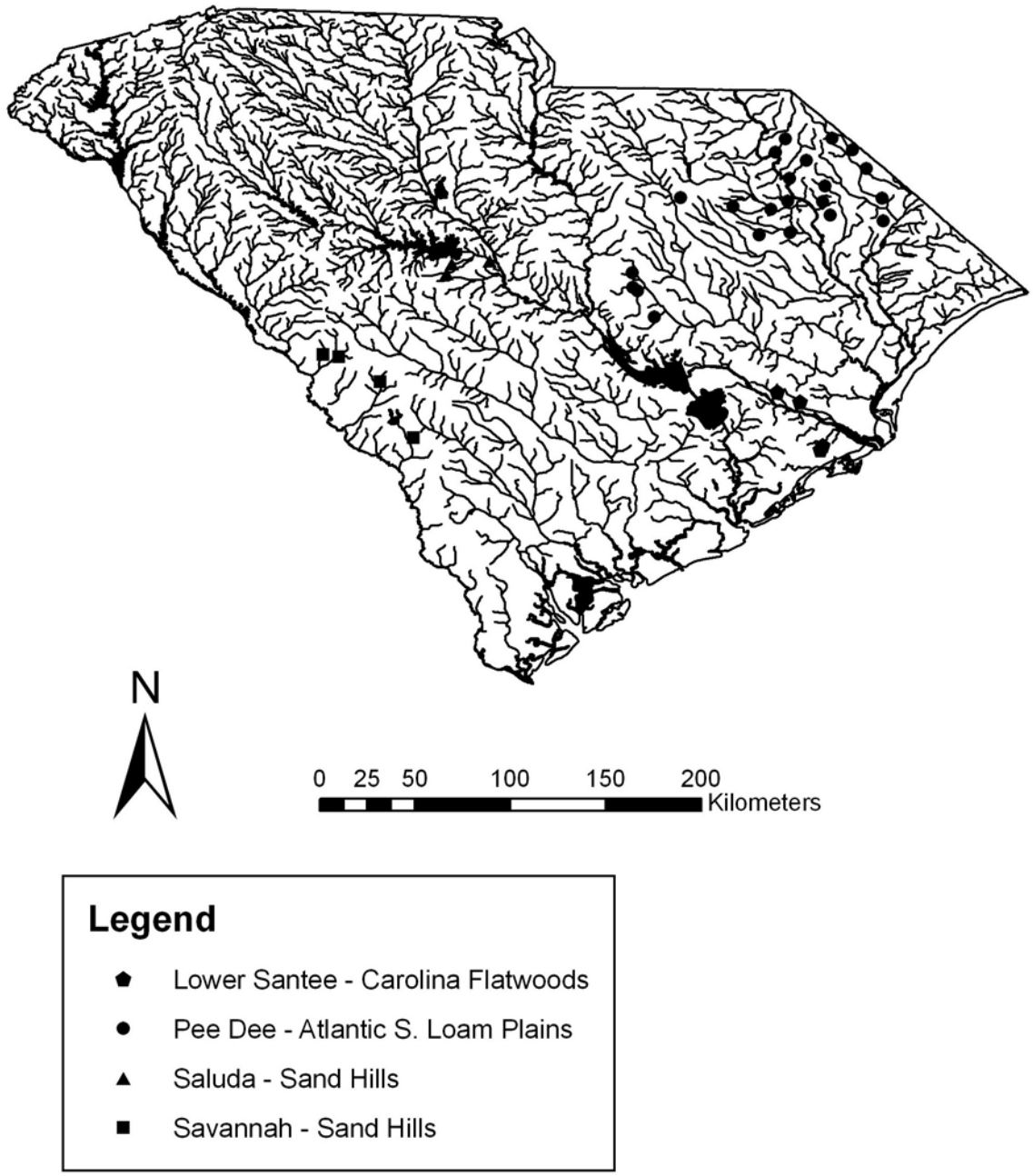

Figure 1. Randomly selected sample sites for the Statewide Stream Assessment in 2006.

Table 2. Fish species presence by site for the Saluda – Sand Hills ecobasin, 2006.

Common Name	Scientific Name	Conservation Priority	Site Number		
			216167	207511	205370
Pirate perch	*Aphredoderus sayanus*		X		
Creek chubsucker	*Erimyzon oblongus*			X	
Spotted sucker	*Minytrema melanops*		X		
Redbreast sunfish	*Lepomis auritus*		X	X	X
Pumpkinseed	*Lepomis gibbosus*			X	
Warmouth	*Lepomis gulosus*		X	X	X
Bluegill	*Lepomis macrochirus*		X	X	X
Dollar sunfish	*Lepomis marginatus*		X		
Redear sunfish	*Lepomis microlophus*		X		
Largemouth bass	*Micropterus salmoides*		X	X	
Bluehead chub	*Nocomis leptocephalus*			X	X
Yellowfin shiner	*Notropis lutipinnis*			X	X
Creek chub	*Semotilus atromaculatus*				X
Redfin pickerel	*Esox americanus*		X		
Chain pickerel	*Esox niger*		X		
Yellow bullhead	*Ameiurus natalis*				X
Margined madtom	*Noturus insignis*		X		
Swamp darter	*Etheostoma fusiforme*		X		
Seagreen darter	*Etheostoma thalassinum*	High	X		
Eastern mosquitofish	*Gambusia holbrooki*		X	X	X
Species Richness			**14**	**9**	**8**

Savannah – Sand Hills

The Savannah – Sand Hills ecobasin produced a total of 29 fish species among four sample sites (Table 3). Mean fish species richness was 14.2 and ranged from 10 to 18. Numerically dominant species were yellowfin shiner, redbreast sunfish, bluehead chub (*Nocomis leptocephalus*), and speckled madtom (*Noturus leptacanthus*). Six freshwater fish species of conservation priority occurred among the sample sites: American eel (*Anguilla rostrata*; Highest Priority), Savannah darter (*Etheostoma fricksium*; Highest Priority), blackbanded sunfish (*Enneacanthus chaetodon*; High Priority), mud sunfish (*Acantharchus pomotis*; Moderate Priority), lowland shiner (*Pteronotropis stonei*; Moderate Priority), and snail bullhead (*Ameiurus brunneus*; Moderate

Priority). Three of four sample sites harbored at least one species of conservation priority, with two of these sites additionally containing at least one Highest Priority species. Site 309818 (Upper Three Runs) yielded five conservation priority species, including the two of Highest Priority.

Table 3. Fish species presence by site for the Savannah – Sand Hills ecobasin, 2006.

			Site Number			
Common Name	**Scientific Name**	**Conservation Priority**	**287580**	**289522**	**309818**	**346456**
American eel	*Anguilla rostrata*	Highest			X	
Pirate perch	*Aphredoderus sayanus*			X	X	X
Lake chubsucker	*Erimyzon sucetta*		X			
Northern hogsucker	*Hypentelium nigricans*		X	X	X	
Spotted sucker	*Minytrema melanops*		X		X	
Mud sunfish	*Acantharchus pomotis*	Moderate		X	X	
Blackbanded sunfish	*Enneacanthus chaetodon*	High			X	
Bluespotted sunfish	*Enneacanthus gloriosus*					X
Redbreast sunfish	*Lepomis auritus*		X			X
Warmouth	*Lepomis gulosus*		X	X	X	
Bluegill	*Lepomis macrochirus*		X			
Dollar sunfish	*Lepomis marginatus*		X		X	X
Spotted sunfish	*Lepomis punctatus*					X
Largemouth bass	*Micropterus salmoides*		X			
Bluehead chub	*Nocomis leptocephalus*		X	X		
Dusky shiner	*Notropis cummingsae*					X
Yellowfin shiner	*Notropis lutipinnis*		X		X	
Lowland shiner	*Pteronotropis stonei*	Moderate			X	X
Redfin pickerel	*Esox americanus*		X	X	X	X
Lined topminnow	*Fundulus lineolatus*				X	
Snail bullhead	*Ameiurus brunneus*	Moderate				X
Yellow bullhead	*Ameiurus natalis*			X	X	
Tadpole madtom	*Noturus gyrinus*			X	X	X
Margined madtom	*Noturus insignis*		X			
Speckled madtom	*Noturus leptacanthus*		X		X	X
Savannah darter	*Etheostoma fricksium*	Highest			X	X
Tessellated darter	*Etheostoma olmstedi*				X	X
Blackbanded darter	*Percina nigrofasciata*		X	X	X	
Eastern mosquitofish	*Gambusia holbrooki*		X	X		X
Species Richness			**15**	**10**	**18**	**14**

Congaree/Lower Santee – Carolina Flatwoods

Twenty-three fish species were collected from four sites in the Congaree/Lower Santee – Carolina Flatwoods ecobasin (Table 4). Fish species richness averaged 15.7 among sampled sites, ranging from 12 to 18 (Note: one site was dry at time of attempted sample and is not included in this average). Pirate perch (*Aphredoderus sayanus*) exhibited the greatest average abundance, followed by yellow bullhead (*Ameiurus natalis*) and eastern mosquitofish (*Gambusia holbrooki*). Two species of conservation priority, American eel and mud sunfish, were both present at all three sites harboring fish.

Pee Dee – Atlantic Southern Loam Plains

The 22 sites within the Pee Dee – Atlantic Southern Loam Plains ecobasin yielded a total of 40 fish species (Table 5). Mean fish species richness was 12.0 (range 1-26). Species displaying the highest average abundance were eastern mosquitofish, pirate perch, and redfin pickerel (*Esox americanus*). Conservation priority freshwater fish species in this ecobasin were American eel (nine sites), *Moxostoma sp.* (one site), mud sunfish (14 sites), and white catfish (*Ameiurus catus*; Moderate Priority; one site). Final identification of the *Moxostoma* species is still pending, but examinations thus far suggest that it is notchlip redhorse (*M. collapsum*; Moderate Priority). Fourteen of 22 sites yielded at least one species of conservation priority.

Table 4. Fish species presence by site for the Congaree/Lower Santee – Carolina Flatwoods ecobasin, 2006.

			Site Number		
Common Name	**Scientific Name**	**Conservation Priority**	**316253**	**322692**	**354133**
Swampfish	*Chologaster cornuta*		X		
American eel	*Anguilla rostrata*	Highest	X	X	X
Pirate perch	*Aphredoderus sayanus*		X	X	X
Creek chubsucker	*Erimyzon oblongus*		X	X	X
Lake chubsucker	*Erimyzon sucetta*		X		X
Mud sunfish	*Acantharchus pomotis*	Moderate	X	X	X
Flier	*Centrarchus macropterus*		X		X
Bluespotted sunfish	*Enneacanthus gloriosus*		X	X	X
Banded sunfish	*Enneacanthus obesus*				X
Warmouth	*Lepomis gulosus*		X		
Dollar sunfish	*Lepomis marginatus*			X	X
Spotted sunfish	*Lepomis punctatus*		X		X
Golden shiner	*Notemigonus crysoleucas*			X	X
Ironcolor shiner	*Notropis chalybaeus*				X
Banded pygmy sunfish	*Elassoma zonatum*				X
Redfin pickerel	*Esox americanus*		X	X	X
Chain pickerel	*Esox niger*		X		
Yellow bullhead	*Ameiurus natalis*		X	X	X
Tadpole madtom	*Noturus gyrinus*		X		X
Swamp darter	*Etheostoma fusiforme*			X	
Sawcheek darter	*Etheostoma serrifer*		X		
Eastern mosquitofish	*Gambusia holbrooki*		X	X	X
Eastern mudminnow	*Umbra pygmaea*		X	X	X
Species Richness			**17**	**12**	**18**

Note: Site 354455 was dry at time of attempted sample and is not included in this table

Table 5. Fish species presence by site for the Pee Dee – Atlantic Southern Loam Plains ecobasin, 2006.

			Site Number																					
Common Name	**Scientific Name**	**Conservation Priority**	**87719**	**89192**	**98871**	**100467**	**108484**	**114174**	**125509**	**132724**	**142478**	**143880**	**145650**	**145731**	**153122**	**155269**	**159553**	**163545**	**177533**	**178408**	**215668**	**231143**	**236192**	**258489**
Swampfish	*Chologaster cornuta*																						X	
Bowfin	*Amia calva*													X							X			
American eel	*Anguilla rostrata*	Highest	X			X				X			X		X	X	X					X	X	
Pirate perch	*Aphredoderus sayanus*		X		X	X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
Brook silverside	*Labidesthes sicculus*												X											
Creek chubsucker	*Erimyzon oblongus*		X			X				X	X		X			X	X				X	X	X	
Lake chubsucker	*Erimyzon sucetta*									X							X			X			X	
Spotted sucker	*Minytrema melanops*												X									X		
Notchlip redhorse[1]	*Moxostoma collapsum*	Moderate											X											
Mud sunfish	*Acantharchus pomotis*	Moderate	X		X	X				X			X	X	X	X	X		X	X	X	X	X	
Flier	*Centrarchus macropterus*					X			X	X			X	X		X	X		X	X	X		X	X
Bluespotted sunfish	*Enneacanthus gloriosus*		X			X			X	X			X	X		X	X		X	X	X		X	
Banded sunfish	*Enneacanthus obesus*												X	X		X	X			X	X		X	
Redbreast sunfish	*Lepomis auritus*									X	X		X		X	X						X	X	
Pumpkinseed	*Lepomis gibbosus*		X		X					X	X		X			X	X			X				
Warmouth	*Lepomis gulosus*					X						X	X		X	X	X		X	X	X		X	X
Bluegill	*Lepomis macrochirus*									X			X		X				X		X	X	X	
Dollar sunfish	*Lepomis marginatus*		X		X	X				X	X		X	X	X	X	X				X	X	X	X
Redear sunfish	*Lepomis microlophus*									X			X			X	X	X						
Spotted sunfish	*Lepomis punctatus*					X							X		X							X	X	
Largemouth bass	*Micropterus salmoides*					X					X		X		X						X	X	X	X
Black crappie	*Pomoxis nigromaculatus*														X									

Table 5. Continued.

Common Name	Scientific Name	Conservation Priority	Site Number																					
			87719	**89192**	**98871**	**100467**	**108484**	**114174**	**125509**	**132724**	**142478**	**143880**	**145650**	**145731**	**153122**	**155269**	**159553**	**163545**	**177533**	**178408**	**215668**	**231143**	**236192**	**258489**
Golden shiner	*Notemigonus crysoleucas*									X	X	X				X	X			X	X		X	
Ironcolor shiner	*Notropis chalybaeus*										X													
Dusky shiner	*Notropis cummingsae*														X									
Banded pygmy sunfish	*Elassoma zonatum*					X			X							X				X	X			
Redfin pickerel	*Esox americanus*		X		X	X		X	X	X	X		X	X	X	X	X		X	X	X		X	X
Chain pickerel	*Esox niger*												X	X	X									
Golden topminnow	*Fundulus chrysotus*																				X			
White catfish	*Ameiurus catus*	Moderate															X							
Yellow bullhead	*Ameiurus natalis*		X			X		X		X	X			X	X	X	X	X	X				X	
Tadpole madtom	*Noturus gyrinus*					X				X			X									X	X	
Margined madtom	*Noturus insignis*																					X		
Swamp darter	*Etheostoma fusiforme*												X			X				X				
Tessellated darter	*Etheostoma olmstedi*					X							X		X							X		
Sawcheek darter	*Etheostoma serrifer*														X	X				X				
Yellow perch	*Perca flavescens*												X											
Eastern mosquitofish	*Gambusia holbrooki*		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hogchoker	*Trinectes maculatus*														X									
Eastern mudminnow	*Umbra pygmaea*		X		X	X	X		X		X	X	X	X			X	X	X	X	X			X
Species Richness			**11**	**1**	**7**	**17**	**1**	**4**	**7**	**17**	**12**	**4**	**26**	**12**	**18**	**19**	**18**	**5**	**10**	**15**	**17**	**14**	**20**	**8**

[1]Final species identification pending

Recommendations

Effective conservation of freshwater resources requires an understanding of how aquatic habitats and biological communities are affected across gradients of environmental degradation. The characterization of relationships between watershed-scale measures of anthropogenic activity and biotic and abiotic conditions at dependent stream reaches, including aquatic habitat and fish and invertebrate assemblage structure, facilitates the identification of critical thresholds in lotic ecosystem integrity. The presence and relative abundance of conservation priority species is just one example of an assemblage-level variable that may correlate with watershed land use parameters and thus represents a potential relative measure of biological integrity among study watersheds (M. Scott, SCDNR, pers. comm.). The degree to which such relationships vary across ecoregions and biotic assemblage types must be assessed if finite conservation resources are to be allocated efficiently. Such models are integral in guiding future development under an environmentally sustainable framework.

In addition to continued sampling as scheduled, the next step in the Statewide Stream Assessment is the incorporation of watershed-scale data for all sample sites in order to provide a means of assessing potential correlations between watershed and site measures. Collaboration with Geographic Information Systems (GIS) specialists in obtaining and quantifying watershed data will be necessary. Target measures include land cover/land use classifications and point- and non-point source influence measures.

The Statewide Stream Assessment was recently expanded to include documentation of aquatic and semi-aquatic crayfish, mussels, and herpetofaunal species at all sample sites. Crayfish are collected and processed at the Eastover invertebrate research laboratory (see Poly 2006 Annual Progress Report). Mussels are photographed (live specimens) or preserved (shells) and records sent

to appropriate personnel for identification. Herpetofaunal species observed at stream assessment sites are photographed or preserved if applicable and records/specimens compiled to be analyzed by appropriate authorities. These taxa represent additional biological parameters that are being incorporated into the overall assessment.

Clemson University (CU) played an integral role in enhancing the scope of the Statewide Stream Assessment by conducting additional toxicological, geomorphological, and biological analyses at the randomly selected sites and simultaneously providing field support on the sampling team in 2006. Personnel from the CU Institute of Environmental Toxicology collected water and sediment samples for analysis of the presence and concentration of metals including aluminum, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, silver, and zinc. Fish tissue was also collected from certain *Lepomis* sunfish species and analyzed using biomarkers to detect exposure to contaminants including polycyclic aromatic hydrocarbons (PAHs), dioxins, organochlorines, polychlorinated biphenyls (PCBs), metals, and endocrine disrupting compounds (EDCs) as potential correlates to urbanization. The CU Department of Forest Resources is conducting further assessment of fish assemblage – habitat relationships as well as macroinvertebrate community structure and channel geomorphology at all randomly selected sites. The project will benefit from continued collaboration with CU.

In addition to sampling annual reference stream sites, regional SCDNR Freshwater Fisheries personnel assisted with many aspects of the randomized sampling in 2006. Personnel from Regions 2 (Liz Osier, Cindy Sanders), 3 (Chris Thomason), and 4 (Jim Glenn, Scott Lamprecht) provided assistance in site reconnaissance, sampling, and/or equipment-related matters. Reciprocally, observations at random sites were useful in identifying high quality areas for recommendation to regional personnel as potential annual reference watersheds.

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South Carolina Department of Natural Resources. 2006. South Carolina Department of Natural Resources Standard Operating Procedures for Sampling Fish in Wadeable Streams. Draft Version 2006. Freshwater Fisheries Section, Columbia, SC.

Prepared By: Kevin Kubach Title: Fisheries Biologist

Job Title: Fish Assemblage Integrity Among Reedy River Tributaries

Period Covered January 1, 2006 – December 31, 2006

Results and Discussion

Twenty streams (16 Reedy River tributaries and 4 Saluda River reference tributaries) were sampled between June – July 2006 to assess fish assemblage integrity within the Reedy River watershed (Table 1; see also Kubach 2005 Annual Report). Sampling was led by Teresa Wilson (Clemson University) in 2006 as the project comprises her doctoral dissertation research. Sample sites were identical to those of 2005 with the following exceptions: the Beaverdam Creek site was relocated approximately 200 m downstream of the 2005 location due to a beaver impoundment in the original location; the Mountain Creek tributary site also could not be sampled due to beaver activity and was replaced with Burdine Creek in the Saluda River system.

Twenty-six fish species were present altogether in 2006, as compared to 37 in 2005 (Table 2). Mean species richness was 10.4 in 2006, slightly lower than the 2005 average of 12.2. The decrease in total and average fish species richness from 2005-2006 may be attributable to multiple factors, including hydrologic, habitat, and stochastic variation. Whereas the summer of 2005 was very wet by South Carolina Piedmont standards, 2006 saw a reversal to near-drought summer conditions, reducing both overall stream habitat area and habitat diversity. Furthermore, habitat quality may have changed between years as a result of anthropogenic activity. Finally, the observed variation in species richness may be a product of stochastic fluctuation in population levels.

Table 1. The 15 Reedy River and five Saluda River tributaries sampled June – July 2006, by development level within river system. Note: development values are preliminary.

Stream	Latitude (°N)	Longitude (°W)	Elevation (m)	Approximate Development Level (%)[1]
Reedy River System				
Brushy Creek	34.79914	82.39190	262	87
Richland Creek	34.85457	82.38395	269	81
Huff Creek	34.71488	82.35223	270	69
Rocky Creek	34.70389	82.29763	246	64
Laurel Creek	34.77899	82.34481	243	61
Langston Creek	34.88538	82.42379	293	57
Baldwin Creek	34.72433	82.30769	248	56
Reedy River headwater	34.94153	82.46429	300	40
Tributary to Baker Creek	34.66114	82.34817	217	29
Little Creek	34.62658	82.31021	215	25
Harrison Creek	34.66914	82.29473	228	24
Walnut Creek	34.40212	82.17350	152	23
Horse Creek	34.52373	82.26418	183	20
Beaverdam Creek (2005)	34.49901	82.23488	183	20
Martin Creek	34.58704	82.24868	203	19
Saluda River System				
Carpenter Creek	34.96404	82.57513	298	17
Gibson Creek	34.38450	82.30067	179	16
Shoal Creek	34.94024	82.57446	294	15
Burdine Creek	N/A	N/A	N/A	N/A
Broad Mouth Creek	34.49065	82.42612	222	N/A

[1]Approximate percent combined low-, medium-, and high-density non-agriculturally developed land cover

Table 2. Fish species presence by site for the Reedy and Saluda River tributaries, 2006. Data from T. Wilson (Oct. 2006 Progress Report, Clemson University)

	Reedy River Tributaries															Saluda River Tributaries				
Species	**Baker**	**Baldwin**	**Beaverdam**	**Brushy**	**Harrison**	**Horse**	**Huff**	**Langston**	**Laurel**	**Little**	**Martin**	**Reedy Headwater**	**Richland**	**Rocky**	**Walnut**	**Broad-Mouth**	**Burdine**	**Carpenter**	**Gibson**	**Shoal**
Catostomus commersoni	X	X		X	X	X	X		X	X			X	X		X	X	X		
Hypentelium nigricans	X	X	X	X	X	X	X		X	X	X			X	X	X		X		X
Scartomyzon rupiscartes					X									X			X	X		X
Lepomis auritus	X	X	X	X		X	X	X		X			X	X	X	X	X	X	X	X
Lepomis cyanellus	X	X		X	X	X		X	X	X		X	X	X	X	X			X	
Lepomis gibbosus												X				X				
Lepomis gulosus	X			X			X		X	X		X				X				
Lepomis macrochirus	X		X	X		X	X	X	X	X		X		X	X	X	X	X		X
Lepomis microlophus											X									
Micropterus coosae																X				
Micropterus salmoides	X	X		X			X	X	X	X		X	X		X	X	X			X
Clinostomus funduloides		X								X									X	
Cyprinella pyrrhomelas																		X		
Hybopsis rubrifrons																		X		
Nocomis leptocephalus	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Notemigonus crysoleucas				X								X								
Notropis hudsonius			X						X	X				X	X	X			X	
Notropis lutipinnis	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Semotilus atromaculatus		X	X	X		X	X	X	X		X		X	X	X	X	X	X	X	X
Ameiurus natalis				X				X	X		X	X	X	X						
Ameiurus platycephalus	X	X				X	X	X		X		X	X		X	X				
Noturus insignis	X		X							X					X		X	X		
Etheostoma olmstedi					X															
Etheostoma thalassinum										X	X				X			X		X
Perca flavescens							X													
Gambusia holbrooki				X			X	X	X		X				X	X				
Species Richness	**11**	**10**	**8**	**13**	**7**	**9**	**11**	**10**	**12**	**14**	**8**	**10**	**9**	**11**	**13**	**15**	**9**	**12**	**7**	**9**

Recommendations

Data analysis will be conducted by Teresa Wilson of Clemson University. Land use/land cover will be quantified for each study watershed using Geographic Information Systems (GIS) technology. Land cover within the Reedy River watershed ranges from forest to high-density urban development; of particular concern is the rapidly urbanizing Greenville metropolitan area spanning the upper watershed. Target analyses should strive to identify relationships between habitat and fish assemblage structure at the stream reach scale with watershed-level measures of anthropogenic activity such as land use type and distribution. The identification of key thresholds in land use at which biological integrity exhibits significant decline provides a means of prioritizing watersheds for conservation and preventing further degradation of aquatic resources in urbanizing areas.

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Kubach, K. 2005. Comprehensive monitoring of the aquatic community of the Reedy River watershed. Annual Progress Report, Freshwater Fisheries Research, January-December 2005. South Carolina Department of Natural Resources, Freshwater Fisheries Section, Columbia, SC.

Prepared By: Kevin Kubach Title: Fisheries Biologist

Job Title: Assessing Hybridization Among Native and Introduced Black Bass Species in the Savannah River Drainage

Period Covered January 1, 2006 – December 31, 2006

Results and Discussion

Objective 1 - Describe the geographic structure of redeye bass Micropterus coosae *throughout its range.*

We reported last year on results that indicated redeye bass populations of the Atlantic slope drainages were distinct from those of the Gulf coast. We recommended collecting individuals from the Altamaha and Ogeechee drainages to better define the genetic structure in the species. Those collections were made. The resulting dataset now includes individuals from all major drainages in the fishes range. Mitochondrial DNA analysis indicates three separate lineages – Mobile, Chatahoochee, and Savannah drainages - for redeye bass (Figure 1). The Altamaha and Ogeechee populations clustered within the Chatahoochee lineage. Interestingly, redeye bass collected from Mobile Bay and Chatahoochee drainages clustered more closely with other *Micropterus spp.* than with redeye bass outside of their drainage. This may be due to ancient hybridization within those drainages. The Savannah drainage was, as was reported previously, genetically distinct. Additionally the Savannah may represent the only drainage where the redeye bass has not experienced significant hybridization with other closely related species.

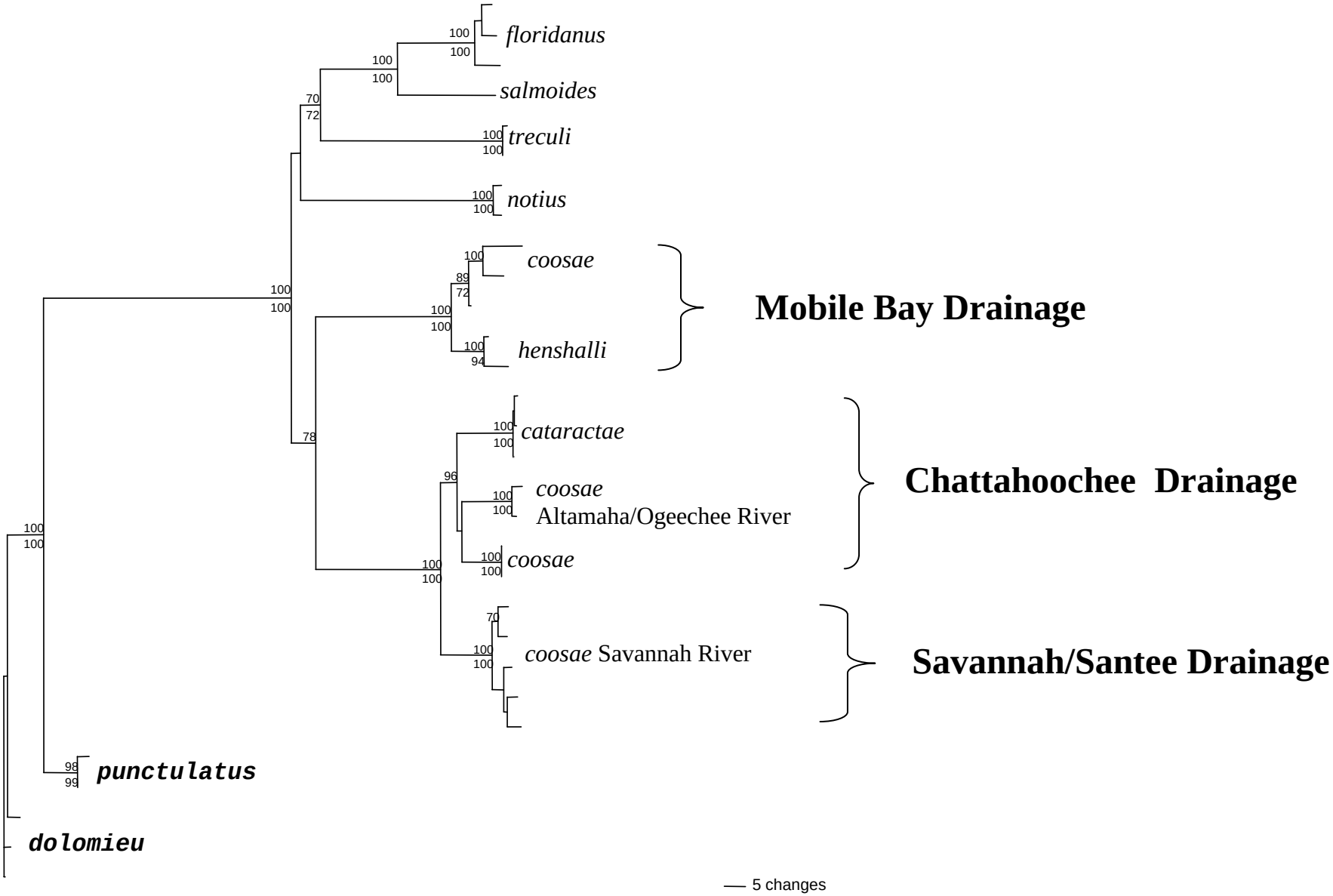

Figure 1. Phylogentic tree showing drainage level relationships among populations of redeye bass *Micropterus coosae*, and other *Micropterus spp.* surveyed.

We reported previously that the genetic distances observed between Saluda River (Santee drainage) and Savannah drainage populations are small, indicating that the Saluda River population is the result of one or more translocations from Savannah drainage streams, and not part of the fish's original range. Further analysis in the last year supports this conclusion, and indicates a more specific source for introduction. Nuclear allele frequency analysis at one locus shows the Saluda River redeye population to be more similar to fish from the Tugaloo and Seneca drainages within the upper Savannah drainage, than to populations from within the Savannah River itself (Table 1). Mixed stock analysis of the Saluda River population indicates a contribution of over 70 % from the Seneca drainage. So, evidence points to a human introduction establishing the redeye bass population in the Saluda with fish transported from the adjacent Seneca River drainage.

Table 1. Allele frequencies at the S7 Intron nuclear locus for redeye bass collected from the Tugaloo and Seneca watersheds within the Savannah drainange, from the Savannah drainage below those systems, and from the Saluda River.

Watershed/Drainage (N)	Allele Frequencies	
	'Fast' allele	'Slow' allele
Tugaloo (41)	0.66	0.34
Seneca (20)	0.88	0.12
Savannah (45)	0.40	0.60
Santee (14)	0.75	0.25

Objective 2 - Assess hybridization among redeye bass, and other Micropterus spp. *of the Savannah drainage.*

These include the native largemouth bass *M. salmoides*, and the introduced smallmouth bass *M. dolomieu* and spotted bass *M. punctulatus*.

Genetic sequencing was recently completed for a portion of the whole sample. Based on these samples, hybrids were relatively common in Lakes Keowee and Russell but they were uncommon (less than 5 percent) in lakes Hartwell and Jocassee (Figure 2). This pattern coincides

well with the pointed introductions of spotted bass in Lakes Keowee and Russell, and indicates that spotted bass have not spread significantly to the other upper Savannah reservoirs. Interestingly, all spotted bass collected in this effort have been identified as the Alabama spotted bass *M. p. henshalli*. This is contrary to previous reports that spotted bass in Lake Russell were the northern subspecies *M. p. punctulatus*. It may be that both subspecies were introduced in Russell, but *M. p. henshalli* now dominates the population. Further examination of the available data may help to answer this question.

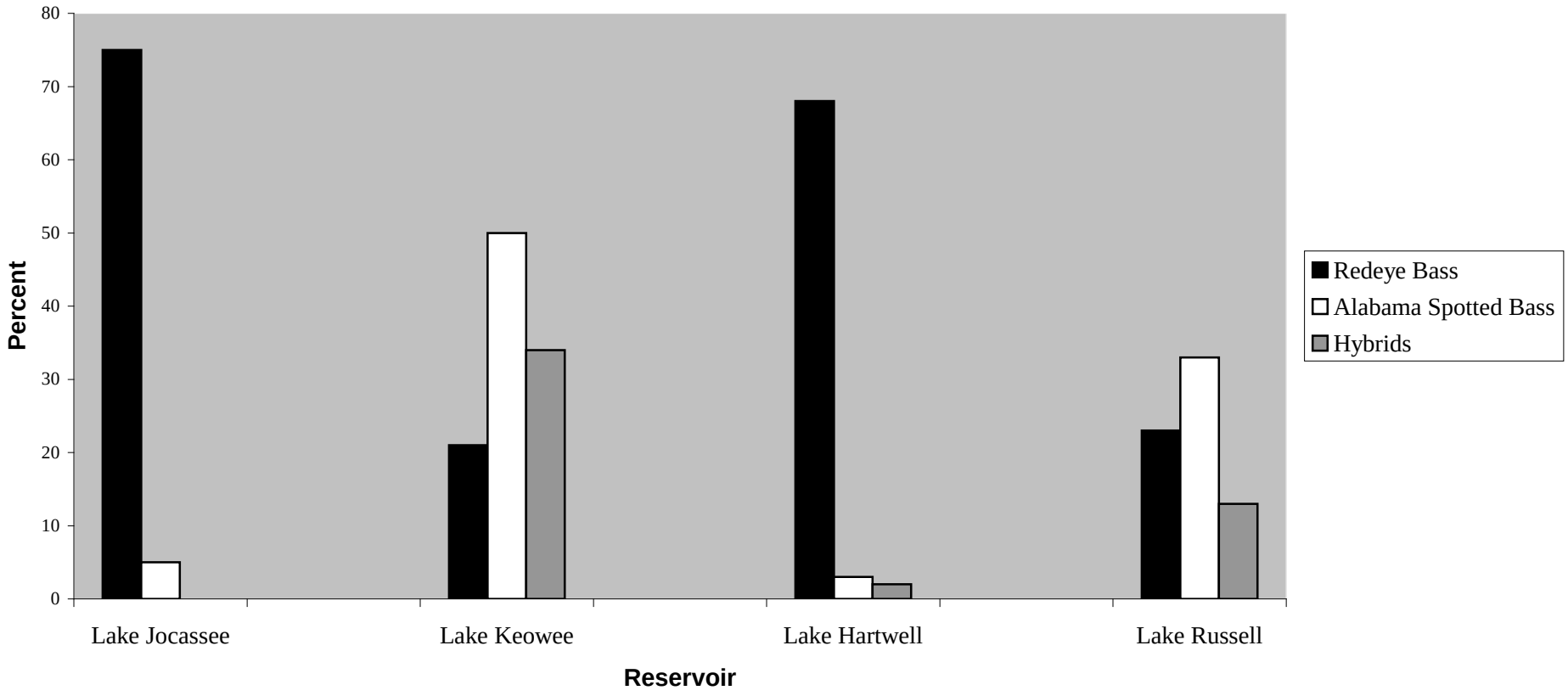

Figure 2. For redeye bass, spotted bass and hybrids, the percentage of total sample they comprise. Total sample includes largemouth bass and smallmouth bass. Percentages are reported by reservoir.

The extensive survey of tributaries to the Savannah and associated reservoirs indicated hybrid individuals in only two populations. Of 22 fish collected from the Little River population 36% were hybrids. Further examination of the data is needed to determine if hybrids were limited to the area sampled below a major fall, and thus accessible to Lake Keowee. One of four fish collected from the Toxaway River just above Lake Jocassee was a hybrid. All other stream fish collected were pure redeye bass (Table 2).

Table 2. Tributary collections and the percent of hybrid individuals in each.

Tributary	N	% Hybrid Individuals
Chatooga River	18	0
Chauga River	26	0
Horse Pasture River	5	0
Toxaway River	4	25
Little River	22	36
Eastatoe River	11	0
Big Generostee	10	0
Little coldwater Creek	12	0
Savannah River at N. Augusta	18	0
Steven's Creek	13	0

Hybridization with introduced spotted bass is a threat to the redeye bass of the Savannah drainage. This is made evident by the proportion of hybrid individuals collected from Lakes Keowee and Russell. Further analysis of the available data is needed to better assess the level of hybridization in the sampled reservoirs. It is positive that redeye populations in the tributaries sampled, and in Lakes Jocasee and Hartwell do not appear to have been dramatically impacted. There is still potential however for the further spread of spotted bass in the drainage. The continued monitoring of these populations, and their protection is warranted, especially considering the unique nature of the Savannah drainage to the redeye bass species.

Recommendations

Continue work on assessment of hybridization in the reservoirs. Data presented here is for two loci. Data exists for two additional loci, but have not been included in analysis. In addition, it is not clear what individual fish we have complete data for. Assess with USC what fish are missing and what data points are most valuable to the study. Complete a final report by May 2007.

Prepared By: Jean Leitner Title: Fisheries Biologist

Job Title: Performance Comparison of Largemouth Bass Strains in Farm Ponds

Period Covered January 1, 2006 – December 31, 2006

Results and Discussion

South Carolina is within the hybrid zone between the two recognized subspecies of largemouth bass *Micropterus salmoides.* They are the northern *M. s. salmoides* and the Florida *M. s. floridanus*. Allozyme surveys have shown that South Carolina largemouth bass populations possess a combination of alleles typical of both subspecies. Further an allelic cline exists where Florida alleles dominate the genome of those Coastal Plain populations surveyed, and the incidence of northern alleles increases as you move up a drainage. In 1994 and 1995 a group of 36 farm ponds, clustered in the Piedmont and Coastal Plain regions of South Carolina, were stocked with largemouth bass from either of two genetic stocks. One stock was produced with brood fish collected from Lake Moultrie, a coastal plain population whose genome is about 95% Florida. The other was produced with Lake Wateree brood fish, a piedmont population that is about 50% Florida. A major objective of this study is to follow the successive generations produced in these ponds, and assess whether selection in each region affects the frequencies of Florida and Northern alleles.

In 2006, we completed genetics work on juvenile largemouth bass from 19 study ponds (n=482). These fish were collected in 2005 and represent the F10 generation produced in those ponds. Chi square analysis was used to compare allele frequencies of the F10 samples with those of the original stocks. Allele frequencies were compared at each of four allozyme loci, *sAAT-2**, *sIDHP-2**, *sMDH-B**, and *sSOD-1**. Comparisons were made by stock/region.

For analysis of Moultrie stocked ponds comparisons at two of four loci did show a significant change in allele frequencies. However those changes did not show a consistent increase or decrease

in allele frequencies of either subspecies. At one locus ponds stocked in the Coastal Plain showed a significant increase in Florida alleles. Those ponds showed a significant decrease in Florida alleles at another locus, and no change at two loci. Ponds stocked in the Piedmont with Moultrie stock largemouth bass showed similar results, with a significant increase in Florida alleles at *sAAT-2** and a significant decrease at *sSOD-1** (Table 1).

Table 1. Allele frequencies for original Moultrie stock of largemouth bass and for F10 progeny collected in 2005 from Coastal and Piedmont treatments. Asterisks denote a significant (P=0.05) frequency difference of the F10 from the original stock (Chi-square test).

Stock	Locus/Allele							
	*sAAT-2**		*sIDHP-2**		*sMDH-B**		*sSOD-1**	
	100,110	126,139	100	121	100	114	100	147
Original	49	255	3	301	0	304	264	39
Coastal F10	2*	166*	3	165	0	168	132*	36*
Piedmont F10	3*	235*	2	236	0	238	171*	59*

Results for Wateree stocked ponds are interesting. For ponds stocked in the Piedmont region of the state there was significant change at two loci, though in different directions. At *sAAT-2** we saw an increase in northern alleles. At *sIDHP-2** we saw an increase in Florida alleles. Wateree stocked ponds in the Coastal Plain are the one group that exhibited a consistent change in allele frequencies. At three of four loci examined these populations had a significant increase in Florida alleles. There was no change in allele frequencies at *sAAT-2**. The increases in Florida alleles for these populations stocked in the Coastal Plain could be the result of environmental selection favoring traits typical of wild coastal plain populations (Table 2).

Table 2. Allele frequencies for original Wateree stock of largemouth bass and for F10 progeny collected in 2005 from Coastal and Piedmont treatments. Asterisks denote a significant (P=0.05) frequency difference of the F10 from the original stock (Chi-square test).

Stock	Locus/Allele							
	*sAAT-2**		*sIDHP-2**		*sMDH-B***		*sSOD-1**	
	100,110	126,139	100	121	100	114	100	147
Original	216	184	132	68	264	136	156	244
Coastal F10	153	106	74*	188*	133*	129*	126*	132*
Piedmont F10	201*	73*	152*	122*	170	104	115	155

Our original Moultrie stock largemouth bass were less diverse at the four loci examined than were our Wateree stock. Two loci, *sMDH-B** and *sIDHP-2**, were fixed or nearly fixed respectively for Florida alleles, leaving little to no opportunity for measurable change due to selection. In comparison Wateree stock largemouth bass had allele frequencies much closer to an even distribution of northern and Florida alleles. As a result, in those ponds we should have a greater capacity to detect selection acting on allele frequencies at all four loci. A trend is evident in the results for those ponds sampled in 2005. That trend suggests that selective pressures in the Coastal Plain favor individuals with a high proportion of Florida alleles. An additional set of ponds was sampled in 2004. Assessing allele frequencies in those populations, and then analysis of the entire dataset is necessary to evaluate this trend to the best of our ability.

Recommendations

In 2007 continue with lab work to determine allele frequencies for populations sampled in 2004. Add resulting data to what was presented here and repeat analysis. Complete a final report.

Prepared By: Jean Leitner Title: Fisheries Biologist