STATEWIDE RESEARCH – FRESHWATER FISHERIES

ANNUAL PROGRESS REPORT

F63

December 1, 2010

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Study Title: STATEWIDE RESEARCH – FRESHWATER FISHERIES

Job Title: An evaluation of multiple families of striped bass stocked in Lake Wateree in 2008

Period Covered July 1, 2009 – June 30, 2010

Summary

In June of 2008 striped bass fingerlings from 7 genetic families were stocked in Lake Wateree. To assess recruitment by family to age 1+, fish were collected during the Winter and Spring of 2009-2010. The population was sampled by gillnetting from December 2009 to February 2010 and 37 individuals from the 2008 year class were collected. To augment these collections, Spring electrofishing and angling were employed. Electrofishing was conducted in March in Lake Wateree and in April – May at Cedar Creek Dam above the lake. Length frequencies of aged samples from the gillnet collections were used to estimate ages of fish collected. Approximately 31 and 129 striped bass from 2008 year class were collected from these two electrofishing strategies, respectively, while angling yielded 16. All collected fish were finclipped and will be identified to family using microsatellite data already generated from parents of the 2008 year class.

Introduction

Multiple factors in the production and stocking of hatchery reared striped bass can contribute to a batch's potential for survival and eventual recruitment to a fishery. The need exist for a better understanding of how, and which, factors contribute significantly to the ultimate success of stocked fish. Ideally study designs will allow for a homogenized gene pool across treatments. The development of microsatellite markers for striped bass provides an excellent tool in that it allows the evaluation of multiple treatment batches of fish. Elimination of genetic effects on treatment groups is not possible however when treatments are identified by their genetic mark. Wang et al. (2006) found that dam and sire effects on juvenile growth and growth rate were significant in hybrid striped bass (*M. chrysops* female x *M. saxatilis* male). Results for measurement at two time intervals also suggested that selection for growth rate at an early life stage could affect growth rate at a later life stage. Thus, genetic effects on growth, and on other aspects of performance, are important to consider when evaluating effects such as time or location of stocking. In 2008, striped bass from 7 different genetic families were stocked in Lake Wateree, with a plan to assess recruitment by family to age 1+. In the last year work has focused on field collections of the 2008 year class.

Materials and Methods

Striped bass were collected by winter gillnetting from Lake Wateree. These collections are part of Region 2's annual monitoring on the lake. In addition to the routine recording of total length (tl) and collection of otoliths from each striped bass, finclips were collected and stored in 100% non-denatured ethanol for genetic analysis.

Age was estimated by one reader for all fish less than or equal to 605 mm tl. Whole otoliths were viewed using a dissecting microscope and ages assigned as 0+ - 3+. The number of 2008 year class striped bass collected was estimated.

Spring electrofishing and angling were employed to augment gillnet collections. Sampling of coves, rocky points and shoals was begun March 1. Beginning April 2 all electrofishing efforts were focused at Cedar Creek Dam, where striped bass congregate in a Spring run. Collecting trips to the dam were made approximately weekly. All fish collected by electrofishing and angling were finclipped and total length was recorded. Likely year class assignment was based on length frequencies for these collections, and those of the previously aged samples.

Selected fin clips were transferred to Marine Resources Research Institute for genetic analysis at 12 microsatellite markers.

Results

Striped bass (N=135) were collected by gillnet between December 15, 2009 and February 19, 2010. Striped bass ranged from 197 – 702 mm tl (Figure 1). Of aged samples, N=37 were assigned to the 2008 year class. These fish ranged from 412 – 501 mm tl (mean = 454.6, se = 3.6; Table 1).

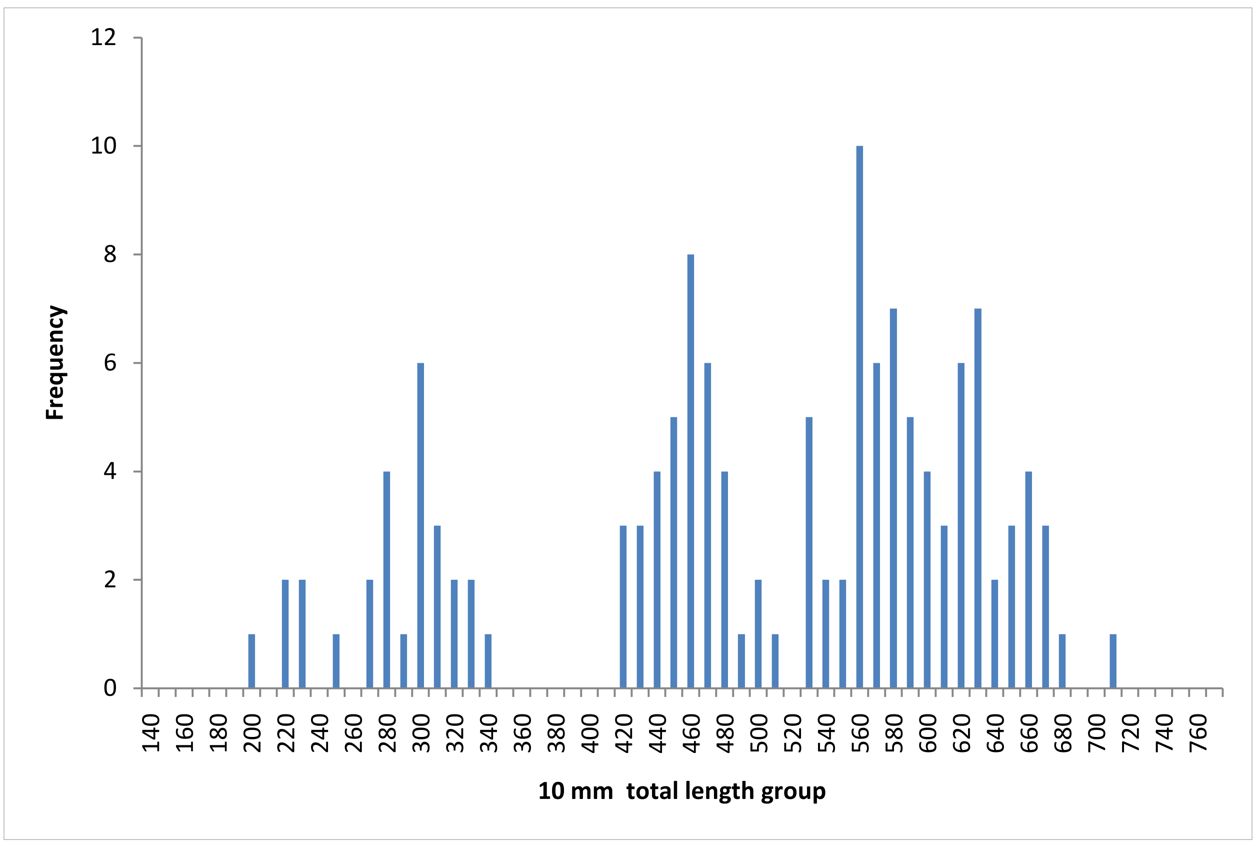

Figure 1. Length frequencies for striped bass collected by gillnetting from Lake Wateree December 2009 – February 2010.

Table 1. Mean length at estimated age for a subset of striped bass collected by gillnetting from Lake Wateree December 2009 – February 2010.

		Total length, mm		
Age	N	Mean	Range	SE
0+	27	279.7	197-333	7.1
1+	37	454.6	412-501	3.6
2+	39	562.6	522-605	3.3

Spring electrofishing of coves was largely unsuccessful with 3 striped bass collected in 5 days of effort. March 8 and 9 N=49 striped bass were collected from one concentrated area of rocky points and shoals. Subsequent trips to this area however indicated the fish had moved on. From April 2 – May 19 N=206 striped bass were collected by electrofishing from Cedar Creek Dam**.** An additional 16 striped bass were collected by anglers.

Spring collected fish (N=274) ranged from 380 - 709 mm tl (Figure 2). N=174 were selected for genetic analysis as potential members of the 2008 year class. Finclips from these fish and from 2008 year class gillnet collections (N=211 total) were transferred to Tanya Darden at Marine Resources Research Institute for analysis at 12 microsatellite markers.

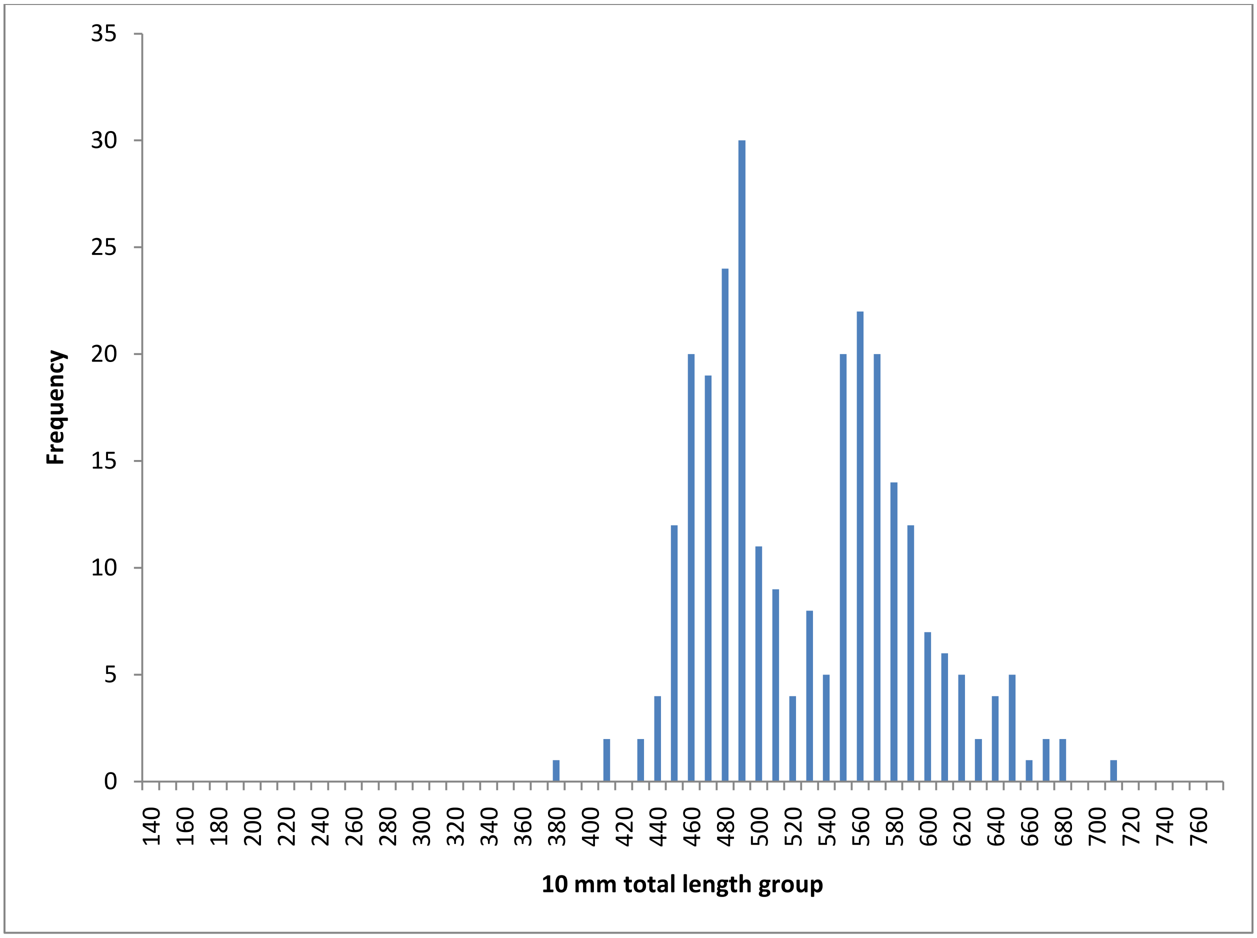

Figure 2. Length frequencies for striped bass collected by electrofishing from Lake Wateree March 8 – May 19, 2010.

Discussion

Collection of 2008 year class striped bass was successful, with N=211 potential fish from the year class sent for genetic analysis. Not all of these fish were aged, but all broodfish used in production of striped bass for stocking South Carolina waters are genotyped. There has not been a documented incidence of repeat crosses. This will allow verification of year class for all fish genotyped for this effort.

While the target number of striped bass was reached in collections, it is disappointing all fish were not collected from the lake prior to Spring movement up to Cedar Creek Dam. It was anticipated from previous years collections that all fish would be collected by Winter gillnetting, before segregation of the population. This would have ensured a sample more representative of the year class, as not all fish will make the run at age 1+, and those that do are predominantly males. Method and time of capture will be considered in analysis of our resulting dataset.

Recommendations

Complete genetic analysis and assign parentage to all fish collected from the 2008 year class. In consult with statistician, evaluate returns by family and individual cross. Depending on returns by family, evaluate samples taken at stocking to assess recruitment of each cross.

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Prepared By: Jean Leitner Title: Fisheries Biologist

Job Title: Assessing introgressive hybridization within and habitat requirements of native South Carolina redeye bass

Period Covered October 1, 2009 – September 30, 2010

Summary

In 2003-2004 black bass were collected from stream and reservoir populations in the Savannah drainage, to assess presence of non-native species and hybridization with native redeye bass *Micropterus coosae*. To assess change in these populations over time, repeat collections were completed. Black bass N=998 were collected from four Savannah reservoirs; Lakes Russell, Hartwell, Keowee and Jocassee. An additional N=185 black bass were collected from 11 stream sites. To streamline genetic analysis of these and future collections, considerable effort went into development of new genetic assays at 3 nuclear DNA loci. This proved unsuccessful however, and work is proceeding on sequencing of all fish collected. Other efforts included presentation of this and related work at the Black Bass Symposium held at the 2009 annual meeting of the American Fisheries Society, and participation in the development of a new funding initiative for National Fish and Wildlife Association directed at conservation of native black bass of the South Eastern United States. Redeye bass of Savannah drainage were selected as one of three keystone species of this initiative.

Introduction

The redeye bass *Micropterus coosae* (Hubbs and Bailey 1940) is one of two black bass native to South Carolina, and has been identified by South Carolina's Comprehensive Wildlife Conservation Strategy as a Species of Highest Priority due its restricted range and threats from introduced species (Kohlsaat et al. 2005). The species' native range is restricted compared to others of its genus and includes the Savannah, Altamaha and Ogeechee River drainages on the

Atlantic slope, and the Mobile Bay and Apalachicola drainages on the Gulf slope. Redeye bass occupy habitats above the Fall Line in fast moving, cool-water streams (Rhode et al. 2009). In addition to native headwater streams and tributaries, *M. coosae* has thrived within four of the Savannah River basin's man-made reservoirs; Jocassee, Keowee, Hartwell and Russell (Koppelman and Garret 2002).

Recent studies have examined the relationship among populations of redeye bass across the range of the species. Mobile Bay drainage redeye bass are morphologically distinct from Atlantic Slope populations, with the common name Bartram's bass assigned to the latter (Bud Freeman, unpublished data). DNA sequence data supports this distinction, and further suggests species-level divergence between Savannah River redeye bass and those of other Atlantic Slope drainages. Savannah River redeye bass represent a highly divergent and distinct evolutionary lineage (Oswald 2007).

Introductions of the non-native Alabama spotted bass (*Micropterus punctulatus henshalli*) into lakes Keowee and Russell have put Savannah River redeye bass at risk due to introgessive hybridization (Barwick et al. 2006). A 2004 genetic survey showed that Alabama spotted bass have expanded within the drainage, as have their hybrids with redeye bass (Oswald 2007). Both are present in all four lakes surveyed. While the survey of tributaries of the drainage showed that those redeye populations were for the most part still unimpacted by hybridization, spotted bass are known to take advantage of stream habitats, and the continued spread of Alabama spotted bass and their hybrids throughout the drainage is a possibility.

Objectives of this study include repeat sampling of redeye bass populations surveyed in 2004, and an assessment of genetic change over time. Work in the last year has focused on completion of field collections, development of new genetic assays, and sequencing of collected samples.

Materials and Methods

Reservoir sites for 2010 black bass collections were selected based on 2004 collection sites where sufficient data exists for a meaningful comparison of species composition (Joseph Quattro, unpublished data). Black bass were collected from Lakes Russell, Hartwell, Keowee, and Jocassee by shoreline electrofishing. Samples were also taken from routine gillnet collections on Lake Jocassee. For all fish collected, field identification, total length and weight were recorded. Fin clips were taken and stored in 100% non-denatured ethanol for genetic analysis. All fish collected by electrofishing were also photographed.

Stream collections were made to complete repeat sampling of 2004 survey locations that was begun in 2009. Streams were sampled by a combination of angling and backpack electrofishing. For all fish collected, field identification, total length and weight were recorded. Fish were photographed, and fin clips were taken and stored in 100% non-denatured ethanol for genetic analysis.

Work continued on the development of new genetic assays. Previously, assays for the mitochondrial DNA (mtDNA) locus ND2 were successfully developed using the program Web-based Allele-Specific Primers (WASP) by Pongsakorn et al. (2007). Following the same methods, assay development proceeded for three nuclear DNA loci, Calmodulin, ITS and Actin. For each locus, primers were sought for haplotypes specific for the five species of black bass present or having genetic influence in South Carolina; largemouth bass, Florida bass, Alabama bass, redeye bass, and smallmouth bass. Genetic sequencing was also begun for 2010 reservoir collections.

Results

Eighteen sites on Lakes Russell, Hartwell, Keowee and Jocassee were selected for 2010 black bass collections. Electofishing was conducted from April 19 – May 24, 2010, and N=998 black bass were collected and processed (Table 1). All finclips were stored pending genetic analysis.

Table 1. Field identifications of black bass collected from Lakes Russel, Harwell, Keowee and Jocassee in 2010; redeye bass (REB), largemouth bass (LMB), Alabama spotted bass (ASB), smallmouth bass (SMB), hybrid (HYB).

		Species (N)				
Reservoir	Period Sampled	REB	LMB*	ASB	SMB	HYB
Lake Russel	4/19 – 4/21/2010	9	119	76	0	46
Lake Hartwell	4/22 – 5/24/2010	121	114	47	0	55
Lake Keowee	5/4 – 5/5/2010	4	62	147	17	38
Lake Jocassee	5/11 – 5/13/2010	61	20	3	23	36

*Both largemouth bass and Florida largemouth bass have genetic influence in South Carolina. These two species are not separated in reported field identifications.

Stream collections were made in the last year at 3 stream sites in the Savannah drainage, Chatooga River, Savannah River at Augusta Shoals, and Little Cold Water Creek. Together with collections from 2009 this completes the re-sampling of 2004 stream sites (Table 2). Field identification of stream samples indicated the presence of non-native species at three of the sites sampled. All stream samples were stored pending genetic analysis.

Table 2. Field identifications of black bass collected from Savannah and Santee (Saluda River at Pelzer) Drainage streams in 2009 and 2010; redeye bass (REB), largemouth bass (LMB), Alabama spotted bass (ASB), smallmouth bass (SMB), hybrid (HYB).

		Species (N)				
Stream	Date	REB	LMB*	ASB	SMB	HYB
Steven's Creek	7/29/09	15	6	0	0	0
Big Generostee Creek	7/30/09	16	0	0	0	0
Saluda River	9/9/09	18	9	0	0	0
Eastatoee Creek	9/24/09	9	0	0	0	0
Chauga River -lower	9/14/09 & 9/29/09	14	6	0	0	0
Chauga River - upper	9/29/09	14	0	0	0	0
Little River - lower	9/30/09	0	0	0	0	0
Little River - upper	9/30/09	4	0	2	0	1
Chatooga River	8/4/10	18	0	0	0	0
Little Coldwater Creek	9/1/10	20	3	2	0	0
Savannah River	9/16/10	17	4	0	4	4

*Both largemouth bass and Florida largemouth bass have genetic influence in South Carolina. These two species are not separated in reported field identifications.

Development of new assays for nuclear DNA loci was not successful. Loci either were not polymorphic enough for the design of assays that would quantify the contribution of genes from all five species in question, or allelic diversity within and among species gave complicated and confusing banding patterns on agarose gels. It was determined the best course of action was to abandon the use of new genetic assays and move forward with DNA sequencing.

Sequences for N = 653 black bass collected in 2010 were generated and added to our database. These include individuals from Lakes Russell, Hartwell, Keowee, and Jocassee. Of these 653 individuals, over half have been characterized for all four loci, mtDNA locus ND2 and nuclear loci Calmodulin, ITS, and Actin. The rest have been characterized for 1-3 loci.

Work from this and related efforts was invited for presentation at the Southeastern Endemic Black Bass symposium held at the October 2009 annual meeting of the American Fisheries Society in Nashville, Tennessee. Three presentations were made. Stemming from participation in this symposium, our investigators were invited to assist in development of a new funding initiative proposal for National Fish and Wildlife Foundation (NFWF), targeting native black bass. During proposal development, redeye bass of the Savannah drainage were chosen as a keystone species for the initiative. A Business Plan for the Conservation of Native Black Bass Species in the Southeastern U.S. (Birdsong et al. 2010) was completed and was accepted by the NFWF board in March 2010.

Discussion

Alabama spotted bass and smallmouth bass have been confirmed previously from the Little River and Savannah River sites, respectively (Leitner 2009). The collection of two spotted bass from Little Coldwater Creek is a new incidence. These identifications will be confirmed genetically in the coming year. Any new collection of non-native bass in redeye bass streams is disturbing in that it represents the potential for loss of a pure population through introgression. It also documents further spread of these species within the Savannah drainage, and highlights the need for public education on the ramifications of such species introductions. Once completed, genetic data generated from this survey will be used in the identification of stream redeye bass populations where protective or restorative actions are warranted.

It is disappointing that development of new genetic assays was not successful. We sought to design new genetic assays that would streamline current and future genetic analyses of redeye bass populations. Although the mitochondrial ND2 locus was relatively easily characterized in this fashion, the diploid nuclear loci proved otherwise. This has slowed progress in that it forces the sequencing of all individuals collected. However, this in no way compromises our objective of comparing genome composition of sampled populations over space and time. Once generated, sequence data will be easily comparable within and among lakes and within and between years sampled. A GIS database will be developed that incorporates all genetic data. Site specific abiotic parameters contributing to presence of Alabama bass or hybrids will be examined.

A cost extension has been approved for this grant to more closely examine redeye bass in the neighboring Santee drainage. Genetic analysis of fish collected from the Saluda River, near Pelzer, S.C., indicate they were introduced from a Savannah drainage source (Oswald 2007). However, historical collections suggest redeye bass may be native to the Santee drainage (Gilbert 2009). Stream team collections in the Santee in 2008 recorded redeye bass in new locations, and recently redeye bass were collected from a site on Enoree River (Kubach 2008; Leitner, unpublished data). Determining the origin of redeye bass in the Santee drainage and their status with respect to hybridization is paramount to species management. An extension of the species native range would open Santee drainage sites to consideration with regard to habitat protections directed at conservation of the species. Whether native or introduced, genetically pure populations of redeye bass in Santee drainage may serve as refuge points for the Savannah genome of the species. In the coming year we will assay individuals from up to 10 Santee populations for genetic variation at three nuclear and a single mitochondrial DNA locus, and compare results to Savannah redeye bass. We will also assay populations of four similarly distributed species from the Savannah and Santee, and compare divergence to that found in redeye bass.

Recommendations

Complete sequencing of all collected fish. Characterize all fish to species and/or hybrid status and make relevant comparisons with results from collections made in 2003-2004. Develop GIS database that incorporates all genetic data. Examine abiotic parameters contributing to presence/absence of Alabama bass or hybrids. Complete collections and genetic analysis of Santee populations of redeye bass and four other species. Examine divergence between the two drainages for each species to assess status of Santee drainage redeye bass as native or introduced. Write final reports. Continue work to publish earlier and current results.

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Prepared By: Jean Leitner Title: Fisheries Biologist

Job Title: A Framework for Freshwater Stream Conservation

Period Covered Through September 30, 2010

Summary

A GIS layer of stream management units was created, using the upper Savannah River Basin as an example that could form the basis for aquatic resource management in the State. Forecasts of resource condition could be made for this population of streams and their watersheds based on the results of analyzing the samples taken during the South Carolina Stream Assessment. A decision support system organized within this watershed-based spatial framework could be used for managing cumulative risk to aquatic habitats and aquatic species of conservation concern.

Introduction

Freshwater species worldwide face accelerated extinction rates relative to most other wildlife taxa. The Southeastern U.S. in particular has been suffering long-term declines in native species of fish and aquatic invertebrates. The participation of SCDNR in the Southeast Aquatic Resource Partnership (SARP) demonstrates our State's concern over the decline of aquatic resources. The Comprehensive Wildlife Conservation Plan that SCDNR has developed (http://www.dnr.sc.gov/cwcs/index.html) contains descriptions of priority species of conservation concern. Over 125 species of fish, herpetofauna (i.e., reptiles and amphibians), mussels, crayfish, and snails are included that are directly dependent on aquatic systems for most or all of their life-stages, accounting for approximately 40% of the State's total number of priority species. Common threats appear in their species accounts, generally associated with pollution from point and nonpoint sources, as well as fragmentation of their habitats. As has been widely noted in conservation literature, successful aquatic conservation must focus on landscapes and watersheds (Angermeier 1995, Warren et al. 1997, Allan 2004). Water coursing through freshwater streams integrates the entire drainage area due to the cumulative nature of hydrologic systems, with the consequences of poor land and water uses (e.g., siltation, excessive nutrients, flow disruption) eventually impacting the rivers, reservoirs, and coastal systems of the State. In short, the quality of water and aquatic habitat reflects the condition of the uplands drained by the stream. A reversal of the decline of native aquatic species requires an understanding of factors that are critical for maintenance of suitable habitat capable of supporting sensitive taxa. By extension, we must also understand the threats that degrade the quality of aquatic habitats to the point where they no longer support species of conservation concern.

To address these issues, the South Carolina Department of Natural Resources (SCDNR), in conjunction with Clemson University, began the South Carolina Stream Assessment (SCSA) in 2006 to determine the status of aquatic resources in wadeable streams throughout the state. The goals of this probabilistic assessment are to understand how aquatic fauna vary according to natural gradients (drainage, ecoregion, slope, elevation, temperature, etc.), to evaluate how human activities affect the natural processes linking terrestrial and aquatic systems, and to develop empirical relationships that will guide conservation decisions. Over four hundred and fifty sites are scheduled to be sampled when the full assessment is completed in 2012. We are working to model relationships among the biological community, physical/chemical habitat, and watershed condition using the complete statewide data set, and from this develop the ability to make forecasts specific to any given watershed that can be used in a decision-making framework. We would like to make forecasts available to decision-makers with stated probabilities, for example, that the loss (or restoration) of X% of the forest in the riparian buffer would reduce (or increase) biotic integrity indices or abundance of a conservation target species by X% in a given ecoregional setting. This capability would enable a proactive, predictive approach to aquatic conservation that brings empirically-derived response functions into the policy and management arena.

SCSA data analysis to date shows that forest cover extent in riparian buffers along South Carolina's coastal plain streams is a significant predictor of the extent of coarse woody debris in stream channels, which is in turn a significant predictor of fish taxonomic and functional diversity (Marion 2008). Although the relationships may be different in the uplands (e.g., bed particle size may be important), we expect that similar functional response models for each ecoregion can be derived and applied using our forecasting approach. We also believe that the database will provide baseline conditions in dealing with climate change effects.

In anticipation of having stressor-response functions based on our sample data that would apply to streams of the state, here I describe a framework that may be used to manage the statewide population of streams and their watersheds. Forecasting models based on the sample data will be projected to statewide watersheds, with the resulting maps and decision support tools being made available through the SC DNR web site to help local planning officials and conservation organizations prioritize actions.

Materials and Methods

A GIS database 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 GIS Digital Elevation Model. The stream layer was then divided into 100 meter sections by converting the line file to points in ArcGIS using the extension “XTools” Pro version. This layer is termed the “points” layer where each point represents a 100 m stream section.

An “ecobasin” GIS layer was prepared by intersecting a spatial layer of major river basins (six digit HUC) in South Carolina with a GIS layer containing level 4 ecoregions. This divided the state of South Carolina, USA into 30 “ecobasins.” The 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 to each point. Streams selected in this layer were constrained to “wadeable” size by imposing a limit on drainage area: $4km^2 < area < 150km^2$.

The final points layer was exported as a database. 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 network and keeps track of stream confluences. 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 re-plotted in the GIS.

The points database was used in random site selection for the SCSA sampling protocol, where points were selected in a multistage design that allocated samples based on an ecobasin area weighted basis and stratified by drainage area (SCDNR 2003). However, in creating a stream management layer, all the 100 m “point” sections are overly fine-grained and the focus instead shifts to stream reaches occurring between confluences. Here, I created a stream management unit layer for the upper Savannah River basin by dropping all points except the most downstream (largest drainage area) for each set of points with a unique “From_Node” and

“To_Node” designation. The resulting layer may be thought of as the population of wadeable stream reaches between confluences in the basin, or between new influences from new watersheds as one traverses the hydrologic network.

Results

The creation of a stream management layer for the upper Savannah River basin of South Carolina for GIS resulted in a reduction in the number of stream points from 20,387 discrete 100m stream sections to 1,181 discrete stream reaches of varying length. The location of a portion of these management reaches is depicted in Figure 1.

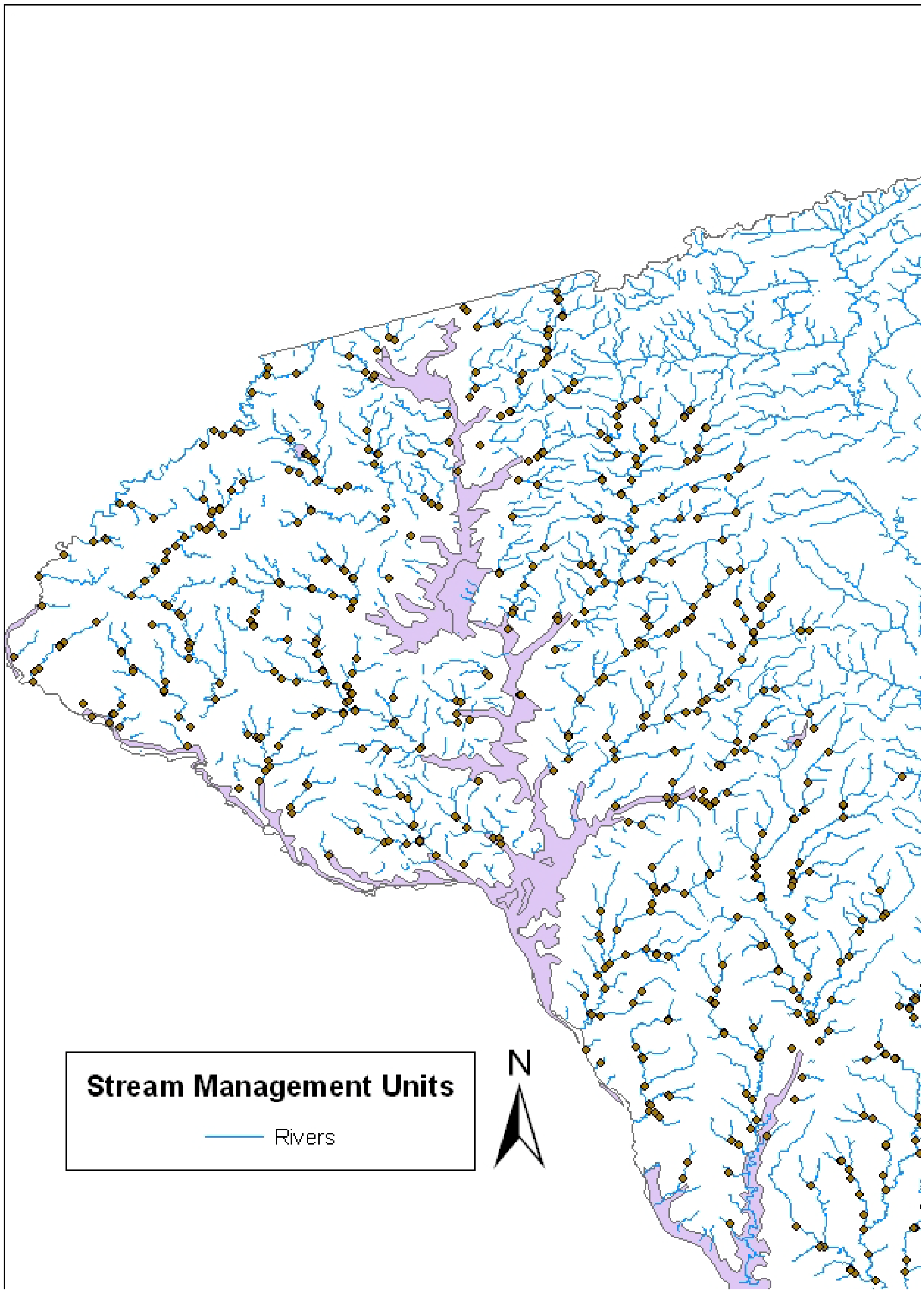

Figure 1. Map of a portion of the upper Savannah River Basin in South Carolina showing rivers, streams, and major lakes. Points indicate stream reaches and their watersheds (i.e., area draining to that point on the stream) that are potential management units for addressing cumulative effects on water quality, stream habitat, and aquatic biota conservation. Similar maps can be generated for all drainages in South Carolina using this data framework.

Discussion

The creation of stream management units for all wadeable streams in South Carolina is a step forward for aquatic resource conservation in the state. Results of analyzing the SCSA sample database can be extrapolated to this population of stream reaches across the State. Forecast models could be used to construct a user-friendly (i.e., web-based, menu-driven) support system that can be loaded with data for a specific locale. User input for the decision system would include hydrologic variables, indicators of human disturbance such as point sources and land use percentages, and allow scenarios of predicted disturbances. The system would generate spatially explicit (mapped) projections of effects of disturbances on aquatic systems including:

- Risks to water and habitat quality
- Risks to biodiversity impairment
- Risk to threatened and endangered species
- Useful indicator species for monitoring risk

SCDNR and other resources management agencies would be able to evaluate potential applications in a suite of new software packages for conservation planning and design, including Ecosystem Management Decision Support from ESRI, MAXTENT, Corridor Design, and FunConn, all packaged software that allow an adaptive management context so that users of the online system could experiment with land use changes and their hypothetical effects on species distributions. Specific strategies that maybe recommended based on such a decision support system include size and extent of riparian buffers to be maintained or restored, greenspace ratios and optimal location on the landscape, and guidance for usage of transferable development rights

(TDRs) that will steer development into least-impact configurations. No climate change forecast models currently exist at fine enough grain for the state of South Carolina (Mark Malsick, SC State Climatology Office, personal comm.). However, new interactive, global-scale climate change software (e.g., Climate Wizard) could be evaluated in a similar context to follow scenarios of climate change consequences for aquatic ecosystems.

Recommendations

Ensure that the South Carolina Stream Assessment is completed; Ensure that support is provided in the Information Technology Section for maintaining the StreamWeb, the database that is populated with SCSA data; Ensure that support is provided in IT for decision support tools based on the SCSA to made available through GIS-based World Wide Web interface.

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Prepared By: Mark Scott Title: Wildlife Biologist III

Job Title: South Carolina Stream Assessment

Period Covered October 1, 2009 – September 30, 2010

Summary

Eighty randomly selected sites were sampled between 01 October 2009 – 30 September 2010 following South Carolina Stream Assessment (SCSA) procedures. Sites were sampled from the following river basins as defined in the SCSA: Broad basin (55 sites), Congaree/Lower Santee basin (14) and Ashepoo-Combahee-Edisto (ACE) basin (11).

Introduction

The degradation of aquatic ecosystems and subsequent imperilment of native aquatic faunas observed in the southeastern United States underscore the demand for proactive, watershed-based conservation. The South Carolina Stream Assessment (SCSA), a multi-organization effort, was implemented in 2006 to address the need for science-based resource management. The goals are to characterize the biological, physical, and chemical condition of wadeable freshwater streams statewide, and relate these stream indicators to conditions in their watersheds.

Watersheds are distributed according to "ecobasins," spatial strata representing unique combinations of South Carolina's four major river basins and seven level-IV ecoregions, with sample size proportional to ecobasin area. Fixed, annually-sampled reference sites are established within each ecobasin to reflect least-disturbed watersheds and capture temporal dynamics in measured parameters. In addition, 75-100 randomly selected sites are sampled annually for spatial representation of watershed conditions, with statewide coverage scheduled by 2011.

Stream reach-scale biological variables include fish and macroinvertebrate assemblage structure as well as crayfish, mussel, and herpetofaunal distribution. Physical stream habitat is assessed in addition to channel geomorphology and water chemistry. Watershed-scale and riparian indicators are derived from land cover and pollution discharge data, facilitating the development of quantitative models describing the effects of watershed management scenarios on aquatic habitats and biological communities. Ultimately, we hope to provide land planners and managers with an empirically-derived, spatially-explicit decision support framework for watershed and riparian management.

Materials and Methods

Eighty randomly selected sites were sampled between 01 October 2009 – 30 September 2010 following South Carolina Stream Assessment (SCSA) procedures (SCDNR 2009). Sites were sampled from the following river basins as defined in the SCSA: Broad basin (55 sites; Table 1), Congaree/Lower Santee basin (14 sites; Table 2) and Ashepoo-Combahee-Edisto (ACE) basin (11 sites; Table 3).

Table 1. SCSA randomly selected sample sites in the Broad River basin, 01 October 2009 – 30 September 2010. Continued on following page.

Ecoregion	Site Number	Date	Stream
Blue Ridge	2285	29-Jun-2010	South Pacolet River
Inner Piedmont	6304	29-Jun-2010	Middle Tyger River
Inner Piedmont	10273	29-Jun-2010	Mush Creek
Outer Piedmont	66	6-Apr-2010	Hooper Creek
Outer Piedmont	1018	12-Aug-2010	Buck Creek
Outer Piedmont	2420	10-Aug-2010	Bowens River
Outer Piedmont	3791	12-Aug-2010	Cudds Creek
Outer Piedmont	5308	10-Aug-2010	Kings Creek
Outer Piedmont	12609	12-May-2010	London Creek
Outer Piedmont	14369	26-May-2010	Lawson's Fork Creek

Ecoregion	**Site Number**	**Date**	**Stream**
Outer Piedmont	19268	11-Aug-2010	Buck Horn Creek
Outer Piedmont	19708	27-May-2010	North Tyger River
Outer Piedmont	20420	6-Jul-2010	Bullock Creek
Outer Piedmont	21852	27-Apr-2010	Jordan Creek
Outer Piedmont	21979	11-Aug-2010	Clark Fork
Outer Piedmont	25580	27-May-2010	Fairforest Creek
Outer Piedmont	28884	6-Apr-2010	Jimmies Creek
Outer Piedmont	29277	19-Apr-2010	Cane Creek
Outer Piedmont	32110	26-May-2010	Brushy Creek
Outer Piedmont	33049	6-Jul-2010	Turkey Creek
Outer Piedmont	35716	24-Mar-2010	Cunningham Creek
Outer Piedmont	35923	6-Jul-2010	Bryson Creek
Outer Piedmont	35995	24-Mar-2010	Gault Creek
Outer Piedmont	37632	17-Jun-2010	Rocky Creek
Outer Piedmont	38018	24-Mar-2010	Reedy Branch
Outer Piedmont	40363	19-Apr-2010	Bens Creek
Outer Piedmont	41275	27-Apr-2010	Mineral Spring Branch
Outer Piedmont	46309	24-Mar-2010	McElwain Creek
Outer Piedmont	47502	17-Jun-2010	Gilder Creek
Outer Piedmont	50104	23-Mar-2010	Mill Creek
Outer Piedmont	50560	27-May-2010	Ferguson Creek
Outer Piedmont	53739	26-Aug-2010	Dutchman Creek
Outer Piedmont	57663	7-Apr-2010	Durbin Creek
Outer Piedmont	57688	7-Jul-2010	Big Browns Creek
Outer Piedmont	58406	7-Jul-2010	Meng Creek
Outer Piedmont	62297	29-Apr-2010	Sugar Creek
Outer Piedmont	63054	23-Mar-2010	Rock Branch
Outer Piedmont	67463	6-Jul-2010	Sandy River
Outer Piedmont	67849	17-Jun-2010	South Durbin Creek
Outer Piedmont	68769	7-Jul-2010	Dutchman Creek
Outer Piedmont	74000	7-Apr-2010	Beaverdam Creek
Outer Piedmont	76410	23-Mar-2010	Isaacs Creek
Outer Piedmont	82202	15-Jun-2010	Cedar Shoals Creek
Outer Piedmont	83983	15-Jun-2010	Warrior Creek
Outer Piedmont	97773	15-Jun-2010	Duncan Creek
Outer Piedmont	98095	28-Apr-2010	Weir Creek
Outer Piedmont	100215	25-Mar-2010	Tributary to Long Branch
Outer Piedmont	123014	28-Apr-2010	Headleys Creek
Outer Piedmont	132324	28-Apr-2010	Hellers Creek
Outer Piedmont	133297	25-Mar-2010	Kings Creek
Outer Piedmont	135356	26-Aug-2010	Second Creek
Outer Piedmont	149873	24-Aug-2010	Little Cedar Creek
Slate Belt	166139	24-Aug-2010	Little Cedar Creek
Slate Belt	174182	24-Aug-2010	Hollinshead Creek
Slate Belt	201501	22-Jun-2010	Smith Branch

Table 2. SCSA randomly selected sample sites in the Congaree/Lower Santee basin, 01 October 2009 – 30 September 2010.

Ecoregion	Site Number	Date	Stream
Sand Hills	208377	22-Jun-2010	Tributary to Congaree River
Sand Hills	214566	22-Jul-2010	Tributary to Savana Branch
Sand Hills	216895	3-Sep-2010	Sixmile Creek
Sand Hills	233136	3-Sep-2010	Second Creek
Atlantic S. Loam Plains	228510	3-Aug-2010	Myers Creek
Atlantic S. Loam Plains	229466	3-Aug-2010	Cabin Branch
Atlantic S. Loam Plains	238548	2-Sep-2010	Toms Creek
Atlantic S. Loam Plains	242497	2-Sep-2010	Tributary to Cedar Creek
Atlantic S. Loam Plains	250524	5-Aug-2010	Griffins Creek
Atlantic S. Loam Plains	267404	4-Aug-2010	Ballard Creek
Atlantic S. Loam Plains	275252	1-Sep-2010	Tributary to Lyons Creek
Atlantic S. Loam Plains	277074	1-Sep-2010	Halfway Swamp Creek
Atlantic S. Loam Plains	282177	4-Aug-2010	Big Branch
Atlantic S. Loam Plains	290931	4-Aug-2010	Tawcaw Creek

Table 3. SCSA randomly selected sample sites in the Ashepoo-Combahee-Edisto (ACE) basin, 01 October 2009 – 30 September 2010.

Ecoregion	Site Number	Date	Stream
Sand Hills	234012	10-Jun-2010	Black Creek
Sand Hills	239880	20-Jul-2010	Tributary to Chinquapin Creek
Sand Hills	262697	8-Jun-2010	Shaw Creek
Sand Hills	271640	21-Jul-2010	Rocky Springs Creek
Sand Hills	272583	21-Jul-2010	Beaverdam Branch
Sand Hills	274542	8-Jun-2010	Dairy Branch
Sand Hills	280765	20-Jul-2010	Jordan Creek
Sand Hills	285479	3-Jun-2010	Dean Swamp Creek
Sand Hills	299331	2-Jun-2010	Pond Branch
Sand Hills	305394	9-Jun-2010	Yarrow Branch (Tinker Creek)
Sand Hills	326961	9-Jun-2010	Rosemary Creek

Results

Broad River Basin

Fifty-three fish species including 13 Priority species (Kohlsaat et al. 2005) were collected altogether from 55 randomly selected sites in the Broad basin (Table 4). The fish fauna overall was comparable to that reported by Bettinger (2003 – 2004) in a previous survey of 38 streams in the Broad basin (45 species). Additional species collected from SCSA randomly selected sites in 2010 were spotted sucker, V-lip redhorse, bluespotted sunfish, central stoneroller, swamp darter, sawcheek darter, yellow perch and the non-native species white crappie, goldfish and fathead minnow (discussed below). These additional species were generally low in abundance and occurred at only one site each. Fish species richness among Broad basin sites averaged 11.1 (range 3 – 26).

Noteworthy collections of non-native species from the Broad basin included fathead minnow (*Pimephales promelas*) from two localities: Smith Branch (Site 201501), an urbanized Slate Belt stream near Columbia and Dutchman Creek (Site 53739), a Piedmont stream in Spartanburg County. The specimen from Dutchman Creek was collected during spot sampling downstream of the standard sample section but is mentioned here for documentation. In both cases only a single individual was collected; further sampling is necessary to determine whether these specimens represent established populations. *P. promelas* has been collected from a handful of scattered localities in South Carolina, most probably the result of release from bait buckets or toxicology facilities (Rohde et al. 2009). A goldfish (*Carassius auratus*) was collected from Fairforest Creek (Site 25580) near Spartanburg, one of only a few known records for this species in South Carolina (Rohde et al. 2009). The origin of this individual is not known but it was probably a released pet. Green sunfish (*Lepomis cyanellus*) were collected at about

25% of sites. *L. cyanellus* is presumably not native to the Atlantic slope yet now occurs in most of the Piedmont and parts of the Coastal Plain of South Carolina (Rohde et al. 2009; see Kubach SCSA annual reports 2007-2009).

Two species not frequently encountered at SCSA random sample sites were collected in the Broad basin: central stoneroller (*Campostoma anomalum*) and V-lip redhorse (*Moxostoma pappillosum*). *C. anomalum* was collected at Bowens River (Site 2420) in the upper portion of the basin. There is currently only one other record for *C. anomalum* in the Broad basin in South Carolina, also from this area (Rohde et al. 2009). *M. pappillosum* was collected at Kings Creek (Site 5308), a tributary to the section of the Broad River where this species is known to occur (Rohde et al. 2009). The thicklip chub (*Cyprinella labrosa*) was not collected despite its known presence in this basin; the closely related Santee chub (*C. zanema*) was present at seven sites.

Table 4. Fish species collected from SCSA random sample sites in the Broad River basin (01 October 2009 – 30 September 2010) and Conservation Priority according to Kohlsaat et al. (2005). Site occupancy values are out of a possible 55 sites sampled. Continued on following page.

Family	**Scientific Name**	**Common Name**	**Conservation Priority**	**Sites Occupied**	
				n	**%**
Aphredoderidae	*Aphredoderus sayanus*	Pirate perch		4	7.3%
Catostomidae	*Catostomus commersoni*	White sucker		17	30.9%
Catostomidae	*Erimyzon oblongus*	Creek chubsucker		11	20.0%
Catostomidae	*Hypentelium nigricans*	Northern hogsucker		9	16.4%
Catostomidae	*Minytrema melanops*	Spotted sucker		1	1.8%
Catostomidae	***Moxostoma collapsum***	**Notchlip redhorse**	**Moderate**	3	5.5%
Catostomidae	***Moxostoma pappillosum***	**V-lip redhorse**	**Moderate**	1	1.8%
Catostomidae	*Scartomyzon rupiscartes*	Striped jumprock		25	45.5%
Catostomidae	*Scartomyzon sp.*	Brassy jumprock		2	3.6%
Centrarchidae	*Enneacanthus gloriosus*	Bluespotted sunfish		1	1.8%
Centrarchidae	*Lepomis auritus*	Redbreast sunfish		49	89.1%
Centrarchidae	*Lepomis cyanellus*	Green sunfish		14	25.5%
Centrarchidae	*Lepomis gibbosus*	Pumpkinseed		4	7.3%
Centrarchidae	*Lepomis gulosus*	Warmouth		13	23.6%
Centrarchidae	*Lepomis macrochirus*	Bluegill		35	63.6%
Centrarchidae	*Lepomis microlophus*	Redear sunfish		3	5.5%
Centrarchidae	*Micropterus dolomieu*	Smallmouth bass		2	3.6%
Centrarchidae	*Micropterus salmoides*	Largemouth bass		26	47.3%
Centrarchidae	*Pomoxis annularis*	White crappie		1	1.8%
Centrarchidae	*Pomoxis nigromaculatus*	Black crappie		1	1.8%
Cyprinidae	***Campostoma anomalum***	**Central stoneroller**	**Moderate**	1	1.8%
Cyprinidae	*Carassius auratus*	Goldfish		1	1.8%
Cyprinidae	*Clinostomus funduloides*	Rosyside dace		9	16.4%
Cyprinidae	***Cyprinella chloristia***	**Greenfin shiner**	**Moderate**	18	32.7%
Cyprinidae	*Cyprinella nivea*	Whitefin shiner		6	10.9%
Cyprinidae	***Cyprinella pyrrhomelas***	**Fieryblack shiner**	**Moderate**	1	1.8%
Cyprinidae	***Cyprinella zanema***	**Santee chub**	**High**	7	12.7%
Cyprinidae	*Hybognathus regius*	Eastern silvery minnow		11	20.0%
Cyprinidae	***Hybopsis hypsinotus***	**Highback chub**	**Moderate**	24	43.6%
Cyprinidae	*Nocomis leptocephalus*	Bluehead chub		53	96.4%
Cyprinidae	*Notemigonus crysoleucas*	Golden shiner		1	1.8%
Cyprinidae	***Notropis chlorocephalus***[1]	**Greenhead shiner**[1]	**High**	46	83.6%
Cyprinidae	*Notropis cummingsae*	Dusky shiner		1	1.8%
Cyprinidae	*Notropis hudsonius*	Spottail shiner		4	7.3%
Cyprinidae	*Notropis petersoni*	Coastal shiner		1	1.8%
Cyprinidae	*Notropis procne*	Swallowtail shiner		5	9.1%
Cyprinidae	*Notropis scepticus*	Sandbar shiner		27	49.1%
Cyprinidae	*Pimephales promelas*	Fathead minnow		1	1.8%
Cyprinidae	*Semotilus atromaculatus*	Creek chub		43	78.2%
Esocidae	*Esox americanus*	Redfin pickerel		5	9.1%
Esocidae	*Esox niger*	Chain pickerel		2	3.6%

Family	Scientific Name	Common Name	Conservation Priority	Sites Occupied	
				n	%
Ictaluridae	*Ameiurus natalis*	Yellow bullhead		12	21.8%
Ictaluridae	***Ameiurus platycephalus***	**Flat bullhead**	**Moderate**	19	34.5%
Ictaluridae	*Noturus insignis*	Margined madtom		22	40.0%
Percidae	***Etheostoma collis***	**Carolina darter**	**High**	7	12.7%
Percidae	***Etheostoma flabellare***	**Fantail darter**	**High**	1	1.8%
Percidae	*Etheostoma fusiforme*	Swamp darter		1	1.8%
Percidae	*Etheostoma olmstedi*	Tessellated darter		27	49.1%
Percidae	*Etheostoma serrifer*	Sawcheek darter		1	1.8%
Percidae	***Etheostoma thalassinum***	**Seagreen darter**	**High**	20	36.4%
Percidae	*Perca flavescens*	Yellow perch		1	1.8%
Percidae	***Percina crassa***	**Piedmont darter**	**High**	4	7.3%
Poeciliidae	*Gambusia holbrooki*	Eastern mosquitofish		8	14.5%

[1]Taxonomy of *Notropis chlorocephalus* and *N. lutipinnis* (yellowfin shiner) is currently being investigated. This report follows Rohde et al. (2009) in using *N. chlorocephalus* although specimens from the Broad River basin may also be considered to be *N. lutipinnis* or a form closely related to these species.

Congaree/Lower Santee River Basin (Sand Hills and Atlantic Southern Loam Plains)

Thirty-seven fish species including 6 Priority species (Kohlsaat et al. 2005) were collected altogether from 14 sites in the Congaree/Lower Santee basin / Sand Hills and Atlantic S. Loam Plains ecoregions during this reporting period (Table 5). On average, sites in these ecobasins produced 8.7 fish species (range 0 – 18; Table 6). One site, a highly urbanized tributary to the Congaree River (Site 208377) in Columbia, did not produce any fish despite all indications that the stream is perennial and did not have any recent major disturbances. Several crayfishes were collected from this site. It is not known at this time whether fish occur in other reaches of this stream, nor have any specific causes of the lack of fish been identified. Water samples are being analyzed.

A green sunfish (*Lepomis cyanellus*) was collected from Sixmile Creek (Site 216895). This presumably non-native species appears to be expanding its distribution in the coastal plain of South Carolina. No blackbanded sunfish (*Enneacanthus chaetodon*) were collected in this river basin during this reporting period despite its known distribution in this area (Rohde et al. 2009; see Discussion).

Table 5. Fish species collected from SCSA random sample sites in the Congaree/Lower Santee basin (01 October 2009 – 30 September 2010) and Conservation Priority according to Kohlsaat et al. (2005).

Code	Family	Scientific Name	Common Name	Conservation Priority
SWF	Amblyopsidae	*Chologaster cornuta*	Swampfish	
BFN	Amiidae	*Amia calva*	Bowfin	
PIP	Aphredoderidae	*Aphredoderus sayanus*	Pirate perch	
BSS	Atherinidae	*Labidesthes sicculus*	Brook silverside	
CCS	Catostomidae	*Erimyzon oblongus*	Creek chubsucker	
LKC	Catostomidae	*Erimyzon sucetta*	Lake chubsucker	
MDS	**Centrarchidae**	***Acantharchus pomotis***	**Mud sunfish**	**Moderate**
BLS	Centrarchidae	*Enneacanthus gloriosus*	Bluespotted sunfish	
RBS	Centrarchidae	*Lepomis auritus*	Redbreast sunfish	
GSF	Centrarchidae	*Lepomis cyanellus*	Green sunfish	
PPS	Centrarchidae	*Lepomis gibbosus*	Pumpkinseed	
WAR	Centrarchidae	*Lepomis gulosus*	Warmouth	
BLG	Centrarchidae	*Lepomis macrochirus*	Bluegill	
DSF	Centrarchidae	*Lepomis marginatus*	Dollar sunfish	
RES	Centrarchidae	*Lepomis microlophus*	Redear sunfish	
SOS	Centrarchidae	*Lepomis punctatus*	Spotted sunfish	
LMB	Centrarchidae	*Micropterus salmoides*	Largemouth bass	
BHC	Cyprinidae	*Nocomis leptocephalus*	Bluehead chub	
GLS	Cyprinidae	*Notemigonus crysoleucas*	Golden shiner	
GHS	**Cyprinidae**	***Notropis chlorocephalus***[1]	**Greenhead shiner**[1]	**High**
DKS	Cyprinidae	*Notropis cummingsae*	Dusky shiner	
SFS	**Cyprinidae**	***Pteronotropis stonei***	**Lowland shiner**	**Moderate**
CRC	Cyprinidae	*Semotilus atromaculatus*	Creek chub	
BPS	Elassomatidae	*Elassoma zonatum*	Banded pygmy sunfish	
RFP	Esocidae	*Esox americanus*	Redfin pickerel	
CHP	Esocidae	*Esox niger*	Chain pickerel	
SBH	**Ictaluridae**	***Ameiurus brunneus***	**Snail bullhead**	**Moderate**
YBH	Ictaluridae	*Ameiurus natalis*	Yellow bullhead	
FBH	**Ictaluridae**	***Ameiurus platycephalus***	**Flat bullhead**	**Moderate**
TPM	Ictaluridae	*Noturus gyrinus*	Tadpole madtom	
MGM	Ictaluridae	*Noturus insignis*	Margined madtom	
SWD	Percidae	*Etheostoma fusiforme*	Swamp darter	
TSD	Percidae	*Etheostoma olmstedi*	Tessellated darter	
SCD	Percidae	*Etheostoma serrifer*	Sawcheek darter	
SGD	**Percidae**	***Etheostoma thalassinum***	**Seagreen darter**	**High**
MSQ	Poeciliidae	*Gambusia holbrooki*	Eastern mosquitofish	
EMM	Umbridae	*Umbra pygmaea*	Eastern mudminnow	

[1]Taxonomy of *Notropis chlorocephalus* and *N. lutipinnis* (yellowfin shiner) is currently being investigated. This report follows Rohde et al. (2009) in using *N. chlorocephalus* although specimens from the Broad River basin may also be considered to be *N. lutipinnis* or a form closely related to these species.

Table 6. Fish species collected from SCSA random sample sites in the Congaree/Lower Santee River basin, 01 October 2009 – 30 September 2010. Priority species (Kohlsaat et al. 2005) appear in bold. Species codes refer to Table 5.

	Site Number													
Code	**208377**	**214566**	**216895**	**228510**	**229466**	**233136**	**238548**	**242497**	**250524**	**267404**	**275252**	**277074**	**282177**	**290931**
SWF							X	X						
BFN														X
PIP			X	X	X		X	X	X	X	X	X		X
BSS							X							
CCS			X		X					X				X
LKC		X												
MDS					**X**		**X**			**X**		**X**		
BLS				X			X							
RBS		X	X				X			X	X	X		X
GSF			X											
PPS														X
WAR		X					X					X		X
BLG		X	X		X							X		X
DSF		X			X		X					X		
RES		X												X
SOS			X		X		X					X		X
LMB		X										X		X
BHC										X	X			
GLS									X					X
GHS										**X**				
DKS			X									X		
SFS			**X**		**X**	**X**	**X**			**X**		**X**		
CRC											X			
BPS					X		X	X						
RFP			X	X	X		X	X	X	X		X		X
CHP						X	X							X
SBH						**X**						**X**		
YBH		X			X		X		X	X		X		
FBH			**X**											
TPM							X							
MGM		X			X					X		X		
SWD		X												
TSD			X									X		
SCD					X		X			X		X		
SGD						**X**								
MSQ		X	X	X	X		X	X		X		X	X	X
EMM				X			X	X		X				
Species Richness	**0**	**11**	**12**	**5**	**13**	**4**	**18**	**6**	**4**	**13**	**4**	**17**	**1**	**14**

Ashepoo-Combahee-Edisto (ACE) River Basin (Sand Hills)

Thirty-eight fish species including 8 Priority species (Kohlsaat et al. 2005) were collected altogether from 11 sites in the ACE basin / Sand Hills ecoregion during this reporting period (Table 7). On average, 13.5 fish species (range 2 – 22) were present at sites in this ecobasin (Table 8).

Only one blackbanded sunfish (*Enneacanthus chaetodon*) was collected in the ACE basin/Sand Hills ecoregion during this reporting period (Pond Branch, Site 299331) despite its known historic distribution across this area and the apparent high quality of many of the 11 sites sampled (see Discussion). Another infrequently encountered species, pugnose minnow (*Opsopoeodus emiliae*), was collected at Yarrow Branch/Tinker Creek (Site 305394). However, like *E. chaetodon*, low representation of *O. emiliae* may reflect sampling bias towards wadeable, channel-constrained streams, as these species may be more abundant in deeper and wider habitats (e.g. swamps) that are not currently sampled in the SCSA. Further analyses are needed to examine habitat associations and sampling efficiency for these species. The turquoise darter (*Etheostoma inscriptum*) was not collected at any of the 11 sites despite many historic records from this area (Rohde et al. 2009).

Table 7. Fish species collected from SCSA random sample sites in the Ashepoo-Combahee-Edisto (ACE) basin / Sand Hills ecoregion (01 October 2009 – 30 September 2010) and Conservation Priority according to Kohlsaat et al. (2005).

Code	Family	Scientific Name	Common Name	Conservation Priority
AEL	**Anguillidae**	***Anguilla rostrata***	**American eel**	**Highest**
PIP	Aphredoderidae	*Aphredoderus sayanus*	Pirate perch	
BSS	Atherinidae	*Labidesthes sicculus*	Brook silverside	
CCS	Catostomidae	*Erimyzon oblongus*	Creek chubsucker	
LKC	Catostomidae	*Erimyzon sucetta*	Lake chubsucker	
SPS	Catostomidae	*Minytrema melanops*	Spotted sucker	
MDS	**Centrarchidae**	***Acantharchus pomotis***	**Mud sunfish**	**Moderate**
FLR	Centrarchidae	*Centrarchus macropterus*	Flier	
BBS	**Centrarchidae**	***Enneacanthus chaetodon***	**Blackbanded sunfish**	**High**
BLS	Centrarchidae	*Enneacanthus gloriosus*	Bluespotted sunfish	
RBS	Centrarchidae	*Lepomis auritus*	Redbreast sunfish	
WAR	Centrarchidae	*Lepomis gulosus*	Warmouth	
BLG	Centrarchidae	*Lepomis macrochirus*	Bluegill	
DSF	Centrarchidae	*Lepomis marginatus*	Dollar sunfish	
SOS	Centrarchidae	*Lepomis punctatus*	Spotted sunfish	
LMB	Centrarchidae	*Micropterus salmoides*	Largemouth bass	
BHC	Cyprinidae	*Nocomis leptocephalus*	Bluehead chub	
DKS	Cyprinidae	*Notropis cummingsae*	Dusky shiner	
YFS	Cyprinidae	*Notropis lutipinnis*	Yellowfin shiner	
CSH	Cyprinidae	*Notropis petersoni*	Coastal shiner	
PNM	**Cyprinidae**	***Opsopoeodus emiliae***	**Pugnose minnow**	**Moderate**
SFS	**Cyprinidae**	***Pteronotropis stonei***	**Lowland shiner**	**Moderate**
BPS	Elassomatidae	*Elassoma zonatum*	Banded pygmy sunfish	
RFP	Esocidae	*Esox americanus*	Redfin pickerel	
CHP	Esocidae	*Esox niger*	Chain pickerel	
LTM	Fundulidae	*Fundulus lineolatus*	Lined topminnow	
SBH	**Ictaluridae**	***Ameiurus brunneus***	**Snail bullhead**	**Moderate**
YBH	Ictaluridae	*Ameiurus natalis*	Yellow bullhead	
FBH	**Ictaluridae**	***Ameiurus platycephalus***	**Flat bullhead**	**Moderate**
TPM	Ictaluridae	*Noturus gyrinus*	Tadpole madtom	
MGM	Ictaluridae	*Noturus insignis*	Margined madtom	
SPM	Ictaluridae	*Noturus leptacanthus*	Speckled madtom	
SVD	**Percidae**	***Etheostoma fricksium***	**Savannah darter**	**Highest**
SWD	Percidae	*Etheostoma fusiforme*	Swamp darter	
TSD	Percidae	*Etheostoma olmstedi*	Tessellated darter	
BBD	Percidae	*Percina nigrofasciata*	Blackbanded darter	
MSQ	Poeciliidae	*Gambusia holbrooki*	Eastern mosquitofish	
EMM	Umbridae	*Umbra pygmaea*	Eastern mudminnow	

Table 8. Fish species collected from SCSA random sample sites in the Ashepoo-Combahee-Edisto (ACE) basin / Sand Hills ecoregion, 01 October 2009 – 30 September 2010. Priority species (Kohlsaat et al. 2005) appear in bold. Species codes refer to Table 7.

	Site Number										
Code	**234012**	**239880**	**262697**	**271640**	**272583**	**274542**	**280765**	**285479**	**299331**	**305394**	**326961**
AEL	**X**		**X**						**X**	**X**	**X**
PIP		X	X		X	X		X	X	X	X
BSS										X	
CCS			X			X		X	X	X	X
LKC	X	X				X					
SPS								X	X		
MDS				**X**	**X**	**X**		**X**	**X**	**X**	
FLR						X		X			
BBS									**X**		
BLS						X					
RBS		X	X					X		X	X
WAR		X		X				X	X		
BLG	X	X	X								X
DSF	X		X	X	X	X			X	X	X
SOS	X		X					X	X	X	X
LMB	X	X		X				X	X		X
BHC		X	X							X	
DKS	X		X					X	X	X	X
YFS		X	X							X	
CSH											X
PNM										**X**	
SFS	**X**			**X**		**X**		**X**	**X**	**X**	**X**
BPS				X	X						
RFP			X	X		X		X	X	X	X
CHP	X			X	X			X		X	
LTM								X			
SBH			**X**					**X**		**X**	
YBH		X		X		X					
FBH		**X**									
TPM				X							
MGM			X							X	
SPM	X		X	X				X	X	X	X
SVD	**X**			**X**				**X**	**X**	**X**	**X**
SWD	X										
TSD	X							X	X	X	X
BBD	X		X	X	X			X	X	X	X
MSQ		X					X	X		X	X
EMM						X	X				
Species Richness	**14**	**11**	**15**	**13**	**6**	**11**	**2**	**20**	**17**	**22**	**17**

Discussion

Blackbanded Sunfish (Enneacanthus chaetodon) Population Status

Efforts are currently underway to assess the population status of the blackbanded sunfish (*Enneacanthus chaetodon*) throughout its range, in portions of which it is known to be declining or imperiled. The South Carolina Stream Assessment (SCSA) employs random sampling of wadeable streams, providing a means of quantifying species abundances at several spatial scales and measuring rarity. SCSA sampling in 2010 included 30 sites within the known range of *E. chaetodon*, specifically the Ashepoo-Combahee-Edisto (ACE) basin / Sand Hills ecoregion (11 sites) and the Congaree/Lower Santee basin / Sand Hills (6) and Atlantic S. Loam Plains (13). Out of these 30 sites, only one specimen of *E. chaetodon* was collected from a site in the ACE basin / Sand Hills ecoregion. This specimen brings the total number of *E. chaetodon* collected at SCSA randomly selected sites (2006 – 2010) to 17 individuals from 5 of 175 sites sampled (2.9%) within its potential range in the Coastal Plain (Sand Hills, Atlantic S. Loam Plains and Carolina Flatwoods ecoregions). However, the apparently low presence and abundance of *E. chaetodon* at SCSA sites may in part reflect sampling selectivity towards wadeable, channel-constrained streams (i.e. those effectively sampled using backpack electrofishing). Historic data suggest *E. chaetodon* may be more abundant in wider and deeper habitats (e.g. swamps) that are not currently sampled as part of the SCSA and thus further evaluation of these habitats is necessary to fully assess the population status of this and other species with similar habitat requirements.

Recommendations

This report summarizes SCSA sampling of randomly selected sites in 2010. Further analyses will focus on standardized estimation of stream resources (summarized by river basin and ecoregion strata), including development of conservation criteria for South Carolina stream fishes based on standardized abundance estimates and other measures. These criteria will assist biologists and resource managers in assigning conservation status in future efforts such as revisions of the Comprehensive Wildlife Conservation Strategy.

Literature Cited

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South Carolina Department of Natural Resources. 2009. The South Carolina Stream Assessment Standard Operating Procedures. Version 2009. Freshwater Fisheries Section.

Prepared By: Kevin Kubach Title: Fisheries Biologist

Job Title: Aquatic Community Monitoring of the Reedy River Tributaries

Period Covered July 1, 2009 through June 30, 2010

Summary

Fifteen Reedy River tributary sites and four Saluda River reference sites were sampled in May of 2010 for water quality, physical habitat, and fish. The preliminary results and characterization of this sampling effort are the focus of this report.

Introduction

The Reedy River watershed represents a case study in watershed development and its associated ramifications on the biological condition of fish communities. The Reedy watershed harbors land use activities ranging from intensive urban/suburban development and associated population growth near the River's headwaters in the Greenville metropolitan area to extensive agricultural and relatively undisturbed forested areas in the lower portion of the watershed. Such heterogeneity provides a spatial framework for characterizing a gradient of urban disturbance and the associated effects on fish assemblage condition.

A recent South Carolina Department of Natural Resources (SCDNR) study examined the biological (fish) status of 15 Reedy tributaries by 'ranking' sites based on their relative biological condition, and examined the spatial distribution of site ranks across a gradient of urban land use intensities (Marion 2008). A threshold in land use level/type where fish community condition exhibited significant decline in rank (i.e. biological condition) was identified at > 20% urban watershed land use. Tributaries within watersheds that had exceeded a 20% urban threshold were characterized by fish assemblages with simplified taxonomic and functional composition, and reductions/eliminations of sensitive species.

Data for the aforementioned study included fish collections from 2005 and 2006. Comprehensive sampling of all 15 Reedy River tributary sites was conducted again in 2010, and the preliminary results and characterization of that sampling effort is the focus of this report.

Materials and Methods

Fifteen Reedy River tributary sites and four Saluda River reference tributary sites were established for water quality, habitat, and biological community monitoring. The fifteen Reedy River tributary sampling locations were selected under a criterion framework based on catchments at least 1km upstream of the Reedy mainstem, catchment size of at least 5 km^2, and absence of dams between the sample site and the mainstem. The four Saluda River tributaries are located a similar distance apart as the extreme downstream and upstream Reedy River tributaries (2 lower watershed sites and 2 higher watershed sites) and are monitored concurrently with the Reedy River tributaries to document variation in aquatic variables over temporal, natural, and anthropogenic gradients. Sample sites, sample dates, and site locations are cited in Table 1.

Fishes sampling consisted of three-pass depletion electrofishing within a sample reach equivalent to 20x average wetted width. All fishes captured were collected, field identified to species level, and released. Water quality and habitat parameters were measured according to the SCDNR stream sampling standard operating procedures (SCDNR 2008).

Results

Results of water quality measurements taken at the time of fish sampling in May are found in Table 2. Water temperatures ranged from 15.6 – 22.2 ° C. Dissolved oxygen ranged from 7.47 – 11.21 mg/L. Conductivities were comparable to those observed in other piedmont localities, ranging from 27 – 97 µS/cm. Conductivities were the highest in sites located closest to the Greenville metropolitan area. Turbidity among sites ranged from 2.86 – 25.87 NTU, and pH ranged from 6.65 – 8.25.

Habitat variables measured at the time of fish sampling in May are found in Table 3. Average width of sites ranged from 2.92 – 6.06 m. Reedy and Saluda tributaries were relatively shallow, ranging from 0.09 - 0.33 m. Average flow velocities ranged from 0.14 – 0.37 m^3/s.

Fish sampling in May resulted in the collection of 5217 individuals representing 30 species (Table 4). As found in previous years, the catch was numerically dominated by two cyprinids, *Nocomis leptocephalus* (n=1845) and *Notropis lutipinnis* (n=1401). Conservation priority species were represented by *Ameiurus platycephalus*, *Cyprinella chloristia, Micropterus coosae, Hybopsis rubrifrons, Ameiurus brunneus*, and *Etheostoma thalassinum*, and comprised 2.95% of total collections. *Micropterus coosae* and *Hybopsis rubrifrons* were only captured in the Saluda River tributaries. One nonnative species, *Lepomis cyanellus*, was collected in nine Reedy River tributaries and one Saluda River tributary.

Table 1. Reedy and Saluda River tributary sample locations and 2010 sample dates.

Stream	Sample Date	Latitude (°N)	Longitude (°W)
Baker	7-May-10	34.66114	82.34817
Baldwin	11-May-10	34.72433	82.30769
Beaverdam	18-May-10	34.49901	82.23488
Brushy	11-May-10	34.79914	82.3919
Harrison	7-May-10	34.66914	82.29473
Horse	18-May-10	34.52373	82.26418
Huff	6-May-10	34.71488	82.35223
Langston	5-May-10	34.88538	82.42379
Laurel	11-May-10	34.77899	82.34481
Little	12-May-10	34.62658	82.31021
Martin	7-May-10	34.58704	82.24868
Reedy HW	5-May-10	34.94153	82.46429
Richland	5-May-10	34.85457	82.38395
Rocky	6-May-10	34.70389	82.29763
Walnut	18-May-10	34.40212	82.1735
Broadmouth	19-May-10		
Carpenter	13-May-10		
Shoal	13-May-10		
Mountain	19-May-10		

Table 2. Water quality measured at sample locations in May 2010.

Stream	DO (MG/L)	Conductivity (uS/cm)	Turbidity (NTU)	Temperature °C	pH
Baker	7.47	52	7.35	22.2	
Baldwin	9.98	46	3.76	15.6	7.05
Beaverdam	10.14	71	16.89	18.74	7.8
Brushy	9.41	79	4.53	15.36	6.4
Harrison	9.09	75	21.31	17.14	
Horse	9.03	45	20.78	17.83	7
Huff	8.28	51	6.01	18.35	7.24
Langston	8.23	47	4.39	17.82	
Laurel	9.78	44	4.44	15.07	
Little	8.3	38	7.37	18.11	6.65
Martin	7.88	61	11.25	18.3	7.01
Reedy HW	8.95	50	9.61	16.52	6.43
Richland	8.24	97	2.86	20.45	
Rocky	9.29	70	2.86	19.78	8.25
Walnut	11.21	69	18.72	17.36	7.67
Broadmouth	8.29	61	25.87	19.22	6.67
Carpenter	9.42	27	11.73	16.32	
Shoal	9.52	28	17.63	15.76	6.68
Mountain	9.24	55	10.7	17	6.91

Table 3. Habitat variables measured at sample locations in May 2010.

Stream	Sample Length (m)	Avg. Width (m)	Avg. Depth (m)	SD Depth	Avg. Velocity (m^3/s)	SD Velocity
Baker	100	3.14	0.19	0.12	0.17	0.15
Baldwin	110	2.92	0.13	0.07	0.15	0.11
Beaverdam	100	3.64	0.13	0.06	0.19	0.12
Brushy	139	6.93	0.27	0.17	0.19	0.15
Harrison	100	3.06	0.19	0.07	0.18	0.1
Horse	116	5.82	0.19	0.08	0.34	0.09
Huff	158	7.8	0.25	0.16	0.19	0.24
Langston	100	4.86	0.22	0.09	0.2	0.09
Laurel	120	6.06	0.23	0.13	0.23	0.15
Little	106	5.2	0.33	0.22	0.14	0.18
Martin	100	2.83	0.12	0.04	0.26	0.11
Reedy HW	105	5.28	0.31	0.11	0.21	0.09
Richland	100	4.78	0.17	0.07	0.27	0.14
Rocky	120	5.88	0.19	0.13	0.27	0.18
Walnut	100	3.84	0.19	0.09	0.22	0.15
Broadmouth	110	5.525	0.21	0.1	0.25	0.19
Carpenter	105	5.22	0.22	0.1	0.37	0.15
Shoal	100	3.88	0.28	0.12	0.31	0.15
Mountain	100	2.84	0.09	0.04	0.22	0.12

Table 4. Fish species and number collected at each sample location in May 2010. Species codes in Appendix A.

Species	Baker	Baldwin	Beaverdam	Brushy	Harrison	Horse	Huff	Langston	Laurel	Little	Martin	Reedy HW	Richland	Rocky	Walnut	Broadmouth	Carpenter	Shoal	Mountain	Total
BBH	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
BHC	62	201	92	176	109	22	376	69	76	33	15	41	79	152	87	75	122	58	30	1845
BLG	4	0	1	22	11	3	20	10	2	26	0	18	0	0	16	47	1	0	19	181
CCS	0	0	0	0	0	3	0	0	0	0	0	0	0	0	8	0	0	0	0	11
CRC	1	24	42	1	2	14	2	10	2	4	5	1	0	4	43	10	15	29	15	209
FBH	2	0	0	6	0	0	4	0	0	1	0	0	2	1	0	0	0	0	0	16
GLS	0	1	0	3	17	0	0	0	0	0	5	0	0	0	1	0	0	0	0	27
GFS	0	0	0	0	0	0	0	0	14	0	0	0	0	20	0	0	0	0	0	34
GSF	0	2	2	0	49	0	0	0	24	8	11	26	7	8	0	15	0	0	0	152
LMB	0	8	1	2	2	0	2	2	0	5	1	0	0	0	0	0	0	0	0	23
MGM	1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	8	0	0	11
MSQ	0	0	0	0	42	0	0	0	0	0	0	0	0	0	0	1	0	0	0	43
NHS	1	3	0	0	7	5	24	0	18	15	8	0	0	61	6	13	6	10	0	177
PPS	0	3	0	0	2	1	0	3	0	0	0	5	0	0	0	0	0	0	0	14
RBS	14	45	13	181	15	6	116	6	17	54	3	17	35	49	31	21	24	11	0	658
REB	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
RES	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	3
RFC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	68	0	0	68
RFP	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	4
RSD	0	35	0	0	0	0	0	0	1	0	0	0	0	2	0	0	1	0	0	39
SBH	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	2
SBS	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	7
SGD	2	0	0	0	8	0	0	0	0	6	2	0	0	4	0	1	8	1	1	32
STJ	0	1	0	0	0	1	0	0	0	1	1	0	0	0	9	2	17	3	0	35
STS	0	0	0	0	0	0	0	0	21	5	0	0	0	85	2	0	0	0	0	113
TSD	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	8
WAR	1	0	1	0	0	0	1	0	0	6	1	5	0	3	0	1	0	0	1	19
WHS	0	1	0	5	0	0	0	0	0	0	0	0	1	0	0	0	0	15	0	22
YBH	2	2	4	19	1	2	1	0	5	0	1	4	7	8	3	0	0	0	0	59
YFS	45	162	148	11	35	11	0	90	165	27	2	17	222	215	91	7	120	33	34	1401
Total	135	489	307	426	302	72	546	190	346	193	55	134	354	614	305	199	390	160	100	5217
Richness	11	14	10	10	14	11	9	7	12	14	12	9	8	15	12	14	11	8	6	30

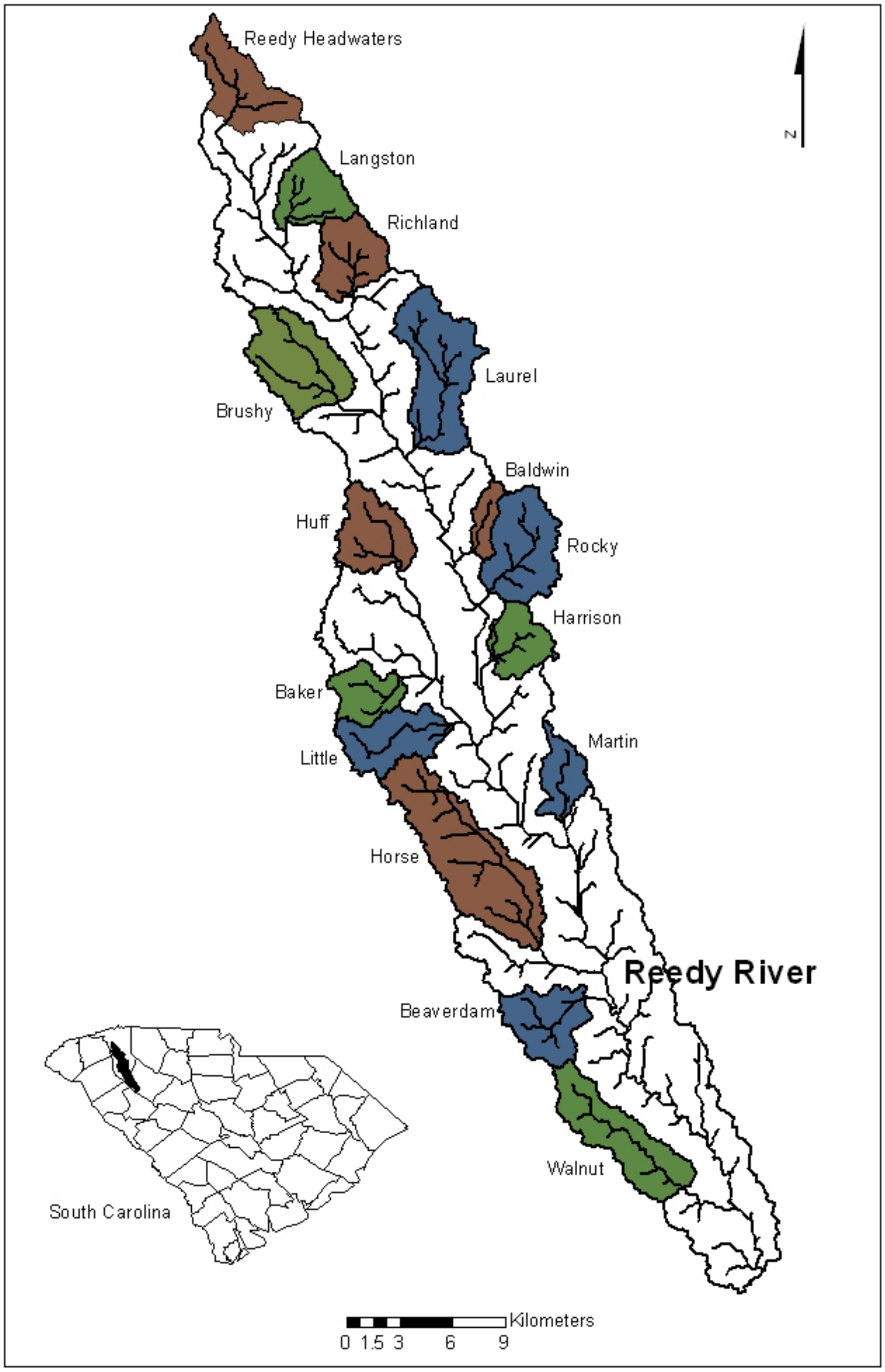

Figure 1. Map of Reedy River watershed showing the fifteen tributary sample locations (at base of delineated watersheds) and associated tributary watersheds.

Discussion

Biological data collected in 2010 along with samples from 2005 and 2006 will continue to be used to document trends in fish community response to changes in the urbanizing Reedy River watershed. This study is ongoing through 2013. Current work includes the development of methodologies to predict areas within the Reedy River watershed that are most (and least) vulnerable to future declines in biological condition, and to prioritize subwatersheds for conservation/restoration efforts based on those predictions. Additionally, collaboration with Clemson University faculty is underway to model the effects of landscape resistance on observed Reedy River tributary fish distributions and dispersal capabilities.

Recommendations

Our sampling program and analyses will continue through 2013. We will prepare reports, make technical presentations, and public presentations of results as they are determined.

Literature Cited

Marion, C. A. 2008. Interrelationships of land use and fish assemblage integrity among tributaries of the Reedy River, South Carolina. SCDNR Statewide Freshwater Fisheries Research Publication F-63:16-24.

SCDNR. 2008. Standard Operating Procedures for Sampling Wadeable Streams. Draft Manual, Freshwater Fisheries Section.

Prepared By: Cathy Marion Title: Research Fisheries Biologist

Job Title: Twelvemile Creek Dam Removal Monitoring

Period Covered January 1, 2010 through December 31, 2010

Summary

Work continued on previous efforts to survey the fish communities of Twelvemile Creek before and after the scheduled removal of two mainstem dams (Woodside I and Woodside II). This report details fish collections, water quality parameters, and physical habitat for two 2010 samples. Each sample was taken during a period of active sediment dredging above Woodside I, however the two 2010 samples are still considered pre-dam removal samples since neither dam has been removed.

Introduction

Few studies on the ecological effects of dam removal have been conducted in North America due to the lack of opportunity, particularly in the Southeast. An opportunity has been presented with the removal of two dams on Twelvemile Creek, Pickens County, as part of the Schlumberger settlement. The project should provide information on a series of questions:

1) How do environmental factors and biological communities in the impounded (i.e., "lake-like") reaches differ from those found in free-flowing sections of Twelvemile Creek?
2) What are the effects of dam removal on downstream channel dimensions, biological communities, and water quality?
3) How long does it take for the geomorphology, water quality, and biological community in the impounded reaches to recover to a typical stream ecosystem?

The objective of this investigation is to document changes in the Twelvemile Creek aquatic ecosystem before and after removal of the Woodside I and II dams. This report will detail fish collections and water quality parameters measured at the time of fish collections (temperature, dissolved oxygen, pH, conductivity, and turbidity) in two 2010 samples. Both 2010 samples were conducted during a period of active sediment dredging above the Woodside I dam prior to its removal.

Materials and Methods

Eight sampling stations were established for geomorphic, water quality, and biological community monitoring. Six stations are located on Twelvemile Creek, distributed as follows: 1) the alluvial stream section downstream of Woodside II dam (Lower River), 2) the bedrock-constrained stream section downstream of Woodside II dam (Woodside II Below), 3) the impounded area above Woodside II dam (Woodside II Above), 4) the bed-rock constrained flowing section downstream of Woodside I dam (Woodside I Below), 5) the impounded area above Woodside I dam (Woodside I Above), and 6) a reference station in the flowing section upstream of the Easley-Central Water district Reservoir (Robinson Bridge) (Figure 1). Two stations are located in nearby Three and Twenty Creek (at LaFrance, and at Burns Bridge), a stream system that is similar in physiography and drainage area but lacking major mainstem dams. The two Three and Twenty Creek reference stations are located a similar distance apart as the extreme downstream and upstream Twelvemile stations and will be monitored concurrently with the Twelvemile Creek stations to document variation in aquatic variables longitudinally and over time in a system not undergoing dam removal. Sampling commenced prior to dam removal, will be repeated three times per year for the first three years after dam removal, and repeated once each year thereafter for two more years, for a total of 96 sampling events (eight stations x twelve sample periods). The impoundment above Woodside I dam was not sampled in 2010 due to access problems resulting from active dredging related to ongoing dam removal activities.

Sampling focuses on measurements in four categories of aquatic ecosystem variables: channel geomorphology, water quality, aquatic invertebrates, and fishes.

Two fish samples were conducted in April and September of 2010 (Table 1). Each sample considered to be a pre-dam removal sample. Fishes were collected within 300m segments at each station with a standardized effort using electrofishing gear and seines. Backpack electrofishers and seines were used in wadeable stream segments to sample a standard area of 15 m^2. A boat-mounted electrofishing rig was used in deeper impounded segments. All fishes encountered were collected, field identified to species level, photo-vouchered, and released.

Table 1. The seven stations sampled in April and September of 2010. Samples taken during active sediment dredging above Woodside I, but prior to dam removal.

Site	Sample Date April 2010	Sample Date September 2010	Latitude (°N)	Longitude (°W)
Robinson Bridge	12-Apr-10	20-Sep-10	34.78079	-82.75465
Woodside I Below	12-Apr-10	21-Sep-10	34.7717	-82.77998
Woodside II Above	14-Apr-10	20-Sep-10	34.76583	-82.79163
Woodside II Below	13-Apr-10	20-Sep-10	34.76262	-82.79202
Twelvemile Lower	13-Apr-10	20-Sep-10	34.75367	-82.79219
3&20 LaFrance	13-Apr-10	21-Sep-10	34.60878	-82.76286
3&20 Burns Bridge	14-Apr-10	21-Sep-10	34.58987	-82.78222

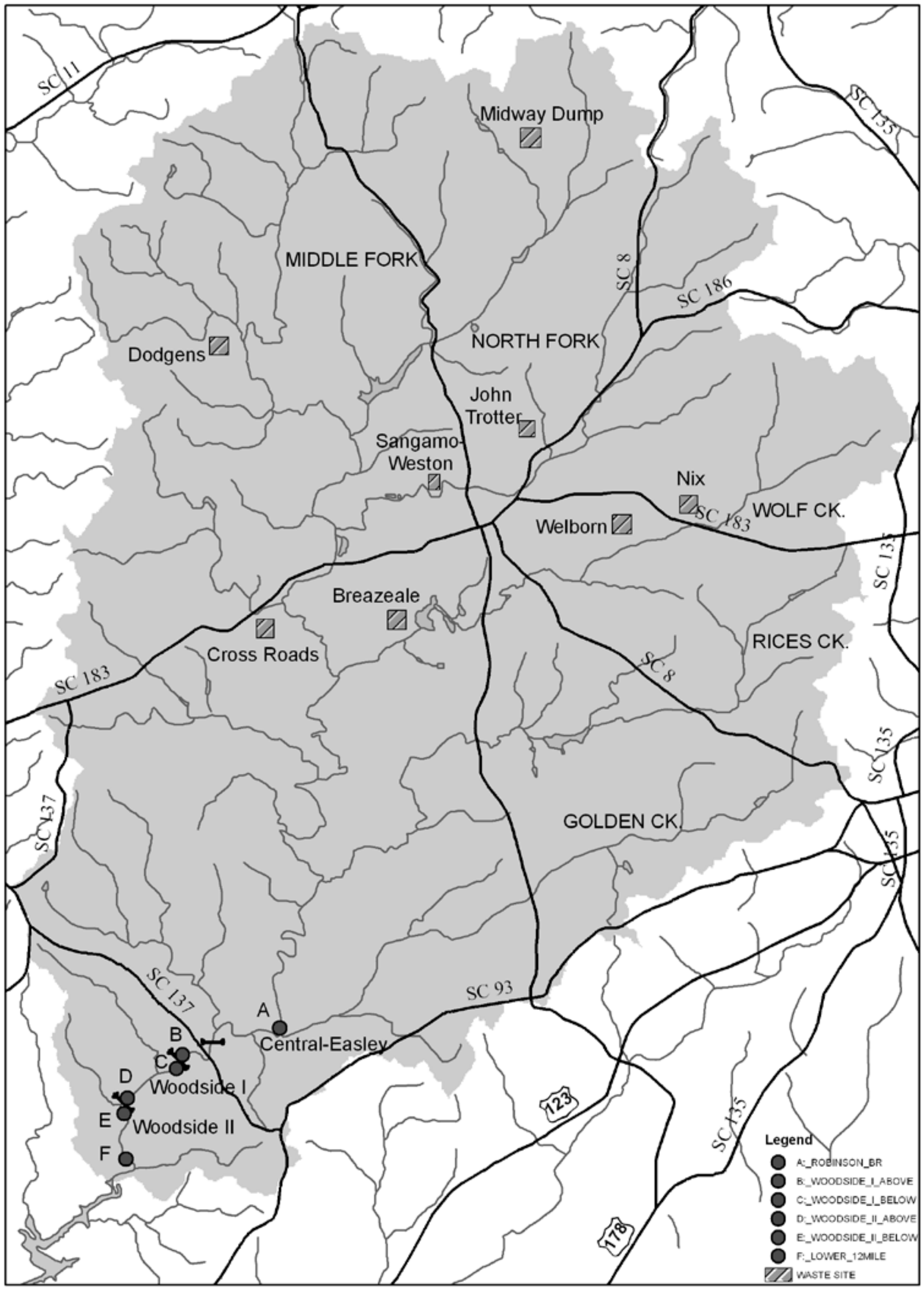

Figure 1. Map of Twelvemile Creek drainage (shaded) showing the existing dams and locations of sampling stations.

Results

Results of water quality measurements taken at the time of fish sampling in April and September are found in Tables 2 and 3, respectively. Water temperature was predictably lower in April (14.15 - 17.98 °C) than in September (21.16 - 23.19 °C). Nonetheless, dissolved oxygen levels were near 11 mg/L in April, and near 10 mg/L in September. Conductivities were between 39 and 63 µs/cm in April, and 47 and 112 µs/cm in September. The two Three and Twenty Creek (3&20) stations had higher conductivities in each sample date, representing the high-end of the conductivity range. Range for pH was 8.72 - 9.28 in April, and tended to be lower in September (6.61 - 7.58). Turbidities were higher at all stations in April (11.46 - 24.71) than September (3.93 - 14.59), a probable result of fall drought conditions. Dredging activities above the Woodside I dam do not appear to cause elevated turbidity in downstream sites during base-flow conditions.

Habitat variables measured at the time of fish sampling in April and September are found in Tables 4 and 5, respectively. Average depth at the Twelvemile stations remained within a fairly tight range (0.4 – 0.62 m) between sample dates. However, average depths at 3&20 sites were lower in September. Average flow velocities at most stations in both systems were slightly lower in September (0.15 - 0.39 m^3/s) compared to April (0.12 - 0.48 m^3/s), particularly 3&20 sites. Additionally, average wetted width tended to decrease between April (11.83 - 51.5m) and September (8.84 - 24.43m).

Fish sampling in April resulted in collection of 1626 individuals representing 23 species (Table 6). The catch was numerically dominated by two sunfishes (*Lepomis microlophus*: n=239, *Lepomis macrochirus*: n=217), and one cyprinid species (*Notropis hudsonius*: n=217). Conservation priority species were represented by *Alosa aestivalis*, *Ameiurus platycephalus*, *Micropterus coosae, Hybopsis rubrifrons, Ameiurus brunneus*, and *Etheostoma inscriptum,* and comprised 12.36% of total collections (SCDNR 2005). One nonnative species, *Lepomis cyanellus*, was collected in April in all Twelvemile and 3&20 stations.

Fish sampling in September resulted in a collection of 1825 individuals representing 26 species (Table 7). The catch was numerically dominated by three cyprinids (*Notropis hudsonius*: n=484, *Nocomis leptocephalus*: n=303, and *Cyprinella nivea*: n=214). Conservation priority species were represented by *Ameiurus platycephalus*, *Carpoides velifer*, *Micropterus coosae, Hybopsis rubrifrons, Ameiurus brunneus,* and *Etheostoma inscriptum,* and comprised only 4.27% of total collections (SCDNR 2005). Two nonnative species, *Pylodictis olivaris* and *Lepomis cyanellus,* were collected in September. One *Pylodictis olivaris* was captured at Woodside II below, and *Lepomis cyanellus* was captured in all Twelvemile and 3&20 stations.

Table 2. Water quality measured at sample stations in April 2010.

Site	Date	Temperature °C	DO (Mg/L)	Conductivity (µS/cm)	pH	Turbidity (NTU)
Robinson Bridge	12-Apr-10	15.18	11.34	39	8.92	11.46
Woodside I Below	12-Apr-10	17.1	11.08	44	8.78	17.65
Woodside II Above	14-Apr-10	17.03	10.52	45	8.97	24.71
Woodside II Below	13-Apr-10	14.98	11.53	43	9.09	16.01
Twelvemile Lower	13-Apr-10	14.15	11.34	41	9.28	11.12
3&20 LaFrance	13-Apr-10	15.01	11.41	54	8.68	16.01
3&20 Burns Bridge	14-Apr-10	17.49	10.96	63	8.72	11.68

Table 3. Water quality measured at sample stations in September 2010.

Site	Date	Temperature °C	DO (Mg/L)	Conductivity (µS/cm)	pH	Turbidity (NTU)
Robinson Bridge	20-Sep-10	23.19	10.08	47	7.58	3.93
Woodside I Below	21-Sep-10	22.91	9.75	52	7.55	5.88
Woodside II Above	20-Sep-10	22.42	11.24	51	7.07	6.98
Woodside II Below	20-Sep-10	22.01	11.25	51	6.78	5.16
Twelvemile Lower	20-Sep-10	21.16	10.82	51	6.91	5.18
3&20 LaFrance	21-Sep-10	21.73	8.21	57	6.61	14.59
3&20 Burns Bridge	21-Sep-10	21.37	10.42	112	7.06	10.65

Table 4. Habitat variables measured at each station in April 2010.

Site	Avg. Depth (m)	SD Depth	Avg. Velocity (m^3/s)	SD Velocity	Avg. Width (m)
Robinson Bridge	0.62	0.15	0.42	0.16	19.1
Woodside I Below	0.47	0.17	0.45	0.34	27.1
Woodside II Above	0.45	0.22	0.12	0.13	51.5
Woodside II Below	0.4	0.17	0.39	0.23	23.25
Twelvemile Lower	0.5	0.18	0.28	0.12	28.1
3&20 LaFrance	0.44	0.2	0.48	0.21	11.83
3&20 Burns Bridge	0.51	0.21	0.29	0.26	21.2

Table 5. Habitat variables measured at each station in September 2010.

Site	Avg. Depth (m)	SD Depth	Avg. Velocity (m^3/s)	SD Velocity	Avg. Width (m)
Robinson Bridge	0.47	0.17	0.21	0.11	17.7
Woodside I Below	0.49	0.17	0.23	0.23	19.02
Woodside II Above	0.55	0.21	0.15	0.12	24.43
Woodside II Below	0.51	0.16	0.39	0.23	20.9
Twelvemile Lower	0.42	0.2	0.32	0.09	21.1
3&20 LaFrance	0.32	0.18	0.15	0.22	8.84
3&20 Burns Bridge	0.42	0.17	0.17	0.16	19.9

Table 6. Fish species and number collected at each station in April 2010. Species codes in Appendix A.

Species	Robinson Bridge	Woodside I Below	Woodside II Above	Woodside II Below	Twelvemile Lower	3&20 LaFrance	3&20 Burns Bridge	Total
BBD	13	23	0	29	14	18	21	118
BHC	18	56	8	17	20	43	30	192
BLC	0	0	0	1	0	0	0	1
BLG	5	8	30	49	9	18	98	217
BLH	0	0	0	0	0	1	44	45
DSF	0	0	1	0	0	0	0	1
FBH	5	0	0	0	0	2	0	7
GSF	3	7	2	4	10	4	5	35
LMB	0	0	3	5	1	0	2	11
MGM	5	9	0	1	1	6	9	31
NHS	3	30	3	7	8	11	6	68
RBS	5	7	21	3	5	9	24	74
REB	1	1	1	23	0	0	2	28
RES	0	0	0	165	23	1	50	239
RFC	14	1	6	0	0	0	0	21
SBH	7	9	0	1	0	0	2	19
STJ	0	1	0	0	0	1	0	2
STS	0	0	0	83	83	32	19	217
TQD	0	65	0	16	0	0	0	81
WAR	0	0	0	0	0	1	0	1
WFS	1	7	13	3	15	0	10	49
YFS	20	46	0	14	13	45	21	159
YLP	0	0	0	6	0	1	3	10
Total	100	270	88	427	202	193	346	1626
Richness	13	14	10	17	12	15	16	23

Table 7. Fish species and number collected at each station in September 2010. Species codes in Appendix A.

Species	Robinson Bridge	Woodside I Below	Woodside II Above	Woodside II Below	Twelvemile Lower	3&20 LaFrance	3&20 Burns Bridge	Total
BBD	16	29	2	25	20	18	34	144
BHC	11	41	45	29	67	34	76	303
BLG	11	6	14	12	66	49	61	219
CCF	0	0	0	0	1	0	0	1
ESM	0	0	0	0	2	2	0	4
FBH	5	0	0	0	0	0	2	7
FCF	0	0	0	1	0	0	0	1
GSF	1	4	5	5	11	3	3	32
HFC	0	0	0	0	2	0	0	2
LMB	0	1	0	0	2	1	0	4
MGM	4	2	0	1	0	5	6	18
NHS	17	38	1	10	6	13	25	110
RBS	8	6	8	4	5	12	14	57
REB	0	2	1	3	2	0	0	8
RES	0	0	0	2	2	1	15	20
RFC	0	0	0	0	0	2	0	2
SBH	1	25	2	0	0	0	2	30
STJ	0	2	0	0	0	0	0	2
STS	0	0	0	220	119	53	92	484
TQD	0	15	0	14	0	0	0	29
WAR	0	0	0	0	1	0	0	1
WFS	4	10	2	20	162	0	16	214
WHS	0	1	0	0	0	0	0	1
YBH	0	0	0	0	1	0	0	1
YFS	0	59	0	11	3	37	19	129
YLP	0	0	0	0	0	1	1	2
Total	78	241	80	357	472	231	366	1825
Richness	10	15	9	14	17	14	14	26

.

Discussion

The sampling events from 2010 along with samples from 2006 and 2009 will serve as benchmarks for comparison as dam removal activities continue through 2010 and beyond. Although some variation exists due to interannual variation in climate and precipitation patterns, as well as watershed differences between 12MI and 3&20 stations, the variation in the pre-dam removal data will allow us to assess the magnitude of impact due to project activities. After dam removal is completed, we plan to continue sampling for at least five years to document the duration of impacts and time to recovery in the system.

Recommendations

We will continue standardized sampling according to schedule at Twelvemile Creek and Three and Twenty Creek to provide a multi-year record of aquatic resource conditions during and after removal of Woodside I and Woodside II dams on Twelvemile creek.

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Prepared By: Cathy Marion & Mark Scott Title: Fisheries Research Biologists

Job Title: Additional simulations with the Saluda Reedy Watershed model. Contributions of each point source to the phosphorus loads to Lake Greenwood.

Period Covered June 1, 2009 – June 30, 2010

Results and Discussion

Taylor and Bulak (2009) built watershed models to quantify the contributions of nonpoint and point sources to the loads of phosphorus delivered to Lake Greenwood. The point sources consist of nine major domestic wastewater treatment plants, seven in the Saluda watershed and two in the Reedy watershed (see Taylor, Bulak, and McKellar, 2008). The report examined their aggregate contributions to the loads. In this supplement, we quantify the contributions separately for each of the point sources.

Models for the Saluda and Reedy watersheds were constructed in WinHSPF. As discussed in Taylor and Bulak (2009), the watershed models require simplifications and approximations about myriad processes operating in the watershed. Accordingly, the simulation results should be interpreted as a general, not precise, descriptions of the dynamics of phosphorus in the watersheds.

The contribution of each point source to Lake Greenwood was estimated as the difference between the phosphorus loads delivered to Lake Greenwood in simulations with and without phosphorus from the point source. The volume of water discharged by the point source was left unchanged. The proportion of discharged phosphorus reaching Lake Greenwood from each point source was estimated as the contribution to Lake Greenwood divided by the amount of phosphorus from the point source. Simulations were run for the years 1999-2006.

Ware Shoals was the largest point source of phosphorus in the Saluda watershed from 1999-2004 (Table 1). By 2005, its diminishing phosphorus discharge was surpassed by the increasing discharge from Easley/Middle Branch. Except in 1999, the Mauldin Road facility was the largest point source of phosphorus in the Reedy watershed.

The contributions of the point sources to the simulated phosphorus loads delivered to Lake Greenwood reflected these patterns (Table 2). The average contributions were greatest from Ware Shoals in the Saluda watershed and from Mauldin Road in the Reedy watershed. However, the annual contribution from Ware Shoals was not surpassed by the annual contribution from Easley/Middle Branch until 2006, suggesting a disproportionately greater impact of the discharge from Ware Shoals.

The proportion of discharged phosphorus reaching Lake Greenwood diminished with distance of the point source from Lake Greenwood (Figure 1). Thus, for Saluda watershed, the model predicts that changes at downstream facilities such as Ware Shoals would have a greater effect on phosphorus loads to Lake Greenwood than would changes at upstream facilities such as Easley/Middle Branch.

Recommendations

Use results from the Saluda-Reedy watershed models to create scenarios for the Lake Greenwood model (McKellar, Bulak, and Taylor, 2008) to examine the effects of weather and reductions in point source loads on water quality, particularly in the historically problematic Reedy Arm.

Table 1. Phosphorus discharged to Saluda and Reedy Rivers from major domestic wastewater treatment plants in the Saluda-Reedy watershed. Sources of data are described in Taylor et al. (2008); missing values for Williamston in 1999 and Georges Creek in 1999-2003 were replaced with values from subsequent time periods. Distance was measured from facility to outlet of watershed at Lake Greenwood.

				Annual phosphorus load (metric tons)							
Facility	***NPDES permit***	***Watershed***	***Distance (km)***	***1999***	***2000***	***2001***	***2002***	***2003***	***2004***	***2005***	***2006***
Ware Shoals	SC0020214	Saluda	9	12.4	9.6	15.0	15.7	11.2	6.9	8.1	2.4
Belton	SC0045896	Saluda	40	4.2	2.5	2.6	1.7	1.7	2.3	1.7	1.2
Williamston	SC0046841	Saluda	43	1.8	1.4	1.7	1.9	1.9	2.1	2.2	2.0
Grove Creek	SC0024317	Saluda	59	2.7	4.2	3.5	3.9	2.8	2.1	2.2	2.9
Piedmont	SC0023906	Saluda	63	0.5	0.4	0.6	0.7	0.7	0.5	0.5	0.6
Easley/Middle Branch	SC0039853	Saluda	79	4.7	4.4	3.7	4.8	7.3	6.7	8.4	10.0
Georges Creek	SC0047309	Saluda	83	1.8	1.8	1.8	1.8	1.8	1.8	3.2	4.0
Lower Reedy	SC0024261	Reedy	64	16.6	7.0	6.3	6.5	4.7	3.4	4.9	3.2
Mauldin Road	SC0041211	Reedy	83	8.1	8.5	15.9	18.7	22.8	12.8	11.9	13.4

Table 2. Contribution from each point source to simulated phosphorus loads to Lake Greenwood. The contribution from each point source is given as metric tons and as a percentage of the simulated phosphorus load to Lake Greenwood. Note that the sum of the contributions from each point source in the watershed may differ from the aggregate contribution reported in Taylor and Bulak (2009; Table 3), reflecting nonlinearities in the response of the load.

	Contribution from point source to phosphorus load delivered to Lake Greenwood (metric tons; percentage)																	
Point source	***1999***		***2000***		***2001***		***2002***		***2003***		***2004***		***2005***		***2006***		***Mean***	
Saluda watershed																		
Ware Shoals	9.5	43%	7.3	37%	11.8	51%	12.2	43%	8.9	19%	5.5	21%	6.8	19%	2.0	9%	8.0	30%
Belton/Ducworth	2.1	10%	1.3	6%	1.4	6%	1.0	3%	1.2	3%	1.3	5%	1.2	3%	0.8	4%	1.3	5%
Williamston	0.7	3%	0.7	4%	0.9	4%	1.1	4%	1.3	3%	1.2	5%	1.5	4%	1.3	6%	1.1	4%
Grove Creek	0.7	3%	1.1	6%	0.9	4%	1.2	4%	1.1	2%	0.5	2%	0.8	2%	0.9	4%	0.9	3%
Piedmont	0.1	0%	0.1	1%	0.1	0%	0.2	1%	0.2	0%	0.2	1%	0.2	1%	0.3	1%	0.2	1%
Easley/Middle Branch	1.0	5%	0.7	4%	0.6	3%	1.4	5%	2.8	6%	1.8	7%	2.7	7%	2.9	14%	1.7	6%
Georges Creek	0.5	2%	0.5	3%	0.5	2%	0.5	2%	0.8	2%	0.5	2%	1.2	3%	1.5	7%	0.8	3%
Reedy watershed																		
Lower Reedy	9.4	54%	3.3	29%	3.8	23%	4.3	20%	3.5	10%	1.7	11%	2.6	13%	2.0	14%	3.8	22%
Mauldin Road	5.9	34%	3.7	32%	9.0	55%	11.3	53%	14.7	40%	5.5	37%	6.1	31%	6.6	47%	7.9	41%

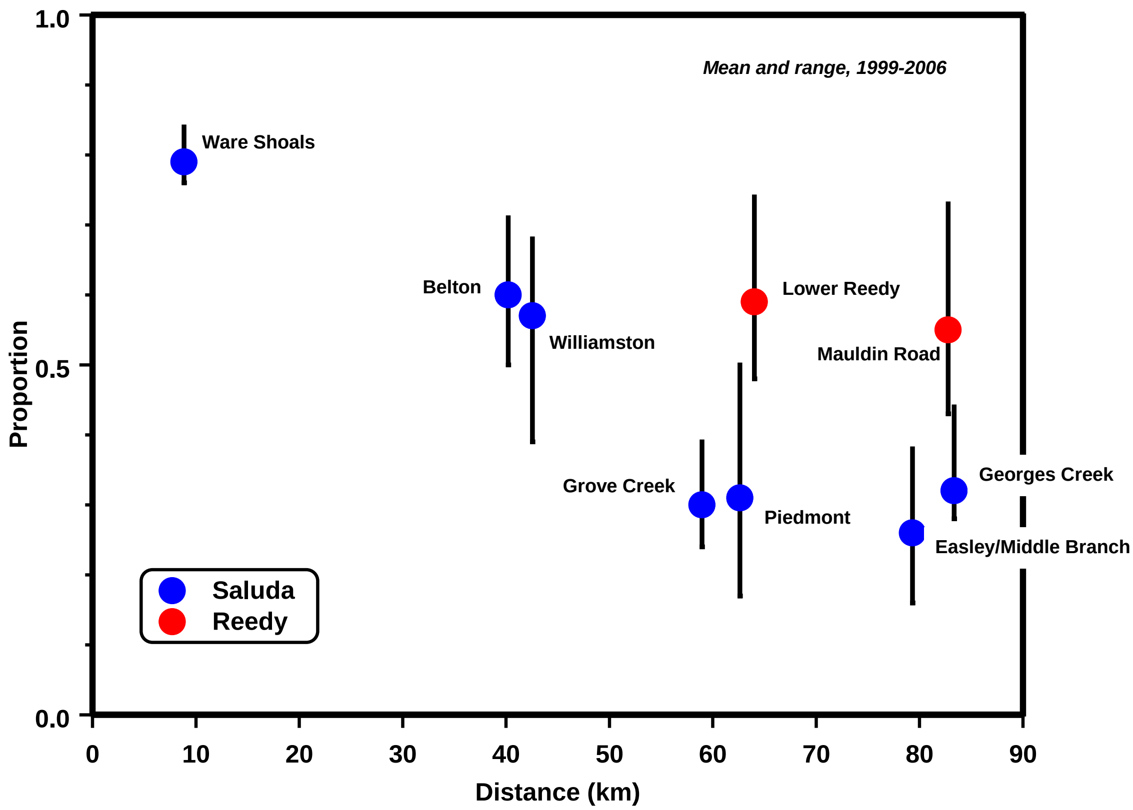

Figure 1. Proportion of discharged phosphorus reaching Lake Greenwood from each point source.

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Prepared By: Barbara Taylor Title: Wildlife Biologist III

Job Title: Trophic resources for larval fish in Lake Marion

Period Covered July 1, 2009 – June 30, 2010

Results and Discussion

The work reported here is part of an ongoing program of studies directed toward developing process-based models of food resources and other factors that may limit recruitment of key resident and anadromous fish species in the Santee-Cooper system,

In 2008, the South Carolina Department of Natural Resources (SCDNR) re-convened the Santee-Cooper Comprehensive Study Group to provide an update and overview of current conditions in the system and to guide and promote development of a scientific basis for management decisions about aquatic resources within the Santee-Cooper basin. The most critical short-term goal identified by the Study Group was to evaluate whether zooplankton abundance may limit the recruitment of key fish species, including striped bass, American shad, blueback herring, threadfin shad, and white perch.

These key species have overlapping spawning seasons (April to June), shared nursery areas in Upper Lake Marion, and similar preferences for zooplankton during early life stages. During recent years, blueback herring and striped bass recruitment dropped to historically low levels (Lamprecht, S., SCDNR, personal communication). The causes for these declines, and the implications for success of the Santee-Cooper anadromous fish passage and restoration efforts, are presently unknown. To date, striped bass has received more attention than the other key species in Lake Marion. However, because all of the key species share habitat and resources during early development, reduced recruitment of striped bass probably indicates changing conditions for the other species.

Investigations of factors influencing successful striped bass recruitment were conducted in Santee-Cooper in the 1980s and early 1990s. Successful recruitment depends on the abundance and timing of zooplankton production. Striped bass appear to require zooplankton densities on the order of 100 animals/liter or more (Bulak et al., 1997).

For Lake Marion, the most important controls on zooplankton abundance in spring are probably intensity of predation, adequacy of phytoplankton, and advective loss. Because spring temperatures are fairly consistent between years, they are unlikely to produce great differences in zooplankton abundances. Feeding by the larval fish could suppress zooplankton abundances, and larval fish may compete for this resource (for example, the hypothesized interaction between anadromous American shad and salmon in the Columbia River; Fresh, 1996). The benthos may also affect the plankton in Lake Marion. *Corbicula fluminea*, the invasive Asiatic clam, is abundant. *Corbicula* can be highly productive (Sousa et al., 2008). *Corbicula* spp. have greatly suppressed phytoplankton and phytoplankton in other shallow systems (for example, Hwang et al., 2004; Lopez et al., 2006), causing major changes in trophic structure.

Our work during this reporting period was focused on the estimating abundances and potential impacts of the benthos and estimating abundances of the plankton in Upper Lake Marion.

Benthos

Our original estimates of abundance and biomass of benthic organisms were based on 50 samples collected in June and July 2009. Samples were collected with a Petite Ponar grab sampler, then gently rinsed on a 0.5 mm stainless steel screen. Material retained on the screen was preserved in 70% alcohol. Biomasses (dry weight) were estimated using regressions from Benke et al. (1999) for *Corbicula fluminea* (Lauritzen and Mozley's summer equation for a population in North Carolina) and *Hexagenia limbata* (Smock's equation for *H. munda* in North Carolina) and a function fit to data for *Viviparus subpurpureus* from Richardson and Brown (1989). The equation for *Corbicula fluminea* was also used for the sphaeriids, which are similar in form to small *Corbicula*. An average biomass of 0.1 mg was used for *Chaoborus punctipennis* (Taylor, unpublished data for mainly 4th instar larvae of *Chaoborus punctipennis* from Pond 4 on the Savannah River Site in South Carolina). The same value was also used for the chironomids, which were similar in size.

In the summer 2009 samples, the benthos was dominated by the Asiatic clam *Corbicula fluminea* and the olive mystery snail *Viviparus subpurpureus*, with the mayfly *Hexagenia limbata* ranking a distant third in biomass (Table 1).

Because mayfly emergence was well underway when we sampled in 2009, we speculated that mayflies might be relatively more important in earlier in the year. To address this concern, we resampled the benthos before the beginning of the annual mayfly emergence. In April 2010, we collected 25 samples. The 2009 samples were collected on ten evenly spaced transects between Stump Hole Swamp and I-95; the 2010 samples were collected at the same locations on five of these transects. The 2010 samples were processed similarly to the 2009 samples.

In the 2010 samples, biomass was again dominated by the Asiatic clam *Corbicula fluminea* and the olive mystery snail *Viviparus subpurpureus*, with the mayfly *Hexagenia limbata* ranking a distant third. The mayflies were more abundant in the 2010 samples, but their average size was smaller. The two sets of samples were generally quite similar, except that larvae of the phantom midge *Chaoborus punctipennis* were absent from the 2010 samples.

To evaluate the potential impact of the benthos on the phytoplankton, and we evaluated filtering rates for *Corbicula* were estimated using an experimentally derived equation from

Lauritsen (1986). The equation is: $FR = 3.534\ SL^{1.723}$, where FR is filtering rate in ml/hr and SL is shell length in mm. The experiments were conducted at 20 ºC, and the filtering rate was estimated by the amount of chlorophyll removed from water column. The equation includes results with animals from three locations; shell lengths were 8.3-27.2 mm.

The estimated filtering rate for the *Corbicula* population per m^2 of substrate was 6.5 m^3/day. Because the average depth of water was 3.4 m for the sampled population, this estimate suggests that *Corbicula* have the capacity to filter the water in Upper Lake Marion nearly twice in a day. Thus, if the lake is well-mixed, the benthic *Corbicula* population may be capable of exerting a strong influence on planktonic production.

Plankton

Counts of the zooplankton samples collected in April-June 2009 are underway, but have not yet been completed. The composition of April and May samples is dominated by small-bodied taxa, including rotifers, copepod nauplii, bosminid cladocerans. Abundances are very low in the April samples.

After completing the zooplankton counts, we will estimate the magnitude of zooplankton production using abundances, birth rates derived from egg ratios for selected taxa, and mass estimates. We will also estimate advective loss using retention times based on flow rates in the Congaree and Wateree Rivers and the Lake Marion hydrologic model (Tufford and McKellar, 1999).

Recommendations

Develop a process-oriented, modeling framework to allow continued refinement of a system-based ecological model, as more data are obtained and lake processes continue to change.

Specific management applications resulting from this effort may include predicting optimal levels and times for striped bass stocking.

Table 1. Benthic invertebrates in Upper Lake Marion. Biomasses were not estimates for some sparsely abundant or small taxa.

Taxon	Size range (mm)	June-July 2009 (n=50) Abundance (number/m^2)	June-July 2009 (n=50) Biomass (g/m^2)	June-July 2009 (n=50) Biomass (% total)	April 2010 (n=25) Abundance (number/m^2)	April 2010 (n=25) Biomass (g/m^2)	April 2010 (n=25) Biomass (% total)
BIVALVES		**550.8**			**460.7**		
Sphaeriidae[1]	2-15	119.5	0.18	0%	88.3	0.34	0%
Corbiculidae: *Corbicula fluminea*	5-40	420.9	48.11	70%	360.3	49.98	71%
Unionidae: *Elliptio* spp.[2]	5-110	8.7			10.4		
Unionidae: *Lampsilis splendida/radiata*	50-60	1.7			1.7		
GASTROPODS		**328.2**			**344.7**		
Viviparus subpurpureus	2-30	2.6			1.7		
Valvata bicarinata	<5	0.9			0.0		
Physidae	<5	319.6	17.66	26%	341.2	17.33	25%
Planorbidae	<5	5.2			1.7		
INSECTS		**575.9**			**568.1**		
Ephemeroptera: *Hexagenia limbata*	5-30	158.5	2.76	4%	258.1	2.91	4%
Ephemeroptera: *Caenis* sp.	<5	13.9			1.7		
Odonata: Gomphidae	5-35	3.5			5.2		
Trichoptera	5-10	2.6			10.4		
Coleoptera: Dytiscidae	10-15	0.9			0.0		
Coleoptera: Elmidae	5-10	0.9			0.0		
Coleoptera: Scirtidae		0.0			1.7		
Coleoptera: undetermined		0.0			1.7		
Diptera: *Chaoborus punctipennis*	5-10	120.4	0.01	0%	0.0	0.00	0%
Diptera: Chironomidae	<5-15	275.4	0.03	0%	289.2	0.03	0%
CRUSTACEANS		**12.1**			**0.0**		
Cyclopoida: *Mesocyclops*	<1	0.9			0.0		
Amphipoda: *Gammarus*	<5-10	10.4			0.0		
Isopoda		0.9			0.0		
TOTAL		**1,467**	**68.8**		**1,373**	**70.6**	

[1]Includes sphaeriids *Eupera cubensis*, *Pisidium* sp., *Sphaerium/Musculium* sp., and possibly some small *Corbicula fluminea*

[2]Includes forms resembling *E. producta*, *E. fisheriana*, and *E. folliculata/angustata*

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Prepared By: Barbara Taylor   Title: Wildlife Biologist III

Job Title: Crayfishes and shrimps from the Statewide Stream Assessment

Period Covered October 1, 2009 – September 30, 2010

Results and Discussion

Between March and November 2010 stream surveys were done at 89 (of 92 scheduled) sites in 7 ecobasins as part of the Statewide Stream Assessment. Four ecobasins in the Broad River drainage were surveyed, including the Blue Ridge (1 site), Inner Piedmont (2 sites), Outer Piedmont (53 of 54 sites), and Slate Belt (3), completing all sampling within the Broad River drainage, except for 1 large site in the Outer Piedmont. In the lower Santee River drainage, the Atlantic Southern Loam Plains (13 sites) and Sandhills (7 sites) ecobasins were surveyed and in the ACE Sandhills (11 of 12 sites).

Collections of crayfishes and shrimps from the Broad, Santee, and ACE river basins were made at 55 of 59 sites, 17 of 19 sites, and 11 of 11 sites, respectively, sampled in 2010 and included a total of 4 species of *Cambarus,* 8 species of *Procambarus* (7 native, 1 introduced), and 1 species of shrimp. A total of 6 species of crayfishes were identified from localities in the Broad River basin (shrimp not collected), 5 species of crayfishes and 1 species of shrimp from the Santee River basin, and 4 species of crayfishes and 1 species of shrimp were identified from sites in the ACE basin. Species richness ranged from 0–5 species of crayfishes and shrimp, with an average of 2 species per site, and abundances of species at sites were 1–131 Individuals. Only 4 sites in the Broad River basin did not yield any crayfishes or shrimps, but many collections consisted of only juveniles/ subadults (29% of collections) or adult females (24%) of *Cambarus* spp., making identification of these specimens difficult. Less than 1% of collections of *Cambarus* spp. had adult form I males included compared with 44% of collections of *Procambarus* spp. Composition of *Cambarus* spp. collections was 7 form I males, 58 form II (adult) males, 96 adult females, and 547 juveniles/subadults. Supplemental collecting at these sites in the future would provide additional specimens that would allow for positive identifications. One of the *Cambarus* species in the Broad River basin is an undescribed species under study by John Cooper, North Carolina State Museum of Natural Sciences.

Species diversity was lower in the Broad River drainage than in others sampled during the previous 4 years, but this could be due, in part, to inability to identify some samples to species as indicated above. Other drainages were only sampled in one or two smaller ecobasins yet still had good species diversity for the small number of sites sampled. During the 2010 surveys, five crayfish species of conservation concern were collected from 20 sites in 4 ecobasins. A species of "Highest" conservation concern, *Procambarus echinatus,* was collected at 6 sites in the ACE Sandhills ecobasin. *Procambarus chacei,* a species of "Moderate" conservation concern (Kohlsaat et al., 2005), was documented at 7 of 89 sites, all of which were in the Santee River ecobasins, but none of the sites represent an extension of the known range of this species. *Procambarus ancylus,* a species of "High" conservation concern, was collected at only 1 of 89 sites and within the overall known distribution for the species. *Procambarus acutus* and/or *P. blandingii*, the latter being a species of "Moderate" conservation concern, were collected at 7 of 89 sites. *Procambarus hirsutus* ("Moderate" conservation concern) was collected at 5 of 89 sites, all within the ACE Sandhills ecobasin. A single specimen of *Cambarus asperimanus* (no conservation status) was captured in the Broad River Blue Ridge ecobasin. During 2010, as with 2009, more species of conservation concern were collected, and from more sites, compared with the 2006–2008 sampling (Poly, 2009). The non-native species, *Procambarus clarkii*, was collected at two sites in the Broad River drainage only.

Cambarus spicatus (Broad River Spiny Crayfish; "High" conservation concern) was not collected at any of the 2010 SCSA random sites in the Broad River basin and has been reported only from one Broad River tributary, Wateree Creek, by Bettinger et al. (2006) based on one juvenile female. Many of the Broad River tributaries sampled in 2010 appeared to have degraded habitat, possibly unsuitable for *C. spicatus*, but the species was not present even in a high quality habitat site such as London Creek (Cherokee Co.; see below). Although potentially present as juveniles/subadults only (see above), this species likely would have been noticed due to its distinctive features of the rostrum. On several dates in 2010, *Cambarus spicatus* and *C. latimanus* were collected in eel ramp tramps placed on the Broad River at the Broad River Dam to assess eel abundance at the dam and potential need for passage of eels attempting to move upstream (although there is a fish passage in place already). The species might be an inhabitant of large river habitats primarily.

Mussels and snails were kept from sites where they were observed, but these collections have not been identified yet. At 89 sites in 2010 mussels were recorded from only 4 sites (1–5 individuals per site), snails were caught at 5 sites (1–20 individuals per site), and the non-native, *Corbicula* sp., was found at 9 sites (1–19 individuals per site, but at some sites was noted as present only). Even though 59 sites were sampled in the Broad River basin, neither dead nor live mussels were encountered at any of them. These results are consistent with those of Bettinger et al. (2006), who reported mussels at only one of 37 sites sampled for invertebrates in the Broad River basin; four species of mussels were collected in upper Clark Fork in Kings Mountain State Park by Bettinger et al. (2006); however, in 2010 at a SCSA random site further downstream, no mussels were observed or collected. Therefore, it appears that Broad River basin tributaries generally do not support native mussels, probably due to disturbed and degraded stream habitat.

However, there could still be native mussel populations existing in isolated expanses of suitable habitat in certain streams (such as in upper Clark Fork). Mussels were found only in the Lower Santee ASLP and Sandhills ecobasins. In Buckhead Creek (Calhoun Co.), a small, lanceolate species of *Elliptio* was collected. The mussel appeared to be common at the site but was less abundant than *Corbicula* sp. in several grab-samples of bottom substrate. Live mussels from several sites were preserved in 95% ethyl alcohol for future use in genetic studies that should help resolve some of the current taxonomic uncertainty with South Carolina's freshwater mussels.

Crayfish and mussel summary for Pond C site (William State Lee III Nuclear Station)

Twenty-eight crayfish collections were made by Duke Energy in 2008 and 2009; these were borrowed and examined in May 2010 to determine species composition. In addition, crayfishes were sampled by SCDNR and Duke Energy personnel on 3 dates in 2010 using 3 different sampling methods (Table 1). Crayfishes collected from London Creek in the area proposed for impoundment (Pond C footprint) included: 1) *Cambarus* sp. cf. *acuminatus* (*Cambarus* “sp. C”) [listed in Duke Energy’s Supplement EA report as *Cambarus acuminatus*; it is an undescribed species being studied by John Cooper at North Carolina State Museum of Natural Sciences], 2) *Cambarus reduncus* [this species was collected by Duke Energy but not listed in their Supplement EA report], and 3) *Procambarus acutus*. None of the 3 crayfish species are of conservation concern in South Carolina presently. Two are stream dwelling species primarily (*C.* sp. cf. *acuminatus* and *P. acutus*), whereas the other is a burrowing species (*C. reduncus*). *Cambarus* sp. cf. *acuminatus* and *P. acutus* were collected in London Creek by both Duke Energy personnel and SCDNR personnel. *Cambarus reduncus* and *P. acutus* were collected in the London Creek floodplain by Duke Energy personnel in 2008 using pitfall traps intended to capture small mammals and herpetofauna (Mark Auten, Duke Energy, pers. comm.). *Cambarus reduncus* was not listed in the Supplement Environmental Assessment report from Duke Energy. *Cambarus spicatus* (Broad River spiny crayfish) is a species of high conservation concern in South Carolina that occurs in the Broad River drainage and potentially could occur in London Creek; however, the species has **not** been collected in London Creek after repeated sampling.

Table 1. Crayfishes collected from London Creek in 2010.

Scientific Name	**Common Name**	**Date Collected**	**Collection Method**	**Conservation Priority**
Cambarus sp. cf. *acuminatus*	none	11 January 2010	Hand picking and dipnets	none
Cambarus sp. cf. *acuminatus*	none	22 January 2010	Crayfish traps	none
Cambarus sp. cf. *acuminatus*	none	12 May 2010	Electrofishing (SCSA)	none
Procambarus acutus	White River Crawfish	12 May 2010	Electrofishing (SCSA)	none

Neither shells nor live individuals of any native freshwater mussels were encountered during any of the sampling trips in 2010, and they were not reported by Duke Energy personnel during 2008 and 2009; thus, London Creek does not appear to support any native mussel species.

Recommendations

Collecting

Continue to collect decapods and mollusks during ecobasin surveys because in 2006–2010 useful distribution information was obtained for several rare species of conservation concern and also for non-native species, and some of the collections will provide data to allow better identifications of species in the future.

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Prepared By: William Poly Title: Aquatic Biologist

Job Title: Smallmouth bass stocking assessment – Broad River, Lake Jocassee, and Lake Robinson

Period Covered July 1, 2009 – June 30, 2010

Summary

We continued our study evaluating the SCDNR smallmouth bass stocking program. Fish stocked as fry and fingerlings into the Broad River during 2008 made a poor contribution to the year class, representing only 5% of age-1 smallmouth bass collected during fall 2009. In contrast fry and fingerlings stocked into Lake Jocassee continue to contribute more to the year class than wild fish. Marking efficacy continues to be good at the Cheraw State Fish Hatchery where smallmouth bass marking efficacy was 100% during 2008.

Introduction

Smallmouth bass have been stocked intermittently into the Broad River and Lake Jocassee since 1984 and 1980, respectively. Each of those systems has developed small, but unique fisheries that have demonstrated the ability to grow trophy-size smallmouth bass. Numbers and sizes of fish stocked have varied greatly depending on availability. Routinely fingerling and sub-adult smallmouth bass are stocked each year; however, it is not known which of these stockings has the higher survival and ultimately contributes to the fishery. Identifying which stocking size has the greater relative survival and adjusting that value for production costs will allow hatchery managers to focus production on the most economically beneficial size group.

Materials and Methods

OTC Marking and Stocking

Smallmouth bass fry (35 - 50 mm TL) and fingerlings (150 – 200 mm TL) will be reared and marked with OTC at the Cheraw State Fish Hatchery in accordance with the SCDNR protocol for immersion marking juvenile fish. Fish to be stocked as fry will receive a single OTC mark and stocked during spring and those stocked during fall as fingerlings will receive a second OTC mark to facilitate differentiation of the two size groups. OTC Marking efficacy will be determined for each marking (immersion) event. Thirty fish from each marking event will be retained and held separately in raceways or aquariums at the Cheraw State Fish Hatchery for at least 14 (preferably 21 d) days post immersion. Sagittal otoliths will then be removed from each fish and mark detection will be conducted at the Eastover Lab.

Stocking of smallmouth bass fry and fingerlings will occur each year from 2005 through 2009. During late May smallmouth bass fry will be stocked into the Broad River and Lake Jocassee. Approximately 8,000 smallmouth bass fry will be equally divided and stocked into three reaches (upper, middle, and lower) of the Broad River. Roughly 9,000 smallmouth bass fry will be divided equally and stocked into Lake Jocassee at two locations. During October approximately 2,700 and 3,000 fingerling fish will be stocked in equal proportions into the Broad River and Lake Jocassee, respectively, at the fingerling stocking locations.

Field Data Collection

Boat electrofishing during late summer and early fall, prior to fall stocking of fingerlings, will be used to collect smallmouth bass from the Broad River. Angling may also be used to collect fish if sufficient numbers are not collected with boat electrofishing gear. Up to 80 age-1 fish from each of the three river sections will be collected for evaluation, but all smallmouth bass collected will be retained for ageing.

Boat electrofishing and littoral gill netting will be used to collect smallmouth bass from Lake Jocassee. Electrofishing will be conducted in March. Smallmouth bass will also be collected using littoral gill net sets. Sampling will include deployment of experimental multi-filament nylon nets, 150 feet x 6 feet, containing three 10-foot panels each of five mesh sizes (1, 1.5, 2, 2.5, and 3 inch, bar measure). Nets will be set horizontal on the bottom (littoral sets) at depths ranging from 10-50 feet for two consecutive days at five standardized locations during the months of January, March, May, and November, for a total of forty net-nights. This is an on-going standardized sampling program on Lake Jocassee, and it will be utilized to collect fish for this study.

Total length and weight will be recorded for each smallmouth bass collected. Sagittal otoliths will be removed from each fish to estimate age. Otoliths of fish from the 2005 – 2009 year class will be examined for OTC marks.

Results

OTC Marking and Stocking

During 2009 an estimated 10,000 smallmouth bass fry (mean TL = 38 mm) and 3,500 smallmouth bass fingerlings (mean TL = 140 mm) were stocked at five locations into the Broad River. In Lake Jocassee 7,500 smallmouth bass fry were stocked during spring and 2,500 smallmouth bass fingerlings were stocked during fall at two locations. All spring stocked fry received a single OTC mark in one immersion event and fall stocked fingerlings received their first OTC mark in a second immersion marking event. Each fall stocked fingerling received a second OTC mark during one of three separate marking events. All OTC immersion marking occurred at the Cheraw State Fish Hatchery. Overall marking efficacy of spring and fall-stocked smallmouth bass was evaluated by reviewing 100 otoliths, with at least 20 otoliths from each marking event. Marking efficacy was 100% with each otolith reviewed containing the correct number of clearly readable marks.

Broad River

During October 2009 smallmouth bass were collected with angling gear from three river sections on 4 sampling days (Table 1). An unusually wet fall limited the number of "good" angling days, as a result smallmouth bass collections were augmented with 3 days of electrofishing on two river sections (Table 2). In all, 202 smallmouth bass were collected during 2009 and their otoliths were read whole to estimate their age (Table 3).

Table 1. River section sampled, number of anglers, effort and CPUE (No/h) of smallmouth bass (SMB) collected from the Broad River with angling gear during October 2009.

Date	River Section	No Anglers	Time Fished (h)	Total Effort (h)	SMB Collected	CPUE (no./h)
10/27/2009	Below Neal Shoals	4	6.5	26	56	2.15
10/28/2009	Below 99-islands	4	NA	NA	4	NA
10/2009	Below Gaston Shoals	NA	NA	NA	44	NA
11/9/2009	Below 99-islands	4	6.5	26	25	0.96
	2009 Total				**129**	**NA**

Table 2. River section sampled, electrofishing effort, number of smallmouth bass collected and catch per unit effort (CPUE) of smallmouth bass collected from the Broad River during Fall 2009.

Date	River section	Effort (h)	Catch	CPUE (no./h)
10/8/2009	Below Neal Shoals	2.07	28	13.5
10/28/2009	Below 99-islands	0.56	10	17.9
11/19/2009	Below Neal shoals	2.77	35	12.6

Total		73	13.5

Table 3. Age, number of smallmouth collected, mean total length (TL) mm, and standard error (SE) of smallmouth bass collected during fall 2009.

Age	Number	Mean TL	SE
0	9	140	4.4
1	98	222	2.9
2	71	263	4.8
3	22	325	10.7
4	1	408	

Otoliths from 201 smallmouth bass collected from the Broad River during 2009 were successfully reviewed for OTC marks to determine whether they were wild fish or hatchery stocked fish. Of the 9 age-0 fish collected and successfully reviewed for OTC marks 5 were marked, two otoliths had a single mark indicating they were stocked in spring 2009 as fry, and 3 were double marked indicating they were stocked during fall 2009 as fingerlings, the other 4 age-0 fish were presumably wild (Table 4). Otoliths from 97 age-1 fish were successfully reviewed for OTC marks, 92 of those fish were unmarked (wild), 1 was single marked (fry-stocked during spring) and 4 were double marked (fingerling-stocked during fall) (Table 4). The contribution of stocked fish to the 2008 year class one year post-stocking was 5%.

Table 4. Collection year, year class (YC) and the number of wild spawned, spring-stocked and fall-stocked smallmouth bass, based on differential OTC marks, collected from the Broad River, South Carolina.

Year	YC	Wild Fish	Spring Stocked	Fall Stocked	Number Reviewed
2006					
	2002	34			34
	2004	64			64
	2005	29	2	24	55
	2006	92	3		95
2007					
	2004	3			3
	2005	5			5
	2006	154	4	2	160
	2007	70	3		73
2008					
	2002	2			2
	2004	3			3
	2005	5			5
	2006	57	2	1	60
	2007	188	12	6	206
	2008	71	5		76
2009					
	2004	1			1
	2005	1			1
	2006	22			22
	2007	67	4		71
	2008	92	1	4	97
	2009	4	2	3	9

Lake Jocassee and Lake Robinson

Otoliths of 30 smallmouth bass collected from Lake Jocassee during fall 2009 and spring 2010 were successfully reviewed for OTC marks (Table 5). Only 6 age-1 smallmouth bass were collected during 2010 and only one of those smallmouth was wild (unmarked), 1 was single marked (fry-stocked during spring) and 4 were double marked (fingerling-stocked during fall) (Table 4). No attempt was made to collect smallmouth bass from Lake Robinson during fall

2009 or spring 2010.

Table 5. Collection year, year class (YC) and the number of wild spawned, spring-stocked and fall-stocked smallmouth bass, based on differential OTC marks, collected from Lake Jocassee, South Carolina.

Year	YC	Wild Fish	Spring Stocked	Fall Stocked	Number reviewed
2006					
	2003	3			3
	2004		6		6
	2005		1	93	94
2007					
	2003	1			1
	2005	1	2	6	9
	2006		1	43	44
2008					
	2004		1		1
	2005		4	1	5
	2006	1	1		2
	2007	2		1	3
2009					
	2003			1	1
	2005		1	2	3
	2006	1		1	2
	2007				
	2008	1	1		2
2010					
	2005			1	1
	2008	3	3	7	13
	2009	1	1	4	6
	2010	2			2

Discussion

In the Broad River the contribution stocked fish to the 2005 year class was 46%, but the contribution of stocked fish to the 2006 - 2008 year classes averaged only 6% (range; 4% - 9%). Based on the first four years of data collection it appears that there could be large annual variation in the recruitment of wild and stocked fish to age-1 in the Broad River. That variation could be due, in part, to winter and spring river discharge. High or low spring discharges can influence success of natural recruitment and survival of young-of-the-year wild and stocked smallmouth bass. During 2005 the Broad River experienced an average spring with river discharge similar to the 60-year average, but during 2006 - 2008 spring discharges were 40% - 68% of average spring flows (Figure 1). After reviewing the contribution of stocked fish to the 2009 year class, a year with average spring flows and above average winter flows, a stocking recommendation will be made for the Broad River.

In Lake Jocassee the majority (92%) of smallmouth bass collected have been stocked fish and most (81%) of the hatchery fish were stocked as fingerlings during the fall. It appears that the Lake Jocassee smallmouth fishery is dependent on hatchery stockings. If the smallmouth fishery is to be maintained smallmouth should continue to be stocked. Based on the poor return of spring-stocked fry smallmouth should be stocked into lake Jocassee during fall as fingerlings.

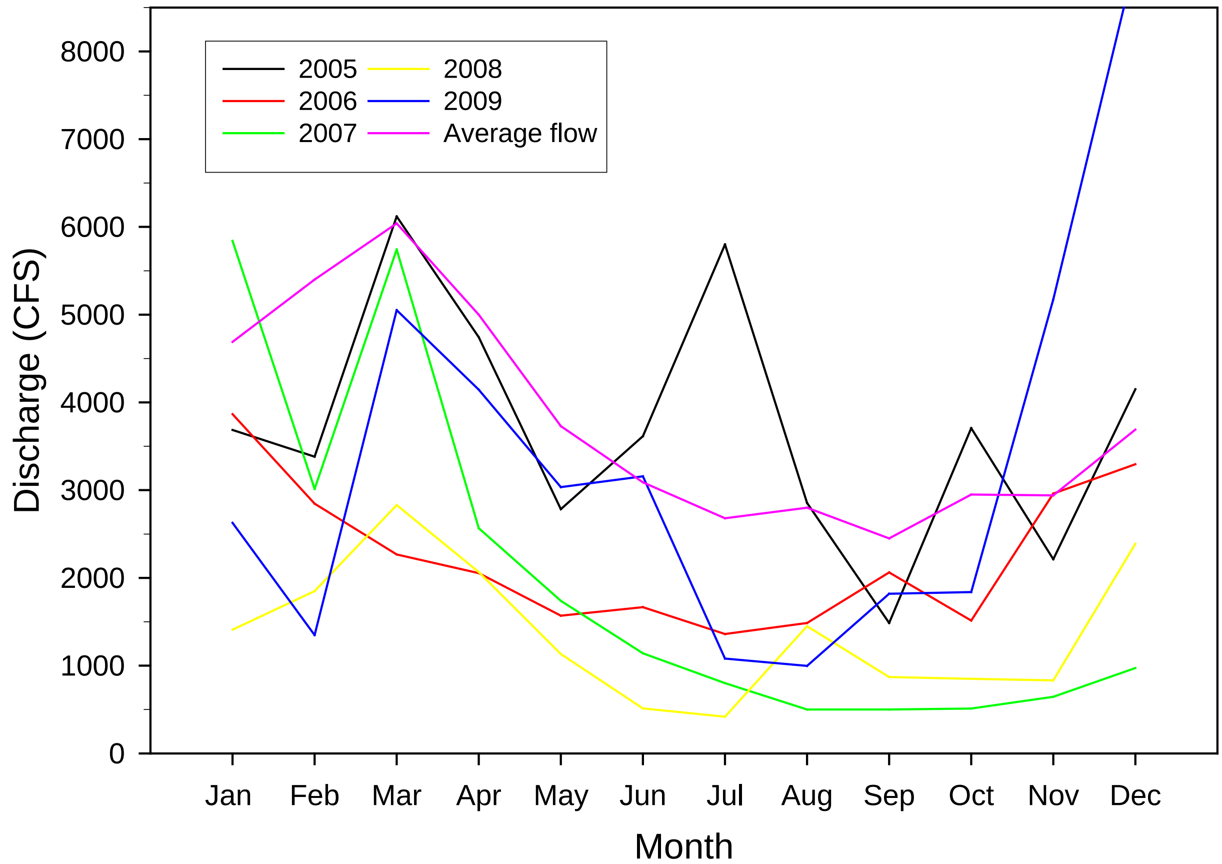

Figure 1. Average monthly discharge (cfs) of the Broad River at Carlisle, South Carolina, mid-point of the river, during 2005 – 2009.

Recommendations

In the Broad River the contribution of stocked fish has been poor; however, fish should be collected during fall of 2010 to determine if contribution of stocked fish differed during a year when young-of-the-year fish were subjected to average spring flows and above average fall – winter flows. In Lake Jocassee, based on limited sample sizes, it appears that fish need to be stocked to maintain the fishery and that spring stocking of fry should be discontinued in favor of fall stocked fingerlings.

Literature Cited

None.

Prepared By: Jason Bettinger Title: Wildlife Biologist III

Job Title: Assessment of condition, growth, contribution to fish community, and diet of striped bass, white perch, and American shad young-of-the-year in the Santee-Cooper lakes, South Carolina

Period Covered July 1, 2009 – June 30, 2010

Summary

Boat electrofishing was conducted each month at two Lake Marion sites during summer of FY10 and FY11 to evaluate relative abundance, growth, condition and diet of key juvenile fish species. During summer 2010 relative abundance of American shad was nearly double that observed during 2009. In contrast, threadfin shad and striped bass relative abundance during 2010 was roughly half of the abundance observed in summer 2009. White perch abundance was similar between years. Growth of American shad, threadfin shad and white perch appeared to be slower in 2010 than 2009 and neither clupeid species grew much, if at all, between August and October 2010. Striped bass appeared to grow slightly faster in 2010 than 2009, but during 2010 their growth ceased after September. Linear regression was used to describe the relationship between wet weights and dry weights for individuals of each key species collected during 2009. Condition (Kn) was calculated for striped bass and compared between years. Kn was not related to total length or week of capture, but was slightly higher in 2010 than 2009.

Introduction

'Fingerling mortality' of striped bass is a key issue for the Santee-Cooper striped bass stakeholders and it has been a key issue of the DNR for many years. Many hypotheses have been generated to define the causes of either good or poor recruitment in a given year. These hypotheses include, but are not limited to, reduction in the adult spawning stock, competition with resident and anadromous species, and reduced nutrient inflow due to drought. The Santee-

Cooper Comprehensive study group of the DNR defined investigation of the 'competition for resources' hypotheses as its primary short-term goal. A strategy was needed to obtain key monitoring data on the species of interest. The objectives of this study are to, 1) Define growth and condition of key juvenile species, 2) describe the diet of each species and 3) define the relative abundance of each key species.

Materials and Methods

Growth, condition and relative abundance

Juvenile American shad, blueback herring, threadfin shad, white perch and striped bass were collected monthly from two Lake Marion sites with boat electrofishing gear. At each site night-time electrofishing was conducted for roughly 10 minutes at each of three transects. We attempted to collect all juveniles of the targeted species. Specimens were preserved on ice and measured (TL, mm) and weighed (mg) within 24 hours of collection. During 2009 a random subsample of up to 15 individuals of each species per site were dried in an oven at 60° C for at least 48 hours. All American shad, white perch, and threadfin shad were dried for 96 hours. Striped bass less than 150 mm TL were dried for 96 hours and those greater than 150 mm TL were dried for 240 hours.

Diet

Up to 15 of each key species per site were preserved in 10% formalin on every sample date. The stomach contents of the preserved specimens will be examined and quantified at the lowest practical taxon.

Results

Growth, condition and relative abundance

Juvenile *Morone sp.* and clupeids were collected at night from two Lake Marion sites with boat electrofishing during June – October 2010. The "Big Water" site was located near I-95 on the Clarendon County side (34.5178, -80.4349) and the "Indian Bluff" site was located midway down the reservoir on the Orangeburg County side (33.4319, -80.3621). Three transects were sampled at each site on 5 different dates. Each site received approximately 0.5 h of electrofishing effort on each sample date. During 2010 thirty transects were sampled with a total electrofishing effort of 5.2 h (Table 1).

Table 1. Number of transects sampled on each date and electrofishing effort (h) during nighttime electrofishing at two sites on Lake Marion, SC during 2010.

	Big Water		Indian Bluff		Total	
Date	Transects	Effort (h)	Transects	Effort (h)	Transects	Effort (h)
6/09/2010	3	0.47	3	0.59	6	1.06
7/19/2010	3	0.49	3	0.55	6	1.04
8/11/2010	3	0.50	3	0.56	6	1.06
9/13/2010	3	0.53	3	0.50	6	1.03
10/5/2010	3	0.45	3	0.55	6	1.00
Total	15	2.45	15	2.75	30	5.20

Overall American shad and white perch dominated the community representing 44% and 41% of all fish collected during 2010, respectively (Figure 1). Striped bass and threadfin shad were common, accounting for 8% and 6%, respectively of the fish collected during 2010. Blueback herring were rare accounting for < 1% of all fish collected in both years. Relative abundance of the target species varied by site and date. American shad were a larger component of the sample at the Big Water site during 2010, where they accounted for more than 67% of all fish collected, than the Indian Bluff site where they represented only17% of all fish collected (Figure 1). Conversely, white perch accounted for 61% of juvenile fish collected during 2010 at Indian Bluff and represented 24% of all fish collected at Big Water. During 2010 striped bass relative abundance was comparable at the two sites (9% and 7%). American shad relative abundance in 2010 was nearly double that of their abundance in 2009 (Figure 1). Striped bass and threadfin shad were much less abundant in 2010 than 2009, while white perch and blueback herring abundance were similar each year.

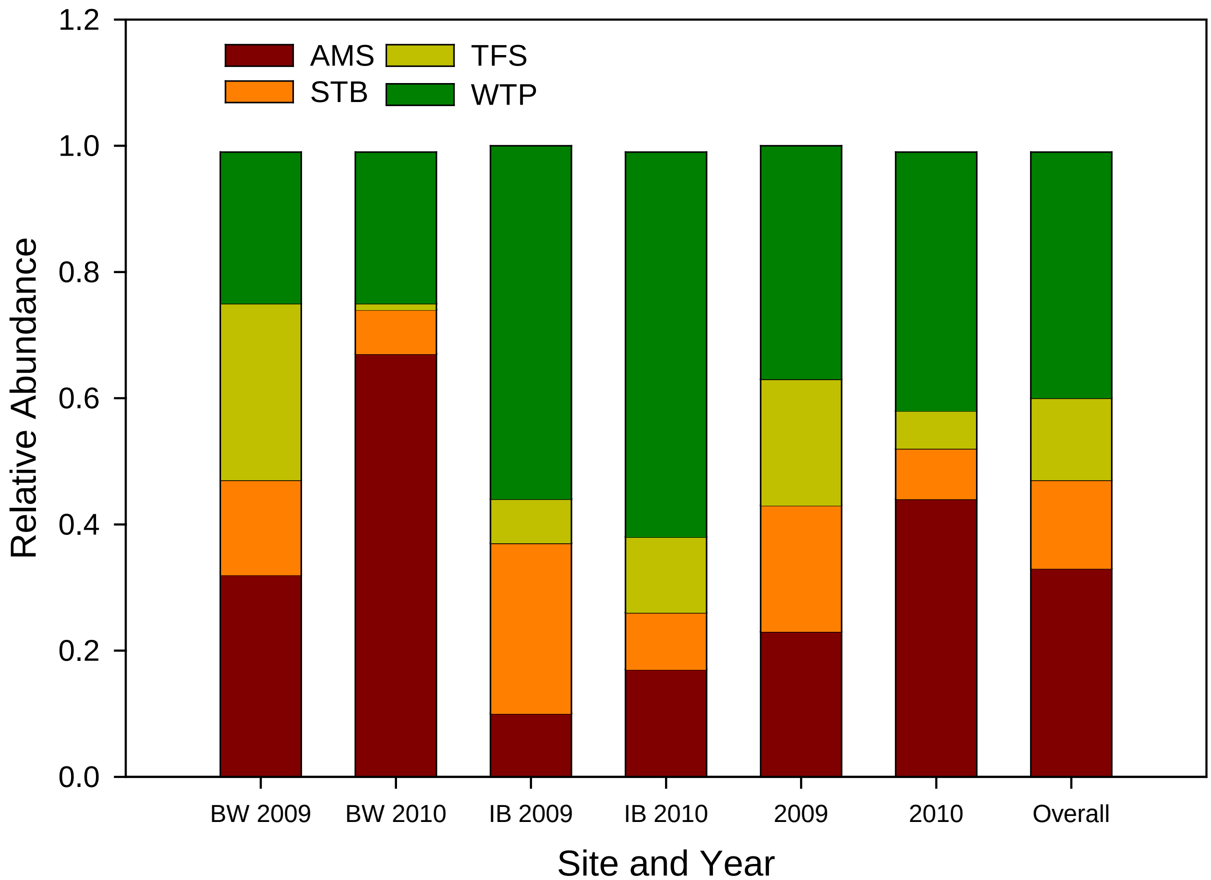

Figure 1. Relative abundance of American shad (AMS), threadfin shad (TFS), Striped bass (STB) and white perch (WTP) collected from the Big Water (BW) and Indian Bluff (IB) sites on Lake Marion, South Carolina, during 2009 and 2010.

Catch per unit effort (CPUE) varied among species and dates. During 2010 American shad CPUE (No/h) ranged from 10 to 590 and was higher at Big Water than Indian Bluff (ANOVA; $P < 0.05$), overall mean catch between years was not significantly different (Table 2). Striped bass CPUE ranged from 2 to 111 during 2010, catch rates did not differ between sites, but CPUE of striped bass was significantly higher in 2009 than 2010 (ANOVA; $P<0.05$) (Table 2). White perch CPUE during 2010 ranged from 0 to 426, CPUE did not differ between years, but white perch CPUE was significantly higher at the Indian Bluff site than the Big Water site (Table 2.)

Table 2. Mean catch per unit effort (no/h), standard error in parentheses, for young of year American shad, striped bass, and white perch at each of two Lake Marion sites sampled with boat electrofishing during 2009 and 2010.

	American shad		Striped bass		White perch	
Date	Big Water	Indian Bluff	Big Water	Indian Bluff	Big Water	Indian Bluff
6/24/2009		36 (22)		132 (83)		31 (27)
6/30/2009	227 (203)		14 (14)		14 (14)	--
7/7/2009	124 (32)	62 (21)	118 (33)	359 (165)	204 (99)	219 (83)
7/21/2009	150 (60)	0 (0)	146 (80)	86 (4)	102 (51)	122 (88)
8/18/2009	50 (33)	18 (0)	74 (32)	84 (9)	186 (40)	574 (157)
9/16/2009	424 (317)	28 (2)	112 (51)	10 (7)	142 (16)	134 (28)
11/3/2009	13 (6)	64 (37)	29 (21)	6(6)	122 (11)	118 (54)
6/9/2010	405 (375)	10 (5)	2 (2)	68 (39)	0 (0)	112 (18)
7/19/2010	222 (105)	122 (49)	23 (12)	35 (29)	115 (45)	286 (28)
8/11/2010	36 (12)	79 (30)	16 (7)	5 (3)	40 (17)	235 (193)
9/13/2010	590 (267)	44 (13)	23 (5)	26 (18)	261 (134)	426 (180)
10/5/2010	460 (254)	110 (44)	111 (52)	33 (27)	225 (73)	155 (33)
Mean 2009	168 (65)	35 (9)	79 (19)	114 (38)	122 (22)	191 (5)
Mean 2010	343 (104)	73 (17)	35 (14)	33(11)	128 (38)	214 (54)
Total Mean	245 (60)	50 (9)	59 (12)	78 (23)	125 (21)	214 (36)

On 9 June 2010 American shad mean total length (TL) was 55 mm (SE = 1.6), American shad grew slowly throughout the summer and reached a mean TL of 72 mm (SE = 0.8) by early

October (Figure 2). Growth of American shad appeared to be much slower in 2010 than 2009; American shad collected in October 2010 were of similar size, approximately 72 mm TL, as those collected during July 2009. Growth of threadfin shad also appeared slower in 2010 than 2009, with very little growth occurring during the summer (Figure 2).

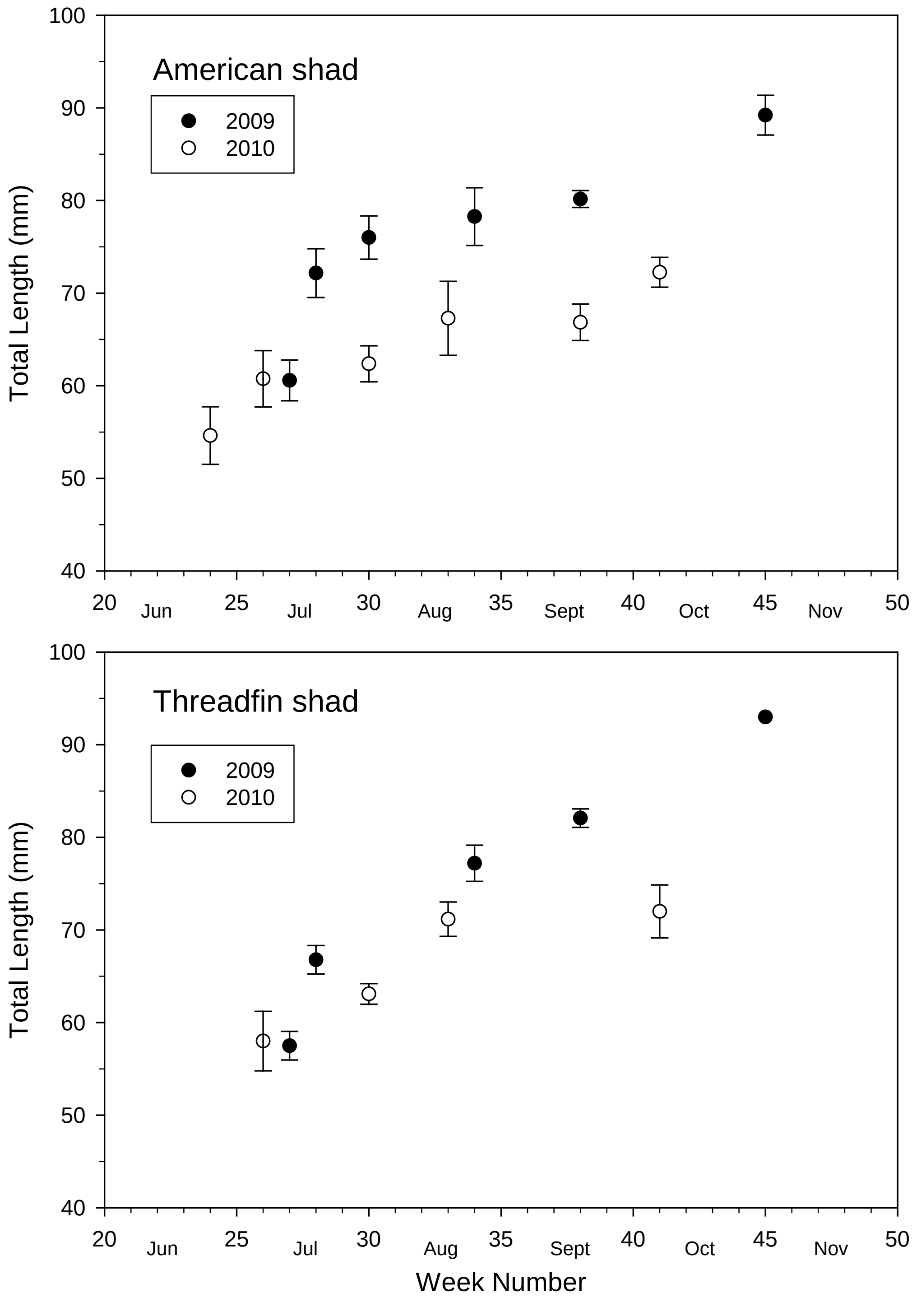

Figure 2. Mean total length (± 2 SE) of American shad and threadfin shad collected from Lake Marion, South Carolina during 2009 and 2010.

In early June white perch mean total length was 49 mm (SE = 0.5), white perch grew steadily throughout the summer and attained a mean TL of 71 mm (SE = 0.45) by early October (Figure 3). As with the Clupeid species white perch also appeared to grow slower in 2010 than 2009. Striped bass mean TL in early June was 68 mm (SE = 1.15) (Figure 3). Striped bass grew steadily through September reaching a mean TL of 124 mm (SE = 6.4), but their growth slowed considerably between September and October. Striped bass growth during 2010 was comparable to the growth observed in 2009 through September, but then decreased drastically. Striped bass growth during 2010 was much slower than that observed in 2008.

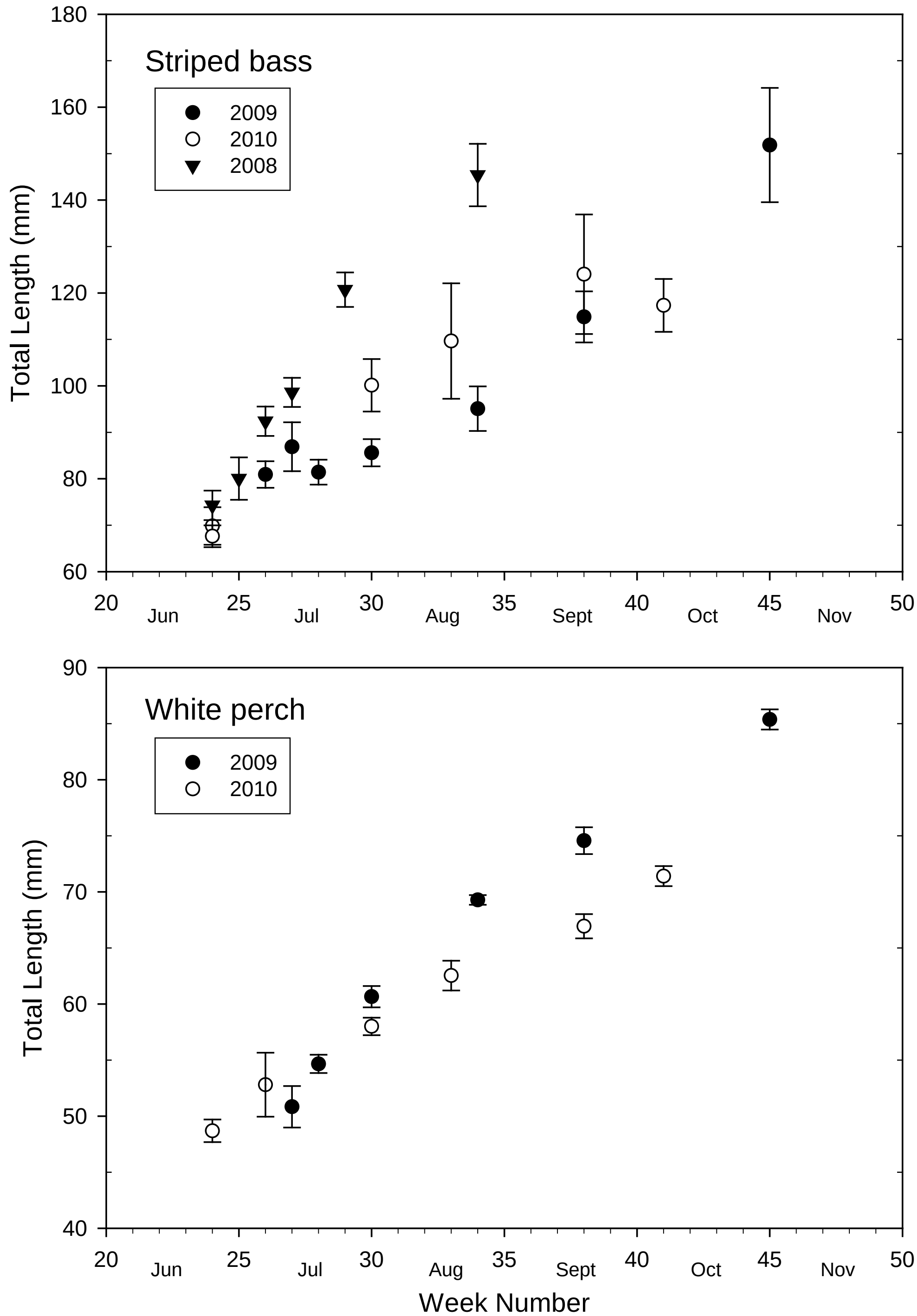

Figure 3. Mean total length (± 2 SE) of striped bass and white perch collected from Lake Marion, South Carolina during 2009 and 2010.

Dry weights after drying for at least 96 hours were determined for 385 individuals collected during 2009 (Table 3). Threadfin shad were processed for fish collected on only two sample date, but all other species were collected on each of the five 2009 sample dates. Weight reduction for fish after drying was > 74% for each species. There was a significant relationship for all species in wet weight-dry weight regressions (Table 3). Wet weight was an excellent predictor of dry weight in all species except American shad where there was more variation in the relationship especially for fish > 4 g wet weight.

Table 3. Number of each species dried for at least 96 hours, mean TL, range in parentheses, mean reduction in weight, SE in parentheses, and linear wet weight-dry weight regression coefficients for fish collected from Lake Marion during 2009.

Species	N	TL (mm)	Mean Reduction (%)	a	b	R^2
American shad	104	80 (59 -105)	74 (0.21)	0.04	3.90	0.92
Striped bass	121	102 (65 -206)	76 (0.17)	0.92	3.79	0.99
Threadfin shad	22	72 (60 -81)	75 (0.44)	0.96	2.98	0.97
White perch	138	70 (50 -93)	76 (0.12)	0.27	3.80	0.99

Condition (Kn) of juvenile striped bass was calculated for fish collected during 2009 and 2010. Striped bass Kn was slightly higher in 2010 (mean Kn = 1.06) than 2009 (mean Kn = 1.02) (ANOVA; $P < 0.05$). Mean Kn was not related to striped bass TL or date in Lake Marion during 2010.

Diet

During 2009 and 2010 a sample of each of the key species was retained on every date for diet analysis. A method for quantifying juvenile fish diets has been developed, but we have not begun processing the samples.

Recommendations

During FY11 we will combine juvenile fish data collected from Lake Marion with similar data collected from Lake Moultrie. Once a database has been constructed the data will be used to describe relative abundance, growth and condition of each species and evaluate spatial and temporal differences within the lakes. Diet samples collected from Lake Marion during 2009 and 2010 will be processed and the diets of each juvenile species described and the potential for resource competition assessed.

Literature Cited

None.

Prepared By: Jason Bettinger   Title: Wildlife Biologist III

Job Title: American eel abundance, and distribution along the spillways of the Lake Wateree Dam on the Wateree River and Columbia Dam on the Broad River

Period Covered July 1, 2009 – June 30, 2010

Summary

Eel ramp traps, minnow traps and backpack electrofishing were used to assess the presence and abundance of American eel below Wateree Dam on the Wateree River and Columbia River Dam on the Broad River. Eel ramp traps were fished for a total of 748 ramp days and 229 minutes of electrofishing effort was expended below the two dams. The extensive sampling resulted in the capture of only 3 American eel. It appears that few American eel utilized the areas below Wateree Dam and Columbia Dam during 2010.

Introduction

Since the 1980's a decrease in American eel *Anguilla rostrata* catch rates has heightened concerns over the status of the population. The cause of this decline is unknown, but several factors (e.g. migration barriers, habitat loss and degradation, overfishing, etc.) have been identified that could affect population size and distribution. American eel were historically abundant along the Atlantic slope where their range extended into the Wateree and Broad rivers and their tributaries. Dams constructed along those rivers and tributaries have impeded the inland migration of juvenile eels as well as the seaward migration of adults and altered their distribution within the Santee River Basin. Facilitating passage of American eel around migrations barriers should benefit American eel populations and augment restoration efforts. Juvenile eels may exhibit specific habitat preferences that could influence where along the dam they attempt upstream passage. Maximizing eel passage will require effective placement of passage facilities. The objectives of this study are to quantify the migrational timing and abundance of American eels at various locations along the spillways of the Lake Wateree Dam on the Wateree River and the Columbia Dam on the Broad River, evaluate factors that effect this distribution, and identify areas where American eel collection rates will be maximized.

Materials and Methods

Eel ramp traps, standard minnow traps and backpack electrofishing were used to collect American eels at the Wateree and Columbia dams. The ramp traps were constructed from ¾ inch plywood and range from roughly 7 ft to 13 ft in length and are 12 inches wide (Figure 1). The ramp deck is covered with 1-in polyethylene Akwadrain material and terminates at a covered collection bucket. Water is supplied to each ramp and collection bucket through gravity fed supply lines. Eel ramp traps were set at three locations across the base of the Wateree and Broad River dams during March and June 2010, respectively. In addition to ramp traps, six standard minnow traps baited with cut gizzard shad were deployed at Wateree Dam on 17 May and were checked and re-baited through 30 June.

Figure 1. Eel ramp #1 at Wateree Dam.

The presence of eels in the vicinity of the Wateree Dam and their abundance was evaluated by backpack electrofishing at least monthly during the spring/summer migration season. All eels collected were enumerated, measured (TL) and released.

Water temperature at each trap location was recorded continuously with HOBO Pendant temperature loggers. Dissolved oxygen and conductivity were recorded during each sampling visit. Water flowing into the trap was occasionally measured to ensure traps had similar discharge rates.

Results

Ramp traps at Wateree Dam were visited on 46 dates between 10 March and 22 September; ramp traps at Columbia Dam were visited on up to 22 dates between 20 May and 22 September (Table 1). Delayed trap installation and frequent spilling of water over Columbia Dam limited the number of successful trap days. Ramp traps 2 and 3 at Columbia were detached, on multiple occasions, from the dam during spilling and needed to be replaced. Backpack electrofishing at the base of the dams was conducted on three dates at Columbia Dam and seven dates at Wateree Dam (Table 2).

Table 1. Installation dates for eel ramp traps at Wateree and Columbia dams, the number of times each trap was visited, and number of operational trap days between installment and 22 September 2010.

Site	Trap No	Date	Visits	Trap Days
Wateree	1	3/10/2010	46	188
	2	3/10/2010	46	196
	3	3/10/2010	46	180
Columbia	1	5/20/2010	22	97
	2	5/20/2010	6	24
	3	6/8/2010	11	63

Table 2. Backpack electrofishing effort (minutes) conducted below Wateree and Columbia dams during 2010, by date.

	Site		
Date	Columbia	Wateree	Total Effort
4/16/2010		30	30
4/28/2010		16	16
5/12/2010		18	18
5/21/2010		17	17
6/11/2010		18	18
6/18/2010	35		35
7/9/2010	29	27	57
8/25/2010	10	27	38
Total Effort	75	154	229

Only 3 American eels have been collected. Two eels were collected in ramp traps at the Wateree Dam: a 108 mm TL eel was collected 21 April and a 394 mm TL eel was collected 10 August. One eel (314 mm TL) was collected from the Columbia Dam with backpack electrofishing gear 25 August.

Due to poor ramp trap catch rates a preliminary evaluation of ramp trap retention and capture efficiency was conducted. In preliminary lab trials 88% of large eels (> 240 mm TL) and 27% of small eels (< 130 mm TL) ascended ramp traps during initial 12 and 4 hour exposures, respectively. Trap collection buckets satisfactorily retained eels > 97 mm TL; smaller eels escaped through drain holes.

Discussion

It does not appear that many eels utilized the bypassed area below Wateree Dam during March – September, 2010, nor were eels abundant below Columbia Dam. Although ramp trap capture efficiency needs further evaluation, it is unlikely eels were abundant and not captured since none were collected in baited minnow traps and only one eel was collected while backpack electrofishing.

Recommendations

We will continue the study as planned, monitoring ramp traps below the two dams and conduct routine backpack electrofishing. Due to the frequent dislodgement of ramp traps below Columbia dam a new eel trap design needs to be evaluated and installed during 2011.

Literature Cited

None.

Prepared By: Jason Bettinger Title: Wildlife Biologist III

Job Title: Distribution of Striped Bass in J. Strom Thurmond Reservoir, South Carolina - Georgia, in Relation to Pump Storage Operation and Hypolimnetic Oxygenation

Period Covered July 1, 2009 – June 30, 2010

Summary

During spring 2010 we initiated a study to monitor striped bass use of an oxygenated area in lower J. Strom Thurmond Reservoir. Seventeen striped bass collected from the reservoir and 4 tributaries were implanted with acoustic transmitters and tracked on 13 dates. Next year additional striped bass will be implanted with transmitters and an acoustic receiver array will be deployed to monitor striped bass use of the oxygenated area.

Introduction

J. Strom Thurmond (Thurmond) Reservoir supports a popular recreational striped bass fishery. Striped bass production at Thurmond is largely due to suitable habitat provided by artificially oxygenated, hypolimnetic releases from Richard B. Russell (Russell) Dam, that provide cool well oxygenated water in the tailrace and upper portions of Thurmond Reservoir.

During 2011 Russell Dam will commence expanded pump-storage operations which could result in warmer tailrace temperatures below Russell Dam, possibly reducing suitable habitat for some species of fish. Given the unsuitable striped bass habitat throughout most of the reservoir during the summer the loss of the refuge in the Russell tailrace and upper Thurmond could have a negative impact on the striped bass fishery. To mitigate for the potential loss of striped bass habitat in the Russell tailrace and upper Thurmond, the USACE plans to install an oxygen injection system in the lower portion of Thurmond to provide striped bass habitat.

It is unknown how striped bass will utilize the expected reduction in habitat in the Russell tailrace and upper Thurmond or the new artificially oxygenated area in the lower reservoir. Considerable expense has been expended in the development of the new oxygen injection system and it is important to document the extent of striped bass use of the newly-created habitat. Information on the seasonal distribution of striped bass after project implementation will be important for successful management of the striped bass fishery in Thurmond Reservoir

Materials and Methods

The study will monitor the seasonal movement of adult striped bass in Thurmond Reservoir. Specifically monitoring their seasonal use of the current refuge area in the upper reaches of Thurmond as well as the area below Modoc, SC scheduled for enhancement. In spring of 2010 and 2011 striped bass will be collected from the Russell tailrace and at least two major tributaries (e.g., Little River, GA and Little River, SC) and surgically implanted with individually coded temperature sensing acoustic transmitters. Two different transmitters manufactured by Sonotronics will be evaluated during the first year. A high powered long-range transmitter (Model CHP-87-L) expected to last 18 months will be implanted in striped bass > 575 mm TL and a less powerful transmitter (Model CTT-83-3) expected to last 36 months will be implanted in striped bass > 480 mm TL. An array of remote acoustic receivers (Sonotronics Inc, SUR-3BT) will be used to collect movement data. Receivers will be positioned throughout the mainstem reservoir with expanded arrays in the tailrace and oxygen injected area to achieve continuous coverage of the Savannah and Little River channels in those areas. Additional location data will be collected with a hand held receiver to identify other potential refuges and locate missing fish. Temperature and oxygen profiles at 1-m depth intervals will be determined biweekly during the summer study period at a series of fixed stations throughout the monitored area. Fish position in relation to temperature and oxygen will be determined.

Results

Seventeen striped bass (mean TL = 833 mm; range 565 – 1400 mm TL) collected from Thurmond Reservoir and four tributaries were implanted with acoustic transmitters between 16 April and 4 May 2010 (Table 1). Two of those fish received the longer lasting, but less powerful CTT model transmitter and the remaining fish received the high powered CHP transmitter. Striped bass implanted with transmitters were manually tracked on 13 days between 26 May 2010 and 1 July 2010. During those tracking events 9 different fish were located at least once.

Table 1. Striped bass date of implantation, transmitter type, total length (TL), and Location collected.

Date	Fish No	Type	TL	Location
4/16/2010	1	CHP	655	Little River, SC
4/16/2010	2	CHP	665	Little River, SC
4/16/2010	3	CHP	820	Little River, SC
4/16/2010	4	CHP	650	Long Cane Creek, SC
4/16/2010	5	CHP	730	Long Cane Creek, SC
4/20/2010	6	CHP	1200	Anthony Shoals, Broad River, GA
4/20/2010	7	CHP	693	Hester's Bottom, JST, SC
4/28/2010	8	CTT	565	Little River, GA
4/28/2010	9	CHP	690	Little River, GA
4/28/2010	10	CHP	632	Little River, GA
5/4/2010	11	CHP	863	Anthony Shoals, Broad River, GA
5/4/2010	12	CHP	930	Anthony Shoals, Broad River, GA
5/4/2010	13	CHP	950	Anthony Shoals, Broad River, GA
5/4/2010	14	CHP	1200	Anthony Shoals, Broad River, GA
5/4/2010	15	CTT	722	Anthony Shoals, Broad River, GA
5/4/2010	16	CHP	1400	Anthony Shoals, Broad River, GA
5/4/2010	17	CHP	800	Anthony Shoals, Broad River, GA

Discussion

To date very little information has been collected on this project.

Recommendations

Continue the study as planned. During summer 2010 and spring 2011 we will attempt implant at least 20 and 30 additional striped bass, respectively, with sonic transmitters. Roughly 50 SUR-3BT receivers (Sonotronics, Inc) will be deployed within the reservoir and tributaries to monitor the movements of striped bass and their use of the oxygenated area.

Literature Cited

None.

Prepared By: Jason Bettinger   Title: Wildlife Biologist III

Appendix A

Codes for South Carolina Fish Species Occurring in Freshwater
New listings include date added (m-d-y). Updated 9/27/01

1	AEL	American eel	*Anguilla rostrata*
2	ALW	Alewife	*Alosa pseudoharengus*
3	AMS	American shad	*Alosa sapidissima*
4	ANF	Atlantic needlefish	*Strongylura marina*
5	ASS	Atlantic silverside	*Menidia menidia (9-26-01)*
6	AST	Atlantic sturgeon	*Acipenser oxyrhynchus*
7	BBD	Blackbanded darter	*Percina nigrofasciata*
8	BBH	Brown bullhead	*Ameiurus nebulosus*
9	BBP	Bluebarred pygmy sunfish	*Elassoma okatie*
10	BBS	Blackbanded sunfish	*Enneacanthus chaetodon*
11	BCF	Blue catfish*	*Ictalurus furcatus*
12	BDD	Banded darter	*Etheostoma zonale (9-26-01)*
13	BDK	Banded killifish	*Fundulus diaphanus*
14	BDS	Banded sunfish	*Enneacanthus obesus*
15	BFK	Bluefin killifish*	*Lucania goodei*
16	BFN	Bowfin	*Amia calva*
17	BFS	Bannerfin shiner	*Cyprinella leedsi*
18	BHC	Bluehead chub	*Nocomis leptocephalus*
19	BJR	Brassy jumprock	*Scartomyzon brassia (9-26-01)*
20	BLB	Black bullhead	*Ameiurus melas*
21	BLC	Black crappie	*Pomoxis nigromaculatus*
22	BLG	Bluegill	*Lepomis macrochirus*
23	BLH	Blueback herring	*Alosa aestivalis*
24	BLS	Bluespotted sunfish	*Enneacanthus gloriosus*
25	BMF	Bigmouth buffalo	*Ictiobus cyprinellus (9-26-01)*
26	BND	Blacknose dace	*Rhinichthys atratulus*
27	BNM	Bluntnose minnow*	*Pimephales notatus*
28	BNT	Brown trout*	*Salmo trutta*
29	BPS	Banded pygmy sunfish	*Elassoma zonatum*
30	BRS	Bridle shiner	*Notropis bifrenatus (9-26-01)*
31	BRT	Brook trout	*Salvelinus fontinalis*
32	BSS	Brook silverside	*Labidesthes sicculus*
33	BTM	Broadtail madtom	*Noturus* sp. n.
34	BYK	Bayou killifish	*Fundulus pulvereus*
35	CAD	Carolina darter	*Etheostoma collis*
36	CCF	Channel catfish*	*Ictalurus punctatus*
37	CCS	Creek chubsucker	*Erimyzon oblongus*
38	CHP	Chain pickerel	*Esox niger*
39	CMD	Christmas darter	*Etheostoma hopkinsi*
40	CMS	Comely shiner	Notropis amoenus

41	CPS	Carolina pygmy sunfish	*Elassoma boehlkei*
42	CRC	Creek chub	*Semotilus atromaculatus*
43	CRP	Carp*	*Cyprinus carpio*
44	CSH	Coastal shiner	*Notropis petersoni*
45	DKS	Dusky shiner	*Notropis cummingsae*
46	DSF	Dollar sunfish	*Lepomis marginatus*
47	DTG	Darter goby	*Gobionellus boleosoma*
48	EMM	Eastern mudminnow	*Umbra pygmaea*
49	EPS	Everglades pygmy sunfish	*Elassoma evergladei*
50	ESM	Eastern silvery minnow	*Hybognathus regius*
51	FAS	Fat Sleeper	*Dormitator maculatus*
52	FBH	Flat bullhead	*Ameiurus platycephalus*
53	FBS	Fieryblack shiner	*Cyprinella pyrrhomelas*
54	FCF	Flathead catfish*	*Pylodictis olivaris*
55	FHM	Fathead minnow*	*Pimephales promelas*
56	FLR	Flier	*Centrarchus macropterus*
57	FTD	Fantail darter	*Etheostoma flabellare*
58	FWG	Freshwater gobie	*Gobionellus shufeldti*
59	GCP	Grass carp*	*Ctenopharyngodon idella*
60	GFS	Greenfin shiner	*Cyprinella chloristia*
61	GHS	Greenhead shiner	*Notropis chlorocephalus*
62	GLF	Goldfish*	*Carassius auratus*
63	GLS	Golden shiner	*Notemigonus crysoleucas*
64	GLT	Golden topminnow	*Fundulus chrysotus*
65	GSF	Green sunfish*	*Lepomis cyanellus*
66	GZS	Gizzard shad	*Dorosoma cepedianum*
67	HBC	Highback chub	*Hybopsis hypsinotus*
68	HCK	Hogchoker	*Trinectes maculatus*
69	HFC	Highfin carpsucker	*Carpiodes velifer*
70	HFS	Highfin shiner	*Notropis altipinnis*
71	HKS	Hickory shad	*Alosa mediocris*
72	ICS	Ironcolor shiner	*Notropis chalybaeus*
73	ILS	Inland silverside	*Menidia beryllina*
74	LES	Longear sunfish*	*Lepomis megalotis*
75	LKC	Lake chubsucker	*Erymyzon sucetta*
76	LMB	Largemouth bass	*Micropterus salmoides*
77	LND	Longnose dace	*Rhinichthys cataractae*
78	LNG	Longnose gar	*Lepisosteus osseus*
79	LSK	Least killifish	*Heterandria formosa*
80	LTM	Lined topminnow	*Fundulus lineolatus*
81	MDS	Mud sunfish	*Acantharchus pomotis*
82	MGM	Margined madtom	*Noturus insignis*
83	MKF	Marsh Killifish	*Fundulus confluentus*
84	MMC	Mummichog	*Fundulus heteroclitus*
85	MRS	Mirror shiner	*Notropis spectrunculus*
86	MSK	Muskellunge	*Esox masquinongy (9-26-01)*

87	MSQ	Mosquitofish	*Gambusia affinis*
88	MTM	Mountain mullet	*Agonostomus monticola*
89	MTS	Mottled sculpin	*Cottus bairdi*
90	NHS	Northern hogsucker	*Hypentelium nigricans*
91	OSS	Orangespotted sunfish*	*Lepomis humilis*
92	PDD	Piedmont darter	*Percina crassa*
93	PIP	Pirate perch	*Aphredoderus sayanus*
94	PNM	Pugnose minnow	*Opsopoeodus emiliae*
95	PPS	Pumpkinseed	*Lepomis gibbosus*
96	PWD	Pinewoods darter	*Etheostoma mariae*
97	QLB	Quillback	*Carpiodes cyprinus*
98	RBR	Robust Redhorse	*Moxostoma robustum ##*
99	RBS	Redbreast sunfish	*Lepomis auritus*
100	RBT	Rainbow trout*	*Oncorhynchus mykiss*
101	RCB	Rock bass	*Ambloplites rupestris*
102	RDT	Redbelly tilapia*	*Tilapia zilli*
103	REB	Redeye bass	*Micropterus coosae*
104	RES	Redear sunfish	*Lepomis microlophus*
105	RFC	Rosyface chub	*Hybopsis rubrifrons*
106	RFP	Redfin pickerel	*Esox americanus*
107	RLS	Redlip shiner	*Notropis chiliticus*
108	RSD	Rosyside dace	*Clinostomus funduloides*
109	RSS	Rough silverside	*Membras martinica (9-26-01)*
110	RVC	River chub*	*Nocomis micropogon*
111	RWK	Rainwater killifish	*Lucania parva*
112	SAU	Sauger	*Stizostedion canadense*
113	SBH	Snail bullhead	*Ameiurus brunneus*
114	SBS	Sandbar shiner	*Notropis scepticus*
115	SCD	Sawcheek darter	*Etheostoma serriferum*
116	SCS	Spinycheek sleeper	*Eleotris pisonis*
117	SEL	Sea lamprey	*Petromyzon marinus*
118	SFK	Spotfin killifish	*Fundulus majalis (9-26-01)*
119	SFL	Southern flounder	*Paralichthys lethostigma*
120	SFM	Sailfin molly	*Poecilia latipinna*
121	SFR	Smallfin redhorse	*Scartomyzon* n.sp. ##
122	SFS	Sailfin shiner	*Pteronotropis hypselopterus*
123	SGD	Seagreen darter	*Etheostoma thalassinum*
124	SHC	Sandhills chub	*Semotilus lumbee*
125	SHM	Sheepshead minnow	*Cyprinodon variegatus*
126	SHR	Shorthead redhorse	*Moxostoma macrolepidotum*
127	SKR	Suckermouth redhorse	*Moxostoma pappillosum*
128	SLB	Smallmouth buffalo*	*Ictiobus bubalus*
129	SLD	Saluda darter	*Etheostoma saludae*
130	SMB	Smallmouth bass*	*Micropterus dolomieu*
131	SMO	Spotfin mojarra	*Eucinostomus argenteus*
132	SNS	Satinfin shiner	*Cyprinella analostana*

133	SOS	Spotted sunfish..................................	*Lepomis punctatus*
134	SPB	Spotted bass*	*Micropterus punctulatus*
135	SPG	Spotted gar	*Lepisosteus oculatus*
136	SPM	Speckled madtom...............................	*Noturus leptacanthus*
137	SPS	Spotted sucker....................................	*Minytrema melanops*
138	SRH	Silver redhorse	*Moxostoma anisurum*
139	SRM	Striped mullet....................................	*Mugil cephalus*
140	SRS	Shortnose sturgeon.............................	*Acipenser brevirostrum*
141	STB	Striped bass	*Morone saxatilis*
142	STC	Santee chub	*Hybopsis zanema*
143	STJ	Striped jumprock...............................	*Moxostoma rupiscartes*
144	STK	Striped killifish..................................	*Fundulus majalis (9-26-01)*
145	STM	Striped mojarra..................................	*Diapterus plumieri*
146	STR	Stoneroller...	*Campostoma anomalum*
147	STS	Spottail shiner	*Notropis hudsonius*
148	SUF	Summer flounder	*Paralichthys dentatus*
149	SVD	Savannah darter.................................	*Etheostoma fricksium*
150	SWD	Swamp darter	*Etheostoma fusiforme*
151	SWE	Speckled worm eel.............................	*Myrophis punctatus*
152	SWF	Swampfish..	*Chologaster cornuta*
153	SWH	Striped bass X white bass hybrid*	
154	SWS	Swallowtail shiner.............................	*Notropis procne*
155	TFS	Threadfin shad*	*Dorosoma petenense*
156	TLC	Thicklip chub	*Hybopsis labrosa*
157	TLS	Taillight shiner..................................	*Notropis maculatus*
158	TNS	Tennessee shiner	*Notropis leuciodus*
159	TPM	Tadpole madtom	*Noturus gyrinus*
160	TQD	Turquoise darter.................................	*Etheostoma inscriptum*
161	TSD	Tessellated darter	*Etheostoma olmstedi*
162	VLR	V-lip redhorse	*Moxostoma collapsum*
163	WAR	Warmouth	*Lepomis gulosus*
164	WCF	White catfish	*Ameiurus catus*
165	WEY	Walleye*	*Stizostedion vitreum*
166	WFS	Whitefin shiner..................................	*Cyprinella nivea*
167	WHS	White sucker	*Catostomus commersoni*
168	WMS	Whitemouth shiner.............................	*Notropis alborus*
169	WPS	Warpaint shiner..................................	*Luxilus coccogenis*
170	WTB	White bass*..	*Morone chrysops*
171	WTC	White crappie.....................................	*Pomoxis annularis*
172	WTP	White perch..	*Morone americana*
173	WTS	Whitetail shiner..................................	*Cyprinella galactura*
174	YBH	Yellow bullhead	*Ameiurus natalis*

175	YFS	Yellowfin shiner	*Notropis lutipinnis*
176	YLP	Yellow perch	*Perca flavescens*

*Denotes species known to be introduced to South Carolina waters.

M. robustum is current being used as the scientific name for the robust redhorse causing much confusion. It has been proposed to change the name of the smallfin redhorse to the brassy jumprock and use the scientific name *Scartomyzon* n.sp.