FRESHWATER FISHERIES RESEARCH

ANNUAL PROGRESS REPORT

F-63

January 1, 2007 – December 31, 2007

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Study Title: STATEWIDE RESEARCH

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

Period Covered October 1, 2006 – September 30, 2007

Results and Discussion

Broad River

During fall 2006, smallmouth bass were collected from 56 electrofishing transects in three sections of the Broad River (Table 1). Roughly 94 km of transects were sampled with a total, pedal on electrofishing effort of 16.5 hours. Two hundred and sixty six smallmouth bass were collected, measured, weighed and aged. Twelve additional smallmouth that were presumably age-0, based on length, were not aged. Otoliths of smallmouth bass from the 2002 through 2006 year-classes were reviewed for oxytetracycline (OTC) marks. Smallmouth bass stocked into the Broad River have been marked with OTC since 2002, but smallmouth bass were not stocked into the Broad River during 2004 due to hatchery production shortages. Twelve fish that were collected with angling gear were not included in electrofishing CPUE calculations, but were aged and evaluated for OTC marks.

Table 1. Location of 56 Broad River transects sampled for smallmouth bass during fall 2006, by river section. Sampling effort is given in both seconds of electrofishing and meters sampled. Distance from nearest stocking location (NSL) is given in meters.

Date	Section	Latitude	Longitude	No. Transects	Effort (s)	Effort (m)	NSL (m)
9/26/06	Below Gaston Shoals	35.1197	-81.5820	3	2,600	3,280	2,561
9/26/06	Below Gaston Shoals	35.1010	-81.5738	3	2,317	2,991	5,318
11/8/06	Below Gaston Shoals	35.0882	-81.5724	3	1,596	4,007	6,791
11/8/06	Below Gaston Shoals	35.0838	-81.5716	3	2,131	3,496	7,358
11/8/06	Below Gaston Shoals	35.0803	-81.5682	2	1,130	1,220	7,875
11/8/06	Below Gaston Shoals	35.0767	-81.5635	2	1,304	2,336	8,469
9/26/06	Below Gaston Shoals	35.0750	-81.5592	3	2,249	2,583	8,899
10/4/06	Below 99-islands	35.0259	-81.4879	3	2,860	3,008	531
10/25/06	Below 99-islands	35.0213	-81.4866	3	2,389	2,184	1,050
10/25/06	Below 99-islands	35.0118	-81.4840	3	1,265	1,083	2,148
10/25/06	Below 99-islands	34.9862	-81.4774	1	1,052	3,203	4,355
10/11/06	Below 99-islands	34.9704	-81.4808	1	1,869	1,528	7,290
10/11/06	Below 99-islands	34.9300	-81.4759	3	3,629	5,932	200
10/11/06	Below 99-islands	34.9215	-81.4751	1	768	1,103	1,052
10/11/06	Below 99-islands	34.8887	-81.4725	1	1,540	3,261	5,239
10/11/06	Below 99-islands	34.8754	-81.4714	1	1,892	3,641	6,695
11/6/06	Below Neal Shoals	34.6586	-81.4449	3	4,094	5,243	400
11/6/06	Below Neal Shoals	34.6548	-81.4428	3	2,682	5,119	954
11/6/06	Below Neal Shoals	34.6495	-81.4311	1	2,099	4,051	2,295
11/6/06	Below Neal Shoals	34.6230	-81.4180	2	1,922	5,112	5,730
11/6/06	Below Neal Shoals	34.6067	-81.4180	1	1,080	2,230	7,559
11/6/06	Below Neal Shoals	34.5949	-81.4209	1	1,859	5,359	8,897
10/5/06	Below Neal Shoals	34.5883	-81.4222	2	2,454	3,839	9,397
10/5/06	Below Neal Shoals	34.5507	-81.4251	2	5,238	8,112	13,957
10/13/06	Below Neal Shoals	34.5060	-81.4221	1	1,761	2,998	21,842
10/13/06	Below Neal Shoals	34.5060	-81.4221	4	5,824	7,286	24,992

Catch per unit effort of all smallmouth bass in the Broad River in 2006 was 17/hour, but CPUE of age-1 fish was only 3/hour (Table 2). During 2003 limited numbers of smallmouth bass were stocked into the Broad River; however, we did not collect any age-3 fish. High spring water flows during 2003 may have had a negative impact on natural recruitment of smallmouth bass and a negative impact on survival of stocked smallmouth bass. Abnormally low or high flows have been shown to negatively impact natural recruitment of smallmouth bass (Smith et al 2005).

Smallmouth bass grow exceptionally fast in the Broad River with the average fish reaching quality size (280 mm) by the fall of its third year (age-two) (Table 2), which is considerably faster than the average North American smallmouth bass population where quality size is not reached until age-4 (Beamesderfer and North 1995).

Table 2. Estimated age, year class, total number collected, CPUE (N/h) and average length (mm) of smallmouth bass collected with boat electrofishing equipment from the Broad River during fall 2006.

Age	Year Class	N	CPUE	TL (mm)
0	2006	105	6.34	146
1	2005	53	3.20	240
2	2004	59	3.56	306
3	2003	0	0.00	
4	2002	34	2.05	356
5	2001	14	0.85	403
6	2000	7	0.42	413
7	1999	5	0.30	414
8	1998	0	0.00	
9	1997	1	0.06	435
Overall		278	16.79	248

Of the 97 fish collected and successfully reviewed for OTC marks from the 2006 spawning cohort only 3 were marked. Each of those otoliths had a single mark indicating it was stocked during spring 2006 as a fry, the other 94 age-0 fish were not marked and were presumably wild. As sampling occurred prior to fall fingerling stocking, they were not available for recapture.

Otoliths from 56 age-1 fish from the 2005 spawning cohort were reviewed for marks, 30 of those fish were unmarked, 2 were single marked (fry-stocked during spring) and 24 were double marked (fingerling stocked during fall). The contribution of stocked fish to the 2005 year class was

46%. Natural recruitment accounted for more than half of the age-1 fish collected. Relative survival, ratio of smallmouth bass stocked to those recaptured, between fingerling and fry-sized smallmouth bass favored smallmouth bass stocked as fingerlings 35 to 1.

Lakes Jocassee and Robinson

During spring 2006 Region 1 personnel collected 105 smallmouth bass from Lake Jocassee with gillnets and boat electrofishing equipment. Otoliths from 94 age-1 smallmouth bass, the 2005 spawning cohort, were successfully reviewed for marks; an otolith from 1 fish contained a single mark (spring-stocked) and the remaining otoliths were double marked (fall-stocked). Fall-stocked fingerlings were much more successful than spring-stocked fry during 2005, with a relative survival of fingerlings to fry of 167 to 1.

Only 7 age-2 fish were collected from the 2004 spawning cohort. Six fish had a single mark and the other otolith was unreadable. During 2004 only a limited number of fry and no fingerlings were stocked into Lake Jocassee, so it is not surprising that the few fish collected were all from fry-sized stockings.It appears that there was very little if any natural reproduction in Lake Jocassee during 2004 or 2005.

During May 2007 boat electrofishing was used to collect smallmouth bass from Lake Robinson. Twenty-two smallmouth bass were collected, measured, weighed, aged and otoliths were reviewed for OTC marks. Otoliths from 21 age-1 fish from the 2006 spawning cohort were reviewed for marks. Otoliths from 20 of those fish were double marked (fall-stocked) and the remaining otolith was single marked (spring-stocked). Only one age-2 fish was collected and its otolith contained a double mark. Fingerlings stocked during fall 2006 were apparently more successful than fry stockings during the spring 2006.

Marking Efficacy

During 2006 an estimated 11,340 smallmouth bass fry were stocked during spring and 2,000 smallmouth bass fingerlings were stocked during fall at four locations into the Broad River. Lake Jocassee received 10,000 spring-stocked fry and 2,375 fall-stocked fingerlings. Spring-stocked fish received a single OTC mark and fall-stocked fish received a double OTC mark at the Cheraw State Fish Hatchery prior to stocking. Fifteen fish from the spring and 45 fish from the fall stockings were retained to evaluate marking efficacy. Marking efficacy of spring and fall-stocked smallmouth bass was 100% with all fish reviewed exhibiting clear single and double marks.

Recommendations

Continue with the study as planned. Based on data collected during the first year of this study it appears that stocking fingerlings in the fall is more cost effective than stocking fry in the spring. Since we have two more opportunities to evaluate fry vs. fingerling stockings, 2006 and 2007 year classes, Region 1 management biologists may want to consider changing their stocking strategy in 2008 to favor fingerling stockings.

Literature Cited

Smith, S. M., J. S. Odenkirk, and S. J. Reeser. 2005. Smallmouth bass recruitment variability and its relation to stream discharge in three Virginia Rivers. North American Journal of Fisheries Management 25:1112-1121.

Beamesderfer, R. P., and J. A. North. 1995. Growth, natural mortality, and predicted response to fishing for largemouth bass and smallmouth bass populations in North America. North American Journal of Fisheries Management 15:688-704.

Prepared By: Jason Bettinger Title: Fisheries Biologist

Job Title: Sunfish Growth and Mortality in South Carolina's State Lakes

Period Covered January 1, 2007 – September 30, 2007

Results and Discussion

During spring 2007 a statewide project was initiated to determine the growth and mortality of redear sunfish, bluegill, largemouth bass and black crappie, in South Carolina's state lakes. The information collected will be used to determine the management potential of those species in each of the lakes. Regional staff collected sunfish, with boat electrofishing equipment, from approximately 11 state lakes during the spring (primarily April) and summer (primarily June) seasons. That data is not yet available.

Eastover staff sampled sunfish populations in Lancaster Reservoir, Lancaster County, SC during April and June with boat electrofishing equipment. Nearly 600 individuals from 8 different sunfish species were collected, measured and weighed. To estimate growth and mortality otoliths were collected from 171 bluegill, 43 largemouth bass, 18 black crappie and 16 redear sunfish. The data collected has not yet been analyzed.

Recommendations

Continue with the study as planned, secure data and aging structures from regional staff, analyze data, and prepare progress report by 1 December 2008.

Literature Cited

Prepared By: Jason Bettinger Title: Fisheries Biologist

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

Period Covered October 1, 2006 – November 30, 2007

Results and Discussion

During spring 2006 a study was initiated to determine the seasonal movement and distribution of adult striped bass that occupy the lower Saluda River, Congaree River, Wateree River and Lakes Marion and Moultrie (i.e., Santee-Cooper system). The information collected will be used to determine if there is annual segregation of a portion of the Santee-Cooper striped bass population (i.e., multiple stocks) and identify potential management implications based on seasonal distribution. During 2007 we continued to monitor the movements of adult striped bass implanted with transmitters during spring 2006. Eighteen additional striped bass (mean TL = 686 mm; range 610-755 mm) collected from the diversion and rediversion canals (Lake Moultrie) were implanted with acoustic transmitters (Vemco LTD., Nova Scotia, Canada) during the winter (December 2006 and February 2007). Tagging mortality of striped bass implanted during the winter was low, one fish went missing after 11 d, but the other 17 fish were alive for at least 30 d.

Of the 63 fish successfully implanted during spring/summer 2006, 21 were dead or missing 49-354 d post implantation and 22 were harvested 4-419 d post implantation (Figure 1), the remaining fish were assumed to be alive at the time of transmitter expiration. Of the 17 fish successfully implanted with transmitters during the winter in Lake Moultrie, 10 were dead or missing 39-270 d post implantation and 3 were harvested 65-201 d post implantation, only four of those fish are currently alive in the system. Overall exploitation of instrumented fish was approximately 31% and most (76%) of the harvest occurred in the lower Saluda River. Nineteen fish were harvested from the lower Saluda River, 3 fish were harvested from the Congaree River, all above Rosewood

Boat Ramp, and three fish were harvested from Lake Marion. Surprisingly no fish were reported as harvested from other segments of the system (e.g., Lake Moultrie). Natural mortality (40%), based on the number of fish classified as “dead” or “missing” was higher than expected, but could have been inflated by unreported harvest, transmitter expulsion, or premature transmitter failure.

Two basic seasonal movement patterns were observed during the study, fish either summered in the lower Saluda River or they spent the summer in the lakes. For Congaree-tagged fish, roughly 50% of the tagged fish summered in the lower Saluda and the other 50% summered in the lakes, all fish (Congaree-tagged and Saluda-tagged) were located below the tributary rivers during the winter. Seven Congaree-tagged fish that were tracked for at least one year spent the summer below the tributary rivers. Five of those fish summered in Lake Moultrie moving into Lake Marion in the fall where they spent the majority of the winter and one fish spent the entire summer and winter seasons in Lake Marion (Figure 2). The other fish spent the summer and winter in the Cooper River (Figure 3). Twenty-one fish (17 Saluda-tagged and 4 Congaree-tagged) that spent the summer season in the Saluda River were tracked for roughly one year. Of those 21 fish, five fish spent the entire winter in Lake Marion (Figure 3), 5 fish spent the majority of winter in Lake Marion, but a made a few brief forays into Lake Moultrie, 9 fish moved in and out of both lakes during the winter (Figure 4), one fish spent the entire winter in Lake Moultrie and one fish spent the winter in the lower Santee River (Figure 5).

During spring 2007 thirty-nine fish made a spawning run up at least one tributary river. Twenty-one fish ascended the Congaree River, 3 fish ascended the Wateree River and 15 fish utilized both rivers at some point during the spring (Table 1). Spring movements into the Congaree River ranged from 1 March to 13 May, the median entry date was 2 April. Spring movements into the Wateree River ranged from 25 January to 16 May, the median entry date was 30 March. Fish spent an average of 34 d (range 3 – 149 d) in the Congaree River before entering the Saluda River or returning to the Lakes, while fish that primarily used the Wateree River spent an average of 54 d (range 7 – 106 d) in the Wateree River before retuning to the lakes. Twenty of the 39 fish that made a tributary spawning movement during 2007 ultimately moved into the Saluda River, movement into the Saluda River ranged from 22 April to 31 May. Eighteen of the fish that entered the Saluda River in 2007 also utilized the Saluda River in 2006, the other two fish that entered the lower Saluda River were tagged during the winter in Lake Moultrie. Eighteen of 19 fish from the spring/summer 2006 tagging events used the Saluda River during both 2006 and 2007, the other fish went missing just below the Saluda River on 7 May 2007.

We did not observe annual segregation of the striped bass population or evidence of multiple stocks. However, there is seasonal segregation of adult striped bass with a portion of the population utilizing the lower Saluda River as a thermal refuge during the summer and another portion of the population inhabiting the lakes, primarily Lake Moultrie. The exact percentage of the population utilizing the various segments during the summer is unknown. Roughly 50% of the adult fish tagged in the Congaree River used the lower Saluda during the summer, but only 2 of 13 fish tagged during winter in Lake Moultrie used the lower Saluda River, although one other fish spent the summer near the confluence of the Broad and Saluda rivers before returning to the lakes. The striped bass tagged in Lake Moultrie (mean = 678 mm TL) were significantly smaller than those fish that utilized the Saluda River (mean = 786 mm TL) (T-test; $P < 0.05$), perhaps larger adults are more likely to use the Saluda River as a thermal refuge. Data collected during the study demonstrates the importance of the lower Saluda River as a thermal refuge for adult striped bass. While occupying the lower Saluda River striped bass are vulnerable to intense angling pressure and high rates of exploitation.

Table 1. The number of striped bass, by tagging location, entering each tributary river during the spring 2007.

	Tributary River		
Tagging Location	Both	Congaree	Wateree
Congaree River	4	4	1
Saluda River	6	11	
Lake Moultrie	5	6	2
Grand Total	15	21	3

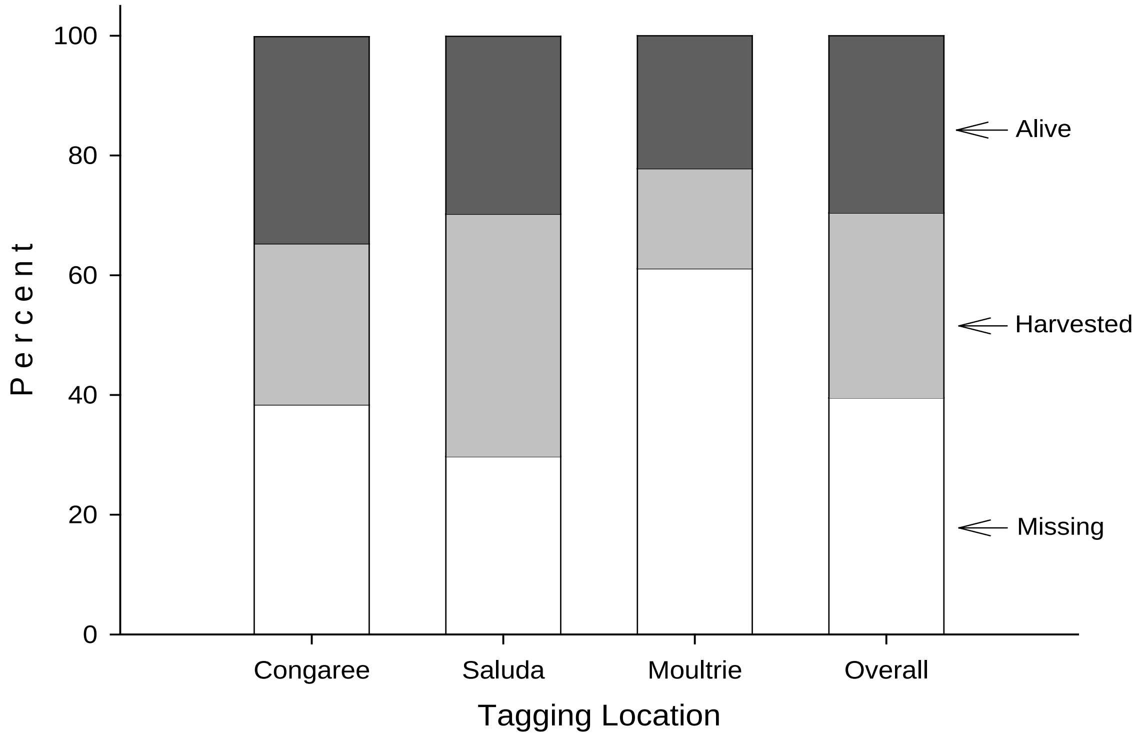

Figure 1. The fate of Santee-Cooper striped bass successfully implanted with ultrasonic transmitters.

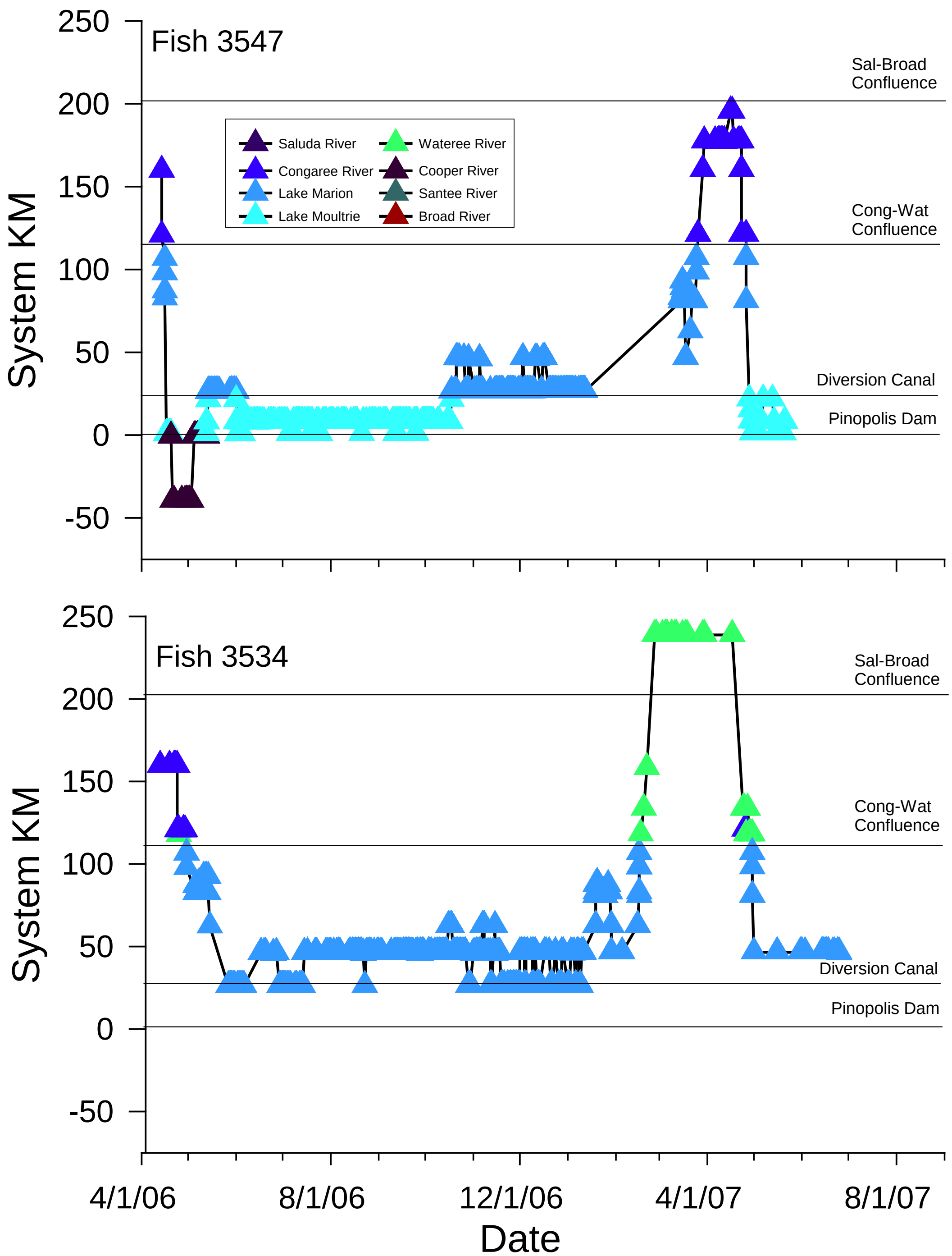

Figure 2. Locations of striped bass 3547 and 3534 in the Santee-Cooper system during 2006 and 2007. Fish 3547 displays a common seasonal pattern, occupying Lake Moultrie during summer, Lake Marion during winter and making a spring spawning migration up the Congaree River, while 3534 utilizes Lake Marion during both summer and winter and ascends the Wateree River.

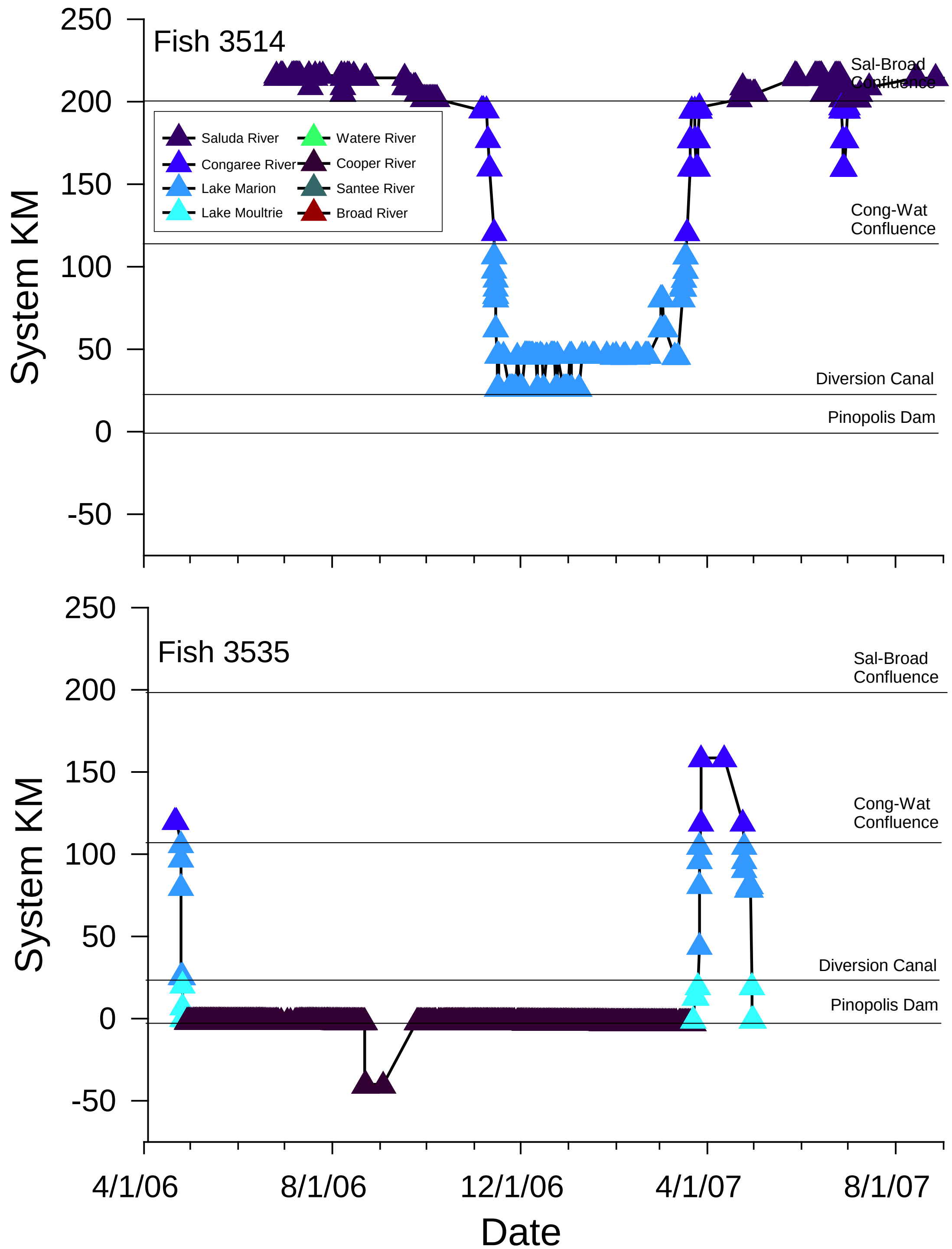

Figure 3. Locations of striped bass 3514 and 3535 in the Santee-Cooper system during 2006 and 2007. Fish 3514 displays a common seasonal pattern, occupying the lower Saluda during the summer and spending the winter in Lake Marion, fish 3535 spends nearly the entire year in the Cooper River.

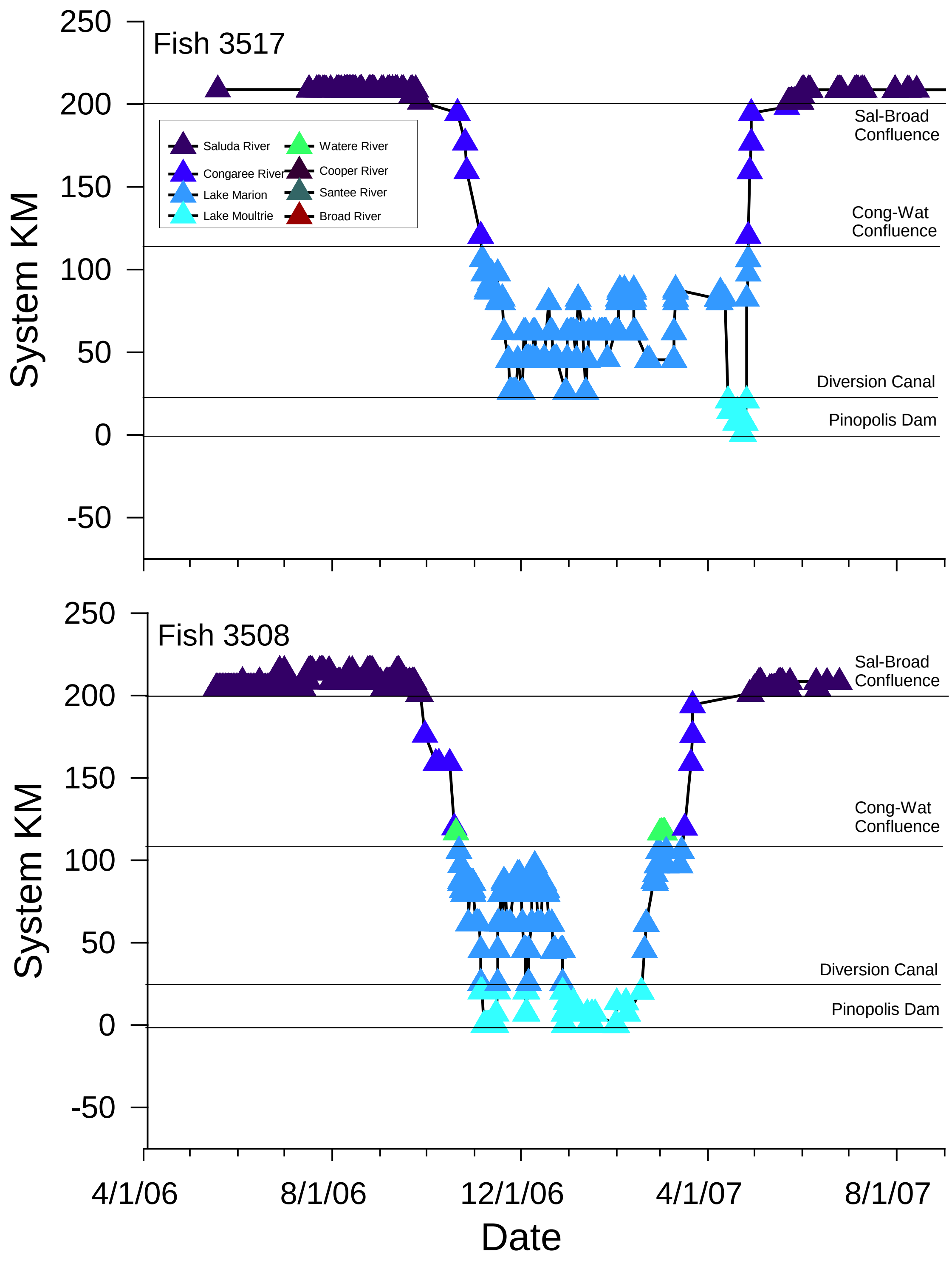

Figure 4. Locations of striped bass 3517 and 3508 in the Santee-Cooper system during 2006 and 2007. Fish 3517 spends the majority of the winter in Lake Marion, fish 3508 moves frequently between the lakes.

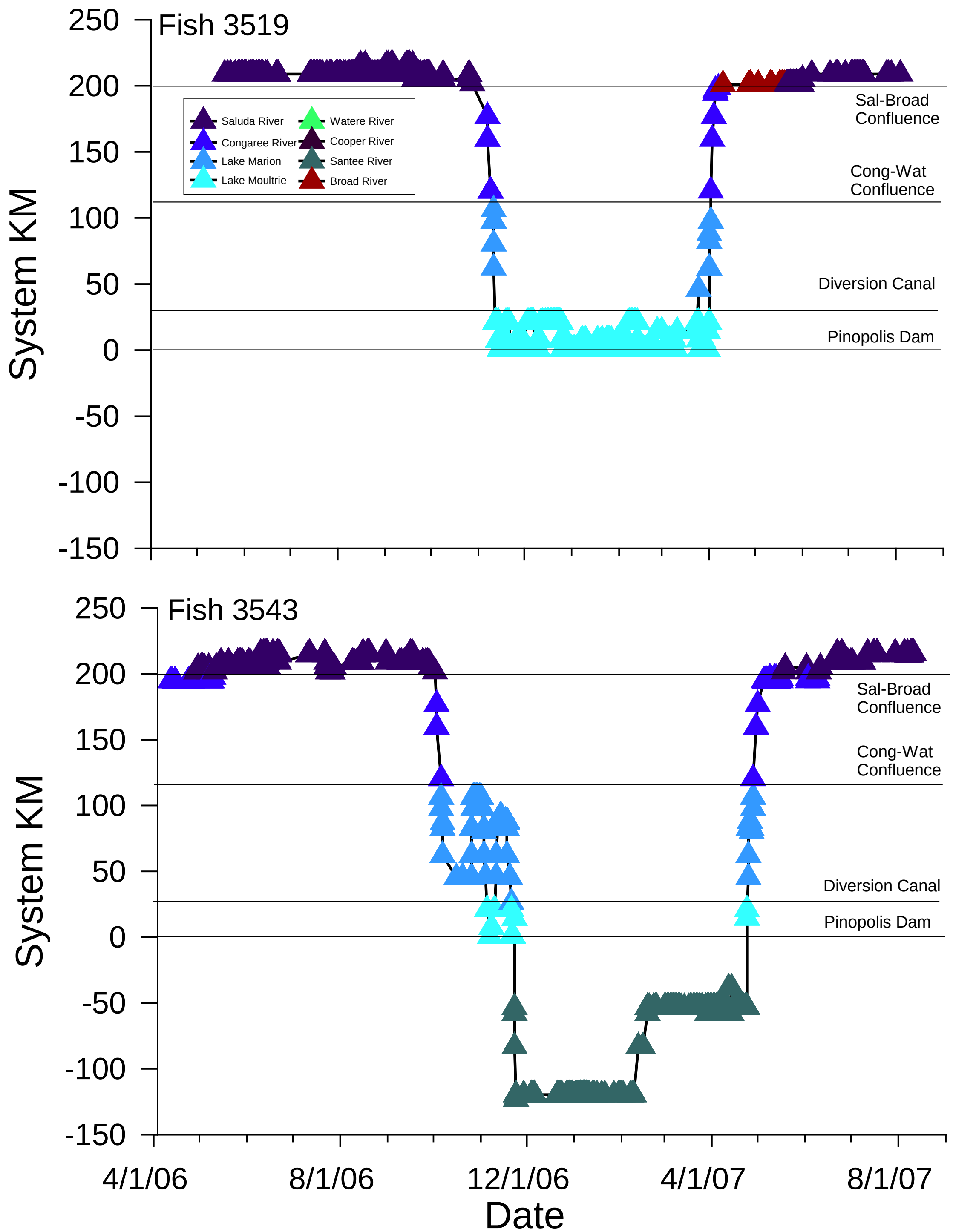

Figure 5. Locations of striped bass 3519 and 3543 in the Santee-Cooper system during 2006 and 2007. Each fish represents an anomalous seasonal pattern with 3519 spending the winter in Lake Moultrie and 3543 spending the winter in the lower Santee River.

Recommendations

Seasonal segregation of the Santee-Cooper striped bass stock warrants, may even necessitate, the use of multiple management strategies (e.g., seasonal closures, length and creel restrictions) to optimize stock management and allocation. For example, during the summer different management strategies could be employed in the lower Saluda River and Lake Moultrie, the two primary summer-time habitats for Santee-Cooper striped bass. In the Saluda River large numbers of adult striped bass are subjected to intense angling pressure and high rates of exploitation, but the cool water temperatures should allow for a successful catch and release fishery. In the lower Saluda River angling mortality could be reduced by implementing more conservative size and or creel limits. Conversely, in Lake Moultrie catch and release mortality due to warm summer water temperatures could negate the effectiveness of any creel or length restrictions enacted to reduce angling mortality. Reducing angling mortality in Lake Moultrie may require seasonal closures as opposed to creel and length restrictions.

Data collection, management and analyses are ongoing and will continue through the spring of 2008. Most transmitters have expired; approximately 4 fish are still at large with transmitters that should function through early spring. A final report will be prepared by 1 December 2008.

Prepared By: Jason Bettinger Title: Fisheries Biologist

Job Title: Evaluation of Oxytetracycline Concentration in Solutions Prepared from Multiple Hatchery Water Sources

Period Covered January 1, 2007 – December 31, 2007

Results and Discussion

Mass marking of hatchery produced fish by immersion in an oxytetracycline (OTC) solution is routinely employed in the research and management of fishes by South Carolina Department of Natural Resources. Annual assessment of fish known to have been marked by immersion has produced variable results both within and among years. This variability in mark quality has raised concerns over our ability to consistently mark fish in this manner. One variable that may affect OTC mark quality is the amount of OTC successfully placed in solution. To assess whether our ability to place OTC in solution is affecting mark quality, we produced test solutions with a target concentration of 600 ppm. Buffered pH of test solutions was recorded, as was water hardness, total dissolved solids (TDS), pH and temperature of each water source. Actual OTC concentration of each solution was measured using high-pressure liquid chromatography (HPLC).

Water was collected from 9 water sources at 7 hatchery locations. Collections were made from July 13 – August 22, 2007. For each source 3 replicate samples and 1 blank sample were evaluated. Sources evaluated include Jack Bayless Striped Bass Hatchery de-ionized water, Dennis Center fish house, Cohen Campbell Fisheries Center fish house, Cheraw Fish Hatchery fish house, Spring Stevens Fish Hatchery reservoir source at fish house, Orangeburg National Fish Hatchery reservoir and well sources at fish house, and Walhalla Fish Hatchery East Fork Creek and Indian Camp Creek sources.

All blank samples evaluated returned an OTC concentration of 0 ppm. Two of the 3 replicates from Bayless were lost due to over acidification. Results for all other test solutions and source water quality parameters are reported in Table 1.

Table 1. Mean OTC concentrations and associated water quality data, with their standard deviations, for SCDNR hatchery water sources. Means are of multiple replicates from each source (N). Means and standard deviations are not reported for hardness or total dissolved solids, which were measured one time only.

		OTC test solution		Water source			
Site	N	OTC Conc. (ppm) Mean, SD	pH Mean, SD	pH Mean, SD	temp © Mean, SD	Hardness	TDS
Bayless	1	646.6, -	7.04, -	6.12, -	20.9, -	-	3.48
Dennis Center	3	613.9, 83.5	7.02, 0.01	7.01, 0.04	24.2, 0.1	23.1	97.0
Campbell	3	692.4, 33.9	7.02, 0.02	7.95, 0.01	24.7, 0.4	17.1	40.8
Cheraw	3	602.4, 47.2	7.01, 0.02	6.65, 0.05	24.8, 0.1	-	21.0
Spring Stevens	3	664.1, 111.9	7.02, 0.02	7.06, 0.22	24.5, 0.2	18.5	61.8
Orangeburg Reservior	3	605.0, 56.8	7.02, 0.01	6.55, 0.17	25.4, 0.0	9.42	-
Orangeburg Well	3	615.1, 18.2	7.00, 0.01	7.61, 0.21	24.8, 0.2	115.92	-
Walhalla East Fork	3	631.8, 42.4	6.97, 0.09	6.60, 0.20	23.4, 0.1	1.78	14.6
Walhalla Indian Camp	3	626.5, 8.9	7.02, 0.02	6.35, 0.31	23.7, 0.1	3.86	49.1

All OTC solutions tested returned a concentration high enough to effectively mark fish. The lowest concentration found was 540 mg/L. Immersion for 6 hours in a prescribed concentration of 500 mg/L has been effective at marking yellow perch (Brown et al. 2002). SCDNR has used the same 500 mg/L protocol to successfully mark multiple species of fish. Achieving a sufficient concentration of OTC in solution does not appear to be a limiting factor when marking fish with any of the water sources tested.

Though all test solutions had OTC concentrations sufficient for marking fish, the measured concentration of OTC was variable. This is especially evident among the replicate samples from Spring Stevens, with concentrations of 569, 635, and 788 mg/L. Replicates run to evaluate precision of the HPLC analysis indicated inherent variation of only 3% (David Ruff, pers. comm.). OTC stability decreases with increasing temperature and pH (Doi et al. 2000). This should not be an issue at the pH and temperature conditions encountered in this study. Further analysis is needed to determine if variation at certain sites can be linked to any of the water quality parameters measured, or to our methods.

Recommendations

Statistical evaluation of this data has been discussed with Dr. John Grego and his recommendations are expected in January. Complete analysis and evaluate results with chemist David Ruff. Run additional samples if necessary. Complete a final report in January that will include any recommended changes in SCDNR protocols for immersion marking fish.

Literature Cited

Brown, Michael L., Jennifer L. Powell and David O. Lucchesi. 2002. In transit oxytetracycline marking, nonlethal mark detection, and tissue residue depletion in yellow perch. North American Journal of Fisheries Management 22:236-242.

Doi, A. M. and M. K. Stoskopf. 2000. The kinetics of oxytetracycline degradation in deionized water under varying temperature, pH, light, substrate, and organic matter. Journal of Aquatic Animal Health 12:246-253.

Prepared By: Jean Leitner Title: Fishery Biologist

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

Period Covered January 1, 2007– December 31, 2007

Results and Discussion

South Carolina is located within the hybrid zone between the two recognized subspecies of largemouth bass *Micropterus salmoides.* They are the northern *M. s. salmoides* and the Florida *M. s. floridanus* (Philipp et al., 1983). Allozyme surveys have shown that South Carolina largemouth bass populations possess a combination of alleles typical of both subspecies. Further, an allelic cline exists where Florida alleles dominate the genome of those Coastal Plain populations surveyed, and the incidence of northern alleles increases as you move northward (Bulak et al., 1995). In 1994 and 1995 a group of 36 farm ponds, clustered in the Piedmont and Coastal Plain regions of South Carolina, were stocked with largemouth bass from either of two genetic stocks. One stock was produced with broodfish collected from Lake Moultrie, a population whose genome is about 95% Florida. The other was produced with Lake Wateree broodfish, a population that is about 50% Florida. A major objective of this study was to follow the successive generations produced in these ponds, and assess whether selection in each region affects the frequencies of Florida and northern alleles. To that end juveniles were collected from these ponds on an annual or semi annual basis from 1995 - 2005. Several year classes were lost due to freezer failures, but tissues from multiple year classes were available for study.

In 2007 we completed genetic analysis on juvenile largemouth bass collected from 6 study ponds in 2004 (n=147). These fish represent the F9 generation of largemouth produced in those ponds. Allele frequencies were calculated for the four loci diagnostic for northern and Florida largemouth bass. Proportions of alleles typical of each subspecies were compiled by region/stock/locus for all year classes analyzed from 1995-2005. Data from ponds that received Moultrie stock largemouth bass showed either little difference, or no consistent difference in the proportion of Florida alleles by region. Wateree stocked ponds exhibit a consistent trend where Coastal Plain populations possessed a greater proportion of Florida alleles than Piedmont populations at two loci. Across 5 filial generations produced in those ponds stocked in 1994, Florida alleles at the *sIDHP-1** and the *sMDH-B** loci are more common in the Coastal Plain than in the Piedmont (Figure 1). The same is true for 3 filial generations produced in ponds stocked in 1995 (Figure 2). No trend was apparent for the *sAAT-2** and *sSOD-1** loci (Figures 1 and 2).

After consulting with a population geneticist, the decision to move forward with genetic analysis of fish collected in 2002 and 2003 was made. These 12 populations (n=285) represent the F9 and F7 generations produced in 1994 and 1995 stocked ponds, respectively. Genetic analysis of these samples was completed. Further analysis and consultation is needed to determine the appropriate statistical tests for our data. Once selected those tests will be applied to determine the significance of allele frequency differences between our Coastal Plain and Piedmont populations. A final report will be completed. Avenues for publication will be explored.

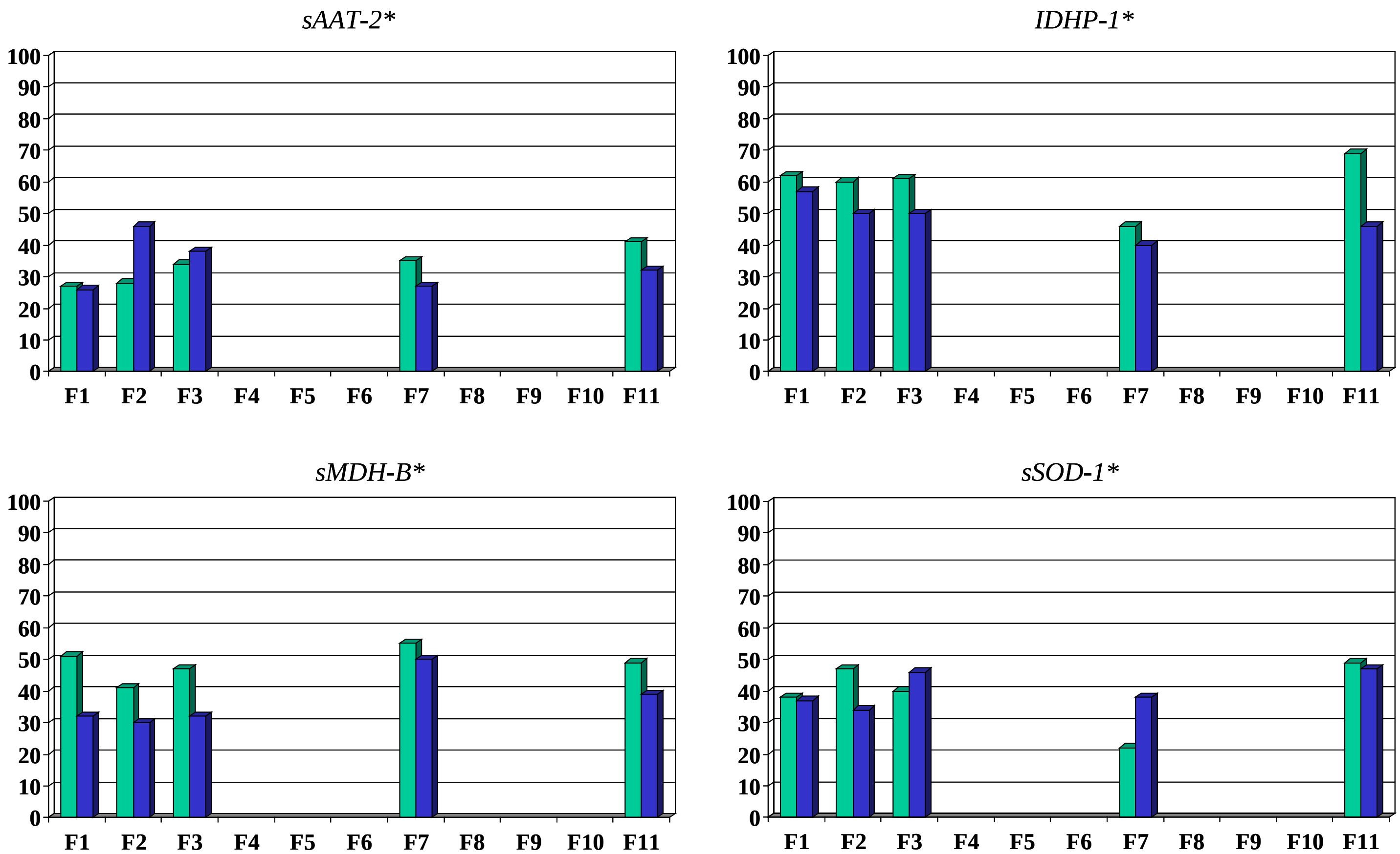

Figure 1. Percent Florida largemouth bass *M. s. floridanus* alleles present in multiple filial generations of largemouth bass from South Carolina farm ponds. Data depicted is from ponds receiving Wateree stock largemouth bass in 1994, and is presented for each of four loci. Green bars represent the proportion of Florida alleles in Coastal Plain ponds, combined. Blue bars represent Piedmont ponds, combined.

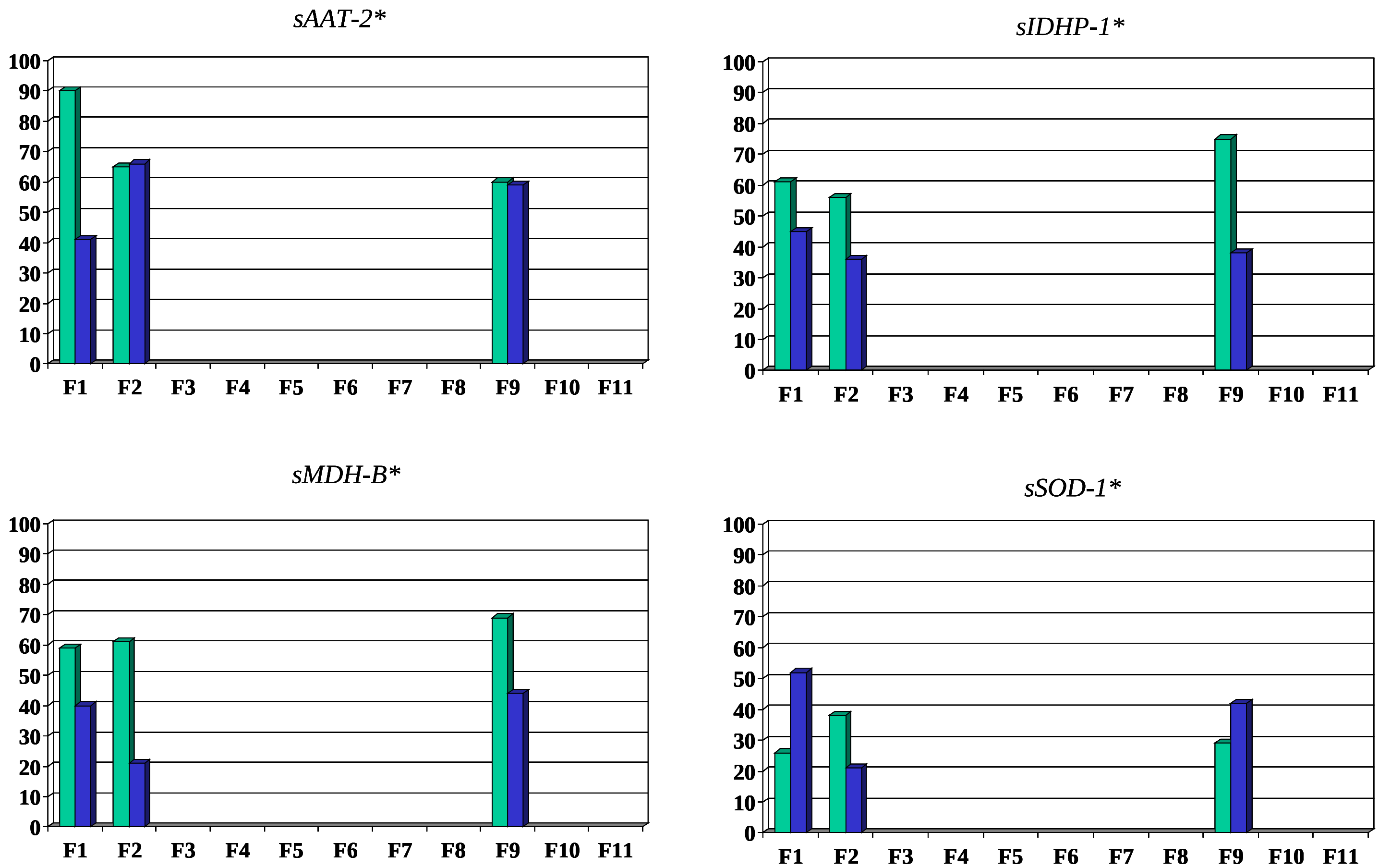

Figure 2. Percent Florida largemouth bass *M. s. floridanus* alleles present in multiple filial generations of largemouth bass from South Carolina farm ponds. Data depicted is from ponds receiving Wateree stock largemouth bass in 1995, and is presented for each of four loci. Green bars represent the proportion of Florida alleles in Coastal Plain ponds, combined. Blue bars represent Piedmont ponds, combined.

Recommendations

This study is complete except for final data analysis. Complete data analysis in January 2008, and produce a final report. Consider peer review publication options and submit where appropriate.

Literature Cited

Bulak, J., J. Leitner, T. Hilbish, and R. A. Dunham. 1995. Distribution of largemouth bass genotypes in South Carolina: initial implications. American Fisheries Society Symposium 15:226-235.

Philipp, D. P., W. R. Childers, and G. S. Whitt. 1983. Biochemical genetic evaluation of two subspecies of largemouth bass, *Micropterus salmoides*. Transactions of the American Fisheries Society 112:1-20.

Prepared By: Jean Leitner Title: Fishery Biologist

Job Title: South Carolina Stream Assessment – Summary Statistics for Reference Stream Fish Sampling 2006-2007

Period Covered January 1, 2007 through December 31, 2007

Results and Discussion

The South Carolina Stream Assessment was implemented to gather data that will allow the Section to: 1) assess Statewide status and trends of aquatic resources; 2) understand causal pathways of threats to aquatic resources; and 3) design effective and efficient management strategies to protect, conserve, and restore aquatic resources throughout the State. The current program was initiated in 2006 with two concurrent sampling designs. The first employed random selection of watersheds within an ecobasin stratification scheme to allow statistically defensible estimates of statewide resource parameters from the sample data; results from these randomly selected sites are reported elsewhere. Here I report some summary statistics from the fish sampling conducted using the second sampling design: reference streams/watersheds. Reference sites were established in the same ecobasin strata to provide for long-term annual monitoring of least-impacted watersheds, identified by biologists familiar with the region, using standardized sampling methods (SCDNR 2003). This design is intended to provide expected resource condition for comparisons as well as the expected range of conditions due to temporal variability (e.g., drought, flood, etc.). Regional biologists will report on the stream assessment activities for their respective regions, whereas this report is intended to summarize data from across all regions in the state.

The state was divided into 30 unique combinations of ecoregion and major river basin, termed "ecobasins" (Table 1). Ninety-three reference sites were apportioned among ecobasins roughly proportional to ecobasin area (Figure 1; Table 2). However, drought during the study (particularly 2007) resulted in a number of dry channels, leading to undersampling in some ecobasins and replacement of some of the sites that had been established in 2006.

Table 1. The 30 ecobasins used to stratify stream sampling. The codes were used to identify ecobasins in subsequent tables.

River Drainage	Ecoregion	Ecobasin Code
ACE	Atlantic Southern Loam Plains	ACEASLP
ACE	Carolina Flatwoods	ACEFLATW
ACE	SandHills	ACESAND
Broad	Blue Ridge	BRBLUER
Broad	Inner Piedmont	BRIPIED
Broad	Outer Piedmont	BROPIED
Broad	Slate Belt	BRSLATE
Catawba/Wateree	Atl. S. Loam Plains	CWASLP
Catawba/Wateree	Outer Piedmont	CWOPIED
Catawba/Wateree	SandHills	CWSAND
Catawba/Wateree	Slate Belt	CWSLATE
Lower Santee (incl Congaree)	Atl. S. Loam Plains	LSASLP
Lower Santee (incl Congaree)	Carolina Flatwoods	LSFLATW
Lower Santee (incl Congaree)	SandHills	LSSAND
Pee Dee	Atl. S. Loam Plains	PDASLP
Pee Dee	Carolina Flatwoods	PDFLATW
Pee Dee	SandHills	PDSAND
Pee Dee	Slate Belt	PDSLATE
Saluda	Blue Ridge	SALBLUER
Saluda	Inner Piedmont	SALIPIED
Saluda	Outer Piedmont	SALOPIED
Saluda	SandHills	SALSAND
Saluda	Slate Belt	SALSLATE
Savannah	Atl. S. Loam Plains	SAVASLP
Savannah	Blue Ridge	SAVBLUER
Savannah	Carolina Flatwoods	SAVFLATW
Savannah	Inner Piedmont	SAVIPIED
Savannah	Outer Piedmont	SAVOPIED
Savannah	SandHills	SAVSAND
Savannah	Slate Belt	SAVSLATE

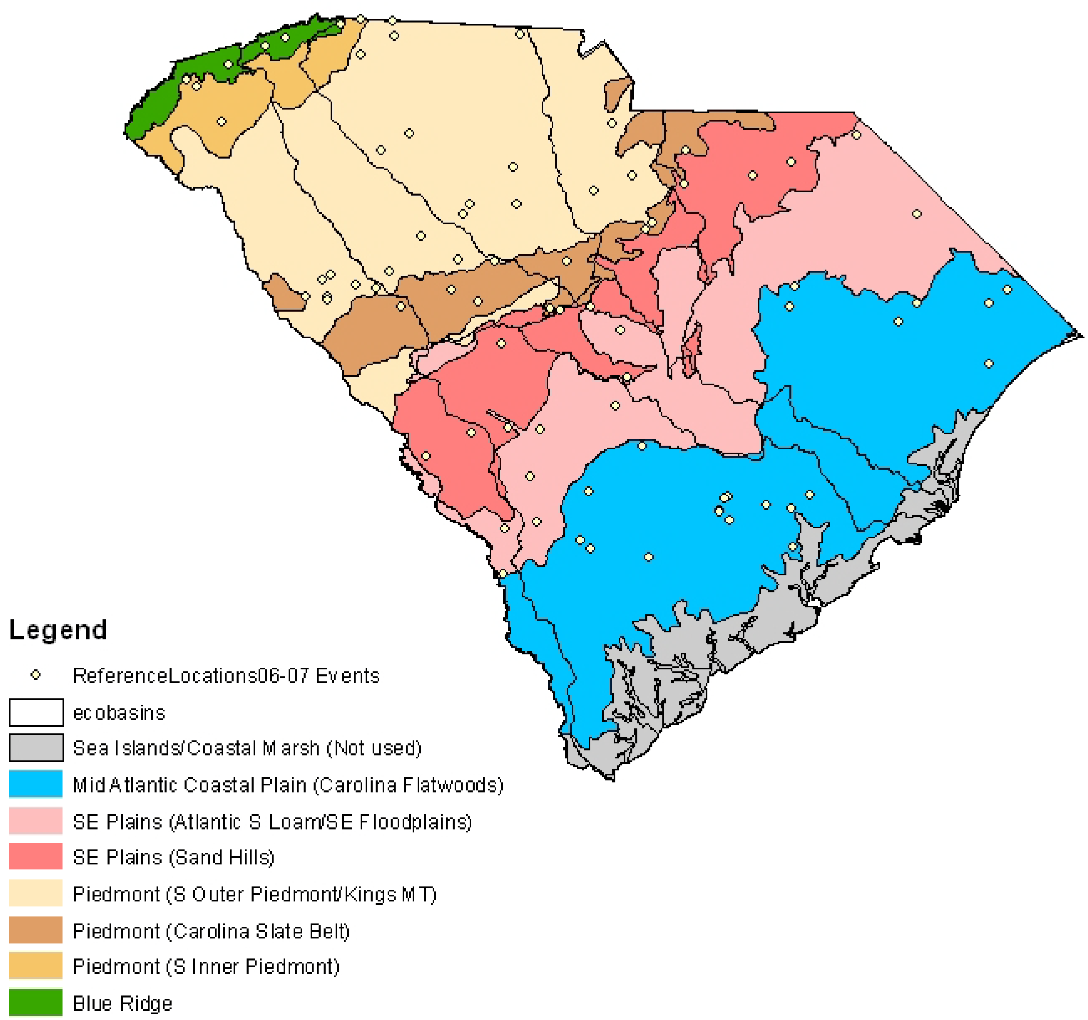

Figure 1. Ecobasins (N=30) used to stratify the state for stream sampling. Distribution of reference streams (N=93) for 2006-2007 is depicted by dots on the map.

Table 2. Ninety-three sites were sampled during the study period, shown with Site ID code, stream name, ecobasin, and site coordinates.

Site ID	Stream Name	Ecobasin	Latitude	Longitude
R1BRBLR1	Jamison Mill Creek	BRBLUER	35.16821	82.26287
R1BRBLR2	Vaughn Creek	BRBLUER	35.18242	82.25149
R1BRIP1	Wolfe Creek	BRIPIED	35.19083	82.16305
R1BROP1	Beaverdam Creek	BROPIED	34.64806	82.05611
R1BROP2	Gilders Creek	BROPIED	34.38672	81.63665
R1BROP3	Indian Creek	BROPIED	34.42488	81.60468
R1BROP4	Jimmies Creek	BROPIED	34.72003	81.90878
R1BROP5	North Tyger River	BROPIED	35.04322	82.16125
R1BROP6	Obed Creek	BROPIED	35.12225	81.99594
R1SALBLR1	Matthews Creek	SALBLUER	35.07639	82.64336
R1SALIP1	Middle Saluda River	SALIPIED	35.10950	82.54797
R1SAVBLR1	Cheohee Creek - Upper	SAVBLUER	34.93638	83.04253
R1SAVBLR2	Cheohee - Lower	SAVBLUER	34.92692	83.04497
R1SAVBLR3	Eastatoee Creek	SAVBLUER	34.99120	82.83411
R1SAVIP1	Six Mile Creek	SAVIPIED	34.75906	82.85918
R1SAVIP2	Nf Little River	SAVIPIED	34.89852	82.99403
R1SLOP1	Little River	SALOPIED	34.29276	81.85186
R1SLOP2	Beaverdam Creek	SALOPIED	34.19917	81.66028
R1SLOP3	Henley Creek	SALOPIED	34.14250	82.00750
R1SLSL1	Clouds Creek	SALSLATE	34.02140	81.56390
R1SLSL2	Big Creek	SALSLATE	34.07350	81.69880
R1SLSL3	Camping Creek	SALSLATE	34.18946	81.47609
R1SVOP1	Reedy Branch	SAVOPIED	34.03944	82.31472
R1SVOP2	Rocky Branch	SAVOPIED	34.02194	82.31330
R1SVOP3	McGill Branch	SAVOPIED	34.10944	82.34194
R1SVOP4	Big Cowhead Creek	SAVOPIED	34.08586	82.16986
R1SVOP5	Cuffytown Creek	SAVOPIED	34.07292	82.07036
R1SVOP6	Big Curltail Creek	SAVOPIED	34.13075	82.30326
R1SVSL1	Lee Creek	SAVSLATE	34.03889	82.42056
R1SVSL2	Sleepy Creek	SAVSLATE	33.99778	81.95000
R2BSOP1	tributary of Clark Fork	BROPIED	35.13589	81.35690
R2BSOP2	Johns Creek	BROPIED	34.58368	81.38305
R2BSOP3	Rocky Creek	BROPIED	34.43093	81.37354
R2CATSOP1	Dunn Creek	CWOPIED	34.76555	80.88901
R2CATSOP2	Grannies Quarter Creek	CWOPIED	34.35032	80.68400
R2CATSOP3	Cedar Creek	CWOPIED	34.54651	80.78801
R2CATSOP4	Big Wateree Creek	CWOPIED	34.48310	80.97840
R2PDCF1	Cypress Creek	PDFLATW	34.00293	79.36695
R2PDCF2	Mulyn Creek	PDFLATW	33.93259	79.45888
R2PDCF3	trib of Pleasant Meadow Swamp	PDFLATW	34.05262	78.91175
R2PDCF4	tributary of Socastee Canal	PDFLATW	33.75115	79.01202
R2PDCSB1	Flat Creek	PDSLATE	34.65297	80.51877
R2PDCSH1	Little Lynches River	PDSAND	34.51014	80.52490

Table 2. Continued.

Site ID	Stream Name	Ecobasin	Latitude	Longitude
R2PDCSH2	Juniper Creek	PDSAND	34.59596	79.98664
R2PDCSH3	Hams Creek	PDSAND	34.54581	80.17980
R2PDSLP1	Jeffries Creek	PDASLP	34.24435	79.98569
R2PDSLP2	Crooked Creek	PDASLP	34.70932	79.65355
R2PDSLP3	Maple Swamp	PDASLP	34.37355	79.35797
R2PDSLP4	Deep Hole Swamp	PDASLP	34.08184	79.97874
R3A001	12 Mile Creek	SALSAND	33.99820	81.19637
R3A002	Lightwood Knot	ACESAND	33.84800	81.44592
R3A003	Sawney Creek	CWSLATE	34.32646	80.72440
R3A004	Little Cedar Creek	BRSLATE	34.19136	81.11597
R3A005	Little Horse Creek	SALOPIED	33.99028	81.14956
R3A006	Cabin Branch	LSASLP	33.90436	80.85194
R3BASH01	Jones Swamp	ACEFLATW	32.95936	80.70489
R3BEDI01	Cow Castle Creek	ACEFLATW	33.42030	80.74076
R3BNFEDI01	Caw Caw Swamp	ACEASLP	33.59097	80.87674
R3BSALK01	Savannah Branch	ACEFLATW	33.03136	81.05179
R3BSALK02	Lemon Creek	ACEFLATW	33.23548	81.00699
R3BSALK03	Wells Branch	ACEASLP	33.11153	81.26257
R3BSALK04	Toby Creek	ACEASLP	33.29720	81.29689
R3BSAV01	Town Creek	SAVSAND	33.37949	81.81140
R3BSAV02	Miller Creek	SAVASLP	33.07980	81.42573
R3BSAV03	Gaul Branch	SAVFLATW	32.89047	81.42991
R3BSAV04	U. Three Runs Creek	SAVSAND	33.47686	81.58834
R3BSFEDI01	Pond Branch	ACESAND	33.50034	81.40712
R3BSFEDI02	Goodland Creek	ACEASLP	33.49313	81.24638
R4_1183	Polk Swamp	ACEFLATW	33.12986	80.57589
R4_1286	Warley Creek	LSASLP	33.66052	80.63505
R4_15086	Guckold's Branch	PDASLP	33.75528	80.32139
R4_20303	Thorntree Swamp	PDFLATW	33.5919	79.83106
R4_2173	Jack's Creek	LSASLP	33.59528	80.38862
R4_43	Indian Field Swamp	ACEFLATW	33.16250	80.49945
R4_5174	Big Poplar Creek	LSASLP	33.53333	80.51667
R4_705	Cattle Creek	ACEFLATW	33.15936	80.69594
R4_MGW1	Molly Branch	LSFLATW	33.13314	80.01792
R4_MGW2	Canterhill Branch	LSFLATW	33.06999	80.0214
R4_MGW3	Ut Gravel Hill Swamp	LSFLATW	33.31533	79.90671
R4_MGW5	Spring Gully	PDFLATW	33.52481	79.67102
R4_MGW6	Stoney Run	PDFLATW	33.57852	79.81683
R4_RIV1	Timothy Creek	ACEFLATW	33.11529	80.30859
R4_RIV10	Nasty Branch	PDASLP	33.86467	80.39501
R4_RIV11	Mill Creek	LSASLP	33.21863	79.91272
R4_RIV12	Walnut Branch 2	ACEFLATW	33.15263	80.35816
R4_RIV2	Mim's Lake	ACEFLATW	33.17781	80.12966

Table 2. Continued.

Site ID	Stream Name	Ecobasin	Latitude	Longitude
R4_RIV3	Merkel Branch	ACEFLATW	33.21167	80.31389
R4_RIV4	Walnut Branch	ACEFLATW	33.15065	80.35596
R4_RIV5	Mallard Lake (Upper)	ACEFLATW	33.20216	80.33257
R4_RIV6	Tyler Creek	PDFLATW	33.68935	79.29715
R4_RIV7	Big Cypress Swamp	PDFLATW	33.79408	79.15781
R4_RIV8	Bates Mill Creek	LSSAND	33.71030	80.81086
R4_RIV9	Port Creek	PDFLATW	33.69111	79.29528

Over 48,200 fish were collected from the 93 reference sites over the two-year period. Data are summarized here by site and sampling date in terms of total number of fish collected, total fish species richness, number of fish species listed as priority conservation concern in SCDNR’s State Wildlife Action Plan (SCDNR 2005), total number of priority fishes, and relative abundance of priority fishes (Table 3). Only those species of conservation concern whose descriptions in the plan mention sensitivity to habitat alteration were included here; therefore, fishes that were included in the plan for other reasons such as susceptibility to predation (e.g., flat bullhead) were not counted. Priority conservation species were relatively concentrated in a few ecobasins: the ACE, basin ecoregions; portions of Savannah Blue Ridge, Piedmont, Slate Belt, and Sandhills; portions of the Saluda Piedmont; portions of the Broad Piedmont; some sites in the Lower Santee. Maximum number of species in a single sample was 28. Two sites tied for this honor, Sawney Creek of the Catawba-Wateree Slate Belt and Caw Caw Swamp of the ACE Southern Loam Plains. The maximum number of priority species in a single sample was six (banded pygmy sunfish, mud sunfish, pugnose minnow, lowland shiner, speckled madtom, and savannah darter), found in Goodland Creek also of the ACE Loam Plains. The highest relative abundance of priority species was found in Pond Branch of the ACE Sandhills, which consistenly averaged near 80% of the assemblage over the two years thanks to good numbers of lowland shiners, Savannah darters, and speckled madtoms.

Table 3. Total number of fish collected, total species richness, number of priority conservation species (all conservation levels expected to respond to habitat alteration), total number of priority individuals, and relative abundance of priority conservation fishes for each site and sample date.

SiteID	Sample Date	Grand Total	Richness	Conserv Rich.	Conserv tot.	Conserv %
R1BRBLR1	6/29/2006	53	1	0	0	0.0%
R1BRBLR2	8/15/2007	288	9	1	18	6.3%
R1BRIP1	7/6/2006	295	11	2	30	10.2%
	7/17/2007	290	9	2	60	20.7%
R1BROP1	7/18/2006	66	7	1	5	7.6%
R1BROP2	7/19/2006	135	7	1	1	0.7%
	8/6/2007	104	7	0	0	0.0%
R1BROP3	7/19/2006	601	21	2	65	10.8%
R1BROP4	11/13/2006	829	21	2	37	4.5%
	9/6/2007	1671	19	3	192	11.5%
R1BROP5	11/14/2006	144	9	0	0	0.0%
	9/6/2007	278	18	4	69	24.8%
R1BROP6	11/13/2006	548	21	4	58	10.6%
	8/15/2007	259	17	2	23	8.9%
R1SALBLR1	3/29/2006	718	14	3	87	12.1%
	8/20/2007	998	13	3	103	10.3%
R1SALIP1	10/10/2006	2162	22	5	483	22.3%
	7/30/2007	1210	20	5	286	23.6%
R1SAVBLR1	5/15/2006	166	7	1	14	8.4%
R1SAVBLR2	5/15/2006	270	11	2	76	28.1%
	9/18/2007	974	13	3	233	23.9%
R1SAVBLR3	7/26/2006	336	15	3	74	22.0%
	9/24/2007	1406	16	3	428	30.4%
R1SAVIP1	8/3/2006	255	15	4	94	36.9%
	9/20/2007	1269	16	4	194	15.3%
R1SAVIP2	9/18/2007	243	15	3	38	15.6%
R1SLOP1	9/7/2006	357	23	2	29	8.1%
	8/22/2007	1161	22	2	125	10.8%
R1SLOP2	8/9/2006	47	16	1	6	12.8%
	8/6/2007	81	14	1	32	39.5%
R1SLOP3	7/12/2006	118	20	1	18	15.3%
	9/5/2007	156	16	2	49	31.4%
R1SLSL1	8/14/2006	126	20	1	2	1.6%
	8/27/2007	673	26	1	76	11.3%
R1SLSL2	8/30/2006	369	20	1	17	4.6%
R1SLSL3	8/7/2007	246	16	2	6	2.4%

Table 3. Continued.

SiteID	Sample Date	Grand Total	Richness	Conserv Rich.	Conserv tot.	Conserv %
R1SVOP1	6/7/2006	271	17	2	14	5.2%
	8/1/2007	108	4	0	0	0.0%
R1SVOP2	6/7/2006	259	7	1	2	0.8%
	8/1/2007	210	9	1	3	1.4%
R1SVOP3	6/13/2006	124	6	2	17	13.7%
	7/26/2007	35	7	2	4	11.4%
R1SVOP4	8/7/2006	91	15	1	5	5.5%
R1SVOP5	7/12/2006	151	17	2	16	10.6%
	7/26/2007	181	13	2	18	9.9%
R1SVOP6	7/16/2007	285	11	1	6	2.1%
R1SVSL1	6/13/2006	285	9	2	26	9.1%
	7/25/2007	90	8	2	15	16.7%
R1SVSL2	6/21/2006	75	13	1	8	10.7%
	7/24/2007	51	9	0	0	0.0%
R2BSOP1	9/6/2006	565	9	1	32	5.7%
	8/3/2007	545	9	1	31	5.7%
R2BSOP2	8/29/2006	914	23	5	38	4.2%
	8/1/2007	1749	18	4	115	6.6%
R2BSOP3	8/30/2006	476	8	2	37	7.8%
	8/2/2007	249	6	2	27	10.8%
R2CATSOP1	8/10/2006	420	15	0	0	0.0%
	7/9/2007	170	14	0	0	0.0%
R2CATSOP2	8/25/2006	742	22	3	22	3.0%
	7/24/2007	841	22	4	31	3.7%
R2CATSOP3	8/9/2006	421	8	1	8	1.9%
	7/11/2007	254	8	1	4	1.6%
R2CATSOP4	9/12/2006	718	17	1	11	1.5%
	7/12/2007	320	14	0	0	0.0%
R2PDCF1	8/3/2006	171	10	1	1	0.6%
R2PDCF2	8/2/2006	248	17	1	1	0.4%
R2PDCF3	8/1/2006	46	9	1	1	2.2%
	7/20/2007	26	9	1	1	3.8%
R2PDCF4	7/31/2006	40	7	1	3	7.5%
	6/27/2007	79	10	1	1	1.3%
R2PDCSB1	8/11/2006	64	9	0	0	0.0%
	7/10/2007	35	12	1	5	14.3%
R2PDSH1	9/3/2006	276	20	1	3	1.1%
	7/25/2007	244	16	1	19	7.8%
R2PDSH2	8/23/2006	22	7	0	0	0.0%
	7/26/2007	93	11	1	1	1.1%
R2PDSH3	9/11/2006	34	13	2	5	14.7%
	8/7/2007	17	7	0	0	0.0%
R2PDSLP1	8/8/2006	174	17	0	0	0.0%
	7/18/2007	290	18	0	0	0.0%

Table 3. Continued.

SiteID	Sample Date	Grand Total	Richness	Conserv Rich.	Conserv tot.	Conserv %
R2PDSLP2	8/24/2006	133	17	1	3	2.3%
R2PDSLP2	6/28/2007	103	14	1	1	1.0%
R2PDSLP3	10/4/2006	214	15	1	2	0.9%
	7/16/2007	148	13	1	8	5.4%
R2PDSLP4	8/4/2006	115	8	1	2	1.7%
	6/27/2007	284	12	1	2	0.7%
R3A001	6/30/2006	353	20	2	12	3.4%
	6/7/2007	553	17	2	12	2.2%
R3A002	7/11/2006	121	23	2	5	4.1%
	6/23/2007	91	19	1	3	3.3%
R3A003	7/17/2006	578	23	5	12	2.1%
	7/25/2007	1219	28	5	60	4.9%
R3A004	8/1/2006	1301	18	2	61	4.7%
	7/12/2007	902	19	3	81	9.0%
R3A005	7/18/2007	353	5	0	0	0.0%
R3A006	8/15/2007	131	14	2	69	52.7%
R3BASH01	8/13/2007	68	6	0	0	0.0%
R3BEDI01	7/30/2007	168	13	1	26	15.5%
R3BNFEDI01	7/23/2007	333	28	3	63	18.9%
R3BSALK01	7/20/2006	165	19	3	34	20.6%
	6/14/2007	168	16	3	46	27.4%
R3BSALK02	6/28/2007	384	22	5	40	10.4%
R3BSALK03	7/16/2007	167	18	3	55	32.9%
R3BSALK04	8/6/2007	149	13	3	51	34.2%
R3BSAV01	10/6/2006	82	22	4	18	22.0%
	8/23/2007	103	20	3	18	17.5%
R3BSAV02	6/23/2006	343	26	3	12	3.5%
	8/2/2007	225	24	2	4	1.8%
R3BSAV03	6/19/2007	26	3	0	0	0.0%
R3BSAV04	8/20/2007	117	13	3	54	46.2%
R3BSFEDI01	7/12/2006	126	13	3	105	83.3%
	8/8/2007	166	15	3	124	74.7%
R3BSFEDI02	7/6/2006	347	25	6	130	37.5%
	7/11/2007	190	22	5	61	32.1%
R4_1183	8/29/2006	26	11	0	0	0.0%
	9/28/2007	67	8	0	0	0.0%
R4_1286	8/4/2006	112	13	0	0	0.0%
	7/3/2007	85	12	0	0	0.0%
R4_15086	9/20/2006	28	10	0	0	0.0%
R4_20303	7/25/2006	230	22	2	10	4.3%
	10/16/2007	12	4	0	0	0.0%
R4_2173	8/23/2006	122	17	2	10	8.2%
	6/28/2007	98	12	1	10	10.2%

Table 3. Continued.

SiteID	Sample Date	Grand Total	Richness	Conserv Rich.	Conserv tot.	Conserv %
R4_43	7/21/2006	254	16	1	1	0.4%
	9/12/2007	489	19	1	4	0.8%
R4_5174	9/19/2006	243	19	0	0	0.0%
	7/31/2007	109	14	0	0	0.0%
R4_705	8/17/2006	33	11	2	3	9.1%
	8/7/2007	52	8	1	4	7.7%
R4_MGW1	7/19/2006	41	8	0	0	0.0%
	6/20/2007	51	11	0	0	0.0%
R4_MGW2	8/18/2006	16	7	0	0	0.0%
	9/5/2007	60	11	1	8	13.3%
R4_MGW3	9/7/2006	73	14	0	0	0.0%
R4_MGW5	10/17/2006	127	16	1	2	1.6%
	7/11/2007	198	18	1	2	1.0%
R4_MGW6	8/24/2006	140	20	1	2	1.4%
R4_RIV1	10/6/2006	90	11	0	0	0.0%
R4_RIV10	8/9/2006	147	18	1	1	0.7%
	8/15/2007	22	6	0	0	0.0%
R4_RIV11	9/10/2007	22	7	0	0	0.0%
R4_RIV12	10/2/2007	117	19	1	3	2.6%
R4_RIV2	7/26/2006	357	21	1	1	0.3%
	7/27/2007	520	20	1	4	0.8%
R4_RIV3	8/2/2006	151	18	0	0	0.0%
	6/21/2007	206	15	1	1	0.5%
R4_RIV4	8/3/2006	191	18	1	3	1.6%
	9/27/2007	60	21	1	3	5.0%
R4_RIV5	8/11/2006	744	22	1	10	1.3%
	10/19/2007	879	21	1	24	2.7%
R4_RIV6	9/12/2006	11	2	0	0	0.0%
R4_RIV7	9/12/2006	141	17	0	0	0.0%
R4_RIV8	10/5/2006	114	18	0	0	0.0%
	8/21/2007	61	12	0	0	0.0%
R4_RIV9	10/25/2006	249	18	1	23	9.2%

The reference sites will provide a baseline of information for less-impacted streams of the state, will provide a basis for comparing different regions and river drainages, and will serve as a yardstick by which to compare the randomly selected sites. Expected species composition, abundance, and, annual variability will be derived for each ecobasin. Repeated sampling of reference sites may also serve as a long-term gauge of the effects of land use and climate change on aquatic systems.

Recommendations

- Continue standardized sampling at reference streams to provide a multi-year record of aquatic resource conditions.
- Maintain a distribution of sites among ecobasins roughly in proportion to ecobasin area, but sites may have to be moved upstream or downstream to remain sampleable under varying hydrologic conditions.
- Reference streams may be replaced as higher quality sites are discovered, for example through the random stream sampling program conducted by the Stream Team.
- Analyze reference streams for relationships between biological variables, habitat conditions, and geographic settings to develop a stream classification for wadeable streams of the state. This work should be published in a peer-reviewed technical journal.

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Job Title: South Carolina Stream Assessment – Randomized Stream Sampling

Period Covered January 1, 2007 – December 31, 2007

Results and Discussion

Sixty-five (65) randomly selected stream sites from three ecobasins—the Congaree/Lower Santee – Carolina Flatwoods (1), Pee Dee – Carolina Flatwoods (24), and Ashepoo-Combahee-Edisto (ACE) – Carolina Flatwoods (40)—were sampled for the South Carolina Stream Assessment in 2007 (Table 1). The single Congaree/Lower Santee – Carolina Flatwoods site was originally scheduled for 2006 but was postponed. Two of the 26 Pee Dee – Carolina Flatwoods sites identified as suitable during reconnaissance (Fall 2006) became unsuitable prior to sampling (1 completely dry, 1 impounded); no biological data was obtained from these sites as of this report. Fourteen of the 54 ACE – Carolina Flatwoods sites identified as suitable during reconnaissance (Winter 2007) became completely dry prior to sampling, in large part due to the severe drought of the past year; no biological data was obtained from these sites as of this report. Sampling followed South Carolina Stream Assessment procedures for aquatic community and habitat assessment (SCDNR 2006).

Table 1. Randomly selected sample sites for the South Carolina Stream Assessment in 2007, by site number within ecobasin (continued on following page).

River Basin	Ecoregion	Site Number	Sample Date	Stream Name	Latitude	Longitude
Pee Dee	Carolina Flatwoods	188319	1-May-2007	Horse Branch	34.08020	-79.89210
		194302	30-May-2007	Buck Creek	34.03134	-78.77860
		198174	30-May-2007	Buck Creek	34.01037	-78.76141
		202676	12-Jun-2007	Savannah Creek	34.01187	-79.25310
		204277	12-Jun-2007	Cypress Creek	34.00352	-79.36696
		212220	31-May-2007	Simpson Creek	33.94832	-78.82709
		214728	2-May-2007	tributary to Lynches River	33.96410	-79.71422
		215410	2-May-2007	tributary to Big Swamp	33.94310	-79.55608
		219094	30-May-2007	Simpson Creek	33.91927	-78.81903
		219819	15-May-2007	Palmetto Swamp	33.91949	-79.17434
		221551	3-May-2007	Camp Branch	33.92754	-79.84045
		234542	16-May-2007	Crab Tree Swamp	33.85215	-79.08905
		234697	9-May-2007	Kingstree Swamp Canal	33.86191	-79.85528
		236403	1-May-2007	Trestles Branch	33.86654	-80.02513
		236982	15-May-2007	Negro Lake Run	33.85924	-79.33826
		245228	29-May-2007	Tearcoat Branch	33.80996	-80.14056
		248621	21-Aug-2007	Kingstree Swamp Canal	33.79551	-79.82185
		257349	7-May-2007	tributary to Kingstree Swamp Canal	33.74226	-79.82822
		265577	13-Jun-2007	Withers Swash	33.69173	-78.89348
		269220	7-May-2007	tributary to Kingstree Swamp Canal	33.69323	-79.84918
		285765	8-May-2007	Dobson Branch	33.57188	-79.56474
		295768	13-Jun-2007	Big Dam Swamp	33.51514	-79.49892
		320217	14-May-2007	Canaan Branch	33.35314	-79.56792
		328809	8-May-2007	White Oak Bay	33.29309	-79.32124
Congaree/ Lower Santee	Carolina Flatwoods	318064	26-Jun-2007	tributary to Lake Marion	33.37770	-80.17488
ACE	Carolina Flatwoods	307367	21-Jun-2007	tributary to Middle Pen Swamp	33.44206	-80.72157
		309005	10-Jul-2007	Cow Castle Creek	33.43010	-80.77969
		315425	10-Jul-2007	Bachelor Branch	33.39301	-80.44290
		316518	10-Jul-2007	Bachelor Branch	33.38547	-80.46813
		319073	11-Jul-2007	Cow Castle Creek	33.36207	-80.68080
		329990	2-Aug-2007	Halfmoon Branch	33.29029	-81.05207
		340267	27-Jun-2007	Mill Creek/Cane Gully Branch	33.21863	-79.91272
		341665	27-Jun-2007	Canady Branch/Broad Ax Branch	33.22117	-79.95136
		341942	17-Jul-2007	Polk Swamp	33.22122	-80.64709
		342523	26-Jun-2007	Bull Head Run	33.19499	-79.91053
		344053	23-Aug-2007	Tom and Kate Branch	33.19549	-80.47324
		345651	11-Jul-2007	Little Walnut Branch	33.19704	-80.41386
		345986	19-Jun-2007	Bush Branch	33.19006	-80.77529
		346136	27-Jun-2007	Nicholson Creek	33.17074	-79.77019
		346575	30-Aug-2007	tributary to Polk Swamp	33.19112	-80.59453

Table 1. Continued.

River Basin	Ecoregion	Site Number	Sample Date	Stream Name	Latitude	Longitude
ACE	Carolina Flatwoods	348723	31-Jul-2007	Cowtail Creek	33.16078	-80.60901
		350213	29-Aug-2007	Colston Branch	33.14701	-81.03522
		351919	10-Sep-2007	Timothy Creek	33.14470	-80.28932
		352268	20-Jun-2007	tributary to Little Salkehatchie River	33.13985	-80.92576
		353386	28-Jun-2007	Turkey Creek	33.11842	-79.75127
		362289	19-Jun-2007	Little Swamp	33.07182	-80.89278
		362410	29-Aug-2007	Buckhead Creek	33.06407	-80.80671
		366613	19-Jul-2007	Savannah Creek	33.03164	-81.05128
		368792	18-Jul-2007	Deep Bottom Creek	33.00286	-80.81820
		369617	18-Jul-2007	Jackson Branch	32.97606	-81.15536
		370004	10-Sep-2007	tributary to Wando River	32.98593	-79.74959
		370317	22-Aug-2007	Sawmill Branch	32.98481	-80.21234
		371574	17-Jul-2007	Jones Swamp Creek	32.99305	-80.70082
		371927	20-Jun-2007	Fullers Swamp Creek	32.97046	-80.57742
		372778	11-Sep-2007	Scotts Creek	32.95086	-80.30957
		380145	20-Jun-2007	Ireland Creek	32.93349	-80.64857
		380391	11-Sep-2007	tributary to Rantowles Creek/Drayton Swamp	32.89799	-80.29398
		380834	11-Sep-2007	Baptist Church Branch	32.88335	-80.48952
		380927	22-Aug-2007	Fishburne Creek	32.89388	-80.24480
		382870	1-Aug-2007	Sanders Branch	32.86787	-81.09833
		387932	11-Sep-2007	tributary to Drayton Swamp	32.81161	-80.27232
		389491	28-Aug-2007	tributary to Deep Branch	32.79681	-80.93974
		389934	28-Aug-2007	Black Creek	32.80329	-80.79599
		391966	1-Aug-2007	Black Creek	32.76962	-81.23981
		415889	1-Aug-2007	tributary to Great Swamp	32.46512	-81.02337

Pee Dee – Carolina Flatwoods

An average of 302 fish (range 23 – 1,908) were collected at each of 23 randomly selected sites in the Pee Dee – Carolina Flatwoods ecobasin (Table 2). The number of fish species per site (i.e., species richness) averaged 12 (range 4 – 21). Sampling of one site in Horry County, Withers Swash (site 265577), revealed a predominantly estuarine fish assemblage; hence, this site will likely be excluded from analyses and is not reflected in the statistics herein. Thirty-five (35) fish species were collected (Table 3), including three species of conservation priority as identified in the South

Carolina Comprehensive Wildlife Conservation Strategy (SCDNR 2005): American eel (*Anguilla rostrata*), flat bullhead (*Ameiurus platycephalus*), and mud sunfish (*Acantharcus pomotis*). Twelve of 23 sites yielded at least one fish species of conservation priority, with priority species comprising 0.14% - 5.39% of total fish abundance in these samples (Table 2). Eastern mosquitofish (*Gambusia holbrooki*) was the dominant species numerically (mean abundance 183.2) and in site frequency (23 sites), followed by redfin pickerel (*Esox americanus*), with a mean abundance of 21.6 and presence at 21 sites. Redbreast sunfish (*Lepomis auritus*) were abundant where present (mean 21.3/site; 10 sites), while pirate perch (*Aphredoderus sayanus*) occurred in lower numbers (mean 7.0) but were frequently encountered (21 sites). More specific information on these stream samples, including environmental data and species abundances by site, can be obtained from the centralized network data files at \\scdnradmin\data\Fisheries\StreamProject\Procedures and Forms\Data Entry and in the future from the stream assessment database (currently under development).

Noteworthy species collected in the Pee Dee – Carolina Flatwoods included green sunfish (*Lepomis cyanellus*) and black bullhead (*Ameiurus melas*). A single specimen of *L. cyanellus*, an introduced species to South Carolina, was collected at Buck Creek in Horry County (site 198174), a tributary to the Waccamaw River. Although well established in certain portions of South Carolina, few, if any, records of *L. cyanellus* from this drainage existed prior to this collection (F.C. Rohde, pers. comm.). *L. cyanellus* represents a potential threat to native aquatic communities and warrants monitoring. *Ameiurus melas* was collected at four sites: Buck Creek in Horry County (site198174), Cypress Creek in Marion County (site 204277), and Kingstree Swamp Canal (site 234697) and a tributary to Kingstree Swamp Canal (site 269220) in Williamsburg County. Few previous records of this species in South Carolina existed (F.C. Rohde, pers. comm.). It is possible that previously collected specimens have been misidentified as the similar brown bullhead, *A. nebulosus*, contributing to the apparent rarity of *A. melas*.

Table 2. Total and priority fish species abundance and richness of Pee Dee – Carolina Flatwoods random sites, 2007.

Site Number	Total Fish Abundance	Species Richness	Priority Species Richness	Priority Fish Abundance	Proportion Priority Individuals
245228	215	21	2	2	0.93%
248621	170	21	2	5	2.94%
219094	1159	19	2	5	0.43%
295768	223	19	1	1	0.45%
198174	293	17	1	1	0.34%
234697	191	15	2	2	1.05%
212220	246	14	0	0	0.00%
221551	1908	14	2	10	0.52%
269220	73	14	1	1	1.37%
202676	200	13	2	8	4.00%
219819	176	12	2	5	2.84%
236982	734	10	1	1	0.14%
285765	109	10	0	0	0.00%
320217	235	10	0	0	0.00%
234542	445	9	1	24	5.39%
328809	61	9	0	0	0.00%
204277	46	7	0	0	0.00%
214728	71	7	0	0	0.00%
215410	39	6	0	0	0.00%
236403	23	6	0	0	0.00%
257349	29	6	0	0	0.00%
188319	242	4	0	0	0.00%
194302	48	4	0	0	0.00%

Table 3. Fish species collected from the Pee Dee – Carolina Flatwoods ecobasin in 2007, with frequency of occurrence (out of 23 sites).

Family	**Common Name**	**Scientific Name**	**Conservation Priority (SCDNR 2005)**	**Site Frequency**
Amiidae	Bowfin	*Amia calva*		3
Anguillidae	American eel	*Anguilla rostrata*	Highest	11
Aphredoderidae	Pirate perch	*Aphredoderus sayanus*		21
Atherinidae	Brook silverside	*Labidesthes sicculus*		1
Catostomidae	Creek chubsucker	*Erimyzon oblongus*		6
	Lake chubsucker	*Erymyzon sucetta*		4
Centrarchidae	Mud sunfish	*Acantharchus pomotis*	Moderate	8
	Flier	*Centrarchus macropterus*		8
	Bluespotted sunfish	*Enneacanthus gloriosus*		14
	Redbreast sunfish	*Lepomis auritus*		10
	Green sunfish*	*Lepomis cyanellus*		1
	Pumpkinseed	*Lepomis gibbosus*		10
	Warmouth	*Lepomis gulosus*		13
	Bluegill	*Lepomis macrochirus*		12
	Dollar sunfish	*Lepomis marginatus*		10
	Redear sunfish	*Lepomis microlophus*		3
	Spotted sunfish	*Lepomis punctatus*		8
	Largemouth bass	*Micropterus salmoides*		5
Cyprinidae	Golden shiner	*Notemigonus crysoleucas*		12
	Ironcolor shiner	*Notropis chalybaeus*		1
	Dusky shiner	*Notropis cummingsae*		2
	Coastal shiner	*Notropis petersoni*		3
Elassomatidae	Banded pygmy sunfish	*Elassoma zonatum*		11
Esocidae	Redfin pickerel	*Esox americanus*		21
Fundulidae	Golden topminnow	*Fundulus chrysotus*		2
Ictaluridae	Black bullhead	*Ameiurus melas*		4
	Yellow bullhead	*Ameiurus natalis*		8
	Flat bullhead	*Ameiurus platycephalus*	Moderate	2
	Tadpole madtom	*Noturus gyrinus*		4
Percidae	Swamp darter	*Etheostoma fusiforme*		4
	Tessellated darter	*Etheostoma olmstedi*		5
	Sawcheek darter	*Etheostoma serrifer*		2
Poeciliidae	Eastern mosquitofish	*Gambusia holbrooki*		23
Soleidae	Hogchoker	*Trinectes maculatus*		3
Umbridae	Eastern mudminnow	*Umbra pygmaea*		12

Ashepoo-Combahee-Edisto (ACE) – Carolina Flatwoods

Fish abundance averaged 230 (range 1 – 1,453) across 40 sites in the ACE – Carolina Flatwoods (Table 4). Mean species richness was 10 (range 1 – 22). Many of the lower abundance and richness values seem to reflect sites experiencing transitional hydrologic conditions due to prevailing drought. Analyses are planned to assess fish assemblage structure in relation to such hydrologic variability. Forty-seven (47) fish species were collected from sites in this ecobasin thus far (Table 5). Conservation priority fishes collected were American eel, mud sunfish, pugnose minnow (*Opsopoeodus emiliae*), lowland shiner (*Pteronotropis stonei*), and Savannah darter (*Etheostoma fricksium*). Conservation priority species occurred in one half of ACE – Carolina Flatwoods samples, with relative abundance ranging from 0.28% - 25.67% (Table 4). Eastern mosquitofish dominated samples numerically (104.3 per site) and in sites occupied (35). Pirate perch was the next most abundant (19 per site) and frequently encountered (32 sites) species. Dusky shiner (*Notropis cummingsae*) ranked third in mean abundance (12.0) and was present at seven sites, while redfin pickerel occurred at 30 sites. More specific information on these stream samples, including environmental data and species abundances by site, can be obtained from the centralized network data files at \\scdnradmin\data\Fisheries\StreamProject\Procedures and Forms\Data Entry and in the future from the stream assessment database (currently under development).

Several sites stood out in overall quality when compared to the other ACE – Carolina Flatwoods random sites. Jackson Branch (site 369617, Hampton County) supported five priority species (19 total species) and was the only random site in the ecobasin harboring pugnose minnow or Savannah darter. Such priority species diversity warrants conservation status and consideration as a regional reference site. Savannah Creek (site 366613, Colleton County) ranked highest in relative abundance of priority species (25.67%) and contained two priority species. Coincidentally, this stream is already designated as a regional reference site. Jones Swamp Creek (site 371574, Colleton County) harbored 22 species total (2 priority), while Colston Branch (site 350213, Bamberg County) yielded three priority species constituting 8.43% of the total abundance. Most of the sites on the Francis Marion National Forest, particularly Nicholson Creek (site 346136, Berkeley County), exhibited good habitat quality.

The known range of introduced green sunfish in South Carolina was expanded by three localities in the ACE – Carolina Flatwoods. *L. cyanellus* was collected in Sawmill Branch (site 370317; n=4) in the Ashley River drainage and Scotts Creek (site 372778; n=1) and a tributary to Rantowles Creek/Drayton Swamp (site 380927; n=1) in the Stono River drainage. This species has the potential to invade native assemblages and should be monitored.

Table 4. Total and priority fish species abundance and richness of ACE – Carolina Flatwoods random sites, 2007.

Site Number	Total Fish Abundance	Species Richness	Priority Species Richness	Priority Fish Abundance	Proportion Priority Individuals
371574	230	22	2	7	3.04%
380927	279	20	1	1	0.36%
369617	638	19	5	83	13.01%
341665	303	16	0	0	0.00%
366613	261	16	2	67	25.67%
382870	241	16	2	16	6.64%
319073	399	15	2	14	3.51%
342523	80	15	0	0	0.00%
346136	696	15	0	0	0.00%
362410	220	15	2	12	5.45%
380145	117	14	0	0	0.00%
380834	157	14	1	3	1.91%
350213	166	13	3	14	8.43%
362289	158	12	0	0	0.00%
368792	129	12	0	0	0.00%
372778	356	12	1	1	0.28%
389491	198	12	2	3	1.52%
370317	1453	11	0	0	0.00%
389934	116	11	1	6	5.17%
345651	54	10	2	5	9.26%
309005	287	8	0	0	0.00%
344053	137	8	0	0	0.00%
307367	34	7	0	0	0.00%
340267	44	7	1	1	2.27%
370004	134	7	1	2	1.49%
380391	835	7	0	0	0.00%
415889	605	7	0	0	0.00%
348723	64	6	1	2	3.13%
346575	181	5	1	1	0.55%
371927	9	5	1	1	11.11%
387932	94	5	0	0	0.00%
391966	14	5	0	0	0.00%
345986	153	4	0	0	0.00%
353386	37	4	1	1	2.70%
351919	226	3	1	3	1.33%
315425	32	2	0	0	0.00%
352268	21	2	0	0	0.00%
316518	27	1	0	0	0.00%
329990	46	1	0	0	0.00%
341942	1	1	0	0	0.00%

Table 5. Fish species collected from the ACE – Carolina Flatwoods ecobasin in 2007, with frequency of occurrence (out of 40 sites). Continued on following page.

Family	**Common Name**	**Scientific Name**	**Conservation Priority (SCDNR 2005)**	**Site Frequency**
Amblyopsidae	Swampfish	*Chologaster cornuta*		3
Amiidae	Bowfin	*Amia calva*		1
Anguillidae	American eel	*Anguilla rostrata*	Highest	14
Aphredoderidae	Pirate perch	*Aphredoderus sayanus*		32
Atherinidae	Brook silverside	*Labidesthes sicculus*		1
Catostomidae	Creek chubsucker	*Erimyzon oblongus*		12
	Lake chubsucker	*Erymyzon sucetta*		5
	Spotted sucker	*Minytrema melanops*		1
Centrarchidae	Mud sunfish	*Acantharchus pomotis*	Moderate	12
	Flier	*Centrarchus macropterus*		19
	Bluespotted sunfish	*Enneacanthus gloriosus*		11
	Banded sunfish	*Enneacanthus obesus*		2
	Redbreast sunfish	*Lepomis auritus*		17
	Green sunfish*	*Lepomis cyanellus*		3
	Pumpkinseed	*Lepomis gibbosus*		6
	Warmouth	*Lepomis gulosus*		17
	Bluegill	*Lepomis macrochirus*		10
	Dollar sunfish	*Lepomis marginatus*		16
	Redear sunfish	*Lepomis microlophus*		2
	Spotted sunfish	*Lepomis punctatus*		14
	Largemouth bass	*Micropterus salmoides*		9
Cyprinidae	Golden shiner	*Notemigonus crysoleucas*		16
	Ironcolor shiner	*Notropis chalybaeus*		2
	Dusky shiner	*Notropis cummingsae*		7
	Coastal shiner	*Notropis petersoni*		7
	Pugnose minnow	*Opsopoeodus emiliae*	Moderate	1
	Lowland shiner	*Pteronotropis stonei*	Moderate	5
Elassomatidae	Banded pygmy sunfish	*Elassoma zonatum*		12
Esocidae	Redfin pickerel	*Esox americanus*		30
	Chain pickerel	*Esox niger*		2
Fundulidae	Golden topminnow	*Fundulus chrysotus*		3
	Marsh Killifish	*Fundulus confluentus*		1
	Mummichog	*Fundulus heteroclitus*		1
	Lined topminnow	*Fundulus lineolatus*		1

Table 5. Continued.

Family	Common Name	Scientific Name	Conservation Priority (SCDNR 2005)	Site Frequency
Ictaluridae	Yellow bullhead	*Ameiurus natalis*		14
	Tadpole madtom	*Noturus gyrinus*		7
	Margined madtom	*Noturus insignis*		1
	Speckled madtom	*Noturus leptacanthus*		2
Lepisosteidae	Longnose gar	*Lepisosteus osseus*		1
Percidae	Savannah darter	*Etheostoma fricksium*	Highest	1
	Swamp darter	*Etheostoma fusiforme*		4
	Tessellated darter	*Etheostoma olmstedi*		5
	Blackbanded darter	*Percina nigrofasciata*		3
Poeciliidae	Eastern mosquitofish	*Gambusia holbrooki*		35
	Least killifish	*Heterandria formosa*		5
	Sailfin molly	*Poecilia latipinna*		1
Umbridae	Eastern mudminnow	*Umbra pygmaea*		11

Recommendations

- Continue scheduled sampling of randomly selected streams. Ecobasins scheduled for 2008 are the Savannah basin (all ecoregions) and the Saluda basin – Blue Ridge, Inner and Outer Piedmont, and Slate Belt.
- If hydrologic conditions improve, sample dry sites from prior ecobasins
- Within ecobasins, examine biological integrity (e.g., fish assemblage structure) and habitat condition in relation to gradients in watershed- and riparian-scale measures such as development level and land use distribution
- Compare watershed – biological integrity relationships among ecobasins
- Examine fish assemblage structure in relation to hydrologic variability

- Determine the feasibility and necessity of increased monitoring of introduced species (e.g., green sunfish)
- Pursue watershed protection measures for highest-quality streams (Jackson Branch)

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Prepared By: Kevin Kubach Title: Fisheries Biologist

Job Title: Crayfishes, shrimps, and crabs from the Statewide Stream Assessment

Period Covered January 1, 2007 – December 31, 2007

Results and Discussion

Collections of crayfishes and shrimps from the Pee Dee Carolina Flatwoods (PDCF) and ACE Carolina Flatwoods (ACECF) were made at 23 of 24 sites and 32 of 40 sites, respectively between May and September 2007 as part of the Statewide Stream Assessment (see report by Kubach, 2007; decapods were not detected at 1 site in the PDCF and 8 sites in the ACECF). Collections from regional offices in 2007 have not all been examined yet as some have arrived only recently.

A total of 8 species of crayfishes, 1 species of shrimp, and 1 species of crab have been identified from 23 localities in the PDCF (Table 1). Species richness ranged from 0–3 species, and usually was one or two species per site. At site# 245228 electrofishing did not produce any crayfishes, but three species were dug from burrows along the stream bank. During the PDCF surveys, collections of two crayfishes, *Procambarus chacei* and *Procambarus ancylus*, were made at one site each; both of these species are listed as "High" conservation concern (Kohlsaat et al., 2005) and neither was abundant where collected. The most common species was *Procambarus troglodytes*, which occurs in the outer piedmont and widely in the coastal plain. The non-native species, *Procambarus clarkii*, was collected at five locations. One site had *P. blandingii*, *P. chacei*, and *P. clarkii* (in decreasing order of abundance); therefore, *P. clarkii* has not eliminated other native species at this site. However, *P. clarkii* was present at two other sites at which native crayfishes were not collected. These two sites were channelized, so lack of native crayfish species could be due to habitat modification and/or presence of the non-native *P. clarkii*. Several sites in North Carolina that once had native species of crayfishes present, now have only *P. clarkii* (Cooper and Armstrong, 2007).

A total of 8 species of crayfishes and 2 species of shrimp have been identified from 40 sites in the ACECF (Table 2). Species richness ranged from 0–4 species and usually was one or two species per site. As in the PDCF ecobasin, *Procambarus troglodytes* was the most common crayfish. Of the five species of conservation concern, *Procambarus hirsutus* was encountered at eight sites, followed by *P. chacei* and *P. echinatus* at two sites each, and *P. ancylus* and *P. blandingii* at one site each. Sites at which no crayfishes or shrimps were collected might have some species present, but sampling in late summer and fall could have contributed to lower numbers of crayfishes being collected. Adult *Procambarus troglodytes* and *P. clarkii* are likely to burrow in the summer and fall and thus avoid detection by electrofishing. Adults of these species were dug from burrows at several sites. Drought conditions in 2007 also could have contributed to changes in crayfish abundance at some sites. Data for *P. troglodytes* revealed that early in the sampling season (May) more adult form I male, adult form II male, and adult female specimens were collected than juveniles, whereas juvenile abundance increased relative to adult abundance later in the sampling season.

Mussels and snails have been collected from sites within the PDCF and ACECF as well, but most of these collections have not been identified yet. A site in the PDCF had a rare species present; one Savannah lilliput, *Toxolasma pullus*, was collected from Crab Tree Swamp in the PDCF and is the first record of the species in that area (Jennifer Price, pers. comm.).

Comparison of Procambarus clarkii and P. troglodytes

I have been examining available collections of *Procambarus clarkii* (non-native) and *P. troglodytes* (native) to look for differences that will enable the two species to be identified easily.

Table 1. Crayfish, shrimp, and crab species collected at 24 randomly chosen sites in the Pee Dee Carolina Flatwoods ecobasin during the months of May, June, and August 2007.

		Site Number																							
Scientific Name	**Conservation Priority***	**188319**	**194302**	**198174**	**202676**	**204277**	**212220**	**214728**	**215410**	**219094**	**219819**	**221551**	**234542**	**234697**	**236403**	**236982**	**245228**	**248621**	**257349**	**265577**	**269220**	**285765**	**295768**	**320217**	**328809**
Procambarus ancylus	High																						X		
Procambarus blandingii	Moderate		X	X	X	X	X	X		X	X					X								X	X
Procambarus chacei	High									X															
Procambarus clarkii	Non-native			X						X		X	X							X					
Procambarus troglodytes		X				X		X	X					X	X	X	X		X		X	X	X		X
Cambarus diogenes																					X				
Cambarus cf. *latimanus*																	X								
Fallicambarus fodiens																	X								
Palaemonetes cf. *paludosus*												X												X	
Callinectes cf. *sapidus*																				X					
Species Richness		**1**	**1**	**2**	**1**	**2**	**1**	**2**	**1**	**3**	**1**	**2**	**1**	**1**	**1**	**2**	**3**	**0**	**1**	**2**	**2**	**1**	**2**	**2**	**2**

*from Kohlsaat et al. (2005)

Table 2. Crayfish and shrimp species collected at 40 randomly chosen sites in the ACE Carolina Flatwoods ecobasin during the months of June, July, August, and September 2007.

		Site Number																			
Scientific Name	**Conservation Priority***	**307367**	**309005**	**315425**	**316518**	**319073**	**329990**	**340267**	**341665**	**341942**	**342523**	**344053**	**345651**	**345986**	**346136**	**346575**	**348723**	**350213**	**351919**	**352268**	**353386**
Procambarus ancylus	High																				
Procambarus blandingii	Moderate																				
Procambarus chacei	High								X						X						
Procambarus clarkii	Non-native																				
Procambarus echinatus	Highest																				
Procambarus hirsutus	Moderate					X						X									
Procambarus troglodytes			X	X	X	X	X	X	X			X		X	X	X	X	X	X	X	X
Fallicambarus fodiens					X																
Palaemonetes cf. *paludosus*						X						X									
Macrobrachium ohione									X												
Species Richness		**0**	**1**	**1**	**2**	**3**	**1**	**1**	**3**	**0**	**0**	**3**	**0**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**

*from Kohlsaat et al. (2005)

Table 2. Continued.

Scientific Name	Conservation Priority*	Site Number																			
		362289	362410	366613	368792	369617	370004	370317	371574	371927	372778	380145	380391	380834	380927	382870	387932	389491	389934	391966	415889
Procambarus ancylus	High						X														
Procambarus blandingii	Moderate													X							
Procambarus chacei	High																				
Procambarus clarkii	Non-native							X					X								
Procambarus echinatus	Highest			X		X															
Procambarus hirsutus	Moderate			X		X			X			X				X			X		
Procambarus troglodytes		X	X		X	X	X	X	X	X		X	X	X		X			X		X
Fallicambarus fodiens																					
Palaemonetes cf. *paludosus*				X		X			X		X		X			X					
Macrobrachium ohione																					
Species Richness		**1**	**1**	**3**	**1**	**4**	**2**	**2**	**3**	**1**	**1**	**2**	**3**	**2**	**0**	**3**	**0**	**0**	**2**	**0**	**1**

*from Kohlsaat et al. (2005)

Collections made during 2007 have added much-needed material to help determine the best characters for separating these two species. Both species were collected as part of the Statewide Stream Assessment and collections of *P. clarkii* were made from a single location over time to accrue more specimens (see below). In addition to the recent collections, museum specimens will be used to gather morphological data to increase the sample size.

Crayfish collections from Nasty Branch

Nasty Branch in Sumter County was a random stream site in 2006 and also was sampled as a potential reference site by Region 4 personnel. A small number of juvenile specimens of several species were collected during these 2006 surveys. In order to identify these specimens three visits were made to Nasty Branch in November 2006, resulting in capture of a few small specimens of what was thought to be *Procambarus clarkii*, which had not been detected at the site previously. Thereafter, further visits were made in early 2007 to collect additional specimens, preferably of adults, using minnow traps and dip nets. Minnow traps were checked on 14 dates between February and May 2007, and on some of the same dates additional samples were made in April (n = 5), May (n = 2), July (n = 1), and September (n = 1) with dip nets and a seine. *Procambarus clarkii* was the most abundant crayfish caught in minnow traps (n = 93 specimens). *P. ancylus* was collected in traps (n = 45) but was most effectively captured with a dip net or a seine (n = 433 [some specimens were released on most sampling dates; therefore, this number likely represents some recaptures]).

A total of six species of crayfishes and one shrimp were collected from Nasty Branch, which doubled the number of decapod species from our initial electrofishing surveys and revealed the presence of a non-native species. The species were (in decreasing order of abundance): *Procambarus ancylus*, *Procambarus clarkii*, *Palaemonetes* cf. *paludosus, Cambarus latimanus*, *Procambarus troglodytes*, *Cambarus diogenes*, and *Procambarus lepidodactylus*. The first three species were abundant, whereas only one to several individuals of the other species were collected. Possible reasons for more species being collected later include: use of more collecting methods (differential susceptibility to the various collection methods), patchy spatial and temporal distribution of some species, or low abundance of some species making detection difficult. Compared with other sites in the state, Nasty Branch has a large population of *P. ancylus* described by Hobbs (1958), but also unfortunately has an established population of the non-native species, *P. clarkii*, which grows to a much larger size than *P. ancylus*. Another threat could be land development, which has been prevalent in the area west of Sumter. Thirteen females of *Procambarus ancylus* were found in berry with a mean egg number of 191 and range of 17 –329, and mean egg diameter was 1.63 mm (1.44–1.88; n = 120 eggs from 12 females). No other species of crayfishes were found with eggs.

Life history and taxonomy of Procambarus echinatus

A State Wildlife Grants project was initiated to study life history and taxonomy of *Procambarus echinatus* from October 2007 to September 2008. All historic localities have been georeferenced and efforts to find new sites and to locate sites at which the species is abundant have been the main focus of sampling in fall 2007. The seasonal distribution of life stages, reproductive information (i.e., when mating occurs, when females are in berry, number of eggs, etc.), and abundance of the species are among the data being recorded.

Recommendations

Collecting

Continue to collect decapods and mollusks during ecobasin surveys and other fish surveys because in 2007 new distribution information was obtained for several rare species of conservation concern and also for non-native species, and the collections will provide data to allow better identifications of species. Resample other random sites to obtain additional specimens to help confirm identifications of species.

Data analysis

Species presence / absence or abundance at random sites will be examined in relation to habitat variables and species composition, but specifics of the analyses have not been determined yet. Only about 25% of the random sites have been sampled. Biologists working on the Statewide Stream Assessment will meet in 2008 to discuss sampling, data collection, and data analysis issues.

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Prepared By: William Poly Title: Aquatic Biologist

Job Title: Potential Mussel Recolonization of the Broad River Associated with Fish Passage at the Columbia Canal

Period Covered January 1, 2007 – December 31, 2007

Results and Discussion

General Inventory of Mussels in the Broad and Upper Congaree Rivers

We conducted searches of 60 sites on the Broad River, and 5 sites on selected tributaries (Table 1). Search methods differed based upon water depth and clarity and included visual searches with the naked eye, snorkeling, SCUBA diving, and batiscopes (clear-bottomed view buckets). The amount of time spent at each site varied depending upon the amount of suitable habitat present, water clarity, and search effectiveness. Repeated trips were made to several of the highest density sites below the Columbia dam to obtain gravid mussels for use in host testing, and to several sites at Parr Reservoir. On the first trip to Parr Reservoir, mussels were located during periods of low water when sand bars were exposed and mussels were either out of the water or in very shallow areas. On a subsequent visit, SCUBA was used to examine the deeper areas of the lake, particularly in deeper pockets surrounding the areas where shallow water mussels were found, because species composition may differ between shallow and deep areas. All SCUBA diving was conducted by NC State University staff. The extremely low water levels particularly in the late summer and fall due to the severe drought minimized the need for SCUBA diving, so we were able to limit SCUBA activity to Parr Reservoir only. Smaller impoundments elsewhere on the Broad River did not appear to contain suitable habitat for mussels and were not searched. Some of the deeper parts of the river below the Columbia dam were searched again in the fall when even the center of the channel was wadeable and could be accessed using snorkeling gear.

We located 9 species below the Columbia dam: *Elliptio complanata*, *E. congaraea*, *E. lanceolata complex*, *E. roanokensis*, *Lampsilis cariosa*, *L. radiata* (tentative identification), *Ligumia nasuta*, *Uniomerus carolinanus* (from shell material only), and *Villosa delumbis* (Table 1). *Lampsilis splendida* and *L. radiata* are easily confused species whose ranges overlap in South Carolina. Since the morphology of these species is variable, and many intermediate forms can be found, conclusively distinguishing between these species can be difficult. Genetic analysis on several specimens is planned so that we can more accurately determine the identity of individuals in this population. The *Elliptio lanceolata* complex is not well resolved, though it does contain several currently recognized species known from South Carolina, *E. producta*, *E. folliculata*, and *E. angustata* as well as several other forms that are not currently recognized as distinct species or not thought to occur in South Carolina. Due to uncertainty regarding the distinctness of members of this complex and difficulty in distinguishing them, we have chosen to group members of this complex. A few representative specimens have been preserved for future genetic analysis, and there is an ongoing study attempting to resolve some of the taxonomic issues regarding this complex.

The section of river below Parr Reservoir and above the Columbia dam contained some very dense populations of mussels, although the diversity was much lower than below the dam (Table 1). The habitat quality appeared to be excellent, although specific parameters were not measured. A wide variety of substrate types were present including gravel beds and large boulders, the substrate was very stable, and the water generally fairly clear. Abundant shoals and rapids were present which can help increase the availability of dissolved oxygen in the water. Four species were observed in this region, *Elliptio complanata*, *E. lanceolata* complex, *Uniomerus carolinanus*, and *Villosa delumbis*.

Of the species found below the Columbia dam and not above, *L. cariosa* is of highest priority, *E. roanokensis*, *L. nasuta*, and *L. radiata*, are of high priority, and *E. congaraea* is of moderate priority as defined in South Carolina's Comprehensive Wildlife Conservation Strategy (Kohlsaat et al. 2005). *E.complanata*, members of the *E. lanceolata* complex, and *V. delumbis*, all found above and below the dam, are classified as moderate priority (Kohlsaat et al. 2005).

The section of the Broad River below Parr Reservoir and above Columbia dam appeared to be of high quality and supported high densities of mussels. Therefore, we expect that the ability of mussels to pass through the Columbia dam through the fish ladder may benefit additional species found below the dam and not above. This is of particular conservation value, since the species found below the dam are, in general, of higher conservation priority.

All of the species from below Parr Reservoir were also found in the reservoir. The presence of one additional species, *Utterbackia imbecillis*, was identified from a single shell. Parr Reservoir has some unusual habitat characteristics. Each day water is pumped back and forth between Lake Monticello and Parr Reservoir, causing the reservoir to experience wide water level fluctuations averaging 4 feet per day but occasionally reaching as much as 9 feet in one day. Therefore, mussels that prefer the shallow and medium depths of the lake may often become exposed by the rapidly changing water levels. They also experience a greater amount of flowing water than in most impoundments, which may explain why species composition was similar to that of the unimpounded sections of the River. Many impoundments in South Carolina are dominated by *Utterbackia imbecillis* and *Pyganodon cataracta* (personal observation), but that was not the case in Parr Reservoir.

Above Parr Reservoir, we found very few mussels relative to the lower sections of the river (Table 1). Although water quality parameters were not taken, the upper sections of the river were observed to be quite turbid, lower in substrate heterogeneity and stability. We were unable to find mussels at many of the sites above Parr Reservoir despite extensive effort. Typically, the sites at which we found a few mussels contained some gravel beds or at least a few boulders among the sand, apparently adding to the stability of the substrate. The mussels were most often found in these substrates rather than in patches of exposed sand, and these substrates were encountered infrequently.

Previous studies (Bettinger et al. 2003) noted that although riparian habitats throughout most sections of the SC portion of the Broad river are in good condition, some bank erosion problems are present in a 7 mile stretch above the highway 34 bridge crossing of the Parr Reservoir. Eighty seven percent of the riparian area was considered to be in good condition (> 50 m wide and composed of mature trees). Although much of the river contained healthy riparian areas, degradation including high turbidity, was observed above Parr Reservoir and it increased in intensity below sand mining operations (Bettinger et al. 2003). Additional assessment to quantify the differences in habitat quality above and below this impoundment and to explore potential restoration options are needed.

Table 1. Results of the general inventory of the main stem broad river. All dates are in 2007. CPUE= catch per unit effort in live mussels per person hour

site no.	latitude	longitude	date	person-hours	species	no. live	no. shells	CPUE
Upper Congaree River								
1	33.9688	81.04007	5/31	0.4	*E. lanceolata* complex	1	0	2.5
					E. roanokensis	1	0	2.5
2	33.97004	81.03893	5/31	0.5	*E. complanata*	2	0	4.0
					E. lanceolata complex	3	0	6.0
					E. roanokensis	2	0	4.0
					V. delumbis	1	0	2.0
3	33.97513	81.04359	5/31	0.33	*E. lanceolata* complex	1	0	3.0
					E. roanokensis	5	0	15.0
					L. cariosa	1	0	3.0
4	33.97782	81.04698	5/16	0.67	*E. roanokensis*	1	0	1.5
5	33.97812	81.04536	5/16	1.67	*E. complanata*	5	0	3.0
					E. lanceolata complex	1	1	0.6
					E. roanokensis	26	0	15.6
					L. cariosa	2	0	1.2
					V. delumbis	1	0	0.6
6	33.98165	81.04714	4/25	0.47	*E. complanata*	0	1	0.0
					E. lanceolata complex	1	0	2.1
7	33.98669	81.04763	5/16	1.25	none	-	-	-

Table 1. Continued.

site no.	latitude	longitude	date	person-hours	species	no. live	no. shells	CPUE
Upper Congaree River (Continued)								
8	33.98708	81.04551	5/16	3.75	*E. complanata*	9	0	2.4
					E. congaraea	1	0	0.3
					E. lanceolata complex	2	0	0.5
					E. roanokensis	73	0	19.5
					L. cariosa	1	0	0.3
					V. delumbis	1	0	0.3
			5/31	0.83	*E. complanata*	5	0	6.0
					E. lanceolata complex	3	0	3.6
					E. roanokensis	51	0	61.4
					L. cariosa	1	0	1.2
			8/14	1.5	*E. complanata*	1	0	0.7
					E. lanceolata complex	3	0	2.0
					E. roanokensis	12	0	8.0
					L. cariosa	4	0	2.7
					V. delumbis	1	0	1.2
9	33.996	81.052	5/16	0.67	*E. complanata*	1	0	1.5
					E. lanceolata complex	1	1	1.5
10	33.99732	81.05421	4/25	0.43	*E. complanata*	0	2	-
					E. lanceolata complex	0	2	-
					E. roanokensis	0	1	-
11	34.00077	81.06044	4/25	0.17	none	-	-	-
12	34.00301	81.05532	6/20	1.0	*E. complanata*	1	0	1
					E. roanokensis	1	0	1

Table 1. Continued.

site no.	latitude	longitude	date	person-hours	species	no. live	no. shells	CPUE
Upper Congaree River (Continued)								
13	34.00421	81.05748	5/15	5.0	*E. complanata*	8	0	1.6
					E. congaraea	3	0	0.6
					E. lanceolata complex	21	1	4.2
					E. roanokensis	22	0	4.4
					L. radiata	2	0	0.4
					L. nasuta	1	0	0.2
					Villosa delumbis	14	1	2.8
Broad River below Columbia dam								
14	34.01587	81.06225	4/25	0.83	*E. complanata*	0	1	-
					E. lanceolata complex	0	2	-
					E. roanokensis	4	3	4.8
					L. nasuta	0	1	-
					U. carolinanus	0	1	-
					V. delumbis	1	0	1.2
			5/15	5.0	*E. complanata*	4	0	0.8
					E. lanceolata complex	5	2	1.0
					E. roanokensis	2	0	0.4
					L. cariosa	1	0	0.2
					L. radiata	2	1	0.4
					L. nasuta	15	0	3.0
					V. delumbis	1	0	0.2
15	34.01879	81.06424	4/25	0.83	*E. complanata*	1	10	1.2
					E. lanceolata complex	2	23	2.4
					E. roanokensis	2	2	2.4
					L. cariosa	0	1	-
					U. carolinanus	0	5	-
16	34.02265	81.06424	4/25	0.5	*E. complanata*	0	1	-
					E. lanceolata complex	0	1	-

Table 1. Continued.

site no.	latitude	longitude	date	person-hours	species	no. live	no. shells	CPUE
Broad River below Columbia dam (Continued)								
17	34.03058	81.04565	4/25	2.5	*E. complanata*	12	2	4.8
					E. lanceolata complex	6	6	2.4
					E. roanokensis	9	0	3.6
					V. delumbis	1	0	0.4
Broad River below Parr Reservoir								
18	34.07909	81.08981	3/27	1.5	*E. complanata*	48	1	32
					E. lanceolata complex	26	0	17.3
					V. delumbis	1	0	0.4
19	34.0934	81.10606	3/27	1.17	*E. complanata*	27	6	23.1
					E. lanceolata complex	1	14	0.9
					U. carolinanus	10	0	8.5
20	34.13413	81.13848	3/28	0.5	*E. complanata*	37	0	74
					E. lanceolata complex	14	0	28
21	34.15881	81.15317	3/28	0.5	*E. complanata*	4	0	8
					E. lanceolata complex	4	0	8
22	34.16693	81.16542	3/28	0.75	*E. complanata*	44	0	58.7
					E. lanceolata complex	4	0	5.3
					U. carolinanus	1	0	1.3
					V. delumbis	2	0	2.6
23	34.19955	81.22483	3/28	1.33	*E. complanata*	3	0	2.3
					E. lanceolata complex	8	0	6.0
					U. carolinanus	38	0	28.5
					V. delumbis	7	0	5.3
24	missing	missing	3/29	0.75	*E. complanata*	13	0	17.3
					E. lanceolata complex	24	0	32.0
					V. delumbis	2	0	2.7

Table 1. Continued.

site no.	latitude	longitude	date	person-hours	species	no. live	no. shells	CPUE
Parr Reservoir								
25	missing	missing	3/29	1.0	*E. complanata*	63	0	63.0
					E. lanceolata complex	35	0	35.0
					V. delumbis	11	0	11.0
26	34.28227	81.34766	8/31	0.75	*E. complanata*	1	0	1.3
					E. lanceolata complex	47	16	62.7
					V. delumbis	3	0	4.0
			9/26	2.17	*E. complanata*	1	0	0.5
					E. lanceolata complex	25	9	11.5
					U. carolinanus	1	0	0.5
					V. delumbis	4	1	1.8
27	34.28503	81.34099	9/26	2.33	none	0	0	-
28	34.2859	81.33821	8/31	0.33	*E. lanceolata* complex	1	6	3.0
			9/26	2.0	*E. lanceolata* complex	4	4	2.0
					U. carolinanus	2	0	1.0
					U. imbecillis	0	1	-
					V. delumbis	1	0	0.5
29	34.29477	81.34232	9/27	2.0	*E. lanceolata* complex	16	7	8.0
					U. carolinanus	2	0	1.0
					V. delumbis	2	0	1.0
30	34.30006	34.34343	8/31	0.58	*E. complanata*	1	0	1.7
					E. lanceolata complex	18	3	31.0
			9/26	2.0	*E. lanceolata* complex	2	0	1.0
					V. delumbis	16	0	8.0
31	34.32524	81.36617	9/7	0.5	*E. lanceolata* complex	3	0	6.0
					V. delumbis	1	0	2.0
			9/27	2.0	*E. lanceolata* complex	1	0	0.5
32	34.33614	81.37004	9/7	0.5	*E. lanceolata* complex	0	2	4.0

Table 1. Continued.

site no.	latitude	longitude	date	person-hours	species	no. live	no. shells	CPUE
Broad River above Parr Reservoir								
33	34.50299	81.42056	4/26	0.27	none	0	0	-
34	34.54028	81.42664	4/26	0.67	none	0	0	-
35	34.5933	81.42075	7/16	1.33	*E. lanceolata* complex *V. delumbis*	11 1	0 0	8.3 0.8
36	34.60525	81.4172	7/16	0.67	*E. lanceolata* complex	1	0	1.5
37	34.63086	81.41812	7/16	0.67	*E. lanceolata* complex	1	0	1.5
38	34.65604	81.44328	7/16	0.5	none	0	0	-
39	34.66316	81.44566	7/16	0.33	none	0	0	-
40	34.72609	81.46175	8/16	0.17	none	0	0	-
41	34.75092	81.47244	8/16	0.5	none	0	0	-
42	34.76659	81.45328	8/16	0.67	none	0	0	-
43	34.77276	81.45538	8/16	0.67	none	0	0	-
44	34.77607	81.45499	8/16	1.0	*E. lanceolata* complex	3	1	3.0
45	34.8766	81.47118	8/22	1.0	*E. lanceolata* complex	2	0	2.0
46	34.91208	81.47171	8/22	1.0	none	0	0	0.0
47	34.93425	81.47374	8/22	1.67	*E. lanceolata* complex	5	1	3.0
48	34.94893	81.49248	7/19	0.5	none	0	0	-
49	34.97158	81.48045	7/19	0.33	none	0	0	-
50	35.00663	81.48038	7/19	0.5	none	0	0	-
51	35.01047	81.48329	7/19	0.57	none	0	0	-
52	35.02319	81.218766	7/19	0.67	none	0	0	-
53	35.05651	81.5395	9/13	0.83	none	0	0	-
54	35.05773	81.54175	9/13	1.25	*E. lanceolata* complex	1	0	0.8
55	35.08725	81.57247	9/5	0.5	*E. lanceolata* complex	3	0	6.0
56	35.09025	81.57183	9/5	1.0	*E. complanata* *E. lanceolata* complex *E. roanokensis*	1 2 1	2 0 0	1.0 2.0 1.0

Table 1. Continued.

site no.	latitude	longitude	date	person-hours	species	no. live	no. shells	CPUE
Broad River above Parr Reservoir (Continued)								
57	35.10257	81.57387	9/5	0.83	*E. complanata* complex	0	1	-
58	35.11959	81.58197	9/5	0.5	none	0	0	-
59	35.1335	81.59599	9/5	0.33	none	0	0	-
60	35.1869	81.6302	9/18	1.5	none	0	0	-
Selected tributaries of the Upper Broad River								
Guyon Moore Creek	34.98664	81.47167	10/9	1.0	none	0	0	-
Buffalo Creek	35.1275	81.55068	10/9	1.33	none	0	0	-
Kings Creek	35.04171	81.47832	10/9	1.5	none	0	0	-
Thickety Creek	34.92847	81.52916	10/11	1.0	none	0	0	-
Pacolet River	34.8736	81.53146	10/11	2.5	none	0	0	-

Determination of the seasonality of reproduction

When time permitted, we checked female mussels and mussels not exhibiting sexual dimorphism for reproductive status (i.e. gravid or not gravid). Due to the potential stress on the mussels associated with checking them for their status (shells were often chipped, and there is also a slight possibility of fatal injury to the anterior adductor muscle) checking the status of mussels was kept to a minimum. This preliminary data can be used to determine the general time of year in which mussels are reproducing and are likely to interact with potential fish hosts. In some cases, it was possible to determine if the stage of gravidity was early or late, but this is a subjective decision, and easier to determine in some cases than in others.

In the Broad River below the Columbia dam, a few (3 out of 24) *E. roanokensis* in the early gravid state were found on May 15. On May 16 in the Congaree River just below its confluence with the Broad and Saluda Rivers, no gravid *E. roanokensis* were found despite the fact that 77 individuals across 3 sites were checked. Gravid individuals were observed in the upper Congaree on May 31, June 20, June 21, and July 3.

No gravid individuals of *E. congaraea* were observed, but only 6 live individuals were found on May 15, May 16 and June 21. As this species is not sexually dimorphic, it is unknown how many, if any, of these individuals are female. Gravid *E. complanata* were observed on March 27 below Parr Reservoir, below Columbia dam on May 15 (early stage gravid only), and May 31. Of eight individuals below Columbia dam whose status was checked on June 20 and 21, none were observed to be gravid. Gravid individuals of the *E. lanceolata* complex were observed on March 28 below Parr Reservoir, and on May 15 and May 31 below Columbia dam. *Ligumia nasuta* was only found on May 15 below Columbia dam, but 12 out of a total of 16 individuals were gravid at this time. Both of the live female individuals of *Lampsilis radiata* were gravid and collected below the

Columbia dam on May 15. *Lampsilis cariosa* gravid females were observed on May 16 and May 31. Gravid *Uniomerus carolinanus* were found on March 27 below the Columbia dam. Gravid *Villosa delumbis* were observed below Parr Reservoir on March 28 and 29 and below Columbia dam on May 15 and 31. No gravid individuals were observed when female *V. delumbis* were collected below the dam on June 20 or 21, or in Parr Reservoir on Septemeber 27.

Determination of suitable fish host species for mussels found below Columbia dam

In order to determine if the species of fish travelling through the fish ladder at the Columbia dam are the appropriate hosts for the freshwater mussels found below the dam but not above, we conducted host trials, testing the compatibility of glochidia released from gravid mussels and various fish species present below the dam. Time and space constraints did not permit every species of fish present to be tested for every mussel, but we chose fish and mussel combinations based upon the most abundant fish species, and in the case of Lampsilis species, the fish species most likely to be attracted by the lures used by the mussels to attract fish. Andadromous species were particularly difficult to keep alive during transportation and for long periods in the lab. We prioritized the use of gizzard shad and blueback herring for use in tests with E. roanokensis, because the distribution of this species (often abundant below dams without fish passage) suggests the use of anadromous species as hosts. Because individual fish may vary in their ability to expel glochidia of various mussel species, when possible, we tested two or more individual fish in separate aquaria. Due to space constraints, it was not often possible to use large numbers of fish in tests, and in most cases we were limited to 1-3 individual fish per fish-mussel combination.

All laboratory host trials were conducted at the Freshwater Mussel Propagation Laboratory (FMPL) at the North Carolina State University College of Veterinary Medicine in Raleigh, NC. Fishes used in host trials were held in aquaria ranging from 8-380 liters in size dependent upon the size and species of fish. Each fish was held in a separate aquarium and infested with the glochidia of only one mussel species to avoid any uncertainty in the identification of juvenile mussels at the time that they were released from the host fish. The water used in the facility was municipal water from Raleigh, NC treated with a carbon filter and Ammo-Lock® (Aquatic Ecosystems, Apopka, FL) to remove chloramines. During holding, all fish were fed according to their preferences either feed pellets, frozen blood worms, live meal worms, nightcrawlers, Asian clams (*Corbicula fluminea*), or feeder fish.

We extracted glochidia from gravid mussels by flushing the marsupia with a water-filled syringe. All fish smaller than 15 cm were infected with glochidia using a batch infestation method. We aerated the tank vigorously to keep glochidia in suspension, allowing them to attach to the fish as the fish respired and passed the mussel larvae over their gills. After infestation was confirmed by visual examination of the gills, we separated the fish by species into various aquaria and maintained them at 20-23°C. All fish 15 cm or larger were anesthetized using tricaine methanosulfate (MS-222), and glochidia were pipetted on to their gills. After the fish recovered from anesthesia, they were separated into aquaria by species. Although no attempt was made to estimate the number of glochidia used to infest each fish, the typical fecundity rates of mussels (thousands per individual) permitted ample numbers of glochidia for one or two mussels to infest a large number of fish. After 12 days, we began siphoning the fish tanks routinely through a 150-μm mesh sieve to check for transformed juvenile mussels. Successful transformation to the juvenile stage was determined under a dissecting microscope by the presence of two adductor muscles or by foot movement.

Ligumia nasuta

Five gravid *Ligumia nasuta* were collected from the Broad River downstream of the Columbia Dam on 15 May 2007. On 17 May 2007, fish representing 23 species were collected by boat electrofishing in the Congaree River near Columbia, SC. Both fish and mussels were transported to the FMPL in Raleigh, NC and held at 20-23°C. On 21 May 2007, we extracted glochidia from two gravid *L. nasuta*.

Two yellow perch (*Perca flavenscens*) and two American eels (*Anguilla rostrata*) were tested in a second batch infestation on 13 August 2007. The yellow perch were collected from Jordan Lake in Chatham County, NC by angling on 3 August 2007. The eels were collected from the Santee River rediversion canal between Lakes Marion and Moultrie. Glochidia were extracted with a water-filled syringe from one of the remaining gravid female *L. nasuta* collected on 15 May 2007 that were held in the FMPL. We then combined the glochidia with the fish in 8 liters of water and aerated them vigorously for 20 minutes. Infestation was confirmed by visual examination of the gills of the yellow perch, and each fish was placed in a separate aquarium and maintained at 21-24°C. Tanks were siphoned routinely to check for transformed juvenile mussels.

Three fish species collected for this host trial – yellow perch (*Perca flavescens*), American shad (*Alosa sapidissima*), and Threadfin shad (*Dorosoma petenense*) – did not survive in the laboratory until the host trial could begin. A fourth species – gizzard shad (*Dorosoma cepedanium*) – died one week into the host trial before any transformed juveniles could be obtained. Of the fish that survived the host trials, largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*) and yellow perch (*Perca flavescens*) served as the most efficient hosts (Table 2). Redbreast sunfish (*Lepomis auritus*) and Redear sunfish (*Lepomis microlophus*) served as poor to moderate hosts, and no other fish species facilitated metamorphosis to the juvenile stage (Table 2). Juveniles were encysted on the fish from 11 to 24 days.

Table 2. Results of host fish testing for *Ligumia nasuta*. Each replicate represents one individual fish kept in a separate tank. *=Infested 13 August 2007

FISH SPECIES	**Replicate**	**Transformed Juveniles Produced**
Anguillidae		
American eel (*Anguilla rostrata*)*	A	0
American eel (*Anguilla rostrata*)*	B	0
Catostomidae		
Quillback (*Carpiodes cyprinus*)	A	0
Northern hogsucker (*Hypentelium nigricans*)	A	0
Spotted sucker (*Minytremia melanops*)	A	0
Shorthead redhorse (*Moxostoma macrolepidotum*)	A	0
Centrarchidae		
Redbreast sunfish (*Lepomis auritus*)	A	2
Redbreast sunfish (*Lepomis auritus*)	B	28
Redbreast sunfish (*Lepomis auritus*)	C	5
Redbreast sunfish (*Lepomis auritus*)	D	9
Redbreast sunfish (*Lepomis auritus*)	E	1
Pumpkinseed (*Lepomis gibbosus*)	A	78
Bluegill (*Lepomis macrochirus*)	A	335
Bluegill (*Lepomis macrochirus*)	B	91
Bluegill (*Lepomis macrochirus*)	C	44
Redear sunfish (*Lepomis microlophus*)	A	4
Redear sunfish (*Lepomis microlophus*)	B	0
Largemouth bass (*Micropterus salmoides*)	A	91
Cyprinidae		
Whitefin Shiner (*Cyprinella nivea*)	A	0
Spottail shiner (*Notropis hudsonius*)	A	0
Coastal shiner (*Notropis petersoni*)	A	0
Ictaluridae		
Flat bullhead (*Ameiurus platycephalus*)	A	0
Channel catfish (*Ictalurus punctatus*)	A	0
Flathead catfish (*Polydyctis olivaris*)	A	0
Moronidae		
White perch (*Morone americana*)	A	0
Striped bass (*Morone saxatilis*)	A	0
Percidae		
Tessellated darter (*Etheostoma olmstedi*)	A	0
Yellow perch (*Perca flavescens*)*	A	344
Yellow perch (*Perca flavescens*)*	B	258
Piedmont darter (*Percina crassa*)	A	0

Elliptio roanokensis

Fish representing 19 species were collected by boat electrofishing in the Congaree River, and an additional species, blueback herring (*Alosa aestivalis*), was purchased from a bait shop in Columbia, SC. We transported the fish to the FMPL in Raleigh, NC and maintained them in various aquaria at 18-24°C. On 3 July 2007, we collected 20 gravid *Elliptio roanokensis* from the Congaree River just downstream of the Blossom Street Bridge in Columbia, SC. They were transported to the FMPL in Raleigh, NC and held in separate 8-liter aquaria in a recirculating system at 22-24°C. Each day they were monitored for release of glochidia into the aquaria. On 8 July 2007, one individual released its brood. The glochidia were determined to be viable and actively snapping by visual examination using a dissecting microscope and were subsequently collected for use in infestation of the fish.

Fish less than 15 cm were batch infested in approximately 12 liters of water for 30 minutes as described above, and fish greater than 15 cm were anesthetized and infested by hand. We separated fish by species, maintained them in aquaria at 19-23°C and siphoned their tanks routinely to check for transformed juveniles.

Of the 20 species used in the host trial, one of them – the northern hogsucker (Hypentelium nigricans) – did not survive to the end of the trial and could not be assessed as a host. Three species – blueback herring (*Alosa aestivalis*), gizzard shad (*Dorosoma cepedanium*), and white perch (*Morone americana*) – served as successful hosts; however, only one of the two white perch tested served as a host (Table 3). Juveniles remained attached to fish from 10-16 days.

Table 3. Results of host fish testing for *Elliptio roanokensis*.

Fish species	**Replicate**	**Transformed Juveniles Produced**
Anguillidae		
American eel (*Anguilla rostrata*)	A	0
Catostomidae		
Quillback (*Carpiodes cyprinus*)	A	0
Quillback (*Carpiodes cyprinus*)	B	0
Northern hogsucker (*Hypentelium nigricans*)	A	Died
Spotted sucker (*Minytremia melanops*)	A	0
Notchlip redhorse (*Moxostoma collapsum*)	A	0
Shorthead redhorse (*Moxostoma macrolepidotum*)	A	0
Centrarchidae		
Redbreast sunfish (*Lepomis auritus*)	A	0
Redbreast sunfish (*Lepomis auritus*)	B	0
Bluegill (*Lepomis macrochirus*)	A	0
Redear sunfish (*Lepomis microlophus*)	A	0
Redear sunfish (*Lepomis microlophus*)	B	0
Largemouth bass (*Micropterus salmoides*)	A	0
Largemouth bass (*Micropterus salmoides*)	B	0
Smallmouth bass (*Micropterus dolomieu*)	A	0
Smallmouth bass (*Micropterus dolomieu*)	B	0
Black crappie (*Pomoxis nigromaculatus*)		0
Clupeidae		
Blueback herring (*Alosa aestivalis*)	A	304
Gizzard shad (*Dorosoma cepedanium*)	A	24
Gizzard shad (*Dorosoma cepedanium*)	B	20
Cyprinidae		
Whitefin Shiner (*Cyprinella nivea*)	A	0
Whitefin Shiner (*Cyprinella nivea*)	B	0
Whitefin Shiner (*Cyprinella nivea*)	C	0
Ictaluridae		
Channel catfish (*Ictalurus punctatus*)	A	0
Flathead catfish (*Polydyctis olivaris*)	A	0
Moronidae		
White perch (*Morone americana*)	A	0
White perch (*Morone americana*)	B	35
Striped bass (*Morone saxatilis*)	A	0
Percidae		
Yellow perch (*Perca flavescens*)	A	0

Lampsilis cariosa

Fish representing 11 species were collected by boat electrofishing in the Congaree River near Columbia, SC and transported to the FMPL. Because of the lure display of *Lampsilis cariosa* and its tendency to attract piscivorous hosts, we eliminated suckers (Catostomidae), minnows (Cyprinidae) and darters (*Etheostoma* and *Percina*) from consideration in the host trials. We collected two yellow perch (*Perca flavescens*) by angling in Jordan Lake in Chatham County, NC. Three gravid *L. cariosa* were collected from the Broad and Congaree Rivers near Columbia, SC and maintained in the FMPL until the host trial could begin. On 6 August 2007, we extracted glochidia from two of the females and batch infested all fish in approximately 70 liters of water for 20 minutes. We then separated fish into separate aquaria by species and siphoned aquaria routinely to check for transformed juveniles.

The channel catfish (*Ictalurus punctatus*) collected for this host trial jumped out of their tank prior to infestation and were not tested as potential hosts. The white perch (*Morone americana*) used in the test did not survive long enough to produce juveniles and could also not be evaluated as potential hosts. The smallmouth bass (*Micropterus dolomieu*), largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), and striped bass (*Morone saxatilis*) each served as efficient hosts (Table 4). Yellow perch (*Perca flavescens*) served as an inefficient host producing only one glochidium from one of two fish. Juveniles remained attached to fish 14-22 days.

Table 4. Results of host fish testing for *Lampsilis cariosa*. Each replicate represents one individual fish kept in a separate tank.

Fish species	Replicate	Transformed Juveniles Produced
Anguillidae		
American eel (*Anguilla rostrata*)	A	0
American eel (*Anguilla rostrata*)	B	0
Centrarchidae		
Redbreast sunfish (*Lepomis auritus*)	A	0
Redbreast sunfish (*Lepomis auritus*)	B	0
Bluegill (*Lepomis macrochirus*)	A	2
Bluegill (*Lepomis macrochirus*)	B	0
Redear sunfish (*Lepomis microlophus*)	A	0
Redear sunfish (*Lepomis microlophus*)	B	0
Smallmouth bass (*Micropterus dolomieu*)	A	57
Smallmouth bass (*Micropterus dolomieu*)	B	64
Largemouth bass (*Micropterus salmoides*)	A	423
Largemouth bass (*Micropterus salmoides*)	B	47
Largemouth bass (*Micropterus salmoides*)	C	0
Black crappie (*Pomoxis nigromaculatus*)	A	816
Moronidae		
White perch (*Morone americana*)	A	Died
White perch (*Morone americana*)	B	Died
Striped bass (*Morone saxatilis*)	A	4079
Percidae		
Yellow perch (*Perca flavescens*)	A	1
Yellow perch (*Perca flavescens*)	B	0

Lampsilis radiata

Fish representing 10 species were collected by boat electrofishing in the Congaree River near Columbia, SC and transported to the FMPL in Raleigh, NC. We also used backpack electrofishing to collect two yellow perch (*Perca flavescens*) from Morgan Creek (Cape Fear River Basin) in Chatham County, NC. Because of the lure display of *Lampsilis radiata* and its tendency to attract piscivorous hosts, we eliminated suckers (Catostomidae), minnows (Cyprinidae), and darters (*Etheostoma* and *Percina*) from consideration in the host trials. On 15 May 2007, we collected two gravid *L. radiata* from the Broad/Congaree River near the confluence with the Saluda at the Riverfront Park in Columbia, SC. These mussels were maintained at 15-17°C at the FMPL until the host trial began. On 6 August 2007, we extracted glochidia from both gravid females and combined with fish in approximately 70 liters of water for 25 minutes. Once infestation was confirmed by visual examination of the gills, fish were divided into separate aquaria and maintained at 21-24°C. We then siphoned tanks routinely to check for transformed juveniles.

All catfish (Ictaluridae) collected for this trial – channel catfish (*Ictalurus punctatus*), flathead catfish (*Polydictis olivaris*), and flat bullhead (*Ameiurus platycephalus*) – jumped out of their tank and died prior to infestation. The black crappie (*Pomoxis nigromaculatus*) and white perch (*Morone americana*) died prior to transformation of juveniles and could not be assessed as potential hosts. Of the fish that successfully survived the trial, both largemouth bass (*Micropterus salmoides*) and yellow perch (*Perca flavescens*) served as efficient hosts (Table 5). The bluegill (*Lepomis macrochirus*) and striped bass (*Morone saxatilis*) produced only one and two juveniles respectively, and none of the other species tested facilitated transformation. Juveniles remained encysted on the fish for 14-30 days.

Table 5. Results of host fish testing for *Lampsilis radiata*. Each replicate represents one individual fish kept in a separate tank.

Fish species	Replicate	Transformed Juveniles Produced
Anguillidae		
American eel (*Anguilla rostrata*)	A	0
American eel (*Anguilla rostrata*)	B	0
Centrarchidae		
Redbreast sunfish (*Lepomis auritus*)	A	0
Redbreast sunfish (*Lepomis auritus*)	B	0
Bluegill (*Lepomis macrochirus*)	A	1
Bluegill (*Lepomis macrochirus*)	B	0
Redear sunfish (*Lepomis microlophus*)	A	0
Redear sunfish (*Lepomis microlophus*)	B	0
Redear sunfish (*Lepomis microlophus*)	C	0
Smallmouth bass (*Micropterus dolomieu*)	A	0
Largemouth bass (*Micropterus salmoides*)	A	517
Largemouth bass (*Micropterus salmoides*)	B	314
Black crappie (*Pomoxis nigromaculatus*)	A	Died
Moronidae		
White perch (*Morone americana*)	A	Died
White perch (*Morone americana*)	B	Died
Striped bass (*Morone saxatilis*)	A	2
Striped bass (*Morone saxatilis*)	B	0
Percidae		
Yellow perch (*Perca flavescens*)	A	242
Yellow perch (*Perca flavescens*)	B	424

The use of the fish ladder by various fish species was evaluated during the 2007 season from March 23-May 14. Fish were monitored two days per week either from 6:00 am to 10:00 am and 4:00 pm to 8:00 pm or from 10:00 am to 6:00 pm, for a total of 122 hours (Kleinschmidt 2007). Some fish species that we demonstrated to be successful host species for some mussels were observed moving through the fish ladder, but many were not. The numbers of individuals of many fish species, particularly threadfin shad and American Shad, were low considering the large number of fish seen schooling below the ladder and the large numbers of American shad (328,828) and blueback herring (49,343) noted to have passed through the St. Stephens fish lift downstream in the Santee drainage (Kleinschmidt 2007). Blueback herring was not observed using the Columbia fish ladder during the observation period, nor were many other species that we collected in the upper Congaree approximately 7-8 miles below the dam. While some of the species may have occasionally passed at times the fish ladder was open but not under observation, the numbers moving through the ladder were not likely to be very high if they were not observed during the 122 observation hours. Therefore, we expect that the ability of the Columbia fish ladder to effectively pass fish could be improved.

The only hosts that we found to be successful for *Ligumia nasuta* observed moving through were largemouth bass (*Micropterus salmoides*) and redbreast sunfish (*Lepomis auritus*), which was only a marginal to moderately successful host. Both of these moved through the ladder in low numbers; 17 largemouth bass, and 21 redbreast sunfish were observed. None of the four other hosts we determined to be successful or marginal for this mussel species, were observed moving through the ladder (Kleinschmidt, 2007). The only successful hosts for *E. roanokensis* observed in the fish ladder were gizzard shad (*Dorosoma cepedianum*), 742 individuals observed, and two individuals of white perch, a marginally effective host, were observed. Blueback herring was the only successful host we know of for *E. roanokensis* for which no individuals were observed moving across the ladder. For *L. cariosa*, the only known successful hosts which were observed moving through the fish ladder were largemouth (*Micropterus salmoides*) and smallmouth bass (*Micropterus dolomieu*) (Kleinschmidt 2007). However, we observed that several others served as successful or marginal hosts, most notably striped bass, which produced large number of transformed glochidia. Likewise, we determined that several species were successful hosts for *L. radiata*, but only largemouth bass was observed to be using the fish ladder (Kleinschmidt 2007). During the 122 hour observation period only 17 largemouth bass and 150 smallmouth bass were observed to move through the fish ladder.

In conclusion, the Columbia dam fish ladder may have the potential to assist mussels in dispersing above the dam. Of the four mussel species for which fish host testing was conducted, at least one successful host species was also observed to be moving through the fish ladder, but it remains to be determined if the dates of operation are compatible with the timing of the mussels' reproduction. Since the rates at which fish passed through the ladder were generally low, and glochidial infestation rates in nature tend to be low (C. Eads, NC State U, personal comm.), mussels, if transported, are probably transported at a fairly low rate. Any changes to the fish ladder operations that could increase the volume and/or species diversity of fish passed may assist in the dispersal of mussels. Likewise, the duration of the time frame the fish ladder is open will need to be evaluated when more data becomes available. Because the duration of mussel glochidial attachment fish gills are relatively short (ranging from 10-16 days for *E. roanokensis* to 14-30 days for *L. radiata*) the timing of the passage of host fish through the fish ladder must be very precise to allow dispersal of juvenile mussels above the dam.

Recommendations

Continue host fish testing and the assessment of the seasonality of reproduction in 2008, as planned. Initiate efforts to optimize passage of glochidia infested fishes at Columbia dam. Assess quantitative differences in substrate and water quality characteristics above the Columbia dam above and below Parr Reservoir. Test the ability of various mussel species to survive in these habitats through in-situ survival assessments or simulated conditions in the laboratory.

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Prepared By: Jennifer Price   Title: Biologist

Job Title: Evaluation of Time of Sampling for Largemouth Bass

Period Covered January 1, 2007 – December 31, 2007

Results and Discussion

The objective was to evaluate whether there was a significant difference in the length-frequency of largemouth bass sampled early (i.e. temperatures had not risen to 15 C) as compared to the standard collection period (i.e when water temperatures are between 15 and 20 C). The research hypothesis was that the percentage of larger fish would be higher during the early collection period.

An early and a standard sample were collected on lakes Wateree and Secession in 2006. Fish lengths were divided into five categories: 7-9, 10-12, 13-15, 16-18, and ≥ 19 inches. The comparison of the 'early' vs. 'standard' sample was made at alpha = 0.05 using chi-square analysis (http://www.georgetown.edu/faculty/ballc/webtools/web_chi.html).

Lake Wateree

An early sample was collected on March 9, 2006, when water temperature averaged 12.4. Seventy-eight largemouth bass at least 175 mm TL were collected. A standard sample later in the year collected 358 bass. Length-frequencies during the two sampling periods were not significantly different (chi-square = 5.71, 4 df).

Table 1 Comparison of early and standard sampling of largemouth bass length frequency in Lake Wateree.

Number	Length group - inches				
	7-9"	10-12"	13-15"	16-18"	≥ 19"
Observed in standard sample	71	75	105	83	26
Observed in early sample	**24**	16	18	17	3

Lake Secession

An early sample was collected on February 28, 2006, when water temperature averaged 9.5. Thirty-eight largemouth bass at least 175 mm TL were collected. A standard sample later in the year collected 62 bass. Length-frequencies during the two sampling periods were not significantly different (chi-square = 4.72, 4 df).

Table 2 Comparison of early and standard sampling of largemouth bass length frequency in Lake Secession.

Number	Length group - inches				
	7-9”	10-12”	13-15”	16-18”	≥ 19”
Observed in standard sample	12	20	14	9	7
Observed in early sample	2	14	12	7	3

Recommendations

These samples did not indicate that a higher percentage of larger bass were sampled in an early collection period; continue sampling using current 15-20 C temperature protocol.

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