Statewide Research – Freshwater Fisheries

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ANNUAL PROGRESS REPORT

F-63

July 1, 2001 through June 30, 2002

SC Department of Natural Resources
Division of Wildlife and Freshwater Fisheries
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JOB PROGRESS REPORT

STATE:	South Carolina PROJECT NUMBER: F-63
PROJECT TITLE:	Fisheries Investigations in Lakes and Streams – Statewide
SECTION TITLE:	Survey and Inventory
JOB TITLE:	Hatchery contribution to the 1998 striped bass spawning cohort in the Santee-Cooper system, South Carolina.

Introduction

The Santee-Cooper Lakes, Marion and Moultrie, are stocked with phase-1 striped bass to augment natural recruitment. In most years, fish are not stocked in either the Congaree or Wateree rivers, which are the major tributaries that flow into the Santee-Cooper lakes.

The management biologist estimates the relative contribution of hatchery-reared and naturally spawned striped bass annually. All stocked fish are marked with oxytetracycline (OTC) so that hatchery-reared fish can be identified. A random sample of approximately 200 age-2 striped bass is then collected with gill nets in December, January, and February from Lakes Marion and Moultrie. Otoliths are removed from sampled striped bass and they are inspected for an OTC mark.

Extremely high recruitment occurred in the 1998 spawning cohort. For this spawning cohort, we assessed the following hypotheses:

1) the relative contribution of hatchery-reared fish was identical in Wateree and Congaree rivers, and,
2) the hatchery contribution estimate obtained in the rivers was identical to a lake-derived estimate obtained in a separate study.

Methods

Age-1 (i.e. < 400 mm total length) striped bass were collected from the Congaree (river mile 50) and Wateree (river mile 20) rivers in April through June, 1999. Otoliths were removed and, at a later time, embedded in Araldite CY8705 resin. The embedded otoliths were polished along the transverse plane until the core was visible. If an otolith was lost or damaged during polishing, the other otolith from the fish was embedded and polished.

After polishing, three readers inspected each otolith for an OTC mark using UV-equipped compound microscope. Each otolith was graded as marked, unmarked, possibly marked, or unreadable. If a definitive assignment was not possible during this assessment, the otolith received additional polishing and was re-inspected by two readers. If conflicting results were obtained after the second read, the otoliths were reexamined and a consensus was reached among the readers. Only otoliths considered marked or unmarked were considered when calculating the percentage of the sample that was of hatchery origin. Using the G-test ($P < 0.05$), we compared the frequency of marked and unmarked fish from the Wateree and Congaree rivers. Confidence intervals around results were derived from a table of binomial confidence limits.

Two quality control efforts were performed to help ensure the accuracy of the results. First, 42 completed otolith samples randomly selected from the total data set were re-read by two of the three readers. Second, the second otolith of 20 fish was read by two readers and compared against results obtained from the first otolith.

Results

Two hundred and five age-1 striped bass were inspected for OTC marks. We were able to determine whether 164 of these were marked or unmarked (Table 1). There was not a significant difference in the frequency of marks in the Congaree and Wateree rivers (G=3.21, 1 df). Combining results, 141 fish were marked and 23 (14%; binomial 0.95 CI = 0.09 to 0.21) were unmarked.

Table 1. Results of OTC mark detection efforts in age-1 striped bass collected from the Wateree and Congaree rivers, SC, in 1999.

River	Marked	Unmarked	Possible mark	Not readable
Congaree	106	13	9	22
Wateree	35	10	5	10

Results from quality control efforts were largely consistent with initial reads. In the re-inspection of 42 completed otoliths, 35 determinations agreed with the initial result (Table 2). There was not a significant difference in the frequency of otoliths that were classified as either marked or unmarked during the initial and second read (G = 0.88). In the inspection of 20 second otoliths, 15 agreed with their initial determination (Table 3). There was not a significant difference in the frequency of marked and unmarked otoliths between the first and second otoliths (G = 0.45).

Table 2. Results of re-inspecting 42 otoliths from age-1 striped bass for OTC marks. Possible determinations were marked (M), unmarked (U), possible mark (P), and not readable (N).

Number	First Read	Second Read
20	M	M
7	U	U
4	P	P
4	N	N
3	M	P
2	P	U
1	M	U

Table 3. Results of inspecting the second otolith from age-1 striped bass for OTC marks. Possible determinations were marked (M), unmarked (U), possible mark (P), and not readable (N).

Number	First Otolith	Second Otolith
7	M	M
8	U	U
2	P	M
1	M	P
1	U	M
1	U	P

Discussion

A major question was, "Did the results obtained in this study of age-1 fish from Congaree and Wateree rivers agree with results obtained in a separate evaluation of age-2 striped bass collected from lakes Marion and Moultrie?" In the age-2 evaluation, 94 were marked and 52 (36%; binomial 0.95 CI = 0.28 to 0.44) were unmarked. These frequencies are significantly different (G = 19.9) from those found in this evaluation (141 marked and 23 unmarked). There was no overlap in the confidence limits of these separate determinations. Possible explanations for the difference are:

- there was selective mortality of hatchery-reared (i.e. marked) fish in during their second year of growth,
- marked fish were not randomly distributed,
- the precision of otolith determinations accounted for differences.

Conclusion and Recommendation

The purpose of OTC marking studies is to monitor the proportion of each cohort accounted for by hatchery-produced progeny. If the proportion becomes 'too high', there could be increased risk of loss of genetic diversity, if the diversity of hatchery-produced fish is less than found in the wild population. In 1998, a 'very large' cohort was produced. This cohort may dominate the spawning stock in the near future. Therefore, it is recommended that future analysis of the potential risks of hatchery stocking employ estimates of the maximum hatchery contribution, as defined by binomial confidence limits. In the above studies, maximum hatchery contribution was 91 and 78% for age-1 and age-2 fish, respectively. Use of maximum hatchery contribution in relevant analysis will minimize the risk of incurring a negative hatchery effect.

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JOB PROGRESS REPORT

STATE:	South Carolina	PROJECT NUMBER:	F-63
PROJECT TITLE:	Fisheries Investigations in Lakes and Streams - Statewide		
SECTION TITLE:	Survey and Inventory		
JOB TITLE:	Development of Reservoir-Specific Largemouth Bass Management Models		

Summary:

During the project period July 1, 2001 - June 30, 2002 spring electrofishing sampling data provided by the fisheries districts were reviewed and analyzed by reservoir. Otolith ages were verified for largemouth bass from five reservoirs and one river.

Introduction:

In 1995 the Freshwater Fisheries Section of SCDNR approved a statewide management plan for black bass, including largemouth bass. Management goals were established to provide continuity and guidance to department personnel and the public, while the need for site-specific management authority was recognized. Having such guidelines would promote uniform, consistent assessments of black bass populations, and could enhance public understanding of and support for the process of managing the fishery. One goal common to all four species of black bass was to develop, maintain, and enhance the biological databases needed to make sound management decisions. Such databases can be used to define reservoir-specific management options, depending on the results of a structured and objective assessment of a population.

A standardized protocol for collecting spring electrofishing data was approved and implemented in 1997, and a standardized data-entry program was distributed to each fisheries district. Data collected annually by the fisheries districts are now sent to the Fisheries Research

Lab in Eastover for compilation and analysis using computer programs developed for that purpose. Current and historic data are then used to produce site-specific estimates of largemouth bass population parameters.

Accuracy in aging has critical implications for management. Age provides the time line upon which a number of rate functions, among them growth, mortality, and recruitment are based. In order to have a good understanding of the dynamics of a population, the underlying age information must be reasonably correct. Otherwise, significant misinterpretations of data can result. To ensure accurate aging of largemouth bass captured during spring electrofishing, the districts follow a standardized otolith aging procedure. The procedure includes review and verification of a random subset of otoliths from each reservoir at the Fisheries Research Lab in Eastover as a quality control measure.

The objectives of the present job were to compile and analyze data collected during spring electrofishing in 2001 and update the existing database, modifying reservoir-specific modeling parameters if warranted.

Materials and Methods:

Spring electrofishing data collected in 2001 in accordance with the 1997 South Carolina Largemouth Bass Sampling Plan (SSP) were obtained from the districts and compiled and analyzed using programs developed previously. At least 25% of otoliths aged by district staff were randomly selected for age verification. Additional otoliths were selected non-randomly to verify aging of older fish or to resolve apparent outliers when age was plotted against total length. If agreement with district-obtained ages was less than 90%, an attempt was made to resolve differences by consensus. If agreement could not be reached on the age of an otolith, the fish was omitted from analyses involving age. Age-length keys prepared for each reservoir were applied to length distribution data to produce age frequency distributions for largemouth bass populations. When more than one year of aging data was available, multiple-year age-length keys were used. Mean total length at age was computed as an approximation of growth in each reservoir. Catch per unit effort (CPUE) of age-1 fish was used as an index of recruitment. CPUE was also computed in terms of length categories, using the five-cell model of Gabelhouse (1984). Stock density indices (PSD, RSD-15, and RSD-20) were computed for each reservoir using the traditional method of Gabelhouse (1984) as described by Anderson and Neumann (1996).

Results and Discussion:

Largemouth bass otoliths were obtained for evaluation of ages from District 1 (Jocassee 2000 and 2001, Keowee 2000, and Hartwell 2001) and District 3 (Murray 2001 and Boyd Mill Pond 2001). Agreement with district-determined ages was 100% for both District 1 reservoirs in 2000 but was 88% for Jocassee and 95% for Hartwell in 2001. Agreement with District 3 ages was 100% for Boyd Mill Pond but only 83% for Murray. No consultation was held to determine the reason for the low agreement on Murray ages. Otoliths taken by District 8 from largemouth bass collected from the Lower Saluda River in 1999, 2000, and 2001 were also evaluated. Agreement with District 8 was 33%. No consultation was held.

Spring electrofishing data for 2001 were received from Districts 1, 3 and 5. Selected population parameters are summarized in Tables 1a-d for the seven reservoirs for which data were available.

Recommendations:

1. Compile 1997-2002 data, defining best-available model parameters (i.e. growth, mortality, and recruitment).
2. Transfer largemouth bass management model results to the fisheries districts, making reservoir-specific management recommendations when sufficient data are available.
3. Define an optimal statewide regulation for largemouth bass.
4. Automate the collection, compilation, summary and reporting of the districts' spring electrofishing data at Eastover.
5. Continue to provide verification of otolith aging at Eastover.
6. Evaluate zonal differences in largemouth bass population parameters.

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Prepared by: John S. Crane Title: Assistant Project Leader

Table 1a-d. Largemouth bass population parameters in selected South Carolina reservoirs, 2001. Age-related parameters in 1a and 1b were computed from age frequency tables based on multi-year age-length keys.

1a. Mean total length (std. error) in cm, by age, derived from frequency tables (Steel and Torrie 1960).

Age	Jocassee	Hartwell	Boyd Mill	Murray	Wateree	Marion	Moultrie
1	15.4 (0.31)	18.4 (0.27)	18.0 (0.83)	21.3 (0.51)	20.8 (0.31)	19.2 (0.92)	21.6 (0.63)
2	27.6 (0.39)	28.1 (0.35)	26.4 (0.56)	29.7 (0.49)	29.4 (0.26)	32.9 (0.56)	31.6 (0.34)
3	35.7 (0.42)	34.2 (0.38)	31.4 (0.79)	34.7 (1.16)	35.6 (0.29)	38.0 (0.70)	37.0 (0.51)
4	40.2 (0.76)	36.1 (0.47)	38.3 (1.19)	44.0 (1.20)	39.8 (0.49)	40.4 (1.22)	41.1 (0.55)
5		40.4 (0.98)			43.1 (0.56)	44.2 (1.33)	44.4 (0.62)

1b. Catch per unit effort (no./hr) by age. Total includes all ages.

Age	Jocassee	Hartwell	Boyd Mill	Murray	Wateree	Marion	Moultrie
1	9.0	17.0	10.5	6.0	10.2	5.7	16.0
2	8.7	15.4	11.5	8.0	25.1	4.7	16.0
3	5.7	10.9	17.5	2.0	25.8	4.0	11.1
4	2.4	6.9	3.0	2.2	8.4	3.2	8.7
5		3.7	6.0	0.8	5.7	1.7	9.1
Total	31.2	58.0	60.0	22.4	86.7	28.5	85.3

1c. Catch per unit effort (no/hr) by length category. TL range (mm) for each category is in parentheses.

Length Category	Jocassee	Hartwell	Boyd Mill	Murray	Wateree	Marion	Moultrie
Prestock (<200)	8.9	12.8	7.0	2.7	3.3	2.8	5.8
Stock (200 - 299)	7.1	16.2	21.5	8.2	21.4	3.5	14.2
Quality (300 - 379)	7.2	20.4	16.5	5.2	32.2	6.8	19.1
Preferred (380 - 509)	6.5	8.3	10.0	5.0	28.9	12.0	37.1
Memorable (510 - 629)	1.3	0.3	5.0	1.2	0.7	3.2	9.1
Trophy (≥630)	0.3	0.0	0.0	0.0	0.0	0.2	0.0

1d. Stock density indices.

Index	Jocassee	Hartwell	Boyd Mill	Murray	Wateree	Marion	Moultrie
PSD	69	64	59	58	74	87	82
RSD-15	37	19	28	32	36	60	58
RSD-20	7	1	9	6	1	13	11

JOB PROGRESS REPORT

STATE:	South Carolina	PROJECT NUMBER:	F-63
PROJECT TITLE:	Fisheries Investigations in Lakes and Streams - Statewide		
SECTION TITLE:	Survey and Inventory		
JOB TITLE:	Contribution of SCDNR and GADNR stocked hybrid bass in Savannah River Lakes		

Introduction

The Georgia and South Carolina Department of Natural Resources (GADNR and SCDNR) share management responsibility for the fisheries in Lakes Thurmond and Hartwell. Hybrid bass (SWH), a cross between the striped bass *Morone saxatilis* and white bass *M. chrysops*, have been introduced into these reservoirs. A popular sport fishery for hybrids has been established on both Lake Thurmond and Lake Hartwell.

These hybrid bass fisheries are supported and maintained by annual stocking. Both South Carolina and Georgia contribute to the stocking effort each year. GADNR produces reciprocal hybrids, the result of crossing white bass females and striped bass males, and stocks them as fry (about 4000/lb) generally in the month of April. SCDNR produces original hybrids by crossing striped bass females and white bass males. SCDNR grows its SWH out to a larger size (about 1500/lb) and stocks them in May. Prior to stocking, SCDNR hybrids are marked by immersion in oxytetracyclene (OTC). Because SCDNR marks its hybrids with OTC and GADNR does not, the contribution each state makes to a given year class can be assessed.

The objective of this effort was to determine the contribution of SCDNR and GADNR stocked hybrids to the 1999 year class. The objective was accomplished by evaluating OTC marks from otoliths collected during routine gill net sampling by both states. Contributions were determined for the 1999 year class at age 0+ and 1+.

Methods

In Spring of 1999 SCDNR and GADNR stocked juvenile hybrid striped bass in Lakes Thurmond and Hartwell. Lake Thurmond was stocked with 829,497 fish, 247,172 (29.8%) from SCDNR and 582,325 (70.2%) from GADNR. Lake Hartwell was stocked with 632,646 fish, 83,075 (13.1%) from SCDNR and 549,571 (86.9%) from GADNR.

Fish were collected by gill nets in the late fall and early winter at age 0+ and 1+. Hybrid striped bass were measured and weighed. Otoliths were pulled and examined to determine age.

Otoliths from wild-caught 1999 year class fish were sectioned, polished to the core, and evaluated for marks. All otoliths were evaluated by two independent readers.

A set of known-marked otoliths from the 1999 year class was evaluated to determine brightness and location of the OTC mark.

Chi-Square analysis was used to compare number stocked of each type, with gill net catch at age 0+ and 1+. Length and weight were compared for marked and unmarked hybrid striped bass at age 0+ and 1+, for each reservoir. Differences were evaluated using the T-test. All statistical evaluations were conducted with an $\alpha = 0.05$.

Results

Ten otoliths from known-marked, age 0+ hybrids from the 1999 year class were examined. All were easily readable with bright OTC marks.

From Lake Thurmond, otoliths were examined from 67 age 0+ and 43 age 1+ SWH. Of otoliths collected at age 0+, 16 (24%) were marked, 19 (28%) were unmarked and 32 (48%) were not readable. Of otoliths collected at age 1+, 6 (14%) were marked, 28 (65%) were unmarked and 9 (21%) were not readable (Table 1).

Otoliths were examined from 64 age 0+ and 53 age 1+ SWH from Lake Hartwell. Of otoliths collected at age 0+, 23 (36%) were marked, 16 (25%) were unmarked and 25 (39%) were not readable. Of otoliths collected at age 1+, 7 (13%) were marked, 45 (85%) were unmarked and 1 (2%) was not readable (Table 1).

Table 1. Number of marked and unmarked otoliths examined form 1999 year class hybrid striped bass, by reservoir and age group.

Reservoir	Age	No. marked	No. Unmarked
Thurmond	0+	16	19
	1+	6	28
Hartwell	0+	23	16
	1+	7	45

Chi-square analysis (Table 2) for age 0+ from Lake Thurmond showed that the frequency of SC and GA fish collected was significantly different than expected frequencies based on stocking rate. The frequency of SC fish in the collection was higher than expected. At age-1+ the frequency of SC and GA fish in the catch were not significantly different than expected frequencies. Results for Lake Hartwell were similar, with SC fish over-represented in the catch at age 0+ and no significant difference between catch frequencies and expected frequencies at age 1+.

Table 2. Results of chi-square (X^2) test by reservoir and age group. Observed (O) and expected (E) values are based on catch rates and stocking rates of 1999 year class hybrid striped bass, respectively. A X^2 test statistic of ≥ 3.84 is significant at $\alpha = 0.05$.

Reservoir	Age	O/E	Marked	Unmarked	X^2
Thurmond	0+	O	16	19	
		E	10.4	24.6	4.24
	1+	O	6	28	
		E	10.1	23.9	2.40
Hartwell	0+	O	23	16	
		E	5.1	33.9	72.08
	1+	O	7	45	
		E	6.8	45.2	0.01

At age 0+, GA hybrids were longer and heavier than SC fish from Lake Thurmond. Length and weight were not significantly different at age 1+ in Lake Thurmond or in Lake Hartwell (Table 3.)

Discussion

Data gathered from the 1999 cohort suggests that the GA and SC stocking strategies produced similar returns to the fishery. This conclusion is based on relative frequencies at age 1+ as hybrids recruit to the fishery around this age. Additional data is needed to confirm this observation from a single cohort. From a management perspective, future efforts should consider limiting analysis to age 1+ hybrids.

Table 3. Mean total length (mm) and weight (g) at age 0+ and 1+ for marked and unmarked hybrid striped bass of the 1999 year class. Corresponding T-test statistics and probabilities are included.

Reservoir	Age	Variable	Marked	Unmarked	T	Prob>|T|
Thurmond	0+	Length	242.6	262.4	3.06	<0.01
		Weight	167.7	219.7	3.45	<0.01
	1+	Length	423.3	425.0	0.13	0.90
		Weight	1006.5	920.0	-0.80	0.43
Hartwell	0+	Length	254.5	263.5	0.86	0.39
		Weight	217.5	245.5	0.86	0.39
	1+	Length	441.3	436.9	-0.47	0.64
		Weight	1162.0	1117.4	-0.58	0.56

The proportion of SCDNR hybrids in the catch at age 0+ was greater than the proportion stocked for both lakes. This possibly indicates better survival of hybrids that are grown out to a larger size prior to stocking. However, analysis of the catch at age 1+ indicated equal survival. One possible explanation for this is differential survival of GA and SC hybrids from age 0+ to age 1+. Another is non-random sampling of SCDNR and GADNR stocked fish at age 0+.

Gear selectivity was one possible reason for non-random sampling. Gear selectivity for larger fish at 0+, could have resulted in inadequate catches of GADNR hybrids. To rule out gear selectivity it is important that we know more about the gear, and about each fish collected. While T-test showed that on Lake Thurmond GADNR hybrids were larger at 0+, our sample only includes those fish subject to capture in the gill nets deployed. In the coming year SCDNR biologist will record catch by panel size. We will ask that GADNR biologist do the same. This data, together with actual net and panel sizes, will give us a better idea of whether we are effectively sampling the smallest fish in the population.

Recommendations

-Continue study by examining fish from the 2002 year classes. Consider limiting future mark analysis to fish at age 1+.

-Change sampling protocol to include record of panel mesh and panel size for each fish collected.

-Increase communication so that both states understand and implement experimental design.

References

Sokal, R. R., and F. J. Rohlf, 1969. Biometry. W. H. Freeman, San Francisco, California.

Prepared by: Jean K. Leitner Title: Fisheries Biologist

JOB PROGRESS REPORT

STATE:	South Carolina PROJECT NUMBER: Broad River
PROJECT TITLE:	Fisheries Investigations in Lakes and Streams - Statewide
STUDY:	Research
JOB TITLE:	An Inventory of the Aquatic Resources of the Broad River, with Emphasis on Fishes.

Introduction

We investigated the health of the largemouth bass (*Micropterus salmoides*) population in the Broad River, South Carolina, as part of the Comprehensive Broad River Aquatic Resources Inventory. We chose largemouth bass because they were readily available and we believed their condition would reflect the overall health of the aquatic community. The position of largemouth bass in the food chain, as a top predator, should integrate the effects of many biotic and abiotic variables that affect aquatic community health (Adams and McLean 1985). Largemouth bass have been used in Tennessee Valley Authority Reservoirs (Brown and Hickman 1990) and the Catawba River of North and South Carolina (Coughlan et al. 1996) to investigate fish health.

Largemouth bass health was determined by conducting a fish health assessment (FHA), an autopsy-based procedure in which organs, structures and blood parameters of individual fish are assessed and scored based on their deviation from normality (Table 1). Scores for organs, structures and blood parameters of individual fish are summed to calculate a fish health assessment index (FHAI) value. Fish with higher FHAI values are considered to be in poorer health than fish with lower values. The FHA was originally described by Goede and Barton (1990) and has been modified by Adams et al. (1993) and Coughlan et al. (1996).

Table 1. Organs, structures and blood parameters scored during the Broad River largemouth bass FHA, associated condition, field designation and values used to calculate index scores using the Adams and Coughlan modified scoring criteria (modified from Adams et al. 1993 and Coughlan et al. 1996).

Tissue or Organ	Condition	Designation	Adams	Coughlan
Liver	Normal. Solid red or light red color.	A	0	0
	"Fatty" liver. Light tan color as "coffee with cream"			
	color moderate[a]	C1	30	15
	color severe	C	30	30
	Cysts/Nodules	D	30	30
	Focal discoloration - change of color in local areas or foci of liver.	E	30	30
	General discoloration of whole liver			
	color moderate[a]	F1	30	15
	color severe	F	30	30
	Other - any observation which does not fit above categories	OT	30	30
Gills	Normal with no apparent aberrations	N	0	0
	Frayed - erosion of tips of lamellae resulting in "ragged" appearing gills	F	30	30
	Clubbed - swelling of gill lamellae tips	C	30	30
	Marginate - light gill margin, discolored lamellar tips	M	30	30
	Pale - light, discolored gills (whole gills)	P	30	30
	Other - any observation which does not fit above categories			
	mild[a]	OT1		10
	moderate[a]	OT2		20
	severe	OT3	30	30
Gill Rakers[a]	Normal			0
	Slightly deformed or missing (<5 rakers)			10
	Moderately deformed or missing (5-10 rakers)			20
	Severely deformed or missing (>10 rakers)			30
Pseudobranch	Normal - flat with no aberrations	N	0	0
	Swollen - convex in appearance	S	30	30
	Lithic - mineral deposits (amorphous white spots)	L	30	30
	Swollen and lithic	X	30	30
	Inflamed	I	30	30
	Other - any observation which does not fit above categories	OT	30	30
Thymus	Normal appearance - no hemorrhage		0	0
	Mild hemorrhage		10	10
	Moderate hemorrhage		20	20
	Severe hemorrhage		30	30
Mesenteric Fat	No fat between pyloric ceca	0		
	Less than 50% of ceca covered with fat	1		
	50% of ceca covered with fat	2		
	More than 50% of ceca covered with fat	3		
	Ceca totally covered with fat	4		
Bile	Straw color, bladder empty	0		
	Straw color, bladder full	1		
	Grass green color, bladder full	2		
	Dark green color, bladder full	3		
Sex	Male	M		
	Female	F		

Table 1. Continued.

Tissue or Organ	Condition	Designation	Adams	Coughlan
Spleen	Normal - black, very dark red, or red	B	0	0
	Granular - rough appearance (normal)	G	0	0
	Nodular - nodules or fistulas of various sizes	N	30	30
	Enlarged	E	30	30
	Other - any observation which does not fit above categories	OT	30	30
Hindgut	Normal - no inflammation or reddening		0	0
	Slight inflammation or reddening		10	10
	Moderate inflammation or reddening		20	20
	Severe inflammation or reddening		30	30
Trunk Kidney	Normal - firm, lying relatively flat dorsally along the ventral surface of the vertebral column	N	0	0
	Swollen - enlarged or swollen, wholly or in part	S	30	30
	Mottled - gray discoloration	M	30	30
	Granular - granular appearance or texture	G	30	30
	Urolithic - white or cream-colored mineral deposits in kidney tubules (nephrocalcinosis)	U	30	30
	Other - any observation which does not fit above categories	OT	30	30
Opercles	Normal - no shortening, gills completely covered			0
	Slight shortening, a very small portion of the gills exposed			10
	Moderate shortening, a small portion of the gills exposed			20
	Severe shortening, a considerable portion of the gills exposed			30
Skin	Normal - no hemorrhagic areas			0
	Mild hemorrhagia on skin surface (<10 %)			10
	Moderate hemorrhagia on skin surface (10 - 60 %)			20
	Severe hemorrhagia on skin surface (>60 %)			30
Fins	Normal - no active erosion		0	0
	Light active erosion		10	10
	Moderate active erosion with some hemorrhaging		20	20
	Severe active erosion with hemorrhaging		30	30
Eye	Normal clear eyes (lens) - no aberrations	N	0	0
	Lenticular opacity (blind)			
	one eye	B1	30	15[a]
	both eyes	B2	30	30
	Exopthalmia - swollen or protruding eye			
	one eye	E1	30	15[a]
	both eyes	E2	30	30
	Hemorrhagic - bleeding			
	one eye	H1	30	15[a]
	both eyes	H2	30	30
	Missing			
	one eye	M1	30	15[a]
	both eyes	M2	30	30
	Other - any observation which does not fit above categories			
	one eye	OT1	30	15[a]
	both eyes	OT2	30	30
Opercles	Normal - no shortening, gills completely covered			0
	Slight shortening, a very small portion of the gills exposed			10
	Moderate shortening, a small portion of the gills exposed			20
	Severe shortening, a considerable portion of the gills exposed			30

Table 1. Continued.

Tissue or Organ	Condition	Designation	Adams	Coughlan
Skin	Normal - no hemorrhagic areas			0
	Mild hemorrhagia on skin surface (<10 %)			10
	Moderate hemorrhagia on skin surface (10 - 60 %)			20
	Severe hemorrhagia on skin surface (>60 %)			30
Fins	Normal - no active erosion		0	0
	Light active erosion		10	10
	Moderate active erosion with some hemorrhaging		20	20
	Severe active erosion with hemorrhaging		30	30
Parasites	No observed parasites		0	0
	Few observed parasites, parasites in just one organ		10	10
	Moderate parasite infestation, parasites observed in several organs		20	20
	Numerous observed parasites, extensive infestation in several organs		30	30
Relative	≥85.00			0
Weight (%)[a]	≥70.00 and <85.00			15
	<70.00			30
Gross	No visible gross abnormalities	N		0
Abnormalities[a]	Tumors visible on external surfaces	E		30
	Tumors visible on internal surfaces	I		30
	Lordosis of vertebral column	L		30
	Scoliosis of vertebral column	S		30
	Skeletal deformities/broken bones of head and jaws	D		30
	Skeletal deformities/broken bones of remaining bony structures	B		30
	Other - any observation which does not fit above categories	OT		30
Hematocrit (%)	Normal range (30 - 45)		0	0
	Above normal range (>45)		10	10
	Below normal range (19 - <30)		20	20
	Well below normal range (<19)		30	30
Leucocrit (%)	Normal range (0 - <4)		0	0
	Above normal range (≥4)		30	30
Plasma	Normal range (3 - 7)		0	0
Protein (g/dL)	Above normal range (>7)		10	10
	Below normal range (<3)		30	30

[a] Parameters used to calculate Coughlan modified scores only.

Methods

Ten sites corresponding to current SCDNR fish community sampling sites were selected for conducting the FHA (Figure 1). Site numbers were assigned longitudinally with the most downstream site being site 1 and the most upstream being site 10. Each site was classified by what were perceived to be the most important anthropogenic impacts. Sites were classified as not impacted (N) or as impacted by industrial effluent (I), municipal/community effluent (M), or hydroelectric facilities (H). Industrial sites were

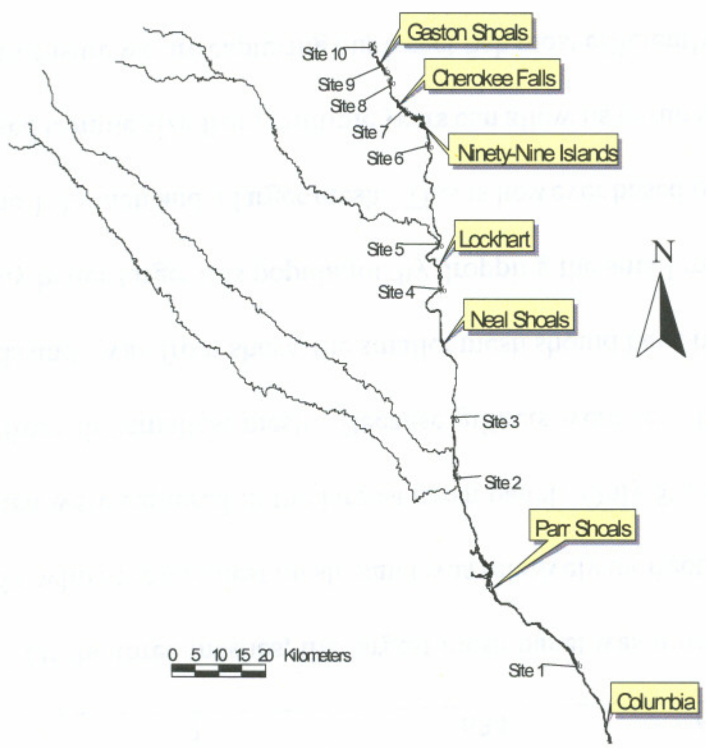

Figure 1. Areas sampled during the Broad River largemouth bass FHA during November of 2001.

defined as areas with one or more major industrial effluents within 4 km of the sample site. Municipal/community sites were those sites with municipal and community effluent within 4 km of the sample site. Sites classified as impacted by hydroelectric facilities were located within 2 km of an upstream hydroelectric facility.

Fifteen largemouth bass were collected, during November 2001, at each site and processed using the autopsy-based fish health assessment described by Adams (1993). Fish were captured during the day with boat mounted electrofishing gear. After capture, largemouth bass were anesthetized with 10% eugenol (Anderson et al. 1997) and held in an aerated live-well. The peritoneal and pericardial cavities were opened to expose the organs for visual assessment. Because liver coloration and blood parameters can change rapidly after death, liver coloration was evaluated and blood was collected from each fish before the other variables were assessed. Liver color was immediately recorded and blood was collected from the heart with a sharpened micro-hematocrit tube. Fish were then tagged and placed on ice until the other variables could be scored. Otoliths were collected from all fish to estimate age.

FHAI scores were calculated using the Adams scoring methodology (Adams et al. 1993) and the modified method suggested by Coughlan et al. (1996) (Table 1). Comparisons among sites were investigated using a Kruskal-Wallis Test (SAS 1989). Multiple comparisons were investigated using a Nemenyi Test (Zar 1996). Linear regression was used to determine if there was a relationship between average age or weight of fish and mean FHAI scores.

Results

We collected 15 largemouth bass from each site during November 2001. We tried to follow the suggestions of Coughlan et al. (1996) and evaluate only fish that were between 250 mm and 450 mm total length (TL). However, occasionally fish outside the suggested size range were evaluated. Four fish greater than 450 mm TL (range 451-464 mm) and one fish 247 mm TL were scored. Estimated ages of largemouth bass ranged from 1 to 13. Mean estimated ages by site are reported in table 2.

Table 2. Mean estimated age, range in parentheses, and mean weight for largemouth bass collected from the Broad River during November 2001.

Site No.	Mean estimated age	Mean weight
1	1.9 (1-3)	394
2	3.5 (1-13)	595
3	2.5 (1-7)	647
4	2.7 (2-5)	448
5	2.7 (1-6)	468
6	3.8 (3-8)	586
7	2.7 (2-4)	372
8	2.9 (2-5)	302
9	2.9 (2-5)	390
10	4.1 (2-7)	737

Coughlan-modified FHAI scores (Coughlan et al. 1996) for individual fish ranged from 0 to 125. Mean Coughlan-modified scores by site ranged from 37 to 59 and averaged 45 (Table 3). The highest average scores, 59 and 54, were observed at sites 3 and 8, respectively and the lowest score (37) was observed at sites 1 and 7. The Adams scoring methodology resulted in FHAI scores ranging from 0 to 150 for individual fish. Mean scores by site ranged from 35 to 73 and averaged 57. The highest mean scores, 73 and 69, were observed at sites 3 and 8, respectively and the lowest score (35) was observed at site 6. There were no significant differences in the Coughlan-modified scores among sites (Kruskal-Wallis test; $P = 0.18$); however, there were significant differences among sites using the Adams scores (Table 3)(Kruskal-Wallis; $P = 0.03$). Significant differences were found between site 6 (lowest scoring non-impacted site) and all the sites impacted by industrial effluent (sites 3, 8 and 9). Significant differences were also found between sites 6 and 10, and between sites 3 and 4. There were no significant relationships

(P> 0.05) between mean age or weight of largemouth bass and FHAI score using either the Adams or Coughlan scoring methodology.

Table 3. Mean Coughlan and Adams fish health assessment index (FHAI) scores and standard deviation for largemouth bass collected from the Broad River, SC, during November 2001. Mean scores with the same letter were not significantly different (Nemenyi Test; P = 0.05).

Site No.	Perceived Impact[a]	N	Coughlan	Adams
1	M	15	37 ± 20	59^{xy} ± 29
2	N	15	39 ± 17	52^{xy} ± 29
3	I	15	59 ± 24	73^{x} ± 28
4	M, H	15	40 ± 20	46^{yz} ± 22
5	N	15	45 ± 26	60^{xy} ± 34
6	N	15	41 ± 34	35^{y} ± 39
7	M, H	15	37 ± 17	50^{xy} ± 21
8	I, M	15	54 ± 35	69^{xz} ± 42
9	I	15	49 ± 20	65^{xz} ± 24
10	N	15	49 ± 31	66^{xz} ± 39
Mean			45 ± 26	57 ± 32

[a]Perceived impacts are classified as: (H) hydroelectric impacts; (I) industrial impacts; (M) municipal impacts; (N) not impacted.

Liver discoloration, poor relative weight (<85%), and skin anomalies were the most frequently observed abnormalities (Table 4). Anomalous livers were observed at every site and in 59% of the fish processed. Most abnormal livers (88%) were scored for moderate general discoloration of the whole liver. The frequency of anomalous livers was greatest at sites 1 and 8 where 12 of 15 fish had discolored livers. Site 6 had the fewest number of fish with anomalous livers (4 of 15). Poor relative weights were observed at every site and in 49% of the fish processed. At sites 4, 7, and 8, 11 of 15 fish had relative weights < 85. Conversely, at sites 2 and 3 only 2 fish had poor relative weights. Mild hemorrhaging of the skin surface was observed at every site and in 47% of the fish processed. Hemorrhaging of the skin surface was most common at site 7 where

10 of 15 fish had mild hemorrhaging and least common at site 10 where only 3 fish had hemorrhagia on the skin surface.

Table 4. Percentage of fish with anomalous tissues, organs, and/or relative weight (Wr), collected from 10 sites in the Broad River, South Carolina during fall 2001.

	Percent atypical in					
Site	Liver	Wr	Skin	Gill rakers	Trunk kidney	Gills
1	80	40	60	13	13	13
2	53	13	40	27	47	7
3	73	13	60	33	67	13
4	60	73	47	33	7	13
5	53	40	47	47	33	33
6	27	60	33	40	33	13
7	47	73	67	40	0	27
8	80	73	60	33	20	20
9	53	60	40	33	47	40
10	67	40	20	27	53	20
All sites	59	49	47	33	32	20

Abnormalities of the gill rakers, trunk kidney and gills were common (Table 4). Gill raker abnormalities were observed at each site and in 33% of the fish processed. Most (96%) gill raker abnormalities consisted of slightly deformed rakers or gill arches missing 5 or fewer rakers. The frequency of gill raker deformities was rather consistent among sites. Abnormal trunk kidneys were observed in 32% of the fish processed. Most (47 of 48) trunk kidney abnormalities were due to swollen or enlarged trunk kidneys. One fish from site 6 had a trunk kidney that was gray in appearance and contained a milky fluid. The highest frequency of anomalous trunk kidneys was observed at site 3 where 10 of 15 fish had abnormal trunk kidneys. No trunk kidney abnormalities were observed at site 7. Gill abnormalities were observed in 20% of the fish processed and at every site. Most gill abnormalities were due to pale filaments and occasionally missing filaments.

Abnormal blood parameters were observed at each site (Table 5). Twenty-three percent of all fish processed had elevated plasma protein levels. Abnormal plasma protein levels were most common at site 3, where 9 of 15 fish had plasma protein levels above the normal range and least common at site 6 where none of the fish had elevated plasma protein levels. Atypical hematocrit levels were observed in 17% of the fish processed. Most (68%) deviant scores were due to hematocrit levels above the normal range. Atypical hematocrit levels were most frequent at site 4, where 6 of 15 fish had abnormal levels and least common at site 9 where one fish had below normal hematocrit levels. Only one of 150 fish processed had elevated leucocrit levels and it was collected at site 8.

Table 5. Percentage of fish with atypical blood parameters collected from 10 sites in the Broad River, South Carolina during fall 2001.

Site	Hematocrit	Leucocrit	Plasma Protein
1	13	0	33
2	13	0	40
3	20	0	60
4	40	0	0
5	20	0	13
6	13	0	0
7	13	0	7
8	13	7	13
9	7	0	27
10	13	0	40
All sites	17	1	23

The remainder of the metrics scored contributed little to the FHA. Four fish had mesenteric adhesions that were scored as gross abnormalities. Only three atypical spleens were observed: two were nodular and one was abnormally small; it appeared to be half the size of a normal spleen. We did not encounter an abnormal thymus, pseudobranch or hindgut.

Discussion

Largemouth bass populations in the Broad River appear to be in good condition based on the results of our FHA. Brown (1993) considered sites with average scores >90, using the Adams scoring methodology, to be areas in need of further study. Using the Coughlan-modified scoring method, areas of concern would have average index scores >75 (Coughlan et al. 1996). None of the Broad River sites had mean Adams scores > 73 or Coughlan-modified scores > 59.

Industrial effluent appears to adversely affect largemouth bass health. Sites located near industrial effluent scored higher than nearly all the other sites using both scoring methodologies. The next highest scores were observed at site 10. The high scores (Coughlan 49; Adams 66) at site 10 may have been confounded by the size and age of fish collected. Mean estimated age and weight were greater at site 10 than any of the other sites sampled. Although there was not a significant relationship between age or weight of fish and FHAI score in this study other studies have documented a positive relationship between largemouth bass age and FHAI score (Coughlan et al. 1996). The other anthropogenic influences identified in this study (municipal impacts and hydropower operations) did not seem to adversely affect the health of largemouth bass.

Although none of the sites warrant further study based on the *a priori* concern levels a relationship between compromised largemouth bass health and industrial sites was identified. Further research is suggested to determine if the trend in largemouth bass health and proximity to industrial sites is consistent annually.

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Prepared by: Jason M. Bettinger Title: Fisheries Biologist

JOB PROGRESS REPORT

STATE:	South Carolina PROJECT NUMBER: F-63
PROJECT TITLE:	Fisheries Investigations in Lakes and Streams - Statewide
SECTION TITLE:	Survey and Inventory
JOB TITLE:	Species Diversity and Condition of the Fish Community of Congaree Swamp National Monument

Introduction

One of the objectives of this survey effort is to develop a baseline dataset that accurately inventories the fishery community in the Congaree Swamp National Monument (COSW). In addition to inventorying the species present, a comprehensive sampling strategy was used that also defines the relative condition of the community. Using this approach, not only can species presence be noted but also, long term monitoring of stream condition will be possible.

With the successful completion of all the FY 2000 and 2001 objectives, four main goals were developed for this third year. First, fully process all collections made in FY 2001. Second, provide a descriptive summary of FY 2001 data to the monument staff. Third, develop a list of sampling sites for this year. Forth, comprehensively survey the selected sites using a sampling strategy that will define the relative health of the fishery community.

All of these goals have been met this year.

All samples from FY 2000 and 2001 have been fully processed and the data has been entered into a GIS database. A summary of this data was presented to the COSW park staff on January 23, 2002 at the Congaree Swamp Research Symposium and in the 2001 Investigators Annual Report (IAR).

This year's sites were selected based on their ability to accomplish both a complete inventory and an accurate measure of the condition of the fishery community. An added emphasis on the guts, sloughs, ponds and lakes in the swamp this year helped to obtain a complete fish inventory. Continued stream sampling in both new and historical sites contributed to the condition assessment of the fish community.

Results (to date)

Public Sampling Day

On October 27, 2001 the public were invited to participate in a sampling trip to Dry Branch. Eleven people attended the outing. After hiking to the sampling location there was a demonstration on how the backpack electrofishing unit works. Participants were given an introduction to the techniques used during this project. The stream yielded a variety of fish and other fauna. Each fish was identified and some life history and interesting characteristics were explained. Those who participated all expressed interest and were all pleased with the trip (Figure 1).

Figure 1: 10/27/2001 Public Sampling Day

Sample Types

The samples of FY 2002 can be divided into two categories based on their objective; those that were intended for condition assessment, and those that were intended for fish inventory. The first objective was to sample streams in a manner consistent with developing an index of biotic integrity (IBI) that can be used in monitoring streams in the future. The second was to gain an accurate and complete inventory of the fish present in the park. 21 sites were sampled this year from May 3rd through September 11th. **Table 1** outlines how the 2002 sampling locations were broken down by objective.

Table 1: 2002 Sampling Locations by Objective

Site Type	Objective 1 Condition Assessment	Objective 2 Fish Inventory
Ponds, Lakes, Guts, Sloughs	N/A	9 (43%)
Streams	12 (57%)	N/A
Total 21	9 (43%)	12 (57%)

In FY 2001 stream sample sites were targeted to take advantage of the low water levels brought on by the drought. Stream sampling is most efficient in low water when the fish are more concentrated. The method used for stream sampling was a species depletion method that allows for comparisons between fish communities in different locations. This method enables the development of metrics to use as an index in assessing the condition of a stream (IBI). Therefore, all of the samples in FY 2001 served to satisfy objective 1; community condition assessment. This year (FY 2002) also turned out to be another drought year. This enabled us to continue to effectively sample some of the streams in the park. While the dry conditions in some respects aided in the stream survey work, it also evaporated many of our proposed sample sites.

This year there was an added emphasis on sampling the guts, sloughs, ponds and lakes in the swamp. These sites were targeted to satisfy objective 2; fish inventory. By including these locations in the sampling schedule a more complete inventory was obtained. Gut, slough, pond and lake samples were sampled with the goal of collecting species rather than comparing the condition of the community.

The total number of *stream* samples on the monument property, for all 3 years of this project was forty. Including off-monument stream sites, and on-monument slough, pond and lake samples the total number of field samples completed for this project was fifty-nine (Table 2). Figure 3 is a map showing the 2001-2002 sampling locations (on-monument sites). Many of the sites were sampled multiple times.

Table 2: Sample Sites By Year

Site Type	FY 2000	FY 2001	FY 2002	TOTAL
Ponds, Lakes, Guts, Sloughs	--	--	9	9
Streams (On-Monument)	--	28	12	40
Streams (Off-Monument)	9	1	--	10
TOTAL	9	29	21	59

Condition Assessment

Stream samples

This year twelve sites were sampled for the purpose of developing and testing the IBI. Due to the unusually low water levels this year, our goal of 18 – 21 sites for 2002 was not reached. On numerous occasions, after scouting the site earlier in the year, the sampling crew arrived to find the creek completely dry. Alternative sites were also dry, forcing the crew to abandon the survey.

When suitable sites were located, a 100-meter stream segment that contained representative habitats was delineated. Block nets were placed at both the upstream and downstream boundaries of the stream segment. A backpack electro-fishing unit was used to make three or more consecutive passes in accordance with standard electrofishing species depletion sampling practices. An attempt was made to collect and numerate all fish (Figure 2).

Figure 2: Dry Branch Stream Survey Backpack Electrofishing

All of the fish collected in 2001 have been fully processed, identified, measured and the information entered into a database. A summary of this data was presented to the COSW park staff on January 23, 2002 at the Congaree Swamp Research Symposium and in the 2001 IAR.

At each sampling location physical, chemical and biological measurements were taken (Table 3). The same measurements were taken at all locations including on and off- monument sites (FY 2000).

Table 3: Stream Survey Sampling Measurements

Sample Information	**Physical Parameters**	**Chemical Parameters**	**Biological Parameters**
Date	Sample length	Conductivity	Fish species**
Stream Name	Avg. width (5 measurements)	Conductance	Length (mm) on all fish
Present	Avg. depth (15 measurements)	Temperature	Fish count
Cedar creek gauge ht*	Flow	pH	Collected specimens
River basin	Discharge	Dissolved O2	
Latitude	Area	% Dissolved O2	
Longitude	Volume	Salinity	
Reach code	Water level		
Access	Substrate type		
Sampling method	Habitat (visual estimation)		
Equipment type	Condition		
All equipment settings	Suitability		
Number of passes			
Duration			
Method			

* Gauge height only recorded for some locations
** Pass number is indexed to every fish to enable us to verify depletion sampling

Fish Inventory
Early Near-River samples

Two stream samples were scheduled for early May before the regular summer sampling began. These samples were chosen to be close to the river and were intended to target the more transient species that may move out of the swamp by the summer. These sites were selected specifically for the purpose of trying to collect new species that summer samples may miss. While these two samples were designed to collect new species not seen during the summer for the inventory, they were not strictly fish inventory samples. As these sites were in streams, they were sampled using the same protocol used for all the other stream survey work. These sites will be available for comparison in the final IBI.

As expected, additional species were collected during the early near river samples. A species list of all the fish collected, identified and sorted so far is available (Appendix 1).

Lake, Pond, Slough and Gut samples

There were nine samples in the guts, sloughs, ponds and lakes of the COSW (Figure 3). These samples are not suitable for inclusion in an IBI and were therefore completed for the purpose of developing the fish inventory.

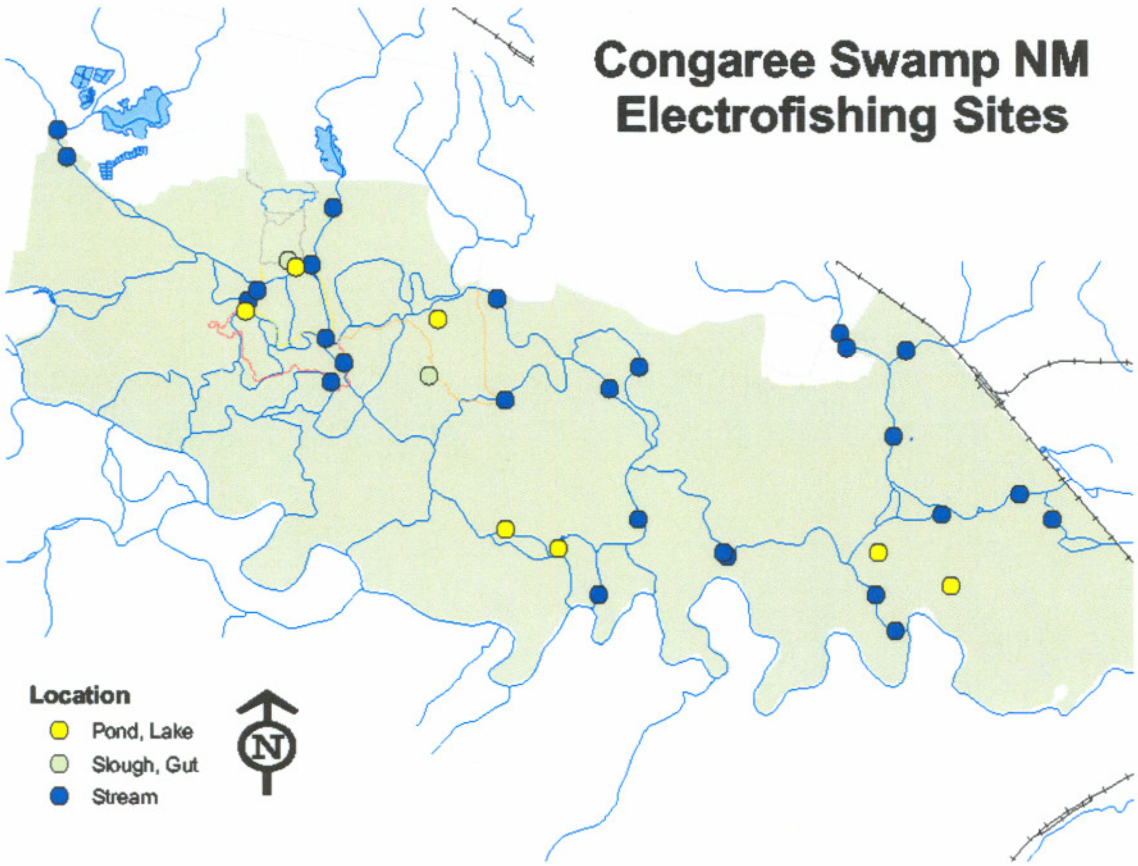

Figure 3: Congaree Swamp National Monument Electrofishing Sites

One or more backpack electrofishers were used to sample the guts, sloughs, ponds and lakes of the COSW. An effort was made to make at least one pass through the entire lake, gut, pond or slough. Where the water body was too big to make a complete pass with the backpack, a segment was selected that was at least 300 meters and included all the representative habitat types. An effort was made to collect and identify to species all fish (Figure 4).


Figure 4: Old Dead River Backpack Electrofishing

The exception to this method was Weston Lake and Wise Lake. Both of these lakes were too deep to effectively sample with a backpack electrofisher. In addition, both of these lakes have historical data available from boat electrofishing. For these two reasons, it was decided that to effectively sample Weston and Wise Lake an electrofishing boat would be required (Figure 5). To comply with the wilderness requirements in the COSW, the motor was removed from the electrofishing boat leaving only the generator to power the electrofishing unit. The boat was paddled around the entire perimeter of both lakes while shocking along the margins. An attempt was made to collect all fish. All fish collected in Weston and Wise Lake were identified to species, measured (total length) and returned to the lake.


Figure 5: Weston Lake Boat Electrofishing

The same method was used to sample these lakes for the historical surveys. In each of the lake, gut, pond and slough samples the same water quality measurements were made (Table 4).

Table 4: Lake, Gut, Pond and Slough Sampling Measurements

Sample Information	**Physical Parameters**	**Chemical Parameters**	**Biological Parameters**
Date	Area (of water body)	Conductivity	Fish species
Stream Name	Water level	Conductance	Length (mm) on all fish*
Present	Substrate type	Temperature	Fish count*
River basin	Habitat (visual estimation)	pH	Collected specimens
Latitude	Condition	Dissolved O2	
Longitude	Suitability	% Dissolved O2	
Reach code		Salinity	
Access			
Sampling method			
Equipment type			
All equipment settings			
Duration			
Method			

* Recorded for Weston and Wise Lakes

All of the fish data and specimens collected in 2002 are currently being processed, identified, measured and the information entered into the database. A descriptive summary will be delivered to the swamp by May 2003 according to schedule.

Drought conditions:

As the swamp is prone to repeated annual flooding, it is reasonable to expect that the fish assemblage in the flood plain would be homogenized by mixing every year (Patterson, et al. 1985). Therefore, flooding events may impede the ability to categorize the condition of a stream based on fish populations. The assumption made is that flooding causes mixing of fish populations in the floodplain thereby masking the effects any stream degradation may be causing in the fish community. This assumption can be tested by comparing data collected under drought conditions (2001 and 2002) when no annual flooding events restocked the fish community, with data collected during normal conditions when the swamp floods multiple times each year.

During the drought year of 2001 extensive samples were taken in the streams in COSW. This year (2002) a goal was to repeat some of the same sites to enable testing for temporal variation. Some sites, however, are more likely to be flooded during a normal non-drought year. Under normal conditions it is reasonable to expect "near-river" sites to flood more often than those near the bluff. Near-river sites will therefore be less suitable as long-term IBI monitoring stations. Streams on or near the bluff in the monument are much less prone to annual flooding and would therefore make better long-term IBI monitoring stations because the effects of mixing would be minimized. This year, many of the stream samples were concentrated in areas away from the river. This will give a more useful comparison for future reference, making better baseline data. Table 5 shows the stream sample locations relative to the river.

Table 5: 2002 Stream Sampling Locations Relative to the River

	Near-River	**Near-Bluff**
Streams	4 (33%)	8 (67%)

Drought conditions persisted through this sampling season. Based on current conditions and forecasts for rain and flooding this year it looks like there will again be lower than average rainfall. If however, conditions change and considerable flooding occurs in the future, additional sampling work should be undertaken. Many of the sites sampled in this project should be re-sampled to determine what effect drought and flooding has on the condition of the fish communities in the COSW. In particular, the assumption that fish communities are repopulated by flood events should be investigated. Under this scenario, one could determine if flood events could be disguising the effects of stream degradation by repopulating streams with fish.

Database:

All the sampled sites have Global Positioning System (GPS) coordinates taken on-site that are referenced to the collection database. Additionally, an extensive photo collection was made and indexed by location and date for almost all the sampled locations. The photo collection will be linked to a Geographical Information System (GIS) database through the World Wide Web.

The current GIS database contains all the data up through FY 2001. All of the fish data and specimens collected in 2002 are currently being processed, identified, measured and the information entered into the GIS. The complete GIS database will be delivered to the park by August 15 with the final project report.

Fish Collection:

An attempt was made to collect voucher specimens from each species observed during the project. To date, fifty-six species have been observed in the project. Forty-one species were observed at the off-monument sites (Appendix 2). Three species were collected at the off-monument sites that were not seen at the on-monument locations. Fifty-three species have been observed in the park (Appendix 1). There are fifty-five unique species in the collection. This number may increase as sorting and identification of some species is still underway.

Public Educational Display:

Preliminary work has begun on the public display. After consultation with the COSW park staff it was decided that the public display will be a website with links to the GIS database and a photo collection made during the project. Additionally, there will be a list of species found in the park with facts, information and photos included.

Interactions:

- Public sampling day – COSW 10/27/2001
- Presentation at 2002 Congaree Swamp Research Symposium – COSW 02/23/2002 (http://www.dnr.state.sc.us/wild/freshfish/fwfi/files/2002-01-23%20COSW%20Meeting%20Presentation.pps)
- Presentation to White Knoll HS Biology students – WKHS 04/12/2002

Budget:

Table 6: Project Budget

	NRPP	**SE Regional Funds**
Total (fy00)	$24,500	$4,354
Total (fy01)	$24,000	
Total (fy02)	$22,000	
Total	$70,500	$4,354

*Note that SE Region contributed an additional $4,354 towards the initial costs of getting this program established.

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Prepared by: Leo Rose   Title: Fisheries Biologist

Appendix 1: Fish Species Found at On-Monument Sites

Family Name	Common Name	Scientific Name
Lepisosteidae		
	Longnose gar	*Lepisosteus osseus*
Amiidae		
	Bowfin	*Amia calva*
Anguillidae		
	American eel	*Anguilla rostrata*
Clupeidae		
	Gizzard shad	*Dorosoma cepedianum*
	Threadfin shad	*Dorosoma petenense*
Umbridae		
	Eastern mudminnow	*Umbra pygmaea*
Esocidae		
	Chain pickerel	*Esox niger*
	Redfin pickerel	*Esox americanus*
Cyprinidae		
	Bluehead chub	*Nocomis leptocephalus*
	Coastal shiner	*Notropis petersoni*
	Dusky shiner	*Notropis cummingsae*
	Eastern silvery minnow	*Hybognathus regius*
	Golden shiner	*Notemigonus crysoleucas*
	Greenfin shiner	*Cyprinella chloristius*
	Sailfin shiner	*Pteronotropis hypselopterus*
	Spottail shiner	*Notropis hudsonius*
	Taillight shiner	*Notropis maculatus*
	Whitefin shiner	*Cyprinella nivea*
Catostomidae		
	Creek chubsucker	*Erimyzon oblongus*
	Shorthead redhorse	*Moxostoma macrolepidotum*
	Spotted sucker	*Minytrema melanops*
Ictaluridae		
	Channel catfish	*Ictalurus punctatus*
	Flat bullhead	*Ameiurus platycephalus*
	Margined madtom	*Noturus insignis*
	Snail bullhead	*Ameiurus brunneus*
	Tadpole madtom	*Noturus gyrinus*
	Yellow bullhead	*Ameiurus natalis*
Amblyopsidae		
	Swampfish	*Chologaster cornuta*
Aphredoderidae		
	Pirate perch	*Aphredoderus sayanus*
Cyprinodontidae		
	Lined topminnow	*Fundulus lineolatus*

Family Name	Common Name	Scientific Name
Poeciliidae		
	Mosquitofish	*Gambusia affinis*
Atherinidae		
	Brook silverside	*Labidesthes sicculus*
Percichthyidae		
	White perch	*Morone americana*
Centrarchidae		
	Banded pygmy sunfish	*Elassoma zonatum*
	Banded sunfish	*Enneacanthus obesus*
	Black crappie	*Pomoxis nigromaculatus*
	Bluegill	*Lepomis macrochirus*
	Bluespotted sunfish	*Enneacanthus gloriosus*
	Dollar sunfish	*Lepomis marginatus*
	Flier	*Centrarchus macropterus*
	Green sunfish	*Lepomis cyanellus*
	Largemouth bass	*Micropterus salmoides*
	Mud sunfish	*Acantharchus pomotis*
	Pumpkinseed	*Lepomis gibbosus*
	Redbreast sunfish	*Lepomis auritus*
	Redear sunfish	*Lepomis microlophus*
	Spotted sunfish	*Lepomis punctatus*
	Warmouth	*Lepomis gulosus*
Percidae		
	Piedmont darter	*Percina crassa*
	Sawcheek darter	*Etheostoma serriferum*
	Swamp darter	*Etheostoma fusiforme*
	Tessellated darter	*Etheostoma olmstedi*
	Yellow perch	*Perca flavescens*

Appendix 2: Fish Species Found at Off-Monument Sites

Family Name	Common Name	Scientific Name
Lepisosteidae		
	Longnose gar	*Lepisosteus osseus*
Anguillidae		
	American eel	*Anguilla rostrata*
Umbridae		
	Eastern mudminnow	*Umbra pygmaea*
Esocidae		
	Chain pickerel	*Esox niger*
	Redfin pickerel	*Esox americanus*
Cyprinidae		
	Bluehead chub	*Nocomis leptocephalus*
	Coastal shiner	*Notropis petersoni*
	Dusky shiner	*Notropis cummingsae*
	Golden shiner	*Notemigonus crysoleucas*
	Sailfin shiner	*Pteronotropis hypselopterus*
	Whitefin shiner	*Cyprinella nivea*
	Yellowfin shiner*	*Notropis lutipinnis*
Catostomidae		
	Creek chubsucker	*Erimyzon oblongus*
	Spotted sucker	*Minytrema melanops*
Ictaluridae		
	Margined madtom	*Noturus insignis*
	Tadpole madtom	*Noturus gyrinus*
	Yellow bullhead	*Ameiurus natalis*
Amblyopsidae		
	Swampfish	*Chologaster cornuta*
Aphredoderidae		
	Pirate perch	*Aphredoderus sayanus*
Cyprinodontidae		
	Lined topminnow	*Fundulus lineolatus*
Poeciliidae		
	Mosquitofish	*Gambusia affinis*
Atherinidae		
	Brook silverside	*Labidesthes sicculus*
Centrarchidae		
	Banded pygmy sunfish	*Elassoma zonatum*
	Banded sunfish	*Enneacanthus obesus*
	Blackbanded sunfish*	*Enneacanthus chaetodon*
	Bluegill	*Lepomis macrochirus*
	Bluespotted sunfish	*Enneacanthus gloriosus*
	Dollar sunfish	*Lepomis marginatus*
	Flier	*Centrarchus macropterus*

Family Name	Common Name	Scientific Name
	Green sunfish	*Lepomis cyanellus*
	Largemouth bass	*Micropterus salmoides*
	Mud sunfish	*Acantharchus pomotis*
	Redbreast sunfish	*Lepomis auritus*
	Redear sunfish	*Lepomis microlophus*
	Spotted sunfish	*Lepomis punctatus*
	Warmouth	*Lepomis gulosus*
Percidae		
	Sawcheek darter	*Etheostoma serriferum*
	Seagreen darter*	*Etheostoma thalassinum*
	Tessellated darter	*Etheostoma olmstedi*
	Yellow perch	*Perca flavescens*

* These fish were found at off-monument sites but not at on-monument sites.