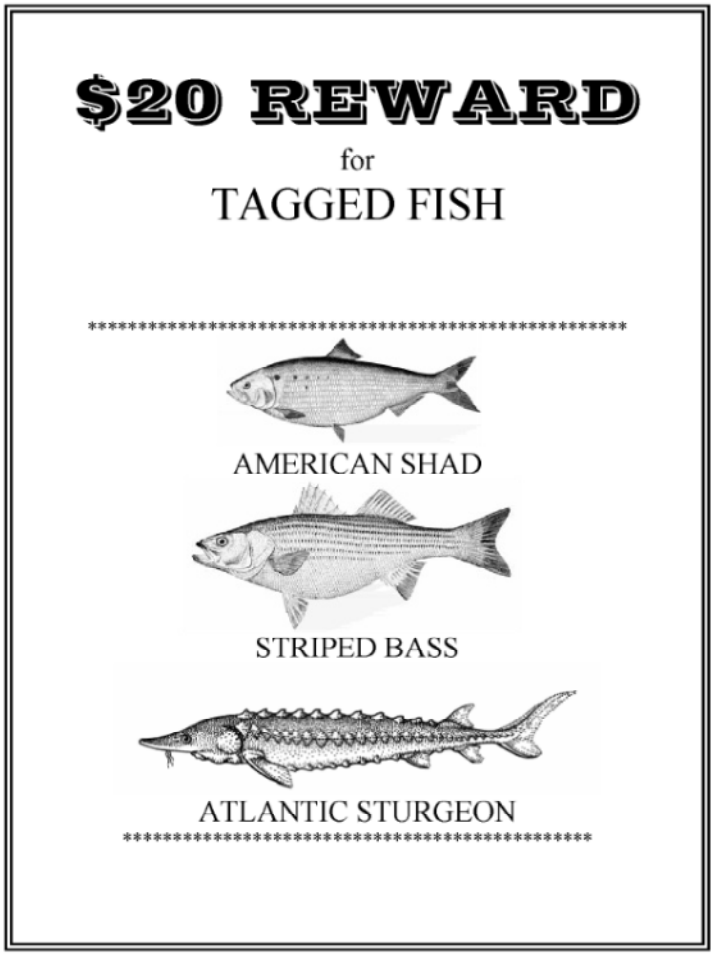
DRAFT

PRE-CONSTRUCTION MONITORING OF AMERICAN SHAD AND STRIPED BASS PASSAGE AT LOCK AND DAM #1 ON THE CAPE FEAR RIVER, NORTH CAROLINA

AUGUST 2004



Prepared for:

U. S. ARMY CORPS OF ENGINEERS
WILMINGTON DISTRICT
Wilmington, North Carolina

Contract No.GS-10F-0043P
Delivery Order W912PM-04-F-7005

Prepared by:

CZR INCORPORATED
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EXECUTIVE SUMMARY

Passage of anadromous fish on the Cape Fear River has been restricted since 1915 by the construction of low head dams. The U.S. Army Corps of Engineers (USACOE), Wilmington District (Corps), has proposed to improve the passage of anadromous fish by constructing a fish passage around Lock and Dam #1. This nature-like fish passage will be approximately 1,160 meters (3,800 feet) long and begin near the downstream base of the dam on the northeast bank and meander through the flood plain directly adjacent to the Cape Fear River. The upstream end of the passage will return to the upper pool above the dam thus allowing fish to bypass the dam and continue upriver to their traditional spawning grounds.

As part of this proposed fish passage the Corps contracted CZR Incorporated (CZR) to perform pre-construction monitoring of two anadromous fish species: striped bass (*Morone saxatilis*) and American shad (*Alosa sapidissima*). The purpose of pre-construction monitoring was to gather baseline data that can be compared to post-construction monitoring data in order to determine fish passage success. Movements of tagged fish were monitored by tracking ultrasonic transmitters with manual and fixed station receivers. Tagging and monitoring efforts in 2004 represent the third year of pre-construction monitoring. Similar monitoring efforts were conducted by CZR during 2002 and 2003 (CZR 2002 and CZR 2003). Forty-nine striped bass and 50 American shad were tagged and monitored in the Cape Fear River between 13 February 2004 and 23 June 2004.

Summary of fish passage success for pre-construction monitoring at Lock and Dam #1, Cape Fear River, Wilmington, North Carolina in 2002, 2003, and 2004.

Monitoring Year	Species Tagged	Number Tagged	Number Returned to Dam	Number Passed	%	Maximum Distance (miles) after Tagging Observed Upstream
2002	American shad	30	8	4	50	N/A[a]
	Striped bass	9	2	0	0	30[a]
	Atlantic sturgeon	1	0	0	0	N/A[a]
2003	American shad	53	12	4	33	100[b]
	Striped bass	41	22	5	23	102[c]
2004	American shad	50	40	10	25	26[b]
	Striped bass	49	30	21	70	165[c]

[a] No tracking above Lock and Dam #1 was conducted in 2002.
[b] Distance from Lock and Dam #1, North Carolina.
[c] Distance from Wilmington, North Carolina.

Fixed station data and manual tracking efforts indicate that forty shad (80%) returned to the vicinity of the dam after tagging. A fish that was determined to have "returned to the vicinity of the dam" is defined as any shad that fell back after tagging and returned upstream of the NC 11 Bridge and was located either by the fixed station or by manual tracking. A shad that never fell back downriver past the NC 11 Bridge and was tracked in multiple locations between the NC 11 Bridge and Lock and Dam #1 indicating that it did not die immediately after tagging was also considered to have "returned to the vicinity of the dam". Of the 40 fish that returned to the vicinity of the dam, ten (25%) were confirmed to have passed to the upstream side of Lock and Dam #1. All shad are believed to have been passed through the locking procedure. Of the remaining 30 fish that approached the dam but did not pass, seven were determined to have died at different times after tagging. The remaining 23 shad were tracked at various locations between International Paper in Riegelwood and Lock and Dam #1 until they disappeared, and were not located again for the remainder of the study. It is believed that some of these fish may have moved to a location below the dam and could not be heard by manual tracking devices or fell back downstream quickly and exited the study area.

Of the 49 fish tagged in 2004, 21 striped bass, or 43%, successfully passed upstream of Lock and Dam #1. Fixed station data and manual tracking efforts indicate that 30 striped bass made deliberate and directed movements upstream in an attempt to reach spawning grounds. Of these 30 fish, 21 (70%) successfully passed upstream of Lock and Dam #1. Striped bass #s 5213 and 5223 were both passed through the lock on 25 March 2004 and represent the first tagged fish to navigate the locking process and striped bass #5203 was passed sometime after 15 June 2004 and represents the last tagged fish to be locked through to the upper pool.

Of the fifteen striped bass and one hybrid striped bass tagged in 2002 and 2003 that returned to the Cape Fear River in 2004, seven successfully passed upstream through the locking process. Only one (#5015) was manually tracked above the dam. The remaining six, #s 5010, 5011, 5012, 5023, 5026, and 5118 were never manually tracked after successfully passing Lock and Dam #1. These fish briefly returned to the vicinity of the Lock and Dam #1 fixed station but moved upstream and out of range of the monitor. Fixed station data at Lock and Dam #1 indicate that striped bass #5010 was already above the dam when the 2004 monitoring period began. This fish was located by the L&D #1 fixed station first on 31 March 2004 and then downstream at each fixed station as it passed moving downriver. This fish was manually tracked once on 15 June 2004 in the Northeast Cape Fear River. Hybrid striped bass #5118 passed through the lock chamber on 6 April 2004 and was recaptured by a recreational fisherman at the base of Lock and Dam #3 on 28 April 2004. Of the remaining nine fish, three (#s 5014, 5020, and 5024) were detected only by fixed stations.

PRE-CONSTRUCTION MONITORING OF AMERICAN SHAD AND STRIPED BASS PASSAGE AT LOCK AND DAM #1 ON THE CAPE FEAR RIVER, NORTH CAROLINA

1.0 INTRODUCTION

Passage of anadromous fish on the Cape Fear River has been restricted since 1915 by the construction of low head dams. The U.S. Army Corps of Engineers (USACOE), Wilmington District (Corps), has proposed to improve the passage of anadromous fish by constructing a fish passage around Lock and Dam #1. This nature-like fish passage will be approximately 1,160 meters (3,800 feet) long and begin near the downstream base of the dam on the northeast bank and meander through the flood plain directly adjacent to the Cape Fear River. The upstream end of the passage will return to the upper pool above the dam thus allowing fish to bypass the dam and continue upriver to their traditional spawning grounds.

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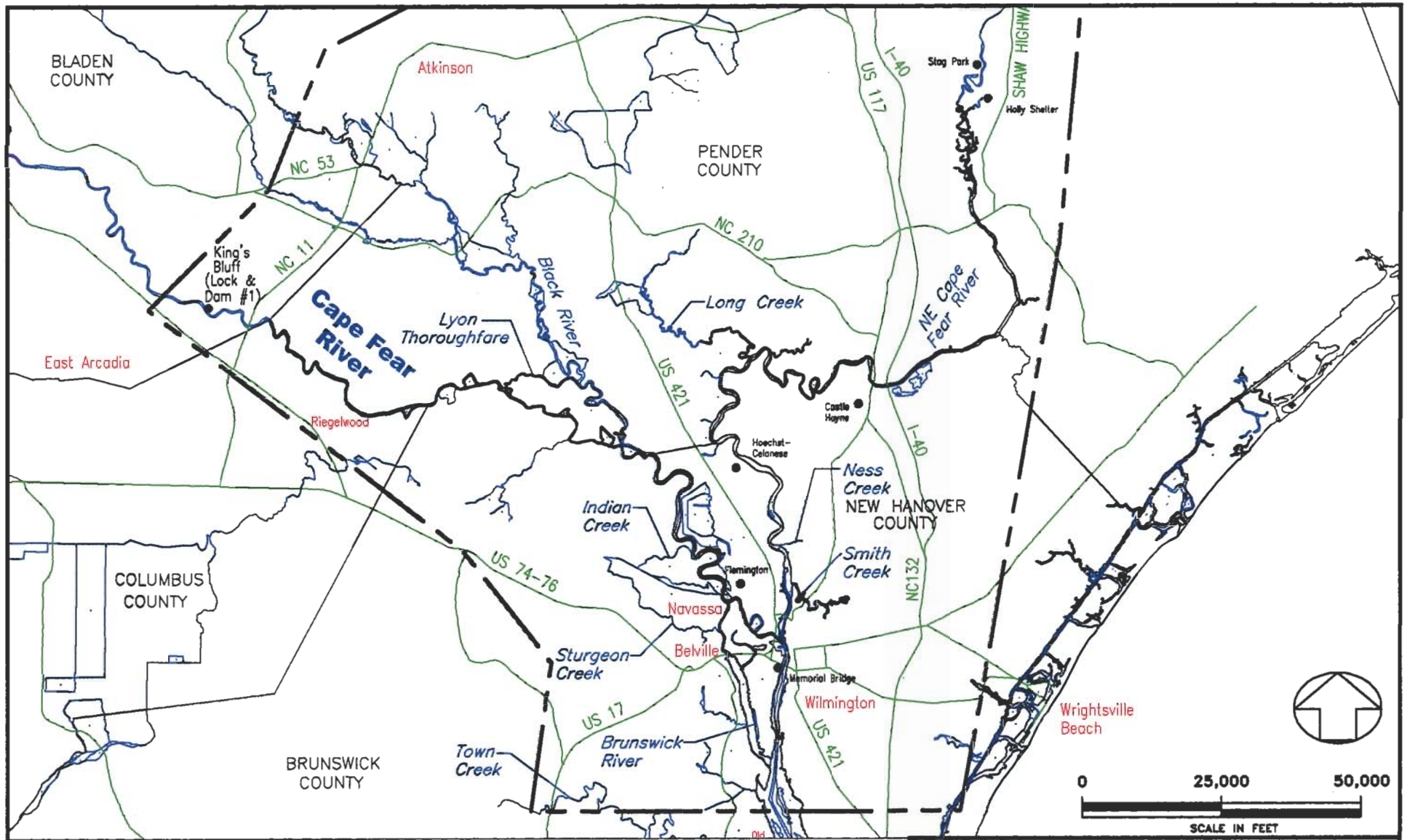
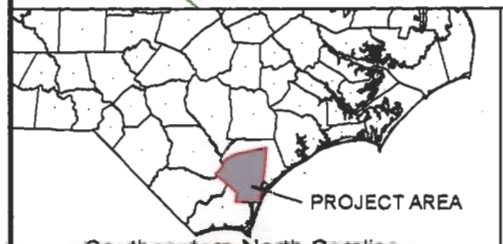
2.0 STUDY AREA

The project study area comprised of the Cape Fear River from its confluence with the Brunswick River south of Eagle Island to Lock and Dam #1, approximately 64 km (40 miles) upriver (Figure 1). Several sites on the Brunswick River were included within the project area as well. The lower portion of the study area is characterized as a drowned river valley with tidally driven river currents and high turbidity. Sediment ranges from soft mud to sand (Moser and Ross 1993). Once upriver of the confluence with the Black River, the Cape Fear River becomes narrower and is fringed with bottomland hardwood forest and contains sediments ranging from soft mud and sand to limestone outcrops.





Southeastern North Carolina
VICINITY MAP (NOT TO SCALE)

VICINITY MAP

WILMINGTON USACOE FISH PASSAGE

SCALE: AS SHOWN	APPROVED BY:	DRAWN BY: BFG
DATE: 08/26/04		FILE: 1976VIC
CZR INCORPORATED ENVIRONMENTAL CONSULTANTS	4709 COLLEGE ACRES DRIVE SUITE 2 WILMINGTON, NORTH CAROLINA 28403 TEL 910/392-9253 FAX 910/392-9139	CP#1976.00
		FIGURE 1

3.0 METHODS

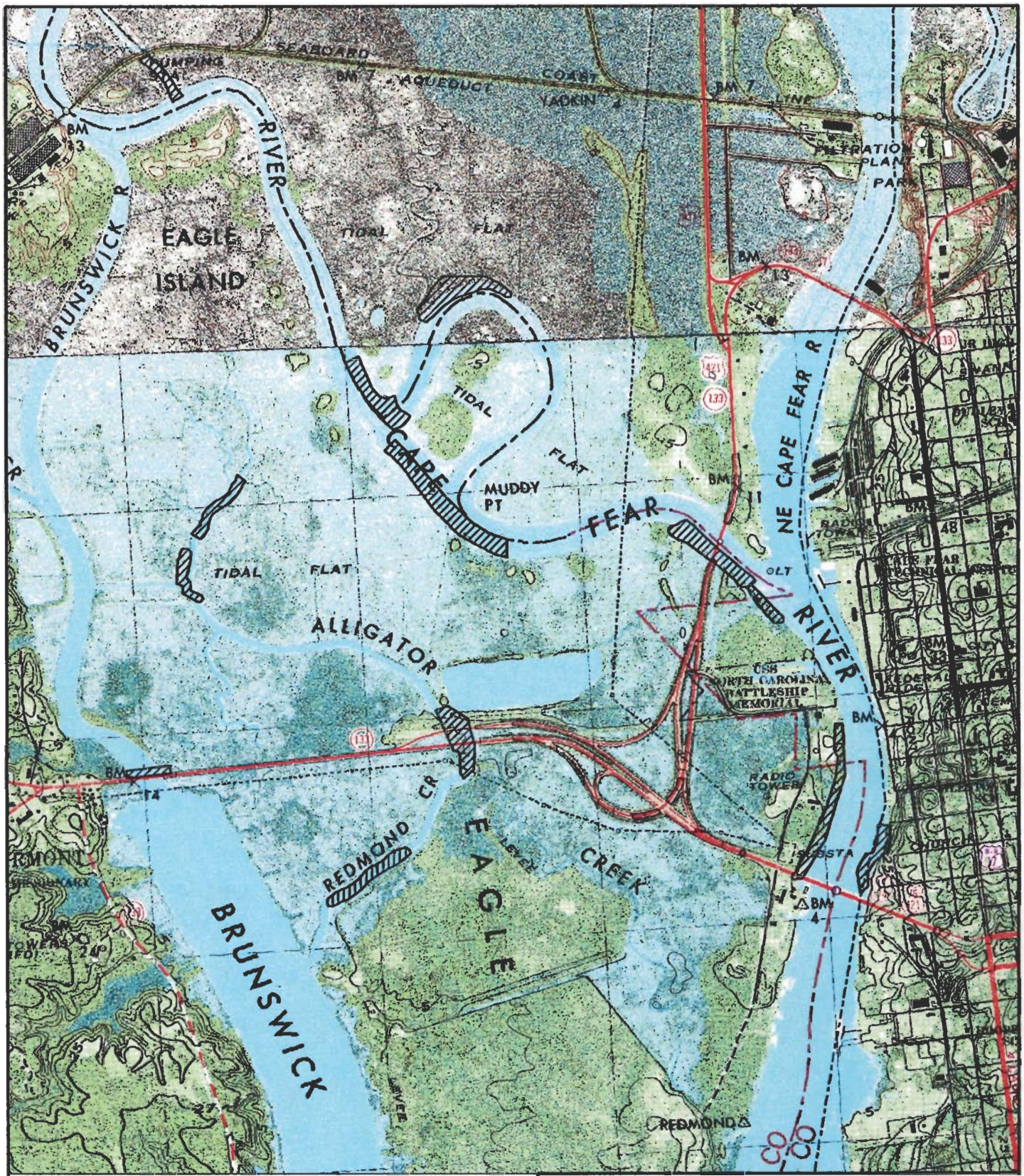
3.1 Striped Bass

3.1.1 Electro-fishing Collections. CZR, with the assistance of electro-fishing boats provided by the North Carolina Division of Marine Fisheries (NCDMF) and the North Carolina Wildlife Resource Commission (NCWRC) (see photos in Appendix A) captured striped bass in the lower portion of the Cape Fear River near Wilmington and from the Brunswick River between 13 February 2004 and 2 March 2004 (Figure 2). Spawning runs of striped bass generally begin late March and end in early May (Carmichael et al. 1998). Striped bass exhibit a strong downriver response following capture and release during the migration period (Carmichael et al. 1998). Efforts to catch striped bass were concentrated during the winter months prior to their upriver migration in order to minimize the downriver flight response.

Transmitters were surgically implanted in striped bass using standardized techniques established in similar studies (Moser and Ross 1993). Photographs of selected steps in this process are found in Appendix A. Striped bass were anesthetized by placing fish in a holding tank and exposed to a 10% solution of tricaine methane sulfonate (MS-222). After five minutes of observation the tag was surgically implanted. The transmitters (Sonotronics CHP-87-L) operated on ten frequencies (70-80 kHz). Unique pulse intervals and “ping” codes within each frequency allowed identification of individual fish. The cylindrical transmitters for striped bass were 90 mm long and 18 mm in diameter, weighed 35.0 grams, and have a battery life of 18 months. Striped bass were also externally tagged with a Floy FT-2-94 type dart tag with a unique number and reward information printed on the streamer. For each fish tagged and released, total length, sex (if it could be determined), date and time of release, site of release (gps $\pm$45 feet), depth, water temperature, and conductivity were recorded. A minimum tagging size for striped bass was set at 533 mm (21 inches) for females and 500 mm (19 inches) for males, and for hybrid striped bass, 500 mm for females and 450 mm (18 inches) for males.

3.2 American Shad

3.2.1 Drift Gill Net Collections. American shad were captured between 17 March 2004 and 6 April 2004 in the vicinity of Lock and Dam #1 on the Cape Fear River (Figure 3). Drift gill nets were 30-yards long, 8-foot deep and 5.5-inch stretch monofilament mesh. Transmitters were surgically implanted in American shad using standardized sterile techniques established in similar studies (Moser and Ross 1993). Photographs of selected steps in this process are found in Appendix A. The transmitter (Sonotronics IBT-96-5) operated on ten frequencies (70-83 kHz); unique pulse intervals and “ping” codes within each frequency allowed identification of individual fish. The cylindrical transmitters were 28 mm long and 8 mm in diameter, weighed 2.5 grams, and have a battery life of five months. A glycerin-coated transmitter was gently inserted into the esophagus to a point where the fish could not expel the tag. Care was taken not to force the transmitter too far down the throat and tear the tissue of the esophagus and stomach. Fish were also externally tagged



LEGEND

STRIPED BASS COLLECTION AREAS

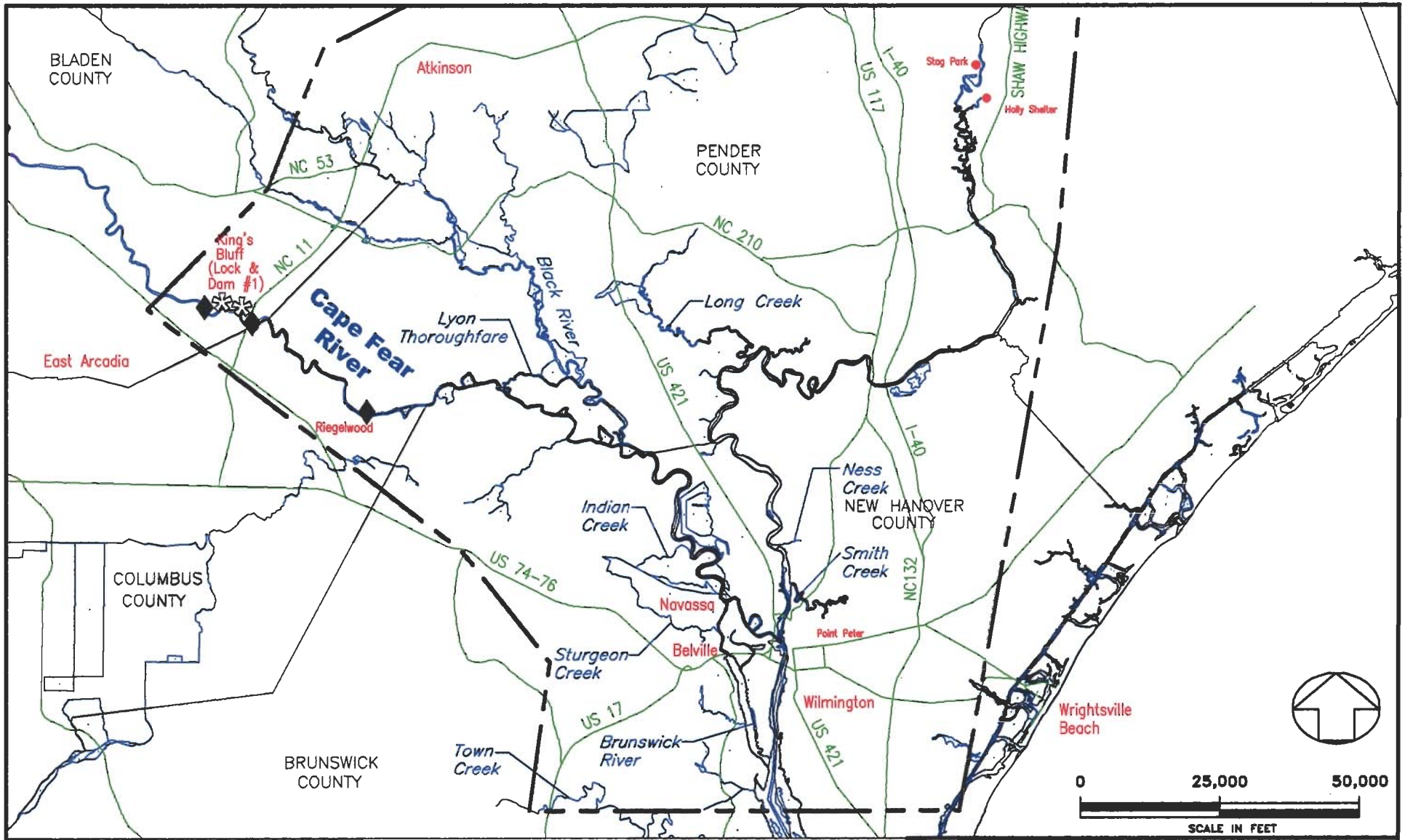
0 2000 4000

SCALE IN FEET

STRIPED BASS COLLECTION AREAS

WILMINGTON USACOE FISH PASSAGE

SCALE: AS SHOWN	APPROVED BY:	DRAWN BY: TLJ/BFG
DATE: 8/12/04		FILE: 1976STRBAS
CZR INCORPORATED ENVIRONMENTAL CONSULTANTS	4709 COLLEGE ACRES DRIVE SUITE 2 WILMINGTON, NORTH CAROLINA 28403 TEL 910/392-9253 FAX 910/392-9139	CP#1976.00
		FIGURE 2



LEGEND

DRIFT NET SETS FOR AMERICAN SHAD

FIXED MONITORING STATIONS

LOCATIONS OF DRIFT GILL NET SETS AND FIXED MONITORING STATIONS

WILMINGTON USACOE FISH PASSAGE

SCALE: AS SHOWN	APPROVED BY:	DRAWN BY: BFG
DATE: 8/26/04		FILE: 1976NET
CZR INCORPORATED ENVIRONMENTAL CONSULTANTS	4709 COLLEGE ACRES DRIVE SUITE 2 WILMINGTON, NORTH CAROLINA 28403 TEL 910/392-9253 FAX 910/392-9139	CP#1976.00
		FIGURE 3

with a Floy FT-2-94 type dart tag with a unique number and reward information printed on the streamer. After tagging, fish were placed in a holding tank/pen containing river water for observation. Fish were released in slower current to prevent them from becoming disoriented. For each fish tagged and released, total length, sex (if it could be determined), date and time of release, site of release (gps ±45 feet), depth, water temperature, and conductivity were recorded. Only fish that were determined to be in excellent condition were tagged due to the fragile nature of American shad. Handling time for each fish did not exceed more than five minutes.

3.2.2 Electro-fishing Collections. CZR, with the assistance of an electro-fishing boat provided by the NCWRC, captured American shad during the peak of their migration on 5 April 2004 in the vicinity of Lock and Dam #1 on the Cape Fear River (Figure 3). American shad were tagged using the same protocol identified above in the "Drift Gill Net Collections" section.

3.3 Fish Monitoring

3.3.1 Manual Tracking. Before fish were implanted with a transmitter, the transmitter was activated and the pulse interval and code were verified with a manual tracking receiver (Sonotronics USR-96) and directional hydrophone (Sonotronics DH-4). Once the fish was implanted with a transmitter, externally tagged, and physiological data recorded, the fish was released. Tagged fish were then monitored with the manual tracking equipment for a short period to confirm position and movements (see photos in Appendix A). The release location for each fish tagged was recorded in Universal Transverse Mercator (UTMs) with a Trimble Pro XR GPS unit (±45 feet).

Fish were relocated during regular tracking efforts beginning at the Castle Street public boat landing in Wilmington, NC. Stops were made at each bend in the river and approximately every 457 meters (1,500 feet). At each stop the outboard engine was turned off and the depth monitor disabled to eliminate interference. Fourteen pre-set frequencies were scanned upstream and downstream for a duration of approximately two minutes. Fish positions were determined by using signal strength and triangulation. Locations of all tagged fish were recorded in UTMs using the Trimble Pro XR GPS unit. Manual tracking continued upriver until all tagged fish were located or until Lock and Dam #1 was reached.

Additional tracking efforts were incorporated into the study near the end of the monitoring period to locate tagged fish in the Black River (15 June 2004), the Northeast Cape Fear River (15 June 2004), and the Cape Fear River [between Ft. Caswell and Wilmington (16 June 2004), and from Buckhorn Dam, near Sanford, N.C., to Lock and Dam #1 (21 June - 23 June)]. The goal was to survey as far as possible up the Black, Cape Fear, and Northeast Cape Fear Rivers in an attempt to locate fish that may have been tagged on the Cape Fear River but relocated to positions outside of the regularly monitored area. Approximately 51.2 km (31.8 miles) of the Black River, 71.8 km (44.6 miles) of the Northeast Cape Fear River, 41.8 km (26.0 miles) of the Cape Fear River from Wilmington

to Ft. Caswell were searched. In addition to these river sections, approximately 202.9 km (126.1 miles) of the upper Cape Fear River from Buckhorn Dam to Lock and Dam #1 were searched.

Range tests were performed during manual tracking efforts to determine the accuracy and reception of the manual tracking equipment since signal strength and reception can be affected by river conditions. This was accomplished by either placing a tag in the water or by using a relocated fish and measuring the greatest distance at which that tag could be identified. This was done to determine the maximum distance between stops while tracking.

3.3.2 Fixed Monitoring Stations. Three fixed monitoring stations were placed along the upper portion of the study area (Figure 3). These stations were located at the International Paper Mill in Riegelwood; the NC 11 Bridge is approximately 11.3 km (7 miles) northwest of Riegelwood, and just upstream of Lock and Dam #1 near Kelly, NC. Each station consisted of a dual input scanning receiver (Sonotronics USR-90), Hewlett Packard 200LX palmtop computer (Sonotronics DL-95 data logger), one 12-volt marine deep cycle gel cell battery, and two directional hydrophones. Each receiver operated continuously, scanning the same preset frequencies as the manual tracking receiver. Output from the receiver was transmitted to the data logger and time and date recordings were stored on a 16MB PCM CIA flashcard. The flashcards were removed once a week and replaced with an empty flashcard and data were downloaded to a file folder for further analysis in the office. Batteries were exchanged every two weeks with fully charged batteries to ensure a constant power supply for the scanning receivers and palmtop data loggers. All electronic monitoring equipment was stored in an aluminum lock box to protect from the elements and vandalism. Reception tests were conducted on the fixed stations periodically during tracking efforts by activating a tag and drifting by the hydrophones to determine accurate reception and approximate distance at which a transmitter could be detected.

3.3.3 Water Quality. Water temperature (°C and °F), dissolved oxygen (mg/l), salinity (ppt), and conductivity (μs) were collected using a YSI 85 water quality meter. Turbidity (ntu) was measured using a LaMotte model 2020 portable turbidity meter. Air temperature was recorded in °C and °F. These parameters (including date and time) were measured at stations located upstream and downstream of Lock and Dam #1. Water quality data were collected during weekly fixed station data downloads and after each fish was tagged.

3.3.4 Rewards. Reward posters were placed at the three Lock and Dam locations as well as at all other public boat ramps and fishing supply stores between Riegelwood and Lock and Dam #3. A twenty dollar reward was offered for recaptured tagged fish information and the return of the internal ultrasonic tag. For Atlantic sturgeon, tagged during previous years, only information pertaining to the recapture location and size of the fish were requested due to its threatened state in the Cape Fear River. Maintenance

of posters occurred once a month for the duration of the project.

4.0 RESULTS

A total of 99 fish representing 2 species were captured between 13 February 2004 and 6 April 2004 (Table 1). Individuals of anadromous species comprised 100% of the total catch, and were represented by the following species: American shad (50.5%) and striped bass (49.5%). Fish collection data (dates, techniques, effort, and catch) are summarized in Appendix B. Ninety-nine fish (50 American shad and 49 striped bass) were internally implanted with a sonic transmitter and externally dart tagged. Movements of fish within the Cape Fear River were monitored using manual tracking units and dual input fixed station monitors. Maps and GPS data depicting positions of tagged fish located by fixed stations and during manual tracking days are found in Appendix C and D, respectively.

Table 1. Total numbers of fish collected at all sampling sites with all gear types used on the Cape Fear River in 2004.

Species	**Individuals**
Alosa sapidissima	50
Morone saxatilis	49
Total Species = 2	Total Number = 99

Tag reception at distances of 608 meters (2,000+ feet) were common in the section of the Cape Fear River from Wilmington to the mouth of the Black River and in the remainder of the river when discharges were 8,000 cubic feet per second (cfs) or less. However, during periods of elevated discharges, (i.e. greater than 8,000 cfs) tag reception varied in the upper river depending on the location of the range test, orientation of the hydrophone (pointed upriver or downriver), and the type of sonic tag used for the test. The “noise” created by large volumes of water flowing through the narrow channel of the Cape Fear River inhibited tag reception at the fixed stations and their ability to register passing fish during increased discharges.

The three fixed monitoring stations were installed and tested in February and March 2004 when discharge was between 2,750 and 9,000 cfs (Figure 4). Reception distance

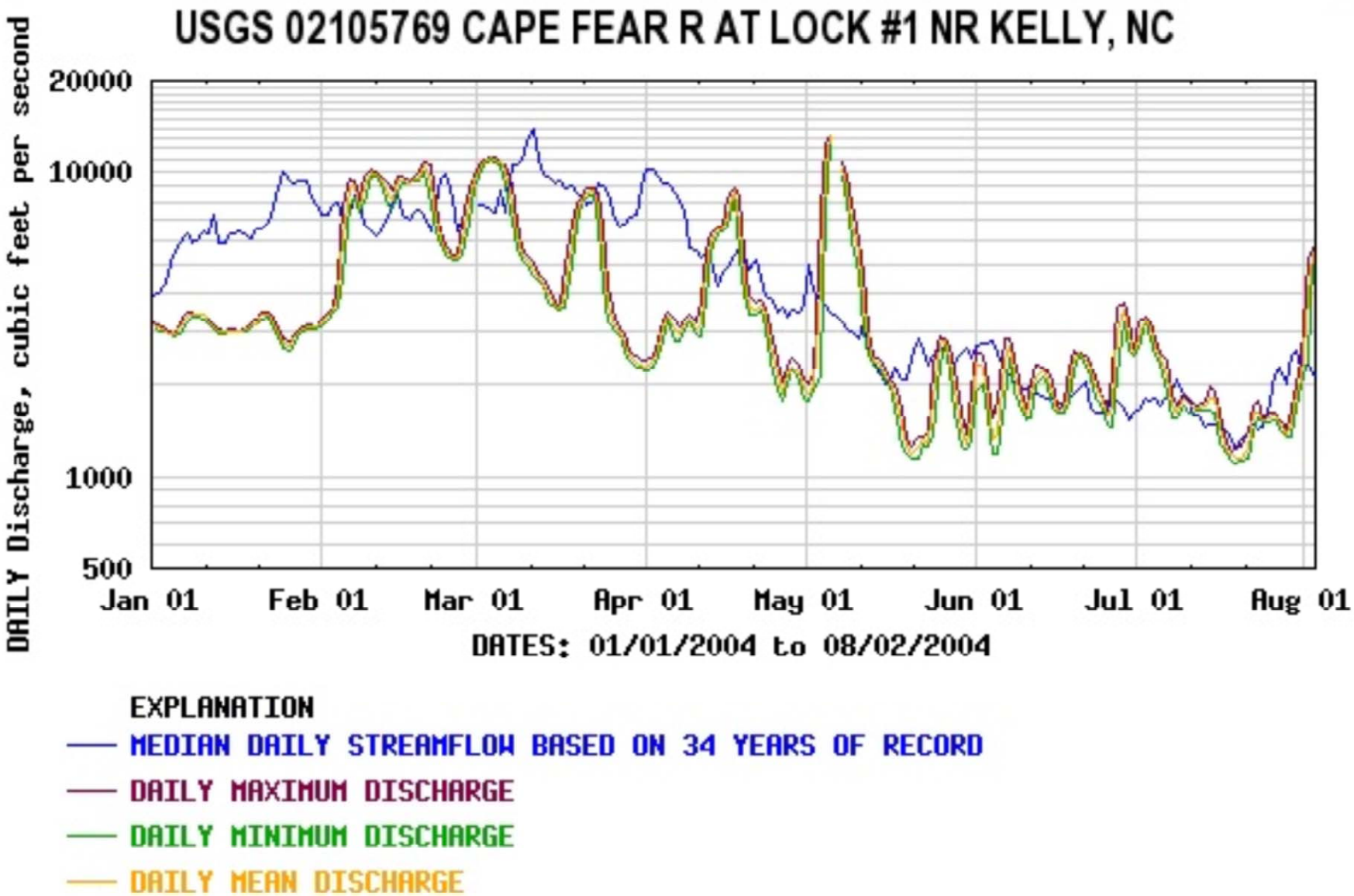


FIGURE 4. Daily river discharge from Lock and Dam #1 during the study period, 2004. (source: http://waterdata.usgs.gov)

was measured using one high powered (striped bass and Atlantic sturgeon) tag and one medium powered (shad) tag. Due to the orientation of the hydrophones at the Lock and Dam #1 station, maximum range on either tag at any given river condition was approximately 300 feet. At the International Paper (IP) and NC 11 stations, the high powered tags could be heard and successfully registered on the data loggers at a distance of 1,000 feet. The tags to be implanted in American shad were heard and successfully registered at approximately 800 feet. A range test performed on the manual tracking equipment at the same time was approximately double the fixed station distances except for the shad tags which could be detected at 1,000 feet. The difference in range between the fixed stations and manual tracking equipment is due to the static orientation of the fixed station hydrophones compared to the mobility of the manual tracking unit.

4.1 American Shad

Electro-fishing and drift gill net collections were conducted over the course of four weeks prior to the peak of the spawning migration of American shad (shad) beginning on 17 March 2004 and ending on 6 April 2004. Fifty shad were collected, tagged and released in the vicinity of Lock and Dam #1. Forty-seven shad were captured using a drifting gill net and three shad were collected through the use of an electro-fishing boat provided by the NCWRC. Only fish considered in excellent condition were tagged. Of the 50 fish tagged eight (16.0%) were male and 42 (84.0%) were female (Table 2). Total lengths ranged between 434 -583 mm (17.0 - 23.0 inches) with an average total length of 529 mm (20.8 inches).

A summary of shad behavior after tagging during 2004 can be found in Appendix E. Immediately after being tagged and released, all fish except five, exhibited varying degrees of the fall back response as confirmed through regular manual tracking efforts and fixed station data.

Ten fish (20%), shad #s 5249, 5259, 5264, 5267, 5269, 5272, 5273, 5278, 5279, and 5286 successfully passed upstream of Lock and Dam #1. All fish except one, #5264, were confirmed by fixed station data to have been passed through the lock chamber. It is assumed that shad #5264 was not detected by the fixed monitor but was later confirmed as passing the lock when the fish was captured on 26 April 2004. Shad #5264 probably passed through the lock sometime around 23 April 2004. It is uncertain when the exact date and time of passage occurred since it was not detected by the Lock and Dam fixed station as it passed. It is believed to have passed on this date since all data for this fish ends on 23 April 2004. No high water conditions that would have allowed passage outside the lock existed during the 2004 study period. This fish was recaptured three days later at Lock and Dam #2 by a recreational fisherman on 26 April 2004. Shad #s 5267, 5269, 5278, and 5286 disappeared after successfully navigating the locking process and were never located again during the remainder of the study. Shad #s 5249, 5259, 5272, and 5279 remained above the dam for varying lengths of time. Each then fell back over the dam, subsequently being tracked downstream of Lock and Dam #1 either manually or by the

Table 2. Physical data collected from American shad tagged near Lock and Dam #1 during pre-construction monitoring for USACOE Fish Passage study during 2004.

Tag #	Date	PI[1]	TL (mm)[2]	Sex	Time
5241	5-Apr	846	435	M	1147
5242	6-Apr	861	517	F	1615
5243	5-Apr	875	561	F	1425
5244	5-Apr	888	506	F	1254
5245	30-Mar	903	564	F	1215
5246	5-Apr	924	555	F	1404
5247	30-Mar	847	538	F	1011
5248	5-Apr	953	465	F	1405
5249	30-Mar	967	506	F	1114
5250	6-Apr	982	535	F	1630
5251	5-Apr	996	456	M	1148
5252	17-Mar	1010	551	F	1200
5253	30-Mar	860	531	F	950
5254	5-Apr	1038	548	F	1248
5255	30-Mar	856	578	F	1315
5256	30-Mar	879	546	F	958
5257	30-Mar	919	583	F	1145
5258	5-Apr	905	539	F	1403
5259	30-Mar	947	488	M	1407
5260	5-Apr	961	571	F	1100
5261	30-Mar	892	539	F	920
5262	30-Mar	1010	503	M	1324
5263	30-Mar	1003	434	M	1200
5264	30-Mar	1047	537	F	820
5265	30-Mar	1031	553	F	1357
5266	24-Mar	1044	519	F	845
5267	30-Mar	904	519	F	1050
5268	30-Mar	923	532	F	820
5269	30-Mar	900	538	F	1200
5270	30-Mar	912	550	F	1412
5271	30-Mar	937	565	F	1045
5272	5-Apr	942	568	F	1257
5273	30-Mar	949	549	M	830
5274	30-Mar	970	530	F	1350
5275	30-Mar	990	554	F	1354
5276	17-Mar	1003	543	F	1200
5277	5-Apr	1017	458	M	1149
5278	24-Mar	1030	551	F	1045
5279	30-Mar	1044	545	F	1356
5280	5-Apr	874	520	F	1323
5281	5-Apr	890	513	F	1440
5282	5-Apr	903	563	F	1315

Table 2. (concluded)

Tag #	Date	PI[1]	TL (mm)[2]	Sex	Time
5283	6-Apr	916	479	M	1620
5284	5-Apr	930	535	F	1056
5285	5-Apr	943	539	F	1251
5286	30-Mar	956	540	F	1110
5287	30-Mar	968	555	F	820
5288	30-Mar	981	480	F	845
5289	5-Apr	1011	521	F	1400
5290	30-Mar	1005	545	F	900

[1] Pulse interval for sonic transmitter
[2] Total length in mm

fixed stations at later dates. Shad #5273 was successfully locked through to the upper pool on 30 April 2004. Fifty-four days later this shad was located approximately 26 miles upstream from Lock and Dam #1 during the extended manual tracking efforts. This fish represents the furthest upstream location of any shad manually tracked. However, shad #5264 represents the furthest upstream location of any shad that was confirmed to have passed Lock and Dam #1.

Fixed station data and manual tracking efforts indicate that forty shad (80%) returned to the vicinity of the dam after tagging. A fish that was determined to have "returned to the vicinity of the dam" is defined as any shad that fell back after tagging and returned upstream of the NC 11 Bridge and was located either by the fixed station or by manual tracking. A shad that never fell back downriver past the NC 11 Bridge and was tracked in multiple locations between the NC 11 Bridge and Lock and Dam #1 indicating that it did not die immediately after tagging was also considered to have "returned to the vicinity of the dam". Of the 40 fish that returned to the vicinity of the dam, ten (25%) were confirmed to have passed to the upstream side of Lock and Dam #1. All shad are believed to have been passed through the locking procedure. Of the remaining 30 fish that approached the dam but did not pass, seven were determined to have died at different times after tagging. The remaining 23 shad were tracked at various locations between International Paper in Riegelwood and Lock and Dam #1 until they disappeared, and were not located again for the remainder of the study. It is believed that some of these fish may have moved to a location below the dam and could not be heard by manual tracking devices or fell back downstream quickly and exited the study area.

Of the remaining 10 shad that did not approach the dam, shad #s 5247, 5254, 5275, and 5290, were recaptured by recreational or commercial fisherman between Lock and Dam #1 and Riegelwood. Three shad, #s 5242, 5258, and 5281 remained upstream after tagging for a brief period of time before falling back downstream and did not return during the remainder of the study. Shad #5277 immediately fell back after tagging and exited the Cape Fear River. Two shad, #s 5255 and 5288 died shortly after tagging and are the only fish believed to have died as a direct result of stress associated with handling.

4.2 Striped Bass

Forty-nine striped bass were captured and implanted with a sonic transmitter. It is believed that all bass in 2004 survived the tagging process. Of the 49 tagged bass, 26 (53.1%) were females, 22 (44.9%) were males, and 1 (2.0%) was undeterminable. Sizes ranged from 520 - 800 mm (20.5 - 31.5 inches) with an average total length of 630 mm (24.8 inches) (Table 3). In addition to the 49 fish tagged in 2004, thirteen striped bass and one hybrid striped bass tagged in 2003 and two striped bass tagged in 2002 were also located. All sixteen fish tagged during previous years were confirmed to be alive and were included in the tracking data presented in 2004.

A total of 294 minutes (4.9 hours) were spent electro-fishing with the NCWRC and NCDMF in the Cape Fear River around Wilmington harbor and the Brunswick River. A map

Table 3. Physical data collected from striped bass tagged during pre-construction monitoring for USACOE Fish Passage Study 2004.

Species[1]	Date	Tag #	Pl[2]	TL (mm)[3]	Sex	Time
SB	13-Feb	5122	849	618	M	900
SB	13-Feb	5123	871	643	F	1030
SB	13-Feb	5124	892	644	M	900
SB	13-Feb	5125	1025	648	F	900
SB	13-Feb	5126	934	655	F	900
SB	13-Feb	5127	955	543	M	1200
SB	13-Feb	5128	975	648	F	900
SB	13-Feb	5129	949	530	M	1030
SB	13-Feb	5130	977	600	M	1030
SB	16-Feb	5201	1045	638	M	1500
SB	16-Feb	5202	885	734	F	1130
SB	16-Feb	5203	905	735	F	1500
SB	16-Feb	5204	918	654	M	1500
SB	16-Feb	5205	931	658	F	1500
SB	18-Feb	5206	945	532	F	1300
SB	18-Feb	5207	965	589	F	1300
SB	16-Feb	5208	978	552	M	1500
SB	16-Feb	5209	991	534	M	1130
SB	16-Feb	5210	1005	686	M	1500
SB	18-Feb	5211	1025	617	F	1600
SB	16-Feb	5212	1038	624	F	1500
SB	20-Feb	5213	900	710	F	1400
SB	16-Feb	5214	913	643	M	1500
SB	20-Feb	5215	926	688	F	1600
SB	2-Mar	5216	939	532	F	1300
SB	16-Feb	5217	959	564	F	1500
SB	16-Feb	5218	972	721	F	1500
SB	16-Feb	5219	985	635	U	1130
SB	18-Feb	5220	1005	635	M	1300
SB	2-Mar	5221	1018	710	M	1430
SB	18-Feb	5222	1031	651	F	1300
SB	20-Feb	5223	1050	604	F	1400
SB	18-Feb	5224	908	719	F	1600
SB	18-Feb	5225	921	603	M	1300
SB	18-Feb	5226	940	694	M	1300
SB	2-Mar	5227	953	660	F	1430
SB	20-Feb	5228	966	558	F	1400
SB	18-Feb	5229	979	581	M	1600
SB	20-Feb	5230	999	535	M	1400
SB	20-Feb	5231	916	655	F	1600
SB	2-Mar	5232	935	646	F	1430

Table 3. (concluded)

Species[1]	Date	Tag #	PI[2]	TL (mm)[3]	Sex	Time
SB	2-Mar	5233	948	630	M	1300
SB	2-Mar	5234	961	520	F	1300
SB	2-Mar	5235	980	580	M	1430
SB	2-Mar	5236	993	640	F	1430
SB	2-Mar	5237	1005	656	M	1300
SB	2-Mar	5238	1025	640	M	1300
SB	20-Feb	5239	1037	630	M	1400
SB	20-Feb	5240	1050	800	F	1400

[1] SB = striped bass
[2] PI = Pulse interval of sonic transmitter
[3] TL = Total length in mm

depicting areas where striped bass were collected during electro-fishing efforts in 2004 can be found in Figure 2. A total of 72 fish were collected using two electro-fishing boats. Of these, 49 (68.1%) fulfilled the size criterion for tagging. Electro-fishing for striped bass was concentrated in areas containing underwater structure. These areas were typically around bridge supports, old dock pilings, ship wrecks and cypress stumps. The mouths of creeks and small tributaries were also targeted.

In general, the 49 striped bass tagged in 2004 tended to be very mobile. A summary of striped bass behavior after tagging during 2004 can be found in Appendix F. Of the 49 fish tagged in 2004, 21 striped bass, or 43%, successfully passed upstream of Lock and Dam #1. Fixed station data and manual tracking efforts indicate that 30 striped bass made deliberate and directed movements upstream in an attempt to reach spawning grounds. Of these 30 fish, 21 (70%) successfully passed upstream of Lock and Dam #1. Striped bass #s 5213 and 5223 were both passed through the lock on 25 March 2004 and represent the first tagged fish to navigate the locking process and striped bass #5203 was passed sometime after 15 June 2004 and represents the last tagged fish to be locked through to the upper pool.

Six striped bass, #s 5129, 5204, 5212, 5227, 5231, and 5232 were never manually tracked after successfully passing Lock and Dam #1. These fish briefly returned to the vicinity of the Lock and Dam #1 fixed station but moved upstream and out of range of the monitor. Eight bass, #s 5202, 5206, 5213, 5215, 5216, 5223, 5226, and 5235, fell back downstream after successfully passing through the lock. These fish were later either manually located below the dam or picked-up by the fixed stations as they moved downriver. Striped bass #s 5213 and 5216 successfully passed through the locking procedure again after having fallen back over the dam once. Seven striped bass, #s 5201, 5203, 5210, 5219, 5227, 5231, and 5237, were recaptured at various locations by recreational fisherman above Lock and Dam #1 after passing. Bass 5201 and 5231 were recaptured near the base of Buckhorn Dam, 165 miles upriver from Wilmington, on 21 April 2004. All fish, except bass 5203, can be confirmed to have been passed through the locking procedure. Striped bass #5203 was not registered by the fixed station at Lock and Dam #1 but is believed to have only been able to pass through the lock chamber due to the low discharges experienced during 2004 not allowing this fish to swim over the top of the dam.

Of the 21 fish that successfully passed to the upper pool through the locking process, seven were located during additional tracking efforts. Two striped bass, #s 5213 and 5214, were manually tracked between Lock and Dam #1 and Lock and Dam #2 on 23 June 2004. Bass #5213 was found approximately one mile downstream from the dam and 5214 was located approximately 2 miles downstream. Striped bass #s 5210, 5230, and 5015 (tagged in 2003) were manually tracked between Lock and Dam #2 and Lock and Dam #3 on 22 June 2004. Bass #s 5210 and 5015 were located near Lock and Dam #3 and 5230 was tracked just above Lock and Dam #2. Also on 22 June 2004, bass #s 5124

and 5237 were manually tracked from a canoe between Buckhorn Dam and Lillington. No fish were located between Lillington and Lock and Dam #3 during extended tracking efforts.

Of the fifteen striped bass and one hybrid striped bass tagged in 2002 and 2003 that returned to the Cape Fear River in 2004, seven successfully passed upstream through the locking process. Only one (#5015) was manually tracked above the dam as mentioned above. The remaining six, #s 5010, 5011, 5012, 5023, 5026, and 5118 were never manually tracked after successfully passing Lock and Dam #1. These fish briefly returned to the vicinity of the Lock and Dam #1 fixed station but moved upstream and out of range of the monitor. Fixed station data at Lock and Dam #1 indicate that striped bass #5010 was already above the dam when the 2004 monitoring period began. This fish was located by the L&D #1 fixed station first on 31 March 2004 and then downstream at each fixed station as it passed moving downriver. This fish was manually tracked once on 15 June 2004 in the Northeast Cape Fear River. Hybrid striped bass #5118 passed through the lock chamber on 6 April 2004 and was recaptured by a recreational fisherman at the base of Lock and Dam #3 on 28 April 2004. Of the remaining nine fish, three (#s 5014, 5020, and 5024) were detected only by fixed stations.

4.3 Water Quality

Water temperature increased throughout the study period and ranged from 10.3 to 28.6°C downstream and 10.7 to 29.1°C upstream of the dam (Table 4). River discharge and water heights were average to below average in 2004 (Figure 4). A discharge of 12,400 cfs was measured on 5 May 2004 and represents the maximum discharge value measured during the study period. The 34-year average discharge for 5 May 2004 is 3,500 cfs. Turbidity measurements ranged from 9.7 to 39.7 ntu's downstream and 9.6 to 36.5 ntu's upstream. The highest turbidity reading of 39.7 ntu's was recorded on 6 May 2004 during a period of the highest river elevations. Dissolved oxygen ranged from a high of 10.98 mg/l recorded downstream of the dam on 4 March 2004, and a low of 3.44 mg/l recorded upstream of the dam on 27 May 2004.

4.4 Rewards

At the time of this report, twenty recaptures had been reported and $400.00 in rewards had been paid. Five returns were reported from American shad captured by commercial shad fishermen in either drift gill nets fished near Lock and Dam #1 or set nets located in the vicinity of Riegelwood. Fourteen tag returns were from striped bass and one was from a hybrid striped bass caught by recreational fishermen at Buckhorn Dam, Fayetteville, and at all three Lock and Dams.

Table 4. Summary of physicochemical measurements taken near Lock and Dam #1 in conjunction with fish sampling during 2004.

Location[1]	Date 2004	Time	Air Temp. °C / °F	Water Temp. °C / °F	D.O. (mg/l)	Turbidity (ntu's)	Water Height[2]
Upstream	04 March	1400	23.9/75.0	10.7/51.3	10.64	16.0	18.4
Downstream	04 March	1400	23.9/75.0	10.3/50.5	10.98	16.3	18.4
Upstream	15 March	1400	24.4/76.0	13.5/56.3	7.67	12.5	16.4
Downstream	15 March	1400	24.4/76.0	13.5/56.3	**	13.1	16.4
Upstream	18 March	1500	19.9/68.0	13.8/56.8	9.18	11.4	16.8
Downstream	18 March	1500	19.9/68.0	13.8/56.8	9.99	12.7	16.8
Upstream	25 March	1430	18.3/65.0	14.0/57.2	6.04	9.4	16.4
Downstream	25 March	1430	18.3/65.0	15.1/59.2	10.78	10.4	16.4
Upstream	01 April	1530	18.3/65.0	15.9/60.6	10.12	10.6	15.8
Downstream	01 April	1530	18.3/65.0	15.9/60.6	9.44	12.1	15.8
Upstream	08 April	1545	23.9/75.0	16.0/60.8	8.64	10.4	16.1
Downstream	08 April	1545	23.9/75.0	15.9/60.6	8.78	9.7	16.1
Upstream	15 April	1445	18.9/66.0	17.4/63.3	5.91	16.9	17.3
Downstream	15 April	1445	18.9/66.0	17.7/63.9	8.28	23.0	17.3
Upstream	22 April	1500	26.1/79.0	20.2/68.4	7.78	10.9	16.3
Downstream	22 April	1500	26.1/79.0	19.7/67.5	8.52	12.2	16.3
Upstream	29 April	1530	21.7/71.0	23.2/73.8	4.29	9.6	15.8
Downstream	29 April	1530	21.7/71.0	22.5/72.5	8.50	10.1	15.8
Upstream	6 May	1430	26.1/79.0	20.0/68.0	7.17	36.5	18.9
Downstream	6 May	1430	26.1/79.0	20.0/68.0	9.23	39.7	18.9
Upstream	13 May	1445	25.0/77.0	24.2/75.6	3.59	13.4	15.9
Downstream	13 May	1445	25.0/77.0	23.5/74.3	6.92	14.2	15.9
Upstream	20 May	--	30.5/87.0	--	--	--	15.2
Downstream	20 May	1600	30.5/87.0	26.4/79.5	6.17	11.9	15.2
Upstream	24 May	1545	30.0/86.0	28.0/82.4	6.21	12.7	15.5
Downstream	24 May	1545	30.0/86.0	27.7/81.9	7.53	14.4	15.5

Table 4. (concluded)

Location[1]	Date 2004	Time	Air Temp. °C / °F	Water Temp. °C / °F	D.O. (mg/l)	Turbidity (ntu's)	Water Height[2]
Upstream	27 May	1630	32.2/90.0	29.1/84.4	3.44	10.9	15.8
Downstream	27 May	1630	32.2/90.0	28.5/83.3	6.63	12.9	15.8
Upstream	03 June	1500	32.2/90.0	29.1/84.4	4.75	15.9	15.4
Downstream	03 June	1500	32.2/90.0	28.5/83.3	5.03	16.5	15.4
Upstream	10 June	1600	23.9/75.0	28.1/82.6	7.27	11.5	15.6
Downstream	10 June	1600	23.9/75.0	28.6/83.5	7.96	12.9	15.6

[1] Position in reference to Lock and Dam #1
[2] Data from USGS gage at Lock and Dam #1
** Water Quality meter malfunction
- - Lockmaster was absent preventing collection of upstream WQ parameters

5.0 DISCUSSION

Striped bass exhibited both fall back and upriver responses after tagging. A high degree of mobility was exhibited for striped bass in 2004. Fixed station data and manual tracking efforts indicate that of the 49 striped bass tagged in 2004, 30 striped bass made deliberate and directed movements upstream in an attempt to reach spawning grounds. Of these 30 fish, 21 (70%) successfully passed upstream of Lock and Dam #1. In addition to the 30 fish that attempted to pass Lock and Dam #1, thirteen striped bass and one hybrid striped bass tagged in 2003 and two striped bass tagged in 2002 returned to the study area in 2004. Of these sixteen fish, 7 (44%) successfully passed upstream of Lock and Dam #1. This brings the total number of striped bass passed through the locking procedure to 28 in 2004.

American shad occur in the Cape Fear River in large numbers. American shad consistently exhibited the fall back response to handling stress as documented in previous tracking studies (Moser and Ross 1993, Moser et al. 2000). Forty shad made return trips back to the dam after tagging and ten of these shad (25%) passed upstream of the dam.

Overall, the data suggest that 2004 was a good year for striped bass passage at Lock and Dam #1 but the dam still remains an impediment to anadromous fish species' ability to continue upriver on their spawning migrations. A summary of passage success by species for 2002, 2003, and 2004 is found in Table 5.

Table 5. Summary of fish passage success for pre-construction monitoring at Lock and Dam #1, Cape Fear River, Wilmington, North Carolina in 2002, 2003, and 2004.

Monitoring Year	Species Tagged	Number Tagged	Number Returned to Dam	Number Passed	%	Maximum Distance (miles) after Tagging Observed Upstream
2002	American shad	30	8	4	50	N/A[a]
	Striped bass	9	2	0	0	30[a]
	Atlantic sturgeon	1	0	0	0	N/A[a]
2003	American shad	53	12	4	33	100[b]
	Striped bass	41	22	5	23	102[c]
2004	American shad	50	40	10	25	26[b]
	Striped bass	49	30	21	70	165[c]

[a] No tracking above Lock and Dam #1 was conducted in 2002.
[b] Distance from Lock and Dam #1, North Carolina.
[c] Distance from Wilmington, North Carolina.

5.1 Difficulties Encountered

The main difficulty encountered in 2004 was the same problem experienced in past monitoring years, when multiple fish on the same frequency were encountered simultaneously, making positive identification of more than two fish at a time difficult or impossible. In 2004, 115 sonic tags, representing fourteen frequencies, were tracked. In one case there were seventeen striped bass using the same frequency of 77 kHz. Generally, this was only a problem in the lower river around Wilmington before the fish had a chance to spread out as they moved upriver on their migration. However, many of these fish were present in the lower river beginning in February and did not move upstream until April. In cases where both striped bass and American shad were utilizing the same frequency such as 75 kHz, the ability to distinguish individual fish was more of a problem upriver between Riegelwood and Lock and Dam #1. This problem is not easily solved since the manufacturer does not have the capability to build sonic tags that utilize only one frequency per tag or the equipment capable of tracking the large number of tags needed for a study of this scope and size.

6.0 REFERENCES

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