AMERICAN SHAD MONITORING PROGRAMS IN COASTAL NORTH CAROLINA - 2008

Report to the Atlantic States Marine Fisheries Commission
Shad and River Herring Technical Committee

COASTAL FISHERIES INVESTIGATIONS

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Abstract.—Electrofishing was used to sample migratory American shad (Alosa sapidissima) populations in the Roanoke, Tar, Neuse and Cape Fear rivers in coastal North Carolina during spring 2008. Pooled catch per unit effort for each river system ranged from 13.8 fish/h in the Cape Fear to 135.0 fish/h in the Roanoke, with overall abundance indices of 103.4 fish/h and 25.4 fish/h in the Tar and Neuse rivers, respectively. Catch rates were highest for males in each system. The age structure of each population was comprised of 3-6 year-old males (0-3 spawning marks), with females ranging from 3-8 years (0-4 spawning marks). Outcomes from 2 separate American shad scale reading workshop exercises indicated a tendency to over-age younger shad using scales and showed an overall scale reader agreement with correct, known ages of 39%. Assignment of the number of spawning marks was also variable. American shad restoration continued in the Roanoke River in 2008 with 8,219,615 fry, a record high to date, stocked into the system. Otolith examination of 290 juvenile American shad collected from the lower river in the fall of 2008 showed 64 juveniles of hatchery origin for a hatchery contribution to emigration of 22.1%. Otolith examination of 193 adult Roanoke River American shad collected in 2008 resulted in the recovery of 5 adult spawners of hatchery origin, all of which were stocked as fry at Weldon. This brings the total of recovered adult OTC-marked shad, the first of which was collected in 2005, to 12 fish.

Introduction

The North Carolina Wildlife Resources Commission (NCWRC) is responsible for the spawning stock assessment of migratory American shad populations in North Carolina's coastal rivers, specifically the Roanoke, Tar, Neuse and Cape Fear. Population characteristics from these river systems are summarized each spring, and then submitted to the North Carolina Division of Marine Fisheries (NCDMF) for inclusion in what will become North Carolina's annual American shad status report to the Atlantic States Marine Fisheries Commission (ASMFC). This information is required of the state of North Carolina by ASMFC as mandated under conditions set forth within the fishery management plan for alosine species established for the eastern United States (ASMFC 1985) and associated addendum (ASMFC 2002). Compliance with this plan is necessary to support the enhancement of American shad populations within coastal North Carolina for the benefit of recreational and commercial fishermen.

There are two specific requirements of the annual reporting process that pertain to the NCWRC: 1) an assessment of the spawning stock characteristics of American shad populations within the Roanoke, Tar, Neuse and Cape Fear rivers; and 2) a summary of accomplishments specific to the Roanoke River American shad restoration plan, including the number of fry reared and stocked, and the number of juvenile and adult shad examined for the presence of oxytetracycline (OTC) marks.

Methods

Spawning Stock Assessment

NCWRC personnel collected American shad *Alosa sapadissima* from North Carolina's coastal river systems during March-May 2008. Rivers sampled included the Roanoke, Tar, Neuse, and Cape Fear (Figure 1). A boat-mounted electrofishing unit (Smith-Root 7.5 GPP) was used (1 or 2 dip netters) to capture fish during daylight hours and electrofishing time (s) was recorded. To minimize size selection during sampling, shad were picked up as they were encountered regardless of size. Relative abundance of each year class was indexed by catch-per-unit-effort (CPUE) and expressed as number of fish captured per hour of electrofishing.

Sex was determined for each captured fish by applying directional pressure to the abdomen toward the vent and observing the presence of milt or eggs. Each fish was measured for total length (TL mm). Scales were removed from the left side of each fish between the lateral line and the dorsal fin. To estimate age, scales were examined at 33X magnification on a microfiche reader and annuli were counted. Spawning marks were recorded separately. Shad that could not be aged were assigned ages based on the gender specific age-length key developed for each river, and included in CPUE and size-distribution analyses.

To address concerns related to the accuracy of ageing American shad from scales, NCWRC and NCDMF staff held a joint-agency shad scale reading workshop at NCDMF's Morehead City office on March 5, 2008. The 14 attendees broke into 6 groups that independently assigned age and number of spawning marks to 5, OTC-marked Roanoke River shad using scales. Following the acquisition of a set of known-age scales (fish originating from the Delaware and Lehigh rivers) from Mike Hendricks of the Pennsylvania Fish Commission later in 2008, another joint-agency shad scale reading workshop was held in Morehead City on January 14, 2009. Prior to attending the workshop, 9 readers independently and blindly (no knowledge of actual fish age) read 37 scales from known-age fish to enable the determination of percent agreement with correct age. Spawning marks were also assigned from these scales.

Roanoke River Restoration Plan– Hatchery Evaluation

American shad fry reared at the USFWS Edenton National Fish Hatchery and at the NCWRC Watha State Fish Hatchery have been stocked annually into the Roanoke River since 1998 (Table 12). This restoration project was initiated by NCWRC and funded by the North Carolina Department of Transportation as mitigation for aquatic habitat damages resulting from highway bridge construction on Roanoke River (see North Carolina's 1999 Shad and River Herring Report for full details).

Initial attempts in 1998 at field collection and fertilization of American shad eggs met with limited success. In 1999, both hatcheries began developing hormone injection/tank spawning techniques to increase fry production. Also in 1999, NCWRC began coordination of fry marking (oxytetracycline-OTC) and stocking activities with the ad hoc interstate OTC Marking Task Force.

Following protocols of other states involved in American shad restoration efforts, brood stock for fry production were obtained from nearby rivers having adequate shad stocks. American shad brood fish were collected in 2008 by electrofishing from the Tar, Neuse, and Cape Fear rivers. Upon collection, brood fish were placed in circular tanks with oxygen and continuously circulating water onboard the electrofishing boats, and were then transferred to large circular, trailer-mounted tanks for transport to the hatcheries. Upon arrival at the hatcheries, some brood fish were injected with hormone (LHRHa or sGnRHa pellets) prior to being transferred to circular spawning tanks. For the remaining fish, spawning inducement relied solely on the gradual warming of tank water using 15,000 watt immersion heaters. As spawning occurred, eggs were siphoned into a collection vessel and transferred to McDonald hatching jars for incubation. Hatched fry swam up and into aquaria and were fed brine shrimp until stocked.

From 1999 through 2001, American shad fry reared and stocked in the Roanoke River were OTC marked with the 3-, 6-, and 12-day combination in accordance with protocols established by the OTC Marking Task Force. In 2002, after revision of the discrete OTC marking requirements by the ASMFC Shad and River Herring Technical Committee, American shad fry reared in North Carolina were marked with a 3-day mark. In 2003, a single mark (3-day) was applied to fry stocked in the Roanoke River below Roanoke Rapids Dam and a double mark (3- and 6-day) was applied to fry to be stocked in the headwaters of the Roanoke River, above John H. Kerr Reservoir. A new marking protocol was established in 2004 that called for a 6-day single mark for fry stocked in the Roanoke River below Roanoke Rapids Dam, and a double mark (6- and 9-day) for fry stocked in headwater areas above John H. Kerr Reservoir. In 2005, a 9-day single mark was used for fry stocked in the Roanoke River below Roanoke Rapids Dam while a 3- and 9-day double mark was used for fry stocked in headwaters above the dams at Altavista, Virginia. In 2006, a 3-day single mark was used for fry destined for the river downstream of the dams while a 3- and 6-day double mark was used for fry sent to the headwaters. For 2007, a 6-day single mark was applied to fry stocked in the lower river and a 6- and 9-day double mark was used for fry stocked above the dams. In 2008, a 9-day single mark was given to fry stocked at Weldon and a 3- and 9-day double mark was used on fry stocked at Altavista (Table 13). The use of a single mark for fry stocked below the dams and a double mark for fish stocked above the dams has been consistent since 2003.

Recreational Harvest Regulations

Anglers in all waters of North Carolina except the Roanoke River may possess no more than 10 hickory shad or American shad per day in aggregate. Effective July 1, 2008 in the Roanoke River, this regulation changed to limit the possession of hickory shad and American shad to 10 fish per day in aggregate with only one American shad allowed.

Results and Discussion

Spawning Stock Assessment

Roanoke River. —A total of 448 American shad was collected from the Roanoke River near the Gaston boating access area in spring 2008. Males comprised 76% of the sample (N=339) while females accounted for 24% (N=109) (Figure 2). Overall CPUE was 135 fish/h, an increase from 2007 (97 fish/h), 2006 (89 fish/h), 2005 (72 fish/h), and 2004 (49 fish/h). Scale age was determined for 141 individuals and ages for the remaining fish were estimated using a gender specific age-length key. Males from the 2004 year class (age 4) dominated the sample (60% of the total). The majority of female American shad were also from the 2004 year class (age 4). Scale analysis showed an age structure ranging from 3-6 years for males with 0-3 spawning marks; female American shad collected ranged in age from 3-7 years, with 0-2 spawning marks (Table 1). Overall, spawning stock size distribution ranged from 368-571 mm (Figure 3). Length at age analysis indicated mean total length of the most abundant age 4 year class was 434 mm for males and 472 mm for females (Table 2).

Tar River. —A total of 211 American shad was collected from the Tar River during the spring of 2008. Of this total, age was estimated for 197 individuals. Overall CPUE was 103.4 fish/h (Figure 4), much higher than in 2007 (38.4 fish/h) and 2006 (42.5 fish/h), but similar to 2005 (131.0 fish/h). Overall CPUE was 190.0 fish/h in 2004 and 307.8 fish/h in 2003. The majority of 2006 and 2007 American shad sampling was conducted during March and under variable flow conditions, while the majority of 2005 and 2008 sampling was conducted during the month of April. Timing of collections (March-early season vs. April-peak season) may have influenced differences among years. In 2008, males comprised 67% (N=141) of the sample while females accounted for 33% (N=70). Three male cohorts and three female cohorts were represented during the 2008 assessment, but males produced from the 2004-2005 (age 3 and 4) year classes and females produced from 2003-2004 (age 4 and 5) year classes accounted for the majority of the total catch. Male American shad ranged in age from 3-5 years with 0-2 spawning marks, while females ranged from 4-6 years with 0-2 spawning marks (Table 3). American shad collected in the 2008 sample ranged from 365-533 mm (Figure 5). The length-frequency distribution for males showed most individuals occurring between 420 and 430 mm length intervals, while the majority of females were in the 480 mm range. Mean length at age analysis for Tar River American shad indicated that males between ages 3-5 had growth rates that ranged from 34-36 mm per year (Table 4). Female American shad were consistently larger than males of the same cohort, although growth rates were slightly less for age 4 and 5 fish. Growth rates for age 4-6 female American shad ranged from 15-18 mm per year.

Neuse River. —A total of 654 American shad was collected from the Neuse River during spring 2008. Age was determined for 59 individuals. Fish age and spawning history was tabulated only for those scales for which two scale readers were in agreement. With an exception of one male for which age could not be derived, ages for the remaining fish were estimated using a sex-specific age-length key. Overall CPUE was 25.4 fish/h, similar to 2007 (21.8 fish/h), 2006 (16.0 fish/h), 2005 (22.3 fish/h), 2004 (15.3 fish/h), and 2003 (20.5 fish/h) values despite changes in sample site selection

between some years. In 2008, males comprised 61% of the catch (Figure 6). Four male cohorts and six female cohorts were represented during the 2008 assessment (Table 5). Males ranged in age from 3-6 with 0-3 spawning marks and females ranged in age from 3-8 with 0-4 spawning marks. Of the total catch, 37% of scales examined indicated scale erosion associated with a previous freshwater migration. Overall, the total catch was supported largely by the 2004 year class, with older and younger fish of each sex contributing much less to the total catch. For fish aged 3-5, males were more abundant than females; however, females were more abundant than males for age classes older than age 5. Size distributions for both sexes were unimodal with the location of the mode approximated by the mean length of fish in the dominant year classes. Males aged 4 were most abundant and corresponded to a size distribution mode ranging from 400 mm to 450 mm (Figure 7). Most females were age 4 and coincided with a size distribution mode from 450 mm to 500 mm. Overall, American shad ranged in length from 356 to 566 mm; 99% of fish larger than 500 mm were females. Although females were larger than males of the same age, growth of American shad overall was slow (Table 6). Annual incremental growth averaged 32 mm/yr (range=2-66 mm/yr). High variability in length within age classes and small incremental growth suggests slowed growth after maturity for the Neuse River stock.

Cape Fear River. —A total of 259 American shad was collected from the Cape Fear River in 2008. Of this total, age was estimated for 93 individuals, with the remaining shad assigned ages from the age-length keys. Overall CPUE was 13.8 fish/h (Figure 8), a slight decrease from 2007 (15.5 fish/h), 2006 (17.5 fish/h), and much less than in 2005 (44.1 fish/h), 2004 (104.0 fish/h) and 2003 (53.6 fish/h). In 2008, males comprised 71% (N=185) of the sample while females accounted for 29% (N=74). Males from the 2004-2005 year classes (ages 3-4) accounted for 70.7% whereas females from the 2004 year class (age 4) made up 19.7% of all shad collected. Male American shad ranged in age from 3-5 years with 0-1 spawning mark, while females ranged from 3-6 years with 0-3 spawning marks (Table 7). Shad collected in the 2008 sample ranged from 368-555 mm total length (Figure 9). The peak in the length-frequency histogram for males occurred between 380 and 450 mm. Females had a distribution with peaks between 450 and 540 mm. Mean length at age analysis for Cape Fear River American shad indicated that males between ages 3-5 had growth rates that ranged from 11-45 mm per year (Table 8). Female shad were consistently larger than males of the same cohort, with growth rates for age 3-6 female shad ranging from 13-50 mm per year.

Ageing Workshops. —The ages assigned by group shad scale reads conducted at the March 5, 2008 workshop did not show strong agreement with ages determined for the same fish using OTC-marked otoliths (Table 9). The exercise indicated a tendency to consistently over-age American shad using scales, particularly fish under age-5. There was more agreement among groups on the number of spawning marks assigned, but the number assigned itself was sometimes questionable (for example, a 4 year old shad with 3 spawning marks). At the January 14, 2009 shad scale workshop, 276 reads of older (age-4 to 6) known-age scales resulted in 109 correct assignments of age (Table 10). Most reads (126) were too young and 41 were too old. Overall agreement with correct age was 39%. Broken down by age classes, agreement with correct age was 57% for age-4, 45% for age-5, 37% for age-6, 15% for age-7, and 0% for age-9 American shad. For comparison, similar work by McBride et al (2005) found agreement of scale readers with

correct age of 34-49% for age-3 to age-6, 12% for age-7, and 4% for age-8 American shad. The number of spawning marks assigned at the January 14, 2009 workshop varied considerably for most scales (Table 11). Most fish in the exercise were 5 or 6 years old. There were age-5 shad with no spawning marks and age-5 shad with 3 spawning marks assigned (suggesting spawning at age-2), creating some question as to their validity. Likewise, a number of age-6 fish were assigned no spawning marks. NCWRC and NCDMF staff are working on a standardized American shad scale ageing protocol in an effort to improve accuracy of scale-based ageing for this species.

Roanoke River Restoration Plan– Hatchery Evaluation

Fry Production and Locations Stocked. —Success in tank spawning and rearing fry has varied from year to year but is generally improving. Continuing experimentation with hormone formulations, use of heated water, and recirculating hatchery systems is expected to improve production although highly variable hatching success among batches of brood stock remains problematic.

Through 2002, all American shad fry produced were stocked in the Roanoke River below Roanoke Rapids Dam. In 2003, 1,081,289 American shad fry were stocked in the Staunton River, Virginia, a headwater tributary of the Roanoke River upstream of John H. Kerr Reservoir. Gaston and Roanoke Rapids dams, built in the 1950s and 1960s, along with John H. Kerr (USACOE) Dam built in the 1940s, have blocked access for American shad to upstream reaches of Roanoke River that once likely functioned as spawning habitat for American shad. Historical records indicate that before construction of dams on the Roanoke River, American shad ascended the river and its tributaries well into the Piedmont region of Virginia and to the Blue Ridge foothills near Salem, Virginia. This fry stocking in 2003 marked the first attempt at reintroducing American shad to the upper Roanoke River basin. An additional 1,204,340 fry were stocked in the Roanoke River below Roanoke Rapids Dam in 2003 as well. The strategy of stocking fry both in the Staunton River above John H. Kerr Reservoir and in the mainstem Roanoke River below Roanoke Rapids Dam continued from 2004-2008. During 2008, 4,278,526 fry were stocked into the Roanoke River below Roanoke Rapids Dam in the vicinity of Weldon, NC. An additional 3,941,089 fry were stocked above John H. Kerr Dam in the Staunton River near Altavista, VA. The total number of American shad fry stocked into the Roanoke River system in 2008 was 8,219,615, representing by far the best production year in North Carolina to date. Production experiments conducted during 2008 comparing hormone-injected fish to fish not injected with hormone, but for which spawning was temperature induced, showed no clear benefit to the use of hormone. Benefits of not using hormone include monetary savings and the ability to return broodstock to their natal streams after spawning. Fry stocking dates, locations, OTC marks used and number of shad fry stocked per trip are listed in Table 13.

Evaluation of Hatchery Contribution. —In 2003, otoliths of young-of-year American shad collected from the lower Roanoke River near Plymouth in 2000, 2001, 2002, and 2003 were examined for the presence of OTC marks. In addition, otoliths from 50 small adult male American shad, presumably shad that could have been three and four year-old fish resulting from the initial fry stockings in 1998 and 1999, were examined. No OTC marks were detected on otoliths from the adults and no OTC marks were detected on

otoliths of juveniles collected during 2000 and 2001. In 2002, out of 148 juvenile American shad collected in the lower Roanoke River, OTC marks were seen on otoliths from two specimens. In 2003, 130 juvenile American shad were collected; two having a single 3-day OTC mark on their otoliths (one 73 mm and one 87 mm in length) and four with the double 3, 6 day OTC mark (lengths ranged from 58 mm to 86 mm).

Otolith examination of 228 juvenile American shad collected in the lower Roanoke River in 2004 discovered 10 fish of hatchery origin. Of these 10 juveniles, five had been stocked as fry below Roanoke Rapids Dam (6-day mark) and ranged in size from 78-94 mm; these fish were collected as early as 16 August and as late as 25 October, 2004. The other 5 juveniles (size range 59-80 mm) had been stocked above John H. Kerr Reservoir and were recaptured on three separate dates in August 2004.

Examination of 420 juvenile American shad otoliths collected from the lower Roanoke River in 2005 revealed 38 fish of hatchery origin. Of these 38 juveniles, 29 were stocked as fry below Roanoke Rapids Dam (9-day mark) while 9 were stocked above John H. Kerr Reservoir (3- and 9-day mark). The recovery of juvenile, hatchery-origin American shad that were stocked in the headwaters of the Roanoke River basin continued to suggest these fish are able to successfully navigate through three mainstem reservoirs and down the Roanoke River to a point near its confluence with Albemarle Sound. Also, of 61 adult Roanoke River American shad sacrificed for otolith analysis in 2005, one OTC-marked male was recovered that was originally stocked at Weldon in 2002. This was the first documented survival to spawning age of a hatchery-reared American shad in the Roanoke River.

During the fall of 2006, a total of 238 juvenile American shad were collected from the lower Roanoke and otoliths from 236 of these were subsequently checked for OTC marks. Hatchery origin fish numbered 14 (overall juvenile contribution of 5.9%), 13 of which were stocked below Roanoke Rapids Dam at Weldon (3-day mark) and 1 of which was stocked above John H. Kerr Reservoir near Alta Vista, VA (3- and 6-day mark). OTC marked juveniles stocked below the reservoirs were collected on 4 occasions between 21 September 2006 and 16 October 2006 with the majority (n=8) collected on 10 October 2006 near Plymouth. The OTC marked juvenile recovered that was stocked above the reservoirs was collected on 16 October 2006 near Plymouth. During spring electrofishing near Gaston in 2006, 111 adult American shad were removed from the Roanoke River to assess hatchery contribution of returning adults. Otoliths from 105 of these fish were examined and 2 male OTC-marked fish originally stocked below the reservoirs at Weldon were recovered.

Between 6 September 2007 and 4 December 2007 a total of 313 juvenile American shad were collected, the majority (298) of which were collected near Plymouth, NC. The remaining 15 juvenile shad were collected during trial collections to identify additional juvenile American shad sampling sites. Of the juvenile American shad collected, 306 were checked for OTC marks. Of those, 33 juvenile American shad appeared to have a single OTC mark and no juvenile American shad of hatchery origin exhibited a double mark. The mean contribution of juvenile American shad of hatchery origin to emigration was 10.8 % (33 of 306) in 2007. In the spring of 2007, collaborative efforts by the NC Wildlife Resources Commission, Dominion Power, and North Carolina State University with studies on the spawning grounds as well as the NC Division of Marine Fisheries independent gill netting project in Albemarle Sound yielded a total of 239 adult

American shad for OTC analysis. Of those, 4 adult American shad were observed with an OTC mark, two collected on the spawning grounds during electrofishing and two collected from Albemarle Sound in independent gill net samples.

Fall 2008 sampling yielded a total of 295 juvenile American shad. Of these, 269 juveniles were collected near Plymouth, NC and the remaining 26 juveniles were collected during routine NCWRC fish sampling. A total of 290 juveniles were checked for OTC marks. Of those, 64 were of hatchery origin. A total of 59 juvenile American shad appeared to have a single OTC mark and ranged in total length from 53 mm to 105 mm. In addition, 5 juvenile American shad of hatchery origin exhibited a double mark and ranged in total length from 82 mm to 94 mm. The mean contribution of juvenile American shad of hatchery origin to emigration was 22.1 % (64 of 290) in 2008. A total of 19 age-1 American shad were also collected in the lower Roanoke River with total length ranging from 160 mm to 221 mm. None of these age-1, sub-adult American shad exhibited an OTC mark. A total of 193 adult American shad were collected for OTC analysis from the Roanoke River and Albemarle Sound in spring 2008 through cooperative efforts with Dominion Power, North Carolina State University and NC Division of Marine Fisheries. From this sample, we observed OTC marks on otoliths of 5 adult American shad, 3 were collected on the spawning grounds of the Roanoke River and 2 were collected from the western Albemarle Sound. Based on a unique single OTC marking pattern, we can conclude that the 2 adult American shad collected from the western Albemarle Sound were stocked in 2004 at Weldon. American shad fry stocked at Weldon are marked with single marks and fry stocked at Altavista, VA are marked with double marks. Although we can conclude that the remaining 3 adult American shad were stocked at Weldon, we cannot conclude the stocking year based only on OTC marking pattern because similar OTC marks were applied in 2002 and 2003. Since we recovered our first OTC marked fish in 2005, we have recovered a total of 12 adult American shad of hatchery origin from stockings in 2002, 2003 and 2004. Because American shad typically return to natal rivers 3 to 4 years after spawning, or stocking, recent American shad fry stockings from 2006, 2007 and 2008 are still at-large. We will continue stocking and recovery efforts of the American shad restoration program on the Roanoke River.

FERC Relicensing Update. —State and federal fisheries management agencies in North Carolina and Virginia have finalized negotiations with Dominion/N.C. Power with regards to relicensing of the Gaston and Roanoke Rapids lakes hydroelectric dams through the Federal Energy Regulatory Commission (FERC). Among the mitigative measures agreed-to as being a condition of relicensing include a long-term, well-funded, and coordinated program to restore American shad in the Roanoke River basin. Measures outlined to be included in this effort are improvements in hatchery production of fry, continued intensive monitoring of fry stocking success upstream and downstream of the mainstem reservoirs, experimentation with radio-telemetered spawners trapped and hauled to upstream reservoirs, and finally, assessment of the feasibility of providing upstream passage facilities. During 2006, Dominion refined the operation of their American shad haul tank purchased and assembled the previous year, stock assessment sampling continued, plans for the shad telemetry study to begin in 2007 were reviewed, hydroacoustic-based population estimate work continued and was supplemented by a

DIDSON unit, assessment of anadromous fish spawning in the bypassed reach continued, and planning continued for studies of lower river erosion and the biological effects of hydropower peaking. In 2007, refinements of annual stock assessment, population estimate, and bypass-use assessment continued. The first year (2007) of the shad telemetry study showed that almost 15% of tagged American shad released in Lake Gaston migrated to the tailrace of Kerr Dam. Approximately 26% of tagged shad released in Kerr Reservoir migrated up to Clarksville, VA and almost 10% migrated into either the lower Dam or Staunton Rivers. Stock assessment electrofishing during 2008 resulted in slightly higher CPUE over previous years. Hydroacoustic and DIDSON-based population estimates of the Roanoke River American shad spawning run indicated the presence of <10,000 fish in 2004, 2005, and 2007, but approximated 39,000 fish in the high flow year 2006. Population estimate data from 2008 is still being analyzed. Bypass reach electrofishing in the spring of 2008 resulted in the collection of 20 American shad. During the second year (2008) of the shad telemetry study, 13 of 33 fish placed in Lake Gaston moved upstream near the base of Kerr Dam, 11 downstream into Roanoke Rapids Lake and 6 of these 11 downstream into the lower Roanoke River. Most of the 35 fish released into Kerr Reservoir again stayed near the middle of the reservoir in 2008 and downstream movement was minimal. Of 32 fish released in the Staunton River, 31 moved downstream into Kerr Reservoir, although 5 eventually moved upstream to Randolph and 1 to Brookneal. Preliminary 2008 peaking study results have not indicated great differences in pre- and post-peaking fish assemblages. Bank erosion studies are still in data acquisition and model-building mode.

Characterization of Other Losses

For 2008, a total of 1,021 adult American shad were collected for Edenton and Watha hatchery brood stock from the Cape Fear River (N=411), Tar River (N=482), and Neuse River (N=128). However, not using hormone to induce spawning for a portion of these fish allowed 323individuals to be returned in good condition to their river of origin. This resulted in a total hatchery production take from North Carolina rivers of 698 adult shad with a post-spawn weight of 544.3 kg, down considerably from 2007's hatchery take of 1,047 fish with a post-spawn weight of 899.5 kg. A total of 193 adult American shad collected from the Roanoke River spawning grounds and Albemarle Sound near the Roanoke River mouth had otoliths extracted for OTC analysis. Most of the shad examined were mortalities from ongoing Roanoke/Albemarle Sound shad studies by the NC Wildlife Resources Commission, Dominion Power, NC State University, and NC Division of Marine Fisheries. In addition, the NC Wildlife Resources Commission collected 295 juvenile American shad from the lower Roanoke River to examine otoliths for OTC marks.

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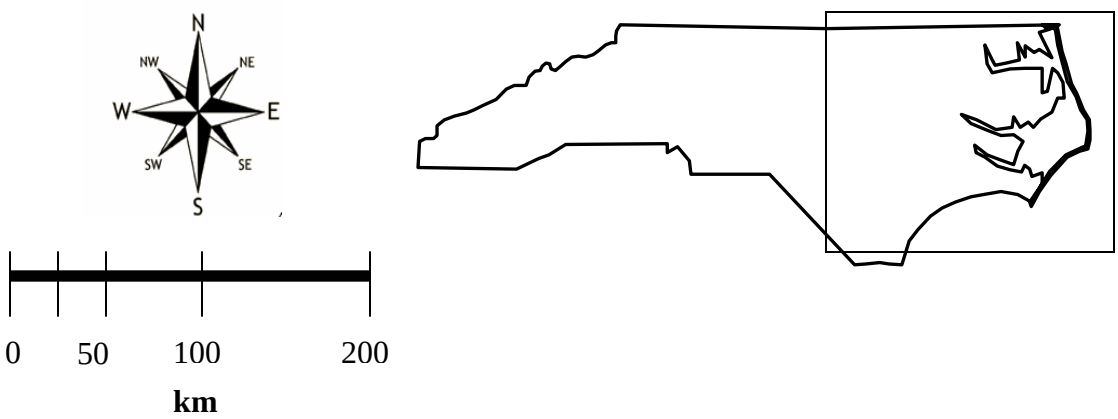

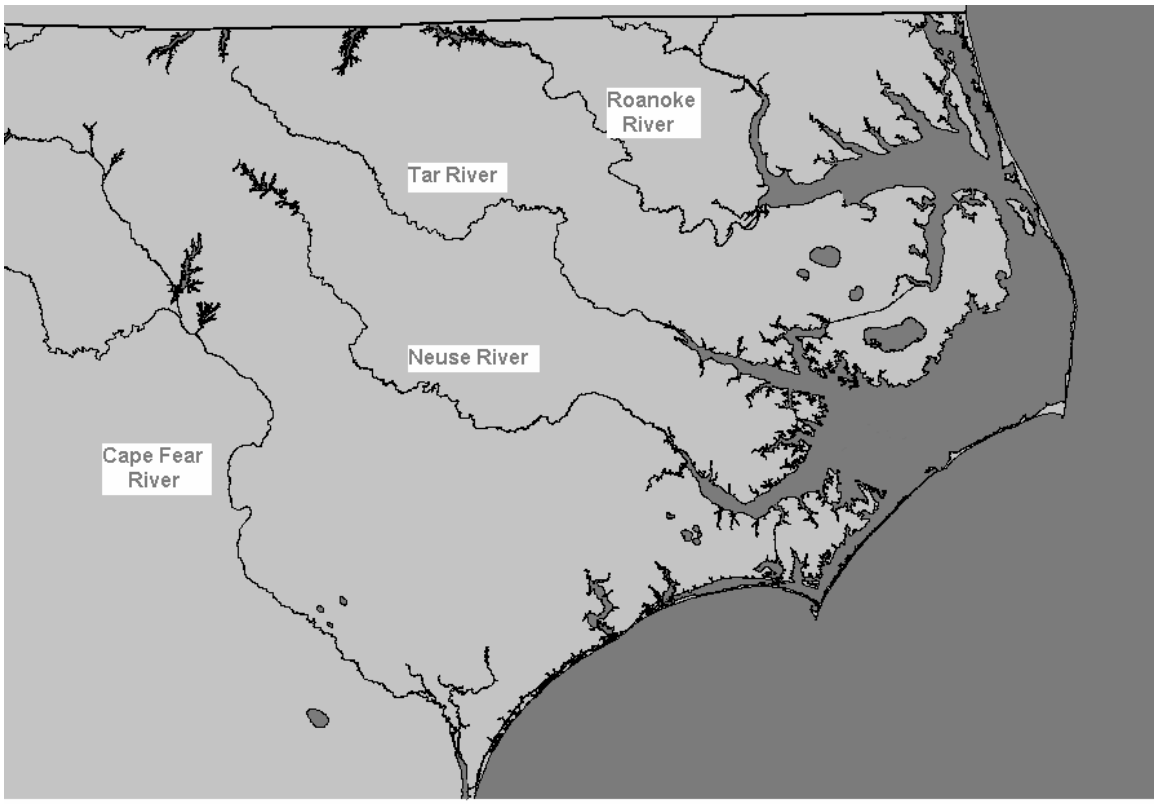

FIGURE 1.—Major river basins in coastal North Carolina where American shad were collected during spring 2008.

FIGURE 2.—Relative abundance (electrofishing CPUE) of American shad collected from the Roanoke River, spring 2008.

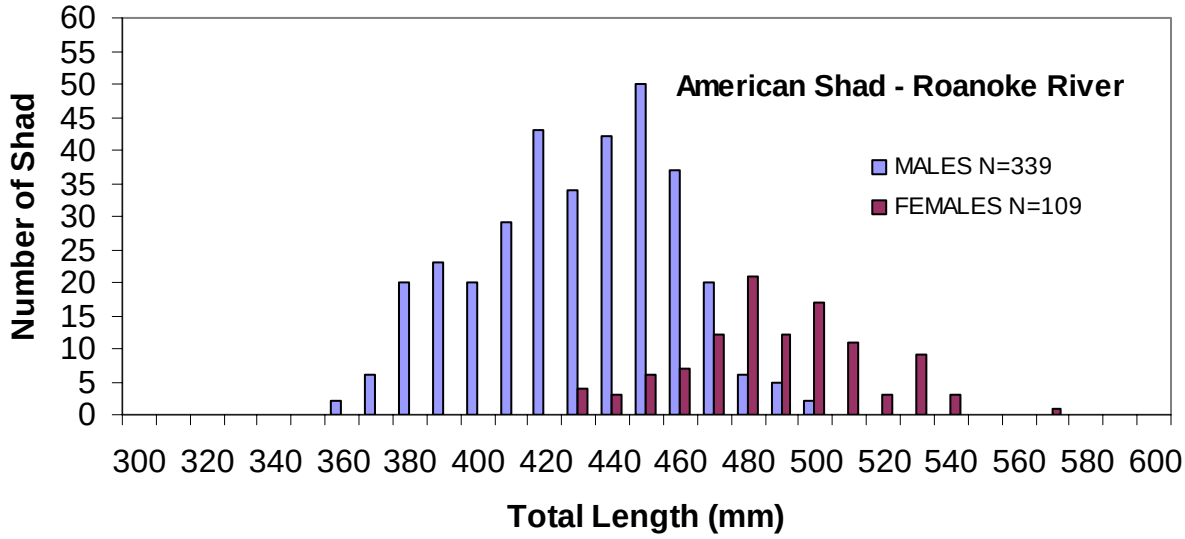

FIGURE 3.—Length-frequency histogram for American shad collected from the Roanoke River, spring 2008.

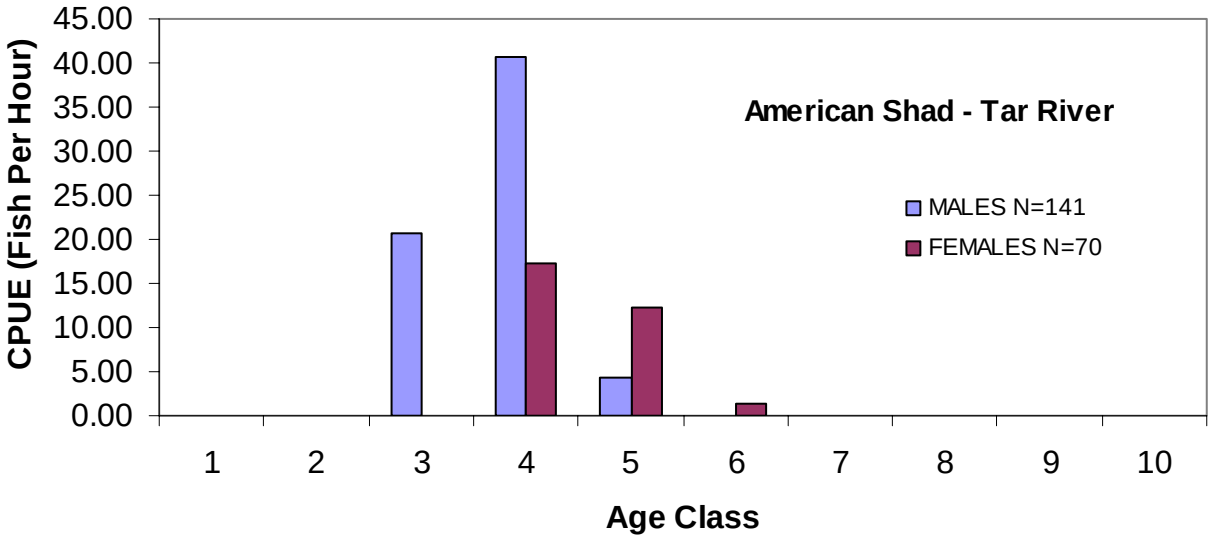

FIGURE 4.—Relative abundance (electrofishing CPUE) of American shad collected from the Tar River, spring 2008.

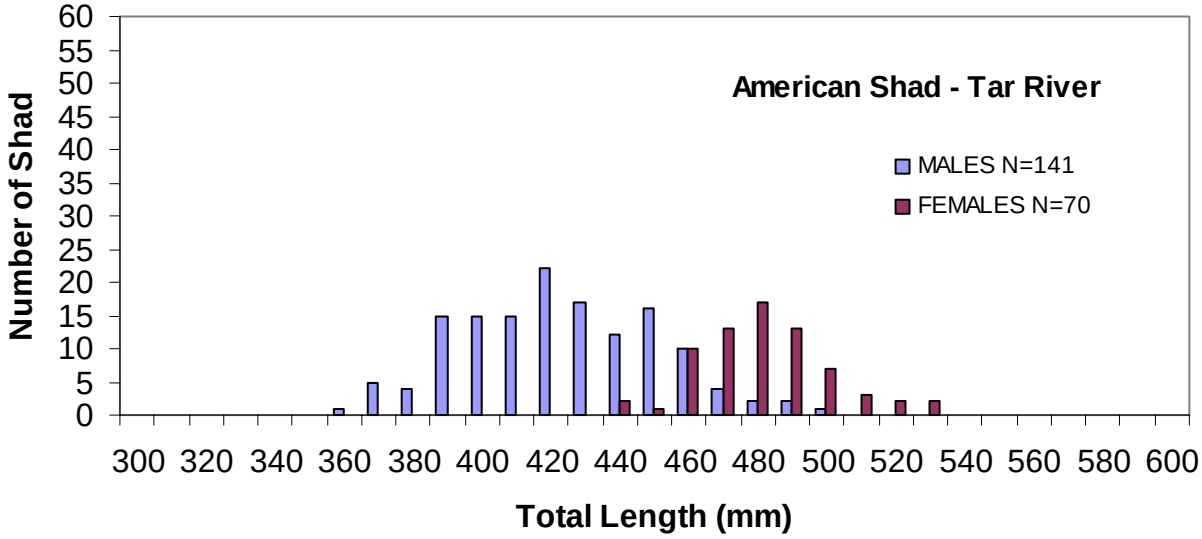

FIGURE 5.—Length-frequency histogram for American shad collected from the Tar River, spring 2008.

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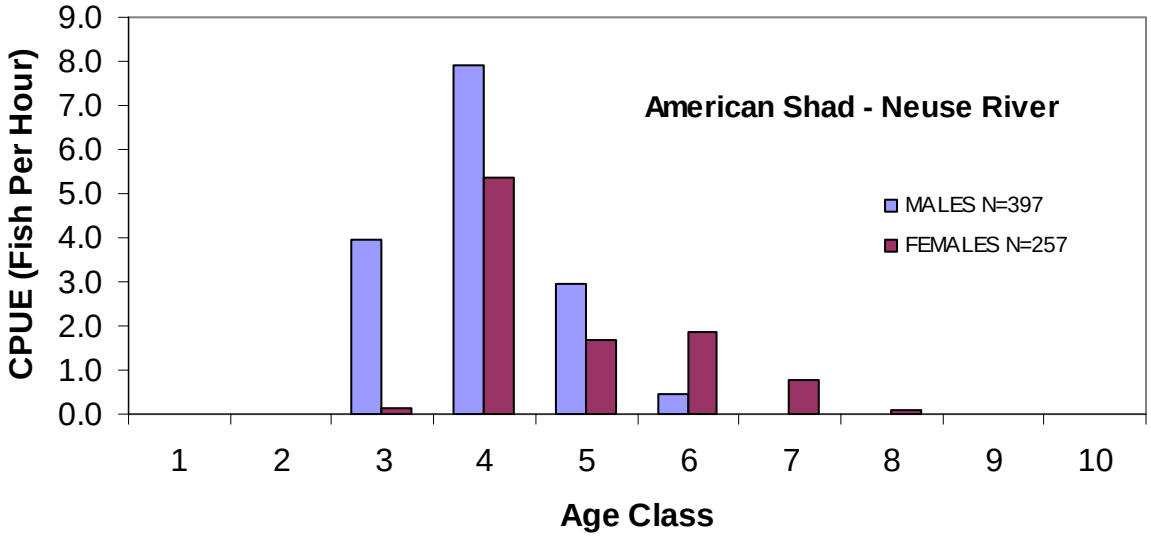

FIGURE 6.—Relative abundance (electrofishing CPUE) of American shad collected from the Neuse River, spring 2008.

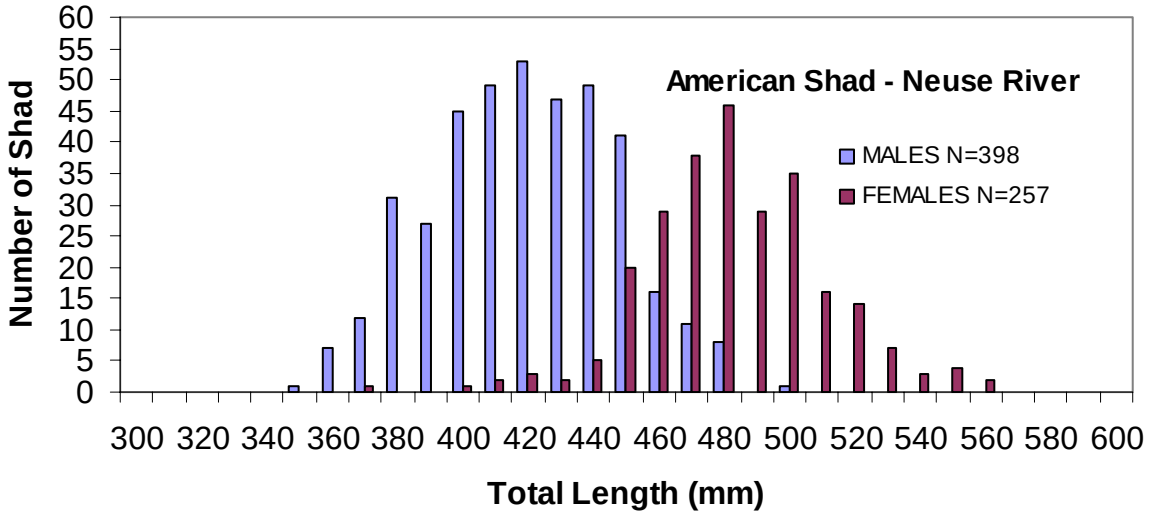

FIGURE 7.—Length-frequency histogram for American shad collected from the Neuse River, spring 2008.

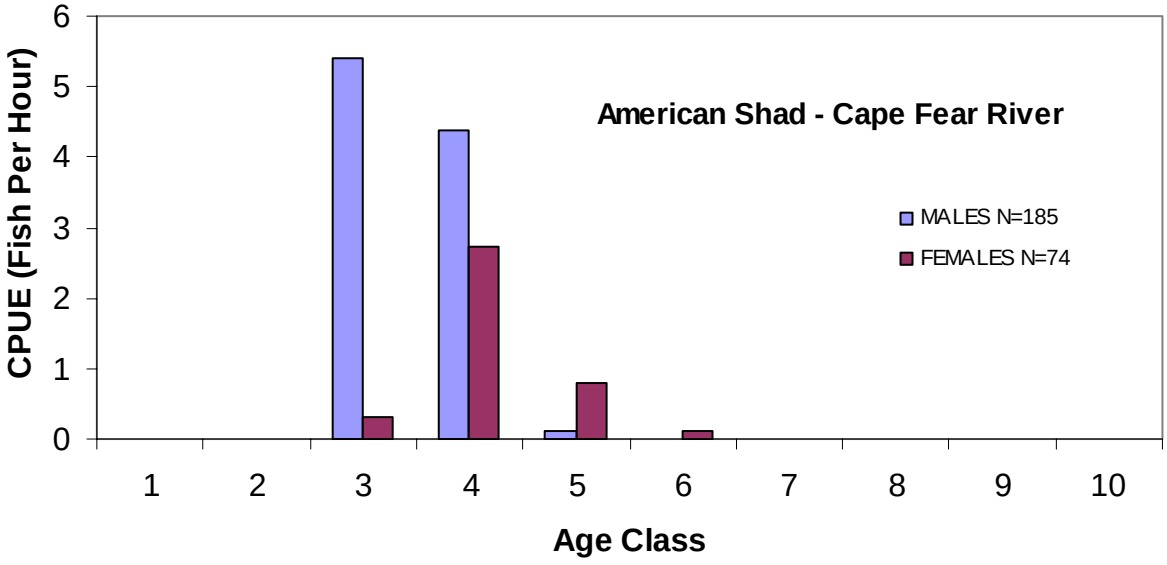

FIGURE 8.—Relative abundance (electrofishing CPUE) of American shad collected from the Cape Fear River, spring 2008.

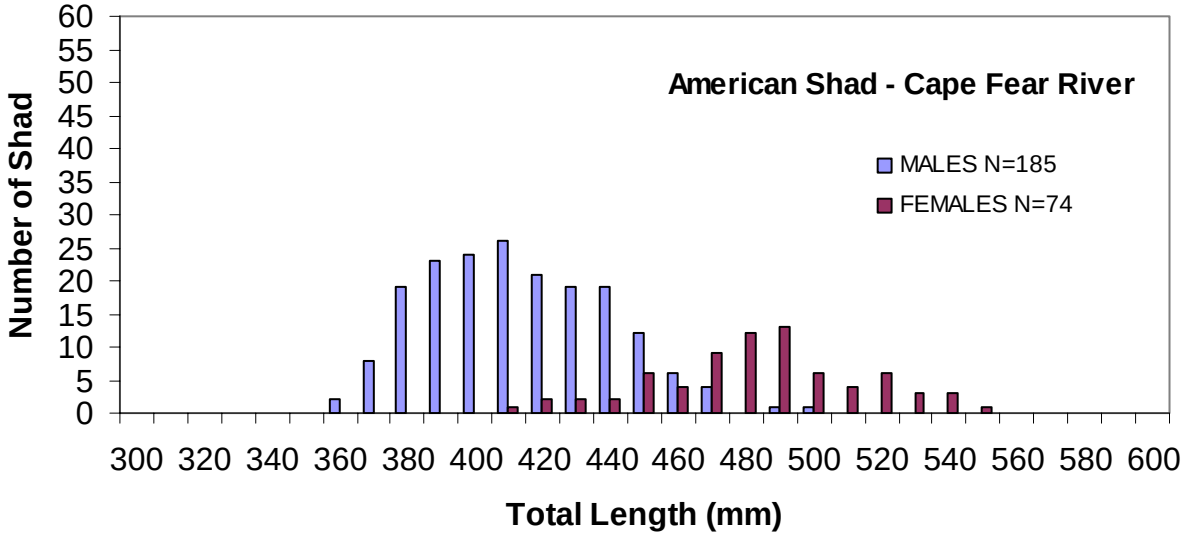

FIGURE 9.—Length-frequency histogram for American shad collected from the Cape Fear River, spring 2008.

TABLE 1.—Age composition and spawning mark frequency for American shad collected from the Roanoke River, spring 2008.

				Spawning Marks											
YEAR		N		0		1		2		3		4		5	
CLASS	AGE	M	F	M	F	M	F	M	F	M	F	M	F	M	F
2005	3	21	2	21	2										
2004	4	33	33	21	32	12	1								
2003	5	22	19	8	13	10	6	4							
2002	6	4	5		3	1	1	1	1	2					
2001	7		2		2										
	Totals	80	61	50	52	23	8	5	1	2	0	0	0	0	0

TABLE 2.—Mean total length (mm) at age for American shad males and females collected from the Roanoke River, spring 2008.

YEAR		Male				Female			
CLASS	AGE	N	Mean	Min	Max	N	Mean	Min	Max
2005	3	21	386	368	411	2	434	431	437
2004	4	33	434	394	477	33	472	439	505
2003	5	22	470	437	493	19	518	492	542
2002	6	4	497	492	505	5	535	523	544
2001	7					2	557	542	571

TABLE 3.—Age composition and spawning mark frequency for American shad collected from the Tar River, spring 2008.

				Spawning Marks											
YEAR		N		0		1		2		3		4		5	
CLASS	AGE	M	F	M	F	M	F	M	F	M	F	M	F	M	F
2005	3	42		42											
2004	4	83	35	32	34	51	1								
2003	5	9	25	1	14	5	11	3							
2002	6		3				2		1						
	Totals	134	63	75	48	56	14	3	1	0	0	0	0	0	0

TABLE 4.—Mean total length (mm) at age for American shad males and females collected from the Tar River, spring 2008.

YEAR		Male				Female			
CLASS	AGE	N	Mean	Min	Max	N	Mean	Min	Max
2005	3	42	402	365	454				
2004	4	83	436	393	486	35	477	447	510
2003	5	9	472	432	504	25	495	460	533
2002	6					3	510	506	512

TABLE 5.—Age composition and spawning mark frequency for American shad collected from the Neuse River, spring 2008.

				Spawning Marks											
YEAR		N		0		1		2		3		4		5	
CLASS	AGE	M	F	M	F	M	F	M	F	M	F	M	F	M	F
2005	3	10	2	9	2	1									
2004	4	14	14	11	10	1	1	1							
2003	5	5	4	1		4	1		1		1				
2002	6	2	4					1	2	1	2				
2001	7		3						1		1		1		
2000	8		1		1										
	Totals	31	28	21	13	6	2	2	4	1	4	0	1	0	0

TABLE 6.—Mean total length (mm) at age for American shad males and females collected from the Neuse River, spring 2008.

YEAR		Male				Female			
CLASS	AGE	N	Mean	Min	Max	N	Mean	Min	Max
2005	3	10	390	363	455	2	409	373	444
2004	4	14	439	389	483	14	475	418	560
2003	5	5	437	403	481	4	515	487	537
2002	6	2	471	458	483	4	507	465	542
2001	7					3	522	503	536
2000	8					1	566	566	566

TABLE 7.—Age composition and spawning mark frequency for American shad collected from the Cape Fear River, spring 2008.

				Spawning Marks											
YEAR		N		0		1		2		3		4		5	
CLASS	AGE	M	F	M	F	M	F	M	F	M	F	M	F	M	F
2005	3	25	5	24	5	1									
2004	4	20	27	13	21	7	6								
2003	5	1	13	1	6		7								
2002	6		2						1		1				
	Totals	46	47	38	32	8	13	0	1	0	1	0	0	0	0

TABLE 8.—Mean total length (mm) at age for American shad males and females collected from the Cape Fear River, spring 2008.

YEAR		Male				Female			
CLASS	AGE	N	Mean	Min	Max	N	Mean	Min	Max
2005	3	25	402	368	470	5	435	412	454
2004	4	20	447	406	500	27	477	429	516
2003	5	1	458	458	458	13	527	502	546
2002	6					2	540	525	555

TABLE 9.—Group Roanoke River American shad scale reads (5 fish) made at 3-5-08 American shad ageing workshop, Morehead City NCDMF office.

	#3075		#3001		#3187		#3226		#2482	
	Age	SM	Age	SM	Age	SM	Age	SM	Age	SM
Group 1	5	0	6	3	4	1	5	0	5	0
Group 2	6	0	6	3	4	1	4	0	4	0
Group 3	5	0	6	0	5	2	5	0	4	0
Group 4	6	0	7	3	4	1	4	0	4	0
Group 5	6	0	-	-	6	2	5	0	4	0
Group 6	6	0	-	-	-	-	4	0	5	0
OTC	9		4*		3*		9		2	
	5*				0		5		3*	
	4						4			
	1						1			

Notes: SM = spawning marks. OTC ages shown are all possible ages that fish could be based on the OTC marks (double or single; 3, 6 or 9-day) on that particular fish's otolith. An asterisk (*) denotes age determined from the otolith and the agreed-upon age by the overall group of attendees. Fish #3226 needed an otolith check as its otolith read was not readily available.

TABLE 10.—Independent, blind reads of known-age American shad scales (37 fish from the Delaware and Lehigh rivers) by 9 readers at 1-14-09 Morehead City shad ageing workshop.

Scale #	Known Age	# Of Readers (of 9 total) Discarding Scales	# Read 2 Yrs Too Young	# Read 1 Yr Too Young	# Read Correctly	# Read 1 Yr Too Old	# Read 2 Yrs Too Old
1	6	0	3	3	2	1	0
2	6	0	0	6	3	0	0
3	5	0	0	0	5	4	0
4	7	5	4	0	0	0	0
5	4	2	0	4	3	0	0
6	9	0	7	2	0	0	0
7	4	2	0	2	5	0	0
8	5	1	0	2	2	3	1
9	6	1	2	1	4	1	0
10	6	0	2	5	2	0	0
11	5	0	0	0	3	5	1
12	5	0	1	6	2	0	0
13	6	1	2	3	3	0	0
14	6	8	1	0	0	0	0
15	6	0	2	4	3	0	0
16	5	0	1	1	6	1	0
17	5	9	0	0	0	0	0
18	7	0	3	4	2	0	0
19	5	0	0	3	5	1	0
20	5	0	0	0	4	3	2
21	6	1	2	4	1	1	0
22	5	0	0	3	4	2	0
23	6	0	0	1	6	2	0
24	5	4	1	3	1	0	0
25	5	0	0	2	7	0	0
26	6	2	1	5	1	0	0
27	6	0	2	3	4	0	0
28	6	0	3	1	5	0	0
29	5	0	0	3	3	2	1
30	5	9 (lost)	-	-	-	-	-
31	6	1	1	4	3	0	0
32	6	0	3	4	2	0	0
33	5	0	0	1	7	1	0
34	5	0	2	2	4	1	0
35	5	0	0	1	1	7	0
36	5	7 (only 7 readers)	-	-	-	-	-
37	6	0	0	0	6	1	0
		Totals	43	83	109	36	5

TABLE 11.—Assignment of number of spawning marks on scales of 37 known-age American shad by 9 independent readers at 1-14-09 shad age workshop.

Scale #	# Of Readers (of 9 total) Discarding Scales	Known Age	0 Spawning Mark Read	1 Spawning Mark Read	2 Spawning Marks Read	3 Spawning Marks Read
5	2	4	6	1		
7	2	4	7			
3		5	5	2	1	1
8	1	5	2	2	3	2
11		5	6	2	1	
12		5	6	3		
16		5	6	3		
17	9	5	-	-	-	-
19		5	6	3		
20		5	5	2		2
22		5	3	5	1	
24	4	5	2	2	1	
25		5	7	1	1	
29		5	3	2	4	
30	9 (lost)	5	-	-	-	-
33		5	4	4		1
34		5	6	2	1	
35		5	5	1	1	2
36	7 (only 7 readers)	5	-	-	-	-
1		6	8		1	
2		6	6		3	
9	1	6	2	4	1	1
10		6	6	3		
13	1	6	4	4		
14	8	6	1			
15		6	2	3	3	1
21	1	6	5		3	
23		6	7	1	1	
26	2	6	3	2	2	
27		6	2	3	4	
28		6	2	2	5	
31	1	6	7		1	
32		6	5	3	1	
37	(only 7 readers)	6	1	3	2	1
4	5 (others unrecorded)	7	-	-	-	-
18		7	3	2	3	1
6		9	2	7		

Note: empty cell means no spawning mark of that category was read.

TABLE 12.—American shad fry produced in North Carolina and stocked into the Roanoke River Basin from 1998-2008.

Year	Edenton NFH	Watha Hatchery	Total
1998	481,000*	-	481,000
1999	225,000	50,000	275,000
2000	535,000	308,000	843,000
2001	700,000	1,369,000	2,069,000
2002		820,000	820,000
2003	612,000	1,673,629	2,285,629
2004	589,822	1,740,000	2,329,822
2005	1,346,834	1,226,000	2,572,834
2006	1,088,936	1,332,000	2,420,936
2007	772,780	3,540,051	4,312,831
2008	3,126,098	5,093,517	8,219,615

*eggs collected and fertilized in the field

TABLE 13.—Date, stocking location, OTC mark sequence, and number of American shad fry stocked per trip in the Roanoke River Basin in 2008. Asterisks denote fry produced at the Edenton National Fish Hatchery. All other fry were produced at the NCWRC Watha State Fish Hatchery.

Date	Location	OTC Mark	Number Stocked
4/11/2008	Staunton River at Altavista	3,9d	82,000
4/17/2008	Staunton River at Altavista	3,9d	294,934
4/23/2008	Staunton River at Altavista	3,9d	311,985
4/28/2008	Roanoke River at Weldon	9d	353,995*
4/29/2008	Roanoke River at Weldon	9d	307,390*
4/29/2008	Staunton River at Altavista	3,9d	190,989
5/01/2008	Staunton River at Altavista	3,9d	351,027
5/06/2008	Staunton River at Altavista	3,9d	171,345
5/06/2008	Roanoke River at Weldon	9d	444,553*
5/08/2008	Roanoke River at Weldon	9d	331,583*
5/09/2008	Staunton River at Altavista	3,9d	125,000
5/12/2008	Roanoke River at Weldon	9d	404,055*
5/14/2008	Roanoke River at Weldon	9d	83,287
5/14/2008	Roanoke River at Weldon	9d	384,309*
5/19/2008	Roanoke River at Weldon	9d	330,935*
5/20/2008	Staunton River at Altavista	3,9d	313,205
5/20/2008	Roanoke River at Weldon	9d	295,008*
5/21/2008	Roanoke River at Weldon	9d	274,270*
5/22/2008	Staunton River at Altavista	3,9d	143,075
5/28/2008	Staunton River at Altavista	3,9d	615,250
6/03/2008	Staunton River at Altavista	3,9d	481,325
6/05/2008	Staunton River at Altavista	3,9d	644,327
6/10/2008	Staunton River at Altavista	3,9d	216,627
6/11/2008	Roanoke River at Weldon	9d	437,113
6/13/2008	Roanoke River at Weldon	9d	632,028
Total			**8,219,615**