

**FISHERY MANAGEMENT PLAN UPDATE  
AMERICAN SHAD  
AUGUST 2020**

**STATUS OF THE FISHERY MANAGEMENT PLAN**

**Fishery Management Plan History**

|                        |  |
|------------------------|--|
| Original FMP Adoption: | October 1985   |
| Amendments:            | Amendment 1 (April 1999)<br>Amendment 3 (February 2010)          |
| Revisions:             | Technical Addendum 1 (February 2000)<br>Addendum I (August 2002) |
| Supplements:           | Supplement (October 1988)  |
| Information Updates:   | None   |
| Schedule Changes:      | None   |
| Next Benchmark Review: | ASMFC started 2018/final results summer 2020                     |

The first Atlantic States Marine Fisheries Commission (ASMFC) Fishery Management Plan (FMP) for Shad and River Herrings was adopted in 1985. The FMP did not require any specific management approach or monitoring programs within the management unit, asking only that states provide annual summaries of restoration efforts and ocean fishery activity. It specified four management objectives: regulate exploitation, improve habitat accessibility and quality, initiate programs to introduce alosine stocks into historic waters, and recommend and support research programs. The 1988 Supplement (ASMFC 1988) reassessed the research priorities identified in the original 1985 plan and created a new listing of research priorities.

Amendment 1 (ASMFC 1999) reported that the majority of American shad (*Alosa sapidissima*) stocks were not overfished, but almost all were believed to be at or near historically low levels. Therefore, Amendment 1 required increased annual reporting requirements on juveniles, adult spawning stocks, annual fishing mortality, and habitat. A fishing mortality threshold (overfishing) was defined as a reference point of  $F_{30}$ . A fishing mortality rate of  $F_{30}$  will result in 30 percent of the maximum spawning potential in the female component of an unfished population. Amendment 1 also implemented the phase-out of the ocean intercept fishery for American shad (effective in 2005). Eliminating the North Carolina ocean intercept fishery was important to controlling harvest to specific river origins.

Technical Addendum 1 (ASMFC 2000) modified several technical errors and provided clarification of several monitoring requirements in Amendment 1.

Addendum I (ASMFC 2002) changed the conditions for marking hatchery-reared alosines. The addendum clarifies the definition and intent of *de minimis* status for the American shad fishery. It also further modifies and clarifies the fishery independent and fishery-dependent monitoring requirements of Technical Addendum 1.

The ASMFC coastwide stock assessment completed in 2007 found that American shad stocks were at all-time lows and did not appear to be recovering to acceptable levels. Therefore, under ASMFC's Amendment 3 to the Interstate FMP for Shad and River Herring, individual states were required to develop Implementation Plans (ASMFC 2010). Implementation Plans consisted of two parts: 1. Review and update of the fishing/recovery plans required under Amendment 1 for the stocks within their jurisdiction; and 2. Habitat plans. North Carolina submitted a fishing/recovery plan that meets the requirements of Amendment 3 and is known as the North Carolina American Shad Sustainable Fishery Management Plan (SFMP) (NCDMF 2011).

To ensure compliance with interstate requirements, North Carolina also manages this species under the North Carolina Fishery Management Plan for Interjurisdictional Fisheries (IJ FMP). The goal of the IJ FMP is to adopt fishery management plans, consistent with N.C. law, approved by the Mid-Atlantic Fishery Management Council, South Atlantic Fishery Management Council, or the ASMFC by reference and implement corresponding fishery regulations in North Carolina to provide compliance or compatibility with approved fishery management plans and amendments, now and in the future. The goal of these plans, established under the Magnuson-Stevens Fishery Conservation and Management Act (federal council plans) and the Atlantic Coastal Fisheries Cooperative Management Act (ASMFC plans) are like the goals of the Fisheries Reform Act of 1997 to “ensure long-term viability” of these fisheries (NCDMF 2015).

### **Management Unit**

The management units for American shad are all the migratory American shad stocks of the Atlantic coast of the United States. American shad and hickory shad management authority lies with the ASMFC and is coordinated by Atlantic coastal states from Maine through Florida through approved Sustainable Fishery Management Plans for American Shad. Responsibility for management action in the Economic Exclusive Zone (EEZ), located from three to 200 miles from shore, lies with the Secretary of Commerce through the Atlantic Coastal Fisheries Cooperative Management Act (ACFCMA) in the absence of a federal FMP.

### **Goal and Objectives**

Migratory stocks of American shad have been managed under the ASMFC since 1985. These species are currently managed under Amendment 3 (American shad) and Amendment 1 (American and hickory shad (*Alosa mediocris*) to the ASMFC FMP, Technical Addendum 1, and Addendum I. Because of the scarcity of data on hickory shad populations, the ASMFC member states decided to focus Amendment I on American shad regulations and monitoring programs. However, the amendment requires states to initiate fishery-dependent monitoring programs for hickory shad while recommending continuance of current fishery-independent programs for these species. The goal of Amendment 3 is to protect, enhance, and restore Atlantic coast

migratory stocks and critical habitat of American shad in order to achieve levels of spawning stock biomass that are sustainable, can produce a harvestable surplus, and are robust enough to withstand unforeseen threats. To achieve this goal, the plan adopts the following objectives:

1. Maximize the number of juvenile recruits emigrating from freshwater stock complexes.
2. Restore and maintain spawning stock biomass and age structure to achieve maximum juvenile recruitment.
3. Manage for an optimum yield harvest level that will not compromise Objectives 1 and 2.
4. Maximize cost effectiveness to the local, state, and federal governments, and the ASMFC associated with achieving Objectives 1 through 3.

## **STATUS OF THE STOCK**

### **Life History**

American shad are anadromous fish, meaning they spend most of their adult lives at sea, only returning to freshwater in the spring to spawn. Shad young leave their home river within the first year and will spend the next few years at sea, schooling in large numbers with shad from other regions and feeding on plankton, small fish, and crustaceans. Upon reaching maturity, at about age 4, they return to the streams they were born in to spawn. Males or "buck shad" return first, followed by females or "roe shad." They spawn usually at night or during overcast days. In the southern range (Cape Fear River to Florida), females release as many as 700,000 eggs during the spawning season, but both males and females normally die after spawning. In the northern range, females typically release 300,000 eggs or less during the spawning season; however, most shad will return to spawn in the following years, with some shad living up to 10 years.

### **Stock Status**

The most recent coastwide stock assessment of American shad stated that populations in the Albemarle Sound and Roanoke River are stable and low, whereas a determination of stock status could not definitively be assigned for the Tar/Pamlico, Neuse and Cape Fear rivers due to limited information (ASMFC 2007).

### **Stock Assessment**

The last coastwide stock assessment for American shad was completed in 2007, which found that stocks are currently at all-time lows and do not appear to be recovering. Recent declines in stock abundance were reported for Maine, New Hampshire, Rhode Island and Georgia, and for the Hudson (NY), Susquehanna (PA), James (VA) and Edisto (SC) Rivers. Low and stable stock abundance was indicated for Massachusetts, Connecticut, Delaware, Chesapeake Bay, the Rappahannock River (VA) and some South Carolina and Florida stocks. The Potomac River stock has shown rebuilding in recent years of the stock assessment. For North Carolina the stock assessment found that American shad populations in the Albemarle Sound and Roanoke River

are stable and low, whereas a determination of stock status could not definitively be assigned for the Tar-Pamlico, Neuse and Cape Fear rivers due to limited information (ASMFC 2007). It should be noted that areas south of Albemarle Sound form a zone where stocks transition from iteroparity (spawns multiple times over the course of its lifetime) to semelparity (spawns once before death), which can also impact the ability to determine stock status.

Primary causes for stock decline were identified, including overfishing, pollution and habitat loss due to dam construction. A peer review panel recommended that current restoration actions should be reviewed and new ones should be identified and applied, and suggested considering a reduction of fishing mortality, enhancement of dam passage and mitigation of dam-related fish mortality, stocking and habitat restoration.

The ASMFC has not conducted a coastwide assessment of hickory shad. The benchmark stock assessment for American shad, currently in progress, will use data through 2017 and is scheduled for completion Summer 2020.

## **STATUS OF THE FISHERY**

### **Current Regulations**

The NCMFC enacted a rule in 1995, which established a closed season for American shad and hickory shad. It is unlawful to take these species by any method except hook-and-line from April 15 through December 31. The ocean intercept fishery for American shad was closed to all harvest January 1, 2005 (ASMFC 2002).

In the Albemarle, Croatan, Roanoke, and Currituck sounds and tributaries (Albemarle Sound Management Area; ASMA), floating gill nets of 5.25-inch stretch mesh (ISM) to 6.5 ISM, were limited to 1,000 yards and can only be utilized from March 3 through March 24 and must be fished at least once during a 24-hour period (no later than noon each day). The western portion of Albemarle Sound near the mouth of the Roanoke River (including Roanoke, Cashie, Middle and Eastmost Rivers) is closed to gill netting year-round. The large mesh gill net restrictions were imposed for striped bass conservation but also provided measures of protection for American shad. Gill nets of less than 3.25 ISM were not allowed due to the river herring closure. Gill nets with a mesh length of 3.25 - 4.00 ISM could not exceed 800 yards and were allowed the entire spring. Attendance for small mesh gill nets (3.0 – 4.0 ISM) was required May 18 – November 20. The ASMA was closed to all gill nets except for 3.0 – 4.0 ISM run-around, strike, drop, and drift gill nets until the area was opened September 1, 2015. Gill net attendance was removed in this area on November 20.

Since May 2016, in other areas outside of the ASMA (excluding the Cape Fear River), a statewide rule limits the amount of large mesh (4.0-inch and greater) gill net set in internal Coastal Fishing Waters to no more than 2,000 yards per vessel. A prior version of the rule (3,000 yards maximum) was suspended for most internal Coastal waters as a result of sea turtle conservation measures to institute no more than 2,000 yards per vessel of 4.0–6.5-inch gill net in the Tar-Pamlico and Neuse river systems in earlier years. Additionally, in certain sections of the Tar-Pamlico and Neuse rivers, gill nets with a mesh size less than five inches must be attended at

all times. Also, it is unlawful to use any gill nets in Joint Fishing Waters from midnight on Friday to midnight on Sunday each week (except for portions of Albemarle and Currituck sounds). These existing gill net measures have likely reduced American Shad harvest since they have remained in effect since the spring 2012 fishing season and remain in effect indefinitely.

In the Cape Fear River there are different gill net restrictions than described above for the Tar-Pamlico and Neuse river systems (i.e. mesh lengths, spacing, set/retrieval days and times). Large mesh gill nets (4.0-6.5-inch) are prohibited in the Cape Fear River (north of the Railroad Bridge) and Northeast Cape Fear River (north of I-40 bridge) north of Wilmington, NC. In other parts of the Cape Fear River, large mesh gill nets can be set in lengths no greater than 100 yards and must have at least a 25-yard space between each individual length of net. Only single overnight sets are allowed; nets can be set one hour prior to sunset and must be retrieved within one hour of sunrise, with no sets allowed Friday, Saturday or Sunday evenings, and the maximum yardage allowed is a 1,000-yard limit per vessel. It is unlawful to use gill nets of any mesh size on weekends in the Cape Fear system. This measure will remain in effect indefinitely.

### **Commercial Landings**

North Carolina's commercial landings in 2019 were 40,975 pounds; well below 2018 landings (53,878 pounds) and the lowest annual total since the implementation of the Albemarle Sound Management Area reduced season in 2014 (Table 1 and Figure 1). Landings show a decreasing trend until 2013 when average landings leveled off with the implementation of the American Shad SFMP. Commercial harvest is sporadic and cyclical and annual trends show these changes. Figure 2 describes that landings break down by the four areas of the state, as stated in the American Shad SFMP. The Albemarle Sound area accounts for approximately 79 percent of total state landings in 2019.

### **Recreational Landings**

Recreational fishing activity is monitored through coordination with the North Carolina Wildlife Resources Commission (WRC) and the NCDMF, methods were developed to conduct recreational creel surveys on the Roanoke, Tar, Neuse, and Cape Fear rivers starting in 2012, except for Cape Fear River which started in 2013. Recreational landings for American shad are minimal throughout the Albemarle Sound/Roanoke River due to limited to no effort focused on American shad in this system. The bulk of the North Carolina recreational fishery occurs in the Cape Fear River system where substantial effort is targeted on American shad with an estimated annual harvest of 2,271 fish in 2019 (Table 2).

## **MONITORING PROGRAM DATA**

### **Fishery-Dependent Monitoring**

Commercial fishing activity is monitored through fishery-dependent sampling conducted by the NCDMF since 1972, with a sampling gap from 1994 to 2000 due to funding. Data collected in this program allow the size and age distribution of American Shad to be characterized by sex (female and male). The predominant fishery for American shad are estuarine gill nets and harvest

is primarily focused on female American Shad, as they are harvested for their roe (eggs). In 2019, gill nets accounted for greater than 95% of the commercial landings (Figure 3).

A total of 444 females and 85 males were measured from the commercial fishery in 2019 (Table 3 and Table 4). The average size of female American Shad was 17 inches fork length and male was 15 inches fork length in 2019, which has decreased over time for both females and males (Figure 4 and Figure 5). Variation in modal, minimum, and maximum ages throughout the fishery-dependent monitoring is described in Table 5, for both sexes combined. The modal age has increased over the time series, while the minimum and maximum ages have remained relatively unchanged. Figure 6 and Figure 7 illustrate the American Shad length at age (mean, minimum, and maximum) for females and males from all age samples collected at any given age from 1972 to 2019.

### **Fishery-Independent Monitoring**

The NCDMF does not have a dedicated juvenile (age-0) survey for American Shad, but conducts two juvenile beach seine surveys in the Albemarle Sound area. Although the surveys were designed to monitor river herring [Blueback Herring (*Alosa aestivalis*) and Alewife (*Alosa pseudoharengus*)] and striped bass (*Morone saxatilis*), both surveys capture American Shad. The river herring beach seine survey has been conducted in the Chowan River and Albemarle Sound area to monitor Blueback Herring and Alewife abundance since 1972. The survey established 11 stations in the near-shore nursery areas of the Chowan River and Albemarle Sound, sampled twice a month. The striped bass (*Morone saxatilis*) beach seine survey has been conducted in the western Albemarle Sound to monitor juvenile striped bass since 1993. This survey was designed to determine the critical point (egg, larval, or early juvenile stage) that was limiting spawning success resulting in near zero catches in the juvenile trawl surveys for striped bass. The survey established nine stations in the near-shore nursery areas of the western Albemarle Sound, where early stage juvenile striped bass would be settling after larval metamorphosis from spawning grounds on the Roanoke River. The stations are sampled once a week, for six weeks (starting the first week in June). American shad captured are recorded but not consistently until 1995. Following the six weeks of sampling, the stations are sampled bimonthly through October.

The ASFMC 2007 benchmark assessment for American Shad only considered only the juvenile river herring beach seine survey data for a relative abundance index for American Shad. Due to the consistently low level of catch since 1972, the authors felt that the survey did not adequately reflect the true abundance of juvenile American Shad and should not be used for management. During the ASMFC 2020 benchmark stock assessment for American Shad (not published) a combination of seine stations from the river herring survey (five stations) and the striped bass survey (9 stations), all samples, were selected to determine a juvenile abundance starting in 1996 (zero catches in 1995). A Zero-inflated Negative Binomial GLM model was determined as the best recommended predications of relative annual abundance. Water temperature, salinity, month and cloud cover were all shown to significantly impact catch rates and presence. The best performing model was  $\text{Counts} \sim \text{Year} + \text{water temperature} + \text{salinity} \mid \text{salinity} + \text{cloud cover} + \text{month}$ . Updates to annual trends in abundance are illustrated in Figure 8 as arithmetic mean, in lieu of updating the model annually.

Adult American shad are monitored using the NCDMF Albemarle Sound Independent Gill Net Survey (IGNS) and North Carolina Wildlife Resources Commission (NCWRC) electrofishing surveys to estimate female catch per unit effort (CPUE) and relative fishing mortality in the Albemarle Sound/Roanoke River area. In other areas of the state, NCWRC conducts electrofishing surveys to estimate abundance and the relative fishing mortality. These data are incorporated into the North Carolina SFMP for American Shad described in more detail in the Management Strategy section.

The Albemarle Sound IGNS began collecting biological data on adult American Shad in 2000, sex was not recorded until 2004. The survey uses a stratified random sampling scheme designed to characterize the size and age distribution for key estuarine species in the Albemarle Sound. American Shad intercepted by NCDMF IGNS surveys outside to the Albemarle Sound/Roanoke River area are biologically sampled and reported annually to the ASMFC, due to low numbers of catch a CPUE is not estimated. In 2019, the Albemarle Sound IGNS overall American Shad CPUE (female and male combined) was 0.06 fish per unit of effort (Figure 9).

A total of 95 females and 91 males were measured from the NCDMF fishery-independent monitoring (Table 6 and Table 7) from all areas of the state. The average size of female American Shad is 16 inches fork length and male are 15 inches fork length. Variation in modal, minimum, and maximum ages throughout the fishery-independent sampling is described in Table 8, for both sexes combined. The modal age has fluctuated over the time series, while the minimum and maximum ages have remained relatively stable. Figure 10 and Figure 11 illustrate the American Shad length at age (mean, minimum, and maximum) for females and males from all age samples collected from the fishery-independent monitoring at any given age from 2000 to 2019.

## MANAGEMENT STRATEGY

Shad are managed under Amendment 3 to the ASMFC Interstate FMP for Shad and River Herring. The Amendment requires states and jurisdictions to develop sustainable fishery management plans, which are reviewed by the ASMFC Technical Committee and approved by the ASMFC Shad and Herring Management Board, in order to maintain commercial and recreational fisheries past January 2013. The ASMFC requires that these plans be re-evaluated every five years to update and modify sustainable management measures. The first NCDMF American Shad SFMP, effective in 2013 through 2017, identified sustainability parameters for four regions of the state: Albemarle Sound/Roanoke River, Tar/Pamlico, Neuse, and Cape Fear River systems. Sustainability parameters are based on the female portion of the stock because the commercial fishery targets roe shad; roe landings can account for as much as 90 percent of the total American shad landings in a year. The second NCDMF American Shad SFMP, approved October 2017 for 2018 through 2022, maintained the original sustainability parameters of relative fishing mortality ( $F$ ) and abundance indices, but relative  $F$  will now be computed by dividing commercial landings by a hind cast 3-year average of a survey index. The previous plan used a centered 3-year average. Proposed thresholds for sustainability parameters are fixed using available survey data through 2017 and will remain fixed during the next 5-year management period.

The NCDMF American Shad SFMP is updated annually in September by the American Shad Work Group, which consists of biologists from the NCDMF and the NCWRC, and the next year's season is determined. Annual updates were completed for all areas to determine if any sustainability parameters were exceeding the thresholds. The Tar/Pamlico, Neuse, and Cape Fear River systems have not exceeded any of the thresholds that have required management changes.

**Albemarle Sound/Roanoke River:**

The Albemarle Sound/Roanoke River system has three sustainability parameters: female CPUE based on the NCDMF Albemarle Sound IGNS, CPUE based on the NCWRC electrofishing survey, and female relative fishing mortality ( $F$ ) computed by dividing commercial landings by a hind cast 3-year average of the NCDMF IGNS index. As written in the SFMP, exceeding the female CPUE based on Albemarle Sound IGNS or the female relative  $F$  parameters for three consecutive years will trigger management action. The female CPUE based on the NCWRC electrofishing survey will be used in conjunction with a second index for triggering management action.

The Albemarle Sound/Roanoke River system exceeded two thresholds, the female CPUE index based on the NCWRC electrofishing survey and the female relative fishing mortality ( $F$ ), during the 2013 commercial fishing season. These parameters exceeding the threshold required management actions to be implemented for the 2014 fishing season. In February 2014, the American Shad Work Group chose to reduce the American shad commercial season in the Albemarle Sound/Roanoke River to March 3-24 to reduce overall commercial landings. The 2015, 2016, 2017, 2018, and 2019 commercial fishing season continued with the same seasonal dates and updates of sustainability parameters indicate that no thresholds are being exceeded. The recreational season is open year-round. Recreational fishermen can possess 10 American shad and hickory shad, in the aggregate, per person per day taken by hook-and-line or for recreational purposes and only one of the 10 shad may be an American shad.

Figure 12 shows the female CPUE based on the NCDMF Albemarle Sound IGNS. Figure 13 shows the CPUE based on the NCWRC electrofishing survey. Figure 14 shows the female relative  $F$  based on commercial landings and a hind cast three-year average of the NCDMF IGNS index.

**Tar/Pamlico system:**

The Tar/Pamlico system has two sustainability parameters: female CPUE based on the NCWRC electrofishing survey, and female relative  $F$  based on the NCWRC electrofishing survey. The NCDMF American shad SFMP set the commercial and recreational seasons and recreational possession limit in 2013. The commercial season is open from February 15 to April 14. The recreational season is open year-round. Recreational fishermen can possess 10 American shad and hickory shad, in the aggregate, per person per day taken by hook-and-line or for recreational purposes.

Figure 15 shows the female CPUE based on the NCWRC electrofishing survey and figure 16 shows the female relative  $F$  based on the NCWRC electrofishing survey.

### **Neuse system:**

The Neuse River system has two sustainability parameters: female CPUE based on the NCWRC electrofishing survey, and female relative  $F$  based on the NCWRC electrofishing survey. The NCDMF American shad SFMP set the commercial and recreational seasons and recreational possession limit in 2013. The commercial season is open from February 15 to April 14. The recreational season is open year-round. Recreational fishermen can possess 10 American shad and hickory shad, in the aggregate, per person per day taken by hook-and-line or for recreational purposes and only one of the 10 shad may be an American shad.

Figure 17 shows the female CPUE based on the NCWRC electrofishing survey and figure 18 shows the female relative  $F$  based on the NCWRC electrofishing survey.

### **Cape Fear River system:**

The Cape Fear River system has two sustainability parameters: female CPUE based on the NCWRC electrofishing survey, and female relative  $F$  based on the NCWRC electrofishing survey. The NCDMF American shad SFMP set the commercial and recreational seasons and recreational possession limit in 2013. The commercial season is open from February 20 to April 11. The recreational season is open year-round. Recreational fishermen can possess 10 American shad and hickory shad, in the aggregate, per person per day taken by hook-and-line or for recreational purposes and only five of the 10 shad may be an American shad.

Figure 19 shows the female CPUE based on the NCWRC electrofishing survey and figure 20 shows the female relative  $F$  based on the NCWRC electrofishing survey.

The 2019 update of the SFMP sustainability parameters throughout the state demonstrated that all the parameters were within the sustainable targets, except for the Albemarle/Roanoke and Tar/Pamlico system female CPUE (no management action triggered).

### **All Other Internal Coastal and Joint Fishing Waters**

For all other internal coastal and joint fishing waters not included under a sustainability parameter in the NCDMF American Shad SFMP the following commercial and recreational measures were established. The commercial season is open from February 15 to April 14. The recreational season is open year-round. Recreational fishermen can possess 10 American shad and hickory shad, in the aggregate, per person per day taken by hook-and-line or for recreational purposes.

### **RESEARCH NEEDS**

On an annual basis the ASMFC publishes a prioritized list of research needs for American Shad and river herring in the Review of the Atlantic States Marine Fisheries Commission Fishery Management Plan for Shad and River Herring (ASMFC 2019). For more information on research needs for American Shad please see

[http://www.asmfc.org/uploads/file/5dc5d3bbShad\\_RiverHerringFMPReview\\_2019.pdf](http://www.asmfc.org/uploads/file/5dc5d3bbShad_RiverHerringFMPReview_2019.pdf).

## LITERATURE CITED

- ASMFC (Atlantic States Marine Fisheries Commission). 1985. Fisheries Management Report No. 6 of the Atlantic States Marine Fisheries Commission: Fishery Management Plan for American Shad and River Herrings. Atlantic States Marine Fisheries Commission. Washington, District of Columbia. 382 pp.  
< <http://www.asmfc.org/uploads/file/1985FMP.pdf>>
- ASMFC (Atlantic States Marine Fisheries Commission). 1988. Fisheries Management Report No. 12 of the Atlantic States Marine Fisheries Commission: 1988 Supplement to American Shad and River Herrings Fishery Management Plan. Atlantic States Marine Fisheries Commission. Washington, District of Columbia. 214 pp.  
< <http://www.asmfc.org/uploads/file/fmr12FMPSupplementShadRiverHerring.pdf>>
- ASMFC (Atlantic States Marine Fisheries Commission). 1999. Amendment 1 to the Interstate Fishery Management Plan for Shad and River Herring. Atlantic States Marine Fisheries Commission. Washington, District of Columbia. 87 pp.  
< <http://www.asmfc.org/uploads/file/shadam1.pdf>>
- ASMFC (Atlantic States Marine Fisheries Commission). 2000. Technical Addendum I to Amendment 1 of the Interstate Fishery Management Plan for Shad and River Herring. Atlantic States Marine Fisheries Commission. Washington, District of Columbia. 6 pp.  
< <http://www.asmfc.org/uploads/file/shadTechAddendumI.pdf>>
- ASMFC (Atlantic States Marine Fisheries Commission). 2002. Fishery Management Report No. 35b of the ASMFC to Amendment 1 to Technical Addendum I to the Interstate Fishery Management Plan for Shad and River Herring. Atlantic States Marine Fisheries Commission. Washington, District of Columbia. 6 pp.  
< [http://www.asmfc.org/uploads/file//52af48cbshad\\_riverHerring\\_addendumI.pdf](http://www.asmfc.org/uploads/file//52af48cbshad_riverHerring_addendumI.pdf)>
- ASMFC (Atlantic States Marine Fisheries Commission). 2007. Stock Assessment Report No. 07-01 of the ASMFC: American Shad Stock Assessment Report for Peer Review Volume II. Atlantic States Marine Fisheries Commission. Washington, District of Columbia. 422 pp.  
< <http://www.asmfc.org/uploads/file/2007ShadStockAssmtReportVolumeII.pdf>>
- ASMFC (Atlantic States Marine Fisheries Commission). 2010. Amendment 3 to the Interstate Fishery Management Plan for Shad and River Herring (American Shad Management). Atlantic States Marine Fisheries Commission. Washington, District of Columbia. 169 pp.  
< [http://www.asmfc.org/uploads/file/Amendment3\\_FINALshad.pdf](http://www.asmfc.org/uploads/file/Amendment3_FINALshad.pdf)>
- ASMFC (Atlantic States Marine Fisheries Commission). 2019. Review of the ASMFC FMP for Shad and River Herring. Atlantic States Marine Fisheries Commission. Arlington, Virginia. 19 pp.  
< [http://www.asmfc.org/uploads/file/5dc5d3bbShad\\_RiverHerringFMPReview\\_2019.pdf](http://www.asmfc.org/uploads/file/5dc5d3bbShad_RiverHerringFMPReview_2019.pdf)>

NCDMF (North Carolina Division of Marine Fisheries). 2015. Fishery Management Plan for Interjurisdictional Fisheries: Information Update. North Carolina Department of Environmental Quality. North Carolina Division of Marine Fisheries. Morehead City, North Carolina. 85 pp.

NCDMF (North Carolina Division of Marine Fisheries) and WRC (North Carolina Wildlife Resources Commission). 2011. North Carolina American Shad Sustainable Fishery Plan, Report to the Atlantic States Fisheries Commission Shad and River Herring Technical Committee. Updated 2016.  
< <http://www.asmfc.org/files/Shad%20SFMPs/ncShadSFMP.pdf> >

**TABLES**

Table 1. Commercial harvest in pounds of American shad in North Carolina from 1972-2019, all waterbodies combined.

| Year | Commercial Weight (lb) |
|------|------------------------|
| 1972 | 468,484                |
| 1973 | 321,000                |
| 1974 | 368,833                |
| 1975 | 241,240                |
| 1976 | 167,190                |
| 1977 | 120,201                |
| 1978 | 402,017                |
| 1979 | 277,818                |
| 1980 | 199,206                |
| 1981 | 351,500                |
| 1982 | 407,034                |
| 1983 | 380,897                |
| 1984 | 382,331                |
| 1985 | 190,044                |
| 1986 | 279,142                |
| 1987 | 111,860                |
| 1988 | 111,567                |
| 1989 | 52,997                 |
| 1990 | 30,833                 |
| 1991 | 29,037                 |
| 1992 | 38,020                 |
| 1993 | 12,544                 |
| 1994 | 110,975                |
| 1995 | 205,867                |
| 1996 | 199,638                |
| 1997 | 219,526                |
| 1998 | 327,556                |
| 1999 | 131,617                |
| 2000 | 297,990                |
| 2001 | 151,075                |
| 2002 | 274,657                |
| 2003 | 395,251                |
| 2004 | 270,245                |
| 2005 | 189,462                |
| 2006 | 184,710                |
| 2007 | 298,597                |
| 2008 | 118,855                |
| 2009 | 167,114                |
| 2010 | 232,326                |
| 2011 | 203,755                |
| 2012 | 235,795                |
| 2013 | 257,348                |
| 2014 | 191,302                |
| 2015 | 95,966                 |
| 2016 | 62,245                 |
| 2017 | 90,868                 |
| 2018 | 53,878                 |
| 2019 | 40,975                 |

ASMFC AND FEDERALLY-MANAGED SPECIES WITH N.C. INDICES – AMERICAN SHAD

Table 2. American shad commercial and recreational landings and releases (recreational only) in numbers and pounds for the Central Southern Management Areas (CSMA), 2012\*-2019.

| Year | Neuse River  |              |               | Tar-Pamlico River |              |               | Cape Fear River |              |               |
|------|--------------|--------------|---------------|-------------------|--------------|---------------|-----------------|--------------|---------------|
|      | Recreational |              | Commercial    | Recreational      |              | Commercial    | Recreational    |              | Commercial    |
|      | Harvest (N)  | Released (N) | Landings (lb) | Harvest (N)       | Released (N) | Landings (lb) | Harvest (N)     | Released (N) | Landings (lb) |
| 2012 | 1,017        | 655          | 23,976        | 959               | 4,396        | 12,936        |                 |              | 10,333        |
| 2013 | 1,388        | 2,771        | 17,320        | 2,603             | 10,180       | 9,776         | 20,519          | 34,902       | 24,888        |
| 2014 | 413          | 998          | 11,358        | 168               | 1,314        | 18,769        | 7,453           | 11,025       | 46,148        |
| 2015 | 94           | 137          | 2,990         | 1,006             | 3,917        | 3,346         | 4,136           | 6,388        | 25,039        |
| 2016 | 252          | 1,423        | 2,568         | 1,051             | 2,820        | 765           | 10,244          | 11,388       | 12,937        |
| 2017 | 519          | 2,591        | 11,451        | 898               | 2,217        | 4,384         | 1,352           | 2,669        | 10,778        |
| 2018 | 112          | 358          | 3,987         | 685               | 2,767        | 1,580         | 5,366           | 7,924        | 14,931        |
| 2019 | 215          | 123          | 1,531         | 552               | 3,120        | 0             | 2,271           | 3,408        | 5,076         |

\*Creel survey began in 2012.

Table 3. Length (fork length, inches) data of female American shad sampled from the commercial fisheries throughout North Carolina, 1972-2019.

| Year | Mean Fork Length | Minimum Fork Length | Maximum Fork Length | Total Number Measured |
|------|------------------|---------------------|---------------------|-----------------------|
| 1972 | 19               | 14                  | 22                  | 244                   |
| 1973 | 18               | 14                  | 21                  | 345                   |
| 1974 | 18               | 15                  | 21                  | 177                   |
| 1975 | 18               | 15                  | 21                  | 774                   |
| 1976 | 18               | 14                  | 23                  | 404                   |
| 1977 | 18               | 14                  | 20                  | 515                   |
| 1978 | 18               | 14                  | 20                  | 554                   |
| 1979 | 18               | 10                  | 22                  | 691                   |
| 1980 | 18               | 14                  | 21                  | 367                   |
| 1981 | 19               | 16                  | 21                  | 374                   |
| 1982 | 18               | 13                  | 21                  | 247                   |
| 1983 | 18               | 12                  | 21                  | 464                   |
| 1984 | 19               | 15                  | 21                  | 613                   |
| 1985 | 19               | 15                  | 23                  | 561                   |
| 1986 | 19               | 15                  | 23                  | 419                   |
| 1987 | 19               | 14                  | 21                  | 360                   |
| 1988 | 18               | 15                  | 22                  | 607                   |
| 1989 | 18               | 15                  | 23                  | 470                   |
| 1990 | 18               | 15                  | 23                  | 156                   |
| 1991 | 18               | 13                  | 20                  | 330                   |
| 1992 | 18               | 15                  | 20                  | 299                   |
| 1993 | 17               | 15                  | 22                  | 220                   |
| 2000 | 17               | 14                  | 20                  | 836                   |
| 2001 | 17               | 13                  | 20                  | 711                   |
| 2002 | 18               | 13                  | 20                  | 794                   |
| 2003 | 18               | 13                  | 22                  | 545                   |
| 2004 | 18               | 12                  | 22                  | 727                   |
| 2005 | 17               | 13                  | 21                  | 847                   |
| 2006 | 17               | 14                  | 20                  | 667                   |
| 2007 | 17               | 12                  | 20                  | 785                   |
| 2008 | 17               | 14                  | 20                  | 740                   |
| 2009 | 17               | 12                  | 22                  | 702                   |
| 2010 | 17               | 12                  | 20                  | 948                   |
| 2011 | 17               | 15                  | 19                  | 1,103                 |
| 2012 | 17               | 15                  | 21                  | 1,169                 |
| 2013 | 18               | 15                  | 21                  | 1,363                 |
| 2014 | 18               | 13                  | 20                  | 870                   |
| 2015 | 18               | 14                  | 20                  | 678                   |
| 2016 | 17               | 15                  | 20                  | 396                   |
| 2017 | 17               | 15                  | 22                  | 456                   |
| 2018 | 17               | 14                  | 20                  | 388                   |
| 2019 | 17               | 14                  | 19                  | 444                   |

Table 4. Length (fork length, inches) data of male American shad sampled from the commercial fisheries throughout North Carolina, 1972-2019.

| Year | Mean Fork Length | Minimum Fork Length | Maximum Fork Length | Total Number Measured |
|------|------------------|---------------------|---------------------|-----------------------|
| 1972 | 17               | 13                  | 19                  | 285                   |
| 1973 | 16               | 12                  | 20                  | 365                   |
| 1974 | 15               | 13                  | 18                  | 225                   |
| 1975 | 16               | 12                  | 20                  | 466                   |
| 1976 | 16               | 12                  | 20                  | 392                   |
| 1977 | 16               | 11                  | 19                  | 253                   |
| 1978 | 16               | 11                  | 22                  | 470                   |
| 1979 | 16               | 13                  | 20                  | 533                   |
| 1980 | 16               | 12                  | 19                  | 429                   |
| 1981 | 16               | 13                  | 19                  | 486                   |
| 1982 | 16               | 11                  | 19                  | 367                   |
| 1983 | 16               | 13                  | 21                  | 630                   |
| 1984 | 16               | 12                  | 19                  | 608                   |
| 1985 | 16               | 13                  | 19                  | 475                   |
| 1986 | 16               | 12                  | 19                  | 348                   |
| 1987 | 16               | 12                  | 19                  | 299                   |
| 1988 | 16               | 11                  | 20                  | 422                   |
| 1989 | 16               | 12                  | 18                  | 346                   |
| 1990 | 16               | 13                  | 19                  | 204                   |
| 1991 | 16               | 12                  | 19                  | 248                   |
| 1992 | 16               | 12                  | 19                  | 232                   |
| 1993 | 15               | 12                  | 19                  | 153                   |
| 2000 | 16               | 13                  | 20                  | 315                   |
| 2001 | 15               | 11                  | 20                  | 130                   |
| 2002 | 16               | 13                  | 21                  | 352                   |
| 2003 | 16               | 10                  | 20                  | 284                   |
| 2004 | 16               | 8                   | 19                  | 239                   |
| 2005 | 15               | 7                   | 18                  | 160                   |
| 2006 | 15               | 11                  | 20                  | 192                   |
| 2007 | 15               | 12                  | 18                  | 216                   |
| 2008 | 15               | 5                   | 20                  | 152                   |
| 2009 | 15               | 12                  | 18                  | 213                   |
| 2010 | 15               | 12                  | 18                  | 199                   |
| 2011 | 15               | 12                  | 18                  | 159                   |
| 2012 | 16               | 10                  | 19                  | 353                   |
| 2013 | 15               | 11                  | 19                  | 175                   |
| 2014 | 15               | 11                  | 18                  | 120                   |
| 2015 | 16               | 12                  | 18                  | 124                   |
| 2016 | 15               | 13                  | 18                  | 50                    |
| 2017 | 15               | 12                  | 17                  | 58                    |
| 2018 | 15               | 13                  | 18                  | 53                    |
| 2019 | 14               | 12                  | 18                  | 85                    |

ASMFC AND FEDERALLY-MANAGED SPECIES WITH N.C. INDICES – AMERICAN SHAD

Table 5. Aging data (male and female combined) collected from North Carolina American shad commercial fisheries, 1972-2019.

| Year | Modal Age | Minimum Age | Maximum Age | Total Number Aged |
|------|-----------|-------------|-------------|-------------------|
| 1972 | 5         | 3           | 9           | 465               |
| 1973 | 4         | 3           | 8           | 656               |
| 1974 | 4         | 3           | 7           | 389               |
| 1975 | 5         | 2           | 9           | 1138              |
| 1976 | 5         | 4           | 9           | 664               |
| 1977 | 5         | 3           | 7           | 585               |
| 1978 | 6         | 3           | 7           | 953               |
| 1979 | 5         | 4           | 9           | 1060              |
| 1980 | 6         | 4           | 9           | 685               |
| 1981 | 6         | 4           | 9           | 528               |
| 1982 | 5         | 3           | 9           | 328               |
| 1983 | 5         | 3           | 9           | 626               |
| 1984 | 5         | 3           | 9           | 707               |
| 1985 | 5         | 3           | 8           | 624               |
| 1986 | 5         | 4           | 9           | 475               |
| 1987 | 5         | 4           | 9           | 403               |
| 1988 | 5         | 4           | 9           | 604               |
| 1989 | 5         | 3           | 8           | 238               |
| 1990 | 6         | 3           | 9           | 233               |
| 1991 | 5         | 4           | 8           | 321               |
| 1992 | 5         | 4           | 9           | 295               |
| 1993 | 5         | 4           | 9           | 221               |
| 2000 | 5         | 3           | 7           | 401               |
| 2001 | 5         | 3           | 8           | 423               |
| 2002 | 5         | 3           | 8           | 580               |
| 2003 | 6         | 3           | 8           | 543               |
| 2004 | 5         | 3           | 8           | 645               |
| 2005 | 5         | 3           | 8           | 477               |
| 2006 | 6         | 3           | 8           | 499               |
| 2007 | 6         | 3           | 8           | 439               |
| 2008 | 6,7       | 3           | 9           | 447               |
| 2009 | 7         | 4           | 10          | 431               |
| 2010 | 6         | 3           | 9           | 453               |
| 2011 | 6         | 3           | 8           | 403               |
| 2012 | 5         | 3           | 8           | 526               |
| 2013 | 7         | 3           | 9           | 449               |
| 2014 | 7         | 3           | 9           | 418               |
| 2015 | 7         | 4           | 8           | 406               |
| 2016 | 7         | 4           | 8           | 280               |
| 2017 | 7         | 4           | 9           | 382               |
| 2018 | 7         | 3           | 8           | 278               |
| 2019 | 6         | 4           | 8           | 273               |

Table 6. Length (fork length, inches) data of female American shad sampled from North Carolina independent sampling programs from 2000-2019.

| Year | Mean Fork Length | Minimum Fork Length | Maximum Fork Length | Total Number Measured |
|------|------------------|---------------------|---------------------|-----------------------|
| 2000 | 18               | 14                  | 20                  | 74                    |
| 2001 | 17               | 15                  | 21                  | 198                   |
| 2002 | 18               | 14                  | 20                  | 144                   |
| 2003 | 18               | 15                  | 20                  | 161                   |
| 2004 | 18               | 15                  | 20                  | 149                   |
| 2005 | 18               | 15                  | 20                  | 106                   |
| 2006 | 17               | 15                  | 20                  | 52                    |
| 2007 | 17               | 14                  | 18                  | 35                    |
| 2008 | 16               | 13                  | 19                  | 45                    |
| 2009 | 17               | 16                  | 19                  | 22                    |
| 2010 | 17               | 15                  | 19                  | 83                    |
| 2011 | 17               | 15                  | 19                  | 14                    |
| 2012 | 17               | 14                  | 19                  | 59                    |
| 2013 | 17               | 13                  | 19                  | 73                    |
| 2014 | 17               | 16                  | 19                  | 28                    |
| 2015 | 17               | 16                  | 18                  | 18                    |
| 2016 | 17               | 13                  | 18                  | 19                    |
| 2017 | 17               | 14                  | 19                  | 65                    |
| 2018 | 16               | 12                  | 19                  | 76                    |
| 2019 | 16               | 6                   | 19                  | 95                    |

ASMFC AND FEDERALLY-MANAGED SPECIES WITH N.C. INDICES – AMERICAN SHAD

Table 7. Length (fork length, inches) data of male American shad sampled from North Carolina independent sampling programs from 2000-2019.

| Year | Mean Fork Length | Minimum Fork Length | Maximum Fork Length | Total Number Measured |
|------|------------------|---------------------|---------------------|-----------------------|
| 2000 | 16               | 13                  | 19                  | 173                   |
| 2001 | 15               | 13                  | 18                  | 84                    |
| 2002 | 15               | 12                  | 18                  | 135                   |
| 2003 | 16               | 12                  | 19                  | 87                    |
| 2004 | 17               | 12                  | 19                  | 14                    |
| 2005 | 15               | 13                  | 17                  | 30                    |
| 2006 | 15               | 13                  | 18                  | 14                    |
| 2007 | 15               | 13                  | 17                  | 34                    |
| 2008 | 14               | 12                  | 17                  | 33                    |
| 2009 | 15               | 13                  | 17                  | 18                    |
| 2010 | 15               | 12                  | 16                  | 40                    |
| 2011 | 15               | 14                  | 17                  | 12                    |
| 2012 | 15               | 13                  | 17                  | 23                    |
| 2013 | 15               | 13                  | 16                  | 34                    |
| 2014 | 15               | 14                  | 16                  | 11                    |
| 2015 | 15               | 14                  | 16                  | 3                     |
| 2016 | 15               | 15                  | 16                  | 7                     |
| 2017 | 15               | 11                  | 17                  | 57                    |
| 2018 | 15               | 12                  | 18                  | 80                    |
| 2019 | 15               | 11                  | 17                  | 91                    |

ASMFC AND FEDERALLY-MANAGED SPECIES WITH N.C. INDICES – AMERICAN SHAD

Table 8. American Shad aging data (male and female combined) collected from North Carolina independent sampling programs from 2000-2019.

| Year | Modal Age | Minimum Age | Maximum Age | Total Number Aged |
|------|-----------|-------------|-------------|-------------------|
| 2000 | 5         | 3           | 7           | 247               |
| 2001 | 5         | 3           | 7           | 282               |
| 2002 | 4         | 3           | 8           | 279               |
| 2003 | 6         | 3           | 8           | 248               |
| 2004 | 6         | 3           | 8           | 163               |
| 2005 | 5         | 3           | 7           | 136               |
| 2006 | 4         | 3           | 8           | 66                |
| 2007 | 4         | 4           | 7           | 69                |
| 2008 | 5         | 3           | 8           | 78                |
| 2009 | 6         | 4           | 8           | 40                |
| 2010 | 6         | 3           | 8           | 123               |
| 2011 | 6         | 3           | 8           | 26                |
| 2012 | 6         | 4           | 8           | 82                |
| 2013 | 5         | 3           | 8           | 107               |
| 2014 | 6         | 4           | 7           | 39                |
| 2015 | 6,7       | 3           | 7           | 21                |
| 2016 | 6         | 3           | 8           | 26                |
| 2017 | 6         | 3           | 8           | 122               |
| 2018 | 5         | 3           | 8           | 146               |
| 2019 | 5         | 3           | 7           | 152               |

**FIGURES**

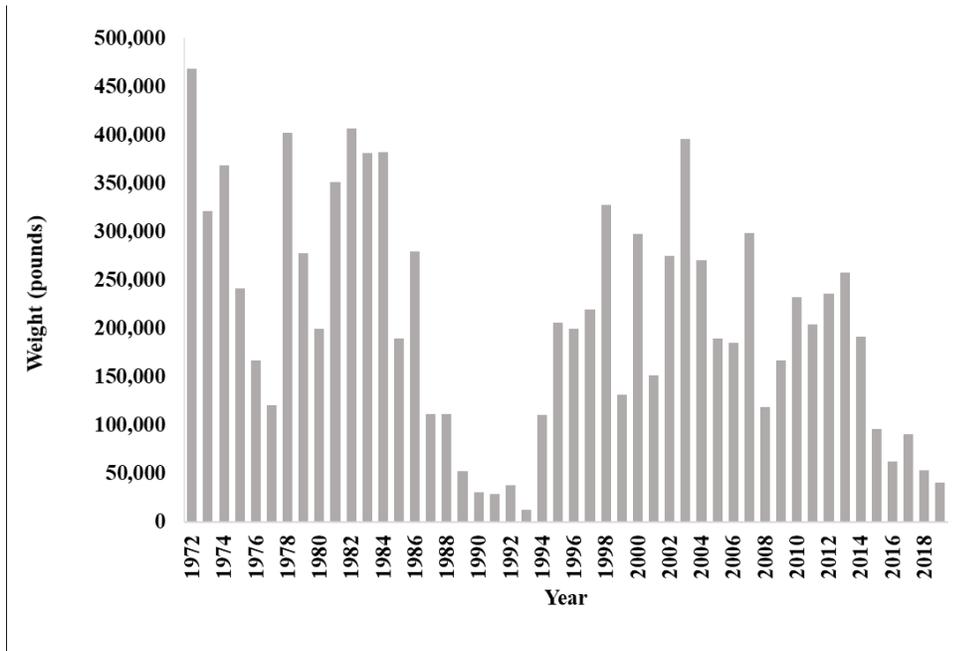


Figure 1. Commercial harvest in pounds of American shad in North Carolina from 1972-2019, all waterbodies combined.

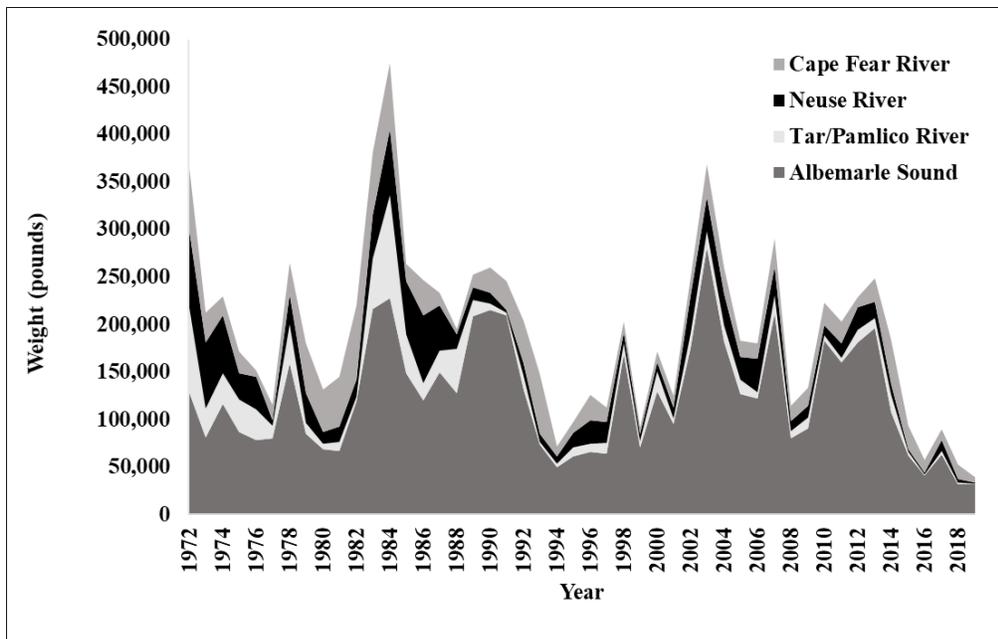


Figure 2. Landings of American shad in North Carolina by major waterbody from 1972-2019.

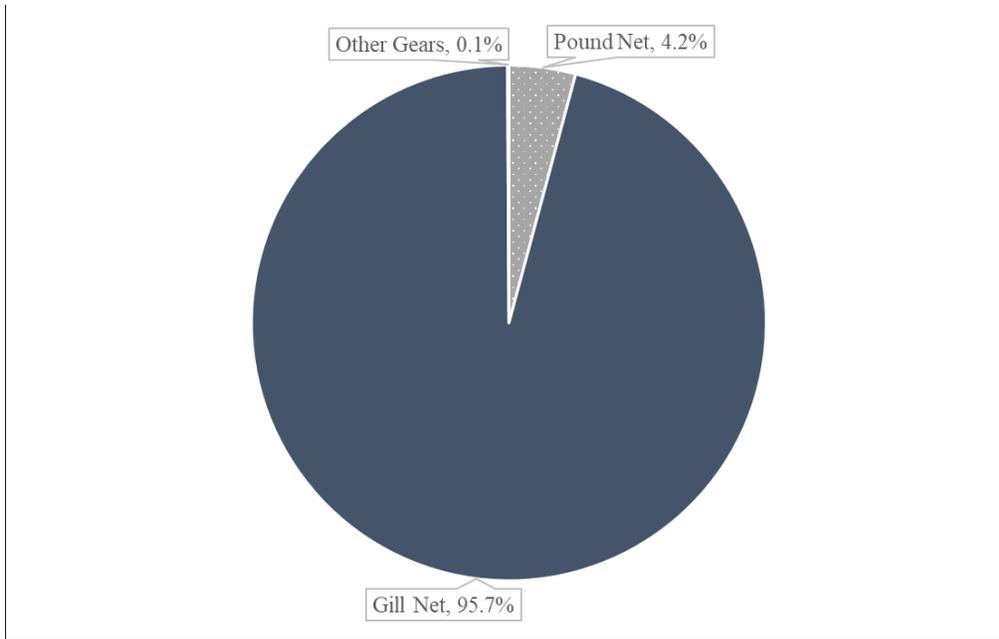


Figure 3. Commercial harvest of American Shad in 2019 by percent gear type.

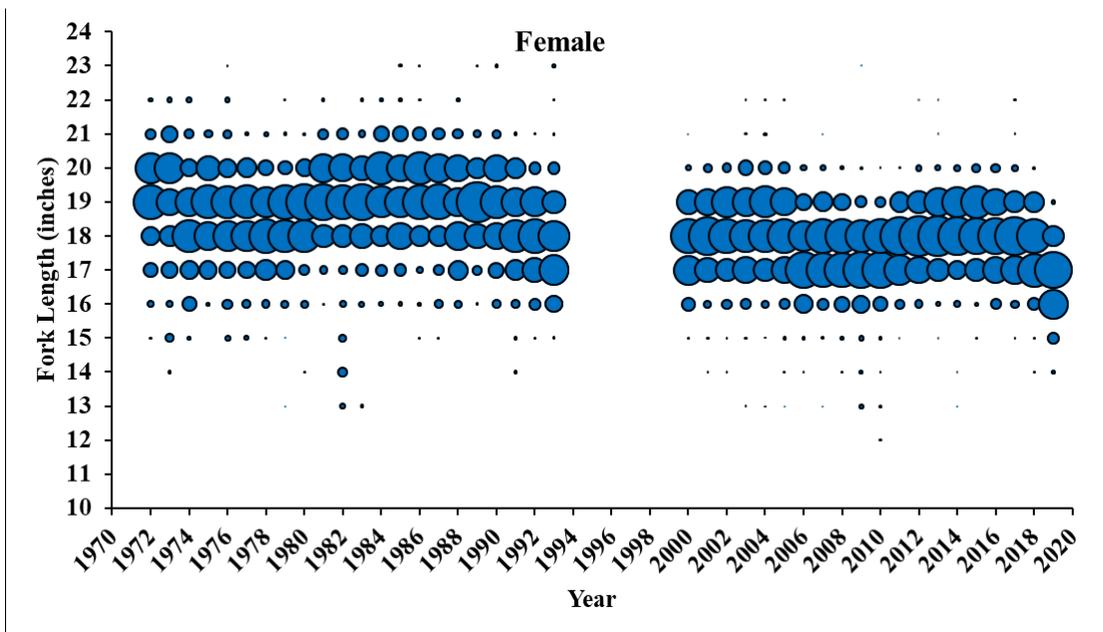


Figure 4. Commercial length frequency (fork length, inches) of female American Shad harvested from 1972-2019. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish measured at that length.

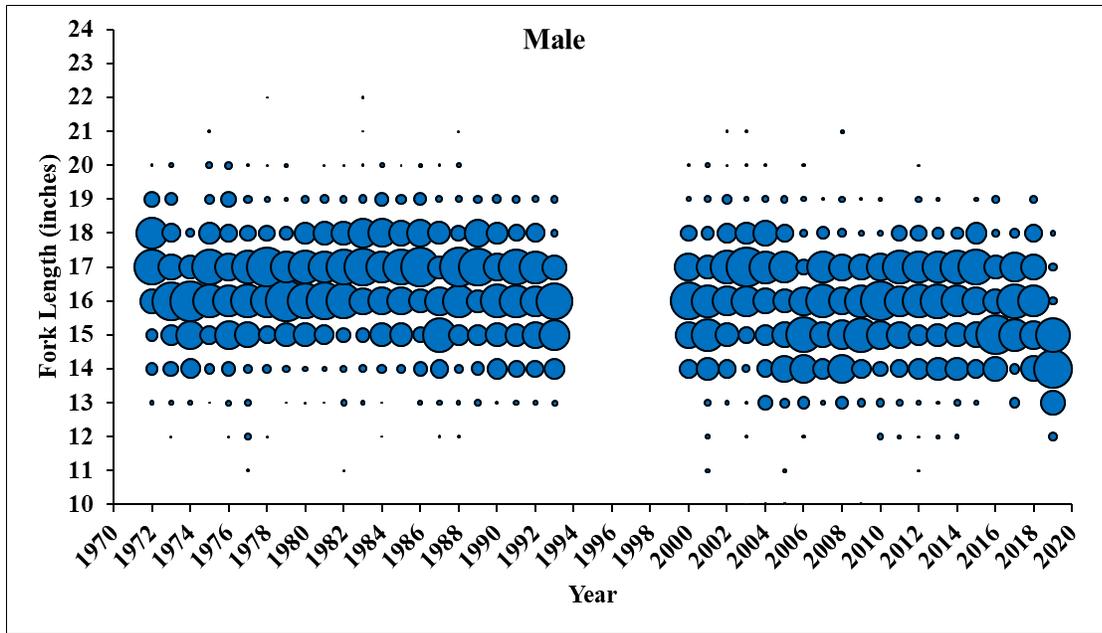


Figure 5. Commercial length frequency (fork length, inches) of male American Shad harvested from 1972-2019. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish measured at that length.

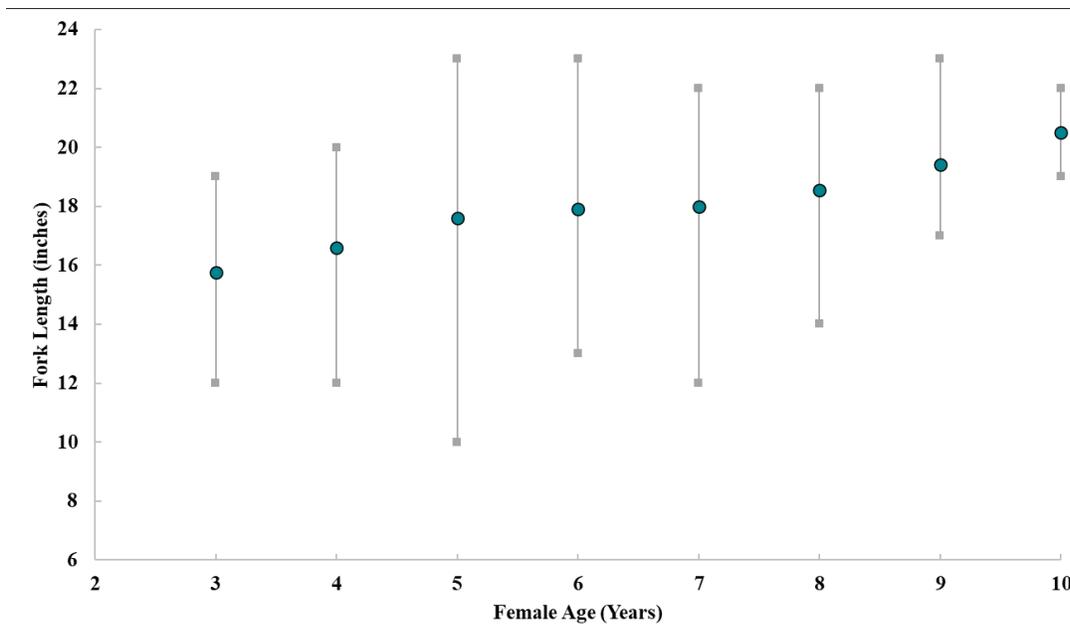


Figure 6. Female American Shad length at age from all age samples collected from commercial fisheries, 1972-2019. Blue circles represent the mean size at a given age while the gray squares represent the minimum and maximum observed size for each age.

ASMFC AND FEDERALLY-MANAGED SPECIES WITH N.C. INDICES – AMERICAN SHAD

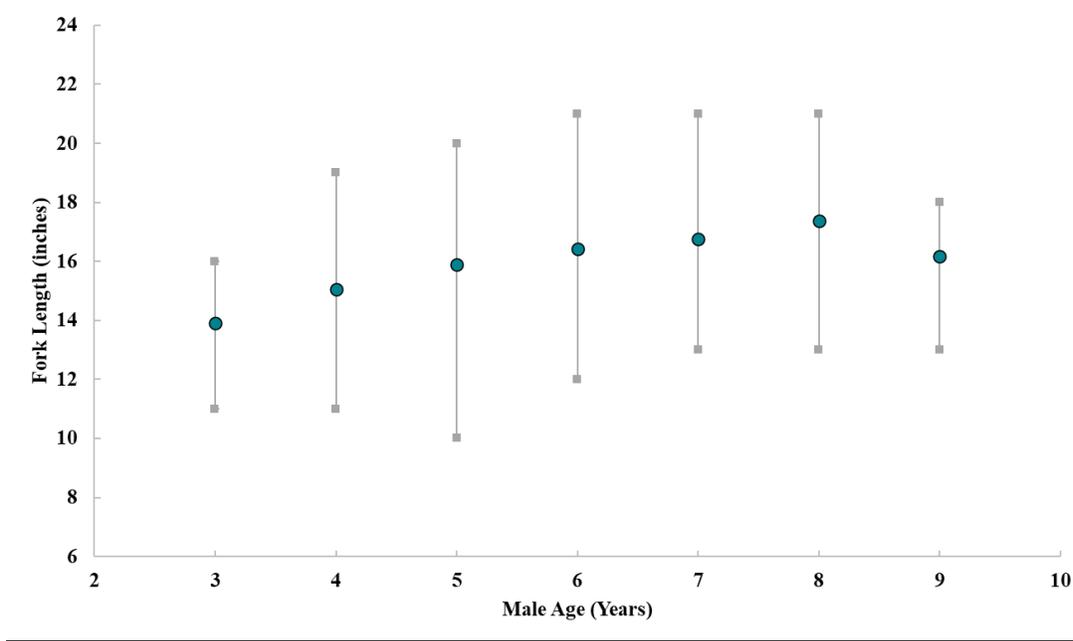


Figure 7. Male American Shad length at age from all age samples collected from commercial fisheries, 1972-2019. Blue circles represent the mean size at a given age while the gray squares represent the minimum and maximum observed size for each age.

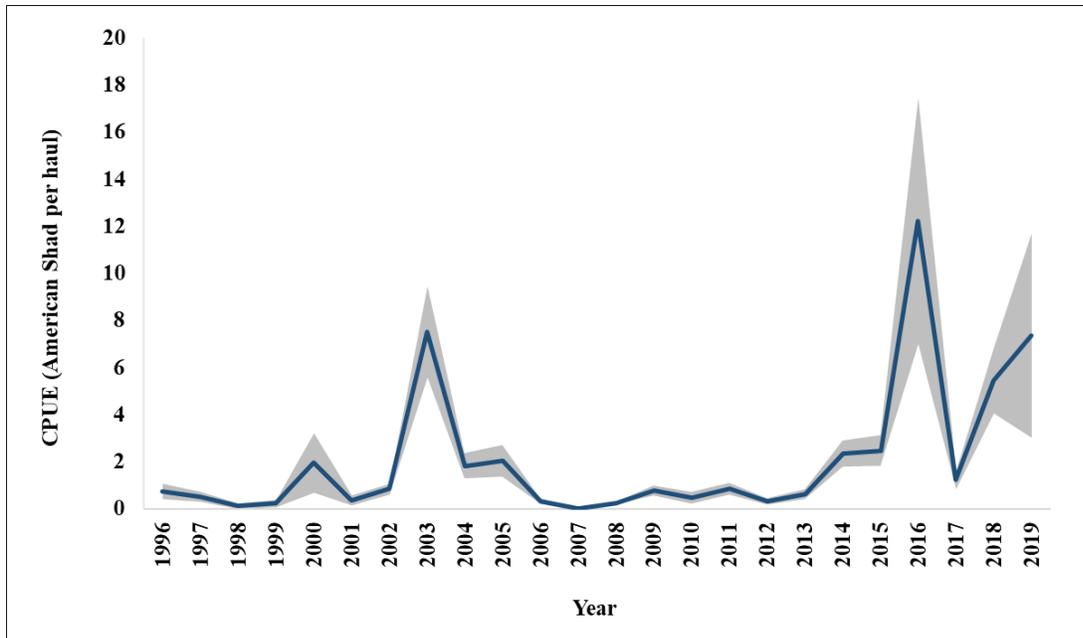


Figure 8. American Shad annual juvenile (age-0) abundance index with standard error shaded in gray from the North Carolina Albemarle Sound juvenile survey, 1996-2019.

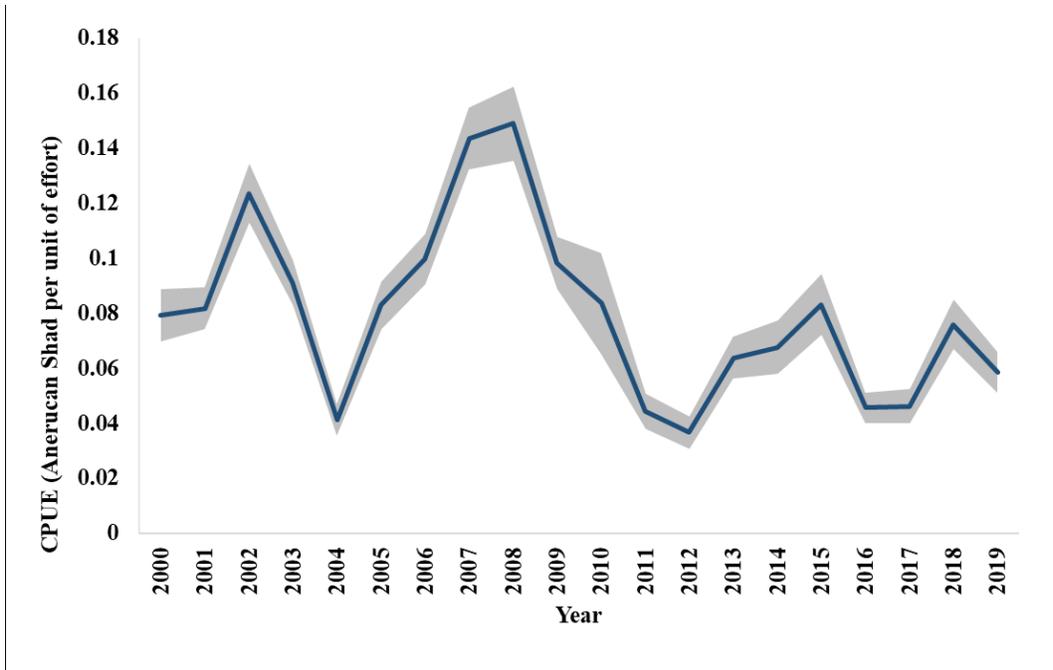


Figure 9. January-May adult American Shad CPUE (all mesh sizes, number captured, ages combined) with standard error shaded in gray from the North Carolina Albemarle Sound independent gill net survey 2000-2019.

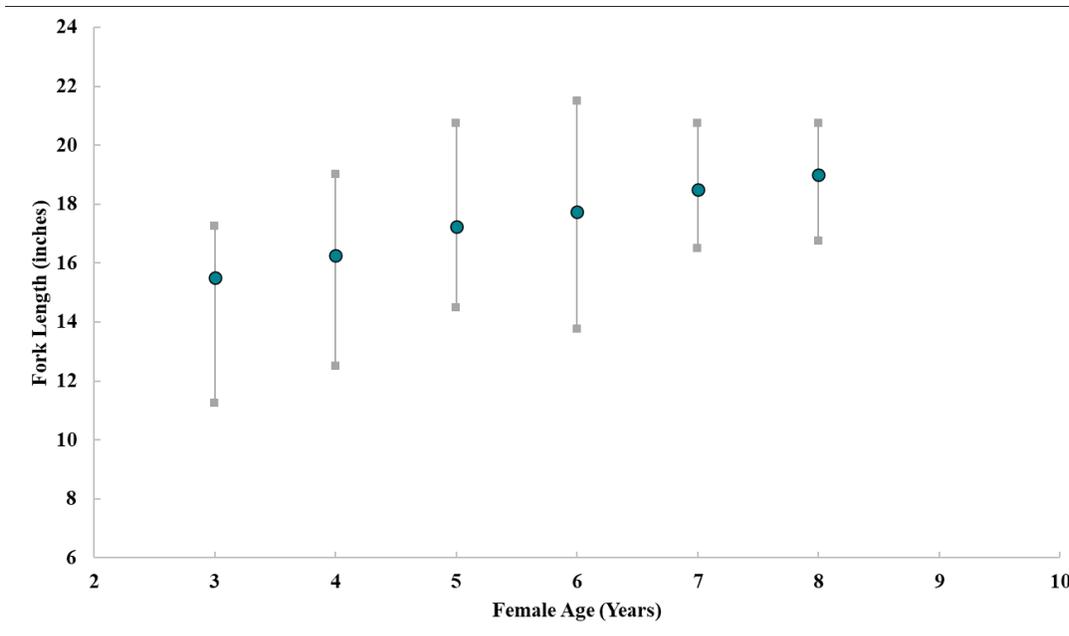


Figure 10. Female American Shad length at age from all age samples collected from North Carolina independent gill net surveys, 2000-2019. Blue circles represent the mean size at a given age while the gray squares represent the minimum and maximum observed size for each age.

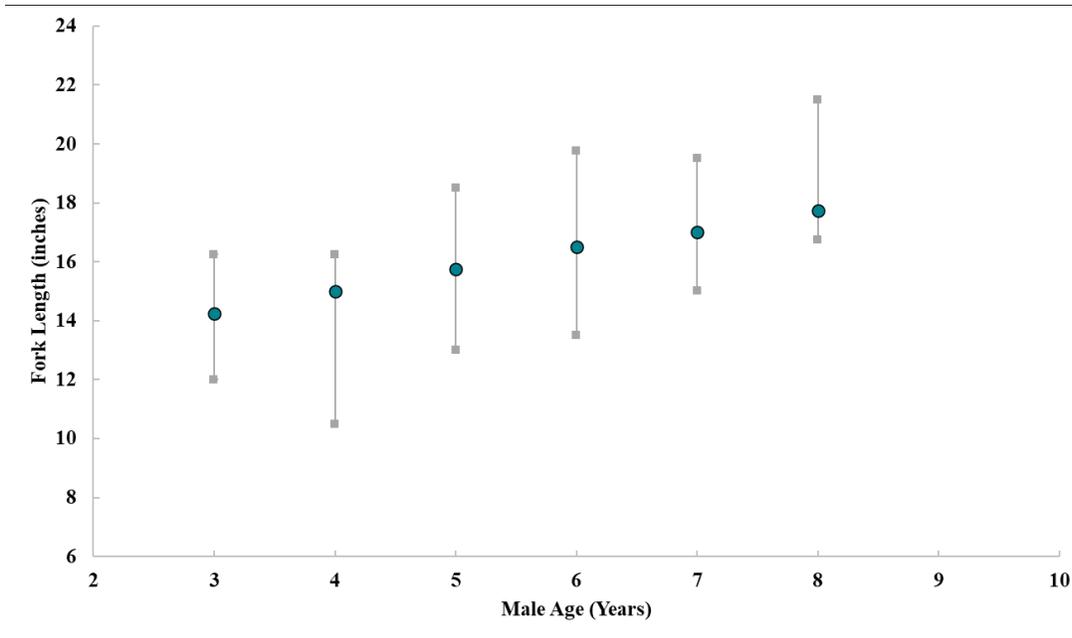


Figure 11. Male American Shad length at age from all age samples collected from North Carolina independent gill net surveys, 2000-2019. Blue circles represent the mean size at a given age while the gray squares represent the minimum and maximum observed size for each age.

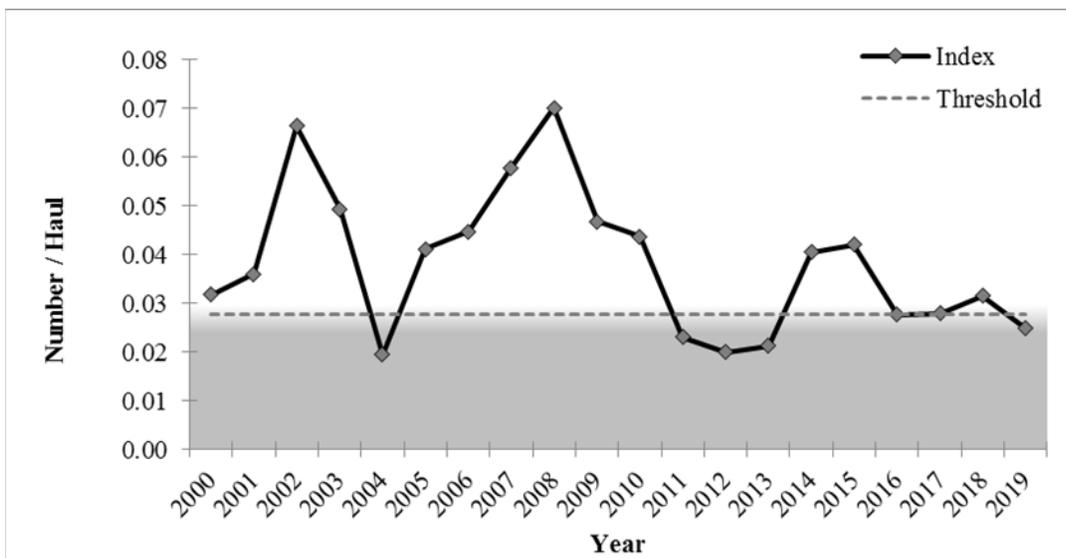


Figure 12. Albemarle Sound/Roanoke River sustainability parameter for female CPUE in the NCDMF IGNS, 2000-2019. Grey areas represent a parameter exceeding the threshold.

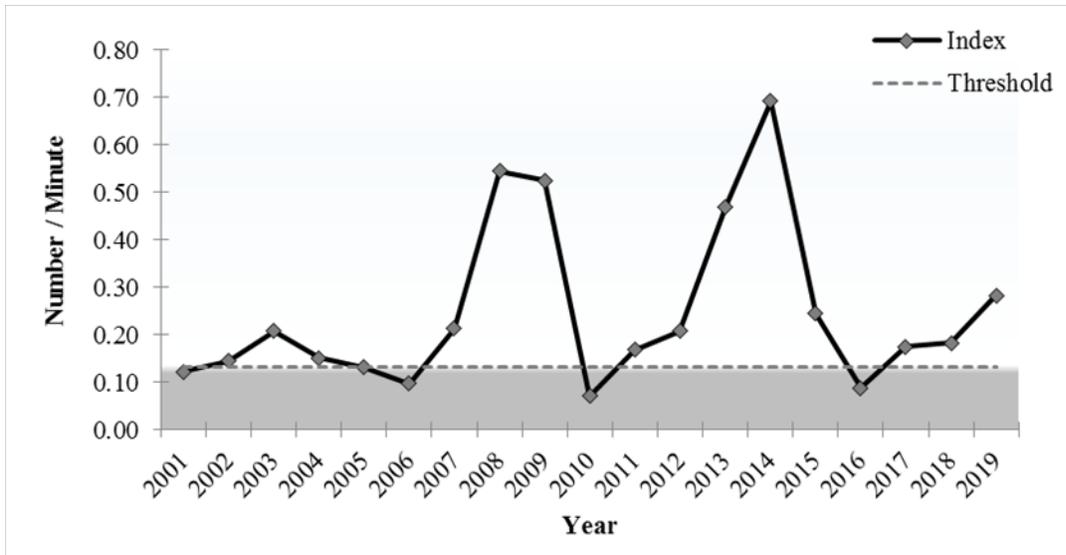


Figure 13. Albemarle Sound/Roanoke River sustainability parameter for female CPUE in NCWRC electrofishing survey, 2001-2019. Grey areas represent a parameter exceeding the threshold.

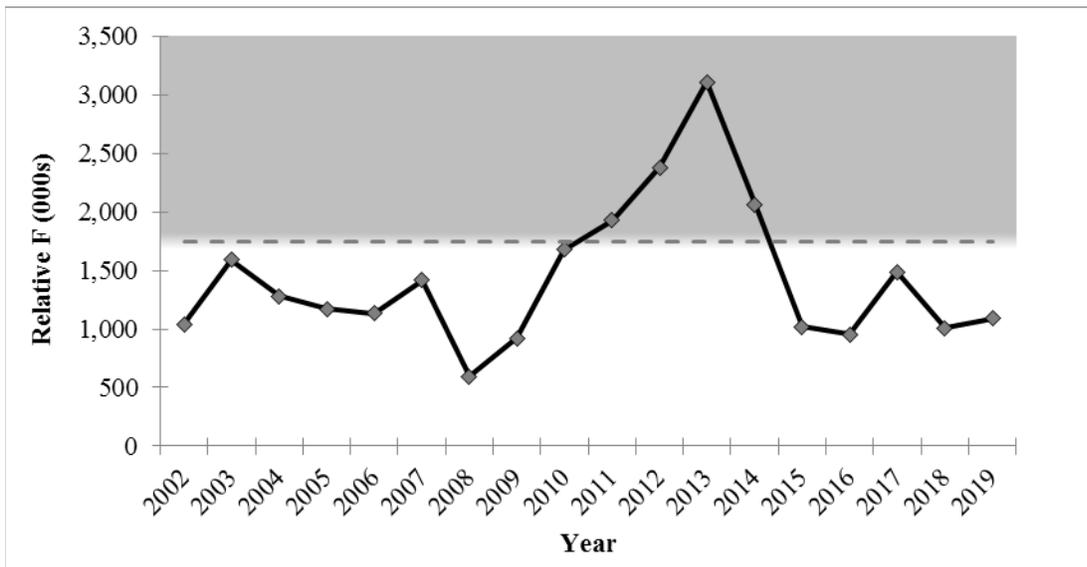


Figure 14. Albemarle Sound/Roanoke River sustainability parameter for female relative  $F$  in the NCDMF IGNS, 2002-2019. Grey areas represent a parameter exceeding the threshold.

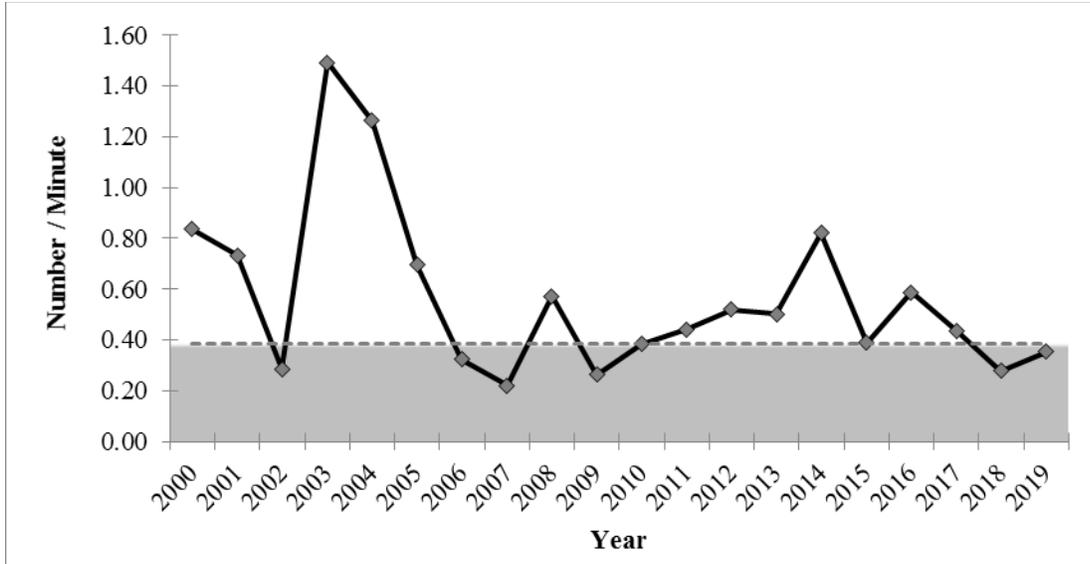


Figure 15. Tar/Pamlico River system sustainability parameter for female CPUE in NCWRC electrofishing survey, 2000-2019. Grey areas represent a parameter exceeding the threshold.

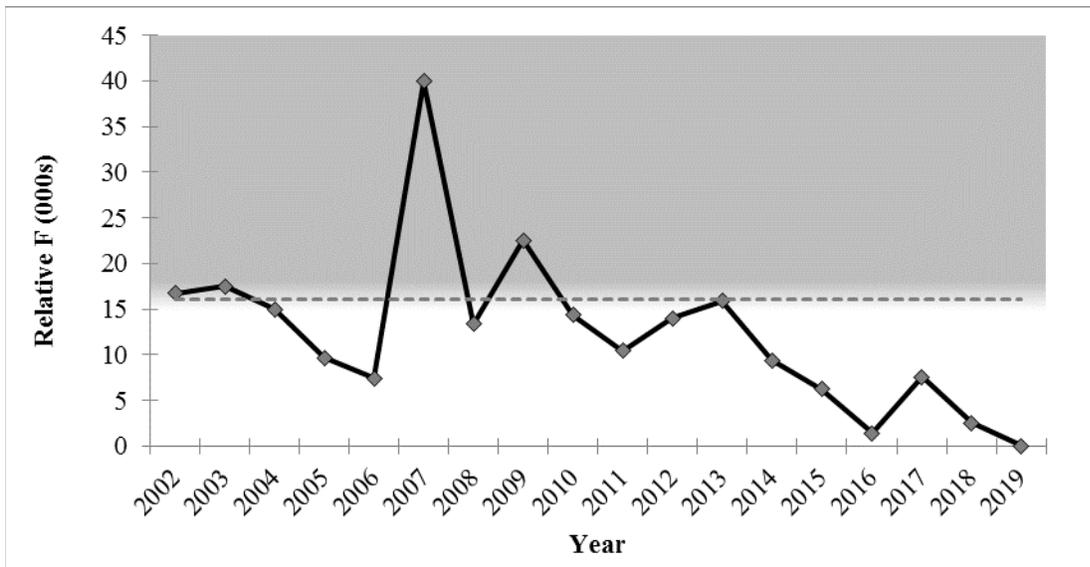


Figure 16. Tar/Pamlico River system sustainability parameter for female relative  $F$  in NCWRC electrofishing survey, 2002-2019. Grey areas represent a parameter exceeding the threshold.

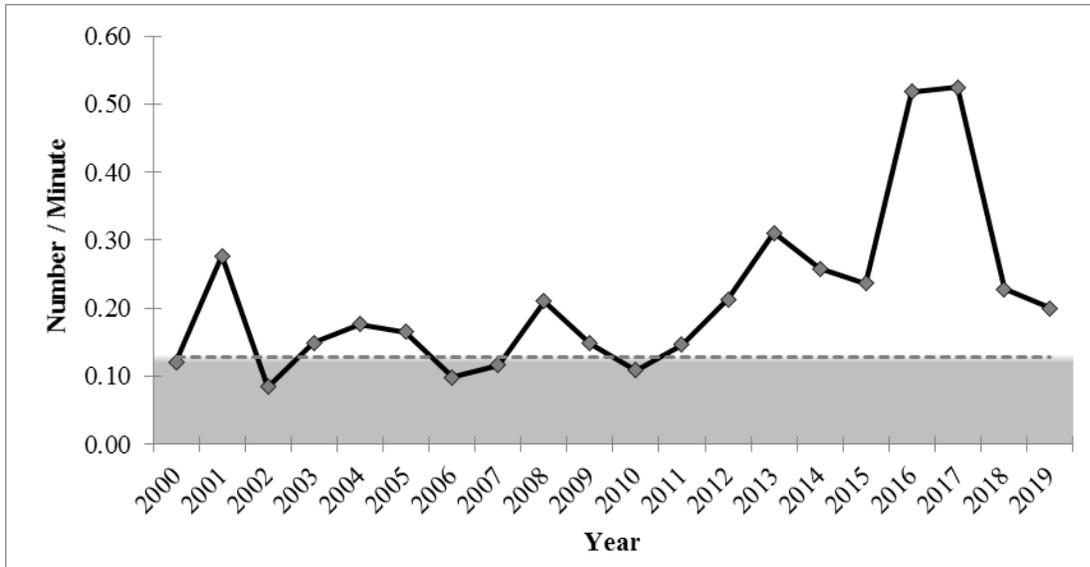


Figure 17. Neuse River system sustainability parameter for female CPUE in NCWRC electrofishing survey, 2000-2019. Grey areas represent a parameter exceeding the threshold.

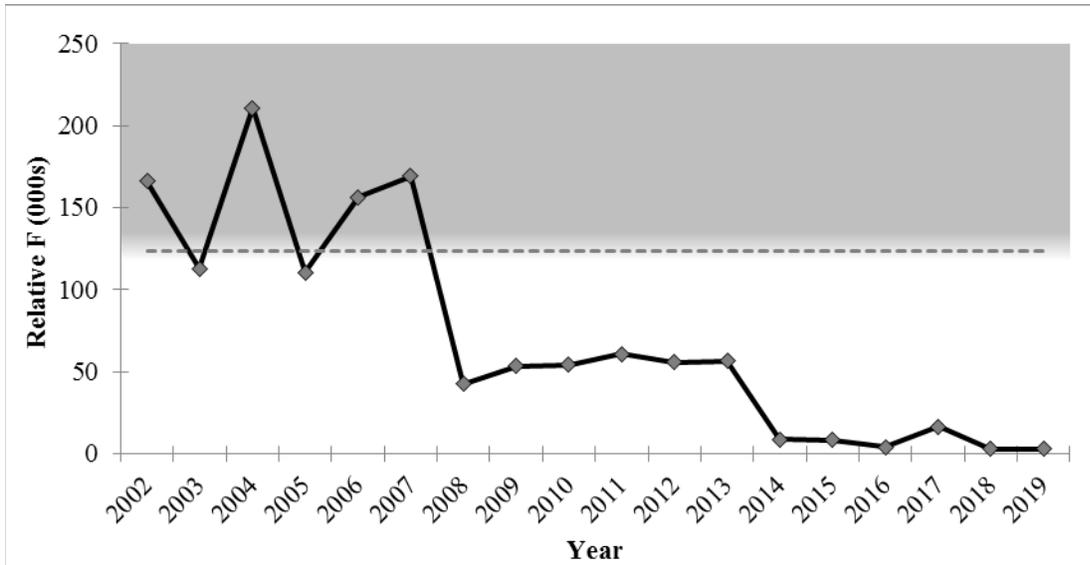


Figure 18. Neuse River system sustainability parameter for female relative  $F$  in NCWRC electrofishing survey, 2002-2019. Grey areas represent a parameter exceeding the threshold.

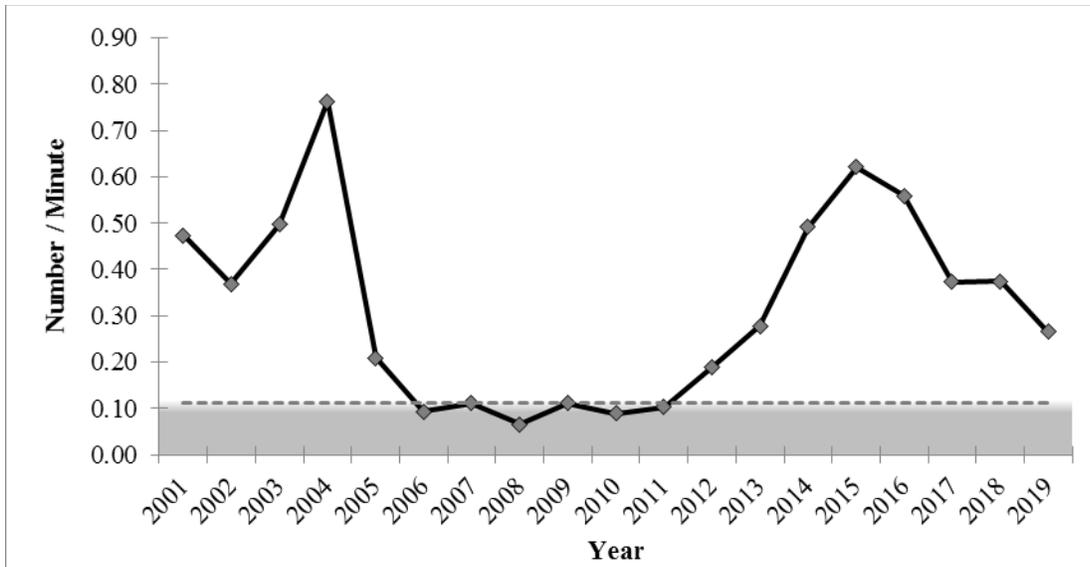


Figure 19. Cape Fear River system sustainability parameter for female CPUE in NCWRC electrofishing survey, 2001-2019. Grey areas represent a parameter exceeding the threshold.

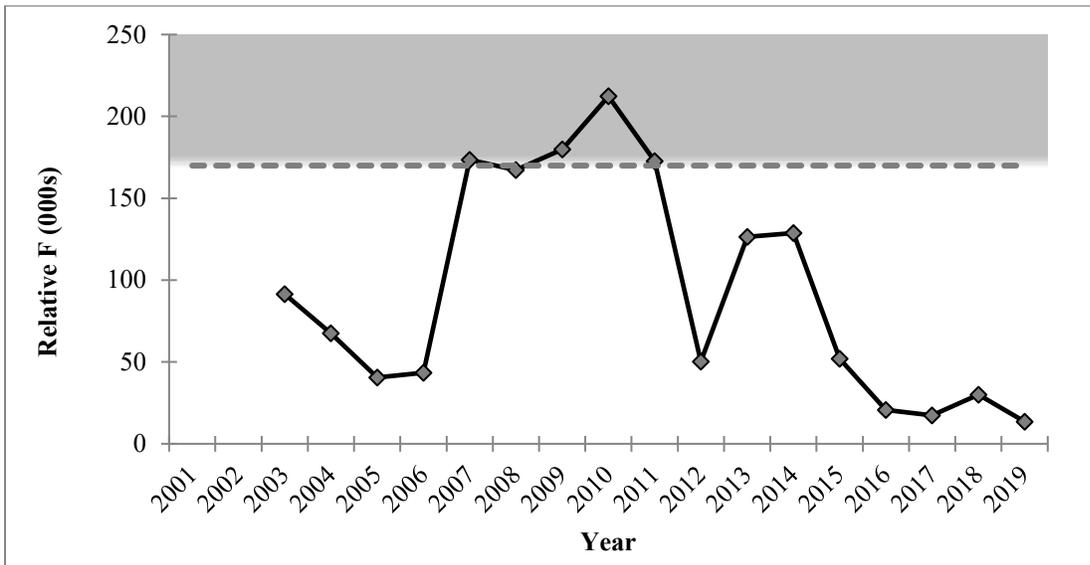


Figure 20. Cape Fear River system sustainability parameter for female relative *F* in NCWRC electrofishing survey, 2003-2019. Grey areas represent a parameter exceeding the threshold.