FISHERY MANAGEMENT PLAN UPDATE
AMERICAN SHAD
AUGUST 2022

STATUS OF THE FISHERY MANAGEMENT PLAN

Fishery Management Plan History

FMP Documentation:	October 1985	
	Amendment 1	April 1999
	Technical Addendum 1	February 2000
	Addendum I	August 2002
	Amendment 3	February 2010
Supplements:	Supplement — October 1988	
Comprehensive Review:	To be determined	

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% 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 fishing/recovery plans that meet the requirements of Amendment 3, known as the North Carolina American Shad Sustainable Fishery Management Plan (SFMP) (NCDMF 2011 and NCDMF 2017). North Carolina submitted habitat plans that meet the requirements of Amendment 3, known as the North Carolina American Shad Habitat Plan (NCDMF 2014 and NCDMF 2020).

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:

- Maximize the number of juvenile recruits emigrating from freshwater stock complexes.
- Restore and maintain spawning stock biomass and age structure to achieve maximum juvenile recruitment.

- Manage for an optimum yield harvest level that will not compromise Objectives 1 and 2.
- Maximize cost effectiveness to the local, state, and federal governments, and the ASMFC associated with achieving Objectives 1 through 3.

DESCRIPTION OF THE STOCK

Biological Profile

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 in which they were born 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, including Roanoke River, are sustainable and not depleted, whereas a determination of stock status could not be assigned for the Tar-Pamlico, Neuse, and Cape Fear rivers due to limited information (ASMFC 2020).

Stock Assessment

The 2020 American shad benchmark stock assessment found coastwide populations of American shad to be depleted. Factors such as overfishing, inadequate fish passage at dams, predation, pollution, water withdrawals, channelization of rivers, changing ocean conditions, and climate change are likely responsible for the decline from historic shad abundance levels. The assessment found that American shad recovery is limited by restricted access to spawning habitat, with 40% of historic habitat in the U.S. and Canada currently blocked by dams and other barriers possibly equating to a loss of more than a third of spawning adults. The abundance of American shad relative to historic levels is unknown for most systems but was determined to be depleted for the Potomac River and Hudson River, and not depleted for the Albemarle Sound. Coastwide adult mortality is largely unknown and juvenile mortality status cannot be determined due to insufficient data collection. The stock assessment chose to use the ‘depleted’ determination instead of ‘overfished’ because of the impact of fishing on American shad stocks cannot be separated from all other factors that impact abundance. The Tar-Pamlico rivers, Neuse River, and Cape Fear River status for adult mortality rate and abundance could not be determined, except for the Neuse River adult mortality rate was found to be sustainable (ASMFC 2020). The 2020 benchmark assessment for American shad was endorsed by the Peer Review Panel and accepted by the ASMFC Shad and River Herring Board for management use in August 2020. The ASMFC has not conducted a coastwide assessment of hickory shad.

DESCRIPTION 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 April 15–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 18 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 3.25–4.0 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 1–November 30. 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 for flounder season on September 1, 2021.

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 rivers 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 rivers 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.

A management response for striped bass has been in effect since March 18, 2019, prohibiting the use of all gill nets upstream of the ferry lines from the Bayview to Aurora ferry in the Tar-Pamlico

River and the Minnesott Beach and Cherry Branch ferry in the Neuse River (Proclamation M-6-2019). This prohibition directed by the N.C. Marine Fisheries Commission was in response to Supplement A to Amendment 1 to the N.C. Estuarine Striped Bass FMP, and was intended to reduce striped bass fishing mortality, and has essentially protected American shad as well by removing gill nets from the normal fishing grounds for American shad in the Tar-Pamlico River.

Commercial Fishery

North Carolina's commercial landings in 2021 were 58,884 pounds; well below 2020 landings (134,556 pounds, Table 1, Figure 1). Gill nets configured for harvesting American shad were prohibited in the ASMA (Management Unit A) effective March 18, 2021, due to the ASMA striped bass commercial quota being met (Proclamation M-10-2021). While American shad could still be landed commercially until March 24, 2021, gill nets are the primary gear used for shad in the ASMA and the gear restriction did have some impact on landings. Overall, 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 the landings break down by the four areas of the state, as stated in the American Shad SFMP. The Albemarle Sound area accounts for approximately 91% of total state landings in 2021.

Recreational Fishery

Recreational fishing activity is monitored through coordination with the North Carolina Wildlife Resources Commission (NCWRC) 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 2,624 fish in 2021 (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 during 1994–2000 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 2020, gill nets accounted for greater than 98% of the commercial landings.

A total of 417 females and 71 males was measured from the commercial fishery in 2021 (Table 3, Table 4). The average size was 17 inches fork length for female and 16 inches fork length for male American shad (Figure 3, Figure 4). 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 5 and Figure 6 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 2021.

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, Juvenile Anadromous Survey (Program 100). Although the surveys were designed to monitor river herring [blueback herring (*Alosa aestivalis*) and alewife (*Alosa pseudoharengus*)] and striped bass, 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 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 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 a combination of seine stations from the river herring survey (five stations) and the striped bass survey (9 stations), all samples June through October, 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 Counts ~ Year + water temperature + salinity | salinity + cloud cover + month. Updates to annual trends in abundance are illustrated in Figure 7 as arithmetic mean, in lieu of updating the model annually. The 2021 relative abundance was 3.19 (American shad per tow) over three times the relative abundance in 2020 (0.93 American shad per tow).

Adult American shad are monitored using the NCDMF Albemarle Sound Independent Gill Net Survey (Program 135) and NCWRC electrofishing surveys to estimate female catch relative abundance 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.

Program 135 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 gill net surveys outside to the Albemarle Sound-Roanoke River area are biologically sampled and reported annually to the ASMFC, due to low numbers of catch relative abundance is not estimated.

An overall index of abundance (female and male combined) is not available for American shad from Program 135 for 2021 (Figure 8). Program 135 was suspended February 20, 2020, due to COVID-19 restrictions and protected species interactions. The 2020 index provided in Figure 8 is based on the limited sampling that occurred in that year. The survey resumed in the fall of 2021.

A total of 9 females and 6 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 17 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 9 and Figure 10 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 during 2000–2021.

RESEARCH NEEDS

On an annual basis the ASMFC publishes a prioritized list of short term and long-term 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 2020).

For more information on research needs for River herring please see: http://www.asmfc.org/uploads/file/627c1f1bShadRiverHerring_FMP_ReviewFY2020.pdf

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-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% 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. 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 each 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. Due to the Covid-19 pandemic in 2020, the NC Wildlife Resources Commission and the NC Division of Marine Fisheries were unable to complete sampling necessary to update the sustainability parameters due to restrictions on sampling implemented by both agencies in response to the Covid-19 pandemic. The Cape Fear River season dates were changed in 2021 to prevent opening the fishery on a weekend but number of days remains the same. Due to the suspension of the Albemarle Sound independent gill net survey, sampling necessary to update the sustainability parameters for the Albemarle Sound were unavailable for 2021. Therefore, the current season length remained unchanged for 2022.

The 2021 updates to sustainability parameters showed no parameter exceeding the respective threshold. Additionally, it is important to note a management response for striped bass has been in effect since March 18, 2019, prohibiting the use of all gill nets upstream of the ferry lines from the Bayview to Aurora ferry in the Tar-Pamlico River. This management measure has essentially protected American shad as well as striped bass by removing gear from the normal fishing grounds.

Albemarle Sound-Roanoke River:

The Albemarle Sound-Roanoke River system has three sustainability parameters: female CPUE based on the NCDMF Albemarle Sound Independent Gill Net Survey (IGNS, Program 135), 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 2015–2021 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 11 shows the female CPUE based on the NCDMF Albemarle Sound IGNS. Figure 12 shows the CPUE based on the NCWRC electrofishing survey. Figure 13 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 14 shows the female CPUE based on the NCWRC electrofishing survey and figure 15 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 16 shows the female CPUE based on the NCWRC electrofishing survey and figure 17 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 21 to April 12 (previously 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 18 shows the female CPUE based on the NCWRC electrofishing survey and figure 29 shows the female relative *F* based on the NCWRC electrofishing survey.

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.

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TABLES

Table 1. Commercial harvest (weight in pounds) of American shad from North Carolina, 1972–2021. Commercial harvest from the Atlantic Ocean prohibited since 2007.

Year	Commercial Weight Landed (lb)	Year	Commercial Weight Landed (lb)
1972	468,484	1997	219,526
1973	321,000	1998	327,556
1974	368,833	1999	131,617
1975	241,240	2000	297,990
1976	167,190	2001	151,075
1977	120,201	2002	274,657
1978	402,017	2003	395,251
1979	277,818	2004	270,245
1980	199,206	2005	189,462
1981	351,500	2006	184,710
1982	407,034	2007	298,597
1983	380,897	2008	118,855
1984	382,331	2009	167,114
1985	190,044	2010	232,326
1986	279,142	2011	203,755
1987	111,860	2012	235,795
1988	111,567	2013	257,348
1989	52,997	2014	191,302
1990	30,833	2015	95,966
1991	29,037	2016	62,245
1992	38,020	2017	90,868
1993	12,544	2018	53,878
1994	110,975	2019	40,975
1995	205,867	2020	134,566
1996	199,638	2021	58,884
		Mean	202,897

Table 2. Recreational harvest (number of fish landed and weight in pounds) and releases (number of fish) and commercial harvest (weight in pounds) of American shad from the North Carolina Central Southern Management Area (CSMA), 2012–2021. Recreational weight landed is estimated using an individual fish weight of 2.8 pounds derived from Fishery-Independent sampling.

	Neuse River					Tar-Pamlico River					Cape Fear River				
	Recreational			Commercial		Recreational			Commercial		Recreational			Commercial	
Year	Numbers Landed	Numbers Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)	Numbers Landed	Numbers Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)	Numbers Landed	Numbers Released	Weight Landed (lb)	Weight Landed (lb)	Total Weight (lb)
2012	1,017	655	2,848	23,976	26,824	959	4,396	2,685	12,936	15,621				10,333	10,333
2013	1,388	2,771	3,886	17,320	21,206	2,603	10,180	7,288	9,776	17,064	20,519	34,902	57,453	24,888	82,341
2014	413	998	1,156	11,358	12,514	168	1,314	470	18,769	19,239	7,453	11,025	20,868	46,148	67,016
2015	94	137	263	2,990	3,253	1,006	3,917	2,817	3,346	6,163	4,136	6,388	11,581	25,039	36,620
2016	252	1,423	706	2,568	3,274	1,051	2,820	2,943	765	3,708	10,244	11,388	28,683	12,937	41,620
2017	519	2,591	1,453	11,451	12,904	898	2,217	2,514	4,384	6,898	1,352	2,669	3,786	10,778	14,564
2018	112	358	314	3,987	4,301	685	2,767	1,918	1,580	3,498	5,366	7,924	15,025	14,931	29,956
2019	215	123	602	1,531	2,133	552	3,120	1,546		1,546	2,271	3,408	6,359	5,076	11,435
2020	830	2,813	2,324	109	2,433	209	838	585	129	714	3,582	3,740	10,030	6,038	16,068
2021	36	69	101	59	160	837	6,950	2,344	16	2,360	2,624	6,914	7,347	4,838	12,185

Table 3. Mean, minimum, and maximum lengths (fork length, inches) of female American shad measured from the commercial fisheries, 1972–2021.

Year	Mean Length	Minimum Length	Maximum 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
2020	15	12	19	281
2021	17	15	19	417

Table 4. Mean, minimum, and maximum lengths (fork length, inches) of male American shad measured from the commercial fisheries, 1972–2021.

Year	Mean Length	Minimum Length	Maximum 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
2020	15	12	17	74
2021	16	14	18	71

Table 5. Modal age, minimum age, maximum age, and number aged for American shad (male and female combined) collected through NCDMF fishery-dependent sampling programs, 1972–2021.

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	1,138
1976	5	4	9	664
1977	5	3	7	585
1978	6	3	7	953
1979	5	4	9	1,060
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
2020	6	4	8	255
2021	6	4	8	301

Table 6. Mean, minimum, and maximum lengths (fork length, inches) of female American shad measured from NCDMF fishery-independent sampling programs, 2000–2021.

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
2020	17	15	18	41
2021	17	15	18	9

Table 7. Mean, minimum, and maximum lengths (fork length, inches) of male American shad measured from NCDMF fishery-independent sampling programs, 2000–2021.

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
2020	15	12	16	32
2021	15	13	16	6

Table 8. Modal age, minimum age, maximum age, and number aged for American shad (male and female combined) collected through NCDMF fishery-independent sampling programs, 2000–2021.

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
2020	6	3	8	71
2021	5	4	7	15

FIGURES

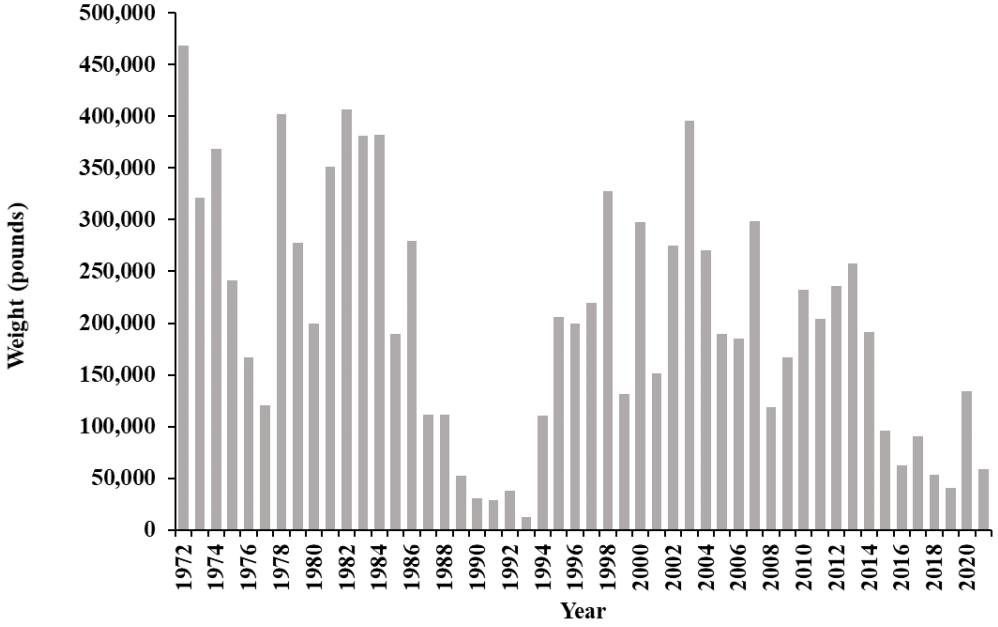

Figure 1. Commercial harvest (weight in pounds) of American shad from North Carolina, 1972–2021.

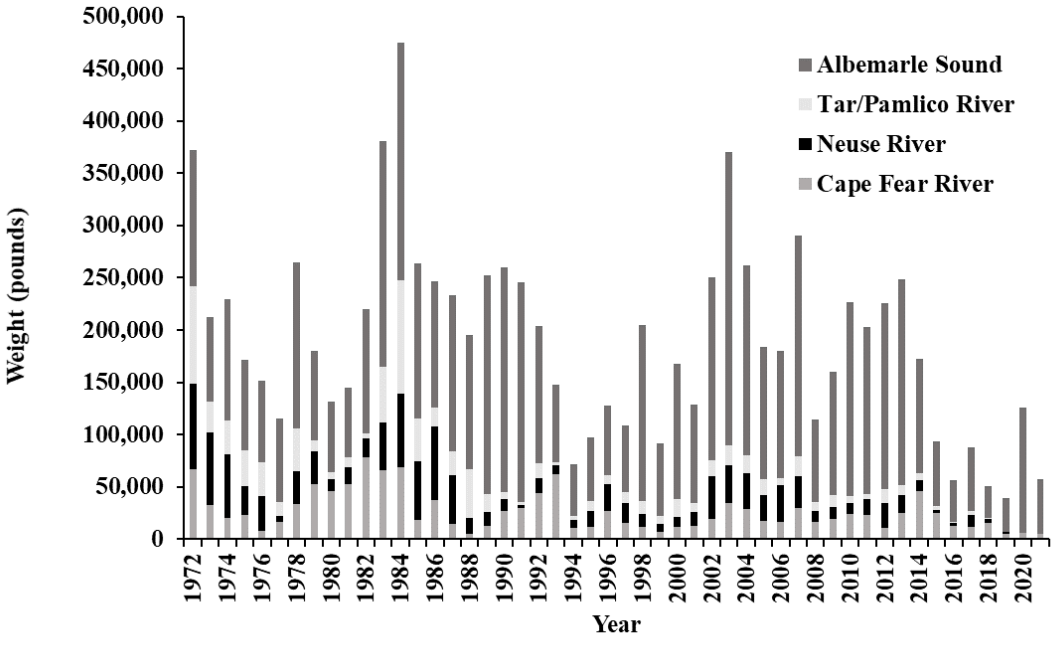

Figure 2. Commercial harvest (weight in pounds) of American shad from North Carolina by major waterbody, 1972–2021.

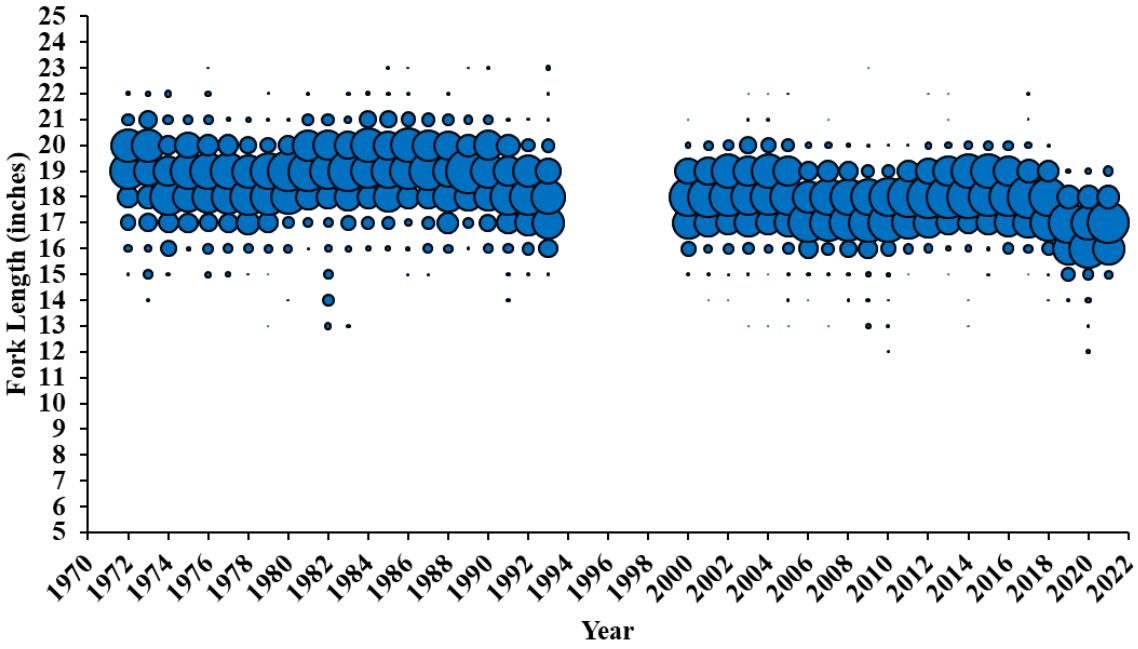

Figure 3. Commercial length frequency (fork length, inches) of female American shad harvested, 1972–2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

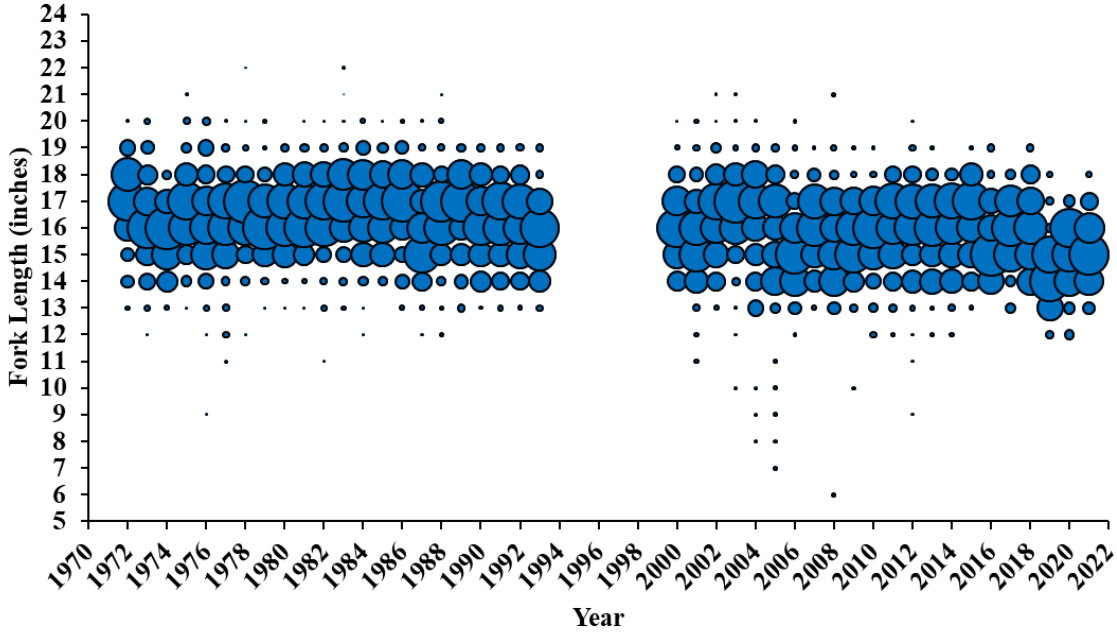

Figure 4. Commercial length frequency (fork length, inches) of male American shad, 1972–2021. Bubbles represent fish harvested at length and the size of the bubble is equal to the proportion of fish at that length.

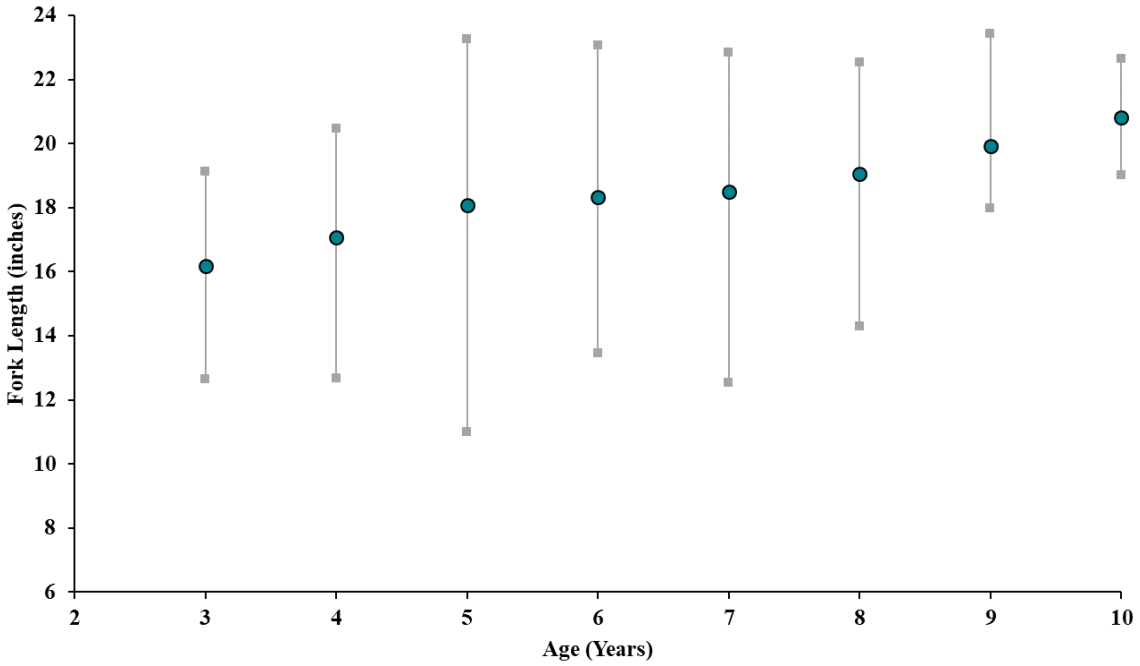

Figure 5. Female American shad length at age from all age samples collected from fishery-dependent monitoring, 1972–2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

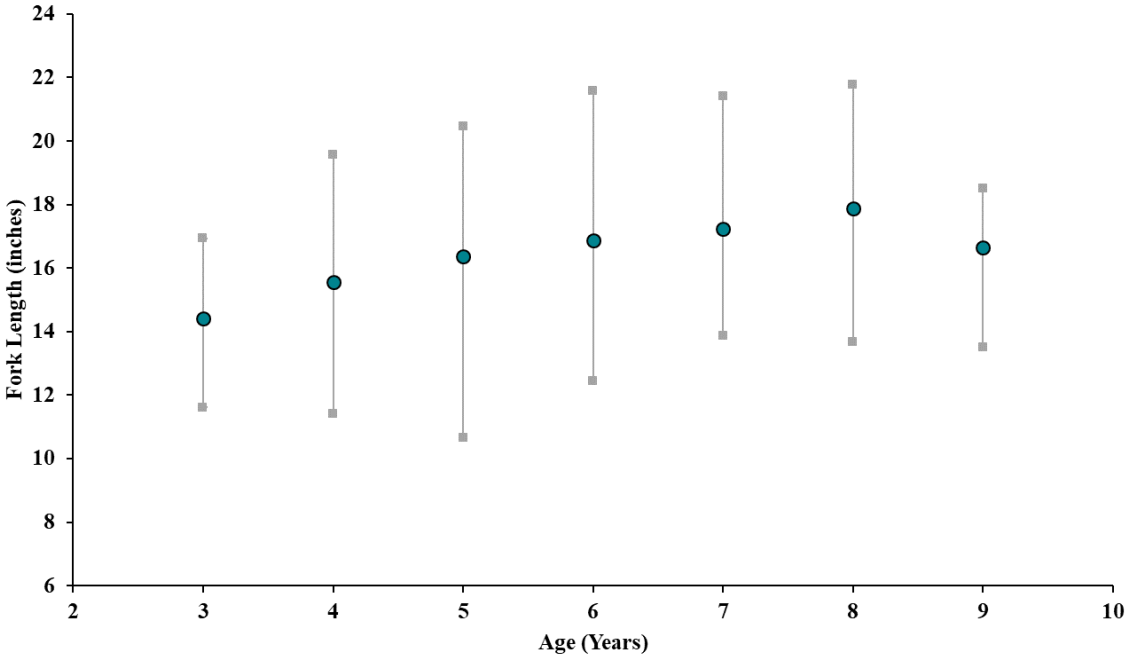

Figure 6. Male American shad length at age from all age samples collected from fishery-dependent monitoring, 1972–2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

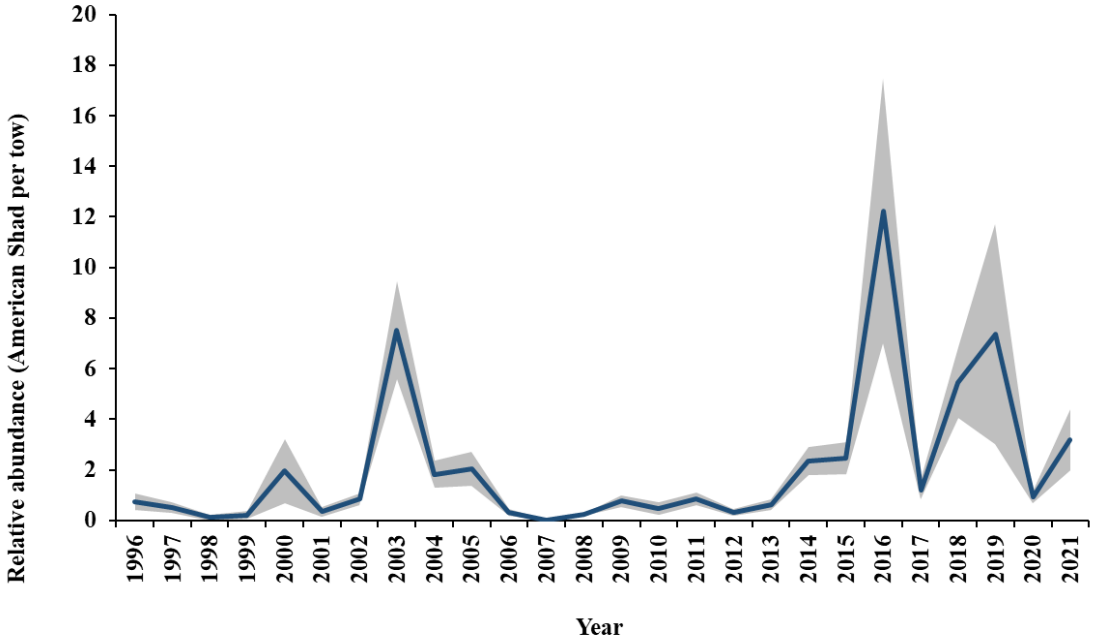

Figure 7. Relative abundance index (fish per tow) of American shad collected from Program 100 in Albemarle Sound during June through October 1996–2021. Error bars represent ± 1 standard error.

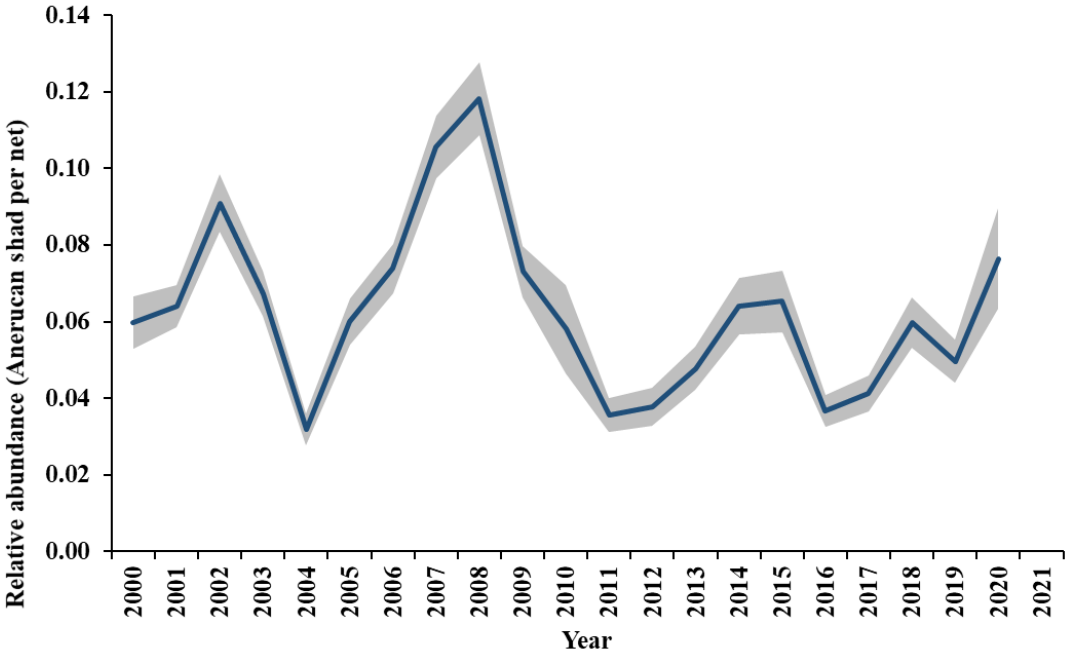

Figure 8. Relative abundance index of American shad (fish per net, all mesh sizes) collected from Program 135 in Albemarle Sound during January through May 2000–2021. Error bars represent ± 1 standard error.* Survey suspended February 20, 2020, and did not resume until fall 2021.

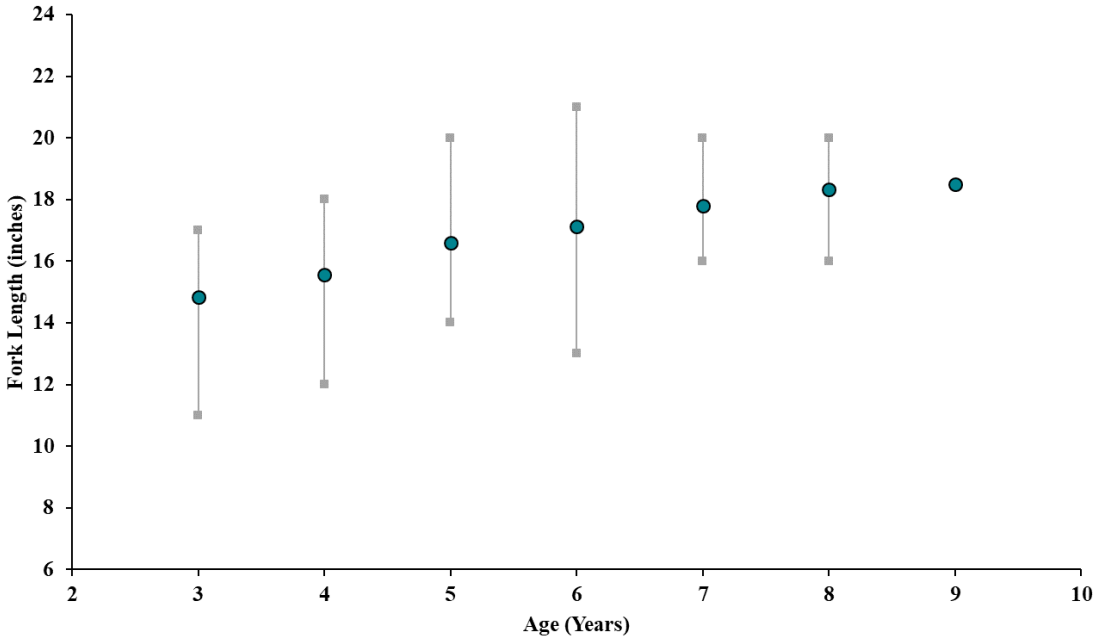

Figure 9. Female American shad length at age from all age samples collected through NCDMF fishery-independent sampling programs, 2000–2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

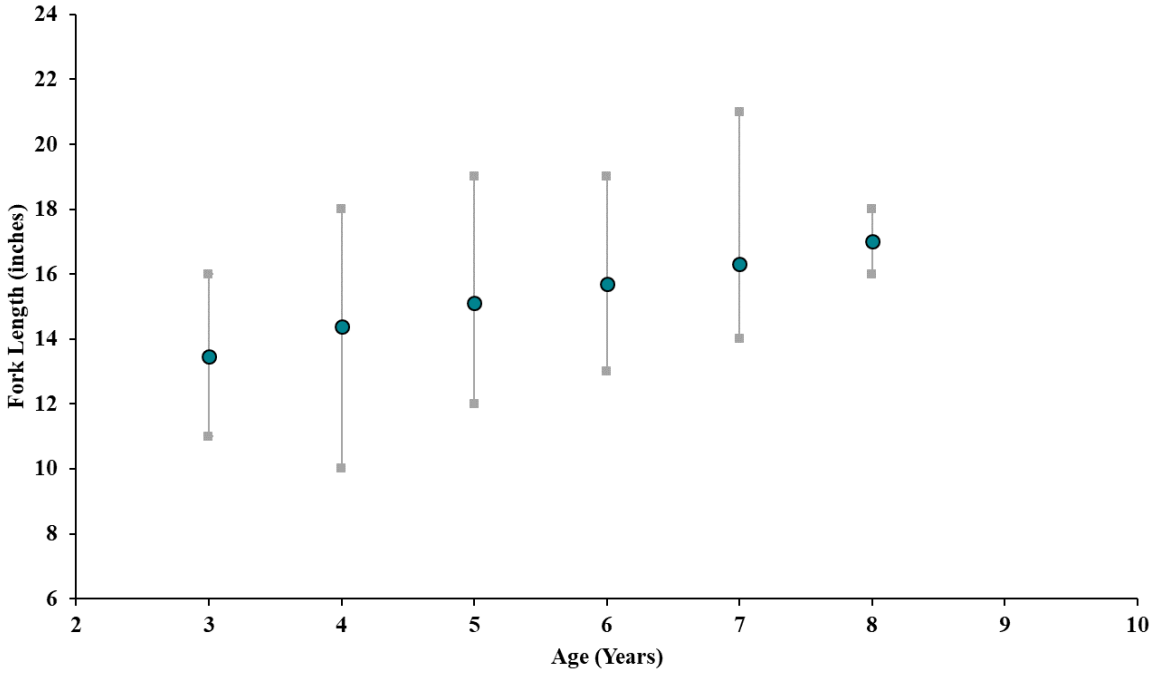

Figure 10. Male American shad length at age from all age samples collected through NCDMF fishery-independent sampling programs, 2000–2021. Blue circles represent the mean size at a given age while the grey squares represent the minimum and maximum observed size for each age.

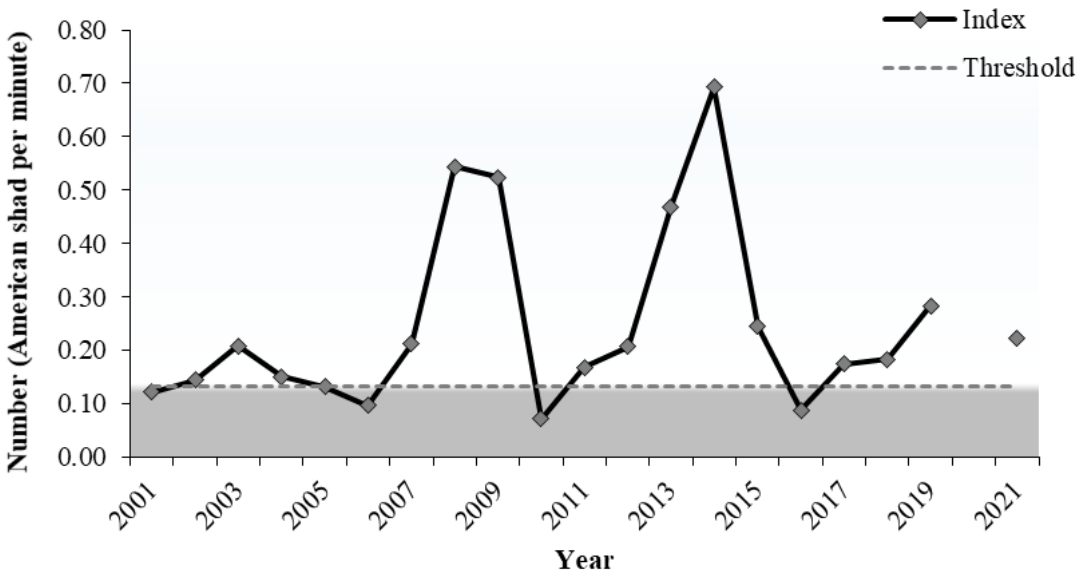

Figure 11. Albemarle Sound-Roanoke River sustainability parameter for female CPUE in the NCDMF IGNS, 2000–2021. Grey areas represent a parameter exceeding the threshold. NCDMF IGNS suspended February 20, 2020, and did not resume until fall 2021.

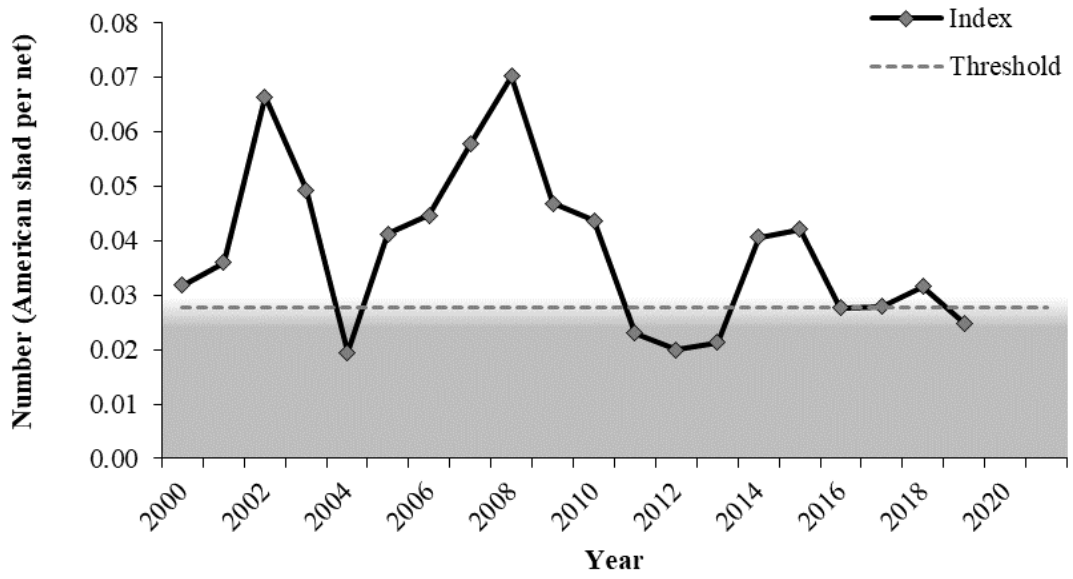

Figure 12. Albemarle Sound-Roanoke River sustainability parameter for female CPUE in NCWRC electrofishing survey, 2001–2021. Grey areas represent a parameter exceeding the threshold.

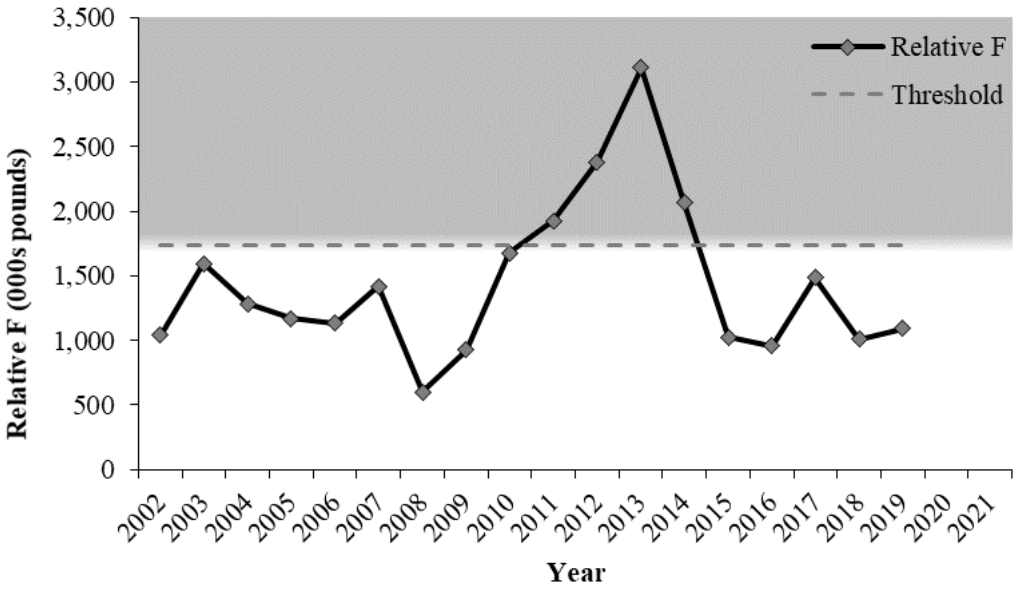

Figure 13. Albemarle Sound-Roanoke River sustainability parameter for female relative *F* in the NCDMF IGNS, 2002–2021. Grey areas represent a parameter exceeding the threshold. NCDMF IGNS suspended February 20, 2020, and did not resume until fall 2021.

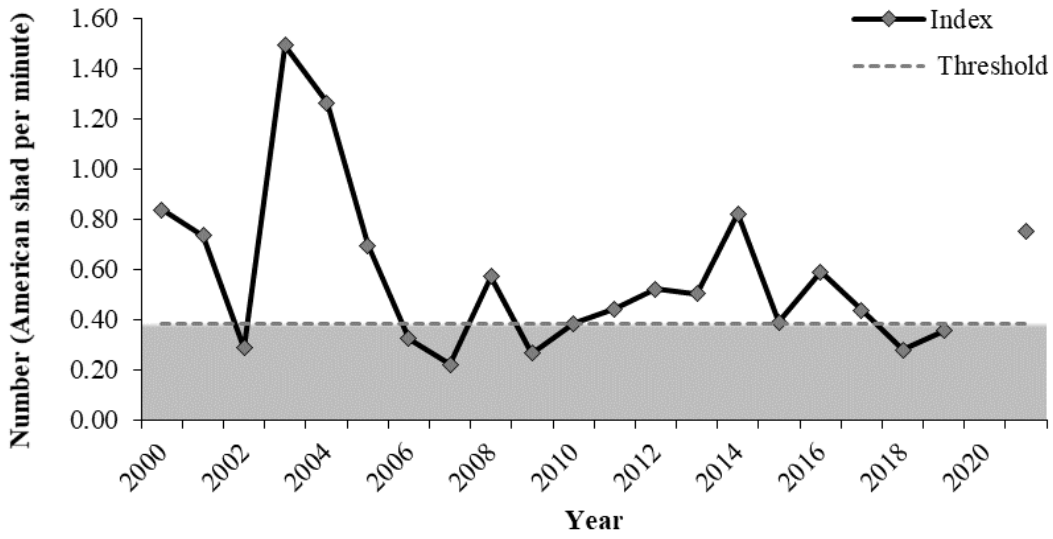

Figure 14. Tar-Pamlico River system sustainability parameter for female CPUE in NCWRC electrofishing survey, 2000–2021. Grey areas represent a parameter exceeding the threshold.

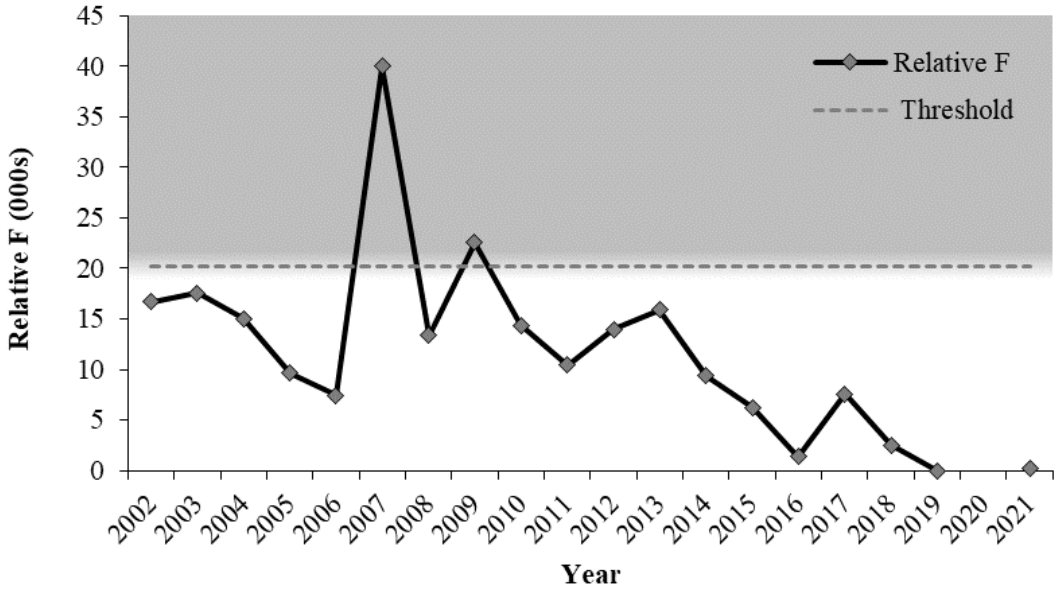

Figure 15. Tar-Pamlico River system sustainability parameter for female relative *F* in NCWRC electrofishing survey, 2002–2021. Grey areas represent a parameter exceeding the threshold.

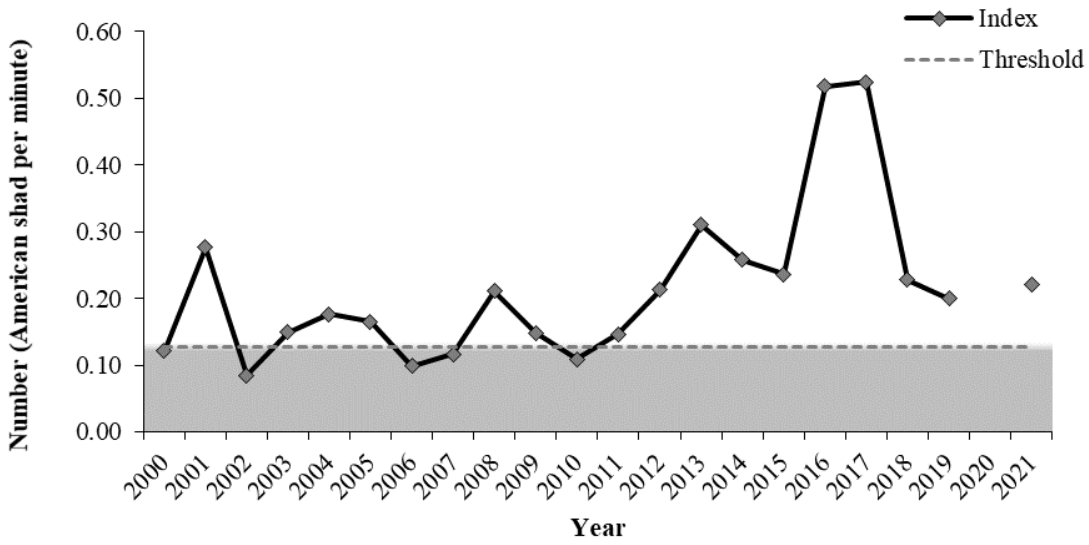

Figure 16. Neuse River system sustainability parameter for female CPUE in NCWRC electrofishing survey, 2000–2021. Grey areas represent a parameter exceeding the threshold.

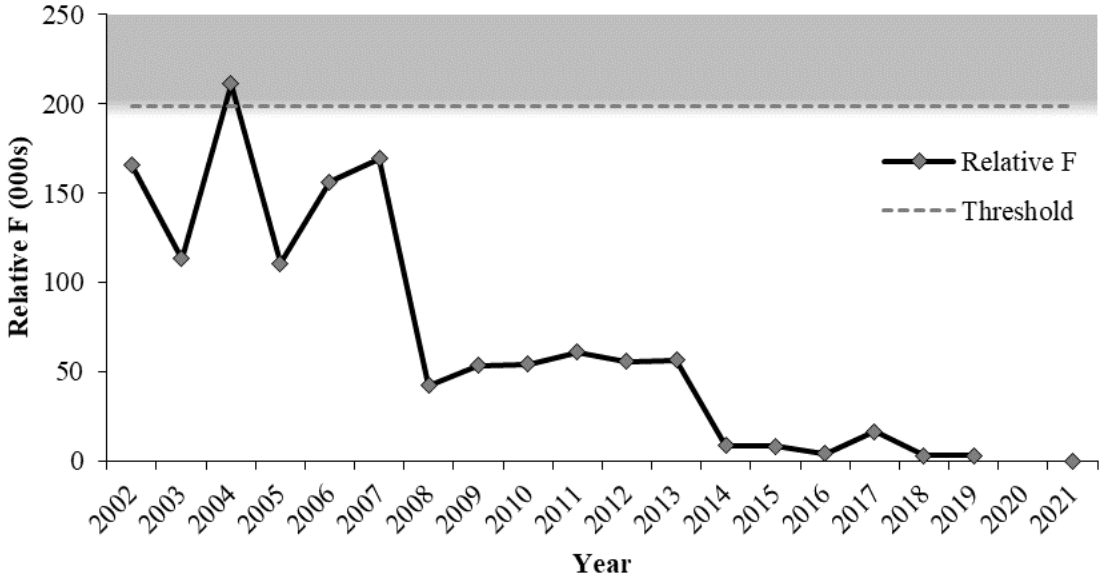

Figure 17. Neuse River system sustainability parameter for female relative *F* in NCWRC electrofishing survey, 2002–2021. Grey areas represent a parameter exceeding the threshold.

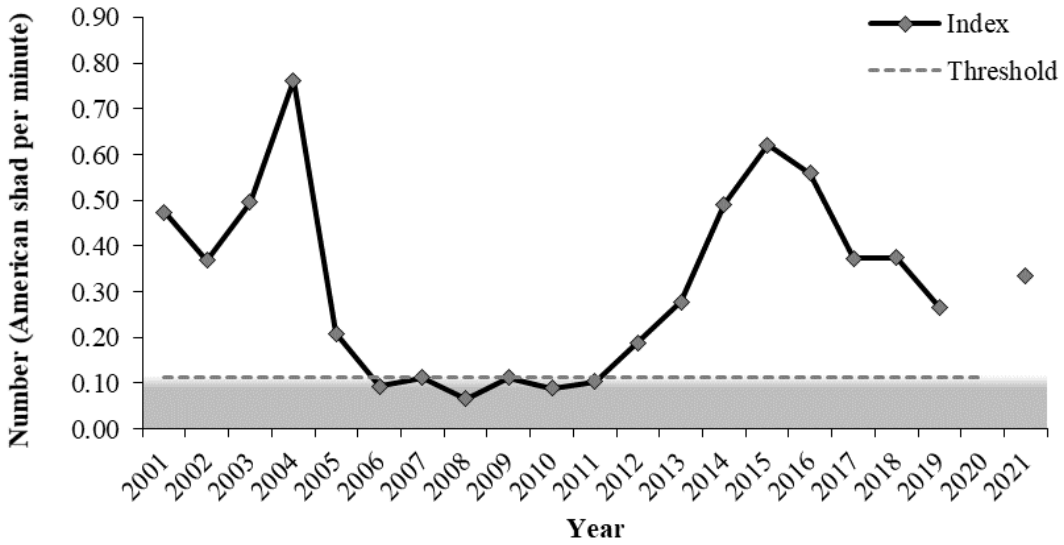

Figure 18. Cape Fear River system sustainability parameter for female CPUE in NCWRC electrofishing survey, 2001–2021. Grey areas represent a parameter exceeding the threshold.

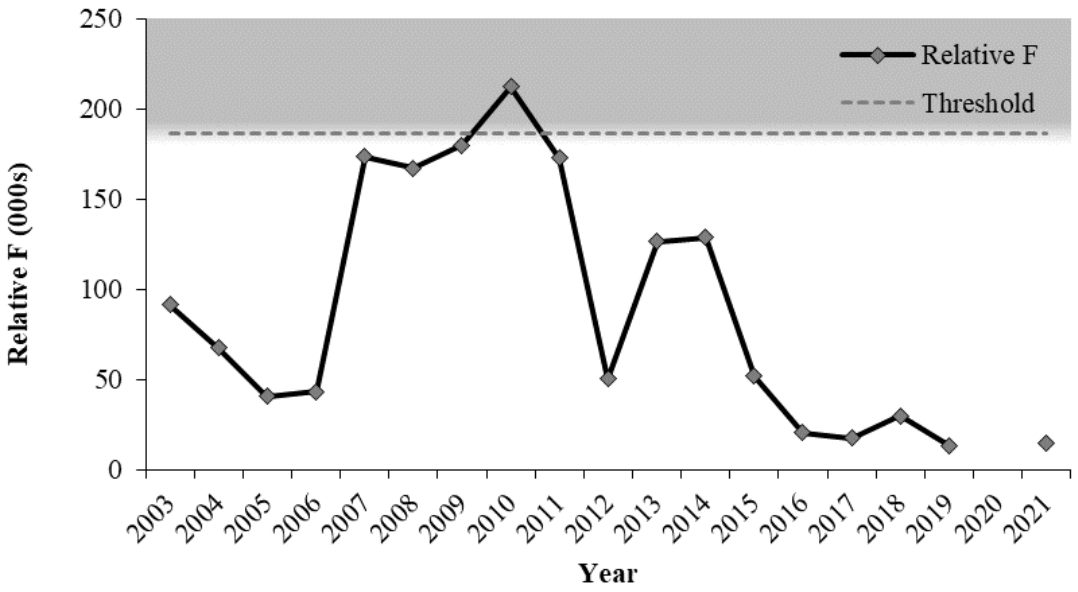

Figure 19. Cape Fear River system sustainability parameter for female relative *F* in NCWRC electrofishing survey, 2003–2021. Grey areas represent a parameter exceeding the threshold.