Appendix 1 - Indices

NMFS Northeast Fisheries Science Center Trawl (starts next page)

https://www.fisheries.noaa.gov/about/northeast-ecosystems-surveys

River herring and American shad indices from the NEFSC spring and fall bottom trawl surveys updated to the degree applicable.

American Shad indices are undergoing transition into the modern database structure used for other commonly queried species and have not been able to be updated.

For the updated river herring indices, the magnitude of the y-axes are slightly different from previous figures due to index redevelopment, but the previous trends are essentially identical. The differences are more noticeable in the figures of proportion of positive tows as a result of different strata being included.

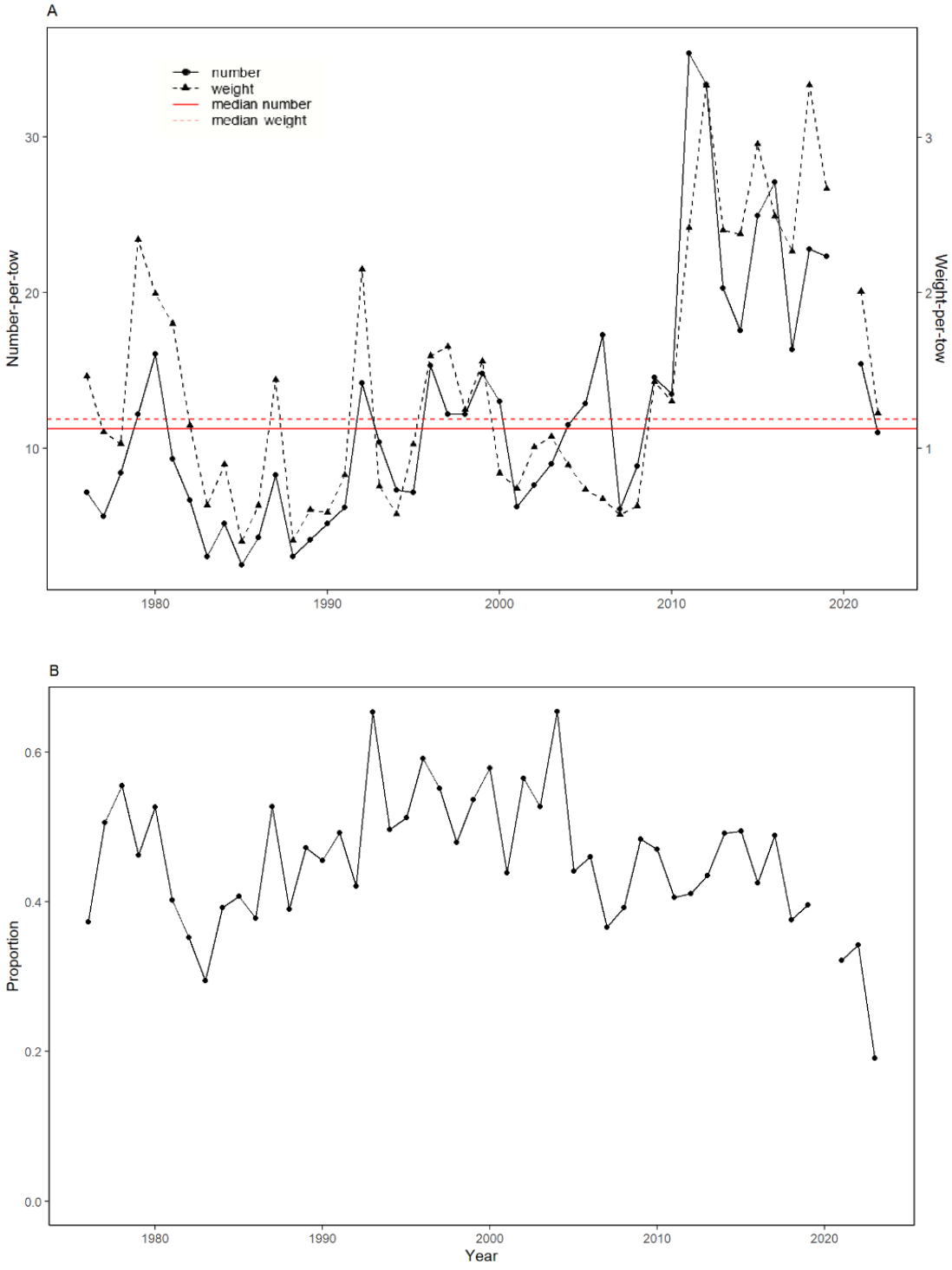


Figure 1: Alewife relative abundance (stratified mean number-per-tow) and biomass (stratified mean kg- per-tow) indices (A) and the proportion of positive tows (B) derived from the NEFSC spring bottom trawl survey for 1976-2022. Indices from 2009 onward were converted to Albatross units. The median number- and weight-per-tow values represent the median indices over 1976-2022. The full strata set was not sampled in 2014 due to delays in the survey (offshore strata 61-68 south of Maryland were not sampled) and the 2020 survey was not completed due to the covid pandemic.

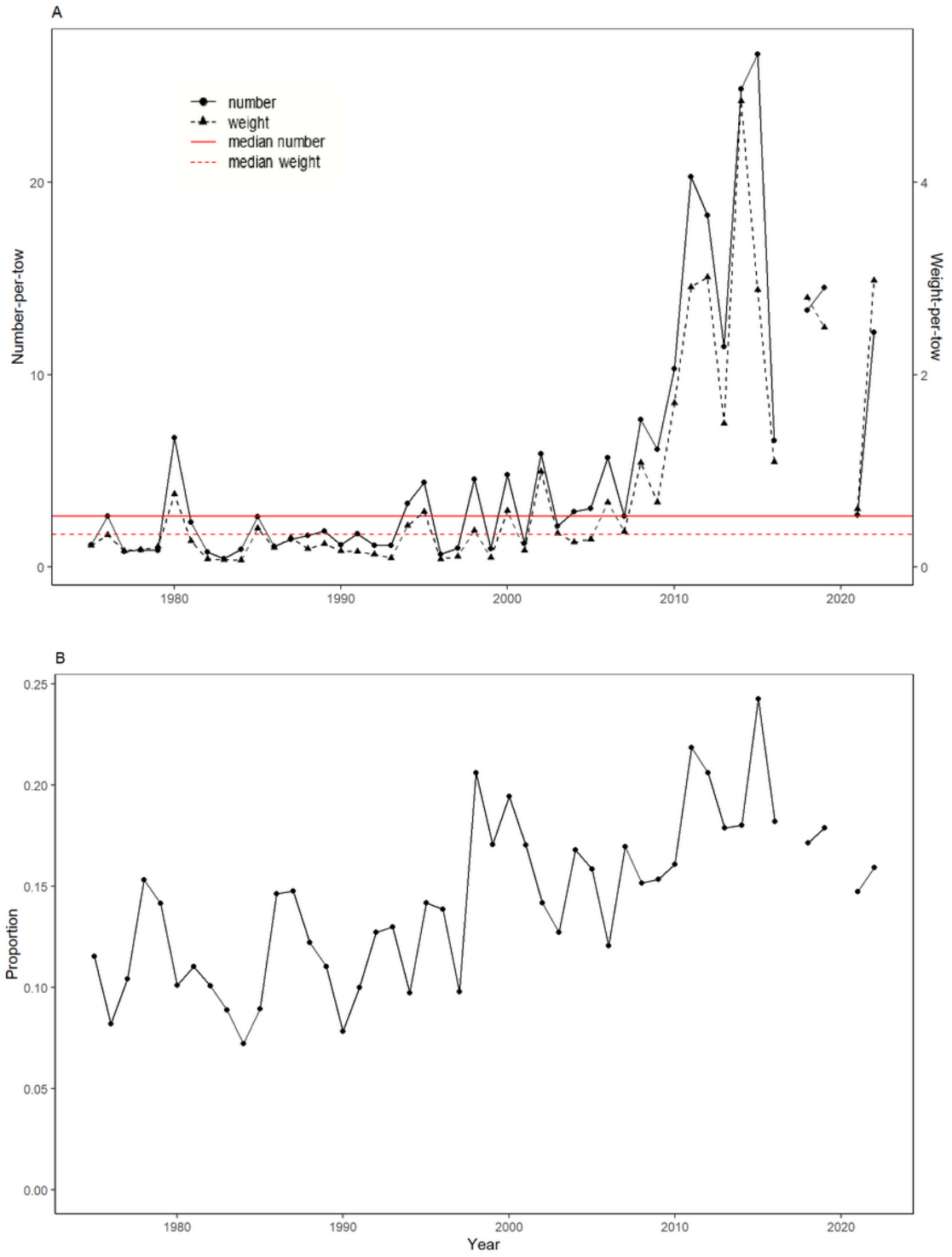


Figure 2: Alewife relative abundance (stratified mean number-per-tow) and biomass (stratified mean kg- per-tow) indices (A) and the proportion of positive tows (B) derived from the NEFSC fall bottom trawl survey for 1975-2022. Indices from 2009 onward were converted to Albatross units. The median number- and weight-per-tow values represent the median indices over 1975-2022. Indices from the 2017 fall bottom trawl survey are treated as missing because the full survey was not completed due to vessel mechanical issues. Additionally, the 2020 survey was not completed due to the covid pandemic

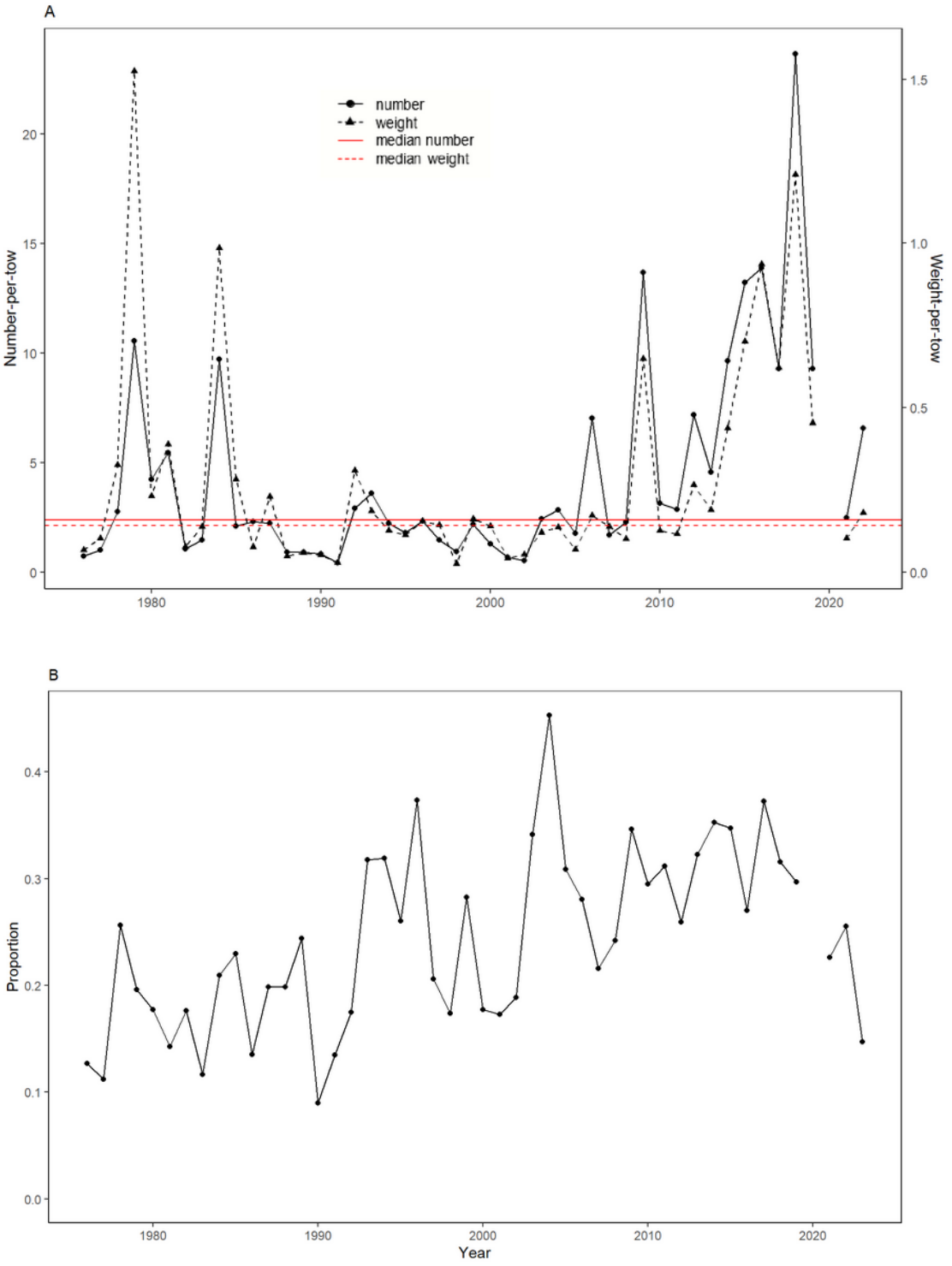


Figure 3: Blueback herring relative abundance (stratified mean number-per-tow) and biomass (stratified mean kg-per-tow) indices (A) and the proportion of positive tows (B) derived from the NEFSC spring bottom trawl survey for 1976-2022. Indices from 2009 onward were converted to Albatross units. The median number- and weight-per-tow values represent the median indices over 1976-2022. The full strata set was not sampled in 2014 due to delays in the survey (offshore strata 61-68 south of Maryland were not sampled) and the 2020 survey was not completed due to the covid pandemic.

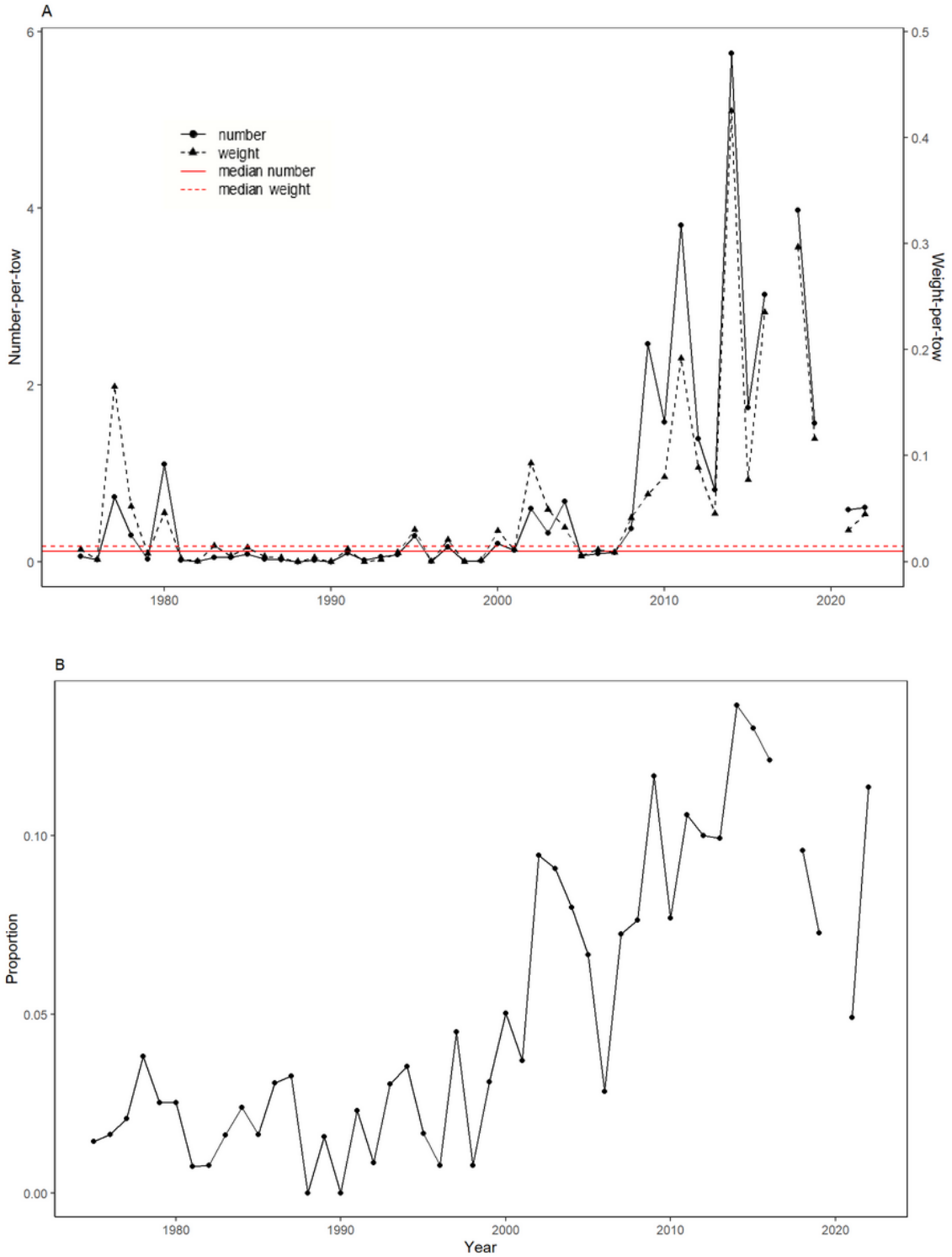


Figure 4: Blueback herring relative abundance (stratified mean number-per-tow) and biomass (stratified mean kg-per-tow) indices (A) and the proportion of positive tows (B) derived from the NEFSC fall bottom trawl survey for 1975-2022. Indices from 2009 onward were converted to Albatross units. The median number- and weight-per-tow values represent the median indices over 1975-2022. Indices from the 2017 fall bottom trawl survey are treated as missing because the full survey was not completed due to vessel mechanical issues. Additionally, the 2020 survey was not completed due to the covid pandemic.

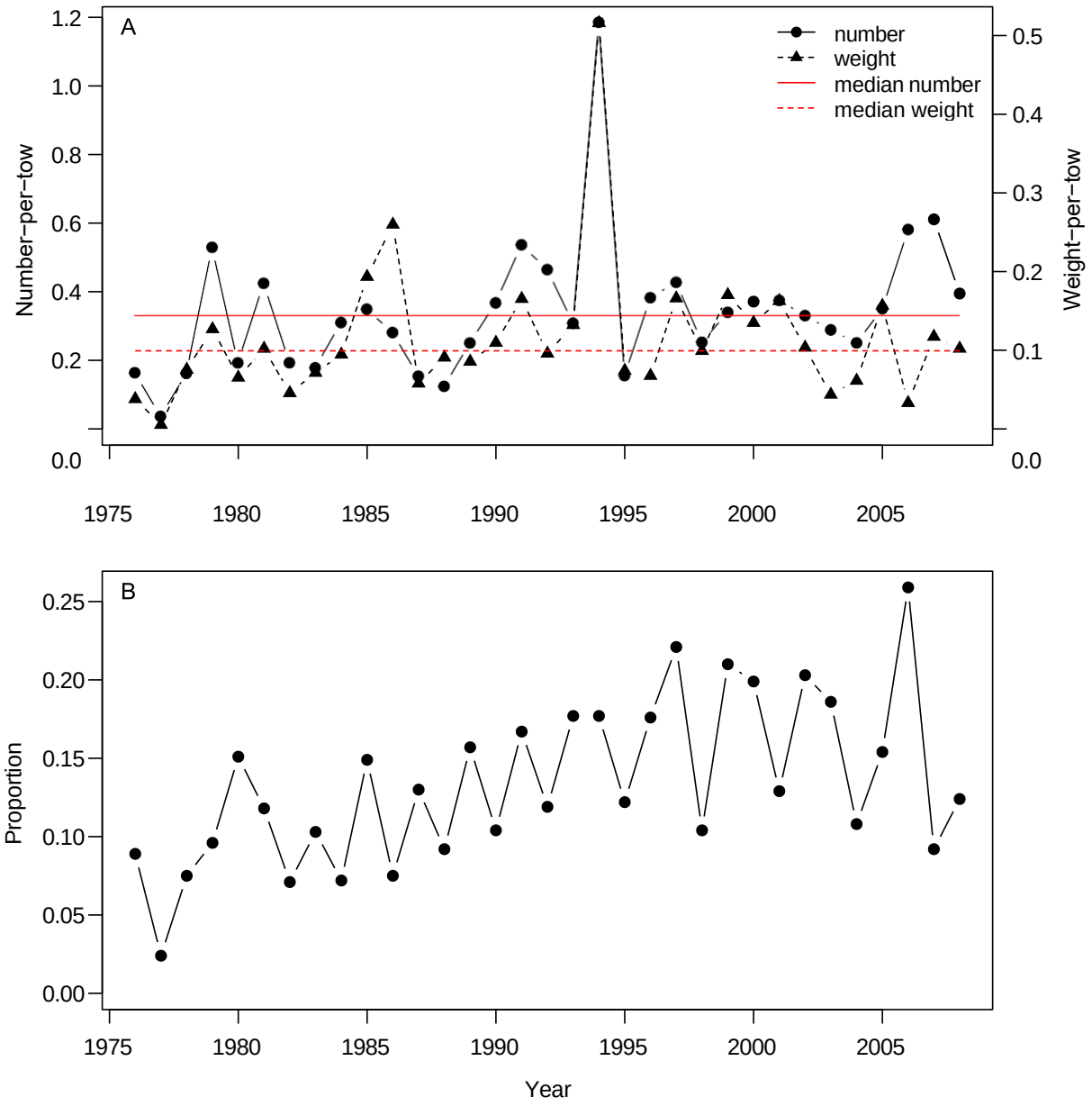


Figure 5: American shad relative abundance (stratified mean number-per-tow) and biomass (stratified mean kg-per-tow) indices (A) and the proportion of positive tows (B) derived from the NEFSC spring bottom trawl survey for 1976-2008. Vessel (Bigelow to Albatross) conversion coefficients are not available for American shad; therefore, the time series was split in 2008. The median number- and weight-per-tow values represent the median indices over 1976-2008.

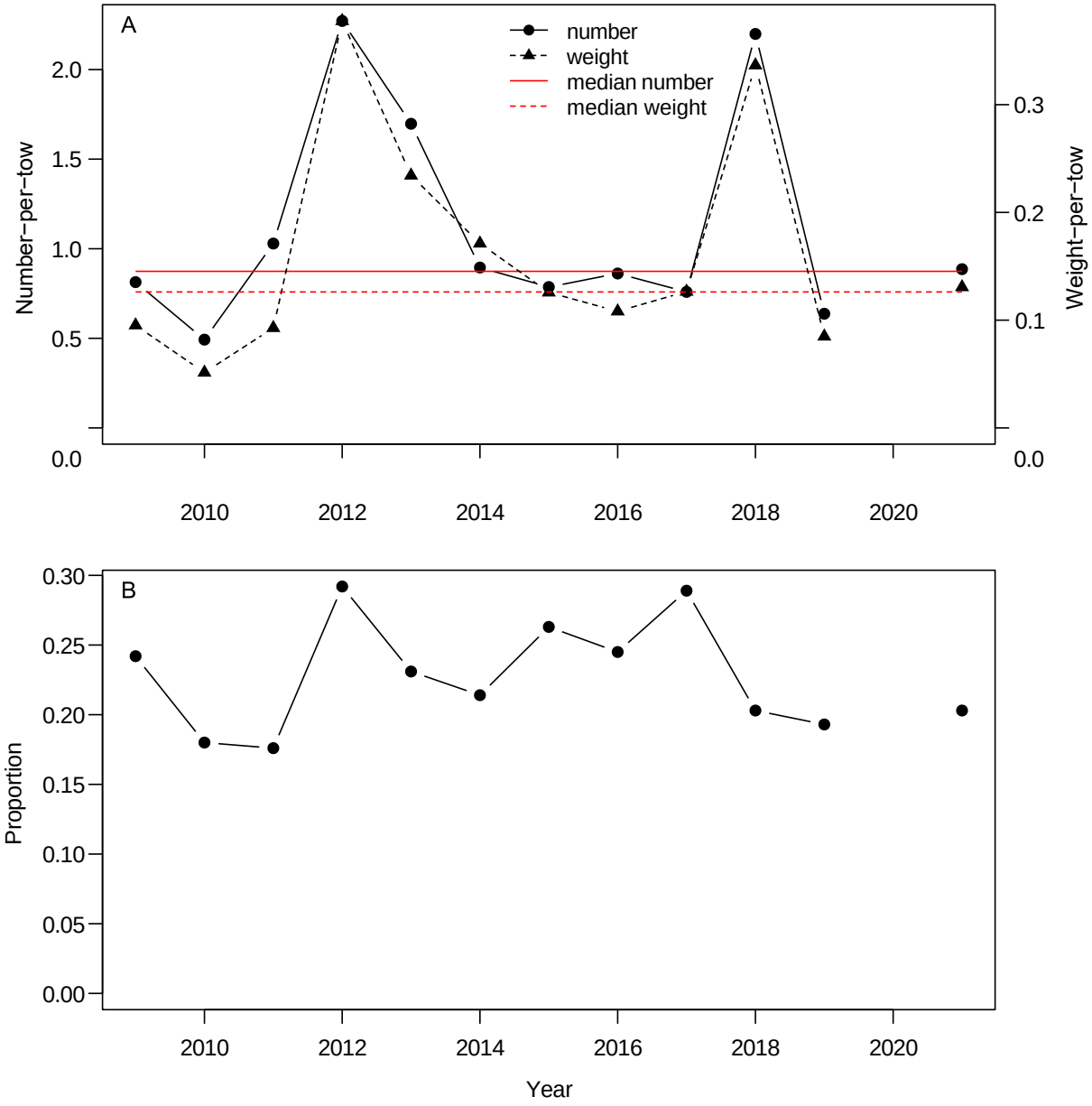


Figure 6: American shad relative abundance (stratified mean number-per-tow) and biomass (stratified mean kg-per-tow) indices (A) and the proportion of positive tows (B) derived from the NEFSC spring bottom trawl survey for 2009-2021 (Bigelow units). The median number- and weight-per-tow values represent the median indices over 2009-2021. The full strata set was not sampled in 2014 due to delays in the survey (offshore strata 61-68 south of Maryland were not sampled) and the 2020 survey was not completed due to the covid pandemic.

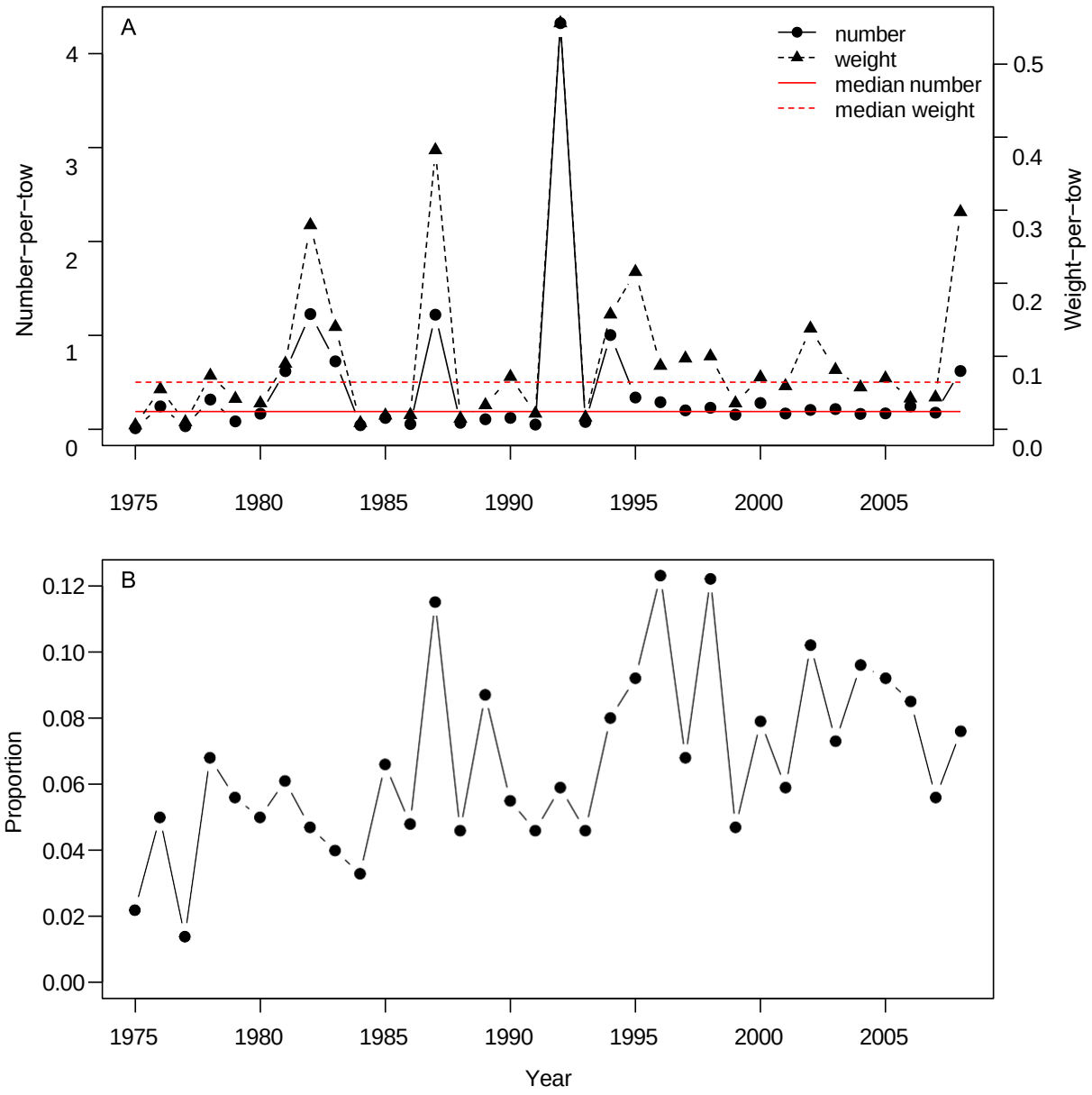


Figure 7: American shad relative abundance (stratified mean number-per-tow) and biomass (stratified mean kg-per-tow) indices (A) and the proportion of positive tows (B) derived from the NEFSC fall bottom trawl survey for 1975-2008. Vessel (Bigelow to Albatross) conversion coefficients are not available for American shad; therefore, the time series was split in 2008. The median number- and weight-per-tow values represent the median indices over 1975-2008.

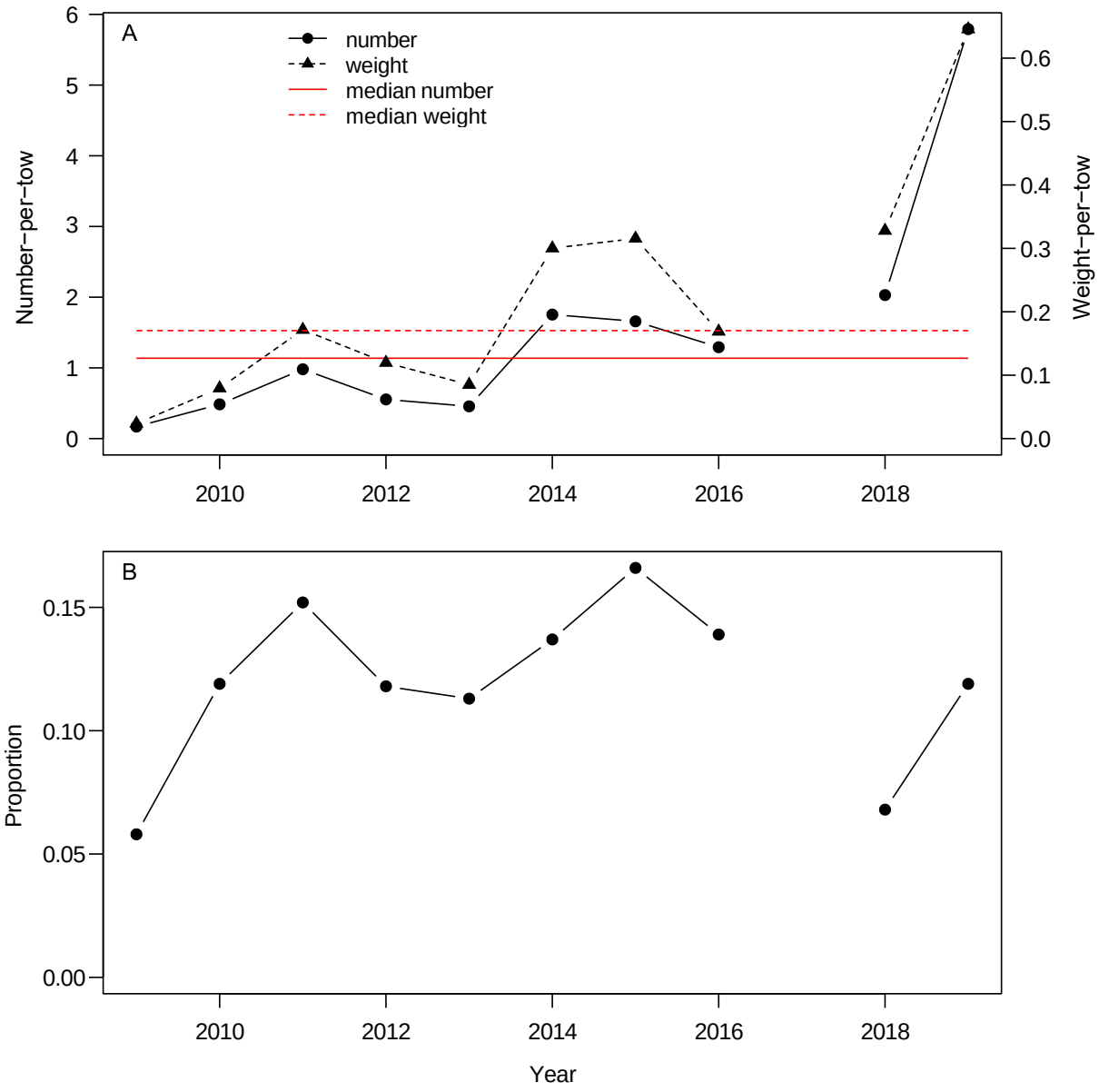
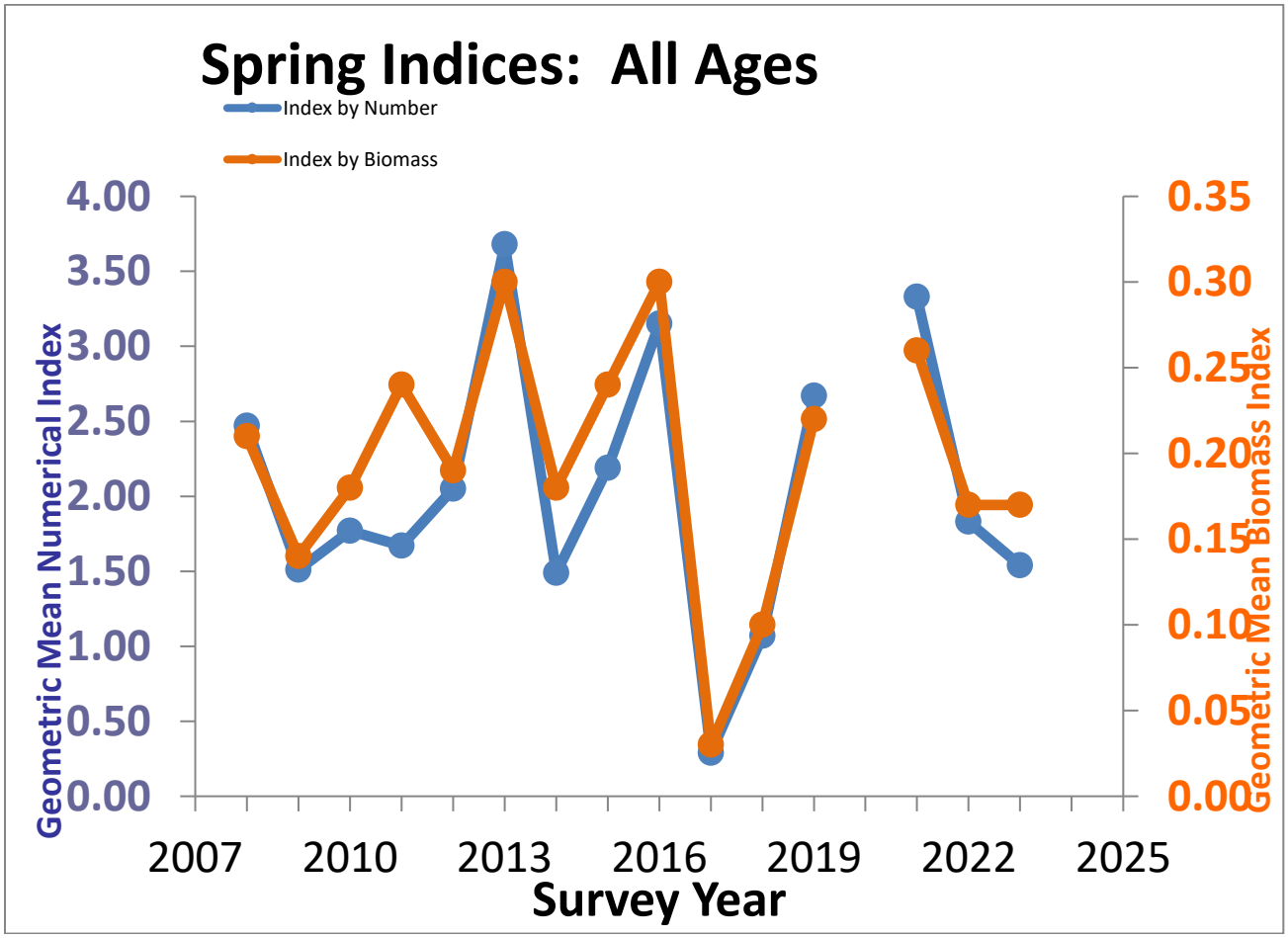


Figure 8: American shad relative abundance (stratified mean number-per-tow) and biomass (stratified mean kg-per-tow) indices (A) and the proportion of positive tows (B) derived from the NEFSC fall bottom trawl survey for 2009-2019 (Bigelow units). The median number- and weight-per-tow values represent the median indices over 2009-2019. Indices from the 2017 fall bottom trawl survey are treated as missing because the full survey was not completed due to vessel mechanical issues. Additionally, the 2020 survey was not completed due to the covid pandemic.

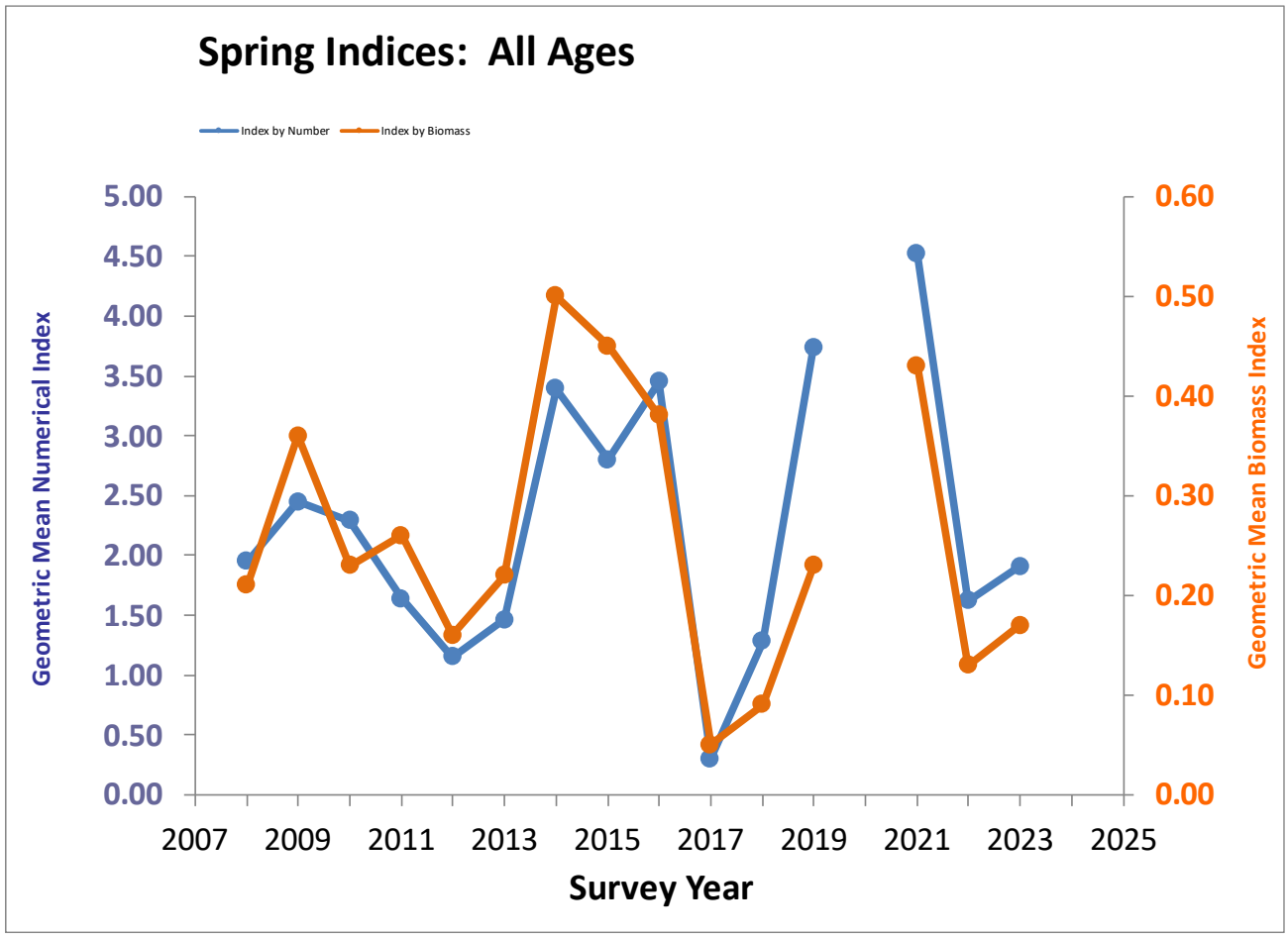
NEAMAP – updated through spring 2023

https://www.vims.edu/research/units/programs/multispecies_fisheries_research/neamap/index.php

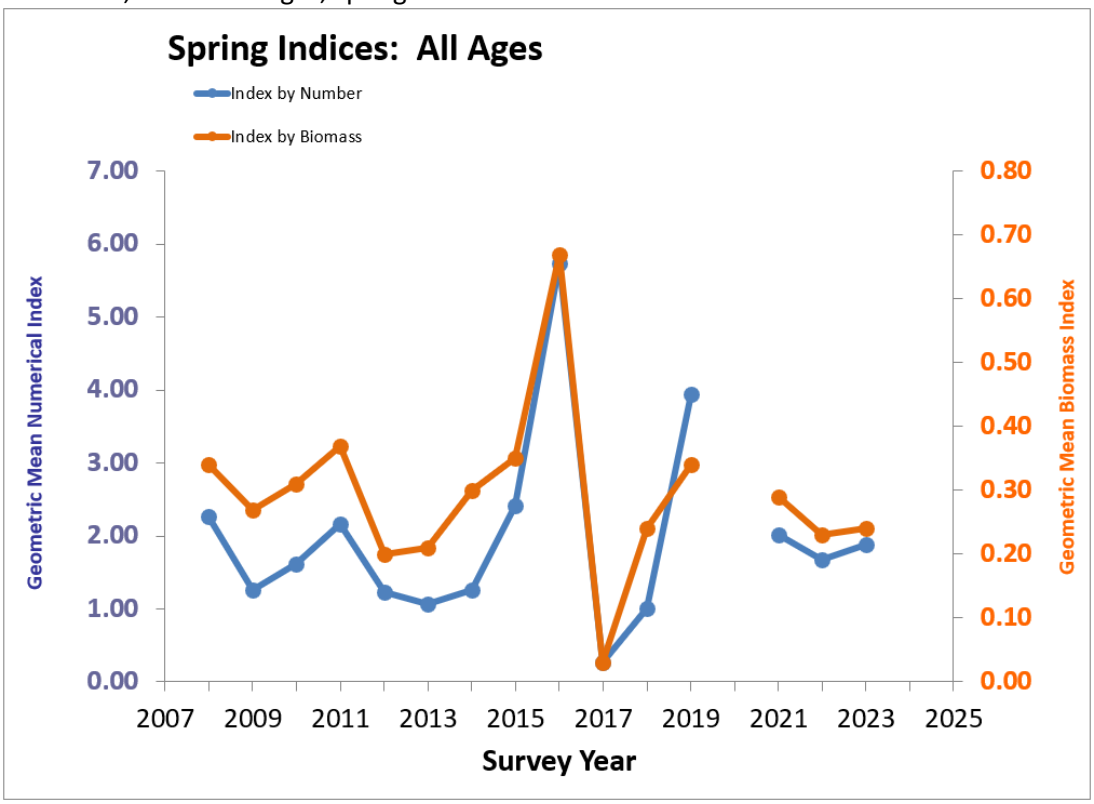
NEAMAP, American Shad all ages, Spring



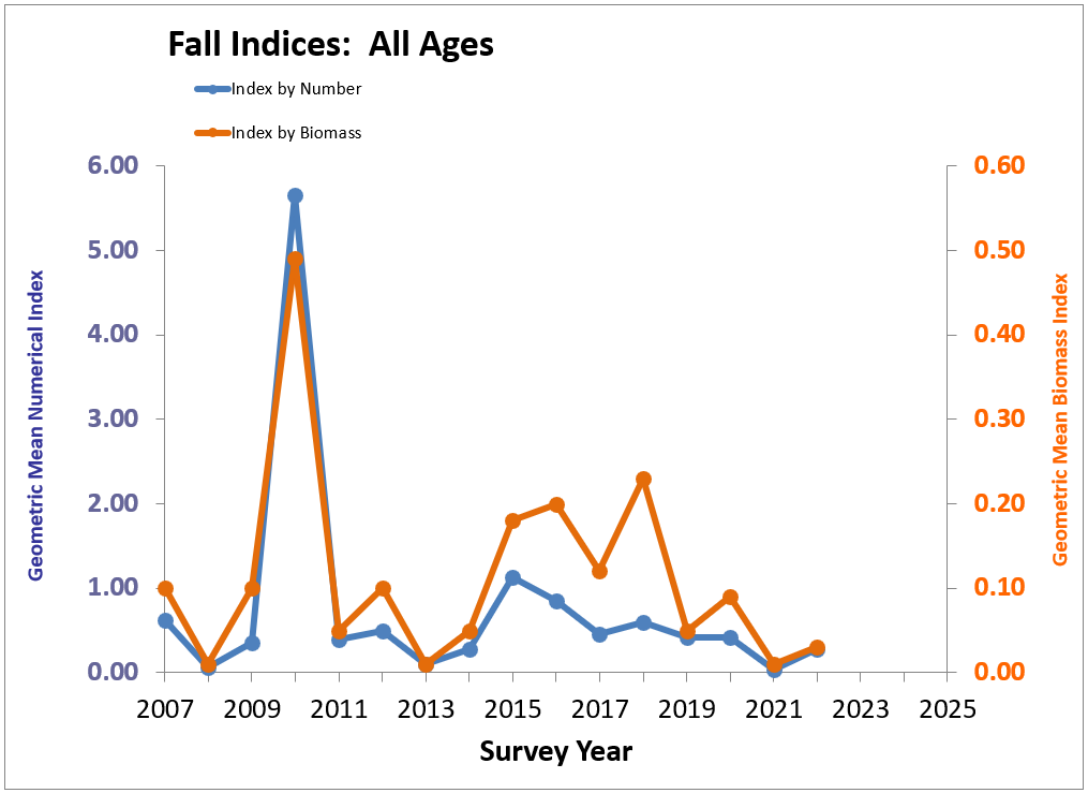
NEAMAP, Blueback Herring all ages, Spring



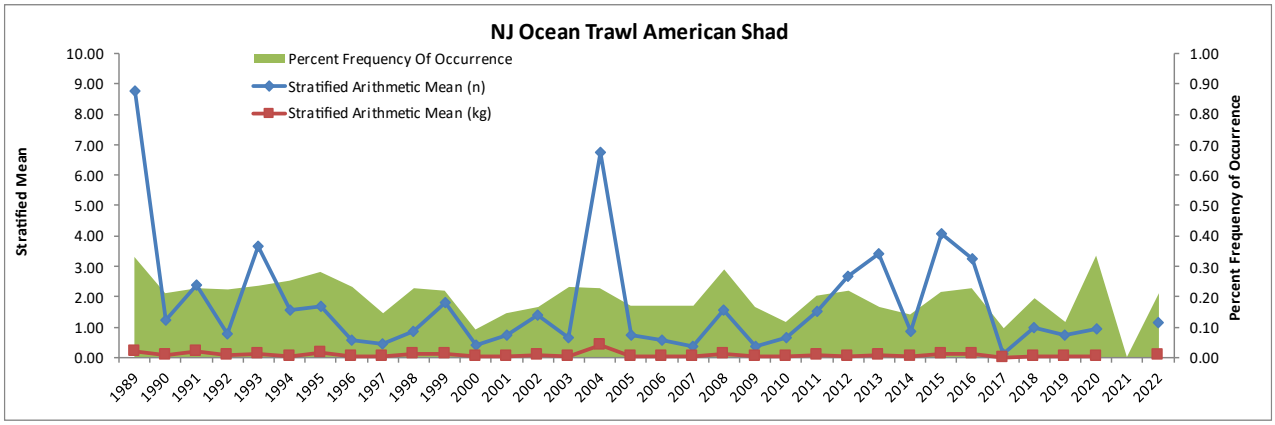
NEAMAP, Alewife all ages, Spring

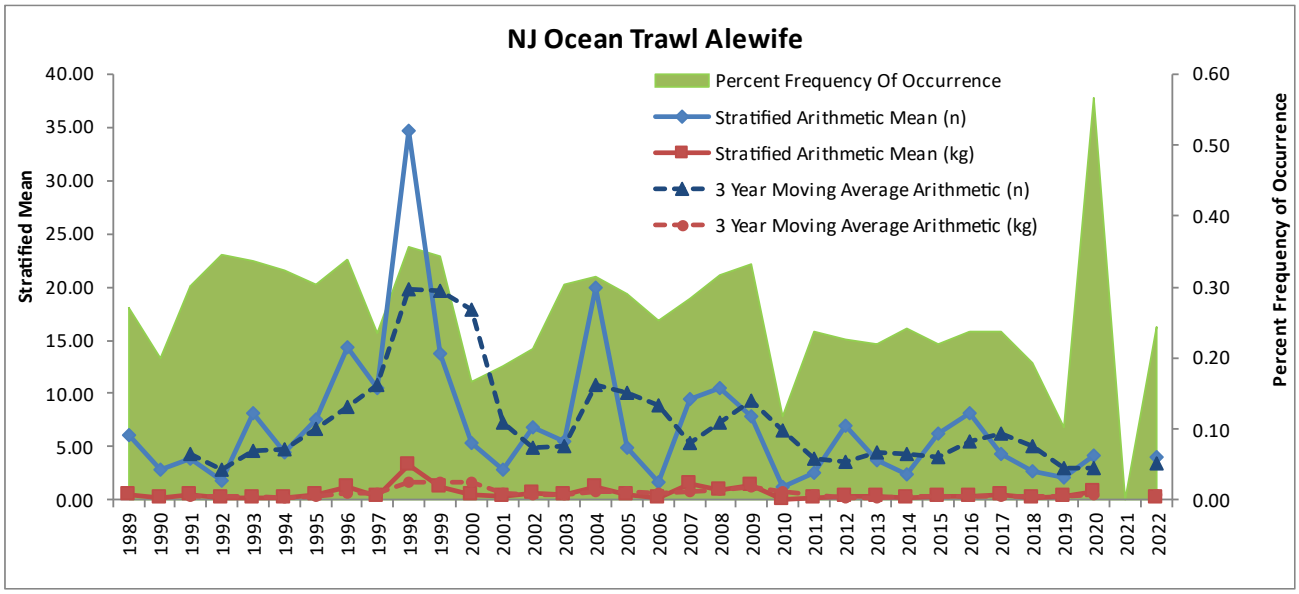


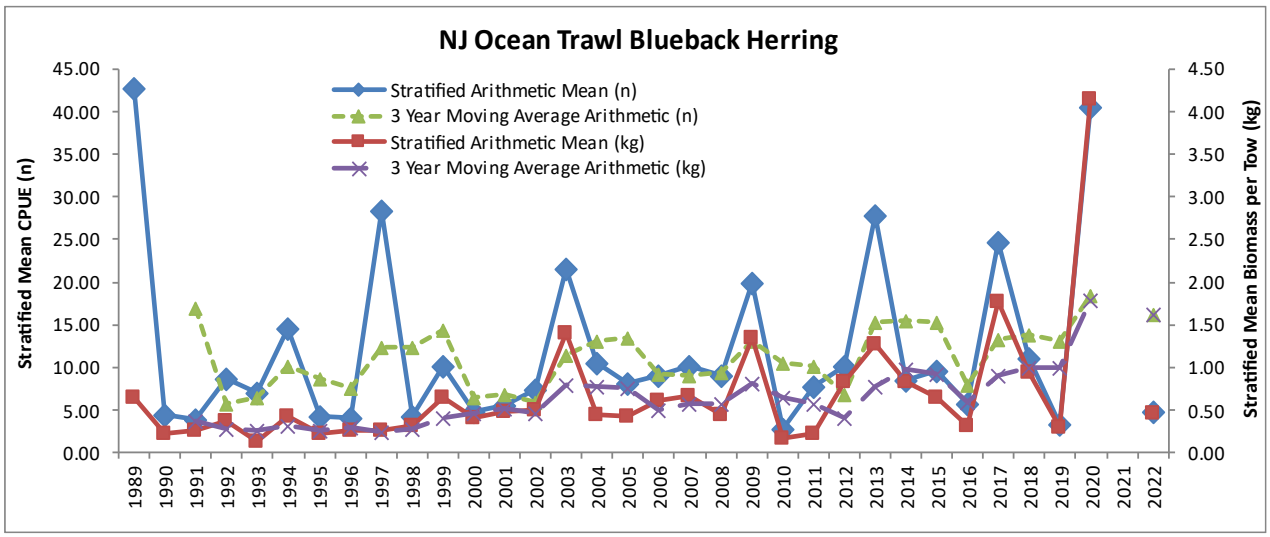
NEAMAP, Alewife all ages, Fall



New Jersey Ocean Trawl – Through 2022 (see notes next page)





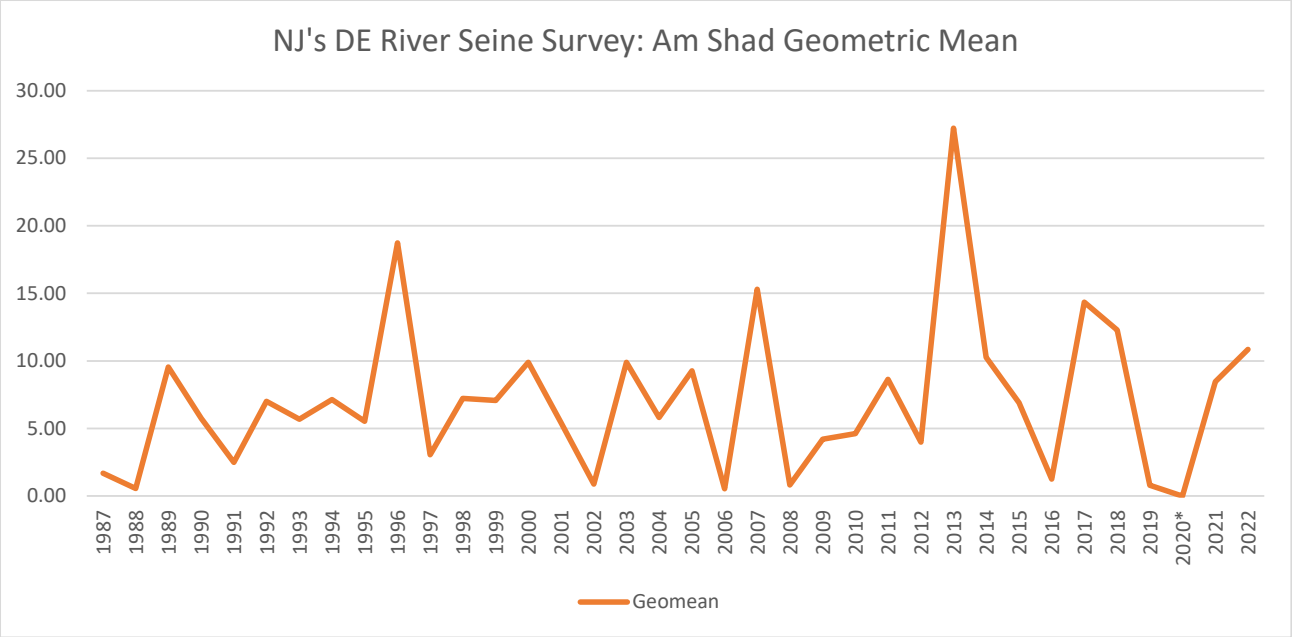


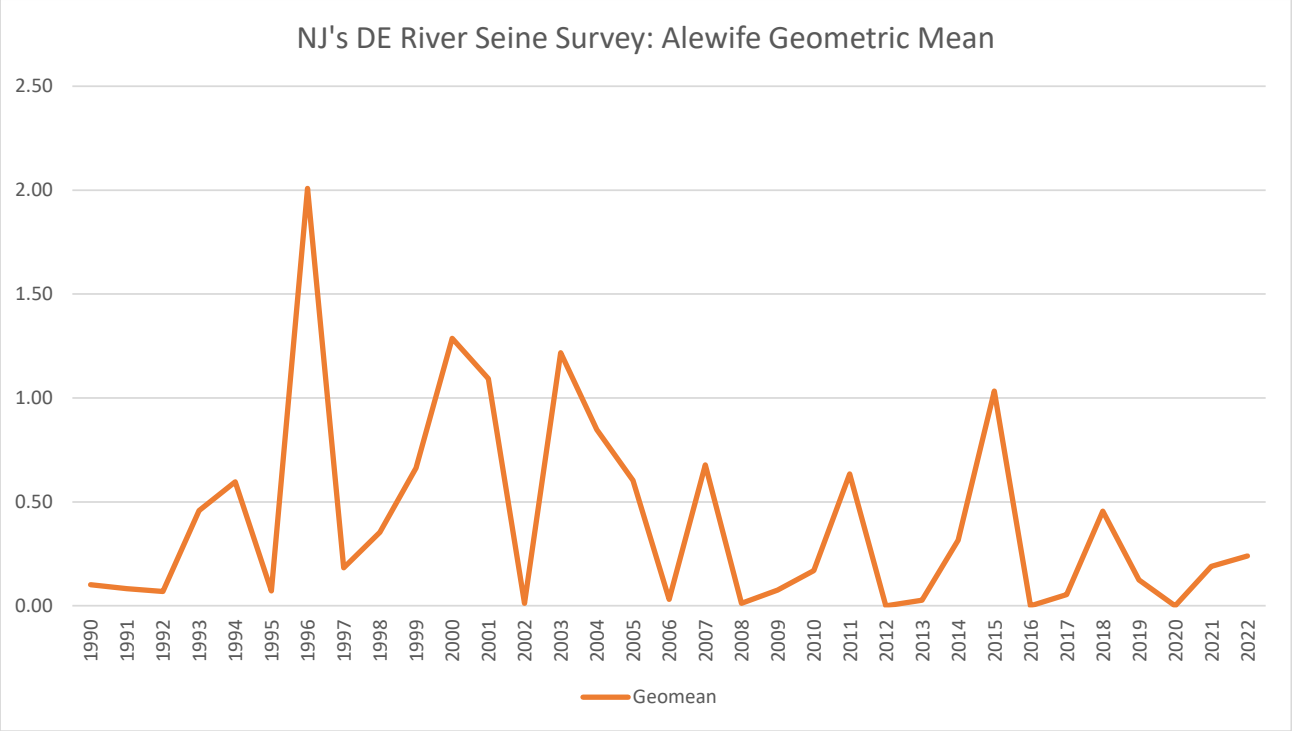
NJ Ocean Trawl Notes Highlights

No April cruise in 2019 (due to vessel/crew issues)
Only January cruise for 2020 (April to October cruises suspended due to COVID)
No sampling in 2021 (Again due to COVID)
No January cruise for 2022 (Sampling resumed in April)

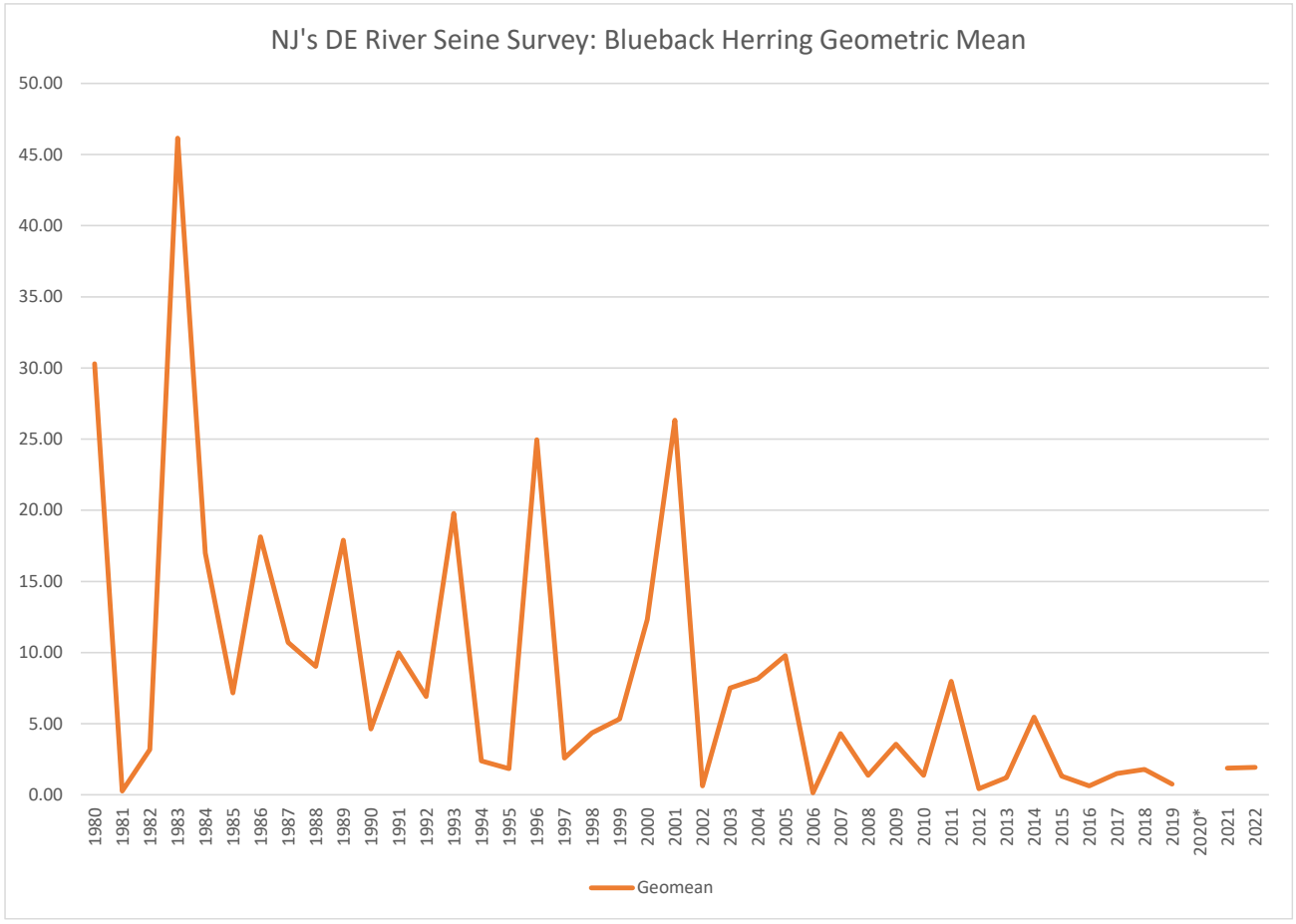
There was also a decrease in the number of samples in October 2022 from the normal 39 down to 30 samples due to budgeting issues.

NJ Upper Tidal Delaware River Seine (striped bass recruitment focus)





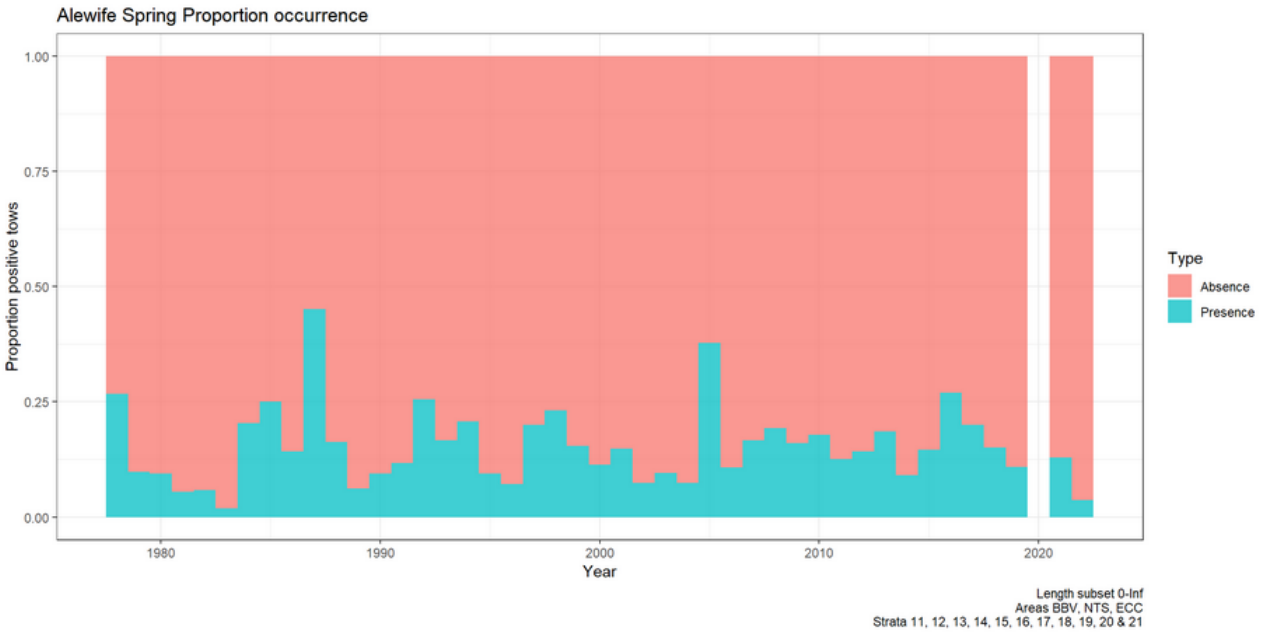
NJ Upper Tidal Delaware River Seine (striped bass recruitment focus)



Massachusetts Inshore Survey – through 2022

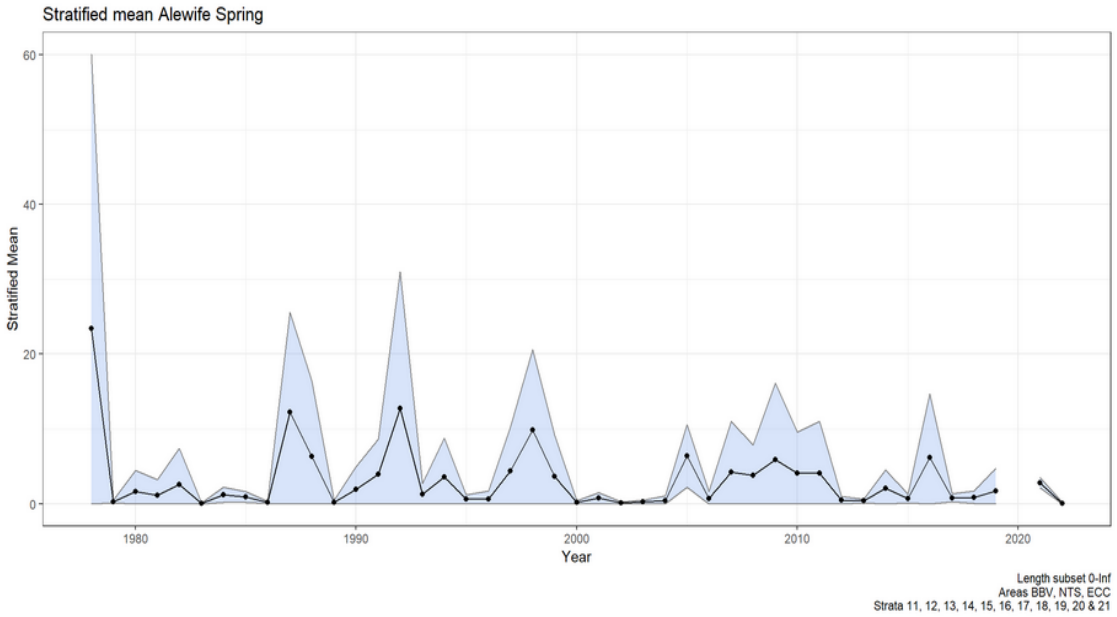
Alewife Spring Regions 1-3 (B. Bay/V. Sound/N. Sound/East of CC)

Percent occurrence by year



Stratified mean and 95% CI

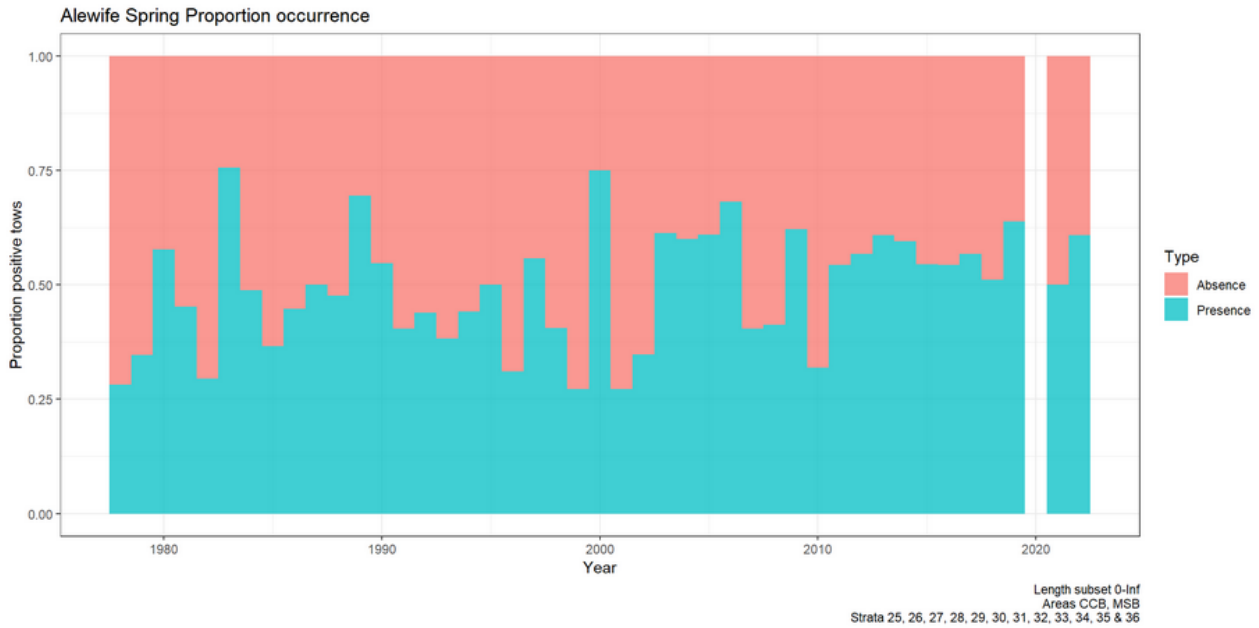
Numbers index



Massachusetts Inshore Survey – through 2022

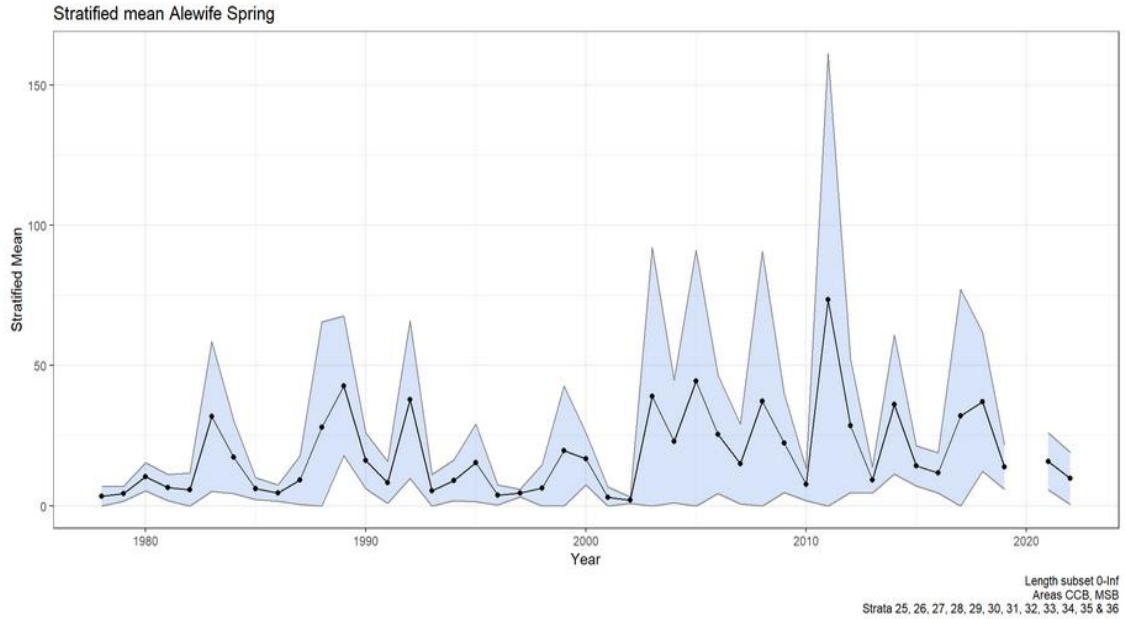
Alewife Spring Regions 4-5 (Cape Cod Bay/Mass Bay/Ipswich Bay)

Percent occurrence by year



Stratified mean and 95% CI

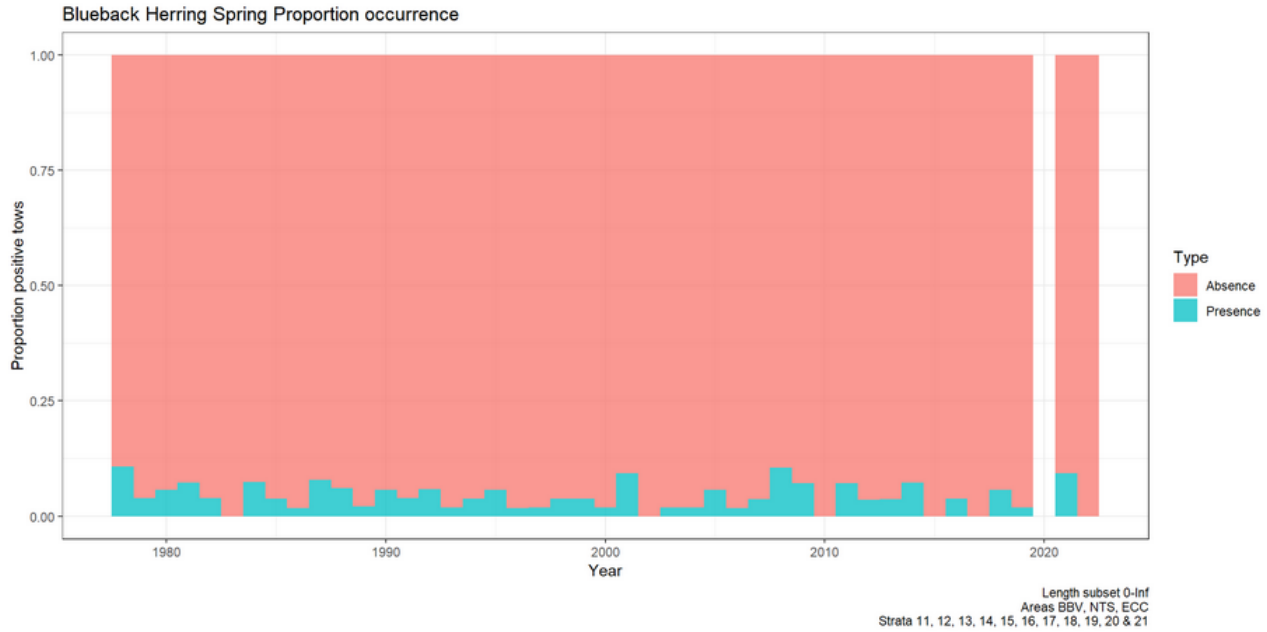
Numbers index



Massachusetts Inshore Survey – through 2022

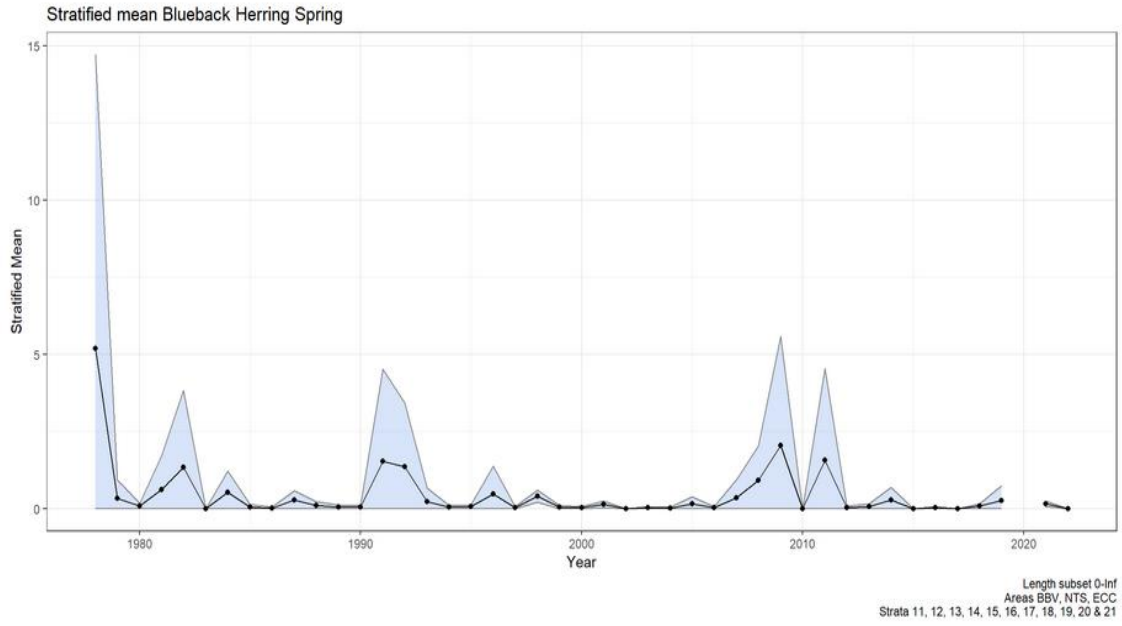
Blueback Spring Regions 1-3 (Cape Cod Bay/Mass Bay/Ipswich Bay)

Percent occurrence by year



Stratified mean and 95% CI

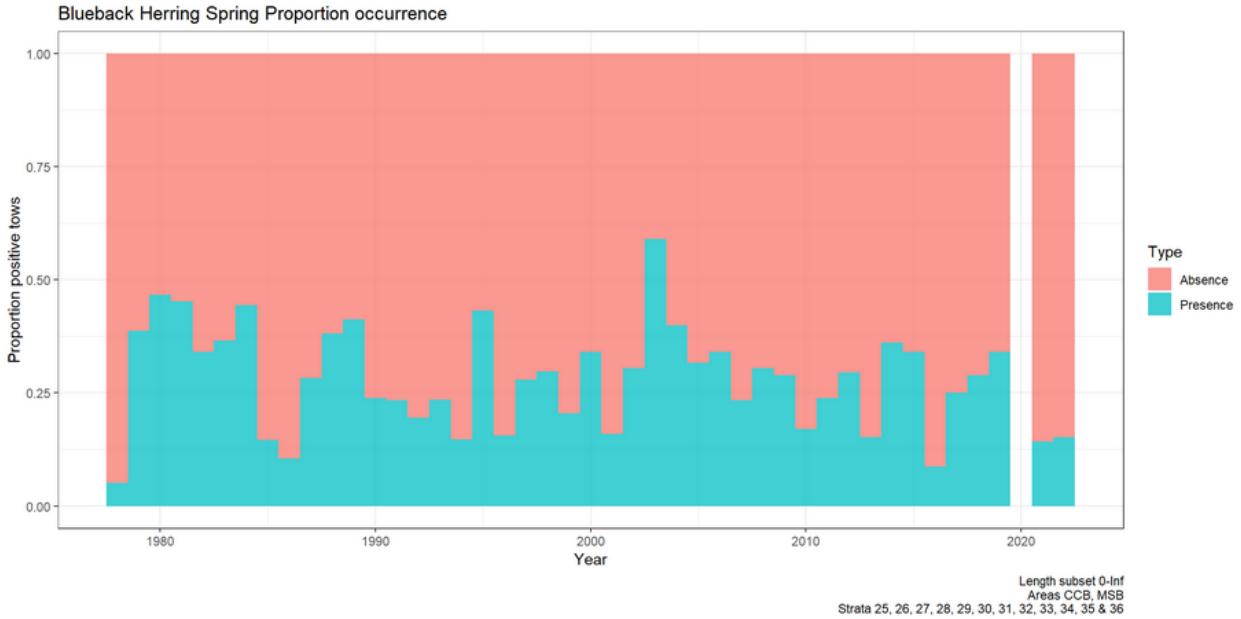
Numbers index



Massachusetts Inshore Survey – through 2022

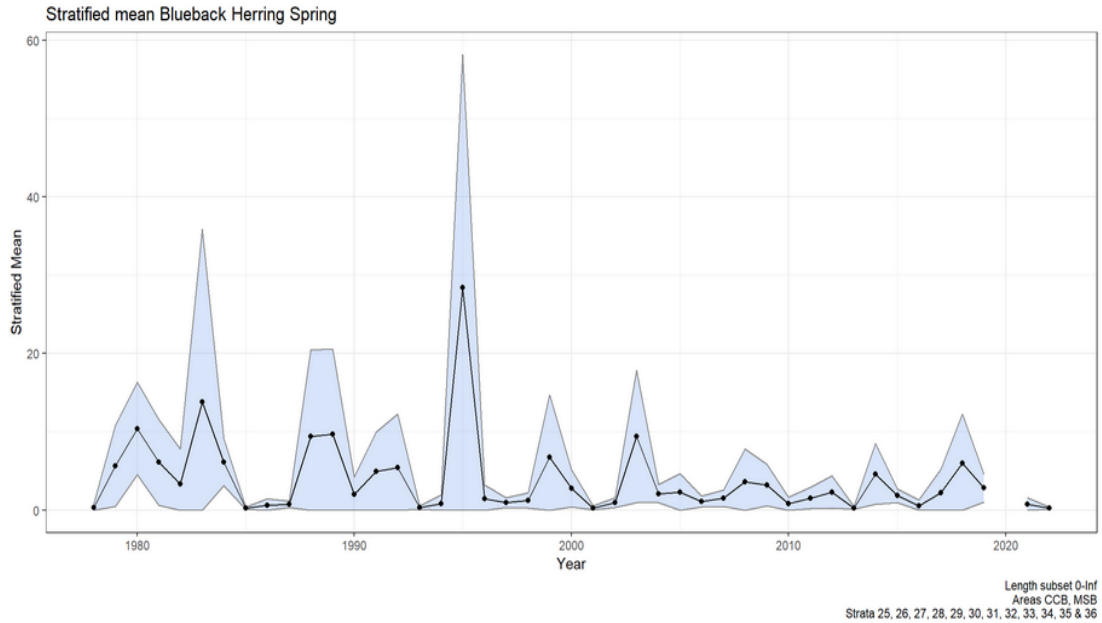
Blueback Spring Regions 4-5 (Cape Cod Bay/Mass Bay/Ipswich Bay)

Percent occurrence by year

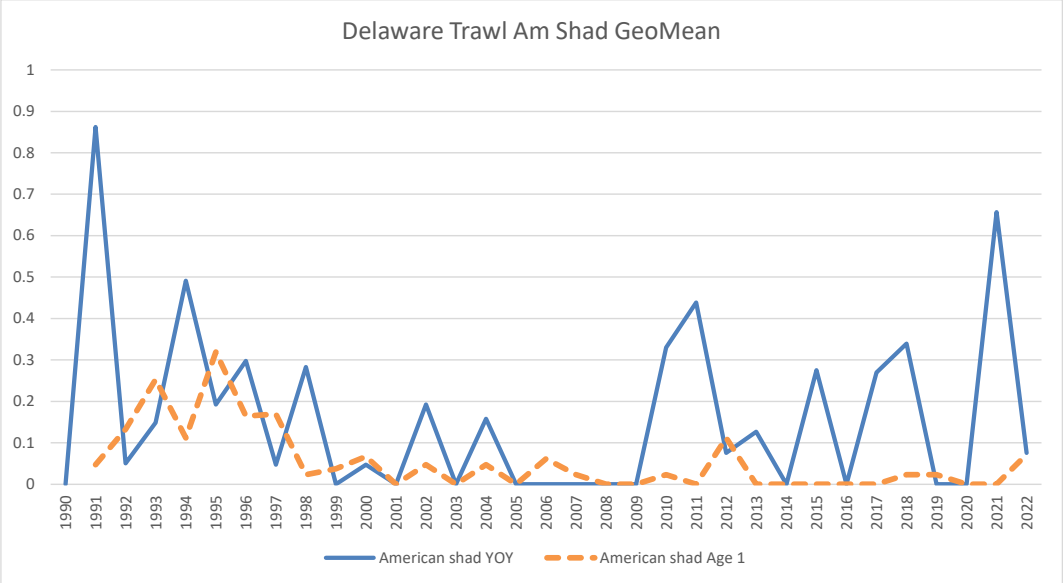


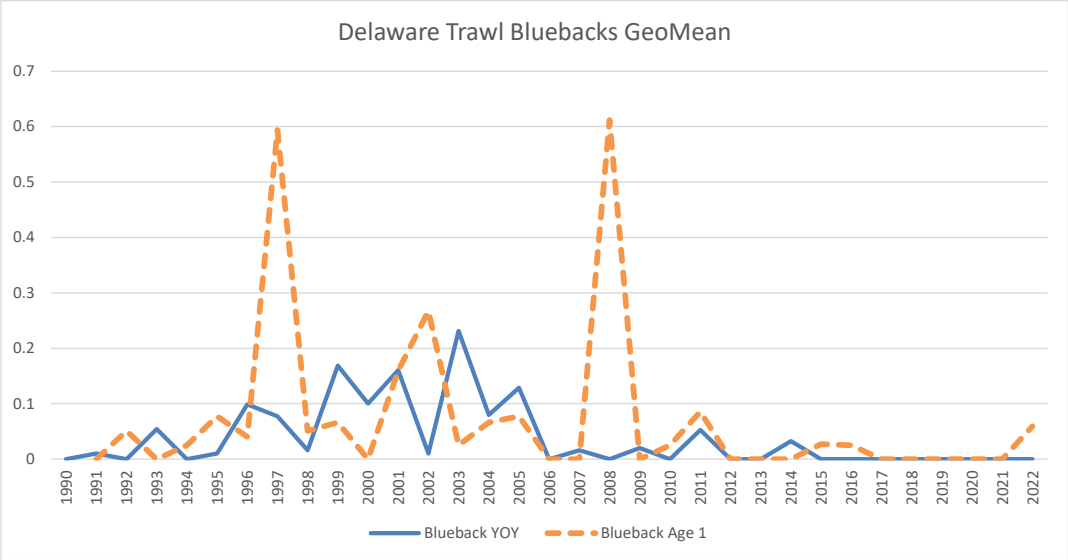
Stratified mean and 95% CI

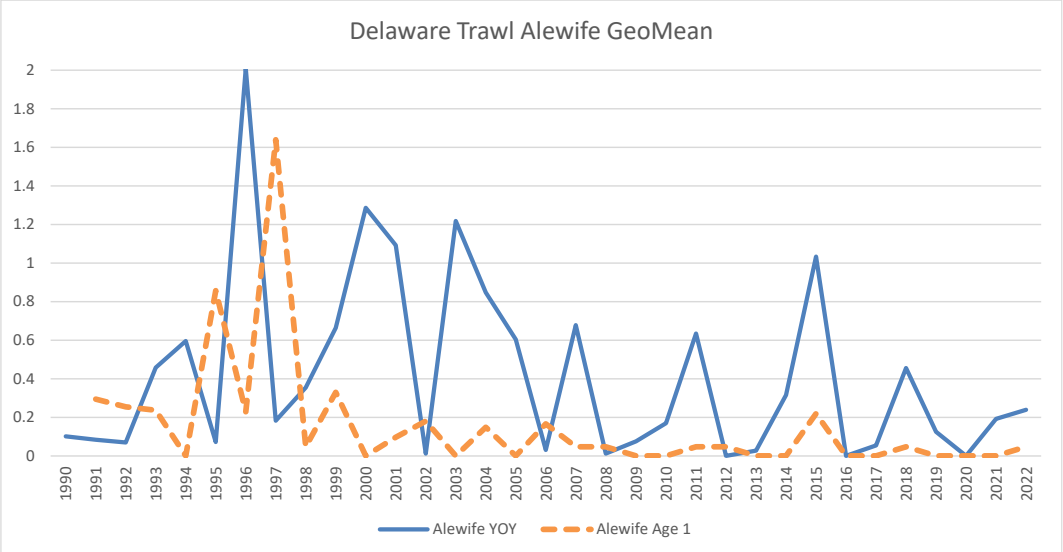
Numbers index



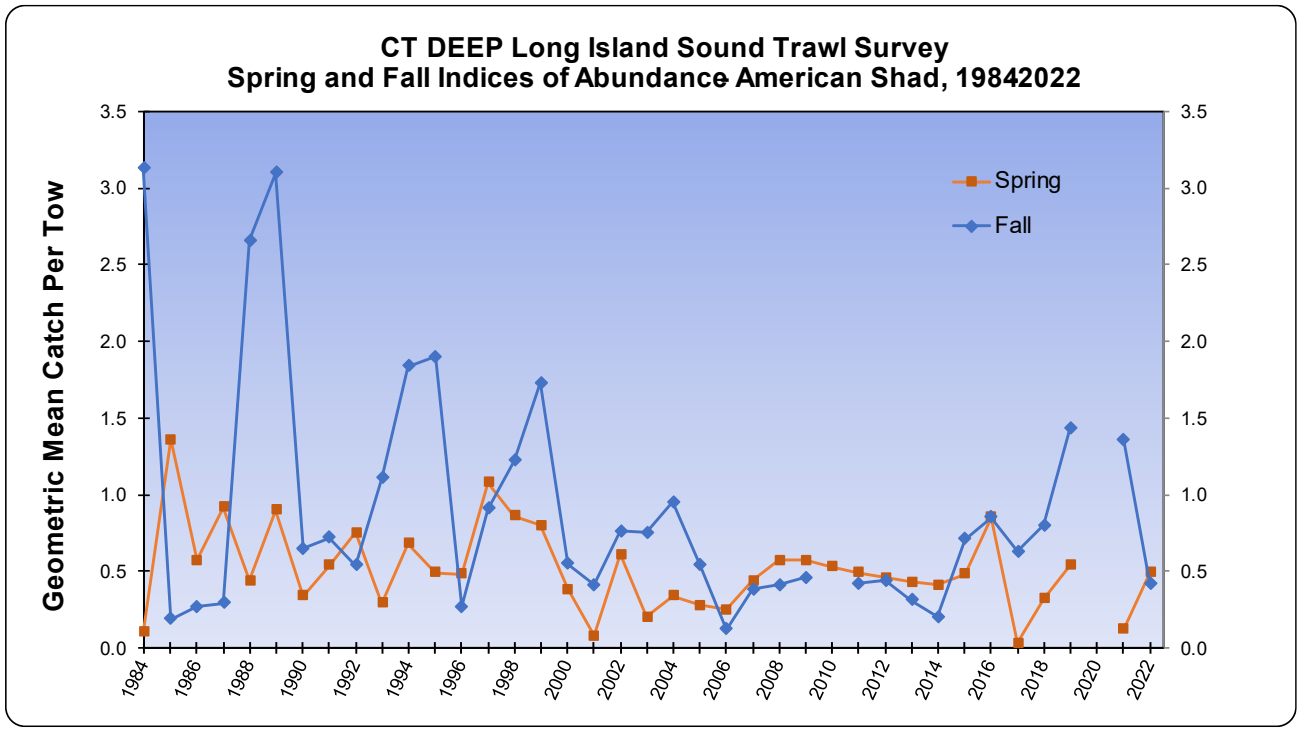
Delaware Trawl Survey – through 2022

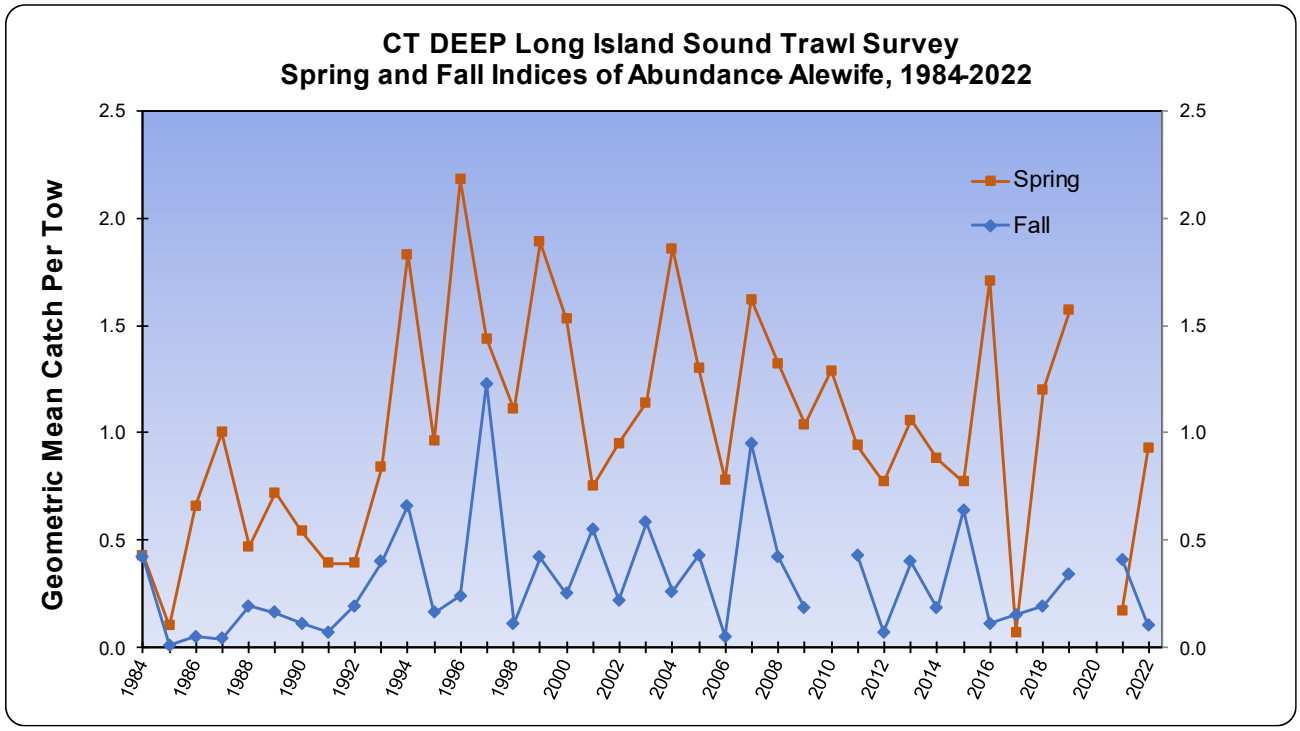




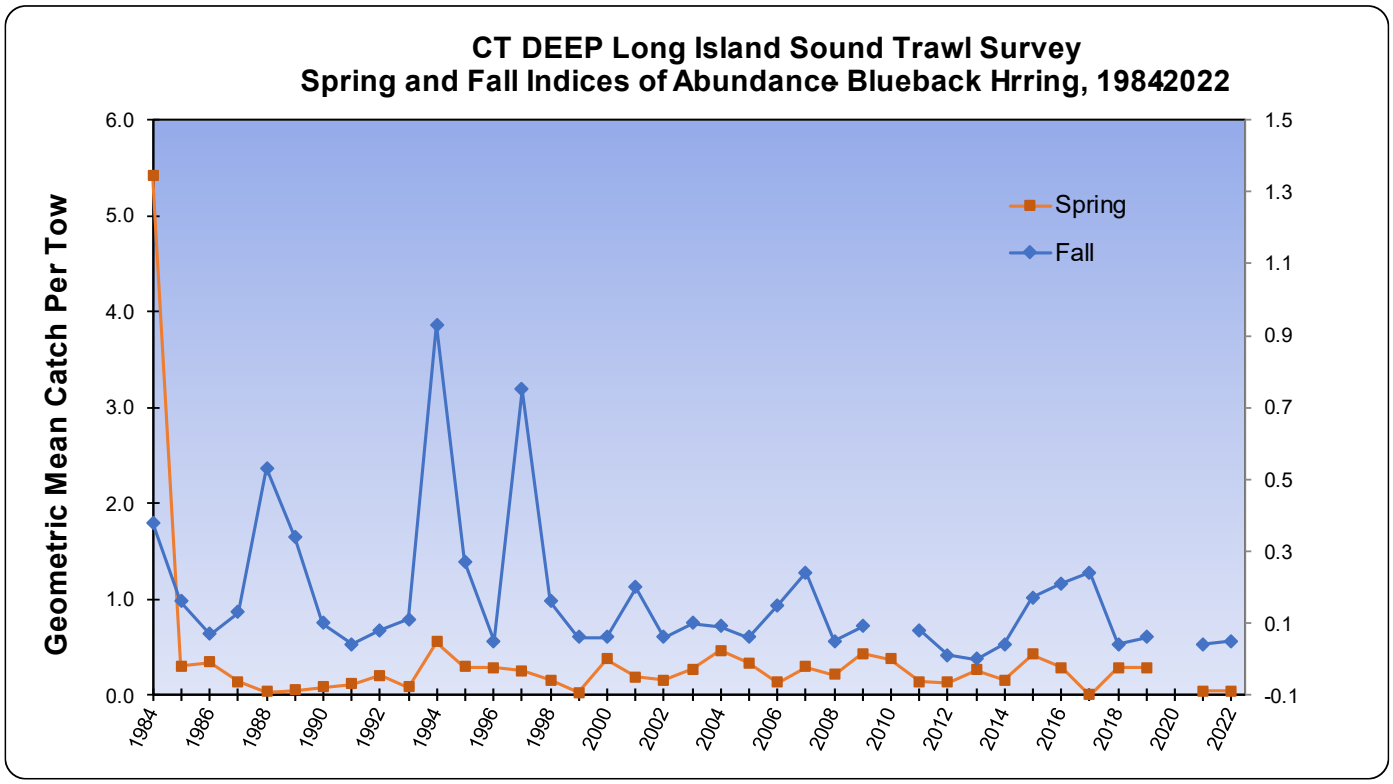


CT - Long Island Sound Indices – through 2022



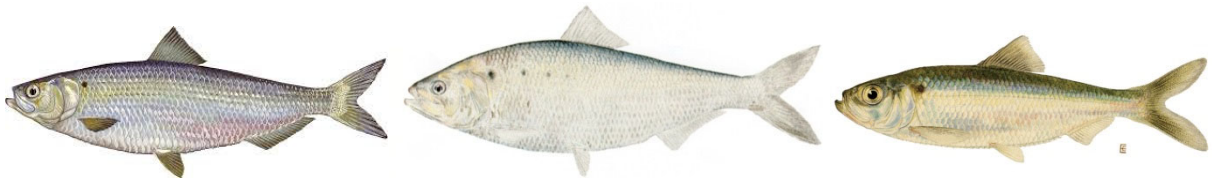


CT - Long Island Sound Indices – through 2022



Monitoring the Abundance of American Shad and River Herring in Virginia's Rivers

2022 Annual Report



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Funding Agencies:	US Fish and Wildlife Service Virginia Marine Resources Commission Virginia Institute of Marine Science
Contract Number:	F-116-R25
Project Period:	15 November 2021 - Nov 14, 2022
Principal Investigator:	Eric J. Hilton

Submitted To:

Virginia Marine Resources Commission
P.O. Box 756
Newport News, VA 23607-0756

21 January 2023

Summary

- This report describes the results of the twenty-fifth year of a continuing study to estimate the relative abundance and assess the status of American shad (*Alosa sapidissima*) stocks in Virginia by monitoring the spawning runs in the James, York and Rappahannock rivers in spring 2022, evaluating hatchery programs, and contributing to coast-wide assessments (ASMFC 2007, ASMFC 2020). We also report on two fishery-independent monitoring programs using anchor gillnets in the Rappahannock River (year 5) and the Chickahominy River (year 8; a major tributary of the James River), to determine relative abundance and stock structure for the adult spawning run of river herring (*A. pseudoharengus*, and *A. aestivalis*). Further, we report on the year 7 of a monitoring program for juvenile alosines by using nighttime surface trawls in the Chickahominy River and present an index of juvenile abundance from this survey. An additional result of this study was analysis of bycatch of American shad in a permitted gill-net fishery and American shad and river herring in pound-net fisheries.
- Sampling for American shad occurred for ten weeks on the James River (16 February to 21 April 2022), eleven weeks on the Rappahannock River (23 February to 1 May 2022), and nine weeks on the York River (17 February to 14 April 2022). One post-spawning female was observed on the York River on 14 April 2022. No post-spawning fish were observed on the James or Rappahannock rivers in 2022. Only pre-spawning females were included in the calculation of catch indices for each river. A total of 105 pre-spawning female American shad (137.8 kg total weight) were captured; this is a decrease in number from the 2021 catch (146 pre-spawning females; 200.4 kg total weight).
- Total numbers and weights of pre-spawning female American shad in 2022 were highest on the Rappahannock River (n=93, 121.9 kg). Numbers of females were lower on the York River (n=10, 13.4 kg). The lowest catches of females were recorded on the James River (n=2, 2.5 kg). Numbers of males captured were: Rappahannock, 5; James, 0; York, 1. Total weight of males captured on all rivers was 6.5 kg. The total catch and weight of males were lower than in 2021 (n=6, 6.6 kg).
- Based on age estimates from otoliths, the 2017 (age 5) year class of female American shad were the most abundant on the James, Rappahannock, and York and rivers. On the Rappahannock River, the total instantaneous mortality rate of females calculated from age-specific catch rates was 0.96 (r^2=0.89). Total instantaneous mortality rates of females on the James and York rivers could not calculated due to a lack of year-classes above age-5. Total instantaneous mortality rates of males were not calculated because all year classes present were not equally catchable by the sampling gear.
- Otoliths of 2 American shad captured on the James River were scanned for hatchery marks. The proportion of the sample with hatchery marks on the James River was 0.0% (0 of 2 fish). The last year of stocking on the Rappahannock River occurred in 2014. All American Shad captured on the Rappahannock in 2022 were from later year classes; therefore, specimens were not examined for hatchery marks. On the York River, there is currently no stocking of hatchery fish, and no specimens were examined from the York River in 2022.

- The geometric mean catches (followed by standard deviation and number of seine hauls in parentheses) of juvenile American shad captured in daylight seine hauls in 2022 were: James River (including Chickahominy River), 0 (NA, 65); Chickahominy River, 0 (NA, 10); Rappahannock River, 11.69 (1.37, 35); York River (including Mattaponi and Pamunkey Rivers), 0.25 (0.65, 95); Mattaponi River, 0.34 (0.73, 50); and Pamunkey River, 0.17 (0.58, 40).
- Thirteen species of fishes (total of 7,072 specimens) were counted as bycatch in the gill net monitoring gear. The total number of striped bass counted was 898 (James River, n=325; York River, n=166; Rappahannock River, n=407). Live striped bass captured in the gear were counted and released. A random subsample of dead striped bass was brought back to the laboratory for analysis. Sex, fork length, and total weight were recorded for each specimen. The proportions of dead striped bass on each river were: James River, 43.7%; York River, 30.7%; and the Rappahannock River, 47.9%.
- Three Atlantic sturgeon were captured as bycatch in the American shad sampling (James River, n=1; York River, n= 0; Rappahannock River, n=2).
- A seasonal catch index for American shad was calculated by estimating the area under the curve of daily catch versus day for the years 1998-2022 and for each year of the historical record of staked gill net catches on each river.
    - On the York River, the seasonal catch index in 2022 (0.32) decreased from the 2021 value (0.96). This is the lowest value of the 25-year time series. The geometric mean of the historical data during the 1980s on the York River is 3.22. The geometric mean of the current monitoring data is higher (3.42) but this mean is lower than the geometric mean of catch indexes from logbook records in the 1950s (17.44). These older data were adjusted for differences in the efficiency of multifilament and monofilament nets using the results of comparison trials in 2002 and 2003.
    - On the James River, the 2022 index (0.07) increased from the 2021 value of 0.06. This is the second lowest value of the 25-year time series. The geometric mean of the historical data during the 1980s on the James River is 6.40. The geometric mean of the current monitoring data is 2.25. In 2022 the hatchery prevalence was 0% (n=0). A correlation analysis among the catch index and hatchery prevalence from 1998-2022 was statistically not significant ($r = 0.21$, df = 23, $p = 0.31$). The strength of the spawning run index on the James River continues to depend heavily on the presence of hatchery fish.
    - The catch index on the Rappahannock River in 2022 (2.97) decreased from the 2021 value (3.56). With the exception of 2016, 2019, 2021, and 2022, the annual index value since 2011 has been above 4.0, with the highest value of the time series occurring in 2020. The geometric mean of the historical data during the 1980s on the Rappahannock River is 1.45. The geometric mean of the current monitoring data is higher (3.98).
- In 2022, gillnet sampling for river herring in the Chickahominy River occurred for thirteen weeks (2 February 2022 to 27 April 2022). A catch index for pre-spawning alewife and blueback herring was calculated for each species. Catches of alewife peaked 23 February.

After 16 March, post-spawning alewives were present in the sample. Catches of blueback herring peaked on 29 March. No post-spawning blueback herring were present in the sample. A total of 532 alewife (162 males; 370 pre-spawning females; 39 post-spawned females) and 116 blueback herring (29 males; 87 pre-spawning females; 0 post-spawned female) were captured.

- Using otolith-based ageing methods, the 2018-year class (age 4) of female alewife and the 2017-year class (age 5) of female blueback herring were dominant. The total instantaneous mortality rate of female alewife was 1.03. Total instantaneous mortality rate of female blueback herring was 0.97.

- The 2022 anchor gillnet seasonal catch indexes on the Chickahominy River, calculated by area under the CPUE curve: alewife, 1.58; blueback herring, 0.36. The index values were higher for alewife and blueback herring compared to the index values in 2021 (alewife, 0.97; blueback herring, 0.10).

- In 2022, the gillnet sampling season for river herring in the Rappahannock River occurred for fifteen weeks (3 February 2022 to 13 May 2022). A total of 509 alewife (190 males; 317 pre-spawning females; 2 post-spawned female) and 203 blueback herring (61 males; 142 pre-spawning females; 0 post-spawned female) were captured. Post-spawning female alewives were present in the sample after 12 April. No post-spawning blueback herring were present in the sample. Catches of alewife peaked on 9 March. Catches of blueback herring peaked on 12 April.

- Using otolith-based ageing methods, the 2018-year class (age 4) of female alewife and 2017-year class (age 5) of female blueback herring were dominant. The total instantaneous mortality rate of female alewife was 0.94. Total instantaneous mortality rate of female blueback herring was 1.15.

- The 2022 anchor gillnet seasonal catch indexes on the Rappahannock River, calculated by area under the CPUE curve: alewife, 3.16; blueback herring, 1.18. The index values were higher for alewife and blueback herring compared to the index values in 2021 (alewife, 1.21; blueback herring, 0.66).

- The geometric mean catches (followed by standard deviation or and number of seine hauls in parentheses) of juvenile alewife captured in daylight seine hauls in 2022 were: James River, 0.00 (NA, 10); York River, 0.03 (0.19, 55); Rappahannock River, 0.08 (0.32, 40). The geometric mean catches (followed by standard deviation and number of seine hauls in parentheses) of juvenile blueback herring captured in daylight seine hauls in 2022 were: James River, 0.19 (0.86, 40); York River, 0.05 (0.22, 35); Rappahannock River, 0.61 (1.15, 25).

- Catches in nighttime surface trawls on the Chickahominy River in 2022, were dominated by blueback herring (total alewife = 2; total blueback herring = 1233). The 2022 seasonal catch index (geometric mean of CPUE) was 5.1 (cruise specific catch index ranged from 1.9 – 15.5) for blueback herring. The 2022 seasonal catch index (geometric mean of CPUE) was 0.01 (cruise specific catch index ranged from 0 – 0.1) for alewife.

Preface

Concern about the decline in landings of American shad (*Alosa sapidissima*) along the Atlantic coast prompted the development of an interstate fisheries management plan (FMP) under the auspices of the Atlantic States Marine Fisheries Management Program (ASMFC 1999). Similarly, as early as the 1970s a substantial decline in the stocks of river herring coast wide was noted, and resulted in the ASMFC to require moratoria on fisheries unless stocks within a jurisdiction were shown to be sustainable (ASMFC 2009). Legislation enables imposition of federal sanctions on fishing in those states that fail to comply with the FMPs. To comply, coastal states are required to implement and maintain fishery-dependent and fishery-independent monitoring programs as specified by the FMPs. For Virginia, these requirements for American shad and river herring include spawning stock assessments, the collection of biological data on the spawning run (e.g., age-structure, sex ratio, and spawning history), estimation of total mortality, indices of juvenile abundance, biological characterization of permitted bycatch and evaluation of restoration programs by detection and enumeration of hatchery-released fish for American shad.

This annual report documents continued compliance with Federal law. Since 1998, scientists at the Virginia Institute of Marine Science have monitored the spawning run of American shad in the James, York, and Rappahannock rivers. The information resulting from this program is reported annually to the ASMFC, has formed the basis for a significant number of technical papers published in the professional literature, formed the basis for a recent coast-wide stock assessment and peer review for American shad (ASMFC 2007a, 2007b) and is contributing substantially to our understanding of the status and conservation of this important species.

A number of individuals make significant contributions to the monitoring program and the preparation of this report. Commercial fishermen Raymond Kellum, Steve Kellum, Marc Brown and Jamie Sanders have participated in the sampling program since its beginning in 1998. Their contributions as authors of historic log books of commercial catches during the 1980s and as expert shad fishermen are essential elements of the monitoring program. George Trice, Hunter Sanders, and Jamie Sanders currently construct, set, and fish the sampling gear and offer helpful advice. We also extend our appreciation to several commercial fishers for their cooperation in our studies of bycatch of American Shad. In 2022, these individuals include: George Trice, John Dryden, Walter Rogers, and JC West. In 2022, the staff of the Virginia Institute of Marine Science who participated in the program were: T. Hoyt, A. Magee, P. McGrath, and S. Muffelman. Their dedication, consistent attention to detail and hard work in the field and in the laboratory are appreciated. A. Magee determined ages of adult shad. P. McGrath determined ages of adult river herring. A. Magee determined the spawning phenology of American shad and river herring. A. Magee determined hatchery origins of adult fish. Fish products from this program are donated to the Food Bank at Gleaning Baptist Church of Gloucester, Virginia. We offer thanks to the Hunters for the Hungry (Virginia Hunters Who Care) organization for their assistance.

Introduction

This report describes the results of a continuing study to estimate the relative abundance and assess the status of American shad (*Alosa sapidissima*) stocks in Virginia by monitoring the spawning runs in the James, York and Rappahannock rivers in spring 2022, evaluating hatchery programs and contributing to coast-wide assessments (ASMFC 2007a; ASMFC 2020). We also report on a fishery-independent monitoring program to determine abundance and stock structure of river herring (*A. pseudoharengus*, and *A. aestivalis*) in Virginia by evaluating the adult spawning runs in the Chickahominy River, a major tributary of the James River, and the Rappahannock River. Further, a recently added objective of this study was to complement the monitoring of the adult spawning population of American shad and river herring in the James River system by monitoring juvenile alosines by using nighttime surface trawls in the Chickahominy River and calculate an index of juvenile abundance. Additional objectives were to monitor bycatch of American shad in a permitted gillnet fishery and American shad and river herring in pound net fisheries.

American shad. A moratorium on the taking of American shad in the Chesapeake Bay and its tributaries was established by the Virginia Marine Resources Commission (VMRC) beginning 1 January 1994. The prohibition applied to both recreational and commercial fishers. The moratorium was imposed at a time when commercial catch rates of American shad in Virginia's rivers were experiencing declines, especially in the York River. Data from the commercial fishery were the best available for assessing the status of individual stocks. Catch-per-unit-effort data were compiled from logbooks that recorded landings by commercial fishermen using staked gillnets at various locations throughout the middle reaches of the three rivers. The logbooks were voluntarily provided to the Virginia Institute of Marine Science (VIMS) during the period 1980-1993, and subsequently used in an assessment of the status of American shad stocks along the Atlantic coast by the Atlantic States Marine Fisheries Commission (ASMFC) (Crecco 1998, ASMFC 1998, Olney & Hoenig 2001a).

Prior to 1998, there were no existing monitoring programs that provided direct assessment of American shad stock recovery in Virginia. The ban on in-river fishing remained in effect, creating a dilemma for managers who needed reliable information in order to make a rational decision on when the in-river ban could be lifted safely. To address this deficiency, VIMS initiated scientific monitoring to estimate catch rates relative to those recorded before the prohibition of in-river fishing in 1994 (Olney & Hoenig 2001a). This monitoring program consisted of sampling techniques and locations that were consistent with, and directly comparable to, those that generated historical logbook data collected by VIMS during the period 1980-1993 in the York, James and Rappahannock rivers. The results of the first eight years of monitoring (1998-2005) formed the basis for recent stock assessments for American shad (ASMFC 2007; 2020). The conclusions of the 2007 assessment were that the James River stock remains at a low level of abundance and requires further protection and restoration; the Rappahannock River stock is stable with recent evidence of increasing abundance; in the York River, catch indexes have been trending downward but there is evidence of some recovery from the severe declines in the 1980s. The conclusions related to the adult mortality and abundance of American shad in Virginia's rivers resulting from the 2020 assessment were as follows: for the Rappahannock River and York River, mortality was considered sustainable, although no trend in abundance was detected since the 2007 assessment; and for the James River adult mortality was unknown (for the last three-year period mortality could be calculated, this was

considered sustainable), but as for the other rivers, there was no trend in adult abundance. Since 2017 (the last year of monitoring data to be incorporated into the 2020 assessment), catch indexes have remained at low levels in both the James and York rivers. The VMRC has not lifted the ban on recreational or commercial fishing, and asked that the monitoring program be continued.

River herring. River herring, including alewife (*Alosa pseudoharengus*) and blueback herring (*A. aestivalis*), were once the most valuable food fishes in Virginia (Atran et al. 1983). These species experienced decline in their value to the fisheries resources of Virginia, and as early as the 1970s a significant decline in the stocks of these fishes was noted. This range-wide decline of stocks culminated in the ASMFC requiring moratoria on fisheries unless stocks within a jurisdiction were shown to be sustainable (ASMFC 2009). Due in part to lack of available data to address the question of sustainability of river herring stocks in the Commonwealth, the VMRC implemented a ban on the possession of alewife and blueback herring to begin January 1, 2012. The ASMFC conducted a stock assessment for river herring that was completed in 2012 (ASMFC 2012), and which concluded that stocks coast-wide are at or near historically low levels. Due to this observed decline of river herring range-wide, the National Marine Fisheries Service (NMFS) received a petition from the Natural Resources Defense Council (NDRC) on August 5, 2011 (Federal Register, vol. 76, no. 212, Nov. 2, 2011) to list river herring, inclusive of both species, as Threatened under the Endangered Species Act (ESA). Although listing was not found to be warranted at the present time (Federal Register, vol. 78, no. 155, Aug. 8, 2013), this process highlighted the need for further data collection for many stocks of river herring, including those in Virginia.

General alosine information needs. In addition, there are other significant information needs relevant to American shad, river herring, or both in Virginia:

1. Extensive efforts have been made to rehabilitate the stocks of American shad through release of hatchery-raised fish. Evaluating the success of these programs is an ASMFC mandate and requires determination of the survival of the stocked fish to adulthood.
2. VMRC specifies a bycatch allowance of American shad in certain commercial fisheries. Bycatch of American shad currently exists in the Virginia commercial striped bass fishery, where mortality is presumed to be high. The VMRC regulation permits a limited number of commercial fishers to utilize this bycatch by selling fish in certain regions of each river. The ASMFC requires monitoring the biological characteristics, hatchery prevalence and magnitude of this harvest.
3. There is a need to evaluate mixed stock contributions to the pound net bycatch in Virginia's portion of Chesapeake Bay. Preliminary evidence using hatchery marks confirms that this bycatch includes adult shad from upper Bay stocks (Hoenig et al. 2008). Geochemical signatures in otoliths can be used to determine natal origins of American shad and estimate mixed stock contributions. This powerful technique has been validated in a study by Walther et al. (2008).
4. By the Treaty of 1677, Virginia tribal governments exercise their fishing rights in the York River and elsewhere. Brood stock is collected to support the activities of hatcheries on the Pamunkey and Mattaponi rivers. The total harvest of American shad is currently unknown but believed to be small. Detailed information concerning this harvest and its characteristics could aid future stock assessments.

The ongoing monitoring of American shad and river herring in Virginia waters is directly significant to recreational fisheries and the ecological health of the river systems that support these important fisheries for at least five reasons:

1. American shad fight well when angled using light tackle and were pursued by recreational fishermen in Virginia in the past, but the extent and success of this activity is not easily assessed. Recreational fishers catch and release shad on the James, Rappahannock, Mattaponi, Piankatank and Nottaway rivers; under moratorium, fishermen are not permitted to keep these fish. A recreational shad fishery in Virginia would constitute an important opportunity to expand or restore recreational fishing opportunities if the Chesapeake stocks are rehabilitated and managed carefully.
2. Until the moratorium took effect in 2012, river herring were recreationally harvested in Virginia's rivers. Lack of scientific data on the status of river herring stocks has been cited as a contributing factor for the inability to determine the sustainability of the stocks in Virginia, which led to the moratorium. This study addresses that shortcoming with the goal of informing management agencies for the objective of rebuilding river herring stocks to lift the moratorium.
3. American shad and river herring are important for trophic and ecological reasons. The abundance of juveniles is closely linked to water quality and the availability of good fish habitat. The shads and river herrings form an important prey group for striped bass and other recreationally important species in Chesapeake Bay. In recent years, there have been shifts in community structure in the major tributaries to the Bay with striped bass and gizzard shad numbers increasing greatly. Monitoring changes in abundance of key species is essential for understanding community dynamics.
4. This study characterizes the bycatch associated with commercial fisheries for American shad and river herring in Virginia's rivers. This is important for determining the impact of reopened commercial fisheries for shad and river herring on other recreationally important species, especially striped bass, as well as protected species such as Atlantic sturgeon.
5. Considerable effort and sport fishing funds have been devoted to enhancement of shad stocks through hatchery programs. This monitoring program provides an opportunity to identify returning hatchery fish. This is important for determining benefits to recreational fishers from the program. From 2004 until 2014, a hatchery-release program for American shad began on the Rappahannock River. This restoration effort is designed specifically for enhancement of recreational fishing and restoration of historic spawning habitat.

Background

American shad and river herring have supported recreational and commercial fisheries along the east coast of the United States and within the Chesapeake Bay since colonial times. Here we provide a brief review of the status and current regulations for American shad and river herring. See Atran et al. (1983), Loesch and Atran (1994), and Hilton et al. (2013) for further background on the stocks, fisheries, and management of these fishes in Virginia.

American shad. Concern about the significant decline in landings of American shad along the Atlantic coast prompted the development of an interstate fisheries management plan under the auspices of the ASMFC (ASMFC 1999). Prior to 1991, there were no restrictions on the American shad commercial fishery in Virginia's rivers and the Chesapeake Bay. A limited season (4 Feb - 30 Apr) was established for 1991 by the Virginia Marine Resources Commission (VMRC), and kept in place in 1992. In 1993, a further limitation to the season was established (15 Mar - 15 Apr 1993). However, due to bad weather conditions, the season was extended through 30 Apr. A complete moratorium was established in 1994.

In 1997 and 1998, during a series of public hearings, commercial and recreational fishing interests asked that the in-river ban on shad fishing be lifted. This proposal was opposed by the VMRC staff, VIMS fishery scientists, and various other public and private agencies. The Commission decided to leave the ban in place but also decried the lack of information necessary to assess the recovery of Virginia stocks of American shad. The current monitoring project began in the spring of 1998 in response to the VMRC's request for information. The initial results of the program provided the basis for the Commission to uphold the ban in December, 1998. The VMRC requested that VIMS continue its monitoring and stock assessment activities.

In 2003 and again in 2005, the ASMFC shad and river herring technical committee considered VMRC proposals for allowance of shad caught as bycatch. VMRC proposed to permit Virginia fishermen to retain American shad, caught as bycatch in Chesapeake Bay and tributary waters. The technical committee did not support either proposal. Members expressed concerns that the proposals included the catches of mixed stocks, had the potential to harvest substantial number of fish, and had the potential to impact other stocks which are under intensive restoration. A modified version of the 2006 proposal was subsequently approved by the Shad and River Herring Management Board. Since this date, bycatch allowances have been continually approved by the Management Board. In addition, VIMS has monitored bycatch of American shad in pound nets located off Reedville, Virginia annually since 2002, and at the mouth of the Rappahannock River since 2007. In this program, samples of up to 50 American shad are collected and returned to VIMS for biological analysis.

The current regulation (effective date January 1, 1994) states that: "It shall be unlawful for any person to catch and retain possession of American shad from the Chesapeake Bay or its tidal tributaries" (VMRC Regulation 4 VAC 20-530-10 ET SEQ) except as specified, related to a bycatch fishery allotment (as amended March 1, 2013).

Under Amendment 3 of the Interstate Fishery Management Plan for American Shad and River Herring (ASMFC 2010), Virginia is mandated to conduct the following, for the Rappahannock, York, and James rivers:

1) Annual spawning stock survey to include passage counts, CPUE, or some other abundance index and representative subsamples that describe size, age, and sex;

2) composition of the spawning stock;
3) calculation of mortality and/or survival estimates where possible;
4) juvenile abundance survey (GM);
5) hatchery evaluation.

River herring. The most recent stock assessment for river herring concluded that stocks coast wide are severely depleted (ASMFC 2017). As early as the 1970s a substantial decline in the stocks of river herring coast wide was noted, and resulted in the ASMFC to require moratoria on fisheries unless stocks within a jurisdiction were shown to be sustainable (ASMFC 2009). Due in part to lack of available fishery-independent data to address the question of sustainability of river herring stocks in the Commonwealth, the VMRC voted to implement a ban on the possession of alewife and blueback herring to begin January 1, 2012.

The current regulation (effective date January 1, 2012) states, in part, that "It shall be unlawful for any person to catch and retain possession of any river herring from Virginia tidal waters." (VMRC Regulation 4 VAC-20-1260-30).

Amendment 2 of the Interstate Fishery Management Plan for Shad and River Herring (ASMFC 2009: table 15) mandates the following fishery-independent monitoring of river herring in Virginia (including the James, York, and Rappahannock rivers):

1) Annual spawning stock survey and representative sampling for biological data (excluding York River);
2) calculation of mortality and/or survival estimates;
3) calculation of juvenile abundance indices (JAI) as a geometric mean.

Current Information

Historic and current catch data can be accessed through the VMRC website (http://www.mrc.state.va.us). Annual monitoring of the abundance of juvenile *Alosa* spp. (American shad, hickory shad, blueback herring and alewife) was conducted on the York River system with a push net developed in the late 1970s (Kriete and Loesch, 1980) until 2002. The data record extends back to 1979 but sampling was not conducted during 1987-1990. The push net survey was terminated in 2002 when it was determined that the survey results were highly correlated with those of the striped bass seine survey (Wilhite et al., 2003). Although fewer individual fish are collected each year in the seine survey as compared to the evening push net survey, the seine survey has larger geographic coverage (all three rivers in Virginia vs. the Mattaponi and Pamunkey Rivers only) and the data record is uninterrupted since 1979. A fishery-independent survey program for monitoring the spawning stocks of river herring in Virginia employing a drift gillnet was implemented on the Chickahominy River from 2014 to 2016. In 2015, an anchor gillnet fishery-independent survey was also implemented on the Chickahominy River to monitor the spawning stocks of river herring. Currently, there is a moratorium on both river herring species (i.e., no fishery-dependent data are available).

Since the alosine monitoring program at VIMS began in 1998, 28 papers on various aspects of the biology of American shad and the VIMS stock assessment program have appeared in peer-reviewed journals (Maki et al., 2001; Olney et al., 2001; Olney and Hoenig, 2001a; Maki et al., 2002; Bilkovic et al., 2002a, 2002b; Olney and McBride, 2003; Olney et al., 2003; Walter and Olney, 2003; Wilhite et al., 2003; Olney 2003b; Hoffman and Olney, 2005;

McBride et al., 2005; Maki et al., 2006; Olney et al., 2006a, b; Hoffman et al. 2007a, b; Hoffman et al. 2008, Walther et al. 2008; Hoenig et al. 2008; Aunins and Olney 2009; Tuckey and Olney, 2010; Latour et al. 2012; Upton et al. 2012; Hyle et al. 2014; McGrath et al., 2022). Reprints of these papers are available on request. The 1998-2021 results of the monitoring program are reported by Olney & Hoenig (2000a, b, 2001b), Olney & Maki (2002), Olney (2003a, 2004, 2005), Olney & Delano (2006, 2007), Olney & Watkins (2008, 2009), Olney et al. (2010), and Hilton et al. (2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021).

VIMS' authors contributed to peer-reviewed sections of the most recent stock assessment for American shad (Olney 2007; Olney et al. 2007; Carpenter et al 2007; also contributing to the ongoing assessment) and river herring (Lee et al., 2012; updated by Hilton for the 2017 stock assessment). The current monitoring program has also served as the basis for several theses and dissertations, including a study of the reproductive biology of American shad in the Mattaponi River (Hyle, 2004) and a description of the spawning grounds of American shad in the James River (Aunins 2006). Two additional studies formed the basis for a thesis and a dissertation that were supported in part by the monitoring program: a validation of age determination of American shad using otolith isotopes as natural tags (Upton 2008) and a study of the population dynamics of juvenile *Alosa* spp. in Virginia rivers (Tuckey 2009). Finally, these monitoring data have been used in a recent revision of the on-line Chesapeake Bay Report presented annually by the Chesapeake Bay Program of the Environmental Protection Agency (http://www.chesapeakebay.net), and will be incorporated into the formulation of a recovery plan for American shad in the James River. Results of this project may also support a petition to ASMFC for a limited commercial fishery for river herring in the Chickahominy River. Bycatch of Atlantic sturgeon is recorded and these data are reported to ASMFC.

Objectives

The primary objectives of the monitoring program (1) to continue a time series of relative abundance indices and biological structure of adult American shad during the spawning runs in the James, York and Rappahannock rivers and to establish a time series of relative abundance indices and biological structure of adult river herring in the Chickahominy and Rappahannock rivers; (2) to relate contemporary indices of abundance of American shad to historical logbook data collected during the period 1980-1992 and older data if available; (3) to assess the relative contribution of hatchery-reared and released cohorts of American shad to adult stocks; (4) to relate recruitment indexes (young-of-the-year index of abundance) of American shad and river herring to relative year-class strength and age-structure of spawning adults; (5) to determine the amount of bycatch of other species in the staked gill nets for American shad; and (6) to monitor the American shad bycatch fishery established by the VMRC. The results of this bycatch monitoring in 2022 are provided here as an appendix comprising a report on this fishery to the ASMFC (Appendix I).

Methods

Collection and processing of adult American shad

The 2022 sampling methods for the American shad monitoring program in the Rappahannock river followed those employed in 1998-2021 (see Appendix I for additional methods used to monitor the bycatch fishery), with the exception that effort was reduced from two to one day per week in 2015. In 1998, a sentinel fishery was developed that was as similar as possible to traditional shad fishing methods in the middle reaches of Virginia's rivers. When the in-river fishing moratorium was imposed in 1994, commercial fishermen who held permits for existing stands of staked gill nets (SGNs) were allowed to retain priority rights for the locations of those stands in the various rivers. VIMS has records of the historic fishing locations (Figures 1-3), and one of these locations on each river was used to monitor catch rates by SGNs from 1998 to 2019 on the James, 2020 on the York, and the present day on the Rappahannock. Mr. Jamie Sanders and Mr. Hunter Sanders were contracted to prepare and set SGN poles, hang nets, replace or repair poles or nets, and set nets for each sampling event during the monitoring period on the Rappahannock River. In 2020, the James River SGN was discontinued due to contractor health and logistical reasons. Starting in 2020, sampling on the James River was conducted using anchored gillnets by Mr. George Trice (Poquoson, Virginia). In 2021, the York River SGN was also discontinued due to logistical reasons. In 2021 and 2022, sampling was conducted using anchored gillnets by Mr. George Trice. Scientists accompanied commercial fishermen during each sampling trip and all catches were returned to the laboratory for analysis.

One SGN, 912 ft (approximately 277 m) in length, was set on the Rappahannock River (Figure 6). In the James and York rivers, three anchored gillnets (AGN), each 300 ft (~92 m) in length, were set. (Figures 4,5) While this is inconsistent with past years for the James and York river, it was a necessary evolution of our approach to monitoring. We attempted to continue SGN fishing in the James and York rivers but were unable to secure new contractors. Staked gillnets have become infrequently used by commercial fishermen in the main rivers due to the logistical constraints (e.g., cutting down 30-ft tall trees for use as poles and bringing them into the river, and danger, having to hand drive poles into the sediment deep enough to withstand storms and high current). Current fisheries that use the fixed gear are minimal and further lower the number of fishermen utilizing staked gillnets. The availability of contractors with SGN experience continues to decline and has become absent in some regions. Anchored nets, which are both logistically easier to set and allow fishermen more flexibility, are currently the most utilized gear for most gillnet fisheries in Chesapeake Bay. Locations of the nets were as follows: middle James River at river mile 37 (37° 10.2' N, 76° 45.3' W); middle York River near York River State Park at river mile 23 (37° 24.0' N, 76° 41.1' W); and middle Rappahannock River near the Downing bridge (at Tappahannock, Virginia) at river mile 36 (37° 55.9' N, 76° 50.4' W). Historical catch-rate data on the York and James rivers were derived from nets constructed of 4 7/8" stretched-mesh monofilament netting, while historic data from the Rappahannock River were based on larger mesh sizes (nets constructed of 5" stretched-mesh). To ensure that catch rates in the current monitoring program were comparable to logbook records, the nets on the York and James rivers were constructed of 4 7/8" (12.4 cm) stretched-mesh monofilament netting, while nets on the Rappahannock River were constructed of 5" (12.7 cm) netting. Panel lengths were consistent with historical records (48 ft [14.63 m] each) on the Rappahannock

River. Each week, nets were fished for one day (i.e., a 24-h set) and then either removed or hung in a non-fishing position until the next sampling episode. Occasionally, weather or other circumstances prevented the regularly scheduled sampling on Sunday, and sampling was postponed, canceled or re-scheduled for another day. In 2022, sampling occurred for eleven weeks on the Rappahannock River (23 February to 1 May 2022); nine weeks on the York River (17 February to 14 April 2022); ten weeks on the James River (16 February to 21 April 2022). Surface water temperature and salinity were recorded at each sampling event.

Individual American shad collected from the monitoring sites were measured and weighed on an electronic fish measuring board interfaced with an electronic balance. The board recorded measurements (fork length (FL) and total length (TL)) to the nearest mm, received weight input to the nearest g from the balance, and allowed manual input of additional data (such as field data and comments) or subsample designations (such as gonad tissue and otoliths) into a data file for subsequent analysis.

Sagittal otoliths were removed from samples of adult American shad, placed in numbered tissue culture trays, and stored for subsequent screening for age determination and hatchery marks. To determine ages, otoliths were submersed in water with the sulcus facing downward, and viewed under a stereomicroscope with reflected light and a magnification of 2.0x. Ages were determined by three individuals (P. McGrath, A. Magee & T. Hoyt) using methods recommended by the ASMFC (ASMFC 2014). To scan for hatchery marks, otoliths were mounted on slides, then ground and polished by hand using wet laboratory-grade sandpaper. Otolith scanning was performed by A. Magee (VIMS) in 2022. Scanning in previous years was performed by D. Hopler (VDGIF), J. Goins (VIMS), G. Holloman (VIMS), and B. Watkins (VIMS).

Scales for spawning phenology and age determination were removed from a mid-lateral area on the left side posterior to the pectoral-fin base of each fish. Scales were cleaned with a dilute bleach solution, mounted and pressed on acetate sheets, and read on a microfilm projector by one individual (A. Magee, VIMS) using the methods of Cating (1953). Ages were determined by different readers in 1998-2002 (K. Maki) and 1998-2021 (B. Watkins).

Catch data from each river were used to calculate a standardized catch index (the area under the curve of daily catch rate versus time of year). The catch index, the duration of the run in days, the maximum daily catch rate in each year and the mean catch rate in each year were compared to summaries of historical logbook data to provide a measure of the relative size of the current shad runs. In the historical data, catches are reported daily through the commercial season with occasional instances of skipped days due to inclement weather or damaged fishing gear. In monitoring years 1998-2014, catches on two successive days were separated by up to five days (usually Tuesday-Saturday) in each week of sampling. From 2015-2022, catches were separated by up to six days (usually Monday-Saturday) in each week of sampling. In some rare cases, catches are separated by more than six days. To compute the catch index during all monitoring years, we estimated catches on skipped days using linear interpolation between adjacent days of sampling.

Collection and processing of adult river herring

Four anchored gillnets were set parallel to the current on the Chickahominy River approximately 2 miles [1.6-3.2 km] upstream from the mouth of the river. Two 2.5" [63.5 mm] stretched mesh (300' x 6') anchored gillnets and two 3.0" [76.2 mm] stretched mesh (300' x 8') anchored gillnets were constructed with top float lines and lead bottom lines. Additional larger floats are added every 50' to ensure that fishing occurs from the surface down. Two anchored gillnets were also set parallel to the current on the Rappahannock River near the Downing bridge (at Tappahannock, VA) at river mile 36 (37° 55.8' N, 76° 50.7' W). One net was a 2.5" [63.5 mm] stretched mesh (300' x 6') anchored gillnet and the other was a 3.0" [76.2 mm] stretched mesh (300' x 8') anchored gillnet. Each week, the anchored gillnets were fished for one 24 h set on each river. Occasionally, weather or other circumstances prevented the regularly scheduled sampling on Tuesday and Wednesday, and sampling was postponed, canceled or re-scheduled for other days. Sampling on the Chickahominy River occurred over thirteen weeks (2 February to 27 April). In 2022, sampling on the Rappahannock River occurred over fifteen weeks (3 February to 13 May). Surface water temperature and salinity were recorded at each sampling event.

Individual alewife and blueback herring were measured (FL and TL) to nearest mm and weighed to nearest g. Sagittal otoliths were removed, placed in numbered tissue culture trays, and stored for age determination. To determine ages, otoliths were submersed in water with the sulcus facing downward, and viewed under a stereomicroscope with reflected light and a magnification of 2.0x. Ages were determined by one individual (P. McGrath) using methods recommended by the ASMFC (ASMFC 2014). Digital imaging software was used in conjunction with the stereomicroscope for ageing and for archiving all images. Scales for spawning phenology were removed from a mid-lateral area on the left side posterior to the pectoral-fin base of each fish. Scales were cleaned with a dilute bleach solution, mounted and pressed on acetate sheets, and read on a microfilm projector by one individual (A. Magee, VIMS).

Catch data from anchored gillnets were used to calculate a standardized catch index (the area under the curve of daily catch rate for pre-spawning females versus time of year). In 2015, the 3.0" mesh was determined to be inefficient at catching blueback herring; therefore, in 2015 and 2016, the catch indices for blueback herring were only calculated with catch data from 2.5" mesh. In 2017, blueback herring catches in the 3.0" mesh increased and in order to not exclude the larger females, catches from both 2.5" and 3.0" mesh were used in the catch index. The 2015 and 2016 catch indices for blueback herring were also recalculated to include the catch from the 3" mesh. In monitoring years 2015-2017, catch data occurred over two successive days and was separated by up to five days in each week of sampling. Since 2018, catches were separated by up to six days in each week of sampling. In some rare cases, catches were separated by more than six days. To compute the catch index, catches on skipped days were estimated using linear interpolation between adjacent days of sampling. The catch index, the duration of the run (in number of days), the maximum daily catch rate in each year, and the mean catch rate in each year will serve as the starting point for future comparisons to determine annual relative abundance of river herring. Age composition and sex ratio, among other attributes of the spawning stock of each species, are reported. Mortality was estimated for pre-spawning females using simple linear regression analysis of the natural log of age-specific catch on the descending limb of the catch curve.

Collection of other species

In both American shad and river herring sampling, catches of all other species were recorded and enumerated on log sheets by observers on each river and released. In the American shad sampling, for striped bass (*Morone saxatilis*), separate records were kept of the number of live and dead fish in the nets and released (if alive) or returned to the laboratory (if dead). Random subsamples of dead striped bass from each river were analyzed for sex, fork length, and total weight. Random subsamples of Atlantic menhaden (*Brevoortia tyrannus*) were collected weekly from each river and returned to the laboratory for processing. Individual specimens were measured (mm), weighed (g) and had scales removed for future age analysis. In the river herring sampling, all hickory shad (*Alosa mediocris*) were kept and returned to the laboratory for processing. Individual specimens were analyzed for sex, fork and total length, total weight and had scales and otoliths removed for spawning mark and age analyses.

Collection of juvenile alosines

Juvenile alewife and blueback herring were captured in the Chickahominy River using the mamou trawl. The mamou trawl is a 6.7 m x 1.8 m floating surface trawl constructed of 35 mm high density polyethylene netting. The cod end is made from 36 mm netting with a 20 mm removable liner. The net consists of 15.2 m bridles connected to 36 x 18 floating mullet doors and 30.5 m tow lines. Tows were conducted using a 7.0 m skiff equipped with a 115 hp engine.

Nine weekly cruises were conducted in 2022 (6 July to 29 August). During each cruise, three stations were randomly chosen within each of four adjacent 9.3 km long river blocks. Stations were designated at every 1.9 river km, beginning approximately 1.2 km (c. 2 miles) below Walker's Dam and ending at the river mouth. Night-time sampling was conducted when juvenile *Alosa* spp. are most susceptible to surface trawling (Loesch et al. 1982). Each tow lasted 5 minutes and was conducted along the central axis of the river channel. All tows were performed with the prevailing current.

Alewife and blueback herring caught at each station were identified and counted. Ten randomly selected individuals of each species from each station were measured and weighed. The geometric mean of the catch per tow was calculated for each cruise and the season (seasonal catch index).

Data of catches of American shad and river herring from the VIMS Striped Bass Seine Survey are also reported, as this survey provides greater spatial coverage within the tributaries of the Chesapeake Bay.

Results

Catches of American shad by gillnets in 2022

Fishing days, numbers of American shad captured, catch rates (males and females) and length frequencies are reported in Tables 1-9. Post-spawning females were not encountered on the James and Rappahannock rivers in 2022. One post-spawning female was observed on the

York River on 14 April 2022. Post-spawning fish were identified macroscopically in the laboratory. Because the historic fishery was a roe fishery and spent or partially-spent fish were not routinely captured or marketed in the historic fishery, post-spawning fish were not included in the monitoring sample.

A total of 111 American shad (6 males; 105 females) were captured (Table 1). The total weight of the sample was 144.3 kg (male, 6.5 kg; female, 137.8 kg). Catches in 2022 were lowest on the James River (2 total fish, 0 males and 2 females) and York River (11 total fish, 1 male and 10 females). Catches on the Rappahannock River (98 total fish, 5 males and 93 females) were highest.

On the James River, catches of females only occurred on 13 April (Table 2). Surface temperature during this time was 16.5ºC. On the York River, catches of females peaked between 11 March – 31 March when catch rates typically exceeded 0.007 fish/m or 0.008 kg/m. During that period, 70.0% (7 of 10) of all females were captured on the York River. Surface temperatures during this time ranged from 10.4ºC – 14.6ºC. The largest catch of pre-spawning female American shad on the York River (3 fish) occurred on 31 March when the surface temperature was 11.5ºC (Tables 2, 4). Catches of females on the Rappahannock River peaked on 5 March – 8 April when catch rates generally exceeded 0.04 fish/m or 0.05 kg/m. During that period on the Rappahannock River, 77.4% (72 of 93) of all females were captured. Surface temperatures during this time ranged from 8.5ºC – 13.8ºC. The largest catch of pre-spawning female American shad on the Rappahannock River (17 fish) occurred on 5 March and 11 March when the surface temperatures were 8.5ºC and 10.3ºC, respectively (Tables 2, 6). As in previous years of monitoring, numbers and catch rates of males were lower than catch rates of females throughout the sampling period. Sex ratios (males: females) were: York River, 1:10.0; James River, 0:1.0 and Rappahannock River, 1:18.6. It is important to note that the monitoring gear mimics an historical fishery that was selective for mature female fish. Catches of males do not likely reflect true abundance.

The duration of the spawning run is defined as the number of days between the first and last observation of a catch rate that equals or exceeds 0.01 female kg/m. The 2022 spawning run duration was estimated to be a minimum of 1 day on the James River (13 April; Table 3), 57 days on the York River (17 February – 14 April; Table 4), and 68 days on the Rappahannock River (23 February – 1 May; Table 6).

Biological characteristics of the American shad catch in 2022

Age, mean length (mm TL) and mean weight (kg) of American shad in staked gillnets are summarized in Tables 8-9. Mean total length at age of males and females from all rivers ranged from 442.0–492.0 mm TL and 477.8–535.0 mm TL, respectively. Mean weight at age of males and females from all rivers ranged from 0.8-1.1 kg and 1.2–1.6 kg, respectively.

Using otolith-based ageing methods, we estimated that the 2017-year class (age 5) of female American shad were the most abundant on the James, York, and Rappahannock rivers (Table 8). On the James River, one age-class of females was represented (2017, age 5). The sample was dominated by age-5 (100.0%) fish. On the York River, two age-classes of females were represented (2017-2018, ages 4-5). The sample was dominated by age-5 (70.0%) fish. On the Rappahannock River, six age-classes of females were taken (2013-2018, ages 4-9), with the

sample dominated by age-5 fish (45.1%). Mean age of females in 2022 was 5 y on the James River, 4.7 y on the York River and 5.4 y on the Rappahannock River. These values are slightly lower than those observed in 2021 on the Rappahannock and York rivers. On the James, York, and Rappahannock rivers, low sample sizes of male shad were observed in 2022.

Age-specific catch rates of American shad are reported in Tables 10 and 11 for females and males, respectively. Total instantaneous mortality (Z) of females was estimated using simple linear regression analysis of the natural log of age-specific catch on the descending limb of the catch curve. On the Rappahannock River, the total instantaneous mortality rate of females calculated from age-specific catch rates was 0.96 (r^2=0.89). It is assumed that year classes above age-4 are equally catchable by the gear. Total instantaneous mortality rates of females on the James and York rivers could not calculated due to a lack of multiple year-classes above age-5. Instantaneous mortality rates of males were not calculated because all year classes present are not equally catchable by the sampling gear.

Spawning histories of American shad collected in 2022 are presented in Tables 12-14. On the James River, two fish (sexes combined) were aged to be 5 with 0 (virgin) to one spawning mark. On the York River, fish (sexes combined) ranged in age from 4-5 years with 0 (virgin) to 2 spawning marks. On the Rappahannock River, fish (sexes combined) ranged in age from 4-9 years with 0-3 spawning marks. The following percentages of fish in each river had at least one prior spawn (termed "repeat spawners"): James River, 50.0% (1 virgin in a sample of 2); York River, 63.6% (4 virgins in a sample of 11); and Rappahannock River 51.7% (43 virgins in a sample of 89 fish).

Seasonal American shad catch indices, 1980-1992 and 1998-2022

A seasonal catch index was calculated by estimating the area under the curve of daily catch versus day for the years 1998-2022 and for each year of the historical record of staked net catches on each river (Tables 15-20 and Figures 7-10). Seasonal catch indices in 2022 were: James River, 0.07; York River, 0.32; Rappahannock River, 2.97.

Evaluation of hatchery origin of American shad in 2021

James River - Otoliths of 2 American shad (100% of the total catch) on the James River were processed for hatchery marks; the proportion with hatchery marks was 0.0% (0 of 2 fish) (Table 21). In most years since 2000, the prevalence of hatchery fish in the James River has been high (>20%); in 2006 and 2009 there were lower proportions of fish with hatchery tags (10.3% and 8.9% respectively); in 2013 the hatchery percentage of fish with hatchery marks was 60.5% on the James (Figure 11). A correlation analysis among the catch index and hatchery prevalence from 1998-2021 was not statistically significant (r = 0.21, df = 23, p = 0.31). In some years, fish with hatchery tags from rivers other than the James River were detected in the monitoring sample. These strays were not included in the estimates of hatchery prevalence and are as follows (year captured as an adult, number, river of release): 1999, n= 1, Patuxent River (Maryland); 2000, n= 7, Pamunkey River (Virginia) and Juniata River (Pennsylvania); 2001, n= 3, Pamunkey River, Juniata River, and the western branch of the Susquehanna River (Pennsylvania); 2002, n= 2, Pamunkey River, n= 2 unknown tag; 2005, n=3, tentatively Pamunkey River and Mattaponi River (Virginia); 2007, n=1, Pamunkey River (Virginia); 2008,

n=1, Undetermined; 2009, n=1, Chemung River (New York); 2010, n=2, Susquehanna River (Pennsylvania). In 2003, 2004, 2006, 2011-2022 there were no stray fish.

York and Rappahannock Rivers - Otoliths of American shad from the York and Rappahannock rivers were not processed for hatchery marks. Stocking of American shad in the Rappahannock River began in 2003 and ended in 2014 (Table 22).

Catches of river herring by anchored gillnets in 2022

Fishing days, numbers of river herring captured, catch rates (males and females) and length frequencies are reported in Tables 23-27 and 34-38. A total of 532 alewives (162 males; 331 pre-spawned females; 39 post-spawned females) and 116 blueback herring (29 males; 87 pre-spawned females; 0 post-spawned females) were captured on the Chickahominy River (Table 23). After 16 March, post-spawning alewives were mixed with pre-spawning alewives. No post-spawning blueback herring were present in the sample. A total of 511 alewives (190 males; 319 pre-spawned females; 2 post-spawned female) and 203 blueback herring (61 males; 142 pre-spawned females; 0 post-spawned females) were captured on the Rappahannock River (Table 34). After 12 April, post-spawning alewives were mixed with pre-spawning alewives. No post-spawning blueback herring were present in the sample. Post-spawning fish were identified macroscopically in the laboratory. Because the historical fishery was a roe fishery and spent or partially-spent fish were not routinely captured or marketed in the fishery, post-spawning fish were not included in the monitoring sample.

On the Chickahominy River, catches of pre-spawned alewife peaked between 15 February and 5 April, with catch rates typically exceeding 0.07 fish/m/day or 0.02 kg/m/day (Table 24). Catches of blueback herring peaked between 29 March and 20 April with catch rates exceeding 0.04 fish/m/day or 0.01 kg/m/day (Table 26). Surface temperatures during these peaks ranged from 6.0ºC – 14.3ºC for alewife and from 10.7ºC – 15.3ºC for blueback herring. The largest catch of pre-spawned female alewife (69 fish) occurred on 23 February when surface temperatures were 9.8ºC and the largest catch of pre-spawned female blueback herring occurred on 29 March (24 fish) when surface temperatures were 10.7ºC. Sex ratio (males: females) for alewife was 1:2.04 and for blueback herring was 1:3.00. It is important to note that the monitoring gear is selective for mature female blueback herring and catches of male blueback herring do not likely reflect true sex ratio for that species.

On the Rappahannock River, catches of pre-spawned alewife peaked between 22 February and 12 April, with catch rates typically exceeding 0.07 fish/m/day or 0.01 kg/m/day (Table 35; Figure 14). Catches of blueback herring peaked between 4 April and 2 May, with catch rates typically exceeding 0.08 fish/m/day or 0.02 kg/m/day (Table 37; Figure 15). Surface temperatures during these peaks ranged from 7.7ºC – 15.3ºC for alewife and from 11.3ºC – 19.0ºC for blueback herring. The largest catch of pre-spawned female alewife (151 fish) occurred on 9 March when surface temperatures were 11.9ºC and the largest catch of pre-spawned female blueback herring occurred on 12 April (38 fish) when surface temperatures were 15.3ºC. Sex ratio (males: females) for alewife was 1:1.68 and for blueback herring was 1:2.33.

Biological characteristics of river herring caught in anchored gillnets in 2021

Age, mean length (mm TL) and mean weight (kg) of river herring in anchored gillnets from the Chickahominy and Rappahannock Rivers are summarized in Table 28 and 39. Mean total length at age of pre-spawned female alewives and blueback herring from both rivers ranged from 273.1 – 323.0 mm TL and 266.7 – 308.4 mm TL, respectively. Mean weight at age of pre-spawned female alewives and blueback herring ranged from 0.20 – 0.35 kg and 0.17 – 0.28 kg, respectively.

Using otolith-based ageing methods, we estimated that the 2018-year class (age 4) of female alewife and 2017-year class (age 5) of female blueback herring on both the Chickahominy and Rappahannock rivers were the most abundant (Tables 28 and 39, respectively). On the Chickahominy River, six age-classes of female alewife were represented (2014 - 2019, ages 3 – 8), with the sample dominated by age-4 fish (52.1% of the total that was aged). Mean age of female alewives in 2022 was 4.29. Six age-classes of female blueback herring were represented (2014-2019, ages 3 - 8), with the sample dominated by age-5 fish (35.7% of the total that was aged). Mean age of female blueback herring in 2022 was 5.07. On the Rappahannock River, six age-classes of female alewife were represented (2014 - 2019, ages 3 – 8), with the sample dominated by age-4 fish (46.6% of the total that was aged). Mean age of female alewives in 2022 was 4.43. Six age-classes of female blueback herring were represented (2014-2019, ages 3 - 8), with the sample dominated by age-5 fish (44.7% of the total that was aged). Mean age of female blueback herring in 2022 was 5.06.

Age-specific catch rates of female alewives and blueback herring are reported in Tables 28 and 39. Total instantaneous mortality (Z) of females was estimated using Chapman-Robson method. On the Chickahominy River, total instantaneous mortality and survival (S) rates of females were: alewife, Z = 1.03 and S = 0.36; blueback herring, Z = 0.97 and S = 0.38. On the Rappahannock River, total instantaneous mortality and survival (S) rates of females were: alewife, Z = 0.94 and S = 0.39; blueback herring, Z = 1.15 and S = 0.32. It is assumed that year classes above age-3 are equally catchable by the gear.

Spawning histories of alewife and blueback herring collected in 2022 are presented in Tables 30-31 and 41-42. On the Chickahominy River, alewife (sexes combined) ranged in age from 3-8 years with 0 (virgin) to 4 spawning marks and blueback herring (sexes combined) ranged in age from 4-8 years with 0 (virgin) to 4 spawning marks. On the Rappahannock River, alewife (sexes combined) ranged in age from 3-7 years with 0 (virgin) to 3 spawning marks and blueback herring (sexes combined) ranged in age from 3-8 years with 0 (virgin) to 3 spawning marks. The following percentages of alewife in each river had at least one prior spawn (termed “repeat spawners”): Chickahominy River, 48.8% (222 virgins in a sample of 458); and Rappahannock River 39.7% (169 virgins in a sample of 426 fish). The following percentages of blueback herring in each river had at least one prior spawn (termed “repeat spawners”): Chickahominy River, 33.0% (30 virgins in a sample of 91); and Rappahannock River 34.5% (58 virgins in a sample of 168 fish).

Seasonal river herring catch indices for 2022

A seasonal catch index was calculated by estimating the area under the curve of daily catch versus day for 2022 (Tables 32-33, 43-44; Figures 12-15). Seasonal catch indices in 2022

on the Chickahominy River were: alewife, 1.58; blueback herring, 0.36. The index values were higher for alewife and blueback herring compared to the index values in 2021 (alewife, 0.97; blueback herring, 0.10). On the Rappahannock River, seasonal catch indices in 2022 were: alewife, 3.16; blueback herring, 1.18. The index values were higher for alewife and blueback herring compared to the index values in 2021 (alewife, 1.21; blueback herring, 0.66).

Juvenile abundance of American shad and river herring

Tables 45 and 46 report index values of juvenile abundance of American shad based on seine surveys (1980-2022) on the James (including the Chickahominy), Chickahominy, Rappahannock, York (including the Mattaponi and Pamunkey rivers), Pamunkey, and Mattaponi rivers. The geometric mean catch (followed by standard deviation and number of seine hauls in parentheses) of juvenile American shad captured in daylight seine hauls in 2022 was: James River, 0 (NA, 65); Chickahominy River, 0 (NA, 10); Rappahannock River, 11.69 (1.37, 35); York River, 0.25 (0.65, 95); Mattaponi River, 0.34 (0.73, 50); and Pamunkey River, 0.17 (0.58, 40). In 2009, calculations for all years were adjusted to include fish greater than 72 mm, which had not been included in the indices in previous years.

The seine survey data (Table 45) showed below average recruitment of American shad in 2022 in all rivers except for the Rappahannock River. In 2010, James River indices for all years were recalculated to include additional seine survey stations located in the upper James and Chickahominy rivers. Independent results from the Chickahominy River are also reported, although it is unknown whether fish captured in this river form a unique stock (i.e., distinct from that of the James River). Stocking of American shad took place on Chickahominy Lake in 2000 and on the Chickahominy River in 2004. Results from an independent survey below Bosher's Dam on the James River depict no measurable recruitment in most years (VDGIF, T. Gunter, pers. comm.). On the Rappahannock River, the highest JAI values in the time series were recorded in 2015, 2016, 2018-2020, and 2022 (4.19, 4.17, 4.65, 11.65, 8.13, and 11.69, respectively). The Rappahannock River time series depicts no measurable recruitment in 1980-1981, 1985, 1988, 1991-1992, 1995, and 2002.

Within the York River system, except for 2003 and 2012, the juvenile index values based on the seine survey are consistently higher on the Mattaponi River than they are on the Pamunkey River (Table 46). In the time series, recruitment is highest (>7.0 on the Mattaponi River and >3.0 on the York River) in 1982, 1984-85, 1996, 2003 and 2004. Recruitment was low (<0.10) on both of these rivers in 2009; there was no measurable recruitment in the Pamunkey River in 1986-1989, 1992-1993, 1999, 2007-2009, and 2021.

Catches of river herring, mean length, mean weight, and the mean fish per tow from the nighttime surface trawls on the Chickahominy River in 2022 are reported in Table 47. Catches were dominated by blueback herring (total alewife = 2; total blueback herring = 1233). Mean length of alewife ranged from 64.0 – 74.0 mm FL and mean weight ranged from 3.1 – 8.8 g. Mean length of blueback herring ranged from 38.8 – 58.1 mm FL and mean weight ranged from 0.8 – 1.9 g. Because of low catches at each sampling station, mean fish/tow and geometric means (cruise specific index) are not reliable for alewife. Mean fish/tow for blueback herring ranged from 2.0 – 31.5 fish per tow, and the geometric means ranged from 1.9 – 15.5. The cruise specific index of blueback herring peaked on 1 August 2022.

Tables 48 and 49 report index values of juvenile abundance of alewife and blueback herring, respectively, based on seine surveys (1989-2022) on the James, York (includes the Mattaponi and Pamunkey rivers), and the Rappahannock rivers. The geometric mean catch (followed by standard deviation and number of seine hauls in parentheses) of juvenile alewife captured in daylight seine hauls in 2022 was: James River, 0.00 (NA, 10); York River, 0.03 (0.19, 55); Rappahannock River, 0.08 (0.32, 40). The geometric mean catch (followed by standard deviation and number of seine hauls in parentheses) of juvenile blueback herring captured in daylight seine hauls in 2022 was: James River, 0.19 (0.86, 40); York River, 0.05 (0.22, 35); Rappahannock River, 0.61 (1.15, 25).

Indexes of juvenile abundance based on the seine survey data are variable, but are almost always higher for blueback herring than for alewife, and the Rappahannock River most often shows the highest abundance for both species. No measurable recruitment of alewife was seen in the James River in 1989-1992, 1995, 1999-2003, 2008, 2011-2012, 2020, and 2022 and in the York River in 1990-1993, 1995, 1998-2000, 2006-2009, 2012-2014, 2017, and 2020-2021. In the Rappahannock River, indexes of juvenile alewife abundance have been relatively low (e.g., <0.1) in many years (1990-1992, 1995, 2002, 2004-2006, 2008, 2012, 2021-2022), but there has always been measurable recruitment throughout the time series. The only instances of no measurable recruitment of blueback herring within the time series occurred in the York River, and in the years 1990, 1992-1993, 1995, 1998-1999, 2002, 2005-2006, 2009, 2012-2013.

Bycatch of striped bass and other species in 2022

Daily numbers and seasonal totals of striped bass and other species captured in staked or anchor gill nets are reported in Tables 50-52. Thirteen species of fishes were counted as bycatch in the staked and anchored gillnet monitoring gear for a total of 7,072 specimens. The most commonly encountered bycatch species were: gizzard shad (*Dorosoma cepedianum*), blue catfish (*Ictalurus furcatus),* menhaden (*Brevoortia tyrannus*), and striped bass (*Morone saxatilis*).

The total number of striped bass recorded was 898 (James River, n=325; York River, n=166; Rappahannock River, n=407). Live striped bass captured in the gear were counted and released. The proportions of dead striped bass on each river were: James River, 43.7%; York River, 30.7%; and the Rappahannock River, 47.9%. A subsample of 202 dead striped bass were selected from the James, York, and Rappahannock rivers. Length of males and females ranged from 415 - 640 mm FL and 315 - 679 mm FL, respectively. Total weights of males and females ranged from 0.93 – 4.09 kg and 0.43 – 4.44 kg, respectively.

Atlantic sturgeon is taken as bycatch in the staked and anchored gillnets used to monitor abundance of adult American shad in the James, York, and Rappahannock rivers. In 2022, three Atlantic sturgeon were caught as bycatch in this sampling (James River, n=1; York River, n= 0; Rappahannock River, n=2; due to reduced effort sturgeon number data from 2015 to 2022 cannot be directly compared to previous years). The total numbers of Atlantic sturgeon captured in this survey from previous years were: 37 (1998), 24 (1999), 16 (2000), 8 (2001), 1 (2002), 3 (2003), 6 (2004), 25 (2005), 40 (2006), 30 (2007), 9 (2008), 7 (2009), 10 (2010), 12 (2011), 4 (2012), 11 (2013), 20 (2014), 10 (2015), 2 (2016). Most of these fish were taken in the James River during each year: 30 (1998); 22 (1999); 15 (2000); 7 (2001); 1 (2002); 3 (2003); 4 (2004); 22 (2005); 31 (2006); 22 (2007); 7 (2008); 6 (2009); 7 (2010); 11 (2011); 4

(2012); 6 (2013); 20 (2014), 9 (2015), 2 (2016), 1 (2017), 11 (2018), 9 (2019), 7 (2020), 1 (2021).

The total number of Atlantic menhaden recorded in the staked and anchored gillnets used to monitor abundance of adult American shad in 2022 was 2691 (James River, n=1595; York River, n=602; Rappahannock River, n=494). A portion (n=488) of this catch was returned to the laboratory and processed for length (mm) and weight (g). Scale samples were collected for future age analysis. Individual lengths ranged from 119 – 370 mm TL. Total weights ranged from 0.02 – 0.47 kg.

The total number of hickory shad recorded in the anchored gillnets used to monitor abundance of adult river herring in 2022 was 330 (Chickahominy River, n=40; Rappahannock River, n=290). Length of males and females ranged from 301 - 425 mm TL and 315 - 443 mm FL, respectively. Total weight of males and females ranged from 0.22 – 0.68 kg and 0.28 – 0.90 kg, respectively. Age of males and females ranged from 2 – 6 and 2 – 5, respectively.

Discussion

This monitoring program continues to be useful for assessment of stocks of American shad in Virginia. It is the only direct method available to determine the size of the spawning runs relative to what was obtained in the decades prior to the moratorium. The program also provides information for evaluating the hatchery-based restoration program, validating the juvenile index of abundance and for determining the amount of bycatch that could be expected in a commercial fishery if the in-river fishing ban is lifted.

In 1998, states were required to develop and submit restoration targets for stocks under moratorium. Virginia presented preliminary targets to the Plan Review Team of the ASMFC Shad and River Herring Management Board with the provision that these targets would be revised as appropriate historical data became available (see below). Criteria to achieve restoration targets were proposed as either: (1) a three-year period during which the catch index remains at or above the target level in the staked gillnet monitoring of the spawning run; (2) a three-year period during which the average catch index is above the target level and the target level is exceeded in two of the years; or (3) a significant increasing trend over a five-year period with the target exceeded in the last two years.

Voluntary logbooks of catches from the York River exist in the archives of the Department of Fisheries Science (Table 17). These historical records from the 1950s form the basis for gear comparison trials conducted in 2002 and 2003 in the York River (Maki et al., 2006). Based on these comparisons, we have concluded that the multifilament nets of the type used in the 1950s have approximately half of the fishing power of monofilament nets used in the 1980s and the current monitoring. Thus, the older data have been adjusted upward (by a factor of 2.16) to make appropriate comparisons with current monitoring results.

Voluntary log books from the 1950s also exist for the James River. The most extensive data are those of Mr. J. C. Smith who fished staked gillnets on the upper James River in 1954-1957, just above the mouth of the Chickahominy River. Current monitoring on the James River is well below this location, complicating direct comparisons with Smith's log books. There are no historic records prior to 1980 in department archives for the Rappahannock River.

Using the information presented above and additional analysis, the ASMFC stock assessment subcommittee developed benchmarks for restoration of Virginia's stock of American shad (ASMFC 2007a). These benchmarks were reviewed and accepted by the ASMFC American shad stock assessment peer review panel in 2007 (ASMFC 2007b). These benchmarks have been upheld with the adoption of Amendment 3 to the Interstate Fishery Management Plan for American shad (ASMFC 2010).

For the York River, a restoration target of 17.44 (the geometric mean of the catch index values observed in 1953-1957) was accepted as an appropriate benchmark to assess the stocks since American shad abundance in the 1980s was insufficient to support the fishery. In the 1950s, shad abundance was higher (estimated at 131,000-218,000 total females annually using data from Nichols and Massmann, 1962), and landings were relatively stable in the face of a high fishing rate (50%). Thus, restoring the York River shad stocks to a 1950s level could allow for a sustainable fishery operating at a lower level of exploitation.

For the James River, an interim target of 6.40 (the geometric mean of the catch index values observed in 1980-1992) is available. However, American shad abundance in the 1980s was insufficient to support the fishery. The James River stock has been dependent on hatchery inputs and there is strong evidence of persistent recruitment failure of wild stocks.

For the Rappahannock River, an interim restoration target of 1.45 (the geometric mean of the catch index values observed in 1980-1992) is available. Because effort of the historical fishery was lower on the Rappahannock than the other rivers, it is possible that this benchmark is artificially lower.

On the York River, the 2022 seasonal catch index (0.32) was the lowest catch index on the York in the 25 years of monitoring the American shad spawning stock. Since 2005 index values have been low, but stable. In years prior (1998-2004) index values were higher (5.42-14.71). The geometric mean of the historical data during the 1980s on the York River is 3.22. The geometric mean of the current monitoring data is higher (3.42), but this mean is still much lower than the benchmark based on 1950s data (17.44). Catch indices in the York River have been trending downward through the time series and, with the exception of 2014, are at all-time lows.

Our overall assessment of the York River stock is that it persists at a low level that is lower than its average abundance during the 1980s. As noted previously, the stock level was low during that period and was evidently incapable of supporting an active fishery. Since 2005, the catch index has shown no recovery to the higher levels seen earlier in the time series, and is cause for concern and continued monitoring. Although there is a moratorium on American shad harvest in the Chesapeake Bay, there are fish taken in the York River each year from several sources. Since 2005 there has been a limited bycatch fishery of American shad, results of which for 2022 are reported in Appendix I. The Mattaponi and Pamunkey tribal governments harvest American shad from the York River system but do not report landings to the VMRC, following the treaty of 1677. In past years there have also been losses to capture of brood stock on the Pamunkey River by the VDGIF. In comparison to other rivers in Virginia, there is currently no stocking of hatchery fish in the York River. The stock is currently well below the proposed 1950s target (Figure 9) when abundance of American shad was higher and harvest was apparently sustainable (Nichols and Massmann, 1963). As a result, the stock requires continued protection.

On the James River, the seasonal catch index was 0.07. It was also below the geometric mean of the current monitoring data (2.25). This value is well below the peak catch index observed in the 1980s (29.20). The geometric mean of the historical data during the 1980s on the James River is 6.40. Prevalence of hatchery fish on the James River reached an all-time high of 60.5% in 2013. Our overall assessment for the James River is that the stock remains at historically low levels and was dependent on hatchery inputs (Figure 11). Due to budget constraints and absence of brood stock, stocking efforts of American shad on the James River have been reduced in recent years. In 2018, the stocking effort ceased operation on the James River.

On the Rappahannock River, the 2022 index was 2.97. The current geometric mean (3.98) is higher than the mean of the historical data (1.45). It should be noted that since the catch index for the Rappahannock River is low in the historical data relative to the York and James rivers, there is uncertainty about what an appropriate target level should be for this stock. There is little evidence of severe stock decline in the Rappahannock River, and this stock is considered to be low but stable (ASMFC 2007a). Stocking of American shad on the Rappahannock River occurred between 2003 and 2012, using the progeny of Potomac River brood stock. In the years since stocked hatchery fish would be expected to return (i.e., age 4 fish in 2007), the percent hatchery origin fish encountered in the Rappahannock River ranged from 0% (2007 and 2021) to 8.9% (2016). Due to the low level of return, VDGIF has ceased stocking American shad in the Rappahannock River for the foreseeable future.

The anchored gillnet survey on the Chickahominy River began in 2015 and was intended to monitor the relative abundance, stock structure, mortality, and biological characteristics of river herring in a major tributary of the James River that, prior to the moratorium, was the focus of a fishery. No historical data exist to allow comparison of those data collected in this survey, and thus the 2015 values will provide a reference point for future comparisons. This survey proved to be effective, although there is significant variation in levels of catches between species and sexes. Catches of adult blueback herring were significantly lower than adult alewife, although in summertime nighttime surface trawls, blueback herring dominated the catches in the Chickahominy River. This suggests that there is variation in species specific catchability, either because of gear (e.g., mesh size) or biological characteristics of the species (e.g., habitat use of juveniles). The 2022 indices were above average for alewife and average for blueback herring compared to the eight years of monitoring herring on the Chickahominy River. Despite 2019 and 2021, a positive trend is apparent for alewife during the current 8-year monitoring period. Blueback herring have a slightly negative trend during the current 8-year monitoring period.

This year marked the fifth year of an adult spawning stock survey of river herring using anchored gillnets on the Rappahannock River. No historical data exist to allow comparison of those data collected in this survey, and thus these values will provide a reference point for future comparisons. The 2022 index was higher for both alewife and blueback herring then the 2021 indices. Despite 2019 and 2021, a positive trend is apparent for alewife during the current 5-year monitoring period. Blueback herring have a negative trend during the current 5-year monitoring period.

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Table 1. Summary of sampling dates, total number, and total weight of American shad captured in gillnets in the James, York, and Rappahannock Rivers, spring 2022.

Sampling Location	Sampling dates in 2022	Total pre-spawn females	Total males	Total pre-spawn female weight (kg)	Total male weight (kg)	Total fish	Total weight (kg)
James River	2/16 – 4/21	2	0	2.5	0	2	2.5
York River	2/17 – 4/14	10	1	13.4	0.8	11	14.2
Rappahannock River	2/23 – 5/1	93	5	121.9	5.7	98	127.6
Totals		105	6	137.8	6.5	111	144.3

Table 2. Daily temperature and number of American shad (both sexes combined) caught in gillnets on the James, York and Rappahannock rivers in 2022. Numbers in parentheses are the number of post-spawning fish caught. Abbreviations: N, number of shad caught; ND, no data. Highlighted cell are non-fishing days.

	James		York		Rappahannock	
Date	Temp ˚C	N	Temp ˚C	N	Temp ˚C	N
2/16/2022	6.7	0				
2/17/2022			6.4	1		
2/23/2022					8.9	3
2/24/2022	11.0	0				
2/25/2022			8.9	0		
2/28/2022					7.9	9
3/3/2022	10.1	0				
3/4/2022			9.4	0		
3/5/2022					8.5	19
3/10/2022	13.1	0				
3/11/2022			10.4	2	10.3	17
3/16/2022	10.5	0				
3/17/2022			11.3	2		
3/20/2022					13.4	12
3/23/2022	15.1	0				
3/24/2022			14.6	0		
3/26/2022					13.8	10
3/30/2022	11.7	0				
3/31/2022			11.5	3		
4/3/2022					11.5	5
4/6/2022	15.5	0				
4/7/2022			15.5	1		
4/8/2022					12.5	11
4/13/2022	16.5	2				
4/14/2022			16.7	3(1)		
4/15/2022					17.2	6
4/21/2022	15.3	0			13.6	4
5/1/2022					17.3	2

Table 3. Dates of capture, number, total weight, and catch rates of pre-spawn female American shad taken in anchored gillnet monitoring on the James River, spring 2022.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (kg)	Catch rate (kg/m/day)
2/16/2022	47	0	0.0000	0.0	0.0000
2/24/2022	55	0	0.0000	0.0	0.0000
3/3/2022	62	0	0.0000	0.0	0.0000
3/10/2022	69	0	0.0000	0.0	0.0000
3/16/2022	75	0	0.0000	0.0	0.0000
3/23/2022	82	0	0.0000	0.0	0.0000
3/30/2022	89	0	0.0000	0.0	0.0000
4/6/2022	96	0	0.0000	0.0	0.0000
4/13/2022	103	2	0.0073	2.5	0.0091
4/21/2022	111	0	0.0000	0.0	0.0000
Totals		2		2.5	

Table 4. Dates of capture, number, total weight, and catch rates of pre-spawn female American shad taken in anchored gillnet monitoring on the York River, spring 2022.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (kg)	Catch rate (kg/m/day)
2/17/2022	48	1	0.0039	1.3	0.0052
2/25/2022	56	0	0.0000	0.0	0.0000
3/4/2022	63	0	0.0000	0.0	0.0000
3/11/2022	70	2	0.0082	2.4	0.0099
3/17/2022	76	2	0.0071	2.4	0.0087
3/24/2022	83	0	0.0000	0.0	0.0000
3/31/2022	90	3	0.0122	4.2	0.0171
4/7/2022	97	1	0.0046	1.4	0.0065
4/14/2022	104	1	0.0042	1.6	0.0067
Totals		10		13.4	

Table 5. Dates of capture, number, total weight, and catch rates of male American shad taken in anchored gillnet monitoring on the York River, spring 2022.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (kg)	Catch rate (kg/m/day)
2/17/2022	48	0	0.0000	0.0	0.000
2/25/2022	56	0	0.0000	0.0	0.0000
3/4/2022	63	0	0.0000	0.0	0.0000
3/11/2022	70	0	0.0000	0.0	0.0000
3/17/2022	76	0	0.0000	0.0	0.0000
3/24/2022	83	0	0.0000	0.0	0.0000
3/31/2022	90	0	0.0000	0.0	0.0000
4/7/2022	97	0	0.0000	0.0	0.0000
4/14/2022	104	1	0.0042	0.8	0.0034
Totals		1	0.0042	0.8	0.0034

Table 6. Dates of capture, number, total weight, and catch rates of pre-spawn female American shad taken in staked gillnet monitoring on the Rappahannock River, spring 2022.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (kg)	Catch rate (kg/m/day)
2/23/2022	54	2	0.0078	2.6	0.0102
2/28/2022	59	7	0.0266	10.0	0.0381
3/5/2022	64	17	0.0667	22.0	0.0865
3/11/2022	70	17	0.0667	24.1	0.0947
3/20/2022	79	12	0.0441	15.5	0.0570
3/26/2022	85	10	0.0367	13.2	0.0483
4/3/2022	93	5	0.0180	6.3	0.0226
4/8/2022	98	11	0.0396	13.3	0.0480
4/15/2022	105	6	0.0220	7.9	0.0291
4/21/2022	111	4	0.0147	4.5	0.0164
5/1/2022	121	2	0.0075	2.4	0.0089
Totals		93		121.9	

Table 7. Dates of capture, number, total weight, and catch rates of male American shad taken in staked gillnet monitoring on the Rappahannock River, spring 2022.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (kg)	Catch rate (kg/m/day)
2/23/2022	54	1	0.0039	1.1	0.0045
2/28/2022	59	2	0.0076	2.3	0.0086
3/5/2022	64	2	0.0078	2.3	0.0089
3/11/2022	70	0	0.0000	0.0	0.0000
3/20/2022	79	0	0.0000	0.0	0.0000
3/26/2022	85	0	0.0000	0.0	0.0000
4/3/2022	93	0	0.0000	0.0	0.0000
4/8/2022	98	0	0.0000	0.0	0.0000
4/15/2022	105	0	0.0000	0.0	0.0000
4/21/2022	111	0	0.0000	0.0	0.0000
5/1/2022	121	0	0.0000	0.0	0.0000
Totals		5		5.7	

Table 8. Mean total length and mean weight of pre-spawn female American shad captured in gillnets in the James, York, and Rappahannock Rivers, spring 2022. The abbreviation NA is “not aged”. Age estimates are based on examination of otoliths.

River	Year class	Number	Mean total length (mm)	Standard deviation	Mean weight (kg)	Standard deviation
James River	2017	2	495.5	6.4	1.3	0.038
York River	2018	3	496.3	18.8	1.3	0.128
	2017	7	502.6	17.1	1.4	0.160
Rappahannock River	2018	15	479.0	13.3	1.2	0.126
	2017	41	488.1	12.5	1.3	0.098
	2016	26	510.1	18.5	1.4	0.164
	2015	7	522.9	12.2	1.5	0.113
	2014	1	546.0		1.5	
	2013	1	585.0		2.1	
	NA	2	482.0	15.6	1.3	0.030

Table 9. Mean total length and mean weight of male American shad captured in gillnets in the York and Rappahannock Rivers, spring 2022. The abbreviation NA is "not aged". Age estimates are based on examination of otoliths.

River	Year class	Number	Mean total length (mm)	Standard deviation	Mean weight (kg)	Standard deviation
York River	2018	1	442.0		0.8	
Rappahannock River	2017	1	480.0		1.2	
	2016	3	480.7	10.0	1.1	0.045
	2015	1	494.0		1.2	

Table 10. Number, total weight, and seasonal catch rates by year class of pre-spawn female American shad captured in gill nets in the James, York, and Rappahannock Rivers, spring 2022. The abbreviation NA is “not aged”. Age estimates are based on examination of otoliths.

River	Year class	Number	Total weight (kg)	Total effort (days)	Seasonal catch rate (count/m/season)	Seasonal catch rate (kg/m/season)
James River	2017	2	2.5	10.1	0.0007	0.0009
York River	2018	3	3.9	8.0	0.0014	0.0018
	2017	7	9.5	8.0	0.0032	0.0043
Rappahannock River	2018	15	18.0	10.6	0.0051	0.0061
	2017	41	51.5	10.6	0.0139	0.0175
	2016	26	36.1	10.6	0.0088	0.0123
	2015	7	10.2	10.6	0.0024	0.0035
	2014	1	1.5	10.6	0.0003	0.0005
	2013	1	2.1	10.6	0.0003	0.0007
	NA	2	2.6	10.6	0.0007	0.0009

Table 11. Number, total weight, and seasonal catch rates by year class of male American shad captured in gillnets in the York and Rappahannock Rivers, spring 2022. The abbreviation NA is “not aged”. Age estimates are based on examination of otoliths.

River	Year class	Number	Total weight (kg)	Total effort (days)	Seasonal catch rate (count/m/season)	Seasonal catch rate (kg/m/season)
York River	2018	1	0.8	8.0	0.0005	0.0004
Rappahannock River	2017	1	1.2	10.6	0.0003	0.0004
	2016	3	3.3	10.6	0.0010	0.0011
	2015	1	1.2	10.6	0.0003	0.0004

Table 12. Spawning histories of American shad (combined sexes) collected in spring, 2022 in the James River. Table entries are total numbers of fish that were aged (n=2). Ages are based on otolith analysis by three readers. Numbers in bold are virgins in year class. The table truncates at age 7 since American shad are mature by that age (Maki et al., 2001).

James River Year Class	Age at Capture	3	4	5	6	7
2017	5	-	1	**1**	-	-

Table 13. Spawning histories of American shad (combined sexes) collected in spring, 2022 in the York River. Table entries are total numbers of fish that were aged (n=11). Ages are based on otolith analysis by three readers. Numbers in bold are virgins in year class. The table truncates at age 7 since American shad are mature by that age (Maki et al., 2001).

		Age at Maturity					
York River Year Class	Age at Capture	2	3	4	5	6	7
2018	4	1	2	**1**	**-**	-	-
2017	5	-	1	3	**3**	**-**	-

Table 14. Spawning histories of American shad (combined sexes) collected in spring, 2022 in the Rappahannock River. Table entries are total numbers of fish that were aged (n=89). Ages are based on otolith analysis by three readers. Numbers in bold are virgins in year class. The table truncates at age 7 since American shad are mature by that age (Maki et al., 2001).

		Age at Maturity					
Rapp. River Year Class	Age at Capture	2	3	4	5	6	7
2018	4	-	3	**11**	**-**	-	-
2017	5	1	1	10	**27**	-	-
2016	6	-	-	8	14	**5**	-
2015	7	-	-	2	2	3	**-**
2014	8	-	-	-	1	-	**-**
2013	9	-	-	-	-	1	**-**

Table 15. Summary of historical catch and effort data of American shad by staked gillnets in the Rappahannock River, Virginia. Historical data are taken from the voluntary logbooks of Mr. M. Delano, Urbanna, Virginia.

Year	Effort (10^3 m*days)	Duration of run (days)	Highest catch rate (female kg/m/day)	Mean catch rate (female kg/m/day)	Area under the catch curve
1980	43.4	35	0.121	0.036	1.79
1981	112.1	57	0.032	0.011	1.89
1982	82.3	51	0.046	0.009	1.68
1983	106.7	59	0.093	0.031	0.59
1984	30.5	48	0.139	0.033	0.60
1985	77.2	60	0.136	0.029	1.83
1986	34.9	43	0.155	0.039	2.18
1987	23.3	37	0.090	0.023	0.97
1988	23.2	53	0.073	0.025	1.25
1989	16.2	44	0.856	0.123	6.19
1990	41.3	55	0.092	0.023	1.31
1991	25.9	54	0.129	0.022	1.13
1992	8.6	51	0.299	0.044	1.44
Geometric mean					**1.45**

Table 16. Summary of recent catch and effort data of American shad by staked gillnets in the Rappahannock River, Virginia.

Year	Effort (10^3 m*days)	Duration of run (days)	Highest catch rate (female kg/m/day)	Mean catch rate (female kg/m/day)	Area under the catch curve
1998	3.7	----	0.053	0.020	1.46
1999	5.8	42	0.055	0.026	1.30
2000	6.6	73	0.141	0.042	1.75
2001	6.6	72	0.167	0.070	5.77
2002	6.0	57	0.110	0.028	3.08
2003	7.3	72	0.311	0.094	7.10
2004	5.7	65	0.232	0.107	7.06
2005	5.7	65	0.164	0.054	3.69
2006	6.7	75	0.088	0.037	3.01
2007	5.8	64	0.130	0.042	2.60
2008	6.1	64	0.175	0.045	3.12
2009	5.6	50	0.259	0.093	5.36
2010	5.2	50	0.088	0.027	2.03
2011	6.8	85	0.216	0.074	6.51
2012	7.0	62	0.313	0.080	7.28
2013	7.0	78	0.289	0.080	6.98
2014	5.1	57	0.322	0.122	8.66
2015	2.7	63	0.200	0.053	5.08
2016	2.9	56	0.085	0.022	1.68
2017	2.0	47	0.173	0.071	4.14
2018	2.3	50	0.557	0.178	9.78
2019	2.4	50	0.106	0.052	3.01
2020	3.5	84	0.371	0.121	10.62
2021	2.4	61	0.135	0.061	3.56
2022	2.9	67	0.095	0.042	2.97
Geometric					**3.98**

Table 17. Historical catch and effort data of American shad captured by staked gillnets in the York River, Virginia. 1950s historical data are taken from the voluntary logbooks of Malvin Green, Aberdeen Creek, Virginia. The data were originally recorded as numbers of female shad per meter of net per day and were converted to weight (kg) of female shad per meter of net per day, assuming an average female weight of 1.45kg. Catch rates were multiplied by 2.16 to adjust for the lower fishing power of multifilament nets compared to current monofilament nets. 1980s historical data are taken from the voluntary logbooks of Mr. R. Kellum, Achilles, Virginia.

Year	Effort (10^3m*days)	Duration of run (days)	Highest catch rate (female kg/m/day)	Mean catch rate (female kg/m/day)	Area under the catch curve
1953	36.0	56	0.549	0.443	14.88
1954	45.5	54	0.699	0.434	14.04
1955	40.1	55	0.310	0.270	8.70
1956	68.8	85	1.201	0.663	33.95
1957	56.2	65	0.955	0.667	26.14
Geometric mean					**17.44**
1980	79.4	44	0.556	0.268	10.15
1981	114.7	51	0.259	0.121	4.35
1982	86.4	44	0.326	0.101	5.31
1983	121.3	40	0.212	0.066	3.06
1984	171.4	48	0.548	0.139	8.21
1985	205.4	49	0.227	0.091	4.61
1986	185.2	38	0.145	0.055	2.17
1987	152.9	37	0.088	0.039	1.78
1988	126.2	40	0.134	0.028	1.34
1989	146.3	55	0.397	0.131	4.92
1990	106.9	38	0.951	0.037	1.31
1991	77.8	40	0.111	0.062	2.72
1992	60.8	41	0.079	0.041	1.60
Geometric mean					**3.22**

Table 18. Summary of recent catch and effort data of American shad by staked gillnets in the York River, Virginia (* switched to anchored gillnets and therefore may not be directly comparable to previous years).

Year	Effort (10^3m*days)	Duration of run (days)	Highest catch rate (female kg/m/day)	Mean catch rate (female kg/m/day)	Area under the catch curve
1998	6.6	78	1.080	0.190	14.71
1999	6.3	65	0.209	0.075	5.42
2000	7.1	76	0.276	0.086	7.52
2001	5.7	79	0.627	0.163	12.97
2002	6.7	70	0.306	0.073	7.47
2003	6.1	70	0.390	0.111	8.98
2004	5.2	65	0.448	0.157	9.72
2005	5.8	73	0.135	0.063	4.64
2006	5.5	62	0.146	0.042	2.85
2007	5.8	70	0.243	0.069	5.04
2008	5.4	65	0.228	0.050	3.28
2009	6.0	69	0.131	0.042	2.92
2010	6.0	44	0.227	0.055	4.19
2011	6.0	58	0.219	0.060	4.58
2012	6.0	66	0.206	0.045	3.17
2013	7.1	78	0.189	0.045	3.98
2014	5.7	70	0.611	0.139	10.06
2015	2.8	58	0.033	0.020	1.93
2016	2.6	58	0.062	0.023	1.54
2017	2.4	46	0.047	0.022	1.27
2018	2.2	50	0.043	0.021	1.36
2019	2.2	43	0.101	0.041	2.39
2020	1.6	26	0.055	0.019	0.75
2021*	2.0	41	0.048	0.021	0.96
2022*	2.2	56	0.017	0.006	0.32
Geometric mean					**3.42**

Table 19. Summary of historical catch and effort data of American shad by staked gillnets in the James River, Virginia. Historical data are taken from the voluntary logbooks of the Brown family, Rescue, Virginia.

Year	Effort (10^3m*days)	Duration of run (days)	Highest catch rate (female kg/m/day)	Mean catch rate (female kg/m/day)	Area under the catch curve
1980	20.5	41	2.239	0.699	29.20
1981	67.7	41	0.547	0.130	5.20
1982	49.3	35	0.331	0.115	4.20
1983	94.0	57	1.274	0.297	16.50
1984	89.7	50	0.897	0.036	19.30
1985	91.3	45	0.295	0.103	4.90
1986	31.5	26	1.289	0.152	6.10
1987	30.1	30	0.352	0.085	2.70
1988	19.1	20	0.487	0.193	9.30
1989	31.5	30	0.331	0.176	6.40
1990	29.7	25	0.184	0.079	2.10
1991	28.3	40	0.138	0.062	1.90
1992	59.8	50	0.562	0.232	7.70
Geometric mean					**6.40**

Table 20. Summary of recent catch and effort data of American shad by staked gillnets in the James River, Virginia (* switched to anchored gillnets and therefore may not be directly comparable to previous years).

Year	Effort (10^3m*days)	Duration of run (days)	Highest catch rate (female kg/m/day)	Mean catch rate (female kg/m/day)	Area under the catch curve
1998	4.6	50	0.198	0.051	2.57
1999	6.0	66	0.183	0.042	2.99
2000	7.1	70	0.279	0.086	6.61
2001	7.3	78	0.285	0.064	5.01
2002	6.5	71	0.205	0.054	5.62
2003	6.6	79	0.284	0.112	9.34
2004	5.9	78	0.234	0.090	7.41
2005	5.6	72	0.357	0.099	7.16
2006	4.6	54	0.078	0.032	1.74
2007	5.7	58	0.159	0.068	4.45
2008	5.2	58	0.069	0.025	1.51
2009	6.6	55	0.130	0.035	2.69
2010	6.9	57	0.513	0.082	6.90
2011	6.2	78	0.357	0.091	9.00
2012	5.1	72	0.294	0.076	6.06
2013	6.6	74	0.222	0.056	4.48
2014	5.1	60	0.251	0.113	7.35
2015	2.1	49	0.057	0.023	1.25
2016	2.5	56	0.032	0.015	0.96
2017	2.9	55	0.097	0.051	3.83
2018	2.0	43	0.049	0.022	1.30
2019	1.4	32	0.013	0.007	0.35
2020*	1.5	44	0.020	0.005	0.25
2021*	2.1	1	0.008	0.001	0.06
2022*	2.5	1	0.009	0.001	0.07
Geometric mean					**2.25**

Table 21. Total numbers of hatchery-marked American shad taken in staked gillnets in the James River, 1998-2022. Ages are based on examination of scales. Hatchery production data courtesy of the Virginia Department of Game and Inland Fisheries (E. Brittle). Abbreviation: NA; not aged.

Hatchery Year Class	Hatchery Production (millions)	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total	% Total
1992	0.05		1																								1	0.1
1993	0.5	7	2	1																							10	0.9
1994	1.6	7	3	9			1																				20	1.9
1995	5.3			59	9	8	4	3																			83	7.8
1996	5.8			53	62	43	10	4	1																		173	16.2
1997	5.9			2	27	78	57	5	4		1																174	16.3
1998	10					13	52	17	13																		95	8.9
1999	7.3						14	29	7																		50	4.7
2000	8.9						1	5	9		1																16	1.5
2001	9.3								3	4	3																10	0.9
2002	8.4									4	20	7	2														33	3.1
2003	8.7										12	8	1	1	2												24	2.2
2004	6.6										2	3	2	13	4												24	2.2
2005	6.0												1	18	22	2	1										44	4.1
2006	7.0													11	35	5		3									54	5.1
2007	6.5														5	10	14	6									35	3.3
2008	6.2															4	19	13	2								38	3.6
2009	3.8																9	18	6								33	3.1
2010	3.7																	3	3	4	3						13	1.2
2011	2.4																			1	2	2					5	0.5
2012	5.4																				2	2					4	0.4
2013	4.8																					1	2				3	0.3
2014	3.3																					1					1	0.1
2015	3.5																							1			1	0.1
2016	1.01																										0	0.0
2017	1.88																										0	0.0
2018	0.0																										0	0.0
2019	0.0																										0	0.0
2020	0.0																										0	0.0
2021	0.0																										0	0.0
2022	0.0																										0	0.0
NA	--	0	2	20	0	12	3	5	3	1	9	2	2	11	15	7	9	16	1	1	2	2	0	1	0	0	124	11.6
Total	130.95	14	6	124	98	154	142	68	40	9	48	20	8	54	83	28	52	59	12	6	9	8	2	1	0	0	1068	100.0

Table 22. Total numbers of hatchery-marked American shad taken in staked gillnets in the Rappahannock River, 2007-2021. Ages are based on examination of scales. Hatchery production data courtesy of the Virginia Department of Game and Inland Fisheries (E. Brittle). Abbreviation: NA; not aged.

Hatchery Year Class	Hatchery Production (millions)	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total	% Total
2003	1.4																	
2004	3.2		1	2	1												4	9.5
2005	3.4			1		1		1									3	7.1
2006	6.3					1	1										2	4.8
2007	4.5					1	5	1	1								8	19.0
2008	4.8						1	2	1								4	9.5
2009	2.7								4	1	1						6	14.3
2010	3.9									1	2						3	7.1
2011	4.1									1		1	1				3	7.1
2012	6.0												1				1	2.4
2013	4.3													1	2		3	7.1
2014	4.3														1		1	2.4
2015	0.0																0	0.0
2016	0.0																0	0.0
2017	0.0																0	0.0
2018	0.0																0	0.0
2019	0.0																0	0.0
2020	0.0																0	0.0
2021	0.0																0	0.0
NA	--						1		1		1				1		4	9.5
Total	48.9	0	1	3	1	3	8	4	7	3	4	1	2	1	4	0	42	100.0

Table 23. Summary of catches of river herring in the Chickahominy River anchored gillnet survey, 2022 (# Females includes both pre- and post-spawn females). The * denotes first post-spawn female collected.

Date	# Alewife		# Blueback		Water Temp (C)
	3" Mesh (# Females)	2.5" Mesh (# Females)	3" Mesh (# Females)	2.5" Mesh (# Females)	
2/2/2022	3 (1)	1 (1)	0	0	3.2
2/9/2022	13 (9)	5 (3)	0	0	5.2
2/15/2022	30 (23)	10 (4)	0	0	6.0
2/23/2022	49 (44)	55 (25)	0	3 (1)	9.8
3/2/2022	16 (16)	14 (8)	1 (1)	3 (2)	9.3
3/10/2022	25 (21)	50 (30)	0	9 (7)	11.8
3/16/2022	11 (10*)	2 (1)	0	6 (4)	11.2
3/22/2022	7 (7)	76 (52)	1 (1)	11 (5)	14.3
3/29/2022	9 (9)	75 (41)	1 (1)	28 (23)	10.7
4/5/2022	9 (9	37 (31)	1 (1)	13 (12)	14.1
4/12/2022	0	19 (15)	1 (1)	19 (14)	15.3
4/20/2022	0	12 (7)	0	18 (13)	14.5
4/27/2022	0	4 (3)	0	1 (1)	20.1
Totals	172 (149)	360 (221)	5 (5)	111 (82)	

Table 24. Dates of capture, number, total weight, and catch rates of pre-spawn female alewife taken in the 2.5” and 3” mesh anchored gillnets on the Chickahominy River, spring 2022.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (kg)	Catch rate (kg/m/day)
2/2/2022	33	2	0.0058	0.51	0.0015
2/9/2022	40	12	0.0348	3.23	0.0094
2/15/2022	46	27	0.0718	7.07	0.0188
2/23/2022	54	69	0.2023	19.00	0.0557
3/2/2022	61	24	0.0627	6.06	0.0158
3/10/2022	69	51	0.1584	12.43	0.0386
3/16/2022	75	10	0.0252	2.80	0.0071
3/22/2022	81	54	0.1443	11.84	0.0316
3/29/2022	88	42	0.1057	8.87	0.0223
4/5/2022	95	22	0.0685	4.76	0.0148
4/12/2022	102	11	0.0308	2.03	0.0057
4/20/2022	110	5	0.0140	0.91	0.0025
4/27/2022	117	2	0.0064	0.42	0.0013
	Totals	331		79.91	

Table 25. Dates of capture, number, total weight, and catch rates of male alewife taken in the 2.5” and 3” mesh anchored gillnets on the Chickahominy River, spring 2022.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (kg)	Catch rate (kg/m/day)
2/2/2022	33	2	0.0058	0.45	0.0013
2/9/2022	40	6	0.0174	1.43	0.0041
2/15/2022	46	13	0.0346	2.79	0.0074
2/23/2022	54	35	0.0126	7.03	0.0206
3/2/2022	61	6	0.0157	1.21	0.0032
3/10/2022	69	24	0.00745	4.46	0.0139
3/16/2022	75	2	0.0050	0.37	0.0009
3/22/2022	81	24	0.0641	4.20	0.0112
3/29/2022	88	34	0.0856	5.85	0.0147
4/5/2022	95	6	0.0187	1.01	0.0032
4/12/2022	102	4	0.0112	0.65	0.0018
4/20/2022	110	5	0.0140	0.86	0.0024
4/27/2022	117	1	0.0032	0.18	0.0006
	Totals	162		30.49	

Table 26. Dates of capture, number, total weight, and catch rates of pre-spawn female blueback herring taken in 2.5” and 3” mesh anchored gillnets on the Chickahominy River, spring 2022.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (kg)	Catch rate (kg/m/day)
2/2/2022	33	0	0.0000	0.00	0.0000
2/9/2022	40	0	0.0000	0.00	0.0000
2/15/2022	46	0	0.0000	0.00	0.0000
2/23/2022	54	1	0.0029	0.20	0.0006
3/2/2022	61	3	0.0078	0.73	0.0019
3/10/2022	69	7	0.0217	1.53	0.0048
3/16/2022	75	4	0.0101	0.90	0.0023
3/22/2022	81	6	0.0160	1.25	0.0033
3/29/2022	88	24	0.0604	4.77	0.0120
4/5/2022	95	13	0.0405	2.86	0.0089
4/12/2022	102	15	0.0420	3.27	0.0092
4/20/2022	110	13	0.0363	2.76	0.0077
4/27/2022	117	1	0.0032	0.25	0.0008
	Totals	87		18.51	

Table 27. Dates of capture, number, total weight, and catch rates of male blueback herring taken in the 2.5” and 3” mesh gillnets on the Chickahominy River, spring 2022.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (kg)	Catch rate (kg/m/day)
2/2/2022	33	0	0.0000	0.00	0.0000
2/9/2022	40	0	0.0000	0.00	0.0000
2/15/2022	46	0	0.0000	0.00	0.0000
2/23/2022	54	2	0.0059	0.37	0.0011
3/2/2022	61	1	0.0026	0.21	0.0005
3/10/2022	69	2	0.0062	0.36	0.0011
3/16/2022	75	2	0.0050	0.37	0.0009
3/22/2022	81	6	0.0160	1.15	0.0031
3/29/2022	88	5	0.0126	0.97	0.0025
4/5/2022	95	1	0.0031	0.21	0.0007
4/12/2022	102	5	0.0140	0.89	0.0025
4/20/2022	110	5	0.0140	0.92	0.0026
4/27/2022	117	0	0.0000	0.00	0.0000
	Totals	29		5.47	

Table 28. Number, mean total length (TL), mean weight, total weight, and seasonal catch rates by year class of pre-spawn female alewife and blueback herring taken during an anchored gillnet survey in the Chickahominy River, spring 2022. The abbreviation NA is “not aged”.

Species	Year class	Number	Mean TL (mm)	Mean weight (kg)	Total weight (kg)	Seasonal catch rate (count/m/season)	Seasonal catch rate (kg/m/season)
Alewife	2019	56	273.1	0.20	10.95	0.0121	0.0024
	2018	171	285.0	0.23	39.23	0.0370	0.0085
	2017	62	300.6	0.28	17.17	0.0134	0.0037
	2016	30	308.9	0.30	8.86	0.0065	0.0019
	2015	7	315.0	0.33	2.34	0.0015	0.0005
	2014	2	321.0	0.32	0.64	0.0004	0.0001
	NA	3	291.0	0.24	0.72	0.0006	0.0002
Blueback herring	2019	3	266.7	0.18	0.53	0.0008	0.0001
	2018	23	279.6	0.19	4.47	0.0065	0.0013
	2017	30	287.0	0.21	6.24	0.0084	0.0018
	2016	22	296.0	0.24	5.19	0.0062	0.0015
	2015	5	299.4	0.25	1.26	0.0014	0.0004
	2014	1	306.0	0.25	0.25	0.0003	0.0001
	NA	3	278.7	0.19	0.57	0.0008	0.0002

Table 29. Number, mean total length (TL), mean weight, total weight, and seasonal catch rates by year class of male alewife and blueback herring taken during an anchored gillnet survey in the Chickahominy River, spring 2022. The abbreviation NA is "not aged".

Species	Year class	Number	Mean TL (mm)	Mean weight (kg)	Total weight (kg)	Seasonal catch rate (count/m/season)	Seasonal catch rate (kg/m/season)
Alewife	2019	66	264.2	0.17	11.31	0.0143	0.0024
	2018	79	274.4	0.19	15.07	0.0171	0.0033
	2017	8	293.9	0.24	1.96	0.0017	0.0004
	2016	6	300.8	0.25	1.53	0.0013	0.0003
	2014	1	315.0	0.30	0.30	0.0002	0.0001
	NA	2	269.0	0.16	0.33	0.0004	0.0001
Blueback herring	2018	9	275.2	0.18	1.62	0.0025	0.0005
	2017	13	282.7	0.19	2.50	0.0037	0.0007
	2016	6	281.0	0.19	1.15	0.0017	0.0003
	NA	1	275.0	0.21	0.21	0.0003	0.0001

Table 30. Spawning histories of male and female Alewife collected in spring 2022 in the Chickahominy River. Table entries are total numbers of fish that were aged and had spawning marks counted (males, n=134; females, n=324). Ages are based on otolith analysis by one reader (P. McGrath) and spawning marks are based on scale analysis by one reader (A. Magee).

		Age at Maturity						
Males Year Class	Age at Capture	1	2	3	4	5	6	7
2019	3	-	17	**37**	-	-	**-**	-
2018	4	-	3	32	**34**	-	-	**-**
2017	5	-	-	3	2	**2**	-	-
2016	6			1	1	1	**1**	-

		Age at Maturity							
Females Year Class	Age at Capture	1	2	3	4	5	6	7	8
2019	3	-	8	**48**	-	-	**-**	-	-
2018	4	-	8	71	**92**	-	-	**-**	**-**
2017	5	-	3	18	30	**8**	-	-	-
2016	6	-	1	8	15	5	**-**	-	-
2015	7	-	-	1	4	1	1	-	**-**
2014	8	-	-	-	-	2	-	-	**-**

Table 31. Spawning histories of male and female blueback herring collected in spring 2022 in the Chickahominy River. Table entries are total numbers of fish that were aged and had spawning marks counted (males, n=21; females, n=70). Ages are based on otolith analysis by one reader (P. McGrath) and spawning marks are based on scale analysis by one reader (A. Magee).

		Age at Maturity						
Males Year Class	Age at Capture	1	2	3	4	5	6	7
2018	4	-	-	6	**2**	-	-	**-**
2017	5	-	-	2	3	**3**	-	-
2016	6	-	-	-	1	3	**1**	-

		Age at Maturity						
Females Year Class	Age at Capture	1	2	3	4	5	6	7
2019	3	-	-	**2**	-	-	-	-
2018	4	-	2	5	**11**	-	-	-
2017	5	-	-	5	15	**9**	-	-
2016	6	-	-	1	6	6	**2**	-
2015	7	-	-	1	1	3	-	-
2014	8	-	-	-	-	1	-	-

Table 32. Summary of recent catch and effort data of pre-spawn female alewife by anchored gillnets in the Chickahominy River, Virginia (* sampling ceased early due to safety precautions related to COVID-19).

Year	Effort (10^3 m*days)	Duration of run (days)	Highest catch rate (female kg/m/day)	Mean catch rate (female kg/m/day)	Area under the catch curve
2015	3.2	77	0.0421	0.0109	1.08
2016	9.1	85	0.0222	0.0070	0.60
2017	8.4	79	0.0337	0.0108	0.91
2018	4.1	78	0.0506	0.0144	1.03
2019	4.7	83	0.0155	0.0053	0.44
2020*	3.2	56	0.0668	0.0232	1.54
2021	4.8	84	0.0286	0.0111	0.97
2022	4.6	84	0.0557	0.0173	1.58
Geometric mean					**0.94**

Table 33. Summary of recent catch and effort data of pre-spawn female blueback herring by anchored gillnets in the Chickahominy River, Virginia (* sampling ceased early due to safety precautions related to COVID-19).

Year	Effort (10^3 m*days)	Duration of run (days)	Highest catch rate (female kg/m/day)	Mean catch rate (female kg/m/day)	Area under the catch curve
2015	3.2	29	0.0181	0.0091	0.37
2016	6.2	57	0.0191	0.0062	0.37
2017	5.5	56	0.0333	0.0082	0.44
2018	4.1	78	0.0381	0.0069	0.57
2019	4.7	70	0.0179	0.0037	0.25
2020*	1.4	22	0.0262	0.0099	0.67
2021	4.8	50	0.0043	0.0019	0.10
2022	3.6	63	0.0120	0.0052	0.36
Geometric mean					**0.35**

Table 34. Summary of catches of river herring in the Rappahannock River anchored gillnet survey, 2022 (# Females includes both pre- and post-spawn females). The * denotes first post-spawn female collected.

Date	# Alewife		# Blueback		Water Temp (C)
	3" Mesh (# Females)	2.5" Mesh (# Females)	3" Mesh (# Females)	2.5" Mesh (# Females)	
2/3/2022	0	0	0	0	2.8
2/10/2022	3 (1)	0	0	0	5.7
2/16/2022	1 (1)	2 (1)	0	0	5.5
2/22/2022	10 (9)	13 (4)	0	0	7.7
3/1/2022	13 (10)	18 (9)	0	1 (1)	8.5
3/9/2022	89 (80)	164 (71)	0	10 (6)	11.9
3/15/2022	31 (27)	52 (26)	4 (4)	5 (3)	9.5
3/21/2022	11 (11)	43 (27)	0	13 (6)	13.0
3/30/2022	10 (10)	6 (4)	0	0	9.1
4/4/2022	5 (4)	7 (4)	2 (2)	30 (23)	11.3
4/12/2022	1 (1*)	20 (14)	1 (1)	57 (37)	15.3
4/21/2022	3 (2)	6 (2)	0	45 (33)	13.9
4/26/2022	0	2 (2)	0	11 (9)	19.0
5/2/2022	1 (1)	0	1 (1)	22 (15)	18.2
5/13/2022	0	0	0	1 (1)	18.1
Totals	178 (157)	333 (164)	8 (8)	195 (134)	

Table 35. Dates of capture, number, total weight, and catch rates of pre-spawn female alewife taken in the 2.5” and 3” mesh anchored gillnet monitoring on the Rappahannock River, spring 2022.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (kg)	Catch rate (kg/m/day)
2/3/2022	34	0	0.0000	0.00	0.0000
2/10/2022	41	1	0.0057	0.32	0.0018
2/16/2022	47	2	0.0111	0.61	0.0034
2/22/2022	53	13	0.0742	3.62	0.0207
3/1/2022	60	19	0.0903	5.14	0.0244
3/9/2022	68	151	0.9325	39.43	0.2435
3/15/2022	74	53	0.2768	13.40	0.0700
3/21/2022	80	38	0.1781	9.19	0.0431
3/30/2022	89	14	0.0754	3.24	0.0174
4/4/2022	94	8	0.0404	1.86	0.0094
4/12/2022	102	13	0.0666	2.69	0.0138
4/21/2022	111	4	0.0231	0.93	0.0053
4/26/2022	116	2	0.0114	0.38	0.0022
5/2/2022	122	1	0.0050	0.24	0.0012
5/13/2022	133	0	0.0000	0.00	0.0000
	Totals	319		81.06	

Table 36. Dates of capture, number, total weight, and catch rates of male alewife taken in the 2.5” and 3” mesh anchored gillnets on the Rappahannock River, spring 2022.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (kg)	Catch rate (kg/m/day)
2/3/2022	34	0	0.0000	0.00	0.0000
2/10/2022	41	2	0.0115	0.52	0.0003
2/16/2022	47	1	0.0055	0.28	0.0015
2/22/2022	53	10	0.0571	2.36	0.0135
3/1/2022	60	12	0.0570	2.60	0.0124
3/9/2022	68	102	0.6299	19.37	0.1196
3/15/2022	74	30	0.1567	5.88	0.0307
3/21/2022	80	16	0.0750	2.81	0.0132
3/30/2022	89	2	0.0108	0.32	0.0017
4/4/2022	94	4	0.0202	0.83	0.0042
4/12/2022	102	6	0.0307	1.02	0.0052
4/21/2022	111	5	0.0288	0.78	0.0045
4/26/2022	116	0	0.0000	0.00	0.0000
5/2/2022	122	0	0.0000	0.00	0.0000
5/13/2022	133	0	0.0000	0.00	0.0000
	Totals	190		36.78	

Table 37. Dates of capture, number, total weight, and catch rates of pre-spawn female blueback herring taken in the 2.5” and 3” mesh anchored gillnet monitoring on the Rappahannock River, spring 2022.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (kg)	Catch rate (kg/m/day)
2/3/2022	34	0	0.0000	0.00	0.0000
2/10/2022	41	0	0.0000	0.00	0.0000
2/16/2022	47	0	0.0000	0.00	0.0000
2/22/2022	53	0	0.0000	0.00	0.0000
3/1/2022	60	1	0.0048	0.22	0.0011
3/9/2022	68	6	0.0371	1.36	0.0084
3/15/2022	74	7	0.0366	1.91	0.0100
3/21/2022	80	6	0.0281	1.28	0.0060
3/30/2022	89	0	0.0000	0.00	0.0000
4/4/2022	94	25	0.1262	5.28	0.0266
4/12/2022	102	38	0.1946	7.96	0.0408
4/21/2022	111	33	0.1904	6.91	0.0398
4/26/2022	116	9	0.0514	1.96	0.0112
5/2/2022	122	16	0.0808	3.41	0.0172
5/13/2022	133	1	0.0057	0.20	0.0012
	Totals	142		30.48	

Table 38. Dates of capture, number, total weight, and catch rates of male blueback herring taken in the 2.5” and 3” mesh anchored gillnet monitoring on the Rappahannock River, spring 2022.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (kg)	Catch rate (kg/m/day)
2/3/2022	34	0	0.0000	0.00	0.0000
2/10/2022	41	0	0.0000	0.00	0.0000
2/16/2022	47	0	0.0000	0.00	0.0000
2/22/2022	53	0	0.0000	0.00	0.0000
3/1/2022	60	0	0.0000	0.00	0.0000
3/9/2022	68	4	0.0247	0.77	0.0048
3/15/2022	74	2	0.0104	0.39	0.0020
3/21/2022	80	7	0.0328	1.34	0.0063
3/30/2022	89	0	0.0000	0.00	0.0000
4/4/2022	94	7	0.0353	1.27	0.0064
4/12/2022	102	20	0.1024	3.65	0.0187
4/21/2022	111	12	0.0692	2.13	0.0123
4/26/2022	116	2	0.0114	0.38	0.0022
5/2/2022	122	7	0.0353	1.33	0.0067
5/13/2022	133	0	0.0000	0.00	0.0000
	Totals	61		11.27	

Table 39. Number, mean total length (TL), mean weight, total weight, and seasonal catch rates by year class of pre-spawn female alewife and blueback herring taken during anchored gillnet survey in the Rappahannock River, spring 2022. The abbreviation NA is “not aged”.

Species	Year class	Number	Mean TL (mm)	Mean weight (kg)	Total weight (kg)	Seasonal catch rate (count/m/season)	Seasonal catch rate (kg/m/season)
Alewife	2019	39	280.4	0.22	8.59	0.0160	0.0035
	2018	145	286.8	0.23	33.86	0.0596	0.0139
	2017	87	303.0	0.28	24.57	0.0357	0.0101
	2016	35	309.4	0.30	10.36	0.0144	0.0043
	2015	4	320.5	0.32	1.29	0.0016	0.0005
	2014	1	323.0	0.35	0.35	0.0004	0.0001
	NA	6	290.5	0.25	1.50	0.0025	0.0006
Blueback herring	2019	3	271.3	0.17	0.52	0.0014	0.0002
	2018	34	279.2	0.19	6.57	0.0164	0.0032
	2017	63	287.7	0.22	13.56	0.0303	0.0065
	2016	35	291.6	0.23	7.94	0.0168	0.0038
	2015	5	308.4	0.28	1.39	0.0024	0.0007
	2014	1	305.0	0.30	0.30	0.0005	0.0001
	NA	1	291.0	0.21	0.21	0.0005	0.0001

Table 40. Number, mean total length (TL), mean weight, total weight, and seasonal catch rates by year class of male alewife and blueback herring taken during an anchored gillnet survey in the Rappahannock River, spring 2022. The abbreviation NA is “not aged”.

Species	Year class	Number	Mean TL (mm)	Mean weight (kg)	Total weight (kg)	Seasonal catch rate (count/m/season)	Seasonal catch rate (kg/m/season)
Alewife	2019	73	269.3	0.18	13.21	0.0300	0.0054
	2018	84	273.2	0.19	15.72	0.0345	0.0065
	2017	20	293.7	0.24	4.89	0.0082	0.0020
	2016	5	295.4	0.25	1.26	0.0021	0.0005
	2015	2	305.5	0.26	0.52	0.0008	0.0002
	NA	6	275.2	0.20	1.18	0.0025	0.0005
Blueback herring	2018	17	270.9	0.18	3.01	0.0082	0.0014
	2017	31	275.6	0.19	5.74	0.0149	0.0028
	2016	8	275.6	0.19	1.50	0.0038	0.0007
	2015	2	290.5	0.22	0.44	0.0010	0.0002
	2014	2	296.0	0.21	0.42	0.0010	0.0002
	NA	1	269.0	0.16	0.16	0.0005	0.0001

Table 41. Spawning histories of male and female Alewife collected in spring 2022 in the Rappahannock River. Table entries are total numbers of fish that were aged and had spawning marks counted (males, n=161; females, n=265). Ages are based on otolith analysis by one reader (P. McGrath) and spawning marks are based on scale analysis by one reader (A. Magee).

Age at Maturity

Males Year Class	Age at Capture	1	2	3	4	5	6	7
2019	3	-	29	**36**	-	-	-	-
2018	4	-	4	31	**40**	-	-	-
2017	5	-	-	5	12	**1**	-	
2016	6	-	-	-	1	1	**-**	-
2015	7	-	-	-	1	-	**-**	-

Age at Maturity

Females Year Class	Age at Capture	1	2	3	4	5	6	7
2019	3	-	13	**22**	**-**	-	-	**-**
2018	4	-	5	60	**63**	-	-	**-**
2017	5	-	4	20	42	**7**	-	-
2016	6	-	-	4	14	9	**-**	-
2017	7	-	-	-	1	1	**-**	-

Table 42. Spawning histories of male and female blueback herring collected in spring 2022 in the Rappahannock River. Table entries are total numbers of fish that were aged and had spawning marks counted (males, n=51; females, n=117). Ages are based on otolith analysis by one reader (P. McGrath) and spawning marks are based on scale analysis by one reader (A. Magee).

		Age at Maturity						
Males Year Class	Age at Capture	1	2	3	4	5	6	7
2018	4	-	1	6	**10**	-	-	**-**
2017	5	-	-	3	13	**8**	-	-
2016	6	-	-	1	1	5	**-**	-
2015	7	-	-	-	-	-	1	**-**
2014	8	-	-	-	-	-	1	1

		Age at Maturity						
Females Year Class	Age at Capture	1	2	3	4	5	6	7
2019	3	-	-	**3**	**-**	-	-	-
2018	4	-	-	12	**21**	-	-	-
2017	5	-	1	3	30	**13**	-	-
2016	6	-	-	2	9	15	**3**	**-**
2015	7	-	-	-	-	4	**-**	**-**
2014	8	-	-	-	-	1	**-**	**-**

Table 43. Summary of recent catch and effort data of pre-spawn female alewife by anchored gillnets in the Rappahannock River, Virginia (* sampling ceased early due to safety precautions related to COVID-19).

Year	Effort (10^3 m*days)	Duration of run (days)	Highest catch rate (female kg/m/day)	Mean catch rate (female kg/m/day)	Area under the catch curve
2018	4.6	77	0.950	0.0394	1.37
2019	2.2	71	0.0407	0.0126	0.97
2020*	1.6	49	0.0508	0.0263	1.85
2021	2.7	85	0.0453	0.0136	1.21
2022	2.4	81	0.2435	0.0351	3.16
Geometric mean					**1.57**

Table 44. Summary of recent catch and effort data of pre-spawn female blueback herring by anchored gillnets in the Rappahannock River, Virginia (* sampling ceased early due to safety precautions related to COVID-19).

Year	Effort (10^3 m*days)	Duration of run (days)	Highest catch rate (female kg/m/day)	Mean catch rate (female kg/m/day)	Area under the catch curve
2018	3.8	63	0.2828	0.0710	2.33
2019	1.4	45	0.1294	0.0564	3.08
2020*	1.6	49	0.0309	0.0129	1.25
2021	2.7	70	0.0239	0.0087	0.66
2022	2.1	73	0.0408	0.0162	1.18
Geometric mean					**1.48**

Table 45. Indexes of abundance of juvenile American shad collected in beach seine surveys (1980-2022) on the James, Chickahominy and Rappahannock rivers. The index is the geometric mean catch per haul. Means are reported for five-year increments for years 1980 – 1999. Abbreviations are: SD, standard deviation; N, number of seine hauls.

Year	James	SD	N	Chickahominy	SD	N	Rappahannock	SD	N
1980 - 84	0.08	0.36	18	0		5	0.32	2.77	4
1985 - 89	0.01	0.22	34	0		8	0.16	0.49	16
1990 - 94	0.01	0.16	62	0		10	0.08	0.35	32
1995 - 99	0.01	0.11	65	0		10	0.17	0.46	33
2000	0		70	0		10	0.08	0.25	34
2001	0		70	0		10	0.34	0.43	35
2002	0		69	0		10	0		35
2003	0.10	0.30	70	0		10	0.59	0.66	28
2004	0.05	0.20	67	0		10	0.81	0.94	35
2005	0		66	0		10	0.27	0.66	33
2006	0.21	0.44	64	0.23	0.34	10	0.11	0.30	34
2007	0.04	0.26	65	0		10	0.40	0.50	34
2008	0.01	0.09	64	0		10	0.02	0.12	35
2009	0.02	0.12	65	0.07	0.22	10	0.13	0.36	34
2010	0.02	0.12	65	0		10	1.19	1.17	33
2011	0.15	0.39	59	0		10	1.15	1.05	27
2012	0.01	0.09	57	0		10	0.19	0.42	35
2013	0		65	0		10	0.35	0.61	35
2014	0.07	0.24	55	0.15	0.29	10	3.79	1.55	35
2015	0.25	0.57	59	0.56	0.94	10	4.19	1.52	28
2016	0.01	0.09	65	0		10	4.17	1.63	35
2017	0		65	0		10	0.87	1.27	35
2018	0.03	0.16	63	0		10	4.65	1.57	35
2019	0.13	0.33	65	0.07	0.22	10	11.65	1.75	35
2020	0		56	0		8	8.13	1.29	32
2021	0		65	0		10	3.36	1.25	35
2022	0		65	0		10	11.69	1.37	35

Table 46. Indexes of abundance of juvenile American shad collected in beach seine surveys (1980-2022) on the Mattaponi, Pamunkey, and York rivers. The index is the geometric mean catch per haul. Means are reported for five-year increments for years 1980 – 1999. Abbreviations are: SD, standard deviation; N, number of seine hauls.

Year	Mattaponi	SD	N	Pamunkey	SD	N	York	SD	N
1980 - 84	7.21	1.01	17	0.42	0.60	12	2.41	1.15	30
1985 - 89	1.94	0.79	32	0.20	1.03	23	0.91	0.70	59
1990 - 94	0.59	0.77	46	0.04	0.22	36	0.28	0.62	87
1995 - 99	3.96	0.98	49	0.53	0.68	39	1.66	0.92	92
2000	5.77	1.31	39	0.08	0.26	31	1.83	1.33	74
2001	0.58	0.70	49	0.15	0.36	40	0.35	0.58	94
2002	0.23	0.50	48	0.02	0.11	40	0.12	0.37	93
2003	8.57	1.32	50	13.11	1.06	39	9.04	1.30	94
2004	7.52	1.39	47	0.10	0.29	38	2.21	1.45	90
2005	1.66	1.35	50	0.05	0.20	40	0.70	1.09	95
2006	0.93	0.92	48	0.09	0.35	37	0.47	0.76	90
2007	0.30	0.51	47	0		36	0.15	0.39	88
2008	0.11	0.30	50	0		40	0.06	0.23	95
2009	0.02	0.16	47	0		40	0.01	0.12	92
2010	0.97	1.03	50	0.06	0.19	38	0.47	0.82	93
2011	1.16	1.39	48	0.27	0.55	35	0.67	1.11	88
2012	0.01	0.10	48	0.02	0.11	39	0.02	0.10	93
2013	0.12	0.36	50	0.05	0.20	40	0.10	0.32	95
2014	1.58	0.94	50	0.12	0.28	41	0.72	0.54	96
2015	2.96	1.22	49	0.89	0.88	40	1.69	1.13	94
2016	0.99	1.05	50	0.36	0.71	40	0.64	0.91	95
2017	0.60	0.82	50	0.13	0.49	40	0.36	0.70	95
2018	4.72	1.28	49	1.14	0.76	40	2.51	1.17	94
2019	2.65	1.13	50	0.40	0.80	40	1.28	1.09	95
2020	0.73	0.78	42	0.06	0.20	34	0.36	0.62	81
2021	1.26	0.85	50	0		39	0.56	0.74	94
2022	0.34	0.73	50	0.17	0.58	40	0.25	0.65	95

Table 47. Summary of catches of juvenile river herring in the Chickahominy River in 2022 during nighttime surface trawls. Cruise specific indexes are reported as geometric means of all stations. There were insufficient catches of alewife to present indexes of abundance.

Date	Species	N	Mean FL (mm)	Mean WT (g)	Mean (fish/tow)	Cruise specific index (SD)
7/6/2022	Alewife	1	64	3.1	0.1	0.1 (0.2)
	Blueback	98	38.8	0.8	8.2	5.5 (3.1)
7/11/2022	Alewife	0			0	0
	Blueback	86	39.6	1.1	7.2	4.2 (3.5)
7/21/2022	Alewife	0			0	0
	Blueback	121	42.4	1.4	10.1	6.1 (3.6)
7/26/2022	Alewife	1	74	8.8	0.1	0.1 (0.2)
	Blueback	135	44.5	1.3	11.3	5.9 (4.1)
8/1/2022	Alewife	0			0	0
	Blueback	378	49.1	1.7	31.5	15.5 (4.9)
8/8/2022	Alewife	0			0	0
	Blueback	24	46.1	1.9	2	1.9 (2.3)
8/16/2022	Alewife	0			0	0
	Blueback	159	48.7	1.7	13.3	5.8 (4.5)
8/23/2022	Alewife	0			0	0
	Blueback	176	51.7	1.8	14.7	4.5 (5.7)
8/29/2022	Alewife	0			0	0
	Blueback	56	58.1	1.9	4.7	3.4 (3.0)
Season Totals	**Alewife**	**2**	**69.0**	**6.0**	**0.02**	**0.01 (0.1)**
	Blueback	**1233**	**46.6**	**1.5**	**11.4**	**5.1 (4.0)**

Table 48. Indexes of abundance of juvenile alewife collected in beach seine surveys (1989-2022) on the James, York, and Rappahannock rivers. The index is the geometric mean catch per haul. Abbreviations are: SD, standard deviation; N, number of seine hauls.

Year	James	SD	N	York	SD	N	Rappahannock	SD	N
1989	0.00		10	0.05	0.33	54	1.01	1.07	36
1990	0.00		10	0.00		55	0.05	0.19	40
1991	0.00		10	0.00		54	0.02	0.12	35
1992	0.00		10	0.00		54	0.04	0.22	40
1993	0.07	0.22	10	0.00		54	0.21	0.57	36
1994	0.07	0.22	10	0.12	0.54	54	0.22	0.52	39
1995	0.00		10	0.00		55	0.09	0.35	37
1996	0.66	1.07	10	0.11	0.40	53	0.61	1.08	37
1997	0.00		10	0.01	0.09	55	0.28	0.80	40
1998	0.07	0.22	10	0.00		51	0.12	0.47	33
1999	0.00		10	0.00		49	0.12	0.32	40
2000	0.00		10	0.00		51	0.17	0.50	39
2001	0.00		10	0.24	0.65	54	0.41	0.90	40
2002	0.00		10	0.01	0.10	53	0.02	0.11	40
2003	0.00		10	0.04	0.24	54	0.25	0.61	39
2004	0.28	0.58	10	0.01	0.10	50	0.05	0.19	40
2005	0.44	1.16	10	0.02	0.15	55	0.03	0.18	37
2006	0.28	0.42	10	0.00		50	0.04	0.16	39
2007	0.55	1.39	10	0.00		48	0.30	0.77	39
2008	0.00		10	0.00		55	0.04	0.15	40
2009	0.30	0.63	10	0.00		52	0.12	0.40	39
2010	0.07	0.22	10	0.23	0.61	53	0.36	0.74	38
2011	0.00		10	0.05	0.21	49	0.98	1.32	39
2012	0.00		10	0.00		56	0.05	0.31	40
2013	0.12	0.35	10	0.00		55	0.16	0.41	40
2014	0.23	0.47	10	0.00		53	0.17	0.37	40
2015	3.29	1.66	10	0.07	0.23	55	0.25	0.53	40
2016	0.98	1.15	11	0.09	0.28	55	0.11	0.45	40
2017	0.20	0.57	10	0.00		55	0.13	0.67	40
2018	2.98	1.54	10	0.06	0.34	54	0.52	1.03	40
2019	0.12	0.35	10	0.03	0.22	55	0.19	0.57	39
2020	0.00		9	0.00		55	0.10	0.32	37
2021	0.07	0.22	10	0.00		54	0.04	0.22	40
2022	0.00		10	0.03	0.19	55	0.08	0.32	40

Table 49. Indexes of abundance of juvenile blueback herring collected in beach seine surveys (1989-2022) on the James, York, and Rappahannock rivers. The index is the geometric mean catch per haul. Abbreviations are: SD, standard deviation; N, number of seine hauls.

Year	James	SD	N	York	SD	N	Rappahannock	SD	N
1989	0.5	0.89	45	0.32	0.69	35	8.93	1.63	22
1990	0.46	1.11	45	0.00	0.00	35	1.89	1.14	25
1991	0.26	0.64	45	0.04	0.16	35	0.15	0.45	21
1992	0.08	0.53	45	0.00	0.00	34	0.06	0.19	25
1993	0.72	1.37	45	0.00	0.00	34	2.05	1.39	21
1994	0.44	1.01	43	0.14	0.39	34	1.48	1.58	24
1995	0.03	0.15	43	0.00	0.00	35	0.40	0.50	23
1996	0.56	1.18	44	0.39	1.05	34	6.14	1.77	22
1997	0.18	0.80	45	0.06	0.26	35	1.51	1.54	25
1998	0.23	0.57	44	0.00	0.00	33	1.97	1.78	19
1999	0.03	0.14	49	0.00	0.00	32	0.46	0.89	25
2000	0.45	1.27	50	0.43	1.09	32	1.47	1.64	24
2001	0.42	1.07	50	0.27	0.92	34	3.30	1.43	25
2002	0.14	0.54	49	0.00	0.00	34	0.34	0.72	25
2003	0.74	1.28	50	0.82	1.10	34	3.22	1.62	25
2004	0.4	0.94	47	0.07	0.31	32	1.80	1.32	25
2005	0.47	1.02	46	0.00	0.00	35	1.29	1.53	23
2006	0.02	0.11	44	0.00	0.00	31	0.93	1.37	24
2007	0.51	1.09	45	0.11	0.44	30	1.30	1.03	24
2008	0.02	0.11	44	0.05	0.22	35	0.46	0.73	25
2009	0.16	0.64	45	0.00	0.00	33	0.65	1.19	24
2010	0.13	0.72	45	0.12	0.67	35	1.35	1.26	25
2011	1.15	1.49	39	0.26	0.10	30	9.14	2.12	24
2012	0.26	0.70	38	0.00	0.00	33	0.31	0.95	25
2013	0.08	0.37	40	0.00	0.00	35	0.45	1.07	25
2014	1.99	1.85	40	0.23	0.59	36	5.02	1.66	25
2015	2.82	1.84	40	1.41	1.59	35	15.84	2.20	25
2016	0.72	1.28	40	0.26	0.61	35	2.60	1.55	25
2017	0.87	1.38	40	0.20	0.57	35	0.69	0.99	25
2018	3.21	1.67	38	0.52	1.01	34	3.87	1.88	25
2019	3.85	1.82	40	0.09	0.31	35	2.66	1.59	25
2020	0.56	1.40	38	0.30	0.88	35	0.99	1.21	22
2021	0.38	0.80	40	0.20	0.81	34	0.85	1.24	25
2022	0.19	0.86	40	0.05	0.22	35	0.61	1.15	25

Table 50. Daily numbers and seasonal totals of live or dead striped bass (SB) and other species captured by anchored gillnets in the James River, 2022.

Date	Live SB	Dead SB	Total SB	Other species	Total
2/16/2022	22	7	29	42	71
2/24/2022	18	11	29	92	121
3/3/2022	35	36	71	172	243
3/10/2022	40	36	76	230	306
3/16/2022	28	15	43	310	353
3/23/2022	11	8	19	222	241
3/30/2022	11	14	25	283	308
4/6/2022	4	5	9	211	220
4/13/2022	3	2	5	625	630
4/21/2022	11	8	19	557	576
Totals	183	142	325	2744	3069

Table 51. Daily numbers and seasonal totals of live or dead striped bass (SB) and other species captured by anchored gillnets in the York River, 2022.

Date	Live SB	Dead SB	Total SB	Other species	Total
2/17/2022	52	11	63	24	87
2/25/2022	25	12	37	85	122
3/4/2022	23	9	32	282	314
3/11/2022	10	12	22	176	198
3/17/2022	3	4	7	85	92
3/24/2022	2	2	4	120	124
3/31/2022	0	0	0	20	20
4/7/2022	0	0	0	43	43
4/14/2022	0	1	1	78	79
Totals	115	51	166	913	1079

Table 52. Daily numbers and seasonal totals of live or dead striped bass (SB) and other species captured by staked gillnets in the Rappahannock River, 2022.

Date	Live SB	Dead SB	Total SB	Other species	Total
2/23/2022	34	22	56	183	239
2/28/2022	67	36	103	151	254
3/5/2022	18	19	37	136	173
3/11/2022	48	46	94	185	279
3/20/2022	23	34	57	166	223
3/26/2022	10	16	26	247	273
4/3/2022	1	4	5	273	278
4/8/2022	2	1	3	331	334
4/15/2022	6	10	16	343	359
4/21/2022	3	7	10	321	331
5/1/2022	0	0	0	181	181
Totals	212	195	407	2517	2924

Figure 1. Number and location of staked gillnets on the James River in 1983.

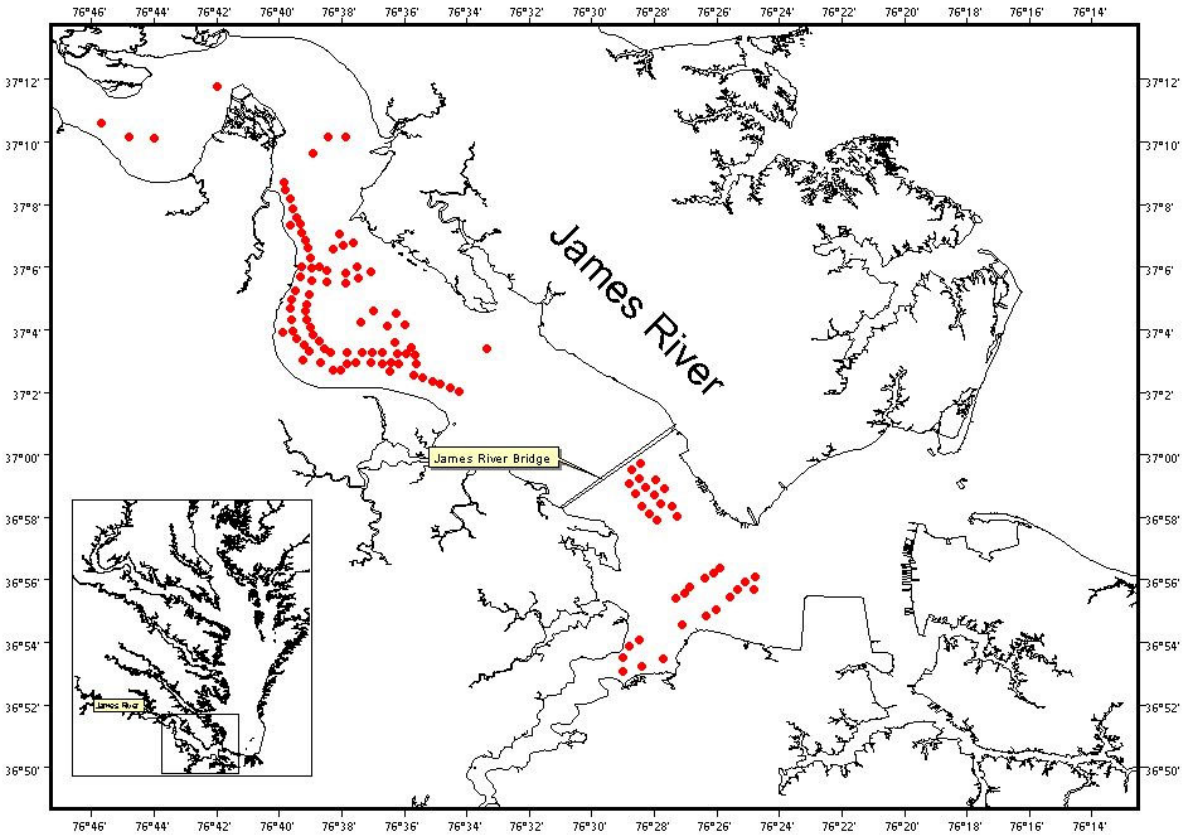


Figure 2. Number and location of staked gillnets on the York River in 1983.

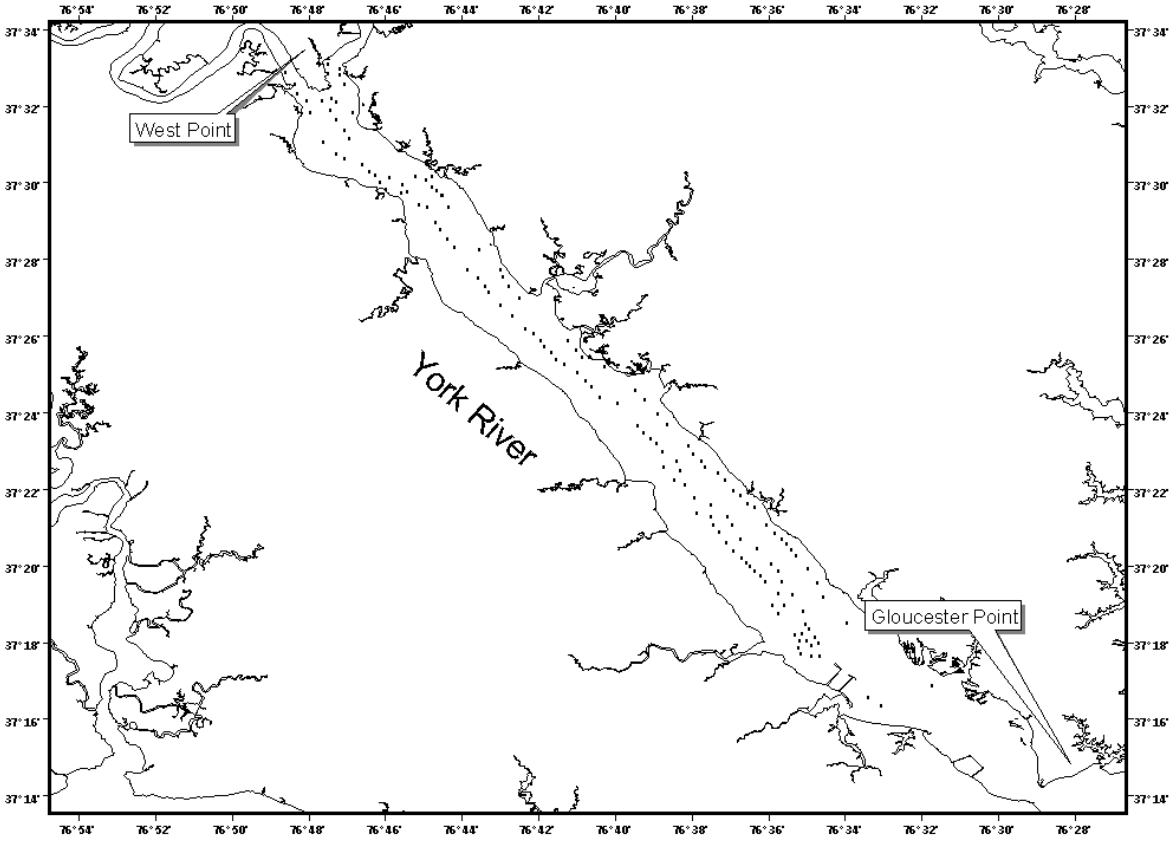


Figure 3. Number and location of staked gillnets on the Rappahannock River in 1983.

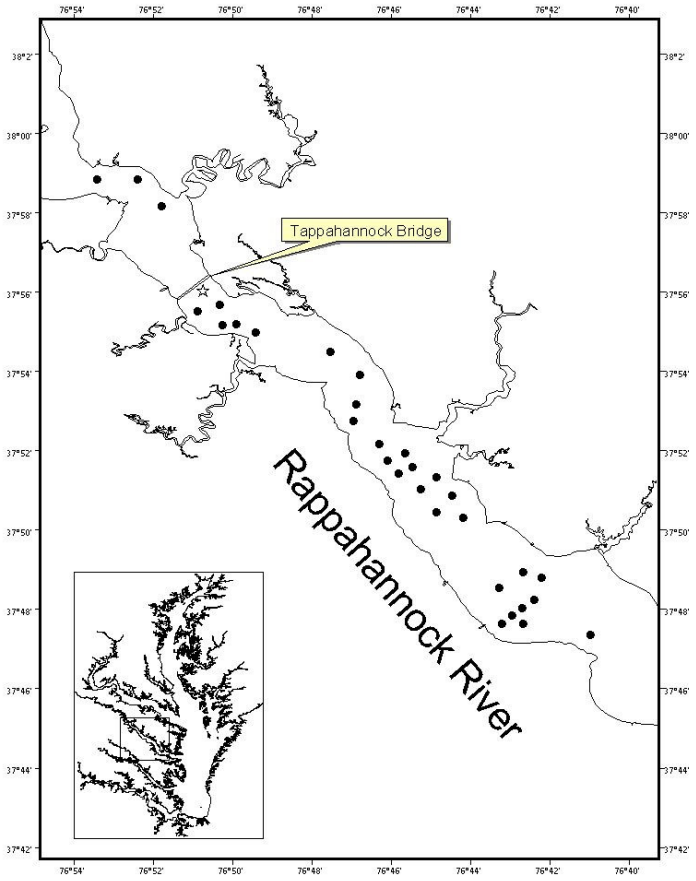


Figure 4. Location of the anchored gillnet fished by Mr. George Trice on the James River.

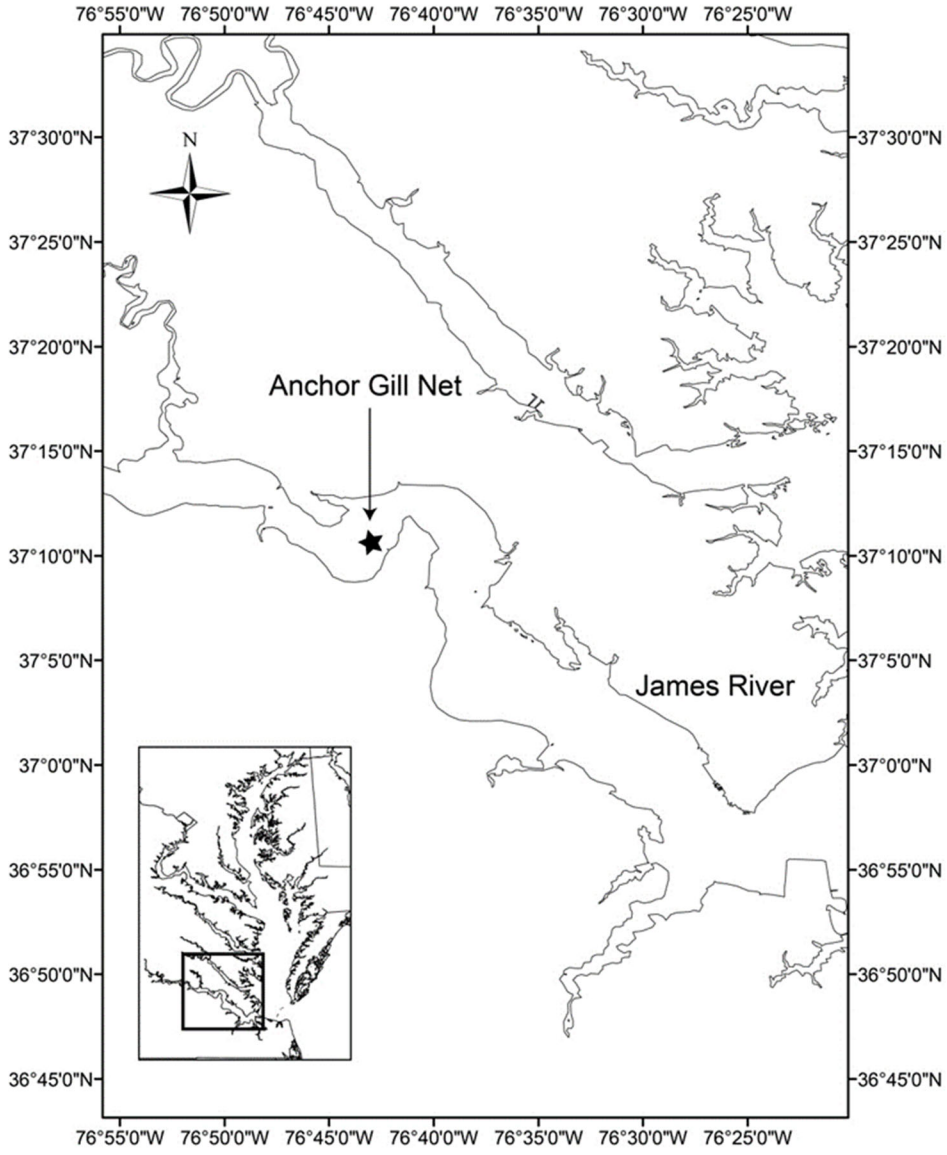


Figure 5. Location of the anchored gillnet fished by Mr. George Trice on the York River.

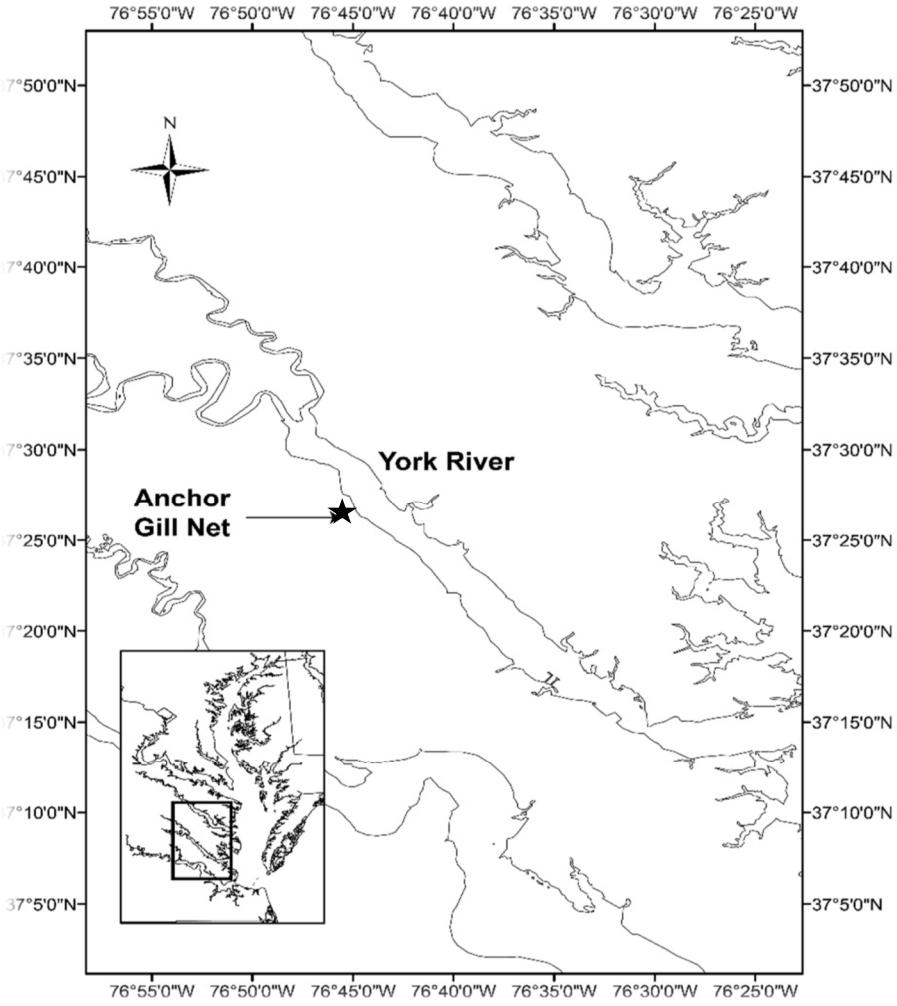


Figure 6. Location of the staked gillnet fished by Mr. Jamie Sanders on the Rappahannock River.

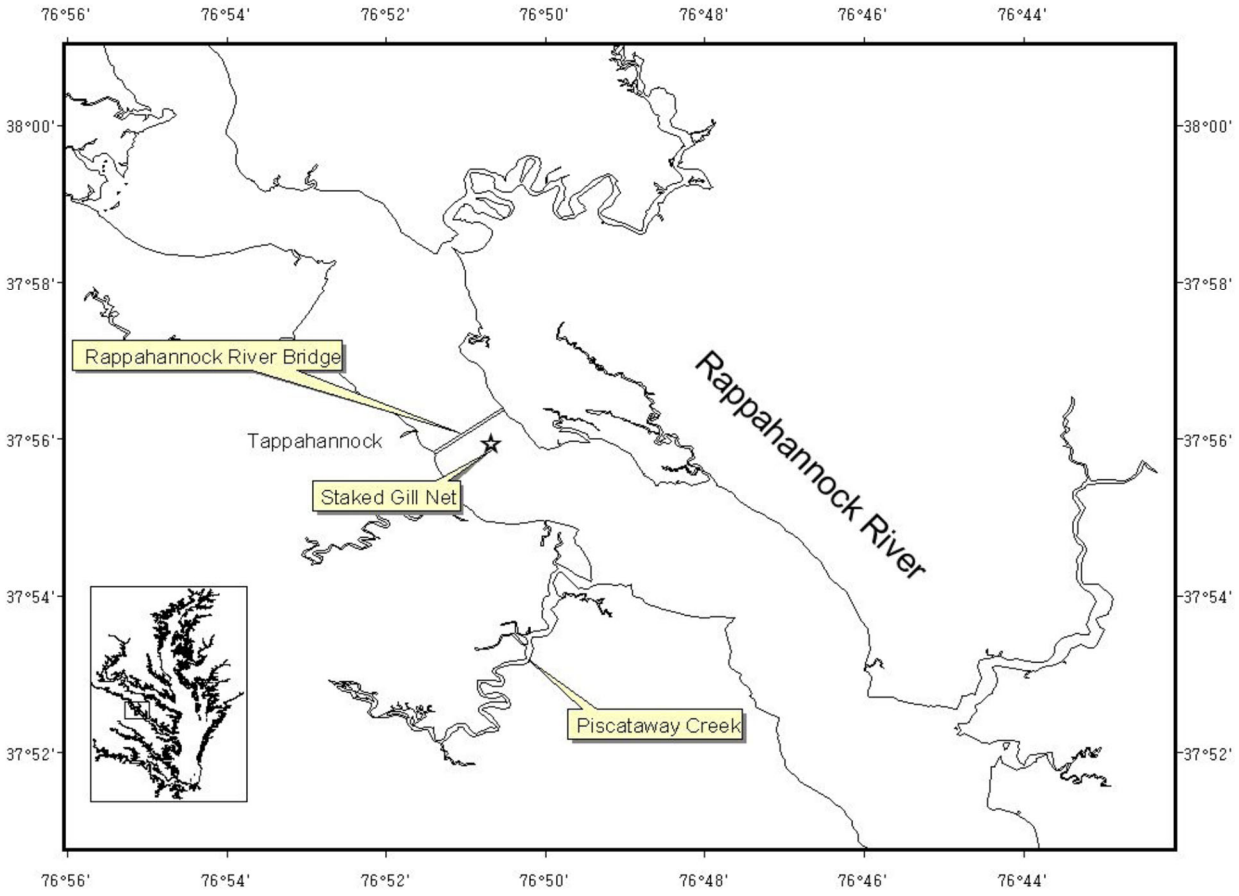


Figure 7. Recent (1998-2022) and historic values of the catch index of female American shad on the James River.

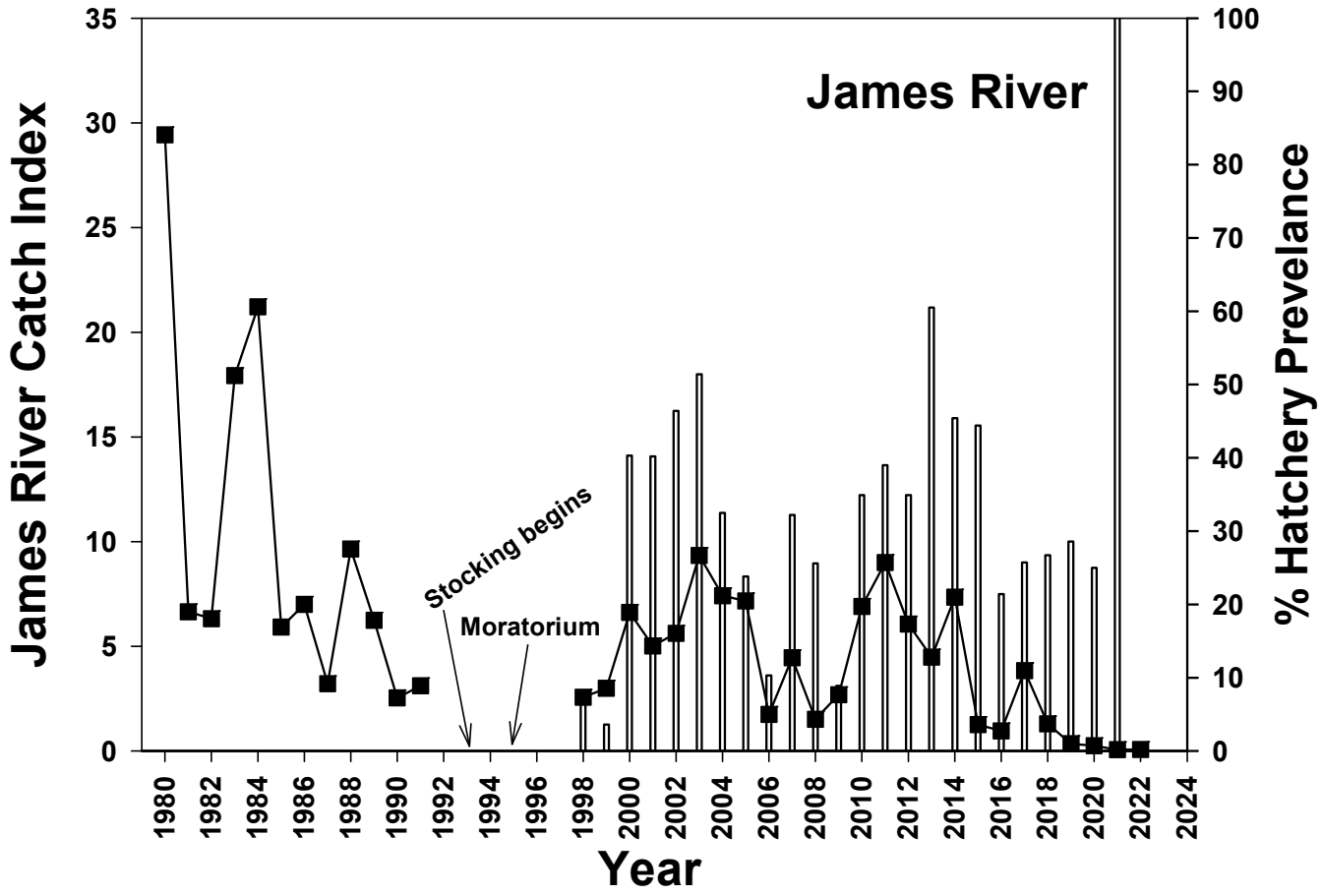


Figure 8. Recent (1998-2022) and historic values of the catch index of female American shad on the York River.

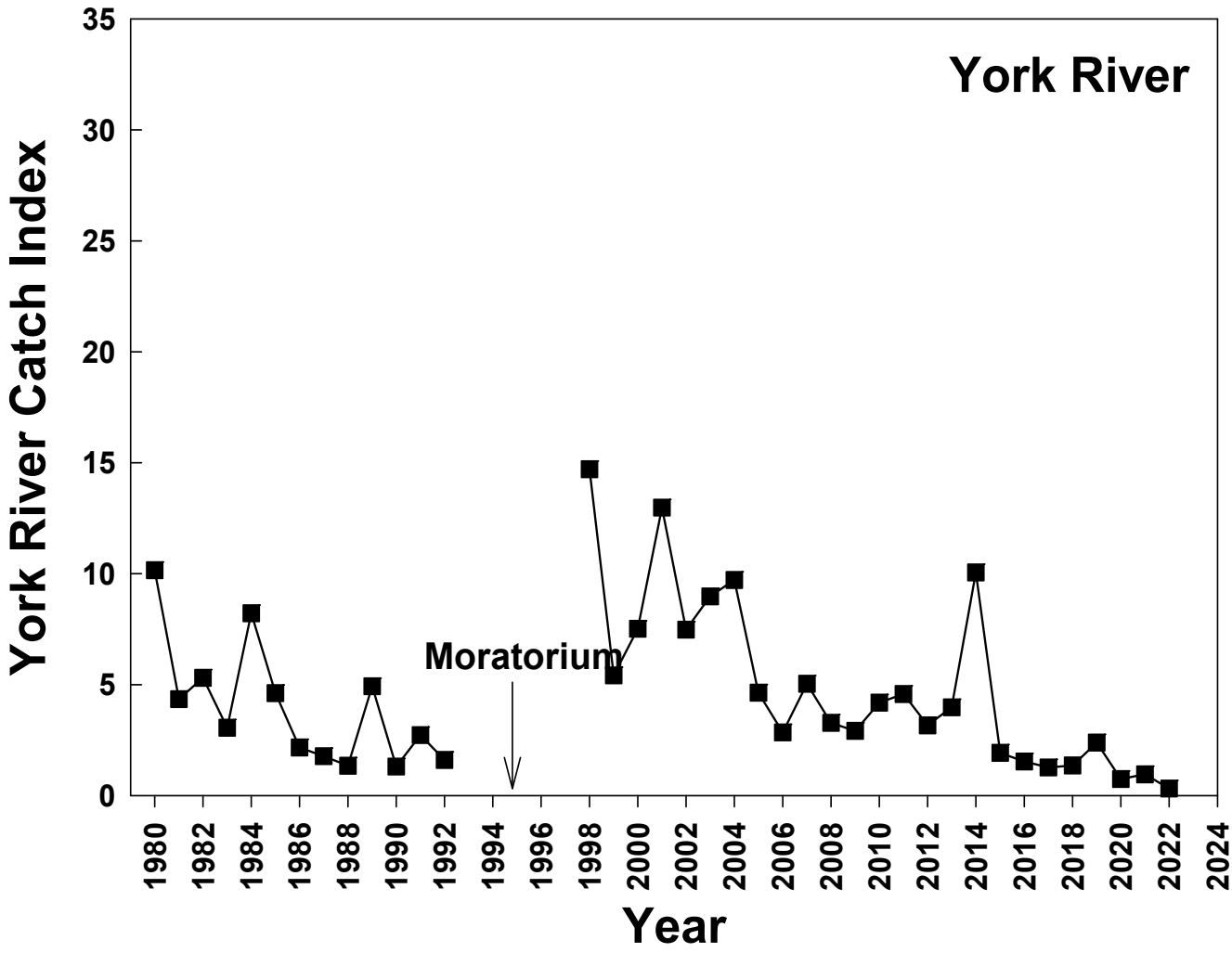


Figure 9. Catch indexes of historical logbook data from the 1950s (M. Greene), 1980s (R. Kellum), and current monitoring. The 1950s data have been adjusted by multiplying index values by 2.16 based on gear comparison trials. Horizontal lines are the geometric means of each data set (solid, 1950s; short dashes, current; long dashes, 1980s)

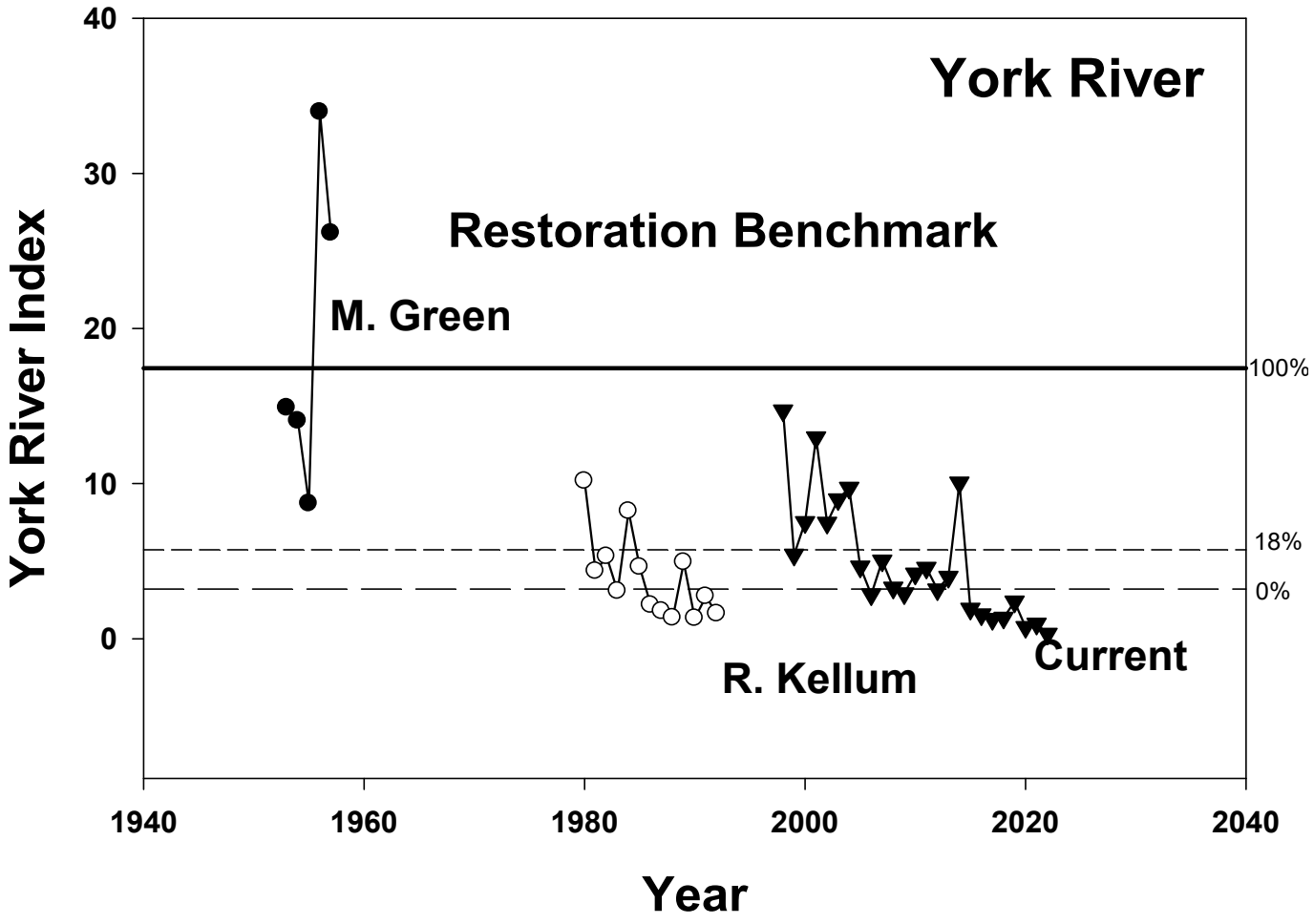


Figure 10. Recent (1998-2022) and historic values of the catch index of female American shad on the Rappahannock River.

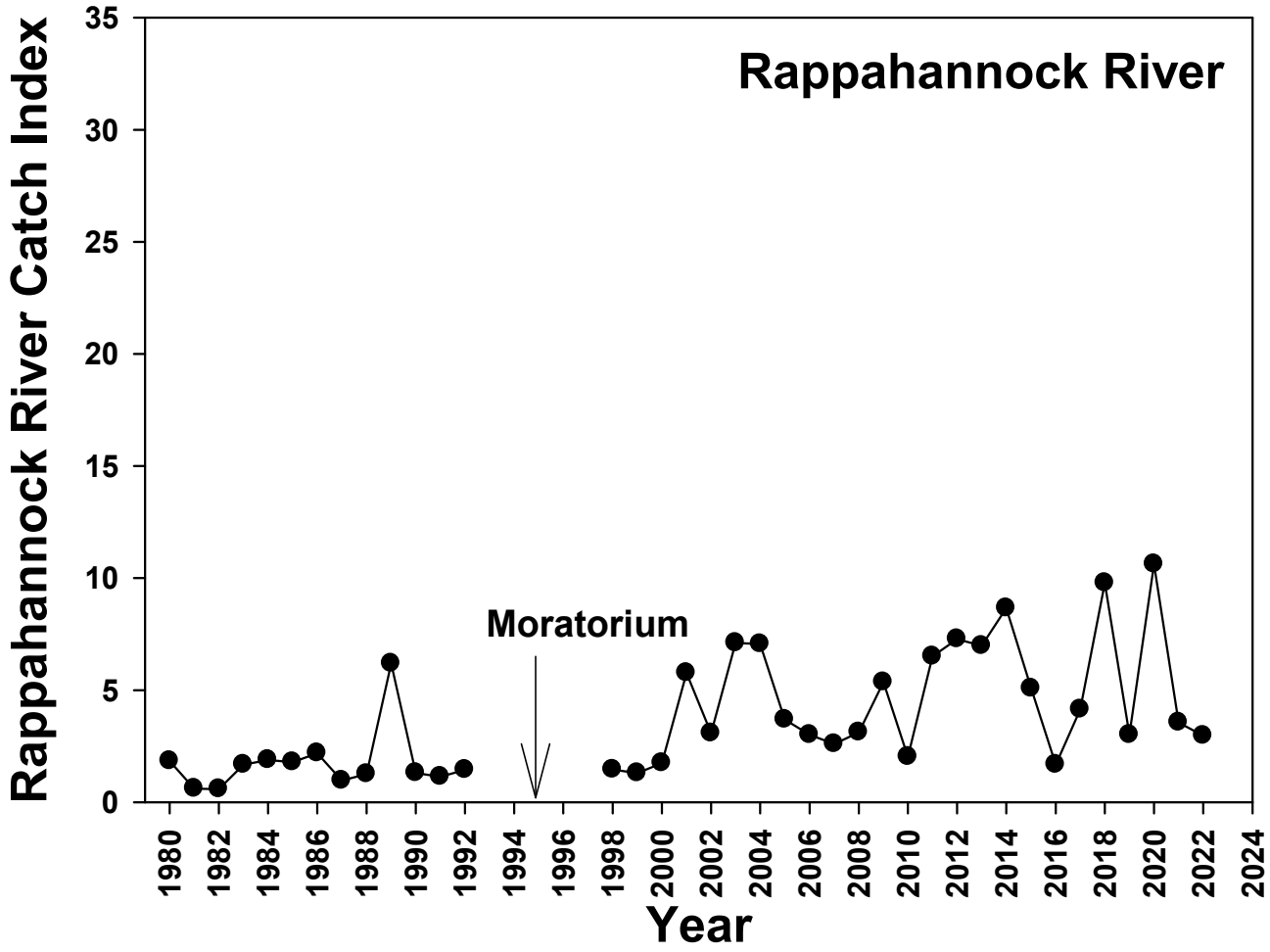


Figure 11. Comparison of the James River catch index to the percent of specimens with OTC hatchery marks.

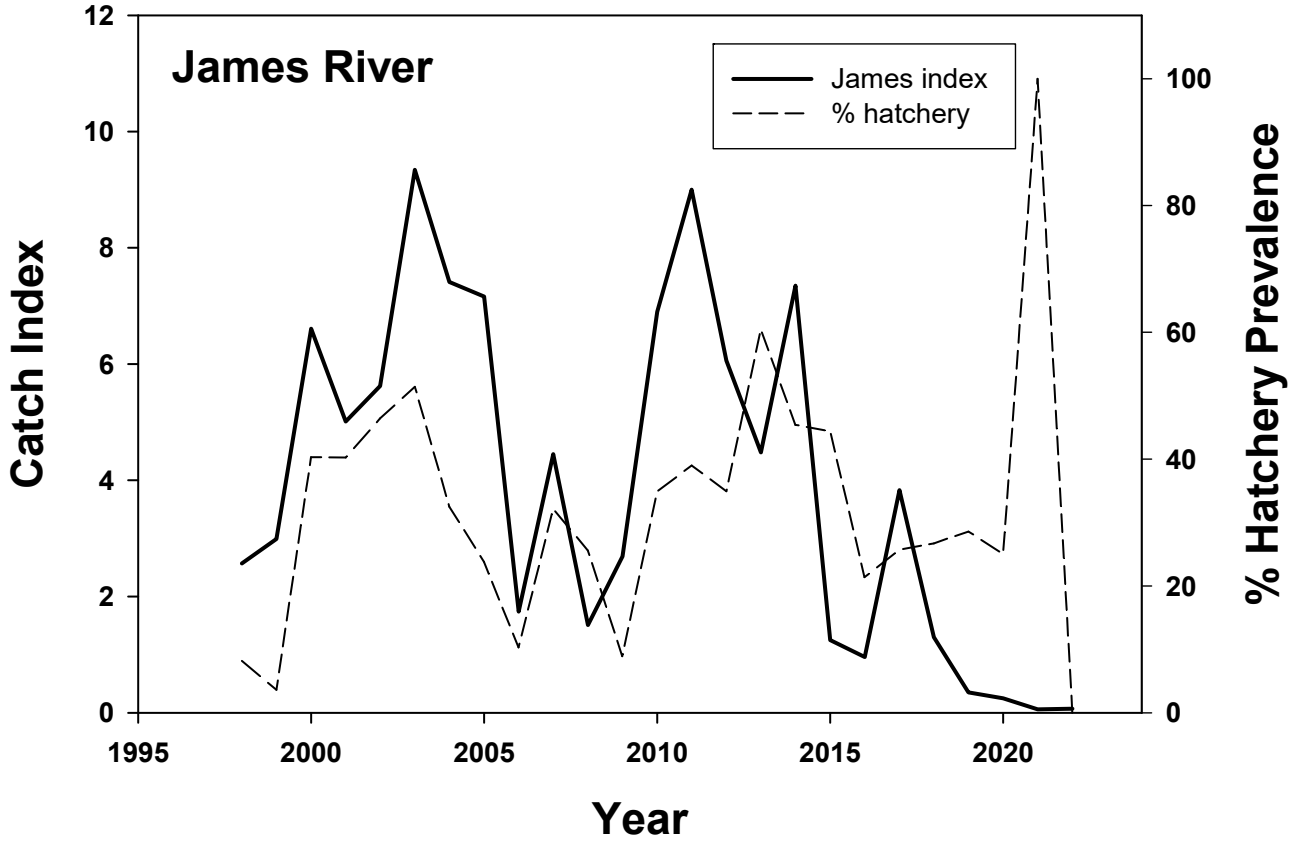


Figure 12. Recent (2015-2022) values of the catch index of female Alewife on the Chickahominy River.

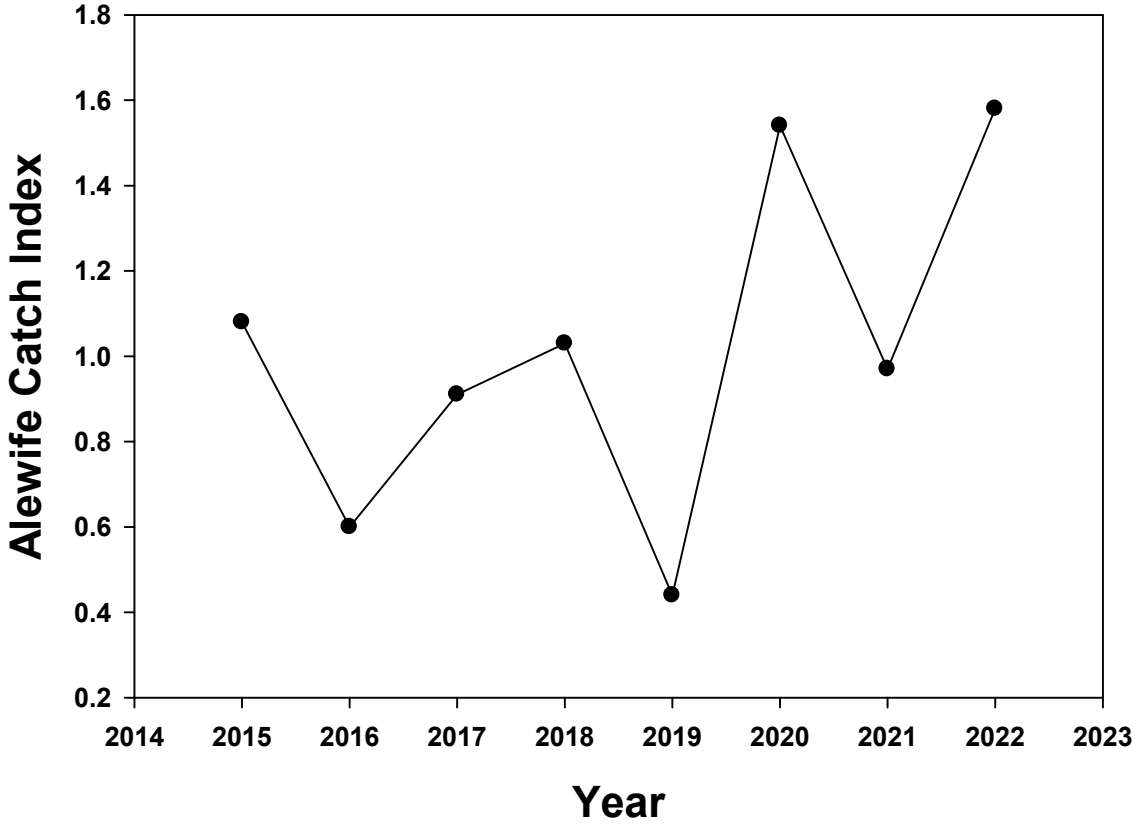


Figure 13. Recent (2015-2022) values of the catch index of female Blueback Herring on the Chickahominy River.

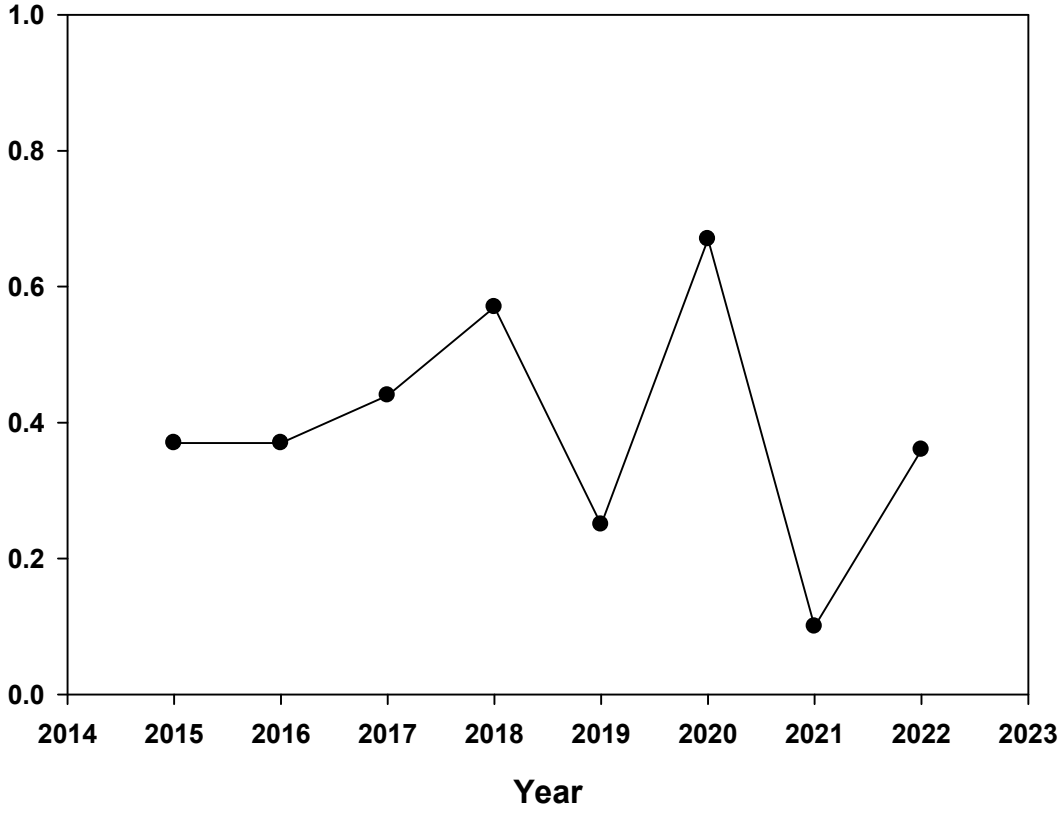


Figure 14. Recent (2018-2022) values of the catch index of female Alewife on the Rappahannock River.

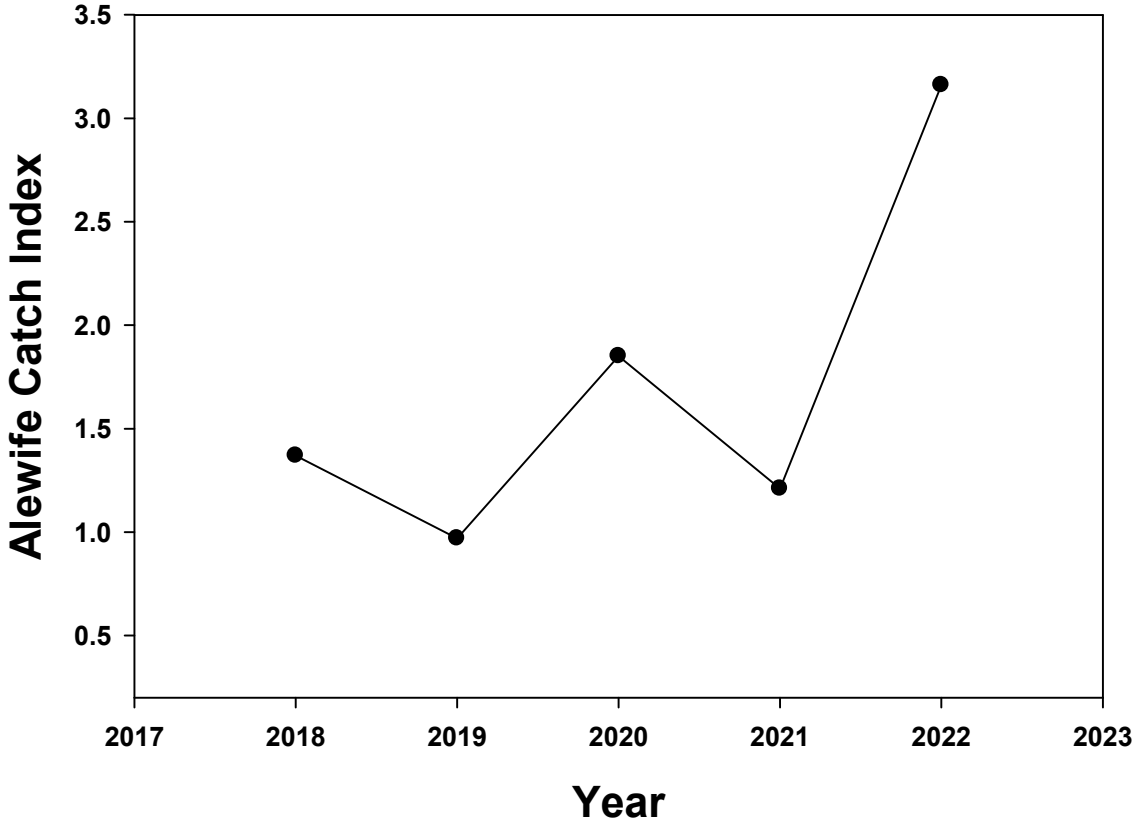
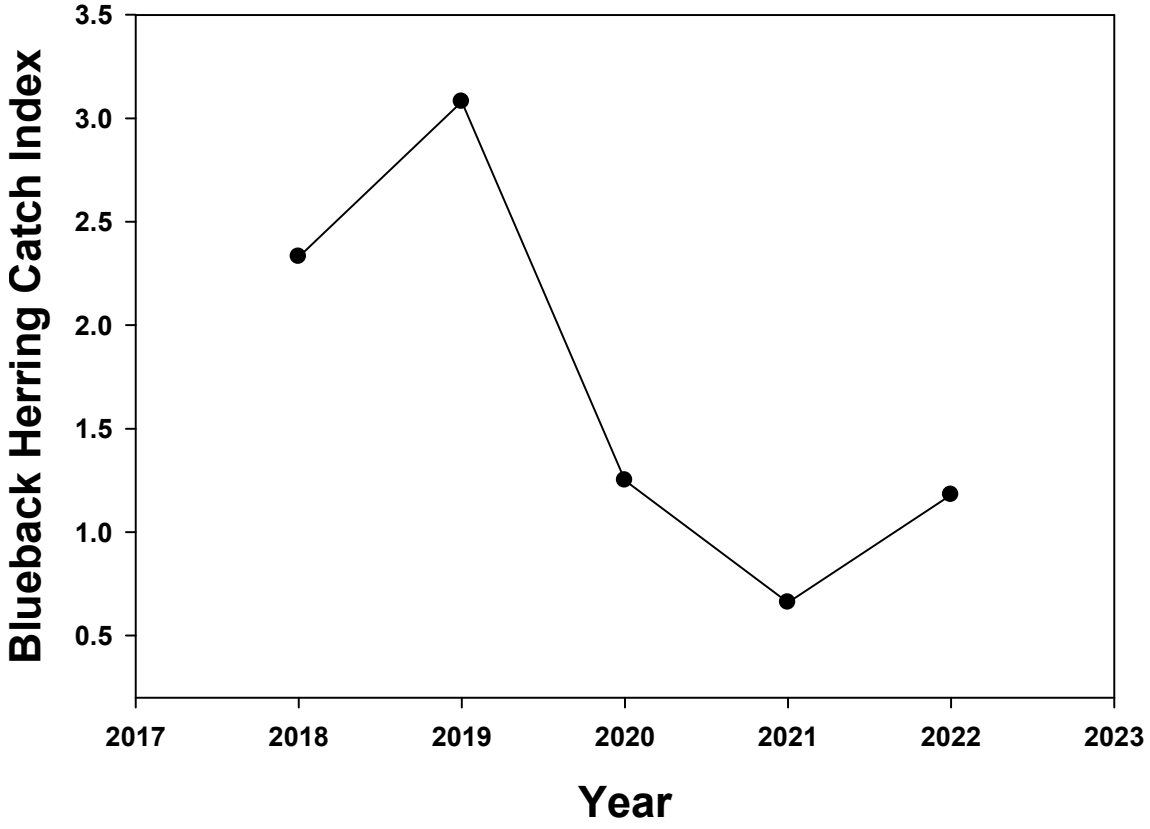


Figure 15. Recent (2018-2022) values of the catch index of female Blueback Herring on the Rappahannock River.



Appendix 1

Assessment of the 2022 Virginia by-catch of American shad and the status of the Virginia stocks

Report to the Atlantic States Marine Fisheries Commission (ASMFC)

October 1, 2022

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Background

In spring 2022, scientists at the Virginia Institute of Marine Science (VIMS) interviewed and obtained samples of by-catch of American shad from permitted fishers who had agreed to participate in the ASMFC required monitoring program. Total effort (number of trips) in the 2022 American shad by-catch fishery decreased compared to effort recorded in 2021 on the York and Rappahannock Rivers and was about equal on the James River; harvest decreased in all three systems (Table 1). A subsample of the by-catch of American shad (n=113), comprising fish from the James and Rappahannock rivers, was obtained from three cooperating fishers; these samples were processed for length, weight, sex, maturity stage, age, and the presence of hatchery (OTC) marks.

This report is a companion to a report of the 2022 by-catch prepared by the Virginia Marine Resources Commission (VMRC) and submitted separately.

Biological Characterization of the 2022 Permitted Gill Net By-Catch in Virginia

James River

8 American shad (0 males and 8 females) were collected from one cooperating fisher on the James River. The subsample ranged in size and age from 436-465 mm FL and 4-7 years, respectively. Virgin and repeat spawners were both present in the sample (16.7% and 83.3%, respectively). Otoliths of 7 fish from the James River subsample were scanned for hatchery marks. The proportion with positive OTC marks was 0%. Biological descriptions of the James River subsample are presented in Table 2.

York River

Zero American Shad were collected from permitted fishers on the York River. All cooperating fishers operating on the York River reported extremely low catches and typically kept the few American Shad encountered for their own consumption.

Rappahannock River

105 American shad (4 males and 101 females) were collected from two cooperating fishers on the Rappahannock River. The subsample ranged in size and age from 398-495 mm FL and 3-7 years, respectively. Virgin and repeat spawners were both present in the sample (51.6% and 48.4%, respectively). No otoliths from the Rappahannock River were scanned for hatchery marks. Biological descriptions of the Rappahannock River subsample are presented in Table 2.

By-Catch and Discards by Pound Nets in Virginia

In addition to the permitted by-catch samples of American shad taken in gill nets, VIMS scientists examined pound-net samples from one pound-net fisher operating in the Great Wicomico River, a location in the upper western portion of Chesapeake Bay (Figure 1). The pound net fisher had a special permit to take American shad for scientific monitoring, but the catch was not permitted to be sold or retained as by-catch by the VMRC.

Samples of American shad were collected at intervals of approximately every two weeks (Figure 2). Fish in these samples were taken randomly from the total catch on a given day or represented the entire catch from a single fishing day. A total of 91 American shad were processed for length, weight, sex, maturity stage, and age. Biological information is recorded for each date of harvest in Table 3. Year-class composition from the pound net location is reported in Table 4.

The number of males sampled was lower than the number of females (67 females; 24 males). Sex ratios (females: males) were 1:0.36. Maturity stages were determined macroscopically for females in the laboratory (Table 3).

Results of the 2022 Fishery-Independent Monitoring Studies

The catch index values (the area under the curve of catch rate versus day of the year) of pre-spawning female American shad in fishery-independent staked gill net monitoring is depicted in Figure 3.

On the Rappahannock River, the 2022 index was 2.97, which is a decrease from the 2021 index (3.56).

In 2022, the catch index on the James River was 0.07. This is an increase from 2021 (0.06).

The 2022 York River index is 0.32. This is a decrease from 2021 (0.96). The index value is consistent with the last ten years of monitoring, which depicts a low, but stable population.

Table 1. Number of fishermen with American shad by-catch permits, active permits, and fishing activity reported by river system, 2006-2022. Permits are considered active if one or more pounds of American shad were reported.

†Due to COVID-19, 2020 data is only available through the VMRC Mandatory Harvest Reporting Program. Number of American shad kept is estimated by dividing the pounds reported by 3.57, the average fish weight according to the VMRC Biological Sampling Program.

This table contains confidential data that has been redacted.

Water Body	Year	# Permit Holders	# Active Permits	Total Trips	# Shad Caught	# Shad Kept	% of Bycatch for Year
James River	2022	6	4	80	13	13	5
	2021	8	5	69	31	31	3
	2020†	8	5	19		76	
	2019	[redacted]					
	2018	10	3	18	32	32	2
	2017	12	3	72	277	277	48
	2016	14	4	107	24	22	26
	2015	14	8	58	31	21	8
	2014	14	9	54	114	112	15
	2013	10	4	55	150	139	32
	2012	[redacted]					
	2011	9	3	25	42	42	32
	2010	9	0	0	0	0	0
	2009	[redacted]					
	2008						
	2007	16	7	58	119	52	19
	2006	32	5	27	24	23	9

Water Body	Year	# Permit Holders	# Active Permits	Total Trips	# Shad Caught	# Shad Kept	% of Bycatch for Year
York River	2022	15	6	32	44	44	15
	2021	14	10	116	550	516	43
	2020†	15	8	93		439	
	2019	11	8	128	257	254	25
	2018	10	6	143	288	284	22
	2017	9	5	45	148	146	25
	2016						
	2015	10	9	36	302	279	76
	2014	8	5	85	453	453	61
	2013	12	6	116	212	203	47
	2012	13	5	71	207	207	94
	2011	11	4	51	88	87	67
	2010	9	5	43	229	208	84
	2009	11	6	97	302	288	100
	2008	10	6	85	89	89	60
	2007	15	8	104	199	199	73
	2006	31	5	198	233	228	90

Water Body	Year	# Permit Holders	# Active Permits	Total Trips	# Shad Caught	# Shad Kept	% of Bycatch for Year
Rappahannock River	2022	9	7	89	228	228	80
	2021	8	6	88	1415	652	54
	2020†	7	7	49		427	
	2019	9	9	99	1025	740	73
	2018	10	11	156	992	894	76
	2017	9	4	48	155	155	27
	2016	5	4	129	27	27	30
	2015	6	5	25	63	63	16
	2014	8	4	49	182	173	23
	2013	7	6	24	273	89	21
	2012						
	2011						
	2010						
	2009	1	0	0	0	0	0
	2008						
	2007						
	2006						

Table 2. Biological descriptions by river and sex for American shad permitted by-catch samples processed at VIMS. Abbreviations: M, Male; F, Female; #, Number; Avg., Average; Yrs, Years; NA, Not applicable; Rap, Rappahannock.

River	Sex	#	Avg. FL (mm)	Avg. Wt (g)	# Aged	Age Range (yrs)	% Repeat Spawner	% Post Spawner	# Hatchery Scanned	# Hatchery Origin
James	M	0	NA	NA	0	NA	NA	NA	0	0
	F	8	449.5	1386.7	6	4-7	83.3	0.0	7	0
	Combined	8	449.5	1386.7	6	4-7	83.3	0.0	7	0
Rapp	M	4	422.3	1034.8	3	3-5	33.3	NA	NA	NA
	F	101	446.9	1373.7	88	3-7	48.9	0.0	NA	NA
	Combined	105	446.0	1360.8	91	3-7	48.4	0.0	NA	NA

Table 3. Biological data of American shad (n=91) collected from a pound net fisher (1) located at the mouth of the Great Wicomico River. Abbreviations: TW, total weight; Avg, Average; P. Spent, Partially Spent.

Date	Maturity Stage	# Females	TW (kg)	Avg Weight Per fish (g)	# Males	TW (kg)	Avg Weight Per fish (g)
3/17/2022	Maturing	14	16.0	1141.9			
	Hydrated						
	P. Spent						
	Spent						
	Unstaged				4	3.0	751.7
3/30/2022	Maturing	12	13.8	1154.1			
	Hydrated						
	P. Spent						
	Spent						
	Unstaged				9	7.1	787.3
4/12/2022	Maturing	14	14.1	1008.6			
	Hydrated						
	P. Spent						
	Spent						
	Unstaged				2	1.3	665.4
4/26/2022	Maturing	10	11.2	1120.8			
	Hydrated						
	P. Spent						
	Spent						
	Unstaged				6	3.7	611.3
5/17/2022	Maturing	17	18.3	1078.3			
	Hydrated						
	P. Spent						
	Spent						
	Unstaged				3	2.0	668.4
Total		67	73.5	1100.7	24	17.1	696.8

Table 5. Year class composition of fish taken in pound nets in 2022, indicated as percent of aged catch from one pound net location in Chesapeake Bay.

	Year Class	Great Wicomico
Males	2019	29.4
	2018	47.0
	2017	11.8
	2016	11.8
Females	2019	23.7
	2018	39.0
	2017	25.4
	2016	8.5
	2015	3.4

Figure 1. Location of pound net operation with special American Shad by-catch permits.

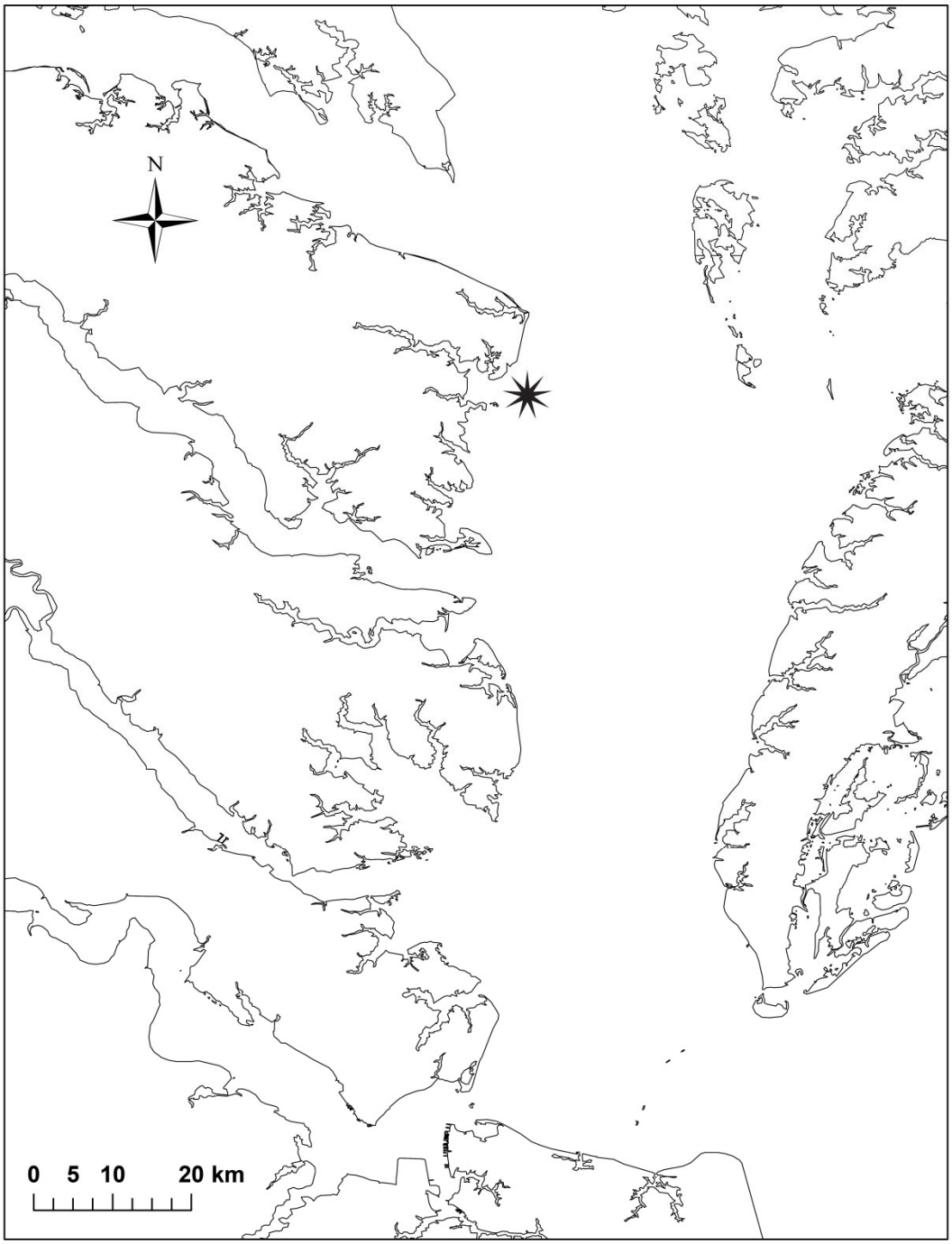


Figure 2. Total number (all samples combined) of American Shad processed by VIMS caught with special pound net by-catch permits in 2022. N is the number of samples obtained.

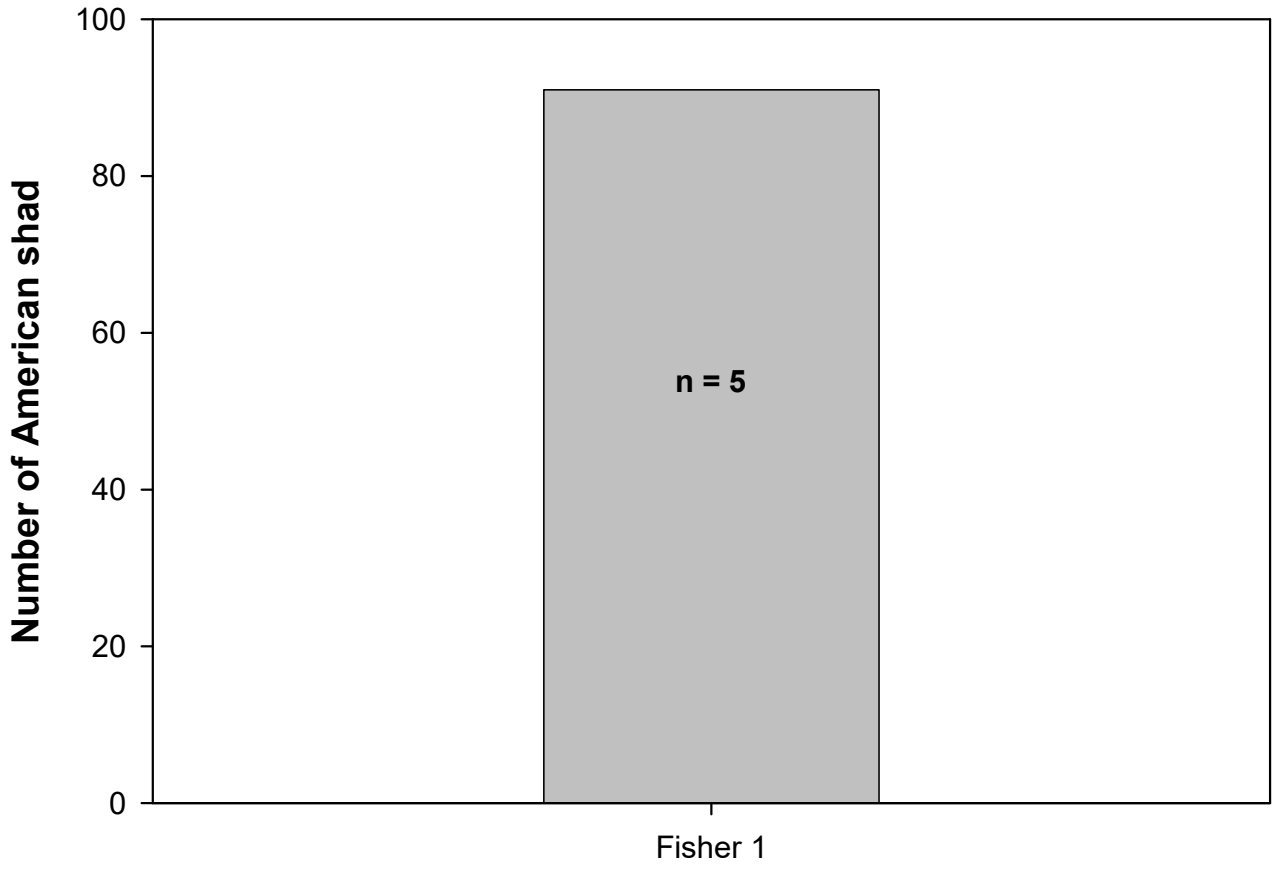
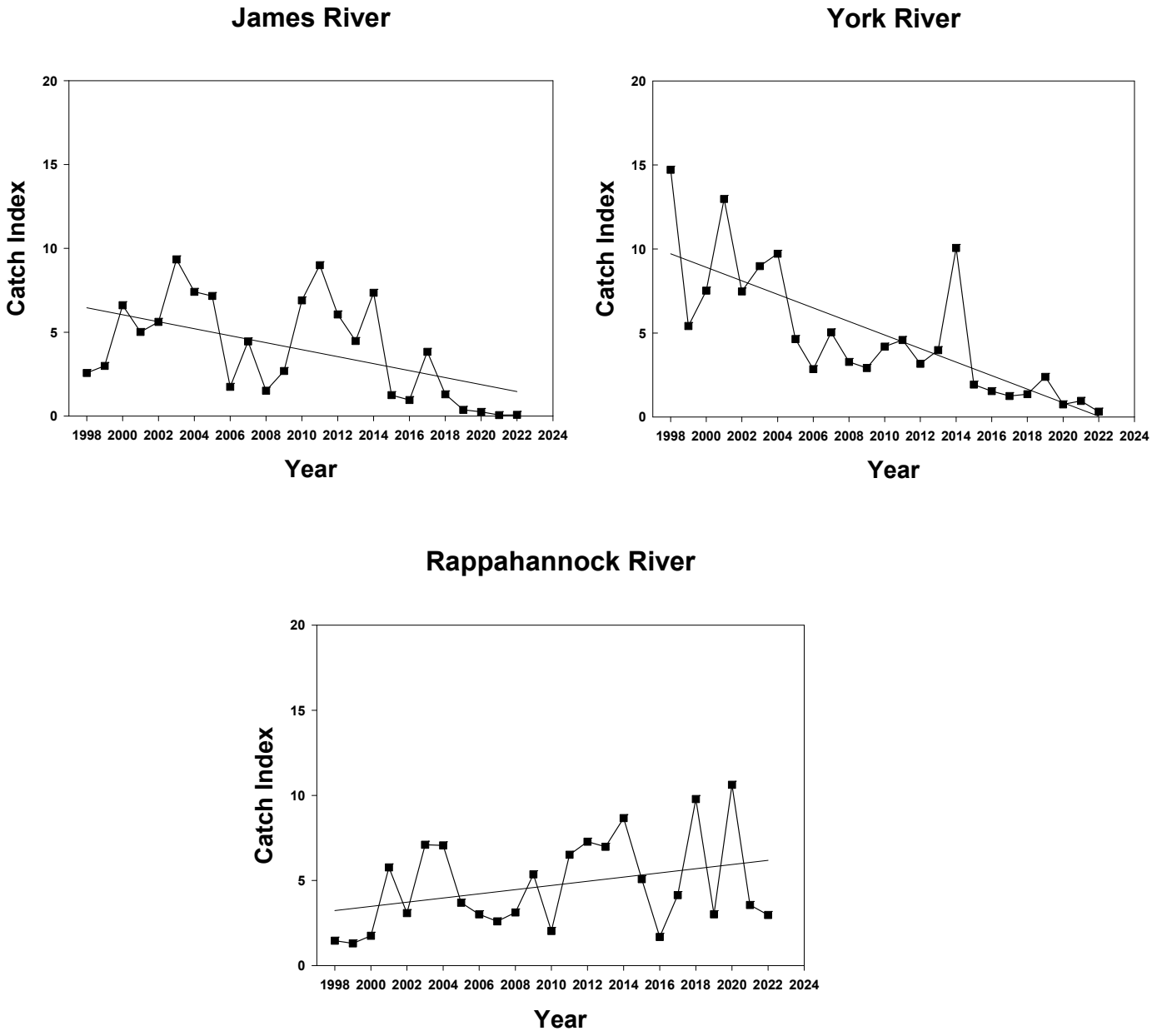


Figure 3. Time series of catch index from staked gill net monitoring in Virginia, 1998-2022.



ROY COOPER
Governor

ELIZABETH S. BISER
Secretary

KATHY B. RAWLS
Director

To: Jason Didden, MAFMC

From: Holly White, NCDMF

CC: Chris Batsavage, NCDMF

Subject: 2021 and 2022 River Herring and American Shad Indices Update

Hey Jason,

Please find attached the updates to the annual indices that you requested on May 22, 2023. If you need anything else. Please let me know.

Best,

Holly White

Holly.White@deq.nc.gov

Description of work: Juvenile Abundance Index

Eleven seine stations were sampled by DMF bi-monthly with an 18.5 m (60 ft.) bag seine in the western Albemarle Sound area during June-October 2020 (Figure 7). Juvenile Abundance Indices (JAI) for Blueback Herring and Alewife were calculated for the eleven core stations sampled from 1972 through 2022. Only the first sample of each month are use in the calculation.

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 (nine stations), all samples, were selected to determine a juvenile abundance starting in 1996 (zero catches in 1995). A Zero-inflated Negative Binomial (ZINB) generalized linear model (GLM) model was determined as the best recommended predictor 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 included here as arithmetic mean, in lieu of updating the ZINB model annually. Juvenile Abundance Indices (JAI) for American Shad were calculated for 14 stations sampled from 1996 through 2022.

One unit of effort is equal to one haul of the seine. Samples were sorted by species and 30 randomly selected individuals of each alosine species present were measured. Other species present were also noted. Water temperature, salinity, and other environmental characteristics were measured and recorded.

- Source: Previously, ASMFC North Carolina Shad and River Herring Compliance Report. In 2022 and 2023, compliance report data reporting moved to a workbook format. Tables are updated below, but are no longer provided to the ASMFC in the body of the report.

American Shad juvenile abundance index, from the 14 core stations, Albemarle Sound area, NC, 1972-2022.

Year	# caught	# samples	JAI	SE	PSE
1996	62	85	0.73	0.33	45
1997	43	85	0.51	0.21	42
1998	10	89	0.11	0.11	100
1999	19	86	0.22	0.16	71
2000	195	100	1.95	1.26	65
2001	35	99	0.35	0.20	55
2002	84	100	0.84	0.22	27
2003	752	100	7.52	1.93	26
2004	188	103	1.83	0.54	30
2005	203	99	2.05	0.68	33
2006	35	106	0.33	0.13	38
2007	2	105	0.02	0.01	70
2008	70	294	0.24	0.04	19
2009	129	167	0.77	0.23	29
2010	80	167	0.48	0.24	50
2011	134	157	0.85	0.24	28
2012	52	158	0.33	0.13	40
2013	97	157	0.62	0.22	35
2014	393	167	2.35	0.56	24
2015	391	158	2.47	0.64	26
2016	1,991	163	12.21	5.23	43
2017	203	167	1.22	0.38	31
2018	910	167	5.45	1.39	25
2019	1,163	158	7.36	4.34	59
2020	155	167	0.93	0.23	24
2021	532	167	3.19	1.20	38
2022	307	167	1.84	0.57	31

Blueback Herring juvenile abundance index, from the 11 core stations, Albemarle Sound area, NC, 1972-2022.

Year	# caught	# samples	JAI	PSE	Geo. Mean
1972	4,166	13	320.46	95	8.63
1973	16,209	38	426.55	34	36.45
1974	3,008	48	62.67	33	7.90
1975	6,641	50	132.82	33	11.73
1976	7,755	47	165.00	73	5.27
1977	5,784	50	115.68	39	11.32
1978	4,626	49	94.41	29	8.16
1979	4,605	36	127.92	34	10.98
1980	11,111	46	241.54	54	16.38
1981	55	50	1.10	54	0.25
1982	3,541	49	72.27	39	7.58
1983	12,561	50	251.22	61	3.80
1984	1,038	52	19.96	42	1.81
1985	7,124	51	139.69	53	2.47
1986	758	55	13.78	64	1.16
1987	1,378	55	25.06	49	1.25
1988	602	52	11.58	54	0.95
1989	1	55	0.02	100	0.01
1990	505	55	9.18	47	0.99
1991	1,196	55	21.75	96	0.40
1992	51	55	0.93	92	0.10
1993	3,571	39	91.56	98	0.83
1994	0	32	0.00	.	0.00
1995	78	55	1.42	60	0.30
1996	827	55	15.04	72	1.09
1997	404	55	7.35	47	0.97
1998	24	55	0.44	69	0.13
1999	97	54	1.80	78	0.20
2000	85	55	1.55	47	0.39
2001	228	55	4.15	48	0.55
2002	43	55	0.78	51	0.22
2003	71	55	1.29	56	0.31
2004	815	55	14.82	51	1.17
2005	354	55	6.44	77	0.49
2006	28	55	0.51	86	0.10
2007	1	55	0.02	100	0.01
2008	143	55	2.60	100	0.09
2009	56	55	1.02	68	0.17
2010	30	55	0.55	93	0.09
2011	3	55	0.06	100	0.03
2012	30	55	0.55	74	0.10
2013	733	55	13.33	63	0.72
2014	100	55	1.82	92	0.15
2015	298	55	5.42	59	0.56
2016	0	55	0.00		0.00
2017	206	56	3.68	74	0.27
2018	53	55	0.96	96	0.10
2019	1,783	54	33.02	51	2.56
2020	223	55	4.06	91	0.19
2021	82	55	1.49	61	0.22
2022	608	55	11.06	76	0.54

Alewife juvenile abundance index, from the 11 core stations, Albemarle Sound area, NC, 1972-2022.

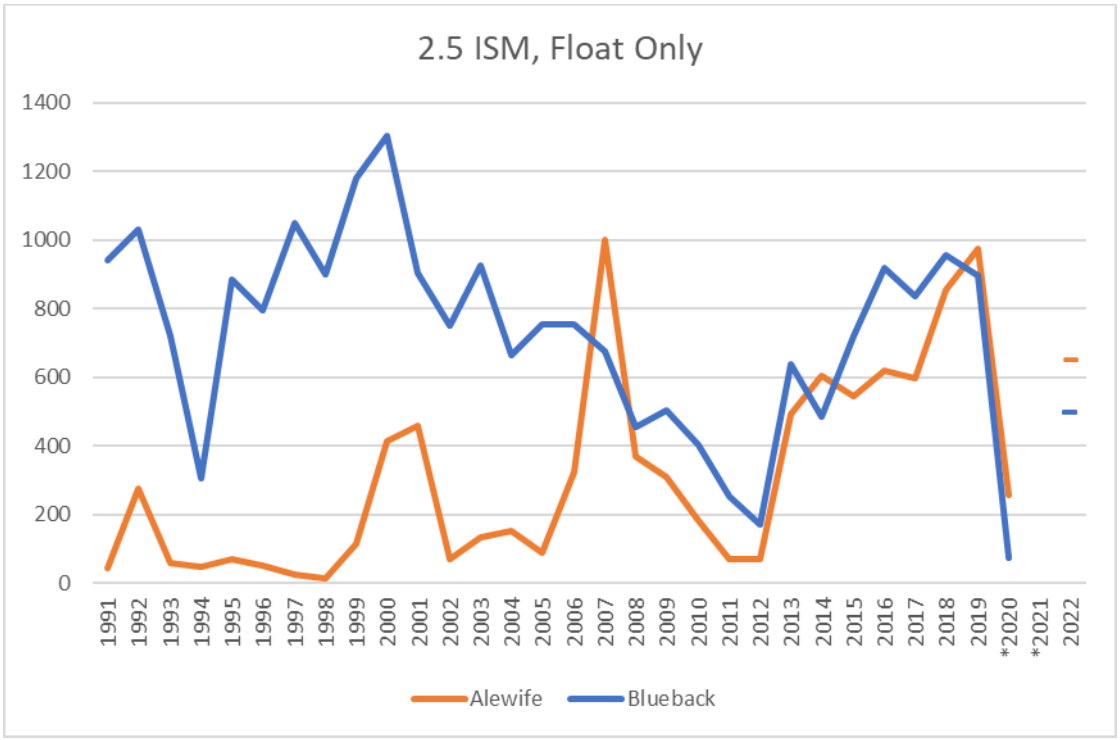
Year	# caught	# samples	JAI	PSE	Geo. Mean
1972	64	13	4.92	95	0.53
1973	320	39	8.21	52	0.76
1974	49	48	1.02	39	0.37
1975	410	50	8.20	68	0.71
1976	64	47	1.36	51	0.38
1977	391	50	7.82	42	1.66
1978	608	51	11.92	27	2.49
1979	160	36	4.44	64	1.03
1980	633	47	13.47	50	1.85
1981	249	50	4.98	96	0.26
1982	28	49	0.57	29	0.32
1983	105	50	2.10	68	0.36
1984	38	52	0.73	45	0.25
1985	200	51	3.92	72	0.46
1986	131	56	2.34	50	0.58
1987	1	55	0.02	100	0.01
1988	10	52	0.19	59	0.09
1989	3	55	0.05	74	0.03
1990	33	55	0.60	94	0.09
1991	0	55	0.00		0.00
1992	1	55	0.02	100	0.01
1993	0	39	0.00		0.00
1994	0	32	0.00		0.00
1995	8	55	0.15	100	0.04
1996	219	55	3.98	37	0.86
1997	1	55	0.02	100	0.01
1998	69	55	1.25	75	0.17
1999	16	54	0.30	58	0.14
2000	23	55	0.42	45	0.19
2001	289	55	5.25	83	0.41
2002	7	55	0.13	50	0.08
2003	81	55	1.47	40	0.42
2004	115	55	2.09	58	0.40
2005	48	55	0.87	82	0.16
2006	1	55	0.02	100	0.01
2007	4	55	0.07	79	0.04
2008	0	55	0.00		0.00
2009	0	55	0.00		0.00
2010	227	55	4.13	40	0.67
2011	44	55	0.80	62	0.17
2012	38	55	0.69	44	0.24
2013	525	55	9.55	46	0.78
2014	0	55	0.00		0.00
2015	392	55	7.13	63	0.40
2016	21	55	0.38	56	0.13
2017	46	55	0.84	82	0.13
2018	329	55	5.98	58	0.51
2019	4	54	0.07	70	0.04
2020	0	55	0.00		0.00
2021	805	55	14.64	50	0.62
2022	25	55	0.45	96	0.07

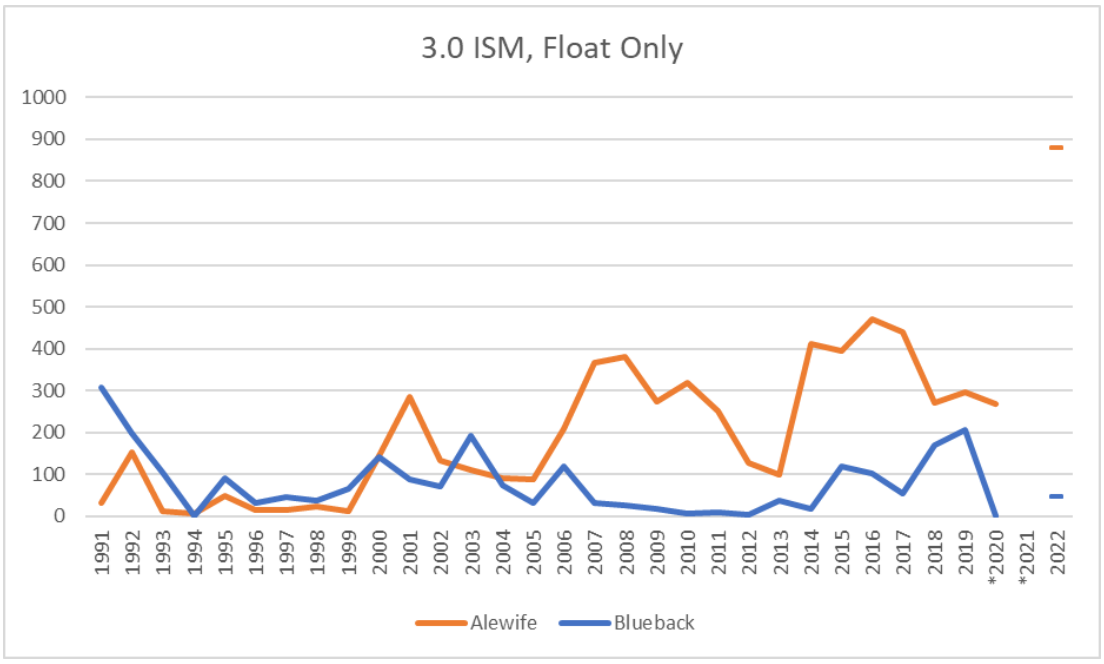
Description of work: Albemarle Sound Independent Gill Net Survey

Since 1990, DMF has been conducting an independent gill net survey (IGNS) throughout the Albemarle Sound area. The survey was designed for Striped Bass data collection, however, American Shad and river herring are captured during the survey and size, age, and sex data are collected. American shad and river herring are aged using the scale-age method. Gill net mesh sizes from 2.5 through 7.0 ISM in half-inch increments and 8.0 and 10.0 ISM in whole mesh increments are utilized. The Albemarle Sound IGNS is conducted from November through May, but results for shad and river herring are only reported for January through May. River herring catch is only reported from gill net mesh 2.5 and 3.0, because catches of these fish at other times and larger gill net mesh are rare. Areas fished, sampling effort and sampling frequency vary seasonally. Each unit of effort is one 40-yard net, fished for 24-hours. Gill nets are fished in 40-yard shots totaling 960 yards per set.

Program 135 was suspended in February 2020 due to COVID-19 restrictions and protected species interactions. The survey resumed in the fall of 2021. In November 2021, the Albemarle Sound Independent Gill Net Survey (IGNS) expanded from six to eight zones and reduced soak time from 24-hours to 12-hours. Additionally, in March 2022, sink gill nets were removed from the survey, reducing effort to 480 yards per set (12 units of effort). Additional zones were added to meet NCDMF research priorities to expand the spatial coverage of the survey. Soak times were reduced and sink nets were removed to reduce interactions with endangered species through ongoing consultation with the United States Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Association (NOAA Fisheries). It should be noted that with such a major change in survey design, the index derived from this survey starting in November 2021 will not be directly comparable to the prior historical time series. When calculating relative abundance using historical IGNS data, all sink gill nets were removed.

- Source: Previously, ASMFC North Carolina Shad and River Herring Compliance Report. In 2023, compliance report data reporting moved to a workbook format. Tables are updated below, but are no longer provided to the ASMFC in the body of the report.
- Total number of river herring from the NC Albemarle Sound independent gill net survey, 1991-*2022.
    - *January-February 2020 sampling only, not sufficient to determine index for 2020. Survey did not occur in 2021.


2.5 ISM, Float Only
1400
1200
1000
800
600
400
200
0
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 *2020 *2021 2022
Alewife
Blueback


3.0 ISM, Float Only
1000
900
800
700
600
500
400
300
200
100
0
1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 *2020 *2021 2022
Alewife
Blueback

- Total number of river herring from the NC Albemarle Sound independent gill net survey, 1991-*2022, float net only.

	2.5 ISM		3.0 ISM	
Year	Blueback	Alewife	Blueback	Alewife
1991	942	43	307	33
1992	1031	277	199	152
1993	722	60	105	12
1994	304	47	1	7
1995	886	69	92	49
1996	794	51	31	16
1997	1048	26	45	16
1998	901	12	38	24
1999	1179	115	67	11
2000	1305	413	142	143
2001	902	460	87	286
2002	749	69	72	133
2003	926	132	192	110
2004	666	151	74	92
2005	754	90	32	87
2006	754	324	119	209
2007	675	1002	32	367
2008	455	367	27	381
2009	505	309	17	274
2010	402	182	7	320
2011	252	71	10	252
2012	171	69	3	128
2013	640	491	37	99
2014	486	603	19	411
2015	719	546	120	396
2016	918	620	101	471
2017	835	598	53	439
2018	955	856	169	272
2019	898	975	206	297
*2020	72	256	2	269
*2021				
2022	496	653	46	880

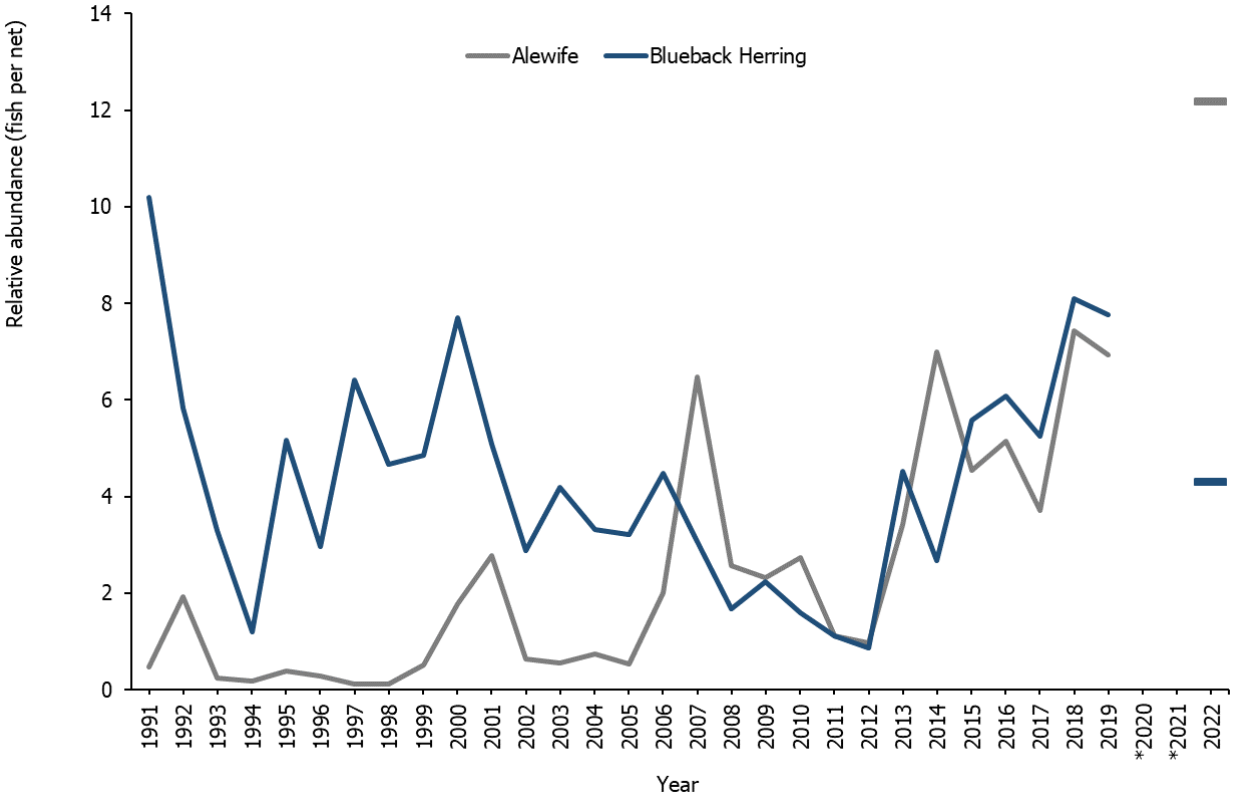
*January-February sampling only, not sufficient to determine index for 2020. Survey did not occur in 2021.

- River herring CPUE from the Albemarle Sound independent gill net survey (2.5 and 3.0 ISM combined, float net only), 1991-*2022. *January-February sampling only, not sufficient to determine index for 2020. Survey did not occur in 2021.
- Source: ASMFC Shad and River Herring Compliance Report NC 2023

Alewife					Blueback Herring				
Year	Effort	Sum	CPUE	PSE	Year	Effort	Sum	CPUE	PSE
1991	235	76	0.3234	22	1991	235	1249	5.3149	15
1992	273	429	1.5714	18	1992	273	1230	4.5055	12
1993	279	72	0.2581	36	1993	279	827	2.9642	15
1994	264	54	0.2045	30	1994	264	305	1.1553	25
1995	257	118	0.4591	21	1995	257	978	3.8054	14
1996	256	67	0.2617	46	1996	256	825	3.2227	16
1997	262	42	0.1603	23	1997	262	1093	4.1718	14
1998	257	36	0.1401	21	1998	256	939	3.668	15
1999	270	126	0.4667	31	1999	272	1246	4.5809	13
2000	260	556	2.1385	15	2000	260	1447	5.5654	12
2001	246	746	3.0325	12	2001	246	989	4.0203	15
2002	251	202	0.8048	14	2002	251	821	3.2709	15
2003	276	242	0.8768	15	2003	276	1118	4.0507	13
2004	249	243	0.9759	16	2004	249	740	2.9719	16
2005	252	177	0.7024	14	2005	252	786	3.119	17
2006	258	533	2.0659	13	2006	258	873	3.3837	14
2007	253	1369	5.4111	10	2007	253	707	2.7945	16
2008	252	748	2.9683	11	2008	250	482	1.928	19
2009	222	583	2.6261	12	2009	225	522	2.32	18
2010	207	502	2.4251	14	2010	207	409	1.9758	21
2011	214	323	1.5093	18	2011	211	262	1.2417	20
2012	178	197	1.1067	13	2012	181	174	0.9613	23
2013	188	590	3.1383	14	2013	188	677	3.6011	17
2014	195	1014	5.2	11	2014	193	505	2.6166	19
2015	223	942	4.2242	11	2015	223	839	3.7623	15
2016	229	1091	4.7642	11	2016	229	1019	4.4498	14
2017	227	1037	4.5683	10	2017	225	888	3.9467	15
2018	189	1128	5.9683	11	2018	189	1124	5.9471	13
2019	228	1272	5.5789	11	2019	230	1104	4.8	13
*2020	73	525	7.1918	15	*2020	73	74	1.0137	34
*2021					*2021				
2022	126	1533	12.1667	11	2022	126	542	4.3016	18

*January-February sampling only, not sufficient to determine index for 2020. Survey did not occur in 2021.

- January-May adult river herring index of abundance (2.5 and 3.0 inch stretch mesh, float net only) from the North Carolina Albemarle Sound independent gill net survey 1991-2022. *January-February sampling only, not sufficient to determine index for 2020. Survey did not occur in 2021.
- Source ASMFC Shad and River Herring Compliance Report NC 2023



- January-May adult American shad female abundance (Quad 2 – western Albemarle Sound, float net only), 2000-2022.
- Source: NC American shad SFP 2023-2027

Year	N	CPUE	SE	PSE
2000	1099	0.0606		
2001	1012	0.05781		
2002	1010	0.08688		
2003	1176	0.06084		
2004	1067	0.02905	0.00637	21.9117
2005	1032	0.05814	0.00933	16.0389
2006	1066	0.06004	0.008	13.3249
2007	1054	0.07875	0.00991	12.5819
2008	994	0.08954	0.01422	15.8795
2009	865	0.06358	0.00972	15.2932
2010	777	0.06306	0.02112	33.4871
2011	814	0.03808	0.00872	22.89675
2012	612	0.03105	0.00702	22.6019
2013	746	0.02681	0.00677	25.248
2014	772	0.06995	0.01336	19.0985
2015	938	0.05437	0.00848	15.6002
2016	924	0.04113	0.00722	17.5509
2017	863	0.02665	0.00655	24.5657
2018	785	0.04586	0.00886	19.3262
2019	924	0.04113	0.00784	19.0658
2020				
2021				
2022	420	0.02857	0.00814	28.4869

- January-May adult American shad female abundance (Quad 2 – western Albemarle Sound, float net only), 2000-2022.
- Source: NC American shad SFP 2023-2027