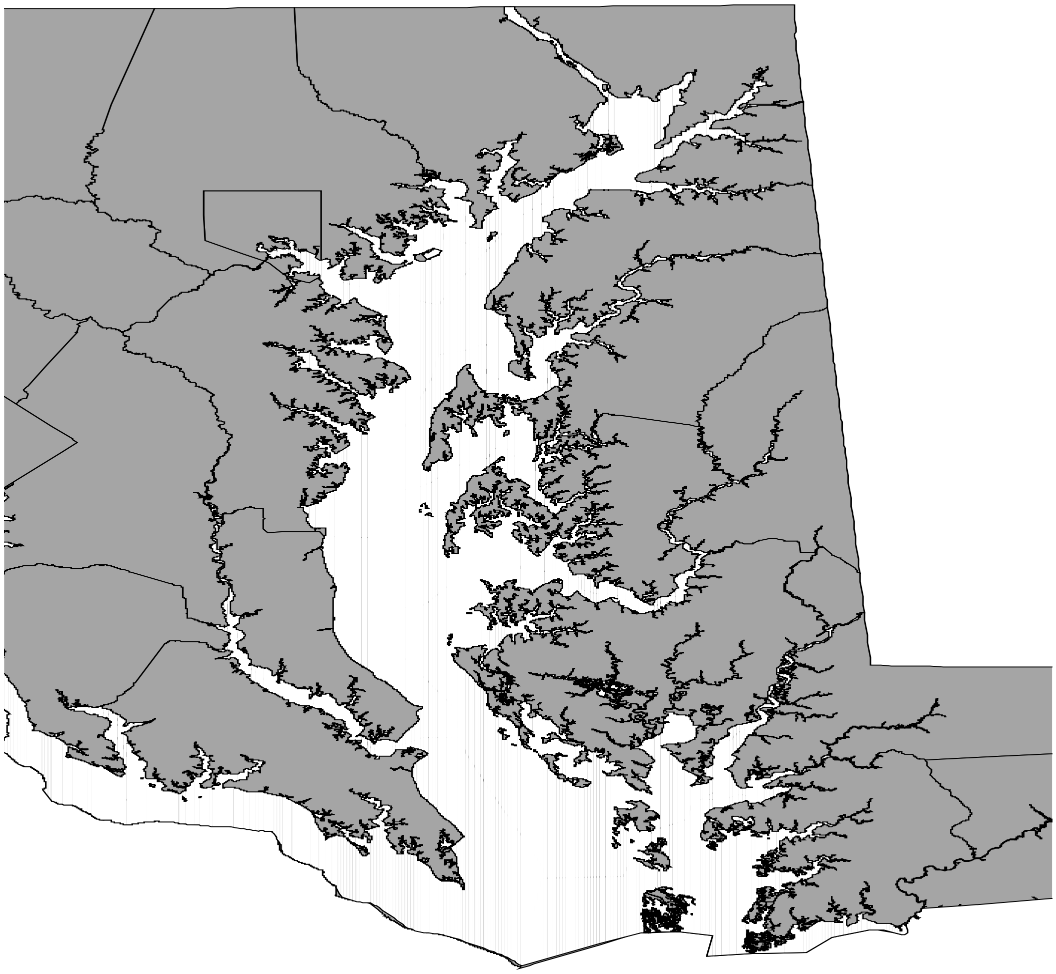

Chesapeake Bay Finfish Investigations

US FWS FEDERAL AID PROJECT
F-61-R-17
2021 - 2022

MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

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Chesapeake Bay Finfish Investigations

July 1, 2021 to June 30, 2022

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UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
PERFORMANCE REPORT

STATE: Maryland

PROJECT NO.: F-61-R-17

PROJECT TYPE: Research and Monitoring

PROJECT TITLE: Chesapeake Bay Finfish Investigations.

PROGRESS: ANNUAL X

PERIOD COVERED: July 1, 2021, through June 30, 2022

Executive Summary

The primary objective of the Chesapeake Bay Finfish Investigations Survey was to monitor and biologically characterize resident and migratory finfish species in the Maryland portion of the Chesapeake Bay. This Survey provides information regarding relative abundance, age and size structure, recruitment, growth, mortality, and migration patterns of finfish populations in Maryland's Chesapeake Bay. The data generated are utilized in both intrastate and interstate management processes and provides reference points for future fisheries management considerations.

Annual winter trawl efforts in upper Chesapeake Bay during 2021 indicated that white perch relative abundance increased relative to 2020 and was the fifth highest since 2000. The 2014, 2015, 2018 and 2019 year-classes were above average. Yellow perch relative abundance increased relative to 2020. The 2014, 2015 and 2018 year-classes were above average. Channel catfish relative abundance continued a five-year increase and was greater than the time series average. Age 1 channel catfish relative abundance was at the time series average in 2019 and 2020 (2018 and 2019 year-classes).

White perch relative abundance in the Choptank River Fyke Net Survey in increased 2021, but was below the time-series mean. Similar to the upper Bay trawl, the 2014, 2015, 2018 and 2019 year-classes were strong. The 2018 year-class was the most abundant year-class in the survey, but the 2015 year-class was also particularly abundant. Yellow perch relative abundance decreased in

2021. The 2015 and 2018 year-classes constituted 81% of the population. Channel catfish relative abundance exhibited a five year increase, with the 2021 estimate above the time-series average. White catfish relative abundance increased during 2019 – 2021, but remained below the time-series average.

Channel catfish population dynamics were modelled with a Catch Survey Analysis for the upper Chesapeake Bay (HOB) and the Choptank River. In the HOB, abundance decreased from a time-series high in 2019, but the 2021 estimate was still above average. Instantaneous fishing mortality was below the suggested threshold value over the past five years. Pre-recruit abundance was above average in 2021 which indicates that the population should remain stable at high levels. The Choptank River channel catfish Catch Survey Analysis utilized data from a fishery independent fyke net survey. Channel catfish abundance declined significantly from the time-series high in 2015. The 2021 estimate was at median levels for the 28 year time-series. Pre-recruit abundance was very low, 2017 – 2021, and suggests that population contraction will continue. Instantaneous fishing mortality was also low, which suggests poor juvenile production, rather than fishing pressure, is causing the population decline.

U.S. Atlantic coast wide Alosine stocks are near historic lows. Predation, bycatch, turbine mortality and limited access to prime spawning habitat continue to impact Alosine populations in Maryland's portion of the Chesapeake Bay and its tributaries. Stock composition and population size of adult American shad in the Susquehanna River below Conowingo Dam were assessed with shore-based sampling (relative abundance was not estimated due to a lack of boat access). Total mortality was estimated at 0.93, which was slightly higher than in 2019 but still below the time-series average. Population size was estimated at 75,308, which was the lowest estimate since 1993. Recreational angler logbook and creel surveys for American and hickory shad were completed in 2021. American shad catch-per-angler-hour decreased for the logbook survey but increased for the creel survey. Both estimates increased for hickory shad.

Sampling of commercial bycatch to estimate stock composition and relative abundance of adult American shad and river herring in the Nanticoke River was completed in 2021. Abundance of American shad and blueback herring increased slightly from 2019; whereas the abundance of alewife decreased slightly. Abundance of river herring in the Nanticoke River has remained stable at historically low levels over the past 10 years. Stock composition and relative abundance of adult river herring in the North East River were assessed using fishery-independent gill nets. Relative abundance for both species decreased slightly in 2021 but were near the time-series averages. Total mortality estimates increased for blueback herring, 2.14, but decreased for alewife, 0.75.

Stock composition and relative abundance of adult American shad in the Potomac River were assessed using fishery-independent gill nets operated for the Striped Bass Spawning Stock Survey (SBSSS; Project 2, Job 3, Task 2). Relative abundance decreased slightly in 2021, and total mortality was estimated at 1.93. Mortality has increased since 2002 and has been above the biological reference point since 2016. Additionally, juvenile abundance indices for American shad and river herring were calculated for various river systems using data collected by the Estuarine Juvenile Finfish Survey (EJFS; Project 2, Job 3, Task 3). American shad juvenile production decreased in the

Potomac River but increased in the upper Chesapeake Bay. Alewife and blueback herring juvenile production increased in the upper Chesapeake Bay and Potomac River but decreased in the Nanticoke River.

Weakfish have experienced a sharp decline in abundance coast-wide. Recreational harvest estimates for Maryland inland waters by the NMFS declined from 741,758 fish in 2000 to 763 in 2006 and have fluctuated at a very low level from 2007 through 2021. The NMFS estimated 1,116 weakfish were harvested in 2021. The 2021 Maryland Chesapeake Bay commercial weakfish harvest remains very low with a harvest of nine pounds in 2021, well below the 1981 – 2021 time series of 38,368 pounds per year. The 2021 mean length for weakfish from the onboard pound net survey was 287 mm TL, but only 21 fish were encountered, the third lowest sample size of the 29-year time series. One weakfish with a length of 339 mm TL was captured in the Choptank River gill net survey in 2021.

Summer flounder mean length from the pound net survey was 252 mm TL in 2021, which was the third lowest value of time series. The length frequency distribution was heavily skewed toward smaller fish. Six summer flounder were encountered in the Choptank River gill net survey in 2021 with lengths ranging from 176 to 194 mm TL. The NMFS 2019 coast wide stock assessment concluded that summer flounder stocks were not overfished, and overfishing was not occurring, but recruitment has been generally low and fishing mortality is just below the threshold value.

Mean length of bluefish from the onboard pound net survey in 2021 was 368 mm TL, the highest value in the time-series. The length distribution indicated a shift back to larger bluefish in 2019 through 2021 following distributions that were skewed toward smaller fish from 2016 through 2018. Only one bluefish was captured in the Choptank River gill net survey in 2021. Bluefish have been encountered in low numbers all eight years of the survey (1 – 24 fish per year). Reported Maryland bluefish commercial and charter boat harvest and inland recreational estimates in 2021 all remained well below their time series means. The 2019 coast wide stock assessment update indicated the stock was overfished, but overfishing was not occurring.

The mean length of Atlantic croaker examined from the onboard pound net survey in 2021 was 225 mm TL, the second lowest value of the time-series. Atlantic croaker age structure from pound net samples was truncated to age three in 2021. Length and age sample sizes were low in 2019 and 2020 due to decreased availability, but were higher in 2021. Atlantic croaker catches from the Choptank River gill net survey declined steadily the first three years of the survey; 476 fish in 2013, 269 fish in 2014 and 21 fish in 2015. The gill net catch has remained low since, with 48 fish being captured in 2021. Maryland 2021 Atlantic croaker Chesapeake Bay commercial harvest, inland waters recreational harvest estimate and charter boat harvest values were all well below their long-term means. The Atlantic croaker juvenile index was just below the time series mean, following two above average years, the recent improved juvenile abundance could potentially provide an increase in adult abundance in the near future.

The 2019 spot mean length of 188 mm TL was the 8^{th} lowest value of the 29 year time-series, and the length frequency distribution remained truncated. Spot aged from the onboard pound net survey were 99% age one, with no age two plus fish encountered. Spot catch in the Choptank River gill net survey was highest in 2020 and 2021, moderate in 2013, 2014, 2017 and 2019, and low in 2015, 2016 and 2018. Chesapeake Bay commercial spot harvest decreased in 2021, remaining below the time-series mean. The inland waters recreational harvest estimates in 2020 and 2021 increased, and were above the time-series mean. The spot juvenile index values in 2014, 2015 and 2016 were the 4th, 1st and 7th lowest values, respectively, in the 32-year time-series. The values increased from 2017 to 2021, with the 2021 value being the 6^{th} highest value of the time series.

Mean length for Atlantic menhaden sampled from the onboard pound net survey in 2021 was 215 mm FL, the 2^{nd} lowest value of the 18-year time-series. Atlantic menhaden was the most common species captured by the Choptank River gill net survey in all years, with annual catches ranging from 1,171 fish to 2,257 fish, and 2,044 fish captured in 2021. Mean lengths for all meshes combined displayed little inter-annual variation prior to 2020, with the 2020 and 2021 values being somewhat lower than previous years. Length frequency distributions from the Choptank River gill net survey indicated the gear selects slightly larger menhaden than the pound net survey, and age samples from both surveys indicate the Choptank River gill net survey selects slightly older ages.

Resident/pre-migratory striped bass sampled from pound nets in the Chesapeake Bay during the summer – fall 2020 season ranged in age from one to ten years old. Age 5 striped bass from the above average 2015 year-class contributed 31% of the sample. Age 9 fish from the above average 2011 year-class contributed 0.4% in 2020 while striped bass age 6 and older comprised 9% of the sample. Striped bass sampled from pound nets ranged from 204 to 1050 mm TL, with a mean length of 437 mm TL in 2020. Check station sampling determined that the commercial summer/fall fishery harvest was comprised of three- to ten-year-old striped bass from the 2010 through 2017 year-classes. Striped bass over 700 mm TL were harvested throughout the season and contributed 2% to the overall harvest.

The December 2020 - February 2021 commercial drift gill net harvest consisted primarily of age five-, six-, and seven-year-old striped bass from the 2016, 2015 and 2014 year-classes that composed 80% of the total harvest. The contribution of fish older than age 9 (8%) was half the 2019-2020 harvest (14%). The youngest fish observed in the 2020-2021 sampled harvest were age 4 from the 2017 year-class. Striped bass present in commercial drift gill net samples collected from check stations ranged in age from age 4 to 11 years old (2017 to 2010 year-classes).

A total of 128 striped bass were sampled at check stations for the Atlantic coast commercial striped bass fishery from October 2020 to May 2021. Striped bass harvested during the 2020-2021 Atlantic coast commercial fishing season ranged from age 6 (2015 year-class) to age 20 (2001 year-class). Thirteen different year-classes were represented in the sampled harvest. The most common age represented in the catch-at-age estimate was age 10 striped bass from the 2011 year-class, which represented 47% of the sampled harvest. Atlantic coast check stations during the 2020 – 2021 season had a mean length of 1008 mm TL and mean weight of 10.6 kg.

The 2021 spring spawning stock survey encountered fewer striped bass than average. This could be due to a two week pause at the end of April in the Upper Bay, due to COVID-19, but actual effects are impossible to know. Survey results indicated there were 17 age-classes of striped bass present on the Potomac River and Upper Bay spawning grounds, from 2 to 18 years old. Male striped bass ranged in age from 2 to 16 years and females ranged in age from 5 to 18. Similar to last year, females from the dominant 2011 year-class (age 10) were most commonly observed. The contribution of age 8+ females to the total female CPUE in 2021 decreased to 77%. This decrease may be driven by the 2015 year-class (age 6 in 2021) females entering the spawning stock, although low numbers of females were captured in both systems. The contribution of females aged 8 and older to the spawning stock was at or above 80% for most years during the period of 1996-2015, but was below the time-series average (72%) for 2016-2018. The 2021 selectivity-corrected, total, weighted catch-per-unit-effort (231), used in the coastwide stock assessment, was the second lowest in the 37-year survey, well below the time-series average of 487.

The striped bass young-of-year index, a measure of striped bass spawning success in Maryland’s Chesapeake Bay, was 3.2 in 2021, below the long-term average of 11.4. The index represents the average number of recently hatched striped bass captured in each sample. The coastal striped bass population has decreased in size but is still capable of strong reproduction with the right environmental conditions. Variable spawning success is a well-known characteristic of the species. Consecutive years of below average reproduction is a concern, and biologists continue to examine factors that might limit spawning success.

Other noteworthy observations of the survey were increased numbers of Atlantic menhaden in the Choptank River, and healthy reproduction of American shad in the Potomac River. The survey also documented reproduction of invasive blue catfish in the Upper Chesapeake Bay for the first time. During this year’s survey, biologists collected 38,865 fish of 61 different species, including 422 young-of-year striped bass. Twenty-two survey sites are located in four major spawning areas: the Choptank, Nanticoke and Potomac rivers and the Upper Chesapeake Bay. Biologists visit each site three times per summer, collecting fish with two sweeps of a 100-foot beach seine net.

During the 2021 spring recreational trophy season, biologists intercepted 21 charter trips and examined 51 striped bass. The average total length of striped bass sampled from the spring trophy fishery was 985 mm total length. The average weight was 9.8 kg. Striped bass sampled from the spring trophy fishery ranged in age from 9 to 18 years old. In 2021 the above average 2011 year-class (Age 10) disproportionately contributed 56.2% to the harvest. This high contribution likely represents the complete maturation and fully migratory status of 10 year old females from the 2011 year-class. The next largest contributions were 18.7% from the 2012 year-class and 14.2% from the 2013 year-class with all other year-classes each contributing less than 10%. In 2021, charter boats caught 2.9 fish per trip at a rate of 0.6 fish per hour, similar to the previous year.

Maryland Department of Natural Resources staff continued to tag and release striped bass in spring 2021 in support of the US FWS coordinated interstate, coastal population study. A total of 755 striped bass were sampled and 494 striped bass were tagged and released in Maryland with US FWS internal anchor tags between March 30 and May 18, 2021, with a two week break at the end of April on the Upper Bay due to COVID protocols. Of this sample, 163 were tagged in the Potomac River and 331 were tagged in the upper Chesapeake Bay area during the spring spawning stock assessment survey. A total of 1,008 striped bass were tagged during US FWS cooperative offshore tagging activities between January 7 and February 8, 2021.

APPROVAL

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ACKNOWLEDGEMENTS

The Maryland Department of Natural Resources (MD DNR) would like to thank the Maryland Watermen's Association commercial captains and their crews who allowed us to sample their commercial harvest. We also wish to thank Normandeau Associates personnel for their aid in acquiring tag returns and catch data from the fish lifts at Conowingo Dam.

Appreciation is also extended to MD DNR Hatchery personnel and staff for otolith analysis of juvenile and adult American shad and to Connie Lewis, Fisheries Statistics, for providing commercial landings and Ingrid Braun (Potomac River Fisheries Commission) for providing Potomac River channel catfish landing data. We would also like to thank Captain Gary Culver of the *R/V Chesapeake* for his assistance during the winter trawl survey.

Striped bass were sampled for portions of this study from commercial pound nets owned and operated by Maryland Watermen's Association commercial captains and their crews and from numerous commercial striped bass check stations. Striped bass were collected from the Atlantic Ocean trawl and gill net fisheries by Steve Doctor and Gary Tyler. Experimental drift gill nets were operated by B. Owen Clark, III on the Upper Chesapeake Bay and William Rice, Sr., on the Potomac River.

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CONTENTS

SURVEY TITLE: CHESAPEAKE BAY FINFISH INVESTIGATIONS

CONTENTS (Continued)

PROJECT NO. 1
JOB NO. 1

POPULATION VITAL RATES OF RESIDENT FINFISH IN SELECTED TIDAL AREAS OF MARYLAND'S CHESAPEAKE BAY

Prepared by Paul G. Piavis and Edward Webb, III

INTRODUCTION

The primary objective of Job 1 was to provide data and analysis from routine monitoring of the following resident species: white perch (*Morone americana*), yellow perch (*Perca flavescens*), channel catfish (*Ictalurus punctatus*) and white catfish (*Ameiurus catus*) from selected tributaries in the Maryland portion of the Chesapeake Bay. In order to update finfish population assessments and management plans, data on population vital rates should be current and clearly defined. Population vital rates include growth, mortality, and recruitment. Efficiency is often lacking when updating or initiating assessments because data are rarely compiled and synopsized in one convenient source. Data collected in an antecedent survey (MULTIFISH, F-54-R) have proved invaluable in compiling technical reports and providing the basis for sound management recommendations for these species. This job will enhance this efficiency by detailing current results of routine monitoring.

METHODS

I. Field Operations

Upper Chesapeake Bay Winter Trawl

The upper Chesapeake Bay winter bottom trawl survey is designed to collect fishery-independent data for the assessment of population trends of white perch, yellow perch, channel catfish and white catfish. The upper Chesapeake Bay was divided into five sampling areas; the

Sassafras River (SAS; 3 sites), the Elk River (EB; 4 sites), the upper Chesapeake Bay (UB; 6 sites), the middle Chesapeake Bay (MB; 4 sites), and the Chester River (CSR; 6 sites). The 23 sampling stations were approximately 2.6 km (1.5 miles) in length and variable in width (Figure 1). Each sampling station was divided into east/west or north/south halves by drawing a line parallel to the shipping channel. Sampling depth was divided into two strata; shallow water (< 6 m) and deep water (>6 m). Each site visit was then randomized for depth strata and the north/south or east/west directional components.

The winter trawl survey employed a 7.6 m wide bottom trawl consisting of 7.6 cm stretch-mesh body, 1.9 cm stretch-mesh in the cod end and a 1.3 cm stretch-mesh liner. Following the 10-minute tow at approximately 2.5 knots, the trawl was retrieved into the boat by winch and the catch emptied into either a culling board or large tub if catches were large. A minimum of 50 fish per species were sexed and measured. Non-random samples of yellow perch and white perch were sacrificed for otolith extraction and subsequent age determination. All species caught were identified and counted. If catches were prohibitively large to process, total numbers were extrapolated from volumetric counts. Volumetric subsamples were taken from the top of the tub, the middle of the tub, and the bottom of the tub. Six sampling rounds were scheduled from early January 2021 through February 2021.

Trawl sites have been mostly consistent throughout the survey, but the Chester River sites were added in 2011. Weather and operational issues caused incomplete sampling in some years (Table 1). During 2021, all 138 tows were completed. Various assessments utilized these data, and generally 2003 – 2005 were the only years where data accuracy was likely compromised due to small sample sizes.

Choptank River Fishery Independent Sampling

Six experimental fyke nets were set in the Choptank River to sample the four target species. Nets were set at river kilometers 63.6, 65.4, 66.6, 72.5, 74.4 and 78.1 and were fished two to three times per week from 24 February 2021 through 9 April 2021 (Figure 2). These nets contained a 64 mm stretch-mesh body and 76 mm stretch-mesh in the wings (7.6 m long) and leads (30.5 m long). Nets were set perpendicular to the shore with the wings at 45° angles.

Net hoops were brought aboard first to ensure that all fish were retained. Fish were then removed and placed into a tub and identified. All yellow perch and a subsample of up to 30 fish of each target species were sexed and measured. All non-target species were counted and released. Otoliths from a subsample of white perch and yellow perch were removed for age determination.

Upper Chesapeake Bay Fishery Dependent Sampling

Commercial fyke net catches were sampled for yellow perch on 3 March 2021 in the North East River (Figure 3), 7 March 2021 in the Gunpowder River (Figure 4) and 11 March 2021 in the Bush River (Figure 4). All yellow perch were measured and sexed (unculled) except when catches were prohibitively large. A subsample was purchased for otolith extraction and subsequent age determination.

Nanticoke River Fishery Dependent Sampling

Resident species were sampled from pound nets and fyke nets set by commercial fishermen on the Nanticoke River from 11 March 2021 to 20 April 2021. This segment of the survey was completed in coordination with Project 2, Job 1 of this grant. Nets were set from Barren Creek (35.7 rkm) downstream to Monday's Gut (30.4 rkm; Figure 5). Net sites and dates fished were at the discretion of the commercial fishermen. Thirty randomly selected white perch from the fyke nets were sexed and measured and a subsample was processed for age determination (otoliths). A bushel of unculled, mixed catfish species was randomly selected, identified to species and total lengths measured.

II. Data compilation

Population Age Structures

Population age structures were determined for yellow perch and white perch from the

Choptank River, the upper Chesapeake Bay trawl survey, yellow perch from the upper Bay commercial fyke net fishery and white perch from the fishery dependent Nanticoke River survey. Age-at-length keys for yellow perch and white perch (separated by sex) from the Choptank River fyke net survey, the upper Bay commercial fyke net survey (yellow perch only) and the upper Chesapeake Bay trawl survey were constructed by determining the proportion-at-age per 20-mm length group. The proportion-at-age for each length interval was multiplied by the total number-at-length from the entire sample for yellow perch from the upper Bay fyke net survey and yellow perch from the Choptank River fyke net survey. The same was done for white perch from the trawl survey, the Choptank River fyke net survey and the Nanticoke River survey, but the age-at-length key was applied to each individual haul/net lift and summed over the total sample. For the upper Bay trawl survey, the yellow perch age-length key was constructed in 10 mm increments and the age-at-length key was applied to individual hauls.

Length-frequency

Relative stock density (RSD) was used to describe length structures for white perch, yellow perch, channel catfish and white catfish. Gablehouse (1984) advocated incremental RSD's to characterize fish length distributions. This method groups fish into five broad length categories: stock, quality, preferred, memorable and trophy. The minimum length of each category is based on all-tackle world records such that the minimum stock length is 20 - 26% of the world record length (WRL), minimum quality length is 36 - 41% of the WRL, minimum preferred length is 45 - 55% of the WRL, minimum memorable length is 59 - 64% of the WRL and minimum trophy length is 74 - 80% of the WRL. Minimum lengths were assigned from either the cut-offs listed by Gablehouse et al (1984) or were derived from world record lengths as recorded by the International Game Fish Association. Current length-frequency histograms were produced for all target species encountered.

Growth

Growth in length and weight was determined for yellow perch (the Choptank River and upper Chesapeake Bay) and white perch (Choptank and Nanticoke rivers). Growth in length over time and weight in relation to length were described with standard fishery equations. The allometric growth equation (weight (g) = α*length (mmTL)$^{\beta}$) described weight change as a function of length, and the vonBertalanffy growth equation (Length=$L_{\infty}(1-e^{-K(t-t_0)})$) described change in length with respect to age. Both equations were fit for white perch and yellow perch males, females, and sexes combined with SAS nonlinear procedures. Growth data for target species encountered in the trawl survey were not compiled due to the size selectivity of the gear. Length curve parameters have been compromised by a lack of younger fish in the collections due to size selectivity of the gear. This usually manifests in low t_0 and K values in the vonBertalanffy solutions. In order to mitigate these biases, we included average sizes of young of year target species collected in either the EJFS seine survey or upper Bay trawl survey within each target system, by month.

Mortality

White perch instantaneous fishing mortality (F) estimates were determined in Piavis and Webb (2021) for the Choptank River and upper Chesapeake Bay through 2019. Estimated F for 2020 and 2021 in the Choptank River and upper Bay were determined from length converted catch curves (Pauly 1984; Huynh et al 2018). Length converted catch curves were utilized to determine white perch F for all years. This method uses vonBertalanffy parameters L_{∞} and K to form a relative age of each length interval. Appropriate annual estimates of the growth parameters by system were utilized. The regression slope of $\log_e$ abundance over a range of relative ages was the estimate of Z and F was Z-M.

Choptank River yellow perch mortality was estimated with a catch curve analysis of $\log_e$ transformed catches of ages 4 – oldest age captured. The slope of the line was –Z and M was assumed to be 0.25. Instantaneous fishing mortality (F) was Z-M. The wildly unequal recruitment and annual changes in catchability proved difficult to overcome in estimating the Choptank River mortality. Instantaneous mortality rates for yellow perch from the upper Bay were calculated with a statistical catch-at-age model (Piavis and Webb 2020) which is updated annually to produce a total allowable catch for the fishery.

Recruitment

Recruitment data were provided from age 1 relative abundance in the winter trawl survey and young-of-year relative abundance from the Estuarine Juvenile Finfish Survey (EJFS; see Project 2, Job2, Task 3 of this report). Cohort splitting was used to determine age 1 abundance in the winter trawl survey. Any yellow perch < 130 mm, white perch < 110 mm, and channel catfish < 135 mm were assumed to be one-year old fish. Since white catfish abundance was not well represented in the upper Bay trawl catches, data were not compiled for this species.

Previous yellow perch assessments indicated a suite of selected head-of-bay sites from the EJFS provided a good index of juvenile abundance. Therefore, only the Fishing Battery, Hyland Pt., Sassafras River Natural Resources Management Area, Handy's Creek, Plum Pt., Parlor Pt., and Oldfield Pt. permanent sites were used to determine the yellow perch juvenile relative abundance index. The index is reported as the geometric mean catch per seine haul. White perch juvenile relative abundance was the geometric mean (GM) abundance from all baywide permanent sites. Sites and methodology are reported in Project 2 Job 3 Task 3 of this report.

Relative Abundance

Relative abundance of catfish species from the Choptank River fyke net survey was determined as the average of the ratio of individual net catch per effort (N/soak time in days). For white perch and yellow perch, relative abundance at age was determined from the catch-at-age matrices. Fyke net effort for yellow perch from the Choptank River fyke net survey was defined as the amount of effort needed to collect 95% of each year's catch. This is necessary to ameliorate the effects of effort expended to catch white perch after the main yellow perch spawning run. The CPUE at age matrix included all yellow perch encountered. Prior to 1993, all sampling began 1 March, but the start date has varied since 1993 (usually beginning mid-February). In order to standardize data for time-trend analysis, CPUE from 1 March to the 95% catch end time was utilized. An exception was made for 2017 because of the extraordinarily warm winter. When nets were first fished on 23 February 2017, a large proportion of the female yellow perch were spent. Therefore, the 2017 index included February's catch and effort.

Relative abundance was also determined for target species from the winter trawl survey. Numbers at age (for yellow perch and white perch) per tow were divided by distance towed, standardized to 1 statue mile. The index was the average catch-at-age per 1 statute mile. For channel catfish, relative abundance was average catch per statute mile, *i.e*., channel catfish were not aged. The results from the Chester River sites were incorporated into the tables and figures for white perch and channel catfish. A cursory examination of CPUE's from the traditional Bay sites and the Chester River showed that these CPUE's were very similar. However, catches of yellow perch were very low, and it appeared that the sites selected in Chester River are not informative for yellow perch abundance. Yellow perch CPUE is still reported as relative abundance from the original 17 sites.

RESULTS

Data are summarized either in tables or figures organized by data type (age structure, length structure, etc.), species, and survey. Data summaries are provided in these locations:

Population Age Structures

White perch	Tables 2-4
Yellow perch	Tables 5-7

Population Length Structures

White perch	Tables 8-10 and Figures 6-8
Yellow perch	Tables 11-13 and Figures 9-11
Channel catfish	Tables 14-16 and Figures 12-14
White catfish	Tables 17-19 and Figures 15-17

Growth

White perch	Tables 20-21
Yellow perch	Tables 22-23

Mortality

White perch	Table 24
Yellow perch	Table 25

Recruitment

White perch	Figures 18-19
Yellow perch	Figures 20-21
Channel catfish	Figure 22

Relative Abundance

White perch	Tables 26-27
Yellow perch	Tables 28-29 and Figure 23
Channel catfish	Figures 24-25
White catfish	Figure 26

PROJECT NO. 1
JOB NO. 1

POPULATION VITAL RATES OF RESIDENT FINFISH IN SELECTED TIDAL AREAS OF MARYLAND'S CHESAPEAKE BAY

2022 PRELIMINARY RESULTS – WORK IN PROGRESS

Project 1 Job 1 is designed to be a clearing house for data collected in the winter/spring for resident species including yellow perch, white perch, channel catfish and white catfish. The project completed the winter trawl survey (upper Chesapeake Bay), commercial yellow perch fishery monitoring, which is essential for the full population analysis, and the Choptank River fishery independent fyke net survey.

The winter trawl completed 100 of the 138 proposed tows. The trawl survey began January 5, 2022 and concluded on February 16, 2022. The survey collected 53,337 white perch, yielding 2,811 length measurements and 143 age samples (otoliths). Yellow perch numbered 733 with 499 length measurements and 104 age samples (otoliths). The catfish complex yielded 3,953 channel catfish (1,277 measurements), 248 white catfish (215 measurements) and 5,283 blue catfish (1,123 measurements).

Three sampling days were allocated to characterize the commercial yellow perch fishery. A total of 4,542 yellow perch were measured and 227 fish were sacrificed for age determination. Areas sampled included the Northeast River (February 27, 2022) Gunpowder River (March 6, 2022) and the Bush River (March 11, 2022).

The Choptank River fyke net survey started February 25, 2022 and ended April 6, 2022. A total of 10,937 white perch were collected, yielding 2,425 length measurements and 94 age samples. Yellow perch numbered 669 (668 measurements and 186 ages); channel catfish numbered 616 (594 measurements) and white catfish numbered 658 (648 length measurements). Invasive blue catfish were also encountered (79 total, 79 length measurements).

In addition to these surveys, Job 1 tabulates data from the Nanticoke River Alosid survey from white perch, channel catfish and white catfish collections. The Nanticoke River was not sampled in 2022 due to a labor shortage for the cooperating commercial fishermen.

CITATIONS

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LIST OF TABLES

LIST OF TABLES (cont'd)

LIST OF FIGURES

LIST OF FIGURES (cont'd)

Figure 1. Upper Chesapeake Bay winter trawl survey locations, January 2021 – February 2021. Different symbols indicate each sampling round.

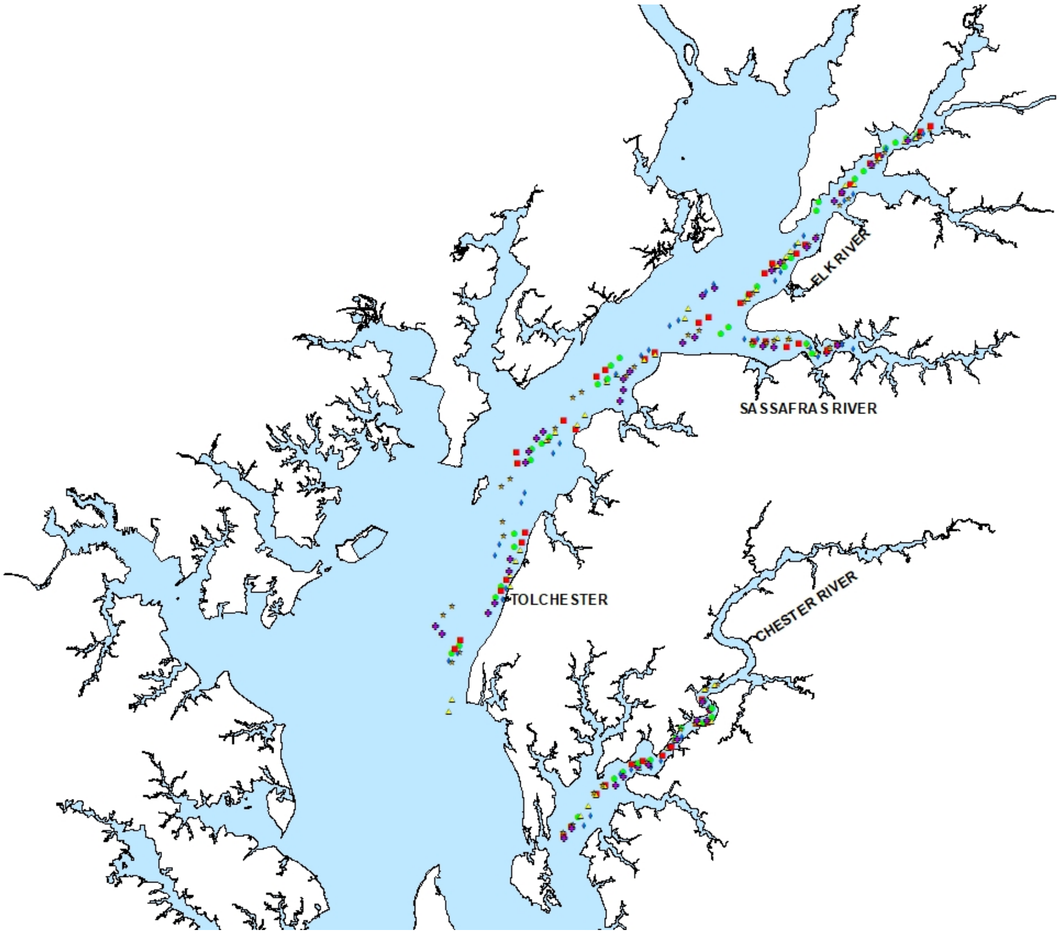


Table 1. Upper Chesapeake Bay winter trawl survey effort, 2000 – 2021.

Trawl Year	Trawls Completed/Trawls Scheduled	Comments
2000	79/79	
2001	114/114	
2002	108/108	
2003	18/108	Ice
2004	0/108	Captain Retired
2005	27/108	Engine Failure
2006	108/108	
2007	72/108	Ice
2008	108/108	
2009	90/108	Ice
2010	56/108	Ice
2011	66/108	Ice
2012	107/108	
2013	86/108	Ice
2014	60/108	Ice
2015	107/144	Ice
2016	112/144	Ice
2017	137/138	
2018	129/138	
2019	63/138	Federal Budget Shutdown
2020	134/138	CoVID Protocol
2021	138/138	

Figure 2. Choptank River fyke net locations, 2021. Circles indicate sites.

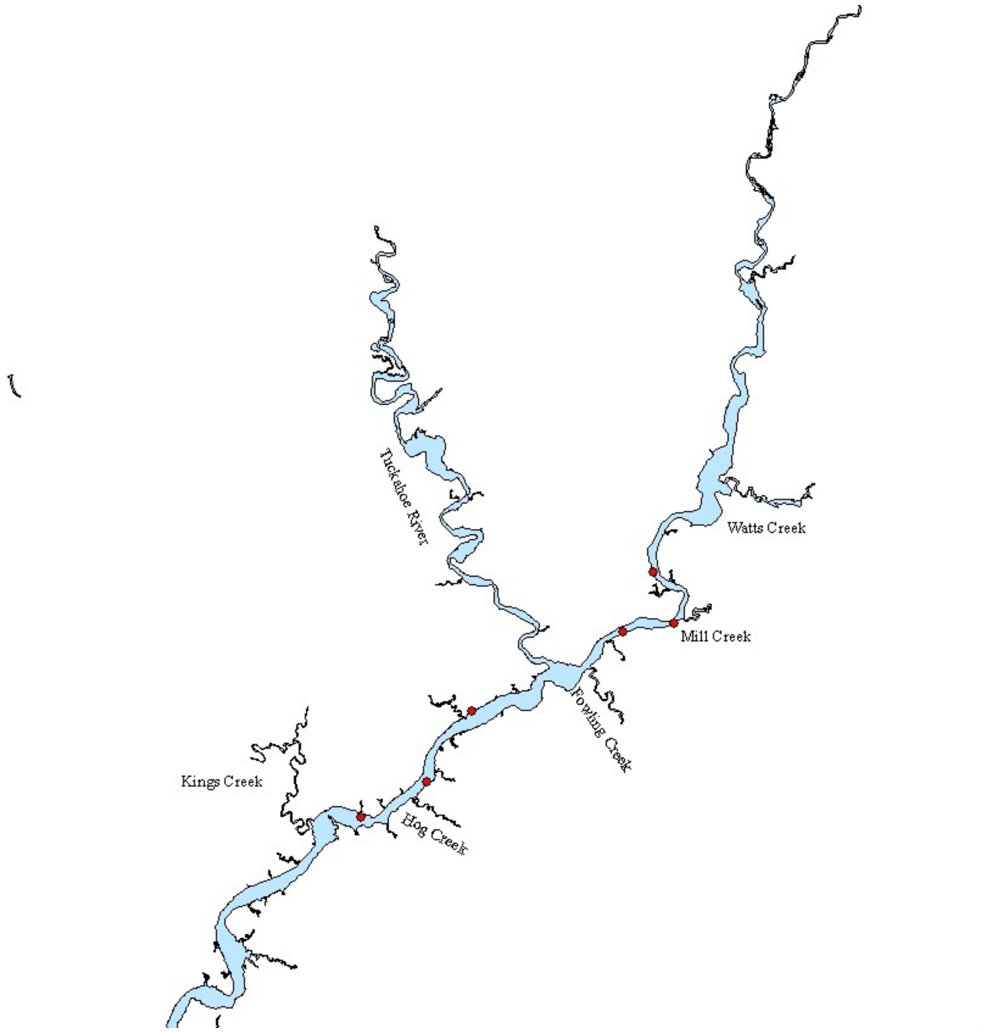


Figure 3. Commercial yellow perch fyke net sites sampled during 2021 in North East River. Circles indicate sites.

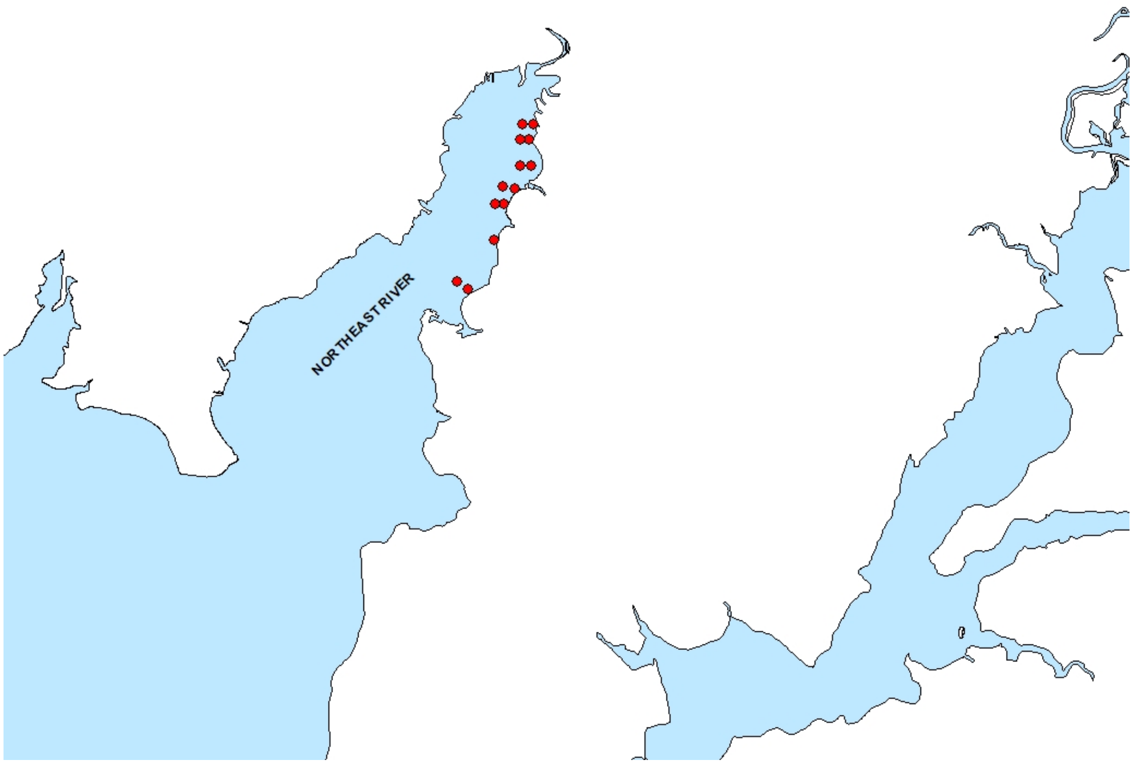


Figure 4. Commercial yellow perch fyke net sites sampled during 2021 in Bush and Gunpowder rivers. Circles indicate fyke net locations.

Figure 5. Commercial fyke net and pound net sites sampled during 2021 in the Nanticoke River. Black lines indicate the geographic range of fyke net locations.

Table 2. White perch catch-at-age matrix from upper Chesapeake Bay winter trawl survey, 2000 – 2021.

YEAR	AGE									
	1	2	3	4	5	6	7	8	9	10+
2000	1,321	9,382	4,256	2,751	1,034	616	845	93	88	55
2001	2,796	5,375	8,628	1,658	2,519	547	1,321	1,402	324	199
2002	17,571	150	3,670	1,516	2,359	1,006	1,947	1,067	277	638
2003	1,655	3,123	573	263	365	419	1,479	33		197
2004	NOT SAMPLED									
2005	973	1,684	460	846	216	77	25	242	28	12
2006	9,597	3,172	7,589	2,283	1,680	469	285	281	65	130
2007	2,521	1,699	1,229	2,408	1,387	335	381	30	26	133
2008	16,173	2,715	6,995	5,269	1,654	571	229	252	93	93
2009	5,838	16,227	686	2,969	5,588	4,716	113	1,628	344	67
2010	4,943	2,679	4,591	159	3,205	1,184	1,963	154	252	388
2011	2,569	3,044	2,164	2,916	710	1,614	884	896	50	153
2012	10,231	3,532	1,713	840	873	938	1,695	756	1,016	304
2013	6,748	7,475	938	2,073	1,888	9,127	1,112	1,343	316	837
2014	2,604	1,587	14,973	2,492	1,661	804	1,664	605	346	604
2015	20,752	13,909	16,529	30,783	6,733	3,506	3,670	4,446	2,513	2,648
2016	32,999	22,876	22,391	11,261	11,165	4,312	1,718	451	1,153	2,398
2017	3,795	40,101	16,261	4,525	1,634	10,664	731	1,491	589	1,758
2018	11,209	7,223	37,094	23,942	1,205	3,402	6,969	917	749	92
2019	5,241	2,366	1,484	3,717	1,938	366	537	875	344	124
2020	10,564	17,789	2,774	7,739	6,091	3,223	957	973	1,169	532
2021	3,141	21,489	26,756	6,644	3,469	3,294	1,293	209	433	632

Table 3. White perch catch-at-age matrix from Choptank River fyke net survey, 2000 – 2021.

YEAR	AGE									
	1	2	3	4	5	6	7	8	9	10+
2000	0	1	1,573	9,923	9,671	1,709	6,212	576	404	0
2001	0	2,177	4,947	14,849	11,090	8,135	1,305	3,399	474	0
2002	0	650	2,390	8,708	5,007	5,626	1,065	1,883	818	30
2003	0	572	9,594	8,773	8,684	364	7,217	1,881	835	834
2004	0	98	9,118	3,083	3,531	4,310	325	2,401	863	559
2005	0	801	3,759	12,029	7,543	4,687	1,682	397	2,531	116
2006	0	402	16,863	816	8,175	4,051	440	515	305	4,013
2007	0	258	1,931	25,125	2,719	11,741	4,194	1,655	1,834	1,452
2008	0	95	5,643	4,387	13,435	1,153	4,592	2,610	478	1,048
2009	0	369	149	5,220	1,427	9,501	1,150	1,793	1,021	650
2010	0	246	4,691	730	12,145	4,258	13,037	1,617	2,170	1,155
2011	0	21	247	5,313	844	5,080	3,115	3,824	553	1,027
2012	0	25	1,190	595	2,412	1,053	1,394	572	1,075	289
2013	0	2,794	2,706	4,060	562	1,639	378	2,649	728	1,767
2014	0	403	12,670	1,122	868	1,213	1,715	1,119	2,264	1,676
2015	0	0	0	22,945	1,654	3,706	1,666	571	293	1,432
2016	0	1,981	1,438	5	11,544	1,182	640	169	130	175
2017	0	3,805	5,788	915	0	11,524	483	37	0	234
2018	0	146	14,560	4,539	284	530	8,629	159	195	35
2019	0	90	323	5,801	3,274	178	382	2,057	40	33
2020	0	334	575	151	2,734	1,217	85	96	1,184	0
2021	0	578	3,807	693	275	3,254	627	297	212	768

Table 4. White perch catch-at-age matrix from Nanticoke River fyke and pound net survey, 2000 – 2021. 2007 -- 2009 include Marshyhope River data.

YEAR	AGE									
	1	2	3	4	5	6	7	8	9	10+
2000	0	42	593	6,074	6,471	2,813	1,942	365	81	0
2001	0	0	681	796	3,262	1,822	689	785	94	38
2002	0	5	1,469	1,927	504	2,124	1,132	632	244	135
2003	0	97	318	2,559	1,567	446	994	652	180	175
2004	0	6,930	3,892	12,215	3,259	1,835	1,297	1,361	443	886
2005	0	826	1,302	5,847	3,903	5,288	2,400	1,237	1,497	2,582
2006	0	0	5,759	3,280	5,298	3,488	3,590	1,287	861	799
2007	0	497	1,948	12,876	727	6,236	2,260	2,716	977	1,573
2008	0	33	902	1,188	2,780	824	1,457	665	593	496
2009	0	70	1,351	4,135	2,117	6,216	1,188	1,651	889	1,470
2010	0	101	273	155	414	315	1,113	88	143	166
2011	0	933	1,625	7,817	1,167	4,433	1,750	5,133	1.050	3,034
2012	4	134	387	176	539	214	330	57	276	85
2013	5	418	1,342	1,587	270	615	433	671	207	723
2014	0	0	1,511	1,444	1,191	372	601	154	464	531
2015	NOT SAMPLED									
2016	10	630	2,627	140	12,472	2,982	1,410	128	266	693
2017	0	386	3,033	2,490	0	6,305	1,054	795	24	361
2018	0	25	481	1,483	483	114	1,104	128	41	13
2019	0	177	260	2,763	3,460	1,223	259	1,165	60	189
2020	NOT SAMPLED									
2021	0	0	438	629	248	616	1,007	369	24	680

Table 5. Yellow perch catch at age from upper Chesapeake Bay winter trawl survey, 2000 – 2021.

YEAR	AGE									
	1	2	3	4	5	6	7	8	9	10+
2000	44	77	13	85	3	15	4	0	0	5
2001	669	43	78	12	44	3	0	3	0	0
2002	1,170	847	83	178	14	86	0	8	4	0
2003	343	985	3,050	327	437	28	175	0	14	0
2004	NOT SAMPLED									
2005	446	320	0	70	9	0	0	0	0	0
2006	1,580	1,738	738	0	146	18	0	15	0	0
2007	167	150	385	112	71	26	2	0	0	0
2008	1,053	256	572	504	131	0	0	0	0	0
2009	215	1,051	54	117	105	23	1	0	0	0
2010	862	101	260	18	28	11	6	0	2	0
2011	51	185	29	118	0	15	6	0	0	0
2012	1,138	464	156	6	9	5	0	45	0	0
2013	135	262	77	32	1	1	1	0	1	0
2014	97	0	495	217	24	0	2	3	3	0
2015	1,144	48	0	692	74	19	0	0	0	0
2016	1,876	1,387	264	15	179	23	10	0	0	0
2017	244	1,364	443	0	0	64	5	0	0	0
2018	171	72	532	154	0	0	4	0	0	0
2019	766	31	20	94	13	0	0	0	0	0
2020	340	512	8	0	14	7	1	0	0	0
2021	53	505	559	0	3	20	5	0	0	0

Table 6. Yellow perch catch at age matrix from Choptank River fyke net survey, 1988 – 2021.

YEAR	AGE								
	1	2	3	4	5	6	7	8	9	10+
1988	0	9	268	9	2	21	19	1	1	5
1989	0	0	80	234	81	41	8	2	2	0
1990	0	22	179	82	273	53	10	8	5	1
1991	0	7	41	53	18	44	9	2	2	0
1992	0	1	8	14	15	7	6	0	0	0
1993	0	3	75	150	98	109	37	7	4	0
1994	0	42	158	25	81	87	78	64	5	18
1995	0	79	258	23	68	67	42	37	5	21
1996	0	857	343	267	35	81	47	27	43	9
1997	0	14	641	99	86	0	19	24	8	0
1998	0	142	77	583	26	31	0	8	3	17
1999	0	306	8,514	86	3,148	32	9	8	0	6
2000	0	329	92	1,378	27	140	0	7	0	0
2001	0	878	1,986	102	1,139	19	72	2	0	0
2002	0	334	1,336	1,169	38	430	104	51	3	0
2003	0	369	440	922	333	34	226	35	32	2
2004	0	60	504	177	120	103	0	61	0	7
2005	0	1,667	137	416	134	55	140	23	52	15
2006	0	173	1,858	176	395	64	66	42	0	7
2007	0	1,512	737	1,560	33	182	109	28	10	12
2008	0	39	1,303	130	326	13	49	20	0	0
2009	0	0	866	2,119	140	127	23	3	0	6
2010	0	48	104	1,045	2,410	52	162	0	9	0
2011	0	193	0	40	721	882	53	109	0	0
2012	50	255	1,088	20	0	259	578	5	12	0
2013	0	178	159	469	13	17	64	114	0	4
2014	0	0	1,626	937	419	5	0	2	39	9
2015	0	186	24	2,635	426	117	4	2	13	3
2016	0	397	137	62	3,908	542	362	43	3	21
2017	0	147	375	139	5	962	213	105	0	18
2018	0	33	2,033	571	62	29	630	101	55	0
2019	0	33	101	907	168	7	4	113	3	14
2020	0	203	135	56	1,417	144	0	6	56	11
2021	0	40	446	132	39	665	45	0	0	24

Table 7. Yellow perch catch at age matrix from upper Chesapeake Bay commercial fyke net survey, 1999 – 2021.

YEAR	AGE									
	1	2	3	4	5	6	7	8	9	10+
1999	0	0	1,621	33	337	408	28	0	2	0
2000	0	35	138	2937	129	369	211	0	0	0
2001	0	0	83	90	432	17	9	17	0	0
2002	0	52	117	528	56	1,000	14	39	53	0
2003	0	27	565	78	361	45	418	6	15	25
2004	0	4	473	499	62	50	3	43	2	2
2005	0	18	27	1,320	414	73	37	0	26	5
2006	0	32	476	9	848	245	0	1	10	0
2007	0	2	290	1,400	23	548	168	3	0	14
2008	0	70	3,855	3,782	4,820	75	789	149	14	2
2009	0	87	128	663	490	648	5	80	35	0
2010	0	3	356	125	274	281	260	0	23	0
2011	0	41	56	703	152	355	183	102	0	0
2012	0	19	462	38	548	14	244	99	54	35
2013	0	83	469	1,143	110	392	43	45	8	14
2014	0	2	846	553	212	45	85	10	35	21
2015	0	25	33	1,356	685	277	0	16	32	32
2016	0	387	45	29	1,792	528	416	0	0	33
2017	0	136	2,282	0	0	1,080	234	194	0	0
2018	0	0	2,123	1,422	6	0	83	8	0	0
2019	0	0	68	2,010	2,235	2	10	192	2	0
2020	0	815	479	111	1,817	729	3	1	0	0
2021	0	373	2,505	371	191	824	370	0	0	1

Table 8. Relative stock densities (RSD's) of white perch from the upper Chesapeake Bay winter trawl survey, 2000 – 2021. Minimum length cut-offs in parentheses.

Year	Stock (125 mm)	Quality (200 mm)	Preferred (255 mm)	Memorable (305 mm)	Trophy (380 mm)
2000	76.9	22.1	0.9	0.1	0.0
2001	89.8	9.9	0.3	0.0	0.0
2002	87.1	12.0	0.8	0.0	0.0
2003	83.6	14.3	1.2	0.5	0.0
2004	NOT SAMPLED				
2005	83.9	16.1	0.0	0.0	0.0
2006	88.4	10.8	0.1	<0.1	0.0
2007	92.3	7.0	0.7	0.0	0.0
2008	91.2	8.2	0.6	0.0	0.0
2009	92.0	7.3	0.6	0.0	0.0
2010	89.6	9.7	0.7	0.0	0.0
2011	87.2	11.6	1.2	0.0	0.0
2012	86.4	12.7	0.9	0.0	<0.1
2013	88.3	11.1	0.6	0.0	0.0
2014	92.8	6.7	0.4	0.1	0.0
2015	93.5	6.2	0.3	0.0	0.0
2016	89.7	9.9	0.3	0.1	0.0
2017	93.0	6.6	0.4	0.0	0.0
2018	92.5	6.6	0.9	0.0	0.0
2019	90.7	9.2	0.1	0.0	0.0
2020	92.3	7.4	0.2	0.0	0.0
2021	93.9	5.9	0.2	0.0	0.0

Figure 6. White perch length-frequency from 2021 upper Chesapeake Bay winter trawl survey.

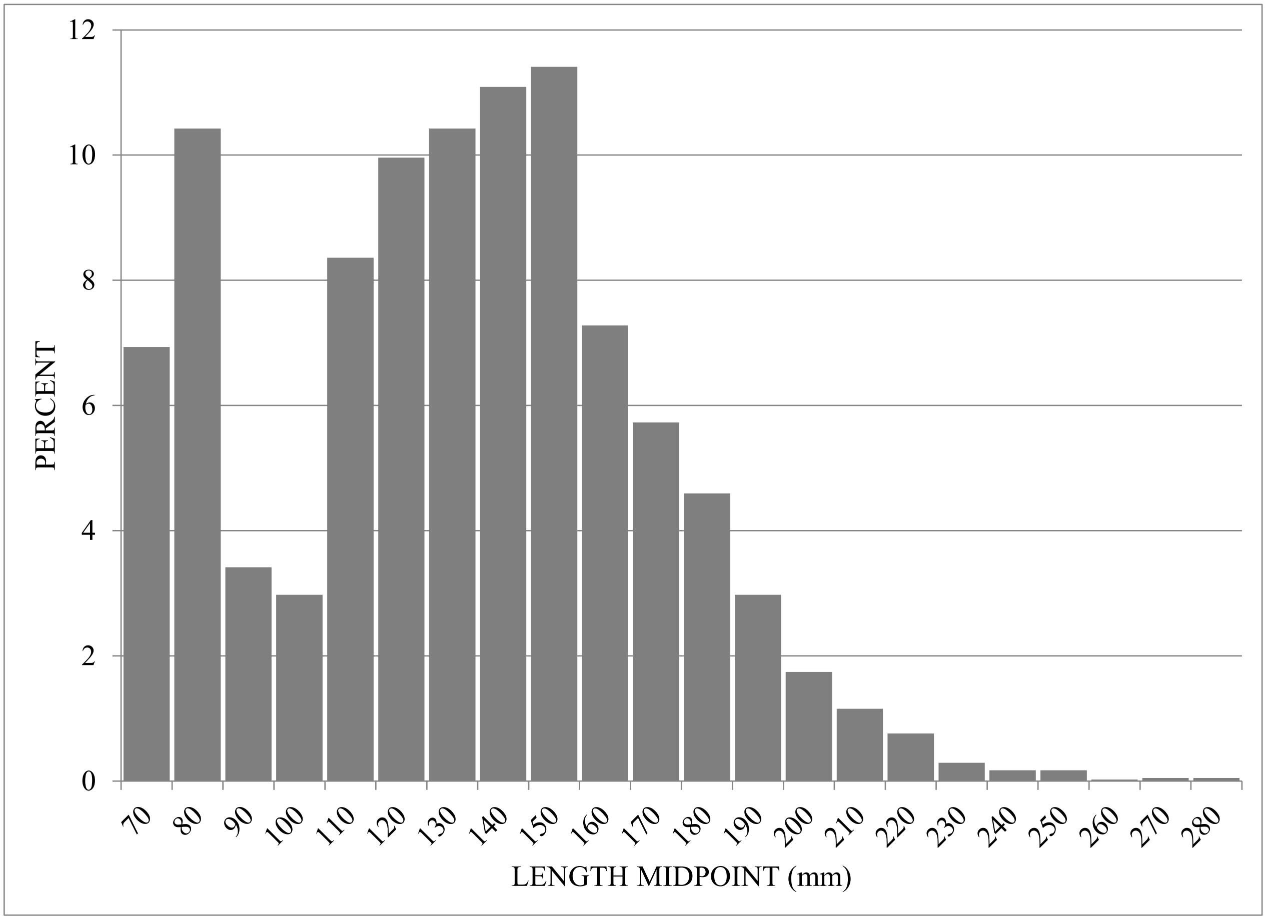


Table 9. Relative stock densities (RSD's) of white perch from the Choptank River fyke net survey, 1993 – 2021. Minimum length cut-offs in parentheses.

Year	Stock (125 mm)	Quality (200 mm)	Preferred (255 mm)	Memorable (305 mm)	Trophy (380 mm)
1993	72.5	25.0	2.4	0.1	0.0
1994	76.8	21.3	1.8	0.1	0.0
1995	84.3	14.9	0.8	0.0	0.0
1996	86.4	13.1	0.5	0.0	0.0
1997	80.0	19.1	0.8	0.1	0.0
1998	71.9	26.2	1.8	<0.1	0.0
1999	80.2	18.7	1.1	<0.1	0.0
2000	72.0	25.9	2.1	0.0	0.0
2001	84.6	14.4	1.0	0.0	0.0
2002	71.6	26.6	1.7	0.1	0.0
2003	76.4	22.2	1.3	0.1	0.0
2004	75.6	23.6	1.0	0.1	0.0
2005	78.5	19.9	1.5	0.1	0.0
2006	70.5	26.7	2.7	<0.1	0.0
2007	76.5	21.7	1.7	0.0	0.0
2008	73.8	24.9	1.2	<0.1	0.0
2009	73.0	25.5	1.4	0.1	0.0
2010	62.3	35.0	2.7	<0.1	0.0
2011	63.0	33.5	3.2	0.3	0.0
2012	51.9	42.9	4.9	0.2	0.0
2013	59.1	36.5	4.1	0.3	0.0
2014	76.0	21.7	2.1	0.2	0.0
2015	80.3	18.4	1.3	0.0	0.0
2016	48.0	46.5	5.2	0.3	0.0
2017	55.5	38.6	5.7	0.2	0.0
2018	56.0	40.9	3.0	0.4	0.0
2019	56.9	40.1	2.8	0.2	0.0
2020	44.8	50.9	4.4	<0.1	0.0
2021	47.0	48.3	4.4	0.3	0.0

Figure 7. White perch length-frequency from 2021 Choptank River fyke net survey.

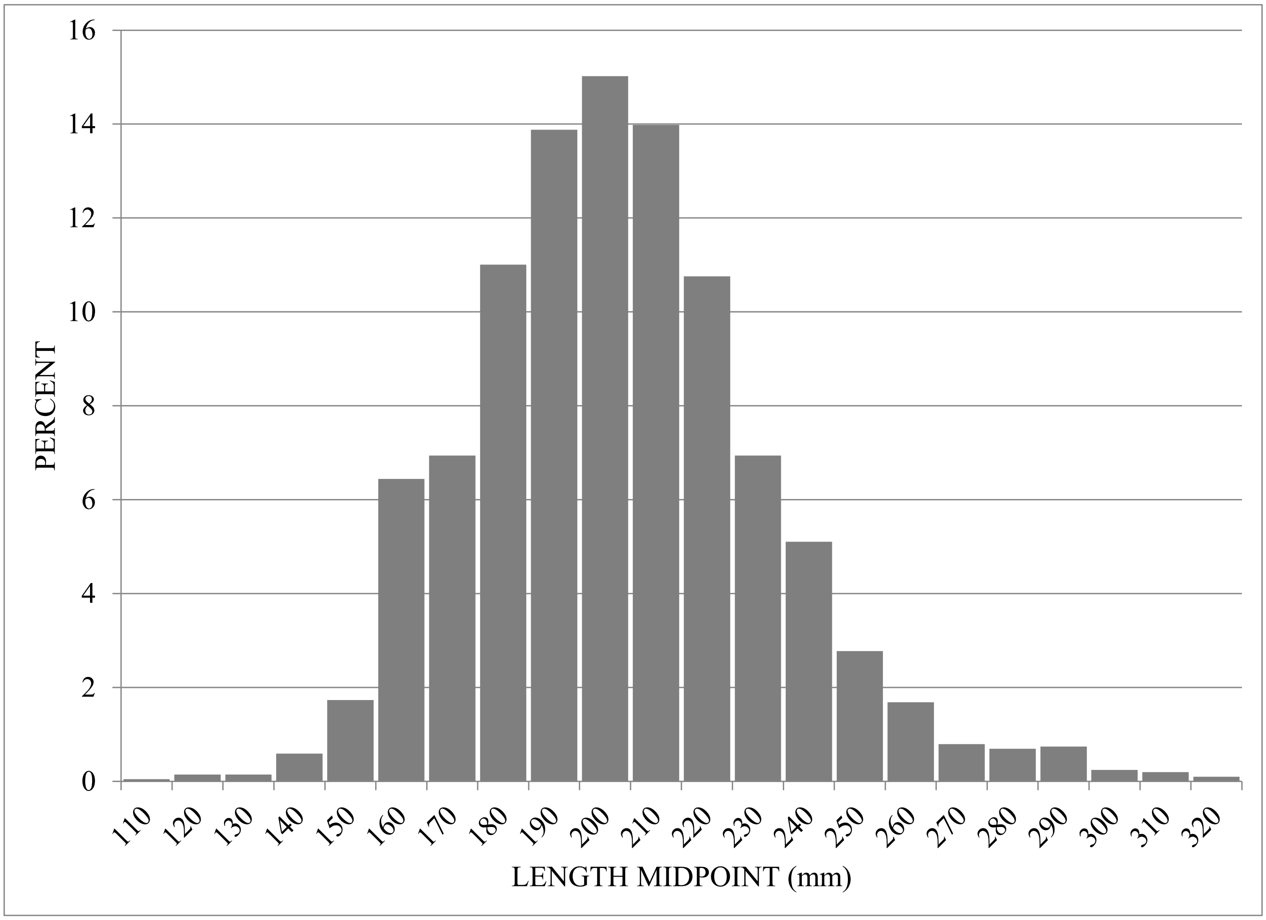


Table 10. Relative stock densities (RSD's) of white perch from the Nanticoke River fyke and pound net survey, 1995 – 2021. Minimum length cut-offs in parentheses. 2007 -- 2009 include Marshyhope River data.

Year	**Stock** (125 mm)	**Quality** (200 mm)	**Preferred** (255 mm)	**Memorable** (305 mm)	**Trophy** (380 mm)
1995	56.3	35.4	5.2	3.0	0.0
1996	37.8	54.2	7.3	0.7	0.0
1997	37.5	58.4	4.0	<0.1	0.0
1998	30.4	63.1	6.4	<0.1	0.0
1999	37.2	57.7	5.0	<0.1	0.0
2000	31.3	58.9	9.7	<0.1	0.0
2001	26.2	60.7	12.5	0.6	0.0
2002	32.4	52.9	14.3	0.4	0.0
2003	26.4	60.6	11.9	1.1	0.0
2004	23.0	61.0	14.0	2.0	0.0
2005	25.3	52.8	19.3	2.6	0.0
2006	26.1	56.7	16.3	<0.1	0.0
2007	36.3	52.4	10.0	1.4	0.0
2008	36.2	50.9	12.2	0.7	0.0
2009	33.6	53.2	12.2	1.0	0.0
2010	22.0	53.6	23.1	1.1	0.2
2011	25.1	53.0	19.1	2.7	0.0
2012	30.4	47.7	19.9	2.0	0.0
2013	23.6	49.8	23.2	3.4	0.0
2014	30.7	54.7	13.1	1.5	0.0
2015	NOT SAMPLED				
2016	22.4	60.8	15.7	1.2	0.0
2017	17.4	65.0	16.0	1.6	0.0
2018	44.3	40.6	14.8	0.3	0.0
2019	23.9	63.6	11.9	0.6	0.0
2020	NOT SAMPLED				
2021	8.1	62.2	28.0	1.8	0.0

Figure 8. White perch length-frequency from 2021 Nanticoke River fyke and pound net survey.

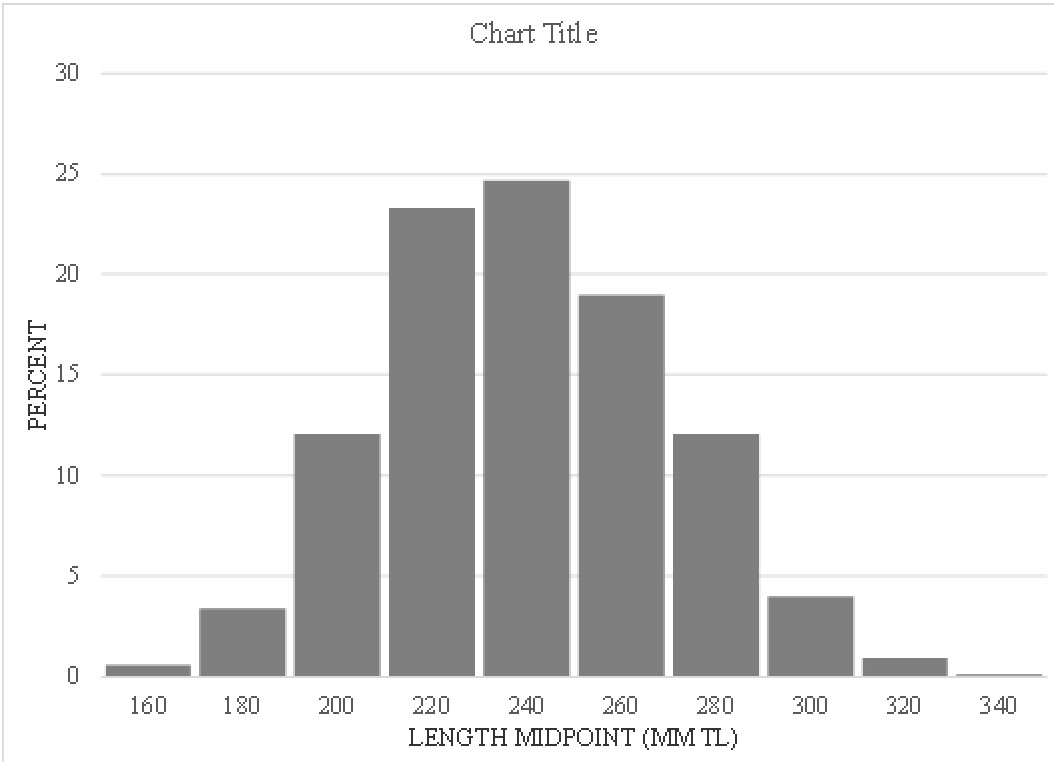


Table 11. Relative stock densities (RSD's) of yellow perch from the upper Chesapeake Bay winter trawl survey, 2000 – 2021. Minimum length cut-offs in parentheses.

Year	**Stock** (140 mm)	**Quality** (216 mm)	**Preferred** (255 mm)	**Memorable** (318 mm)	**Trophy** (405 mm)
2000	84.2	14.3	1.5	0.0	0.0
2001	90.6	7.9	1.4	0.0	0.0
2002	87.8	10.7	1.5	0.0	0.0
2003	87.5	9.9	1.9	0.0	0.0
2004	NOT SAMPLED				
2005	98.6	1.4	0.0	0.0	0.0
2006	97.7	1.7	0.5	0.0	0.0
2007	98.7	0.4	0.8	0.0	0.0
2008	94.2	4.6	1.2	0.0	0.0
2009	93.4	4.6	2.0	0.0	0.0
2010	80.7	16.7	2.6	0.0	0.0
2011	83.7	12.8	3.5	0.0	0.0
2012	92.6	5.9	1.5	0.0	0.0
2013	96.4	3.2	0.4	0.0	0.0
2014	94.9	4.3	0.8	0.0	0.0
2015	83.5	15.2	1.3	0.0	0.0
2016	89.3	7.9	2.6	0.2	0.0
2017	96.2	2.8	1.0	0.0	0.0
2018	89.1	9.7	1.1	0.0	0.0
2019	85.6	12.9	1.5	0.0	0.0
2020	94.9	4.0	1.1	0.0	0.0
2021	94.2	3.2	2.5	0.0	0.0

Figure 9. Yellow perch length-frequency from the 2021 upper Chesapeake Bay winter trawl survey.

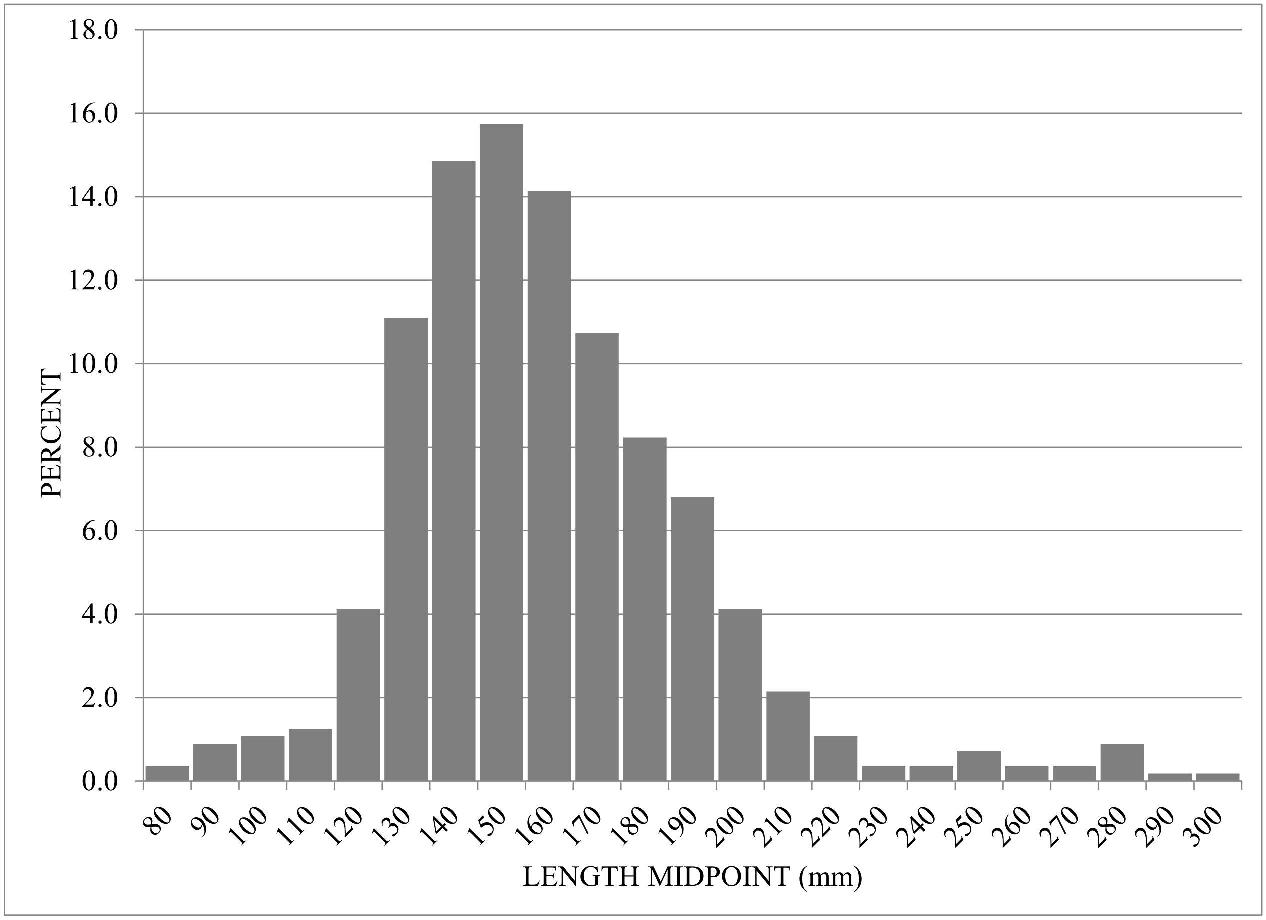


Table 12. Relative stock densities (RSD's) of yellow perch from the Choptank River fyke net survey, 1989 – 2021. Minimum length cut-offs in parentheses.

Year	Stock (140 mm)	Quality (216 mm)	Preferred (255 mm)	Memorable (318 mm)	Trophy (405 mm)
1989	66.7	24.4	8.2	0.7	0.0
1990	64.8	27.3	7.8	0.0	0.0
1991	58.7	23.4	18.0	0.0	0.0
1992	45.3	26.4	24.5	3.8	0.0
1993	34.6	31.7	30.3	3.3	0.0
1994	23.4	33.6	36.6	6.4	0.0
1995	45.5	28.1	23.1	3.3	0.0
1996	74.1	18.2	7.2	0.5	0.0
1997	57.5	29.3	12.9	0.3	0.0
1998	10.5	72.9	16	0.6	0.0
1999	86.0	12.4	2.4	<0.1	0.0
2000	71.6	19.0	9.1	0.2	0.0
2001	83.6	13.0	3.3	<0.1	0.0
2002	59.8	33.1	6.9	0.2	0.0
2003	67.0	27.4	5.4	0.2	0.0
2004	54.2	34.6	10.7	0.4	0.0
2005	75.1	17.2	7.4	0.2	0.0
2006	53.5	32.1	13.8	0.6	0.0
2007	74.9	15.0	9.9	0.2	0.0
2008	76.4	16.1	7.3	0.2	0.0
2009	77.3	17.4	5.1	<0.1	0.0
2010	64.3	25.6	10.0	0.1	0.0
2011	50.1	32.6	16.9	0.3	0.0
2012	51.5	30.8	16.7	1.0	0.0
2013	48.5	29.2	21.6	0.7	0.0
2014	79.9	13.9	6.0	0.2	0.0
2015	64.3	24.7	10.8	0.2	0.0
2016	49.5	30.4	19.8	0.4	0.0
2017	45.4	29.9	23.8	0.8	0.0
2018	65.4	24.6	9.6	0.3	0.0
2019	51.4	31.1	17.2	0.3	0.0
2020	44.4	29.7	25.5	0.5	0.0
2021	43.9	29.1	26.3	0.6	0.0

Figure 10. Yellow perch length-frequency from the 2021 Choptank River fyke net survey.

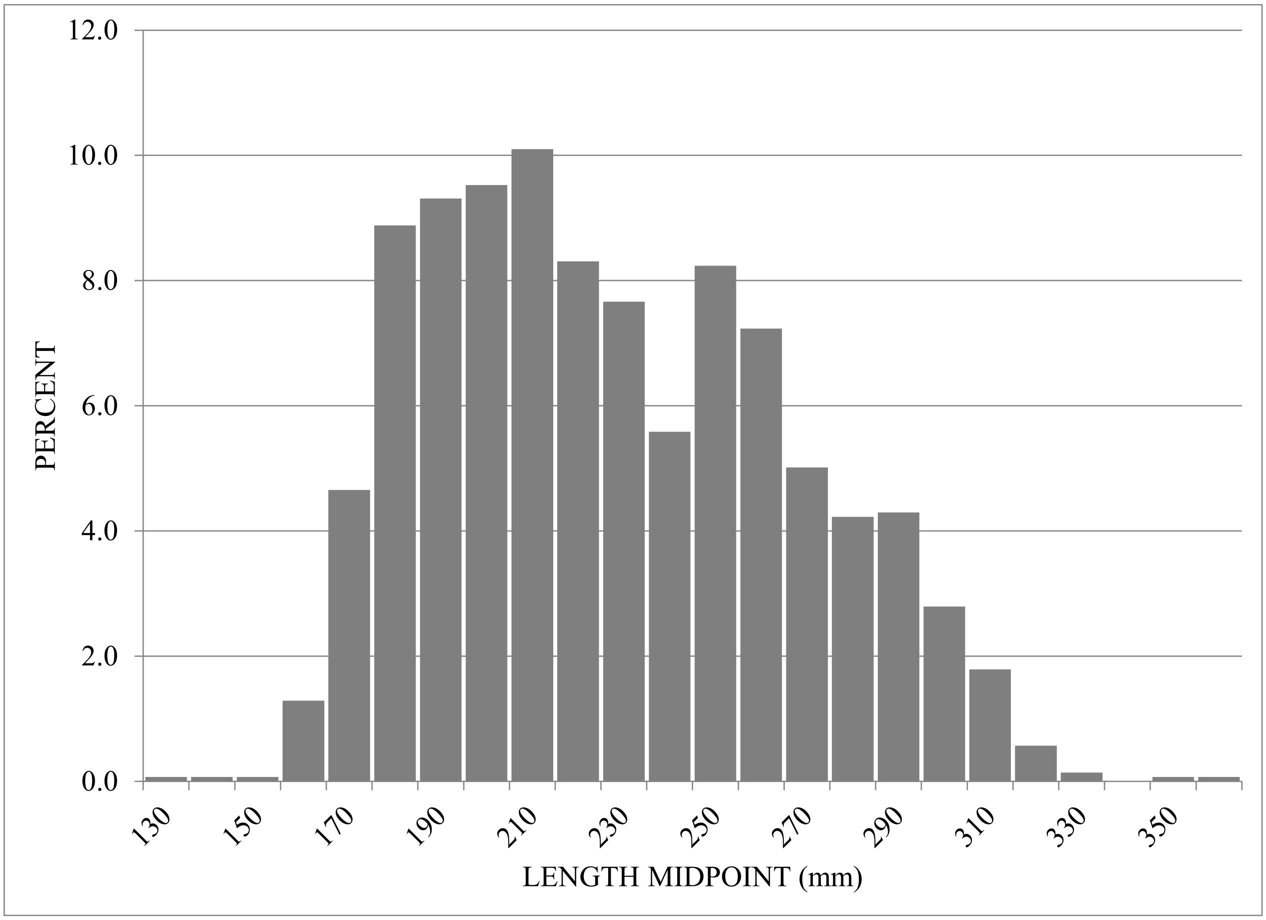


Table 13. Relative stock densities (RSD's) of yellow perch from the upper Chesapeake Bay commercial fyke net survey, 1988, 1990, 1998 – 2021. Minimum length cut-offs in parentheses.

Year	Stock (140 mm)	Quality (216 mm)	Preferred (255 mm)	Memorable (318 mm)	Trophy (405 mm)
1988	71.8	25.3	3.1	0.0	0.0
1990	6.7	71.7	21	0.1	0.0
1998	24.2	51.0	24.7	<0.1	0.0
1999	40.2	52.3	7.3	0.2	0.0
2000	55.1	37.2	7.6	<0.1	0.0
2001	27.1	48.8	24.0	0.0	0.0
2002	17.8	63.1	18.9	0.2	0.0
2003	19.5	54.6	24.6	1.3	0.0
2004	9.6	66.3	23.8	0.3	0.0
2005	45.2	42.2	12.1	0.5	0.0
2006	35.0	52.8	12.0	0.2	0.0
2007	40.1	47.9	11.5	0.5	0.0
2008	31.6	55.3	13.0	0.1	0.0
2009	30.6	47.6	21.4	0.4	0.0
2010	20.9	60.3	18.2	0.6	0.0
2011	27.0	50.2	22.4	0.4	0.0
2012	22.1	54.5	22.6	0.7	0.0
2013	18.5	69.2	10.6	1.8	0.0
2014	50.6	44.2	5.0	0.2	0.0
2015	42.8	48.1	9.0	0.1	0.0
2016	35.1	44.0	20.8	0.1	0.0
2017	45.0	45.0	9.9	0.1	0.0
2018	52.3	42.6	4.8	0.3	0.0
2019	52.0	38.9	9.0	0.1	0.0
2020	58.7	32.7	8.2	0.4	0.0
2021	63.9	30.7	5.3	0.1	0.0

Figure 11. Yellow perch length frequency from the 2021 upper Chesapeake commercial fyke net survey.

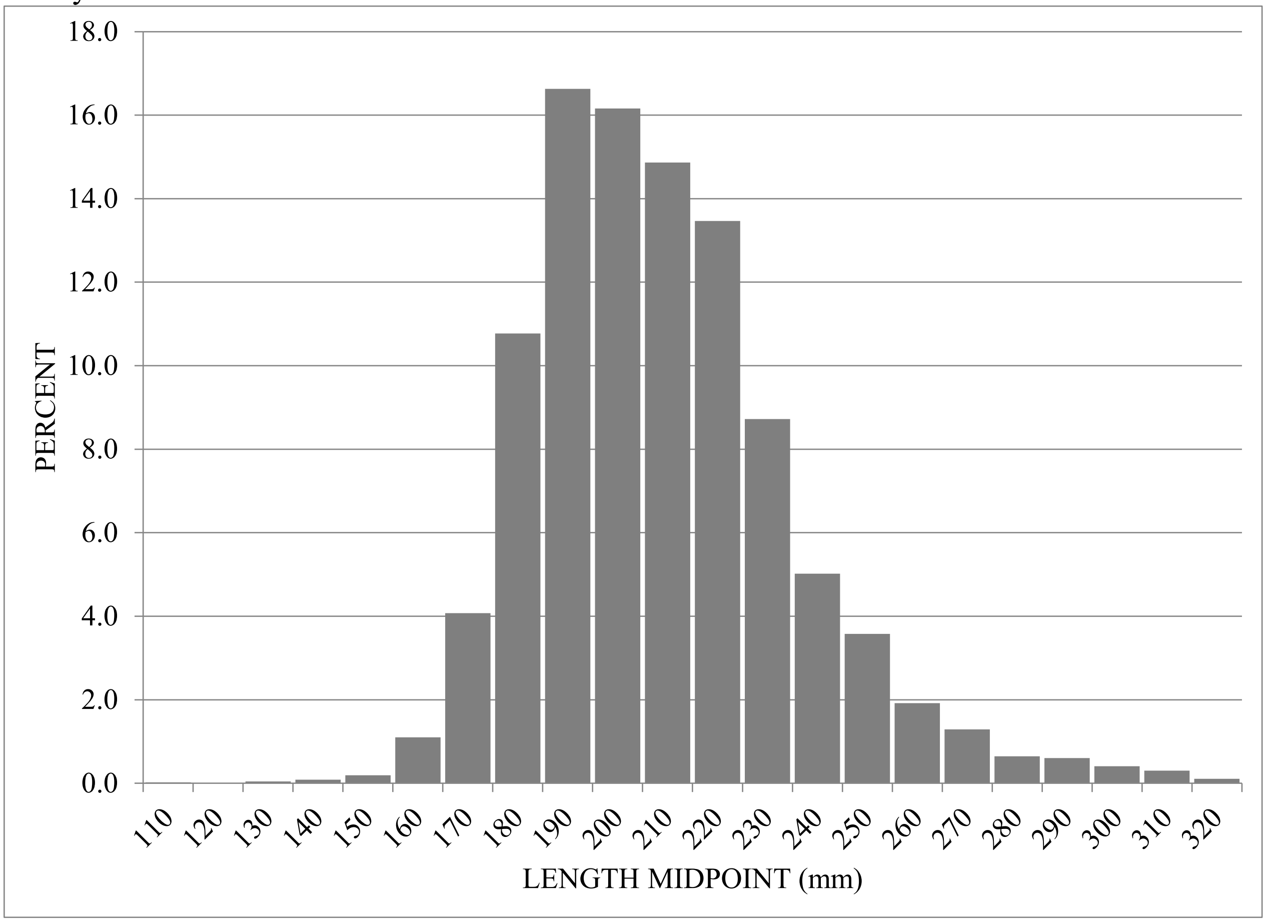


Table 14. Relative stock densities (RSD's) of channel catfish from the upper Chesapeake Bay winter trawl survey, 2000 – 2021. Minimum length cut-offs in parentheses.

Year	Stock (255 mm)	Quality (460 mm)	Preferred (510 mm)	Memorable (710 mm)	Trophy (890 mm)
2000	88.5	4.5	6.4	0.6	0.0
2001	92.7	2.5	4.7	0.0	0.0
2002	89.4	7.3	3.2	0.0	0.0
2003	89.5	5.3	5.3	0.0	0.0
2004	NOT SAMPLED				
2005	73.8	10.0	16.2	0.0	0.0
2006	96.4	2.0	1.6	0.0	0.0
2007	95.6	2.2	2.2	0.0	0.0
2008	91.4	3.7	4.9	0.0	0.0
2009	94.1	2.1	3.8	0.0	0.0
2010	84.6	9.2	5.8	0.4	0.0
2011	76.3	14.0	9.7	0.0	0.0
2012	88.5	5.9	5.1	0.4	0.0
2013	88.2	2.4	9.5	0.0	0.0
2014	82.1	9.8	7.4	0.7	0.0
2015	93.8	2.0	3.8	0.4	0.0
2016	93.7	3.8	22.4	0.0	0.0
2017	92.1	3.5	3.8	0.6	0.0
2018	89.0	6.3	4.4	0.3	0.0
2019	85.6	12.9	1.5	0.0	0.0
2020	82.1	7.8	10.1	0.0	0.0
2021	84.6	8.2	6.9	0.3	0.0

Figure 12. Length frequency of channel catfish from the 2021 upper Chesapeake Bay winter trawl survey.

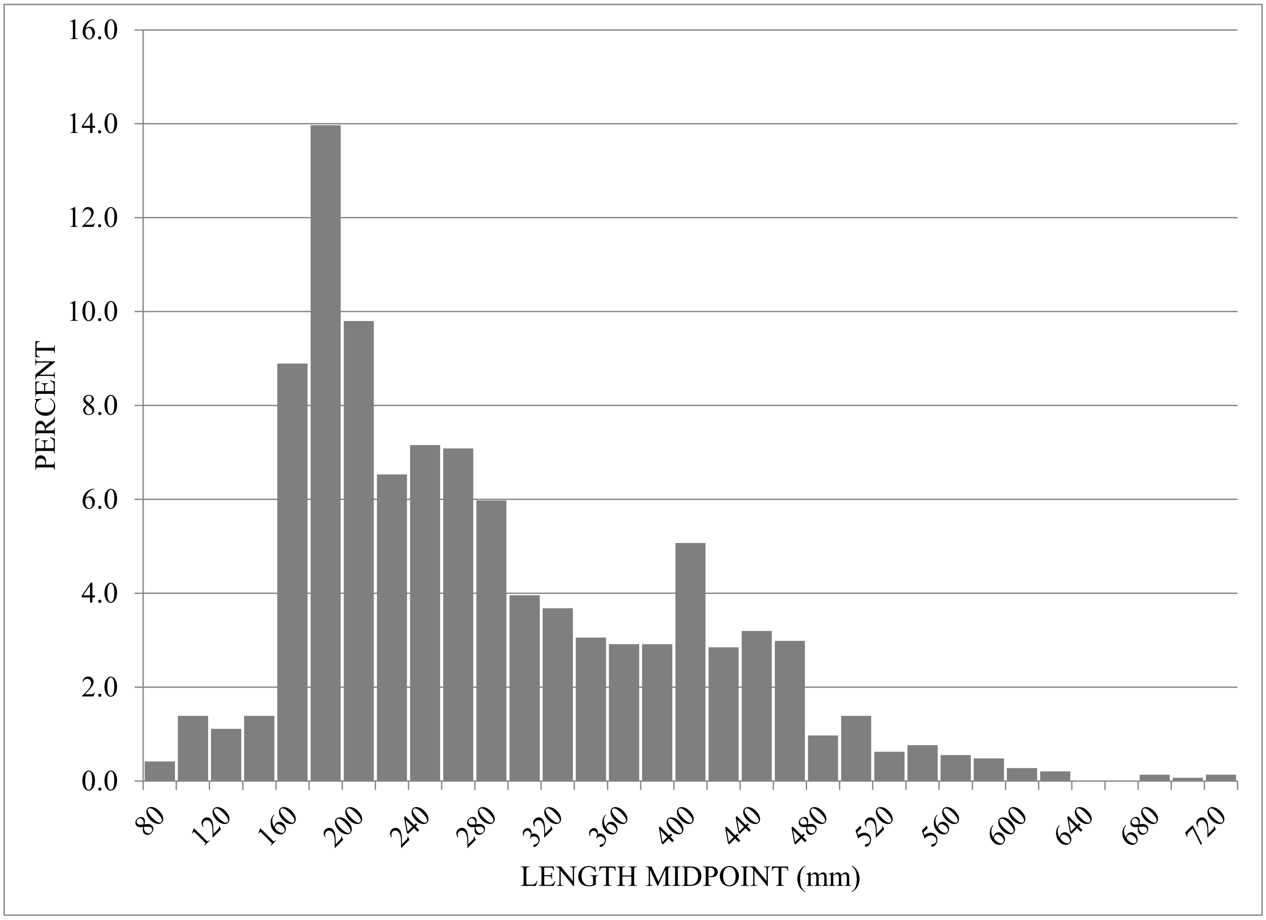


Table 15. Relative stock densities (RSD's) of channel catfish from the Choptank River fyke net survey, 1993 – 2021. Minimum length cut-offs in parentheses.

Year	**Stock** (255 mm)	**Quality** (460 mm)	**Preferred** (510 mm)	**Memorable** (710 mm)	**Trophy** (890 mm)
1993	53.4	24.0	22.6	0.0	0.0
1994	61.9	15.8	22.2	0.0	0.0
1995	21.0	20.4	58.6	0.0	0.0
1996	40.8	14.1	35.6	0.0	0.0
1997	19.8	16.4	63.8	0.0	0.0
1998	33.3	9.2	57.5	0.0	0.0
1999	31.3	10.6	58.1	0.0	0.0
2000	63.7	8.4	27.9	0.0	0.0
2001	53.2	6.7	40.1	0.0	0.0
2002	19.8	14.3	65.9	0.0	0.0
2003	84.2	5.8	9.9	0.0	0.0
2004	58.8	10.0	31.2	0.0	0.0
2005	79.2	9.3	11.5	0.0	0.0
2006	72.3	12.6	15.1	0.0	0.0
2007	84.9	7.1	8.0	0.0	0.0
2008	79.6	8.1	12.3	0.0	0.0
2009	74.3	8.2	27.0	0.0	0.0
2010	69.0	12.0	18.9	0.0	0.0
2011	73.4	13.4	13.2	0.0	0.0
2012	14.1	7.0	78.5	0.2	0.1
2013	33.3	11.6	54.9	0.2	0.0
2014	50.8	17.2	32.0	0.0	0.0
2015	73.6	12.9	13.5	0.0	0.0
2016	36.4	13.9	49.7	0.0	0.0
2017	37.5	14.4	48.1	0.0	0.0
2018	31.1	22.0	46.5	0.4	0.0
2019	23.1	10.0	66.7	0.2	0.0
2020	9.1	6.5	84.4	0.0	0.0
2021	14.4	9.2	75.8	0.6	0.0

Figure 13. Channel catfish length frequency from the 2021 Choptank River fyke net survey.

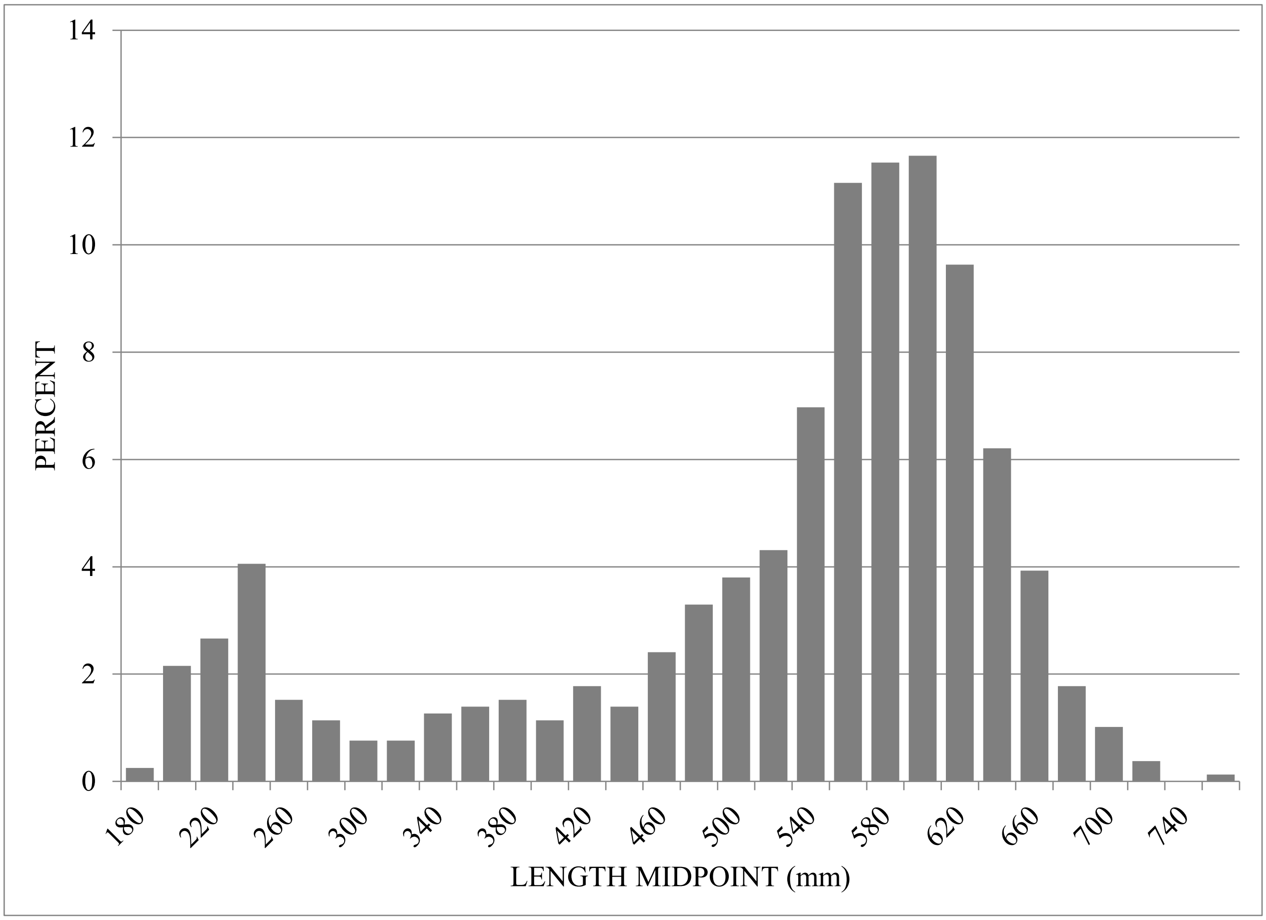


Table 16. Relative stock densities (RSD's) of channel catfish from Nanticoke River fyke and pound net survey, 1995 – 2021. 2007 -- 2009 include Marshyhope River fyke net data. Minimum length cut-offs in parentheses.

Year	**Stock** (255 mm)	**Quality** (460 mm)	**Preferred** (510 mm)	**Memorable** (710 mm)	**Trophy** (890 mm)
1995	72.3	19.4	8.2	0.0	0.0
1996	65.8	23.8	10.4	0.0	0.0
1997	62.2	27.5	10.2	0.0	0.0
1998	60.3	27.7	12.0	0.0	0.0
1999	80.6	14.6	4.7	0.0	0.0
2000	70.9	22.1	7.1	0.0	0.0
2001	70.2	22.9	6.9	0.0	0.0
2002	56.4	31.1	12.5	0.0	0.0
2003	52.3	29.2	18.4	0.0	0.0
2004	60.8	27.8	11.5	0.0	0.0
2005	48.8	30.6	20.6	0.0	0.0
2006	63.7	23.0	13.3	0.0	0.0
2007	67.4	22.8	9.8	0.0	0.0
2008	69.4	17.8	12.6	0.3	0.0
2009	66.5	18.4	15.1	0.0	0.0
2010	45.0	23.3	30.0	1.7	0.0
2011	74.1	13.0	13.0	0.0	0.0
2012	22.5	30.2	47.3	0.0	0.0
2013	32.5	27.3	49.2	0.0	0.0
2014	10.0	17.0	73.0	0.0	0.0
2015	NOT SAMPLED				
2016	15.2	13.3	70.5	0.9	0.0
2017	15.5	15.0	68.9	0.5	0.0
2018	11.3	10.6	77.3	0.7	0.0
2019	23.6	1.8	58.1	0.4	0.0
2020	NOT SAMPLED				
2021	23.8	21.1	54.8	0.2	0.0

Figure 14. Channel catfish length frequency from the 2021 Nanticoke River fyke and pound net survey.

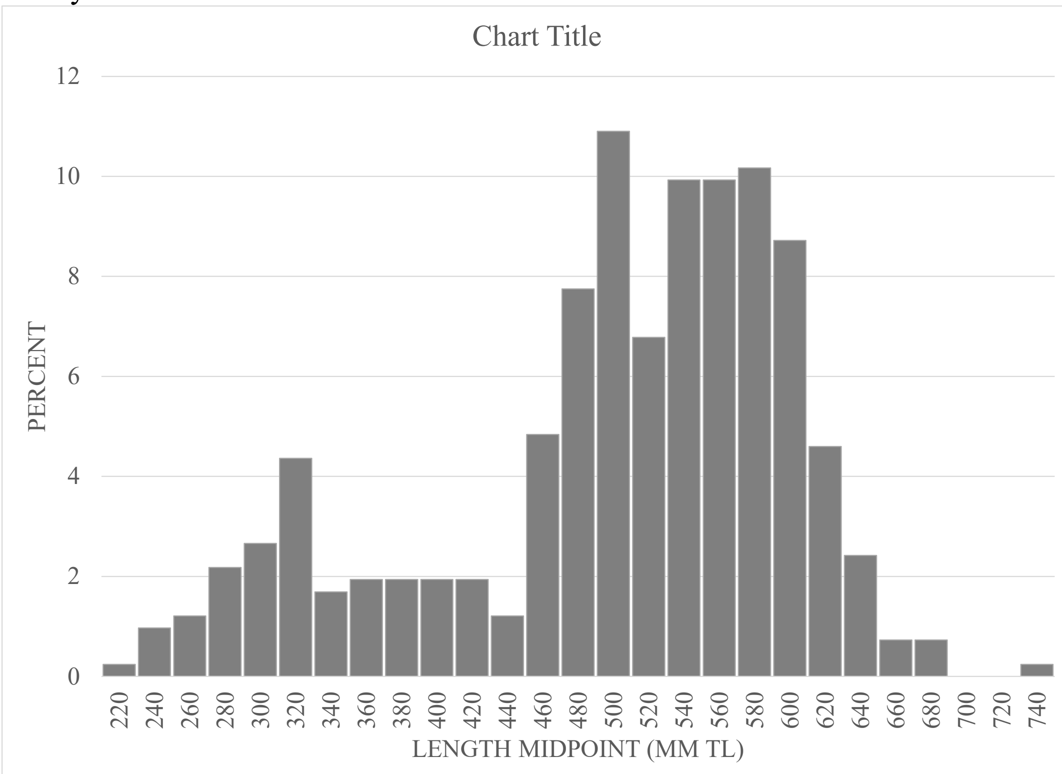


Table 17. Relative stock densities (RSD's) of white catfish from the upper Chesapeake Bay winter trawl survey, 2000 – 2021. Minimum length cut-offs in parentheses.

Year	Stock (165 mm)	Quality (255 mm)	Preferred (350 mm)	Memorable (405 mm)	Trophy (508 mm)
2000	NONE COLLECTED				
2001	41.9	54.8	3.2	0.0	0.0
2002	57.1	42.9	0.0	0.0	0.0
2003	85.0	15.0	0.0	0.0	0.0
2004	NOT SAMPLED				
2005	96.6	3.4	0.0	0.0	0.0
2006	90.0	10.0	0.0	0.0	0.0
2007	85.7	14.3	0.0	0.0	0.0
2008	85.7	14.3	0.0	0.0	0.0
2009	83.0	17.0	0.0	0.0	0.0
2010	87.0	10.9	2.2	0.0	0.0
2011	81.9	17.3	0.8	0.0	0.0
2012	70.2	26.9	3.0	0.0	0.0
2013	70.5	28.2	0.7	0.7	0.0
2014	77.1	20.0	2.9	0.0	0.0
2015	69.6	26.4	2.0	2.0	0.0
2016	59.1	34.1	3.8	3.0	0.0
2017	68.4	27.9	3.0	0.7	0.0
2018	53.1	31.6	11.2	4.1	0.0
2019	37.5	50.0	0.0	12.5	0.0
2020	53.4	24.2	17.3	5.1	0.0
2021	74.4	16.3	4.1	4.7	0.6

Figure 15. White catfish length frequency from the 2021 upper Chesapeake Bay winter trawl survey.

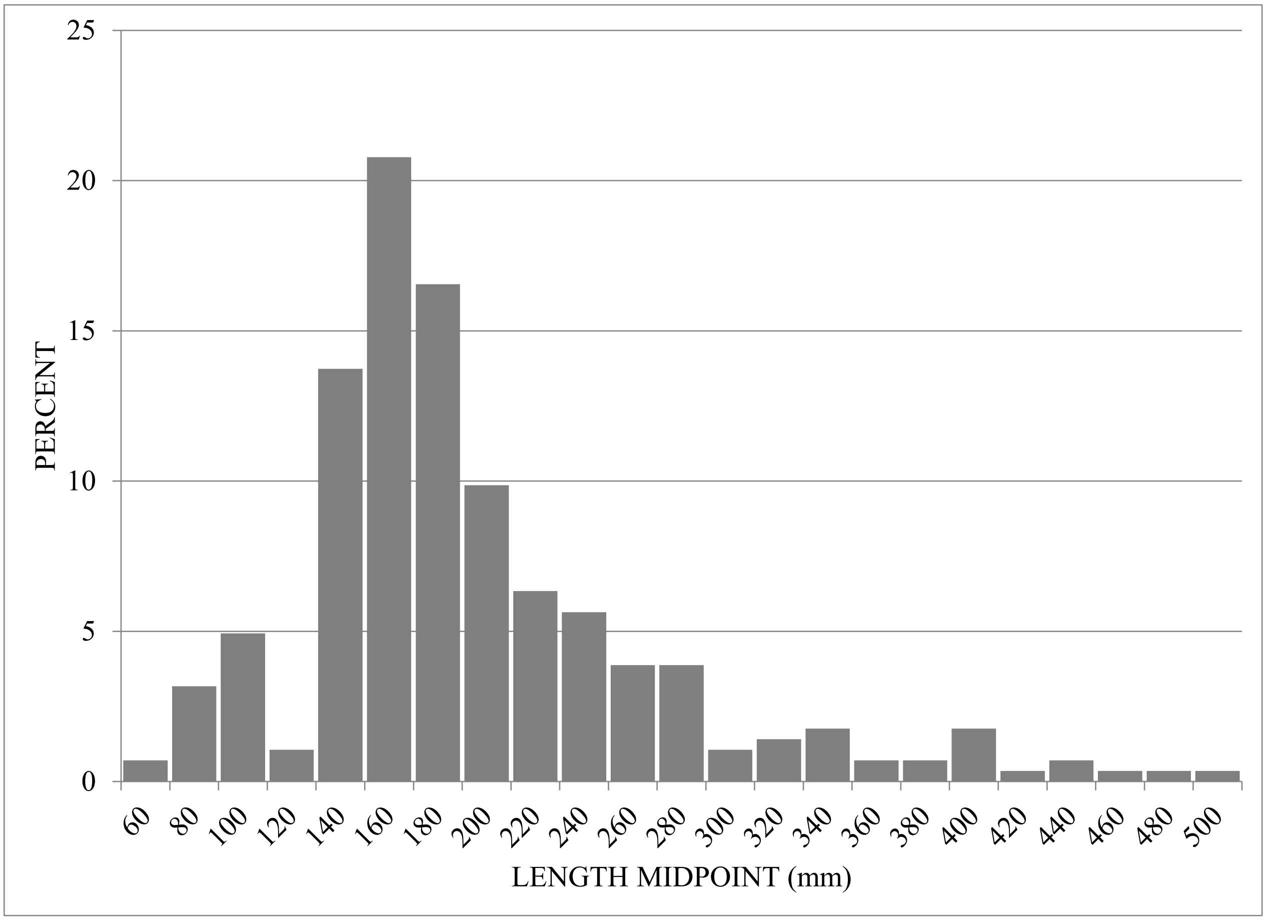


Table 18. Relative stock densities (RSD's) of white catfish from the Choptank River fyke net survey, 1993 – 2021. Minimum length cut-offs in parentheses.

Year	Stock (165 mm)	Quality (255 mm)	Preferred (350 mm)	Memorable (405 mm)	Trophy (508 mm)
1993	45.6	19.4	4.9	27.2	2.9
1994	42.2	28.9	10.2	18.8	0.0
1995	19.3	47.8	8.9	23.1	0.9
1996	45.6	22.1	6.1	24.4	1.5
1997	29.7	48.5	6.9	12.9	2.0
1998	42.6	44.1	2.9	10.3	0.5
1999	44.8	38.6	5.9	10.8	0.0
2000	50.6	29.2	7.6	12.4	0.3
2001	44.8	29.5	4.8	20.0	1.0
2002	7.8	38.9	15.4	35.5	2.4
2003	25.2	35.8	11.9	26.5	0.4
2004	15.2	54.8	20.9	9.5	0.0
2005	37.4	41.0	15.5	6.0	0.0
2006	29.1	45.4	13.3	12.0	0.2
2007	49.6	39.1	7.5	3.8	0.0
2008	26.1	44.4	13.8	15.5	0.3
2009	25.3	48.6	9.9	15.8	0.5
2010	19.6	52.5	11.3	16.2	0.4
2011	23.5	33.5	9.7	33.1	0.2
2012	12.5	50.6	13.3	22.9	0.8
2013	4.7	34.9	17.8	41.5	1.1
2014	11.0	35.9	15.3	35.6	2.2
2015	3.1	46.0	5.3	17.7	0.9
2016	23.5	32.2	14.8	28.2	1.2
2017	21.2	34.1	17.2	27.3	0.3
2018	25.3	44.3	12.3	17.6	0.5
2019	19.3	50.3	8.5	19.4	2.4
2020	22.4	52.0	7.8	17.8	0.0
2021	11.6	37.9	17.0	32.9	0.5

Figure 16. White catfish length frequency from the 2021 Choptank River fyke net survey.

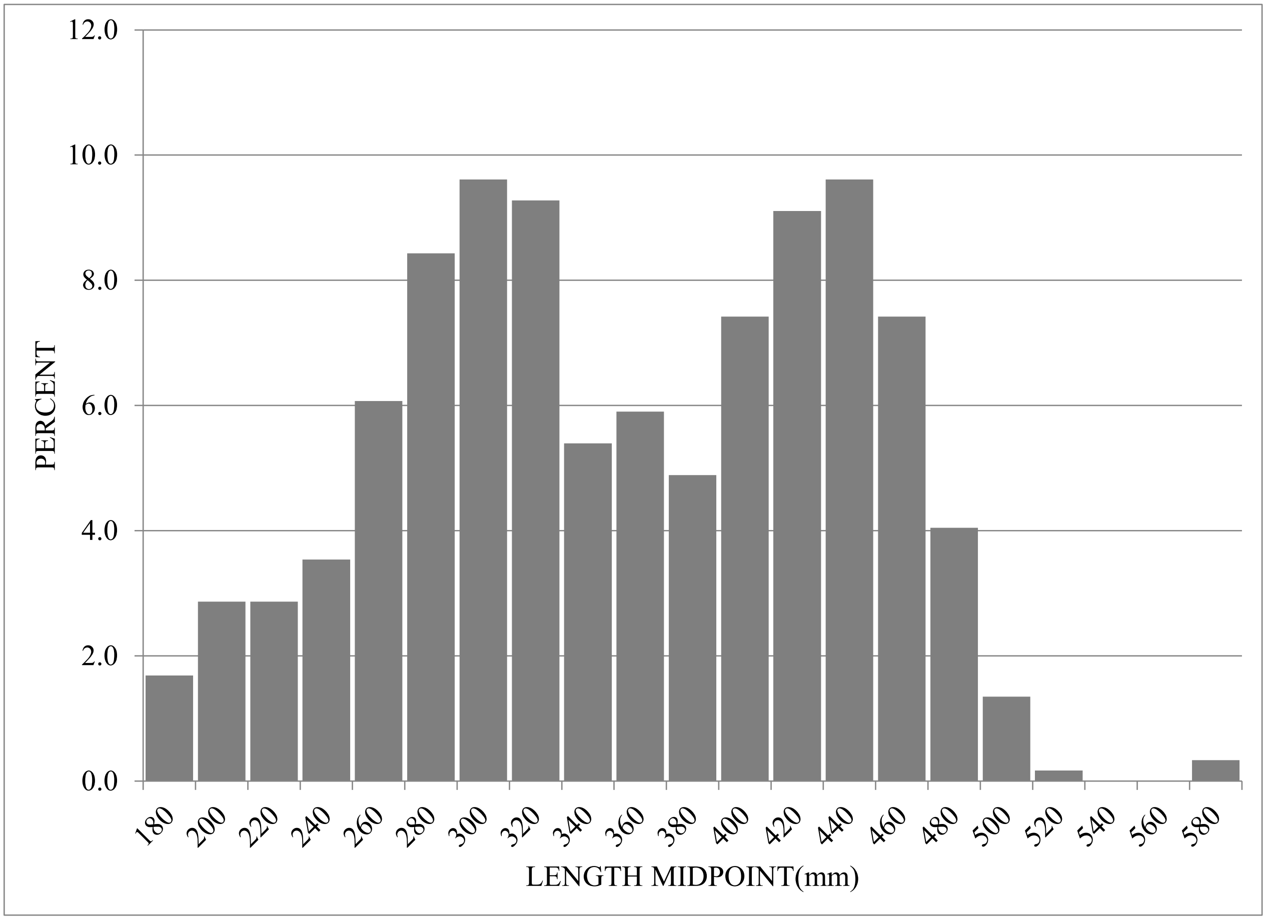


Table 19. Relative stock densities (RSD's) of white catfish from the Nanticoke River fyke and pound net survey, 1995 – 2021. 2007 -- 2009 include Marshyhope River fyke net data. Minimum length cut-offs in parentheses.

Year	**Stock** (165 mm)	**Quality** (255 mm)	**Preferred** (350 mm)	**Memorable** (405 mm)	**Trophy** (508 mm)
1995	35.7	32.8	14.3	16.6	0.6
1996	42.4	36.9	10.5	9.6	0.6
1997	42.1	37.4	10.9	8.2	1.4
1998	27.9	48.2	17.4	6.0	0.0
1999	41.0	34.5	14.4	10.1	0.0
2000	39.9	42.1	12.0	6.0	0.0
2001	46.2	28.2	16.0	9.0	0.6
2002	37.0	34.6	15.2	12.8	0.5
2003	17.6	32.4	23.5	25.0	1.5
2004	13.2	45.3	34.9	6.6	0.0
2005	47.0	30.3	13.6	9.1	0.0
2006	70.0	21.1	4.3	4.6	0.0
2007	40.0	37.3	14.7	8.0	0.0
2008	62.5	24.1	8.5	4.6	0.3
2009	55.8	21.8	10.5	10.5	1.4
2010	21.4	25.0	14.3	28.6	10.7
2011	43.7	43.7	5.7	5.7	6.9
2012	11.9	25.8	29.6	30.5	2.2
2013	25.4	23.9	16.4	29.4	5.0
2014	10.5	29.7	19.2	38.0	2.6
2015	NOT SAMPLED				
2016	39.2	17.7	17.9	24.3	1.0
2017	10.6	28.4	29.4	31.3	0.3
2018	3.4	16.8	20.8	57.0	0.5
2019	14.0	40.3	21.7	22.9	1.1
2020	NOT SAMPLED				
2021	8.8	23.7	24.6	42.4	0.6

Figure 17. White catfish length frequency from the 2021 Nanticoke River fyke and pound net survey.

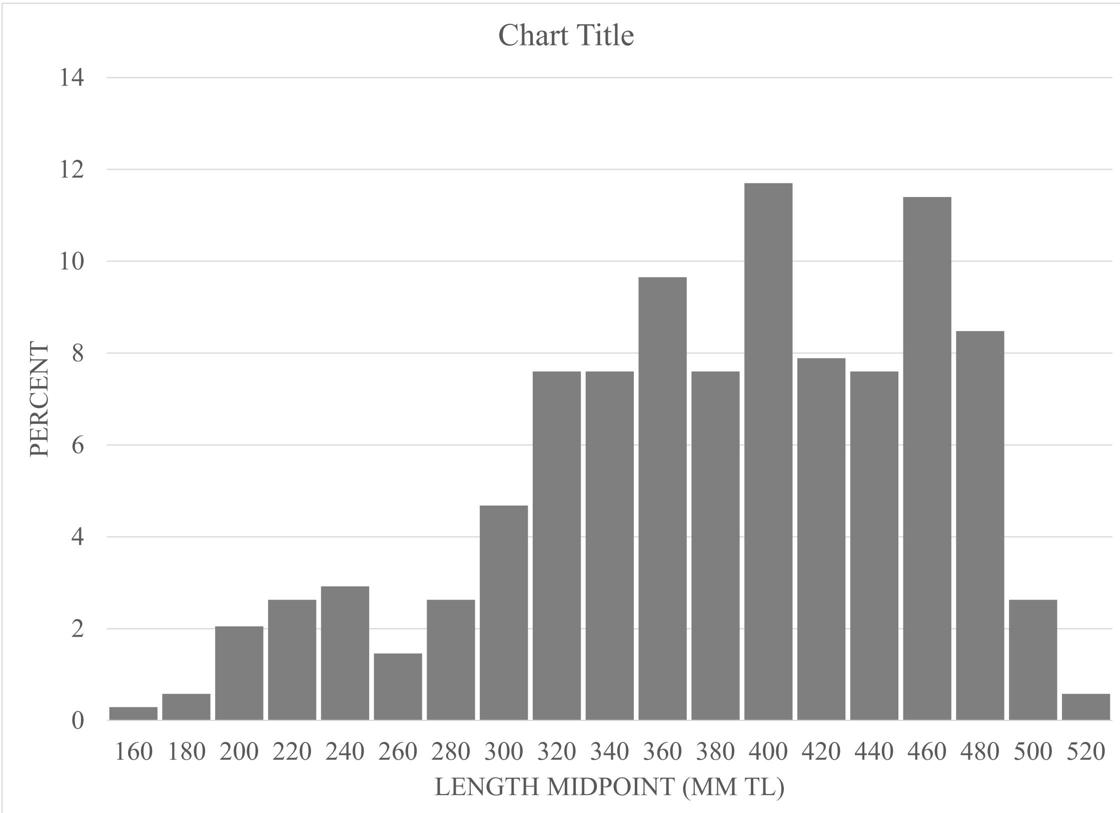


Table 20. White perch growth parameters from Choptank River for males, females, and sexes combined. NA=data not available NSF=no solution found or small sample size.

Sample Year	Sex	Allometry		von Bertalanffy		
		alpha	beta	L-inf	K	t_0
2013	F	8.9×10^{-6}	3.10	273	0.34	-0.39
	M	4.4×10^{-6}	3.21	228	0.42	-0.43
	Combined	3.8×10^{-6}	3.25	259	0.31	-0.82
2014	F	5.9×10^{-6}	3.18	278	0.33	-0.18
	M	1.2×10^{-6}	3.46	226	0.42	-0.16
	Combined	2.9×10^{-6}	3.30	259	0.35	-0.13
2015	F	2.3×10^{-6}	2.92	278	0.27	-0.57
	M	3.2×10^{-6}	3.23	228	0.29	-0.68
	Combined	1.3×10^{-5}	3.03	267	0.26	-0.78
2016	F	3.4×10^{-6}	3.29	334	0.19	-0.95
	M	7.9×10^{-7}	3.56	215	0.60	0.01
	Combined	3.2×10^{-6}	3.30	340	0.15	-1.80
2017	F	5.2×10^{-6}	3.21	338	0.16	-1.58
	M	2.4×10^{-6}	3.34	219	0.74	-0.16
	Combined	3.0×10^{-6}	3.31	310	0.15	-2.77
2018	F	1.6×10^{-5}	3.00	256	0.51	0.01
	M	1.5×10^{-6}	3.21	211	0.80	0.16
	Combined	7.8×10^{-6}	3.28	249	0.48	-0.11
2019	F					
	M	1.4×10^{-5}	3.02	284	0.26	-0.46
	Combined	1.7×10^{-4}	2.54	234	0.36	-0.25
		1.1×10^{-5}	3.06	280	0.24	-0.71
2020	F	1.6×10^{-5}	2.99	233	0.51	0.01
	M	2.4×10^{-5}	2.90	201	0.60	-0.12
	Combined	1.4×10^{-5}	3.01	229	0.46	-0.19
2021	F	1.2×10^{-6}	3.12	266	0.31	-0.84
	M	3.0×10^{-5}	2.85	224	0.49	-0.14
	Combined	7.4×10^{-6}	3.11	2.62	0.28	-1.14
2000 – 2021	F	4.6×10^{-6}	3.23	285	0.27	-0.50
	M	5.6×10^{-6}	3.18	226	0.38	-0.35
	Combined	3.2×10^{-6}	3.29	274	0.25	-0.74

Table 21. White perch growth parameters from Nanticoke River for males, females, and sexes combined. NA=data not available NSF=no solution found or small sample size

Sample Year	Sex	(allometry)		(von Bertalanffy)		
		alpha	beta	L-inf	K	t_0
2013	F	7.7 X 10^{-6}	3.14	307	0.28	-0.16
	M	1.7 X 10^{-5}	2.99	276	0.27	-0.35
	Combined	6.2 X 10^{-6}	3.18	295	.27	-0.29
2014	F	1.5 X 10^{-5}	2.60	311	0.25	-0.29
	M	6.5 X 10^{-5}	2.73	269	0.33	-0.09
	Combined	5.4 X 10^{-5}	2.77	295	0.27	-0.25
2015	F	NA	NA		NA	
	M	NA	NA		NA	
	Combined	NA	NA		NA	
2016	F	9.2 X 10^{-5}	2.70	302	0.33	0.25
	M	1.1 X 10^{-5}	3.07	288	0.27	-0.21
	Combined	2.9 X 10^{-5}	2.90	296	0.30	0.05
2017	F	5.2 X 10^{-6}	3.21	323	0.26	-0.25
	M	4.7 X 10^{-6}	3.21	308	0.21	-0.52
	Combined	3.1 X 10^{-6}	3.29	318	0.23	-0.49
2018	F	NSF		287	0.30	0.06
	M	1.4 X 10^{-5}	3.02	262	0.33	-0.13
	Combined	NSF		311	0.23	-0.56
2019	F	7.2 X 10^{-6}	3.14	284	0.38	-0.06
	M	2.2 X 10^{-5}	2.98	234	0.59	0.08
	Combined	7.0 X 10^{-6}	3.14	475	0.75	0.49
2020	F	NA	NA	NA	NA	NA
	M	NA	NA	NA	NA	NA
	Combined	NA	NA	NA	NA	NA
2021	F	9.7 X 10^{-6}	3.08	285	0.34	-0.23
	M	2.7 X 10^{-5}	2.88	233	0.76	0.20
	Combined	5.5 X 10^{-6}	3.18	273	0.36	-0.41
2000 - 2021	F	5.5 X 10^{-4}	2.37	300	0.27	-0.32
	M	1.7 X 10^{-5}	2.98	266	0.29	-0.38
	Combined	2.1 X 10^{-4}	2.54	293	0.25	-0.55

Table 22. Yellow perch growth parameters from Choptank River for males, females, and sexes combined. NA=data not available NSF=no solution found or small sample size. **Bold indicates unreliable estimates.**

Sample Year	Sex	allometry		von Bertalanffy		
		alpha	beta	L-inf	K	t_0
2013	F	9.2×10^{-6}	3.02	294	0.53	-0.02
	M	1.7×10^{-5}	2.92	**322**	**0.10**	**-6.10**
	Combined	1.5×10^{-5}	2.94	267	0.53	-0.23
2014	F	1.5×10^{-5}	2.94	308	0.39	0.12
	M	9.7×10^{-6}	3.03	276	0.30	-0.71
	Combined	1.5×10^{-5}	2.94	282	0.42	0.05
2015	F	1.7×10^{-5}	2.94	337	0.27	-0.41
	M	2.1×10^{-6}	3.32	234	0.52	-0.22
	Combined	9.6×10^{-6}	3.04	334	0.22	-0.98
2016	F	3.3×10^{-7}	3.66	300	0.34	-1.18
	M	3.6×10^{-6}	3.21	290	0.22	-1.85
	Combined	4.0×10^{-7}	3.62	269	0.45	-0.36
2017	F	2.1×10^{-4}	2.52	321	0.20	-1.90
	M	3.9×10^{-5}	2.79	282	0.18	-2.74
	Combined	3.8×10^{-5}	2.82	286	0.24	-1.59
2018	F	4.7×10^{-5}	2.75	318	0.35	-0.09
	M	4.0×10^{-6}	3.19	254	0.65	1.22
	Combined	2.1×10^{-5}	2.89	265	0.60	0.67
2019	F	2.6×10^{-5}	2.86	338	0.18	-2.82
	M	6.9×10^{-7}	3.52	267	0.34	-0.75
	Combined	9.5×10^{-6}	3.04	291	0.28	-1.43
2020	F	NSF		360	0.18	-2.22
	M	NSF		290	0.21	-1.85
	Combined	NSF		307	0.26	-1.27
2021	F	6.8×10^{-6}	3.09	290	.52	0.10
	M	3.5×10^{-6}	3.21	271	0.25	-1.46
	Combined	5.9×10^{-6}	3.11	258	0.48	-0.30
2000 –2021	F	8.6×10^{-5}	2.65	300	0.37	-0.45
	M	8.3×10^{-6}	3.06	271	0.26	-1.49
	Combined	2.8×10^{-5}	2.84	269	0.40	-0.61

Table 23. Yellow perch growth parameters from upper Chesapeake Bay fyke nets for males, females, and sexes combined. NA=data not available NSF=no solution found. **Bold indicates unreliable estimates.**

Sample Year	Sex	allometry		von Bertalanffy		
		alpha	beta	L-inf	K	t_0
2013	F	2.5×10^{-6}	3.31	**393**	**0.15**	**-2.02**
	M	1.5×10^{-5}	2.95	264	0.31	-0.39
	Combined	1.2×10^{-6}	3.44	294	0.29	-0.82
2014	F	9.0×10^{-6}	3.08	**410**	**0.10**	**-4.50**
	M	9.1×10^{-6}	3.05	250	0.45	-0.33
	Combined	4.8×10^{-6}	3.18	270	0.45	-0.25
2015	F	1.1×10^{-7}	3.89	**473**	**0.40**	**-12.80**
	M	1.7×10^{-5}	2.96	**246**	**1.52**	**0.33**
	Combined	7.5×10^{-7}	3.54	**248**	**1.45**	**0.31**
2016	F	1.4×10^{-6}	3.41	273	0.75	0.67
	M	$1.4 \text{ x } 10^{-6}$	3.40	247	0.61	-0.04
	Combined	$9.2 \text{ x } 10^{-7}$	3.48	263	0.59	0.04
2017	F	2.6×10^{-6}	3.28	298	0.56	0.63
	M	3.3×10^{-6}	3.23	253	0.46	-0.16
	Combined	1.1×10^{-6}	3.45	270	0.55	0.19
2018	F	2.5 X 10-6	3.31	347	0.28	-0.35
	M	1.4 X 10-6	3.40	238	0.47	-0.33
	Combined	1.3 X 10-6	3.42	349	0.23	-0.69
2019	F	1.2×10^{-6}	3.45	314	0.37	-0.27
	M	6.6×10^{-7}	3.54	242	0.55	-0.19
	Combined	5.7×10^{-7}	3.57	273	0.47	-.019
2020	F	3.5×10^{-6}	3.23	351	0.26	-0.71
	M	2.3×10^{-6}	3.30	249	0.44	-1.38
	Combined	1.8×10^{-6}	3.35	330	0.22	-1.61
2021	F	8.8 X 10-7	3.50	309	0.42	-0.03
	M	5.0 X 10-6	3.16	276	0.29	-0.73
	Combined	5.5 X 10-7	3.58	277	0.46	-0.09
1998 – 2021	F	4.2×10^{-6}	3.22	302	0.37	-0.37
	M	3.3×10^{-6}	3.24	242	0.53	-0.24
	Combined	1.9×10^{-6}	3.35	268	0.50	-0.17

Table 24. Estimated instantaneous fishing mortality rates (F) for white perch. NR= not reliable; NA=not available; MIN= minimal, at or near M estimate.

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Choptank[1]	0.57	0.31	0.31	0.23	0.42	0.32	0.40	0.77	0.52	0.65
Nanticoke	0.20	0.29	0.41	NA	0.49	0.41	0.43	0.47	NA	0.20
Upper Bay[1]	0.56	0.94	0.25	0.21	0.26	0.24	0.47	0.74	0.71	0.68

[1]Estimated F from stock assessment for 2011 – 2019 (Piavis and Webb 2021). 2020-2021 estimated from length converted catch curves.

Table 25. Estimated instantaneous fishing mortality rates (F) for yellow perch. NR= not reliable; MIN=minimal, at or near M estimate.

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Choptank	0.05	0.01	0.41	NR	0.32	MIN	MIN	0.38	0.27	0.02
Upper Bay[1]	0.52	0.35	0.25	0.24	0.97	0.99	0.33	0.46	0.32	0.21

[1]Fully recruited F from annual update of Piavis and Webb (2020).

Figure 18. Baywide young-of-year relative abundance index for white perch, 1962 – 2021, based on EJFS data. Bold horizontal line=time series average. Error bars indicate 95% CI's.

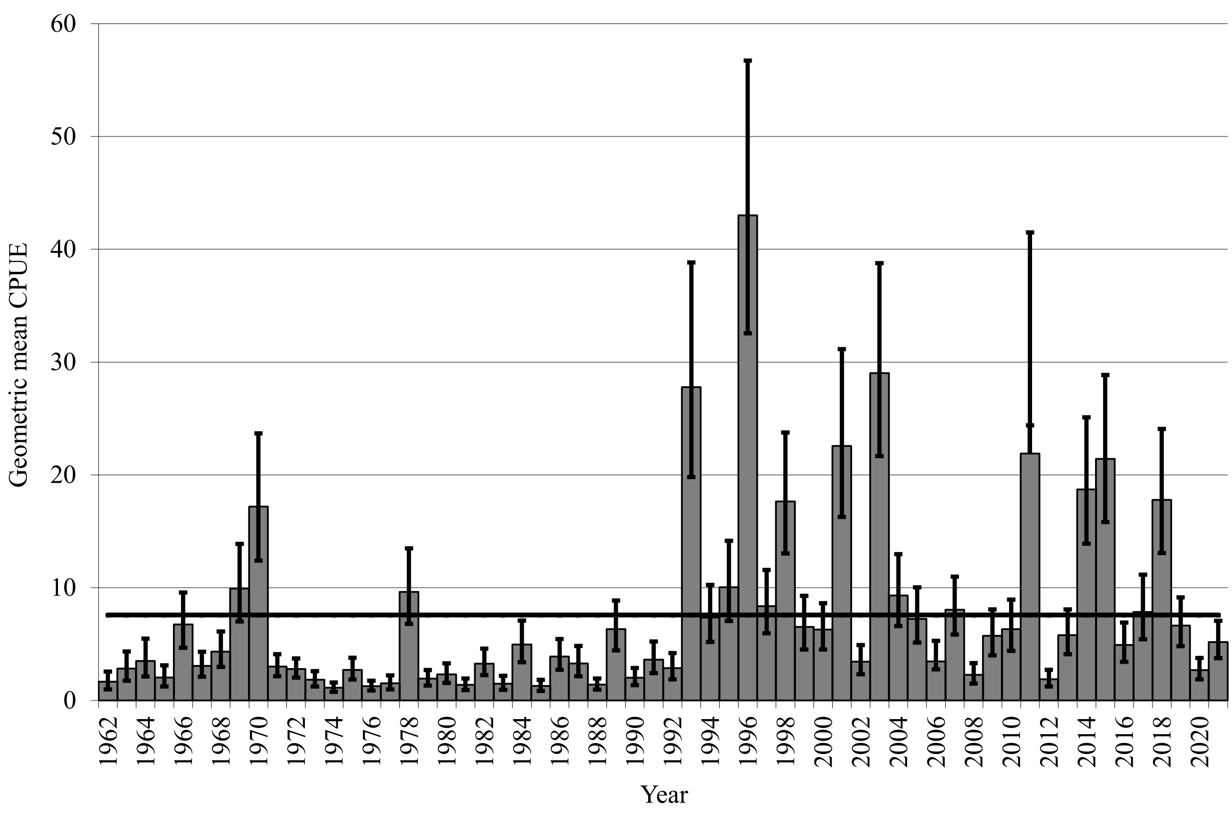


Figure 19. Age 1 white perch relative abundance from upper Chesapeake Bay winter trawl survey. Not sampled in 2004, small sample sizes 2003 and 2005. Error bars=95% CI.

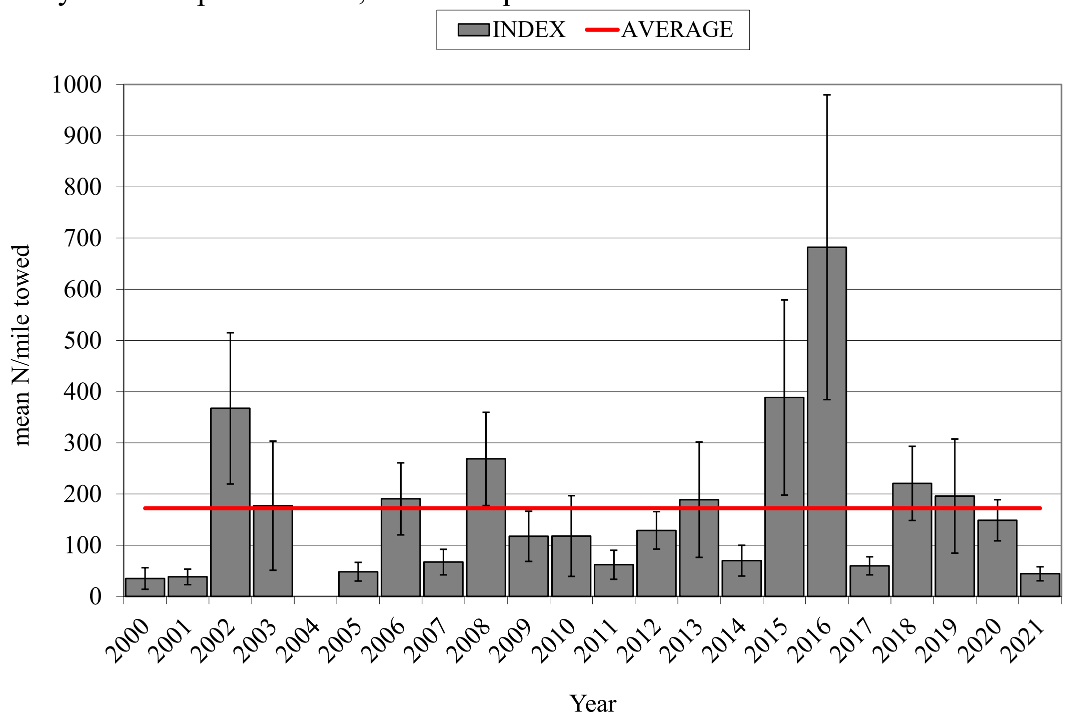


Figure 20. Head-of-Bay young-of-year relative abundance index for yellow perch, 1979 – 2021, based on Estuarine Juvenile Finfish Survey data. Horizontal line=time series average. Error bars indicate 95% confidence interval.

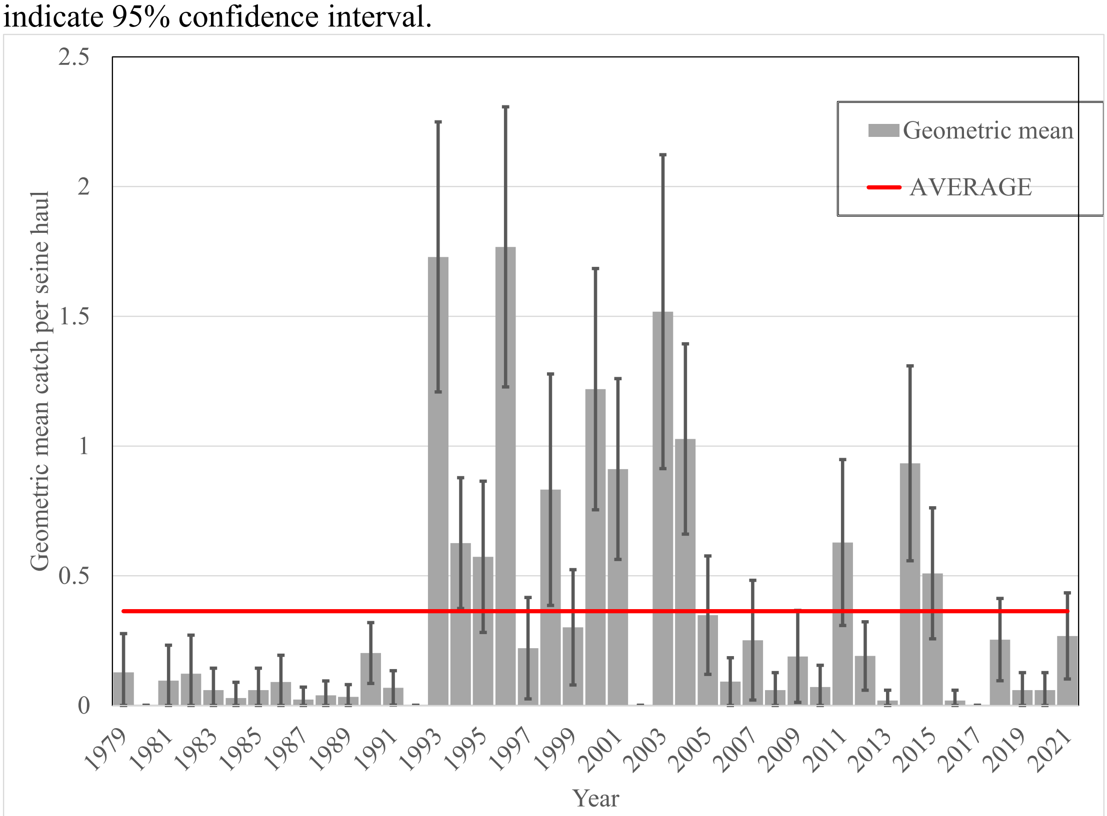


Figure 21. Age 1 yellow perch relative abundance from upper Chesapeake Bay winter trawl survey. Not sampled in 2004, small sample sizes 2003 and 2005. Error bars=95% CI.

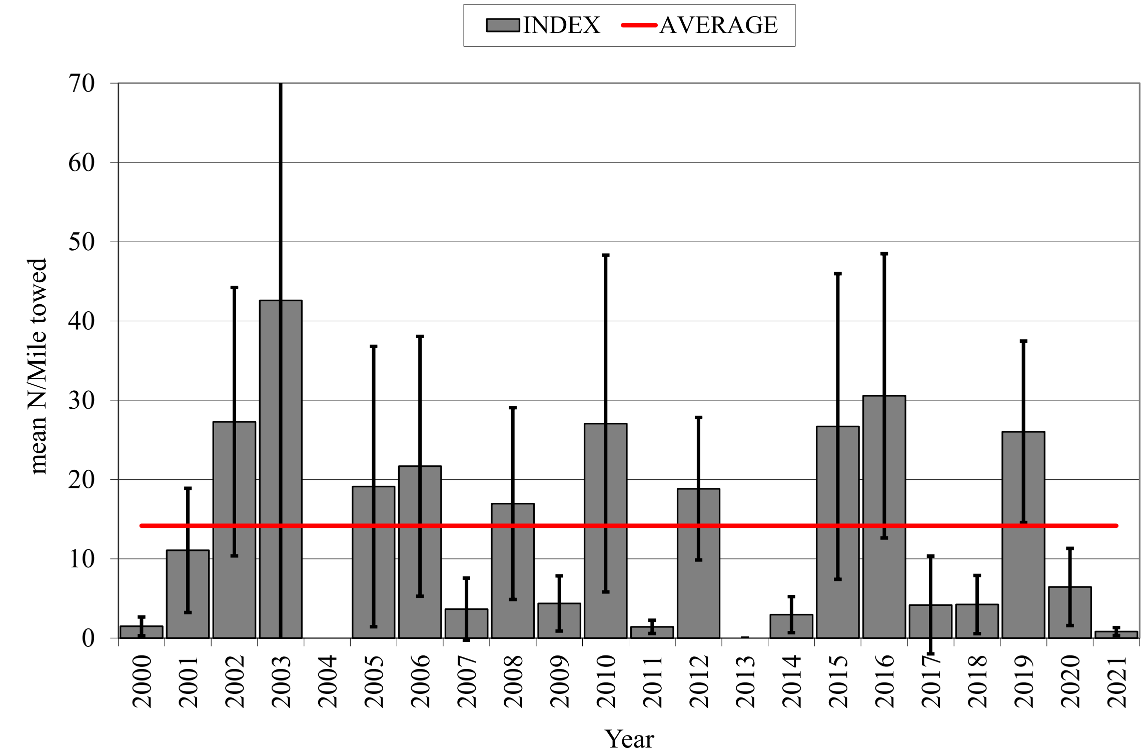


Figure 22. Age 1 channel catfish relative abundance from upper Chesapeake Bay winter trawl survey. Not sampled in 2004, small sample sizes 2003 and 2005.

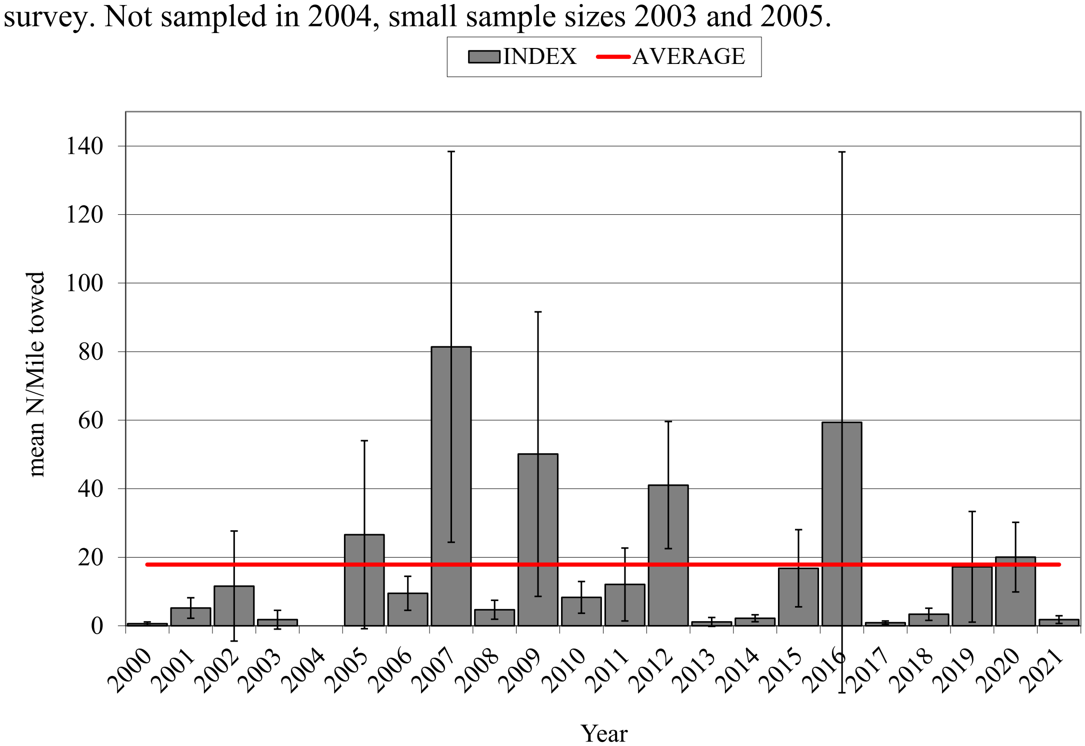


Table 26. White perch relative abundance (N/MILE TOWED) and number of tows from the upper Chesapeake Bay winter trawl survey, 2000 – 2021. Chester River sites included starting 2011.

YEAR	AGE											
	1	2	3	4	5	6	7	8	9	10+	Sum CPE	No. Tows
2000	34.9	227.3	102.2	65.9	24.8	15.0	20.7	2.4	2.3	1.6	497.0	79
2001	38.1	78.9	123.2	23.5	37.4	7.9	19.4	20.6	4.7	2.9	356.6	115
2002	367.4	2.9	71.1	28.8	44.5	19.0	36.8	20.5	5.3	12.3	608.6	110
2003	177.3	343.6	71.5	33.7	45.8	55.9	180.7	4.4	0.0	26.6	939.5	20
2004	NOT SAMPLED											
2005	46.1	78.1	22.7	41.1	10.5	3.7	1.2	11.7	1.4	0.6	217.0	43
2006	190.6	63.2	153.2	47.2	35.7	10.2	6.3	6.1	1.5	2.7	516.6	108
2007	67.0	44.3	31.8	61.6	34.9	8.4	9.2	0.8	0.6	3.0	261.7	71
2008	268.7	44.7	113.3	84.5	25.7	8.8	3.5	3.8	1.4	1.4	555.9	108
2009	117.3	486.9	13.7	59.4	112.1	95.2	2.3	33.4	7.2	1.4	928.9	90
2010	177.9	130.4	163.4	5.6	96.7	41.7	68.9	5.8	9.5	13.9	714.0	56
2011	61.8	73.2	52.0	69.8	16.9	38.5	21.1	21.5	1.2	4.0	360.0	78
2012	128.9	44.5	21.1	10.3	10.7	11.6	20.9	9.4	12.5	3.7	273.7	143
2013	188.8	237.4	29.8	66.5	61.8	288.6	37.2	44.8	10.8	27.7	993.3	116
2014	69.8	43.1	411.1	67.4	44.2	21.1	41.4	13.2	7.4	9.1	727.9	72
2015	388.5	264.8	312.9	572.4	125.0	63.9	67.2	80.3	45.0	47.6	1,967.7	108
2016	682.1	457.0	451.7	222.8	236.1	86.4	34.2	9.2	23.2	35.4	2,238.0	112
2017	59.6	614.4	246.2	69.1	24.8	164.5	11.4	23.3	9.6	27.3	1,250.0	137
2018	220.6	139.7	711.8	461.2	23.5	65.8	137.5	18.4	15.2	2.0	1,795.8	129
2019	196.1	79.0	47.5	117.7	60.2	11.4	16.7	27.1	11.1	3.8	570.7	62
2020	148.6	253.5	39.9	111.5	87.9	46.6	13.8	14.1	16.9	7.7	740.6	134
2021	44.1	325.4	400.4	96.5	51.9	47.4	18.6	2.9	6.4	9.5	1,003.1	138

Table 27. White perch relative abundance (N/net day) and total effort from the Choptank River fyke net survey, 2000 – 2021.

YEAR	AGE											
	1	2	3	4	5	6	7	8	9	10+	Sum CPE	Total effort
2000	0.0	0.0	5.1	32.0	31.2	5.5	20.0	1.9	1.3	0.0	97.0	310
2001	0.0	7.0	16.0	47.9	35.8	26.2	4.2	11.0	1.5	0.0	149.6	310
2002	0.0	2.1	7.8	28.5	16.4	18.4	3.5	6.2	2.7	0.1	85.5	306
2003	0.0	2.2	36.8	33.6	33.3	1.4	27.7	7.2	3.2	3.2	148.5	261
2004	0.0	0.4	36.3	12.3	14.1	17.2	1.3	9.6	3.4	2.2	96.8	251
2005	0.0	3.4	16.0	51.2	32.1	19.9	7.2	1.7	10.8	0.5	142.7	235
2006	0.0	1.7	71.5	3.5	34.6	17.2	1.9	2.2	1.3	17.0	150.8	236
2007	0.0	1.3	9.5	123.8	13.4	57.8	20.7	8.2	9.0	7.2	250.8	203
2008	0.0	0.4	22.8	17.7	54.2	4.6	18.5	10.5	1.9	4.2	134.8	248
2009	0.0	1.8	0.7	24.9	6.8	45.2	5.5	8.5	4.9	3.1	101.3	210
2010	0.0	1.7	32.6	5.1	84.3	29.6	90.5	11.2	15.1	8.0	195.5	223
2011	0.0	0.1	1.0	22.0	3.5	21.0	12.9	15.8	2.3	4.2	82.7	242
2012	0.0	0.1	5.4	2.7	11.0	4.8	6.4	2.6	4.6	1.4	62.0	220
2013	0.0	9.3	9.0	13.6	1.9	5.5	1.3	8.9	2.4	5.9	57.8	299
2014	0.0	1.5	46.4	4.1	3.2	4.4	6.3	4.1	8.3	6.1	84.4	273
2015	0.0	0.0	0.0	107.7	7.8	17.4	7.8	2.7	1.4	6.7	151.5	213
2016	0.0	6.5	4.7	<0.1	38.1	3.9	2.1	0.6	0.4	0.6	56.9	303
2017	0.0	17.8	27.2	4.3	0.0	54.1	2.3	0.2	0.0	1.1	101.5	213
2018	0.0	0.5	47.6	14.8	0.9	1.7	28.2	0.5	0.6	<0.1	99.4	306
2019	0.0	0.3	1.1	20.6	11.6	0.6	1.4	7.3	0.2	0.1	43.2	282
2020	0.0	2.0	3.4	0.9	16.3	7.2	0.5	0.6	7.0	0.0	38.0	168
2021	0.0	2.4	15.7	2.9	1.1	13.4	2.6	1.2	0.9	3.2	41.9	242

Table 28. Yellow perch relative abundance (N/MILE TOWED) and number of tows from the upper Chesapeake Bay winter trawl survey, 2000 – 2021.

YEAR	AGE											
	1	2	3	4	5	6	7	8	9	10+	Sum CPE	No. Trawls
2000	1.0	1.5	0.2	1.6	0.1	0.3	0.1	0.0	0.0	0.1	4.8	79
2001	9.6	0.6	1.0	0.2	0.6	<0.1	0.0	<0.1	0.0	0.0	12.0	115
2002	24.8	17.2	1.7	3.6	0.3	1.8	0.0	0.2	0.1	0.0	49.7	110
2003	38.3	135.7	422.1	46.3	61.6	4.0	24.8	0.0	2.0	0.0	735.0	20
2004	NOT SAMPLED											
2005	19.1	13.4	<0.1	3.1	0.4	<0.1	<0.1	0.0	<0.1	0.0	36.0	43
2006	21.7	36.5	15.8	0.0	3.3	0.4	0.0	0.4	0.0	0.0	78.1	108
2007	3.6	3.3	8.4	2.4	1.5	0.6	0.1	<0.1	0.0	0.0	19.9	71
2008	17.0	4.1	9.1	8.0	2.1	0.0	0.0	0.0	0.0	0.0	40.2	108
2009	4.4	21.2	1.1	2.4	2.1	0.5	<0.1	0.0	0.0	0.0	31.7	90
2010	27.1	3.3	8.5	0.6	0.9	0.4	0.2	0.0	0.1	0.0	41.1	56
2011	1.4	4.6	0.7	2.9	0.0	0.4	0.1	0.0	0.0	0.0	10.1	66
2012	18.8	6.8	2.2	0.1	0.1	0.1	0.0	0.7	0.0	0.0	29.0	107
2013	4.5	9.6	2.8	1.2	<0.1	<0.1	<0.1	0.0	<0.1	0.0	18.2	86
2014	0.4	0.0	15.5	6.8	0.8	0.0	0.1	0.1	0.1	0.0	23.7	60
2015	26.7	1.1	0.0	16.1	1.8	0.4	0.0	0.0	0.0	0.0	46.1	86
2016	30.6	44.8	6.1	0.3	4.3	0.6	0.2	0.0	0.0	0.0	87.0	83
2017	4.2	24.8	8.2	0.0	0.0	1.2	0.1	0.0	0.0	0.0	38.4	101
2018	4.2	1.7	12.6	3.6	0.0	0.0	0.1	0.0	0.0	0.0	22.2	99
2019	26.0	1.0	0.7	3.2	0.5	0.0	0.0	0.0	0.0	0.0	31.4	63
2020	6.4	9.6	0.1	0.0	0.3	0.1	<0.1	0.0	0.0	0.0	16.5	105
2021	0.8	9.2	9.9	0.0	0.1	0.4	0.1	0.0	0.0	0.0	20.5	102

Table 29. Yellow perch relative abundance (N/net day) and total effort from the Choptank River fyke net survey, 1988 – 2021.

YEAR	AGE										Sum	Total
	1	2	3	4	5	6	7	8	9	10+	CPE	effort
1988	0.0	0.2	4.5	0.2	0.0	0.4	0.3	0.0	0.0	0.1	5.7	59
1989	0.0	0.0	1.2	3.4	1.2	0.6	0.1	0.0	0.0	0.0	6.6	68
1990	0.0	0.3	2.6	1.2	4.0	0.8	0.1	0.1	0.1	0.0	9.3	68
1991	0.0	0.1	0.6	0.8	0.3	0.6	0.1	0.0	0.0	0.0	2.5	70
1992	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.5	113
1993	0.0	0.0	0.6	1.3	0.8	0.9	0.3	0.1	0.0	0.0	4.0	120
1994	0.0	0.4	1.4	0.2	0.7	0.8	0.7	0.6	0.0	0.2	4.9	114
1995	0.0	0.7	2.1	0.2	0.6	0.6	0.3	0.3	0.0	0.2	5.0	121
1996	0.0	6.1	2.5	1.9	0.3	0.6	0.3	0.2	0.3	0.1	12.2	140
1997	0.0	0.1	4.2	0.6	0.6	0.0	0.1	0.2	0.1	0.0	5.8	153
1998	0.0	0.9	0.5	3.8	0.2	0.2	0.0	0.1	0.0	0.1	5.8	154
1999	0.0	1.7	47.8	0.5	17.7	0.2	0.1	0.0	0.0	0.0	68.0	178
2000	0.0	2.0	0.6	8.4	0.2	0.9	0.0	0.0	0.0	0.0	12.0	164
2001	0.0	5.3	11.9	0.6	6.8	0.1	0.4	0.0	0.0	0.0	25.1	167
2002	0.0	1.9	7.5	6.6	0.2	2.4	0.6	0.3	0.0	0.0	19.5	178
2003	0.0	3.1	3.6	7.6	2.8	0.3	1.9	0.3	0.3	0.0	19.8	121
2004	0.0	0.4	3.2	1.1	0.8	0.7	0.0	0.4	0.0	0.0	6.6	156
2005	0.0	9.0	0.7	2.2	0.7	0.3	0.8	0.1	0.3	0.1	14.2	186
2006	0.0	1.1	11.8	1.1	2.5	0.4	0.4	0.3	0.0	0.0	17.6	158
2007	0.0	10.8	5.3	11.1	0.2	1.3	0.8	0.2	0.1	0.1	29.9	140
2008	0.0	0.2	7.8	0.8	2.0	0.1	0.3	0.1	0.0	0.0	11.3	166
2009	0.0	0.0	6.1	14.8	1.0	0.9	0.2	0.0	0.0	0.0	23.0	143
2010	0.0	0.4	0.8	7.9	18.3	0.4	1.2	0.0	0.1	0.0	26.3	144
2011	0.0	1.2	0.0	0.2	4.6	5.6	0.3	0.7	0.0	0.0	12.6	158
2012	0.4	2.3	9.8	0.2	0.0	2.3	5.2	<0.1	0.1	0.0	20.5	111
2013	0.0	0.7	0.6	1.9	<0.1	<0.1	0.3	0.5	0.0	<0.1	3.5	249
2014	0.0	0.0	8.6	4.9	2.2	<0.1	0.0	<0.1	0.2	<0.1	16.0	190
2015	0.0	1.4	0.2	17.2	2.9	1.3	<0.1	<0.1	<0.1	<0.1	23.2	147
2016	0.0	2.3	0.8	0.4	22.5	3.1	2.1	0.3	0.2	0.1	29.9	174
2017	0.0	0.9	2.3	0.8	<0.1	5.9	1.3	0.6	0.0	0.1	12.1	162
2018	0.0	0.2	9.9	2.8	0.3	0.1	3.1	0.5	0.3	0.0	17.1	204
2019	0.0	0.2	0.5	4.7	0.9	<0.1	<0.1	0.6	<0.1	0.1	7.0	195
2020	0.0	1.4	0.9	0.4	9.8	1.0	0.0	<0.1	0.4	0.1	14.1	144
2021	0.0	0.2	2.6	0.8	0.2	3.8	0.3	0.0	0.0	0.1	7.9	175

Figure 23. Choptank River yellow perch relative abundance from fyke nets, 1988 – 2021. Effort standardized from 1 March – 95% total catch date.

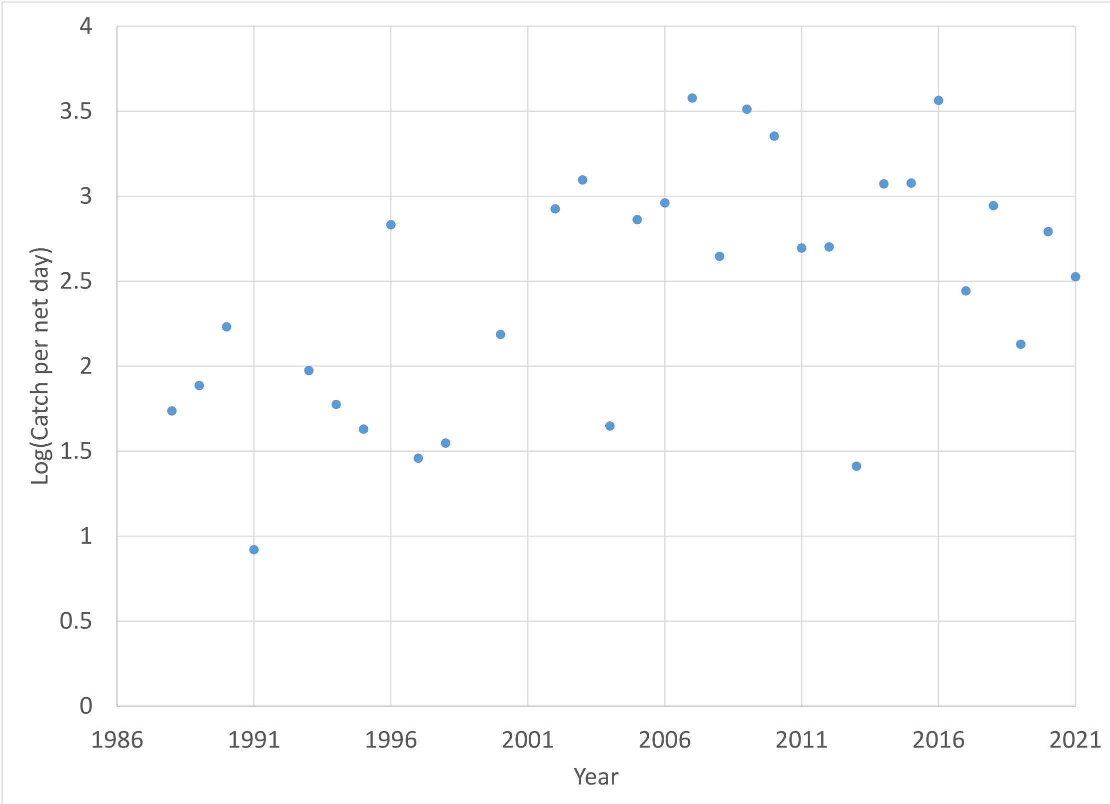


Figure 24. Channel catfish relative abundance (N/mile towed) from the upper Chesapeake Bay winter trawl survey, 2000-2021. Not surveyed in 2004, small sample sizes in 2003 and 2005.

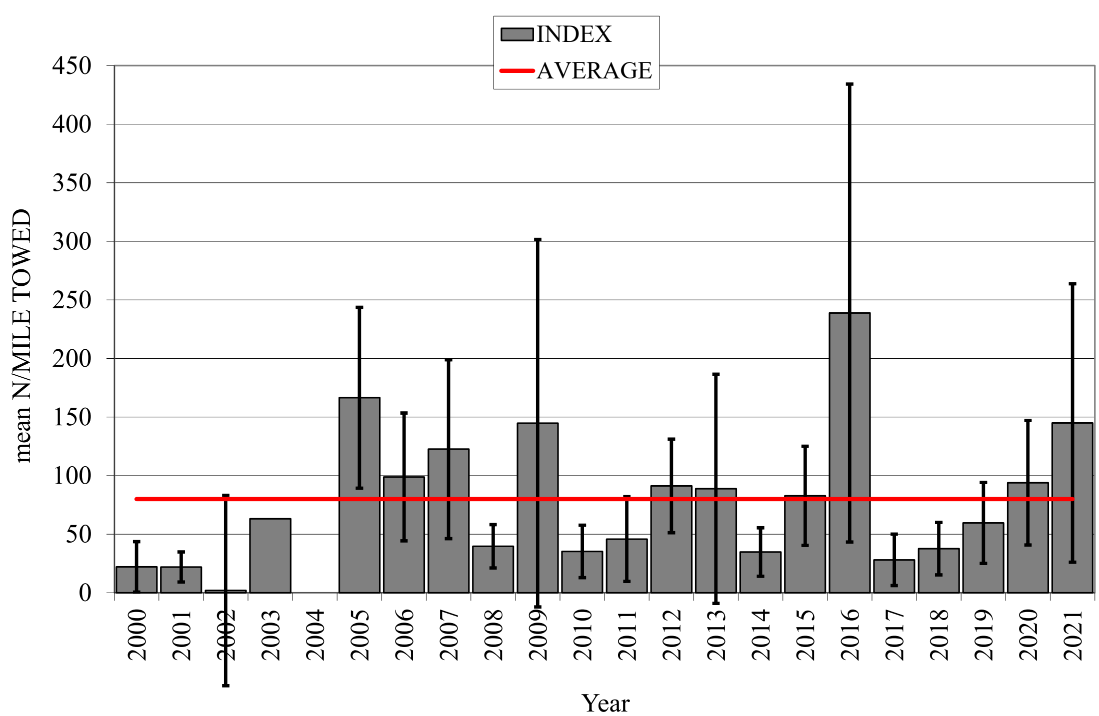


Figure 25. Channel catfish relative abundance (N/net day) from the Choptank River fyke net survey, 2000 – 2021. Horizontal line indicates time series average relative abundance.

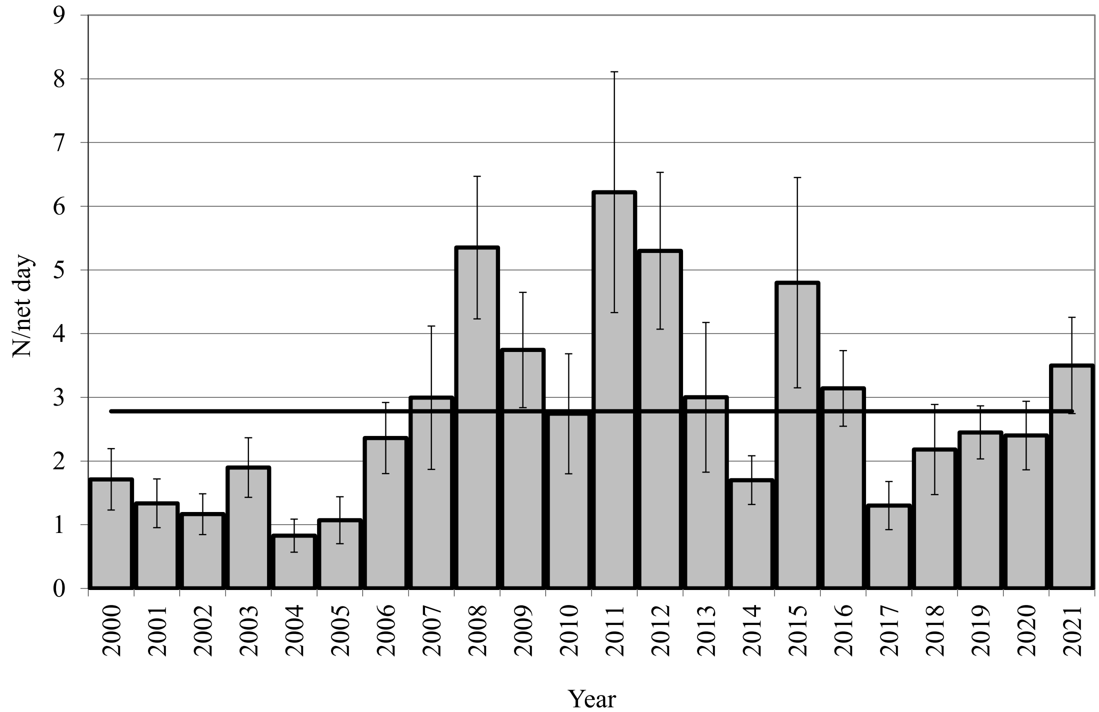
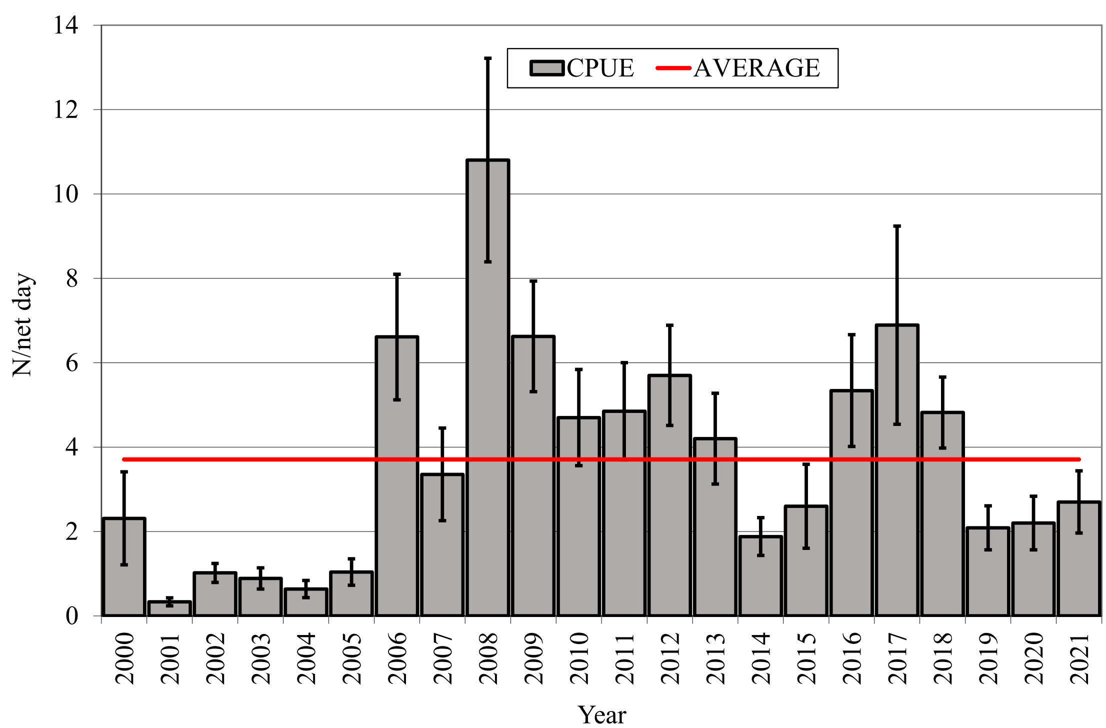


Figure 26. White catfish relative abundance (N/net day) from the Choptank River fyke net survey, 2000 – 2021. Horizontal line indicates time series average relative abundance.



PROJECT NO. 1
JOB NO. 2

POPULATION ASSESSMENT OF CHANNEL CATFISH IN SELECT TIDAL AREAS OF MARYLAND'S CHESAPEAKE BAY

Prepared by Paul G. Piavis and Edward Webb, III

INTRODUCTION

The objective of Job 2 was to assess channel catfish (*Ictalurus punctatus*) stock size, describe trends in recruitment and relate current and historical mortality estimates to various biological reference points. Channel catfish were introduced into Maryland waters as early as the late 1800's. Since those introductions, channel catfish have become self-sustaining, expanded their range, and are considered a naturalized species (Sauls et al 1998).

Channel catfish inhabit fresh or brackish waters in Chesapeake Bay and its tributaries. Currently, recreational and commercial channel catfish fisheries are unregulated in tidal waters in Maryland (no minimum size limit, creel limit or seasonal closures). The Potomac River Fisheries Commission (PRFC) manages channel catfish in the Potomac River mainstem. The minimum size limit in the Potomac River is 203 mm (8 inches; TL) for commercial and recreational fisheries with no closed season or catch limits.

Channel catfish are important to recreational and commercial fishers throughout Maryland's portion of Chesapeake Bay. The Marine Recreational Information Program (MRIP) produces estimates of recreational catch with fair precision (National Oceanic and Atmospheric Administration, personal communication, August 23, 2022). Estimated channel catfish recreational harvest (MRIP) averaged 1.1 million pounds during 1982 –

2021; for the five year period, 2017 – 2021, average recreational catfish harvest was 1.5 million pounds (36% above the long term average).

Maryland's baywide commercial channel catfish harvest peaked in 2014 at 2.43 million pounds, slightly above the previous peak in 1996 (2.41 million pounds). Baywide landings averaged 1.3 million pounds, 2017 – 2021. Areas above the Chesapeake Bay bridges accounted for 95% of the total Maryland channel catfish commercial harvest in 2021.

Channel catfish populations were last assessed in 2018 (Piavis and Webb 2019). This Job is an update of the 2018 assessment. The 2018 assessment described population dynamics in two systems, the Head-of-Bay (HOB; areas north of the Preston Lane Memorial Bridges) with a surplus production model, and the Choptank River with a Catch Survey Analysis (CSA) model. This assessment modelled population dynamics of both systems with a CSA model. Indices of relative abundance (fishery dependent and fishery independent, when available) were utilized to illustrate trends in population abundance in areas other than HOB and the Choptank River.

METHODS

Bay-wide Landings

Maryland commercial fishery landings were available from the 1920's, but fishers were only required to report catch as general catfish landings (mixed species, predominately bullheads (*Ameiurus spp.*), channel catfish, and white catfish (*A. catus*)) until 1996. Beginning in 1996, commercial fishers were required to report catfish landings as general, channel catfish, or white catfish. Beginning in 2012, the general catfish category was omitted and commercial harvesters recorded catch to species, including blue catfish (*I. furcatus*) and flathead catfish (*Pylodictis olivaris*). The amount of channel catfish reported in the general category for the years 1996 – 2011 was calculated by determining the proportion of channel catfish in the combined white and channel catfish landings. This proportion was then multiplied by the amount of general catfish landed. The estimated annual landings of channel catfish in the general category were then added to the declared channel catfish landings for an estimated total commercial removal. To determine commercial channel catfish landing prior to 1996, the general catfish landings were multiplied by the average proportion of channel catfish of the total declared catfish landings by species for the years 1996 – 2011. Bullheads were considered an insignificant portion of landings prior to 1996.

Recreational landings, as estimated by the MRIP, were fairly precise, but several years contained estimates where the proportional standard error (PSE) was > 40%. A regression of estimated recreational harvests with PSE's < 0.40 versus commercial landings was highly significant (R^2 =0.88 $P<0.001$). Therefore, estimated harvest from years with PSE < 40% were compared to commercial landings to determine the average proportion of recreational landings to commercial landings. The average proportion was then applied to annual commercial harvest of years when PSE's of the recreational estimate exceeded 40%.

Catch Survey Analysis

Model Description

Catch Survey Analysis (CSA) is a two stage population assessment model that requires relatively modest input data (Collie and Sissenwine 1983). Most assessments that utilize CSA are length based so the time and cost burdens of aging fishery dependent and independent samples are negated. Data requirements are indices of pre-recruit and post-recruit abundance, total removals from the population, assumed natural mortality (M) and a scalar relating pre-recruit selectivity to post-recruit selectivity.

The CSA relates pre-recruit relative abundance to post-recruit relative abundance in numbers in the following year, such that:

$$R_{t+1} = (R_t + P_t)\, e^{-M t} - C_t\, e^{-M t (1-T t)} \qquad [4]$$

where R_t is the post-recruit abundance at the start of year t, P_t is the pre-recruit abundance at the start of year t, M is instantaneous natural mortality, C_t is harvest in year t (in numbers), and T is the fraction of time between the survey and the harvest.

The model assumes survey catch r and p for post-recruits and pre-recruits, respectively, relate to absolute abundance by a survey catchability (q) such that:

$$r_t = R_t\, q \quad [5]$$

and,

$$p_t = P_t\, q\, \Phi \quad [6]$$

where Φ is a scalar relating the pre-recruit selectivity to post-recruit selectivity,

$$\Phi = s_p/s_r \qquad [7]$$

and s_p and s_r are pre-recruit and post-recruit selectivity coefficients from the fishery independent survey, respectively. Note that the absolute selectivity values are not required, rather the relative value is utilized in the model.

Substituting [5] and [6] into equation [4] yields

$$r_{t+1} = (r_t + p_t / \Phi) e^{-M} - q C_t e^{-Mt(1 - Tt)} \qquad [8]$$

This assessment reparameterized the model (Mensil 2003). Instead of solving for expected survey indices, this model searches and solves for actual pre-recruit abundance (P) and the first year's post-recruit abundance (R_1). Subsequent post-recruit abundance is determined from equation [4].

Expected pre- and post-recruit indices were derived from the geometric mean catchability (q_{avg}) where

$$q_{avg} = e^{(1/n) * \sum (\log_e (n_t/N_t)} \qquad [9]$$

It follows that the expected pre-recruit and post-recruit indices were

$$p_{exp,\, t} = P_t/(q_{avg} * \Phi) \qquad [10]$$

$$r_{exp,\, t} = R_t/q_{avg} \qquad [11].$$

The objective function then becomes the minimization of the sums of squared errors between the observed and expected pre- and post-recruit indices:

$$SSQ = W_p * \sum (\log_e (p_{obs,\, t}) - (\log_e (p_{exp,\, t}))^2 + W_r * \sum (\log_e (r_{obs,\, t}) - (\log_e (r_{exp,\, t}))^2 \ [12]$$

where W_p and W_r are weighting factors for pre-recruit and post-recruit indices, respectively.

Fishing mortality (F) is not analytically estimated within the model. Rather, harvest rate (*h*) is estimated from total removals (C) and abundance estimates (P and R). Harvest rate *h* was estimated as

$$h_t = C_t / ((P_t + R_t) * e^{-Mt*Tt}) \quad [13]$$

Total instantaneous fishing mortality (F) can then be determined from

$$F_t = -\log_e (1-h_t). \quad [14]$$

The model was compiled in a Microsoft Excel spreadsheet and the Solver routine was used to fit the model.

Inputs

The CSA model requires an estimate of M, Φ (a scalar relating pre-recruit selectivity to post recruit selectivity), survey indices of pre-recruit (p_t) and post-recruit (r_t) abundance, and total removals (C_t). The HOB model included indices of abundance derived from the upper Bay winter trawl survey (Figure 1; See Job 1 of this report for methods). The pre-recruit abundance was determined as the average number of channel catfish between 305 mm TL and 405 mm TL captured per statute mile. The post-recruit index was the average number of channel catfish greater than 405 mm TL captured per statute mile.

Channel catfish indices of abundance for the Choptank River were derived from the fishery independent fyke net survey (Figure 2; See Job 1 of this report for methods). Pre-recruits were those channel catfish less than 405 mm TL and greater than 305 mm TL. Post-recruit channel catfish were those fish greater than 404 mm TL. Natural mortality was set at a constant M = 0.2 for both analyses. The scalar Φ was 1.0 for the Choptank River model based on length frequency diagrams. However, Φ was set at 1.5 for the HOB assessment because larger sized channel catfish may avoid the trawl. Time of removals (T) was set at mid-year (0.5) for both models.

Harvest estimates (in numbers) were determined for the commercial and recreational fisheries. Numbers of commercially harvested channel catfish were determined by dividing pounds harvested (by gear type) by estimated average weight of legal channel catfish. Average weight of HOB legal channel catfish was determined from channel catfish greater than 405 mm TL captured in the winter trawl survey. Average weight of Choptank River legal channel catfish was determined from channel catfish > 405 mm TL captured in the Choptank River fyke net survey. Both HOB and Choptank River average weights were based on annual estimates. Each channel catfish length was assigned a weight based on a length weight equation (Fewless 1980):

$$\log_{10}(W) = 3.09684 \times \log_{10}(L) - 2.1622$$

Total numbers of harvested channel catfish were landings/average weight.

Recreational channel catfish harvest from HOB was estimated from the MRIP survey (National Marine Fisheries Service, personal communication, September 2022). A SAS program to determine regional harvest estimates was supplied by MRIP and was coded to provide estimates based on access sites and effort for HOB counties. The same program was attempted within the Choptank River watershed, but proportional standard errors were too large to provide reliable estimates. Therefore, we determined the proportion of Choptank River commercial landings to total baywide commercial landings, which averaged 10%. Choptank River recreational catch was then estimated as 10% of the MRIP baywide harvest estimate. Negligible release losses were assumed for all fisheries.

Uncertainty

The model was bootstrapped 5,000 times by resampling residuals and adding them to the natural logarithm of the expected index values, then re-exponentiating the values. Mean, median, coefficient of variation (CV) and bias were calculated for *q* and each estimate of P_t and R_t, exclusive of the terminal year for the pre-recruit value. Confidence intervals (80%) were determined from cumulative percent distributions of the bootstrapped parameter estimates.

Other Areas

Previous attempts to fit population models to other areas have failed, largely due to lack of fishery independent surveys (Piavis and Webb 2013). Qualitative methods to describe population trends in the Nanticoke, Pocomoke, Patuxent, and Potomac rivers were employed.

Landings

Channel catfish landings were determined from MD DNR commercial landings database for the Nanticoke, Pocomoke and Patuxent rivers. Adjustments due to changes in the species reporting requirements were identical to the bay-wide landings discussed above. The Potomac River Fisheries Commission (PRFC) provided commercial landings from the Potomac River (Potomac River Fisheries Commission, personal communication, November 17, 2022). Catfish landings were identified to species from 2003 – 2021. From 1985 – 2002, catfish were coded as mixed (white catfish and channel catfish) and bullhead species. Channel catfish landings for the period 1985 – 2002 were estimated as mixed catfish landings × proportion of channel catfish of total catfish landings during the nearest 5 year period, 2003 – 2007 (0.85). From 1964 – 1984, catfish landings were reported as mixed bullhead and catfish species. Channel catfish landings for the period 1964 – 1984 were estimated as catfish landings × proportion of channel catfish of total landings during the period 1985 – 2002. Potomac River mainstem landings (PRFC data) were added to MD DNR's landings from the Potomac River tributaries to get a total Potomac River landings history.

Fishery Dependent Relative Abundance Indices

Area specific relative abundance indices were determined from the MD DNR Fisheries Service commercial landings database. Effort data for these gear types were available from 1980 – 1984, 1990, and 1992 – 2017. An index of effort was constructed to standardize landings because commercial catch reporting was completed monthly and not on a per trip basis. The index was nominal fishing effort, or simply the total number of nets declared by fishers in any month. Only fishers that reported catfish harvest > 500 pounds were used for relative abundance estimates. This eliminated fishers that were not targeting channel catfish. The final annual index was total pounds harvested divided by total nominal effort.

Gear specific indices were constructed for the fyke net, pound net and fish pot fisheries. In some cases, a combined fyke net and fish pot index was utilized.

Fishery Independent Relative Abundance Indices

A gill net survey designed to estimate spawning stock biomass of striped bass in Potomac River (SBSSS) was utilized to describe population trends (Figure 3). Data were selected from net sets in April and May, only, and from mesh sizes equal to or less than seven inches stretched mesh.

RESULTS

Landings

Baywide commercial landings generally varied between 400,000 pounds and 700,000 pounds from 1929 through the mid-1970’s (Figure 4). Landings increased rapidly from 1976 through 1996 to 2.4 million pounds. Since 1996, landings decreased to a recent low in 2007, and then increased to over 2.4 million pounds in 2012 and 2014. Since 2014, baywide commercial landings decreased linearly to 1.3 million pounds in 2020. The 2020 harvest level compares favorably to the time series median (0.6 million pounds). Baywide recreational landings estimates varied greatly over the period 1983 – 2008 (Figure 5). Recreational landings increased from 2008 through 2014, before declining drastically through 2016. Since 2016, landings increased through 2020 with an estimated 2.0 million pounds harvested recreationally.

Head-of-Bay Catch Survey Analysis

Total channel catfish removals from the Head of Bay, in numbers, were estimated for the assessment time period 2005 – 2020. Commercial and recreational harvest increased for a large portion of the time series, from 116,000 channel catfish in 2005 to 744,000 channel catfish in 2017. Channel catfish removals then decreased from 2017 through 2020 to 587,000. Annual removals during 2005 – 2020 averaged 490,000 channel catfish (Figure 6).

The model included two indices from the MD DNR Fisheries Service fishery independent winter trawl survey. One index was a pre-recruit relative abundance index and the other was a post-recruit relative abundance index. The observed pre-recruit index exhibited an increasing bias from 2005 through 2016. The 2016 relative abundance index was more than five times greater than the 2005 value (Figure 7). The observed pre-recruit index declined through 2021. The observed post-recruit index was quite variable, but the fitted values indicated an increasing trend in relative abundance through 2020. Predicted relative abundance values were greater than the time series average in every year since 2008 (Figure 8).

The CSA model fit the population data moderately well. Catchability of the survey (q) was estimated as 3.3×10^{-6}. Pre-recruit population abundance generally tracked the increase in the survey's relative abundance values, with relatively low pre-recruit abundance during 2005 – 2012, followed by relatively high pre-recruit abundance through 2019 (Figure 9). Pre-recruit abundance increased from 0.2 million channel catfish during 2005 – 2011, then plateaued in a range of 0.6 -- 0.9 million channel catfish through 2015. Abundance peaked at 1.1 million pre-recruits in 2016 and trended lower through 2020 at 0.6 million pre-recruits. Post-recruit channel catfish abundance varied between 200,000 and 347,000 channel catfish from 2005 – 2009 (Figure 10). After 2009, recruited channel catfish abundance accelerated quite swiftly with the recruited population increasing from an estimated 347,000 fish in 2009 to 1.1 million fish in 2020. Total population abundance (pre-recruit and post-recruit combined) increased fairly consistently from 0.5 million channel catfish in 2005 to 2.0 million channel catfish in 2019. Terminal abundance estimate (2021) was 1.6 million channel catfish (Figure 11). Over the time-series, total population averaged 1.3 million channel catfish.

Instantaneous fishing mortality (F) increased from 0.2 (2005) to 1.18 (2012; Figure 12). Average F for the entire time series was 0.59 and F in the final year of the assessment was 0.50. No F-based, biomass-based or abundance-based biological reference points have been adopted for Chesapeake Bay area channel catfish stocks. Therefore, no conclusions may be definitively drawn regarding overfishing or overfished status for HOB channel catfish stocks.

Bootstrapping provided estimates of uncertainty for this model (5,000 trials; Table 1). Survey catchability (*q*) was precisely estimated (CV=16.5%). Coefficients of variation for pre-recruit abundance estimates ranged from 28.4 % – 46.4%, and averaged 37%. Coefficients of variation for post-recruit abundance ranged from 33.5% – 50.4% and averaged 40.3%. Confidence intervals (80%) were produced for pre-recruit abundance (Figure 9), post-recruit abundance (Figure 10), total abundance (Figure 11) and F (Figure 12).

Choptank River Catch-Survey Analysis (CSA)

Total channel catfish removals from the Choptank River, in numbers, were estimated for the assessment time period 1993 – 2020. Commercial and recreational harvest was generally low during 1993 – 2001, ranging from 12,600 – 80,400 fish. Harvest increased substantially after 2001, and peaked in 2011 at 138,500 fish. Harvest decreased to 46,100 fish by 2020. Annual removals during 1993 – 2020 averaged 68,200 channel catfish (Figure 13).

The model included two indices from a MD DNR Fisheries Service fishery independent fyke net survey. One index was a pre-recruit relative abundance index and the other was a post-recruit relative abundance index. The pre-recruit index remained generally flat from 1993 – 2006. The pre-recruit index increased after 2006, more than doubling the previous high relative abundance value by 2008. The observed index varied throughout the rest of the time-series, but had a decreasing bias through 2020 (Figure 14). The post-recruit index had a similar pattern, but the higher relative abundance of the recruited fish did not begin until 2008. Relative abundance values were greater than the time-series average in eight of the final ten years (Figure 15).

The CSA model fit the population data very well. Catchability of the survey (q) was estimated as 4.5×10^{-6}. Pre-recruit population abundance generally tracked the increase in the survey's relative abundance values, with relatively low pre-recruit abundance during 1995 – 2004, followed by relatively high pre-recruit abundance through 2011 (Figure 16). Since 2011, pre-recruit abundance trended lower except for 2015. Pre-recruit abundance averaged 150,400 channel catfish throughout the time-series, but was below average since 2016. The 2015 pre-recruit abundance estimate was the highest in the time-series at > 600,000 fish. The time-series low was 33,900 in 2017.

Post-recruit channel catfish abundance varied between 90,000 and 325,000 channel catfish from 1993 – 2008 (Figure 17). After 2008, recruited channel catfish abundance accelerated quite swiftly with the recruited population increasing to the time-series high of 749,000 fish in 2016. Post-recruit abundance declined to 276,000 fish by 2021. Abundance averaged 313,100 channel catfish, 1993 – 2021. Estimates were above average from 2008 – 2020, but 12% below average in 2021.

Total population abundance (pre-recruit and post-recruit combined) varied between 173,700 – 468,500 channel catfish during 1993 – 2007. Total abundance rose to 987,600 channel catfish by 2015 and declined to 322,900 by 2021. Over the time-series, total population averaged 460,000 channel catfish. Total abundance was above average in 8 of the final 10 years, but was below average in 2020 and 2021 due largely to poor pre-recruit abundance (Figure 18).

Instantaneous fishing mortality (F) was generally low, varying between 0.07 and 0.25 for most of the assessment period (Figure 19). Average F for the entire time series was 0.21 and F in the final year of the assessment was 0.14. No F-based, biomass-based or abundance-based biological reference points have been adopted for Chesapeake Bay area channel catfish stocks. Therefore, no conclusions may be definitively drawn regarding overfishing or overfished status for Choptank River channel catfish stocks.

Bootstrapping provided estimates of uncertainty for this model (5,000 trials; Table 2). Survey catchability (*q*) was precisely estimated (CV=14%). Coefficients of variation for pre-recruit abundance estimates ranged from 0.4 % – 61.2%, but the majority were below 10%. Coefficients of variation for post-recruit abundance were more variable than the pre-recruit abundances. Coefficients of variation ranged from 3 % – 81.5 %, but the large majority were between 10% and 15%. Confidence intervals (80%) were produced for pre-recruit abundance (Figure 16), post-recruit abundance (Figure 17), total abundance (Figure 18) and F (Figure 19).

Other Areas

Channel catfish harvest and fishery dependent relative abundance estimates were hampered by some degree due to CoVID shutdowns and market conditions. Nanticoke River channel catfish data included commercial fishery landings and a fishery dependent relative abundance index. Commercial landings from 1987 – 2011 were variable ranging from just under 20,000 pounds to 145,000 pounds (Figure 20). Since 2011, landings increased to a time-series high in 2014 of more than 180,000 pounds before declining through 2019 to nearly 90,000 pounds. Harvest in 2020 was less than 10,000 pounds, but that was likely influenced by CoVID dynamics and worker shortages. Commercial fishery CPUE's generated from the fish pot fishery were quite variable and exhibited no discernable trend other than a notable increase in relative abundance from 2010 through 2014 (Figure 21). Relative abundance was above the 75th percentile in four of the five years since 2014, excluding 2020.

Prior to the 2015 assessment, Pocomoke River channel catfish had not been investigated due to low or no commercial landings, and therefore, perceived lower availability to recreational fishermen (Piavis and Webb 2016). This is demonstrated by the fact that prior to 2003 commercial landings were intermittent, at best. From 2003 – 2010, landings were less than 30,000 pounds annually. Landings increased dramatically to over 150,000 pounds from 2011 – 2015 (Figure 22). Landings reverted back to lower harvest levels in 2016 through 2020. Since landings were non-existent in 2019 and only 3,100 pounds in 2020, any fishery dependent CPUE data would be considered non-informative and are not reported.

Patuxent River channel catfish data included commercial fishery landings and a fishery dependent relative abundance. Patuxent River channel catfish landings were generally stable around median landings, 1999 -- 2008 (Figure 23). Landings decreased to very low levels since 2015. During that time period, blue catfish landings increased to nearly 100,000 pounds which far exceeded channel catfish landings. Both the fyke net and fish pot fisheries were examined for a suitable relative abundance index. Relative abundance values were at or above the 75th percentile during 1998 – 2008 (Figure 24).

Relative abundance declined rapidly in 2015 and has remained very low. In contrast, blue catfish relative abundance increased during 2013 – 2016. Since 2016, blue catfish CPUE declined for the fyke/pot fishery, but that may be due to increased haul seine and recently legalized trot line harvest.

Potomac River channel catfish landings, as reported to the Potomac River Fishery Commission (PRFC), had to be adjusted for differences in reporting requirements similar to landings from the MD DNR commercial database. Estimated combined Maryland and PRFC landings of channel catfish from Potomac River and tributaries indicated a protracted decline in landings from 1987 through 2020. Landings have been below 150,000 pounds since 2003 except for a peak above 150,000 pounds in 2018 (Figure 25). Blue catfish harvest grew to over 2.7 million pounds in 2018 and was above 2.5 million pounds each year since 2016. No fishery dependent relative abundance indices could be calculated. After 2003, catches became sparse and/or intermittent for various gears. The fishery independent Potomac River drift gill net survey indicated that the biomass index was below the 75th percentile since 2010 and was at or below median relative abundance in each of the last nine years (Figure 26). No channel catfish were encountered in 2019 or 2020. Blue catfish in the gill net survey first appeared in 1995. Blue catfish relative abundance increased greatly as channel catfish relative abundance declined.

DISCUSSION

Channel catfish provide valuable recreational and commercial fisheries while occupying an important ecological niche among brackish-tidal fresh ecosystems in Maryland's portion of the Chesapeake Bay. Recreational and commercial fishermen, combined, harvested an estimated 3.3 million pounds of channel catfish in tidal waters of Maryland in 2020. The primary objective of this Job was to describe trends in channel catfish abundance throughout the Bay region. Model runs proved informative for HOB and Choptank River channel catfish populations. Using commercial landings as a proxy of channel catfish availability to recreational anglers, the assessment areas accounted for 86% of the total channel catfish population in Maryland's tidal waters (HOB = 85%; Choptank River = 1%). In contrast to previous years, HOB and Choptank River accounted for 91% and 59% of the total in 2017 and 2014, respectively (Piavis and Webb 2019, 2016).

The HOB CSA model provided a moderate fit and the general population trends were similar to previous assessments (Piavis and Webb 2013; Piavis and Webb 2016; Piavis and Webb 2019). The previous assessments included data back to 1980, but over the similar time periods, populations increased from 2005 to 2010 followed by a slight decline through 2015. The most recent years had channel catfish HOB population levels declining from highs in 2019, but still at high levels. Total abundance estimates for 2020 were 32% and 27% higher than median and average abundance, respectively. No biomass or abundance biological reference points were determined for channel catfish, but it is highly unlikely that the stock is overfished since abundance exceeded median and average levels. The winter trawl, in addition to providing the indices of abundance for pre-recruit channel catfish (generally ages 3 and 4 year old) also provides an age 1 index (see Project 1 Job 1, Figure 22 of this report). Age 1 channel catfish production was at or above average in 2019 and 2020. The near average production should maintain populations for the near term, resulting in similar availability to recreational anglers.

Instantaneous fishing mortality was moderate to high from 2006 through 2012, but was relatively low from 2018 through 2020. No biological reference points have been established to formally determine overfishing status. However, the time series of F rates, combined with previous assessments can allow for a broad evaluation of the fishery and the channel catfish population. Age data collected in the mid 1990's from Choptank River channel catfish were analyzed and a critical F threshold was determined as F=0.6 (Uphoff et al. 2007). This value is similar to channel catfish threshold F's simulated for the upper Mississippi River channel catfish population where a threshold F reference point was F=0.54 (Slipke et al. 2002). Our model estimated a range of F from 0.32 to 0.55 during the final five years of the assessment. If critical threshold F is approximately 0.6, then stocks are likely not experiencing overfishing. Bootstrap estimation of F indicated that there was only a 16% chance that F exceeded 0.6 in 2018 and 2019, and a 35% chance that F exceeded 0.6 in 2020.

Catch Survey Analysis does not analytically estimate fishing mortality. Instead of searching for an F estimate that produces the best fit, CSA models deterministically estimate F as number of removals divided by population size. Therefore, not only can bias be introduced from a less than optimal model fit, but also by misspecified harvest estimates. The MRIP estimation process underwent significant changes in 2018. The recalibration process produced recreational harvest estimates that appear overstated. Comparisons of the recreational estimates to reported commercial landings indicated that the new estimation process may have unrealistically elevated recreational harvest estimates.

The uncertainty analysis indicated a moderate fit, with most abundance estimates having coefficients of variation between 30% and 45%. Higher uncertainty of true numbers of removals (discussed above), and insufficient contrast among relative abundance indices could produce the uncertainty evidenced by the bootstrapped results.

Insufficient contrast in the abundance indices may also confound both model precision and accuracy. Magnusson and Hilborn (2007) investigated what population trajectories and models provided informative fishery management advice. Although the authors did not investigate CSA type models, results indicated that fishery population models that performed the best did so when there were sustained contrasting periods of population abundance. Piavis and Webb (2019) demonstrated that the Choptank River channel catfish assessment was greatly enhanced by increased contrast in the relative abundance indices. The ratio of pre-recruit selectivity to post-recruit selectivity was also a potential source of uncertainty. Indexing abundance with an active gear like bottom trawls has a bias toward smaller channel catfish due to the escapablity of larger fish. Runs were made with the selectivity ratio at 1, 1.5 and 2.0, with the 1.5 version providing the most coherent results.

The Choptank River channel catfish assessment utilized a CSA model fit to our long term experimental fyke net survey (see Project 1 Job 1 of this report). Population trajectories indicated an expanding population through 2011 which closely tracked our experimental fyke net indices. Pre-recruit indices began a decline in 2010 which broke the uptrend seen during 2004 – 2009. A previous assessment (Piavis and Webb 2016) indicated that this was the first demonstrable cycle during the time-series, providing a much needed contrast for the model to fit. The contrast provided by a decline in pre-recruit indices greatly increased the precision of the model. The population declined after 2011, but a large increase in pre-recruits in 2015 and muted fishing removals sustained the number of recruits such that the total population remained above median levels. Since 2015 pre-recruit abundance returned to lower levels. Estimated total population ended in 2020 right at median levels. The 2021 estimate was below median levels, but the pre-recruit abundance in the terminal year is not part of the analytical solution, and therefore, has to be regarded as a best guess estimate.

Our model estimated the time-series highest F in 2003 as 0.64. Average F for the time series was 0.21, below both the Mississippi River and the Choptank River proposed threshold F's. In spite of the low estimated F rates during the period 2015 – 2021, the total population estimate declined 60%. This indicates that the recent population contraction while F's remained low (below F=0.23) likely was not due to overfishing, but rather decreased production. The decreased production may be from poor spawning success or an increase in natural mortality (M). Alternatively, the F estimates may be biased low if the estimate of removals was misspecified. Overfishing was not occurring during the final year of the assessment since estimates of F rates were below the putative thresholds suggested for Choptank River stocks and Mississippi River stocks. The 2020 total abundance estimate was equal to the median which suggests that the Choptank River channel catfish stock should be considered fully exploited.

The Choptank River CSA model fit was considerably better than the HOB model. Most coefficients of variation were below 13% since 2000. Prior to 2000, CV's were very high, likely because of increased sampling efforts. Around 2000, the project shifted from a focus on yellow perch to a more multi-species approach which entailed more nets, a larger geographic coverage and most importantly, a longer sampling season. The Choptank River model runs were not impacted by uncertain selectivity ratios since the length frequencies from the passive gear (fyke nets) indicated that pre-recruits were more evenly encountered compared to post-recruit channel catfish. However, the same uncertainty regarding recreational catch from the Choptank River, similar to the HOB assessment, may have introduced error.

Channel catfish relative abundance trends were different between the eastern shore river (Nanticoke) and the two western shore rivers (Patuxent and Potomac). The Pocomoke River commercial channel catfish fishery returned to baseline harvest levels which suggests that market-based factors drove commercial effort, making any conclusions of population status unrealistic. The Nanticoke River channel catfish fishery showed low landings in 2020, but that is likely due to Covid pandemic causes. Commercial relative abundance through 2019 were > 75th percentile. This high level of relative abundance suggests that the population remained at high levels.

Both the Potomac and Patuxent rivers' data indicated that channel catfish are at extremely low levels. The Potomac River channel catfish population has been below historical levels for quite some time, while the Patuxent River population appears to have contracted considerably since the previous assessment (Piavis and Webb 2016).

Patuxent River channel catfish population levels, determined from fishery dependent relative abundance measurements, were at or above median levels for most the 1998 – 2014 time period. Since 2014, relative abundance declined rapidly to time series lows in 2019. These declines coincided with increased blue catfish landings and relative abundance. Declines in channel catfish landings while blue catfish increased could be caused by commercial fishermen shifting to target blue catfish directly. Relative abundance values would be impacted if directed channel catfish effort was below meaningful levels. This is a particular problem when using fishery dependent relative abundance to index population levels. Recently, trotlines were included as an authorized commercial fishing gear in tidal waters of Maryland. Significant channel catfish commercial effort may have shifted to trot-lining which targets blue catfish. In 2017, trotlines accounted for 91% of Patuxent River blue catfish commercial harvest, whereas fish pots (traditional catfish gear) landed almost 10,000 pounds of blue catfish in 2016, and none in 2017. This obvious shift in commercial catfish effort makes the interpretation of fishery dependent data difficult.

Potomac River channel catfish landings declined to relatively low levels after 2002. Relative abundance from an experimental gill net survey similarly declined, but abundance did rebound to safe levels, 2009 – 2012. Since 2012, relative abundance has only been one-half of median levels and no channel catfish were encountered in the gill net survey in 2019 and 2020 suggesting dire population contraction. The channel catfish landings decline preceded the large increase in blue catfish landings, and in 2017 blue catfish landings exceeded channel catfish landings by a factor of 30. Blue catfish relative abundance peaked in 2015 and 2016 before declining somewhat in 2017. Blue catfish colonization may be acting to preclude channel catfish stock growth through interspecific competition, both directly through predation and indirectly by out-competing channel catfish for prey or critical habitat.

Blue catfish have emerged as a potential threat to channel catfish populations in Maryland's Chesapeake Bay region. The omnivore has dominated large Chesapeake Bay tributaries in Virginia, and are firmly established in the Potomac and Patuxent rivers. Colonization is also in an advanced state in the Nanticoke River. The ability of blue catfish to overwhelm an ecosystem was documented in Virginia rivers where blue catfish comprised 75% of fish biomass from an electrofishing survey (Schloesser et al. 2011). Similarly, tagging studies in the James River (VA) estimated 1.6 million blue catfish, 240 mm – 460 mm, in a 12 km reach of river (Fabrizio et al. 2018). Prior to blue catfish and flathead catfish introductions to the Cape Fear (NC) River system in 1966, channel catfish accounted for approximately 25% of the ictalurid fish community, but by the late 1990's blue catfish accounted for 85% of the ictalurid community with channel catfish accounting for less than 10% (Moser and Roberts 1999). Beyond these surveys in Atlantic slope rivers, channel catfish and blue catfish co-exist in fishable numbers. Mississippi River drainage systems including the Mississippi River, the Missouri River, impounded sections of the Tennessee River and the Osage River contain sympatric populations of channel and blue catfish (Pugh and Schramm 1999, Timmons 1999, Gale et al. 1999, Graham and DeiSanti 1999).

Blue catfish may compete with channel catfish for available resources or more directly through predation. Stomach analyses of blue catfish in the Chesapeake Bay region and other east coast regions indicated some degree of direct predation on channel catfish. Most analyses explored the impact of blue catfish on depleted fishes such as *Alosa* spp., economically important species like blue crab (*Callinectes sapidus*) or ecologically important forage species. However, channel catfish were the second most prevalent finfish food item in blue catfish stomachs in five Maryland Chesapeake Bay tributaries (Aguilar et al. 2017). The five systems surveyed were all within areas assessed in this report including two systems in HOB, a tributary to the Nanticoke River, the Potomac River and the Patuxent River. In the Potomac River, catfish species were also prevalent in blue catfish stomachs, but given low channel catfish population levels it is more likely that unidentified catfish species were blue catfish (M. Groves personal communication, presentation to the Invasive Catfish Symposium Nov 6, 2017 https://www.chesapeakebay.net/what/event/catfish_symposium). A diet analysis in Lake Oconee, GA found that channel catfish were a seasonally important component of blue catfish diets (Jennings et al. 2018). Channel catfish were the second highest finfish on a relative importance scale during the spring. Even infrequent predation on channel catfish could substantially raise natural mortality if blue catfish densities approach those seen in Virginia tributaries as Schmitt et al. (2018) posited for species such as blue crab and alosids.

Indirect competition between channel catfish and blue catfish is likely harder to prove. There are no recent channel catfish feeding studies in Chesapeake Bay, but gizzard shad, Atlantic menhaden and white perch were large components of blue catfish finfish diets in Chesapeake Bay tributaries (Aguilar et al. 2017; Schmitt et al. 2018) and likely overlap with channel catfish diets. Benthic invertebrates, including *Gammarus* spp. and Dipterans, comprised a portion of blue catfish diets (Schmitt et al. 2018; Schloesser et al. 2011). Benthic invertebrates and *Gammarus* spp. were also important to channel catfish, particularly young channel catfish, in Maryland's portion of the

Susquehanna River (Fewlass 1980; Weisberg and Janicki 1985). These dietary overlaps are a potential competitive bottleneck for both channel catfish and blue catfish.

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LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (continued)

Table 1. Uncertainty parameters for Head-of-Bay channel catfish catch survey analysis model.

Estimate/Parameter	Estimate	Mean	Median	CV	Bias[1]
q	3.27E-06	3.65E-06	3.63E-06	16.5	-9.8
Pre-Recruit N 2005	204,271	210,457	200,837	43.6	1.7
Pre-Recruit N 2006	236,049	239,479	230,715	39.7	2.3
Pre-Recruit N 2007	496,174	495,150	482,214	31.2	2.9
Pre-Recruit N 2008	596,083	590,433	577,955	31.4	3.1
Pre-Recruit N 2009	705,883	695,562	672,133	35.9	5.0
Pre-Recruit N 2010	869,848	856,284	845,422	31.6	2.9
Pre-Recruit N 2011	528,706	552,859	544,230	38.7	-2.9
Pre-Recruit N 2012	668,364	671,908	667,912	28.4	0.1
Pre-Recruit N 2013	893,260	882,076	866,311	30.3	3.1
Pre-Recruit N 2014	658,673	659,440	638,225	38.6	3.2
Pre-Recruit N 2015	960,630	949,875	920,311	33.1	4.4
Pre-Recruit N 2016	1,100,584	1,090,038	1,056,657	36.4	4.2
Pre-Recruit N 2017	929,819	931,363	891,194	39.2	4.3
Pre-Recruit N 2018	957,001	937,915	904,893	38.8	5.8
Pre-Recruit N 2019	952,509	936,152	904,705	38.9	5.3
Pre-Recruit N 2020	585,101	614,315	579,911	43.0	0.9
Pre-Recruit N 2021	814,781	854,330	794,677	46.4	2.5
Post-Recruit N 2005	257,171	250,617	241,643	40.8	6.4
Post-Recruit N 2006	272,834	272,531	261,954	33.5	4.2
Post-Recruit N 2007	206,672	209,232	196,052	43.7	5.4
Post-Recruit N 2008	285,341	286,599	269,491	45.4	5.9
Post-Recruit N 2009	346,695	343,099	324,081	44.9	7.0
Post-Recruit N 2010	570,578	559,183	534,603	38.3	6.7
Post-Recruit N 2011	665,373	644,939	629,074	33.7	5.8
Post-Recruit N 2012	388,306	391,352	373,472	43.3	4.0
Post-Recruit N 2013	266,990	272,385	251,831	50.4	6.0
Post-Recruit N 2014	581,635	576,896	553,823	38.9	5.0
Post-Recruit N 2015	573,464	570,211	539,960	40.6	6.2
Post-Recruit N 2016	640,509	629,040	599,760	42.4	6.8
Post-Recruit N 2017	1,013,195	995,170	948,391	35.7	6.8
Post-Recruit N 2018	918,048	904,554	873,579	38.2	5.1
Post-Recruit N 2019	1,015,927	989,253	951,067	36.4	6.8
Post-Recruit N 2020	1,056,991	1,021,761	973,885	35.8	8.5
Post-Recruit N 2021	813,658	808,733	762,905	43.3	6.7

[1] Bias defined as 100*(est-med)/med

Table 2. Uncertainty parameters for Choptank River channel catfish catch survey analysis model.

Estimate/Parameter	Estimate	Mean	Median	CV	Bias[1]
q	4.48E-06	4.82E-06	4.70E-06	14.8	-4.6
Pre-Recruit N 1993	100,908	91,404	87,964	12.8	14.7
Pre-Recruit N 1994	255,576	170,711	140,486	61.2	81.9
Pre-Recruit N 1995	52,325	47,733	46,122	11.9	13.5
Pre-Recruit N 1996	74,910	79,487	80,642	7.3	-7.1
Pre-Recruit N 1997	18,707	19,010	19,083	2.0	-2.0
Pre-Recruit N 1998	33,960	34,973	35,201	3.8	-3.5
Pre-Recruit N 1999	153,894	170,309	174,685	12.2	-11.9
Pre-Recruit N 2000	101,358	107,953	109,730	7.7	-7.6
Pre-Recruit N 2001	58,674	60,853	61,442	4.5	-4.5
Pre-Recruit N 2002	38,292	39,210	39,460	3.0	-3.0
Pre-Recruit N 2003	148,209	160,974	164,457	10.0	-9.9
Pre-Recruit N 2004	46,407	47,489	47,784	2.9	-2.9
Pre-Recruit N 2005	168,885	180,029	183,075	7.8	-7.8
Pre-Recruit N 2006	153,708	161,339	163,421	6.0	-5.9
Pre-Recruit N 2007	274,846	294,378	299,718	8.4	-8.3
Pre-Recruit N 2008	321,344	345,582	352,210	8.9	-8.8
Pre-Recruit N 2009	299,202	319,480	325,019	8.1	-7.9
Pre-Recruit N 2010	233,679	245,995	249,358	6.4	-6.3
Pre-Recruit N 2011	392,347	426,607	435,963	10.2	-10.0
Pre-Recruit N 2012	79,696	81,145	81,541	2.3	-2.3
Pre-Recruit N 2013	139,950	144,272	145,452	3.8	-3.8
Pre-Recruit N 2014	150,726	155,321	156,576	3.8	-3.7
Pre-Recruit N 2015	637,956	707,939	727,051	12.5	-12.3
Pre-Recruit N 2016	80,984	82,131	82,444	1.8	-1.8
Pre-Recruit N 2017	33,861	34,058	34,112	0.7	-0.7
Pre-Recruit N 2018	67,186	67,889	68,081	1.3	-1.3
Pre-Recruit N 2019	55,123	55,505	55,609	0.9	-0.9
Pre-Recruit N 2020	39,400	39,522	39,554	0.4	-0.4
Pre-Recruit N 2021	46,943	68,361	60,718	40.5	-22.7
Post-Recruit N 1993	150,423	133,352	126,857	15.7	18.6
Post-Recruit N 1994	166,048	144,290	136,155	18.5	22.0
Post-Recruit N 1995	323,113	235,818	204,412	45.5	58.1
Post-Recruit N 1996	272,389	197,159	170,126	46.9	60.1
Post-Recruit N 1997	211,640	153,794	132,607	46.2	59.6
Post-Recruit N 1998	158,122	111,010	93,723	52.2	68.7
Post-Recruit N 1999	92,223	55,381	40,513	81.5	127.6
Post-Recruit N 2000	131,715	114,991	106,427	17.6	23.8
Post-Recruit N 2001	176,157	167,865	164,954	6.0	6.8
Post-Recruit N 2002	180,863	175,858	174,322	3.5	3.8
Post-Recruit N 2003	145,182	141,835	140,686	3.0	3.2
Post-Recruit N 2004	127,243	134,954	135,645	7.9	-6.2
Post-Recruit N 2005	118,398	125,597	126,436	7.8	-6.4
Post-Recruit N 2006	170,772	185,790	189,125	10.5	-9.7
Post-Recruit N 2007	193,669	212,213	216,673	11.3	-10.6
Post-Recruit N 2008	324,585	355,760	363,865	11.2	-10.8
Post-Recruit N 2009	437,189	482,557	494,655	12.0	-11.6
Post-Recruit N 2010	514,494	568,240	582,714	12.0	-11.7
Post-Recruit N 2011	497,110	551,197	565,788	12.5	-12.1
Post-Recruit N 2012	602,954	675,286	694,879	13.6	-13.2
Post-Recruit N 2013	451,777	512,185	528,550	15.0	-14.5
Post-Recruit N 2014	390,402	443,398	457,762	15.2	-14.7
Post-Recruit N 2015	349,650	396,801	409,592	15.1	-14.6
Post-Recruit N 2016	748,982	844,884	870,971	14.4	-14.0
Post-Recruit N 2017	636,546	716,003	737,618	14.1	-13.7
Post-Recruit N 2018	478,643	543,859	561,600	15.2	-14.8
Post-Recruit N 2019	405,631	459,600	474,282	14.9	-14.5
Post-Recruit N 2020	348,569	393,068	405,173	14.4	-14.0
Post-Recruit N 2021	275,923	312,455	322,392	14.8	-14.4

[1] Bias defined as 100*(est-med)/med

Figure 1. Head-of-Bay winter trawl sites. (triangles=main bay sites, squares=Elk River sites, circles=Sassafras River sites).

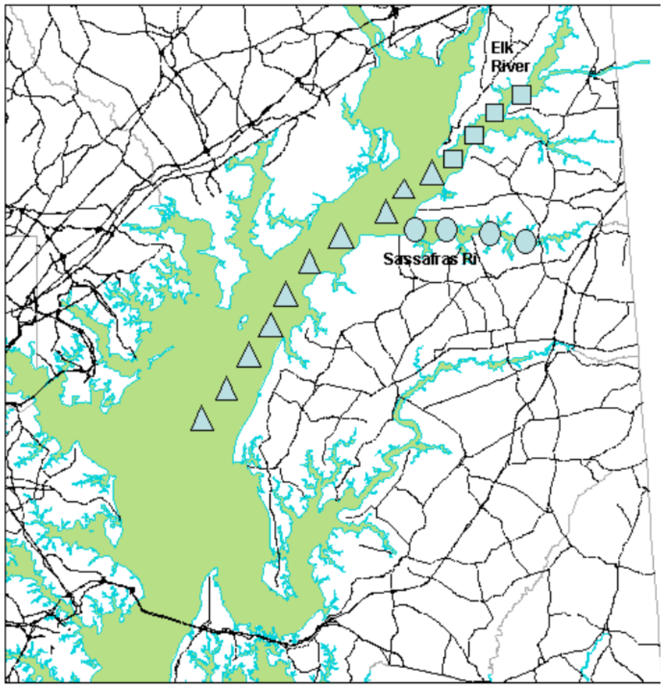


Figure 2. Choptank River fyke net locations, 2020. Circles indicate sites.

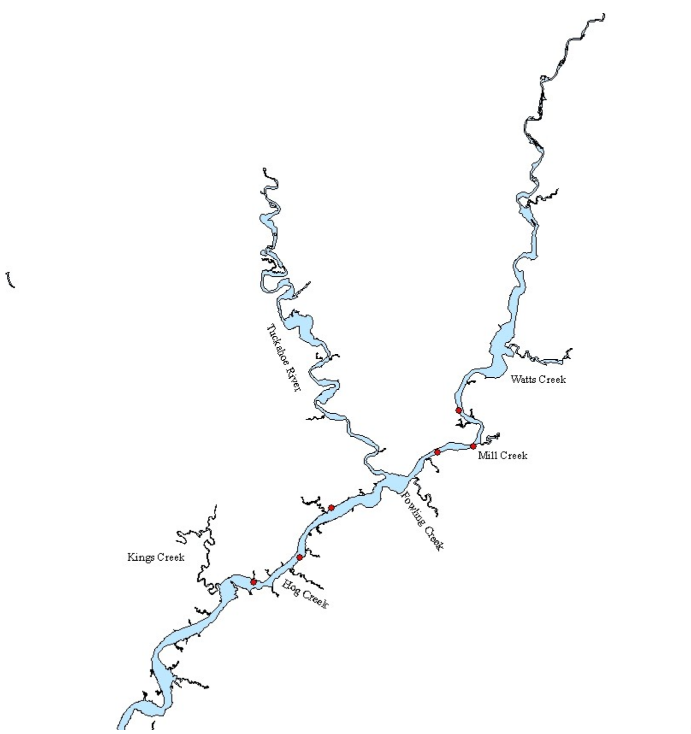


Figure 3. Head-of-Bay and Potomac River fishery independent drift gill net sampling locations, 1985 -- 2021.

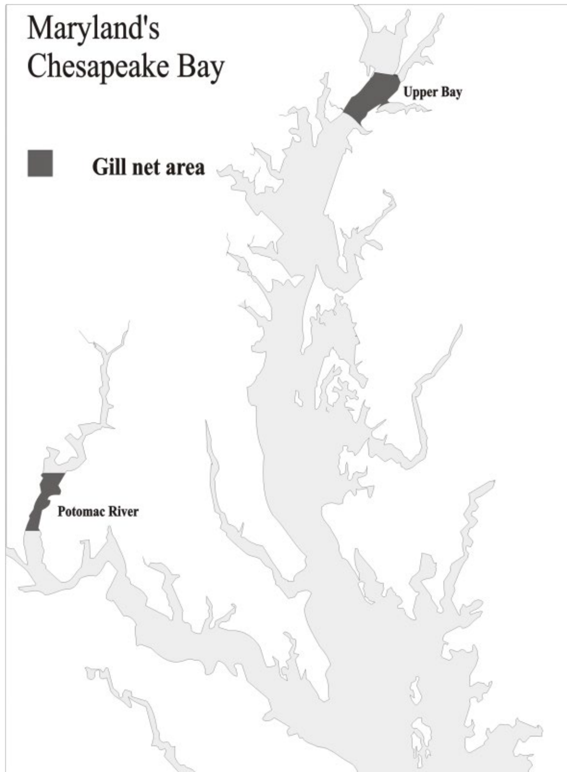


Figure 4. Adjusted Maryland commercial channel catfish landings, 1929 – 2020.

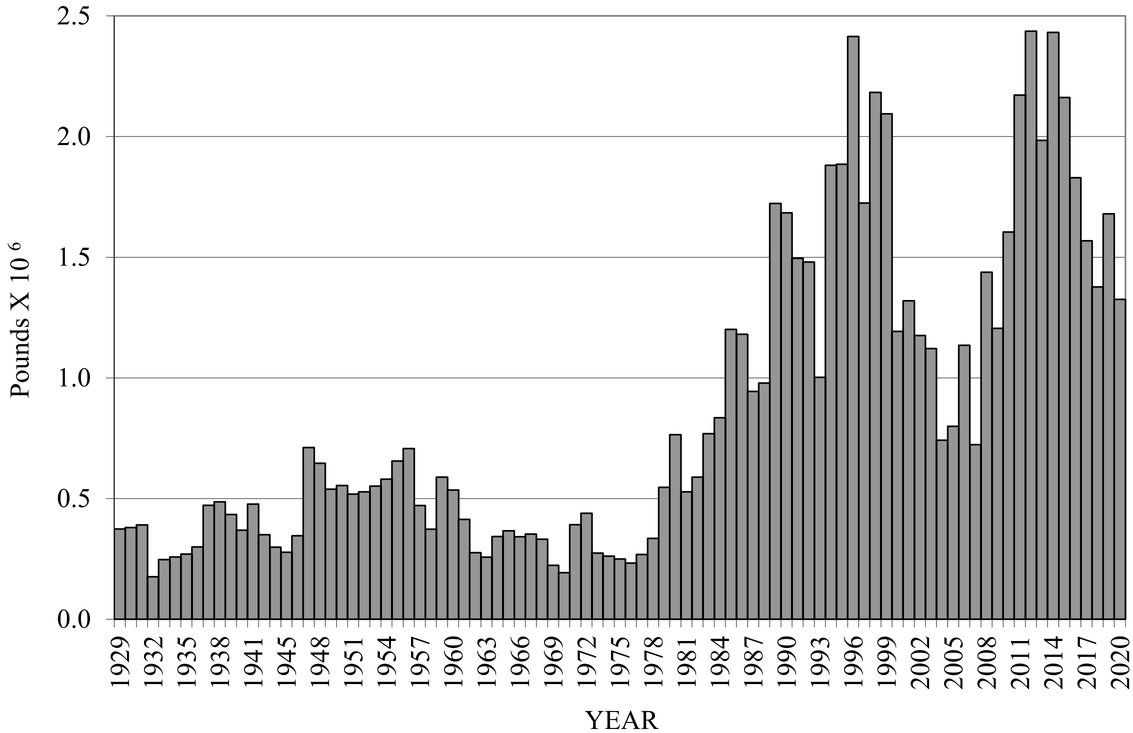


Figure 5. Estimated channel catfish landings from the recreational fishery, 1983 – 2020. Error bars = 1 standard error.

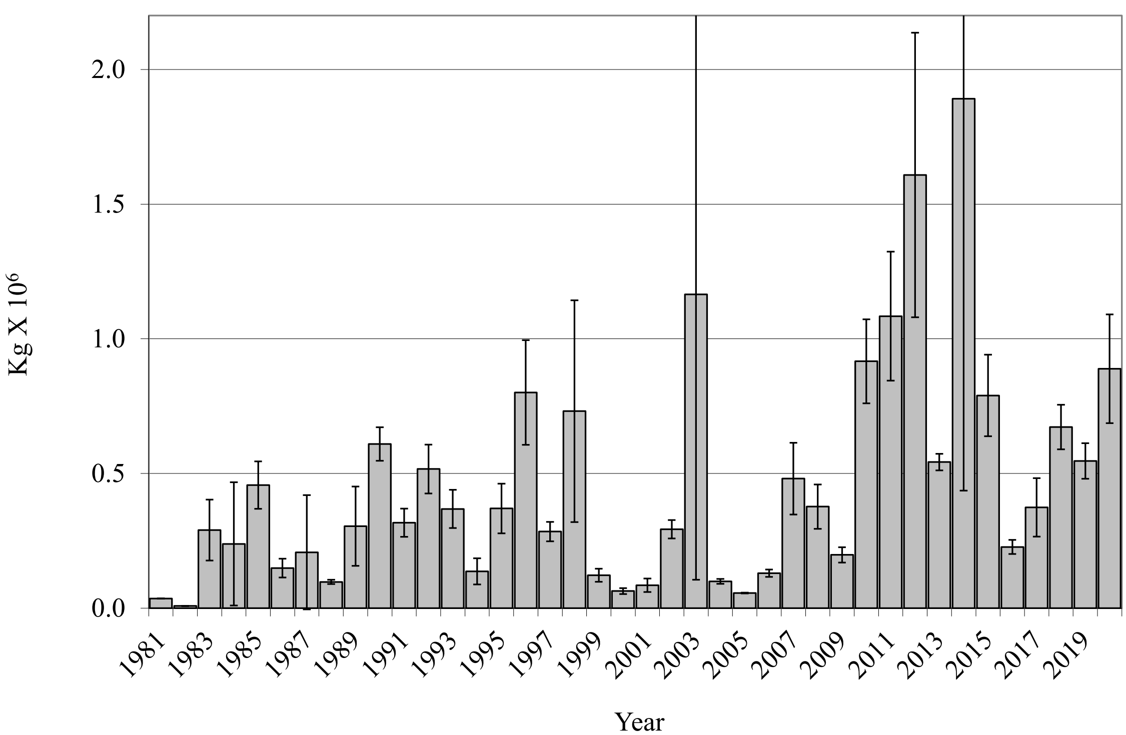


Figure 6. Head-of Bay channel catfish removals from commercial and recreational fisheries, 2005 – 2020.

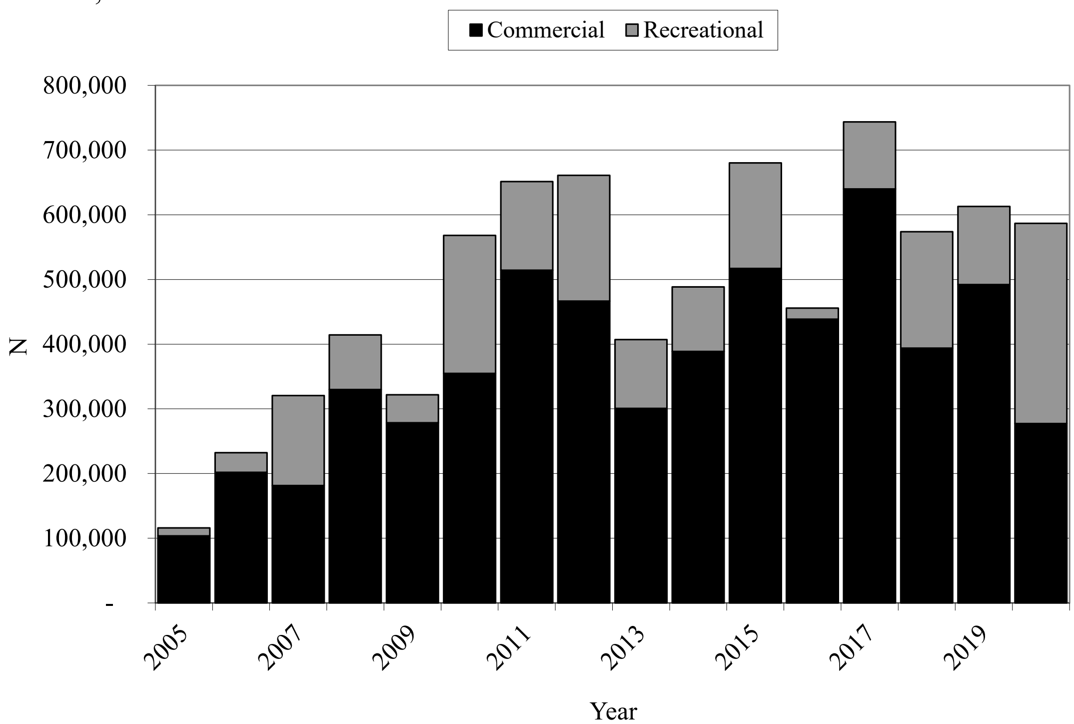


Figure 7. Observed and expected pre-recruit channel catfish index from the Head-of-Bay catch survey analysis.

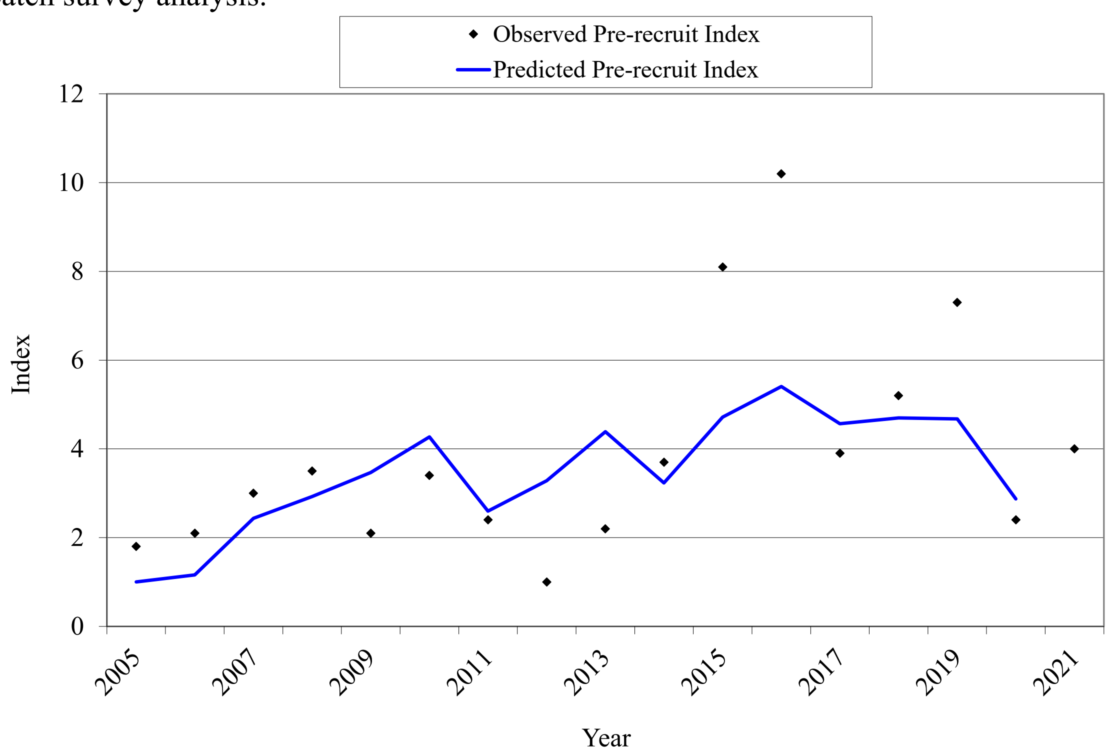


Figure 8. Observed and expected post-recruit channel catfish index from the Head-of-Bay catch survey analysis.

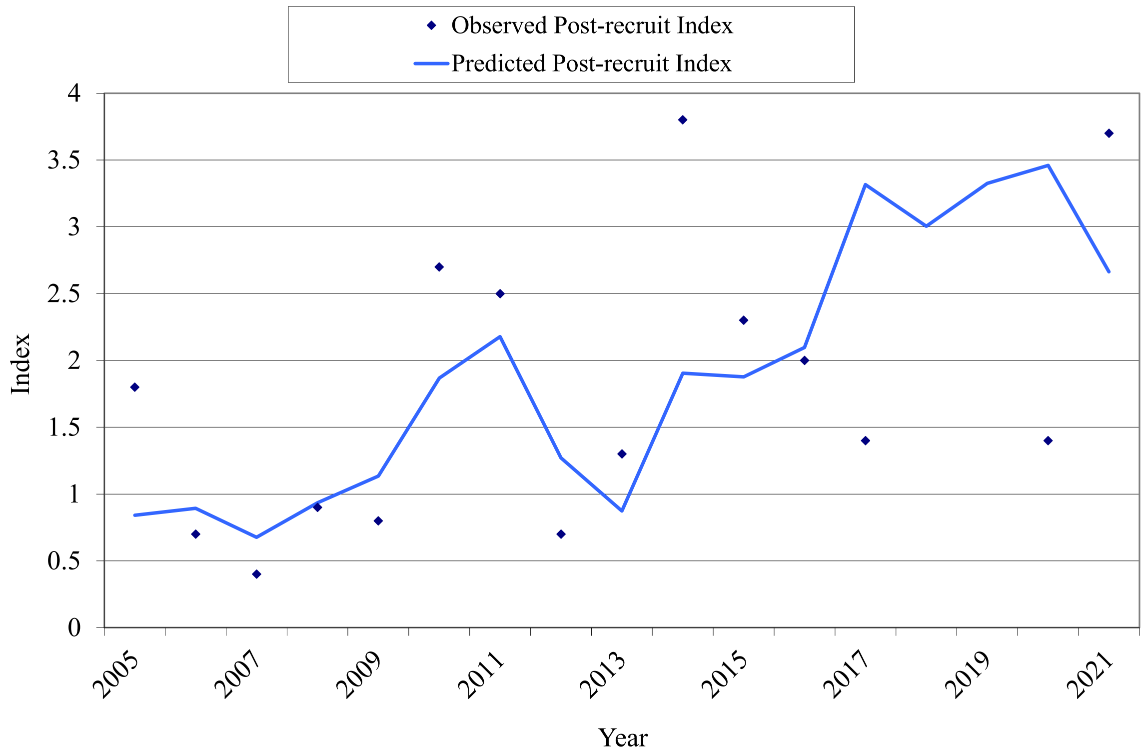


Figure 9. Head-of-Bay channel catfish pre-recruit abundance with 80% confidence intervals from catch survey analysis.

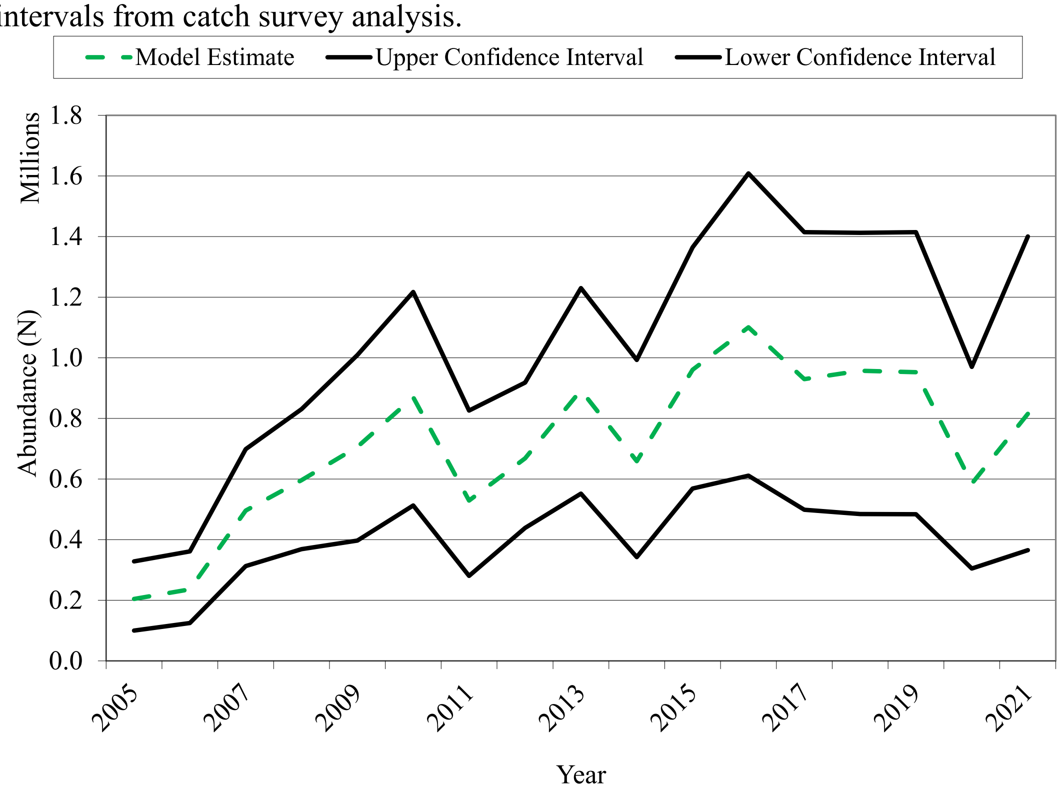


Figure 10. Head-of-Bay channel catfish post-recruit abundance with 80% confidence intervals from catch survey analysis.

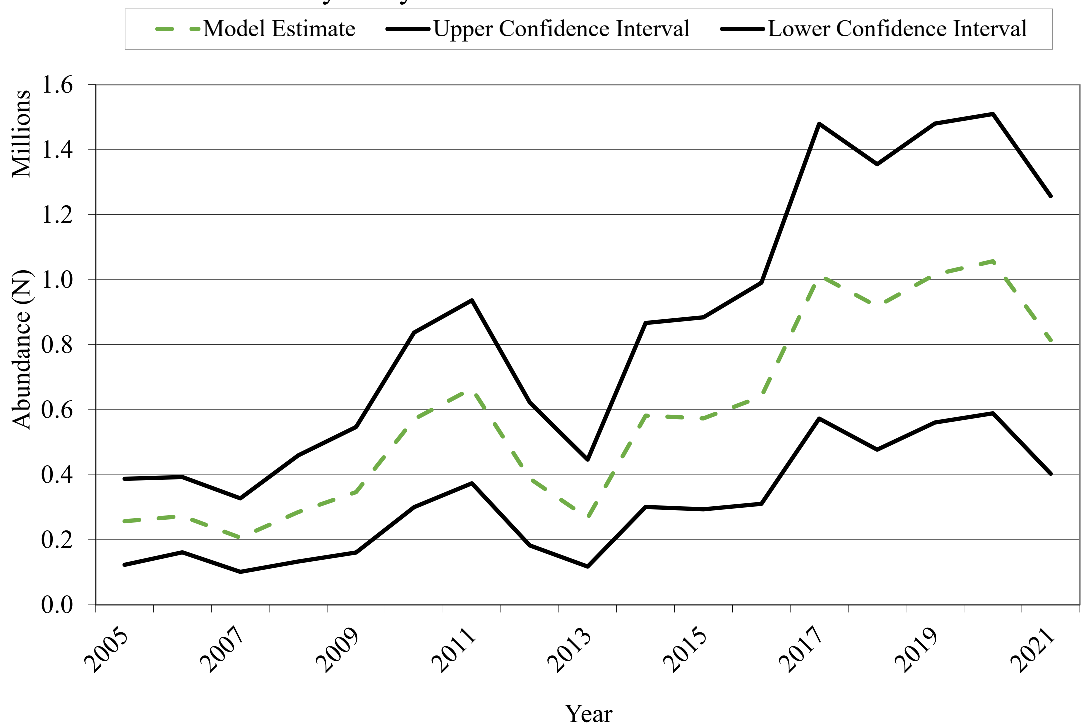


Figure 11. Total channel catfish population abundance estimates and 80% confidence intervals from Head-of-Bay catch survey analysis.

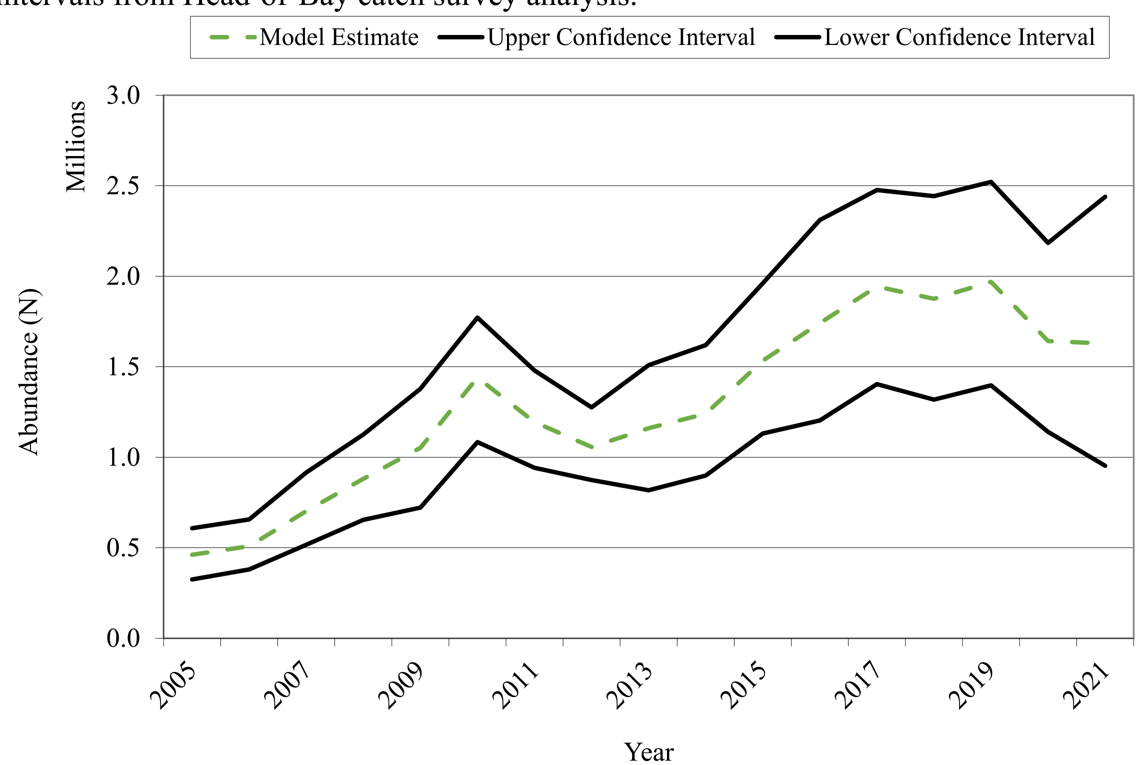


Figure 12. Estimated fishing mortality and 80% confidence intervals for Head-of-Bay channel catfish from catch survey analysis.

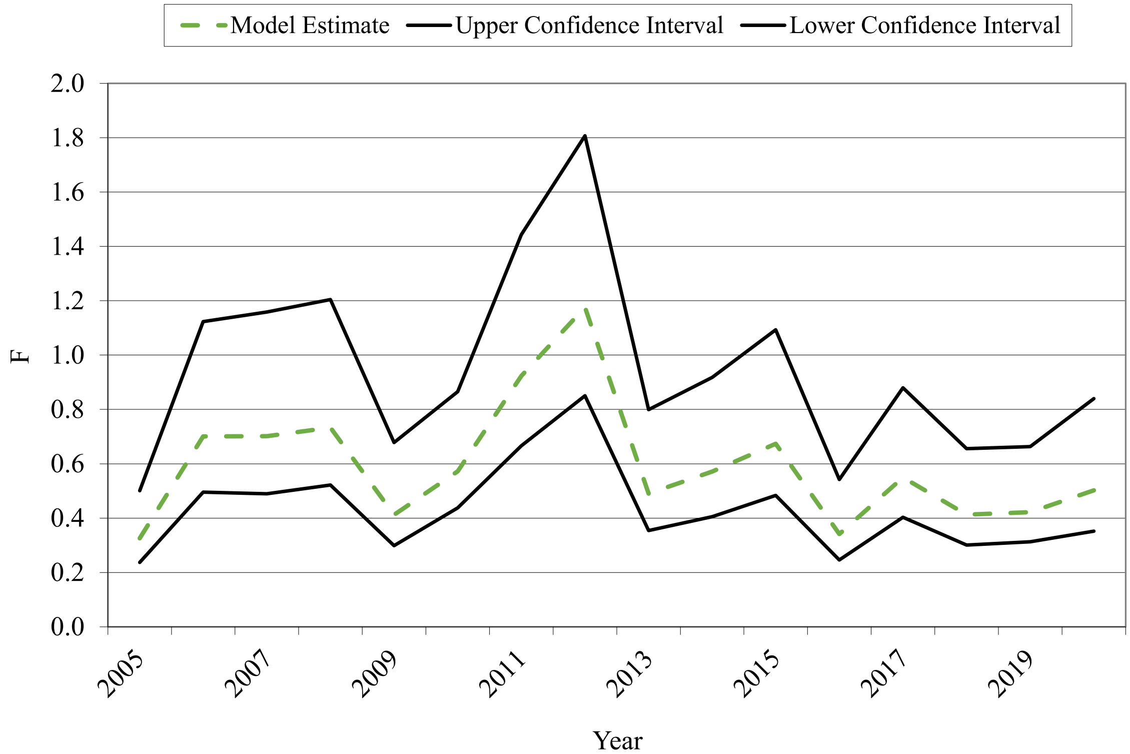


Figure 13. Choptank River channel catfish removals from commercial and recreational fisheries, 1993 – 2020.

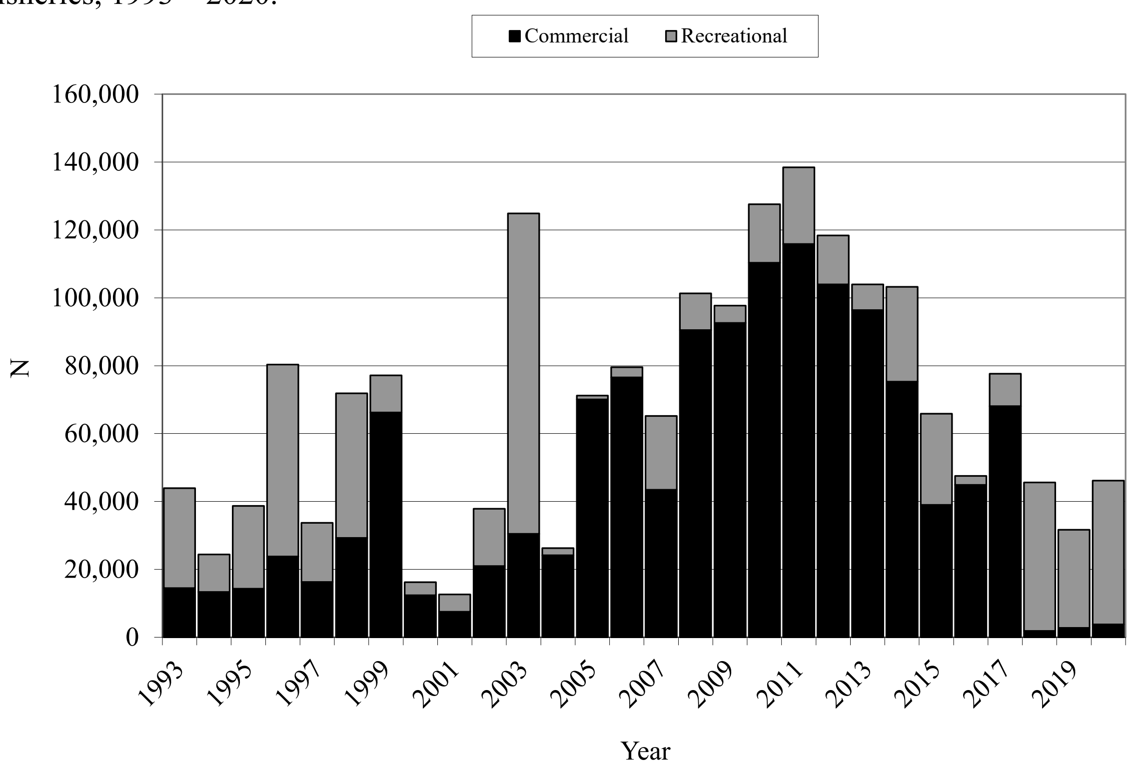


Figure 14. Observed and expected pre-recruit channel catfish index from Choptank River catch survey analysis.

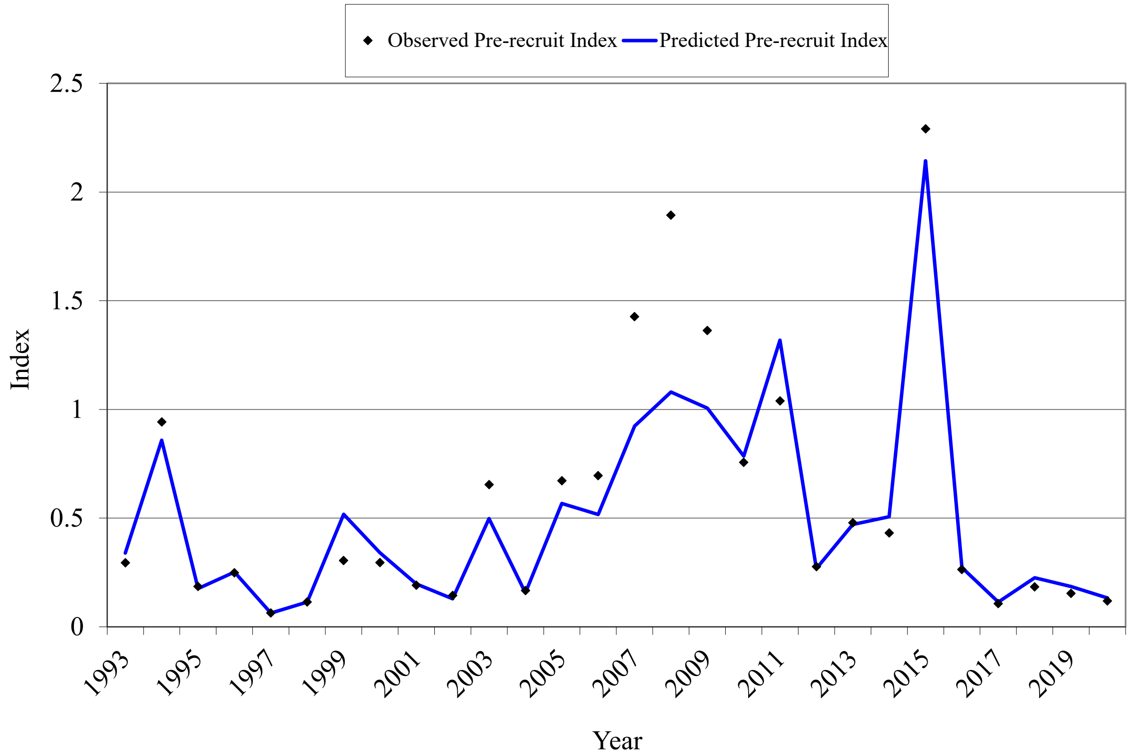


Figure 15. Observed and expected post-recruit channel catfish index from Choptank River catch survey analysis.

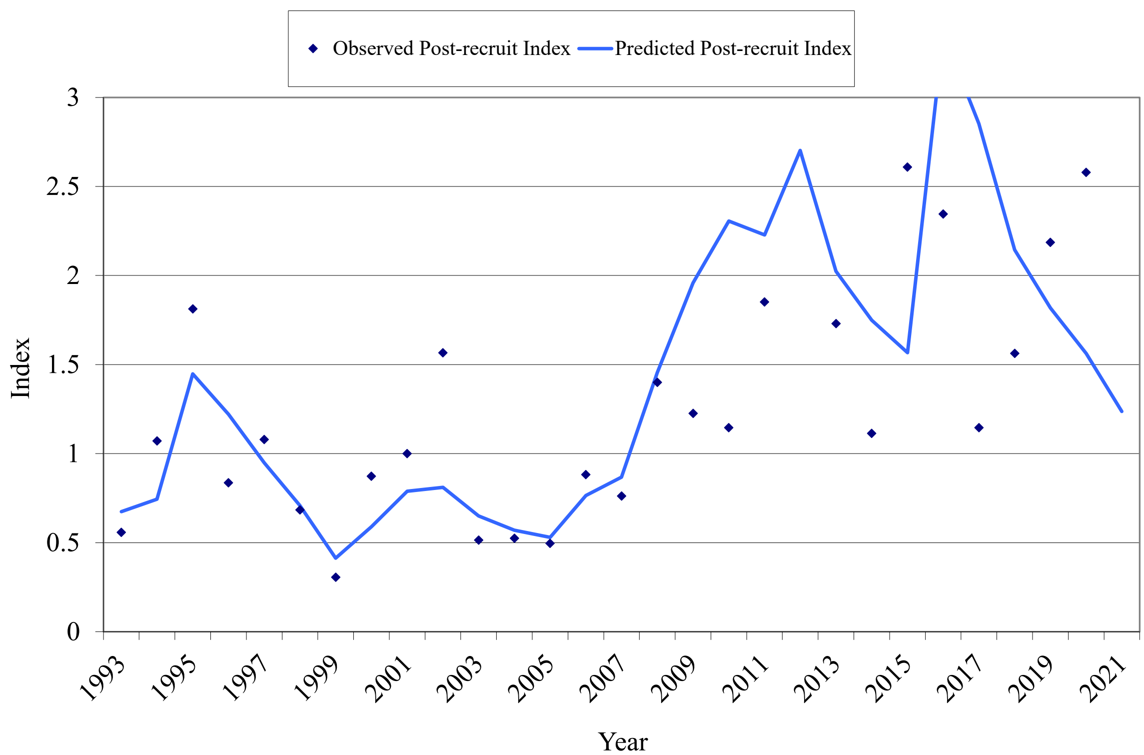


Figure 16. Choptank River channel catfish pre-recruit abundance with 80% confidence intervals from catch survey analysis.

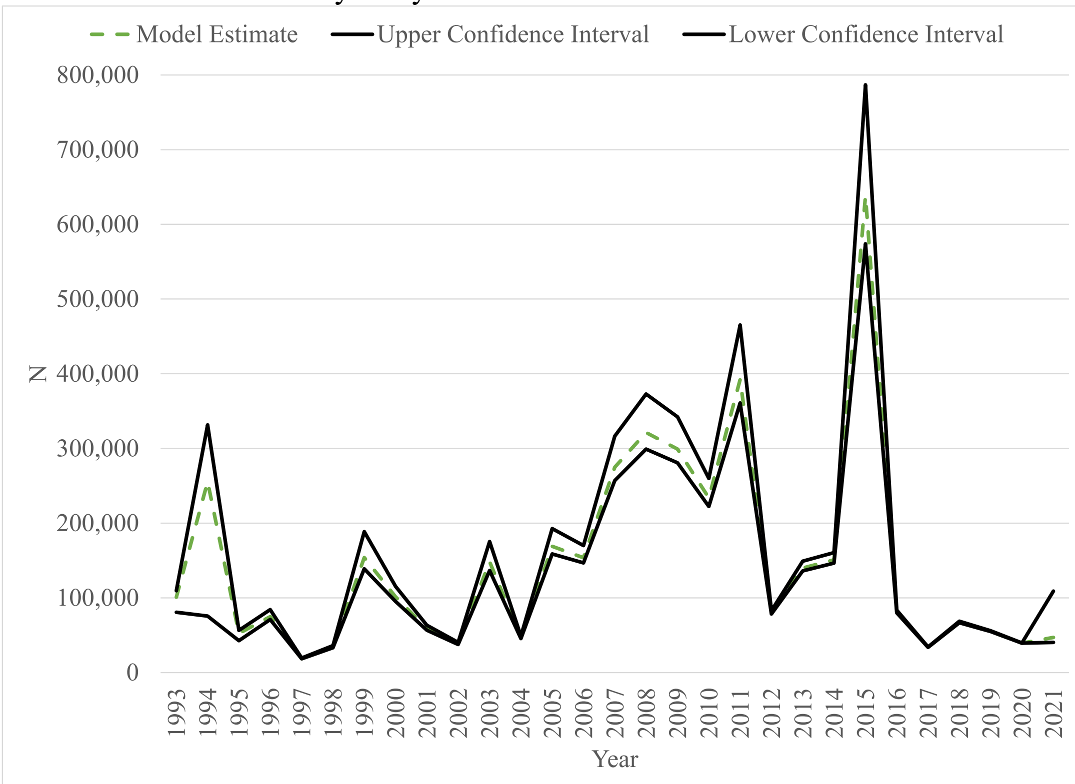


Figure 17. Choptank River channel catfish post-recruit abundance with 80% confidence intervals from catch survey analysis.

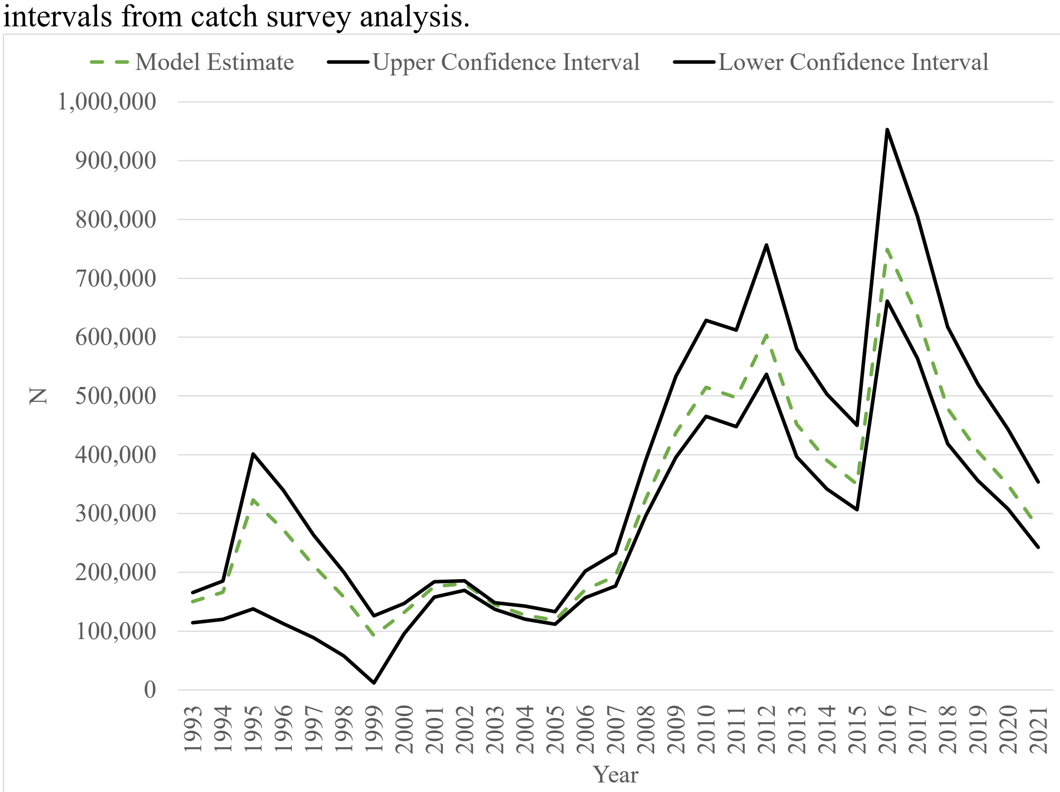


Figure 18. Total channel catfish population abundance estimates and 80% confidence intervals from Choptank River catch survey analysis.

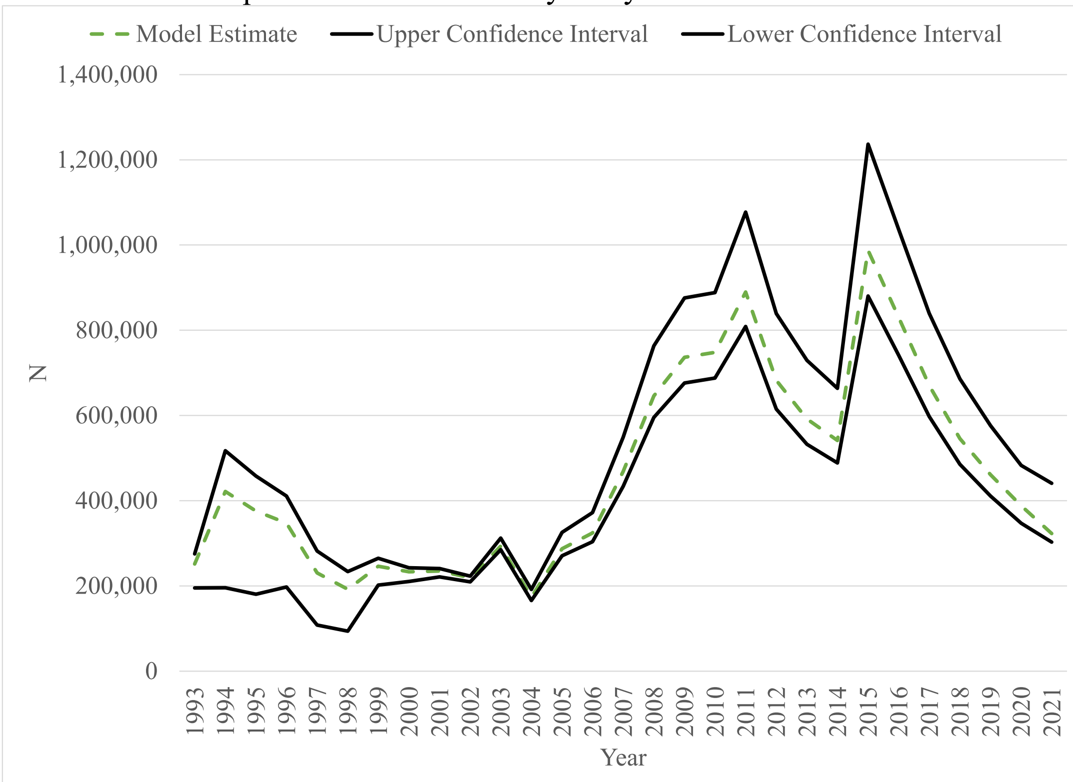


Figure 19. Estimated fishing mortality and 80% confidence intervals for Choptank River channel catfish from catch survey analysis.

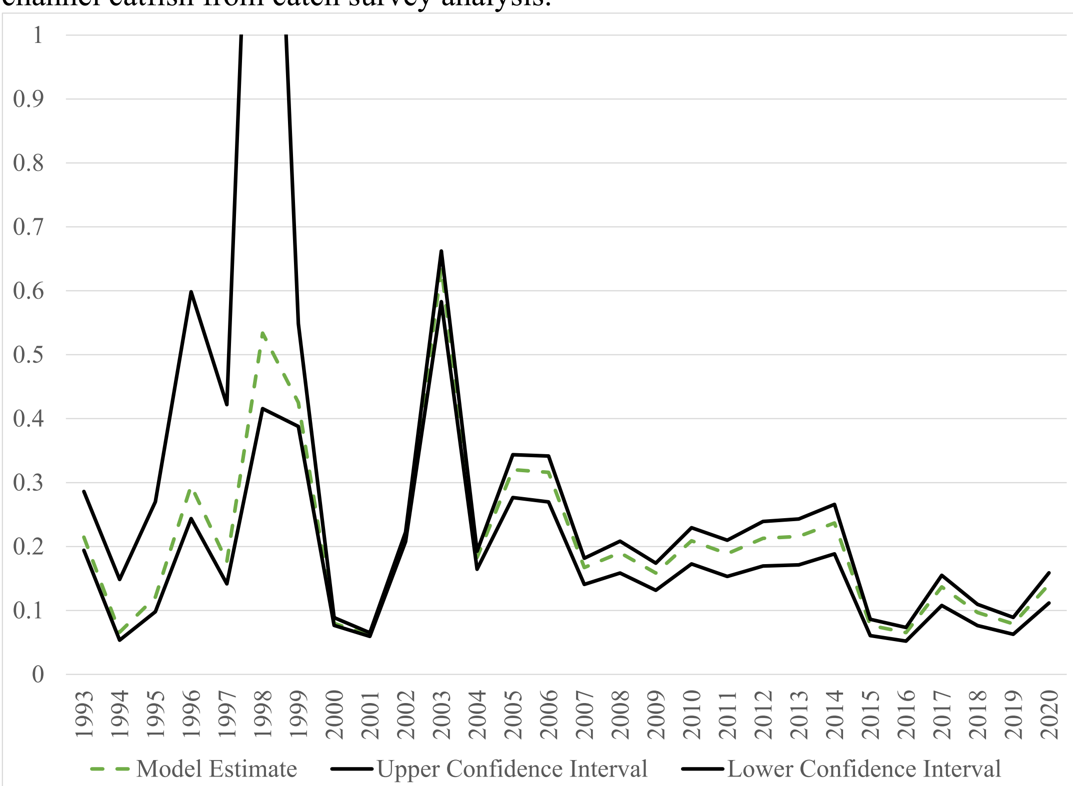


Figure 20. Nanticoke River channel catfish commercial landings, 1987 – 2020.

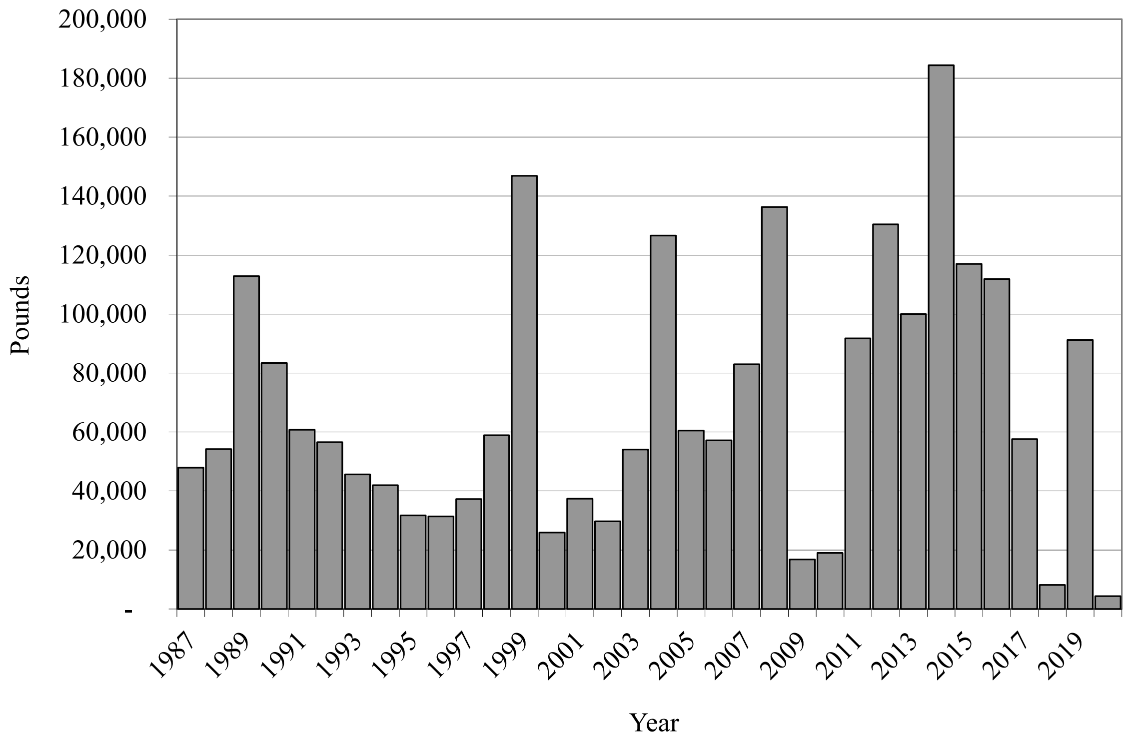


Figure 21. Nanticoke River commercial fish pot channel catfish relative abundance and 75th percentile, 1980 – 2020.

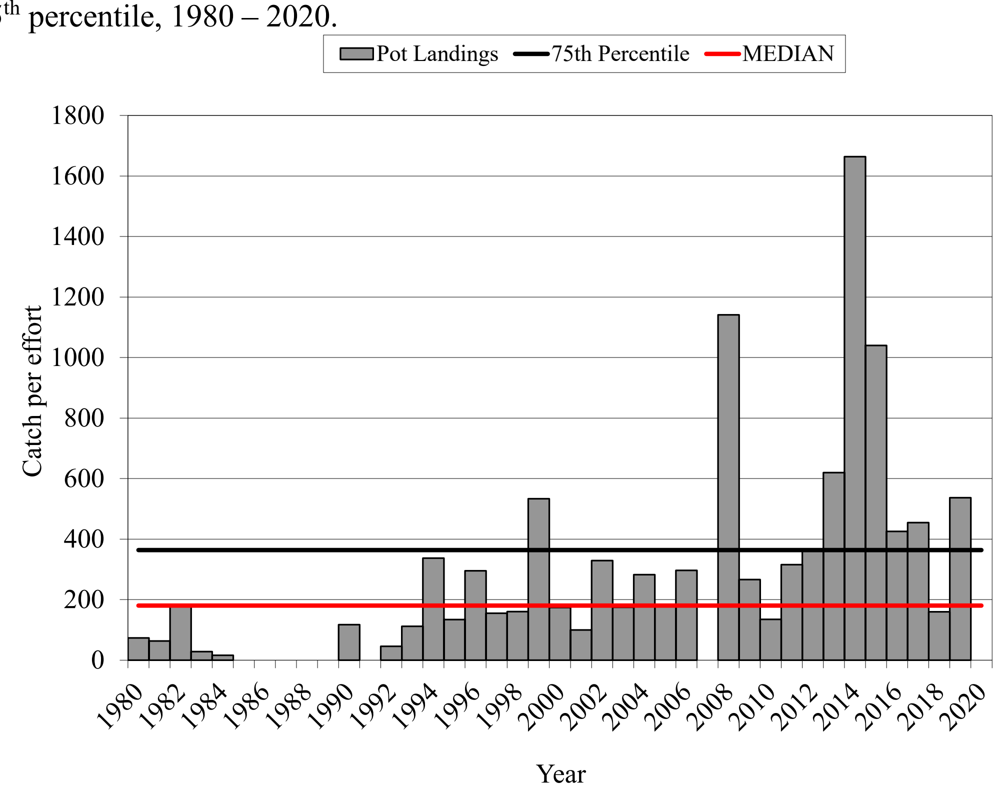


Figure 22. Pocomoke River channel catfish commercial landings, 2003 – 2020.

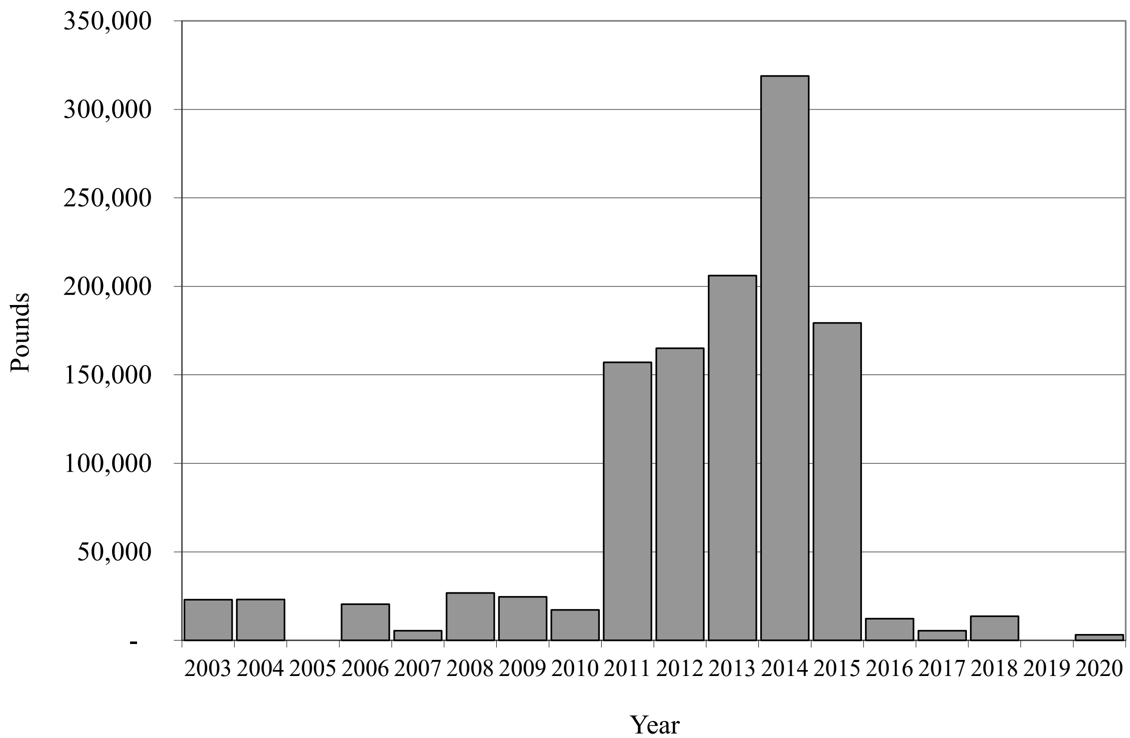


Figure 23. Patuxent River channel catfish and blue catfish commercial landings, 1987 – 2020.

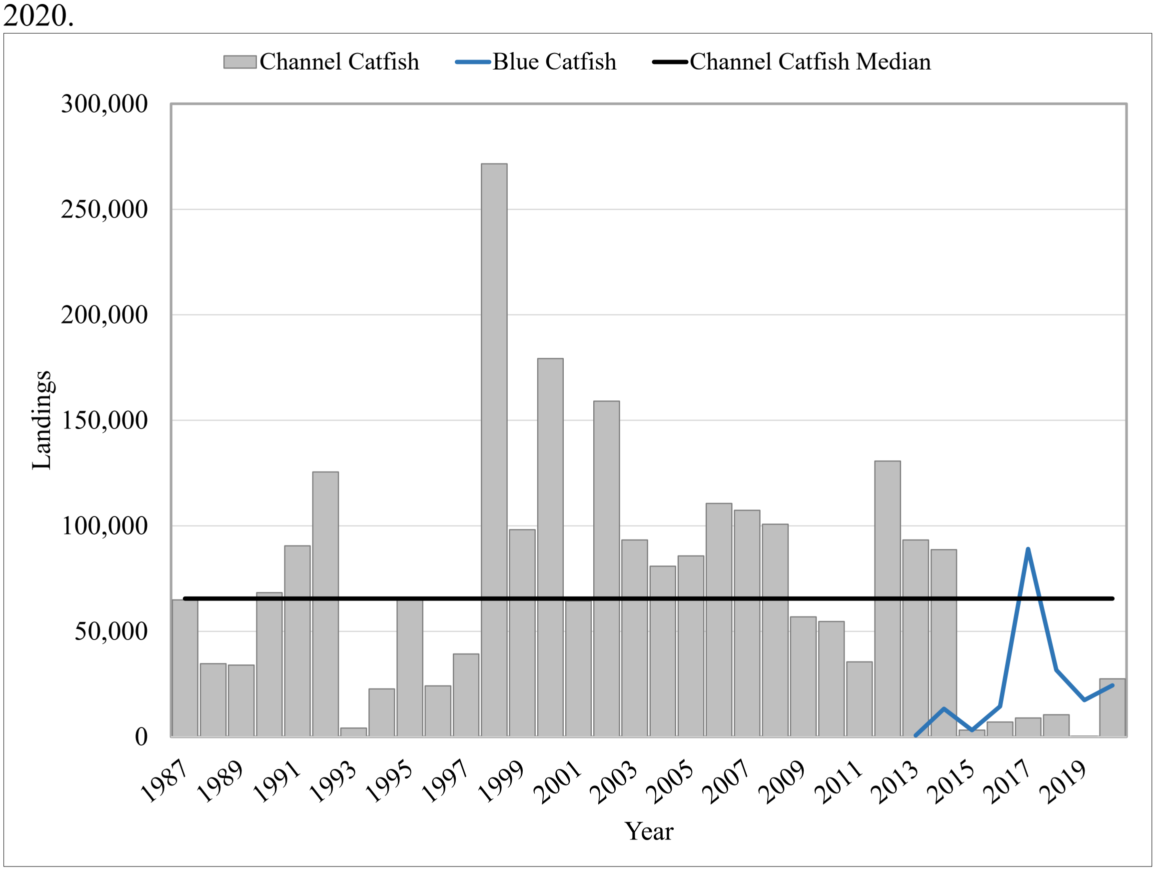


Figure 24. Patuxent River commercial fish pot/fyke net channel catfish and blue catfish relative abundance, 1990 – 2020.

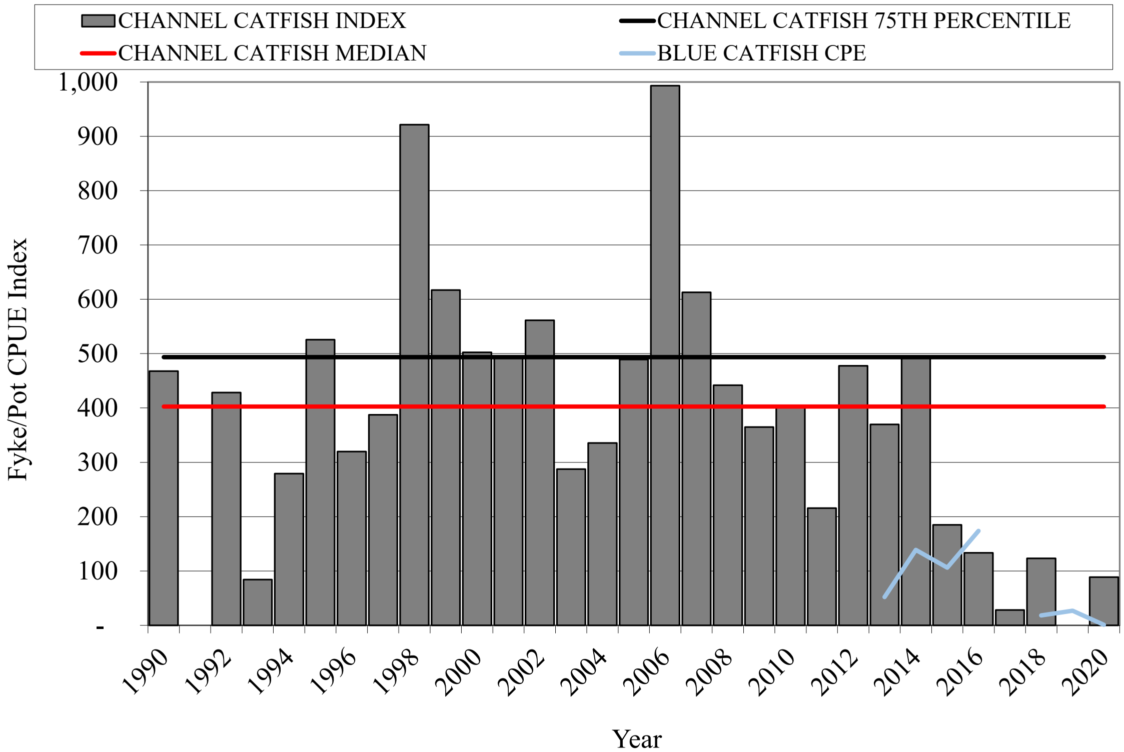


Figure 25. Potomac River channel catfish commercial landings, 1987 – 2020. Data from Potomac River Fishery Commission and MD DNR.

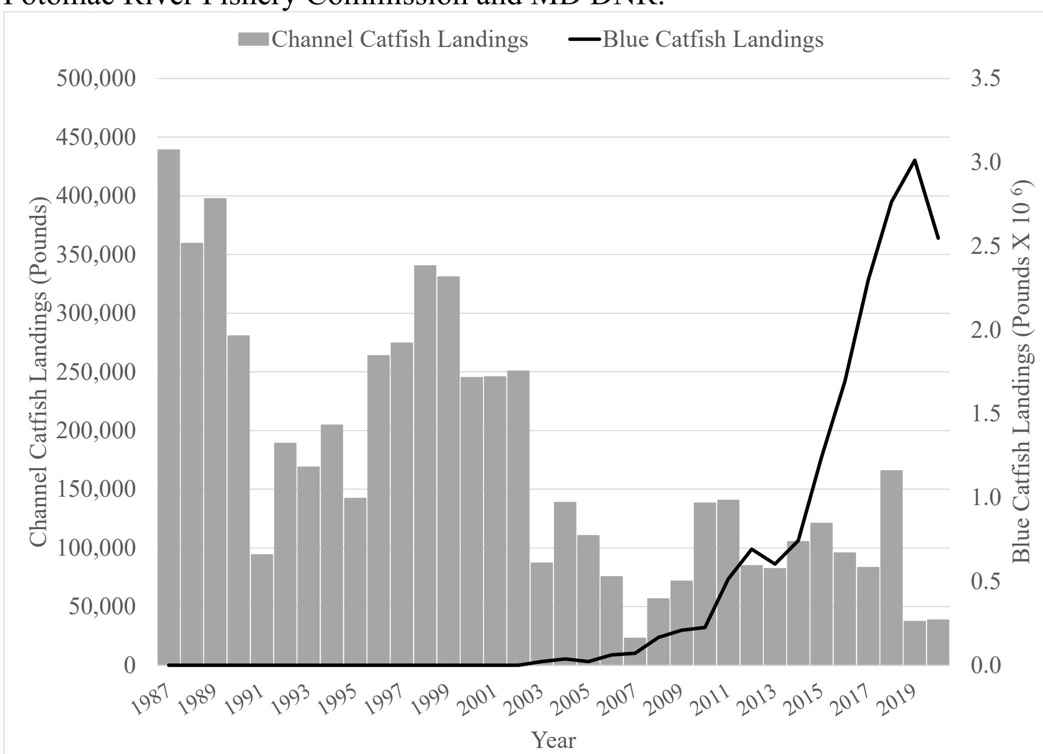
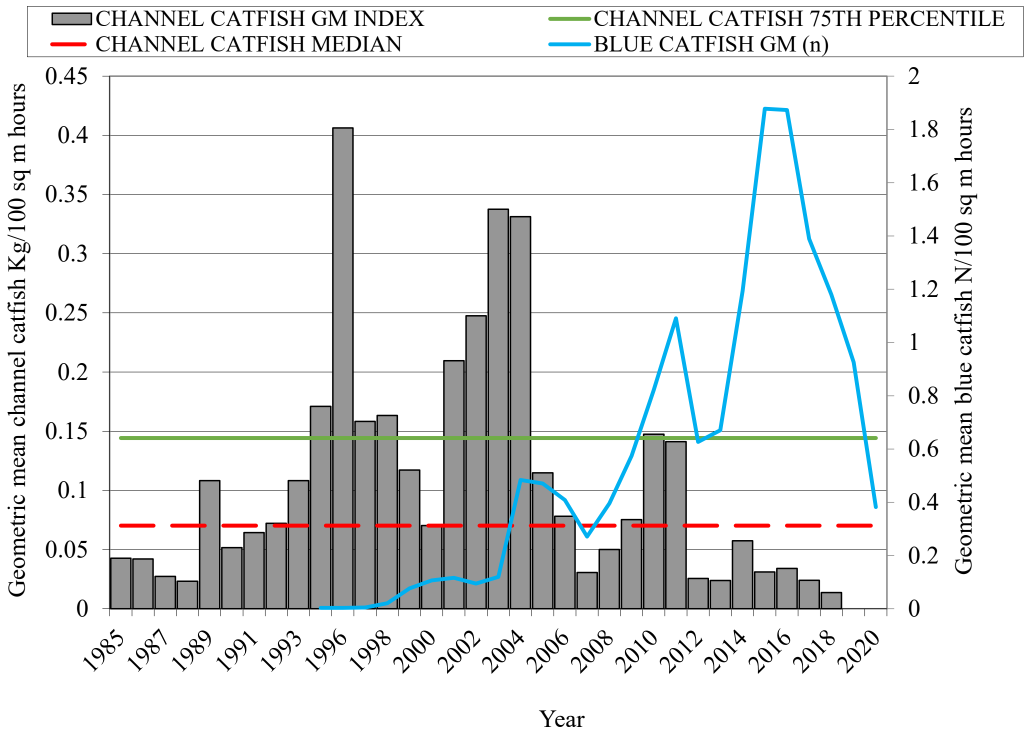


Figure 26. Channel catfish biomass index and blue catfish N index from Potomac River gill net survey, 1985-2020.



PROJECT NO. 2
JOB NO. 1

STOCK ASSESSMENT OF ADULT AND JUVENILE ALOSINE SPECIES IN THE CHESAPEAKE BAY AND SELECTED TRIBUTARIES

Prepared by
Matthew B. Jargowsky and David Sanderson-Kilchenstein

INTRODUCTION

The primary objective of Project 2, Job 1 was to assess trends in the stock status of American shad *Alosa sapidissima*, hickory shad *A. mediocris,* alewife *A. pseudoharengus* and blueback herring *A. aestivalis* in Maryland's portion of the Chesapeake Bay and selected tributaries. Maryland Department of Natural Resources personnel utilized both fishery independent and dependent sampling gear to provide information regarding adult alosine species and their subsequent spawning success in Maryland tributaries. Biologists sampled adult American shad by hook and line fishing from the Susquehanna River below the Conowingo Dam to collect stock composition data and to estimate population size. For Potomac River American shad, this Job utilized fishery-independent gill net data from the Striped Bass Spawning Stock Survey (Project 2, Job 3, Task 2) to describe stock composition, relative abundance and mortality rates. Biologists worked with commercial fishermen in the Nanticoke River to collect stock composition data, estimate relative abundance and determine mortality rates of adult American shad and river herring (i.e., alewife and blueback herring). Hickory shad stock composition was assessed in the Susquehanna River by the Maryland Department of Natural Resources Fish Health and Hatcheries Program. River herring were assessed using fishery-independent gill nets in the North East River. Data collected by this project were used to prepare and update stock assessments and fishery management plans for the Atlantic States Marine Fisheries Commission (ASMFC), the

Susquehanna River Anadromous Fish Restoration Cooperative (SRAFRC) and the Chesapeake Bay Program's Sustainable Fisheries Goal Implementation Team.

METHODS

Data Collection

Susquehanna River

Adult American shad were sampled by Maryland Department of Natural Resources staff in the Conowingo Dam tailrace on the lower Susquehanna River two to four times per week from 22 April through 25 May 2021 (Figure 1). Staff angled American shad from shore, while also opportunistically sampling American shad caught by cooperative recreational anglers. Historically, Maryland Department of Natural Resources staff angled American shad from boat using two to three rods simultaneously; each rod was rigged with two shad darts and lead weight was added when necessary to achieve proper depth. This was not done in 2021 due to complications with boat access at the Conowingo Dam tailrace. Captured American shad were sexed (by expression of gonadal products), measured to the nearest mm (fork length [FL] and total length [TL]) and scales were removed below the insertion of the dorsal fin for aging and spawning history analysis. Fish in good physical condition, with the exception of spent or post-spawn fish, were tagged with Floy tags (color-coded by year) and released. A Maryland Department of Natural Resources hat was awarded for tags returned by recreational anglers.

Normandeau Associates, Inc. was responsible for observing and/or collecting American shad at the Conowingo Dam fish lifts. From 2001 to 2019, the East Fish Lift (EFL) emptied fish into a raceway that directed fish past a viewing window and into the pool above the dam. The West Fish Lift (WFL) captured fish for research purposes using a manual sorting process. Due to the COVID-19 pandemic, the WFL did not operate in 2020 and the EFL did not start operation until

12 May. The EFL only operated four days before it was shut down due to the passage of 21 northern snakehead *Channa argus* into Conowingo Pond. The EFL did not operate in 2021 to prevent the upstream passage of invasive species (specifically northern snakehead, blue catfish *Ictalurus furcatus*, and flathead catfish *Pylodictis olivaris*). The WFL did operate in 2021 and, in addition to collecting fish for research purposes, also collected American shad and river herring for the purposes of upstream transportation.

A non-random roving creel survey provided both American and hickory shad catch and effort data from recreational anglers in the Conowingo Dam tailrace, concurrent with the Maryland Department of Natural Resources American shad hook and line survey. Stream bank anglers were interviewed about shad catch that day and hours spent fishing. A voluntary logbook survey also provided location, hours fished and catch for American and hickory shad for each participating angler. Anglers could also participate in the logbook survey by recording fishing trips through the Volunteer Angler Shad Survey, created in 2014, on the Maryland Department of Natural Resources' website (http://dnr.maryland.gov/Fisheries/Pages/survey/index.aspx).

Maryland Department of Natural Resources' Fish Health and Hatcheries Program provided additional hickory shad data (2004–2021) from their brood stock collection. Hickory shad were collected in the Susquehanna River near Lapidum, MD for hatchery brood stock and were sub-sampled for age, repeat spawning marks, sex, length (FL) and weight. Fish were collected primarily by electrofishing, supplemented by hook and line fishing. Scale samples were taken from the first 20 fish per day for age determination.

Nanticoke River

Six commercial fyke nets and one pound net were surveyed for American shad, hickory shad and river herring between 11 March and 20 April 2021 (Figure 2). Fish captured from these nets were sorted according to species and transferred to the survey boat for processing. All nets were generally sampled once per week during the survey period. Fish were sexed (by expression of gonadal products), measured to the nearest mm (FL and TL) and scales were removed below the insertion of the dorsal fin for aging and spawning history analysis. The first ten alewife and the first ten blueback herring encountered per sampling day were sacrificed to remove otoliths for aging. A variety of other important sport fish were also measured to the nearest mm TL.

Ichthyoplankton sampling was conducted on the Nanticoke River in cooperation with the Fish Habitat and Ecosystem Program (Federal Aid Grant F-63–R, Segment 2, Job 1, Section 3) on three days between 8 April to 20 April 2021. The presence/absence of alosine eggs or larvae was noted (time and field conditions prevented species identification of alosine eggs or larvae). These samples were collected following historical methodology: the river was divided into eighteen one-mile cells and ten of these cells were randomly selected during each sampling day (Figure 3). The ichthyoplankton net was constructed of 500 μm mesh net with a 500 mm diameter frame. The net was towed with the tide for two minutes at approximately two knots. At the conclusion of the tow, the contents were flushed down into a mason jar and poured into a sorting pan for presence/absence determination.

Potomac River

The Striped Bass Spawning Stock Survey (SBSSS; Project 2, Job 3, Task 2) provided American shad scales from the Potomac River to examine age distribution and repeat spawning of fish in this river. American shad were captured in gill nets targeting striped bass from 5 April to 8 May 2021. All American shad were sexed and measured (FL and TL) to the nearest mm. A random subset of fish (10/sex/20mm length group) were scaled for age and spawning history analysis; scales were removed below the insertion of the dorsal fin.

North East River

A multi-panel anchored sinking gill net was deployed in the North East River to assess the adult river herring spawning stock. The gill net was fished at four randomly chosen sites once per week for 10 weeks from 10 March to 13 May 2021. Sampling locations were randomly assigned from a grid superimposed on a map of the system (Figure 4). The grid consisted of 112, 305 m x 305 m (1000 ft x 1000 ft) quadrats. Sampling sites were subsequently randomized for depth to determine if the net would be set in shallow or deep water within the quadrat. Four alternate sites were also randomly chosen and sampled in cases where the chosen site was inadequate. For example, if depth was below 1.8 m (6 ft) at a given site, the next available alternate site was selected.

Individual net panels were 30.5 m (100 ft) long and 1.8 m (6 ft) deep. The net had a 0.9 cm – 1.3 cm (0.4 – 0.5 in) poly-foamcore float line and a 22.7 kg (50 lb) lead line. Nets were hung with 61 m (200 ft) of stretch netting for every 30.5 m (100 ft) of net. From 2013 – 2014, the panels were constructed of 0.33 mm diameter monofilament twine in 6.4 cm (2.5 in), 7.0 cm (2.75 in) and 7.6 cm (3 in) mesh. In 2015, the 7.6 cm mesh panel was replaced with a 5.7 cm (2.25 in) mesh panel, as there was evidence that the previous mesh size selections were not effective in capturing smaller blueback herring. The three panels were tied together to fish simultaneously and were soaked for 30 minutes before retrieval. Panel order was randomly chosen before the net was assembled at the start of the survey for each year. Two nets were assembled annually, and routine maintenance to mend holes in the net was conducted throughout the sampling season.

Following deployment of the net, water quality (temperature [°C], salinity [ppt], dissolved oxygen [mg/L] and Secchi disk depth [m]), depth and tidal stage were recorded. All river herring were sexed and measured (TL and FL) to the nearest mm. Scales were removed from the first 20 alewife and the first 20 blueback herring encountered per panel for aging and spawning history analysis. The first ten alewife and the first ten blueback herring encountered per sampling day were sacrificed to remove otoliths for aging. Other recreationally important fishes were also measured to the nearest mm TL when time permitted.

Aging Protocol

Aging shad and river herring using scales is common practice, as it is the only non-lethal aging structure for these fishes. Since 1984, Maryland Department of Natural Resources staff have aged shad and river herring using scales, although methods for age determination have changed over time (Cating 1953; Elzey et al. 2015a). Many researchers have called into question the accuracy of scale aging (Elzey et al. 2015b). Hard structures, such as otoliths, often produce higher age agreement among readers compared to scales, though they lack repeat spawning information (Duffy et al. 2012; Elzey et al. 2015b). Only scales were aged in 2021 due to time constraints, sample availability and the desire to remain consistent across years.

Alosine scales collected from all rivers were aged following established protocols (Elzey et al. 2015a) as recommended by ASMFC aging experts. A minimum of four scales per sample were cleaned, mounted between two glass slides and read for age and spawning history using a Micron 385 microfiche reader. The scale edge was counted as an annuli due to the assumption that each fish had completed a full year's growth at the time of capture. Ages were not assigned to regenerated scales or to scales that were difficult to read. Repeat spawning marks were counted on all alosine scales during aging.

In 2021, age determination was done independently by three readers. In the event of a disagreement in the age or spawning mark estimates, the readers consulted with each other and either reached an agreement or deemed the scale unreadable. If a consensus age or spawning mark could not be determined jointly, the sample was eliminated from further analysis. Hickory shad scales from the Susquehanna River were aged by the Maryland Department of Natural Resources Fish Health and Hatcheries Program.

Data Analysis

Ichthyoplankton

The percent of positive tows (i.e., those containing alosine eggs or larvae) was determined as the number of tows with eggs and/or larvae divided by the total number of tows. These data have been reported since 2005.

Sex, Age and Stock Composition

Male-female ratios were derived for American shad, hickory shad and river herring from each system sampled. Alosine scales were collected from each system as described above. When the total number of samples per species for a river was greater than 300, approximately 300 random subsamples, proportional to catch by date, were processed for aging and then applied to total catch using an age-length key derived from the subsampled ages. The percentages of repeat spawners by species and system (sexes combined) were arcsine-transformed (in degrees) and then examined for linear trends over time. For all statistics, significance was determined at $\alpha = 0.05$.

Otoliths collected from American shad sampled at the Conowingo Dam were primarily used for hatchery versus wild origin determination. All hatchery produced juvenile American shad stocked in Maryland, Delaware and the Susquehanna River basin have unique fluorescent OTC marks. Otolith examination by the Pennsylvania Fish and Boat Commission (PFBC) indicated the percent of non-hatchery fish present from American shad collected in the WFL.

Adult Relative Abundance

Using catch-per-unit-effort (CPUE) as a measure of relative abundance is a common practice in fisheries science. Catch-per-unit-effort calculated using the arithmetic mean can often be biased by atypical sampling events with excessively high catches. Therefore, for most surveys in this project, CPUE was calculated using the geometric mean (GM CPUE), calculated as the average LN (CPUE + 1) for each fishing/sampling day, transformed back to the original scale. Geometric mean CPUE was calculated using the total number of adult fish lifted per hour of operation at the WFL at Conowingo Dam. Geometric mean catch-per-angler-hour (GM CPAH) for American shad angled in the Susquehanna River and hickory shad angled in Maryland were calculated from the data provided by the logbook survey (paper logbook data and online angler reports were combined) and roving creel survey. Start and end dates were defined by the first and last dates a fish was captured for both recreational surveys.

From 1988–1995, catches from all pound nets sampled on the Nanticoke River were factored into a measure of relative abundance (GM CPUE) for American shad. Methods were revised in 1996 to only include data from one pound net (Mill Creek) because it was consistently sampled over the time series; harvest from other pound nets was sporadic. Fyke nets were not included in the calculation because anecdotal evidence from the Nanticoke River suggested that they have a poor success rate in the capture of American shad relative to pound nets, rendering the efforts between the two methods uncomparable. Conversely, alewife and blueback herring GM CPUE was only calculated with fyke net data because pound nets were not consistently set in ideal habitats for river herring. Only sampling trips from the first to the last date of positive catch were included in GM CPUE calculations. No CPUE was calculated for hickory shad in the Nanticoke River due to the low number encountered by either gear type. In the Potomac River, the SBSSS calculated GM CPUE as the number of American shad caught per 914 square meters (1,000 square yards) of drift gill net per hour fished. There was a slight decrease in the fishing effort by the SBSSS in the Potomac River beginning in 2015. The program reduced the lengths of three smallest mesh panels (7.6 cm [3.0 in], 9.5 cm [3.75 in] and 11.4 cm [4.5 in]) from 45.7 m (150 ft) to 22.9 m (75 ft) in an attempt to catch fewer blue catfish.

The North East River gill net CPUE was estimated separately for alewife and blueback herring using catch from the 6.4 cm and 7.0 cm mesh panels, as these two panels were consistently sampled in all years. Alewife CPUE was calculated using the catch and effort data from the start of the survey until the end of the alewife spawning run. Conversely, blueback herring CPUE was calculated using catch and effort data from the start of the blueback herring spawning run until the end of the survey. Run times were estimated to start or end when the total weekly catch for a species was greater than one. Catch was pooled across mesh sizes for each trip, and a GM CPUE was reported as the number of fish caught per hour. A second GM CPUE calculation was completed for both river herring species using all meshes currently being fished (5.7 cm, 6.4 cm and 7.0 cm). Since the 5.7 cm inch mesh was only added in 2015, the resulting CPUE time series was truncated to 2015–2021. Each gill net mesh size has a size selectivity bias, and this bias cannot be totally removed by utilizing multiple mesh size panels (Hamely 1975; Millar and Fryer 1999).

Population Estimates

Chapman's modification of the Petersen method was used to estimate abundance of American shad in the Conowingo Dam tailrace (Chapman 1951):

$$N = (C+1)(M+1)/(R+1)$$

where N is the relative population estimate, C is the number of fish examined for tags after the annual tagging effort began, M is the number of fish tagged minus 3% tag loss and R is the number of tagged fish recaptured, excluding recapture of previous years' tags. Prior to 2001, data from both the EFL and WFL were used in the population estimate. Beginning in 2001, observations at the WFL were omitted to avoid double counting, as it became protocol for some fish captured at the WFL to be returned to the tailrace. However, in 2021, due to the EFL not operating, only data from the WFL were used. Calculation of 95% confidence limits (N^*) for the Petersen method were based on sampling error associated with recaptures in conjunction with Poisson distribution approximation (Ricker, 1975):

$$N^* = (C+1)(M+1)/(R^t+1)$$

where

$$R^t = (R+1.92) \pm (1.96\sqrt{(R+1)})$$

Mortality

Chapman-Robson methodology (Chapman and Robson 1960) was used to estimate total instantaneous mortalities (Z) of adult American shad, hickory shad and river herring from all systems surveyed where age data were available. Age composition data were used in the analysis, where the first age-at-full recruitment was the age with the highest frequency and estimates were only made when data was available from three or more age-classes (including first fully-recruited age). Total instantaneous mortality (Z) was calculated as:

$$Z = -1 * ln\ (\mathrm{T} / (N + T - 1))$$

where N is the total number of fully recruited fish and T was calculated as:

$$T = 0 * n_0 + 1 * n_1 + 2 * n_2 + \ldots A * n_A$$

where n_0 is the number of fish at the first fully recruited age, n_1 is the number of fish one year older than first fully recruited age and this is carried out for all age groups greater than the first fully recruited age (A). The Chapman-Robson estimate is less biased than traditional catch curve methods (Dunn et al. 2002) and was recommended for use by peer reviewers of the 2012 river herring benchmark stock assessment (ASMFC 2012).

Juvenile Abundance

The Maryland Department of Natural Resources Estuarine Juvenile Finfish Seine Survey (EJFS; Project 2, Job 3, Task 3) provided juvenile indices (geometric mean catch-per-seine-haul) for American shad and river herring from fixed stations in the Nanticoke River, the Potomac River and upper Chesapeake Bay dating back through 1959. The survey uses a 30.5 m (100 ft) x 1.24 m (4.1 ft) bagless beach seine of untreated 6.4 mm (0.25 in) bar mesh, which is set by hand. One end is held from shore and the other is fully stretched perpendicular from the beach, or until depths reach 1.6 m (5.2 ft), and is swept with the current. When depths do not exceed 1.6 m, the area swept is the equivalent to a 729 m^2 (2392 ft^2) quadrant. Hickory shad data are not reported by the EJFS due to historically infrequent encounters.

RESULTS

Larval Fish

Ichthyoplankton

Ichthyoplankton tows were conducted on three days in 2021. Fertilized alosine eggs and/or larvae were present at 52.3% of tow stations in 2021 (Figure 5). Salinity at tow stations ranged from 0.0 to 2.1 ppt. An absence of observed eggs and/or larvae occurred from 2006–2008, and in 2012.

American Shad

Sex, Age and Stock Composition

The male-female ratio of adult American shad captured by hook and line from the Conowingo Dam tailrace in 2021 was 1:1.23. Of the 293 fish sampled by this gear, 288 were successfully scale-aged (Table 1). Males were present in age groups three through seven and females were found in age groups four through seven. The 2016 year-class (age five) was the most abundant for males (40.7%) and the 2015 year-class (age six) was most abundant for females (39.9%; Table 2). Forty-six percent of males and 53.6% of females were repeat spawners (Figure 6). The arcsine-transformed proportion of repeat spawners (sexes combined) significantly increased over the time series (1984–2021; $R^2 = 0.68$, $P < 0.001$; Figure 7). Analysis by PFBC of 189 American shad otoliths collected from the WFL at Conowingo Dam showed that 64% were wild fish and 36% were hatchery-produced fish in 2021, which are similar to percentages estimated in 2019.

The male-female ratio for adult American shad captured in the Nanticoke River was 1:3.5. Of the 30 American shad collected from Nanticoke River pound and fyke nets in 2021, 27 were successfully analyzed for age and repeat spawning marks (Table 3). Males were present in age groups five and six, and females were present in age groups five through eight (Table 4). The 2015 year-class (age six) was the most abundant for females (66.7%; Table 4). Eighty-three percent of males and 66.7% of females were repeat spawners. The arcsine-transformed proportion of Nanticoke River repeat spawning American shad (sexes combined) has significantly increased over the time series (1988–2021; $R^2 = 0.31$, $P < 0.001$; Figure 8).

In response to increasing catches on the Potomac River, scales were only taken from a subsample of American shad beginning in 2017. The goal was to collect scales from ten individuals per sex per 20 mm length group for each year of the survey. Of the 99 total shad observed by the survey in 2021, 79 were scaled and successfully analyzed for age and repeat spawning marks (Table 5). An age-length key was applied to assign ages to the female population (Table 5). The male-female ratio for adult American shad captured in the Potomac River was 1:1.48. Males were present in age groups three through seven, and females were present in age groups four through eight (Table 6). The 2016 year-class (age five) was the dominant age group for males (37.5%), and the 2015 year-class (age six) was the dominant age group for females (49.2%; Table 6). Sixty percent of males and 66.1% of females were repeat spawners. The arcsine-transformed proportion of Potomac River repeat spawning American shad (sexes combined) showed no significant trend over the time series (2002–2021; Figure 9).

Adult Relative Abundance

Hook and line sampling from shore at the Conowingo Dam tailrace was conducted over 13 days in 2021. A total of 293 adult American shad were sampled by Maryland Department of Natural Resources staff. Peak sampling (92 fish) occurred on 6 May 2021 at a surface water temperature of 15°C. Maryland Department of Natural Resources staff tagged 276 (94%) of the sampled fish. Since all sampling was done from shore in 2021, an estimate of American shad relative abundance could not be calculated from the hook and line data. One tagged American shad was recaptured by a recreational angler in 2021.

The Conowingo WFL operated for 59 days between 1 April and 5 June 2021 and lifted a total of 6,825 American shad. Most American shad 79.3% (5,410 fish) were lifted between either 27 April and 3 May (2,499 fish) or 19 May and 28 May (2,911 fish) 2021. Peak passage was on 22 May, when 735 American shad were counted. During the period of lift operations in 2021, Conowingo Dam was in spill conditions on 12 May and 13 May, though the WFL was still able to operate during this time. Twenty-two tagged American shad were counted at the WFL and were identified as being tagged in 2021 (8% of the total number of shad tagged). Since the start of the tagging study in 1986, the percentage of tags recaptured at the fish lifts has significantly declined over time ($R^2 = 0.50$, $P < 0.001$; Figure 10). Of the 6,825 American shad lifted at the WFL, 6,413 were successfully transported upstream of the Safe Harbor Dam, 220 were released back downstream due to being in poor condition or spent, 136 were sacrificed for life history information, 42 were holding mortalities, 10 were lift mortalities and 4 were transport mortalities.

The Conowingo Dam fish lifts provided another opportunity to measure American shad relative abundance. Like all measures of relative abundance, there are caveats to accepting these indices as indicative of true abundance. Lift efficiency and river flows affected run counts at Conowingo Dam, while the number and frequency of lifts affected GM CPUE. Both indices measured in this region of the Susquehanna River showed a broad general trend that abundance was low in the 1990s, increased to a peak in the early 2000s and then declined to low levels of abundance (Figure 11).

Ninety interviews were conducted over eleven days during the creel survey at the Conowingo Dam tailrace. While GM CPAH increased in 2021 relative to 2019 (Figure 12), GM CPAH has decreased over the time series (2001–2021; $R^2 = 0.26$, $P = 0.018$). Two anglers returned paper logbooks in 2021. Forty-one anglers participated online by recording their trips through the Maryland Department of Natural Resources' Volunteer Angler Shad Survey (34 of these anglers fished in the Susquehanna River). American shad GM CPAH calculated from shad logbook data combined with data from Maryland Department of Natural Resources' Volunteer Angler Shad Survey decreased in 2021 relative to 2020 (Figure 12). Online angler data was included in the CPAH calculation beginning in 2014. The logbook GM CPAH estimate of adult American shad relative abundance peaked in 2001 but has exhibited no significant trend over the time series (2001–2021; Figure 12).

The Nanticoke River pound net GM CPUE increased in 2021; however, yearly estimates are highly variable and show no significant trend over the time series (1996–2021; Figure 13). Only the indices from 1996–2021 were used in the trend analysis because prior to 1996, estimates were calculated using all pound net data, not just Mill Creek. The Potomac River gill net CPUE significantly increased over the time series (1996–2021; $R^2 = 0.52$, $P < 0.001$; Figure 14).

Population Estimates

The Petersen method estimated 75,671 American shad in the Conowingo Dam tailrace in 2021, with an upper confidence limit of 112,140 fish and a lower confidence limit of 50,712 fish (Figure 15). The Petersen estimates followed a similar pattern to that of the lift GM CPUE estimates, with low numbers of American shad in the 1990s, increasing to a peak in the early 2000s and then declining to low numbers thereafter (Figure 15). American shad abundance has likely been relatively stable at low levels in recent years, though the estimate for 2021 is the lowest estimate since 1994.

Mortality

The Conowingo Dam tailrace total instantaneous mortality (Z) estimate for American shad, sexes combined, in 2021 was 0.93; there was no significant trend in mortality estimates from the Conowingo Dam over the time series (1984–2021; Figure 16). The Z estimate for American shad, sexes combined, in the Nanticoke River could not be calculated in 2021 due to a low sample size (Figure 17). The Potomac River Z estimate for American shad, sexes combined, in 2021 was 1.81; mortality increased significantly over the time series (2002–2021; $R^2 = 0.46$, $P < 0.001$; Figure 18).

Juvenile Abundance

Juvenile American shad abundance indices provided by the EJFS (1959–2021) demonstrated increased juvenile production in the Potomac River (R^2 = 0.36, P < 0.001; Figure 19), no significant trend in the upper Chesapeake Bay (Figure 20) and minor declines in the Nanticoke River (R^2 = 0.20, P < 0.001; Figure 21). Juvenile indices were not corrected for hatchery contribution.

Hickory Shad

Sex, Age and Stock Composition

Only one hickory shad was captured in the Nanticoke River pound and fyke net survey in 2021; the hickory shad sample size from this river is generally not large enough to draw meaningful conclusions about sex or age composition. In the Susquehanna River, 63 hickory shad were sampled by the broodstock collection survey in 2021. The male-female ratio was 1:1.03. All were successfully aged (Table 7). Males were present in age groups three through six and females were present in age groups three through seven (Table 8). The 2017 year-class (age 4) was the most abundant year-class for both males (61.3%) and females (46.9%; Table 8). The arcsine-transformed proportion of repeat spawners (sexes combined) decreased significantly over the time series (2004–2021; R^2 = 0.49, P = 0.001; Figure 22).

Relative Abundance

Hickory shad GM CPAH in 2021 for both the creel survey and the logbook survey marginally increased from the previous year (Figure 23). Hickory shad relative abundance from both the creel and logbook surveys show no significant trend over time.

Mortality

Total instantaneous mortality (Z) for hickory shad, sexes combined, in the Susquehanna River was estimated to be 1.03, which increased from 2019 (Z = 0.85). Mortality has gradually increased over the time series (2004–2021; R^2 = 0.25, P = 0.026; Figure 24).

Alewife and Blueback Herring

Sex, Age and Stock Composition

The 2021 male-female ratio for Nanticoke River alewife was 1:1.73. Of the total 393 alewife observed by the survey, 190 were subsequently aged. Alewife were present from ages three to eight and the 2016 year-class (age five, sexes combined) was the most abundant, accounting for 35.8% of the total catch (Table 9). The 2021 male-female ratio for Nanticoke River blueback herring was 1:4.13. Of the 44 blueback herring sampled, 34 were subsequently aged. Blueback herring were present from ages three to six and the 2016 year-class (age five, sexes combined) was the most abundant, accounting for 55.9% of the sample (Table 10). Blueback herring ages nine through eleven have not been observed since 2000 (Table 10).

For the Nanticoke River, 44.7% of alewife and 41.2% of blueback herring were repeat spawners (sexes combined) in 2021. There was no trend in the arcsine-transformed proportion of alewife repeat spawners over the time series (1990–2021; Figure 25). Blueback herring repeat spawning decreased over the same time period (1990–2021; R^2 = 0.57, P < 0.001; Figure 25). Alewife mean length (FL mm) from the Nanticoke River varied without trend since the inception of this survey (1989–2021; Figure 26), while blueback herring mean length (FL mm) significantly decreased across the time series (1989–2021; R^2 = 0.27, P = 0.001; Figure 26).

Since the inception of the North East River gill net survey, more female alewife were encountered by the gear than male alewife. The male-female ratio for alewife in 2021 was 1:1.13.

Alewife of ages three to eight were present in 2021. The 2017 (age four) year-class was the dominant age group for both males and females in 2021, comprising 34.8% and 39.3% of the sample, respectively (Table 11). Female blueback herring catch far exceeded that of males in 2021; the male-female ratio for blueback herring was 1:2.35. Blueback herring were present from ages three to eight in 2021. The 2015 (age six) year-class for blueback herring was the most abundant in 2021, comprising 28.0% of the sample (Table 12). Thirty-four percent of alewife and 61.0% of blueback herring were repeat spawners in 2021 (sexes combined). No significant trend in the occurrence of repeat spawning alewife (2013–2021; Figure 27) or blueback herring (2013–2021; Figure 27) was observed over the time series.

Adult Relative Abundance

Data from six fyke nets on the Nanticoke River were used to calculate relative abundance of river herring in 2021. The GM CPUE for Nanticoke River alewife has decreased over the time series (1990–2021; $R^2 = 0.22$, $P = 0.006$; Figure 28). The GM CPUE for blueback herring has also decreased over the time series (1989–2021; $R^2 = 0.55$, $P < 0.001$; Figure 28).

The North East River gill net survey captured 769 alewife, which was the highest total catch in the history of the survey, and 478 blueback herring. Peak catch of alewife (217 fish) occurred on 31 March 2021 when the water temperature was 13°C (Figure 29). Peak catch of blueback herring (218 fish) occurred on 4 May 2021 when the water temperature was 18.1°C (Figure 29). Similar to most years, the majority of alewife (54%) were caught in the 6.4 cm (2.5 inch) mesh in 2021 (Table 13). The majority of blueback herring (52%) were caught in the 5.7 cm (2.25 inch) mesh in 2021 (Table 14).

Geometric mean CPUE estimates for the North East River survey were made with pooled catches from the 6.4 cm and 7.0 cm meshes, as those meshes were fished since the inception of the survey. No significant linear trends were observed over the time series for either species (2013–2021; Figure 30). Geometric mean CPUE was also calculated with catch pooled for the 5.7 cm, 6.4 cm and 7.0 cm meshes, resulting in the truncation of the time series to 2015–2021. This method produced similar year to year changes in GM CPUE, and no significant trends were observed for alewife or blueback herring (2015–2021; Figure 31). Total catches of other fish are noted in Table 15.

Mortality

Total instantaneous mortality (Z) for Nanticoke River alewife (sexes combined) in 2021 was estimated to be 0.93. Total instantaneous mortality for Nanticoke River blueback herring could not be calculated in 2021 due to a low sample size. There was no significant trend in mortality estimates for either species over the time series (1989–2021; Figure 32; 1989–2019; Figure 33). The 2021 Z estimate for alewife from the North East River was 0.75 and the blueback herring estimate was 2.14. There was no significant trend in mortality estimates for either species over the time series (2013–2021; Figure 34).

Juvenile Abundance

Data provided by the EJFS (1959–2021) indicated that juvenile GM CPUE of alewife has declined over time in the Nanticoke River ($R^2 = 0.09$, $P = 0.011$; Figure 35) and in the Potomac River ($R^2 = 0.11$, $P = 0.005$; Figure 36), but no significant trend exists in the upper Chesapeake Bay (Figure 37). Blueback herring juvenile GM CPUE has declined in the Nanticoke River ($R^2 = 0.55$, $P < 0.001$; Figure 35) and in the upper Chesapeake Bay ($R^2 = 0.05$, $P = 0.037$; Figure 37), but no significant trend exists in the Potomac River (Figure 36).

DISCUSSION

American Shad

American shad were historically one of the most important fish species in North America, but the stock drastically declined throughout the twentieth century due to the loss of habitat, overfishing, ocean bycatch, stream blockages, pollution and exposure to invasive predators. American shad restoration in the upper Chesapeake Bay began in the 1970s with the building of fish lifts and the stocking of juvenile American shad. Maryland closed both the commercial and recreational American shad fisheries in 1980, and the ocean intercept fishery closed in 2005. While the American shad adult stock has shown some improvement in select river systems, a 2020 ASMFC stock assessment indicated that most stocks have not recovered and populations remain near historic lows (ASMFC 2020).

The population size of American shad in the lower Susquehanna basin has been relatively stable since 2010, although at a much lower level than the peak observed in the early 2000s and compared to historical abundance. However, since the population of American shad is not closed during sampling (i.e., mortality, immigration and emigration are occurring), the Petersen method likely overestimates the population size. The recapture rates of tagged American shad have also drastically declined over the past twenty years, so any comparisons of population size estimates among years should be made with caution. Therefore, the trend in population size, rather than the actual estimates themselves, should be emphasized when assessing the American shad population at the Conowingo Dam tailrace.

Estimates of relative abundance for the lower Susquehanna River also show peaks in abundance around 2001, followed by declines thereafter. The recreational creel and logbook survey GM CPAH has been relatively stable since 2004; however, Conowingo lift totals and GM CPUE have only partially stabilized in recent years. American shad lift totals briefly increased in

2016 and 2017 but less than 8,000 shad have been lifted per year since then, which are the lowest totals since 1988.

While American shad abundances decreased in the lower Susquehanna basin over the past 20 years, this has not been the trend in other Maryland systems. Pound net GM CPUE (1988–2021) in the Nanticoke River indicated that the abundance of American shad in the river remained relatively stable over the past 30 years, though trends in juvenile catch indicated that American shad were more abundant in the river over 50 years ago. In the upper Chesapeake, after many years of minimal juvenile production from the early 1980s through the mid-1990s, there were several years of successful spawns. In the Potomac River, both adult and juvenile relative abundance significantly increased over time. Both indices increased in the early 2000s and mid-2010s, followed by years of relatively stable catch. However, these increases in relative abundance have also coincided with increasing levels of total mortality (*Z*), with 2021 having the highest estimate in the history of the survey. These high levels of mortality resulted in the 2020 benchmark stock assessment finding adult mortality in the river to be at unsustainable levels (ASMFC 2020).

The percent of repeat spawning American shad below the Conowingo Dam increased over time. The percent of repeat spawners was usually less than 10% in the Conowingo Dam tailrace throughout the 1980s (Weinrich et al. 1982). In contrast, 50% of aged American shad at the Conowingo Dam were repeat spawners in 2021, and on average, 47% of aged fish were repeat spawners over the past five years. Similar estimates of repeat spawning were observed in recent years for American shad collected from Virginia rivers (Hilton et al. 2022) and from the Potomac River, which is unimpeded by dam construction within the natural migration range of anadromous fishes. The average percent of repeat spawners from the Potomac River was 17% in the 1950s (Walburg and Sykes 1957), but was 64% in 2021 (Table 6). While increased repeat spawning in these river systems may indicate increased survival of adult fish, it could also be a sign of poor recruitment (i.e., few virgin fish showing up to spawn).

Significant resources have been invested in the restoration of American shad in the Susquehanna River basin. While initial restoration efforts were successful, population declines over the past 20 years and the arrival of new invasive predators have cast uncertainty over the long-term viability of the species in the river. Population declines may be driven in part by the limited suitable spawning habitat below Conowingo Dam, poor upstream passage efficiency, low stocking success, poor water quality and offshore bycatch. Declines in recapture rates of tagged American shad at the Conowingo Dam fish lifts also indicate that a lower percentage of American shad in the Conowingo Dam tailrace are using the fish lifts than in the past. While the reason for this is unknown, it could be due to increasing gizzard shad, *Dorosoma cepedianum*, populations overcrowding the fish lifts, precluding other anadromous fish species from entering them (SRAFRC 2010). While increasing gizzard shad abundance at the dam may be independent of American shad recapture rates, there is a strong negative correlation between the two since 1997 (1997–2021; $R^2 = 0.49$, $P < 0.001$; Figure 38).

The relicensing agreement for the Conowingo Dam included more than $200 million to improve both upstream and downstream fish passage, water quality and environmental monitoring. Trap and transport will also again be used to transport American shad upstream. From 1985 to 1996, most American shad that were lifted at the Conowingo Dam were placed in a holding tank and transported upstream of the York Haven Dam. The York Haven Dam is the last of the four downstream dams on the Susquehanna River, so any shad transported above it had access to 60 miles of unimpeded river for spawning habitat. Beginning in 1997, upon completion of fish lifts at the three most downstream dams, the EFL began releasing fish directly upstream into Conowingo Pond, and only a portion of shad (6%) were trapped and transported. Following the completion of York Haven Dam's fish ladder in 2000, trap and transport was suspended in favor of volitional passage. Unfortunately, while all four dams passed record numbers of American shad in 2001, those numbers drastically declined in subsequent years.

The trap and transport program was reinstated in 2021 when increases in invasive predator populations at Conowingo Dam caused volitional passage to be suspended. Volitional passage will remain suspended through at least 2025, meaning trap and transport will be the only mode of upstream transportation for the next several years. In 2021, American shad were only transported upstream of the Safe Harbor Dam (i.e., south of the York Haven Dam); however, fish will also be transported upstream of the York Haven Dam starting in 2022. If the trap and transport of American shad was one of the primary reasons for the population increase seen in the 1990s, and if the suspension of it was partially responsible for the subsequent decline, American shad populations at the Conowingo Dam could increase again as early as 2024 when part of the 2021 year-class returns.

Hickory Shad

Hickory shad stocks in Maryland and along the U.S. Atlantic Coast have drastically declined due to habitat loss, overfishing, stream blockages and pollution. A statewide moratorium on the harvest of hickory shad in Maryland waters was implemented in 1981 and is still in effect today. Adult hickory shad are difficult to capture due to their aversion to fishery independent (fish lifts) and dependent (pound and fyke net) gears, which makes assessing their populations difficult. Very few hickory shad have ever been observed using the fish lifts at the Conowingo Dam, with no more than 20 hickory shad being counted at the EFL viewing window during a given year. Despite these low numbers of hickory shad, Deer Creek (a tributary of the Susquehanna River, downstream of Conowingo Dam) has some of the greatest densities of hickory shad in Maryland (Richardson et al. 2009).

Prior to 2012, hickory shad age distribution was relatively consistent, with a wide range of ages, up to age-nine, and a high percentage of older fish. Age distribution has truncated since that time, and only a single age-seven fish was present in 2021. Richardson et. al (2004) found 90% of hickory shad from the upper Chesapeake Bay had spawned by age four, and this stock generally consisted of few virgin fish. Since then, the percentage of repeat spawning fish decreased significantly over the time series. Fewer older fish combined with a smaller proportion of repeat spawners may indicate poor year-classes and/or an increase in mortality at older ages.

Estimates of total mortality (*Z*) are primarily attributed to natural mortality (*M*) because only a catch and release fishery exists for hickory shad in Maryland. Hickory shad ocean bycatch is minimized compared to the other alosines because both mature adults and immature sub-adults migrate and overwinter closer to the coast (ASMFC 2009). This is confirmed by the fact that few hickory shad are observed portside as bycatch in the ocean small-mesh fisheries (Matthew Cieri, Maine Dep. Marine Res., pers. comm.).

Adult hickory shad may spawn up to six weeks before American shad (late March to late April versus late April to early June), and juvenile hickory shad reach a larger size earlier in the summer. Juveniles also exhibit negative phototaxis, migrating to deeper, darker water away from the shallow beaches sampled by haul seines. Because of their larger size, ability to avoid gear and preference for deeper water, sampling for juvenile hickory shad from mid-summer through fall is generally unsuccessful (Richardson et al. 2009).

Alewife and Blueback Herring

The 2012 river herring benchmark stock assessment attributed high mortality of river herring to a combination of factors including commercial fishing (in-river directed and ocean bycatch), inadequate access to habitats, impaired water quality, excessive predation and climate change (ASMFC 2012). The most recent stock assessment, released in 2017, showed the coastwide meta-complex of river herring stocks on the U.S. Atlantic coast was depleted to near historic lows, and declines in mean length of at least one age were observed in most rivers examined (ASMFC 2017). The coastwide assessment corroborated the low indices of abundance for adults and juveniles of both species observed in the Nanticoke River by this project through 2021.

Alewife and blueback herring relative abundance declined in the North East River in 2021 relative to 2019, but no significant trends were detected over time (2013–2021). Based on weekly run times, it appears that sampling in 2021 overlapped with the majority of the alewife spawning run; however, the survey appeared to only sample just past the peak of the blueback spawning run. The annual variation in spawning runs makes it difficult to appropriately compare GM CPUE across years. While using positive catch to determine the start and end of spawning runs for calculating GM CPUE is likely to capture true run times more accurately, it is also more likely to underestimate true abundance during years of protracted spawning runs (e.g., extra weeks of low but positive catch will result in a lower abundance estimates than if there was no catch those weeks). As the survey nears its tenth year, a more advanced model that can incorporate time of year and/or water temperature may be more appropriate for examining trends in relative abundance.

The age distribution of river herring in the North East River and the Nanticoke River is similar to that of other river herring populations in the region (Hilton et al. 2022), but should be interpreted with caution. Results from the ASMFC River Herring Aging Workshop found that precision among states and even within aging labs was low and highly variable (ASMFC 2013). The workshop also revealed otolith ages to be younger than scale ages for younger fish and otolith ages to be older than scale ages for older fish. More research is required with known age fish to validate aging methods for these species, as was recommended by the 2012 River Herring Stock Assessment (ASMFC 2012).

Mortality estimates in 2021 were higher for blueback herring than alewife in both the Nanticoke and North East rivers. In the North East River, mortality estimates appear to be strongly influenced by individual year-classes. For instance, the 2011 alewife, 2014 alewife and 2015 blueback herring year-classes were each the most abundant year-classes for three separate years of the survey. These strong year-classes resulted in low Chapman-Robson mortality estimates when the year-classes were young, and high mortality estimates as the year-classes advanced in age. Therefore, these mortality estimates for river herring in the North East River should be interpreted with care.

Juvenile river herring abundance has either declined over time or no trend is present in all systems monitored by the Maryland Department of Natural Resources. In most systems, abundance was highest in the 1960s, declined in the 1970s and has remained stable at low levels since. Any increases in abundance have been brief, not long enough to sustain a trend and often followed by brief declines in abundance.

Amendment 2 of the ASMFC Interstate Fishery Management Plan for American Shad and River Herring required states to develop and implement a sustainable fishery plan for jurisdictions wishing to maintain an open commercial or recreational fishery. Due to declines and persistently low levels of river herring in Maryland, a moratorium on the possession of river herring went into effect on 26 December 2011. The moratorium on river herring eliminated any directed in-river fishing mortality experienced by these species, and there are several efforts underway to reduce incidental catch of river herring in ocean fisheries as well. Beginning in 2014, the Mid-Atlantic and New England Fisheries Management Councils placed incidental catch caps for river herring and American shad on the Atlantic herring and mackerel fleets (Federal Register 2014a, 2014b). Genetic studies suggest a high proportion of Mid-Atlantic blueback herring are caught as incidental catch in the southern New England Atlantic herring fishery (78% of samples; Hasselman et al. 2015), which could contribute to the high mortality of blueback herring estimated by this project. However, the fishing effort in the Atlantic Herring fishery has declined substantially in recent years due to reduced quota. This quota reduction, combined with the aforementioned catch caps, substantially reduced the magnitude of at sea bycatch.

Invasive predators in the Chesapeake Bay region also pose a threat to alosines. Flathead catfish and blue catfish are documented predators of alosine (Moran et al. 2016). Results from Schmitt et al. (2017) demonstrated that flathead catfish of all sizes were highly piscivorous and displayed an affinity for the consumption of blueback herring and American shad. Blue catfish, while certainly a predator of alosines, tended to be more opportunistic and displayed fewer conclusive selectivity patterns. In addition, while diet studies showing direct predation by northern snakehead on river herring are lacking, this predation is likely occurring given that northern snakehead in Maryland ecosystems have been found to be opportunistic piscivores, capable of consuming significant biomasses of fishes (Love and Newhard 2021). Thus, the lack of improvement to river herring stocks in Maryland, despite stricter fishing regulations, may be partially due to increases in predation by invasive predators.

PROJECT NO. 2
JOB NO. 1

STOCK ASSESSMENT OF ADULT AND JUVENILE ALOSINE SPECIES IN THE CHESAPEAKE BAY AND SELECTED TRIBUTARIES

2022 PRELIMINARY RESULTS - WORK IN PROGRESS

Analysis of the data collected in 2022 for Project 2, Job 1 to assess trends in adult and juvenile alosine species in the Chesapeake Bay and selected tributaries is currently in progress. Data were collected by several surveys of American shad, hickory shad and river herring (i.e., alewife and blueback) in the Susquehanna, Potomac and North East rivers. Sampling did not occur in the Nanticoke River due to the watermen not fishing in the historical sampling area.

River herring were independently sampled using a gill net deployed in the North East River at four randomly chosen sites once a week from 10 March to 11 May 2022. The gill net was set 38 times (2 sites were lost due to gear issues) and encountered 535 alewife and 360 blueback herring. A total of 300 alewife scale samples and 360 blueback herring scale samples are being processed for aging.

Adult American shad were angled by staff from the lower Susquehanna River one to four times per week from 22 April through 26 May 2022. Through 16 May, Maryland Department of Natural Resources staff angled American shad from shore, while also opportunistically sampling American shad caught by willing recreational anglers. However, permission for boat access at the dam was granted in mid-May, so the sampling of American shad was done from boat starting on 17 May through the rest of the month. In total, staff encountered 113 adult American shad, 105 of which were marked with Floy tags to formulate mark-recapture population estimates. Male American shad ranged in size from 328 - 422 mm FL and female American shad ranged in size from 356 – 467 mm FL. Recreational angler logbook and creel surveys were completed as usual in 2022.

The Striped Bass Spawning Stock Survey (SBSSS; Project 2, Job 3, Task 2) gill net survey in the Potomac River was also completed as usual in 2022. A total of 98 American shad were caught, 82 of which were scaled for age and repeat spawning analysis. Preliminary analysis indicates that CPUE increased slightly in 2022, reversing two years of declines in 2020 and 2021.

The complete analyses of the data collected in 2022 to assess trends in adult and juvenile alosine species will appear in the next F-61 Chesapeake Bay Finfish Investigations report.

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LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

Table 1. Percent catch-at-age for American shad, sexes combined, angled from the Conowingo Dam tailrace, 1982–2021.

Year	N	Mean Age	Age							
			2	3	4	5	6	7	8	9
1982	73	3.88	0	25	63	12	0	0	0	0
1983	9	4.89	0	0	11	89	0	0	0	0
1984	124	4.31	0	24	36	26	11	2	0	0
1985	174	4.40	0	13	48	28	10	1	0	0
1986	425	4.00	0	24	53	22	1	0	0	0
1987	386	4.17	0	17	49	33	1	0	0	0
1988	252	4.00	1	25	49	21	3	0	0	0
1989	269	4.29	0	17	43	32	7	0	0	0
1990	305	4.56	0	5	45	39	9	1	0	0
1991	347	5.08	0	2	19	49	27	2	0	0
1992	371	5.12	0	5	16	48	22	8	0	0
1993	233	4.87	0	3	36	36	21	4	0	0
1994	435	4.77	0	3	33	50	12	2	0	0
1995*	620	4.88	0	2	25	52	19	1	0	0
1996*	446	4.75	0	6	34	36	22	2	0	0
1997*	606	4.92	0	10	42	33	12	2	0	0
1998	308	4.68	0	3	44	38	11	2	0	0
1999*	821	4.50	0	9	44	39	7	0	0	0
2000*	737	4.59	0	1	52	41	5	1	0	0
2001*	969	4.83	0	4	27	48	20	2	0	0
2002*	800	5.21	0	2	20	37	29	12	1	0
2003	781	4.96	0	2	29	38	22	8	0	1
2004	386	5.05	0	2	21	52	22	3	0	0
2005	385	5.22	0	2	26	31	32	9	1	0
2006	338	4.65	0	5	46	35	7	4	2	0
2007	449	4.82	0	4	36	38	20	1	1	0
2008	161	4.60	0	4	48	36	11	1	0	1
2009	622	4.45	0	3	59	30	8	1	0	0
2010	437	4.64	0	3	43	43	10	1	0	0
2011	172	5.13	0	0	19	52	27	2	0	0
2012	177	5.36	0	3	18	34	32	13	1	0
2013	297	6.03	0	0	5	30	33	24	6	2
2014	428	5.37	0	1	13	43	35	8	0	0
2015	279	4.77	0	8	29	45	15	3	0	0
2016	366	5.09	0	1	15	59	23	2	0	0
2017	264	4.67	0	5	33	52	10	0	0	0

* indicates years where not all fish were aged and an age-length key was subsequently used to assign ages.

Table 1. (Continued)

Year	N	Mean Age	Age							
			2	3	4	5	6	7	8	9
2018	160	5.16	0	3	14	52	28	3	1	0
2019	44	5.27	0	0	25	34	32	7	2	0
2020	-	-	-	-	-	-	-	-	-	-
2021	288	5.27	0	1	21	38	30	10	0	0

Table 2. Number of adult American shad and repeat spawners by sex and age sampled from the Conowingo Dam tailrace (hook and line) in 2021.

Age	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
3	3	0	0	0	3	0
4	43	9	18	3	61	12
5	55	23	54	25	109	48
6	24	20	61	39	85	59
7	10	10	20	15	30	25
Totals	135	62	153	82	288	144
Percent Repeats	45.9%		53.6%		50.0%	

Table 3. Percent catch-at-age for American shad, sexes combined, captured in the Nanticoke River, 1989–2021.

Year	N	Mean Age	Age								
			2	3	4	5	6	7	8	9	10
1989	335	4.36	0	13	54	23	5	2	2	0	0
1990	291	4.92	0	2	28	53	12	4	1	0	0
1991	372	4.97	0	6	26	42	19	6	1	0	0
1992	135	5.41	1	3	16	32	31	17	0	0	0
1993	199	5.65	1	1	14	39	22	15	7	2	1
1994	146	4.41	1	17	39	31	9	3	1	0	0
1995	126	4.73	1	7	33	39	19	2	0	0	0
1996	112	4.84	0	8	34	33	16	9	0	0	0
1997	84	4.65	0	8	44	30	11	6	1	0	0
1998	65	4.82	0	5	34	42	15	5	0	0	0
1999	23	4.87	0	4	26	52	13	4	0	0	0
2000	185	4.69	0	4	43	38	14	1	2	0	0
2001	102	4.80	0	12	26	34	25	3	0	0	0
2002	138	5.02	0	8	30	24	30	8	1	0	0
2003	126	5.17	0	2	25	39	26	8	1	0	0
2004	56	4.88	0	5	27	48	14	5	0	0	0
2005	40	5.33	0	5	25	30	23	10	5	3	0
2006	8	4.88	0	25	0	63	0	0	13	0	0
2007	65	4.58	0	12	43	32	5	3	3	2	0
2008	40	4.23	0	25	45	20	8	0	0	3	0
2009	80	4.48	0	9	45	39	5	3	0	0	0
2010	33	4.88	0	6	24	45	24	0	0	0	0
2011	62	4.45	0	10	47	34	8	2	0	0	0
2012	174	4.97	0	3	24	41	26	4	0	0	0
2013	31	6.35	0	0	0	16	52	16	13	3	0
2014	69	5.67	0	0	13	28	43	13	1	1	0
2015	-	-	-	-	-	-	-	-	-	-	-
2016	50	5.54	0	2	14	38	24	18	4	0	0
2017	36	4.67	0	8	36	36	19	0	0	0	0
2018	5	4.80	0	0	20	80	0	0	0	0	0
2019	40	5.30	0	0	18	45	28	10	0	0	0
2020	-	-	-	-	-	-	-	-	-	-	-
2021	27	5.93	0	0	0	26	63	4	7	0	0

Table 4. Number of adult American shad and repeat spawners by sex and age sampled from the Nanticoke River (pound and fyke nets) in 2021.

Age	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
5	3	3	4	3	7	6
6	3	2	14	9	17	11
7	0	0	1	0	1	0
8	0	0	2	2	2	2
Totals	6	5	21	14	27	19
Percent Repeats	83.3%		66.7%		70.4%	

Table 5. Percent catch-at-age for American shad, sexes combined, captured in the Potomac River, 2002–2021.

Year	N	Mean Age	Age							
			3	4	5	6	7	8	9	10
2002	48	5.65	2	19	17	40	21	2	0	0
2003	141	5.52	1	22	31	26	11	8	1	0
2004	97	5.38	0	21	36	33	5	5	0	0
2005	97	5.20	1	34	28	25	9	1	1	1
2006	52	5.44	2	25	27	31	8	4	4	0
2007	200	4.44	7	57	27	8	1	1	1	0
2008	176	4.60	6	45	36	9	3	1	0	0
2009	31	5.90	0	16	19	39	16	6	0	3
2010	75	4.75	7	48	27	9	4	3	3	0
2011	56	4.98	13	18	36	27	7	0	0	0
2012	67	5.75	0	6	40	31	18	4	0	0
2013	105	6.38	0	1	10	50	30	9	0	1
2014	105	6.12	0	0	16	58	23	3	0	0
2015	120	5.35	3	8	46	35	8	0	0	0
2016	140	5.26	0	14	54	25	6	1	0	0
2017*	140	5.18	1	14	50	34	1	0	0	0
2018*	182	5.91	0	2	23	59	13	4	0	0
2019*	284	5.68	2	13	19	45	20	1	0	0
2020*	140	5.57	0	15	23	40	19	4	0	0
2021*	99	5.33	3	17	32	39	7	1	0	0

* indicates years where not all fish were aged and an age-length key was subsequently used to assign ages.

Table 6. Number of adult American shad and repeat spawners by sex and age sampled from the Potomac River (gill net) in 2021.

Age	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
3	3	0	0	0	3	0
4	11	2	6	0	17	2
5	15	12	17	8	32	20
6	10	10	29	24	39	34
7	1	0	6	6	7	6
8	0	0	1	1	1	1
Totals	40	24	59	39	99	63
Percent Repeats	60.0%		66.1%		63.6%	

Table 7. Percent catch-at-age for hickory shad, sexes combined, sampled by the brood stock collection survey in the Susquehanna River and Deer Creek (a lower Susquehanna tributary), 2004–2021.

Year	N	Mean Age	Age							
			2	3	4	5	6	7	8	9
2004	80	5.3	0	8	24	28	19	19	4	0
2005	80	5.4	0	6	18	29	34	11	1	1
2006	178	4.9	1	9	32	30	20	7	2	0
2007	139	5.2	0	7	24	34	21	12	2	1
2008	149	4.9	0	9	30	34	20	5	2	0
2009	118	5.1	0	8	17	45	20	10	1	0
2010	240	4.6	0	13	38	31	11	7	0	0
2011	216	4.3	0	30	30	27	9	3	1	0
2012	200	4.2	0	27	40	25	8	2	0	0
2013	193	4.2	0	21	46	24	8	1	0	0
2014	100	4.5	0	11	37	40	12	0	0	0
2015	113	4.0	1	30	43	20	5	0	0	0
2016	120	4.4	0	21	31	36	12	1	0	0
2017	59	4.5	0	17	31	37	14	2	0	0
2018	40	4.3	0	15	53	25	8	0	0	0
2019	98	4.5	0	14	45	25	11	4	1	0
2020	-	-	-	-	-	-	-	-	-	-
2021	63	4.4	0	6	54	30	8	2	0	0

Table 8. Number of adult hickory shad and repeat spawners by sex and age sampled from the brood stock collection survey in the Susquehanna River in 2021.

Age	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
3	3	0	1	0	4	0
4	19	3	15	1	34	4
5	8	5	11	2	19	7
6	1	1	4	2	5	3
7	0	0	1	1	1	1
8	0	0	0	0	0	0
Totals	31	9	32	6	63	15
Percent Repeats	29. 0%		18. 8%		23. 8%	

Table 9. Percent catch-at-age for adult alewife, sexes combined, sampled from the Nanticoke River from 1989–2021.

Year	N	Mean Age	Age							
			2	3	4	5	6	7	8	9
1989	435	4.79	0	5	37	38	16	4	0	0
1990	749	5.02	0	9	23	38	22	5	3	0
1991	850	4.78	0	3	48	26	15	6	1	1
1992	778	4.87	0	5	28	49	12	5	1	0
1993	637	5.16	0	3	24	38	28	6	2	0
1994	642	4.98	0	6	25	40	22	7	0	0
1995*	728	4.83	0	6	42	30	15	8	0	0
1996*	548	4.47	0	21	37	27	9	4	1	0
1997	256	4.52	0	9	47	31	9	1	2	0
1998	271	4.68	0	4	45	34	14	3	0	0
1999	317	4.93	0	9	21	40	27	2	0	0
2000	228	4.44	0	7	59	21	11	3	0	0
2001	239	4.68	0	7	36	43	11	3	0	0
2002	282	5.26	0	1	21	35	35	7	1	0
2003	168	5.21	0	4	19	35	35	7	0	0
2004	203	5.04	0	6	31	31	21	9	3	0
2005	169	4.99	0	4	40	25	19	11	2	0
2006	170	5.10	0	4	18	49	23	4	2	0
2007	218	4.81	0	7	40	27	19	6	1	0
2008	183	4.99	0	4	27	45	15	8	1	1
2009	216	4.80	0	4	38	35	18	5	0	0
2010	69	5.09	0	3	28	33	30	6	0	0
2011	182	4.93	0	4	36	28	25	5	1	0
2012*	527	4.83	0	13	31	33	18	5	0	0
2013	128	5.06	0	6	24	38	22	9	1	0
2014*	564	4.79	0	2	32	51	13	2	1	0
2015	-	-	-	-	-	-	-	-	-	-
2016*	1058	5.10	0	2	16	55	26	1	0	0
2017*	586	4.37	0	21	31	34	13	1	0	0
2018	172	4.37	0	17	47	22	11	3	0	0
2019*	959	4.66	0	3	45	35	12	4	1	0
2020	-	-	-	-	-	-	-	-	-	-
2021	189	5.03	0	2	34	36	17	8	3	0

* indicates years where not all fish were aged and an age-length key was subsequently used to assign ages.

Table 10. Percent catch-at-age for adult blueback herring, sexes combined, sampled from the Nanticoke River from 1989–2021.

Year	N	Mean Age	Age									
			2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1989	701	5.07	0	2	32	35	22	7	2	0	0	0
1990	732	5.76	0	2	15	29	25	20	6	2	1	0
1991	719	5.57	0	2	24	21	29	15	6	2	0	0
1992	258	5.68	0	3	21	24	23	17	9	2	0	0
1993	509	5.73	0	1	13	32	28	16	6	2	0	0
1994	452	4.94	0	6	29	38	19	6	1	0	0	0
1995	65	5.00	0	8	35	25	20	8	5	0	0	0
1996	223	4.77	0	3	38	42	13	1	2	0	0	0
1997	347	5.41	0	4	15	30	43	7	1	0	0	0
1998	232	5.34	0	3	26	27	27	16	1	0	0	0
1999	123	5.04	0	7	19	46	23	7	0	0	0	0
2000	198	4.66	0	6	51	25	11	6	1	0	0	1
2001	105	4.54	0	8	45	35	10	2	0	0	0	0
2002	146	4.70	0	6	35	44	14	1	0	0	0	0
2003	128	4.96	0	2	30	41	21	4	1	0	0	0
2004	132	4.65	0	12	37	33	9	8	1	0	0	0
2005	18	4.17	0	22	50	17	11	0	0	0	0	0
2006	68	4.82	0	3	28	54	13	1	0	0	0	0
2007	74	4.20	0	26	41	24	7	3	0	0	0	0
2008	82	4.44	0	10	51	30	4	4	1	0	0	0
2009	66	4.06	0	21	56	20	2	2	0	0	0	0
2010	26	4.38	0	8	58	23	12	0	0	0	0	0
2011	122	4.42	0	7	55	27	10	1	0	0	0	0
2012	136	4.43	1	15	38	37	8	2	0	0	0	0
2013	82	4.84	0	6	40	29	18	2	4	0	0	0
2014*	455	4.35	0	14	46	33	7	1	0	0	0	0
2015	-	-	-	-	-	-	-	-	-	-	-	-
2016	147	4.60	0	10	37	39	12	2	0	0	0	0
2017	76	4.53	0	13	39	30	16	1	0	0	0	0
2018	77	4.13	0	30	35	29	5	1	0	0	0	0
2019*	487	4.39	0	7	62	21	8	2	0	0	0	0
2020	-	-	-	-	-	-	-	-	-	-	-	-
2021	34	5.03	0	6	12	56	26	0	0	0	0	0

* indicates years where not all fish were aged and an age-length key was subsequently used to assign ages.

Table 11. Percent catch-at-age for adult alewife, sexes combined, sampled from the North East River from 2013–2021.

Year	**N**	**Mean Age**	**Age**					
			3	**4**	**5**	**6**	**7**	**8**
2013	175	5.62	2	12	29	37	19	2
2014	547	4.22	37	34	18	6	4	1
2015*	688	4.19	8	72	17	2	<1	0
2016*	454	4.94	7	13	58	19	2	0
2017*	413	4.02	43	28	17	11	2	0
2018*	470	4.18	9	71	12	6	2	0
2019*	498	4.68	1	44	44	7	4	<1
2020	-	-	-	-	-	-	-	-
2021*	764	4.56	18	37	25	13	5	2

* indicates years where not all fish were aged and an age-length key was subsequently used to assign ages.

Table 12. Percent catch-at-age for adult blueback herring, sexes combined, sampled from the North East River from 2013–2021.

Year	**N**	**Mean Age**	**Age**					
			3	**4**	**5**	**6**	**7**	**8**
2013	33	4.52	9	52	24	9	6	0
2014	155	4.26	19	41	36	3	1	0
2015*	507	4.12	12	73	11	4	<1	0
2016	192	4.70	11	25	47	15	2	0
2017	184	3.98	49	15	26	9	1	0
2018	130	3.66	58	27	6	7	2	0
2019*	709	4.50	3	65	23	5	5	1
2020	-	-	-	-	-	-	-	-
2021*	471	4.70	20	25	22	28	4	<1

* indicates years where not all fish were aged and an age-length key was subsequently used to assign ages.

Table 13. Percent of total catch by mesh size of alewife from the North East River, 2013–2021.

Year	N	Mesh Size (cm)			
		5.7 cm	6.4 cm	7 cm	7.6 cm
2013	178	-	53	28	19
2014	550	-	61	27	12
2015	689	14	59	27	-
2016	457	12	44	43	-
2017	417	18	50	32	-
2018	470	20	43	37	-
2019	503	3	45	52	-
2020	-	-	-	-	-
2021	776	20	54	26	-
Total	4040	12	52	33	3

Table 14. Percent of total catch by mesh size of blueback herring from the North East River, 2013–2021.

Year	N	Mesh Size (cm)			
		5.7 cm	6.4 cm	7 cm	7.6 cm
2013	33	-	94	6	0
2014	172	-	84	14	2
2015	511	59	37	3	-
2016	195	42	44	14	-
2017	193	61	34	6	-
2018	131	82	22	2	-
2019	713	55	38	7	-
2020	-	-	-	-	-
2021	478	52	42	5	-
Total	2426	52	42	7	0

Table 15. Counts of species (other than alewife and blueback) captured in the North East River gill net survey from 2013–2021.

Species	2013	2014	2015	2016	2017	2018	2019	2020	2021
American shad		2						-	
Atlantic menhaden	145	145	476	908	145	141	19	-	49
Blue catfish			1	1				-	
Black crappie								-	1
Bluegill				1			1	-	1
Brown bullhead	66	132	78	123	15	25	46	-	8
Carp	2	1	2					-	1
Channel catfish	17	45	50	7	6	19	18	-	17
Gizzard shad	2617	850	104	568	112	13	54	-	400
Golden shiner			1		4	2	2	-	4
Goldfish	2		2	1			2	-	3
Hickory shad	19	25	5	15	5	2	10	-	7
Largemouth bass	1		1	1		1		-	1
Pumpkinseed	1	1	2	4	1			-	1
Quillback			2					-	
Redear sunfish					1			-	
Shorthead redhorse								-	1
Striped bass	39	39	42	50	42	15	13	-	22
Walleye		1					1	-	
White catfish	1	1		1	1		2	-	1
White perch	287	227	1273	813	257	320	268	-	373
White sucker	3	1	1	1	2		1	-	2
Yellow perch			6	2	1	1	1	-	4

Figure 1. Conowingo Dam tailrace (Susquehanna River) hook and line sampling location for American shad in 2021.

Figure 2. Nanticoke River pound and fyke net sites for adult alosine sampling in 2021.

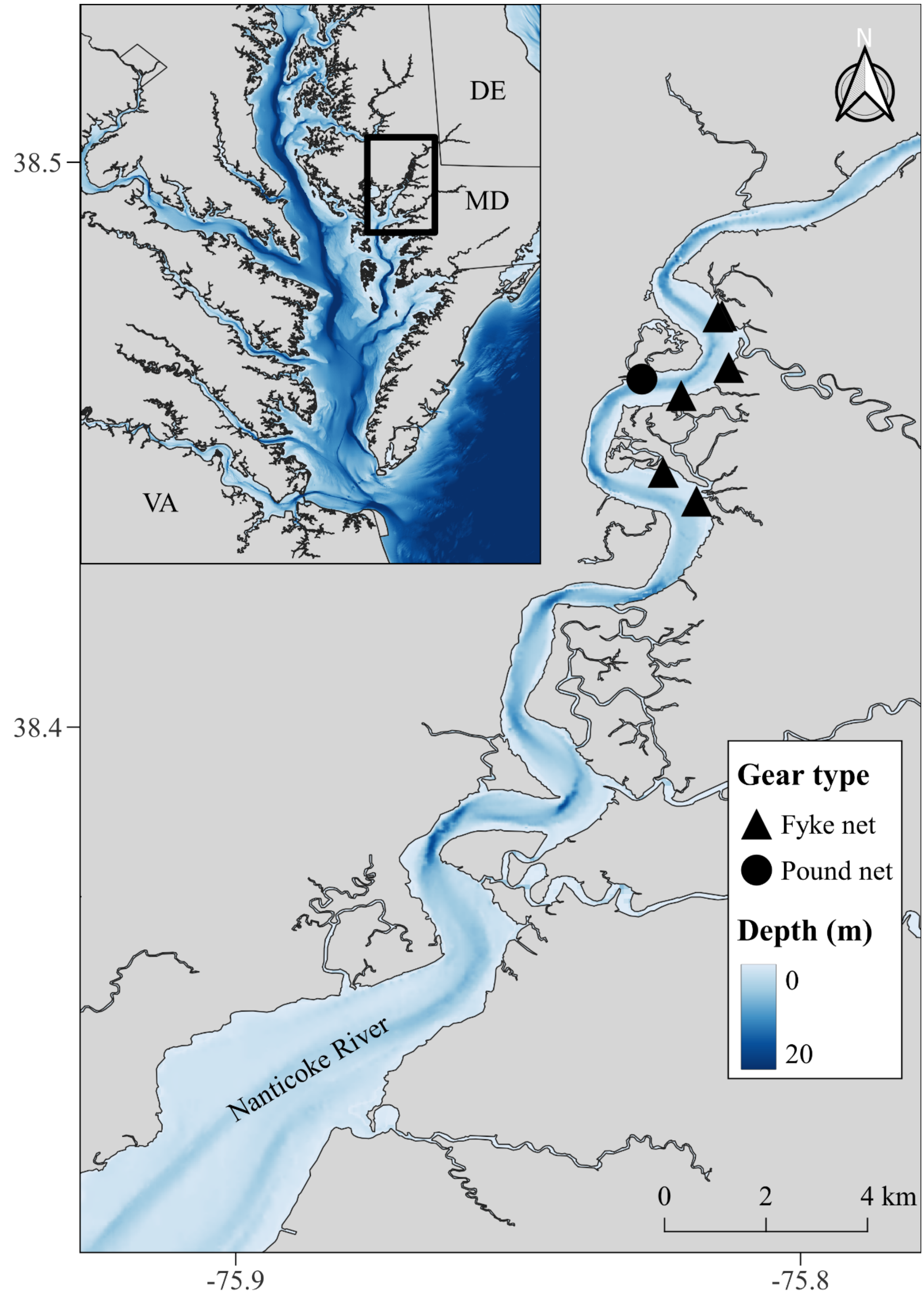


Figure 3. Nanticoke River sites for alosine ichthyoplankton sampling.

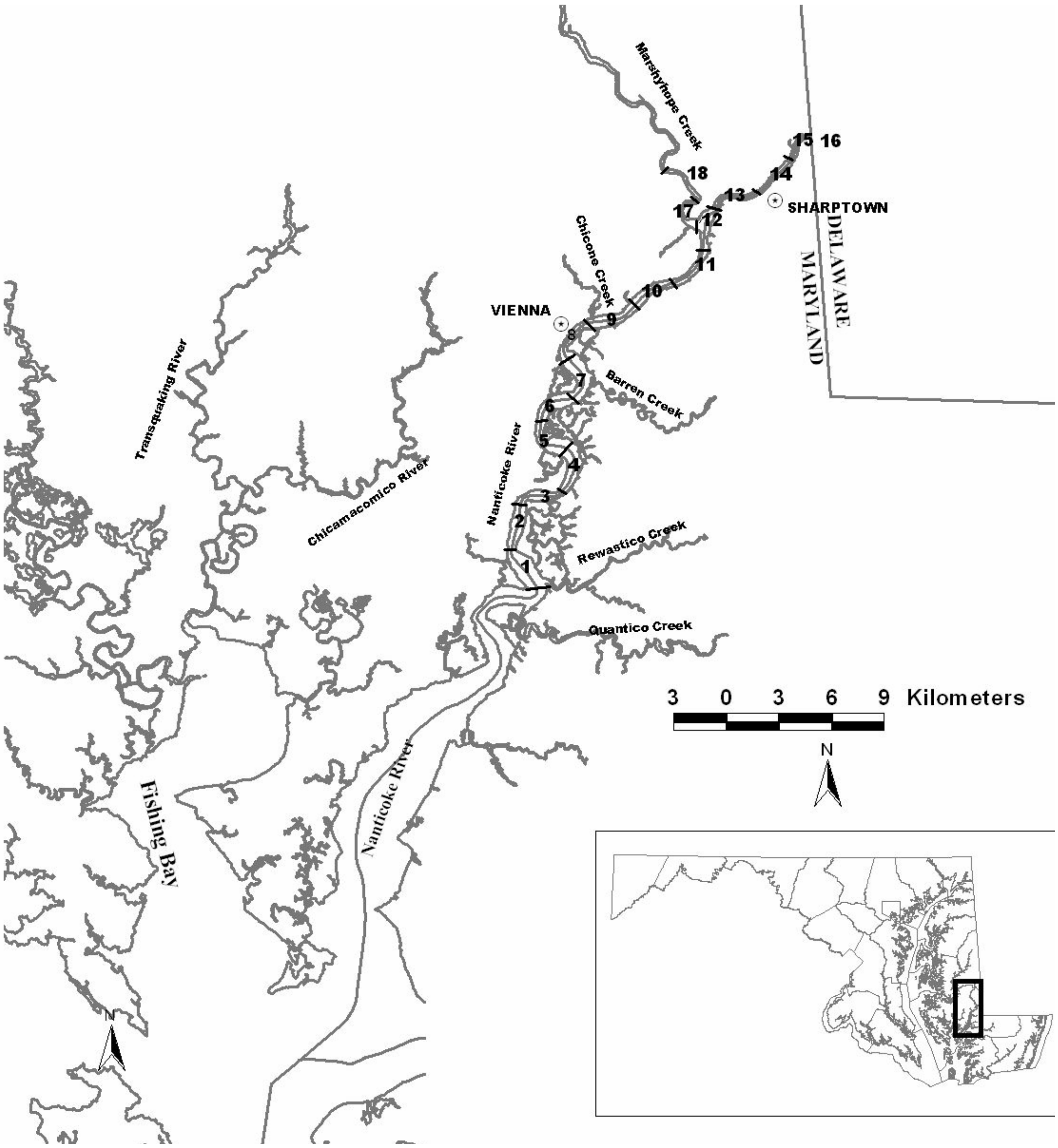


Figure 4. Grid of 305 m x 305 m quadrats overlaid on a map of the North East River from which sites were randomly chosen for the North East River sinking gill net survey, 2013–2021.

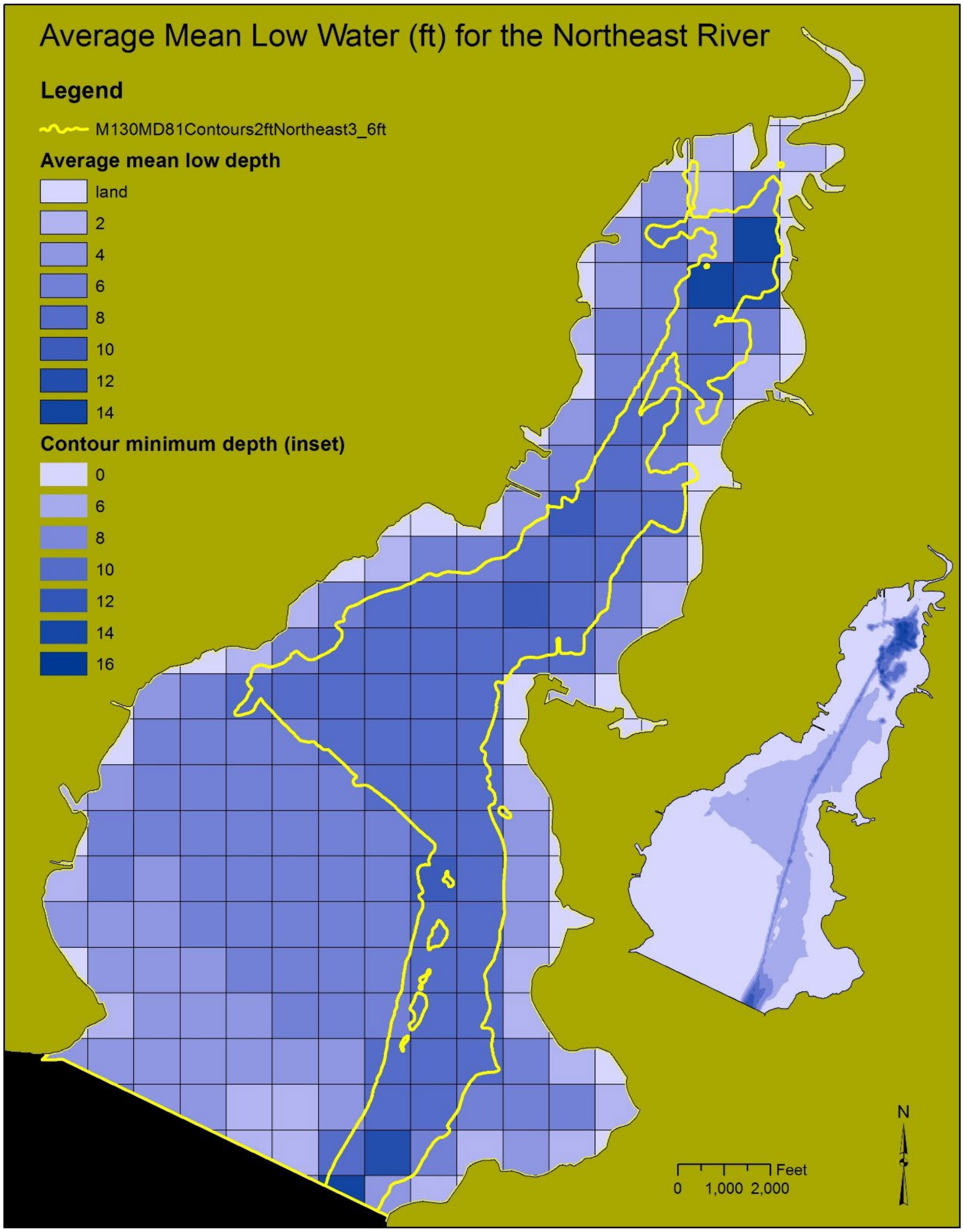


Figure 5. Percentage of sites with clupeid eggs or larvae in the Nanticoke River, 2005–2021.

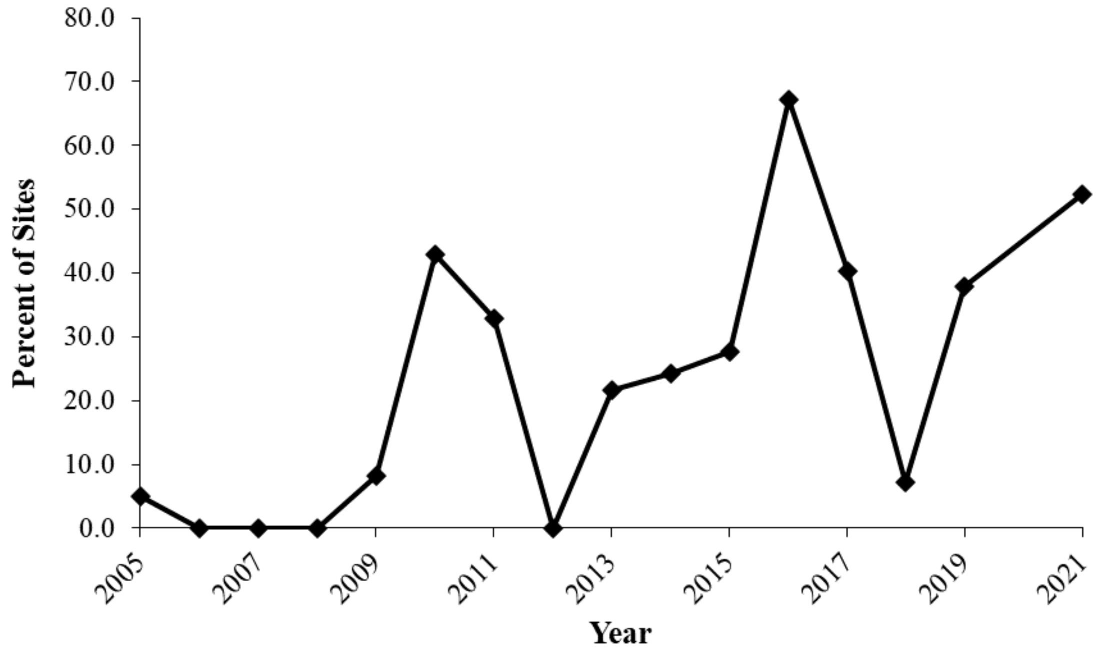


Figure 6. Percentage of American shad repeat spawners by sex collected in the Conowingo Dam tailrace, 1982–2021.

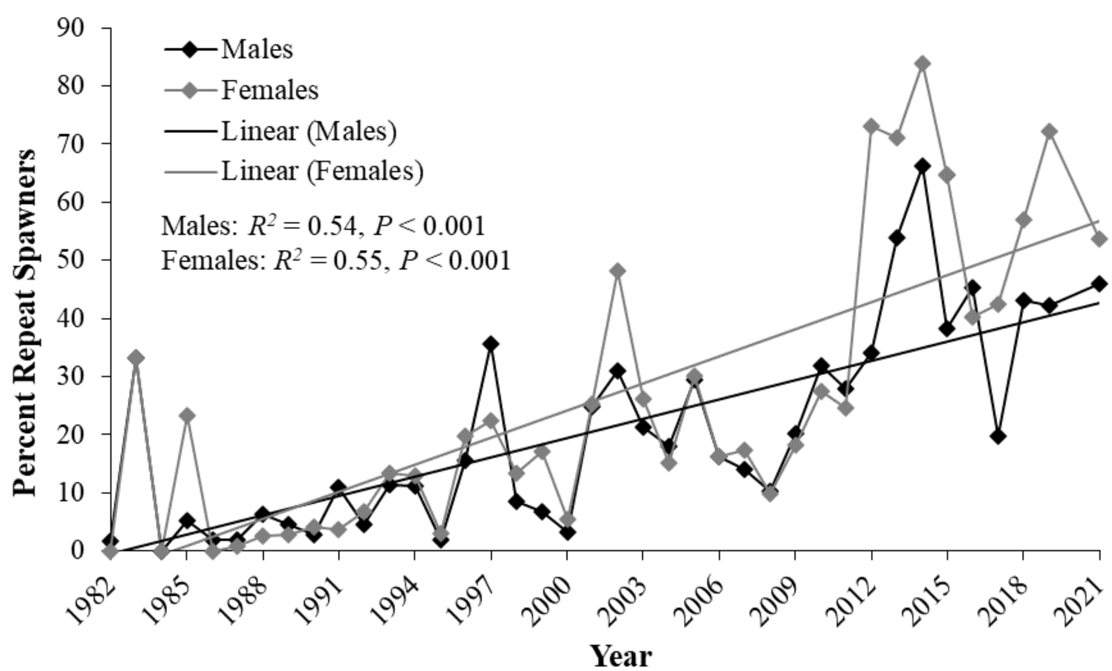


Figure 7. Arcsine-transformed percentages of repeat spawning American shad (sexes combined) collected from the Conowingo Dam tailrace, 1984–2021.

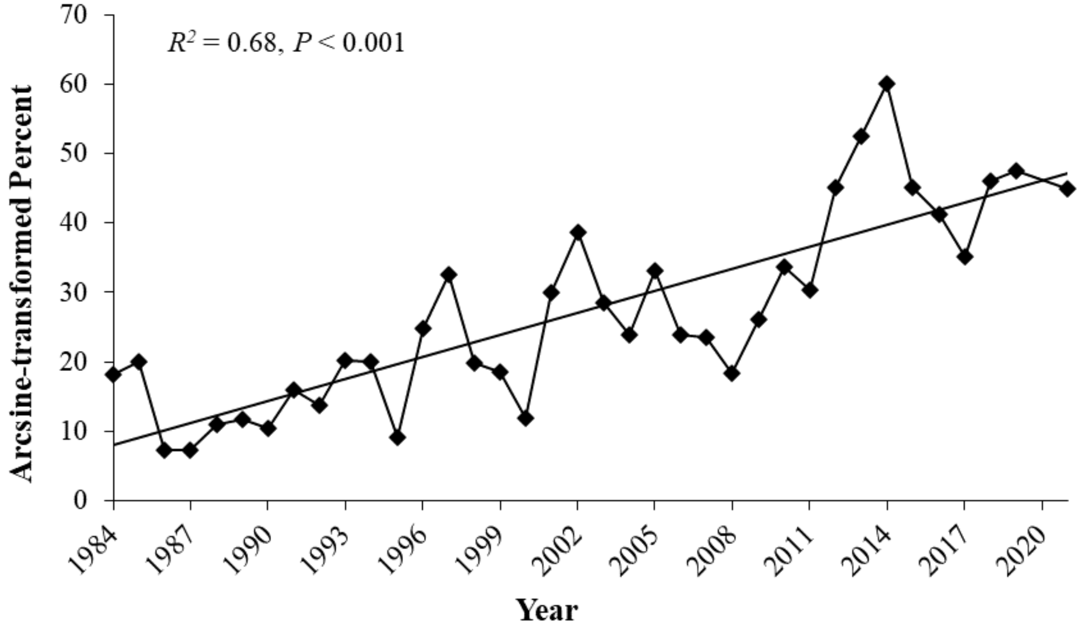


Figure 8. Arcsine-transformed percentages of repeat spawning American shad (sexes combined) collected from the Nanticoke River, 1988–2021.

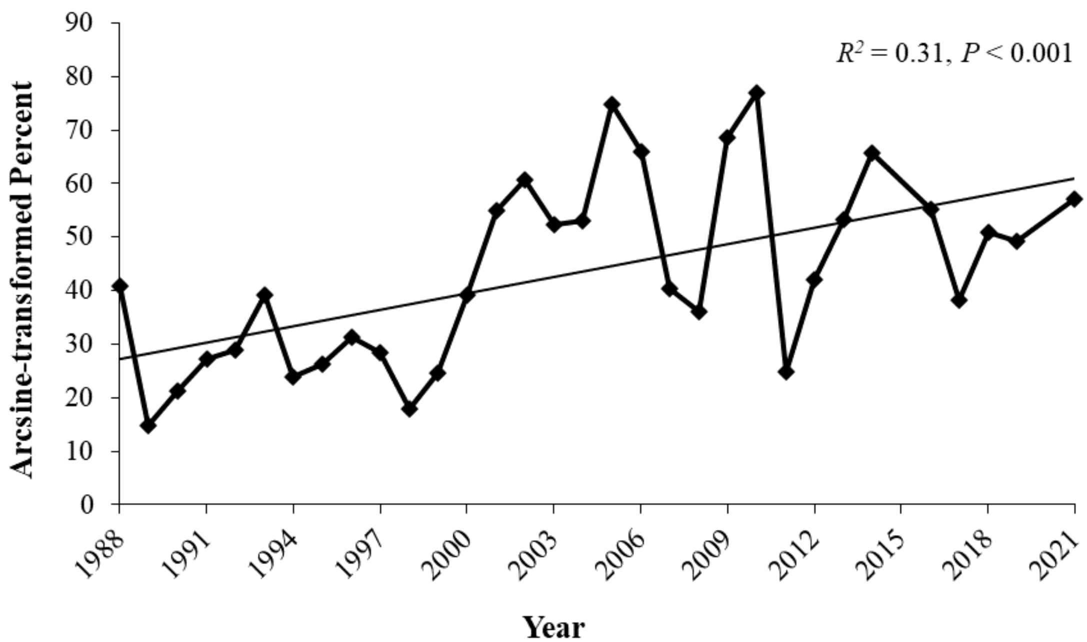


Figure 9. Arcsine-transformed percentages of repeat spawning American shad (sexes combined) collected from the Potomac River, 2002–2021.

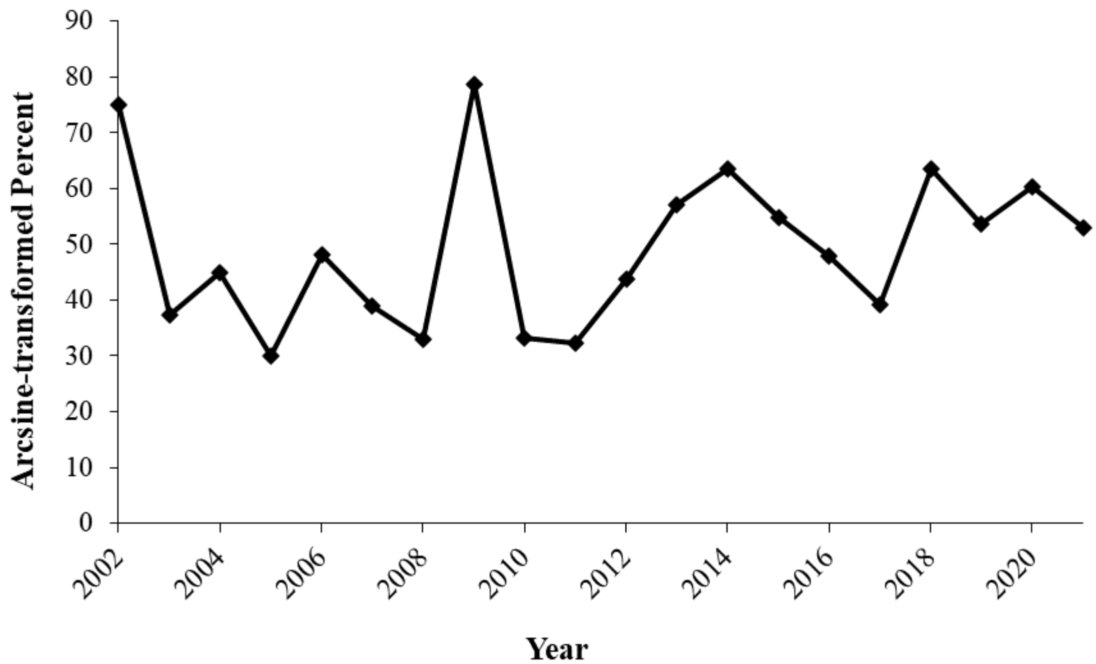


Figure 10. Percentage of tagged American shad recaptured at the Conowingo Dam fish lifts, 1986–2021.

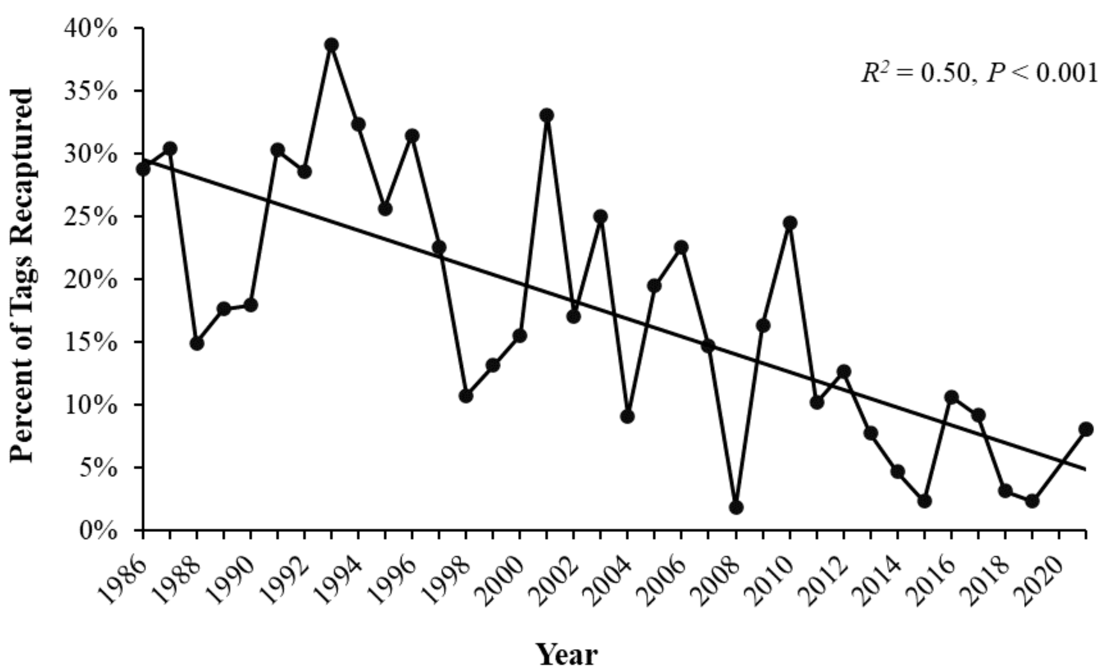


Figure 11. American shad GM CPUE (fish-per-lift-hour), 1985–2021, and the total number of American shad lifted at the East and West Fish Lifts, 1972–2021, at the Conowingo Dam. From 1972–1990, and in 2021, only the West Fish Lift operated.

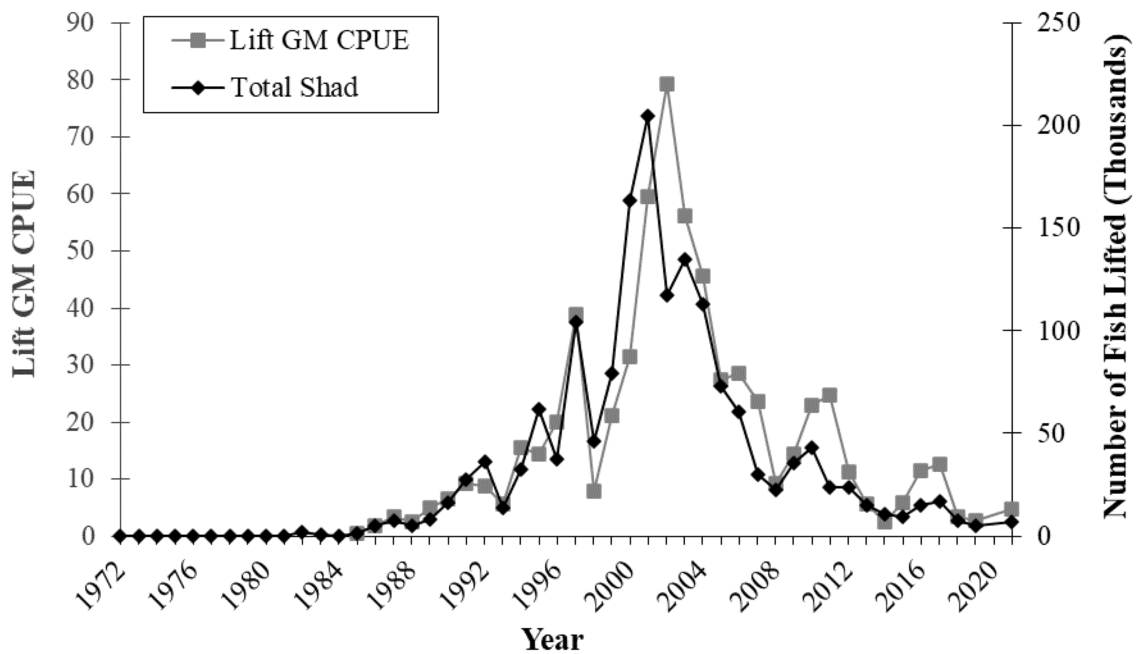


Figure 12. Geometric mean CPAH (catch-per-angler-hour) of American shad by recreational anglers in the Susquehanna River below Conowingo Dam, measured through creel and logbook surveys, 2001–2021.

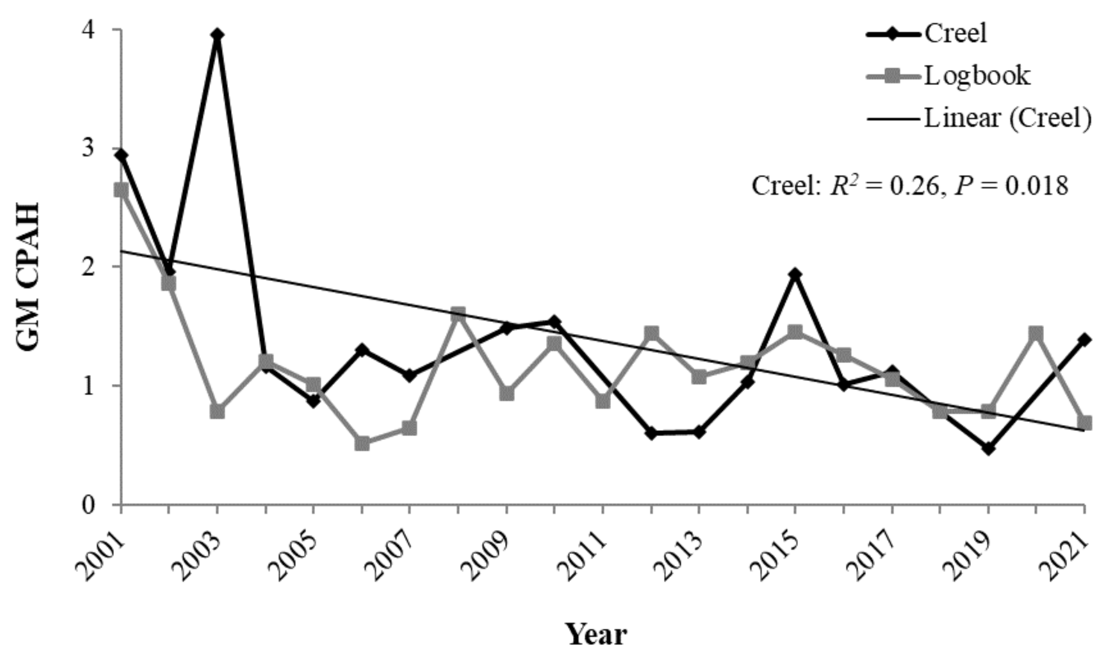


Figure 13. American shad GM CPUE (fish per net day) from pound nets in the Nanticoke River, 1988–2021.

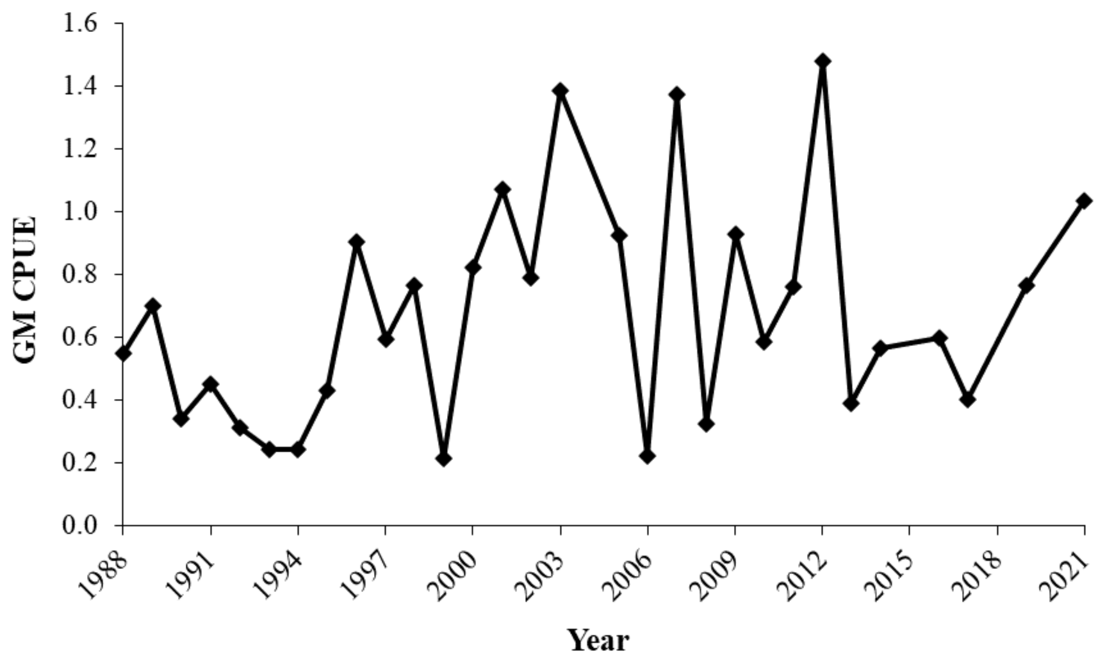


Figure 14. American shad GM CPUE (fish per 914 square meters of drift gill net per hour fished) from the Potomac River, 1996–2021.

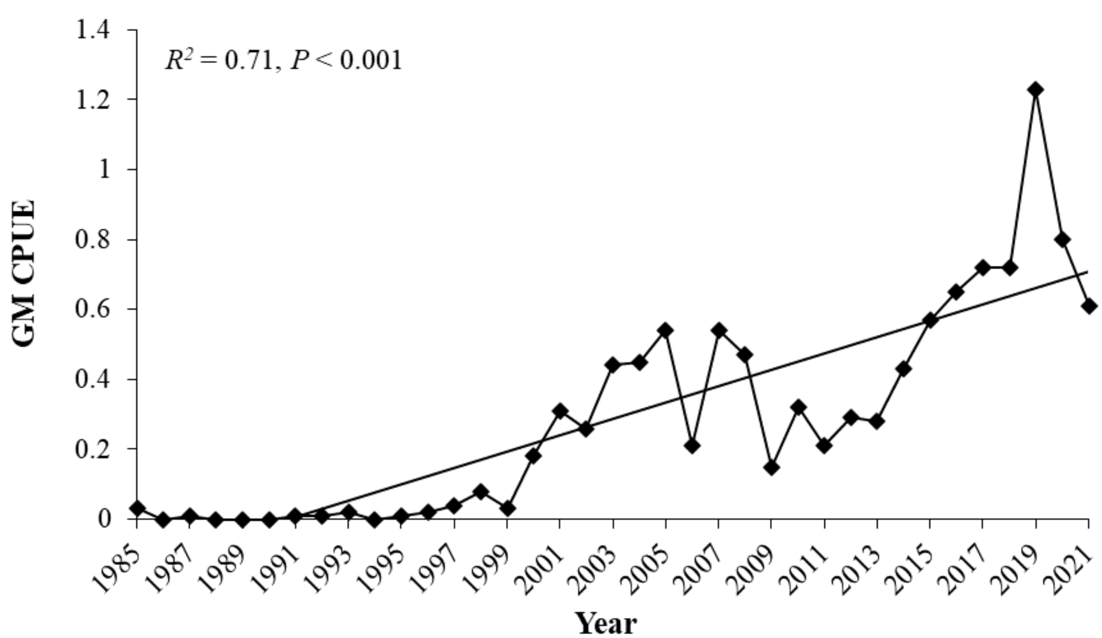


Figure 15. Conowingo Dam tailrace adult American shad abundance estimates from the Petersen method with 95% confidence limits, 1986–2021.

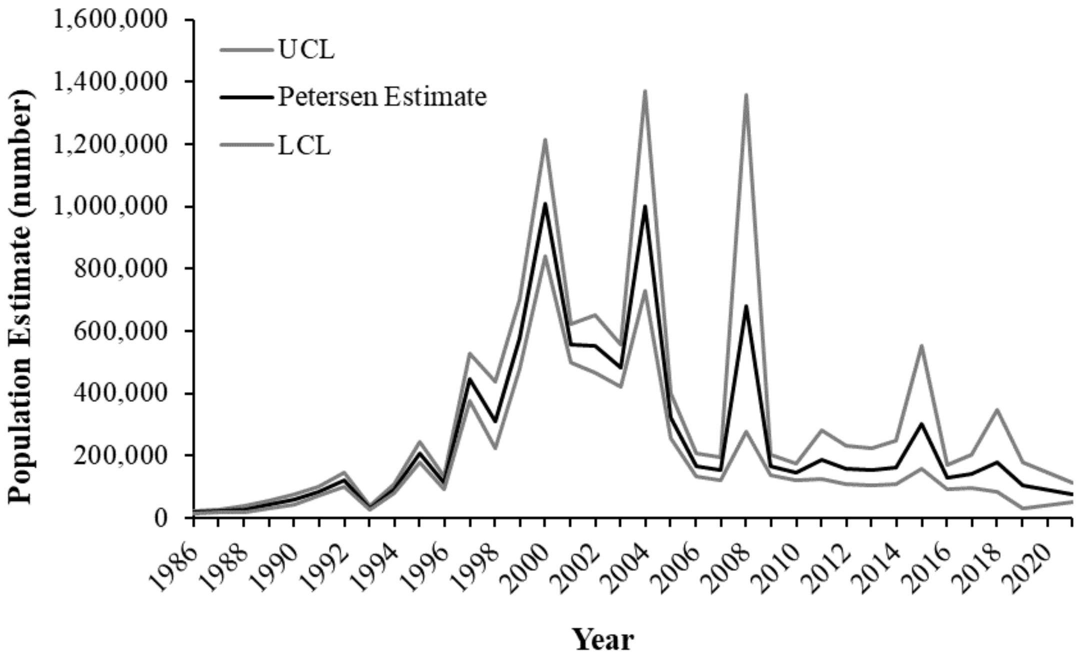


Figure 16. Age-based Chapman-Robson total instantaneous mortality (*Z*) estimates for American shad, sexes combined, captured in the Conowingo Dam tailrace (1984–2021). The $Z_{40\%SBPR}$ reference point was determined in the 2020 ASMFC benchmark stock assessment for American shad and is specific to the southern iteroparous region.

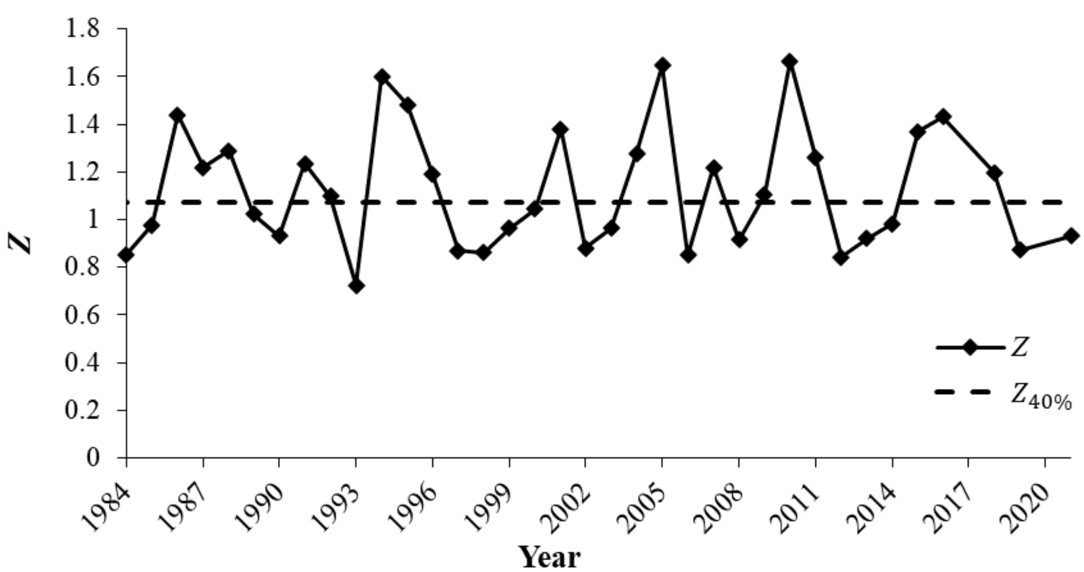


Figure 17. Age-based Chapman-Robson total instantaneous mortality (Z) estimates for American shad, sexes combined, captured in the Nanticoke River (1989–2021). The $Z_{40\%SBPR}$ reference point was determined in the 2020 ASMFC benchmark stock assessment for American shad and is specific to the southern iteroparous region.

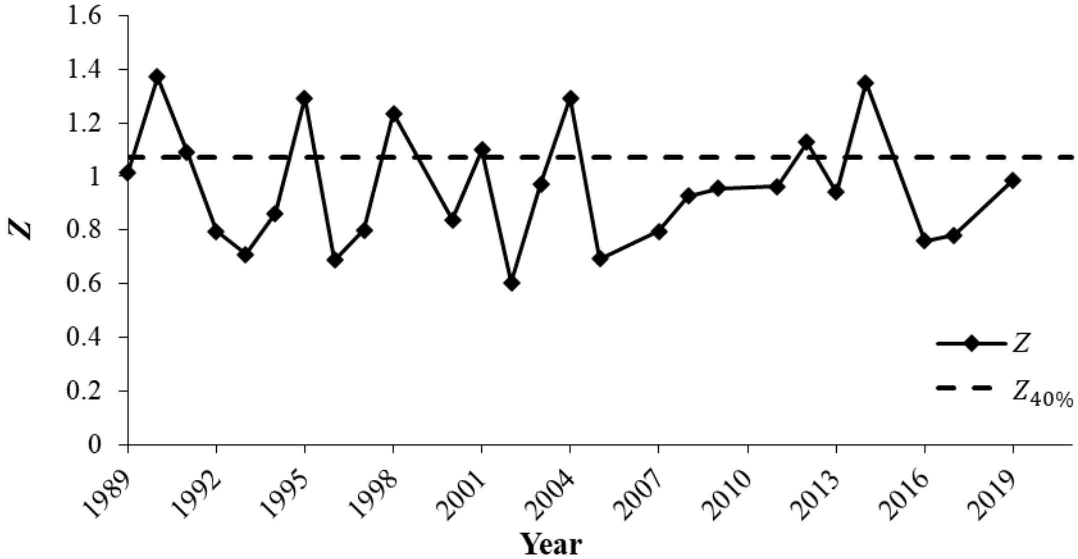


Figure 18. Age-based Chapman-Robson total instantaneous mortality (Z) estimates for American shad, sexes combined, captured in the Potomac River (2002–2021). The $Z_{40\%SBPR}$ reference point was determined in the 2020 ASMFC benchmark stock assessment for American shad and is specific to the southern iteroparous region.

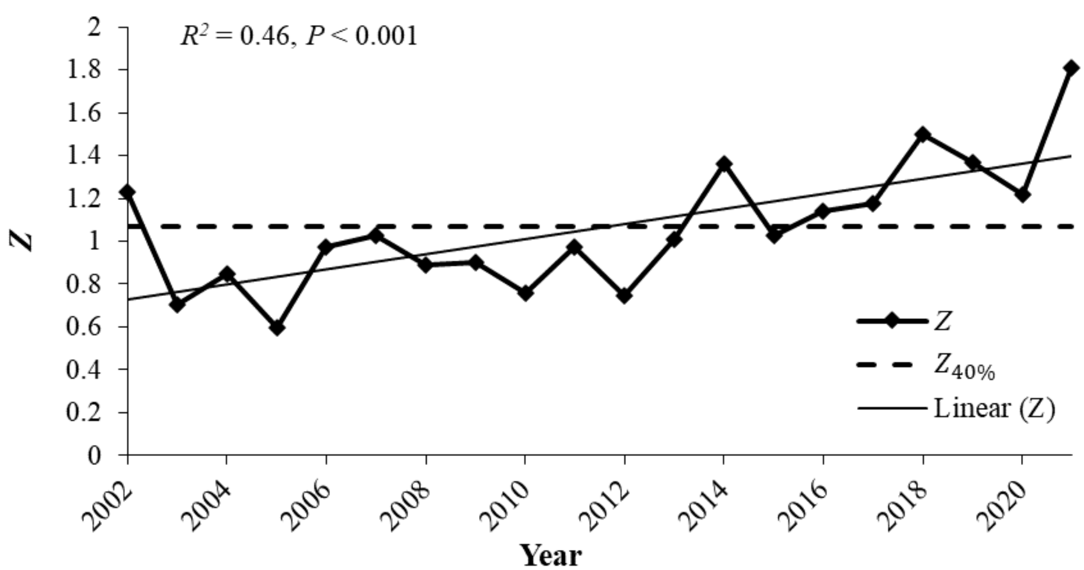


Figure 19. Potomac River juvenile American shad GM CPUE (catch-per-seine-haul), 1959–2021.

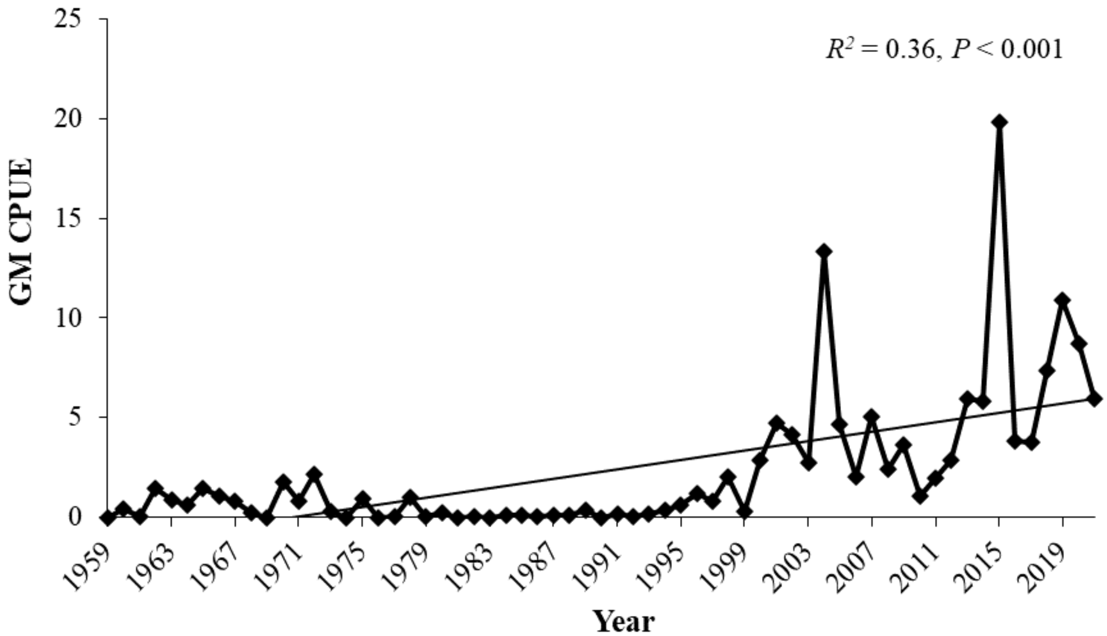


Figure 20. Upper Chesapeake Bay juvenile American shad GM CPUE (catch-per-seine-haul), 1959–2021.

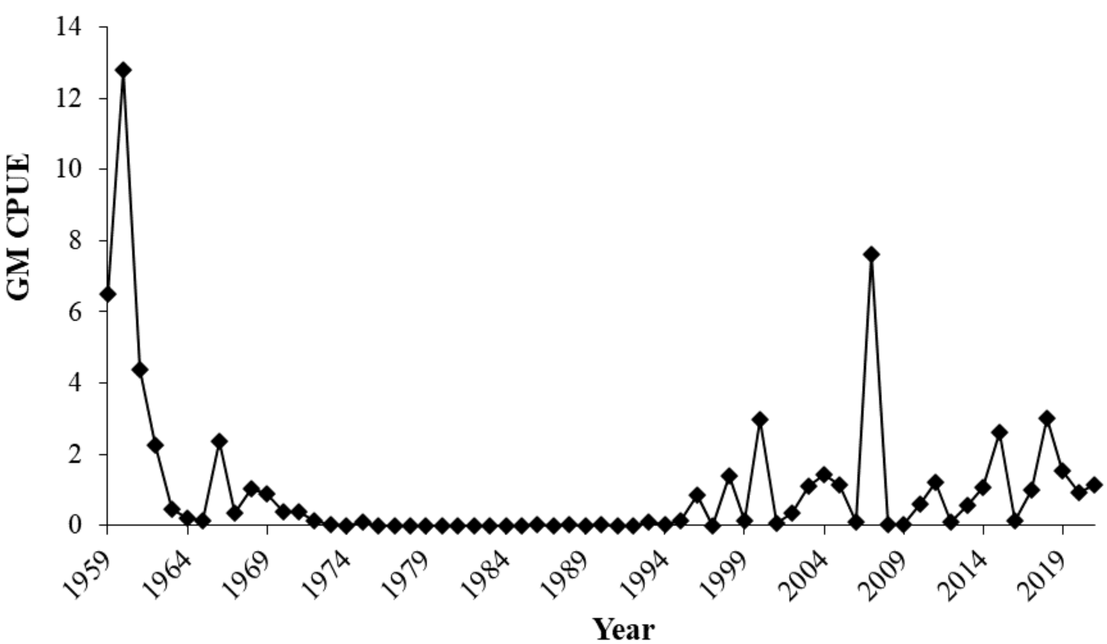


Figure 21. Nanticoke River juvenile American shad GM CPUE (catch-per-seine-haul), 1959–2021.

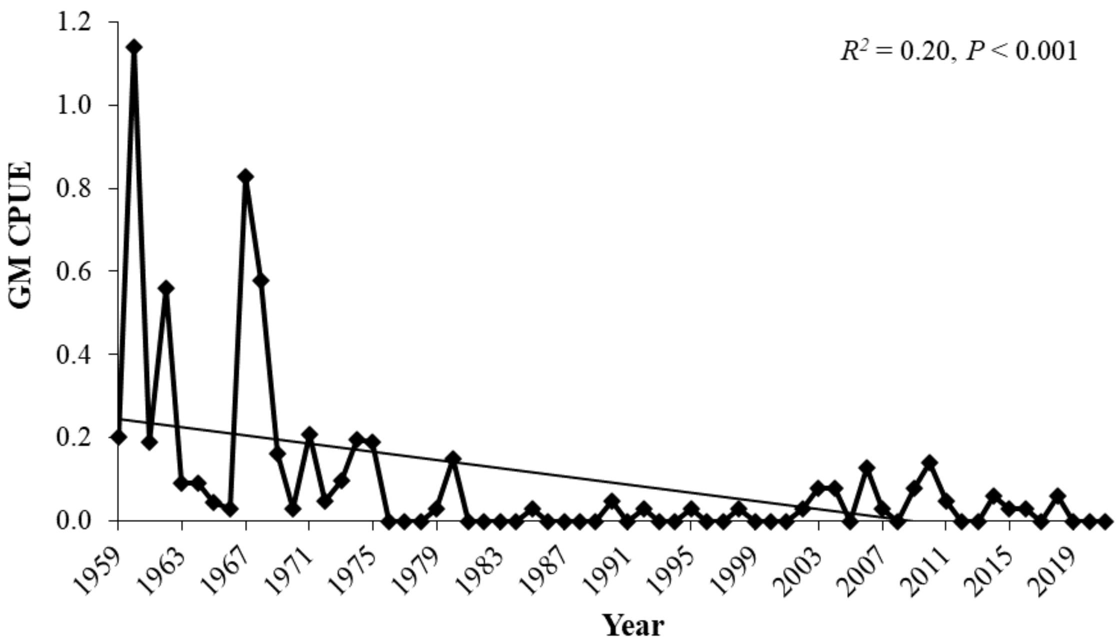


Figure 22. Arcsine-transformed percentages of repeat spawning hickory shad (sexes combined) collected from the Susquehanna River and Deer Creek (a lower Susquehanna River tributary), 2004–2021.

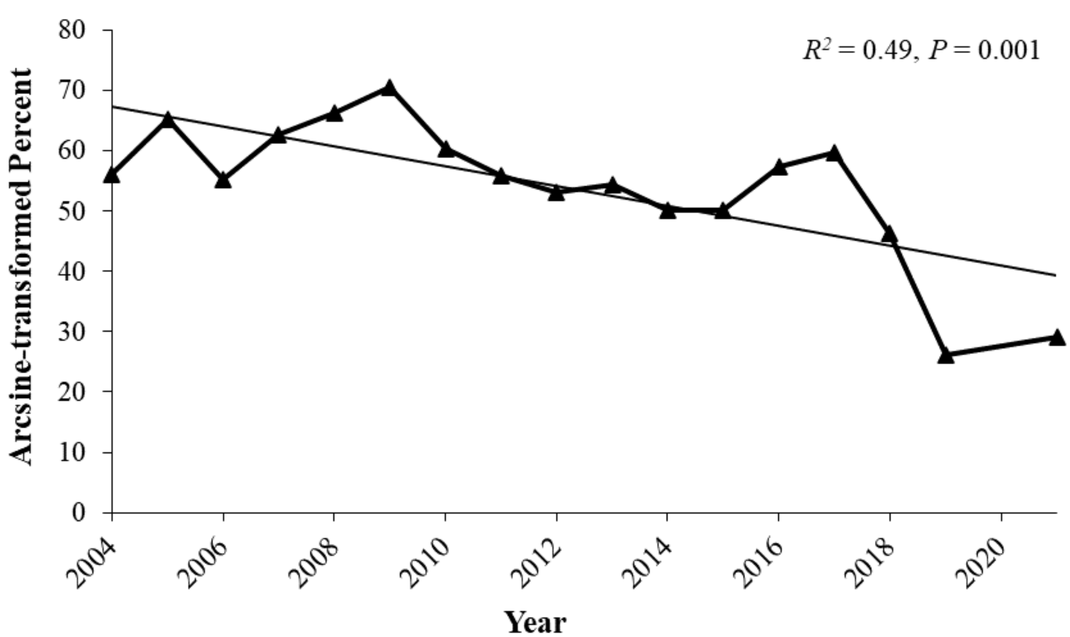


Figure 23. Geometric mean CPAH (catch-per-angler-hour) of hickory shad by recreational anglers, measured through creel surveys (at the Conowingo Dam) and logbook surveys (throughout Maryland), 2001–2021.

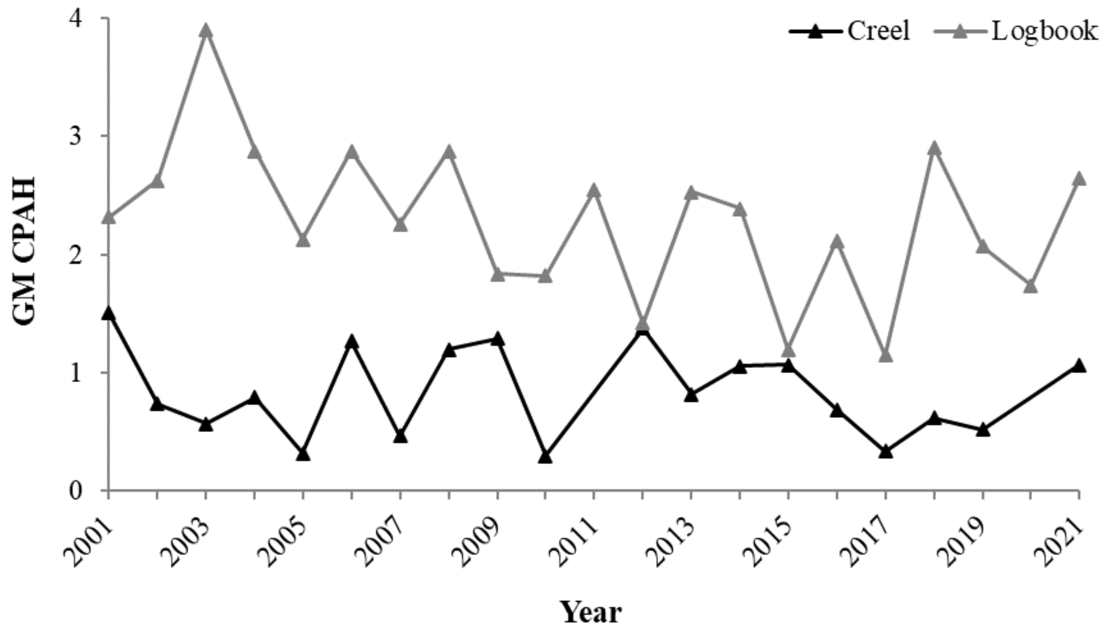


Figure 24. Age-based Chapman-Robson total instantaneous mortality (Z) estimates for hickory shad, sexes combined, captured in the Susquehanna River (2004–2021).

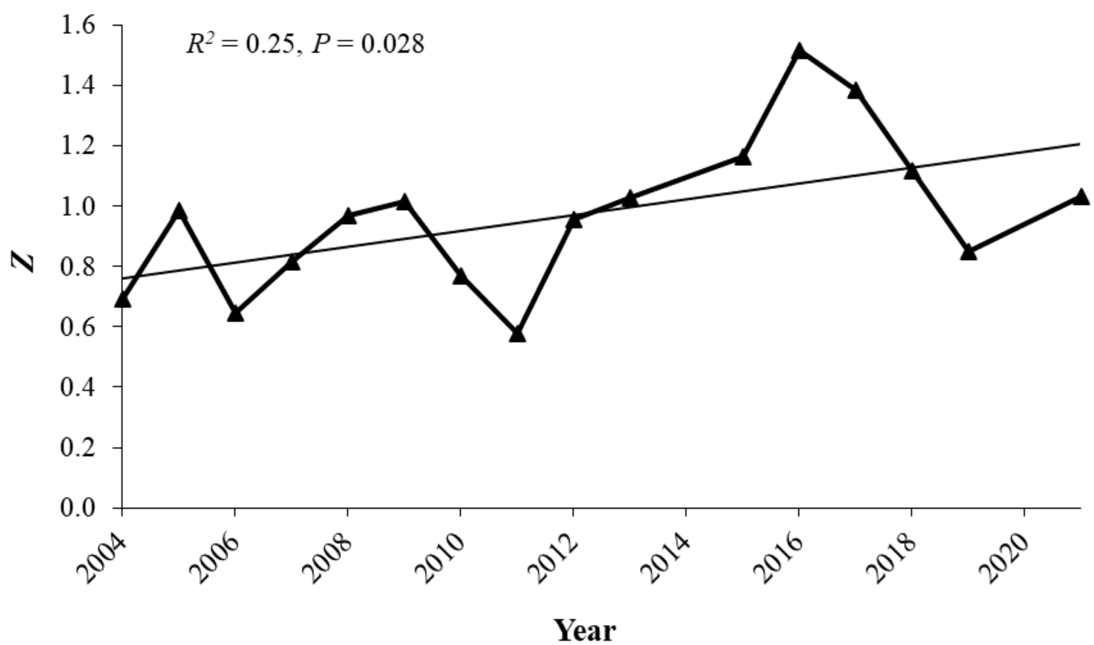


Figure 25. Arcsine-transformed percentage of repeat spawning alewife and blueback herring (sexes and gears combined) from the Nanticoke River, 1990–2021.

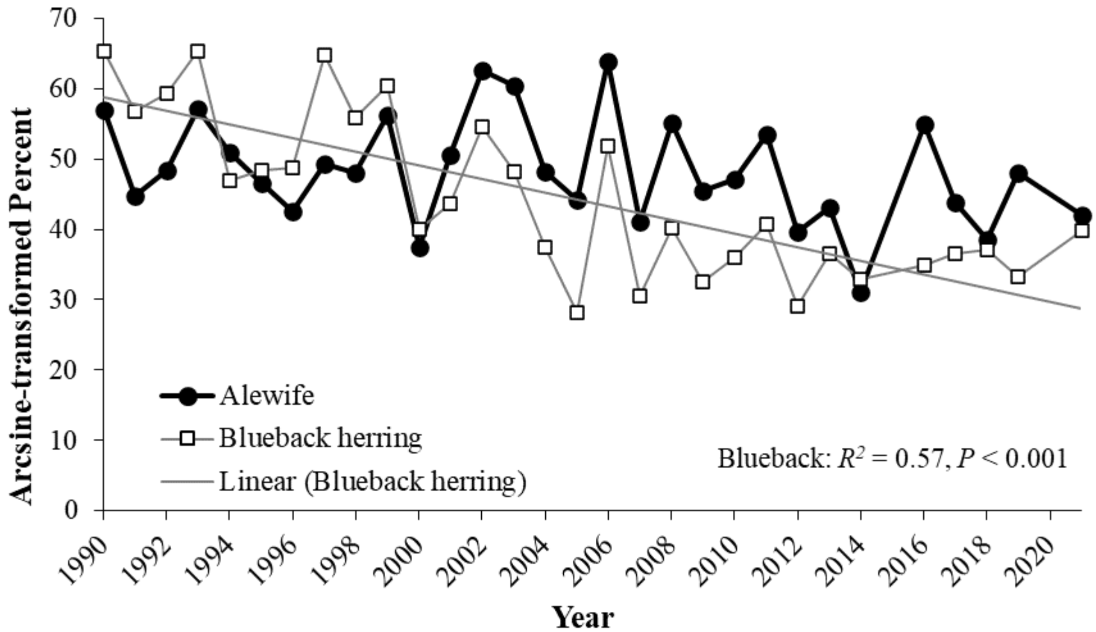


Figure 26. Mean fork length (mm) of adult alewife and blueback herring from the Nanticoke River, 1989–2021.

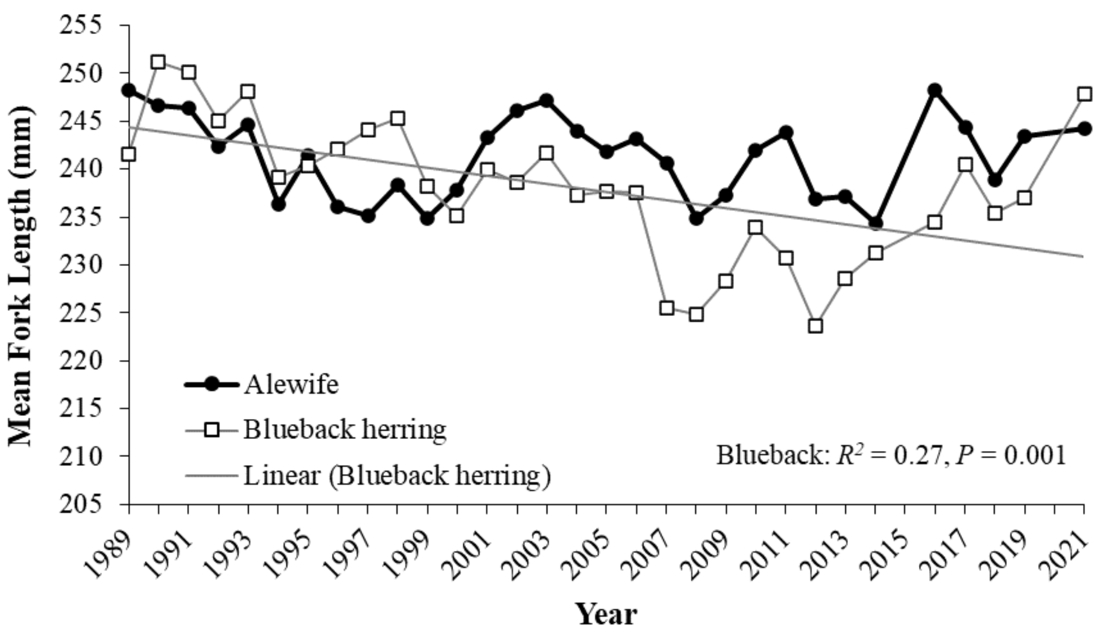


Figure 27. Arcsine-transformed percentages of repeat spawning alewife and blueback herring (sexes combined) collected from the North East River, 2013–2021.

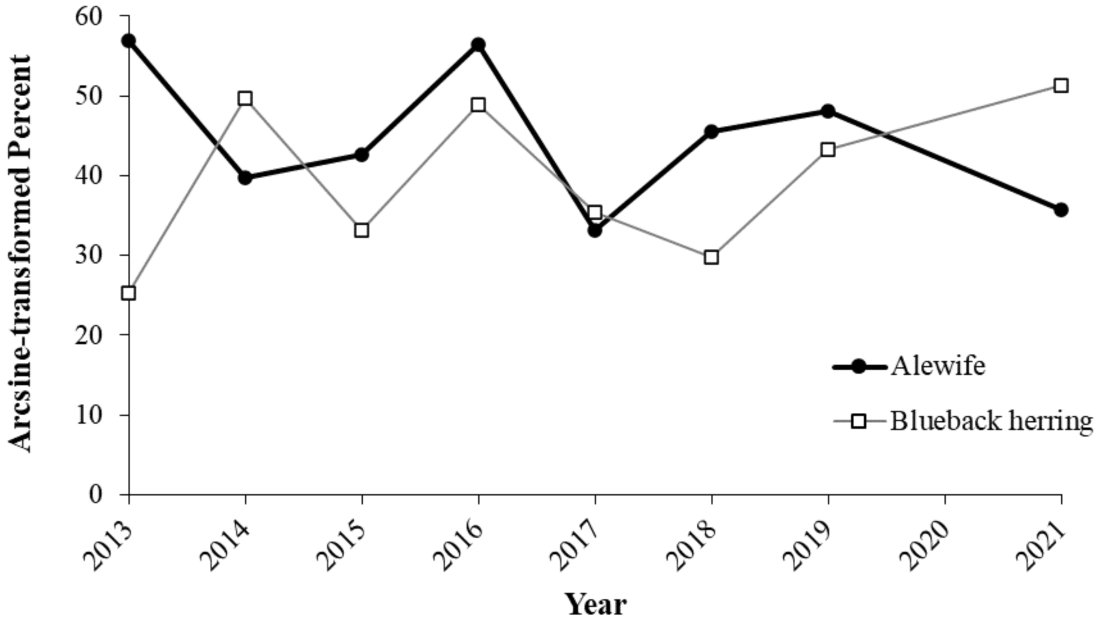


Figure 28. Adult alewife and blueback herring GM CPUE (catch-per-net-day) from Nanticoke River fyke nets, 1989–2021.

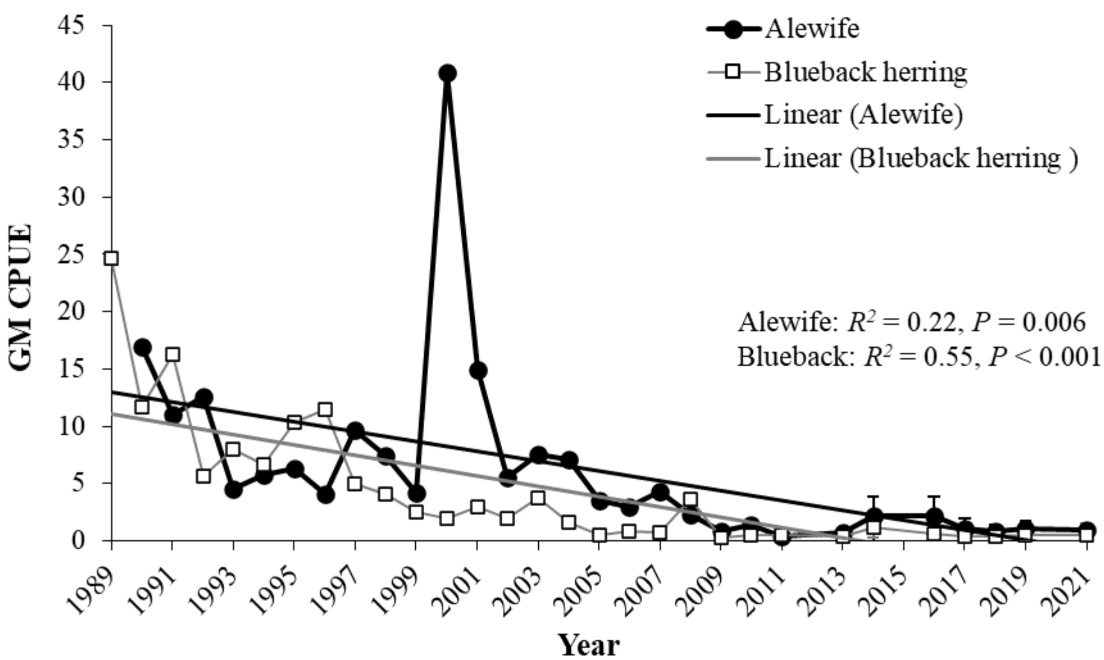


Figure 29. North East River catch-per-day of alewife and blueback herring, plotted with surface water temperature for 2021.

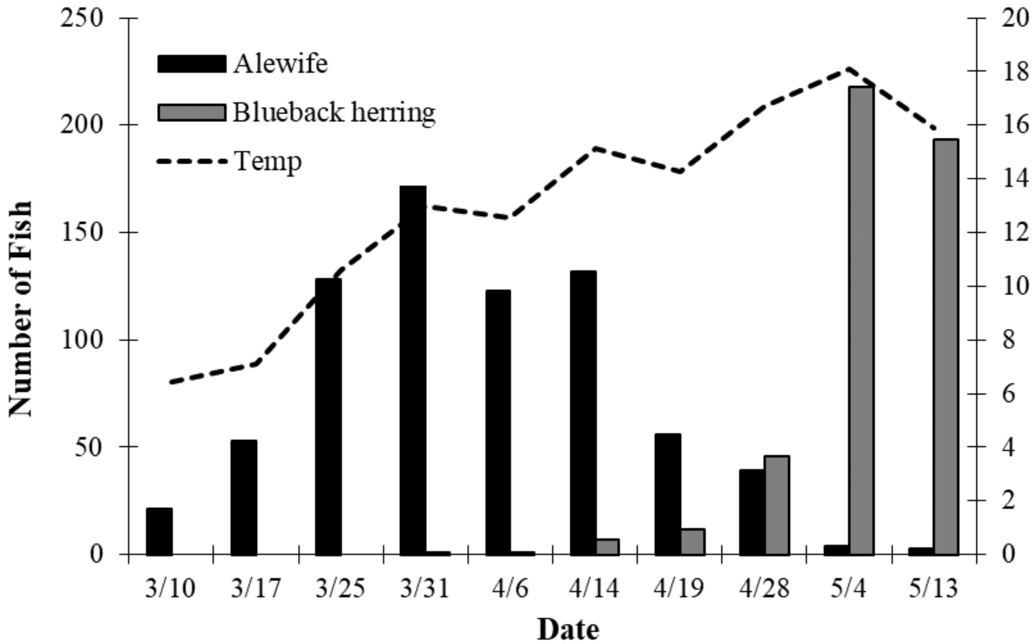


Figure 30. Alewife and blueback herring GM CPUE (number of fish caught per set of gill net per hour fished) from the North East River gill net survey, 2013–2021. Catch was pooled across the 6.4 cm and 7.0 cm mesh panels for all years.

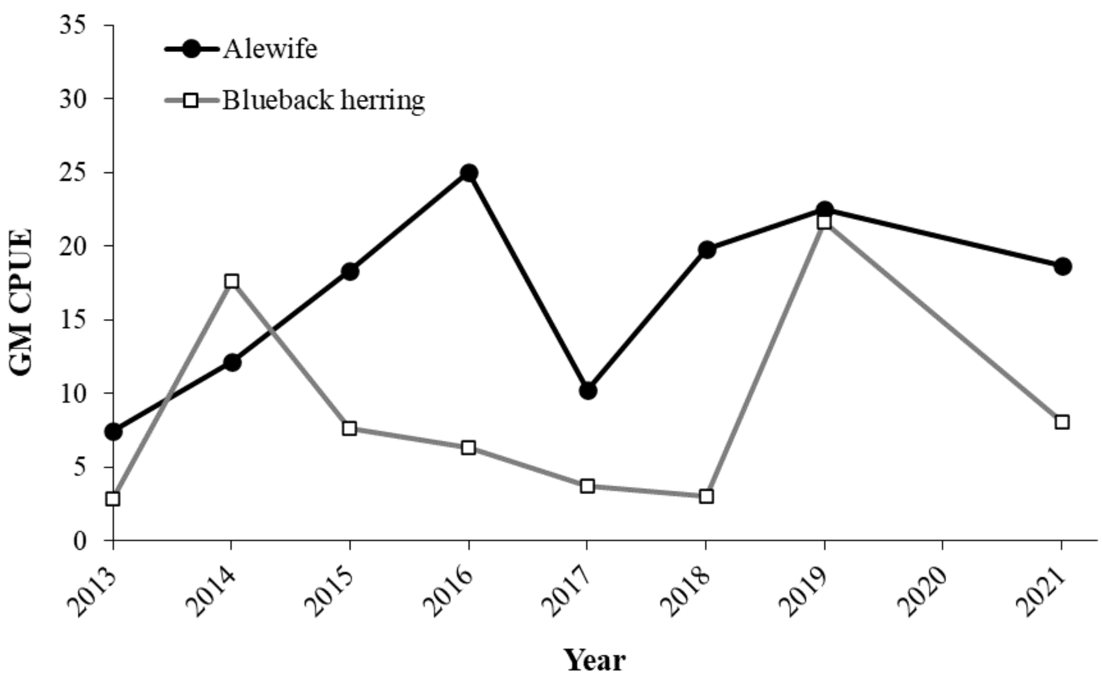


Figure 31. Alewife and blueback herring GM CPUE (number of fish caught per set of gill net per hour fished) from the North East River gill net survey, 2015–2021. Catch was pooled across the 5.7 cm, 6.4 cm and 7.0 cm mesh panels for all years.

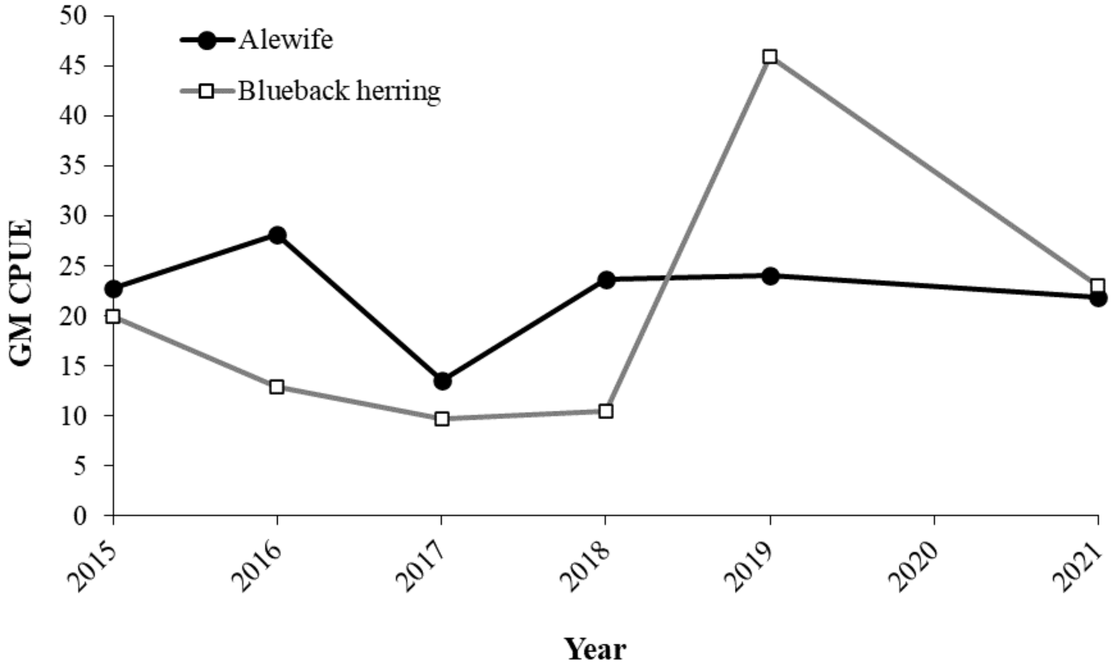


Figure 32. Age-based Chapman-Robson total instantaneous mortality (*Z*) estimates for alewife, sexes combined, captured in the Nanticoke River (1989–2021). $Z_{20\%SPR}$ and $Z_{40\%SPR}$ benchmarks were determined by the 2017 ASMFC river herring stock assessment update and are specific to the Nanticoke River.

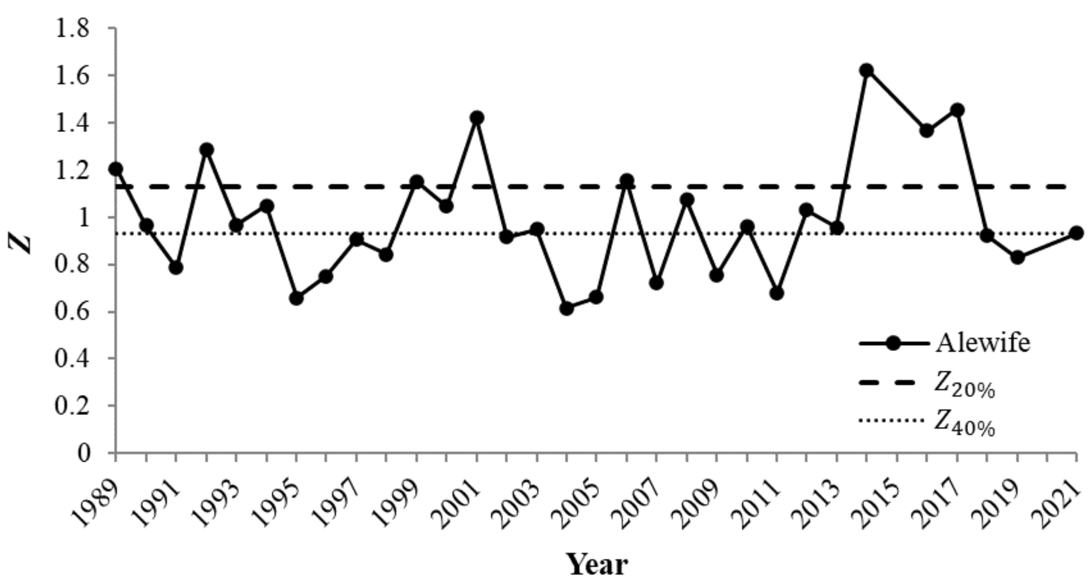


Figure 33. Age-based Chapman-Robson total instantaneous mortality (Z) estimates for blueback herring, sexes combined, captured in the Nanticoke River (1989–2021). $Z_{20\%SPR}$ and $Z_{40\%SPR}$ benchmarks were determined by the 2017 ASMFC river herring stock assessment update and are specific to the Nanticoke River.

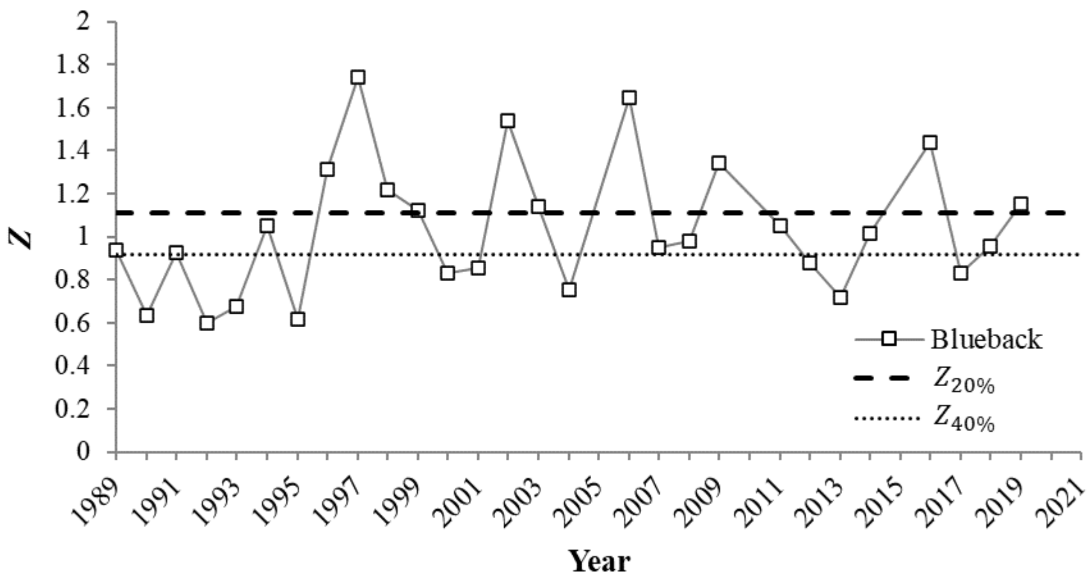


Figure 34. Age-based Chapman-Robson total instantaneous mortality (Z) estimates for alewife and blueback herring, sexes combined, captured in the North East River (2013–2021).

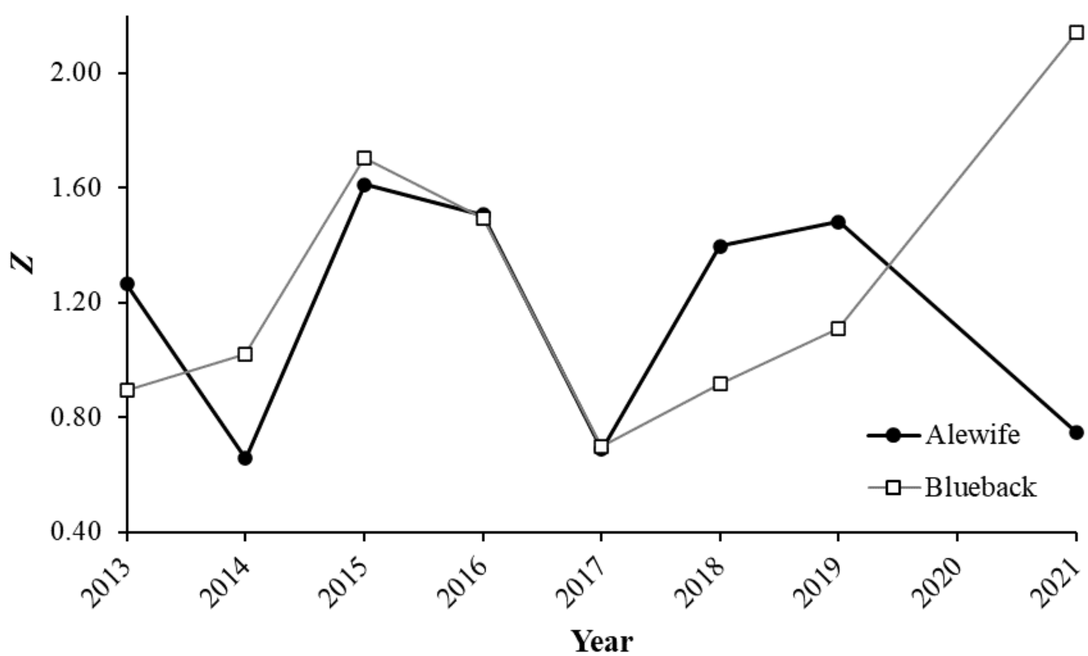


Figure 35. Nanticoke River juvenile alewife and blueback herring GM CPUE (catch-per-seine-haul), 1959–2021.

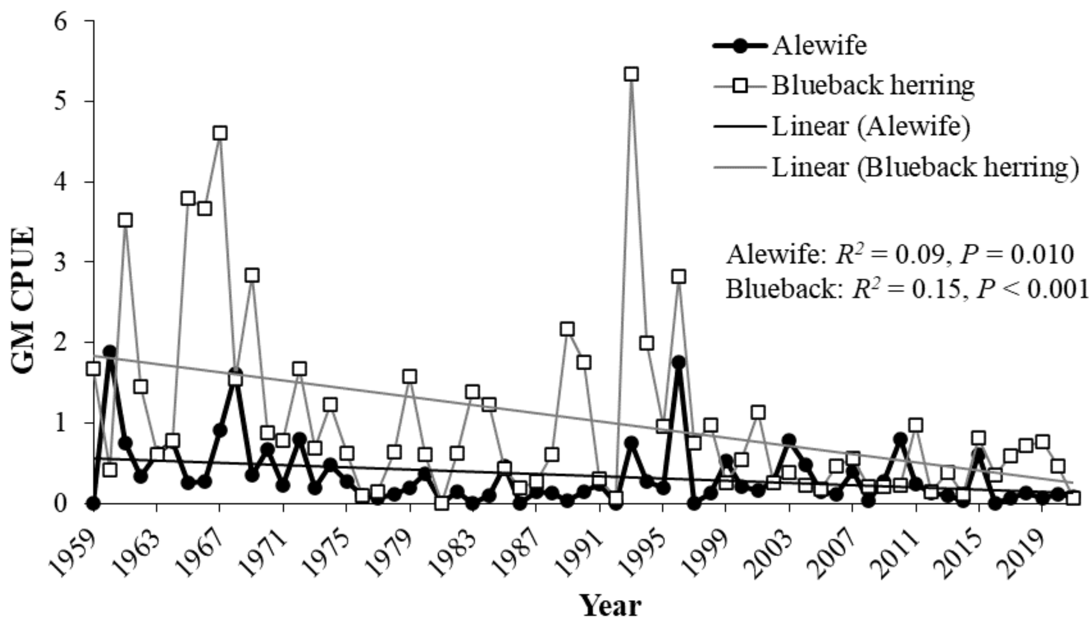


Figure 36. Potomac River juvenile alewife and blueback herring GM CPUE (catch-per-seine-haul), 1959–2021.

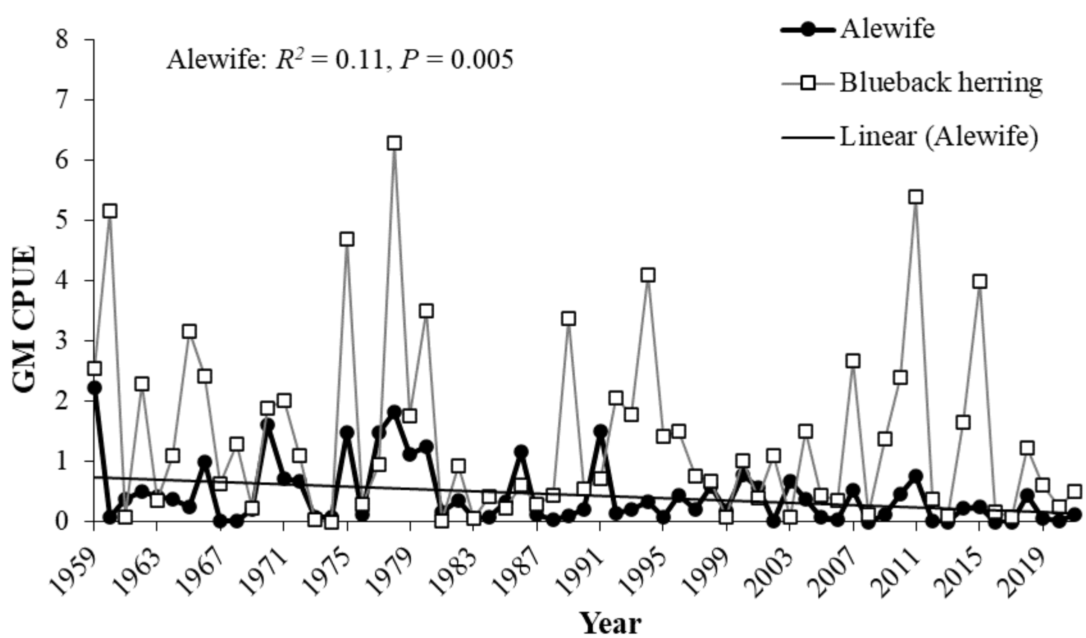


Figure 37. Upper Chesapeake Bay juvenile alewife and blueback herring GM CPUE (catch-per-seine-haul), 1959–2021.

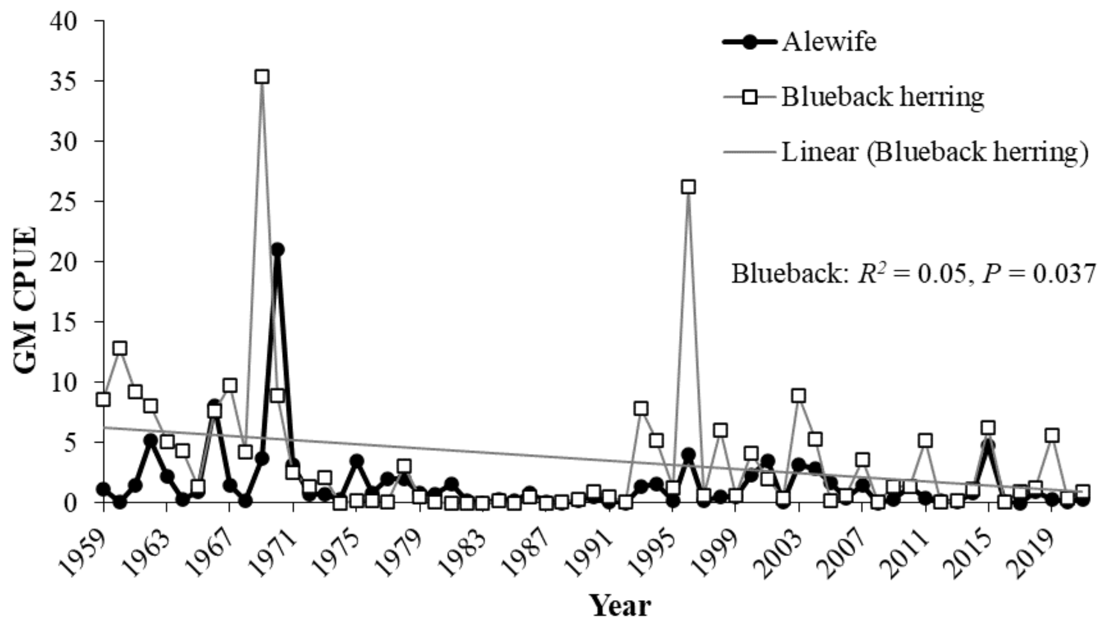
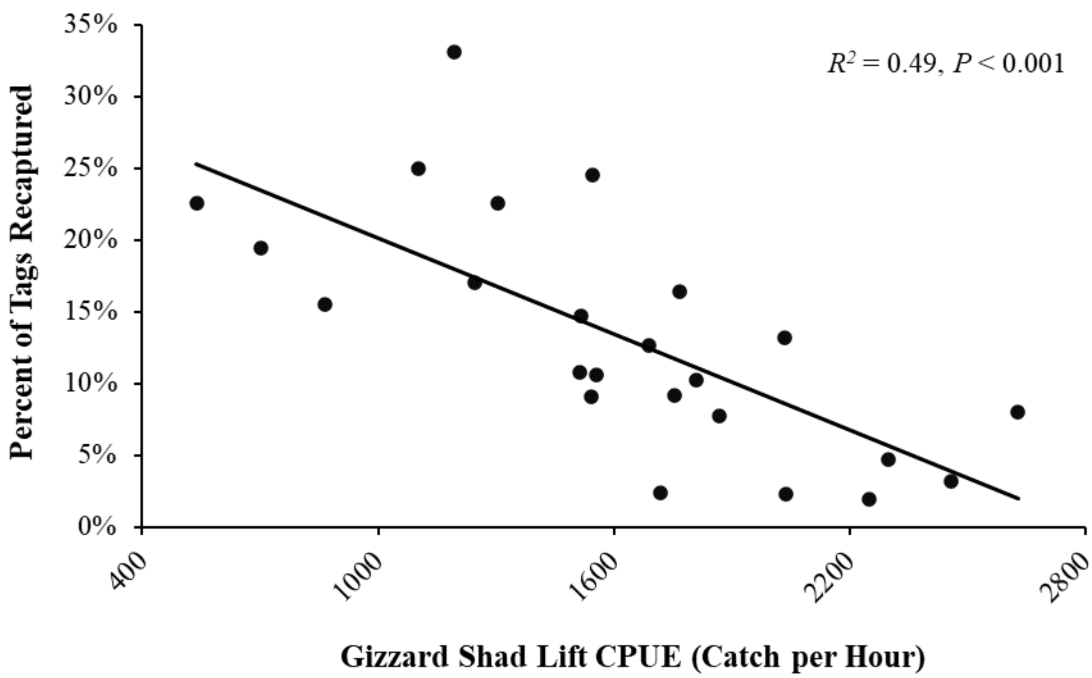


Figure 38. Percentage of tagged American shad recaptured at the Conowingo Dam fish lifts, 1997–2021, and gizzard shad CPUE at the East Fish Lift, 1997–2020, and West Fish Lift, 2021.



PROJECT NUMBER 2
JOB NUMBER 2

STOCK ASSESSMENT OF SELECTED RECREATIONALLY IMPORTANT ADULT MIGRATORY FINFISH IN MARYLAND'S CHESAPEAKE BAY

Prepared by Harry W. Rickabaugh Jr. and Katherine M. Messer

INTRODUCTION

The primary objective of Project 2 Job 2 was to characterize recreationally important migratory finfish stocks in Maryland's Chesapeake Bay by age, length, weight, growth and sex. Atlantic croaker (*Micropogonias undulates*), bluefish (*Pomatomus saltatrix*), spot (*Leiostomus xanthurus*), summer flounder (*Paralichthys dentatus*) and weakfish (*Cynoscion regalis*) are very important sportfish in Maryland's Chesapeake Bay. Black drum (*Pogonias cromis*), red drum (*Sciaenops ocellatus*), Spanish mackerel (*Scomberomorus maculates*) and spotted seatrout (*Cynoscion nebulosus*) are less popular in Maryland because of lower abundance, but are targeted by anglers when available (Chesapeake Bay Program 1993). Atlantic menhaden (*Brevoortia tyrannus*) are a key component to the Bay's food chain as forage for predatory sportfish (Hartman and Brandt 1995, Overton et al 2000).

The Maryland Department of Natural Resources (Department) has conducted summer pound net sampling since 1993, and began a fishery independent gill net survey in the Choptank River in 2013. The data collected from these efforts provide information for the preparation and updating of stock assessments and fishery management plans by the Department, the Atlantic States Marine Fisheries Commission (ASMFC), the Mid-Atlantic Fishery Management Council (MAFMC) and the South Atlantic Fisheries Management

Council. This information is also utilized by the Department in managing the state's valuable migratory finfish resources through the regulatory/statutory process.

METHODS

Data Collection

The onboard pound net survey relies on the cooperation of pound net fishermen. Pound nets from the lower Chesapeake Bay and Potomac River were monitored throughout the 29 years of this survey (1993-2021). In 2021, commercial pound nets were sampled inside the mouth of the Potomac River and in Chesapeake Bay north of the Potomac River to Barren Island (Figure 1). Each site was sampled once every two weeks, weather and fisherman's schedule permitting. Data from pound nets were also included from Job 3 from the lower Chester River in 2021 (Figure 1). Staff collected length data and Atlantic menhaden scale samples when target species of Job 2 were encountered and staff could sample them without impacting the completion of Job 3 sampling. Net soak time and the manner in which the pound nets were fished were consistent with the fisherman's day-to-day operations. No fish dealer sampling was conducted in 2021 since pound net sampling produced adequate samples of most species.

During onboard sampling, all targeted species were measured from each net when possible. When it was not practical to measure all fish, a random sample of each species was measured and the remaining individuals enumerated, if possible. All measurements were to the nearest millimeter total length (TL) except for Spanish mackerel which were measured to the nearest millimeter fork length (FL). Fifty randomly selected Atlantic menhaden were measured to the nearest millimeter FL each day, when available, and scale samples were taken from 10 to 25 of the measured fish. Water temperature (°C), salinity (parts per thousand), GPS coordinates (NAD 83), date and hours fished were also recorded at each net. Hours fished was not entered in the database if the net was not emptied on the day of sampling or the previous day fished.

A subsample of fish was retained and brought back to the lab for processing from the onboard sampling effort. Otoliths were taken and individual weights (grams), TL (millimeters) and sex were determined from subsampled Atlantic croaker, spot and weakfish. Prior to 2011, Atlantic croaker and weakfish otoliths were processed and aged by the South Carolina Department of Natural Resources. Otoliths from 2011 to 2021 were processed and aged by project biologists. All spot otoliths were processed and aged by project biologists. For all three species, the left otolith from each specimen was mounted to a glass slide for sectioning. If the left otolith was damaged or missing the right otolith was substituted. Otoliths were mounted to a glass slide using Crystalbond® 509 and sectioned with a Buehler IsoMet® low speed saw using two blades separated by a 0.4 mm spacer. Allied High Tech Products Inc. impregnated diamond metal bonded, high concentration cutting blades, measuring 102 millimeters in diameter and 0.31 millimeters thick (model number 60-20070) were used. The 0.4 millimeter sections were then mounted on microscope slides and viewed under a microscope at five to six power to determine the number of annuli. All age structures were read by two readers. If readers did not agree, both readers reviewed the structures together, and if agreement still could not be reached the sample was not assigned an age. In 2013 and 2020 two readers made initial age evaluations, but due to logistical limitations only one reader reexamined structures in which annuli counts differed. Atlantic menhaden scales were aged by two Department biologists using the same procedure outlined above. A minimum of four scales per sample were cleaned, mounted between two glass slides and read for age using an Anacomp Inc. Micron 385 microfiche reader. In 2015, the ASMFC conducted an Atlantic menhaden aging workshop. Workshop results indicated that Department biologist were sometimes over aging Atlantic menhaden by counting accessory rings on some scales (ASMFC 2015). This discrepancy was corrected for fish aged in 2015 and thereafter, therefore Atlantic menhaden age estimates prior to 2015 may be biased high.

A fishery independent gill net survey targeting adult Atlantic croaker, Atlantic menhaden, bluefish and spot was conducted in the lower Choptank River beginning in 2013 to provide an index of relative abundance and collect biological information for these species. The survey was conducted weekly in June, July and August in the main stem of the river (52 sets per year) from an imaginary line crossing from Howell Point to Jenkins Creek downstream to the river mouth (Figure 2). Logistical issues led to changes in sampling dates or missed sets in most years (Table 1). The survey utilized a simple random design in which the river was divided into a block grid, with each block being a 457.2 meter square (Figure 3). An experimental gill net constructed of four 30.5 meter by 1.8 meter net panels with stretch mesh sizes of 6.4 centimeters (2.5 inches), 7.6 centimeters (3.0 inches), 8.9 centimeters (3.5 inches) and 10.2 centimeters (4.0 inches) was anchored within the randomly selected grid. The order of the mesh sizes was randomly selected prior to net construction, and each panel was separated by an approximately 1.2 meter gap. Nets were rigged to sink using 5/8 inch float core line and 65 pound lead core line. Mesh was constructed of number eight monofilament netting, except for the 6.4 centimeter mesh which was constructed of number four monofilament. New nets were ordered prior to the

2020 fishing season and 65 pound lead core line was not available; therefore, 75 pound lead core line was substituted and these nets were used in 2020 and 2021. Four sampling blocks were sampled each day beginning approximately 30 minutes prior to sunrise. A GPS unit was used to navigate to the center of the grid. Each net site was designated as either shallow or deep using an alternating pattern that was set randomly at the beginning of the sampling season. Sampling blocks with appreciable depth change were set toward the shallow or deep side of the block perpendicular to the channel according to the shallow or deep designation. Any site with no appreciable depth change was set in the center of the sampling block perpendicular to the channel. Sets were not made in less than 1.5 meters or more than 12.2 meters to avoid net inefficiency at shallow sites or potential areas of hypoxia at deeper sites. Nets soaked for one hour prior to retrieval.

Immediately following deployment of each set, salinity (parts per thousand), secchi disk reading (meters), tidal stage, time, weather, wind direction and wind speed (knots) were recorded. All fish were enumerated by species and mesh size in which they were captured. All Atlantic croaker, bluefish, spot, striped bass, summer founder, weakfish and white perch were measured to the nearest millimeter TL. The first five Atlantic menhaden from each site and net panel were measured to the nearest millimeter FL, with scales and otoliths being taken from a total of 10 fish, the first five fish for two mesh panels each day (not each site).

Juvenile indices were calculated for Atlantic croaker, spot and weakfish from the Department Blue Crab Trawl Survey data. This survey utilizes a 4.9 meter semi-balloon otter trawl with a body and cod end of 25-millimeter-stretch-mesh and a 10-millimeter-stretch-mesh cod end liner towed for six minutes at 4.0-4.8 kilometers/hour. The systems sampled included the Chester River, the Choptank River, Eastern Bay, the Patuxent River (six fixed sampling stations each), Tangier Sound (five fixed stations) and Pocomoke Sound (eight fixed stations). Each station was sampled once a month from May through October. Juvenile Atlantic croaker, spot and weakfish collected by this survey have been enumerated and entered into a computer database since 1989 (Davis et al.1995).

Analytical Procedures

Commercial and recreational harvests for the target species were examined utilizing Maryland's mandatory commercial reporting system and the Marine Recreational Information Program (MRIP; National Marine Fisheries Service, Fisheries Statistics division, personal communication), respectively. Only commercial harvest from Maryland's portion of Chesapeake Bay is included in this report. MRIP data was downloaded in April 2022. MRIP estimates of recreational harvest are for Maryland inland waters only. This includes both Maryland's portion of Chesapeake Bay and coastal bays, but not the Atlantic Ocean. Chesapeake Bay waters are not separable in the MRIP online data query.

The Department has required charter boat captains to submit log books indicating the number of trips, number of anglers and number of fish harvested and released by species since 1993. Trips in which a species was targeted but not caught could not be distinguished from the log books, since no indication of target species is given. Therefore, no CPUE was calculated. All Maryland charter boat data in this report were from Chesapeake Bay.

Instantaneous total mortality rates (Z) for weakfish and Atlantic croaker were calculated using the Ssentongo and Larkin (1973) length based method,

$$Z = \{K/(y_{bar} - y_c)\}$$

where lengths are converted: $y = -\log_e (1-L/L_\infty)$, and $y_c = -\log_e (1-L_c/L_\infty)$, L = total length, L_c = length of first recruitment to the fisheries, K = growth coefficient and L_∞ = length that an average fish would achieve if it continued to grow. Von Bertalanffy parameters (K and L_∞) for weakfish for all years were estimated from otolith ages collected during the 1999 Chesapeake Bay pound net survey (Jarzynski *et al* 2000). The 1999 survey growth data had to be utilized because of severe age truncation in the weakfish population in subsequent years. Parameters for weakfish were L_∞ = 840 millimeters TL and K= 0.38. L_c was 305 millimeters TL. Von Bertalanffy parameters for Atlantic croaker mortality estimates were derived from pooled ages (otoliths; n = 3,473) determined from 2003-2019 Chesapeake Bay pound net survey data, and June through September 2003-2019 measurements of age zero Atlantic croaker (n=463) from the MD DNR Blue Crab Trawl Survey's Tangier Sound samples (Chris Walstrum MD DNR personnel communication 2019). Trawl data were included to provide age zero fish that had not recruited to the pound net gear, and represented samples taken from the same time period and region as the pound net samples. Parameters for Atlantic croaker estimates from 2003-2019 were L_∞ = 380 millimeters TL and K= 0.38, while L_c for Atlantic croaker was 229 millimeters TL. L_∞ has continued to decrease as additional years of data have been added, leading to more lengths in earlier years being above L_∞. Growth parameters used in the 2016 ASMFC stock assessment (ASMFC 2017a), using coast-wide data and combined sexes, were L_∞ = 459 millimeters TL and K= 0.16. Total mortality estimates were generated using both sets of growth parameters for comparison purposes.

Annual length frequency distributions were constructed when sample size was sufficient for Atlantic croaker, Atlantic menhaden, bluefish, spot, summer flounder, and weakfish utilizing 20 millimeter length groups for both the onboard pound net and Choptank River gill net surveys. Length-at-age keys were constructed for Atlantic croaker, Atlantic menhaden and weakfish using age samples through 2021. Age and length data were assigned to 20 millimeter groups for each species and then the length-at-age key was applied to the length frequency by year to determine the proportion at age for Atlantic croaker in 2000 and 2002 through 2021, weakfish from 2003 through 2021 and Atlantic menhaden from 2005 through 2021. Age and length data for spot were assigned to 10 millimeter TL groups and the length-at-age key was applied to the length frequency to determine the proportion at age by year for 2007 through 2021. It was necessary to supplement Maryland spot ages with Virginia Marine Recourses Commission (VMRC) spot age data for a small number of fish greater than 270 millimeters in the 2007, 2011 and 2012 samples.

Geometric mean catch per gill net hour fished, for all four mesh sizes combined, was calculated for Atlantic croaker, Atlantic menhaden and spot from the Choptank River gill net survey. A set was all four mesh panels combined by site. Since zero hauls were common, all catch data were catch+1 to avoid taking the natural logarithm of zero.

Chesapeake Bay juvenile indices were calculated as the geometric mean (GM) catch per tow. All catch data were catch+1 to avoid taking the logarithm of zero tows. Since juvenile weakfish have been consistently caught only in Tangier and Pocomoke sounds, only these areas were utilized in this analysis to minimize zeros that may represent unsuitable habitat rather than relative abundance. Similarly, the Atlantic croaker index was limited to Tangier Sound, Pocomoke Sound and the Patuxent River. All sites and areas were used for the spot index. Indices and 95% confidence intervals were derived using SAS® software (SAS 2010). Maps displaying sampling sites were created using ArcGIS version ArcMap 10.3 software for both the Choptank River gill net and onboard pound net surveys.

RESULTS and DISCUSSION

The onboard pound net survey sampled the Potomac River and Chesapeake Bay from June 4, 2021 through September 20, 2021 (Table 2). All of the target species and nineteen non-target species were encountered in 2021 (Table 3). The Choptank River fishery independent gill net survey was conducted once per week from June 2, 2021 to August 25, 2021. Six of the target species and ten non-target species were captured in 2021 (Table 4).

Weakfish

Twenty-one weakfish were sampled in the 2021 pound net survey, an increase from 2020, but it was still the third lowest number sampled in the 29 year time series. Weakfish mean length in 2021 was 287 millimeters TL, but due to low sample size may not be representative of the true mean length (Table 5). With the exception of 2016 and 2019, sample sizes in the past eight years have been too small to make valid length frequency comparisons across years, but the 2021 weakfish length frequency did have a broader length distribution than the past seven years (Figure 4).

Chesapeake Bay weakfish length frequencies were truncated during 1993 – 1998, while those for 1999 and 2000 contained considerably more weakfish greater than 380 millimeters TL. This trend reversed from 2001 to 2021, with far fewer large weakfish being encountered. Five of the 21 weakfish sampled in the 2021 pound net survey were above the commercial size limit of 305 millimeters TL (12 inches) and two were above the recreational size limit of 331 millimeters TL (13 inches).

One weakfish was captured and measured in the Choptank River gill net survey in 2021, with a length of 339 millimeters TL. Weakfish catch was very low throughout the survey ranging from zero to four fish per year (Table 4). Thirteen of the 14 weakfish captured by the survey were in the 6.4 centimeter mesh, and one was captured in the 7.6 centimeter mesh. Traditionally, weakfish have been a common catch by anglers in late summer and early fall in the lower Choptank River. The slightly later arrival of weakfish to the sampling area and the current depleted condition of the coast wide stock are likely causes of this scarcity of weakfish in the survey.

The 2021 Maryland Chesapeake Bay commercial weakfish harvest of nine pounds was a decrease from 2020, and was the second lowest value of the 1981-2021 time series (Figure 5). The 1981 – 2021 Maryland Chesapeake Bay average commercial harvest was 38,368 pounds per year. Harvest was higher in the 1980s averaging 121,732 pounds per year, declined in the 1990s averaging 32,779 pounds per year, and was much lower the past ten years, averaging 216 pounds per year. Estimated Maryland recreational harvest from inland waters during 2021 was 1,116 fish (PSE = 56.8; Figure 5). The time series mean harvest for Maryland inland waters from 1981-2021 was 263,182 fish. According to the MRIP estimates, Maryland anglers released 8,641 (PSE = 45.2) weakfish from inland waters in 2021, the fourth lowest value of the 1981-2021 time series, and well below the time series mean of 270,807 fish per year. Estimated recreational harvest decreased steadily from 741,758 fish in 2000 to 763 in 2006, and has fluctuated at a very low level from 2006 through 2021. Both the recreational harvest estimates and the reported commercial landings since 2010 may have been affected by a regulation change that took place in April 2010. The new regulation reduced the bag limit from three fish to one fish per recreational angler per day, and the commercial harvest was limited to a bycatch only fishery, with daily catch limits of 50 pounds in the Chesapeake Bay and 100 pounds in the Atlantic Ocean. Very few commercial trips landed weakfish at these bycatch limits since their inception, making it likely that low abundance, and not current regulations, was primarily responsible for the low total harvest. The reported harvest from Maryland charter boat captains ranged from 28 to 75,011 weakfish from 1993 to 2021 (Figure 6), with a sharp decline occurring in 2003. The 2021 value of 28 fish was the lowest on record. Reported charter boat harvest slowly increased from 2014 to 2017, reaching 2,152 fish prior to the sharp decline in 2018.

The weakfish juvenile GM was stable from 2013 to 2015, with values just below the time series mean, but declined in 2016 and remained low through 2018 (Figure 7). The 2019 and 2020 index values increased to 2.11 and 2.03 fish per tow, respectively, with values similar to 2013 to 2015. The 2021 index value decreased to 0.98 fish per tow. Weakfish juvenile abundance generally increased from 1989 to 1996, and remained at a relatively high level through 2001, but generally decreased from 2003 to 2008 with moderate to low values since.

Eleven weakfish otoliths were collected in 2021 and 10 were successfully aged, which was the third lowest number of ages since 2003. Seventeen and a half percent of sampled weakfish were age one, 17.5% were age two, 35.0% age three, and 30% were age four (Table 6). The proportion at age of the sampled fish is unlikely to represent the actual age structure due to the small sample size. Age samples from 2003 – 2005 were comprised of 45% or more age two plus weakfish, and then dramatically shifted to primarily age one fish from 2006-2011, with 0% to 30% age two plus fish and no age three fish from 2008 to 2011. Age structure expanded to include three year old weakfish in 2012 and 2013, with 46% and 65% of sampled fish being age two plus, respectively, indicating a slight shift back toward older weakfish. The 2014, 2020 and 2021 age sample sizes were too small to make valid comparisons (six to ten ages per year). No age three plus fish were sampled in 2015 – 2017 or 2019 -2020, and only one in 2018, but low sample size could have led to missed age classes.

Mortality estimates for 2006 through 2012 and 2014 through 2021 could not be calculated because of extremely low sample size, while instantaneous total mortality estimates calculated for 2004, 2005 and 2013 were $Z=1.29$, $Z = 1.44$ and $Z = 1.55$, respectively (Table 7), indicating total mortality has remained high. Maryland's length-based estimates in the mid-2000s were similar to the coastal assessment of $Z = 1.4$ for cohorts since 1995 (Kahn et al. 2005), and the estimates from the 2019 ASMFC stock assessment, which estimated Z values of 1.83, 1.72, and 1.84 in 2004, 2005 and 2013, respectively (ASMFC 2019).

The most recent weakfish benchmark Stock Assessment Workshop, completed by ASMFC in 2016, utilized a Bayesian model with time-varying M and spatial heterogeneity (ASMFC 2016), and was updated in 2019 with data through 2017, including the recalibrated MRIP time series (ASMFC 2019). The assessment update indicated weakfish biomass was very low; F was moderate in 2017 and instantaneous natural mortality (M) was high but stable to slightly decreasing from 2014 to 2017. The stock was classified as depleted and total mortality was just above the threshold in 2017, indicating that mortality was too high to allow for recovery. The stock assessment confirmed that the low commercial and recreational weakfish harvest in Maryland and low abundance in the sampling surveys, was directly related to a very low coast wide stock abundance.

Summer Flounder

Summer flounder pound net survey mean lengths varied widely from 2004-2021. Mean total lengths have ranged from the time series high of 374 millimeters TL in 2005 and 2010 to the time series low of 191 millimeters TL in 2017 (n = 394, Table 5). The mean length decreased to 252 mm TL in 2021 (Table 5), and was the third lowest value of the 29 year time series. The length frequency distributions from the onboard sampling from 2004-2012 were either bimodal with peaks between 130 to 190 millimeter TL intervals and between 310 to 430 millimeter TL intervals, or more normal in distribution with a singular peak between the 310 to 430 millimeter TL length groups. Generally, the bimodal distribution occurs when an abundant year class recruits to the fishing gear (at around 130 millimeters TL). The 2013, 2014 and 2021 length frequency distributions were heavily skewed toward smaller fish, with 66%, 58% and 69% below 290 millimeter TL in length, respectively (Figure 8). The 2021 distribution was bimodal but with a stronger peak for smaller fish and a weaker peak for larger fish than in most years (Figure 8). Recreational size limits have been adjusted annually, but comparing the onboard pound net survey catches to the 2021 recreational size limit of 420 millimeter TL indicated 2% of the 154 sampled flounder were of legal size in 2021, compared to 18% in 2020, with a range of 0% to 10% from 2013 to 2019. Six summer flounder were encountered during the Choptank River gill net survey in 2021 (Table 4), ranging from 176 to 194 millimeters TL. Five specimens were captured in the 64 millimeter mesh and one in the 76 millimeter mesh. Only 21 summer flounder have been captured in the nine years of the survey.

The 2021 Maryland Chesapeake Bay commercial summer flounder harvest totaled 1,450 pounds, a slight increase from 2020 (1,323 pounds), but still the fourth lowest value of the 1981 – 2021 time series (Figure 9). Maryland Chesapeake Bay landings decreased from 2005 - 2016, and have since fluctuated at a low level, well below the annual mean harvest of 24,780 pounds. In recent years the commercial flounder fishery has been managed by quota, with varying regulations and season closures to ensure the quota was not exceeded. The recreational inland harvest estimate of 48,071 fish (PSE = 27.2) in 2021 increased from the 2020 estimate, but was still well below the time series mean of 257,724 fish per year (Figure 9). The 2021 MRIP recreational inland release estimate of 484,208 fish (PSE = 18.5) decreased compared to 2020's estimate (691,335 fish, PSE = 23.9), and was below the time series mean of 1,176,208 fish per year. The recreational inland fishery has primarily been from the Maryland coastal bays in recent years. Regulations have been more restrictive in recent years than earlier in the time series.

Reported Chesapeake Bay summer flounder charter boat harvest has generally declined throughout the 1993 – 2021 time series, with the highest number harvested in 1993 (10,445 fish), the lowest in 2020 (one fish), and only 13 harvested in 2021 (Figure 10). Magnitude of harvest generally decreased in discrete time blocks, with 1993-2000 averaging 5,072 fish per year, 2001-2009 averaging 944 fish per year and 2010-2021 averaging 159 fish per year, with annual catch varying within these time blocks.

A coast wide stock assessment using the Age Structured Assessment Program (ASAP) was conducted in 2019, with a terminal year of 2017 (NEFSC 2019). The NMFS assessment concluded that summer flounder stocks were not overfished, and overfishing was not occurring. However, spawning stock biomass has been declining, fishing mortality has been just below the threshold, and recruitment has generally been below average in recent years. The stock assessment review panel warned fishing reductions may be necessary if these condition persist, particularly if recruitment remains low.

Bluefish

Bluefish sampled from the onboard pound net survey averaged 368 millimeters TL during 2021, the highest value of the 29 year time series (Table 5). The pound net survey length frequency distributions were bimodal for most years (Figure 11). The 2005-2007 and 2012-2015 pound net sampling indicated that a larger grade of bluefish were available in those years, although small bluefish still dominated the population with primary peaks in the 230-270 millimeter TL groups. This trend reversed in 2008–2011 and 2016-2018 when larger bluefish became scarce. The 2019 length distribution was the first year with the primary peak of the bimodal distribution occurring for larger fish (350 millimeter TL group), the 2020 distribution was more of a single peak centered on the 350 millimeter TL group, and the 2021 distribution was weekly bimodal also with the higher peak occurring for larger fish (390 millimeter TL group), indicating that a slightly bigger grade of bluefish was available in 2019 through 2021. Variable migration patterns into Chesapeake Bay may be responsible for these differences. Crecco (1996) reviewed bluefish commercial catch and effort data and suggested that the bulk of the stock was displaced offshore. Lack of forage and inter-specific competition with striped bass were possible reasons for this displacement.

Bluefish were captured in low numbers during all nine years of the Choptank River gill net survey, with one being captured in 2021 (Table 4). Bluefish lengths for all net panels and years combined ranged from 189 to 500 millimeters TL (n=62), with the one measurement from 2021 being 303 millimeters TL. Sample size was too small to make meaningful comparisons of length by net mesh size. Bluefish were most often captured in the 6.4 centimeter mesh for all years combined, with the 7.6 centimeter mesh panel accounting for the second highest catch (Figure 12).

Maryland's Chesapeake Bay commercial bluefish harvest in 2021 was 4,248 pounds, a decrease from 2020 (9,381 pounds), the second lowest value in the 1981-2021 time series, and well below the average of 99,207 pounds per year (Figure 13). Chesapeake Bay commercial landings were higher in the 1980s averaging 321,402 pounds per year, but were variable from 1990 to 2021, averaging 38,235 pounds. Recreational inland harvest estimates for bluefish were high through most of the 1980's, but fluctuated at a lower level since 1991 (Figure 13). The 2021 harvest estimate of 104,476 fish (PSE = 26.5) decreased compared to 2020 (164,918 fish), and was the second lowest value of the 1981-2021 time series. Estimated inland recreational releases were 138,489 fish (PSE = 23.1) in 2021, below the time series mean of 734,077 fish, and was the lowest value of the time series (Figure 13). Reported bluefish harvest from Chesapeake Bay charter boat logs ranged from 4,548 – 133,499 fish per year from 1993 to 2021, with the 2021 harvest being the lowest of the 29 year time series (4,548 fish; Figure 14).

A stock assessment of Atlantic coast bluefish utilized a forward projecting catch at age model including data through 2014 (NEFSC 2015). An operational assessment was conducted by the North East Fisheries Science Center in 2019, using the same model structure, with data through 2018 and the recalibrated MRIP estimates of recreational harvest. The assessment indicated overfishing was not occurring in the terminal year, but overfishing occurred during most of the previous years, and the stock was overfished (NEFSC 2020). These findings mandated coast wide regulation changes in 2020 to reduce harvest and rebuild the stock. Maryland reduced the bluefish recreational bag limit to three fish per person for shore and private boat anglers and five fish per person on for-hire fishing vessels. Maryland's commercial fishery operates under a quota set by the National Marine Fisheries Service. The commercial harvest never reached the harvest cap.

Atlantic Croaker

Atlantic croaker mean length from the onboard pound net survey decreased to 225 millimeters TL in 2021 (n=973), and was the second lowest value of the 29 year time series (Table 5). The onboard pound net length frequency distribution for 2019 was heavily skewed toward smaller fish, with 74% of all sampled fish being below 230 millimeter TL, and only seven percent of the sample over 250 millimeters TL (Figure 15). Low sample size in 2020 made any meaningful comparison difficult, but the 2021 sample size improved and the length frequency remained skewed toward younger fish, with 65% being less than 230 millimeters TL (Figure 15).

Atlantic croaker geometric mean catch per hour from the Choptank River gill net survey declined through the first three years of the survey and remained low in recent years (Figure 16). Catches ranged from 476 fish in 2013 to eight fish in 2018, with 48 being caught in 2021. The 6.4 centimeter mesh net caught the highest proportion of Atlantic croaker in all years except 2015, with proportion of catch declining as mesh size increased (Figure 17). In 2015, the 7.6 centimeter mesh accounted for the highest proportion of catch, but sample size was very low. Length frequency shifted to longer fish as mesh size increased (Figure 18), indicating the size selective nature of gill nets. Annual length frequency comparisons were not made do to the low sample sizes in 2015 through 2021. Anecdotal reports from commercial and recreational fishermen indicated Atlantic croaker catches were unusually low from the Choptank River and northward since 2015, but catches were somewhat higher in Tangier Sound and the Potomac River. The decreased catches, coupled with declining landings, suggest decreased availability in the mid to upper Bay in recent years.

The Maryland Atlantic croaker Chesapeake Bay commercial harvest continued to decline to 564 pounds in 2020, and remained low in 2021 equaling 1,042 pounds, well below the 1981 to 2019 mean of 362,689 pounds per year, and were the lowest and second lowest harvest values since 1991, respectively (Figure 19). The 2021 recreational inland harvest estimate was 174,056 fish (PSE = 25.3), a decrease from 2020 (174,056 fish), and well below the 1981-2021 average of 1,134,551 fish per year. The 2021 recreational release estimate of 1,870,120 (PSE = 21.5) fish also decreased compared to 2020 (2,852,724; Figure 19), and was below the 1981-2019 average of 2,297,578 fish per year. Reported Atlantic croaker harvest from charter boats ranged from 607 – 418,313 fish per year during the 29 year time period (Figure 20), with a value of 1,771 fish in 2021, and has been below 3,000 fish since 2017.

Since 1989, the Atlantic croaker juvenile index varied without trend with the highest values occurring in the late 1990s. This index increased to the fourth highest value of the 32 year time series in 2008, but fell sharply in 2009 and remained low through 2011 before spiking again in 2012 (Figure 21). The GM steadily decreased the following three years to the 2nd lowest value of the time series in 2015 (0.21 fish per tow). The index value has varied since, with the 2019 and 2020 values (4.9 and 3.7 fish per tow respectively) increasing above the time series mean and the 2021 value of 2.7 being just below the time series mean. Atlantic croaker recruitment has been linked to environmental factors including winter temperature in nursery areas (Lankford and Targett 2001, Hare and Able 2007); prevailing winds, currents and hurricanes during spawning; and larval ingress (Montane and Austin 2005, Norcross and Austin 1986). Because of these strong environmental influences, high spawning stock biomass may not result in good recruitment, and a high degree of variability can be expected.

Ages derived from Atlantic croaker otoliths from the onboard pound net survey in 2021 ranged from zero to three (n=155; Table 8). The 973 lengths were applied to the age length key for 2021 to derive a catch at age in 2021 (Table 8). Age zero accounted for 1% of sampled fish, age one accounted for 97% of sampled fish, age two accounted for 2% and age three accounted for less than 1% (Table 8). Age structure in 2021 was heavily skewed to younger fish, with no age four plus fish encountered for the first time since aging began in 1999. Atlantic croaker typically recruit to the fishery at age two, with full recruitment occurring at age three or four. Age zero fish are retained near the end of the season, but are not of marketable size. The contribution of strong year classes (1998, 2002, 2006, 2008 and 2012) to the catch can be seen in Table 8. The high percentage of age zero fish in age samples corroborates the indication of a stronger 2019 and 2020 year classes suggested by the juvenile index. The very low abundance of the 2019 year class as age two fish in 2021 is concerning.

Instantaneous total mortality estimates in 2021 using Maryland growth parameters and ASMFC stock assessment growth parameters were Z = 2.00 and Z = 1.36, respectively (Table 7). Both sets of estimates indicate the same trend, with Maryland only growth parameters indicating a larger range of values (Figure 22). Total mortality estimates were relatively stable at a low level from 1999 through 2009. Estimates of Z increased rapidly during 2010 - 2014 and were more variable. Total mortality generally increased through 2017, declined slightly in 2018, and increased to the time series high in 2021. Total mortality estimates would be expected to slowly decline as the stronger 2019 and 2020 year classes recruit to the fishery, provided they are not rapidly depleted prior to reaching older ages.

In 2017, the ASMFC Atlantic Croaker Technical Committee completed a stock assessment using a statistical catch at age model and data through 2014 (ASMFC 2017a). The assessment was not endorsed for management use by an independent review panel, primarily due to conflicting signals in trends from independent indices and fishery removals. The panel did agree, based on the information provided, that immediate management actions were not necessary. The panel also recommended the Traffic Light Analysis (TLA) continue to be used to trigger management action as needed. The ASMFC South Atlantic Board tasked the Atlantic Croaker Technical Committee to explore revisions to the TLA following the assessment. That work was completed in 2018, and the ASMFC voted to incorporate those changes at its February 2019 meeting. The new TLA was updated with data through 2019 and evaluated in October of 2020. The TLA triggered coast wide management action, which was implemented in 2021 and must stay in effect at least through the 2024 fishing season. Maryland was not required to implement any additional harvest restrictions, since a commercial and recreational size limit and a recreational bag limit were already in place.

Spot

The 2021 spot mean length from the onboard sampling of 188 millimeters TL was similar to the 2020 value of 186 millimeters TL, and was the eighth lowest value of the 29 year time series (Table 5). Seventy-nine percent of spot encountered in the onboard pound net survey in 2021 were between 170 and 209 millimeters TL, indicating a truncated length frequency distribution (Figure 23). Four jumbo spot (>254 millimeter TL) were present in the 2021 onboard sampling (n = 2,026). Abundance of jumbo spot in the survey was low for the past several years (0-3% of sample, 2005-2021). This followed good catches in the early 2000's (10% in 2003, 13% in 2004).

Spot geometric mean catch per hour in the Choptank River gill net survey was highest in 2020 and 2021, moderate in 2013, 2014, 2017 and 2019, and lowest in 2015, 2016 and 2018 (Figure 24). Total annual catch ranged from a low of 109 fish in 2016 to a high of 812 in 2020. The 6.4 centimeter mesh captured the majority of spot each year (Figure 25), accounting for over 92% of catch in 2013, 2014, 2016 and 2018 through 2021, and accounted for 73% and 82% of the catch in 2015 and 2017 respectively. The 7.6 centimeter mesh accounted for the second highest proportion of spot captured in all years. Only one to four spot were captured in the 8.9 centimeter mesh in 2013, 2015, and 2017, and only one spot was captured in the 10.2 centimeter mesh through the nine year time series (captured in 2021). Annual length frequency distributions have been variable throughout the survey, with similar distributions in 2013, 2014 and 2020 centered on the 200 and 210 millimeter length groups. Bimodal distributions were apparent in 2015 and

2017, and singular peak distributions were centered on the 190 millimeter TL group in 2016, 2018, 2019 and 2021 (Figure 26). These shifts are likely driven by year class strength, which had been generally poor from 2013 to 2019. Large shifts in length distribution are not uncommon in short lived species with variable recruitment, such as spot.

Commercial harvest from Maryland's portion of Chesapeake Bay remained stable in 2013 and 2014 at 257,881 and 254,443 pounds, respectively (Figure 27), but declined to 62,251 pounds in 2015, and to 17,760 pounds in 2016, the fourth lowest value of the 41 year time series. Harvest increased in 2017 to 97,075 pounds, but declined in 2018 to 41,453 pounds and again in 2019 to 31,831 pounds, and remained stable in 2020 and 2021 at 33,585 pounds and 31,124 pound, respectively. Recent landings were below the long term mean of 120,972 pounds per year. Maryland recreational inland harvest estimates from the MRIP indicated that spot catches since 1981 have been highly variable (Figure 27). Recreational harvest ranged from 927,140 fish in 1996 to 6,295,175 fish in 1987, while the number released fluctuated from 374,925 in 1996 to 6,462,976 in 2021 (PSE=15.5). The 2020 and 2021 recreational inland waters harvest estimates of 3,618,594 fish (PSE 16.9) and 4,019,372 fish (PSE = 12.4), respectively, were above the time series mean of 2,694,810 fish per year. The 2020 release estimate of 553,809 fish (PSE = 20.1) was the fourth lowest of the 41 year time series, but increased to the time series high in 2021 (Figure 27). Reported spot charter boat logbook harvest from 1993 to 2021 ranged from 74,763 to 847,311 fish per year (Figure 28). The 2021 reported harvest increased to 211,521 fish, but was well below the time series mean of 402,139 fish.

Spot juvenile trawl index values from 1989-2021 were quite variable (Figure 29). The 2010 GM value of 104.5 spot per tow was the highest value of the time series, the 2011 value declined to the second lowest of the 33 year time series, and the 2012 value increased to nearly the time series mean. The index values declined from 2012 to the time series low in 2015 (0.29 fish per tow). The index values remained low through 2018, but increased from 2019 through 2021, with the 2021 value of 34.4 fish per tow being the sixth highest value of the time series.

In 2021, 99% of spot sampled from the onboard pound net survey were age one, 1% were age zero, and no age two plus spot were encountered (176 ages and 2,026 lengths; Table 9). Age two plus spot were absent in 2013, 2016, 2018, 2019 and 2021. Age one spot dominated the pound net catch from 2007 to 2021, accounting for 75% to 99% of sampled fish in all but four years. In those four years, age zero spot accounted for a higher proportion of the catch, and age two plus spot remained rare.

In a relatively short-lived species such as spot, age and length structure will be greatly influenced by recruitment events. The shift in length frequency distribution, general decrease in mean size and reduction in percent jumbo spot observed from 2005 through 2019 could be indicative of growth overfishing. Reduced recreational harvest and reduced proportion of age one spot in 2016 was likely due to the very poor 2015 year class. The continued low abundance of age two fish and lack of age three plus fish is likely due to below average year classes from 2013 to 2018. The juvenile index has been increasing since 2019 which may lead to greater availability of age one and age two spot in 2022.

In 2017, the ASMFC Spot Stock Assessment Committee completed a stock assessment using a catch survey analysis model, utilizing data through 2014 (ASMFC

2017b). The assessment was not endorsed for use by an independent review panel primarily due to conflicting signals in trends from independent indices and fishery removals. The panel did agree, based on the information provided, that immediate management actions were not necessary. The panel also recommended the TLA continue to be used to trigger management action, as needed. The ASMFC South Atlantic Board tasked the Spot Plan Review Team to explore revisions to the TLA following the assessment. That work was completed in 2018, and the ASMFC voted to incorporate those changes at its February 2019 meeting. The new TLA was updated with data through 2019 and evaluated in October of 2020. The TLA triggered coast wide management action, which was implemented in 2021 and must remain in effect through at least the 2022 fishing season. In response, Maryland instituted a reduced commercial season and a 50 fish per person per day recreational bag limit.

Red Drum

Red drum were encountered sporadically through the 29 years of the onboard pound net survey, with none being measured in nine years and 458 being measured in 2012 (Table 5). Twenty-three red drum were measured in 2021 averaging 916 millimeters TL, ranging from 252 to 1,280 millimeters TL. Recreational anglers in Maryland are allowed one red drum between 457 and 686 millimeters TL (18 and 27 inches TL), and only one of the red drum encountered in 2021 was within the slot limit.

Maryland Chesapeake Bay commercial fishermen reported harvesting 21 pounds of red drum in 2021, compared to the 2013 spike of 2,923 pounds, and the 1981 to 2018 mean of 452 pounds per year (Figure 30). The high 2013 landings value was likely due to a large year class growing into the 457 – 635 millimeter TL (18 –25 inch) slot limit. The current slot limit and a five fish per commercial licensee daily harvest limit were put into place in 2003. Prior to 2003 a five fish limit was in place with a 457 millimeter TL (18 inch) minim size limit and only one fish over 686 millimeter TL (27 inches).

MRIP estimated a recreational harvest of 1,415 (PSE = 79.3) red drum in 2021 for Maryland inland waters, and estimated releases were 18,589 (PSE = 34.9) red drum (Figure 30). These values were similar to those of 2019 following above average estimates for both harvest and releases in 2020 (Figure 30). Recreational harvest estimates were extremely variable with zero harvest estimates for 28 of 41 years with very high PSE values. Recreational release estimates in 2012 indicated juvenile red drum were plentiful throughout much of Maryland's portion of Chesapeake Bay and its tributaries, and that most of these fish were sub-legal. Red drum catches returned to lower levels beginning in 2013.

Maryland charter boat captains reported harvesting red drum from the Chesapeake Bay in every year from 1993-2021, except for 1996. Harvest was low for all years, ranging from zero to a high of 269 fish in 2012, with 18 red drum being harvested in 2021 (Figure 31). The low reported annual harvest indicated red drum were available in Maryland's portion of Chesapeake Bay, but confirms the species limited availability to recreational anglers, as also indicated by the annual MRIP estimates. Maryland is near the northern limit of the red drum range, and catches of legal size fish should increase if the stock expands in response to the current Atlantic coast stock recovery plan (ASMFC 2002).

Black Drum

Black drum are encountered in small numbers during the onboard pound net sampling, 12 were sampled in 2021 with a mean TL of 505 millimeters (Table 5). Lengths throughout the time series ranged from 137 to 1,330 millimeters TL. No black drum under 202 millimeters TL were captured prior to 2021, but seven fish 200 millimeters TL or less were encountered in 2021. Commercial harvest of black drum was banned for Maryland's portion of Chesapeake Bay from 1999 to 2018, but was reopened in 2019 with a 10 fish per vessel limit and a 711 millimeter TL (28 inch) minimum size limit. Chesapeake Bay commercial harvest was 681 pounds in 2021 (Figure 32). Recreational inland water harvest and release estimates from 1981 to 2021 were variable, with harvest ranging from zero (20 years) to 11,374 fish in 1983 (Figure 32). In 2021, MRIP estimated 2,724 black drum were harvested (PSE = 94.4) and 92,542 were released (PSE = 90.1). The 2021 released alive estimate was the highest in the time series, and coupled with the occurrence of smaller length individuals in the pound net sampling, may indicate higher than normal abundance of young of the year black drum in Maryland's inland waters. The harvest estimates are tenuous since the MRIP survey is unlikely to accurately represent a small short lived seasonal fishery, such as the black drum fishery in Maryland, as evidenced by the high PSE values of the estimates in most years (2019 is the only year with a PSE value below 50). Charter boat logs indicated black drum were harvested in Maryland's portion of Chesapeake Bay in all years of the 1993-2021 time series, with a mean catch of 286 fish per year (range = 2 – 894; Figure 33). The lowest value of the time series was reported in 2018, and only 12 were reported in 2021.

Spanish Mackerel

Spanish mackerel have been measured for FL, TL or both, each year of the onboard pound net sampling. Since 2001, the majority of samples were measured as FL to be consistent with data collected by other state and federal agencies. During this time period, FL from the onboard sampling ranged from 123 – 751 millimeters. The survey encountered 691 Spanish mackerel in 2021 with a mean length of 378 millimeters FL (n=120; Table 5). The largest samples occurred from 2005-2007, 2013, 2019 and 2021. No Spanish mackerel were encountered in the Choptank River gill net survey in 2021. Spanish mackerel have been encountered in four of the nine years of the survey, and three of the past four years.

The 2021 commercial harvest of Spanish mackerel in Maryland's portion of Chesapeake Bay was 5,160 pounds (Figure 34), and was just above the 1981 to 2021 mean of 4,854 pounds per year. Reported commercial harvests of zero pounds were common in the early 1980s, but landings have become more stable since 1988 with a peak of 23,266 pounds in 2000.

Recreational inland waters harvest estimates were variable from 1981 – 2021, with 11 years of zero harvest and a peak of 150,529 fish in 2021 (PSE = 29.9; Figure 34), the third year in a row of setting a new time series high. The 2021 release estimate of 87,479 fish (PSE = 62.9) was also the time series high and third year of increasing values, indicating an unusually high availability of Spanish mackerel in Maryland inland waters. Estimates in most years have high PSE values, so these estimates are considered tenuous. Spanish mackerel charter boat harvest from 1993 to 2021 ranged from 53 – 10,638 fish per year, with a harvest of 8,436 fish in 2021, the third year in a row with values well above the time series mean of 3,111 (Figure 35). Spanish mackerel are providing a small but somewhat consistent opportunity for recreational anglers in Maryland's portion of Chesapeake Bay.

Spotted Seatrout

Spotted seatrout are occasionally encountered during the onboard pound net survey sampling, with annual observations ranging from zero (12 years) to 64 (2020). Seven spotted seatrout were encountered during the onboard pound net survey in 2021, with a mean TL of 448 millimeters (Table 5). No spotted seatrout were captured in the Choptank River gill net survey in 2021, with only two years in which any were captured. Commercial harvest of spotted seatrout in Maryland's portion of Chesapeake Bay increased to 1,135 pounds in 2021 and averaged 2,420 pounds from 1981-2021; however, 12 of 41 years had zero harvest (Figure 36). Recreational harvest estimates for inland waters indicated a modest but variable fishery during the mid-1980s through the mid-1990s. Estimated harvest averaged 45,272 fish per year from 1986 to 1999, but was lower from 2000 to 2021, including seven years of zero harvest, and averaged 10,256 fish per year. MRIP estimated 17,664 (PSE = 44.6; Figure 36) spotted seatrout were harvested in Maryland inland waters in 2021. Conversely, release estimates were generally higher in recent years, with the past three years being above the time series average of 70,668 fish per year (Figure 36). The high PSE values indicate the MRIP survey does not provide reliable estimates for this species in Maryland inland waters in most years.

Reported spotted seatrout harvest from 2021 charter boat logs was 414 fish. Reported harvest ranged from 2 – 20,003 fish per year and averaged 2,489 fish per year for the 27 year time series (Figure 37). No harvest was reported in 1993 and 1994, but it is not clear if spotted seatrout were not reported at that time or none were captured. Therefore, these years were not included in the time series. The recreational spotted seatrout fishery in Chesapeake Bay is prosecuted by a small group of anglers that are likely under-represented in the MRIP estimation design. This is supported by the 2007 and 2008 reported charter boat harvest values that exceeded the time series mean coinciding with zero value estimates by MRIP. The increase in released fish and lower harvest levels in recent years may be in part due to a regulation change in April of 2014 that reduced the creel limit from ten fish per person per day to four fish per person per day. This change was requested by recreational anglers, and coincided with a shift to a more trophy or catch and release fishery for many anglers targeting spotted seatrout.

Atlantic Menhaden

Mean length for Atlantic menhaden sampled onboard commercial pound net vessels in 2021 was 215 millimeters FL (n = 1,359), the second lowest value of the 18 year time series (Table 5). Atlantic menhaden length frequencies from onboard sampling have varied annually (Figure 38). The 2016 onboard pound net sampling distribution was more evenly distributed than previous years, but the 2017 and 2018 distributions were dominated by the 190, 210 and 230 millimeter size groups. The 2019 distribution was bimodal and heavily skewed toward smaller fish, but 2020 and 2021 were more evenly distributed with peaks at the 210 and 170 millimeter length groups, respectively.

Atlantic menhaden was the most common species captured by the Choptank River gill net survey, with annual catches ranging from 1,171 fish (2016) to 2,257 fish (2018; Table 4). The 2021 catch was 2,044 fish, the third lowest value of the nine year survey. The geometric mean catch per hour of Atlantic menhaden from the gill net survey was steady from 2013 to 2015, slightly lower in 2016 and 2017, variable at higher values from 2018 to 2020, and decreased in 2021 to a value similar to the beginning of the survey time period (Figure 39). The 7.6 centimeter mesh and the 6.4 centimeter mesh accounted for over 70% of the catch, annually (Figure 40). The 7.6 centimeter mesh caught the highest proportion of Atlantic menhaden from 2013 through 2015 and in 2019, and the 6.4 centimeter mesh caught the most Atlantic menhaden from 2016 through 2018 and in 2020 and 2021. Length frequency distributions from the Choptank River gill net survey indicated the gear selected slightly larger Atlantic menhaden than the pound net survey from 2013 to 2020 (Figure 41), with the 230 and 250 millimeter length groups, combined, accounting for over 60% of the catch annually from 2013-2018. The 2019 length frequency was the first year with a bimodal distribution, the primary peak still occurred at the 250 millimeter FL group, but a lesser peak occurred at the 190 millimeter FL group. The 2020 distribution peaked at the 210 millimeter length group with the 230 and 250 millimeter groups being the next most abundant. The distribution shifted to small fish in 2021 with the 210 millimeter length group accounting for 42% of measured fish. Prior to 2020 mean lengths for all meshes combined displayed little inter-annual variation, with values between 254 and 257 millimeters FL for five of the years and a value of 243 millimeters FL in 2017 and 2019 (Table 10). The 2020 and 2021 values declined to 235 and 226 millimeters FL, respectively.

Atlantic menhaden scale samples were taken from 428 fish from the onboard pound net survey in 2021, but ages could only be assigned to 404 fish (Table 11). After applying the 2021 length frequency (1,359 lengths in 2021) to the age length key, 45% of sampled fish were age one, 30% were age two and 14% were age three, 7% were age four and 4% were age five (Table 11). Corrections in Maryland's assigning of annuli following the 2015 ASMFC Atlantic menhaden aging workshop likely reduced the age estimates of some fish from 2015 to 2021 compared to the method used in previous years. One hundred seven scale samples were taken and aged from the Choptank River gill net survey in 2021. Age two accounted for 47%, age one accounted for 23%, age three accounted for 14%, age four accounted for 12%, and age five accounted for 4% of sampled Atlantic menhaden (Table 12). Commercial pound nets and the Choptank River gill net survey selected slightly different ages. The gill net survey had fewer age one fish in all years, and a higher proportion of age three plus fish in all years. However, the proportion of age three plus fish was similar in 2021 for both surveys, and the proportion of age one and two fish was higher for the gill net survey in the past two years. The shift to younger ages and smaller fish in the independent gill net survey seems to indicate a shift to smaller menhaden being available in the lower Choptank River in recent years.

Average annual Atlantic menhaden commercial harvest in Maryland's portion of Chesapeake Bay was 6.7 million pounds from 1981 to 1989, 3.2 million pounds from 1990 to 2004 and 7.9 million pounds from 2005 to 2016 (Figure 42). Harvest fell to 2.8 million pounds in 2017, the first year landings were below 5 million pounds since 2003, and averaged 2.8 million pounds from 2017 to 2021, with a 2021 value of 2,888,498 pounds. A coast wide quota was established by ASMFC during the 2013 fishing year (ASMFC 2012), with individual states getting a percentage of the total allowable catch based on historical landings. Prior to 2013, the Atlantic menhaden fishery in Maryland had no restrictions, aside from general commercial fishing license requirements and regulations, including a prohibition on purse seining. Maryland did not reach its quota from 2017 through 2021, but did reach the quota from 2013 to 2016.

A benchmark ASMFC Atlantic menhaden stock assessment was conducted in 2019 using the Beaufort Assessment Model which is a forward-projecting statistical catch-at-age model (SEDAR 2020a). A suite of Ecological Reference Point (ERP) models were also developed to try and account for Atlantic menhaden as a prey species. (SEDAR 2020b). The single species model concluded overfishing was not occurring and the stock was not overfished, and was not in danger of exceeding single species reference points in the near future. An Environmental Reference Point (ERP) model was presented to the ASMFC Atlantic Menhaden Board that also indicated the same stock status, but current fecundity and fishing mortality values were closer to the target values than the single species reference points, indicating there is little room to expand the fishery and a higher probability of exceeding the target in the near future. Following development of projections based on the ERP model reference points, the Board accepted them for management use at a subsequent meeting in 2020. An update of the assessment is scheduled for completion in 2022.

PROJECT NUMBER 2
JOB NUMBER 2

STOCK ASSESSMENT OF SELECTED RECREATIONALLY IMPORTANT ADULT MIGRATORY FINFISH IN MARYLAND'S CHESAPEAKE BAY

2022 PRELIMINARY RESULTS – WORK IN PROGRESS

Onboard pound net survey sampling, through the 2022 portion of the reporting period, was conducted on May 25, June 1, June 6, June 14, June 22 and June 28, 2022, with one to four nets sampled each day. During these trips the survey took length measurements from three American shad, three Atlantic croaker, 399 Atlantic menhaden, two Atlantic sturgeon, four black drum, one channel catfish, one cobia, 77 bluefish, 10 northern kingfish, two red drum, 303 summer flounder, 20 Spanish mackerel, 829 spot, seven spotted seatrout and 240 striped bass. Subsamples for aging were collected from three Atlantic croaker, 135 Atlantic menhaden, 84 spot and 25 striped bass. Sampling continued into the next reporting period.

Two cooperating fishermen were contracted for the 2022 sampling season, one in lower Eastern Shore area, and one at the mouth of the Potomac River. Seafood dealer sampling was not conducted in the first half of the 2022 sampling season, since regional coverage of the onboard pound net survey was deemed adequate.

The Choptank River gill net survey was conducted on four days for a total of 16 sites from June 8, 2021 to June 29, 2022. The survey caught two Atlantic croaker, 1,201 Atlantic menhaden, five bluefish, one channel catfish, three harvestfish, five hogchoker, 234 spot, one striped bass, and 64 white perch. Scale samples were collected from 53 Atlantic menhaden for age analysis. Sampling continued into the next reporting period.

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LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

Table 1. Total number of sets and number of sets per month by year for the Choptank River gill net survey, 2013 - 2021.

Year	June	July	August	September	Total Sets
2013	8	16	16	8	48
2014	16	20	16		52
2015	16	16	16		48
2016	12	14	16	4	46
2017	16	16	19		51
2018	16	20	16		52
2019	16	20	16		52
2020	16	19	12	4	51
2021	20	16	13		49

Table 2. Areas sampled, number of sampling trips, mean surface water temperature and mean surface salinity by month for 2021 commercial pound net sampling.

Area	Month	Number of Samples	Mean Water Temp. C	Mean Salinity (ppt)
Point Lookout	June	3	23.1	12.1
East Bay	June	4	23.8	12.7
West Bay	June	3	24.0	12.8
Point Lookout	July	2	27.0	12.9
East Bay	July	1	26.5	12.8
West Bay	July	5	26.4	13.3
Upper Bay	July	1	26.5	6.9
Point Lookout	August	2	27.0	13.8
East Bay	August	1	N/A	N/A
West Bay	August	5	26.8	12.6
Upper Bay	August	1	25.9	7.6
Point Lookout	September	1	25.9	12.6
East Bay	September	5	24.8	13.6
West Bay	September	7	25.5	13.9
Point Lookout	October	1	23.3	11.7
Point Lookout	November	1	13.2	12.1
Upper Bay	November	1	14.1	7.5

Table 3. List of non-target species observed during the 2021 onboard pound net survey.

Common Name	Scientific Name
Atlantic cutlassfish	*Trichiurus lepturus*
Atlantic needlefish	*Strongylura marina*
Atlantic spadefish	*Chaetodipterus faber*
Atlantic thread herring	*Opisthonema oglinum*
Butterfish	*Peprilus triacanthus*
Cobia	*Rachycentron canadum*
Cownose ray	*Rhinoptera bonasus*
Florida pompano	*Trachinotus carolinus*
Gizzard shad	*Dorosoma cepedianum*
Hogchoker	*Trinectes maculates*
Inshore lizardfish	*Synodus foetens*
Northern kingfish	*Menticirrhus saxatilis*
Northern puffer	*Sphoeroides maculatus*
Oyster toadfish	*Opsanus tau*
Sheepshead	*Archosargus probatocephalus*
Silver perch	*Bairdiella chrysoura*
Southern stingray	*Dasyatis americana*
Striped bass	*Morone saxatilis*
Striped burrfish	*Chilomycterus schoepfi*

Table 4. Total catch by species in numbers from the Choptank River gill net survey, 2013 – 2021.

Common Name	2013	2014	2015	2016	2017	2018	2019	2020	2021
Atlantic Croaker	476	269	21	32	53	8	43	45	48
Atlantic Menhaden	1,584	2,247	1,782	1,171	1,292	2,257	2,045	1,866	1,234
Black Drum	0	0	0	1	0	0	0	0	0
Blue Catfish	0	0	0	0	0	0	2	0	0
Blue Crab	34	44	165	127	107	107	103	157	101
Bluefish	11	22	7	3	3	11	3	1	1
Butterfish	0	2	2	0	0	1	0	5	13
Channel Catfish	0	0	0	0	0	1	3	0	2
Cownose Ray	0	1	0	0	0	2	0	0	1
Gizzard Shad	180	231	188	36	28	12	42	19	11
Harvestfish	0	0	0	2	2	13	2	7	0
Hickory Shad	0	0	0	0	1	3	0	0	0
Hogchoker	3	39	6	6	14	5	14	20	25
Horseshoe Crab	0	0	0	0	0	3	1	0	0
Northern Kingfish	1	9	0	1	1	0	0	3	1
Oyster Toadfish	0	0	0	0	0	0	1	0	0
Spanish Mackerel	0	0	0	1	0	6	7	3	0
Spot	272	749	222	109	298	154	389	812	568
Spotted Seatrout	0	0	0	0	0	0	6	2	0
Striped Bass	16	33	14	50	79	103	48	26	24
Summer Flounder	2	0	0	2	5	4	0	2	6
Weakfish	0	0	1	3	1	3	4	2	1
White Catfish	0	0	0	0	0	0	3	0	1
White Perch	18	41	55	64	67	8	32	20	7
Total Catch	2,597	3,687	2,463	1,608	1,951	2,701	2,748	2,990	2,044

Table 5. Mean length (millimeter TL, unless otherwise noted), standard deviation, and sample size of summer migrant fishes from Chesapeake Bay onboard pound net sampling, 1993-2021.

	Weakfish			Summer flounder			Bluefish		
Year	Mean Length	Standard Deviation	n	Mean Length	Standard Deviation	n	Mean Length	Standard Deviation	n
1993	276	46	435	347	58	209	312	75	45
1994	291	50	642	309	104	845	316	55	621
1995	306	54	565	297	62	1,669	323	54	912
1996	293	54	1,431	335	65	930	307	50	619
1997	297	39	755	295	91	818	330	74	339
1998	337	37	1,234	339	53	1,301	343	79	378
1999	334	53	851	325	63	1,285	306	65	288
2000	361	83	333	347	46	1,565	303	40	398
2001	334	66	76	358	50	854	307	41	406
2002	325	65	196	324	93	486	293	45	592
2003	324	68	129	353	56	759	320	58	223
2004	273	32	326	327	101	577	251	60	581
2005	278	39	304	374	76	499	325	92	841
2006	290	30	62	286	92	1,274	311	71	1,422
2007	275	42	61	341	66	1,056	318	70	1,509
2008	276	52	42	347	72	982	260	41	2,676
2009	262	22	23	368	64	277	265	43	1,181
2010	253	24	47	374	84	197	297	60	493
2011	236	24	26	359	67	213	245	48	290
2012	284	48	93	338	130	161	298	77	877
2013	304	33	67	268	89	194	297	59	1,000
2014	332	65	6	268	73	101	319	62	443
2015	293	31	23	336	61	43	327	79	392
2016	256	31	64	273	77	41	289	48	132
2017	257	35	27	191	86	394	299	53	111
2018	265	29	16	250	69	125	291	59	72
2019	252	26	63	272	74	168	345	50	756
2020	300	36	6	304	105	40	361	54	395
2021	287	58	21	252	74	159	368	74	320

Table 5. Continued.

	Atlantic croaker			Spot			Spotted Seatrout		
Year	Mean Length	Standard Deviation	n	Mean Length	Standard Deviation	n	Mean Length	Standard Deviation	n
1993	233	35	471	184	28	309			
1994	259	34	1,081	207	21	451	448	86	4
1995	286	42	974	206	28	158	452	42	6
1996	294	31	2,190	235	28	275			
1997	301	39	1,450	190	35	924			
1998	310	40	1,057	230	16	60	541		1
1999	296	54	1,399	213	25	572	460	134	2
2000	302	45	2,209	230	21	510			
2001	317	37	733	239	33	126			
2002	279	73	771	184	36	681			
2003	287	55	3,352	216	30	1,354			
2004	311	43	1,653	208	36	882			
2005	317	48	2,398	197	37	2,818			
2006	304	66	1,295	191	29	2,195			
2007	307	54	2,963	208	23	519	414	43	3
2008	298	62	1,532	198	21	1,195	464	72	10
2009	320	50	91	185	21	33	262	22	23
2010	295	34	1,970	201	22	51			
2011	281	31	1,764	193	18	582	361	142	4
2012	274	42	1,842	179	24	1,508	436	112	8
2013	276	36	2,320	196	20	1,302	456	29	5
2014	249	31	1,438	194	20	420	499	70	4
2015	265	22	942	194	18	127	487		1
2016	254	23	2,239	175	19	135	625		1
2017	258	50	2,037	200	25	1,063	464	51	3
2018	271	24	214	180	18	1,149			
2019	212	30	202	198	22	1,396	391	70	13
2020	252	21	14	186	11	655	442	68	64
2021	225	25	973	188	16	2,026	448	116	7

Table 5. Continued.

	Black Drum			Red Drum			Menhaden (Fork Length)		
Year	Mean Length	Standard Deviation	n	Mean Length	Standard Deviation	n	Mean Length	Standard Deviation	n
1993									
1994	1,106	175	2						
1995	741	454	3						
1996	353	20	2						
1997									
1998	1,074	182	12	302		1			
1999				332	71	16			
2000				648		1			
2001									
2002	435	190	7	316	44	177			
2003	475	20	4	506		1			
2004	780	212	44	647	468	2	262	28	213
2005	1,130		1	353		1	282	36	1,052
2006	1,031	228	8	366	21	16	238	42	826
2007	1,144	95	9	658	40	2	243	41	854
2008	875	238	5	361	57	21	246	29	826
2009	1,147	84	13				245	40	366
2010	1,061	345	3				232	36	836
2011	978	188	3	678	18	2	213	39	773
2012	997		1	318	71	458	243	25	755
2013	882	236	4	469	39	16	251	31	762
2014	1,080	150	14	954		1	223	38	775
2015	993	171	4				219	28	864
2016	952	429	4	340	10	3	208	42	732
2017				549	105	19	217	24	723
2018	610	350	3	1,191	162	4	231	24	668
2019	564	383	4	528	247	6	215	41	868
2020	909	203	24	341	28	53	221	27	777
2021	505	419	12	1,060	827	23	215	38	1,359

Table 5. Continued.

Year	Spanish Mackerel (Total Length)			Spanish Mackerel (Fork Length)		
	Mean Length	Standard Deviation	n	Mean Length	Standard Deviation	n
1993	261	114	3			
1994	391	55	78			
1995	487	38	39	418	34	44
1996	481	55	27	401	62	27
1997	520		1	437		1
1998	418	45	4	379		1
1999	468	82	45			
2000	455	66	35	386	34	49
2001				406	34	19
2002				422	81	20
2003				405	63	11
2004				391	95	8
2005				422	33	373
2006				439	35	445
2007				436	51	158
2008				407	59	18
2009				418	53	7
2010						
2011						
2012				393	74	107
2013	508	37	124	428	36	331
2014				536		1
2015	343		1	437	41	3
2016	404	53	10	345	16	10
2017				446	54	9
2018				427	144	9
2019				374	54	1,337
2020	599	50	2	407	78	120
2021				378	86	691

Table 6. Percentage of weakfish by age and year, number of age samples and number of length samples by year, using pound net length and age data 2003-2021.

Year	Age 1	Age 2	Age 3	Age 4	# of Ages	# of Lengths
2003	8.8	72.6	15.7	2.9	48	129
2004	55.9	39.2	4.9		59	326
2005	39.8	55.2	4.8	0.3	109	304
2006	70.1	22.2	7.6	0.1	62	62
2007	67.8	24.2	7.9	0.1	61	61
2008	85.7	7.1	7.1		41	42
2009	77.3	22.7			22	22
2010	100.0				45	47
2011	80.8	15.4			26	27
2012	54.2	42.3	3.5		71	93
2013	34.7	51.9	13.4		52	67
2014	33.3	16.7	50.0		6	6
2015	47.0	53.0			19	23
2016	85.9	14.2			63	64
2017	77.8	22.2			27	27
2018	73.4	18.8	7.8		15	16
2019	88.71	11.29			63	63
2020	50	50			6	6
2021	17.5	17.5	35	30	10	21

Table 7. Atlantic croaker and weakfish instantaneous total mortality rate estimates (Z) from Chesapeake Bay pound net data, 1999–2021.

		Growh parameters From MD only	Growh parameters From ASMFC SA
Year	Weakfish	Atlantic Croaker	Atlantic Croaker
1999	0.74	0.28	0.34
2000	0.4	0.31	0.36
2001	0.62	0.24	0.28
2002	0.58	0.25	0.27
2003	0.73	0.33	0.40
2004	1.29	0.26	0.32
2005	1.44	0.22	0.27
2006	*	0.19	0.24
2007	*	0.22	0.31
2008	*	0.22	0.29
2009	*	0.37	0.38
2010	*	0.25	0.47
2011	*	0.67	0.55
2012	*	0.66	0.89
2013	1.55	0.72	0.83
2014	*	1.41	1.02
2015	*	1.24	0.87
2016	*	1.61	1.11
2017	*	1.41	1.00
2018	*	0.81	0.60
2019	*	1.82	1.25
2020	*	1.89	1.27
2021	*	2.00	1.36

* Insufficient sample size to calculate 2006 – 2012, 2014 - 2021 weakfish estimates.
**Very low sample size.

Table 8. Percentage of Atlantic croaker by age and year, number of age samples and number of length samples by year, using pound net length and age data, 1999-2021.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9	Age 10	Age 11	Age 12	Age 13	# Aged	# Measured
1999		34.0	22.5	3.3	9.4	4.2	16.0	6.0	4.2	0.4					180	1,399
2000		10.1	42.5	25.1	1.0	1.4	4.9	7.4	5.3	2.2					145	2,209
2001	No Data															
2002	18.4	4.0	10.1	8.9	29.4	24.0	1.0		3.0	0.5	0.6				66	771
2003		15.2	38.6	1.3	12.2	26.6	3.8	0.1	0.2	0.1	0.7	0.3	1.0		129	3,352
2004		0.6	54.9	5.0	5.4	6.9	23.3	3.1	0.0	0.2		0.6			161	1,653
2005		10.1	4.8	51.5	7.6	1.5	7.3	11.4	5.6		0.1	0.1			190	2,398
2006	16.7	6.3	18.1	4.8	36.8	2.3	3.2	5.0	5.2	1.8				0.1	253	1,295
2007		11.2	14.4	30.0	8.8	27.0	1.3	1.1	1.6	3.3	1.0	0.3			275	2,963
2008	5.5	7.2	28.3	14.0	19.0	4.5	17.6	1.0	0.4	0.5	1.7	0.3			288	1,532
2009		30.9	8.5	37.4	11.1	7.8	1.8	2.2	0.3						222	1,381
2010		1.2	25.7	8.7	36.5	15.8	9.4	0.9	1.3	0.3		0.3			267	2,516
2011		0.8	17.4	48.2	11.3	16.6	3.6	1.7	0.3	0.1					245	1,886
2012	10.2	0.9	22.5	21.8	34.1	6.5	2.8	0.9	0.3						255	1,842
2013		13.5	2.3	24.7	22.2	27.9	4.1	4.9	0.1		0.2				247	2,320
2014		6.23	67.78	1.39	14.97	6.55	2.25	0.58	0.12	0.12					193	1,436
2015			7.04	81.67	0.74	6.77	1.18	2.61							126	942
2016	2.76	1.62	5.44	20.37	63.91	1.50	4.31	0.06	0.04						175	2,239
2017	1.02	9.28	5.54	17.81	19.51	46.48	0.36								230	2,064
2018	5.14	18.03	18.48	8.42	14.29	18.19	17.45								83	214
2019	79.56	13.05	2.96	1.48	0.49	1.48	0.49	0.49							134	203
2020	14.29	57.14	14.29	7.14	7.14										14	14
2021	0.90	96.75	1.93	0.41											155	973

Table 9. Percentage of spot by age and year, number of age samples and number of length samples by year, using pound net length and age data, 2007-2021.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Ages	Lengths
2007	21.3	75.0	3.3		0.4	98	519
2008	20.8	78.6	0.6			206	1,201
2009	7.7	90.7	1.6			232	614
2010	5.9	90.1	4.0			91	300
2011	0.4	99.4	0.2			173	582
2012	39.5	59.8	0.7			230	1,408
2013	3.6	96.4				167	1,285
2014	5.0	88.5	6.5			161	420
2015	9.1	88.4	2.6			78	127
2016	53.1	46.9				111	137
2017	19.1	80.5	0.3			228	1063
2018	62.2	37.8				185	1149
2019	48.12	51.88				192	1395
2020	7.09	92.16	0.75			97	655
2021	1.29	98.71				176	2026

Table 10. Atlantic menhaden mean length (millimeter FL), standard deviation, and sample size from the Choptank River gill net survey, 2013- 2021.

Year	Mean Length	Std. Dev.	n
2013	254	27	278
2014	256	24	459
2015	258	24	420
2016	254	24	308
2017	243	22	362
2018	257	23	573
2019	243	34	473
2020	235	30	475
2021	226	31	348

Table 11. Atlantic menhaden percentage at age, number of age samples and number of length samples by year using pound net length and age data, 2005-2021.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	# Aged	# Measured
2005		2.74	25.86	42.61	25.64	3.15			345	1,061
2006		40.44	28.27	18.36	9.70	2.62	0.60		289	826
2007		22.64	37.44	24.70	10.72	3.95	0.55		379	854
2008		16.60	44.55	29.36	7.27	1.94	0.28		385	826
2009	0.40	16.79	24.92	38.04	17.15	2.72			258	512
2010		42.98	30.61	14.93	8.26	2.50	0.60		388	836
2011		38.03	31.41	19.88	9.12	1.57			392	773
2012		14.51	56.74	21.45	4.26	1.80	0.77	0.48	355	755
2013		23.89	27.73	24.33	15.98	6.49	1.35	0.23	315	762
2014		33.00	36.20	18.70	10.00	2.20			229	775
2015		34.28	54.42	8.08	2.51	0.71			245	882
2016		42.75	30.02	19.27	7.23	0.72			241	732
2017		42.60	44.12	8.81	3.71	0.75			295	1058
2018		45.28	29.72	15.41	6.20	3.05	0.35		187	668
2019		64.93	10.86	12.13	8.38	3.48	0.22		271	867
2020		25.59	61.06	6.87	4.81	1.48	0.19		288	777
2021		44.89	30.46	13.58	6.66	4.42			404	1359

Table 12. Atlantic menhaden percentage at age, number of age samples and number of length samples by year using the Choptank River gill net length and age data, 2015-2021.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	# Aged	# Measured
2015		2.04	49.94	34.28	12.65	1.08			157	420
2016		12.26	29.29	44.74	11.68	2.02			140	308
2017		7.05	53.27	29.18	8.83	1.67			163	362
2018		5.91	30.37	35.89	22.72	5.11			131	558
2019		21.84	23.91	33.90	15.00	5.36			115	473
2020		15.96	52.19	15.48	10.99	5.38			113	475
2021		23.34	47.21	14.16	11.48	3.81			107	348

Figure 1. Onboard pound net survey sampling site locations for 2021.

Figure 2. The Choptank River gill net survey sampling site locations for 2021.

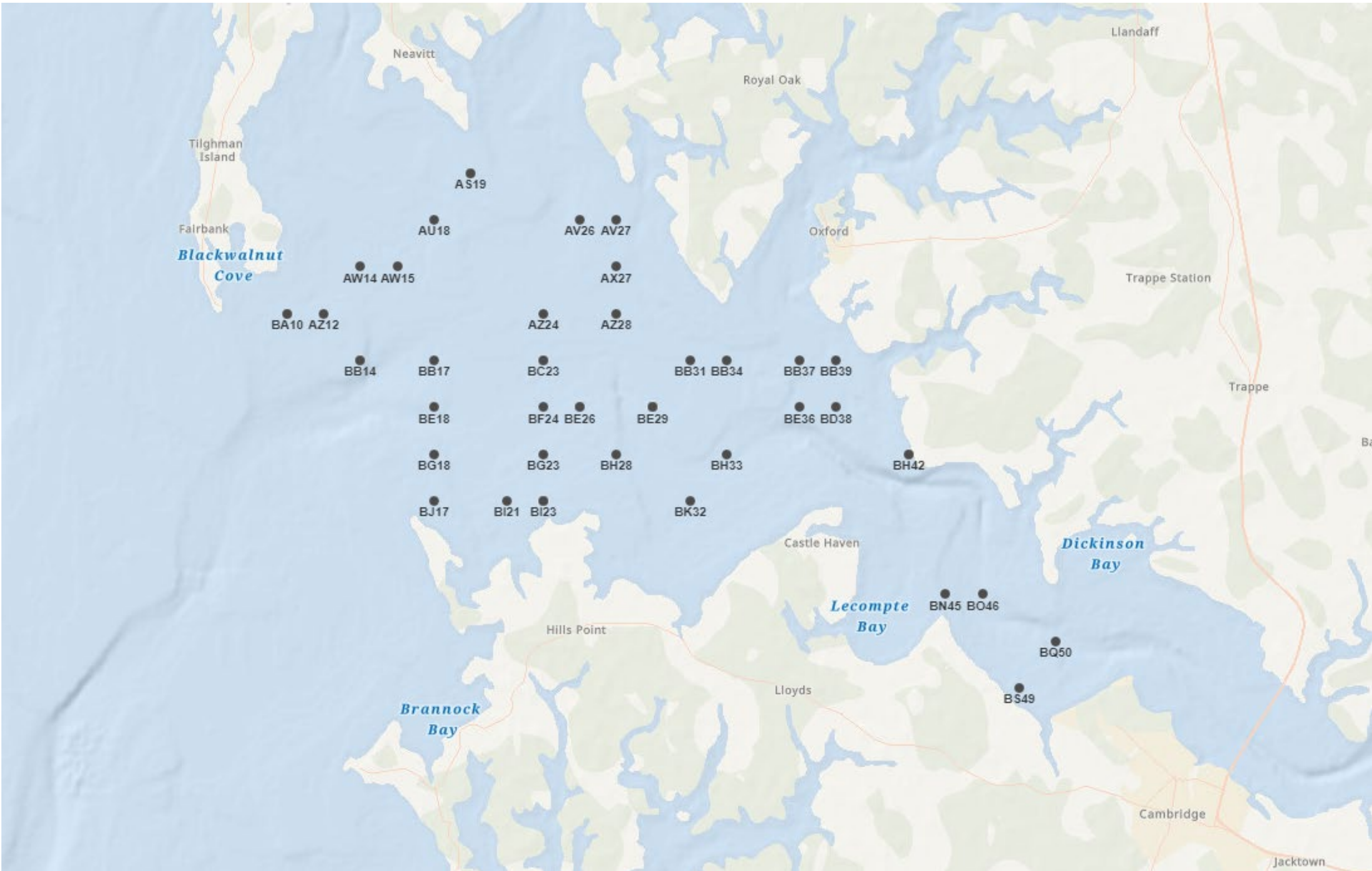


Figure 3. The Choptank River gill net survey sampling grid and grid names used in all years of the survey.

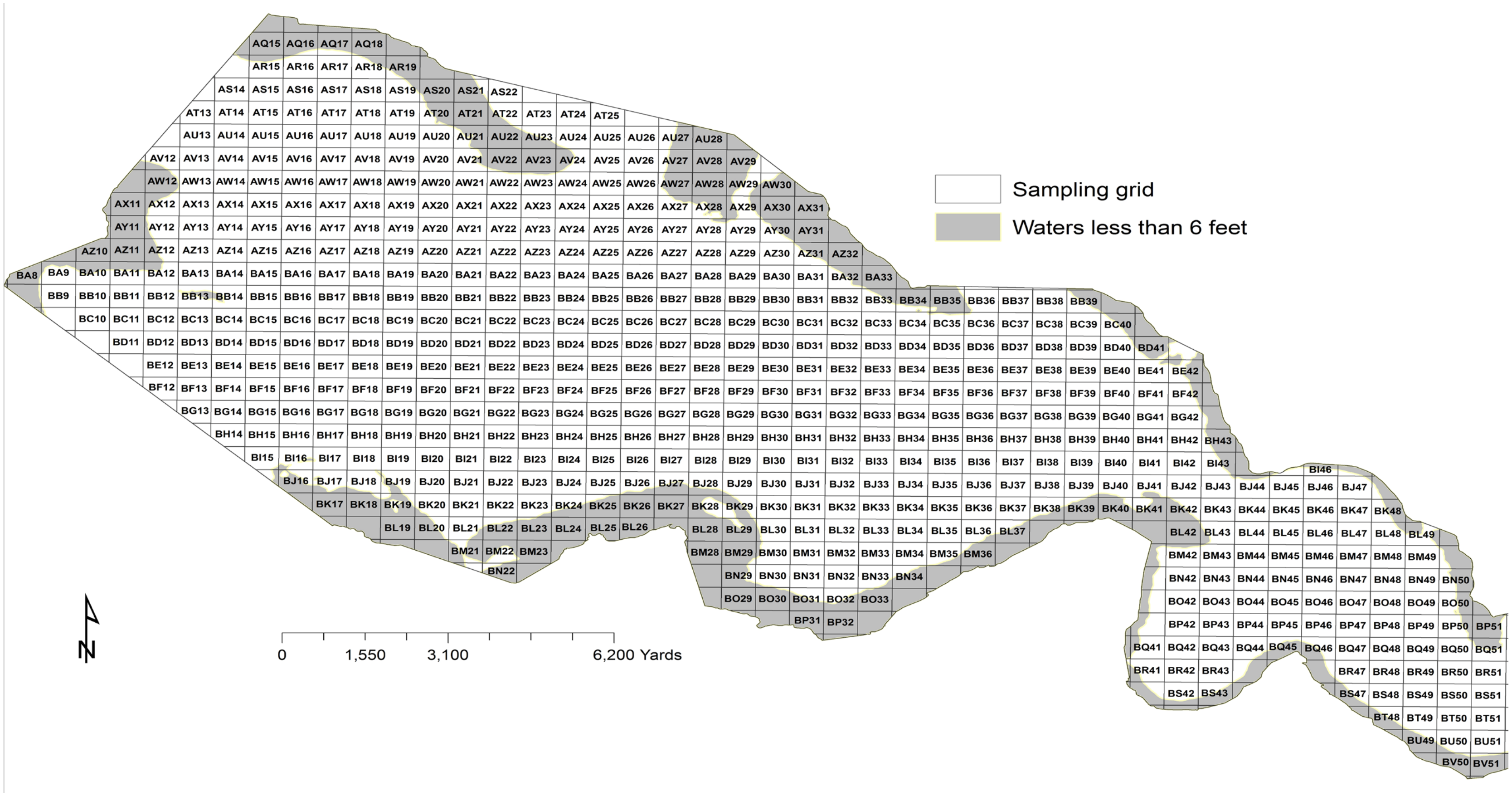


Figure 4. Weakfish length frequency distributions from onboard pound net sampling, 2012-2021. Note: In 2018 the 270 millimeter length group was truncated to preserve scale, actual value is 44%.

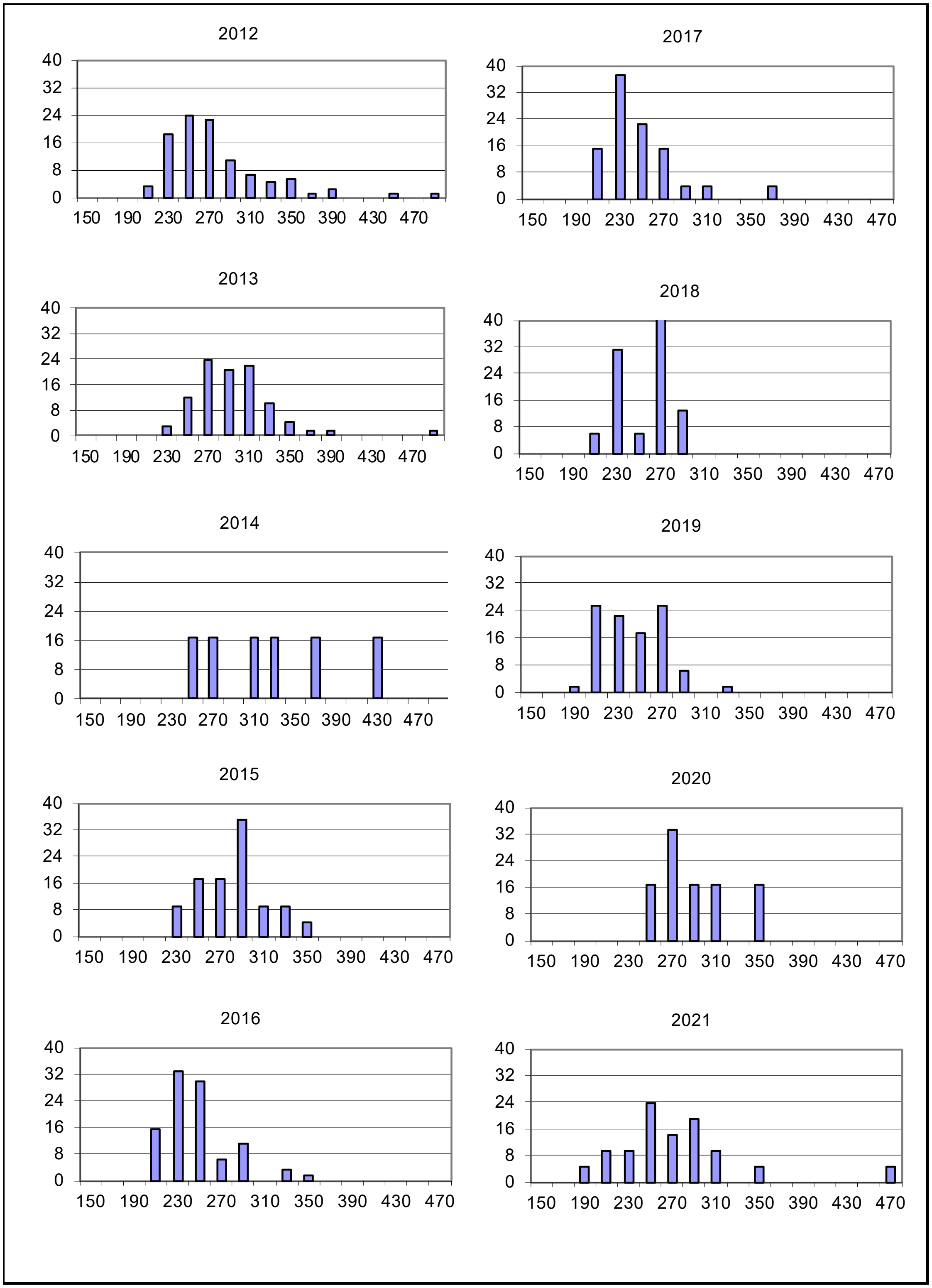


Figure 5. Maryland's commercial landings of weakfish in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational weakfish harvest and release estimates in numbers from 1981-2021.

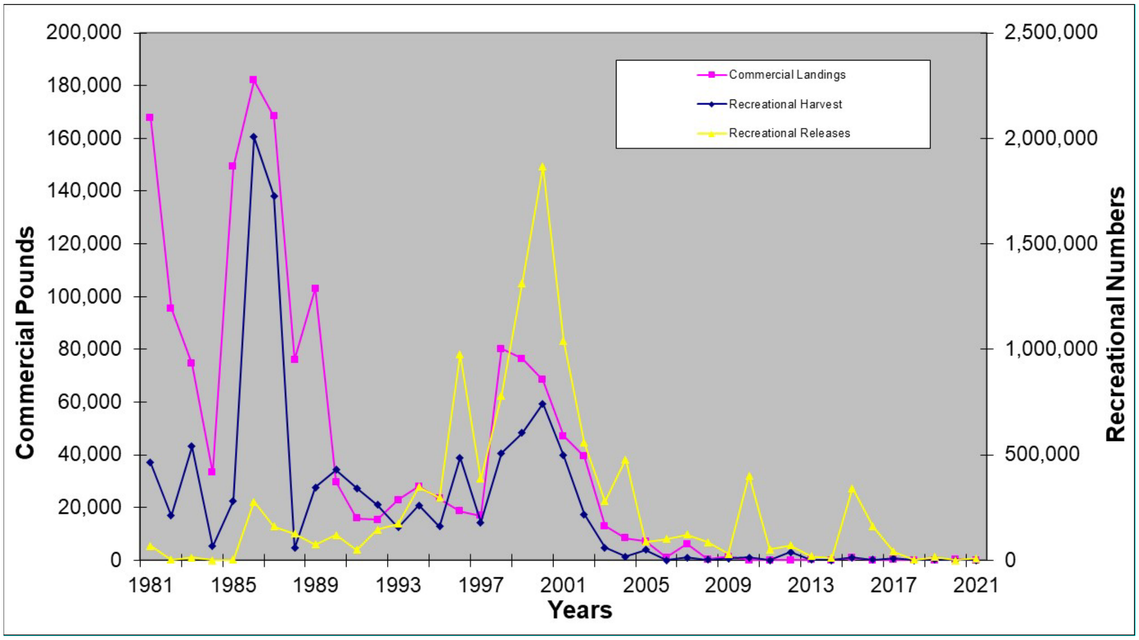


Figure 6. Maryland charter boat log book weakfish harvest in numbers and the number of anglers participating in trips catching weakfish, 1993-2021.

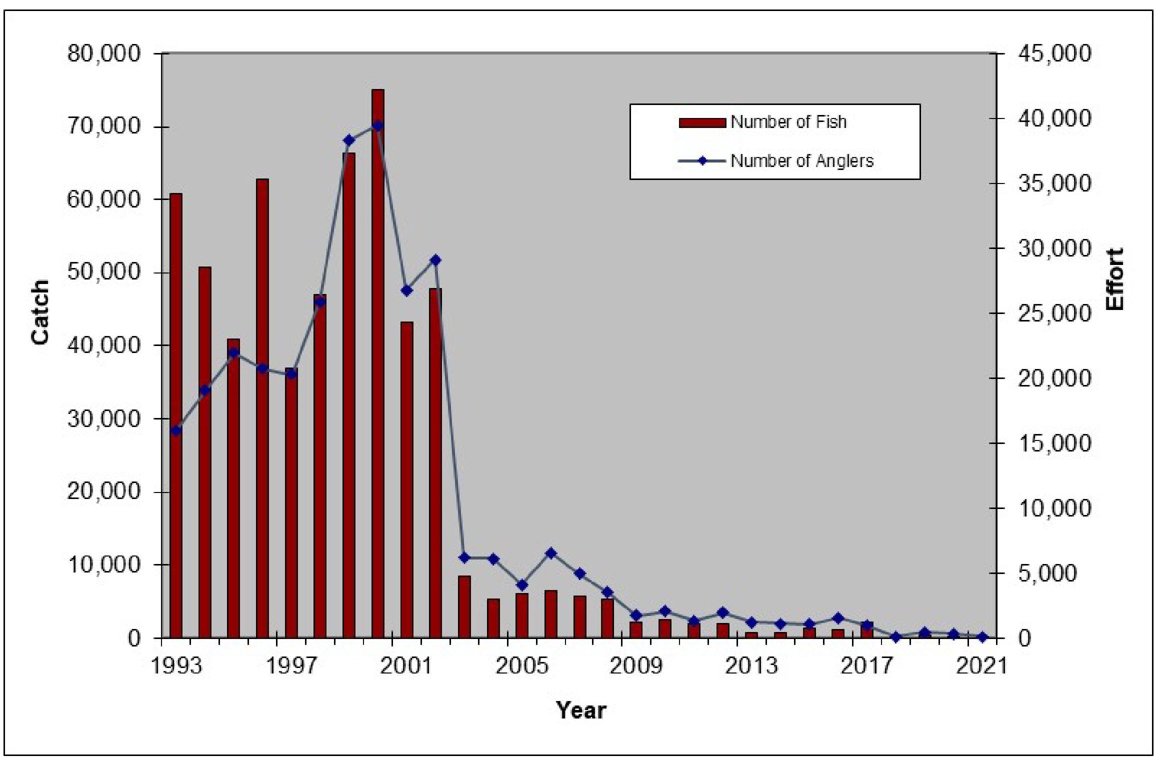


Figure 7. Maryland juvenile weakfish geometric mean catch per trawl, 95% confidence intervals and time series mean for Maryland's lower Chesapeake Bay, 1989-2021.

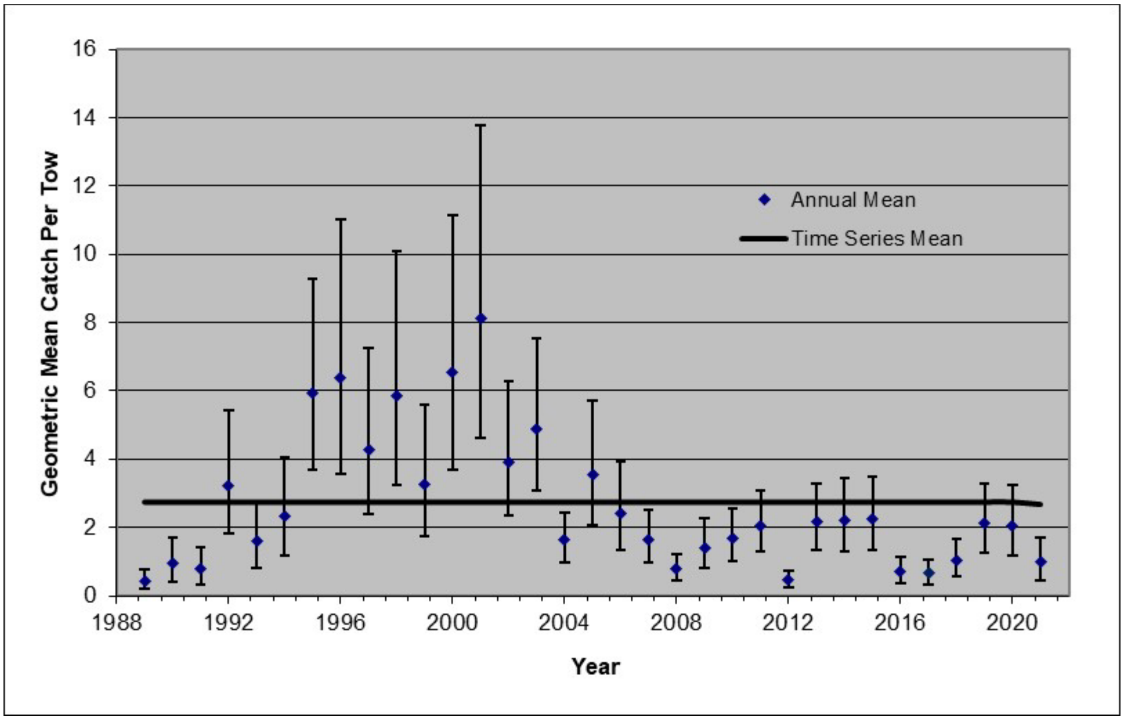


Figure 8. Summer flounder length frequency distributions from onboard pound net sampling, 2012-2021.

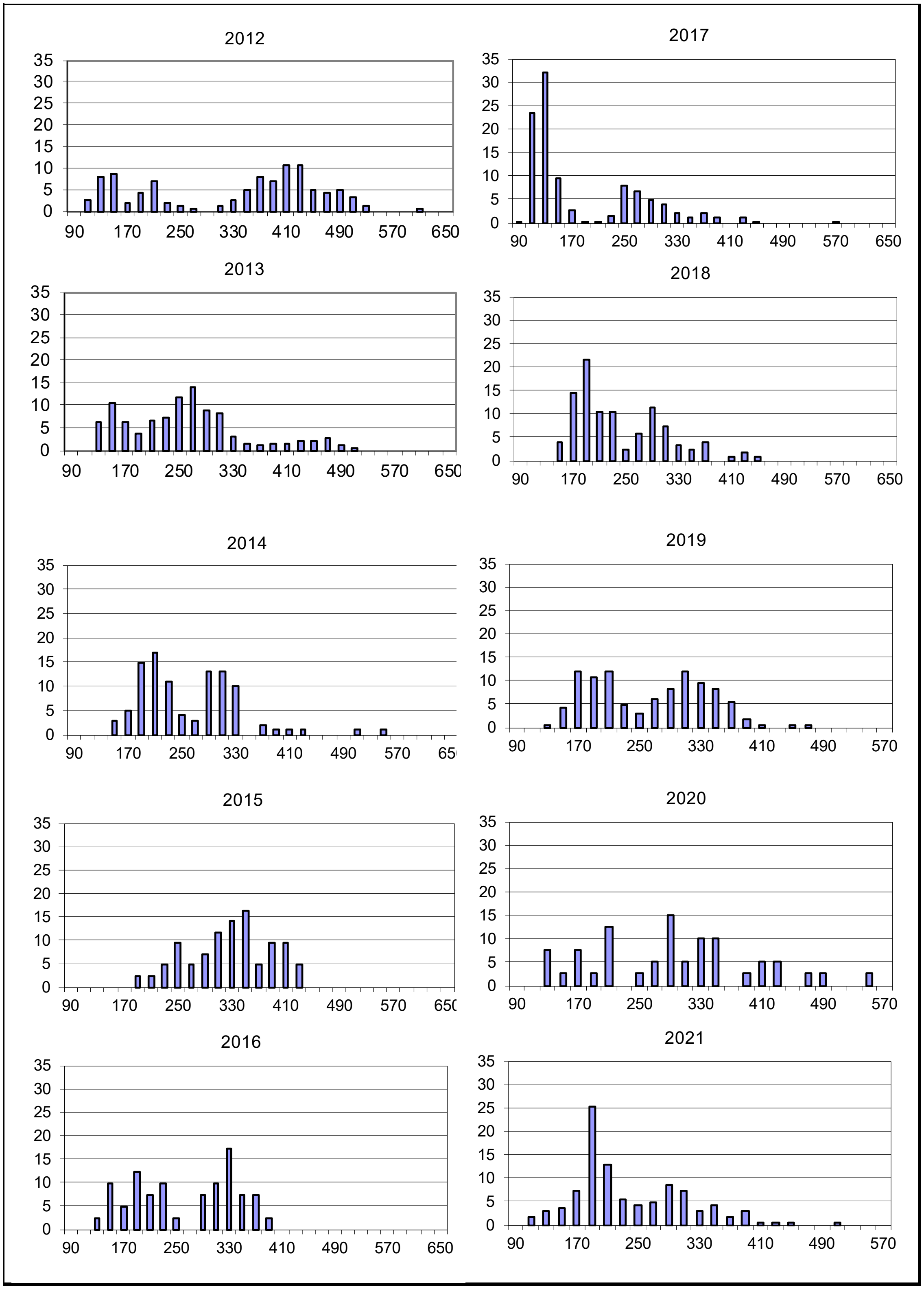


Figure 9. Maryland's commercial landings of summer flounder in pounds from the Chesapeake Bay and the MRIP Maryland summer flounder inland recreational harvest and release estimates in numbers from 1981-2021.

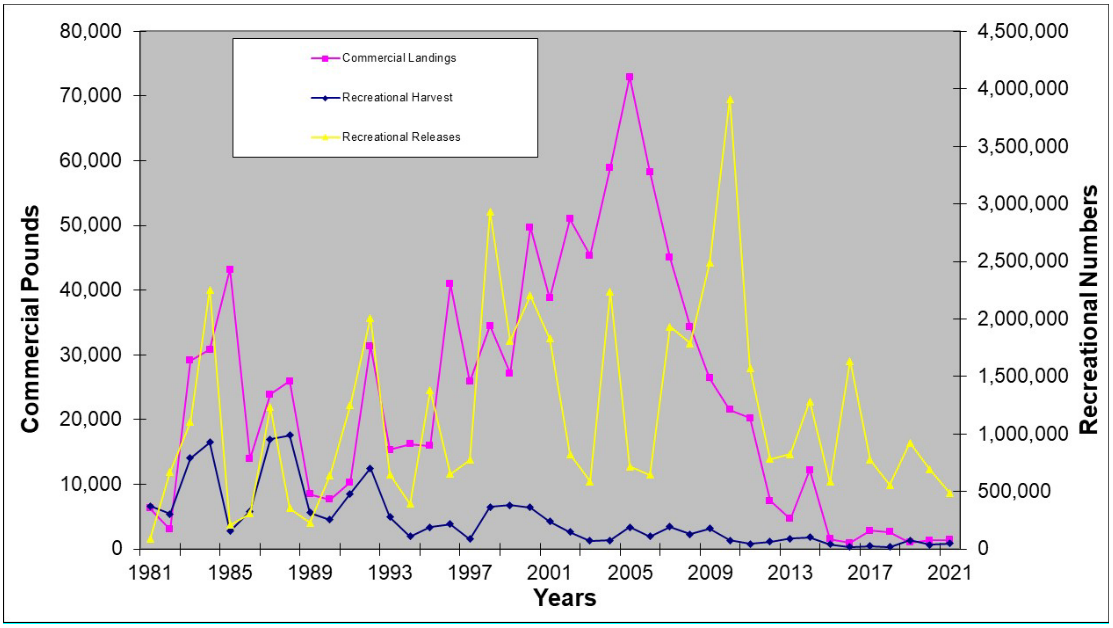


Figure 10. Maryland charter boat log book summer flounder harvest in numbers and the number of anglers participating in trips catching summer flounder, 1993-2021.

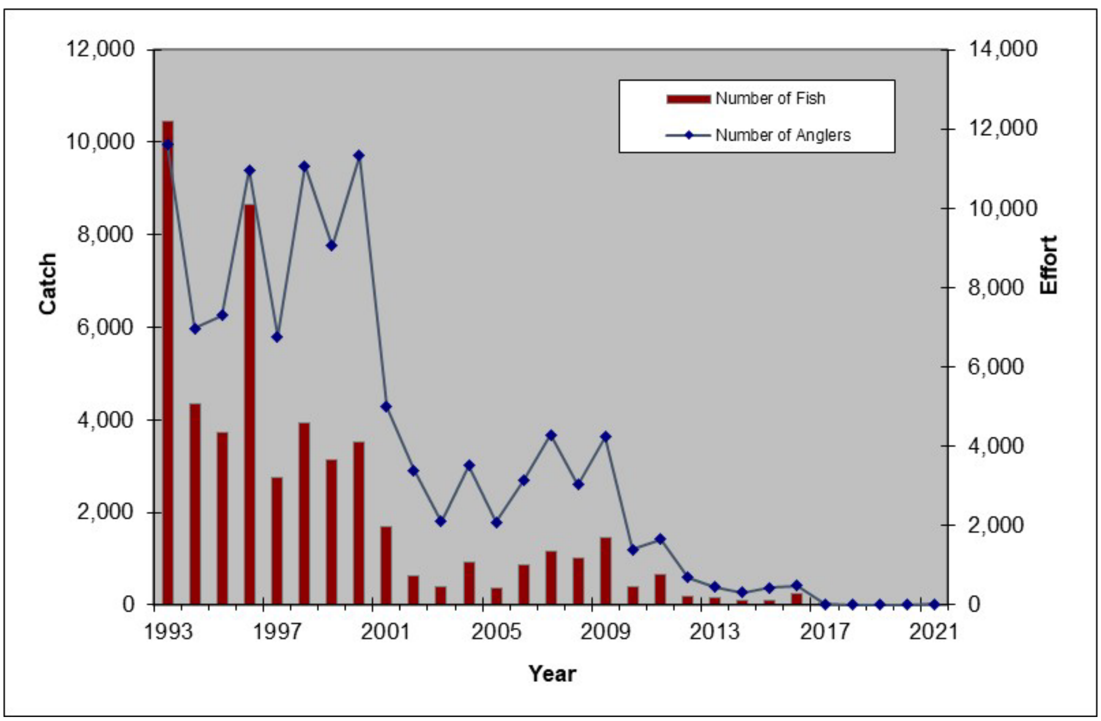


Figure 11. Bluefish length frequency distributions from onboard pound net sampling, 2012-2021.

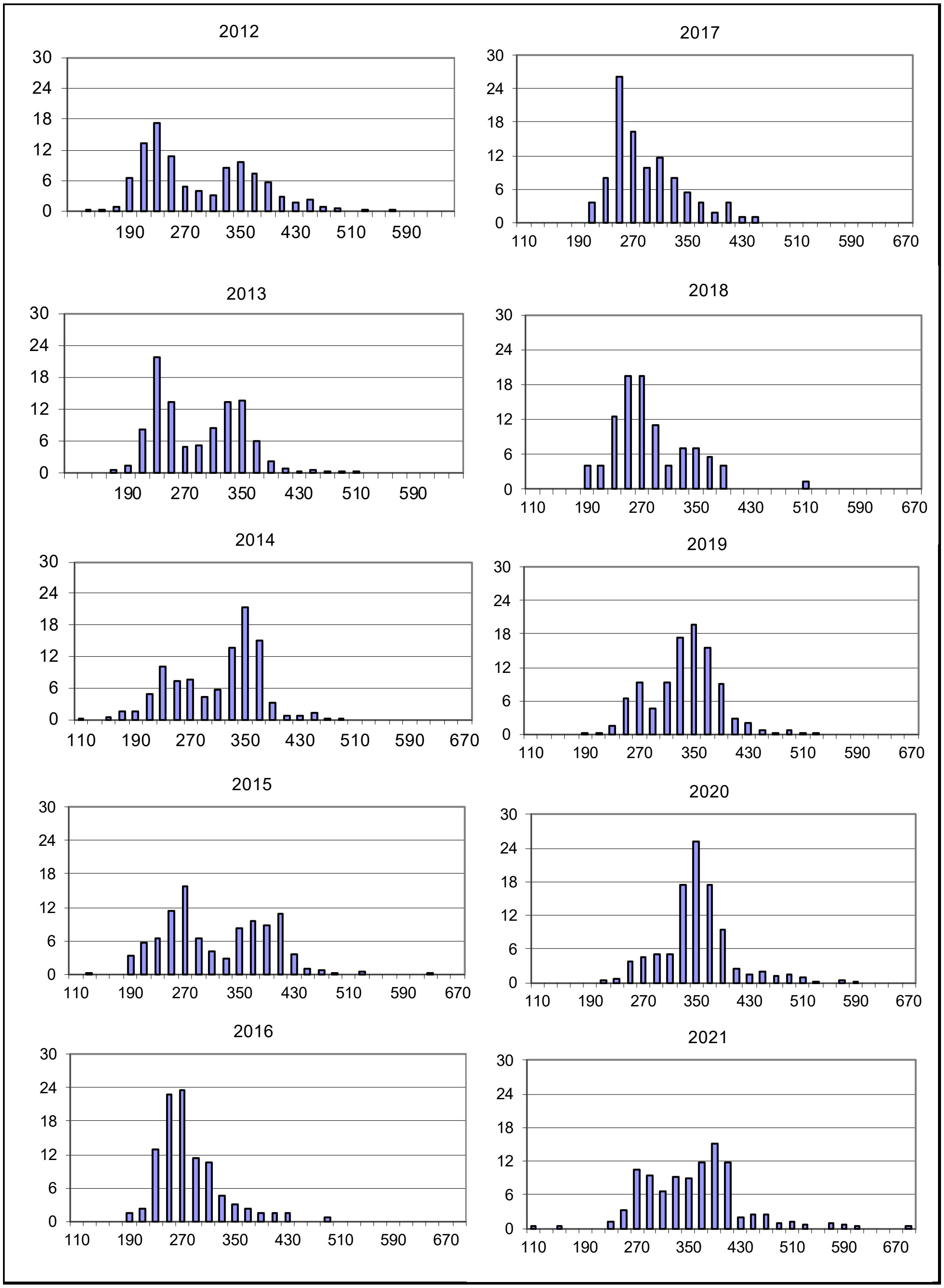


Figure 12. Proportion of bluefish catch by mesh size, all years combined, for the Choptank River gill net survey, 2013-2021.

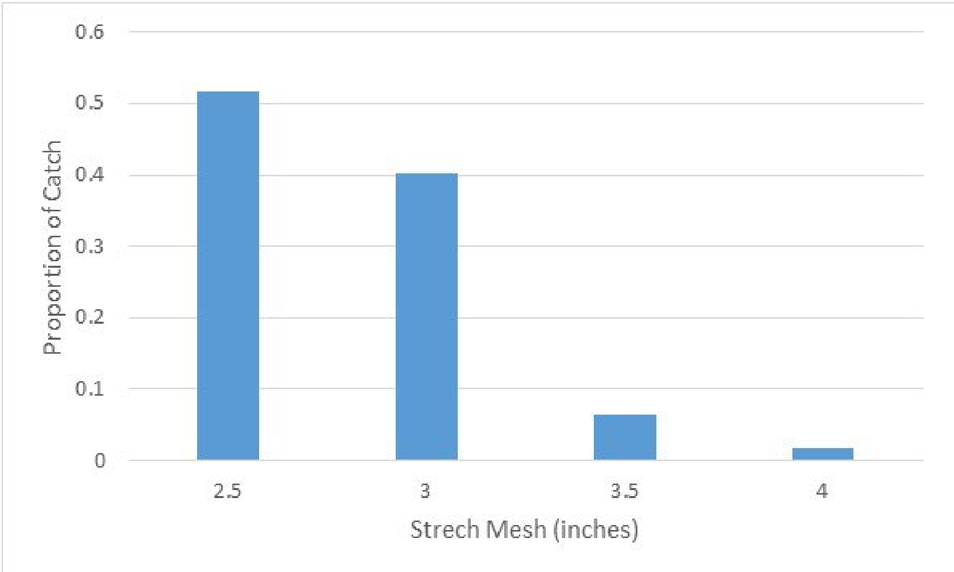


Figure 13. Maryland's commercial landings of bluefish in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational bluefish harvest and release estimates in numbers from 1981-2021.

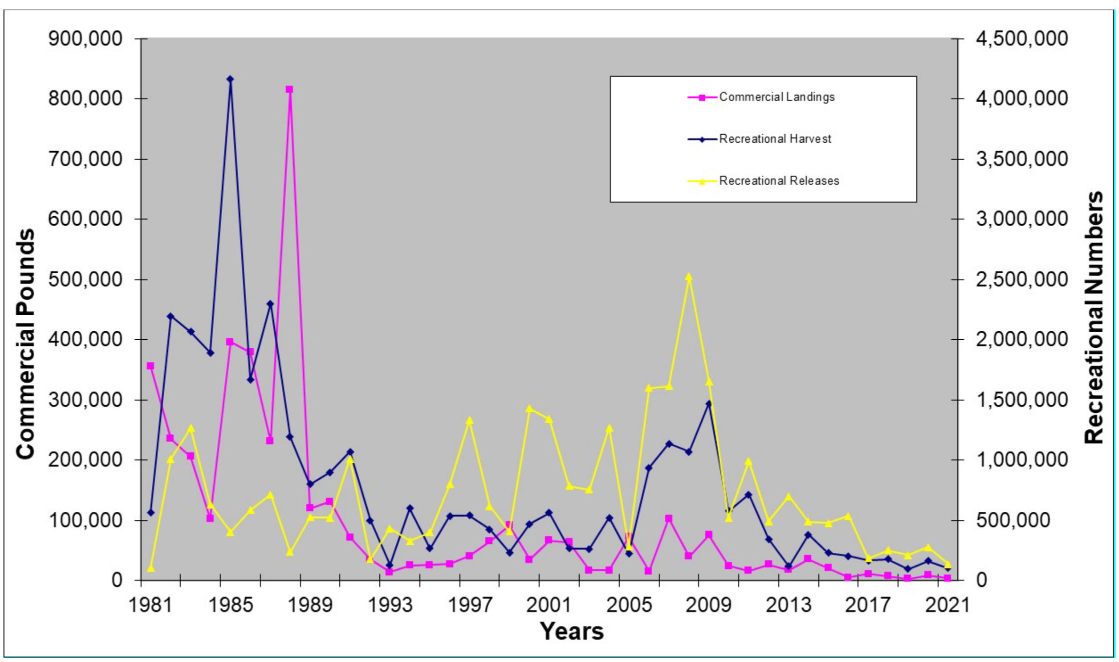


Figure 14. Maryland charter boat log book bluefish harvest in numbers and the number of anglers participating in trips catching bluefish, 1993-2021.

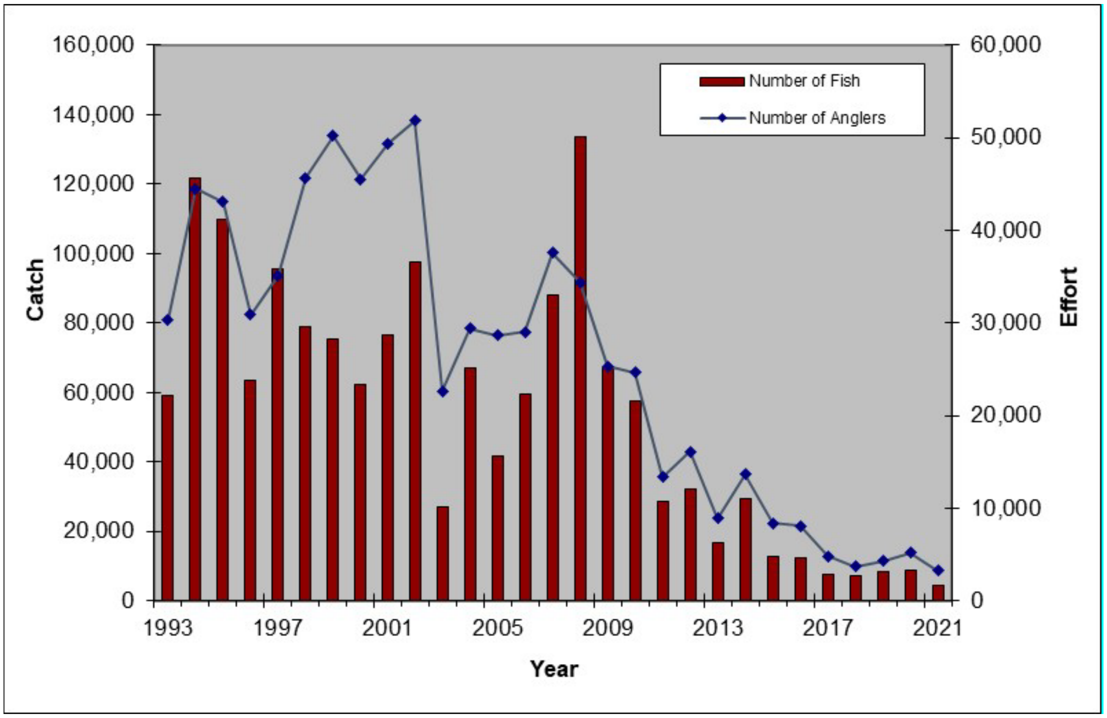


Figure 15. Atlantic croaker length frequency distributions from onboard pound net sampling, 2012-2021.

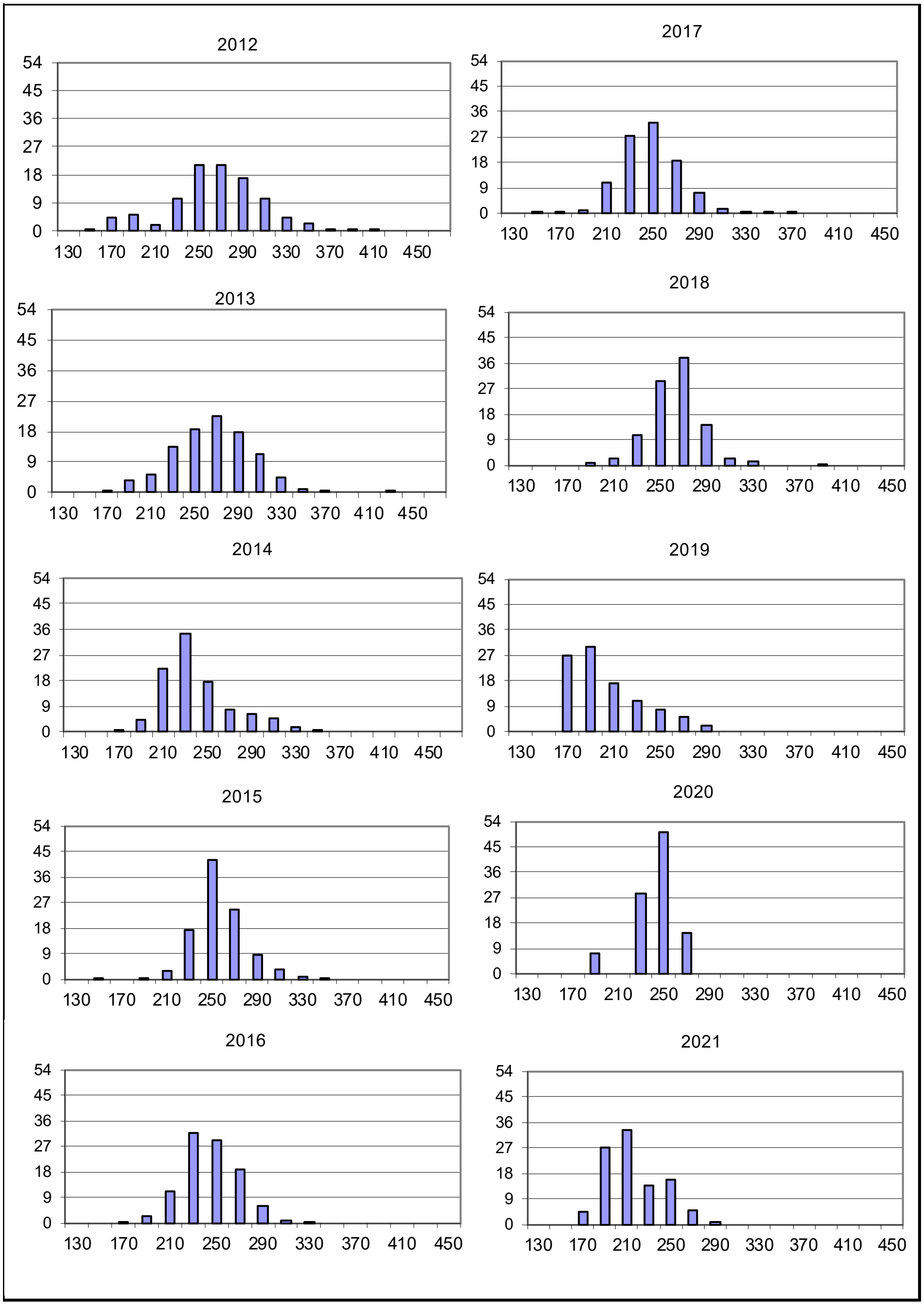


Figure 16. Geometric mean catch per hour and 95% confidence intervals for Atlantic croaker captured in the Choptank River gill net survey, 2013-2021.

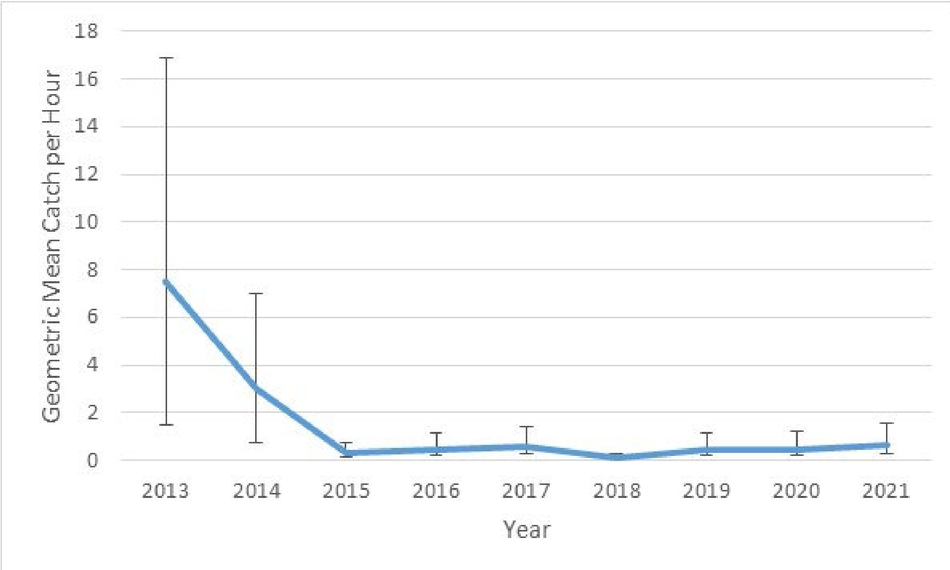


Figure 17. Proportion of Atlantic croaker catch by mesh size and year for the Choptank River gill net survey, 2013-2021.

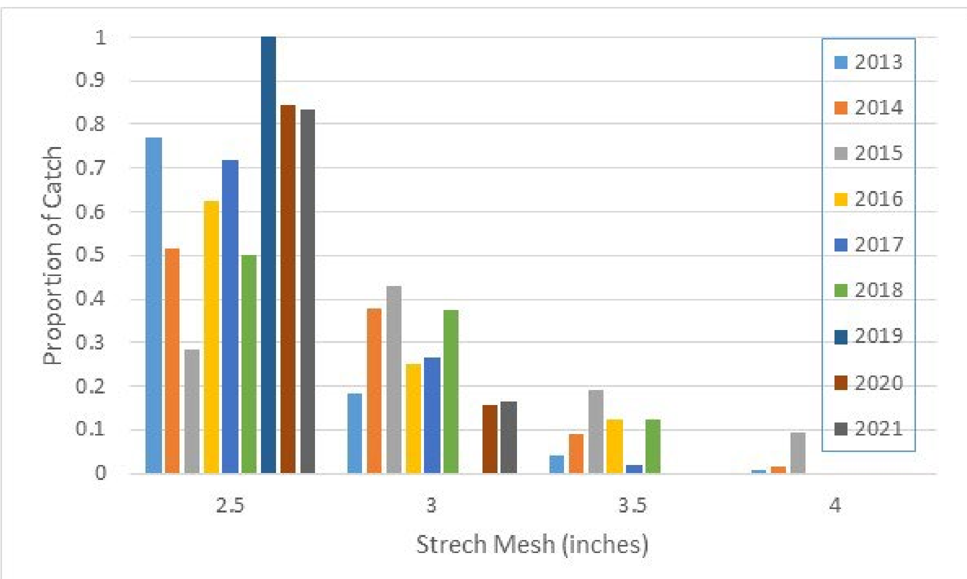


Figure 18. Atlantic croaker length frequency distribution from the Choptank River gill net survey by stretched mesh size in inches, 2013-2021 combined.

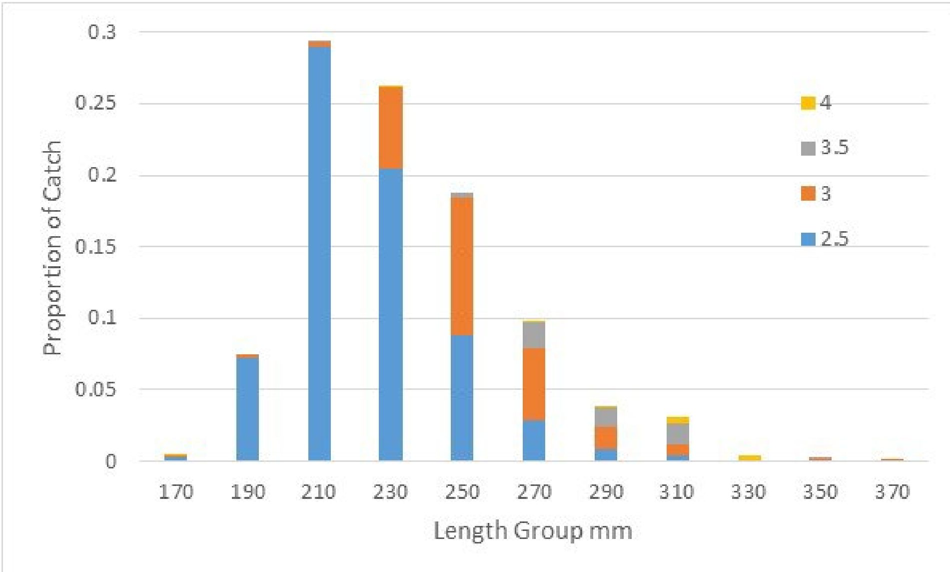


Figure 19. Maryland's commercial landings of Atlantic croaker in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational Atlantic croaker harvest and release estimates in numbers from 1981-2021.

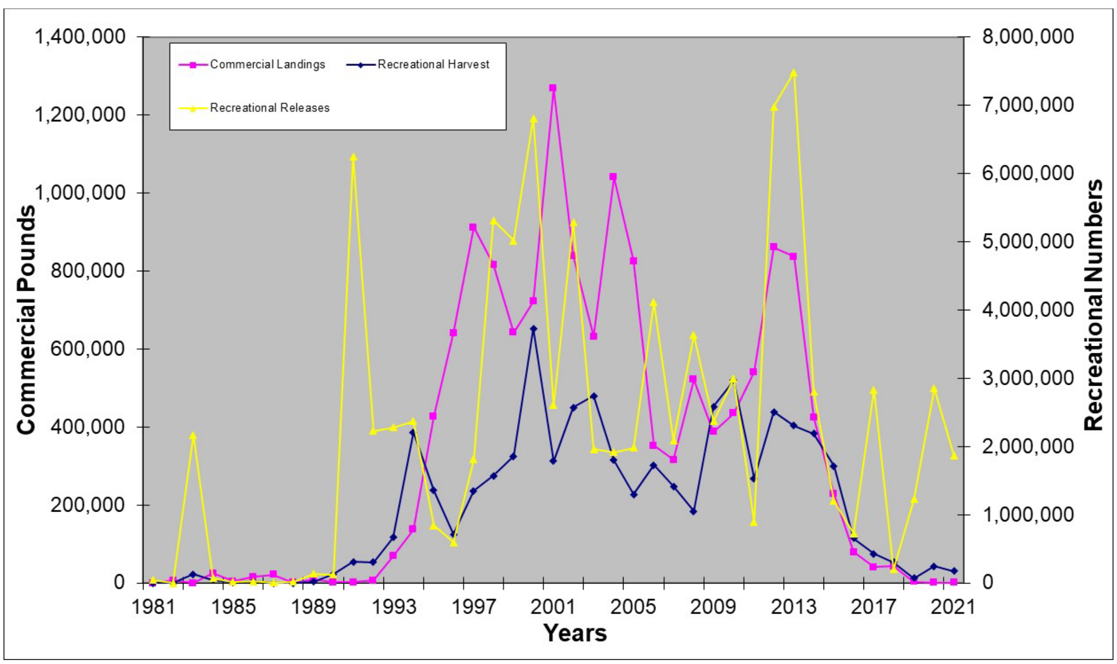


Figure 20. Maryland charter boat log book Atlantic croaker harvest in numbers and the number of anglers participating in trips catching Atlantic croaker, 1993-2021.

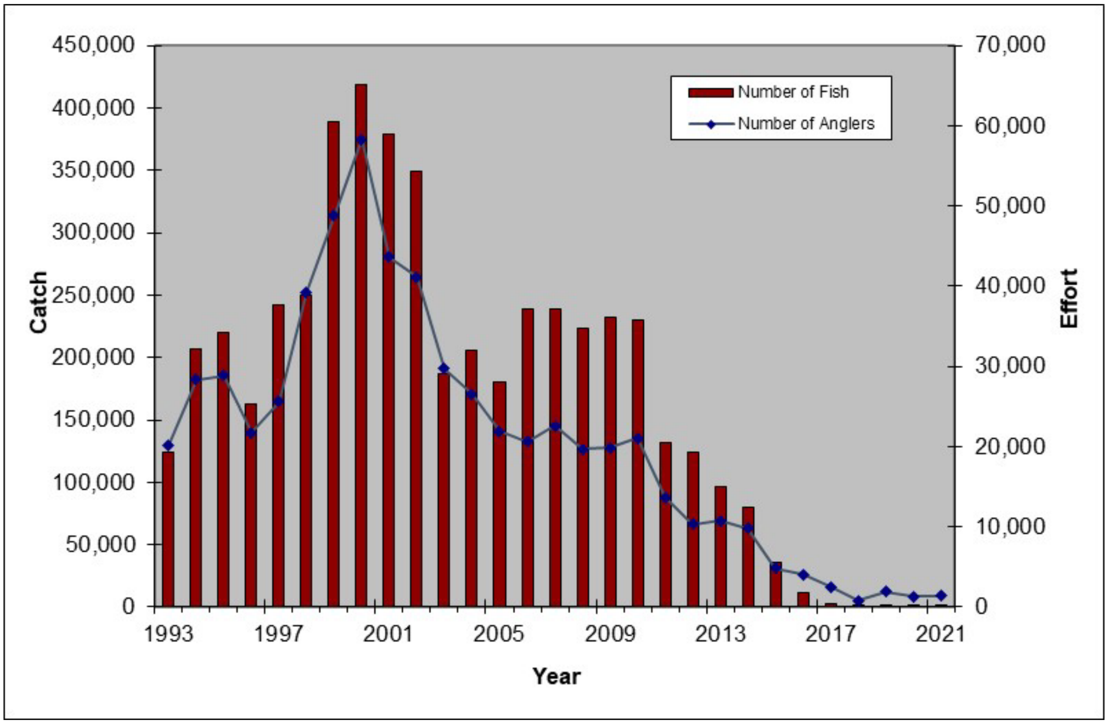


Figure 21. Maryland juvenile Atlantic croaker geometric mean catch per trawl, 95% confidence intervals and time series mean for Maryland's lower Chesapeake Bay, 1989-2021. 1998 data point was omitted for scale (GM 1998 = 30.05 - 9.02, +12.72).

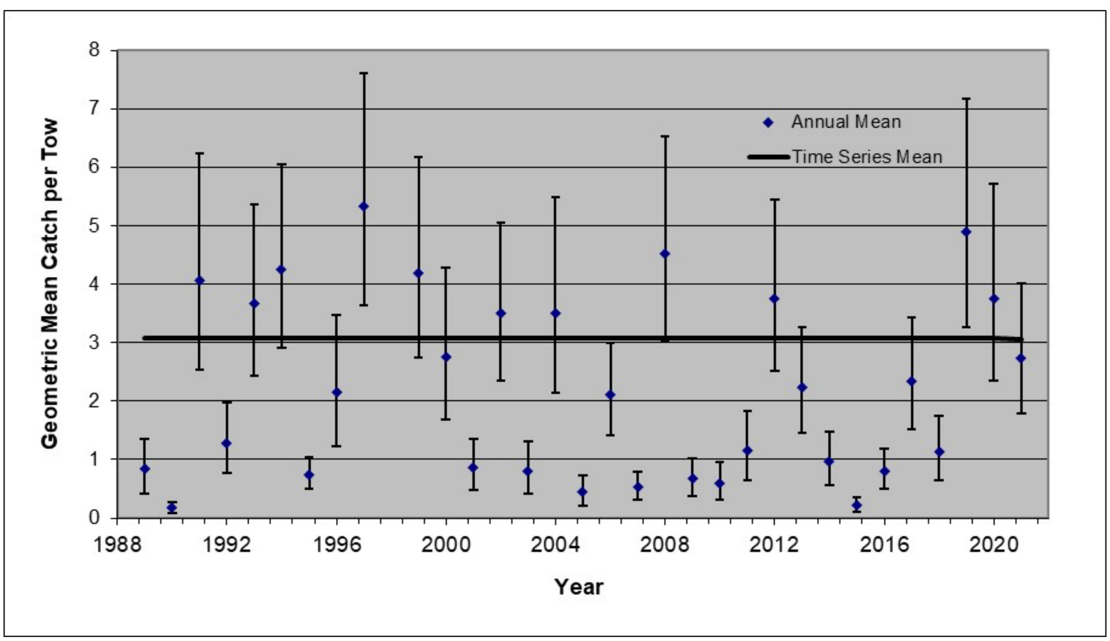
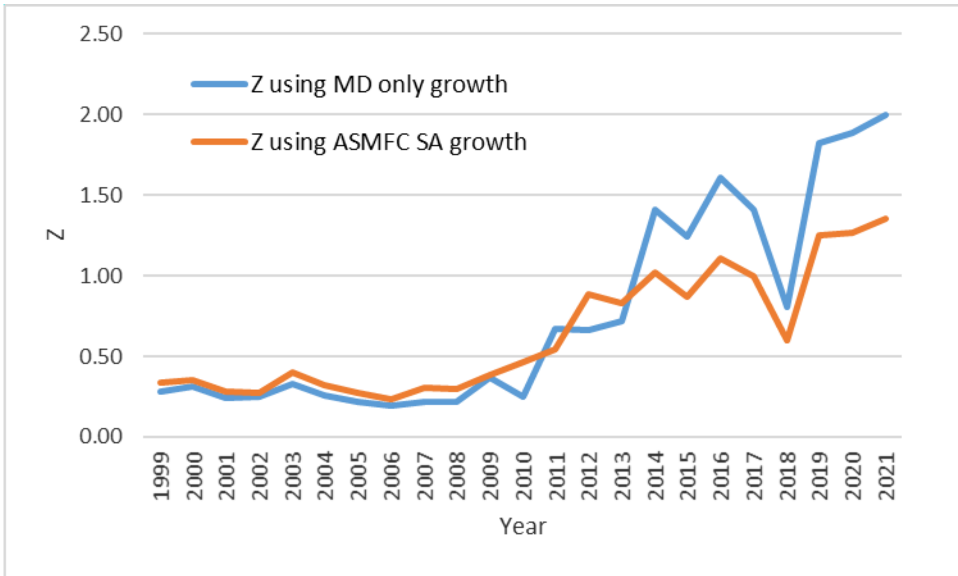


Figure 22. Atlantic croaker total mortality estimates using Maryland age data to derive growth parameters and using the growth parameters from the ASMFC 2017 stock assessment, 1999 - 2021.



Note: Very low sample size in 2020.

Figure 23. Spot length frequency distributions from onboard pound net sampling, 2012-2021.

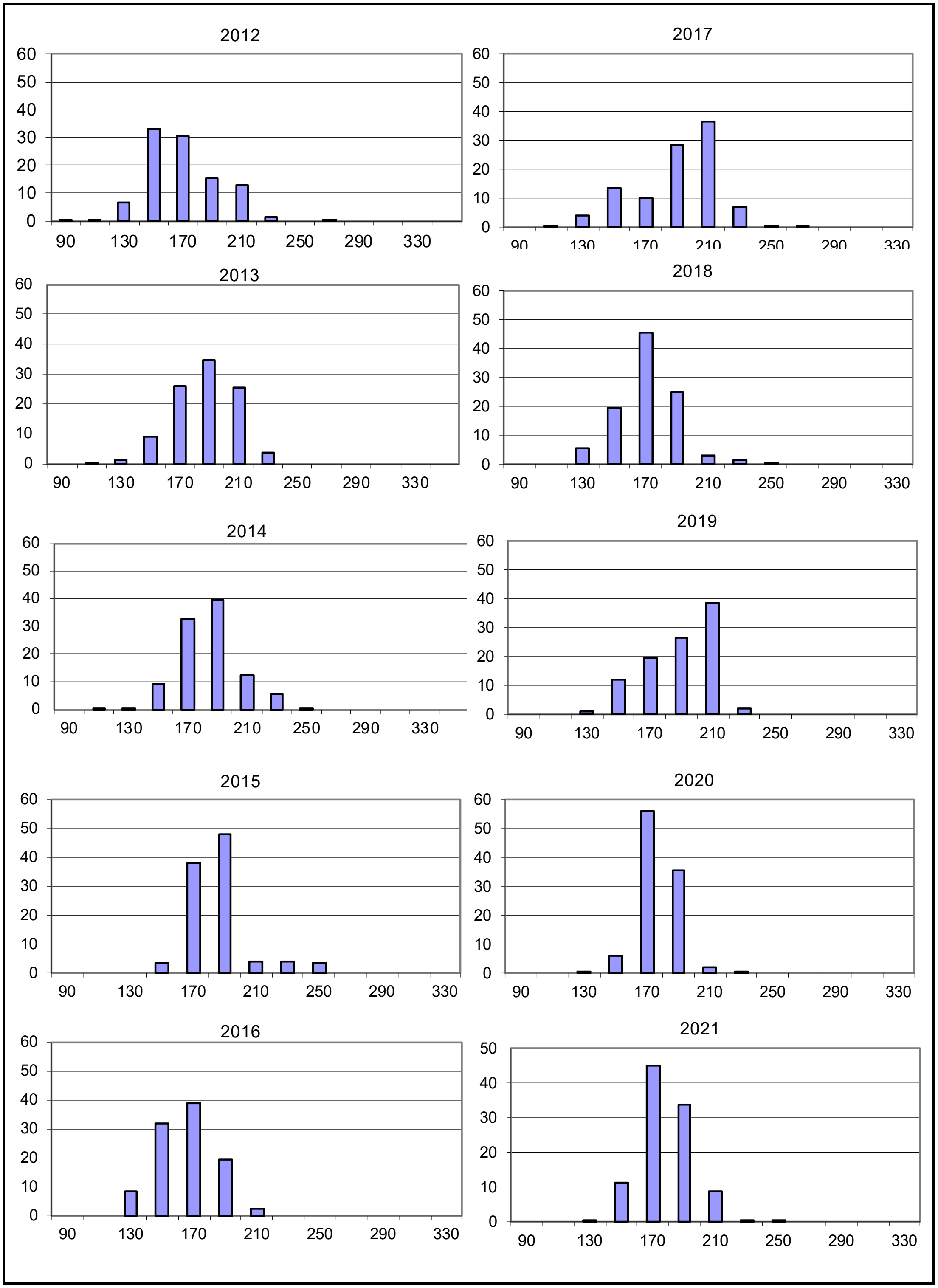


Figure 24. Geometric mean catch per hour and 95% confidence intervals for spot captured in the Choptank River gill net survey, 2013-2021.

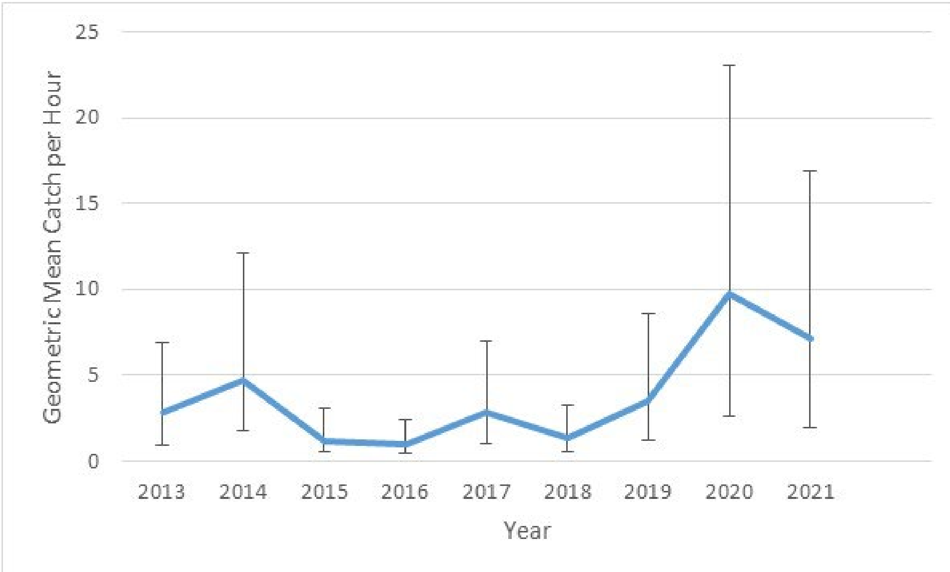


Figure 25. Proportion of spot captured in the Choptank River gill net survey by mesh size and year, 2013-2021.

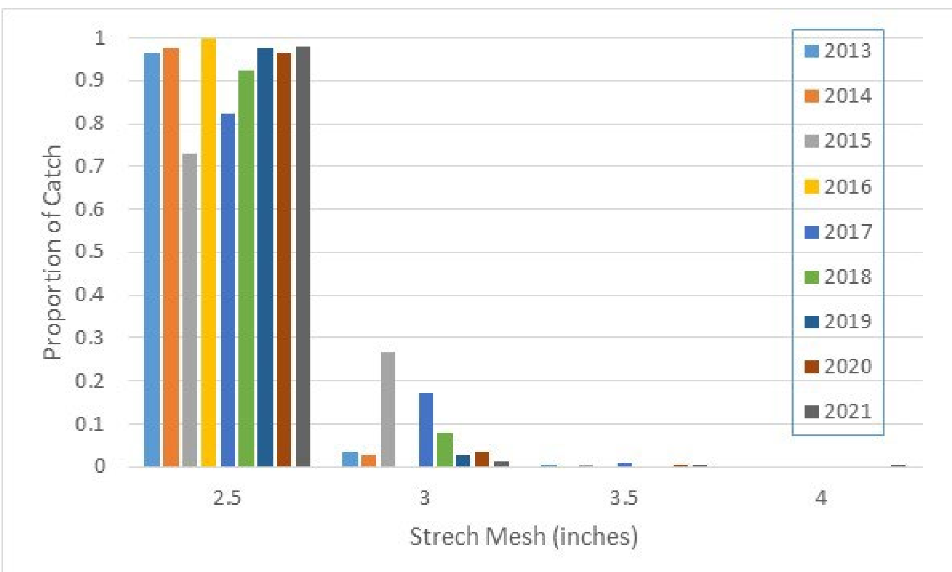


Figure 26. Spot length frequency distributions from the Choptank River gill net survey for 2014-2021.

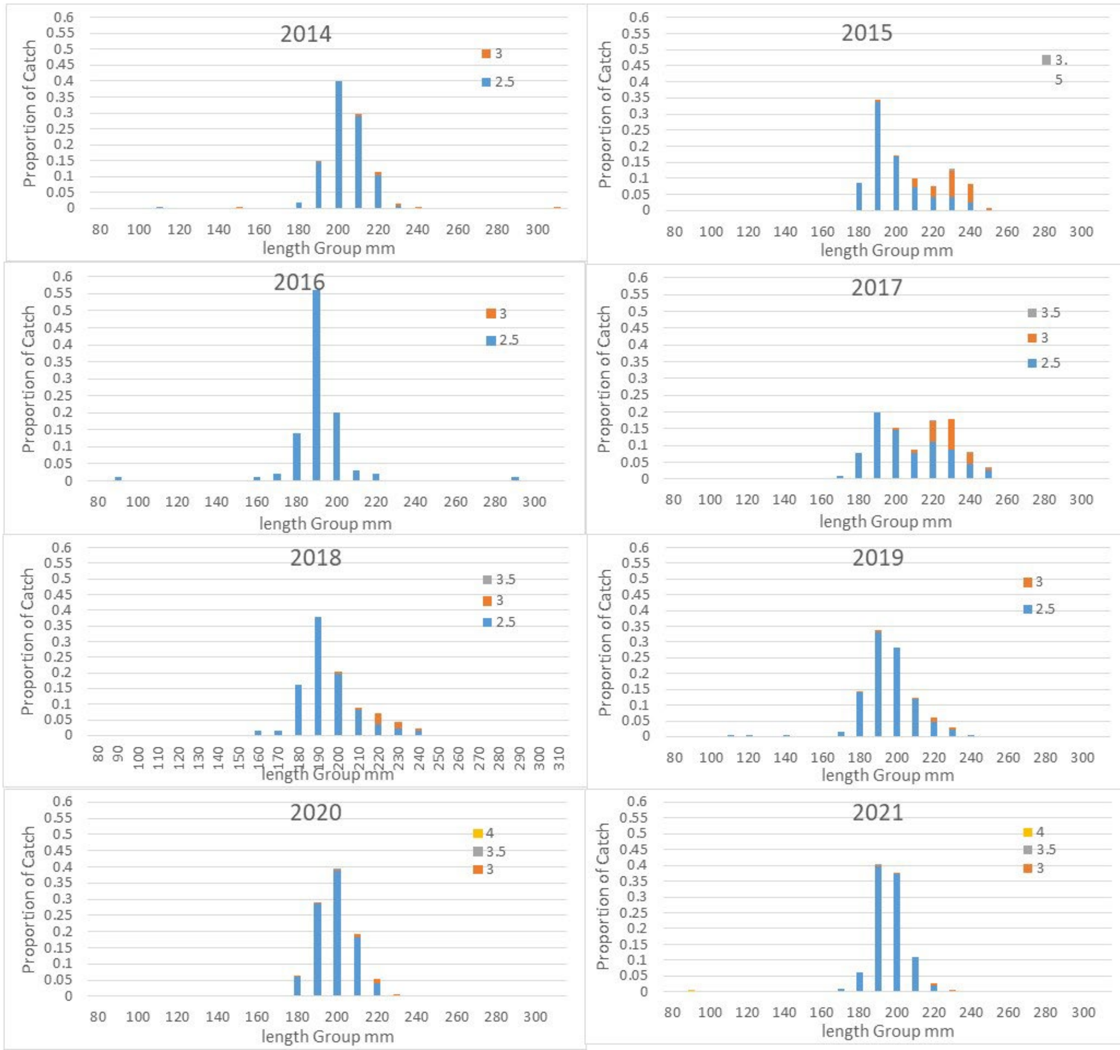


Figure 27. Maryland's commercial landings of spot in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational spot harvest and release estimates in numbers from 1981-2021.

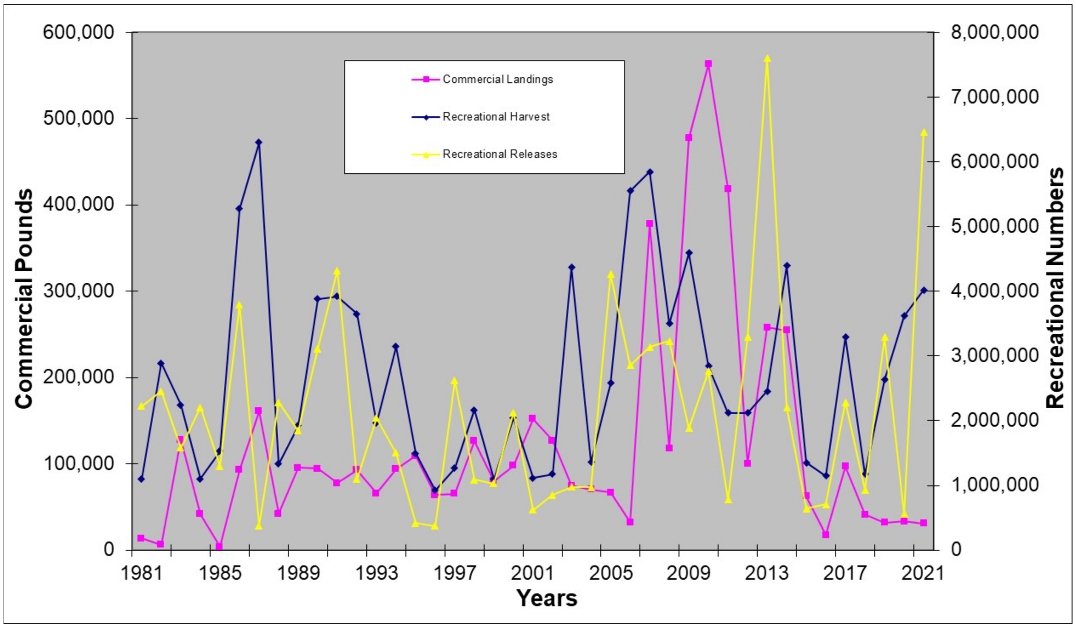


Figure 28. Maryland charter boat log book spot harvest in numbers and the number of anglers participating in trips catching spot, 1993-2021.

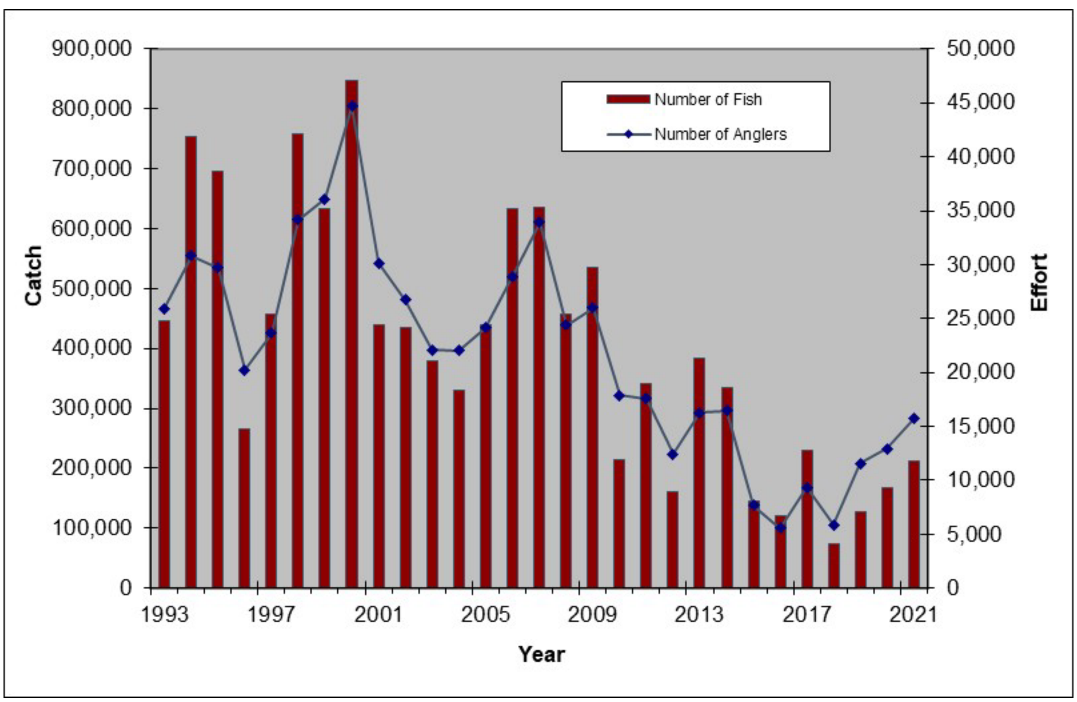


Figure 29. Maryland juvenile spot geometric mean catch per trawl, 95% confidence intervals and time series mean for Maryland's lower Chesapeake Bay, 1989-2021.

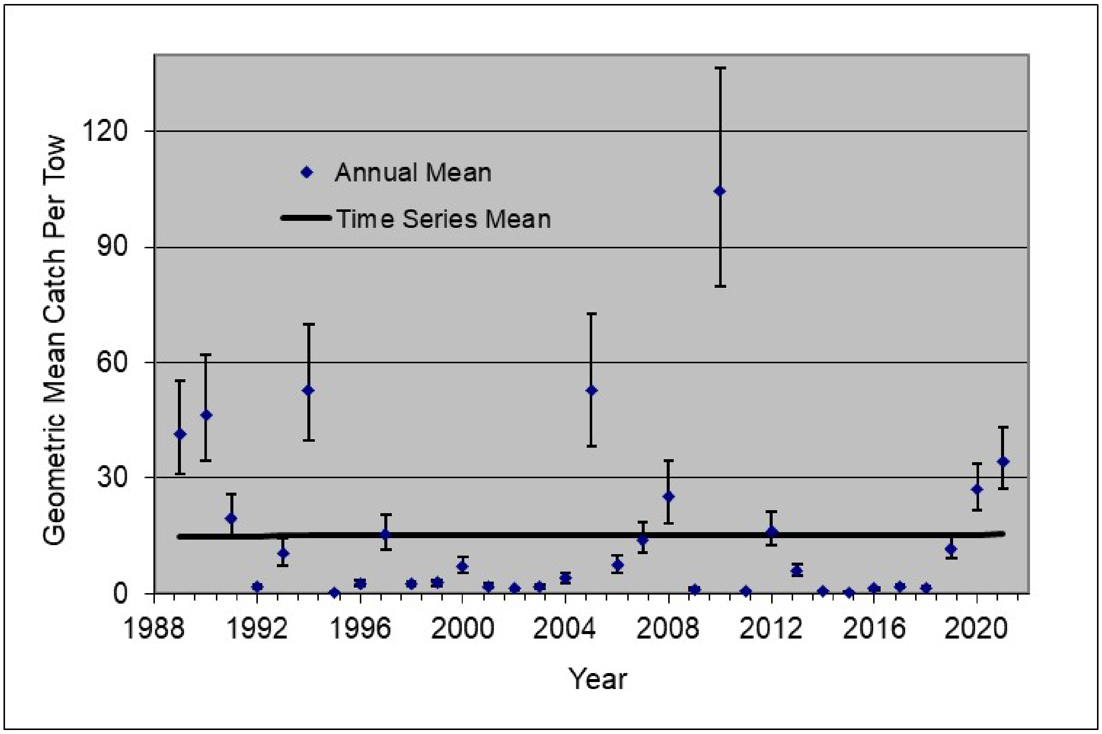


Figure 30. Maryland's commercial landings of red drum in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational red drum harvest and release estimates in numbers from 1981-2021.

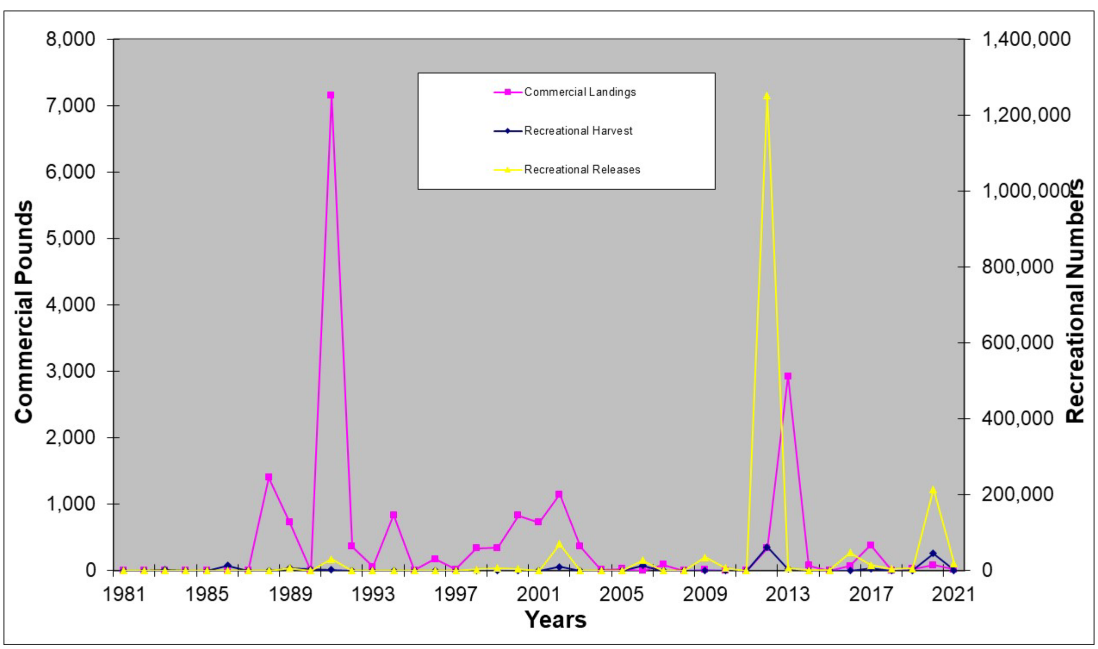


Figure 31. Maryland charter boat log book red drum harvest in numbers and the number of anglers participating in trips catching red drum, 1993-2021.

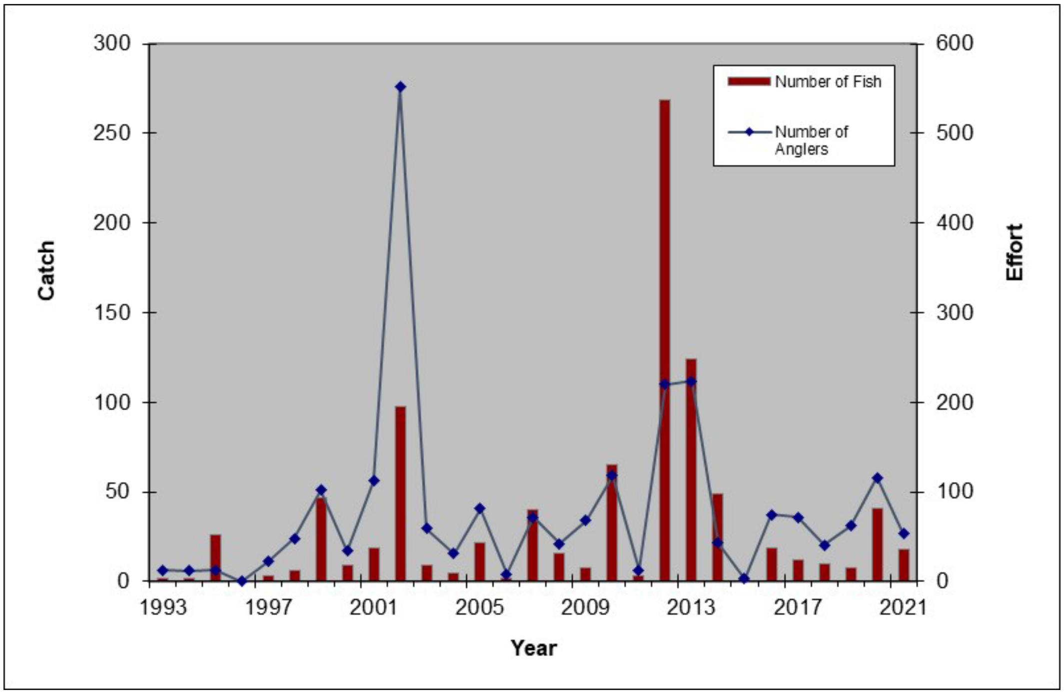


Figure 32. Maryland's commercial landings of black drum in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational black drum harvest and release estimates in numbers from 1981-2021.

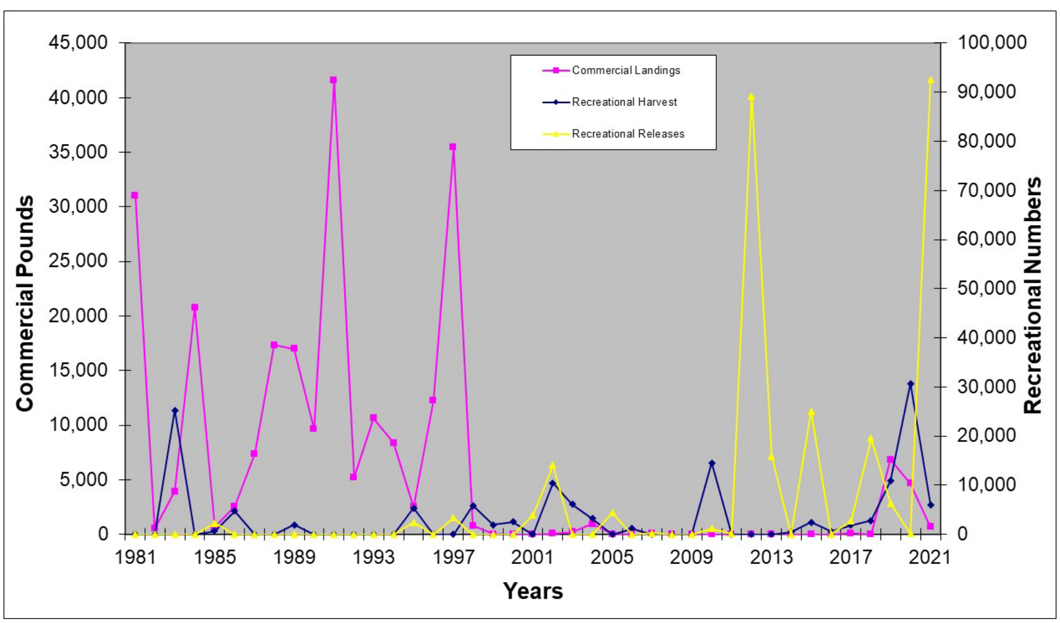


Figure 33. Maryland charter boat log book black drum harvest in numbers and the number of anglers participating in trips catching black drum, 1993-2021.

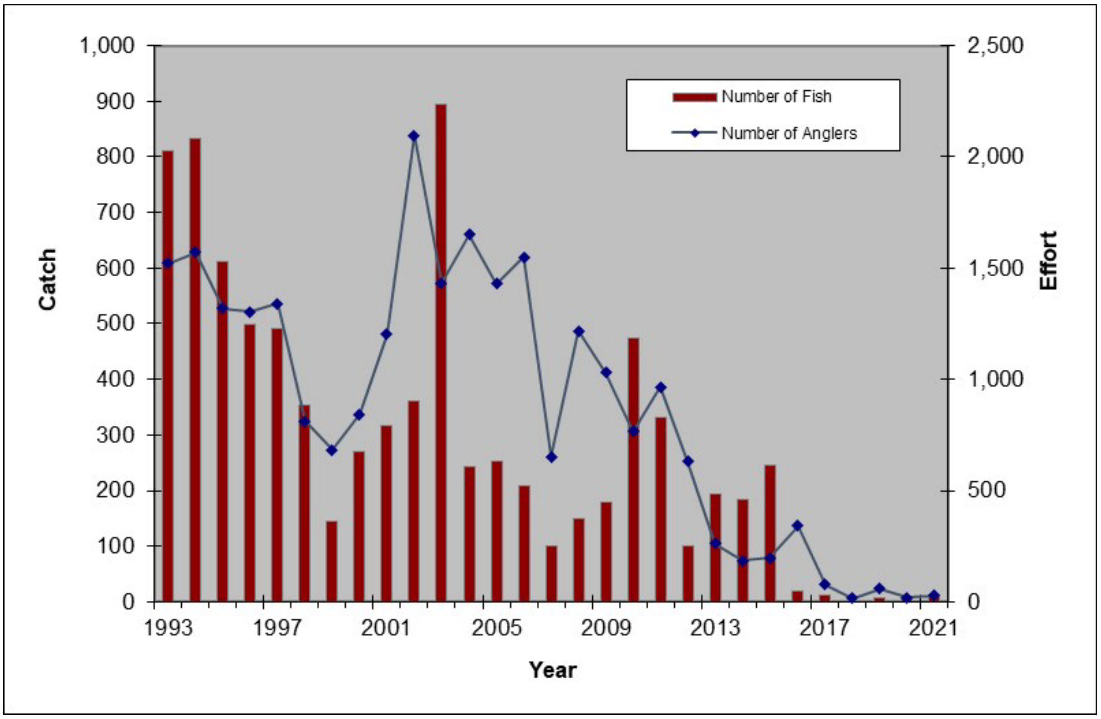


Figure 34. Maryland's commercial landings of Spanish mackerel in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational Spanish mackerel harvest and release estimates in numbers from 1981-2021.

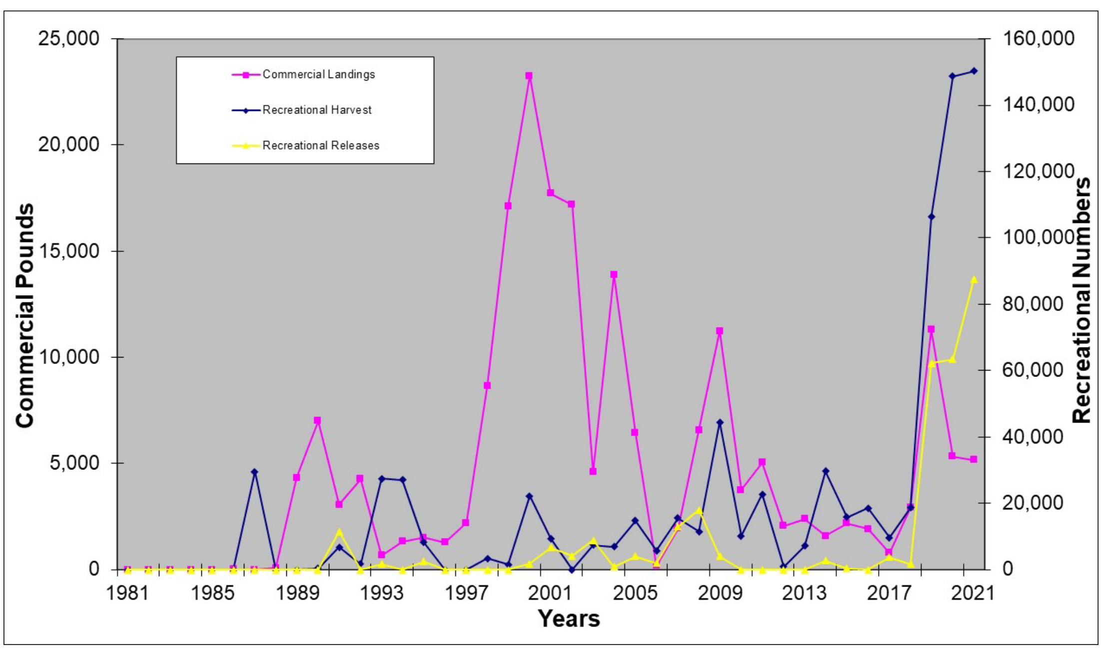


Figure 35. Maryland charter boat log book Spanish mackerel harvest in numbers and the number of anglers participating in trips catching Spanish mackerel, 1993-2021.

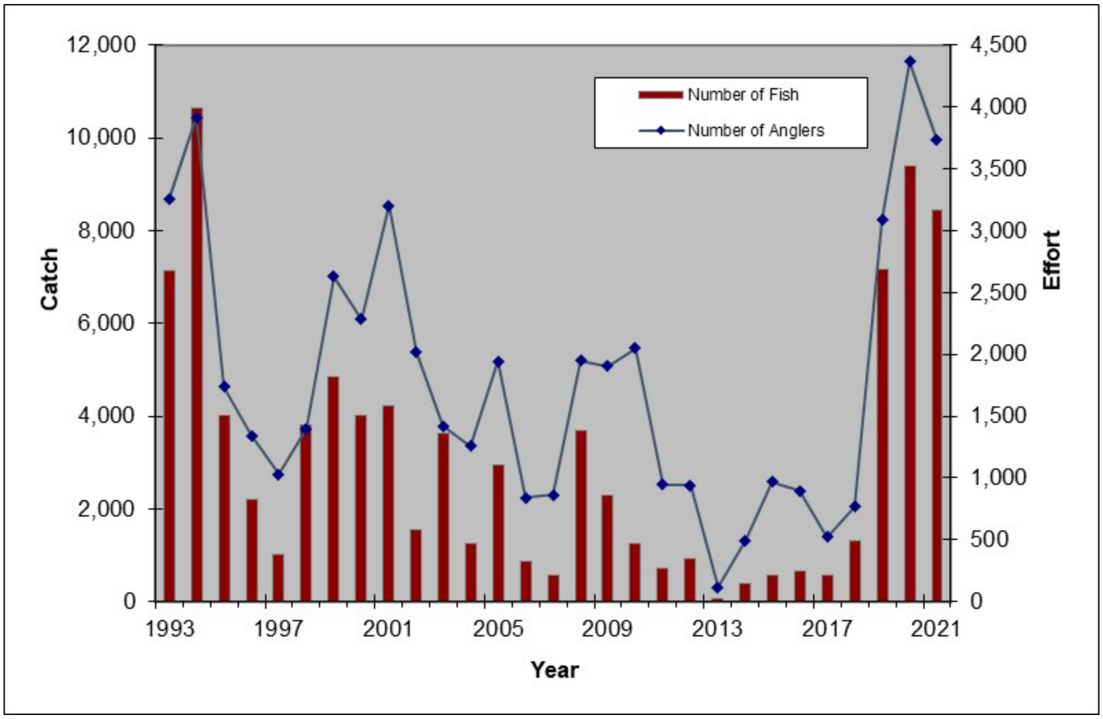


Figure 36. Maryland's commercial landings of spotted seatrout in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational spotted seatrout harvest and release estimates in numbers from 1981-2021.

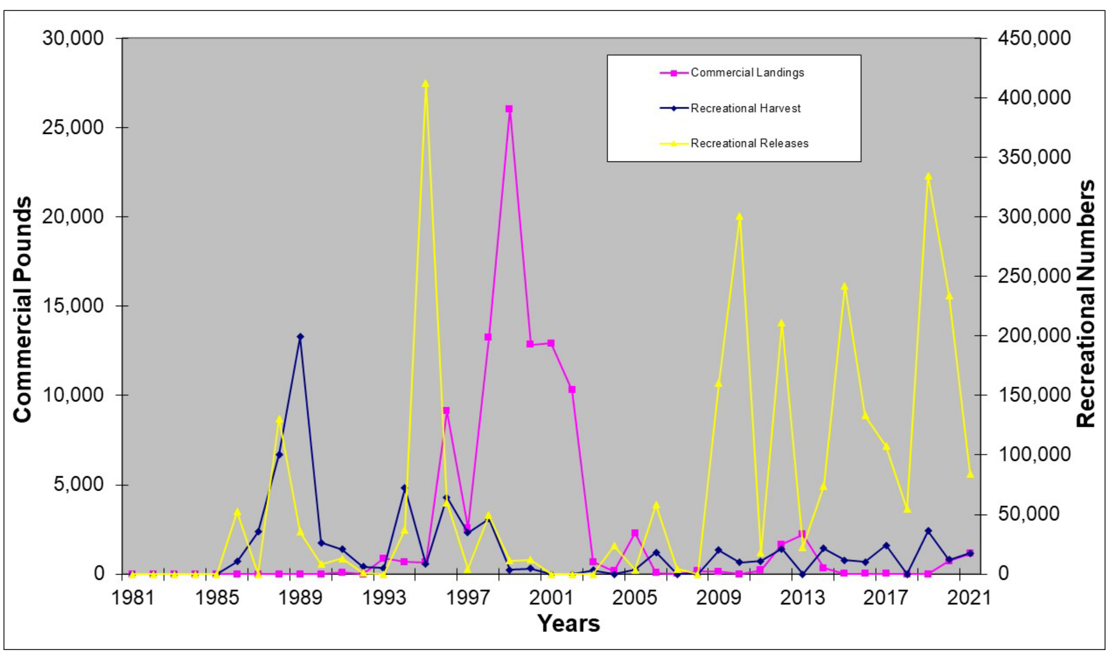


Figure 37. Maryland charter boat log book spotted seatrout harvest in numbers and the number of anglers participating in trips catching spotted seatrout, 1995-2021.

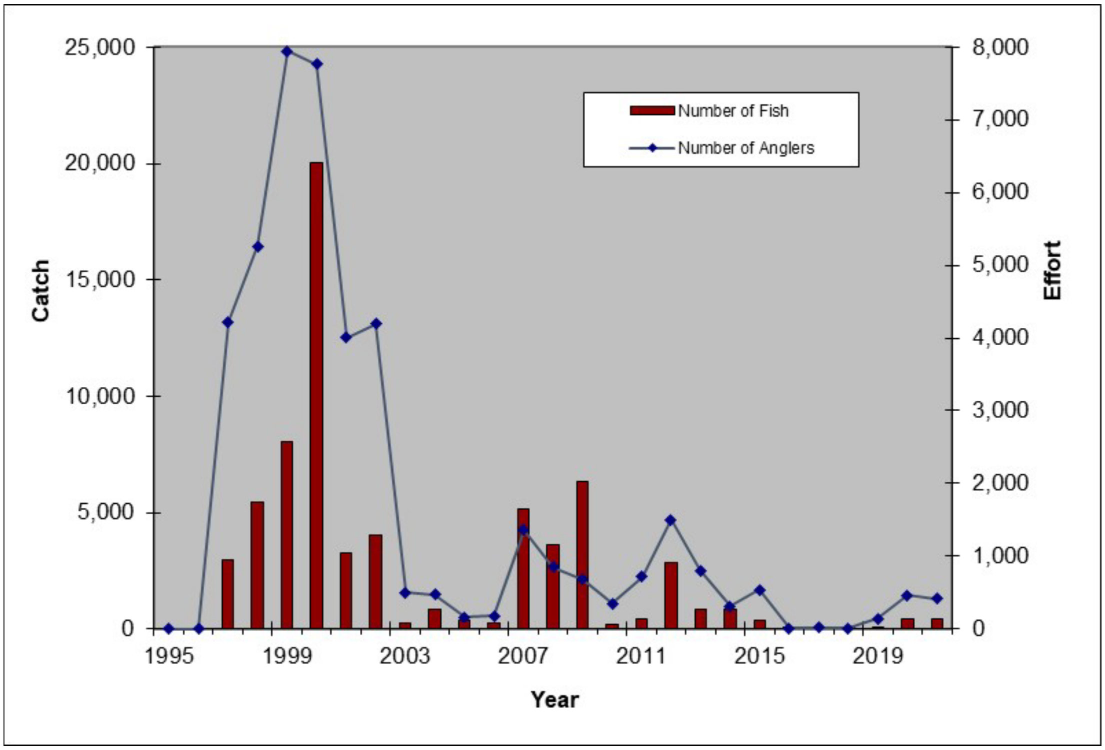


Figure 38. Atlantic menhaden length frequency distributions from onboard pound net sampling, 2012-2021, Note: In 2012 the 230 FL value is 40 percent.

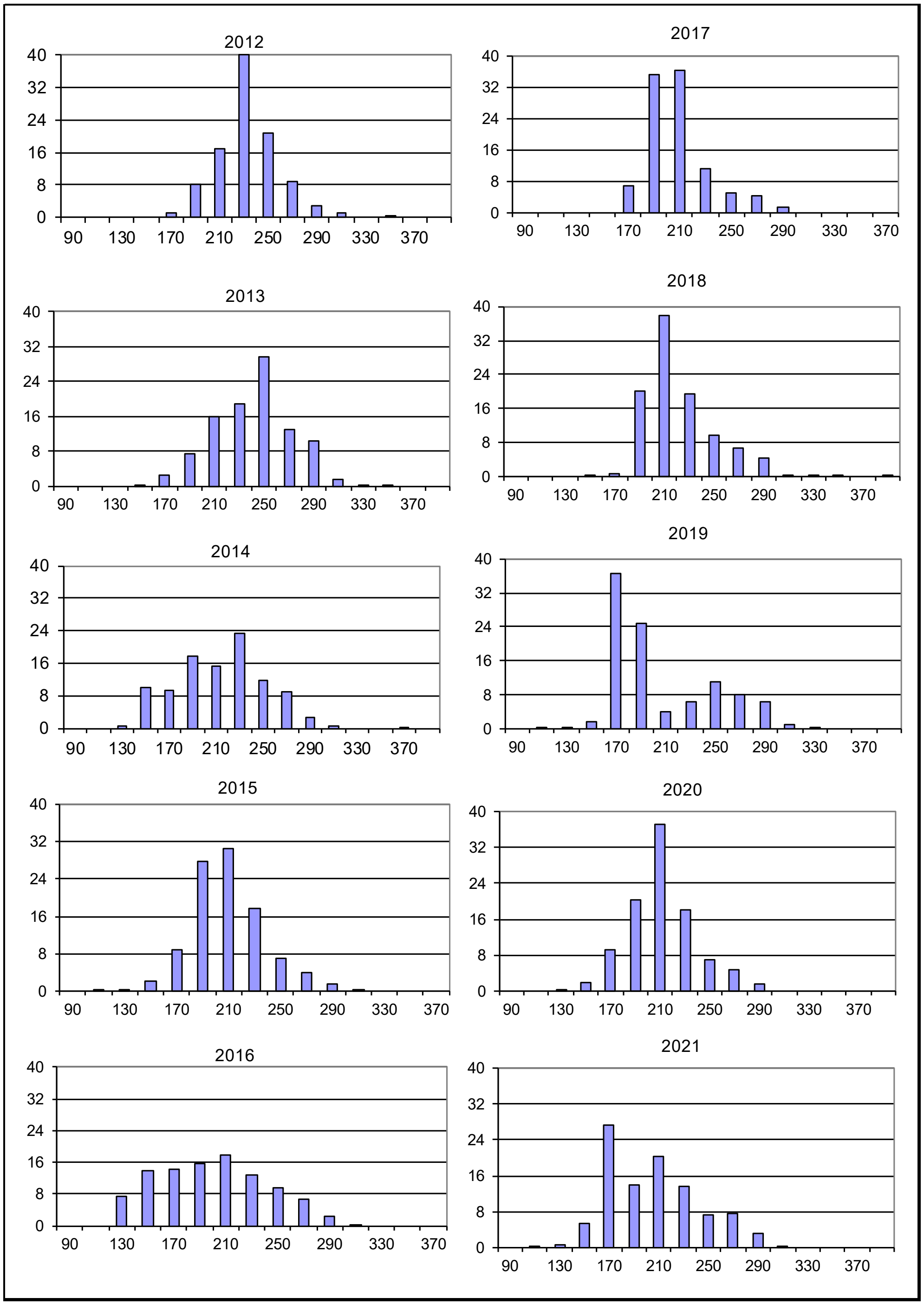


Figure 39. Geometric mean catch per hour and 95% confidence intervals for Atlantic menhaden captured in the Choptank River gill net survey, 2013-2021.

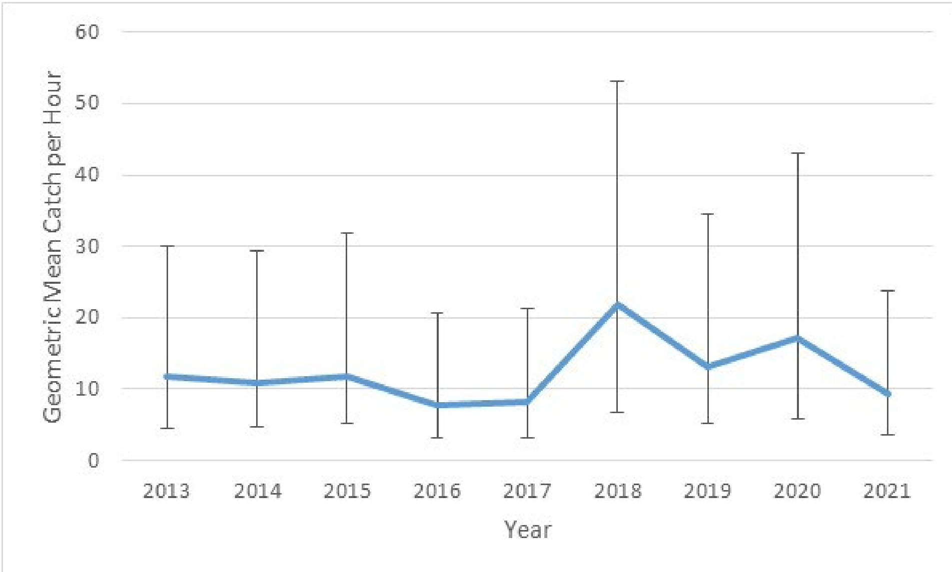


Figure 40. Atlantic menhaden proportion of catch by panel and year from the Choptank River gill net survey, 2013-2021.

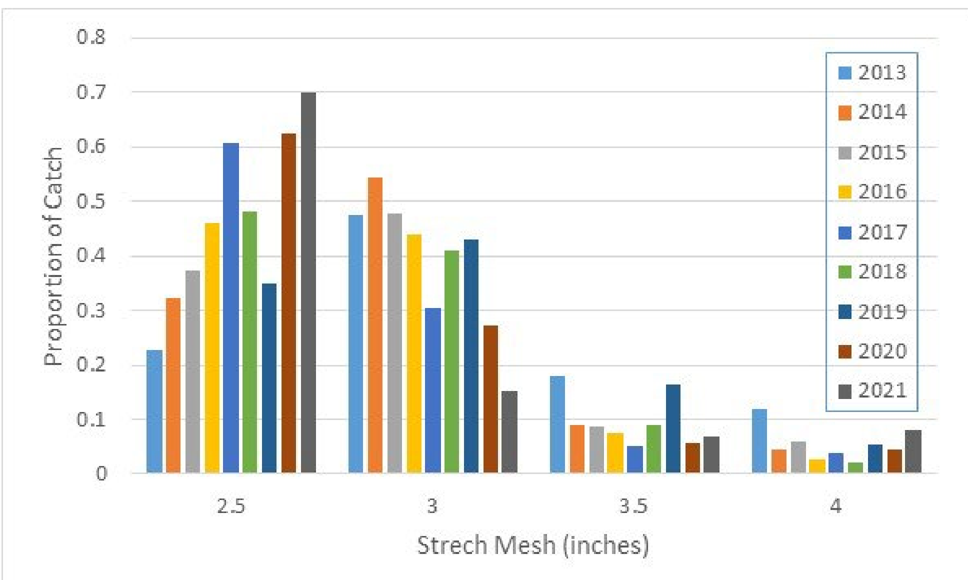


Figure 41. Atlantic menhaden length frequency distributions from the Choptank River gill net survey by year, 2014-2021.

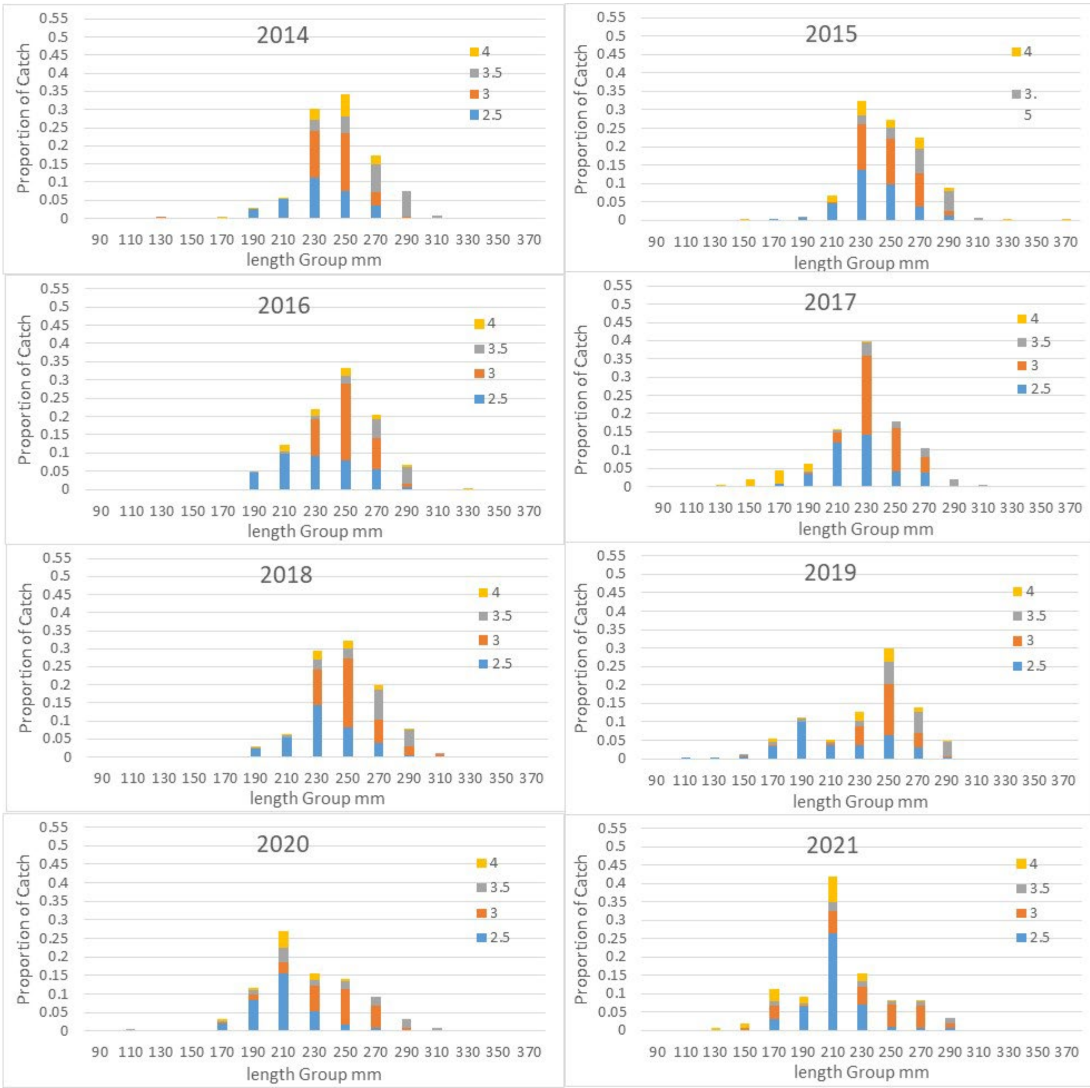
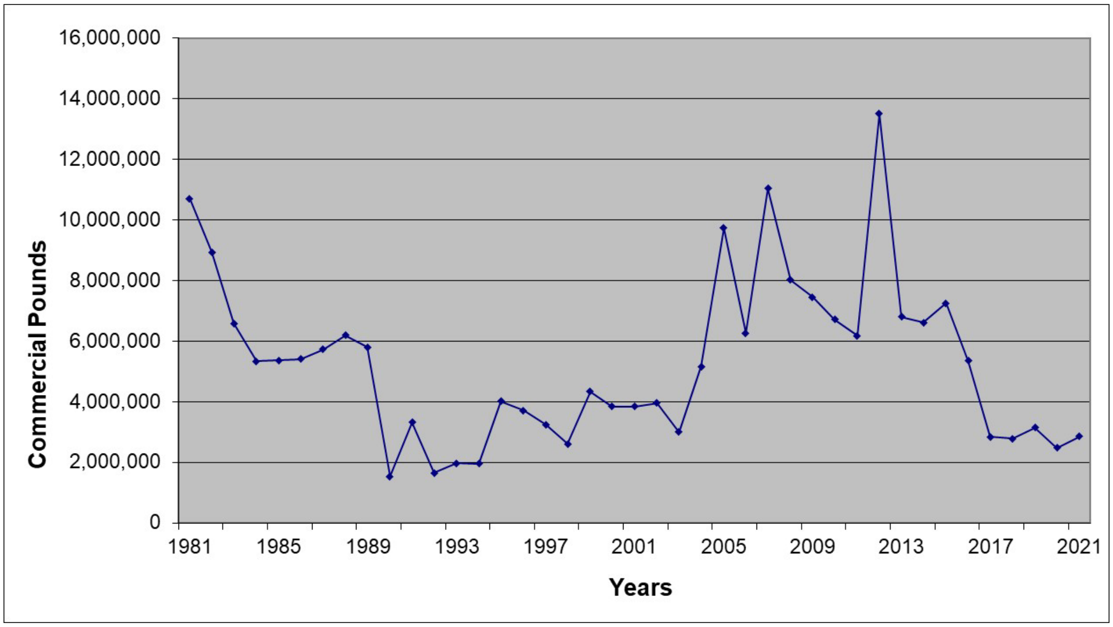


Figure 42. Maryland's Chesapeake Bay commercial landings for Atlantic menhaden from 1981-2021.



PROJECT NO. 2
JOB NO 3.
TASK NO. 1A

SUMMER – FALL STOCK ASSESSMENT AND COMMERCIAL FISHERY MONITORING

Prepared by Jeffrey Horne

INTRODUCTION

The primary objective of Project 2, Job 3, Task 1A was to finalize the characterization of the size and age structures of the 2020 Maryland striped bass *Morone saxatilis* commercial summer/fall fishery and provide preliminary results, as available, for the 2021 summer/fall season. Completed results for the 2021 summer/fall sample season will be reported in the F61-R-18 Chesapeake Bay Finfish Investigations report. The 2020 commercial summer/fall fishery operated on a combination of common pool and individual transferable quota (ITQ) systems (see Project 2, Job 3, Task 5A). The 2020 ITQ commercial summer/fall fishery was open from 1 June through 31 December for pound net gear and 1 June through 30 November for hook and line gear. The 2020 common pool fishery was open two days each month in June, July, and October and one day in November. The common pool fishery was closed in August and September. These fisheries targeted resident/pre-migratory striped bass. Harvested fish were sampled at commercial check stations and additional fish were sampled by visiting pound nets throughout the season.

In addition to characterizing the size and age structures of the commercial catch, data from this survey were used to monitor temporal trends in size-at-age of the harvest. These data also provided the foundation for the construction of the Maryland catch-at-age matrix utilized by the Atlantic States Marine Fisheries Commission (ASMFC) in coastal striped bass stock assessment. Length and age distributions constructed from the 2020 commercial summer/fall fishery were used to characterize the length and age structure of the summer/fall 2020 Chesapeake Bay commercial harvest and the majority of the summer/fall recreational harvest.

METHODS

Commercial pound net monitoring

Before sampling was implemented at check stations in 2000, fish were sampled only from pound nets. Between 1993 and 1999, pound net monitoring and accompanying tagging studies were restricted to legal-sized striped bass (≥ 457 mm or 18 inches TL). In 2000, full-net sampling was initiated at pound nets to quantify the size and age structure of striped bass catch. Commercial pound net monitoring had been conducted in tandem with a mark-recapture study designed to estimate the total instantaneous fishing mortality rate (F) on resident Chesapeake Bay striped bass (Hornick et al. 2005). In 2005, the tagging study was eliminated but striped bass were still sampled monthly from pound nets to continue the characterization of the resident stock.

From 1993-1999, it was assumed that the size and age structures of striped bass sampled at pound nets were representative of the size and age structures of striped bass landed by the commercial pound net fishery. This assumption was questioned because commercial fishermen sometimes removed fish over 650 mm TL from nets prior to Fishing and Boating Services (FABS) staff examination, or during the culling process. These larger striped bass are highly marketable, so fishermen prefer to sell them rather than let them be tagged and released. In 2000, potential biases in the tagging study length distributions were ascertained by adding a check station component to the commercial pound net monitoring (MD DNR 2002). This allowed for the direct comparison of the length distribution of striped bass sampled from pound nets to the length distribution of harvested striped bass sampled at check stations.

Pound net sampling occurred one to nine times per month from June through December 2020 (Table 1). The pound nets sampled were not randomly selected, but were chosen according to watermen's schedules and the best chance of obtaining fish. During 2020, striped bass were sampled from pound nets in the upper and lower Bay. Whenever possible, all striped bass in a pound net were measured in order to characterize by-catch. A full net sample was not possible when pound nets contained too many fish to be transferred to holding tanks on FABS boats. If a full net could not be sampled, a random sub-sample was taken.

At each net sampled, striped bass were measured for total length (mm TL), and the presence and category of external anomalies were noted. Scales were removed from two fish per 10 mm length group per month, up to 700 mm TL, and from all fish greater than 700 mm TL. Other data recorded included latitude and longitude, date the net was last fished, depth, surface salinity, surface water temperature, air temperature, Secchi depth (m), and whether the net was fully or partially sampled.

<u>Commercial summer/fall check station monitoring</u>

All striped bass harvested in Maryland's commercial striped bass fisheries are required to pass through a MD DNR approved check station (see Project 2, Job 3, Task 5A). Check stations across Maryland were sampled for summer/fall harvested fish each month from June through November 2020 (Figure 1). The change to an ITQ system resulted in the use of one type of commercial tag for all gears and prevented differentiation between pound net and hook and line harvested striped bass because the seasons are concurrent. Therefore, the combined fishery will be referred to as the summer/fall fishery for sampling purposes. An overall sample size target was established based on the combined hook and line and pound net targets from previous years. This resulted in a sample target of 500 fish per month for the season. Original target sample sizes were based on methods and age-length keys (ALKs) derived from the 1997 and 1998 MD DNR pound net tagging studies. Check stations were chosen by monitoring their activity and selecting from those landing 8% or more of the monthly harvest in the previous year. Stations that reported higher harvests were sampled more frequently. This method generally distributed the sampling effort so that sample sizes were proportional to landings.

Scale samples were removed from two fish per 10 mm length group per month from fish less than 650 mm TL, 3 fish per 10 mm length group per month from fish 650 to less than 700 mm TL, and from all fish greater than 700 mm TL. A subsample of five fish per 10 mm length group per trip was used if a high number of large fish 700 to 800 mm TL were encountered. All scales from fish >800 mm TL were taken.

<u>Analytical Procedures</u>

Scale ages from the pound net and check station surveys were combined and applied to all fish lengths sampled. Striped bass sampled from pound nets and from commercial hook and line check stations do not significantly differ in length at age (Fegley 2001). Striped bass harvested by each gear exhibited statistically indistinguishable ($P>0.05$, $F=0.8532$) and nearly identical age-length relationships; therefore ages derived from one fishery could be applied to the other. This is not surprising since both fisheries are concurrent within Maryland, and minimum and maximum size regulations are identical.

Age composition of the summer/fall fishery was estimated via two-stage sampling (Kimura 1977, Quinn and Deriso 1999). In the first stage, total length and scale samples were taken based on 10 mm length groups, which were assumed to be a random sample of the commercial harvest. In stage two, a fixed sub-sample of scales were randomly chosen to be aged based on 20 mm length groups. Scales from check stations and pound net monitoring were combined to create the ALK.

Approximately twice as many scale samples as ages per length group were selected to be read based on the variance of ages per length group (Barker et al. 2004). Target sample sizes were: length group<300 mm=3 scales per length group; 300-400 mm=4 scales per length group; 400-700 mm=5 scales per length group; >700 mm=10 scales per length group. In some cases, the actual number of scales aged was limited by the number of samples available per length group.

Year-class was determined by reading acrylic impressions of the scales placed in microfiche readers, and age was calculated by subtracting year-class from collection year. The resulting ages were used to construct an ALK. The catch-at-age for the fishery was calculated by applying the ALK to the summer/fall fishery sampled length frequency and expanding the resulting age distribution to the landings for the summer/fall fishery.

To determine recruitment into the summer/fall fishery, the age structure of the harvest over time was examined. The age structure of the harvest for the 2020 summer/fall fishery was also compared to previous years. An ANOVA with a Duncan's multiple range test (SAS 2006) was performed to compare lengths and weights of striped bass harvested between months in 2020.

Mean length- and weight-at-age of striped bass landed in the summer/fall fishery were derived by applying ages to all sampled fish, and then weighting the means on the length distribution at each age. Mean length- and weight-at-age were calculated by year-class for the aged sub-sample of fish. Mean length-at-age and weight-at-age were also estimated for each year-class using an expansion method. Expanded means were calculated with an age-length key and a probability table which applied ages from the sub-sample of aged fish to all sampled fish. Due to non-normality, age-specific length distributions based on the aged sub-sample are often biased compared to the age-specific length distribution based on the entire length sample (Bettoli and Miranda 2001). Finally, length frequencies from the pound net monitoring and check station samples were examined.

RESULTS and DISCUSSION

Commercial pound net monitoring

During the 2020 striped bass pound net study, a total of 4,056 striped bass were sampled from three pound nets in the upper Bay and seven pound nets in the lower Bay. The ten nets were sampled a total of 29 times during the study (Table 1).

Striped bass sampled from pound nets ranged from 204-1050 mm TL, with a mean length of 437 mm TL (Figure 2). In 2020, 79% of striped bass collected from full net samples were less than the commercial minimum legal size of 18 inches (457 mm) TL and 42% of fish from partially sampled nets were sub-legal.

Mean total length of the aged sub sample are presented in Table 2. Striped bass sampled from pound nets ranged from 1 to 10 years of age when the combined age length key was applied to the entire sample (Table 3, Figure 2). Age 5 fish from the above average 2015 year-class contributed 31% of the sample. Age 9 fish from the above average 2011 year-class contributed <1% in 2020, which was a decrease compared to the contribution in the previous year (3%). Striped bass age 6 and older comprised 9% of the sample, which was lower than their contribution in the previous year (12%; Figure 3).

Commercial summer/fall check station monitoring

A total of 994 striped bass were sampled at summer/fall check stations in 2020. The mean length of sampled striped bass was 545 mm TL. Length frequencies of legal sized striped bass (n=1,815) sampled at pound nets were slightly smaller compared to length distributions from the check stations (Figure 4). Striped bass sampled from the summer/fall fishery ranged from 457 to 801 mm TL and from 3 to 10 years of age (Figure 5). No sub-legal (<457 mm TL) fish were encountered in the subsample. Mean lengths-at-age and weights-at-age of the aged sub sample for the 2020 summer/fall fishery are shown in Tables 4 and 5.

Striped bass in the 450-550 mm length groups accounted for 70% of the summer/fall harvest (Figure 5). Larger fish from the above average 2011 year-class have influenced the number of larger fish in the harvest in previous years, however, did not contribute as much to the fishery in 2020. Striped bass over 700 mm TL were harvested throughout the season (Figure 6) and contributed 2% to the overall harvest. Historically, these fish have not been available in large numbers during the summer (MD DNR 2002).

The 2020 summer/fall reported harvest accounted for 57%, by weight, of the Maryland Chesapeake Bay total commercial harvest in 2020 with 726,672 pounds landed (see Project 2, Job 3, Task 5A). Landings reported by the MD DNR commercial reporting section were 78,880 pounds for hook and line gear and 647,792 pounds for pound net gear. The combined length frequency and ages of the sampled fish were applied to the total summer/fall fishery harvest. The estimated 2020 catch-at-age in pounds and numbers of fish for the summer/fall fishery is presented in Table 6. A three year old fish (2017 year-class) was encountered in pound net monitoring, but was not encountered in the check station subsample so average weight from 2019 was used to calculate catch-at-age in pounds. By weight, the majority (91%) of the harvest was composed of four to seven year-old striped bass. Striped bass from the above average 2015 year class (age 5) contributed the highest percentage to the harvest (59%). Striped bass age 8 and older contributed 3% to the overall harvest in 2020, which was lower than 2019 (6%).

Monitoring summary

Striped bass ranging from 457 to 550 mm TL composed 70% of the 2020 summer/fall harvest (Figure 5). A smaller percentage of fish >630 mm TL were harvested in 2020 (8%)

compared to 2019 (12%). In 2020, 105 fish from pound net monitoring and 55 fish from check station sampling were aged. Younger fish (age 4 to 7) were abundant, accounting for the majority of the harvest (Figure 7). Length frequencies of legal-sized fish sampled from pound nets and all fish from check stations were similar, however, pound net fish were slightly smaller (Figure 4). Mean lengths-at-age have remained nearly the same since 2000 (Figure 8).

A Duncan's multiple range test (SAS 2006) was performed on lengths and weights of striped bass harvested between months (α=0.05). Striped bass were significantly larger (TL= 570 mm and WT=1.84 kg) in August. Lengths and weights were similar in June, September, October, and November (TL=542 mm, 531 mm, 542 mm, 543 mm and WT=1.63 kg, 1.53 kg, 1.77, 1.73 kg), respectively. The lowest average length and weight of striped bass was in July (605 mm and 1.25 kg). Duncan's groups are presented in Tables 7 and 8.

PROJECT NO. 2
JOB NO 3.
TASK NO. 1A

SUMMER – FALL STOCK ASSESSMENT AND COMMERCIAL FISHERY MONITORING

2021 PRELIMINARY RESULTS – WORK IN PROGRESS

Commercial pound net monitoring

During the 2021 striped bass pound net study, a total of 4,887 striped bass were sampled and 494 scale samples were collected for ageing from two pound nets in the upper Bay and six pound nets in the lower Bay. The eight nets were sampled a total of 45 times during the study.

Striped bass sampled from pound nets ranged from 210-1210 mm TL, with a mean length of 430 mm TL. A complete breakdown of catch by length and age for the 2021 summer/fall season will be available in the F61-R-18 Chesapeake Bay Finfish Investigations report.

Commercial summer/fall check station monitoring

A total of 1,756 striped bass were sampled and 314 scale samples were collected for ageing at summer/fall check stations in 2021. The mean length of sampled striped bass was 552 mm TL. Striped bass sampled from the summer/fall fishery ranged from 449 to 819 mm TL. Less than 1% of the sampled harvest was sub-legal (<457 mm TL). Mean lengths-at-age and weights-at-age will be available in the next F-61 Chesapeake Bay Finfish Investigations report.

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LIST OF TABLES

LIST OF FIGURES

Table 1. Summary of sampling areas, sampling dates, surface temperature, surface salinity and numbers of fish encountered during the 2020 Maryland Chesapeake Bay commercial pound net monitoring survey.

Month	**Area**	**Number of Nets Sampled**	**Mean Water Temp (°C)**	**Mean Salinity (ppt)**	**Number of Fish Sampled**
June	Upper	1	21.4	7.3	342
	Middle	-	-	-	-
	Lower	8	23.8	11.4	396
July	Upper	1	29.3	9.4	363
	Middle	-	-	-	-
	Lower	3	28.4	12.2	29
August	Upper	1	26.7	1.3	128
	Middle	-	-	-	-
	Lower	4	26.8	13.8	402
September	Upper	1	26.7	9.2	400
	Middle	-	-	-	-
	Lower	3	24.6	14.0	600
October	Upper	3	19.4	9.0	890
	Middle	-	-	-	-
	Lower	2	18.4	15.1	144
November	Upper	1	10.3	10.4	239
	Middle	-	-	-	-
	Lower	-	-	-	-
December	Upper	-	-	-	-
	Middle	-	-	-	-
	Lower	1	12.9	15.2	124

Table 2. Mean length-at-age (mm TL) of striped bass sampled from pound nets in Maryland's Chesapeake Bay, June through December 2020.

Year-class	Age	N	Mean Length (mm TL)	Lower CL	Upper CL
2019	1	11	252	224	280
2018	2	16	335	303	367
2017	3	19	393	360	426
2016	4	9	456	428	483
2015	5	17	511	485	537
2014	6	9	577	534	621
2013	7	9	695	660	729
2012	8	6	708	637	779
2011	9	8	745	705	786
2010	10	1	801	*	*

*Due to low sample size, lower and upper CL values are not included.

Table 3. Number of striped bass, by age, sampled from pound nets, in Maryland's Chesapeake Bay, June through December 2020. Sum of columns may not equal due to rounding.

Year-class	Age	Pound Net Monitoring	
		Number Sampled at Age (n)	Percent of Total
2019	1	230	5.7
2018	2	722	17.8
2017	3	959	23.6
2016	4	535	13.2
2015	5	1,254	30.9
2014	6	293	7.2
2013	7	23	0.6
2012	8	21	0.5
2011	9	17	0.4
2010	10	2	<0.1
Total		**4,056**	**100.0**

Table 4. Mean length-at-age (mm TL) of legal-size striped bass (≥457 mm TL/18 in TL) sampled from the commercial summer/fall check stations in Maryland's Chesapeake Bay, June through November 2020.

Year-class	Age	n	Mean Length (mm TL)	Lower CL	Upper CL
2016	4	2	544	*	*
2015	5	20	570	536	604
2014	6	8	623	574	672
2013	7	9	699	675	723
2012	8	8	723	677	769
2011	9	7	710	678	742
2010	10	1	753	*	*

*Due to low sample size, lower and upper CL values are not included.

Table 5. Mean weight-at-age (kg) of legal-size striped bass (≥457 mm TL/18 in TL) sampled from the commercial summer/fall check stations in Maryland's Chesapeake Bay, June through November 2020.

Year-class	Age	n	Mean Weight (kg)	Lower CL	Upper CL
2016	4	2	1.8	*	*
2015	5	20	2.0	1.58	2.35
2014	6	8	2.5	1.89	3.12
2013	7	9	3.1	2.78	3.47
2012	8	8	3.6	2.93	4.24
2011	9	7	3.3	2.80	3.86
2010	10	1	3.8	*	*

*Due to low sample size, lower and upper CL values are not included.

Table 6. Estimated catch-at-age of striped bass landed by the Maryland Chesapeake Bay commercial summer/fall fishery, June through November 2020.

Year-class	Age	Summer/Fall Total Catch at Age			
		Landings in Pounds of Fish	Percent of Total	Landings in Numbers of Fish	Percent of Total
2017	3	21,079	2.9	11,804	7.3
2016	4	62,140	8.6	15,659	9.8
2015	5	431,649	59.4	97,897	60.5
2014	6	168,225	23.2	30,522	18.9
2013	7	19,211	2.6	2,811	1.7
2012	8	15,677	2.2	1,975	1.2
2011	9	7,920	1.1	1,089	0.7
2010	10	772	0.1	92	0.1
Total*		**726,672**	**100.0**	**161,849**	**100.0**

* Sum of columns may not equal totals due to rounding.

Table 7. Duncan's multiple range test for mean length by month for the Maryland Chesapeake Bay commercial summer/fall fishery, June through November 2020. Months with the same Duncan grouping letter are not significantly different (α=0.05) in mean length.

Duncan Grouping	Month	Mean Length (mm)	Number of Fish Sampled
A	August	570	185
B	November	543	118
B	June	542	321
B	October	542	180
B	September	531	166
C	July	506	24

Table 8. Duncan's multiple range test for mean weight by month for the Maryland Chesapeake Bay commercial summer/fall fishery, June through November 2020. Months with the same Duncan grouping letter are not significantly different (α=0.05) in mean weight.

Duncan Grouping	Month	Mean Weight (kg)	Number of Fish Sampled
A	August	1.84	185
AB	October	1.77	180
AB	November	1.73	117
BC	June	1.63	320
C	September	1.53	166
D	July	1.25	24

Figure 1. Locations of Chesapeake Bay commercial summer/fall check stations and pound nets sampled from June through December 2020.

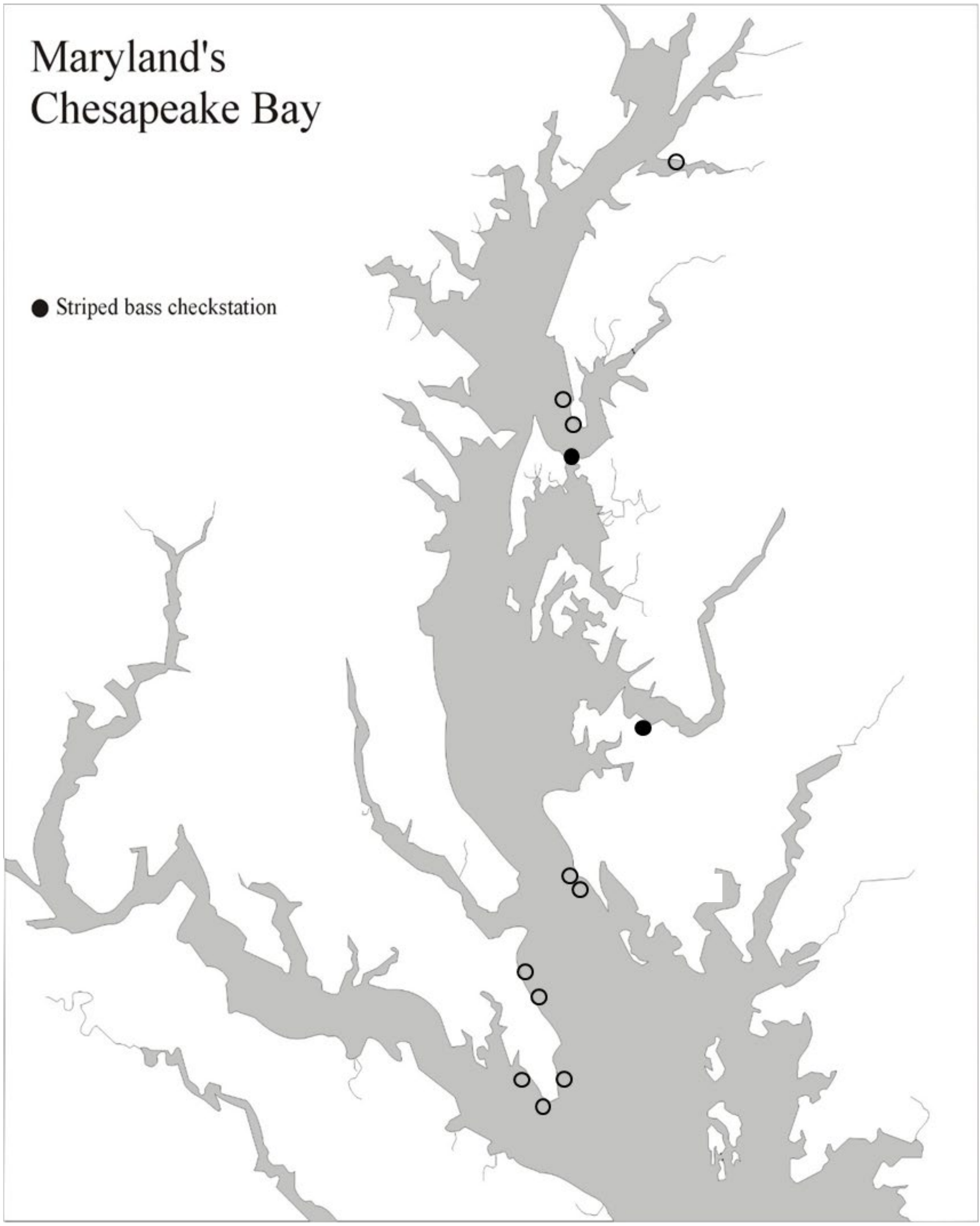


Figure 2. Age and length (mm TL) frequencies of striped bass sampled during Maryland Chesapeake Bay pound net monitoring study, June through December 2020.

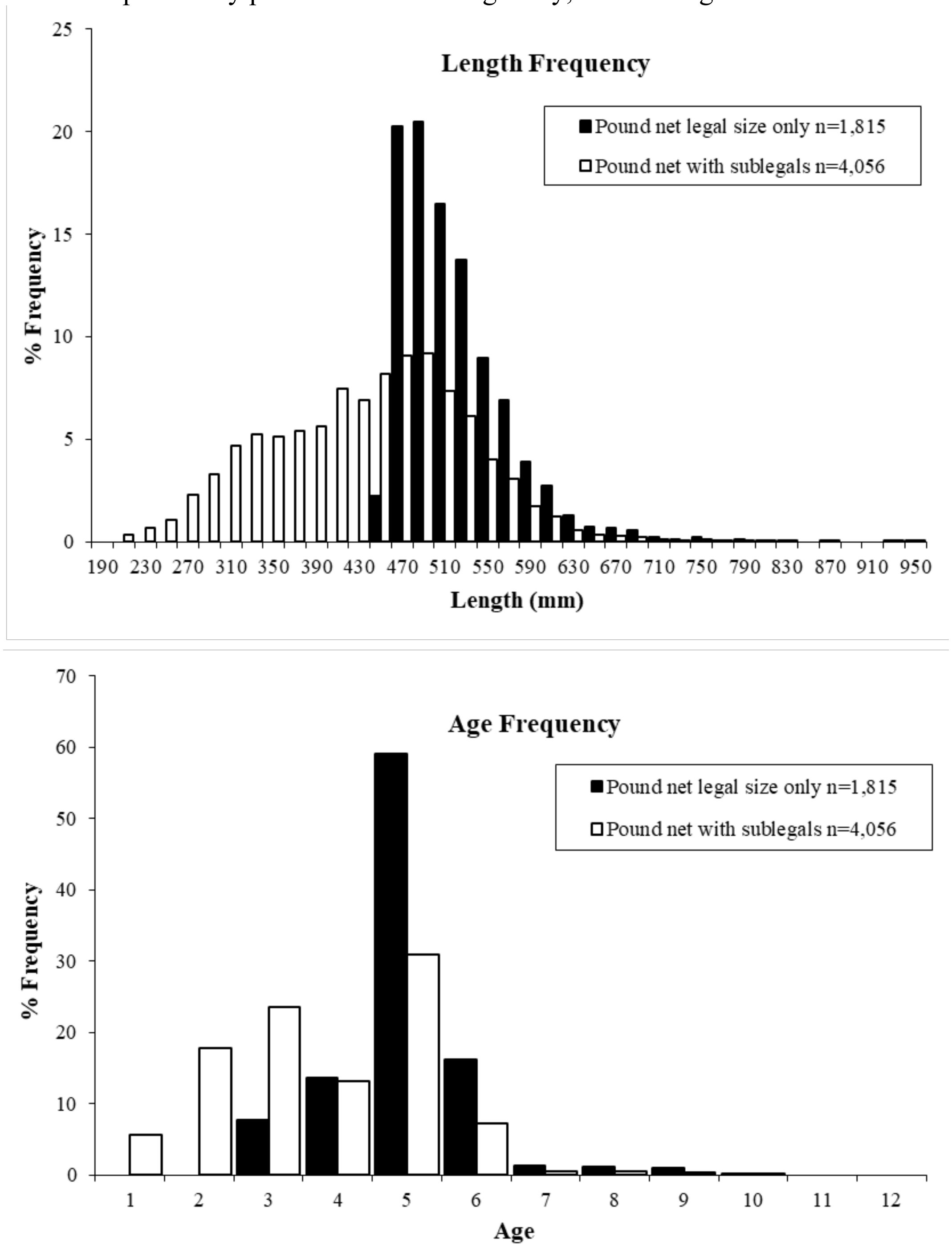
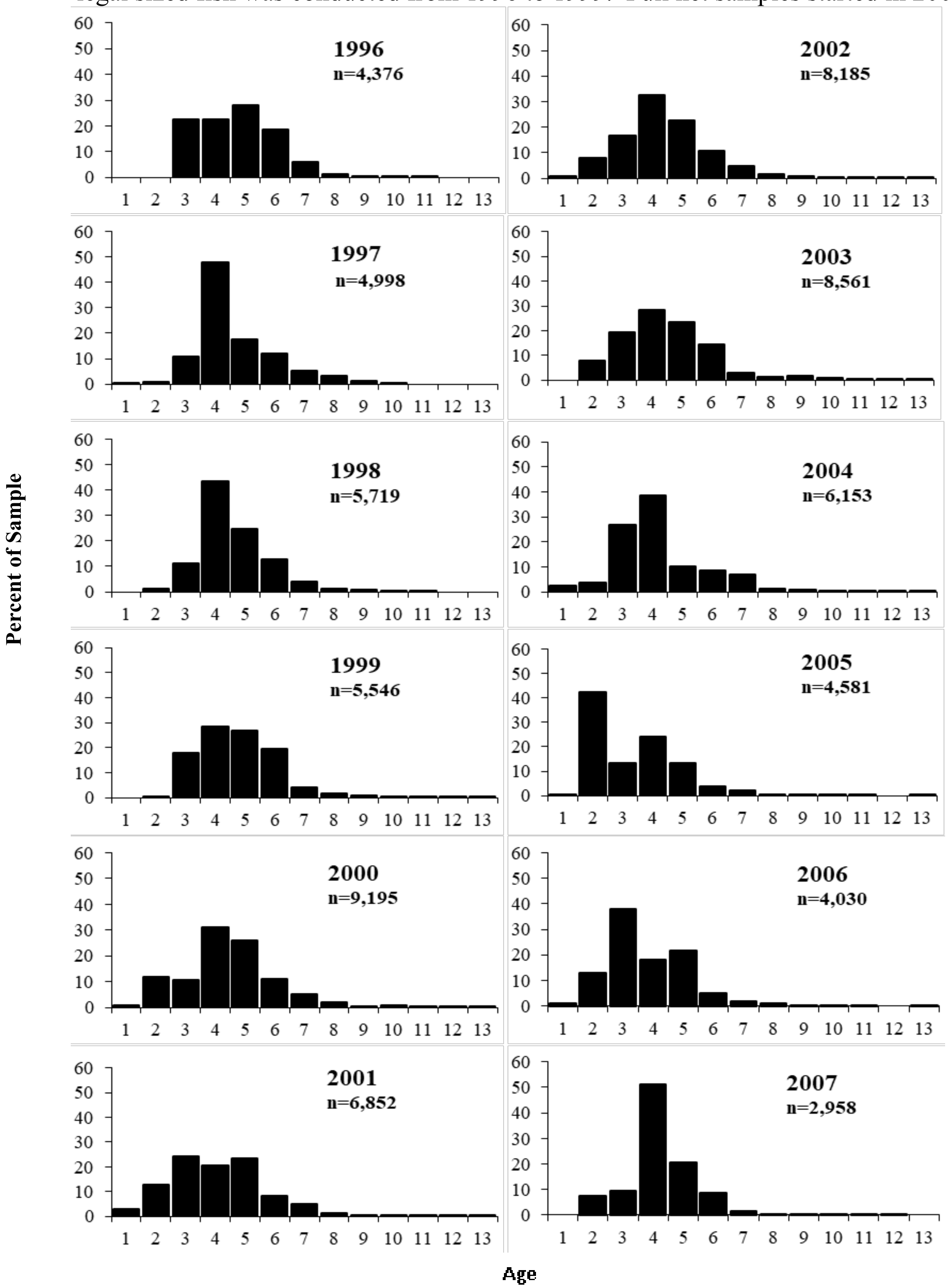


Figure 3. Age structure of striped bass sampled from Maryland Chesapeake Bay commercial pound net monitoring study from 1996 through 2020. *Note partial net sampling for legal sized fish was conducted from 1996 to 1999. Full net samples started in 2000.



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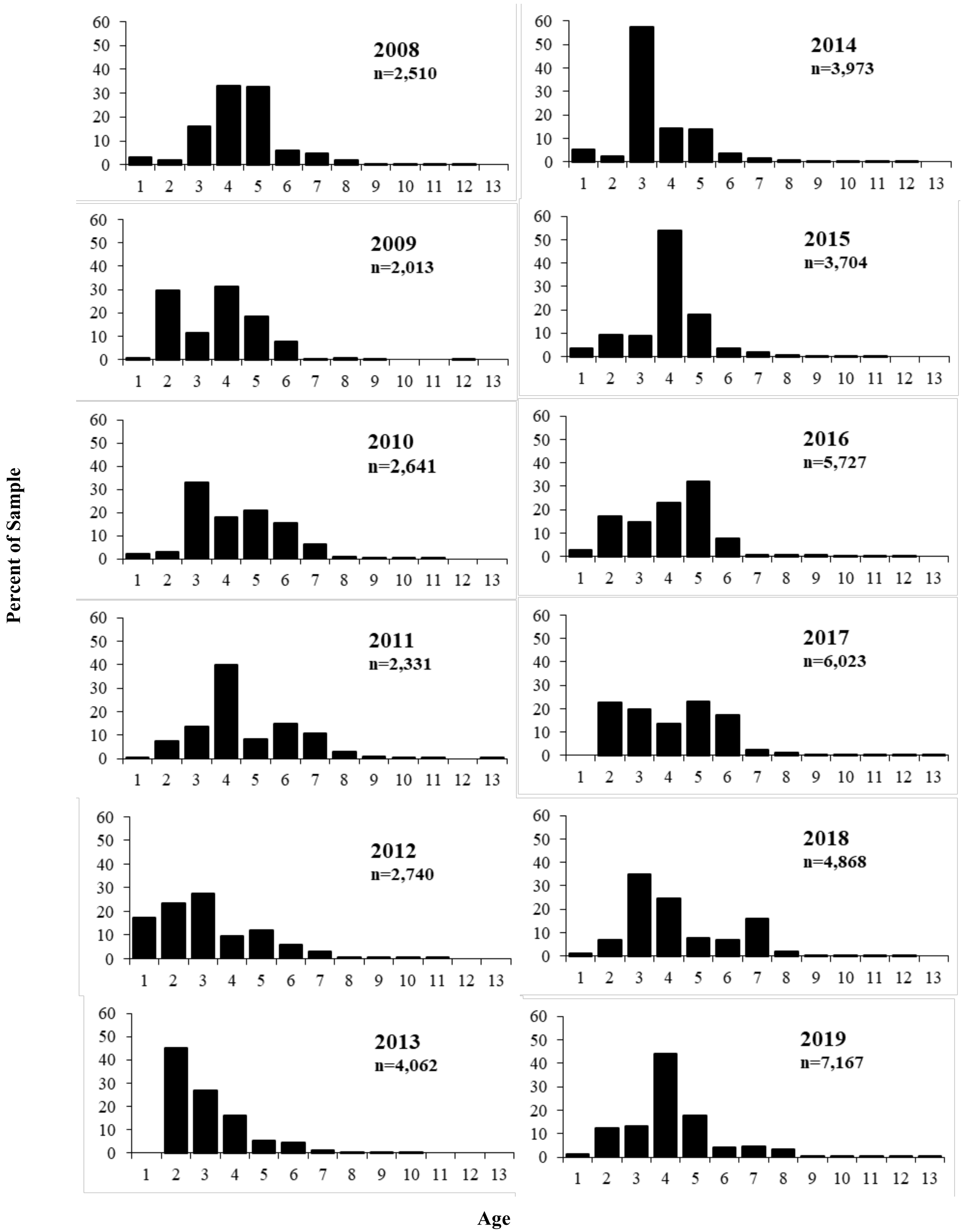

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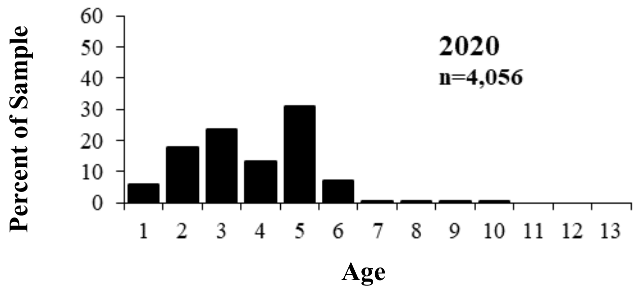


Figure 4. Length frequency of striped bass sampled during the 2020 pound net monitoring and the summer/fall check station surveys. All fish were sampled from June through December 2020. Pound net monitoring length frequency is for legal-size fish only (≥457 mm TL/18 in TL).

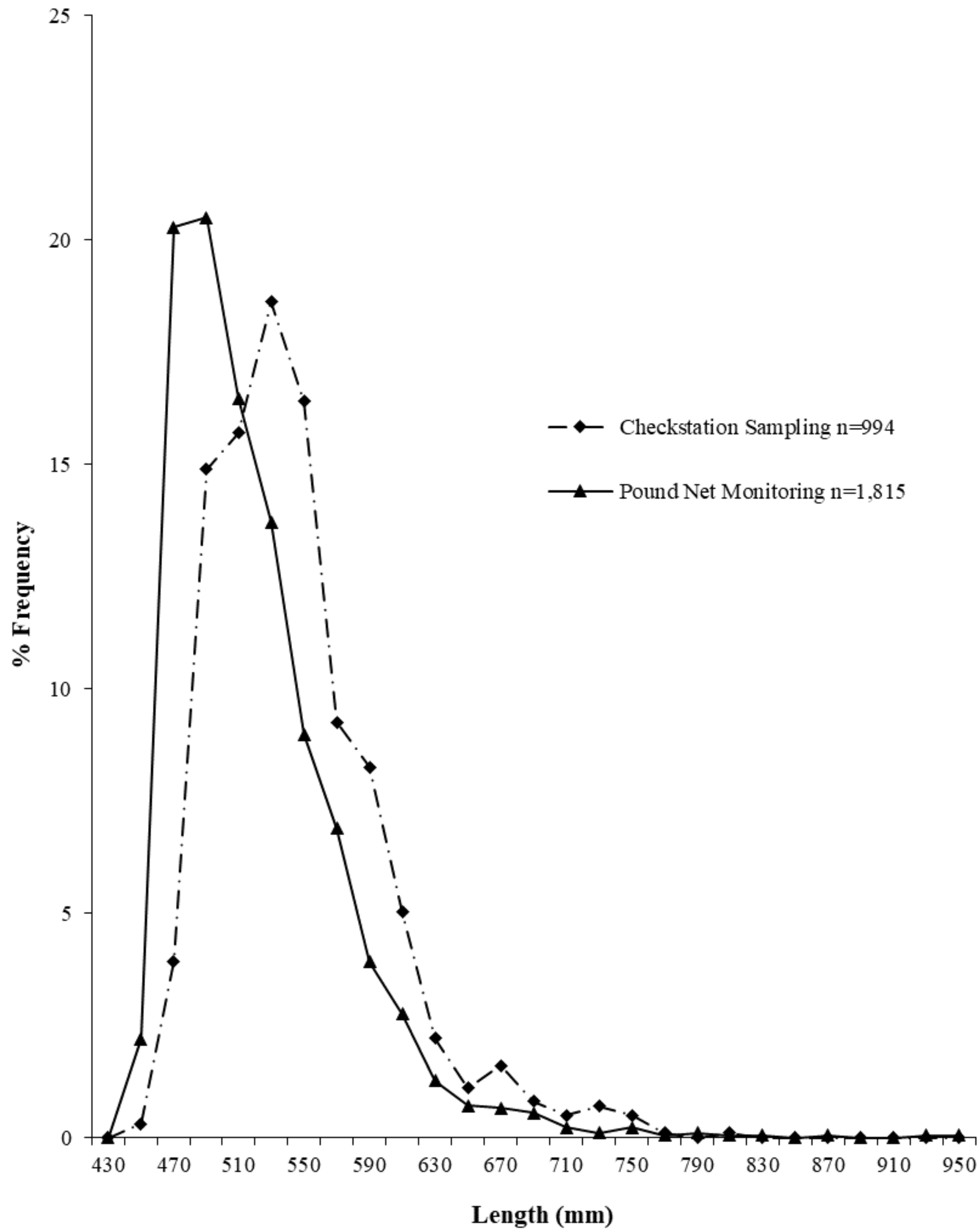
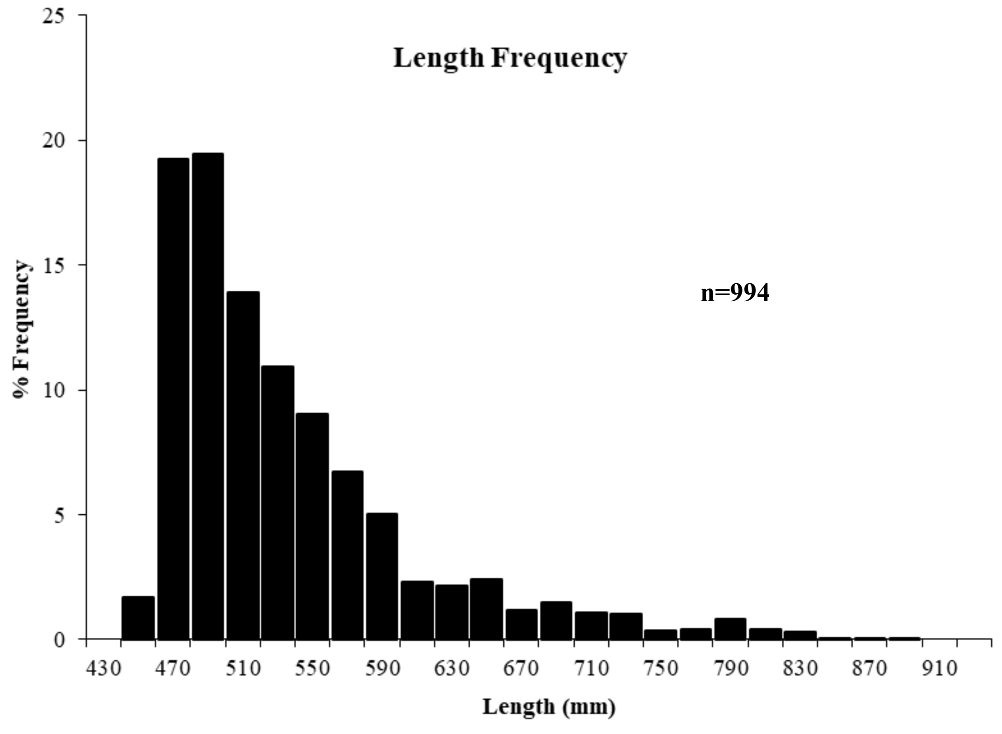


Figure 5. Age and length frequencies of striped bass sampled from Maryland Chesapeake Bay commercial summer/fall check stations, June through November 2020.



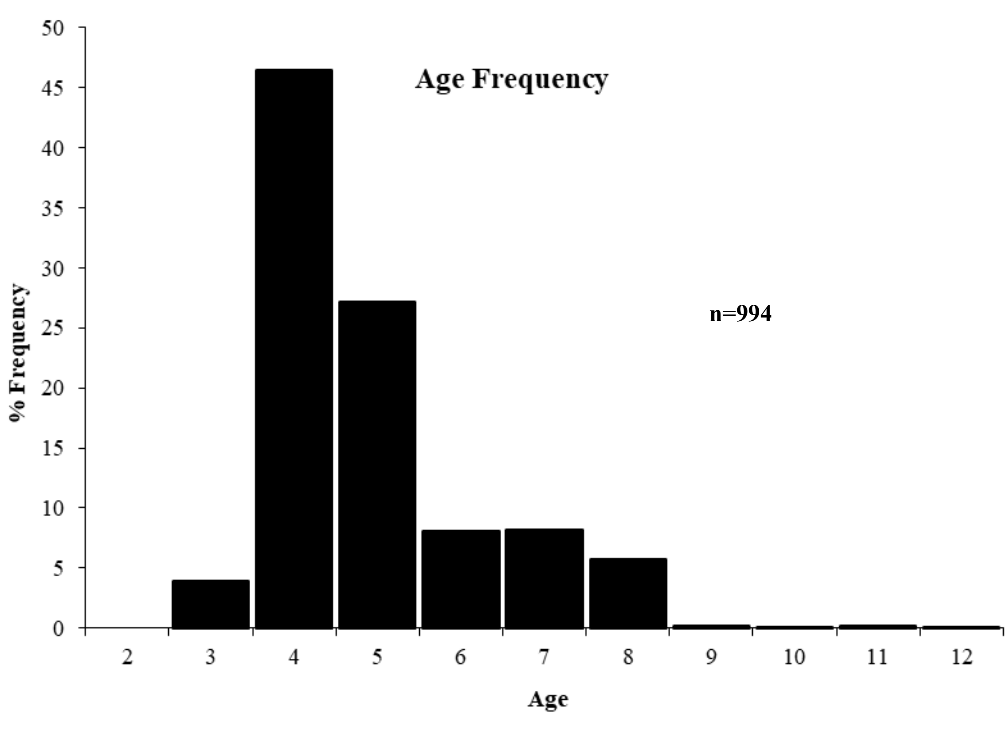


Figure 6. Month-specific length distributions of striped bass sampled from Maryland Chesapeake Bay commercial summer/fall check stations, June through November 2020.

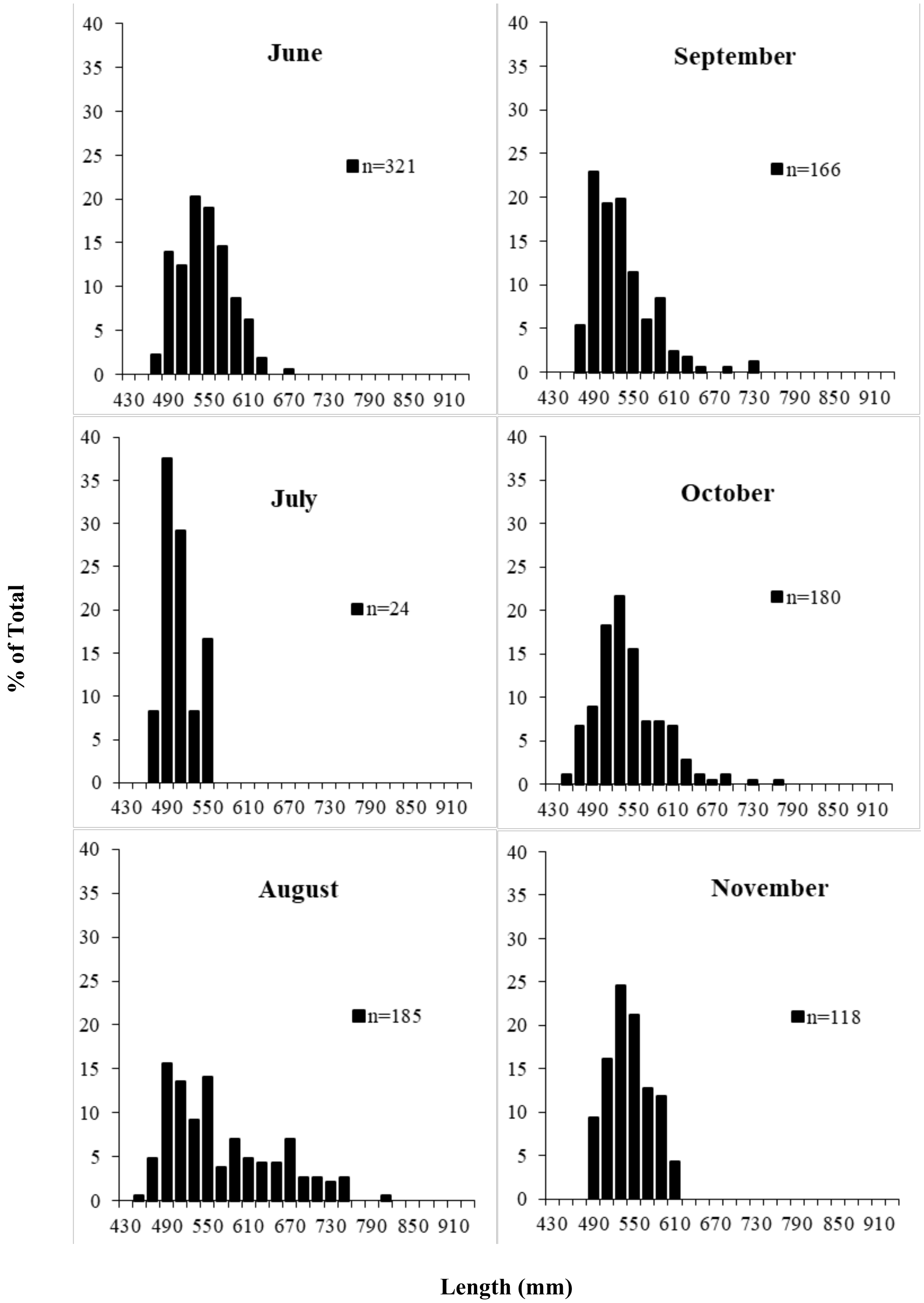
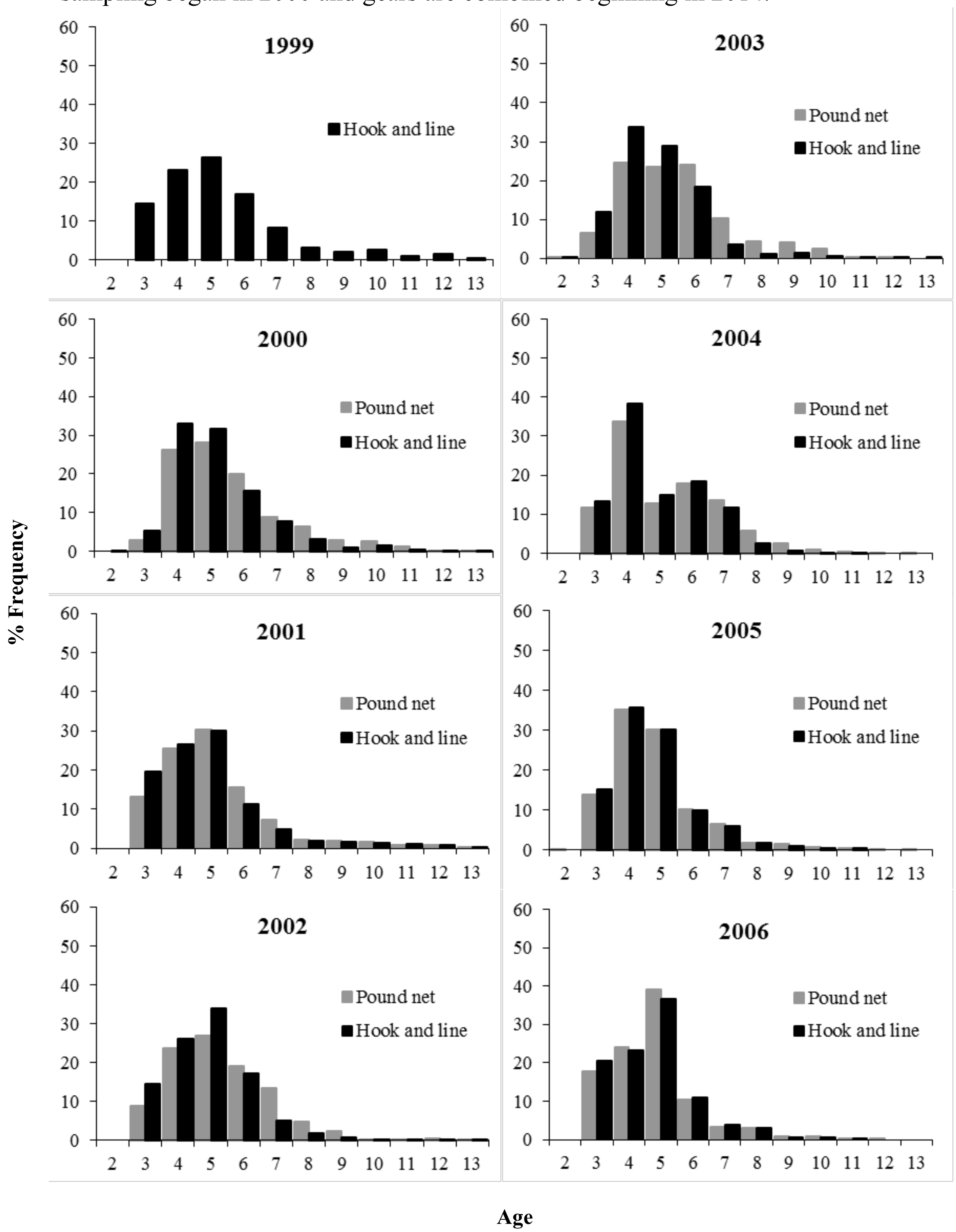


Figure 7. Age structure of striped bass sampled from Maryland Chesapeake Bay commercial summer/fall check stations, 1999 through 2020. Note-pound net check station sampling began in 2000 and gears are combined beginning in 2014.



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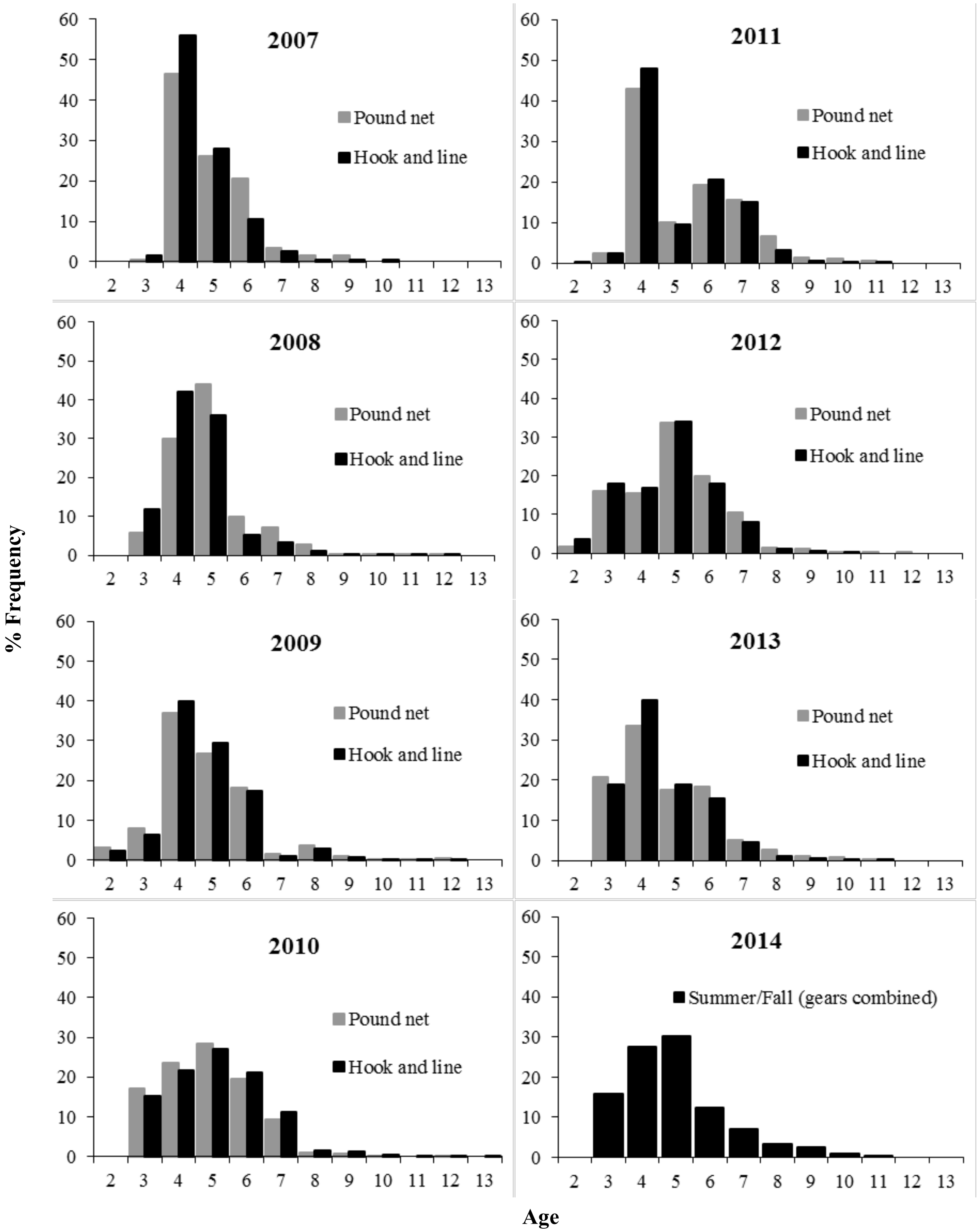

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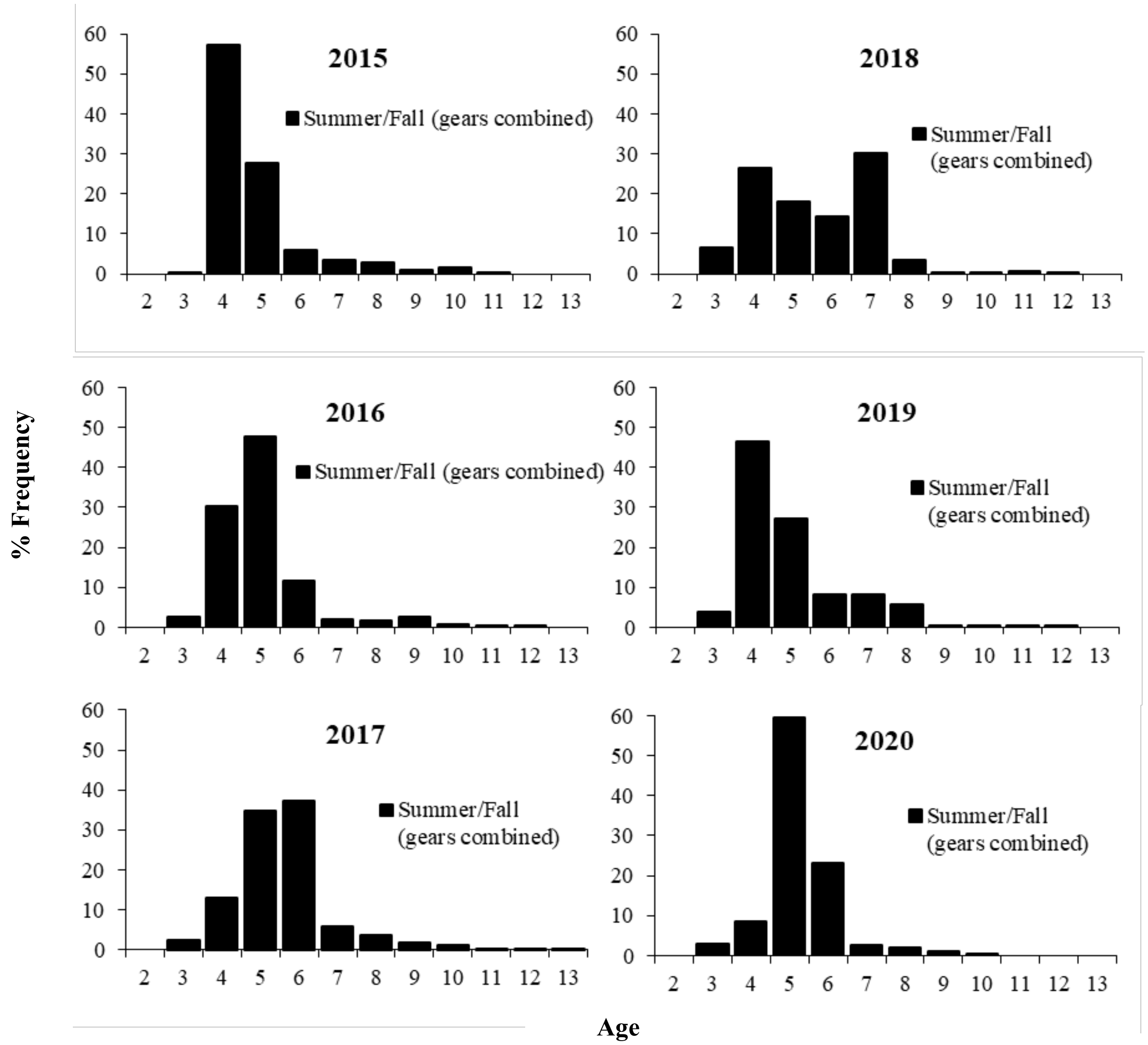
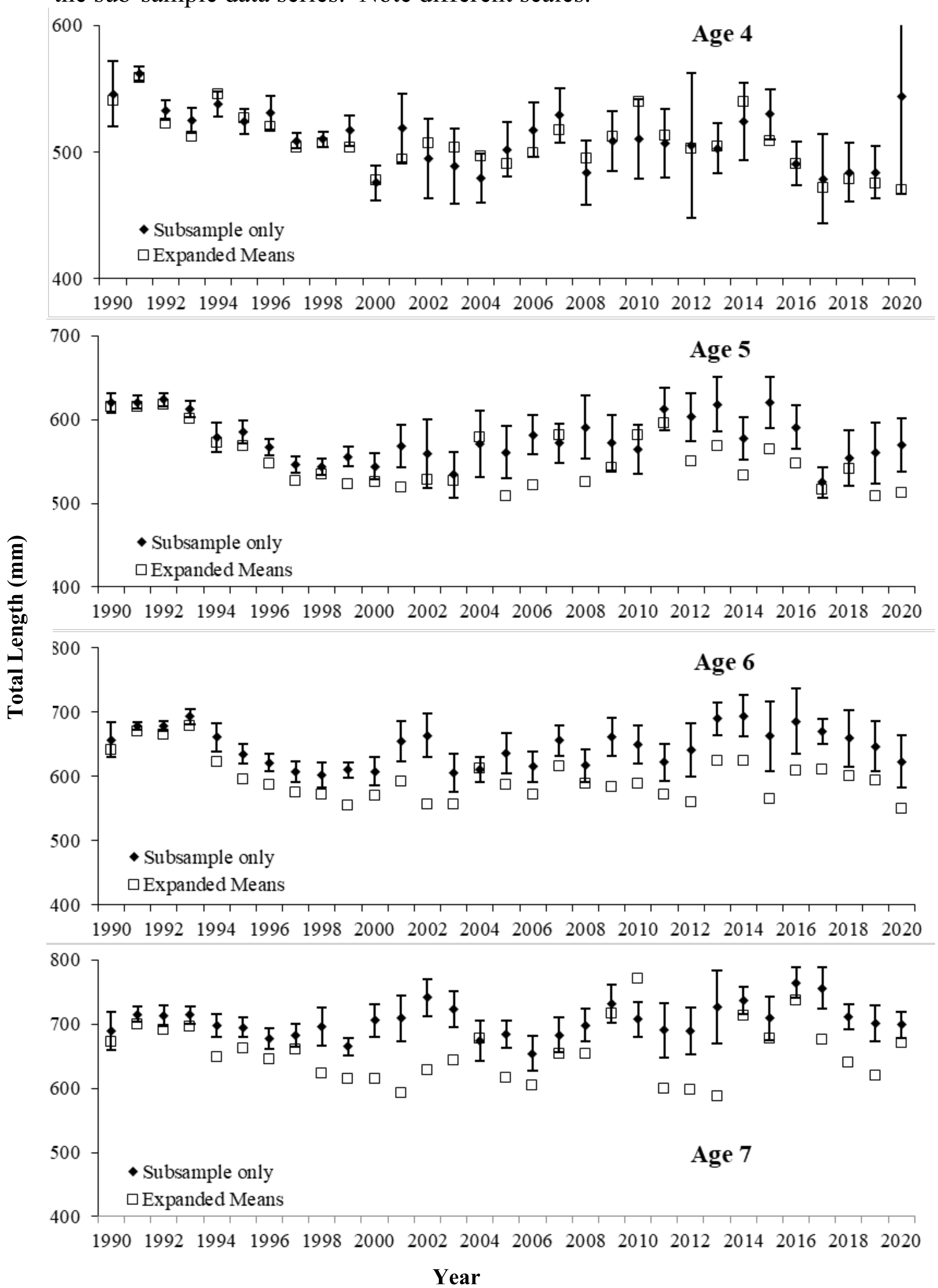


Figure 8. Mean lengths for legal-size striped bass (≥457 mm TL) by year for age 4, 5, 6, and 7 striped bass sampled from Maryland Chesapeake Bay pound nets and commercial summer/fall check stations, 1990 through 2020. Mean lengths were calculated by using sub-sampled ages only and by expanding ages to sample length frequency before calculating means. The 95% confidence intervals are shown around points in the sub-sample data series. Note different scales.



PROJECT NO. 2
JOB NO. 3
TASK NO. 1B

WINTER STOCK ASSESSMENT AND COMMERCIAL FISHERY MONITORING

Prepared by Jeffrey Horne

INTRODUCTION

The primary objective of Project 2, Job 3, Task 1B was finalize the characterization of the size and age structure of striped bass (*Morone saxatilis*) sampled from the December 1, 2020 – February 28, 2021 commercial drift gill net fishery and provide preliminary results, as available, for the 2021-2022 winter season. Completed results for the 2021-2022 winter sample season will be reported in the F61-R-18 Chesapeake Bay Finfish Investigations report. This fishery targets resident/pre-migratory Chesapeake Bay striped bass and accounts for 40-50% of the annual Maryland Chesapeake Bay commercial harvest.

In addition to characterizing the size and age structure of this component of the commercial harvest, these data were used to monitor temporal trends in length and weight-at-age of resident/pre-migratory striped bass. These data were also used as part of the Maryland catch-at-age matrix utilized in the Atlantic States Marine Fisheries Commission's (ASMFC) coastal striped bass stock assessment.

Maryland's Chesapeake Bay commercial fisheries have been using an individual transferable quota (ITQ) system since 2014 (see Project 2, Job 3, Task 5A). Watermen were assigned an individual quota for the year that they could harvest during any open season. For each month of the ITQ drift gill net fishery, fish could be harvested Monday through Friday during the entire month. A small number of watermen elected to stay in a common pool fishery, in which they shared a monthly quota, with daily harvest limits, similar to the old system. The common pool fishery was open for two days in December, open for three days in January and three days in February.

METHODS

Data collection procedures

All striped bass harvested in Maryland's commercial striped bass fishery are required to pass through a Maryland Department of Natural Resources (MD DNR) approved check station. Striped bass check stations were sampled for the winter stock assessment according to a stratified random sampling design. Strata were defined as either high-use, medium-use, or low-use check stations based on landings from the previous year. Individual check stations that processed 8% or greater of the monthly catch were designated as high-use stations, stations that processed between 3% and 7.9% of the catch were designated as medium-use, and any stations that processed less than 3% of the catch were designated as low-use. High-use and medium-use stations were sampled at a 3 to 1 ratio; three high-use stations were sampled for every visit to a medium-use station with a sample intensity of one visit per week for the duration of the fishery, or multiple times per week when quota was caught quickly. Low-use sites were not sampled. Days and stations were randomly selected each month, although the results of the random draw were frequently modified because of weather, check station hours, and other logistical constraints.

Monthly sample targets were 1,000 fish in December and 1,250 fish in both January and February, for a total target sample size of 3,500 fish. Sampling at this level provides an accurate representation of both the length and age distributions of the harvest (Fegley et al. 2000). Estimated number of fish caught was calculated by using mean weight of fish sampled by month. At each check station a random sample of striped bass was measured (mm TL) and weighed (kg). For fish less than 700 mm TL, scales were taken randomly from five fish per 10 mm length group per month. For fish between 700 mm TL and 799 mm TL, scales were taken randomly from ten fish per 10 mm length group per month and scales were taken from all fish greater than or equal to 800 mm TL.

Analytical procedures

Age composition of the sample was estimated via two-stage sampling (Kimura 1977, Quinn and Deriso 1999). In the first stage, length and scale samples were taken. These were assumed to be a random sample of the commercial harvest. In stage two, a fixed subsample of scales was randomly chosen to be aged. Approximately twice as many scales as ages per 20 mm length group were selected to be read based on the range of ages per length group (Barker et al. 2004). Target sample sizes of scales to be read were five scales per length groups 400-700 mm and 10 scales per length groups >700 mm. In some cases, the actual number of scales aged was limited by the number of samples available per length group.

Ages were assigned to scales by viewing acetate impressions in a microfiche reader. The resulting age-length key was applied to the sample length-frequency to generate a sample age distribution. Finally, the age distribution of the total 2020-2021 winter gill net harvest was estimated by applying the sample age distribution to the total reported landings. Because the winter gill net season straddles two calendar years, ages were calculated by subtracting year-class (assigned by scale readers) from the year in which the fishery ended. For example, for the December 2020 – February 2021 gill net season, the year used for age calculations was 2021.

Mean lengths- and weights-at-age were calculated by year-class for the aged subsample of fish. Mean length-at-age and weight-at-age were also estimated for each year-class using an expansion method (Hoover 2008). Age-specific length distributions based on the aged subsample are often different than the age-specific length distribution based on the entire length sample. Bettoli and Miranda (2001) suggest that the subsample means-at-age are often biased. Expanded means were calculated with an age-length key and a probability table that applied ages from the subsample of aged fish to all sampled fish. The two calculation methods would result in equal means only if the length distributions for each age-class were normal, which rarely occurs with these data.

To examine recruitment into the winter drift gill net fishery and the age-class structure of the harvest over time, the expanded age structure of the 2020-2021 harvest was compared to that of previous years beginning with the 1993-1994 gill net season. Trends in growth were examined by plotting actual mean length-at-age and mean weight-at-age of aged subsamples, with confidence intervals, by year, for individual age-classes. Expanded mean lengths-at-age and weights-at-age were also plotted on the same time-series graph for comparison.

RESULTS and DISCUSSION

A total of 3,034 striped bass was sampled and 128 striped bass were aged from the harvest between December 2020 - February 2021. The northern-most check station sampled in this survey was located in Middle River, MD on the western shore, while the southern-most station was located in Crisfield, MD on the eastern shore (Figure 1). Check stations were visited by biologists six times in December, six times in January, and three times in February.

Commercial drift gill nets have been limited to mesh sizes no less than 5 and no greater than 7 inches since the fishery reopened after the 1985-1990 moratorium. As a result, the range in ages of the commercial striped bass drift gill net landings has not fluctuated greatly since the inception of MD DNR check station monitoring during the 1993-1994 gill net season (Figure 2). In most years, the majority of fish landed were between 4 and 8 years old. However, the contribution of individual ages to the overall landings has varied annually based on year-class strength.

Commercial landings are reported to MD DNR through multiple electronic and written reporting systems (Project No. 2, Job No. 3, Task No. 5A). The number of fish landed for the 2020-2021 season was estimated by dividing reported monthly harvest weight by the mean monthly weight of check station samples. Total reported landings were 566,262 pounds and the estimated number of fish was 95,070 (Table 1). According to the catch-at-age analysis, the 2020-2021 commercial drift gill net harvest consisted primarily of age 6 striped bass from the 2015 year-class (42%; Table 2). The 2014 and 2013 year-classes (ages 7 and 8) composed an additional 29% of the total harvest. The contribution of fish older than age 9 (8%) was lower than the 2019-2020 harvest (14%). The youngest fish observed in the 2020-2021 sampled harvest were age 4 from the 2017 year class (5%).

Mean lengths and weights-at-age of the aged subsample and the estimated means from the expansion technique are presented in Tables 3 and 4. Expanded mean lengths and weights-at-age were generally similar to previous years. Striped bass were recruited into the winter gill net fishery beginning at age 4 (2017 year-class), with an expanded mean length and weight of 519 mm TL and 1.81 kg, respectively. The 2015 year-class (age 6) was most commonly observed in the sampled landings and had an expanded mean length and weight of 575 mm TL and 2.48 kg, respectively. The expanded mean length and weight of the oldest fish in the aged subsample (age 11, 2010 year-class) were 866 mm TL and 8.69 kg, respectively.

The length frequency of the check station samples is presented in Figure 3. The length frequency distribution was dominated by fish in the 490-670 mm length groups. A total of 7 sub-legal fish <457 mm TL (18 inches) were observed in 2020-2021 sampling.

Time-series of subsampled and expanded mean lengths and weights for the period 1994-2021 are shown in Figures 4 and 5 for fish ages 4 through 9, which generally make up 95% or more of the harvest. In recent years, mean length-at-age and weight-at-age for ages 6 to 8 have become less variable as the ITQ system has encouraged the harvest of larger, more profitable fish and sample sizes of these larger fish have increased. Mean length-at-age and weight-at-age for ages 4, 5 and 9 striped bass are more variable, likely due to smaller sample sizes or greater range of lengths and weights for each age group.

PROJECT NO. 2
JOB NO. 3
TASK NO. 1B

2021-2022 WINTER STOCK ASSESSMENT AND COMMERCIAL FISHERY MONITORING

2021-2022 SEASON PRELIMINARY RESULTS

A total of 3,616 striped bass were sampled and 503 scale samples were collected from the harvest between December 2021 - February 2022. The northern-most check station sampled in this survey was located in Millington, MD on the eastern shore, while the southern-most station was located near Crisfield. Check stations were visited by biologists four times in December, four times in January, and four times in February.

Commercial gill nets have been limited to mesh sizes no less than 5 and no greater than 7 inches since the fishery reopened after the 1985-1990 moratorium. As a result, the range in ages of the commercial striped bass drift gill net landings has not fluctuated greatly since the inception of MD DNR check station monitoring during the 1993-1994 gill net season. In most years, the majority of fish landed were between 4 and 8 years old. However, the contribution of individual ages to the overall landings has varied annually based on year-class strength. Data analysis is ongoing and complete results for the 2021-2022 winter season of harvest-, length-, and weight-at-age will be provided in the F61-R-18 Chesapeake Bay Finfish Investigations report.

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LIST OF TABLES

LIST OF FIGURES

Table 1. Reported pounds harvested, check station average weights, and estimated fish harvested by the Maryland Chesapeake Bay commercial drift gill net fishery, December 2020 - February 2021.

Month	**Harvest (lbs)**	**Check station average wt. (lb)**	**Estimated # harvested**
December 2020	161,926	5.13	31,589
January 2021	196,408	5.79	33,945
February 2021	207,928	7.04	29,535
Total*	**566,262**		**95,070**

* Sum of columns may not equal totals due to rounding.

Table 2. Estimated catch-at-age of striped bass (numbers of fish) landed by the Maryland Chesapeake Bay commercial drift gill net fishery, December 2020 - February 2021.

Year-class	**Age**	**Catch**	**Percentage of the catch**
2017	4	4,361	5
2016	5	16,064	17
2015	6	39,803	42
2014	7	20,094	21
2013	8	7,259	8
2012	9	4,141	4
2011	10	3,316	3
2010	11	31	<1
Total*		95,070	**100**

* Sum of columns may not equal totals due to rounding.

Table 3. Mean total lengths (mm TL) by year-class of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, December 2020 - February 2021.

Year-class	Age	n fish aged	Mean TL (mm) of subsample	Estimated # at-age in sample	Expanded mean TL(mm)
2017	4	7	475	139	519
2016	5	17	516	513	544
2015	6	28	582	1,270	575
2014	7	23	645	641	597
2013	8	15	699	232	619
2012	9	16	732	132	646
2011	10	21	742	106	669
2010	11	1	866	1	866
Total*		**128**		**3,034**	

* Sum of columns may not equal totals due to rounding.

Table 4. Mean weights (kg) by year-class of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, December 2020 - February 2021.

Year-class	Age	n fish aged	Mean WT (kg) of subsample	Estimated # at-age in sample	Expanded mean weight (kg)
2017	4	7	1.37	139	1.81
2016	5	17	1.88	513	2.13
2015	6	28	2.65	1,270	2.48
2014	7	23	3.49	641	2.78
2013	8	15	4.15	232	3.08
2012	9	16	4.86	132	3.49
2011	10	21	5.23	106	3.83
2010	11	1	8.69	1	8.69
Total*		**128**		**3,034**	

* Sum of columns may not equal totals due to rounding.

Figure 1. Registered Maryland Chesapeake Bay check stations sampled for commercial drift gill net harvested striped bass, December 2020 - February 2021.

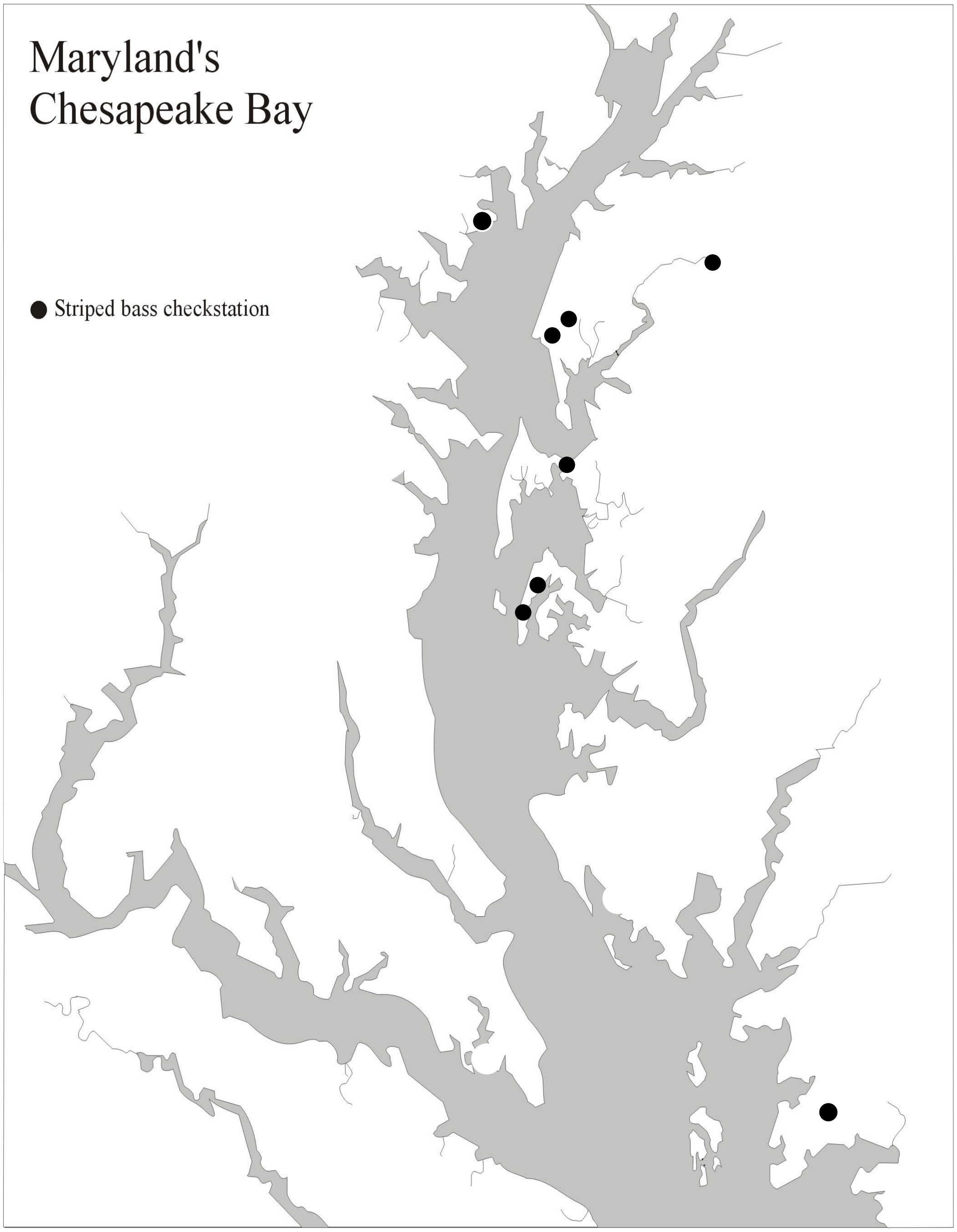
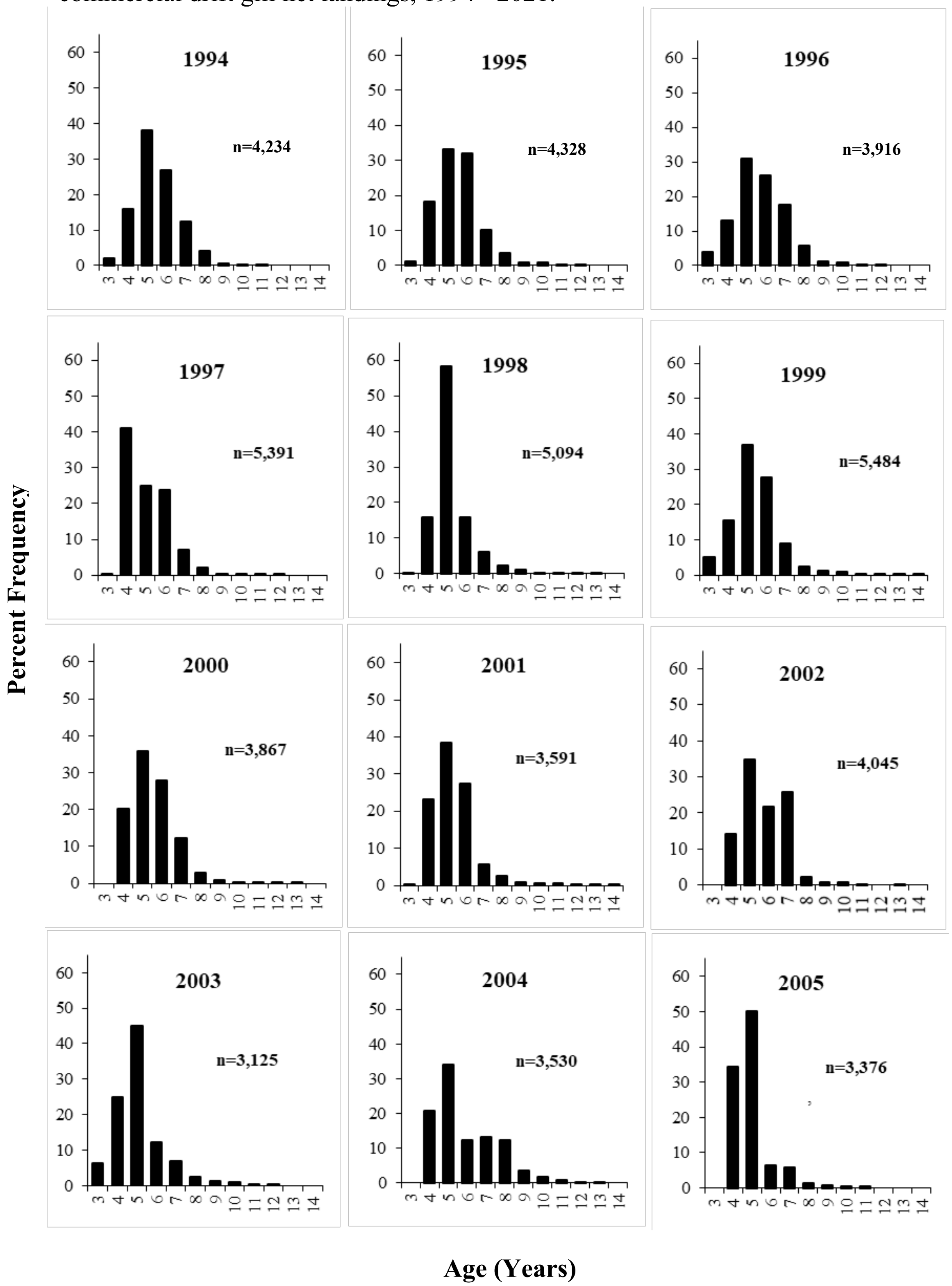


Figure 2. Age distribution of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, 1994 - 2021.



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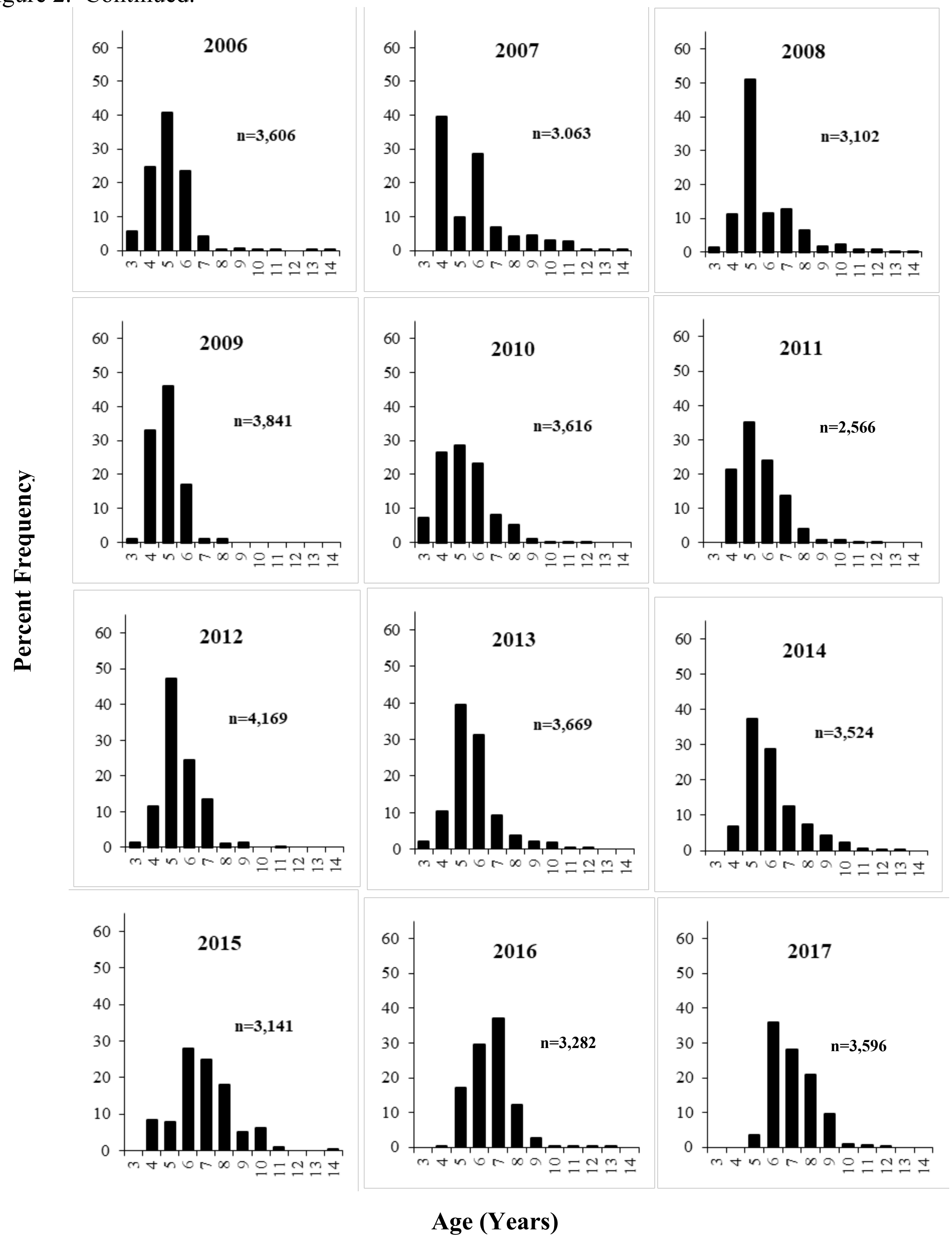

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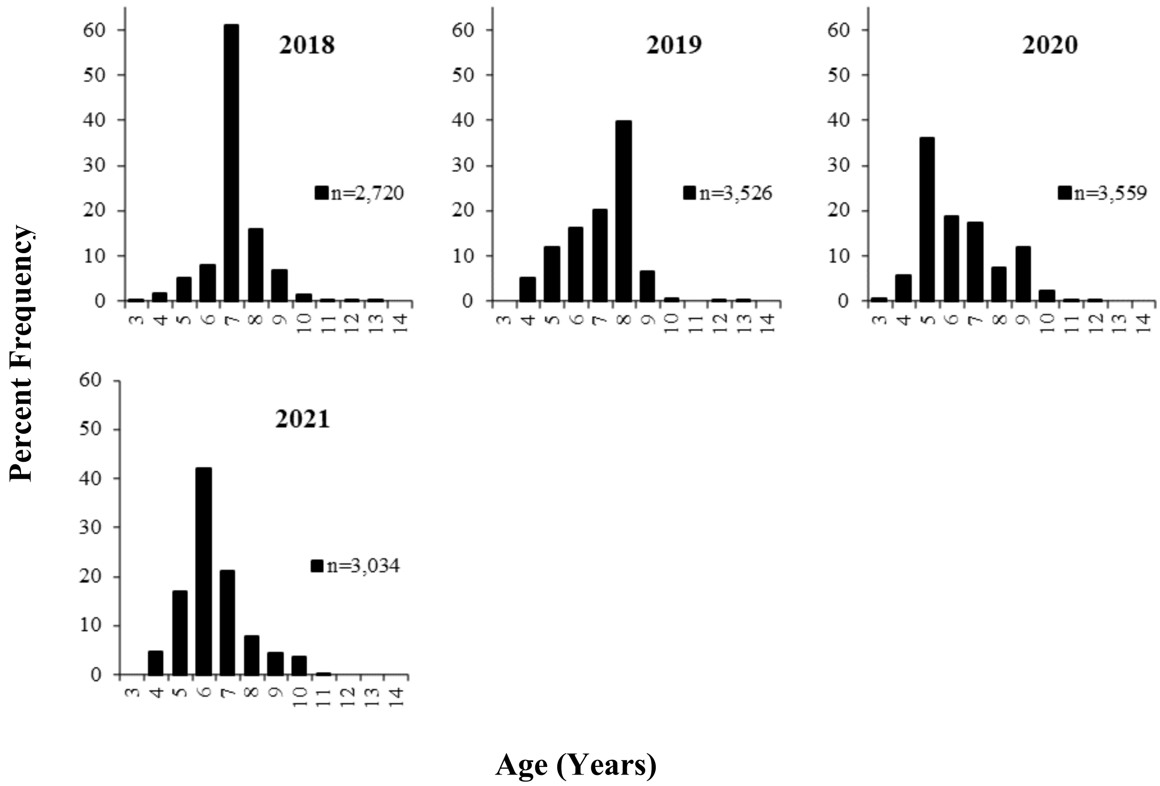


Figure 3. Length frequency distribution of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, December 2020 - February 2021.

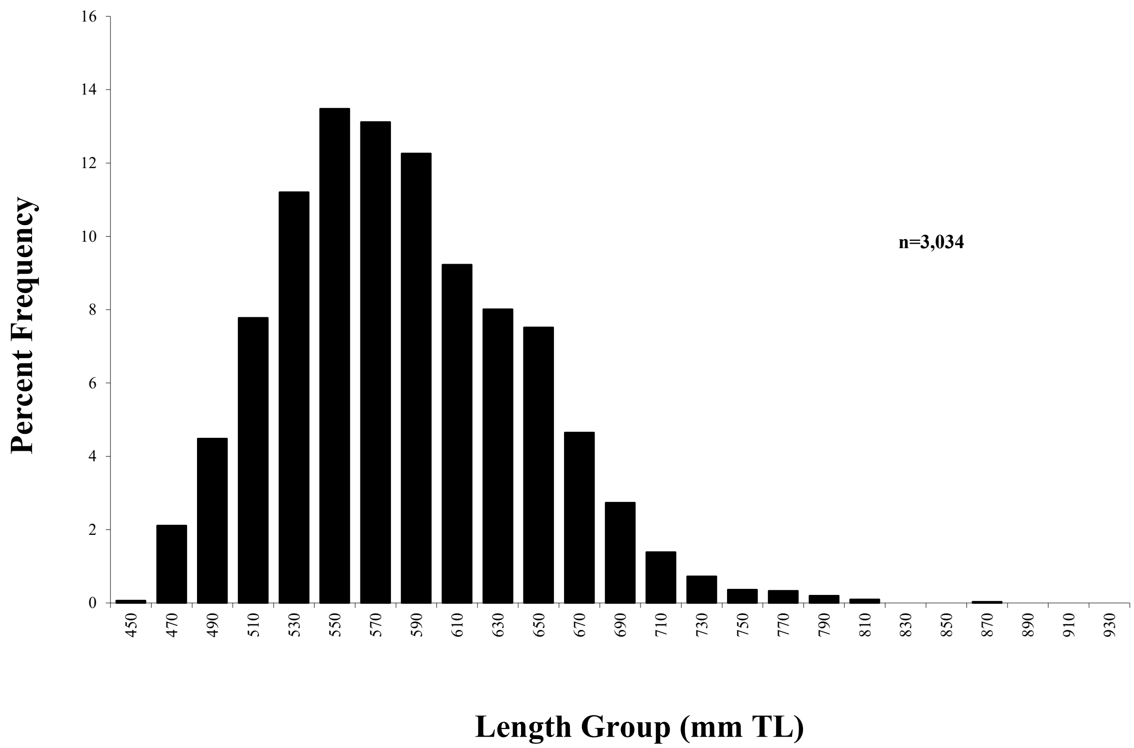
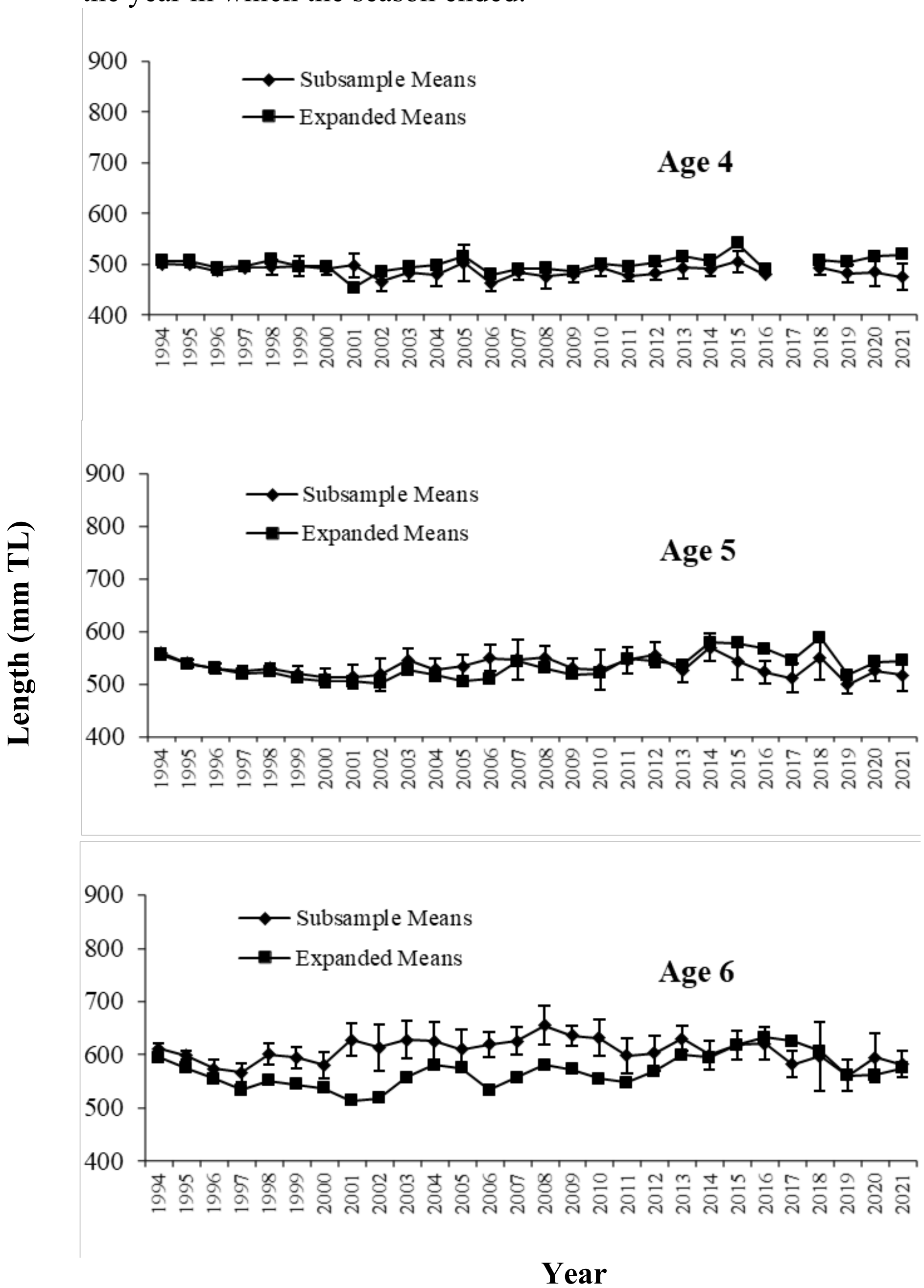


Figure 4. Mean total lengths (mm TL) of the aged subsample, by year, for individual age-classes of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, 1994 - 2021 (95% confidence intervals are shown around each point). Expanded means (estimated from entire sample) are also shown. Year refers to the year in which the season ended.



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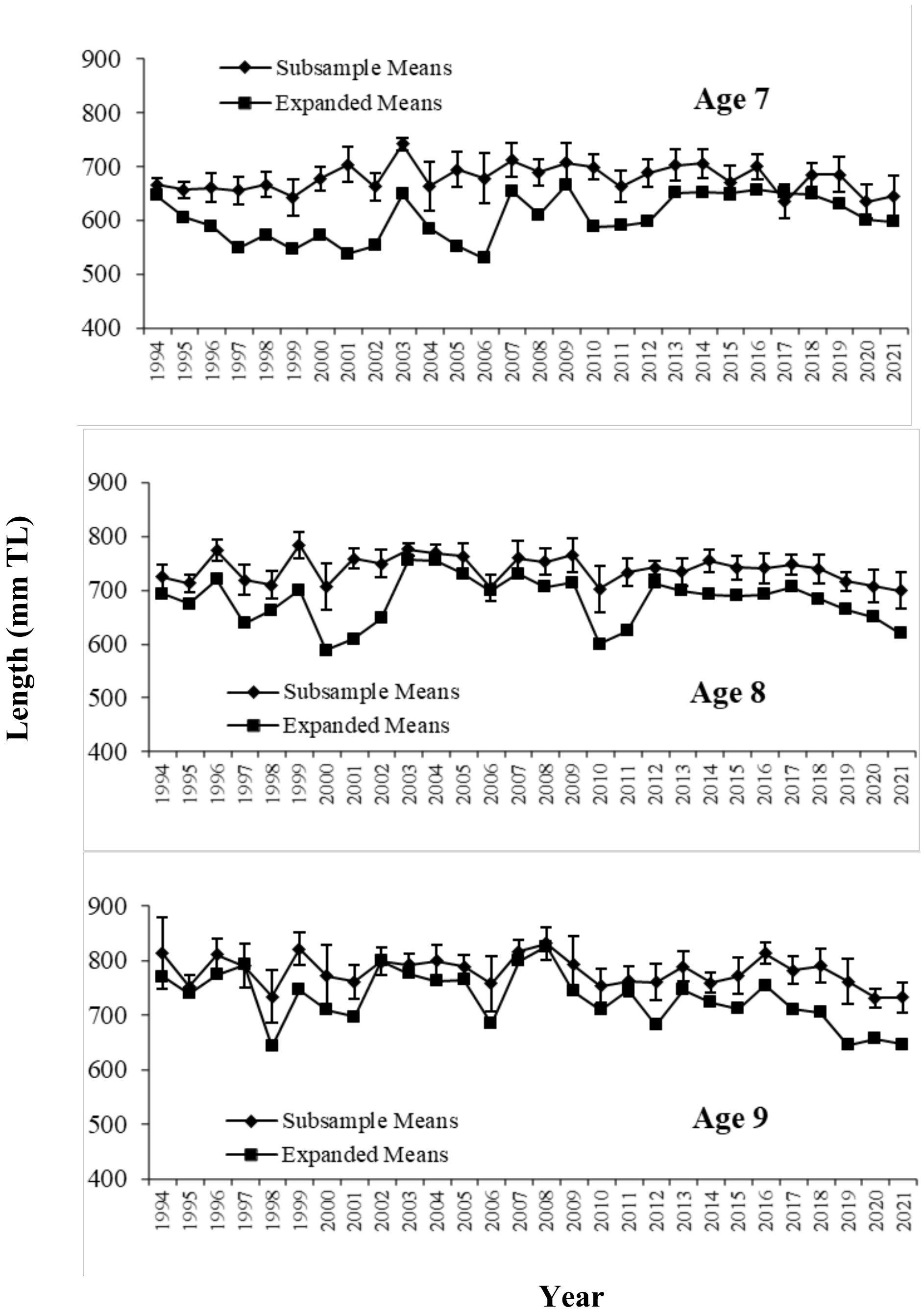
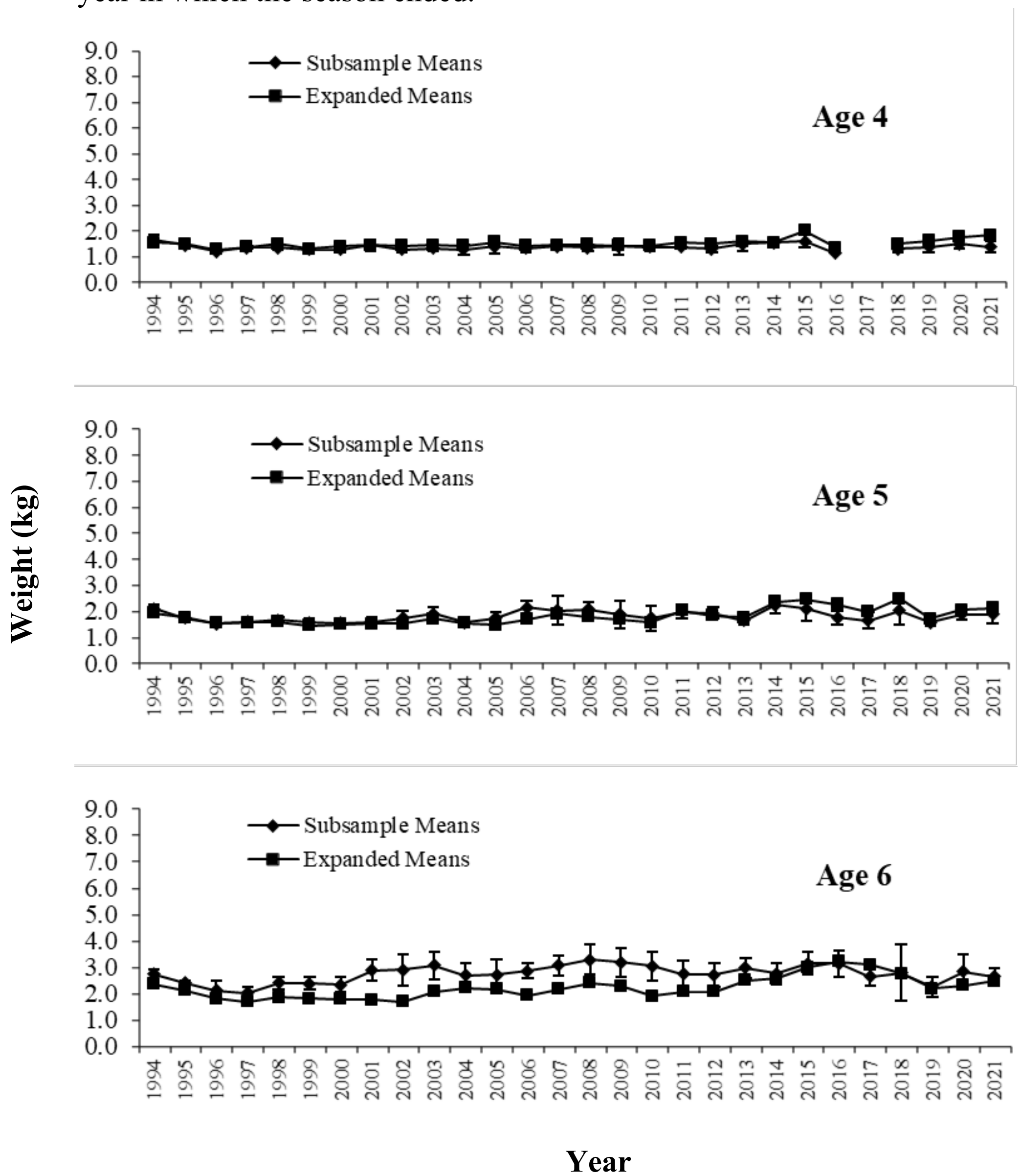


Figure 5. Mean weights (kg) of the aged subsample, by year, for individual age-classes of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net fishery, 1994 - 2021 (95% confidence intervals are shown around each point). Expanded means (estimated from entire sample) are also shown. Year refers to the year in which the season ended.



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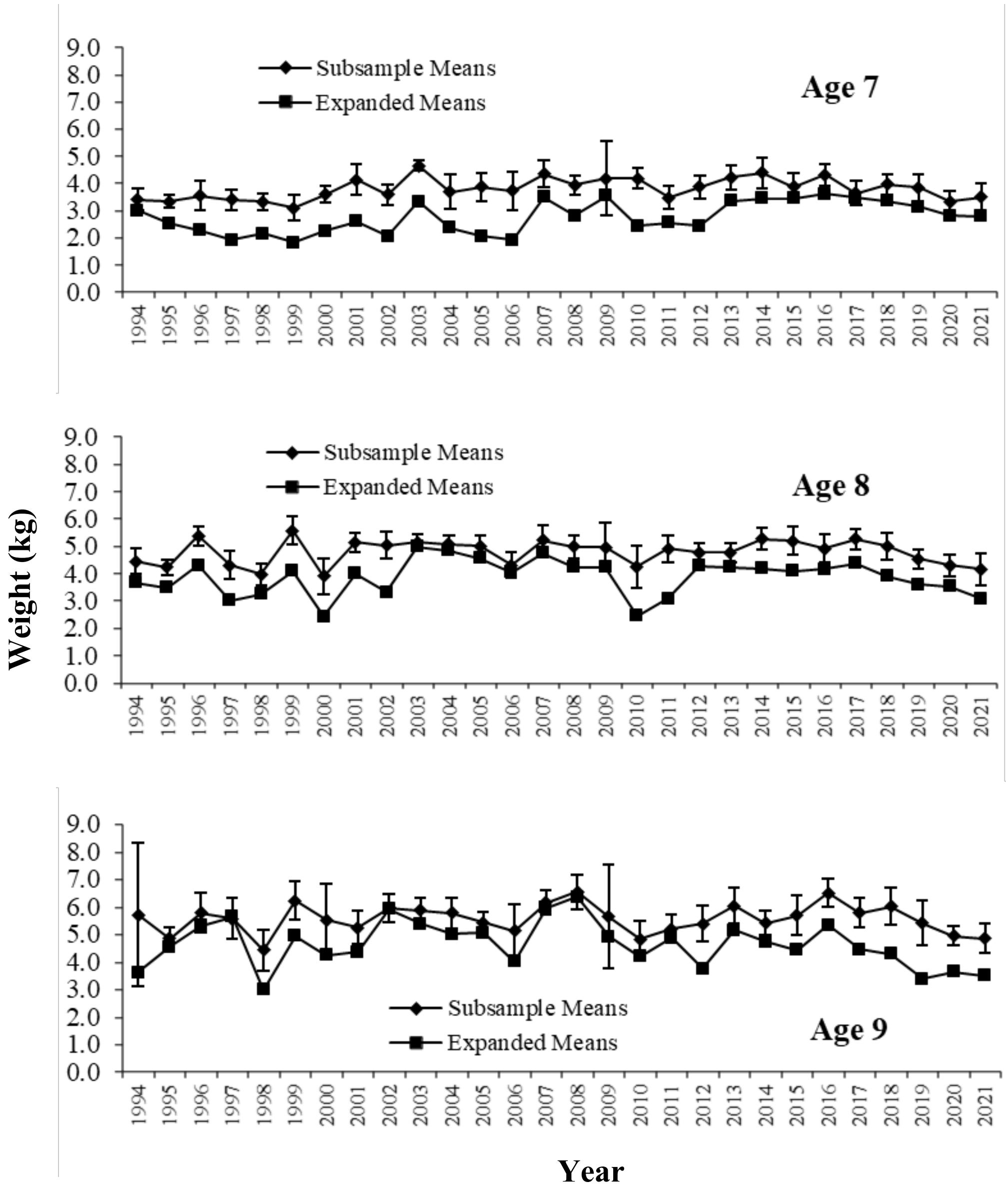

PROJECT NO. 2
JOB NO. 3
TASK NO. 1C

ATLANTIC COAST STOCK ASSESSMENT AND COMMERCIAL HARVEST MONITORING

Prepared by Jeffrey Horne

INTRODUCTION

The primary objective of Project 2, Job 3, Task 1C was to finalize the characterization of the size and age structure of commercially harvested striped bass from Maryland's Atlantic coast during the 2020-2021 season and provide preliminary results, as available, for the 2021-2022 season. Completed results for the 2021-2022 sample season will be reported in the F61-R-18 Chesapeake Bay Finfish Investigations report. Trawls and gill nets were permitted during the Atlantic season within state waters (to 3 miles offshore). The 2021 season opened October 1, 2020 and ended May 31, 2021. The 2021 Atlantic striped bass season was managed with a reduced annual quota under Addendum VI to Amendment 6 of the Atlantic Striped Bass Interstate Fishery Management Plan (Giuliano et al. 2014). Although this report covers the October 2020 – May 2021 fishing season, the quota is managed by calendar year. This fishery was managed with a 24 inch total length (TL) minimum size limit and an annual quota of 89,094 pounds. Maryland's Atlantic coast fishery is not as large as the Chesapeake Bay commercial fishery and its annual quota composes only 6% of Maryland's ocean and bay quotas combined. Monitoring of the coastal fishery began for the 2007 fishing season (November 1, 2006 – April 29, 2007) to improve Maryland's catch-at-age and weight-at-age estimates used in the annual compliance report to the Atlantic States Marine Fisheries Commission, as well as the coast-wide stock assessment.

METHODS

Data collection procedures

All striped bass commercially harvested in Maryland are required to pass through a Maryland Department of Natural Resources (MD DNR) approved check station. Check stations are typically cooperating fish dealers who report daily landings to MD DNR. A review of 2005 – 2016 check station activity indicated that 86% of striped bass harvested along Maryland's Atlantic coast passed through two check stations in Ocean City, Maryland. Consequently, sampling occurred between these two check stations as fish came in during the season. Catches were typically intermittent and MD DNR personnel sampled when fish were available. A monthly sample target of 150 fish was established. Fish were measured (mm TL) and weighed (kg) and scales were randomly taken from five fish per 10 mm length group per day for age determination.

Analytical procedures

Age composition of the Atlantic fisheries was estimated via two-stage sampling (Kimura 1977, Quinn and Deriso 1999). In the first stage, total length and scale samples were taken, which were assumed to be a random sample of the commercial harvest. In stage two, a fixed sub-sample of scales were randomly chosen to be aged.

Year-class was determined by reading acrylic impressions of the scales that were projected in microfiche readers. Because the Atlantic coast fishery spans two calendar years, age was calculated by subtracting the assigned year-class from the year in which the fishery ended. In the October 2020 – May 2021 Atlantic fishery, the year used for age calculations was 2021. These ages were then used to construct the age-length key (ALK). The age distribution of the Atlantic coast harvest was estimated by applying the sample age distribution to the total landings as reported from the check stations.

An expansion method was applied to an aged sub-sample to estimate mean lengths- and weights-at-age. Bettoli and Miranda (2001) suggested that age-specific length distributions based on an aged sub-sample are often different than the age-specific length distribution based on the entire length sample. The two calculation methods (sub-sample means and expanded means) would result in equal means only if the length distributions for each age-class were normal, which rarely occurs in these data. Therefore, expanded means were calculated with an ALK and a probability table that applied ages from the sub-sample of aged fish to all sampled fish.

RESULTS and DISCUSSION

Check stations reported 3,622 fish landed during the 2020 – 2021 Atlantic coast season (Table 1) (Chris Jones, Data Management and Quota Monitoring Program, Personal Communication). This was similar to the previous two years and among the lowest number of striped bass reported at Atlantic check stations in the time series (Figure 1). Commercial fishermen have a limited area to harvest striped bass (~62 square miles) within Maryland waters. During the 2021 Atlantic striped bass fishing season, fish were frequently observed by commercial fisherman in the Exclusive Economic Zone, where harvest is prohibited (Gary Tyler, Coastal Fisheries Program, Personal Communication). Consequently, fish were harvested intermittently and were difficult to intercept at the check stations with most being harvest in April and May the last few years. A total of 128 striped bass were measured and weighed and had scale samples taken to age. From the sample, 108 fish were aged (Tables 2 & 3).

The catch-at-age estimate determined that thirteen year-classes were represented in the sampled harvest, ranging from age 6 (2015 year-class) to age 20 (2001 year-class)(Table 1; Figure 2). The most frequent age represented in the catch-at-age estimate was age 10, the 2011 year-class, which represented 47% of the estimated harvest (Table 1). Striped bass recruit into the Atlantic coast fishery as young as age 4, but due to the 24 inch minimum size limit, few fish younger than age 5 are harvested.

Striped bass sampled at Atlantic coast check stations during the 2020 – 2021 season had a mean length of 1008 mm TL and mean weight of 10.55 kg. The sample length distribution ranged from 705 to 1227 mm TL (Figure 3). The weight of fish sampled ranged from 6.2 to 15.4 kg. Expanded mean lengths and weights were calculated for the entire sample of fish (Figure 4 and Figure 5).

PROJECT NO. 2
JOB NO. 3
TASK NO. 1C

ATLANTIC COAST STOCK ASSESSMENT AND COMMERCIAL HARVEST MONITORING

2021-2022 SEASON PRELIMINARY RESULTS – WORK IN PROGRESS

A total of 186 striped bass were sampled and 186 scale samples were collected from the harvest between October 2021 - May 2022. Fish ranged in length from 837 mm to 1208 mm TL and in weight from 6.23 kg to 17.50 kg. Most of the fish were sampled at one check station in Ocean City, MD. Check stations were visited by biologists three times in April and three times in May.

In most years, the majority of fish landed were between 7 and 11 years old. However, the contribution of individual ages to the overall landings has varied annually based on year-class strength. Data analysis for the 2021-2022 season is ongoing and complete results of harvest-, length-, and weight-at-age will be provided in the F61-R-18 Chesapeake Bay Finfish Investigations report.

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LIST OF TABLES

LIST OF FIGURES

Table 1. Estimated harvest-at-age of striped bass (numbers of fish) landed by the Maryland Atlantic coast commercial fishery, October 2020 – May 2021.

Year-Class	Age	Number of Fish	Percent
2015	6	28	0.8
2014	7	0	0.0
2013	8	147	4.1
2012	9	365	10.1
2011	10	1,715	47.3
2010	11	436	12.0
2009	12	192	5.3
2008	13	28	0.8
2007	14	158	4.4
2006	15	57	1.6
2005	16	325	9.0
2004	17	28	0.8
2003	18	113	3.1
2002	19	0	0.0
2001	20	28	0.8
Total*		3,622	100

*Sum of columns may not equal totals due to rounding.

Table 2. Mean total lengths (mm) by year-class of striped bass sampled from Atlantic coast fishery, October 2020 – May 2021. Includes the lower and upper 95% confidence limits (LCL and UCL, respectively).

Year-Class	Age	n Fish Aged	Mean TL (mm)	LCL	UCL
2015	6	1	917	*	*
2013	8	5	947	852	1042
2012	9	10	947	904	989
2011	10	49	972	951	994
2010	11	11	1017	989	1046
2009	12	6	983	911	1055
2008	13	1	805	*	*
2007	14	6	1074	970	1178
2006	15	2	1098	1066	1129
2005	16	11	1142	1104	1179
2004	17	1	1193	*	*
2003	18	4	1207	1182	1231
2001	20	1	1208	*	*
Total		**108**			

*Values omitted due to high variability from small sample size.

Table 3. Mean weights (kg) by year-class of striped bass sampled from Atlantic coast fishery, October 2020 – May 2021. Includes the lower and upper 95% confidence limits (LCL and UCL, respectively).

Year-Class	Age	n Fish Aged	Mean Weight (kg)	LCL	UCL
2015	6	1	8.1	*	*
2013	8	5	9.0	7.4	10.6
2012	9	10	10.5	9.5	11.6
2011	10	49	10.4	10.0	10.7
2010	11	11	11.2	9.9	12.5
2009	12	6	10.1	8.6	11.7
2008	13	1	6.2	*	*
2007	14	6	11.7	6.6	16.9
2006	15	2	12.6	3.7	21.5
2005	16	11	14.7	5.8	23.6
Total		**102**			

*Values omitted due to high variability from small sample size.

Figure 1. Reported number of Atlantic striped bass landed per season at Maryland Atlantic check stations.

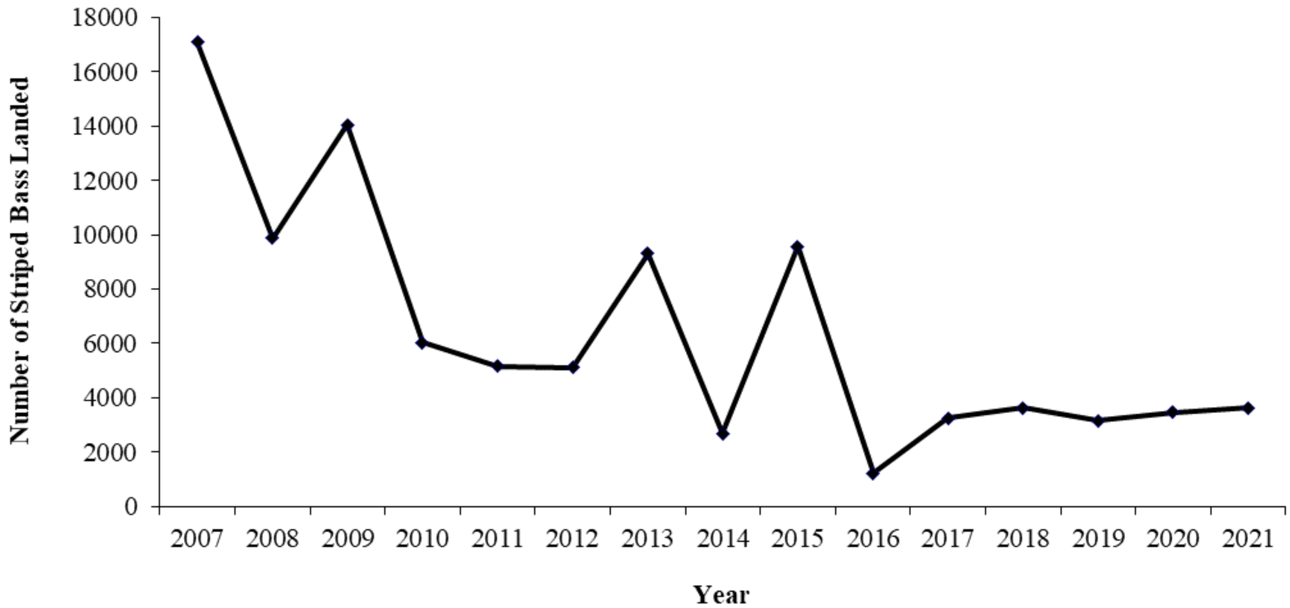
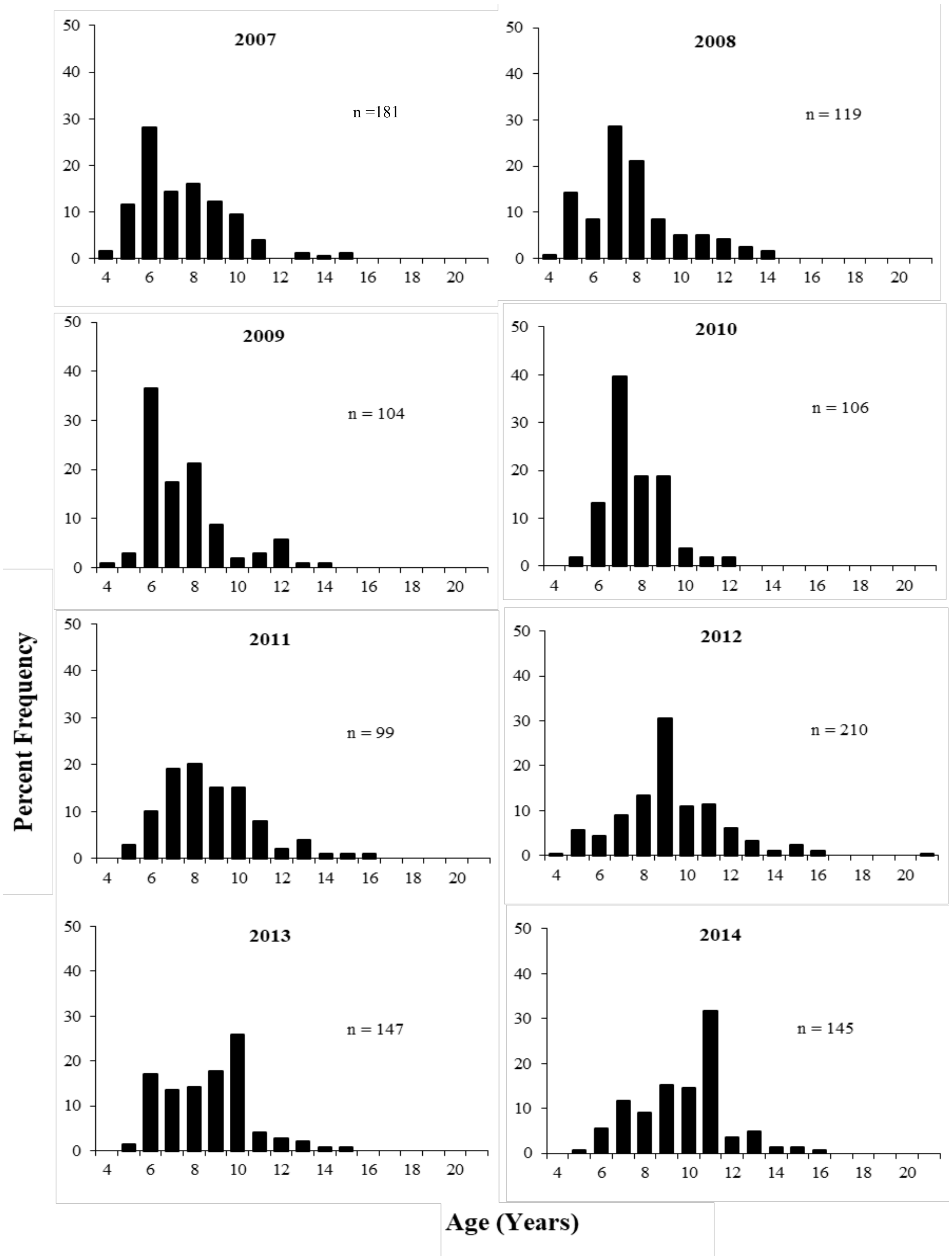


Figure 2. Age distribution of striped bass sampled from the Atlantic coast fishery, 2007 – 2021 seasons.



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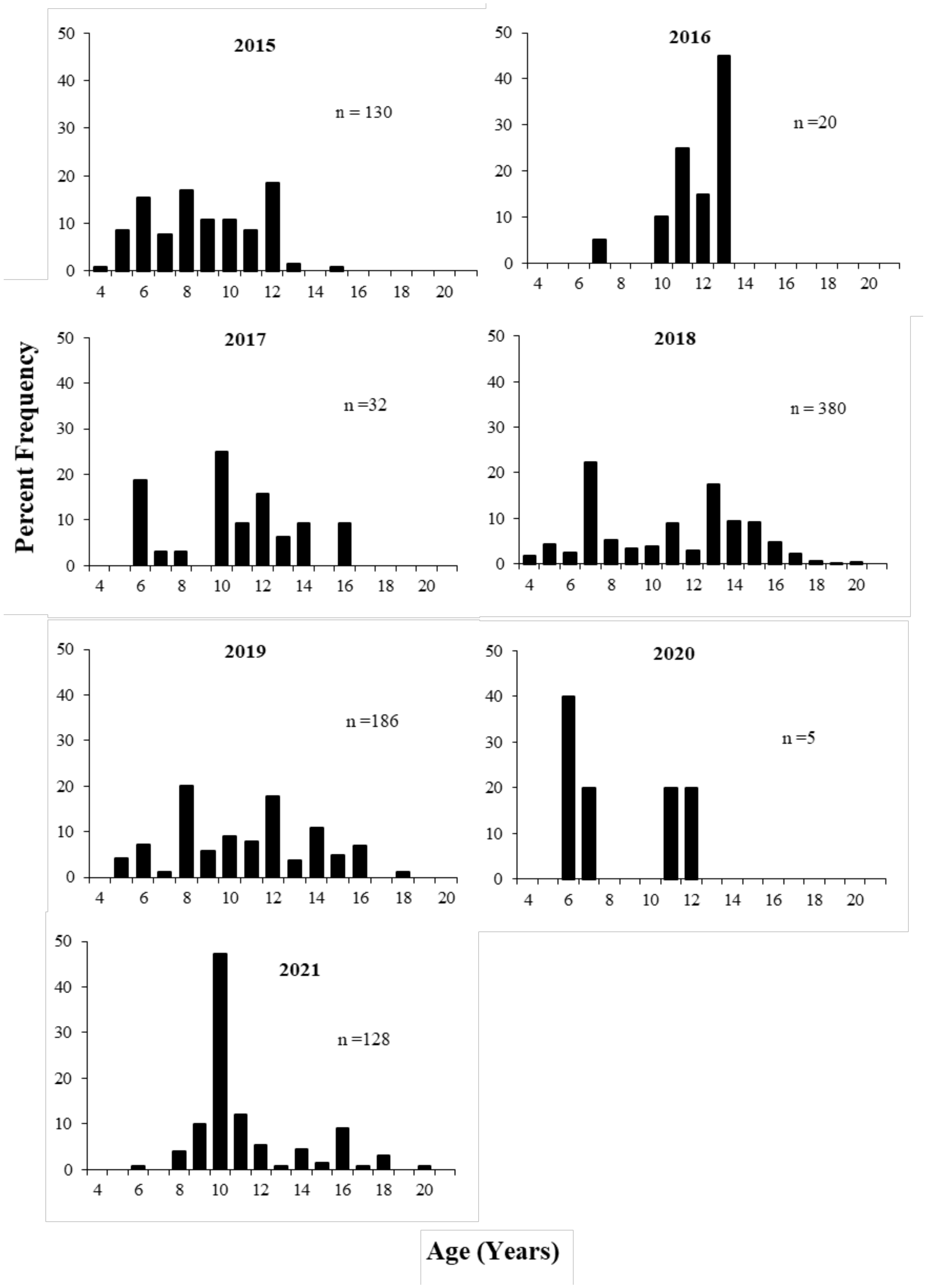


Figure 3. Length distribution of striped bass sampled from the Atlantic coast fishery, 2007 – 2021 seasons. *Note different x and y-axis scales.

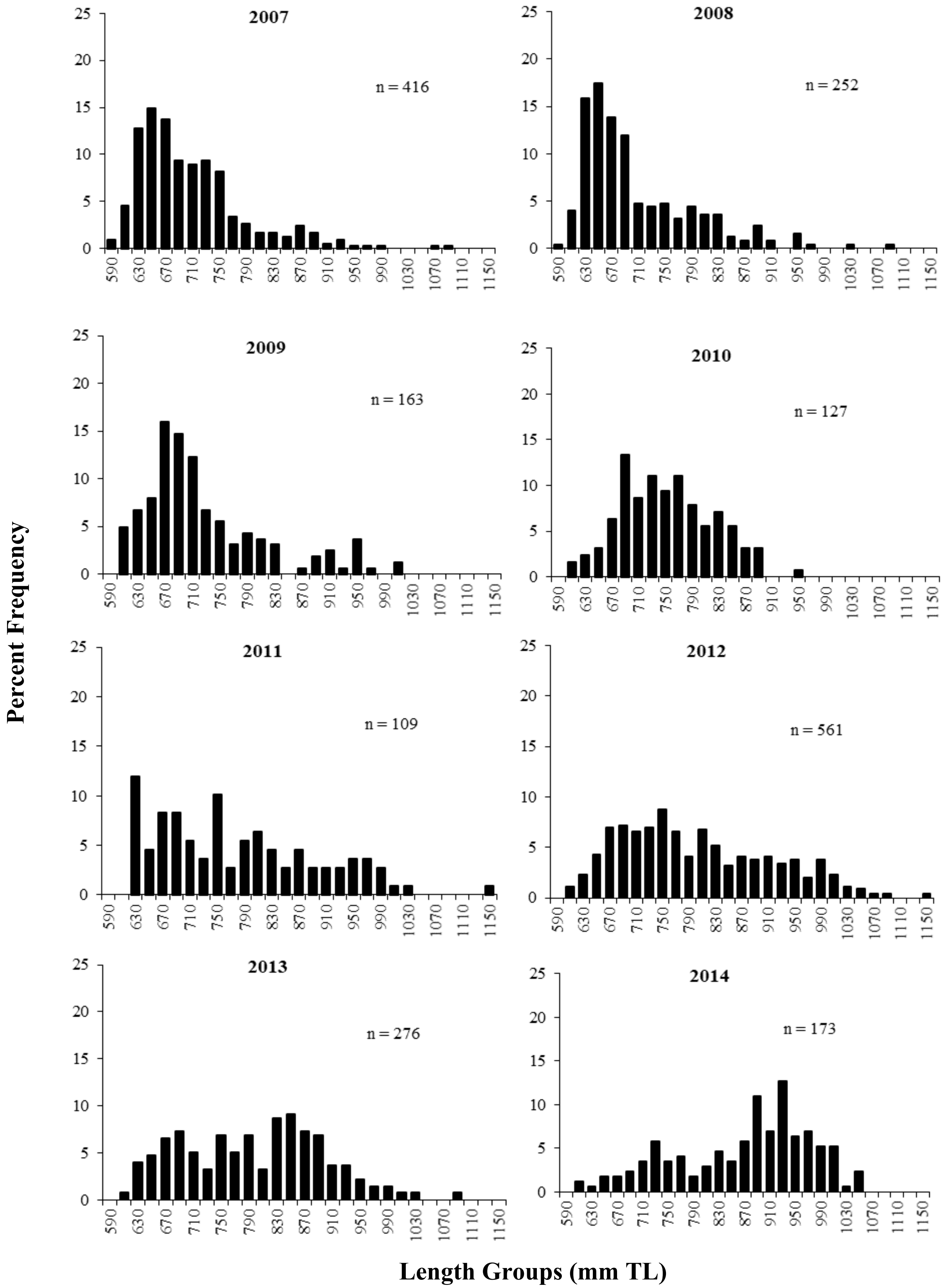


Figure 3. Continued.

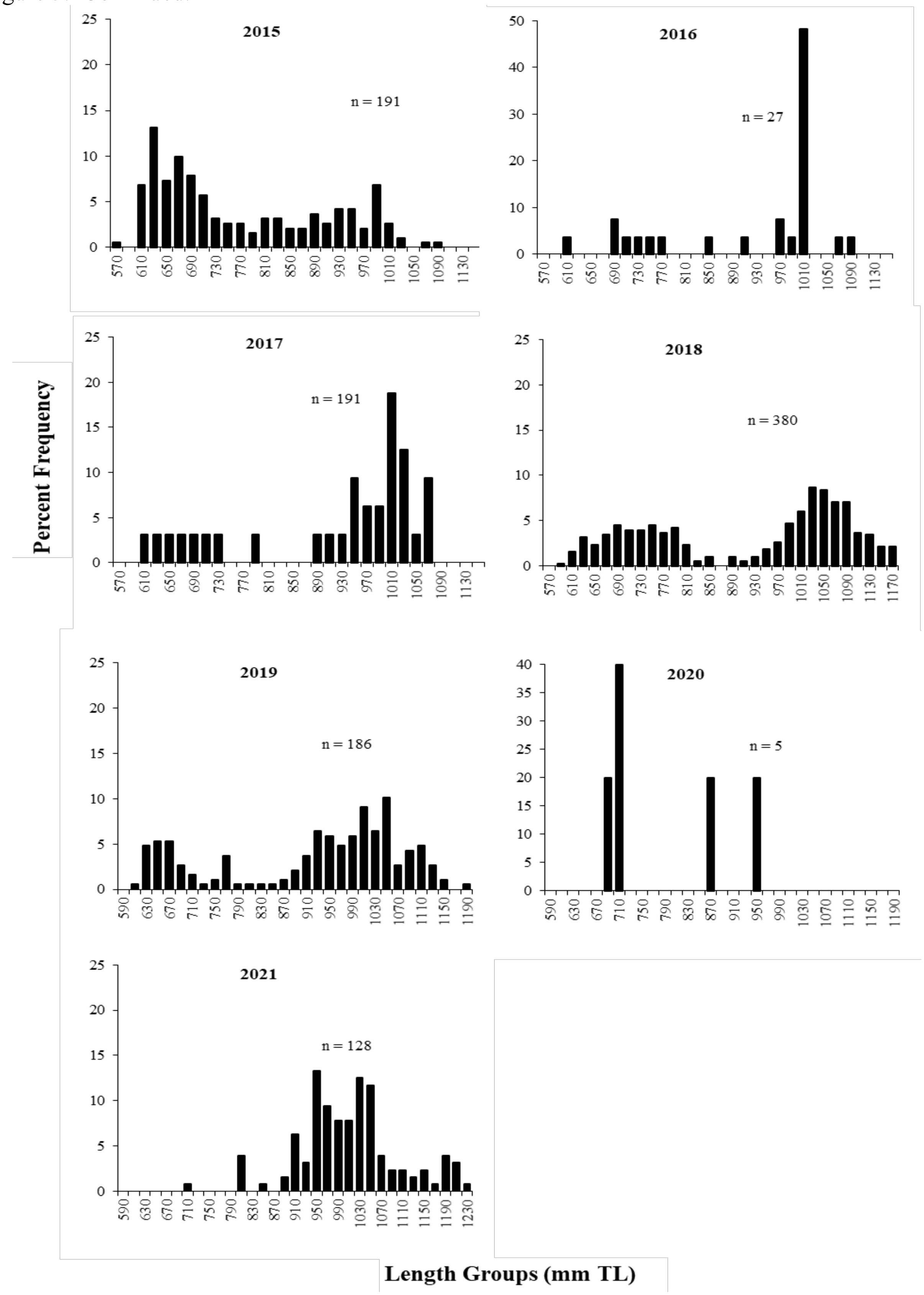


Figure 4. Mean total lengths (mm TL) of the aged sub-sample, by year, for individual age-classes of striped bass (through age 12) sampled from the Maryland Atlantic coast trawl and gill net landings, 2007 – 2021 (95% confidence intervals included when permitted by sample size). Expanded means (estimated from entire sample) are also shown, but were not calculated in 2016/2017 as all samples were chosen for aging. 2020 data excluded due to sampling limitations. *Note different y-axis scales.

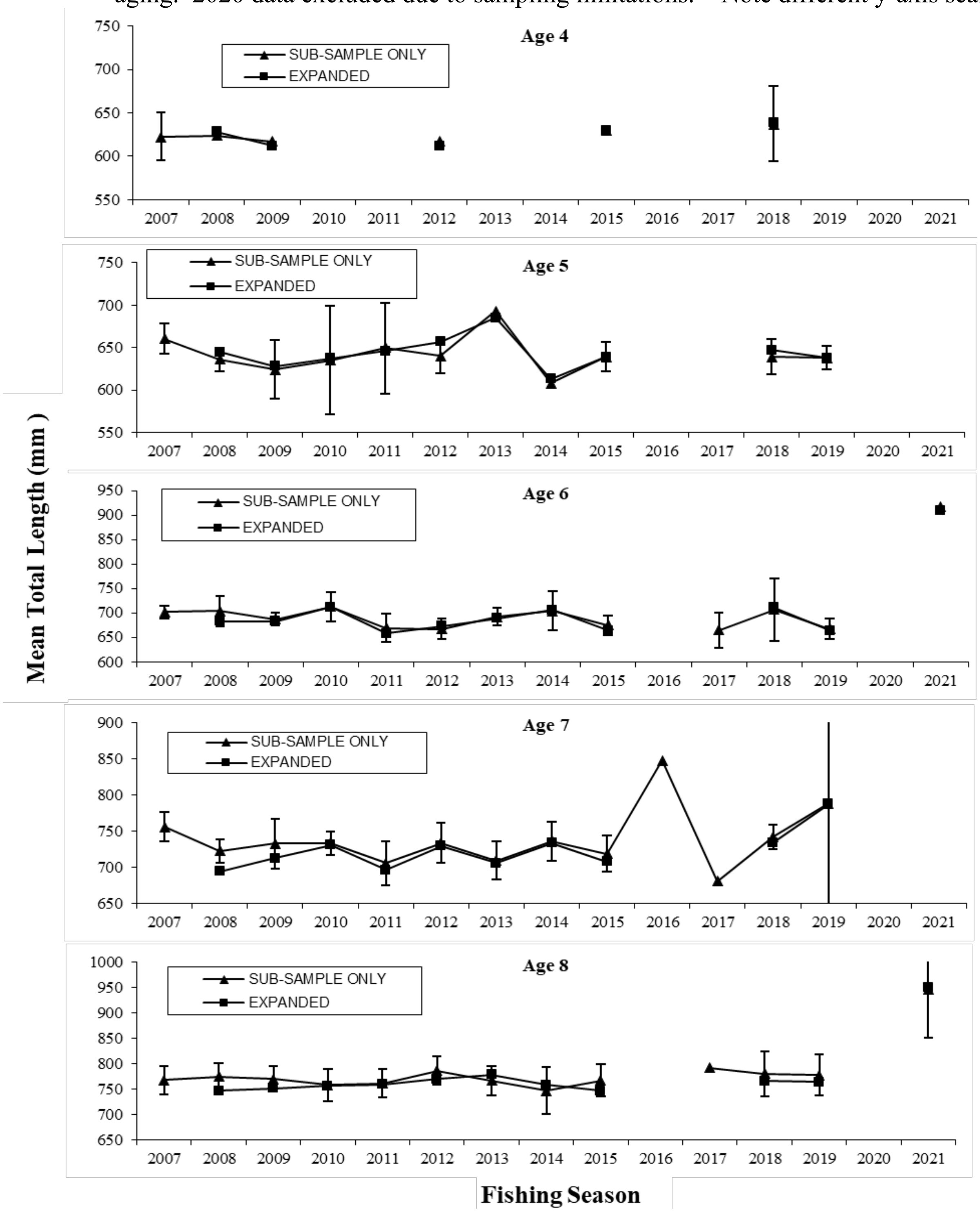


Figure 4. Continued

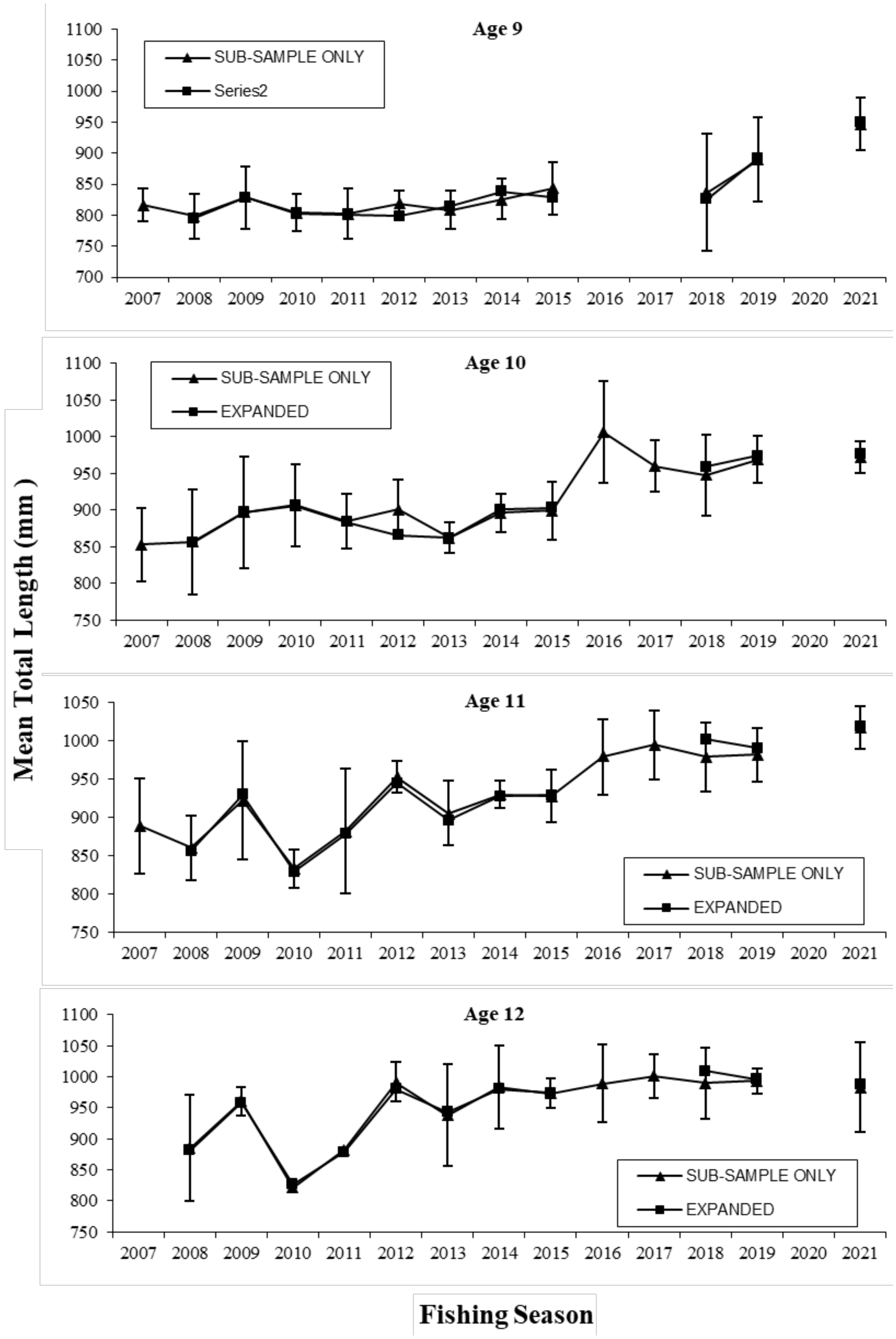


Figure 5. Mean weight (kg) of the aged sub-sample, by year, for individual age-classes of striped bass (through age 12) sampled from the Maryland Atlantic coast trawl and gill net landings, 2007 – 2021 (95% confidence intervals included when permitted by sample size). Expanded means (estimated from entire sample) are also shown, but were not calculated in 2016/2017 as all samples were chosen for aging. 2020 data excluded due to sampling limitations. *Note different y-axis scales.

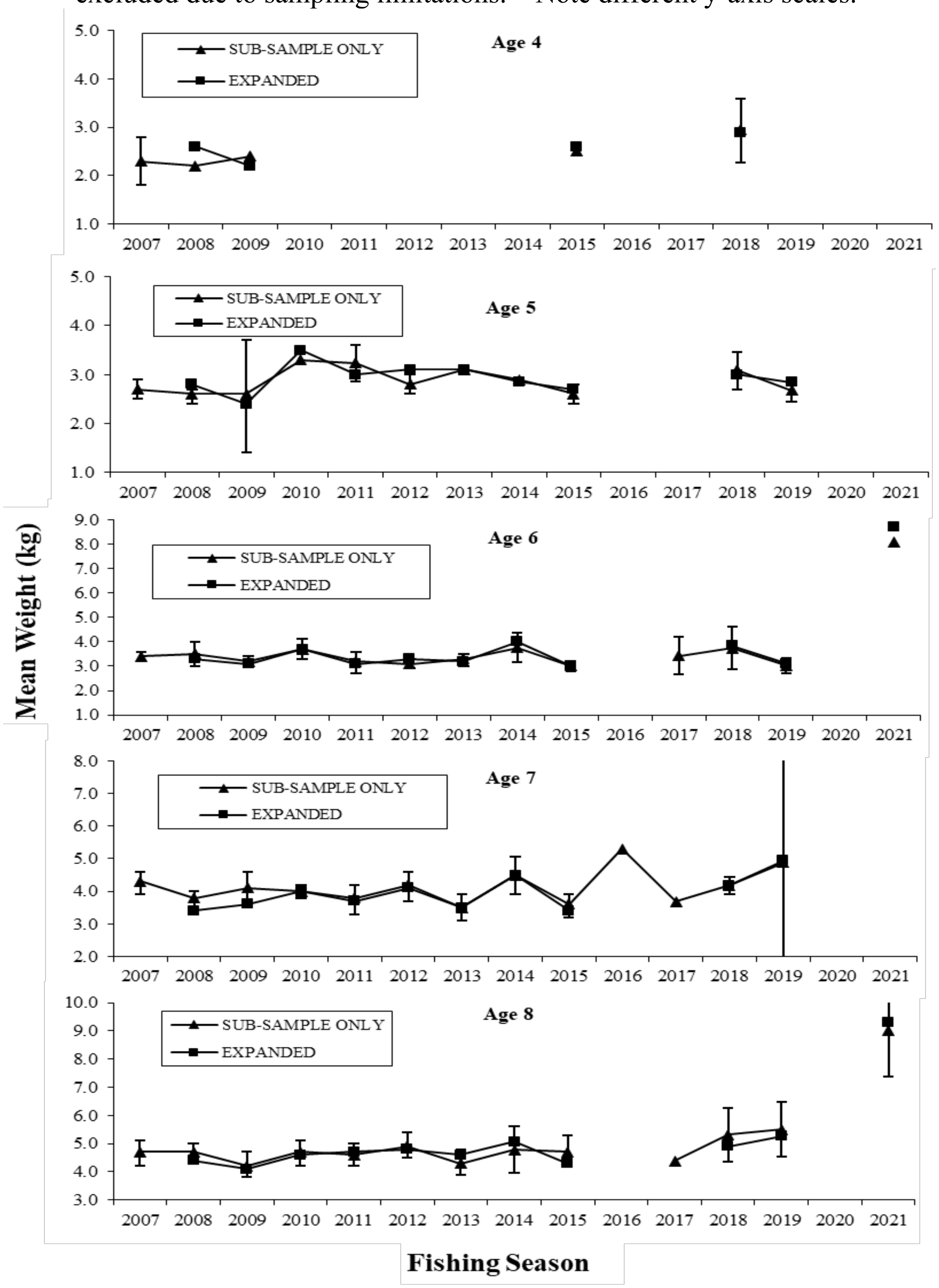
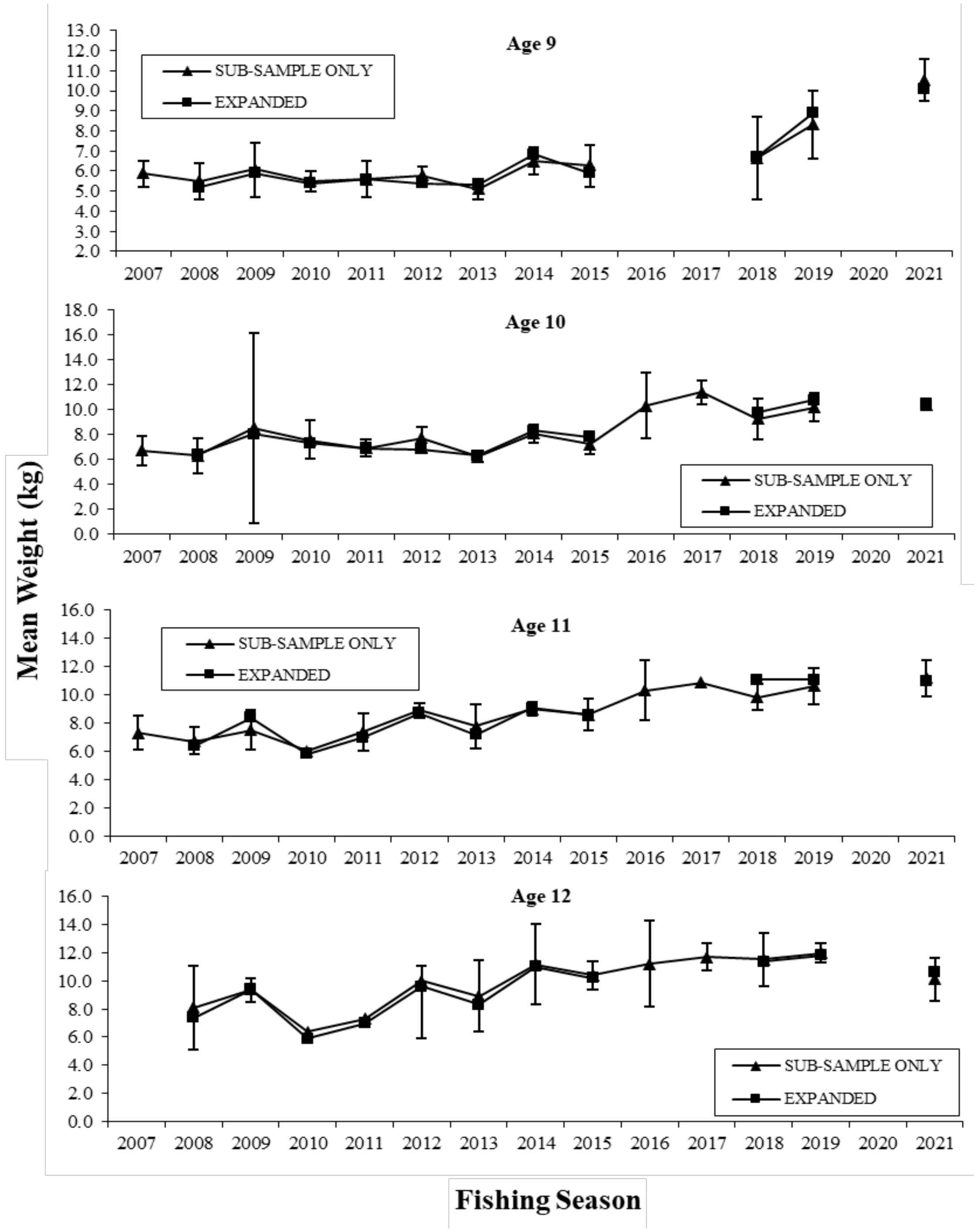


Figure 5. Continued.



PROJECT NO. 2
JOB NO. 3
TASK NO. 2

CHARACTERIZATION OF STRIPED BASS SPAWNING STOCKS IN MARYLAND

Prepared by Beth A. Versak

INTRODUCTION

The primary objectives of Project 2, Job 3, Task 2 were to finalize estimates of relative abundance-at-age for striped bass in Chesapeake Bay during the 2021 spring spawning season and to provide preliminary results for characterizing the 2022 spawning population. Completed abundance estimates and additional results for the 2022 spawning season will be reported in the next F-61-R-18 Chesapeake Bay Finfish Investigations report.

Since 1985, the Maryland Department of Natural Resources (MD DNR) has employed multi-panel experimental drift gill nets to monitor the Chesapeake Bay component of the Atlantic coast striped bass population. Because Chesapeake Bay spawners can contribute up to 90% of the Atlantic coastal stock in some years (Richards and Rago 1999), indices derived from this effort are important in the coastal stock assessment process. Indices produced from this study are currently used to guide management decisions concerning recreational and commercial striped bass fisheries from North Carolina to Maine.

A secondary objective of Task 2 was to characterize the striped bass spawning population within the Chesapeake Bay. Length distribution, age structure, average length-at-age, and percentage of striped bass older than age 8 present on the spawning grounds were examined. In addition, an Index of Spawning Potential (ISP) for female striped bass, an age-independent measure of female spawning biomass within the Chesapeake Bay, was calculated.

METHODS

Data Collection Procedures

Multi-panel experimental drift gill nets were deployed in the Potomac River and in the Upper Chesapeake Bay in 2021 (Figure 1). Gill nets were fished six days per week, weather permitting, in late March, April and May.

Individual net panels were approximately 150 feet long and ranged from 8.0 to 11.5 feet deep depending on mesh size. The panels were constructed of multifilament nylon webbing in 3.0, 3.75, 4.5, 5.25, 6.0, 6.5, 7.0, 8.0, 9.0 and 10.0-inch stretch-mesh, with gaps of 5 to 10 feet between each panel. In the Upper Bay, all 10 panels were tied together, end to end, to fish the entire suite of meshes simultaneously. In the Potomac River, because of the design of the fishing boat, the gang of panels was split in half, with two suites of panels (5 meshes tied together) fished simultaneously end to end. Additionally on the Potomac River, to avoid the small mesh panels being destroyed by large catches of blue catfish, the 3.0, 3.75 and 4.5 inch panels were cut in half to approximately 75 feet each. In both systems, all 10 panels were fished twice daily unless weather, tide or large catches prohibited a second set. Soak times were determined based on several conditions (weather, tide, water temperature, fish activity) and normally ranged from 10 to 30 minutes.

Sampling locations were assigned using a stratified random design. The Potomac River and Upper Bay spawning areas were each considered a stratum. One randomly chosen site per day was fished in each spawning area. On rare occasions, an alternate site was selected if an obstruction or changing weather conditions were encountered on the sampling day. Sites were chosen from a grid superimposed on a map of each system. The Potomac River grid consisted of 40, 0.5-square-mile quadrats, while the Upper Bay grid consisted of 31, 1-square-mile quadrats. GPS equipment, buoys, and landmarks were used to locate the appropriate quadrat in the field.

After nets were deployed in the designated quadrat, air and surface water temperatures, surface salinity, and water clarity (Secchi depth) were measured.

All striped bass captured in the nets were measured for total length (mm TL), sexed by expression of gonadal products, and released. Scales were taken from 2-3 randomly chosen male striped bass per 10 mm length group up to 700 mm TL, per week, for a maximum of 10 scale samples per length group over the entire season. Scales were taken from all males over 700 mm TL and from all females regardless of total length. Scales were removed from the left side of the fish, above the lateral line, and between the two dorsal fins. Additionally, if time and fish condition permitted, U. S. Fish and Wildlife Service internal anchor tags were applied (Project No. 2, Job No. 3, Task 4).

Analytical Procedures

Development of age-length keys

Sex-specific age-length keys (ALKs) were used to develop catch-per-unit-effort (CPUE) estimates. The scale allocation procedure, in use since 2003, designated two sex-specific groups of scales pooled from both the spring gill net sampling and the spring striped bass recreational season creel survey (Project No. 2, Job No. 3, Task 5B; Barker et al., 2003).

Development of selectivity-corrected CPUEs and variance estimates

CPUEs for individual mesh sizes and length groups were calculated for each spawning area. CPUE was standardized as the number of fish captured in 1000 square yards of experimental drift gill net per hour. Mesh-specific CPUEs were calculated by summing the catch in each length group across days and meshes, and dividing the result by the total effort for each mesh. This ratio of sums approach was assumed to provide the most accurate characterization of the spawning population, which exhibits a high degree of emigration and immigration from the sampling area during the two-month sampling interval. The dynamic state of the spawning population precludes obtaining an instantaneous, representative sample on a given day, whereas a sum of the catches absorbs short-term variability and provides a cumulative snapshot of spawning stock density. In addition, it was necessary to compile catches across the duration of the survey in each length group so that sample sizes were large enough to characterize gill net selectivity.

Sex-specific models have been used since 2000 to develop selectivity coefficients for female and male fish sampled from the Potomac River and Upper Bay. Model building and hypothesis testing determined that unique physical selectivity characteristics were evident by sex, but not by area (Waller 2000, unpublished data). Therefore, sex-specific selectivity coefficients for each mesh and length group were estimated by fitting a skew-normal model to spring data from 1990 to 2000 (Helser et al., 1998).

Sex-specific selectivity coefficients were used to correct the mesh-specific length group CPUE estimates. The selectivity-corrected CPUEs were then averaged across meshes and weighted by the capture efficiency of the mesh, resulting in a vector of selectivity-corrected length group CPUEs for each spawning area and sex.

Sex-specific ALKs were applied to the appropriate vectors of selectivity-corrected length group CPUEs to attain estimates of selectivity-corrected year-class CPUEs. Sex- and area-specific, selectivity-corrected, year-class CPUEs were calculated using the skew-normal selectivity model. These area- and sex-specific estimates of relative abundance were summed to develop estimates of relative abundance for Maryland's Chesapeake Bay. Before pooling over spawning areas, weights corresponding to the fraction of total spawning habitat encompassed by each spawning area were assigned. The Choptank River has not been sampled since 1996, therefore, values for 1997 to the present were weighted using only the Upper Bay (0.615) and the

Potomac River (0.385; Hollis 1967). To incorporate Bay-wide indices into the coastal assessment model, 15 age-specific indices were developed, one for each age from age 1 through age 14 and an age 15-plus group.

Confidence limits for the individual sex- and area-specific CPUEs were calculated. In addition, confidence limits for the pooled age-specific CPUE estimates were produced according to the methods presented in Cochran (1977), utilizing estimation of variance for values developed from stratified random sampling. Details of this procedure can be found in Barker and Sharov (2004).

Finally, additional spawning stock analyses for Chesapeake Bay striped bass were performed, including:

- Development of daily water temperature and catch patterns to examine relationships;
- Examination of the spawning stock length-at-age (LAA) structure among areas and over time, and calculation of confidence intervals for sex- and area-specific length-at-age (α=0.05);
- Examination of trends in the age composition of the Bay spawning stock, the percentage of the female spawning stock older than age 8, and calculation of the total stock older than age 8;
- Development of an index of spawning potential (ISP) for each system by converting the selectivity-corrected length group CPUE of female striped bass over 500 mm TL to biomass utilizing the regression equation (Rugolo and Markham 1996):

$$\ln weight_{kg} = 2.91 * \ln length_{cm} - 11.08 \qquad \text{(Equation 1)}$$

This equation was re-evaluated using length and weight data from female striped bass sampled during the 2009-2013 spring recreational seasons (Project No. 2, Job No. 3, Task No. 5B, this report). The resulting equation was almost identical and therefore no changes were made in the calculation of ISP.

RESULTS AND DISCUSSION

Sampling times

In the Potomac River, sampling was conducted from March 30 to May 8 for a total of 28 sample days. Due to COVID-19 protocols, Upper Bay sampling was paused for two weeks during the end of April. In the Upper Bay, sampling was conducted from April 2 to April 19, and May 2 to May 18 for a total of 29 sample days. Overall soak times for each panel ranged from 10 to 93 minutes.

CPUEs and variance

A total of 358 scales were aged to create the sex-specific ALKs (Table 1). Annual CPUE calculations produced four vectors of selectivity-corrected sex- and age-specific CPUE values. The un-weighted time-series data are presented by area in Tables 2-7.

All 2021 un-weighted CPUEs decreased relative to the previous year. The 2021 un-weighted CPUE for Potomac females (20) ranked 21 out of 36 in the time-series, below the average of 26 (Table 2). The un-weighted CPUE for Potomac males (193) was seventh lowest in the time series, well below the average of 420 (Table 3).

In 2021, Upper Bay catches were well below average. The Upper Bay female CPUE (30) was below the time-series average of 42. It ranked 24th in the 37 years of the survey (Table 4). The un-weighted CPUE for Upper Bay males (212) was well below any values in recent years, and well below the average of 454 (Table 5). This value was the fourth lowest in the 37-year time series.

The abundant 2011 year-class (age 10 fish) produced the highest age-class CPUE values for female fish in both systems. Age 3 males from the 2018 year-class were abundant on the Potomac River. Age 3 and age 6 (2015 year-class) males produced the highest CPUEs in the

Upper Bay. The Choptank River has not been sampled since 1996, but the results are included here for the historical record (Tables 6 and 7).

Area- and sex-specific, weighted CPUE values were pooled for use in the coastwide striped bass stock assessment. These indices are presented in a time-series for ages one through 15+ (Table 8). The 2021 selectivity-corrected, total, weighted CPUE (231) was the second lowest in the 37-year survey, well below the time-series average of 487.

An investigation into the potential impact of the two-week COVID interruption during the 2021 survey found that the missed sampling likely had a small effect on survey results. The same two-week period (April 20 - May 1) was excluded from Upper Bay data for each of the previous 10 years. CPUEs were re-calculated and compared to original results. Trends in recalculated CPUEs were similar to the original values. Positive and negative changes resulted, indicating that large catches do not always occur during that two-week period, due to annual variations in the time of spawning peaks. The greatest differences occurred in sex-specific Upper Bay CPUE indices; however, they were muted when the pooled, weighted CPUEs were calculated. Re-calculated CPUEs ranged from 16% higher (2013) to 22% lower (2019), with an average difference of just 2%. Additionally, the CPUE calculation methods were designed to absorb short-term variability and provide a broader overall estimate of spawning stock density.

Confidence limits were calculated for the pooled and weighted CPUEs (Tables 9 and 10). Confidence limits could not be calculated for the 15+ age group in years when these values are the sum of multiple age-class CPUEs. Coefficients of Variation (CV) of the 2021 age-specific CPUEs were all below 0.10, with the exceptions of age 12 and 13 (low sample sizes), indicating a small variance in CPUE. Historically, 84% of the CV values were less than 0.10 and 92% were less than 0.25 (Table 11). CV values greater than 1.0 were limited to older age-classes sampled during and immediately following the moratorium. The increased variability was likely attributed to small sample sizes associated with those older age-classes when the population size was low.

Tables 12 and 13 present CPUEs by year-class, un-weighted and weighted by spawning area, respectively. In most cases, the percentages by age, sex, and area were similar for the un-weighted and weighted CPUEs. Unless otherwise noted, all CPUEs and percentages discussed here are the weighted values (Table 13).

The above-average 2018 year-class was the most prevalent cohort in the spawning stock this year, composing 27% of the total CPUE, followed by the 2015 year-class at 22%. Males were most frequently encountered, composing 89% of the total CPUE. All fish under the age of 5 were males and made up 47% of the total CPUE.

The 2018 year-class made the largest contribution to the male CPUE in the Potomac River at 42%, followed by the 2015 year-class at 20%. In the Upper Bay, the 2018 and 2015 year-classes each contributed 25% to the male CPUE. Older males were encountered infrequently. In the Potomac, 94% of the male CPUE was made up of fish ages 6 and younger, while in the Upper Bay, that number was 83%.

Historically, the female contribution has been less than 10% to each system's CPUE. In 2021 the female contribution to the Upper Bay CPUE was 13%, and 9% to the Potomac CPUE. Female CPUEs were distributed across many year-classes in the Upper Bay, with 10 year-old female fish from the 2011 year-class contributing the most to its female CPUE (47%). Similarly on the Potomac, 2011 year-class females contributed 54%. This was higher than their contribution last year, as the year-class becomes fully recruited to the spawning stock. Age 6 females from the 2015 year-class contributed 17% in the Upper Bay CPUE.

Temperature and catch patterns

Potomac River sampling began on March 30, with a surface water temperature of 13°C. Temperatures rose slowly during the first week of April, passing the 14°C mark necessary to initiate spawning in the second week of April (Fay et al., 1983). Daily surface water temperature fluctuated some throughout the survey and was 18°C when the survey ended on May 8. Female CPUEs were very low through the entire survey (Figure 2) with the exception of April 24. The largest peaks in male CPUE were observed early in the survey and during the last week of April.

Upper Bay surface water temperatures fluctuated throughout the survey. It began on April 2 with water temperature at 10°C, and it rose to 14°C when sampling stopped on April 19. When sampling resumed on May 2, water temperature was 16°C and increased over the next week to a peak of 18°C. Temperature varied through the remainder of the survey and was 17°C when the survey ended on May 18. No spawning activity was observed but may have been missed during the end of April. Females were encountered throughout the sampling time, with higher catches in April than May (Figure 3). Male CPUE was relatively low for the survey, with the highest catches occurring as the water warmed during the first week and again in the second week.

Length composition of the stock

In 2021, a total of 755 striped bass was measured, which is less than half of the average number sampled per year for the last 15 years. On the Potomac River, 258 male and 25 female striped bass were measured. Upper Bay numbers were particularly low, possibly due to the inability to sample the last two weeks of April, with 429 males and 43 females measured (Figure 4). The mean length of female striped bass (976 ± 38 mm TL) was significantly larger than the mean length of male striped bass (483 ± 9 mm TL, $P < 0.0001$), consistent with the known biology of the species. Mean lengths are presented with 2 standard errors.

The mean length of male striped bass collected from the Potomac River (459 ± 12 mm TL) was significantly smaller than that of Upper Bay males (498 ± 12 mm TL, $P < 0.0001$). Male striped bass in the Potomac ranged from 292 to 949 mm TL. Males between 330 and 590 mm TL composed almost all (91%) of the Potomac River male catch in 2021. These smaller, younger fish were primarily from the above average 2018, 2017 and 2015 year-classes (Figure 4). The influence of these young fish was also evident in peaks of the uncorrected and selectivity-corrected CPUEs between 330 mm TL and 570 mm TL (Figure 5).

Male striped bass on the Upper Bay ranged from 248 to 1102 mm TL. There are two peaks evident in the male length frequency (Figure 4). The peak between 330-390 mm TL likely represents males from the 2018 year-class, while the second peak between 470-570 mm TL includes fish from the above average 2015 year-class. Similarly, those peaks are also present in the Upper Bay male selectivity-corrected and uncorrected CPUEs in Figure 5. Few large males were encountered in either system.

Mean length of female striped bass sampled from the Potomac River (984 ± 53 mm TL) in 2021 was not statistically different than the Upper Bay (971 ± 52 mm TL; $P<0.0001$). Female striped bass in the Potomac ranged from 662 to 1169 mm TL, and females sampled in the Upper Bay ranged from 564 to 1217 mm TL (Figure 4). Several smaller females were encountered in both systems from the 2015 year-class. Females sampled in the 950 to 1030 mm TL groups represent the high numbers of the 2011 year-class that were encountered. The largest females (≥1110 mm TL) likely represent the 2005 and 2003 year-classes (Figure 4).

Female CPUE in the Potomac River was generally present in larger length groups, with the exception of a few 2015 year-class fish present in the 670 and 690 mm TL groups (Figure 6). In the Upper Bay, female CPUEs were generally low, but covered a wide range of length groups

(Figure 6). Application of the selectivity model to the data corrected the catch upward in cases where few fish were captured in meshes that had a low selectivity for their size.

Length at age (LAA)

Based on previous investigations which indicated no influence of area on mean LAA, samples from the Potomac River, Upper Bay and the spring recreational creel sampling (Project 2, Job 3, Task 5B) were again combined in 2021 to produce separate male and female ALKs (Warner et al., 2006; Warner et al., 2008; Giuliano and Versak 2012).

Age- and sex-specific LAA statistics are presented in Tables 14 and 15. Small sample sizes of ages in both systems precluded testing for differences in LAA relationships in some cases. When year-classes are below average in abundance, or at extremes in age, sample sizes are sometimes too small to analyze statistically. This is the case particularly for female striped bass and older males, as they are encountered much less frequently on the spawning grounds. A one-way analysis of variance (ANOVA) was performed, where possible, to determine differences in mean LAA by sex, between areas (Upper Bay and Potomac). Few differences between sample areas were detected in LAA for either sex in 2021. All female lengths-at-age with sufficient sample sizes were similar between the two areas. Similarly to 2020, age 2 male fish were significantly longer on the Potomac River (mean = 331 mm TL) than the Upper Bay (mean = 278 mm TL, P=0.0084). Age 5 males were significantly longer on the Potomac River (mean = 527 mm TL) than the Upper Bay (mean = 480 mm TL, P=0.015).

Mean lengths-at-age were compared between years for each sex, areas combined (ANOVA, α=0.05). Male and female LAAs have been relatively stable since the mid-1990s (Figures 7 and 8). Mean lengths of females were all similar in 2020 and 2021 except for age 9 (P=0.041). Age 9 fish were from the 2011 year-class in 2020 (mean = 968 mm TL) and were significantly longer than age 9 fish in 2021 (mean = 891 mm TL). Mean lengths of males were similar in 2020 and 2021, except for ages 3 and 9. Age 3 males in 2020 (mean = 340 mm TL) were significantly shorter than age 3 fish in 2021 (mean = 377 mm TL, P=0.0006). Like the females, age 9 males were significantly longer in 2020 (mean = 810 mm TL) than those in 2021 (mean = 726 mm TL, P=0.0399).

Age composition of the stock

Seventeen age-classes, ranging from 2 to 18 were encountered (Tables 14 and 15). Of the 200 male fish aged from the survey (Table 1), ages 3 and 6 (2018 and 2015 year-classes) were the most commonly encountered. On the Potomac River, the males encountered ranged from age 2 through 10, while on the Upper Bay, males ages 2 through 16 were captured. Females ranged in age from 6 to 18 on the Potomac River, and 5 to 18 on the Upper Bay. Of the 67 aged female scales (Table 1), age 10 females from the dominant 2011 year-class were most commonly observed.

The abundance of 2 to 5 year-old striped bass in the Maryland Chesapeake Bay spawning stock has been variable since 1985, with clear peaks of abundance corresponding to strong year-classes (Figure 9). Relative to 2020, all but two of the fourteen age-specific CPUEs decreased in 2021. The two that increased were the above average 2015 and 2011 year-classes. The contribution of the 15+ age group has been strong for the past 12 years, driven by older females (Figure 9).

The contribution of age 8+ females to the total female CPUE decreased again in 2021 to 77% (Figure 10). The decrease may be driven by a portion of the 2015 year-class (age 6 in 2021) females recruiting to the spawning stock, as well as by the lower sample size observed due to a break in sampling. The contribution of females age 8 and older to the spawning stock was at or above 80% for most years during the period of 1996-2015, but was below the time-series average (72%) for 2016 - 2018.

The percentage of the overall sample (males and females combined) age 8 and older has been variable since 1997 (Figure 11). The 2021 value of 17% was a slight increase from last year, and slightly above the time-series average of 16%. The percentage of age 8+ fish is heavily influenced by strong year-classes and shows cyclical variations (Figure 9). In 2021, fewer fish were caught overall, including younger males, which normally dominate the catch on the spawning grounds.

The Chesapeake Bay estimates of female ISP, expressed as biomass, have been calculated for the two largest spawning areas in Maryland's portion of the Bay. Maryland's estimates are more variable than the female spawning stock biomass (SSB) estimates produced in the coastwide stock assessment. Coastal estimates had shown a decline from 2010 through 2018, although the most recent stock assessment indicates that SSB has been increasing since then (ASMFC 2022). Maryland's Chesapeake Bay estimates have not shown the increasing trend in recent years. The MD DNR estimates of ISP generated from the Upper Bay have been variable but were very high for the period of 2012 to 2015. The 2021 ISP value of 238 was well below the high values of that previous period, and below the time-series average of 348 (Table 16, Figure 12). The Potomac River ISP has varied without trend in recent years. The 2021 Potomac River female ISP of 190 was below the time series average of 229 (Table 16, Figure 12).

PROJECT NO. 2
JOB NO. 3
TASK NO. 2

CHARACTERIZATION OF STRIPED BASS SPAWNING STOCKS IN MARYLAND

2022 PRELIMINARY RESULTS

Data collected during the 2022 spring spawning season are currently being analyzed. In the Potomac River in 2022, sampling was conducted from April 4 to May 12 for a total of 22 sample days. In the Upper Bay, sampling was conducted from April 8 to May 14 for a total of 27 sample days.

Scale samples are currently being processed and aged, therefore no CPUE estimates are available at this time. A total of 509 scales were collected for use in creating the sex-specific ALKs. In the Potomac River, a total of 261 striped bass were sampled: 241 males and 20 females. Of those 261 fish, 140 (54%) were tagged with U. S. Fish and Wildlife Service internal anchor tags. In the Upper Bay, a total of 623 striped bass were captured: 596 males and 27 females. Of the 623 fish encountered, 229 (37%) were tagged.

Male striped bass on the Potomac ranged from 294 to 975 mm TL, with a mean of 471 mm TL. Male striped bass on the Upper Bay ranged from 288 to 1096 mm TL, with a mean of 442 mm TL. Female striped bass sampled from the Potomac ranged from 671 to 1216 mm TL, with a mean of 1025 mm TL. Upper Bay female striped bass ranged from 951 to 1204 mm TL, and had a mean of 1061 mm TL.

The final, complete analyses of the spring 2022 spawning stock survey data will appear in the next F-61-R-18 Chesapeake Bay Finfish Investigations report.

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LIST OF TABLES

LIST OF TABLES (continued)

LIST OF FIGURES

LIST OF FIGURES (continued)

Table 1. Scales aged for each sex, area, and survey, by length group (mm TL) in spring 2021.

	MALES				FEMALES			
Length group (mm)	**Upper Bay**	**Potomac River**	**Creel**	**Male Total**	**Upper Bay**	**Potomac River**	**Creel**	**Female Total**
250	2	0	0	**2**	0	0	0	**0**
270	1	0	0	**1**	0	0	0	**0**
290	2	2	0	**4**	0	0	0	**0**
310	5	3	0	**8**	0	0	0	**0**
330	4	4	0	**8**	0	0	0	**0**
350	4	4	0	**8**	0	0	0	**0**
370	4	4	0	**8**	0	0	0	**0**
390	4	4	0	**8**	0	0	0	**0**
410	4	4	0	**8**	0	0	0	**0**
430	4	4	0	**8**	0	0	0	**0**
450	4	4	0	**8**	0	0	0	**0**
470	4	4	0	**8**	0	0	0	**0**
490	4	4	0	**8**	0	0	1	**1**
510	4	4	0	**8**	0	0	4	**4**
530	4	4	0	**8**	0	0	2	**2**
550	4	4	0	**8**	0	0	1	**1**
570	5	5	0	**10**	1	0	2	**3**
590	5	5	0	**10**	0	0	2	**2**
610	6	4	0	**10**	1	0	2	**3**
630	7	3	0	**10**	1	0	4	**5**
650	5	4	2	**11**	0	0	1	**1**
670	6	1	3	**10**	1	2	3	**6**
690	8	1	1	**10**	1	1	2	**4**
710	1	2	1	**4**	2	0	1	**3**
730	8	0	4	**12**	0	0	2	**2**
750	2	0	1	**3**	0	0	2	**2**
770	0	0	0	**0**	1	0	0	**1**
790	0	0	0	**0**	1	0	0	**1**
810	2	0	0	**2**	0	0	1	**1**
830	0	0	0	**0**	0	0	0	**0**
850	1	0	0	**1**	0	0	1	**1**
870	0	0	0	**0**	0	0	0	**0**
890	0	0	1	**1**	1	0	1	**2**
910	0	0	0	**0**	1	1	0	**2**
930	2	0	1	**3**	0	0	4	**4**
950	0	1	0	**1**	1	3	10	**14**
970	2	0	1	**3**	3	3	4	**10**
990	1	0	1	**2**	3	1	9	**13**
1010	0	0	0	**0**	5	2	8	**15**
1030	1	0	0	**1**	4	4	2	**10**
1050	0	0	0	**0**	0	1	2	**3**
1070	0	0	0	**0**	3	1	2	**6**
1090	0	0	0	**0**	0	1	0	**1**
1110	1	0	0	**1**	3	4	2	**9**
1130	0	0	0	**0**	5	0	0	**5**
1150	0	0	0	**0**	3	0	0	**3**
1170	0	0	0	**0**	0	1	0	**1**
1190	0	0	0	**0**	0	0	0	**0**
1210	0	0	0	**0**	1	0	0	**1**
Total	**121**	**79**	**16**	**216**	**42**	**25**	**75**	**142**

Table 2. Estimates of selectivity-corrected age-class CPUE by year for female striped bass captured in the Potomac River during the 1985-2021 spawning stock surveys. CPUE is standardized as the number of fish captured in 1000 square yards of experimental drift gill net per hour. The Potomac River was not sampled in 1994.

	Age														
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15 +**	**Total**
1985	0.0	0.0	0.0	0.0	0.1	0.5	0.2	0.0	0.2	0.1	0.1	0.0	0.5	0.0	0.6	**2**
1986	0.0	0.0	1.0	7.3	0.7	0.0	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**10**
1987	0.0	0.0	0.0	2.9	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	**10**
1988	0.0	0.0	0.0	1.7	2.4	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	**10**
1989	0.0	0.0	0.0	0.0	6.9	4.7	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**16**
1990	0.0	0.0	0.0	0.0	1.6	3.7	3.5	1.7	0.2	0.0	0.0	0.0	0.0	0.0	0.0	**11**
1991	0.0	0.0	0.0	0.0	0.6	0.6	1.5	2.0	6.6	0.3	1.8	0.0	0.0	0.0	0.6	**14**
1992	0.0	0.0	0.0	2.6	6.4	6.7	8.7	11.4	8.2	8.7	0.0	0.0	0.0	0.0	0.0	**53**
1993	0.0	0.0	0.0	1.0	8.2	7.7	9.4	15.2	14.3	8.6	4.3	0.0	0.0	0.0	0.0	**69**
1994																
1995	0.0	0.0	0.0	0.0	0.0	3.1	4.6	4.8	4.6	6.6	5.5	5.0	0.7	0.0	0.0	**35**
1996	0.0	0.0	0.0	0.0	0.8	0.2	3.9	7.1	6.8	8.8	5.4	8.1	3.3	0.0	0.0	**45**
1997	0.0	0.0	0.0	3.1	0.5	4.0	3.0	5.3	9.2	10.2	4.2	4.8	1.4	1.5	0.0	**47**
1998	0.0	0.0	0.0	0.0	0.0	0.8	0.3	1.0	3.2	2.7	4.4	4.6	1.6	0.7	0.0	**19**
1999	0.0	0.0	0.0	0.0	0.0	2.1	3.7	4.2	4.8	2.0	6.4	2.6	0.6	0.0	0.3	**27**
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	1.4	2.4	7.8	1.2	1.4	5.1	0.0	**27**
2001	0.0	0.0	0.0	1.0	0.0	0.0	2.9	4.6	7.2	4.0	4.3	3.0	5.2	0.0	0.0	**32**
2002	0.0	0.0	0.0	0.0	0.0	0.0	1.0	3.1	12.3	5.9	5.5	2.7	6.0	1.8	2.2	**40**
2003	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.8	3.5	2.8	1.6	0.3	1.5	0.0	**12**
2004	0.0	0.0	0.0	0.0	0.0	1.6	2.8	13.5	6.3	8.6	11.6	6.6	3.5	4.8	1.3	**61**
2005	0.0	0.0	0.0	0.0	1.9	0.0	1.6	0.6	2.7	2.5	4.6	4.1	1.7	0.8	2.3	**23**
2006	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.8	6.3	9.2	4.1	5.1	9.6	2.3	6.5	**44**
2007	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.9	1.4	3.2	7.5	4.5	1.4	3.8	3.2	**26**
2008	0.0	0.0	0.0	0.4	0.4	0.0	0.9	0.1	0.4	1.8	2.4	4.9	1.2	1.2	1.4	**15**
2009	0.0	0.0	0.3	0.0	0.5	0.5	0.3	2.6	4.3	1.9	2.3	1.9	4.6	1.2	1.4	**22**
2010	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	2.1	2.3	0.7	1.5	2.2	5.9	4.1	**19**
2011	0.0	0.0	0.1	0.8	0.4	0.0	0.0	0.9	0.4	2.0	1.1	1.1	1.1	0.4	2.6	**11**
2012	0.0	0.0	0.0	1.0	1.4	4.7	2.6	1.1	1.6	1.0	1.6	1.8	0.8	1.0	3.1	**22**
2013	0.0	0.0	0.0	0.0	0.2	1.5	0.7	2.0	0.7	3.3	2.0	1.5	1.1	0.8	3.9	**18**
2014	0.0	0.0	0.0	0.0	0.2	0.3	1.8	1.3	2.8	4.1	7.3	0.5	2.5	0.5	3.2	**25**
2015	0.0	0.0	0.0	0.0	0.0	0.4	0.9	1.3	0.6	2.3	4.0	9.7	1.9	4.5	3.1	**29**
2016	0.0	0.0	0.0	0.0	5.2	2.3	1.5	0.4	0.8	0.6	1.8	1.9	3.1	0.6	2.8	**21**
2017	0.0	0.0	0.0	0.3	0.3	7.1	3.8	2.8	0.8	6.9	3.6	5.7	4.7	3.4	4.9	**44**
2018	0.0	0.0	0.0	0.0	0.0	0.0	1.9	0.4	0.9	0.1	0.9	0.1	0.7	0.6	1.9	**8**
2019	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.2	0.3	0.0	0.0	0.1	1.2	2.1	**5**
2020	0.0	0.0	0.0	0.0	1.1	2.2	1.1	0.2	7.3	2.6	2.5	0.9	1.1	1.8	14.0	**35**
2021	0.0	0.0	0.0	0.0	0.0	1.7	1.0	0.1	0.2	10.6	2.6	1.3	0.4	0.1	1.7	**20**
Average																**26**

Table 3. Estimates of selectivity-corrected age-class CPUE by year for male striped bass captured in the Potomac River during the 1985-2021 spawning stock surveys. CPUE is standardized as the number of fish captured in 1000 square yards of experimental drift gill net per hour. The Potomac River was not sampled in 1994.

	Age															
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15 +**	**Total**
1985	0.0	285.3	517.6	80.6	10.5	0.7	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**896**
1986	0.0	241.5	375.9	531.2	8.2	8.2	0.6	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**1,166**
1987	0.0	144.5	283.5	174.6	220.8	3.6	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	**829**
1988	0.0	18.2	107.4	63.8	75.9	81.2	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**347**
1989	0.0	51.9	240.9	134.5	39.1	55.2	21.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**543**
1990	0.0	114.2	351.8	172.8	73.8	28.3	33.8	26.6	1.3	0.0	0.0	0.0	0.0	0.0	0.0	**803**
1991	0.0	19.9	91.2	96.6	49.7	37.8	28.7	22.3	6.3	0.0	0.0	0.0	0.0	0.0	0.0	**352**
1992	0.3	36.3	202.4	148.9	97.6	73.0	39.1	19.0	6.1	0.8	8.4	0.0	0.0	0.0	0.0	**632**
1993	0.0	30.4	141.7	133.9	101.4	83.7	62.6	43.6	21.9	1.8	0.0	0.0	0.0	0.0	0.0	**621**
1994																
1995	0.0	9.1	143.9	61.1	18.7	20.4	25.3	32.2	11.3	10.7	0.1	0.0	0.8	0.0	0.0	**334**
1996	0.0	0.0	230.6	172.9	24.8	26.8	17.7	22.7	19.3	3.6	0.6	0.8	0.0	0.0	0.0	**520**
1997	0.0	49.5	54.3	112.9	95.7	12.2	5.7	10.8	17.2	13.6	2.2	2.6	0.0	0.0	0.0	**377**
1998	0.0	72.9	200.7	29.8	128.9	49.8	16.9	11.7	4.3	9.0	8.6	5.0	2.9	0.5	0.0	**541**
1999	0.0	9.9	316.9	151.2	103.6	65.4	19.1	10.3	6.9	3.8	4.4	3.1	1.9	0.0	0.0	**696**
2000	0.0	1.9	42.2	136.8	48.5	18.1	14.8	9.8	5.5	0.0	0.1	3.7	0.1	0.4	0.9	**283**
2001	0.0	10.6	36.1	43.5	33.8	12.6	8.9	7.8	4.8	1.7	2.2	4.0	0.8	0.6	0.0	**167**
2002	0.0	27.2	75.4	48.7	52.4	23.0	20.9	7.9	2.3	3.4	2.2	1.6	2.0	0.0	0.6	**268**
2003	0.0	12.6	79.0	39.6	24.5	31.6	22.5	10.0	7.0	9.5	3.2	3.7	5.8	0.2	0.2	**249**
2004	0.0	10.5	148.8	90.4	25.9	17.6	19.5	17.2	8.4	8.1	11.5	1.8	1.1	1.6	1.6	**364**
2005	0.0	10.9	11.0	14.9	16.3	4.7	4.5	3.6	4.1	3.1	1.9	1.2	0.0	0.0	0.0	**76**
2006	0.0	8.3	127.1	20.7	33.5	14.5	6.3	6.9	8.2	9.1	7.4	4.7	0.6	0.4	0.0	**248**
2007	0.0	10.4	16.6	37.1	5.3	5.6	4.3	2.1	2.6	2.8	5.4	1.0	0.8	2.0	0.1	**96**
2008	0.0	6.1	35.8	20.1	12.0	1.7	1.8	2.3	1.1	1.2	1.3	2.5	0.4	0.0	0.2	**86**
2009	0.0	35.2	35.9	116.5	23.1	56.9	9.1	10.5	10.5	2.8	3.8	2.6	3.7	0.6	0.6	**312**
2010	0.0	3.2	104.9	58.0	49.2	29.7	23.9	1.7	6.8	3.6	0.9	1.2	1.3	0.6	0.4	**285**
2011	0.0	27.6	95.7	164.4	51.2	54.4	29.6	24.7	6.2	5.2	6.1	4.1	4.9	2.1	5.3	**481**
2012	0.0	19.0	44.4	15.1	13.9	6.4	6.0	4.8	4.1	1.4	2.1	1.3	0.6	4.1	0.0	**123**
2013	0.0	6.7	19.9	50.9	23.7	17.6	8.6	5.0	1.5	1.9	0.2	0.1	0.0	0.0	0.0	**136**
2014	0.0	1.0	196.1	40.1	55.2	18.2	19.8	3.7	9.1	4.5	6.9	0.8	1.8	0.0	0.0	**357**
2015	0.0	33.4	12.9	613.7	49.8	50.2	15.5	12.1	9.4	5.5	3.0	2.1	0.9	1.6	4.0	**814**
2016	0.0	71.0	66.5	11.9	79.8	11.1	6.7	1.6	1.4	1.2	2.6	1.1	0.6	0.0	0.2	**256**
2017	0.0	59.4	116.3	32.9	70.8	141.7	20.9	15.9	11.7	9.8	7.4	20.2	0.8	1.7	0.4	**510**
2018	0.0	1.8	261.2	148.3	23.5	18.8	51.9	6.2	2.3	0.3	0.4	2.2	2.2	8.1	0.0	**527**
2019	0.0	28.8	35.1	118.1	54.5	6.2	12.5	13.1	1.0	0.6	0.0	5.2	1.0	0.8	0.8	**278**
2020	0.0	33.8	88.0	61.6	119.9	20.6	4.8	6.5	6.0	0.8	0.6	0.0	0.6	0.4	0.7	**344**
2021	0.0	12.2	80.5	30.7	19.0	39.2	5.9	1.0	0.5	4.0	0.0	0.0	0.0	0.0	0.0	**193**
Average																**420**

Table 4. Estimates of selectivity-corrected age-class CPUE by year for female striped bass captured in the Upper Bay during the 1985-2021 spawning stock surveys. CPUE is standardized as the number of fish captured in 1000 square yards of experimental drift gill net per hour.

	Age														
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15 +**	**Total**
1985	0.0	0.0	0.8	0.0	0.3	0.1	0.5	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.3	**2**
1986	0.0	0.0	0.3	24.3	0.0	0.0	0.5	0.5	3.8	0.0	0.0	0.0	0.0	0.0	0.3	**30**
1987	0.0	0.0	0.0	3.1	26.8	0.0	0.0	2.7	0.0	0.0	0.0	0.0	0.0	8.8	8.5	**50**
1988	0.0	0.0	4.2	8.8	6.5	31.7	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**52**
1989	0.0	0.0	1.2	1.8	6.2	3.9	9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**22**
1990	0.0	0.0	0.0	0.3	0.0	0.3	1.8	5.3	0.0	0.0	0.0	0.9	0.6	0.0	0.0	**9**
1991	0.0	0.0	0.0	0.5	3.2	0.5	2.3	3.1	2.2	0.0	1.2	0.0	0.0	0.0	1.2	**14**
1992	0.0	0.0	0.2	4.4	3.5	5.6	4.4	4.9	4.3	4.2	0.3	0.0	0.5	1.1	0.4	**34**
1993	0.0	0.0	0.0	3.0	5.1	2.0	4.0	4.8	4.0	3.9	2.0	1.3	2.3	2.1	0.0	**35**
1994	0.0	0.0	0.0	0.4	0.8	3.0	1.3	2.9	1.5	2.9	1.1	0.0	0.0	0.0	0.0	**14**
1995	0.0	0.0	0.0	0.0	1.7	20.2	19.5	7.7	11.2	5.2	5.7	2.0	7.0	0.0	0.0	**80**
1996	0.0	0.0	0.0	0.0	0.0	1.3	11.2	10.2	6.4	5.4	7.0	1.8	0.0	0.0	0.0	**43**
1997	0.0	0.0	0.0	0.0	0.0	0.0	1.9	10.9	17.9	1.6	0.0	0.7	0.5	0.0	0.0	**33**
1998	0.0	0.0	0.0	0.0	0.0	0.0	0.7	5.0	2.6	5.2	1.3	1.3	0.0	0.0	0.5	**17**
1999	0.0	0.0	0.0	0.0	0.0	2.8	0.0	1.7	6.7	3.2	0.7	0.9	0.0	3.5	0.0	**19**
2000	0.0	0.0	0.0	0.0	0.0	2.2	3.3	1.0	3.0	5.9	2.5	5.7	0.1	0.3	0.0	**24**
2001	0.0	0.0	0.0	0.0	0.5	2.1	4.6	13.5	5.6	5.8	7.5	5.0	1.4	1.5	0.3	**48**
2002	0.0	0.0	0.0	0.0	0.0	6.9	1.1	3.1	9.0	2.6	2.3	2.0	1.6	0.8	0.0	**29**
2003	0.0	0.0	0.0	0.0	0.0	1.7	7.0	8.5	8.9	16.8	12.1	4.3	3.9	2.6	0.0	**66**
2004	0.0	0.0	0.0	0.0	0.0	0.3	2.2	7.9	11.0	7.2	9.4	3.0	1.5	0.5	3.0	**46**
2005	0.0	0.0	0.0	0.0	0.0	0.2	1.4	3.3	7.9	9.0	10.2	9.5	3.4	1.2	4.8	**51**
2006	0.0	0.0	0.0	0.0	2.8	4.2	3.1	0.3	4.3	6.2	3.2	5.4	7.4	1.8	5.9	**45**
2007	0.0	0.0	0.0	0.0	0.0	0.5	3.4	2.8	4.3	5.5	11.4	5.0	1.3	3.8	7.1	**45**
2008	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.8	2.6	4.2	3.6	7.8	2.1	0.8	1.7	**25**
2009	0.0	0.0	0.0	0.0	3.2	3.8	0.2	2.9	8.5	2.8	6.6	4.8	10.5	3.8	5.1	**52**
2010	0.0	0.0	0.0	0.0	0.0	0.0	2.3	1.3	2.2	2.7	1.4	2.0	2.1	6.6	6.3	**27**
2011	0.0	0.0	0.0	4.9	2.0	1.2	1.3	6.4	1.3	2.5	1.2	1.0	2.1	1.2	2.2	**27**
2012	0.0	0.0	0.0	0.0	1.5	6.8	6.2	6.4	15.4	5.8	8.8	9.3	4.5	3.8	19.2	**87**
2013	0.0	0.0	0.3	2.4	1.8	15.2	5.2	10.8	8.1	16.7	4.5	9.0	3.9	5.3	13.0	**96**
2014	0.0	0.0	0.0	0.0	1.3	6.6	14.7	5.3	12.7	11.5	18.6	1.5	11.6	3.0	17.4	**104**
2015	0.0	0.0	0.0	3.7	2.3	4.5	8.0	7.3	3.1	10.6	10.7	14.1	3.0	8.9	11.1	**87**
2016	0.0	0.0	0.0	0.1	12.5	3.9	3.3	2.1	3.5	1.5	4.9	4.8	7.9	1.2	6.2	**52**
2017	0.0	0.0	0.0	2.4	2.6	12.6	3.0	1.8	1.4	5.9	3.6	6.7	5.1	3.6	4.3	**53**
2018	0.0	0.0	0.0	1.1	1.9	1.2	9.9	2.1	1.6	1.2	1.4	0.6	3.2	2.5	9.8	**37**
2019	0.0	0.0	0.0	1.3	0.6	0.6	3.5	9.4	6.2	5.5	0.5	2.3	0.5	5.1	8.0	**44**
2020	0.0	0.0	1.5	0.7	4.0	1.0	0.5	2.1	13.0	2.9	2.7	0.9	1.1	1.4	3.3	**35**
2021	0.0	0.0	0.0	0.0	1.9	5.2	0.9	0.3	1.8	14.4	1.1	0.2	0.3	0.5	3.5	**30**
Average																**42**

Table 5. Estimates of selectivity-corrected age-class CPUE by year for male striped bass captured in the Upper Bay during the 1985-2021 spawning stock surveys. CPUE is standardized as the number of fish captured in 1000 square yards of experimental drift gill net per hour.

	Age														
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15 +**	**Total**
1985	0.0	47.5	148.8	1.9	0.0	0.8	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**199**
1986	0.0	219.0	192.3	450.8	0.4	3.4	2.2	3.8	1.3	0.0	0.0	0.0	0.0	0.0	1.2	**874**
1987	0.0	131.7	231.0	68.1	138.8	0.0	2.1	4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**576**
1988	0.0	52.1	38.0	61.6	37.8	36.8	0.6	0.0	0.0	7.2	0.0	0.0	0.0	0.0	0.0	**234**
1989	0.0	8.1	102.3	17.4	21.1	26.9	16.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**192**
1990	0.0	56.7	28.4	92.8	20.1	24.9	22.9	16.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**263**
1991	0.0	84.1	254.9	36.8	40.9	11.3	16.0	9.5	4.3	0.1	0.0	0.0	0.0	0.0	0.0	**458**
1992	0.0	22.5	193.9	150.1	19.4	52.9	27.7	19.1	7.5	0.5	0.0	0.0	0.0	0.0	0.0	**494**
1993	0.0	30.6	126.2	149.1	63.0	16.3	27.3	9.9	7.5	0.5	0.0	0.0	0.0	0.0	0.0	**430**
1994	0.0	25.4	54.5	96.3	101.8	43.2	14.5	26.8	6.4	2.1	0.3	0.0	0.0	0.0	0.0	**371**
1995	0.0	79.0	108.4	75.8	89.8	52.9	30.0	11.6	12.4	3.7	7.2	0.9	0.0	0.0	0.0	**471**
1996	0.0	6.2	433.5	57.6	23.3	86.2	59.2	34.1	29.0	11.8	12.0	0.0	0.6	0.0	0.0	**753**
1997	0.0	28.9	38.8	155.5	15.4	23.9	23.5	15.0	8.9	2.0	12.1	0.0	0.7	0.0	0.0	**325**
1998	0.0	13.0	106.6	34.6	162.0	20.9	10.0	17.1	20.9	11.9	5.4	8.7	0.0	0.0	0.0	**411**
1999	0.0	7.7	81.8	33.6	30.4	14.6	4.8	0.6	4.7	1.6	0.4	0.2	0.3	0.0	0.0	**181**
2000	0.0	22.2	64.6	83.6	47.7	80.4	28.0	10.6	6.1	6.2	3.9	3.3	1.4	0.4	0.3	**359**
2001	0.0	1.4	40.9	70.2	64.9	27.6	35.3	33.0	5.8	10.4	3.5	0.4	0.5	0.0	0.4	**294**
2002	0.0	120.7	19.1	34.1	106.7	48.2	42.2	43.7	20.1	5.2	2.4	1.1	1.9	0.0	0.0	**445**
2003	0.0	17.7	131.9	62.1	42.2	89.8	62.9	29.7	29.1	22.3	8.1	4.0	2.4	0.4	0.4	**503**
2004	0.0	40.3	221.1	140.5	52.7	44.0	56.0	49.7	28.7	20.0	13.7	2.6	2.5	1.4	0.0	**673**
2005	0.0	100.6	161.8	110.2	145.9	36.3	36.8	29.4	32.5	20.7	14.2	5.7	0.3	0.0	0.0	**694**
2006	0.0	7.0	339.9	52.2	53.6	34.3	16.9	15.5	16.6	17.3	11.0	6.3	1.3	1.0	0.0	**573**
2007	0.0	6.3	26.2	100.4	20.9	20.8	15.7	7.3	7.8	7.1	6.5	4.5	2.2	1.4	0.2	**227**
2008	0.0	1.5	117.5	163.5	175.0	26.4	35.2	28.8	14.8	13.5	10.4	10.3	18.7	3.8	3.2	**623**
2009	0.0	43.2	45.7	175.9	66.0	185.1	28.3	25.7	32.9	8.8	15.4	12.1	22.3	2.9	1.5	**666**
2010	0.0	10.2	177.8	45.6	74.8	63.6	72.1	8.4	14.8	10.1	4.1	4.7	5.4	5.4	22.5	**520**
2011	0.0	20.1	59.2	92.8	39.5	57.9	42.0	50.7	10.9	7.9	7.0	8.5	0.7	4.2	8.3	**410**
2012	0.0	12.8	56.8	27.7	27.5	15.3	26.0	26.7	21.8	4.8	15.8	10.8	1.7	4.0	0.7	**252**
2013	0.0	53.7	81.2	138.5	56.9	56.6	33.9	31.9	24.9	25.7	3.6	9.2	3.5	1.1	5.4	**526**
2014	0.0	13.2	331.5	60.6	59.3	20.6	25.3	7.5	12.6	7.8	13.2	1.5	2.7	0.4	6.7	**563**
2015	0.0	10.1	3.8	357.4	41.9	45.8	21.3	18.7	16.3	21.5	16.6	11.8	5.9	3.8	3.5	**578**
2016	0.0	63.9	45.7	22.7	200.3	26.7	17.0	4.6	5.1	6.1	7.5	6.2	4.9	0.3	8.0	**419**
2017	0.0	66.7	116.0	31.1	74.6	117.2	17.5	15.3	9.4	8.0	8.5	16.7	3.3	1.2	2.1	**488**
2018	0.0	1.8	145.1	133.7	32.7	30.2	89.7	9.7	11.1	3.1	4.8	1.0	4.5	11.3	0.0	**479**
2019	0.0	28.5	42.2	188.8	89.0	13.8	24.6	23.5	7.5	5.4	1.6	2.4	5.9	6.9	5.3	**445**
2020	0.0	49.6	121.4	106.9	214.2	38.9	11.6	14.3	41.2	3.5	2.8	0.4	4.5	3.4	2.8	**616**
2021	0.0	11.4	52.3	33.4	26.4	52.1	8.9	4.1	2.5	10.9	3.2	0.0	0.0	0.8	5.6	**212**
Average																**454**

Table 6. Estimates of selectivity-corrected age-class CPUE by year for female striped bass captured in the Choptank River during the 1985-1996 spawning stock surveys. CPUE is standardized as the number of fish captured in 1000 square yards of experimental drift gill net per hour. The Choptank River was not sampled in 1995, and has not been sampled since 1996.

	AGE														
YEAR	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**
1985	0	0.0	0.0	0.0	2.2	0.8	2.9	0.8	1.0	0.4	0.0	0.6	1.3	0.5	1.0	**12**
1986	0	0.0	0.0	12.8	1.9	1.0	1.6	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.5	**18**
1987	0	0.0	0.0	6.8	20.7	3.3	0.6	0.0	5.6	0.0	0.0	0.0	0.0	0.0	0.5	**38**
1988	0	0.0	0.0	9.2	10.8	16.4	3.2	0.0	1.0	1.0	0.0	0.0	0.0	0.7	0.4	**43**
1989	0	0.0	0.0	17.0	31.8	22.7	39.1	3.0	0.5	0.6	0.0	0.0	0.5	0.0	0.0	**115**
1990	0	0.0	0.0	0.0	15.7	24.2	15.9	40.7	3.1	3.0	0.0	0.0	4.7	2.5	4.4	**114**
1991	0	0.0	0.0	1.3	0.8	22.9	23.1	15.5	32.9	4.8	3.4	0.0	14.1	14.1	5.1	**138**
1992	0	0.0	1.0	0.0	1.4	9.9	28.1	18.7	19.0	15.6	0.0	0.0	16.3	3.4	0.0	**113**
1993	0	0.0	0.0	3.0	0.0	5.4	15.2	30.1	23.5	19.0	8.2	1.6	2.8	5.6	2.8	**117**
1994	0	0.0	0.0	0.0	7.5	7.1	8.8	7.7	31.3	6.1	4.0	0.0	0.0	0.0	0.0	**73**
1995																
1996	0	0.0	0.0	0.0	6.9	26.4	38.3	37.0	36.5	37.5	21.6	8.7	1.1	0.0	0.0	**214**
Average																**90**

Table 7. Estimates of selectivity-corrected age-class CPUE by year for male striped bass captured in the Choptank River during the 1985-1996 spawning stock surveys. CPUE is standardized as the number of fish captured in 1000 square yards of experimental drift gill net per hour. The Choptank River was not sampled in 1995, and has not been sampled since 1996.

	AGE														
YEAR	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Total**
1985	0.0	162.2	594.7	23.9	7.3	4.8	10.0	0.0	3.5	0.0	0.0	0.0	0.5	0.0	0	**807**
1986	0.0	290.2	172.6	393.9	12.0	6.1	1.6	1.2	0.0	0.0	0.0	0.0	0.6	0.0	0	**878**
1987	0.0	223.3	262.0	79.0	156.4	9.6	0.7	1.2	0.4	0.0	0.0	0.0	0.7	0.0	0	**733**
1988	0.0	27.0	223.3	114.6	53.5	111.5	4.7	0.0	0.0	1.4	0.0	0.0	0.0	0.0	0	**536**
1989	0.0	228.5	58.1	466.1	278.6	191.9	173.9	1.1	1.1	0.0	0.0	0.0	0.0	0.0	0	**1,399**
1990	0.0	59.5	280.4	36.3	198.1	165.8	75.9	116.9	5.0	0.0	2.3	0.0	4.3	0.0	0	**944**
1991	0.0	410.4	174.9	112.2	62.1	115.6	79.8	55.5	18.2	0.6	0.0	0.0	0.0	0.0	0	**1,029**
1992	0.0	16.2	733.0	135.2	168.4	141.9	136.4	81.2	23.6	10.1	0.0	0.0	0.0	11.3	0	**1,457**
1993	0.0	291.3	128.8	1,156.4	193.5	158.8	161.5	147.3	45.9	11.3	3.5	0.0	0.0	0.0	0	**2,298**
1994	0.0	112.8	463.3	99.5	835.2	270.9	139.4	188.5	54.9	9.2	7.6	8.3	0.9	0.0	0	**2,191**
1995																
1996	0.0	7.8	682.2	106.0	280.6	171.5	334.1	91.1	85.6	11.8	23.1	0.0	0.0	0.0	0	**1,794**
Average																**1,279**

Table 8. Mean values of the annual, pooled, weighted, age-specific CPUEs (1985–2021) for the Maryland Chesapeake Bay striped bass spawning stock. CPUE is reported as the number of fish captured in 1000 square yards of net per hour.

	Age															
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**	**Sum**
1985	0.0	140.5	305.5	31.9	4.8	1.3	2.2	0.0	0.4	0.1	0.0	0.4	0.3	0.0	0.7	**488**
1986	0.0	230.2	261.1	497.6	4.0	5.3	2.0	2.9	2.8	0.0	0.0	0.0	0.0	0.0	0.9	**1,007**
1987	0.0	142.2	258.0	115.1	176.1	17.9	2.2	2.6	0.2	0.0	0.0	0.0	0.0	0.3	0.3	**715**
1988	0.0	40.8	77.6	71.3	57.0	74.6	1.3	0.0	0.0	4.3	0.0	0.0	0.0	0.0	0.3	**327**
1989	0.0	33.1	154.7	80.5	45.5	48.8	32.9	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	**396**
1990	0.0	78.1	158.1	120.4	48.3	34.3	32.0	29.8	0.9	0.1	0.1	0.5	0.7	0.1	0.2	**504**
1991	0.0	73.4	191.9	62.2	47.1	26.7	26.0	19.2	10.6	0.4	1.5	0.0	0.6	0.6	1.1	**461**
1992	0.1	27.4	221.1	153.5	58.6	69.9	42.9	29.1	13.7	7.0	3.3	0.0	0.9	1.2	0.2	**629**
1993	0.0	41.0	132.0	187.2	88.2	51.0	51.9	37.1	22.6	7.4	3.1	0.8	1.4	1.4	0.1	**625**
1994	0.0	26.8	103.5	98.0	117.9	59.5	34.0	42.9	17.6	8.6	3.1	1.3	0.3	0.0	0.0	**513**
1995	0.0	50.0	117.2	68.4	60.9	51.6	40.0	25.0	19.7	11.6	9.6	3.5	4.6	0.0	0.0	**462**
1996	0.0	4.0	368.3	102.2	34.7	69.5	64.4	42.3	35.4	16.7	15.2	4.7	1.6	0.0	0.0	**759**
1997	0.0	36.8	44.8	140.3	46.5	20.9	18.9	22.1	26.6	11.4	9.9	3.3	1.2	0.6	0.0	**383**
1998	0.0	36.1	142.8	32.7	149.3	32.3	13.2	18.5	17.3	15.0	9.1	9.9	1.7	0.4	0.3	**479**
1999	0.0	8.6	172.4	78.9	58.6	36.7	11.7	7.0	11.5	5.2	4.8	2.8	1.1	2.1	0.1	**402**
2000	0.0	14.4	55.9	104.1	48.0	57.7	25.0	13.8	8.3	8.3	7.0	7.4	1.5	2.5	0.5	**354**
2001	0.0	4.9	39.1	60.3	53.2	23.1	29.1	33.3	11.6	12.1	9.3	6.1	3.5	1.2	0.4	**287**
2002	0.0	84.6	40.8	39.7	85.8	42.7	35.0	33.1	23.5	8.4	5.8	3.6	5.2	1.2	0.4	**410**
2003	0.0	15.7	111.5	53.4	35.4	68.4	51.6	27.6	26.7	29.1	14.7	7.2	6.1	2.5	0.3	**450**
2004	0.0	28.8	193.2	121.2	42.4	34.6	44.4	47.3	30.1	23.1	23.1	6.7	4.2	3.7	2.7	**605**
2005	0.0	66.0	103.6	73.5	96.6	24.3	25.9	21.7	27.5	20.4	17.5	11.3	3.0	1.0	3.8	**496**
2006	0.0	7.5	257.9	40.1	47.6	29.2	14.8	12.7	18.4	21.6	13.1	11.0	9.3	2.7	6.1	**492**
2007	0.0	7.9	22.5	76.0	14.9	15.3	13.5	7.4	9.0	10.0	16.0	8.0	3.0	5.4	5.3	**214**
2008	0.0	3.3	86.0	108.4	112.3	16.9	23.0	19.7	11.3	12.0	10.1	14.0	13.4	3.3	3.6	**437**
2009	0.0	40.1	42.1	153.0	51.6	138.2	21.1	22.7	31.2	9.0	15.8	12.1	23.4	4.8	4.8	**570**
2010	0.0	7.5	149.7	50.4	65.0	50.5	54.9	6.7	13.9	10.2	4.0	5.1	5.9	9.9	19.4	**453**
2011	0.0	23.0	73.3	123.7	45.4	57.3	38.0	44.9	10.1	9.1	7.9	7.8	4.0	4.3	9.6	**458**
2012	0.0	15.2	52.0	23.2	23.7	17.8	23.1	22.6	25.0	7.4	16.5	13.6	4.4	6.7	13.5	**265**
2013	0.0	35.6	57.8	106.2	45.3	51.5	27.6	28.9	21.1	28.0	5.8	11.8	5.0	4.3	12.8	**442**
2014	0.0	8.5	279.3	52.7	58.6	23.9	32.9	9.8	20.1	15.2	25.0	2.3	10.5	2.3	16.0	**557**
2015	0.0	19.1	7.3	458.5	46.4	50.4	24.3	21.2	15.8	22.7	19.5	20.5	6.6	10.2	11.7	**734**
2016	0.0	66.6	53.7	18.6	163.6	24.0	15.6	4.9	6.2	5.4	9.3	7.9	9.3	1.1	9.9	**396**
2017	0.0	63.9	116.1	33.5	74.9	137.2	22.2	17.8	11.5	15.0	11.7	24.3	7.3	4.9	5.9	**546**
2018	0.0	1.8	189.9	140.0	30.3	26.5	81.9	9.8	9.0	2.9	4.3	1.9	5.9	11.8	6.8	**523**
2019	0.0	28.6	39.5	162.4	76.1	11.3	22.1	25.5	8.8	7.1	1.3	4.9	4.4	8.1	9.3	**409**
2020	0.0	43.5	109.5	89.8	180.8	33.3	9.7	12.6	38.4	5.3	4.6	1.2	4.1	3.8	9.4	**546**
2021	0.0	11.7	63.2	32.3	24.7	50.9	8.7	3.1	2.9	21.2	3.7	0.6	0.4	0.9	6.3	**231**
Average																**487**

Table 9. Lower confidence limits (95%) of the annual, pooled, weighted, age-specific CPUEs (1985–2021) for the Maryland Chesapeake Bay striped bass spawning stock. CPUE is reported as the number of fish captured in 1000 square yards of net per hour.

	Age														
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
1985	0.0	127.3	277.1	28.8	4.2	1.0	0.9	*0.0*	*0.0*	*0.0*	0.0	*0.0*	*0.0*	*0.0*	*
1986	0.0	214.2	245.6	464.6	3.6	4.8	1.7	2.7	1.8	0.0	0.0	0.0	0.0	*0.0*	*
1987	0.0	130.4	245.1	110.6	167.8	12.1	*0.0*	2.3	*0.0*	0.0	0.0	0.0	0.0	0.1	*
1988	0.0	36.2	69.3	65.8	53.8	68.0	0.1	*0.0*	*0.0*	0.7	0.0	0.0	0.0	*0.0*	*
1989	0.0	24.7	148.0	66.1	35.5	41.5	24.8	*0.0*	0.0	*0.0*	0.0	0.0	*0.0*	0.0	*
1990	0.0	65.6	148.3	116.3	42.3	28.9	29.4	23.9	0.4	*0.0*	*0.0*	0.0	*0.0*	*0.0*	*
1991	0.0	57.0	182.6	58.6	44.8	22.6	22.4	16.5	5.4	*0.0*	0.6	0.0	*0.0*	*0.0*	*0.0*
1992	0.1	23.0	206.8	145.6	54.6	65.7	38.7	26.1	11.0	4.1	2.3	0.0	*0.0*	*0.0*	*
1993	0.0	30.5	125.3	159.4	83.6	47.7	47.1	31.7	18.1	3.8	1.7	*0.0*	0.0	*0.0*	*
1994	0.0	21.7	89.3	94.5	96.8	52.9	31.3	38.7	12.5	7.5	2.3	1.0	0.3	0.0	*
1995	0.0	45.8	114.5	66.4	59.3	49.6	38.5	24.1	18.7	11.0	9.2	3.2	1.9	0.0	*
1996	0.0	*0.0*	347.2	98.2	26.3	65.2	57.3	37.9	30.4	10.3	10.3	3.1	1.1	0.0	0.0
1997	0.0	35.9	43.5	136.8	44.9	20.3	18.2	20.5	21.9	10.7	6.3	3.0	1.1	0.5	0.0
1998	0.0	35.7	138.9	31.4	144.5	31.6	11.3	17.7	16.7	14.3	8.7	8.8	1.2	0.3	0.2
1999	0.0	6.9	168.6	76.5	56.8	35.5	11.4	6.6	10.3	4.6	4.4	2.5	1.1	0.5	0.1
2000	0.0	13.5	53.7	101.8	46.7	55.8	23.4	13.2	7.9	7.6	6.5	5.5	1.4	1.2	0.5
2001	0.0	4.4	37.6	58.6	51.7	22.1	28.2	32.1	11.0	11.5	8.7	5.3	3.0	0.8	0.4
2002	0.0	75.7	39.3	38.8	83.3	40.4	33.9	32.2	22.0	7.4	5.4	3.3	3.7	0.3	*
2003	0.0	14.4	107.5	51.8	34.2	65.8	49.3	26.7	25.5	26.7	13.2	6.3	5.1	1.5	0.3
2004	0.0	22.8	188.7	118.3	41.1	33.3	43.3	45.5	28.0	22.3	21.8	6.1	3.8	3.2	*
2005	0.0	62.8	98.9	71.0	92.8	23.3	24.9	21.0	26.4	19.2	16.4	10.2	2.6	0.9	*
2006	0.0	6.4	242.1	38.4	45.6	27.6	14.2	12.3	17.2	20.0	12.1	9.8	7.2	2.2	*
2007	0.0	6.9	21.4	74.0	14.5	14.9	12.5	6.2	8.0	9.3	13.2	7.0	2.8	3.9	*
2008	0.0	2.8	82.1	104.0	106.8	16.2	22.0	18.7	10.7	11.3	9.3	12.6	6.8	2.9	*
2009	0.0	38.5	40.6	148.4	49.8	133.1	20.5	21.9	29.3	8.5	15.0	10.8	20.6	4.3	*
2010	0.0	7.0	144.8	49.2	63.3	49.0	53.1	6.2	13.3	9.7	3.8	4.8	5.6	8.8	*
2011	0.0	22.0	71.1	120.2	43.8	55.2	37.1	43.1	9.8	8.8	7.6	5.5	3.5	3.8	*
2012	0.0	14.2	50.2	22.4	22.8	16.7	22.0	20.7	23.2	6.9	15.6	9.2	3.8	5.5	*
2013	0.0	30.4	55.2	103.0	43.6	48.8	26.3	25.7	20.2	26.1	5.4	10.8	4.5	3.7	*
2014	0.0	7.9	271.5	50.6	56.6	21.5	30.0	8.5	18.4	13.7	22.9	2.1	9.0	1.8	*
2015	0.0	18.0	7.0	448.3	44.6	48.9	23.3	20.5	15.3	21.4	18.3	19.0	5.6	7.1	*
2016	0.0	63.0	52.6	18.1	159.3	23.1	14.7	4.6	5.8	5.2	8.7	7.3	8.4	0.9	*
2017	0.0	58.7	113.1	32.4	72.7	133.5	21.4	17.1	11.0	13.8	10.7	22.5	6.5	4.5	*
2018	0.0	1.7	182.5	135.2	29.2	25.4	78.8	9.4	8.2	2.6	4.1	1.7	5.3	7.5	*
2019	0.0	25.3	38.1	158.5	74.0	10.8	20.8	24.3	7.5	6.0	1.3	4.4	4.0	5.9	*
2020	0.0	39.2	104.5	87.9	176.6	31.6	8.9	12.3	37.0	4.9	4.2	1.0	3.6	3.2	*
2021	0.0	11.3	61.4	29.7	23.8	48.8	8.2	3.0	2.6	18.6	3.2	0.5	0.2	0.7	*

* Notes: Shadings note negative values that have been changed to zero. Confidence intervals could not be calculated for age 15+ when more than one age class was present in the group.

Table 10. Upper confidence limits (95%) of the annual, pooled, weighted, age-specific CPUEs (1985–2021) for the Maryland Chesapeake Bay striped bass spawning stock. CPUE is reported as the number of fish captured in 1000 square yards of net per hour.

	Age													
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
1985	0.0	153.6	334.0	35.1	5.4	1.6	3.4	0.2	2.6	0.2	0.1	0.8	0.6	0.1	*
1986	0.0	246.2	276.6	530.6	4.5	5.8	2.4	3.2	3.8	0.0	0.0	0.0	0.0	0.1	*
1987	0.0	154.0	270.9	119.6	184.5	23.7	5.4	2.8	2.3	0.0	0.0	0.0	0.0	0.5	*
1988	0.0	45.3	86.0	76.8	60.2	81.1	2.5	1.0	1.1	8.0	0.0	0.0	0.0	0.1	*
1989	0.0	41.6	161.4	95.0	55.5	56.0	41.0	0.6	0.1	0.2	0.0	0.0	0.1	0.0	*
1990	0.0	90.5	168.0	124.5	54.3	39.6	34.7	35.7	1.3	0.5	0.3	1.0	5.3	1.7	*
1991	0.0	89.8	201.2	65.8	49.4	30.8	29.6	21.8	15.8	1.2	2.3	0.0	6.3	5.4	2.9
1992	0.3	31.8	235.4	161.4	62.7	74.1	47.1	32.0	16.3	10.0	4.2	0.0	7.3	8.9	*
1993	0.0	51.4	138.7	215.1	92.9	54.2	56.7	42.5	27.1	11.0	4.5	1.7	2.8	7.6	*
1994	0.0	32.0	117.8	101.5	138.9	66.1	36.7	47.0	22.7	9.6	3.8	1.5	0.3	0.0	*
1995	0.0	54.2	120.0	70.3	62.5	53.5	41.5	25.9	20.6	12.1	10.1	3.8	7.2	0.0	*
1996	0.0	10.8	389.5	106.1	43.2	73.9	71.5	46.6	40.4	23.2	20.1	6.3	2.2	0.0	0.0
1997	0.0	37.8	46.1	143.9	48.2	21.6	19.7	23.8	31.2	12.1	13.6	3.6	1.3	0.6	0.0
1998	0.0	36.4	146.7	34.1	154.0	33.0	15.1	19.4	17.9	15.7	9.5	11.0	2.2	0.5	0.4
1999	0.0	10.3	176.2	81.3	60.4	37.9	12.1	7.4	12.7	5.7	5.3	3.1	1.2	3.8	0.2
2000	0.0	15.2	58.2	106.4	49.2	59.7	26.5	14.4	8.6	9.0	7.4	9.3	1.6	3.8	0.6
2001	0.0	5.4	40.5	61.9	54.6	24.2	30.0	34.5	12.1	12.8	9.8	6.8	4.0	1.6	0.5
2002	0.0	93.6	42.3	40.7	88.3	45.0	36.2	33.9	25.0	9.3	6.2	3.9	6.7	2.1	*
2003	0.0	17.1	115.5	55.1	36.6	71.0	54.0	28.5	28.0	31.4	16.2	8.1	7.2	3.5	0.4
2004	0.0	34.9	197.7	124.0	43.7	35.9	45.4	49.0	32.2	24.0	24.3	7.3	4.7	4.2	*
2005	0.0	69.2	108.4	76.0	100.5	25.2	26.8	22.5	28.5	21.5	18.5	12.5	3.3	1.2	*
2006	0.0	8.6	273.7	41.7	49.5	30.9	15.4	13.1	19.6	23.1	14.2	12.2	11.3	3.2	*
2007	0.0	8.9	23.6	78.1	15.3	15.7	14.4	8.5	10.1	10.8	18.8	8.9	3.3	7.0	*
2008	0.0	3.7	90.0	112.8	117.9	17.6	24.0	20.7	11.8	12.7	10.8	15.4	20.0	3.6	*
2009	0.0	41.7	43.6	157.6	53.5	143.3	21.8	23.4	33.1	9.4	16.7	13.5	26.2	5.3	*
2010	0.0	8.0	154.6	51.6	66.6	52.0	56.7	7.2	14.5	10.7	4.1	5.4	6.2	11.1	*
2011	0.0	24.0	75.6	127.3	46.9	59.4	39.0	46.8	10.3	9.5	8.1	10.2	4.6	4.8	*
2012	0.0	16.2	53.8	24.0	24.6	19.0	24.1	24.6	26.9	7.9	17.5	17.9	4.9	8.0	*
2013	0.0	40.8	60.4	109.4	47.1	54.2	28.9	32.1	21.9	30.0	6.2	12.8	5.5	4.8	*
2014	0.0	9.1	287.0	54.7	60.6	26.2	35.8	11.0	21.9	16.6	27.1	2.6	11.9	2.8	*
2015	0.0	20.1	7.7	468.8	48.1	51.9	25.2	21.8	16.2	24.0	20.7	22.0	7.5	13.3	*
2016	0.0	70.2	54.8	19.1	168.0	24.8	16.4	5.1	6.5	5.5	9.8	8.5	10.2	1.4	*
2017	0.0	69.1	119.1	34.5	77.0	140.8	23.0	18.4	11.9	16.2	12.7	26.1	8.0	5.3	*
2018	0.0	1.9	197.2	144.9	31.5	27.6	85.0	10.1	9.8	3.1	4.6	2.1	6.4	16.2	*
2019	0.0	31.9	40.8	166.3	78.1	11.8	23.3	26.7	10.2	8.1	1.4	5.4	4.7	10.3	*
2020	0.0	47.9	114.4	91.7	185.0	35.0	10.4	13.0	39.8	5.7	4.9	1.4	4.6	4.4	*
2021	0.0	12.1	64.9	35.0	25.7	53.1	9.1	3.3	3.3	23.7	4.1	0.8	0.5	1.0	*

* Note: Confidence intervals could not be calculated for age 15+ when more than one age class was present in the group.

Table 11. Coefficients of Variation of the annual, pooled, weighted, age-specific CPUEs (1985–2021) for the Maryland Chesapeake Bay striped bass spawning stock.

	Age													
Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15+**
1985	0	0.05	0.05	0.05	0.06	0.11	0.28	2.16	2.50	1.04	0.29	0.58	0.64	2.14	*
1986	0	0.03	0.03	0.03	0.06	0.05	0.09	0.05	0.18	0	0	0	0.28	2.62	*
1987	0	0.04	0.03	0.02	0.02	0.16	0.76	0.05	4.32	0	0	0	0.34	0.36	*
1988	0	0.06	0.05	0.04	0.03	0.04	0.45	0.00	13.03	0.42	0	0	0	1.10	*
1989	0	0.13	0.02	0.09	0.11	0.07	0.12	1.17	0.29	2.92	0	0	1.31	0	*
1990	0	0.08	0.03	0.02	0.06	0.08	0.04	0.10	0.28	1.51	1.07	0.49	3.18	7.85	*
1991	0	0.11	0.02	0.03	0.02	0.08	0.07	0.07	0.25	0.96	0.29	0	5.10	4.29	0.82
1992	0.79	0.08	0.03	0.03	0.03	0.03	0.05	0.05	0.10	0.21	0.14	0	3.38	3.16	*
1993	0	0.13	0.03	0.07	0.03	0.03	0.05	0.07	0.10	0.24	0.23	0.54	0.49	2.19	*
1994	0	0.10	0.07	0.02	0.09	0.06	0.04	0.05	0.15	0.06	0.13	0.11	0.06	0	*
1995	0	0.04	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.29	0	*
1996	0	0.87	0.03	0.02	0.12	0.03	0.06	0.05	0.07	0.19	0.16	0.17	0.16	0	0
1997	0	0.01	0.01	0.01	0.02	0.02	0.02	0.04	0.09	0.03	0.18	0.05	0.05	0.07	0
1998	0	0.00	0.01	0.02	0.02	0.01	0.07	0.02	0.02	0.02	0.02	0.05	0.15	0.11	0.21
1999	0	0.10	0.01	0.01	0.02	0.02	0.02	0.03	0.05	0.06	0.05	0.06	0.02	0	0.19
2000	0	0.03	0.02	0.01	0.01	0.02	0.03	0.02	0.02	0.04	0.03	0.13	0.03	0.26	0.02
2001	0	0.05	0.02	0.01	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.06	0.07	0.18	0.03
2002	0	0.05	0.02	0.01	0.01	0.03	0.02	0.01	0.03	0.06	0.03	0.04	0.14	0.37	*
2003	0	0.04	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.05	0.06	0.09	0.20	0.04
2004	0	0.10	0.01	0.01	0.02	0.02	0.01	0.02	0.03	0.02	0.03	0.04	0.06	0.07	*
2005	0	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.05	0.06	0.07	*
2006	0	0.07	0.03	0.02	0.02	0.03	0.02	0.02	0.03	0.04	0.04	0.06	0.11	0.09	*
2007	0	0.06	0.02	0.01	0.01	0.01	0.03	0.08	0.06	0.04	0.09	0.06	0.04	0.14	*
2008	0	0.07	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.04	0.05	0.25	0.05	*
2009	0	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.06	0.06	0.05	*
2010	0	0.03	0.02	0.01	0.01	0.01	0.02	0.04	0.02	0.02	0.02	0.03	0.03	0.06	*
2011	0	0.02	0.02	0.01	0.02	0.02	0.01	0.02	0.01	0.02	0.02	0.15	0.07	0.06	*
2012	0	0.03	0.02	0.02	0.02	0.03	0.02	0.04	0.04	0.03	0.03	0.16	0.07	0.10	*
2013	0	0.07	0.02	0.01	0.02	0.03	0.02	0.06	0.02	0.03	0.04	0.04	0.05	0.06	*
2014	0	0.03	0.01	0.02	0.02	0.05	0.04	0.06	0.04	0.05	0.04	0.04	0.07	0.10	*
2015	0	0.03	0.02	0.01	0.02	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.07	0.15	*
2016	0	0.03	0.01	0.01	0.01	0.02	0.03	0.02	0.02	0.02	0.02	0.03	0.05	0.11	*
2017	0	0.04	0.01	0.02	0.01	0.01	0.02	0.02	0.02	0.04	0.04	0.04	0.05	0.04	*
2018	0	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.04	0.04	0.03	0.04	0.05	0.18	*
2019	0	0.06	0.02	0.01	0.01	0.02	0.03	0.02	0.07	0.07	0.02	0.05	0.04	0.13	*
2020	0	0.05	0.02	0.01	0.01	0.03	0.04	0.01	0.02	0.04	0.04	0.08	0.06	0.07	*
2021	0	0.02	0.01	0.04	0.02	0.02	0.03	0.03	0.05	0.06	0.07	0.11	0.16	0.09	*

* Note: CV values >1.00 are noted by shading. CVs could not be calculated for age 15+ when more than one age class was present in the group.

Table 12. Un-weighted striped bass catch per unit effort (CPUE) by year-class, late March through May 2021. Values are presented by sex, area, and percent of total. CPUE is number of fish per hour in 1000 yards of experimental drift net.

Year-class	Age	Pooled Unweighted CPUE	% of Total	Females		Males	
				Potomac	Upper Bay	Potomac	Upper Bay
2020	1	0.0	0.0	0.0	0.0	0.0	0.0
2019	2	23.6	5.2	0.0	0.0	12.2	11.4
2018	3	132.8	29.2	0.0	0.0	80.5	52.3
2017	4	64.1	14.1	0.0	0.0	30.7	33.4
2016	5	47.4	10.4	0.0	1.9	19.0	26.4
2015	6	98.1	21.6	1.7	5.2	39.2	52.1
2014	7	16.7	3.7	1.0	0.9	5.9	8.9
2013	8	5.5	1.2	0.1	0.3	1.0	4.1
2012	9	5.0	1.1	0.2	1.8	0.5	2.5
2011	10	39.9	8.8	10.6	14.4	4.0	10.9
2010	11	6.9	1.5	2.6	1.1	0.0	3.2
2009	12	1.5	0.3	1.3	0.2	0.0	0.0
2008	13	0.7	0.2	0.4	0.3	0.0	0.0
2007	14	1.4	0.3	0.1	0.5	0.0	0.8
≤2006	15+	10.8	2.4	1.7	3.5	0.0	5.6
Total		454.5		19.7	30.2	193.0	211.6
% of Total				4.3	6.7	42.5	46.6
% of Sex				39.4	60.6	47.7	52.3
% of System				9.3	12.5	90.7	87.5

Table 13. Striped bass catch per unit effort (CPUE) by year-class, weighted by spawning area*, late March through May 2021. Values are presented as percent of total, sex-specific, and area-specific CPUE. CPUE is number of fish per hour in 1000 yards of experimental drift net.

Year-class	Age	Pooled Weighted CPUE	% of Total	Females		Males	
				Potomac	Upper Bay	Potomac	Upper Bay
2020	1	0.0	0.0	0.0	0.0	0.0	0.0
2019	2	11.7	5.1	0.0	0.0	4.7	7.0
2018	3	63.2	27.4	0.0	0.0	31.0	32.1
2017	4	32.3	14.0	0.0	0.0	11.8	20.5
2016	5	24.7	10.7	0.0	1.1	7.3	16.3
2015	6	50.9	22.1	0.6	3.2	15.1	32.0
2014	7	8.7	3.8	0.4	0.6	2.3	5.5
2013	8	3.1	1.4	0.0	0.2	0.4	2.5
2012	9	2.9	1.3	0.1	1.1	0.2	1.6
2011	10	21.2	9.2	4.1	8.8	1.6	6.7
2010	11	3.7	1.6	1.0	0.7	0.0	2.0
2009	12	0.6	0.3	0.5	0.1	0.0	0.0
2008	13	0.4	0.2	0.2	0.2	0.0	0.0
2007	14	0.9	0.4	0.0	0.3	0.0	0.5
≤2006	15+	6.3	2.7	0.6	2.2	0.0	3.5
Total		230.6		7.6	18.6	74.4	130.0
% of Total				3.3	8.1	32.3	56.4
% of Sex				29.0	71.0	36.4	63.6
% of System				9.3	12.5	90.7	87.5

* Spawning area weights used: Potomac (0.385); Upper Bay (0.615).

Table 14. Mean length-at-age (mm TL) statistics for male striped bass collected in the Potomac River and the Upper Bay, and areas combined, late March through May 2021.

YEAR-CLASS	AGE	AREA	N	MEAN	LCL	UCL	SD	SE
2019	2	POTOMAC	6	331	306	356	24	10
		UPPER	5	278	242	313	29	13
		COMBINED	11	307	282	332	37	11
2018	3	POTOMAC	19	381	358	404	47	11
		UPPER	27	374	356	392	46	9
		COMBINED	46	377	363	390	46	7
2017	4	POTOMAC	15	438	410	466	51	13
		UPPER	5	383	270	496	91	41
		COMBINED	20	424	394	455	65	15
2016	5	POTOMAC	9	527	503	551	32	11
		UPPER	8	480	446	513	40	14
		COMBINED	17	505	483	526	42	10
2015	6	POTOMAC	21	596	572	620	53	12
		UPPER	33	581	557	605	68	12
		COMBINED	54	587	570	604	62	8
2014	7	POTOMAC	7	617	578	656	43	16
		UPPER	11	650	605	694	66	20
		COMBINED	18	637	608	666	59	14
2013	8	POTOMAC	0	-	-	-	-	-
		UPPER	7	681	640	721	44	17
		COMBINED	7	681	640	721	44	17
2012	9	POTOMAC	0	-	-	-	-	-
		UPPER	8	726	652	800	88	31
		COMBINED	8	726	652	800	88	31
2011	10	POTOMAC	2	832	*	*	*	*
		UPPER	14	780	704	855	131	35
		COMBINED	16	786	716	856	131	33
2010	11	POTOMAC	0	-	-	-	-	-
		UPPER	1	857	-	-	-	-
		COMBINED	1	857	-	-	-	-
2007	14	POTOMAC	0	-	-	-	-	-
		UPPER	1	1039	-	-	-	-
		COMBINED	1	1039	-	-	-	-
2005	16	POTOMAC	0	-	-	-	-	-
		UPPER	1	1102	-	-	-	-
		COMBINED	1	1102	-	-	-	-

* Values omitted for being biologically unreasonable due to small sample sizes.

Table 15. Mean length-at-age (mm TL) statistics for female striped bass collected in the Potomac River and the Upper Bay, and areas combined, late March through May 2021.

YEAR-CLASS	AGE	AREA	N	MEAN	LCL	UCL	SD	SE
2016	5	POTOMAC	0	-	-	-	-	-
		UPPER	1	564	-	-	-	-
		COMBINED	1	564	-	-	-	-
2015	6	POTOMAC	2	668	598	737	8	6
		UPPER	3	650	501	798	60	34
		COMBINED	5	657	603	711	44	19
2014	7	POTOMAC	1	691	-	-	-	-
		UPPER	1	667	-	-	-	-
		COMBINED	2	679	527	831	17	12
2013	8	POTOMAC	0	-	-	-	-	-
		UPPER	2	694	580	808	13	9
		COMBINED	2	694	580	808	13	9
2012	9	POTOMAC	2	953	895	1010	6	5
		UPPER	1	767	-	-	-	-
		COMBINED	3	891	624	1157	107	62
2011	10	POTOMAC	9	987	956	1019	41	14
		UPPER	19	985	951	1020	72	17
		COMBINED	28	986	962	1010	63	12
2010	11	POTOMAC	3	993	895	1092	40	23
		UPPER	2	1053	*	*	*	*
		COMBINED	5	1017	947	1087	56	25
2009	12	POTOMAC	1	1088	-	-	-	-
		UPPER	1	1018	-	-	-	-
		COMBINED	2	1053	*	*	*	*
2008	13	POTOMAC	3	1079	1003	1156	31	18
		UPPER	0	-	-	-	-	-
		COMBINED	3	1079	1003	1156	31	18
2007	14	POTOMAC	0	-	-	-	-	-
		UPPER	1	1155	-	-	-	-
		COMBINED	1	1155	-	-	-	-
2006	15	POTOMAC	1	1100	-	-	-	-
		UPPER	5	1108	1064	1151	35	16
		COMBINED	6	1106	1073	1139	31	13
2005	16	POTOMAC	2	1135	*	*	*	*
		UPPER	4	1157	1094	1221	40	20
		COMBINED	6	1150	1108	1191	40	16
2004	17	POTOMAC	0	-	-	-	-	-
		UPPER	1	1105	-	-	-	-
		COMBINED	1	1105	-	-	-	-
2003	18	POTOMAC	1	1116	-	-	-	-
		UPPER	1	1122	-	-	-	-
		COMBINED	2	1119	1081	1157	4	3

* Values omitted for being biologically unreasonable due to small sample sizes.

Table 16. Index of spawning potential by year, for female striped bass ≥ 500 mm TL sampled from spawning areas of the Chesapeake Bay during March, April and May since 1985. The index is selectivity-corrected CPUE converted to biomass (kg) using parameters from a length-weight regression.

Year	Upper Bay	Potomac River
1985	65	26
1986	152	46
1987	400	89
1988	250	64
1989	120	81
1990	98	63
1991	109	139
1992	275	379
1993	279	421
1994	87	Not Sampled
1995	548	294
1996	348	392
1997	240	362
1998	156	227
1999	168	281
2000	193	325
2001	479	272
2002	276	399
2003	563	118
2004	376	530
2005	470	196
2006	406	458
2007	419	263
2008	229	163
2009	483	190
2010	280	213
2011	168	105
2012	799	150
2013	770	172
2014	876	222
2015	765	309
2016	414	165
2017	411	387
2018	323	73
2019	371	58
2020	271	425
2021	238	190
Average	**348**	**229**

Figure 1. Drift gill net sampling locations in spawning areas of the Upper Chesapeake Bay and the Potomac River.

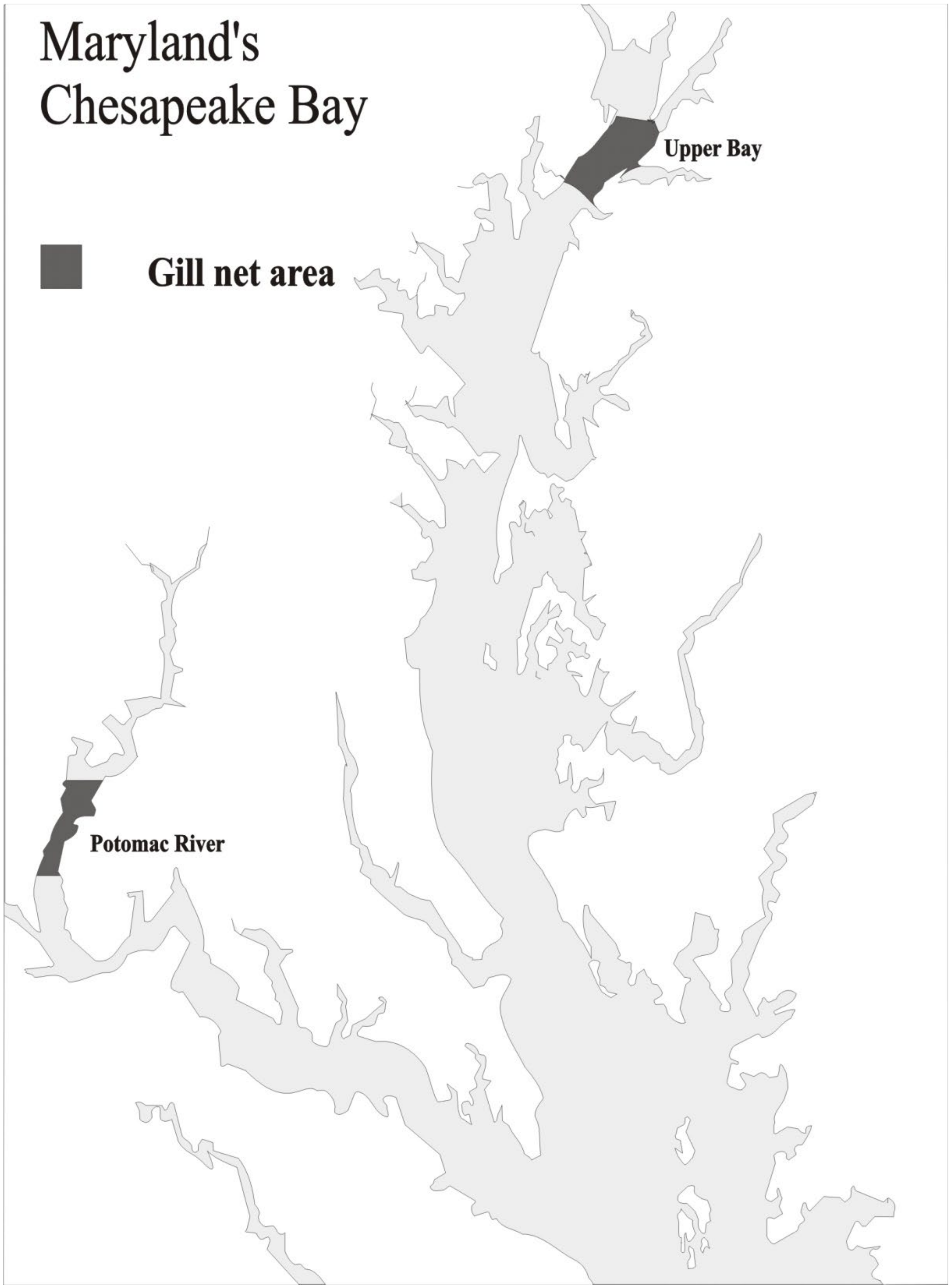


Figure 2. Daily effort-corrected catch of female and male striped bass, with surface water temperature in the spawning reach of the Potomac River, late March through May 2021. Effort is standardized as 1000 square yards of experimental gill net per hour. Note different scales.

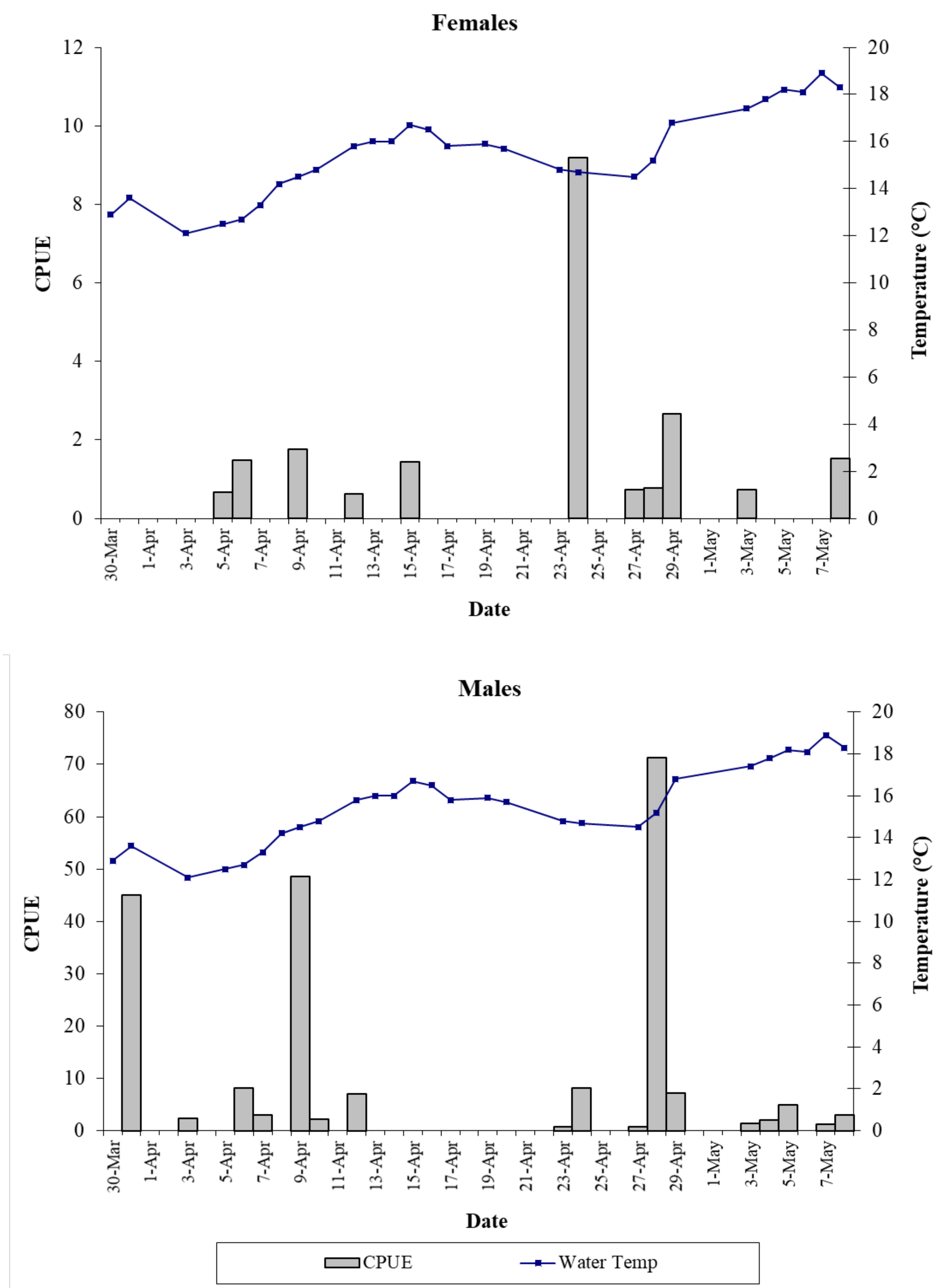


Figure 3. Daily effort-corrected catch of female and male striped bass, with surface water temperature in the spawning reach of the Upper Chesapeake Bay, April through May 2021. Effort is standardized as 1000 square yards of experimental drift gill net per hour. Note different scales. Sampling did not occur from April 20 – May 1.

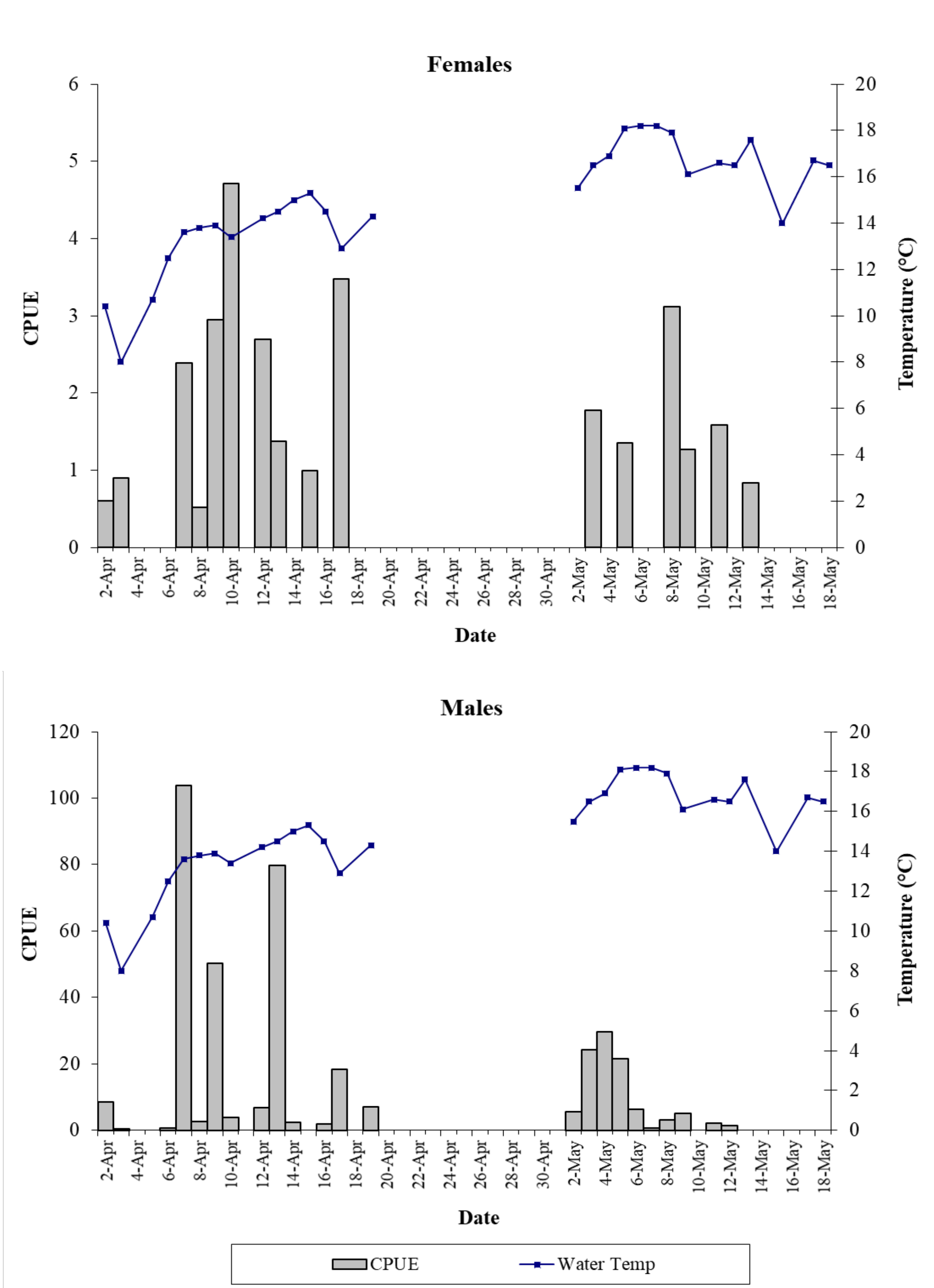
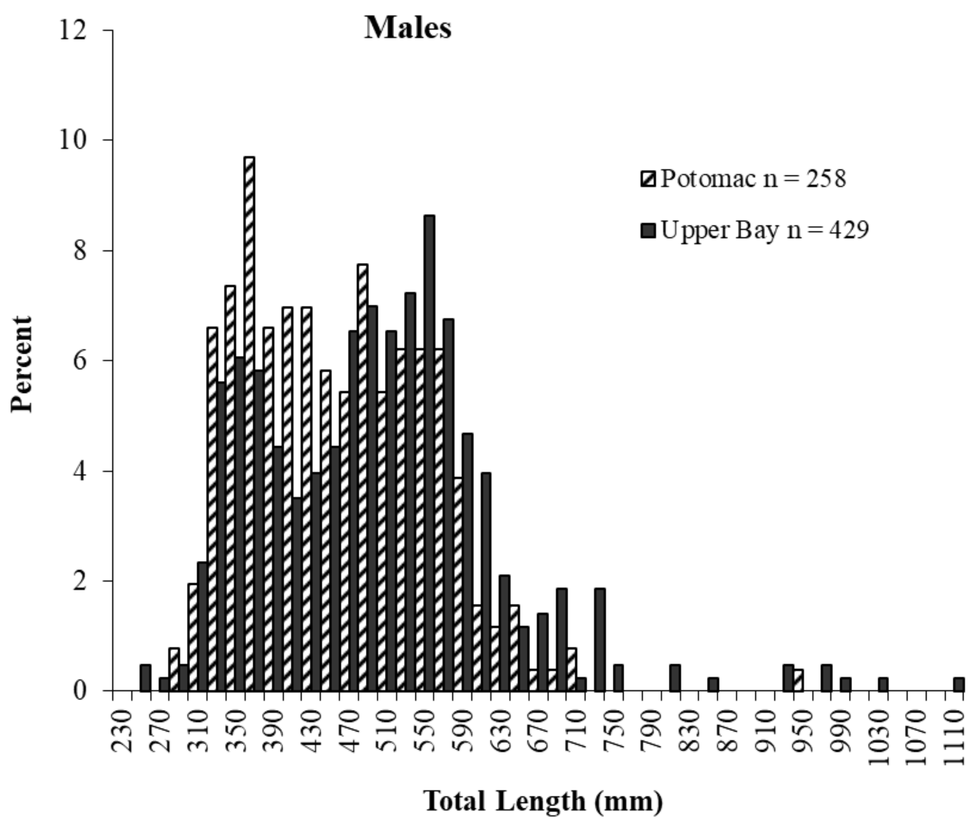


Figure 4. Length frequency of male and female striped bass from the spawning areas of the Upper Chesapeake Bay and Potomac River, late March through May 2021. Note different scales.



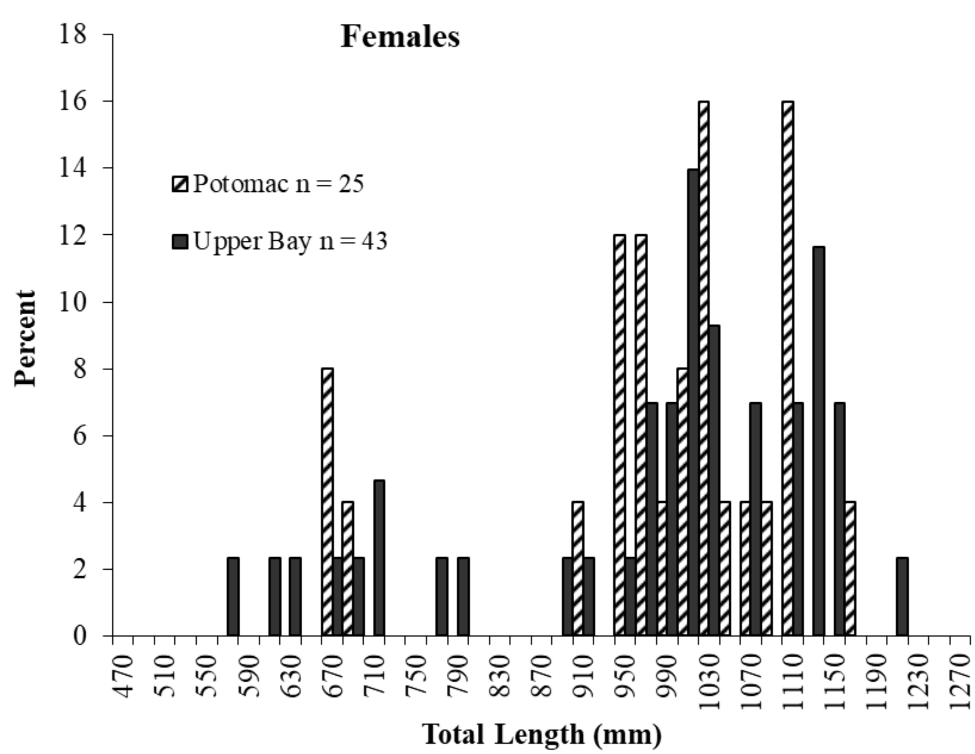
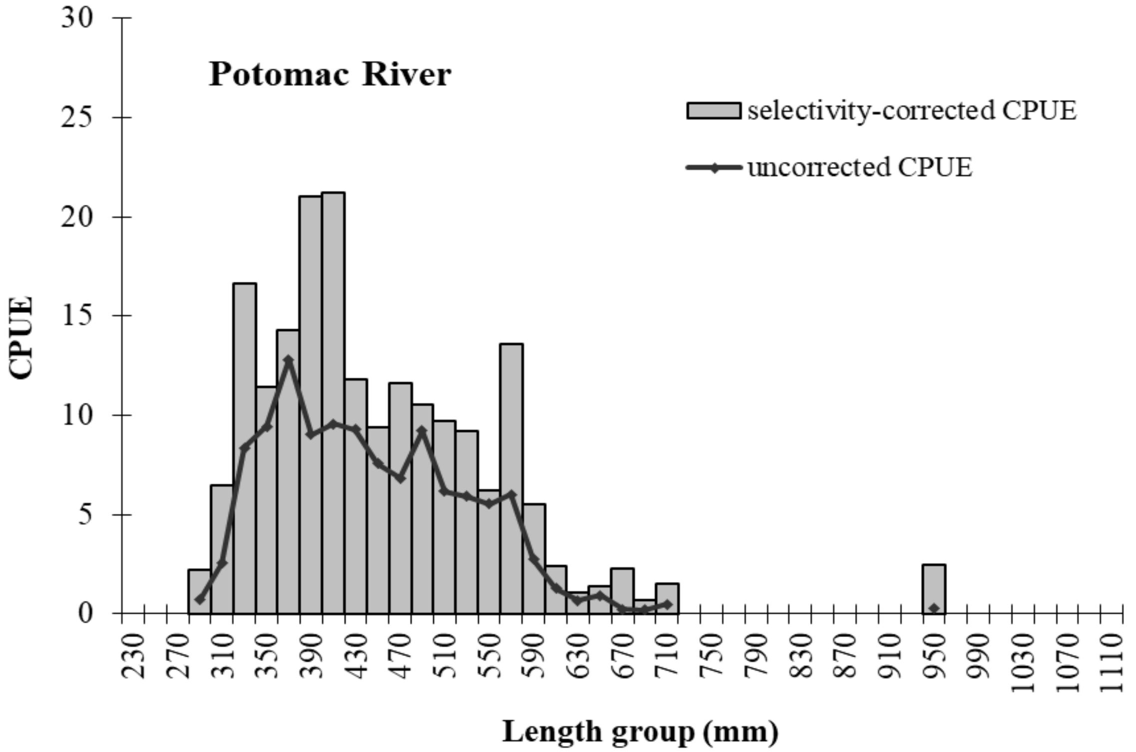


Figure 5. Length group CPUE (uncorrected and corrected for gear selectivity) of male striped bass collected from spawning areas of the Upper Bay and Potomac River, late March - May 2021. CPUE is the number of fish captured per hour in 1000 square yards of experimental drift net.



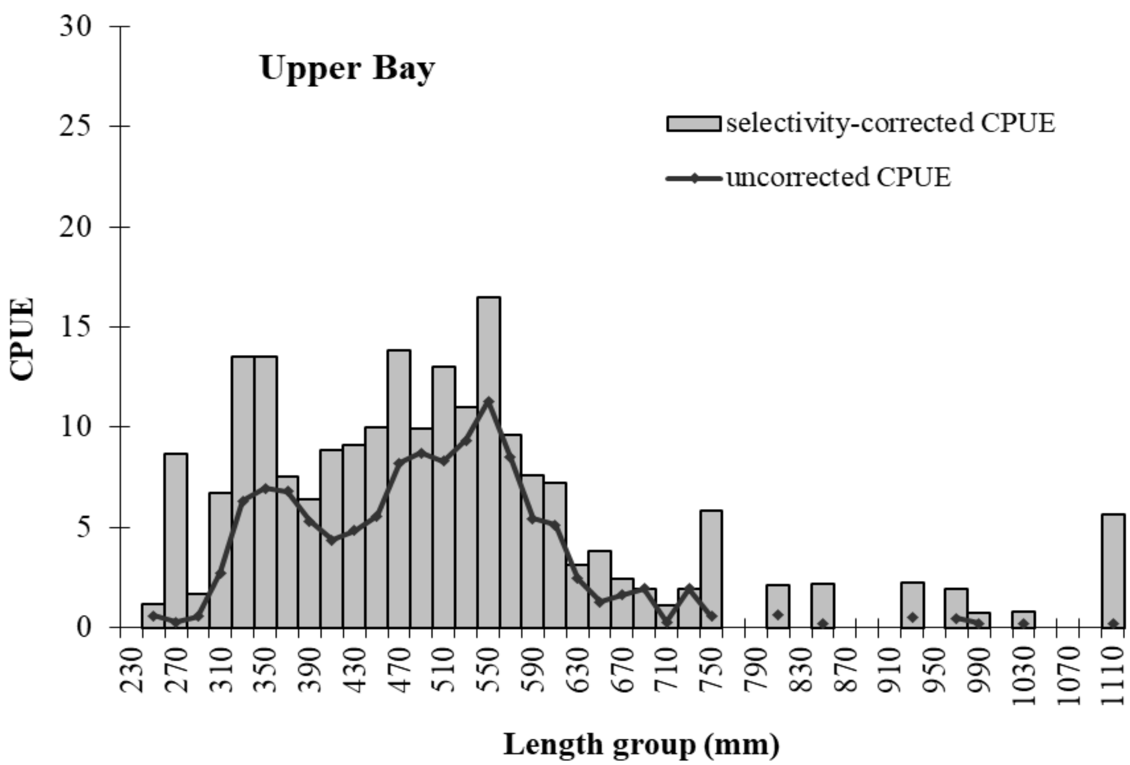
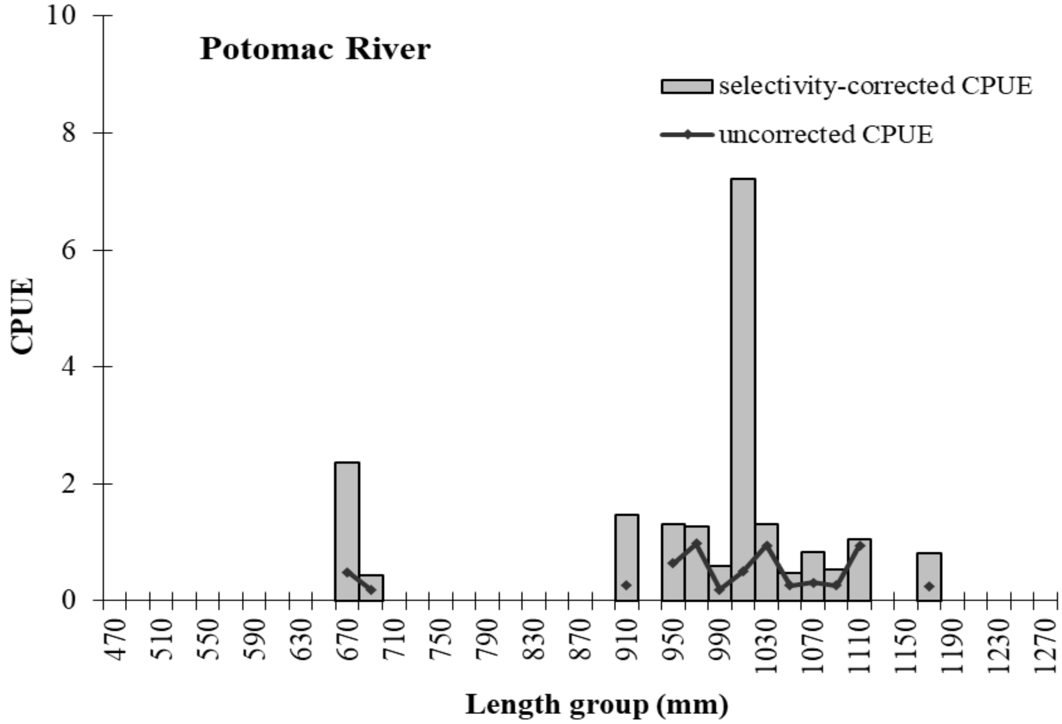


Figure 6. Length group CPUE (uncorrected and corrected for gear selectivity) of female striped bass collected from spawning areas of the Upper Bay and Potomac River, late March - May 2021. CPUE is the number of fish captured per hour in 1000 square yards of experimental drift net.



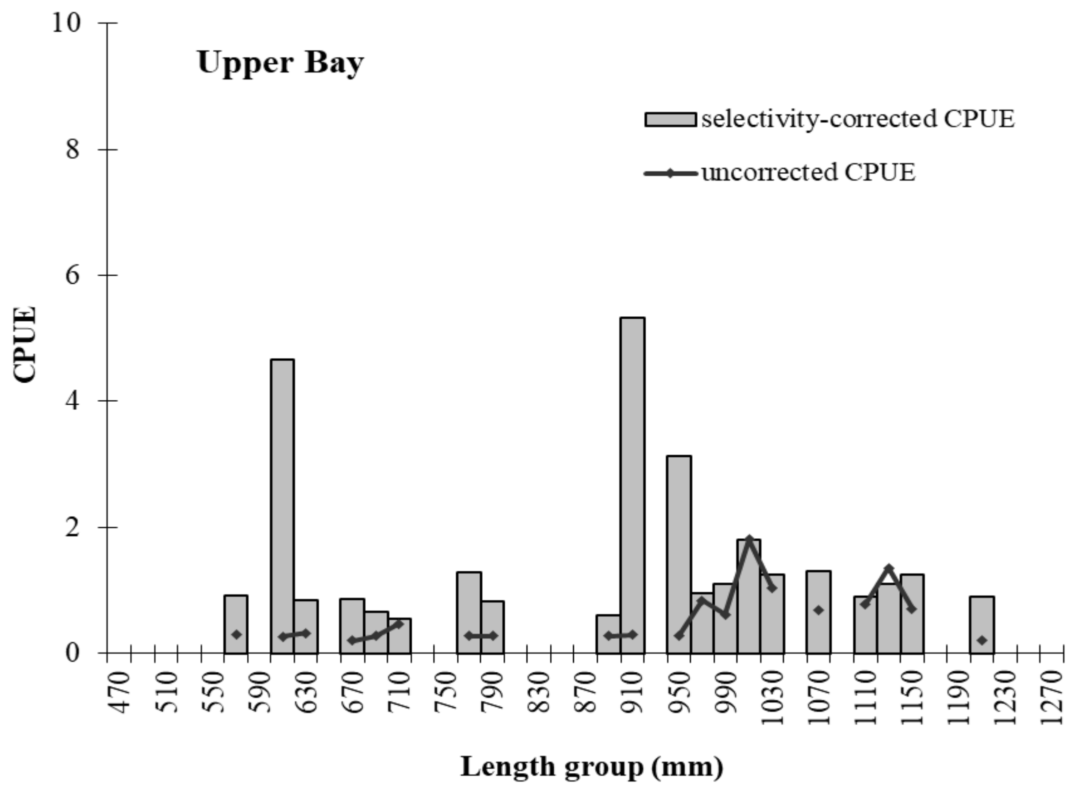


Figure 7. Mean length (mm TL) by year for individual ages of male striped bass sampled from spawning areas of the Potomac River and Upper Chesapeake Bay during March through May, 1985-2021. Error bars are ± 2 standard errors (SE). The Potomac River was not sampled in 1994. *Note difference in scales on y-axis.

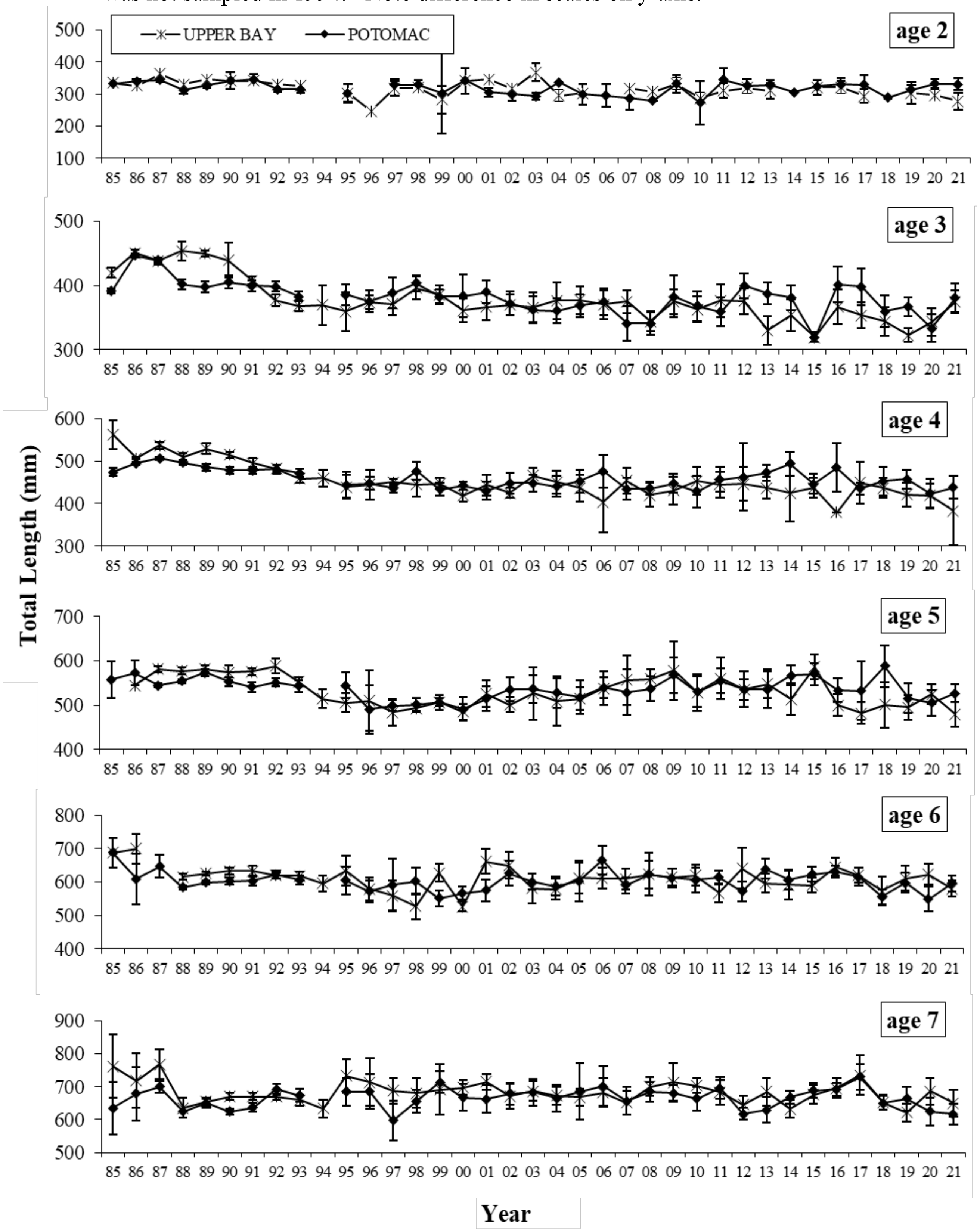


Figure 7. Continued.

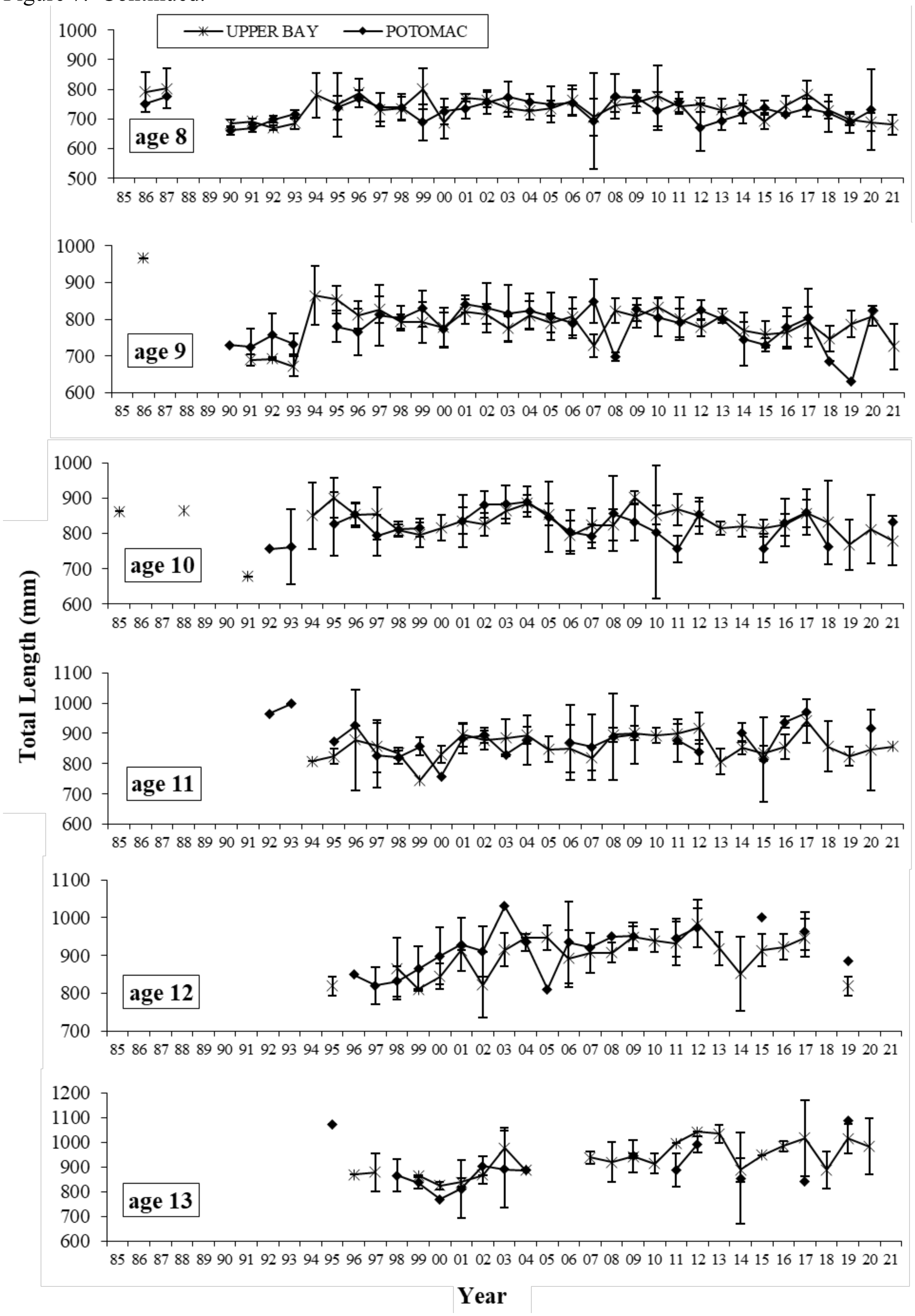


Figure 8. Mean length (mm TL) by year for individual ages of female striped bass sampled from spawning areas of the Potomac River and Upper Chesapeake Bay during March through May, 1985–2021. Error bars are ± 2 standard errors (SE). Note the Potomac River was not sampled in 1994. *Note difference in scales on y-axis.

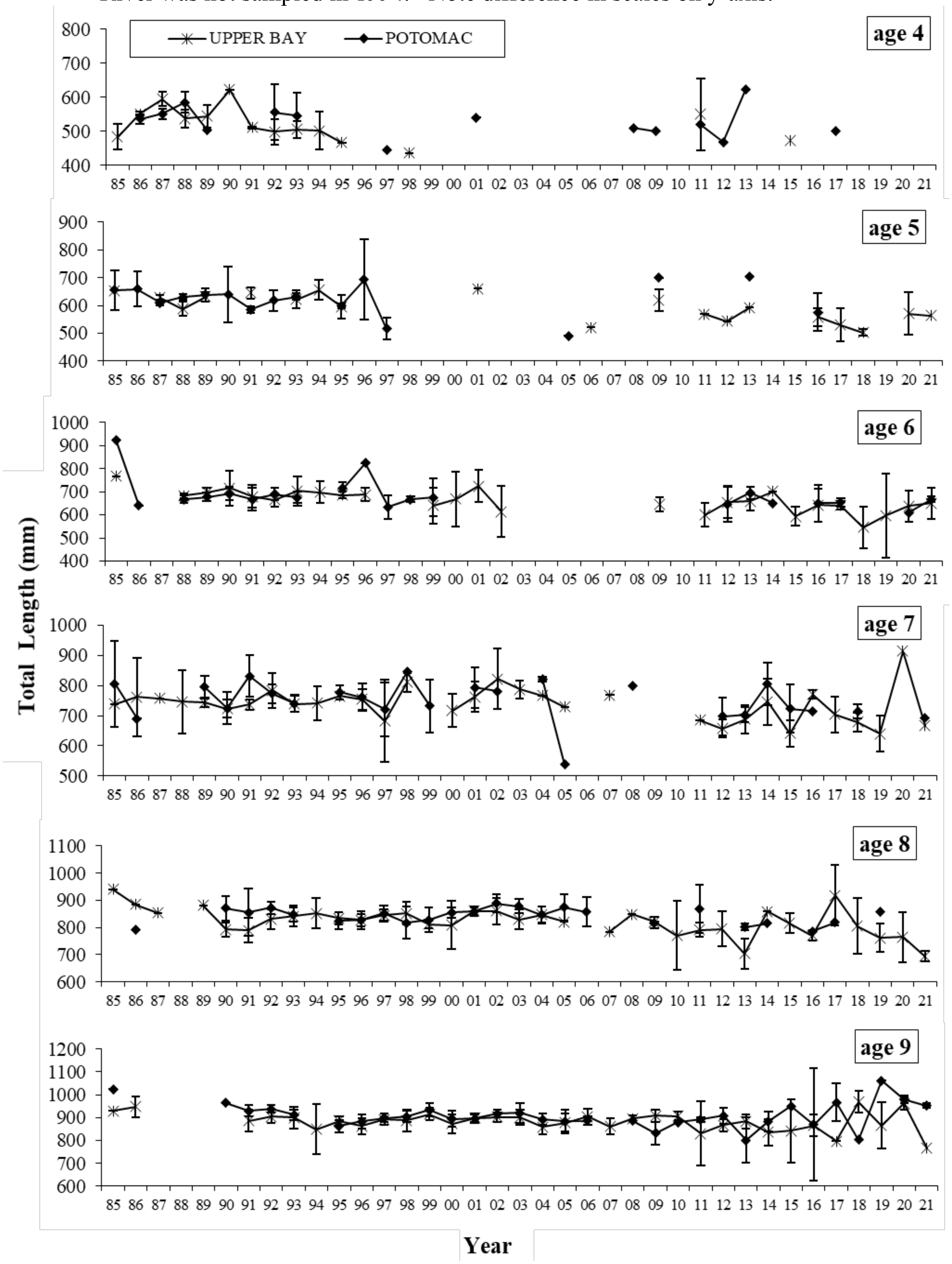


Figure 8. Continued.

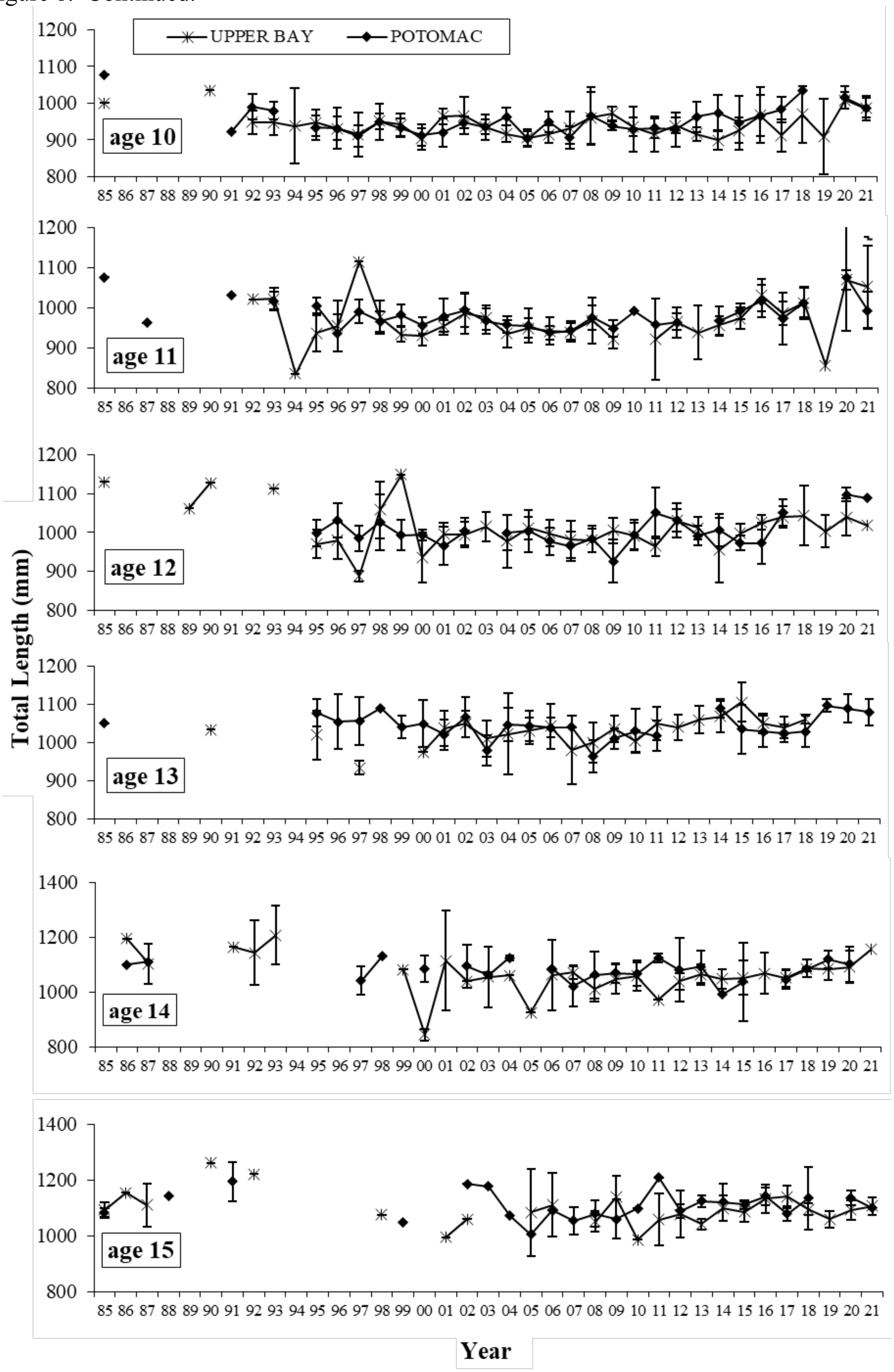


Figure 9. Maryland Chesapeake Bay spawning stock indices used in the coastal assessment. These are selectivity-corrected estimates of CPUE by year for ages 2 through 15+. Areas and sexes are pooled, although the contribution of sexes is shown in the stacked bars. Note different scales.

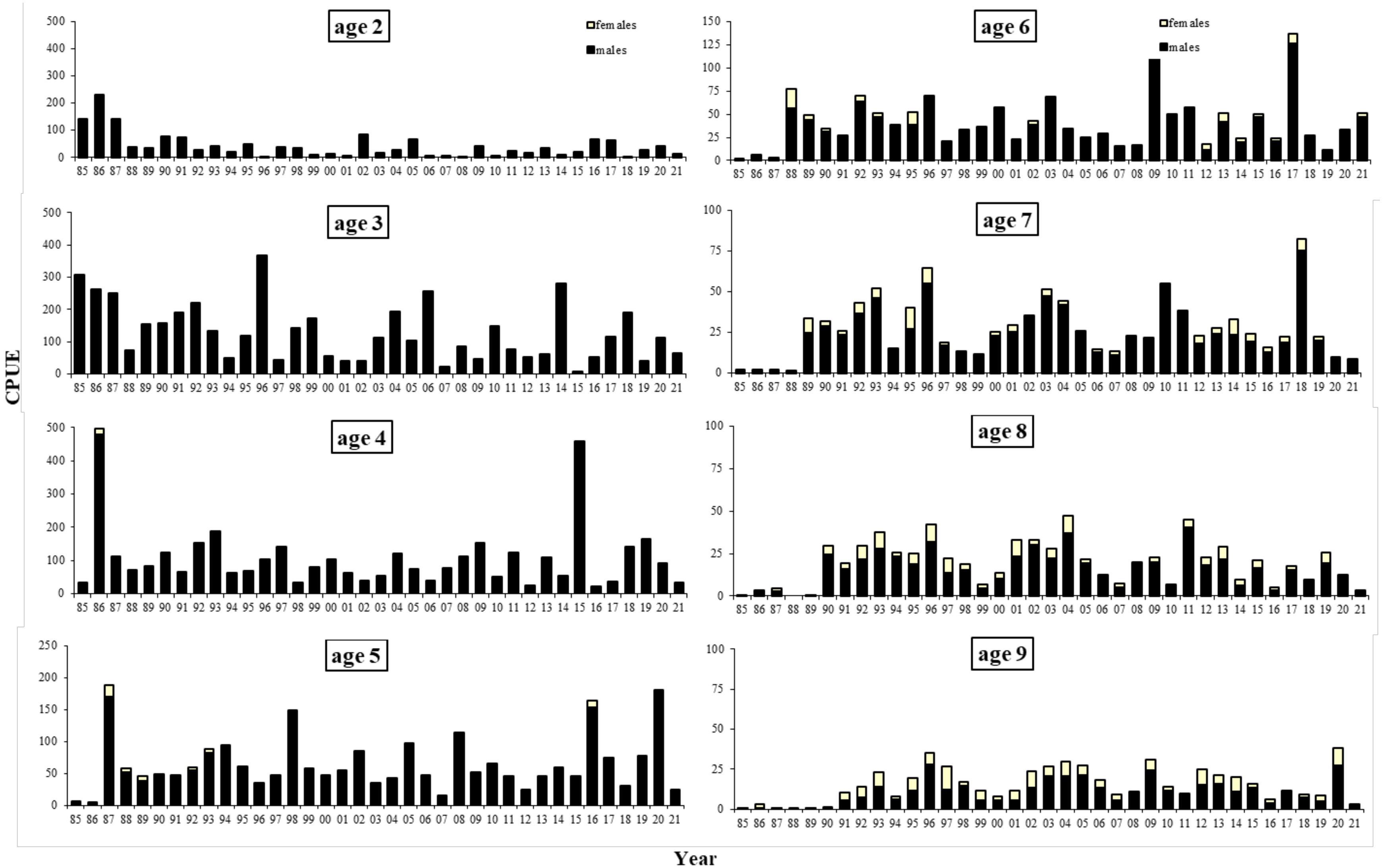


Figure 9. Continued.

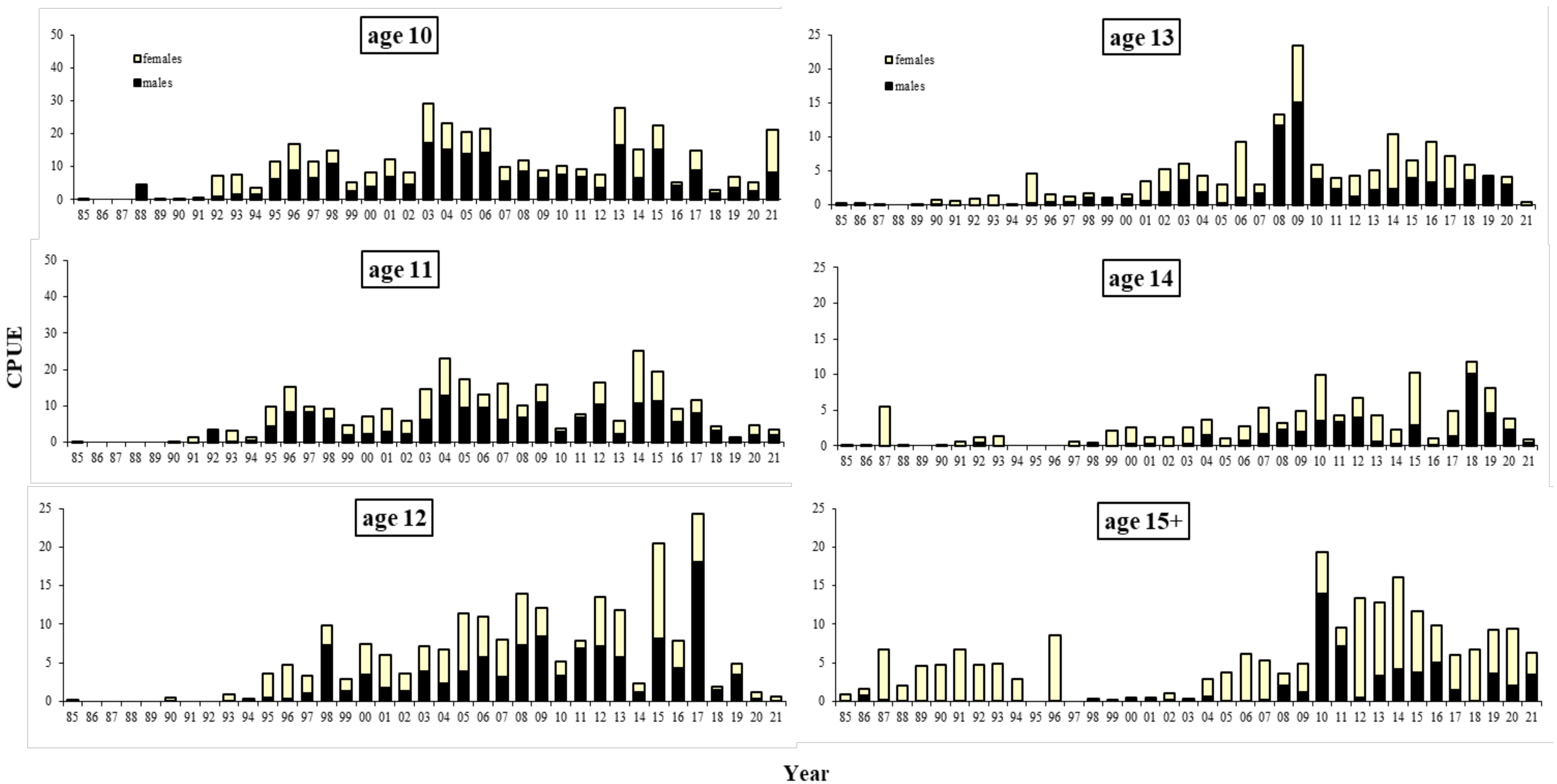
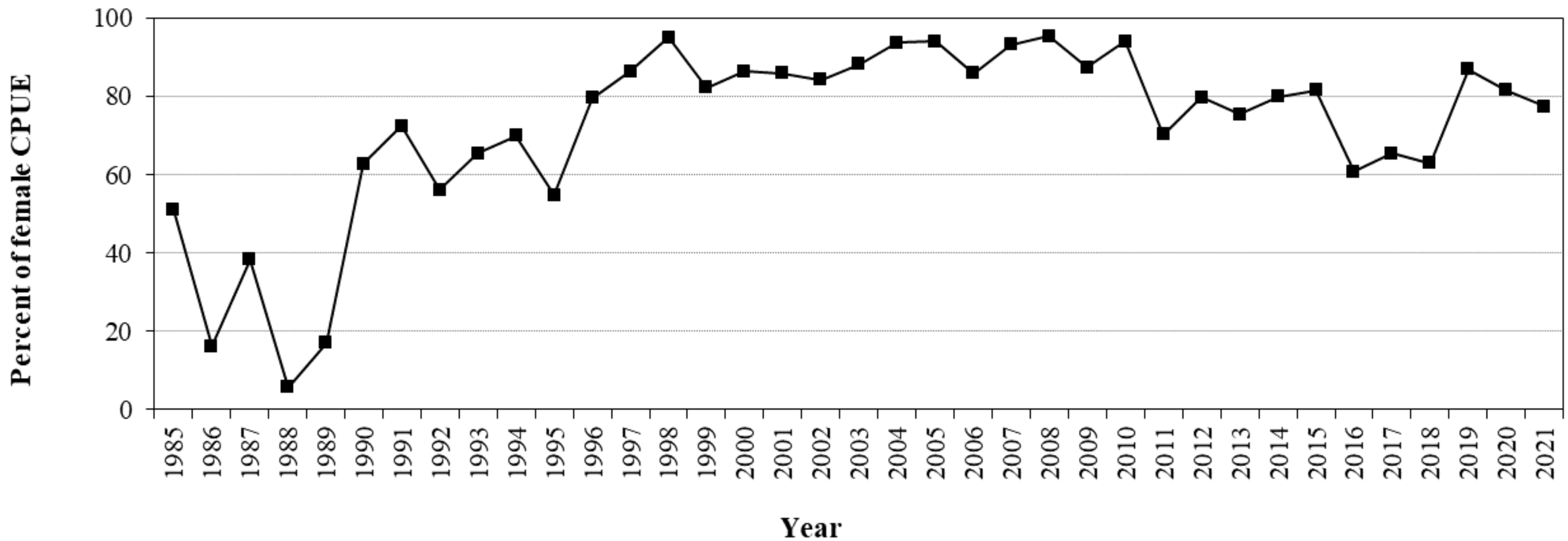
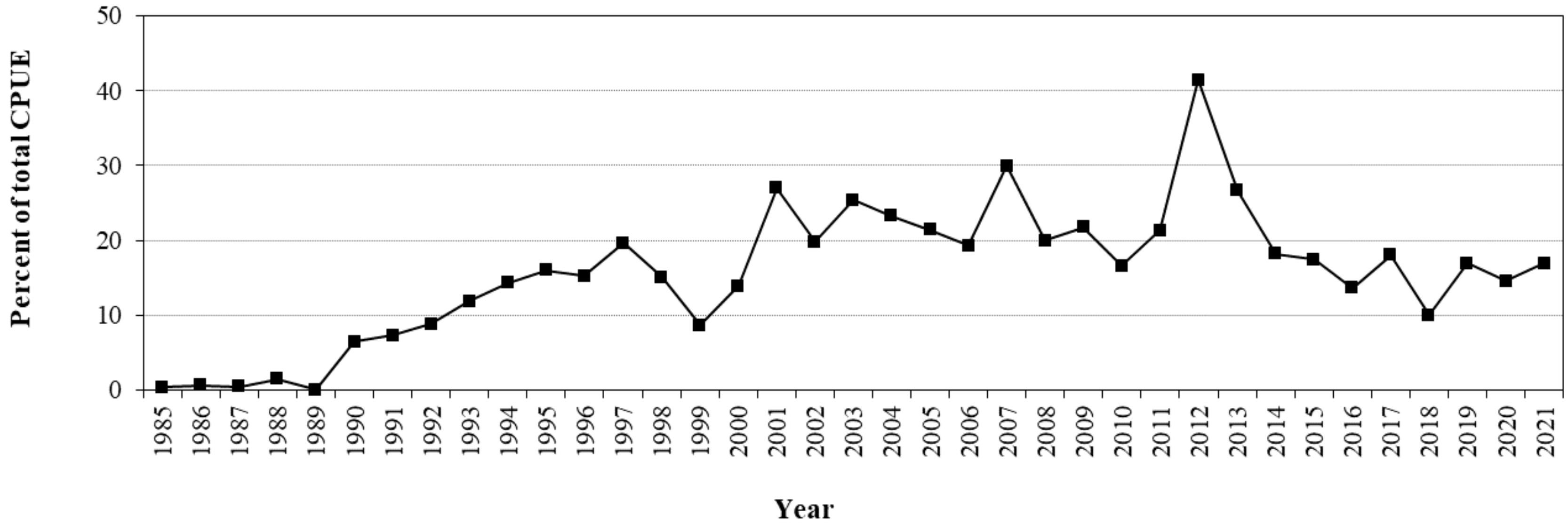


Figure 10. Percentage (selectivity-corrected CPUE) of female striped bass that were age 8 and older sampled from experimental drift gill nets set in spawning reaches of the Potomac River, Choptank River and the Upper Chesapeake Bay, March through May, 1985-2021 (Choptank River to 1996). Effort is standardized as 1000 square yards of net per hour. Area-specific indices were weighted based on the relative size of the spawning areas* before area-specific indices were pooled.



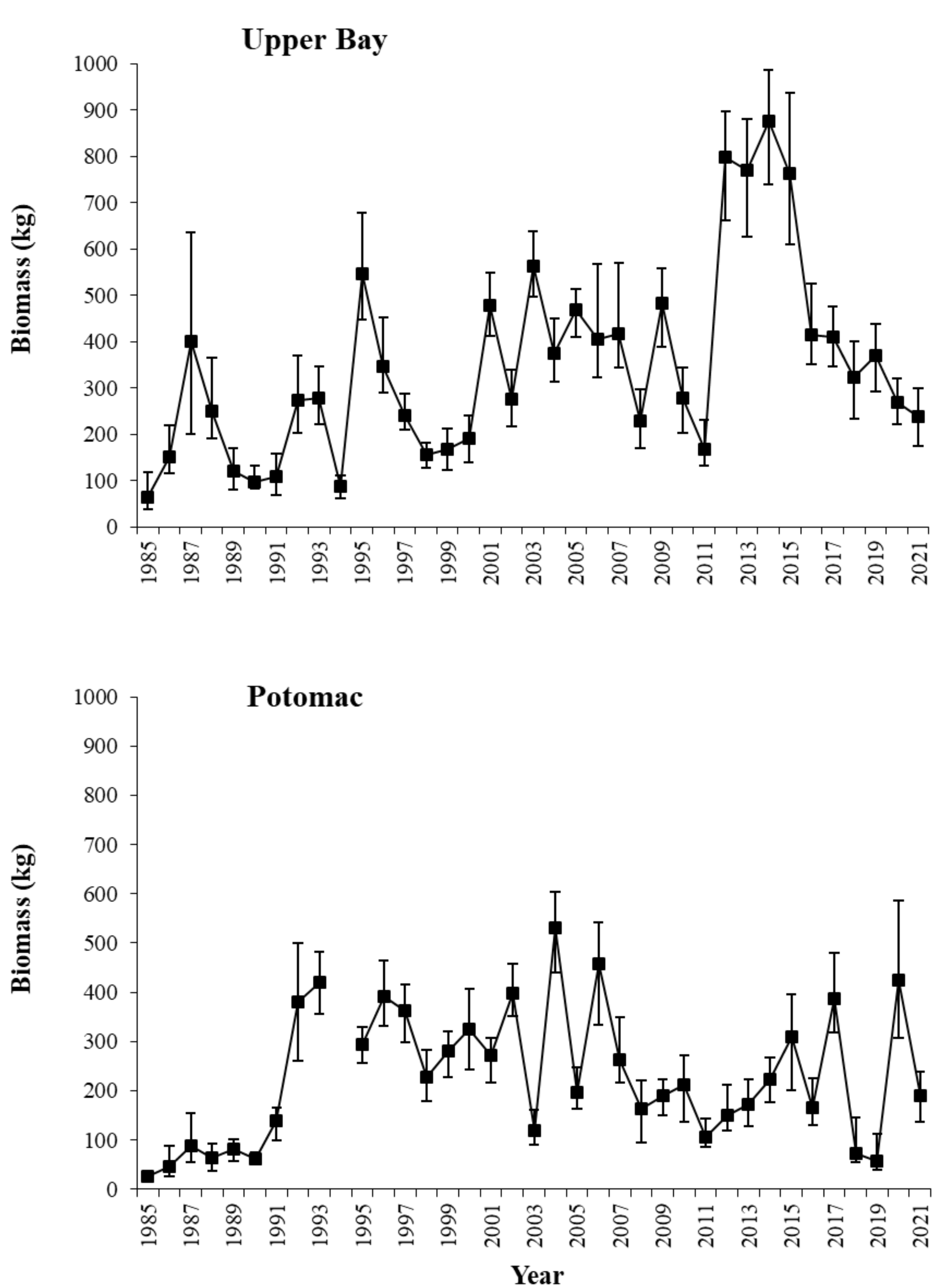
* Weights for spawning areas (1985 - 1996): Upper Bay=0.59; Potomac River=0.37; Choptank River=0.04.
(1997 - Present): Upper Bay=0.615; Potomac River=0.385. (Hollis 1967).

Figure 11. Percentage (selectivity-corrected CPUE) of male and female striped bass age 8 and over sampled from experimental drift gill nets set in spawning reaches of the Potomac River, Choptank River and the Upper Chesapeake Bay, March through May, 1985-2021 (Choptank River to 1996). Effort is standardized as 1000 square yards of net per hour. Area-specific indices were weighted based on the relative size of the spawning areas* before area-specific indices were pooled.



* Weights for spawning areas (1985 - 1996): Upper Bay=0.59; Potomac River=0.37; Choptank River=0.04.
(1997 - Present): Upper Bay=0.615; Potomac River=0.385. (Hollis 1967).

Figure 12. Index of spawning potential, expressed as biomass (kg), of female striped bass greater than or equal to 500 mm TL collected from experimental drift gill nets fished in two spawning areas of the Maryland Chesapeake Bay during March through May, 1985-2021. The index is corrected for gear selectivity, and bootstrap 95% confidence intervals are shown around each point.



PROJECT NO. 2
JOB NO. 3
TASK NO. 3

MARYLAND JUVENILE STRIPED BASS SURVEY

Prepared by Eric Q. Durell

INTRODUCTION

The primary objective of Project 2, Job 3, Task 3, was to document annual year-class success for young-of-the-year (YOY) striped bass (*Morone saxatilis*) in Chesapeake Bay. Annual indices of relative abundance provide an early indicator of future adult stock recruitment (Schaefer 1972; Goodyear 1985) and document annual variation and long-term trends in abundance and distribution.

METHODS

Sample Area and Intensity

Juvenile indices were derived from sampling at 22 fixed stations within Maryland's portion of the Chesapeake Bay (Table 1, Figure 1). Sample sites were divided among four of the major spawning and nursery areas; seven each in the Potomac River and Head of Bay areas and four each in the Nanticoke and Choptank rivers. Sites have been sampled continuously since 1954, with changes in some site locations when physical conditions or access restrictions dictate.

Permission to access private property at Lower Cedar Point (#171) on the Potomac River could not be obtained, so a new site, Lower Cedar Point II (#172), was established approximately 0.25 miles upstream. The auxiliary site on the Susquehanna Flats at Tyding's Estate (#144) could not be sampled due to thick submerged aquatic vegetation and matted algae. Since no suitable replacements are available the Tyding's Estate site will be revisited in the future.

From 1954 to 1961, Maryland's juvenile survey included inconsistent stations and rounds.

Sample sizes ranged from 34 to 46. Indices derived for this period include only stations which are consistent with subsequent years. In 1962, stations were standardized, and a second sample round was added for a total of 88 samples. A third sample round, added in 1966, increased sample size to 132.

Sites were sampled monthly, with rounds (sampling excursions) occurring during July (Round I), August (Round II), and September (Round III). Replicate seine hauls, a minimum of thirty minutes apart, were taken at each site in each sample round. This protocol produced a total of 132 samples from which Bay-wide means were calculated.

Auxiliary stations have been sampled on an inconsistent basis and were not included in survey indices. These data enhance geographical coverage in rivers with permanent stations or provide information from areas not otherwise surveyed. They are also useful for replacement of permanent stations when necessary. Replicate hauls at auxiliary stations were discontinued in 1992 to conserve time and allow increased geographical coverage of spawning areas. Auxiliary stations were sampled at the Head of Bay (Susquehanna Flats and one downstream station), and the Patuxent River (Table 1, Figure 1).

Sample Protocol

A 30.5-m x 1.24-m bagless beach seine of untreated 6.4-mm bar mesh was set by hand. One end was held on shore while the other was fully stretched perpendicular from the beach and swept with the current. Field trials have shown that 492 m^2 is a realistic estimate of the area swept by the seine under ideal field conditions. When depths of 1.2 m or greater were encountered, the offshore end was deployed along this depth contour. An estimate of distance from the beach to this depth was recorded.

Striped bass and selected other species were separated into 0 and 1+ age groupings. Ages were assigned from length-frequencies and verified through scale examination. Age 0 fish were measured (mm total length) from a random sample of up to 30 individuals per site and round. All other finfish were identified to species and counted.

Additional data were collected at each site and sample round. These included: time of first haul, maximum distance from shore, weather, maximum depth, surface water temperature (°C), tide stage, surface salinity (ppt), primary and secondary bottom substrates, and submerged aquatic vegetation within the sample area (ranked by quartiles). Dissolved oxygen (DO), pH, and turbidity (Secchi disk) were added in 1997. All data since 1957 were entered and archived in Statistical Analysis System (SAS) databases (SAS 1990).

Estimators

The most commonly referenced striped bass 'juvenile index' is the arithmetic mean (AM). The AM has been used to predict harvest in New York waters (Schaefer 1972). Goodyear (1985) validated this index as a predictor of harvest in the Chesapeake Bay. The AM is an unbiased estimator of the mean regardless of the underlying frequency distribution (McConnaughey and Conquest 1992). The AM, however, is sensitive to high sample values (Sokol and Rolhf 1981). Additionally, detection of significant differences between annual arithmetic means is often not possible due to high variances (Heimbuch et al. 1983; Wilson and Wiesburg 1991).

The geometric mean (GM) was adopted by the Atlantic States Marine Fisheries Commission (ASMFC) Striped Bass Technical Committee in 1992 as the preferred index of relative abundance to model stock status. The GM is calculated from the $\log_e(x+1)$ transformation, where x is an individual seine haul catch. One is added to all catches in order to transform zero catches, because the log of 0 is undefined (Ricker 1975). Since the $\log_e$-transformation stabilizes the variance of catches (Richards 1992) the GM estimate is more precise than the AM and is not as sensitive to a single large sample value. It is almost always lower than the AM (Ricker 1975). The GM is presented with 95% confidence intervals (CIs) which are calculated as antilog ($\log_e(x+1)$ mean $\pm$ 2 standard errors), and provide a visual depiction of sample variability.

A third estimator, the proportion of positive hauls (PPHL), is the ratio of hauls containing juvenile striped bass to total hauls. Because the PPHL is based on the binomial distribution, it is very robust to bias and sampling error and greatly reduces variances (Green 1979). Its use as supplementary information is appropriate since seine estimates are often neither normally nor log-normally distributed (Richards 1992).

Comparison of these three indices is one method of assessing their accuracy. Similar trends among indices create more certainty that indices reflect actual changes in juvenile abundance. Greatly diverging trends may identify error in one or more of the indices.

Bay-wide annual indices are compared to the target period average (TPA). The TPA is the average of indices from 1959 through 1972. These years have been suggested as a period of stable biomass and general stock health (ASMFC 1989) and "an appropriate stock rebuilding target" (Gibson 1993). The TPA provides a fixed reference representing an average index produced by a healthy population. A fixed reference is an advantage over a time-series average that is revised annually and may be significantly biased by long-term trends in annual indices.

Differences among annual means were tested with an analysis of variance (GLM; SAS 1990) on the $\log_e(x+1)$ transformed data. Means were considered significant at the $\alpha=0.05$ level. Duncan's multiple range test was used to differentiate means.

RESULTS

Bay-wide Means

A total of 422 YOY striped bass was collected at permanent stations in 2021, with individual samples yielding between 0 and 44 fish. The AM (3.20) and GM (1.65) were both below their respective time-series averages and TPAs (Tables 2 and 3, Figures 2 and 3). The PPHL was 0.64, indicating that 64% of samples produced juvenile striped bass. The PPHL was below the time-series average of 0.71 (Table 4, Figure 4).

A one-way analysis of variance (ANOVA) performed on the $\log_e$-transformed catch values indicated significant differences among annual means (ANOVA: P<0.0001) (SAS 1990). Duncan's multiple range test (α=0.05) found that the 2021 $\log_e$-mean was significantly greater than only the 5 worst years of the time-series (1959, 1981, 1983, 1988 and 2012).

System Means

Head of Bay - In 42 samples, 221 juveniles were collected at the Head of Bay sites for an AM of 5.3, less than the time-series average (11.6) and the TPA (17.3) (Table 2, Figure 5). The GM of 3.16 was also less than the time-series average (5.70) and the TPA (7.27) (Table 3, Figure 6). Differences in annual $\log_e$-means were significant (ANOVA: P<0.0001). Duncan's multiple range test (p=0.05) found the 2021 Head of Bay $\log_e$-mean greater than 11 year-classes of the time-series and indiscernible from 32 others.

Potomac River - A total of 32 juveniles was collected in 42 samples on the Potomac River. The AM of 0.8 was lower than both the time-series average (7.9) and TPA (9.2) (Table 2, Figure 5). The GM of 0.44 was also below the time-series average (3.47) and TPA (3.93) (Table 3, Figure 7). Analysis of variance of $\log_e$-means indicated significant differences among years (ANOVA: P<0.0001). Duncan's multiple range test (α=0.05) ranked the 2021 Potomac River year-class significantly smaller than 38 years of the time-series and indiscernible from 26 others.

Choptank River - A total of 79 juveniles was collected in 24 Choptank River samples. The AM of 3.3 was below the time-series average of 20.1 and the TPA (10.8) (Table 2, Figure 5). The GM of 1.93 was less than its time-series average (7.75) and TPA (5.00) (Table 3, Figure 8). Differences among years were significant (ANOVA: P<0.0001). Duncan's multiple range test (α=0.05) found the 2021 Choptank River year-class significantly larger than just 3 years of the time-series (1959, 2012 and 2020).

Nanticoke River - A total of 90 juveniles was collected in 24 samples on the Nanticoke River. The AM of 3.8 was below the time-series average (8.7) and the TPA (8.6) (Table 2, Figure 5). The GM of 2.14 was below its time-series average (4.00) and TPA (3.12) (Table 3, Figure 9). Striped bass recruitment in the Nanticoke River exhibited significant differences among years (ANOVA: $P<0.0001$). Duncan's multiple range test ($\alpha=0.05$) found the 2021 index significantly greater than just 2 years of the time-series (1968 and 2012) and indiscernible from 52 other years.

Auxiliary Indices

At the **Head of Bay auxiliary sites**, 78 juveniles were caught in 12 samples, resulting in an AM of 6.5, and a GM of 4.62. Both indices were above their respective time-series averages (Table 5).

On the **Patuxent River**, 3 YOY striped bass were caught in 18 samples. The AM of 0.2 and GM of 0.12 were both less than their respective time-averages (Table 5).

DISCUSSION

Striped bass recruitment in Maryland's portion of Chesapeake Bay was below average for the third consecutive year. The 2021 GM of 1.65, however, does not meet the definition of recruitment failure specified by Addendum II to Amendment 6 of the Interstate Fishery Management Plan (ASMFC 2010). Recruitment failure in Maryland's portion of the Chesapeake Bay is defined as a GM index below 75% of the values from 1959 to 2009, or a GM less than 1.6.

Recruitment in individual systems is often variable, but was consistently poor again in 2021. The highest performing systems were the Head-of-Bay and Nanticoke, with GMs just below the median values of their respective time-series. The Potomac River was the poorest performing system, with the GM ranked in the sixth percentile of its time-series.

RELATIONSHIP OF AGE 0 TO AGE 1 INDICES

INTRODUCTION

Indices of age 1 (yearling) striped bass (Table 6) developed from the Maryland juvenile striped bass surveys were tested for relationship to YOY indices by year-class. Previous analysis yielded a significant relationship with age 0 indices explaining 73% (r^2=0.73, $P \leq 0.001$) of the variability in age 1 indices one year later (MD DNR 1994). The strength of this relationship led to the incorporation of the age 1 index into coastal stock assessment models by the ASMFC Striped Bass Technical Committee. The utility of age 1 indices as a potential fishery independent verification of the YOY index also makes this relationship of interest.

METHODS

Age 1 indices were developed from the Maryland beach seine data (Table 6). Size ranges were used to determine catch of age 1 fish from records prior to 1991. Since 1991, striped bass have been separated into 0, 1 and 2+ age groups in the recorded data. Age groups were assigned by length-frequencies and later confirmed through direct examination of scales. Annual indices were computed as arithmetic means of log transformed catch values [$\log_e (x+1)$], where x is an individual seine haul catch. Regression analysis was used to test the relationship between age 0 and subsequent age 1 mean catch per haul.

RESULTS AND DISCUSSION

The relationship of age 0 to subsequent age 1 relative abundance was significant and explained 57% of the variability (r^2 =0.57, $p \leq 0.001$) in the age 1 indices (Figure 10). The equation that best described this relationship was: $C_1=(0.174)(C_0)- 0.0544$, where C_1 is the age 1 index and C_0 is the age 0 index. While still significant, the model has lost predictive power since 1994 when r^2=0.73. The addition of quadratic and cubic terms yielded even poorer fits.

This year's actual index of age 1 striped bass (0.17) was greater than the predicted index of

0.08. Examination of residuals (Figure 11) shows that this regression equation can be often be used to predict subsequent yearling striped bass abundance with reasonable certainty in the case of average sized year-classes but predictions are less reliable with large or small year-classes. Lower than expected abundance of age 1 striped bass may be an indication of density-dependent processes operating at high levels of abundance, such as cannibalism, increased competition for food, increased spatial distribution, or overwintering mortality. Higher than expected abundance of age 1 striped bass may identify particularly good conditions that enhanced survival.

CITATIONS

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LIST OF TABLES

LIST OF FIGURES

Table 1. Maryland juvenile striped bass survey sample sites.

Site Number	River or Creek	Area or Nearest Landmark
	HEAD OF CHESAPEAKE BAY SYSTEM	
* 168	Susquehanna Flats	North side Fishing Battery Light Island
* 130	Susquehanna Flats	North side of Plum Point
* 144	Susquehanna Flats	Tyding's Estate, west shore of flats
* 59	Northeast River	Carpenter Point, old K.O.A. Campground beach
3	Northeast River	Elk Neck State Park beach
31	Elk River	Oldfield Point
5	Elk River	Hyland Point Light
115	Bohemia River	Parlor Point
160	Sassafras River	Sassafras N.R.M.A., opposite Ordinary Point
10	Sassafras River	Howell Point, 500 yards east of point
164	Worton Creek	Handy Point, 0.3 miles west of Green Point Wharf
* 88	Chesapeake Bay	Beach at Tolchester Yacht Club
	POTOMAC RIVER SYSTEM	
139	Potomac River	Hallowing Point, VA
50	Potomac River	Indian Head, old boat basin
51	Potomac River	Liverpool Point, south side of pier
52	Potomac River	Blossom Point, mouth of Nanjemoy Creek
172	Potomac River	Lower Cedar Point II
55	Wicomico River	Rock Point
56	Potomac River	St. George Island, south end of bridge

* Indicates auxiliary seining site

Table 1. Continued.

Site Number	River or Creek	Area or Nearest Landmark
	CHOPTANK RIVER SYSTEM	
2	Tuckahoe Creek	Northeast side near mouth
148	Choptank River	North side of Jamaica Point
161	Choptank River	Dickinson Bay, 0.5 miles from Howell Point
29	Choptank River	Castle Haven, northeast side
	NANTICOKE RIVER SYSTEM	
36	Nanticoke River	Sharptown, pulpwood pier
166	Nanticoke River	Opposite Red Channel Marker #26
38	Nanticoke River	Opposite Chapter Point, above light #15
39	Nanticoke River	Tyaskin Beach
	PATUXENT RIVER SYSTEM	
* 85	Patuxent River	Selby Landing
* 86	Patuxent River	Nottingham, Windsor Farm
* 91	Patuxent River	Milltown Landing
* 92	Patuxent River	Eagle Harbor
* 106	Patuxent River	Sheridan Point
* 170	Patuxent River	Grammers Cove

* Indicates auxiliary seining site

Table 2. Maryland juvenile striped bass survey arithmetic mean (AM) catch per haul at permanent sites.

Year	Head of Bay	Potomac River	Choptank River	Nanticoke River	Bay-wide
1954	0.9	5.2	1.2	25.1	5.2
1955	4.4	5.7	12.5	5.9	5.5
1956	33.9	6.2	9.8	8.2	15.2
1957	5.4	2.5	2.1	1.3	2.9
1958	28.2	8.4	19.5	22.5	19.3
1959	1.9	1.6	0.1	1.8	1.4
1960	9.3	4.3	9.0	4.7	7.1
1961	22.1	25.8	6.0	1.5	17.0
1962	11.4	19.7	6.1	6.6	12.2
1963	6.1	1.1	5.4	4.1	4.0
1964	31.0	29.1	10.6	13.3	23.5
1965	2.2	3.4	9.5	21.6	7.4
1966	32.3	10.5	13.6	3.3	16.7
1967	17.4	1.9	5.3	4.1	7.8
1968	13.1	0.7	6.3	9.0	7.2
1969	26.6	0.2	4.8	6.2	10.5
1970	33.1	20.1	57.2	17.1	30.4
1971	23.7	8.5	6.3	2.0	11.8
1972	12.1	1.9	11.0	25.0	11.0
1973	24.5	2.1	1.3	1.1	8.9
1974	19.9	1.5	15.3	3.9	10.1
1975	7.6	7.8	4.7	5.2	6.7
1976	9.9	3.2	2.4	1.7	4.9
1977	12.1	1.9	1.2	1.0	4.8
1978	12.5	7.9	6.0	4.8	8.5
1979	8.3	2.2	2.8	0.9	4.0
1980	2.3	2.2	1.0	1.8	2.0
1981	0.3	1.4	1.3	2.4	1.2
1982	5.5	10.0	13.0	6.2	8.4
1983	1.2	2.0	0.9	1.0	1.4
1984	6.1	4.7	2.8	1.5	4.2
1985	0.3	5.6	3.7	2.1	2.9
1986	1.6	9.9	0.5	2.2	4.1
1987	1.3	6.4	12.1	2.5	4.8
1988	7.3	0.4	0.7	0.4	2.7
1989	19.4	2.2	97.8	2.9	25.2
1990	3.8	0.6	3.1	0.9	2.1
1991	3.9	2.5	12.2	1.1	4.4

Table 2. Continued.

Year	Head of Bay	Potomac River	Choptank River	Nanticoke River	Bay-wide
1992	1.3	22.1	4.3	4.3	9.0
1993	23.0	36.4	105.5	9.3	39.8
1994	23.4	3.9	19.3	21.5	16.1
1995	4.4	8.7	17.7	10.4	9.3
1996	25.0	48.5	154.4	43.7	59.4
1997	8.3	10.6	7.3	3.5	8.0
1998	8.3	10.8	32.6	3.8	12.7
1999	3.1	15.7	48.2	18.7	18.1
2000	13.3	7.8	21.2	17.6	13.8
2001	13.4	7.8	201.9	40.1	50.8
2002	3.1	7.0	0.7	7.8	4.7
2003	28.4	23.6	41.8	8.7	25.8
2004	7.8	4.0	22.8	19.5	11.4
2005	13.2	10.3	55.2	1.5	17.8
2006	1.5	6.7	5.8	3.2	4.3
2007	20.2	4.9	14.3	15.4	13.4
2008	5.9	3.3	0.5	1.0	3.2
2009	6.8	7.8	11.3	6.5	7.9
2010	7.3	5.7	3.3	4.6	5.6
2011	10.3	12.8	125.7	24.3	34.6
2012	0.7	1.7	0.1	0.6	0.9
2013	4.9	7.0	4.8	6.1	5.8
2014	15.2	2.3	12.5	17.3	11.0
2015	9.9	11.3	43.0	53.0	24.2
2016	2.0	3.7	1.1	0.9	2.2
2017	26.5	8.5	6.8	4.4	13.2
2018	24.2	5.5	20.3	8.9	14.8
2019	3.9	2.5	3.1	4.3	3.4
2020	3.5	3.0	0.2	2.1	2.5
2021	5.3	0.8	3.3	3.8	3.2
Average	11.6	7.9	20.1	8.7	11.4
TPA*	17.3	9.2	10.8	8.6	12.0

* TPA (target period average) is the average from 1959 through 1972.

Table 3. Maryland juvenile striped bass survey geometric mean (GM) catch per haul at permanent sites.

Year	Head of Bay	Potomac River	Choptank River	Nanticoke River	Bay-wide
1955	1.49	3.78	2.36	2.26	2.26
1956	6.88	4.50	6.22	5.29	5.29
1957	1.92	1.78	1.16	1.40	1.40
1958	22.07	3.93	11.01	11.12	11.12
1959	0.95	0.61	0.09	0.59	0.59
1960	3.18	2.44	4.31	3.01	3.01
1961	7.46	12.82	5.40	6.61	6.61
1962	3.73	6.70	3.14	4.25	4.25
1963	3.01	0.54	2.01	1.61	1.61
1964	15.41	9.15	4.92	9.04	9.04
1965	0.76	0.92	2.18	1.56	1.56
1966	15.89	4.95	5.52	6.24	6.24
1967	3.92	1.03	2.80	2.28	2.28
1968	6.13	0.39	3.85	2.69	2.69
1969	12.21	0.12	2.55	2.81	2.81
1970	13.71	10.97	25.41	12.48	12.48
1971	10.45	3.48	2.51	4.02	4.02
1972	4.95	0.96	5.36	3.26	3.26
1973	11.92	1.10	0.43	2.33	2.33
1974	6.79	0.66	3.55	2.62	2.62
1975	2.34	3.56	2.71	2.81	2.81
1976	2.70	1.46	0.89	1.58	1.58
1977	4.99	0.78	0.81	1.61	1.61
1978	6.51	3.33	2.65	3.75	3.75
1979	4.56	1.15	1.12	1.73	1.73
1980	1.43	1.04	0.58	1.01	1.01
1981	0.17	0.68	0.84	0.59	0.59
1982	2.98	3.50	5.68	3.54	3.54
1983	0.61	0.62	0.64	0.61	0.61
1984	2.23	1.42	2.13	0.81	1.64
1985	0.19	1.45	1.78	0.94	0.91
1986	0.90	3.09	0.32	1.24	1.34
1987	0.16	3.01	3.06	1.36	1.46
1988	2.25	0.22	0.40	0.28	0.73
1989	8.54	1.15	28.10	1.94	4.87
1990	2.20	0.38	1.34	0.56	1.03
1991	1.99	0.84	4.42	0.52	1.52

Table 3. Continued.

Year	Head of Bay	Potomac River	Choptank River	Nanticoke River	Bay-wide
1992	0.87	6.00	2.07	1.72	2.34
1993	15.00	15.96	27.87	4.56	13.97
1994	12.88	2.01	7.71	9.06	6.40
1995	2.85	4.47	9.96	3.76	4.41
1996	15.00	13.60	33.29	19.13	17.61
1997	6.15	3.67	3.95	1.74	3.91
1998	4.32	4.42	21.10	2.74	5.50
1999	1.91	5.84	20.01	5.52	5.34
2000	8.84	3.52	12.53	10.86	7.42
2001	7.15	5.01	86.71	20.31	12.57
2002	1.35	3.95	0.38	4.89	2.20
2003	11.89	12.81	20.56	3.25	10.83
2004	4.17	2.36	9.52	9.65	4.85
2005	8.48	7.92	16.81	1.07	6.91
2006	0.95	2.42	2.81	1.65	1.78
2007	8.21	2.20	7.87	5.41	5.12
2008	2.33	1.40	0.34	0.73	1.26
2009	2.85	3.75	6.61	4.18	3.92
2010	2.90	2.17	2.23	2.96	2.54
2011	5.79	7.18	26.14	12.99	9.57
2012	0.44	0.95	0.08	0.37	0.49
2013	3.29	3.13	3.53	4.14	3.42
2014	8.02	1.07	6.28	5.10	4.06
2015	7.20	6.07	21.69	25.71	10.67
2016	1.14	2.36	0.64	0.68	1.25
2017	18.52	3.82	3.40	2.23	5.88
2018	14.48	2.97	8.85	5.78	6.96
2019	2.33	1.27	1.97	2.72	1.95
2020	1.95	1.05	0.11	1.41	1.12
2021	3.16	0.44	1.93	2.14	1.65
Average	5.70	3.47	7.75	4.00	4.21
TPA*	7.27	3.93	5.00	3.12	4.32

* TPA (target period average) is the average from 1959 through 1972.

Table 4. Maryland Chesapeake Bay arithmetic mean (AM) and log mean with coefficients of variation (CV), proportion of positive hauls (PPHL) with 95% confidence intervals (CI), and number of seine hauls (n) for juvenile striped bass.

Year	AM	CV (%) of AM	Log Mean	CV (%) of Log Mean	PPHL	Low CI	High CI	n
1957	2.9	205.5	0.87	100.72	0.66	0.52	0.80	44
1958	19.3	94.2	2.50	48.56	0.89	0.79	0.99	36
1959	1.4	198.3	0.47	171.23	0.30	0.14	0.45	34
1960	7.1	149.2	1.39	86.32	0.72	0.58	0.87	36
1961	17.0	183.3	2.03	61.04	0.96	0.90	1.02	46
1962	12.2	160.8	1.66	82.85	0.75	0.66	0.84	88
1963	4.0	182.6	0.96	111.85	0.56	0.45	0.66	88
1964	23.5	162.3	2.31	60.35	0.90	0.83	0.96	88
1965	7.4	247.7	0.94	140.06	0.47	0.36	0.57	88
1966	16.7	184.8	1.98	67.16	0.86	0.80	0.92	132
1967	7.8	263.9	1.19	100.40	0.69	0.61	0.77	132
1968	7.2	175.3	1.31	94.10	0.65	0.57	0.73	132
1969	10.5	224.0	1.34	104.40	0.62	0.54	0.70	132
1970	30.4	157.5	2.60	52.73	0.95	0.91	0.99	132
1971	11.8	187.0	1.61	80.43	0.81	0.74	0.88	132
1972	11.0	250.8	1.45	91.54	0.72	0.64	0.80	132
1973	8.9	229.2	1.20	110.90	0.61	0.53	0.70	132
1974	10.1	261.9	1.29	102.42	0.65	0.57	0.74	132
1975	6.7	152.2	1.34	86.76	0.73	0.66	0.81	132
1976	4.9	279.4	0.95	113.88	0.60	0.51	0.68	132
1977	4.8	236.4	1.96	113.00	0.62	0.54	0.70	132
1978	8.5	145.6	1.56	77.24	0.77	0.69	0.84	132
1979	4.0	182.1	1.00	100.24	0.66	0.58	0.74	132
1980	2.0	174.8	0.70	114.68	0.54	0.45	0.62	132
1981	1.2	228.2	0.46	150.34	0.39	0.30	0.47	132
1982	8.4	160.1	1.51	79.73	0.76	0.68	0.83	132
1983	1.4	268.0	0.48	152.37	0.38	0.30	0.46	132
1984	4.2	228.2	0.97	106.58	0.65	0.57	0.73	132
1985	2.9	253.0	0.65	152.02	0.42	0.33	0.50	132
1986	4.1	272.2	0.85	121.40	0.55	0.47	0.64	132
1987	4.8	262.1	0.90	124.54	0.51	0.42	0.59	132
1988	2.7	313.8	0.55	170.46	0.37	0.29	0.45	132
1989	25.2	309.1	1.77	90.18	0.75	0.68	0.82	132
1990	2.1	174.8	0.71	120.74	0.49	0.41	0.58	132
1991	4.4	203.8	0.93	120.27	0.52	0.43	0.60	132

Table 4. Continued.

Year	AM	CV (%) of AM	Log Mean	CV (%) of Log Mean	PPHL	Low CI	High CI	n
1992	9.0	267.0	1.20	105.19	0.67	0.59	0.75	132
1993	39.8	279.1	2.71	49.53	0.96	0.93	0.99	132
1994	16.1	150.4	2.00	66.96	0.84	0.78	0.90	132
1995	9.3	153.3	1.69	66.42	0.86	0.80	0.92	132
1996	59.4	369.2	2.92	45.50	0.99	0.96	1.00	132
1997	8.0	135.6	1.59	70.98	0.80	0.74	0.87	132
1998	12.7	164.8	1.87	65.72	0.86	0.78	0.92	132
1999	18.1	208.4	1.85	77.45	0.80	0.75	0.88	132
2000	13.8	120.8	2.13	53.69	0.91	0.86	0.96	132
2001	50.8	308.9	2.61	57.22	0.92	0.88	0.97	132
2002	4.7	141.3	1.16	91.89	0.67	0.59	0.75	132
2003	25.8	136.9	2.47	55.42	0.92	0.88	0.97	132
2004	11.4	177.8	1.77	67.01	0.87	0.81	0.93	132
2005	17.8	237.3	2.07	59.12	0.90	0.86	0.95	132
2006	4.3	178.6	1.02	103.67	0.59	0.51	0.67	132
2007	13.4	177.3	1.81	71.92	0.83	0.76	0.89	132
2008	3.2	213.1	0.81	119.32	0.54	0.45	0.62	132
2009	7.9	154.3	1.59	66.66	0.86	0.80	0.92	132
2010	5.6	175.0	1.26	82.49	0.77	0.69	0.84	132
2011	34.6	580.4	2.36	51.94	0.93	0.89	0.97	132
2012	0.9	197.5	0.40	152.53	0.35	0.27	0.43	132
2013	5.8	115.7	1.49	63.93	0.84	0.78	0.90	132
2014	11.0	179.7	1.62	80.21	0.77	0.69	0.84	132
2015	24.2	179.2	2.46	49.21	0.98	0.96	1.00	132
2016	2.2	140.0	0.81	99.38	0.61	0.52	0.69	132
2017	13.2	136.6	1.93	65.98	0.83	0.77	0.90	132
2018	14.8	137.7	2.07	58.19	0.91	0.86	0.96	132
2019	3.4	134.0	1.08	79.95	0.75	0.68	0.82	132
2020	2.5	214.0	0.75	116.26	0.54	0.45	0.62	132
2021	3.2	166.7	0.97	93.60	0.64	0.55	0.72	132
Average	11.5	204.5	1.44	91.47	0.71	0.64	0.78	
TPA*	12.0	194.8	1.52	93.18	0.71	0.62	0.80	

* TPA (target period average) is the average from 1959 through 1972.

Table 5. Maryland juvenile striped bass survey arithmetic (AM) and geometric (GM) mean catch per haul and number of seine hauls per year (n) for auxiliary sample sites.

	Patuxent River			Head of Bay		
Year	AM	GM	n	AM	GM	n
1983	0.1	0.04	18	0.6	0.33	12
1984	0.6	0.39	18	0.9	0.43	12
1985	3.2	1.95	18	1.0	0.24	12
1986	2.4	1.17	18	0.9	0.54	12
1987	2.9	0.94	17	0.3	0.26	9
1988	0.6	0.40	17	1.6	1.07	21
1989	1.4	0.92	18	10.4	1.91	21
1990	0.3	0.17	18	5.0	2.24	21
1991	0.9	0.53	18	2.2	0.98	20
1992	9.5	1.85	18	0.5	0.26	20
1993	104.3	47.18	18	28.0	11.11	21
1994	4.1	2.82	18	6.3	2.31	21
1995	7.3	3.46	18	3.0	1.15	21
1996	420.4	58.11	18	12.4	4.69	20
1997	7.3	2.72	18	2.7	2.18	20
1998	13.2	7.58	18	3.0	1.51	16
1999	7.3	5.39	18	3.6	2.13	13
2000	9.7	5.03	18	8.6	5.68	15
2001	17.3	10.01	18	19.5	6.62	15
2002	1.2	0.69	18	1.0	0.42	15
2003	61.1	22.17	18	16.1	11.79	16
2004	2.1	1.29	18	7.7	4.40	15
2005	8.9	3.91	18	5.5	4.35	15
2006	1.0	0.66	18	0.7	0.31	15
2007	15.2	6.07	18	5.3	2.72	15
2008	0.3	0.24	18	3.5	2.02	15
2009	3.0	1.87	18	2.1	1.14	15

Table 5. Continued.

	Patuxent River			Head of Bay		
Year	**AM**	**GM**	**n**	**AM**	**GM**	**n**
2010	3.3	2.49	18	3.7	1.45	15
2011	42.5	13.41	18	12.3	5.75	21
2012	0.1	0.04	18	1.9	0.71	21
2013	6.0	2.63	18	4.9	2.82	15
2014	5.1	2.70	18	5.3	4.34	15
2015	11.5	4.15	18	6.3	4.15	15
2016	1.4	0.83	18	1.5	0.90	15
2017	7.9	2.08	18	12.4	6.62	14
2018	6.9	2.65	18	12.6	7.37	12
2019	1.7	1.05	18	5.5	3.97	12
2020	0.5	0.3	18	6.0	2.97	12
2021	0.2	0.12	18	6.5	4.62	12
Average	20.3	5.64		5.9	3.04	
Median	3.33	1.95		4.9	2.18	

Table 6. Log mean catch per haul of age 0 and age 1 striped bass by year-class.

Year-class	Age 0	Age 1
1957	0.87	0.08
1958	2.50	0.45
1959	0.47	0.07
1960	1.39	0.14
1961	2.03	0.39
1962	1.66	0.19
1963	0.96	0.07
1964	2.31	0.29
1965	0.94	0.19
1966	1.98	0.14
1967	1.19	0.20
1968	1.31	0.19
1969	1.34	0.10
1970	2.60	0.74
1971	1.61	0.37
1972	1.45	0.35
1973	1.20	0.21
1974	1.29	0.20
1975	1.32	0.12
1976	0.95	0.05
1977	0.96	0.16
1978	1.56	0.26
1979	1.00	0.16
1980	0.70	0.02
1981	0.46	0.02
1982	1.51	0.28
1983	0.48	0.00
1984	0.97	0.14
1985	0.65	0.03
1986	0.85	0.05
1987	0.90	0.06
1988	0.55	0.14
1989	1.77	0.28
1990	0.71	0.17
1991	0.93	0.11
1992	1.20	0.18
1993	2.71	0.56

Table 6. Continued.

Year-class	Age 0	Age 1
1994	2.00	0.12
1995	1.69	0.07
1996	2.92	0.23
1997	1.59	0.16
1998	1.87	0.31
1999	1.85	0.23
2000	2.13	0.28
2001	2.61	0.58
2002	1.16	0.07
2003	2.47	0.55
2004	1.77	0.25
2005	2.07	0.25
2006	1.02	0.07
2007	1.81	0.27
2008	0.81	0.11
2009	1.59	0.16
2010	1.26	0.02
2011	2.36	0.30
2012	0.40	0.05
2013	1.49	0.11
2014	1.62	0.20
2015	2.46	0.35
2016	0.81	0.13
2017	1.93	0.09
2018	2.07	0.23
2019	1.08	0.20
2020	0.75	0.17
2021	0.97	N/A

Figure 1. Maryland Chesapeake Bay juvenile striped bass survey site locations.

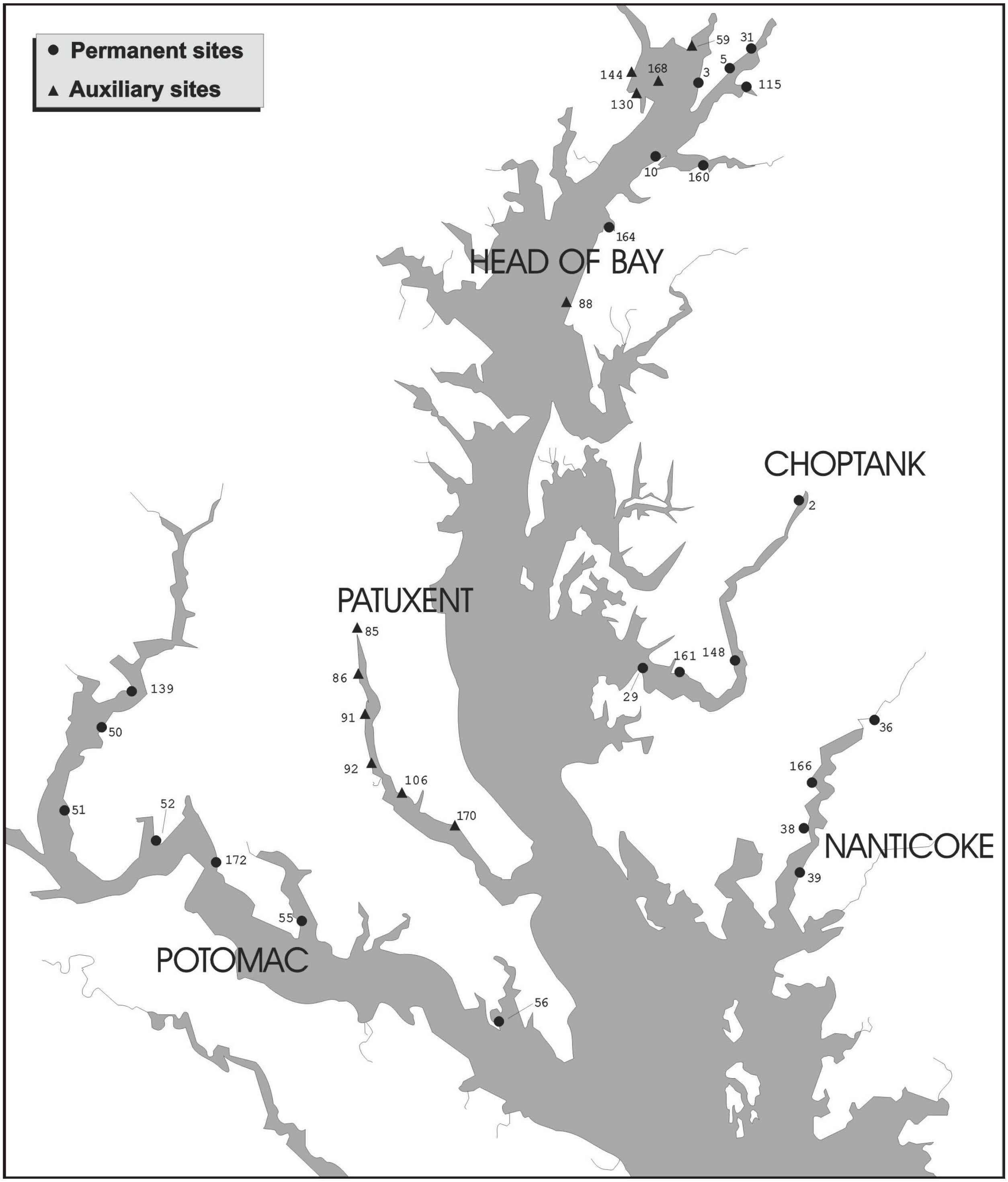


Figure 2. Maryland Chesapeake Bay arithmetic mean (AM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

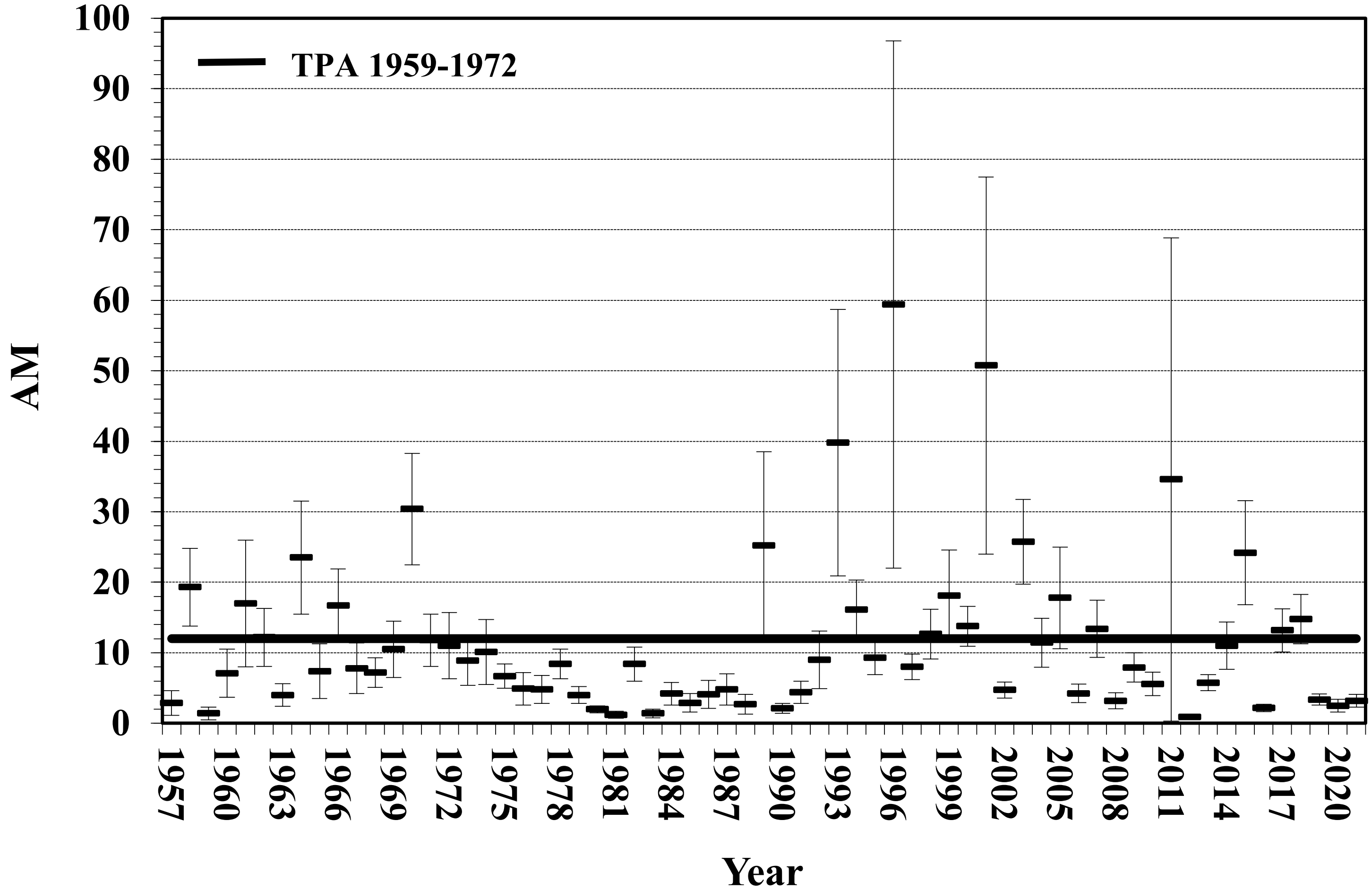


Figure 3. Maryland Chesapeake Bay geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

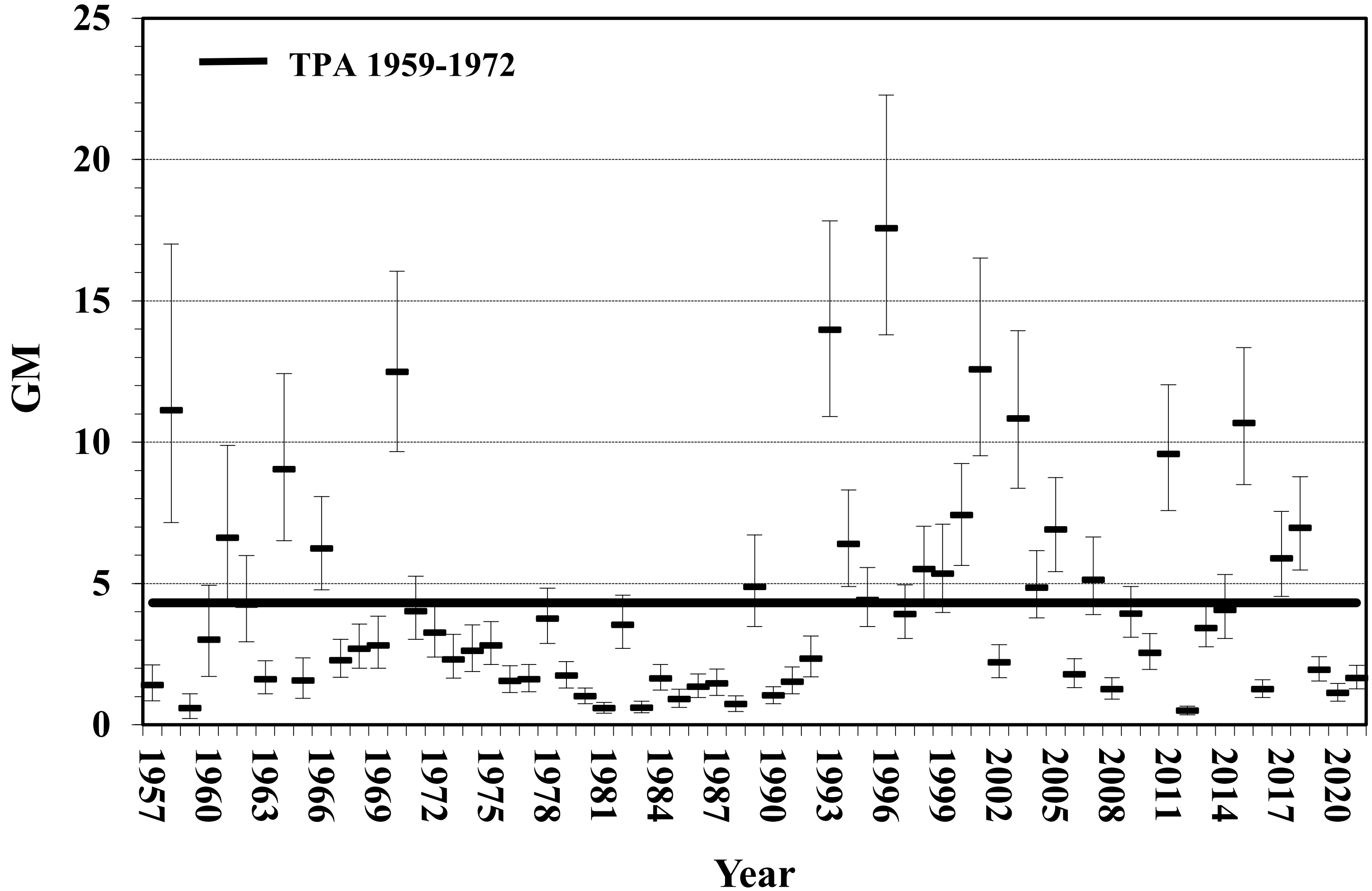


Figure 4. Maryland Chesapeake Bay juvenile striped bass indices. Arithmetic mean (AM), scaled geometric mean (GM)*, and proportion of positive hauls (PPHL) as percent.

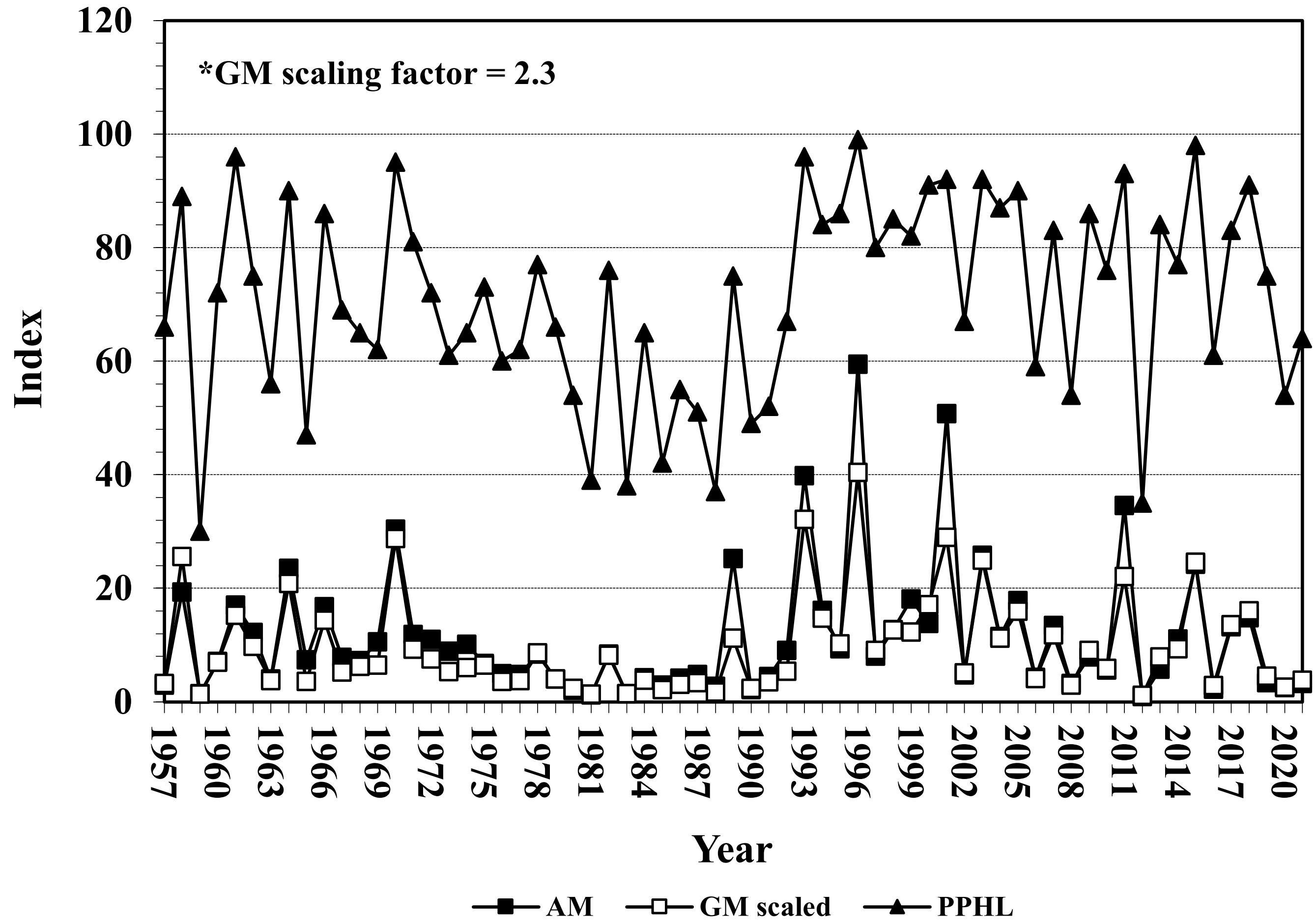


Figure 5. Arithmetic mean (AM) catch per haul by system for juvenile striped bass. Note different scales.

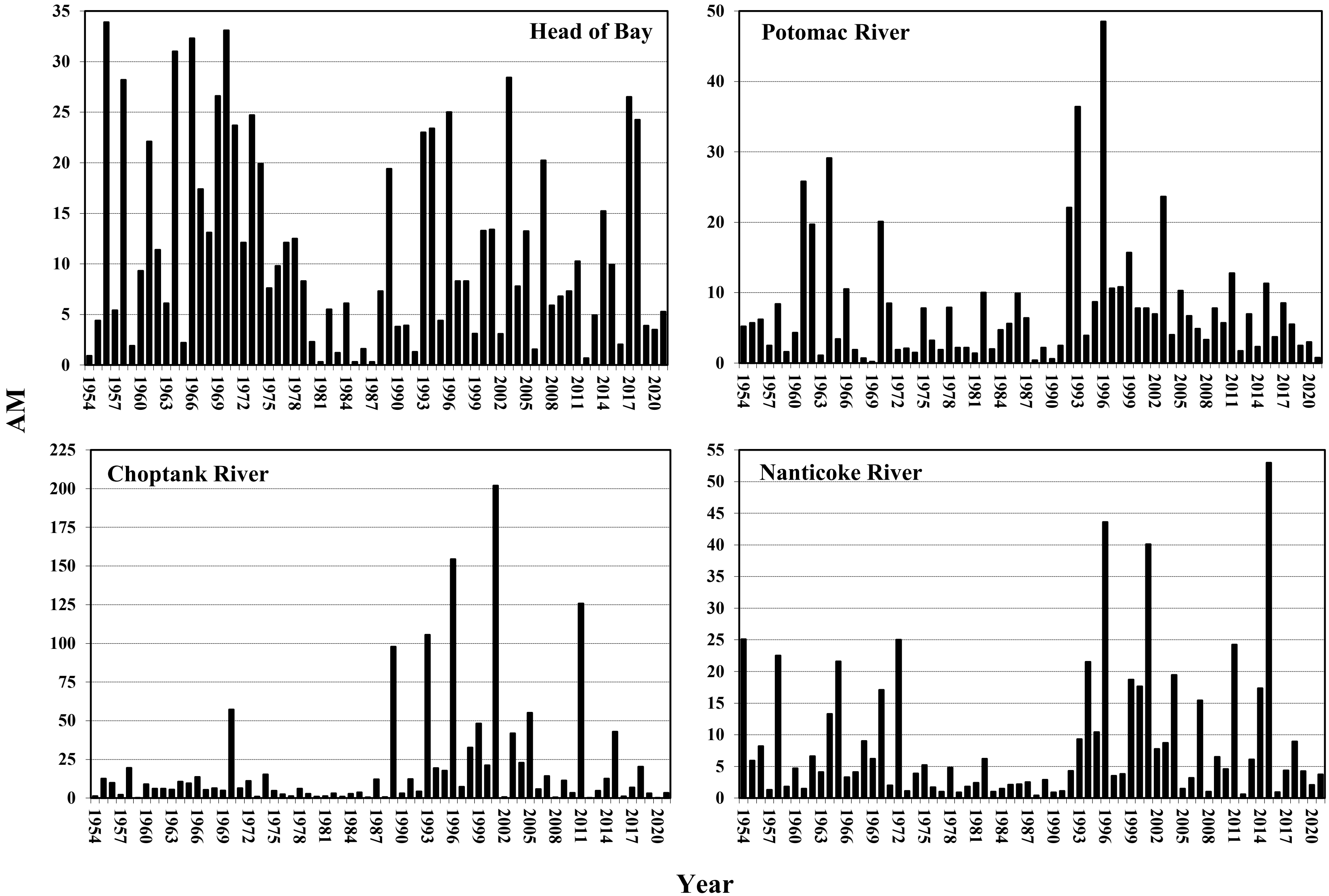


Figure 6. Head of Bay geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

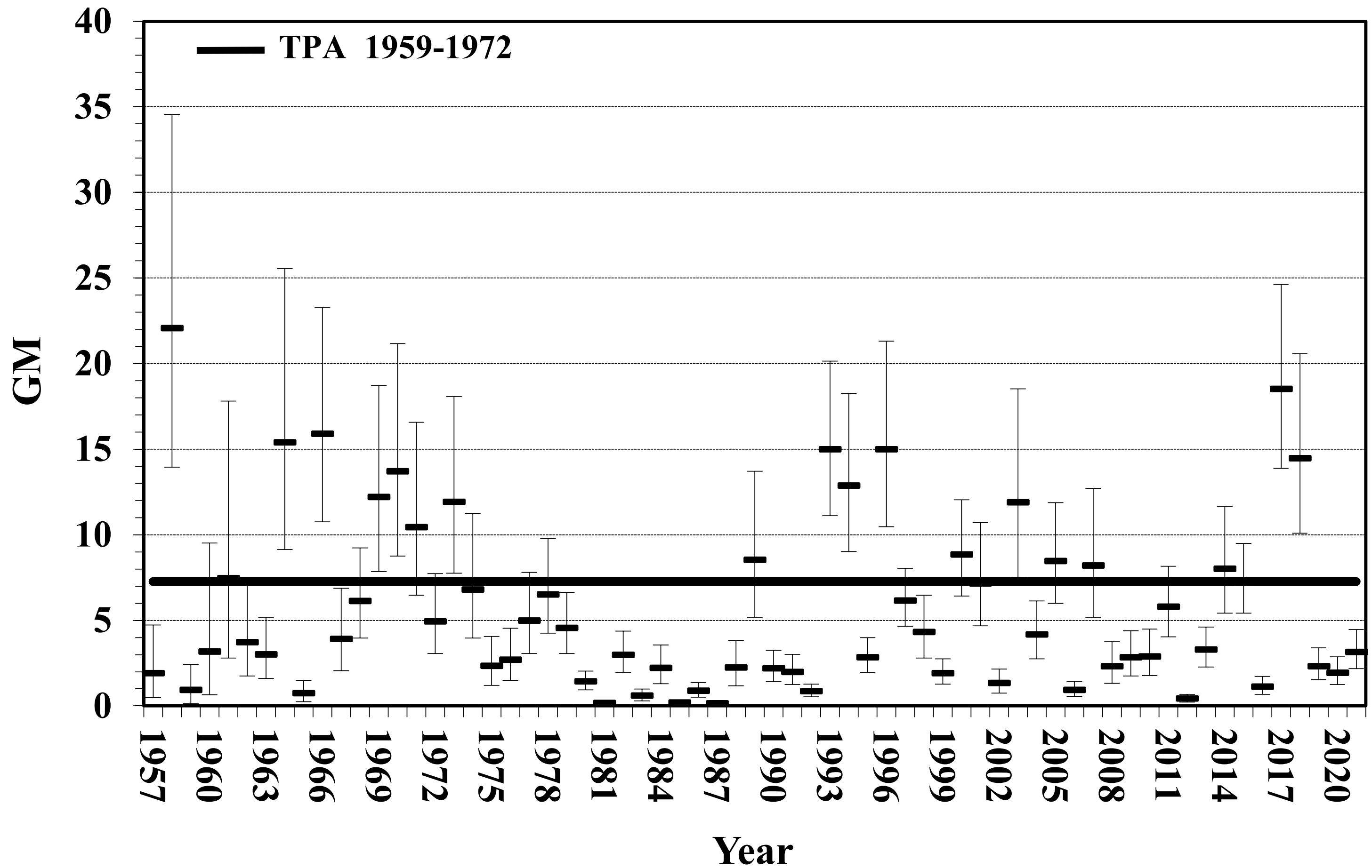


Figure 7. Potomac River geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

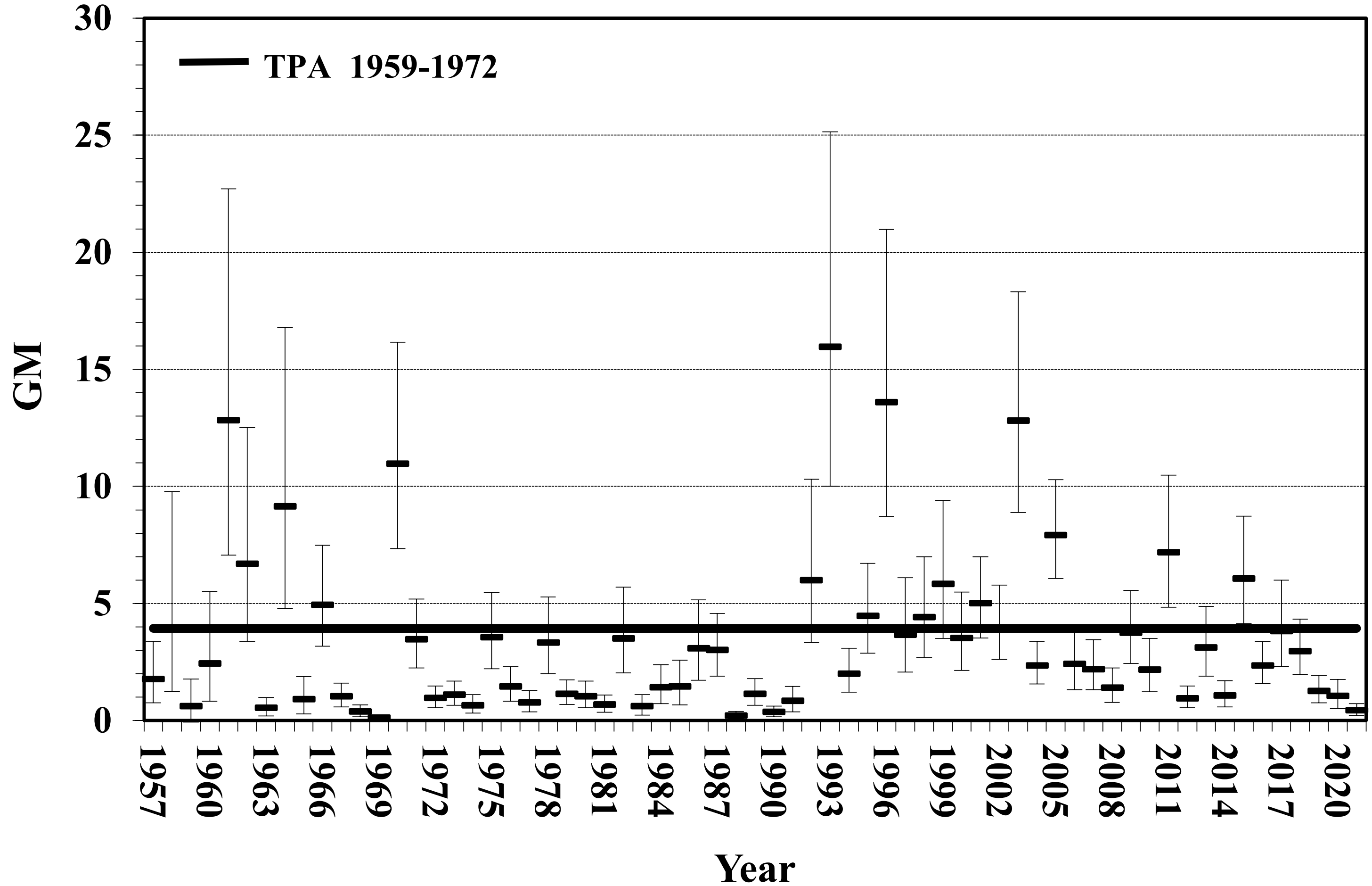


Figure 8. Choptank River geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

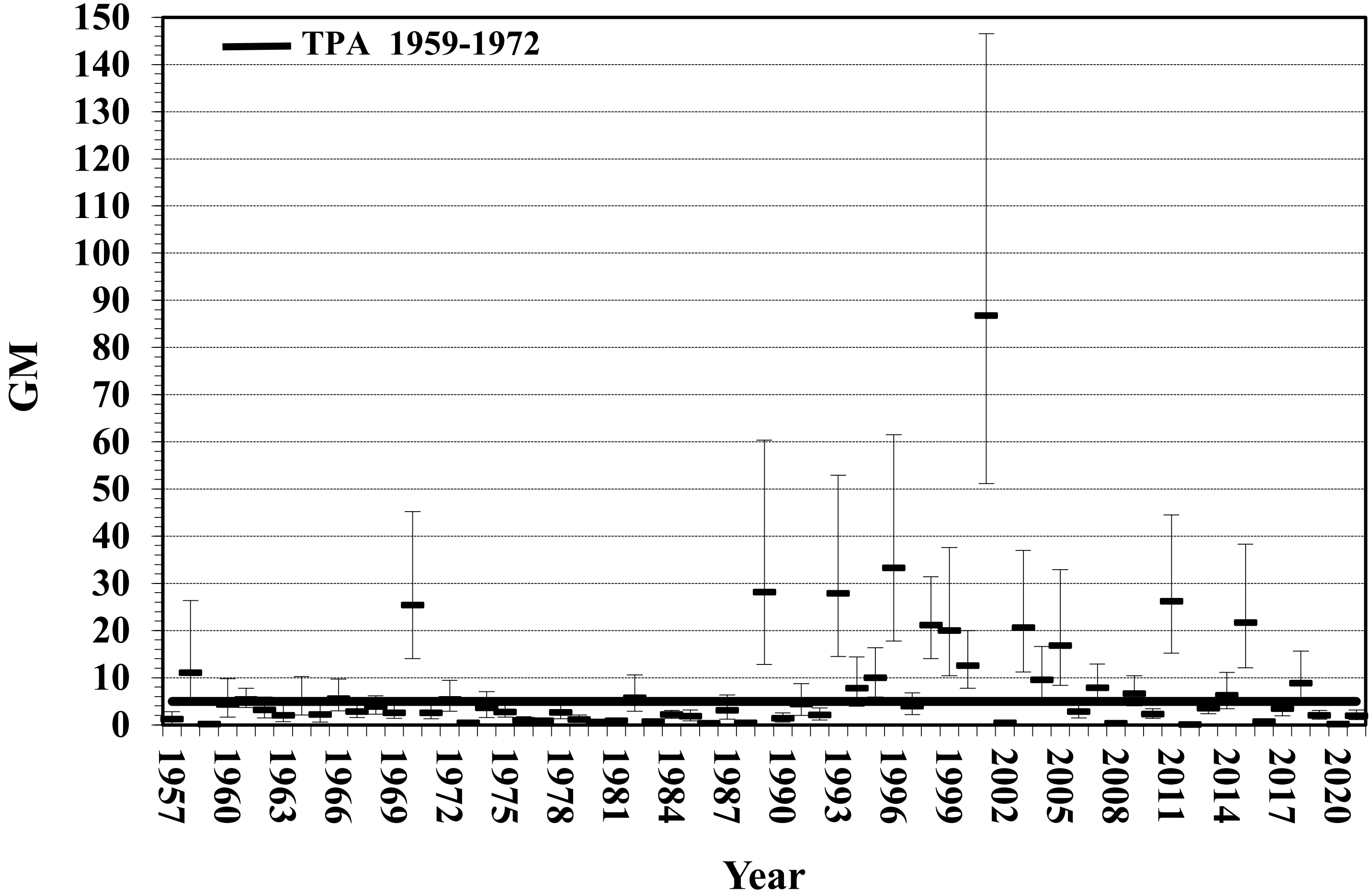


Figure 9. Nanticoke River geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

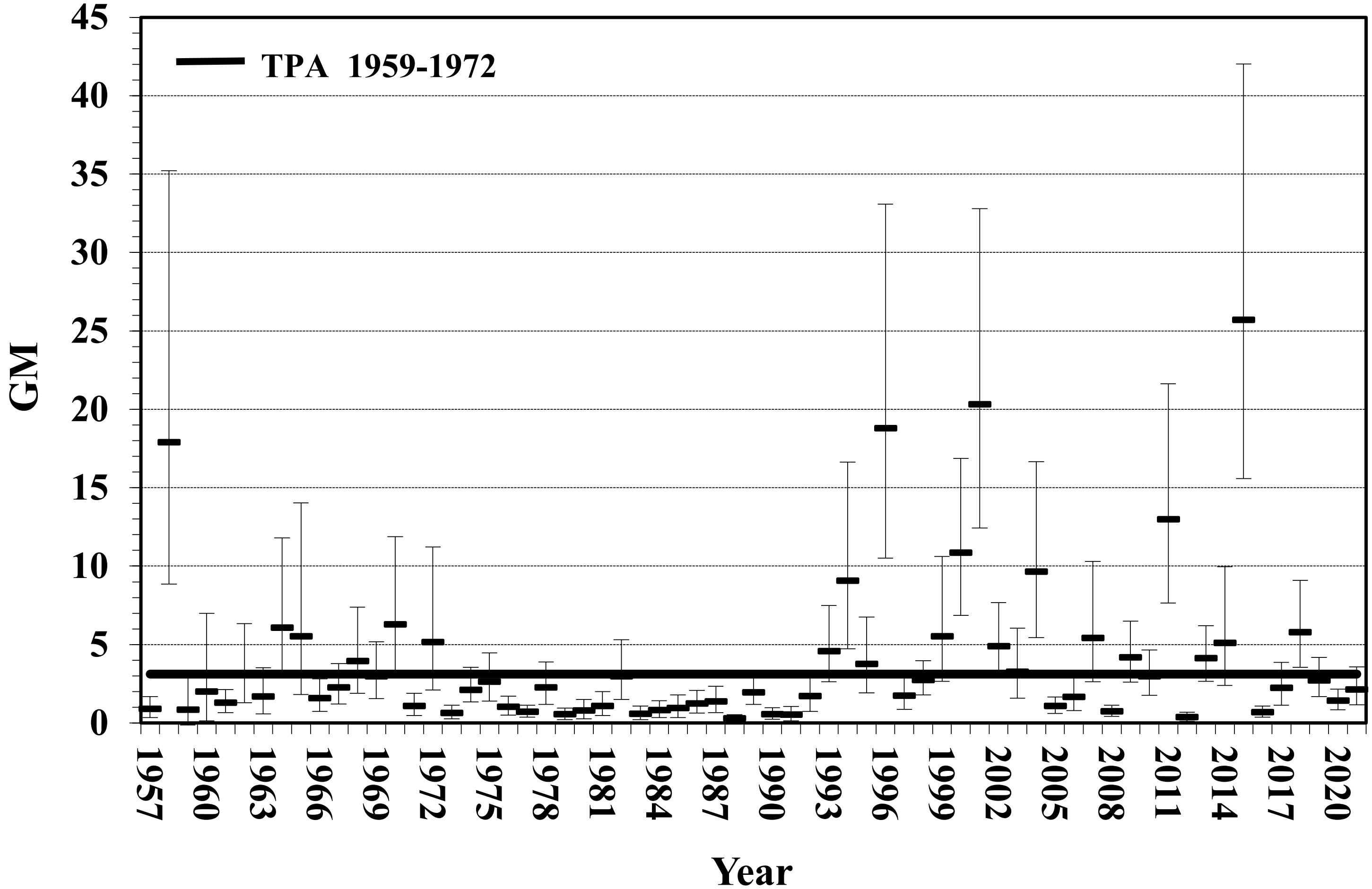


Figure 10. Relationship between age 0 and subsequent age 1 striped bass indices.

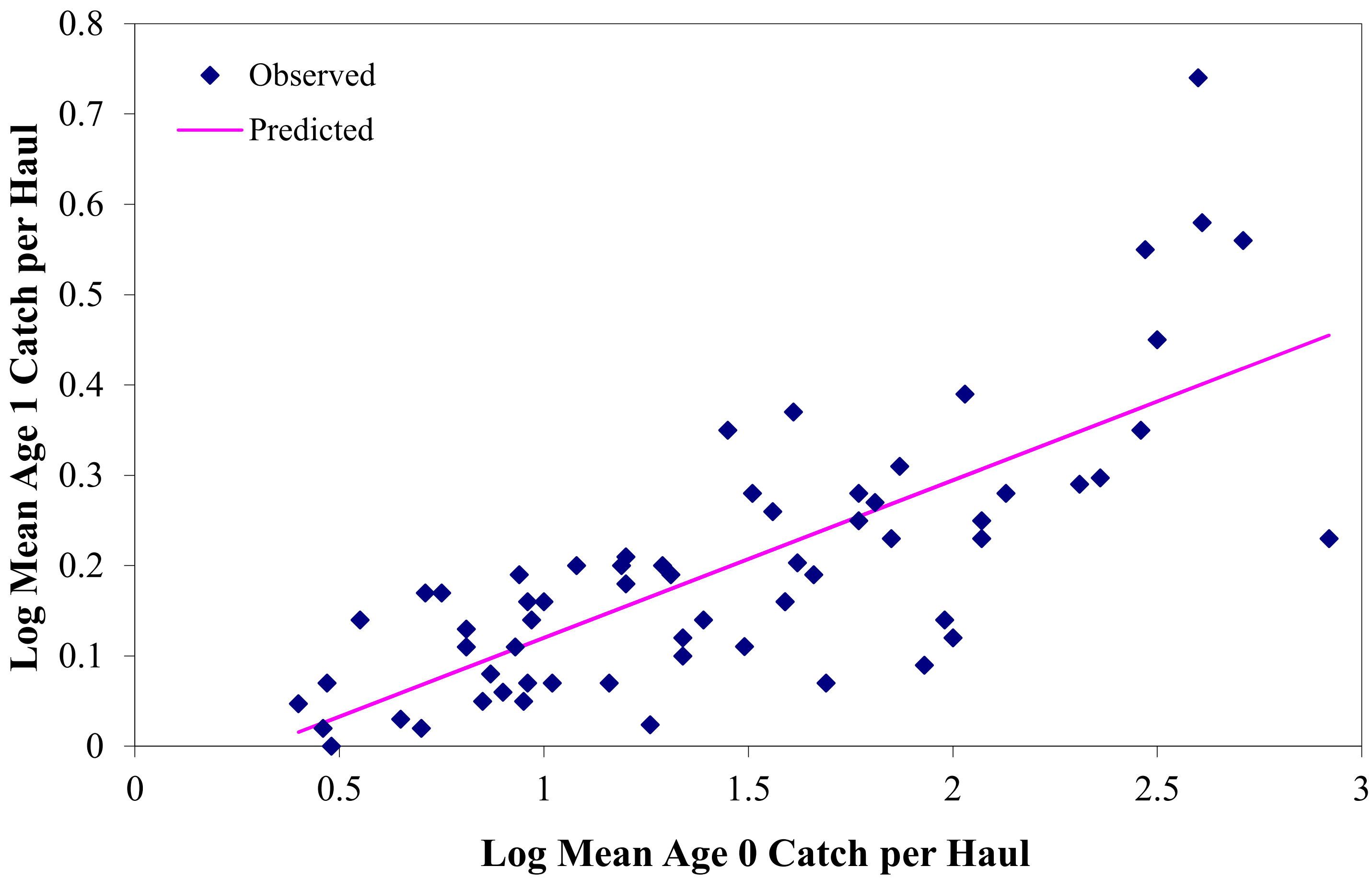
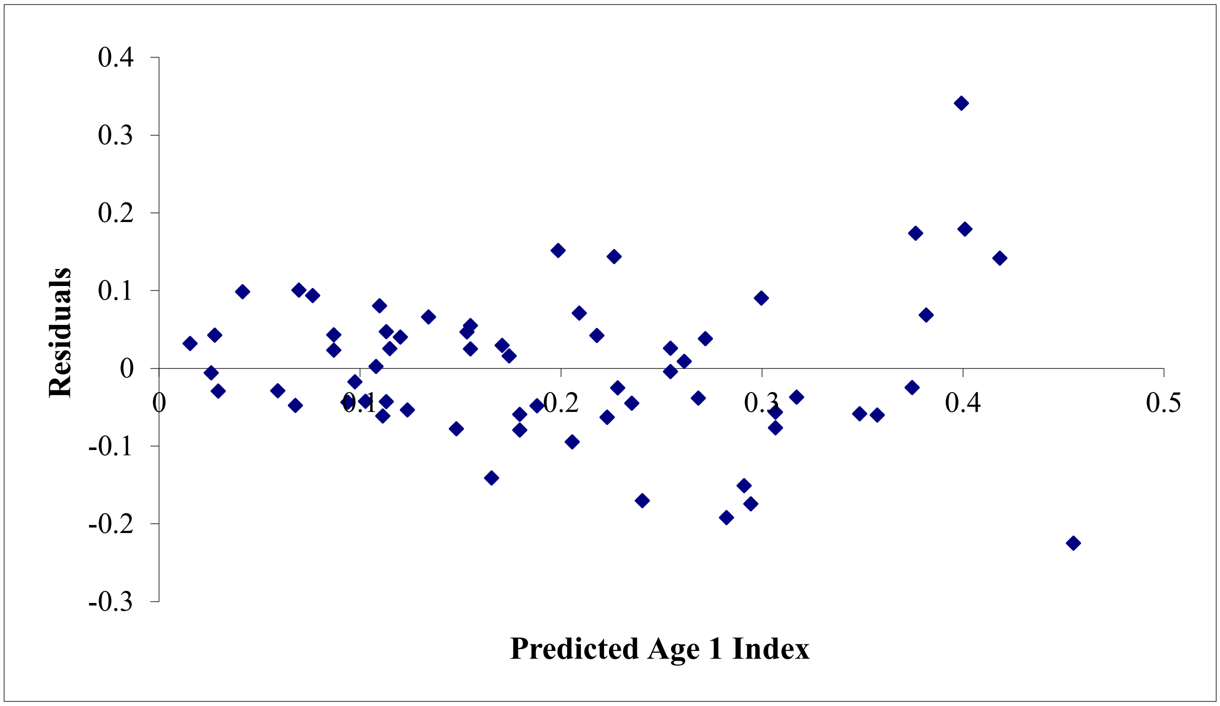
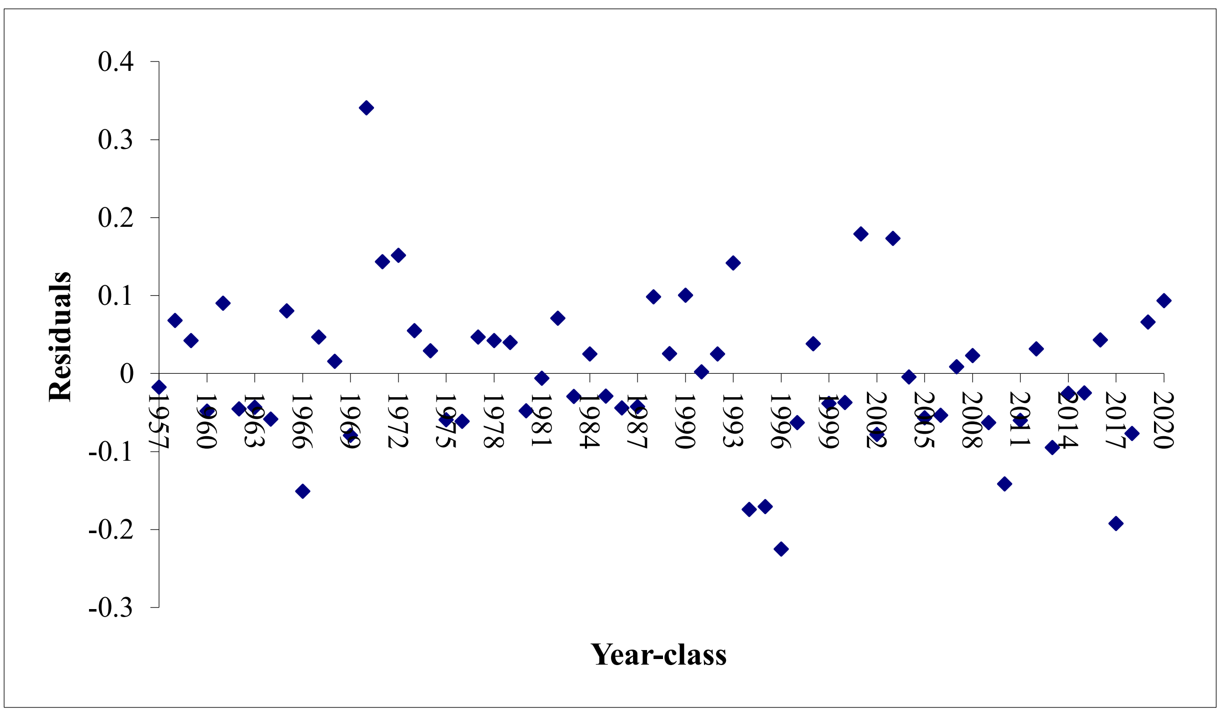


Figure 11. Residuals of age 1 and age 0 striped bass regression.





PROJECT NO. 2
JOB NO. 3
TASK NO. 4

STRIPED BASS TAGGING

Prepared by Beth A. Versak

INTRODUCTION

The primary objectives of Project 2, Job 3, Task 4 were to finalize the characterization of striped bass tagging activities in Maryland's portion of the Chesapeake Bay in 2021 and to provide preliminary results for the 2022 tagging programs. Completed results for the 2022 tagging activities will be reported in the F-61-R-18 Chesapeake Bay Finfish Investigations report. The Maryland Department of Natural Resources (MD DNR) has been a key partner in the offshore cooperative winter tagging cruise and continues to maintain the long-term data set for the cruise. For these reasons, the offshore tagging activities were also summarized and included in this report.

MD DNR and partnering agencies tagged striped bass as part of the United States Fish and Wildlife Service's (USFWS) Cooperative Coastwide Striped Bass Tagging Program. Fish were tagged from the Chesapeake Bay resident/pre-migratory and spawning stocks, and from the Atlantic coastal stock. Subsequently, tag numbers and associated fish attribute data were forwarded to the USFWS, with the captor providing recovery information directly to the USFWS. These data are used to evaluate stock dynamics (mortality rates, survival rates, growth rates, etc.) of Chesapeake Bay resident and Atlantic coast striped bass stocks.

METHODS

Sampling procedures

During late March, April and May of 2021, a fishery-independent spawning stock study was conducted in which tags were applied to fish captured with experimental multi-panel drift gill nets in the upper Chesapeake Bay and the Potomac River (see Project 2, Job 3, Task 2) (Figure 1). Fish sampled during this study were measured for total length to the nearest millimeter (mm TL) and examined for sex, reproductive stage and external anomalies. Internal anchor tags were applied to healthy fish, regardless of size, and scale samples were collected from a sub-sample for age determination. Scales were taken from two to three male fish per week per 10-mm length group up to 700 mm TL, for a total of 10 scale samples per length group over the course of the survey. Scale samples were taken from all males over 700 mm TL, all female fish and all recaptures of previously tagged fish.

In 2021, the offshore tagging cruise was conducted using hook and line, onboard a contracted sportfishing vessel departing from Ocean City, MD and Virginia Beach, VA. The goal was to tag as many coastal migratory striped bass as possible while they were wintering in the Atlantic Ocean. Participants in the sampling effort included USFWS, Atlantic States Marine Fisheries Commission (ASMFC), MD DNR, North Carolina Department of Environment and Natural Resources and Potomac River Fisheries Commission.

Captured fish were placed in holding tanks equipped with an ambient water flow-through system for observation prior to tagging. Vigorous, healthy fish were measured for total length to the nearest millimeter (mm TL) and tagged. Scales were taken from the first five striped bass per 10-mm TL group up to 800 mm, and from the first 10 striped bass per 10-mm TL group greater than or equal to 800 mm.

Tagging procedures

For all surveys, internal anchor tags, supplied by the USFWS, were inserted through an incision made in the left side of the fish, slightly behind and below the tip of the pectoral fin. This small, shallow incision was made with a #12 curved scalpel after removing a few scales from the tag area. The incision was angled anteriorly through the musculature, encouraging the incision to fold together and the tag streamer to lie back along the fish's side. The tag anchor was then pushed through the remaining muscle tissue and peritoneum into the body cavity and checked for retention.

Analytical Procedures

Survival, fishing mortality and natural mortality rates from fish tagged during the spring in Maryland were estimated based on historic release and recovery data. The instantaneous rates – catch and release (IRCR) model is the primary model utilized and employs an age-independent form of the IRCR model developed by Jiang et al. (2007) to estimate survival, fishing mortality and natural mortality. The candidate models run in the IRCR model are formulated based on historical regulatory changes in striped bass management. Additional details on the methodologies can be found in the latest peer reviewed stock assessment report (Northeast Fisheries Science Center 2019), however it does not contain 2021 data.

Estimates for Maryland’s spawning stock are broken into two size groups: ≥457 mm TL (18 inches) and ≥711 mm TL (28 inches). The recovery year began on the first day of spring tagging in the time series (March 28) and continued until March 27 of the following year. Survival and mortality estimates for fish tagged in spring 2021 will be included in the next ASMFC stock assessment.

Estimates of fishing mortality for the Chesapeake Bay pre-migratory stock were developed using tag release and return data from spring male fish, ≥457 mm TL and <711 mm TL (18 – 28 inches TL). Male fish less than 28 inches are generally accepted to compose the majority of the Chesapeake Bay resident stock, while larger fish are predominantly coastal migrants. Release and recapture data from Maryland and Virginia (provided by Virginia Institute of Marine Science) were combined to produce a baywide fishing mortality estimate. Similar to the coastwide methods, the IRCR model was utilized to calculate the Chesapeake Bay estimates. Further details on the methodologies and results can be found in the latest stock assessment report (Northeast Fisheries Science Center 2019).

Estimates of survival, fishing mortality and recovery rates for the cooperative offshore tagging data are calculated using the same methods as Maryland's spring tagging data and will be conducted by the USFWS.

For each study, t-tests were used to test for significant differences between the mean lengths of striped bass that were tagged and all striped bass measured for total length (SAS 1990). This was done to determine if the tagged fish were representative of the entire sample. Lengths were considered different at $P \leq 0.05$. Additionally a Kolmogorov-Smirnov test (KS-test) was used to test for differences between length distributions. Distributions were considered different at $P \leq 0.05$.

RESULTS AND DISCUSSION

Spring tagging

The spring sampling component monitored the size and sex characteristics of striped bass spawning in the Potomac River and the upper Chesapeake Bay. Sampling occurred between March 30 and May 18, 2021, with a two week break at the end of April on the Upper Bay due to COVID protocols. A total of 755 striped bass were sampled and 494 (65%) were tagged as part of this long-term survey (Table 1). Fewer fish were sampled and a higher percentage was tagged in 2021, possibly due to some spawning being missed on the Upper Bay.

On many occasions, large samples were caught in a short period of time which required fish to spend a considerable amount of time submerged in the gill net or in the boat, thereby increasing the potential for mortality. In these cases, biologists measured all fish but were only able to tag a sub-sample. Typically, these large concentrations of fish were of a smaller size and captured in small mesh panels. Larger fish were encountered less frequently, and therefore a higher proportion was tagged. This resulted in a significantly greater mean length of tagged fish than the mean length of all fish sampled. Mean total length of striped bass tagged during spring 2021 (572 mm TL) was significantly greater (t-value = -4.02, $P<0.0001$) than that of the sampled population (527 mm TL) (Figure 2). This was also evident in the significant difference of the two length frequencies ($D=0.122$, $P=0.0003$).

Tag releases and recaptures from both Maryland and Virginia's sampling (combined spring 2021 data) will be used to estimate an instantaneous fishing mortality rate on resident fish for the 2021-2022 recreational and commercial fisheries for the entire Chesapeake Bay. Estimates of survival and mortality for the 2021 Chesapeake Bay spawning stock, as well as the resident stock, will be presented in a future report of the ASMFC Striped Bass Tagging Subcommittee.

Cooperative offshore tagging activities

The primary objective of the offshore tagging trips was to apply tags to as many striped bass as possible. The overwintering population has been shifting north over the past decade. In 2021, the majority of fish were captured in federal waters off the coast of Maryland.

Sampling was conducted during 13 fishing trips, between January 7 and February 8, 2021. Four or five lines with custom-made tandem parachute rigs were trolled at 2 to 4 knots, in depths of 40 to 101 feet (12 to 31 m).

In 2021, the study encountered 1,021 striped bass and 1,008 (99%) were tagged (Table 2). The mean lengths of all fish sampled and of those tagged (965 mm TL) were the same (Figure 3). The mean total length of striped bass tagged in 2021 (965 mm TL) was significantly smaller than the length of fish tagged from the 2020 hook and line trips (1048 mm TL, t-value=12.32, $P<0.0001$). Length distributions between the two years were also significantly different ($D=0.414$, $P<0.0001$). Estimates of survival and mortality based on fish tagged in the 2021 offshore study will be presented in a future report of the ASMFC Striped Bass Tagging Subcommittee.

PROJECT NO. 2
JOB NO. 3
TASK NO. 4

STRIPED BASS TAGGING

2022 PRELIMINARY RESULTS

Spring tagging

Sampling occurred between April 4 and May 14, 2022. A total of 884 striped bass were sampled and 369 (42%) were tagged as part of this long-term survey. Mean total length of striped bass tagged during spring 2022 (576 mm TL) was significantly greater (t-value = -7.63, $P<0.0001$) than that of the sampled population (482 mm TL). Estimates of survival and fishing mortality for the 2022 Chesapeake Bay spawning stock, as well as the resident stock, will be presented in a future report of the ASMFC Striped Bass Tagging Subcommittee.

Cooperative offshore tagging activities

In 2022, hook and line sampling was conducted onboard a contracted sportfishing vessel departing from Virginia Beach, VA. Sampling was conducted during 12 fishing trips, between January 24 and February 10, 2022.

While fishing with hook and line, 740 striped bass were encountered and 726 (98%) were tagged. The mean length of all fish sampled was 1097 mm TL and of those tagged was 1096 mm TL. Estimates of survival and fishing mortality based on fish tagged in the 2022 offshore study will be presented in a future report of the ASMFC Striped Bass Tagging Subcommittee.

The final, complete analyses of the 2022 striped bass tagging activities will appear in the F-61-R-18 Chesapeake Bay Finfish Investigations report.

CITATIONS

Jiang H., K. H. Pollock, C. Brownie, J. M. Hoenig, R. J. Latour, B. K. Wells, and J. E. Hightower. 2007. Tag return models allowing for harvest and catch and release: evidence of environmental and management impacts on striped bass fishing and natural mortality rates. North American Journal of Fisheries Management 27:387-396.

Northeast Fisheries Science Center (NEFSC). 2019. 66th Northeast Regional Stock Assessment Workshop (66th SAW) Assessment Report. US Dept Commer, Northeast Fish Sci Cent Ref Doc. 19-08; 1170 p.

SAS. 1990. SAS Institute Inc., SAS/STAT User's Guide, Version 6, Fourth Edition, Volume 2. SAS Institute Inc., Cary, North Carolina. 1989. 846 pp.

LIST OF TABLES

LIST OF FIGURES

Table 1. Summary of USFWS internal anchor tags applied to striped bass in Maryland's portion of Chesapeake Bay and Potomac River, March - May 2021.

System	Inclusive Release Dates	Total Fish Sampled	Total Fish Tagged	Approximate Tag Sequences [a]
Potomac River	3/30/21 - 5/8/21	283	163	616223 – 616386
Upper Chesapeake Bay	4/2/21 - 4/19/21 5/2/21 – 5/18/21	472	331	612609 – 612939
Spring spawning survey totals:		755	494	

[a] Not all tags in reported sequences were applied; some were lost, destroyed, or applied out of order.

Table 2. Summary of USFWS internal anchor tags applied to striped bass during the 2021 cooperative offshore tagging trips.

System	Gear	Inclusive Release Dates	Total Fish Sampled	Total Fish Tagged	Approximate Tag Sequences [a]
Nearshore Atlantic Ocean (Near MD, VA coasts)	Hook & Line	1/7/21 – 2/8/21	1,021 [b, c]	1,008 [b]	614001 – 615000 617501 – 617508

[a] Not all tags in reported sequences were applied; some were lost, destroyed, or applied out of order.
[b] Total sampled and tagged includes one fish with no total length measurement.
[c] Total sampled includes one USFWS recapture.

Figure 1. Tagging locations in spawning areas of the Upper Chesapeake Bay and the Potomac River, March - May 2021.

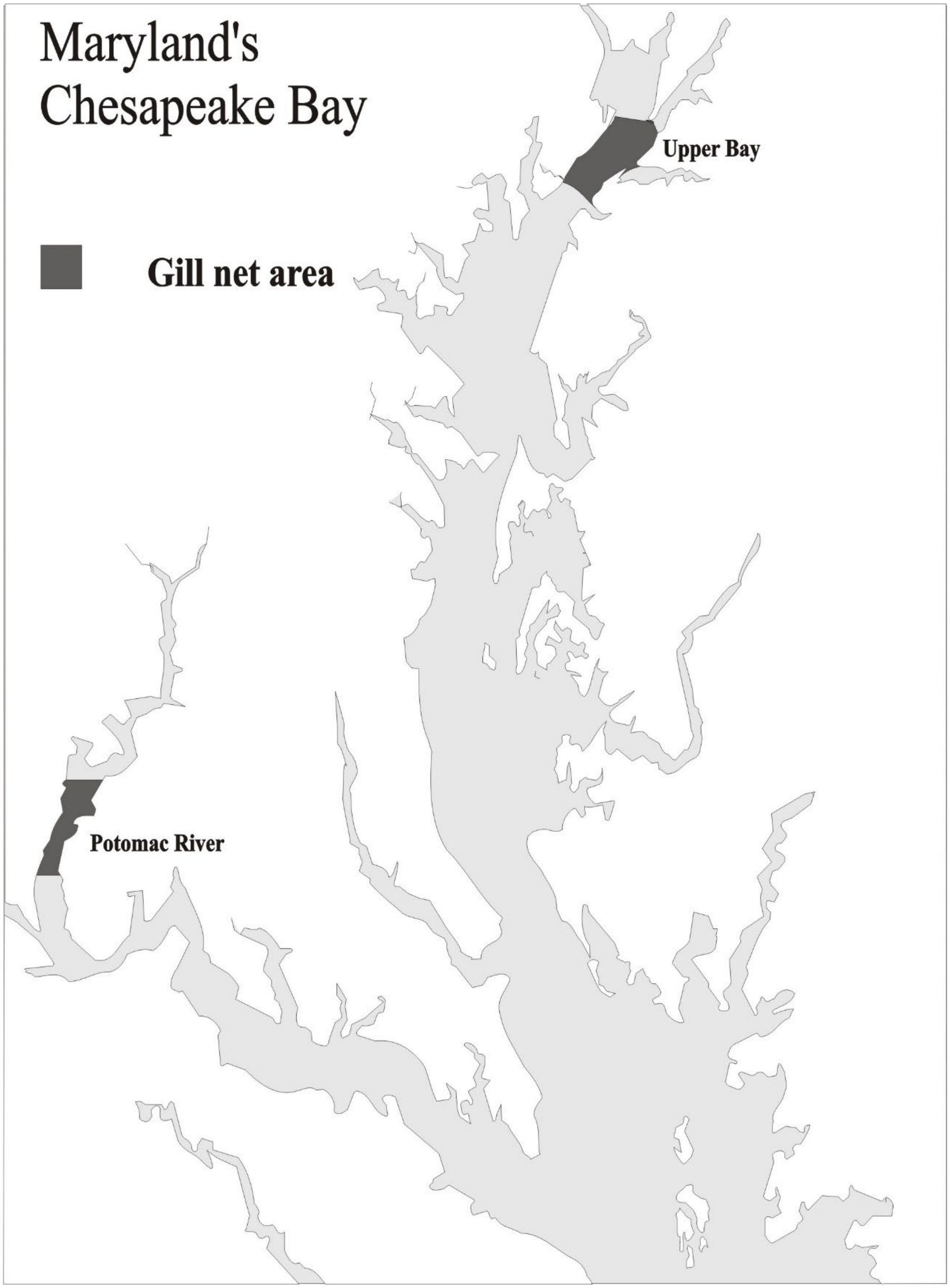


Figure 2. Length frequencies of striped bass measured and tagged during the spring in Chesapeake Bay, March - May 2021.

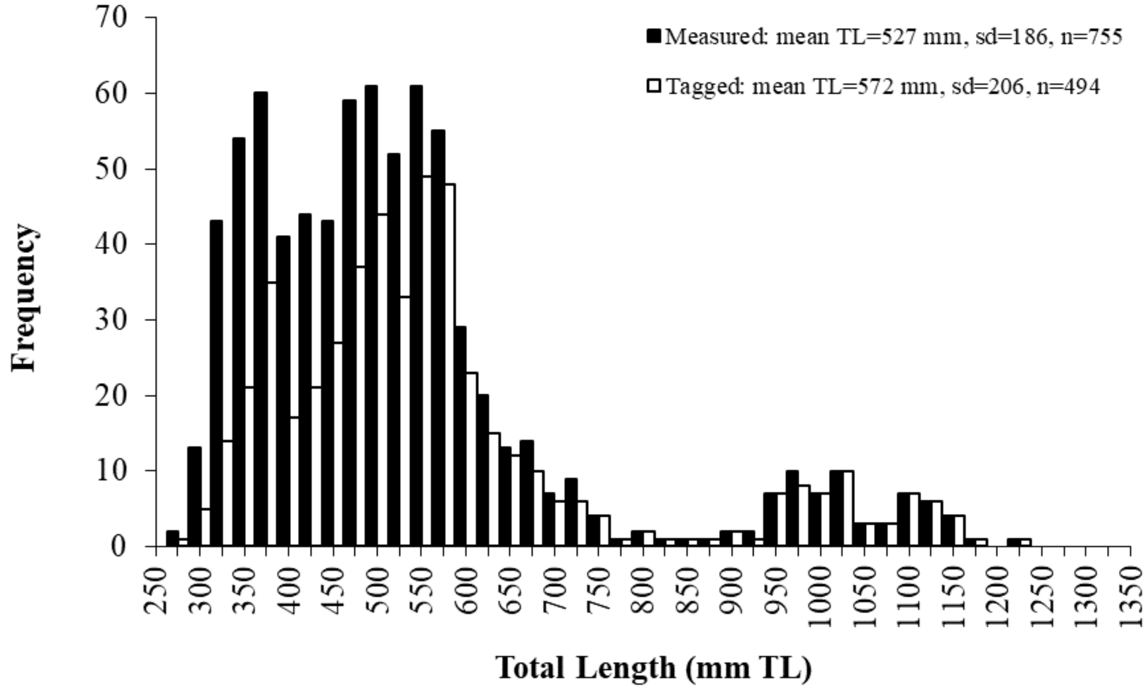
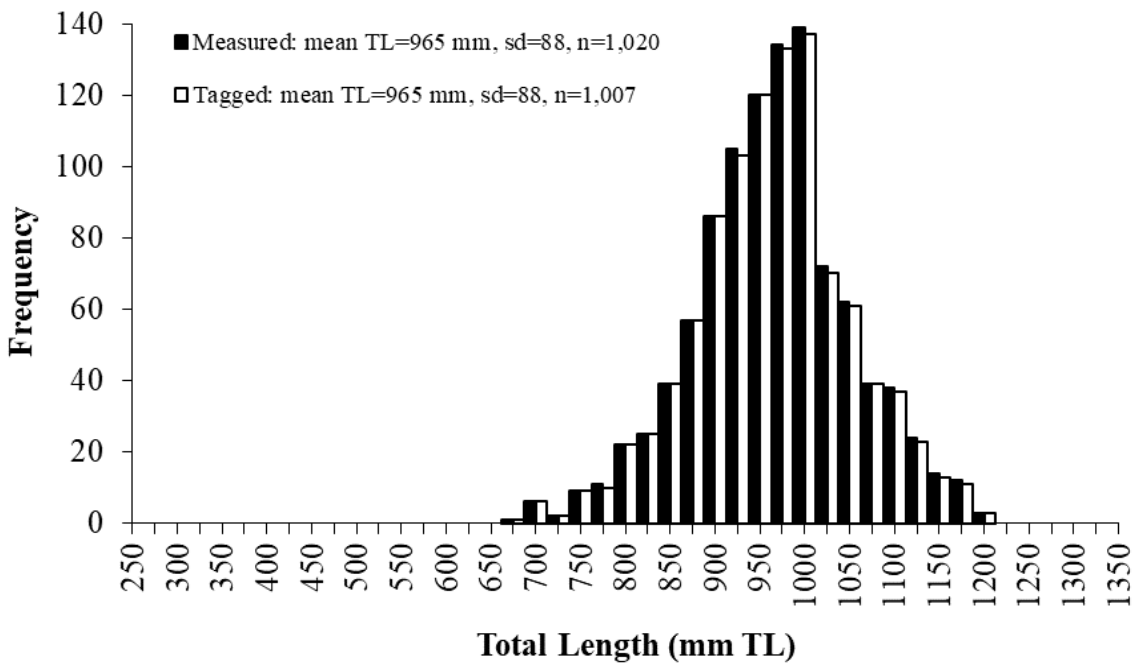


Figure 3. Length frequencies of striped bass measured and tagged during the cooperative offshore tagging trips, January – February 2021.



PROJECT NO. 2
JOB NO. 3
TASK NO. 5A

STRIPED BASS COMMERCIAL FISHERY HARVEST MONITORING

Prepared by Eric Q. Durell

INTRODUCTION

The objectives of Project 2, Job 3, Task 5A were to: present a final accounting of the commercial striped bass harvest in 2020; describe the harvest monitoring conducted by the Maryland Department of Natural Resources (MD DNR); and present preliminary information regarding Maryland's 2021 commercial fishery monitoring. A final accounting of the 2021 commercial fishery and monitoring activities will be presented in the F-61-R-18 Chesapeake Bay Finfish Investigations report.

Maryland completed its twenty-ninth year of commercial fishing under the quota system since the striped bass fishing moratorium was lifted in 1990. The original 2020 commercial quota for Maryland's Chesapeake Bay and tributaries was 1,445,394 pounds, less than in 2019. This quota was further reduced to 1,442,120 pounds when it was determined that the 2019 commercial fishery exceeded quota by 3,274 pounds. Historically, the commercial fishery received 42.5% of the state's total annual Chesapeake Bay striped bass quota, but the current quota was formulated under Addendum VI to Amendment 6 of the Atlantic Striped Bass Interstate Fisheries Management Plan, which prescribed an 18% reduction in quota (Atlantic States Marine Fisheries Commission, 2019). Maryland achieved the required reduction through an approved conservation equivalency plan. The Chesapeake Bay commercial fishery was subject to an 18 – 36 inch total length (TL) slot limit. There was a separate quota of 89,904 pounds for the Atlantic fishery, also mandated by Addendum VI through a conservation equivalency plan. The Atlantic fishery was subject to a 24 inch (TL) minimum size and limited to the state's jurisdictional coastal waters. Detailed fishery regulations are presented in Table 1. The commercial quota system is based on a calendar year.

Beginning in 2014, Maryland's Chesapeake Bay commercial striped bass fisheries were changed to an individual transferable quota (ITQ) management system. Fishermen were given the option of remaining in the previous derby-style fishery, now called the Common Pool. The 2020 commercial fishery operated on a combination of a Common Pool and the ITQ system, with 97% of the quota in the ITQ system. ITQ participants were assigned a share of the commercial quota based partly on their harvest history, and could fish any open season and legal gear. A portion of the commercial quota was reserved for commercial fishermen who opted to remain in the old, derby-style management system. The total Common Pool quota was 39,026 pounds and was determined by combining individual allocations from participants. Individuals in the Common Pool system were only allowed to fish on certain days during the season, and had a maximum allowable catch per day and week. Common Pool gear was limited to hook-and-line (summer/fall) and gill net (winter). All pound net and haul seine harvest was under the ITQ system.

Each fishery was managed with specific seasons that could be modified by MD DNR as necessary. The 2020 ITQ commercial summer/fall fishery opened on June 1 and closed on December 31. Hook-and-line gear was permitted Monday – Thursday; haul seines were permitted Monday – Friday; and pound nets were permitted Monday – Saturday. The Chesapeake Bay 2020 ITQ drift gill net season was split, with the first segment from January 1 through February 29 and the second segment from December 1 through December 31, Monday – Sunday. The Common Pool fishery was open by public notice as follows: 2 days each January – February, June – July, October and December; 1 day in November. The Atlantic coast fishery permitted two gear types, drift gill net and trawl. The Atlantic season occurred in two segments: January 1 through May 31, and October 1 through December 31, Monday – Friday.

Commercial harvest data for striped bass can be used as a general measure of stock size (Schaefer 1972, Goodyear 1985). Catch per unit effort (CPUE) data have traditionally been used more widely outside of the Chesapeake Bay as an indicator of stock abundance (Ricker 1975, Cowx 1991). Catch and effort data provide useful information regarding the various components of a fishery and group patterns of use for the fisheries resource. Catch data collected from check station reports and effort data from monthly fishing reports (MFR) from striped bass fishermen were analyzed with the primary objective of presenting a post-moratoria summary of baseline data on commercial catch and CPUE.

METHODS

All commercially harvested striped bass were required to be tagged by fishermen prior to landing with colored, serial numbered, tamper-evident tags inserted in the mouth of the fish and out through the operculum. These tags could verify the harvester and fishery type, and easily identify legally harvested fish to the public and law enforcement. Each harvest day and prior to sale, all tagged striped bass were required to pass through a MD DNR approved commercial fishery check station. Fish dealers distributed throughout the state volunteered to act as check stations (Figure 1). Check station employees, acting as representatives of MD DNR, were responsible for counting, weighing and verifying that all fish were tagged. Check stations also recorded harvest data on the individual fisherman's striped bass permit. Harvest data were reported to MD DNR by gear or fishery type through multiple of the following systems: 1) Weekly written log reports from designated check stations; 2) daily reporting from the Atlantic Coastal Cooperative Statistics Program's (ACCSP) Standard Atlantic Fisheries Information System (SAFIS); 3) the Fishing Activity and Catch Tracking System (FACTS); 4) daily phone reports from check stations (only required during Common Pool fishery); 5) monthly fishing reports (MFRs) from those fishermen opting not to use daily electronic reporting methods. These reports allowed MD DNR to monitor progress towards quotas (Figures 2 and 3). Fishermen were then required to return their striped bass permits and unused tags to MD DNR at the end of the season. Due to COVID-19 closures, the 2020 tag return period was significantly delayed.

The following information was compiled from each commercial fisherman's harvest reports: Day of Month, NOAA Fishing Area, Gear Code, Quantity of Gear, Duration Fished, Number of Sets, Trip Length (hours), Number of Crew and Pounds (by species). CPUE estimates for each gear type were derived by dividing total pounds landed by each gear by the number of reported trips.

The striped bass harvest weights presented in this report were supplied by the Data Management and Quota Monitoring Program of MD DNR Fishing and Boating Services. Prior to 2001, the pounds landed were determined using the MFRs. Due to delays in submission of the MFRs and the time necessary to enter the data, there would often appear to be discrepancies between the MFRs, check station activity reports, and daily check station reports. Since 2001, in order to avoid these issues and obtain more timely data, the pounds landed have come from the weekly check station activity reports, online SAFIS and FACTS reports, and daily check station telephone reports regarding the Common Pool fishery. However, all four data sources are generally corroborative and the change in data source reported here was considered to have no appreciable effect on the results and conclusions.

The average weight of fish harvested was calculated using two methods. The first was by dividing the total weight of landings by the number of fish reported in the weekly check station activity reports. The second method involved direct sampling of striped bass at check stations by MD DNR biologists to characterize the harvest of commercial fisheries by measuring and weighing a sub-sample of fish (Project 2, Job 3, Tasks 1A, 1B and 1C, in this report). The change to the ITQ system prevented biologists from discerning what gear types were used to harvest striped bass sampled at check stations. Therefore, striped bass measured and weighed by biologists at check stations were combined into seasons (Summer/Fall, Winter, Atlantic). However, based on permitted gear types and harvest trends during those seasons, biologists could eliminate certain gear types within seasons and locations.

The number of fishing trips in which striped bass were landed was determined from harvest reports (Table 2). The reported harvest was divided by the number of trips to calculate an estimate of CPUE, expressed as pounds harvested per trip.

RESULTS AND DISCUSSION

On the Chesapeake Bay and its tributaries, 1,273,757 pounds of striped bass were harvested in 2020. This was 168,363 pounds, or 12%, under the 1,442,120 pound quota. The reported number of fish landed was 320,191 (Table 2). The pound net fishery landed 51% of the total landings by weight, followed by the drift gill net fishery at 43% and the hook-and-line fishery with 6% of the total Bay landings. No striped bass were harvested with haul seines.

Maryland's Atlantic coast landings were reported at 3,371 striped bass, weighing 83,594 pounds (Table 2). This was 6% below the quota of 89,094 pounds. The gill net fishery was responsible for 100% of the Atlantic harvest. Approximately 98% of the harvest occurred in April and May (Figure 3).

Comparisons of Average Weight

The mean weight per fish of striped bass harvested in Chesapeake Bay, regardless of gear type, was 3.98 pounds when calculated from the check station activity reports and 5.05 pounds when measured by biologists (Table 3). Mean weights by specific gear type or season ranged from 3.25 to 4.99 pounds from check station activity reports, and 3.70 to 5.41 pounds when measured by biologists. By both methods of estimation, the largest striped bass landed in the Chesapeake Bay were taken by the winter drift gill net fishery. The smallest fish harvested in the Bay were taken by pound nets, according to check station activity reports.

COVID shutdowns prevented sampling at Atlantic coast check stations (Project 2, Job 3, Task 1C, this report). The average weight of striped bass calculated from check station activity reports was 24.80 pounds.

Commercial Harvest Trends

Commercial striped bass quotas and harvests have been relatively consistent in the Chesapeake Bay since 2015 (Figure 4). Gill nets have historically been responsible for most of the Bay striped bass harvest. In 2020, however, a recent pattern continued of pound nets accounting for more harvest than gill nets. The hook-and-line fishery generally harvests the least of the three major Chesapeake Bay gears, and has been steadily decreasing since 2009. The 2020 hook-and-line fishery continued that trend with the lowest harvest observed since 1996 (Table 4, Figure 5).

Similar to the Chesapeake Bay fisheries, the Atlantic harvest increased in the early 1990s after the moratorium was lifted, but has been highly variable since 2000 (Figure 4). Since 2016, the drift gill net fishery has accounted for an increasing share of the total Atlantic harvest, culminating in 100% of the harvest in 2020 (Table 4, Figure 5).

Commercial CPUE Trends

In Chesapeake Bay, pound net CPUE (509) increased slightly while drift gill net (468) and hook-and-line CPUE (132) both decreased slightly relative to their respective 2019 values (Table 5, Figure 6). Hook-and-line was the only Chesapeake Bay gear with CPUE below its 5-year average in 2020 (Table 5).

On the Atlantic coast, drift gill net was by far the most efficient harvest gear with a CPUE of 746 pounds per trip. The CPUE for trawlers dropped to 0 because no harvest was reported. Since the Atlantic season was expanded to include May and October in 2016, large catches of striped bass have occurred by gill net in May (Figure 3). These large catches are responsible for the high Atlantic gill net CPUE for the fourth consecutive year (Table 5, Figure 6).

PROJECT NO. 2
JOB NO. 3
TASK NO. 5A

COMMERCIAL FISHERY HARVEST MONITORING

2021 PRELIMINARY REPORT - WORK IN PROGRESS

Maryland's 2021 commercial striped bass quota for Chesapeake Bay was 1,445,394 pounds. A portion of that total (31,186 pounds) was designated for Common Pool participants and the rest was available to the ITQ fishery.

The 2021 ITQ commercial summer/fall fishery opened on June 1 and closed on December 31. Hook-and-line gear was permitted Monday – Thursday; haul seines were permitted Monday – Friday; and pound nets were permitted Monday – Saturday. The Chesapeake Bay 2021 ITQ drift gill net season was split, with the first segment from January 1 through February 28, and the second segment from December 1 through December 31. The Common Pool fishery was open by public notice for 3 days each in January and February, 2 days each June – August. Chesapeake Bay fisheries were subject to an 18-36 inch (TL) slot limit.

Maryland's 2021 Atlantic coast quota was set at 89,094 pounds. The Atlantic fishery permitted two gear types, drift gill net and trawl, and the season occurred in two segments: January 1 through May 31, and October 1 through December 31. The Atlantic fishery was subject to a 24 inch (TL) minimum size limit.

Mandatory harvest reporting methods remained unchanged. MD DNR biologists continued fisheries-dependent surveys of the harvest. Landings were not finalized at the time of this writing but will be reported in the F-61-R-18 Chesapeake Bay Finfish Investigations report.

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LIST OF TABLES

LIST OF FIGURES

Table 1. Striped bass commercial regulations by gear type for the 2020 calendar year.

Area	Gear Type	Annual Quota	Number of Participants	Trip Limit	Minimum Size	Reporting Requirement
Bay and Tributaries	Pound Net	No gear-specific quotas for ITQ	145	No trip limits for ITQ	18-36 in TL slot	Monthly Harvest Report
	Haul Seine	No gear-specific quotas for ITQ	0	No trip limits for ITQ	18-36 in TL slot	Monthly Harvest Report
	Hook-and-Line	Included in Common Pool 39,026; No ITQ Quota	90	Common Pool – 250 lbs/license/week, 500 lbs/vessel/day; No trip limits for ITQ	18-36 in TL slot	Monthly Harvest Report
	Gill Net	Included in Common Pool 39,026; No ITQ Quota	205	Common Pool – 300 lbs/license/week, 1,200lbs/vessel/day; No trip limits for ITQ	18-36 in TL slot	Monthly Harvest Report
Total Bay Quota		**1,442,120***				
Atlantic Coast	Trawl and Gill Net	89,094	41	No trip limits for ITQ	24 in TL min	Monthly Harvest Report
Total Maryland Quota		**1,531,214**				

*Originally 1,445,394 pounds but reduced to account for 3,274 pound overage in 2019

Table 2. Summary of striped bass commercial harvest statistics by gear type for the 2020 calendar year.

Area	Gear Type	Pounds[1]	Number of Fish[1]	Trips[2]
Chesapeake Bay[3]	Haul Seine	0	0	0
	Pound Net	647,792	186,247	1,273
	Hook-and-Line	78,880	24,306	598
	Gill Net	547,085	109,638	1,168
	Chesapeake Total	**1,273,757**	**320,191**	**3,039**
Atlantic Coast	Trawl	0	0	0
	Gill Net	83,594	3,371	112
	Atlantic Total	**83,594**	**3,371**	**112**
Maryland Totals		**1,357,351**	**323,562**	**3,151**

1. Data from check station activity reports.

2. Trips were defined as days fished when striped bass catch was reported on MFRs.

3. Includes all Maryland Chesapeake Bay and tributaries, except main stem Potomac River.

Table 3. Striped bass average weight (pounds) by gear type for the 2020 calendar year. Average weights calculated by MD DNR biologists include 95% confidence intervals.

<table>
<tr><th>Area</th><th>Gear Type</th><th>Average Weight from Check Station Logs (pounds)[1]</th><th>Average Weight from Biological Sampling (pounds)[2]</th><th>Sample Size from Biological Sampling[2]</th></tr>
<tr><td rowspan="5">Chesapeake Bay[3]</td><td>Haul Seine</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Pound Net</td><td>3.48</td><td rowspan="2">3.70 (3.63-3.78)</td><td rowspan="2">992</td></tr>
<tr><td>Hook-and-Line</td><td>3.25</td></tr>
<tr><td>Gill Net</td><td>4.99</td><td>5.41 (5.35-5.47)</td><td>3,668</td></tr>
<tr><td>Chesapeake Total Harvest</td><td>3.98</td><td>5.05 (4.99-5.10)</td><td>4,660</td></tr>
<tr><td rowspan="3">Atlantic Coast</td><td>Trawl</td><td></td><td rowspan="2">N/A</td><td rowspan="2">N/A</td></tr>
<tr><td>Gill Net</td><td>24.80</td></tr>
<tr><td>Atlantic Total Harvest</td><td>24.80</td><td>N/A</td><td>N/A</td></tr>
</table>

1. Data from check station activity reports, pounds divided by the number of fish reported.

2. Data from check station sampling by MD DNR biologists.

3. Includes all Maryland Chesapeake Bay and tributaries, except main stem Potomac River.

Table 4. Pounds of striped bass harvested by commercial gear type, 1990 to 2020.

Year	Hook-and-Line	Pound Net	Drift Gill Net	Atlantic Gill Net	Atlantic Trawl
1990	700	1,533	130,947	83	4,843
1991	2,307	37,062	331,911	1,426	14,202
1992	7,919	157,627	609,197	422	17,348
1993	8,188	181,215	647,063	127	3,938
1994	51,948	227,502	831,823	3,085	15,066
1995	29,135	290,284	869,585	10,464	71,587
1996	54,038	336,887	1,186,447	23,894	38,688
1997	367,287	467,217	1,216,686	28,764	55,792
1998	536,809	613,122	721,987	36,404	51,824
1999	790,262	667,842	1,087,123	24,590	51,955
2000	747,256	462,086	1,001,304	40,806	66,968
2001	398,695	647,990	586,892	20,660	71,156
2002	359,344	470,828	901,407	21,086	68,300
2003	372,551	602,748	744,790	24,256	73,893
2004	355,629	507,140	921,317	27,697	87,756
2005	283,803	513,519	1,211,365	12,897	33,974
2006	514,019	672,614	929,540	45,710	45,383
2007	643,598	528,683	1,068,304	38,619	74,172
2008	432,139	559,087	1,216,581	37,117	80,888
2009	650,207	566,898	1,050,188	32,937	94,390
2010	519,117	650,628	934,742	28,467	16,335
2011	441,422	646,978	865,537	18,595	2,806
2012	424,408	565,079	861,135	25,935	51,609
2013	382,783	530,601	747,798	26,240	67,292
2014	218,987	664,508	922,203	22,515	98,408
2015	160,750	614,478	661,639	14,621	20,005
2016	154,238	611,075	660,148	19,197	478
2017	196,538	612,556	630,666	79,276	1,181
2018	122,894	675,991	625,418	79,486	350
2019	99,245	711,730	664,187	82,345	408
2020	78,880	647,792	547,085	83,594	0

Table 5. Striped bass average catch per trip (CPUE) in pounds by commercial gear type, 1990 to 2020.

Year	Hook-and-Line	Pound Net	Drift Gill Net	Atlantic Gill Net	Atlantic Trawl
1990	25	81	76	21	161
1991	77	96	84	65	254
1992	70	130	114	84	271
1993	52	207	125	25	188
1994	108	248	139	129	284
1995	71	220	156	75	994
1996	85	210	188	151	407
1997	145	252	228	215	465
1998	164	273	218	217	381
1999	151	273	293	167	416
2000	160	225	276	281	485
2001	154	231	202	356	416
2002	178	208	252	248	382
2003	205	266	292	240	582
2004	170	162	285	148	636
2005	168	200	324	143	336
2006	251	360	340	315	873
2007	201	322	359	327	1,325
2008	205	303	298	383	1,108
2009	206	351	324	326	1,348
2010	193	391	448	235	511
2011	224	390	397	155	187
2012	179	321	374	157	832
2013	205	359	411	190	1,602
2014	165	367	503	221	1,295
2015	176	359	537	287	1,819
2016	162	433	465	231	68
2017	200	477	425	562	118
2018	188	540	448	598	44
2019	143	492	505	722	102
2020	132	509	468	746	0
Average	155	299	308	259	577
5 year avg	165	490	462	572	66

Figure 1. Map of the 2020 Maryland Chesapeake Bay authorized commercial striped bass check stations.

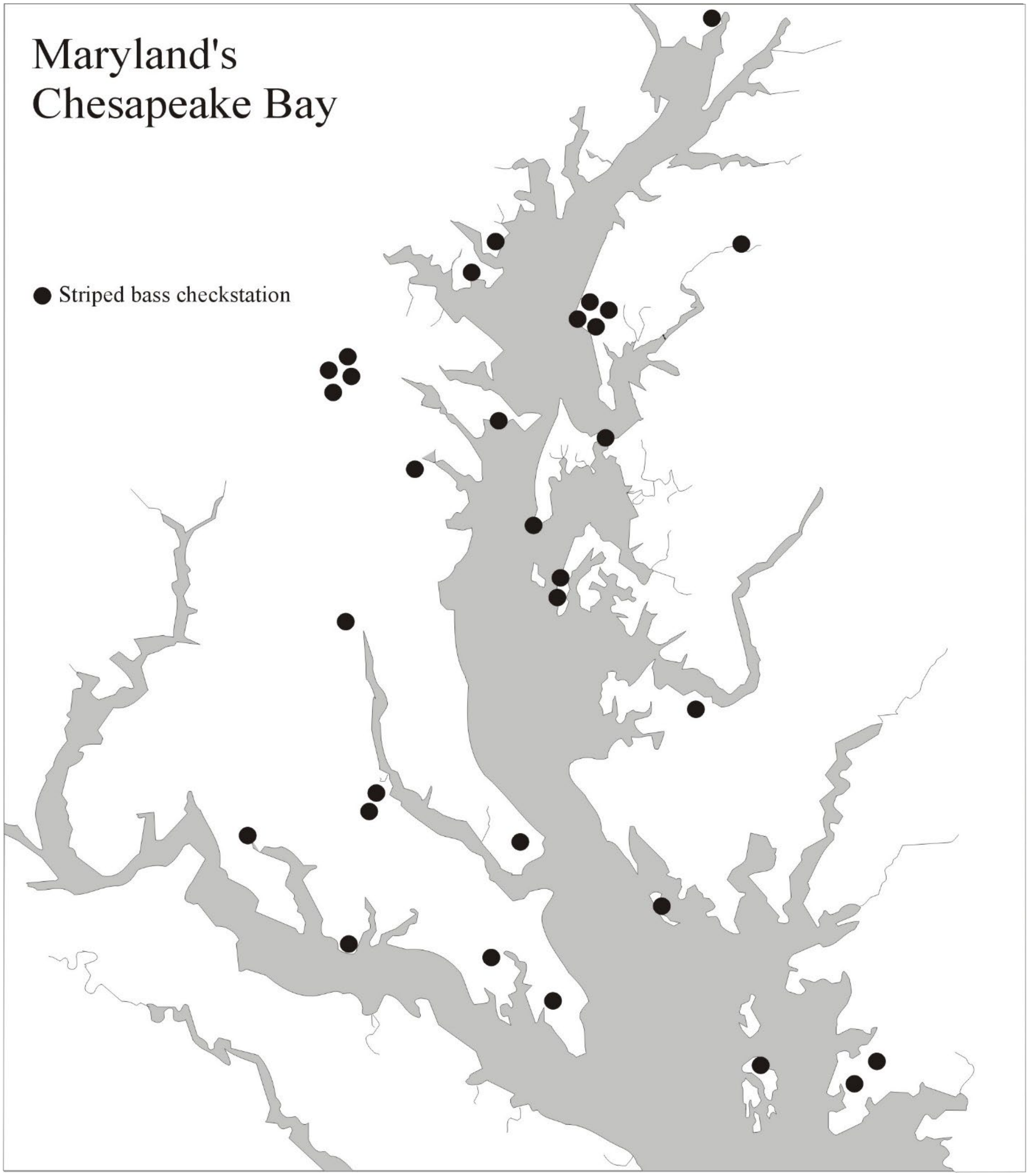
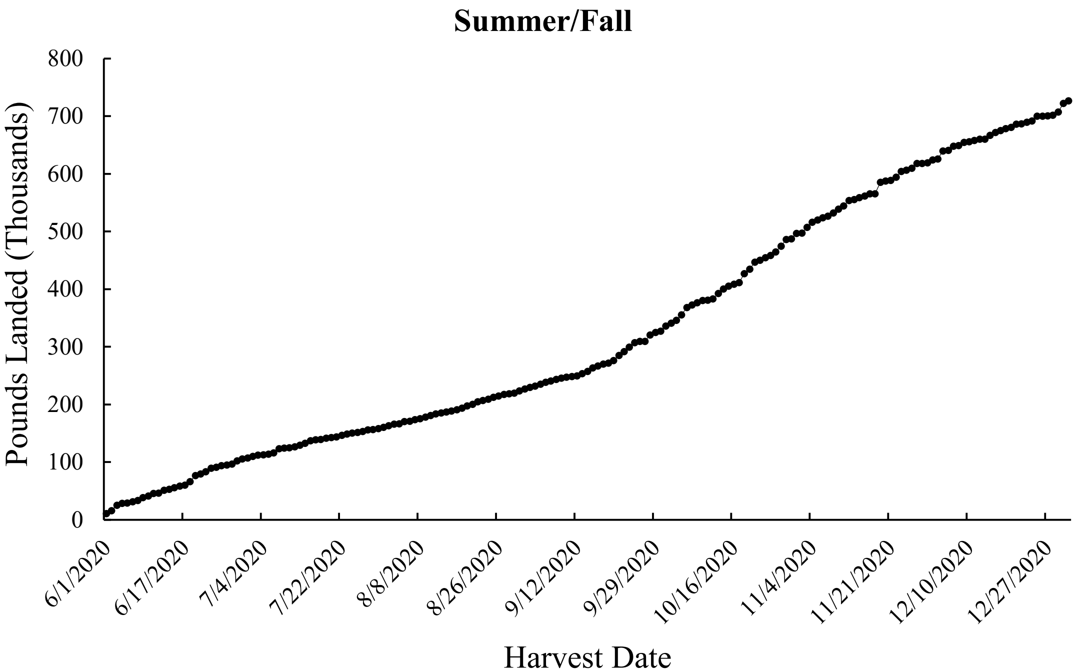


Figure 2. Maryland's Chesapeake Bay summer/fall (pound net and hook-and-line) and winter (gill net) fisheries cumulative striped bass landings from check station reports for calendar year 2020. Note different scales.



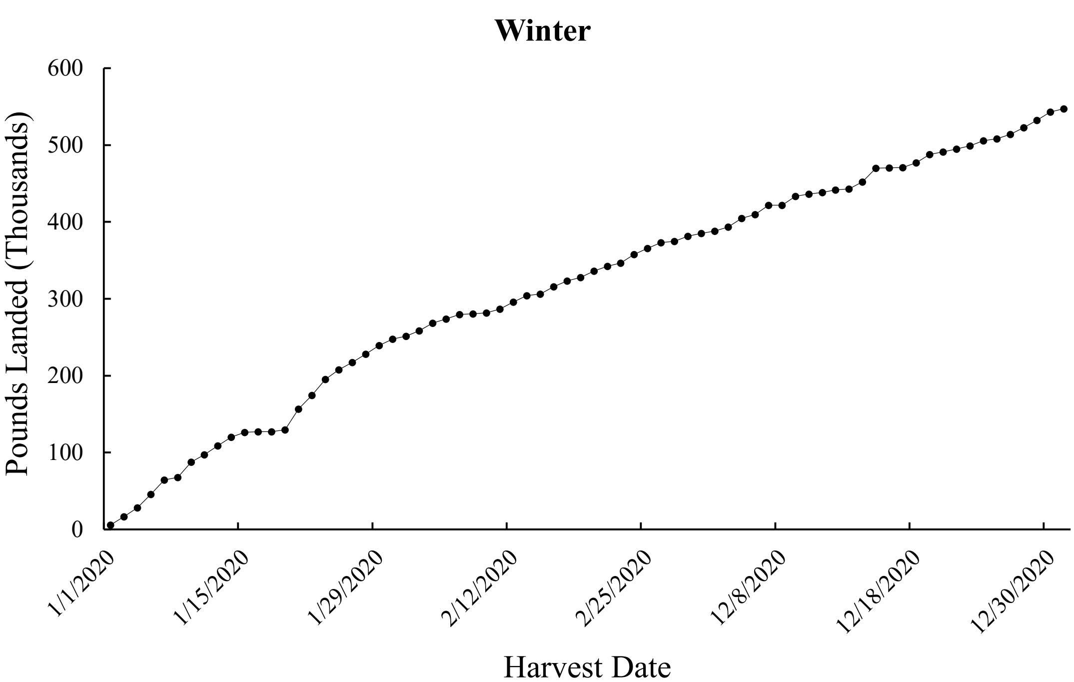


Figure 3. Maryland's Atlantic trawl and gill net fisheries (combined) cumulative striped bass landings from check station reports, January-May and October-December 2020.

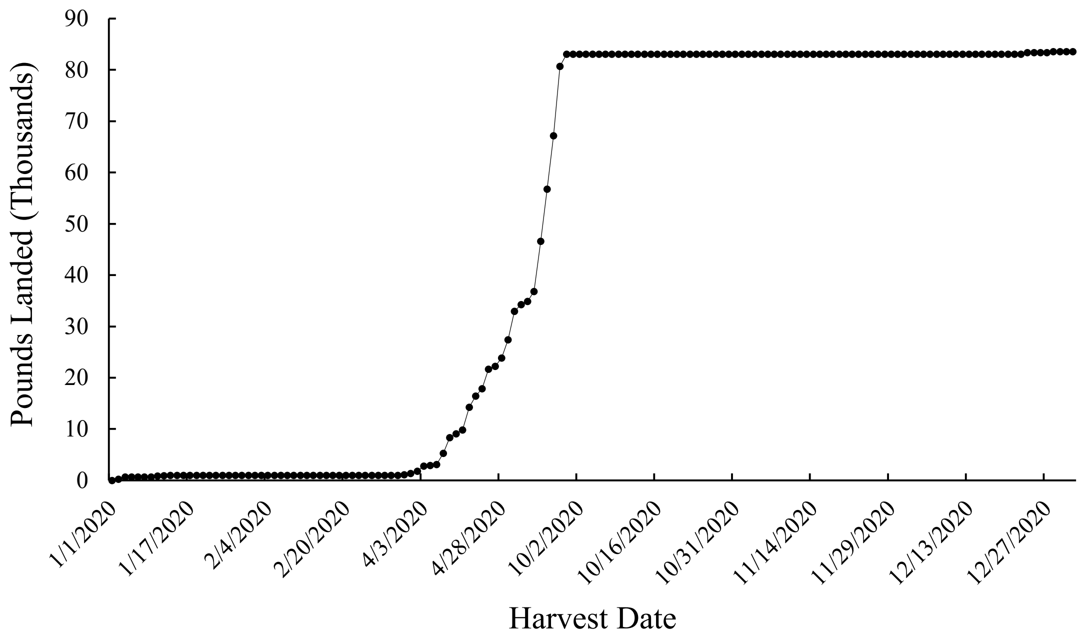
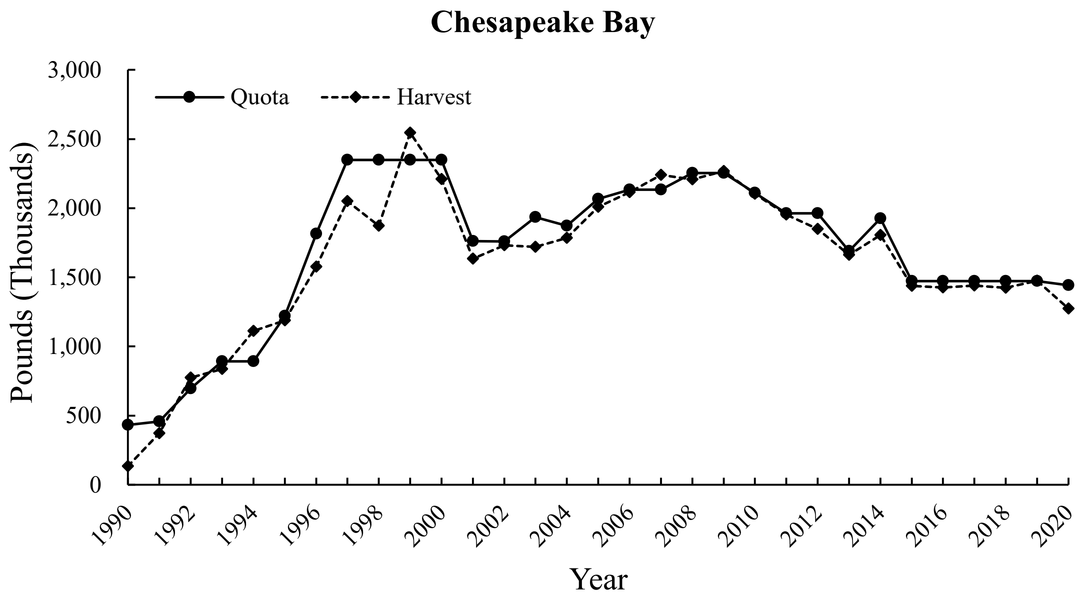


Figure 4. Maryland's Chesapeake Bay and Atlantic Ocean quotas (pounds) and harvests (pounds) for all gears, 1990-2020. Note different scales.



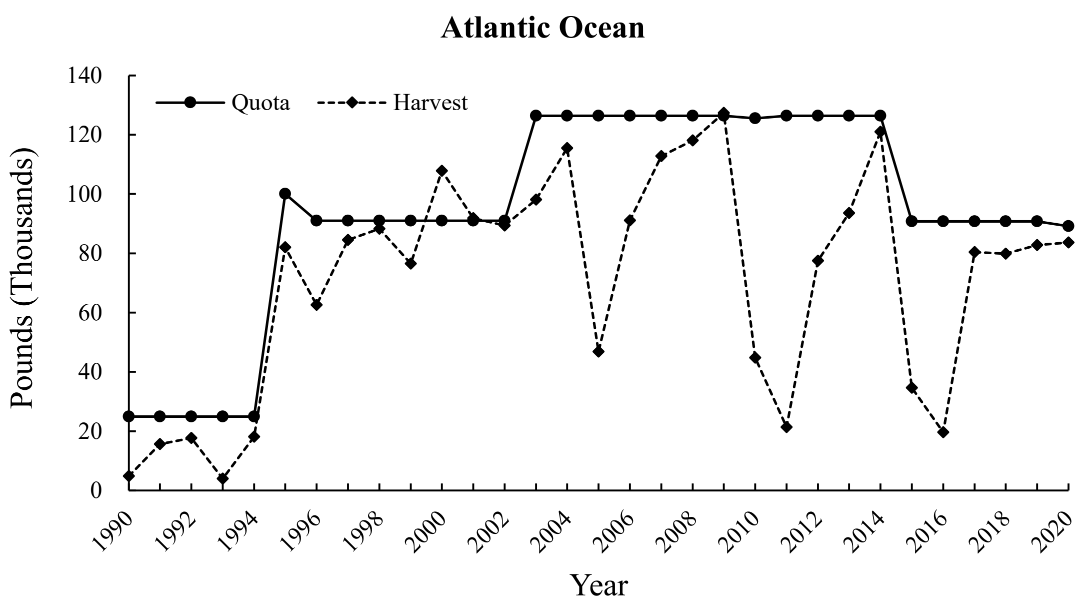
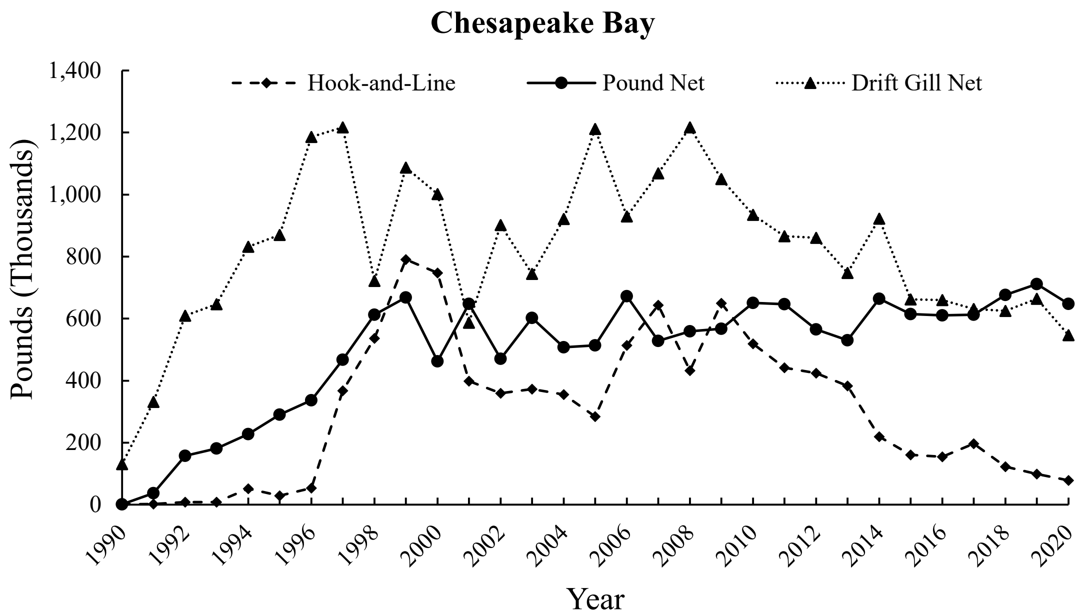


Figure 5. Maryland's Chesapeake Bay and Atlantic Ocean striped bass total harvest (thousands of pounds) per calendar year by commercial gear type, 1990-2020. Note different scales.



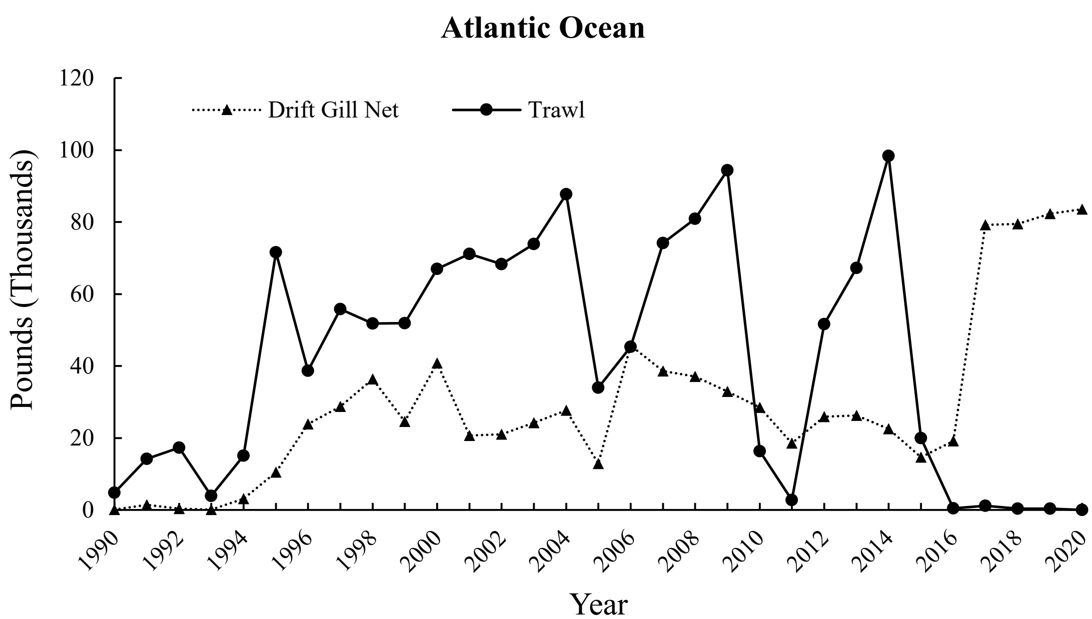
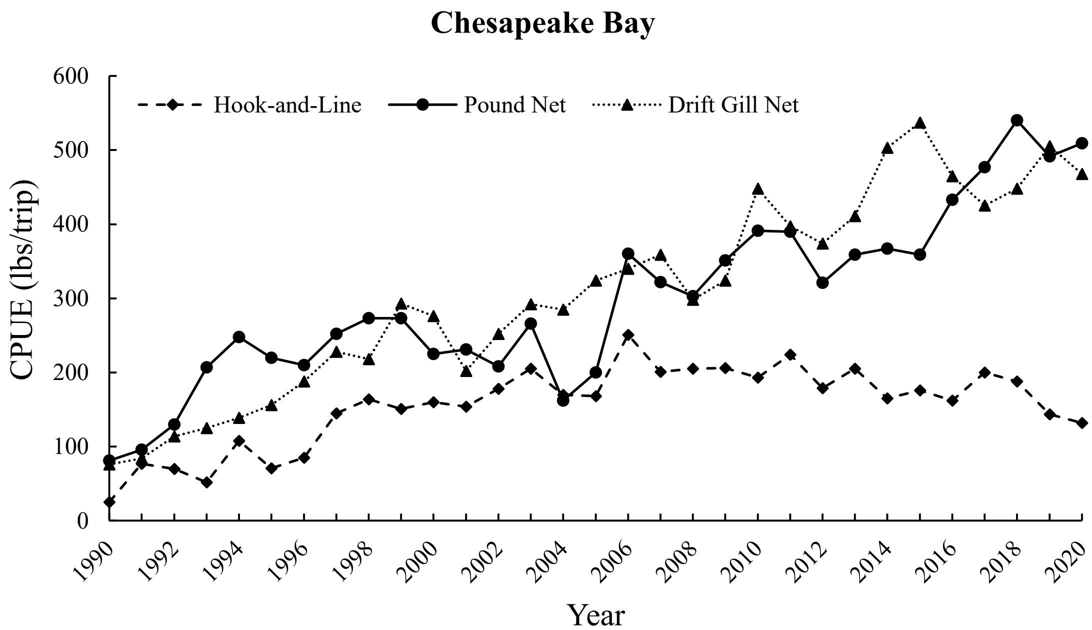
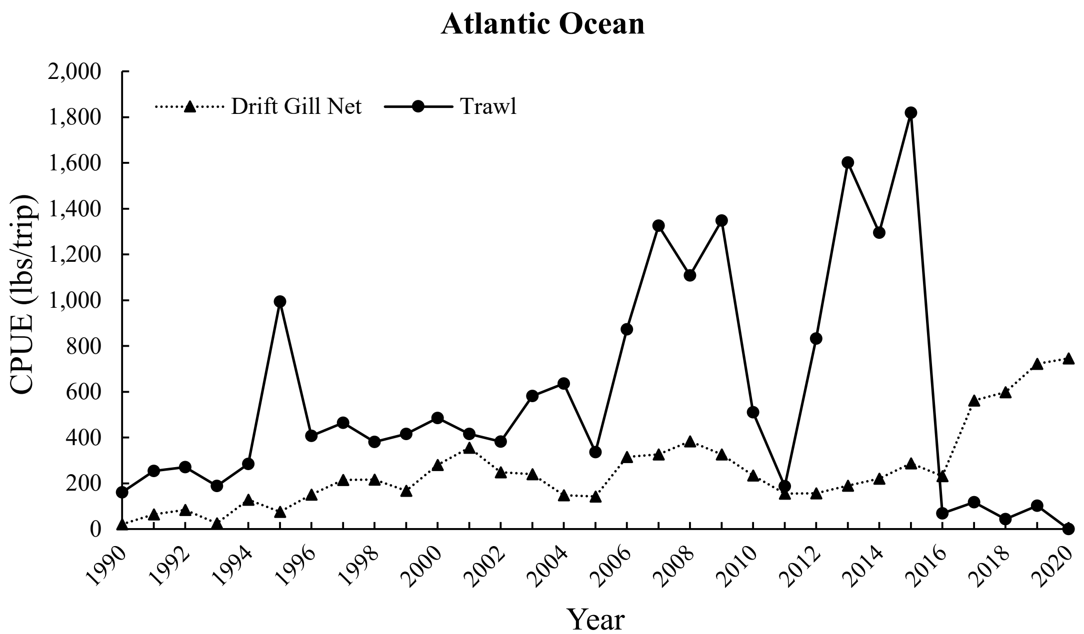


Figure 6. Maryland's Chesapeake Bay and Atlantic Ocean striped bass catch (pounds) per trip (CPUE) by commercial gear type, 1990-2020. Trips were defined as days on which striped bass were landed. Note different scales.





PROJECT NO. 2
JOB NO. 3
TASK NO. 5B

CHARACTERIZATION OF THE STRIPED BASS SPRING RECREATIONAL SEASON AND SPAWNING STOCK IN MARYLAND

Prepared by Simon C. Brown

INTRODUCTION

The primary objective of Project 2, Job 3, Task 5B was to finalize the characterization of the size, age and sex composition of striped bass (*Morone saxatilis*) sampled from the 2021 spring recreational season, which began on Friday, May 1 and continued through May 15. The secondary objective was to estimate recreational harvest rates and catch per unit effort during the spring recreational season. Preliminary results as available for the 2022 spring recreational season are reported and complete results for the 2022 spring recreational season will be reported in the F61-R-18 Chesapeake Bay Finfish Investigations report.

A portion of the Atlantic migratory striped bass stock returns to Chesapeake Bay annually in the spring to spawn in the various tributaries (Pearson 1938; Merriman 1941; Tresselt 1952; Raney 1952; Raney 1957; Chapoton and Sykes 1961; Dovel 1971; Dovel and Edmunds 1971; Kernehan et al. 1981). Mansueti and Hollis (1963) reported that the spawning season runs from April through June. After spawning, migratory striped bass leave the tributaries and exit the bay to their summer feeding grounds in the Atlantic Ocean. Water temperatures can significantly influence the harvest of migratory striped bass in any one year, with coastal migrants remaining in Chesapeake Bay longer during cool springs (Jones and Sharov 2003). In some years, ripe, pre-spawn females have been captured as late as the end of June and early July (Pearson 1938; Raney

1952; Vladykov and Wallace 1952), although this has not been observed in recent years. Increasing water temperatures tend to trigger migrations out of the bay and northward along the Atlantic coast (Merriman 1941; Raney 1952; Vladykov and Wallace 1952).

Estimates indicate that in the mid-1970s, over 90% of the coastal striped bass harvested from southern Maine to Cape Hatteras were fish spawned in Chesapeake Bay (Berggren and Lieberman 1978; Setzler et al. 1980; Fay et al. 1983). Consequently, spawning success and young-of-year survival in the Chesapeake Bay and its tributaries have a significant effect on subsequent striped bass stock size and catch from North Carolina to Maine (Raney 1952; Mansueti 1961; Alperin 1966; Schaefer 1972; Austin and Custer 1977; Fay et al. 1983).

Maryland's post-moratorium spring striped bass season targets coastal migrant fish in the main stem of Chesapeake Bay. The first spring season opened in 1991 with a 16-day season, 36-inch minimum size, and a one fish per season creel limit (Speir et al. 1999). Spring season regulations became progressively more liberal since 1991 as stock abundance increased (Table 1).

In response to the results of the 2019 benchmark stock assessment indicating the stock is overfished with overfishing occurring, the ASMFC Management Board approved Addendum VI to Amendment 6 in October 2019. The Addendum implements measures to reduce total striped bass removals by 18% relative to 2017 levels in order to achieve the fishing mortality target in 2020. The 2021 spring season was 15 days long (May 1 – May 15), with a one fish (≥35 inches) per person, per day, creel limit. Fishing was permitted in Chesapeake Bay from Brewerton Channel to the Maryland – Virginia line, excluding all bays and tributaries (Figure 1). The final estimates of the 2021 Maryland and Virginia spring harvest of coastal migrant striped bass in Chesapeake Bay are reported annually to ASMFC.

The Maryland Department of Natural Resources (MD DNR) Striped Bass Program initiated a dockside creel survey for the spring fishery in 2002. The main objectives are:

1. Develop a time-series of catch per unit effort (CPUE) of the spring trophy fishery,
2. Determine the sex ratio and spawning condition of harvested fish,
3. Characterize length and weight of harvested fish,
4. Characterize the age-distribution of harvested fish, and
5. Collect scales and otoliths to supplement MD DNR age-length keys and for an ongoing ageing validation study of older fish.

METHODS

A dockside creel survey was conducted at least two days per week at high-use charter boat marinas (Table 2) with effort focused on collecting biological data on the catch. Because of the half-day structure of some charter trips, charter boats returned in two waves. Return times depended on how fast customers reached the creel daily limit. Sites were not chosen by a true random draw. Biologists arrived at a chosen site between 9:00 and 10:00 AM to intercept the first wave of returning boats. If it became apparent that fishing activity from that site was minimal (i.e. most charter boats were tied up at the dock), biologists moved to the nearest site in search of higher fishing activity.

Biologists alternated between four major charter fishing ports in 2021: Kentmorr Marina, Chesapeake Beach/Rod & Reel, Deale/Happy Harbor, and Queen Anne Marina (Table 2). Preference was given to high-use sites to ensure the target of 60 fish per week would be sampled. Biological data were collected from charter boat harvest. Interviews with anglers from charter boats were eliminated in 2008. Charter boat fishing activity is adequately characterized through the mandated charter logbook system. Charter boat mates, however, were asked how long lines were in the water so that CPUE could be calculated.

A separate creel survey was previously conducted at public boat ramps to specifically target private boat and shore anglers, but was concluded in 2017. The National Oceanic and

Atmospheric Administration's Marine Recreational Information Program (MRIP) performs similar angler interviews of private boat and shore anglers (https://www.fisheries.noaa.gov/topic/recreational-fishing-data). For continuity, MRIP data were used to estimate spring trophy season CPUEs from 2002-2022 and are presented alongside private boat creel survey data for 2002-2017. To calculate CPUEs, MRIP data for wave 3 (May/June) were downloaded and filtered for private boat and shore angler trips targeting striped bass, that were intercepted in Maryland during the spring trophy season, and where fishing occurred in the mainstem of the Bay. The list of MRIP variable and value combinations used to filter the MRIP data for the striped bass spring trophy season and to calculate CPUEs is contained in Tables 3A and 3B. In 2021, there was not sufficient MRIP data to calculate reliable CPUE's due to the shortened two-week season.

Biological Data Collection

Biologists approached mates of charter boats and requested permission to collect data from the catch (Table 4). Total length (mm TL) and weight (kg) were measured. Mean annual lengths and weights were calculated along with bootstrapped 95% confidence intervals. Mean lengths and weights between years were analyzed using an analysis of variance (ANOVA, $\alpha=0.05$). Because female striped bass grow larger than males (Bigelow and Schroeder 1953) a one-way ANOVA was performed separately on males and females. When significant differences were detected among years, a Duncan's multiple range test ($\alpha=0.05$) was then performed to examine pairwise differences across all years. Additional data on the lengths of striped bass captured and released during the spring season were obtained through the Volunteer Angler Survey which was initiated in 2006 by MD DNR.

The season sampling target for collecting scales was 12 scale samples per 10 mm length group up to 1000 mm TL, for each sex. Scales were collected from every fish greater than 1000 mm TL. A portion of these scale samples was used to supplement scales collected during the spring spawning stock gill net survey (Project No. 2, Job No. 3, Task No. 2) for the construction of a combined spring age-length key. The age structure of fish sampled by the creel survey was estimated using the sex- and survey-combined spring age-length key.

The season sampling target for otoliths was 2 fish per 10 mm length group greater than or equal to 800 mm TL, for each sex. Otoliths were extracted by using a hacksaw to make a vertical cut from the top of the head above the margin of the pre-operculum down to a level above the eye socket. A second cut was made horizontally from the front of the head above the eye until it intersected the first cut, exposing the brain. The brain was removed carefully to expose the sagittal otoliths, which lie below and behind the brain. Otoliths were removed with tweezers and stored dry in labeled plastic vials for later processing.

Spawning condition was determined based on descriptions of gonad maturity presented by Snyder (1983). Spawning condition was coded as pre-spawn, post-spawn or unknown, and sex was coded as male, female, or unknown. “Unknown” for sex or spawning condition refers to fish that were not examined internally, or were not identified with certainty. Ovaries that were swollen and either orange colored (early phase) or green colored (late phase) indicated a pre-spawn female. Shrunken ovaries of a darker coloration indicated post-spawn females. Pre- and post-spawn males were more difficult to distinguish. To verify sex and spawning condition of males, pressure was applied to the abdomen to judge the amount of milt expelled, and an incision was made in the abdomen for internal inspection. Those fish yielding large amounts of milt were determined to be pre-spawn. Male fish with flaccid abdomens or that produced only small amounts of milt were considered post-spawn.

Calculation of Harvest and Catch Rates

For previous years, a striped bass spring trophy season dataset derived from the MRIP database for private boat and shore anglers was used to estimate Harvest Per Trip (HPT), Harvest Per Angler (HPA), Catch Per Trip (CPT), and Catch Per Hour (CPH). Harvest and release numbers of incidental species other than striped bass were transformed to zero, in order to retain all catch level data for trips where striped bass was the primary target. HPA was calculated by dividing the number of striped bass harvested on a trip by the number of anglers in the fishing party. CPT was defined as number of striped bass harvested, plus number of striped bass released, for each trip. CPH was calculated by dividing the total catch of striped bass by the number of hours fished for each trip. MRIP variables used for these calculations are defined in Table 3B.

HPT, HPA and CPT were also calculated from charter boat logbook data. CPH was calculated using the charter boat log data and the average duration of charter boat trips from mate interview data. Charter boat captains are required to submit data to MD DNR indicating the days and areas fished, number of anglers fishing, and numbers of striped bass caught and released. In place of a paper logbook, captains can also submit their data electronically to MD DNR through the Fishing Activity and Catch Tracking System (FACTS) and the Standard Atlantic Fisheries Information System (SAFIS), coordinated by the Atlantic Coastal Cooperative Statistics Program (ACCSP). In cases where a captain combined data from multiple trips into one log entry, those data were excluded, so only single trip entries were analyzed. Approximately 20% of the charter data has been excluded each year using this criterion.

The analysis of charter boat catch rates used a subset of data to include only fishing that occurred in areas specified in the MD DNR regulations during the spring season (Figure 1). Data from the fisheries in the Susquehanna Flats area (NOAA codes 013 and 089) were therefore excluded from this analysis.

RESULTS AND DISCUSSION

The numbers of MRIP trip and angler interviews intercepted in Maryland, which targeted striped bass in the Chesapeake Bay during the spring trophy season are presented in Table 5A. In 2021, there were not sufficient MRIP data to calculate reliable CPUE estimates due to the shortened two-week season.

The number of charter boats intercepted, and number of striped bass examined each year are presented in Table 5B. In 2021, a total of 51 fish were examined from 21 charter trips intercepted with nonzero striped bass harvest (Table 5B).

BIOLOGICAL DATA

Length and Weight

Length distribution

In the 2021 spring striped bass season, fish lengths measured from the harvest ranged from 894 mm TL to 1107 mm TL with a mean of 985 mm TL (n=51, Table 6A, Figure 2). The average size of harvested striped bass increased since 2016 when regulatory changes increased the minimum size limit to 35 inches but has shown a decreasing trend since 2018 (Figure 2). In 2021, the mean length estimate was above the long-term mean of 933 mm TL (95% CIs=912-955 mm TL).

Mean length

The mean length of females (988 mm TL) was greater than the mean length of males (951 mm TL), which is typical of the biology of the species (Bigelow and Schroeder 1953). Only four male striped bass were encountered in 2021 and ranged from 894 to 999 mm TL. Female striped bass length in 2021 was 5% larger than the long-term average (Table 6A, Figure 3). ANOVA indicated significant differences in mean length among years for females ($p<0.0001$). Duncan's multiple range test for females ($\alpha=0.05$) found that the mean length in 2021 was significantly different than 2018 which was the year female mean length was largest, but not significantly different than other years since the size limit increased in 2016 (Table 6A, Figure 3).

The mean daily length of female striped bass sampled from the harvest in 2021 declined during the trophy season (Figure 4). Mean daily length data for 2002 has shown larger females were caught earlier in the season (Barker et al. 2003). However, in other years mean daily length has been variable throughout the season.

Mean weight

Not all fish measured were weighed due to filleting occurring prior to fish being intercepted on shore. Fish weights sampled during the 2021 spring striped bass season ranged from 7.4 kg to 14.4 kg. The mean weight in 2021 was 9.8 kg and 95% confidence intervals indicate it was similar to the mean weight in 2019 and 2020 but smaller than the mean weight in 2018 (Table 6B, Figure 5).

The mean weight of females was 9.9 kg. Females tend to grow larger than males, and most striped bass over 13.6 kg (30.0 lb) are females (Bigelow and Schroeder 1953). ANOVA indicated significant differences in mean weight among years for females ($p<0.0001$). The weight of females in the harvest has generally increased from 2012 to 2018 but has since decreased (Figure 5). Duncan's multiple range test for females ($\alpha=0.05$) found that the mean weight in 2021 was significantly different than 2017-2019, but not significantly different than 2016 when the size limit was first increased to a minimum of 35 inches TL (Table 6B, Figure 5).

Age Structure

The number of scales aged from the creel survey has varied between years. In 2021, 90 scale samples from the creel survey were aged, which includes supplementary scale samples obtained through June 15. The age distribution estimated from the combined age-length key applied to lengths of striped bass sampled from the 2021 spring recreational harvest ranged from 9 to 18 years old (Figure 6). Striped bass between 8 and 12 years old have typically contributed the most to the spring recreational harvest with each age comprising an average 10% to 20%. However, in 2021 the above average 2011 year-class (Age 10) disproportionately contributed 56.2% to the harvest, like the previous year (Figure 6). This high contribution likely represents the complete maturation and fully migratory status of 10-year-old females from the 2011 year-class. Similar disproportionate contributions from the 2003 year-class occurred in 2012-2014, also starting at age 9 (Figure 6). The next largest contribution was 18.7% from the 2012 year-class, followed by 14.2% from the 2013 year-class (Figure 6). All other year-classes contributed less than 10% to the harvest.

Sex Ratio

There were no striped bass which received an unknown sex designation in 2021 (Table 7A). As in past years, the 2021 spring season harvest was dominated by female striped bass, comprising 92% of the total sample (Table 7B).

Spawning Condition

Percent pre-spawn females

The need to understand spawning condition of the female portion of the catch helped initiate this study in 2002. Goshorn et al. (1992) studied the spawning condition of large female striped bass in the upper Chesapeake Bay spawning area during the 1982-1991 spawning seasons. Their results suggested that most large females spawn before mid-May in the upper Chesapeake

Bay spawning area, indicating a high potential to harvest gravid females in the spring fishery. From 2002 – 2021 the percentage of pre-spawn females in the spring season harvest has declined from a maximum of 63% in 2005 to a minimum of 0% in 2021 (Table 8). The onset of striped bass spawning is related to warming water temperatures on the spawning grounds in the spring, and alterations to the timing of spring warming from year-to-year could alter striped bass spawning phenology in warm versus cold years (Peer and Miller 2014). However, in recent years with prolonged cold spring seasons (2015 and 2018), the percent of pre-spawn females in the harvest still declined to all-time lows as compared with previous years, which is the opposite result of what would be expected if female spawning phenology is driven solely by spring water temperatures on the spawning grounds. The average annual mean total length (mm) of the trophy harvest was inversely related to the proportion of pre-spawn females sampled each year (Figure 7, $p<0.0001$, Adjusted R-squared=0.76). Shifting demographics of the striped bass stock towards higher proportions of older and larger females combined with increased minimum size limits could be altering the proportion of pre-spawn females in the trophy harvest since larger individuals may spawn earlier in the season than smaller individuals (Cowan et al. 1993).

Daily spawning condition of females

The percentage of pre-spawn females tends to be higher at the beginning of the season and then decrease after the beginning of May. When spawning condition data from all years of the survey are summarized by day of the year, this trend becomes more apparent (Figure 8). In 2021, the proportion of pre-spawn females was lower than predicted by the average annual mean total length (mm) (Figure 7), which may be attributed to the starting date the trophy season moving from the third Saturday in April to May 1st.

CATCH RATES AND FISHING EFFORT

Harvest Per Trip Unit Effort

Charter boat activity can be accurately characterized from existing reporting methods, so no targeted interviews of charter boat anglers were conducted during the spring season in 2021. Creel survey interview data were previously used to obtain harvest rate estimates for private vessels, however this portion of the survey was ended in 2017. For continuity, MRIP interview data were used to calculate harvest rates for private boats for 2002-2019. In 2020, MRIP interview data were not available for the time period covering the spring trophy season due to COVID-19. In 2021, there was not sufficient MRIP interview data to produce reliable catch rate estimates for private boats. Harvest per trip (HPT) was calculated from combined charter boat logbook and SAFIS data, and creel survey interviews, using only fish kept during each trip.

The mean HPT in 2021 according to charter boat data was 1.0 fish per trip (Table 9A) which was 75% below the long term mean charter boat HPT (4.1 fish per trip). The charter and private HPT have decreased by design since 2016 when minimum size limit regulations in the recreational fishery were implemented (Table 9A).

Mean harvest per angler, per trip (HPA) was calculated by dividing the total number of fish kept on a vessel by the number of people in the fishing party. Like HPT above, HPA was expected to be reduced from previous years due to regulations implemented to achieve harvest reduction. HPA from charter boat data in 2021 was 0.17 fish per person (Table 9B) which was a 74% reduction from the long-term mean (0.66 fish per trip). HPA for private anglers, calculated from MRIP interview data, was <0.1 fish per person for both 2018 and 2019 which is the lowest in the time series, but MRIP data were unavailable to make a 2020 calculation due to COVID-19 and there were insufficient interview data in 2021 due to the shortened two-week season (Table 9B).

Catch Per Unit Effort

In every year, charter boats have caught (kept and released) more fish per trip and per hour than have private boats (Tables 10A and 10B). The higher charter boat catch rates are likely attributable to the greater level of experience of the charter boat captains. Also, charter captains are in constant communication amongst themselves, enabling them to better track daily movements and feeding patterns of migratory striped bass and consistently operate near larger aggregations of fish. In 2021, there were a total of 571 recorded logbook trips during the spring trophy season, with 0% excluded as multiple trips. The total number of qualifying striped bass logbook trips has declined 59% compared with the long-term mean (Table 10B). Charter boats caught 2.9 fish per trip, which was 49% below the long-term average (5.7 fish per trip, Table 10B). The charter boat catch per hour (CPH) was 0.6 fish per hour.

Angler Characterization

States of residence

In 2021, limited MRIP angler interview data showed most anglers participating in the spring trophy fishery were residents of Maryland (75%), followed by the surrounding states of Pennsylvania (16%), West Virginia (7%) and Virginia (2%) (Table 11).

PROJECT NO. 2
JOB NO. 3
TASK NO. 5B

CHARACTERIZATION OF THE STRIPED BASS
SPRING RECREATIONAL SEASON
AND SPAWNING STOCK IN MARYLAND

2022 PRELIMINARY RESULTS

Data collected during the 2022 spring recreational season (May 1-May15) are currently being analyzed. In 2022, biological sampling of harvested striped bass from the charter boat fleet was conducted two or more days a week depending on the availability of fish from for a total of six sample days. The final, complete analyses of the spring 2022 recreational survey data will be available in the F-61-R-18 Chesapeake Bay Finfish Investigations report.

During the 2022 spring recreational season, 28 striped bass from 15 intercepted charter boat trips were measured, weighed, and internally examined for spawning condition. Biological samples collected from examined fish for aging studies include 28 scale samples and 17 otoliths. Female striped bass (n=25) had a mean total length of 1075 mm and mean weight of 12.97 kg. Internal examination revealed 92% of female striped bass harvested had recently spawned. Male striped bass (n=3) had a mean total length of 925 mm and a mean weight of 8.15 kg. Scale samples are currently being processed and aged, therefore no age distribution of the 2022 spring recreational harvest is available at this time.

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LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

Table 1. History of changes made to MD DNR fishing regulations for Maryland striped bass spring trophy seasons, 1991-2021.

Year	Open Season	Min Size Limit (In.)	Bag Limit (# Fish)	Open Fishing Area
1991	5/11-5/27	36	1 per person, per season, with permit	Main stem Chesapeake Bay, Annapolis Bay Bridge-VA State line
1992	5/01-5/31			
1993	5/01-5/31		1 per person, per season	
1994	5/01-5/31	34	1 per person, per day, 3 per season	
1995	4/28-5/31	32	1 per person, per day, 5 per season	Main stem Chesapeake Bay, Brewerton Channel-VA State line
1996	4/26-5/31		1 per person, per day	
1997	4/25-5/31			
1998	4/24-5/31			
1999	4/23-5/31	28		
2000	4/25-5/31			
2001	4/20-5/31			
2002	4/20-5/15			
2003	4/19-5/15			
2004	4/17-5/15			
2005	4/16-5/15			
2006	4/15-5/15	33		
2007	4/21-5/15	28-35 or >41		
2008	4/19-5/13	28		
2009	4/18-5/15			
2010	4/17-5/15			
2011	4/16-5/15			
2012	4/21-5/15			
2013	4/20-5/15			
2014	4/19-5/15			
2015	4/18-5/15	28-36 or >40		
2016	**4/16-5/15**	35 inches	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
2017	**4/15-5/15**			
2018	**4/21-5/15**			
2019	**4/20-5/15**			
2020	**5/01-5/15**			
2021	**5/01-5/15**			

Table 2. Survey sites for the Maryland striped bass spring season dockside creel survey, 2002-2021. Sites are listed in a clockwise direction around Maryland's section of the Chesapeake Bay.

Region	Site Name	Site Number
Eastern Shore-Upper Bay	Rock Hall	01
Eastern Shore-Middle Bay	Matapeake Boat Ramp	02
Eastern Shore-Middle Bay	Kent Island Marina/Hemingway's	15
Eastern Shore-Middle Bay	Kentmorr Marina	03
Eastern Shore-Middle Bay	Queen Anne Marina	04
Eastern Shore-Middle Bay	Knapps Narrows Marina	13
Eastern Shore-Middle Bay	Tilghman Is./Harrison' s	05
Western Shore-Lower Bay	Pt. Lookout State Park	16
Western Shore-Lower Bay	Solomons Island Boat Ramp	17
Western Shore-Lower Bay	Solomons Island/Harbor Marina	18
Western Shore-Lower Bay	Solomons Island/Beacon Marina	19
Western Shore-Lower Bay	Solomons Island/Bunky's Charter Boats	06
Western Shore-Lower Bay	Solomons /Calvert Marina	07
Western Shore-Middle Bay	Breezy Point Fishing Center and Ramp	08
Western Shore-Middle Bay	Chesapeake Beach/Rod & Reel	09
Western Shore-Middle Bay	Herrington Harbor South	14
Western Shore-Middle Bay	Deale/Happy Harbor	10
Western Shore-Middle Bay	South River	12
Western Shore-Upper Bay	Sandy Pt. State Park Boat Ramp and Beach	11

Table 3A. Variable and value combinations used to filter MRIP interview data for relevance to the spring trophy season.

Variable	Definition	Value
ST	Fips code for state of intercept	24 (Maryland)
DATE	Date	May 1 – May 15
AREA	Area of fishing	"F" (Chesapeake Estuary)
PRIM1_COMMON	Primary species targeted	"STRIPED BASS"
MODE_F	Fishing mode	1:5 (shore), 8 (private/rental boat)

Table 3B. MRIP variables used to calculate harvest and catch per unit effort rates

Variable	Definition
COMMON	Common name of fish species
ID_CODE	Angler interview identifier
PRT_CODE	Trip identifier
CLAIM_UNADJ	Unadjusted count of fish that were caught, landed whole, and available for identification to species and enumeration by the interviewer.
HARVEST_UNADJ	Unadjusted number of fish that were caught, not released live, but not available in whole form for examination, identification, or enumeration.
RELEASE_UNADJ	Unadjusted number of fish that were caught and released alive.
HRSF	Hours fished

Table 4. Biological data collected by the Maryland striped bass spring season creel survey, 2021.

Measurement or Test	Units or Categories
Total length (TL)	to nearest millimeter (mm)
Weight	kilograms (kg) to the nearest tenth
Sex	male, female, unknown
Spawning condition	pre-spawn, post-spawn, unknown

Table 5A. Annual number of selected trips intercepted by MRIP, by type, and number of anglers interviewed, through May 15th.

Year	Trips Intercepted	Private Boat	Shore	Number of Anglers
2002	40	39	1	85
2003	40	40	0	68
2004	102	100	2	177
2005	37	37	0	58
2006	21	21	0	31
2007	54	43	11	88
2008	28	18	10	33
2009	60	51	9	82
2010	30	24	6	42
2011	70	60	10	118
2012	25	25	0	38
2013	38	31	7	52
2014	66	59	7	91
2015	77	72	5	130
2016	90	78	12	149
2017	108	106	2	191
2018	181	170	11	380
2019	80	69	11	166
2020	DATA NOT AVAILABLE DUE TO COVID-19			
2021	40	37	3	44

Table 5B. Number of intercepted trips, by type (fishing mode), anglers interviewed and fish examined by the Maryland striped bass spring season creel survey, through May 15.

Year	Charter Boat	Private Boat	Shore	Not Specified	Anglers Interviewed	Fish Examined
2002	140	45	0	2	458	503
2003	114	65	0	2	332	478
2004	88	42	1	7	178	462
2005	53	1	0	0	93	275
2006	101	28	10	0	344	464
2007	50	483	9	0	809	301
2008	34	265	6	0	329	200
2009	27	275	1	0	747	216
2010	45	193	0	0	601	263
2011	63	299	0	0	824	234
2012	37	172	0	0	447	130
2013	35	169	3	0	456	182
2014	48	209	1	0	580	211
2015	57	201	3	0	546	177
2016	58	221	0	0	585	197
2017	77	180	7	0	501	150
2018	41	--	--	--	--	118
2019	11	--	--	--	--	25
2020	8	--	--	--	--	30
2021	21	--	--	--	--	51

Table 6A. Mean lengths of striped bass (mm TL) with 95% confidence limits sampled by the Maryland striped bass spring season creel survey, through May 15.

Year	Mean TL (mm) All Fish	Mean TL (mm) Females	Mean TL (mm) Males
2002	887 (879-894)	895 (886-903)	846 (828-864)
2003	894 (885-903)	899 (889-909)	834 (813-864)
2004	889 (881-897)	896 (886-903)	827 (810-845)
2005	893 (885-902)	898 (888-907)	867 (852-883)
2006	923 (917-930)	929 (922-936)	886 (875-897)
2007	861 (852-871)	869 (858-881)	827 (806-848)
2008	920 (910-931)	933 (922-944)	877 (853-900)
2009	913 (902-925)	930 (917-942)	860 (836-883)
2010	913 (902-924)	932 (921-944)	833 (812-855)
2011	890 (880-901)	906 (895-917)	829 (808-851)
2012	863 (849-876)	885 (872-899)	795 (771-818)
2013	924 (914-934)	934 (924-943)	853 (824-883)
2014	946 (937-956)	952 (942-961)	882 (850-915)
2015	935 (921-949)	952 (939-967)	859 (832-888)
2016	999 (992-1006)	1002 (995-1010)	951 (937-965)
2017	1005 (994-1017)	1011 (1000-1022)	928 (892-972)
2018	1037 (1024-1050)	1044 (1031-1057)	967 (943-993)
2019	990 (956-1027)	1014 (977-1051)	895 (883-911)
2020	994 (971-1019)	996 (971-1021)	969 (935-1003)*
2021	985 (973-998)	988 (975-1002)	951 (914-987)
Mean	933 (912-955)	943 (921-964)	876 (855-899)

*Because only two males were sample in 2020, the range instead of 95% Confidence Interval is reported**.**

Table 6B. Mean weight of striped bass (kg) with 95% confidence limits sampled by the Maryland striped bass spring season creel survey, through May 15.

Year	Mean Weight (kg) All Fish	Mean Weight (kg) Females	Mean Weight (kg) Males
2002	7.3 (7.1-7.5)	7.4 (7.2-7.6)	6.1 (5.7-6.4)
2003	7.6 (7.3-7.9)	7.7 (7.3-8.0)	5.9 (5.2-6.6)
2004	7.6 (7.4-7.8)	7.8 (7.5-8.0)	5.9 (5.5-6.4)
2005	7.3 (7.1-7.6)	7.5 (7.2-7.8)	6.4 (6.0-6.7)
2006	8.1 (7.9-8.4)	8.3 (8.0-8.5)	6.7 (6.4-7.1)
2007	6.8 (6.4-7.1)	7.1 (6.7-7.5)	5.7 (5.2-6.1)
2008	7.8 (7.5-8.1)	8.2 (7.8-8.5)	6.7 (6.1-7.2)
2009	7.9 (7.6-8.2)	8.3 (8.0-8.7)	6.4 (5.8-6.9)
2010	7.8 (7.5-8.1)	8.3 (8.0-8.6)	5.7 (5.2-6.1)
2011	7.3 (7.0-7.6)	7.7 (7.4-8.0)	5.6 (5.1-6.1)
2012	6.7 (6.4-7.1)	7.2 (6.9-7.6)	5.3 (4.7-5.8)
2013	8.3 (8.0-8.6)	8.6 (8.3-8.9)	6.3 (5.7-7.0)
2014	9.1 (8.8-9.4)	9.3 (9.0-9.6)	6.8 (6.1-7.5)
2015	8.6 (8.2-9.0)	9.1 (8.7-9.6)	6.5 (5.8-7.1)
2016	10.2 (10.0-10.4)	10.3 (10.1-10.6)	8.4 (7.6-9.2)
2017	10.7 (10.3-11.1)	10.8 (10.4-11.2)	8.9 (7.7-10.5)
2018	11.7 (11.1-12.3)	12.0 (11.5-12.6)	8.9 (8.1-9.7)
2019	11.0 (9.3-12.7)	12.0 (10.2-13.7)	7.9 (7.3-9.0)
2020	10.4 (9.6-11.1)	10.4 (9.7-11.2)	9.5 (NA-NA)*
2021	9.8 (9.4-10.2)	9.9 (9.5-10.3)	8.4 (7.4-9.4)
Mean	8.6 (8.0-9.3)	8.9 (8.3-9.6)	6.9 (6.4-7.5)

*Only one male weight was recorded in 2020.

Table 7A. Number of female (F), male (M), and unknown (U) sex striped bass sampled by the Maryland striped bass spring season creel survey, through May 15.

Year	F	M	U	Total (Include U)	Total (Exclude U)	F + U
2002	342	70	92	504	412	434
2003	404	37	39	480	441	443
2004	406	45	11	462	451	417
2005	233	39	3	275	272	236
2006	393	63	8	464	456	401
2007	242	49	10	301	291	252
2008	155	45	0	200	200	155
2009	166	48	2	216	214	168
2010	212	50	1	263	262	213
2011	186	48	0	234	234	186
2012	98	32	0	130	130	98
2013	160	22	0	182	182	160
2014	194	17	0	211	211	194
2015	143	33	1	177	176	144
2016	184	13	0	197	197	184
2017	137	12	1	150	149	137
2018	105	11	2	118	116	107
2019	20	5	0	25	25	25
2020	28	2	0	30	30	30
2021	47	4	0	51	51	47

Table 7B. Percent females, using three different calculation methods, sampled by the Maryland striped bass spring season creel survey, through May 15.

Year	%F (Include U)	%F (Exclude U)	%F (Assume U were Female)
2002	68	83	86
2003	84	92	92
2004	88	90	90
2005	85	86	86
2006	85	86	86
2007	80	83	84
2008	78	78	78
2009	77	78	78
2010	81	81	81
2011	79	79	79
2012	75	75	75
2013	88	88	88
2014	92	92	92
2015	81	81	81
2016	93	93	93
2017	91	92	92
2018	91	90	91
2019	80	80	80
2020	80	80	80
2021	92	92	92
Mean	83.4	84.9	85.2

Table 8. Spawning condition of the female portion of catch, sampled by the Maryland striped bass spring season creel survey, through May 15. Females of unknown spawning condition are excluded.

	Pre-spawn Females		**Post-spawn Females**	
Year	**n**	**%**	**n**	**%**
2002	150	45	181	55
2003	231	58	168	42
2004	222	55	180	45
2005	144	63	85	37
2006	162	41	231	59
2007	142	59	97	41
2008	47	30	108	70
2009	81	49	83	50
2010	62	29	150	71
2011	79	42	107	58
2012	29	30	69	70
2013	46	29	114	71
2014	53	27	141	73
2015	34	24	109	76
2016	23	13	157	87
2017	17	12	120	88
2018	6	6	99	94
2019	2	10	18	90
2020	2	7	26	93
2021	0	0	47	100
Mean	--	31.4	--	68.5

Table 9A. Mean harvest of striped bass per trip (HPT), with 95% confidence limits, calculated from Maryland charter boat logbook data, spring season creel survey interview data, and MRIP data, through May 15. SAFIS data were combined with the charter logbook data from 2011 through the present.

Year	Charter Trips	Charter Mean HPT	Private Creel Mean HPT	MRIP Mean HPT
2002	1,424	4.7 (4.6-4.8)	1.1 (0.6-1.4)	0.3 (0.1-0.4)
2003	1,393	5.7 (5.6-5.8)	1.1 (0.7-1.4)	1.0 (0.6-1.3)
2004	1,591	5.4 (5.3-5.5)	2.2 (1.7-2.8)	0.7 (0.5-1.0)
2005	1,965	5.5 (5.4-5.6)	--	1.0 (0.8-1.3)
2006	1,934	5.3 (5.2-5.4)	1.4 (0.6-2.1)	0.8 (0.4-1.3)
2007	1,607	4.3 (4.2-4.4)	0.7 (0.6-0.8)	0.3 (0.1-0.6)
2008	1,755	4.9 (4.8-5.1)	0.6 (0.5-0.7)	0.6 (0.2-1.1)
2009	1,849	5.0 (4.9-5.1)	0.9 (0.7-1.0)	0.8 (0.5-1.1)
2010	1,986	4.8 (4.7-4.9)	1.1 (0.9-1.3)	0.4 (0.1-0.8)
2011	1,849	5.0 (4.9-5.1)	0.9 (0.7-1.0)	0.6 (0.4-0.9)
2012	1,546	4.2 (4.0-4.4)	0.5 (0.3-0.6)	0.4 (0.2-0.7)
2013	1,822	4.9 (4.8-5.1)	0.9 (0.7-1.1)	0.3 (0.2-0.5)
2014	1,481	5.5 (5.3-5.6)	0.9 (0.8-1.1)	1.0 (0.7-1.4)
2015	1,392	2.8 (2.7-3.0)	0.2 (0.1-0.3)	0.5 (0.3-0.8)
2016	1,380	3.9 (2.8-4.1)	0.5 (0.4-0.7)	0.7 (0.5-0.9)
2017	995	2.4 (2.3-2.5)	0.2 (0.1-0.3)	0.4 (0.3-0.6)
2018	713	2.1 (1.9-2.2)	--	0.1 (0.1-0.2)
2019	347	1.5 (1.3-1.6)	--	0.2 (0.1-0.3)
2020	185	2.7 (2.5-3.0)	--	COVID-19
2021	571	1.0 (0.9-1.1)	--	--
Mean	1,409	4.1 (3.4-4.7)	0.9 (0.7-1.1)	0.6 (0.4-0.7)

Table 9B. Mean harvest of striped bass per angler, per trip (HPA), with 95% confidence limits, calculated from Maryland charter boat logbook data, spring season creel survey interview data, and MRIP data, through May 15. SAFIS data were combined with the charter logbook data from 2011 through the present.

Year	Charter Trips	Charter Mean HPA	Private Creel Mean HPA	MRIP Mean HPA
2002	1,424	0.78 (0.76-0.79)	0.4 (0.3-0.6)	0.1 (<0.1-0.2)
2003	1,393	0.93 (0.92-0.94)	0.4 (0.3-0.5)	0.6 (0.3-0.8)
2004	1,591	0.88 (0.86-0.89)	0.7 (0.5-0.8)	0.4 (0.3-0.6)
2005	1,965	0.88 (0.87-0.89)	--	0.7 (0.5-0.8)
2006	1,934	0.86 (0.87-0.85)	0.5 (0.2-0.7)	0.5 (0.2-0.9)
2007	1,607	0.69 (0.68-0.71)	0.3 (0.2-0.3)	0.2 (0.1-0.3)
2008	1,755	0.79 (0.78-0.81)	0.2 (0.2-0.3)	0.5 (0.1-0.9)
2009	1,849	0.81 (0.80-0.82)	0.3 (0.3-0.4)	0.6 (0.4-0.8)
2010	1,986	0.76 (0.75-0.77)	0.4 (0.3-0.5)	0.3 (0.1-0.6)
2011	1,849	0.78 (0.77-0.80)	0.3 (0.3-0.3)	0.4 (0.2-0.5)
2012	1,546	0.67 (0.64-0.71)	0.2 (0.1-0.2)	0.3 (0.1-0.5)
2013	1,822	0.75 (0.74-0.77)	0.3 (0.3-0.4)	0.2 (0.1-0.4)
2014	1,481	0.82 (0.81-0.84)	0.3 (0.3-0.4)	0.7 (0.5-1.0)
2015	1,392	0.45 (0.43-0.47)	0.1 (0.0-0.1)	0.3 (0.2-0.5)
2016	1,380	0.65 (0.63-0.67)	0.2 (0.2-0.3)	0.4 (0.3-0.5)
2017	995	0.41 (0.39-0.42)	0.1 (<0.1-0.1)	0.2 (0.2-0.3)
2018	713	0.35 (0.33-0.37)	--	0.1 (<0.1-0.1)
2019	347	0.26 (0.23-0.29)	--	0.1 (<0.1-0.1)
2020	185	0.52 (0.48-0.57)	--	COVID-19
2021	571	0.17 (0.15-0.19)	--	--
Mean	563	0.66 (0.56-0.75)	0.3 (0.2-0.4)	0.4 (0.3-0.5)

Table 10A. Private boat mean catch, effort, and catch per hour, with 95% confidence limits, from the Maryland striped bass spring season creel survey interview data and MRIP interview data, through May 15. Catch is defined as number of fish harvested plus number of fish released.

Year	Private Boat catch/trip	Private Boat hours/trip	Private Boat catch/hour	MRIP catch/trip	MRIP hours/trip	MRIP catch/hour
2002	1.6 (0.9-2.4)	4.9 (4.3-5.5)	0.3 (0.2-0.5)	0.9 (0.3-1.6)	5.5 (4.9-6.2)	0.1 (<0.1-0.2)
2003	1.8 (0.9-2.8)	5.4 (4.8-6.0)	0.5 (0.2-0.7)	1.9 (1.2-2.6)	4.5 (4.0-5.1)	0.4 (0.2-0.6)
2004	3.5 (2.0-4.9)	4.6 (3.8-5.3)	1.0 (0.6-1.4)	0.9 (0.6-1.2)	5.1 (4.7-5.5)	0.2 (0.1-0.2)
2005	--	2.5	--	1.9 (1.2-2.7)	3.8 (3.3-4.5)	0.6 (0.4-0.8)
2006	2.3 (1.1-3.5)	4.9 (4.2-5.7)	0.7 (0.3-1.1)	2.2 (1.3-3.3)	5.1 (4.1-6.2)	0.4 (0.3-0.6)
2007	1.6 (1.2-2.0)	5.0 (4.9-5.1)	0.3 (0.2-0.4)	0.8 (0.5-1.2)	4.9 (4.4-5.5)	0.2 (0.1-0.3)
2008	1.0 (0.7-1.3)	4.5 (4.2-4.7)	0.3 (0.2-0.4)	1.1 (0.3-1.9)	5.4 (4.2-6.6)	0.2 (0.1-0.3)
2009	1.6 (1.0-2.1)	4.7 (4.5-4.8)	0.4 (0.2-0.5)	1.4 (0.8-2.3)	4.8 (4.4-5.2)	0.3 (0.2-0.6)
2010	1.6 (1.2-2.0)	4.7 (4.5-4.9)	0.4 (0.3-0.5)	3.5 (1.0-6.7)	5.5 (4.9-6.1)	0.8 (0.2-1.6)
2011	1.2 (1.0-1.4)	4.4 (4.2-4.6)	0.3 (0.2-0.4)	1.3 (0.6-2.4)	4.0 (3.7-4.4)	0.3 (0.2-0.5)
2012	0.8 (0.5-1.1)	4.8 (4.6-5.1)	0.2 (0.1-0.3)	2.7 (0.8-5.7)	5.7 (4.8-6.5)	0.5 (0.1-1.0)
2013	1.3 (1.0-1.7)	4.4 (4.2-4.7)	0.3 (0.2-0.4)	2.0 (0.7-3.5)	4.3 (3.4-5.3)	0.5 (0.2-0.8)
2014	1.2 (1.0-1.4)	4.7 (4.4-4.9)	0.3 (0.2-0.4)	2.3 (1.1-3.9)	5.1 (4.5-5.7)	0.6 (0.3-1.0)
2015	0.7 (0.5-1.0)	6.3 (4.7-9.5)	0.2 (0.1-0.2)	1.2 (0.7-1.8)	5.2 (4.7-5.7)	0.2 (0.1-0.4)
2016	2.6 (1.5-4.0)	5.1 (4.9-5.3)	0.5 (0.3-0.8)	3.0 (1.4-5.0)	5.3 (4.8-5.8)	0.7 (0.3-1.3)
2017	0.7 (0.4-0.9)	4.6 (4.4-4.8)	0.2 (0.1-0.2)	1.4 (0.9-2.0)	5.7 (5.3-6.1)	0.3 (0.2-0.6)
2018	--	--	--	0.7 (0.4-1.0)	5.7 (5.3-6.0)	0.1 (0.1-0.2)
2019	--	--	--	0.6 (0.3-0.9)	5.5 (5.1-6.0)	0.1 (0.1-0.2)
2020	--	--	--	COVID-19	COVID-19	COVID-19
2021	--	--	--	--	--	--
Mean	1.6 (1.2-2.0)	4.7 (4.3-5.0)	0.4 (0.3-0.5)	1.7 (1.3-2.0)	5.1 (4.8-5.3)	0.4 (0.3-0.5)

Table 10B. Charter boat mean catch, effort, and catch per hour, with 95% confidence limits, calculated from charter boat logbook data, through May 15. Catch is defined as number of fish harvested plus number of fish released. Mean hours per trip are from creel survey interview data until 2009 where the mean hours per trip are from mate interviews. SAFIS data were combined with the charter logbook data from 2011 through the present.

Year	**n**	**Mean catch/trip**	**Mean hours/trip** (From interview data)	**Mean catch/hour**
2002	1,487	5.5 (5.4-5.7)	5.5 (5.3-5.7)	1.0 (0.9-1.1)
2003	1,420	7.3 (7.0-7.6)	4.0 (3.7-4.4)	1.8 (1.7-1.9)
2004	1,629	7.4 (7.0-7.7)	4.0 (3.6-4.4)	1.8 (1.7-1.9)
2005	1,994	6.9 (6.6-7.1)	3.1 (2.6-3.5)	2.2 (2.1-2.3)
2006	1,990	8.0 (7.7-8.2)	3.6 (3.2-3.9)	2.2 (2.1-2.3)
2007	1,793	8.1 (7.8-8.4)	4.6 (4.1-5.0)	1.8 (1.7-1.8)
2008	1,755	6.4 (6.2-6.6)	--	--
2009	1,849	6.0 (5.9-6.2)	3.4 (2.9-4.0)	1.8 (1.7-1.8)
2010	1,986	5.7 (5.5-5.8)	4.4 (4.0-4.9)	1.3 (1.2-1.3)
2011	1,849	5.8 (5.6-6.0)	4.2 (3.5-4.9)	1.4 (1.3-1.4)
2012	1,546	5.0 (4.8-5.2)	5.5 (4.9-6.1)	0.9 (0.9-1.0)
2013	1,822	5.4 (5.3-5.6)	5.2 (4.7-5.7)	1.0 (1.0-1.1)
2014	1,481	5.9 (5.7-6.1)	4.8 (4.3-5.2)	1.2 (1.2-1.3)
2015	1,392	6.0 (5.7-6.4)	6.3 (6.0-6.7)	1.0 (0.9-1.0)
2016	1,380	5.2 (4.9-5.5)	5.7 (5.6-5.9)	0.9 (0.9-1.0)
2017	995	4.5 (3.9-5.1)	6.3 (6.1-6.5)	0.7 (0.6-0.8)
2018	713	4.4 (3.9-5.1)	5.8 (5.4-6.3)	0.8 (0.7-0.9)
2019	347	3.8 (3.3-4.3)	5.9 (5.5-6.4)	0.6 (0.6-0.7)
2020	185	3.0 (2.7-3.2)	6.0 (6.0-6.0)	0.5
2021	571	2.9 (2.7-3.2)	5.2 (4.7-5.8)	0.6 (0.5-0.7)
Mean	1,409	5.7 (5.0-6.3)	4.9 (4.5-5.4)	1.2 (1.0-1.5)

Table 11. State of residence and number of anglers interviewed by the Maryland striped bass spring season creel survey, through May 15. MRIP data were used beginning in 2018.

Year	MD	VA	PA	DE	WV	NJ	Other
2002	353	48	27	6	0	2	15
2003	260	31	19	7	1	2	7
2004	107	30	17	3	0	6	11
2005	66	13	4	0	2	0	6
2006	227	56	22	9	6	3	10
2007	679	71	32	8	3	2	11
2008	266	29	16	1	2	4	4
2009	651	44	46	0	4	0	2
2010	482	42	18	3	4	0	52
2011	491	23	19	1	0	1	9
2012	381	26	23	2	4	3	8
2013	407	20	21	0	2	0	6
2014	484	39	30	5	10	2	4
2015	483	27	24	2	3	0	7
2016	474	49	25	2	5	0	10
2017	413	31	32	10	1	2	10
2018	279	16	55	14	2	2	4
2019	142	7	9	3	1	0	4
2020	NOT AVAILABLE DUE TO COVID-19						
2021	33	1	7	0	3	0	0

Figure 1. MD DNR maps showing legal open and closed striped bass fishing areas in Chesapeake Bay during the spring season, May 1 – May 15 (2021).

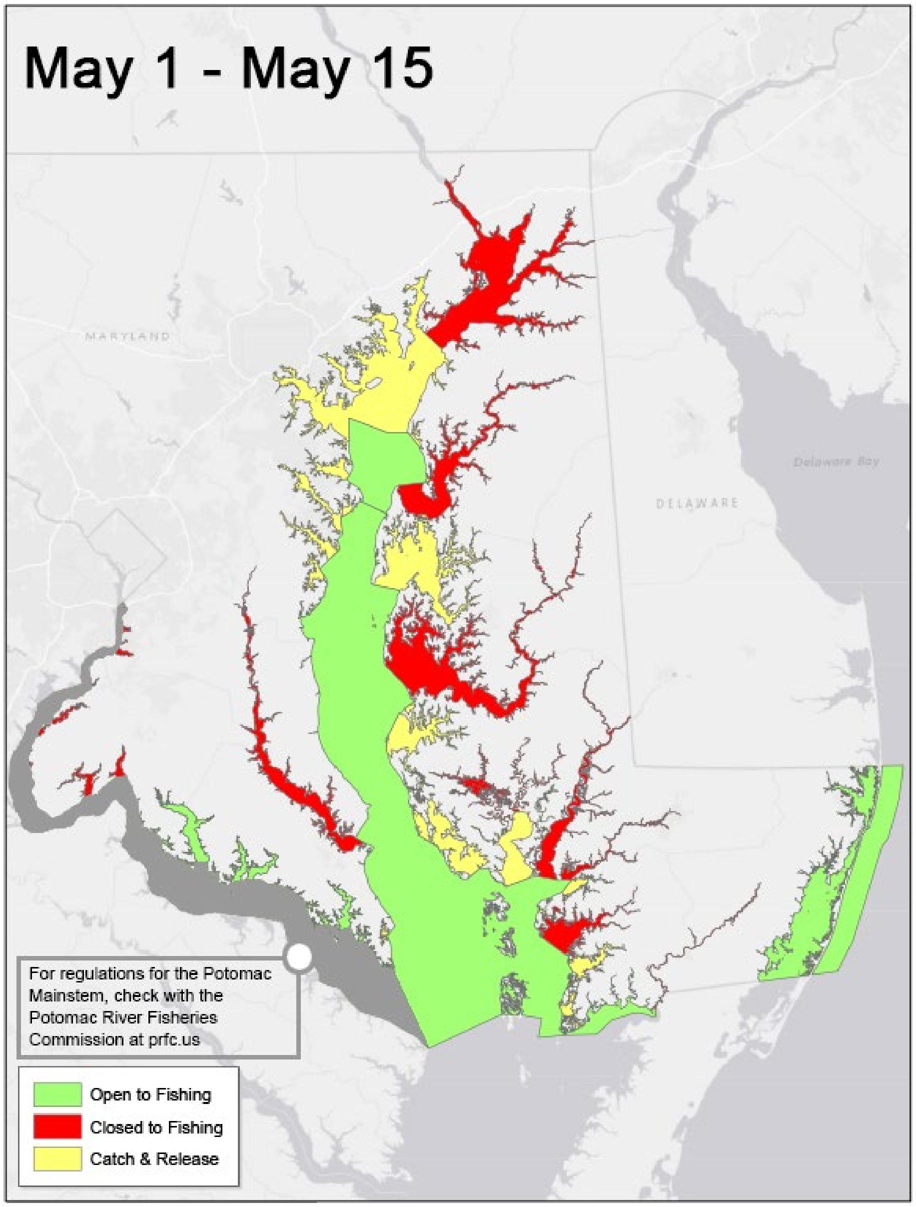


Figure 2. Length distribution of striped bass sampled by year, during the Maryland striped bass spring season creel survey, through May 15.

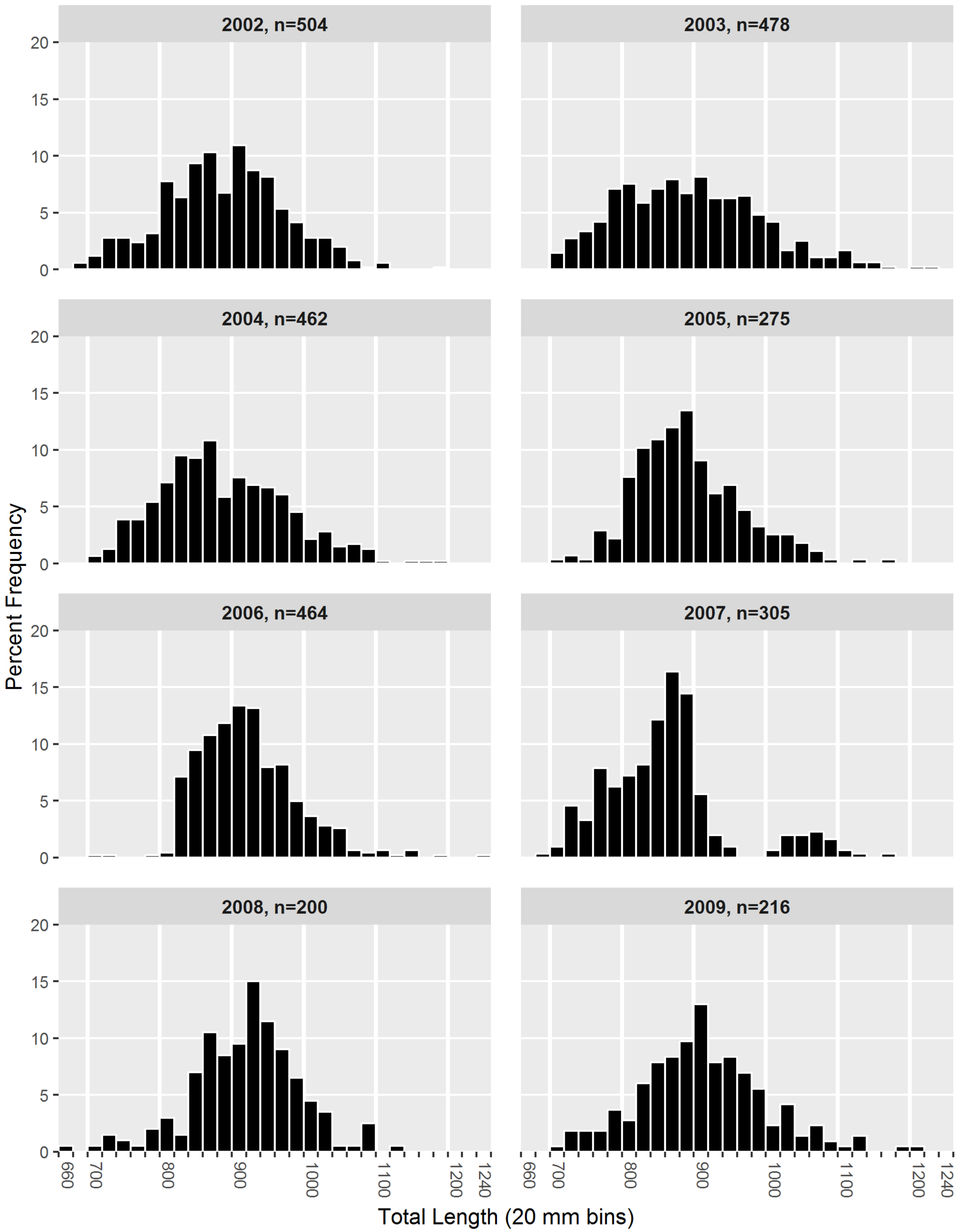


Figure 2. Continued.

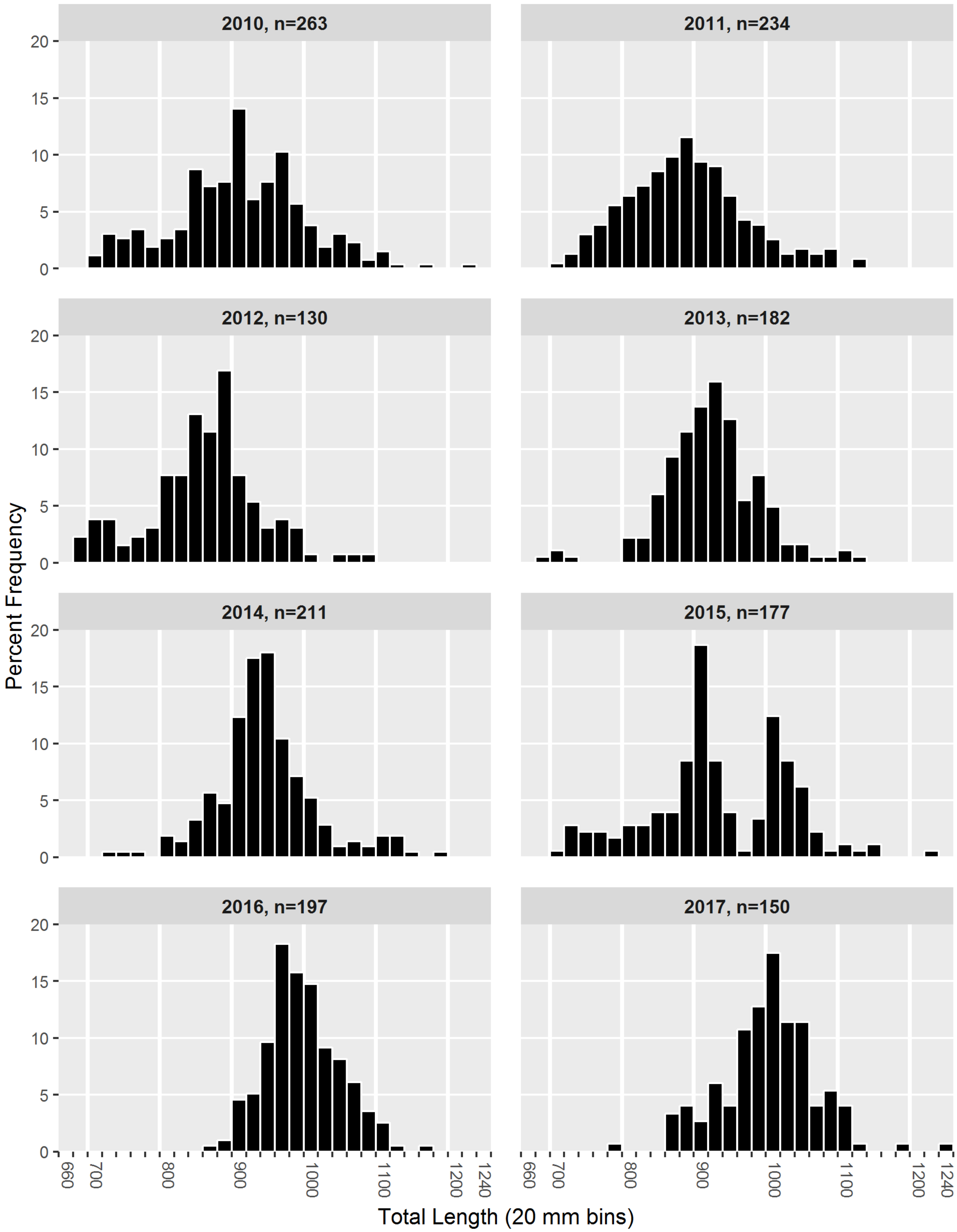


Figure 2. Continued.

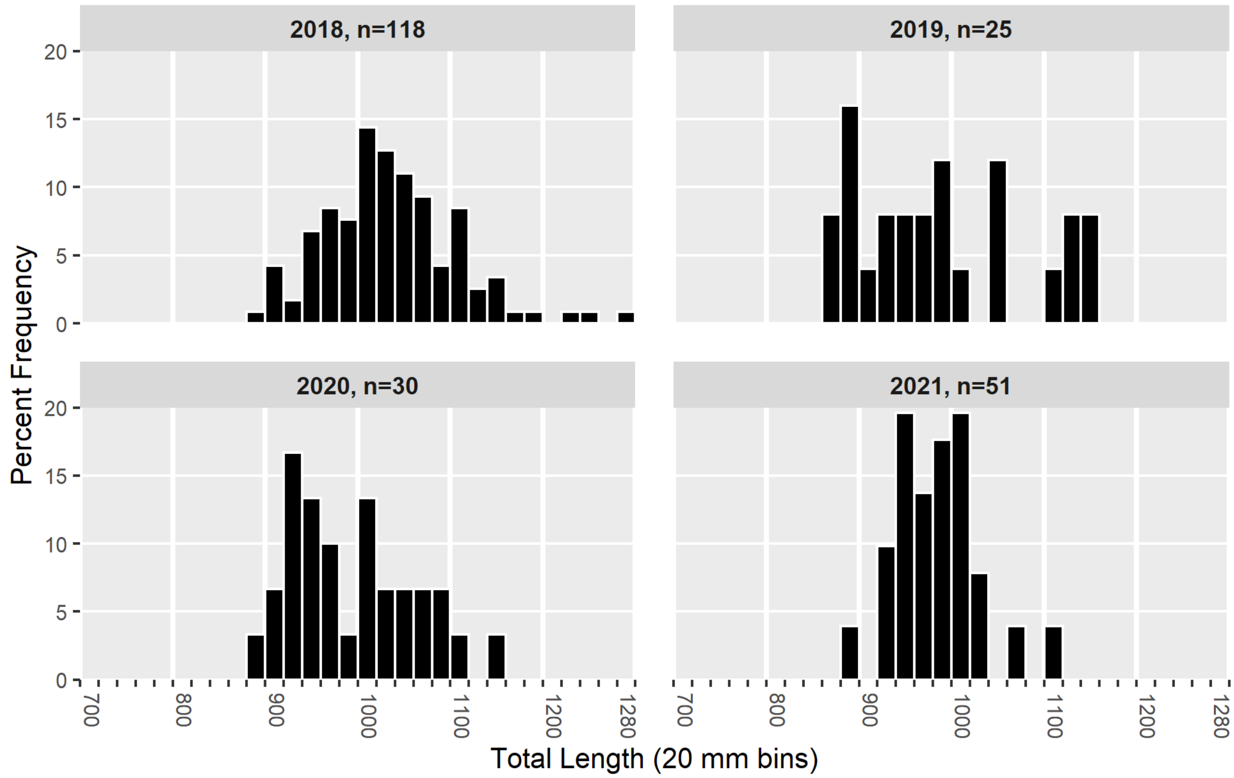


Figure 3. Mean length of female and male striped bass (mm TL) with 95% confidence intervals, sampled by the Maryland striped bass spring season creel survey, through May 15.

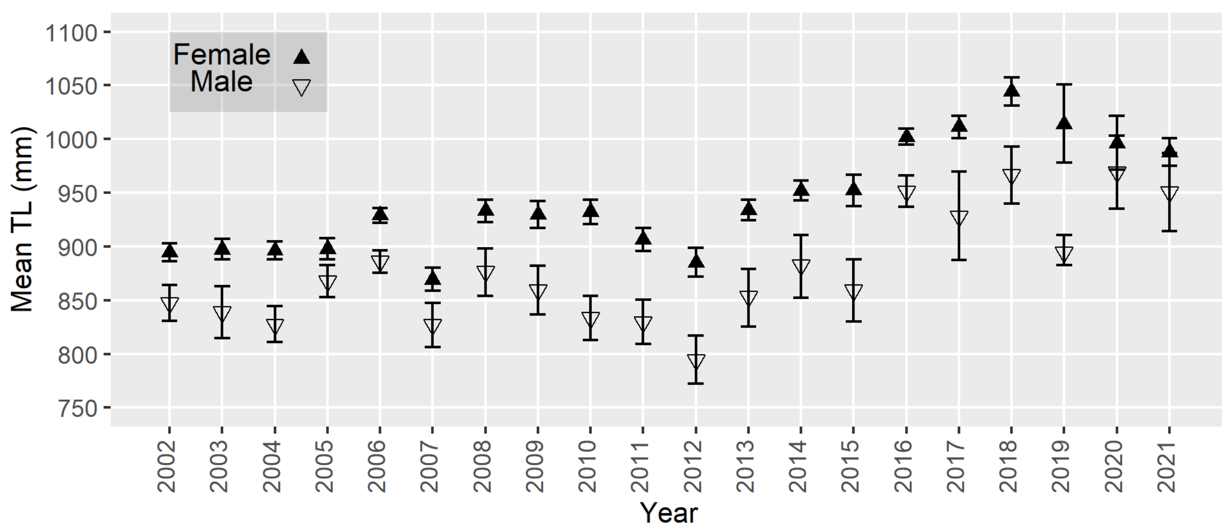


Figure 4. Mean daily length of female striped bass with 95% confidence intervals, sampled by the Maryland striped bass spring season creel survey, through May 15.

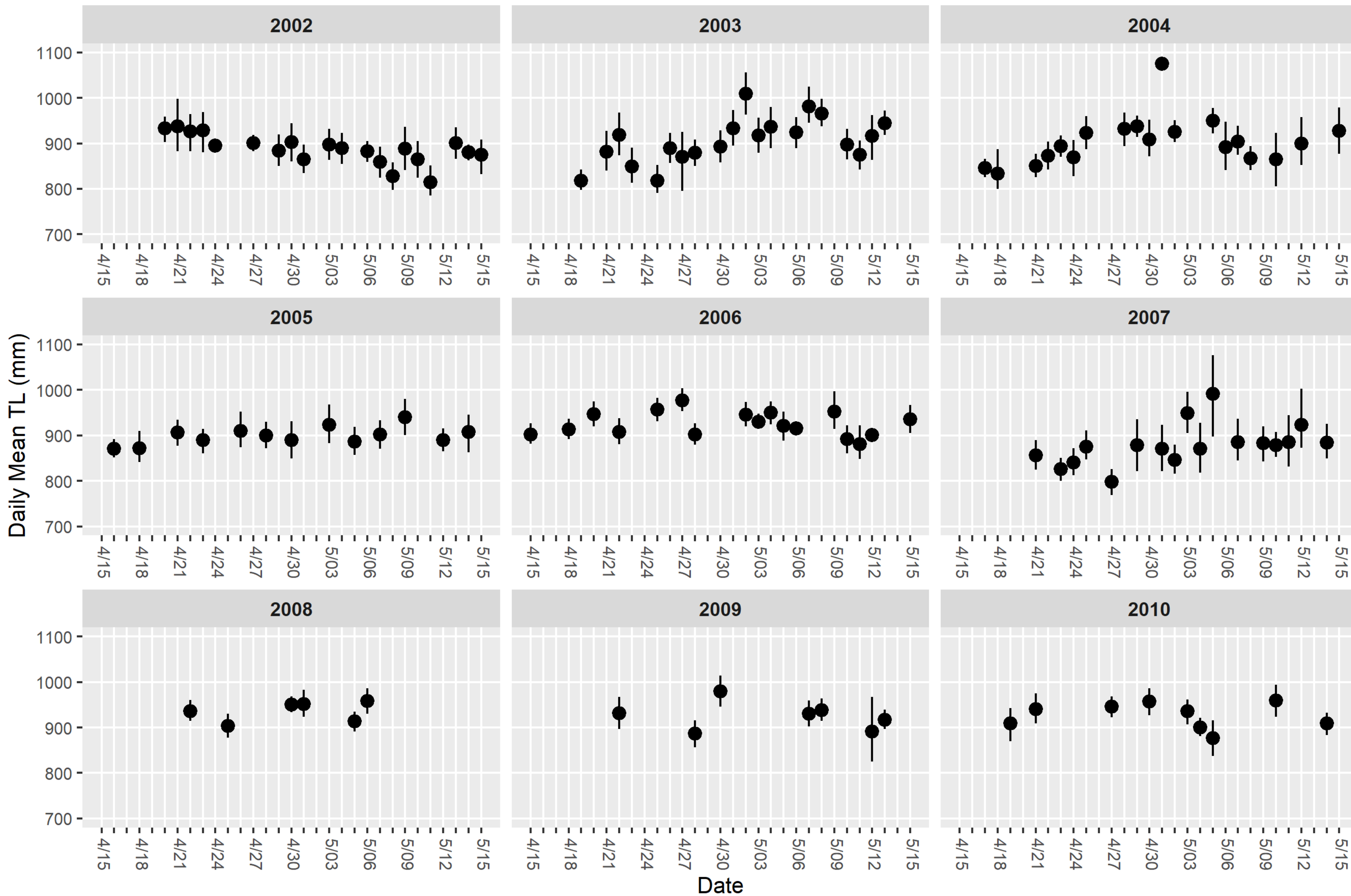


Figure 4. Continued.

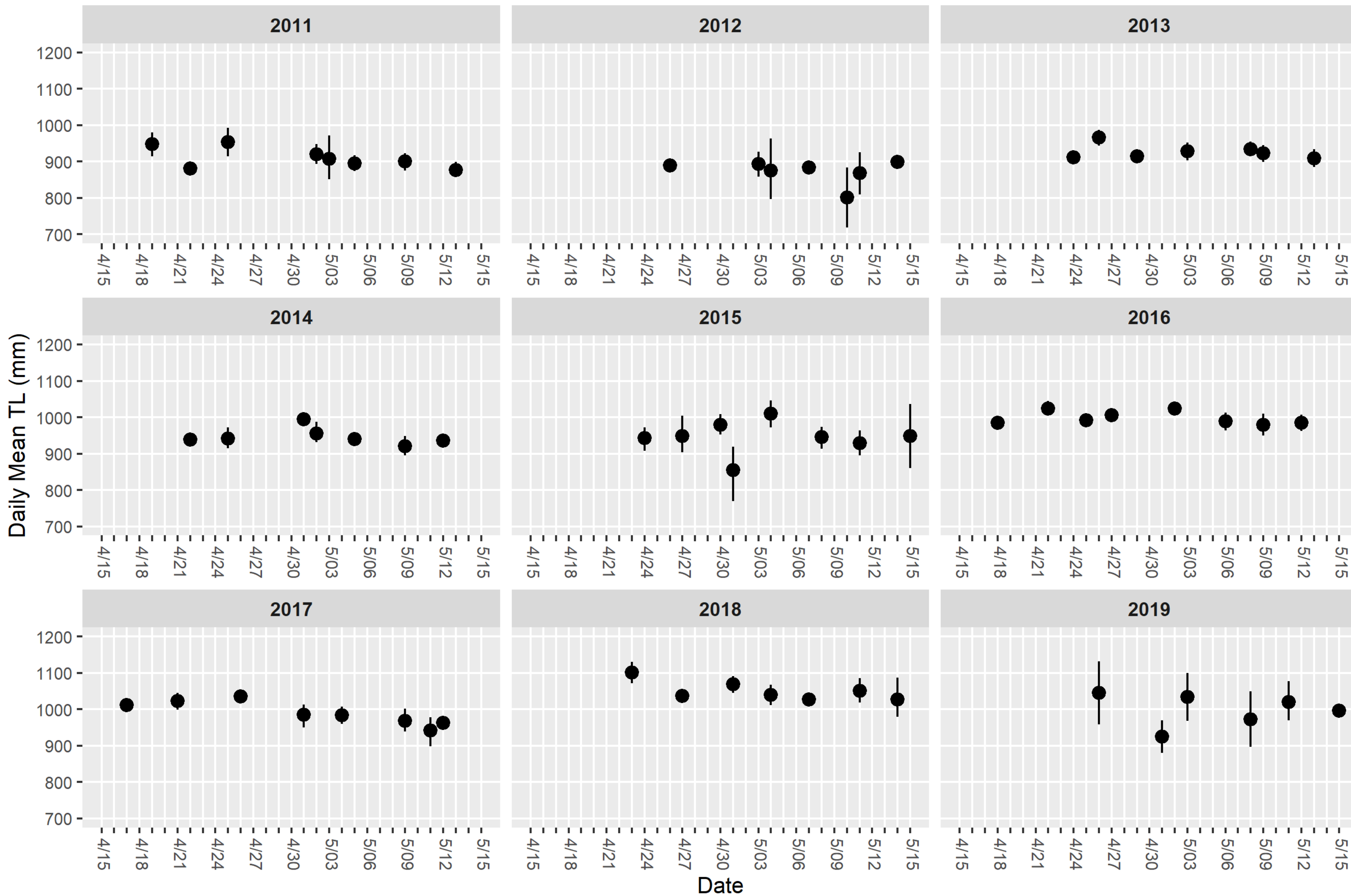


Figure 4. Continued.

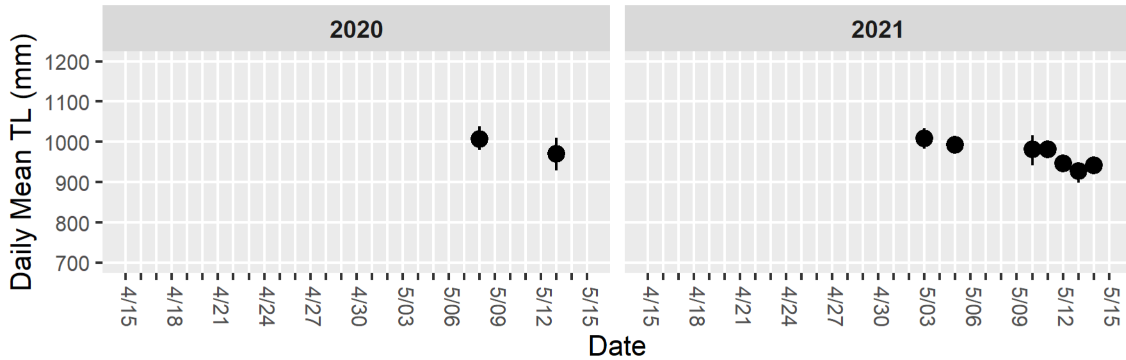


Figure 5. Mean weight of female and male striped bass (kg) with 95% confidence intervals sampled by the Maryland striped bass spring season creel survey, through May 15.

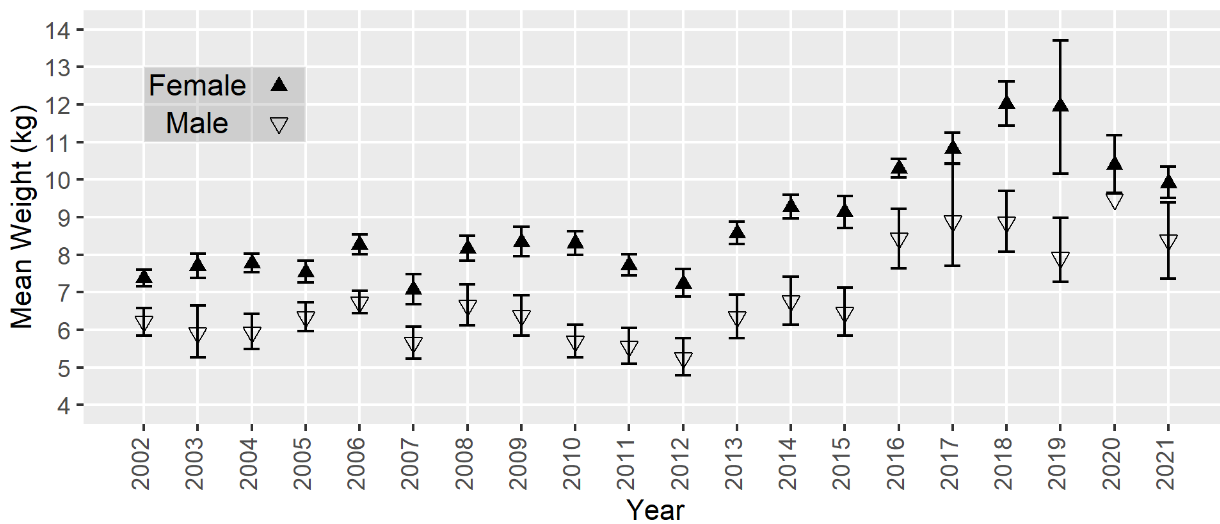


Figure 6. Estimated age distribution of striped bass sampled through May 15th.

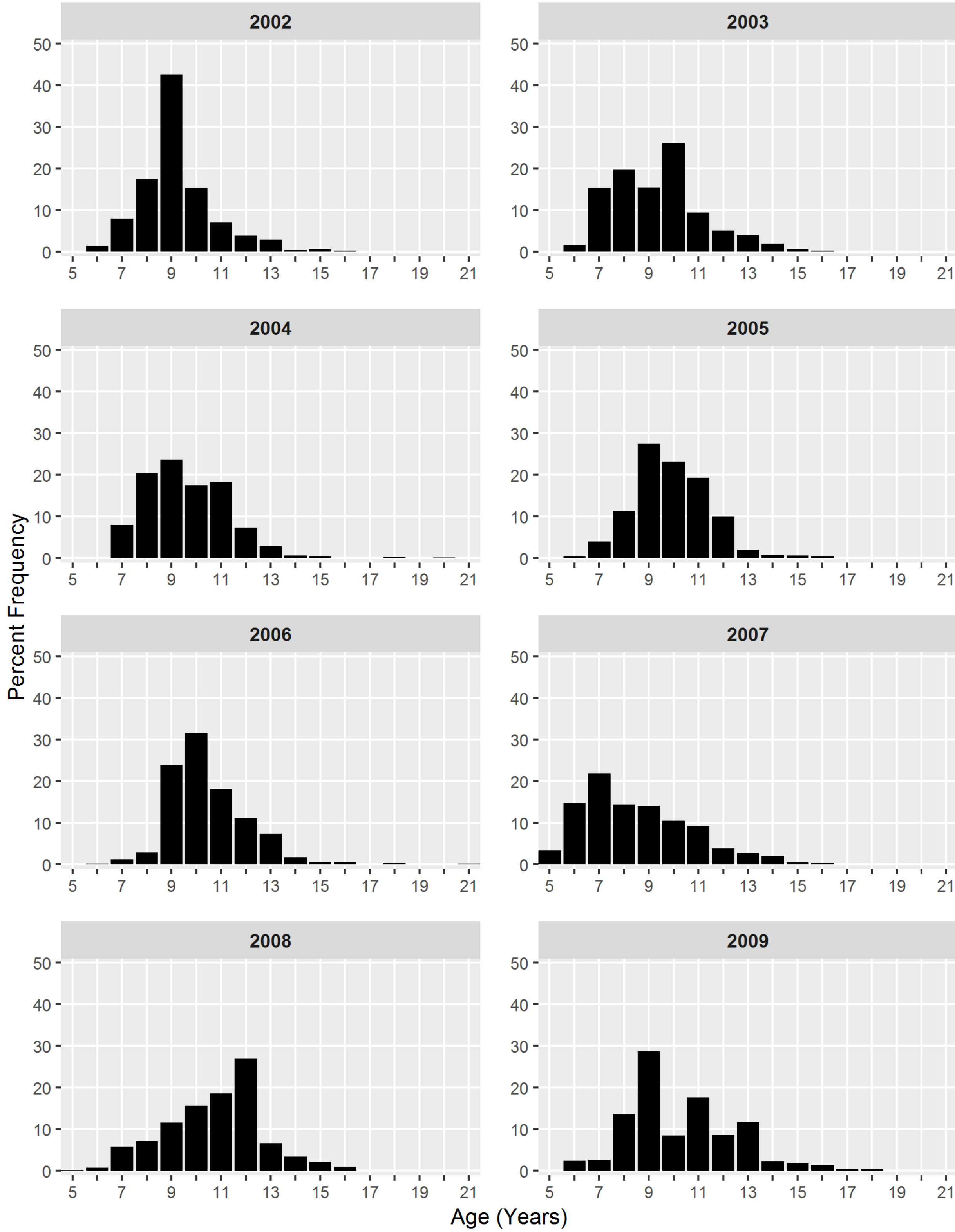


Figure 6. Continued.

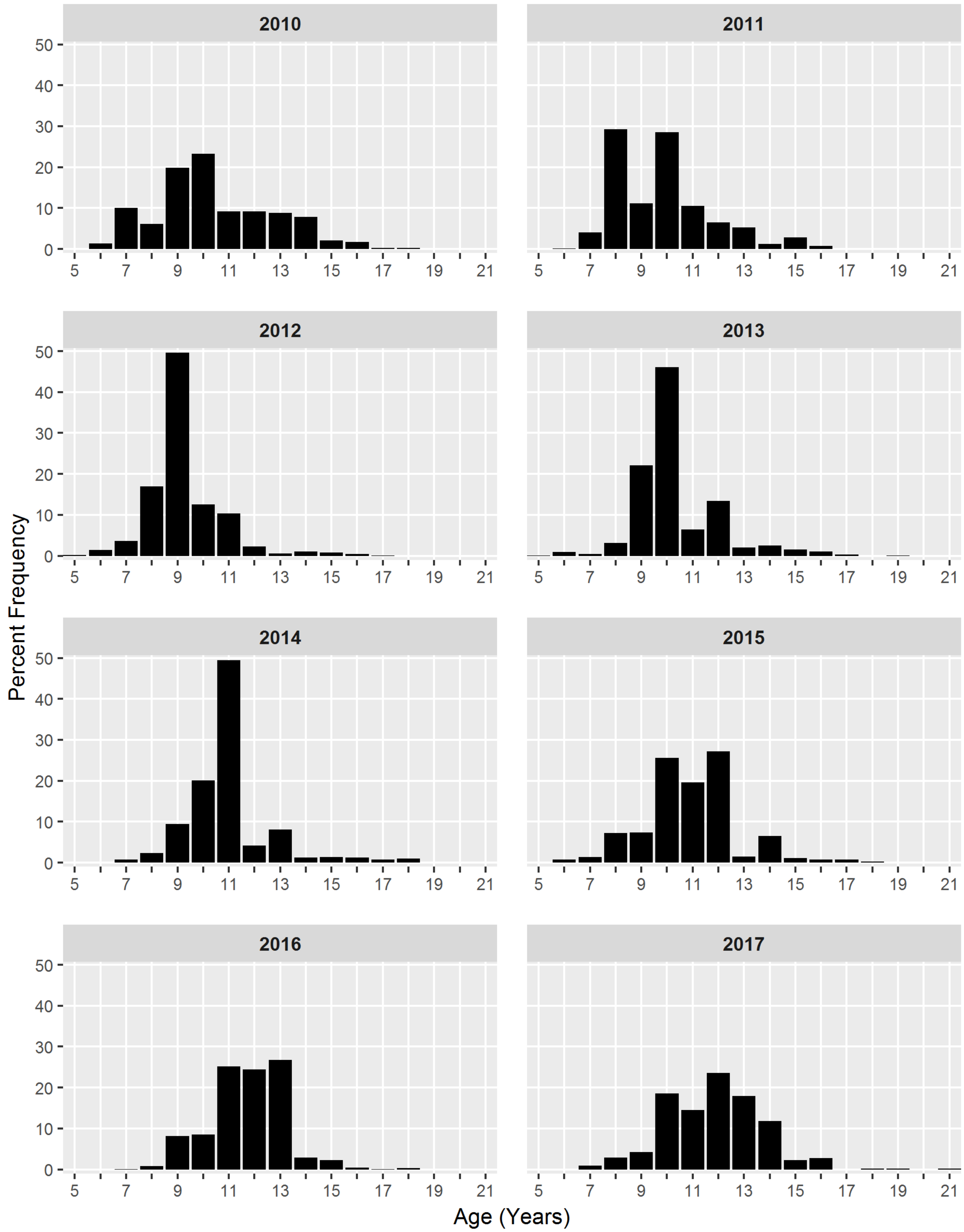


Figure 6. Continued.

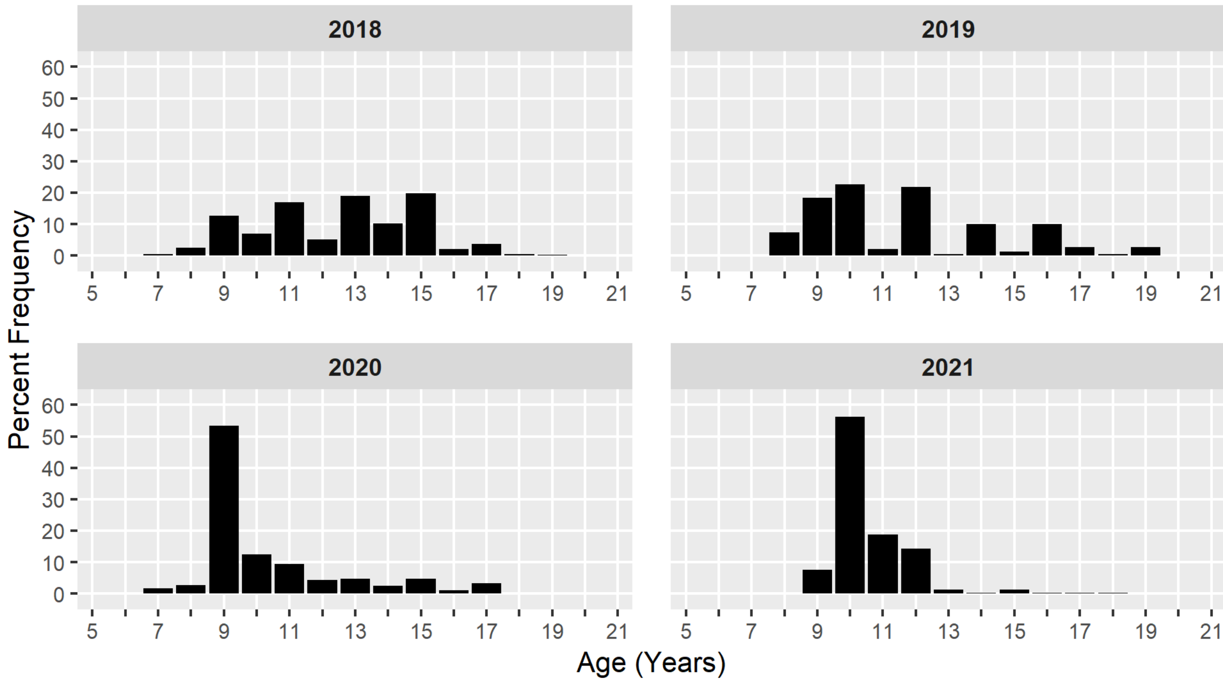


Figure 7. Proportion of pre-spawn females versus the annual mean total length (mm) of female striped bass sampled. Linear regression coefficients are intercept=354.05, slope=-0.34 (Adjusted R-squared=0.76, p<0.0001). Shading indicates 95% confidence intervals. Current year labeled for reference.

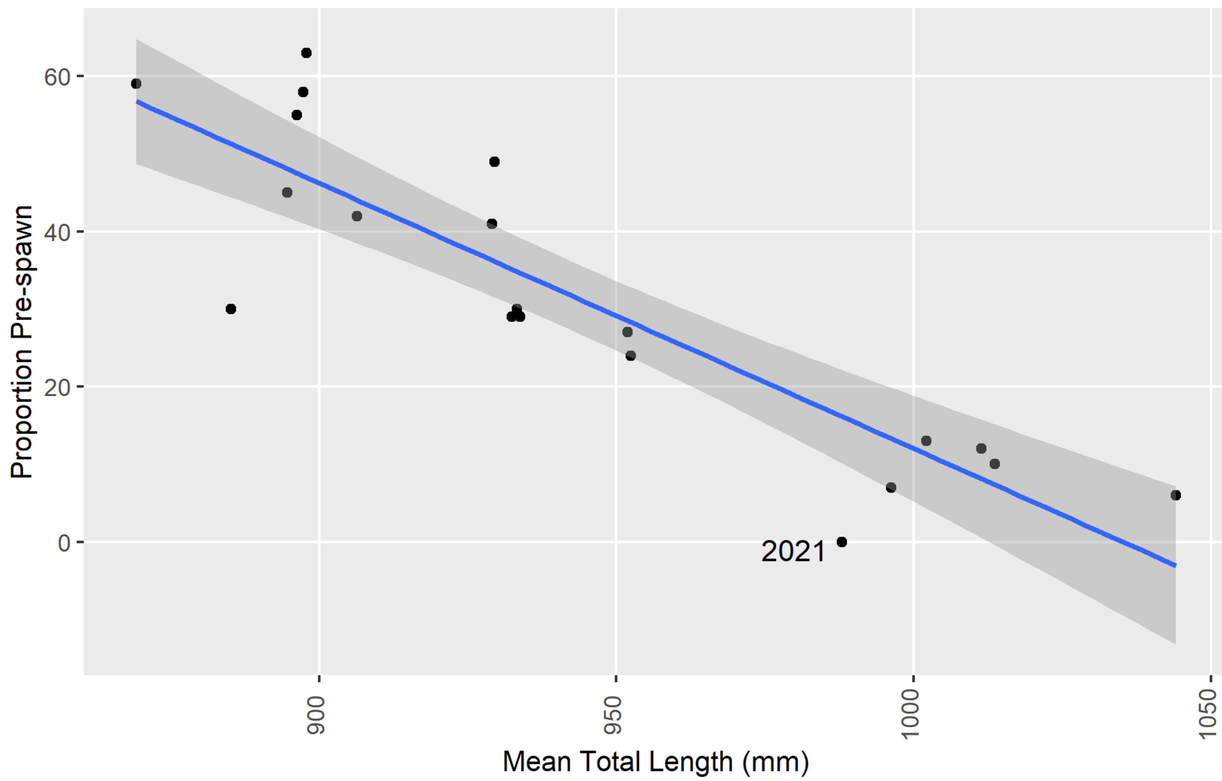
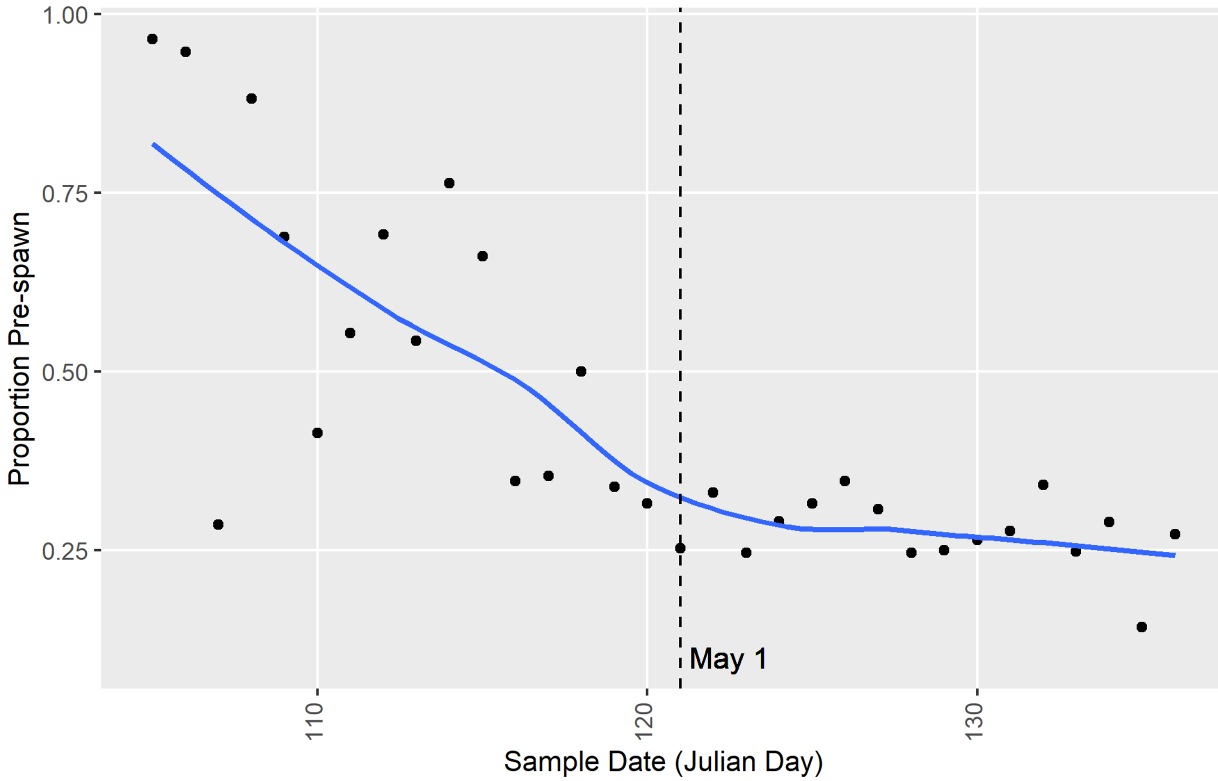


Figure 8. Proportion pre-spawn females sampled in all years of the charter creel survey summarized by sample date (Julian Day). Locally weight smoothing line (loess) added for visual aid. Dashed reference line is May 1st.



PROJECT NO. 2
JOB NO. 4

INTER-GOVERNMENT COORDINATION

Prepared by Eric Q. Durell, Harry Rickabaugh, Matthew B. Jargowsky and Harry T. Hornick

The objective of Job 4 was to document and summarize participation of Survey personnel in various research and management forums regarding fifteen resident and migratory finfish species found in Maryland's Chesapeake Bay. With the passage of the Atlantic Coastal Fisheries Cooperative Management Act, various management entities such as the Atlantic States Marine Fisheries Commission (ASMFC), the Mid-Atlantic Migratory Fish Council (MAMFC), the Chesapeake Bay Living Resources Subcommittee (CBLRS), the Potomac River Fisheries Commission (PRFC), and the Susquehanna River Anadromous Fish Restoration Cooperative (SRAFRC), require current stock assessment information in order to assess management measures. The Survey staff also participated in ASMFC, US Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) fishery research and management forums.

Direct participation by Survey personnel as representatives to various management entities provided effective representation of Maryland interests through the development, implementation and refinement of management options for Maryland as well as coastal fisheries management plans. In addition, survey information was used to formulate management plans for thirteen finfish species as well as providing evidence of compliance with state and federal regulations. A summary of this participation and contributions is presented below.

Alosines:

Project staff attended SRAFRC meetings as Maryland representatives to discuss American shad and river herring stock status, restoration, and management in the Susquehanna River.

The ASMFC Technical Committee representative served as a member of the Plan Review Team, attended the American shad Technical Committee meetings, and prepared the annual American Shad and River Herring Compliance Report for Maryland.

Project staff served as a Maryland representative for the Atlantic Coast River Herring Collaborative Forum (formerly the River Herring Technical Expert Working Group), attending virtual meetings.

Atlantic Croaker:

Project staff served on the Atlantic Croaker Technical Committee (TC) and prepared the ASMFC Annual Maryland Atlantic Croaker Compliance Report. The Technical Committee representative was also assigned to the Traffic Light Analysis (TLA) Subgroup of the TC and assisted in updating the 2022 TLA.

Atlantic Menhaden:

Project staff served on the ASMFC Plan Review Team and prepared the Annual Maryland Atlantic Menhaden Compliance Report required by ASMFC and served on the Plan Development Team (PDT) working to develop and finalize Addendum I to Amendment III to address commercial allocation by completing analyses, drafting document sections and attending multiple PDT webinars.

Black Drum:

ASMFC Technical Committee representative prepared the Annual Black Drum Compliance Report for Maryland, and as Technical Committee chair was a member of the Stock Assessment Subcommittee (SAS). The SAS met several times via webinar and to evaluate and analyze data, develop assessment models and begin drafting the assessment report.

Bluefish:

The ASMFC Bluefish Technical Committee representative prepared the ASMFC Annual Bluefish Status Compliance Report for Maryland and provided Chesapeake Bay juvenile bluefish data to the Mid-Atlantic Fishery Management Council.

Red Drum:

A staff member served as ASMFC Red Drum Technical Committee representative and prepared the Maryland Red Drum Compliance Report required by ASMFC. Staff participated in ASMFC red drum technical committee meetings and meetings for the red drum simulation assessment.

Spanish Mackerel:

Staff prepared the Maryland Spanish Mackerel Compliance Report required by ASMFC.

Spot:

Project staff member served on the Spot Plan Review Team and was chair of the Spot Technical Committee (TC) and prepared the ASMFC Annual Maryland Spot Compliance Report. Staff member was also assigned to the Traffic Light Analysis (TLA) Subgroup of the TC and the assisted in updating the 2022 TLA. These duties required attended several webinars and presenting analysis to the ASMFC Sciaenid Management Board**.**

Spotted Seatrout:

Staff prepared the Maryland Spotted Seatrout Compliance Report required by ASMFC**.**

Striped Bass:

Staff served on the ASMFC Striped Bass Tagging Sub Committee, the Interstate Tagging Committee, the ASMFC Bluefish Technical Committee, and as Maryland representatives to the Potomac River Fisheries Commission (PRFC) Finfish Advisory Board.

Project staff served as Maryland alternate representatives to the ASMFC Striped Bass Scientific and Statistical Committee, the Striped Bass Stock Assessment Subcommittee, and produced Maryland's Annual Striped Bass Compliance Report to the ASMFC.

Weakfish:

ASMFC Weakfish Technical Committee representative for Maryland prepared the ASMFC Annual Maryland Weakfish Compliance Report.

PROJECT NO. 2
JOB NO. 4

INTER-GOVERNMENT COORDINATION

2022 PRELIMINARY RESULTS – WORK IN PROGRESS

A staff member served as Spot Technical Committee (TC) chair and led a webinar of the TC to finalize the 2022 Spot Traffic Light Analysis (TLA) and prepared a presentation to be given to the ASMFC Sciaenid Board. Staff also participated in webinar of the Atlantic Croaker TC to finalize the 2022 TLA. Staff attended one in person meeting and several webinars to finalize as Chair of the Black drum TC and Stock Assessment Subcommittee to finalize development of a preferred model and finalize the Assessment Report for peer review. Staff submitted and presented data for the upcoming river herring Stock Assessment. Staff also participated in multiple conference calls of the Susquehanna River Anadromous Fish Restoration Cooperative Technical Committee to discuss fish passage issues, invasive species, and dam relicensing. Staff participated in multiple webinars to continue work on draft Addendum I to Amendment III of the ASMFC Atlantic Menhaden FMP.

Staff completed and submitted required ASMFC compliance reports for alewife, American shad, Atlantic croaker, Atlantic menhaden, black drum, blueback herring, bluefish, red drum and striped bass. Staff reviewed state compliance reports to ASMFC fisheries management plans for alewife, American shad, blueback herring, Atlantic Menhaden, and spot, and attended the corresponding conference calls, as members of the ASMFC plan review teams for those species.

Striped Bass Data Sharing and Web Page Development

To augment data sharing efforts, Striped Bass Program staff in 2002 developed a web page within the MD DNR web site presenting historical Juvenile Striped Bass Survey (Job 3) results. This effort has enabled the public to access Striped Bass Program data directly. In 2016, the Program's web presence was expanded to include individual pages for many surveys conducted by the Striped Bass Program. The new web pages added survey reports, species data, glossary, and information about the biologists. The new home page can be found at http://dnr.maryland.gov/fisheries/pages/striped-bass/index.aspx.

Total page views to specific Striped Bass Program pages for the period January 1, 2021 to December 31, 2021 are provided in Table 1. The Juvenile Index survey page is still the most viewed page by visitors. A significant spike in page views occurred in late October coinciding with the issue of the striped bass juvenile index press release. Many large or complex data requests are still handled directly by Striped Bass Program staff. However, web page access to survey information has saved staff a considerable amount of time answering basic and redundant data requests.

Table 1. Visits to the Striped Bass Program's web pages (http://dnr.maryland.gov/fisheries/Pages/striped-bass/), January 1, 2021 through December 31, 2021.

Striped Bass Program Project Sites	Page Views
Juvenile Index (/juvenile-index.aspx)	1,615
Home Page (/index.aspx)	637
Volunteer Angler Survey (sb_survey.aspx)	290
Commercial (/commercial.aspx)	228
Adult Spawning Stock Survey (/studies.aspx)	270
Recreational (/recreational.aspx)	145
Glossary (/glossary.aspx)	199
Reports (/reports.aspx)	125
Species (/species.aspx)	97
Biologists (/biologists.aspx)	65
Total	3,671

Project staff also provided Maryland striped bass data and biological samples such as scale and finfish samples, to other state, federal, private and academic researchers. These included the National Marine Fisheries Service (NMFS), US Fish and Wildlife Service (USFWS), University of Maryland, University of Delaware, Virginia Institute of Marine Sciences, Georgetown University, and State management agencies. For the past contract year, (July 1, 2020 through June 30, 2021) the following specific requests for information have been accommodated:

-Atlantic States Marine Fisheries Commission (ASMFC).
Provision of striped bass juvenile index data; results from fishery dependent monitoring programs and age/length keys developed from results of fishery monitoring programs; updated striped bass fishery regulations; striped bass commercial fishery data, striped bass spawning stock CPUE data; current striped bass commercial fishery data; bluefish recruitment data.

-Ms. Alexandra Fries, University of Maryland Center for Environmental Science. Provision of bay anchovy data from the Juvenile Seine Survey.

-Mr. Edward Hobbs, University of Maryland Center for Environmental Science. Provision of bay anchovy data from the Juvenile Seine Survey.

-Dr. John Jackson, Stroud Water Research Center. Provision of American shad data from the spring spawning stock and juvenile seine surveys.

-Mr. Matthew Mobley, Stripers Forever. Provision of data from the Spring Spawning Stock Survey.

-Ms. Samara Nehemia, University of Maryland Center for Environmental Science. Provision of data from striped bass spring spawning stock survey, Juvenile Seine Survey, commercial fishery monitoring and recreational fishery monitoring.

-Ms. Olivia Phillips, Virginia Marine Resources Commission. Provision of raw data from the Striped Bass Volunteer Angler Survey.

-Mr. Fred Pomeroy, Nanticoke Watershed Alliance. Provision of Juvenile Seine Survey data.

-Ms. Adena Schonfeld, Virginia Institute of Marine Science. Provision of historic striped bass age-length keys.

-Mr. Martin Gary, Potomac River Fisheries Commission (PRFC).
Provision of striped bass juvenile survey data, spring spawning stock survey procedures and commercial harvest data.

-Mr. David Sikorski, CCA, Maryland. Provision of striped bass juvenile survey data and APAIS Survey background information.

-Maryland Charterboat Association (MCA) members. Provided APAIS Survey background information, provided clarification of striped bass fishery regulations, and striped bass recreational harvest information.

-The Striped Bass Program staff also fulfilled requests by provided biological information and related reports to fifteen (15) additional scientists, students, and concerned constituents but no retired politicians.

Atlantic Sturgeon, Shortnose Sturgeon and Sea Turtle Interaction Summary for Chesapeake Bay Finfish Investigations
Project No.: F-61-R-17

Prepared by Paul G. Piavis, Harry W. Rickabaugh, Eric Q. Durell, Matthew B. Jargowsky and Harry T. Hornick

Summary

The primary objective of the Chesapeake Bay Finfish Investigations Survey, F-61-R-17, was to monitor and biologically characterize resident and migratory finfish species in the Maryland portion of the Chesapeake Bay during the 2021 – 2022 sampling season. The F-61-R Survey provides a long-term series of annual reports that provide information regarding recruitment, relative abundance, age and size structure, growth, mortality, and migration patterns of finfish populations in Maryland's Chesapeake Bay. This intent of this report is to summarize any interactions of these biological surveys with endangered species such as Atlantic sturgeon, shortnose sturgeon, and sea turtles. During the 2021 – 2022 sampling season, there were two documented Atlantic sturgeon encounters.

CONTENTS:

PROJECT I: **RESIDENT SPECIES STOCK ASSESSMENT**

JOB 1: Population vital rates of resident finfish in selected tidal areas of Maryland's Chesapeake Bay.

JOB 2: Population assessment of white perch in select regions of Chesapeake Bay, Maryland.

PROJECT 2: **INTERJURISDICTIONAL SPECIES STOCK ASSESSMENT**

JOB 1: Alosa Species: Stock assessment of adult and juvenile anadromous *Alosa* species in the Chesapeake Bay and selected tributaries.

JOB 2: Migratory Species: Stock assessment of selected recreationally important adult migratory finfish in Maryland's Chesapeake Bay.

JOB 3: Striped Bass: Stock assessment of adult and juvenile striped bass in Maryland's Chesapeake Bay and selected tributaries.

- Task 1: Summer-Fall stock assessment and commercial fishery monitoring.
- Task 2: Characterization of striped bass spawning stocks in Maryland.
- Task 3: Maryland juvenile striped bass survey.

PROJECT I: RESIDENT SPECIES STOCK ASSESSMENT

JOB 1: Population vital rates of resident finfish in selected tidal areas of Maryland's Chesapeake Bay.

JOB 2: Population assessment of channel catfish in select tidal areas of Maryland's Chesapeake Bay, Maryland.

Introduction

The objective of Project 1, Job 1 is to determine population vital rates (relative abundance, age, growth, mortality, and recruitment) of yellow perch, white perch, and catfish species in tidal regions of Chesapeake Bay. Job 2 is a rotational, triennial stock assessment of yellow perch (integrated analysis), white perch (catch survey analysis) or channel catfish (surplus production modeling). However, all data collections and surveys are performed under Job 1.

Research Surveys:

1. Upper Chesapeake Bay Winter Trawl
2. Fishery Dependent Yellow Perch Fyke Net Survey
3. Fishery Independent Choptank River Fyke Net Survey

1. Upper Chesapeake Bay Winter Trawl Survey

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed in the Upper Chesapeake Bay Winter Trawl Survey during the Survey period of July 1, 2021, through June 30, 2022.

Shortnose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed in the Upper Chesapeake Bay Winter Trawl Survey during the Survey period of July 1, 2021, through June 30, 2022.

2. Fishery Dependent Yellow Perch Fyke Net Survey

Atlantic Sturgeon Interactions

This survey is performed with the cooperation of commercial fishermen and the objective is to collect commercial catch at age and length data of yellow perch. No data on other species are collected. However, no Atlantic sturgeon were sampled or observed in the Commercial Fyke Net Survey during the Survey period of July 1, 2021, through June 30, 2022.

Shortnose Sturgeon and Sea Turtle Interactions

This survey is performed with the cooperation of commercial fishermen and the objective is to collect commercial catch at age and length data of yellow perch. No data on other species are collected. However, no shortnose sturgeon or sea turtles were sampled or observed in the Commercial Fyke Net Survey during the Survey period of July 1, 2021, through June 30, 2022.

3. Fishery Independent Choptank River Fyke Net Survey

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed in the Choptank River Fyke Net Survey during the Survey period of July 1, 2021, through June 30, 2022.

Shortnose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed in the Choptank River Fyke Net Survey during the Survey period of July 1, 2021, through June 30, 2022.

<u>PROJECT 2</u>: INTERJURISDICTIONAL SPECIES STOCK ASSESSMENT

<u>JOB 1</u>: Alosa Species: Stock assessment of adult and juvenile anadromous *Alosa* in the Chesapeake Bay and select tributaries.

Research Surveys:
1. Nanticoke River Pound/Fyke Net Survey
2. Nanticoke River Ichthyoplankton Survey
3. Conowingo Dam Tailrace Tag Recapture Survey
4. North East River Gill Net Survey

1. Nanticoke River Pound/Fyke Net Survey

<u>Atlantic Sturgeon Interactions</u>

No Atlantic sturgeon were sampled or observed during the Survey period of this project from July 1, 2020, through June 30, 2021.

<u>Shortnose Sturgeon and Sea Turtle Interactions</u>

No shortnose sturgeon or sea turtles were sampled or observed during the Survey period of this project from July 1, 2021, through June 30, 2022.

2. Nanticoke River Ichthyoplankton Survey

<u>Atlantic Sturgeon Interactions</u>

No Atlantic sturgeon were sampled or observed during the Survey period of July 1, 2021, through June 30, 2022.

<u>Shortnose Sturgeon and Sea Turtle Interactions</u>

No shortnose sturgeon or sea turtles were sampled or observed during the Survey period of July 1, 2021, through June 30, 2022.

3. Conowingo Dam Tailrace Tag Recapture Survey

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed during the Survey period of July 1, 2021, through June 30, 2022.

Shortnose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed during the Survey period of July 1, 2021, through June 30, 2022.

4. North East River Gill Net Survey

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed during the Survey period of July 1, 2021, through June 30, 2022.

Shortnose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed during the Survey period of July 1, 2021, through June 30, 2022.

<u>PROJECT 2</u>:

<u>JOB 2</u>: Migratory Species: Stock assessment of selected recreationally important adult migratory finfish in Maryland's Chesapeake Bay.

Research Surveys:
1. Summer Pound Net Survey
2. Fishery Independent Choptank River Gill Net Survey

1.Summer Pound Net Survey

<u>Atlantic Sturgeon Interactions</u>
No Atlantic sturgeon were sampled or observed during the Survey period of July 1, 2021, through June 30, 2022.

<u>Shortnose Sturgeon and Sea Turtle Interactions</u>
No shortnose sturgeon or sea turtles sampled or observed during the Survey period of July 1, 2021, through June 30, 2022.

2. Fishery Independent Choptank River Gill Net Survey

<u>Atlantic Sturgeon Interactions</u>
No Atlantic sturgeon were sampled or observed during the Survey period of July 1, 2021, through June 30, 2022.

<u>Shortnose Sturgeon and Sea Turtle Interactions</u>
No shortnose sturgeon or sea turtles sampled or observed during the Survey period of July 1, 2021, through June 30, 2022.

<u>PROJECT 2, JOB 3</u>: Striped Bass: Stock assessment of adult and juvenile striped bass in Maryland's Chesapeake Bay and selected tributaries.

<u>Task 1</u>: Summer-Fall stock assessment and commercial fishery monitoring.

Research Survey:

1. **Summer - Fall Pound Net Survey**

<u>Atlantic Sturgeon Interactions</u>
No Atlantic sturgeon were sampled or observed during this Survey for the period of July 1, 2021, through June 30, 2022.

<u>Shortnose Sturgeon and Sea Turtle Interactions</u>
No shortnose sturgeon or sea turtles were sampled or observed during this Survey for the period of July 1, 2021, through June 30, 2022.

<u>Task 2:</u> Characterization of striped bass spawning stocks in Maryland.

Research Survey:

1. **Spring Striped Bass Experimental Drift Gill Net Survey**

<u>Atlantic Sturgeon Interactions</u>
There were two (2) Atlantic sturgeon sampled during this Survey for the period of July 1, 2021 through June 30, 2022. Interaction Reports on following pages.

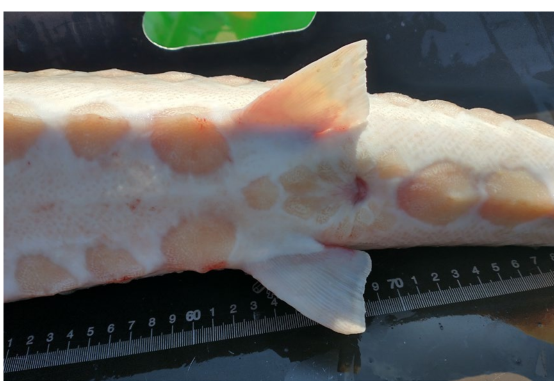
ESA Report Information: Interaction #1:

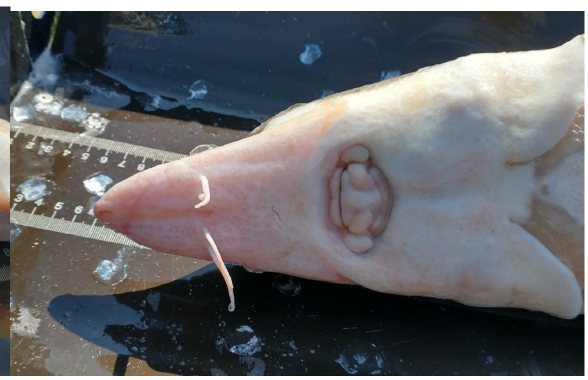
Observer's Name: Jeffrey Horne, MD Department of Natural Resources, Fishing and Boating Services
Reporter's Name: Same as above
Survey: Striped Bass Spawning Stock Survey
Species Identification: Atlantic Sturgeon
How documented: Identified to species by biologists and photos taken.
Type of gear and length of deployment: Experimental, multifilament, nylon drift gill net, ten different mesh sizes, soak time varies – see specific details below.

Encounter # 1:
Date: April 30, 2022 **Time:** 11:00 AM
Location: Upper Chesapeake Bay, off Taylor Island, west of main shipping channel. N 39 22.0110 - W 76 09.3268
Water temp: 12.7º C **Salinity:** 0.8 ppt
Air temp: 15.5º C
Water depth: 21 feet **Tide:** beginning of ebb tide
Gear: drift gill net, 6.5 inch stretch mesh, soak time = 55 minutes
Total length: 816 mm **Fork length:** 702 mm
Condition/description: Appeared healthy and robust, no visible marks, released unharmed
Photograph taken: Yes, see below
Genetic sample taken: Yes, clip from caudal fin
Genetic sample given to: Chuck Stence On date: May 2, 2022
Scanned for PIT tag: No
PIT tag inserted: Yes **Tag #: 3DD003BD7C192**, Tagged below dorsal fin

<u>ESA Report Information: Interaction #2:</u>
Observer's Name: Eric Q. Durell, MD Department of Natural Resources, Fishing and Boating Services
Reporter's Name: Same as above
Survey: Striped Bass Spawning Stock Survey
Species Identification: Atlantic Sturgeon
How documented: Identified to species by biologists and photos taken.
Type of gear and length of deployment: Experimental, multifilament, nylon drift gill net, ten different mesh sizes, soak time varies – see specific details below.

Encounter # 2:
Date: May 2, 2022 **Time:** 9:30 AM
Location: Upper Potomac River, near Dominion Possum Point Power Plant.
N 38 31.654 - W 77 16.287
Water temp: 16.1º C **Salinity:** 0.1 ppt
Air temp: 14º C
Water depth: 32 feet **Tide:** beginning of ebb tide
Gear: drift gill net, 5.25 inch stretch mesh, soak time = 45 minutes
Total length: 1000 mm **Fork length:** 894 mm
Condition/description: Appeared healthy and robust, no visible marks, released unharmed
Photograph taken: Yes, see below
Genetic sample taken: Yes, clip from caudal fin
Genetic sample given to: Chuck Stence On date: May 16, 2022
Scanned for PIT tag: No
PIT tag inserted: Yes, **Tag #: 112737522A**, Tagged below dorsal fin, left side





Shortnose Sturgeon and Sea Turtle Interactions
No shortnose sturgeon or sea turtles were sampled or observed during this Survey for the period of July 1, 2020, through June 30, 2021.

PROJECT 2, Job 3,

Task 3: Maryland juvenile striped bass survey

Research Survey:

1. Juvenile Striped Bass Seine Survey

Atlantic Sturgeon Interactions
No Atlantic sturgeon were sampled or observed during this Survey for the period of July 1, 2021, through June 30, 2022.

Shortnose Sturgeon and Sea Turtle Interactions
No shortnose sturgeon or sea turtles were sampled or observed during this Survey for the period of July 1, 2021, through June 30, 2022.