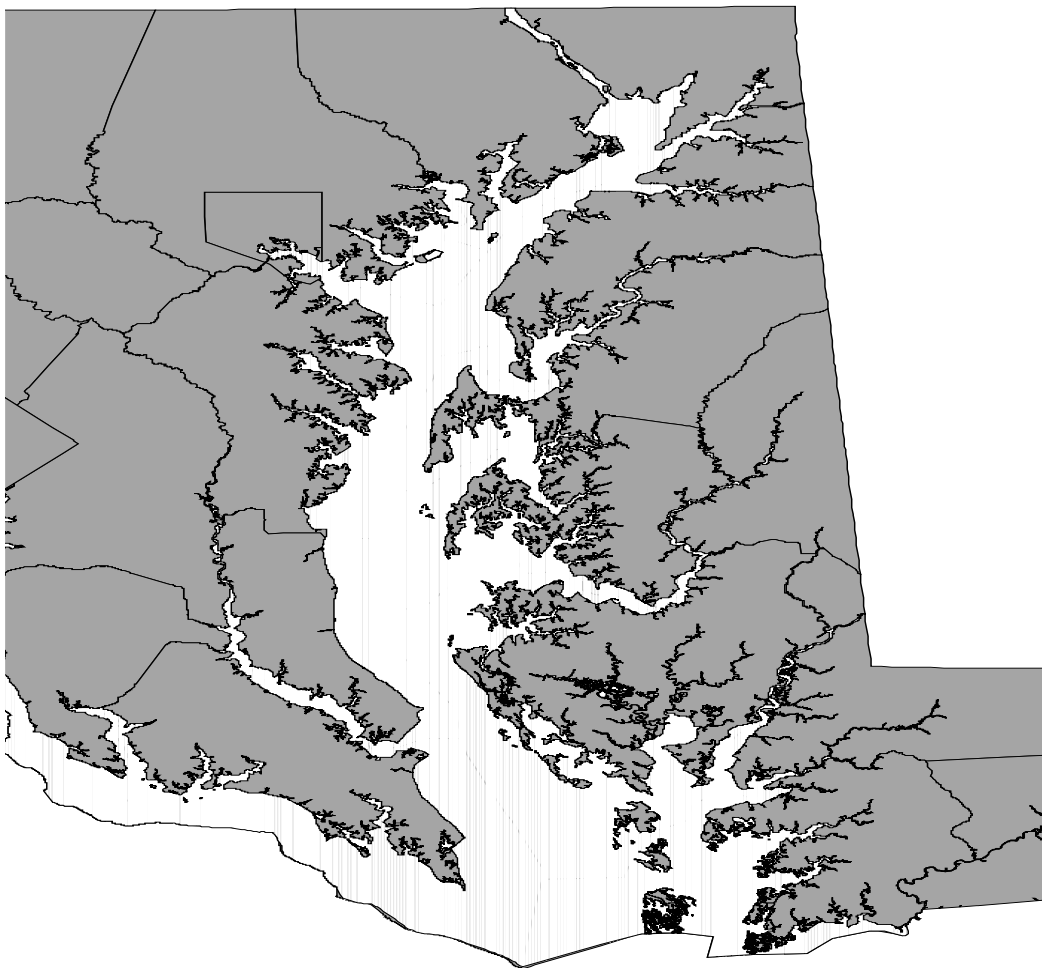




Chesapeake Bay Finfish Investigations

US FWS FEDERAL AID PROJECT

F-61-R-18

2022 - 2023



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Chesapeake Bay Finfish Investigations

July 1, 2022 to June 30, 2023

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UNITED STATES DEPARTMENT OF THE INTERIOR
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PERFORMANCE REPORT

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PROJECT TITLE: Chesapeake Bay Finfish Investigations.

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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 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 2023 indicated that white perch relative abundance decreased relative to 2022 and was the lowest since 2011. Yellow perch relative abundance decreased relative to 2022. The 2014, 2015 and 2018 year-classes were above average. Channel catfish relative abundance continued a three-year decline and was less 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), but the 2022 year-class was well below average. Catches of all species in the winter trawl were hampered by warm water temperatures. Anecdotally, fish were not aggregated to the extent that they normally are with colder water temperatures.

White perch relative abundance in the Choptank River Fyke Net Survey increased in 2023 and was the highest since 2018. 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. Yellow perch relative abundance decreased in 2023 to the lowest level in the time series. The 2018 and 2019 year-classes constituted 67% of the population. Channel catfish relative abundance decreased in 2023 and was below the time series average. White catfish relative abundance increased during 2019 – 2023 and was above the time-series average.

Yellow perch population dynamics in the upper Chesapeake Bay were described with a statistical catch at age model, and the Choptank River yellow perch population was described by linear regression of relative abundance in either increasing or decreasing phases. In the upper Bay, abundance decreased to time series lows. Estimates of fishing mortality indicated that terminal year F was below the target. Recruitment levels have been very low in five of the last seven years. Invasive blue catfish predation may be having an as yet unquantifiable effect on yellow perch populations. Choptank River yellow perch experienced a similar decline in relative abundance. Analysis indicated that the population relative abundance increased from 1991-2014, but the population declined steadily from 2014 – 2023. The estimated instantaneous rate of decrease was -0.19.

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 1.69, which was the highest estimate in the history of the time-series. Population size was estimated at 24,323, 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 both surveys. Catch-per-angler-hour estimates increased for hickory shad in both surveys, with both estimates reaching or surpassing survey highs.

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 increased slightly in 2022, and total mortality was estimated at 0.62. This was the first year that total was estimated to be below the biological reference point since 2016. Juvenile abundance indices for American shad 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 declined or was very low in all monitored systems in 2022.

Stock composition and relative abundance of adult river herring in the Northeast River were assessed using fishery-independent gill nets. Relative abundance estimates in 2022 were similar to 2021 for both species and were near the time-series averages. Total mortality estimates decreased from 2021 for blueback herring, 0.64, but were similar for alewife, 0.75. Juvenile abundance indices for river herring were calculated for various river systems using data collected by the Estuarine Juvenile Finfish Survey (EJFS; Project 2, Job 3, Task 3). Juvenile production was low for river herring in most systems, with the exception of blueback herring in the Potomac River, which saw a modest increase in 2022.

Population structure and dynamics of non-anadromous recreationally important finfish species that migrate into Maryland's portion of Chesapeake Bay were monitored through a summer fishery dependent pound net survey, a fishery independent gill net survey on the Choptank River, and through examination of commercial and recreational catch. 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 1,292 weakfish were harvested in 2022. The 2022 Maryland Chesapeake Bay commercial weakfish harvest remains very low with a harvest of 213 pounds in 2021, well below the 1981 – 2022 time series of 37,460 pounds per year. The 2022 mean length for weakfish from the onboard pound net survey was 264 mm TL, but only six fish were encountered, the lowest sample size of the 30-year time series. No weakfish were captured in the Choptank River gill net survey in 2022.

Summer flounder mean length from the pound net survey was 279 mm TL in 2022, which was the eighth lowest value of time series. The length frequency distribution was bimodal with a primary peak occurring at the 310 mm TL group. Eleven summer flounder were encountered in the Choptank River gill net survey in 2022 with lengths ranging from 174 to 209 mm TL. Commercial harvest in Maryland's portion of Chesapeake Bay and recreational harvest in Maryland inland waters both remained below their time series means. The NMFS 2019 coast wide stock assessment concluded the stock remained in a not overfished and not overfishing state, with generally below average recruitment in recent years.

Mean length of bluefish from the onboard pound net survey in 2022 was 330 mm TL, the fifth highest value in the time-series. The length distribution indicated a shift back to larger bluefish in 2019 through 2022 following distributions that were skewed toward smaller fish from 2016 through 2018. Eleven bluefish were captured in the Choptank River gill net survey in 2022, with lengths ranging from 263 to 396 mm TL. Bluefish have been encountered in low numbers in all eight years of the survey (1 – 24 fish per year). Reported Maryland bluefish commercial, charter boat harvest and inland recreational estimates in 2022 all remained well below their time series means. The 2021 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 2022 was 225 mm TL, the second lowest value of the time-series. Atlantic croaker age structure from pound net samples was truncated to age two in 2022. Length and age sample sizes were low in 2019, 2020 and 2022 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 11 fish being captured in 2022. Maryland 2022 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 2022 Atlantic croaker juvenile index was below the time series mean.

The 2022 spot mean length from the onboard sampling of 192 mm TL was the eleventh lowest value of the 30-year time series. Spot aged from the onboard pound net survey were 95% age one, 3% age zero, and 2% age two, indicating age structure remains truncated. Spot catch in the Choptank River gill net survey was highest from 2020 to 2022, moderate in 2013, 2014, 2017 and 2019, and low in 2015, 2016 and 2018. Chesapeake Bay commercial spot harvest decreased in 2022, remaining below the time-series mean. The inland waters recreational harvest estimate in 2022 decreased, and fell below 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 34-year time-series. The values have increased since 2017, and remained high in 2022 with the value being the 7th highest value of the time series.

Mean length for Atlantic menhaden sampled from the onboard pound net survey in 2022 was 214 mm FL, the 2nd lowest value of the 19-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 1,921 fish captured in 2022. Mean lengths for all meshes combined displayed little inter-annual variation prior to 2020, with the 2020 to 2022 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 2022 season ranged in age from one to fifteen years old. Age 3 striped bass from the 2019 year-class contributed 44% of the sample. Age 2 (2020) and Age 4 (2018) contributed 14% and 25% to the sample, respectively. Age 7 fish from the above average 2015 year-class contributed 2.6% in 2022 while striped bass age 6 and older comprised 7% of the sample. Striped bass sampled from pound nets ranged from 207 to 1115 mm TL, with a mean length of 449 mm TL in 2022. Check station sampling determined that the commercial summer/fall fishery harvest was comprised of three- to eleven-year-old striped bass from the 2011 through 2019 year-classes. Striped bass over 700 mm TL were harvested throughout the season and contributed 2% to the overall harvest.

The December 2021 - February 2022 commercial drift gill net harvest consisted primarily of age five-, six-, seven, and eight-year-old striped bass from the 2014 to 2017 year-classes that comprised 88% of the total harvest. The contribution of fish older than age 9 (8%) was similar to the 2020-2021 harvest (8%). The youngest fish observed in the 2021-2022 sampled harvest were age 4 from the 2018 year-class. Striped bass present in commercial drift gill net samples collected from check stations ranged in age from age 4 to 14 years old (2008 to 2018 year-classes).

A total of 186 striped bass were sampled at check stations for the Atlantic coast commercial striped bass fishery from October 2021 to May 2022. Striped bass harvested during the 2021-2022 Atlantic coast commercial fishing season ranged from age 8 (2014 year-class) to age 20 (2002 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 11 striped bass from the 2011 year-class, which represented 47% of the sampled harvest. Atlantic coast check stations during the 2021 – 2022 season had a mean length of 1043 mm TL and mean weight of 11.5 kg.

Again in 2022, the spring spawning stock survey encountered fewer striped bass than average. Survey results indicated there were 18 age-classes of striped bass present on the Potomac River and Upper Bay spawning grounds, ranging in age from 2 to 19 years old. Male striped bass ranged in age from 2 to 17 years and females ranged in age from 6 to 19. Like the last two years, females from the dominant 2011 year-class (age 11) were most commonly observed. The contribution of age 8+ females to the total female CPUE in 2022 increased to 98%, the highest in the time series. This increase was driven by the low sample sizes observed in both systems, and very few young females caught. 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 (73%) for 2016-2018. The 2022 selectivity-corrected, total, weighted catch-per-unit-effort (271), used in the coastwide stock assessment, was slightly higher than 2021. However, it was the fourth lowest in the 38-year survey, well below the time-series average of 482.

The striped bass young-of-year index, a measure of striped bass spawning success in Maryland's Chesapeake Bay was 3.6 in 2022. This was slightly higher than the previous year's results but remains below the long-term average of 11.3. The Atlantic 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. Biologists continue to examine factors that might limit spawning success. Biologists captured more than 40,000 fish of 58 different species during the 3-month survey. One positive result was the increased abundance of spot, a popular species used for food and bait. Spot abundance was the highest observed in over a decade.

Atlantic Coast states enacted responsible conservation measures in recent years to reduce harvest and protect striped bass during the spawning season. Maryland will continue to work with other states in the Atlantic States Marine Fisheries Commission to develop additional measures to enhance the striped bass population through the Atlantic striped bass fishery management plan. For this annual survey, fishery managers examine 22 sites 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. The index represents the average number of recently hatched striped bass captured in each sample.

During the 2022 spring recreational trophy season, biologists intercepted 14 charter trips and examined 28 striped bass. The average total length of striped bass sampled from the spring trophy fishery was 1059 mm total length. The average weight was 12.4 kg. Striped bass sampled from the spring trophy fishery ranged in age from 8 to 21 years old. In 2022 there was a broad contribution of year-classes to the age structure of the sampled charter boat harvest with the 2014 (age 8), 2011 (age 11), and 2008 (age 14) year-classes each contributing around 20%. The next largest contribution was 13% from the 2013 year-class. All other year-classes contributed less than 10% to the harvest. In 2022, charter boats caught 4.3 fish per trip at a rate of 0.9 fish per hour.

Maryland Department of Natural Resources staff continued to tag and release striped bass in spring 2022 in support of the US FWS coordinated interstate, coastal population study. A total of 884 striped bass were sampled and 369 striped bass were tagged and released in Maryland with US FWS internal anchor tags between April 4 and May 14, 2022. Of this sample, 140 were tagged in the Potomac River and 229 were tagged in the upper Chesapeake Bay area during the spring spawning stock assessment survey. A total of 726 striped bass were tagged during US FWS cooperative offshore tagging activities between January 24 and February 10, 2022.

APPROVAL

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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 Bobby Owen Clark, III on the Upper Chesapeake Bay and William R. Rice, Sr., on the Potomac River.

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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

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 2023 through February 2023.

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). 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 2023 through 4 April 2023 (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 2 March 2023 in the Bush River (Figure 3), 5 March 2023 in the North East River (Figure 4) and 9 March 2023 in the Gunpowder River (Figure 3). 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

Nanticoke River finfish sampling did not occur in either 2022 or 2023 due to a lack of cooperating commercial fishermen. In 2022, inability to hire mates hindered the waterman;s ability to set nets, and for 2023 there were unknown reasons for lack of cooperation. Historical data are presented, except current length frequencies. The latest length frequencies can be found in Piavis and Webb (2022).

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 and yellow perch from the upper Bay commercial fyke net fishery. Age-at-length (ALK) 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 ALKs for yellow perch and white perch from the trawl survey were not sex specific because sex determination at that time of year is not reliable for length-only samples. 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 and the Choptank River fyke net 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 River). Growth in length over time and weight in relation to length were described with standard fishery equations. The allometric

growth equation ($\text{weight (g)} = \alpha * \text{length (mmTL)}^\beta$) described weight change as a function of length, and the vonBertalanffy growth equation ($\text{Length} = L_\infty(1 - e^{-K(t-t_0)})$) 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 -- 2023 in the Choptank River and upper Bay were determined from length converted catch curves (Pauly 1984; Huynh et al 2018). 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 length converted catch curve. The slope of the line was $-Z$ and M was assumed to be 0.25, so that $F=Z-0.25$. Instantaneous mortality rates for yellow perch from the upper Bay were calculated with a statistical catch-at-age model 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., Sassafra 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 statute 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 5-6
Yellow perch	Tables 11-13 and Figures 7-9
Channel catfish	Tables 14-16 and Figures 10-11
White catfish	Tables 17-19 and Figures 12-13

Growth

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

Mortality

White perch	Table 24
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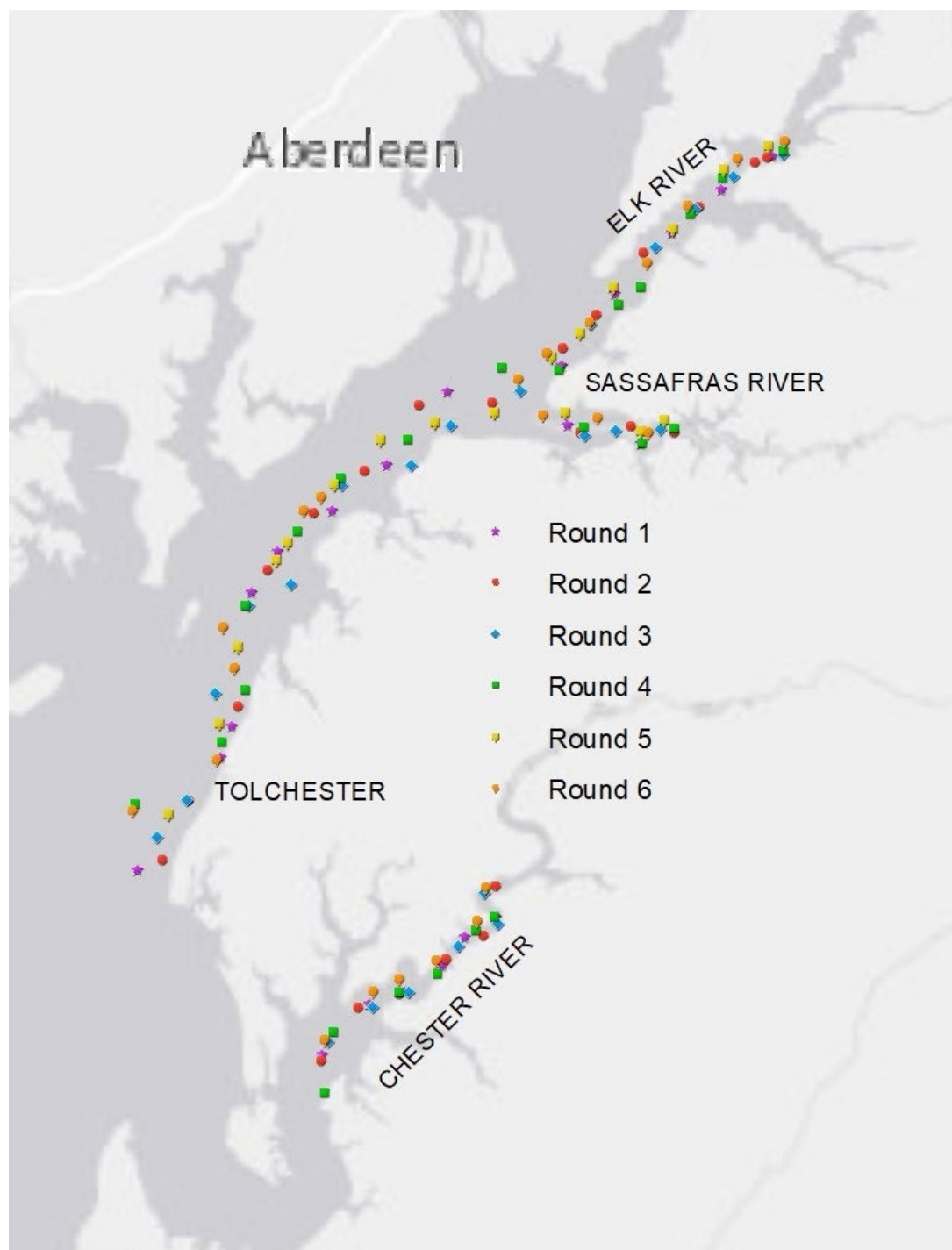


Table 1. Upper Chesapeake Bay winter trawl survey effort, 2000 – 2023.

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	
2022	100/138	Vessel Maintenance
2023	131/138	Manpower

Figure 2. Choptank River fyke net locations, 2023. Circles indicate sites.

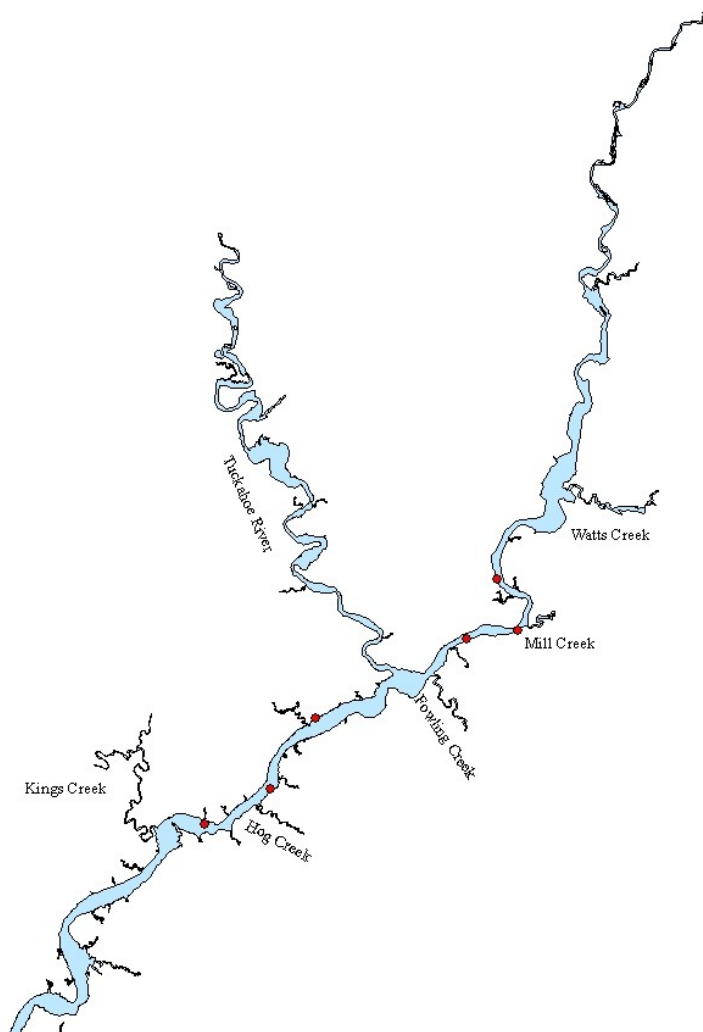


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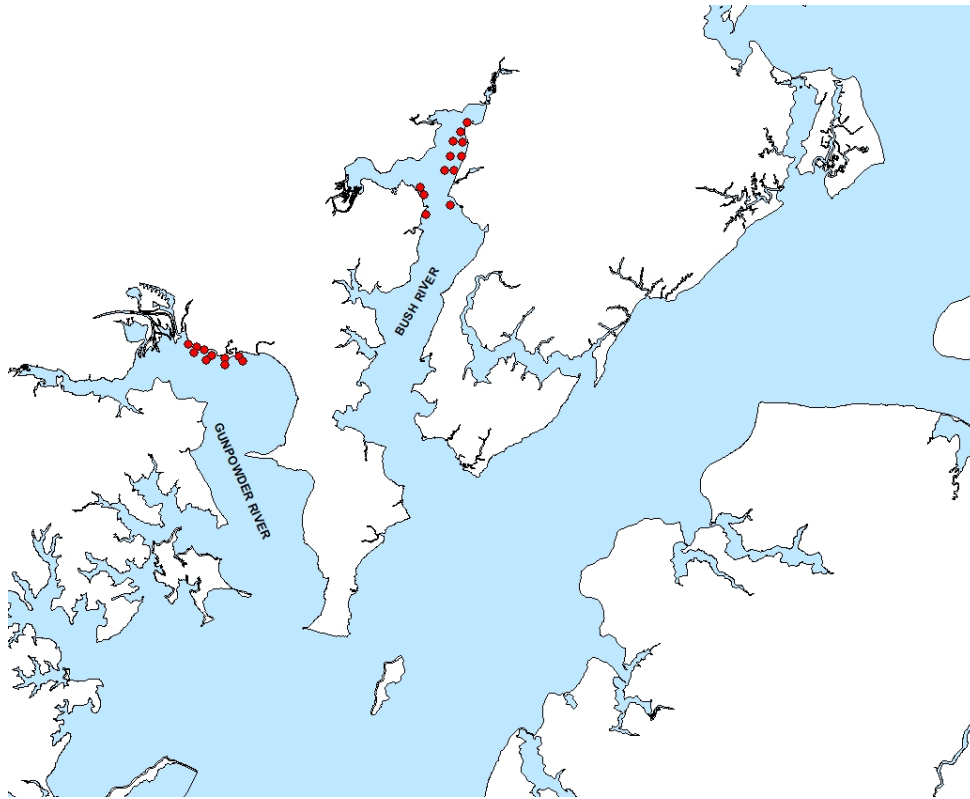


Figure 4. Commercial yellow perch fyke net sites sampled during 2023 in North East River. Circles indicate sites.



Table 2. White perch catch-at-age matrix from upper Chesapeake Bay winter trawl survey, 2000 – 2023.

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
2022	11,903	11,864	9,721	9,120	2,580	2,367	2,839	1,252	194	488
2023	3,594	8,281	8,724	3,476	8,702	1,157	536	312	353	165

Table 3. White perch catch-at-age matrix from Choptank River fyke net survey, 2000 – 2023.

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
2022	0	251	3,080	3,885	694	777	1,047	772	6	287
2023	0	77	470	2,612	4,746	470	307	1,491	587	391

Table 4. White perch catch-at-age matrix from Nanticoke River fyke and pound net survey, 2000 – 2023. 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
2022	NOT SAMPLED									
2023	NOT SAMPLED									

Table 5. Yellow perch catch at age from upper Chesapeake Bay winter trawl survey, 2000 – 2023.

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
2022	284	48	193	200	0	0	7	0	0	0
2023	100	37	3	27	26	0	0	0	0	0

Table 6. Yellow perch catch at age matrix from Choptank River fyke net survey, 1988 – 2023.

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
2022	0	14	243	205	19	8	145	163	3	2
2023	0	93	29	163	220	27	12	65	8	3

Table 7. Yellow perch catch at age matrix from upper Chesapeake Bay commercial fyke net survey, 1999 – 2023.

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
2022	0	49	1,813	2,454	23	0	151	14	0	0
2023	0	246	378	1,159	1,009	33	9	5	41	0

Table 8. Relative stock densities (RSD's) of white perch from the upper Chesapeake Bay winter trawl survey, 2000 – 2023. 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
2022	92.2	7.4	0.3	0.0	0.0
2023	93.0	6.5	0.5	<0.1	0.0

Figure 5. White perch length-frequency from 2023 upper Chesapeake Bay winter trawl survey.

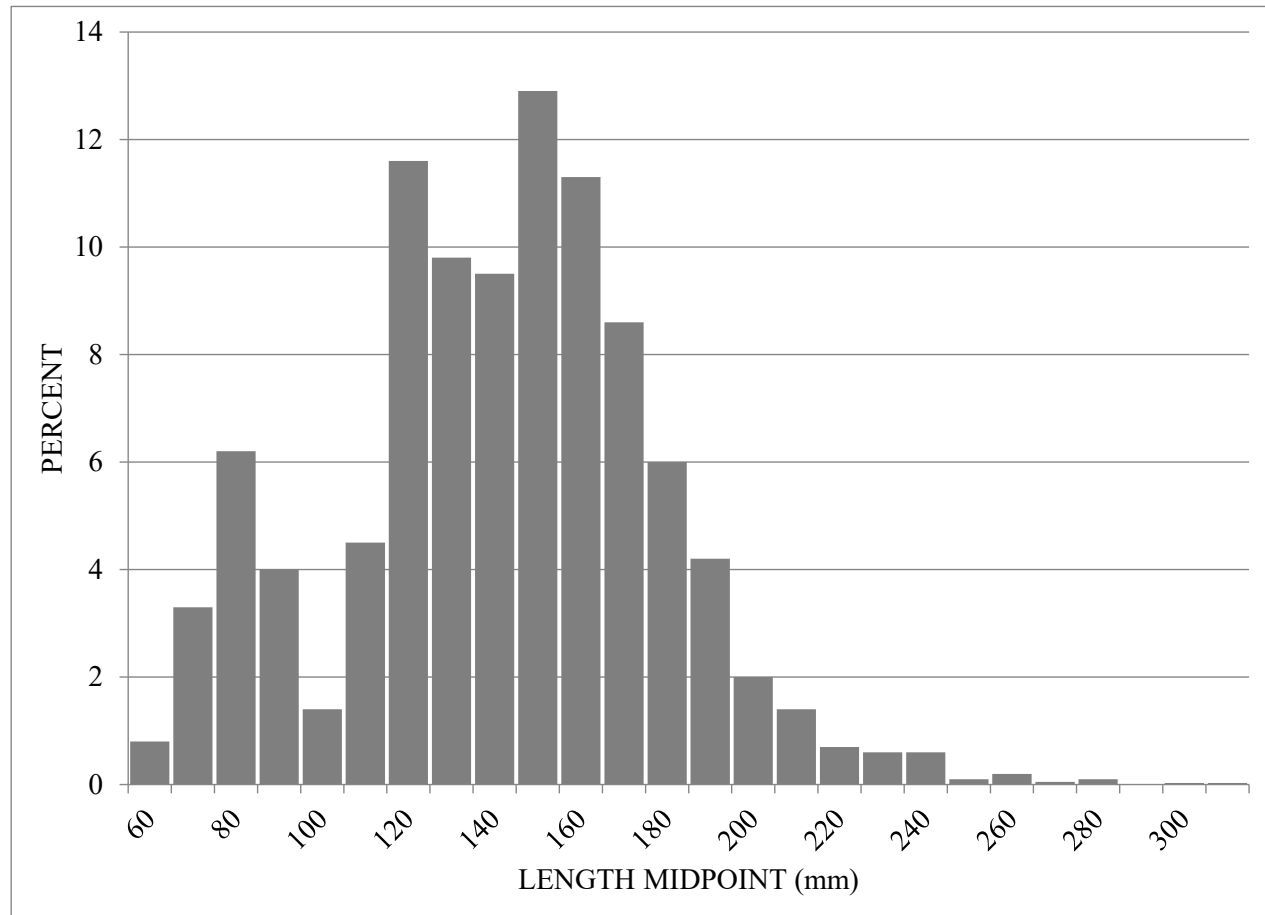


Table 9. Relative stock densities (RSD's) of white perch from the Choptank River fyke net survey, 1993 – 2023. Minimum length cut-offs in parentheses.

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
2022	62.5	35.1	2.4	0.0	0.0
2023	36.5	57.5	5.6	0.5	0.0

Figure 6. White perch length-frequency from 2023 Choptank River fyke net survey.

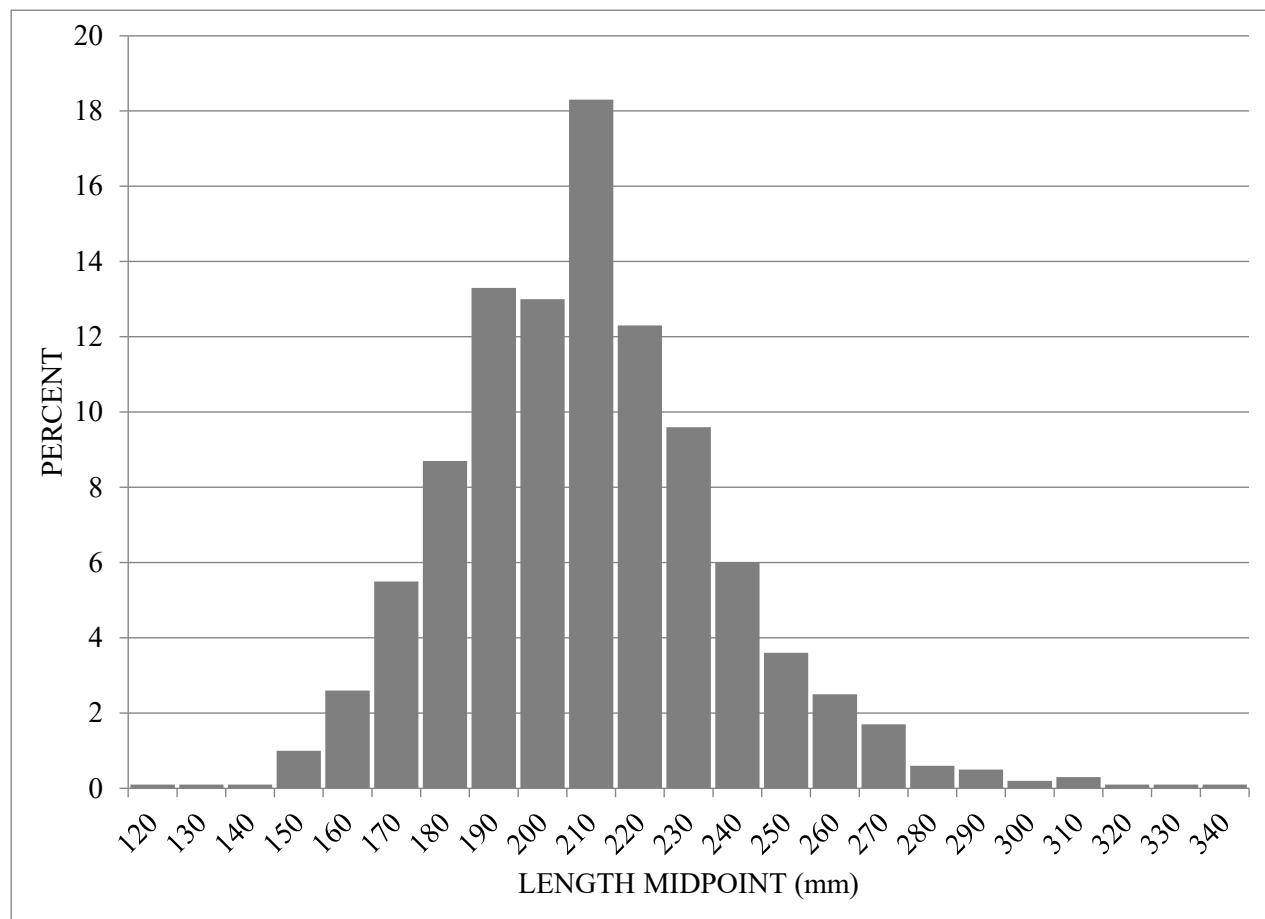


Table 10. Relative stock densities (RSD's) of white perch from the Nanticoke River fyke and pound net survey, 1995 – 2023. Minimum length cut-offs in parentheses. 2007 -- 2009 include Marshyhope River data.

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
2022	NOT SAMPLED				
2023	NOT SAMPLED				

Table 11. Relative stock densities (RSD's) of yellow perch from the upper Chesapeake Bay winter trawl survey, 2000 – 2023. 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
2022	84.7	14.2	1.1	0.0	0.0
2023	86.0	9.7	4.3	0.0	0.0

Figure 7. Yellow perch length-frequency from the 2023 upper Chesapeake Bay winter trawl survey.

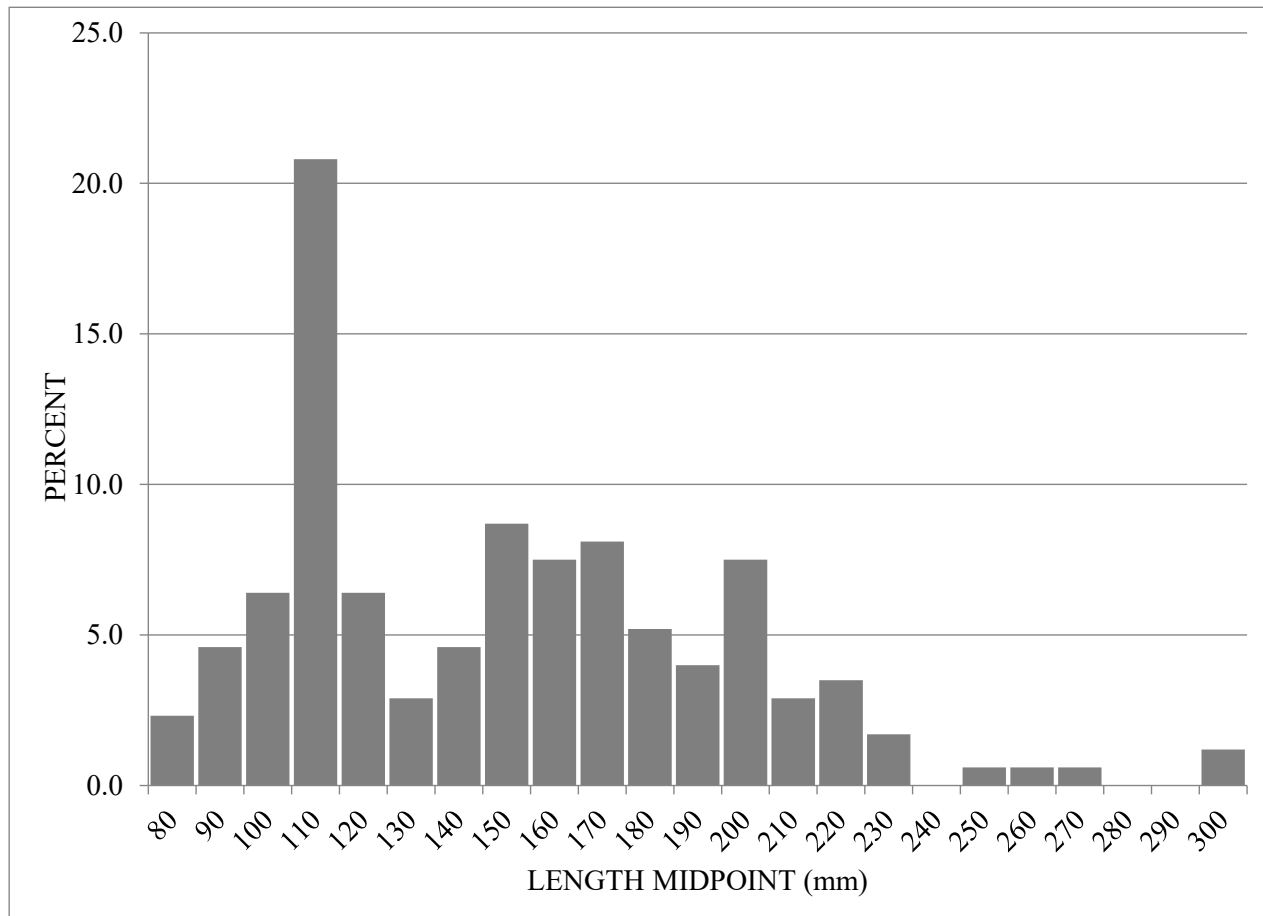


Table 12. Relative stock densities (RSD's) of yellow perch from the Choptank River fyke net survey, 1989 – 2023. Minimum length cut-offs in parentheses.

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
2022	49.3	22.9	26.8	0.9	0.0
2023	23.0	31.7	43.5	1.8	0.0

Figure 8. Yellow perch length-frequency from the 2023 Choptank River fyke net survey.

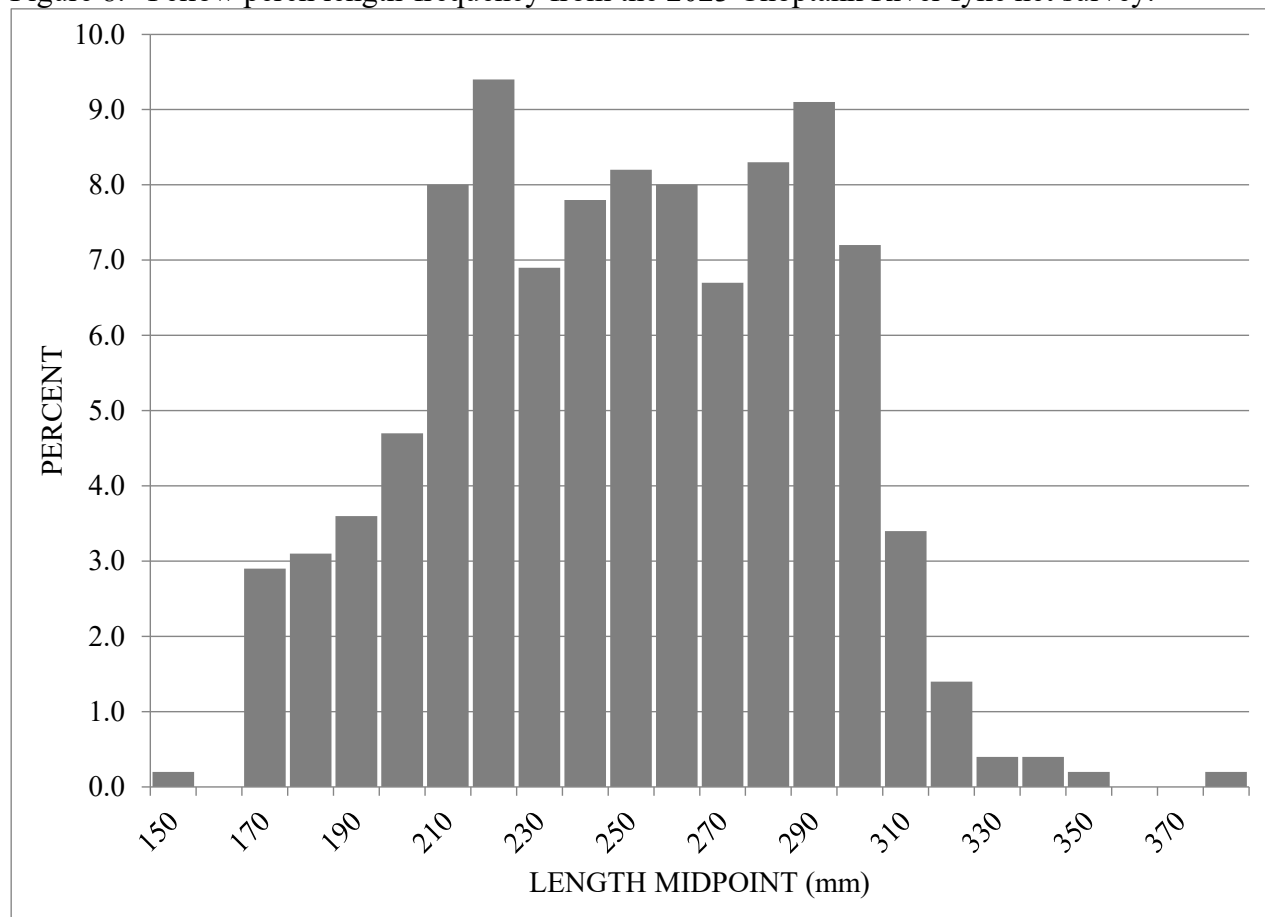


Table 13. Relative stock densities (RSD's) of yellow perch from the upper Chesapeake Bay commercial fyke net survey, 1988, 1990, 1998 – 2023. Minimum length cut-offs in parentheses.

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
2022	37.0	50.6	12.2	0.3	0.0
2023	42.7	41.2	15.0	1.0	0.0

Figure 9. Yellow perch length frequency from the 2023 upper Chesapeake commercial fyke net survey.

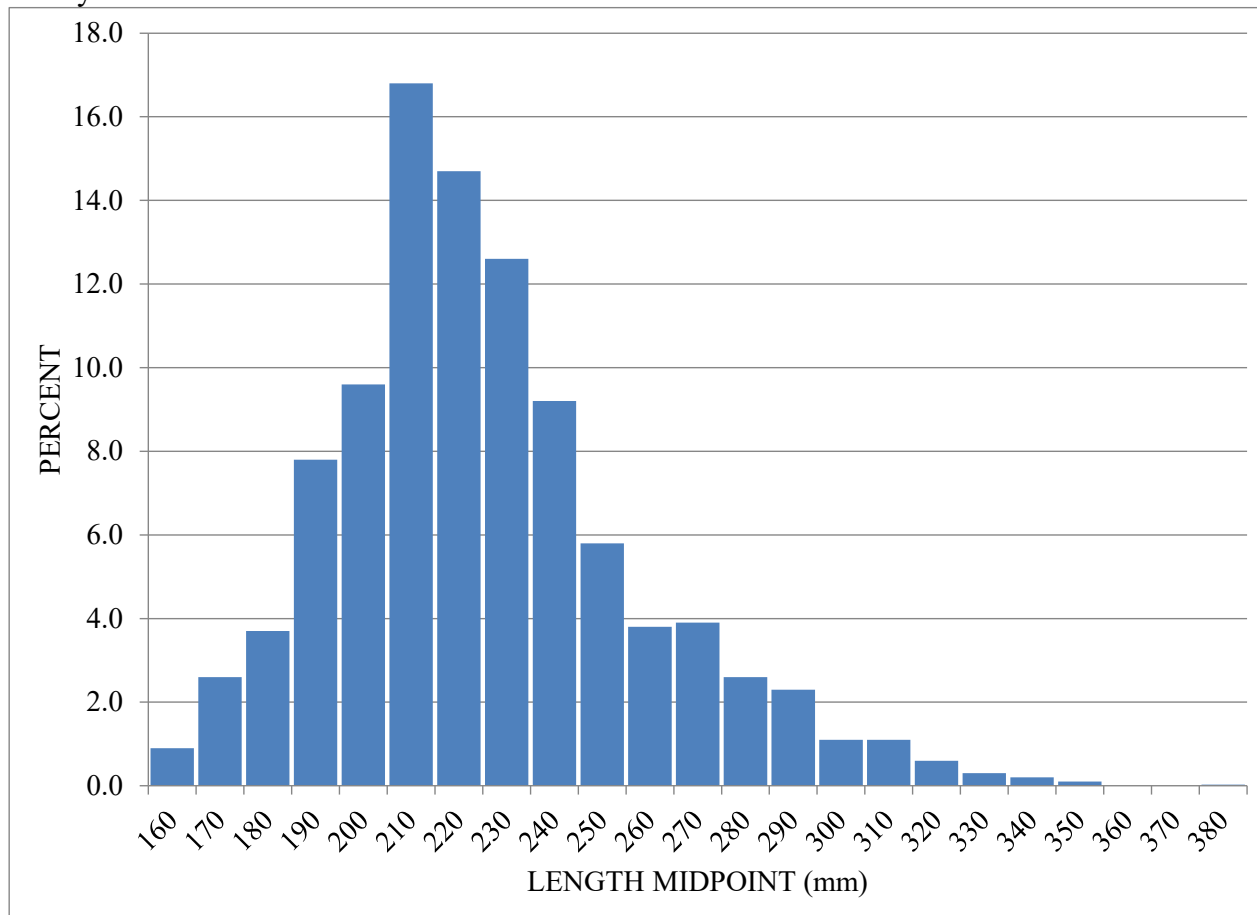


Table 14. Relative stock densities (RSD's) of channel catfish from the upper Chesapeake Bay winter trawl survey, 2000 – 2023. Minimum length cut-offs in parentheses.

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
2022	89.1	7.8	3.1	0.0	0.0
2023	93.2	3.2	3.6	0.0	0.0

Figure 10. Length frequency of channel catfish from the 2023 upper Chesapeake Bay winter trawl survey.

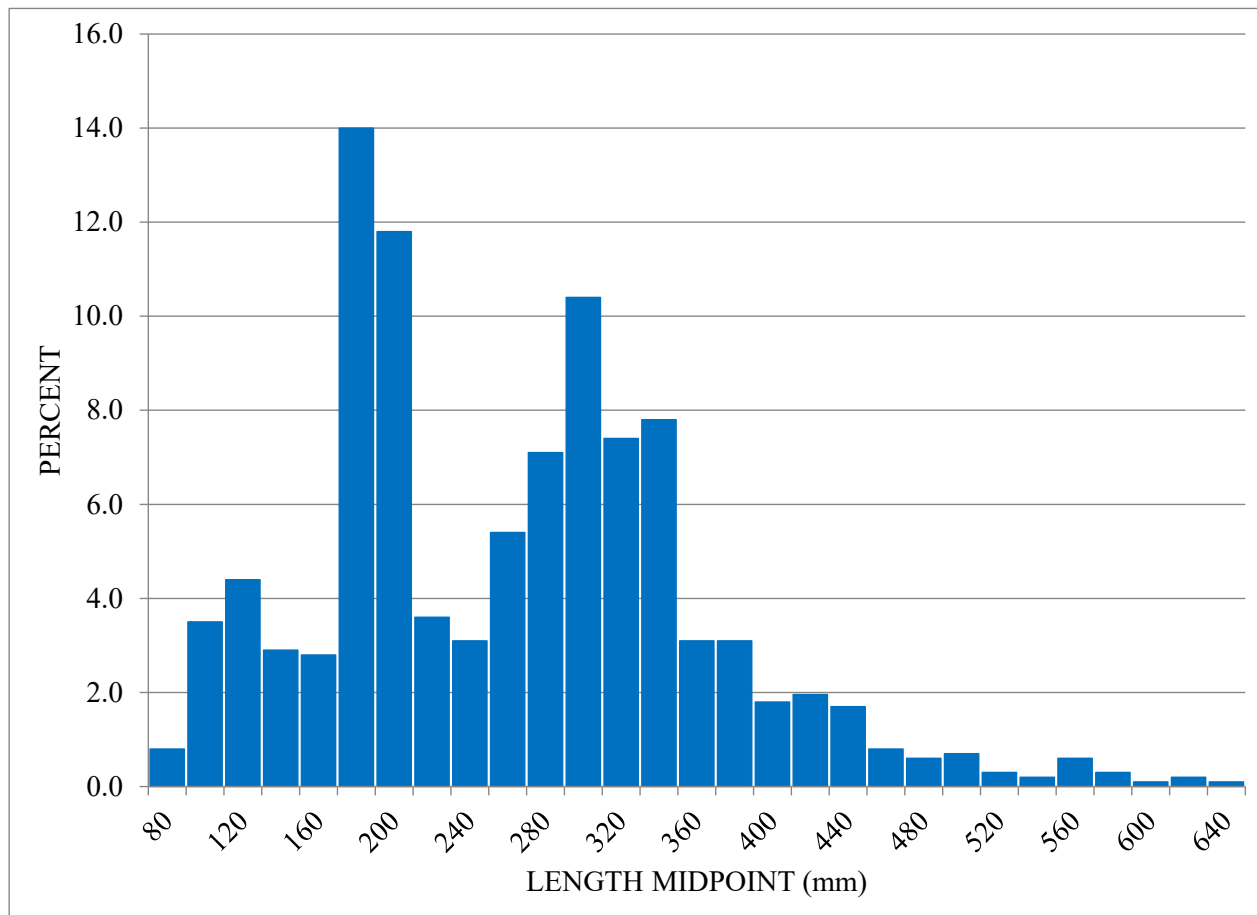


Table 15. Relative stock densities (RSD's) of channel catfish from the Choptank River fyke net survey, 1993 – 2023. Minimum length cut-offs in parentheses.

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
2022	18.3	14.0	67.6	0.2	0.0
2023	42.8	11.5	45.7	0.0	0.0

Figure 11. Channel catfish length frequency from the 2023 Choptank River fyke net survey.

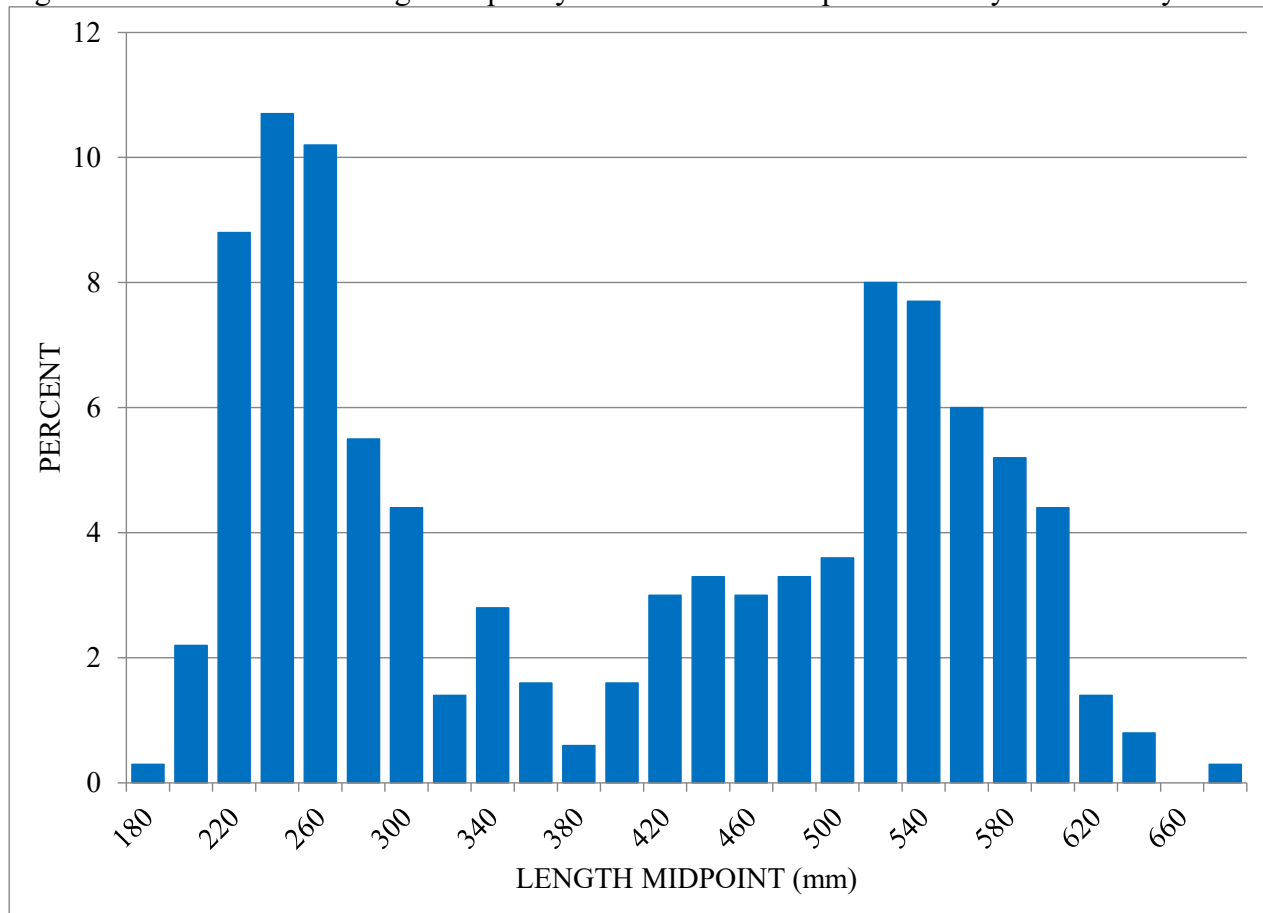


Table 16. Relative stock densities (RSD's) of channel catfish from Nanticoke River fyke and pound net survey, 1995 – 2023. 2007 -- 2009 include Marshyhope River fyke net data. Minimum length cut-offs in parentheses.

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
2022	NOT SAMPLED				
2023	NOT SAMPLED				

Table 17. Relative stock densities (RSD's) of white catfish from the upper Chesapeake Bay winter trawl survey, 2000 – 2023. 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
2022	66.0	18.4	4.9	10.7	0.0
2023	28.3	23.6	28.3	19.8	0.0

Figure 12. White catfish length frequency from the 2023 upper Chesapeake Bay winter trawl survey.

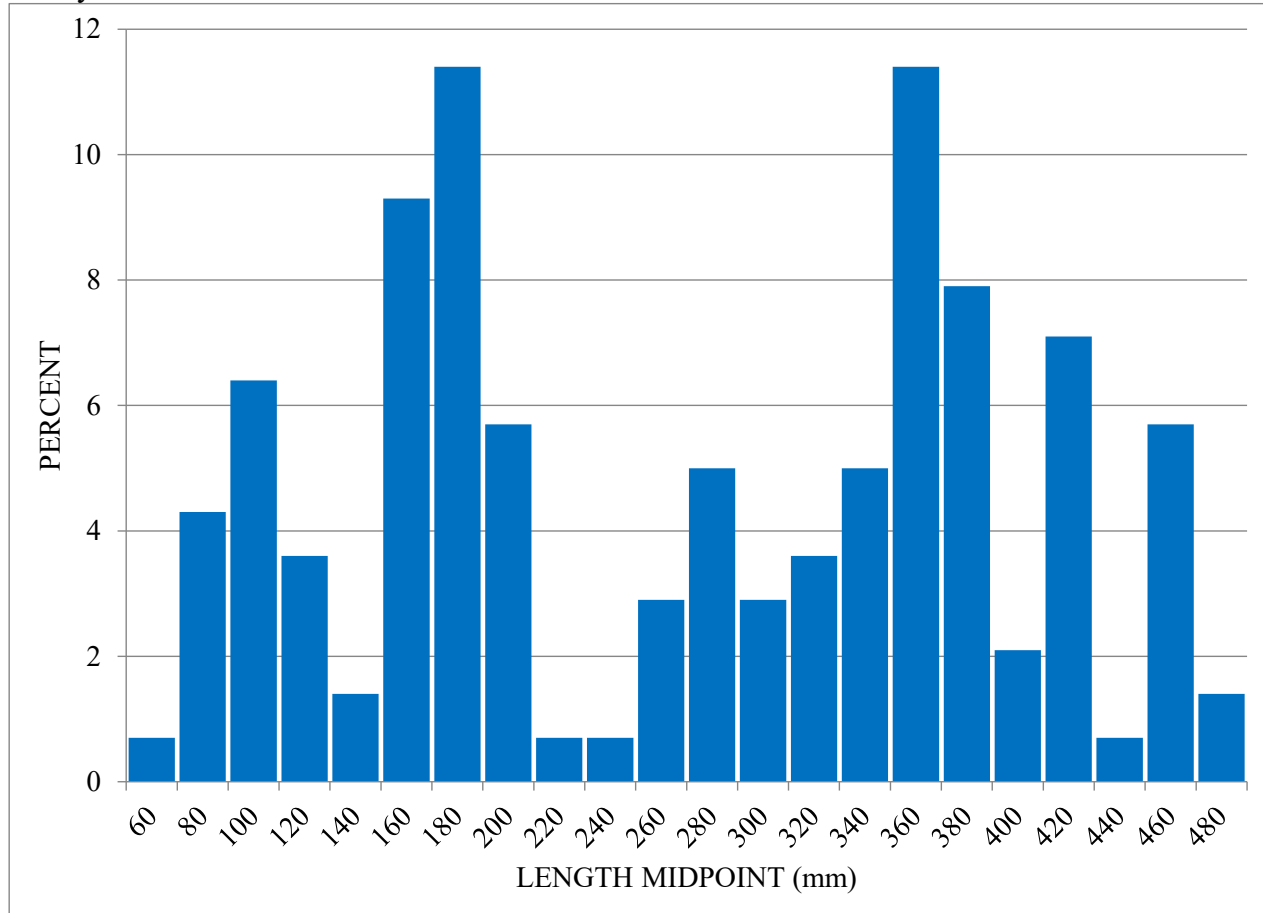


Table 18. Relative stock densities (RSD's) of white catfish from the Choptank River fyke net survey, 1993 – 2023. Minimum length cut-offs in parentheses.

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
2022	17.8	46.6	11.6	23.7	0.3
2023	16.2	19.6	6.6	52.4	5.3

Figure 13. White catfish length frequency from the 2023 Choptank River fyke net survey.

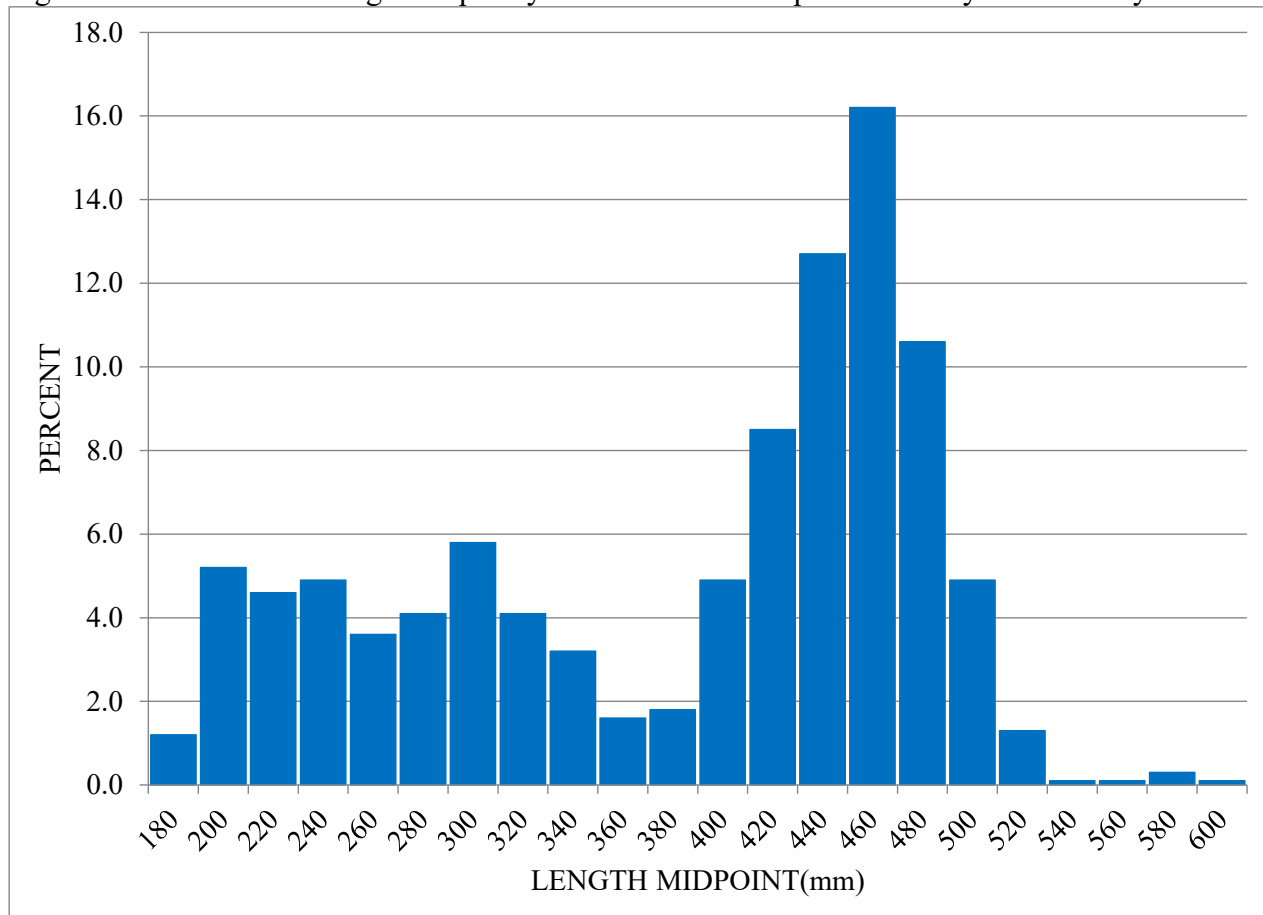


Table 19. Relative stock densities (RSD's) of white catfish from the Nanticoke River fyke and pound net survey, 1995 – 2022. 2007 -- 2009 include Marshyhope River fyke net data. Minimum length cut-offs in parentheses.

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
2022	NOT SAMPLED				
2023	NOT SAMPLED				

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
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	262	0.28	-1.14
2022	F	7.4×10^{-6}	3.12	250	0.47	0.08
	M	8.8×10^{-6}	3.08	213	0.54	0.01
	Combined	5.5×10^{-6}	3.17	245	0.42	-0.03
2023	F	7.1×10^{-6}	3.14	276	0.28	-0.20
	M	3.9×10^{-6}	3.24	223	0.39	-0.15
	Combined	5.3×10^{-6}	3.19	264	0.29	-0.23
2000 – 2023	F	4.2×10^{-6}	3.24	283	0.27	-0.46
	M	5.4×10^{-6}	3.18	225	0.38	-0.33
	Combined	3.0×10^{-6}	3.30	271	0.26	-0.70

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. Survey not initiated in 2022 or 2023.

Sample Year	Sex	(allometry)	(von Bertalanffy)			
		alpha	beta	L-inf	K	t ₀
2015	F	NA	NA		NA	
	M	NA	NA		NA	
	Combined	NA	NA		NA	
2016	F	9.2×10^{-5}	2.70	302	0.33	0.25
	M	1.1×10^{-5}	3.07	288	0.27	-0.21
	Combined	2.9×10^{-5}	2.90	296	0.30	0.05
2017	F	5.2×10^{-6}	3.21	323	0.26	-0.25
	M	4.7×10^{-6}	3.21	308	0.21	-0.52
	Combined	3.1×10^{-6}	3.29	318	0.23	-0.49
2018	F	NSF		287	0.30	0.06
	M	1.4×10^{-5}	3.02	262	0.33	-0.13
	Combined	NSF		311	0.23	-0.56
2019	F	7.2×10^{-6}	3.14	284	0.38	-0.06
	M	2.2×10^{-5}	2.98	234	0.59	0.08
	Combined	7.0×10^{-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	9.7×10^{-6}	3.08	285	0.34	-0.23
	M	2.7×10^{-5}	2.88	233	0.76	0.20
	Combined	5.5×10^{-6}	3.18	273	0.36	-0.41
2022	F	NA	NA	NA	NA	NA
	M	NA	NA	NA	NA	NA
	Combined	NA	NA	NA	NA	NA
2023	F	NA	NA	NA	NA	NA
	M	NA	NA	NA	NA	NA
	Combined	NA	NA	NA	NA	NA
2000 - 2023	F	5.5×10^{-4}	2.37	300	0.27	-0.32
	M	1.7×10^{-5}	2.98	266	0.29	-0.38
	Combined	2.1×10^{-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
2015	F	1.7 X 10 ⁻⁵	2.94	337	0.27	-0.41
	M	2.1 X10 ⁻⁶	3.32	234	0.52	-0.22
	Combined	9.6 X 10 ⁻⁶	3.04	334	0.22	-0.98
2016	F	3.3 X 10 ⁻⁷	3.66	300	0.34	-1.18
	M	3.6 X 10 ⁻⁶	3.21	290	0.22	-1.85
	Combined	4.0 X 10 ⁻⁷	3.62	269	0.45	-0.36
2017	F	2.1 X 10 ⁻⁴	2.52	321	0.20	-1.90
	M	3.9 X 10 ⁻⁵	2.79	282	0.18	-2.74
	Combined	3.8 X 10 ⁻⁵	2.82	286	0.24	-1.59
2018	F	4.7 X 10 ⁻⁵	2.75	318	0.35	-0.09
	M	4.0 X 10 ⁻⁶	3.19	254	0.65	1.22
	Combined	2.1 X 10 ⁻⁵	2.89	265	0.60	0.67
2019	F	2.6 X 10 ⁻⁵	2.86	338	0.18	-2.82
	M	6.9 X 10 ⁻⁷	3.52	267	0.34	-0.75
	Combined	9.5 X 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 X 10 ⁻⁶	3.09	290	0.52	0.10
	M	3.5 X 10 ⁻⁶	3.21	271	0.25	-1.46
	Combined	5.9 X 10 ⁻⁶	3.11	258	0.48	-0.30
2022	F	3.3 X 10 ⁻⁴	2.42	297	0.62	0.73
	M	7.5 X 10 ⁻⁶	3.08	312	0.17	-2.72
	Combined	1.3 X 10 ⁻⁵	3.00	275	0.54	0.45
2023	F	6.7 X 10 ⁻⁵	2.69	316	0.38	-0.27
	M	1.5 X 10 ⁻⁵	2.94	382	0.06	-2.56
	Combined	4.3 X 10 ⁻⁵	2.77	275	0.56	0.13
2000 –2023	F	8.0 X 10 ⁻⁵	2.66	301	0.38	-0.42
	M	8.3 X 10 ⁻⁶	3.06	274	0.24	-1.60
	Combined	2.6 X 10 ⁻⁵	2.86	270	0.40	-0.58

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
2015	F	1.1 X 10 ⁻⁷	3.89	473	0.40	12.80
	M	1.7 X 10 ⁻⁵	2.96	246	1.52	0.33
	Combined	7.5 X 10 ⁻⁷	3.54	248	1.45	0.31
2016	F	1.4 X 10 ⁻⁶	3.41	273	0.75	0.67
	M	1.4 x 10 ⁻⁶	3.40	247	0.61	-0.04
	Combined	9.2 x 10 ⁻⁷	3.48	263	0.59	0.04
2017	F	2.6 X 10 ⁻⁶	3.28	298	0.56	0.63
	M	3.3 X 10 ⁻⁶	3.23	253	0.46	-0.16
	Combined	1.1 X 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 X 10 ⁻⁶	3.45	314	0.37	-0.27
	M	6.6 X 10 ⁻⁷	3.54	242	0.55	-0.19
	Combined	5.7 X 10 ⁻⁷	3.57	273	0.47	-0.19
2020	F	3.5 X 10 ⁻⁶	3.23	351	0.26	-0.71
	M	2.3 X 10 ⁻⁶	3.30	249	0.44	-1.38
	Combined	1.8 X 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
2022	F	2.8 X 10 ⁻⁶	3.28	365	0.28	-0.33
	M	7.9 X 10 ⁻⁷	3.50	236	0.72	0.00
	Combined	1.6 X 10 ⁻⁶	3.38	302	0.39	-0.29
2023	F	9.0 X 10 ⁻⁶	3.06	369	0.28	-0.30
	M	4.5 X 10 ⁻⁶	3.18	270	0.40	-0.37
	Combined	5.6 x 10 ⁻⁶	3.14	322	0.31	-0.44
1998 – 2023	F	4.9 X 10 ⁻⁶	3.18	303	0.37	-0.33
	M	3.2 X 10 ⁻⁶	3.24	244	0.52	-0.24
	Combined	2.3 X 10 ⁻⁶	3.32	269	0.50	-0.15

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

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Choptank ¹	0.31	0.23	0.42	0.32	0.40	0.77	0.52	0.65	0.54	0.44
Nanticoke	0.41	NA	0.49	0.41	0.43	0.47	NA	0.20	NA	NA
Upper Bay ¹	0.29	0.29	0.28	0.22	0.36	0.68	0.71	0.68	0.69	0.65

¹Estimated F from stock assessment for 2014 – 2021 (Piavis and Webb 2021).

2022-2023 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.

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Choptank	0.41	NR	0.32	MIN	MIN	0.38	0.27	0.02	0.45	0.27
Upper Bay ¹	0.26	0.26	0.97	1.12	0.42	0.72	0.63	0.44	0.26	0.24

¹Fully recruited F from annual update of Piavis and Webb (2023).

Figure 14. Baywide young-of-year relative abundance index for white perch, 1962 – 2023, based on EJFS data. Bold horizontal line=time series average. Error bars indicate 95% CI's.

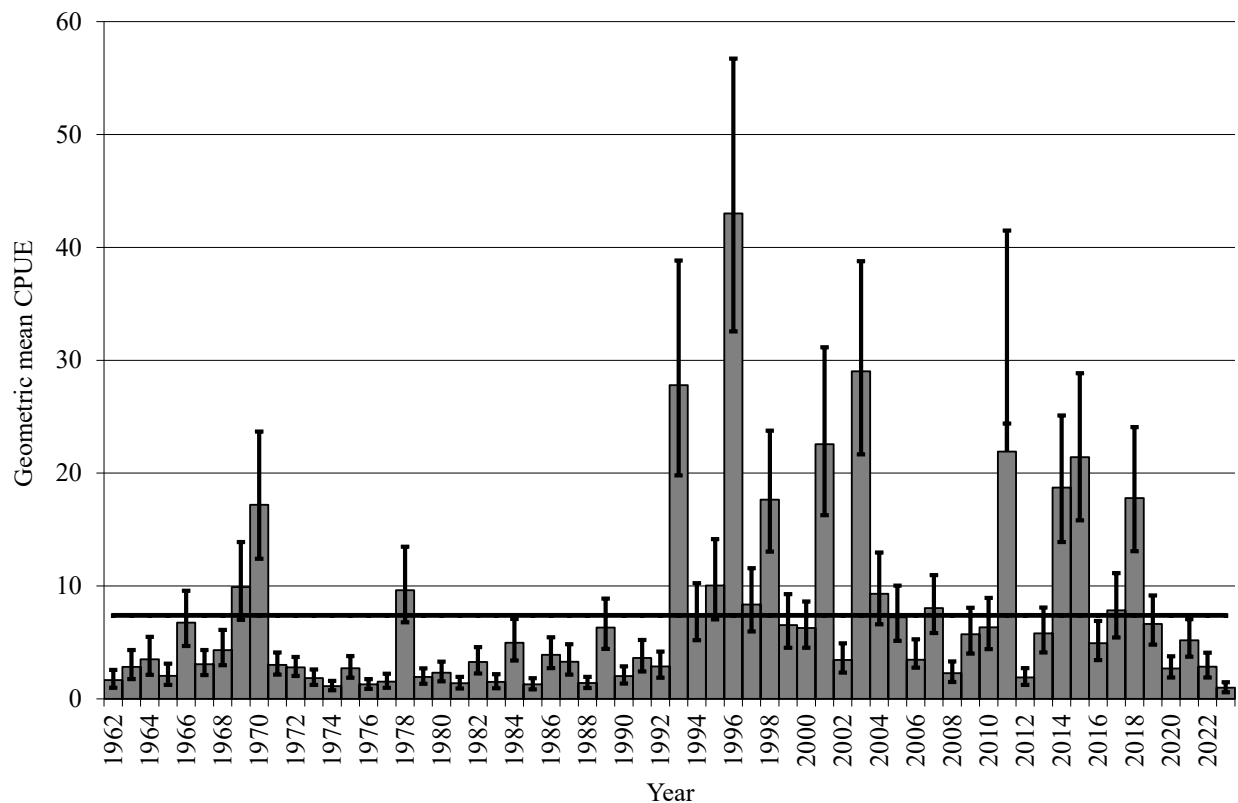


Figure 15. Age 1 white perch relative abundance from upper Chesapeake Bay winter trawl survey. Not sampled in 2004, small sample sizes 2003 and 2005. Error bars=95% CI.

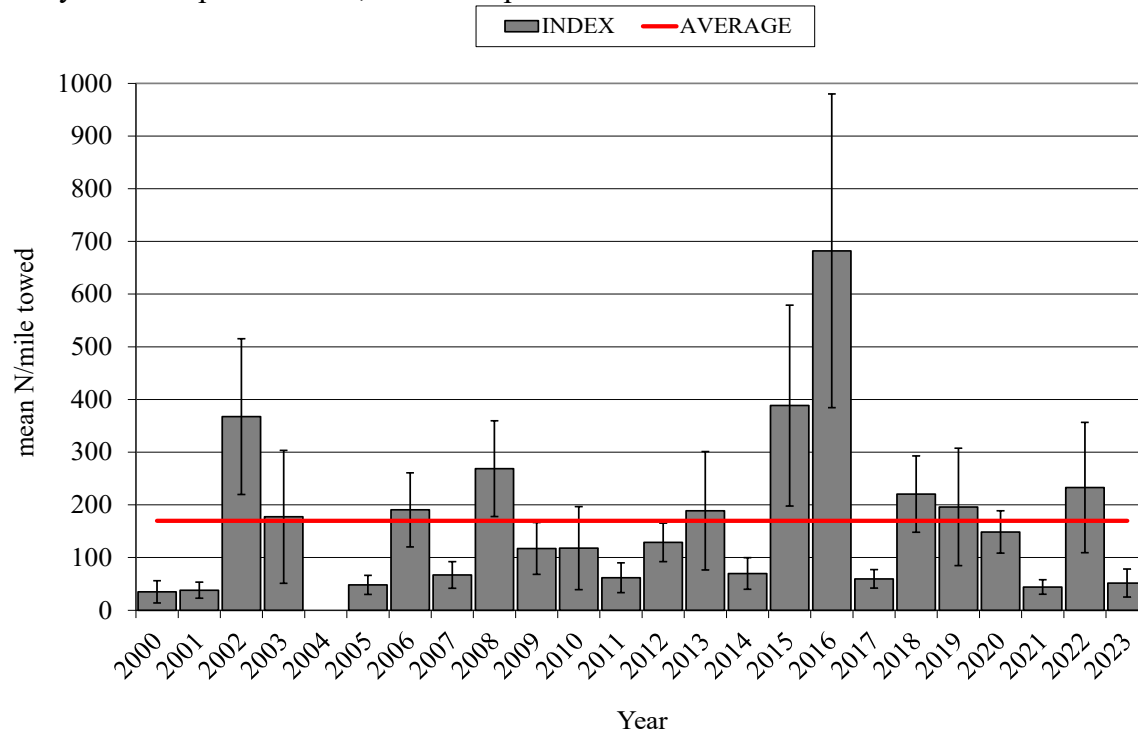


Figure 16. Head-of-Bay young-of-year relative abundance index for yellow perch, 1979 – 2023, based on Estuarine Juvenile Finfish Survey data. Horizontal line=time series average. Error bars indicate 95% confidence interval.

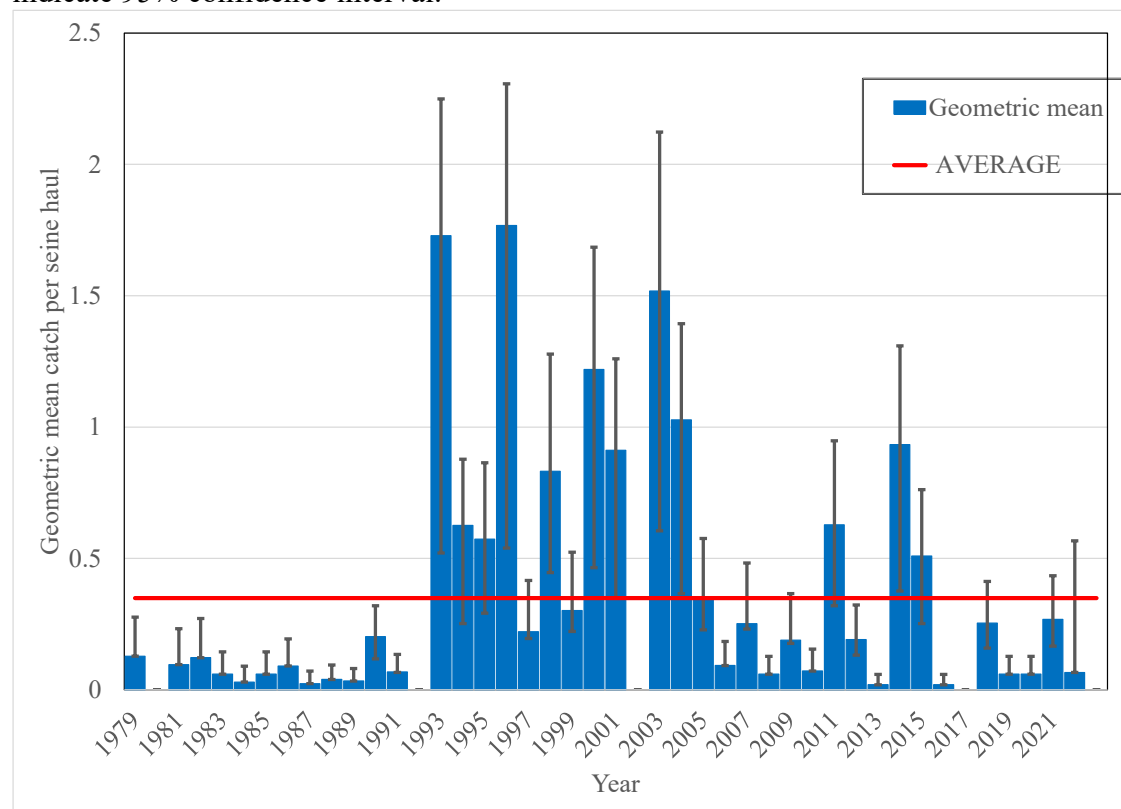


Figure 17. Age 1 yellow perch relative abundance from upper Chesapeake Bay winter trawl survey. Not sampled in 2004, small sample sizes 2003 and 2005. Error bars=95% CI.

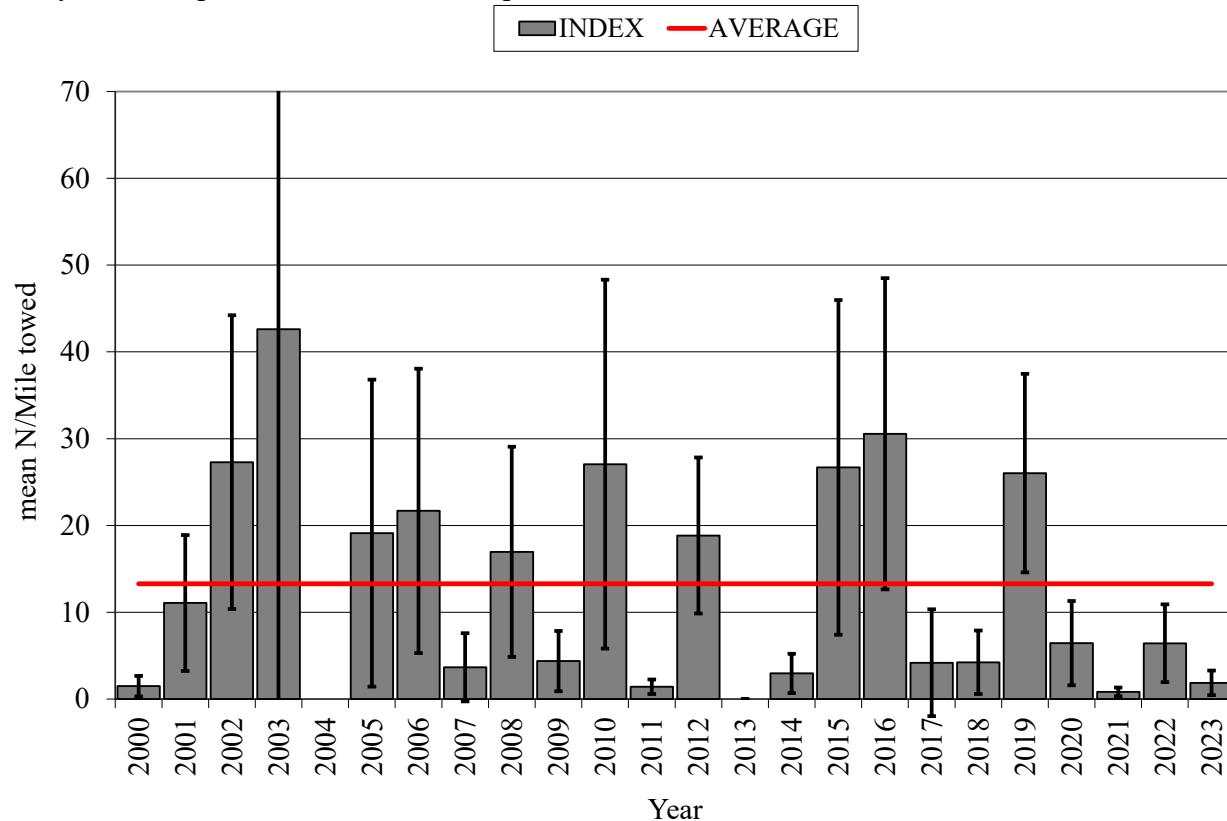


Figure 18. Age 1 channel catfish relative abundance from upper Chesapeake Bay winter trawl survey. Not sampled in 2004, small sample sizes 2003 and 2005.

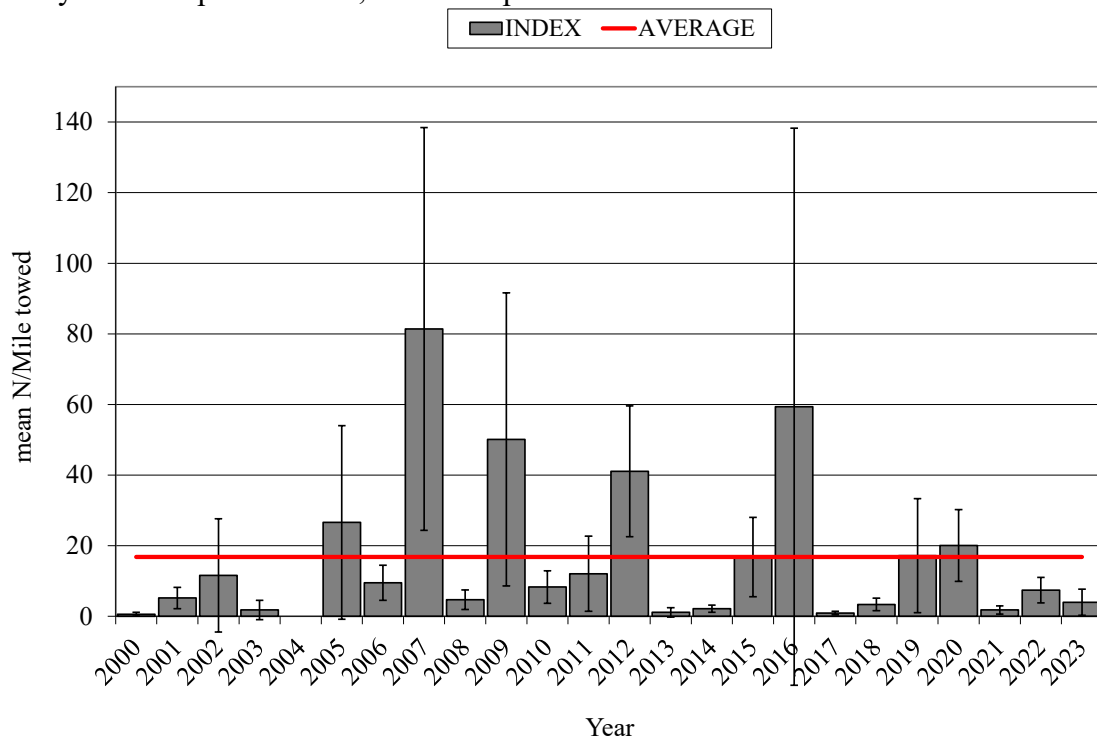


Table 26. White perch relative abundance (N/MILE TOWED) and number of tows from the upper Chesapeake Bay winter trawl survey, 2000 – 2023. Chester River sites included starting 2011.

YEAR	AGE										Sum CPE	No. Tows
	1	2	3	4	5	6	7	8	9	10+		
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
2022	232.8	231.0	189.6	178.9	50.9	46.8	56.4	24.8	3.9	9.7	1,025.0	100
2023	51.7	119.1	127.0	51.0	128.2	17.0	7.9	4.6	5.2	2.4	514.2	131

Table 27. White perch relative abundance (N/net day) and total effort from the Choptank River fyke net survey, 2000 – 2023.

YEAR	AGE										Sum CPE	Total effort
	1	2	3	4	5	6	7	8	9	10+		
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
2022	0.0	0.9	11.5	14.6	2.6	2.9	3.9	2.9	<0.1	1.1	40.4	267
2023	0.0	0.3	2.0	11.4	20.6	2.0	1.3	6.5	2.6	1.7	48.4	230

Table 28. Yellow perch relative abundance (N/MILE TOWED) and number of tows from the upper Chesapeake Bay winter trawl survey, 2000 – 2023.

YEAR	AGE										Sum CPE	No. Trawls
	1	2	3	4	5	6	7	8	9	10+		
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
2022	6.4	1.1	4.6	4.7	0.0	0.0	0.2	0.0	0.0	0.0	17.0	85
2023	1.9	0.7	<0.1	0.5	0.5	0.0	0.0	0.0	0.0	0.0	3.7	100

Table 29. Yellow perch relative abundance (N/net day) and total effort from the Choptank River fyke net survey, 1988 – 2023.

YEAR	AGE										Sum CPE	Total effort
	1	2	3	4	5	6	7	8	9	10+		
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
2022	0.0	0.1	1.5	1.3	0.1	0.1	0.9	1.0	<0.1	<0.1	5.0	159
2023	0.0	0.2	1.3	1.7	0.2	0.1	0.5	0.1	<0.1	0.5	4.9	127

Figure 19. Choptank River yellow perch relative abundance from fyke nets, 1988 – 2023. Effort standardized from 1 March – 95% total catch date.

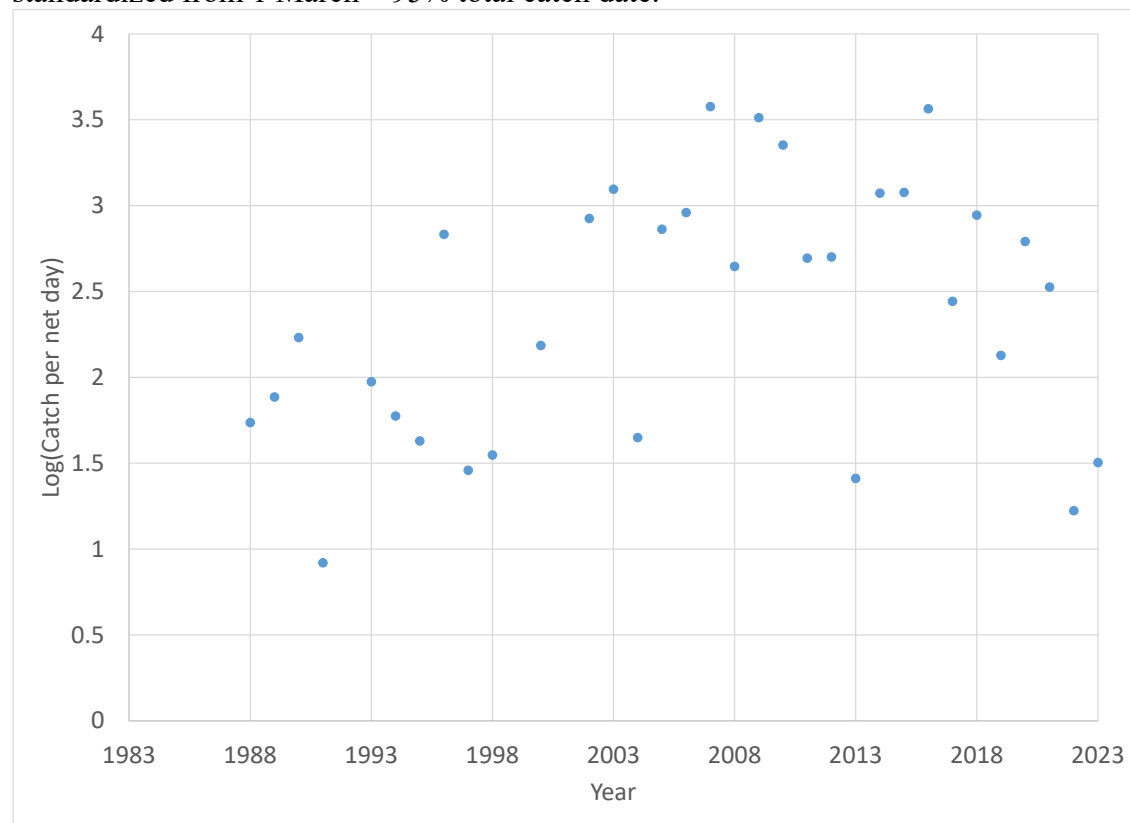


Figure 20. Channel catfish relative abundance (N/mile towed) from the upper Chesapeake Bay winter trawl survey, 2000-2023. Not surveyed in 2004, small sample sizes in 2003 and 2005.

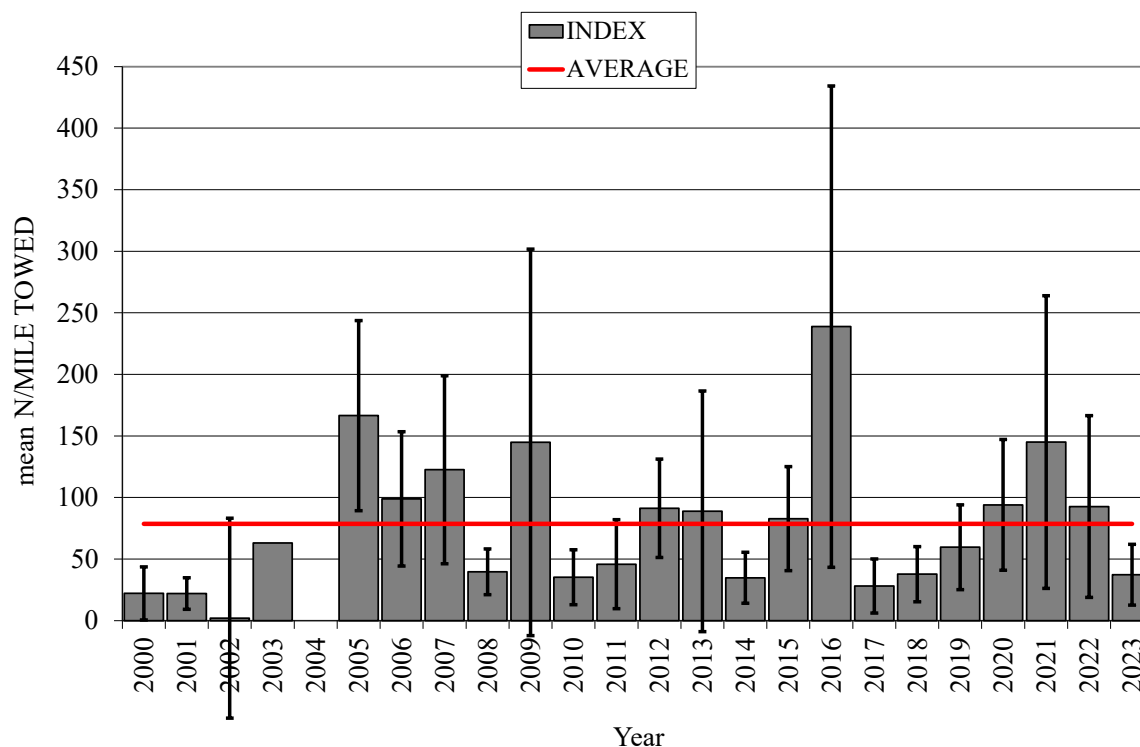


Figure 21. Channel catfish relative abundance (N/net day) from the Choptank River fyke net survey, 2000 – 2023. Horizontal line indicates time series average relative abundance.

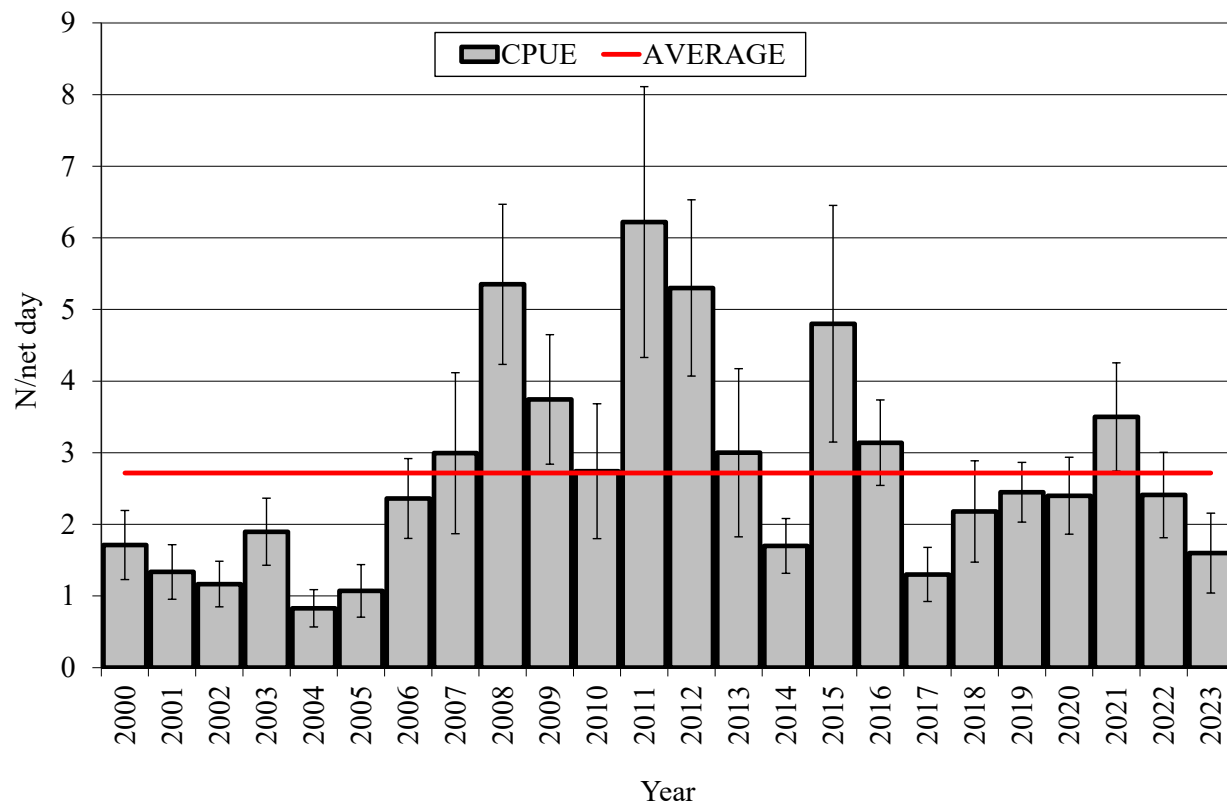
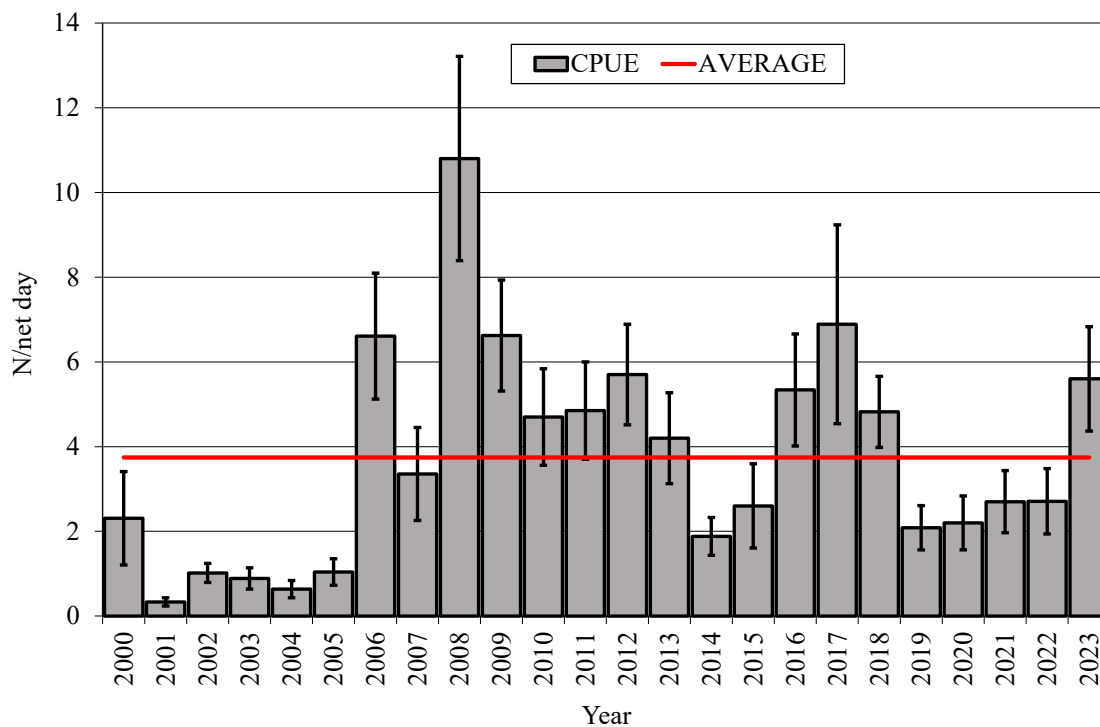


Figure 22. White catfish relative abundance (N/net day) from the Choptank River fyke net survey, 2000 – 2023. Horizontal line indicates time series average relative abundance.



PROJECT NO. 1
JOB NO. 2

POPULATION ASSESSMENT OF HEAD-OF-BAY YELLOW PERCH STOCKS
IN MARYLAND

Prepared by Paul G. Piavis

INTRODUCTION

Yellow perch (*Perca flavescens*) are an important finfish resource in Maryland's tidewater region. The dense aggregation during the late February – March spawning period offers recreational anglers the earliest opportunity to fish. Yellow perch are similarly an important seasonal fishery for commercial fishers. The modest commercial fishery occurs during a slack season between striped bass (*Morone saxatilis*) and white perch (*M. americana*) gill netting and the white perch spawning run. Over the 15 year period 2009 -- 2023, annual commercial harvest in Maryland ranged from 6,502 kg in 2021 to 25,624 kg in 2016 and averaged 15,399 kg. Reported commercial harvest was 7,449 kg in 2023.

The commercial fishery is predominately a fyke net fishery located above the Preston Lane Memorial Bridges in the upper Chesapeake Bay region. Fyke net harvest accounted for more than 98% of the total yellow perch commercial harvest, historically. From 1988 – 1999, commercial fishers in the upper Bay had a closed season in February, and an 8 ½" minimum size limit (no maximum size limit). During 2000 – 2007, the commercial fishery had a closed season in February, and an 8½" – 11" slot limit in order to preserve larger spawning females and to enhance population age structure (Uphoff and Piavis 1999). Regulations changed for the 2008 fishing season due to a legislative

mandate that caused a closure of the commercial yellow perch fishery from 1 January 2008 through 15 March 2008. The January – mid March closure encompassed a significant part of the commercial yellow perch season. Completion of a suitable stock assessment in late 2008 prompted the establishment of a total allowable catch (TAC) for the upper Bay commercial yellow perch fishery. Hard caps on the upper Chesapeake Bay commercial fishery were determined annually from 2009 – 2023 (Table 1).

The recreational fishery is generally a bank-based bait fishery in upstream reaches of spawning tributaries. Recreational participation can vary among years due to inclement weather patterns, availability of public access and yellow perch population levels (personal observation). Recreational fishers had a 5 fish daily creel limit and a 9” minimum size limit (msl) with no closed season, 1988 -- 2008. Middle western shore tributaries and the Nanticoke River on the eastern shore remained closed to recreational harvest. Recreational yellow perch fishery restrictions were eased in 2009, whereby all areas were opened to harvest under a 9” msl and a 10 fish daily creel limit. Recreational creel surveys were conducted during the 2008 and 2009 spawning runs (Wilberg and Humphrey 2008, 2009). Results from the creel surveys indicated that recreational harvest was minor. Another survey indicated that yellow perch harvest in the uppermost reach of the Susquehanna River in Maryland ranged from 4,500 – 6,000 yellow perch during the late 1950’s and early 1960’s (McCauley et al. 2007).

This report updated and refined the statistical catch-at-age model to estimate fishing mortality, abundance in both biomass and numbers, and recruitment of upper Bay yellow perch. The update included four more years of data (2020 -- 2023). The previous assessment (Piavis and Webb 2020) truncated the time series to include only years with

fishery independent indices (2005 – 2019). The comparison of the full time series and truncated time series indicated no meaningful differences in the output, so this assessment reverted to the full time series. In addition, we updated the spawning stock biomass per recruit model (SSB/R) that was used to set biological reference points contained in the current Fisheries Management Plan (Piavis and Uphoff 1999; Yellow Perch Workgroup 2019). The $F_{0.1}$ reference point from a yield per recruit model (YPR) was also determined. We incorporated the fishery selectivity vector produced from the current assessment along with updated growth parameters into the new SSB/R model.

Data from an on-going fishery independent fyke net survey in the Choptank River were also analyzed. The Choptank River is located in the mid-Bay region on Maryland's eastern shore. The watershed encompasses 371,000 acres. The Choptank River has an active recreational-only yellow perch fishery (9" minimum size limit, 10 fish creel limit). The fyke net survey provided a time-series of relative abundance estimates spanning 36 years. This survey provides the only dataset of adult yellow perch relative abundance outside of the upper Chesapeake Bay.

METHODS

Upper Chesapeake Bay statistical catch-at-age model

Data

Fishery dependent data

The area assessed included the Chesapeake Bay north of the Preston Lane Memorial Bridges and all tributaries except the Chester River (Figure 1). Data supported a model run covering 1998 – 2023. Commercial landings and effort were needed for the assessment. Commercial fishermen are obligated to submit monthly catch reports and effort (number of nets) by gear and area for each day fished (Lewis 2010). Effort was calculated as the number of fyke nets utilized by watermen that landed more than 100 pounds of yellow perch during the commercial season, multiplied by the number of days the gear were deployed.

No estimates of recreational harvest prior to 2008 were available from creel surveys specifically designed to estimate yellow perch harvest, but we assumed recreational harvest to be a minor component of the total removals. Directed creel surveys conducted in the upper Bay during 2008 and 2009 estimated that recreational harvest in the Bush River was only 242 yellow perch in 2008 and 234 in 2009, and 1,480 yellow perch in Northeast River in 2009 (Wilberg and Humphrey 2008, 2009). The Marine Recreational Information Program (MRIP) samples tidal-fresh areas, but in many years encounter rates are insufficient to produce informative recreational estimates. Estimates from MRIP coinciding with the assessment time frame provided relatively precise estimates for only seven of twenty-six years (Personal communication, National Marine Fisheries Service, Fisheries Statistics Division, 2023). Additionally, the accuracy

of those more precise estimates is doubtful given that estimates included years where recreational harvest topped 63,500 kg.

Biological samples were taken from cooperating commercial fyke net fishermen, from 1998 – 2023. Not all regions were sampled every year, but biologists generally visited at least two areas per year. These included the Middle River, Back River, Bush River, Gunpowder River, Sassafras River and Northeast River. Random samples were taken from pre-culled catches (Table 2). Yellow perch were measured (mm TL) and sex was determined by examining external gonadal exudation. A non-random subsample was procured for otolith extraction and subsequent age determination. Ages were determined by counting annular rings on otoliths submersed in glycerin under a dissecting microscope with direct light. Weights and lengths were also taken for these specimens. Ages were mostly determined by one experienced reader. Percent agreement and precision were recently determined between the two age readers with percent agreement at 97% and mean CV of 0.56% (see Appendix A in Piavis and Webb 2011). These values compared favorably with estimates of precision from a yellow perch population in Pennsylvania (Niewinski and Ferreri 1999) and a population in Lake Erie (Vandergoot et al. 2008).

We formulated a commercial catch-at-age (CAA) matrix for each sample year by sex, for ages 2 – 8+. Length and weight data were disaggregated by sex into 20 mm length intervals. Average weight, by sex, in each interval was multiplied by the number of yellow perch (by sex) in each interval to get a total interval weight. Sample weights of all intervals were summed to get total sample weight by sex. Total landings by sex were calculated by multiplying reported commercial landings by the proportion of sex-specific

sample weights. Total number of harvested yellow perch was determined by multiplying the sex-specific landings estimates by the number of sex-specific yellow perch in the sample divided by the total sex-specific sample weight. Total number harvested by sex and age-class was determined by formulating annual sex-specific age-length keys in 20 mm increments for legal sized fish only. The estimated total number harvested by sex was multiplied by the sex-specific proportion catch-at-age to get the number at age and sex harvested. Male and female CAA matrices were added together to arrive at a final annual CAA matrix. We substituted the lowest annual catch for an age-group if there was no representation of an age-class in any particular year (Table 3).

Fishery independent data

We also incorporated data from a fishery-independent survey into the model. The upper Bay winter trawl survey, initiated in December 1999, provided age-specific relative abundance data (Figure 2; see Project 1 Job1 for operational details). Weather, logistic, and mechanical problems led to either no data or very small sample sizes during 2003 through 2005. Therefore, trawling effort was sufficient to generate a relative abundance index of age 1 and age 2 yellow perch and an aggregated age 3+ abundance index for the years 2000 – 2002 and 2006 – 2023. An annual age-length key (10 mm intervals) was created and applied to the length structure of each individual haul. The age-length key was not sex-specific because male yellow perch were not routinely ripe, making sex determination difficult. The age 1, age 2, and age 3+ trawl indexes were geometric mean catch per statute mile towed.

Population Model

The statistical catch-at-age model used to assess yellow perch took the basic form of an Integrated Analysis (Haddon 2001). Minimum requirements include a CAA matrix, and either an independent estimate of population size or an index of effort, or both, to tune the catch to true population levels. The goal of determining abundance at age and year is accomplished through several steps, but essentially the model searches for the correct annual F (instantaneous fishing mortality), abundance starting values, annual recruitment levels (age 1 abundance) and fishery and survey catchability and selectivity that produce the most likely results seen in the data.

The model determines the most likely fit by solving an objective function. The objective function is solved by minimizing the sums of squared errors between observed and predicted values of the CAA, F , and fishery independent tuning indices. We assumed a log-normal error structure for all parameters.

The objective function to be minimized can be represented by the equation

$$\begin{aligned} SSR = & \sum \lambda_F [\text{Ln}(E_y \cdot q_{comm}) - \text{Ln}(F_y \text{ pred})]^2 + \sum \lambda_C [\text{Ln}(C_{a,y \text{ obs}}) - \text{Ln}(C_{a,y \text{ pred}})]^2 \\ & + \sum \lambda_{T1} [\text{Ln}(I_{\text{trwl } 1,y \text{ obs}}) - \text{Ln}(I_{\text{trwl } 1,y \text{ pred}})]^2 + \sum \lambda_{T2} [\text{Ln}(I_{\text{trwl } 2,y \text{ obs}}) - \text{Ln}(I_{\text{trwl } 2,y \text{ pred}})]^2 + \\ & \sum \lambda_{T3+} [\text{Ln}(I_{\text{trwl } 3+,y \text{ obs}}) - \text{Ln}(I_{\text{trwl } 3+,y \text{ pred}})]^2 \end{aligned}$$

where E_y is the commercial fishing effort index in year y , q_{comm} is catchability of the commercial fyke net fishery, F_y is instantaneous fishing mortality in year y , $C_{a,y}$ is the catch of age a yellow perch in year y , $I_{\text{trwl } 1,y}$, $I_{\text{trwl } 2,y}$ and $I_{\text{trwl } 3+,y}$ are the trawl indexes of ages 1, 2 and 3+ yellow perch in year y , and λ_F , λ_C , λ_Y , λ_{T1} , λ_{T2} and λ_{T3+} are weighting factors. The final model run was not weighted, so all lambdas were 1.0.

All components of the objective function stem from iteratively estimating numbers-at-age for each year in the assessment. Numbers-at-age are determined from common fishery equations

$$N_{a+1,y+1} = N_{a,y} \bullet e^{-(M+F_y \bullet s_a)} \quad \text{for } a = 1 \text{ to } 7$$

$$N_{8+,y+1} = N_{a-1,y} \bullet e^{-(M+F_y \bullet s_a)} + N_{8+,y} \bullet e^{-(M+F_y \bullet s_{a-1})} \quad \text{for } a = 8+$$

where s_a is an age-specific selectivity factor. Biomass at age was estimated by multiplying the abundance-at-age matrix by the annual weight at age matrix from the fishery weights.

The predicted components of the objective function are constructed from the abundance matrix. The first step in forming the objective function is to determine a predicted CAA matrix from the equation

$$CAA_{pred} = (F_y / Z_y) \bullet N_{a,y} \bullet (1 - s_{a,y})$$

where Z_y (instantaneous total mortality) is $F_y + M$ (instantaneous natural mortality), and $s_{a,y}$ is age and year specific survivorship ($e^{-(M+s_a \bullet F_{a,y})}$).

The model needs information other than the CAA matrix to scale the abundance estimates to the correct level (Haddon 2001). Predicted F and fishery independent indexes were used. An F_{pred} vector was produced from the model runs, and F_{obs} was the q_{comm} multiplied by the annual commercial fishing effort index (E_y). In essence, this is a “semi-observed F ” because the fitted parameter q_{comm} was used to calculate F_{obs} (Haddon 2001). The predicted age 1 trawl index was $N_{1,y} \bullet q_{trawl} \bullet s_{trawl 1}$. Similarly the predicted age 2 and age 3+ trawl indices were $N_{2,y} \bullet q_{trawl} \bullet s_{trawl 2}$ and $N_{3+,y} \bullet q_{trawl} \bullet s_{trawl 3+}$, respectively.

Model run

The model requires estimation of $N_{2...8+, 1998}$, $R_{1998...2023}$ (where R is recruitment or abundance at age 1), F_y , q_{comm} , $q_{trawl,1}$, $q_{trawl,2}$, $q_{trawl,3+}$ and age specific selectivities (s_a) for the trawl and CAA matrix. Initial estimates of abundance ($N_{2...8+, 1998}$) were taken from previous assessments. We held initial recruitment constant initial recruitment value of 50 yellow perch ($R_{1998...2023}$). Starting values of catchability for the commercial fishery and trawl survey, and F were taken from previous assessments. In addition, fishery selectivity was estimated for two time periods because commercial regulations changed over the course of the assessment. A 9" minimum size limit was enforced during 1998 – 1999, suggesting a flat-topped selectivity pattern. During 2000 – 2023, the commercial fishery had an 8 ½" – 11" slot limit which should produce a dome-shaped selectivity pattern. For the first time period, selectivity was constrained to a maximum of 1. For the second time period (slot limit), selectivity was modelled with a gamma distribution. Each age-class was divided by the maximum selectivity to ensure that at least one age class was fully selected (Quinn and Deriso, 1999). Previous model runs indicated that the model fit was quite insensitive to starting values of N , R , q , and F (Piavis and Webb 2011). Previous models assumed instantaneous natural mortality (M) as 0.25 for all age groups. This produced an unrealistic "pile-up" or accumulation of yellow perch in the final age group (8+ years old). Natural mortality was increased to $M=0.60$ for the 8+ age group. This value was chosen by simulating population decay so that abundance was very low (approximately 1% of age 7 yellow perch) by age 15. This was reasonable since the commercial fishery has a maximum size limit and natural mortality would be the major component of removals for the plus group.

The model was implemented in an Excel spreadsheet, and all fitting was done with the Microsoft Excel Solver algorithm. Uncertainty was quantified by bootstrapping. Residuals were randomized and added back to the fishery independent indexes, and the model was rerun. The model was bootstrapped 3,000 times. Uncertainty estimates were presented as +/- 2 standard deviation of the bootstrap distribution for F, R, N, and biomass. In addition, coefficients of variation (CV) and bias were produced for parameters of interest.

Spawning stock biomass per recruit and biological reference points

We used a Thompson-Bell Spawning Stock Biomass per Recruit analysis (SSB/R) following the procedures of Gabriel et al. (1989) to determine the percentage of SSB/R of an unfished stock that current harvest was producing and at what level of fishing intensity various reference points would have been met. The method uses the fishery selectivity pattern to scale F and the number mature at age to define SSB/R more precisely. The Thompson-Bell modification determines the number (N_{ts}) and weight (W_{ts}) available at spawning as

$$N_{ts} = N_t \bullet e^{-((c \bullet p_t \bullet F) + d \bullet M)}$$

$$\text{where } N_t = N_{t-1} \bullet e^{-((p_{t-1} \bullet F) + M)}$$

$$\text{and } W_{ts} = fr_{ts} \bullet N_{ts} \bullet W_t$$

where c is the fraction of F before spawning, p is the fraction vulnerable to harvest at age (selectivity), d is the fraction of M that occurs before spawning, fr_{ts} is the fraction mature at age t, and W_t is the mean weight at age (Table 4). We used an arbitrary initial cohort of 100,000 at age 0. The assessment was run for 12 age-classes. Female yellow perch growth rate was modeled with vonBertalanffy growth parameters ($L_{\infty} = 303$ mm $K = 0.37$

$t_0 = -0.33$) and an allometric length-weight relationship ($\alpha = 4.9 \times 10^{-6}$ $\beta = 3.18$) from upper Bay yellow perch during 1998 -- 2023 (see Project 1 Job1). The fishery selectivity vector for a fishery with an 8 1/2" to 11" slot limit was taken from the current assessment. This models the SSB/R for a predominantly commercial fishery. For a predominantly recreational fishery (9" minimum size limit) selectivity was the same as an earlier assessment (Piavis and Uphoff 1999).

The Thompson-Bell SSB/R analysis was constructed as a Microsoft Excel spreadsheet. An initial run with $F = 0$ determined the unfished (virgin) spawning stock biomass. We selected $F_{35\%}$ and $F_{25\%}$ as target and limit reference points, consistent with the current Yellow Perch Fisheries Management Plan (Yellow Perch Workgroup 2019). These reference points are the level of F that produce the reproductive output of stock sizes that are 35% and 25% of virgin stock size, respectively.

The biomass corresponding to the various reference points were identified, and the Goal Seek option within a Microsoft Excel spreadsheet was used to determine what instantaneous fishing mortality rates produced $F_{25\%}$, and $F_{35\%}$. The model was also run with F values of 0 to 1.2 in increments of 0.1 to produce SSB/R curves.

The Thompson-Bell yield per recruit model was used to determine $F_{0.1}$ reference point. The yield per recruit model stated that

$$N_t = N_{t-1} \bullet e^{-(p_{t-1} \bullet F + M)}$$

$$\text{and yield } (Y_t) = W_t \bullet ((p_t \bullet F) / (p_t \bullet F + M)) \bullet (1 - e^{-(p_t \bullet F + M)}) \bullet N_t$$

The fishery specific selectivity-at-age vectors (p_t) were the same as the SSB/R model.

Yield was determined for F 's ranging from 0 - 1.2 in increments of 0.1, except the yield at $F=0.01$ was determined to find the slope of the line at the origin to assess $F_{0.1}$.

Choptank River relative abundance analysis

Relative abundance data were derived from fyke net sampling in the Choptank River (Project 1 Job 1). Data from 1988 were taken from a previous survey (Casey et al 1988). Catch per unit effort (CPUE) was determined as the number of yellow perch caught per net day. Over the years, the starting date of this survey has varied. In order to standardize the dataset as accurately as possible, a 1 March start date was used. The Choptank River survey is a multi-species survey, so fyke netting was generally extended well past the end of the yellow perch spawning run. An effort cut-off was determined for each year as the day when 95% of the total yellow perch catch from 1 March occurred.

Previous analyses were modeled with SAS PROC NLIN procedure utilizing catch per unit effort data since 1988 (Piavis and Webb 2017). The non-linear estimation is unlikely to accurately describe finer scale population trajectory over thirty plus years. For this assessment, the plotted catch per effort was fit with a polynomial trendline to identify upward or downward phases (splines) in relative abundance. Once these discrete time periods were identified, we ran a linear regression of each spline to ascertain the significance of the trend. Outliers were identified as standardized residuals greater than or equal to ± 2.0 . Outliers were removed and the regression was rerun.

RESULTS

Upper Chesapeake Bay statistical catch-at-age model

The model fit the commercial selectivity to a dome-shaped pattern, as was expected given the adoption of the slot limit during 2000 -- 2023. Yellow perch were fully recruited at age 6 and s_{8+} was 0.60 (Figure 3). Catchability for the commercial fyke

net fishery was estimated as 4.08×10^{-5} , catchability of the trawl survey was 8.62×10^{-6} and the selectivity at age for the trawl survey was 1.0 for age 1, 0.96 for age 2 and 0.31 for age 3+.

Abundance estimates (all ages) ranged from 0.39 million in 2023 to 2.4 million in 1998. Estimates averaged 0.98 million yellow perch during 1998 – 2023, and averaged 0.63 million yellow perch in the last five years of the assessment. The terminal year (2023) abundance was estimated at 0.39 million yellow perch. Precision, as described by two standard deviations of the simulation results, was within acceptable ranges. Two standard deviations of the estimates averaged $\pm 22\%$, but uncertainty was high for the final four years of the assessment (Figure 4). Biomass was at a time series low in 2023 (63,000 kg) and the time series average was 113,000 kg (Figure 5). Maximum biomass was 288,000 kg in 1999. Analysis of the standard deviations of the simulations indicated that the values were precisely estimated.

Instantaneous fishing mortality (fully selected F) ranged from 0.07 – 1.25 during 1998 through 2023. Fishing mortality peaked in 2002 at 1.25. Fully recruited F was 0.21 in the terminal year and averaged 0.51 since 1998 (Figure 6). Estimates were fairly well estimated, with 2 standard deviations averaging 16% of the estimates, but the final two years were imprecise.

Estimated recruitment (abundance of age 1 yellow perch) ranged from 12,000 yellow perch in 2013 (2012 year-class) to 669,000 yellow perch in 2004 (2003 year-class) and averaged 234,000 yellow perch, 1998 – 2023 (Figure 7). Yellow perch recruitment was notably poor over the final three years of the assessment, and the last above average year-class was the 2018 year-class. Recruitment was imprecisely

estimated, with 2 standard deviations averaging 48% of the estimates. The 2023 terminal year estimates of abundance at age illustrate the impact of uneven recruitment (Figure 8).

Coefficients of variation (CV) for estimates of N ranged from 5.4% to 25%, with the highest values over the last four years of the assessment. Instantaneous fishing mortality C.V.'s ranged from 5.4% to 31.3%. Biomass estimates had CV's that largely mimicked CV's of abundance (Tables 5-6). Recruitment CV's ranged from 13% to 88%, with the final four years being extremely variable (CV range = 33% to 88%).

Spawning stock biomass per recruit and biological reference points

Spawning stock biomass per recruit modeling produced percent maximum spawning potential (%MSP) at F curves for a fishery with an 8 ½" – 11" slot limit (commercial fishery; Figure 9) and a fishery with a 9" minimum size limit (recreational fishery; Figure 10). For the upper Bay, which is a predominately commercial fishery, the target reference point ($F_{35\%}$) was 0.48 and the limit reference point ($F_{25\%}$) was 0.74.

Yield per recruit modeling produced $F_{0.1}$ reference point of 0.11 and $F_{\max}$ was 1.25. Fully selected F in 2023 (0.21) produced a %MSP of 59%. The distribution of F from the bootstrap runs indicated that there was a 0.6% chance that F exceeded $F_{35\%}$ in the upper Chesapeake Bay during 2023 (Figure 11). For a predominately recreational fishery (9" minimum size limit), the target reference point ($F_{35\%}$) was 0.37 and the limit reference point ($F_{25\%}$) was 0.55. Yield per recruit modeling produced $F_{0.1}$ reference point of 0.37, and $F_{\max}$ was 0.87.

Choptank River relative abundance analysis

A third order polynomial trend line indicated a period of population increase from 1991 to 2014 and population decline from 2014 to 2023 ($R^2=0.46$; Figure 12).

Regression analysis of the two splines was informative. The first time period investigated was 1991 through 2014. After removal of outliers, a statistically significant increasing slope was identified ($R^2=0.33$ $P=0.002$; Figure 13). The instantaneous rate of increase (the slope of the line) was 0.08 (95% C.I.=0.04 to 0.12). Regression analysis of the declining spline (2014 – 2023) was highly statistically significant ($R^2=0.64$ $P=0.005$; Figure 14). The instantaneous rate of decrease equaled -0.19 (95% C.I.=0.08 to 0.31).

DISCUSSION

The current upper Bay assessment included some substantial modifications over the previous assessment (Piavis and Webb 2020). The current upper Bay assessment reverted to Integrated Catch Analysis Model that was utilized for earlier assessments (Piavis and Webb 2017). The 2020 assessment utilized a truncated time series and initialized the first year abundance at age from bootstrap distributions of the full model run. There was very little difference between the truncated assessment with the full model run for all parameters of interest. Therefore, the full model run was adopted for this assessment.

Model assumptions remained similar despite the modifications. Most important are the assumptions that there is no net immigration or emigration in the stock (unit stock assumption), that M is constant and accurately assigned and that catchability does not vary over time. Each of these assumptions were discussed in great detail previously (Piavis and Webb 2017). Beginning in 2020, the assessments assumed a higher natural mortality rate for age 8+ yellow perch, as detailed previously (Piavis and Webb 2020).

The model fit the available data in an acceptable manner, but the final few years had higher variability that may render estimates somewhat tenuous. Coefficients of variation among the parameters were similar and were generally less than 10% (very good) for years up until 2020. The final four years still had acceptable but higher CV's, still less than 30%, which is common for fisheries assessments, *i.e.*, the largest uncertainty is contained in the most recent years, unfortunately. However, the variability of the recruitment estimates for 2021 – 2023 were extremely high ($CV_{2023}=88\%$). Again, as the younger year-classes recruit to the fishery, abundance would be more precisely estimated. The high variability could be caused by ineffectiveness of the trawl survey to accurately assess year-class strength. When production is low, the probability of encounter may not be equal to the probability when actual abundance is higher. Additionally, for at least one year the water temperatures were very warm, and fishes were generally scattered and not present in their usual haunts or aggregated in deep waters. The low production estimates are likely qualitatively accurate. Analysis of the data from Job 1 of this report indicated that the upper Bay seine survey captured few if any juvenile yellow perch in six of the last eight years (see Figure 16 of Job 1 in this report).

The assessment indicated that the upper Bay yellow perch population declined from historically high levels in the late 1990's through 2011 but were range-bound and trendless from 2000 -- 2008. The final five years of the assessment indicated that the upper Bay yellow perch population declined linearly through 2023. Seven of the last 11 years produced far fewer one year old yellow perch than an average year; year classes 2012, 2013, 2016, 2017 and 2020 – 2022 were far below average. The sustained below

average recruitment events were the primary cause of the total population decline, as F was well below the conservative target for most of the time period. Currently, the fishery is operating on only two year classes. Strong year classes were produced in 2018 and 2019 and accounted for 88% of the commercial catch.

Population expansion is unlikely, in spite of the strong 2018 and 2019 year classes because the 2016, 2017 and 2020 -- 2022 year classes were so weak. This demonstrates the boom and bust nature of yellow perch population dynamics (Piavis et al. 1993). The decline will become more prominent as age four and five yellow perch are removed from the population due to fishing and natural mortality.

The Choptank River yellow perch population growth and decline was estimated from a fishery independent fyke net survey. The population expanded relatively quickly and for a sustained period from 1991 – 2014. The most recent period investigated, 2014 – 2023 saw a statistically significant decline. Inspection of age 3 relative abundance (see Table 29 in Project 1 Job 1) as an indication of recruitment to the adult population, suggests that eight of the last ten years abundance of three year old yellow perch were below average.

Both the upper Bay and Choptank River yellow perch populations have exhibited declining abundance trends since the mid-2010's. The similarity of the magnitude of the decline and the timing of the decline suggests that regional factors are acting between the two systems. Both systems have a modest to minor recreational fishery, whereas the upper Bay has a controlled commercial fishery that operates on a total allowable catch basis. Both systems were colonized by snakehead and blue catfish, and spring weather patterns are similar and likely the most important factor in yellow perch juvenile

production. Given the commonality of factors and declines, it is unlikely that the commercial fishery is having an undue impact on recreational availability in the upper Bay. Fishing mortality estimates for 2016 and 2017 were anomalously high in the current assessment but were estimated considerably lower in the previous assessment. Inspection of the residuals indicated a 330% difference from the average for age 4 and age 5 fish. Blue catfish colonization likely occurred during this time and if substantial direct predation ensued there would be “missing” fish which the model has no choice but to allocate them to predicted commercial catch which would also explain the anomalous residuals.

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Figure 13. Linear regression of Choptank River yellow perch catch per unit effort, 1991 – 2014.

Figure 14. Linear regression of Choptank River yellow perch catch per unit effort, 2014 – 2023.

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Table 1. Upper Chesapeake Bay commercial yellow perch total allowable catch (TAC, pounds), actual harvest, and adjusted TAC (adjusted based on previous years' quota overage).

UPPER BAY				
Year	TAC Computed	TAC Adjusted	Harvest	Difference
2009	38,000		42,951	4,951
2010	44,900	39,949	49,629	9,680
2011	47,200	37,520	37,543	23
2012	38,973	38,950	36,975	-1,975
2013	29,800	29,800	19,352	-10,448
2014	27,200	27,200	19,305	-7,895
2015	30,489	30,489	34,478	3,989
2016	46,098	42,109	56,501	14,392
2017	52,992	45,976	44,426	-1,550
2018	59,662	59,662	33,502	-26,160
2019	53,368	53,368	51,737	-1,631
2020	47,513	47,513	25,195	-22,318
2021	26,535	26,535	14,337	-12,198
2022	27,874	27,874	26,968	-906
2023	23,367	23,367	16,425	-6,942

Table 2. Sample sizes for lengths and ages and the years used in forming the catch-at-age matrix for upper Chesapeake Bay yellow perch.

Year	Length sample size	Age sample size	
		Females	Males
1998	890	131	67
1999	1,453	231	42
2000	1,670	187	59
2001	4,45	79	19
2002	1,440	79	43
2003	1,078	69	35
2004	964	70	39
2005	973	56	45
2006	1,015	56	44
2007	1,386	53	34
2008	8,927	272	89
2009	1,321	69	42
2010	1,322	56	49
2011	1,031	58	59
2012	1,057	64	38
2013	1,127	80	48
2014	871	65	31
2015	1,379	35	27
2016	1,861	54	48
2017	2,033	43	43
2018	1,701	54	31
2019	2,051	56	40
2020	1,524	55	41
2021	1,593	55	40
2022	2,691	91	43
2023	1,455	46	51

Table 3. Catch-at age matrix for upper Chesapeake Bay yellow perch, 1998 –2023. Entries in bold were lowest value to substitute for 0 estimated catch.

Year	2	3	4	5	6	7	8+
1998	5,460	3,086	51,318	151,407	127	1,437	414
1999	0	224,304	7,503	65,241	79,448	6,984	794
2000	0	876	162,415	4,826	9,278	15,570	414
2001	0	27,708	11,273	169,957	3,936	4,546	7,441
2002	4,902	24,777	119,202	11,544	211,205	4,101	27,478
2003	231	45,646	1,400	34,692	4,621	37,693	3,612
2004	0	55,005	70,522	8,333	8,088	1,437	6,462
2005	0	377	99,246	24,017	3,068	1,437	4,127
2006	1,735	24,636	580	31,575	7,688	1,437	580
2007	0	5,604	54,280	1,564	20,722	6,972	1,173
2008	0	1,643	5,076	7,509	127	1,551	414
2009	1,596	1,746	34,940	27,300	29,895	1,681	3,194
2010	268	31,845	11,182	24,510	25,136	23,258	2,057
2011	874	2,498	37,262	11,092	15,746	13,532	7,413
2012	282	25,352	1,313	40,802	1,126	15,353	14,779
2013	659	8,741	25,652	3,250	7,555	1,757	1,889
2014	0	23,789	12,008	6,035	1,410	4,073	1,699
2015	412	412	49,496	14,831	11,300	1,437	4,708
2016	6,083	2,151	1,780	87,015	22,180	16,320	2,448
2017	0	63,772	580	348	38,891	6,505	7,039
2018	0	57,674	35,290	348	127	2,784	414
2019	0	377	55,054	69,398	127	1,437	10,487
2020	7,465	8,269	2,599	42,524	11,009	142	414
2021	0	13,991	4,222	1,220	12,715	5,209	414
2022	0	12,320	49,561	1,332	127	6,260	799
2023	333	2,511	19,158	19,709	908	212	1,242

Table 4. Input variables for Thompson-Bell spawning stock biomass per recruit and yield per recruit models. f_{rs} = proportion mature, c =proportion of fishing mortality before spawning, d =proportion of natural mortality before spawning, and M =instantaneous natural mortality.

Age	f_{rs}	selectivity pattern (p)		c	d	M
		Slot limit	9"msl			
1	0.00	0.0	0.00	0.95	0.15	0.25
2	0.35	0.00	0.18	0.95	0.15	0.25
3	0.80	0.30	0.50	0.95	0.15	0.25
4	1.00	0.72	0.80	0.95	0.15	0.25
5	1.00	1.00	1.00	0.95	0.15	0.25
6	1.00	0.98	1.00	0.95	0.15	0.25
7	1.00	0.76	1.00	0.95	0.15	0.25
8	1.00	0.60	1.00	0.95	0.15	0.25
9	1.00	0.50	1.00	0.95	0.15	0.25
10	1.00	0.20	1.00	0.95	0.15	0.25
11	1.00	0.10	1.00	0.95	0.15	0.25
12	1.00	0.10	1.00	0.95	0.15	0.25

Table 5. Coefficient of variation and bias of population abundance (N), and biomass (B) for upper Chesapeake Bay yellow perch.

Parameter	Estimate	C.V.	Bias	Parameter	Estimate	C.V.	Bias
N 1998	2,393,181	8.63	-0.75	B 1998	286,726	6.88	-0.44
N 1999	2,080,142	7.94	-0.51	B 1999	287,977	8.17	-0.74
N 2000	1,249,973	7.78	-0.48	B 2000	200,132	8.20	-0.53
N 2001	1,203,954	6.52	-0.24	B 2001	163,412	8.17	-0.48
N 2002	1,268,752	6.69	-0.24	B 2002	122,156	6.70	-0.15
N 2003	778,399	8.56	-0.50	B 2003	99,070	7.50	-0.49
N 2004	1,190,933	9.19	-0.57	B 2004	84,985	9.29	-0.52
N 2005	1,167,942	8.29	-0.65	B 2005	106,807	9.05	-0.57
N 2006	1,082,574	7.61	-0.39	B 2006	119,394	8.89	-0.55
N 2007	872,741	7.24	-0.38	B 2007	124,367	8.16	-0.42
N 2008	968,422	6.65	-0.18	B 2008	107,979	8.17	-0.43
N 2009	773,935	6.51	-0.19	B 2009	117,574	6.61	-0.16
N 2010	762,955	5.74	-0.18	B 2010	93,967	6.79	-0.14
N 2011	684,242	5.44	-0.16	B 2011	81,534	6.11	-0.12
N 2012	1,058,583	7.95	-0.64	B 2012	71,116	5.50	-0.12
N 2013	766,656	8.64	-0.79	B 2013	93,440	6.62	-0.34
N 2014	565,436	9.22	-0.94	B 2014	90,594	8.35	-0.73
N 2015	874,443	8.22	-0.48	B 2015	74,473	9.37	-0.96
N 2016	1,132,241	8.31	-0.69	B 2016	89,450	7.92	-0.47
N 2017	781,615	9.40	-0.52	B 2017	95,574	8.47	-0.48
N 2018	557,579	9.80	-0.53	B 2018	79,887	9.89	-0.64
N 2019	857,623	16.10	-1.98	B 2019	67,128	10.32	-0.72
N 2020	788,161	19.92	-2.07	B 2020	71,287	15.60	-1.72
N 2021	608,278	21.98	-2.28	B 2021	76,772	20.76	-1.97
N 2022	498,116	22.89	-1.86	B 2022	70,582	23.48	-2.23
N 2023	392,005	24.72	-3.07	B 2023	63,995	24.84	-2.07

Table 6. Coefficient of variation and bias of instantaneous fishing mortality (F) and recruitment (R).

Parameter	Estimate	C.V.	Bias		Parameter	Estimate	C.V.	Bias
R 1998	54,165	15.43	-1.82		F 1998	0.221	2.44	0.06
R 1999	313,152	15.34	-2.16		F 1999	0.735	4.03	-0.01
R 2000	58,883	15.15	-2.09		F 2000	0.330	3.84	-0.08
R 2001	378,330	13.91	-1.48		F 2001	0.466	4.02	-0.23
R 2002	515,203	13.44	-1.04		F 2002	1.250	5.22	-0.02
R 2003	16,995	16.38	-2.13		F 2003	0.770	5.72	0.05
R 2004	668,835	13.80	-1.22		F 2004	0.636	6.13	0.05
R 2005	336,316	14.72	-1.62		F 2005	0.523	7.02	0.20
R 2006	250,762	14.35	-1.26		F 2006	0.227	8.06	-0.03
R 2007	74,308	15.25	-1.68		F 2007	0.347	7.55	0.12
R 2008	372,713	13.80	-1.41		F 2008	0.065	8.13	0.18
R 2009	40,503	14.98	-1.96		F 2009	0.334	5.77	0.19
R 2010	246,509	12.95	-1.15		F 2010	0.412	5.14	0.02
R 2011	172,021	13.69	-0.95		F 2011	0.521	4.82	0.10
R 2012	608,917	14.26	-1.48		F 2012	0.557	4.97	0.11
R 2013	12,282	15.72	-1.96		F 2013	0.379	4.57	0.17
R 2014	14,452	15.30	-1.76		F 2014	0.269	4.30	0.11
R 2015	481,775	13.68	-1.12		F 2015	0.263	4.46	-0.12
R 2016	505,511	14.29	-1.25		F 2016	1.019	7.88	-6.48
R 2017	19,202	17.34	-2.34		F 2017	1.223	3.30	-1.01
R 2018	54,950	21.78	-3.11		F 2018	0.441	5.62	0.05
R 2019	486,619	25.52	-3.20		F 2019	0.775	9.20	-0.04
R 2020	230,030	33.05	-5.56		F 2020	0.674	12.85	-0.64
R 2021	53,332	45.07	-10.56		F 2021	0.456	18.05	-1.33
R 2022	71,759	58.89	-18.90		F 2022	0.245	22.49	-2.91
R 2023	41,841	88.02	-49.56		F 2023	0.215	31.29	-6.00

Figure 1. Upper Chesapeake Bay study area. Solid lines indicate areas not included in the assessment.

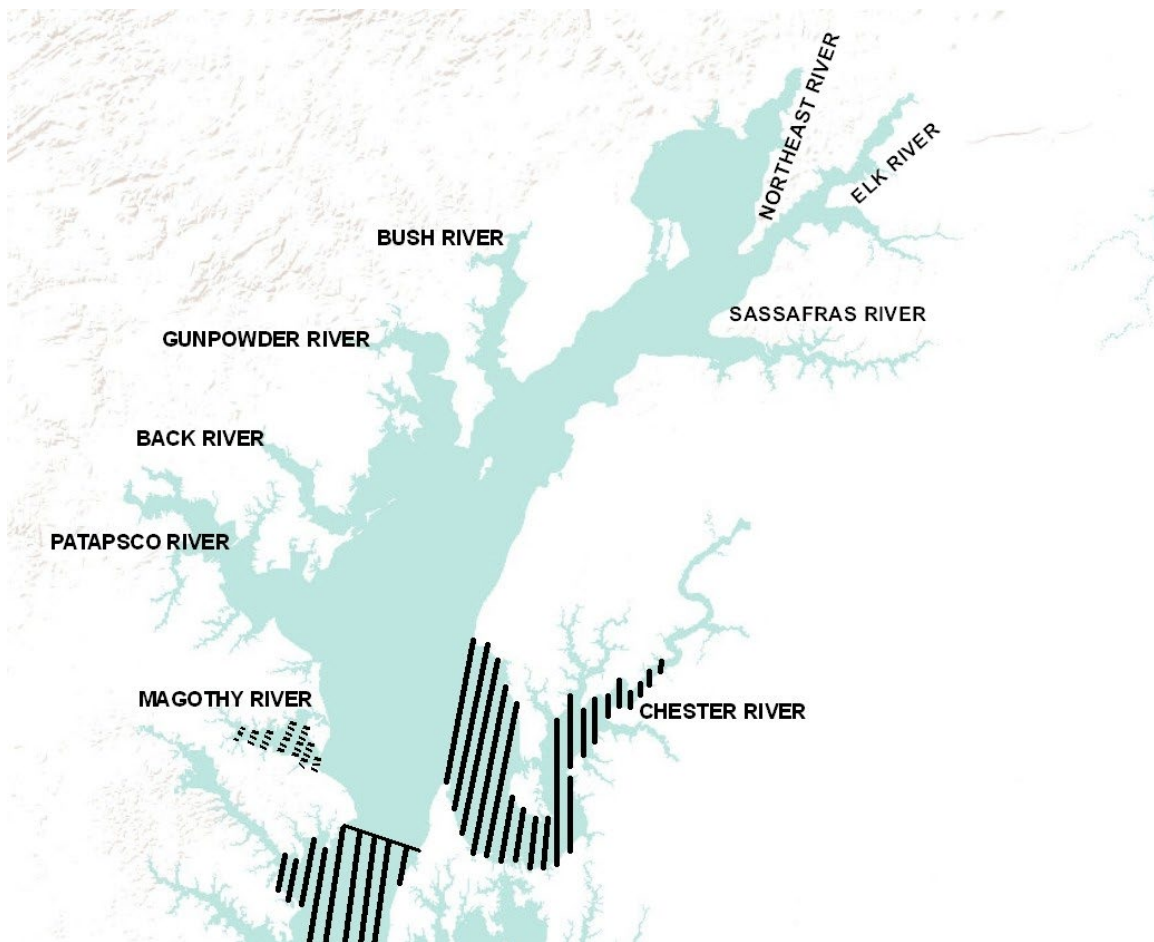


Figure 2. Upper Chesapeake Bay winter trawl survey locations for the 2023 sampling season.

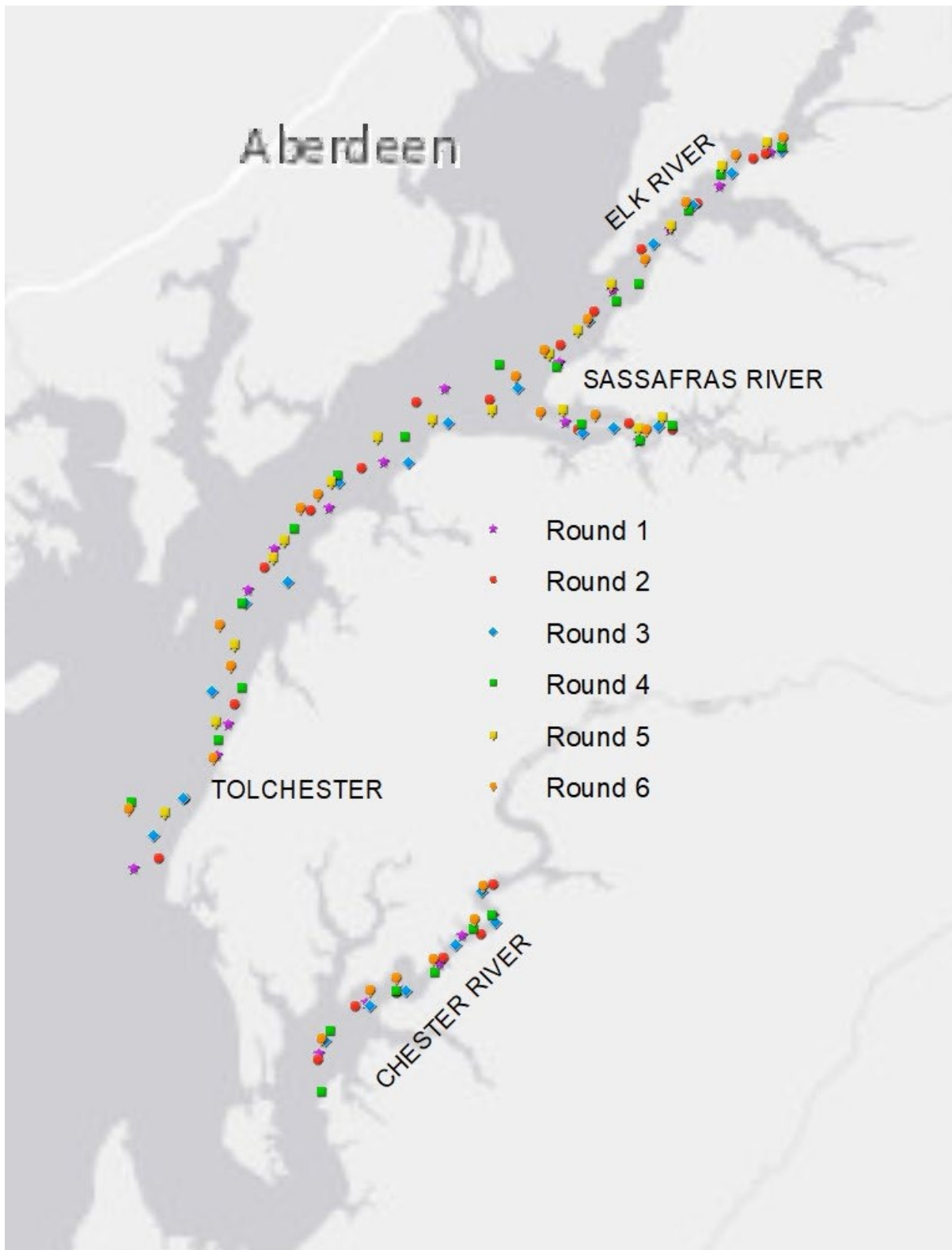


Figure 3. Yellow perch commercial fyke net selectivity curve from final model run.

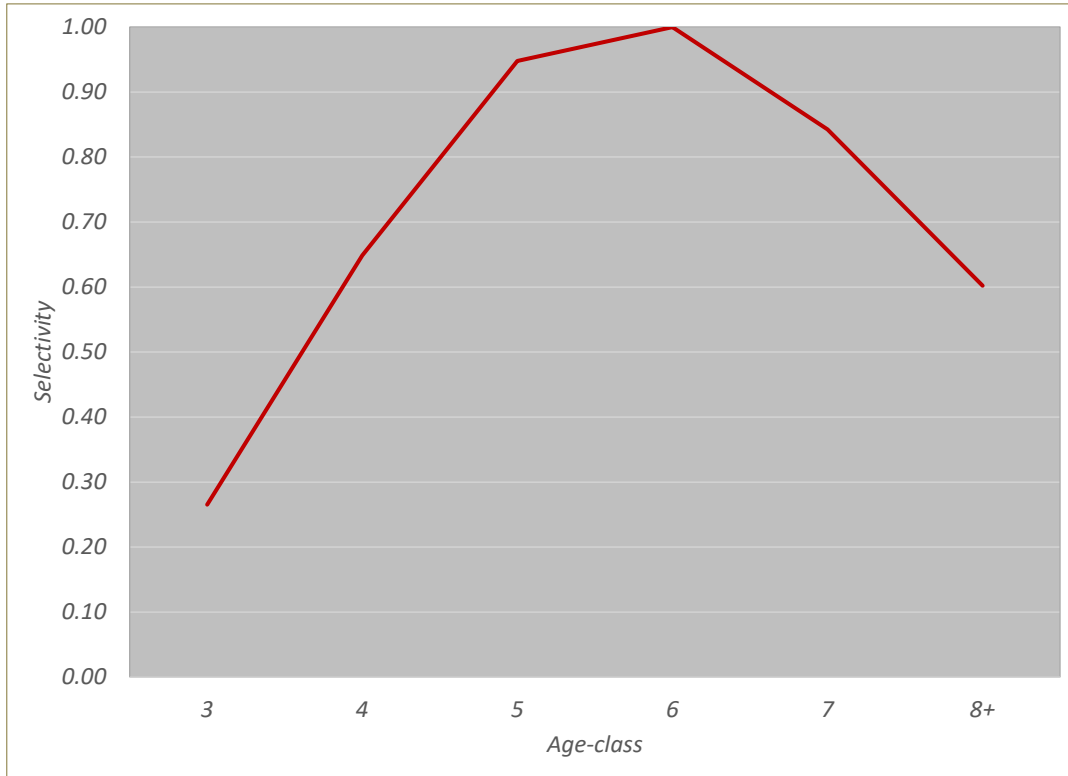


Figure 4. Upper Chesapeake Bay yellow perch abundance estimates (N, all ages), 1998 – 2023. Error bars are 2 standard deviations.

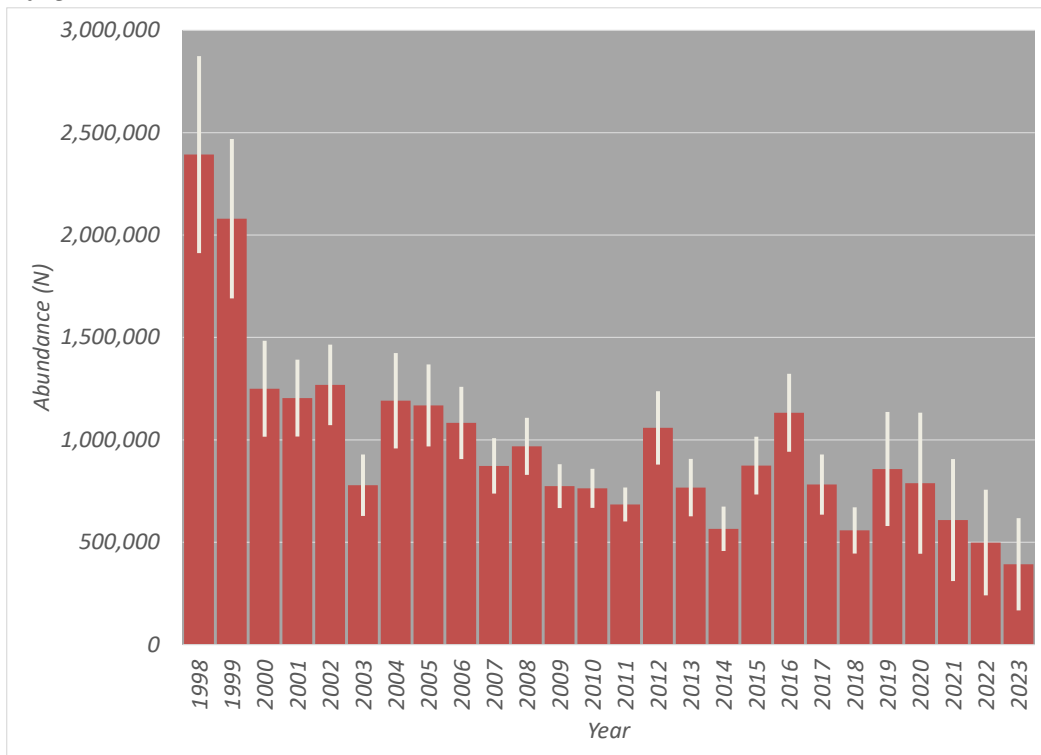


Figure 5. Upper Chesapeake Bay yellow perch biomass (kg, all ages) estimates, 1998 – 2023. Error bars are 2 standard deviations.

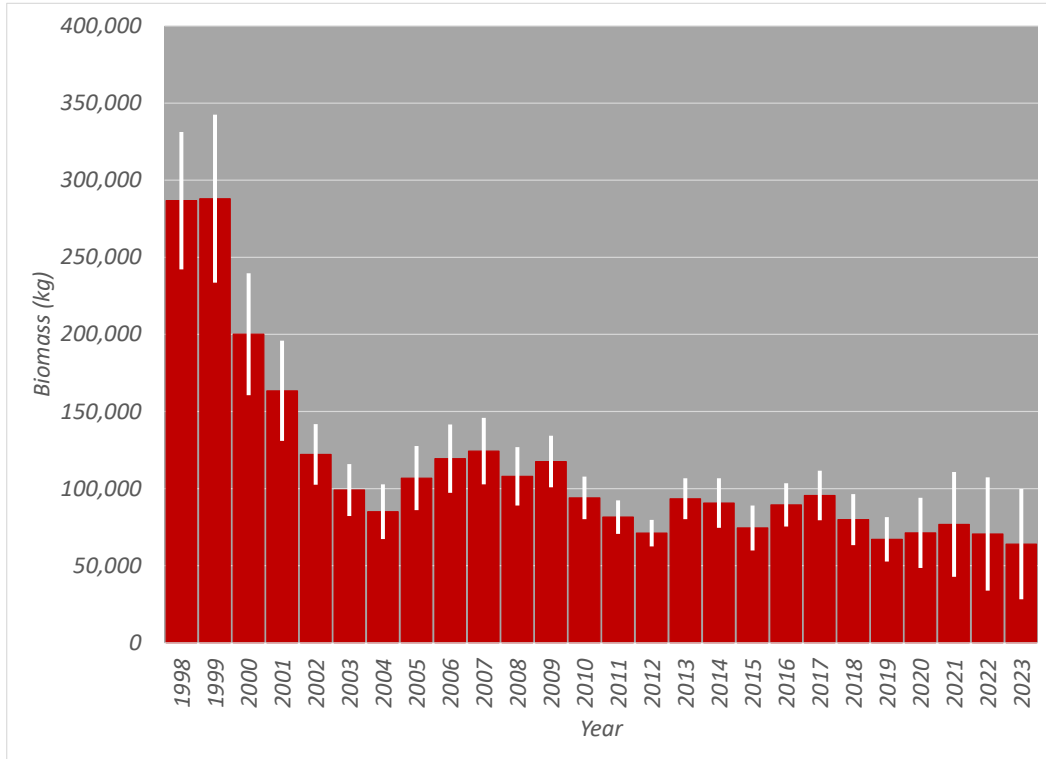


Figure 6. Upper Chesapeake Bay yellow perch fully recruited instantaneous fishing mortality (F) estimates, 1998 -- 2023. Error bars are 2 standard deviations.

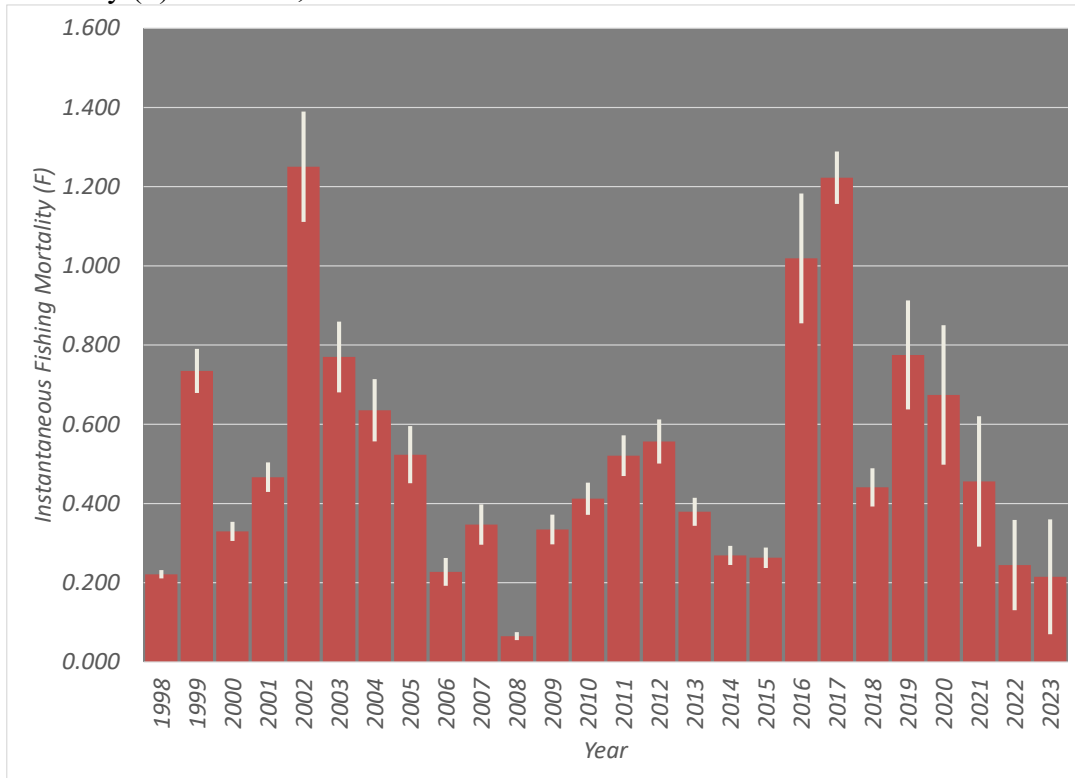


Figure 7. Upper Chesapeake Bay yellow perch recruitment (R, age 1) estimates, 1998 – 2023. Horizontal line indicates time series average. Error bars are 2 standard deviations.

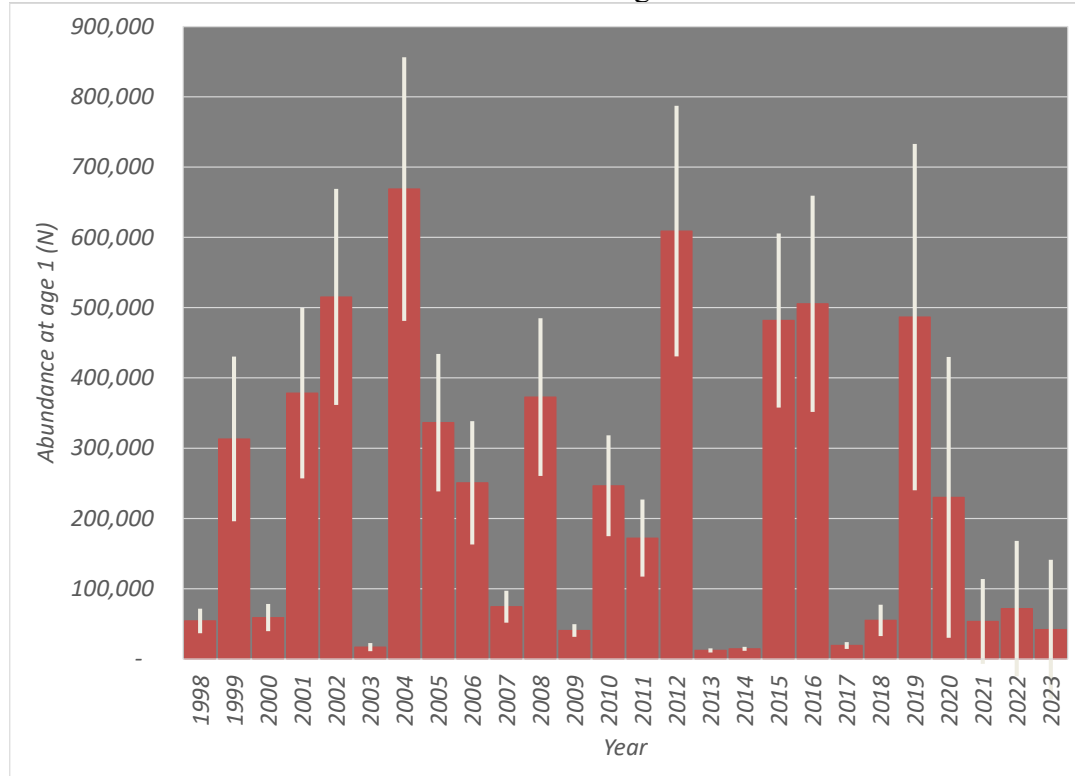


Figure 8. Abundance at age of upper Bay yellow perch in the terminal year of the assessment (2023). Error bars = +/- 2 standard deviations.

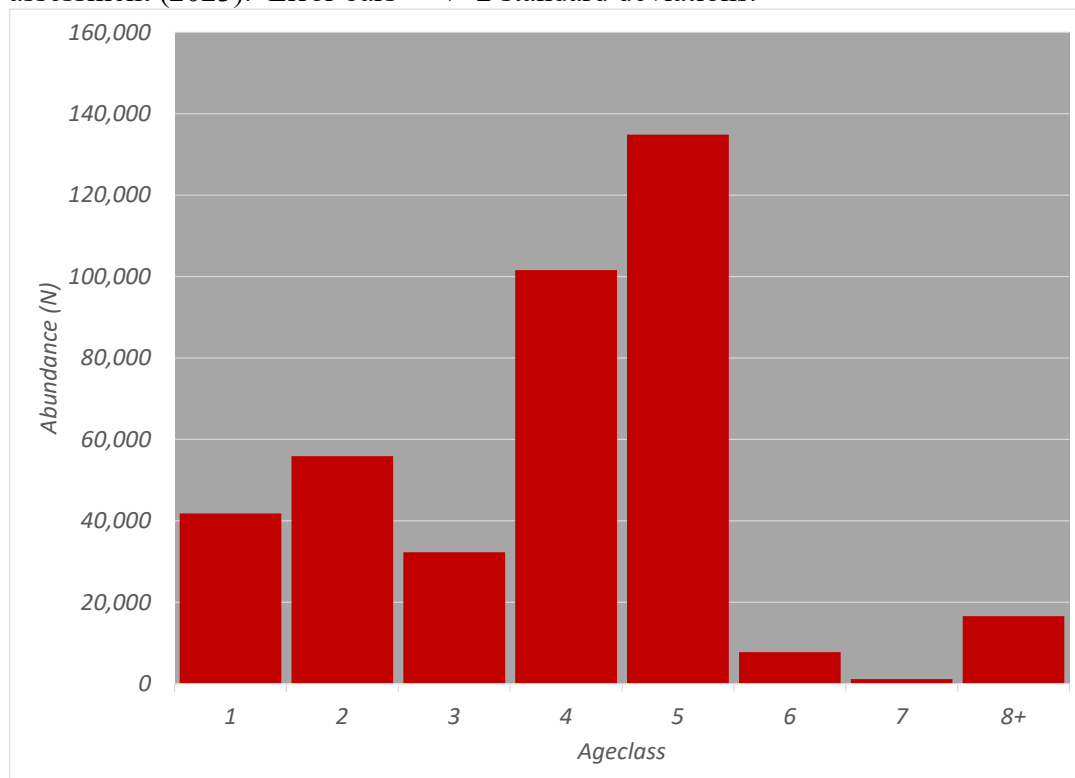


Figure 9. Percent maximum spawning potential (%MSP) versus F from Chesapeake Bay yellow perch spawning stock biomass/recruit model for 8 1/2" – 11" slot limit.

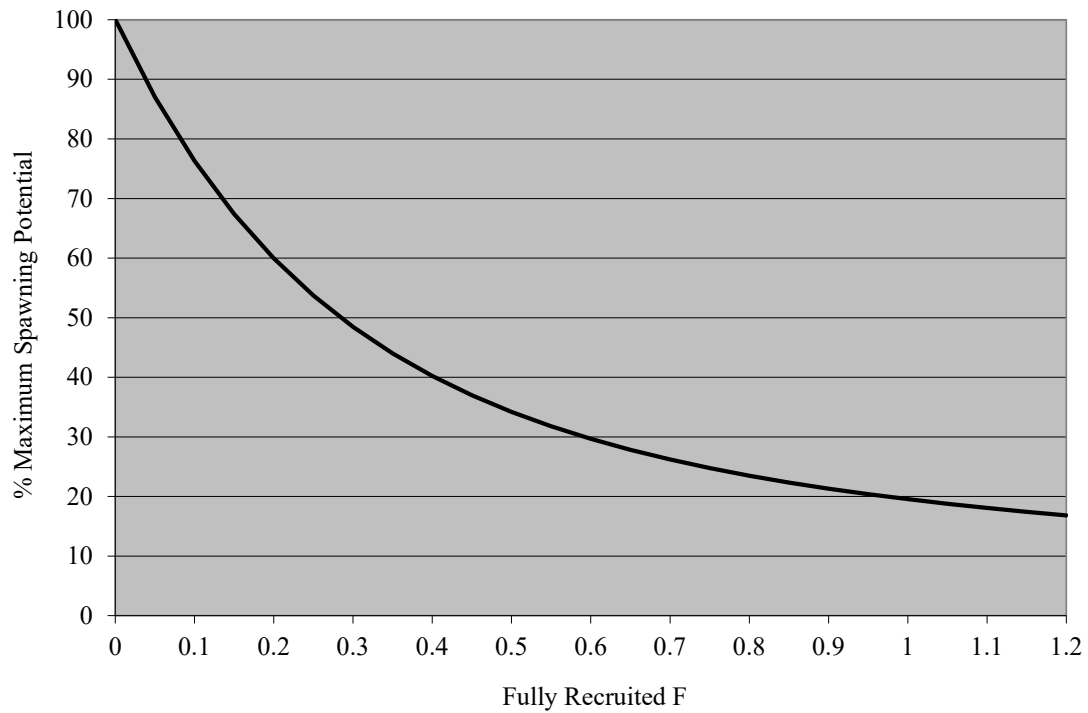


Figure 10. Percent maximum spawning potential (%MSP) versus F from Chesapeake Bay yellow perch spawning stock biomass/recruit model for 9" minimum size limit.

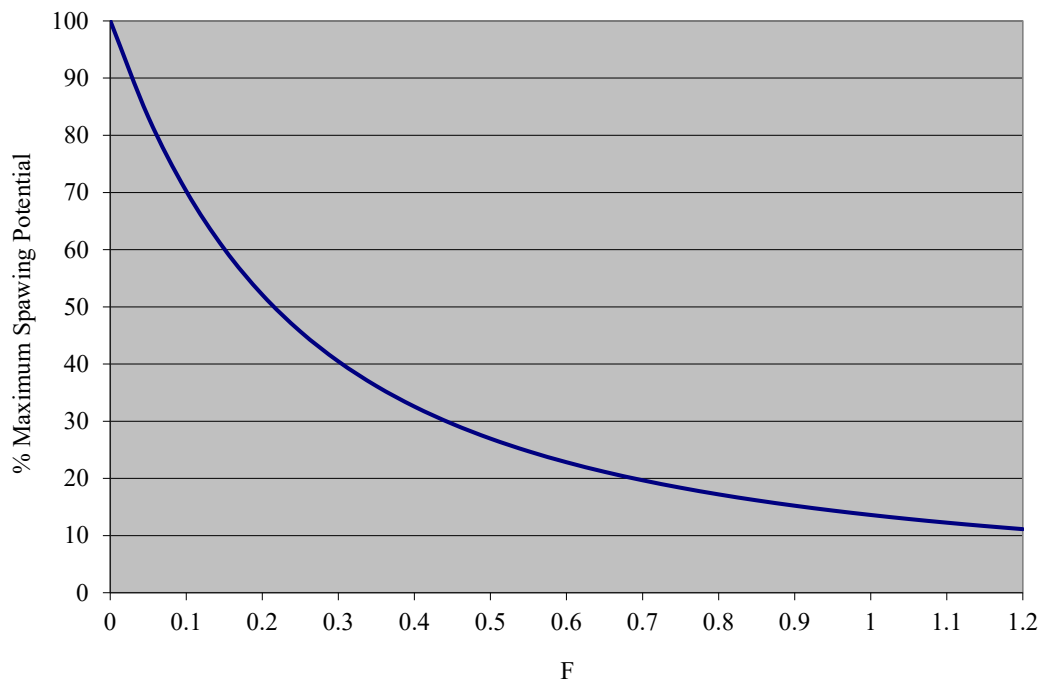


Figure 11. Frequency distribution of instantaneous fishing mortality (F) estimates from upper Bay yellow perch for 2023. Vertical line is target F.

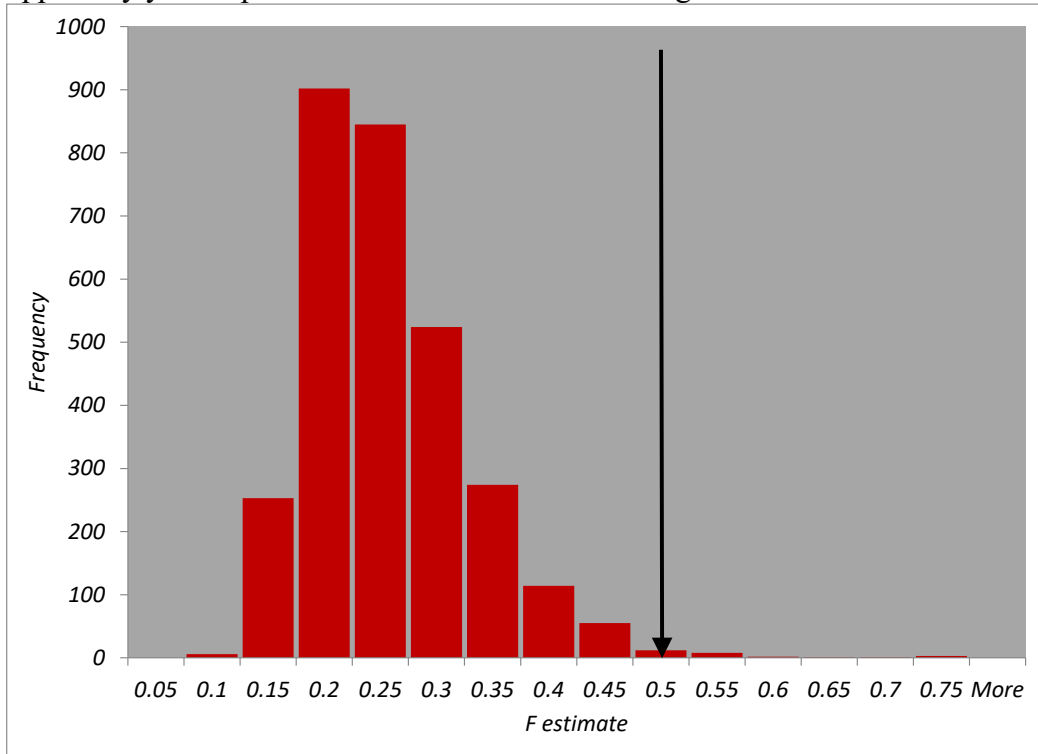


Figure 12. Yellow perch relative abundance [$\log_e$ (fish/net day)] from the Choptank River fishery independent fyke net survey, 1988 – 2023. Trendline fit is a third order polynomial.

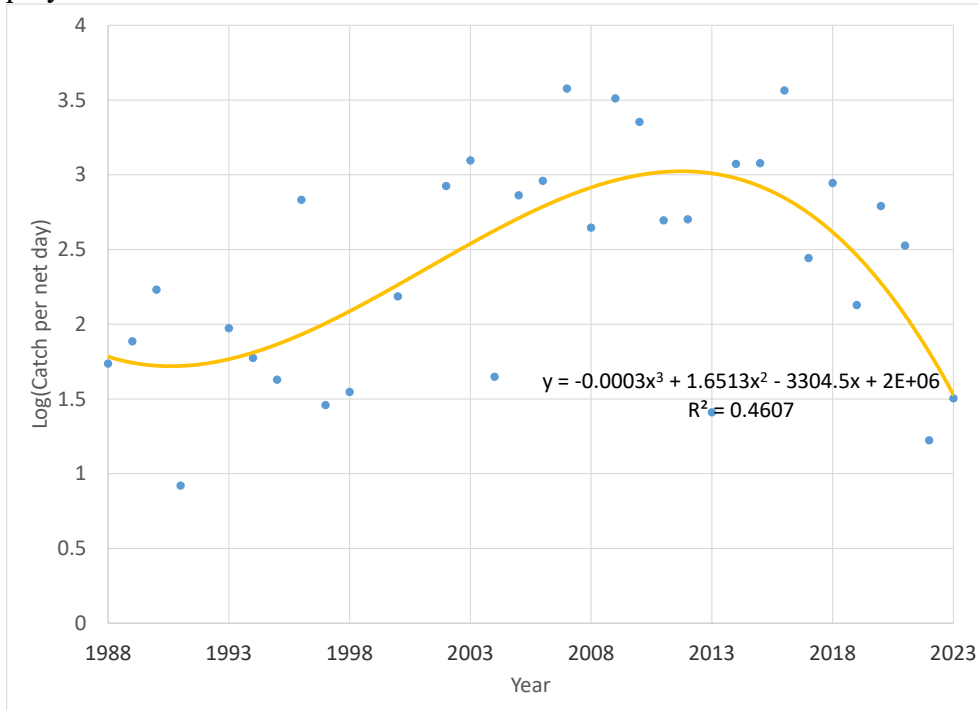


Figure 13. Linear regression of Choptank River yellow perch catch per unit effort, 1991 – 2014.

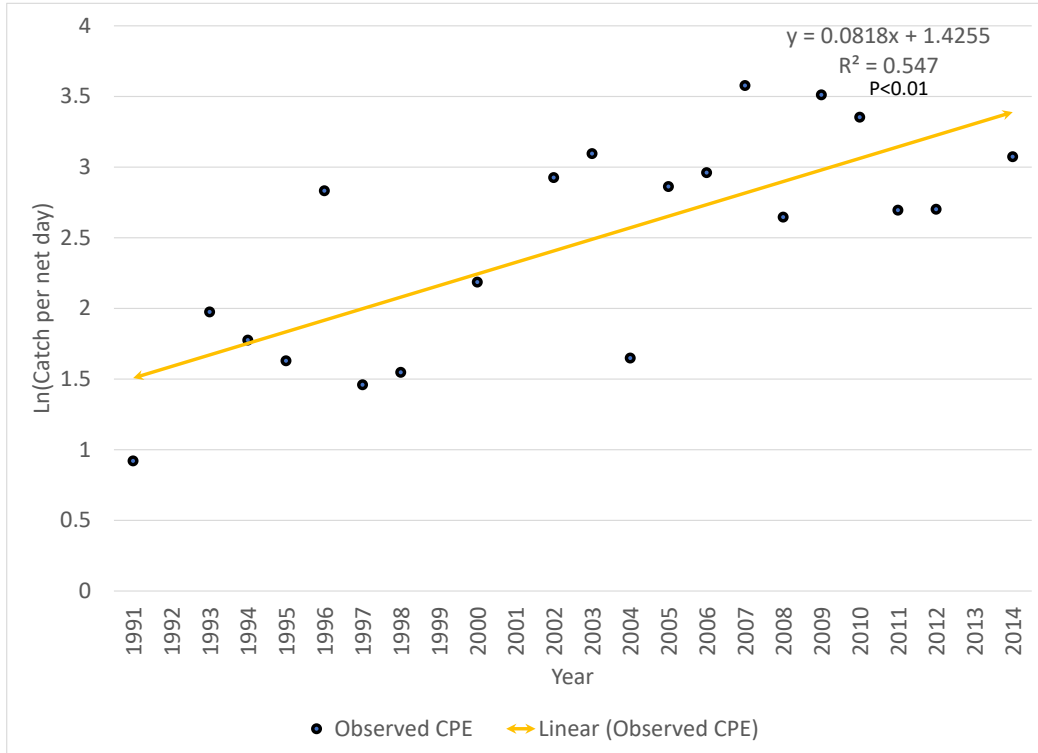
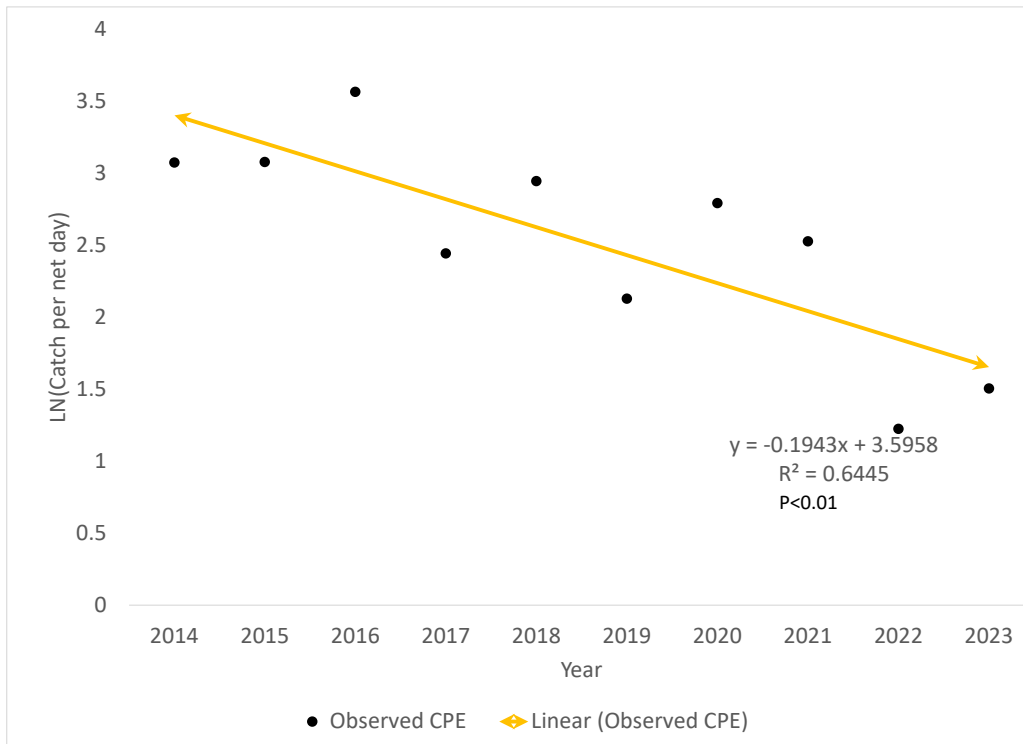


Figure 14. Linear regression of Choptank River yellow perch catch per unit effort, 2014 – 2023.



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 used both fishery-independent and -dependent sampling to provide information regarding adult alosine species and their subsequent spawning success in Maryland tributaries. Biologists sampled adult American shad with hook and line fishing from the Susquehanna River below the Conowingo Dam to collect stock composition data and to estimate population size. Stock composition and relative abundance of adult American shad in the Potomac River were assessed using fishery-independent gill nets from the Striped Bass Spawning Stock Survey (SBSSS; Project 2, Job 3, Task 2). Hickory shad stock composition was assessed in the Susquehanna River by using data from the Maryland Department of Natural Resources Fish Health and Hatcheries Program. Relative abundance of adult American and hickory shad in the upper Chesapeake Bay were assessed using fishery-independent gill nets from the Striped Bass Spawning Stock Survey (SBSSS; Project 2, Job 3, Task 2). Relative abundance of adult American and hickory shad were assessed at Conowingo Dam using creel surveys and throughout Maryland using volunteer logbook surveys. Stock composition and relative abundance of adult river herring were assessed using fishery-independent gill nets in the North East River. Juvenile alosine abundance was assessed by the Maryland Department of

Natural Resources Estuarine Juvenile Finfish Seine Survey (EJFS; Project 2, Job 3, Task 3). Sampling of commercial fyke and pound nets, as well as Ichthyoplankton sampling, on the Nanticoke River did not occur in 2022. 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 (SRAFR) 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 26 May 2022 (Figure 1). Staff angled American shad from shore until 16 May 2022, while also opportunistically sampling American shad caught by cooperative recreational anglers. After that date, staff angled American shad from boat. Two to three rods were fished simultaneously; each rod was rigged with two shad darts and lead weight was added when necessary to achieve proper depth. 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 the public.

Normandeau Associates, Inc. was responsible for observing and/or collecting American shad at the Conowingo Dam fish lifts. We used these collections as a source of catch and recapture

data in the tag-based population estimate. 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 (also known as volitional passage). 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 operations 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 operated in 2021, sorting all fish that entered the fish lift. American shad and river herring were transported upstream of the Safe Harbor Dam (i.e., south of the York Haven Dam) and invasive species were removed from the tailrace. Both the EFL and WFL operated in 2022. All fish that entered both fish lifts were sorted. Most American shad and river herring were transported upstream of the York Haven Dam and all invasive species were removed from the tailrace. Volitional passage will remain suspended at Conowingo Dam through at least 2026.

A non-random roving creel survey provided both American and hickory shad catch and effort data from recreational anglers at the Conowingo Dam tailrace, concurrent with the Maryland Department of Natural Resources volunteer angler shad logbook survey. Stream anglers were asked how long they had been fishing and how many shad they caught. The voluntary logbook survey provided location, hours fished and shad catch. Anglers participated in the logbook survey either by recording their trip data in a paper logbook or by entering their trip data online on the Maryland Department of Natural Resources' website.

Maryland Department of Natural Resources' Fish Health and Hatcheries Program provided additional hickory shad data (2004–2022) from their broodstock collection. Hickory shad were collected in the Susquehanna River near Lapidum, MD for hatchery broodstock 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.

Potomac River

The Striped Bass Spawning Stock Survey (SBSSS; Project 2, Job 3, Task 2) provided catch data and American shad scales from the Potomac River. American shad were captured in drift gill nets targeting striped bass from 4 April to 12 May 2022. 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. Since 1991, 10 different mesh sizes have been used, ranging in size from 7.6 cm (3.0 in) to 25.4 (10 in). Individual panel lengths and widths have varied over time, ranging from 9.4 m (31 ft) to 49.1 m (161 ft) in length and 2.4 m (8 ft) to 3.8 m (11.4 ft) in depth. 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 the 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) to reduce blue catfish catch.

Upper Chesapeake Bay

The Striped Bass Spawning Stock Survey (SBSSS; Project 2, Job 3, Task 2) provided catch data for American and hickory shad captured in drift gill nets set in the upper Chesapeake Bay targeting striped bass from 8 April to 14 May 2022. Since 1991, 10 different mesh sizes have been used, ranging in size from 7.6 cm (3.0 in) to 25.4 (10 in). Individual panel lengths and widths have

varied over time, ranging from 3.0 m (10 ft) to 49.1 m (161 ft) in length and 2.4 m (8 ft) to 3.8 m (11.4 ft) in depth.

North East River

A multi-panel anchored sinking gill net was deployed in the North East River to assess the river herring spawning stock. The gill net was fished at four randomly chosen sites once per week for 10 weeks from 10 March to 11 May 2022. Sampling sites were randomly assigned from a grid superimposed on a map of the system consisting of 112, 305 m x 305 m (1000 ft x 1000 ft) quadrats (Figure 2). Sites were selected with replacement across all weeks but without replacement within a week. 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. 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 panels. 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 fished 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.

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).

Juvenile Data

Juvenile alosine were sampled by the Maryland Department of Natural Resources Estuarine Juvenile Finfish Seine Survey (EJFS; Project 2, Job 3, Task 3). Data were collected from fixed stations in the Nanticoke River, the Potomac River and upper Chesapeake Bay. The survey used 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 was set by hand. One end was held from shore and the other was fully stretched perpendicular from the beach, or until depths reached 1.6 m (5.2 ft), and was swept with the current. When depths did not exceed 1.6 m, the area swept was equivalent to a 729 m² (2392 ft²) quadrant. Each station was sampled once per month during July, August and September. A replicate seine haul, a minimum of thirty minutes apart, was taken at each site. Hickory shad data were not reported by the EJFS due to historically infrequent encounters.

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 1989, 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 2022 due to time constraints, survey precedent and sample availability.

Alosine scales 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 annulus 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 interpret. Repeat spawning marks were counted on all alosine scales during aging.

In 2022, age determination was done independently by three readers. In the event of a disagreement in the age or spawning mark estimates between all three readers, the readers consulted and either reached an agreement or deemed the scales unreadable and removed the sample from further analysis. Hickory shad scales from the Susquehanna River were aged by the Maryland Department of Natural Resources Fish Health and Hatcheries Program following protocols from Cating 1953.

Data Analysis

Sex, Age and Stock Composition

Male-female ratios were derived for American shad, hickory shad and river herring. Alosine scales were collected as described above. When the annual number of samples per species for a system 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. At least one fish from each length bin for each sex was aged, when

possible, to ensure complete coverage for the age-length key. Otoliths collected from American shad sampled from the Conowingo Dam Fish Lifts were examined by the Pennsylvania Fish and Boat Commission (PFBC) 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.

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, CPUE was calculated using the geometric mean (GM CPUE), calculated as the average LN (CPUE + 1) for each sampling day, reverse transformed back to the original scale:

$$\text{GM CPUE} = e^{\frac{\sum \ln(\text{CPUE}+1)}{n}} - 1$$

Another issue with CPUE is that inter-annual fluctuations may be due to variables other than a change in abundance (e.g., temperature, flow, turbidity, etc.). Index standardization is a method that attempts to remove the influence of such factors on CPUE. Standardization is done by fitting statistical models to catch and effort data that incorporate the relationship of the covariates with catch (Maunder and Punt 2004). Due to the non-linear relationship of alosine catch in many of the surveys, generalized linear models (GLMs), generalized linear mixed models (GLMMs) and generalized additive models (GAMs) were used, when appropriate, to create a standardize index of relative abundance. Variables thought to influence catch were added to the models using forward stepwise model selection. Non-significant covariates were removed during model selection. For all statistics, significance was determined at $\alpha = 0.05$. Variance Inflation Factors (VIFs) were used to assess collinearity of the covariates to determine which covariates were

appropriate to incorporate in the model (Zuur et al. 2009). Concurvity was assessed in each GAM to test for nonlinear dependence among covariates (Wood 2011). For each GAM, to prevent model overfitting, the basis degrees of freedom used in the smoothing functions were limited to 5 (Zuur et al. 2009). Several statistical distributions for the response variable were investigated and model selection was determined based on the model dispersion statistic, *DHARMA* diagnostic tests (Hartig 2021), Akaike Information Criterion (AIC) and annual coefficients of variation (CVs). The bootstrap method ($B = 500$) was used to calculate model CVs. All models were run in RStudio (R Core Team 2022) using the *glmmTMB* (Brooks et al. 2017) and *mgcv* (Wood 2011) packages.

Geometric mean CPUE was calculated for American shad caught per hour using hook and line at the Conowingo Dam. A standardized index was created for this survey, with the following covariates explored during model selection: surface water temperature (°C), river flow (thousands of cubic feet per second; USGS Water Resources station 01578310 Susquehanna River at Conowingo, MD; USGS 2016), predicted river flow (thousands of cubic feet per second; estimated from the number of active generators during fishing), start time (fraction of the day) and day length (hours). Geometric mean CPUE was calculated for the total number of American shad lifted per hour of operation at the EFL and 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 roving creel survey and logbook survey. Start and end dates for GM CPAH calculations were defined by the first and last dates a fish was captured for both recreational surveys.

For the SBSSS in the Potomac River and upper Chesapeake Bay, GM CPUE was calculated as the number of shad caught per 914 square meters (1,000 square yards) of drift gill net per hour fished. This was calculated for American shad in both systems, but not hickory shad in the Potomac River due to low rates of positive catch. Following this convention, three standardized indices were

created. Since GLMMs and GAMs can be sensitive to low positive catch rates, only catch from the 9.5 cm (3.75 in), 11.4 cm (4.5 in) and 13.3 cm (5.25 in) mesh panels for American shad and 7.6 cm (3.0 in), 9.5 cm (3.75 in) and 11.4 cm (4.5 in) mesh panels for hickory shad were used. Catch from these panels comprised 84% of American shad caught in the Potomac River and 81% and 95% of American and hickory shad caught in the upper Chesapeake Bay, respectively. Geometric mean CPUE calculations also followed this convention to allow for direct comparisons between the two methods, and to mitigate potential bias associated with the reduction in lengths of the 9.5 cm and 11.4 cm mesh panels in the Potomac River beginning in 2015. Each panel was treated as an individual sampling event. The following covariates were explored during model selection: surface water temperature (°C), Potomac River flow (thousands of cubic feet per second; USGS Water Resources station 01646500 Potomac River near Wash, DC Little Falls Pump; USGS 2016), Susquehanna River flow (thousands of cubic feet per second; USGS Water Resources station 01578310 Susquehanna River at Conowingo, MD; USGS 2016), start time (fraction of the day), day length (hours), depth (meters), air temperature (°C), salinity (ppt), mesh size and site (as a random effect).

The North East River gill net GM CPUE was estimated separately for alewife and blueback herring using catch from only the 6.4 cm and 7.0 cm mesh panels, as these two panels were consistently sampled in all years. Catch was pooled across mesh sizes for each set, 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 2015–2022. Standardized indices were created for this survey following the convention above, with the following covariates explored during model selection: surface water temperature (°C), Susquehanna River flow (thousands of cubic feet per second; USGS Water

Resources station 01578310 Susquehanna River at Conowingo, MD; USGS 2016), Elk creek flow (cubic feet per second: USGS Water Resources station 01495000 Elk Creek at Elk Mills, MD; USGS 2016), start time (fraction of the day), day length (hours), dissolved oxygen (mg/L), conductivity ($\mu\text{S/m}$), tide (high, low, ebb and flood), depth (meters), area (northern or southern portion of sampling area), sea level pressure (hPa; National Data Buoy Center 1971) and air temperature ($^{\circ}\text{C}$; National Data Buoy Center 1971). For each species, the best fitting models for the full and truncated datasets were compared and a final model was selected. Preference was given to the dataset with all years when the two models performed similarly. 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, since volitional passage was suspended in 2021, data from both the EFL and WFL are again being 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):

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

where

$$R' = (R + 1.92) \pm (1.96 * \sqrt{R + 1})$$

In 2022, the population estimates were updated to account for the duration between a shad being tagged and the end of lift operations and post-tagging fallback. The individual durations between a shad being tagged and then being recaptured in the fish lifts were calculated using data from DNR-tagged shad that were recaptured in the fish lifts since 2021 and from American shad acoustic tagging studies performed at Conowingo Dam in the spring of 2010 and 2012 (Normandeau Associates Inc. and Gomez and Sullivan Engineers 2011; Normandeau Associates Inc. and Gomez and Sullivan Engineers 2012). These data were then used to estimate what proportion of recaptured fish entered the fish lift after a specified number of days. Then each fish was assigned a weighted value equal to this proportion (d) based on the number of days between its tagging and the final day of lift operations (e.g., a fish tagged two days, two weeks or three weeks before lift operations end would have a d of 0.05, 0.49 or 0.89, respectively). This weighted value was then summed to create wM :

$$wM = \sum_{i=1}^n d_i$$

Fallback in alosine research is commonly defined as the unnatural downstream movement related to a tagging event (Frank et al. 2009). Not accounting for fallback can bias estimates, leading to underestimates of upstream movement. The proportion of American shad that leave the tailrace post-tagging (i.e., fallback) and don't return was estimated using data from the previously mentioned acoustic tagging studies (Normandeau Associates Inc. and Gomez and Sullivan Engineers 2011; Normandeau Associates Inc. and Gomez and Sullivan Engineers 2012). Using this fallback rate, the corrected formula for M used in the Petersen method was:

$$cM = (wM - 0.453 * wM) * (0.97)$$

Since the error associated with d and the fallback rate are unaccounted for, the 95% confidence limits (N^*) should be interpreted with caution and assumed to be underestimates of the true variation.

Fish Lift Efficiency and Overcrowding

Fish lift efficiency was estimated by dividing the number of tags recaptured in the fish lifts (R) by the corrected number of tagged fish (cM). A quasi-binomial model was then used to examine American shad tag recapture rates in the Conowingo Dam fish lifts as a function of gizzard shad CPUE (catch per lift hour). Data prior to 2000 were not included in the model because during the 1990s, attraction flow at the EFL entrance was increased, in part, to deter gizzard shad from entering (SRAFRFC 2010). Thus, gizzard shad CPUE data pre- and post-2000 are not analogous.

Mortality

Chapman-Robson methodology (Chapman and Robson 1960) was used to estimate total instantaneous mortality (Z) of adult shad and river herring from all systems surveyed where age data were available. 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). Age composition data were used in the analysis, where the age-at-full recruitment was the age with the highest frequency (peak age). Total instantaneous mortality (Z) was calculated as:

$$Z = \ln\left(\frac{1 + \bar{a} - 1/n}{\bar{a}}\right)$$

where $\bar{a}$ is the mean age above age-at-full recruitment and n is the sample size. A minimum sample size of 30 fish and at least two age classes past peak age were required to estimate Z . Catch curve

analysis was primarily done cross-sectionally (i.e., catch-at-age for each year); however, longitudinal analysis (i.e., each cohort tracked through time) was also performed when strong patterns with year-class were detected.

Juvenile Relative Abundance

Geometric mean CPUE was calculated as the number of American shad or river herring caught per site. Catch for both hauls, the original and replicate, were summed prior to CPUE calculations. Standardized indices were created for this survey following the convention above, with the following covariates explored during model selection: water temperature (°C), salinity (ppt), start time (fraction of the day), day length (hours), tide (high, low, ebb and flood), weather, primary bottom type, submersed aquatic vegetation (SAV; both presence/absence and percent cover) and station ID. Stations with less than a 5% positive catch rate were excluded from analysis.

Trend Analysis

Mann-Kendall trend analysis (Mann 1945; Kendall 1975) was used to explore trends in relative abundance, as well as detect temporal trends in mean length, mean age, repeat spawning percentage and mortality over the course of a survey. Trend analysis was also performed on the terminal 10 years of surveys with greater than 20 years of data to examine whether recent trends in the data exist. The Mann-Kendall test is non-parametric and thus not restricted to the assumption of normality like a linear regression. All models were run in RStudio (R Core Team 2022) using the *Kendall* package (McLeod 2022).

RESULTS

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 2022 was 1:0.44. A total of 113 fish were sampled by this gear; 111 were successfully scale-aged (Table 1). Males were present in age groups three through six and females were found in age groups four through seven. The 2018 year-class (age four) was the most abundant for males (48.7%) and the 2017 year-class (age five) was most abundant for females (60.6%; Table 2). Twenty-five percent of males and 69.7% of females were repeat spawners (Table 2). The proportion of repeat spawners (sexes combined) significantly increased over the time series (1984–2022; $P < 0.001$; Figure 3) but has been stable the past 10 years ($P = 0.211$). Analysis by PFBC of 92 American shad otoliths collected from the WFL at Conowingo Dam found that 61% were wild fish and 39% were hatchery-produced fish in 2022, which were similar to percentages estimated in 2021.

A total of 98 American shad were caught in the Potomac River SBSSS in 2022; 81 were successfully scale-aged (Table 3). An age-length key was applied to assign ages to both sexes (Table 3). The male-female ratio for adult American shad captured in the Potomac River was 1:0.96. Males were present in age groups four through seven, and females were present in age groups four through eight (Table 4). The 2018 year-class (age four) was the dominant age group for males (63.3%), and the 2016 year-class (age six) was the dominant age group for females (34.0%; Table 4). The mean fork length of American shad in 2022 was 399.8 mm, which is the smallest average size since 1995, when only one American shad was caught. Fifty-five percent of males and 72.3% of females were repeat spawners. The proportion of Potomac River repeat

spawning American shad (sexes combined) showed no significant trend over the time series (2002–2022; Figure 4).

Adult Relative Abundance

Hook and line sampling at the Conowingo Dam tailrace was conducted over 12 days in 2022. A total of 113 adult American shad were sampled by Maryland Department of Natural Resources staff, of which 105 (93%) were tagged. The first six sampling days were conducted from shore; the final six sampling days were done from boat. No tagged American shad were recaptured by recreational anglers in 2022.

The Conowingo Dam hook and line survey CPUE was standardized using a GAM with a Tweedie distribution and the variables, day length, water temperature and predicted river flow (Figure 5). The GAM had a dispersion statistic of 0.99 and a CV of 0.17, which was lower than the GM CPUE CV of 0.23. The index shows an increasing trend in abundance in the 1990s, and then a declining trend since 1998, though trend analysis found neither the entire time series nor the most recent 10 years to be significant.

The Conowingo fish lifts operated for 74 days from 22 March to 15 June 2022. Fish lift operations after 1 June were performed for reasons other than fish passage, so they were excluded from CPUE analysis. From 22 March to 1 June 2022, a total of 4,356 American shad were lifted; 2,137 fish were lifted in the EFL and 2,219 were lifted in the WFL. The first American shad was lifted on 15 April. Most American shad (60%; 2,605 fish) were lifted between 15 May and 22 May. Peak passage was on 18 May when 486 American shad were counted. The fish lifts did not operate due to spill conditions from 8 May to 10 May. Seven American shad tagged in 2022 were counted at the fish lifts (7% of the total shad tagged). Of the 4,356 American shad lifted, 3,204 were successfully transported upstream of the York Haven Dam and 797 were successfully

transported upstream of the Safe Harbor Dam. A total of 179 American shad from the fish lifts were sacrificed for otoliths and an additional 65 fish were either lift, holding or transport mortalities. Both the total number of American shad lifted and the fish lift GM CPUE were the lowest values since 1985. Both indices show a trend that abundance was low in the 1980s, increased to a peak in the early 2000s and then declined to low levels of abundance (Figure 6).

Sixty-two creel survey interviews were conducted over twelve days, concurrent with the hook and line survey at the Conowingo Dam tailrace. The creel GM CPAH decreased in 2022 relative to 2021 (Figure 7) and decreased over the time series (2001–2022; $P = 0.032$), though it has been relatively stable over the past 10 years. Two anglers returned paper logbooks and 14 anglers participated online (10 of these anglers fished in the Susquehanna River). Logbook GM CPAH decreased in 2022 relative to 2021 and was the lowest estimate in the history of the survey (2001–2022; Figure 7). The logbook GM CPAH estimate of adult American shad relative abundance peaked in 2001, then stabilized for around a decade, but has significantly declined over the past 10 years (2013–2022; $P = 0.049$).

The SBSSS CPUE in the Potomac River was standardized using a GLMM with a negative binomial distribution and the variables depth, water temperature, mesh and site (Figure 8). The GLMM had a dispersion statistic of 1.07 and a CV of 0.26, which was lower than the GM CPUE CV of 0.29. The index shows a significant increasing trend in abundance both since the start of the survey ($P < 0.001$) and over the past 10 years ($P = 0.012$).

The SBSSS CPUE in the upper Chesapeake Bay was standardized using a GAM with a negative binomial distribution and the variables water temperature, day length, depth, salinity, set time, mesh and site (Figure 9). The GAM had a dispersion statistic of 1.07 and a CV of 0.42, which was higher than the GM CPUE CV of 0.40. The index shows a significant increasing trend in abundance since the start of the survey ($P < 0.001$), but no trend over the past 10 years.

Population Estimates

The Petersen method estimated 24,323 American shad in the Conowingo Dam tailrace in 2022 (Figure 10). The upper confidence limit was 44,462 fish and the lower confidence limit was 12,583 fish. The population size estimate for 2022 is the lowest estimate since 1993. The updated yearly Petersen estimates were an average of 51% lower than those estimated without accounting for the end of lift operations and post-tagging fallback. The Petersen estimates followed a similar pattern to that of the lift GM CPUE estimates, with low numbers of American shad in the 1980s, increasing to a peak around 2000 and then declining to low numbers thereafter (Figure 10). Trend analysis suggests that the population size of American shad in the Conowingo Dam tailrace has declined over the past 10 years ($P = 0.032$).

Fish Lift Efficiency and Overcrowding

Tag recapture rates indicate that lift efficiency was approximately 16% in 2022 (Figure 11). The updated tag recapture rates increased an average of 104% compared to those estimated without accounting for the end of lift operations and post-tagging fallback. Tag recapture rates were highest in the 1990s and have declined over the time series (1986–2022; $P < 0.001$). The quasi-binomial model that examined American shad tag recapture rates in the Conowingo Dam fish lifts as a function of gizzard shad CPUE was significant (2000–2022; $P = 0.003$), with a pseudo R^2 of 0.43 (Figure 12).

Mortality

The Conowingo Dam tailrace total instantaneous mortality (Z) estimate for American shad, sexes combined, in 2022 was 1.687, which is the highest estimate in the history of the survey

(1984–2022; Figure 13). Total instantaneous mortality (Z) estimates have varied without trend over the course of the survey. The Potomac River Z estimate for American shad, sexes combined, in 2022 was 0.624, which is the lowest estimate since 2005. Total mortality has increased significantly over the time series (2002–2022; $P = 0.010$), but not over the past 10 years (Figure 14).

Juvenile Abundance

Juvenile American shad GM CPUE from the EJFS (1959–2022) demonstrated no trends in juvenile production for the upper Chesapeake Bay (Figure 15). The GM CPUE estimates for the Nanticoke River indicate a declining trend over the times series ($P < 0.001$), but no trend over the past 10 years (Figure 16). Juvenile American shad catch from the Potomac River was standardized using a GLM with a negative binomial distribution and the variables year, salinity and day length (Figure 17). The GLM had a dispersion statistic of 0.9, an AIC of 4381.3 and a CV of 0.46, which was lower than the GM CPUE CV of 0.65. The index shows a significantly increasing trend in abundance over the time series ($P < 0.001$), though juvenile abundance over the past 10 years has no trend.

Hickory Shad

Sex, Age and Stock Composition

In the Susquehanna River, 80 hickory shad were sampled by the broodstock collection survey in 2022. The male-female ratio was 1:0.82. All were successfully aged (Table 5). Males were present in age groups three through six and females were present in age groups four through seven (Table 6). The 2018 year-class (age 4) was the most abundant year-class for males (40%) and the 2017 year-class (age 5) was the most abundant for females (47.5%; Table 6). The average

age of hickory shad (sexes combined) has significantly decreased over the time series ($P = 0.012$). The proportion of repeat spawners (sexes combined) has significantly decreased over the time series (2004–2022; $P = 0.002$; Figure 18).

Relative Abundance

The 2022 creel GM CPAH and logbook GM CPAH estimates for hickory shad were the highest estimates in the history of both surveys (2001–2022; Figure 19). No significant trends in GM CPAH were detected in either survey. The SBSSS CPUE in the upper Chesapeake Bay was standardized using a GAM with a negative binomial distribution and the variables day length, depth, set time, river flow, mesh and site (Figure 20). The GAM had a dispersion statistic of 0.92 and a CV of 0.39, which was higher than the GM CPUE CV of 0.36. No significant trends were detected in the standardized index.

Mortality

Total instantaneous mortality (Z) for hickory shad, sexes combined, in the Susquehanna River in 2022 was estimated to be 1.79, which increased from 2021 ($Z = 1.03$), and was the highest estimate in the history of the survey (Figure 21). Mortality has significantly increased over the time series (2004–2022; $P = 0.007$).

Alewife and Blueback Herring

Sex, Age and Stock Composition

More female alewife have been encountered than males in the North East River gill net survey since its inception in 2013 (1.44:1, $n = 4572$). The male-female ratio for alewife in 2022 was 1:1.2. Alewife of ages three to eight were present in 2022. The 2018 (age four) year-class was

the dominant age group for both males and females in 2022, comprising 42.7% and 38.2% of the sample, respectively (Table 7). More than twice as many female blueback herring have been caught than males since the inception of the survey (2.66:1, $n = 2,761$). The male-female ratio for blueback herring in 2022 was 1:3.4. The 2018 (age four) year-class was the dominant age group for both males and females in 2022, comprising 40.5% and 40.1% of the sample, respectively (Table 8). Sixty-two percent of alewife and 50.1% of blueback herring were repeat spawners in 2022 (sexes combined). No significant trends in the occurrence of repeat spawning alewife or blueback herring (2013–2022; Figure 22) were observed over the time series.

Adult Relative Abundance

The North East River gill net survey captured 582 alewife and 368 blueback herring in 2022. Peak catch of alewife (105 fish) occurred on 22 March 2022 when the water temperature was 10.9°C (Figure 23). Peak catch of blueback herring (156 fish) occurred on 11 May 2022 when the water temperature was 15.4°C (Figure 23). The majority of alewife (46%) were caught in the 6.4 cm (2.5 inch) mesh in 2022 (Table 9). The majority of blueback herring (48%) were caught in the 5.7 cm (2.25 inch) mesh in 2022 (Table 10).

For the North East River survey, alewife catch from the 6.4 cm and 7.0 cm mesh panels across all years was standardized using a GAM with a Tweedie distribution and the variables day length, conductivity, air temperature, Susquehanna River flow, sea level pressure and sampling area (Figure 24). The GAM had a dispersion statistic of 1.03 and a CV of 0.20, which was lower than the GM CPUE CV of 0.27. No significant trends were detected in the standardized index. Blueback herring catch from the 5.7 cm, 6.4 cm and 7.0 cm mesh panels, excluding 2013 and 2014, was standardized using a GAM with a negative binomial distribution and the variables day length, air temperature, conductivity and sampling area (Figure 25). The GAM had a dispersion statistic

of 0.88 and a CV of 0.36, which was slightly lower than the GM CPUE CV of 0.37. No significant trends were detected in the standardized index. Total catches of other fishes are noted in Table 11.

Mortality

The 2022 cross-sectional Z estimate for alewife from the North East River was 0.75 and the blueback herring estimate was 0.64 (2013–2022; Figure 26). There was no significant trend in the cross-sectional mortality estimates for either species over the time series. Longitudinal Z estimates were calculated for alewife and blueback herring for the 2008 to 2015 cohorts (Figure 27). Estimates for the 2008, 2009 and 2010 cohorts are likely biased due to mesh sizes changing in 2015 but were still calculated. Total mortality estimates for terminal cohort, 2015, were 0.74 for alewife and 0.83 for blueback herring. The standard errors of the Z estimates calculated using the longitudinal analysis were lower, 0.11 for alewife and blueback herring, than those calculated using the cross-sectional analysis, 0.13 for alewife and 0.17 for blueback herring. The longitudinal Z estimates significantly decreased over time for alewife ($P = 0.035$), but not for blueback herring.

Juvenile Abundance

Juvenile alewife GM CPUE from the EJFS (1959–2022) in the upper Chesapeake Bay declined over the time series ($P = 0.020$) but remained stable at low levels in recent years (Figure 28). Juvenile blueback herring GM CPUE in the upper Chesapeake Bay exhibited no trend over the time series and remained stable at low levels in recent years (Figure 29). Juvenile alewife and blueback herring GM CPUEs in the Nanticoke River declined over the time series (alewife: $P = 0.003$; blueback herring: $P < 0.001$) but remained stable at low levels in recent years (Figures 30 and 31). Juvenile alewife GM CPUE in the Potomac River declined over the time series ($P = 0.008$)

but remained stable at low levels in recent years (Figure 32). Juvenile blueback herring GM CPUE in the Potomac River varied without trend over the time series (Figure 33).

DISCUSSION

American Shad

American shad were historically one of the most important fishes in North America, but stocks drastically declined coastwide throughout the twentieth century due to habitat loss, overfishing, ocean bycatch, stream blockages, pollution and exposure to invasive predators (ASMFC 2020). 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 coastal stocks have not recovered and populations remain near historic lows (ASMFC 2020).

The current abundance of American shad in the lower Susquehanna River Basin is much lower than both the peak observed in the early 2000s and before the stock collapsed in the 1960s. The Petersen estimate for American shad in the Conowingo Dam tailrace was less than 25,000 fish in 2022, the lowest estimate since 1989. Since the population of American shad is not closed during sampling (i.e., mortality, immigration and emigration are occurring), the trend in population size, rather than the actual estimates themselves, should be emphasized. Abundance estimates for American shad in the Susquehanna River show numbers increased in the 1990s, peaked around 2001 and declined thereafter. The Petersen estimates and the logbook survey both show significant declines over the past 10 years, indicating that the population may still be declining. Furthermore, nearly every metric of relative abundance or population size in 2022 was at or near historic lows.

The fish lift recapture rates of American shad tagged in the Conowingo Dam also drastically declined over the past twenty years. This was the first year that recapture rates were corrected to account for the duration between a shad being tagged and the end of lift operations and post-tagging fallback. This method introduces additional variability that is difficult to account for; however, the updated recapture rates for 2010 (48%, previously 25%) and 2012 (24%, previously 13%) more closely aligned with the upstream fish passage efficiency estimates calculated in the telemetry studies for those years (45% for 2010, 26% for 2012; Normandeau Associates Inc. and Gomez and Sullivan Engineers 2011; Normandeau Associates Inc. and Gomez and Sullivan Engineers 2012). The declines in recapture rates could be due to increasing gizzard shad, *Dorosoma cepedianum*, populations overcrowding the fish lifts, precluding other anadromous fish species from entering (SRAFRFC 2010). While increasing gizzard shad populations at the dam may be independent of American shad recapture rates, there is a strong negative correlation between the two since 2000 (Figure 12).

Significant resources have been invested in restoring 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. From 1985 to 1996, most American shad that were lifted at Conowingo Dam were placed in holding tanks and then 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. 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. Volitional passage was seen as superior to trap and

transport as it allowed for the passage of other native fishes and the total number of alosines that could be transported upstream was not limited by holding and transport tank constraints. Although 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 2026, meaning trap and transport will be the only mode of upstream transportation for the next several years. If the trap and transport program was one of the primary reasons for the American shad population increase in the 1990s, a similar increase could be seen as early as 2025 when part of the 2021 year-class returns (though most females would not return until 2026).

While American shad abundances decreased in the lower Susquehanna River 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 has remained relatively stable over the past 30 years, though trends in juvenile catch indicate that American shad were more abundant in the river over 50 years ago (Jargowsky and David Sanderson-Kilchenstein 2022). In the upper Chesapeake Bay, after many years of minimal juvenile production from the early 1980s through the mid-1990s, there have appeared to be several years of successful spawns. The relative abundance of American shad in the upper Chesapeake Bay SBSSS has also increased over the time series. Up until 2007, the upper Chesapeake Bay SBSSS index appeared to closely follow the trends seen in the Susquehanna River: increasing in the 1990s, peaking around 2000 and then declining thereafter. However, unlike the indices from the Susquehanna River that continued to decline after 2007, the upper Chesapeake Bay SBSSS index stabilized, with the highest estimate in the history of the survey coming in 2020. Why catches in

the upper Chesapeake Bay SBSSS index deviated from those in the Susquehanna River is unknown. One theory is that restoration efforts in the Susquehanna River helped established concurrent American shad spawning runs in other upper Chesapeake Bay tributaries due to straying (i.e., shad not returning to their natal tributary). Unfortunately, we lack the spawning stock data necessary from other upper Chesapeake Bay tributaries to properly evaluate this theory.

In the Potomac River, both adult and juvenile relative abundance has significantly increased over time, with the Potomac River SBSSS index also significantly increasing over the past 10 years. Interestingly, Z estimates from the survey have also significantly increased over the past 20 years. Reasons for this conflicting trend are unknown, but the increases in mortality could be due to concurrent increases in both the size and abundance of invasive blue catfish in the Potomac River. In part due to this high adult mortality and conflicting population trends from 2005 – 2017, the 2020 benchmark stock assessment found adult mortality in the river to be at unsustainable levels (ASMFC 2020). In the five years since the terminal year of the assessment, the SBSSS index for the river has had four of its five highest annual estimates. During this same time, catch of blue catfish in the survey has fallen to numbers not seen since 2003. However, Z estimates post-2017 have remained high, with the exception of 2022. The Z estimate for 2022 was the lowest since 2005 and the second lowest in the history of the survey. This was due to an unusually high proportion of age-4 males in 2022, with the corresponding lack of larger females being the possible reason for low juvenile production.

The average proportion of repeat spawners from the Potomac River was 17% in the 1950s (Walburg and Sykes 1957) but was 62% in 2022. Increased repeat spawning in these river systems may indicate increased survival of adult fish, but it could also be a sign of poor recruitment (i.e., few virgin fish returning to spawn). Similarly, the proportion of repeat spawning American shad below Conowingo Dam has increased over time. The proportion of repeat spawners was usually

less than 10% in the Conowingo Dam tailrace throughout the 1980s (Weinrich et al. 1989). In contrast, this percentage has been above 30% every year since 2012. To examine whether changes in scale interpretation over the 40-year survey were responsible for this trend, American shad scales from 1995 were re-aged. The percent agreement was relatively high, 67.8%, and the percentage of repeat spawners was calculated to be 11.1%. While this repeat spawning percentage was higher than reported for 1995 (2.5%), the reported values for 1993, 1994 and 1996 were 12.0%, 11.8% and 17.5%, respectively. Thus, this re-examination of scales from 1995 suggests that this trend in the data is not due to changes in scale interpretation.

It is possible that this trend in the Susquehanna River is due to the switch from trap and transport to volitional passage. Based on adjusted tag recapture rates, over 40% of American shad that entered the Conowingo Dam tailrace from 1982 to 1996 were eventually trap and transported upstream of the York Haven Dam. Conversely, this number was estimated to be less than one percent from 2000 to 2017. While trap and transport appeared to lead to increases in juvenile production, it also inevitably led to increases in adult turbine mortalities. Thus, the Susquehanna River likely switched from a system with high juvenile production and high adult mortality to a system with low juvenile production and lower adult mortality. While the lack of trend with the Chapman-Robson Z estimates contradict this claim, it would help explain how the population of American shad was able to increase so sharply despite high Z estimates. If this theory is correct, with trap and transport resuming in 2021, we would expect to see declines in the proportion of repeat spawners moving forward.

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 (ASMFC 1999). A

statewide moratorium on the harvest of hickory shad in Maryland waters was implemented in 1981 and is still in effect today. Both adult and juvenile hickory shad are difficult to capture due to their aversion to fishery-independent (e.g., fish lifts and haul seines) and -dependent (e.g., pound and fyke net) gears, which makes assessing their populations difficult. Very few hickory shad were ever observed in 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, immediately downstream of Conowingo Dam) has some of the greatest densities of hickory shad in Maryland (Richardson et al. 2009). This is consistent with other studies which found hickory shad were more likely to spawn in tributaries, as opposed to a river's main channel (Harris and Hightower 2011). Hickory shad also do not migrate as far upstream as other alosines, generally spawning at or below the fall line of a river (Klauda et al. 1991).

Prior to 2012, the hickory shad age distribution was relatively consistent, with a wide range of ages, up to age-nine, and a high percentage of older fish. The age distribution has truncated since that time, and only a single age-seven fish was present in 2022. Richardson et. al (2004) found 90% of hickory shad from the upper Chesapeake Bay had spawned by age four, and the stock generally consisted of few virgin fish. Since then, the proportion of repeat spawning fish has significantly declined. 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 Z have also increased over the time series. Estimates of Z are primarily attributed to natural mortality (M) as there is only a catch and release fishery 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.).

Despite truncating age distributions and increases in Z estimates, GM CPAH estimates for hickory shad in both the creel and logbook surveys were record highs in 2022. Similarly, the upper Chesapeake Bay SBSSS index for hickory shad increased every year since 2017. Surprisingly, this hickory shad index closely mirrored American shad abundance in the Susquehanna until recently. Like American shad, hickory shad populations in Deer and Octoraro creeks (a Susquehanna tributary just below Conowingo Dam) suffered population declines in the 1970s and were essentially extirpated from the creeks by the early 1980s (Klauda et al. 1991). The shad moratorium was likely the reason why their numbers started to increase again in the late 1980s (Klauda et al. 1991), but why their populations increased so rapidly in the 1990s is unknown. Hickory shad do not use fish lifts, so their population trends in the Susquehanna River should be independent of the other alosines that were trapped and transported in the 1980s and 1990s. One hypothesis is that some hickory shad followed the large numbers of returning alosines in the 1990s into the Susquehanna River, leading them to quickly reestablish their historic spawning runs in the river's tributaries.

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 (ASMFC 2017).

Declines in mean length at age is concerning as it is often the result of overfishing, habitat degradation or climate change (Ikpewe et al. 2021).

Alewife and blueback herring relative abundance in the North East River was relatively stable over the respective time series, with no significant trends detected. Based on weekly run times, it appears that sampling in 2022 overlapped with most of the alewife spawning run; however, the survey appeared to only sample about half the blueback spawning run (Figure 24). The age distribution of river herring in the North East River was 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).

In the North East River, mortality estimates appeared to be strongly influenced by individual year-classes, so longitudinal catch curve analysis was used. The most recent longitudinal Z estimates were relatively low for both alewife (0.74) and blueback herring (0.83) in 2022. Cross-sectional Z estimates for 2022 were also low for both alewife (0.75) and blueback herring (0.64).

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 immediately followed by a decline.

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, except for in states with a sustainable fisheries management plan, 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). In 2022, the catch caps were 361 mt and 129 mt for the Atlantic herring and mackerel fisheries, respectively. 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 efforts of the Atlantic herring and mackerel fisheries have declined substantially in recent years due to quota reductions. These quota reductions, combined with the aforementioned catch caps, substantially reduced the magnitude of at-sea bycatch. The total alosine ocean bycatch in 2022 was 12.5 mt, a 160% increase from 2021.

Invasive predators in the Chesapeake Bay region also pose a threat to alosines. Diet studies showing direct predation by northern snakehead on river herring are lacking, but 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). Flathead catfish and blue catfish are documented predators of alosines (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. Schmitt et al. (2017) also found that alosine predation was highest in the tailwaters of a dam, indicating that predation by invasive predators in the Conowingo Dam tailrace is likely a significant source of alosine mortality. 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

2023 PRELIMINARY RESULTS - WORK IN PROGRESS

Analysis of the data collected in 2023 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, alewife and blueback herring 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.

Adult American shad were angled by staff from the lower Susquehanna River 15 times from 17 April through 26 May 2023. The first four sampling trips, and two additional trips later in the season, were completed from shore; the other nine sampling trips were completed from boat. In total, staff encountered 317 adult American shad, 276 of which were marked with Floy tags to formulate mark-recapture population estimates. Male American shad ranged in size from 299 – 470 mm FL and female American shad ranged in size from 350 – 476 mm FL. Recreational angler logbook and creel surveys were completed as usual in 2023.

The Striped Bass Spawning Stock Survey (SBSSS; Project 2, Job 3, Task 2) in the Potomac River had a small gear change 2023; the three smallest mesh panels were restored to their original, pre-2015, lengths. A total of 191 American shad were caught, 102 of which were scaled for age and repeat spawning analysis. Preliminary analysis indicates that CPUE decreased slightly in 2023, compared to 2022. The Maryland Department of Natural Resources' Fish Health and Hatcheries Program did not collect any hickory shad for hatchery brood stock in 2023.

River herring were independently sampled using a gill net deployed in the North East River at four randomly chosen sites once a week from 16 March to 15 May 2023. The gill net was set 40 times and encountered 423 alewife and 251 blueback herring. A total of 357 alewife scale samples and 209 blueback herring scale samples are being processed for aging.

The complete analyses of the data collected in 2023 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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Table 1. Percent catch-at-age for American shad, sexes combined, angled from the Conowingo Dam tailrace, 1982–2022.

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
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	-	-	-	-	-	-	-	-	-	-

* 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
2021	288	5.27	0	1	21	38	30	10	0	0
2022	111	4.72	0	2	38	48	12	1	0	0

Table 2. Number of adult American shad and repeat spawners by sex and age sampled from the Conowingo Dam tailrace in 2022.

Age	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
3	2	0	0	0	2	0
4	37	3	4	1	42	4
5	32	14	20	14	53	29
6	5	2	8	7	13	9
7	0	0	1	1	1	1
Totals	76	19	33	23	111	43
Percent	25.0%		69.7%		38.7%	

Table 3. Percent catch-at-age for American shad, sexes combined, captured in the Potomac River, 2002–2022.

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
2022*	98	5.14	0	38	30	19	7	6	0	0

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

Table 4. Number of adult American shad and repeat spawners by sex and age sampled from the Potomac River in 2022.

Age	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
4	31	13	5	1	37	14
5	15	11	14	5	29	16
6	2	2	16	16	19	18
7	1	1	6	6	7	7
8	0	0	6	6	6	6
Totals	49	27	47	34	98	61
Percent	55.1%		72.3%		62.2%	

Table 5. Percent catch-at-age for hickory shad, sexes combined, sampled by the broodstock collection survey in the Susquehanna River and Deer Creek (a lower Susquehanna River tributary), 2004–2022.

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
2022	80	4.7	0	3	40	48	9	1	0	0

Table 6. Number of adult hickory shad and repeat spawners by sex and age sampled from the broodstock collection survey in the Susquehanna River in 2022.

Age	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
3	2	0	0	0	2	0
4	20	1	12	0	32	1
5	19	4	19	6	38	10
6	3	3	4	2	7	5
7	0	0	1	1	1	1
Totals	44	8	36	9	80	17
Percent	18.2%		25.0%		21.3%	

Table 7. Percent catch-at-age for adult alewife, sexes combined, sampled from the North East River from 2013–2022.

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
2022*	550	4.79	6	40	37	7	7	3

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

Table 8. Percent catch-at-age for adult blueback herring, sexes combined, sampled from the North East River from 2013–2022.

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
2022	373	4.75	17	40	10	16	15	1

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

Table 9. Percent of total catch by mesh size of alewife from the North East River, 2013–2022.

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	-
2022	582	12	46	43	-
Total	4622	12	51	34	2

Table 10. Percent of total catch by mesh size of blueback herring from the North East River, 2013–2022.

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	-
2022	368	48	43	10	-
Total	2794	59	48	8	0

Table 11. Counts of species (other than alewife and blueback) captured in the North East River gill net survey from 2013–2022.

Species	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
American shad		2								
Atlantic menhaden	145	145	476	908	145	141	19		49	12
Blue catfish			1	1						5
Black crappie									1	5
Bluegill				1			1		1	
Brown bullhead	66	132	78	123	15	25	46		8	13
Common Carp	2	1	2						1	3
Channel catfish	17	45	50	7	6	19	18		17	22
Gizzard shad	2617	850	104	568	112	13	54		400	156
Golden shiner			1		4	2	2		4	5
Goldfish	2		2	1			2		3	6
Hickory shad	19	25	5	15	5	2	10		7	2
Largemouth bass	1		1	1		1			1	1
Pumpkinseed	1	1	2	4	1				1	7
Quillback			2							1
Redear sunfish					1					
Shorthead redhorse									1	
Striped bass	39	39	42	50	42	15	13		22	38
Walleye		1					1			
White catfish	1	1		1	1		2		1	
White perch	287	227	1273	813	257	320	268		373	116
White sucker	3	1	1	1	2		1		2	
Yellow perch			6	2	1	1	1		4	3

Figure 1. Conowingo Dam tailrace (Susquehanna River) hook and line survey location.



Figure 2. 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 gill net survey, 2013–2022.

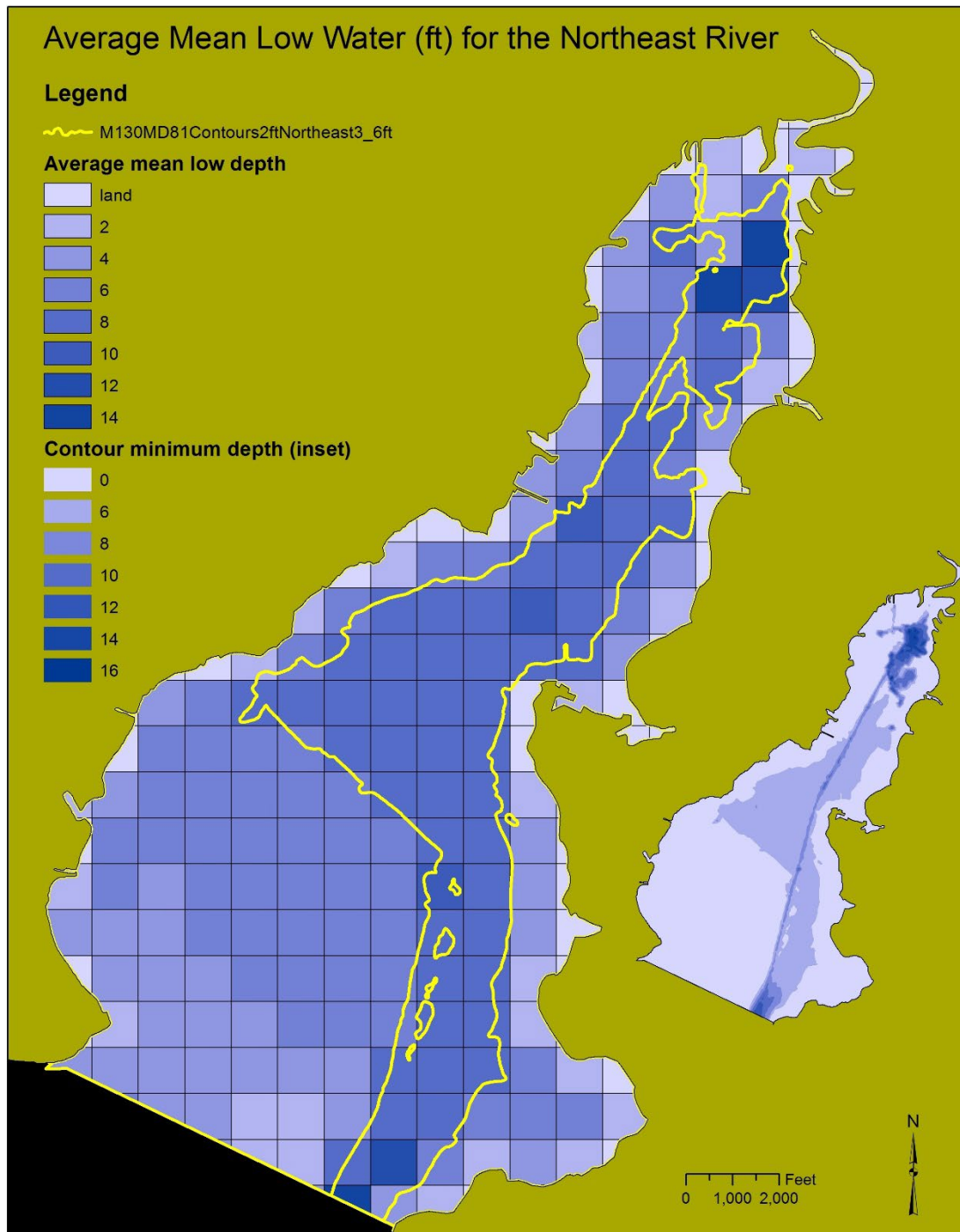


Figure 3. Proportion of American shad repeat spawners, sexes combined, collected in the Conowingo Dam tailrace, 1984–2022 (time series trend: $P < 0.001$, 10-year trend: $P = 0.211$).

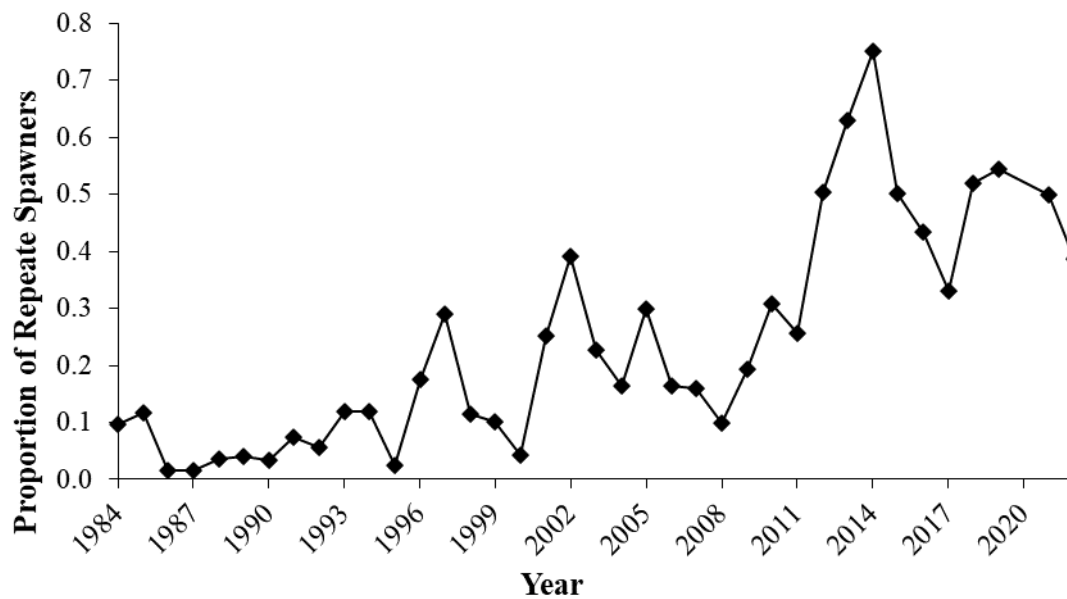


Figure 4. Proportion of American shad repeat spawners, sexes combined, collected from the Potomac River, 2002–2022 (time series trend: $P = 0.097$, 10-year trend: $P = 0.858$).

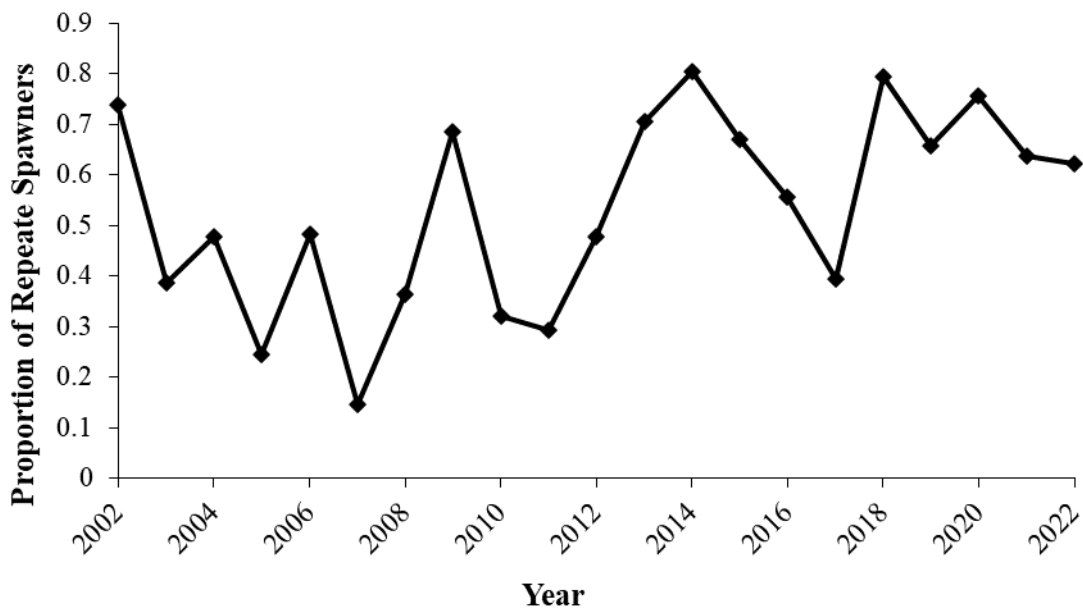


Figure 5. American shad standardized index and GM CPUE (catch per hour) from the Conowingo Dam tailrace hook and line survey, 1987–2022 (index time series trend: $P = 0.150$, index 10-year trend: $P = 0.283$). The shaded area indicates 95% confidence intervals.

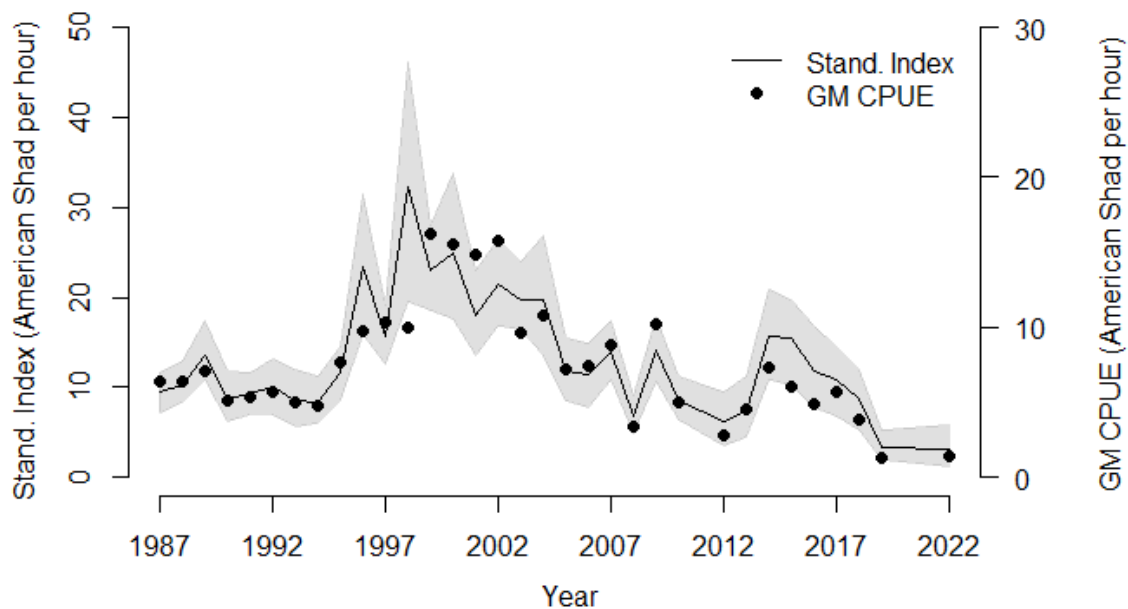


Figure 6. American shad GM CPUE (fish per lift hour), 1985–2022, and the total number of American shad lifted at the East and West Fish Lifts, 1972–2022, at the Conowingo Dam. From 1972–1990, and in 2021, only the West Fish Lift operated (time series trend: $P = 0.804$, 10-year trend: $P = 0.283$).

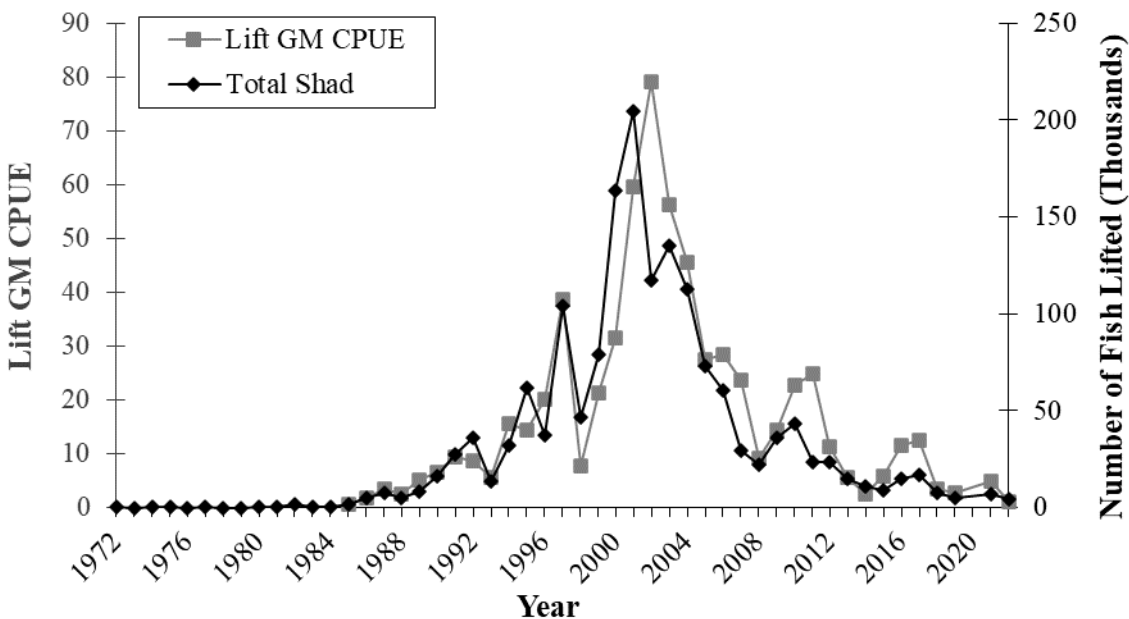


Figure 7. American shad GM CPAH (catch per angler hour) by recreational anglers in the Susquehanna River below Conowingo Dam from creel and logbook surveys, 2001–2022 (creel: time series trend: $P = 0.032$, 10-year trend: $P = 0.653$; logbook: time series trend: $P = 0.121$, 10-year trend: $P = 0.049$).

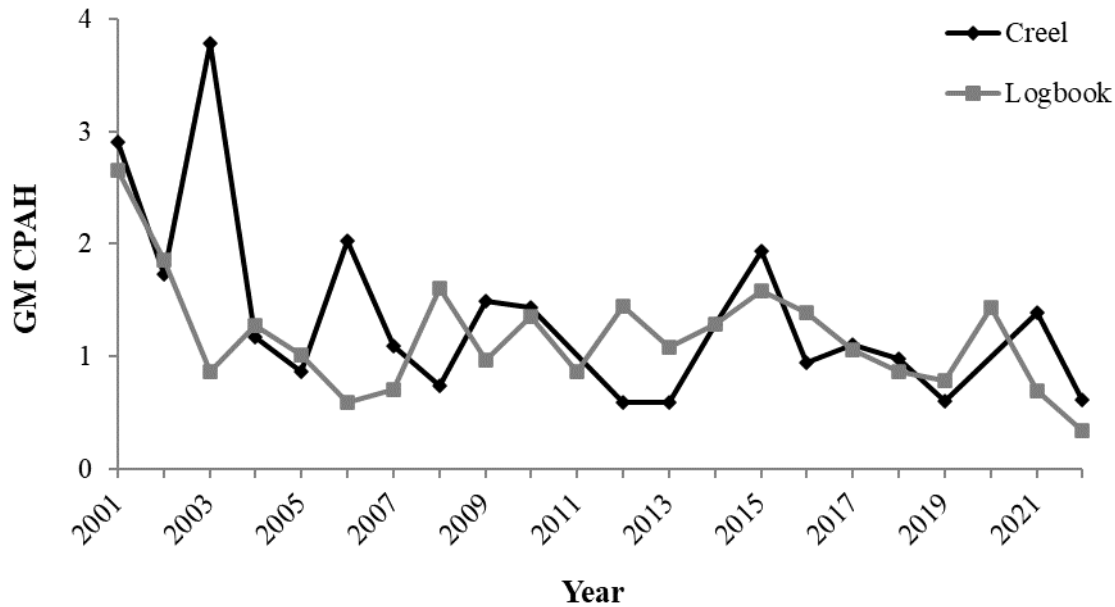


Figure 8. American shad standardized index and GM CPUE (catch per 914 m² of drift gill net per hour) in the Potomac River from the Striped Bass Spawning Stock, 1991–2022 (index time series trend: $P < 0.001$, index 10-year trend: $P = 0.012$). The shaded area indicates 95% confidence intervals.

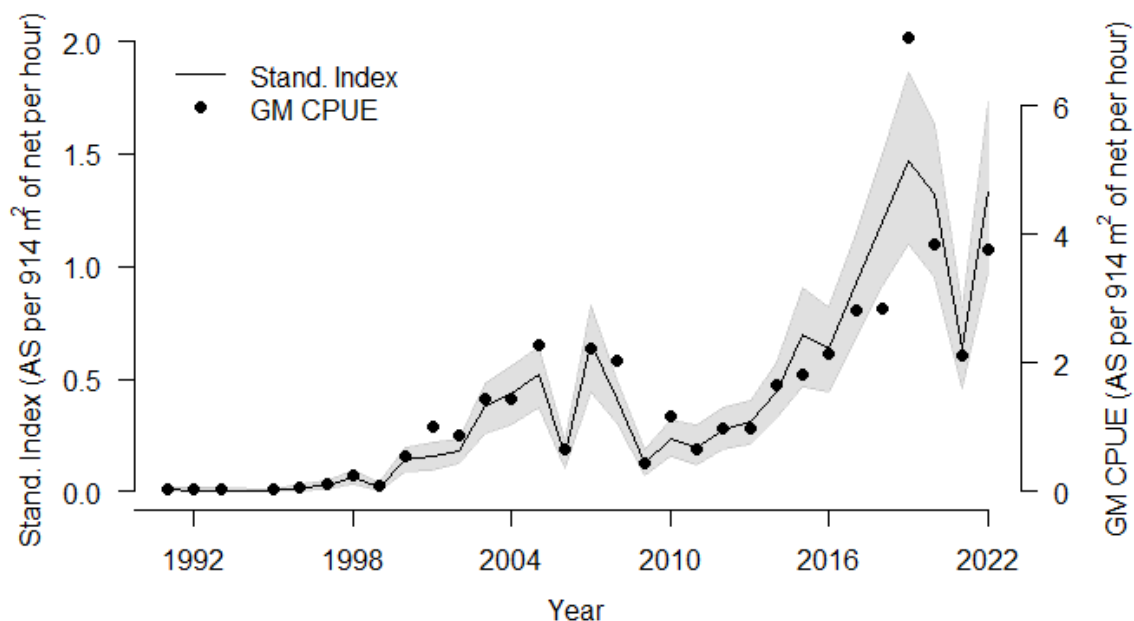


Figure 9. American shad standardized index and GM CPUE (catch per 914 m² of drift gill net per hour) in the upper Chesapeake Bay from the Striped Bass Spawning Stock Survey, 1991–2022 (index time series trend: $P = 0.003$, index 10-year trend: $P = 0.721$). The shaded area indicates 95% confidence intervals.

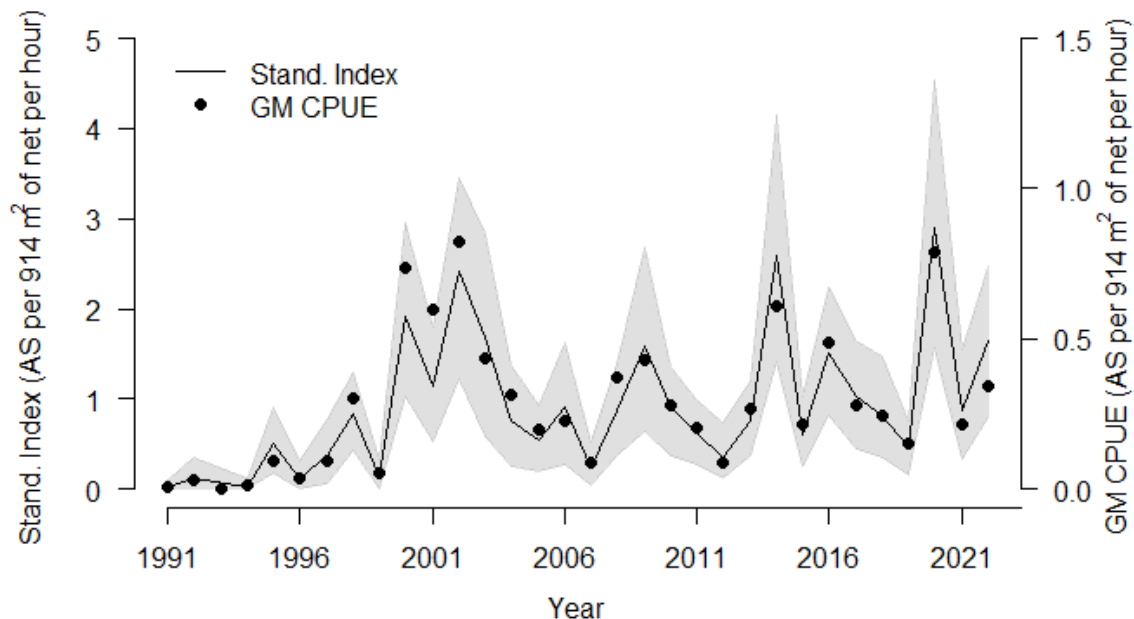


Figure 10. American shad population size, with 95% confidence limits, from the Conowingo Dam tailrace estimated using the Petersen method, 1986–2022 (time series trend: $P = 0.286$, 10-year trend: $P = 0.032$).

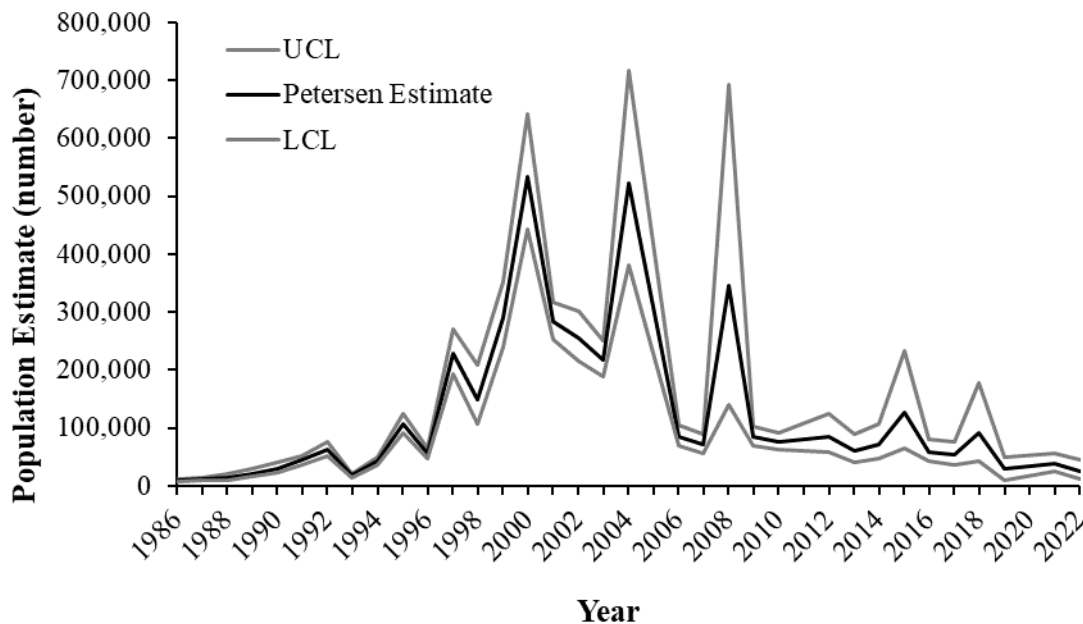


Figure 11. Percentage of tagged American shad recaptured at the Conowingo Dam fish lifts, 1986–2022 (time series trend: $P < 0.001$, 10-year trend: $P = 0.721$).

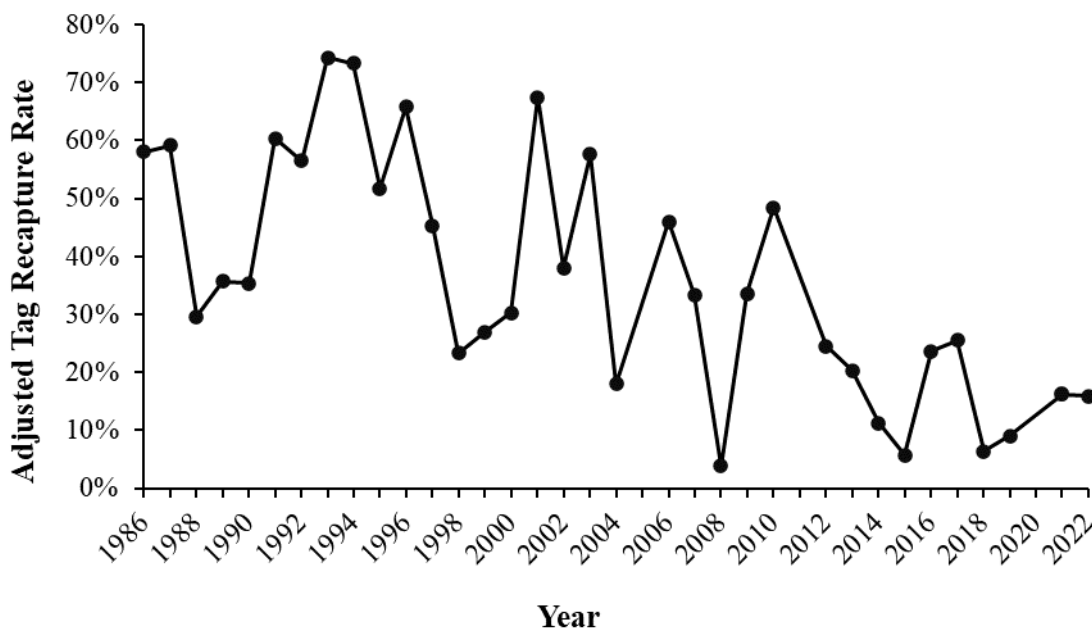


Figure 12. American shad tag recapture rates in the Conowingo Dam fish lifts as a function of gizzard shad CPUE (fish per lift hour) fit using a quasi-binomial model, 2000–2022. The shaded area indicates 95% confidence intervals.

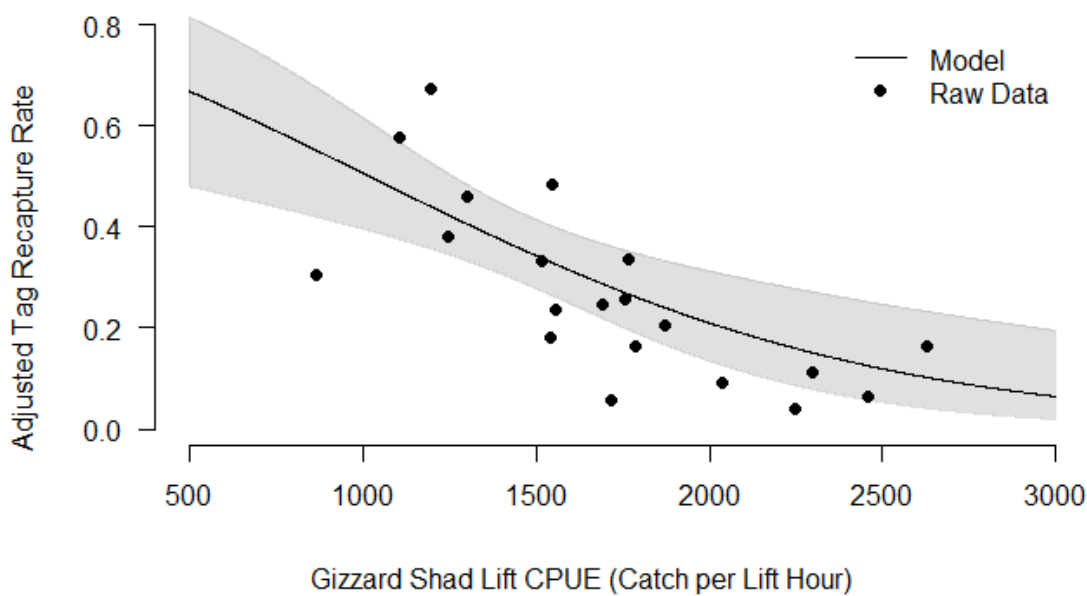


Figure 13. Age-based Chapman-Robson total instantaneous mortality (Z) estimates for American shad, sexes combined, captured in the Conowingo dam tailrace, 1984–2022. The $Z_{40\%SBPR}$ reference point was determined in the 2020 ASMFC benchmark stock assessment for American shad and is specific to the southern iteroparous region (time series trend: $P = 0.704$, 10-year trend: $P = 0.175$).

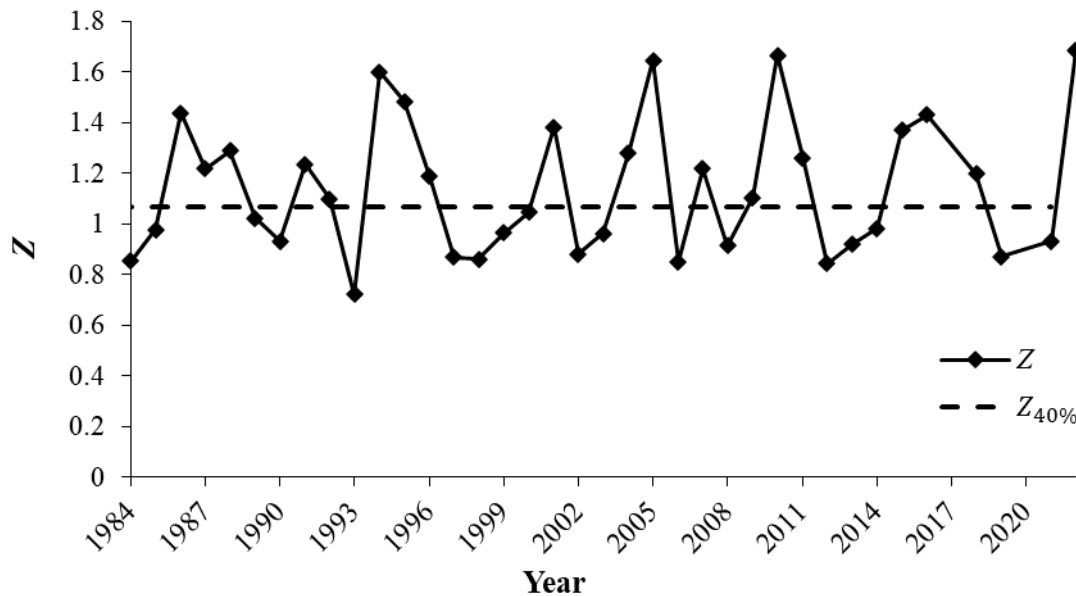


Figure 14. Age-based Chapman-Robson total instantaneous mortality (Z) estimates for American shad, sexes combined, captured in the Potomac River, 2002–2022. The $Z_{40\%SBPR}$ reference point was determined in the 2020 ASMFC benchmark stock assessment for American shad and is specific to the southern iteroparous region (time series trend: $P = 0.010$, 10-year trend: $P = 0.283$).

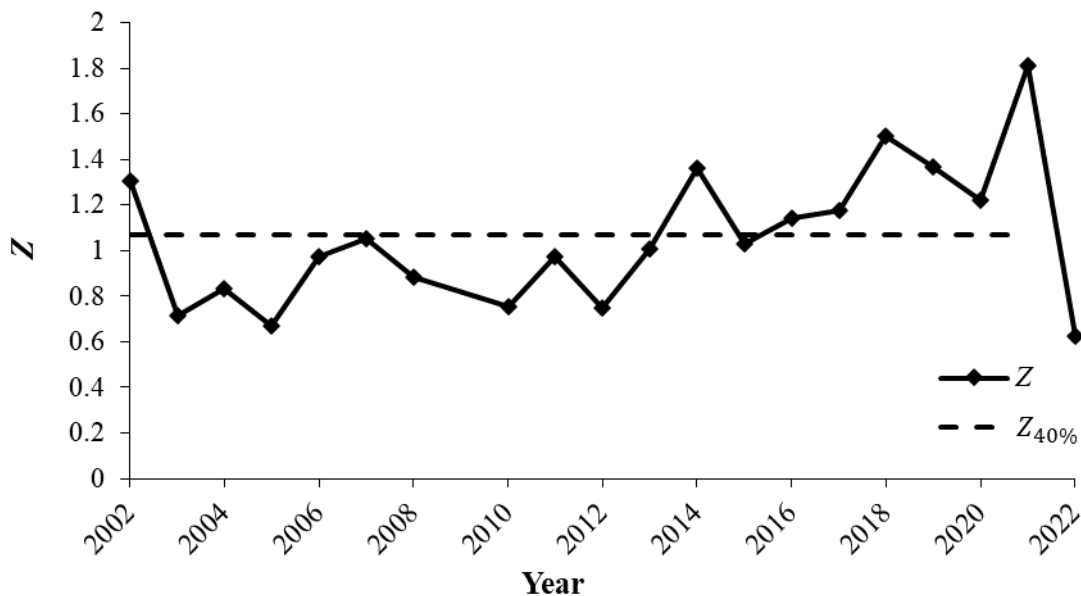


Figure 15. Juvenile American shad GM CPUE (catch per site) in the upper Chesapeake Bay from the Estuarine Juvenile Finfish Seine Survey, 1959–2022 (time series trend: $P = 0.307$, 10-year trend: $P = 0.858$). The error bars indicate 95% confidence intervals.

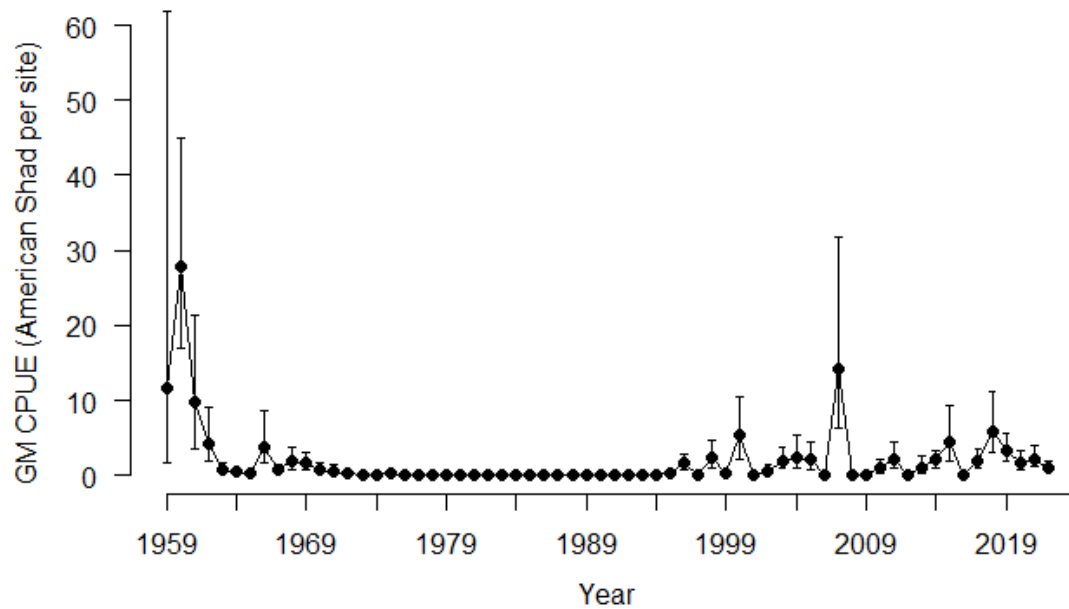


Figure 16. Juvenile American shad GM CPUE (catch per site) in the Nanticoke River from the Estuarine Juvenile Finfish Seine Survey, 1959–2022 (time series trend: $P < 0.001$, 10-year trend: $P = 0.152$). The error bars indicate 95% confidence intervals.

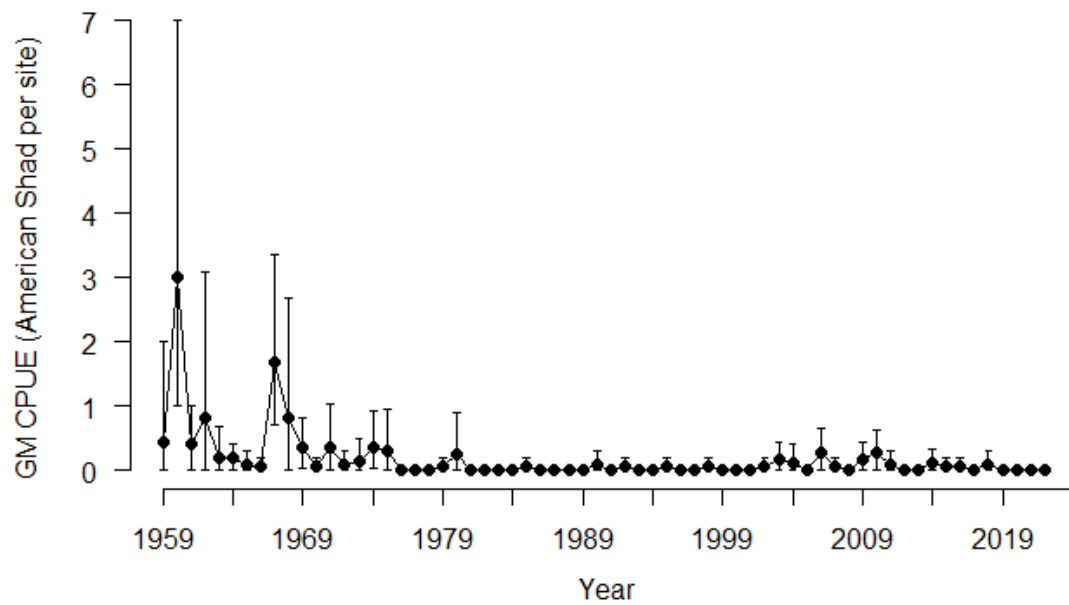


Figure 17. Juvenile American shad standardized index and GM CPUE (catch per site) in the Potomac River from the Estuarine Juvenile Finfish Seine Survey, 1959–2022 (index time series trend: $P < 0.001$, index 10-year trend: $P = 1.000$). The shaded area indicates 95% confidence intervals.

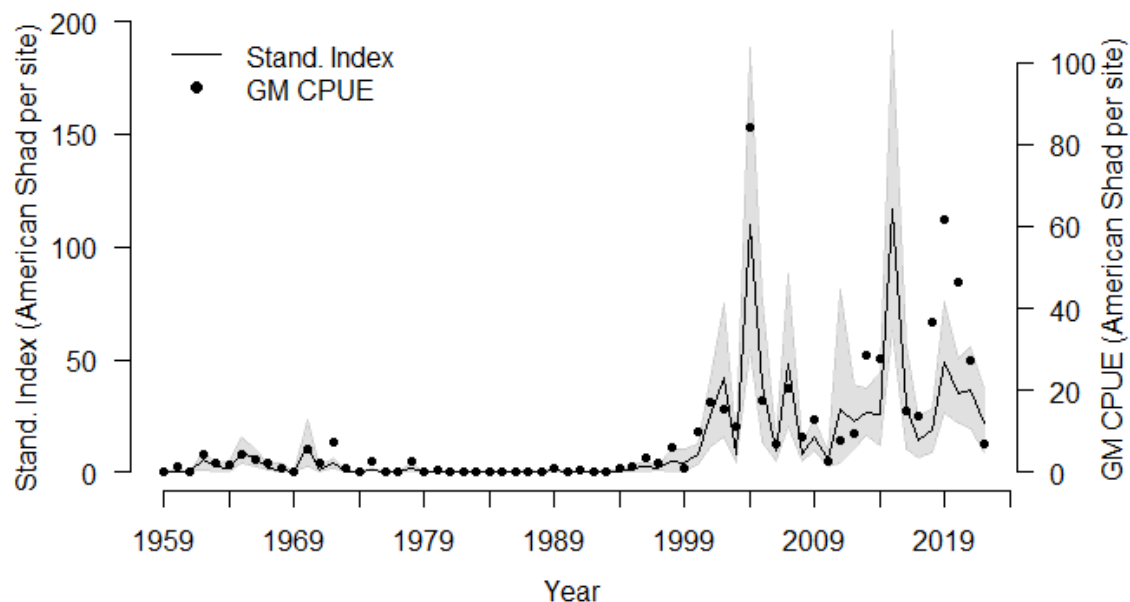


Figure 18. Proportion of hickory shad repeat spawners, sexes combined, collected from the Susquehanna River and Deer Creek (a lower Susquehanna River tributary), 2004–2022 (time series trend: $P = 0.002$).

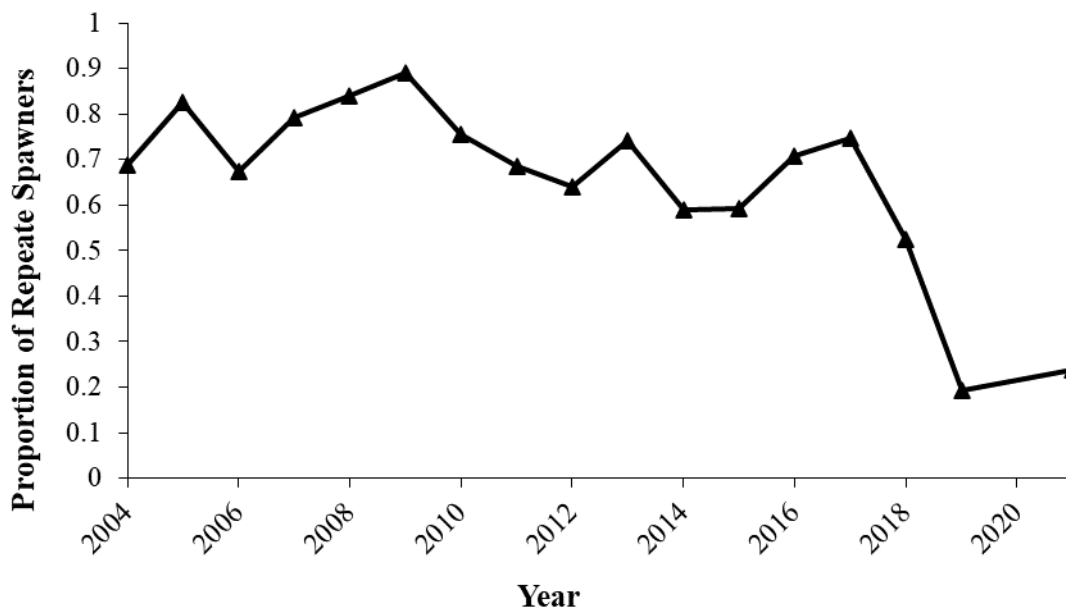


Figure 19. Hickory shad GM CPAH (catch per angler hour) by recreational anglers, measured through creel surveys (at the Conowingo Dam) and logbook surveys (throughout Maryland), 2001–2022 (creel: time series trend: $P = 0.559$, 10-year trend: $P = 1.000$; logbook: time series trend: $P = 0.554$, 10-year trend: $P = 0.371$).

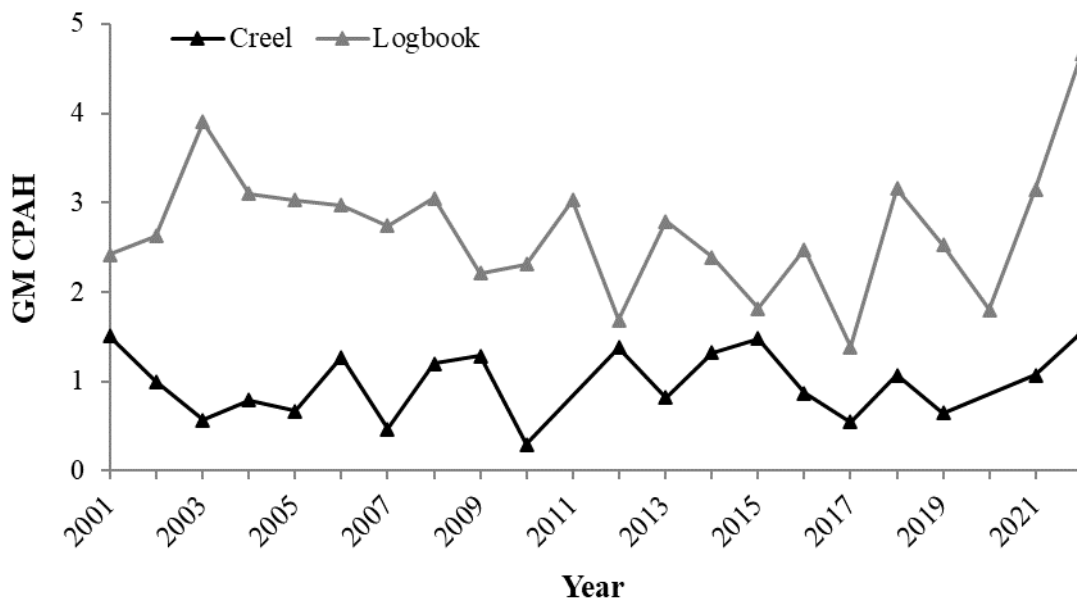


Figure 20. Hickory shad standardized index and GM CPUE (catch per 914 m² of drift gill net per hour) in the upper Chesapeake Bay from the Striped Bass Spawning Stock Survey, 1991–2022 (index time series trend: $P = 0.935$, index 10-year trend: $P = 0.474$). The shaded area indicates 95% confidence intervals.

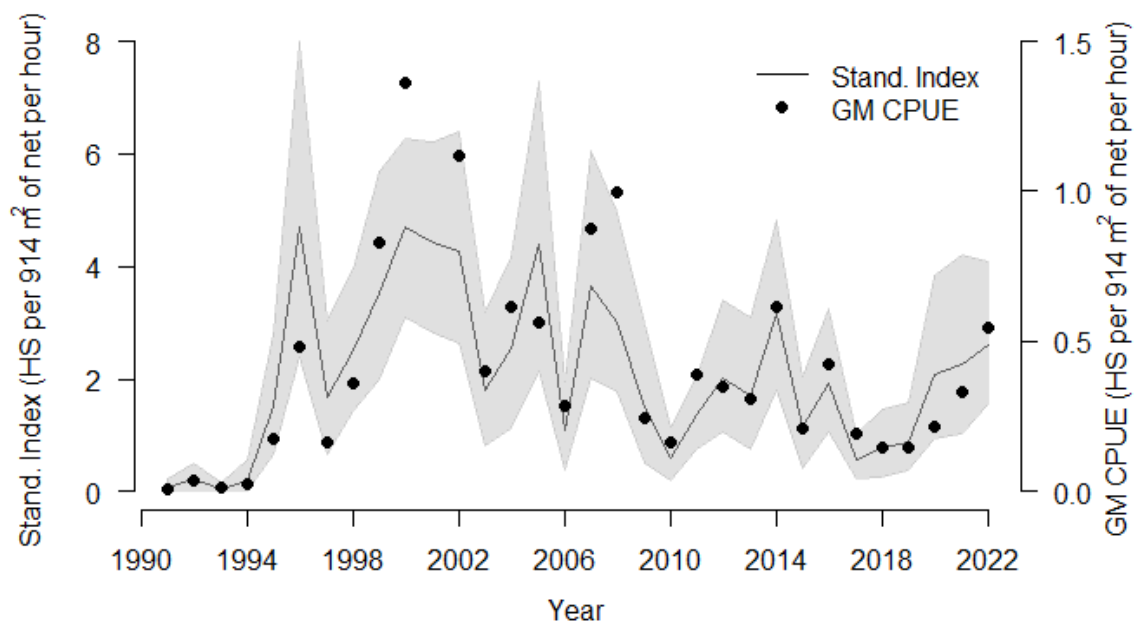


Figure 21. Age-based Chapman-Robson total instantaneous mortality (Z) estimates for hickory shad, sexes combined, captured in the Susquehanna River, 2004–2022 (time series trend: $P = 0.007$).

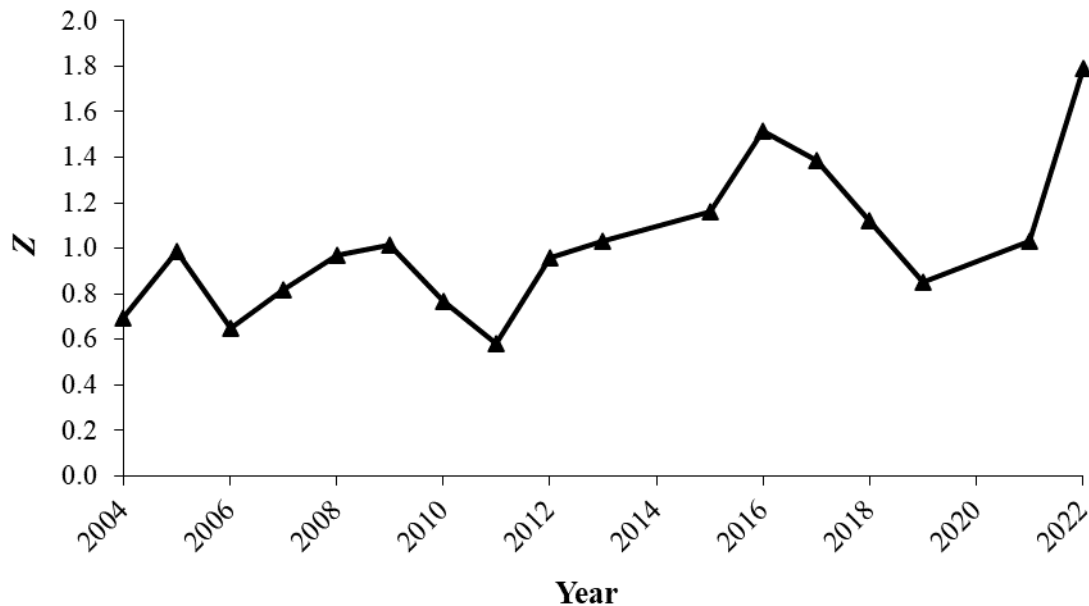


Figure 22. Proportion of alewife and blueback herring repeat spawners, sexes combined, collected from the North East River, 2013–2022 (alewife: time series trend: $P = 0.917$; blueback herring: time series trend: $P = 0.348$).

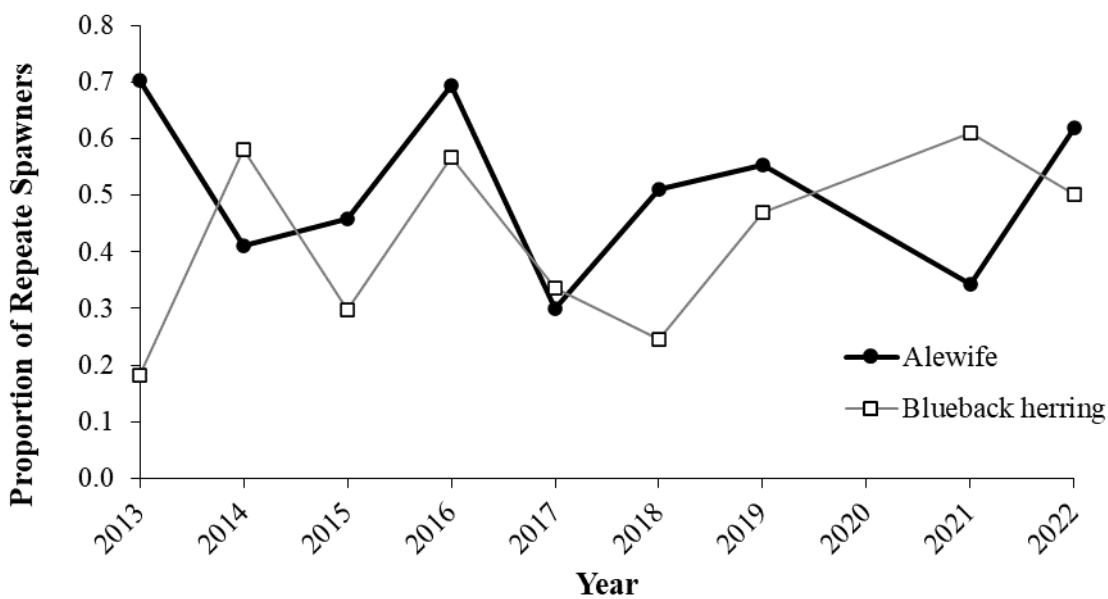


Figure 23. Alewife and blueback herring daily catch from the North East River gill net survey, plotted with surface water temperature, for 2022.

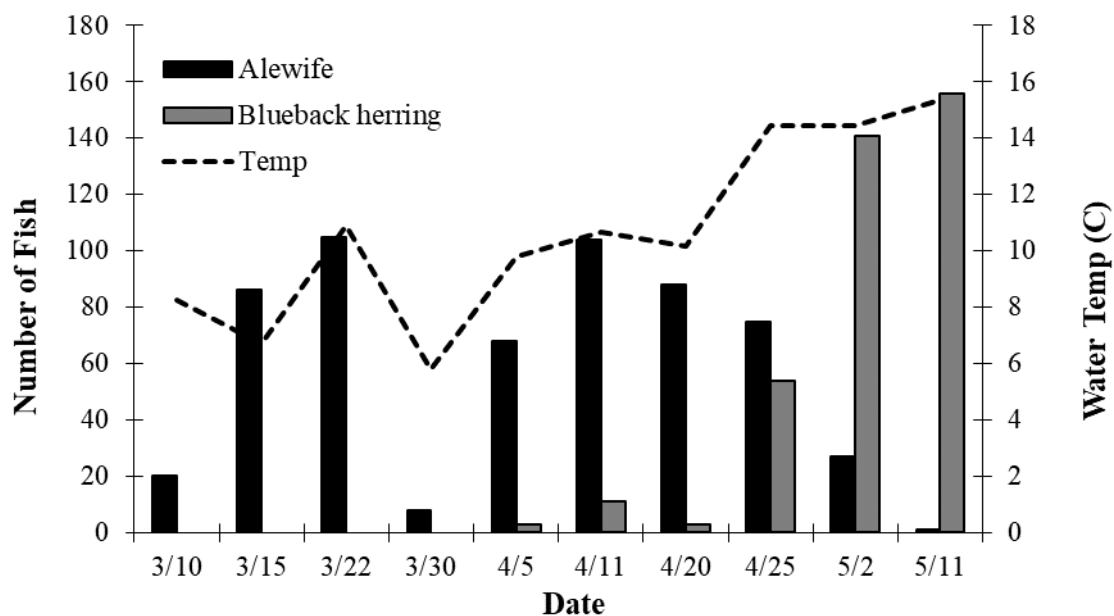


Figure 24. Alewife standardized index and GM CPUE (catch per net hour) in the North East River from the North East River gill net survey, 2013–2022. Catch was pooled across the 6.4 cm and 7.0 cm mesh panels (index time series trend: $P = 0.917$). The shaded area indicates 95% confidence intervals.

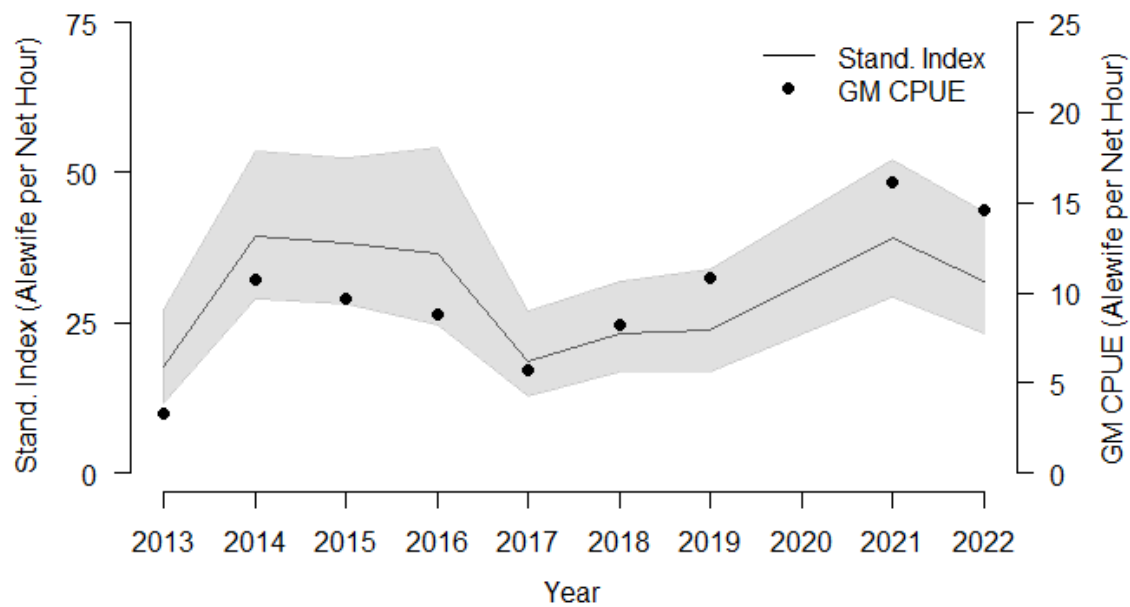


Figure 25. Blueback herring standardized index and GM CPUE (catch per net hour) in the North East River from the North East River gill net survey, 2015–2022. Catch was pooled across the 5.7 cm, 6.4 cm and 7.0 cm mesh panels (index time series trend: $P = 0.548$). The shaded area indicates 95% confidence intervals.

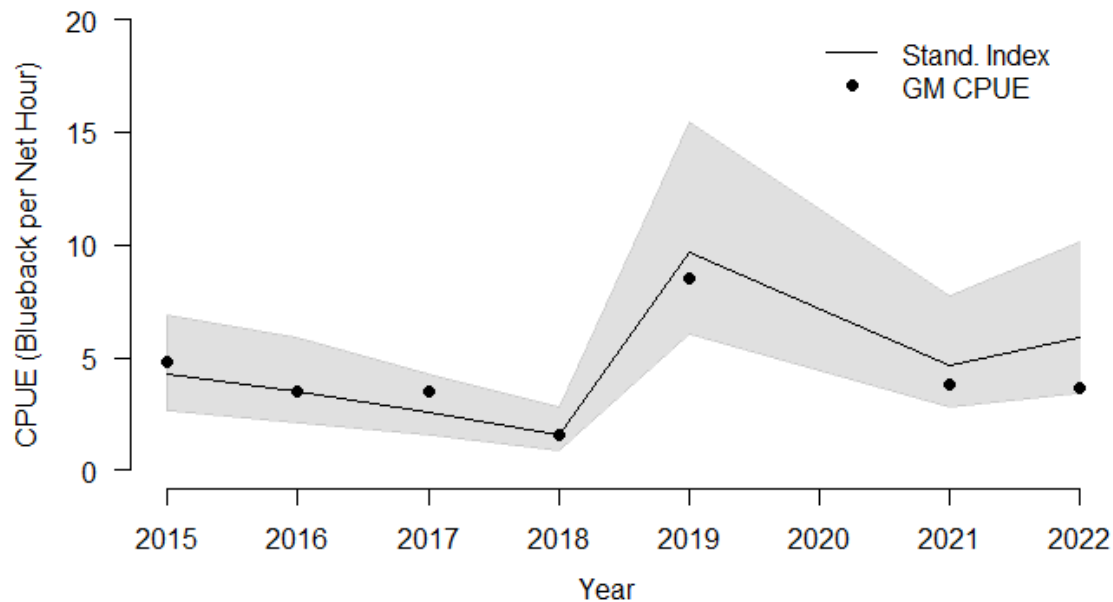


Figure 26. Cross-sectional age-based Chapman-Robson total instantaneous mortality (Z) estimates for alewife and blueback herring, sexes combined, captured in the North East River, 2013–2022 (alewife: time series trend: $P = 0.754$; blueback herring: time series trend: $P = 1.000$).

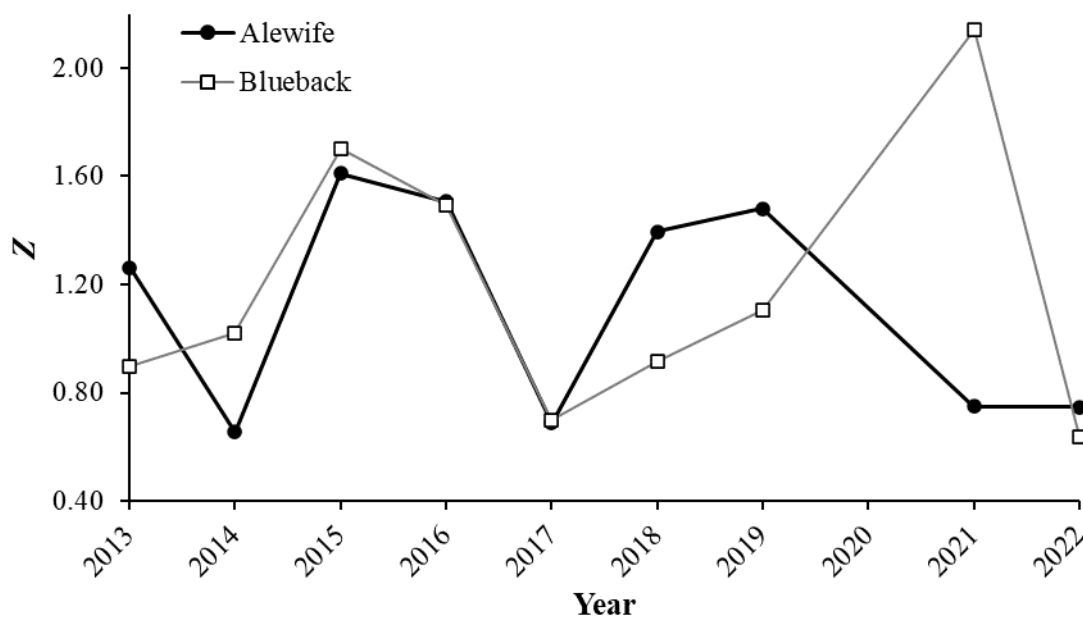


Figure 27. Longitudinal age-based Chapman-Robson total instantaneous mortality (Z) estimates for alewife and blueback herring, sexes combined, captured in the North East River, 2013–2022 (alewife: time series trend: $P = 0.035$; blueback herring: time series trend: $P = 0.711$).

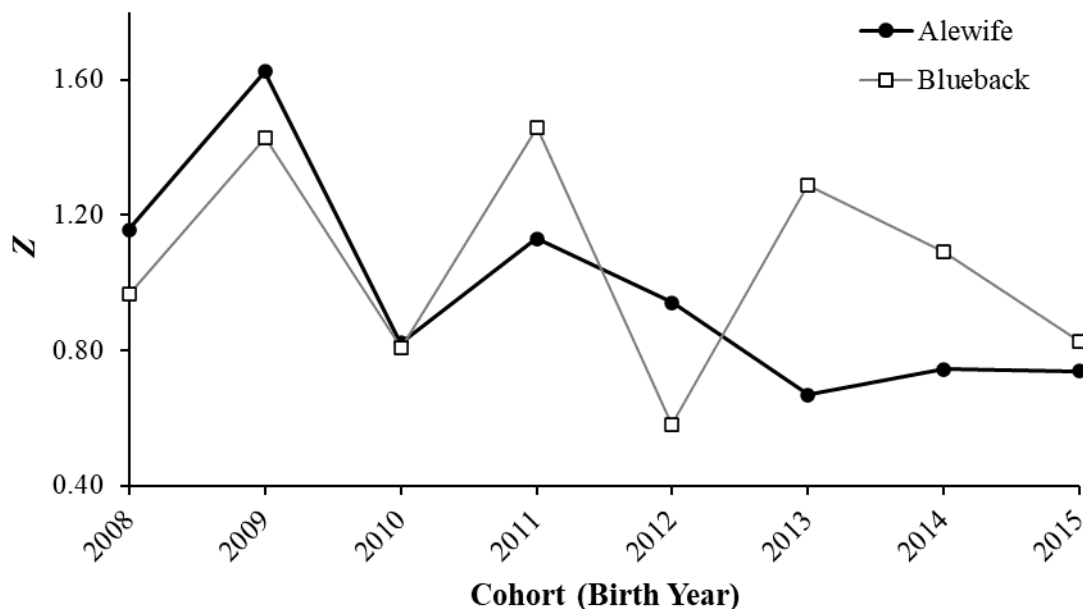


Figure 28. Juvenile alewife GM CPUE (catch per site) in the upper Chesapeake Bay from the Estuarine Juvenile Finfish Seine Survey, 1959–2022 (time series trend: $P = 0.020$, 10-year trend: $P = 0.721$). The error bars indicate 95% confidence intervals.

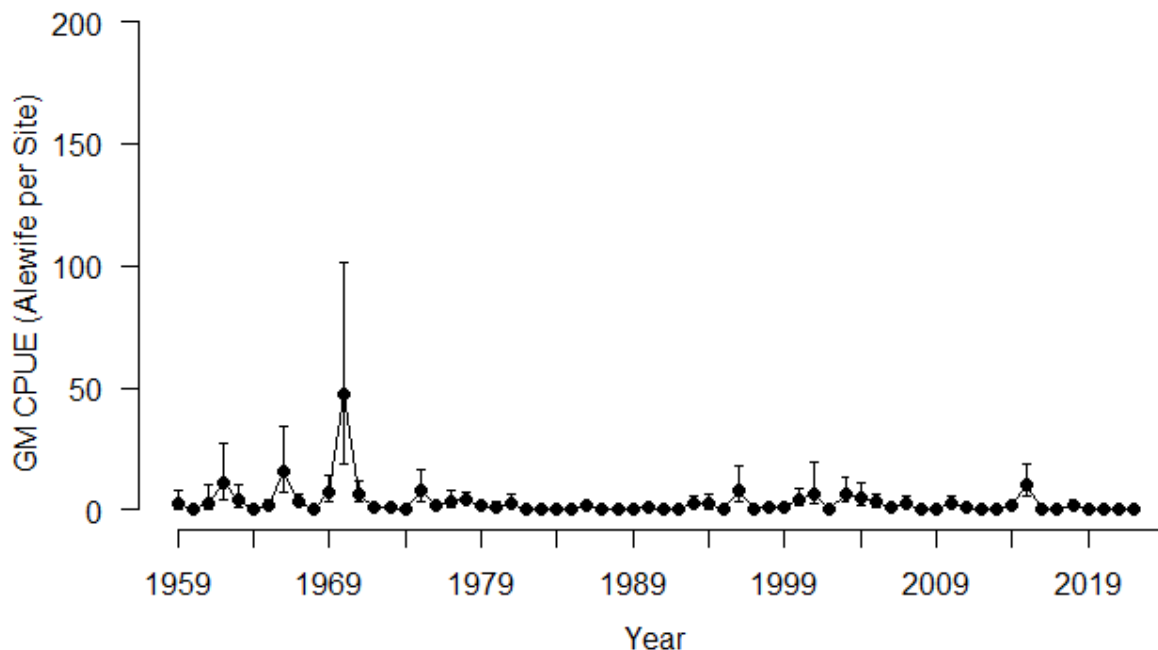


Figure 29. Juvenile blueback herring GM CPUE (catch per site) in the upper Chesapeake Bay from the Estuarine Juvenile Finfish Seine Survey, 1959–2022 (time series trend: $P = 0.123$, 10-year trend: $P = 0.721$). The error bars indicate 95% confidence intervals.

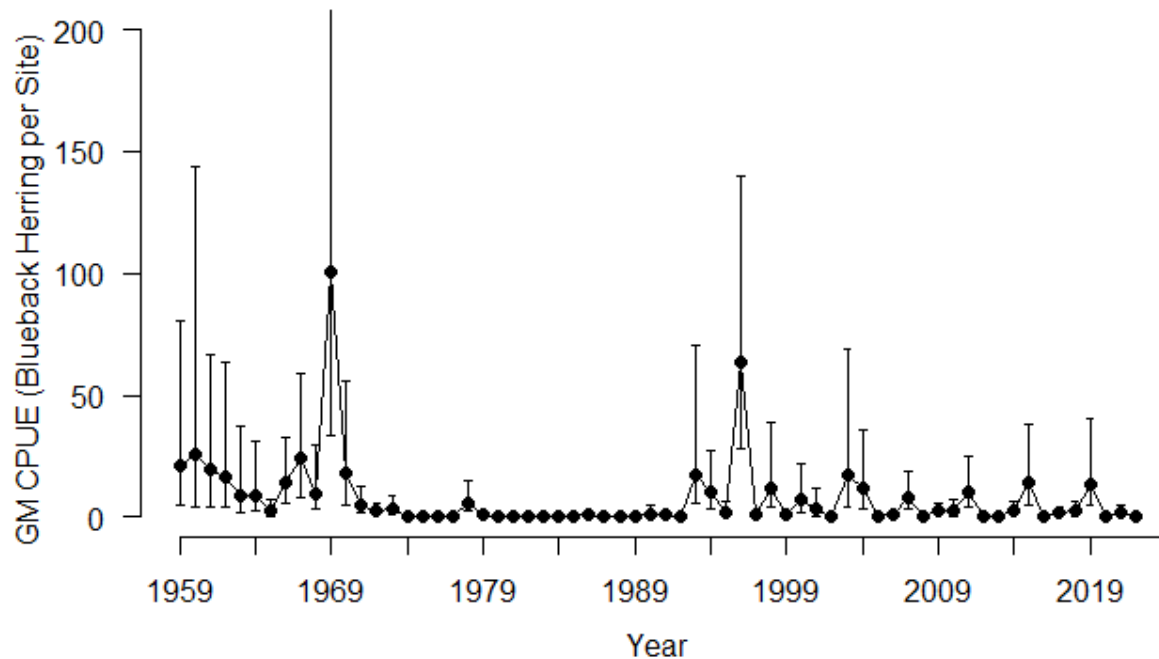


Figure 30. Juvenile alewife GM CPUE (catch per site) in the Nanticoke River from the Estuarine Juvenile Finfish Seine Survey, 1959–2022 (time series trend: $P = 0.003$, 10-year trend: $P = 1.000$). The error bars indicate 95% confidence intervals.

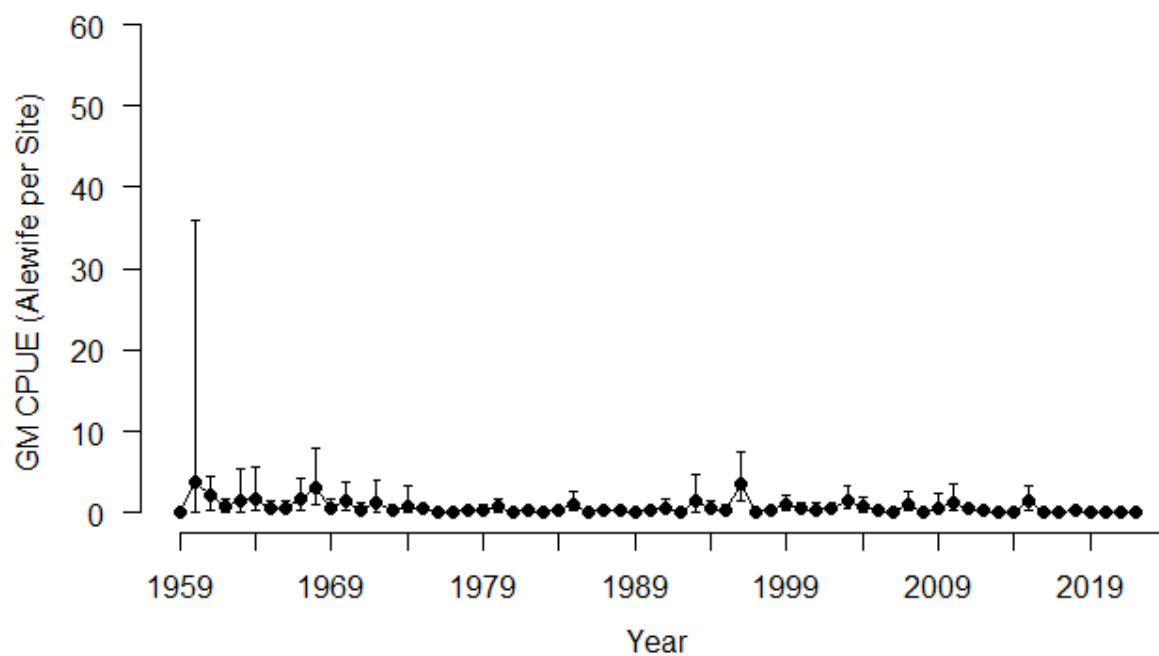


Figure 31. Juvenile blueback herring GM CPUE (catch per site) in the Nanticoke River from the Estuarine Juvenile Finfish Seine Survey, 1959–2022 (time series trend: $P < 0.001$, 10-year trend: $P = 0.592$). The error bars indicate 95% confidence intervals.

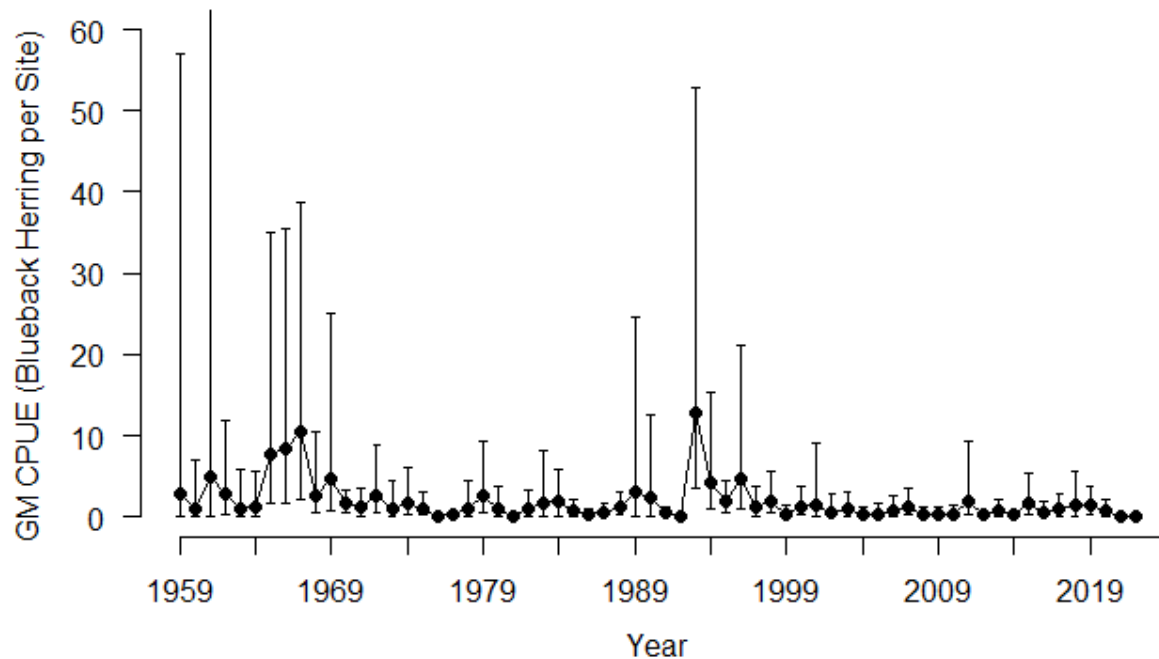


Figure 32. Juvenile alewife GM CPUE (catch per site) in the Potomac River from the Estuarine Juvenile Finfish Seine Survey, 1959–2022 (time series trend: $P = 0.008$, 10-year trend: $P = 0.650$). The error bars indicate 95% confidence intervals.

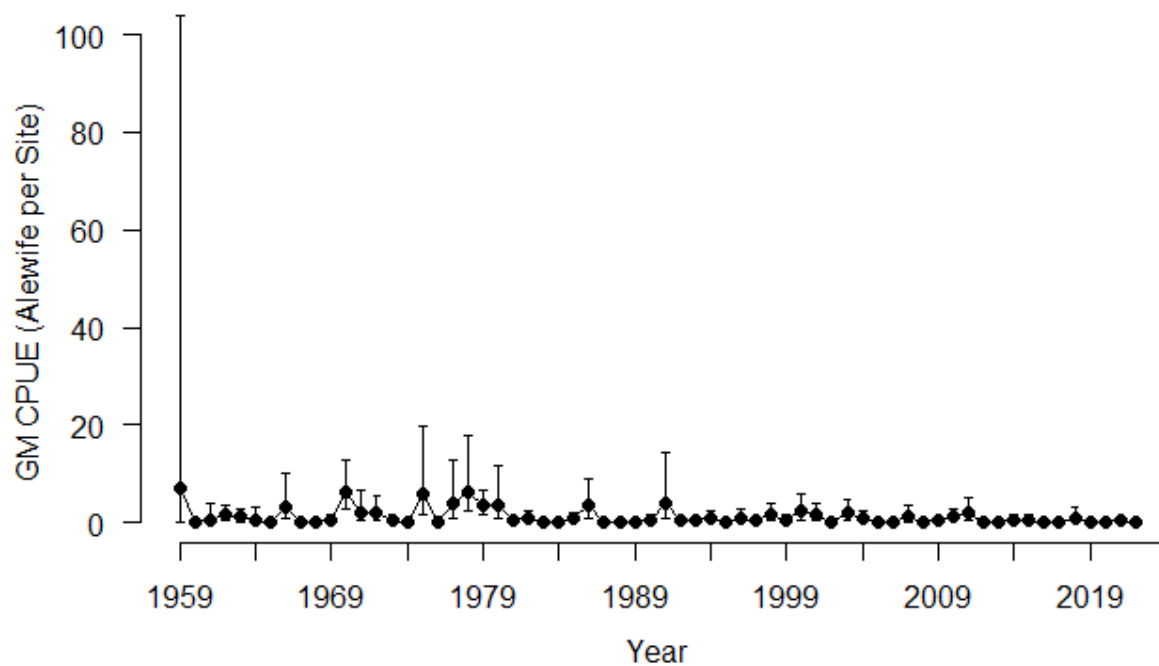
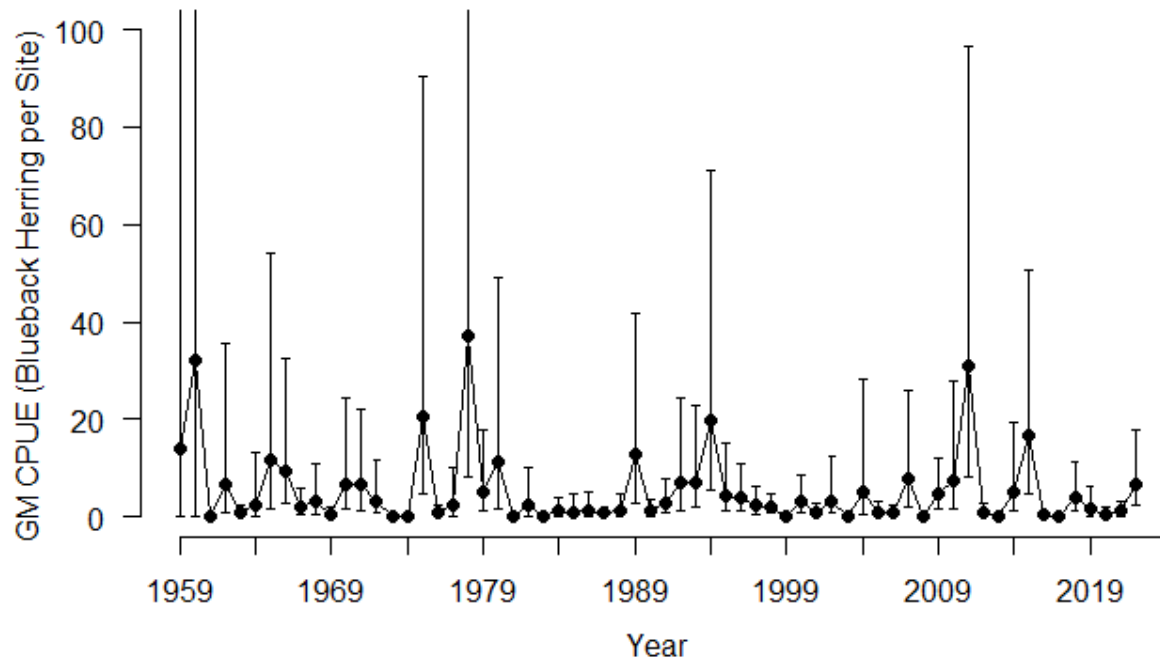


Figure 33. Juvenile blueback herring GM CPUE (catch per site) in the Potomac River from the Estuarine Juvenile Finfish Seine Survey, 1959–2022 (time series trend: $P = 0.363$, 10-year trend: $P = 0.721$). The error bars indicate 95% confidence intervals.



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 maculatus*) 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

Fishery Dependent Sampling

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 30 years of this survey (1993-2022). In 2022, 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 2022 (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 for both pound net sampling programs. No fish dealer sampling was conducted in 2022 since pound net sampling produced adequate samples of most species.

During onboard sampling, all target 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 mm total length (TL) except for Atlantic menhaden and Spanish mackerel which were measured to the nearest mm fork length (FL). Fifty randomly selected

Atlantic menhaden were measured to the nearest mm 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 2022 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 mm in diameter and 0.31 mm thick (model number 60-20070) were used. The 0.4 mm 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 biologists 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.

Fishery Independent Sampling

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 a fishery independent 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, 2021 and 2022. 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 flounder, weakfish and white perch were measured to the nearest mm TL. The first five Atlantic menhaden from each site and net panel were measured to the nearest mm 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).

Young-of-Year Sampling

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-mm-stretch-mesh and a 10-mm-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 June 2023. 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,

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

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 $L_\infty = 840$ mm TL and $K = 0.38$. L_c was 305 mm 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 $L_\infty = 380$ mm TL and $K = 0.38$, while L_c for Atlantic croaker was 229 mm 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 $L_{\infty} = 459$ mm 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 mm 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 2022. Age and length data were assigned to 20 mm 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 2022, weakfish from 2003 through 2022 and Atlantic menhaden from 2005 through 2022. Age and length data for spot were assigned to 10 mm 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 2022. It was necessary to supplement Maryland spot ages with Virginia Marine Resources Commission (VMRC) spot age data for a small number of fish greater than 270 mm 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 consisted of 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 10.8.1 software for both the Choptank River gill net and onboard pound net surveys (ArcGIS 2020).

RESULTS and DISCUSSION

The onboard pound net survey sampled the Potomac River and Chesapeake Bay from May 25, 2022 through September 25, 2022 (Table 2). All of the target species and seventeen non-target species were encountered in 2022 (Table 3). The Choptank River fishery independent gill net survey was conducted once per week from June 2, 2022 to September 2, 2022. Six of the ten target species and eight non-target species were captured in 2022 (Table 4).

Weakfish

Six weakfish were sampled in the 2022 pound net survey, a decrease from 2021, and tied with 2014 and 2020 for the lowest number sampled in the 30 year time series. Weakfish mean length in 2022 was 264 mm 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 nine years have been too small to make valid length frequency comparisons across 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 mm TL. This trend reversed from 2001 to 2022, with far fewer large weakfish being

encountered. None of the six weakfish sampled in the 2022 pound net survey were above the commercial size limit of 305 mm TL (12 inches) or the recreational size limit of 331 mm TL (13 inches).

No weakfish were captured in the Choptank River gill net survey in 2022. 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 2022 Maryland Chesapeake Bay commercial weakfish harvest of 213 pounds was an increase from 2021, but was the ninth lowest value of the 1981-2022 time series (Figure 5). The 1981 – 2022 Maryland Chesapeake Bay average commercial harvest was 37,460 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 234 pounds per year. Estimated Maryland recreational harvest from inland waters during 2022 was 1,292 fish (PSE = 101; Figure 5). The time series mean harvest for Maryland inland waters from 1981-2022 was 256,947 fish. According to the MRIP estimates, Maryland anglers released 8,196 (PSE = 87.7) weakfish from inland waters in 2022, the fourth lowest value of the 1981-2022 time series, and well below the time series mean of 264,262 fish per year. Estimated recreational harvest decreased steadily from 741,758 fish in 2000 to 763 fish in 2006, and has fluctuated at a very low level from 2006 through 2022. 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 18 to 75,011 weakfish from 1993 to 2022 (Figure 6), with a sharp decline occurring in 2003. The 2022 value of 18 fish was the lowest on record. Reported charter boat harvest slowly increased from 2014 to 2017, reaching 2,152 fish prior to a second 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 and remained low in 2022 at 1.18 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.

Six weakfish otoliths were collected in 2022 and were successfully aged, which was tied for the lowest number of ages since 2003. Two of the sampled weakfish were age one and four weakfish were age two (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 and 2020-2022 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, 2019 -2020 or in 2022 , 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 2022 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 Z estimates from the 2019 ASMFC stock assessment 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 2004-2022. Mean total lengths have ranged from the time series high of 374 mm TL in 2005 and 2010 to the time series low of 191 mm TL in 2017 (n = 394, Table 5). The mean length increased to 279 mm TL in 2022 (Table 5), the eighth lowest value of the 30 year time series. Length frequency distributions from the onboard sampling from 2004-2012 were either bimodal with peaks between 130 to 190 mm TL intervals and between 310 to 430 mm TL intervals, or more normal in distribution with a singular peak between the 310 to 430 mm TL length groups. Generally, the bimodal distribution occurs when an abundant year class recruits to the fishing gear (around 130 mm TL). The 2013, 2014 and 2021 length frequency distributions were heavily skewed toward smaller fish, with 66%, 58% and 69% below 290 mm TL, respectively (Figure 8). The 2022 distribution was bimodal with a stronger second peak at the 310 mm TL group, and a weaker peak for smaller fish at the 190 mm TL group (Figure 8). Recreational size limits have been adjusted annually, but comparing the onboard pound net survey catches to the 2022 recreational size limit of 407 mm TL indicated three of the 168 sampled flounder were of legal size. Eleven summer flounder were encountered during the Choptank River gill net survey in 2022 (Table 4), nine of which were measured, ranging from 174 to 209 mm TL. Ten specimens were captured in the 64 mm mesh and one in the 76 mm mesh. Only 32 summer flounder have been captured in the ten years of the survey.

The 2022 Maryland Chesapeake Bay commercial summer flounder harvest totaled

1,439 pounds, which was similar to the 2021 value of 1,450 pounds, and was the fourth lowest value of the 1981 – 2022 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 44,211 fish (PSE = 34.9) in 2022 decreased from the 2021 estimate, and remained well below the time series mean of 252,640 fish per year (Figure 9). The 2022 MRIP recreational inland release estimate of 615,013 fish (PSE = 23.5) increased compared to 2021's estimate (484,208 fish, PSE = 18.5), but was below the time series mean of 1,16,721 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 generally declined throughout the 1993 – 2022 time series, with the highest number harvested in 1993 (10,445 fish), the lowest in 2020 (one fish), and only 58 harvested in 2022 (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 2010-2022 averaging 151 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. An update of the assessment was completed in 2021 with a terminal year of 2019 and concluded the stock remained in a not overfished and not overfishing state, with generally below average recruitment in recent years (Personal communication NMFS <https://apps-st.fisheries.noaa.gov/sis/docServlet?fileAction=download&fileId=7413>). A second update is underway and expected to be available for management use in late 2023.

Bluefish

Bluefish sampled from the onboard pound net survey averaged 330 mm TL during 2022, the fifth highest value of the 30 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 mm 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 mm TL group), the 2020 distribution was more of a single peak centered on the 350 mm TL group, and the 2021 distribution was weakly bimodal also with the dominant peak occurring for larger fish (390 mm TL group). The 2022 distribution returned to a singular peak centered on the 330 mm TL size group, indicating a continued availability of a slightly larger grade of bluefish. 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 ten years of the Choptank River gill net survey, with 11 being captured in 2022 (Table 4). Bluefish lengths for all net panels and years combined ranged from 189 to 500 mm TL (n=73), with those from 2022 ranging from 263 to 396 mm 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 2022 was 3,422 pounds, a decrease from 2021 (4,248 pounds), the second lowest value in the 1981-2022 time series, and well below the average of 96,927 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 2022, averaging 37,180 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 2022 harvest estimate of 236,396 fish (PSE = 26.6) increased compared to 2021 (104,476 fish), the highest value since 2016, but still the 9th lowest value of the 1981-2022 time series. Estimated inland recreational releases were 217,435 fish (PSE = 33.6) in 2022, below the time series mean of 721,776 fish (Figure 13). Reported bluefish harvest from Chesapeake Bay charter boat logs ranged from 4,548 – 133,499 fish per year from 1993 to 2022, with the 2022 harvest increasing to 14,867 compared to 2021, which was the lowest harvest of the 30 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). Operational assessments were conducted by the North East Fisheries Science Center in 2019 and 2021, using the same

model structure, with data through 2018 and 2019, respectively, including the recalibrated MRIP estimates of recreational harvest. Both assessments indicated overfishing was not occurring in the terminal year, but the stock was overfished (NEFSC 2020). These findings in 2019 mandated coast wide regulation changes in 2020 to reduce harvest and rebuild the stock. The 2021 update indicated these measures need to remain in place. 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. A research assessment was scheduled for peer review at the end of 2022, but no information regarding results was available in time for inclusion in this report.

Atlantic Croaker

Atlantic croaker mean length from the onboard pound net survey was 225 mm TL in 2021 (n=973) and 2022 (n=25), the second lowest value of the 30 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 mm TL, and only seven percent of the sample over 250 mm 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 mm TL (Figure 15). The 2022 length frequency may not represent the population size structure due to low sample size, but did indicate a continued lack of larger individuals with 80% of sampled fish being under 250 mm TL.

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 11 fish being

caught in 2022. The 6.4 centimeter mesh net caught the highest proportion of Atlantic croaker in all years except 2015. The proportion of catch declined 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 due to low sample sizes in 2015 through 2022. Anecdotal reports from commercial and recreational fishermen indicated Atlantic croaker catches were unusually low from the Choptank River and northward since 2015. 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 395 pounds in 2022, which was well below the 1981 to 2022 mean of 336,830 pounds per year and was the lowest harvest value since 1991 (Figure 19). The 2022 recreational inland harvest estimate was 42,728 fish (PSE = 31.5), a decrease from 2021 (174,056 fish), and well below the 1981-2022 average of 1,108,556 fish per year. The 2022 recreational release estimate of 1,520,273 (PSE = 21.7) fish also decreased compared to 2021 (1,820,273; Figure 19) and was below the 1981-2022 average of 2,297,070 fish per year. Reported Atlantic croaker harvest from charter boats ranged from 544 – 418,313 fish per year during the 30-year time period (Figure 20). The time series low value occurred in 2022.

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 33-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 second lowest value of the time series in 2015 (0.21 fish per tow). The index value increased in 2019 to the third highest value in the time series (4.90 fish per tow), but declined steadily to 1.30 fish per tow in 2022 (Figure 21.). 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 recruitment variability can be expected.

Ages derived from Atlantic croaker otoliths from the onboard pound net survey in 2022 ranged from zero to two (n=25; Table 8). Age zero croaker accounted for 36% of sampled fish, and ages one and two each accounted for 32% of sampled fish (Table 8). Age structure in 2022 was heavily skewed to younger fish, with no age three 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 and their absence in 2022 is concerning. The high percentage of age zero fish in 2022 is likely a function of small sample size and low abundance of older fish.

Instantaneous total mortality could not be estimated for 2022 due to low sample size. Total mortality estimates for 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. Even though sample size was insufficient for a Z calculation in 2022, the continued truncation of ages makes it likely that total mortality remained high in 2022.

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. A coastwide benchmark stock assessment was initiated early 2023, with peer review projected to occur in late 2024. The 2017 review 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 2022 spot mean length from the onboard sampling of 192 mm TL was a slight increase compared to the 2021 value of 188 mm TL, and was the eleventh lowest value of the 30 year time series (Table 5). Eighty-five percent of spot encountered in the onboard pound net survey in 2022 were between 170 and 209 mm TL, indicating a truncated length frequency distribution (Figure 23). No jumbo spot (>254 mm TL) were present in the 2022 onboard sampling (n = 1,772). Abundance of jumbo spot in the survey was low for the past several years (0-3% of sample, 2005-2022). 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 - 2022, 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, with 617 encountered in 2022. 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 2022, 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 three spot were captured in the 10.2 centimeter mesh through the ten year time series (one captured in 2022). Annual length frequency distributions have been variable throughout the survey, with similar distributions in 2013,

2014, 2020 and 2022 centered on the 200 mm length group. Bimodal distributions were apparent in 2015 and 2017, and singular peak distributions were centered on the 190 mm 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 42 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 declined slowly from 2020 to 2022, with harvests of 33,585 pounds, 31,124 pound and 27,084 pounds, respectively. Recent landings were below the long term mean of 118,737 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 2022 recreational inland waters harvest estimate of 1,638,380 fish (PSE 16.5) was below the time series mean of 2,669,657 fish per year. The 2022 release estimate of 3,671,723 fish (PSE = 15.7) was a decrease from 2021, but remained above the time series mean of 2,185,399 (Figure 27). Reported spot charter boat logbook harvest from 1993 to 2022 ranged from 74,763 to 847,311 fish per year (Figure 28). The 2022 reported harvest decreased to 132,280 fish, and remained below the time series mean of 393,144 fish per year.

Spot juvenile trawl index values from 1989-2022 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 34 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, increased from 2019 through 2021, and remained high in 2022 with the value of 30.43 fish per tow being the seventh highest value of the time series.

In 2022, 95% of spot sampled from the onboard pound net survey were age one, 3% were age zero, and 2% were age two (173 ages and 1,769 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 2022, 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 plus fish, even with improved Maryland Chesapeake Bay juvenile index values, indicates spot age two plus are either not surviving to older ages or are not returning to Maryland's portion of Chesapeake Bay when reaching older ages. The juvenile index was near the long term mean in 2019 and above it from 2020 to 2022, which may lead to greater availability of age one and age two plus spot in 2023.

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. A coastwide benchmark stock assessment is scheduled to be started in 2024, with peer review projected to occur in late 2025. The 2017 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 30 years of the onboard pound net survey, with none being measured in nine years and 458 being measured in 2012 (Table 5). Fifteen red drum were measured in 2022 averaging 710 mm TL, ranging from 350 to 1,250 mm TL. Recreational anglers in Maryland are allowed one red drum between 457 and 686 mm TL (18 and 27 inches TL), none of the red drum encountered in 2022 were within the slot limit.

Maryland Chesapeake Bay commercial fishermen reported harvesting 26 pounds of red drum in 2022, compared to the 2013 spike of 2,923 pounds, and the 2003 to 2022 (the time period with consistent regulations) mean of 222 pounds per year (Figure 30). The high 2013 landings value was likely due to a large year class growing into the 457 – 635 mm TL (18 –25 inch) commercial 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 mm TL (18 inch) minimum size limit and only one fish over 686 mm TL (27 inches).

MRIP estimated no recreational harvest of red drum in 2022 for Maryland inland waters, and estimated releases were 15,382 (PSE = 84.4) red drum in 2022 (Figure 30). Recreational harvest estimates were extremely variable with zero harvest estimates for 29 of 42 years with very high PSE values most years. 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. While the released alive estimates have been highly imprecise, an estimate was made for each of the past 11 years indicating red drum have been available to Maryland inshore anglers over that time period. MRIP only generated released alive and/or harvest estimates in 13 of the previous 31 years, indicating a more sporadic availability earlier in the time series.

Maryland charter boat captains reported harvesting red drum from the Chesapeake Bay in every year from 1993-2022, except for 1996. Harvest was low for all years, ranging from zero to a high of 269 fish in 2012, with eight red drum being harvested in 2022 (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) and if the current trend of warming ocean waters continues.

Black Drum

Black drum are encountered in small numbers during the onboard pound net sampling, 7 were sampled in 2022 with a mean TL of 545 mm (Table 5). Lengths throughout the time series ranged from 137 to 1,330 mm TL. 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 mm TL (28 inch) minimum size limit. Chesapeake Bay commercial harvest was 1,970 pounds in 2022 (Figure 32). Recreational inland water harvest and release estimates from 1981 to 2022 were variable, with harvest ranging from zero (20 years) to 11,374 fish in 1983 (Figure 32). In 2021, MRIP estimated 2,945 black drum were harvested (PSE = 72.8) and 2,294 were released (PSE = 32.2). The 2021 released alive estimate was the highest in the time series, but dropped down to a more typical value in 2022. 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 8 were reported in 2022.

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 mm. The survey encountered 261 Spanish mackerel in 2022 with a mean length of 407 mm FL (Table 5). The largest samples occurred from 2005-2007, 2013, 2019-2022. No Spanish mackerel were encountered in the Choptank River gill net survey in 2022. Spanish mackerel have been encountered in four of the ten years of the survey, and three of the past five years.

The 2022 commercial harvest of Spanish mackerel in Maryland's portion of Chesapeake Bay was 5,951 pounds (Figure 34) and was above the 1981 to 2022 mean of 4,880 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 – 2022, with 11 years of zero harvest and a peak of 150,529 fish in 2021 (PSE = 29.9; Figure 34), and a 2022 value of 69,245 fish (PSE = 37.4). The 2022 release estimate of 2,894 fish (PSE = 62.9) was a decline from the time series high in 2021, and below the time series mean of 7,224 Fish per year. Estimates in most years have high PSE values, so these estimates are considered tenuous. Spanish mackerel charter boat harvest from 1993 to 2022 ranged from 53 – 10,638 fish per year, with a harvest of 4,601 fish in 2022, the fourth year in a row with values above the time series mean of 3,161 fish per year (Figure 35). Spanish mackerel are

providing a small but somewhat consistent fishing opportunity for recreational anglers in Maryland's portion of Chesapeake Bay.

Spotted Seatrout

Spotted seatrout are occasionally encountered during onboard pound net survey sampling, with annual observations ranging from zero (12 years) to 64 (2020). Nine spotted seatrout were encountered during the onboard pound net survey in 2022, with a mean TL of 508 mm (Table 5), eight of the nine were above the recreational size limit of 356 mm (14 inches) TL. No spotted seatrout were captured in the Choptank River gill net survey in 2022, with only two years in which any were captured. Commercial harvest of spotted seatrout in Maryland's portion of Chesapeake Bay has been highly variable, is likely primarily by-catch in gear targeting other species, and was 35 pounds in 2022, below the 1981 to 2022 average of 2,363 pounds (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 2022, including seven years of zero harvest, and averaged 10,190 fish per year. MRIP estimated 8,739 (PSE = 67.1; Figure 36) spotted seatrout were harvested in Maryland inland waters in 2022. Conversely, release estimates were generally higher in recent years, with the past four years being above the time series average of 71,301 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 2022 charter boat logs was 143 fish. Reported harvest ranged from 2 – 20,003 fish per year and averaged 2,405 fish per year

for the 28 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 2022 was 214 mm FL (n = 1,132), the second lowest value of the 19 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 mm size groups. The 2019 distribution was bimodal and heavily skewed toward smaller fish, but 2021 and 2022 were more evenly distributed with peaks at the 170 and 210 mm length groups.

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 2022 catch was 1,921 fish, above the 10-year mean catch of 1,740 fish per

year. 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 2022, with the exception of 2021, which had a similar value 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 through 2022. 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 mm 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 mm FL group, but a lesser peak occurred at the 190 mm FL group. The 2020 distribution peaked at the 210 mm length group with the 230 and 250 mm groups being the next most abundant. The distribution shifted to small fish in 2021 and 2022 with the 210 mm length group accounting for 42% and 39% of measured fish, respectively. Prior to 2020 mean lengths for all meshes combined displayed little inter-annual variation, with values between 254 and 257 mm FL for five of the years and a value of 243 mm FL in 2017 and 2019 (Table 10). The 2020, 2021 and 2022 values declined to 235, 226 and 231 mm FL, respectively.

Atlantic menhaden scale samples were taken from 325 fish from the onboard pound net survey in 2022, but ages could only be assigned to 309 fish (Table 11). After applying the 2022 length frequency (1,131 lengths in 2022) to the age length key, 35% of

sampled fish were age one, 36% were age two and 17% were age three, 10% were age four, 2% were age five and <1% were age 6 (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 2022 compared to the method used in previous years. One hundred thirty scale samples were taken and 117 were successfully aged from the Choptank River gill net survey in 2022. Age two accounted for 41%, age one accounted for 17%, age three accounted for 24%, age four accounted for 15%, and age five accounted for 3% 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 four years than previous four 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 2.9 million pounds from 2017 to 2022, with a 2022 value of 3,339,671 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 2022, 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 was completed in 2022 that indicated the stock was still not overfished and overfishing was not occurring (ASMFC 2022), that fishing mortality had decreased, and fecundity had increased in 2020 and 2021.

PROJECT NUMBER 2
JOB NUMBER 2

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

2023 PRELIMINARY RESULTS – WORK IN PROGRESS

Onboard pound net survey sampling, through the 2023 portion of the reporting period, was conducted on May 23, May 30, June 6, June 13, June 19 and June 27, 2023, with one or two nets sampled each day. During these trips the survey took length measurements from four American shad, 331 Atlantic menhaden, three black drum, one blueback herring, 156 bluefish, one channel catfish, four hickory shad, 25 red drum, 12 summer flounder, 13 Spanish mackerel, 703 spot, eight spotted seatrout and 103 striped bass. Subsamples for aging were collected from 150 Atlantic menhaden, 57 spot and 44 striped bass. Sampling continued into the next reporting period.

Two cooperating fishermen were contracted for the 2023 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 2023 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 5, 2023 to June 28, 2023. The survey caught 457 Atlantic menhaden, one bluefish, one butterfish, three hogchoker, 21 spot and 34 white perch. Scale samples were collected from 40 Atlantic menhaden for age analysis. Sampling continued into the next reporting period.

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Table 1. Total number of sets and number of sets per month by year for the Choptank River gill net survey, 2013 - 2022.

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
2022	16	16	16	4	52

Table 2. Areas sampled, number of sampling trips, mean surface water temperature and mean surface salinity by month for 2022 commercial pound net sampling.

Area	Month	Number of Samples	Mean Water Temp. C	Mean Salinity (ppt)
East Bay	May	3	19.3	11.0
East Bay	June	6	22.6	11.6
West Bay	June	2	23.2	11.7
Point Lookout	June	3	24.8	11.3
Point Lookout	July	2	26.9	12.8
West Bay	July	2	26.6	13.0
Upper Bay	July	1	26.3	8.2
Point Lookout	August	2	27.1	15.1
East Bay	August	1	28.5	14.9
West Bay	August	3	27.5	13.6
Upper Bay	August	1	27.5	N/A
Point Lookout	September	2	24.5	16.4
East Bay	September	1	24.3	15.8
West Bay	September	2	25.4	16.6
Upper Bay	September	1	24.6	11.5
Point Lookout	October	1	16.5	17.1
Upper Bay	October	1	16.1	11.9
Point Lookout	November	1	11.2	16.8

Table 3. List of non-target species observed during the 2022 onboard pound net survey.

Common Name	Scientific Name
Atlantic cutlassfish	<i>Trichiurus lepturus</i>
Atlantic needlefish	<i>Strongylura marina</i>
Atlantic spadefish	<i>Chaetodipterus faber</i>
Butterfish	<i>Peprilus triacanthus</i>
Cownose ray	<i>Rhinoptera bonasus</i>
Crevalle jack	<i>Caranx hippos</i>
Florida pompano	<i>Trachinotus carolinus</i>
Gizzard shad	<i>Dorosoma cepedianum</i>
Harvestfish	<i>Peprilus alepidotus</i>
Hogchoker	<i>Trinectes maculatus</i>
Lookdown	<i>Selene vomer</i>
Northern kingfish	<i>Menticirrhus saxatilis</i>
Northern puffer	<i>Sphoeroides maculatus</i>
Southern stingray	<i>Dasyatis americana</i>
Striped bass	<i>Morone saxatilis</i>
Striped burrfish	<i>Chilomycterus schoepfi</i>
White mullet	<i>Mugil curema</i>

Table 4. Total catch by species in numbers from the Choptank River gill net survey, 2013 – 2022.

Common Name	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Atlantic Croaker	476	269	21	32	53	8	43	45	48	11
Atlantic Menhaden	1,584	2,247	1,782	1,171	1,292	2,257	2,045	1,866	1,234	1,921
Black Drum	0	0	0	1	0	0	0	0	0	0
Blue Catfish	0	0	0	0	0	0	2	0	0	0
Blue Crab	34	44	165	127	107	107	103	157	101	153
Bluefish	11	22	7	3	3	11	3	1	1	11
Butterfish	0	2	2	0	0	1	0	5	13	0
Channel Catfish	0	0	0	0	0	1	3	0	2	1
Cownose Ray	0	1	0	0	0	2	0	0	1	0
Gizzard Shad	180	231	188	36	28	12	42	19	11	36
Harvestfish	0	0	0	2	2	13	2	7	0	3
Hickory Shad	0	0	0	0	1	3	0	0	0	0
Hogchoker	3	39	6	6	14	5	14	20	25	12
Horseshoe Crab	0	0	0	0	0	3	1	0	0	0
Northern Kingfish	1	9	0	1	1	0	0	3	1	1
Oyster Toadfish	0	0	0	0	0	0	1	0	0	0
Spanish Mackerel	0	0	0	1	0	6	7	3	0	0
Spot	272	749	222	109	298	154	389	812	568	607
Spotted Seatrout	0	0	0	0	0	0	6	2	0	0
Striped Bass	16	33	14	50	79	103	48	26	24	21
Summer Flounder	2	0	0	2	5	4	0	2	6	11
Weakfish	0	0	1	3	1	3	4	2	1	0
White Catfish	0	0	0	0	0	0	3	0	1	0
White Perch	18	41	55	64	67	8	32	20	7	94
Total Catch	2,597	3,687	2,463	1,608	1,951	2,701	2,748	2,990	2,044	2,882

Table 5. Mean length (mm TL, unless otherwise noted), standard deviation, and sample size of summer migrant fishes from Chesapeake Bay onboard pound net sampling, 1993-2022.

Year	Weakfish			Summer flounder			Bluefish		
	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
2022	264	11	6	279	69	168	330	43	603

Table 5. Continued.

Year	Atlantic croaker			Spot			Spotted Seatrout		
	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
2022	225	41	25	192	14	1,772	508	86	9

Table 5. Continued.

Year	Black Drum			Red Drum			Menhaden (Fork Length)		
	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	916	368	23	215	38	1,359
2022	545	353	7	710	404	15	214	41	1,132

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
2022				407	73	261

Table 6. Weakfish catch at age (%) from annual age length keys, number of age samples and number of length samples by year, using onboard pound net survey data, 2003-2022.

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
2022	33.33	66.67			6	6

Table 7. Atlantic croaker and weakfish instantaneous total mortality rate estimates (Z) from Chesapeake Bay pound net data, 1999–2022.

		Growth parameters From MD only	Growth 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
2022	*	*	*

* Insufficient sample size to calculate 2006 – 2012, 2014 - 2021 weakfish estimates or a 2022 Atlantic croaker estimate.

Table 8. Atlantic Croaker catch at age (%) from annual age length keys, number of age samples and number of length samples by year, using onboard pound net survey data, 1999-2022.

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
2022	36.00	32.00	32.00												25	25

Table 9. Spot catch at age (%) from annual age length keys, number of age samples and number of length samples by year, using onboard pound net survey data, 2007-2022.

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
2022	3.27	95.23	1.54			173	1769

Table 10. Atlantic menhaden mean length (mm FL), standard deviation, and sample size from the Choptank River gill net survey, 2013- 2022.

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
2022	231	36	443

Table 11. Atlantic menhaden catch at age (%) from annual age length keys, number of age samples and number of length samples by year, using onboard pound net survey data, 2005-2022.

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
2022		34.84	35.56	17.06	9.67	2.43	0.44		309	1131

Table 12. Atlantic menhaden catch at age (%) from annual age length keys, number of age samples and number of length samples by year, using Choptank River gill net survey data, 2015-2022.

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
2022		17.25	41.45	23.61	15.16	2.53			117	443

Figure 1. Onboard pound net survey sampling site locations for 2022.



Figure 2. The Choptank River gill net survey sampling site locations for 2022.

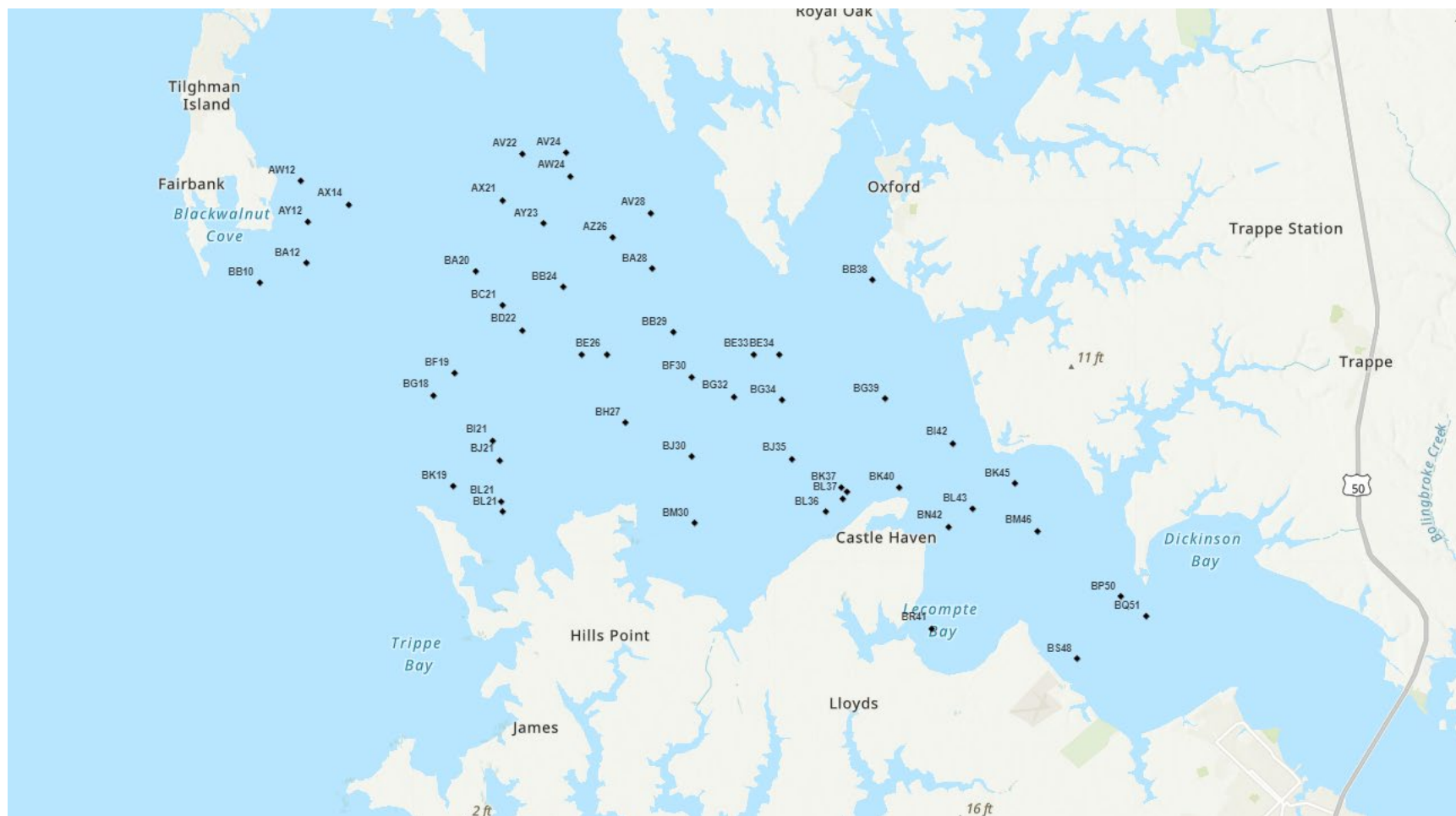


Figure 3. The Choptank River gill net survey sampling grid and grid names used in all years of the survey.

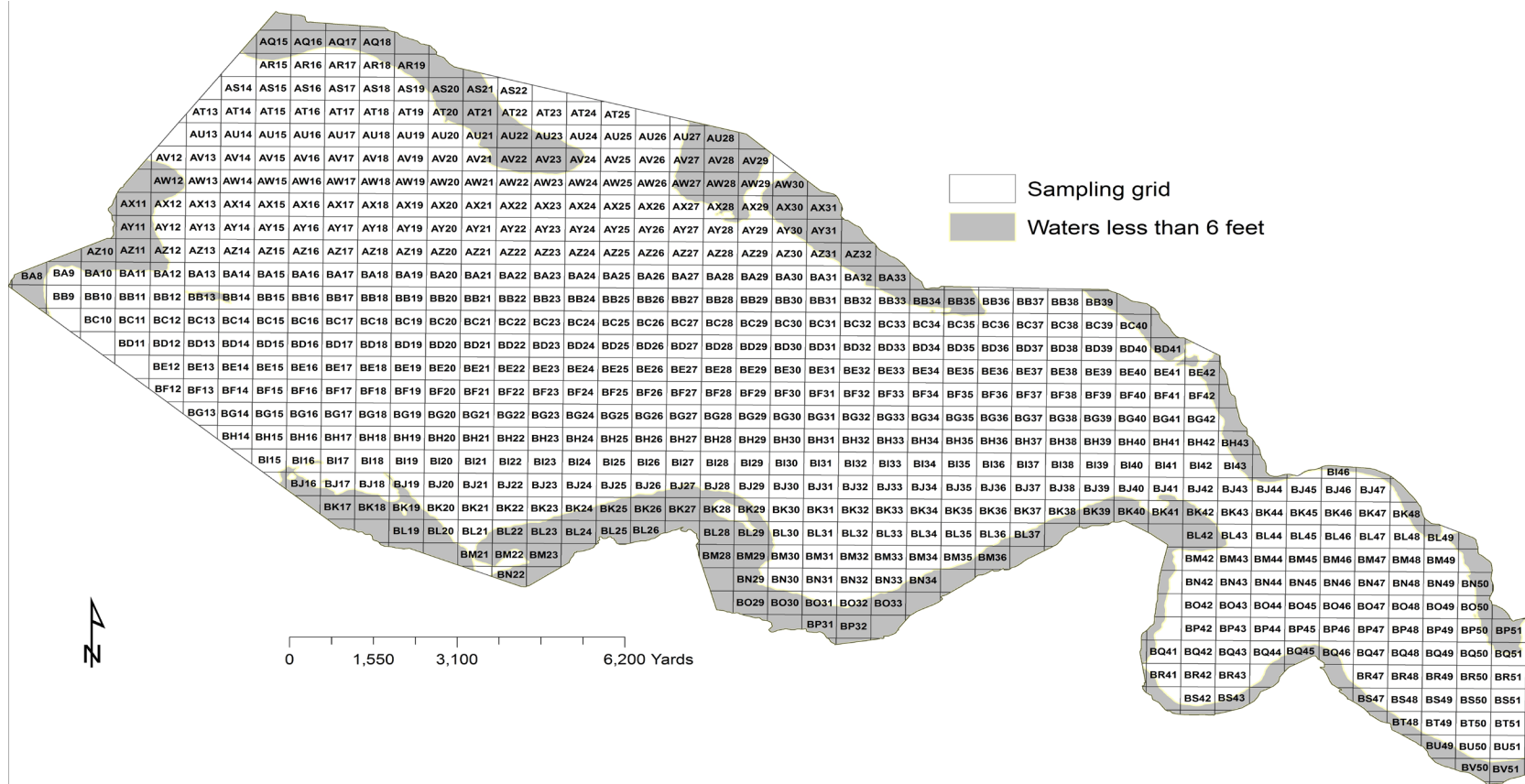


Figure 4. Weakfish length frequency distributions from onboard pound net sampling, 2013-2022. Note: In 2018 the 270 mm length group was truncated to preserve scale, actual value is 44%.

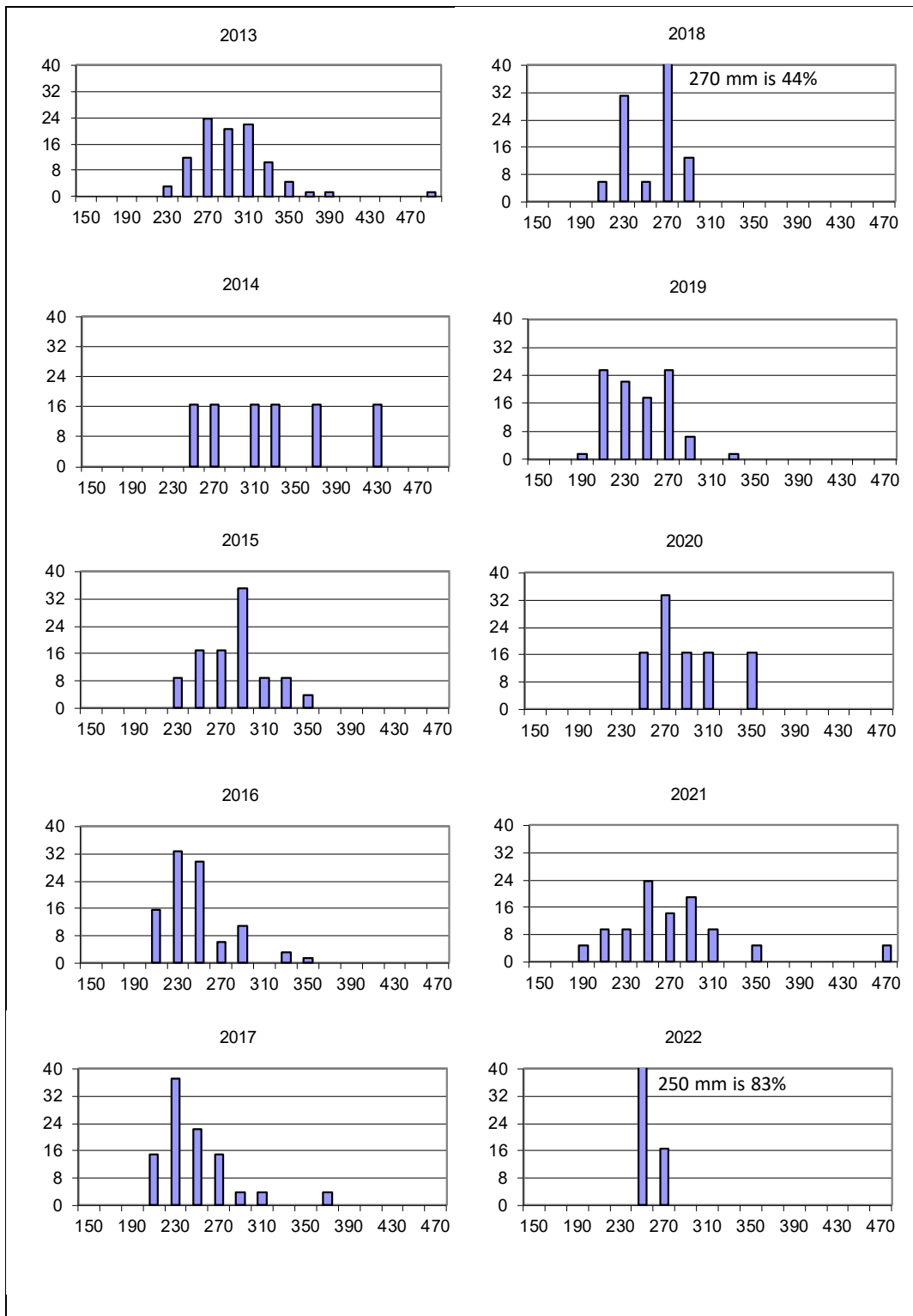


Figure 5. Maryland's commercial landings of weakfish in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational weakfish harvest and release estimates in numbers from 1981-2022.

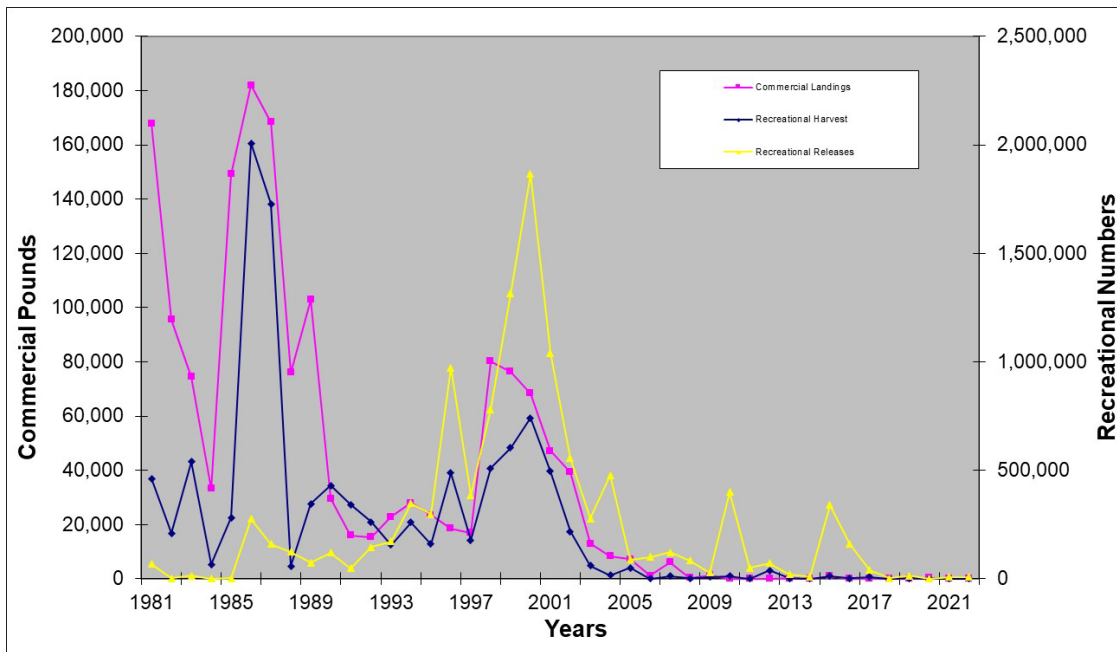


Figure 6. Maryland charter boat log book weakfish harvest in numbers and the number of anglers participating in trips catching weakfish, 1993-2022.

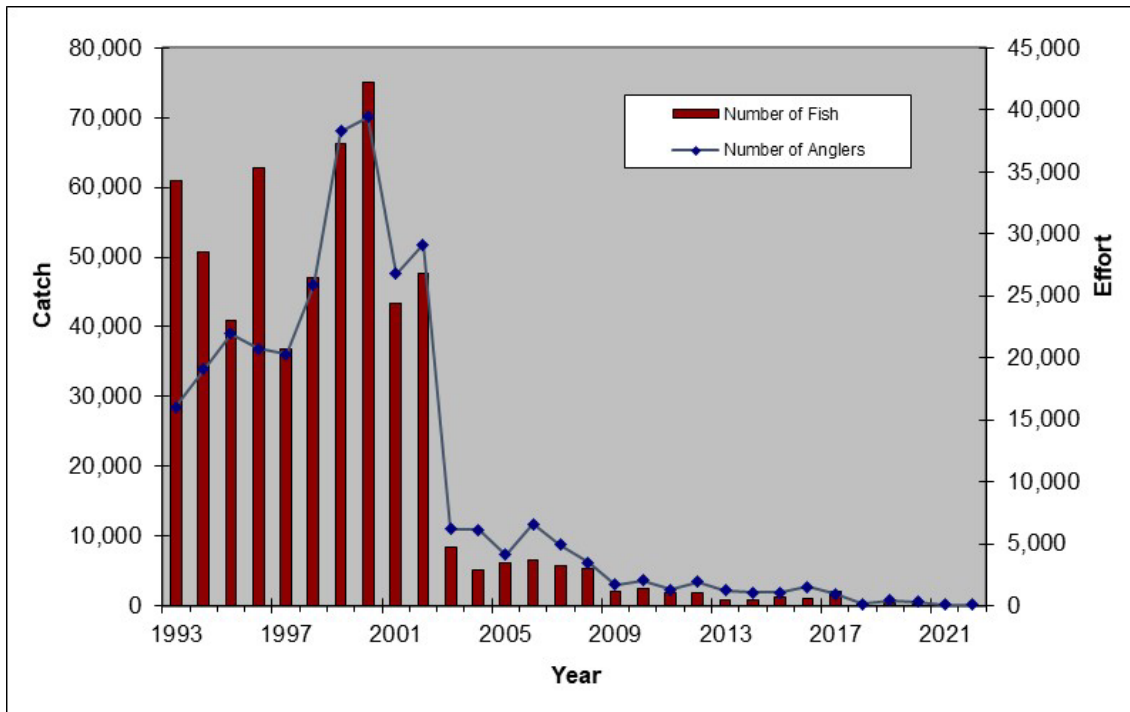


Figure 7. Maryland juvenile weakfish geometric mean catch per trawl, 95% confidence intervals and time series mean for Maryland's lower Chesapeake Bay, 1989-2022.

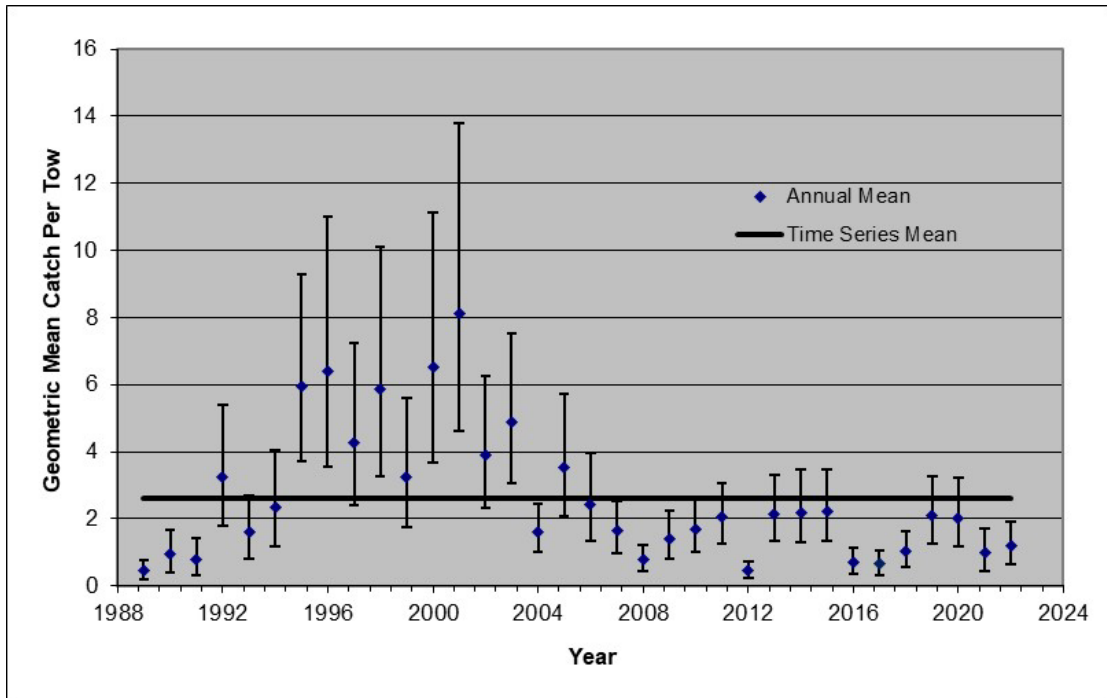


Figure 8. Summer flounder length frequency distributions from onboard pound net sampling, 2013-2022.

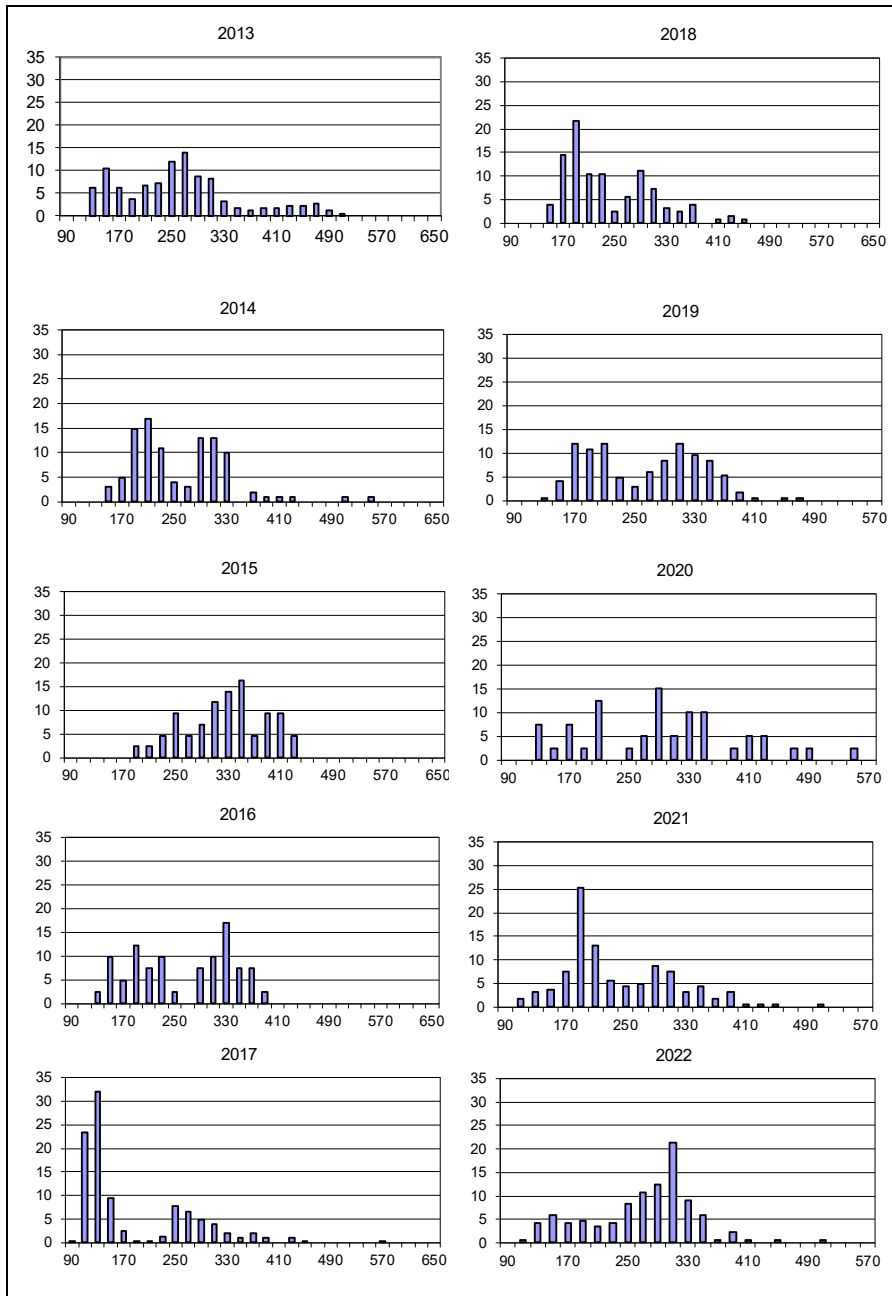


Figure 9. Maryland's commercial landings of summer flounder in pounds from the Chesapeake Bay and the MRIP Maryland summer flounder inland recreational harvest and release estimates in numbers from 1981-2022.

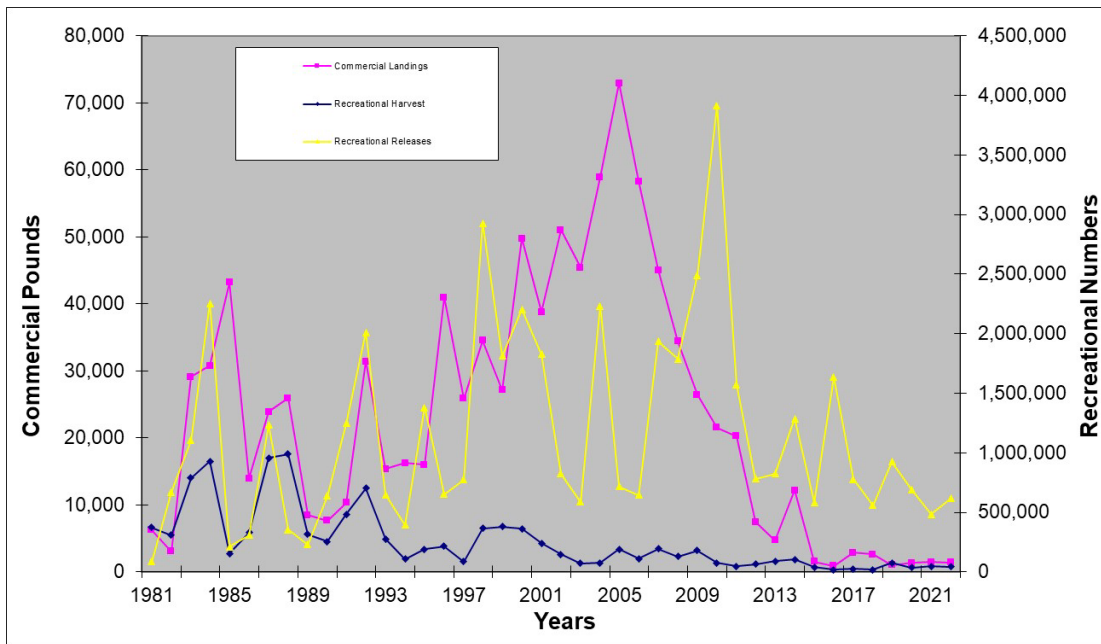


Figure 10. Maryland charter boat log book summer flounder harvest in numbers and the number of anglers participating in trips catching summer flounder, 1993-2022.

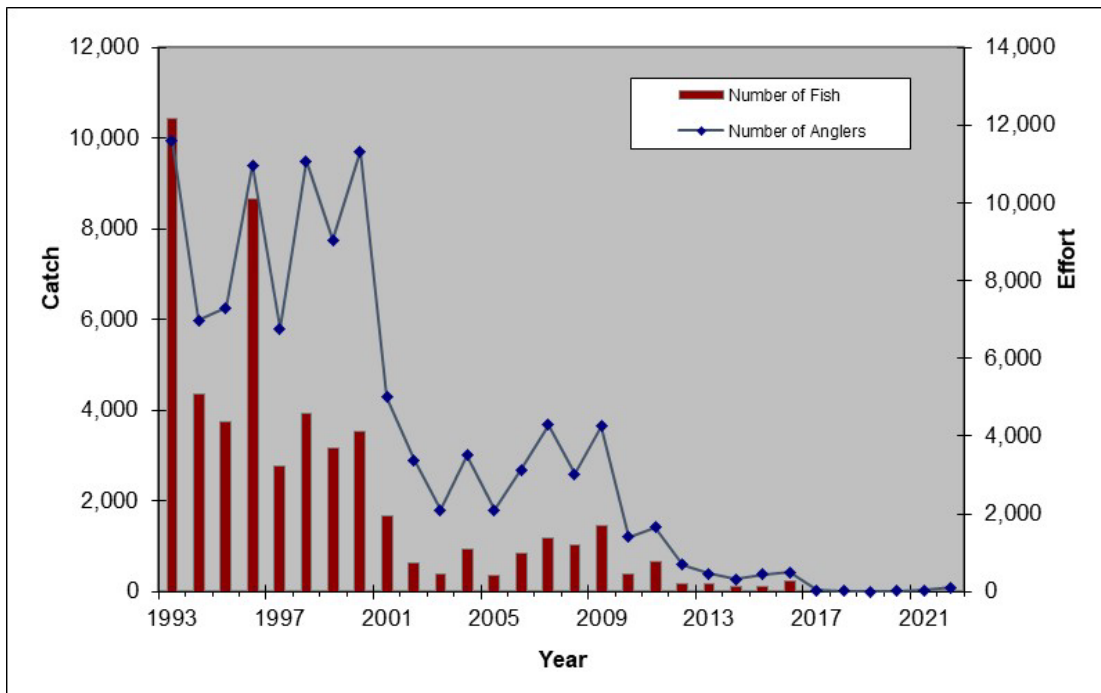


Figure 11. Bluefish length frequency distributions from onboard pound net sampling, 2013-2022.

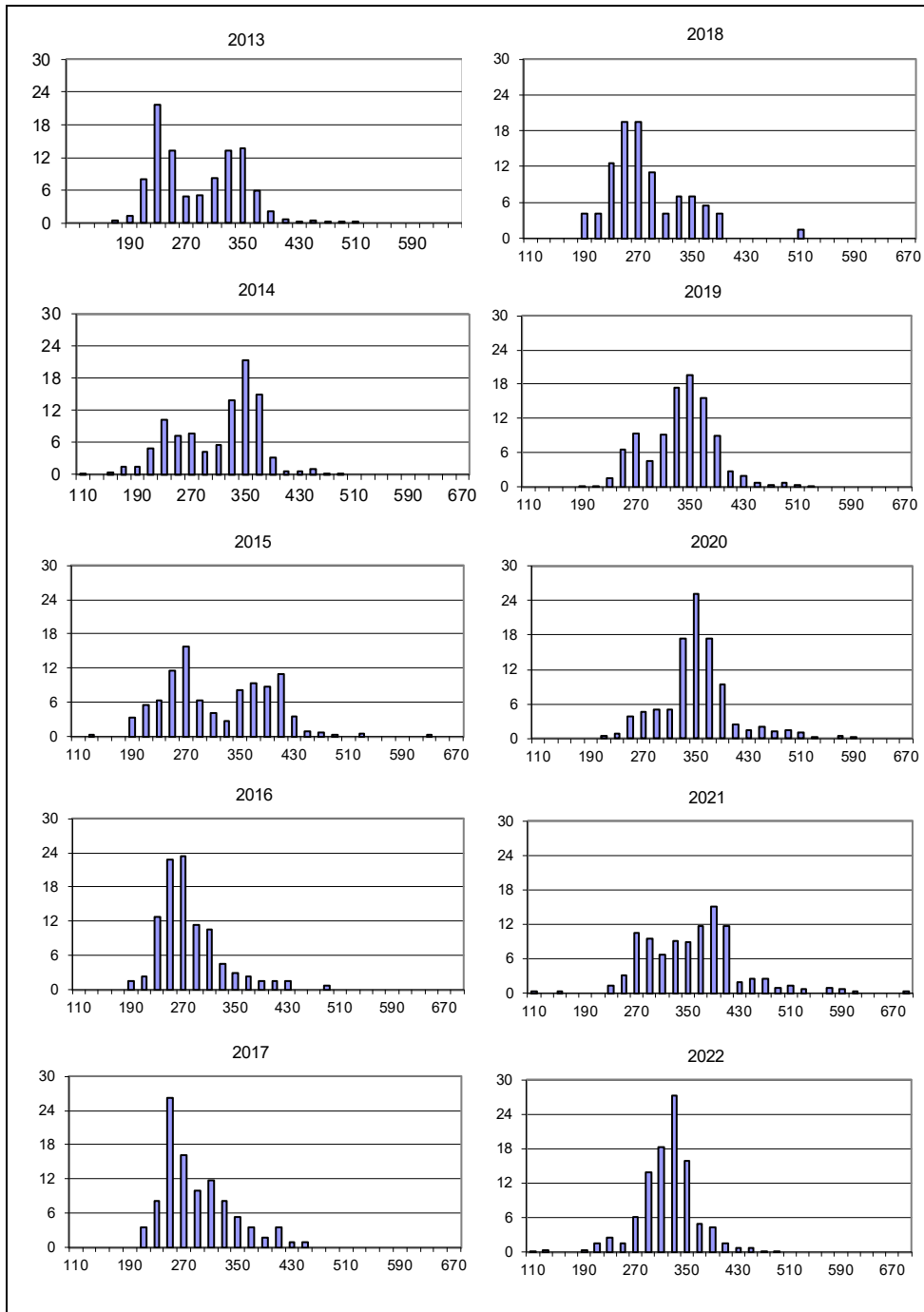


Figure 12. Proportion of bluefish catch by mesh size, all years combined, for the Choptank River gill net survey, 2013-2022.

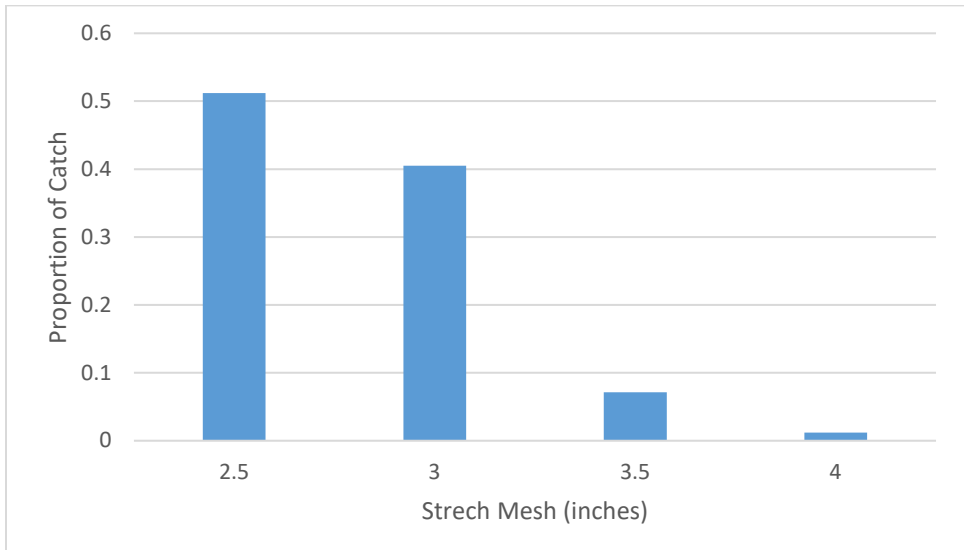


Figure 13. Maryland's commercial landings of bluefish in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational bluefish harvest and release estimates in numbers from 1981-2022.

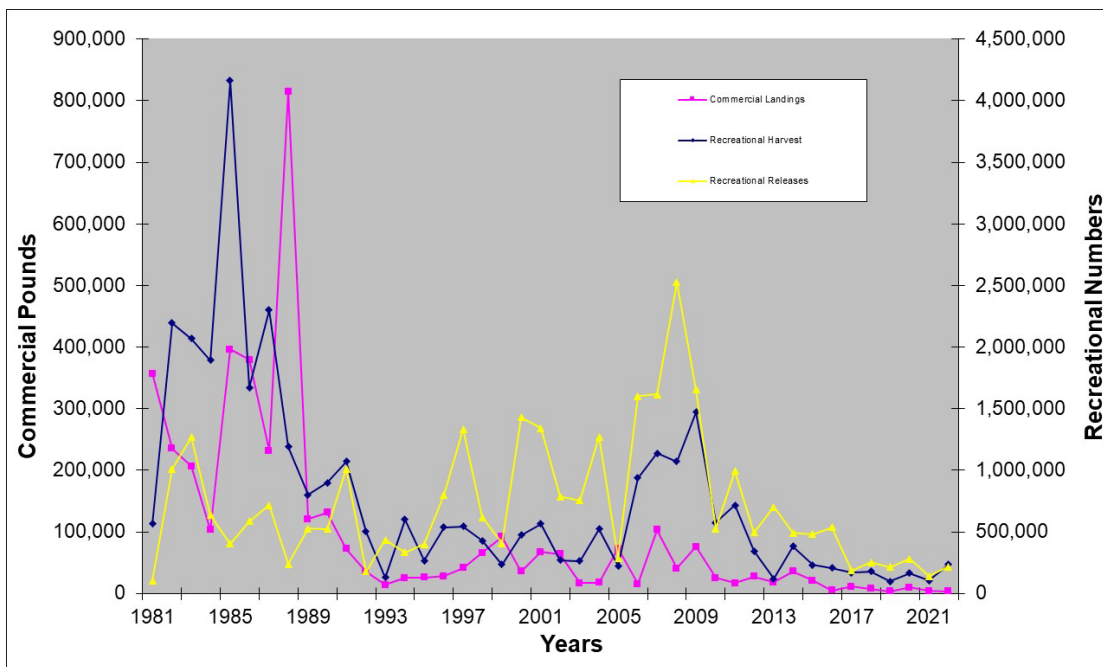


Figure 14. Maryland charter boat log book bluefish harvest in numbers and the number of anglers participating in trips catching bluefish, 1993-2022.

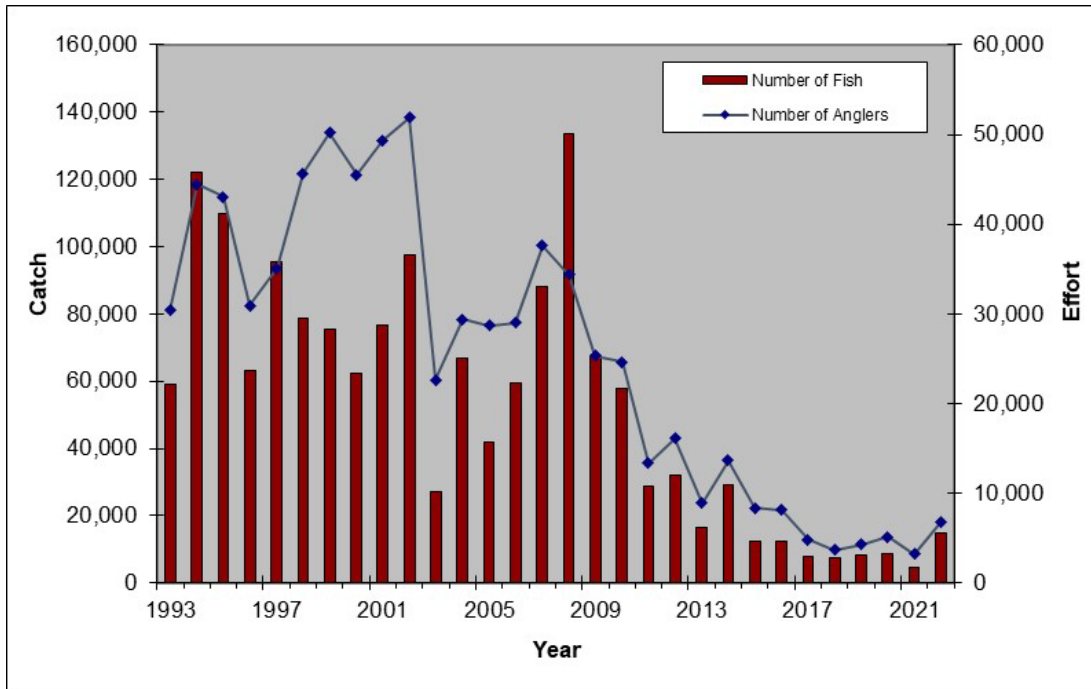


Figure 15. Atlantic croaker length frequency distributions from onboard pound net sampling, 2013-2022.

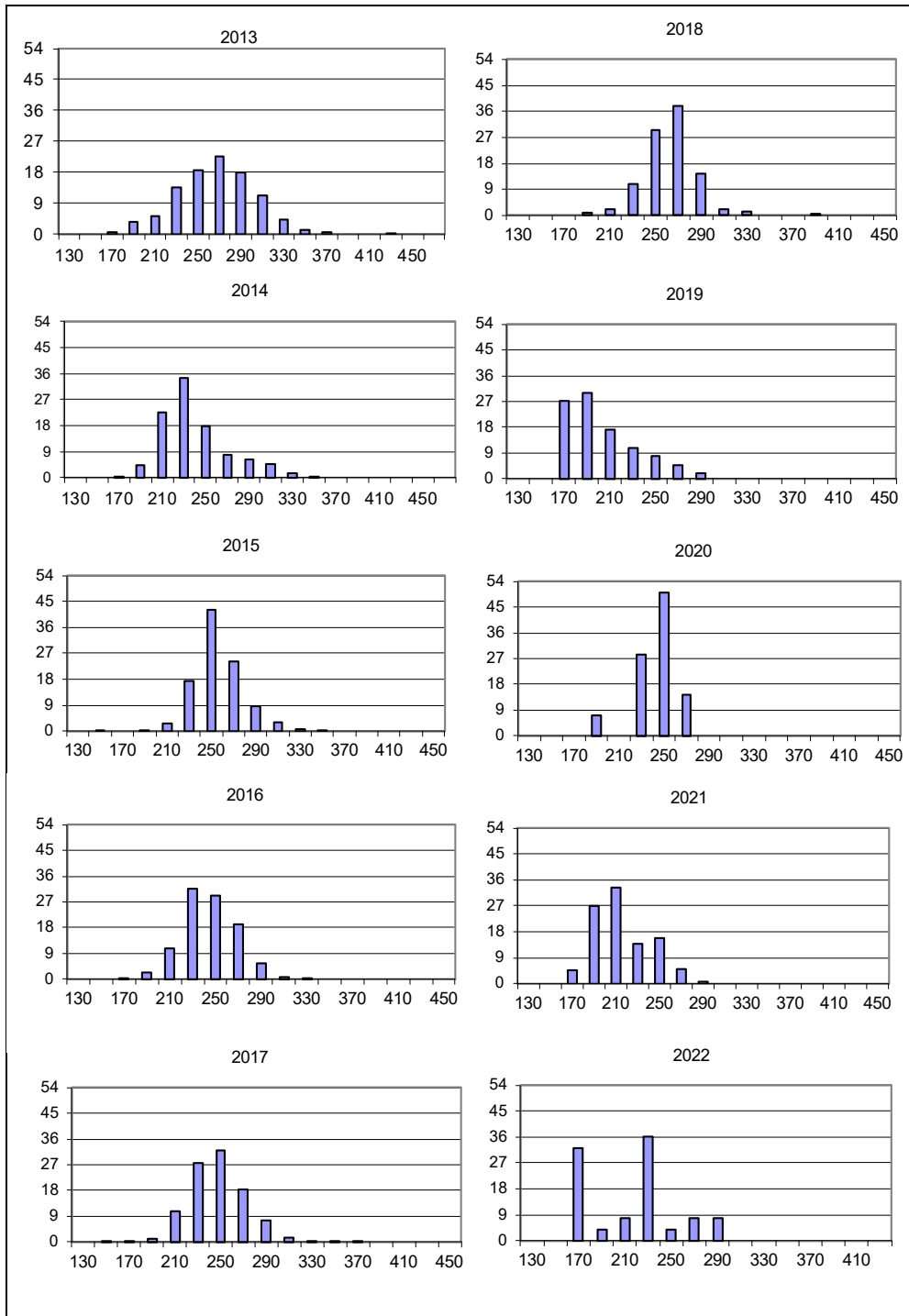


Figure 16. Geometric mean catch per hour and 95% confidence intervals for Atlantic croaker captured in the Choptank River gill net survey, 2013-2022.

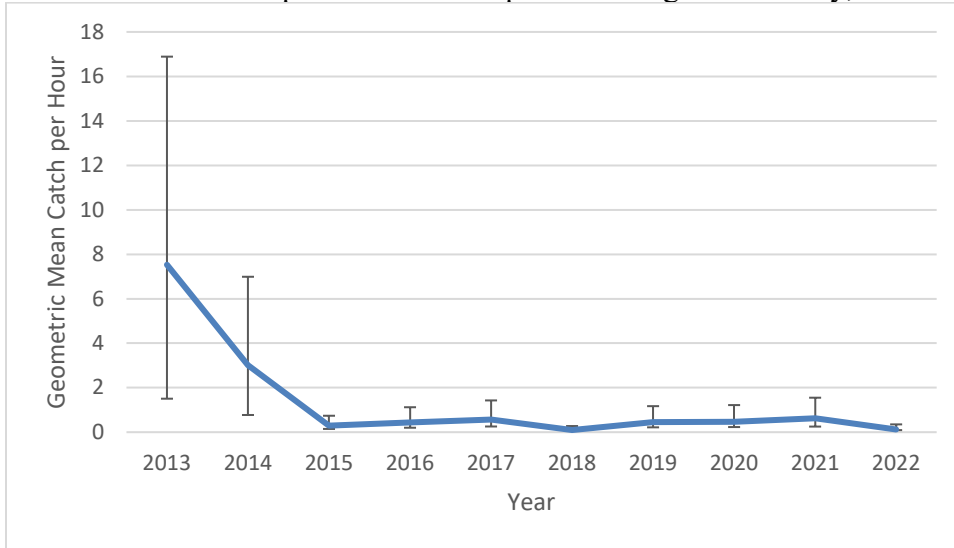


Figure 17. Proportion of Atlantic croaker catch by mesh size and year for the Choptank River gill net survey, 2013-2022.

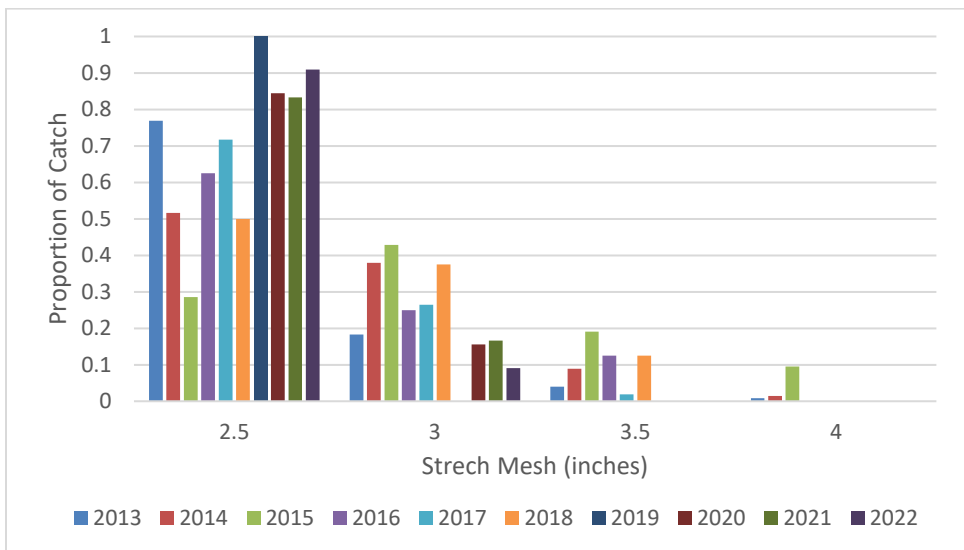


Figure 18. Atlantic croaker length frequency distribution from the Choptank River gill net survey by stretched mesh size in inches, 2013-2022 combined.

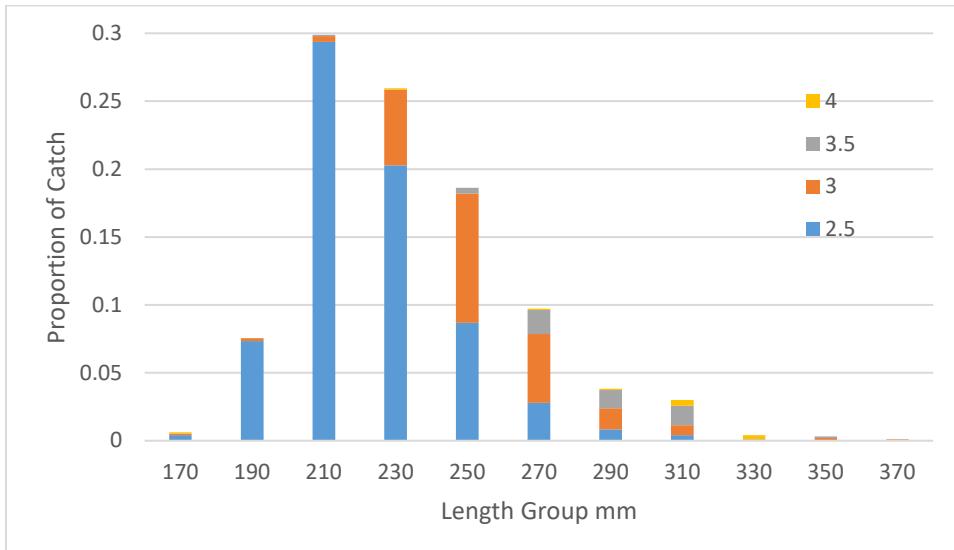


Figure 19. Maryland's commercial landings of Atlantic croaker in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational Atlantic croaker harvest and release estimates in numbers from 1981-2022.

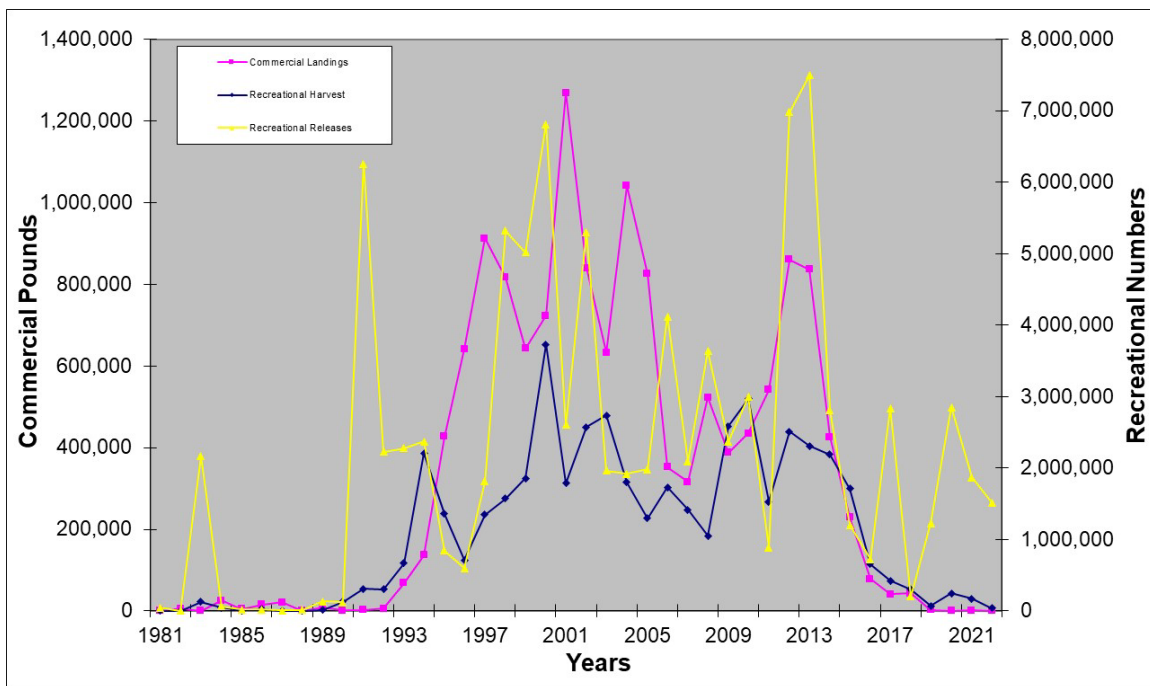


Figure 20. Maryland charter boat log book Atlantic croaker harvest in numbers and the number of anglers participating in trips catching Atlantic croaker, 1993-2022.

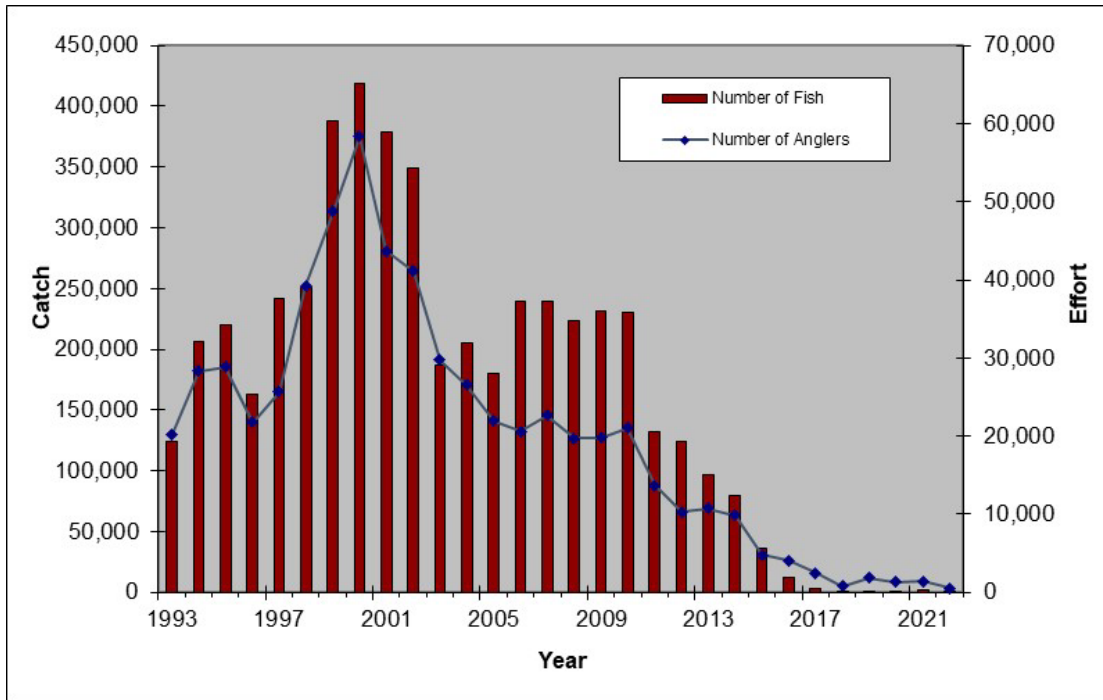


Figure 21. Maryland juvenile Atlantic croaker geometric mean catch per trawl, 95% confidence intervals and time series mean for Maryland's lower Chesapeake Bay, 1989-2022. 1998 data point was omitted for scale (GM 1998 = 30.05 - 9.02, +12.72).

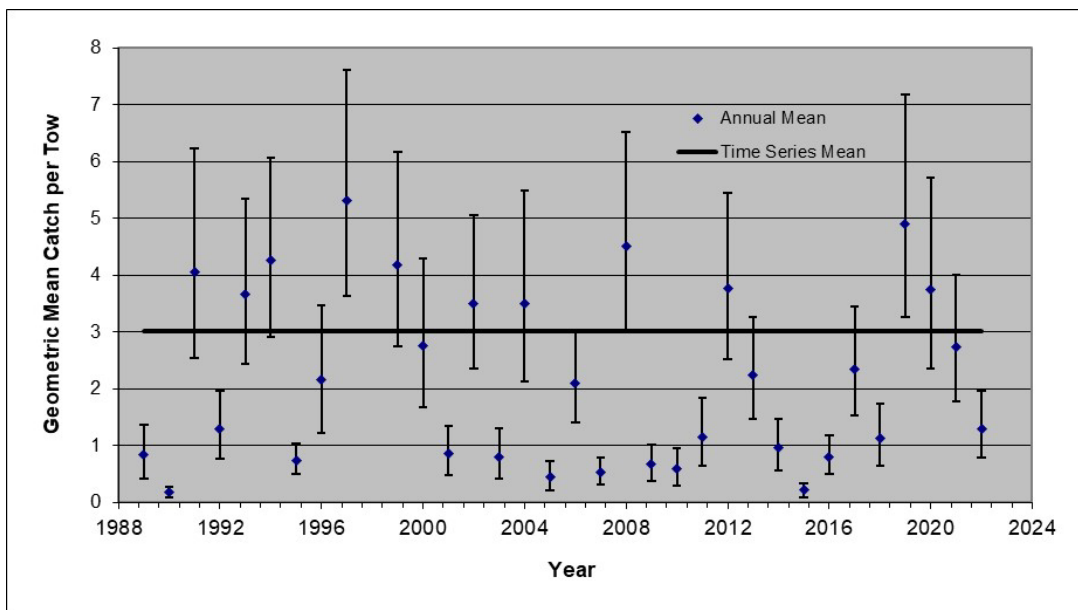
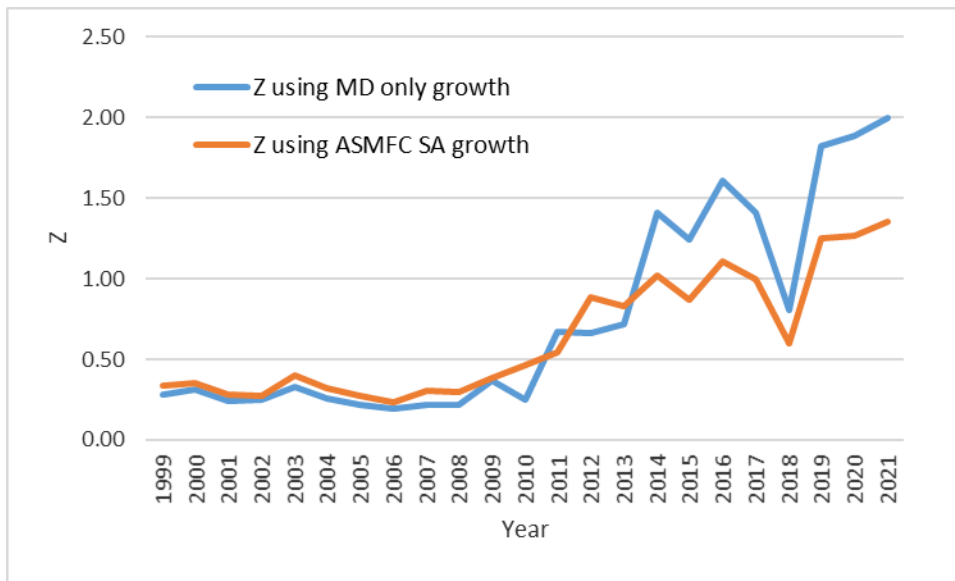


Figure 22. Atlantic croaker total mortality estimates using Maryland age data to derive growth parameters and using the growth parameters from the ASMFC 2017 stock assessment, 1999 - 2021.



Note: Very low sample size in 2020, and insufficient sample size for a 2022 estimate.

Figure 23. Spot length frequency distributions from onboard pound net sampling, 2013-2022.

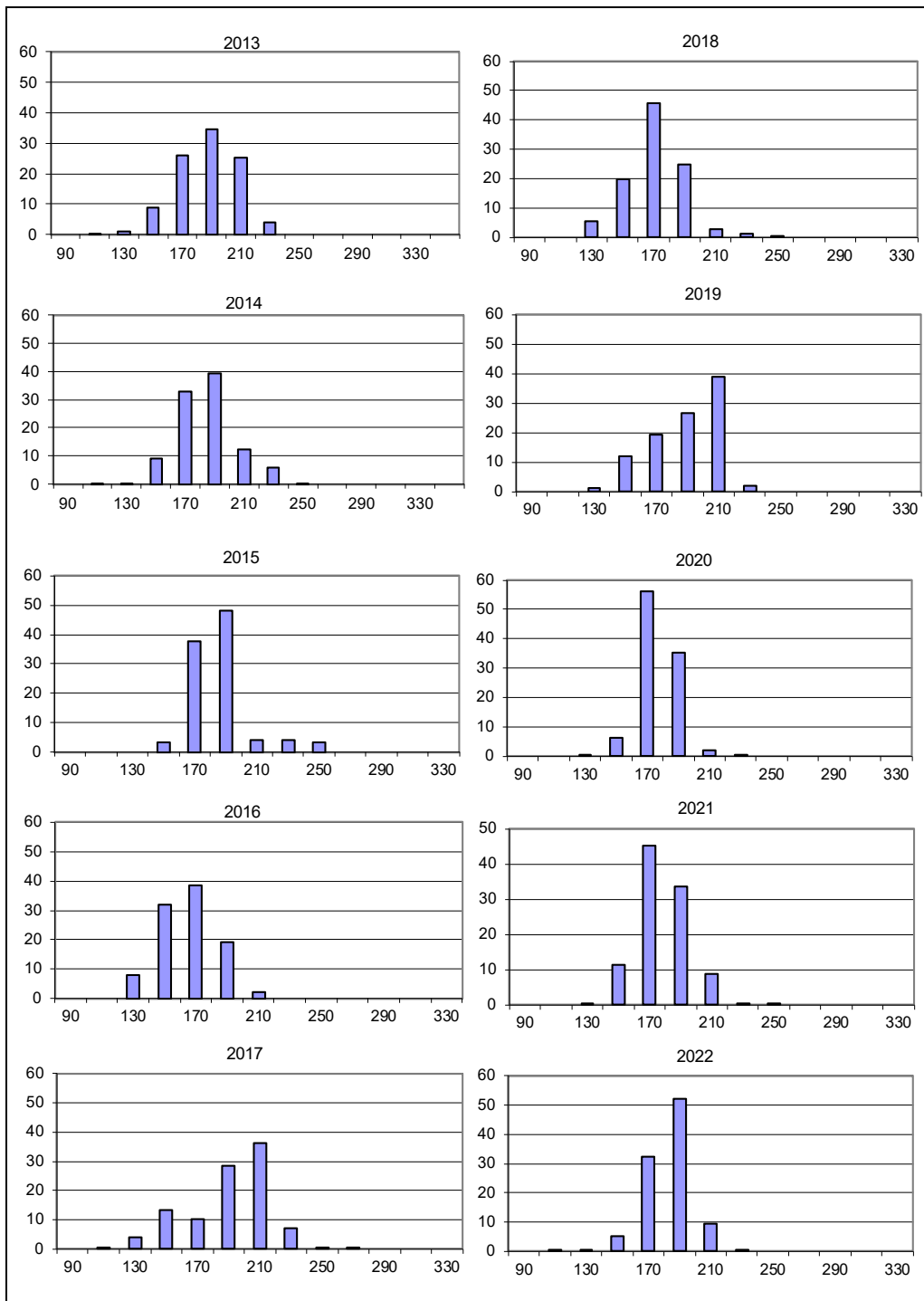


Figure 24. Geometric mean catch per hour and 95% confidence intervals for spot captured in the Choptank River gill net survey, 2013-2022.

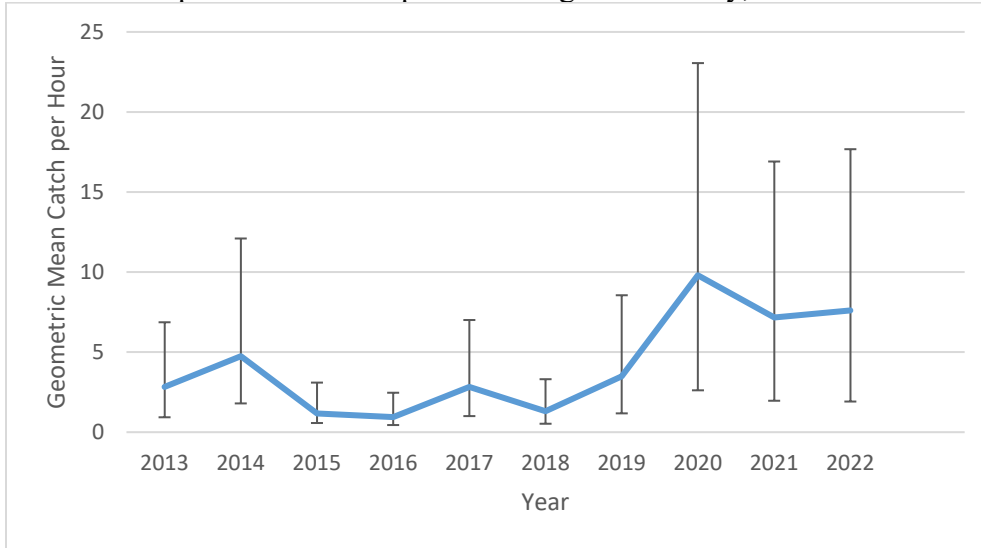


Figure 25. Proportion of spot captured in the Choptank River gill net survey by mesh size and year, 2013-2022.

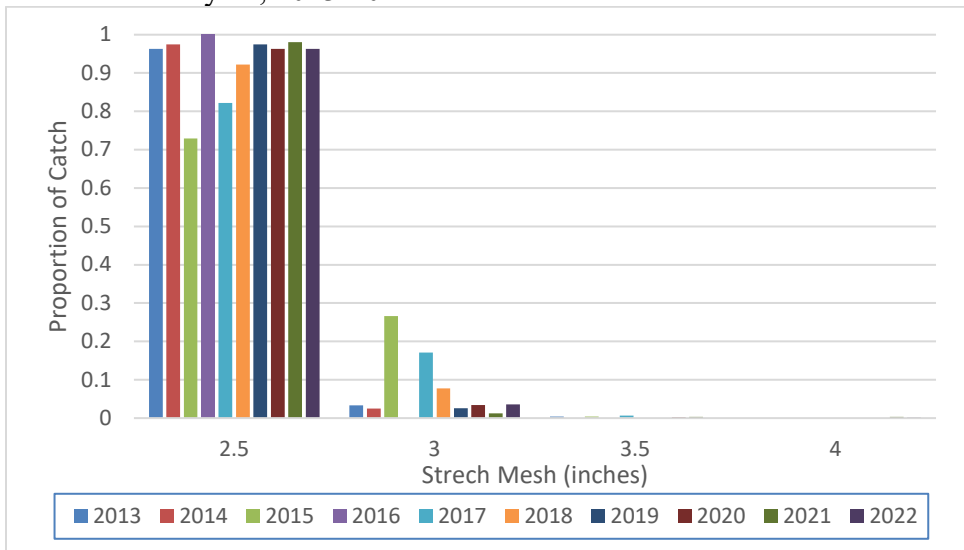


Figure 26. Spot length frequency distributions from the Choptank River gill net survey for 2015-2022.

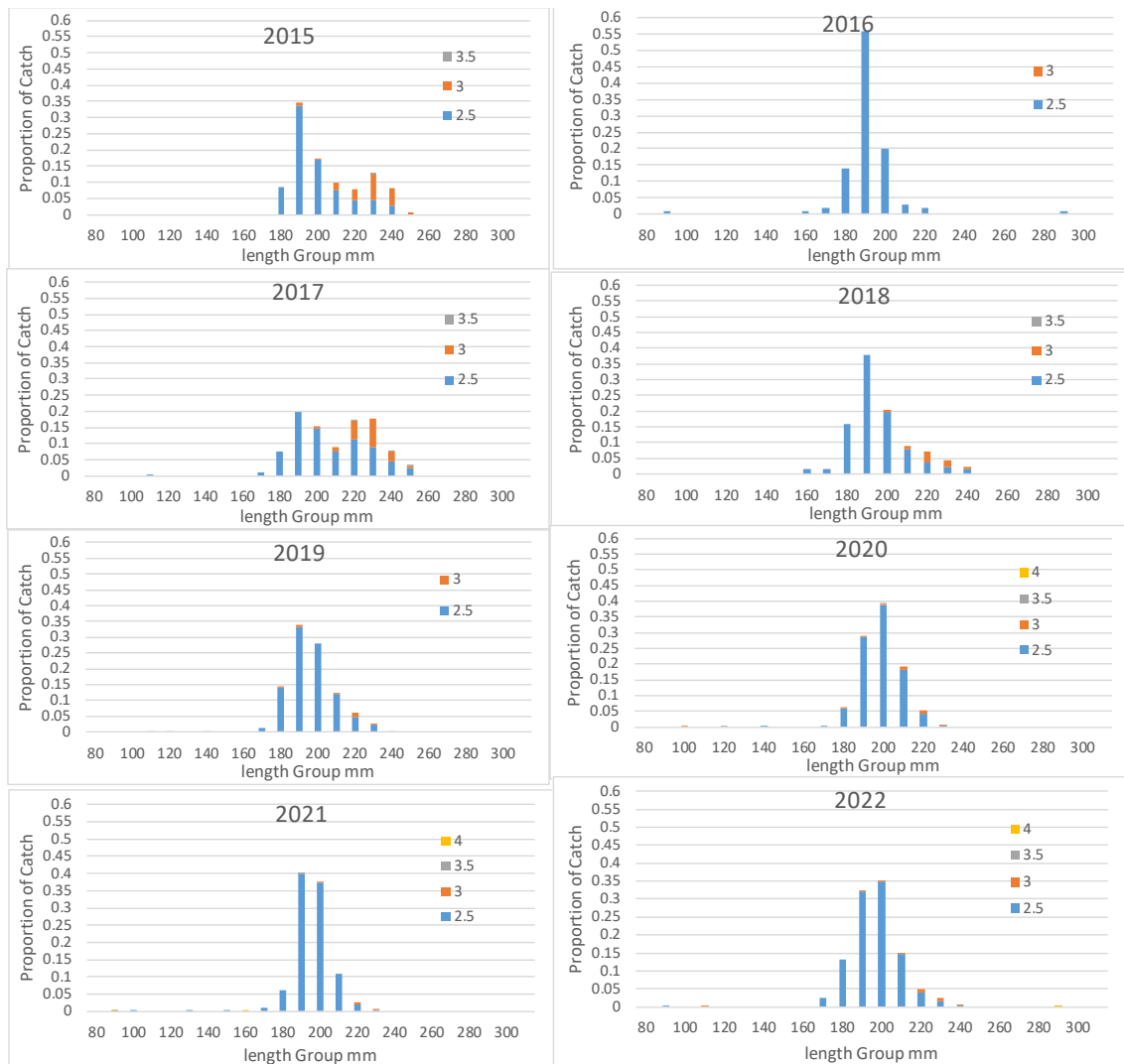


Figure 27. Maryland's commercial landings of spot in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational spot harvest and release estimates in numbers from 1981-2022.

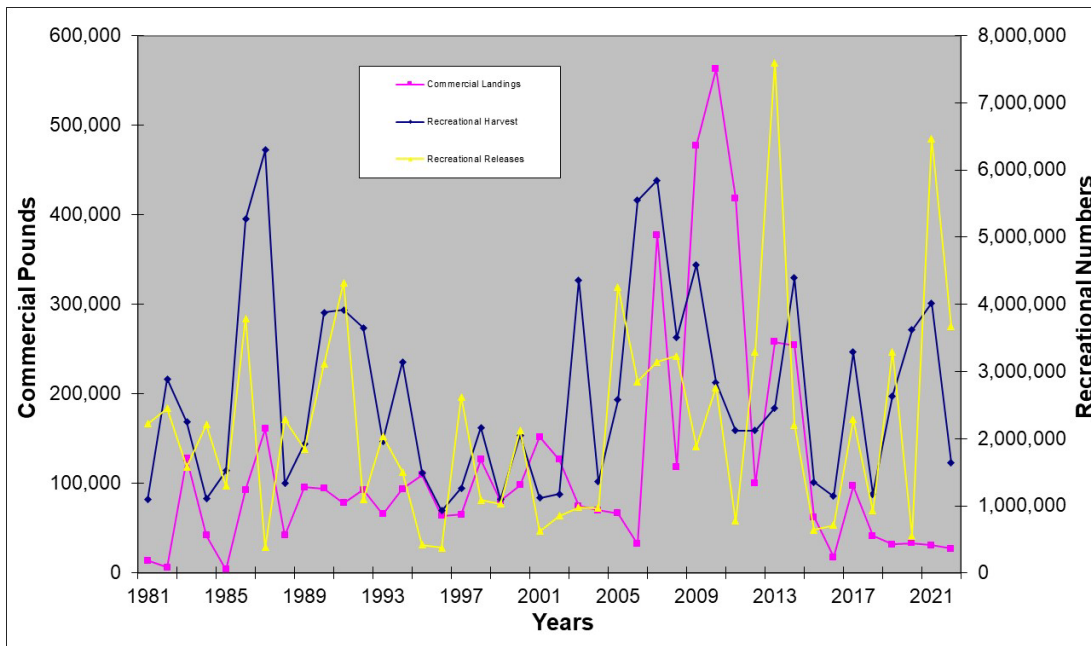


Figure 28. Maryland charter boat log book spot harvest in numbers and the number of anglers participating in trips catching spot, 1993-2022.

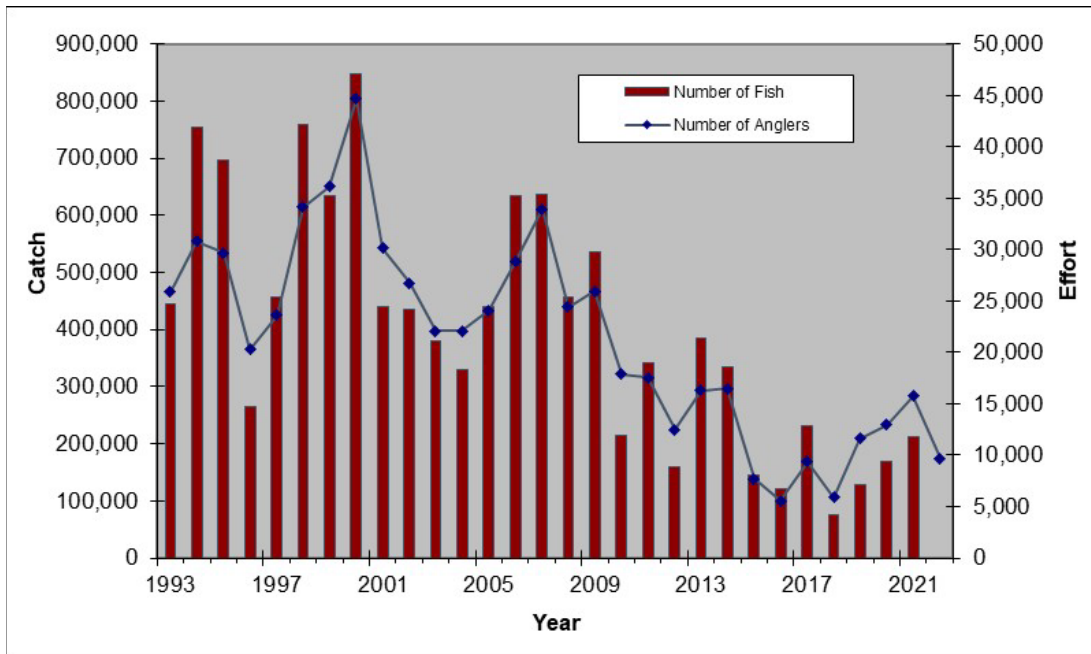


Figure 29. Maryland juvenile spot geometric mean catch per trawl, 95% confidence intervals and time series mean for Maryland's lower Chesapeake Bay, 1989-2022.

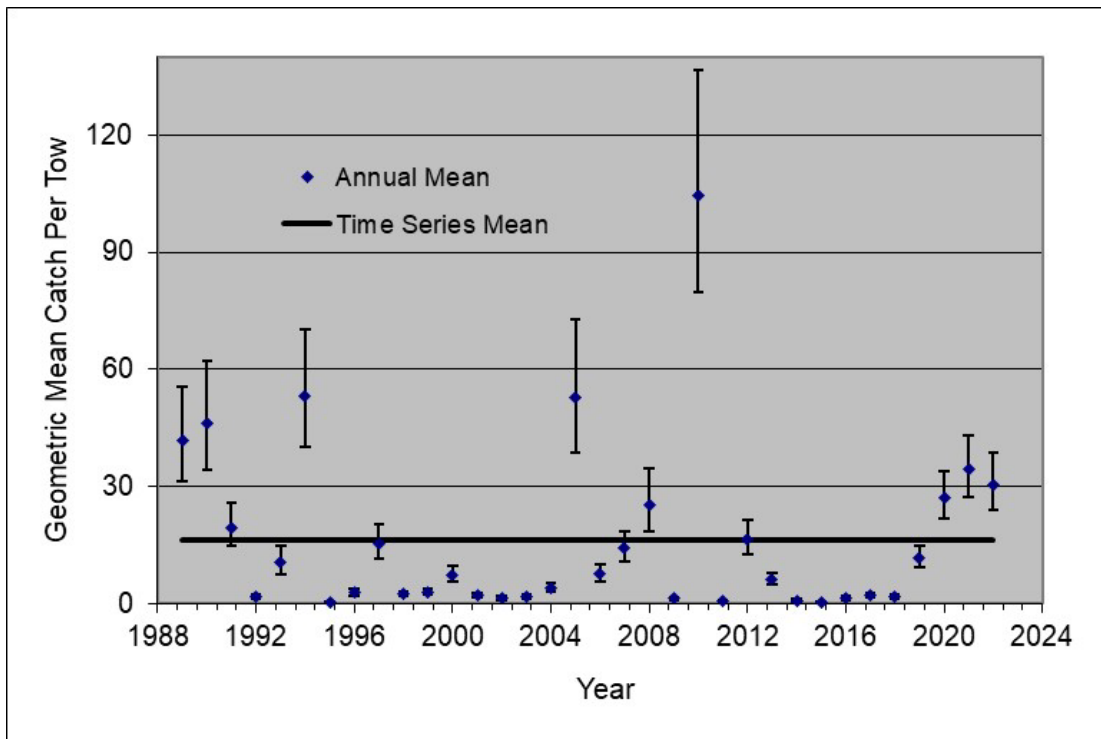


Figure 30. Maryland's commercial landings of red drum in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational red drum harvest and release estimates in numbers from 1981-2022.

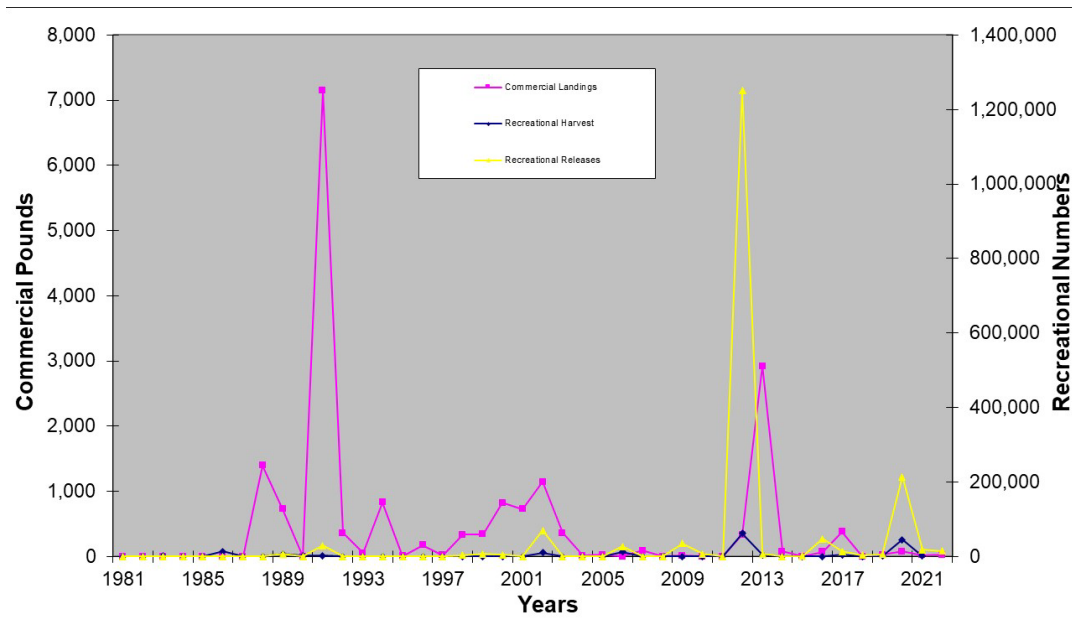


Figure 31. Maryland charter boat log book red drum harvest in numbers and the number of anglers participating in trips catching red drum, 1993-2022.

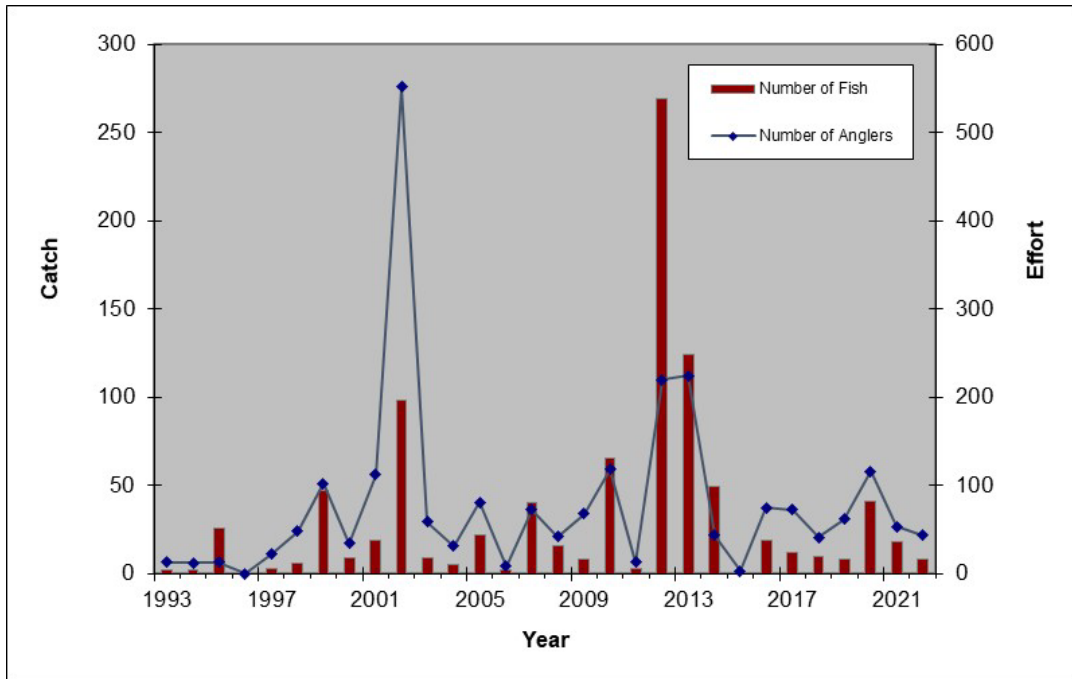


Figure 32. Maryland's commercial landings of black drum in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational black drum harvest and release estimates in numbers from 1981-2022.

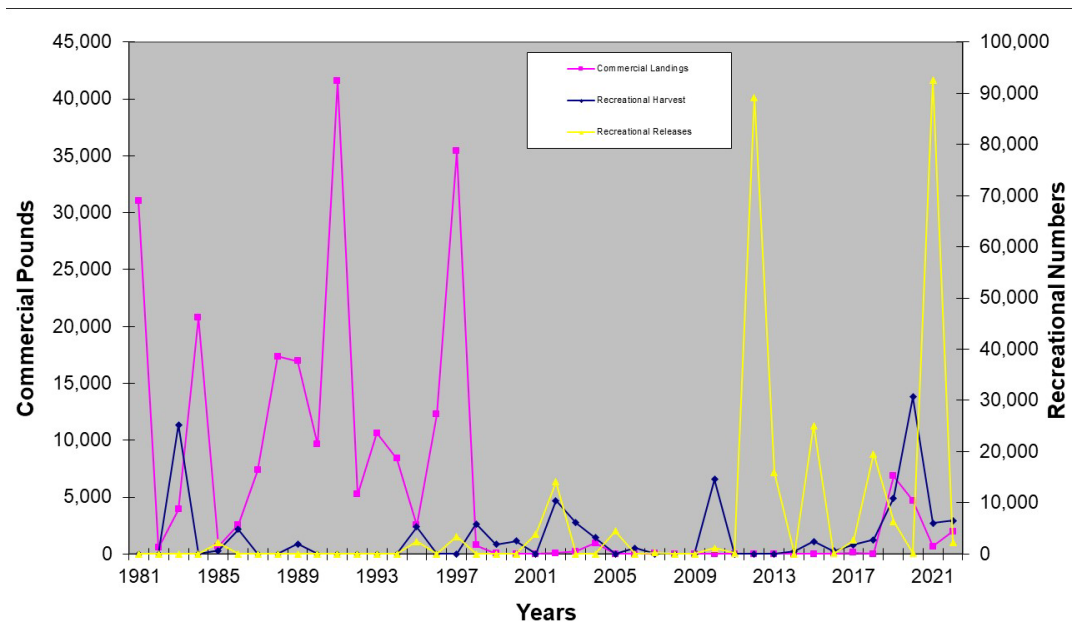


Figure 33. Maryland charter boat log book black drum harvest in numbers and the number of anglers participating in trips catching black drum, 1993-2022.

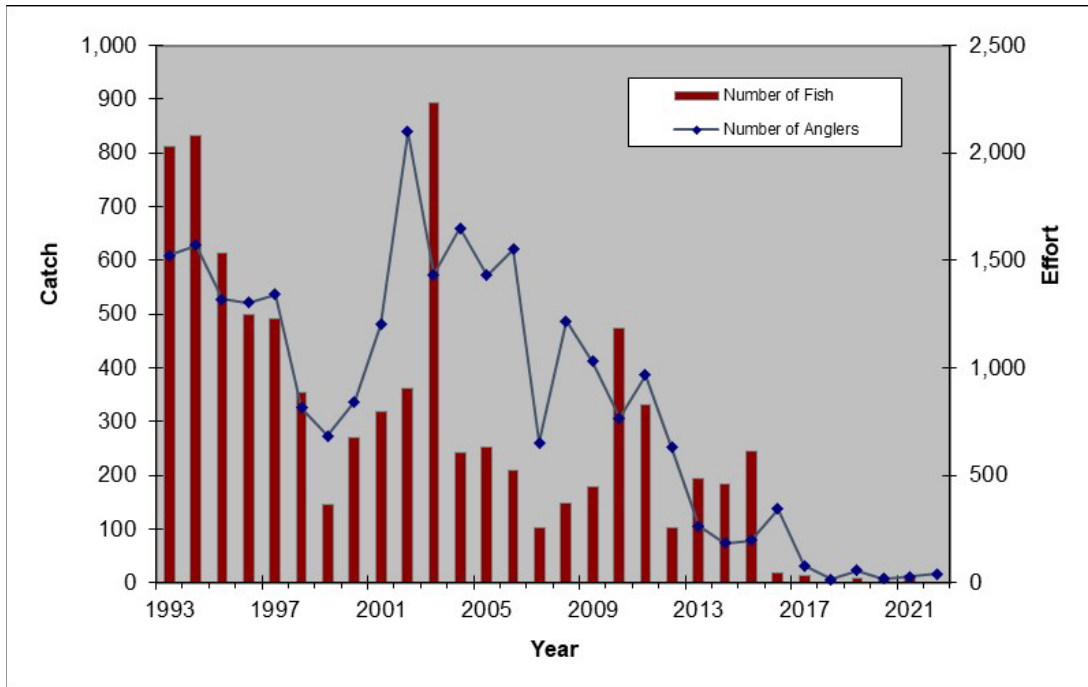


Figure 34. Maryland's commercial landings of Spanish mackerel in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational Spanish mackerel harvest and release estimates in numbers from 1981-2022.

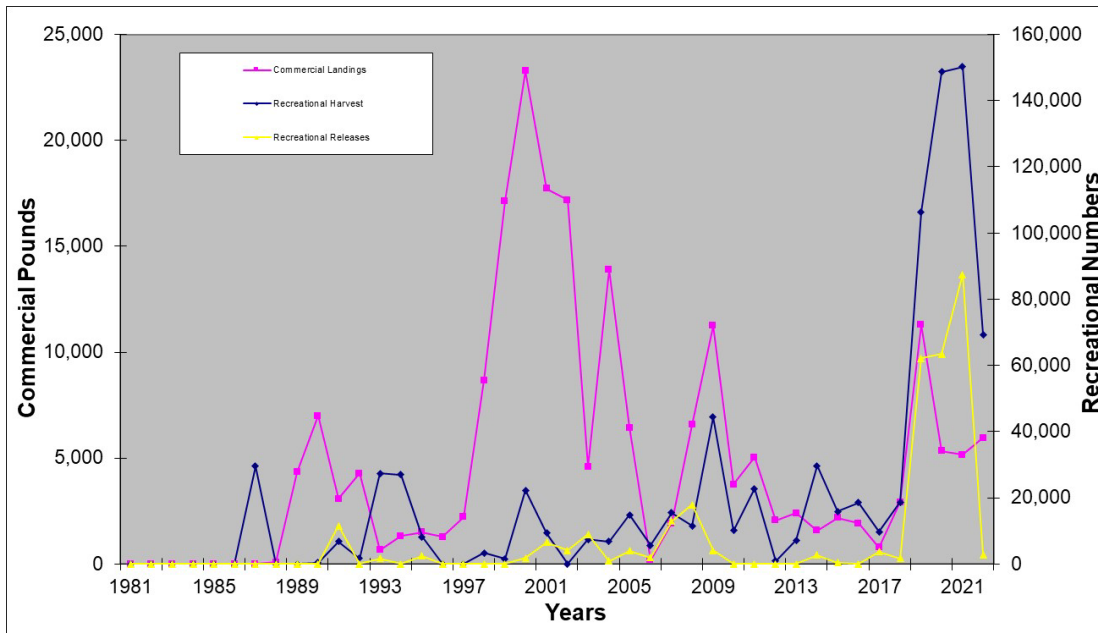


Figure 35. Maryland charter boat log book Spanish mackerel harvest in numbers and the number of anglers participating in trips catching Spanish mackerel, 1993-2022.

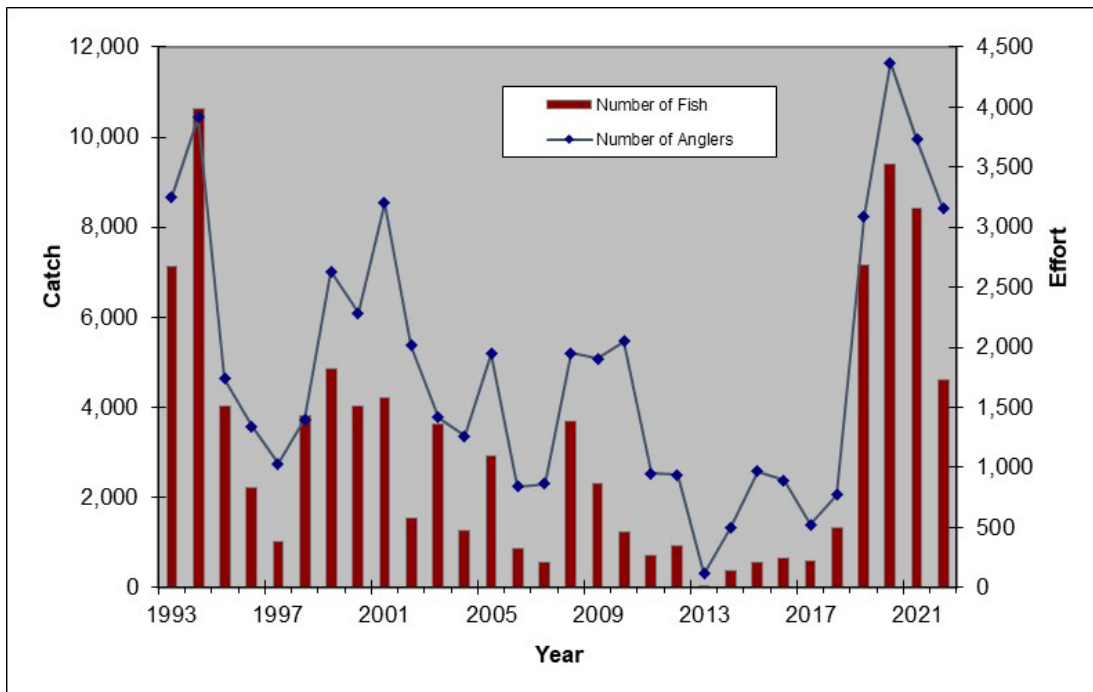


Figure 36. Maryland's commercial landings of spotted seatrout in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational spotted seatrout harvest and release estimates in numbers from 1981-2022.

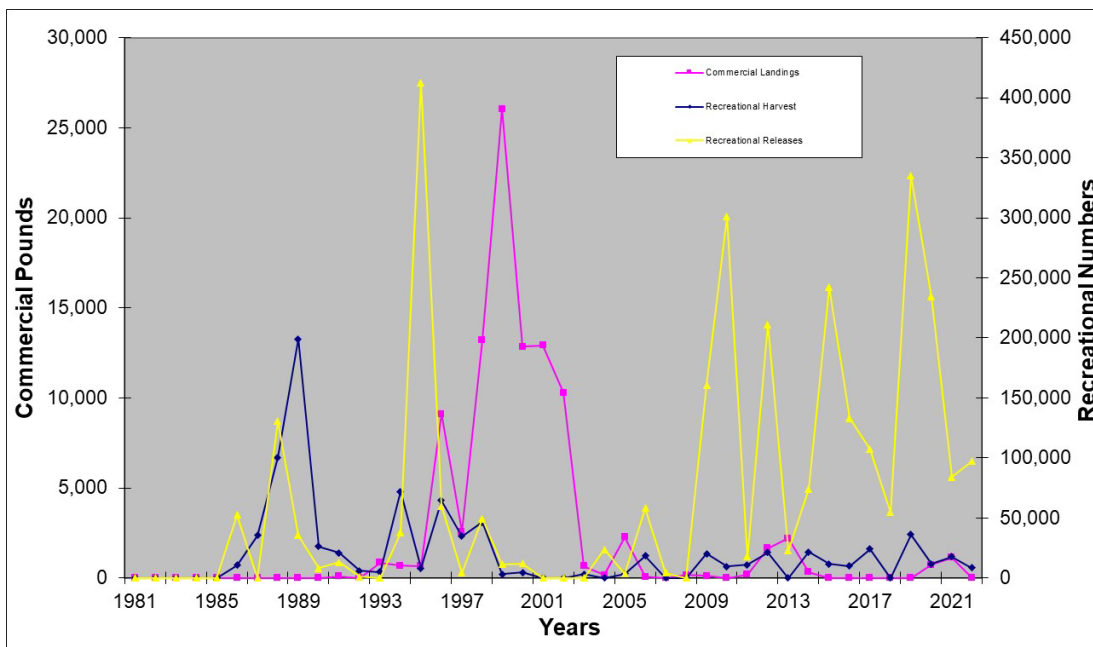


Figure 37. Maryland charter boat log book spotted seatrout harvest in numbers and the number of anglers participating in trips catching spotted seatrout, 1995-2022.

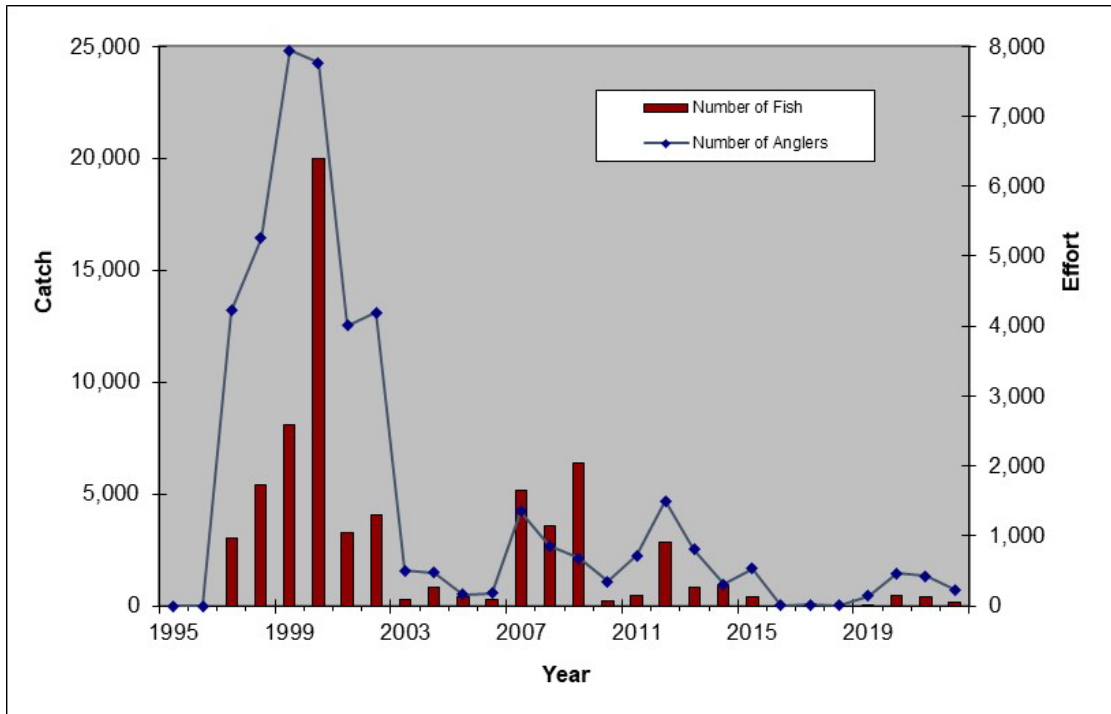


Figure 38. Atlantic menhaden length frequency distributions from onboard pound net sampling, 2013-2022, Note: In 2012 the 230 FL value is 40 percent.

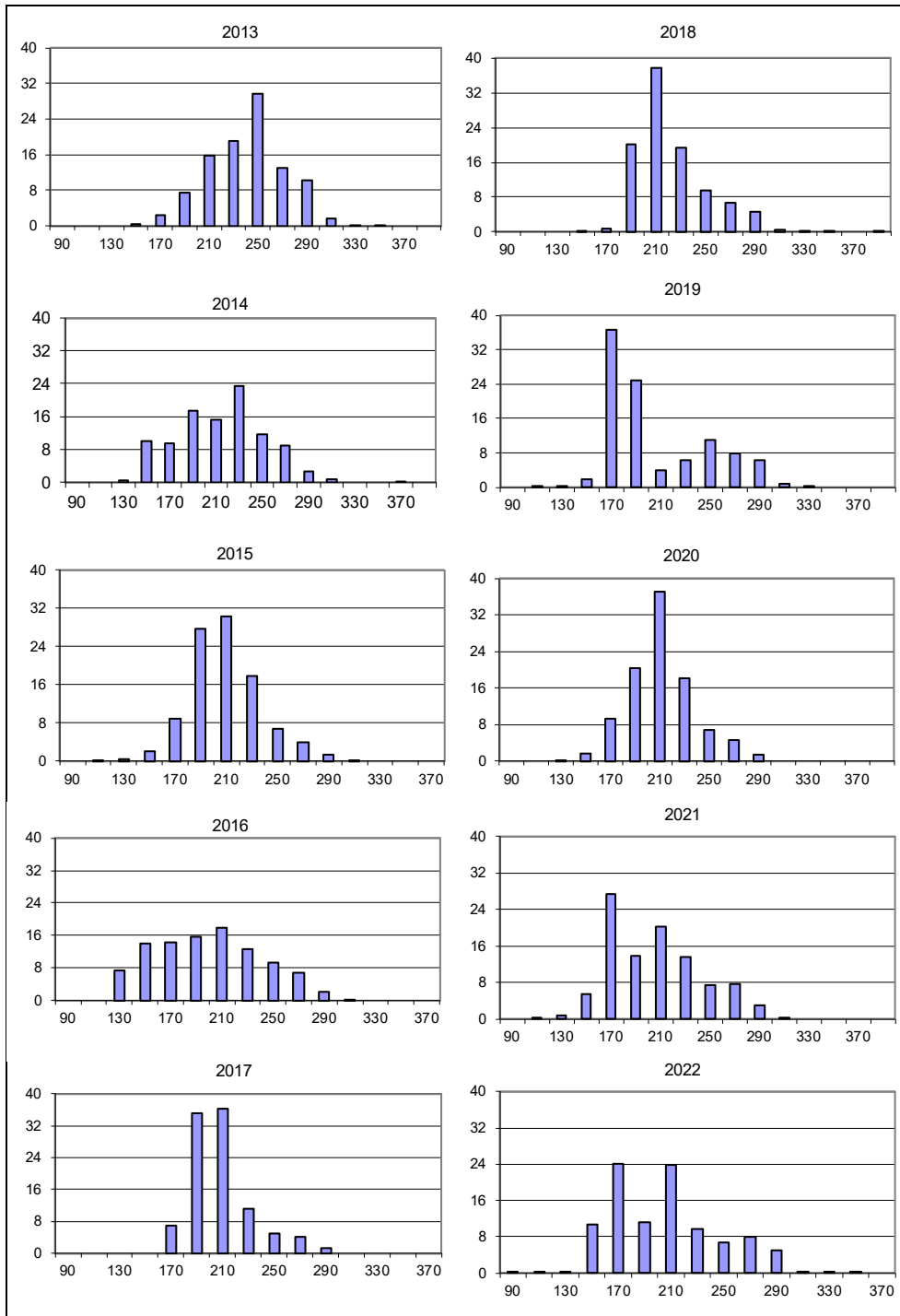


Figure 39. Geometric mean catch per hour and 95% confidence intervals for Atlantic menhaden captured in the Choptank River gill net survey, 2013-2022.

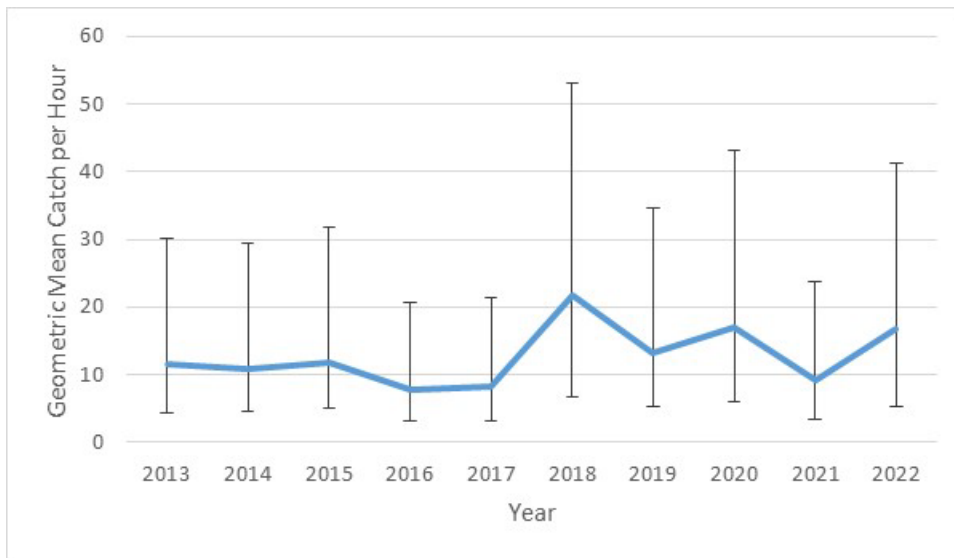


Figure 40. Atlantic menhaden proportion of catch by panel and year from the Choptank River gill net survey, 2013-2022.

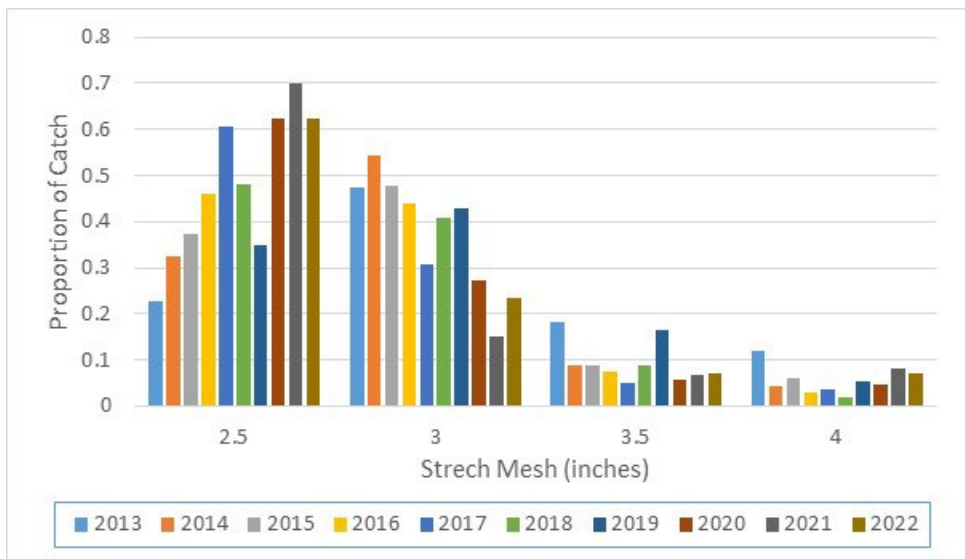


Figure 41. Atlantic menhaden length frequency distributions from the Choptank River gill net survey by year, 2015-2022.

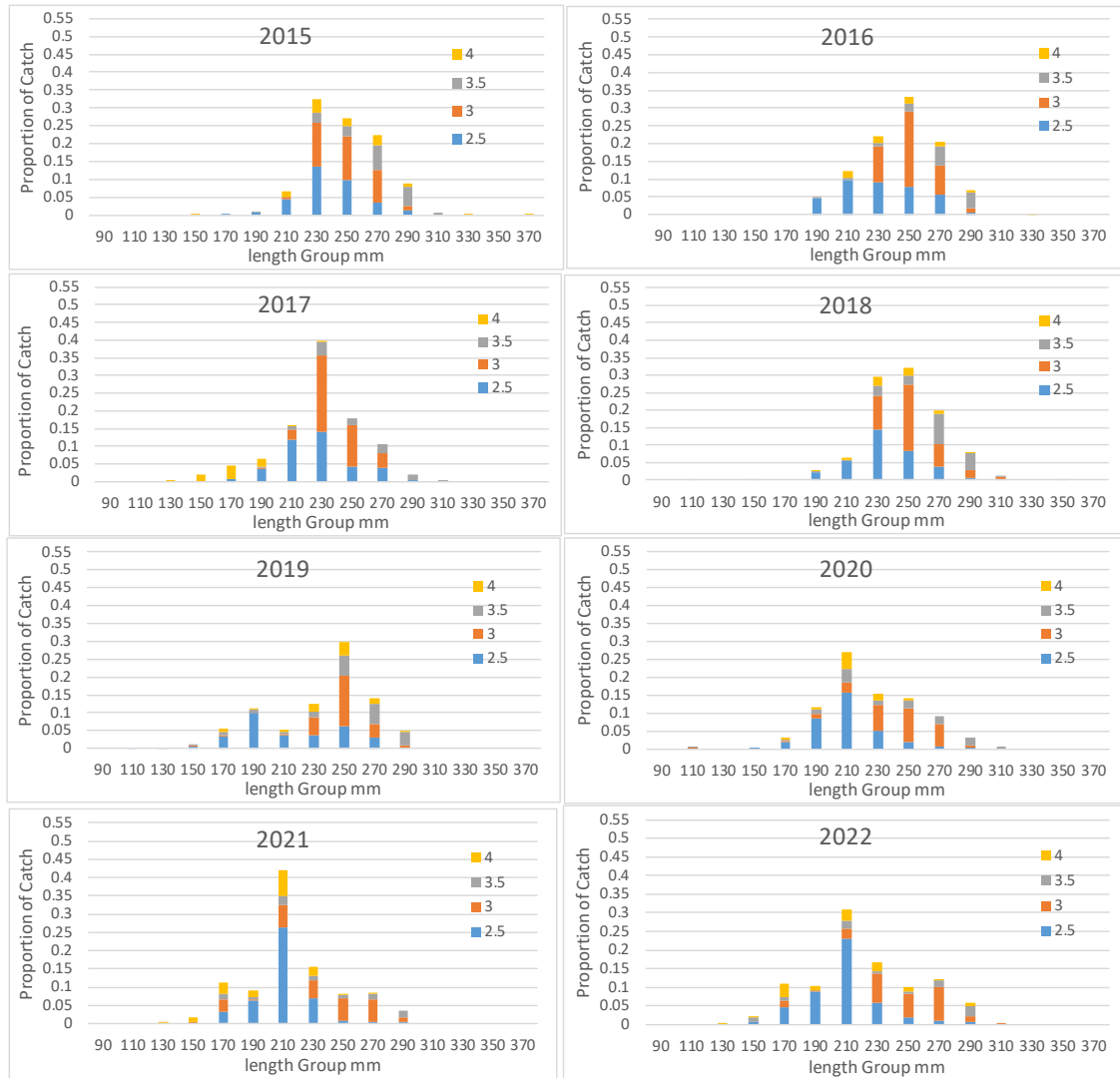
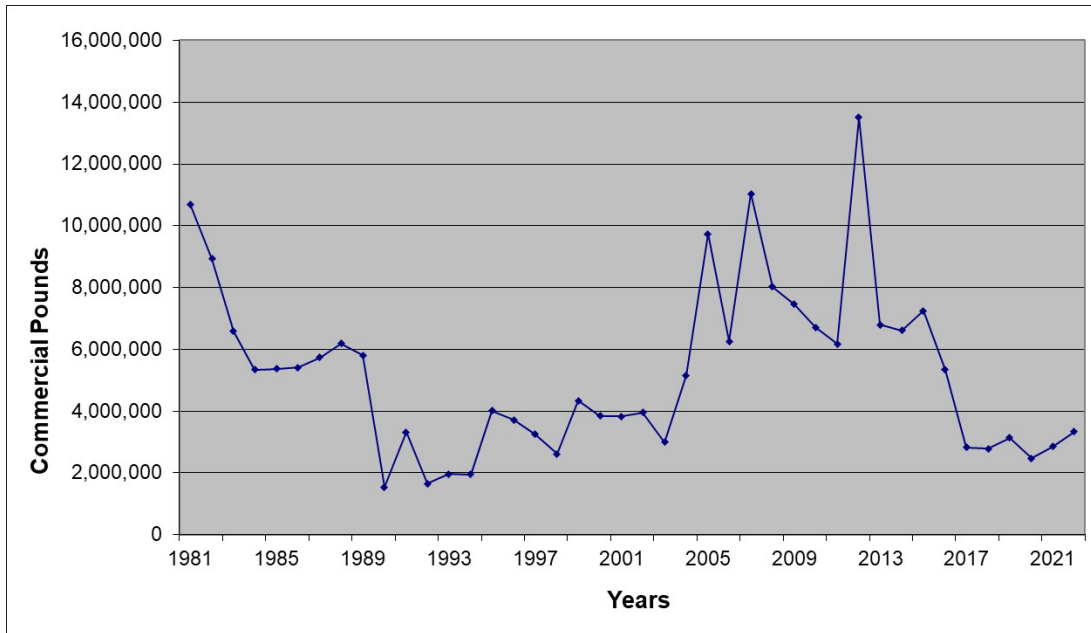


Figure 42. Maryland's Chesapeake Bay commercial landings for Atlantic menhaden from 1981-2022.



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 2021 and 2022 Maryland striped bass *Morone saxatilis* commercial summer/fall fisheries and provide preliminary results, as available, for the 2023 summer/fall season. Completed results for the 2023 summer/fall sample season will be reported in the F61-R-19 Chesapeake Bay Finfish Investigations report. The 2021 and 2022 commercial summer/fall fisheries operated on a combination of common pool and individual transferable quota (ITQ) systems (see Project 2, Job 3, Task 5A). The 2021 and 2022 ITQ commercial summer/fall fisheries were open from 1 June through 31 December for pound net and hook and line gear. The 2021 common pool fishery was open two days each month in June and August. The 2022 common pool fishery was not open for the summer/fall fishery. 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 2021 and 2022 commercial summer/fall fisheries

were used to characterize the length and age structure of the summer/fall 2021 and 2022 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 at two to twelve pound nets per month from June through November 2021 (Table 1a). Pound net sampling occurred one to eleven times per month from May through November 2022 (Table 1b). The pound nets sampled were not randomly selected but were chosen according to watermen's schedules and the best chance of obtaining fish. During 2021 and 2022, striped bass were sampled from pound nets in the upper and lower Bay (Figure 1). 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.

Commercial summer/fall check station monitoring

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 2021 and June through December 2022 (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. Scale samples were taken from all fish >800 mm TL.

Analytical Procedures

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 commercial 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 2021 and 2022 summer/fall fisheries were 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 2021 and 2022.

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. A Kolmogorov–Smirnov test (K-S test) was used to test for differences in the length distributions. Distributions were considered different at $P < 0.05$.

RESULTS and DISCUSSION for 2021

Commercial pound net monitoring

During the 2021 striped bass pound net study, a total of 4,887 striped bass were sampled from two pound nets in the upper Bay and seven pound nets in the lower Bay. The nine nets were sampled a total of 45 times during the study (Table 1a).

Striped bass sampled from pound nets ranged from 210-1210 mm TL, with a mean length of 430 mm TL (Figure 2a). In 2021, 87% of striped bass collected from full net samples were less than the commercial minimum legal size of 18 inches (457 mm) TL and 50% of fish from partially sampled nets were sub-legal.

Mean total length of the aged sub sample are presented in Table 2a. Striped bass sampled from pound nets ranged from 1 to 16 years of age when the combined age length key was expanded to the entire sample (Table 3a, Figure 2a). Age 3 fish from the above average 2018 year-class were the most numerous, contributing 44%. Age 4 fish from the above average 2017 year-class contributed 16%. Age 6 fish from the above average 2015 year-class contributed 10% of the sample. Striped bass age 6 and older comprised 11% of the sample, which was higher than their contribution in the previous year (9%; Figure 3).

Commercial summer/fall check station monitoring

A total of 1,765 striped bass were sampled 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 and from 3 to 11 years of age (Figure 5a). Two sub-legal (<457 mm TL) fish were encountered in the subsample. Mean lengths- and weights-at-age of the aged subsample for the 2021 summer/fall fishery are shown in Tables 4a and 5a.

Striped bass in the 450-550 mm length groups accounted for 60% of the summer/fall harvest (Figure 5a). Fish from the above average 2011 year-class have influenced the number of larger fish in the harvest in recent years, however, did not contribute as much to the fishery in 2021. Striped bass over 700 mm TL were harvested throughout the season (Figure 6a) and contributed 2% to the overall harvest. Historically, these fish have not been available in large numbers during the summer (MD DNR 2002).

The 2021 summer/fall harvest accounted for 57%, by weight, of the Maryland Chesapeake Bay total commercial harvest with 773,963 pounds landed (see Project 2, Job 3, Task 5A). Landings reported by the MD DNR commercial reporting program were 127,575 pounds for hook and line gear and 646,388 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 2021 catch-at-age in pounds and numbers of fish for the summer/fall fishery is presented in Table 6a. By weight, the majority (88%) of the harvest consisted of four to seven year-old striped bass. By weight, striped bass from the above average 2017 year class (age 4) contributed the highest percentage to the harvest (37%). Striped bass age 8 and older contributed 1% to the overall harvest in 2021, which was lower than 2020 (3%).

Monitoring summary

Striped bass ranging from 457 to 550 mm TL comprised 60% of the 2021 summer/fall harvest (Figure 5a). A larger percentage of fish >630 mm TL were harvested in 2021 (11%)

compared to 2020 (8%). In 2021, 104 fish from pound net monitoring and 56 fish from check station sampling were aged. Younger fish (age 4 to 6) were abundant, accounting for the majority of the harvest (Figure 7). Length distributions between the legal-sized fish sampled from pound nets and all fish from check stations was significantly different ($D=0.203$, $P<0.0001$; Figure 4a), suggesting certain size classes of fish may be harvested compared to the sizes of fish present in pound nets. 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 ($\alpha=0.05$). Striped bass were significantly longer in June, August and September (TL=563 mm, 556 mm, 567 mm). Striped bass were significantly heavier in September (WT=1.89 kg). The lowest average length and weight of striped bass was in July (523 mm and 1.40 kg). Duncan's groups are presented in Tables 7a and 8a.

RESULTS and DISCUSSION for 2022

Commercial pound net monitoring

During the 2022 striped bass pound net study, a total of 4,044 striped bass were sampled from two pound nets in the upper Bay and six pound nets in the lower Bay. The eight nets were sampled a total of 34 times during the study (Table 1b).

Striped bass sampled from pound nets ranged from 207-1115 mm TL, with a mean length of 449 mm TL (Figure 2b). In 2022, 69% of striped bass collected from full net samples were less than the commercial minimum legal size of 18 inches (457 mm) TL. In partially sampled nets, 56% of fish were sub-legal.

Mean total length of the aged sub sample are presented in Table 2b. Striped bass sampled from pound nets ranged from 1 to 15 years of age when the combined age length key was expanded to the entire sample (Table 3b, Figure 2b). Age 3 fish from the 2019 year-class were the most

numerous, contributing 43% of the sample. Age 4 fish from the above average 2018 year-class contributed 25%. Age 7 fish from the above average 2015 year-class contributed 3% of the sample. Striped bass age 6 and older comprised 7% of the sample, which was lower than their contribution in the previous year (11%; Figure 3).

Commercial summer/fall check station monitoring

A total of 2,099 striped bass were sampled at summer/fall check stations in 2022. The mean length of sampled striped bass was 549 mm TL. Striped bass sampled from the summer/fall fishery ranged from 450 to 843 mm TL and from 3 to 11 years of age (Figure 5b). Five sub-legal (<457 mm TL) fish were encountered in the subsample. Mean lengths-at-age and weights-at-age of the aged subsample for the 2022 summer/fall fishery are shown in Tables 4b and 5b.

Striped bass in the 450-550 mm length groups accounted for 63% of the summer/fall harvest (Figure 5b). 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 2022, as most are no longer resident fish. Striped bass over 700 mm TL were harvested throughout the season (Figure 6b) but contributed 2% to the overall harvest. Historically, these fish have not been available in large numbers during the summer (MD DNR 2002).

The 2022 summer/fall reported harvest accounted for 58%, by weight, of the Maryland Chesapeake Bay total commercial harvest in 2022 with 714,067 pounds landed (see Project 2, Job 3, Task 5A). Landings reported by the MD DNR commercial reporting program were 63,779 pounds for hook and line gear and 650,288 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 2022 catch-at-age in pounds and numbers of fish for the summer/fall fishery is presented in Table 6b. By

weight, the majority (99%) of the harvest was composed of three to seven year-old striped bass. Striped bass from 2017 and 2018 year classes (age 4 and 5) contributed the highest percentage to the weight of the harvest (53%). Striped bass age 8 and older contributed <1% by weight to the overall harvest in 2022, which was lower than 2021(1%).

Monitoring summary

Striped bass ranging from 457 to 550 mm TL comprised 63% of the 2022 summer/fall harvest (Figure 5b). A larger percentage of fish >630 mm TL were harvested in 2022 (15%) compared to 2021 (11%). In 2022, 108 fish from pound net monitoring and 80 fish from check station sampling were aged. Younger fish (age 3 to 7) were abundant, accounting for the majority of the harvest (Figure 7). Length distributions between the legal-sized fish sampled from pound nets and all fish from check stations were significantly different ($D=0.245$, $P<0.0001$; Figure 4b). 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 ($\alpha=0.05$). Striped bass were significantly longer and heavier in November (TL=620 mm, WT=2.56 kg). The shortest average length of striped bass was in August, September, and December (TL=524 mm, 529 mm, 517 mm). The lowest average weight of striped bass was in July, August, and September (WT=1.34 kg, 1.43 kg, 1.47 kg). Duncan's groups are presented in Tables 7b and 8b.

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

SUMMER – FALL STOCK ASSESSMENT
AND COMMERCIAL FISHERY MONITORING

2023 PRELIMINARY RESULTS – WORK IN PROGRESS

Commercial pound net monitoring

During the 2023 striped bass pound net study, a total of 1,768 striped bass were sampled and 465 scale samples were collected for ageing pound nets in the upper Bay and in the lower Bay on twenty two different sampling days from ten unique pound nets.

Striped bass sampled from pound nets ranged from 211-1090 mm TL, with a mean length of 482 mm TL. A complete breakdown of catch by length and age for the 2023 summer/fall season will be available in the F61-R-19 Chesapeake Bay Finfish Investigations report.

Commercial summer/fall check station monitoring

A total of 1,648 striped bass were sampled and 371 scale samples were collected for ageing at summer/fall check stations in 2023. The mean length of sampled striped bass was 547 mm TL. Striped bass sampled from the summer/fall fishery ranged from 455 to 908 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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Table 1a. Summary of sampling areas, sampling dates, surface temperature, surface salinity and numbers of fish encountered during the 2021 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	23.5	7.2	350
	Middle	-	-	-	-
	Lower	10	24.0	12.5	239
July	Upper	1	26.5	6.9	289
	Middle	-	-	-	-
	Lower	8	26.6	13.1	386
August	Upper	2	26.9	7.8	670
	Middle	-	-	-	-
	Lower	7	26.9	13.0	421
September	Upper	1	21.6	5.4	426
	Middle	-	-	-	-
	Lower	11	25.2	13.6	1,061
October	Upper	1	18.3	7.1	350
	Middle	-	-	-	-
	Lower	1	23.3	11.7	138
November	Upper	1	14.1	7.5	286
	Middle	-	-	-	-
	Lower	1	13.2	12.1	271

Table 1b. Summary of sampling areas, sampling dates, surface temperature, surface salinity and numbers of fish encountered during the 2022 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
May	Upper	-	-	-	-
	Middle	-	-	-	-
	Lower	2	19.0	10.9	24
June	Upper	1	23.2	7.6	363
	Middle	-	-	-	-
	Lower	10	23.4	11.4	216
July	Upper	1	26.3	8.2	164
	Middle	-	-	-	-
	Lower	4	26.7	12.9	69
August	Upper	1	27.5	-	338
	Middle	-	-	-	-
	Lower	6	27.7	14.1	154
September	Upper	1	24.6	11.5	547
	Middle	-	-	-	-
	Lower	5	24.8	16.3	1,058
October	Upper	1	16.1	11.9	322
	Middle	-	-	-	-
	Lower	1	16.5	17.1	505
November	Upper	-	-	-	-
	Middle	-	-	-	-
	Lower	1	11.2	16.8	284

Table 2a. Mean length-at-age (mm TL) of striped bass sampled from pound nets in Maryland's Chesapeake Bay, June through November 2021.

Year-class	Age	N	Mean Length (mm TL)	Lower CL	Upper CL
2020	1	3	244	158	330
2019	2	20	309	284	333
2018	3	25	404	386	422
2017	4	12	478	455	500
2016	5	12	582	548	615
2015	6	17	600	570	630
2014	7	5	704	653	756
2013	8	2	809	*	*
2012	9	4	745	718	772
2011	10	4	835	772	898

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

Table 2b. Mean length-at-age (mm TL) of striped bass sampled from pound nets in Maryland's Chesapeake Bay, May through November 2022.

Year-class	Age	N	Mean Length (mm TL)	Lower CL	Upper CL
2021	1	9	253	230	277
2020	2	19	330	307	353
2019	3	19	423	402	445
2018	4	12	470	437	503
2017	5	6	574	510	639
2016	6	8	621	578	664
2015	7	18	717	667	766
2014	8	5	847	781	914
2013	9	1	957	*	*
2012	10	3	926	*	*
2011	11	5	1041	989	1092
2009	13	2	1068	*	*
2007	15	2	1083	987	1178

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

Table 3a. Number of striped bass, by age, sampled from pound nets, in Maryland's Chesapeake Bay, June through November 2021. Sum of columns may not equal due to rounding.

Year-class	Age	Pound Net Monitoring	
		Number Sampled at Age (n)	Percent of Total
2020	1	16	0.3
2019	2	1,033	21.1
2018	3	2,126	43.5
2017	4	800	16.4
2016	5	385	7.9
2015	6	485	9.9
2014	7	16	0.3
2013	8	6	0.1
2012	9	10	0.2
2011	10	7	0.2
2007	14	2	<0.1
2005	16	1	<0.1
Total		4,887	100.0

Table 3b. Number of striped bass, by age, sampled from pound nets, in Maryland's Chesapeake Bay, May through November 2022. Sum of columns may not equal due to rounding.

Year-class	Age	Pound Net Monitoring	
		Number Sampled at Age (n)	Percent of Total
2021	1	52	1.3
2020	2	580	14.3
2019	3	1,769	43.7
2018	4	1,028	25.4
2017	5	328	8.1
2016	6	158	3.9
2015	7	103	2.6
2014	8	8	0.2
2013	9	3	0.1
2012	10	4	0.1
2011	11	7	0.2
2009	13	2	0.1
2007	15	2	0.1
Total		4,044	100.0

Table 4a. 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 2021.

Year-class	Age	n	Mean Length (mm TL)	Lower CL	Upper CL
2018	3	2	479	*	*
2017	4	5	499	473	524
2016	5	9	612	568	657
2015	6	18	644	609	678
2014	7	7	708	681	735
2013	8	4	740	620	859
2012	9	5	728	698	758
2011	10	5	744	740	748
2010	11	1	741	*	*

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

Table 4b. 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 December 2022.

Year-class	Age	n	Mean Length (mm TL)	Lower CL	Upper CL
2019	3	5	468	454	482
2018	4	8	522	471	573
2017	5	17	601	569	633
2016	6	13	649	602	696
2015	7	23	703	682	725
2014	8	2	746	*	*
2013	9	4	769	715	822
2012	10	4	763	730	797
2011	11	4	812	745	878

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

Table 5a. 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 2021.

Year-class	Age	n	Mean Weight (kg)	Lower CL	Upper CL
2018	3	2	1.1	*	*
2017	4	5	1.2	1.2	1.2
2016	5	9	2.2	2.1	2.3
2015	6	18	2.6	2.1	3.1
2014	7	7	3.2	2.8	3.6
2013	8	4	3.5	3.2	3.8
2012	9	5	3.5	2.7	4.3
2011	10	5	3.7	3.4	4.0
2010	11	1	4.3	4.1	4.5

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

Table 5b. 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 December 2022.

Year-class	Age	n	Mean Weight (kg)	Lower CL	Upper CL
2019	3	5	1.1	0.9	1.3
2018	4	8	1.5	0.9	2.0
2017	5	17	2.2	1.8	2.6
2016	6	13	2.7	2.2	3.3
2015	7	23	3.4	3.1	3.7
2014	8	2	3.8	*	*
2013	9	4	4.2	4.0	4.5
2012	10	4	5.2	3.9	6.6
2011	11	4	5.7	4.3	7.2

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

Table 6a. Estimated catch-at-age of striped bass landed by the Maryland Chesapeake Bay commercial summer/fall fishery, June through December 2021.

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
2018	3	52,765	6.8	21,758	11.3
2017	4	190,964	24.7	72,183	37.5
2016	5	223,441	28.9	46,069	23.9
2015	6	285,118	36.8	49,741	25.8
2014	7	12,351	1.6	1,751	0.9
2013	8	4,546	0.6	589	0.3
2012	9	2,880	0.4	373	0.2
2011	10	1,569	0.2	192	0.1
2010	11	328	<0.1	35	<0.1
Total*		773,963	100.0	192,691	100.0

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

Table 6b. Estimated catch-at-age of striped bass landed by the Maryland Chesapeake Bay commercial summer/fall fishery, June through December 2022.

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
2019	3	121,676	17.0	50,174	28.2
2018	4	179,878	25.2	54,394	30.6
2017	5	195,940	27.4	40,399	22.7
2016	6	118,929	16.7	19,980	11.2
2015	7	91,078	12.8	12,151	6.8
2014	8	3,572	0.5	426	0.2
2013	9	987	0.1	107	0.1
2012	10	1,043	0.1	91	0.1
2011	11	964	0.1	77	<0.1
Total*		714,067	100.0	177,798	100.0

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

Table 7a. Duncan's multiple range test for mean length by month for the Maryland Chesapeake Bay commercial summer/fall fishery, June through November 2021. Months with the same Duncan grouping letter are not significantly different ($\alpha=0.05$) in mean length.

Duncan Grouping	Month	Mean Length (mm)	Number of Fish Sampled
A	September	567	279
A	June	563	536
A	August	556	334
B	November	539	257
C	October	528	276
C	July	523	83

Table 7b. Duncan's multiple range test for mean length by month for the Maryland Chesapeake Bay commercial summer/fall fishery, June through December 2022. Months with the same Duncan grouping letter are not significantly different ($\alpha=0.05$) in mean length.

Duncan Grouping	Month	Mean Length (mm)	Number of Fish Sampled
A	November	620	288
B	June	556	520
C	October	534	556
C	July	532	240
CD	September	529	366
CD	August	524	38
D	December	517	91

Table 8a. Duncan's multiple range test for mean weight by month for the Maryland Chesapeake Bay commercial summer/fall fishery, June through November 2021. Months with the same Duncan grouping letter are not significantly different ($\alpha=0.05$) in mean weight.

Duncan Grouping	Month	Mean Weight (kg)	Number of Fish Sampled
A	September	1.89	279
B	June	1.78	536
B	November	1.72	257
C	August	1.52	334
CD	October	1.43	276
D	July	1.40	83

Table 8b. Duncan's multiple range test for mean weight by month for the Maryland Chesapeake Bay commercial summer/fall fishery, June through December 2022. Months with the same Duncan grouping letter are not significantly different ($\alpha=0.05$) in mean weight.

Duncan Grouping	Month	Mean Weight (kg)	Number of Fish Sampled
A	November	2.56	288
B	June	1.73	520
B	October	1.66	556
B	December	1.64	91
C	September	1.47	366
C	August	1.43	37
C	July	1.34	240

Figure 1. Locations of Chesapeake Bay commercial summer/fall check stations and pound nets sampled in 2021 and 2022.

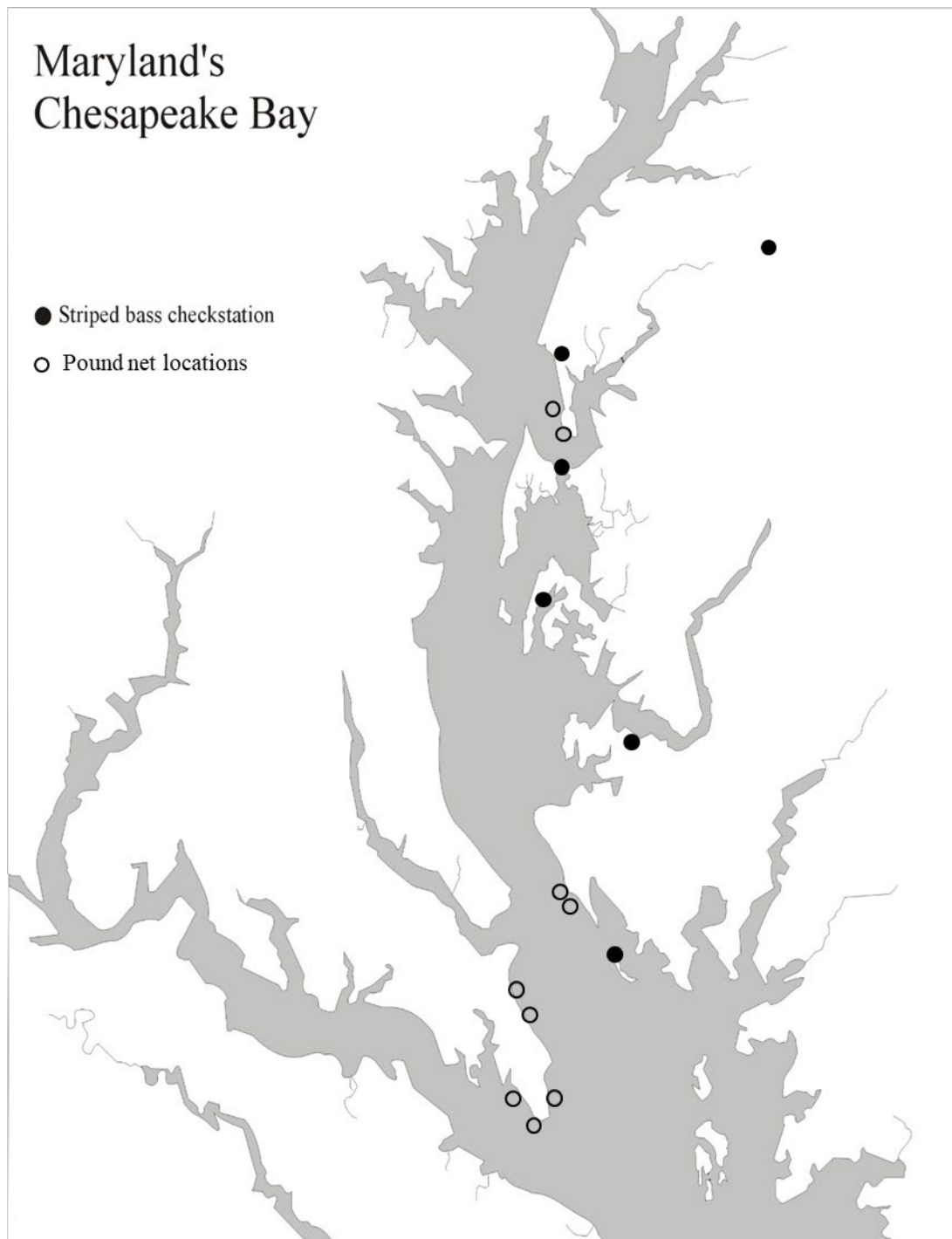


Figure 2a. Age and length (mm TL) frequencies of striped bass sampled during Maryland Chesapeake Bay pound net monitoring study, June through November 2021.

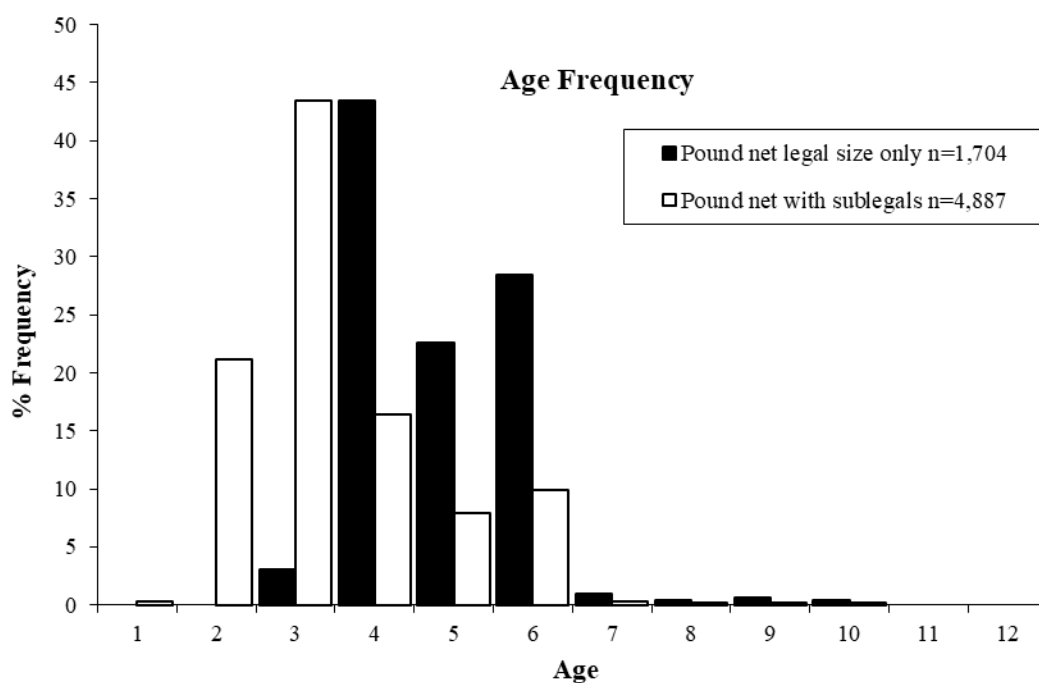
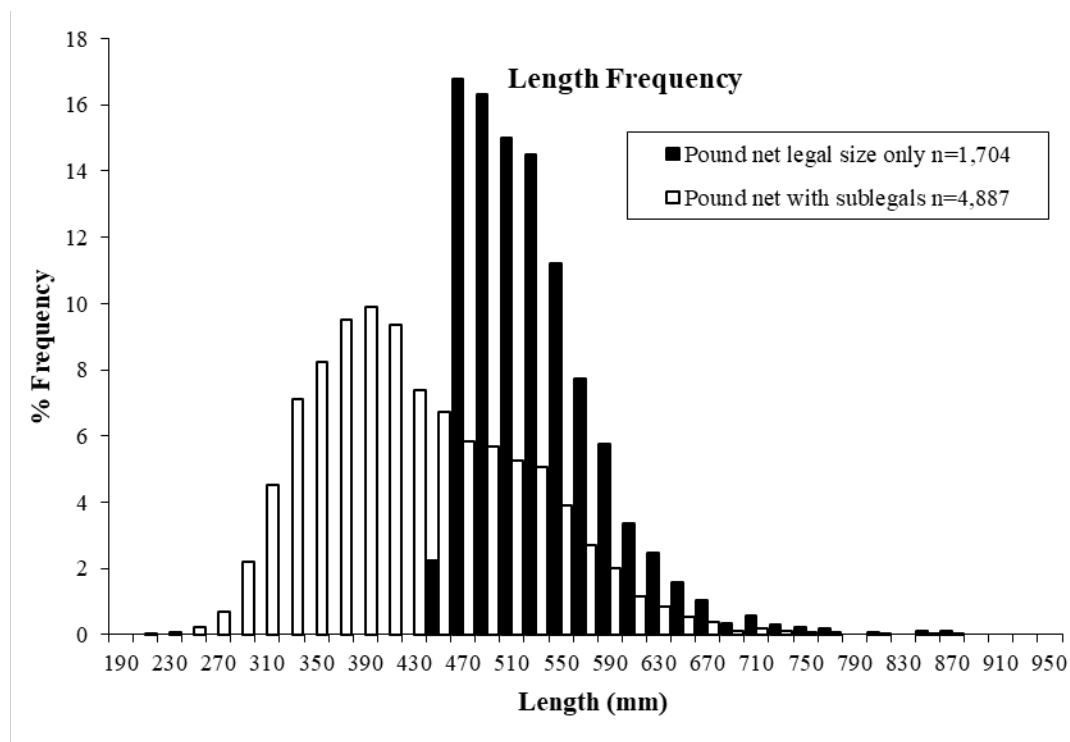


Figure 2b. Age and length (mm TL) frequencies of striped bass sampled during Maryland Chesapeake Bay pound net monitoring study, May through November 2022.

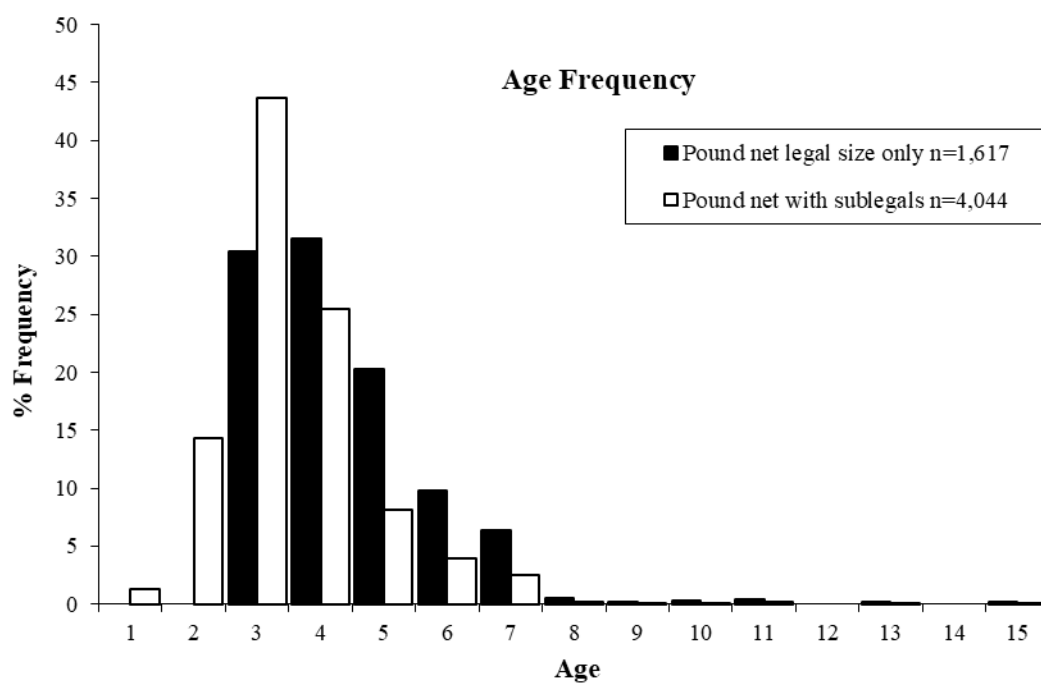
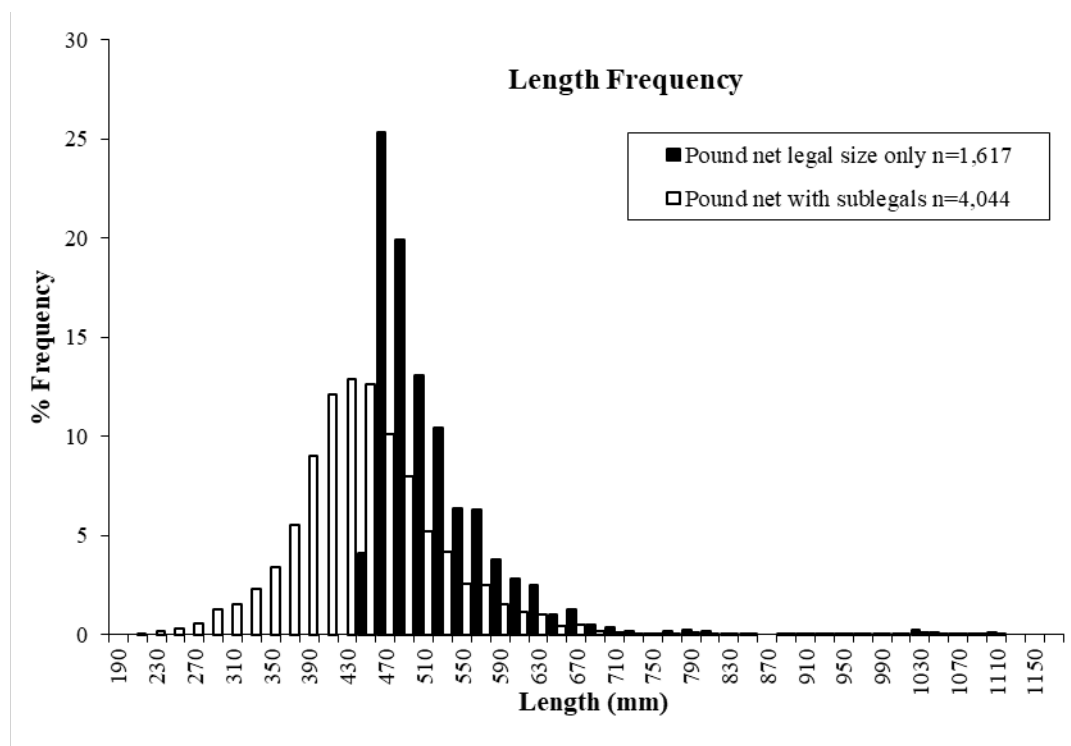


Figure 3. Age structure of striped bass sampled from Maryland Chesapeake Bay commercial pound net monitoring study from 1996 through 2022. *Note partial net sampling for legal sized fish was conducted from 1996 to 1999. Full net samples started in 2000.

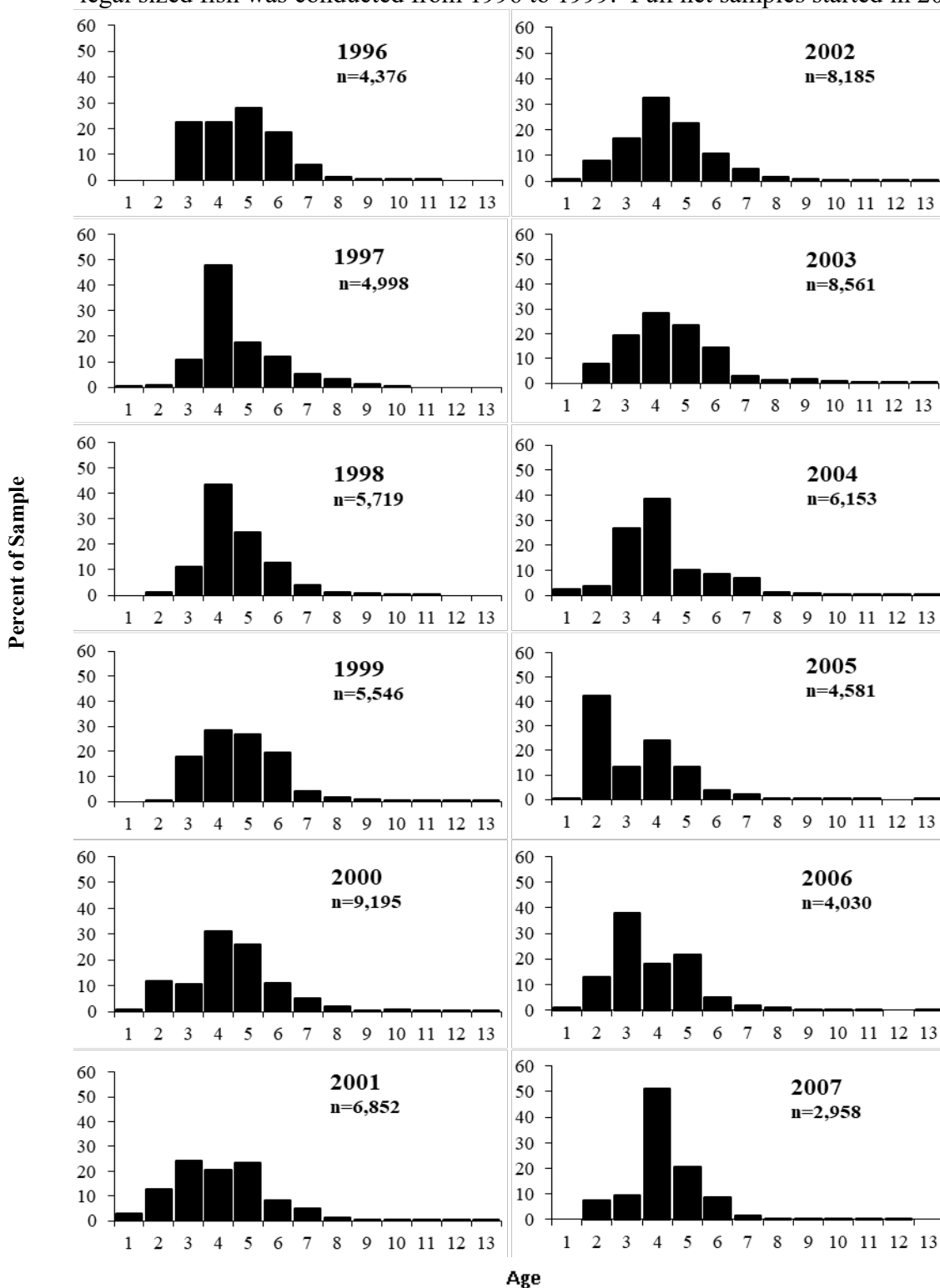


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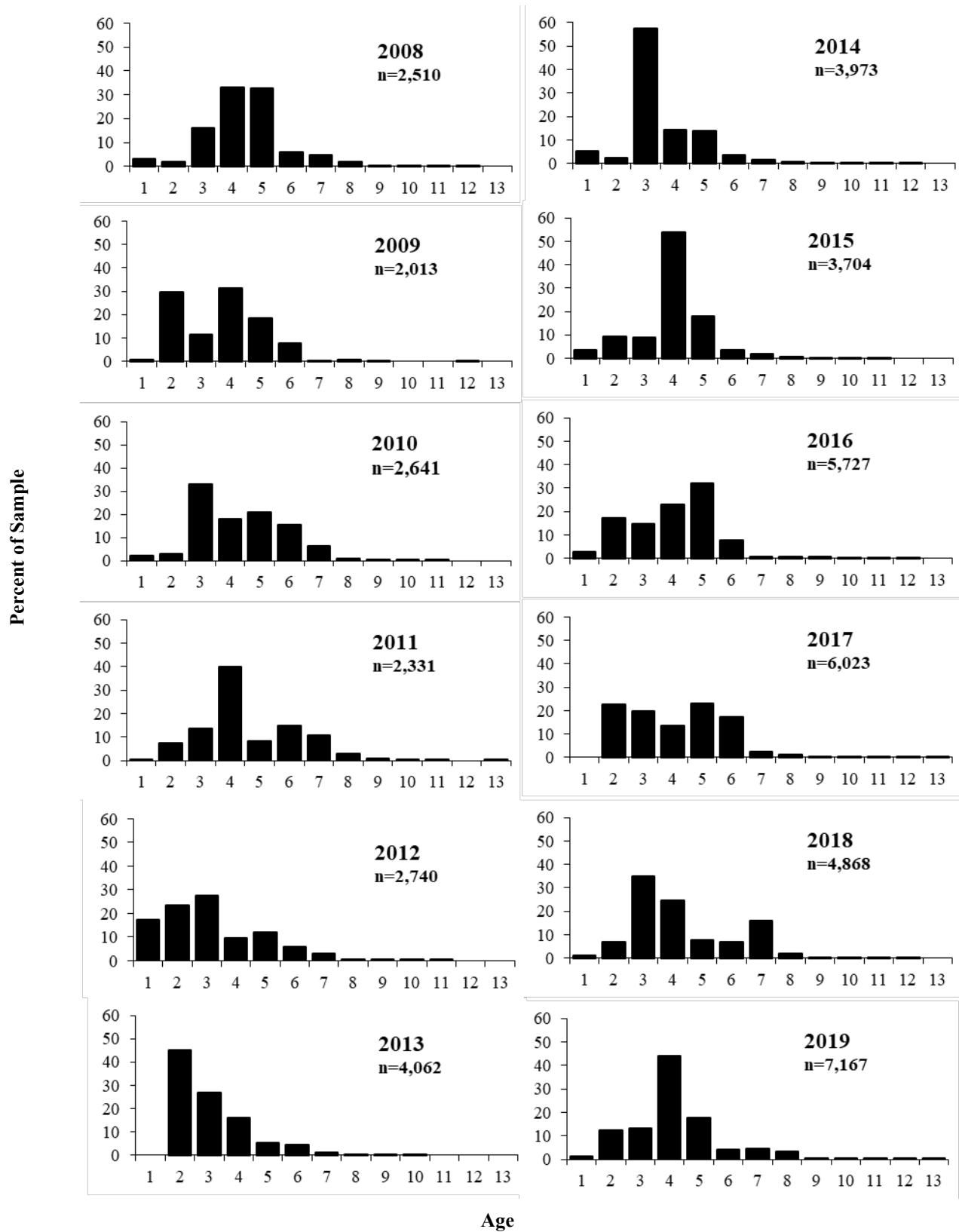


Figure 3. Continued

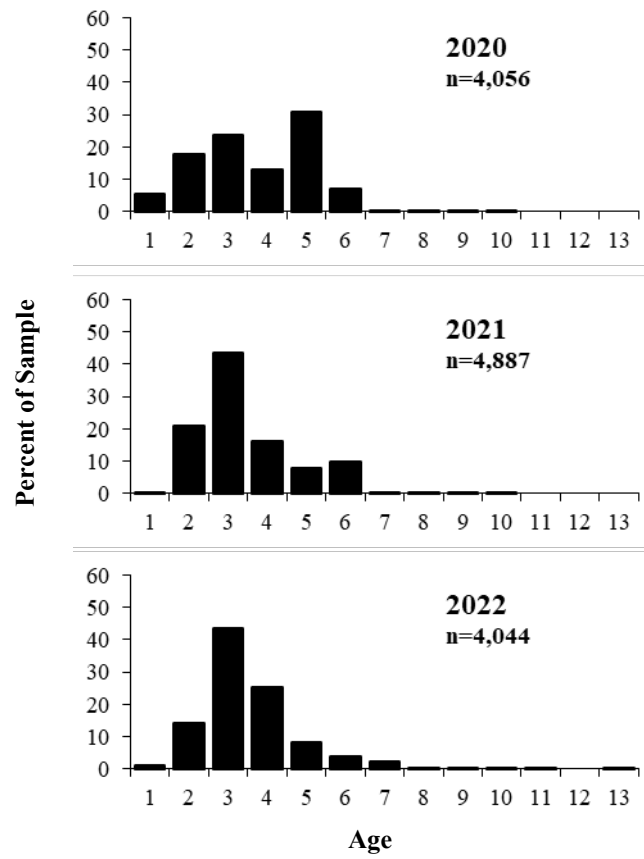


Figure 4a. Length frequency of striped bass sampled during the 2021 pound net monitoring and the summer/fall check station surveys. All fish were sampled from June through November 2021. Pound net monitoring length frequency is for legal-size fish only (≥ 457 mm TL/18 in TL).

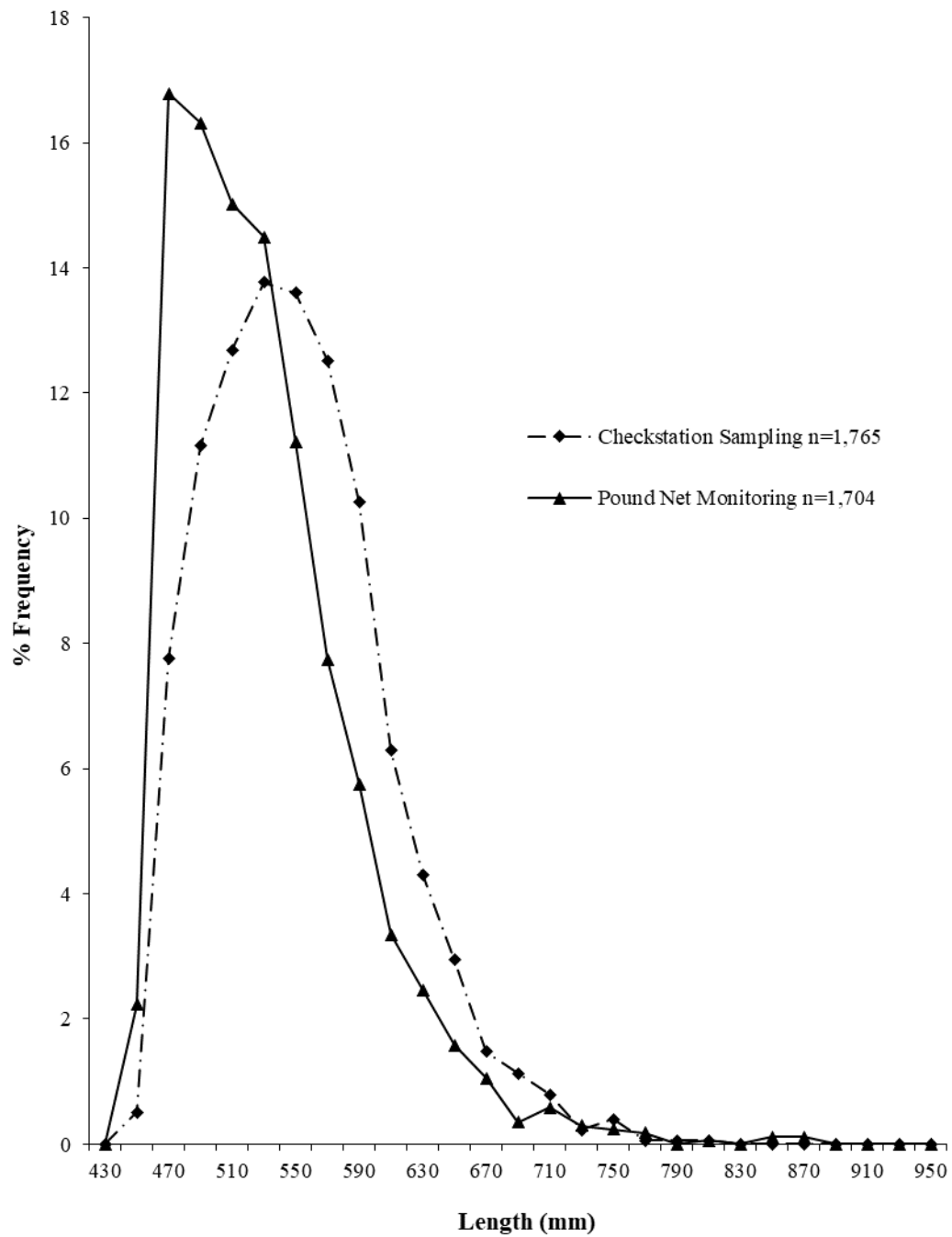


Figure 4b. Length frequency of striped bass sampled during the 2022 pound net monitoring and the summer/fall check station surveys. All fish were sampled from May through December 2022. Pound net monitoring length frequency is for legal-size fish only (≥ 457 mm TL/18 in TL).

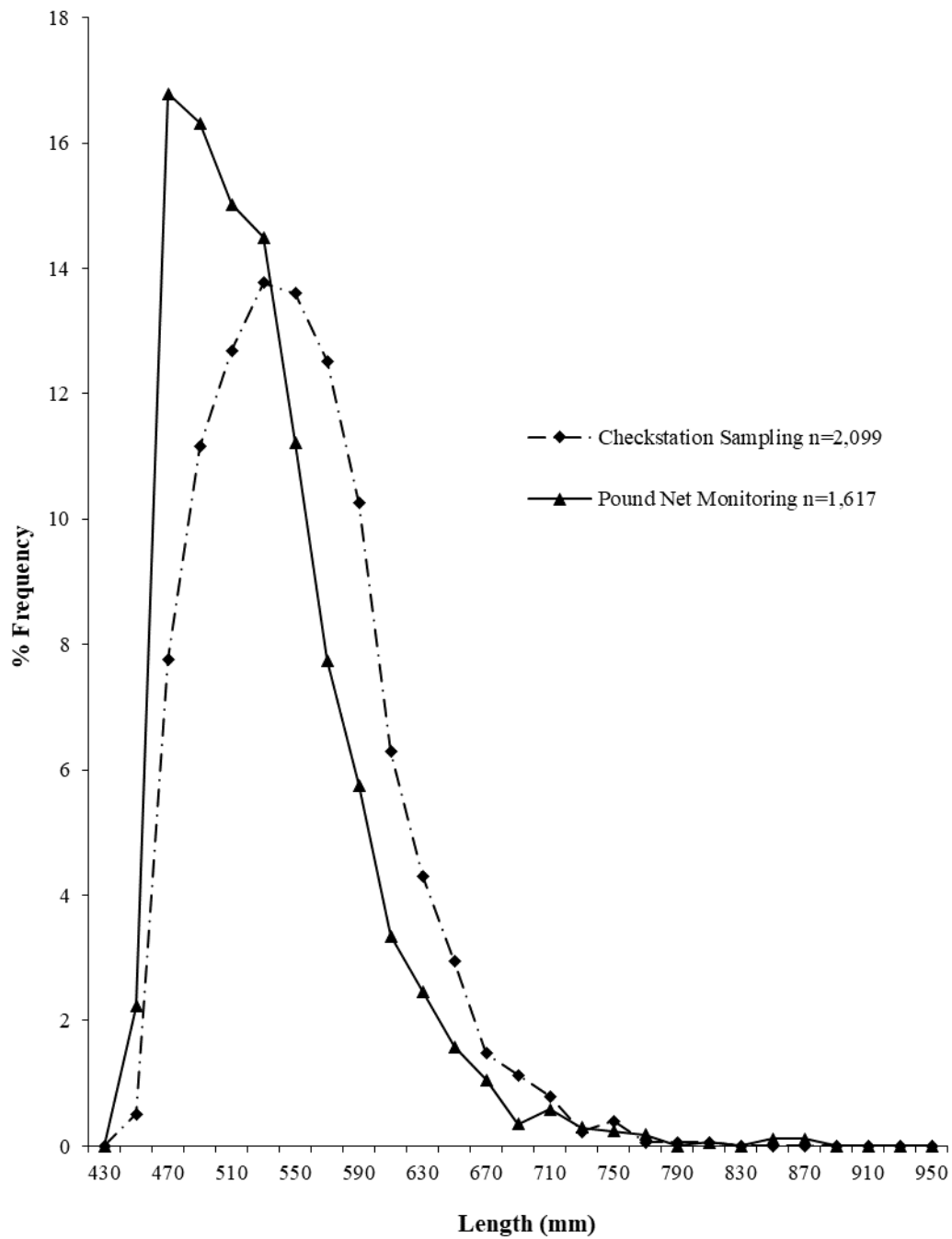


Figure 5a. Age and length frequencies of striped bass sampled from Maryland Chesapeake Bay commercial summer/fall check stations, June through November 2021.

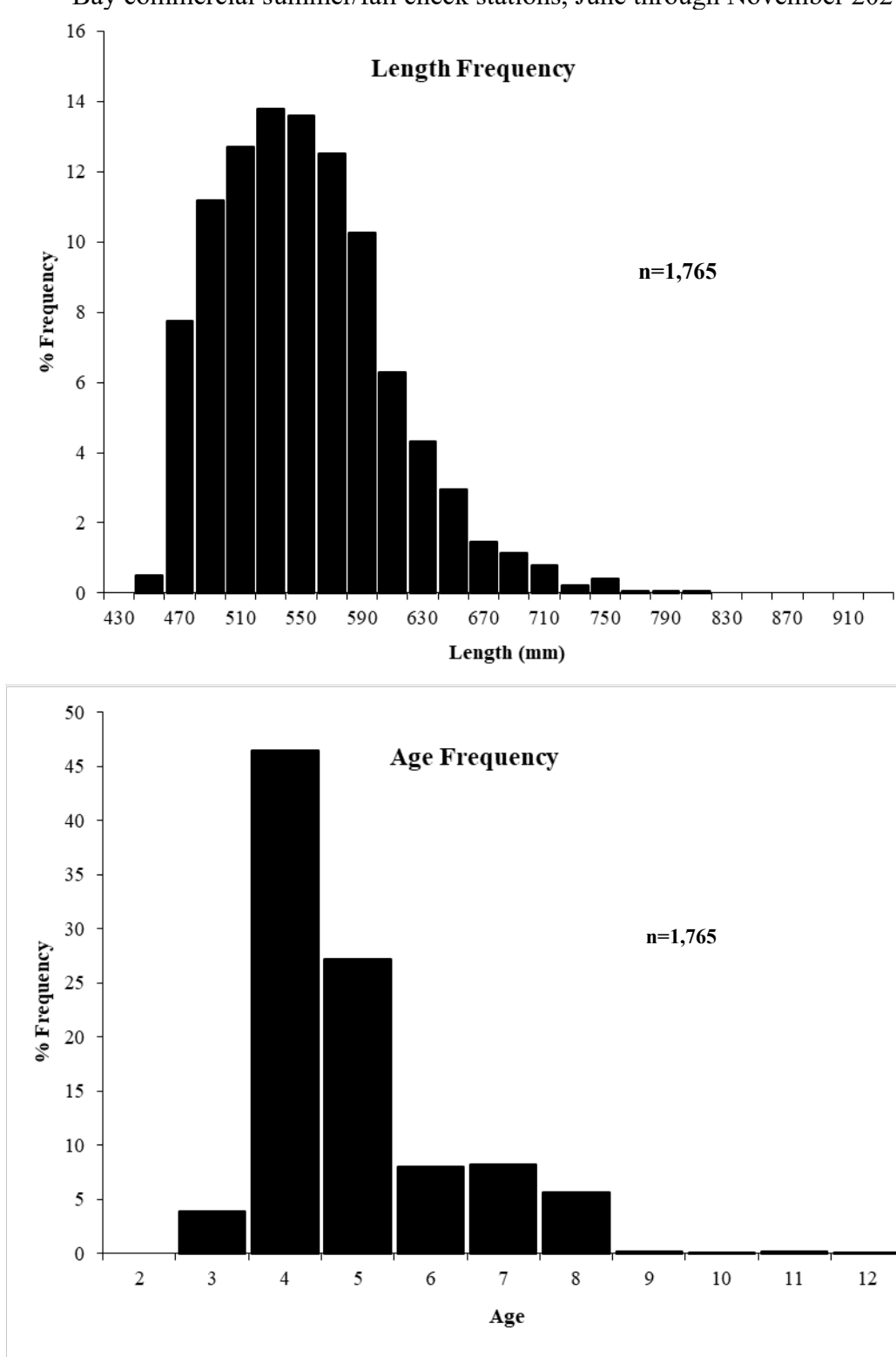


Figure 5b. Age and length frequencies of striped bass sampled from Maryland Chesapeake Bay commercial summer/fall check stations, June through December 2022.

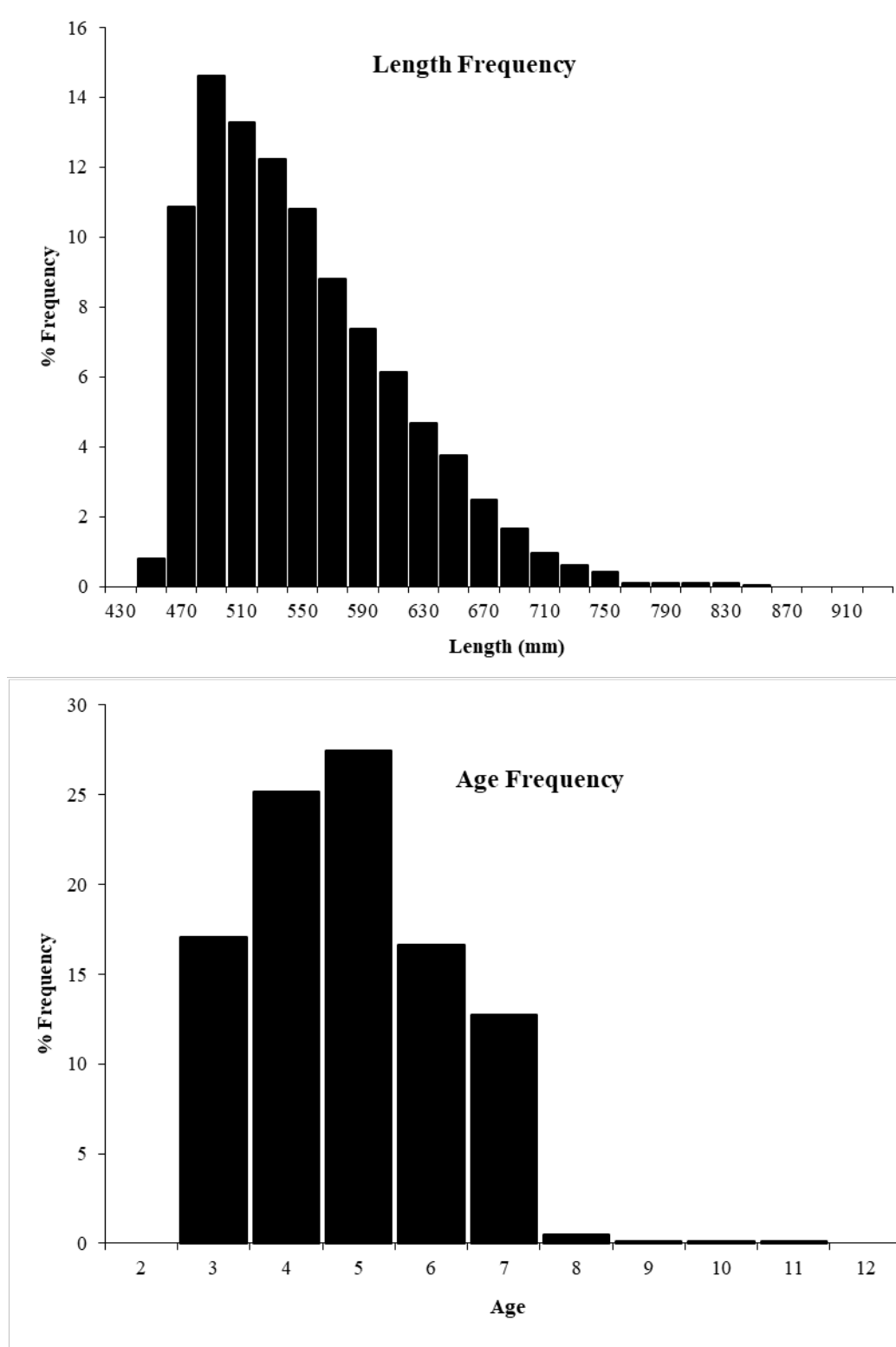


Figure 6a. Month-specific length distributions of striped bass sampled from Maryland Chesapeake Bay commercial summer/fall check stations, June through November 2021.

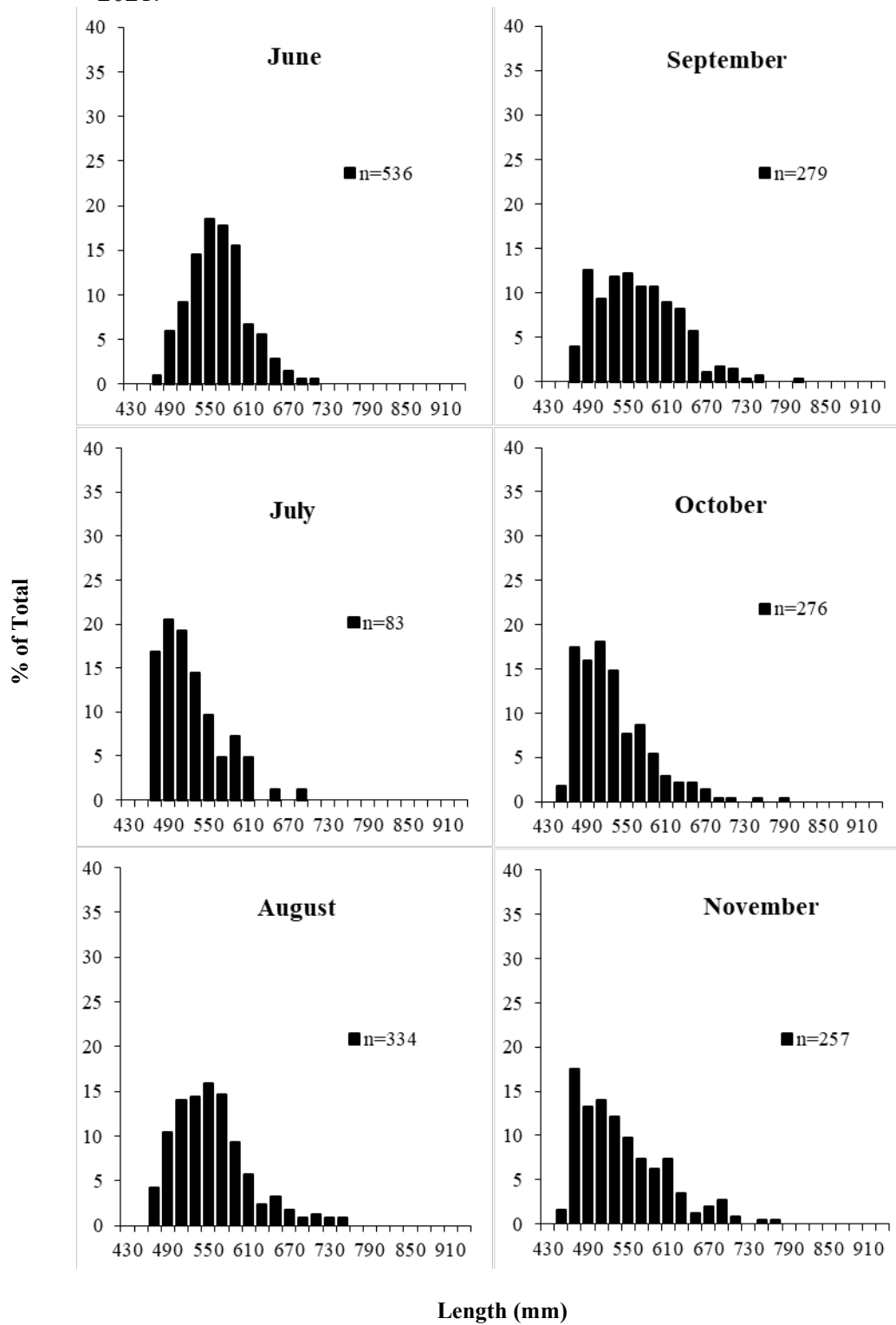


Figure 6b. Month-specific length distributions of striped bass sampled from Maryland Chesapeake Bay commercial summer/fall check stations, June through December 2022.

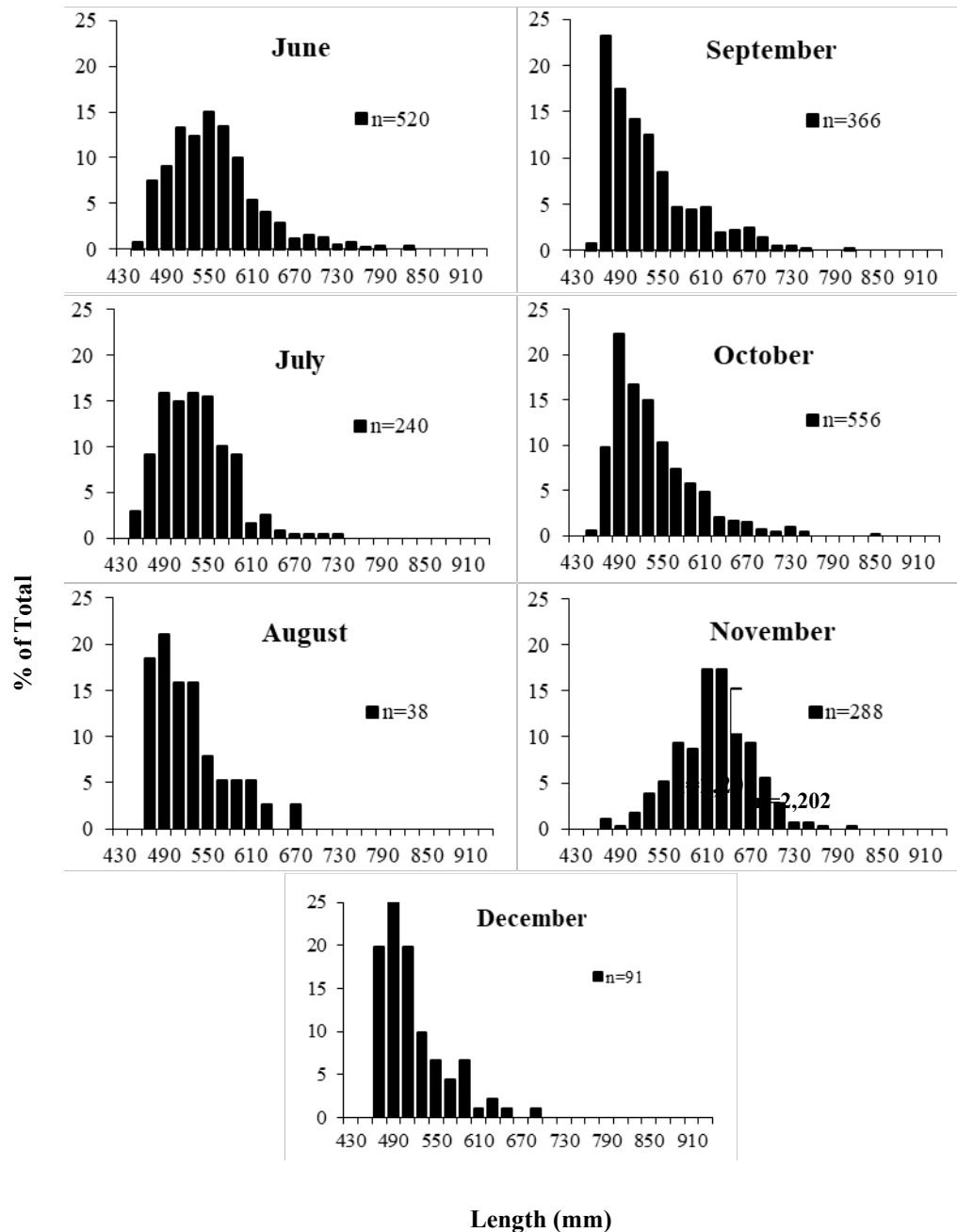


Figure 7. Age structure of striped bass sampled from Maryland Chesapeake Bay commercial summer/fall check stations, 1999 through 2022. Note-pound net check station sampling began in 2000 and gears are combined beginning in 2014.

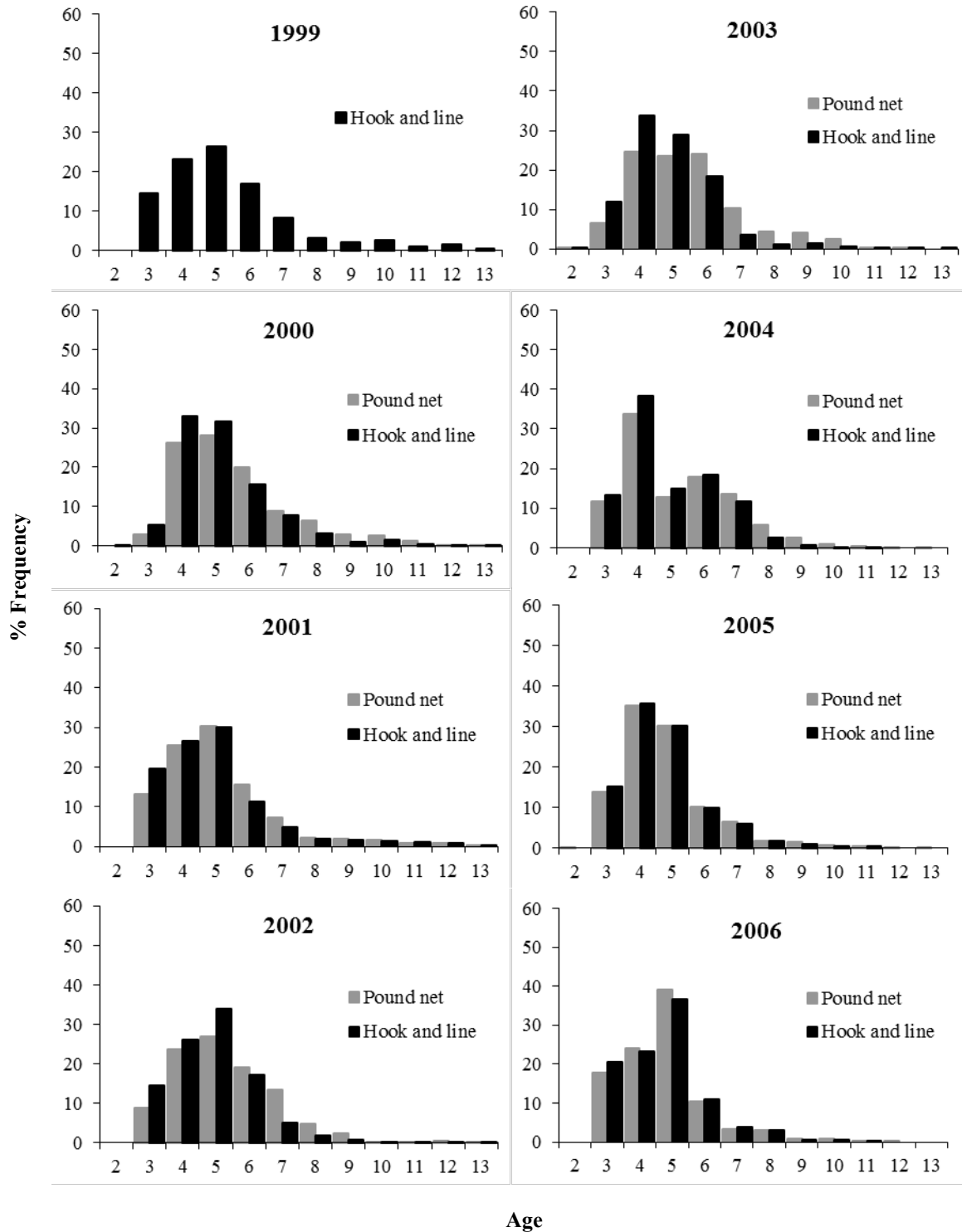


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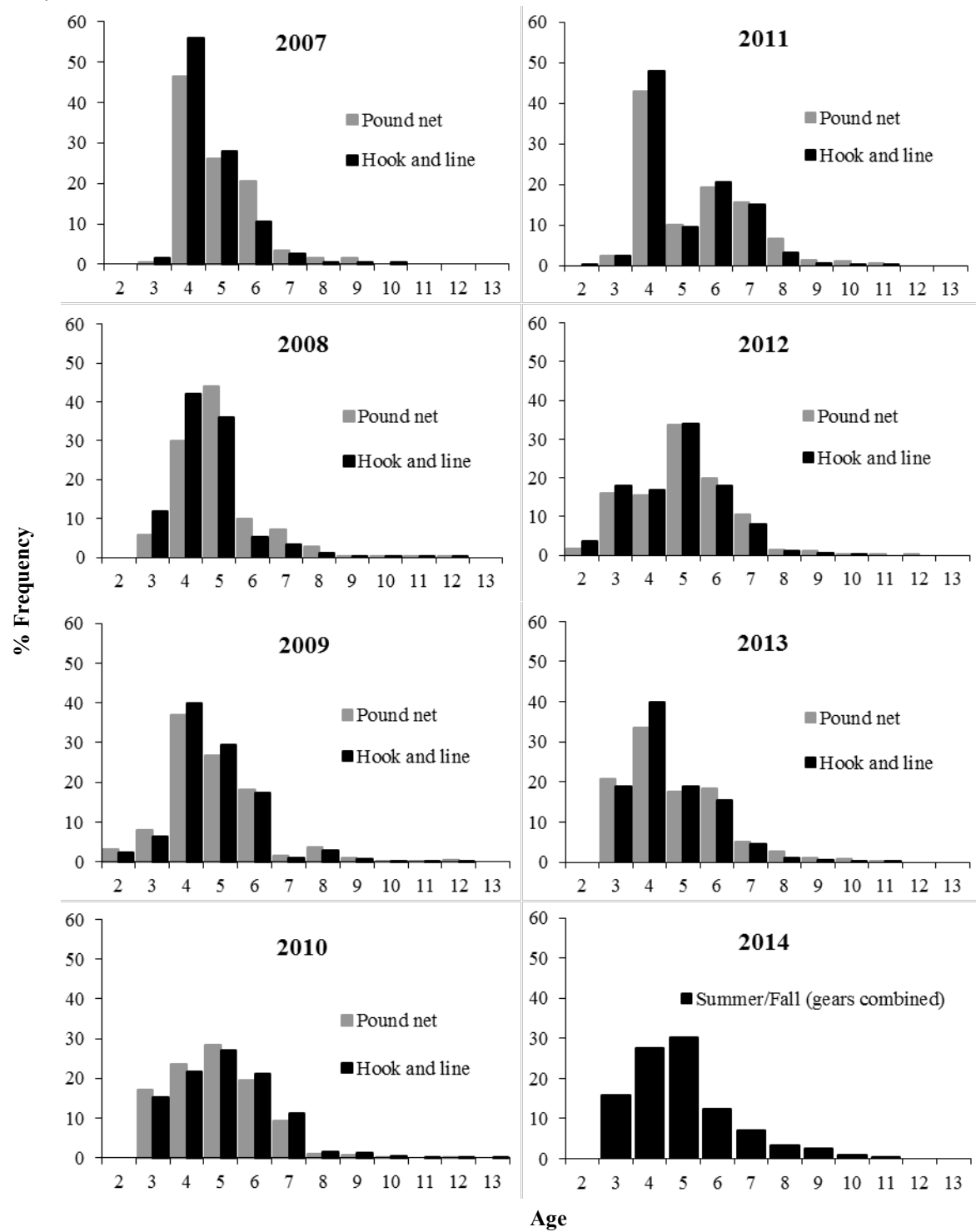


Figure 7. Continued

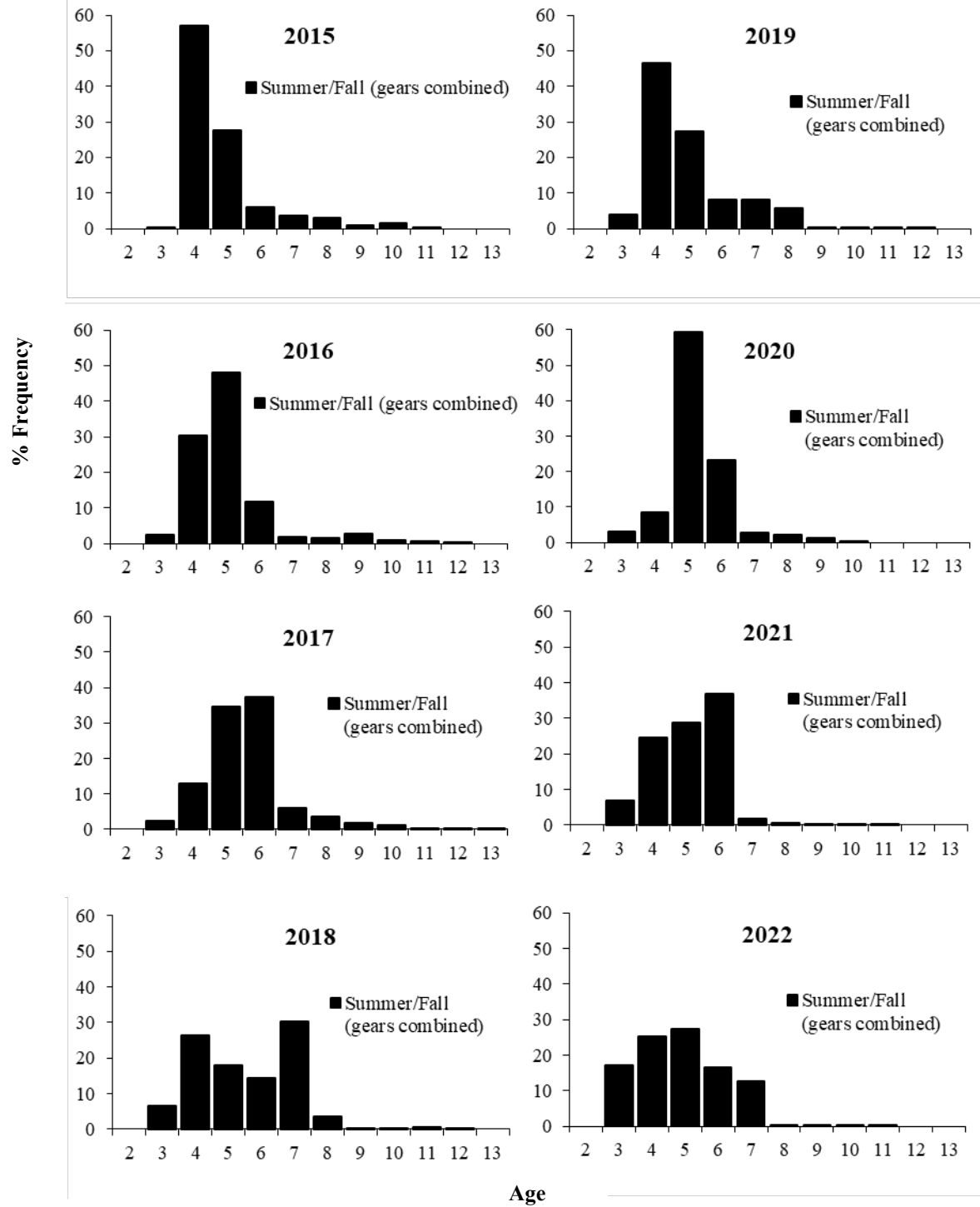
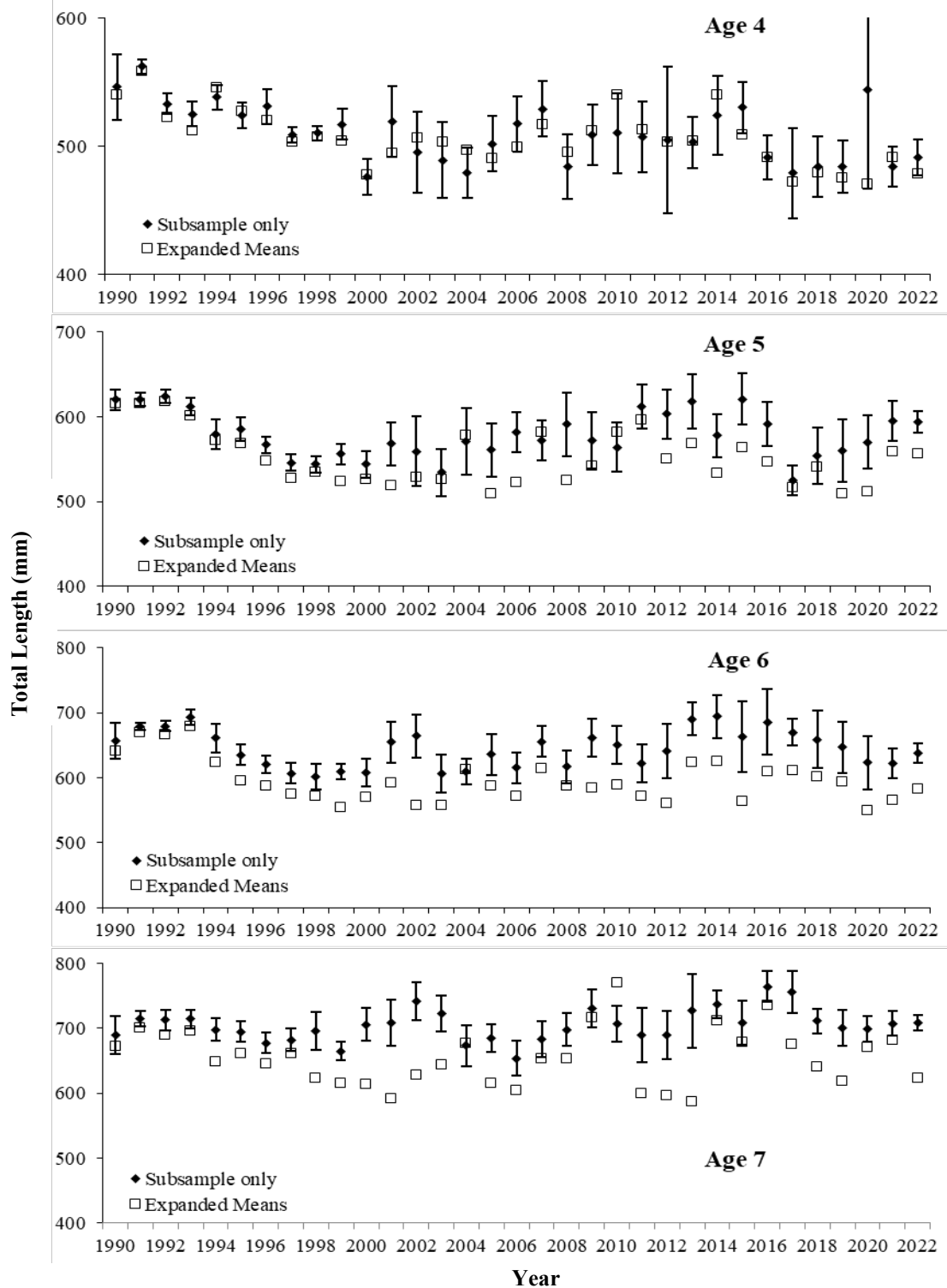


Figure 8. Mean lengths for legal-size striped bass (≥ 457 mm TL) by year for age 4, 5, 6, and 7 striped bass sampled from Maryland Chesapeake Bay pound nets and commercial summer/fall check stations, 1990 through 2022. Mean lengths were calculated by using sub-sampled ages only and by expanding ages 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, 2021 – February 28, 2022, commercial drift gill net fishery and provide preliminary results, as available, for the 2022-2023 winter season. Completed results for the 2022-2023 winter sample season will be reported in the F61-R-19 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 Sunday 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 three days in January and two 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 acrylic 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 2021-2022 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 2021 – February 2022 gill net season, the year used for age calculations was 2022.

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 2021-2022 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 3,616 striped bass was sampled and 126 striped bass were aged from the harvest between December 2021 - February 2022. 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 four times in December, four times in January, and four 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 2021-

2022 season was estimated by dividing reported monthly harvest weight by the mean monthly weight of check station samples. Total reported landings were 532,433 pounds and the estimated number of fish was 80,412 (Table 1). According to the catch-at-age analysis, the 2021-2022 commercial drift gill net harvest consisted primarily of age 7 striped bass from the 2015 year-class (49%; Table 2). The 2014 and 2017 year-classes (ages 8 and 5) composed an additional 23% of the total harvest. The contribution of fish age 9 and older (8%) was the same as the 2020-2021 harvest (8%). The youngest fish observed in the 2021-2022 sampled harvest were age 4 from the 2018 year class (4%).

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 (2018 year-class), with an expanded mean length and weight of 528 mm TL and 1.96 kg, respectively. The 2015 year-class (age 7) was the most commonly observed in the sampled landings and had an expanded mean length and weight of 610 mm TL and 3.01 kg, respectively. The expanded mean length and weight of the oldest fish in the aged subsample (age 14, 2008 year-class) were 788 mm TL and 6.27 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 490-710 mm length groups. A total of 2 sub-legal fish <457 mm TL (18 inches) were observed in 2021-2022 sampling.

Time-series of subsampled and expanded mean lengths and weights for the period 1994-2022 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

2022-2023 WINTER STOCK ASSESSMENT
AND COMMERCIAL FISHERY MONITORING

2022-2023 SEASON PRELIMINARY RESULTS

A total of 3,245 striped bass were sampled and 514 scale samples were collected from the harvest between December 2022 - February 2023. 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, six 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 2022-2023 winter season of harvest-, length-, and weight-at-age will be provided in the F61-R-19 Chesapeake Bay Finfish Investigations report.

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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 - 2022 (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.

Table 1. Reported pounds harvested, check station average weights, and estimated numbers of fish harvested by the Maryland Chesapeake Bay commercial drift gill net fishery, December 2021 - February 2022.

Month	Harvest (lbs)	Check station average wt. (lb)	Estimated # harvested
December 2021	148,056	6.03	24,561
January 2022	228,301	7.22	31,638
February 2022	156,076	6.45	24,213
Total*	532,433		80,412

* 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 2021 - February 2022.

Year-class	Age	Catch	Percentage of the catch
2018	4	3,395	4
2017	5	9,147	11
2016	6	12,169	15
2015	7	39,698	49
2014	8	9,695	12
2013	9	4,425	6
2012	10	1,665	2
2011	11	196	<1
2008	14	22	<1
Total*		80,412	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 2021 - February 2022.

Year-class	Age	n fish aged	Mean TL (mm) of subsample	Estimated # at-age in sample	Expanded mean TL(mm)
2018	4	9	496	153	528
2017	5	18	505	411	545
2016	6	12	591	547	598
2015	7	42	654	1,785	610
2014	8	18	705	436	638
2013	9	12	724	199	677
2012	10	7	752	75	666
2011	11	7	801	9	784
2008	14	1	785	1	788
Total*		126		3,616	

* 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 2021 - February 2022.

Year-class	Age	n fish aged	Mean WT (kg) of subsample	Estimated # at-age in sample	Expanded mean weight (kg)
2018	4	9	1.56	153	1.96
2017	5	18	1.73	411	2.18
2016	6	12	2.94	547	2.87
2015	7	42	3.70	1,785	3.01
2014	8	18	4.60	436	3.44
2013	9	12	4.95	199	4.04
2012	10	7	5.69	75	3.86
2011	11	7	6.85	9	6.44
2008	14	1	5.47	1	6.27
Total*		126		3,616	

* 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 2021 - February 2022.

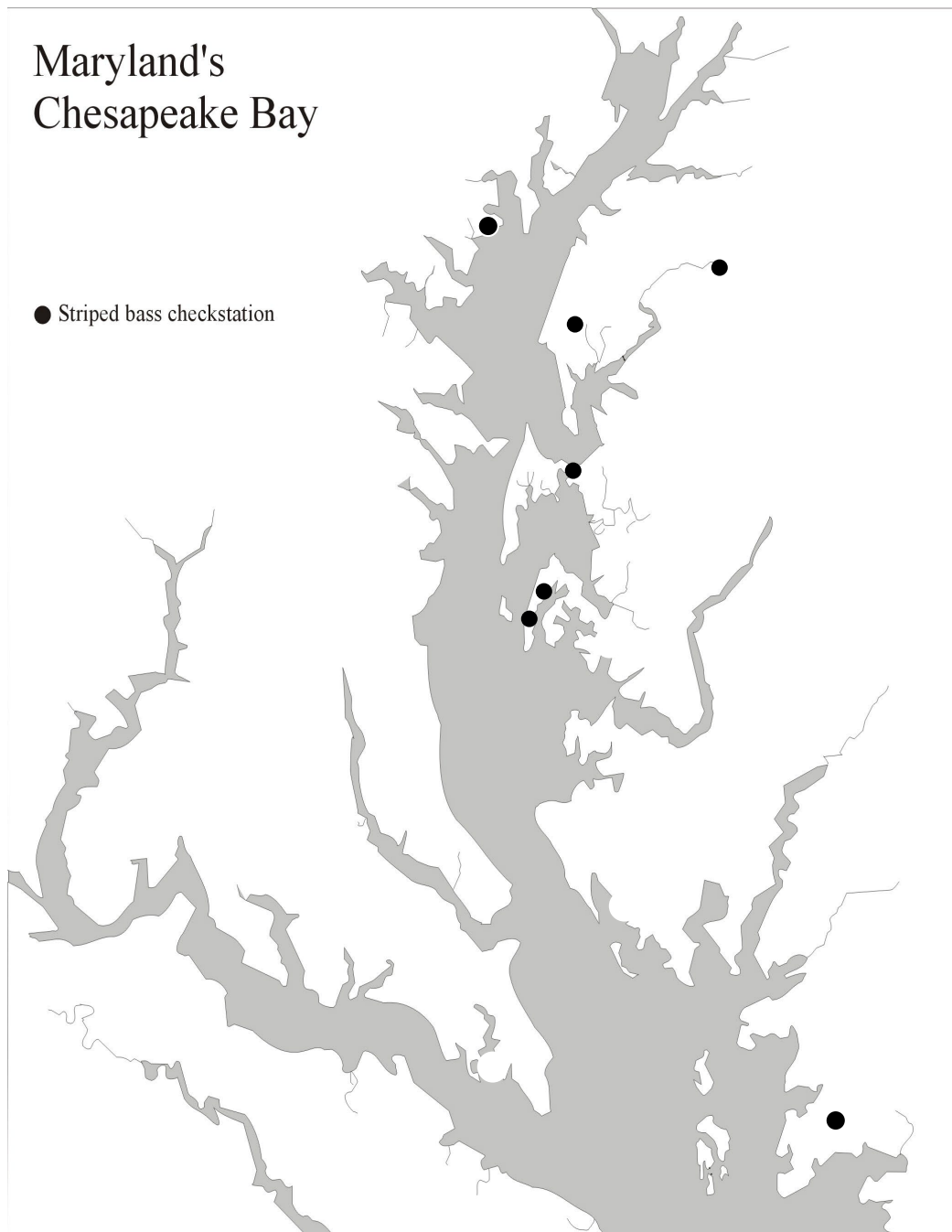


Figure 2. Age distribution of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, 1994 - 2022.

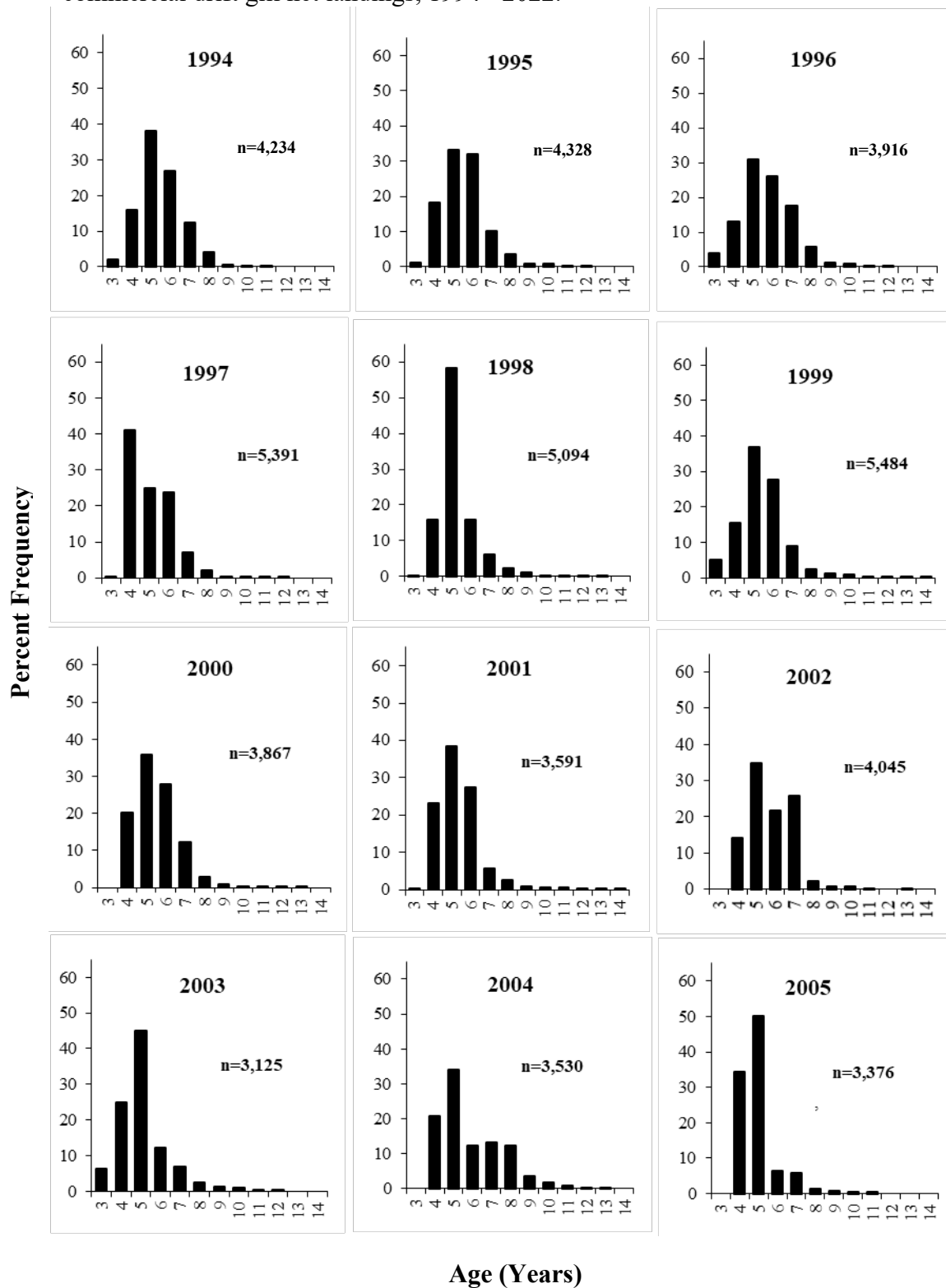


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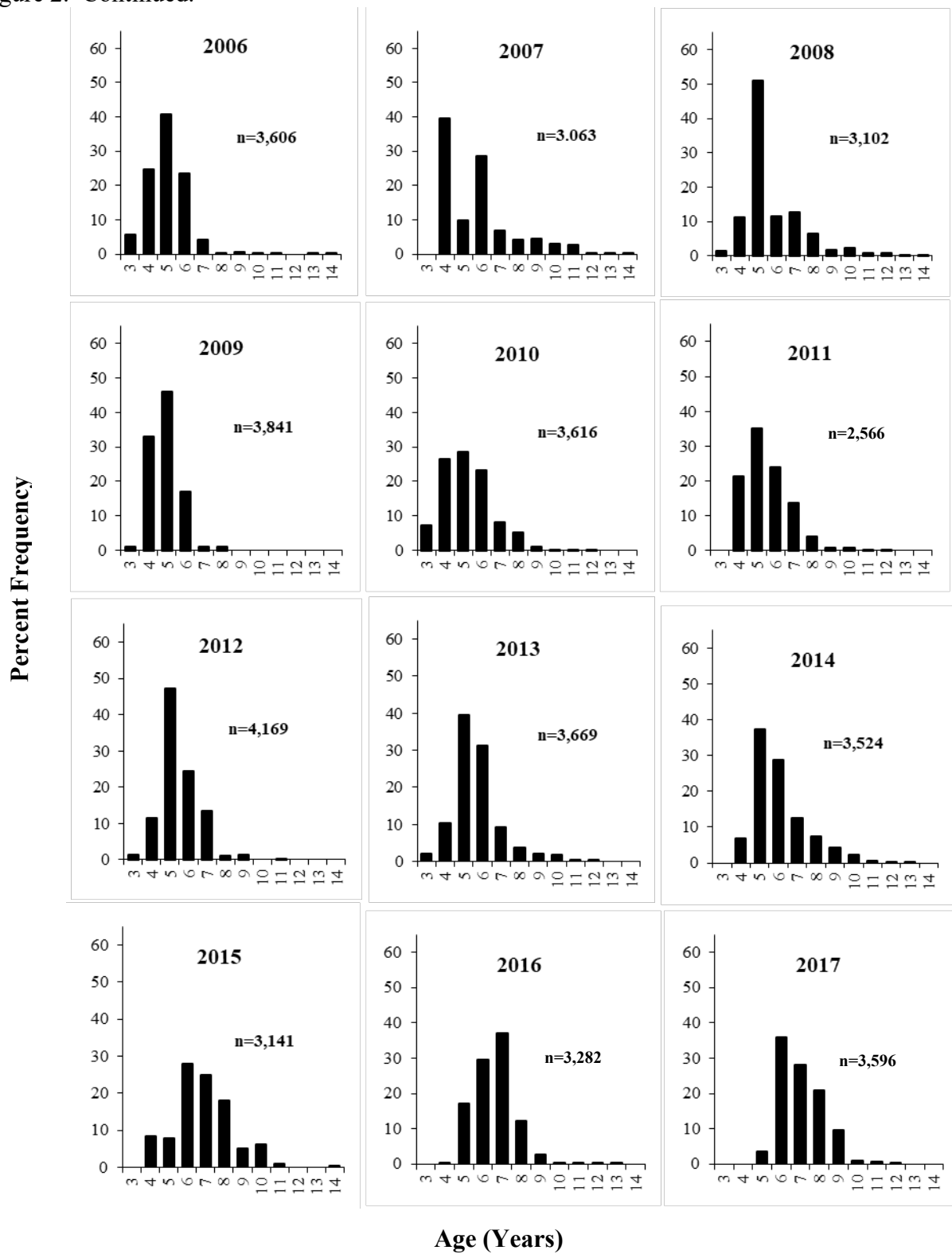


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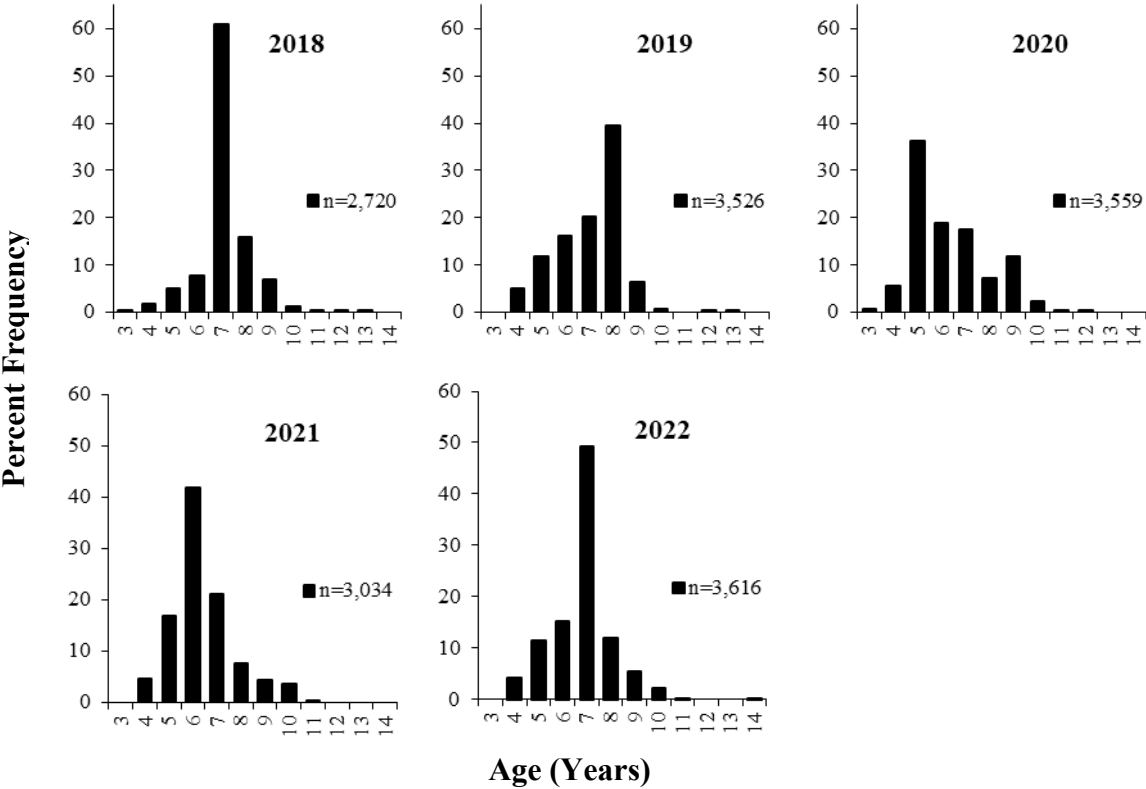


Figure 3. Length frequency distribution of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, December 2021 - February 2022.

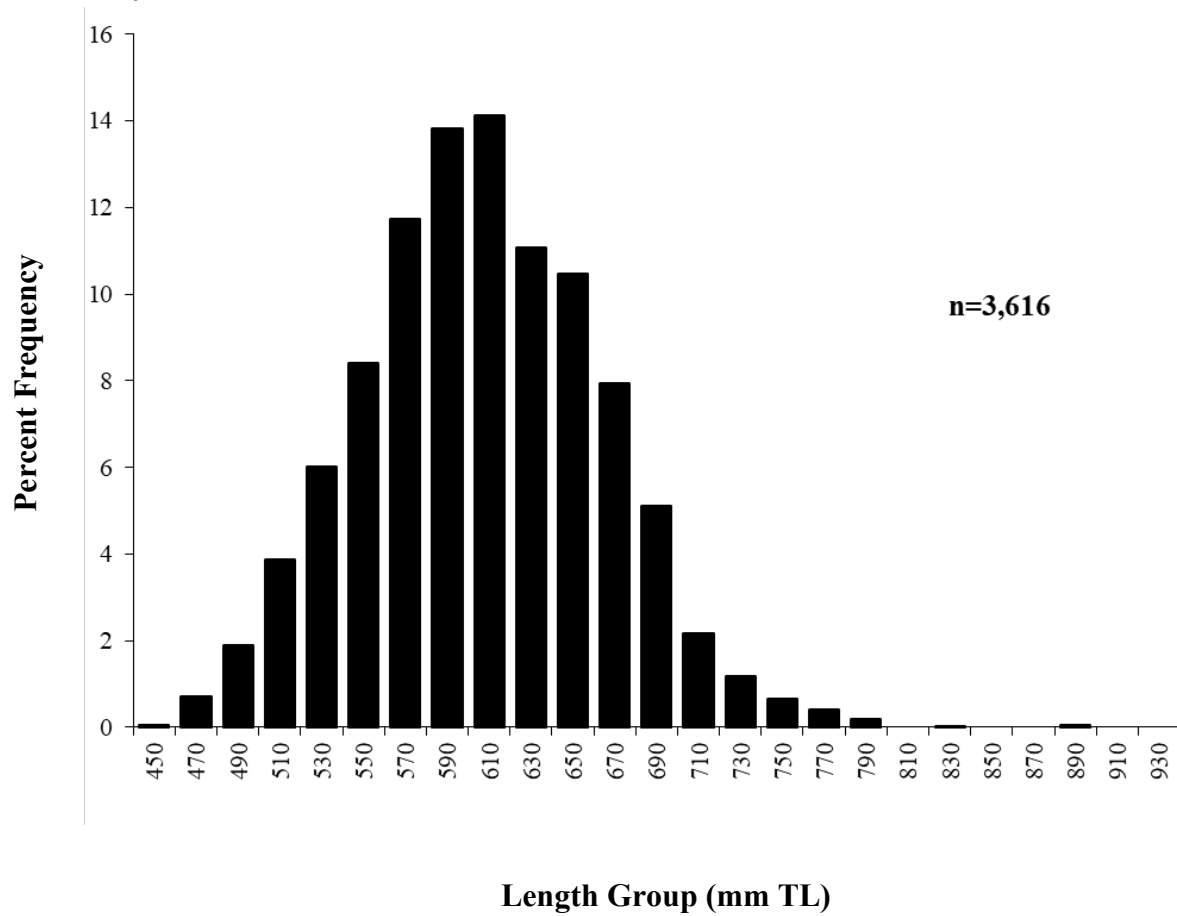


Figure 4. Mean total lengths (mm TL) of the aged subsample, by year, for individual age-classes of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, 1994 - 2022 (95% confidence intervals are shown around each point). Expanded means (estimated from entire sample) are also shown. Year refers to the year in which the season ended.

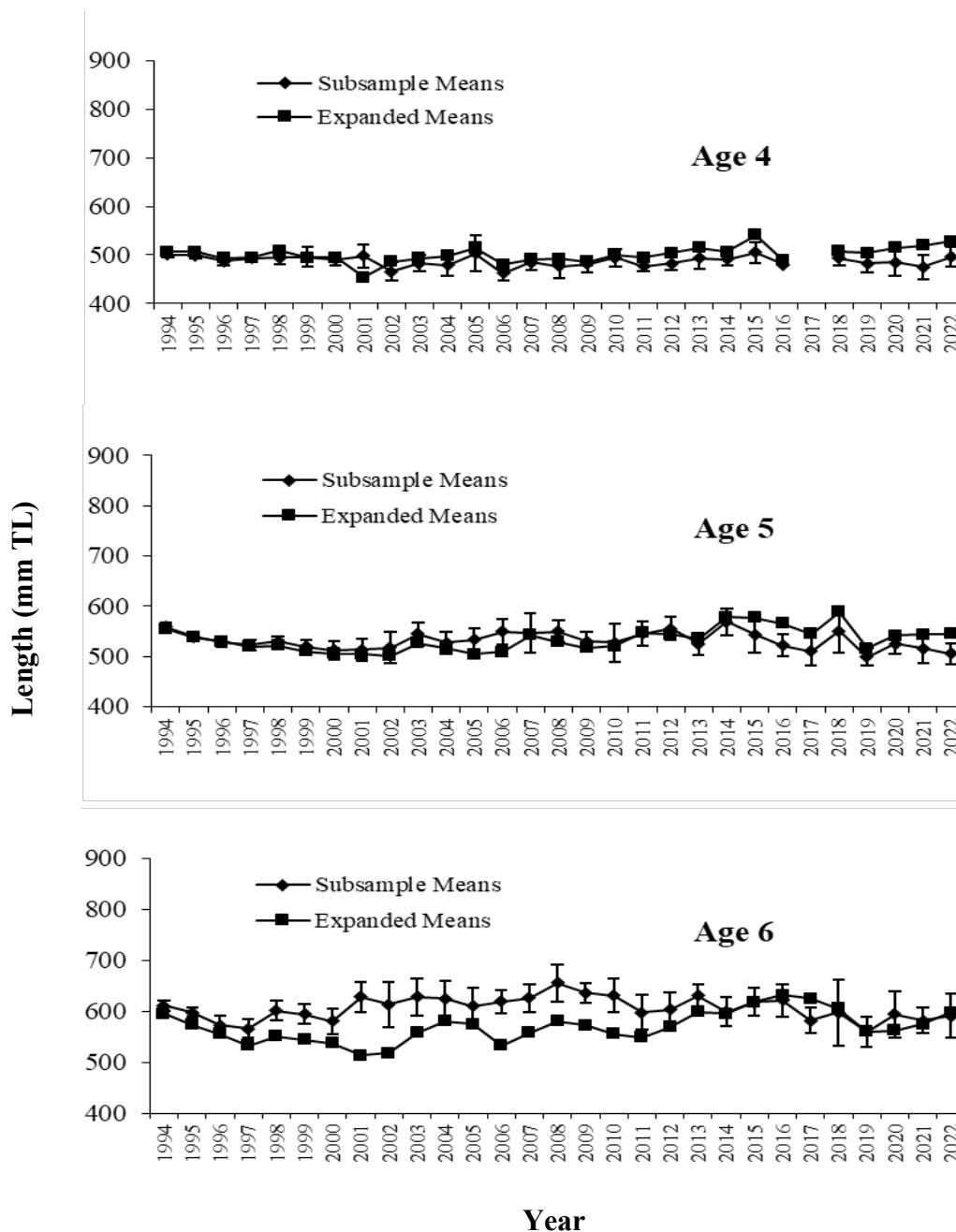


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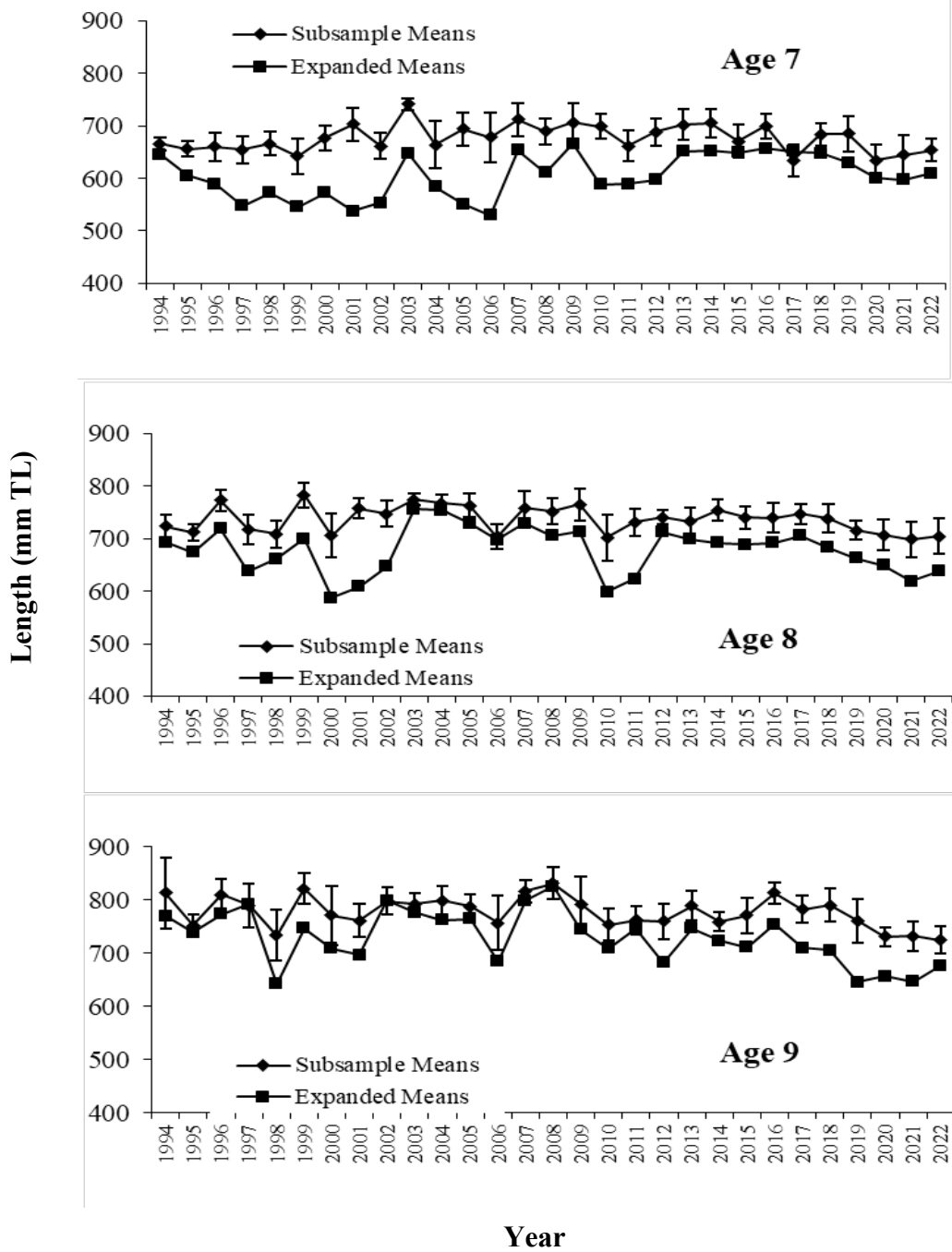


Figure 5. Mean weights (kg) of the aged subsample, by year, for individual age-classes of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net fishery, 1994 - 2022 (95% confidence intervals are shown around each point). Expanded means (estimated from entire sample) are also shown. Year refers to the year in which the season ended.

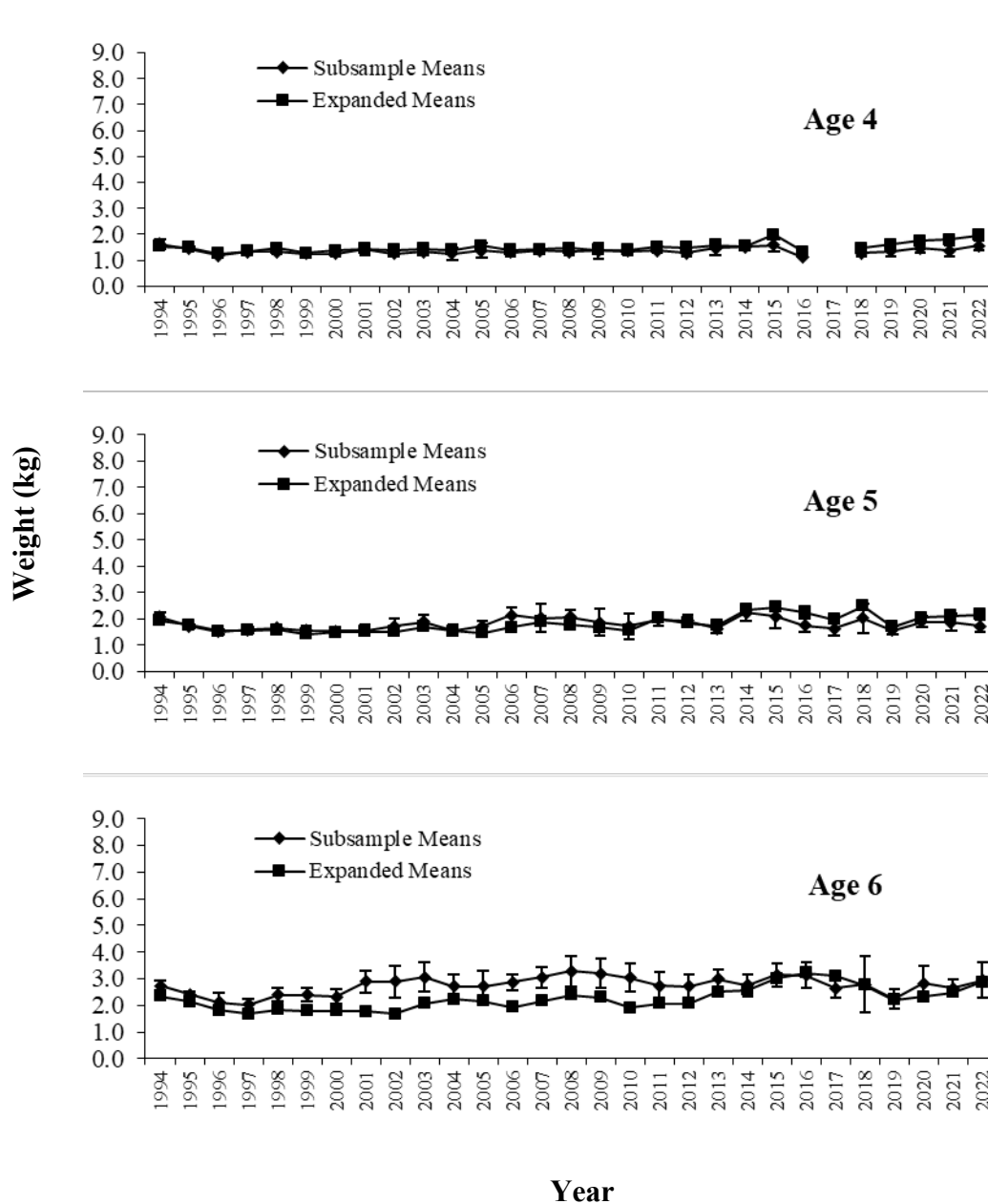
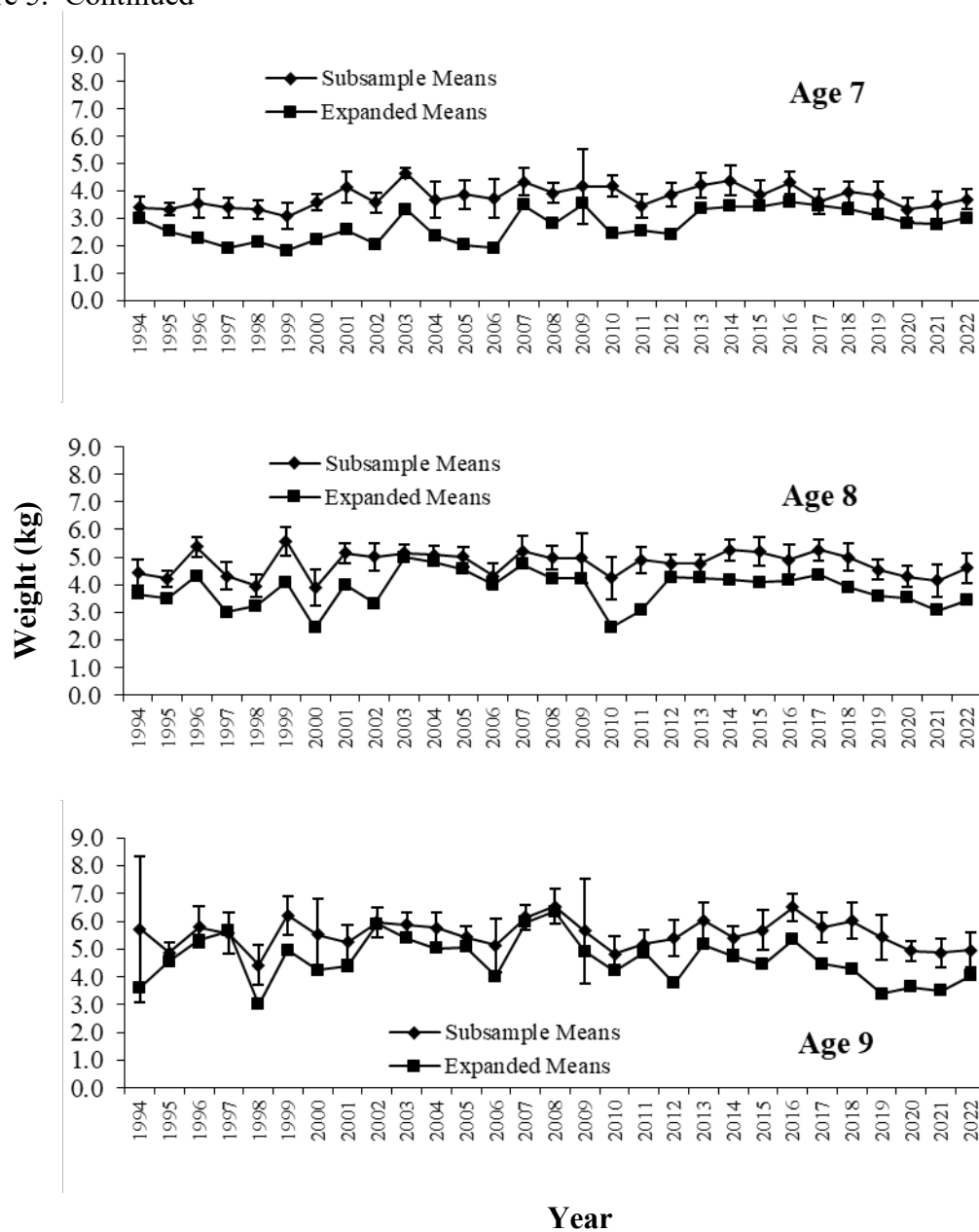


Figure 5. Continued



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 2021-2022 season and provide preliminary results, as available, for the 2022-2023 season. Completed results for the 2022-2023 sample season will be reported in the F61-R-19 Chesapeake Bay Finfish Investigations report. Trawls and gill nets were permitted during the Atlantic season within state waters (to 3 miles offshore). The 2022 season opened October 1, 2021 and ended May 31, 2022. The 2022 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 2021 – May 2022 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 2021 – May 2022 Atlantic fishery, the year used for age calculations was 2022. 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

A total of 186 striped bass were sampled at check stations in Ocean City, MD. Check stations reported 3,396 fish landed during the 2021 – 2022 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 2022 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.

The catch-at-age estimate determined that thirteen year-classes were represented in the sampled harvest, ranging from age 8 (2014 year-class) to age 20 (2002 year-class) (Table 1; Figure 2). The most frequent age represented in the catch-at-age estimate was age 11, the 2011 year-class, which represented 47% of the sampled 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 2021 – 2022 season had a mean length of 1043 mm TL and mean weight of 11.49 kg. The sample length distribution ranged from 837 to 1208 mm TL (Figure 3). The weight of fish sampled ranged from 6.23 to 17.50 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

2022-2023 SEASON PRELIMINARY RESULTS – WORK IN PROGRESS

A total of 240 striped bass were sampled and 240 scale samples were collected from the harvest between October 2022 - May 2023. Fish ranged in length from 850 mm to 1251 mm TL and in weight from 8.08 kg to 21.77 kg. Most of the fish were sampled at two check stations in Ocean City, MD. Check stations were visited by biologists two times in March, six times in April, and two 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 2022-2023 season is ongoing and complete results of harvest-, length-, and weight-at-age will be provided in the F61-R-19 Chesapeake Bay Finfish Investigations report.

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- Quinn, T.J. and R.B. Deriso. 1999. Quantitative Fish Dynamics Oxford University Press.

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- 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 – 2022 (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.

Table 1. Estimated harvest-at-age of striped bass (numbers of fish) landed by the Maryland Atlantic coast commercial fishery, October 2021 – May 2022.

Year-Class	Age	Number of Fish	Percent
2016	6	0	0.0
2015	7	0	0.0
2014	8	37	1.1
2013	9	150	4.4
2012	10	511	15.0
2011	11	1,583	46.6
2010	12	354	10.4
2009	13	142	4.2
2008	14	104	3.1
2007	15	164	4.8
2006	16	42	1.2
2005	17	150	4.4
2004	18	86	2.5
2003	19	55	1.6
2002	20	18	0.5
Total*		3,396	100

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

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

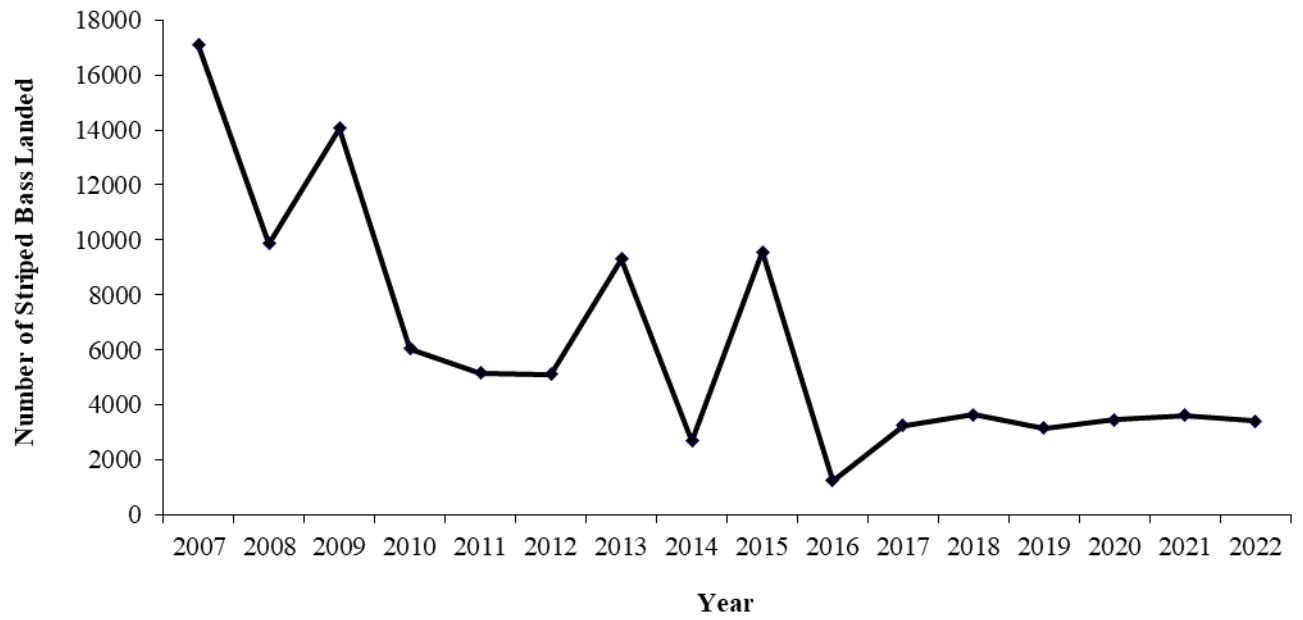


Figure 2. Age distribution of striped bass sampled from the Atlantic coast fishery, 2007 – 2022 seasons.

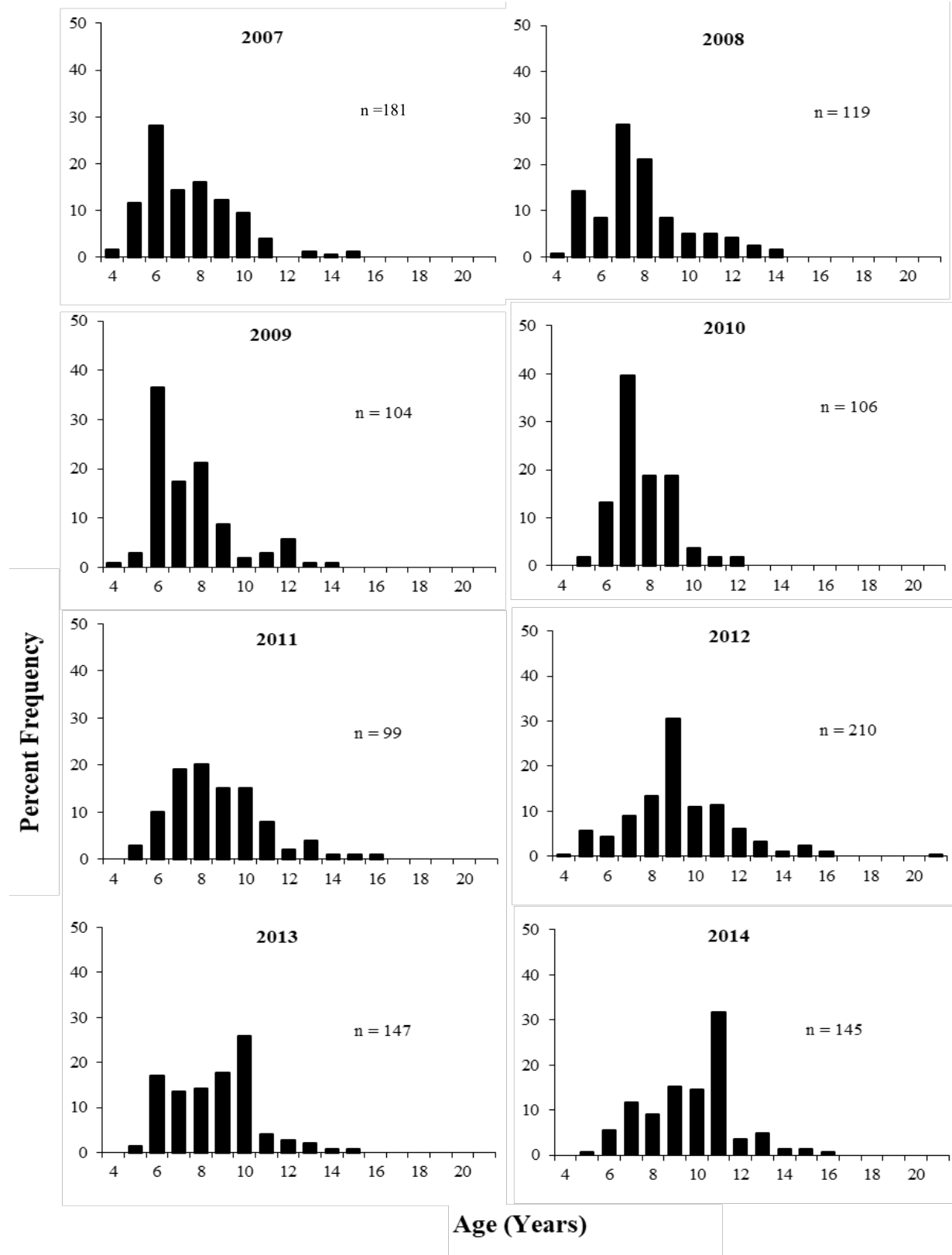


Figure 2. Continued.

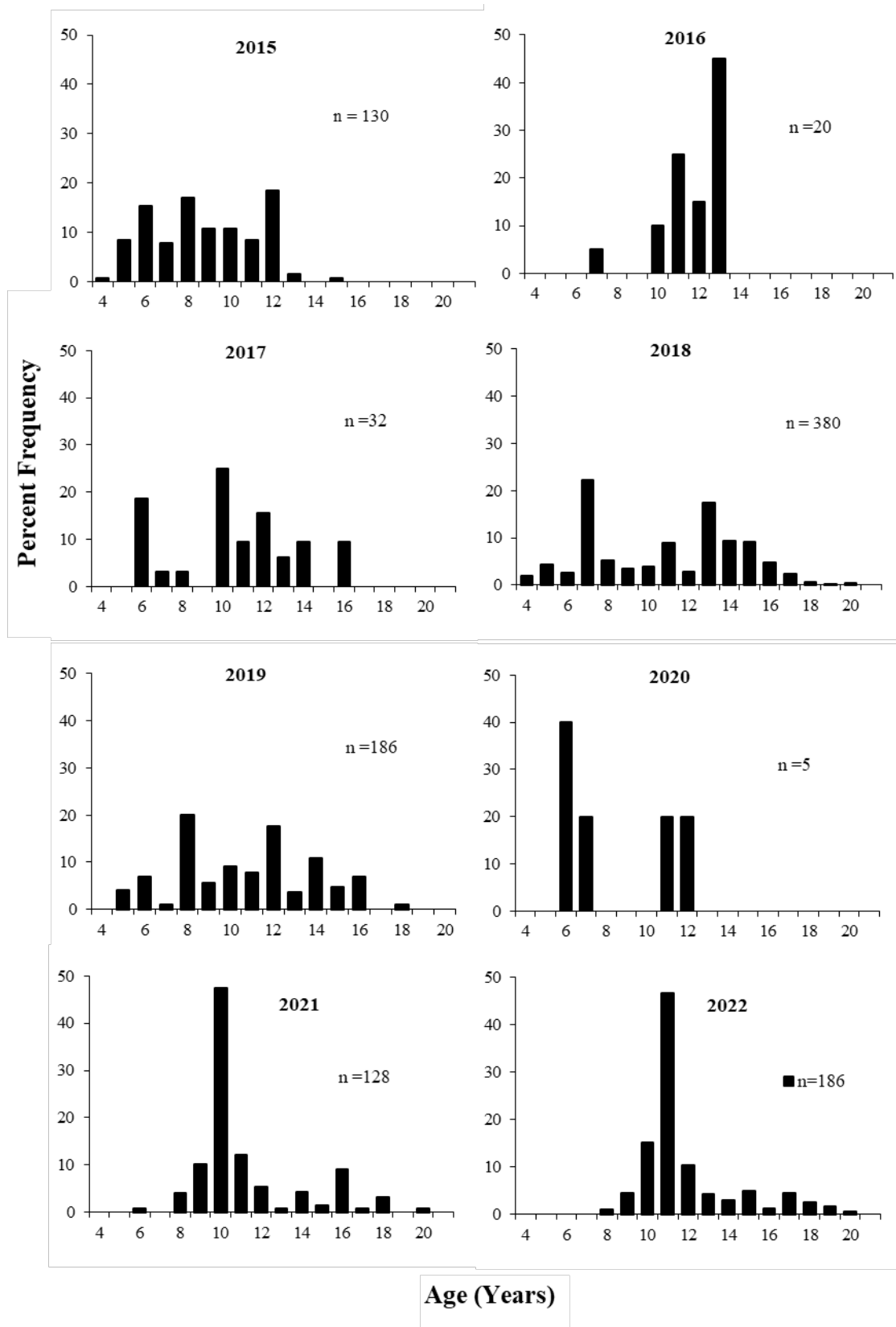


Figure 3. Length distribution of striped bass sampled from the Atlantic coast fishery, 2007 – 2022 seasons. *Note different x and y-axis scale for 2016 and 2020.

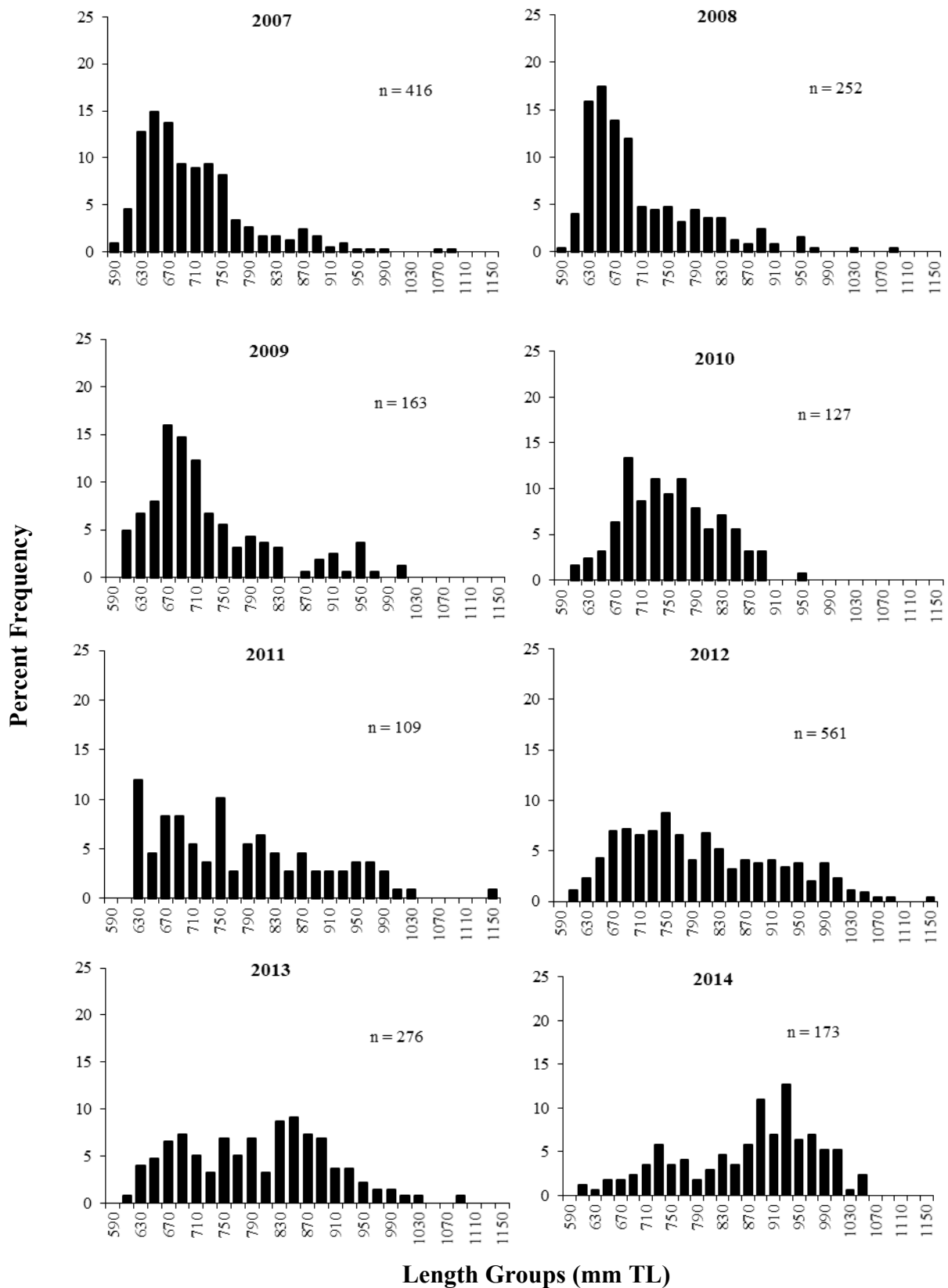


Figure 3. Continued.

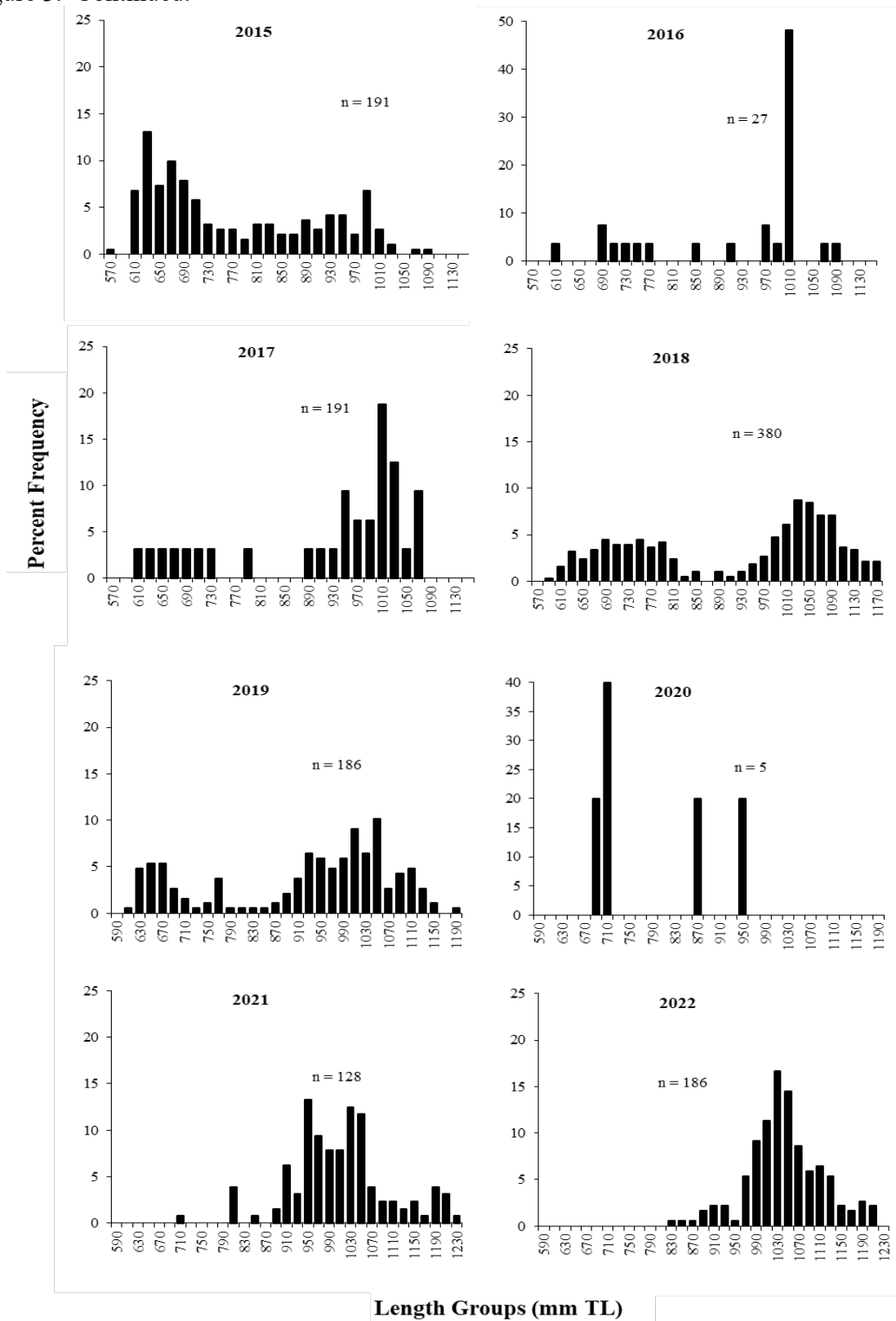


Figure 4. Mean total lengths (mm TL) of the aged sub-sample, by year, for individual age-classes of striped bass (through age 12) sampled from the Maryland Atlantic coast trawl and gill net landings, 2007 – 2022 (95% confidence intervals included when permitted by sample size). Expanded means (estimated 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.

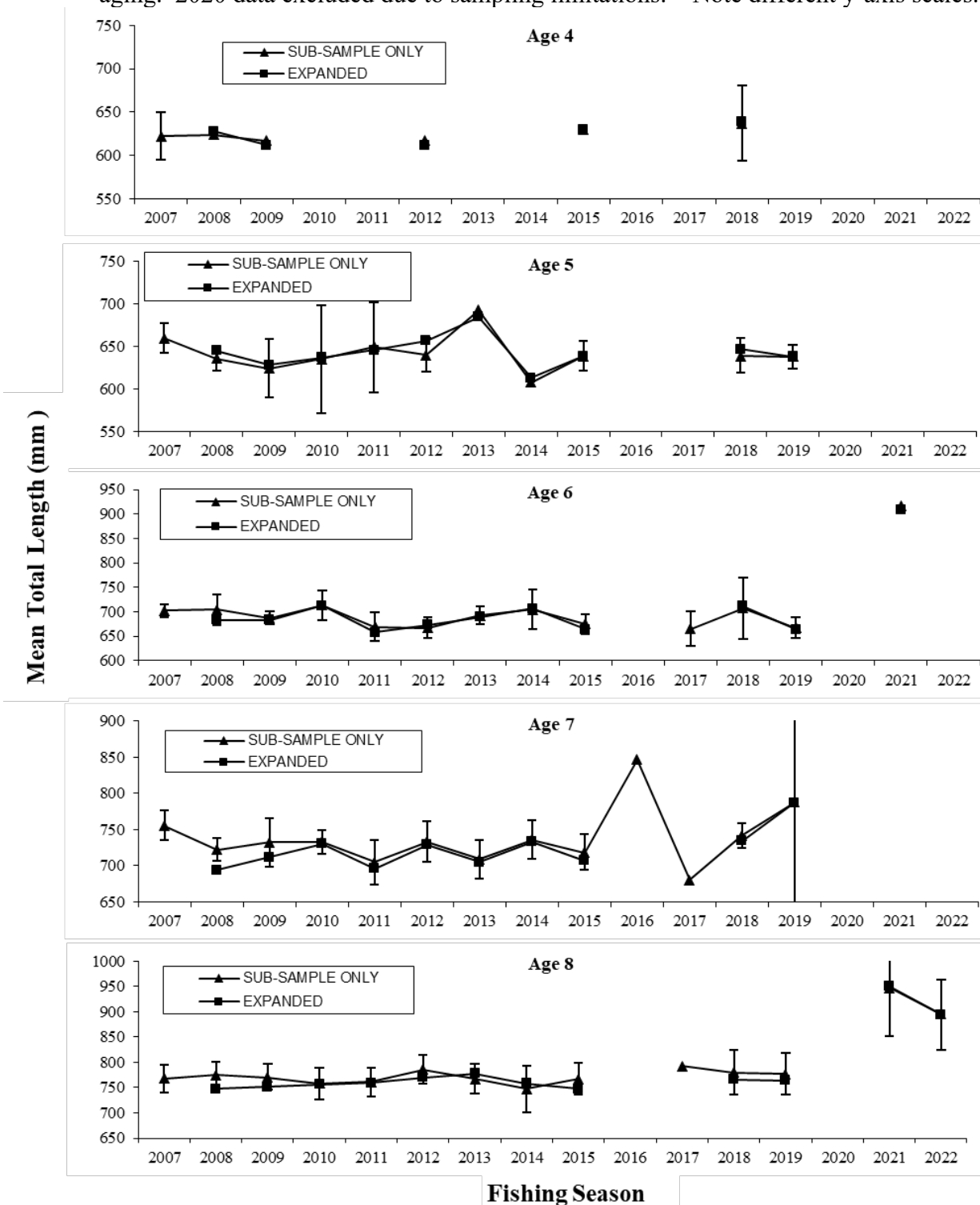


Figure 4. Continued.

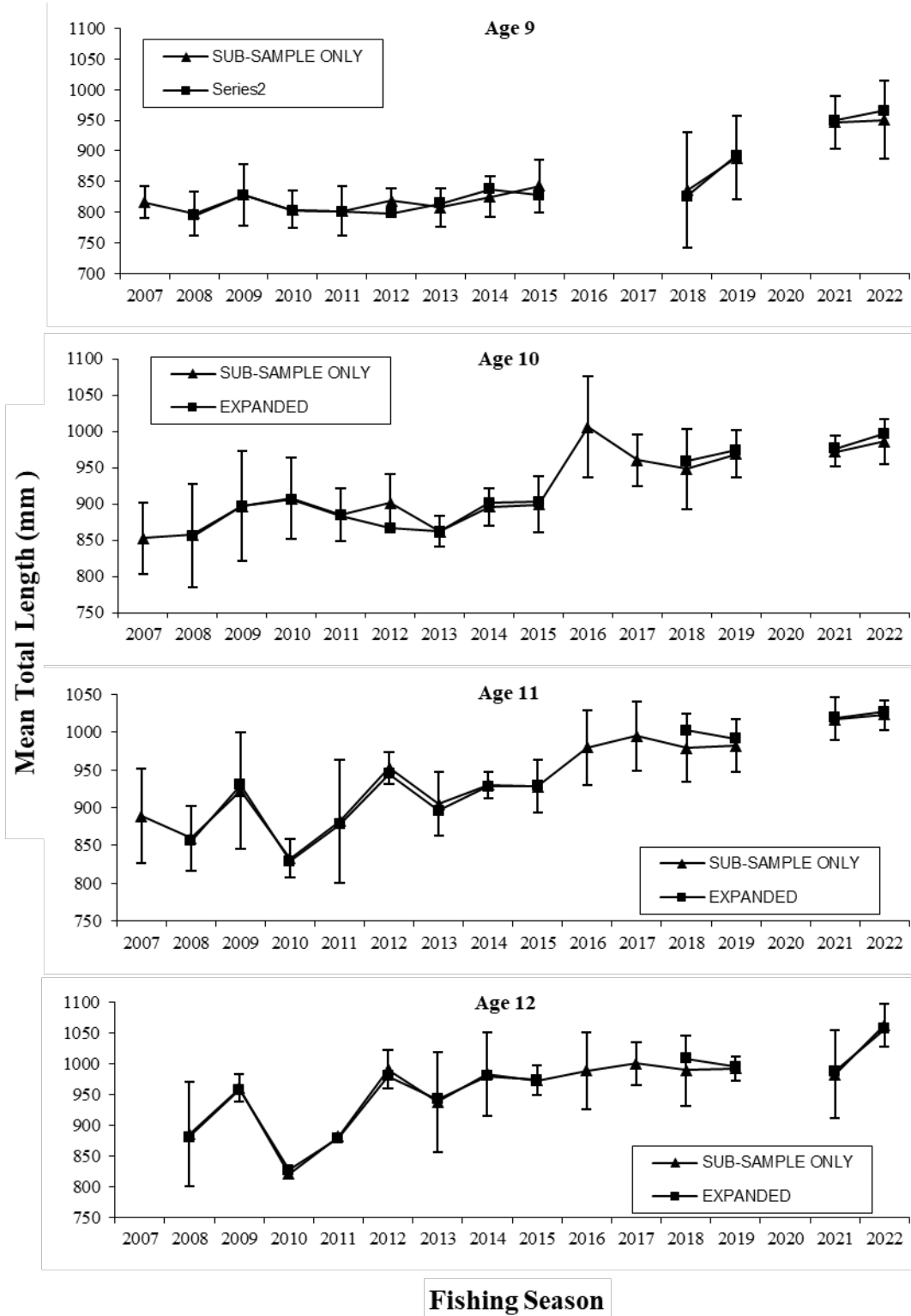


Figure 5. Mean weight (kg) of the aged sub-sample, by year, for individual age-classes of striped bass (through age 12) sampled from the Maryland Atlantic coast trawl and gill net landings, 2007 – 2022 (95% confidence intervals included when permitted by sample size). Expanded means (estimated from entire 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.

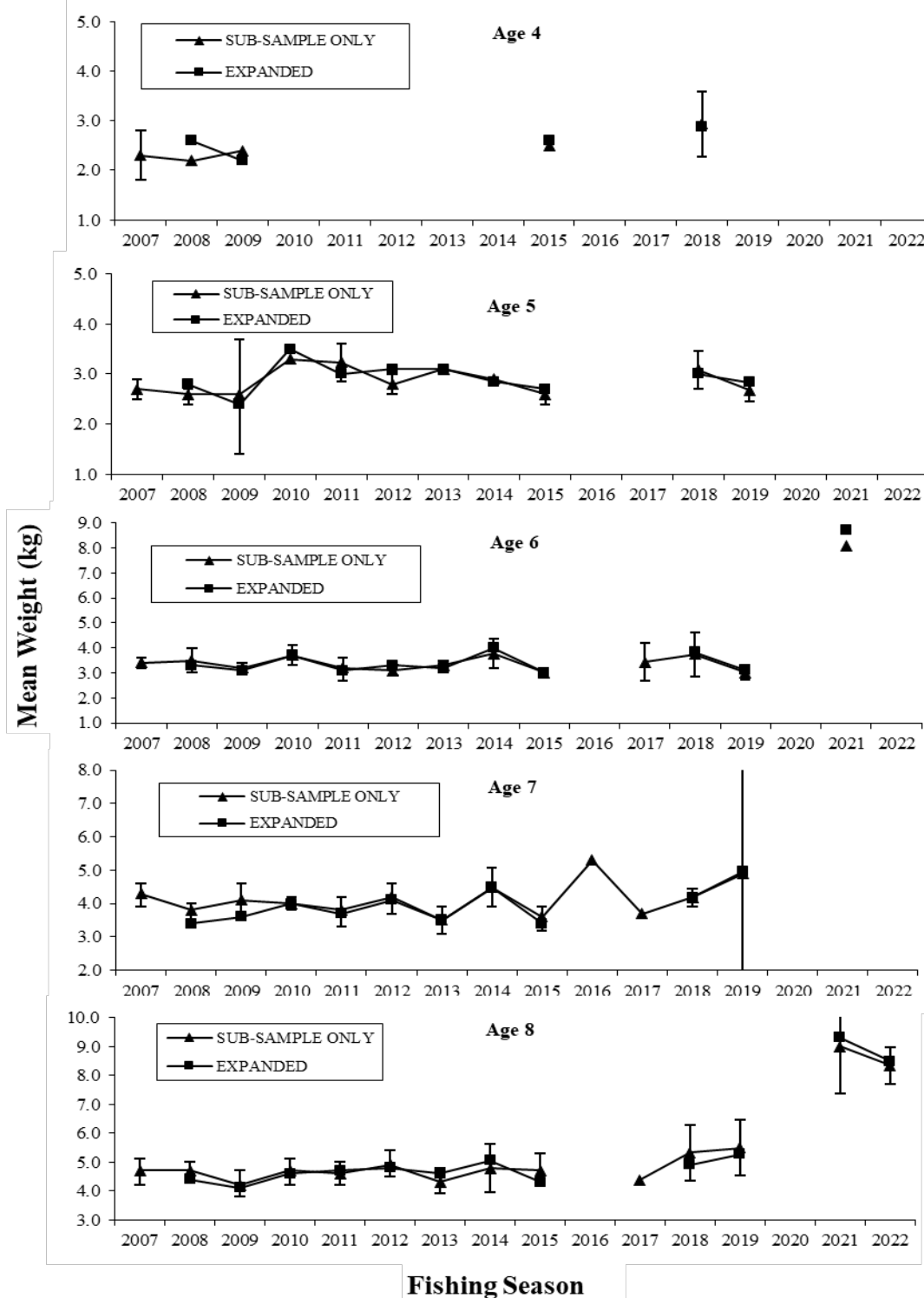
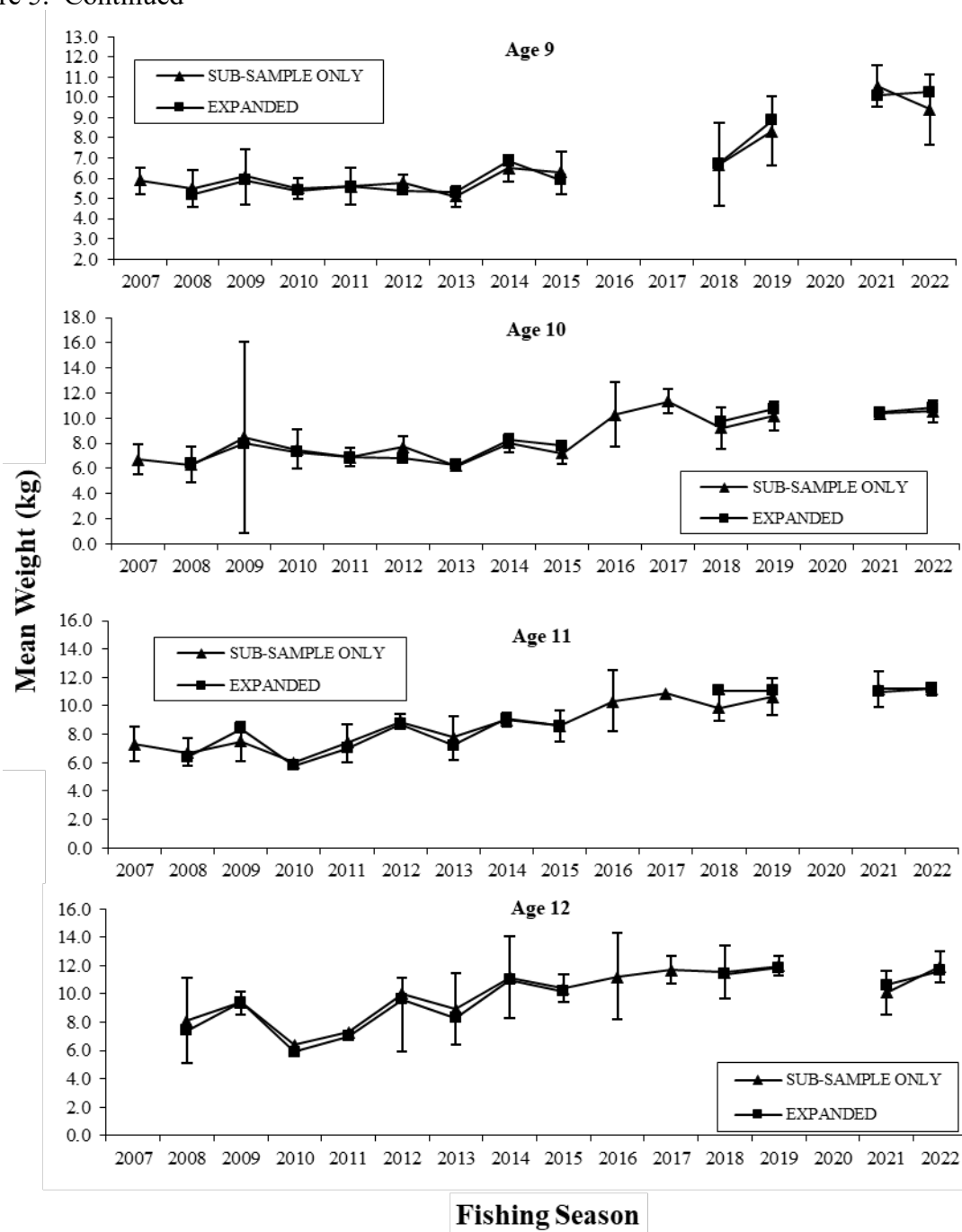


Figure 5. Continued



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 2022 spring spawning season and to provide preliminary results for characterizing the 2023 spawning population. Completed abundance estimates and additional results for the 2023 spawning season will be reported in the next F-61-R-19 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 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 2022 (Figure 1). Gill nets were fished six days per week, weather permitting, in 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 ($\alpha=0.05$);
- 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):

$$\ln \text{weight}_{\text{kg}} = 2.91 * \ln \text{length}_{\text{cm}} - 11.08 \quad (\text{Equation 1})$$

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 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. Overall soak times for each panel ranged from 10 to 92 minutes.

CPUEs and variance

A total of 287 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.

Un-weighted female CPUEs in 2022 decreased in both systems relative to the previous year, while the un-weighted male CPUEs increased. The 2022 un-weighted CPUE for Potomac females (15) ranked 26 out of 37 in the time-series, below the average of 25 (Table 2). The un-weighted CPUE for Potomac males (263) ranked 27th in the time series, well below the average of 416 (Table 3).

In 2022, Upper Bay catches were again well below average. The Upper Bay female CPUE (12) was the third lowest value in the 38 years of the survey (Table 4). The un-weighted CPUE for Upper Bay males (255) increased slightly from 2021 but was still well below the average of 449 (Table 5). This value was the eighth lowest in the 38-year time series.

The highest female CPUE values were observed in the age 15+ group, indicating continued strong contribution of older spawners in both systems. The abundant 2011 year-class (age 11 fish) also produced high CPUE values for female fish on the Potomac River and Upper Bay. Age 3 males from the 2019 year-class were abundant in both systems. 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 2022 selectivity-corrected, total, weighted CPUE (271) was the fourth lowest in the 38-year survey, well below the time-series average of 482.

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 2022 age-specific CPUEs were all below 0.10, with the exceptions of older ages with low sample sizes, indicating a small variance in CPUE. Historically, 83% 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 CPUE percentages discussed here are calculated from the weighted values in Table 13.

The below-average 2019 year-class was the most prevalent cohort in the spawning stock this year, composing 31% of the total CPUE, followed by the above-average 2018 year-class at 23%. Typically, younger males make up the largest part of the catch, regardless of year-class strength. Males were most frequently encountered, composing 95% of the total CPUE. All fish under the age of 6 were males and made up 82% of the total CPUE.

The 2019 year-class made the largest contribution to the male CPUE in the Potomac River at 33%, followed by the 2018 year-class at 31%. In the Upper Bay, the 2019 and 2020 below-average year-classes contributed 33% and 21%, respectively, to the male CPUE. Older

males were encountered infrequently. In the Potomac, 93% of the male CPUE was made up of fish ages 6 and younger, while in the Upper Bay, that number was 87%.

Historically, the female contribution has been less than 10% to each system's CPUE. In 2022 the female contribution to the Upper Bay CPUE was only 4%, and 6% to the Potomac CPUE. No females younger than age 9 were encountered on the Upper Bay. Females from the age 15+ group contributed the most to the Upper Bay female CPUE at 43%, and 40% to the Potomac female CPUE. Eleven year-old female fish from the 2011 year-class contributed 35% to the Upper Bay female CPUE. On the Potomac, 2011 year-class females contributed 22%.

Temperature and catch patterns

Potomac River sampling began on April 4, with a surface water temperature of 11°C (Figure 2). Temperatures rose slowly during the first week of the survey, passing the 14°C mark necessary to initiate spawning (Fay et al., 1983) in the middle of April. Daily surface water temperature continued to rise through the first week of May to 18°C, but then dropped to 15°C when the survey ended on May 12. Female CPUEs were very low through the entire survey with the exception of April 20. Male CPUEs were also low and scattered throughout the survey, except for one large peak on April 15.

Upper Bay surface water temperatures fluctuated throughout the survey (Figure 3). The survey began on April 8 with water temperature at 9°C, and did not reach 14°C until April 27. Temperatures dropped over the next week but rose to 16°C on May 3, where it remained until the end of the survey on May 14. Females were encountered sporadically throughout the sampling time, with higher catches in April than May. Male CPUE was very low for most of the survey, with the highest catches occurring on April 16 and April 23.

Length composition of the stock

In 2022, a total of 884 striped bass was measured, slightly more than last year, but still less than half of the average number sampled per year for the last 15 years. On the Potomac River, 241 male and 20 female striped bass were measured. In the Upper Bay, 596 males and 27 females were measured (Figure 4). The mean length of female striped bass (1045 ± 33 mm TL) was significantly larger than the mean length of male striped bass (451 ± 7 mm TL, $P < 0.0001$), consistent with the known biology of the species. Mean lengths are presented here with two standard errors.

The mean length of male striped bass collected from the Potomac River (471 ± 13 mm TL) in 2022 was significantly larger than that of Upper Bay males (442 ± 9 mm TL, $P = 0.0004$). Male striped bass in the Potomac ranged from 294 to 975 mm TL. The first peak in the length frequency between 410 and 450 mm TL represents fish from the 2019 and 2018 year-classes (Figure 4). The influence of these young fish was also evident in peaks of the uncorrected and selectivity-corrected CPUEs (Figure 5). The second smaller peak between 590 and 610 mm TL includes fish from the above average 2015 year-class (Figure 4).

Male striped bass on the Upper Bay ranged from 288 to 1096 mm TL. There are two peaks evident in the male length frequency (Figure 4). The peak between 310-470 mm TL encompasses males aged 5 and younger, while the second peak between 550-590 mm TL includes some fish from the above average 2015 year-class. The second peak is less evident 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 (1025 ± 70 mm TL) in 2022 was not statistically different than the Upper Bay (1061 ± 24 mm TL; $P=0.3386$). Female striped bass in the Potomac ranged from 671 to 1216 mm TL, and females sampled in the Upper

Bay ranged from 951 to 1204 mm TL (Figure 4). Few small females were encountered in either system. Female catches were low and scattered across a range of length groups. Many females sampled were from the 2011 year-class, with the largest females (≥ 1110 mm TL) likely representing the 2005 and 2003 year-classes (Figure 4).

Female CPUE in the Potomac River was generally low but covered a wide range of length groups (Figure 6). In the Upper Bay, female CPUEs were low, and mostly present in larger 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, which is the case when selectivity-corrected CPUE is much higher than the uncorrected CPUE.

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 2022 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). Female samples sizes were small in both areas in 2022, though only age 10 lengths-at-age were significantly different. Age 10 females on the Upper Bay (mean = 1021 mm TL) were significantly longer than on the Potomac

River (mean = 776 mm TL, $P=0.009$). As in the last two years, younger males on the Potomac River are significantly longer than Upper Bay male fish. Age 2 male fish were significantly longer on the Potomac River (mean = 351 mm TL) than the Upper Bay (mean = 301 mm TL, $P=0.0005$). Age 3 males were significantly longer on the Potomac River (mean = 409 mm TL) than the Upper Bay (mean = 356 mm TL, $P=0.014$). Age 4 males were significantly longer on the Potomac River (mean = 460 mm TL) than the Upper Bay (mean = 415 mm TL, $P=0.0448$). Age 5 males were significantly longer on the Potomac River (mean = 562 mm TL) than the Upper Bay (mean = 498 mm TL, $P=0.0064$).

Mean lengths-at-age were compared between years for each sex, areas combined (ANOVA, $\alpha=0.05$). Male and female LAAs have been relatively stable since the mid-1990s (Figures 7 and 8). Mean lengths of females were all similar in 2021 and 2022, even in older ages with small sample sizes. Mean lengths-at-age of all males were similar in 2022 compared to 2021.

Age composition of the stock

Eighteen age-classes, ranging from 2 to 19 were encountered (Tables 14 and 15). Of the 188 male fish aged from the survey (Table 1), ages 3 and 7 (2019 and 2015 year-classes) were the most commonly aged fish, which does not always translate to high CPUE values. On the Potomac River, the males encountered ranged from age 2 through 11, while on the Upper Bay, males ages 2 through 17 were captured. Females ranged in age from 6 to 19 on the Potomac River. On the Upper Bay, no young females were observed, and ranged from 9 to 19. All of the 47 females captured were aged (Table 1), with age 11 females from the dominant 2011 year-class the 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 2021, nine of the fourteen age-specific male CPUEs increased in 2022, and four of the fourteen female CPUEs increased. The contribution of the 15+ age group has been strong for the past 13 years, driven by the continued presence of older females in the spawning stock (Figure 9).

The contribution of age 8+ females to the total female CPUE increased in 2022 to 98%, the highest in the time series (Figure 10). This increase was driven by the low sample sizes observed in both systems, and very few young females caught. 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 (73%) 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 2022 value of 10% was below 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 2022, sample sizes of older, larger fish were low, with the catch dominated by younger males.

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 were 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 an 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, with a declining trend since then. The 2022 ISP value of 153 was well below the high values of that previous period, and below the time-series average of 343 (Table 16, Figure 12). The Potomac River ISP has varied without

trend in recent years. The 2022 Potomac River female ISP of 169 was also below its time series average of 227 (Table 16, Figure 12).

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

CHARACTERIZATION OF STRIPED BASS
SPAWNING STOCKS IN MARYLAND

2023 PRELIMINARY RESULTS

Data collected during the 2023 spring spawning season are currently being analyzed. In the Potomac River in 2023, sampling was conducted from April 3 to May 12 for a total of 22 sample days. In the Upper Bay, sampling was conducted from April 8 to May 11 for a total of 26 sample days.

Scale samples are currently being processed and aged, therefore CPUE estimates are not available at this time. A total of 656 scales were collected for use in creating the sex-specific ALKs. In the Potomac River, a total of 1,093 striped bass were sampled: 1,058 males and 35 females. Of those 1,093 fish, 418 (38%) were tagged with U. S. Fish and Wildlife Service internal anchor tags. In the Upper Bay, a total of 468 striped bass were captured: 436 males and 32 females. Of the 468 fish encountered, 269 (57%) were tagged.

Male striped bass on the Potomac ranged from 300 to 963 mm TL, with a mean of 496 mm TL. Male striped bass on the Upper Bay ranged from 296 to 1004 mm TL, with a mean of 501 mm TL. Female striped bass sampled from the Potomac ranged from 488 to 1227 mm TL, with a mean of 1016 mm TL. Upper Bay female striped bass ranged from 498 to 1226 mm TL and had a mean of 932 mm TL.

The final, complete analyses of the spring 2023 spawning stock survey data will appear in the next F-61-R-19 Chesapeake Bay Finfish Investigations report.

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Table 1. Scales aged for each sex, area, and survey, by length group (mm TL) in spring 2022.

Length group (mm)	MALES				FEMALES			
	Upper Bay	Potomac River	Creel	Male Total	Upper Bay	Potomac River	Creel	Female Total
250	0	0	0	0	0	0	0	0
270	0	0	0	0	0	0	0	0
290	8	0	0	8	0	0	0	0
310	6	2	0	8	0	0	0	0
330	7	1	0	8	0	0	0	0
350	6	2	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	2	2
510	4	4	0	8	0	0	2	2
530	4	4	0	8	0	0	1	1
550	4	4	0	8	0	0	0	0
570	6	4	0	10	0	0	2	2
590	5	5	0	10	0	0	2	2
610	5	5	0	10	0	0	0	0
630	5	5	0	10	0	0	1	1
650	6	2	2	10	0	0	0	0
670	5	3	2	10	0	1	0	1
690	0	3	2	5	0	0	1	1
710	2	0	0	2	0	0	1	1
730	1	1	1	3	0	0	0	0
750	3	0	0	3	0	0	1	1
770	1	0	0	1	0	1	1	2
790	2	0	1	3	0	1	1	2
810	1	0	0	1	0	0	0	0
830	0	0	0	0	0	0	1	1
850	0	0	0	0	0	0	0	0
870	0	0	0	0	0	2	0	2
890	1	0	2	3	0	0	1	1
910	0	0	0	0	0	0	0	0
930	0	0	0	0	0	0	0	0
950	0	0	0	0	1	0	0	1
970	1	2	0	3	1	0	0	1
990	0	0	0	0	2	0	1	3
1010	0	0	1	1	4	4	3	11
1030	0	0	0	0	4	1	5	10
1050	0	0	0	0	2	0	3	5
1070	1	0	0	1	3	2	3	8
1090	1	0	0	1	0	1	1	2
1110	0	0	0	0	6	0	1	7
1130	0	0	0	0	1	1	0	2
1150	0	0	0	0	2	3	2	7
1170	0	0	0	0	0	1	4	5
1190	0	0	0	0	0	0	1	1
1210	0	0	0	0	1	2	0	3
Total	113	75	11	199	27	20	41	88

Table 2. Estimates of selectivity-corrected age-class CPUE by year for female striped bass captured in the Potomac River during the 1985-2022 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
2022	0.0	0.0	0.0	0.0	0.0	0.9	0.0	3.4	0.2	0.8	3.3	0.3	0.1	0.2	6.3	15
Average																25

Table 3. Estimates of selectivity-corrected age-class CPUE by year for male striped bass captured in the Potomac River during the 1985-2022 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
2022	0.0	30.8	87.1	80.3	38.6	6.6	13.6	3.0	0.7	0.8	1.2	0.0	0.0	0.0	0.0	263
Average																416

Table 4. Estimates of selectivity-corrected age-class CPUE by year for female striped bass captured in the Upper Bay during the 1985-2022 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
2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.3	4.1	0.6	0.1	0.8	5.0	12
Average																42

Table 5. Estimates of selectivity-corrected age-class CPUE by year for male striped bass captured in the Upper Bay during the 1985-2022 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
2022	0.0	52.7	83.4	50.3	26.4	8.1	14.5	4.9	3.1	1.3	3.3	0.0	0.0	6.2	1.1	255
Average																449

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 (1985–2022) 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
2022	0.0	44.3	84.8	61.8	31.1	7.8	14.2	5.5	2.8	1.6	6.3	0.5	0.1	4.4	6.1	271
Average																482

Table 9. Lower confidence limits (95%) of the annual, pooled, weighted, age-specific CPUEs (1985–2022) 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	17.6	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	*
2022	0.0	40.9	82.0	60.1	30.1	7.5	13.7	4.6	2.6	1.3	5.4	0.3	0.1	1.9	*

* 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 (1985–2022) 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	*
2022	0.0	47.6	87.6	63.6	32.2	8.2	14.6	6.4	3.0	2.0	7.3	0.6	0.2	6.8	*

* 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 (1985–2022) 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	*
2022	0	0.04	0.02	0.01	0.02	0.02	0.02	0.08	0.03	0.11	0.07	0.15	0.16	0.28	*

* 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, April through May 2022. 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
2021	1	0.0	0.0	0.0	0.0	0.0	0.0
2020	2	83.5	15.3	0.0	0.0	30.8	52.7
2019	3	170.5	31.3	0.0	0.0	87.1	83.4
2018	4	130.5	23.9	0.0	0.0	80.3	50.3
2017	5	65.0	11.9	0.0	0.0	38.6	26.4
2016	6	15.5	2.8	0.9	0.0	6.6	8.1
2015	7	28.1	5.2	0.0	0.0	13.6	14.5
2014	8	11.4	2.1	3.4	0.0	3.0	4.9
2013	9	4.8	0.9	0.2	0.9	0.7	3.1
2012	10	3.2	0.6	0.8	0.3	0.8	1.3
2011	11	12.0	2.2	3.3	4.1	1.2	3.3
2010	12	0.8	0.2	0.3	0.6	0.0	0.0
2009	13	0.2	0.0	0.1	0.1	0.0	0.0
2008	14	7.2	1.3	0.2	0.8	0.0	6.2
≤2007	15+	12.4	2.3	6.3	5.0	0.0	1.1
Total		545.3		15.5	11.8	262.7	255.4
% of Total				2.8	2.2	48.2	46.8
% of Sex				56.8	43.2	50.7	49.3
% of System				5.6	4.4	94.4	95.6

Table 13. Striped bass catch per unit effort (CPUE) by year-class, weighted by spawning area*, April through May 2022. 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
2021	1	0.0	0.0	0.0	0.0	0.0	0.0
2020	2	44.3	16.3	0.0	0.0	11.9	32.4
2019	3	84.8	31.3	0.0	0.0	33.6	51.3
2018	4	61.8	22.8	0.0	0.0	30.9	30.9
2017	5	31.1	11.5	0.0	0.0	14.9	16.2
2016	6	7.8	2.9	0.3	0.0	2.5	5.0
2015	7	14.2	5.2	0.0	0.0	5.2	8.9
2014	8	5.5	2.0	1.3	0.0	1.2	3.0
2013	9	2.8	1.0	0.1	0.5	0.3	1.9
2012	10	1.6	0.6	0.3	0.2	0.3	0.8
2011	11	6.3	2.3	1.3	2.5	0.5	2.0
2010	12	0.5	0.2	0.1	0.3	0.0	0.0
2009	13	0.1	0.0	0.0	0.1	0.0	0.0
2008	14	4.4	1.6	0.1	0.5	0.0	3.8
≤2007	15+	6.1	2.3	2.4	3.1	0.0	0.6
Total		271.4		6.0	7.2	101.2	156.9
% of Total				2.2	2.7	37.3	57.8
% of Sex				45.2	54.8	39.2	60.8
% of System				5.6	4.4	94.4	95.6

* 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, April through May 2022.

YEAR-CLASS	AGE	AREA	N	MEAN	LCL	UCL	SD	SE
2020	2	POTOMAC	7	351	324	377	29	11
		UPPER	9	301	290	313	15	5
		COMBINED	16	323	305	341	33	8
2019	3	POTOMAC	11	409	385	432	35	11
		UPPER	23	357	338	375	43	9
		COMBINED	34	374	357	390	47	8
2018	4	POTOMAC	17	460	433	487	53	13
		UPPER	15	415	378	453	68	17
		COMBINED	32	439	416	462	63	11
2017	5	POTOMAC	10	562	532	592	42	13
		UPPER	19	498	468	527	62	14
		COMBINED	29	520	496	544	63	12
2016	6	POTOMAC	8	570	532	609	46	16
		UPPER	7	608	536	680	78	29
		COMBINED	15	588	553	623	64	16
2015	7	POTOMAC	15	616	588	645	51	13
		UPPER	22	623	601	646	51	11
		COMBINED	37	621	604	637	51	8
2014	8	POTOMAC	5	663	596	729	54	24
		UPPER	7	665	606	724	64	24
		COMBINED	12	664	628	700	57	16
2013	9	POTOMAC	1	975	-	-	-	-
		UPPER	4	780	619	941	101	51
		COMBINED	5	819	665	973	124	55
2012	10	POTOMAC	0	-	-	-	-	-
		UPPER	2	725	611	839	13	9
		COMBINED	2	725	611	839	13	9
2011	11	POTOMAC	1	967	-	-	-	-
		UPPER	3	809	424	1194	155	89
		COMBINED	4	849	611	1086	149	75
2008	14	POTOMAC	0	-	-	-	-	-
		UPPER	1	1075	-	-	-	-
		COMBINED	1	1075	-	-	-	-
2005	17	POTOMAC	0	-	-	-	-	-
		UPPER	1	1096	-	-	-	-
		COMBINED	1	1096	-	-	-	-

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, April through May 2022.

YEAR-CLASS	AGE	AREA	N	MEAN	LCL	UCL	SD	SE
2016	6	POTOMAC	1	671	-	-	-	-
		UPPER	0	-	-	-	-	-
		COMBINED	1	671	-	-	-	-
2014	8	POTOMAC	1	792	-	-	-	-
		UPPER	0	-	-	-	-	-
		COMBINED	1	792	-	-	-	-
2013	9	POTOMAC	1	861	-	-	-	-
		UPPER	2	959	857	1061	11	8
		COMBINED	3	926	784	1068	57	33
2012	10	POTOMAC	1	776	-	-	-	-
		UPPER	2	1021	996	1046	3	2
		COMBINED	3	939	588	1291	141	82
2011	11	POTOMAC	7	1014	951	1077	68	26
		UPPER	9	1027	1004	1050	30	10
		COMBINED	16	1021	995	1047	49	12
2010	12	POTOMAC	2	1044	669	1418	42	30
		UPPER	1	1046	-	-	-	-
		COMBINED	3	1044	971	1118	30	17
2009	13	POTOMAC	0	-	-	-	-	-
		UPPER	1	1064	-	-	-	-
		COMBINED	1	1064	-	-	-	-
2008	14	POTOMAC	1	1155	-	-	-	-
		UPPER	3	1084	974	1194	44	26
		COMBINED	4	1102	1021	1182	51	25
2007	15	POTOMAC	1	1138	-	-	-	-
		UPPER	2	1061	*	*	*	*
		COMBINED	3	1087	924	1249	65	38
2006	16	POTOMAC	1	1216	-	-	-	-
		UPPER	2	1177	827	1526	39	28
		COMBINED	3	1190	1101	1278	36	21
2005	17	POTOMAC	2	1166	1064	1268	11	8
		UPPER	3	1124	1051	1197	29	17
		COMBINED	5	1141	1102	1180	32	14
2004	18	POTOMAC	1	1156	-	-	-	-
		UPPER	1	1105	-	-	-	-
		COMBINED	2	1131	806	1455	36	26
2003	19	POTOMAC	1	1216	-	-	-	-
		UPPER	1	1124	-	-	-	-
		COMBINED	2	1170	*	*	*	*

* 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
2022	153	169
Average	343	227

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

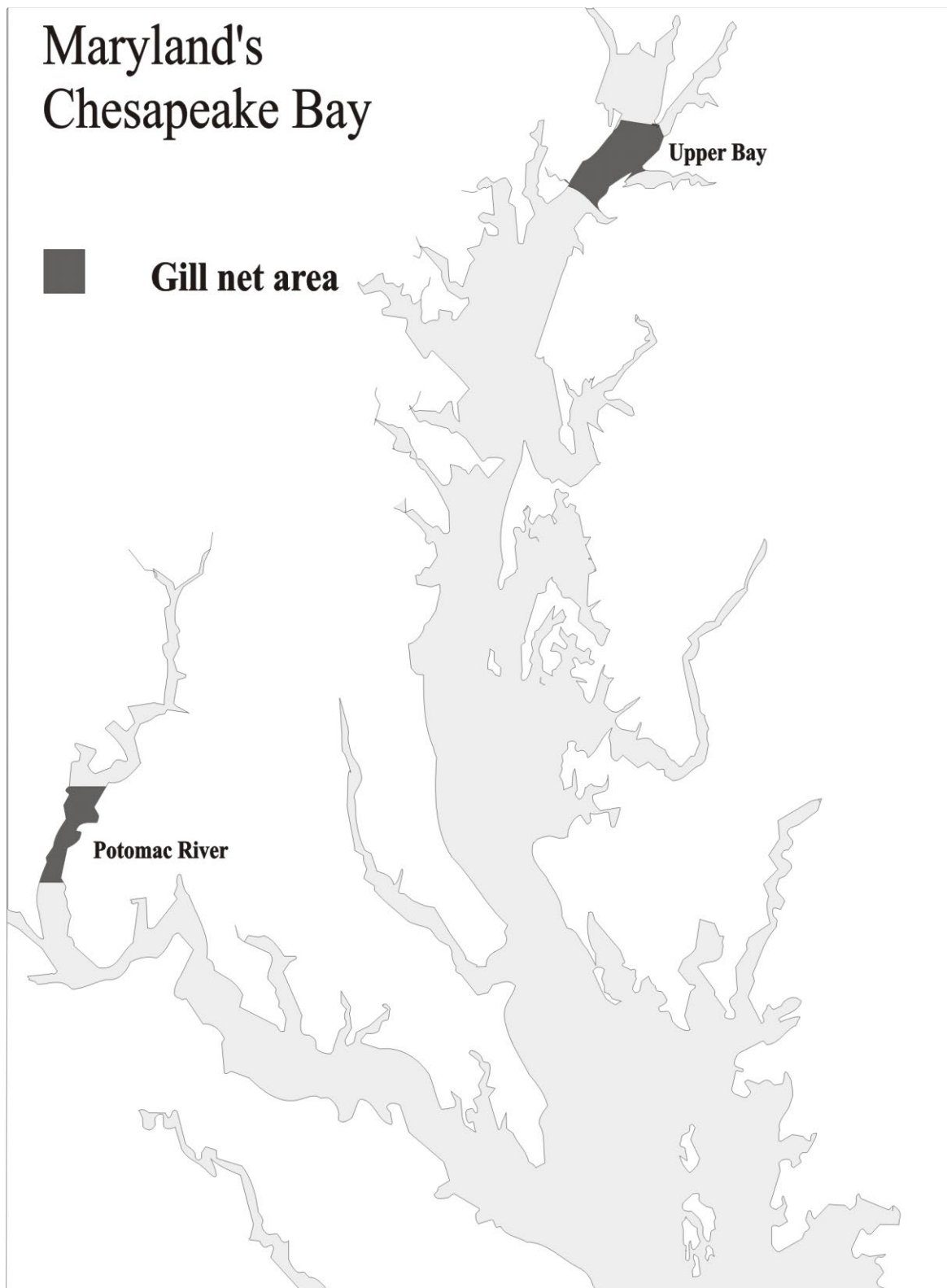


Figure 2. Daily effort-corrected catch of female and male striped bass, with surface water temperature in the spawning reach of the Potomac River, April through May 2022. Effort is standardized as 1000 square yards of experimental gill net per hour. Note different scales.

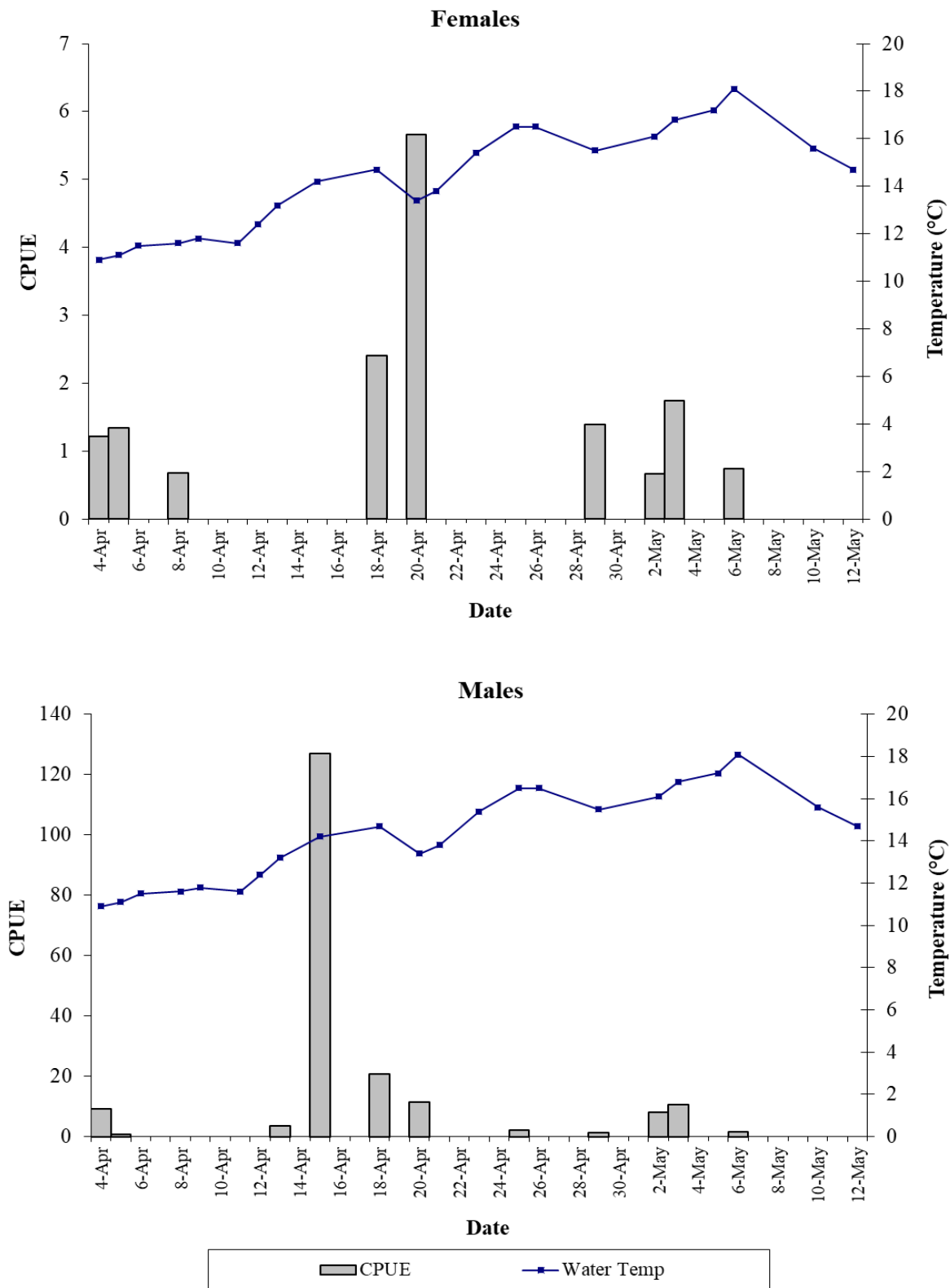


Figure 3. Daily effort-corrected catch of female and male striped bass, with surface water temperature in the spawning reach of the Upper Chesapeake Bay, April through May 2022. Effort is standardized as 1000 square yards of experimental drift gill net per hour. Note different scales.

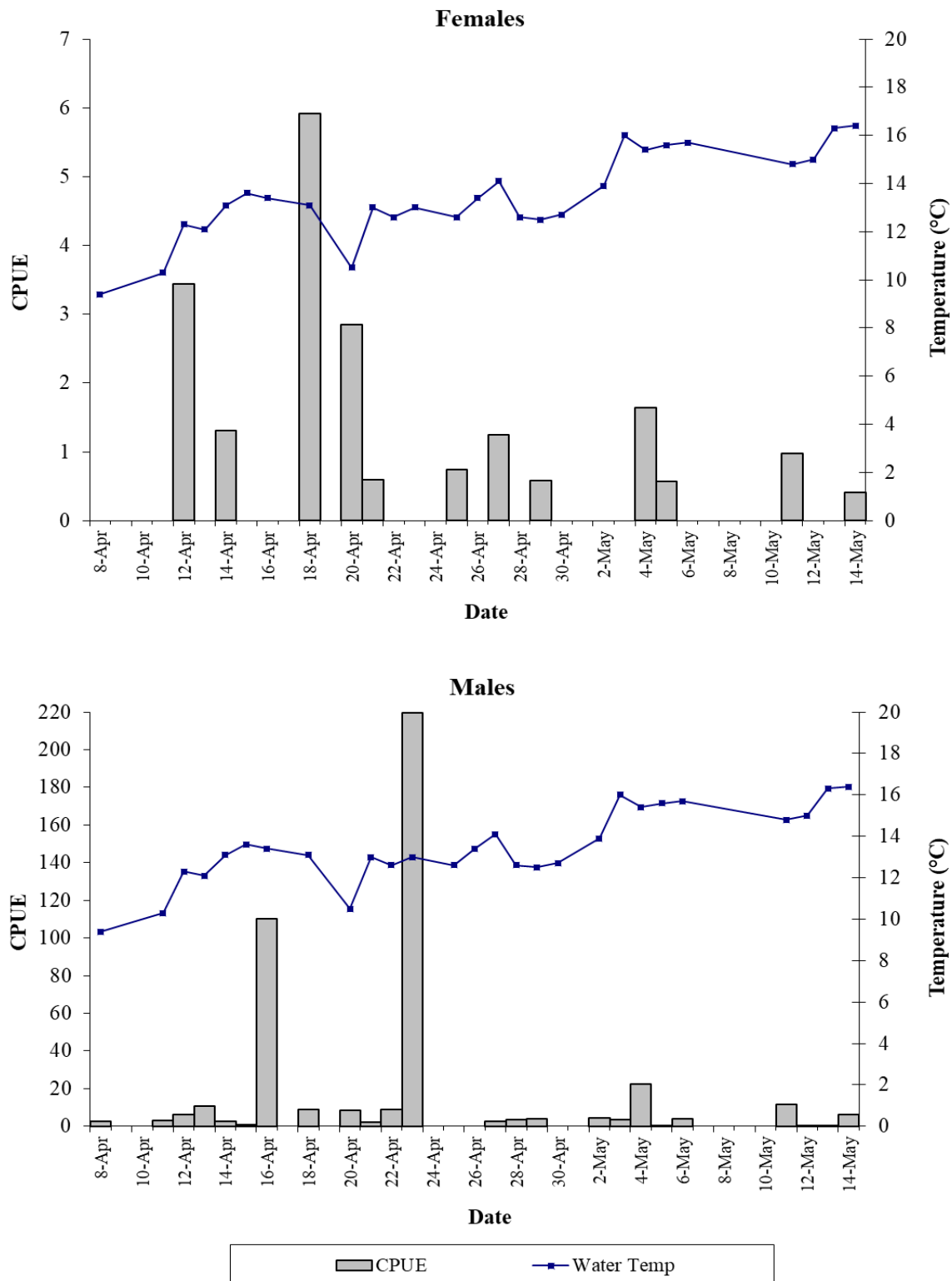


Figure 4. Length frequency of male and female striped bass from the spawning areas of the Upper Chesapeake Bay and Potomac River, April through May 2022. Note different scales.

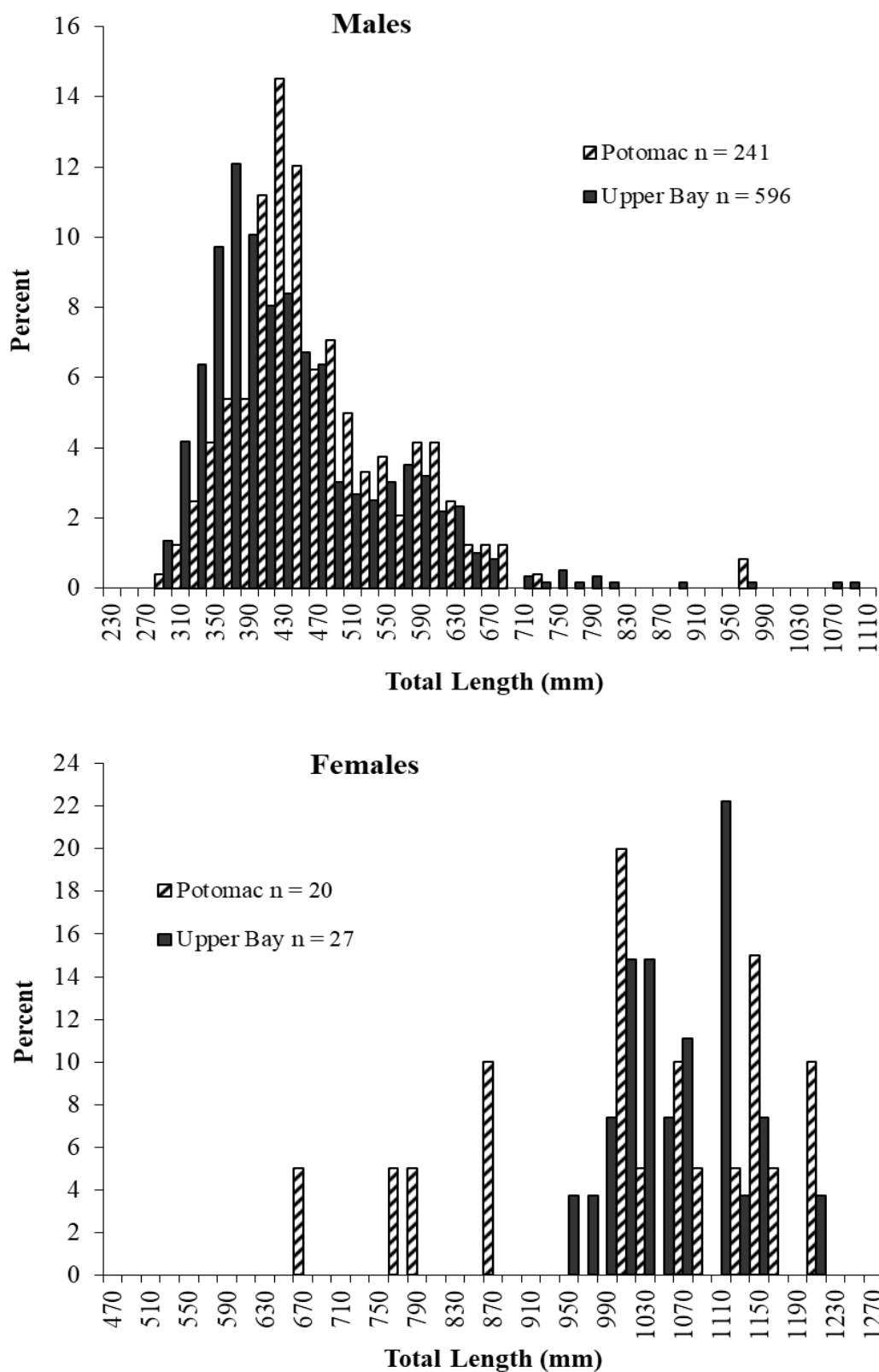


Figure 5. Length group CPUE (uncorrected and corrected for gear selectivity) of male striped bass collected from spawning areas of the Upper Bay and Potomac River, April - May 2022. CPUE is the number of fish captured per hour in 1000 square yards of experimental drift net.

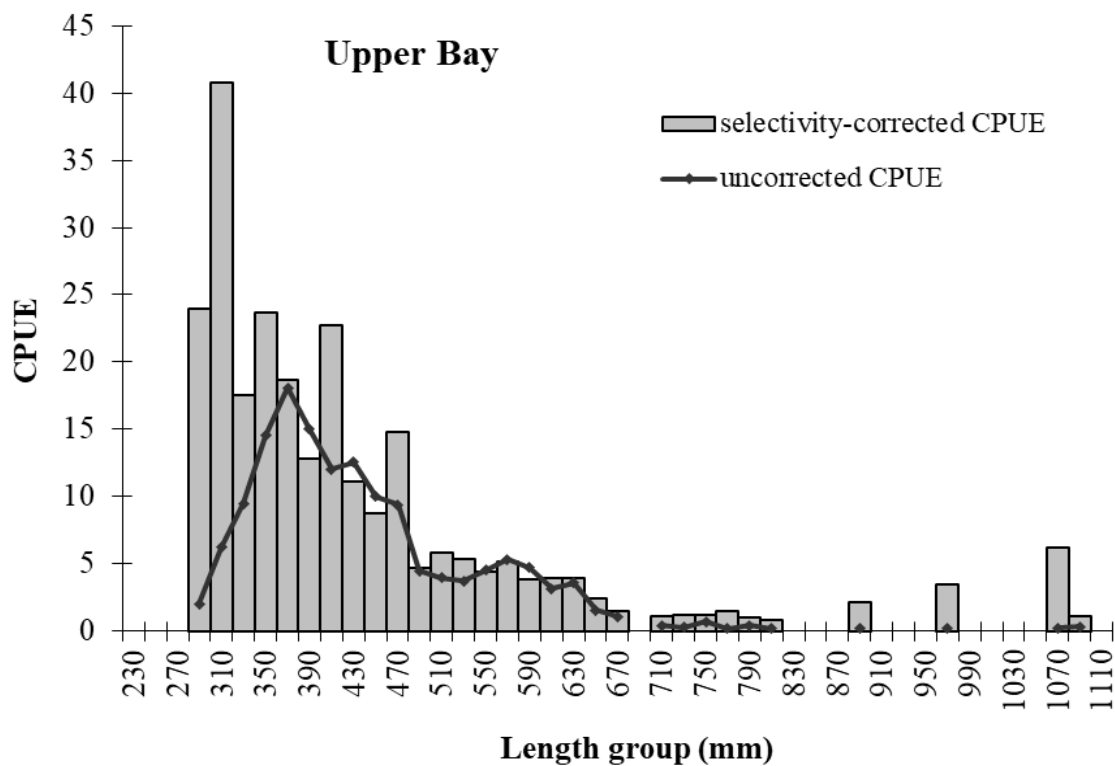
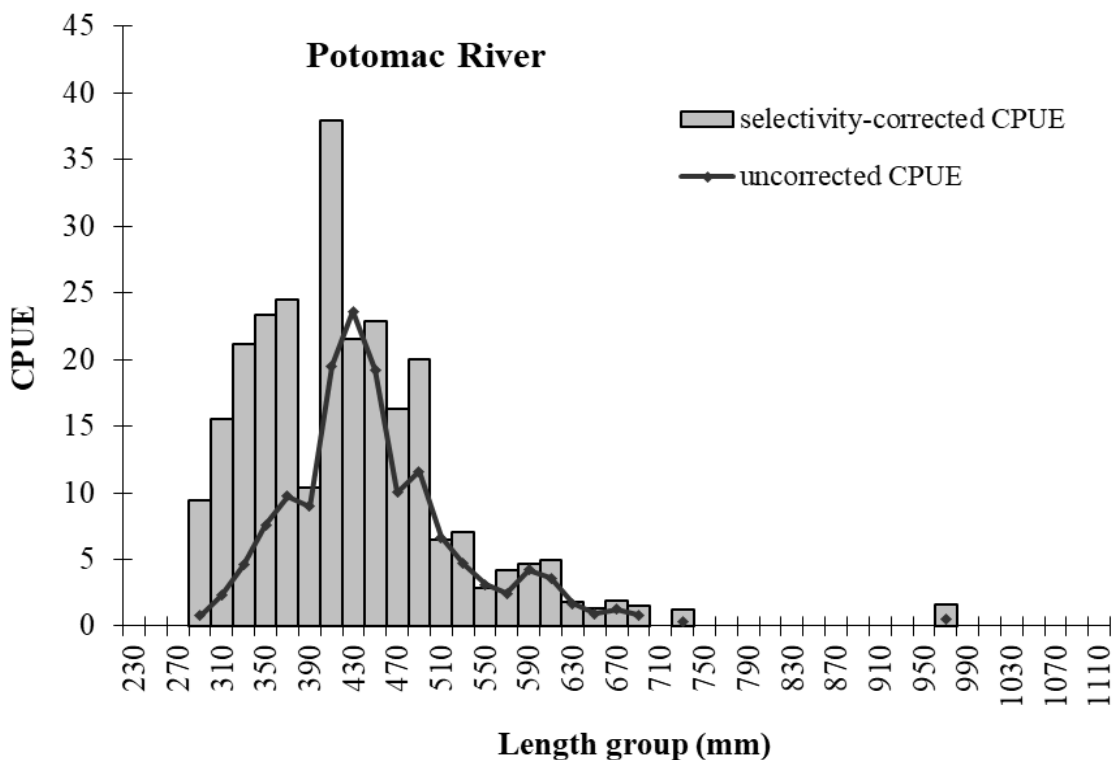


Figure 6. Length group CPUE (uncorrected and corrected for gear selectivity) of female striped bass collected from spawning areas of the Upper Bay and Potomac River, April - May 2022. CPUE is the number of fish captured per hour in 1000 square yards of experimental drift net.

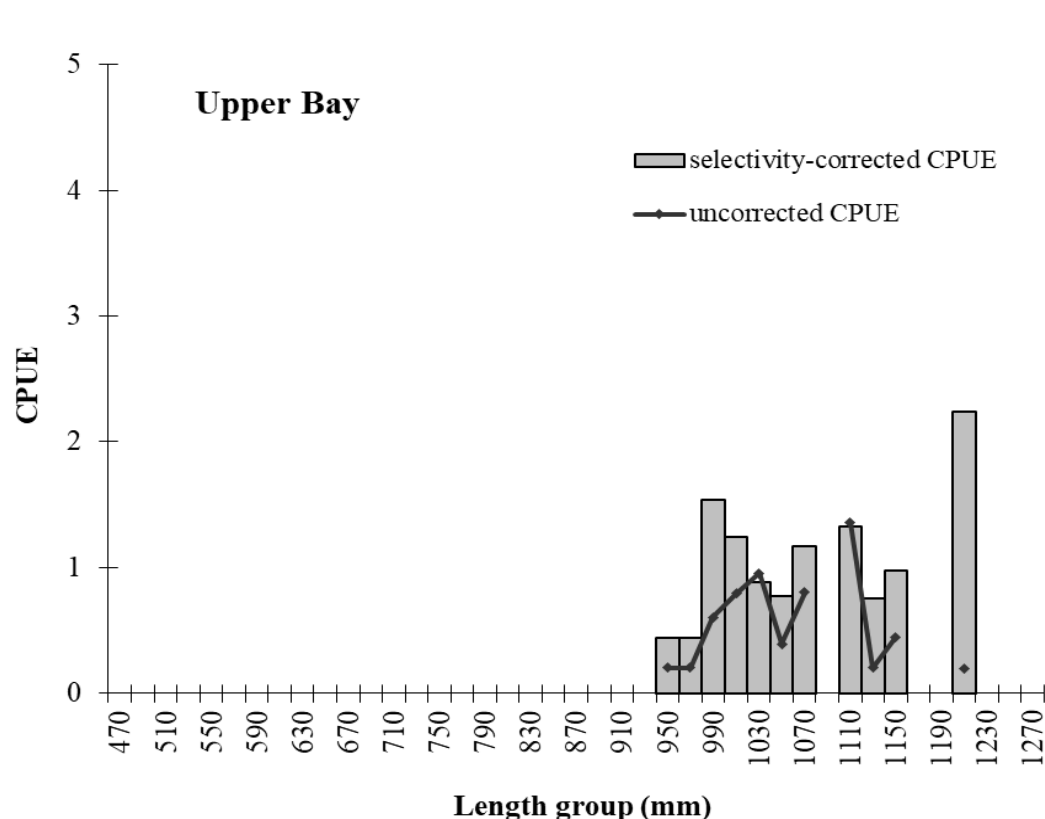
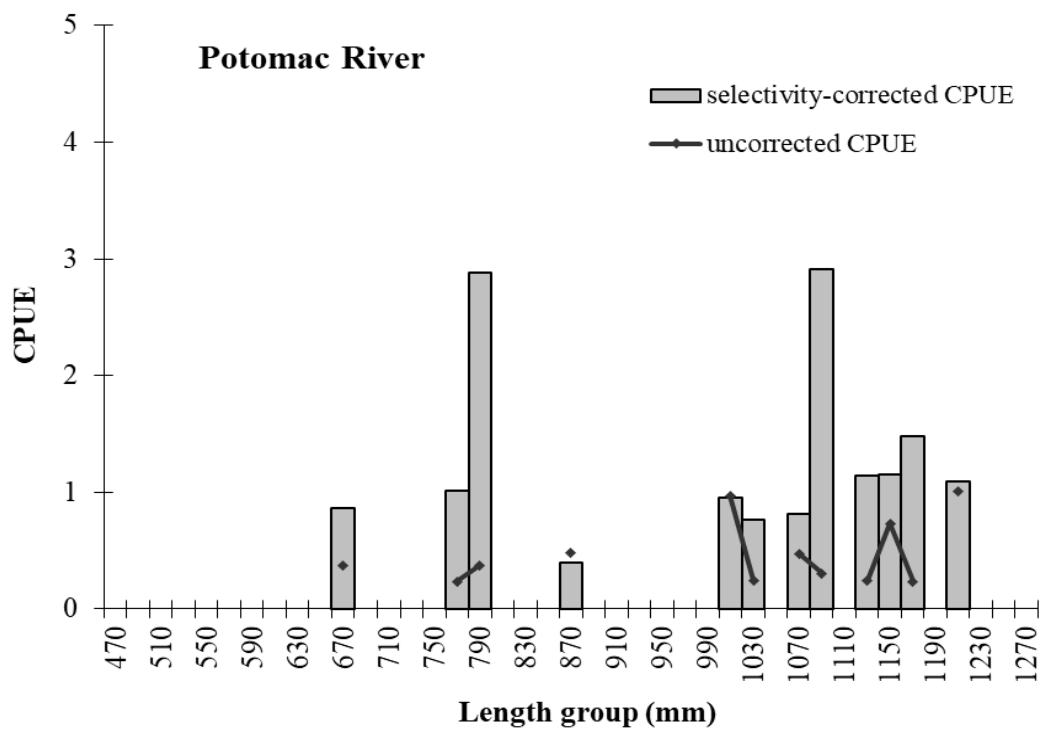


Figure 7. Mean length (mm TL) by year for individual ages of male striped bass sampled from spawning areas of the Potomac River and Upper Chesapeake Bay during March through May, 1985-2022. Error bars are ± 2 standard errors (SE). The Potomac River was not sampled in 1994. *Note difference in scales on y-axis.

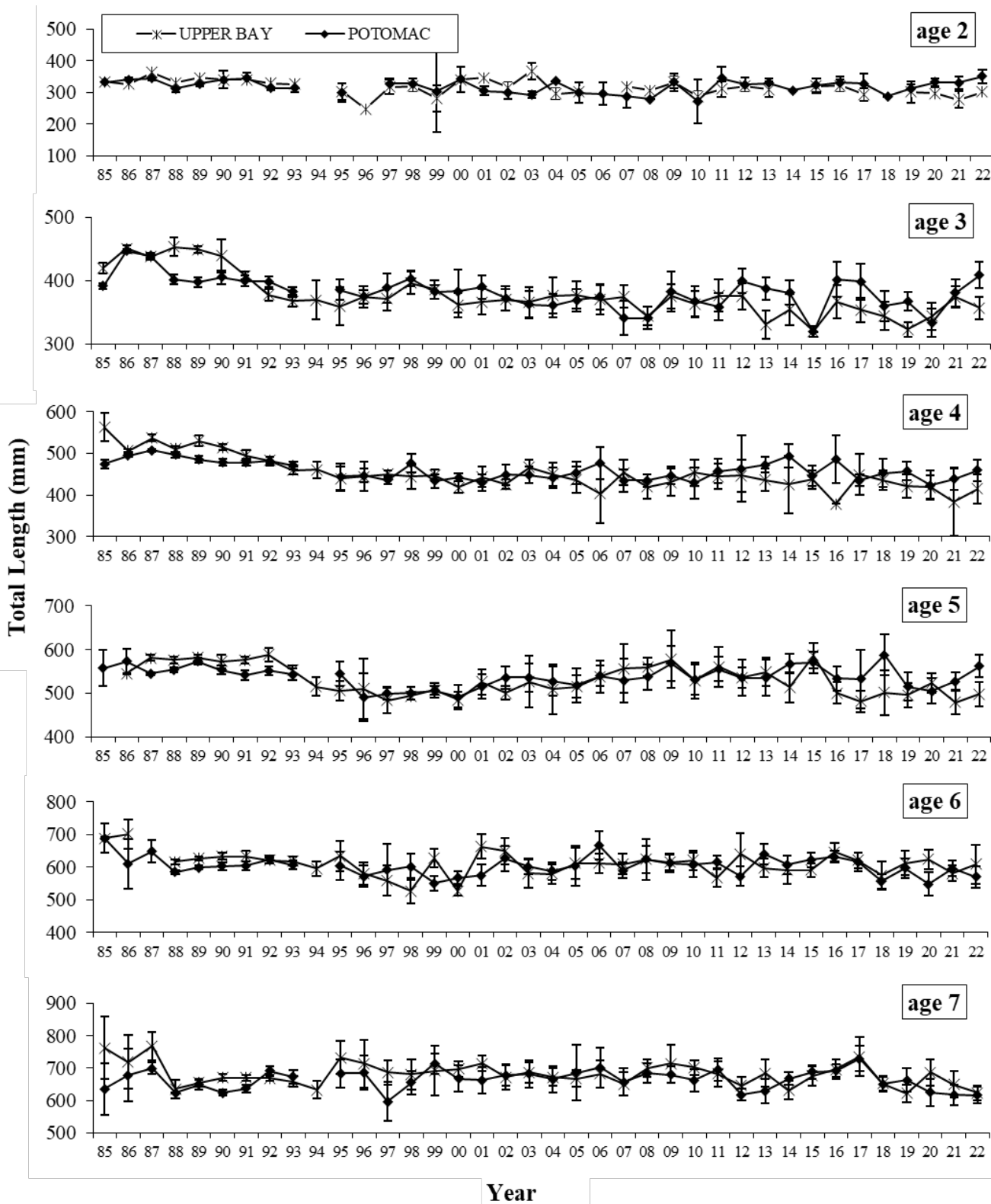


Figure 7. Continued.

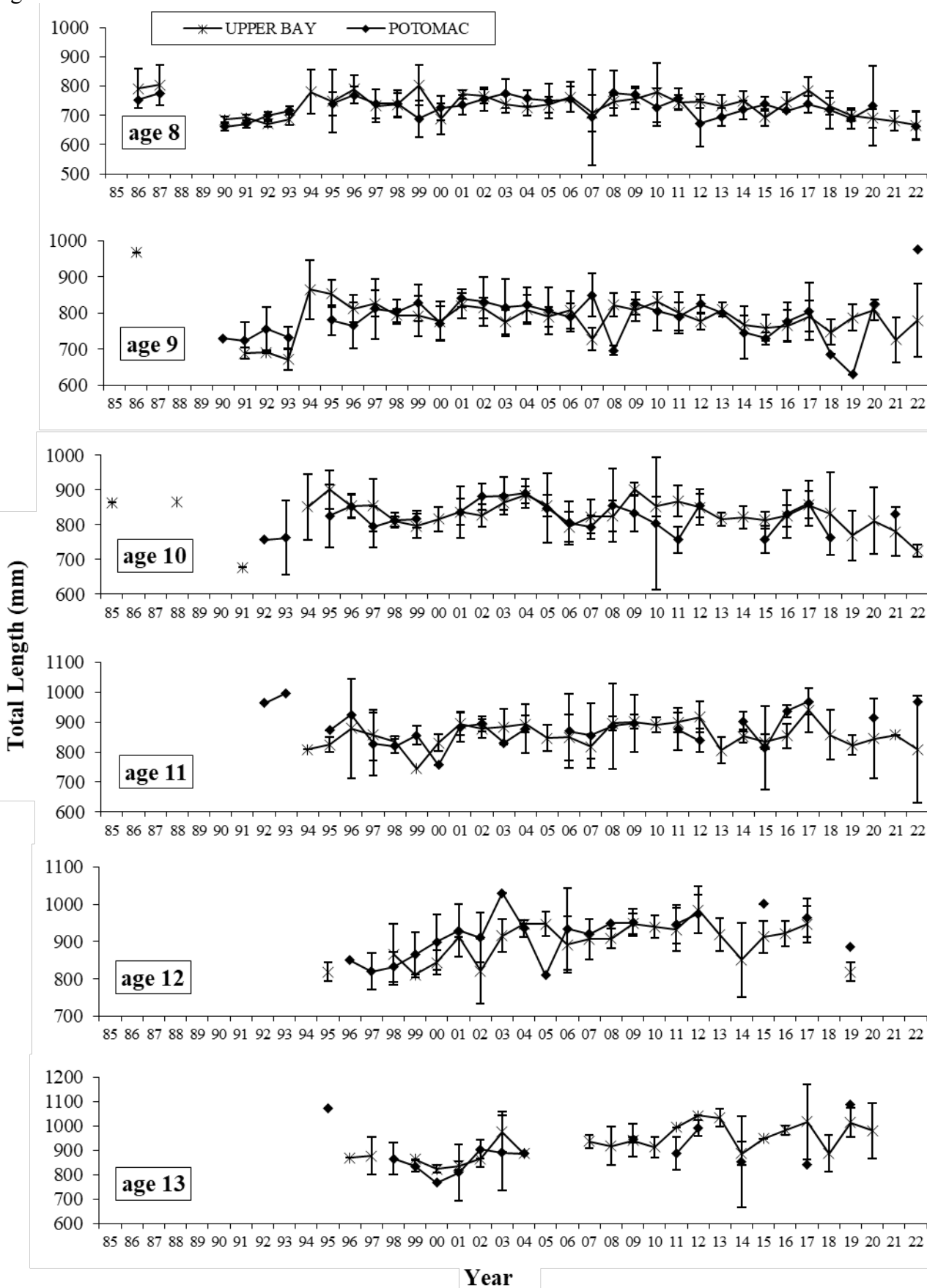


Figure 8. Mean length (mm TL) by year for individual ages of female striped bass sampled from spawning areas of the Potomac River and Upper Chesapeake Bay during March through May, 1985–2022. Error bars are ± 2 standard errors (SE). Note the Potomac River was not sampled in 1994. *Note difference in scales on y-axis.

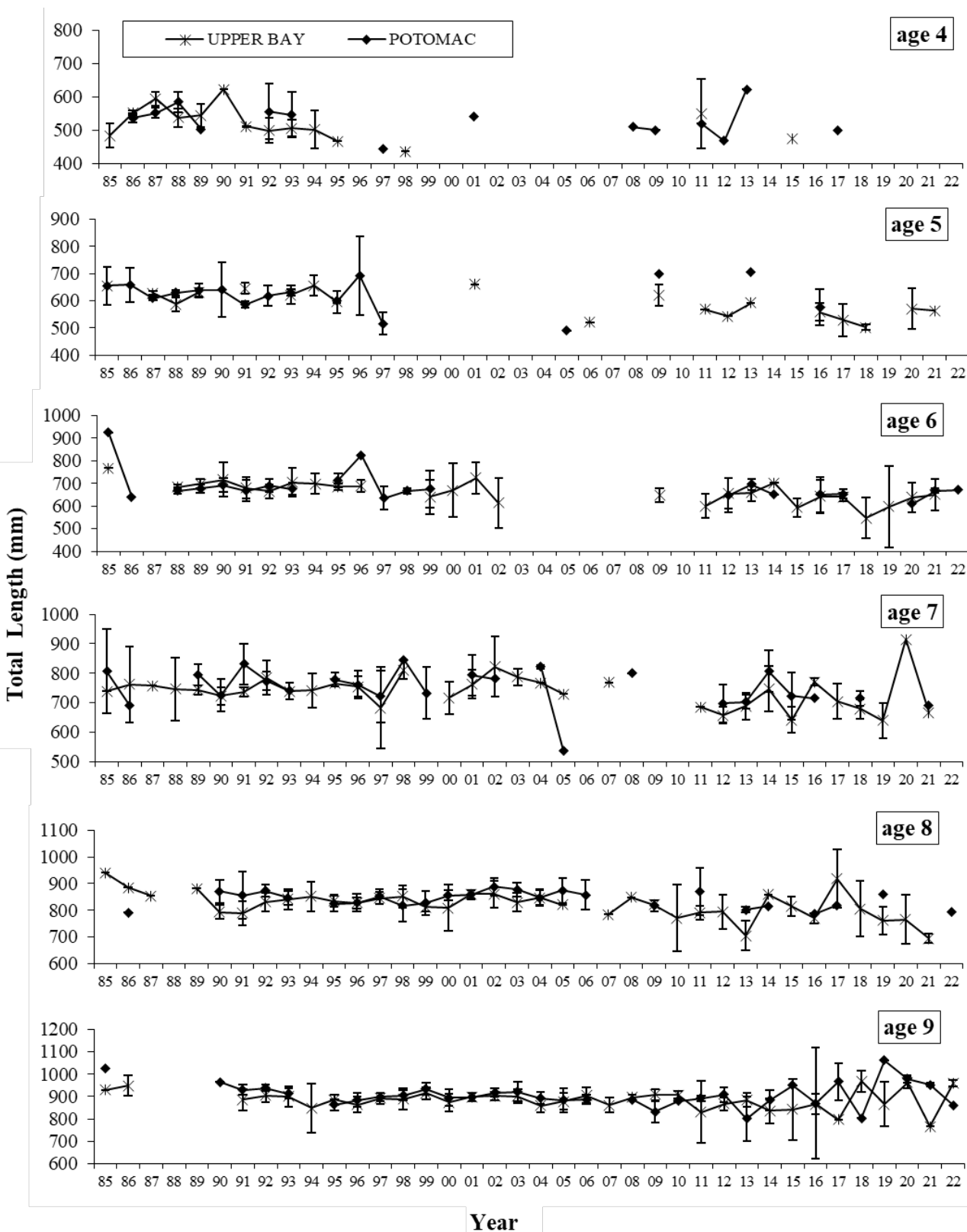


Figure 8. Continued.

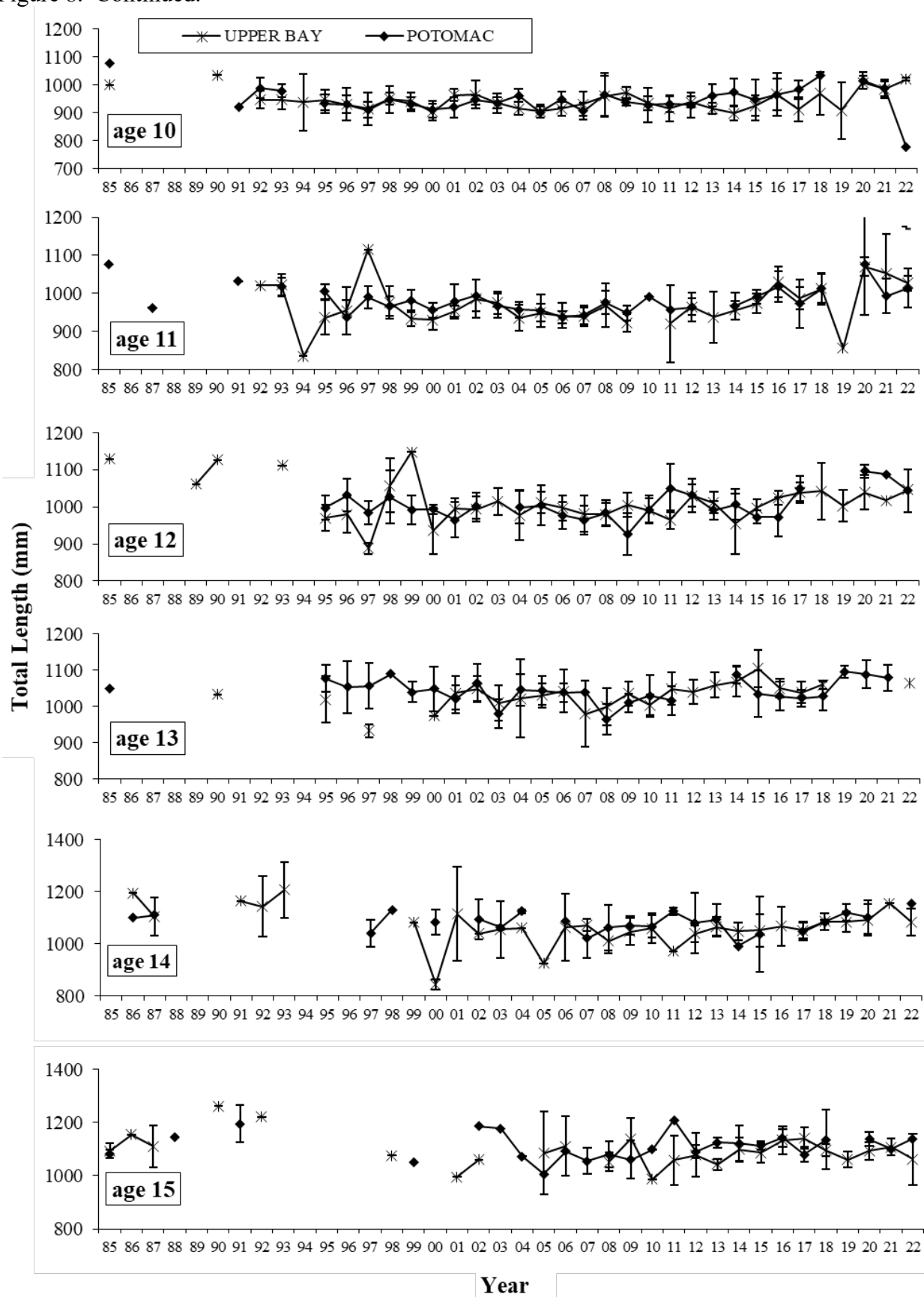


Figure 9. Maryland Chesapeake Bay spawning stock indices used in the coastal assessment. These are selectivity-corrected estimates of CPUE by year for ages 2 through 15+. Areas and sexes are pooled, although the contribution of sexes is shown in the stacked bars. Note different scales.

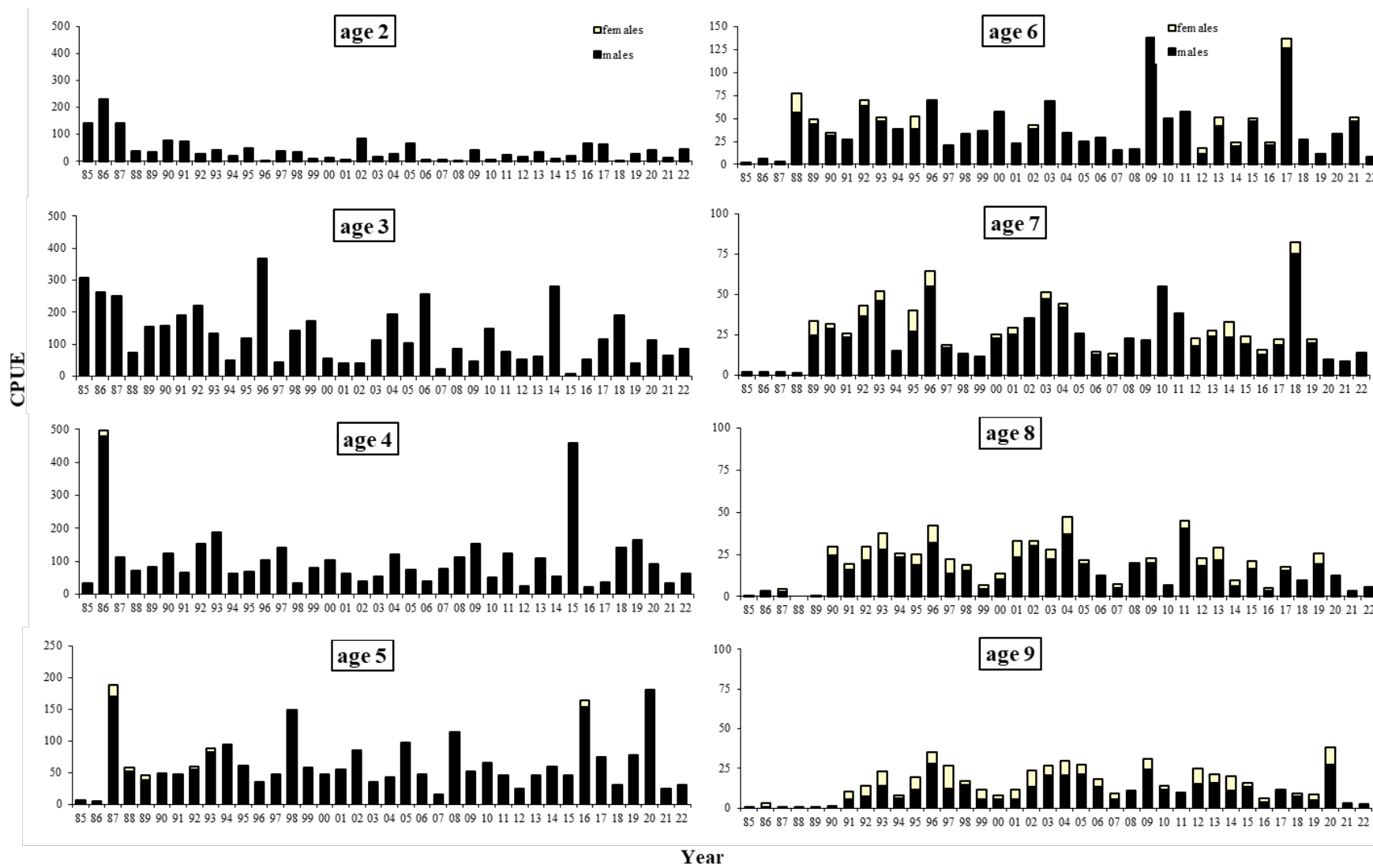


Figure 9. Continued.

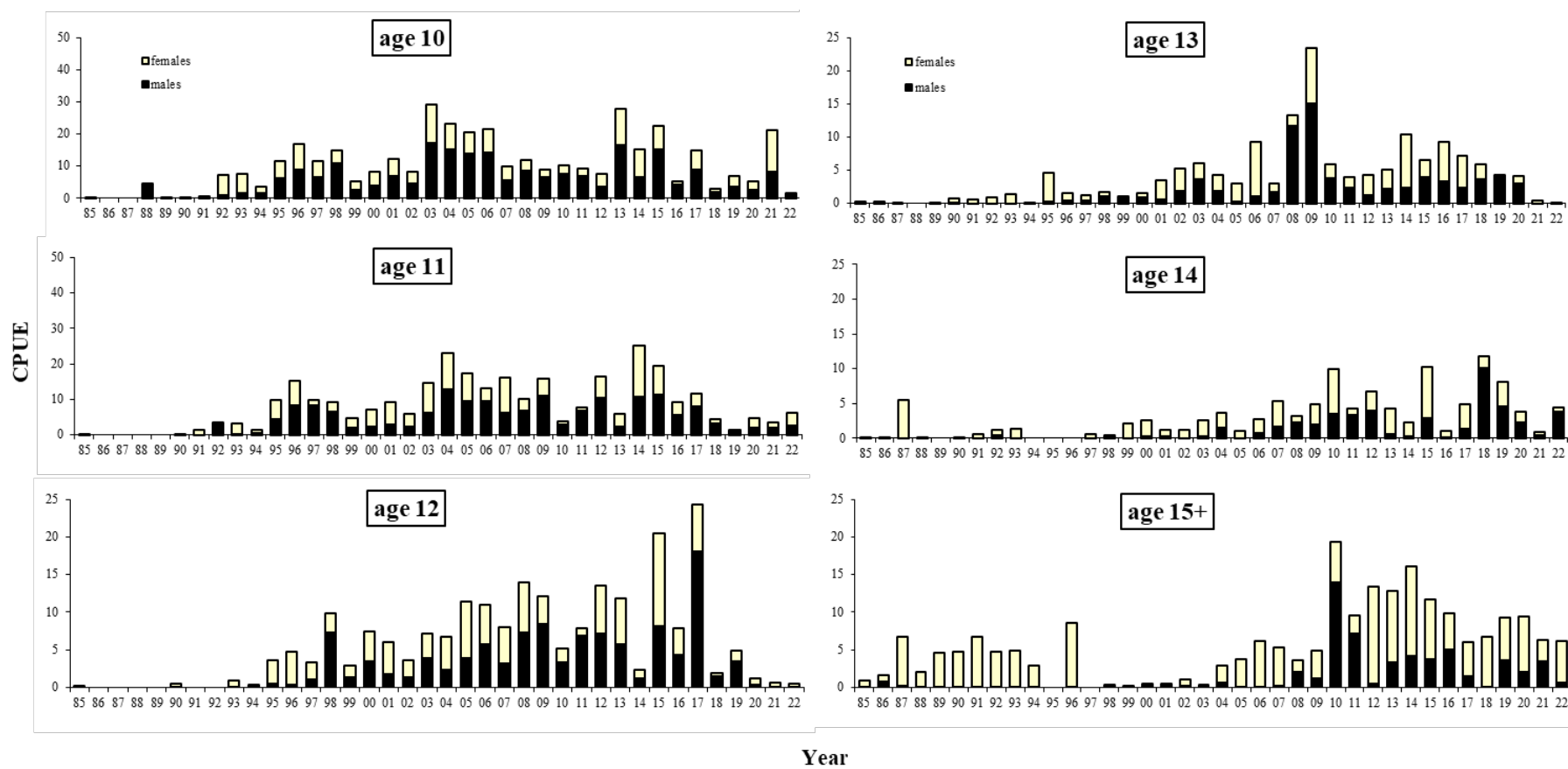
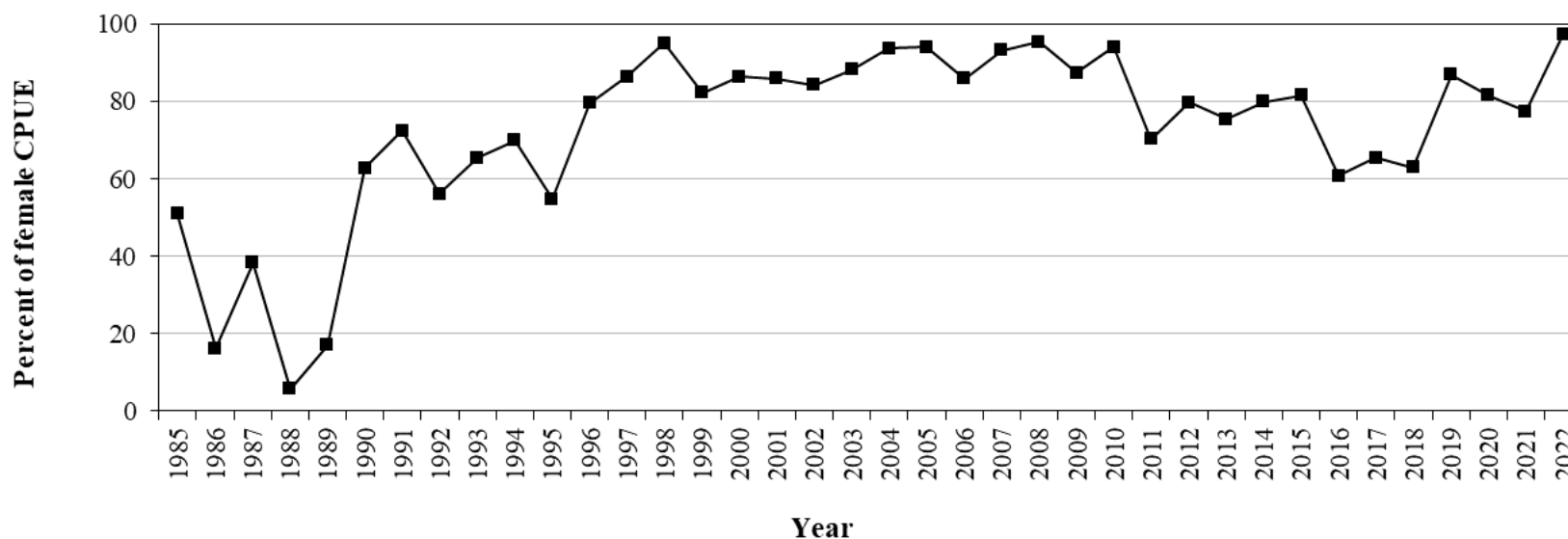
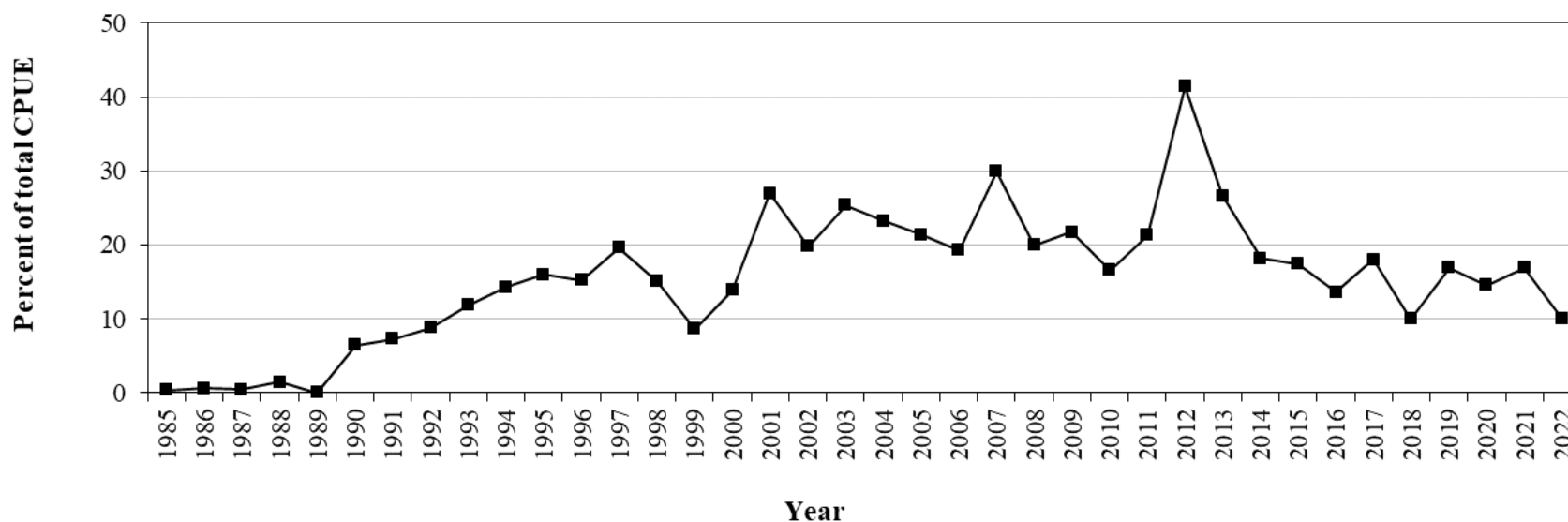


Figure 10. Percentage (selectivity-corrected CPUE) of female striped bass that were age 8 and older sampled from experimental drift gill nets set in spawning reaches of the Potomac River, Choptank River and the Upper Chesapeake Bay, March through May, 1985-2022 (Choptank River to 1996). Effort is standardized 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.



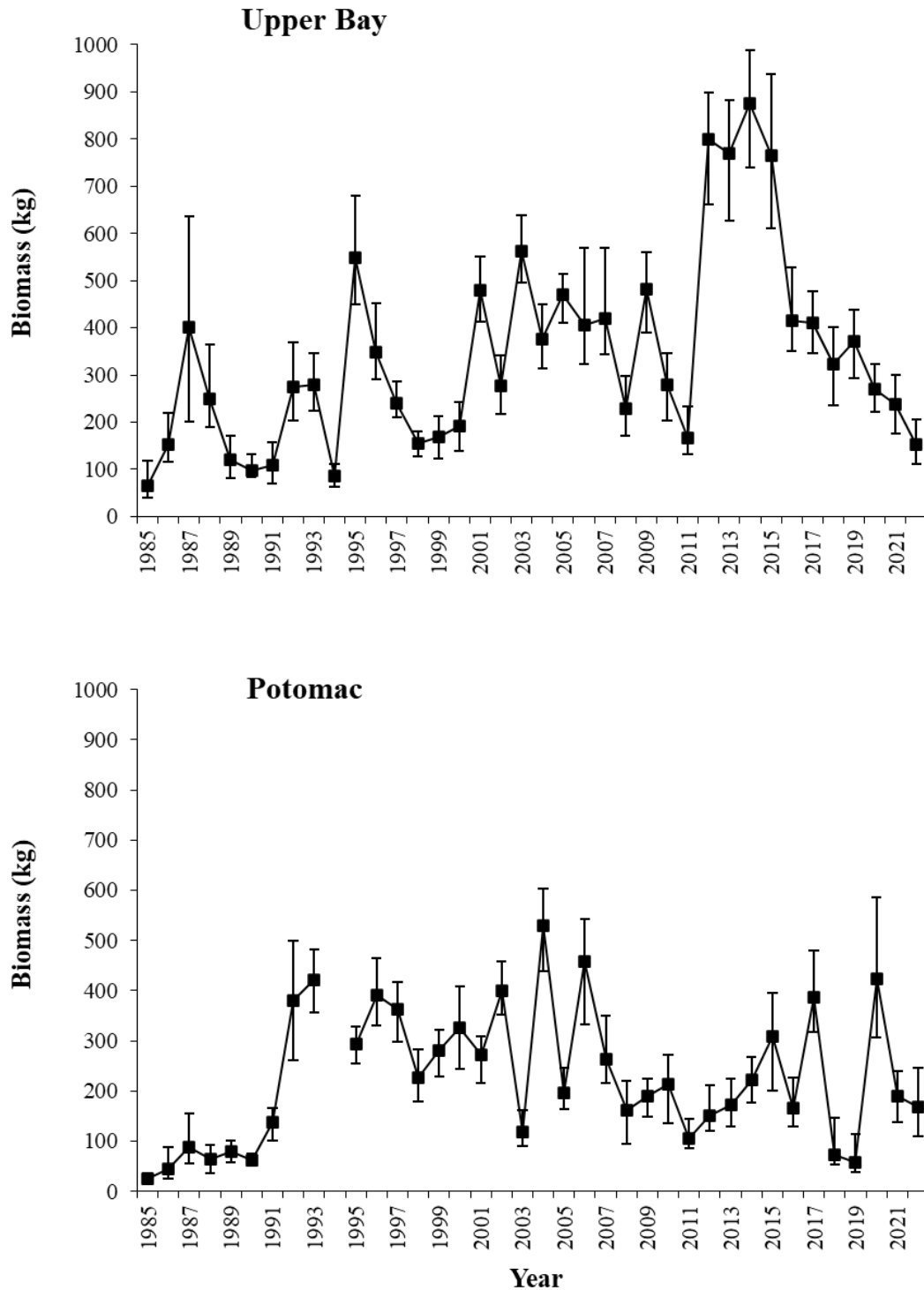
* Weights for spawning areas (1985 - 1996): Upper Bay=0.59; Potomac River=0.37; Choptank River=0.04.
(1997 - Present): Upper Bay=0.615; Potomac River=0.385. (Hollis 1967).

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, 1985-2022 (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, 1985-2022. 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 m² 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 $\text{antilog}(\log_e(x+1) \text{ mean} \pm 2$

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 478 YOY striped bass was collected at permanent stations in 2022. Individual samples yielded between 0 and 41 fish. The AM (3.6) and GM (1.78) were both below their respective time-series averages and TPAs (Tables 2 and 3, Figures 2 and 3). The PPHL was 0.65,

indicating that 65% 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 ($\alpha = 0.05$) found that the 2022 $\log_e$ -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, 99 juveniles were collected at the Head of Bay sites for an AM of 2.4, less than the time-series average (11.4) and the TPA (17.3) (Table 2, Figure 5). The GM of 1.38 was also less than the time-series average (5.64) 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 2022 Head of Bay $\log_e$ -mean greater than just the three smallest year-classes of the time-series (1981, 1985 and 1987).

Potomac River - A total of 197 juveniles was collected in 42 samples on the Potomac River. The AM of 4.7 was below both the time-series average (7.8) and TPA (9.2) (Table 2, Figure 5). The GM of 1.94 was also below the time-series average (3.44) 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 ($\alpha = 0.05$) ranked the 2022 Potomac River year-class significantly greater than only six years of the time-series (1963, 1968, 1969, 1988, 1990 and 2021).

Choptank River - A total of 73 juveniles was collected in 24 Choptank River samples. The AM of 3.0 was below the time-series average of 19.9 and the TPA (10.8) (Table 2, Figure 5). The GM of 1.52 was less than its time-series average (7.66) and TPA (5.00) (Table 3, Figure 8). Differences among years were significant (ANOVA: $P < 0.0001$). Duncan's multiple range test ($\alpha = 0.05$) found the 2022 Choptank River year-class significantly larger than just the two smallest

year-classes of the time-series (1959 and 2012).

Nanticoke River - A total of 109 juveniles was collected in 24 samples on the Nanticoke River. The AM of 4.5 was below the time-series average (8.7) and the TPA (8.6) (Table 2, Figure 5). The GM of 2.68 was also below its time-series average (3.98) 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 2022 index significantly greater than just six years of the time-series (1973, 1983, 1988, 1990, 1991 and 2012).

Auxiliary Indices

At the **Head of Bay auxiliary sites**, 76 juveniles were caught in 12 samples, resulting in an AM of 6.3, and a GM of 3.64. Both indices were above their respective time-series averages (Table 5).

On the **Patuxent River**, 4 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 for 2022 was remarkably similar to the previous year as measured by AM, GM and PPHL (Tables 2-4). Chesapeake Bay recruitment was below average for the fourth consecutive year. The 2022 GM of 1.78 meets the newly adopted definition of recruitment failure as described in Amendment 7 of the Interstate Fishery Management Plan (ASMFC 2022). Recruitment failure in Maryland's portion of the Chesapeake Bay is now defined as a GM index below the 25th percentile of the values from 1992 to 2006, or a GM less than 4.16.

Recruitment in individual systems is often variable, but was consistently poor again in 2022. The worst performing system was the Head of Bay, with a GM ranked in the 18th percentile of its time-series. The Nanticoke was the highest performing system, ranked in the 55th percentile of its

respective time-series. Although the Potomac River GM ranked below the 50th percentile of its time-series, this was the only system to perform significantly better than 2021 as determined by Duncan's Multiple Range test.

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: $C_1 = (0.1754)(C_0) - 0.0567$, 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 (0.06) was less than the predicted index of 0.11. Examination of residuals (Figure 11) shows that this regression equation can 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.

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Table 1. Maryland juvenile striped bass survey sample sites.

Site Number	River or Creek	Area or Nearest Landmark
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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
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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
2022	2.4	4.7	3.0	4.5	3.6
Average	11.4	7.8	19.9	8.7	11.3
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
2022	1.38	1.94	1.52	2.68	1.78
Average	5.64	3.44	7.66	3.98	4.17
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
2022	3.6	161.2	1.02	93.78	0.65	0.57	0.73	132
Average	11.4	203.8	1.44	91.51	0.71	0.63	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
2022	0.2	0.12	18	6.3	3.64	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	0.06
2022	1.02	N/A

Figure 1. Maryland Chesapeake Bay juvenile striped bass survey site locations.

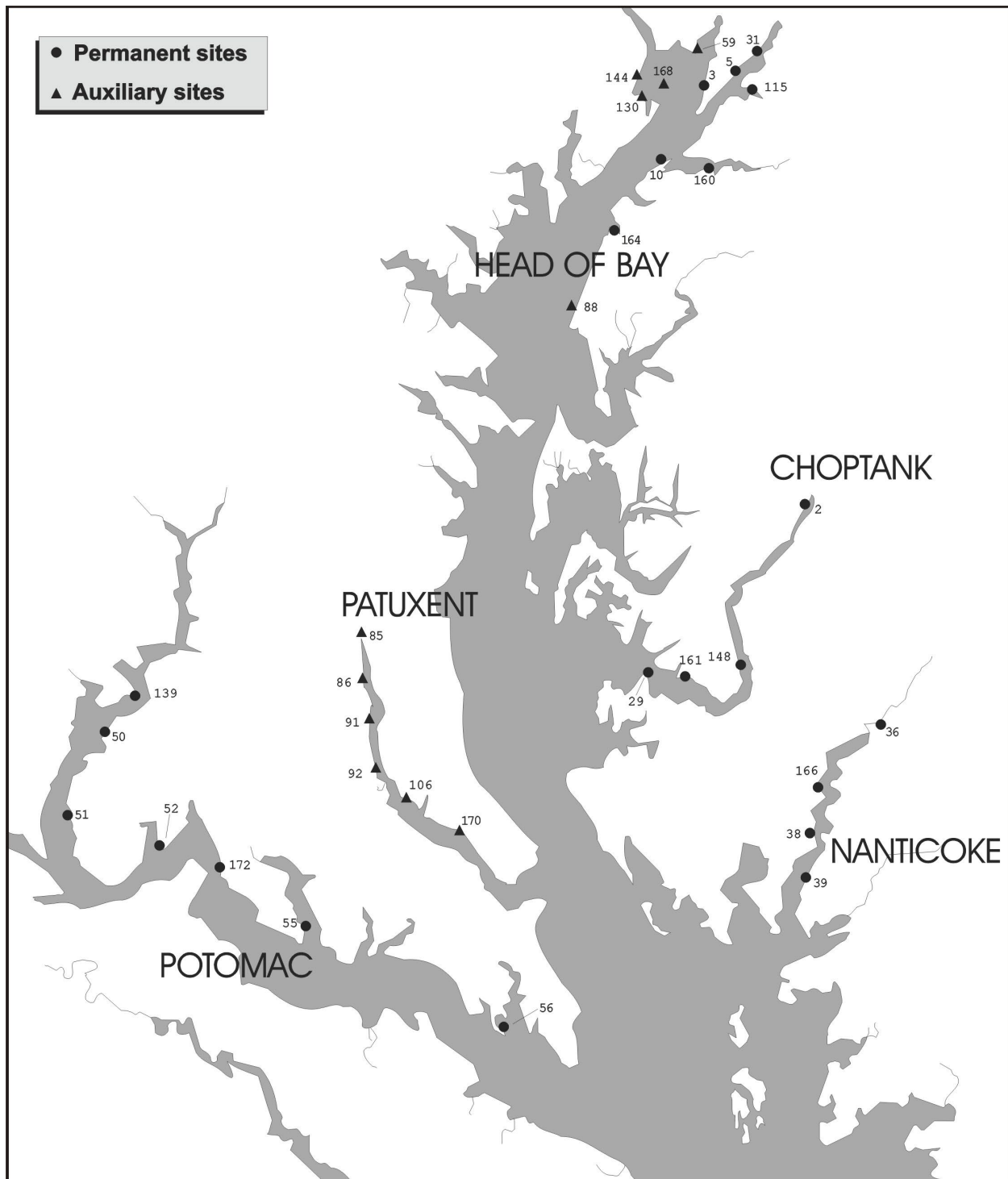


Figure 2. Maryland Chesapeake Bay arithmetic mean (AM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

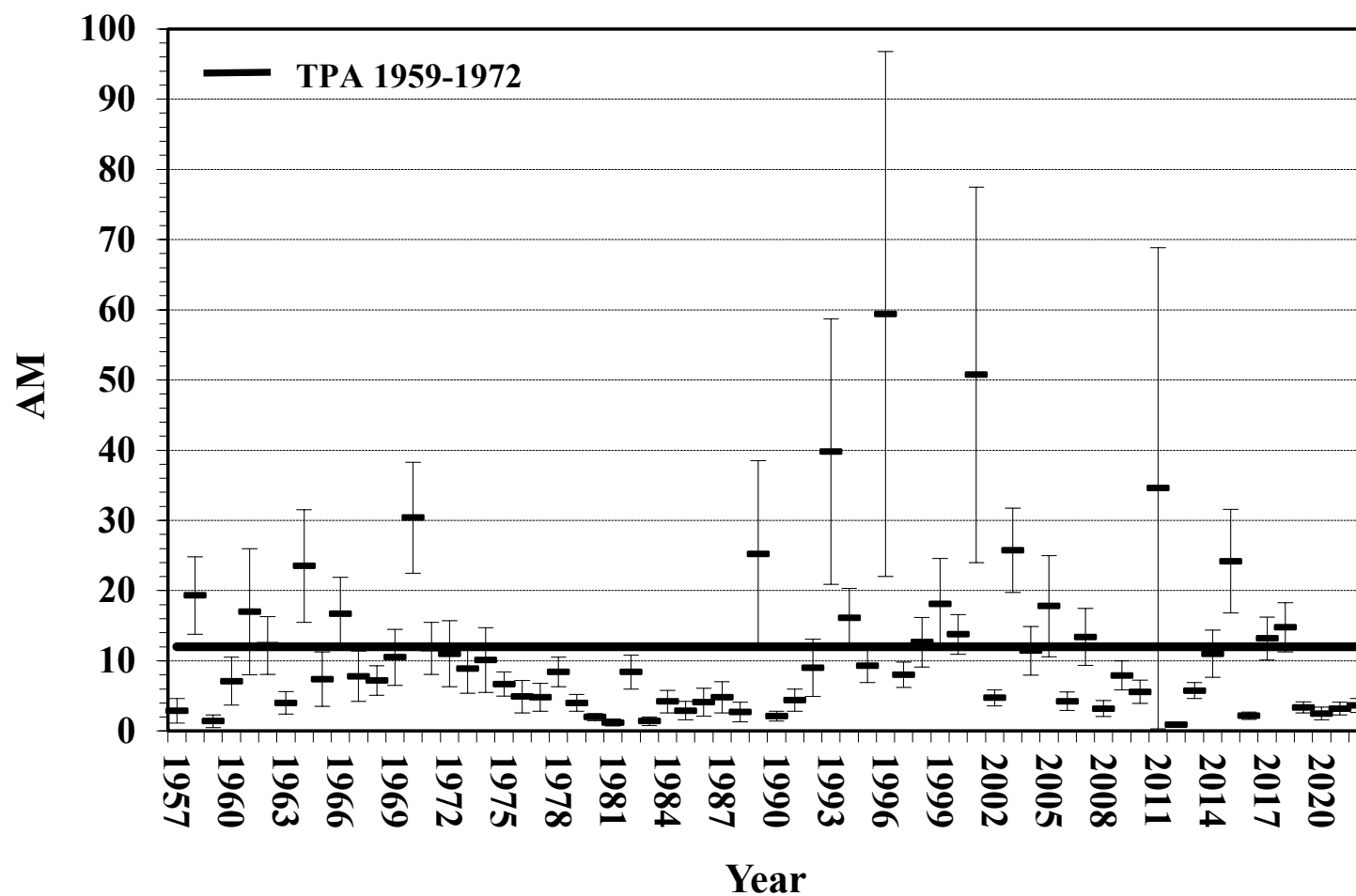


Figure 3. Maryland Chesapeake Bay geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

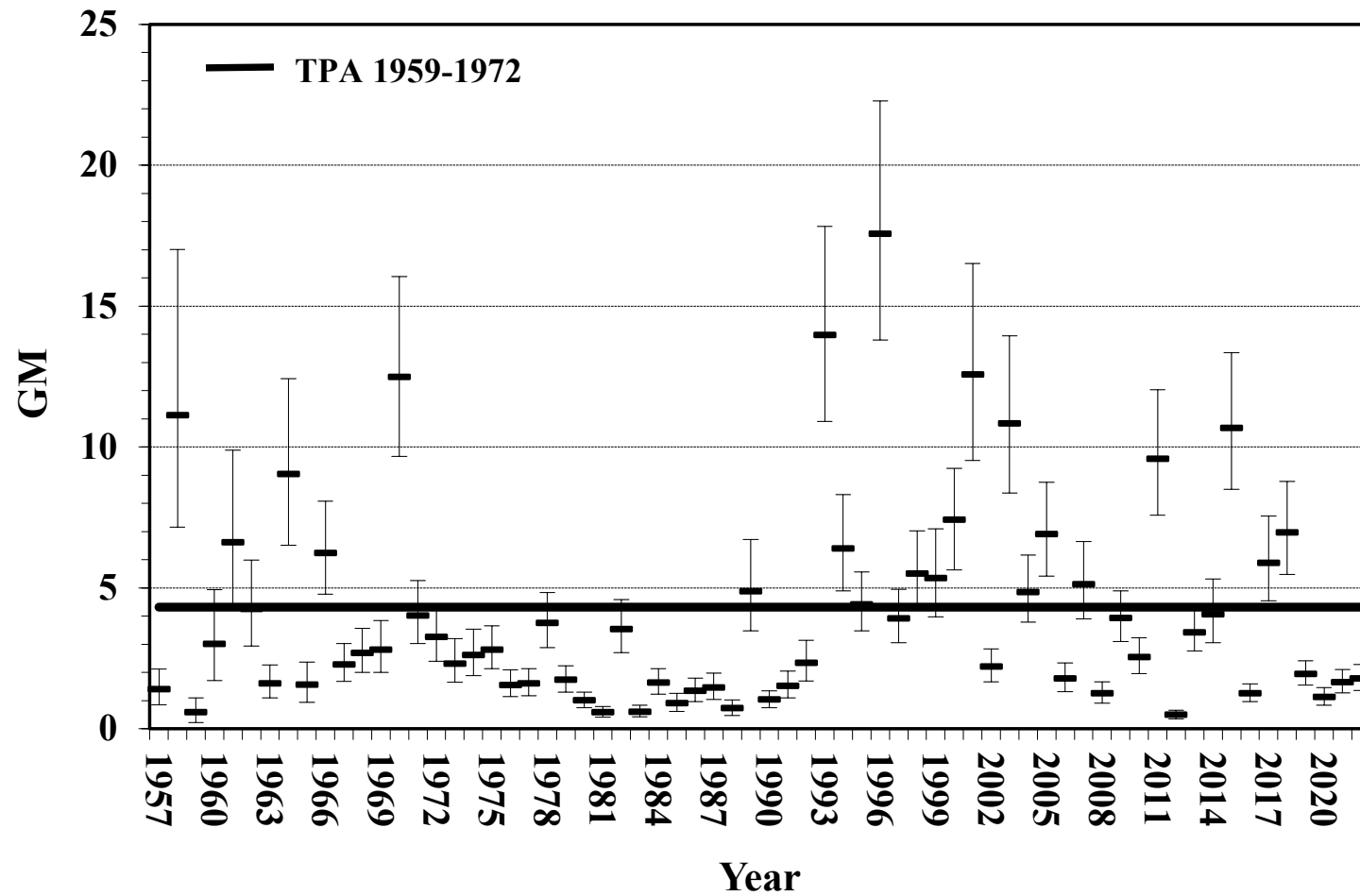


Figure 4. Maryland Chesapeake Bay juvenile striped bass indices. Arithmetic mean (AM), scaled geometric mean (GM)*, and proportion of positive hauls (PPHL) as percent.

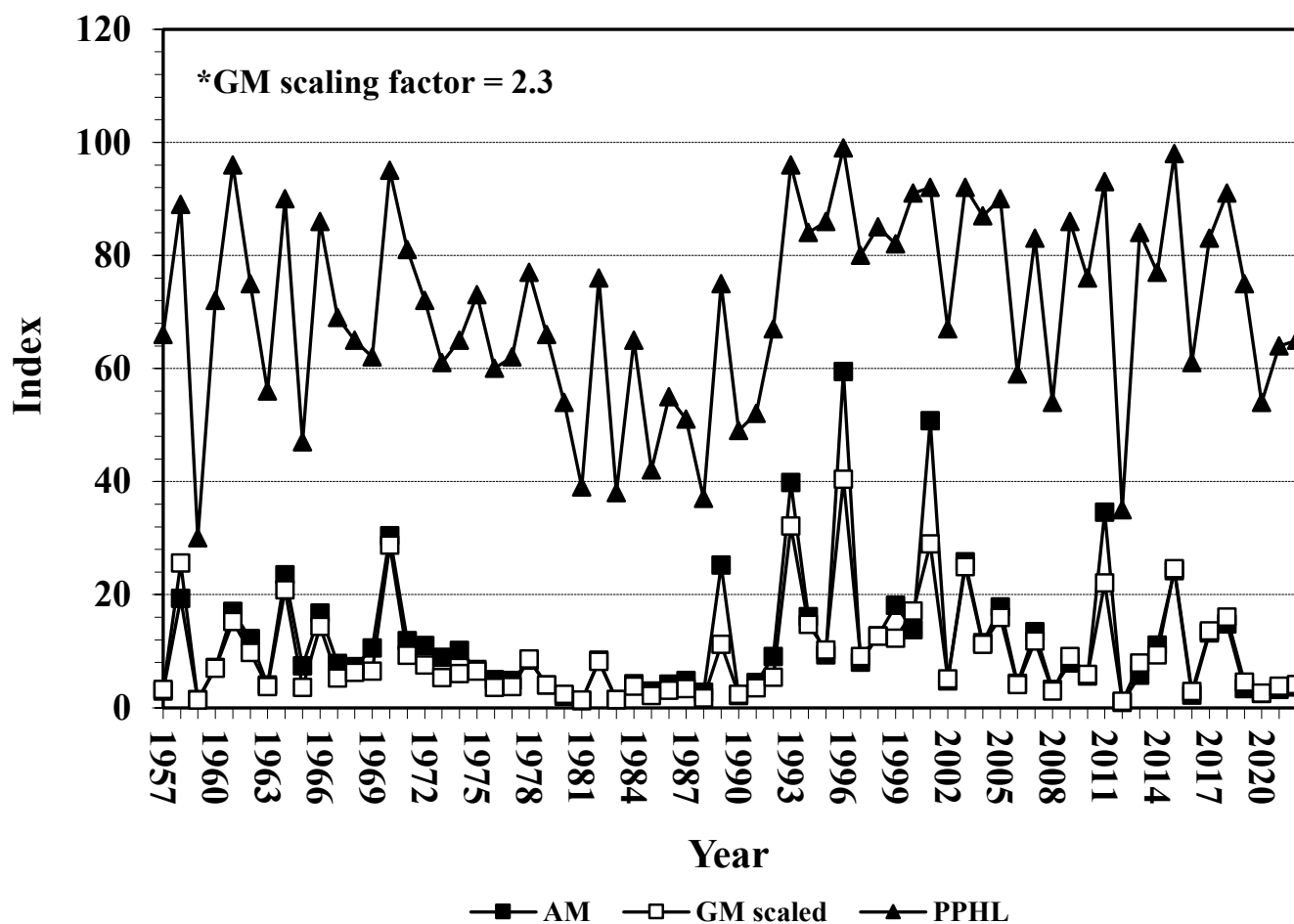


Figure 5. Arithmetic mean (AM) catch per haul by system for juvenile striped bass. Note different scales.

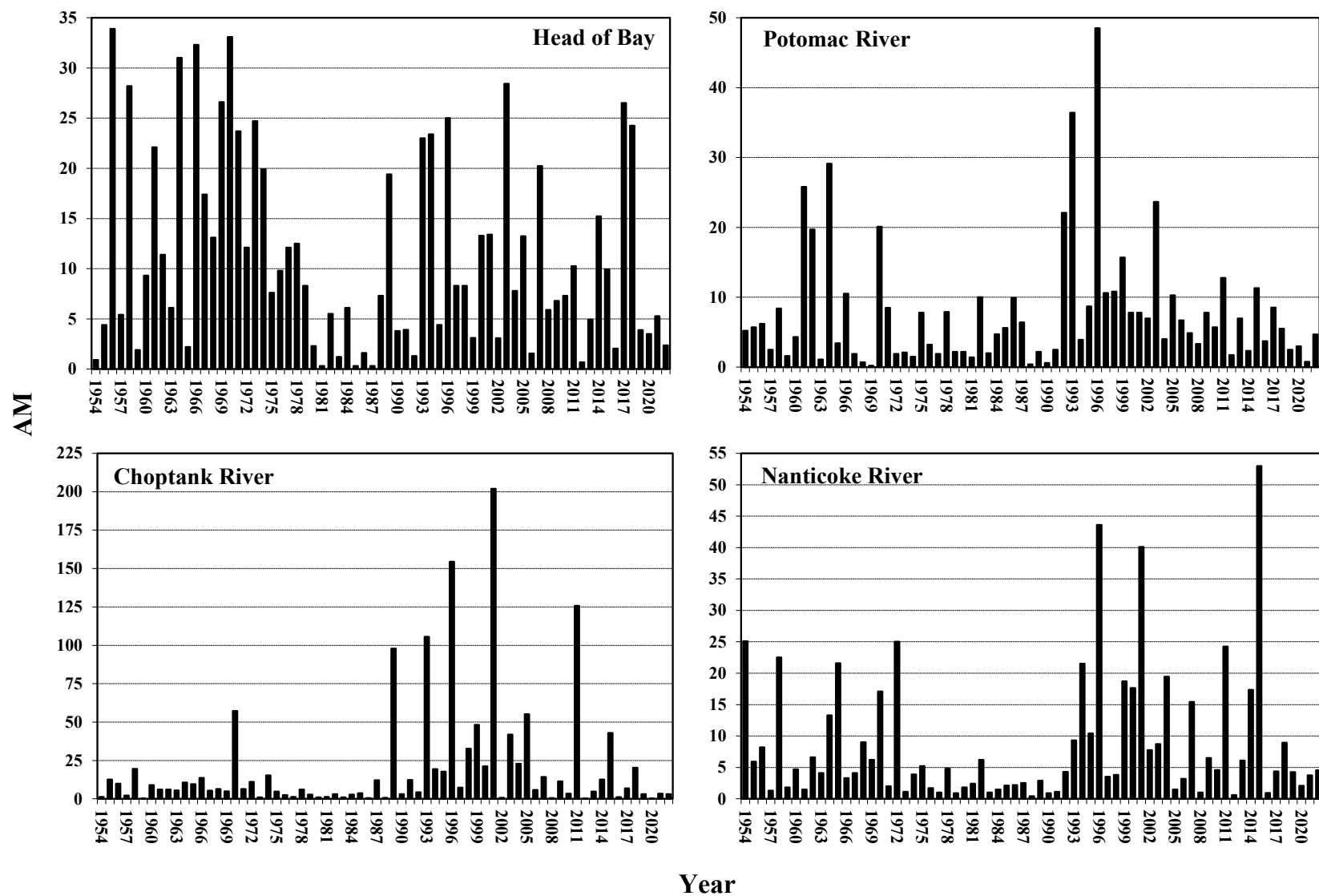


Figure 6. Head of Bay geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

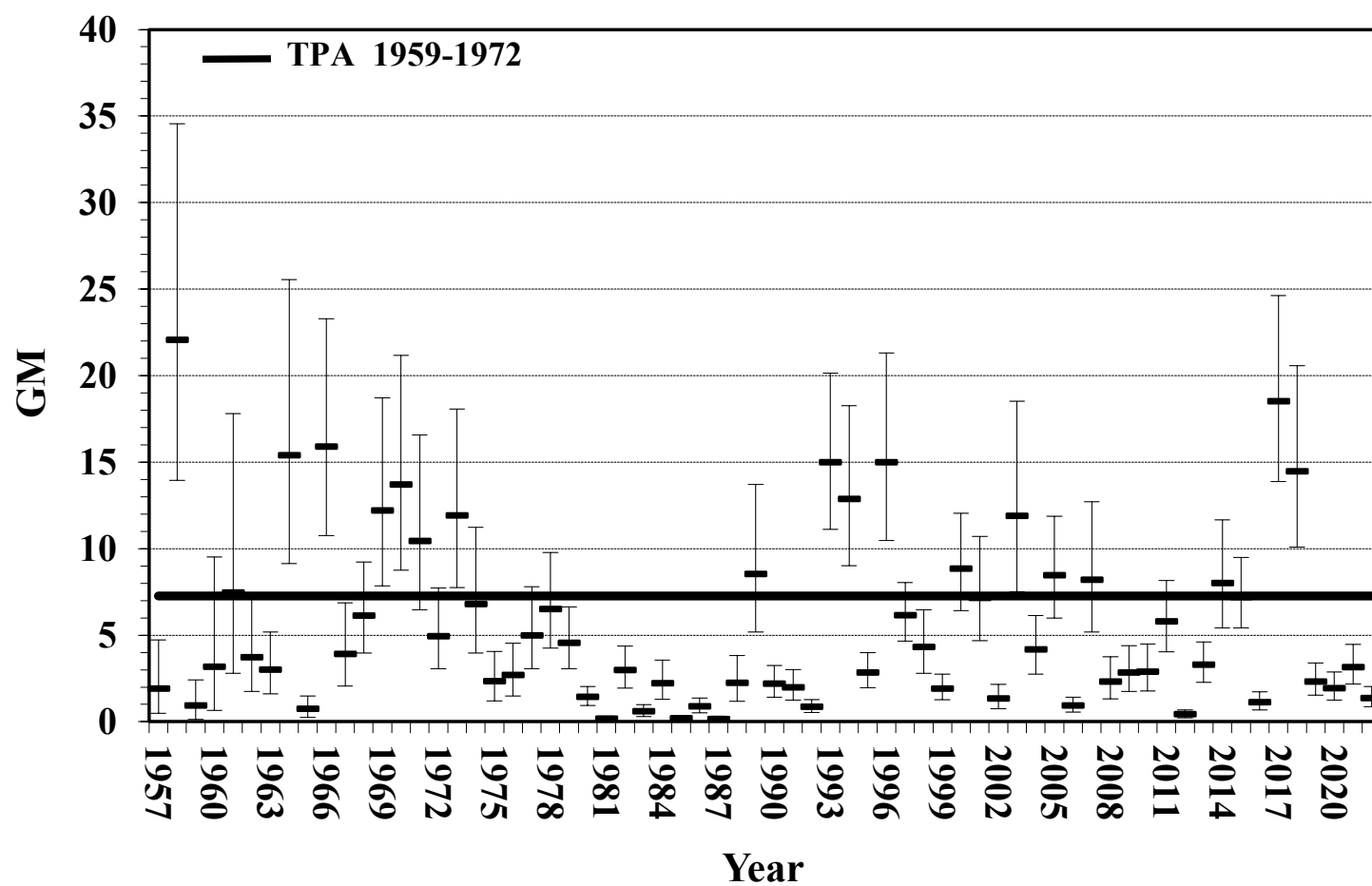


Figure 7. Potomac River geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

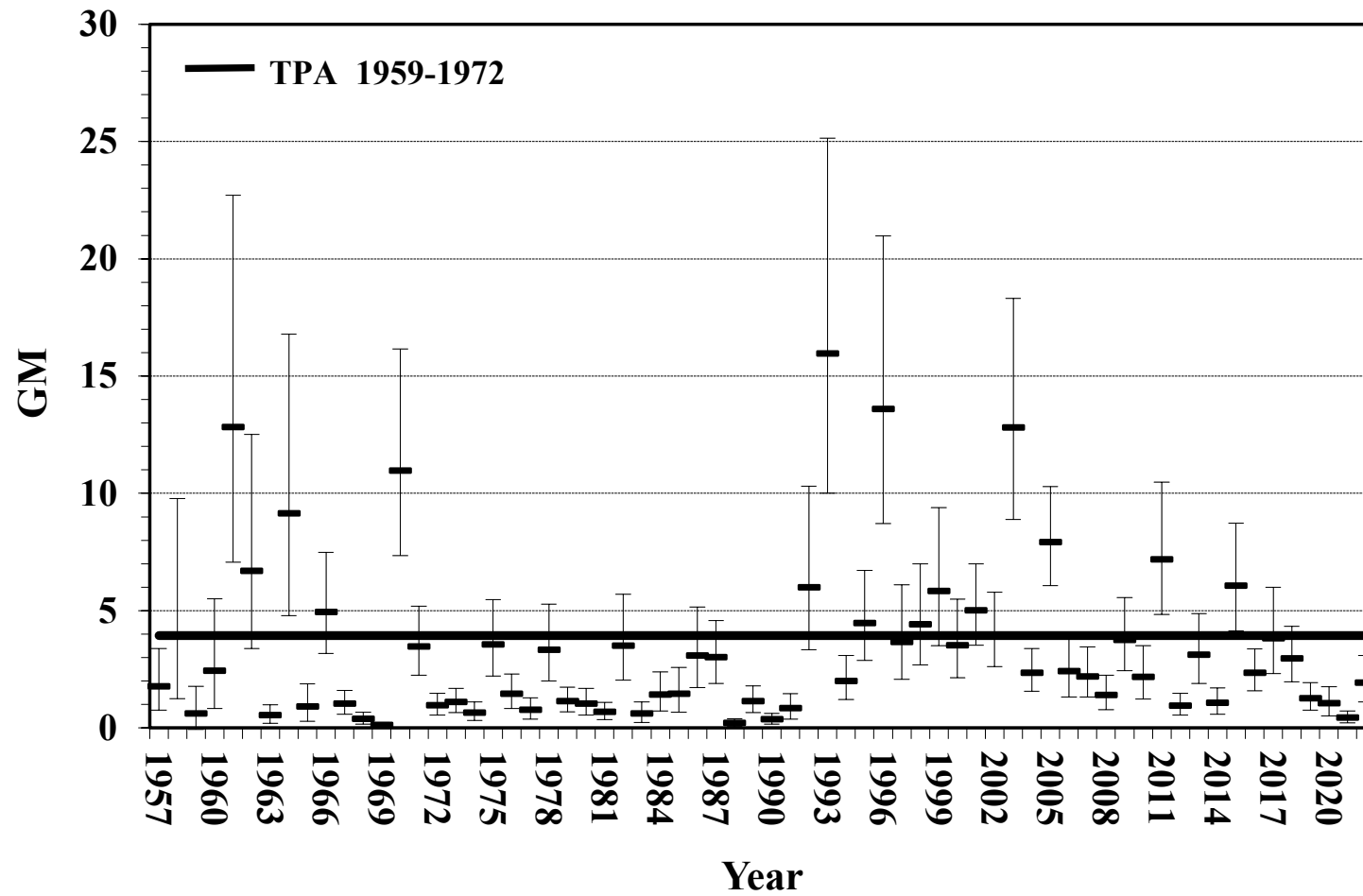


Figure 8. Choptank River geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

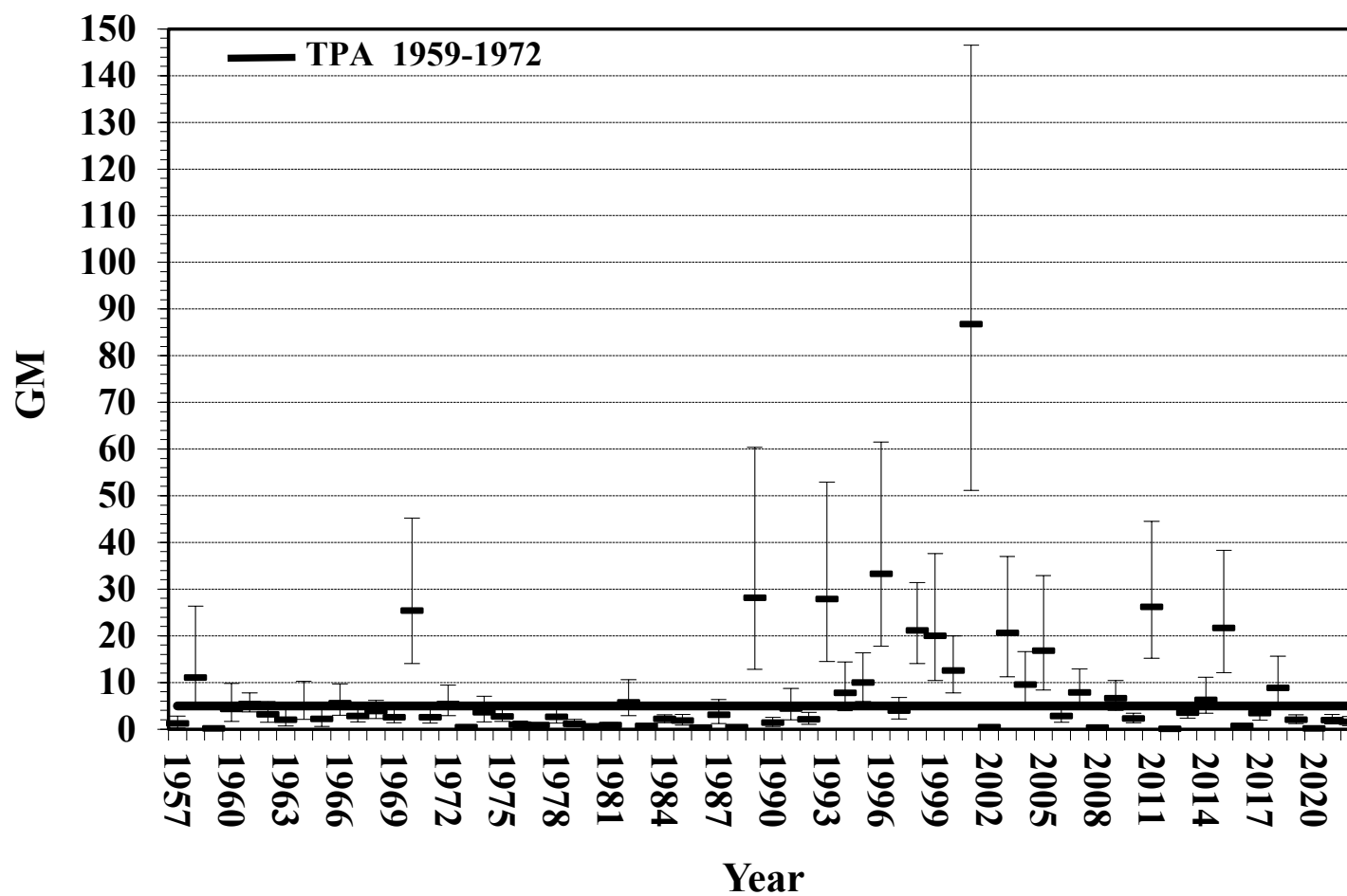


Figure 9. Nanticoke River geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

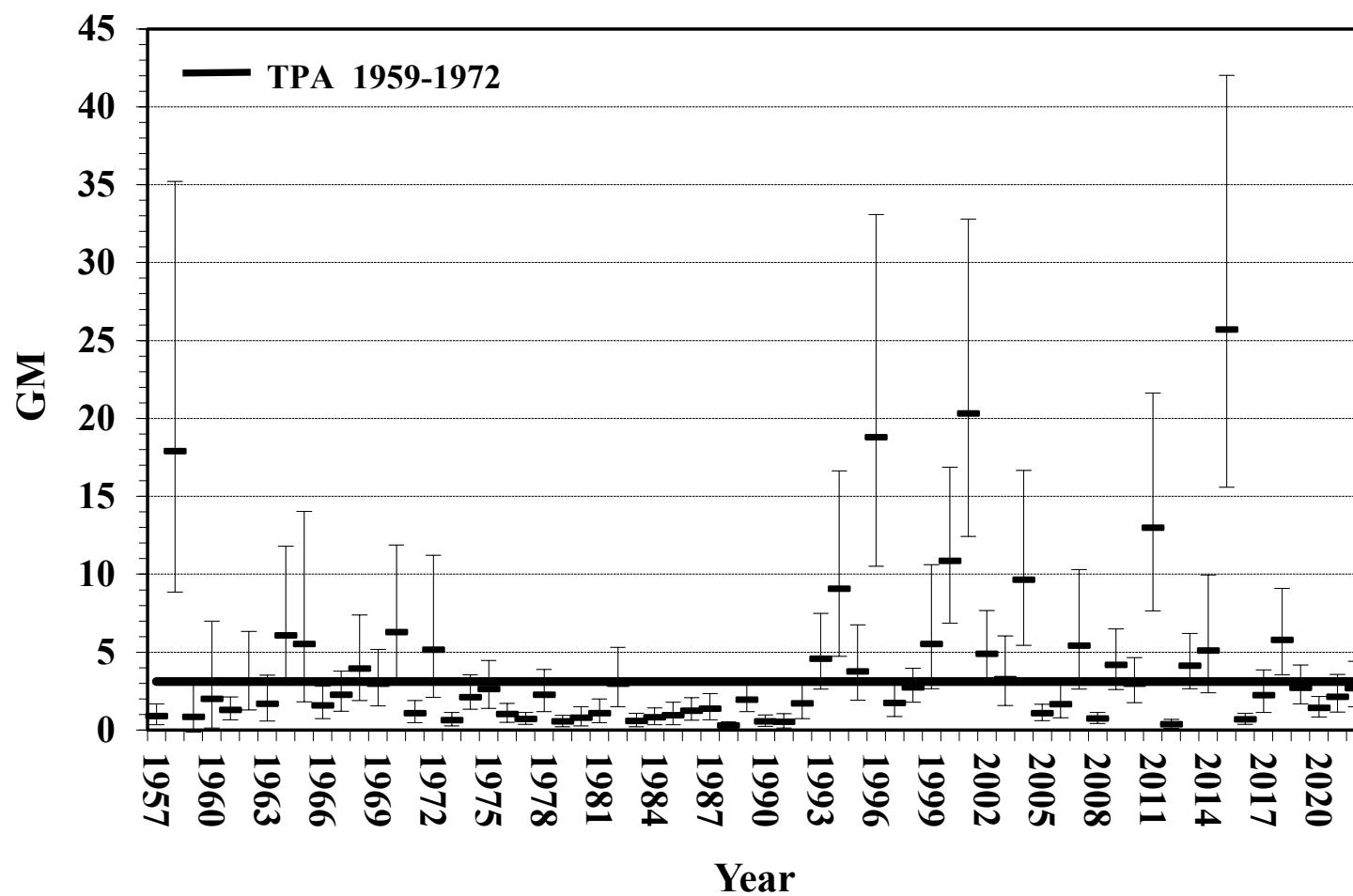


Figure 10. Relationship between age 0 and subsequent age 1 striped bass indices.

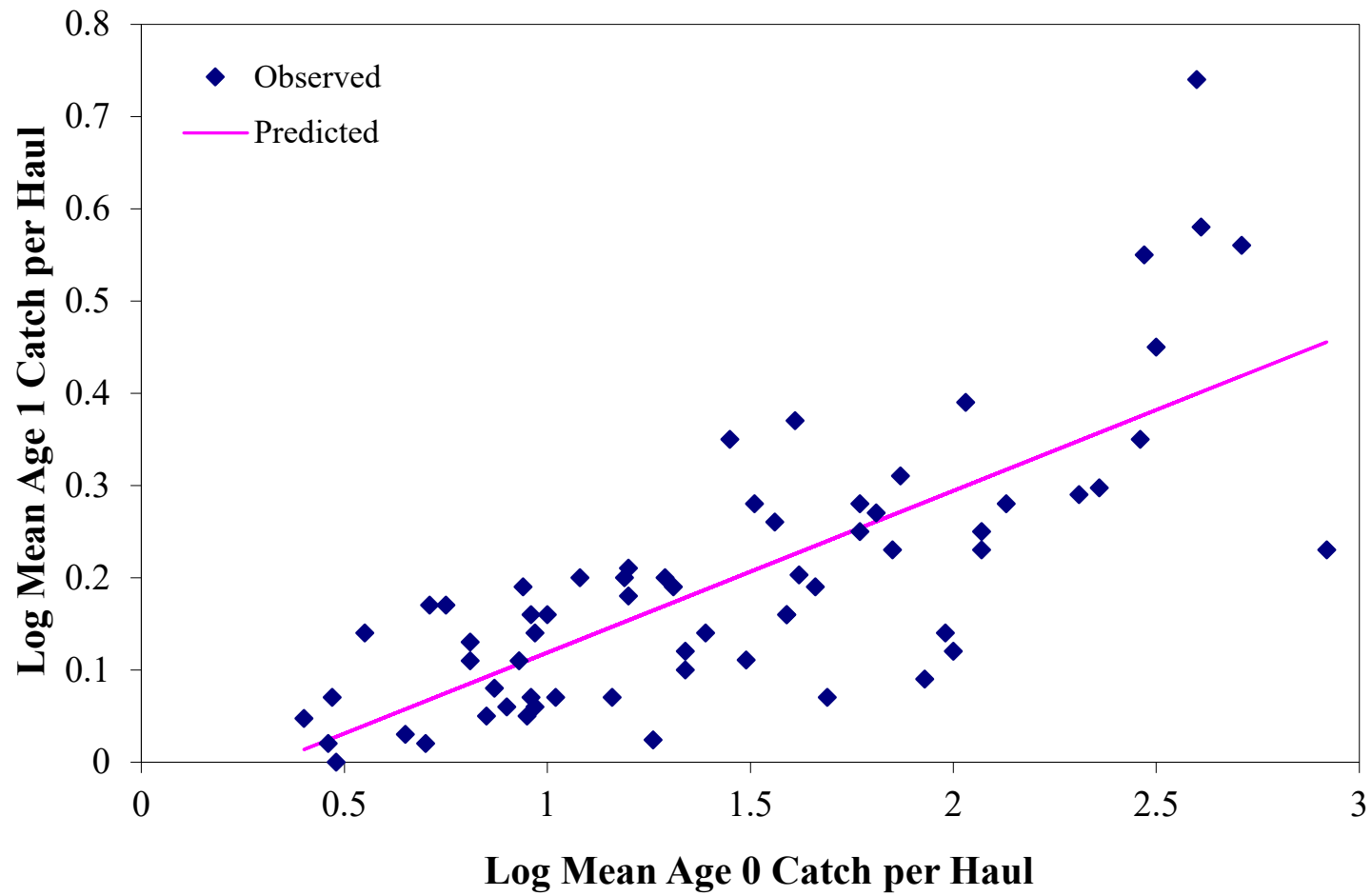
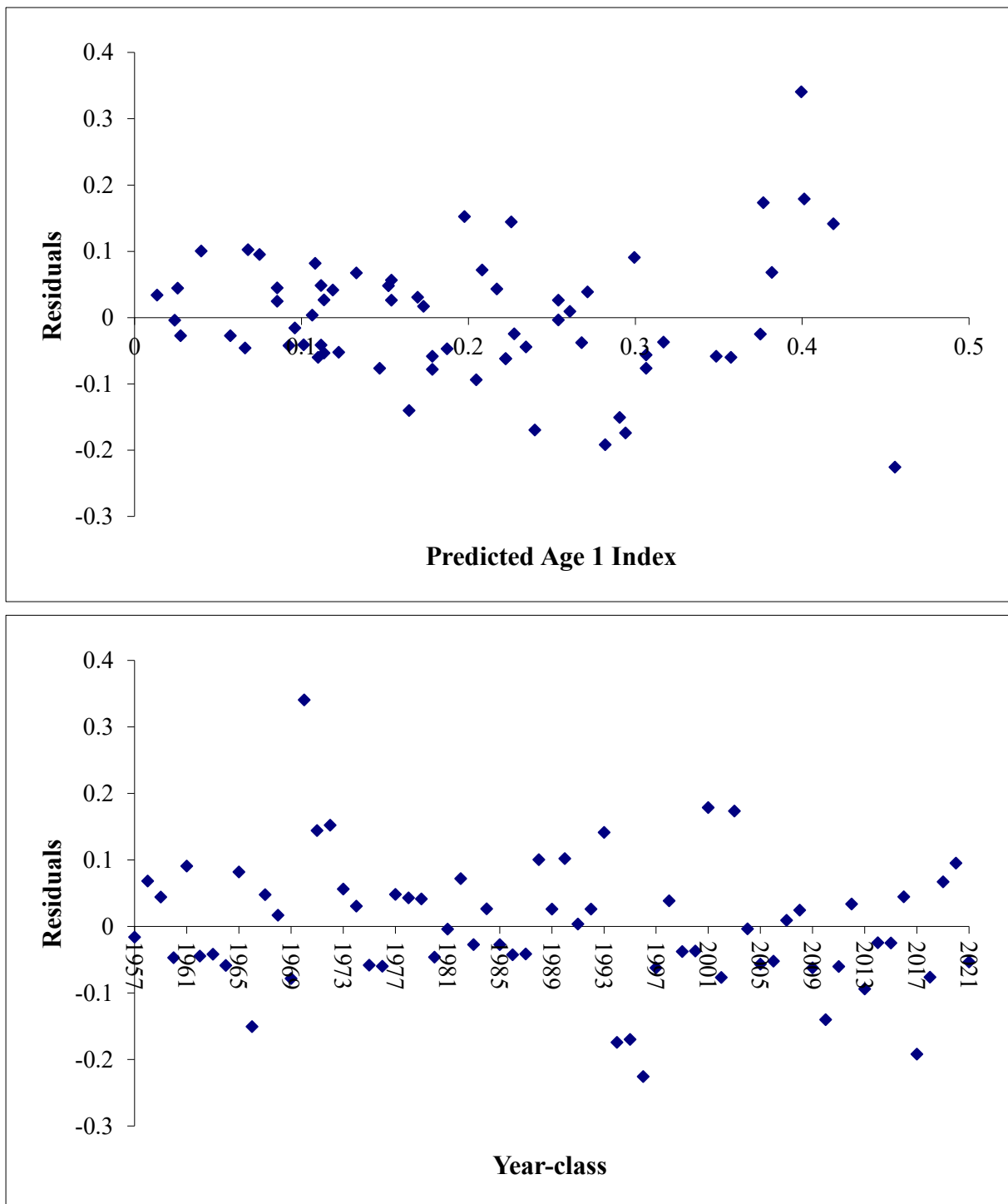


Figure 11. Residuals of age 1 and age 0 striped bass regression.



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 2022 and to provide preliminary results for the 2023 tagging programs. Completed results for the 2023 tagging activities will be reported in the F-61-R-19 Chesapeake Bay Finfish Investigations report. The Maryland Department of Natural Resources (MD DNR) has been a key partner in the offshore cooperative winter tagging study and continues to maintain the long-term data set. 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 and migratory portions of the spawning stock, 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 April and May of 2022, 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 2022, the offshore tagging cruise was conducted using hook and line, onboard a contracted sportfishing vessel departing from 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, North Carolina Division of Marine Fisheries and the National Oceanic and Atmospheric Administration.

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 was the utilized and employed 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 were 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). The tagging models were run to complement and compare to the primary statistical catch-at-age (SCA) model used in the coastwide stock assessment. In recent years, tagging analyses have only been conducted for benchmark stock assessments, and were not used during the more frequent stock assessment updates.

Estimates for Maryland's spawning stock were 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 2022 may be included in a future ASMFC stock assessment, but were not included in the recent stock assessment update.

In 2014, Addendum IV to Amendment 6 of the Atlantic Striped Bass Interstate Fishery Management Plan removed Chesapeake Bay specific reference points and the Bay stock was subsequently managed under the coastal reference points (ASMFC 2014). Therefore, it was no longer necessary to estimate fishing mortality for the Chesapeake Bay on an annual basis using tagging data. Estimates of fishing mortality for the Chesapeake Bay pre-migratory stock were developed for comparison to the SCA model 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.

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 fish 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, the mean length of fish tagged in the offshore study was compared to that of fish tagged in the previous year. 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 activities

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 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 (Table 1). Similar to 2021, low numbers of fish were sampled and tagged.

On some 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 2022 (576 mm TL) was significantly greater (t -value = -7.63, $P < 0.0001$) than that of the sampled population (482 mm TL) (Figure 2). This was also evident in the significant difference of the two length frequencies ($D = 0.285$, $P < 0.0001$).

Estimates of survival and mortality for the 2022 Chesapeake Bay spawning stock, as well as the resident stock, will likely be presented in a future report of the ASMFC Striped Bass Tagging Subcommittee, following the next benchmark stock assessment.

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 2022, the start of sampling was delayed due to weather, and the majority of fish were captured in federal waters off the coast of Virginia.

Sampling was conducted during 12 fishing trips, between January 24 and February 10, 2022. Between four and seven lines with custom-made tandem parachute rigs were trolled at 2 to 3 knots, in depths of 60 to 91 feet (18 to 28 m).

In 2022, the study encountered 740 striped bass and 726 (98%) were tagged (Table 2). The mean lengths of all fish sampled (1097 mm TL) and of those tagged (1096 mm TL) were not significantly different (t -value=0.04, P =0.967, Figure 3). The mean total length of striped bass tagged in 2022 (1096 mm TL) was significantly longer than the length of fish tagged from the 2021 hook and line trips (965 mm TL, t -value=-33.23, P <0.0001). Length distributions between the two years were also significantly different (D =0.628, P <0.0001). Estimates of survival and mortality based on fish tagged in the 2022 offshore study will likely be presented after the next benchmark stock assessment.

PROJECT NO. 2
JOB NO. 3
TASK NO. 4

STRIPED BASS TAGGING

2023 PRELIMINARY RESULTS

Spring tagging activities

Sampling occurred between April 3 and May 12, 2023. A total of 1,561 striped bass were sampled and 687 (44%) were tagged as part of this long-term survey. Mean total length of striped bass tagged during spring 2023 (562 mm TL) was significantly greater (t-value = -6.07, $P < 0.0001$) than that of the sampled population (518 mm TL). Estimates of survival and fishing mortality for the 2023 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 2023, hook and line sampling was conducted onboard a contracted sportfishing vessel departing from Ocean City, MD and ending in Virginia Beach, VA. All fish were encountered in waters off Delaware and southern New Jersey. Sampling was conducted during 11 fishing trips, between January 8 and January 31, 2023.

While fishing with hook and line, 407 striped bass were encountered and 400 (98%) were tagged. The mean length of all fish sampled and of those tagged was 836 mm TL. Estimates of survival and fishing mortality based on fish tagged in the 2023 offshore study will be presented in a future report of the ASMFC Striped Bass Tagging Subcommittee.

The final, complete analyses of the 2023 striped bass tagging activities will appear in the F-61-R-19 Chesapeake Bay Finfish Investigations report.

CITATIONS

ASMFC. 2014. Addendum IV to Amendment 6 of the Atlantic Striped Bass Interstate Fishery Management Plan, Atlantic States Marine Fisheries Commission, Arlington, VA. 20 p.

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.

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Table 1. Summary of USFWS internal anchor tags applied to striped bass in Maryland's portion of Chesapeake Bay and Potomac River, April - May 2022.

System	Inclusive Release Dates	Total Fish Sampled	Total Fish Tagged	Approximate Tag Sequences ^a
Potomac River	4/4/22 - 5/12/22	261	140	616387 – 616527
Upper Chesapeake Bay	4/8/22 - 5/14/22	623 ^b	229	612940 – 613000 619751 – 619919
Spring spawning survey totals:		884	369	

^a Not all tags in reported sequences were applied; some were lost, destroyed, or applied out of order.

^b Total sampled includes one American Littoral Society recapture.

Table 2. Summary of USFWS internal anchor tags applied to striped bass during the 2022 cooperative offshore tagging trips.

System	Gear	Inclusive Release Dates	Total Fish Sampled	Total Fish Tagged	Approximate Tag Sequences
Nearshore Atlantic Ocean (Near MD, VA coasts)	Hook & Line	1/24/22 – 2/10/22	740 ^a	726	618001 – 618726

^a Total sampled includes two USFWS recaptures and one Delaware Natural Resources and Environmental Control recapture.

Figure 1. Tagging locations in spawning areas of the Upper Chesapeake Bay and the Potomac River, April - May 2022.

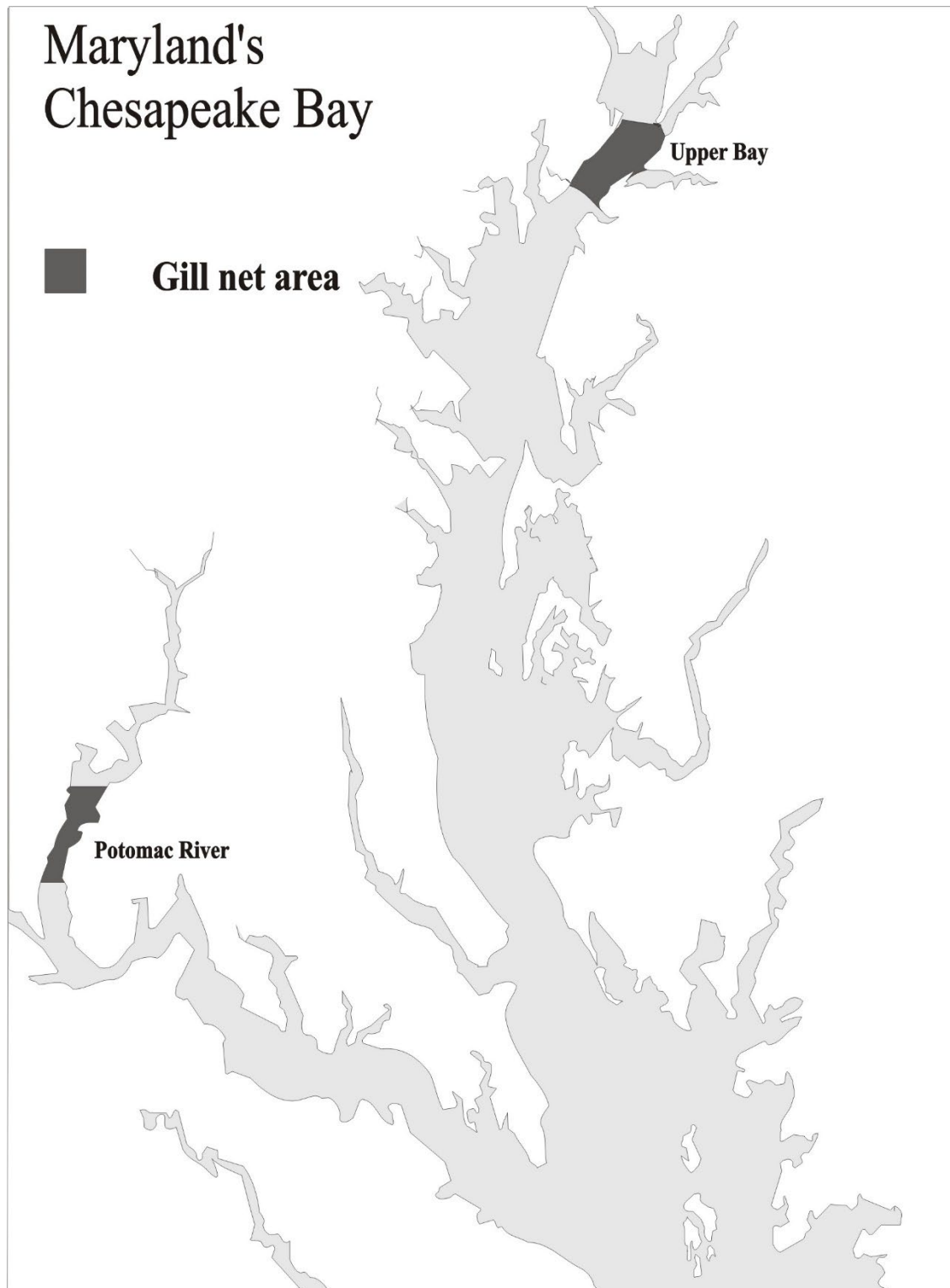


Figure 2. Length frequencies of striped bass measured and tagged during the spring in Chesapeake Bay, April - May 2022.

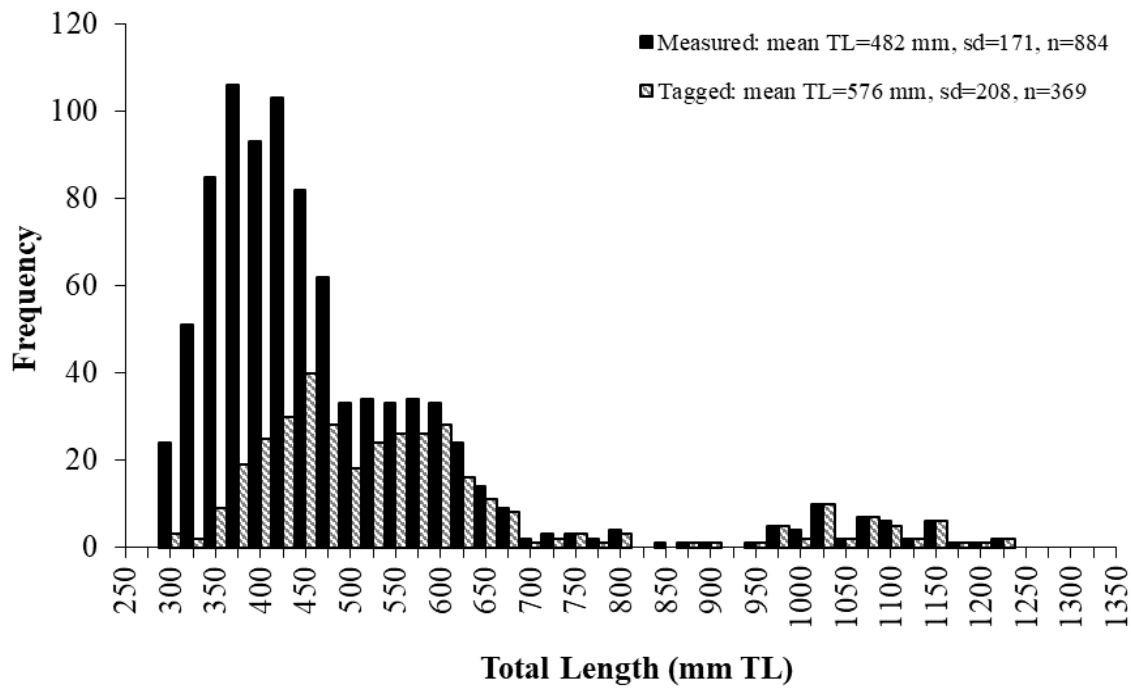
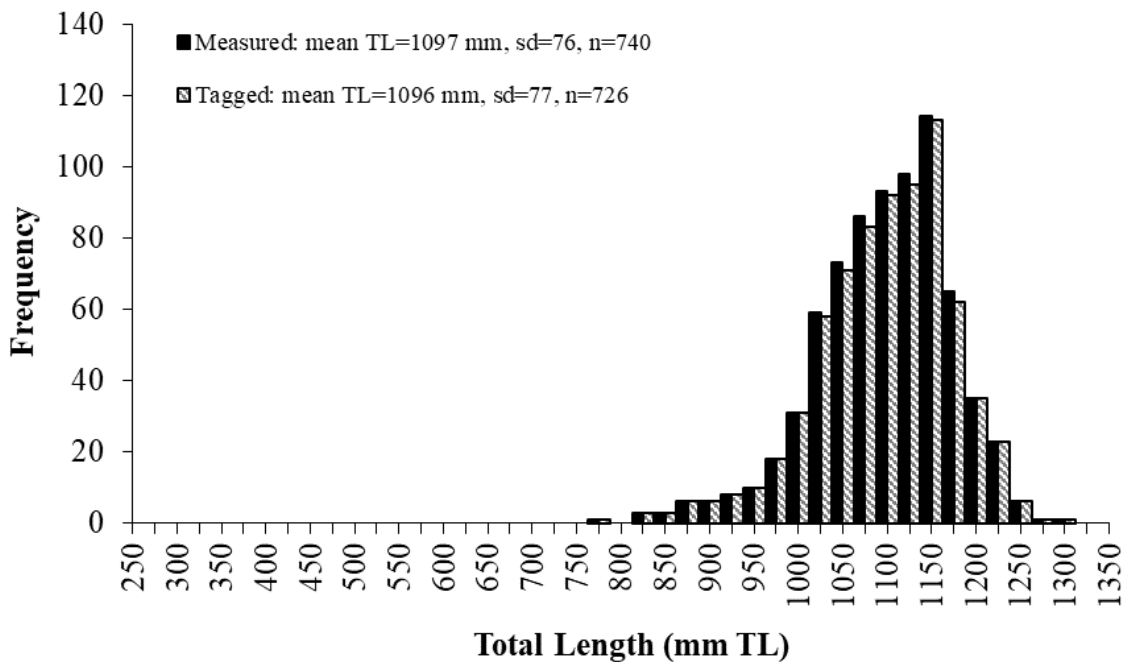


Figure 3. Length frequencies of striped bass measured and tagged during the cooperative offshore tagging trips, January – February 2022.



PROJECT NO. 2

JOB NO. 3

TASK NO. 5A

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 2021; describe the harvest monitoring conducted by the Maryland Department of Natural Resources (MD DNR); and present preliminary information regarding Maryland's 2022 commercial fishery monitoring. A final accounting of the 2022 commercial fishery and monitoring activities will be presented in the F-61-R-19 Chesapeake Bay Finfish Investigations report.

Maryland completed its thirty-second year of commercial fishing under the quota system since the striped bass fishing moratorium was lifted in 1990. The 2021 commercial quota for Maryland's Chesapeake Bay and tributaries was 1,445,394 pounds, identical to the original 2020 quota. 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 2021 commercial fishery operated on a combination of a Common Pool and the ITQ system, with 98% 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 31,186 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 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, Monday – Sunday. The Common Pool fishery was open by public notice as follows: 2 days each month, January – February, and June – August. 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.

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 from the MFRs.

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 the MFRs (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

COVID-19 shutdowns have led to lingering problems with staffing, harvest reporting and data reconciliation. Landings figures reported here are the best available at the time of this writing, but are subject to change.

On the Chesapeake Bay and its tributaries, 1,351,452 pounds of striped bass were harvested in 2021. This was 93,942 pounds, or 6%, under the 1,445,394 pound quota. The reported number of fish landed was 327,421 (Table 2). The pound net fishery landed 48% of the total landings by weight, followed by the drift gill net fishery at 43% and the hook-and-line fishery with 9% of the total Bay landings. No striped bass were reported harvested with haul seines.

Maryland's Atlantic coast landings were reported at 3,575 striped bass, weighing 88,652 pounds (Table 2). This was 0.5% below the quota of 89,094 pounds. The gill net fishery was responsible for 100% of the Atlantic harvest. Approximately 91% 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 4.13 pounds when calculated from the check station activity reports and 5.17 pounds when measured by biologists (Table 3). Mean weights by specific gear type or season ranged from 3.59 to 5.11 pounds from check station activity reports, and 3.67 to 6.08 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.

Check station sampling on the Atlantic coast resulted in an average weight of 23.25 pounds for striped bass harvested in the ocean. The average weight of Atlantic coast 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 were historically responsible for most of the

Bay striped bass harvest. Since 2018, however, pound nets have overtaken gill nets as the predominant harvest gear. The hook-and-line fishery generally harvests the least of the three major Chesapeake Bay gears, and has trended downward since 2009. The 2021 hook-and-line fishery harvest increased for the first time since 2017 after experiencing very low harvest in 2020 (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). In 2021, drift gill nets accounted for 100% of the Atlantic harvest for the second consecutive year (Table 4, Figure 5).

Commercial CPUE Trends

In Chesapeake Bay, drift gill net CPUE (801) increased sharply to the highest value of the time series due to a decline in reported trips relative to the previous year. Hook-and-line CPUE (203) also increased while pound net CPUE (509) remained unchanged from 2020 (Table 5, Figure 6). CPUE for all Chesapeake Bay gear-types was above their respective 5-year averages in 2021 (Table 5).

On the Atlantic coast, drift gill net CPUE (1,094) continued to trend upward as it has since 2016. The CPUE for trawlers remained at zero because no harvest was reported for the second consecutive year. Large catches in April and May led to the high Atlantic gill net CPUE for the fifth consecutive year (Figures 3 and 6).

PROJECT NO. 2

JOB NO. 3

TASK NO. 5A

COMMERCIAL FISHERY HARVEST MONITORING

2022 PRELIMINARY REPORT - WORK IN PROGRESS

Maryland's 2022 commercial striped bass quota for Chesapeake Bay was 1,445,394 pounds. A portion of that total (28,333 pounds) was designated for Common Pool participants and the rest was available to the ITQ fishery.

The 2022 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 2022 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 5 days in January and 2 days in February. Chesapeake Bay fisheries were subject to an 18-36 inch (TL) slot limit.

Maryland's 2022 Atlantic coast quota was 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-19 Chesapeake Bay Finfish Investigations report.

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- Table 2. Summary of striped bass commercial harvest statistics by gear type for the 2021 calendar year.
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- Table 4. Pounds of striped bass harvested by commercial gear type, 1990 to 2021.
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- Figure 5. Maryland's Chesapeake Bay and Atlantic Ocean striped bass total harvest (thousands of pounds) per calendar year by commercial gear type, 1990-2021. Note different scales.
- Figure 6. Maryland's Chesapeake Bay and Atlantic Ocean striped bass catch (pounds) per trip (CPUE) by commercial gear type, 1990-2021. Trips were defined as days on which striped bass were landed. Note different scales.

Table 1. Striped bass commercial regulations by gear type for the 2021 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	387	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 31,186 lbs; No ITQ Quota	220	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 31,186 lbs; No ITQ Quota	221	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		1,445,394				
Atlantic Coast	Trawl and Gill Net	89,094	40	No trip limits for ITQ	24 in TL min	Monthly Harvest Report
Total Maryland Quota		1,534,488				

Table 2. Summary of striped bass commercial harvest statistics by gear type for the 2021 calendar year.

Area	Gear Type	Pounds¹	Number of Fish¹	Trips²
Chesapeake Bay³	Haul Seine	0	0	0
	Pound Net	646,388	179,913	1,269
	Hook-and-Line	127,575	34,463	628
	Gill Net	577,489	113,045	721
	Chesapeake Total	1,351,452	327,421	2,618
Atlantic Coast	Trawl	0	0	0
	Gill Net	88,652	3,575	81
	Atlantic Total	88,652	3,575	81
Maryland Totals		1,440,104	330,996	2,699

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 2021 calendar year. Average weights calculated by MD DNR biologists include 95% confidence intervals.

Area	Gear Type	Average Weight from Check Station Logs (pounds) ¹	Average Weight from Biological Sampling (pounds) ²	Sample Size from Biological Sampling ²
Chesapeake Bay³	Haul Seine	N/A	N/A	N/A
	Pound Net	3.59	3.67 (3.62-3.73)	1,765
	Hook-and-Line	3.70		
	Gill Net	5.11	6.08 (6.02-6.15)	2,904
	Chesapeake Total Harvest	4.13	5.17 (5.11-5.23)	4,669
Atlantic Coast	Trawl		23.25 (22.58-23.93)	104
	Gill Net	24.80		
	Atlantic Total Harvest	24.80	23.25 (22.58-23.93)	104

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 2021.

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
2021	127,575	646,388	577,489	88,652	0

Table 5. Striped bass average catch per trip (CPUE) in pounds by commercial gear type, 1990 to 2021.

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
2021	203	509	801	1,094	0
Average	157	305	324	285	559
5 year avg	173	505	529	745	53

Figure 1. Map of the 2021 Maryland Chesapeake Bay authorized commercial striped bass check stations.

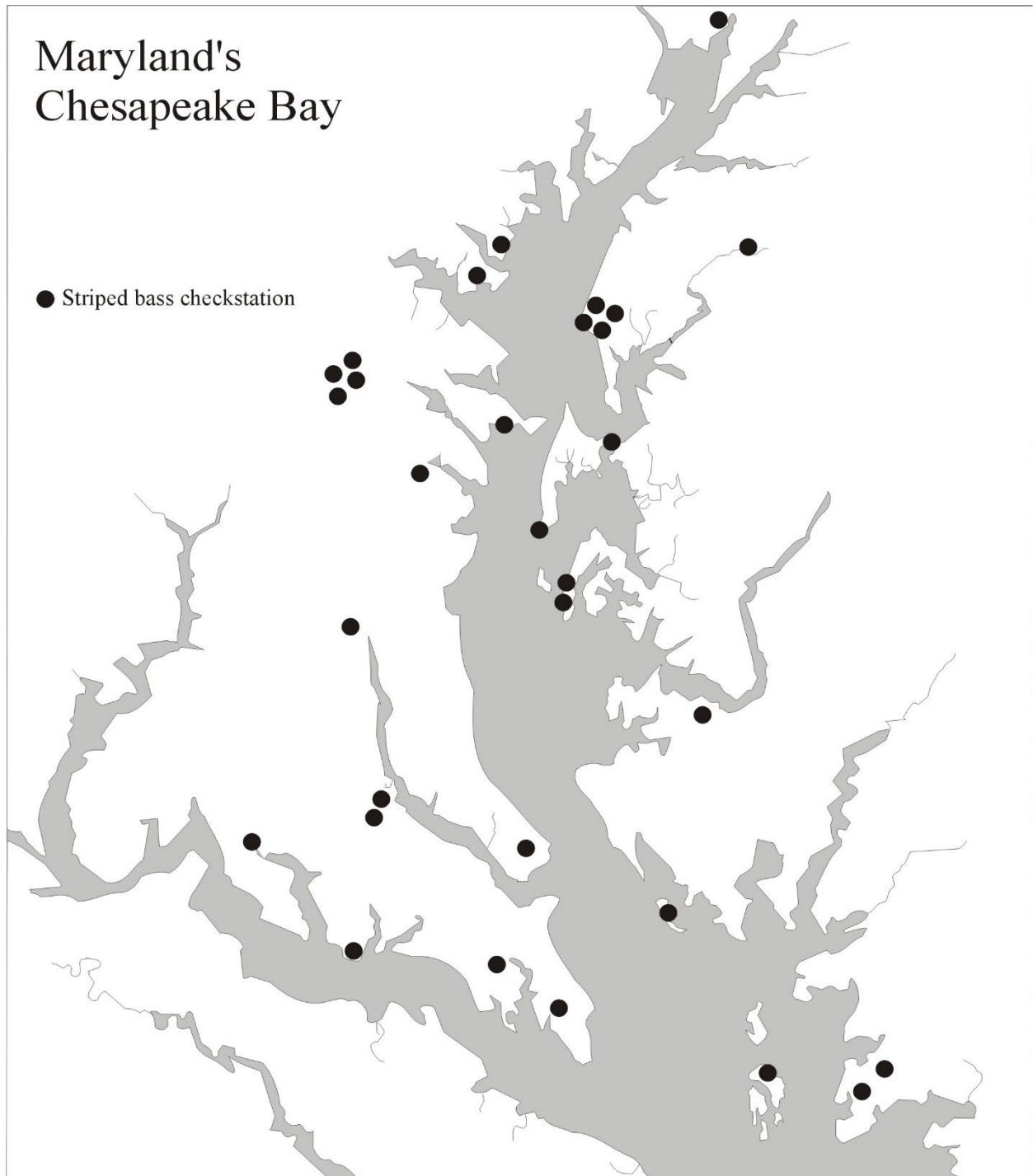


Figure 2. Maryland's Chesapeake Bay summer/fall (pound net and hook-and-line) and winter (gill net) fisheries cumulative striped bass landings from check station reports for calendar year 2021. Note different scales.

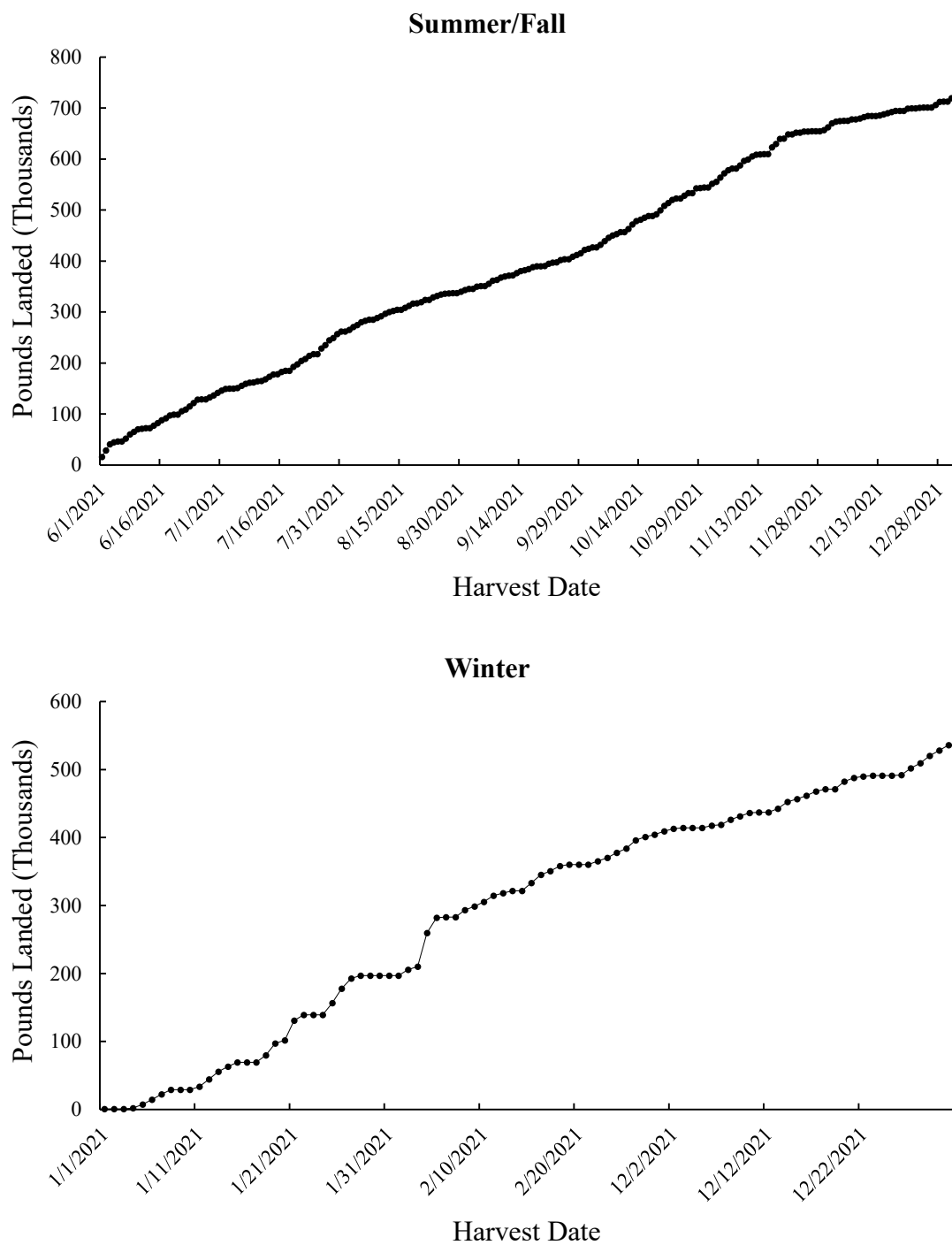


Figure 3. Maryland's Atlantic trawl and gill net fisheries (combined) cumulative striped bass landings from check station reports, January-May and October-December 2021.

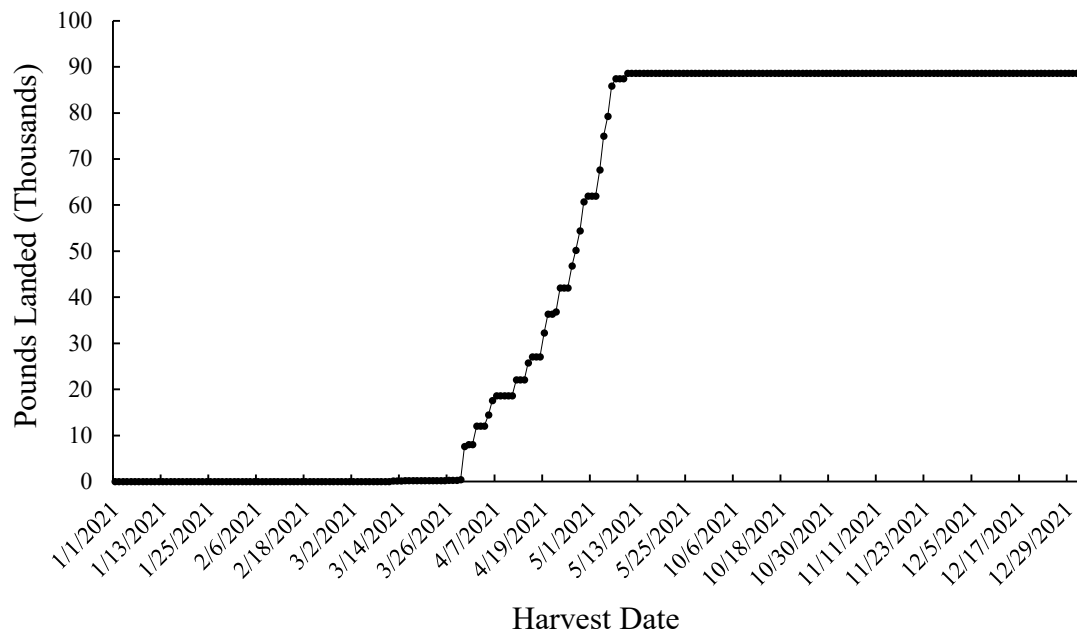


Figure 4. Maryland's Chesapeake Bay and Atlantic Ocean quotas (pounds) and harvests (pounds) for all gears, 1990-2021. Note different scales.

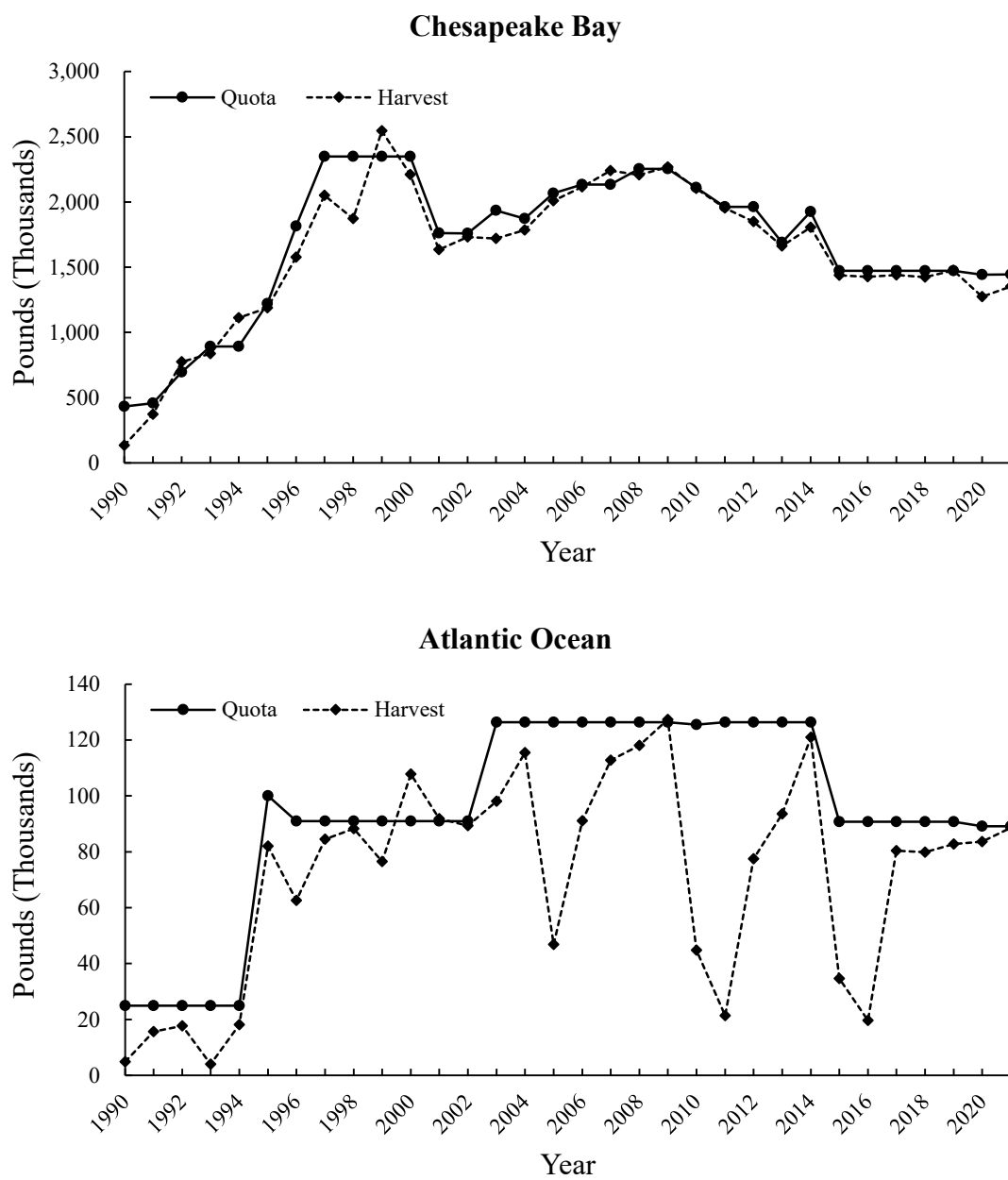


Figure 5. Maryland's Chesapeake Bay and Atlantic Ocean striped bass total harvest (thousands of pounds) per calendar year by commercial gear type, 1990-2021. Note different scales.

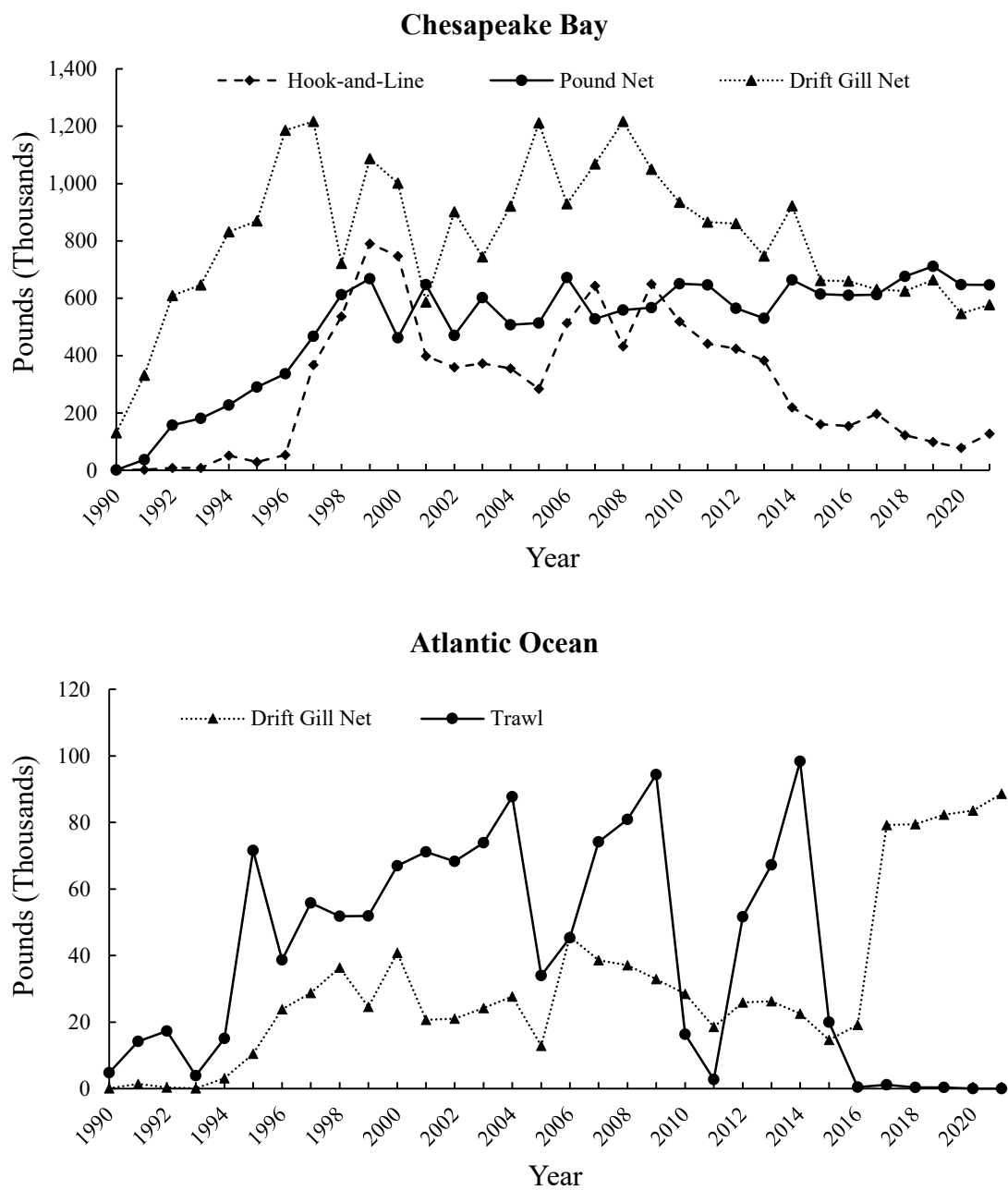
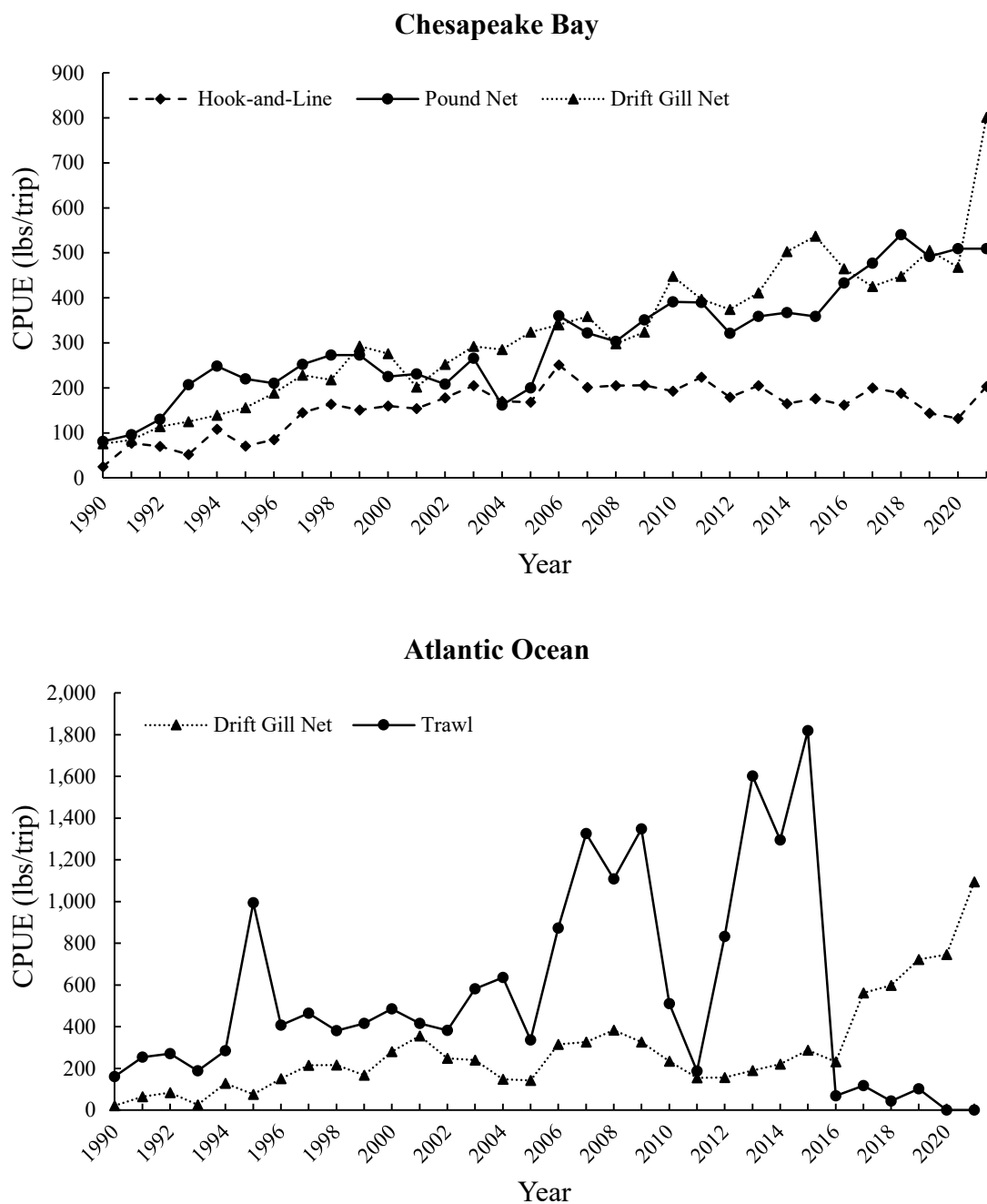


Figure 6. Maryland's Chesapeake Bay and Atlantic Ocean striped bass catch (pounds) per trip (CPUE) by commercial gear type, 1990-2021. Trips were defined as days on which striped bass were landed. Note different scales.



333PROJECT 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 2022 spring recreational season, which began on Sunday, 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 2023 spring recreational season are reported and complete results for the 2023 spring recreational season will be reported in the F61-R-19 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 2018 benchmark stock assessment indicating the stock is overfished with overfishing occurring, the ASMFC Management Board approved Addendum VI to Amendment 6 in October 2019. To further address rebuilding the stock and other issues, the ASMFC Management Board passed Amendment 7 in 2022 which replaces Amendment 6 but leaves in place measures from Addendum VI. The Addendum implements measures to reduce total striped bass removals by 18% relative to 2017 levels to achieve the fishing mortality target and remained in place in 2022. The 2022 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 2022 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 2022: 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. Geographic coverage was spread out as much as possible between the middle and lower Bay. 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 2022, there was not sufficient MRIP coverage 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 4B.

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 Standard Atlantic Fisheries Information System (SAFIS), coordinated by the Atlantic Coastal Cooperative Statistics Program (ACCSP) and the Fishing Activity and Catch Tracking Systems (FACTS) . 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 2022, there was not sufficient MRIP coverage 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 2022, a total of 28 fish were examined from 14 charter trips intercepted with nonzero striped bass harvest (Table 5B).

In 2022, there were a total of 308 recorded logbook trips during the spring trophy season, with 0% excluded as multiple trips resulting in the analysis of 308 single trips. The total number of qualifying striped bass logbook trips has declined 41% compared with the long-term mean (Table 10B).

BIOLOGICAL DATA

Length and Weight

Length distribution

In the 2022 spring striped bass season, fish lengths measured from the harvest ranged from 883 mm TL to 1197 mm TL with a mean of 1059 mm TL ($n = 28$ 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 (Figure 2). In 2022, the mean length estimate was the largest in the timeseries.

Mean length

The mean length of females (1075 mm TL) was greater than the mean length of males (925 mm TL), which is typical of the biology of the species (Bigelow and Schroeder 1953). Only three male striped bass were encountered in 2022 and ranged from 883 to 1005 mm TL. Female striped bass length in 2022 was 13% 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 2022 was significantly larger than the previous three years (2019-2021), but not significantly different than 2018.

The mean daily lengths of female striped bass harvested in 2022 displayed a declining trend however, due to the shortened two-week season, temporal coverage was limited (Figure 4). Mean daily length data for 2002 and 2011 have shown larger females were caught earlier in the season (Goshorn et al. 1992, Barker et al. 2003).

Mean weight

Fish weights sampled during the 2022 spring striped bass season ranged from 7.0 kg to 19.2 kg. The mean weight in 2022 was 12.4 kg which was the largest in the time series (Table 6B). The mean weight of females was 13.0 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 peaked in 2018 and again in 2022 (Figure 5). Duncan's multiple range test for females ($\alpha = 0.05$) found that the mean weight in 2022 was significantly different than all previous years except 2018 (Table 6B).

Age Structure

The number of scales aged from the creel survey has varied between years. In 2022, 52 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 2022 spring recreational harvest ranged from 8 to 21 years old (Figure 6). Striped bass between eight and twelve years old have typically contributed the most to the spring recreational harvest with each age comprising an average 10% to 20%. However, in 2022 there was a broader contribution of year-classes to the age structure with the 2014 (age 8), 2011 (age 11), and 2008 (age 14) year-classes each contributing around 20% (Figure 6). The next largest contribution was 13% 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 2022 (Table 7A). As in previous years, the 2022 spring season harvest was dominated by female striped bass, comprising 89% 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 – 2022 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). In 2022, 8% (n=2) of

the sampled harvest was in pre-spawn condition. 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 (Figure 8). When spawning condition data from all years of the survey are summarized by day of the year, this trend becomes more apparent (Figure 9). In 2022, the proportion of pre-spawn females was higher than predicted by the average annual mean total length (mm) (Figure 7), although it was based on observing only two pre-spawn females out of the total sample of 25.

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 2022. 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 2022, there were 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 2022 according to charter boat data was 0.7 fish per trip (Table 9A) which was 82% below the long-term mean charter boat HPT (3.9 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 2022 was 0.13 fish per person (Table 9B) which was an 80% reduction from the long-term mean (0.63 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 insufficient interview data were collected in 2022 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 2022, charter boats caught 4.3 fish per trip, which was 23% below the long-term average (5.6 fish per trip, Table 10B). The charter boat catch per hour (CPH) was 0.9 fish per hour.

Angler Characterization

States of residence

In 2022, limited MRIP angler interview data showed most anglers participating in the spring trophy fishery were residents of Maryland (72%), followed by the surrounding states of Virginia (13%) and Pennsylvania (5%) (Table 11).

PROJECT NO. 2
JOB NO. 3
TASK NO. 5B

CHARACTERIZATION OF THE STRIPED BASS
SPRING RECREATIONAL SEASON
AND SPAWNING STOCK IN MARYLAND

2023 PRELIMINARY RESULTS

Data collected during the 2023 spring recreational season (May 1-May15) are currently being analyzed. In 2023, 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 4 sample days. The final, complete analyses of the spring 2023 recreational survey data will be available in the F-61-R-19 Chesapeake Bay Finfish Investigations report.

During the 2023 spring recreational season, 5 striped bass from 27 intercepted charter boat trips were measured, weighed, and internally examined for spawning condition. Biological samples collected from examined fish for aging studies include 5 scale samples and 5 otoliths. Female striped bass (n=5) were a mean Total Length of 1110 mm and mean weight of 14.50 kg. Internal examination revealed 100% of female striped bass harvested had recently spawned. No male striped bass were encountered during the spring trophy season. Scale samples are currently being processed and aged, therefore no age distribution of the 2023 spring recreational harvest is available at this time.

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Table 1. History of changes made to MD DNR fishing regulations for Maryland striped bass spring trophy seasons, 1991-2022.

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	↓	↓	↓
2020-2022	5/01-5/15	↓	↓	↓

Table 2. Survey sites for the Maryland striped bass spring season dockside creel survey, 2002-2022. 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, 2022.

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	27	37	3	44
2022	46	86	1	87

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
2022	14	--	--	--	--	28

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)
2022	1059 (1027-1090)	1075 (1047-1103)	925 (883-1005)
Mean	939 (916-963)	949 (927-974)	879 (858-901)

*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)
2022	12.4 (11.3-13.7)	13.0 (11.9-14.1)	8.2 (7.0-10.1)
Mean	8.8 (8.1-9.5)	9.1 (8.4-9.8)	7 (6.5-7.5)

*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
2022	25	3	0	28	28	25

Table 7B. Percent females, using three different calculation methods, sampled by the Maryland striped bass spring season creel survey, through May 15. Means are presented with 95% confidence intervals.

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
2022	89	89	89
Mean	84 (81-86)	85 (83-87)	85 (83-88)

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. Means are presented with 95% confidence intervals.

Year	Pre-spawn Females		Post-spawn Females	
	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
2022	2	8	23	92
Mean	--	30 (22-39)	--	70 (62-78)

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)	--	--
2022	308	0.7 (0.6-0.9)	--	--
Mean	520	3.9 (3.2-4.6)		

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)	--	--
2022	308	0.13 (0.11-0.15)	--	--
Mean	520	0.64 (0.53-0.73)		

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	--	--	--	--	--	--
2022	--	--	--	--	--	--
Mean	1.6 (1.2-2.0)	4.7 (4.3-5.1)	0.4 (0.3-0.5)	1.7 (1.3-2.1)	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)
2022	308	4.3 (3.0-5.8)	5.0 (5.0-5.0)	0.9 (0.6-1.2)
Mean	520	5.6 (5.0-6.2)	4.9 (4.5-5.3)	1.2 (1.0-1.4)

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
2022	63	11	4	0	0	0	9

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 (2022).

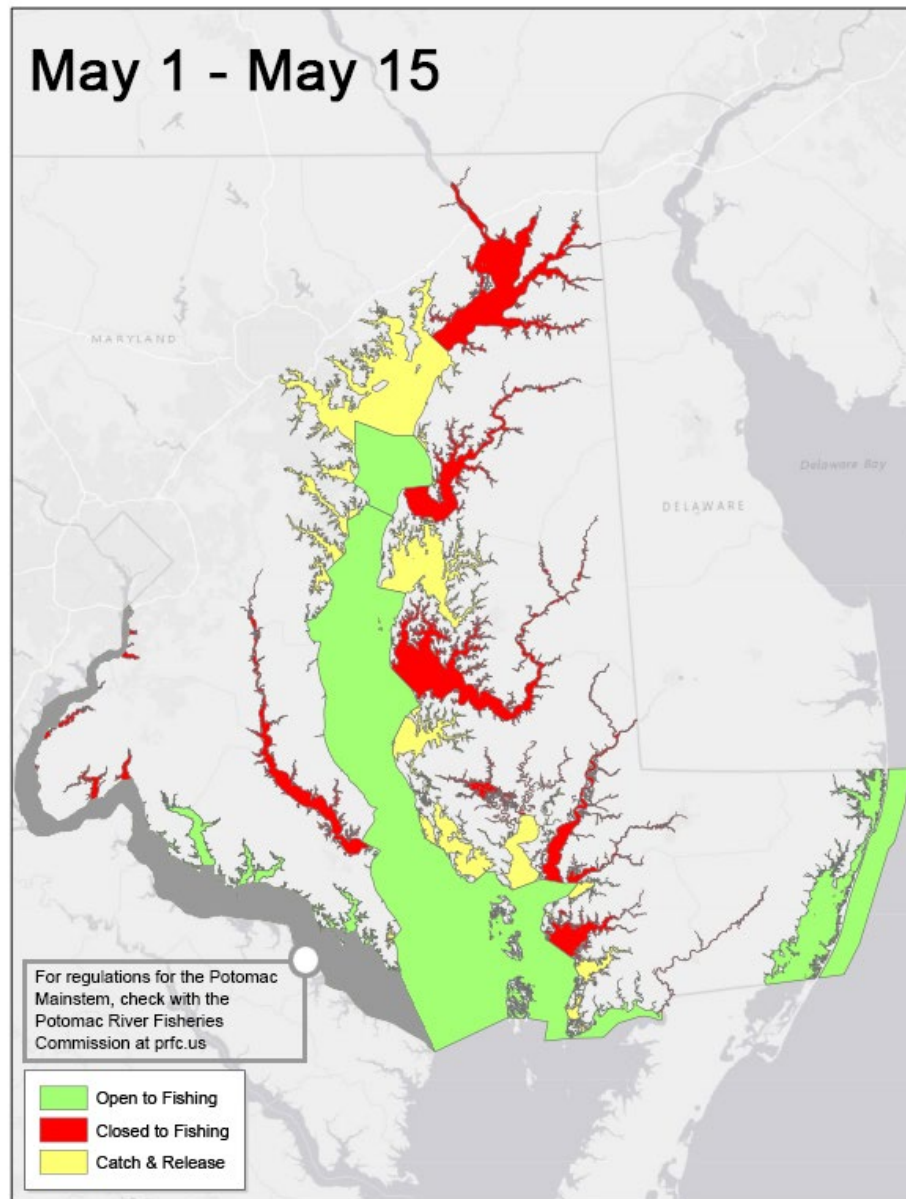


Figure 2. Length distribution of striped bass sampled by year, during the Maryland striped bass spring season creel survey, through May 15.

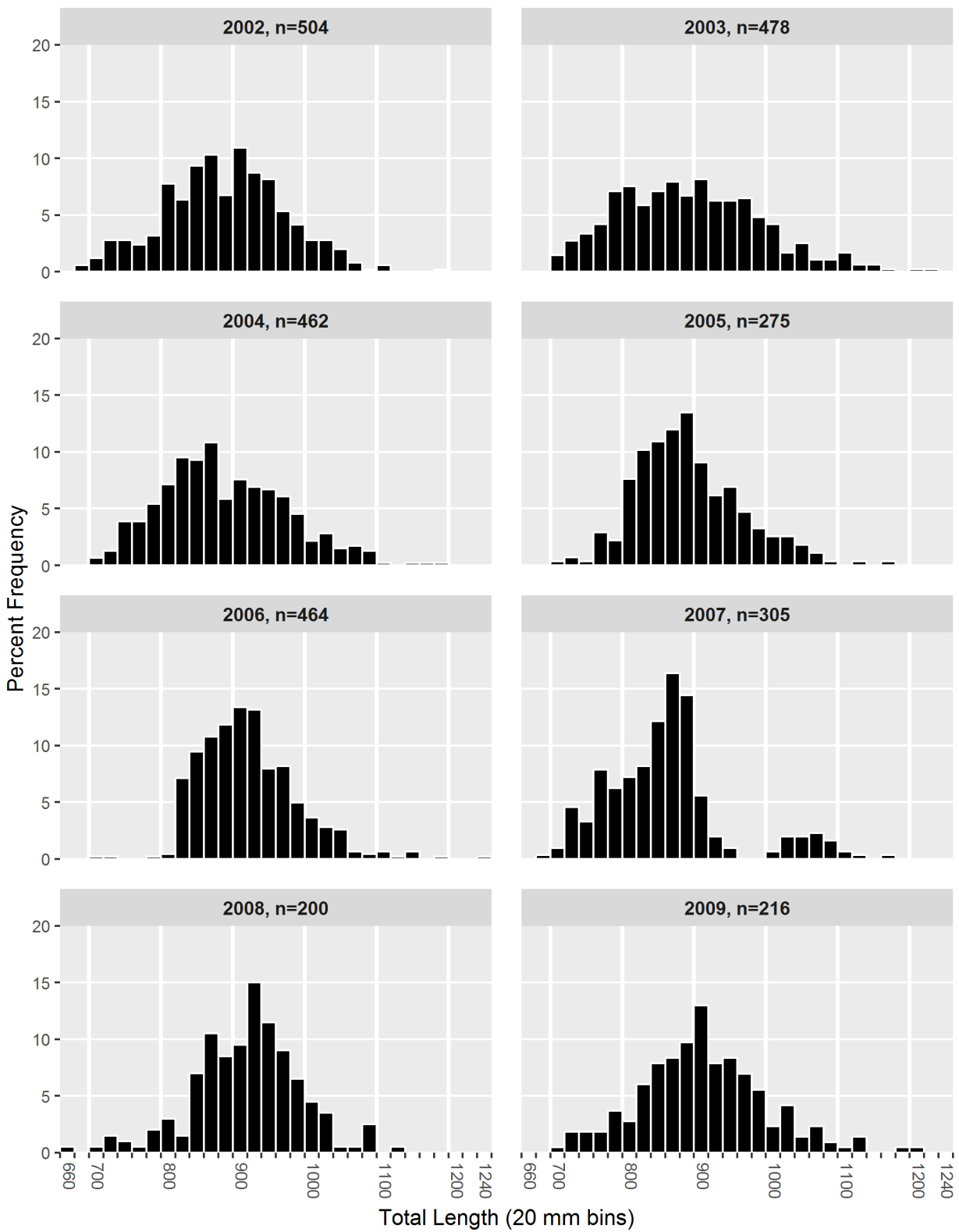


Figure 2. Continued.

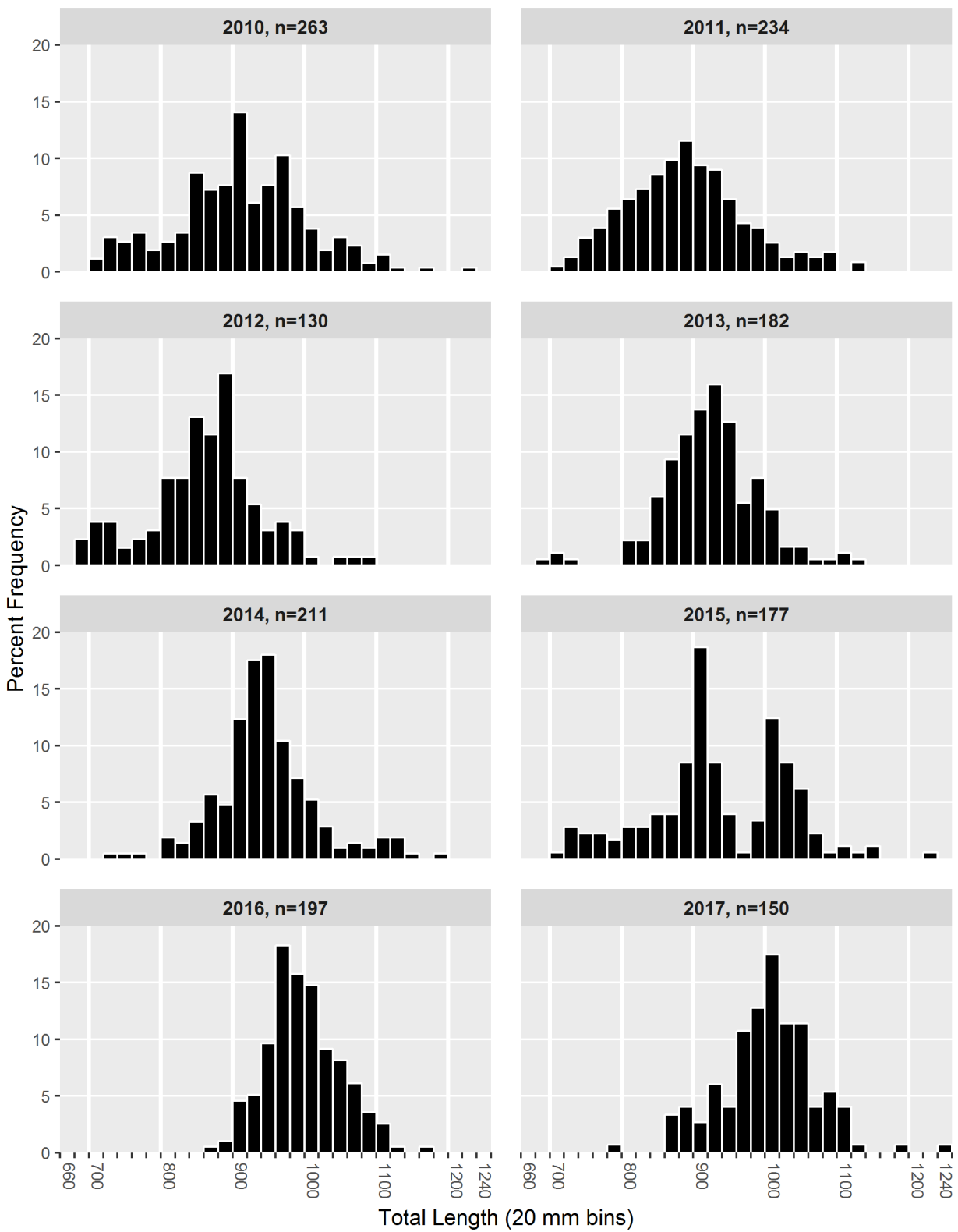


Figure 2. Continued.

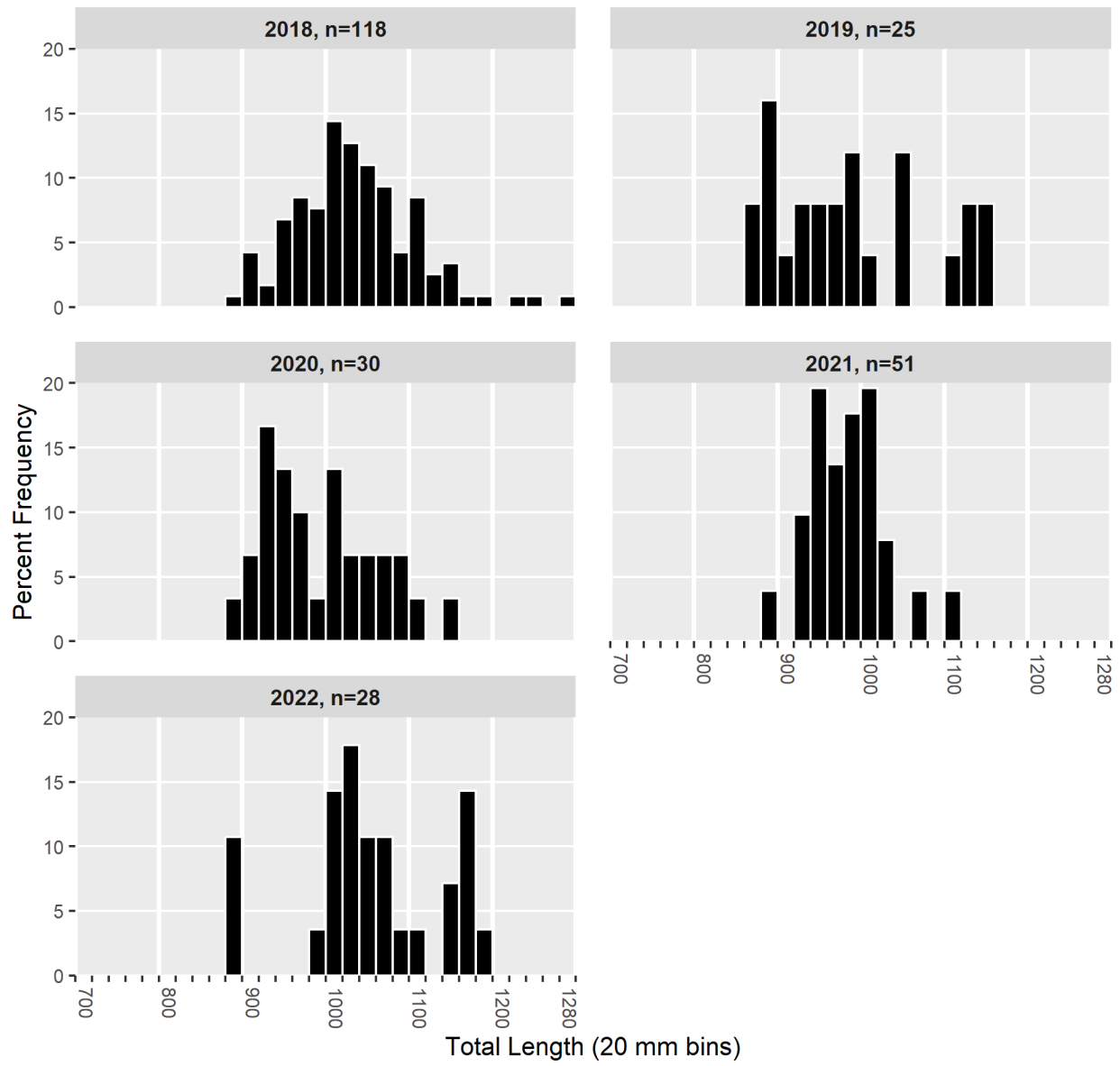


Figure 3. Mean length of female and male striped bass (mm TL) with 95% confidence intervals, sampled by the Maryland striped bass spring season creel survey, through May 15.

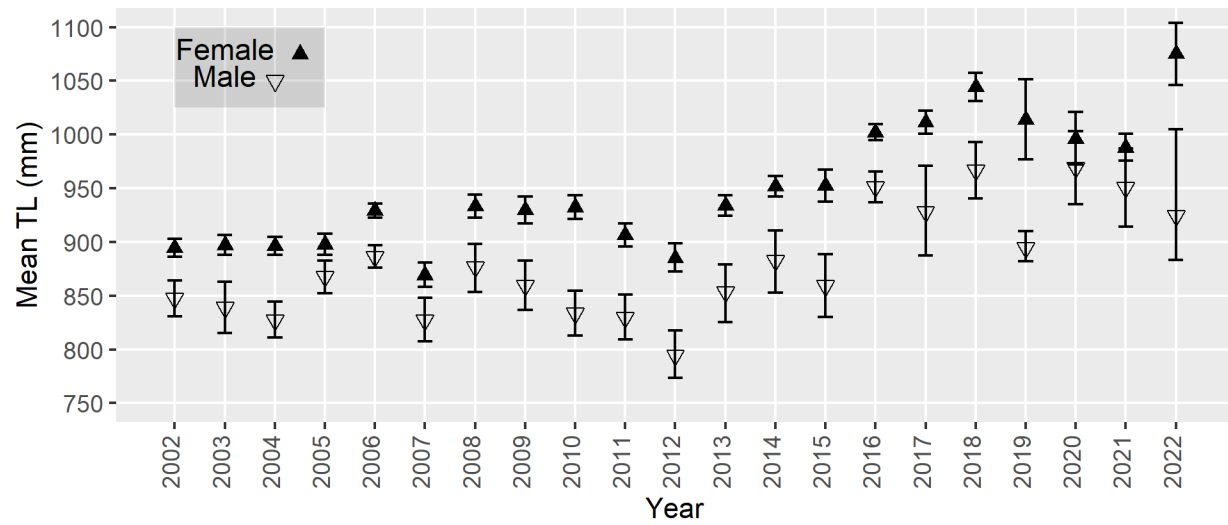


Figure 4. Mean daily length of female striped bass with 95% confidence intervals, sampled by the Maryland striped bass spring season creel survey, through May 15.

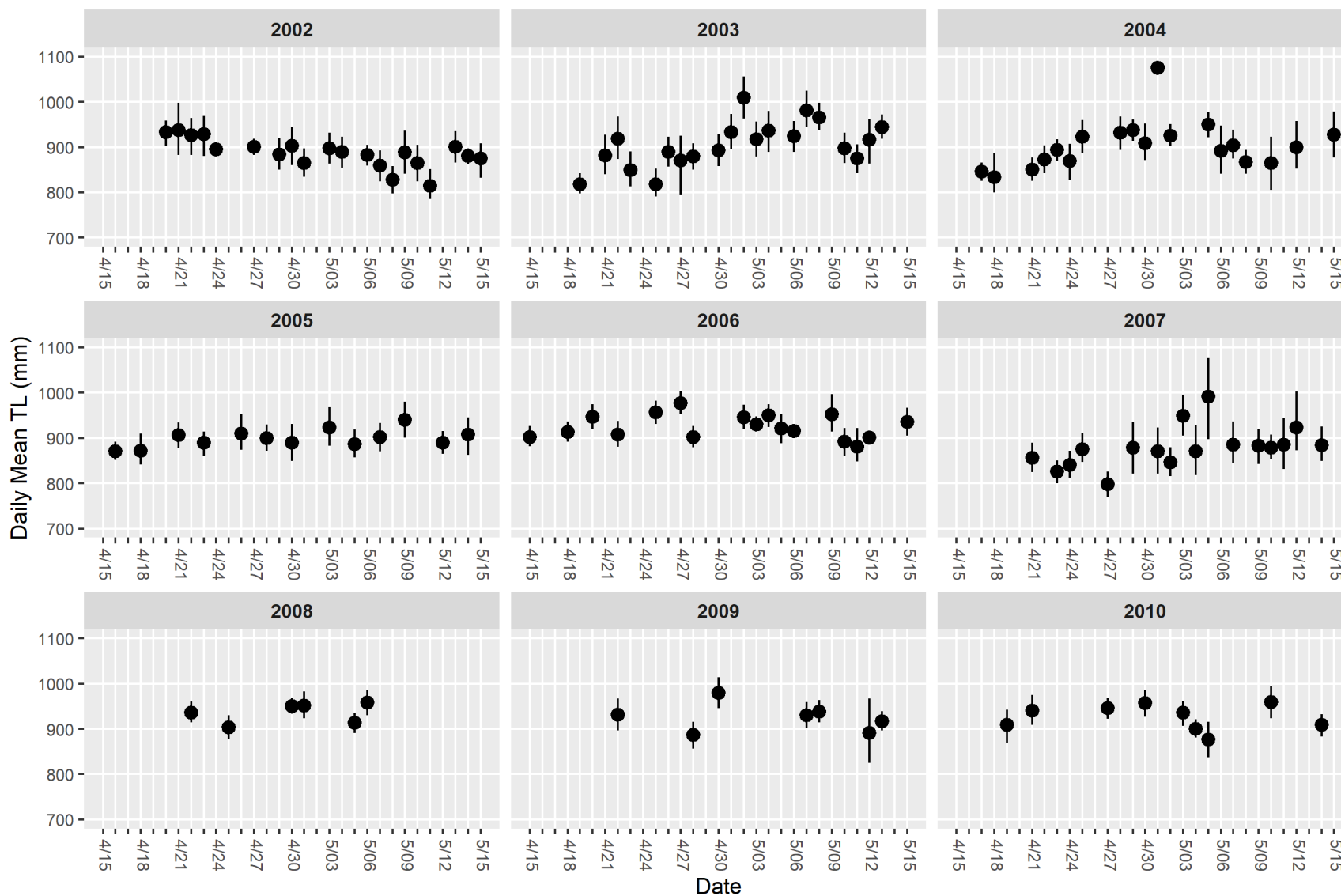


Figure 4. Continued.

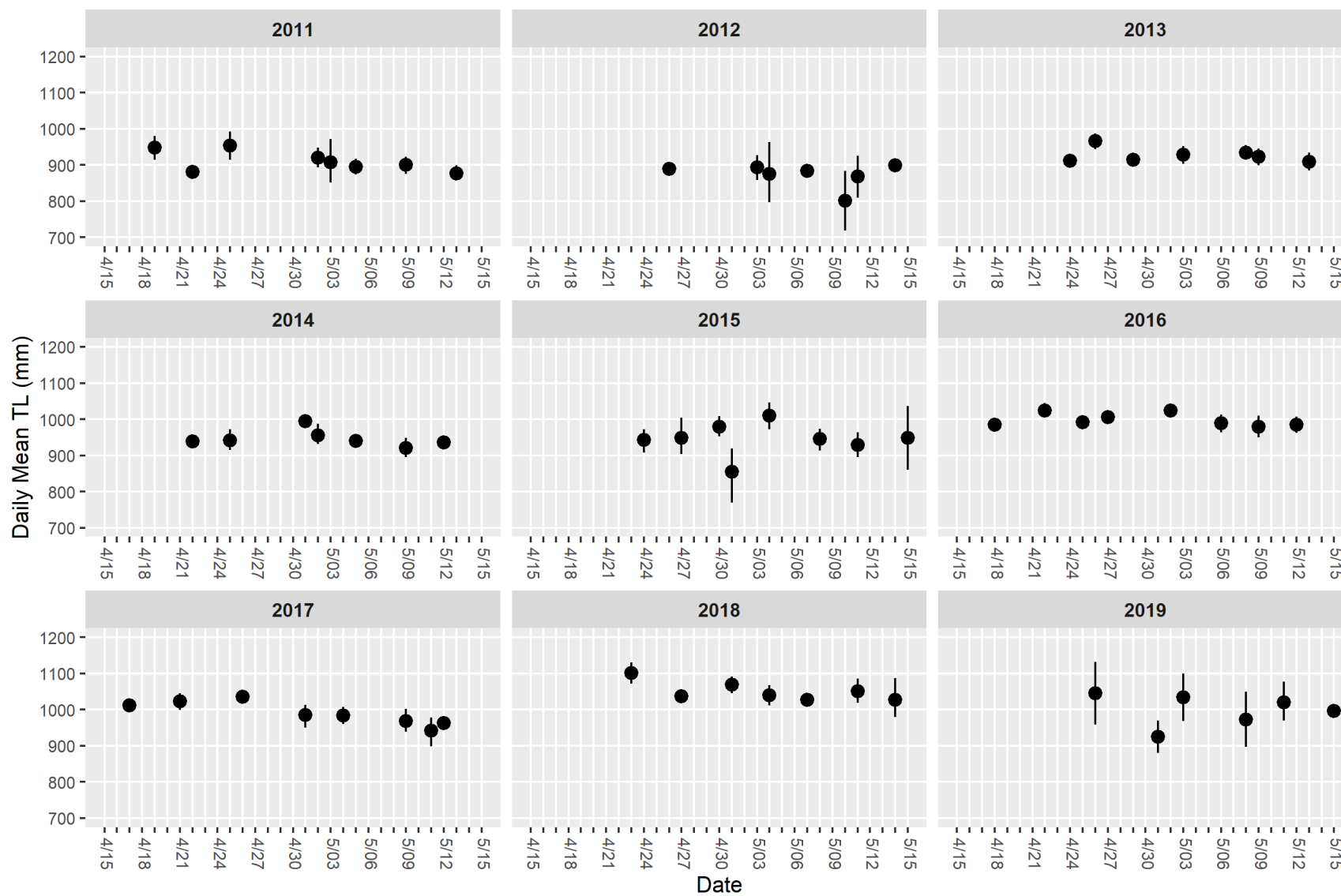


Figure 4. Continued.

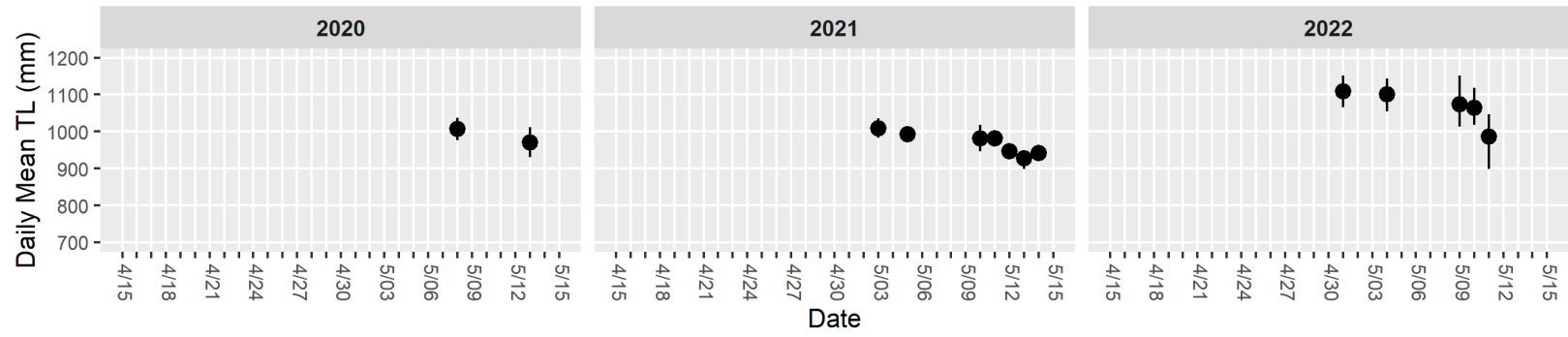


Figure 5. Mean weight of female and male striped bass (kg) with 95% confidence intervals sampled by the Maryland striped bass spring season creel survey, through May 15.

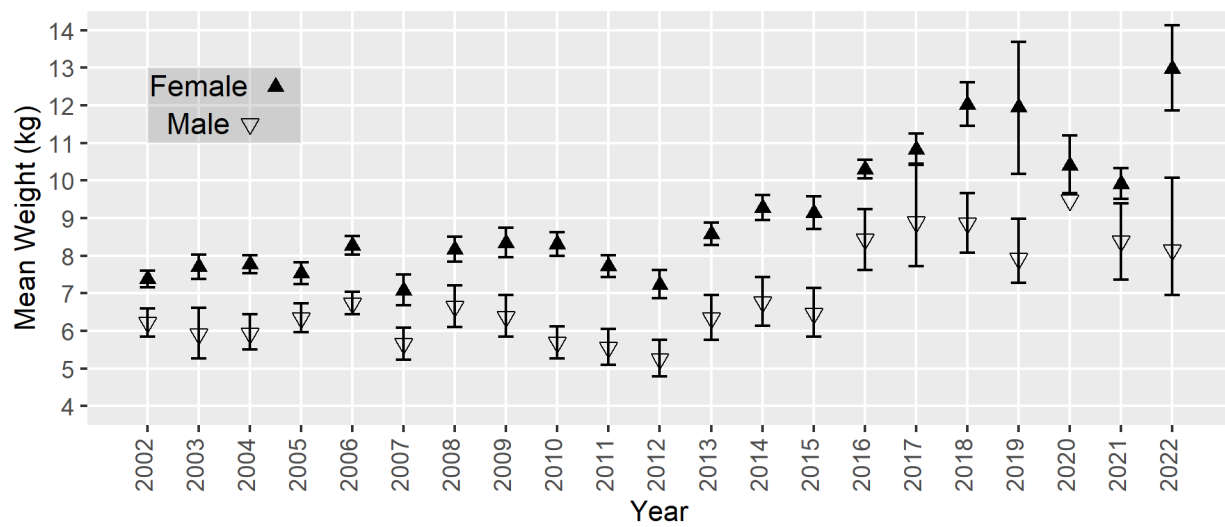


Figure 6. Estimated age distribution of striped bass sampled through May 15th.

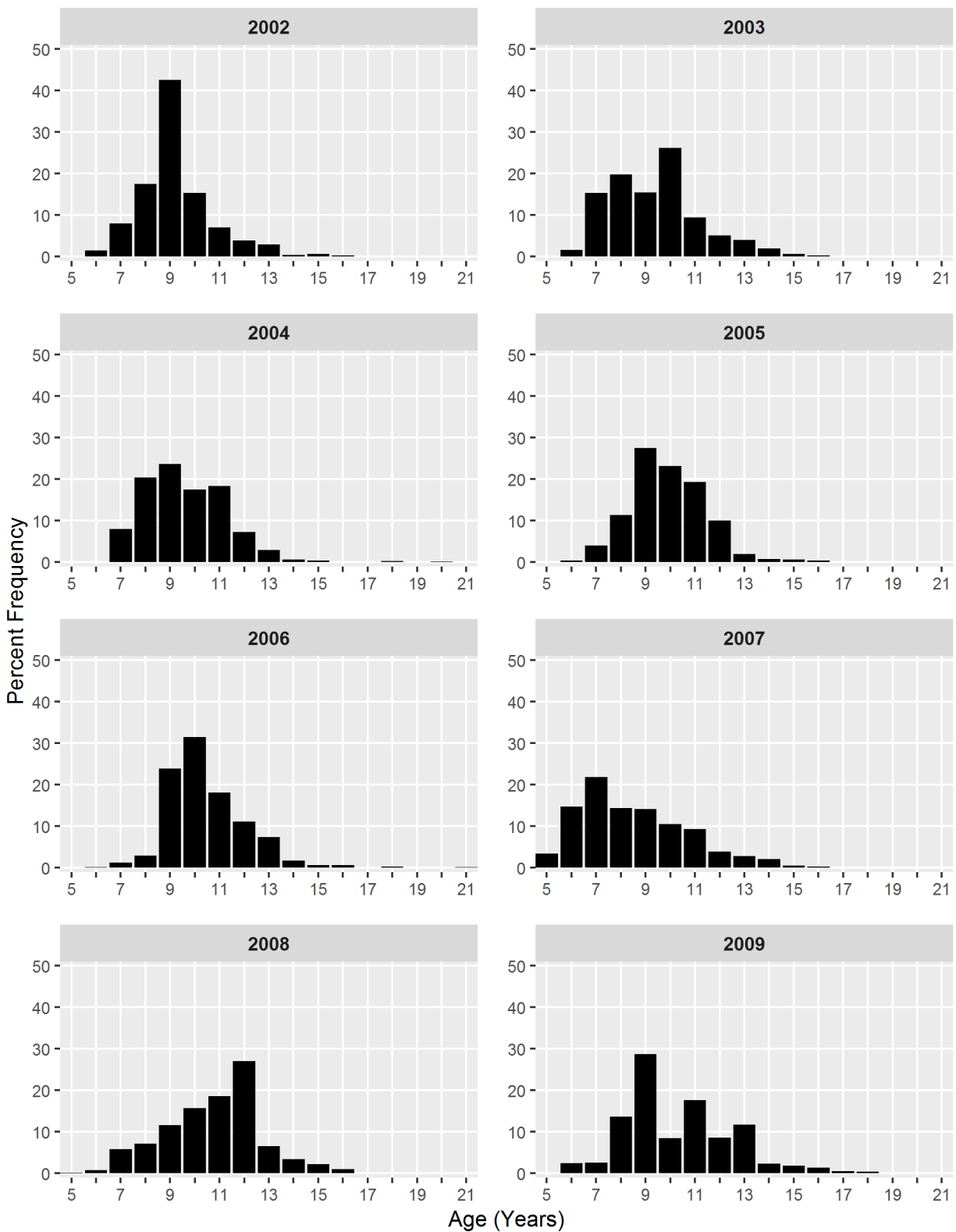


Figure 6. Continued.

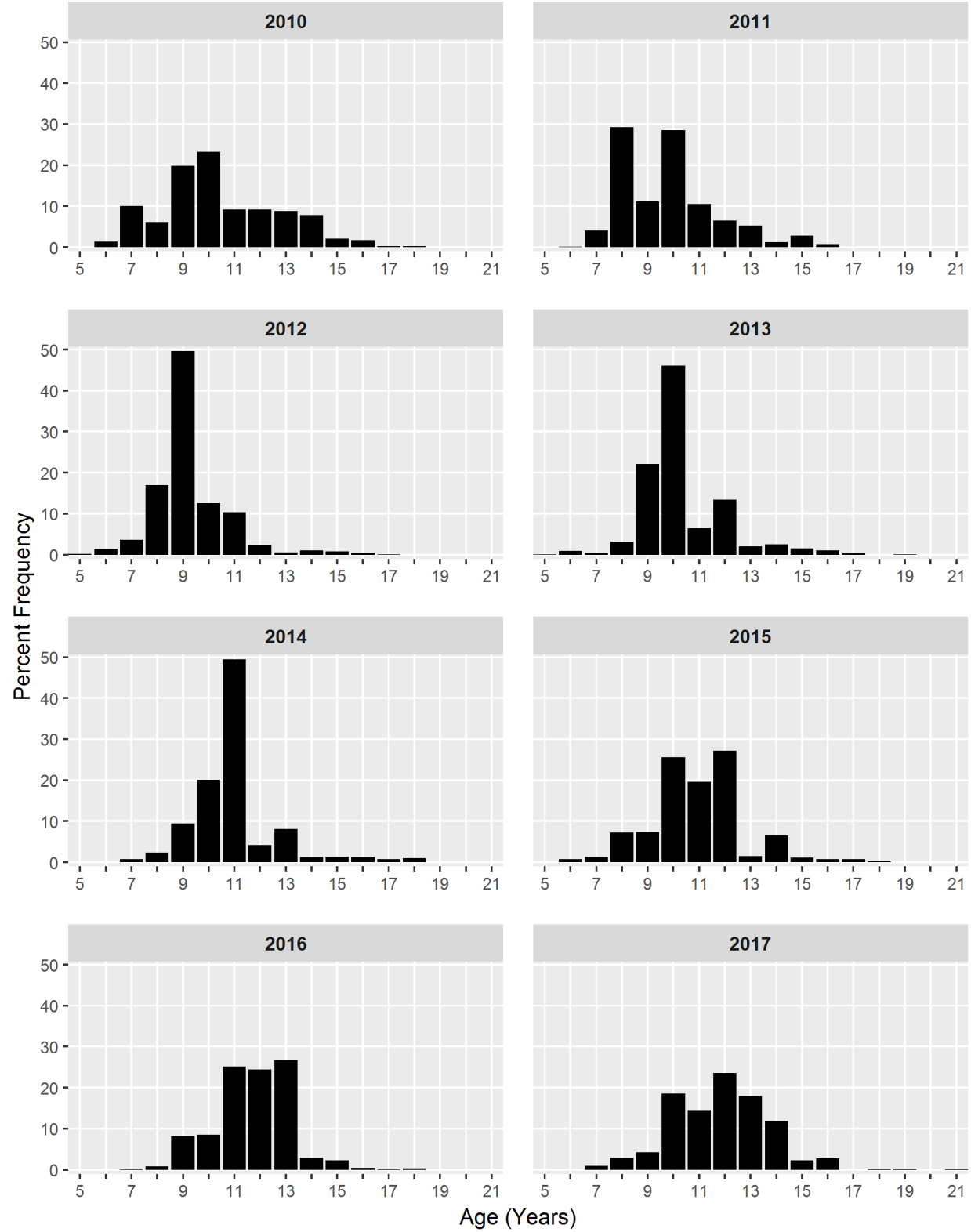


Figure 6. Continued.

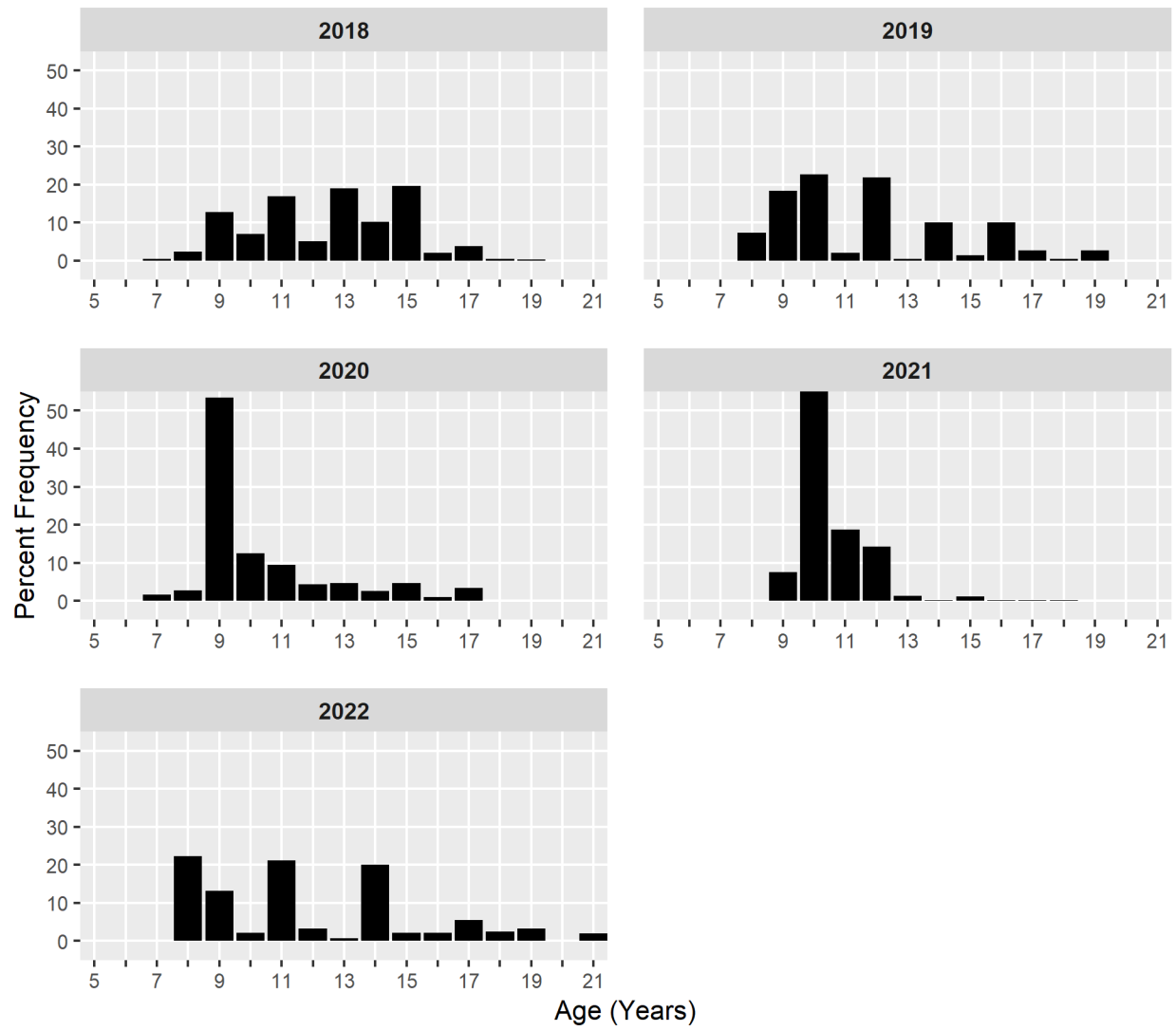


Figure 7. Proportion of pre-spawn females versus the annual mean total length (mm) of female striped bass sampled. Weighted linear regression coefficients are intercept = 363, slope = -0.35 (Adjusted R-squared = 0.76, $p < 0.0001$). Shading indicates 95% confidence intervals. Points are scaled relative to annual sample size. Current year labeled for reference.

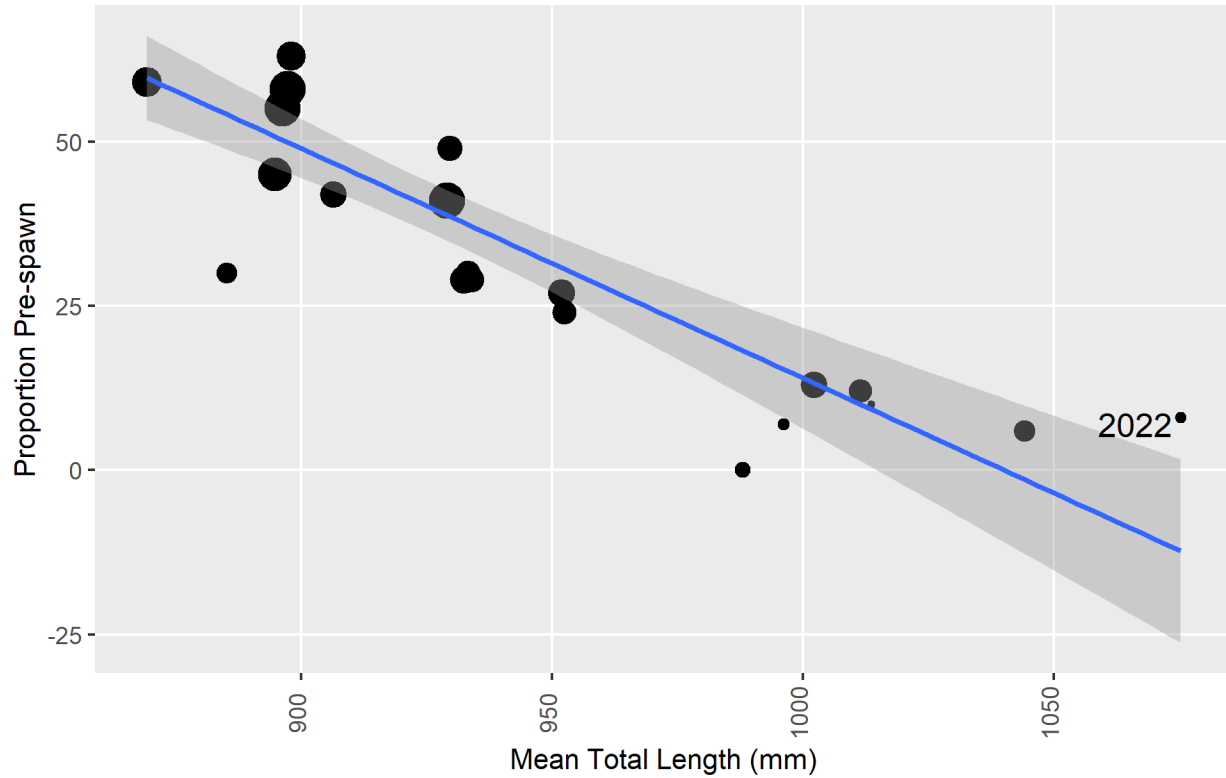
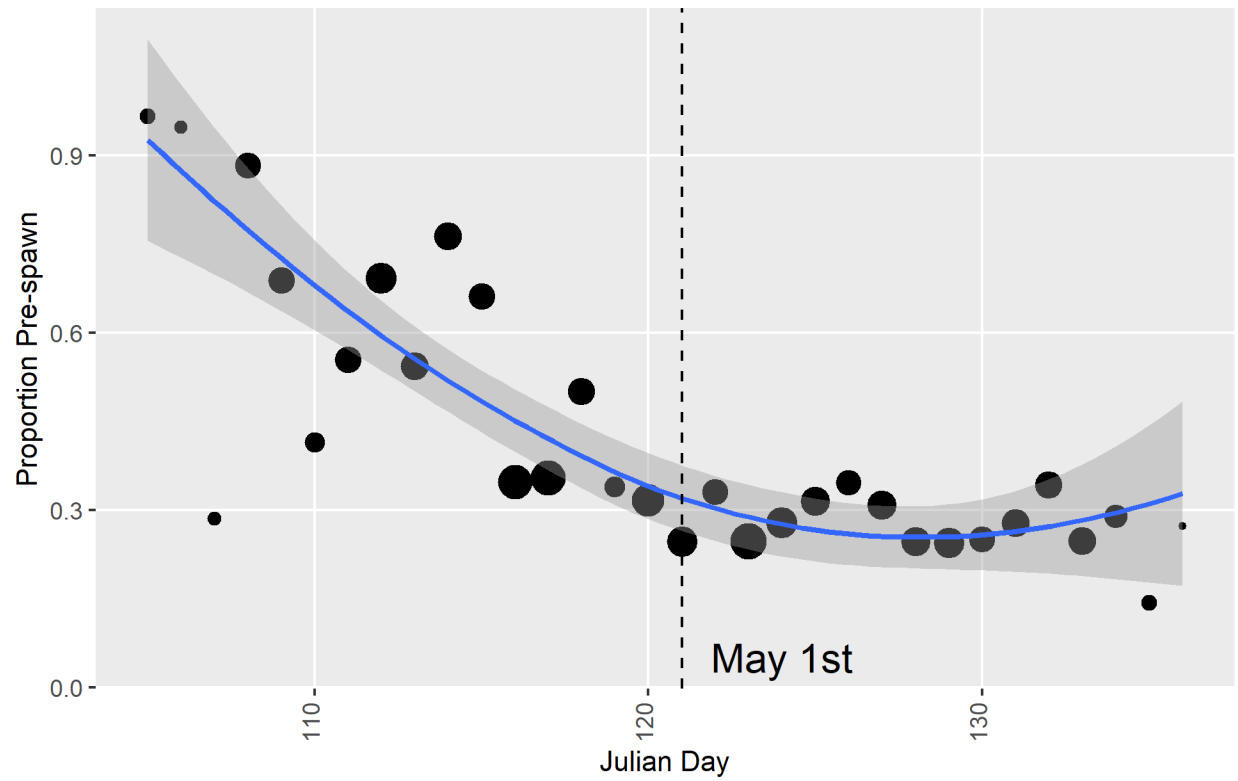


Figure 8. Proportion pre-spawn females sampled in all years of the charter creel survey summarized by sample date (Julian Day). Locally weighted smoothing line (loess) added for visual aid. Points are scaled relative to sample size. Dashed reference line is May 1st.



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 of the of F-61-R-18 Survey, 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 (SRAFC), 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 and River Herring 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 TC chair was a member of the Stock Assessment Subcommittee (SAS). The SAS met several times via webinar and twice in person to evaluate and analyze data, develop assessment models and finalize 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 assisted in updating the 2022 TLA. These duties required attending several webinars and presenting analysis to the ASMFC Sciaenid Management Board. Staff also participated in a planning call for the upcoming spot stock assessment.

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

2023 PRELIMINARY RESULTS – WORK IN PROGRESS

A staff member co-led a data workshop including the Spot and Atlantic Croaker Technical Committees (TC), as spot TC chair and a member of the Atlantic Croaker and Spot Stock Assessment Sub-Committee, to plan for the upcoming Benchmark Stock Assessments for Atlantic croaker and spot. A staff member participated in the Black Drum Stock Assessment Review Workshop, lead a TC meeting to approve the assessment results, and participated in the presentation of results to the ASMFC Sciaenids Board. Staff submitted and presented data for the upcoming River Herring Benchmark Stock Assessment. Staff submitted and presented data for the upcoming Red Drum Benchmark 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 completed and submitted required ASMFC compliance reports for alewife, American shad, Atlantic croaker, Atlantic menhaden, blueback herring, bluefish, red drum and striped bass. Staff reviewed state compliance reports to ASMFC fisheries management plans for Alewife, American Shad, Blueback Herring, Red Drum, 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/stripped-bass/index.aspx>.

Total page views to specific Striped Bass Program pages for the period January 1, 2022 to December 31, 2022 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/stripped-bass/...>), January 1, 2022, through December 31, 2022.

Striped Bass Program Project Sites	Page Views
Juvenile Index (/juvenile-index.aspx)	1,604
Home Page (/index.aspx)	575
Glossary (/glossary.aspx)	291
Adult Spawning Stock Survey (/studies.aspx)	284
Commercial (/commercial.aspx)	178
Volunteer Angler Survey (sb_survey.aspx)	172
Reports (/reports.aspx)	131
Recreational (/recreational.aspx)	119
Species (/species.aspx)	93
Biologists (/biologists.aspx)	66
Total	3,513

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 calendar year 2022 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.

- Mr. Charles Poukish, Maryland Department of the Environment. Provision of striped bass samples for tissue contaminant analyses.

- Ms. Alexandra Fries, University of Maryland Center for Environmental Science. Provision of bay anchovy data from the Juvenile Seine Survey.

- Mr. Angel Reyes Delgado, University of Maryland Center for Environmental Science. Provision of weakfish data from the Juvenile Seine Survey.

- Ms. Lindsay Bomgardner, Virginia Institute of Marine Science. Provision of cownose ray data from the Juvenile Seine Survey.

- Ms. Rachel Dixon, Virginia Institute of Marine Science. Provision of striped bass data from the Juvenile Seine 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.

- Mr. Marty Gary, Potomac River Fisheries Commission (PRFC).

Provision of striped bass Juvenile Seine Survey data, commercial harvest data and commercial regulation information.

- Ms. Brooke Lowman, PhD, Virginia Marine Resources Commission. Provision of raw data from the Striped Bass Volunteer Angler Survey.

- Mr. David Sikorski, CCA, Maryland. Provision of striped bass Juvenile Seine Survey data and APAIS Survey background information.

- Maryland Charterboat Association (MCA) members. Provided updated APAIS Survey background information, provided clarification of striped bass fishery regulations and striped bass recreational fishery information.

- The Striped Bass Program staff also fulfilled requests by providing biological information and related reports to seventeen (17) additional scientists, students, and concerned constituents.

Atlantic Sturgeon, Shortnose Sturgeon and Sea Turtle Interaction Summary for
Chesapeake Bay Finfish Investigations
Project No.: F-61-R-18

Prepared by Paul G. Piavis, Harry W. Rickabaugh, Eric Q. Durell, Jeffery Horne,
Katherine Messer, and Harry T. Hornick

Summary

The primary objective of the Chesapeake Bay Finfish Investigations Survey, F-61-R-18, was to monitor and biologically characterize resident and migratory finfish species in the Maryland portion of the Chesapeake Bay during the 2022 – 2023 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. The 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 July 1, 2022–June 30, 2023 sampling season, there were two (2) documented Atlantic sturgeon encounters.

CONTENTS:

PROJECT 1: 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, 2022, through June 30, 2023.

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, 2022, through June 30, 2023.

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, 2022, through June 30, 2023.

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, 2022, through June 30, 2023.

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, 2022, through June 30, 2023.

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, 2022, through June 30, 2023.

PROJECT 2: INTERJURISDICTIONAL SPECIES STOCK ASSESSMENT

JOB 1: 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

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed during the Survey period of this project from July 1, 2022, through June 30, 2023.

Shortnose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed during the Survey period of this project from July 1, 2022, through June 30, 2023.

2. Nanticoke River Ichthyoplankton Survey

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed during the Survey period of July 1, 2022, through June 30, 2023.

Shortnose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed during the Survey period of July 1, 2022, through June 30, 2023.

3. Conowingo Dam Tailrace Tag Recapture Survey

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed during the Survey period of July 1, 2022, through June 30, 2023.

Shortnose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed during the Survey period of July 1, 2022, through June 30, 2023.

4. North East River Gill Net Survey

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed during the Survey period of July 1, 2022, through June 30, 2023.

Shortnose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed during the Survey period of July 1, 2022, through June 30, 2023.

PROJECT 2:

JOB 2: 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

Atlantic Sturgeon Interactions

There was one (1) Atlantic sturgeon sampled during this Survey for the period of July 1, 2022 through June 30, 2023. The Interaction Report follows.

ESA Report Information: Interaction #1:

Observer's Name: Katherine Messer, MD Department of Natural Resources, Fishing and Boating Services – Matapeake Work Center

Reporter's Name: Same as above

Survey: Summer-Fall Pound Net Survey

Species Identification: Atlantic Sturgeon

How documented: Identified to species by biologists and photos taken.

Type of gear and length of deployment: Commercial pound net gear, soak time 2 days
- see specific details below.

Encounter # 1:

Date: September 14, 2022 **Time:** 7:30 AM

Location: Chesapeake Bay, Low. East Shore. N 38 12.710 - W 76 22.410

Water temp: 18.4° C **Salinity:** 16.4 ppt

Air temp: 25.4° C

Water depth: 12 feet **Tide:** beginning of ebb tide

Gear: Commercial Pound Net, Soak time = 4 days

Total length: 668 mm **Fork length:** 570 mm

Condition/description: Appeared healthy and robust, no visible marks, released unharmed

Photograph taken: Yes

Genetic sample taken: Yes, clip from caudal fin

Genetic sample given to: Chuck Stence **On date:** October 25, 2022

Scanned for PIT tag: No

PIT tag inserted: No

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, 2022, through June 30, 2023.

2. Fishery Independent Choptank River Gill Net Survey

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed during the Survey period of July 1, 2022, through June 30, 2023.

Shortnose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles sampled or observed during the Survey period of July 1, 2022, through June 30, 2023.

PROJECT 2, 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.

Research Survey:

1. Summer - Fall Pound Net Survey

Atlantic Sturgeon Interactions

There was one (1) Atlantic sturgeon sampled during this Survey for the period of July 1, 2022 through June 30, 2023. The Interaction Report follows.

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 Summer-Fall Pound Net Survey

Species Identification: Atlantic Sturgeon

How documented: Identified to species by biologists and photos taken.

Type of gear and length of deployment: Commercial pound net gear, soak time 4 days
- see specific details below.

Encounter # 1:

Date: October 24, 2022 **Time:** 8:00 AM

Location: Near mouth of Potomac River. N 38 02.86 - W 76 20.01

Water temp: 16.5° C **Salinity:** 17.1 ppt

Air temp: 15.0° C

Water depth: 14.5 feet **Tide:** beginning of ebb tide

Gear: Commercial Pound Net, Soak time = 4 days

Total length: 788 mm **Fork length:** 705 mm

Condition/description: Appeared healthy and robust, no visible marks, released unharmed

Photograph taken: Yes

Genetic sample taken: Yes, clip from caudal fin

Genetic sample given to: Chuck Stence **On date:** October 25, 2022

Scanned for PIT tag:No

PIT tag inserted: Yes **Tag #:** 3DD003BD7C165, Tagged below dorsal fin

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, 2022, through June 30, 2023.

Task 2: Characterization of striped bass spawning stocks in Maryland.

Research Survey:

1. Spring Striped Bass Experimental Drift Gill Net Survey

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed during this Survey for the period of July 1, 2022, through June 30, 2023.

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, 2022, through June 30, 2023

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, 2022, through June 30, 2023.

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, 2022, through June 30, 2023.