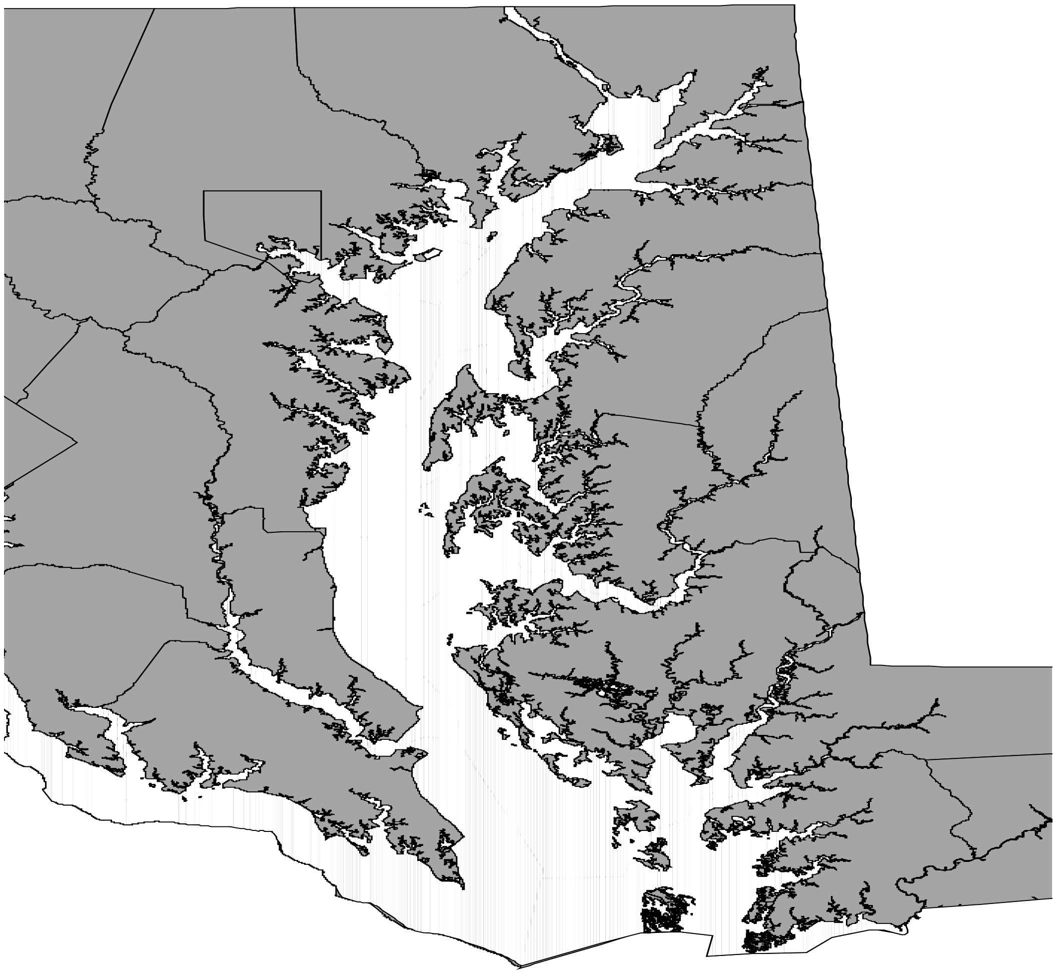

Chesapeake Bay Finfish Investigations

US FWS FEDERAL AID PROJECT
F-61-R-16
2020 - 2021

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Chesapeake Bay Finfish Investigations

July 1, 2020 to June 30, 2021

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

STATE: Maryland

PROJECT NO.: F-61-R-16

PROJECT TYPE: Research and Monitoring

PROJECT TITLE: Chesapeake Bay Finfish Investigations.

PROGRESS: ANNUAL X

PERIOD COVERED: July 1, 2020, through June 30, 2021

Executive Summary

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

Annual winter trawl efforts in upper Chesapeake Bay during 2020 indicated that white perch relative abundance increase relative to 2019 but was still below levels seen during 2014 -- 2018. The 2014, 2015, 2017 and 2018 year-classes were above average. Yellow perch relative abundance decreased relative to 2019 and was the lowest value since 2010. The 2014, 2015 and 2018 year-classes were above average. Channel catfish relative abundance continued a four-year increase and was greater than the time series average. Age 1 channel catfish relative abundance was at the time series average in 2019 and 2020 (2018 and 2019 year-classes).

White perch relative abundance in the Choptank River Fyke Net Survey in 2020 was at a time series low (2000 – 2020). Similar to the upper Bay trawl, the 2014, and 2015 year-classes were

strong. The 2018 year-class was not fully recruited to the gear, but catches indicated that the year-class was also a strong year-class. Yellow perch relative abundance increased in 2020 and was above the time series average. The 2018, 2015 and 2014 year-classes were strong. Channel catfish relative abundance was stable near the time series average. White catfish relative abundance remained low and was below the time series average.

White perch population dynamics were modeled with a Catch Survey Analysis for the upper Chesapeake Bay stock and the Choptank River population. In the upper Chesapeake Bay, total population size declined from 2016 through 2020, but was still quite higher than the time series average. Instantaneous fishing mortality increased in 2019 to a level slightly above target. Analysis indicated that the population was neither over-fished and over-fishing was not occurring. The Choptank River white perch Catch Survey Analysis utilized data from a fishery independent fyke net survey. The population expanded relatively quickly and for a sustained period from 1998 – 2010. Terminal year (2019) estimates indicated that the population is near average levels and has increased since 2013. Pre-recruit abundance was very low, which indicated that population expansion is unlikely in the very near future. Lower Chesapeake Bay white perch stocks were assessed qualitatively by utilizing fishery dependent relative abundance and fishery independent metrics from the Potomac River. All adult white perch indices and juvenile relative abundance suggested that population levels were stable and above time series medians.

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 Chesapeake Bay and its tributaries. Sampling activities to characterize shad and herring stocks were severely impacted by the COVID-19 pandemic. The State of Maryland proclaimed a state of emergency on March 5, 2020, which extended through the 2020 and 2021 Alosine sampling seasons. On March 13, 2020, the state workforce entered an "Elevated Level II" operational status, imposing a mandatory telework status for all non-essential state employees. The regularly scheduled survey to estimate stock composition and abundance of adult American shad in the Susquehanna River below Conowingo Dam was suspended for the entirety of the 2020 sampling season. Stock characterization of adult hickory shad on the Susquehanna River and sampling of commercial bycatch to estimate stock composition and relative abundance of adult American shad and river herring on the Nanticoke River were similarly cancelled. A survey of adult river herring to estimate stock characterization and relative abundance in the North East River was conducted on only one of ten regularly scheduled sampling days prior to the implementation of COVID-19 work restrictions.

Stock composition and relative abundance of adult American shad in the Potomac River were assessed using fishery-independent gill nets operated for the Striped Bass Spawning Stock Survey (SBSSS; Project 2, Job 3, Task 2). Relative abundance decreased slightly in 2020, and total mortality was estimated at 1.22. Mortality has increased since 2002 and was above the biological reference point since 2016. Additionally, juvenile abundance indices for American shad and river herring were formulated for various river systems using data collected by the Estuarine Juvenile Finfish Survey (EJFS; Project 2, Job 3, Task 3). American shad juvenile production was marginally lower in the

Potomac River and upper Chesapeake Bay in 2020. Alewife herring juvenile production was low but stable across regions and blueback herring production was lower than 2019.

Weakfish have experienced a sharp decline in abundance coast-wide. Recreational harvest estimates for inland waters by the NMFS for Maryland waters declined from 741,758 fish in 2000 to 763 in 2006 and have fluctuated at a very low level from 2007 through 2019. The NMFS estimated no weakfish were harvested in 2018. The 2018 Maryland Chesapeake Bay commercial weakfish harvest remains very low with a harvest of 96 pounds in 2019, well below the 1981 – 2019 time series of 40,324 pounds per year. The 2020 mean length for weakfish from the onboard pound net survey was 300 mm TL, but only six fish were encountered, the lowest sample size of the 28-year time series. Two weakfish with lengths of 301 to 327 mm TL were captured in the Choptank River gill net survey in 2020.

Summer flounder mean length from the pound net survey was 304 mm TL in 2020, which was an increase compared to the past four years, but only 40 were encountered - the lowest number sample for the time series. Two summer flounder were encountered in the Choptank River gill net survey in 2020 with lengths of 213 and 222 mm TL. The NMFS 2019 coast wide stock assessment concluded that summer flounder stocks were not overfished, and overfishing was not occurring, but recruitment has been generally low and fishing mortality is just below the threshold value.

Mean length of bluefish from the onboard pound net survey in 2020 was 361 mm TL, the highest value in the time-series. The length distribution indicated a shift back to larger bluefish in 2019 and 2020 following distributions that were skewed toward smaller fish from 2016 through 2018. Only one bluefish was captured in the Choptank River gill net survey in 2020. Bluefish have been encountered in low numbers all eight years of the survey (1 – 24 fish per year). Reported Maryland bluefish commercial and charter boat harvest and inland recreational estimates in 2019 were all well below their time series means. The 2019 coast wide stock assessment update indicated the stock was overfished, but overfishing was not occurring.

The mean length of Atlantic croaker examined from the onboard pound net survey in 2020 was 252 mm TL, the fourth lowest value of the 28-year time-series. Atlantic croaker age structure from pound net samples was truncated to age four, but only 14 fish were sampled in 2020. Length and age sample sizes were low in 2019 and 2020 due to decreased availability. 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 remained low since, with 45 fish being captured in 2020. Maryland 2019 Atlantic croaker Chesapeake Bay commercial harvest, inland waters recreational harvest estimate and charter boat harvest values were all well below their long-term means. The Atlantic croaker juvenile index was above the time series mean for the second consecutive year, which could potentially provide an increase in adult abundance in the near future.

The 2019 spot mean length of 186 mm TL was the 7th lowest value of the time-series, and the length frequency distribution remained truncated. Spot aged from the onboard pound net survey were 92% age one, with one age two fish encountered. Spot catch in the Choptank River gill net survey was highest in 2020 and 2014, moderate in 2013, 2017 and 2019, and low in 2015, 2016 and 2018. Chesapeake Bay commercial spot harvest decreased in 2019, remaining below the time-series mean. The inland waters recreational harvest estimate in 2019 increased to nearly the time-series mean. The spot juvenile index values in 2014, 2015 and 2016 were the 4th, 1st and 7th lowest values, respectively, in the 32-year time-series. The values increased from 2017 to 2020, with the 2020 value being the first above the time series mean since 2012.

Mean length for Atlantic menhaden sampled from the onboard pound net survey in 2020 was 221 mm FL, the 7th lowest value of the 17-year time-series. The 2020 length frequency distribution returned to a single peak distribution following a bimodal distribution in 2019 that was heavily skewed toward smaller fish. 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 1,866 fish captured in 2020. Mean lengths for all meshes combined displayed little inter-annual variation prior to 2020, with the 2020 value 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 2019 season ranged in age from one to fourteen years old. Age 4 striped bass from the above average 2015 year-class contributed 44% of the sample. Age 8 fish from the above average 2011 year-class contributed 3% in 2019 while striped bass age 6 and older comprised 12% of the sample. Striped bass sampled from pound nets ranged from 184 to 953 mm TL, with a mean length of 469 mm TL in 2019. Check station sampling determined that the commercial summer/fall fishery harvest was comprised of three to twelve year-old striped bass from the 2007 through 2016 year-classes. Striped bass over 700 mm TL were harvested throughout the season and contributed 5% to the overall harvest.

The December 2019 - February 2020 commercial drift gill net harvest consisted primarily of age five, six, and seven year-old striped bass from the 2015, 2014 and 2013 year-classes that composed 72% of the total harvest. The contribution of fish older than age 9 (14%) was double the 2018-2019 harvest (7%) due to the contribution of the above average 2011 year-class. The youngest fish observed in the 2019-2020 sampled harvest were age 3 from the 2017 year-class. Striped bass present in commercial drift gill net samples collected from check stations ranged in age from age 3 to 12 years old (2017 to 2008 year-classes).

Due to COVID-19 restrictions, a low sample size (n=5) was collected at check stations for the Atlantic coast commercial striped bass fishery. An age length key from the previous year was used to break down the fishery by age. Striped bass harvested during the 2019-2020 Atlantic coast commercial fishing season ranged from age 6 (2014 year-class) to age 19 (2001 year-class). Thirteen different year-classes were represented in the sampled harvest. The most common age represented in the catch-at-age estimate was age 9 striped bass from the 2011 year-class, which represented 20% of the sampled harvest. Age 13 (2007 year-class) fish were also a significant contributor to the sample population at 18%. Striped bass sampled at Atlantic coast check stations during the 2019 – 2020 season had a mean length of 785 mm TL and mean weight of 5.9 kg.

The start of the spring 2020 spawning stock survey was delayed by two weeks due to COVID-19. Survey results indicated that there were 17 age-classes of striped bass present on the Potomac River and Upper Bay spawning grounds. These fish ranged in age from 2 to 19 years old. Male striped bass ranged in age from 2 to 15 years old and females ranged in age from 5 to 19. Age 9 females from the dominant 2011 year-class were most commonly observed, followed by age 11 females from the 2009 year-class. The contribution of age 8+ females to the total female CPUE decreased in 2020 to 82%. This decrease may be driven by the appearance of some 2015 year-class (age 5 in 2020) females in the spawning stock. The contribution of females age 8 and older to the spawning stock was at or above 80% for most years during the period of 1996-2015, but was below the time-series average (72%) for 2016 - 2018. The 2020 selectivity-corrected, total, weighted catch-per-unit-effort (546), used in the coastwide stock assessment, ranked 11th in the 36-year survey, above the time-series average of 494.

The striped bass young-of-year index, a measure of striped bass spawning success in Maryland's Chesapeake Bay, was 2.5 in 2020, below the long-term average of 11.5. The index represents the average number of recently hatched striped bass captured in each sample. Although the size of the striped bass population has decreased recently, the number of mature fish is not believed to be a limiting factor in reproduction. Striped bass are known for highly variable annual reproduction that is often influenced by environmental factors. Other species with spawning strategies like striped bass such as white perch, yellow perch and river herring also experienced poor reproductive success. The mild winter appears to have favored species that spawn in the fall off the coast such as Atlantic croaker and spot. During this year's survey, biologists collected over 36,000 fish of 59 different species, including 327 young-of-year striped bass.

During the 2020 spring recreational trophy season, biologists intercepted 8 charter trips and examined 30 striped bass. The average total length of striped bass sampled from the spring trophy fishery was 994 mm total length. The average weight was 10.4 kg. Striped bass sampled from the spring trophy fishery ranged in age from 7 to 17 years old. In 2020 the above average 2011 year-class (Age 9) disproportionately contributed 53.4% to the harvest. This high contribution likely represents the complete maturation and fully migratory status of 9 year old females from the 2011 year-class. The next largest contribution was 12.5% from the 2012 year-class with all other year-classes each contributing less than 10%. In 2020, charter boats caught 3.0 fish per trip at a rate of 0.5 fish per hour. Due to COVID-19, MRIP data for estimating private boat catch rates were not available.

Maryland Department of Natural Resources staff continued to tag and release striped bass in spring 2020 in support of the US FWS coordinated interstate, coastal population study. A total of 1,990 striped bass were sampled and a total of 864 striped bass were tagged and released with US FWS internal anchor tags between April 14 and May 22, 2020 in Maryland. Of this sample, 222 were tagged in the Potomac River and 642 were tagged in the upper Chesapeake Bay area during the spring spawning stock assessment survey. A total of 199 striped bass were tagged during US FWS cooperative offshore tagging activities between January 23 and February 18, 2020.

APPROVAL

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ACKNOWLEDGEMENTS

The Maryland Department of Natural Resources (MD DNR) would like to thank the Maryland Watermen's Association commercial captains and their crews who allowed us to sample their commercial harvest. We also wish to thank Normandeau Associates personnel for their aid in acquiring tag returns and catch data from the fish lifts at Conowingo Dam. Appreciation is also extended to MD DNR Hatchery personnel and staff for otolith analysis of juvenile and adult American shad and to Connie Lewis, Fisheries Statistics, for providing commercial landings. We would also like to thank Captain Gary Culver of the *R/V Chesapeake* for his assistance during the winter trawl survey.

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

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CONTENTS

SURVEY TITLE: CHESAPEAKE BAY FINFISH INVESTIGATIONS

CONTENTS (Continued)

PROJECT NO. 1
JOB NO. 1

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

Prepared by Paul G. Piavis and Edward Webb, III

INTRODUCTION

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

The CoVID pandemic surged toward the end of the sampling season. The winter trawl survey and the upper Chesapeake Bay yellow perch survey were unaffected by a stay-at-home order, but the Choptank River fyke net survey was halted approximately three weeks prior to the historical end dates. The entire sampling season on the Nanticoke River was eliminated.

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 2020 through February 2020.

Trawl sites have been mostly consistent throughout the survey, but the Chester River sites were added in 2011. Weather and operational issues caused incomplete sampling in some years (Table 1). During 2020, 134 of 138 sites were sampled. Close contact CoVID protocol caused a loss of available sampling dates. 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

In 2020, a stay-at-home order in mid-March necessitated an early end to the sampling season. Six of the scheduled ten weeks were completed, and data loss appeared minimal. 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 2020 through 17 March 2020 (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 1 March 2020 and 10 March 2020 in the Gunpowder River (Figure 3) and on 6 March 2020 in the Bush River (Figure 4). All yellow perch were measured and sexed (unculled) except when catches were prohibitively large. A subsample was purchased for otolith extraction and subsequent age determination.

Nanticoke River Fishery Dependent Sampling

The Nanticoke River was not sampled during 2020 due to a stay-at-home order (CoVID 19). Historical data from the Nanticoke River are available in a previous report (Piavis and Webb 2020).

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 keys for yellow perch and white perch (separated by sex) from the Choptank River fyke net survey, the upper Bay commercial fyke net survey (yellow perch only) and the upper Chesapeake Bay trawl survey were constructed by determining the proportion-at-age per 20-mm length group. The proportion-at-age for each length interval was multiplied by the total number-at-length from the entire sample for yellow perch from the upper Bay fyke net survey and yellow perch from the Choptank River fyke net survey. The same was done for white perch from the trawl survey 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 and Nanticoke rivers). Growth in length over time and weight in relation to length were described with standard fishery equations. The allometric growth equation (weight (g) = α*length (mmTL)$^{\beta}$) described weight change as a function of length, and the vonBertalanffy growth equation (Length=$L_{\infty}(1-e^{-K(t-t_0)})$) described change in length with respect to age. Both equations were fit for white perch and yellow perch males, females, and sexes combined with SAS nonlinear procedures. Growth data for target species encountered in the trawl survey were not compiled due to the size selectivity of the gear. Length curve parameters have been compromised by a lack of younger fish in the collections due to size selectivity of the gear. This usually manifests in low t_0 and K values in the vonBertalanffy solutions. In order to mitigate these biases, we included average sizes of young of year target species collected in either the EJFS seine survey or upper Bay trawl survey within each target system, by month.

Mortality

White perch instantaneous fishing mortality (F) estimates were determined in Piavis and Webb (Project 1 Job 2 of this report) for the Choptank River and upper Chesapeake Bay through 2019. Estimated F for 2020 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 catch curve analysis of $\log_e$ transformed catches of ages 4 – oldest age captured. The slope of the line was –Z and M was assumed to be 0.25. Instantaneous fishing mortality (F) was Z-M. The wildly unequal recruitment and annual changes in catchability proved difficult to overcome in estimating the

Choptank River mortality. Instantaneous mortality rates for yellow perch from the upper Bay were calculated with a statistical catch-at-age model (Piavis and Webb 2020) which is updated annually to produce a total allowable catch for the fishery.

Recruitment

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

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

Relative Abundance

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

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

RESULTS

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

Population Age Structures

White perch	Tables 2-3
Yellow perch	Tables 4-6

Population Length Structures

White perch	Tables 7-8 and Figures 5-6
Yellow perch	Tables 9-11 and Figures 7-9
Channel catfish	Tables 12-13 and Figures 10-11
White catfish	Tables 14-15 and Figures 12-13

Growth

White perch	Table 16
Yellow perch	Tables 17-18

Mortality

White perch	Table 19
Yellow perch	Table 20

Recruitment

White perch	Figures 14-15
Yellow perch	Figures 16-17
Channel catfish	Figure 18

Relative Abundance

White perch	Tables 21-22
Yellow perch	Tables 23-24 and Figure 19
Channel catfish	Figures 20-21
White catfish	Figure 22

PROJECT NO. 1
JOB NO. 1

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

2021 PRELIMINARY RESULTS – WORK IN PROGRESS

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

The winter trawl completed 138 of the 138 proposed tows. The trawl survey began January 4, 2021 and concluded on February 16, 2021. The survey collected 67,427 white perch, yielding 4,157 length measurements and 150 age samples (otoliths). Yellow perch numbered 1,137 with 559 length measurements and 87 age samples (otoliths). The catfish complex yielded 10,197 channel catfish (1,439 measurements), 395 white catfish (285 measurements) and 803 blue catfish (377 measurements).

Three sampling days were allocated to characterize the commercial yellow perch fishery. However, 4,642 yellow perch were measured and 197 fish were sacrificed for age determination. Areas sampled included the Northeast River (March 3, 2021) Gunpowder River (March 7, 2021) and the Bush River (March 11, 2021).

The Choptank River fyke net survey started March 1, 2021 and ended April 9, 2021. A total of 10,581 white perch were collected, yielding 2,017 length measurements and 152 age samples. Yellow perch numbered 1,396 (1,396 measurements and 198 ages); channel catfish numbered 826 (789 measurements) and white catfish numbered 633 (593 length measurements). Invasive blue catfish were also encountered (48 total, 48 length measurements).

In addition to these surveys, Job 1 tabulates data from the Nanticoke River Alosid survey from white perch, channel catfish and white catfish collections. The invasive blue catfish are also encountered frequently, and although blue catfish are not a species of interest in this grant, length data are collected. A total of 770 blue catfish were measured in 2021 along with 413 channel catfish and 342 white catfish. A total of 855 white perch were measured and 165 fish were sacrificed for ages.

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Figure 1. Upper Chesapeake Bay winter trawl survey locations, January 2020 – February 2020. Different symbols indicate each of 4 different sampling rounds.

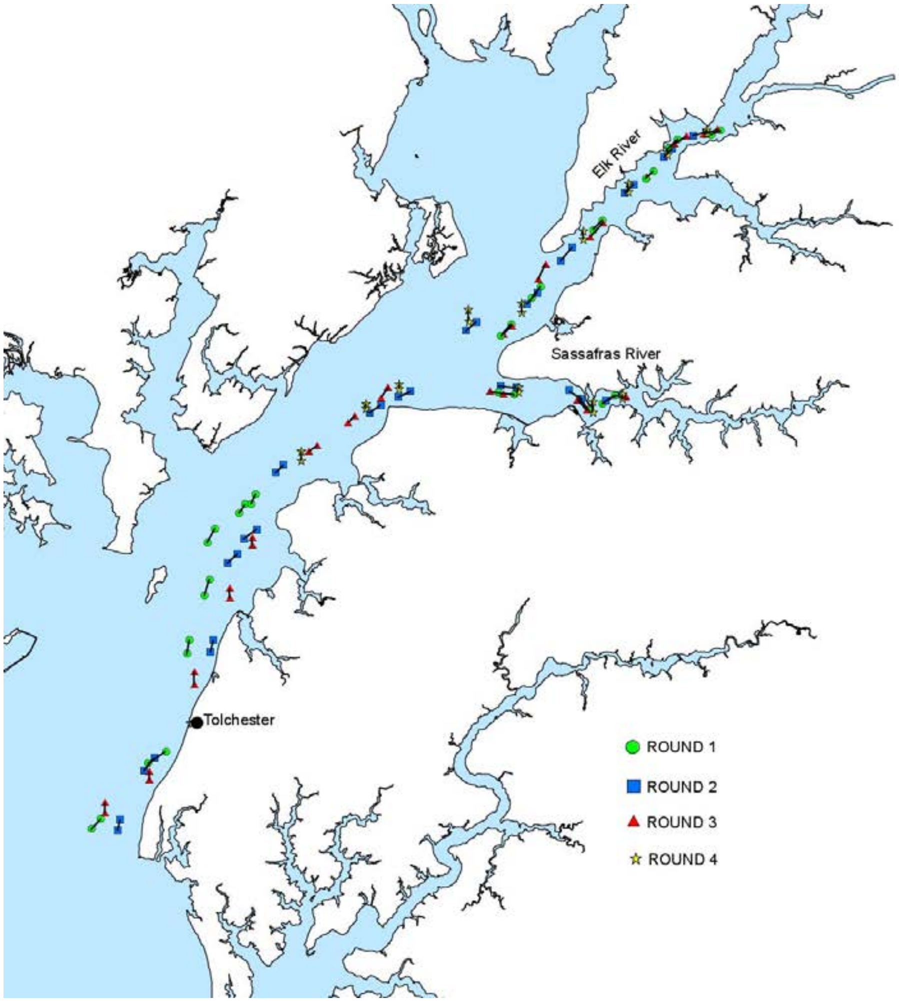


Table 1. Upper Chesapeake Bay winter trawl survey effort, 2000 – 2020.

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	Ice
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

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

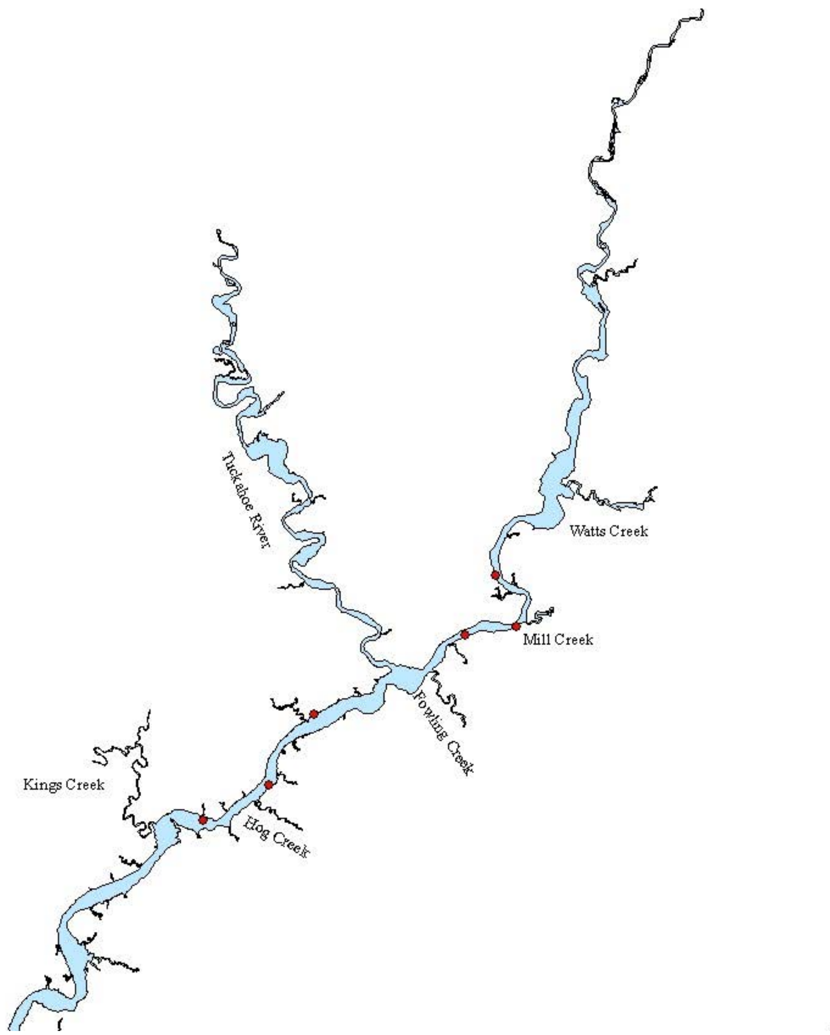


Figure 3. Commercial yellow perch fyke net sites sampled during 2020 in Gunpowder River. Circles indicate sites.

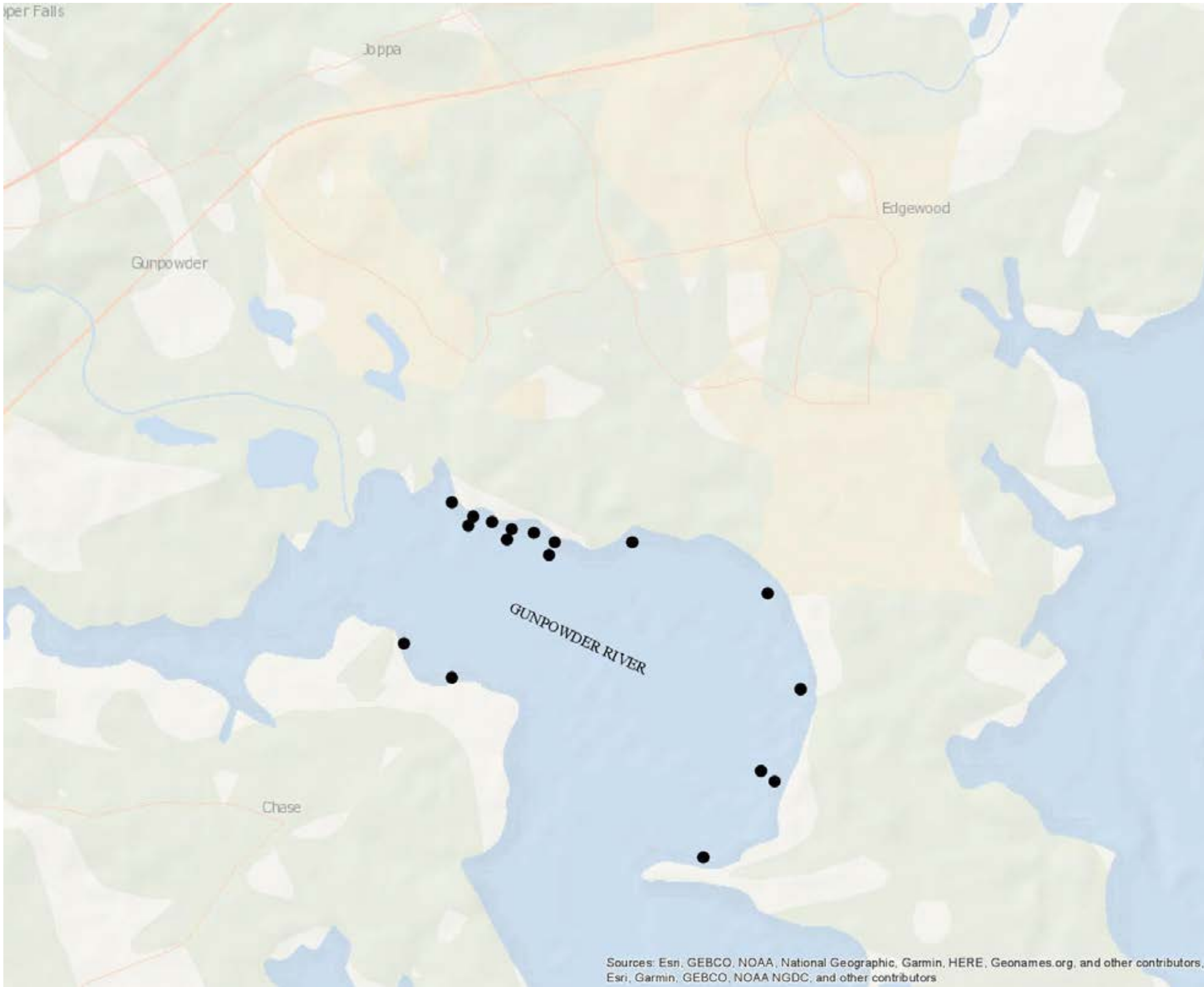


Figure 4. Commercial yellow perch fyke net sites sampled during 2020 in Bush River. Circles indicate fyke net locations.

Table 2. White perch catch-at-age matrix from upper Chesapeake Bay winter trawl survey, 2000 – 2020.

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

Table 3. White perch catch-at-age matrix from Choptank River fyke net survey, 2000 – 2020.

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

Table 4. Yellow perch catch at age from upper Chesapeake Bay winter trawl survey, 2000 – 2020.

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

Table 5. Yellow perch catch at age matrix from Choptank River fyke net survey, 1988 – 2020.

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

Table 6. Yellow perch catch at age matrix from upper Chesapeake Bay commercial fyke net survey, 1999 – 2020.

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

Table 7. Relative stock densities (RSD's) of white perch from the upper Chesapeake Bay winter trawl survey, 2000 – 2020. 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

Figure 5. White perch length-frequency from 2020 upper Chesapeake Bay winter trawl survey.

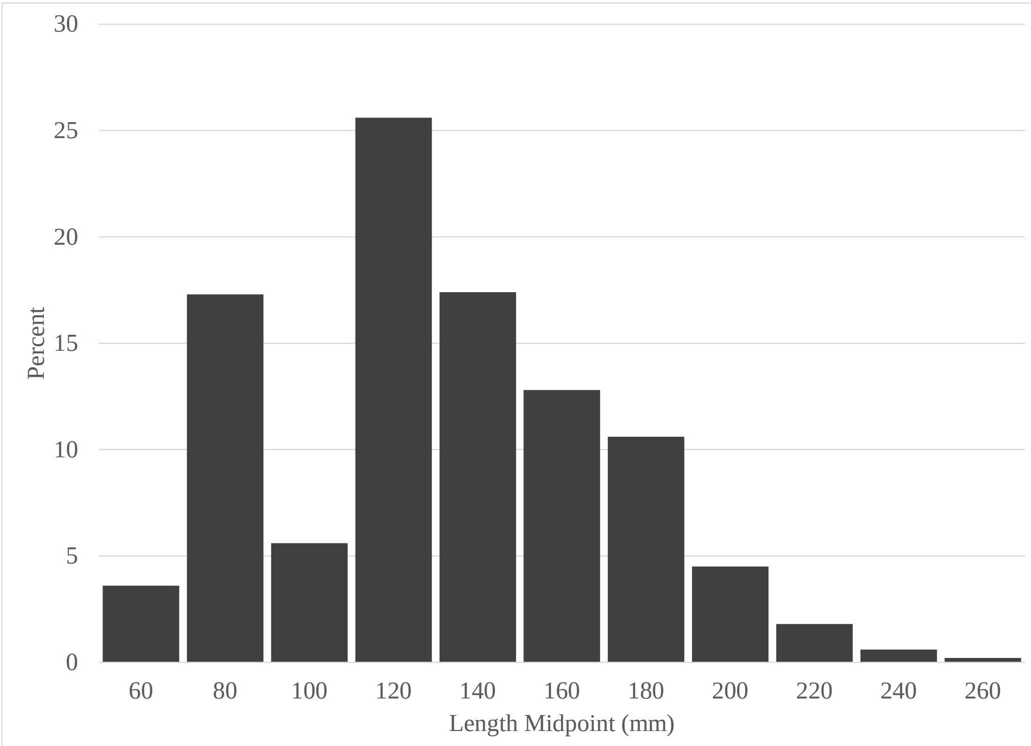


Table 8. Relative stock densities (RSD's) of white perch from the Choptank River fyke net survey, 1993 – 2020. Minimum length cut-offs in parentheses.

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

Figure 6. White perch length-frequency from 2020 Choptank River fyke net survey.

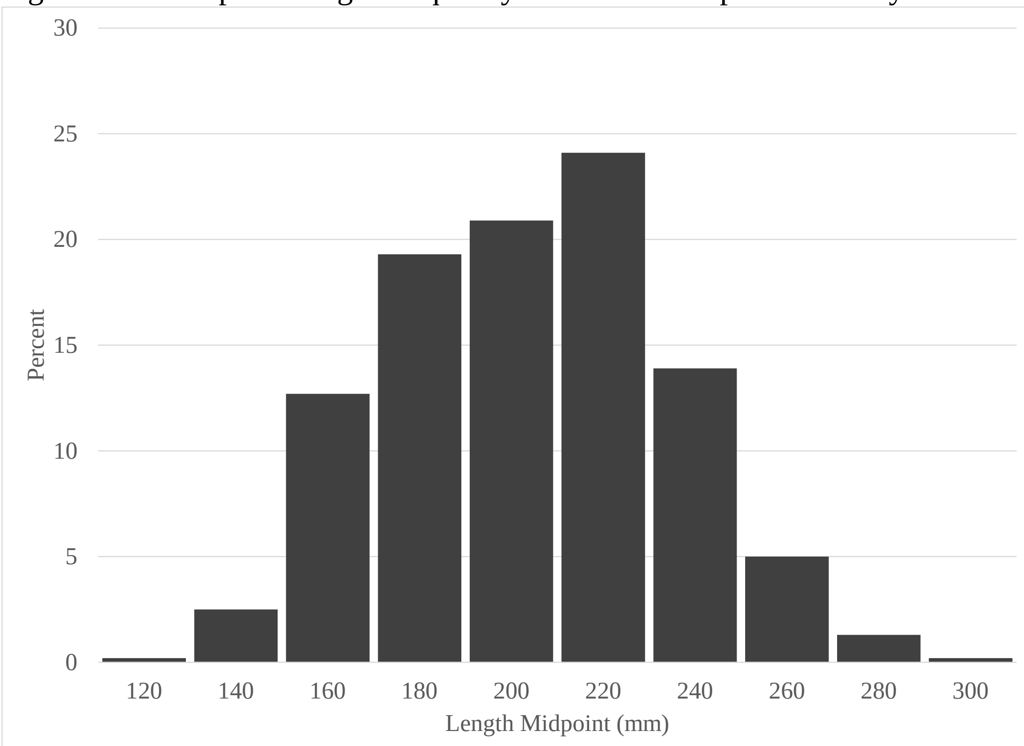


Table 9. Relative stock densities (RSD's) of yellow perch from the upper Chesapeake Bay winter trawl survey, 2000 – 2020. Minimum length cut-offs in parentheses.

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

Figure 7. Yellow perch length-frequency from the 2020 upper Chesapeake Bay winter trawl survey.

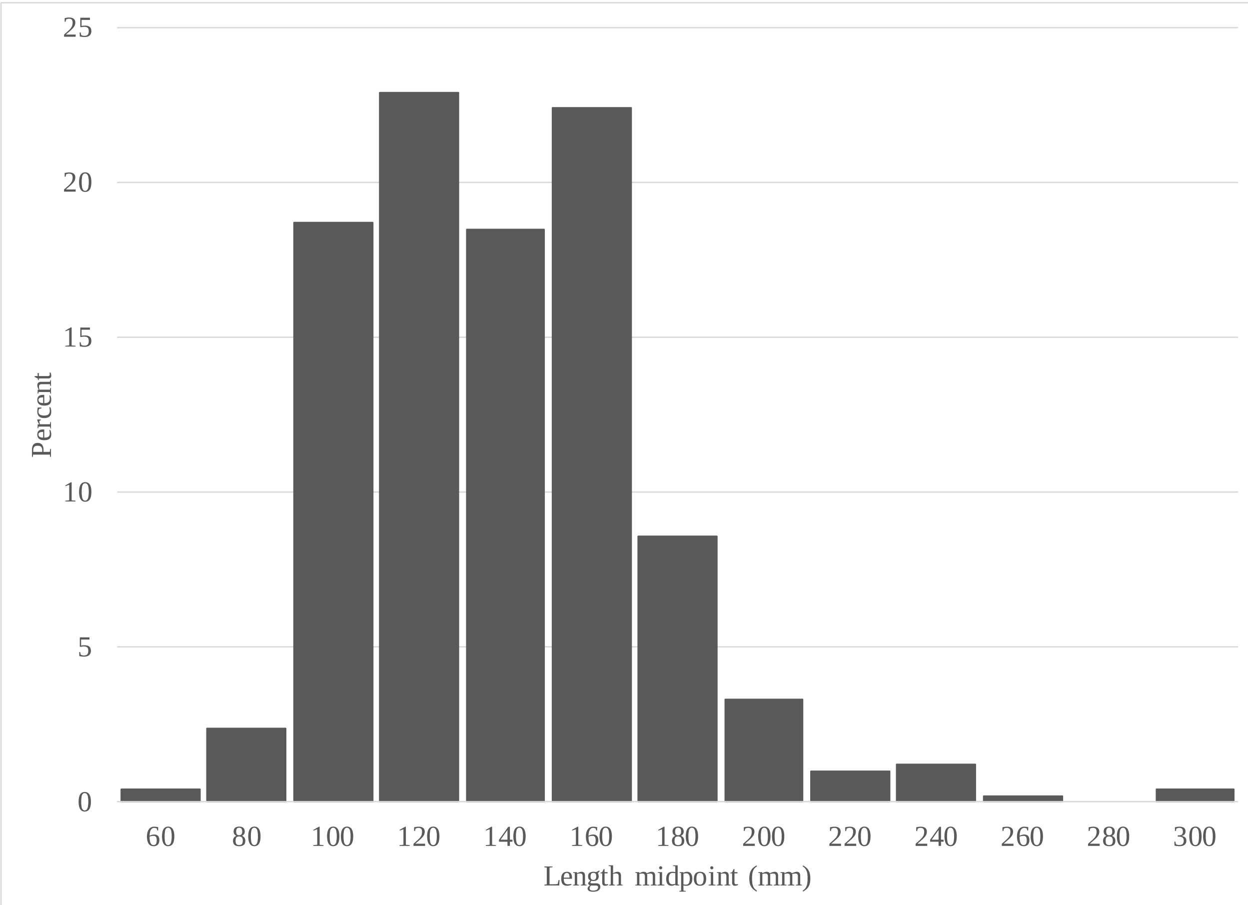


Table 10. Relative stock densities (RSD's) of yellow perch from the Choptank River fyke net survey, 1989 – 2020. Minimum length cut-offs in parentheses.

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

Figure 8. Yellow perch length-frequency from the 2020 Choptank River fyke net survey.

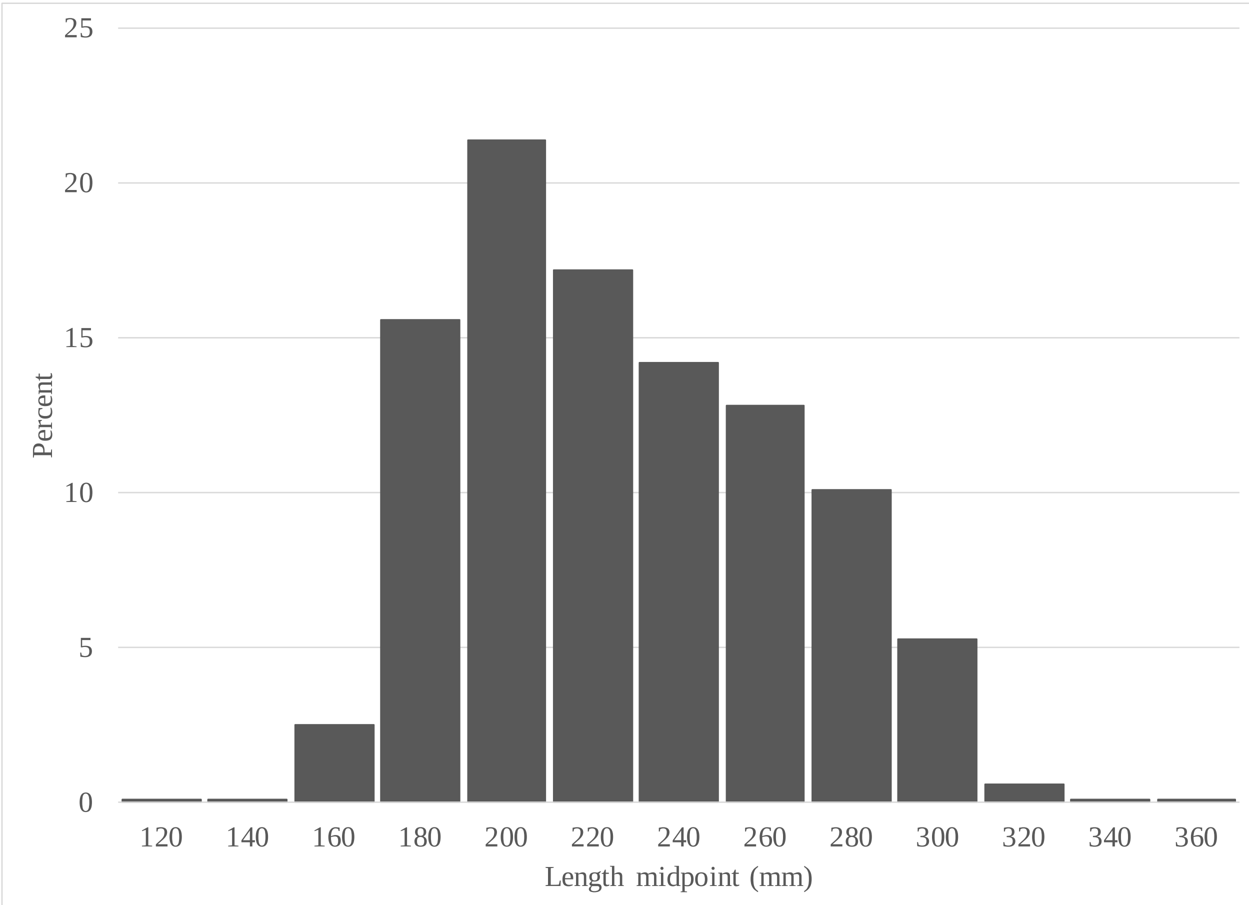


Table 11. Relative stock densities (RSD's) of yellow perch from the upper Chesapeake Bay commercial fyke net survey, 1988, 1990, 1998 – 2020. Minimum length cut-offs in parentheses.

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

Figure 9. Yellow perch length frequency from the 2020 upper Chesapeake commercial fyke net survey.

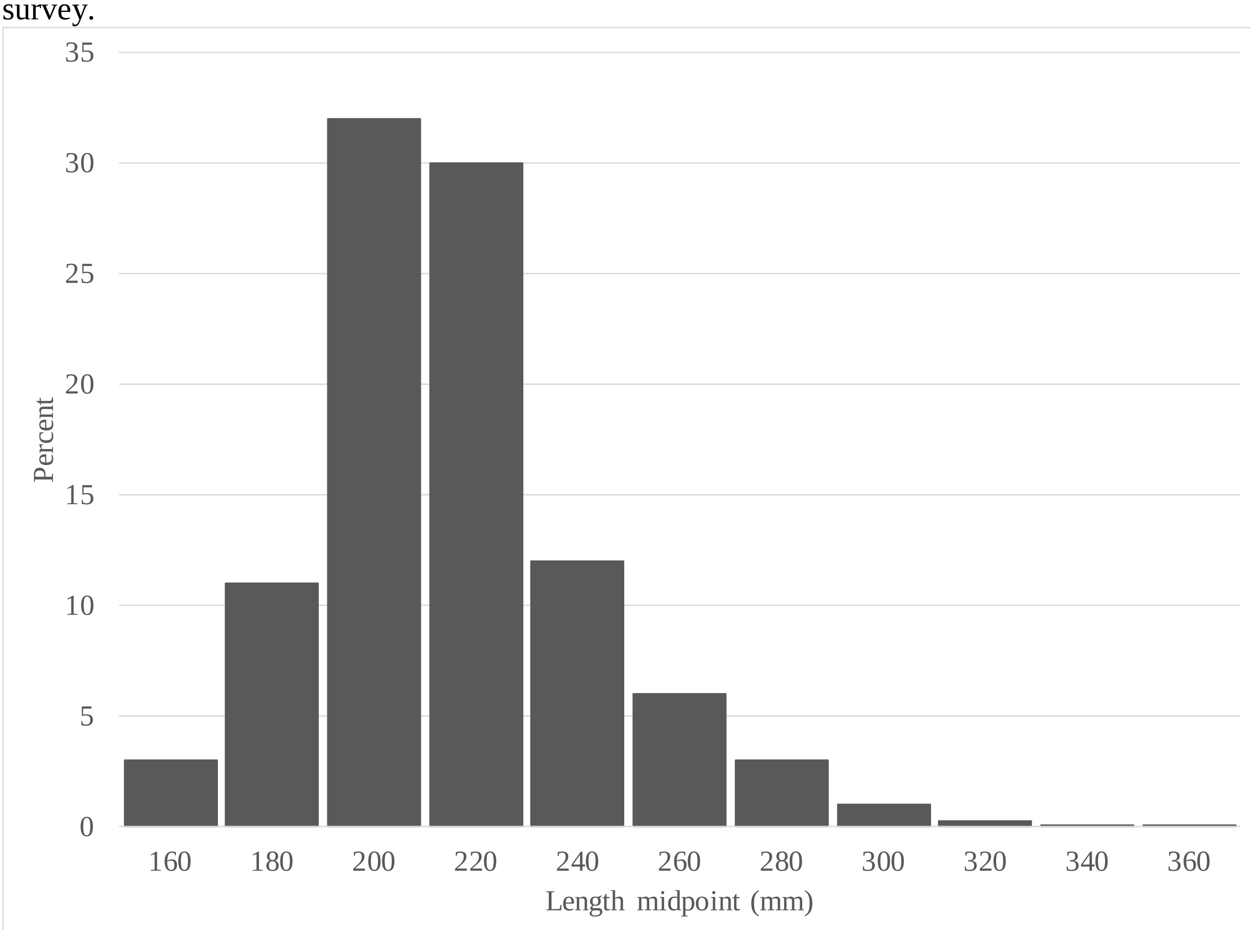


Table 12. Relative stock densities (RSD's) of channel catfish from the upper Chesapeake Bay winter trawl survey, 2000 – 2020. Minimum length cut-offs in parentheses.

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

Figure 10. Length frequency of channel catfish from the 2020 upper Chesapeake Bay winter trawl survey.

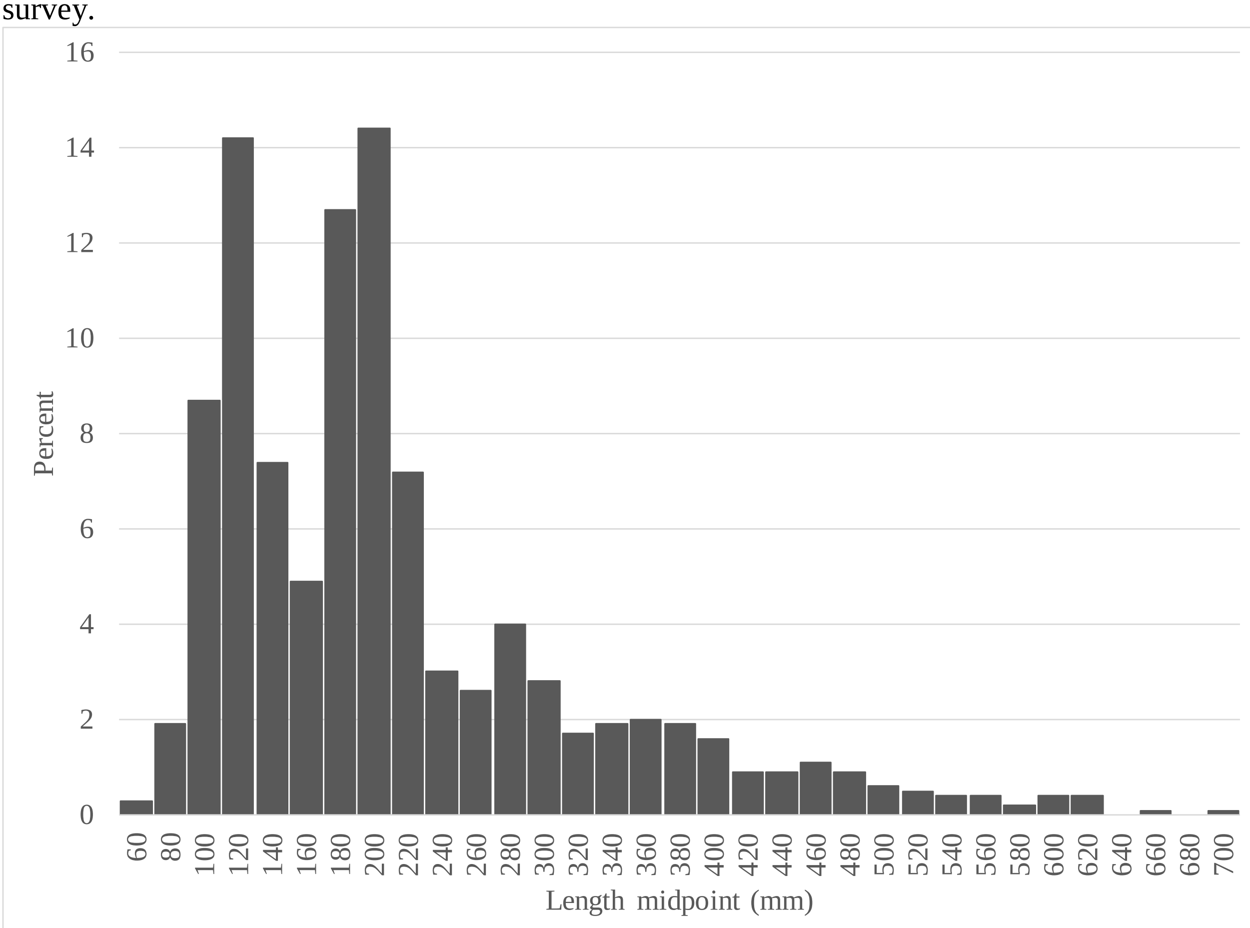


Table 13. Relative stock densities (RSD's) of channel catfish from the Choptank River fyke net survey, 1993 – 2020. Minimum length cut-offs in parentheses.

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

Figure 11. Channel catfish length frequency from the 2020 Choptank River fyke net survey.

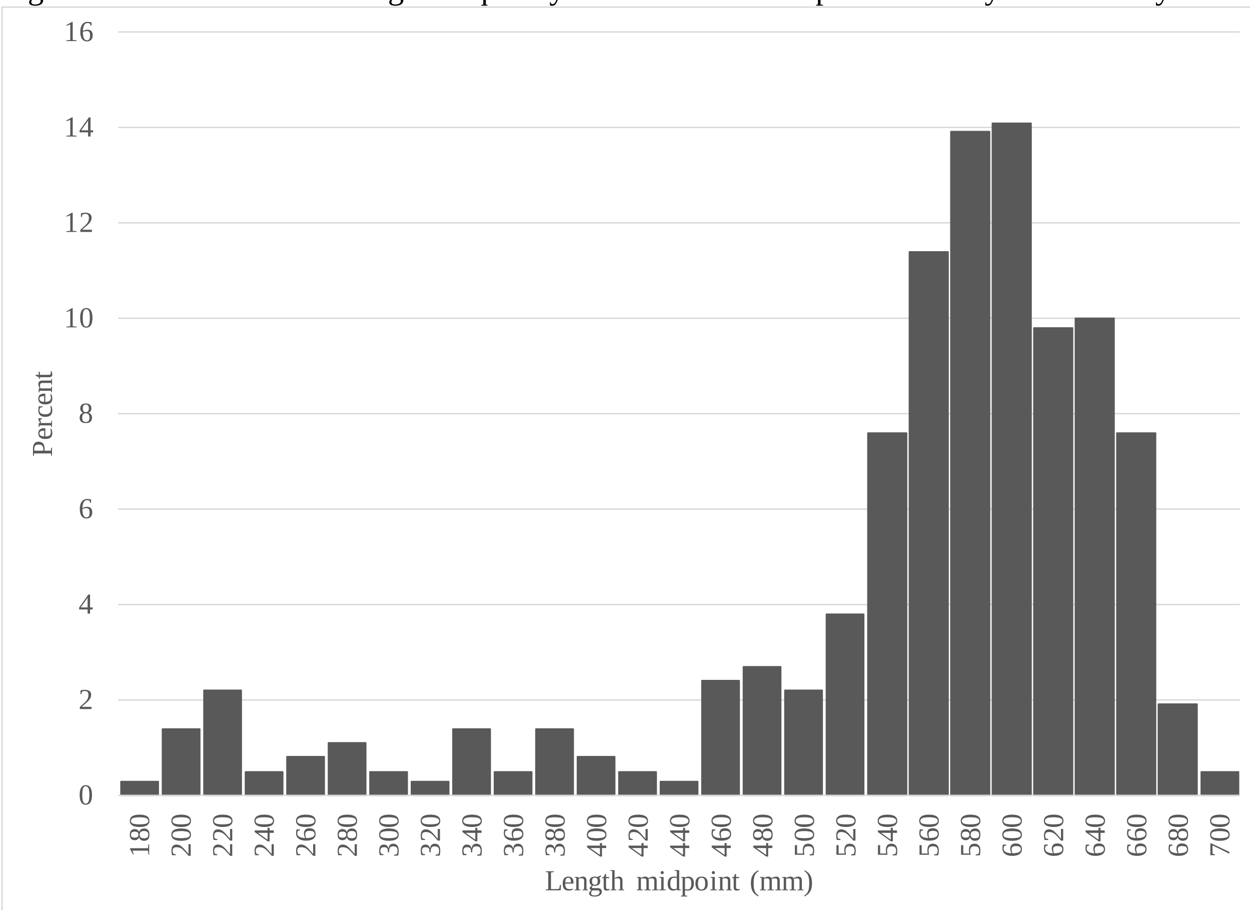


Table 14. Relative stock densities (RSD's) of white catfish from the upper Chesapeake Bay winter trawl survey, 2000 – 2020. Minimum length cut-offs in parentheses.

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

Figure 12. White catfish length frequency from the 2020 upper Chesapeake Bay winter trawl survey.

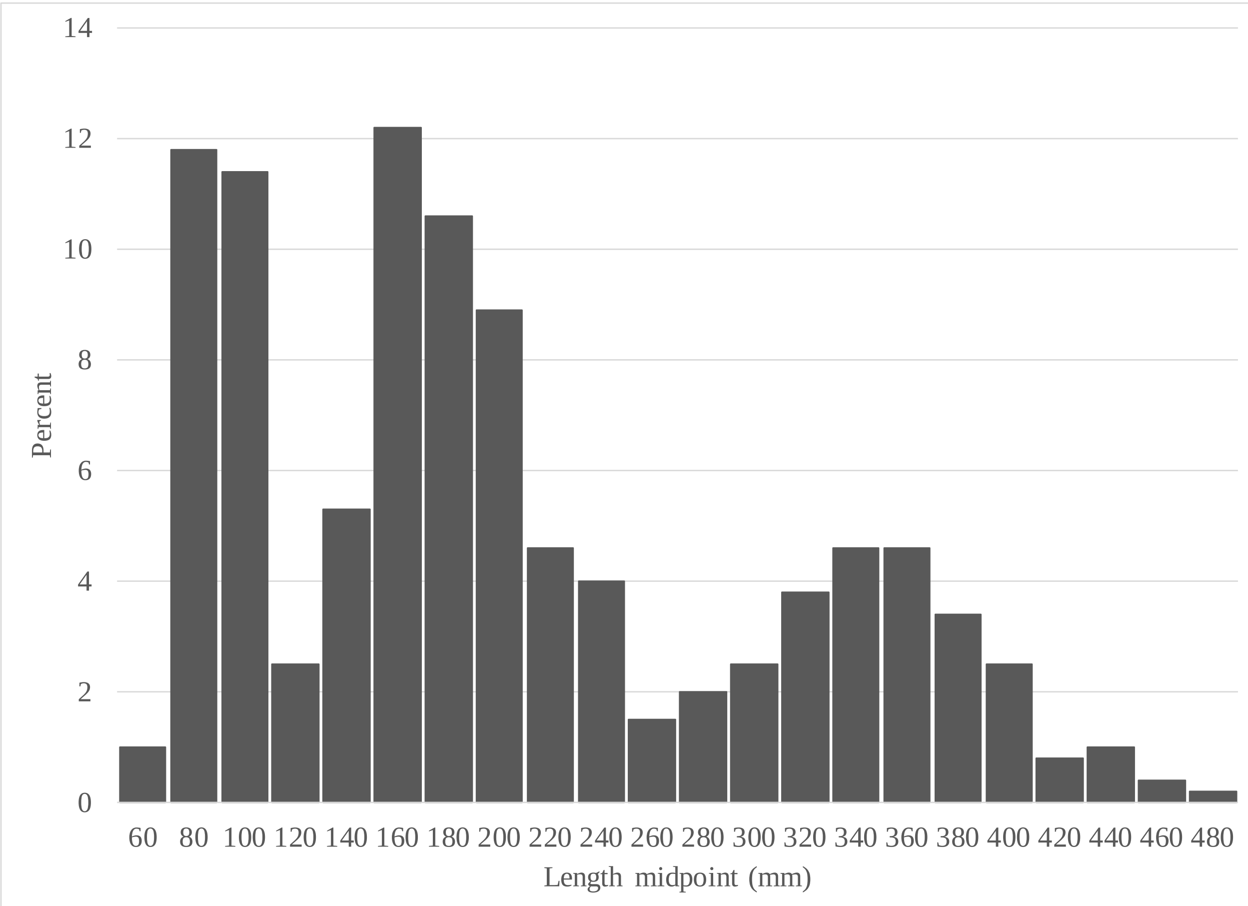


Table 15. Relative stock densities (RSD's) of white catfish from the Choptank River fyke net survey, 1993 – 2020. Minimum length cut-offs in parentheses.

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

Figure 13. White catfish length frequency from the 2020 Choptank River fyke net survey.

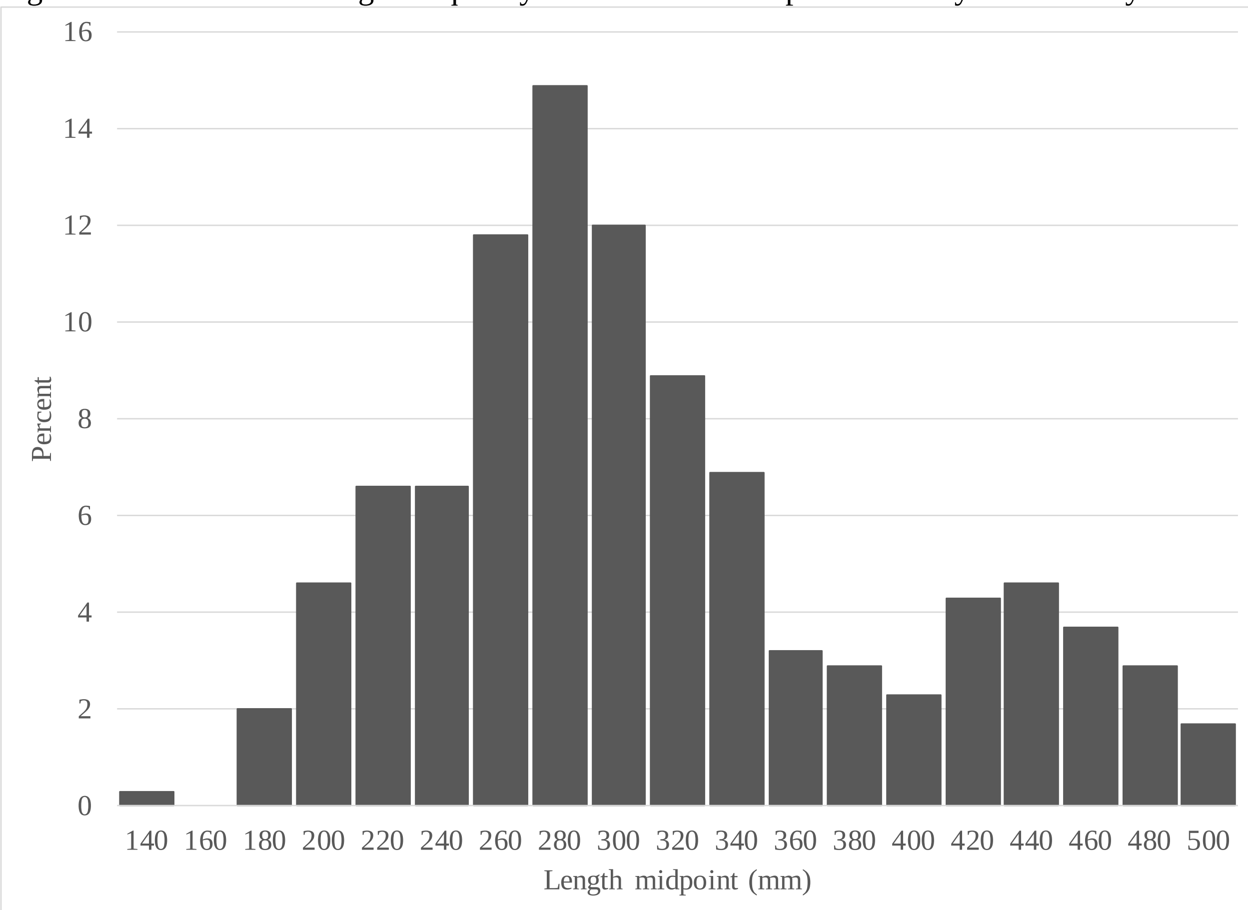


Table 16. White perch growth parameters from Choptank River for males, females, and sexes combined. NA=data not available NSF=no solution found or small sample size.

Sample Year	Sex	Allometry		von Bertalanffy		
		alpha	beta	L-inf	K	t_0
2012	F	6.9 X 10^{-6}	3.17	273	0.34	-0.02
	M	4.5 X 10^{-6}	3.23	229	0.36	-0.16
	Combined	3.1 X 10^{-6}	3.31	259	0.34	0.00
2013	F	8.9 X 10^{-6}	3.10	273	0.34	-0.39
	M	4.4 X 10^{-6}	3.21	228	0.42	-0.43
	Combined	3.8 X 10^{-6}	3.25	259	0.31	-0.82
2014	F	5.9 X 10^{-6}	3.18	278	0.33	-0.18
	M	1.2 X 10^{-6}	3.46	226	0.42	-0.16
	Combined	2.9 X 10^{-6}	3.30	259	0.35	-0.13
2015	F	2.3 X 10^{-6}	2.92	278	0.27	-0.57
	M	3.2 X 10^{-6}	3.23	228	0.29	-0.68
	Combined	1.3 X 10^{-5}	3.03	267	0.26	-0.78
2016	F	3.4 X 10^{-6}	3.29	334	0.19	-0.95
	M	7.9 X 10^{-7}	3.56	215	0.60	0.01
	Combined	3.2 X 10^{-6}	3.30	340	0.15	-1.80
2017	F	5.2 X 10^{-6}	3.21	338	0.16	-1.58
	M	2.4 X10^{-6}	3.34	219	0.74	-0.16
	Combined	3.0 X 10^{-6}	3.31	310	0.15	-2.77
2018	F	1.6 X 10^{-5}	3.00	256	0.51	0.01
	M	1.5 X 10^{-6}	3.21	211	0.80	0.16
	Combined	7.8 X 10^{-6}	3.28	249	0.48	-0.11
2019	F					
	M	1.4 X 10^{-5}	3.02	284	0.26	-0.46
	Combined	1.7 X 10^{-4}	2.54	234	0.36	-0.25
		1.1 X 10^{-5}	3.06	280	0.24	-0.71
2020	F	1.6 X 10^{-5}	2.99	233	0.51	0.01
	M	2.4 X 10^{-5}	2.90	201	0.60	-0.12
	Combined	1.4 X 10-5	3.01	229	0.46	-0.19
2000 – 2020	F	4.7 X 10^{-6}	3.22	285	0.27	-0.47
	M	5.6 X 10^{-6}	3.18	226	0.37	-0.36
	Combined	3.2 X 10^{-6}	3.29	274	0.25	-0.71

Table 17. 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
2012	F	7.0×10^{-6}	3.08	374	0.18	-1.97
	M	1.5×10^{-6}	3.37	**258**	**0.29**	**-2.37**
	Combined	6.7×10^{-6}	3.09	292	0.34	-1.07
2013	F	9.2×10^{-6}	3.02	294	0.53	-0.02
	M	1.7×10^{-5}	2.92	**322**	**0.10**	**-6.10**
	Combined	1.5×10^{-5}	2.94	267	0.53	-0.23
2014	F	1.5×10^{-5}	2.94	308	0.39	0.12
	M	9.7×10^{-6}	3.03	276	0.30	-0.71
	Combined	1.5×10^{-5}	2.94	282	0.42	0.05
2015	F	1.7×10^{-5}	2.94	337	0.27	-0.41
	M	2.1×10^{-6}	3.32	234	0.52	-0.22
	Combined	9.6×10^{-6}	3.04	334	0.22	-0.98
2016	F	3.3×10^{-7}	3.66	300	0.34	-1.18
	M	3.6×10^{-6}	3.21	290	0.22	-1.85
	Combined	4.0×10^{-7}	3.62	269	0.45	-0.36
2017	F	2.1×10^{-4}	2.52	321	0.20	-1.90
	M	3.9×10^{-5}	2.79	282	0.18	-2.74
	Combined	3.8×10^{-5}	2.82	286	0.24	-1.59
2018	F	4.7×10^{-5}	2.75	318	0.35	-0.09
	M	4.0×10^{-6}	3.19	254	0.65	1.22
	Combined	2.1×10^{-5}	2.89	265	0.60	0.67
2019	F	2.6×10^{-5}	2.86	338	0.18	-2.82
	M	6.9×10^{-7}	3.52	267	0.34	-0.75
	Combined	9.5×10^{-6}	3.04	291	0.28	-1.43
2020	F	NSF		360	0.18	-2.22
	M	NSF		290	0.21	-1.85
	Combined	NSF		307	0.26	-1.27
2000 –2020	F	9.6×10^{-5}	2.63	300	0.37	-0.46
	M	9.0×10^{-6}	3.05	271	0.26	-1.48
	Combined	3.2×10^{-5}	2.82	270	0.40	-0.62

Table 18. 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
2012	F	1.4×10^{-6}	3.39	294	0.44	-0.06
	M	7.8×10^{-6}	3.06	258	0.46	-0.57
	Combined	7.7×10^{-7}	3.50	273	0.50	-0.27
2013	F	2.5×10^{-6}	3.31	**393**	**0.15**	**-2.02**
	M	1.5×10^{-5}	2.95	264	0.31	-0.39
	Combined	1.2×10^{-6}	3.44	294	0.29	-0.82
2014	F	9.0×10^{-6}	3.08	**410**	**0.10**	**-4.50**
	M	9.1×10^{-6}	3.05	250	0.45	-0.33
	Combined	4.8×10^{-6}	3.18	270	0.45	-0.25
2015	F	1.1×10^{-7}	3.89	**473**	**0.40**	**-12.80**
	M	1.7×10^{-5}	2.96	**246**	**1.52**	**0.33**
	Combined	7.5×10^{-7}	3.54	**248**	**1.45**	**0.31**
2016	F	1.4×10^{-6}	3.41	273	0.75	0.67
	M	$1.4 x 10^{-6}$	3.40	247	0.61	-0.04
	Combined	$9.2 x 10^{-7}$	3.48	263	0.59	0.04
2017	F	2.6×10^{-6}	3.28	298	0.56	0.63
	M	3.3×10^{-6}	3.23	253	0.46	-0.16
	Combined	1.1×10^{-6}	3.45	270	0.55	0.19
2018	F	2.5 X 10-6	3.31	347	0.28	-0.35
	M	1.4 X 10-6	3.40	238	0.47	-0.33
	Combined	1.3 X 10-6	3.42	349	0.23	-0.69
2019	F	1.2×10^{-6}	3.45	314	0.37	-0.27
	M	6.6×10^{-7}	3.54	242	0.55	-0.19
	Combined	5.7×10^{-7}	3.57	273	0.47	-.019
2020	F	3.5×10^{-6}	3.23	351	0.26	-0.71
	M	2.3×10^{-6}	3.30	249	0.44	-1.38
	Combined	1.8×10^{-6}	3.35	330	0.22	-1.61
1998 – 2020	F	4.4×10^{-6}	3.21	302	0.37	-0.37
	M	3.2×10^{-6}	3.24	242	0.53	-0.24
	Combined	2.0×10^{-6}	3.34	268	0.50	-0.17

Table 19. Estimated instantaneous fishing mortality rates (F) for white perch. NR= not reliable; NA=not available; MIN= minimal, at or near M estimate.

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Choptank[1]	0.35	0.57	0.31	0.31	0.23	0.42	0.32	0.40	0.77	0.52
Nanticoke	0.27	0.20	0.29	0.41	NA	0.49	0.41	0.43	0.47	NA
Upper Bay[1]	0.94	0.56	0.94	0.25	0.21	0.26	0.24	0.47	0.74	0.71

[1]Estimated F from stock assessment for 2011 – 2019 (Piavis and Webb Job 2, this report). 2020 estimated from length converted catch curves.

Table 20. Estimated instantaneous fishing mortality rates (F) for yellow perch. NR= not reliable; MIN=minimal, at or near M estimate.

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Choptank	MIN	0.05	0.01	0.41	NR	0.32	MIN	MIN	0.38	0.27
Upper Bay[1]	0.60	0.63	0.42	0.30	0.38	1.00	1.01	0.37	0.77	0.48

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

Figure 14. Baywide young-of-year relative abundance index for white perch, 1962 – 2020, based on EJFS data. Bold horizontal line=time series average. Error bars indicate 95% CI's.

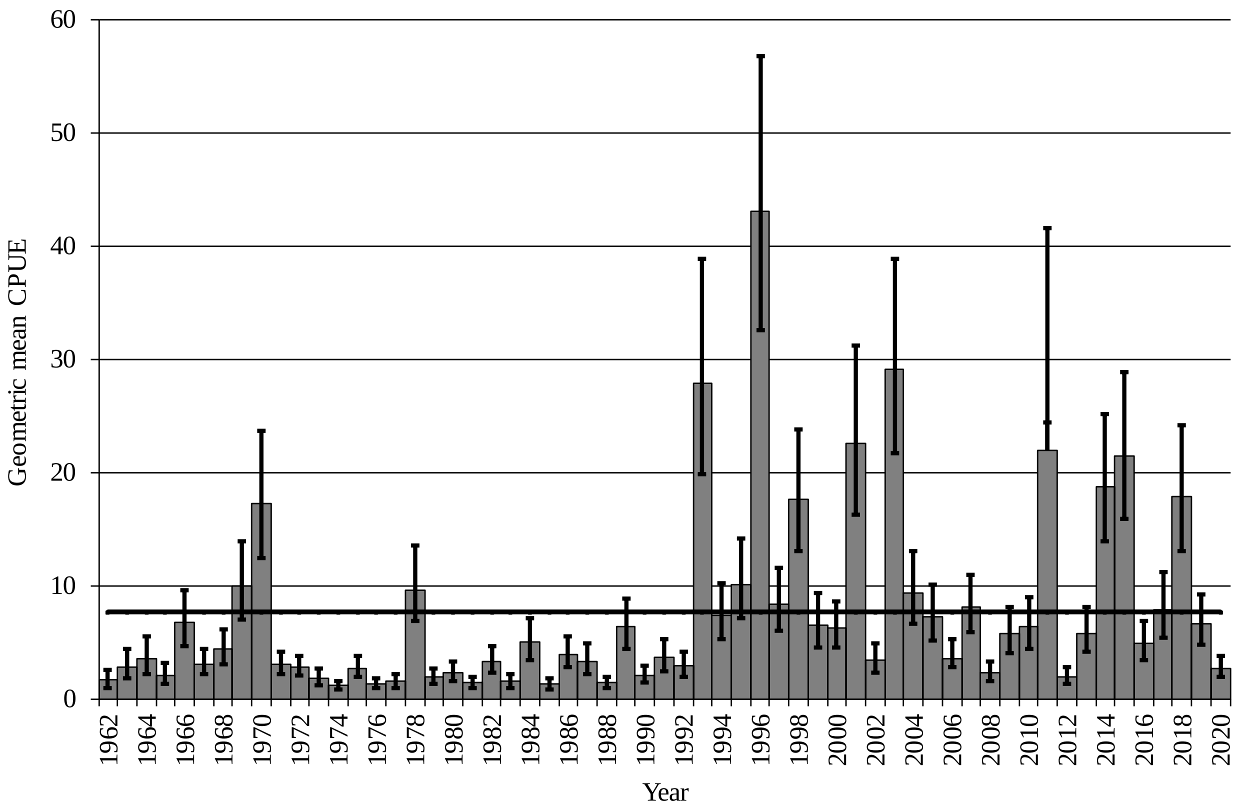


Figure 15. Age 1 white perch relative abundance from upper Chesapeake Bay winter trawl survey. Not sampled in 2004, small sample sizes 2003 and 2005. Error bars=95% CI.

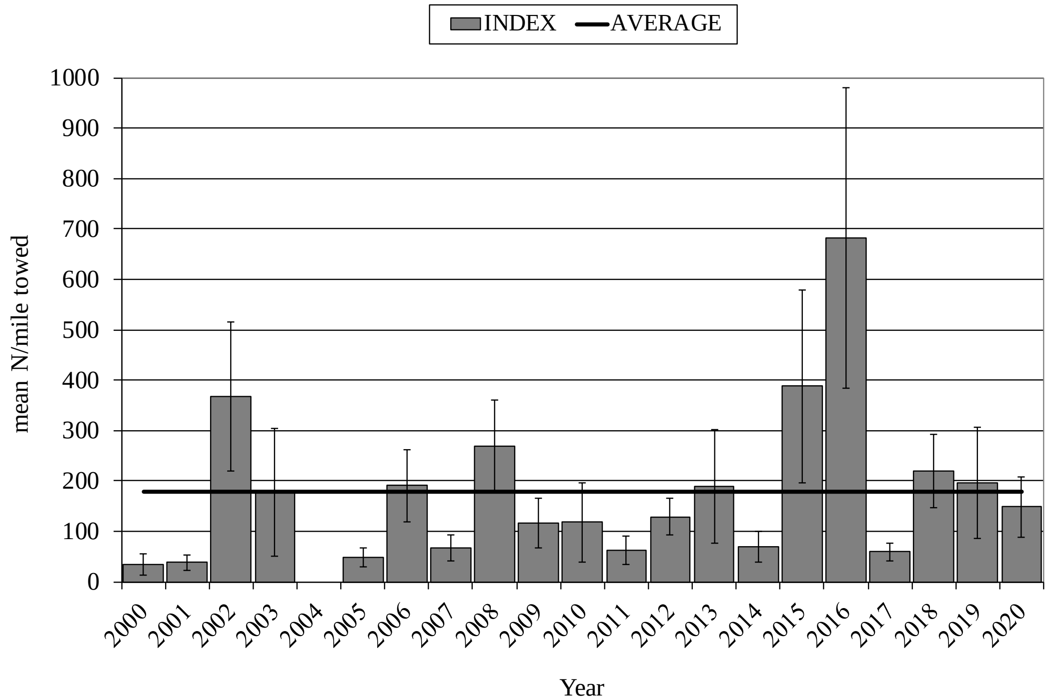


Figure 16. Head-of-Bay young-of-year relative abundance index for yellow perch, 1979 – 2020, based on Estuarine Juvenile Finfish Survey data. Horizontal line=time series average. Error bars indicate 95% confidence interval.

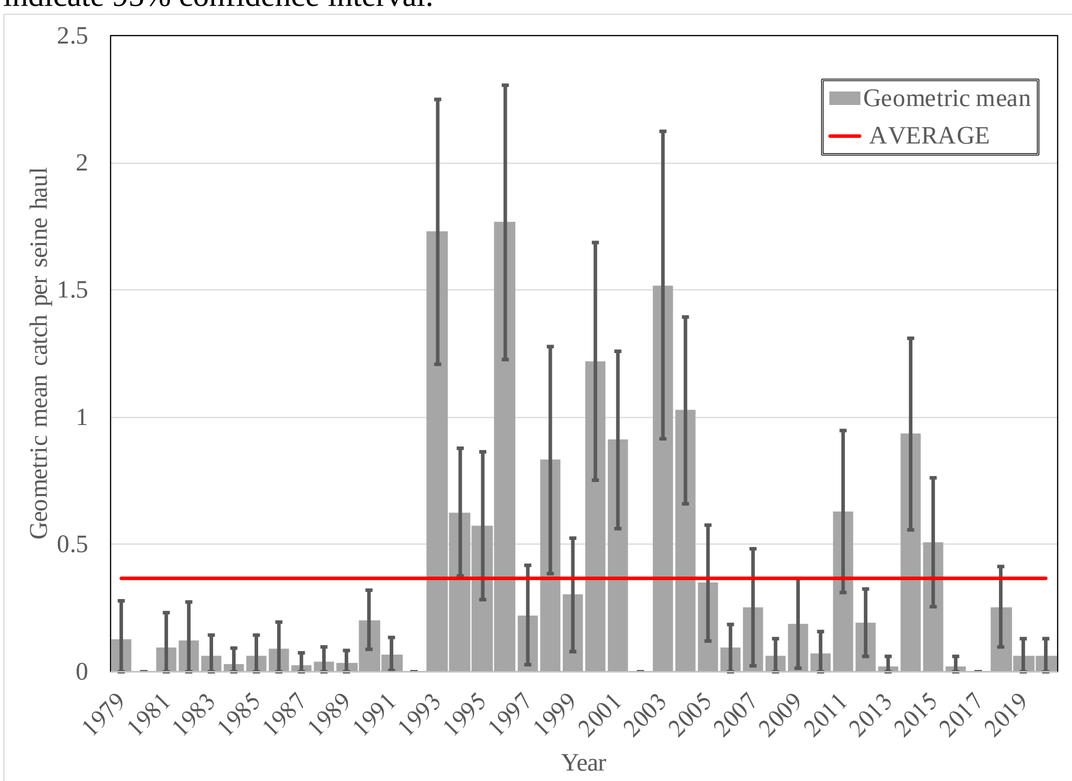


Figure 17. Age 1 yellow perch relative abundance from upper Chesapeake Bay winter trawl survey. Not sampled in 2004, small sample sizes 2003 and 2005. Error bars=95% CI.

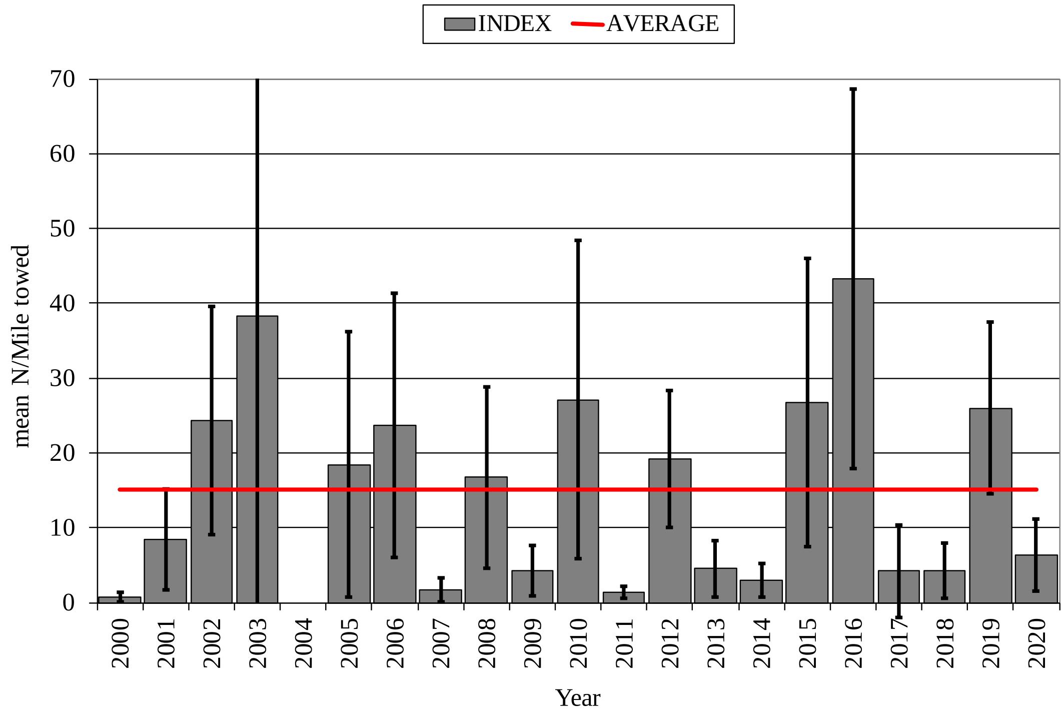


Figure 18. Age 1 channel catfish relative abundance from upper Chesapeake Bay winter trawl survey. Not sampled in 2004, small sample sizes 2003 and 2005.

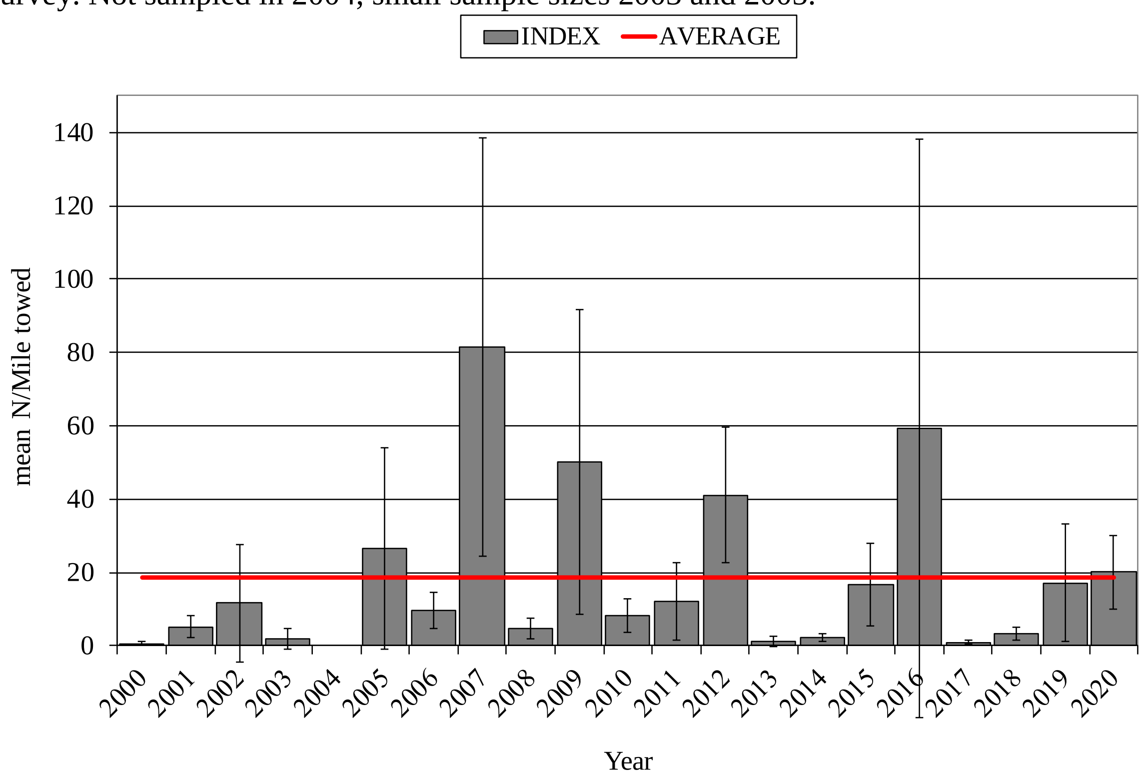


Table 21. White perch relative abundance (N/MILE TOWED) and number of tows from the upper Chesapeake Bay winter trawl survey, 2000 – 2020. Chester River sites included starting 2011.

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

Table 22. White perch relative abundance (N/net day) and total effort from the Choptank River fyke net survey, 2000 – 2020.

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

Table 23. Yellow perch relative abundance (N/MILE TOWED) and number of tows from the upper Chesapeake Bay winter trawl survey, 2000 – 2020.

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

Table 24. Yellow perch relative abundance (N/net day) and total effort from the Choptank River fyke net survey, 1988 – 2020.

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

Figure 19. Choptank River yellow perch relative abundance from fyke nets, 1988 – 2020. Effort standardized from 1 March – 95% total catch date.

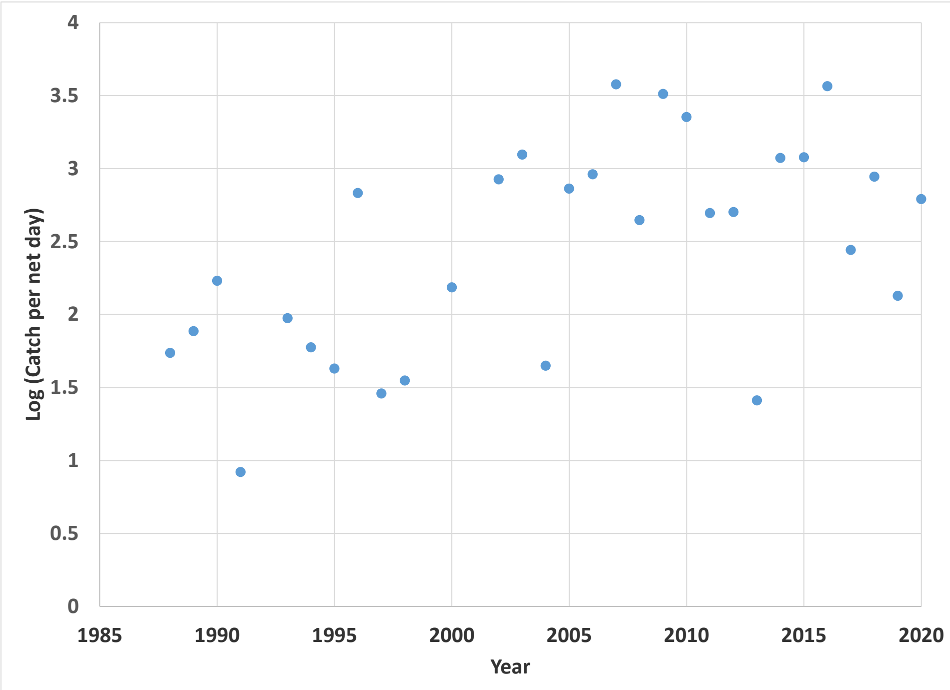


Figure 20. Channel catfish relative abundance (N/mile towed) from the upper Chesapeake Bay winter trawl survey, 2000-2020. Not surveyed in 2004, small sample sizes in 2003 and 2005.

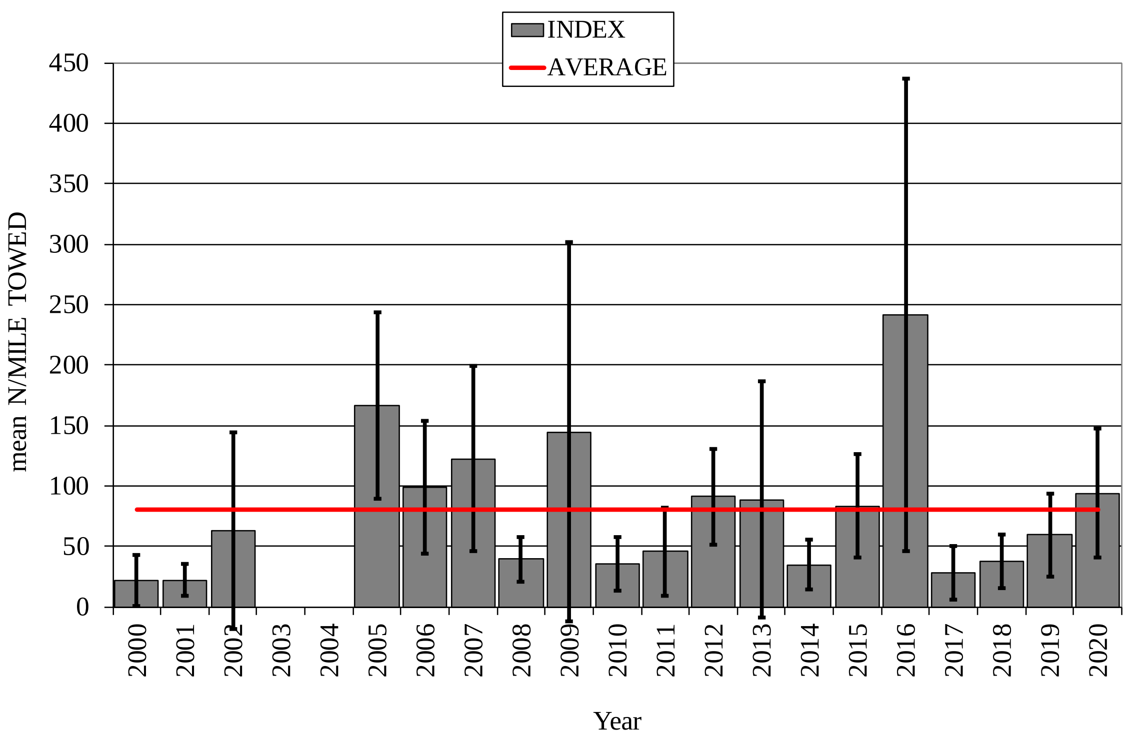


Figure 21. Channel catfish relative abundance (N/net day) from the Choptank River fyke net survey, 2000 – 2020. Horizontal line indicates time series average relative abundance.

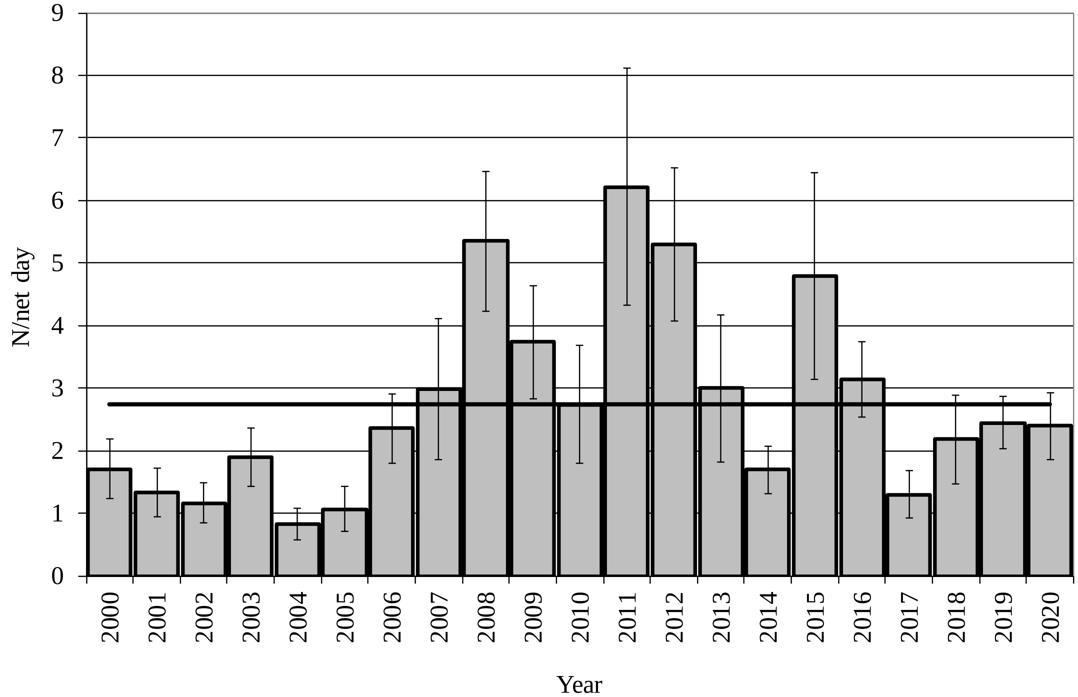
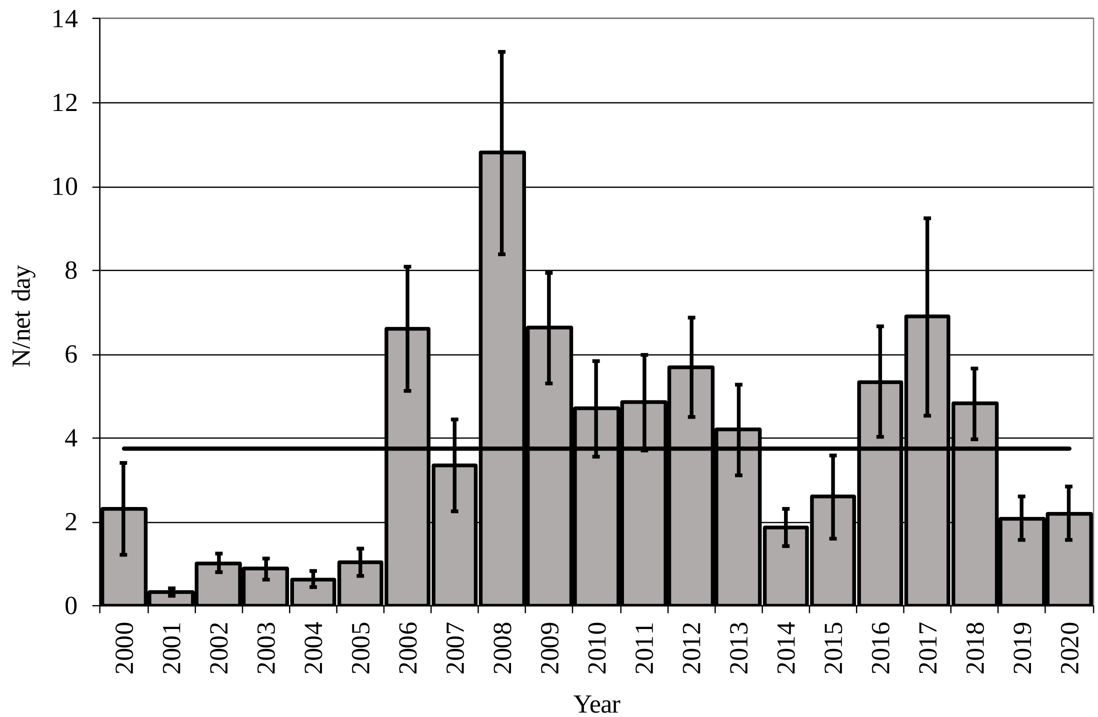


Figure 22. White catfish relative abundance (N/net day) from the Choptank River fyke net survey, 2000 – 2020. Horizontal line indicates time series average relative abundance.



PROJECT NO. 1
JOB NO. 2

POPULATION ASSESSMENT OF WHITE PERCH IN SELECT REGIONS OF CHESAPEAKE BAY, MARYLAND

Prepared by Paul G. Piavis and Edward Webb, III

INTRODUCTION

The objectives of Job 2 were to assess white perch stock size, describe trends in recruitment and mortality, and compare current fishing mortality estimates with previously identified biological reference points (Piavis and Webb 2006). White perch (*Morone americana*) are semi-anadromous fish that inhabit east coast ecosystems from South Carolina to Nova Scotia and are especially abundant in Chesapeake Bay. In Maryland, white perch migrate into tributaries to spawn in March and April. Spawning normally occurs when water temperatures reach 12 - 14°C and at salinities less than 4.2 ppt (Setzler-Hamilton 1991).

White perch fisheries are important in the Chesapeake Bay region. Based on the Marine Recreational Information Program (MRIP; National Marine Fisheries Service, Fisheries Statistics Division, personal communication), Maryland's 2019 recreational white perch landings (inland only) were 2.02 million pounds, and averaged 956,636 pounds from 2015 – 2019. White perch also support a robust commercial fishery in Maryland. Commercial white perch landings were 1.10 million pounds in 2019 and averaged 1.59 million pounds from 2015 – 2019.

Maryland's white perch stocks were last assessed in 2017 (Piavis and Webb 2018). The 2017 assessment modeled upper Bay white perch dynamics with a Catch Survey Analysis (CSA) based on Maryland Department of Natural Resources (MDNR) winter trawl fishery independent data (see Job 1) for the years 2000 -- 2020. The CSA model was also utilized to describe the population dynamics of white perch in the Choptank River based on fishery independent MDNR fyke net survey data (1989 – 2020). The data poor status of lower Bay stocks necessitated a qualitative approach of inspecting fishery dependent relative abundance indices and fishery independent indices, including a young-of-year index from the Estuarine Juvenile Finfish Survey (EJFS; Project 2 Job 3 Task 3), and an adult white perch relative abundance index from the Potomac River Striped Bass Spawning Stock Survey which is a drift gill net survey (SBSSS; Project 2, Job 3).

The current assessment utilized the identical framework/models as the 2017 assessments with the addition of 3 more years of data. Model results were compared against proposed biological reference points (Piavis and Webb 2006) to determine overfishing status in the upper Bay and Choptank River. In addition, this updated assessment provided important information regarding management of this species, particularly in the upcoming preparation of the Chesapeake Bay White Perch Fisheries Management Plan.

METHODS

Catch Survey Analysis Model Structure

Model Description

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

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

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

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

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

$$r_t = R_t\, q \quad [2]$$

and,

$$p_t = P_t\, q\, \Phi \quad [3]$$

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

$$\Phi = s_p/s_r \qquad [4]$$

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

Substituting [2] and [3] into equation [1] yields

$$r_{t+1} = (r_t + p_t / \Phi) e^{-M} - q C_t e^{-Mt(1 - Tt)} \qquad [5]$$

This assessment reparameterized the model to allow for missing survey data (Mensil 2003a). Instead of solving for expected survey indices, this model searches and solves for actual pre-recruit abundance (P) and the first year's post-recruit abundance (R_1). Subsequent post-recruit abundance is determined from equation [1].

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

$$q_{avg} = e^{(1/n) * \sum (\log_e (n_t/N_t)} \qquad [6]$$

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

$$p_{exp,\,t} = P_t/(q_{avg} * \Phi) \qquad [7]$$

$$r_{exp,\,t} = R_t/q_{avg} \qquad [8].$$

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

$$SSQ = W_p * \sum (\log_e (p_{obs,\,t}) – (\log_e (p_{exp,\,t}))^2 + W_r * \sum (\log_e (r_{obs,\,t}) – (\log_e (r_{exp,\,t}))^2 \; [9]$$

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

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

$$h_t = C_t / ((P_t + R_t) * e^{-Mt*Tt}) \quad [10]$$

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

$$F_t = -\log_e(1-h_t). \quad [11]$$

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

Inputs Common to both Assessments

The CSA model requires an estimate of M, Φ (a scalar relating pre-recruit selectivity to post recruit selectivity (equation [4])), survey indices of pre-recruit (p_t) and post-recruit (r_t) abundance, and total removals (C_t). Pre-recruits were those white perch between 185 and 202 mm TL. Post-recruit white perch were those fish greater than 202 mm TL because the commercial fishery operates under a 203 mm TL minimum size limit. The pre-recruit length range was selected because that range of sublegal white perch will likely recruit to the fishery in the following year.

Natural mortality was set at a constant M = 0.2 for both analyses. This value was selected based on the maximum white perch longevity from age studies from all Maryland Department of Natural Resources (MDNR) Fisheries Service surveys. The scalar Φ was 1.0 for both assessments based on length frequency diagrams of catches from the upper Bay winter trawl survey and the Choptank River fyke net survey (Figures 1 and 2). Time of removals (T) was set at mid-year (0.5).

Upper Chesapeake Bay Catch Survey Analysis Model

Fishery Independent Catch per Unit Effort Indices

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. Eighteen sampling stations, each approximately 2.6 km (1.5 miles) in length and variable in width, were created throughout the study area (Figure 3). Data were not available for the 2003 sampling season due to ice coverage, and the retirement of the vessel captain prevented us from sampling during 2004. The study area was divided into four sampling areas; Sassafras River (4 sites), Elk River (4 sites), upper Chesapeake Bay (6 sites), and middle Chesapeake Bay (4 sites). Each sampling station was divided into west/north or east/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 in the wings and 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 3 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. All species caught were identified and counted. A minimum of 50 fish per species were sexed and measured. 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. In addition, when white perch catches were greater than 50 fish, the proportion of pre-recruit white perch (185 mm -- 202 mm) and the proportion of post-recruit white perch (>202 mm) were determined and the total number of each phase was derived by multiplying the proportion by the total white perch catch per statute mile.

Removals

Harvest estimates (removals) were determined for upper Chesapeake Bay commercial and recreational fisheries. Commercial harvesters are required to submit daily landings by river system and gear type (Lewis 2010). There are 3 primary commercial gears: fyke nets, pound nets, and drift gill nets. Average length of white perch from fyke nets and pound nets was estimated from Fisheries Service surveys in Choptank River (fyke nets) and Nanticoke River (fyke and pound nets). Average length of white perch in the drift gill net fishery was estimated from the Fisheries Service Striped Bass Spawning Stock Survey (SBSSS). The SBSSS is a drift gill net survey in the spring of each year centered in the upper Bay (see Project 2 Job 3). Average weight for all subfisheries was determined by applying average lengths to annual allometric equations (Job 1). Numbers of commercially caught white perch were determined by dividing gear specific harvest (pounds) by the estimated average weight of the gear specific catch.

Recreational white perch harvest for upper Chesapeake Bay was estimated from angler intercept and effort data compiled by MRIP (National Marine Fisheries Service, Fisheries Statistics Division, personal communication). Data were queried to include only those counties bordering the upper Bay to formulate an area-specific catch estimate (in numbers). Inspection of CV's of estimates indicated that these data were suitable for inclusion in our analysis.

Uncertainty

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

Choptank River Catch Survey Analysis Model

Fishery Independent Catch per Unit Effort Indices

Fyke nets sampled resident and anadromous fishes and were fished two to three times per week. Fisheries Service fyke nets were located from river km 65.4 to km 78.1 (Figure 4).   The Choptank River is tidal and generally fresh at the five survey sites. However, during the severe drought of 2001 - 2002, salinity increased to 6 ppt, but has never exceeded white perch tolerance limits (18 ppt; Setzler-Hamilton 1991).

Fyke net bodies were constructed of 64 mm stretch-mesh and 76 mm stretch-mesh for both the wings (7.6 m long) and leads (30.5 m long). Nets were set perpendicular to the shore with the wings positioned approximately 45° from the lead. In some instances, the leads were shortened where river depth exceeded practical deployment. Generally, fyke net bodies were located in 1.3 - 3.0 m water depth at low tide.

Net hoops were brought aboard first to ensure that all fish were retained. Fish were then removed and placed into a sorting tank and identified. All fish were counted and a subsample of 30 white perch was sexed and measured (mm TL).

Effort varied considerably as the project moved from a pilot phase to a more integrated monitoring program for white perch, yellow perch, channel catfish, and white catfish. Only two fyke net sets were monitored during 1989 - 1991. Three fyke net sets were used during 1992, and five fyke net sets were fished from 1993 to 2005. Locations were consistent during 1993 - 2005, except for the uppermost net where conflicts arose with commercial gear. This necessitated moving this net set approximately 500 m down stream. In 2006, an additional fyke net site was added.

Removals

For the Choptank River assessment, average length of white perch caught in the gill net fishery was determined from data collected between 1989 - 1994 and 1996 by the MDNR Fisheries Service SBSSS gill net survey in the Choptank River. Data from the MDNR Fisheries Service upper Bay SBSSS was utilized for the 1995 and 1997 –2019 mean length estimates. Length data from the Choptank River fyke net survey were utilized to characterize mean lengths of legal white perch from the pound net and fyke net fisheries. Average lengths were transformed to average weight with annual allometric equations (Job 1). Total numbers harvested was estimated as total catch by gear type divided by average weight of legal white perch.

The same approach for estimating recreational removals in upper Chesapeake Bay was attempted for Choptank River, but annual CV's were generally too poor throughout the time series. Therefore, we selected the annual Choptank River specific estimates with CV's less than 40%. For those years, a ratio of Choptank recreational harvest: baywide recreational harvest was determined. Those values were averaged and used as a multiplier and applied to annual baywide catch estimates to then estimate recreational removals in Choptank River.

Uncertainty

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

Lower Chesapeake Bay Relative Abundance Indices

Fishery Dependent

Fishery dependent relative abundance indices were calculated from the three primary commercial fishing gears: fyke nets, pound nets, and drift gill nets. The MDNR commercial landings database was queried for landings and effort for the three main gear types for all areas below the Preston Lane Memorial Bridges. All license holders reporting more than 1,000 pounds landed per month were included in the index. Total effort for fixed gear (fyke nets and pound nets) was calculated as the number of nets fished during any one month. Drift gill net effort was 1,000 gill net feet per hour. Catch-per-unit effort (CPUE) was total pounds landed divided by total effort. Effort records were intermittent throughout the earlier portion of the time series, but in general, data were available from 1980 – 1985, 1990 and 1992 – 2019.

Fishery Independent

Fishery independent relative abundance indices were calculated from the EJFS seine survey. The index was the geometric mean of the number of juvenile white perch from all sites below the Bay Bridges from 1962 – 2019.

Fisheries Service has conducted a striped bass drift gill net survey in the Potomac River since 1985 (Project 2 Job 3). Catch data for adult white perch from the survey were used to formulate a geometric mean index (N), restricted to white perch caught in mesh sizes less than 5-inch stretched mesh from March through May.

RESULTS

Upper Chesapeake Bay Catch Survey Analysis Model

Estimated total white perch removals by the commercial and recreational fisheries in the upper Bay averaged 2.3 million white perch during 2000 – 2019. Landings declined from 2000 (2.8 million) to a time series low in 2008 of 1.1 million white perch, and then varied from 1.5 – 3.0 million fish through 2018. In the final year, estimated removals increased to 4.2 million white perch (Figure 5). Pre-recruit CPUE's from the fishery independent trawl survey were range-bound 2000 – 2012, but increased to high levels after 2013 (Figure 6). The 2016 CPUE was the highest in the time series. The final three years produced lower indices, but they were still somewhat greater than the 2000 – 2012 time period. Post-recruit white perch CPUE's mimicked the decline in landings, falling from higher values in 2000 to the lowest in the time series in 2007 (Figure 7). The CPUE's were higher during 2015 – 2018 than any other four-year period, but indices in 2019 and 2020 declined rapidly.

Total population abundance (pre- and post-recruits combined) decreased from 5.9 million white perch in 2000 to 2.6 million fish in 2006 (Figure 8). Total abundance rose to 10.6 million white perch in 2016 before a gradual decline to 8.7 million fish in the terminal year (2020). Pre-recruit abundance (185 mm TL – 202 mm TL) ranged from 1.5

million white perch in 2006 to 5.3 million in 2015, and averaged 3.2 million during 2000 – 2019. Post-recruit white perch abundance ranged from 0.5 million white perch in 2007 to 6.9 million fish in 2018, and averaged 2.9 million fish. Instantaneous fishing mortality (F) varied throughout the time series from F=0.22 (2017) to F=1.4 (2006; Figure 9). Final year F was 0.69 and averaged 0.68 during 2000 – 2019.

A suite of biological reference points was determined for Chesapeake Bay white perch in a previous assessment (Piavis and Webb 2006). Spawning stock biomass per recruit analysis determined maximum spawning potential (MSP) reference points. Given the early time at first maturity, $F_{30\%}$ (target) and $F_{20\%}$ (limit) MSP reference points were selected for white perch. Target F and limit F were 0.6 and 1.12, respectively. Estimated F marginally exceeded limit F in 2003 and 2006. Over the final five years (2015 – 2019), F was well below target F except in 2019 when F slightly exceeded the target (Figure 9).

Bootstrap evaluation of the model indicated precise results. Of the 5,000 bootstrap trials, 98.8 % were successful. Catchability was precisely estimated (CV=12.3 %). Pre-recruit abundance estimates were less precise compared to other Chesapeake Bay white perch assessments, but they were still deemed acceptable with CV's ranging from 13.0 % in 2003 to 36.6 % in 2019 (Table 1). Post-recruit white perch abundance estimates generally ranged from 21 % to 35 %, with an extremely high value of 78% in 2003 which corresponded to a year when the trawl survey was idled. Confidence intervals (80%) of pre-recruit and post-recruit abundance were determined from bootstrap samples (Figures 10, 11). Confidence intervals around the abundance estimates indicated that abundance was precisely estimated but larger confidence intervals were evident over the final five years. Confidence intervals of fishing mortality indicated that F was estimated very precisely, except for 2002 and 2003 when the trawl survey was idled (Figure 12).

Choptank River Catch Survey Analysis Model

Total removals by the commercial and recreational fisheries from the Choptank River rose nearly linearly from 250,000 white perch in 1989 to a peak removal of 1.5 million fish in 1997 (Figure 13). Recently, removals have rebounded from 503,000 white perch in 2014 to 1.3 million fish in 2019. Pre-recruit fishery independent CPUE values showed a generally increasing trend over a large portion of the time series, but the index has declined since 2007 (Figure 14). Post-recruit white perch CPUE was flat from 1989 – 1998 (Figure 15). The post-recruit index exhibited an increasing trend from 1998 – 2010 before declining through 2019.

Choptank River white perch data fit the CSA model well. Total population abundance in numbers increased from 1.0 million white perch in 1989 to more than 4.0 million fish during 2006 -- 2011(Figure 16). Since 2011, abundance varied between 2.1 million and 3.7 million white perch. Pre-recruit abundance (185 mm – 202 mm) ranged from 467,000 white perch in 1989 to 2.2 million in 2015 before declining to 567,000 in 2019. Post-recruit white perch abundance increased from 1.1 million white perch in 1989 to 4.7 million fish in 2010. Since 2010, post-recruit abundance declined to 1.7 million fish in the terminal year (2020). Instantaneous fishing mortality (F) increased through 1997 followed by a general decline through 2010 (Figure 17). Since 2010, F increased; final year F was 0.77.

Comparing the derived F with the proposed biological reference points indicated that F limit was never exceeded and F target was breeched in only three of 31 years.

During the final five years (2015 through 2019) F increased from 0.23 to 0.78, above target F (Figure 17).

Bootstrap evaluation of the model indicated precise results. Of the 5,000 bootstrap trials, over 99 % were successful. Catchability was very precisely estimated at 2.1 % (CV). Pre-recruit abundance fit very well with CV's, ranging from 20 % in 1997 to 34 % in 2016 (Table 2). CV's of fully recruited white perch ranged from 12 % in 2011 to 28 % in 1998. Confidence intervals (80%) of pre-recruit and post-recruit abundance and fishing mortality (F) were also determined from bootstrap samples (Figures 18, 19, 20).

Lower Chesapeake Bay Relative Abundance Indices

Fishery Dependent

Fishery dependent relative abundance indices from three gear types produced similar information. The fyke net index was variable from 2015 through 2019, with relative abundance values oscillating around the time series median (Figure 21). The final year (2019) was considerably above the median, and was the sixth highest value out of 34 years of data. The pound net index had anomalously high values in 2001, 2005, and 2014 which greatly distorted the scale and tended to mask population trajectories. However, the general recent trend from 2015 – 2019 was variable, ending slightly below median values (Figure 22). The drift gill net index increased from 2013 – 2018, and was decidedly above median values in each of those five years (Figure 23).

Fishery Independent

An adult white perch relative abundance index was derived from a striped bass spawning stock survey (drift gill net) in the Potomac River. The index was generally noisy, but corroborated the fishery dependent indices' signal of high abundance around 2004 – 2005 with a decline through 2009 (a time series low; Figure 24). As with the fishery dependent relative abundance values, the fishery independent survey indicated higher relative abundance 2011 – 2017. The 2019 fishery independent relative abundance value was well above median values, similar to the fyke net and drift fill net fisheries.

A juvenile abundance index was derived from a long-term seine survey. Sites from the lower Bay produced strong recruitment from the early 1990's through the mid 2000's (Figure 25). The index trended lower during 2005 – 2010, but recruitment levels were more similar to the late 1960's than the period of extended poor recruitment (1971 – 1986). Recruitment appeared strong in 2011, 2014, 2015 and 2018. The recruitment index was at or above median values in four of the last five years (2016 – 2020). An eight-year moving average was also estimated to encompass the majority of the fish in the population. This exercise indicated a stable population at middling levels during 2007 – 2013, but the strong recruitment years of 2014 and 2015 pushed the moving average much higher through 2017. This full population index has remained considerably higher over the last 20 years when compared to the first 25 years (Figure 25).

DISCUSSION

The catch survey analysis (CSA) can be a powerful assessment tool when catch-at-age data is limiting or non-existent (Collie and Sissenwine 1983; Mesnil 2003b). Published CSA assessments have focused on various crab and shrimp species because of the difficulty in aging invertebrates (Cadrin et al 1999; Collie and Kruse 1993; Zheng et al 1997). Simulation studies have documented the CSA's utility, but it is less widely implemented for finfish stocks despite the fact that the initial publication of the model dealt with haddock and flounder stocks (Collie and Sissenwine 1983). Surplus production modeling and CSA modeling were compared on synthetic data sets that mimicked the life history and fisheries of Gulf of Maine northern shrimp (Cadrin 2000). Results indicated that CSA was superior to surplus production models in assessing stock size. As with many fisheries models, the CSA performed best when there was contrast in population size over time and was sensitive to imprecise survey data.

The CSA assessed white perch dynamics for two systems, the upper Chesapeake Bay covering all areas north of the Preston Lane Memorial Bridges, and the Choptank River. Upper Chesapeake Bay commercial white perch landings accounted for 32% of total Maryland Chesapeake Bay landings, and commercial landings from the Choptank River accounted for 18% of total baywide landings in 2018 and 2019 (50% of statewide total). Recreational removals in the upper Bay accounted for, on average, 56% of the baywide recreational harvest, by weight, over the two-year period, 2018 and 2019. Recreational removals in the Choptank River accounted for, on average 15% of the baywide recreational harvest over the two-year period (2018 and 2019). Therefore, these two systems accounted for 71% of the recreational harvest during that time period.

Upper Chesapeake Bay Assessment

The upper Chesapeake Bay assessment covered the 2000 – 2019 timeframe. The previous assessment evaluated utilizing a shorter time series (beginning 2006) because fishery independent indices were not available for 2003 – 2005 (Piavis and Webb 2018).

Results from the shortened time series were within full data confidence intervals and varied less than ten percent from the base model. Since results were robust between the two models, we opted to run the full dataset for this assessment.

The upper Bay post-recruit abundance rose to very high levels in 2016 – 2019 before falling in 2020. Confidence intervals were relatively large for those years, indicating some uncertainty. Recreational removals, as estimated by the Marine Recreational Information Program (MRIP; Personal communication from National Marine Fisheries Service, Fisheries Statistics Division, 1 August 2020), were very large in 2019. This high estimate was likely influenced by the MRIP-recalibration process that occurred in 2018. Comparing the recreational estimates to reported commercial landings indicated that the new estimation process may have unrealistically influenced recreational harvest estimates.

Biological reference points utilized to assess stock status appear appropriate, but the influence of larger recreational removal estimates due to MRIP recalibration needs to be evaluated. Higher estimated removals and rising relative abundance indices suggest that a higher F can be sustained. Based on the bootstrap distribution of the 2019 estimate, there was a 74 % chance that F was above target, but there was only a 2 % chance that overfishing was occurring, *i.e*, that F exceeded F_{limit}. Therefore, overfishing was not occurring and given current population levels relative to previous years, it is unlikely that the stock is overfished.

Choptank River Assessment

The Choptank River white perch assessment covered the years 1989 – 2019, utilizing a fishery independent fyke net survey as the relative abundance index. The previous assessment investigated utilizing a shorter time series, beginning in 1993, because fishing effort was lower during the period 1989 – 1992 compared to 1993 onward (Piavis and Webb 2018). Results indicated that there was little benefit in shortening the time series, so this assessment utilized the full time series.

The model run for Choptank River white perch indicated that total population abundance declined after reaching a peak in 2011 (time series = 1989 – 2019). Pre-recruit abundance, the ultimate driver of exploitable biomass, was at higher levels for a large part of the time series, at least from 1997 – 2007. Since 2007, estimated pre-recruit abundance declined except for 2015 which probably consisted of the large 2011 year class.

Post-recruit abundance showed dramatic increases from the early 2000's through 2011. Removals were fairly variable throughout the survey, with < 800,000 removals prior to 1997. During the period 1997 – 2004, removals ranged from 800,000 to about 1.5 million. Removals were generally < 800,000 since 2004, but estimates for 2011 and 2012 were in excess of 1 million fish annually. Removals increased through 2019 likely as a result of increased post-recruit abundance due to the of strong year classes in 2011, 2014 and 2015. The terminal year (2019) total population abundance (pre- and post-recruit combined) was at about median levels.

Fishing mortality rates exhibited a declining trend, 1997 – 2009, but increased from 2009 through 2019. The terminal (2019) F rate was above F_{target}. Terminal year F estimate was 0.77 (F_{target} = 0.60). Estimated F rates are not statistically derived from the model, so a fair degree of uncertainty remains due to the deterministic approach of estimating F and the amount of uncertainty in quantifying recreational removals. The

MRIP recalibration discussed in the upper Chesapeake Bay assessment discussion applies to the Choptank River assessment also, but higher harvest levels do not appear to be as drastic. Stock specific estimates of F from age data or other methods need to be investigated for comparisons to biological reference points.

White perch stock status in the Choptank River was similar to the upper Bay population. The bootstrap distribution of terminal F indicated that there was a 90% chance that F was above F_{target}, but only a 3 % chance that overfishing was occurring, *i.e.*, that F exceeded F_{limit}. In addition, in that the total population level was near the time series median and post-recruit white perch abundance was greater than the time series median, it is unlikely that the stock is overfished.

Lower Chesapeake Bay Assessment

The lower Bay assessment was qualitative in nature. Fishery dependent indices of relative abundance were not identical, but they did provide a general indication of stock trends. All three fishery dependent indices showed a generally increasing trend up to 2004 or 2005. Over the last ten years, the fyke net index was above median level six times, the pound net index was above median levels five times and the gill net index was above median values nine times. The fyke net index and gill net index were considerably above median levels in 2019. The pound net index was at median levels but this index is likely less informative of stock status (Piavis and Webb 2018).

The fishery independent indices corroborated the fishery dependent fyke net and drift gill net indices. The experimental gill net index bottomed in 2009 and increased through 2017. Fyke net, drift gill net and experimental drift gill net surveys were very similar in this response and all three indices had high index values relative to their medians in 2019. Therefore, overfishing likely did not occur. Similarly, the young-of year index indicated a period of high productivity from the mid 1990's through 2004. The eight-year moving average, utilized as a proxy for population trends for 1 to 8-year old white perch, suggested that abundance did decline after 2003, but stabilized during the period 2010 – 2014. The 2018 moving average was the highest since 2003, declined slightly in 2019, but exceeded all values from 1962 -- 1996.

PROJECT NO. 1
JOB NO. 2

POPULATION ASSESSMENT OF CHANNEL CATFISH IN SELECT REGIONS OF CHESAPEAKE BAY, MARYLAND

2021 PRELIMINARY RESULTS – WORK IN PROGRESS

Job 2 is designed to assess white perch, yellow perch and channel catfish on a rotating, triennial basis. The channel catfish assessment is currently in progress. The upper Chesapeake Bay assessment and the Choptank River assessment will utilize a surplus production model. The population models have been written, and now that commercial and recreational harvest data are finalized preliminary runs were finished. Other models will also be explored with the available data. Channel catfish relative population abundance will be inferred from fishery dependent indices for areas other than the upper Chesapeake Bay and the Choptank River.

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Table 1. Uncertainty parameters for upper Chesapeake Bay white perch CSA model (q=catchability).

Estimate/Parameter	Estimate	Mean	Median	CV	Bias[1]
q	1.13E-05	1.20E-05	1.19E-05	12.3	-4.7
Pre-Recruit N 2000	2,232,721	2,295,716	2,047,895	36.1	9.0
Pre-Recruit N 2001	2,832,289	2,866,197	2,702,384	28.6	4.8
Pre-Recruit N 2002	1,638,614	1,806,432	1,437,204	47.5	14.0
Pre-Recruit N 2003	3,326,544	3,235,408	3,228,076	13.0	3.1
Pre-Recruit N 2004	3,397,858	3,324,584	3,353,540	17.6	1.3
Pre-Recruit N 2005	2,107,077	2,117,953	2,074,448	24.8	1.6
Pre-Recruit N 2006	1,487,276	1,501,528	1,480,901	22.2	0.4
Pre-Recruit N 2007	4,979,933	4,893,740	4,831,945	13.9	3.1
Pre-Recruit N 2008	1,863,242	1,889,346	1,728,596	33.8	7.8
Pre-Recruit N 2009	3,334,903	3,300,531	3,189,912	26.1	4.5
Pre-Recruit N 2010	2,802,851	2,829,522	2,713,074	27.5	3.3
Pre-Recruit N 2011	2,519,092	2,509,737	2,450,579	25.1	2.8
Pre-Recruit N 2012	1,928,203	1,946,454	1,837,736	29.3	4.9
Pre-Recruit N 2013	3,920,307	3,887,869	3,790,125	21.0	3.4
Pre-Recruit N 2014	4,397,349	4,303,084	4,084,501	29.0	7.7
Pre-Recruit N 2015	5,259,775	5,153,025	4,857,554	30.0	8.3
Pre-Recruit N 2016	5,029,566	4,982,404	4,636,317	32.0	8.5
Pre-Recruit N 2017	3,874,132	3,874,162	3,477,948	36.4	11.4
Pre-Recruit N 2018	3,632,915	3,684,603	3,276,727	36.2	10.9
Pre-Recruit N 2019	3,319,392	3,446,492	3,086,113	36.6	7.6
Post-Recruit N 2000	3,665,040	3,552,187	3,562,160	24.2	2.9
Post-Recruit N 2001	2,229,223	2,188,403	2,158,675	29.0	3.3
Post-Recruit N 2002	1,990,608	1,984,949	1,850,047	34.2	7.6
Post-Recruit N 2003	1,052,207	1,184,972	955,450	77.8	10.1
Post-Recruit N 2004	1,122,526	1,156,609	1,077,918	48.1	4.1
Post-Recruit N 2005	1,691,403	1,659,316	1,626,129	28.7	4.0
Post-Recruit N 2006	1,130,758	1,113,391	1,108,557	28.6	2.0
Post-Recruit N 2007	496,094	493,545	475,764	35.5	4.3
Post-Recruit N 2008	1,962,193	1,889,536	1,840,916	30.0	6.6
Post-Recruit N 2009	2,150,468	2,112,354	2,069,777	28.0	3.9
Post-Recruit N 2010	3,074,175	3,014,828	2,979,901	24.0	3.2
Post-Recruit N 2011	2,167,995	2,141,242	2,116,704	27.9	2.4
Post-Recruit N 2012	1,457,048	1,427,485	1,386,704	31.1	5.1
Post-Recruit N 2013	1,573,377	1,564,115	1,505,834	31.7	4.5
Post-Recruit N 2014	2,022,574	1,988,434	1,901,994	33.7	6.3
Post-Recruit N 2015	3,948,353	3,843,224	3,683,235	28.6	7.2
Post-Recruit N 2016	5,613,980	5,440,508	5,295,578	25.9	6.0
Post-Recruit N 2017	6,558,916	6,378,276	6,275,396	23.6	4.5
Post-Recruit N 2018	6,854,015	6,706,145	6,647,368	21.9	3.1
Post-Recruit N 2019	5,998,280	5,919,532	5,804,730	23.4	3.3
Post-Recruit N 2020	3,844,538	3,884,125	3,715,562	34.4	3.5

[1]Bias as defined as (est-median)/median

Table 2. Uncertainty parameters for Choptank River white perch CSA model. (q=catchability).

Estimate/Parameter	Estimate	Mean	Median	CV	Bias1
q	1.87E-05	1.93E-05	1.93E-05	2.1	-3.1
Pre-Recruit N 1989	467,681	490,783	468,337	30.3	-0.1
Pre-Recruit N 1990	979,029	969,159	949,944	23.2	3.1
Pre-Recruit N 1991	501,654	524,241	496,704	30.3	1.0
Pre-Recruit N 1992	891,439	886,840	864,515	23.9	3.1
Pre-Recruit N 1993	826,066	827,765	808,418	24.2	2.2
Pre-Recruit N 1994	1,167,463	1,158,192	1,134,555	22.2	2.9
Pre-Recruit N 1995	1,103,527	1,112,798	1,080,891	24.8	2.1
Pre-Recruit N 1996	1,555,179	1,530,590	1,510,879	21.5	2.9
Pre-Recruit N 1997	1,534,110	1,532,776	1,519,118	20.5	1.0
Pre-Recruit N 1998	1,199,113	1,201,912	1,166,012	24.9	2.8
Pre-Recruit N 1999	1,781,216	1,734,790	1,704,739	21.4	4.5
Pre-Recruit N 2000	1,133,502	1,152,035	1,109,793	27.2	2.1
Pre-Recruit N 2001	1,471,357	1,450,227	1,408,891	25.1	4.4
Pre-Recruit N 2002	1,252,337	1,269,800	1,209,158	28.5	3.6
Pre-Recruit N 2003	1,743,897	1,712,889	1,648,271	26.3	5.8
Pre-Recruit N 2004	1,484,950	1,484,239	1,420,203	27.8	4.6
Pre-Recruit N 2005	1,673,824	1,654,875	1,580,096	27.9	5.9
Pre-Recruit N 2006	1,584,534	1,565,146	1,489,021	28.6	6.4
Pre-Recruit N 2007	1,765,809	1,728,203	1,655,753	28.0	6.6
Pre-Recruit N 2008	1,294,139	1,306,922	1,237,786	30.7	4.6
Pre-Recruit N 2009	1,128,395	1,140,461	1,084,915	30.7	4.0
Pre-Recruit N 2010	1,453,257	1,414,978	1,364,054	27.0	6.5
Pre-Recruit N 2011	775,606	793,442	751,051	31.0	3.3
Pre-Recruit N 2012	510,224	537,637	506,295	32.9	0.8
Pre-Recruit N 2013	794,504	818,456	777,101	30.1	2.2
Pre-Recruit N 2014	1,286,228	1,294,366	1,243,466	27.0	3.4
Pre-Recruit N 2015	2,199,992	2,118,633	2,071,711	22.5	6.2
Pre-Recruit N 2016	593,967	641,159	604,597	34.2	-1.8
Pre-Recruit N 2017	1,829,851	1,815,990	1,772,336	24.7	3.2
Pre-Recruit N 2018	1,635,732	1,637,272	1,584,467	25.7	3.2
Pre-Recruit N 2019	567,832	618,192	582,563	33.3	-2.5
Recruit N 1989	640,701	590,221	577,318	26.8	11.0
Recruit N 1990	679,617	657,201	647,006	21.9	5.0
Recruit N 1991	988,671	962,238	950,813	18.8	4.0
Recruit N 1992	806,633	803,485	791,719	20.2	1.9
Recruit N 1993	794,807	788,464	777,177	22.0	2.3
Recruit N 1994	633,553	629,750	618,790	25.9	2.4
Recruit N 1995	858,483	847,779	832,612	24.2	3.1
Recruit N 1996	902,688	901,515	879,427	24.8	2.6
Recruit N 1997	1,112,778	1,091,685	1,075,035	23.4	3.5
Recruit N 1998	800,424	782,063	770,002	27.6	4.0
Recruit N 1999	1,100,631	1,087,890	1,076,257	23.1	2.3
Recruit N 2000	1,335,068	1,286,625	1,267,202	22.4	5.4
Recruit N 2001	1,295,207	1,270,720	1,255,655	22.0	3.1
Recruit N 2002	1,556,414	1,519,066	1,498,978	20.5	3.8
Recruit N 2003	1,742,007	1,725,727	1,700,545	19.6	2.4
Recruit N 2004	2,058,477	2,019,760	1,991,569	19.1	3.4
Recruit N 2005	2,005,830	1,973,549	1,945,810	19.9	3.1
Recruit N 2006	2,408,022	2,366,078	2,338,885	17.8	3.0
Recruit N 2007	2,831,839	2,781,626	2,751,725	15.9	2.9
Recruit N 2008	3,210,626	3,138,725	3,114,471	14.7	3.1
Recruit N 2009	3,211,910	3,163,509	3,147,790	13.8	2.0
Recruit N 2010	3,210,701	3,180,952	3,166,210	12.6	1.4
Recruit N 2011	3,210,255	3,154,559	3,140,300	11.5	2.2
Recruit N 2012	2,296,619	2,265,621	2,251,455	13.0	2.0
Recruit N 2013	1,299,174	1,296,240	1,284,804	19.2	1.1
Recruit N 2014	1,258,612	1,275,820	1,258,693	19.5	0.0
Recruit N 2015	1,525,714	1,546,466	1,519,516	20.1	0.4
Recruit N 2016	2,429,618	2,379,996	2,357,524	16.4	3.1
Recruit N 2017	1,628,808	1,626,819	1,611,536	20.3	1.1
Recruit N 2018	2,059,939	2,046,962	2,030,303	18.7	1.5
Recruit N 2019	2,037,467	2,028,102	2,009,175	16.6	1.4
Recruit N 2020	983,519	1,017,083	998,998	27.4	-1.5

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

Figure 1. Length frequency of white perch from upper Chesapeake Bay trawl survey, 2017.

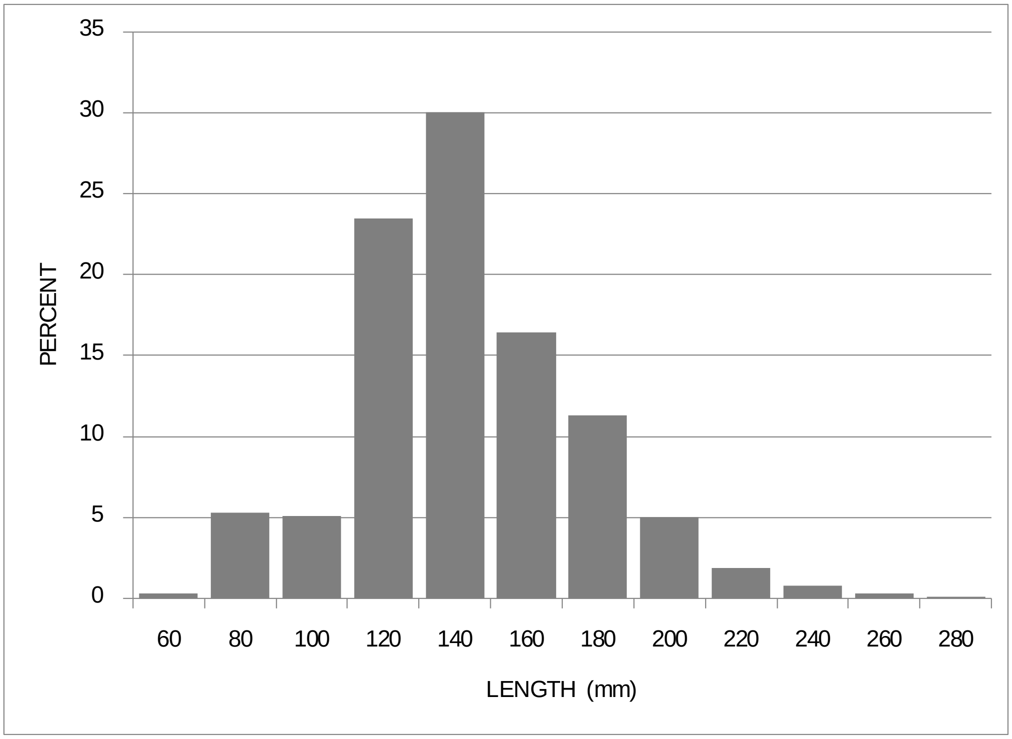


Figure 2. Length frequency of white perch from Choptank River fyke net survey, 2017.

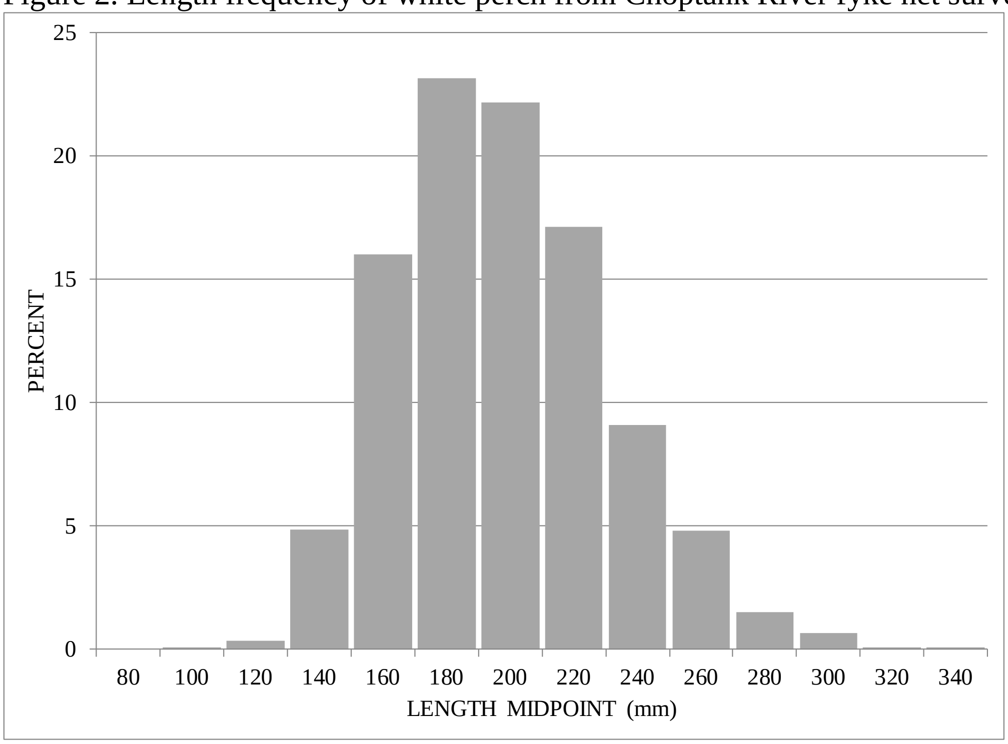


Figure 3. Upper Chesapeake Bay trawl sites, 2017.

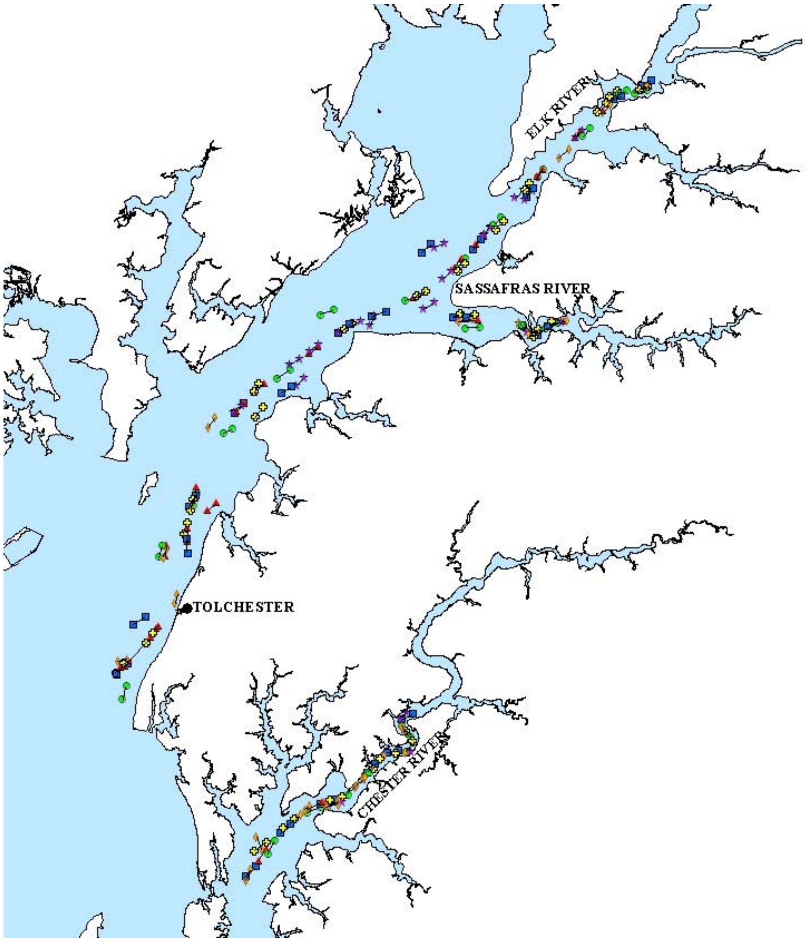


Figure 4. Choptank River fyke net sites (circles), 2017.

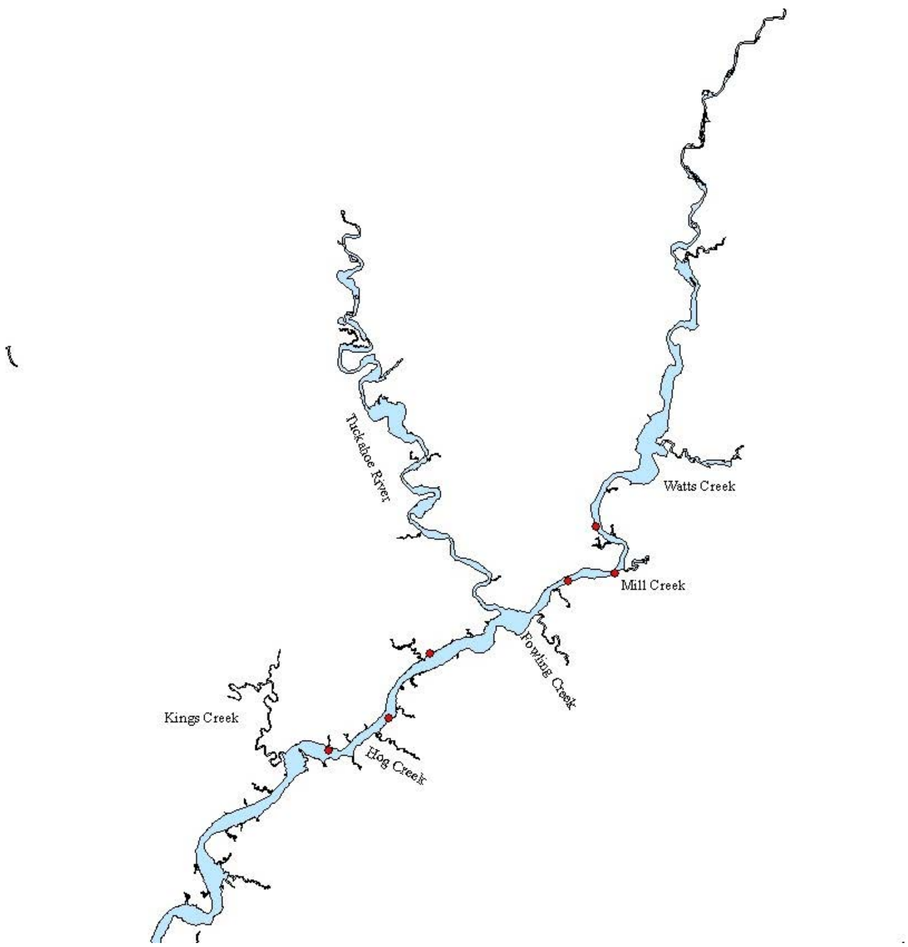


Figure 5. Estimated upper Chesapeake Bay white perch removals (commercial and recreational), 2000 – 2019.

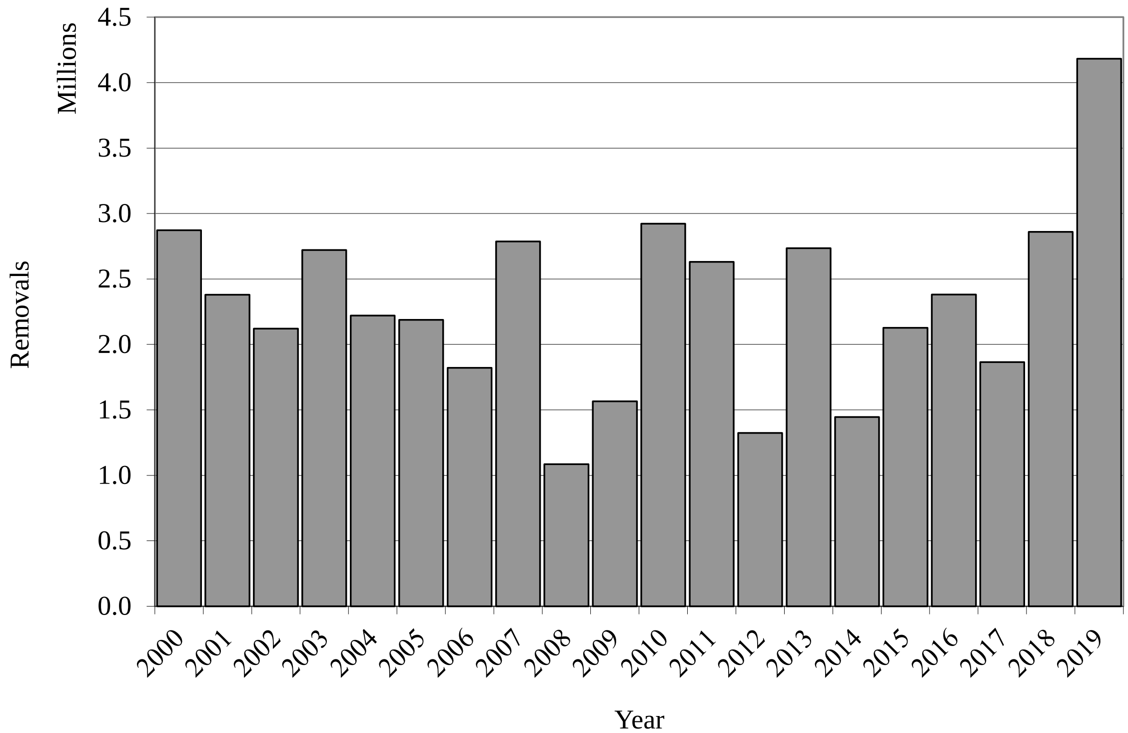


Figure 6. Observed and expected white perch pre-recruit indices from upper Chesapeake Bay trawl survey, 2000 – 2019.

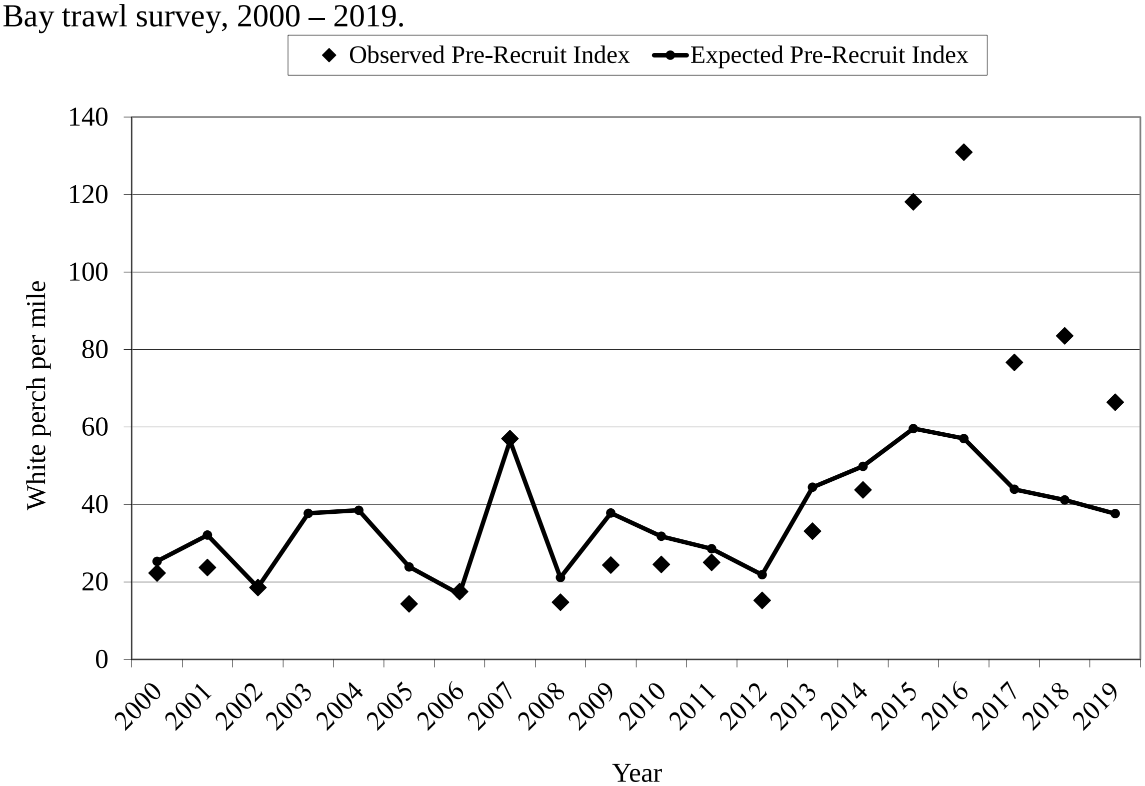


Figure 7. Observed and expected white perch post-recruit indices from upper Chesapeake Bay trawl survey, 2000 – 2020.

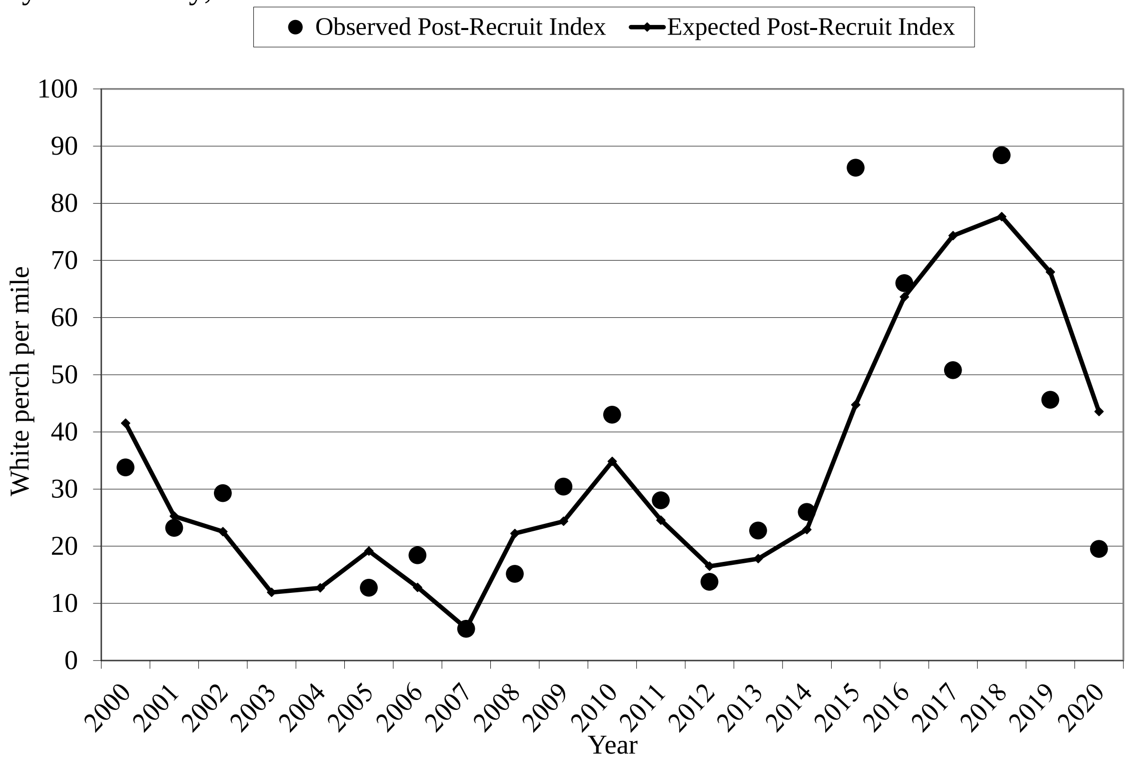


Figure 8. Total population estimate of upper Chesapeake Bay white perch from Catch Survey Analysis, 2000 – 2020.

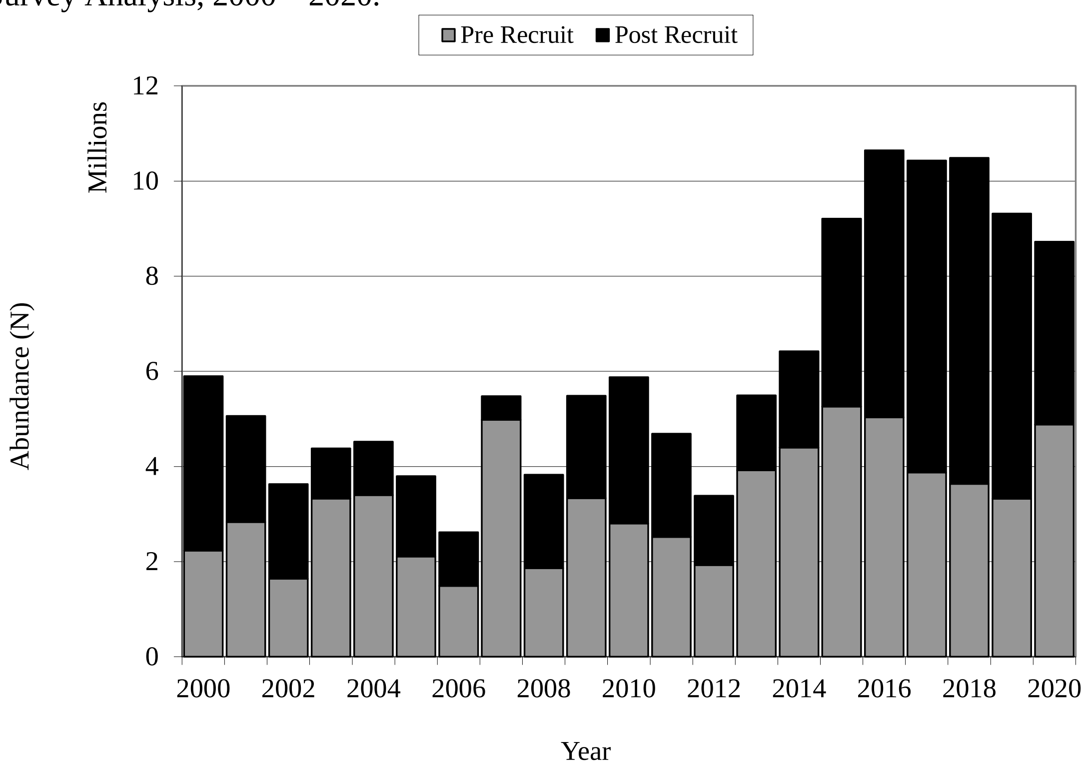


Figure 9. Instantaneous fishing mortality (F) of upper Chesapeake Bay white perch and proposed biological reference points for F, 2000—2019.

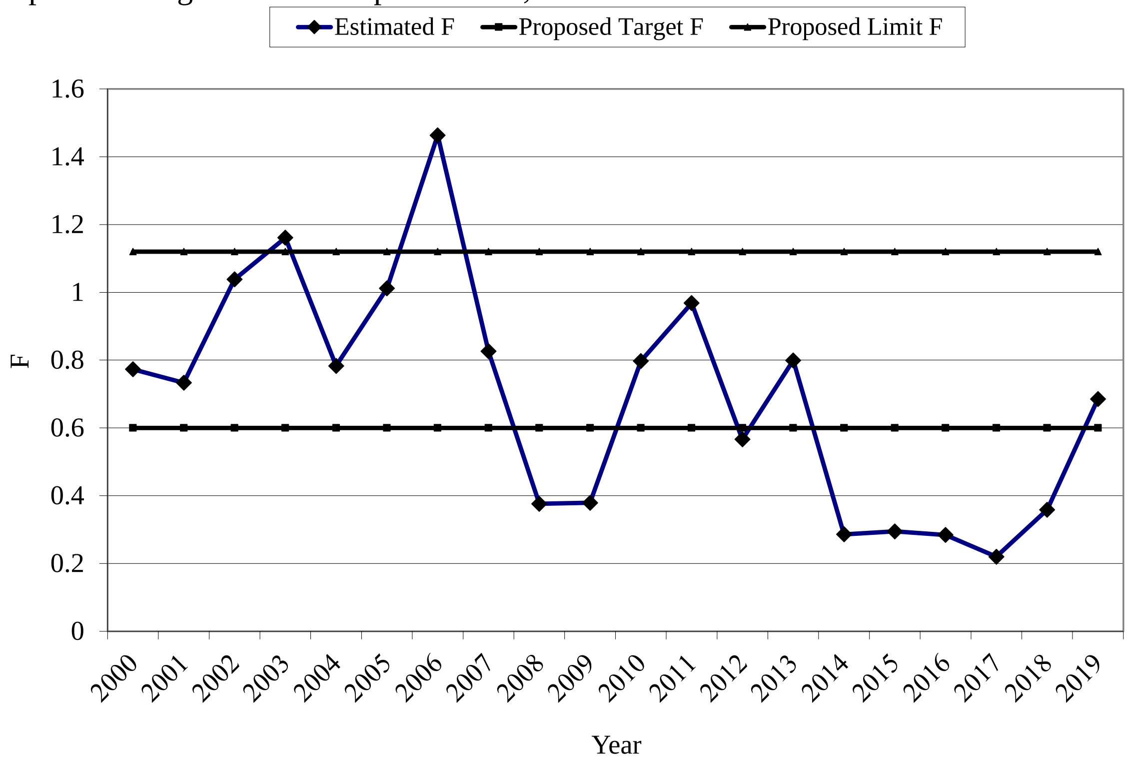


Figure 10. Bootstrap derived confidence intervals (80 %) for upper Chesapeake Bay pre-recruit white perch.

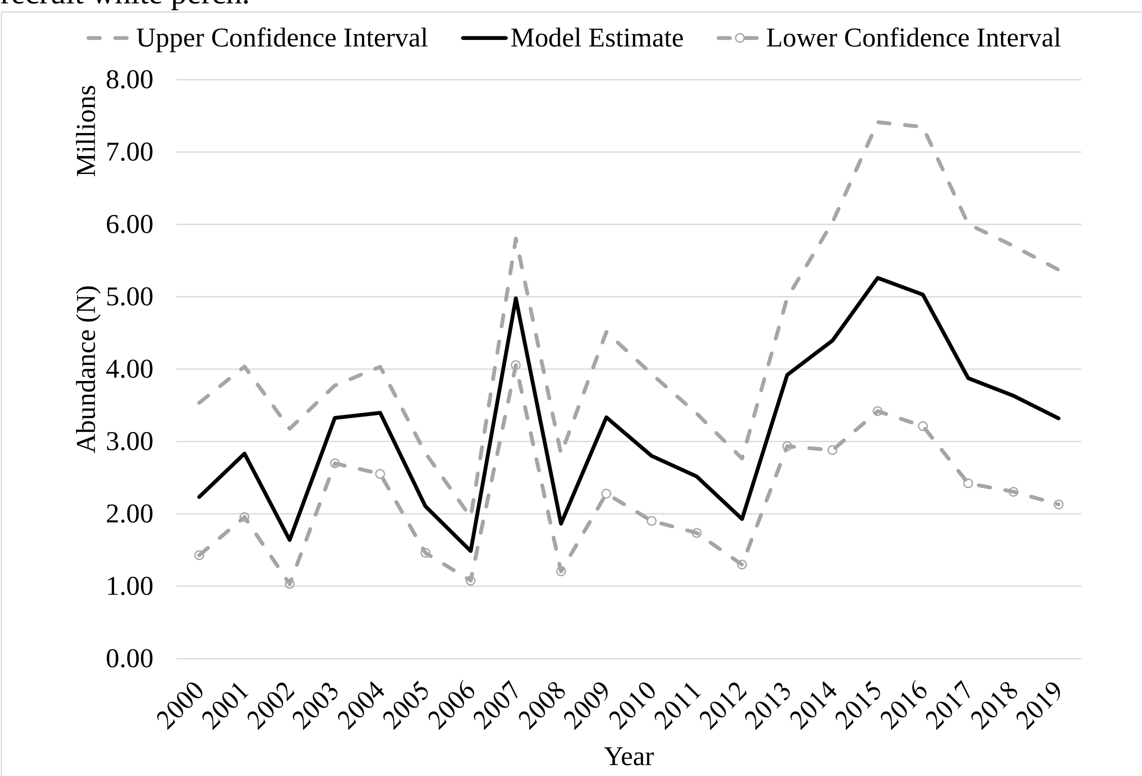


Figure 11. Bootstrap derived confidence intervals (80 %) for upper Chesapeake Bay post-recruit white perch.

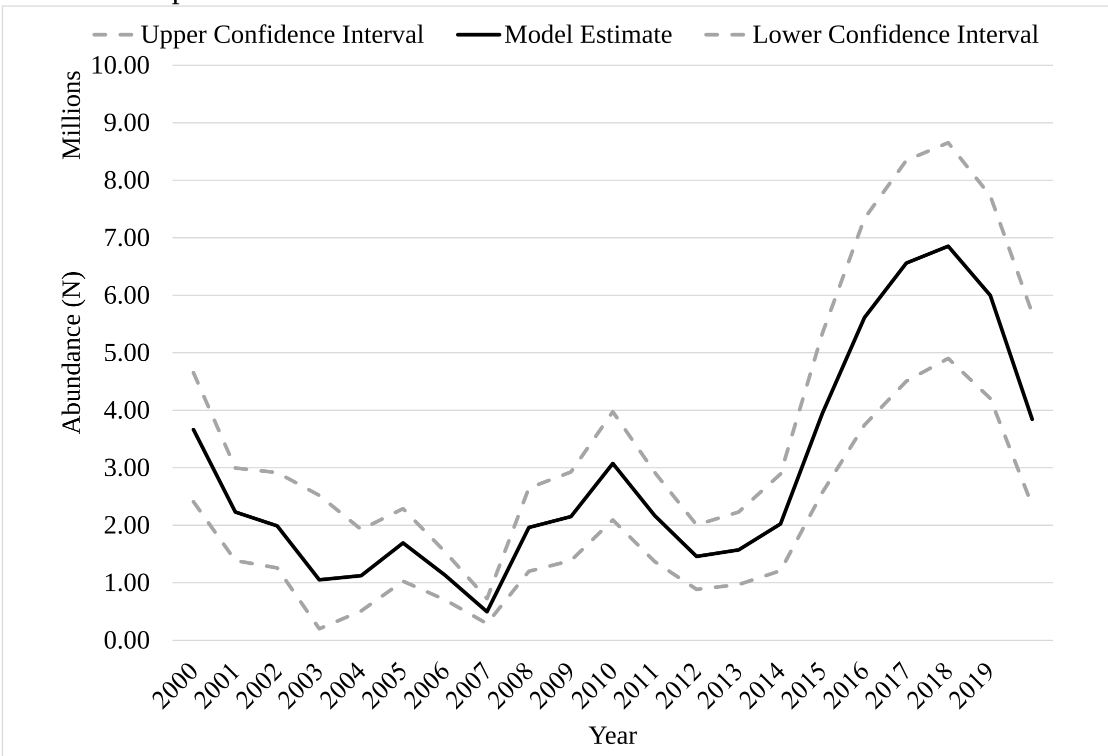


Figure 12. Bootstrap derived confidence intervals (80 %) for upper Chesapeake Bay white perch instantaneous fishing mortality (F).

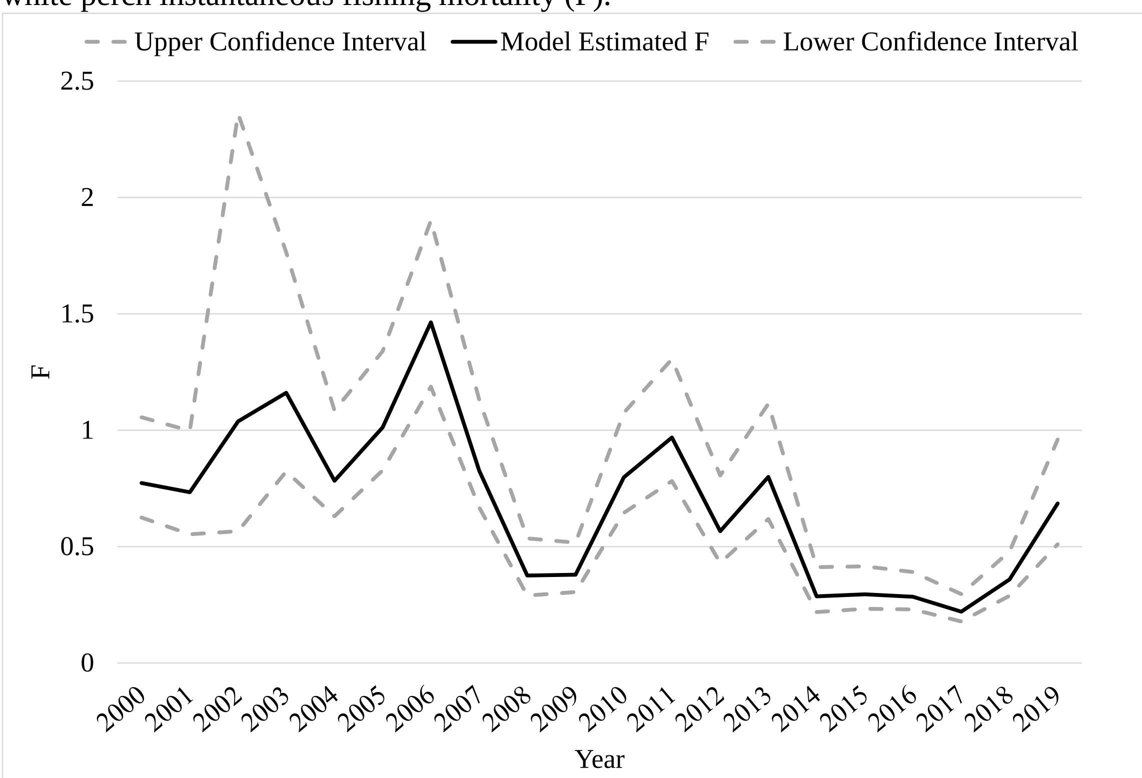


Figure 13. Estimated Choptank River white perch removals (commercial and recreational), 2000 – 2019.

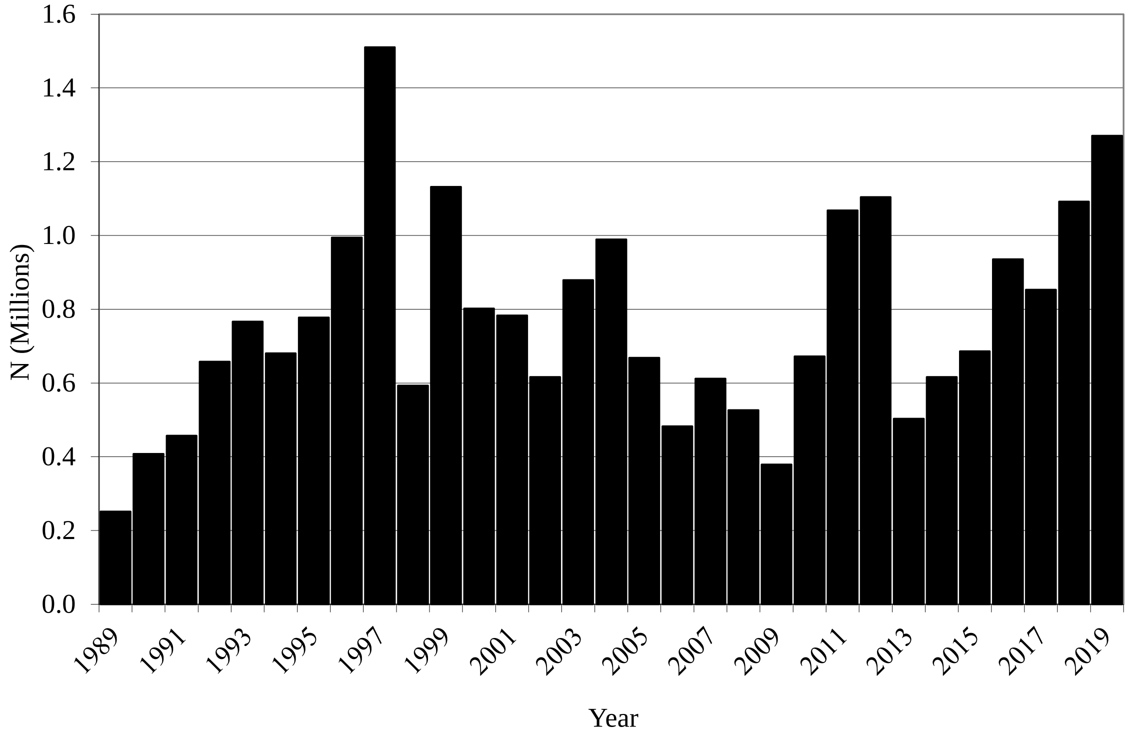


Figure 14. Observed and expected Choptank River pre-recruit white perch fyke indices, 1989—2019.

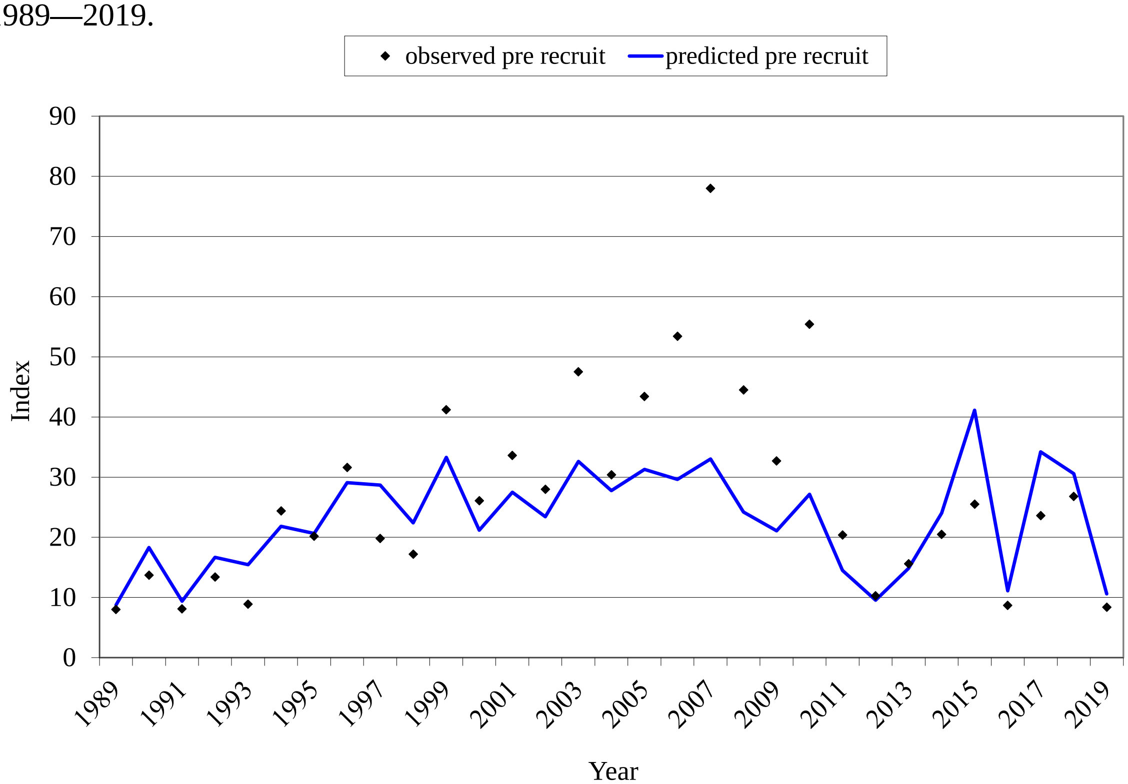


Figure 15. Observed and expected Choptank River post-recruit white perch fyke indices, 1989—2020.

Figure 16. Estimated population abundance of pre-recruit and post-recruit white perch in the Choptank River, 1989 – 2020.

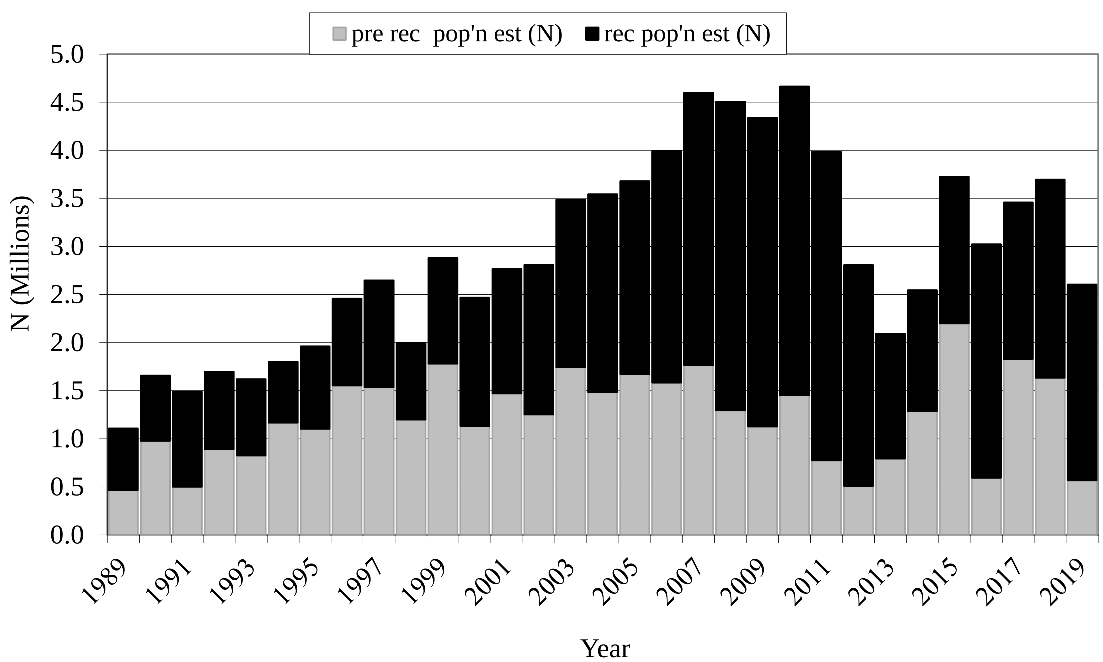


Figure 17. Instantaneous fishing mortality (F) of Choptank River white perch and proposed biological reference points for F, 2000—2019.

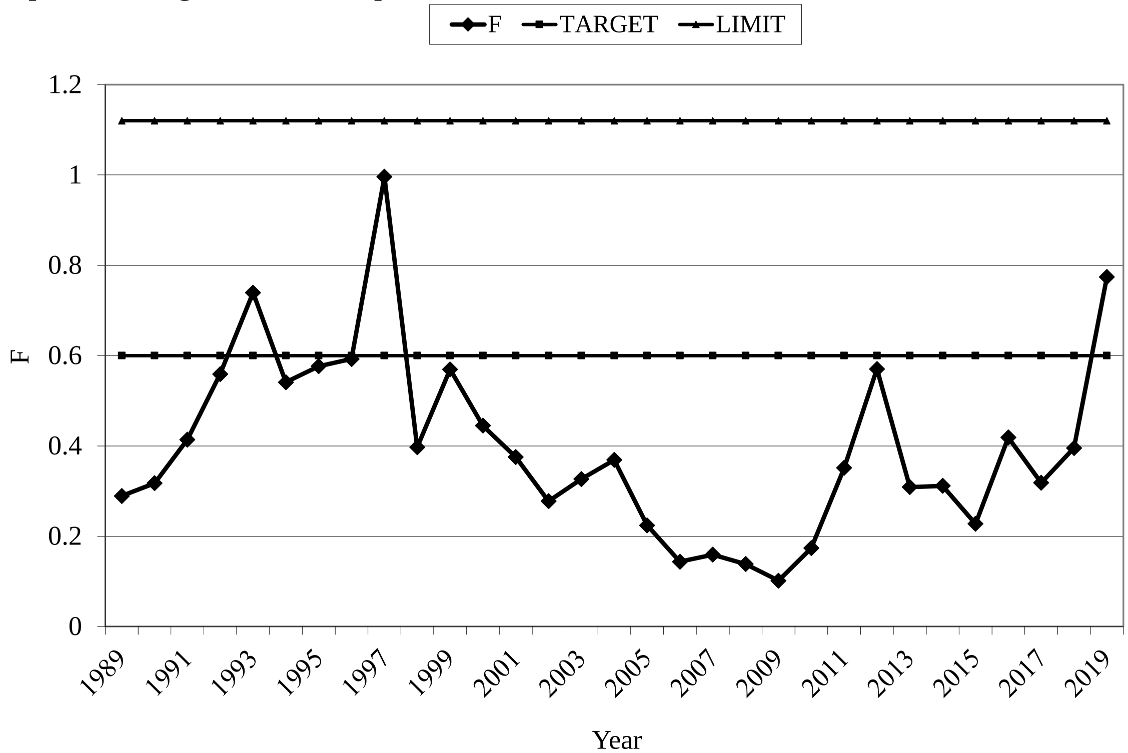


Figure 18. Bootstrap derived confidence intervals (80 %) for Choptank River pre-recruit white perch.

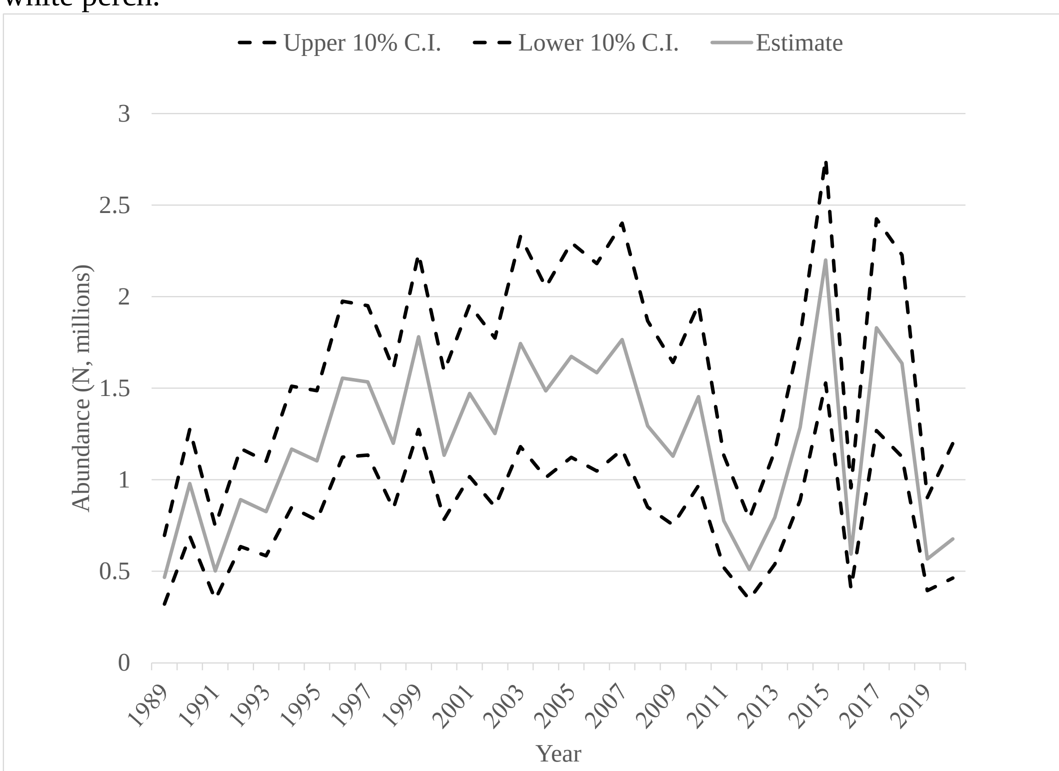


Figure 19. Bootstrap derived confidence intervals (80 %) for Choptank River post-recruit white perch.

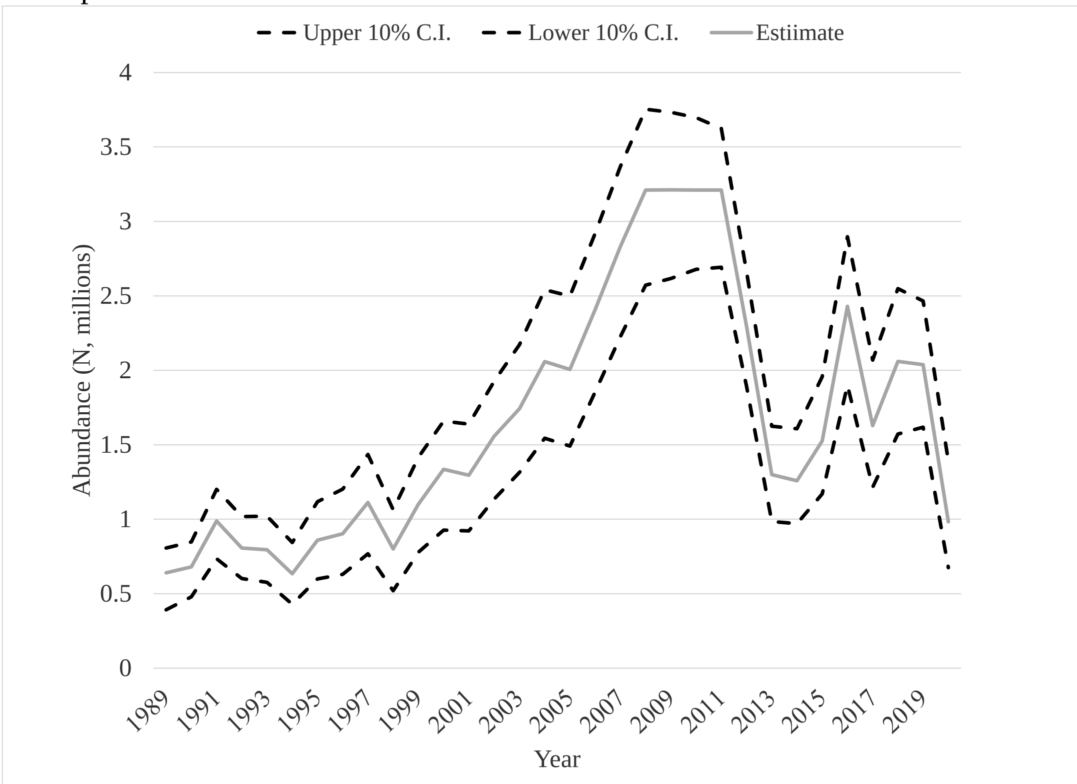


Figure 20. Bootstrap derived confidence intervals (80 %) for Choptank River white perch instantaneous fishing mortality.

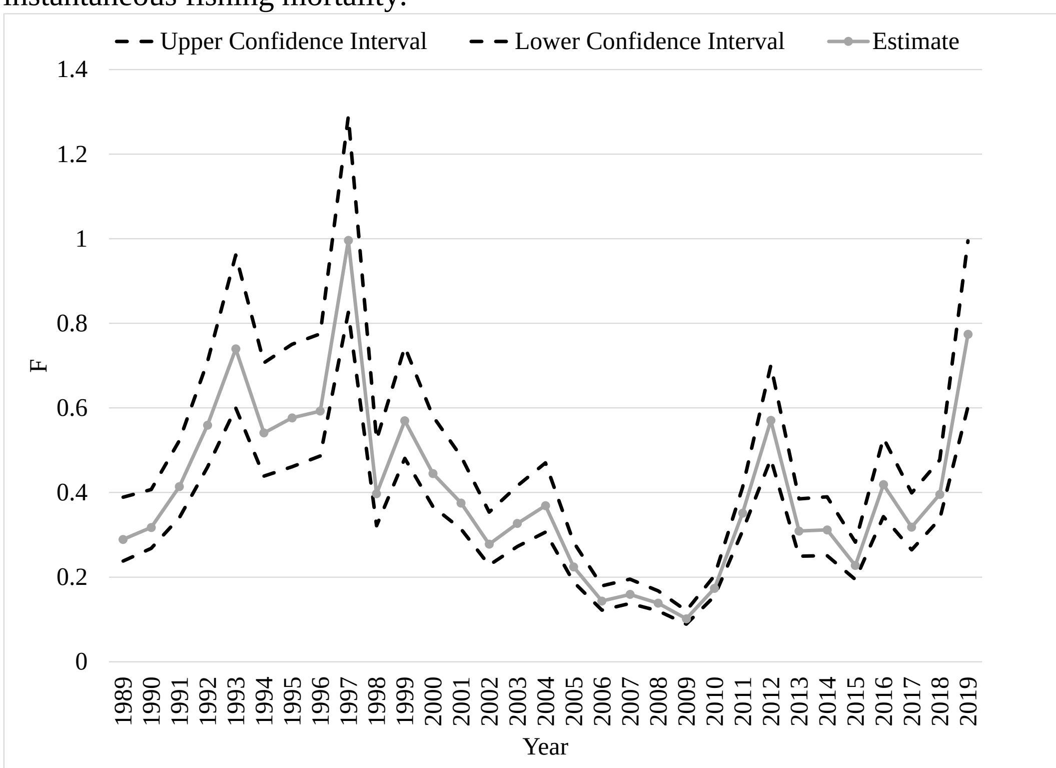


Figure 21. Lower Chesapeake Bay fishery dependent white perch fyke net index, 1980 – 2019. Horizontal line = time series average.

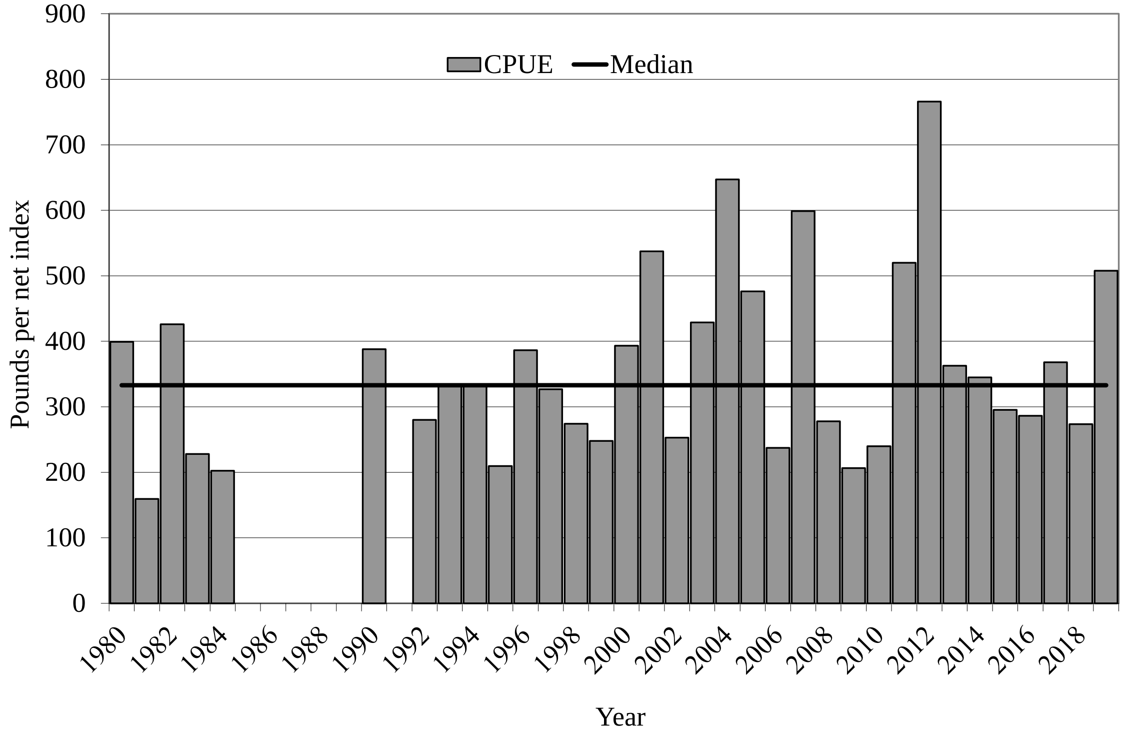


Figure 22. Lower Chesapeake Bay fishery dependent white perch pound net index, 1981 – 2019. Horizontal line = time series average.

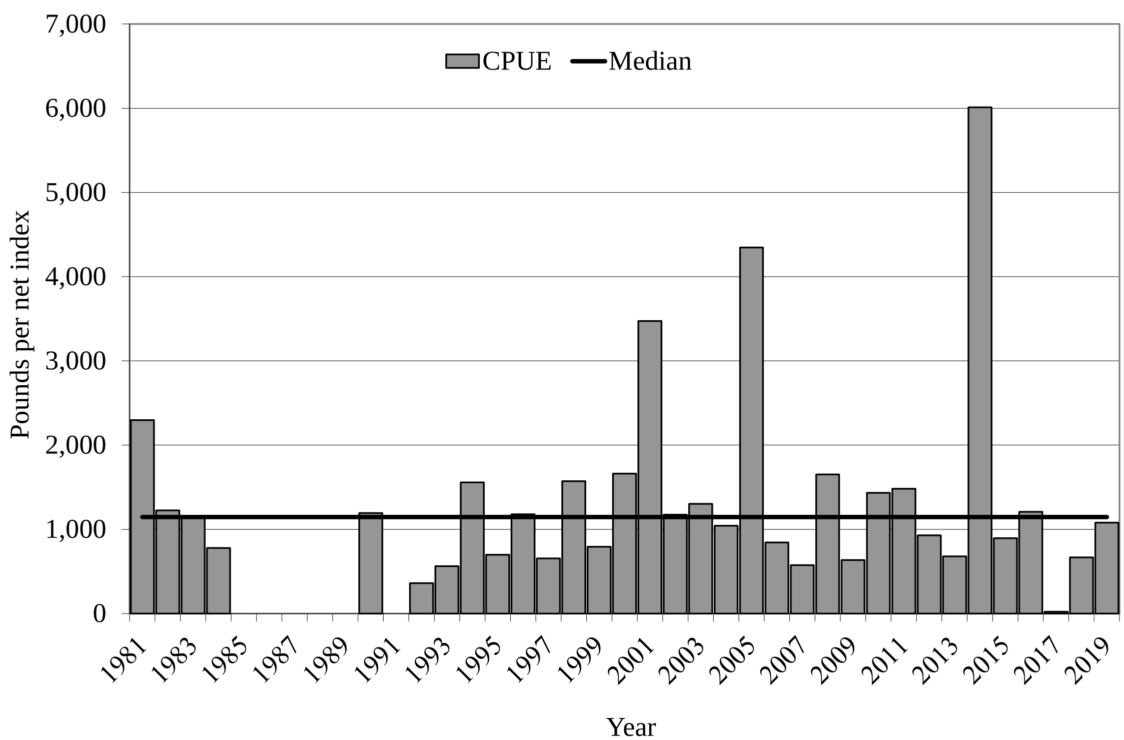


Figure 23. Lower Chesapeake Bay fishery dependent white perch gill net index, 1980 – 2019. Horizontal line = time series average

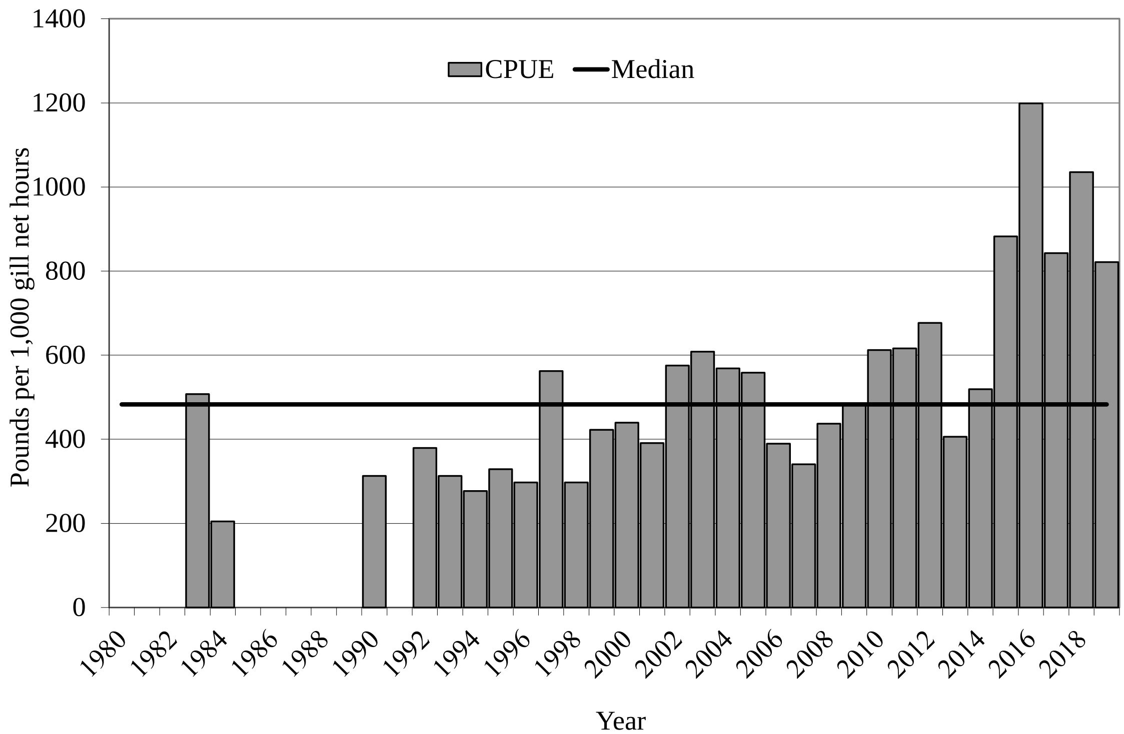


Figure 24. Potomac River fishery independent gill net survey white perch index, 1985—2020. Horizontal line = time series average.

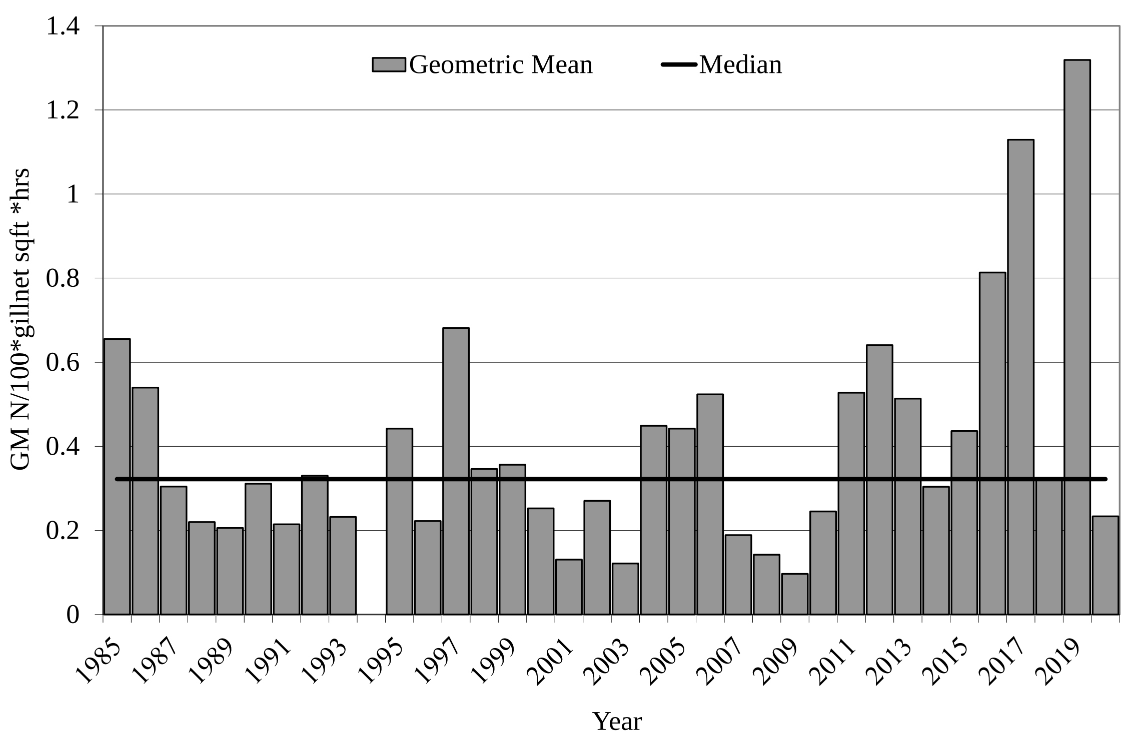
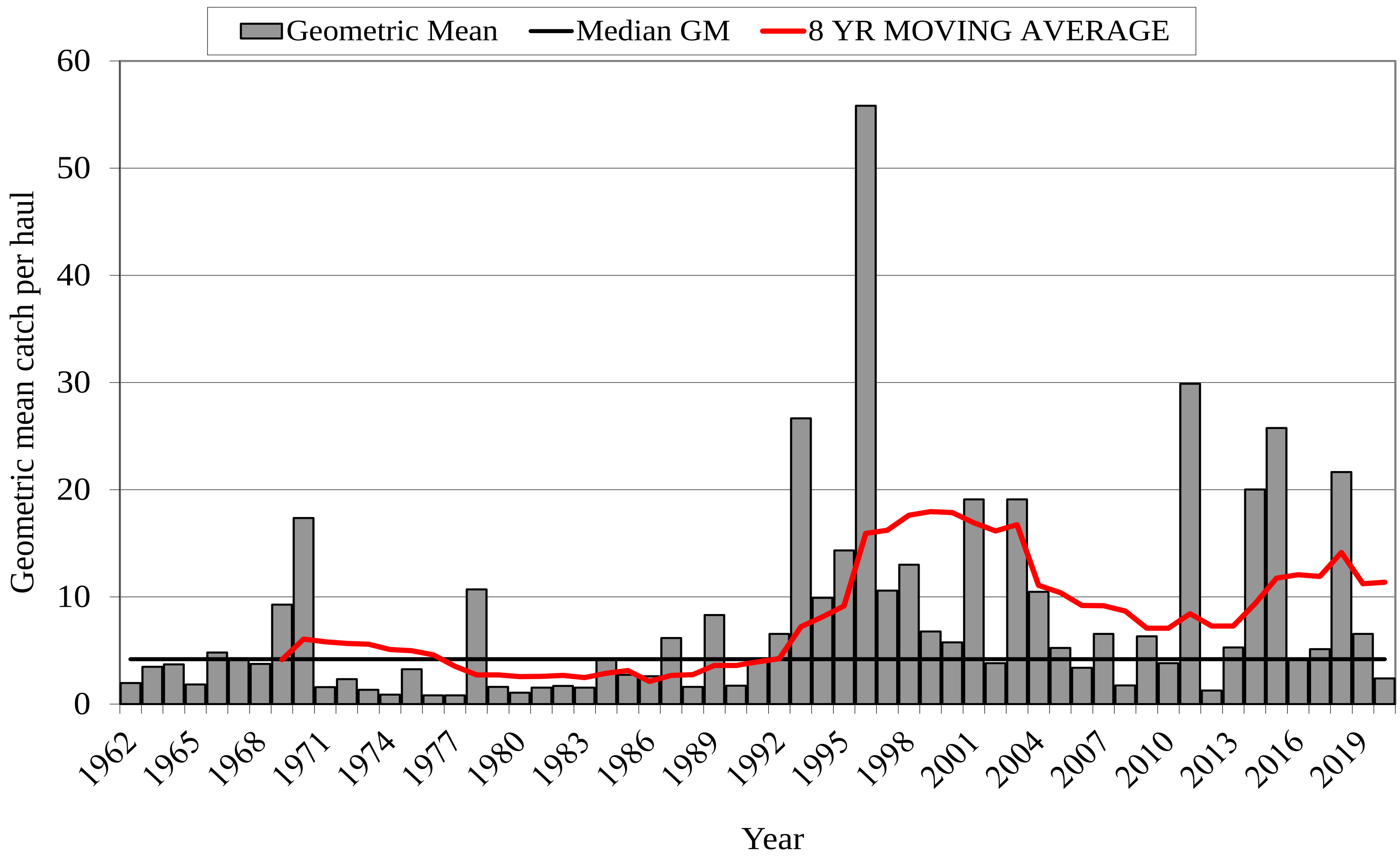


Figure 25. Lower Chesapeake Bay young-of-year white perch seine index, 1962 – 2020.



PROJECT NO. 2
JOB NO. 1

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

Prepared by
Robert J. Bourdon

INTRODUCTION

The primary objective of Project 2, Job 1 was to assess trends in the stock status of American shad, hickory shad and river herring (i.e., alewife and blueback herring) in Maryland's portion of the Chesapeake Bay and selected tributaries. Sampling activities to address these tasks were severely impacted by the COVID-19 pandemic. The State of Maryland proclaimed a state of emergency on March 5, 2020, which extended through the 2020 and 2021 alosine sampling seasons. On March 13, 2020, the state workforce entered an "Elevated Level II" operational status, imposing a mandatory telework status for all non-essential state employees. The regularly scheduled survey to estimate stock composition and abundance of adult American shad in the Susquehanna River below Conowingo Dam was suspended for the entirety of the 2020 sampling season. Stock characterization of adult hickory shad on the Susquehanna River and sampling of commercial bycatch to estimate stock composition and relative abundance of adult American shad and river herring on the Nanticoke River were similarly cancelled. A survey of adult river herring to estimate stock characterization and relative abundance in the North East River was conducted on only one of ten regularly scheduled sampling days prior to the implementation of COVID-19 work restrictions.

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). Additionally, juvenile abundance indices for American shad and river herring were formulated for various river systems using data collected by the Estuarine Juvenile Finfish Survey (EJFS; Project 2, Job 3, Task 3).

Data collected by this project were used to prepare and update stock assessments and fishery management plans for the Atlantic States Marine Fisheries Commission (ASMFC), the Susquehanna River Anadromous Fish Restoration Cooperative (SRAFRC), and the Chesapeake Bay Program's Sustainable Fisheries Goal Implementation Team.

METHODS

Data Collection

Susquehanna River

The bulk of regularly scheduled sampling in the Susquehanna River was cancelled in 2020, but a voluntary logbook survey provided location, catch, and hours fished for American and hickory shad for anglers participating in this catch and release fishery. Beginning in 2014, anglers could participate in the logbook survey by recording fishing trips through the Volunteer Angler Shad Survey on the Maryland Department of Natural Resources' website: http://dnr.maryland.gov/Fisheries/Pages/survey/index.aspx. To control the spread of COVID-19, the State of Maryland banned recreational fishing during a portion of spring 2020. Thus, anglers averaged fewer fishing days than in previous years.

State and federal restrictions enacted in response to the COVID-19 pandemic prevented the operation of the Conowingo Dam East Fish Lift (EFL) for the bulk of the 2020 alosine migratory season. Easing of restrictions allowed for a brief period of EFL operation between 12 May and 15 May 2020 before the lift was closed to prevent further upstream spread of invasive northern snakehead (*Channa argus*). All fish collected in the EFL were deposited into a trough, directed past a 1.2 m x 3.0 m counting window, identified to species, and counted by experienced technicians. Visual analysis of American shad was conducted to monitor for any floy tagged fish that were marked in previous seasons by the Maryland Department of Natural Resources hook and line survey. The West Fish Lift, previously used for broodstock collection and experimental purposes, did not operate in 2020.

Potomac River

The Striped Bass Spawning Stock Survey (SBSSS; Project 2, Job 3, Task 2) provided American shad scales from the Potomac River to compare age structure and repeat spawning of alosines in this river with fish sampled from the Susquehanna and Nanticoke rivers. American shad were captured in gill nets targeting striped bass that were fished from 14 April to 16 May 2020. All American shad were sexed and measured (TL and FL) to the nearest mm. A random subset of fish (10/sex/20mm length group) were scaled for age and spawning history analysis; scales were removed below the insertion of the dorsal fin.

North East River

A multi-panel experimental anchored sinking gill net was deployed in the North East River to assess the adult river herring spawning stock on 11 March 2020. Further sampling trips, usually scheduled once per week for an additional 9 weeks, were cancelled due to COVID-19 work restrictions. The gill net was fished at four randomly chosen sites assigned from a grid superimposed on a map of the system (Figure 1). The grid consisted of 112 quadrats equaling 0.093 square kilometer per cell. 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 selected and sampled in cases where the chosen site was inadequate. For example, if depth was below 1.8 m at a given site, the next available alternate site was selected.

Individual net panels were 30.5 m (100 feet) long and 1.8 m (6 feet) deep. The net had a 0.9 cm – 1.3 cm (3/8 – ½ inch) poly-foamcore float line and a 22.7 kg (50 pound) lead line. Nets were hung with 61 m (200 feet) of stretch netting for every 30.5 m of net. From 2013 – 2014, the panels were constructed of 0.33 mm diameter monofilament twine in 6.4 cm (2.5 inch), 7.0 cm (2.75 inch) and 7.6 cm (3 inch) stretched mesh. Beginning in 2015, the 7.6 cm mesh panel was replaced with a 5.7 cm (2.25 inch) stretched mesh panel, as there was evidence that the previous mesh size selections were not successful in capturing smaller sized blueback herring. The three panels were tied together to fish simultaneously and were soaked for 30 minutes before retrieval. Panel order was randomly chosen before the net was assembled at the start of the survey for each year.

Following deployment of the net, water quality, depth and tidal stage were noted. 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 future comparison of aging method. A variety of other important sport fish were also measured to the nearest mm TL.

Baywide

The Estuarine Juvenile Finfish Survey (EJFS; Project 2, Job 3, Task 3) provided juvenile abundance indices of American shad, blueback herring, and alewife in the Potomac River, Nanticoke River, Upper Chesapeake Bay, and baywide (all surveyed Chesapeake Bay tributaries combined). Each system was sampled once per month during July, August, and September. All finfish species were enumerated, and subsamples of select species, including American shad and both river herring species, were measured for total length.

Aging Protocol

Alosine scales collected from all rivers were aged following established protocols (Elzey et al., 2015) as recommended by Atlantic states' aging experts (ASMFC 2013). A minimum of four scales per sample were cleaned, mounted between two glass slides and read for age and spawning history using a Micron 385 microfiche reader. The scale edge was counted as an annuli due to the assumption that each fish had completed a full year of growth at the time of capture. Ages were not assigned to regenerated scales or to scales that were difficult to read. Repeat spawning marks were counted on all alosine scales during aging.

In 2020, age determination was done independently by two readers. If the age and spawning mark estimates did not fully match between the two individuals, the scale was jointly re-read. If a consensus age or spawning mark could not be determined, the sample was eliminated from further analysis.

During the 2018 aging process, biologists noted that scales with faint or non-distinct annuli produced different age estimates when analyzed on different microfiche readers. Most notably, a Bell and Howell MT-609 microfiche frequently used in past seasons had the tendency to produce younger ages for such scales. Beginning in 2018, efforts were made for all scales to be read on comparable equipment to eliminate any potential bias towards younger ages.

Otoliths from subsamples of river herring (10/species/sampling day) were collected and archived for comparison of aging structure results; otoliths will be processed as time allows.

Data Analysis

Sex, Age and Stock Composition

Male-female ratios were derived for American shad captured in gill nets deployed in the Potomac River and for alewife captured in experimental gill nets in the North East River. Due to COVID-19 work restrictions that limited North East River sampling to one day in 2020, blueback herring were not captured.

Scales were collected as described above for the duration of the sampling season. When the total number of samples per species amounted to greater than 300 samples by river, approximately 300 random subsamples, proportional to catch by date, were processed for aging and then applied to total catch using an age-length key derived from the subsampled ages.

The percentages of repeat spawners by species and system (sexes combined) were arcsine-transformed (in degrees) before looking for linear trends over time. For all statistics, significance was determined at $\alpha = 0.05$.

Adult Relative Abundance

Using catch-per-unit-effort (CPUE) as a measure of relative abundance is a common practice in fisheries science. A geometric mean CPUE (GM CPUE) was calculated as the average LN (CPUE + 1) for each fishing/sampling day, transformed back to the original scale for most of the surveys analyzed by this project. Catch-per-angler-hour (CPAH) for American shad angled in the Susquehanna River and hickory shad angled throughout the region were calculated from the data collected by the logbook survey (paper logbook data and online angler reports were combined).

In the Potomac River, the SBSSS calculated CPUE as the number of American shad caught per 836 square meters (1,000 square yards) of experimental drift gill net per hour fished. There was a slight decrease in the fishing effort in the Potomac River beginning in 2015. The program reduced the length of three mesh panels (7.6 cm, 9.5 cm and 11.4 cm) from 45.7 m to 22.9 m in an attempt to catch fewer blue catfish.

The North East River gill net CPUE was the geometric mean catch of alewife per hour of fishing. Given that only one day of sampling was conducted, only a daily CPUE of alewife was calculated. Thus, data from 2020 cannot be compared to the yearly CPUE previously available from 2013-2019. Catch was pooled across all mesh sizes prior to CPUE calculation. 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). Correction factors for each mesh size selectivity have not been estimated for river herring.

Juvenile Abundance

Juvenile indices (geometric mean catch per haul) generated by the EJFS were used to complement adult spawning stock indices. American shad juvenile indices were reported for the Nanticoke River, Potomac River, Upper Chesapeake Bay, and baywide. Alewife and blueback herring juvenile indices were reported for the Nanticoke River, Upper Chesapeake Bay, and baywide. Hickory shad data are not reported by the EJFS due to historically infrequent encounters.

Mortality

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

$$Z = -1 * ln (T / (N + T - 1))$$

where T is calculated as:

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

where n_0 is the number of fish at the first fully recruited age, n_1 is the number of fish one year older than first fully recruited age, and this is carried out for all age groups greater than the first fully recruited age. 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 most recent river herring benchmark stock assessment (ASMFC 2012). Total mortality of adult alewife from the North East River gill net survey was not calculated; the age data available from the single day of sampling was not representative of the entire spawning stock.

RESULTS

American Shad

Sex, Age and Stock Composition

In response to increasing catches on the Potomac River, scales were only taken from a subsample of American shad beginning in 2017. The goal was to collect scales from ten individuals per sex per 20 mm length group for each year of the survey. Of the 141 total shad observed in 2020, 140 were scaled and successfully analyzed for age and repeat spawning marks. An age-length key was applied to assign ages to the entire sampled population. The male-female ratio for adult American shad captured in the Potomac River was 1:2.8. Males were present in age groups four through seven, and females were present in age groups four through eight (Table 1). The 2015 year-class (age five) was the dominant age group for males (37.8%; Table 1) and the 2014 year-class (age six) was the dominant age group for females (45.6%; Table 1). The 2014 year-class (age six) was the dominant age group when sexes were combined (40.0%; Table 2). Seventy-five percent of both males and females were repeat spawners. The arcsine-transformed proportion of Potomac River repeat spawning American shad (sexes combined) showed no significant trend over the time series (2002-2020; $r^2 = 0.04$, $P = 0.39$; Figure 2).

Adult Relative Abundance

The Conowingo EFL operated for four days between 12 May and 15 May 2020. Of the 485 American shad that passed at the EFL, 74% (360 fish) passed on 14 May 2020. No floy tagged American shad from previous years of the Maryland Department of Natural Resources' tagging efforts were counted at the EFL.

Despite a state mandated ban on recreational fishing during a portion of Spring 2020, the number of individuals participating in American shad angler surveys was consistent with recent years. However, largely due to the truncated fishing season, the reported number of fishing trips was below average. One angler returned a paper logbook for American shad in 2020. Additionally, eight anglers participated online by recording their trips through the Maryland Department of Natural Resources' Volunteer Angler Shad Survey. American shad CPAH calculated from shad logbook data combined with data from Maryland Department of Natural Resources' Volunteer Angler Shad Survey increased marginally in 2020 relative to 2019 (Table 3). Online angler data was included in the CPAH calculation beginning in 2014. The logbook CPAH estimate of adult American shad relative abundance peaked in 2001 but exhibited no significant trend over the time series (2001-2020; $r^2 = 0.09$, $P = 0.19$; Table 3).

Fishing effort by the Potomac River SBSSS was lower than in previous years. COVID-19 work restrictions delayed the start of the survey and persistent windy conditions further hampered sampling efforts. Relative abundance (CPUE) of American shad decreased marginally relative to the survey peak in 2019, but a significant increasing trend was observed over the time series (1996-2020; $r^2 = 0.57$, $P < 0.001$, Figure 3).

Mortality

The Potomac River total instantaneous mortality estimate (Z) for American shad, sexes combined, in 2020 was 1.22; mortality increased significantly over the time series (2002-2020; $r^2 = 0.40$, $P = 0.004$, Figure 4). Total instantaneous mortality estimates for males and females were 0.98 and 1.18 respectively. No trend analyses were conducted for sex-specific mortality estimates due to limited availability of estimates. Sample size limitations or the failure to exhibit two ages past the age of full recruitment, a requirement of the Chapman-Robson age-based method, often precludes the ability to formulate sex-specific estimates.

Juvenile Abundance

In 2020, juvenile American shad abundance indices provided by the EJFS demonstrated marginal decreases in juvenile production in the Upper Chesapeake Bay and the Potomac River (Figures 5 & 6). As was the case for 2019, no juvenile American shad were captured on the Nanticoke River in 2020; this is a common occurrence across the timeseries for this river (Figure 7). Baywide juvenile abundance declined relative to 2019 (Figure 8). Juvenile indices were not corrected for hatchery contribution.

Alewife and Blueback Herring

The limited adult alewife data collected by the North East River gill net survey should not be considered representative of the entire spawning stock. Thus, the following results reported for that system should not be compared to previous years of the survey. Collection of juvenile abundance data was consistent with established protocols and is comparable to prior years.

Sex, Age and Stock Composition

The male-female ratio for alewife captured by the North East River gill net survey in 2020 was 1:0.9. Males were present in age groups three through six, and females were present in age groups four through seven. The 2015 year-class (age five) was the dominant age group for males (50.0%) and the 2015 (age five) and 2014 (age six) year-classes were co-dominant age groups for females (43.8%). The occurrence of repeat spawners was 81% and 91% for males and females, respectively. Discretion should be used when interpreting these results as they have not been corrected for selectivity bias of the mesh sizes.

Adult Relative Abundance

The North East River gill net survey captured 83 alewife on one sampling day in 2020 when the average water temperature was 8.8 °C. The majority of alewife were caught in the 7.0 cm mesh and ranged in size from 210 mm to 268 mm (FL). The daily CPUE of alewife, calculated with catch pooled across the 5.7 cm, 6.4 cm and 7.0 cm meshes, was 41.5 fish per hour.

Juvenile Abundance

Data provided by the EJFS indicated that juvenile abundance of alewife remained low and stable in the Upper Chesapeake Bay, the Nanticoke River and baywide in 2020 (Figures 9-11). Blueback herring juvenile abundance remained low and stable on the Nanticoke River but dropped substantially in the Upper Chesapeake Bay and baywide relative to 2019 (Figures 9-11).

DISCUSSION

American Shad

American shad are historically one of the most important exploited fish species in North America, but the stock has drastically declined due to the loss of habitat, overfishing, ocean bycatch, stream blockages, pollution and exposure to invasive predators. American shad restoration in the upper Chesapeake Bay began in the 1970s with the building of fish lifts and the stocking of juvenile American shad. Maryland closed 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, the 2020 ASMFC stock assessment indicated that most stocks have not recovered and populations remain near historic lows (ASMFC 2020).

While no population assessment of American shad in the lower Susquehanna River at Conowingo Dam was available in 2020, previous years findings suggest that the population is stable at low levels. Results of 2020 volunteer angler surveys support a consistent population size since 2003. Recovery of this population is limited by the available spawning habitat below Conowingo Dam and low stocking success. Relicensing of Conowingo Dam is anticipated in 2020. Stipulations of the settlement agreement between Exelon Generation Co LLC and the Maryland Department of the Environment should improve fish passage and contribute to rebuilding anadromous fish stocks in the Susquehanna River.

Despite a marginal decline compared to 2019, relative abundance (CPUE) of American shad in the Potomac River (1996-2020) increased over time and reached the second highest value recorded by the SBSSS, indicating substantial improvement in this river. However, high levels of total mortality (Z) were documented in the Potomac River in recent years; the 2020 benchmark stock assessment found that the terminal three-year (2015-2017) average Z for adult American shad exceeded the $Z_{40\%SBPR}$ reference point (ASMFC 2020). Maryland Department of Natural Resources estimates of Z increased over time, supporting the results of the stock assessment.

Aging American shad using scales is common practice, as it the only non-lethal aging structure for this fish. However, many researchers have called into question the accuracy of scale aging (ASMFC 2020). Aging other hard structures, such as otoliths, produces higher age agreement between readers compared to scales (Duffy et al. 2012), but aging from otoliths sacrifices repeat spawning information. We will remain consistent with historical aging methods until alternative aging structures or techniques can be implemented in our lab.

Juvenile American shad indices have shown some positive signs in recent years. After many years of minimal juvenile production from the early 1980s through the mid 1990s, both the Potomac River and Upper Chesapeake Bay systems have had several years of successful spawns. Recent Potomac River and cumulative baywide juvenile abundance indices exceeded the values observed in the early years of the survey that dates back to 1959. Nanticoke River American shad juvenile production remained at low levels of juvenile abundance since 1969.

Alewife and Blueback Herring

Alewife and blueback herring numbers declined drastically for the same reasons discussed for American shad. The most recent stock assessment, released in 2017, showed the coastwide meta-complex of river herring stocks on the US Atlantic coast was depleted to near historic lows, and declines in mean length of at least one age were observed in most rivers examined (ASMFC 2017). This assessment corresponded with the low indices of abundance for both species observed in the Nanticoke River by this project through 2019. Crecco and Gibson (1990) found alewife in the Nanticoke River to be fully exploited and severely depleted prior to the start of Maryland Department of Natural Resources fishery-dependent sampling in this river.

While no representative data was available in 2020, relative abundance of both alewife and blueback herring in the North East River increased in recent years, but no significant trends were detected over time (2013-2019). However, blueback herring relative abundance increased substantially in 2019, exceeding that of alewife for the first time. The significance of these fluctuations in the North East River is unclear given that the survey is temporally limited. The shorter time series may be reflecting near-term variability rather than broad scale population gains or losses.

Amendment 2 of the ASMFC Interstate Fishery Management Plan for American Shad and River Herring required states to develop and implement a sustainable fishery management plan for jurisdictions wishing to maintain an open commercial or recreational fishery. Due to the 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, and there are several efforts underway to reduce incidental catch of river herring in the 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). The expectation is that these efforts to reduce bycatch mortality on river herring will increase the size of the spawning stock, with a corresponding increase in repeat spawning and production of juvenile river herring. The ASMFC 2017 stock assessment update did not indicate a change to the stock status for Maryland's river herring populations. However, given that these bycatch measures were implemented relatively recently, any resulting population impacts may take more time to become apparent.

While not available for 2020, mortality estimates in recent years for alewife and blueback herring in the North East and Nanticoke Rivers were generally high. In 2019, the mortality estimate for alewife was higher in the North East River than the Nanticoke River, while blueback mortality estimates were similar for both rivers. The 2012 river herring stock assessment attributed high mortality of river herring to a combination of factors including fishing (in-river directed and ocean bycatch), inadequate access to habitats, impaired water quality, excessive predation, and climate change (ASMFC 2012). Genetic studies suggest a greater 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 for North East River and Nanticoke River blueback herring estimated by this project. However, the fishing effort in the Atlantic Herring fishery has declined substantially in recent years due to reduced quota. This quota reduction, combined with the aforementioned catch caps, has substantially reduced at sea mortality of river herring. Invasive catfish in the Chesapeake Bay region also pose a threat to these species, as alosines are known prey items for flathead catfish and blue catfish (Moran et al. 2016) that are spreading throughout the region. 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.

Recent assessments of river herring population age structure for the North East River and the Nanticoke River are similar to that of other stocks in the region (Hilton et al. 2020) but should be interpreted with caution. Results from the ASMFC River Herring Aging Workshop found that precision between 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 scales 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.

PROJECT NO. 2
JOB NO. 1

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

2021 PRELIMINARY RESULTS - WORK IN PROGRESS

Analysis of the data collected in 2021 for Project 2 Job 1 to assess trends in adult and juvenile alosine species in the Chesapeake Bay and selected tributaries is currently in progress. Data were collected by several surveys of American shad, hickory shad, and river herring (i.e. alewife and blueback) in the Susquehanna, Nanticoke, Potomac and North East rivers.

Adult American shad from the lower Susquehanna River were tagged by Maryland Department of Natural Resources (MDNR) biologists one to four times per week from 22 April through 25 May 2021. Unlike most previous years, most American shad were landed by recreational anglers from shore in the Conowingo Dam tailrace and subsequently tagged by MDNR staff. Two-hundred ninety-three adult American shad were measured for length and scaled for age and spawning history analysis. Two-hundred seventy-six of those fish were marked with floy tags to formulate mark-recapture population estimates. Twenty-two fish were documented as recaptures in the Conowingo West Fish Lift.

Biologists worked with commercial fishermen on the Nanticoke River to collect stock composition data and to estimate relative abundance of adult American shad, hickory shad, and river herring from 11 March through 20 April 2021. Thirty-two American shad, one hickory shad, 393 alewife, and 44 blueback herring were observed by the survey. The abundance of blueback herring was markedly lower than previous years of the survey. Biologists also completed limited ichthyoplankton tows during the month of April in the Nanticoke River.

The Striped Bass Spawning Stock Survey (SBSSS; Project 2, Job 3, Task 2) provided American shad scales from the Potomac River. Ninety-nine American shad were encountered by this survey in 2020, representing the lowest catch on record since 2012. Seventy-nine American shad were scaled for age and repeat spawning analysis.

River herring were independently sampled using an experimental gill net deployed in the North East River at four randomly chosen sites once a week from 10 March to 13 May 2021. The gill net was set 40 times and encountered 478 blueback herring and a survey record 776 alewife. Random subsamples of approximately 300 alewife and 300 blueback herring scale samples are currently being processed for age and spawning history analysis.

The complete analyses of the data collected in 2021 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. Number of adult American shad and repeat spawners by sex and age sampled from the Potomac River Striped Bass Spawning Stock Survey (gill net) in 2020.

AGE	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
3	0		0		0	0
4	11	9	10	9	21	18
5	14	8	18	14	32	22
6	9	8	47	30	56	38
7	3	3	23	19	26	22
8	0		5	5	5	5
9	0		0		0	0
Totals	37	28	103	78	140	105
Percent Repeats	75.3%		75.3%		75.3%	

Table 2. Proportion at age of American shad, sexes combined, captured in the Potomac River, 2002-2020. * indicates years where not all fish were aged and an age-length key was subsequently used to assign ages.

Year	**N**	**Age**							
		3	**4**	**5**	**6**	**7**	**8**	**9**	**10**
2002	48	0.02	0.19	0.17	0.40	0.21	0.02	0.00	0.00
2003	141	0.01	0.22	0.31	0.26	0.11	0.08	0.01	0.00
2004	97	0.00	0.21	0.36	0.33	0.05	0.05	0.00	0.00
2005	97	0.01	0.34	0.28	0.25	0.09	0.01	0.01	0.01
2006	52	0.02	0.25	0.27	0.31	0.08	0.04	0.04	0.00
2007	200	0.07	0.57	0.27	0.08	0.01	0.01	0.01	0.00
2008	176	0.06	0.45	0.36	0.09	0.03	0.01	0.00	0.00
2009	31	0.00	0.16	0.19	0.39	0.16	0.06	0.00	0.03
2010	75	0.07	0.48	0.27	0.09	0.04	0.03	0.03	0.00
2011	56	0.13	0.18	0.36	0.27	0.07	0.00	0.00	0.00
2012	67	0.00	0.06	0.40	0.31	0.18	0.04	0.00	0.00
2013	105	0.00	0.01	0.10	0.50	0.30	0.09	0.00	0.01
2014	105	0.00	0.00	0.16	0.58	0.23	0.03	0.00	0.00
2015	120	0.03	0.08	0.46	0.35	0.08	0.00	0.00	0.00
2016	140	0.00	0.14	0.54	0.25	0.06	0.01	0.00	0.00
2017*	140	0.01	0.14	0.50	0.34	0.01	0.00	0.00	0.00
2018*	182	0.00	0.02	0.23	0.59	0.13	0.04	0.00	0.00
2019*	284	0.02	0.13	0.19	0.45	0.20	0.01	0.00	0.00
2020*	140	0.00	0.15	0.23	0.40	0.19	0.04	0.00	0.00

Table 3. Catch, effort and catch-per-angler-hour (CPAH) from spring logbooks for American shad, 2001-2020. Since 2014, data from Maryland's Volunteer Angler Shad Survey has been combined with logbook data.

Year	Number of Participants	Total Reported Angler Hours	American Shad Catch (numbers)	Catch Per Angler Hour
2001	12	347.5	1,735	4.99
2002	12	508.5	1,801	3.54
2003	13	621.0	1,222	1.97
2004	17	442.0	1,036	2.34
2005	18	406.5	533	1.31
2006	19	740.0	769	1.04
2007	17	558.0	873	1.56
2008	22	790.0	1,269	1.61
2009	15	543.8	967	1.78
2010	16	490.0	981	2.00
2011	9	201.8	413	2.05
2012	5	180.5	493	2.73
2013	6	219.3	313	1.43
2014	15	225.0	467	2.08
2015	10	171.0	364	2.13
2016	9	304.0	687	2.26
2017	10	155.0	288	1.86
2018	7	191.5	242	1.26
2019	8	101.0	218	2.16
2020	9	138.0	352	2.55

Figure 1. Grid of 305 m x 305 m quadrats overlaid on a map of the North East River from which sites were randomly chosen for the North East River sinking gill net survey, 2013-2020.

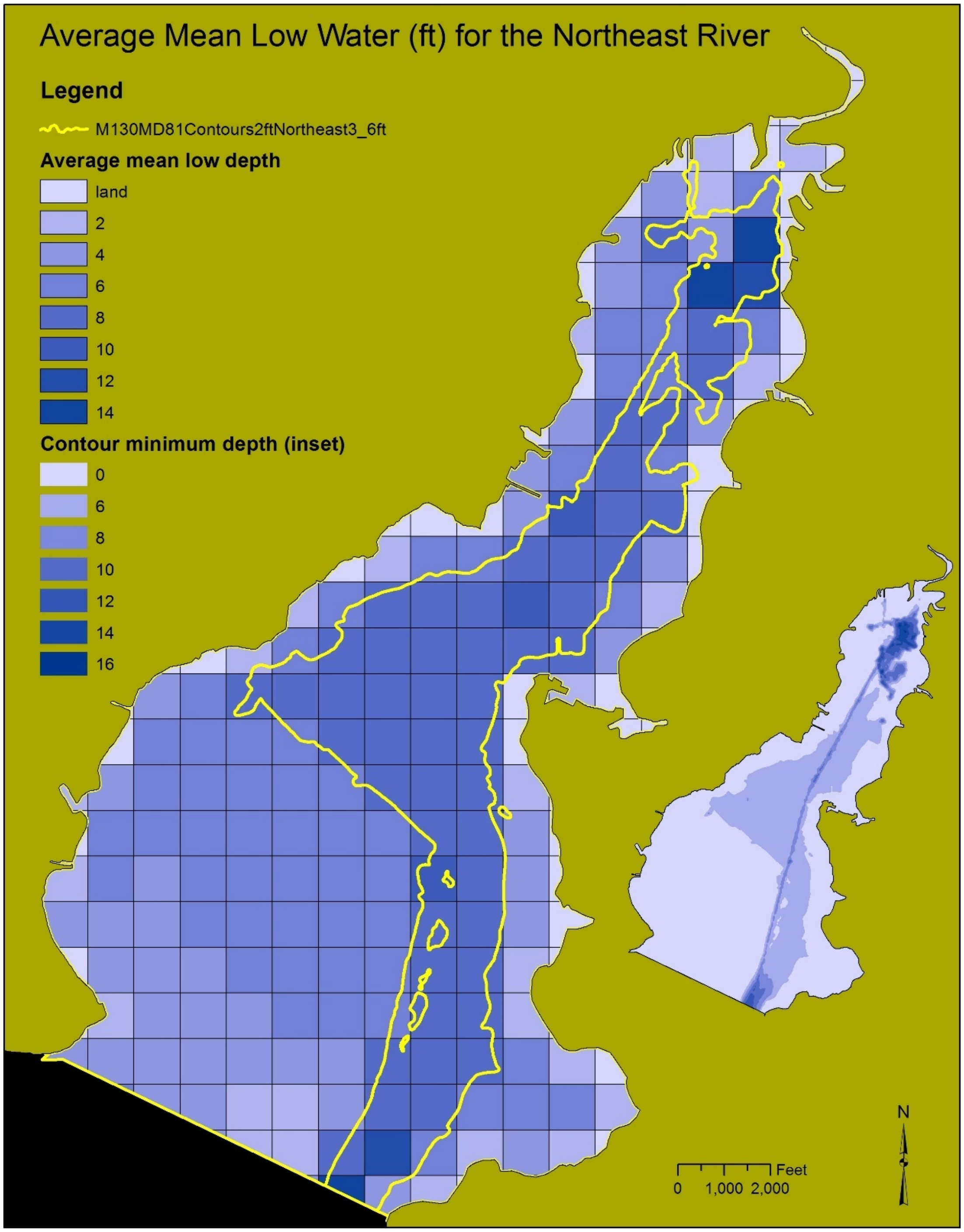


Figure 2. Arcsine-transformed percentages of repeat spawning American shad (sexes combined) collected from the Potomac River, 2002-2020.

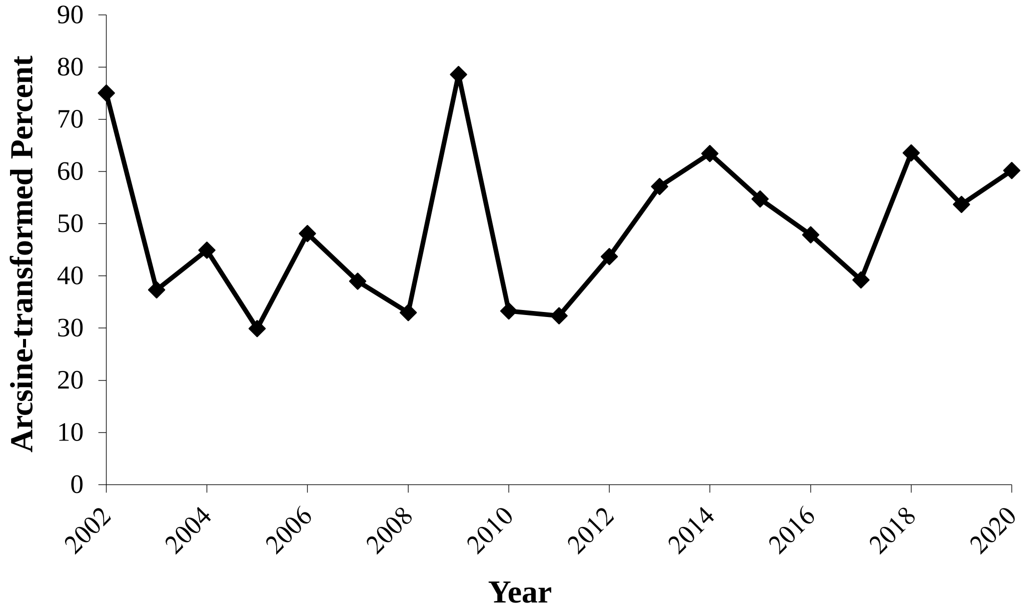


Figure 3. American shad CPUE (fish per 914 square meters of experimental drift gill net per hour fished) from the Potomac River, 1996-2020.

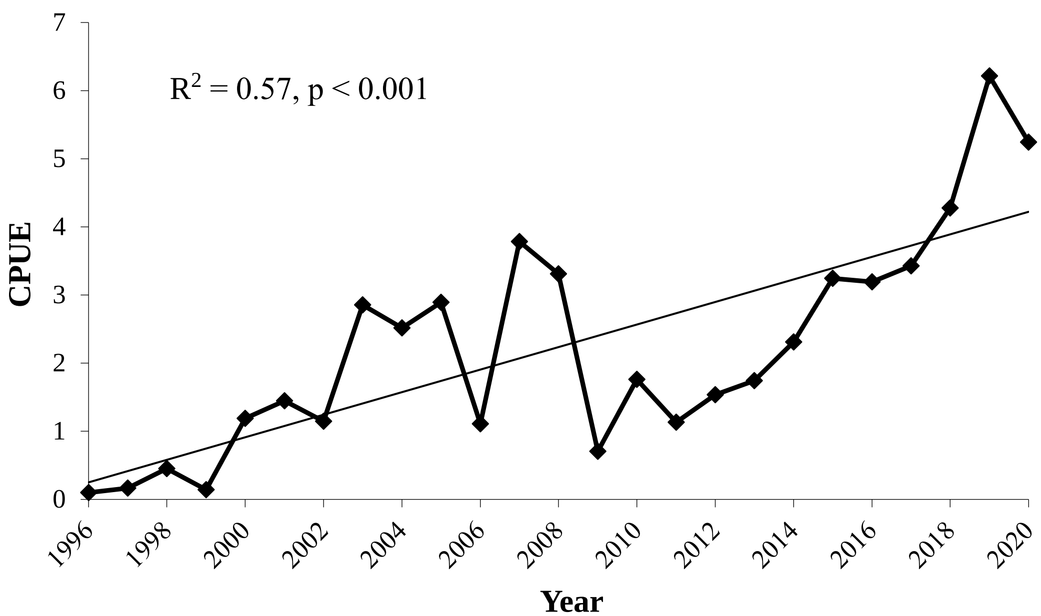


Figure 4. Age-based Chapman-Robson total instantaneous mortality (Z) estimates for American shad, sexes combined, captured in the Potomac River (2002-2020). The $Z_{40\%\ SBPR}$ reference point was determined in the 2020 ASMFC benchmark stock assessment for American shad and is specific to the southern iteroparous region.

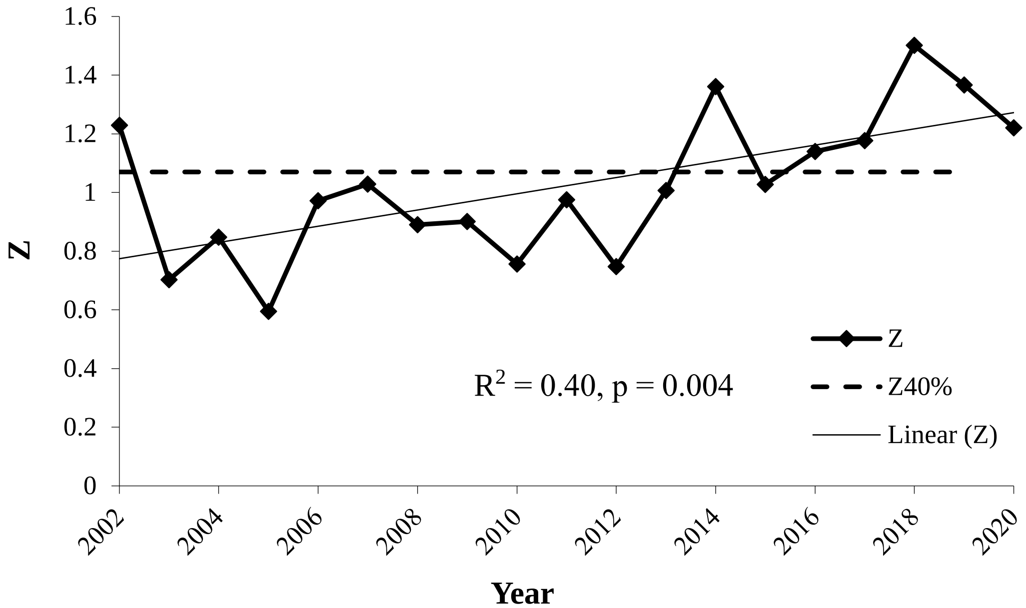


Figure 5. Upper Chesapeake Bay juvenile American shad geometric mean CPUE (catch per haul), 1959-2020.

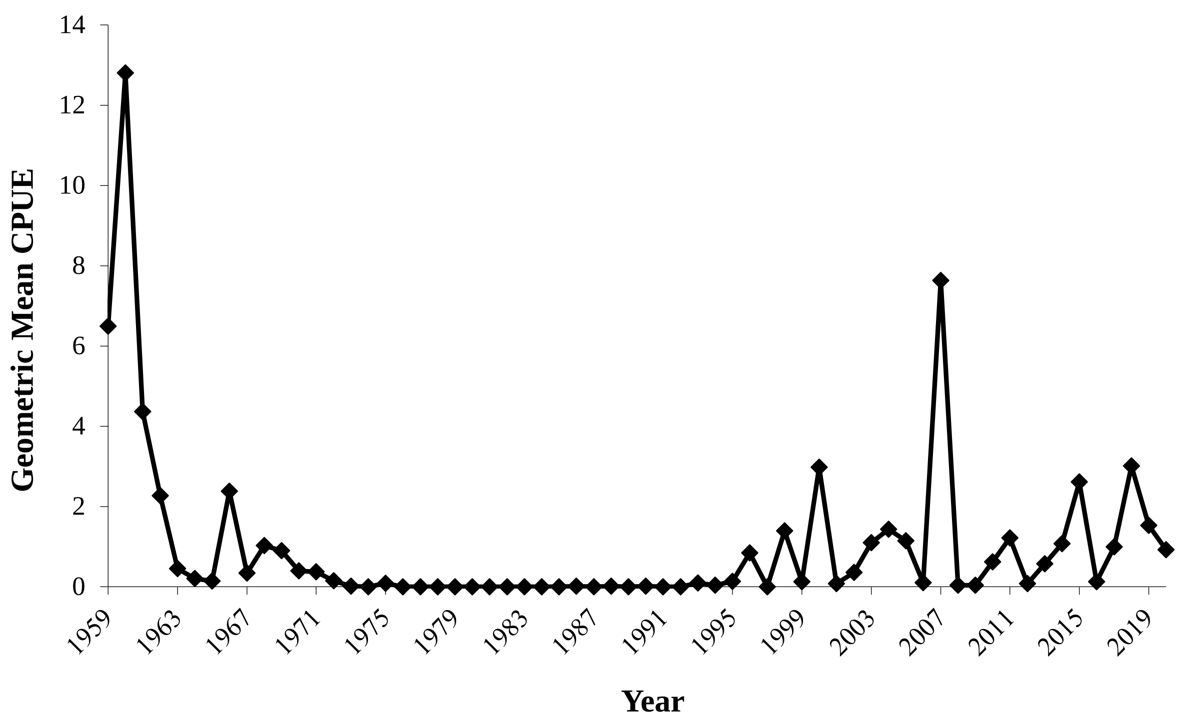


Figure 6. Potomac River juvenile American shad geometric mean CPUE (catch per haul), 1959-2020.

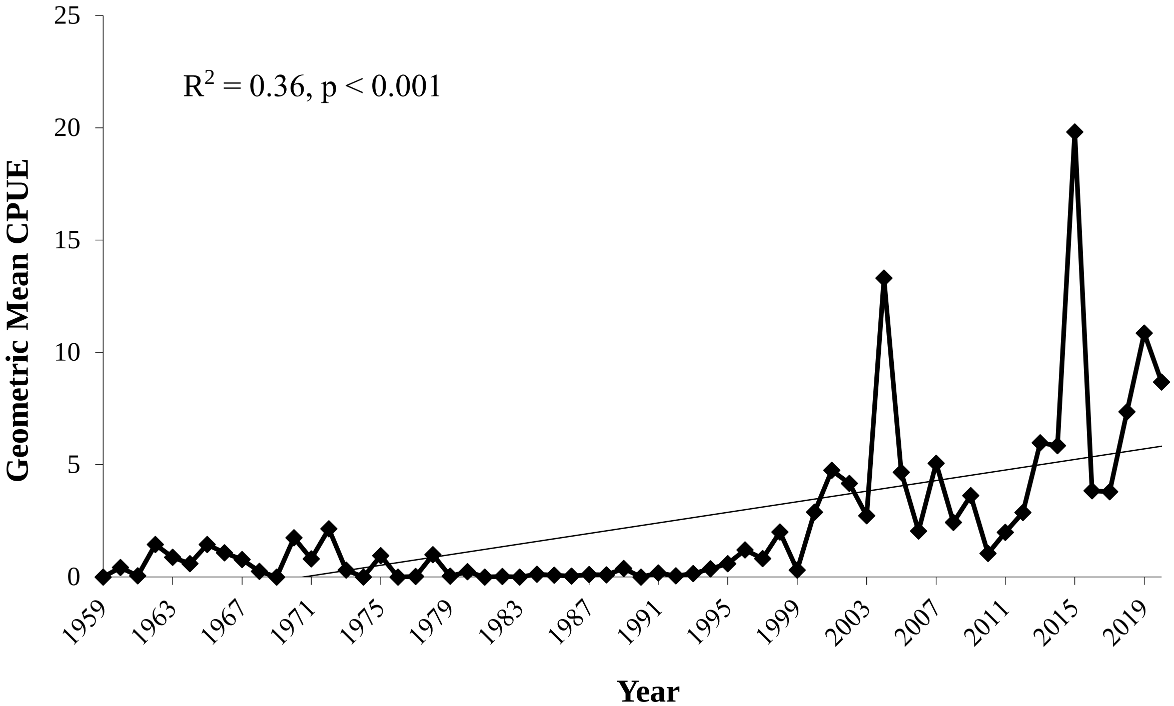


Figure 7. Nanticoke River juvenile American shad geometric mean CPUE (catch per haul). 1959-2020.

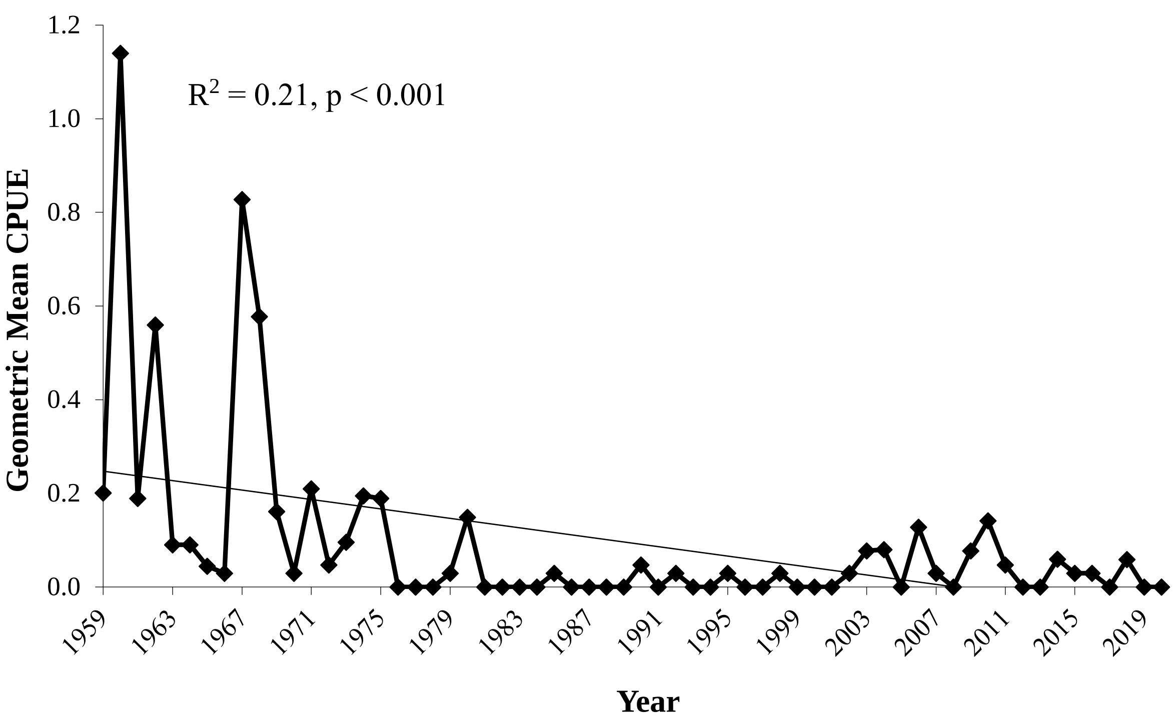


Figure 8. Baywide (all surveyed Chesapeake Bay tributaries) juvenile American shad geometric mean CPUE (catch per haul), 1959-2020.

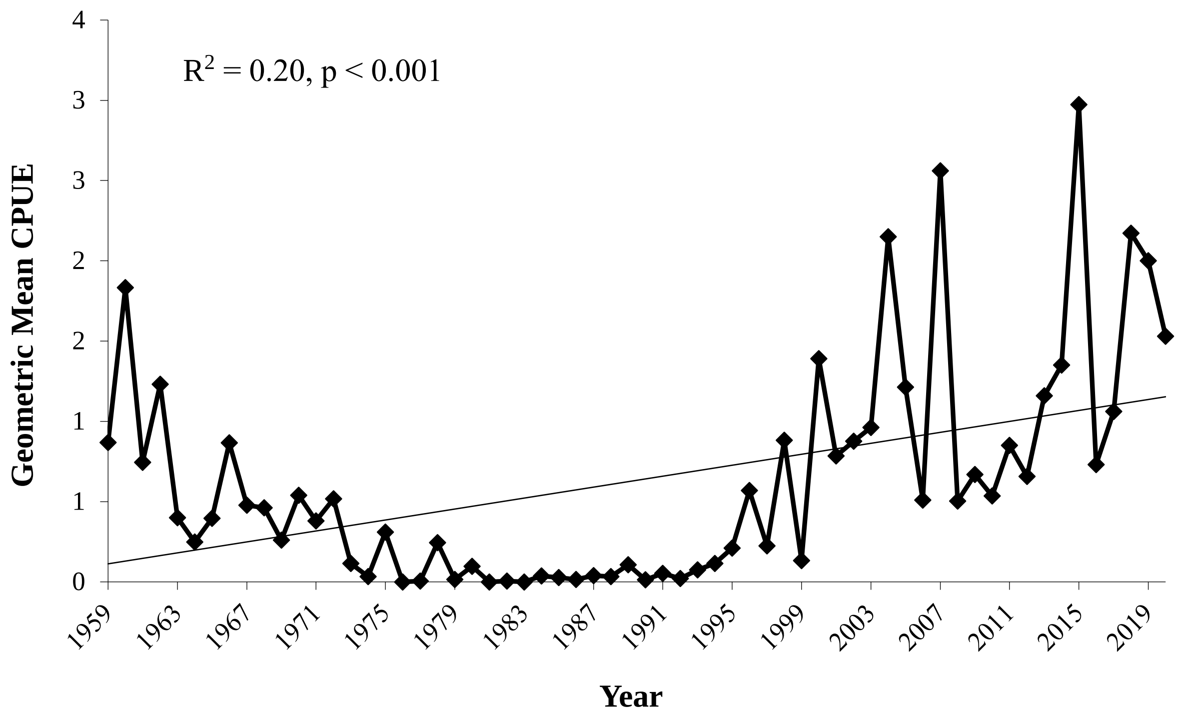


Figure 9. Upper Bay juvenile alewife and blueback herring geometric mean CPUE (catch per haul), 1959-2020.

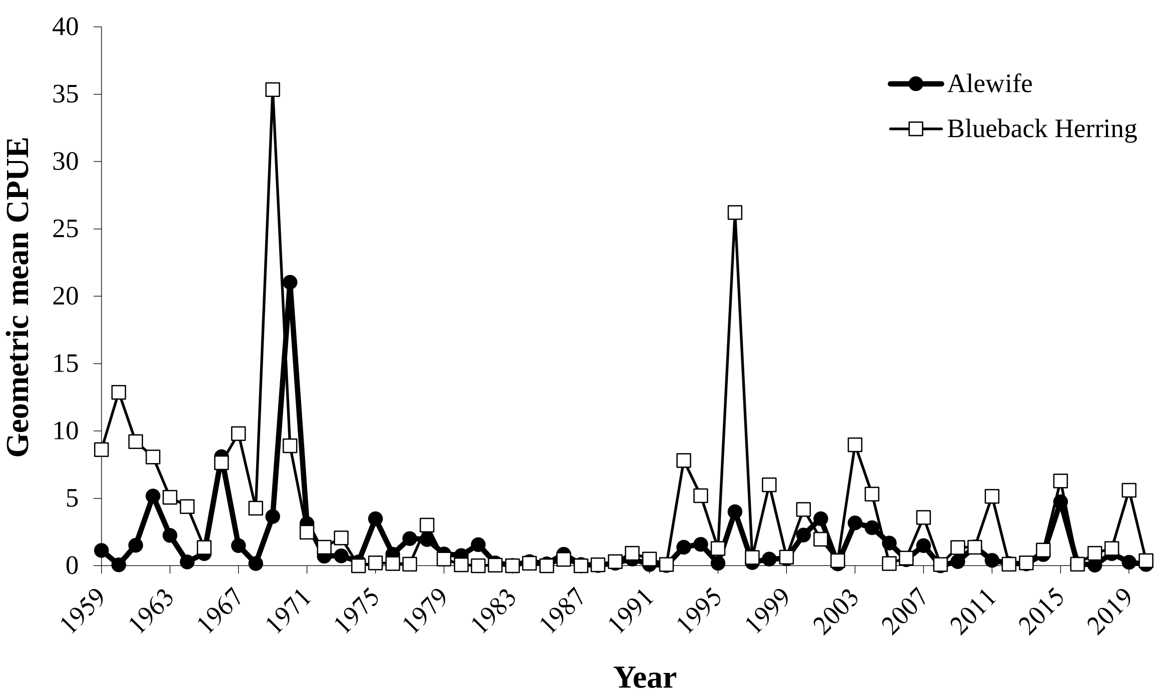


Figure 10. Nanticoke River juvenile alewife and blueback herring geometric mean CPUE (catch per haul), 1959-2020.

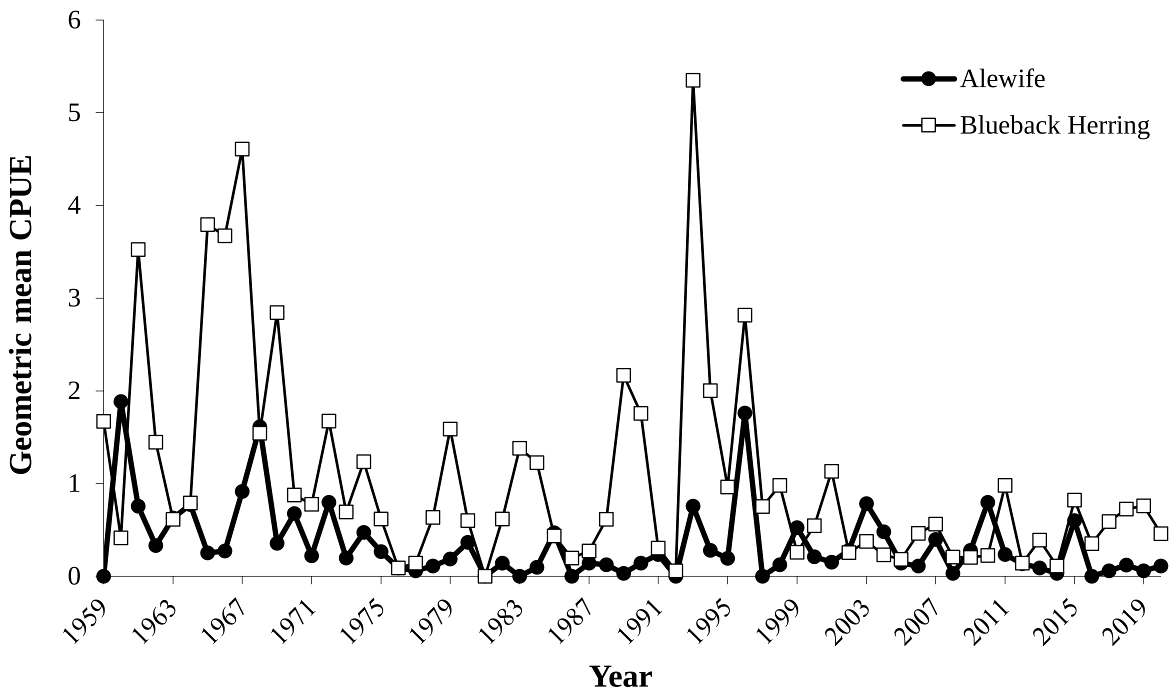
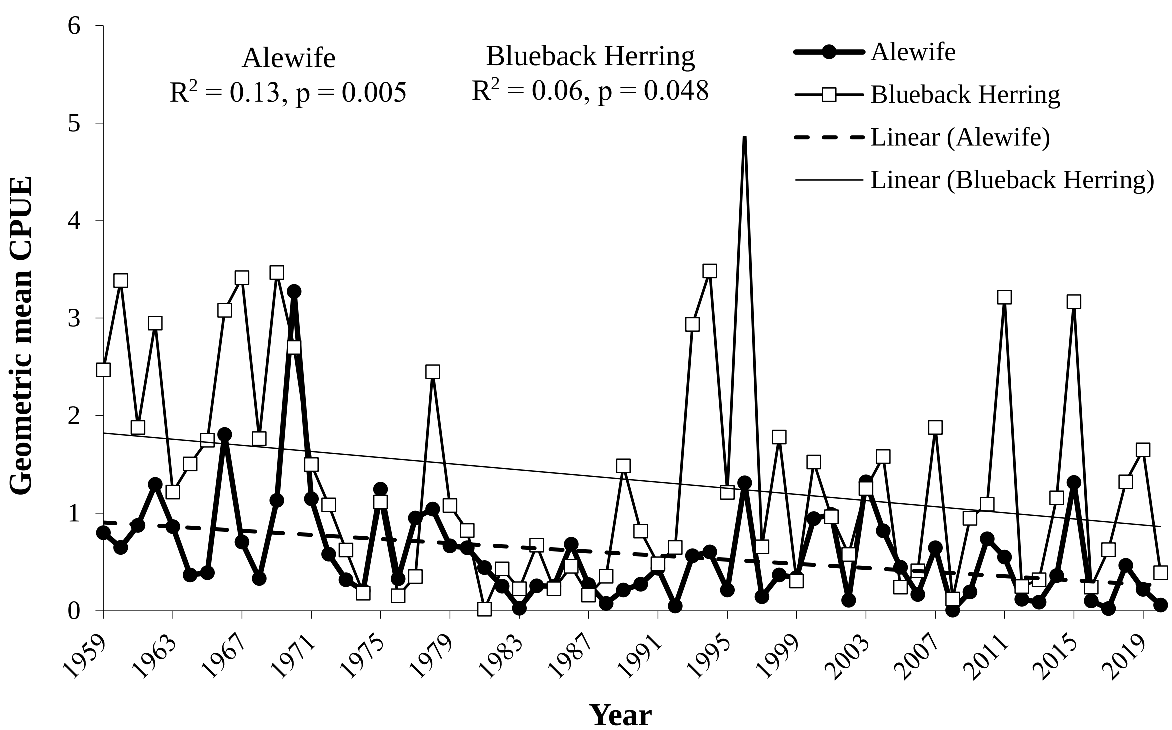


Figure 11. Baywide (all surveyed Chesapeake Bay tributaries) juvenile alewife and blueback herring geometric mean CPUE (catch per haul), 1959-2020.



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

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

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

METHODS

Data Collection

The onboard pound net survey relies on the cooperation of pound net fishermen. Pound nets from the lower Chesapeake Bay and Potomac River were monitored throughout the 28 years of this survey (1993-2020). In 2020, 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, fisherman's schedule and Covid-19 pandemic restrictions permitting. Data from pound nets were also included from Job 3 from the lower Chester River in 2020 (Figure 1). Staff collected length data and Atlantic menhaden scale samples when target species of Job 2 were encountered and staff could sample them without impacting the completion of Job 3 sampling. Net soak time and the manner in which the pound nets were fished were consistent with the fisherman's day-to-day operations. No fish dealer sampling was conducted in 2020 to help limit the potential spread of Covid-19 between fish house employees and Department staff.

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

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

A fishery independent gill net survey targeting adult Atlantic croaker, Atlantic menhaden, bluefish and spot was conducted in the lower Choptank River beginning in 2013 to provide an index of relative abundance and collect biological information for these species. The survey was conducted once a week 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 2013, 2015, 2016, 2017 and 2020 (Table 1). The survey utilized a simple random design in which the river has been 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, and mesh 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. 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 set randomly at the beginning of the sampling season. Sampling blocks with appreciable depth change were set toward the shallow or deep side of the block perpendicular to the channel according to the shallow or deep designation. Any site with no appreciable depth change was set in the center of the sampling block perpendicular to the channel. Sets were not made in less than 1.5 meters or more than 12.2 meters to avoid net inefficiency at shallow sites or potential areas of hypoxia at deeper sites. Nets soaked for one hour prior to retrieval.

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

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

Analytical Procedures

Commercial and recreational harvests for the target species were examined utilizing Maryland's mandatory commercial reporting system and the Marine Recreational Information Program (MRIP; National Marine Fisheries Service, Fisheries Statistics division, personal communication), respectively. MRIP data was downloaded in January 2021. Since these data sets are not finalized until the spring of the following year, harvest data for this report are through 2019. Only commercial harvest from Maryland's portion of Chesapeake Bay is included in this report. 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. Since the 2020 charter log book data had not been finalized, only data through 2019 were analyzed.

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

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

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

Annual length frequency distributions were constructed when sample size was sufficient for Atlantic croaker, Atlantic menhaden, bluefish, spot, summer flounder, and weakfish utilizing 20 millimeter length groups for both the onboard pound net and Choptank River gill net surveys. Length-at-age keys were constructed for Atlantic croaker, Atlantic menhaden and weakfish using age samples through 2020. Age and length data were assigned to 20 millimeter groups for each species and then the length-at-age key was applied to the length frequency by year to determine the proportion at age for Atlantic croaker in 2000 and 2002 through 2020, weakfish from 2003 through 2020 and Atlantic menhaden from 2005 through 2020. Age and length data for spot were assigned to 10 millimeter TL groups and the length-at-age key was applied to the length frequency to determine the proportion at age by year for 2007 through 2020. It was necessary to supplement Maryland spot ages with Virginia Marine Recourses Commission (VMRC) spot age data for a small number of fish greater than 270 millimeters in the 2007, 2011 and 2012 samples.

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

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

RESULTS and DISCUSSION

The onboard pound net survey sampled the Potomac River and Chesapeake Bay from June 1, 2020 through September 14, 2020 (Table 2). All of the target species and eleven non-target species were encountered in 2020 (Table 3). The Choptank River fishery independent gill net survey was conducted once per week from June 5, 2020 to September 2, 2020. Eight of the target species and nine non-target species were captured in 2020 (Table 4).

Weakfish

Six weakfish were sampled in the 2020 pound net survey, a decrease from 2019, and was the lowest number sampled in the 28 year time series. Weakfish mean length in 2020 was 300 millimeters TL, an increase from 2019, but due to low sample size may not be representative of the true mean length (Table 5). Sample size was too small to make valid length frequency comparisons to previous years, but the six weakfish that were encountered in 2020 were distributed among five length groups (Figure 4).

Chesapeake Bay weakfish length frequencies were truncated during 1993 – 1998, while those for 1999 and 2000 contained considerably more weakfish greater than 380 millimeters TL. However, this trend reversed from 2001 to 2020, with far fewer large weakfish being encountered. One of the six weakfish sampled in the 2020 pound net survey was above the commercial size limit of 305 millimeters TL (12 inches) and the recreational size limit of 331 millimeters TL (13 inches).

Two weakfish were captured and measured in the Choptank River gill net survey in 2020, with lengths of 301 and 327 millimeters TL. Weakfish catch was very low throughout the survey ranging from zero to four fish per year (Table 4). Twelve of the thirteen 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 weakfish being rarely encountered by the survey.

The 2019 Maryland Chesapeake Bay commercial weakfish harvest of 96 pounds was an increase from 2018, which was the record low for the time series (Figure 5). The 1981 – 2019 Maryland Chesapeake Bay average commercial harvest was 40,324 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 178 pounds per year. Estimated Maryland recreational harvest from inland waters during 2019 was 2,985 fish (PSE = 88.7; Figure 5). The time series mean harvest for Maryland inland waters from 1981-2019 was 276,649 fish. According to the MRIP estimates, Maryland anglers released 14,944 (PSE = 45.5) weakfish from inland waters in

2019, the third lowest value of the 1981-2019 time series, and well below the time series mean estimate of 284,140 fish per year. Estimated recreational harvest decreased steadily from 741,758 fish in 2000 to 763 in 2006, and fluctuated at a very low level from 2006 through 2019. 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 limits since the 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 51 to 75,011 weakfish from 1993 to 2019 (Figure 6), with a sharp decline occurring in 2003, and a 2019 value of 323 fish. Reported charter boat harvest slowly increased from 2014 to 2017, reaching 2,152 fish prior to the sharp decline in 2018.

The weakfish juvenile GM was stable from 2013 to 2015, with values just below the time series mean, but declined in 2016 and remained low through 2018 (Figure 7). The 2019 and 2020 index values increased to 2.11 and 2.03 fish per tow, respectively, with values similar to 2013 to 2015. 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.

Weakfish otoliths were collected from six fish in 2020, the lowest number sampled since 2014. Half of sampled weakfish were age one, half were age two, and no age three plus fish were sampled (Table 6). 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 age sample sizes were too small to make valid comparisons (six fish each year). No age three plus fish were sampled in 2015 – 2017 or 2019, 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 2020 could not be calculated because of extremely low sample size, while instantaneous total mortality estimates calculated for 2004, 2005 and 2013 were Z=1.29, Z = 1.44 and Z = 1.55, respectively (Table 7), indicating total mortality has remained high. Maryland's length-based estimates in the mid-2000s were similar to the coastal assessment of Z = 1.4 for cohorts since 1995 (Kahn et al. 2005), and the estimates from the 2019 ASMFC stock assessment, which estimated Z values of 1.83, 1.72, and 1.84 in 2004, 2005 and 2013, respectively (ASMFC 2019).

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

Summer Flounder

Summer flounder pound net survey mean lengths varied widely from 2004-2020. Mean total lengths have ranged from the time series high of 374 millimeters TL in 2005 and 2010 to the time series low of 191 millimeters TL in 2017 (n = 394, Table 5). The mean length increased to 304 mm TL in 2020 (Table 5), but only 40 summer flounder were measured, the lowest sample size of the 28 year survey time series. The length frequency distributions from the onboard sampling from 2004-2012 were either bimodal with peaks at the 130 to 150 millimeter TL intervals and between 310 to 430 millimeter TL intervals, or more normal in distribution with a singular peak between the 310 to 430 millimeter TL length groups. Generally, the bimodal distribution occurs when an abundant year class recruits to the fishing gear (at around 130 millimeters TL). The 2013 and 2014 length frequency distributions were heavily skewed toward smaller fish, with 66% and 58% below 290 millimeter TL in length, respectively. The 2015 distribution shifted to larger fish, but reverted back to smaller fish in 2016. The 2017 - 2019 length distributions were bimodal, with both peaks shifting to slightly larger fish each year (Figure 8). The 2020 distribution showed no clear pattern, likely due to the small sample size (Figure 8). Recreational size limits have been adjusted annually, but comparing the onboard pound net survey catches to the 2020 recreational size limit of 420 millimeter TL indicated 18% of the 40 sampled flounder were of legal size in 2020, compared to 1% in 2019 and a range of 0% to 10% from 2013 to 2018. Two summer flounder were encountered during the Choptank River gill net survey in 2020 (Table 4), measuring 213 and 222 millimeters TL. Both specimens were captured in the 76 millimeter mesh. Only 14 summer flounder have been captured in the eight years of the survey.

The 2019 Maryland Chesapeake Bay commercial summer flounder harvest totaled 1,023 pounds, a decrease from 2018 (2,617 pounds), and the second lowest value of the 1981 – 2019 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 75,518 fish (PSE = 31.5) caught in 2019 was an increase from the 2018 estimate, but was still well below the time series mean of 268,778 fish per year (Figure 9). The 2019 MRIP recreational inland release estimate of 923,479 fish (PSE = 27.9) increased compared to 2018 (558,590 fish, PSE = 29.6), and was approaching the time series mean of 1,206,116 fish per year. The recreational inland fishery has primarily been from the Maryland coastal bays in recent years. Regulations have been more restrictive in recent years than earlier in the time series.

Reported Chesapeake Bay summer flounder charter boat harvest has generally declined throughout the 1993 – 2019 time series, with the highest number harvested in 1993 (10,445 fish), the lowest in 2018 (seven fish), and only 11 harvested in 2019 (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 2010-2019 averaging 189 fish per year, with annual catch varying within these time blocks.

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

Bluefish

Bluefish sampled from the onboard pound net survey averaged 361 millimeters TL during 2020, the highest value of the 28 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 a larger grade of bluefish were available in those years, although small bluefish still dominated the population with primary peaks in the 230-270 millimeter TL groups. This trend reversed in 2008–2011 and 2016-2018 when larger bluefish became scarce. The 2019 length distribution was the first year with the primary peak of the bimodal distribution occurring for larger fish (350 millimeter TL group), and the 2020 distribution was more of a single peak centered on the 350 mm TL group, indicating that a slightly better grade of bluefish was available in 2019 and 2020. Variable migration patterns into Chesapeake Bay may be responsible for these differences. Crecco (1996) reviewed bluefish angler catches 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 have been captured in low numbers during all eight years of the Choptank River gill net survey, with one being captured in 2020 (Table 4). Bluefish lengths for all panels and years combined ranged from 189 to 500 millimeters TL (n=59), with the one measurement from 2020 being 189 millimeters TL. Sample size was too small to make meaningful comparisons of length by net mesh size. Bluefish were most often captured in the 6.4 centimeter mesh for all years combined, with the 7.6 centimeter mesh panel accounting for the second highest catch (Figure 12).

Maryland's Chesapeake Bay commercial bluefish harvest in 2019 was 3,304 pounds, the lowest value in the 1981-2019 time series, and well below the average of 103,945 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 2019, averaging 40,330 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 2019 harvest estimate of 99,117 fish (PSE = 27.4) decreased to the 1981-2019 time series minimum. Estimated inland recreational releases were 212,620 fish (PSE = 31.2) in 2019, below the time series mean of 760,987 fish, and was the second lowest value of the time series (Figure 13). Reported bluefish harvest from Chesapeake Bay charter boat logs ranged from 7,316 – 133,499 fish per year from 1993 to 2019, with the 2019 harvest being the third lowest of the 27 year time series (8,748 pounds; Figure 14).

A stock assessment of Atlantic coast bluefish utilized a forward projecting catch at age model including data through 2014 (NEFSC 2015). An operational assessment was conducted by the North East Fisheries Science Center in 2019, using the same model structure, with data through 2018 and the recalibrated MRIP estimates of recreational harvest. The assessment indicated overfishing was not occurring in the terminal year, but overfishing occurred during most previous years, and the stock was overfished (NEFSC 2020). These findings mandated coast wide regulation changes in 2020 to reduce harvest and rebuild the stock. Maryland reduced the bluefish recreational bag limit to three fish per person for shore and private boat anglers and five fish per person on for-hire fishing vessels, and Maryland's commercial fishery operates under a quota set by the National Marine Fisheries Service.

Atlantic Croaker

Atlantic croaker mean length from the onboard pound net survey increased to 252 millimeters TL in 2020, but was the still the fourth lowest value of the 28 year time series (Table 5). Only 14 Atlantic croaker were encountered in the survey in 2020, by far the lowest number sampled, and well below the 1,445 annual average. The onboard pound net length frequency distribution for 2019 was heavily skewed toward smaller fish, with 74% of all sampled fish being below 230 millimeter TL, and only seven percent of the sample over 250 millimeters TL (Figure 15). Low sample size in 2020 makes meaningful comparisons difficult, but the sampled fish were primarily in the 230 to 270 millimeter size groups (Figure 15). Sample size in 2020 was insufficient to analyze mean length and weight by sex.

Atlantic croaker geometric mean catch per hour from the Choptank River gill net survey declined through the first three years of the survey and has remained low in recent years (Figure 16). Catches ranged from 476 fish in 2013 to eight fish in 2018. The 6.4 centimeter mesh net caught the highest proportion of Atlantic croaker in all years except 2015, with proportion of catch declining as mesh size increased (Figure 17). In 2015 the 7.6 centimeter mesh accounted for the highest proportion of catch, but sample size was very low. Length frequency shifted to longer fish as mesh size increased (Figure 18), indicating the size selective nature of gill nets. Year to year length frequency comparisons were not made do to the low sample sizes in 2015 through 2020. Anecdotal reports from commercial and recreational fishermen indicated Atlantic croaker catches were unusually low from the Choptank River and northward since 2015, but catches were somewhat higher in Tangier Sound and the Potomac River. The decreased catches, coupled with declining landings, suggest decreased availability in the mid to upper Bay in recent years.

The 2019 Maryland Atlantic croaker Chesapeake Bay commercial harvest of 3,094 pounds was a sharp decline compared to the 2017 value of 40,599 pounds, well below the 1981 to 2019 mean of 362,689 pounds per year, and the lowest harvest value since 1991 (Figure 19). The 2019 recreational inland harvest estimate was 69,771 fish (PSE = 74.7) a 77% decrease from 2018, and well below the 1981-2019 average of 1,181,994 fish per year. The 2019 recreational release estimate of 1,229,849 (PSE = 26.7) fish was six times higher than the 2018 value (Figure 19), but still well below the 1981-2019 average of 2,294,304 fish per year. Reported Atlantic croaker harvest from charter boats ranged from 607 – 418,313 fish per year during the 27 year time period (Figure 20), with the low value occurring in 2018, and the second lowest value occurring in 2019 (1,153 fish).

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 31 year time series in 2008, but fell sharply in 2009 and remained low through 2011, before spiking again in 2012 (Figure 21). The GM steadily decreased the following three years to the 2nd lowest value of the time series in 2015 (0.21 fish per tow). The index value has varied since, with the 2019 and 2020 values (4.9 and 3.7 fish per tow respectively) increasing above the time series mean. Atlantic croaker recruitment has been linked to environmental factors including winter temperature in nursery areas (Lankford and Targett

2001, Hare and Able 2007); prevailing winds, currents and hurricanes during spawning; and larval ingress (Montane and Austin 2005, Norcross and Austin 1986). Because of these strong environmental influences, high spawning stock biomass may not result in good recruitment, and a high degree of variability can be expected.

Ages derived from Atlantic croaker otoliths from the onboard pound net survey in 2020 ranged from zero to four (n=14; Table 8). All Atlantic croaker sampled in 2020 were aged (n=14) and included in the age length key, which is likely biased for 2020 due to low sample size (Table 8). Age zero accounted for 14% of sampled fish, age one accounted for 57% of sampled fish, age two accounted for 14% and ages three and four accounted for 7% of sampled fish each (Table 8). Age structure in 2020 was heavily skewed to younger fish, with no age five plus fish encountered for the first time since aging began in 1999. Sample size for aged fish was much lower than in previous years, likely leading to missed ages, and is very likely not representing the true age structure. 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.

Instantaneous total mortality estimates in 2020 using Maryland growth parameters and ASMFC stock assessment growth parameters were $Z = 1.89$ and $Z = 1.27$, 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 2020. While sample size was very low in 2020, mortality estimates were very similar to those of 2019. Recruitment was generally poor through 2018, leading to increased mortality rates on recent year classes, and fewer fish reaching older ages and larger lengths. Total mortality estimates would be expected to slowly decline as the stronger 2019 and 2020 year classes recruit to the fishery, provided they are not rapidly depleted prior to reaching older ages.

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

Spot

The 2020 spot mean length from the onboard sampling of 186 millimeters TL decreased compared to the 2019 value of 198 millimeters TL, and was the seventh lowest value of the 28 year time series (Table 5). Ninety percent of spot encountered in the onboard pound net survey in 2019 were between 170 and 209 millimeters TL, indicating a truncated length frequency distribution (Figure 23). No jumbo spot (>254 millimeter TL) were present in the 2020 onboard sampling (n = 655). Abundance of jumbo spot in the survey has been low for the past several years (0-3% of sample, 2005-2020). This followed good catches in the early 2000's (10% in 2003, 13% in 2004).

Spot geometric mean catch per hour in the Choptank River gill net survey was highest in 2020 and 2014, moderate in 2013, 2017 and 2019, and lowest in 2015, 2016 and 2018 (Figure 24). Total annual catch ranged from a low of 109 fish in 2016 to a high of 812 in 2020. The 6.4 centimeter mesh captured the majority of spot each year (Figure 25), accounting for over 92% of catch in 2013, 2014, 2016 and 2018 through 2020, 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 no spot were captured in the 10.2 centimeter mesh through the eight year time series. Annual length frequency distributions have been variable throughout the survey, with similar distributions in 2013, 2014 and 2020 centered on the 200 and 210 millimeter length groups. Bimodal distributions were apparent in 2015 and 2017, and singular peak distributions were centered on the 190 millimeter TL group in 2016, 2018 and 2019 (Figure 26). These shifts are likely driven by year class strength, which has been generally poor in recent years. 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 38 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, remaining below the long term mean of 125,517 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 4,320,616 in 1991. The 2019 recreational inland waters harvest estimate of 2,634,233 fish (PSE = 23.9) was nearly equal to the time series mean of 2,637,160 fish per year. The release estimate of 3,292,319 fish (PSE = 20.1) was above the time series mean of 2,079,442 fish (Figure 27). Reported spot charter boat logbook harvest from 1993 to 2019 ranged from 74,763 to 847,311 fish per year (Figure 28). The 2019 reported harvest increased to 127,183 pounds, but was still the second lowest value on record, and well below the time series mean of 417,845 fish.

Spot juvenile trawl index values from 1989-2020 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 32 year time series, and the 2012 value increased to nearly the time series mean. The index values declined from 2012 to the time series low in 2015 (0.29 fish per tow). The index values remained low through 2018, but increased in 2019 and 2020, with the 2020 value of 27.1 fish per tow being the first above the series mean since 2012.

In 2020, 92% of spot sampled from the onboard pound net survey were age one, 7% were age zero, and one age two fish was encountered (97 ages and 655 lengths; Table 9). Age two plus spot were absent in 2013, 2016, 2018 and 2019. Age one spot dominated the pound net catch from 2007 to 2020 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 are likely due to the very poor 2015 year class. The continued low abundance of age two fish and lack of age three plus fish is likely due to below average year classes from 2013 to 2018. Based on the juvenile index, the 2019 year class was a marked increase and likely led to greater availability of age one spot in 2020.

In 2017, the ASMFC Spot Stock Assessment Committee completed a stock assessment using a catch survey analysis model, utilizing data through 2014 (ASMFC 2017b). The assessment was not endorsed for use by an independent review panel primarily due to conflicting signals in trends from independent indices and fishery removals. The panel did agree, based on the information provided, that immediate management actions were not necessary. The panel also recommended the TLA continue to be used to trigger management action, as needed. The ASMFC South Atlantic Board tasked the Spot Plan Review Team to explore revisions to the TLA following the assessment. That work was completed in 2018, and the ASMFC voted to incorporate those changes at its February 2019 meeting. The new TLA was updated with data through 2019 and evaluated in October of 2020. The TLA triggered coast wide management action, which will be implemented in 2021.

Red Drum

Red drum have been encountered sporadically through the 28 years of the onboard pound net survey, with none being measured in nine years and 458 being measured in 2012 (Table 5). Fifty-three red drum were measured in 2020 averaging 341 millimeters TL, ranging from 257 to 414 millimeters TL. Recreational anglers in Maryland are allowed one red drum between 18 and 27 inches TL all of the red drum encountered in 2020 were below the slot limit.

Maryland Chesapeake Bay commercial fishermen reported harvesting 25 pounds of red drum in 2019, compared to the 2013 spike of 2,923 pounds, and the 1981 to 2018 mean of 484 pounds per year (Figure 30). The high 2013 landings value was likely due to a large year class growing into the 18 – 25 inch slot limit. The current slot limit and a five fish daily harvest limit were put into place in 2003. Prior to 2003 a five fish limit was in place with an 18 inch minim size limit and only one fish over 27 inches.

MRIP estimated a recreational harvest of 1,258 (PSE = 73.6) red drum in 2019 for Maryland inland waters, and estimated releases were 5,740 (PSE = 63.5) red drum (Figure 30). Recreational harvest estimates have been extremely variable with zero harvest estimates for 28 of the 39 years, and very high PSE values. Recreational release estimates in 2012 indicated juvenile red drum were plentiful throughout much of Maryland's portion of Chesapeake Bay and its tributaries, and that most of these fish were sub-legal. Red drum catches returned to lower levels beginning in 2013.

Maryland charter boat captains reported harvesting red drum from the Chesapeake Bay in every year from 1993-2019, except for 1996. Harvest was low for all years, ranging from zero to a high of 269 fish in 2012, with 41 red drum being harvested in 2019 (Figure

31). The low reported annual harvest indicated red drum were available in Maryland's portion of Chesapeake Bay, but confirms the species limited availability to recreational anglers, as also indicated by the annual MRIP estimates. Maryland is near the northern limit of the red drum range, and catches of legal size fish should increase if the stock expands in response to the current Atlantic coast stock recovery plan (ASMFC 2002).

Black Drum

Black drum are encountered in small numbers during the onboard pound net sampling, 24 were sampled in 2020 with a mean TL of 909 millimeters (Table 5). Lengths throughout the time series have ranged from 202 to 1,330 millimeters 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 28 inch minimum size limit. Chesapeake Bay commercial harvest was 6,838 pounds in 2019 (Figure 32). Recreational inland water harvest and release estimates from 1981 to 2019 have been variable, with harvest ranging from zero (20 years) to 11,374 fish in 1983 (Figure 32). In 2019, MRIP estimated 4,897 black drum were harvested (PSE = 25.9) and 6,346 were released (PSE = 26.8). 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 1993-2019 time series, with a mean catch of 307 fish per year (range = 2 – 894; Figure 33). The lowest value of the time series was reported in 2018, and only eight were reported in 2019.

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 has ranged from 123 – 682 millimeters. The survey encountered 122 Spanish mackerel in 2020 with a mean length of 407 millimeters FL (n=120; Table 5). The largest samples occurred from 2005-2007, 2013 and 2019. Three Spanish mackerel were encountered in the Choptank River gill net survey in 2020. Spanish mackerel have been encountered in four of the eight years of the survey, and three of the past four years. Two were captured in the 6.4 centimeter mesh and one in the 7.6 centimeter mesh.

The 2019 commercial harvest of Spanish mackerel in Maryland's portion of Chesapeake Bay was 11,292 pounds (Figure 34), and was above the 1981 to 2019 mean of 4,834 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 – 2019, with 11 years of zero harvest and a peak of 106,392 fish in 2019 (PSE = 26.2; Figure 34). The 2019 release estimate of 62,203 fish (PSE = 41.5) was also the time series high, indicating an unusually high availability of Spanish mackerel in Maryland inland waters. Estimates in most years have high PSE values, so these estimates are considered tenuous. Spanish mackerel charter boat harvest from 1993 to 2019 ranged from 53 – 10,638 fish per year, with a harvest of 7,324 fish in 2019, the second highest value of the time series (Figure

35). It would appear that Spanish mackerel are providing a small but somewhat consistent opportunity for recreational anglers in Maryland's portion of Chesapeake Bay.

Spotted Seatrout

Spotted seatrout are occasionally encountered during the onboard pound net survey sampling, with annual observations ranging from zero (12 years) to 23 fish prior to 2020. Sixty-four spotted seatrout were encountered during the onboard pound net survey in 2020, with a mean TL of 442 millimeters (Table 5). Two spotted seatrout were captured in the gill net survey in 2020, the second year any were captured in the survey. One fish each were captured in the 6.4 and 10.2 centimeter mesh, and were 335 and 557 millimeters TL, respectively. Commercial harvest of spotted seatrout in Maryland's portion of Chesapeake Bay averaged 2,496 pounds from 1981-2019, however, 12 of 39 years had zero harvest including years 1981-1990, 1992 and 2019 (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 2019, including seven years of zero harvest, and averaged 9,801 fish per year. MRIP estimated 36,294 (PSE = 50.9) spotted seatrout were captured in Maryland inland waters in 2019, the highest estimate since 1998. The high PSE values indicate the MRIP survey does not provide reliable estimates for this species in Maryland inland waters.

Reported spotted seatrout harvest from 2019 charter boat logs was 63 fish. Reported harvest ranged from 2 – 20,003 fish per year and averaged 2,654 fish per year for the 25 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 harvest values that exceeded the time series mean coinciding with zero value estimates by MRIP.

Atlantic Menhaden

Mean length for Atlantic menhaden sampled onboard commercial pound net vessels in 2020 was 221 millimeters FL (n = 777), the sixth lowest value of the 17 year time series (Table 5). Atlantic menhaden length frequencies from onboard sampling have varied annually (Figure 38). The 2016 onboard pound net sampling distribution was more evenly distributed than previous years, but the 2017 and 2018 distributions were dominated by the 190, 210 and 230 millimeter size groups. The 2019 distribution was bimodal and heavily skewed toward smaller fish, but 2020 was more evenly distributed around a single peak at the 210 millimeter length group.

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 2020 catch was 1,866 fish, the fourth highest of the eight year survey. The geometric mean catch per hour of Atlantic menhaden from the gill net survey was steady from 2013 to 2015, slightly lower in 2016 and 2017, increased to the time series high in 2018, decreased in 2109, and increased slightly in 2020, and was still the second highest value of the time series (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 croaker from 2016 through 2018 and in 2020. Length frequency distributions from the Choptank River gill net survey indicated the gear selected slightly larger Atlantic menhaden than the pound net survey (Figure 41), with the 230 and 250 millimeter length groups, combined, accounting for over 60% of the catch annually from 2013-2018. The 2019 length frequency was the first year with a bimodal distribution, the primary peak still occurred at the 250 millimeter FL group, but a lesser peak occurred at the 190 millimeter FL group. The 2020 distribution peaked at the 210 millimeter length group with the 230 and 250 millimeter groups being the next most abundant. Prior to 2020 mean lengths for all meshes combined displayed little inter-annual variation, with values between 254 and 257 millimeters FL for five of the years and a value of 243 millimeters FL in 2017 and 2019 (Table 10). The 2020 value was somewhat lower at 235 millimeters FL.

Atlantic menhaden scale samples were taken from 293 fish from the onboard pound net survey in 2020, but ages could only be assigned to 288 fish (Table 11). After applying the 2020 length frequency (777 lengths in 2020) to the age length key, 61% of sampled fish were age two, 26% were age one and 7% were age three. Ages four through six were also present. 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 2020 compared to the method used in previous years. One hundred thirteen scale samples were taken and aged from the Choptank River gill net survey in 2020. Age two accounted for 52% of sampled fish, age one accounted for 16%, age three accounted for 15%, age four accounted for 11%, and age five accounted for 5% 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. Both surveys had their highest proportion of age one fish in 2019 and values at or near their highest proportion of age two fish in 2020, indicating the lower mean lengths and shifts to smaller fish in the length frequency distributions may be due a strong 2018 year class. A strong 2018 year class may also explain the bimodal length distribution in 2019 onboard samples and smaller mean length and shift to a lower peak in the 2020 gill net length distribution.

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 remained low in 2018 and 2019 at 2,785,393 and 3,135,342 pounds, respectively. 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 2019, 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 subsequent meeting in 2020.

PROJECT NUMBER 2
JOB NUMBER 2

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

2021 PRELIMINARY RESULTS – WORK IN PROGRESS

Onboard pound net survey sampling, through the 2021 portion of the reporting period, was conducted on June 4, June 9, June 15, June 23 and June 29, 2021, with one to four nets sampled each day. During these trips the survey took length measurements from 23 American Shad, 359 Atlantic menhaden, four Atlantic sturgeon, 5 black drum, 39 bluefish, three cobia, six hickory shad, one northern kingfish, 10 red drum, 17 summer flounder, 84 Spanish mackerel, 769 spot, two spotted seatrout, 238 striped bass, two weakfish, one white catfish and one white perch. Subsamples for aging were collected from 103 Atlantic menhaden, 113 spot and two weakfish. Sampling continued into the next reporting period.

Two cooperating fishermen were contracted for the 2021 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 2020 sampling season, since regional coverage of the onboard pound net survey was deemed adequate.

The Choptank River gill net survey was conducted on five days for a total of 20 sites from June 2, 2021 to June 30, 2021. The survey caught 15 Atlantic croaker, 676 Atlantic menhaden, one bluefish, 13 butterfish, two channel catfish, one cownose ray, three gizzard shad, 22 hogchoker, 276 spot, 18 striped bass, one white catfish and five white perch.   Scale samples were collected from 53 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 - 2020.

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

Table 2. Areas sampled, number of sampling trips, mean surface water temperature and mean surface salinity by month for 2020 commercial pound net sampling.

Area	Month	Number of Samples	Mean Water Temp. C	Mean Salinity (ppt)
Point Lookout	June	2	25.7	11.2
East Bay	June	3	22.5	11.7
West Bay	June	1	26.6	11.0
Chester River	June	1	21.4	7.3
Point Lookout	July	1	28.3	10.5
East Bay	July	2	28.0	13.0
Chester River	July	1	29.3	9.4
Point Lookout	August	1	26.8	13.9
East Bay	August	2	26.4	13.5
West Bay	August	1	27.1	14.0
Point Lookout	September	2	23.8	13.8
East Bay	September	1	26.3	14.6
Chester River	September	1	26.7	9.2
Chester River	October	1	19.1	11.5
West Bay	October	1	18.3	15.3
Chester River	November	1	10.3	10.4

Table 3. List of non-target species observed during the 2020 onboard pound net survey.

Common Name	Scientific Name
Atlantic needlefish	*Strongylura marina*
Cobia	*Rachycentron canadum*
Common Carp	*Cyprinus carpio*
Cownose ray	*Rhinoptera bonasus*
Florida pompano	*Trachinotus carolinus*
Gizzard shad	*Dorosoma cepedianum*
Harvestfish	*Peprilus alepidotus*
Northern puffer	*Sphoeroides maculatus*
Southern stingray	*Dasyatis americana*
Striped bass	*Morone saxatilis*
Striped burrfish	*Chilomycterus schoepfi*

Table 4. Total catch by species in numbers from the Choptank River gill net survey, 2013 – 2020.

Common Name	2013	2014	2015	2016	2017	2018	2019	2020
Atlantic Croaker	476	269	21	32	53	8	43	45
Atlantic Menhaden	1,584	2,247	1,782	1,171	1,292	2,257	2,045	1,866
Atlantic Sturgeon								2
Black Drum				1				
Blue Catfish							2	
Blue Crab	34	44	165	127	107	107	103	157
Bluefish	11	22	7	3	3	11	3	1
Butterfish	0	2	2			1		5
Chanel Catfish						1	3	
Cownose Ray						2		
Gizzard Shad	180	231	188	36	28	12	42	19
Harvestfish				2	2	13	2	7
Hickory Shad					1	3		
Hogchoker	3	39	6	6	14	5	14	20
Horseshoe Crab							1	
Northern Kingfish	1	9		1	1			3
Oyster Toadfish							1	
Spanish Mackerel				1		6	7	3
Spot	272	749	222	109	298	154	389	812
Spotted Seatrout							6	2
Striped Bass	16	33	14	50	76	103	48	26
Summer Flounder	2			2	5	4		2
Weakfish			1	3	1	3	4	2
White Catfish							3	
White Perch	18	41	55	64	67	8	32	20
Total catch	2,597	3,686	2,463	1,608	1,948	2,698	2,748	2,992

Table 5. Mean length (millimeter TL, unless otherwise noted), standard deviation, and sample size of summer migrant fishes from Chesapeake Bay onboard pound net sampling, 1993-2020.

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Weakfish																												
mean length	276	291	306	293	297	337	334	361	334	325	324	273	278	290	275	276	262	253	236	284	304	332	293	256	257	265	252	300
std. dev.	46	50	54	54	39	37	53	83	66	65	68	32	39	30	42	52	22	24	24	48	33	65	31	31	35	29	26	36
n	435	642	565	1,431	755	1,234	851	333	76	196	129	326	304	62	61	42	23	47	26	93	67	6	23	64	27	16	63	6
Summer flounder																												
mean length	347	309	297	335	295	339	325	347	358	324	353	327	374	286	341	347	368	374	359	338	268	268	336	273	191	250	272	304
std. dev.	58	104	62	65	91	53	63	46	50	93	56	101	76	92	66	72	64	84	67	130	89	73	61	77	86	69	74	105
n	209	845	1,669	930	818	1,301	1,285	1,565	854	486	759	577	499	1,274	1,056	982	277	197	213	161	194	101	43	41	394	125	168	40
Bluefish																												
mean length	312	316	323	307	330	343	306	303	307	293	320	251	325	311	318	260	265	297	245	298	297	319	327	289	299	291	345	361
std. dev.	75	55	54	50	74	79	65	40	41	45	58	60	92	71	70	41	43	60	48	77	59	62	79	48	53	59	50	54
n	45	621	912	619	339	378	288	398	406	592	223	581	841	1,422	1,509	2,676	1,181	493	290	877	1,000	443	392	132	111	72	756	395
Atlantic croaker																												
mean length	233	259	286	294	301	310	296	302	317	279	287	311	317	304	307	298	320	295	281	274	276	249	265	254	258	271	212	252
std. dev.	35	34	42	31	39	40	54	45	37	73	55	43	48	66	54	62	50	34	31	42	36	31	22	23	50	24	30	21
n	471	1,081	974	2,190	1,450	1,057	1,399	2,209	733	771	3,352	1,653	2,398	1,295	2,963	1,532	91	1,970	1,764	1,842	2,320	1,438	942	2,239	2,037	214	202	14
Spot																												
mean length	184	207	206	235	190	230	213	230	239	184	216	208	197	191	208	198	185	201	193	179	196	194	194	175	200	180	198	186
std. dev.	28	21	28	28	35	16	25	21	33	36	30	36	37	29	23	21	21	22	18	24	20	20	18	19	25	18	22	11
n	309	451	158	275	924	60	572	510	126	681	1,354	882	2,818	2,195	519	1,195	33	51	582	1,508	1,302	420	127	135	1,063	1,149	1,396	655
Spotted Seatrout																												
mean length		448	452			541	460								414	464	262		361	436	456	499	487	625	464		391	442
std. dev.		86	42				134								43	72	22		142	112	29	70			51		70	68
n		4	6			1	2								3	10	23		4	8	5	4	1	1	3		13	64
Black Drum																												
mean length		1,106	741	353		1,074				435	475	780	1,130	1,031	1,144	875	1,147	1,061	978	997	882	1,080	993	952		610	564	909
std. dev.		175	454	20		182				190	20	212		228	95	238	84	345	188		236	150	171	429		350	383	203
n		2	3	2		12				7	4	44	1	8	9	5	13	3	3	1	4	14	4	4		3	4	24

Table 5. Continued.

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Red Drum																												
mean length						302	332	648		316	506	647	353	366	658	361			678	318	469	954		340	549	1,191	528	341
std. dev.							71			44		468		21	40	57			18	71	39			10	105	162	247	28
n						1	16	1		177	1	2	1	16	2	21			2	458	16	1		3	19	4	6	53
Spanish Mackerel (Total Length)																												
mean length	261	391	487	481	520	418	468	455													508		343	404				599
std. dev.	114	55	38	55		45	82	66													37			53				50
n	3	78	39	27	1	4	45	35													124		1	10				2
Spanish Mackerel (Fork Length)																												
mean length			418	401	437	379		386	406	422	405	391	422	439	436	407	418			393	428	536	437	345	446	427	374	407
std. dev.			34	62				34	34	81	63	95	33	35	51	59	53			74	36		41	16	54	144	54	78
n			44	27	1	1		49	19	20	11	8	373	445	158	18	7			107	331	1	3	10	9	9	1,337	120
Menhaden (Fork Length)																												
mean length												262	282	238	243	246	245	232	213	243	251	223	219	208	217	231	215	221
std. dev.												28	36	42	41	29	40	36	39	25	31	38	28	42	24	24	41	27
n												213	1,052	826	854	826	366	836	773	755	762	775	864	732	723	668	868	777

Table 6. Percentage of weakfish by age and year, number of age samples and number of length samples by year, using pound net length and age data 2003-2020.

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

Table 7. Atlantic croaker and weakfish instantaneous total mortality rate estimates (Z) from Chesapeake Bay pound net data, 1999–2020.

		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**

* Insufficient sample size to calculate 2006 – 2012, 2014 - 2020 weakfish estimates.
**Very low sample size.

Table 8. Percentage of Atlantic croaker by age and year, number of age samples and number of length samples by year, using pound net length and age data, 1999-2020.

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

Table 9. Percentage of spot by age and year, number of age samples and number of length samples by year, using pound net length and age data, 2007-2020.

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

Table 10. Atlantic menhaden mean length (millimeter FL), standard deviation, and sample size from the Choptank River gill net survey, 2013- 2020.

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

Table 11. Atlantic menhaden percentage at age, number of age samples and number of length samples by year using pound net length and age data, 2005-2020.

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

Table 12. Atlantic menhaden percentage at age, number of age samples and number of length samples by year using the Choptank River gill net length and age data, 2015-2020.

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

Figure 1. Onboard pound net survey and fish house sampling site locations for 2020.

Figure 2. The Choptank River gill net survey sampling site locations for 2020.

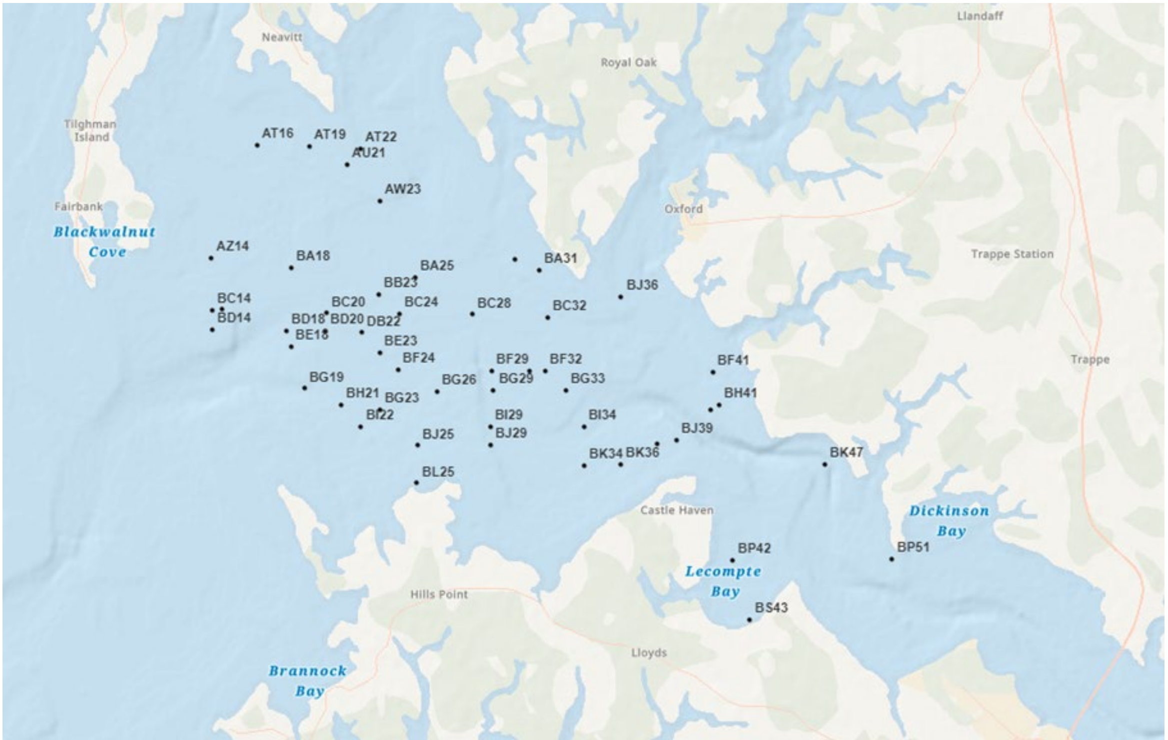


Figure 3. The Choptank River gill net survey sampling grid and grid names used in all years of the survey.

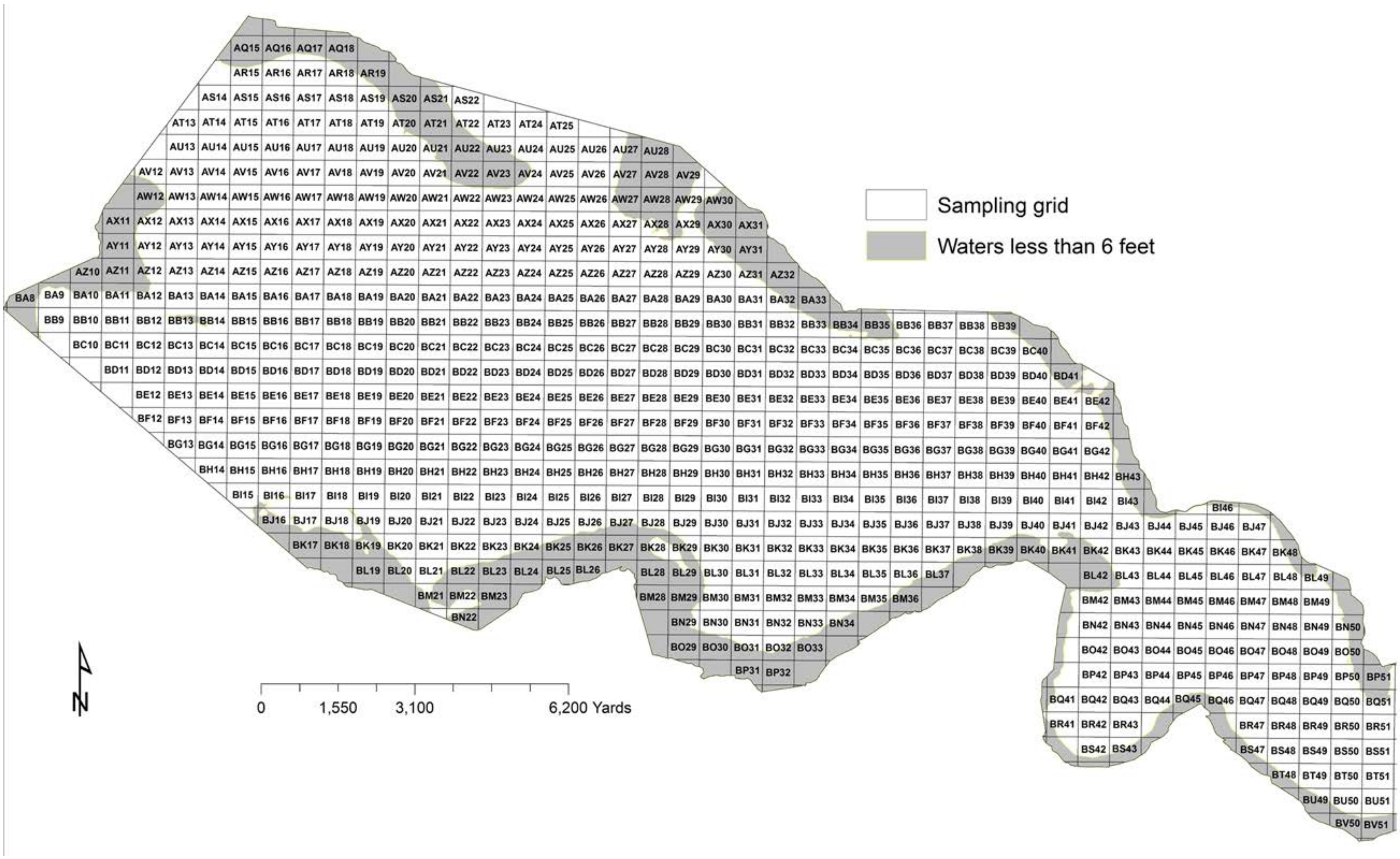


Figure 4. Weakfish length frequency distributions from onboard pound net sampling, 2011-2020. Note: In 2011 the 210 millimeter length group was truncated to preserve scale, actual value is 50%, and in 2018 the 270 millimeter length group was truncated to preserve scale, actual value is 44%.

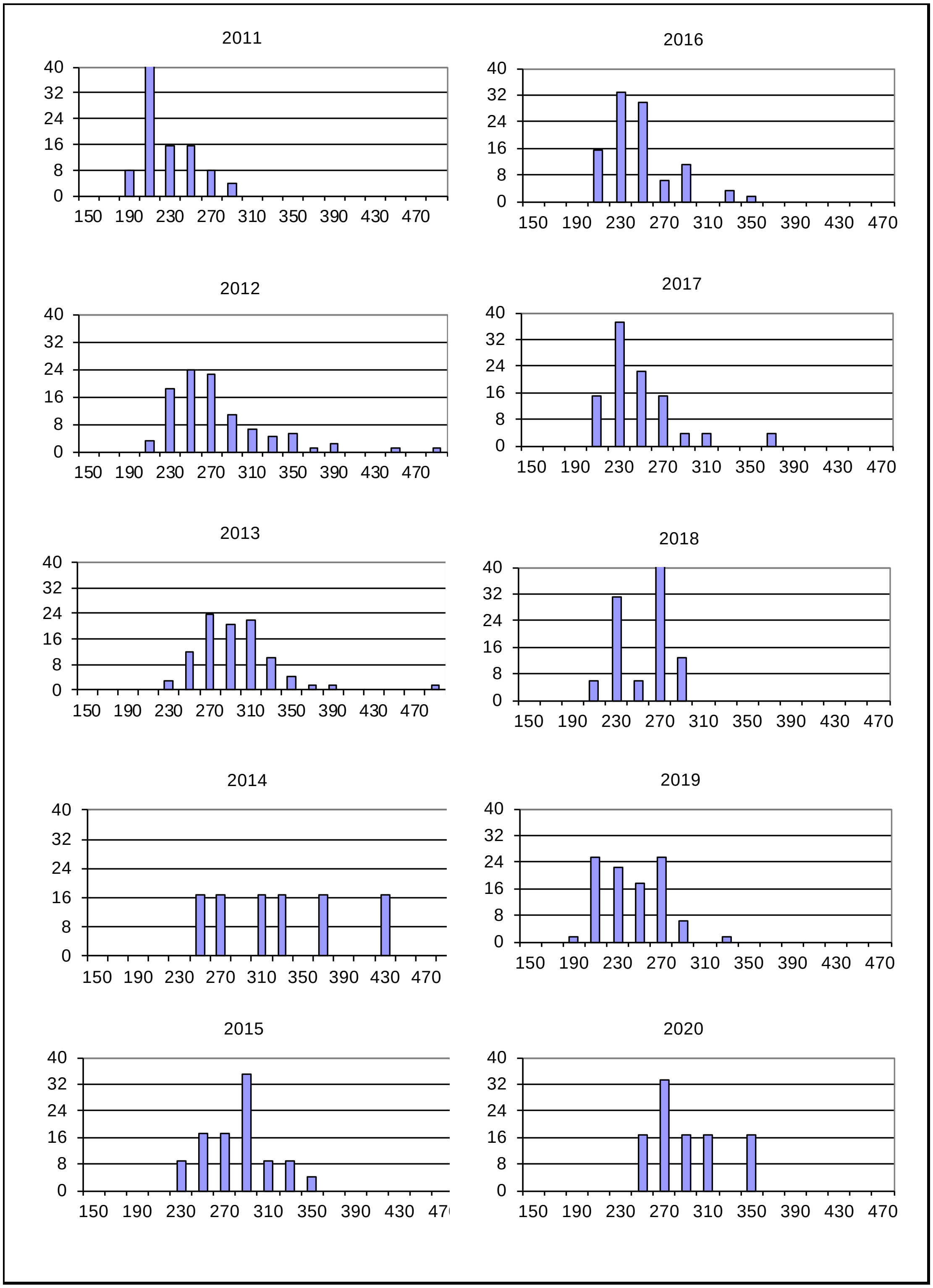


Figure 5. Maryland's commercial landings of weakfish in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational weakfish harvest and release estimates in numbers from 1981-2019.

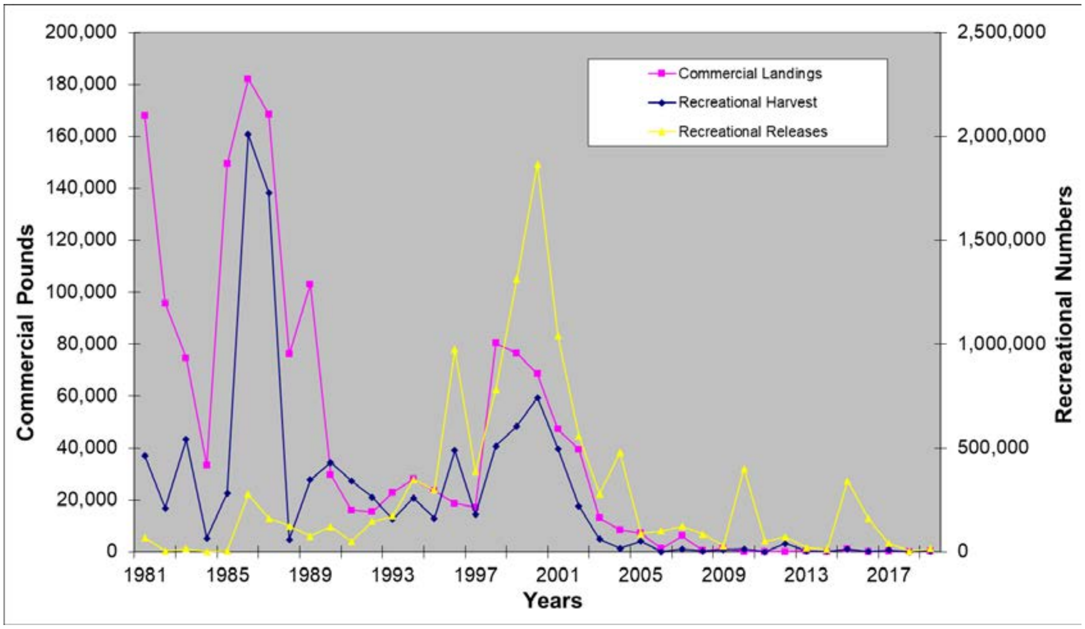


Figure 6. Maryland charter boat log book weakfish harvest in numbers and the number of anglers participating in trips catching weakfish, 1993-2019.

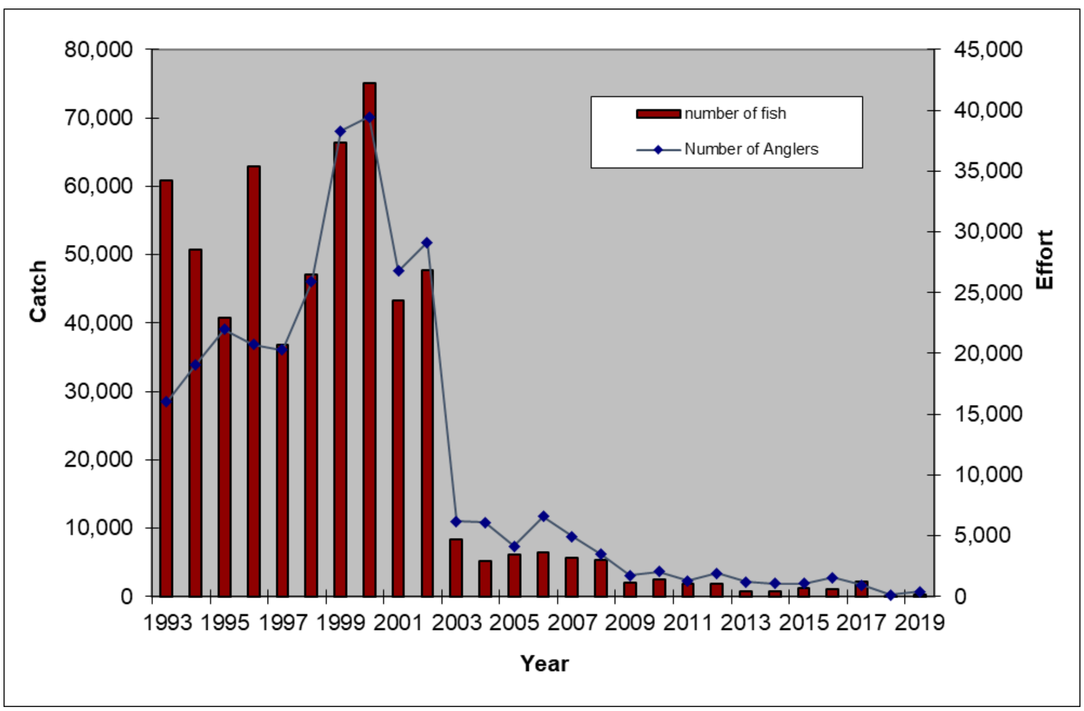


Figure 7. Maryland juvenile weakfish geometric mean catch per trawl, 95% confidence intervals and time series mean for Maryland's lower Chesapeake Bay, 1989-2020.

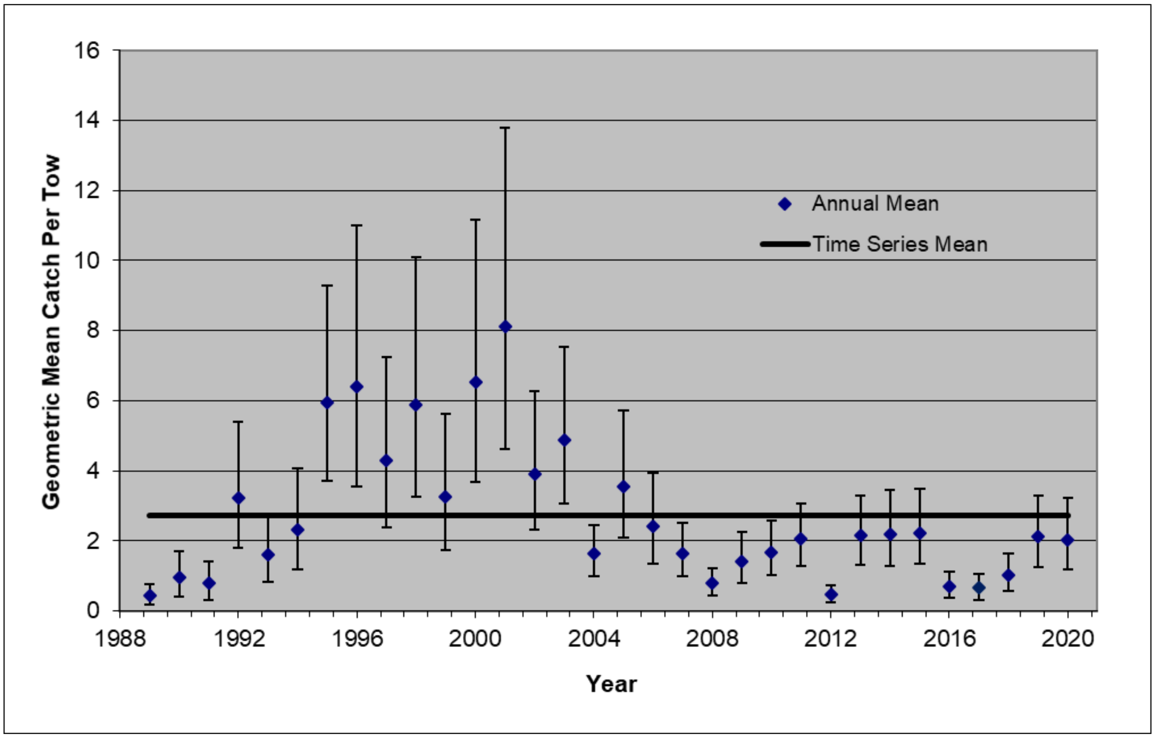


Figure 8. Summer flounder length frequency distributions from onboard pound net sampling, 2011-2020.

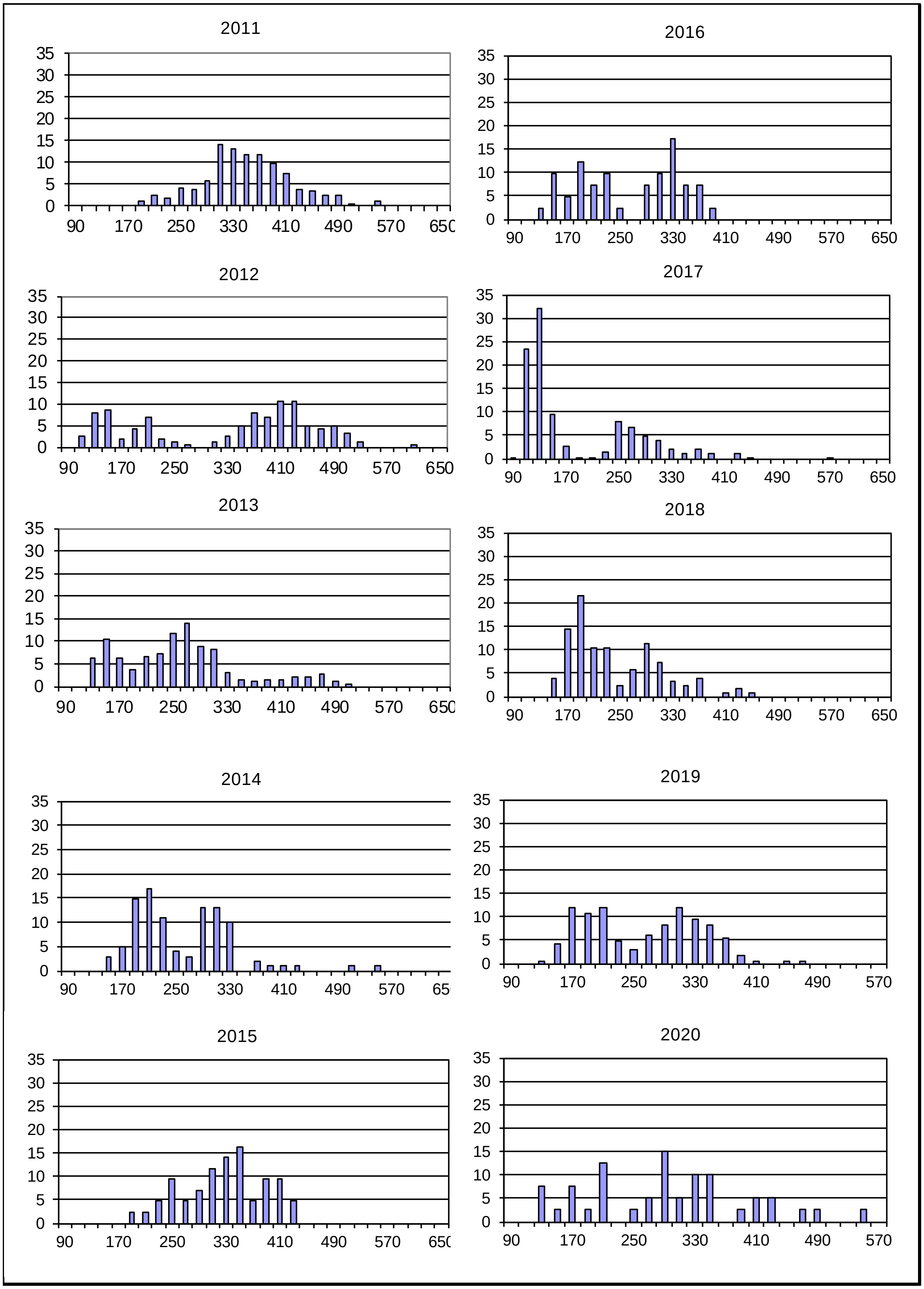


Figure 9. Maryland's commercial landings of summer flounder in pounds from the Chesapeake Bay and the MRIP Maryland summer flounder inland recreational harvest and release estimates in numbers from 1981-2019.

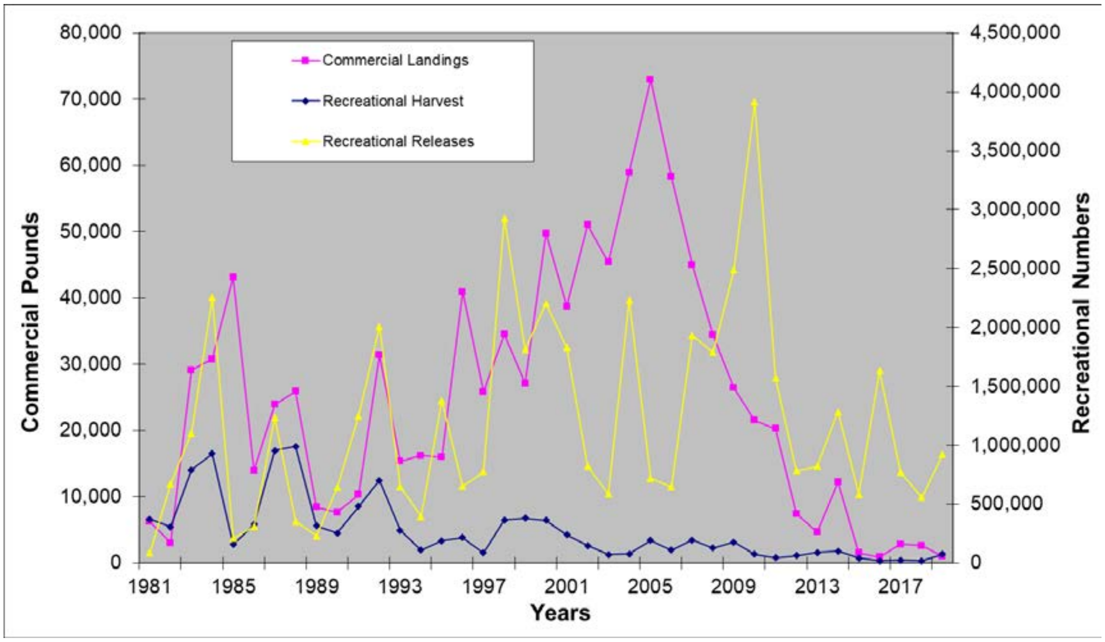


Figure 10. Maryland charter boat log book summer flounder harvest in numbers and the number of anglers participating in trips catching summer flounder, 1993-2019.

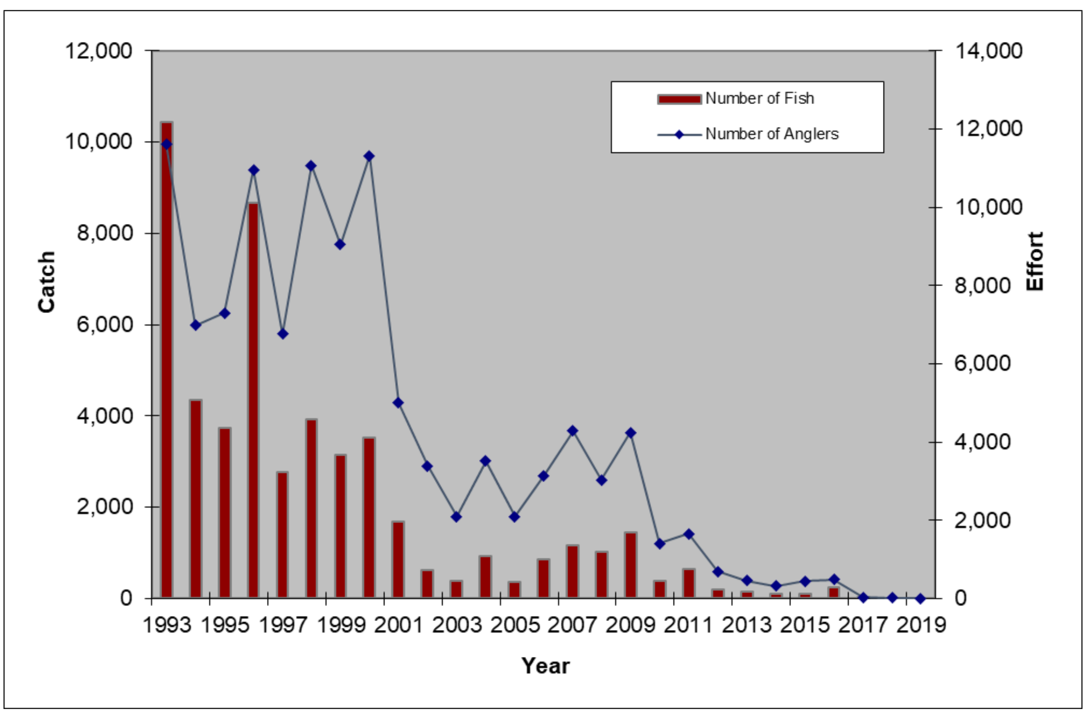


Figure 11. Bluefish length frequency distributions from onboard pound net sampling, 2011-2020. Note: In 2011 the 210 millimeter length group was truncated to preserve scale, actual value is 44%.

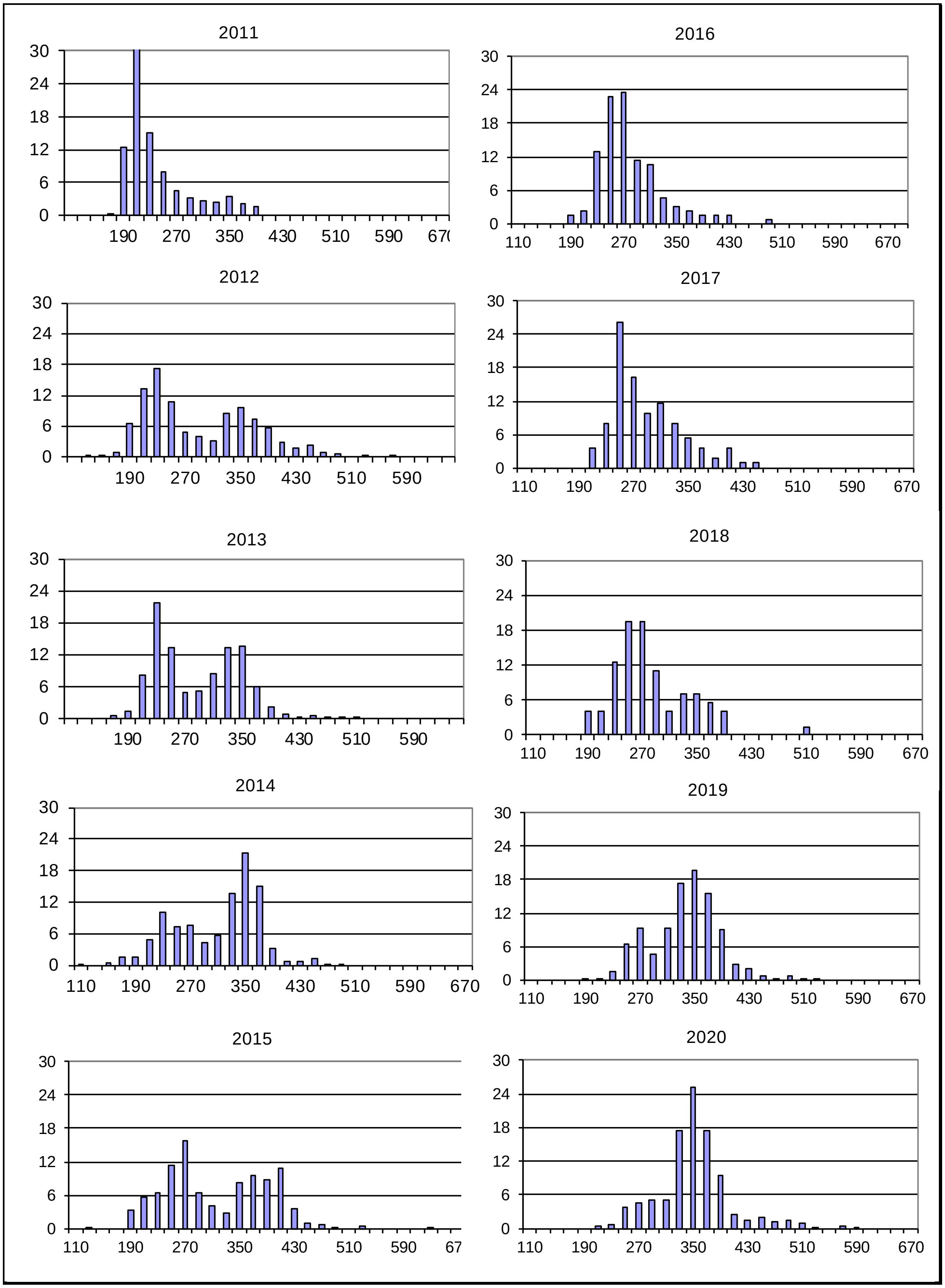


Figure 12. Proportion of bluefish catch by mesh size, all years combined, for the Choptank River gill net survey, 2013-2020.

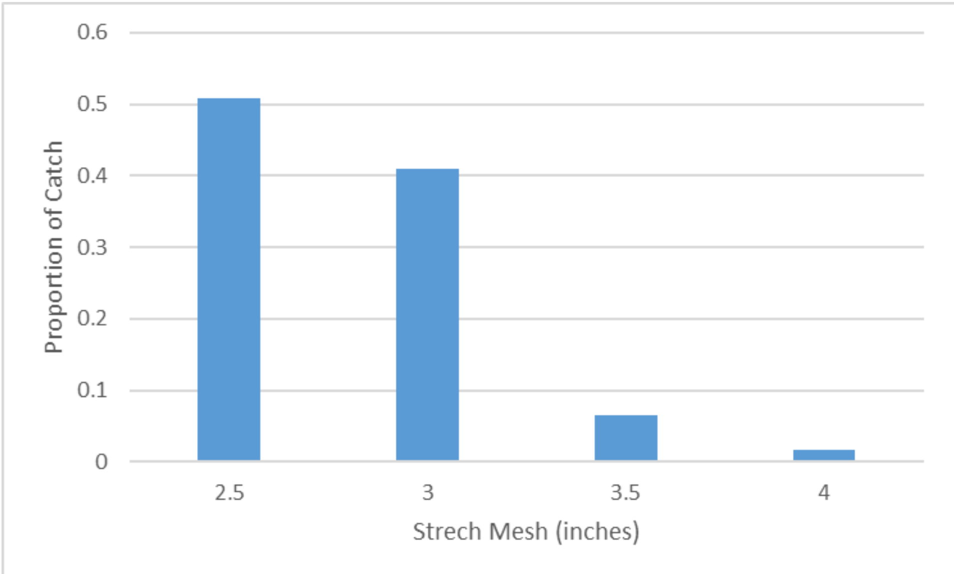


Figure 13. Maryland's commercial landings of bluefish in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational bluefish harvest and release estimates in numbers from 1981-2019.

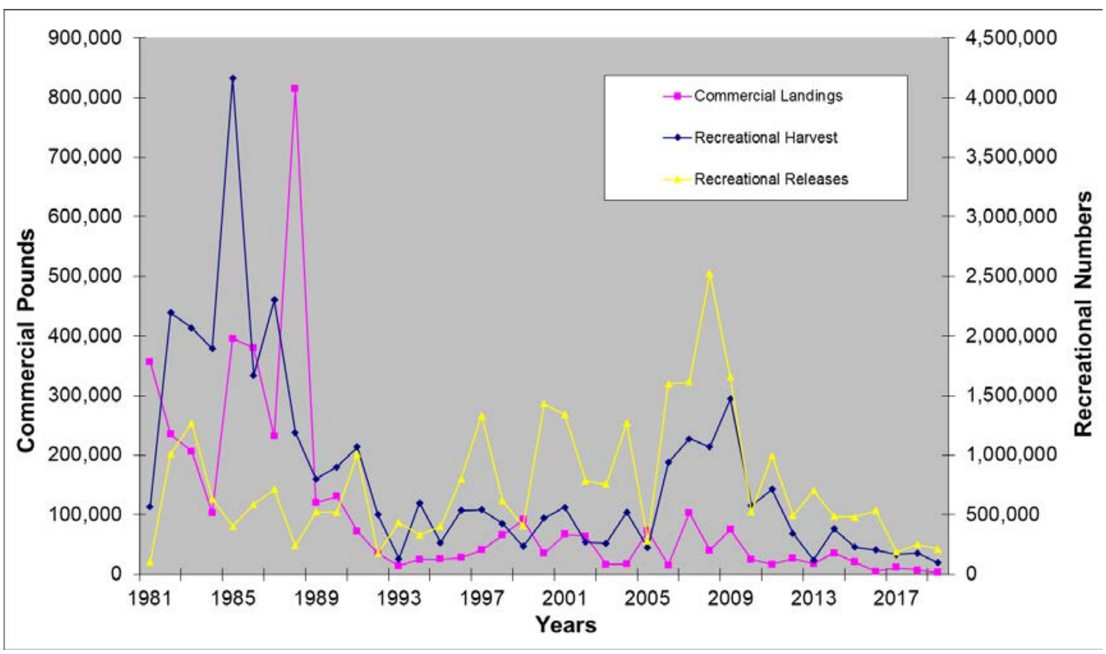


Figure 14. Maryland charter boat log book bluefish harvest in numbers and the number of anglers participating in trips catching bluefish, 1993-2019.

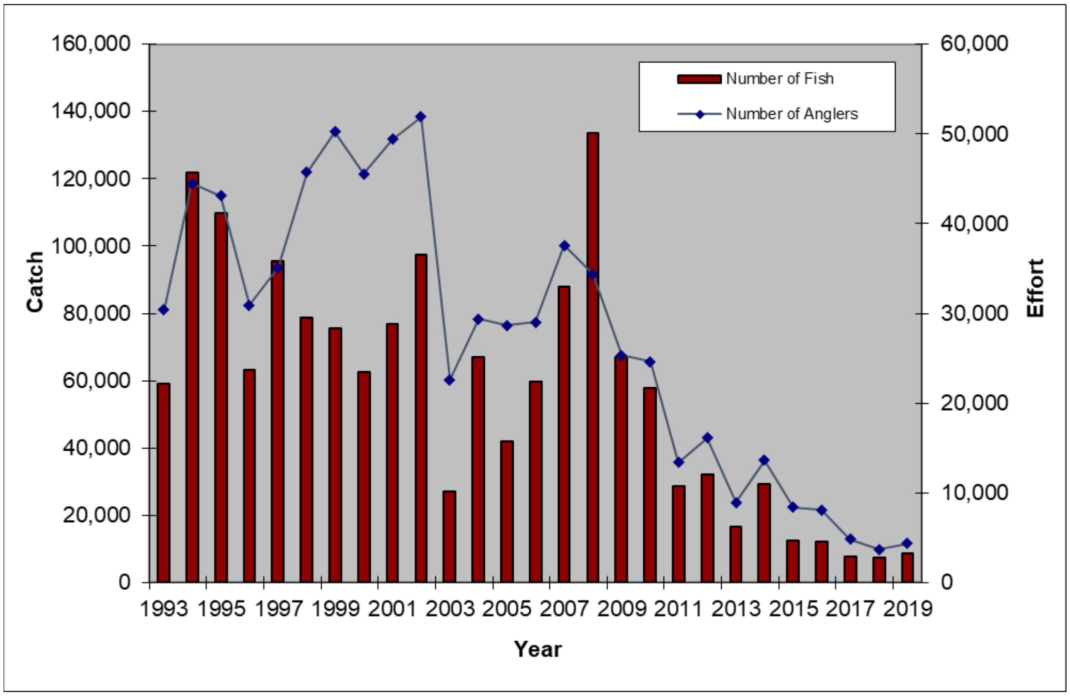


Figure 15. Atlantic croaker length frequency distributions from onboard pound net sampling, 2011-2020.

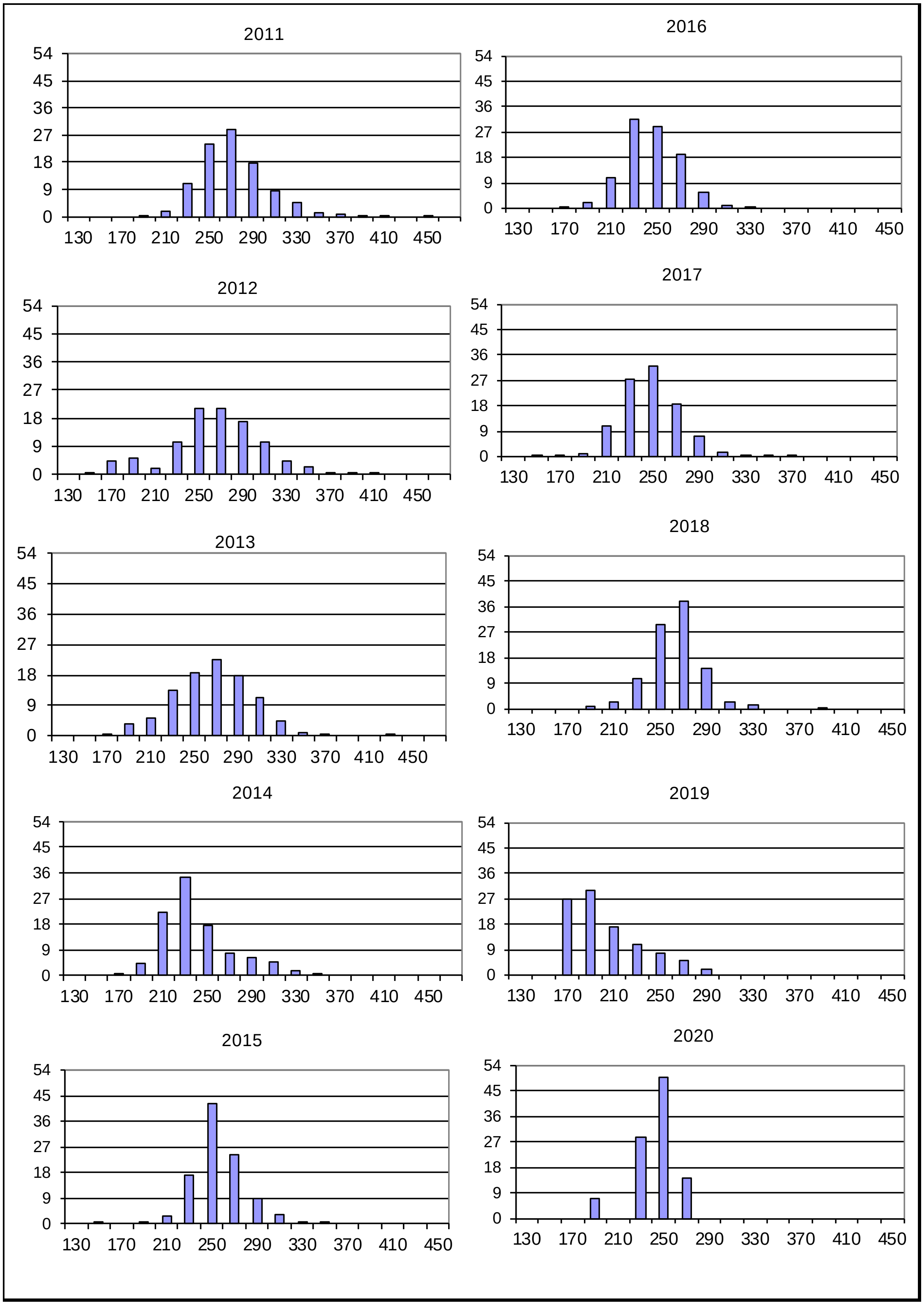


Figure 16. Geometric mean catch per hour and 95% confidence intervals for Atlantic croaker captured in the Choptank River gill net survey, 2013-2020.

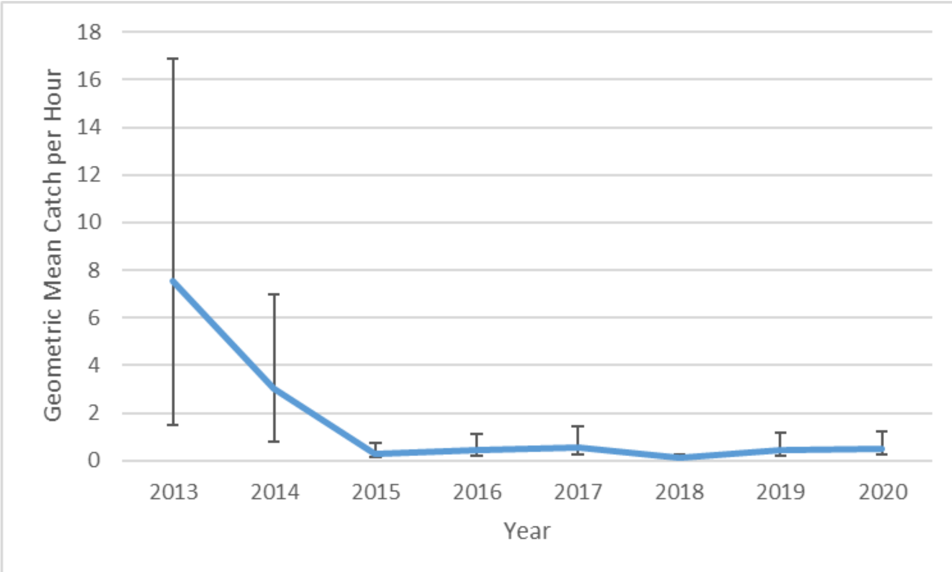


Figure 17. Proportion of Atlantic croaker catch by mesh size and year for the Choptank River gill net survey, 2013-2020.

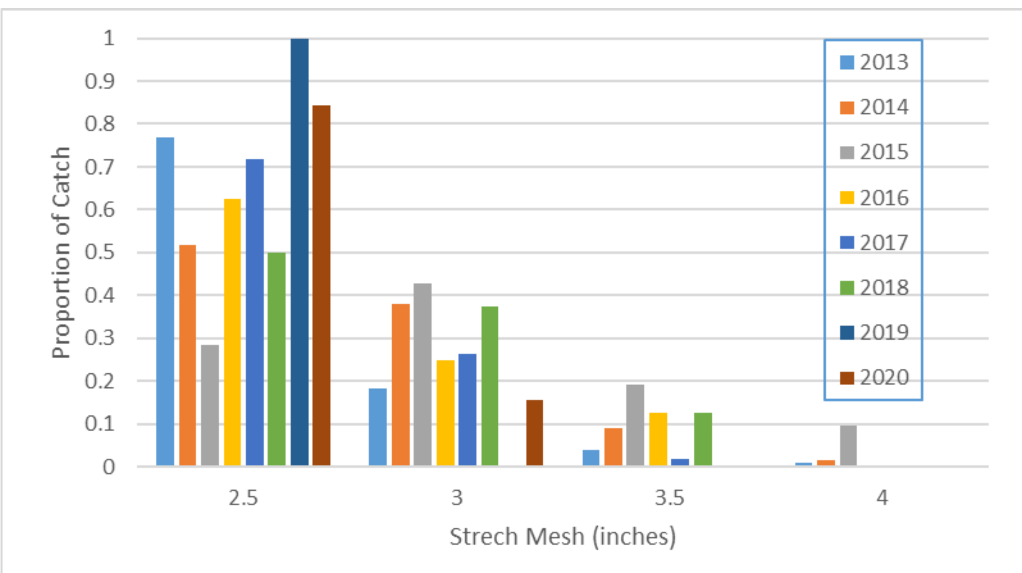


Figure 18. Atlantic croaker length frequency distribution from the Choptank River gill net survey by stretched mesh size in inches, 2013-2020 combined.

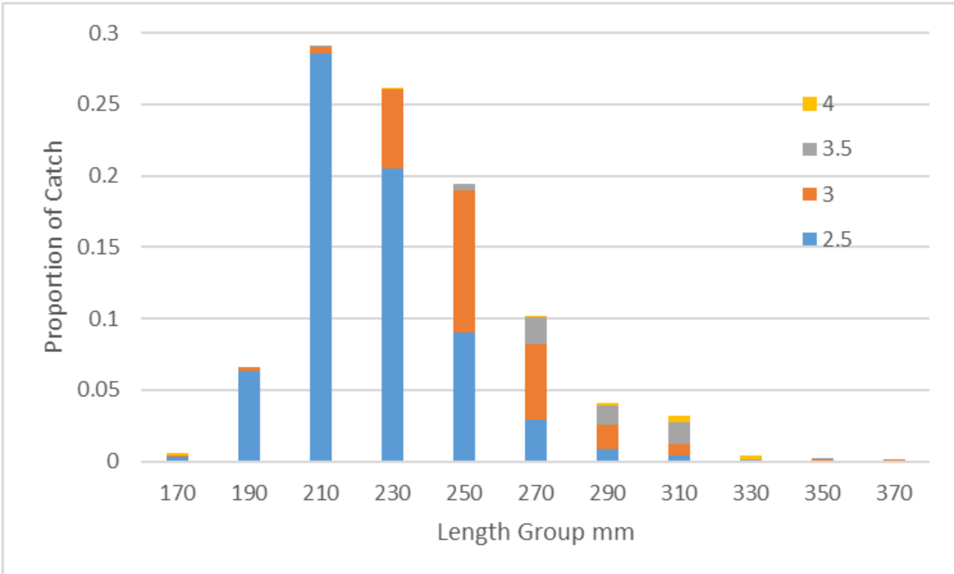


Figure 19. Maryland's commercial landings of Atlantic croaker in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational Atlantic croaker harvest and release estimates in numbers from 1981-2019.

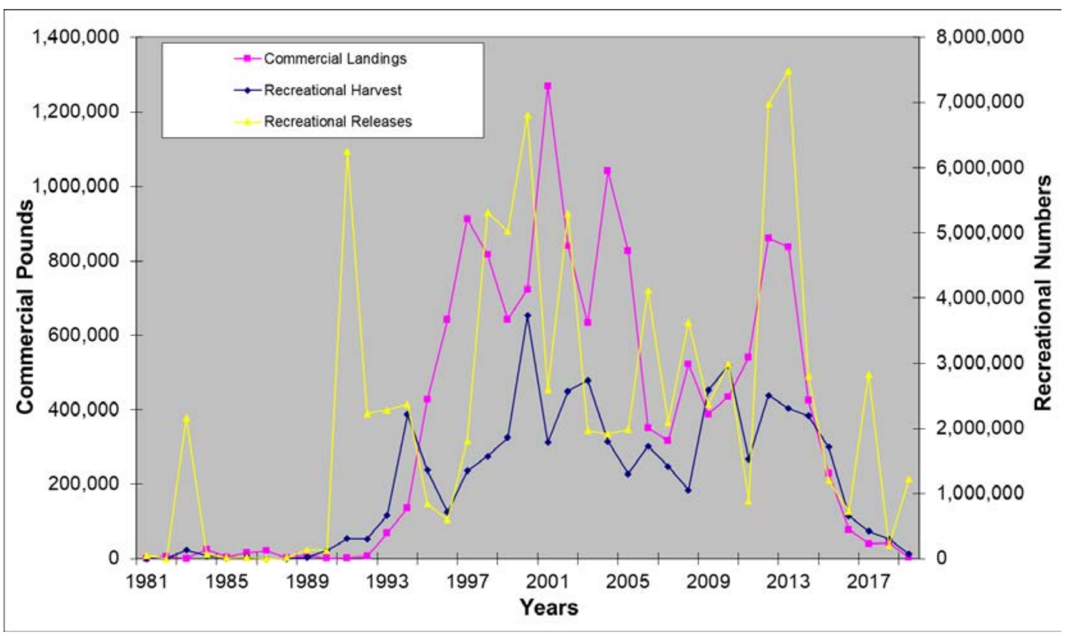


Figure 20. Maryland charter boat log book Atlantic croaker harvest in numbers and the number of anglers participating in trips catching Atlantic croaker, 1993-2019.

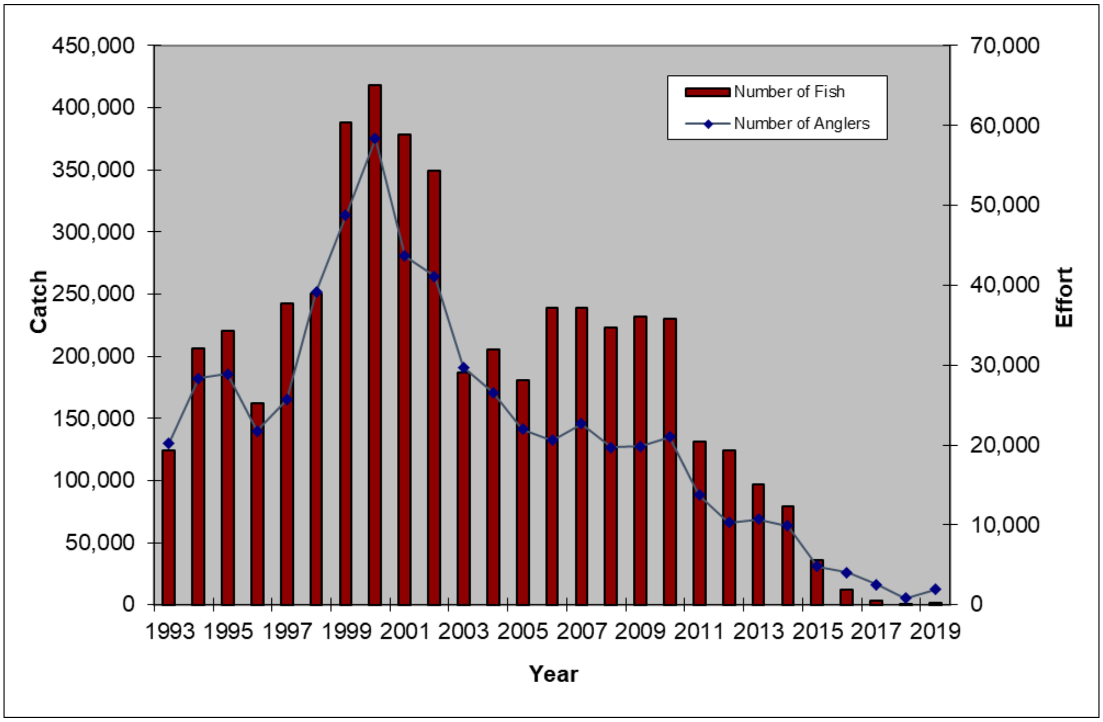


Figure 21. Maryland juvenile Atlantic croaker geometric mean catch per trawl, 95% confidence intervals and time series mean for Maryland's lower Chesapeake Bay, 1989-2020. 1998 data point was omitted for scale (GM 1998 = 30.05 - 9.02, +12.72).

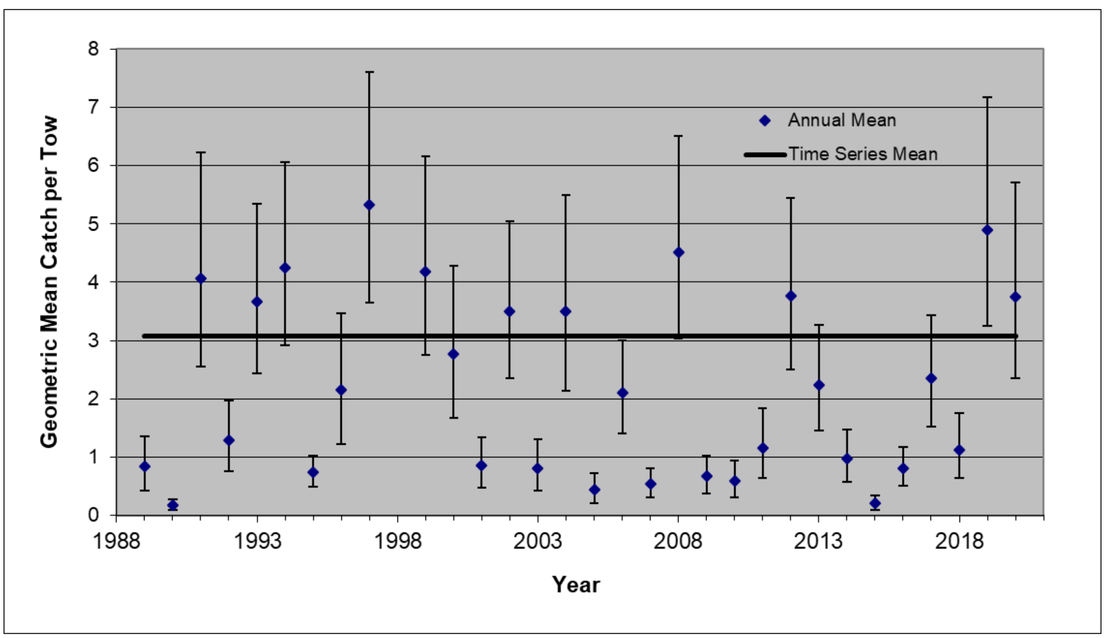
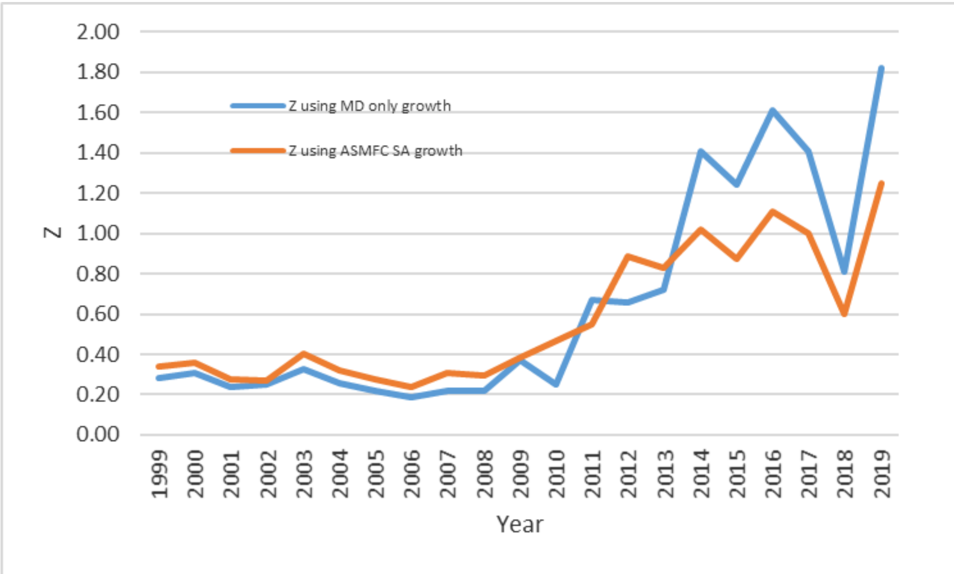


Figure 22. Atlantic croaker total mortality estimates using Maryland age data to derive growth parameters and using the growth parameters from the ASMFC 2017 stock assessment, 1999 - 2020.



Note: Very low sample size in 2020.

Figure 23. Spot length frequency distributions from onboard pound net sampling, 2011-2020.

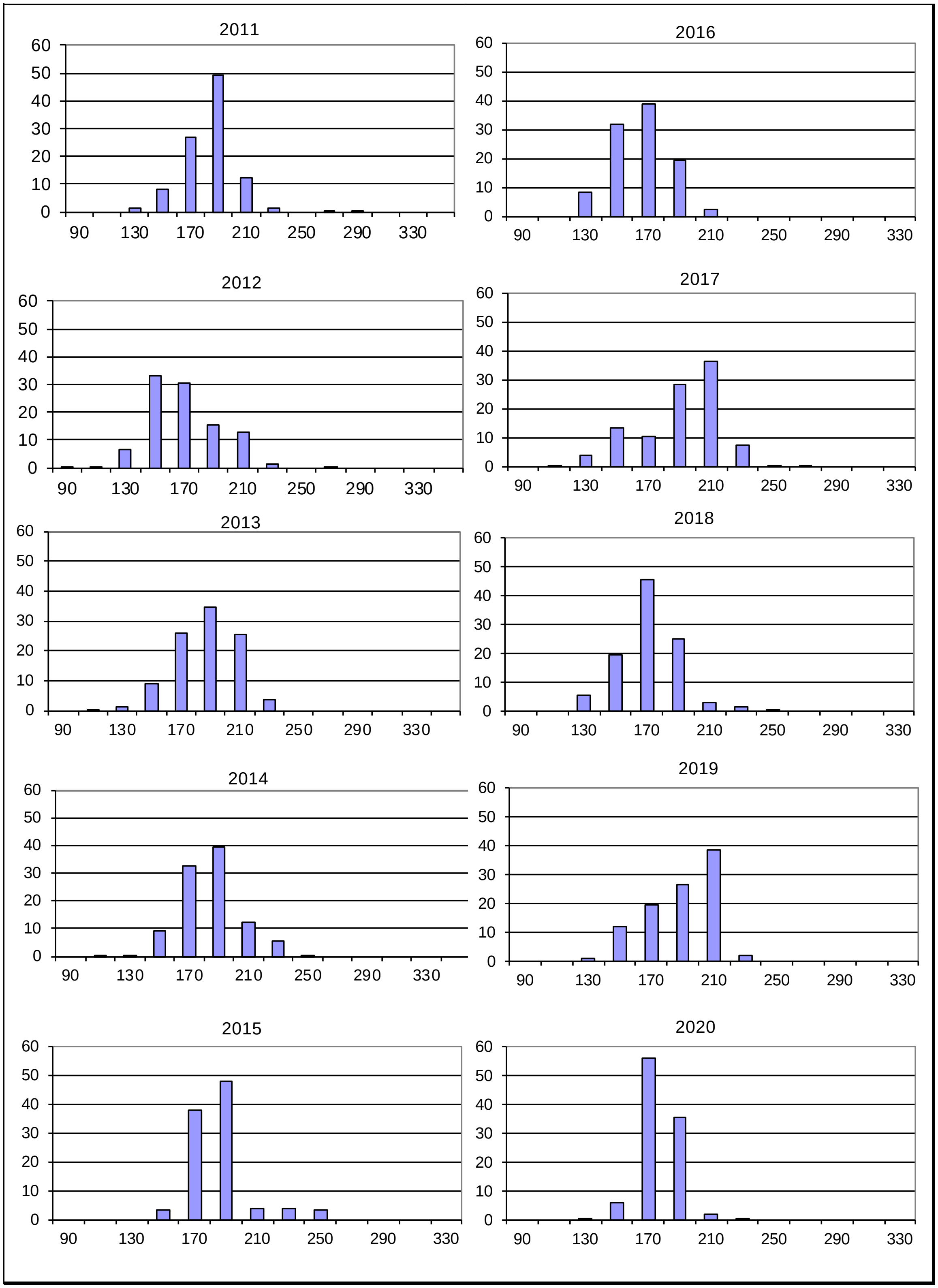


Figure 24. Geometric mean catch per hour and 95% confidence intervals for spot captured in the Choptank River gill net survey, 2013-2020.

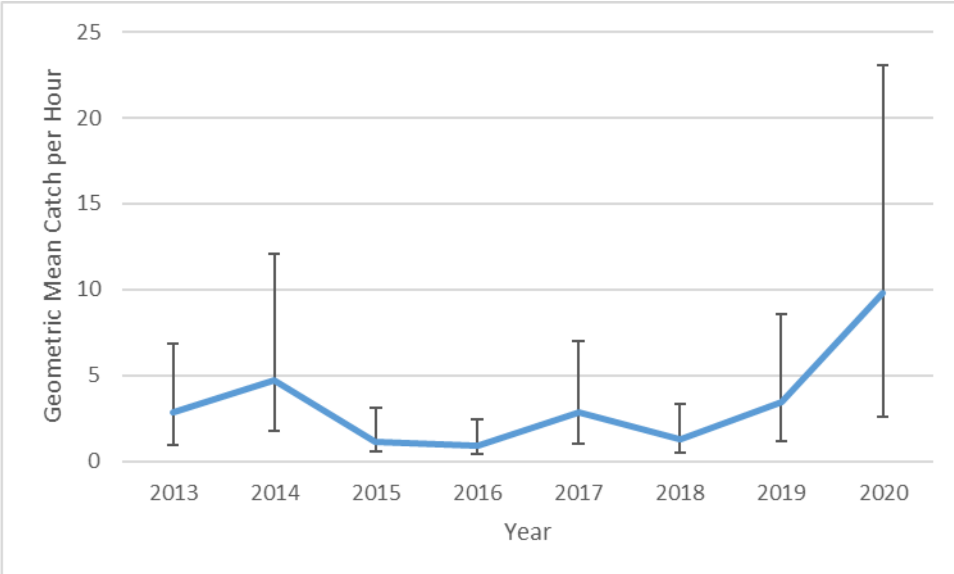


Figure 25. Proportion of spot captured in the Choptank River gill net survey by mesh size and year, 2013-2020.

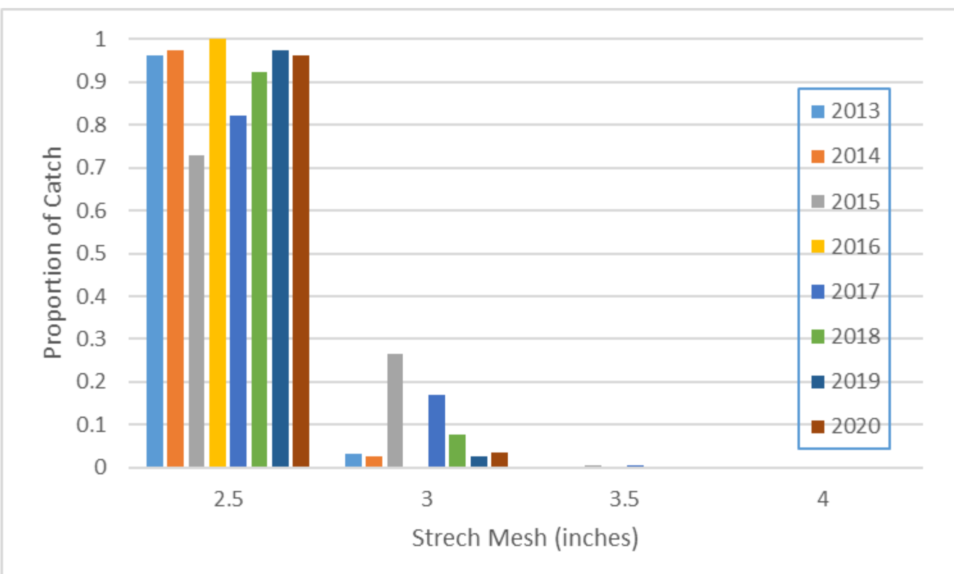


Figure 26. Spot length frequency distributions from the Choptank River gill net survey for 2013-2020.

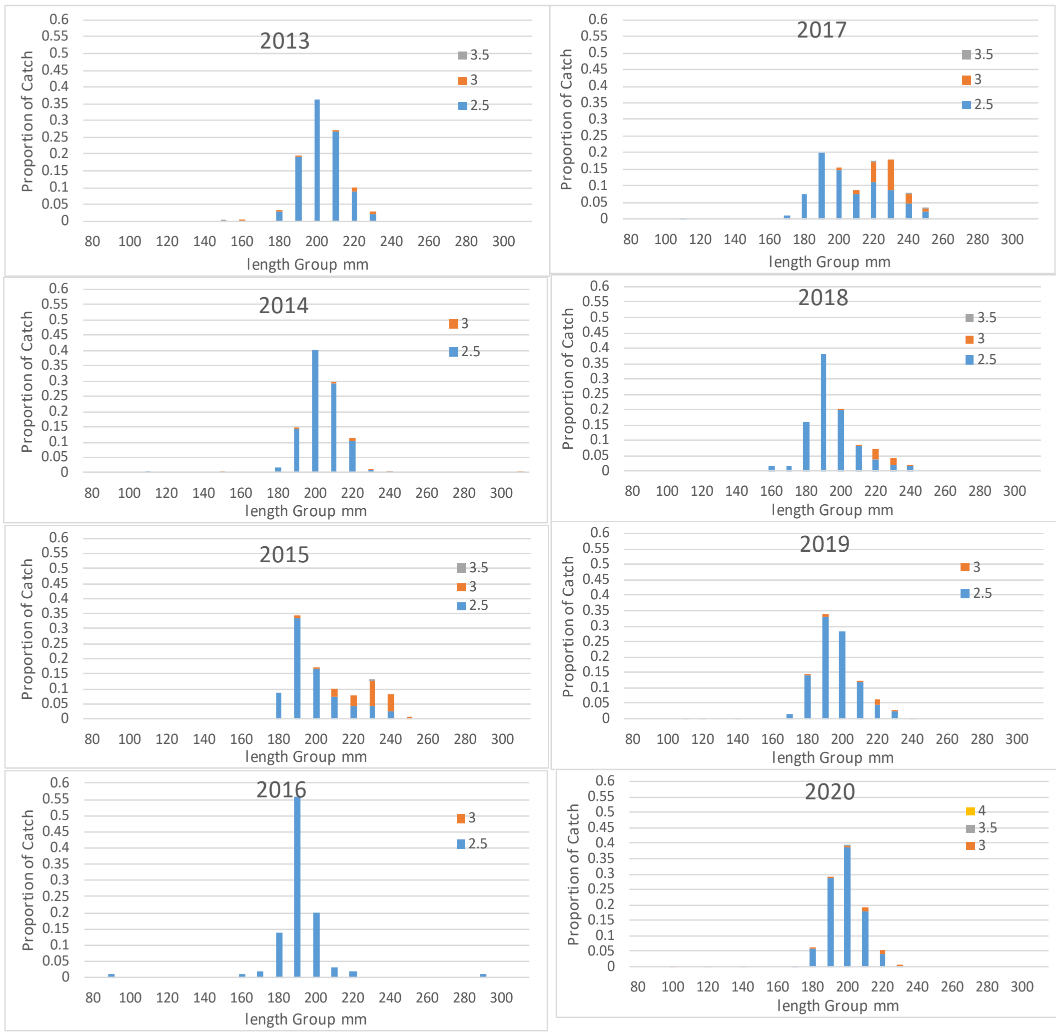


Figure 27. Maryland's commercial landings of spot in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational spot harvest and release estimates in numbers from 1981-2019.

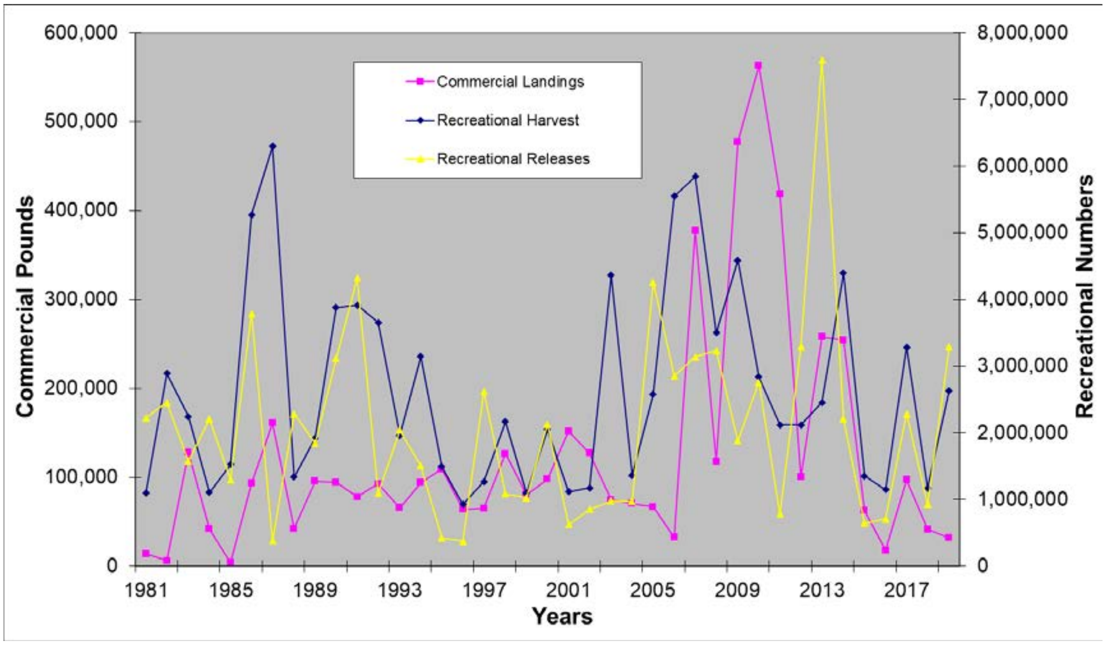


Figure 28. Maryland charter boat log book spot harvest in numbers and the number of anglers participating in trips catching spot, 1993-2019.

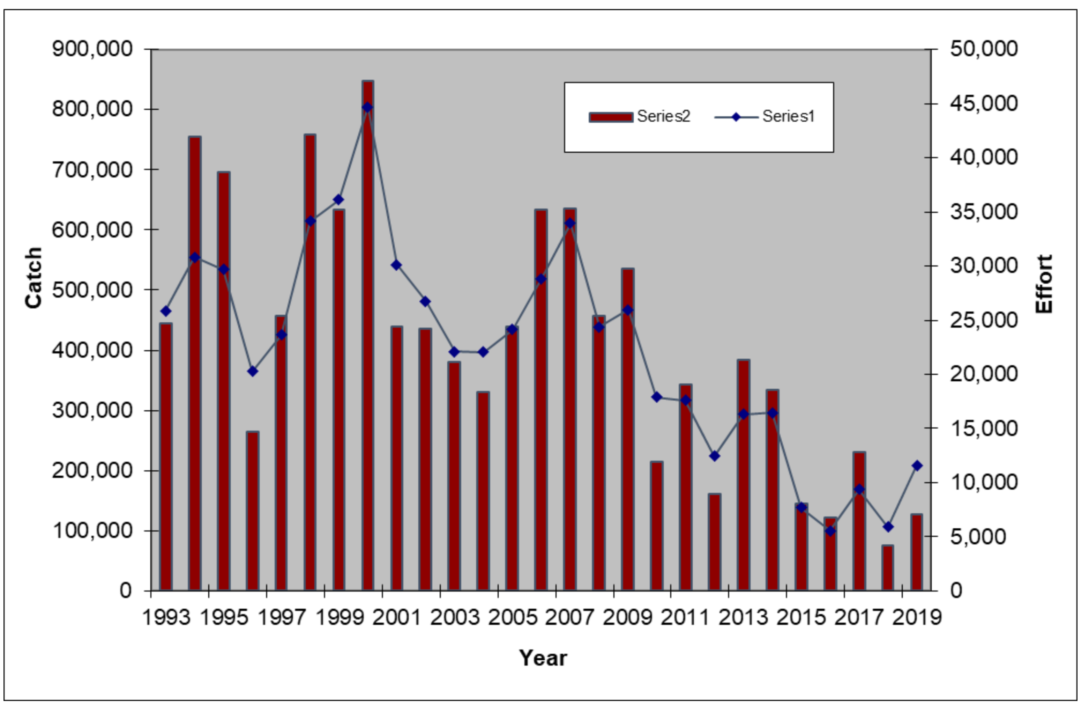


Figure 29. Maryland juvenile spot geometric mean catch per trawl, 95% confidence intervals and time series mean for Maryland's lower Chesapeake Bay, 1989-2020.

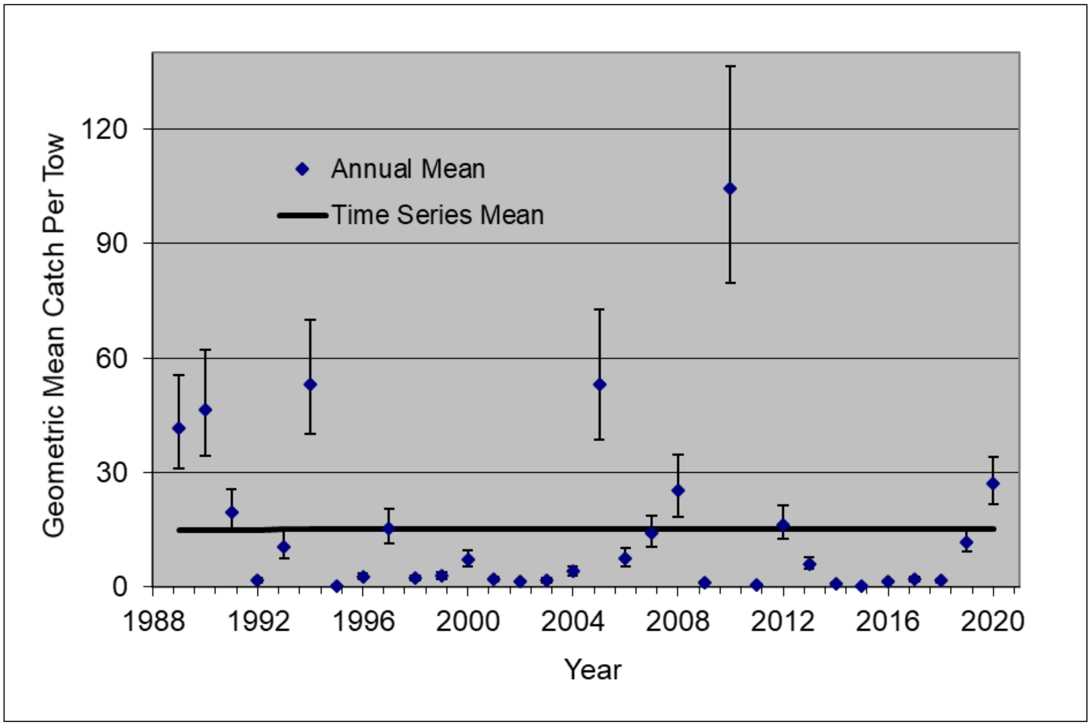


Figure 30. Maryland's commercial landings of red drum in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational red drum harvest and release estimates in numbers from 1981-2019.

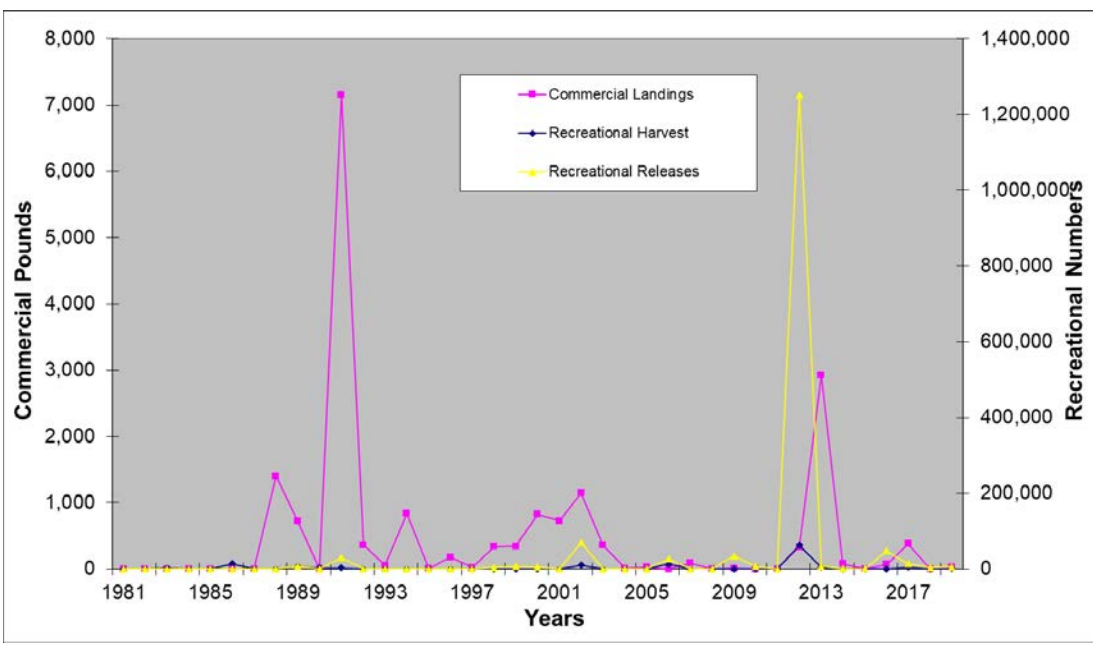


Figure 31. Maryland charter boat log book red drum harvest in numbers and the number of anglers participating in trips catching red drum, 1993-2019.

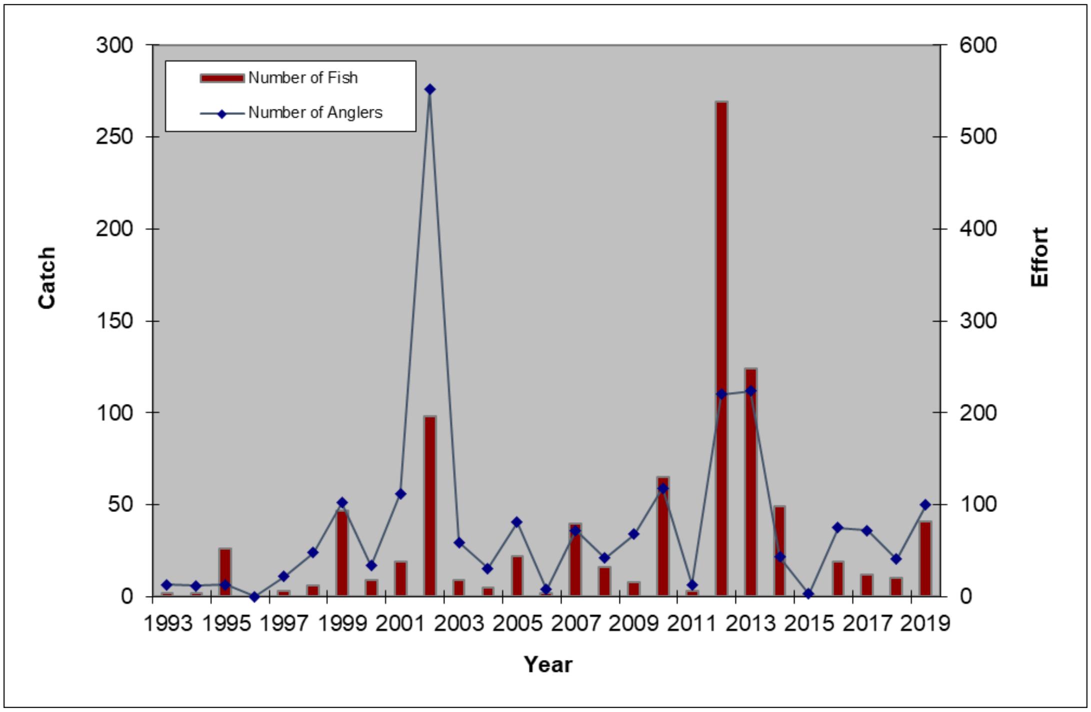


Figure 32. Maryland's commercial landings of black drum in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational black drum harvest and release estimates in numbers from 1981-2019.

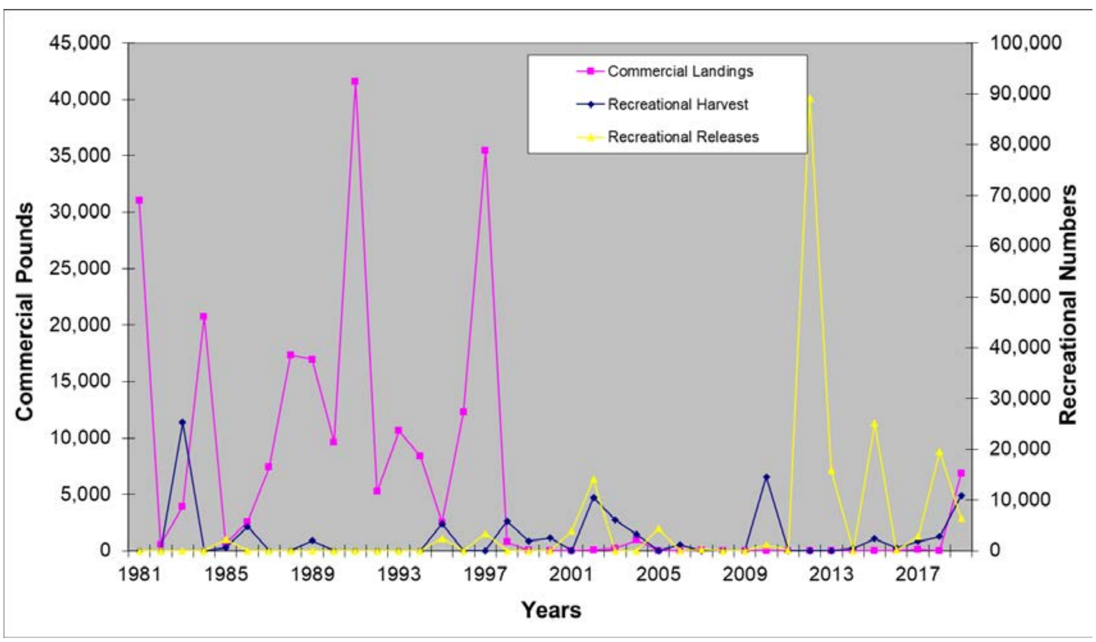


Figure 33. Maryland charter boat log book black drum harvest in numbers and the number of anglers participating in trips catching black drum, 1993-2019.

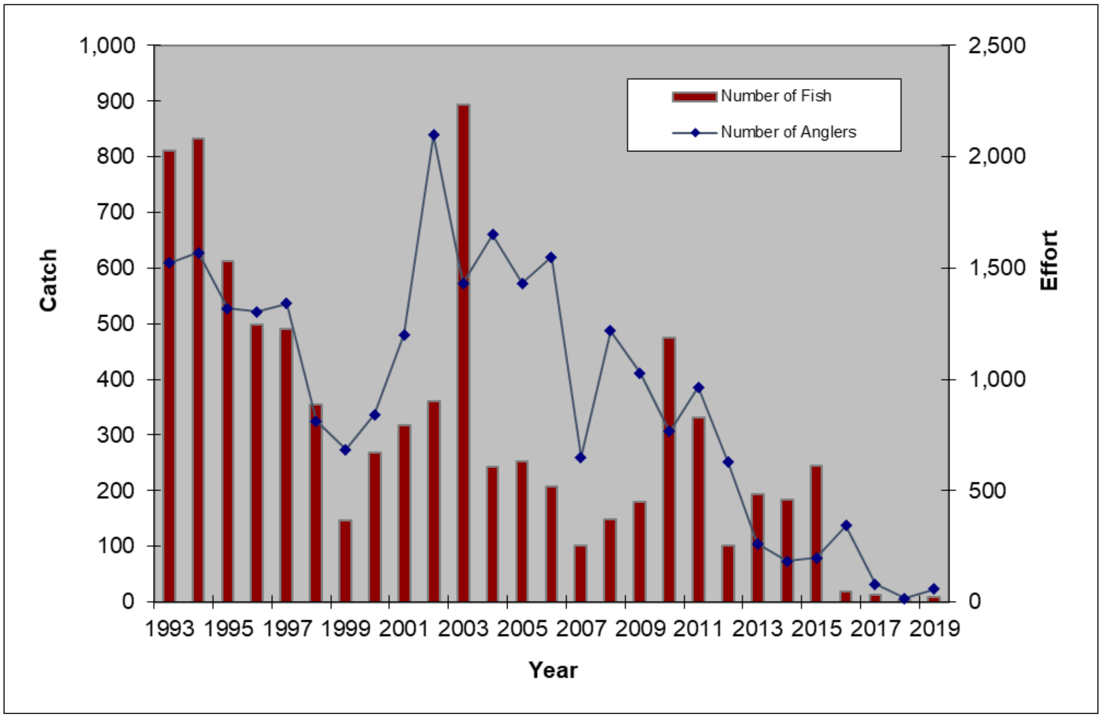


Figure 34. Maryland's commercial landings of Spanish mackerel in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational Spanish mackerel harvest and release estimates in numbers from 1981-2019.

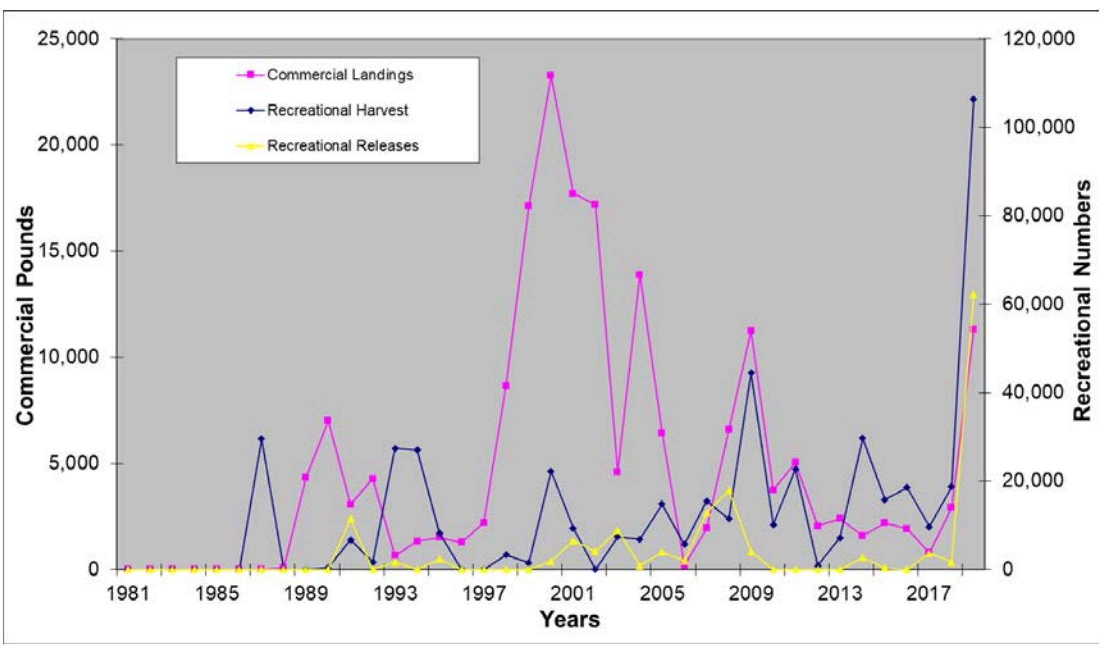


Figure 35. Maryland charter boat log book Spanish mackerel harvest in numbers and the number of anglers participating in trips catching Spanish mackerel, 1993-2019.

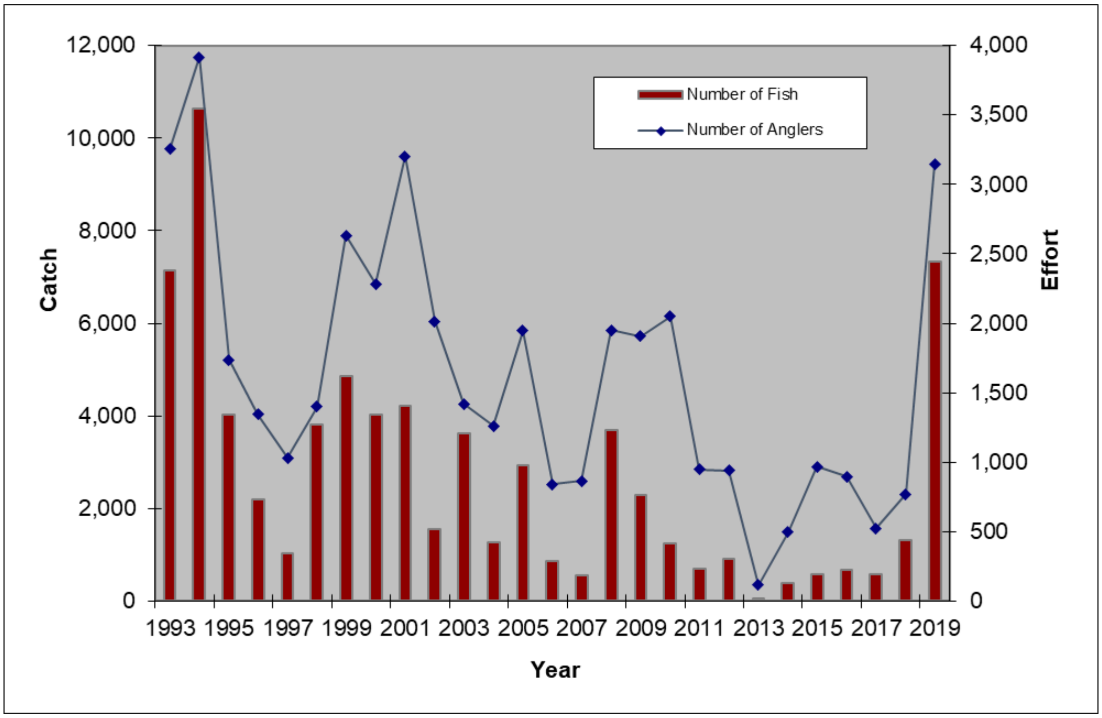


Figure 36. Maryland's commercial landings of spotted seatrout in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational spotted seatrout harvest and release estimates in numbers from 1981-2019.

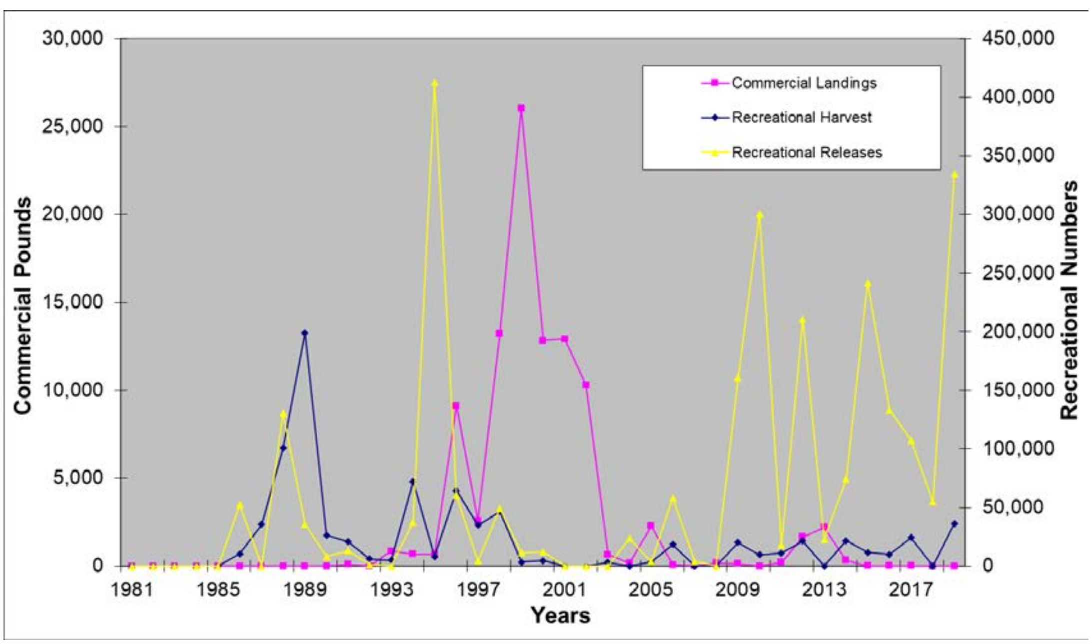


Figure 37. Maryland charter boat log book spotted seatrout harvest in numbers and the number of anglers participating in trips catching spotted seatrout, 1995-2019.

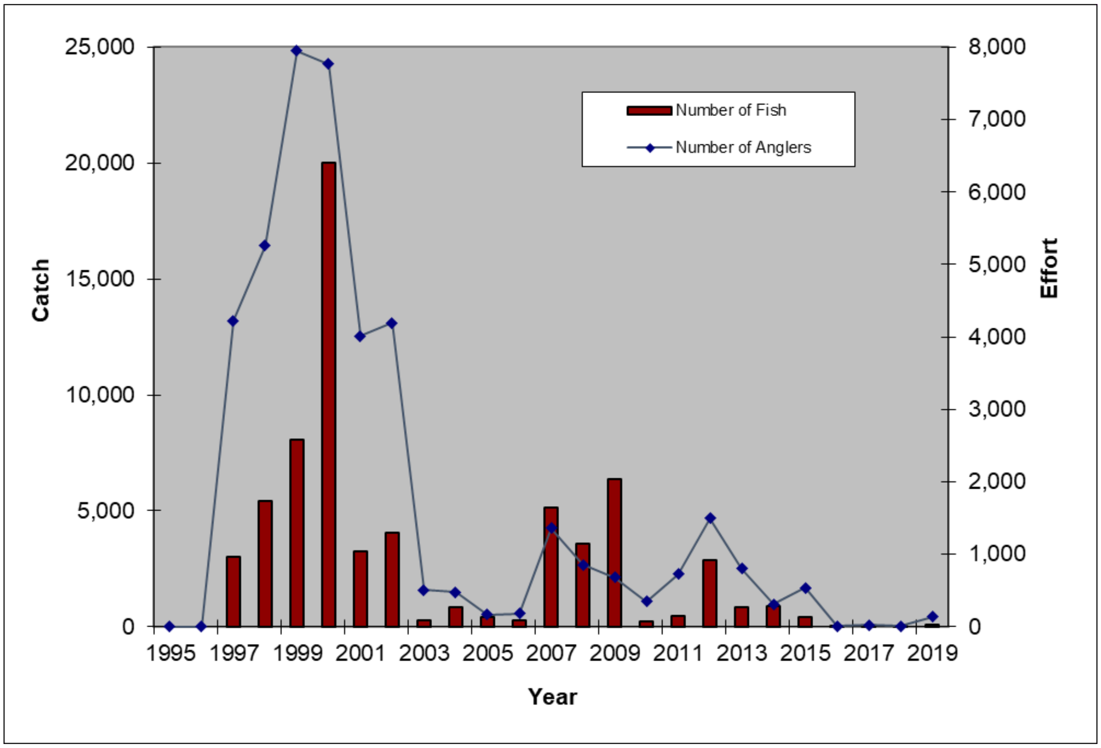


Figure 38. Atlantic menhaden length frequency distributions from onboard pound net sampling, 2011-2020, Note: In 2012 the 230 FL value is 40 percent.

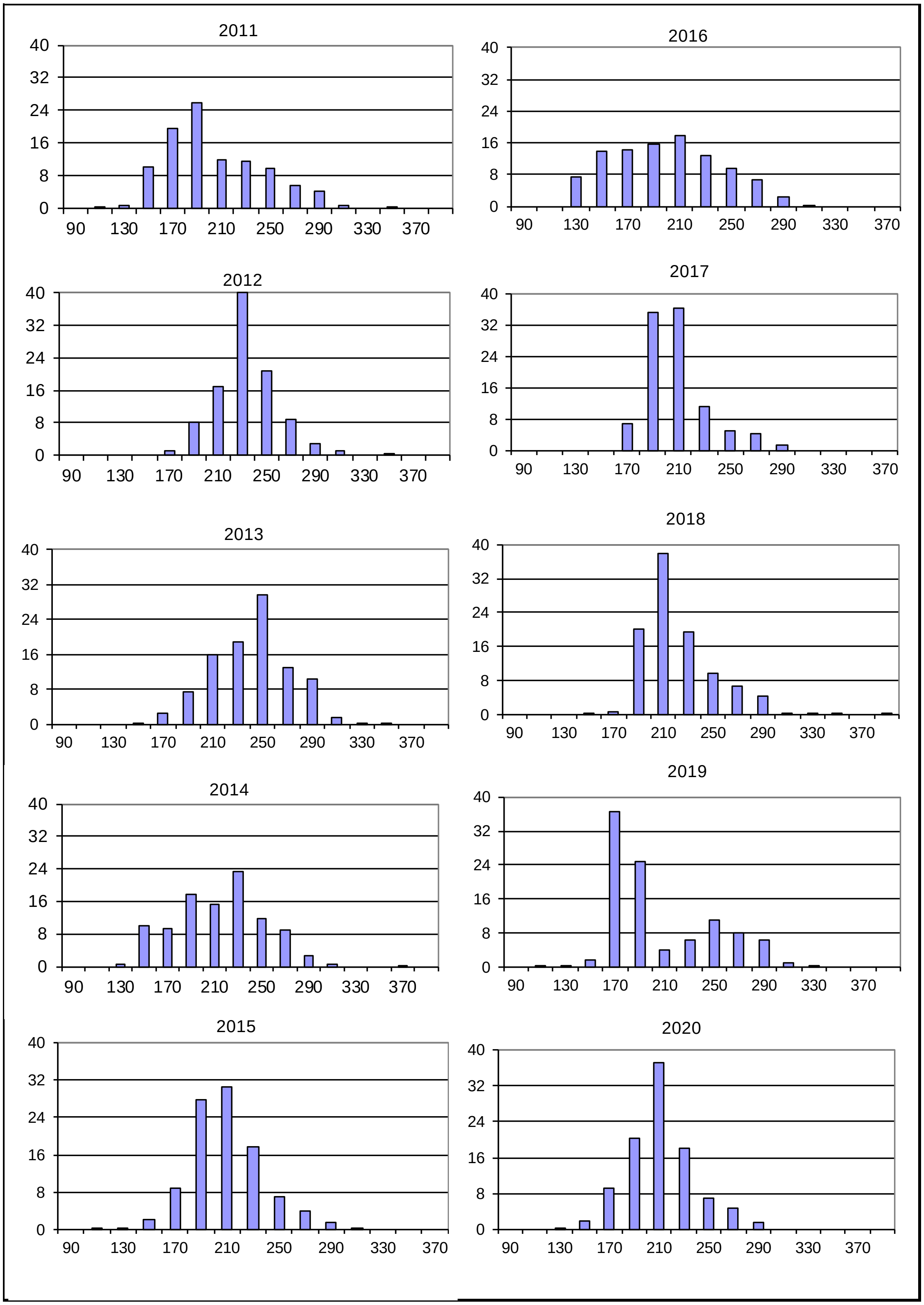


Figure 39. Geometric mean catch per hour and 95% confidence intervals for Atlantic menhaden captured in the Choptank River gill net survey, 2013-2020.

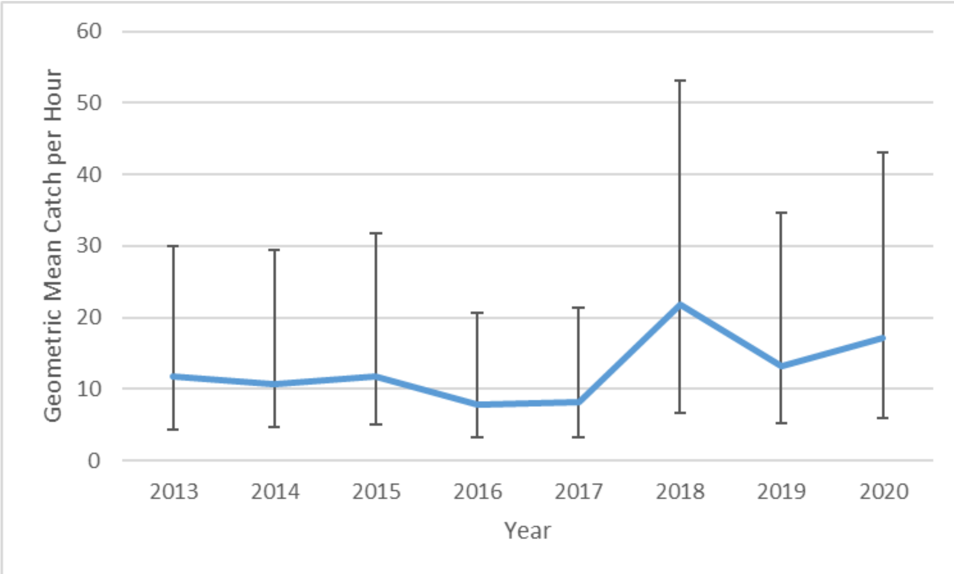


Figure 40. Atlantic menhaden proportion of catch by panel and year from the Choptank River gill net survey, 2013-2020.

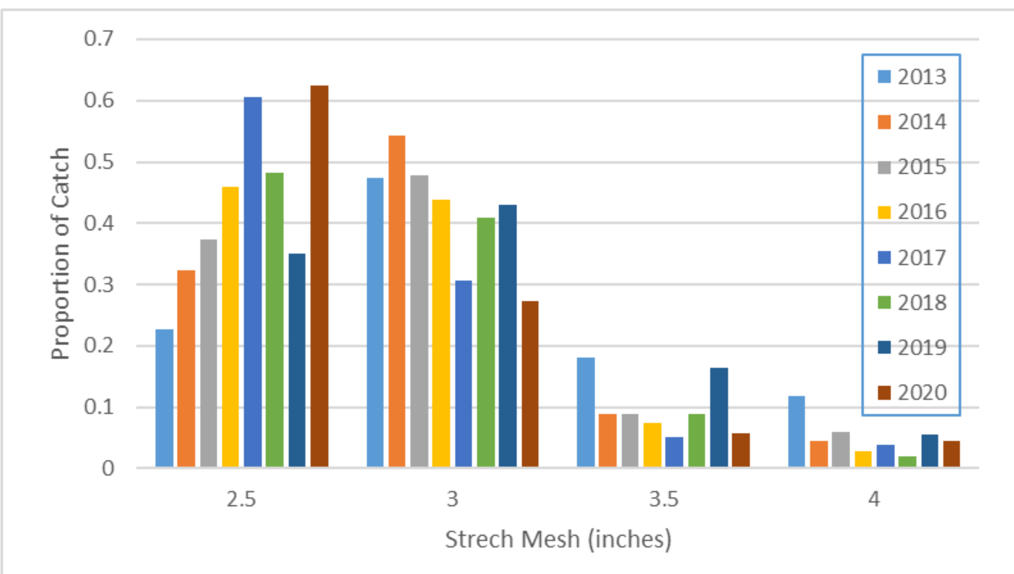


Figure 41. Atlantic menhaden length frequency distributions from the Choptank River gill net survey by year, 2013-2020.

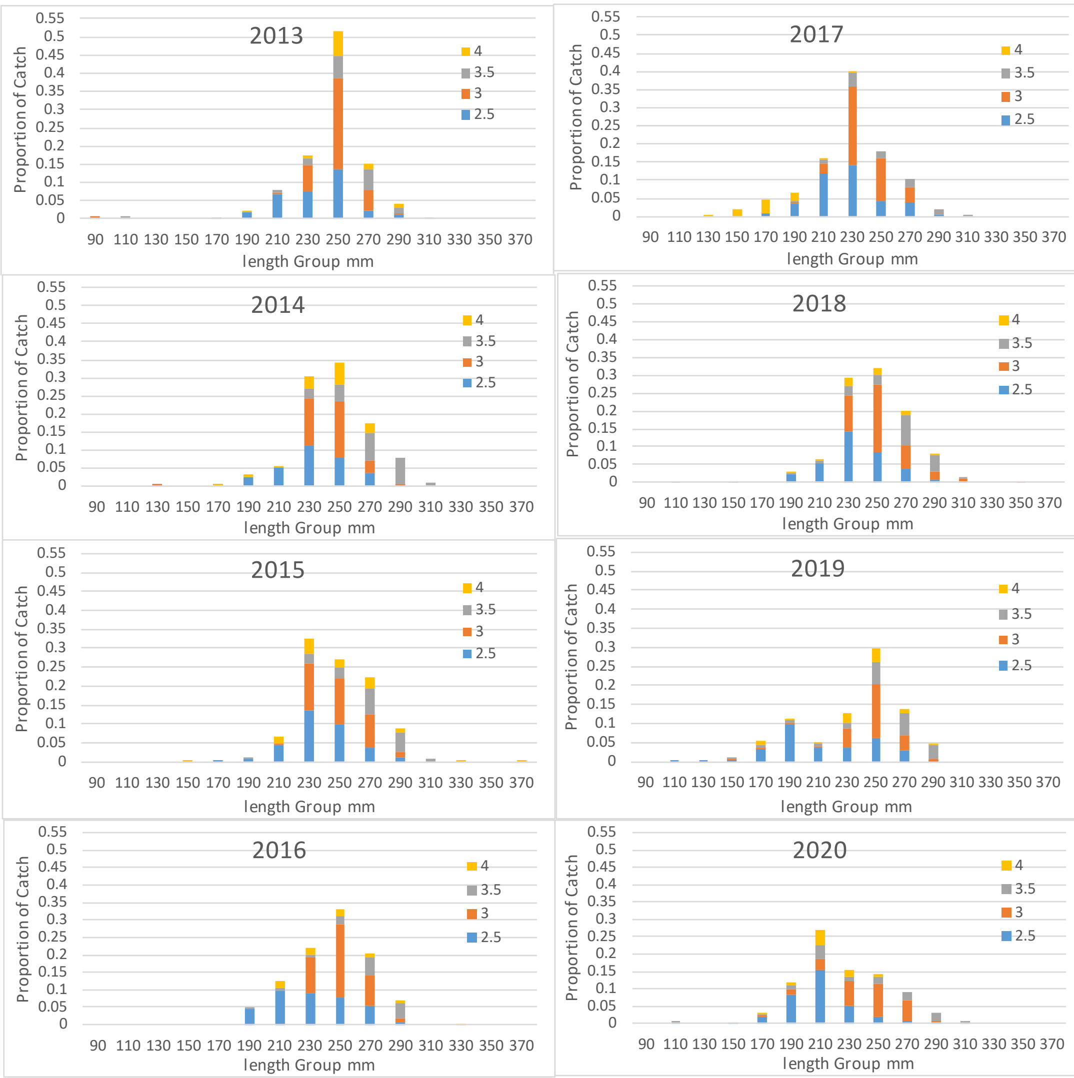
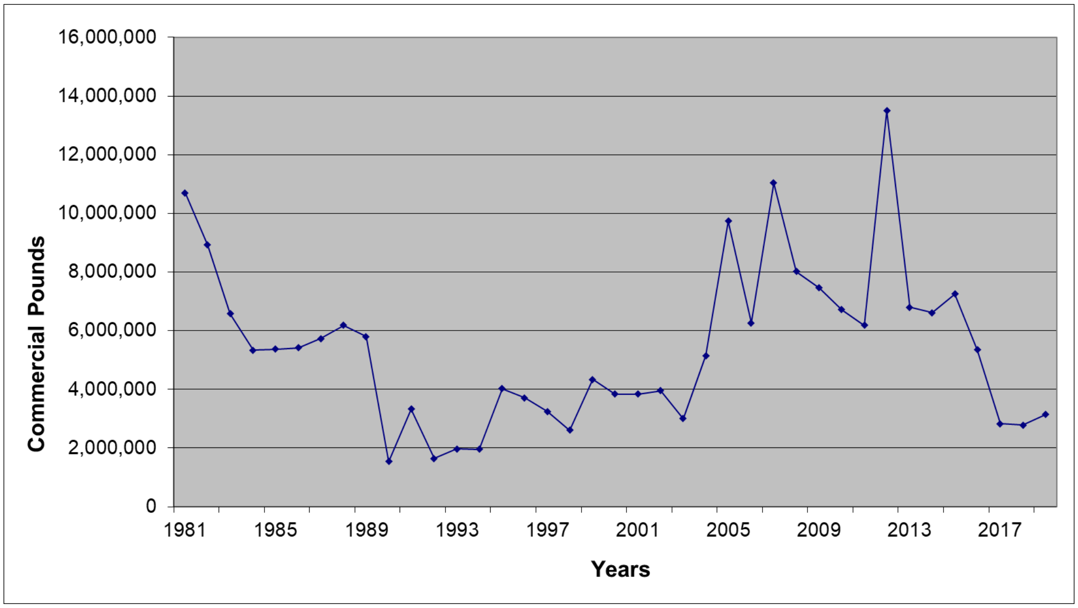


Figure 42. Maryland's Chesapeake Bay commercial landings for Atlantic menhaden from 1981-2019.



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 2019 Maryland striped bass *Morone saxatilis* commercial summer/fall fishery and provide preliminary results, as available, for the 2020 summer/fall season. Completed results for the 2020 summer/fall sample season will be reported in the F61-R-17 Chesapeake Bay Finfish Investigations report. The 2019 commercial summer/fall fishery operated on a combination of common pool and individual transferable quota (ITQ) systems (see Project 2, Job 3, Task 5A). The 2019 ITQ commercial summer/fall fishery was open from 1 June through 31 December for pound net gear and 1 June through 30 November for hook and line gear. The 2019 common pool fishery was open two days each month from June to September. The common pool fishery was closed in October and November. 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 2019 commercial summer/fall fishery sampling were used to characterize the length and age structure of the summer/fall 2019 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 in an effort 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 two to eight times per month from June through November 2019 (Table 1). The pound nets sampled were not randomly selected, but were chosen according to watermen's schedules and the best chance of obtaining fish. During 2019, striped bass were sampled from pound nets in the upper, middle, and lower Bay. Whenever possible, all striped bass in a pound net were measured in order to characterize by-catch. A full net sample was not possible when pound nets contained too many fish to be transferred to holding tanks on FABS boats. If a full net could not be sampled, a random sub-sample was taken.

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

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 2019 (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 visit from fish less than 700 mm TL (maximum three samples per length group per month). Up to five scale samples per 10 mm length group per visit were taken for fish greater than 700 to 800 mm TL. All scales from fish greater than 800 mm TL were taken.

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

Age composition of the summer/fall fishery was estimated via two-stage sampling (Kimura 1977, Quinn and Deriso 1999). In the first stage, total length and scale samples were taken based on 10 mm length groups, which were assumed to be a random sample of the commercial harvest. In stage two, a sub-sample of scales were randomly chosen to be aged based on 20 mm length groups. Selected 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, and >700 mm=10 scales per length group. In some cases, there were fewer scale samples available than the target sample size.

Year-class was determined by reading acetate 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 age-at-recruitment into the summer/fall fishery, the age structure of the harvest over time was examined. The age structure of the harvest for the 2019 summer/fall fishery was also compared to previous years. An ANOVA followed by a Duncan's multiple range test (SAS 2006) was performed to compare lengths and weights of striped bass harvested between different months in 2019.

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

RESULTS and DISCUSSION

Commercial pound net monitoring

During the 2019 striped bass pound net study, a total of 7,167 striped bass were sampled from two upper Bay, one middle Bay, and six lower Bay pound nets (Figure 1). The nine nets were sampled a total of 29 times during the study (Table 1).

Striped bass sampled from pound nets ranged from 184-953 mm TL, with a mean length of 469 mm TL (Figure 2). In 2019, 40% and 22% of striped bass collected from full and partial pound net samples, respectively, were sub-legal (<457 mm TL, <18 inches).

Mean total lengths of the aged sub sample are presented in Table 2. When the combined ALK was applied to the entire pound net sampling, striped bass ranged from 1 to 14 years of age (Table 3, Figure 2). Age 4 fish from the above average 2015 year-class contributed 44% to the sample. Age 8 fish from the above average 2011 year-class contributed 3% in 2019, which was a decrease compared to the contribution in the previous year (16%). Striped bass age 6 and older comprised 12% of the sample, which was lower than their contribution in the previous year (25%; Figure 3).

Commercial summer/fall check station monitoring

A total of 1,897 striped bass were sampled at summer/fall check stations in 2019. The mean length of sampled striped bass was 534 mm TL. Length frequencies of striped bass sampled at check stations and legal sized striped bass sampled at pound nets (n=3,814) were similar (Figure 4). Striped bass sampled from the summer/fall fishery ranged from 446 to 880 mm TL and from 3 to 12 years of age (Figure 5). Less than 1% of the sampled harvest was sub-legal (<457 mm TL). Mean lengths-at-age and weights-at-age of the aged sub sample for the 2019 summer/fall fishery are shown in Tables 4 and 5.

Striped bass in the 450-550 mm length groups accounted for 74% of the summer/fall harvest (Figure 5). Larger fish from the above average 2011 year-class have influenced the number of larger fish in the harvest in recent years, however, did not contribute as much to the fishery in 2019. Striped bass over 700 mm TL were harvested throughout the season (Figure 6) and contributed 5% to the overall harvest. Historically, these fish have not been available in large numbers during the summer (MD DNR 2002).

The 2019 summer/fall reported harvest of 810,975 pounds accounted for 55%, by weight, of the Maryland Chesapeake Bay commercial harvest in 2019 (see Project 2, Job 3, Task 5A). Landings reported by the MD DNR commercial reporting section were 99,245 pounds for hook and line gear and 711,730 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 2019 catch-at-age in pounds and numbers of fish for the summer/fall fishery is presented in Table 6. A nine year old fish (2010 year-class) was encountered in pound net monitoring, but was not encountered in the check station subsample so no weight was available for a fish of this age. By weight, the majority (90%) of the harvest was composed of four to seven year-old striped bass. Striped bass from the above average 2015 year class (age 4) contributed the highest percentage to the harvest (47%). Striped bass age 8 and older contributed 6% to the overall harvest in 2019, which was similar to 2018 (5%).

Monitoring summary

Striped bass ranging from 457 to 550 mm TL composed 74% of the 2019 summer/fall harvest (Figure 5). A smaller percentage of fish greater than 630 mm TL were harvested in 2019 (12%)

compared to 2018 (28%). In 2019, 133 and 57 fish from pound net monitoring and check station sampling were aged. Younger fish (age 4 to 7) were abundant, accounting for most of the harvest (Figure 7). Length frequencies of legal-sized fish sampled from pound nets and all fish from check stations were almost identical, except for a small increase in frequency around 790 mm (Figure 4). Mean lengths-at-age have remained nearly the same since 2000 (Figure 8).

Duncan's multiple range test (SAS 2006) was performed on lengths and weights of striped bass harvested between months (α=0.05). Striped bass were significantly larger (TL= 616 mm and WT=2.47 kg) in June. Lengths and weights were similar in July, September, and October (TL=504 mm, 504 mm, 504 mm and WT=1.19 kg, 1.14 kg, 1.22 kg), respectively. The lowest average weight of striped bass was in August (1.08 kg). Duncan's groups are presented in Tables 7 and 8.

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

SUMMER – FALL STOCK ASSESSMENT AND COMMERCIAL FISHERY MONITORING

2020 PRELIMINARY RESULTS – WORK IN PROGRESS

Commercial pound net monitoring

During the 2020 striped bass pound net study, a total of 4,057 striped bass were sampled and 448 scale samples were collected for ageing from three pound nets in the upper Bay and seven pound nets in the lower Bay. The ten nets were sampled a total of 29 times during the study.

Striped bass sampled from pound nets ranged from 204-1050 mm TL, with a mean length of 437 mm TL. A complete breakdown of catch by length and age for the 2020 summer/fall season will be available in the F61-R-17 Chesapeake Bay Finfish Investigations report.

Commercial summer/fall check station monitoring

A total of 994 striped bass were sampled and 271 scale samples were collected for ageing at summer/fall check stations in 2020. The mean length of sampled striped bass was 545 mm TL. Striped bass sampled from the summer/fall fishery ranged from 457 to 801 mm TL. None 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 1. Summary of sampling areas, sampling dates, surface temperature, surface salinity and numbers of fish encountered during the 2019 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	2	23.8	4.2	653
	Middle	-	-	-	-
	Lower	3	24.8	8.3	484
July	Upper	1	28.1	5.1	393
	Middle	-	-	-	-
	Lower	2	27.6	9.1	39
August	Upper	1	28.2	7.9	525
	Middle	-	-	-	-
	Lower	7	27.8	12.0	860
September	Upper	1	23.3	11.1	594
	Middle	-	-	-	-
	Lower	7	24.4	14.6	1,740
October	Upper	1	16.0	11.8	474
	Middle	-	-	-	-
	Lower	1	20.5	15.6	232
November	Upper	2	11.4	9.4	625
	Middle	1	9.6	10.0	548
	Lower	-	-	-	-

Table 2. Mean length-at-age (mm TL) of striped bass sampled from pound nets in Maryland's Chesapeake Bay, June through November 2019.

Year-class	Age	n	Mean Length (mm TL)	Lower CL	Upper CL
2018	1	2	344	*	*
2017	2	19	313	291	334
2016	3	10	420	373	466
2015	4	21	466	441	491
2014	5	11	556	501	610
2013	6	12	650	599	701
2012	7	15	726	685	766
2011	8	36	745	728	761
2010	9	4	847	728	966
2009	10	1	950	*	*
2008	11	1	871	*	*
2007	12	1	895	*	*
2006	13	0	-	-	-
2005	14	0	-	-	-

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

Table 3. Number of striped bass, by age, sampled from pound nets, in Maryland's Chesapeake Bay, June through November 2019. Sum of columns may not equal due to rounding.

Year-class	Age	Pound Net Monitoring	
		Number Sampled at Age (n)	Percent of Total
2018	1	96	1.3
2017	2	880	12.3
2016	3	937	13.1
2015	4	3,143	43.9
2014	5	1,263	17.6
2013	6	293	4.1
2012	7	317	4.4
2011	8	223	3.1
2010	9	5	0.1
2009	10	3	<0.1
2008	11	3	<0.1
2007	12	3	<0.1
2006	13	1	<0.1
2005	14	1	<0.1
Total		**7,167**	**100.0**

Table 4. Mean length-at-age (mm TL) of legal-size striped bass (≥457 mm TL/18 in TL) sampled from the commercial summer/fall check stations in Maryland's Chesapeake Bay, June through November 2019.

Year-class	Age	n	Mean Length (mm TL)	Lower CL	Upper CL
2016	3	1	457	*	*
2015	4	12	517	481	554
2014	5	10	565	498	632
2013	6	3	634	436	832
2012	7	14	675	634	716
2011	8	14	756	711	802
2010	9	0	-	-	-
2009	10	1	817	*	*
2008	11	1	834	*	*
2007	12	1	800	*	*

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

Table 5. Mean weight-at-age (kg) of legal-size striped bass (≥457 mm TL/18 in TL) sampled from the commercial summer/fall check stations in Maryland's Chesapeake Bay, June through November 2019.

Year-class	Age	n	Mean Weight (kg)	Lower CL	Upper CL
2016	3	1	0.81	*	*
2015	4	12	1.30	1.05	1.55
2014	5	10	1.91	1.19	2.64
2013	6	3	2.77	0.53	5.00
2012	7	14	3.05	2.53	3.57
2011	8	14	4.31	3.54	5.07
2010	9	0	-	-	-
2009	10	1	5.52	*	*
2008	11	1	6.07	*	*
2007	12	1	5.44	*	*

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

Table 6. Estimated catch-at-age of striped bass landed by the Maryland Chesapeake Bay commercial summer/fall fishery, June through November 2019.

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**
2016	3	31,776	3.9	17,794	7.8
2015	4	377,105	46.5	131,579	57.8
2014	5	220,792	27.2	52,434	23.0
2013	6	65,283	8.1	10,690	4.7
2012	7	66,629	8.2	9,909	4.4
2011	8	46,068	5.7	4,848	2.1
2010	9	1,411	0.2	121	0.1
2009	10	342	<0.1	28	<0.1
2008	11	800	0.1	60	<0.1
2007	12	769	0.1	64	<0.1
Total*		**810,975**	**100.0**	**227,527**	**100.0**

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

Table 7. Duncan's multiple range test for mean length by month for the Maryland Chesapeake Bay commercial summer/fall check stations, June through November 2019. Months with the same Duncan grouping letter are not significantly different (α=0.05) in mean length.

Duncan Grouping	Month	Mean Length (mm)	Number of Fish Sampled
A	June	616	287
B	November	566	432
C	October	504	379
C	September	504	71
C	July	504	356
C	August	504	373

Table 8. Duncan's multiple range test for mean weight by month for the Maryland Chesapeake Bay commercial summer/fall check stations, June through November 2019. Months with the same Duncan grouping letter are not significantly different (α=0.05) in mean weight.

Duncan Grouping	Month	Mean Weight (kg)	Number of Fish Sampled
A	June	2.47	287
B	November	1.93	430
C	October	1.22	376
C	July	1.19	356
C	September	1.14	71
D	August	1.08	373

Figure 1. Locations of Chesapeake Bay commercial summer/fall check stations and pound nets sampled from June through November 2019.

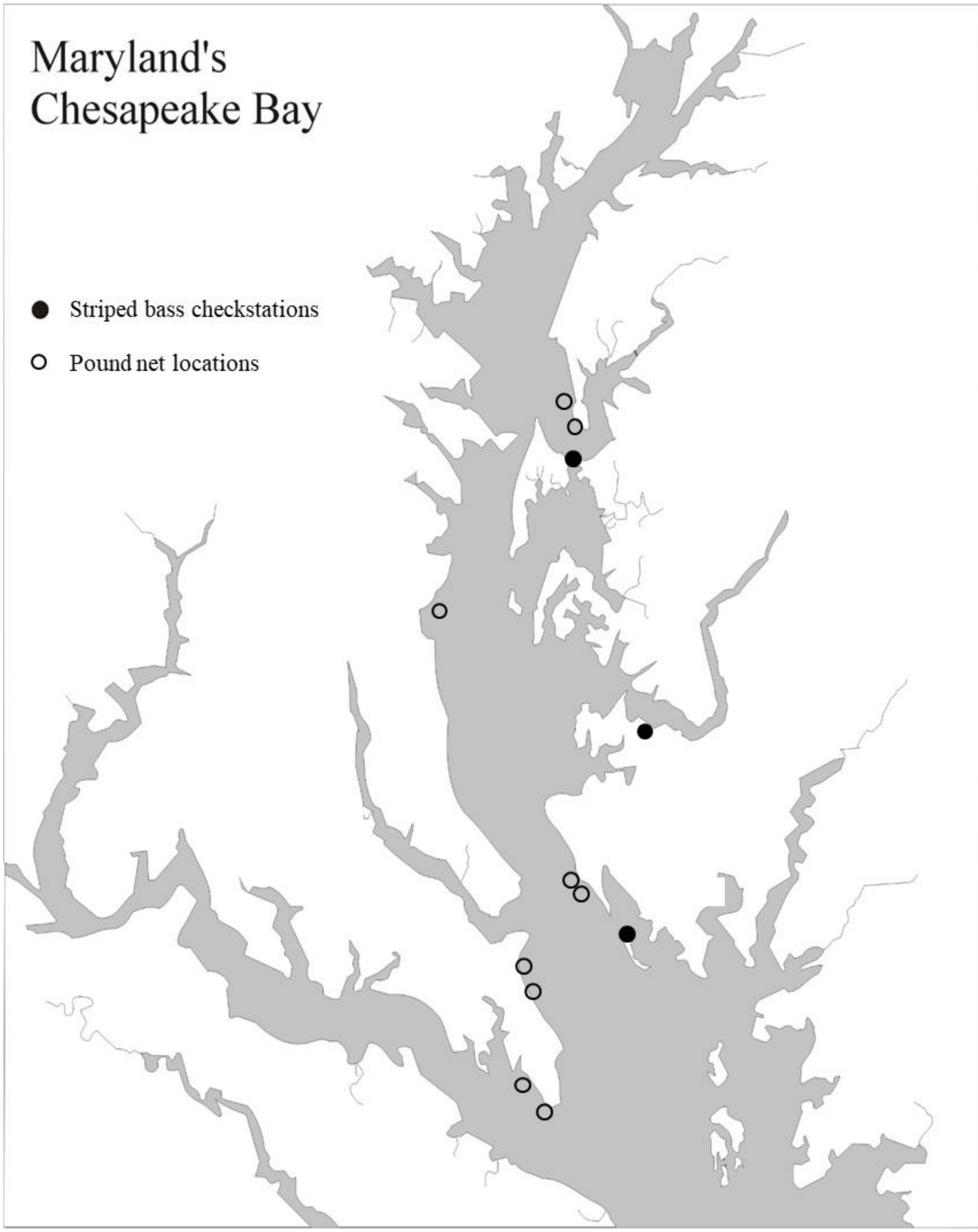


Figure 2. Age and length (mm TL) frequencies of striped bass sampled during Maryland Chesapeake Bay pound net monitoring study, June through November 2019.

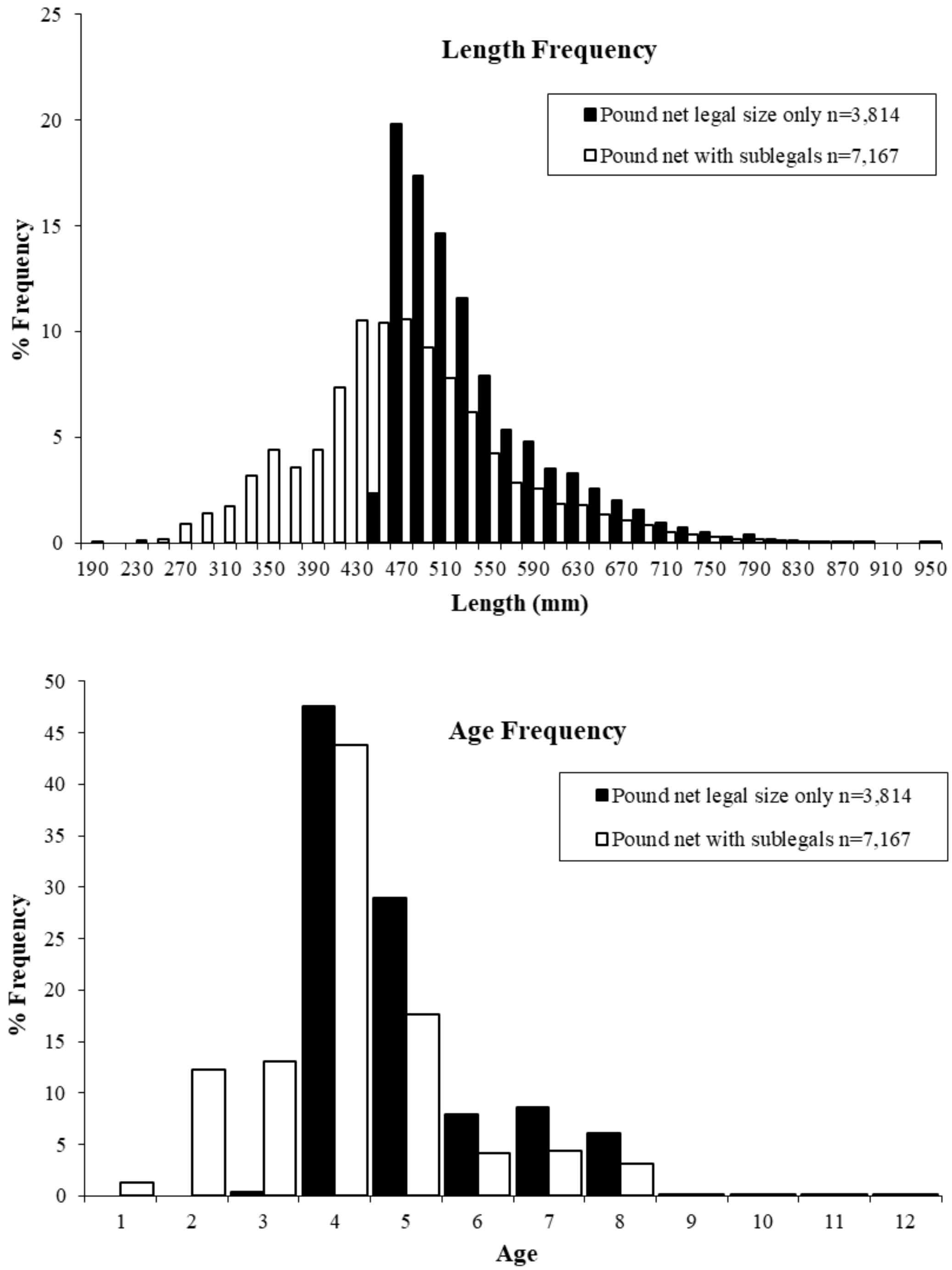


Figure 3. Age structure of striped bass sampled from Maryland Chesapeake Bay commercial pound net monitoring study from 1996 through 2019. *Note partial net sampling for legal sized fish was conducted from 1996 to 1999. Full net samples started in 2000.

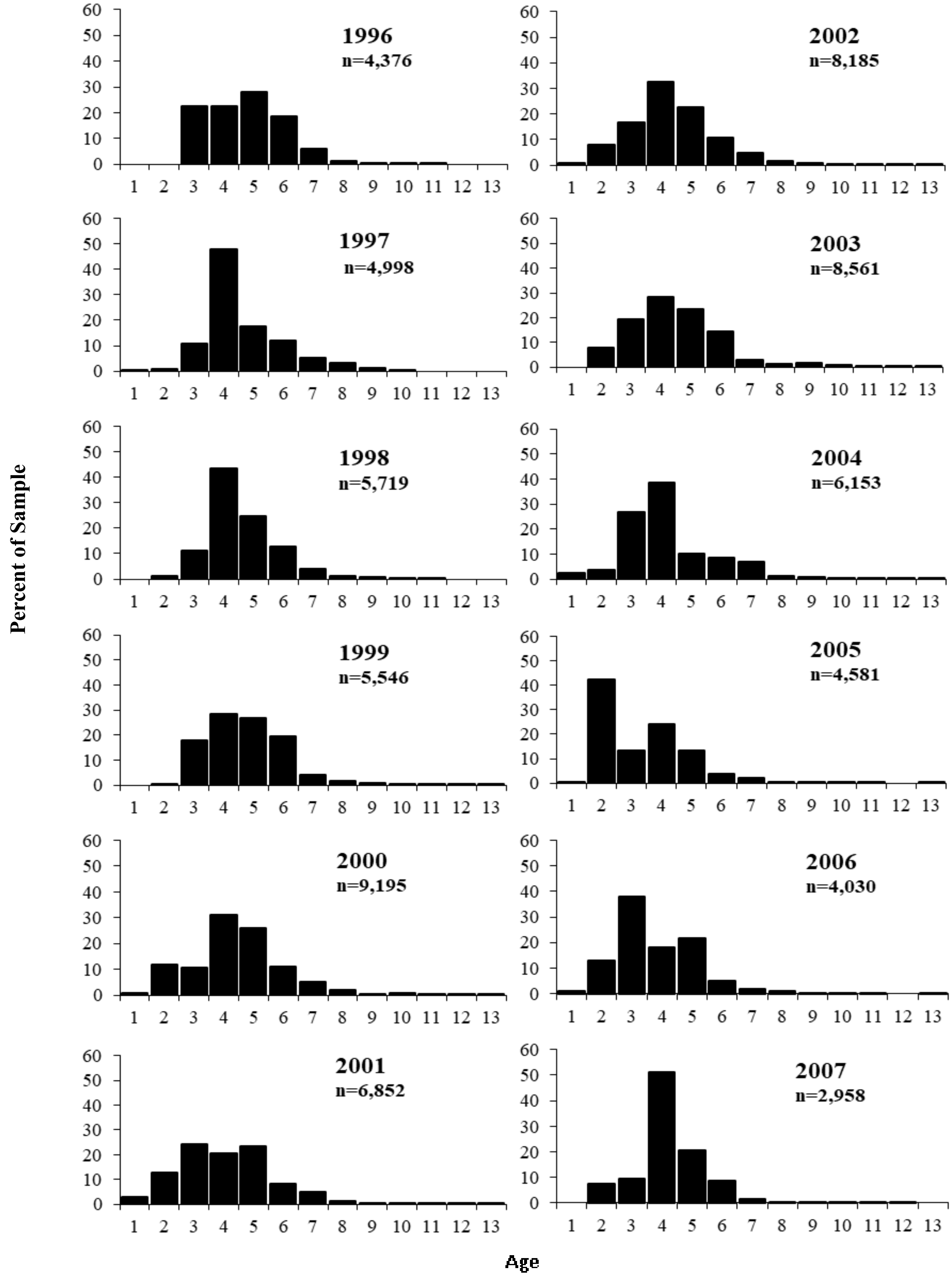


Figure 3. Continued.

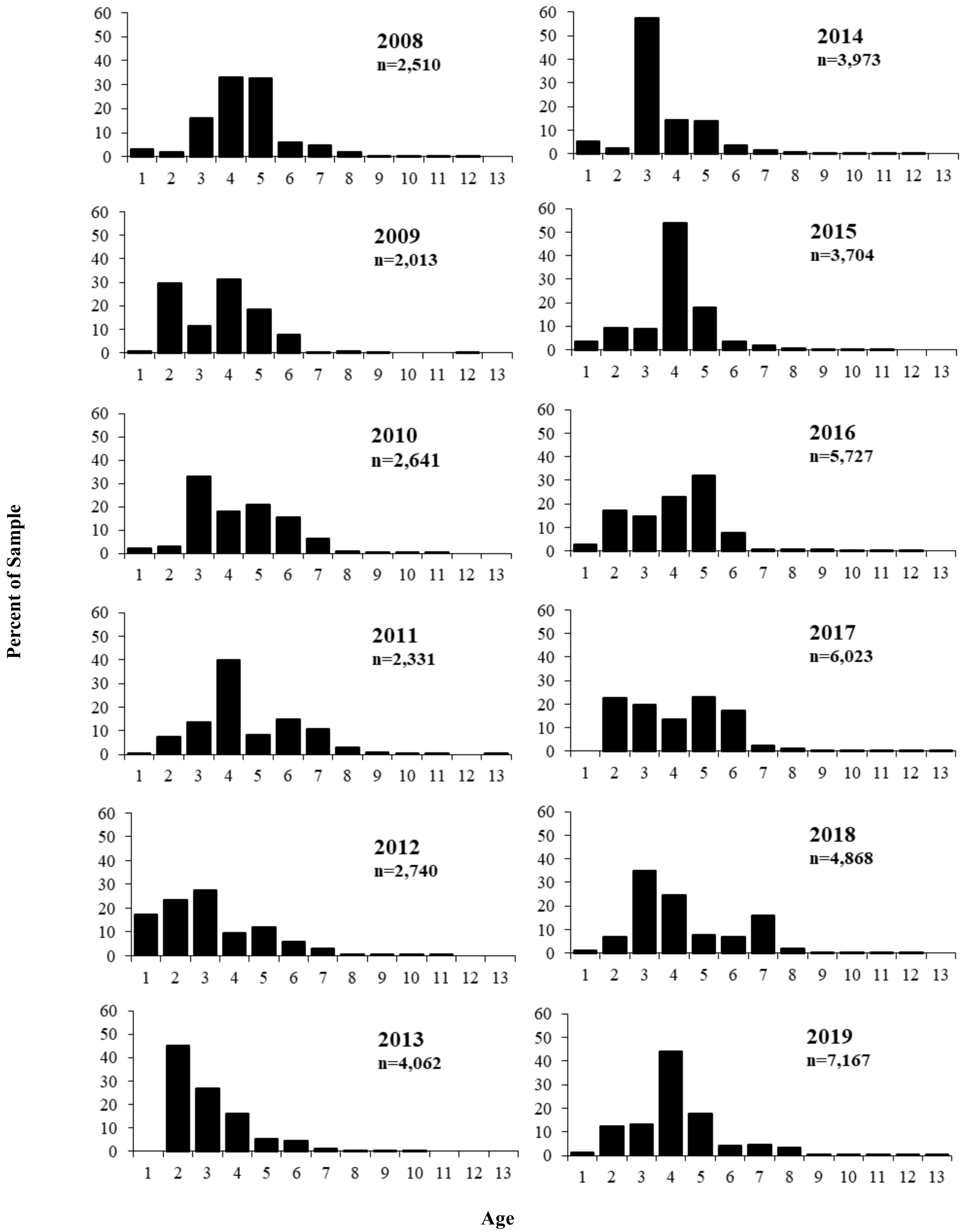


Figure 4. Length frequency of striped bass sampled during the 2019 pound net monitoring and the summer/fall check station surveys. All fish were sampled from June through November 2019. Pound net monitoring length frequency is for legal-size fish only (≥457 mm TL/18 in TL).

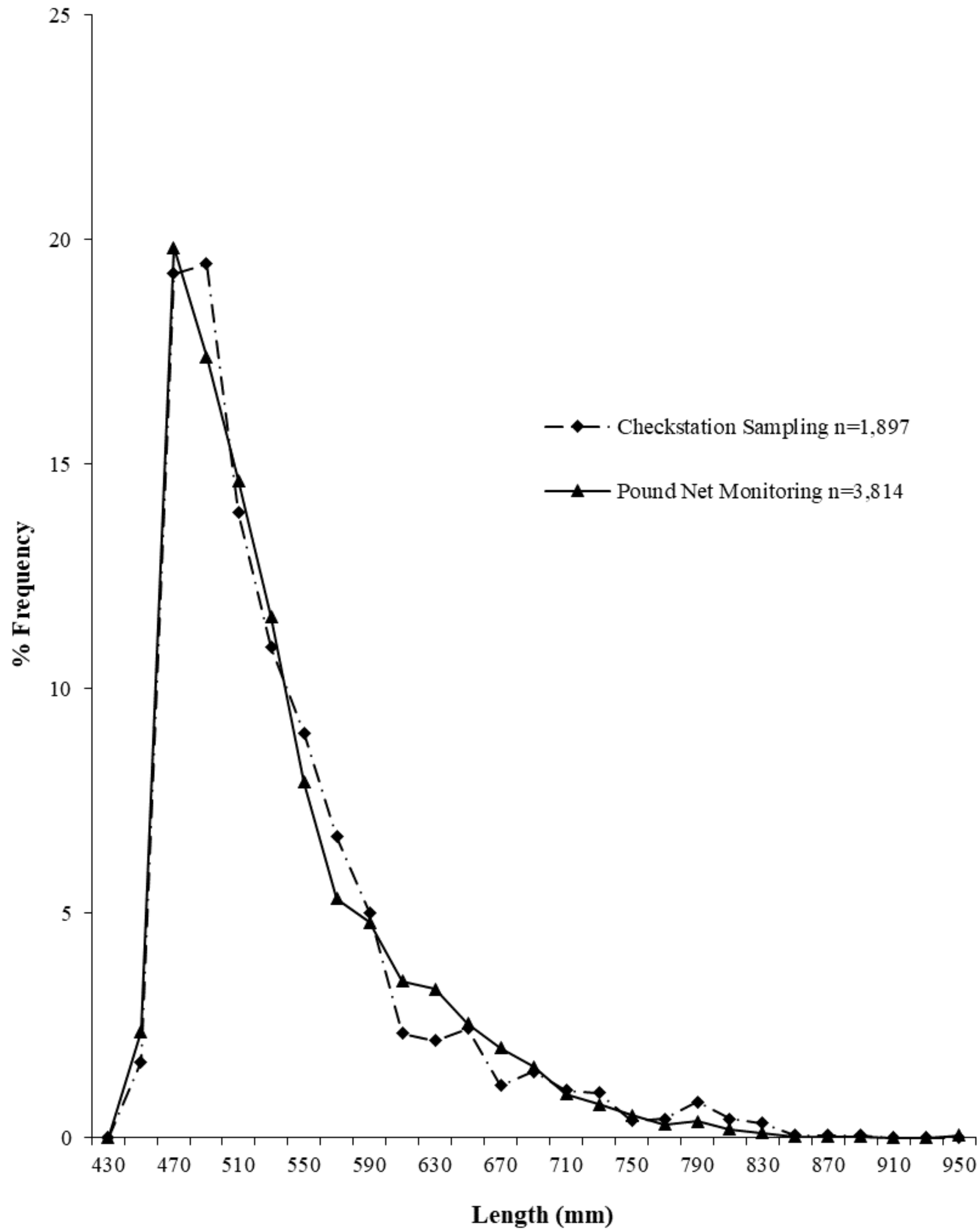


Figure 5. Age and length (mm TL) frequencies of striped bass sampled from Maryland Chesapeake Bay commercial summer/fall check stations, June through November 2019.

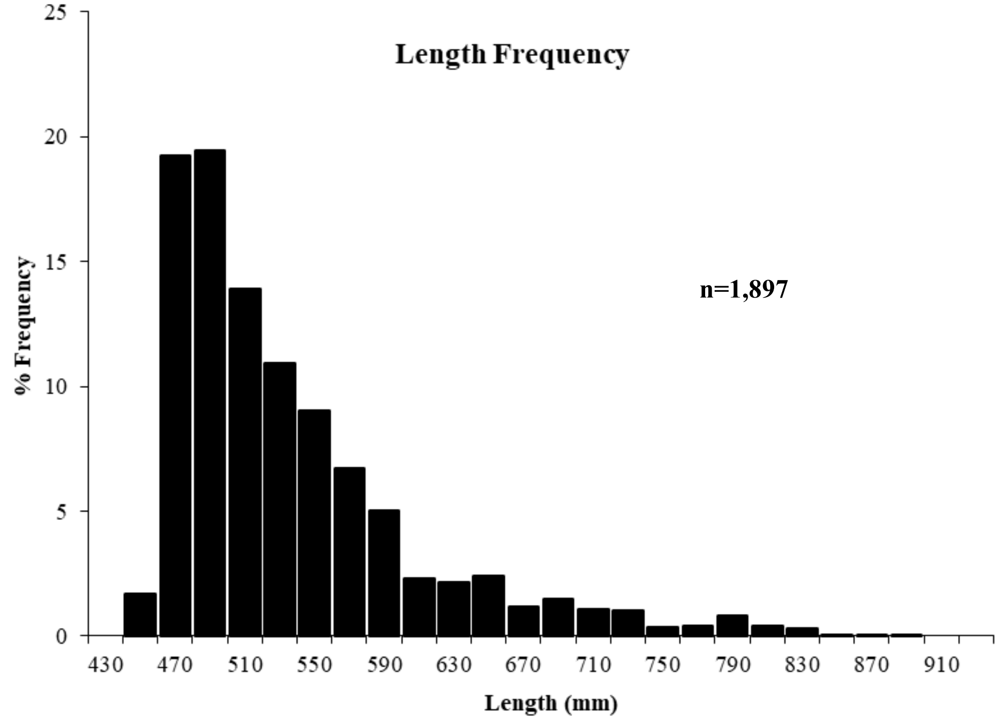


Figure 6. Month-specific length distributions of striped bass sampled from Maryland Chesapeake Bay commercial summer/fall check stations, June through November 2019.

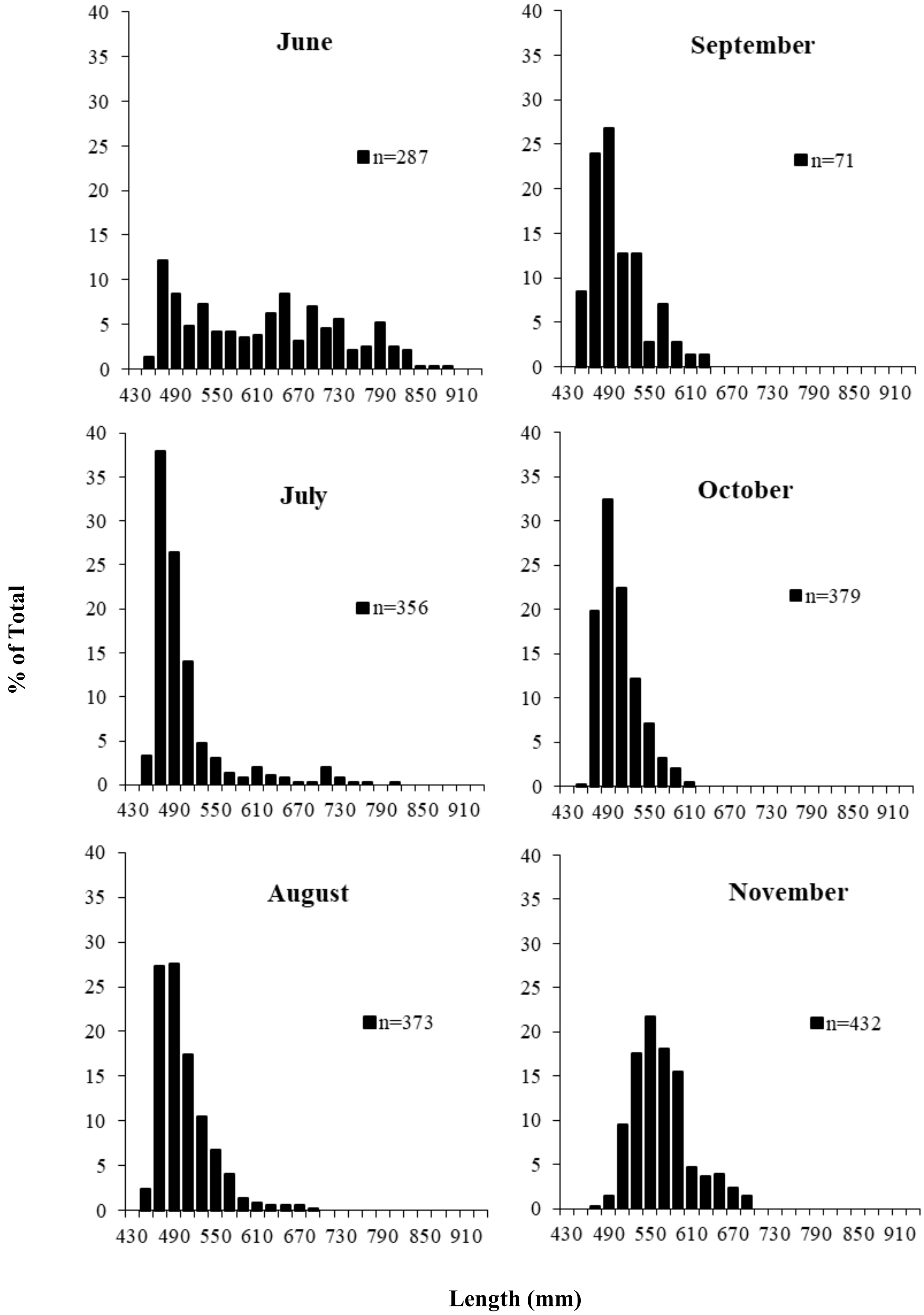


Figure 7. Age structure of striped bass sampled from Maryland Chesapeake Bay commercial summer/fall check stations, 1999 through 2019. Note-pound net check station sampling began in 2000 and gears are combined beginning in 2014.

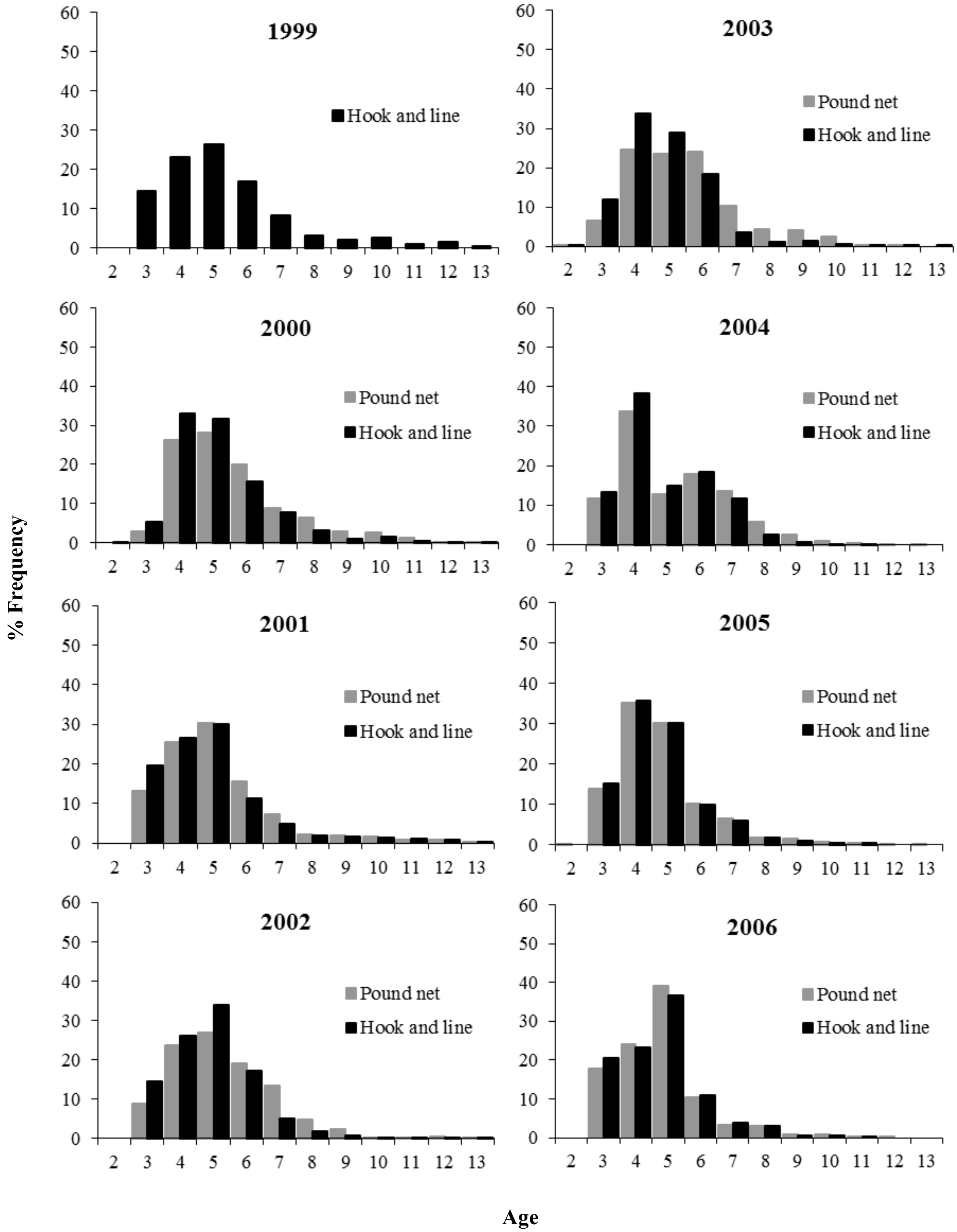


Figure 7. Continued.

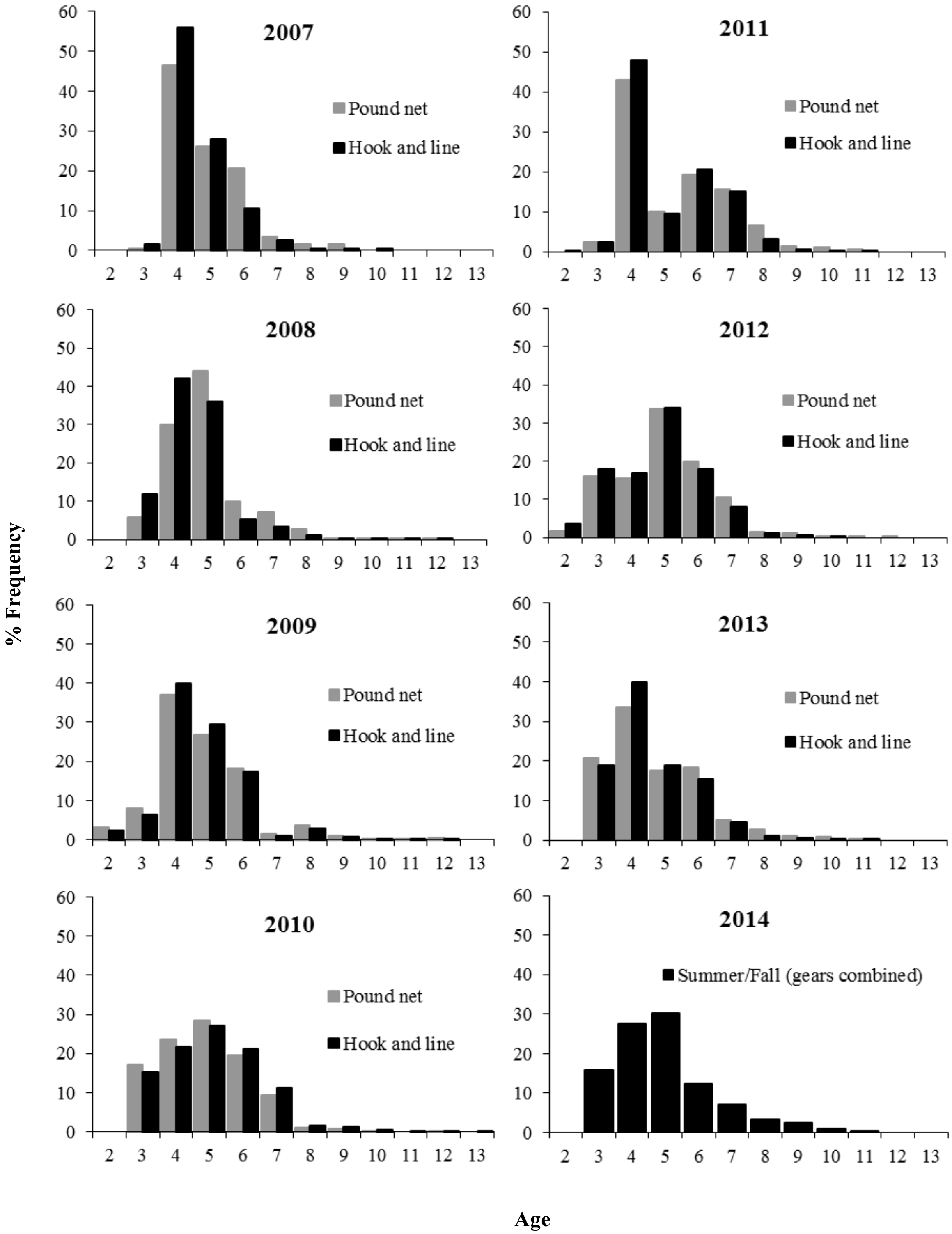


Figure 7. Continued

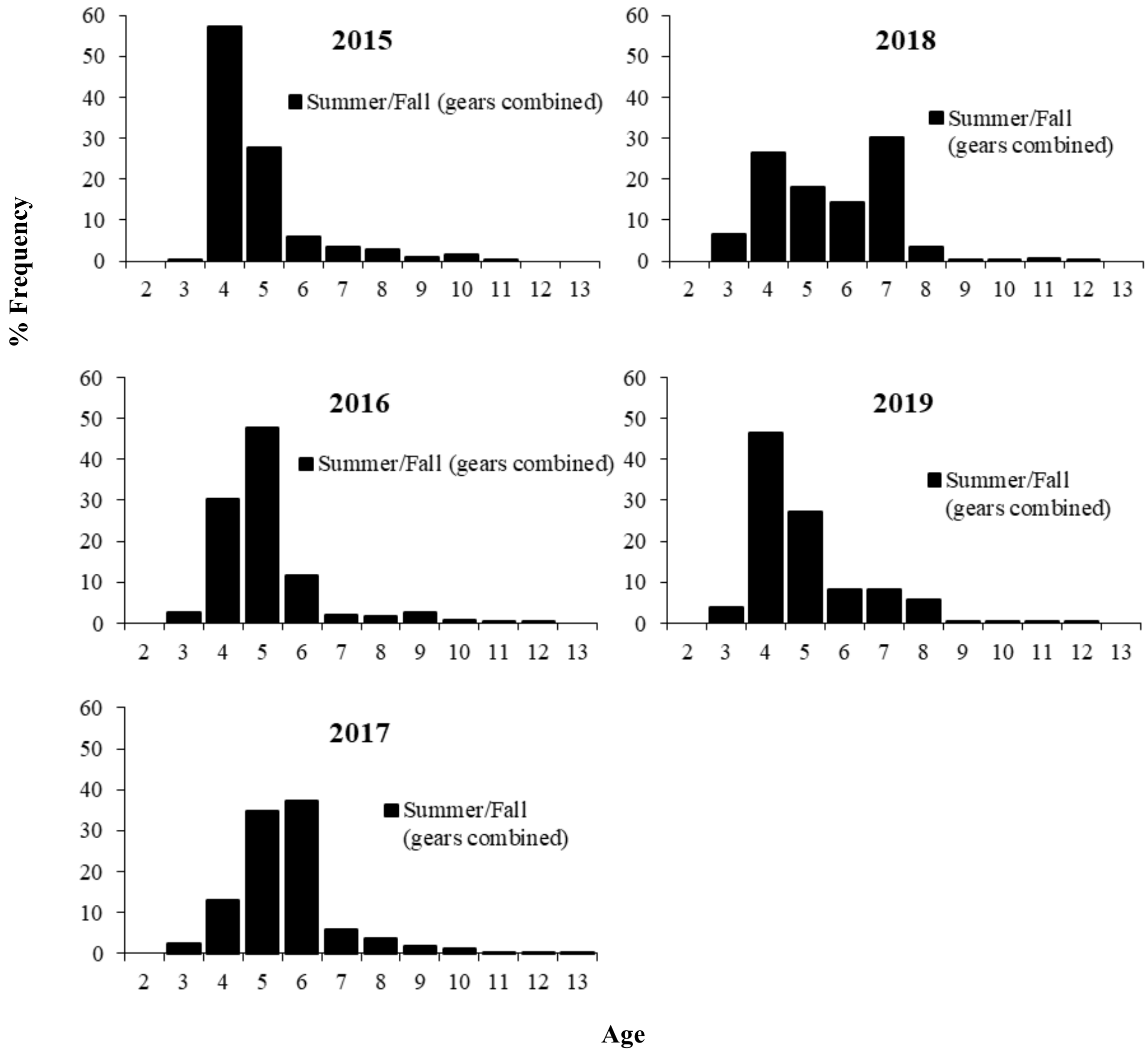
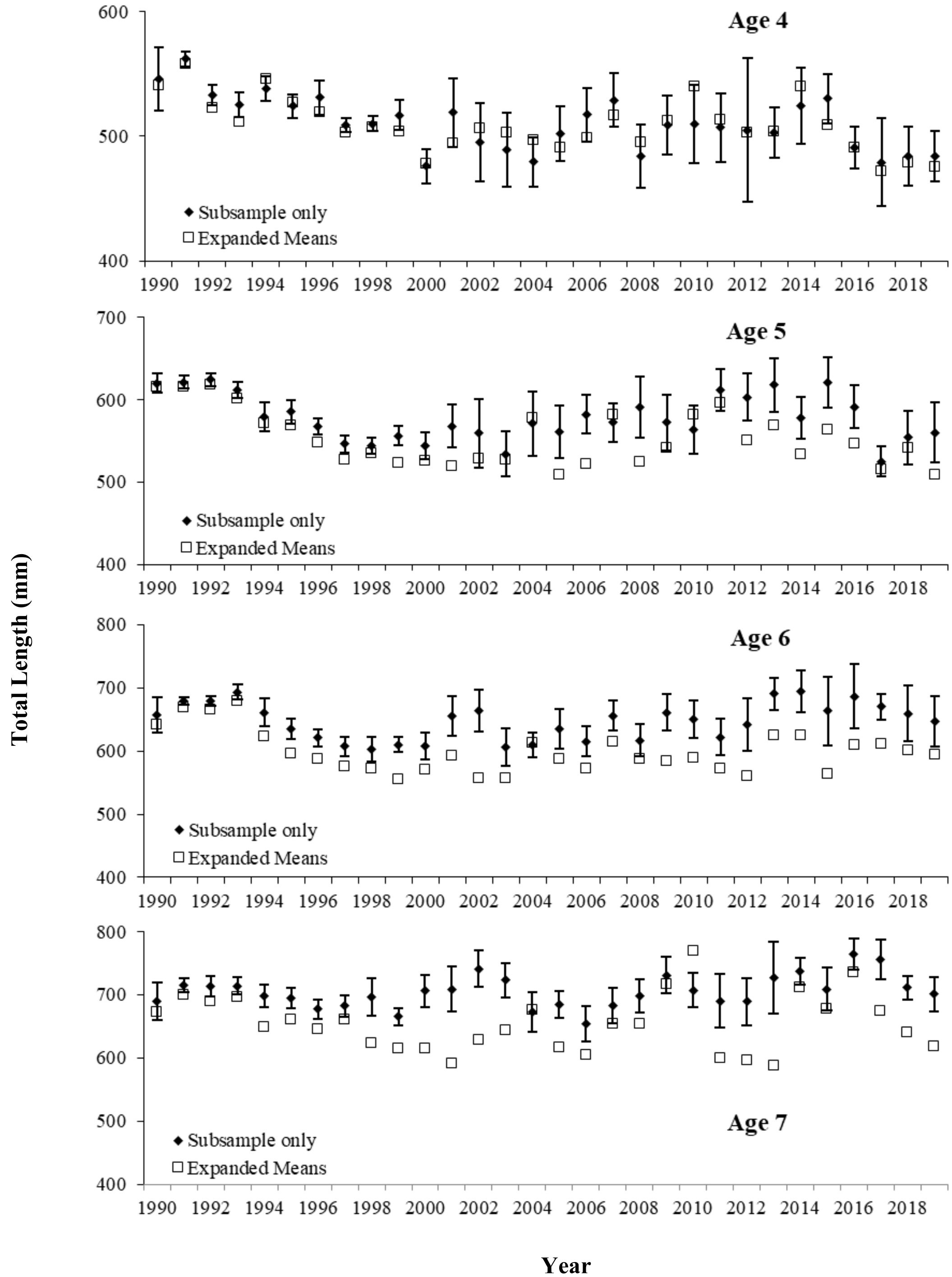


Figure 8. Mean lengths for legal-size striped bass (≥457 mm TL) by year for age 4, 5, 6, and 7 striped bass sampled from Maryland Chesapeake Bay pound nets and commercial summer/fall check stations, 1990 through 2019. Mean lengths were calculated by using sub-sampled ages only and by expanding ages to 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 to finalize the characterization of the size and age structure of striped bass (*Morone saxatilis*) sampled from the December 1, 2019 – February 29, 2020 commercial drift gill net fishery and provide preliminary results, as available, for the 2020-2021 winter season. Completed results for the 2020-2021 winter sample season will be reported in the F61-R-17 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 the 2014 season (see Project 2, Job 3, Task 5A). Watermen were assigned an individual quota for the year that they could harvest during any open season. For each month of the ITQ drift gill net fishery, fish could be harvested Monday through

Friday during the entire month. A small number of watermen elected to stay in a common pool fishery, in which they shared a monthly quota, with daily harvest limits, similar to the old system. The common pool fishery was closed in December, open for three days in January and three days in February.

METHODS

Data collection procedures

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

Monthly sample targets were 1,000 fish in December and 1,250 fish in both January and February, for a total target sample size of 3,500 fish. Sampling at this level provides an accurate representation of both the length and age distributions of the harvest (Fegley et al. 2000). Estimated number of fish caught was calculated by using mean weight of fish sampled by month. At each check station a random sample of striped bass was measured (mm TL) and weighed (kg). For fish less than 700 mm TL, scales were taken randomly from five fish per 10 mm length group per month. For fish between 700 mm TL and 800 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 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 2019-2020 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 from the year in which the fishery ended. For example, for the December 2019 – February 2020 gill net season, the year used for age calculations was 2020.

Mean lengths- and weights-at-age were calculated by year-class for the aged subsample of fish and 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 2019-2020 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 3,559 striped bass was sampled and 132 striped bass were aged from the harvest between December 2019 - February 2020. 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 in Crisfield (Figure 1). Check stations were visited by biologists five times in December, five 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 2019-2020 season was estimated by dividing reported monthly harvest weight by the mean monthly weight of check station samples. Total reported landings were 516,028 pounds and the estimated number of fish was 91,608 (Table 1). According to the catch-at-age analysis, the 2019-2020 commercial drift gill net harvest consisted primarily of age 5 striped bass from the 2015 year-class (36%; Table 2). The 2014 and 2013 year-classes (ages 6 and 7) composed an additional 36% of the total harvest. The contribution of fish age 9 and older (14%) was higher than the 2018-2019 harvest (7%). The youngest fish observed in the 2019-2020 sampled harvest were age 3 from the 2017 year- class (1%).

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 3 (2017 year-class), with an expanded mean length and weight of 471 mm TL and 1.33 kg, respectively. The 2011 year-class (age 9) was most observed in the sampled landings and had an expanded mean length and weight of 656 mm TL and 3.63 kg, respectively. The expanded mean length and weight of the oldest fish in the aged subsample (age 12, 2008 year-class) were 728 mm TL and 4.74 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 490-650 mm length groups. A total of 10 sub-legal fish <457 mm TL (18 inches) were observed in 2019-2020 sampling.

Time-series of subsampled and expanded mean lengths and weights for the period 1994-2020 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

2020-2021 WINTER STOCK ASSESSMENT AND COMMERCIAL FISHERY MONITORING

2020-2021 SEASON PRELIMINARY RESULTS

A total of 3,034 striped bass were sampled and 443 scale samples were collected from the harvest between December 2020 - February 2021. 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 six times in December, six times in January, and three 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 2020-2021 winter season of harvest-, length-, and weight-at-age will be provided in the F61-R-17 Chesapeake Bay Finfish Investigations report.

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Table 1. Reported pounds harvested, check station average weights, and estimated fish harvested by the Maryland Chesapeake Bay commercial drift gill net fishery, December 2019 - February 2020.

Month	Harvest (lbs)	Check station average wt. (lb)	Estimated # harvested
December 2019	130,869	5.83	22,448
January 2020	251,271	5.81	43,263
February 2020	133,888	5.17	25,897
Total*	**516,028**		**91,608**

* 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 2019 - February 2020.

Year-class	Age	Catch	Percentage of the catch
2017	3	532	1
2016	4	5,066	6
2015	5	33,110	36
2014	6	17,234	19
2013	7	15,960	17
2012	8	6,676	7
2011	9	10,828	12
2010	10	2,014	2
2009	11	51	<1
2008	12	136	<1
Total*		91,608	**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 2019 - February 2020.

Year-class	Age	n fish aged	Mean TL (mm) of subsample	Estimated # at-age in sample	Expanded mean TL (mm)
2017	3	1	468	21	471
2016	4	6	485	197	515
2015	5	28	525	1,286	541
2014	6	15	594	670	562
2013	7	16	634	620	601
2012	8	16	707	259	650
2011	9	40	731	421	656
2010	10	8	753	78	676
2009	11	1	874	2	867
2008	12	1	730	5	728
Total*		**132**		**3,559**	

* 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 2019 - February 2020.

Year-class	Age	n fish aged	Mean WT (kg) of subsample	Estimated # at-age in sample	Expanded mean weight (kg)
2017	3	1	1.28	21	1.33
2016	4	6	1.47	197	1.76
2015	5	28	1.89	1,286	2.06
2014	6	15	2.83	670	2.32
2013	7	16	3.32	620	2.82
2012	8	16	4.30	259	3.52
2011	9	40	4.94	421	3.63
2010	10	8	5.37	78	3.90
2009	11	1	8.83	2	8.83
2008	12	1	5.38	5	4.74
Total*		**132**		**3,559**	

* 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 2019 - February 2020.

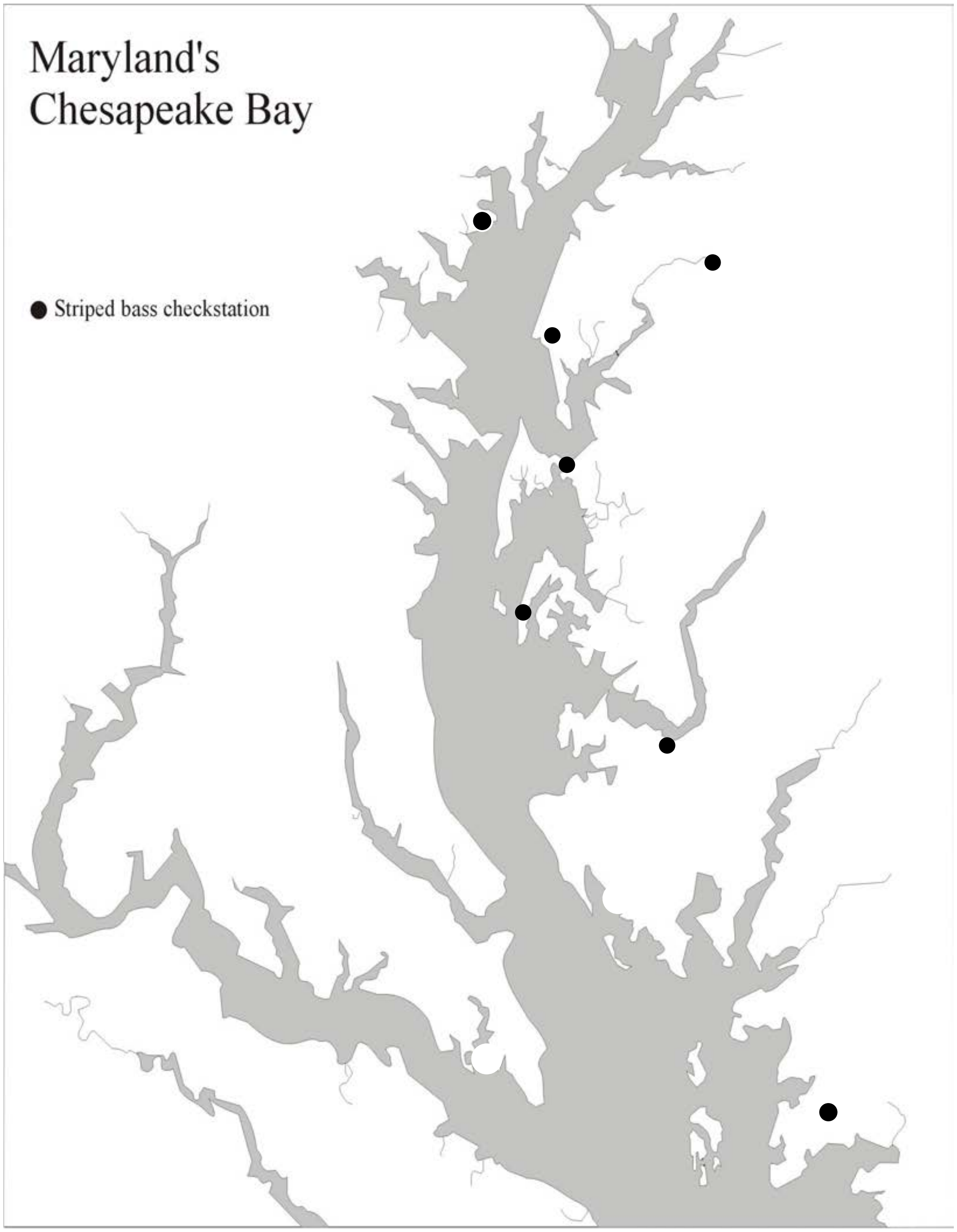
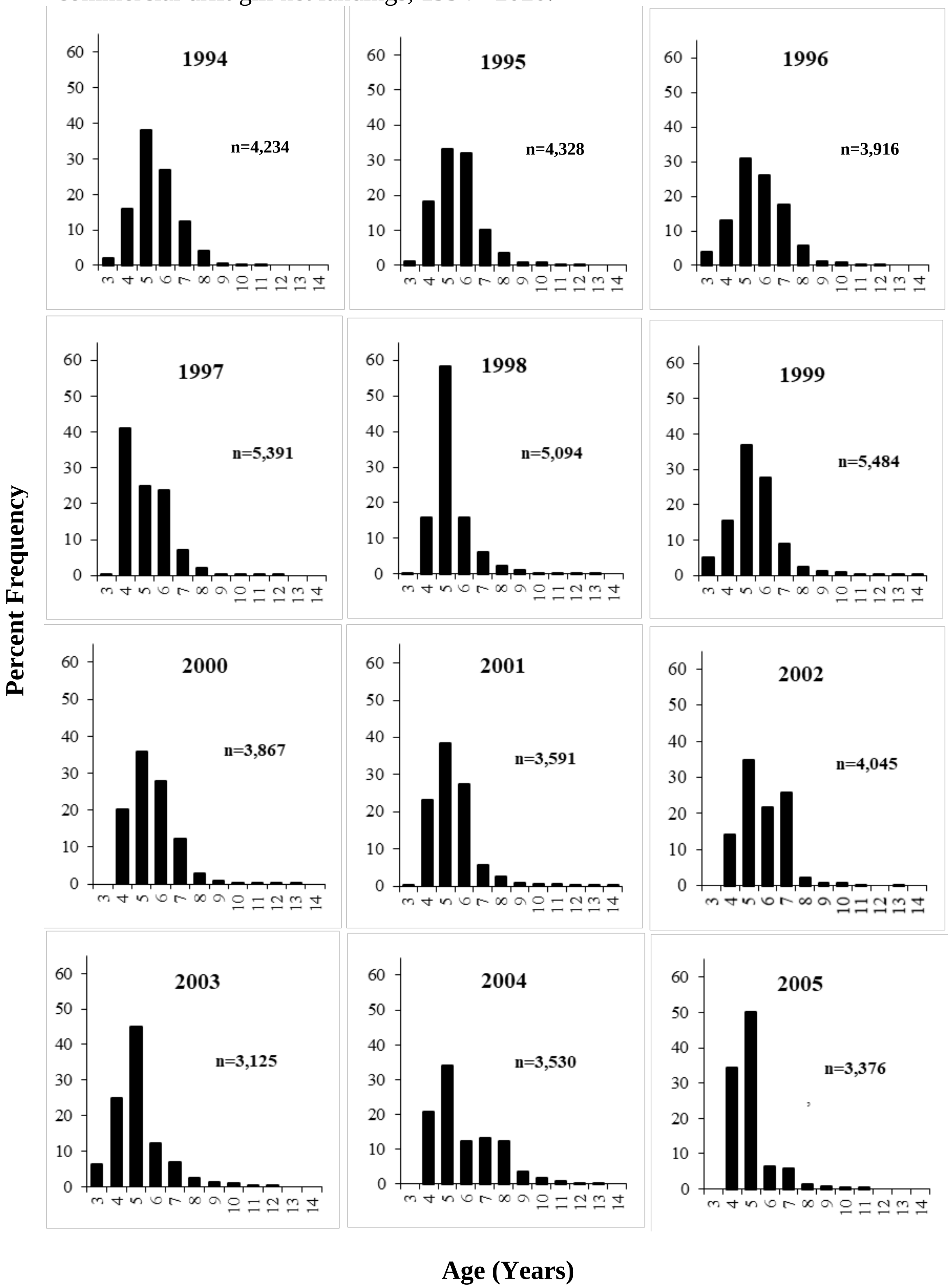


Figure 2. Age distribution of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, 1994 - 2020.



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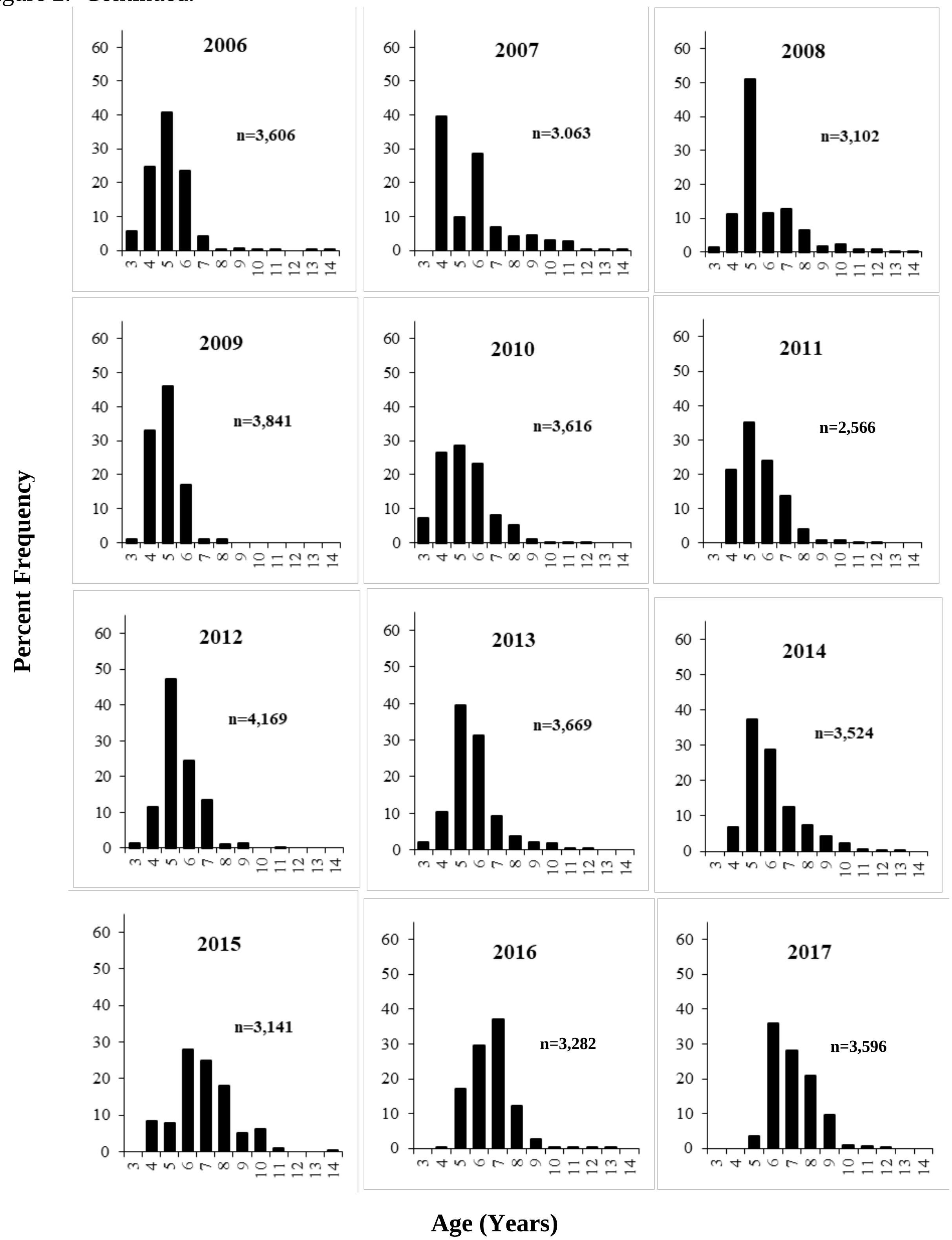

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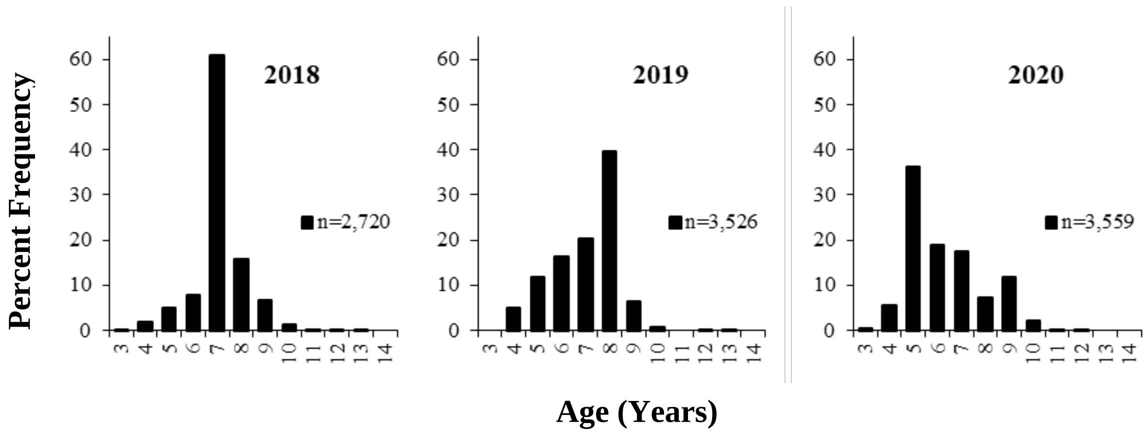


Figure 3. Length frequency distribution of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, December 2019 - February 2020.

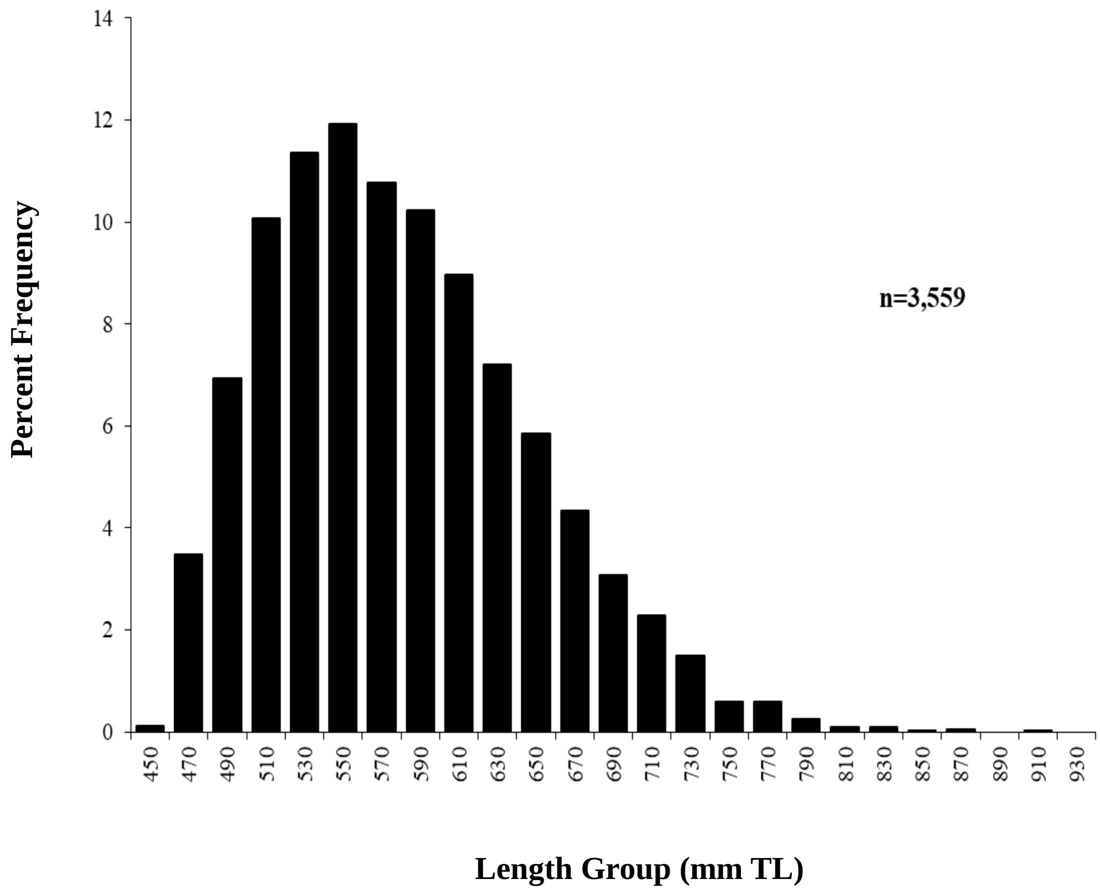
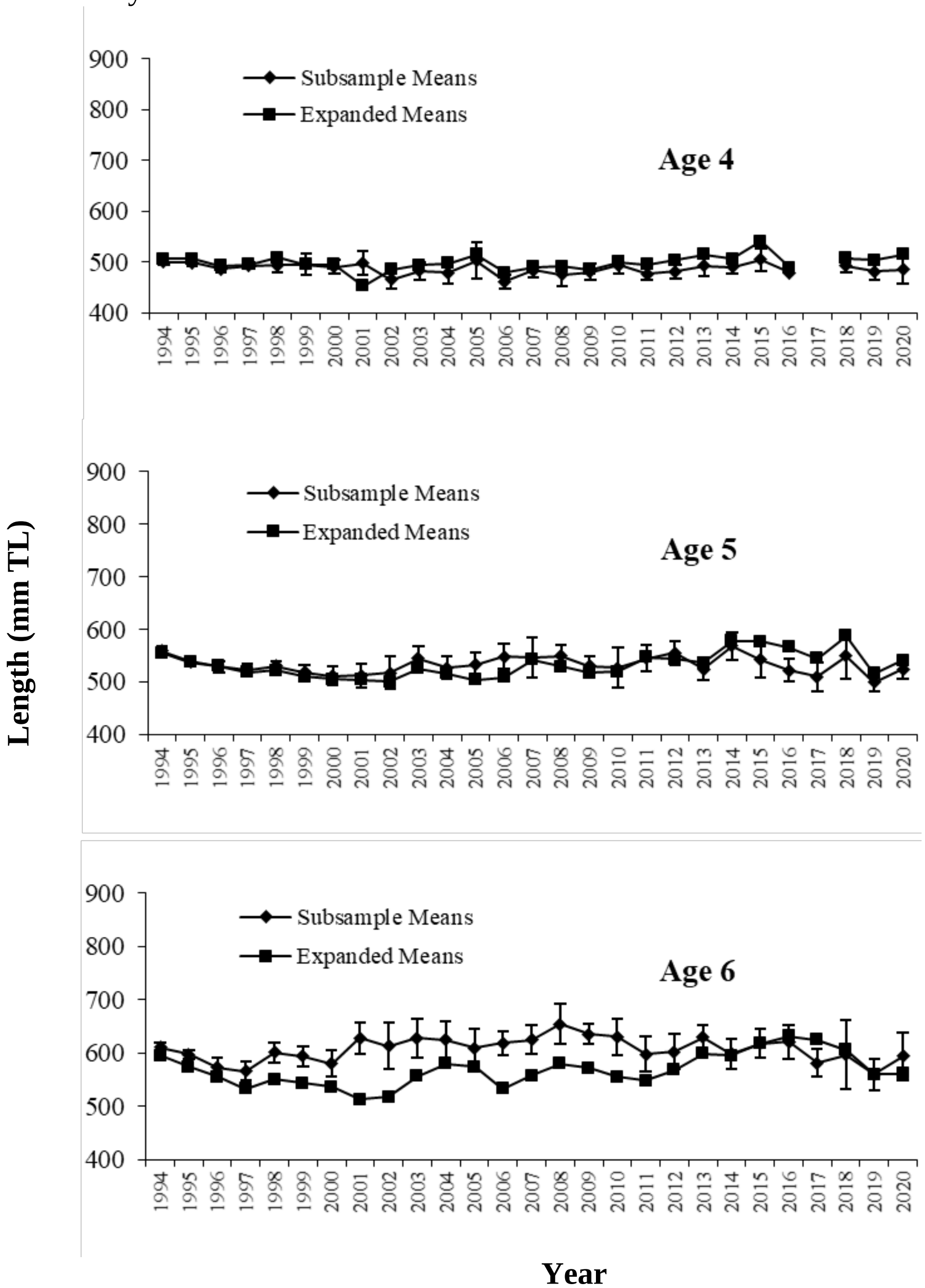


Figure 4. Mean total lengths (mm TL) of the aged subsample, by year, for individual age-classes of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, 1994 - 2020 (95% confidence intervals are shown around each point). Expanded means (estimated from entire sample) are also shown. Year refers to the year in which the season ended.



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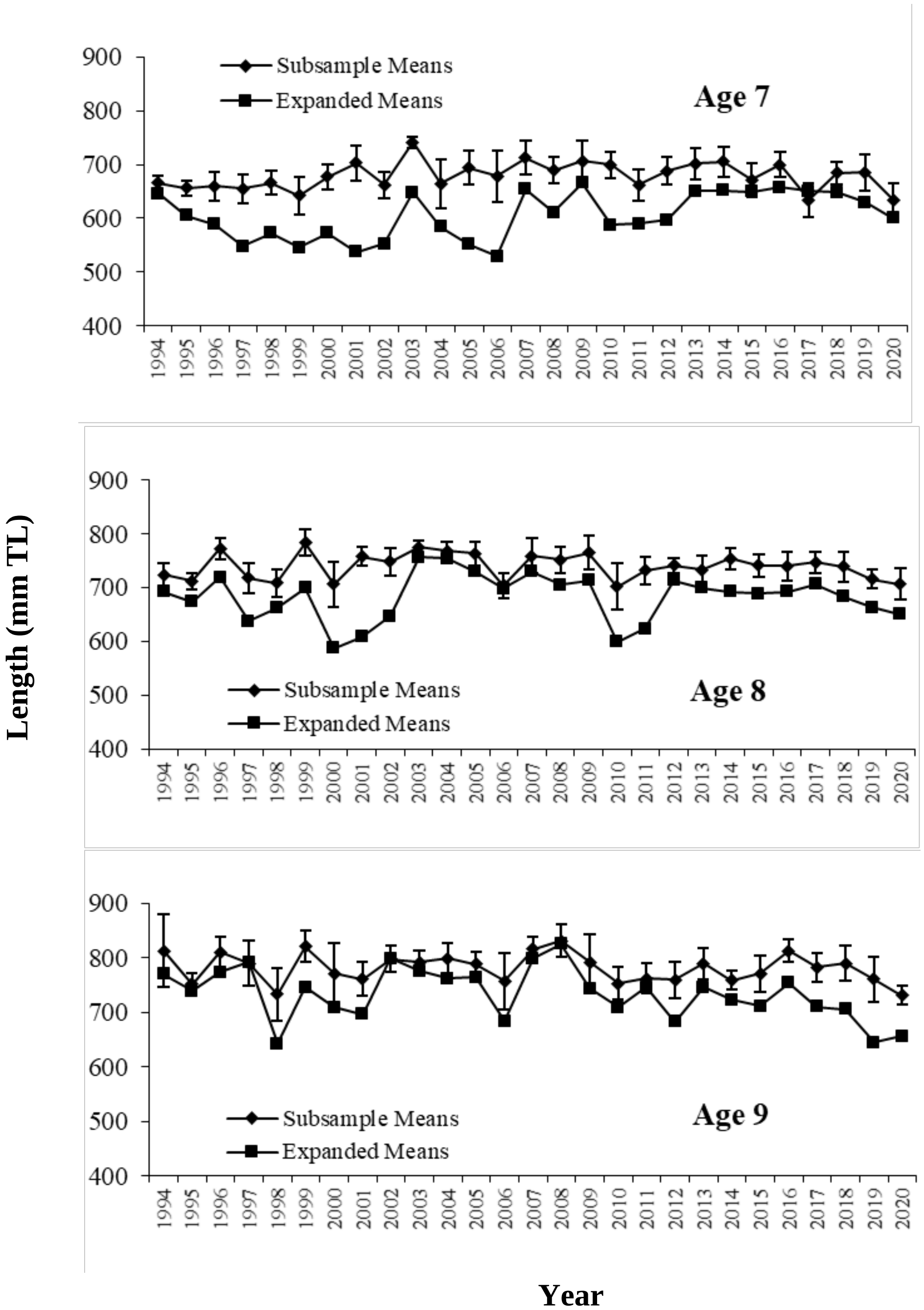
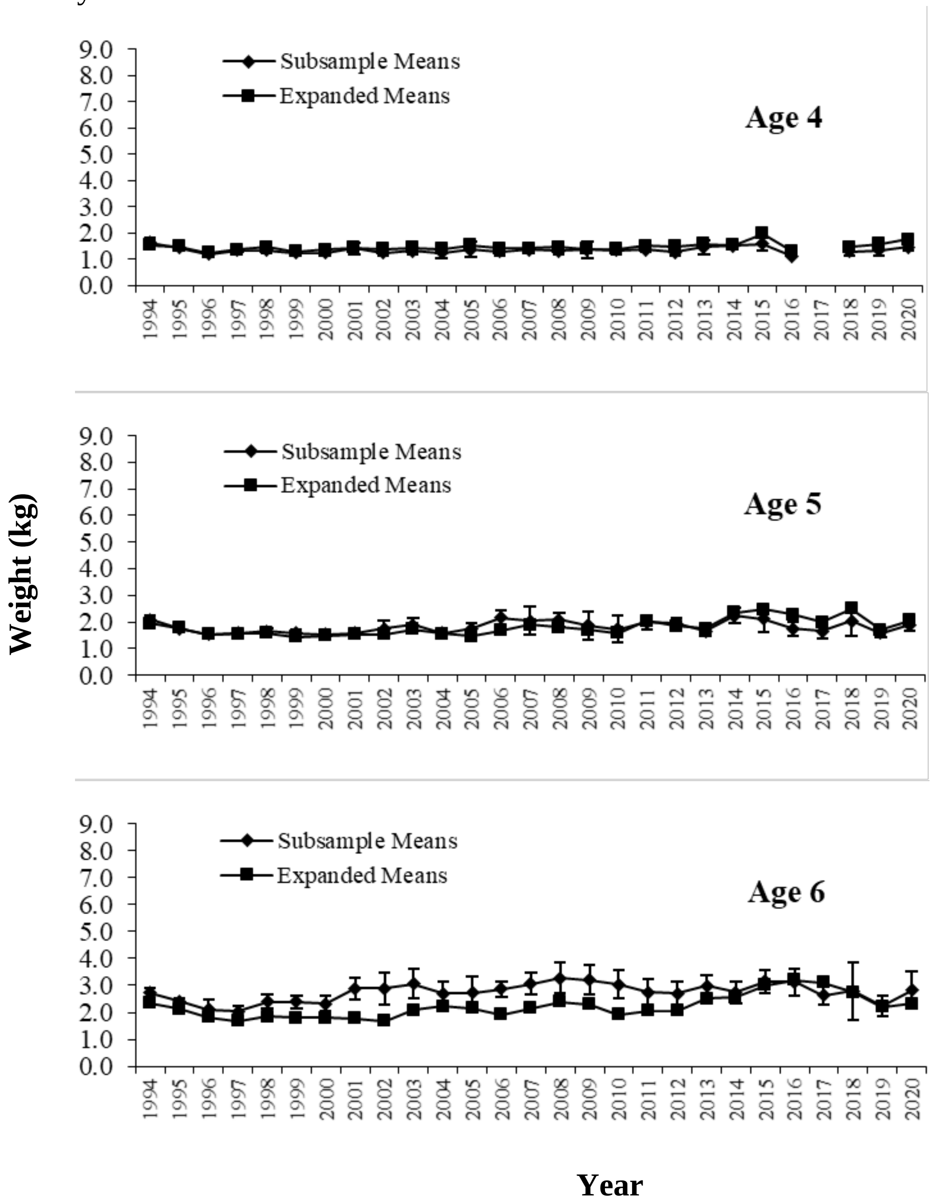


Figure 5. Mean weights (kg) of the aged subsample, by year, for individual age-classes of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net fishery, 1994 - 2020 (95% confidence intervals are shown around each point). Expanded means (estimated from entire sample) are also shown. Year refers to the year in which the season ended.



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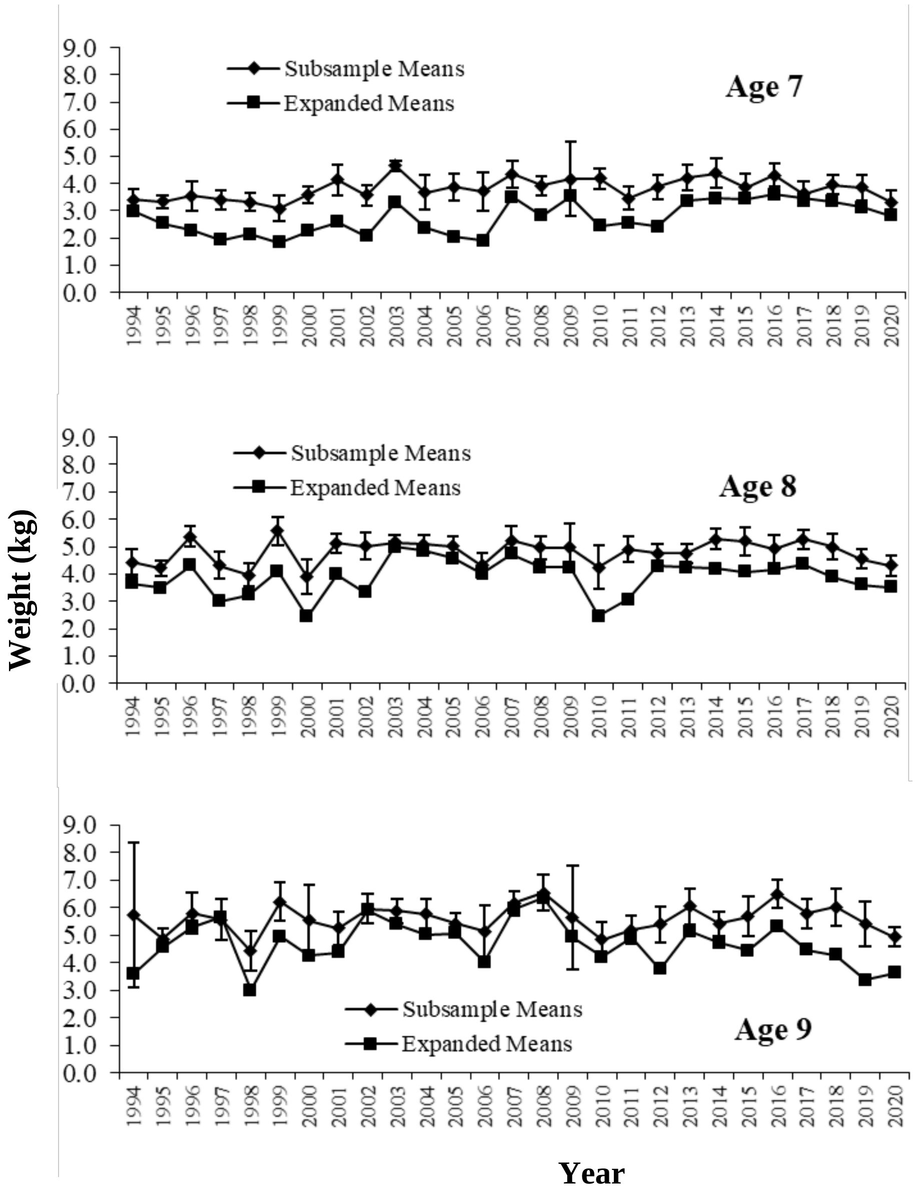

PROJECT NO. 2
JOB NO. 3
TASK NO. 1C

ATLANTIC COAST STOCK ASSESSMENT AND COMMERCIAL HARVEST MONITORING

Prepared by Jeffrey Horne

INTRODUCTION

The primary objective of Project 2, Job 3, Task 1C was to finalize the characterization of the size and age structure of commercially harvested striped bass from Maryland's Atlantic coast during the 2019-2020 season and provide preliminary results, as available, for the 2020-2021 season. Completed results for the 2020-2021 sample season will be reported in the F61-R-17 Chesapeake Bay Finfish Investigations report. Trawls and gill nets were permitted during the Atlantic season within state waters (to 3 miles offshore).

The 2020 season opened October 1, 2019 and ended May 31, 2020. The 2019 portion of the 2020 Atlantic striped bass season continued to be managed under Addendum IV to Amendment 6 of the Atlantic Striped Bass Interstate Fishery Management Plan (Giuliano et al. 2014). Beginning in 2020 Atlantic striped bass season was managed under Addendum VI to Amendment 6 of the Atlantic Striped Bass Interstate Fishery Management Plan. Although this report covers the October 2019 – May 2020 fishing season, the quota is managed by calendar year. In 2019, this fishery was managed with a 24 inch total length (TL) minimum size limit and an annual quota of 90,727 pounds. Addendum VI reduced the annual quota to 89,094 pounds for the 2020 calendar year.

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 acetate or 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 2019 – May 2020 Atlantic fishery, the year used for age calculations was 2020. 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. For the 2020 season, the length frequency and ALK used were from the 2019 season due to low sample sizes and COVID-19 restrictions.

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

RESULTS and DISCUSSION

Check stations reported 3,457 fish landed during the 2019 – 2020 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). Due to COVID-19 restrictions, sampling was not conducted in April or May 2020 when most of the fish are typically harvested. Sampling at coastal check stations was conducted on one day in January 2020. A total of 5 fish were weighed and measured. Fish ages were determined directly from 5 scale samples. These samples were added to the length frequency and ALK from 2019 to develop the catch-at-age matrix.

Commercial fishermen have a limited area to harvest striped bass (~62 square miles) within Maryland waters. During the 2020 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 harvest, ranging from age 6 (2014 year-class) to age 19 (2001 year-class) (Table 1; Figure 2). The most frequent age represented in the catch-at-age estimate was age 9, the 2011 year-class, which represented 20% 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. Age 13 (2007 year-class) fish were also significant contributors to the sample population at 17% (Table 1; Figure 2).

Striped bass sampled at Atlantic coast check stations during the 2019 – 2020 season had a mean length of 785 mm TL and mean weight of 5.9 kg. The sample length distribution ranged from 690 to 955 mm TL (Figure 3). The weight of fish sampled for both seasons ranged from 3.5 to 11.0 kg. Mean and expanded lengths and weights at age were not calculated for 2020 due to data limitations.

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

ATLANTIC COAST STOCK ASSESSMENT AND COMMERCIAL HARVEST MONITORING

2020-2021 SEASON PRELIMINARY RESULTS – WORK IN PROGRESS

A total of 128 striped bass were sampled and 128 scale samples were collected from the harvest between October 2020 - May 2021. Fish ranged in length from 705 mm to 1227 mm TL and in weight from 6.2 kg to 15.4 kg. Most of the fish were sampled at one check station in Ocean City, MD. Check stations were visited by biologists four 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 2020-2021 season is ongoing and complete results of harvest-, length-, and weight-at-age will be provided in the F61-R-17 Chesapeake Bay Finfish Investigations report.

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Table 1. Estimated harvest-at-age of striped bass (numbers of fish) landed by the Maryland Atlantic coast commercial fishery, October 2019 – May 2020.

Year-Class	Age	Number of Fish	Percent
2014	6	142	4.1
2013	7	256	7.4
2012	8	72	2.1
2011	9	697	20.2
2010	10	213	6.2
2009	11	306	8.8
2008	12	266	7.7
2007	13	597	17.3
2006	14	127	3.7
2005	15	347	10.0
2004	16	161	4.7
2003	17	237	6.9
2002	18	0	0.0
2001	19	36	1.0
Total*		3,457	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.

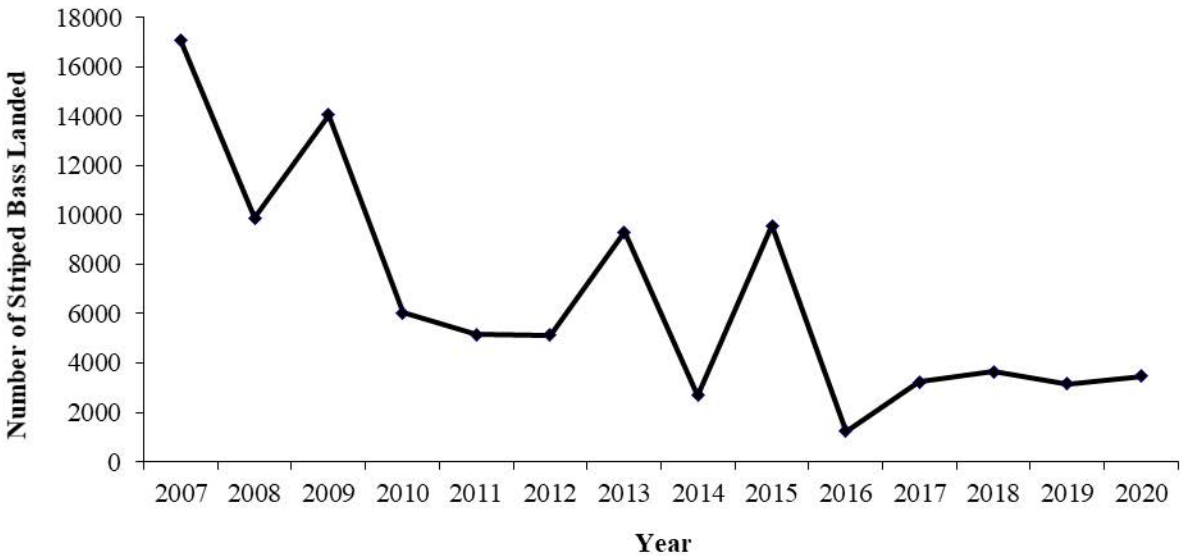
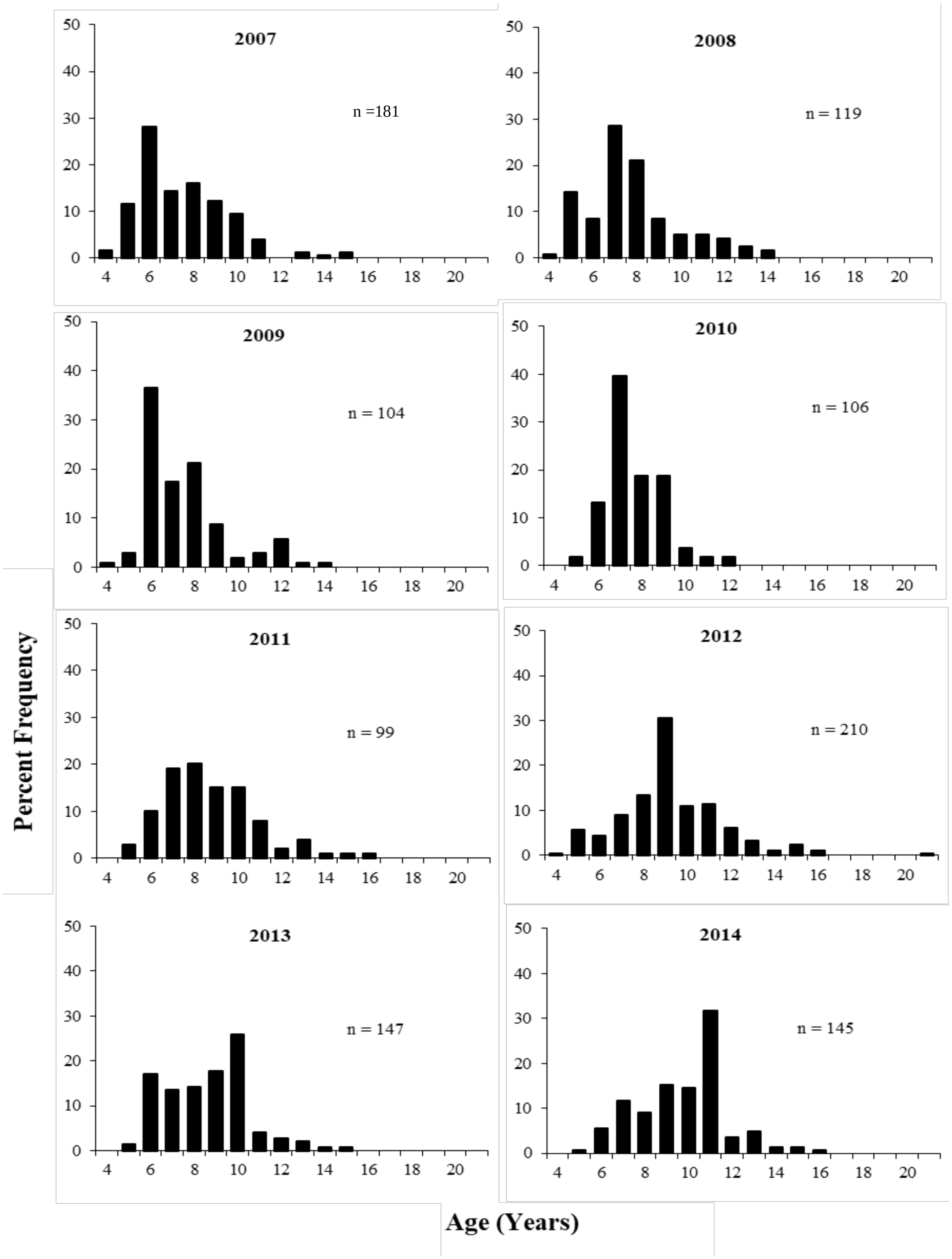


Figure 2. Age distribution of striped bass sampled from the Atlantic coast fishery, 2007 – 2020 seasons.



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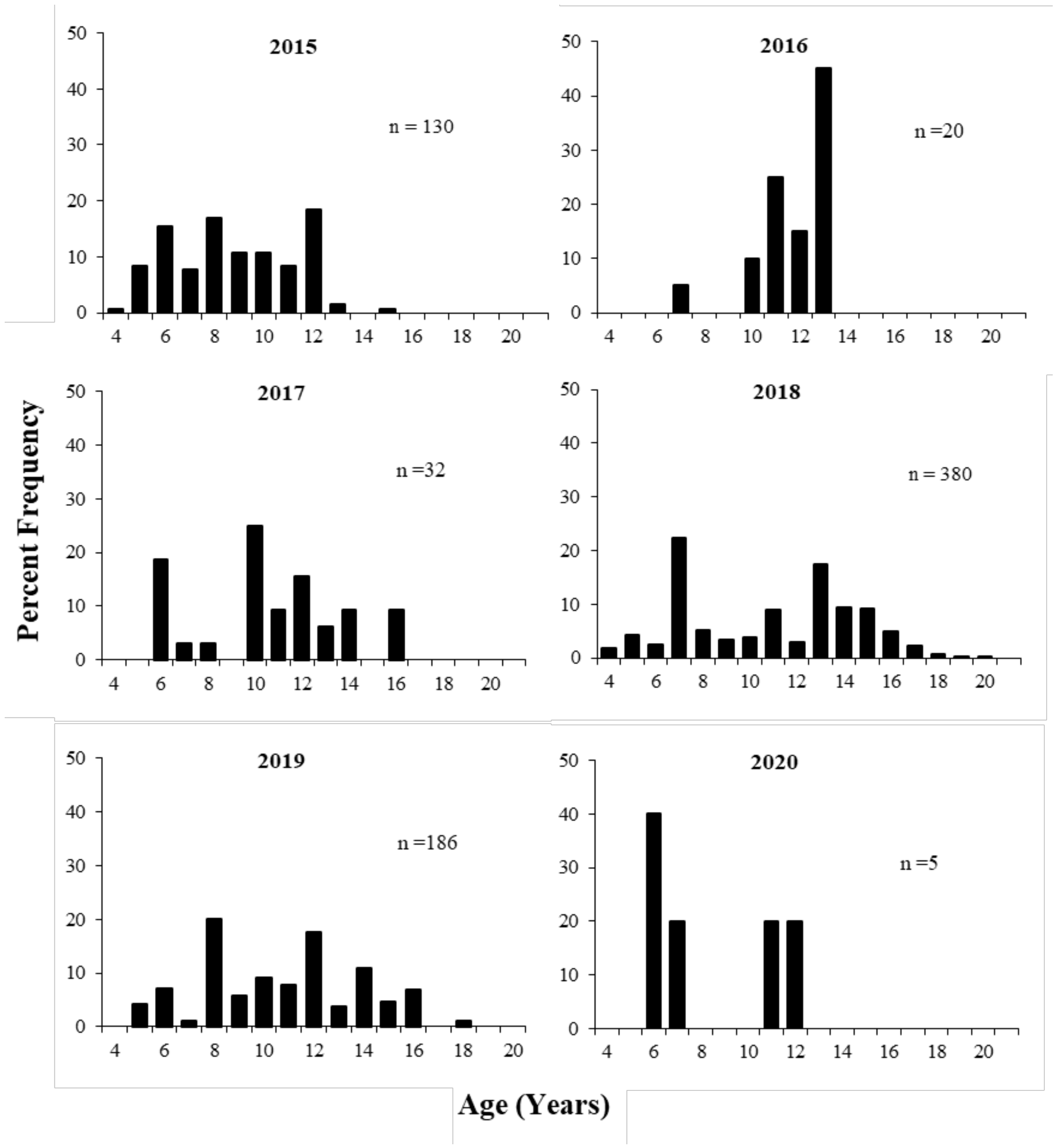
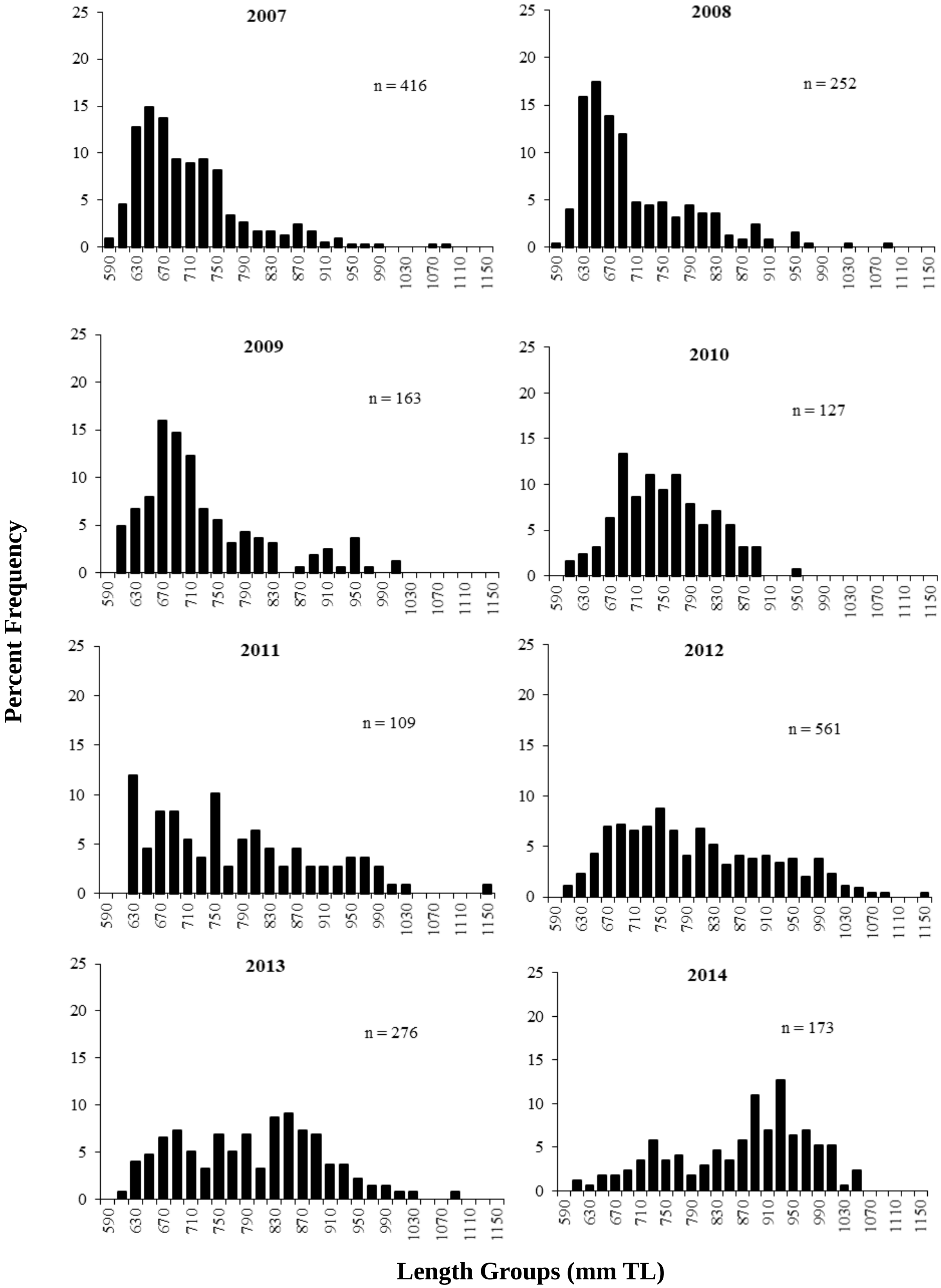


Figure 3. Length distribution of striped bass sampled from the Atlantic coast fishery, 2007 – 2020 seasons. *Note different x and y-axis scale for 2015 – 2020.



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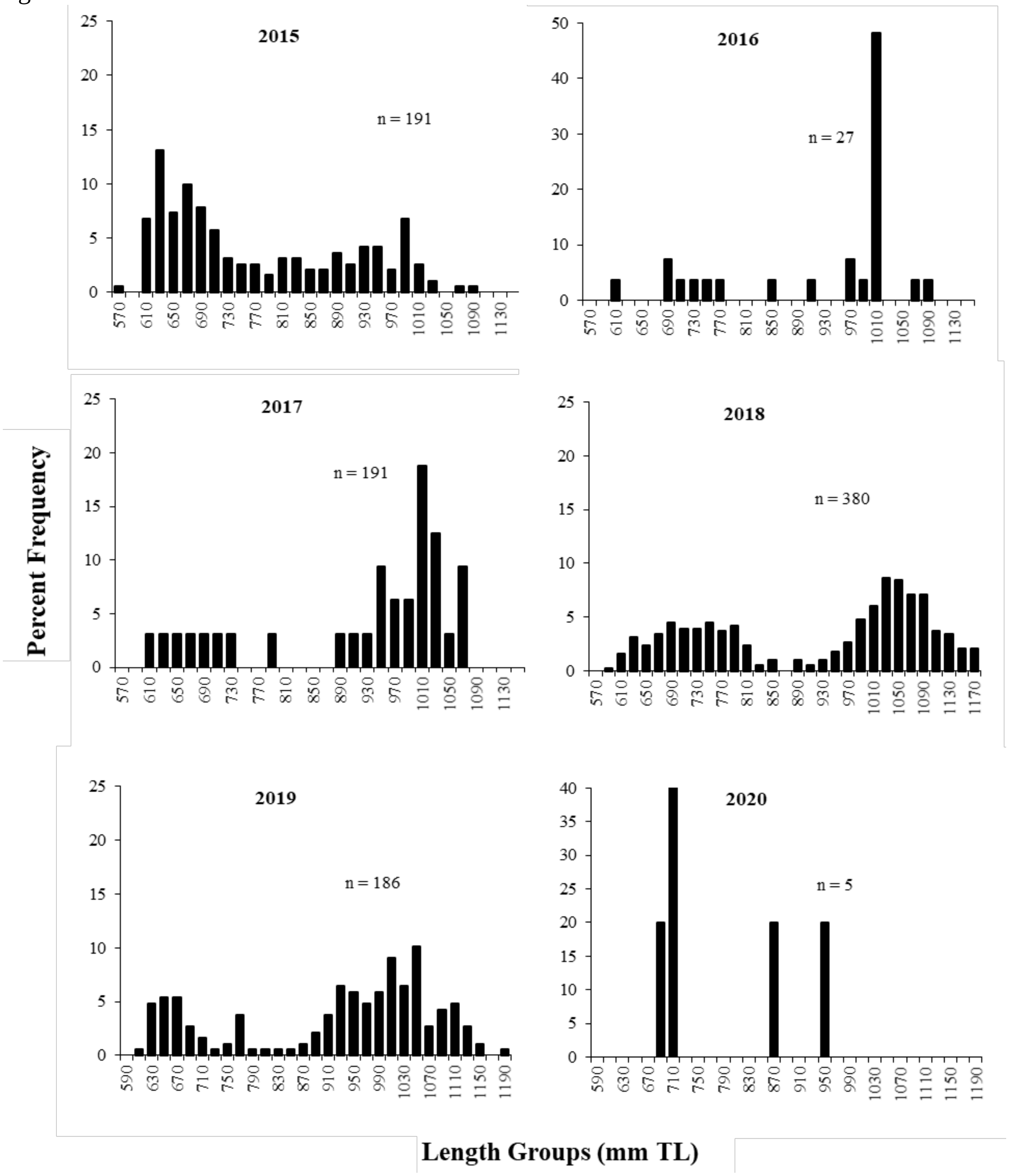

PROJECT NO. 2
JOB NO. 3
TASK NO. 2

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 2020 spring spawning season and to provide preliminary results for characterizing the 2021 spawning population. Completed abundance estimates and additional results for the 2021 spawning season will be reported in the next F-61-R-17 Chesapeake Bay Finfish Investigations report.

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

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

METHODS

Data Collection Procedures

Multi-panel experimental drift gill nets were deployed in the Potomac River and in the Upper Chesapeake Bay in 2020 (Figure 1). Due to COVID-19 the start of the survey was delayed by two weeks. Gill nets were fished seven 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 or tide 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. 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. Once 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). In order 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 15-plus.

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

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

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

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

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

RESULTS AND DISCUSSION

Sampling times

In the Potomac River, sampling was conducted from April 14 to May 16 for a total of 25 sample days. In the Upper Bay, sampling was conducted from April 14 to May 22 for a total of 32 sample days. Overall soak times for each panel ranged from six to 95 minutes.

CPUEs and variance

A total of 449 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.

With one exception, the 2020 un-weighted CPUEs increased relative to the previous year. Female catches on the Potomac were substantially higher than the last two years, with the majority caught at one site, on one day. The 2020 un-weighted CPUE for Potomac females (35) was the ninth highest value in the time-series, above the average of 26 (Table 2). The un-weighted CPUE for Potomac males (344) was higher than 2019, but still below the time-series average of 426 (Table 3).

The Upper Bay female CPUE (35) was the only decrease observed, and was below the time-series average of 43. It ranked 20th in the 36 years of the survey (Table 4). CPUE values were calculated for age 3 and 4 females in the Upper Bay, even though they were not actually captured in the survey. This resulted from using a combined ALK that contains younger female fish harvested and sampled during the late spring portion of the recreational creel survey (Project No. 2, Job No. 3, Task 5B). The youngest female encountered during the spawning stock survey in 2020 was age 5, but some of these age 5 fish fell into the length groups of the age 3 and age 4 fish sampled during the creel survey. The model then assigns CPUE to those ages, even though they were not actually encountered on the spawning grounds. The un-weighted CPUE for Upper Bay males (616) was the highest observed since 2009, and above the average of 461 (Table 5).

The abundant 2011 year-class (age 9 fish) produced the highest age-class CPUE value for female fish in the Upper Bay. The combined 15+ age group produced the largest CPUE value for females in the Potomac, mainly from the above average 2003 year-class (age 17 fish). Age 5 males from the 2015 year-class were very 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 2020 selectivity-corrected, total, weighted CPUE (546) ranked 11th in the 36 year survey, above the time-series average of 494.

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 2020 age-specific CPUEs were all below 0.10 indicating a small variance in CPUE. Historically, 83% of the CV values were less than 0.10 and 91% were less than 0.25 (Table 11). CV values greater than 1.0 were limited to older age-classes sampled during and immediately following the moratorium. The increased variability was likely attributed to small sample sizes associated with those older age-classes when the population size was low.

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

For the third consecutive year, the above-average 2015 year-class was the most prevalent cohort in the spawning stock this year, composing 33% of the total CPUE, followed by the 2017 year-class at 20%. Males were most frequently encountered, composing 94% of the total CPUE. This was due to the large contribution of the 2017 and 2015 year-class males.

The 2015 year-class made the largest contribution to the male CPUE in the Potomac River at 35%, followed by the 2017 year-class at 26%. In the Upper Bay, the 2015 year-class contributed 35% to the male CPUE and the 2017 year-class contributed 20%. Older males were encountered infrequently, although the 2011 year-class did contribute 7% to the Upper Bay male CPUE. In the Potomac, 88% of the male CPUE was made up of fish ages 5 and younger, while in the Upper Bay, that number was 80%.

Historically, the female contribution has been less than 10% to each system's CPUE. The female contribution to the Upper Bay CPUE was 5%, and 9% to the Potomac CPUE. Female CPUEs were distributed across many year-classes in the Upper Bay, with 9 year-old female fish from the 2011 year-class contributing the most to its female CPUE (37%). This is higher than their contribution last year, as more are recruiting to the spawning stock. Five age 5 females were sampled on the Upper Bay, contributing 12% to that system's female CPUE. Females from the age 15+ group, comprised mainly of 17 year old fish from the 2003 year-class contributed 9% in the Upper Bay and 40% to the female Potomac CPUE.

Temperature and catch patterns

The survey began approximately two weeks later than normal, on April 14, and surface water temperature on the Potomac River was already at the 14°C mark necessary to initiate spawning (Fay et al., 1983). Daily surface water temperatures were fairly stable through the entire survey period. Water temperature was 16°C when the survey ended on May 16. Female CPUEs were very low through the entire survey (Figure 2) with the exception of April 28. The largest peaks in male CPUE were observed during the end of April. Another peak was observed at the end of the first week of May as water temperatures rose slightly.

Upper Bay surface water temperatures fluctuated throughout the survey and likely contributed to a delayed or protracted spawn. The survey began at 14°C and decreased to a low of 11°C on April 28. Temperatures came back up to 14°C in the first week of May, dropped to 12°C by the second week, and increased to 16°C by the survey's end. Females were encountered during most of the survey, with peak catches on April 22, May 5 and May 12 (Figure 3). Male CPUE peaked in May, with the highest catches occurring as the water warmed during the first week and again in the third week.

Length composition of the stock

In 2020, a total of 1,990 striped bass was measured. On the Potomac River, 350 male and 42 female striped bass were measured, with 35 of those females sampled on April 28; and 1,531 males and 67 females were measured from the Upper Bay (Figure 4). The mean length of female striped bass (985 ± 30 mm TL) was significantly larger than the mean length of male striped bass (479 ± 5 mm TL, $P < 0.0001$), consistent with the known biology of the species. Mean lengths are presented with 2 standard errors.

The mean length of male striped bass collected from the Potomac River (470 ± 10 mm TL) was statistically similar to that sampled in the Upper Bay (481 ± 6 mm TL, $P < 0.0542$). Male striped bass on the Potomac ranged from 272 to 1030 mm TL. Males between 470 and 530 mm TL composed 43% of the Potomac River male catch in 2020, representing fish primarily from the above average 2015 year-class (Figure 4). The influence of these young fish was evident in the uncorrected CPUE peak in Figure 5. Younger age 2 and 3 males were also visible in the selectivity-corrected peaks between 290 mm TL and 390 mm TL (Figure 5).

Male striped bass on the Upper Bay ranged from 251 to 1118 mm TL. The peak in the length frequency between 450-530 mm TL (47% of catch; Figure 4) likely represents males from the 2015 year-class. Coinciding peaks in Upper Bay male selectivity-corrected and uncorrected CPUEs representing the 2015 year-class were also evident in Figure 5. There were also smaller males present in great numbers on the spawning grounds, as shown by the largest peak in selectivity-corrected CPUE at 290 mm TL (Figure 5).

Mean length of female striped bass sampled from the Potomac River (1062 ± 34 mm TL) in 2020 was significantly greater than in the Upper Bay (937 ± 40 mm TL; $P<0.0001$). This size difference was also observed in 2019. Female striped bass on the Potomac ranged from 609 to 1246 mm TL, while females sampled in the Upper Bay ranged from 468 to 1157 mm TL (Figure 4). Several small females were encountered on the Upper Bay from the 2015 year-class. The largest Potomac females (≥1110 mm TL) likely represent the 2003 year-class. Females sampled in the 950 to 1010 mm TL groups show the influx of the 2011 year-class (Figure 4).

Female CPUE in the Potomac River was generally present in larger length groups with the exception of the 610 mm TL group (Figure 6). In the Upper Bay, female CPUEs covered a wide range of length groups (Figure 6). Application of the selectivity model to the data corrected the catch upward in cases where few fish were captured in meshes that had a low selectivity for their size.

Length at age (LAA)

Based on previous investigations which indicated no influence of area on mean LAA, samples from the Potomac River, Upper Bay and the spring recreational creel sampling (Project 2, Job 3, Task 5B) were again combined in 2020 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 at age 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, as they are encountered much less frequently on the spawning grounds. A one-way analysis of variance (ANOVA) was performed, where possible, to determine differences in mean LAA by sex, between areas (Upper Bay and Potomac). Few differences between sample areas were detected in LAA for either sex in 2020 (α >0.05). All female lengths-at-age were similar between the two areas. Age 2 male fish were significantly longer on the Potomac River (333 mm TL) than the Upper Bay (297 mm TL, P=0.0159). Age 6 males were significantly shorter on the Potomac River (549 mm TL) than the Upper Bay (623 mm TL, P=0.0081).

Mean lengths-at-age were compared between years for each sex, areas combined (ANOVA, α=0.05). Male and female LAAs have been relatively stable since the mid-1990s (Figures 7 and 8). Mean lengths of males were similar in 2019 and 2020 for all ages. Mean lengths of females were similar in 2019 and 2020 for all ages except age 7 (P=0.0179), age 9 (P=0.0186), age 11 (P=0.0014) and age 15 (P=0.0202). Age 7 females in 2019 (640 mm TL) were significantly shorter than age 7 fish in 2020 (914 mm TL), however only one age 7 fish was sampled in 2020. Age 9 fish were from the 2011 year-class in 2020 (968 mm TL) and were significantly longer than age 9 fish in 2019 (894 mm TL). Age 11 and age 15 females were significantly longer in 2020 than those ages in 2019.

Age composition of the stock

Seventeen age-classes, ranging from 2 to 19 were encountered (Tables 14 and 15). Of the 269 male fish aged from the survey (Table 1), ages 5 and 9 (2015 and 2011 year-classes) were the most commonly encountered. On the Potomac River, the males encountered ranged from age

2 through 11, while on the Upper Bay, males ages 2 through 15 were captured. Females ranged in age from 6 to 19 on the Potomac River, and 5 to 17 on the Upper Bay. Of the 106 aged female scales (Table 1), age 9 females from the dominant 2011 year-class were most commonly observed, followed by age 11 females from the 2009 year-class.

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 2019, seven of the fourteen age-specific CPUEs decreased in 2020. The contribution of the 15+ age group has been strong for the past 11 years, driven by older females (Figure 9).

The contribution of age 8+ females to the total female CPUE decreased in 2020 to 82% (Figure 10). The decrease may be driven by the appearance of 2015 year-class (age 5 in 2020) females to the spawning stock. The contribution of females age 8 and older to the spawning stock was at or above 80% for most years during the period of 1996-2015, but was below the time-series average (72%) for 2016 - 2018.

The percentage of the overall sample (males and females combined) age 8 and older has been variable since 1997 (Figure 11). The 2020 value of 15% was a slight decrease from last year, and approximately equal to 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). The lower proportions of age 8+ fish in recent years were due to the high number of young fish (from the 2017, 2015 and 2014 year-classes) encountered on the spawning grounds.

The Chesapeake Bay estimates of female ISP, expressed as biomass, have been calculated for the two largest spawning areas in Maryland's portion of the Bay. Maryland's estimates are more variable than the female spawning stock biomass (SSB) estimates produced in the coastwide stock assessment. Coastal estimates have shown a slow decline over the past decade (ASMFC 2019). Maryland's Chesapeake Bay estimates showed an increase from 2011 to 2015, before declining in recent years. The MD DNR estimates of ISP generated from the Upper Bay have been variable, but were very high for the period of 2012 to 2015. The 2020 ISP value of 271 was well below the high values of that previous period, and below the time-series average of 351 (Table 16, Figure 12). The 2020 Potomac River female ISP of 425 was the highest value since 2006 and well above the time series average of 230. This is likely due to the large catch of female fish on April 28, which does not often occur while sampling on the Potomac River.

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

CHARACTERIZATION OF STRIPED BASS SPAWNING STOCKS IN MARYLAND

2021 PRELIMINARY RESULTS

Data collected during the 2021 spring spawning season are currently being analyzed. In the Potomac River in 2021, sampling was conducted from March 30 to May 8 for a total of 28 sample days. In the Upper Bay, sampling was conducted from April 2 to May 18 for a total of 29 sample days. Sampling was not conducted during the last two weeks of April on the Upper Bay due to COVID-19 protocols, and peak spawning activity was likely missed.

Scale samples are currently being processed and aged, therefore no CPUE estimates are available at this time. A total of 575 scales were collected for use in creating the sex-specific ALKs. In the Potomac River, a total of 283 striped bass were sampled: 258 males and 25 females. Of those 283 fish, 163 (58%) were tagged with U. S. Fish and Wildlife Service internal anchor tags. In the Upper Bay, a total of 472 striped bass were captured: 429 males and 43 females. Of the 472 fish encountered, 331 (70%) were tagged.

Male striped bass on the Potomac ranged from 292 to 949 mm TL, with a mean of 459 mm TL. Male striped bass on the Upper Bay ranged from 248 to 1102 mm TL, with a mean of 498 mmd TL. Female striped bass sampled from the Potomac ranged from 662 to 1169 mm TL, with a mean of 984 mm TL. Upper Bay female striped bass ranged from 564 to 1217 mm TL, and had a mean of 971 mm TL.

The final, complete analyses of the spring 2021 spawning stock survey data will appear in the next F-61-R-17 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 2020.

	MALES				FEMALES			
Length group (mm)	Upper Bay	Potomac River	Creel	Male Total	Upper Bay	Potomac River	Creel	Female Total
230	0	0	0	**0**	0	0	0	**0**
250	1	0	0	**1**	0	0	0	**0**
270	2	1	0	**3**	0	0	0	**0**
290	6	2	0	**8**	0	0	0	**0**
310	4	4	0	**8**	0	0	0	**0**
330	4	4	0	**8**	0	0	0	**0**
350	5	3	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**	1	0	1	**2**
490	4	4	0	**8**	0	0	1	**1**
510	5	4	0	**9**	1	0	3	**4**
530	4	4	0	**8**	0	0	3	**3**
550	4	4	0	**8**	0	0	3	**3**
570	5	5	0	**10**	2	0	4	**6**
590	5	5	0	**10**	0	0	5	**5**
610	8	2	0	**10**	0	1	3	**4**
630	10	0	0	**10**	0	0	1	**1**
650	9	1	0	**10**	3	0	1	**4**
670	7	3	0	**10**	0	0	0	**0**
690	8	2	0	**10**	2	0	0	**2**
710	11	0	1	**12**	2	0	3	**5**
730	11	0	1	**12**	0	0	1	**1**
750	5	1	0	**6**	2	0	0	**2**
770	2	0	1	**3**	0	0	1	**1**
790	2	0	2	**4**	0	0	0	**0**
810	4	1	0	**5**	0	0	0	**0**
830	6	0	1	**7**	0	0	2	**2**
850	3	0	2	**5**	0	0	0	**0**
870	2	0	0	**2**	1	0	0	**1**
890	6	0	1	**7**	0	0	1	**1**
910	5	1	0	**6**	3	0	3	**6**
930	6	0	1	**7**	2	2	4	**8**
950	2	0	0	**2**	8	1	4	**13**
970	3	0	0	**3**	5	2	3	**10**
990	1	1	0	**2**	3	4	2	**9**
1010	1	0	1	**2**	7	5	3	**15**
1030	3	1	0	**4**	4	2	3	**9**
1050	1	0	0	**1**	5	2	1	**8**
1070	2	0	0	**2**	4	2	3	**9**
1090	0	0	0	**0**	3	2	2	**7**
1110	1	0	0	**1**	2	4	1	**7**
1130	0	0	0	**0**	4	4	0	**8**
1150	0	0	0	**0**	1	3	1	**5**
1170	0	0	0	**0**	0	2	0	**2**
1190	0	0	0	**0**	0	2	0	**2**
1210	0	0	0	**0**	0	2	0	**2**
1230	0	0	0	**0**	0	0	0	**0**
1250	0	0	0	**0**	0	1	0	**1**
Total	**192**	**77**	**11**	**280**	**65**	**41**	**63**	**169**

Table 2. Estimates of selectivity-corrected age-class CPUE by year for female striped bass captured in the Potomac River during the 1985-2020 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**
Average																**26**

Table 3. Estimates of selectivity-corrected age-class CPUE by year for male striped bass captured in the Potomac River during the 1985-2020 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**
Average																**426**

Table 4. Estimates of selectivity-corrected age-class CPUE by year for female striped bass captured in the Upper Bay during the 1985-2020 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**
Average																**43**

Table 5. Estimates of selectivity-corrected age-class CPUE by year for male striped bass captured in the Upper Bay during the 1985-2020 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**
Average																**461**

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 (1985–2020) 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**
Average																**494**

Table 9. Lower confidence limits (95%) of the annual, pooled, weighted, age-specific CPUEs (1985–2020) for the Maryland Chesapeake Bay striped bass spawning stock. CPUE is reported as the number of fish captured in 1000 square yards of net per hour.

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

* 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 (1985–2020) 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	*

* 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 (1985–2020) 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	*

* 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 2020. 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
2019	1	0.0	0.0	0.0	0.0	0.0	0.0
2018	2	83.4	8.1	0.0	0.0	33.8	49.6
2017	3	210.9	20.5	0.0	1.5	88.0	121.4
2016	4	169.2	16.4	0.0	0.7	61.6	106.9
2015	5	339.3	33.0	1.1	4.0	119.9	214.2
2014	6	62.7	6.1	2.2	1.0	20.6	38.9
2013	7	17.9	1.7	1.1	0.5	4.8	11.6
2012	8	23.0	2.2	0.2	2.1	6.5	14.3
2011	9	67.5	6.6	7.3	13.0	6.0	41.2
2010	10	9.9	1.0	2.6	2.9	0.8	3.5
2009	11	8.6	0.8	2.5	2.7	0.6	2.8
2008	12	2.3	0.2	0.9	0.9	0.0	0.4
2007	13	7.2	0.7	1.1	1.1	0.6	4.5
2006	14	7.0	0.7	1.8	1.4	0.4	3.4
≤2005	15+	20.8	2.0	14.0	3.3	0.7	2.8
Total		1029.6		34.8	35.0	344.3	615.5
% of Total				3.4	3.4	33.4	59.8
% of Sex				49.9	50.1	35.9	64.1
% of System				9.2	5.4	90.8	94.6

Table 13. Striped bass catch per unit effort (CPUE) by year-class, weighted by spawning area*, April through May 2020. 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
2019	1	0.0	0.0	0.0	0.0	0.0	0.0
2018	2	43.5	8.0	0.0	0.0	13.0	30.5
2017	3	109.5	20.1	0.0	0.9	33.9	74.6
2016	4	89.8	16.5	0.0	0.4	23.7	65.7
2015	5	180.8	33.1	0.4	2.5	46.2	131.7
2014	6	33.3	6.1	0.8	0.6	7.9	23.9
2013	7	9.7	1.8	0.4	0.3	1.8	7.1
2012	8	12.6	2.3	0.1	1.3	2.5	8.8
2011	9	38.4	7.0	2.8	8.0	2.3	25.3
2010	10	5.3	1.0	1.0	1.8	0.3	2.2
2009	11	4.6	0.8	1.0	1.6	0.2	1.7
2008	12	1.2	0.2	0.4	0.5	0.0	0.3
2007	13	4.1	0.7	0.4	0.6	0.2	2.8
2006	14	3.8	0.7	0.7	0.9	0.2	2.1
≤2005	15+	9.4	1.7	5.4	2.0	0.3	1.7
Total		545.9		13.4	21.5	132.7	378.3
% of Total				2.5	3.9	24.3	69.3
% of Sex				38.5	61.5	26.0	74.0
% of System				9.2	5.4	90.8	94.6

* 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 2020.

YEAR-CLASS	AGE	AREA	N	MEAN	LCL	UCL	SD	SE
2018	2	POTOMAC	4	333	313	352	13	6
		UPPER	8	297	278	316	23	8
		COMBINED	12	309	292	325	26	7
2017	3	POTOMAC	13	333	310	357	39	11
		UPPER	20	344	321	366	49	11
		COMBINED	33	340	324	355	45	8
2016	4	POTOMAC	13	423	385	461	63	18
		UPPER	10	419	387	450	44	14
		COMBINED	23	421	398	445	55	11
2015	5	POTOMAC	22	505	476	535	67	14
		UPPER	35	524	501	547	66	11
		COMBINED	57	517	499	534	66	9
2014	6	POTOMAC	12	549	508	589	64	18
		UPPER	9	623	587	659	47	16
		COMBINED	21	581	550	611	67	15
2013	7	POTOMAC	5	625	566	684	48	21
		UPPER	16	686	643	730	82	21
		COMBINED	21	672	636	708	79	17
2012	8	POTOMAC	4	732	515	948	136	68
		UPPER	23	689	657	721	74	15
		COMBINED	27	696	662	729	84	16
2011	9	POTOMAC	2	826	*	*	*	*
		UPPER	54	809	781	838	104	14
		COMBINED	56	810	781	839	108	14
2010	10	POTOMAC	0	-	-	-	-	-
		UPPER	5	812	677	946	108	48
		COMBINED	5	812	677	946	108	48
2009	11	POTOMAC	2	916	*	*	*	*
		UPPER	3	845	557	1134	116	67
		COMBINED	5	874	723	1024	121	54
2007	13	POTOMAC	0	-	-	-	-	-
		UPPER	4	982	801	1162	113	57
		COMBINED	4	982	801	1162	113	57
2006	14	POTOMAC	0	-	-	-	-	-
		UPPER	2	1029	*	*	*	*
		COMBINED	2	1029	*	*	*	*
2005	15	POTOMAC	0	-	-	-	-	-
		UPPER	3	1059	930	1188	52	30
		COMBINED	3	1059	930	1188	52	30

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

Table 15. Mean length-at-age (mm TL) statistics for female striped bass collected in the Potomac River and the Upper Bay, and areas combined, April through May 2020.

YEAR-CLASS	AGE	AREA	N	MEAN	LCL	UCL	SD	SE
2015	5	POTOMAC	0	-	-	-	-	-
		UPPER	5	571	466	676	85	38
		COMBINED	5	571	466	676	85	38
2014	6	POTOMAC	1	609	-	-	-	-
		UPPER	3	637	495	780	57	33
		COMBINED	4	630	552	708	49	24
2013	7	POTOMAC	0	-	-	-	-	-
		UPPER	1	914	-	-	-	-
		COMBINED	1	914	-	-	-	-
2012	8	POTOMAC	0	-	-	-	-	-
		UPPER	5	765	636	893	103	46
		COMBINED	5	765	636	893	103	46
2011	9	POTOMAC	12	979	960	997	29	8
		UPPER	25	962	935	989	66	13
		COMBINED	37	968	949	986	57	9
2010	10	POTOMAC	2	1015	824	1206	21	15
		UPPER	7	1008	980	1037	31	12
		COMBINED	9	1010	989	1031	28	9
2009	11	POTOMAC	2	1077	*	*	*	*
		UPPER	9	1070	1041	1099	37	12
		COMBINED	11	1071	1041	1101	45	13
2008	12	POTOMAC	2	1097	983	1211	13	9
		UPPER	2	1040	741	1338	33	24
		COMBINED	4	1068	1006	1130	39	20
2007	13	POTOMAC	4	1089	1029	1149	38	19
		UPPER	0	-	-	-	-	-
		COMBINED	4	1089	1029	1149	38	19
2006	14	POTOMAC	4	1102	999	1205	65	32
		UPPER	3	1092	963	1221	52	30
		COMBINED	7	1098	1047	1149	55	21
2005	15	POTOMAC	4	1137	1096	1179	26	13
		UPPER	4	1093	1039	1147	34	17
		COMBINED	8	1115	1084	1146	37	13
2004	16	POTOMAC	2	1147	*	*	*	*
		UPPER	0	-	-	-	-	-
		COMBINED	2	1147	*	*	*	*
2003	17	POTOMAC	7	1149	1085	1213	69	26
		UPPER	1	1157	-	-	-	-
		COMBINED	8	1150	1096	1203	64	23
2001	19	POTOMAC	1	1211	-	-	-	-
		UPPER	0	-	-	-	-	-
		COMBINED	1	1211	-	-	-	-

* 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
Average	**351**	**230**

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

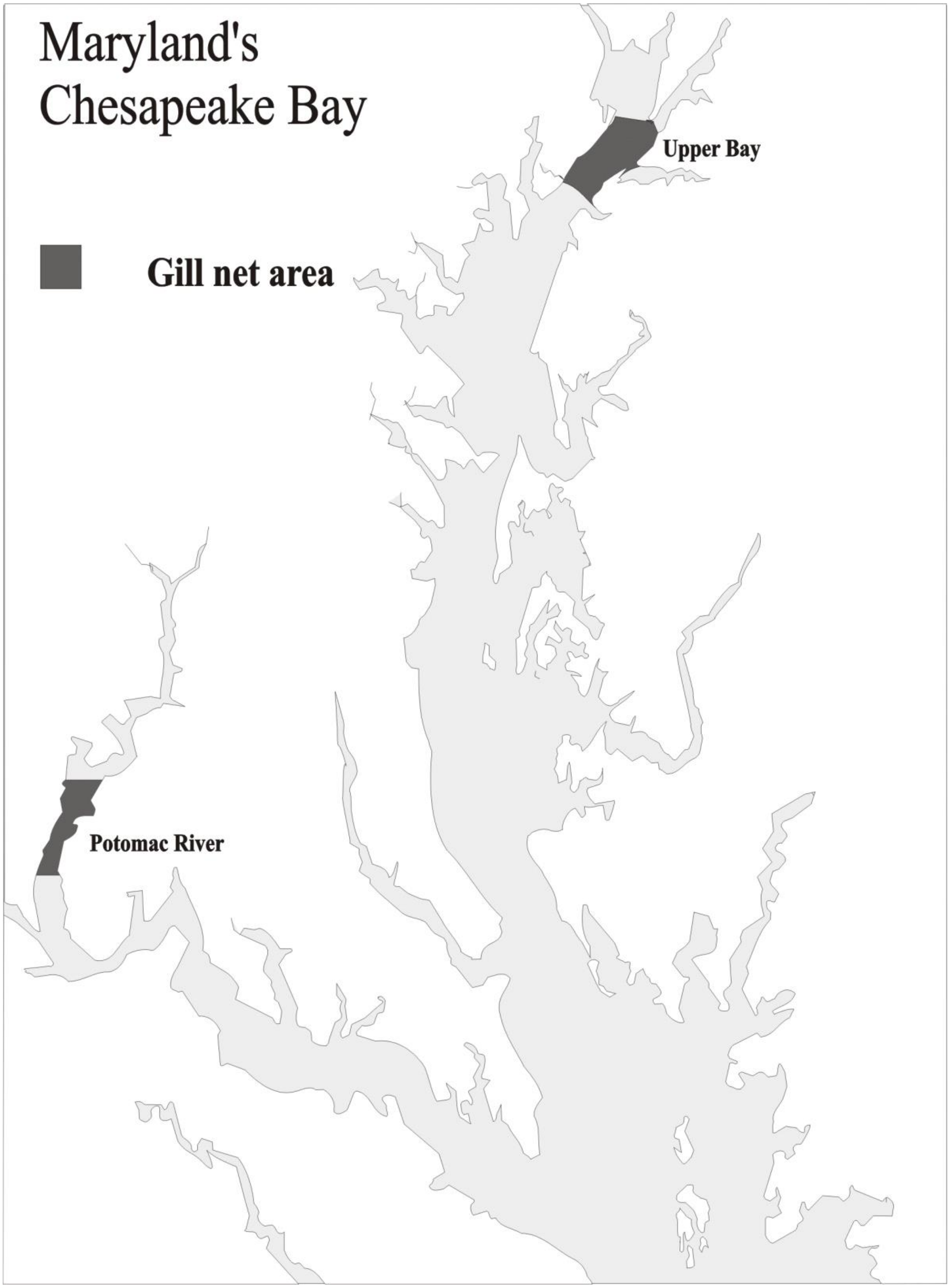


Figure 2. Daily effort-corrected catch of female and male striped bass, with surface water temperature in the spawning reach of the Potomac River, April through May 2020. Effort is standardized as 1000 square yards of experimental gill net per hour. Note different scales.

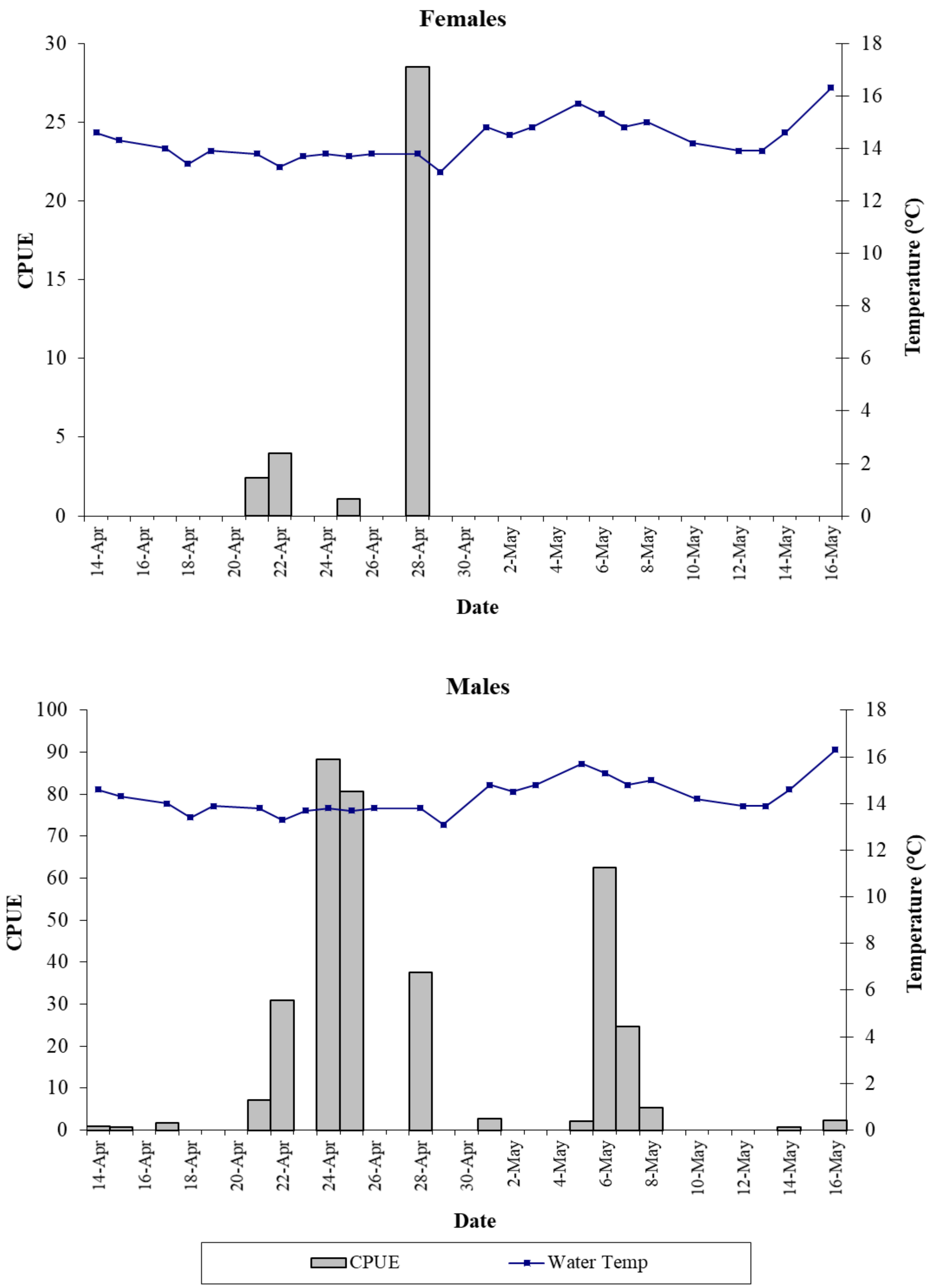


Figure 3. Daily effort-corrected catch of female and male striped bass, with surface water temperature in the spawning reach of the Upper Chesapeake Bay, April through May 2020. Effort is standardized as 1000 square yards of experimental drift gill net per hour. Note different scales.

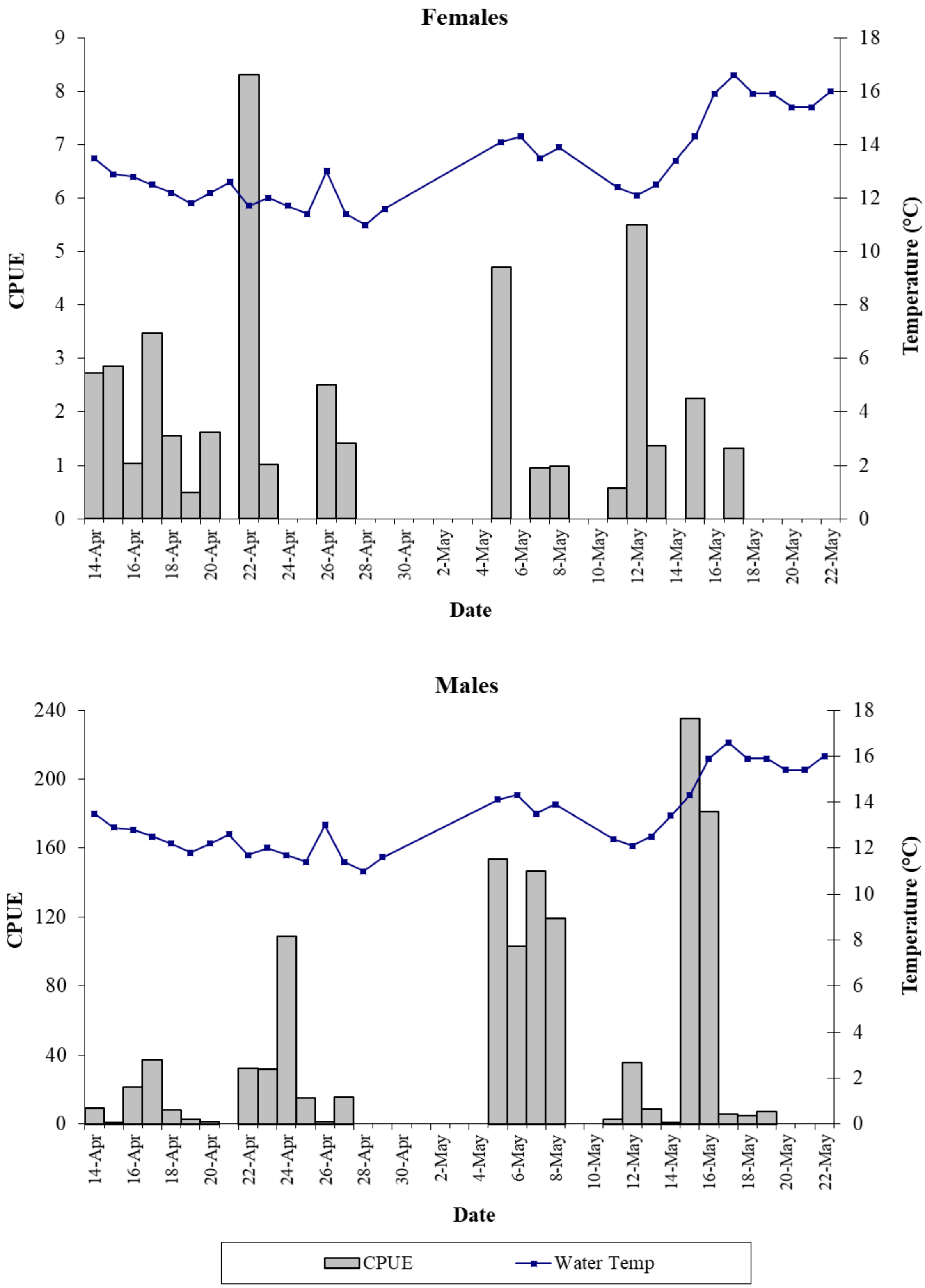
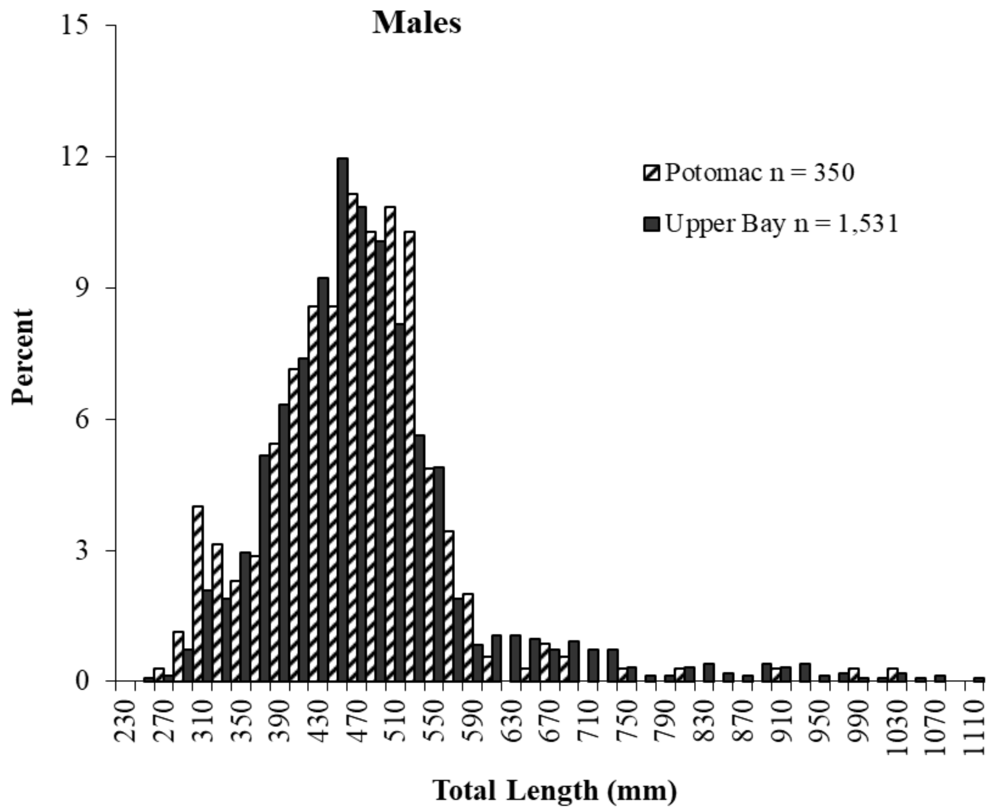


Figure 4. Length frequency of male and female striped bass from the spawning areas of the Upper Chesapeake Bay and Potomac River, April through May 2020. Note different scales.



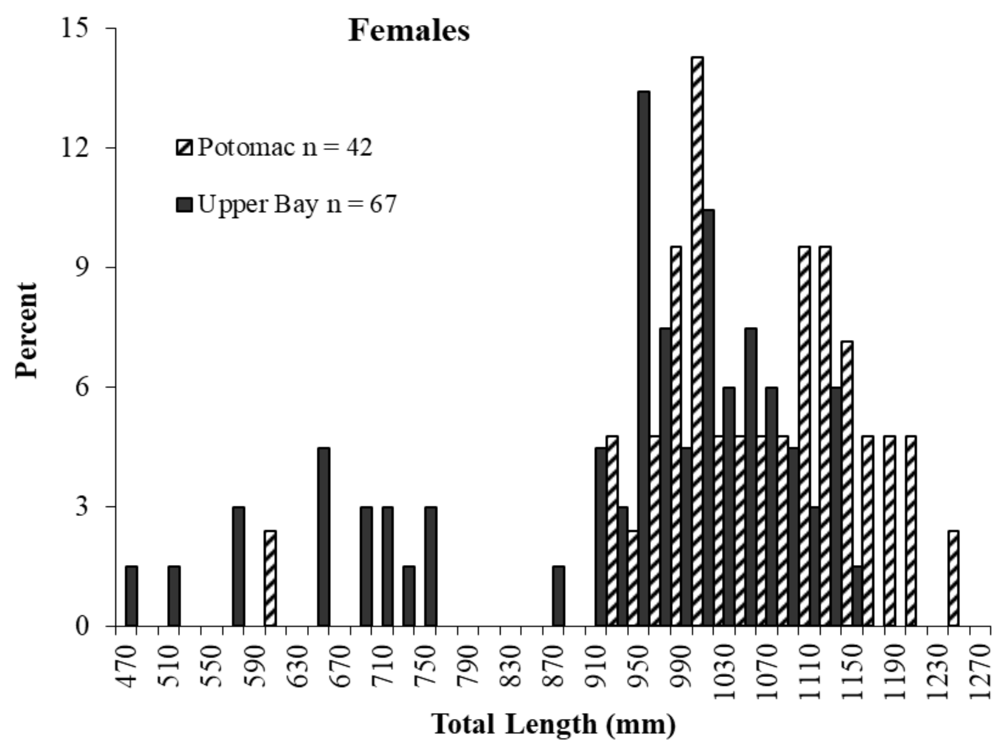
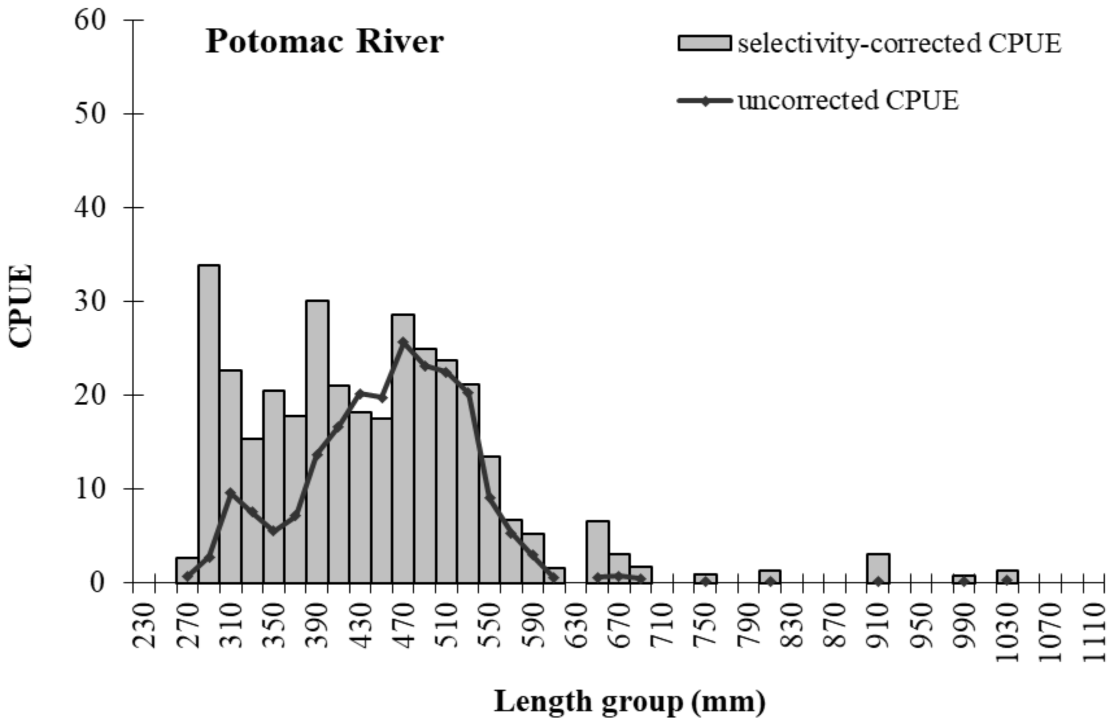


Figure 5. Length group CPUE (uncorrected and corrected for gear selectivity) of male striped bass collected from spawning areas of the Upper Bay and Potomac River, April - May 2020. CPUE is the number of fish captured per hour in 1000 square yards of experimental drift net.



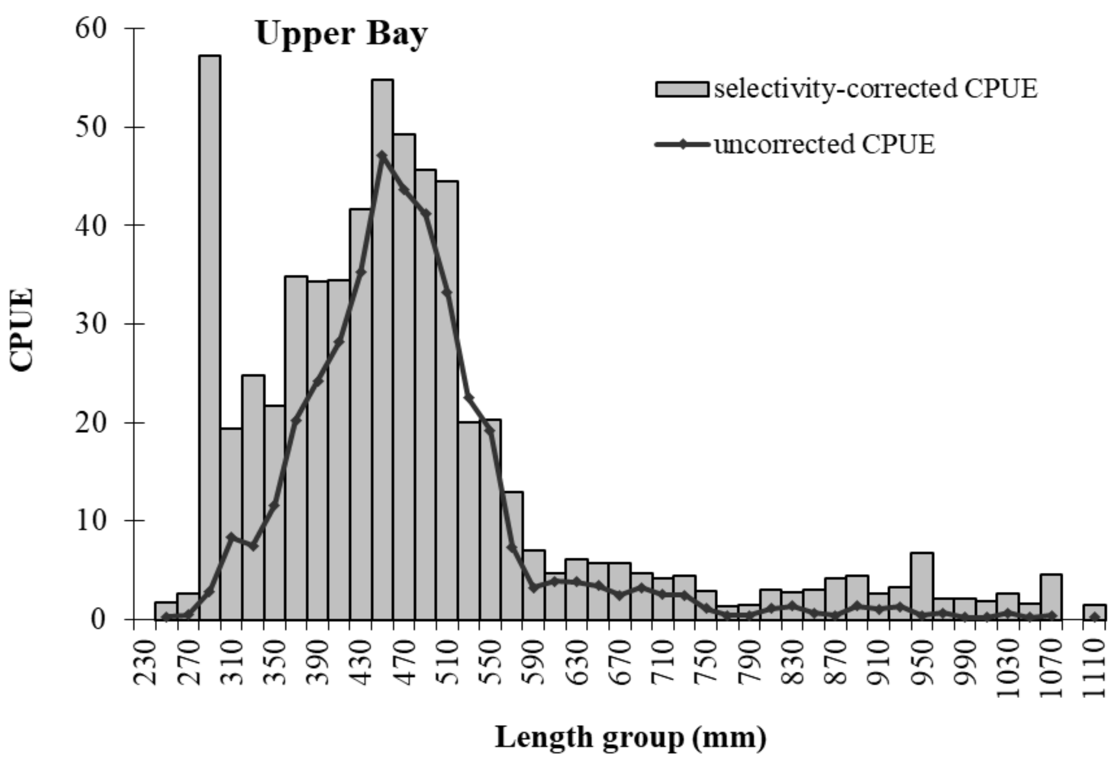
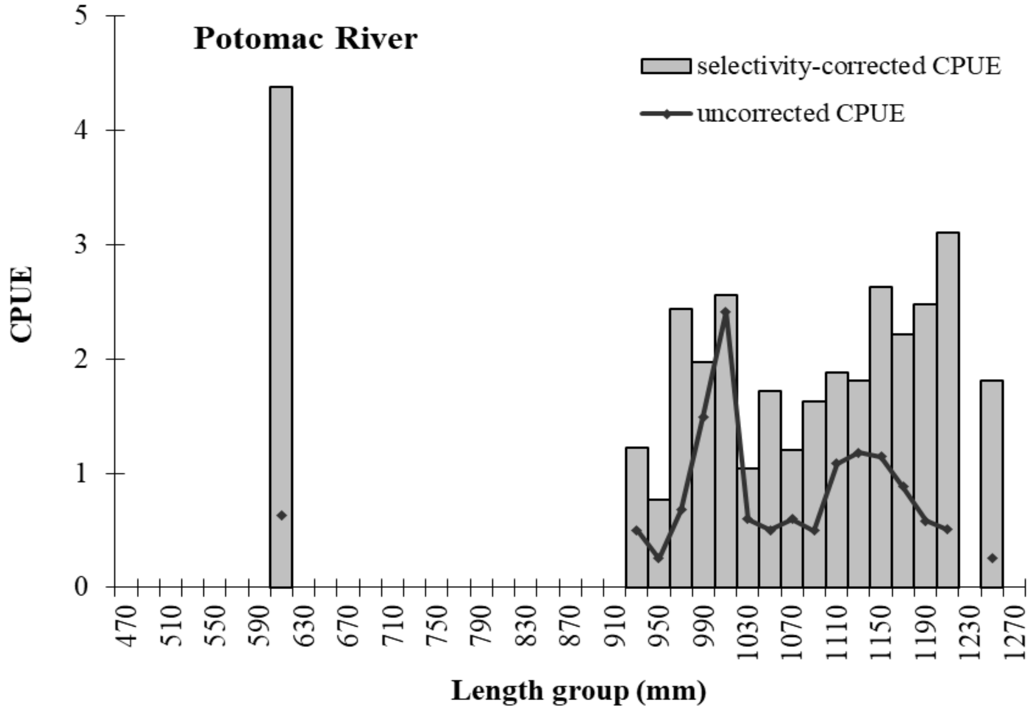


Figure 6. Length group CPUE (uncorrected and corrected for gear selectivity) of female striped bass collected from spawning areas of the Upper Bay and Potomac River, April - May 2020. CPUE is the number of fish captured per hour in 1000 square yards of experimental drift net.



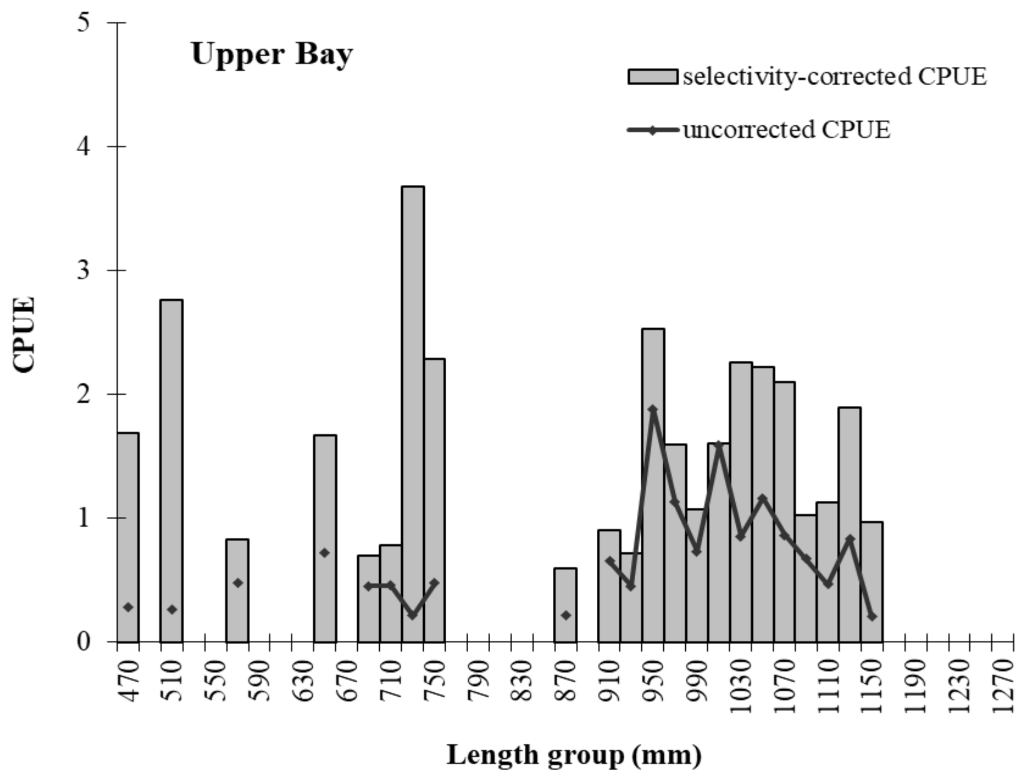


Figure 7. Mean length (mm TL) by year for individual ages of male striped bass sampled from spawning areas of the Potomac River and Upper Chesapeake Bay during March through May, 1985-2020. Error bars are ± 2 standard errors (SE). The Potomac River was not sampled in 1994. *Note difference in scales on y-axis.

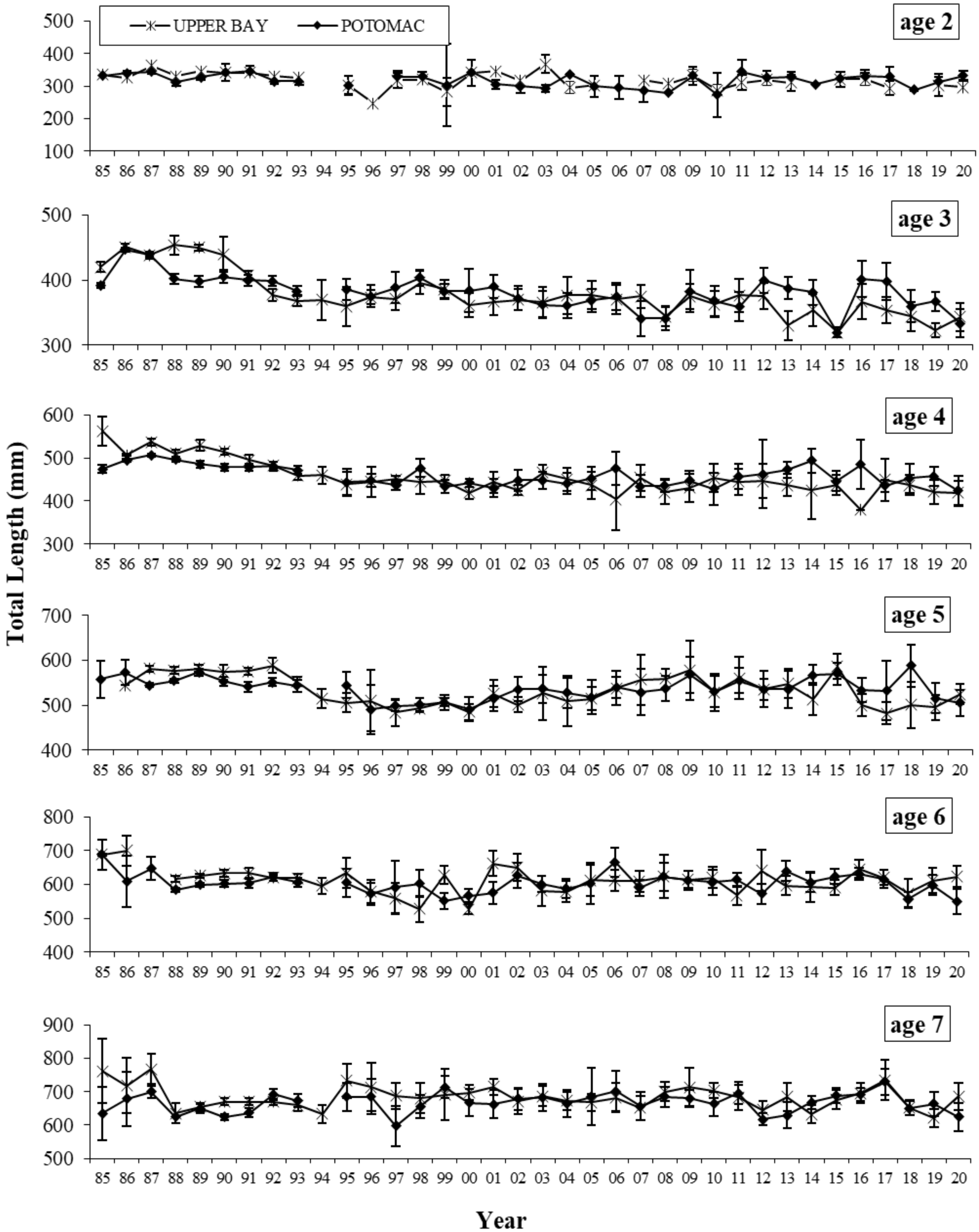


Figure 7. Continued.

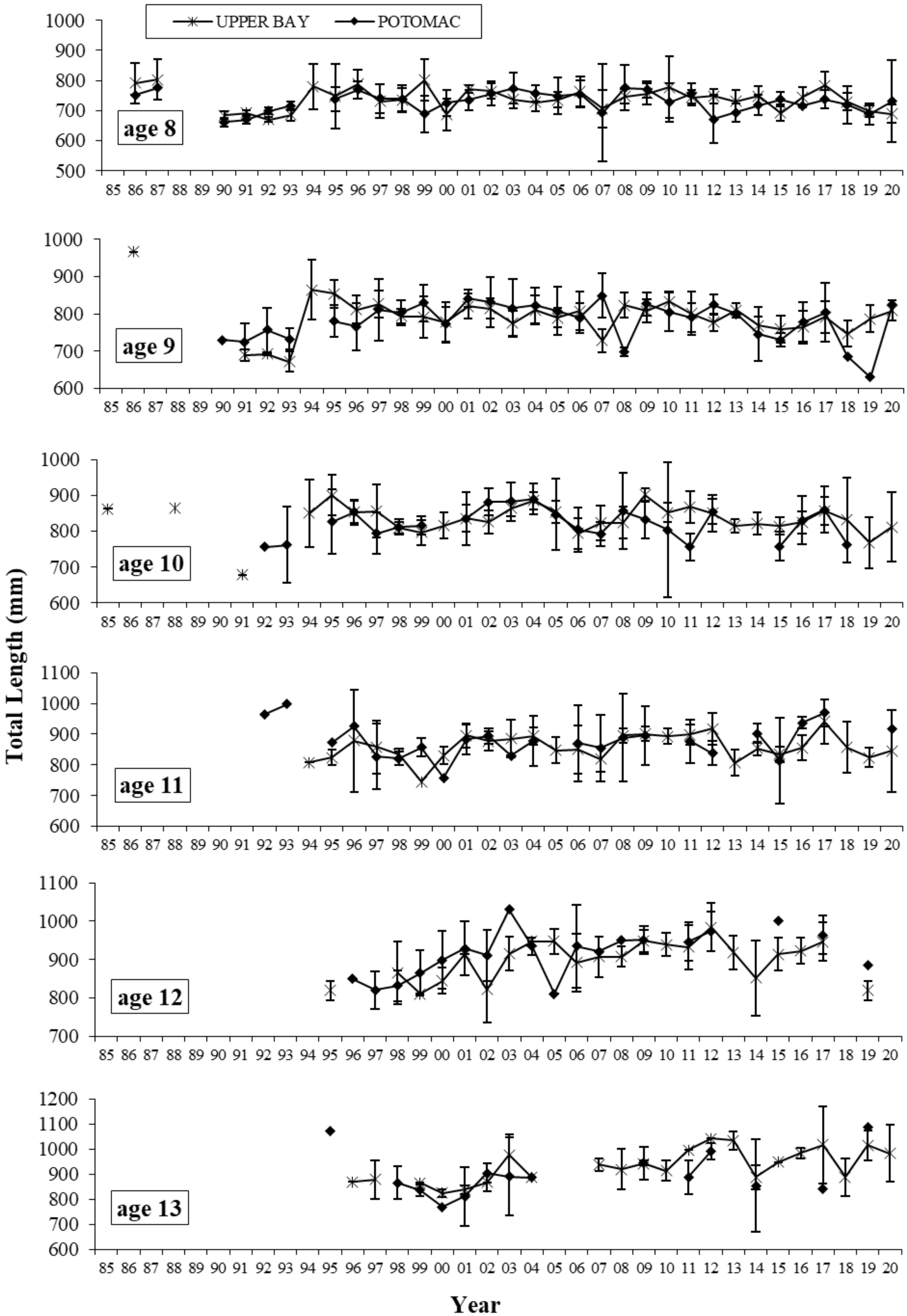


Figure 8. Mean length (mm TL) by year for individual ages of female striped bass sampled from spawning areas of the Potomac River and Upper Chesapeake Bay during March through May, 1985–2020. Error bars are ± 2 standard errors (SE). Note the Potomac River was not sampled in 1994. *Note difference in scales on y-axis.

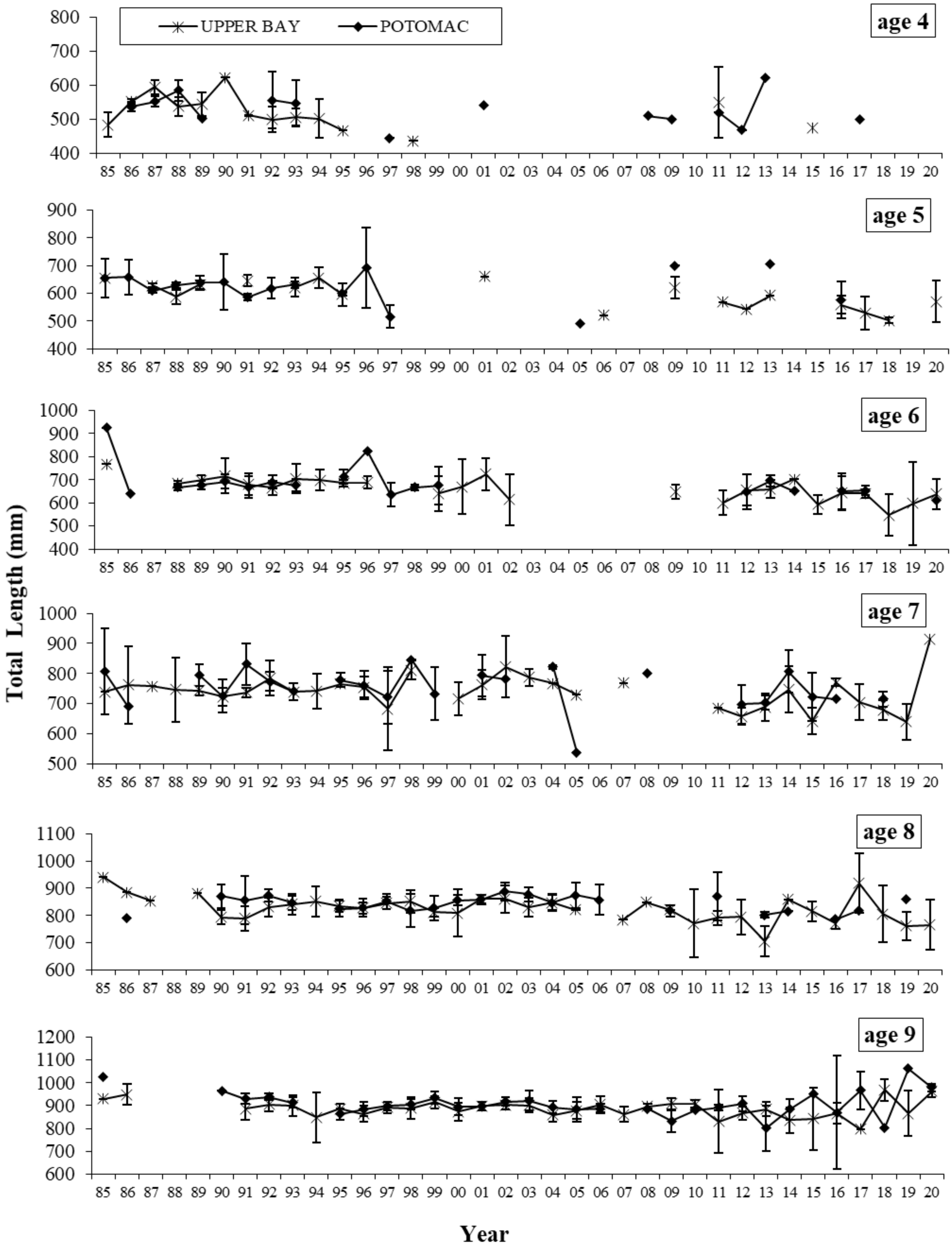


Figure 8. Continued.

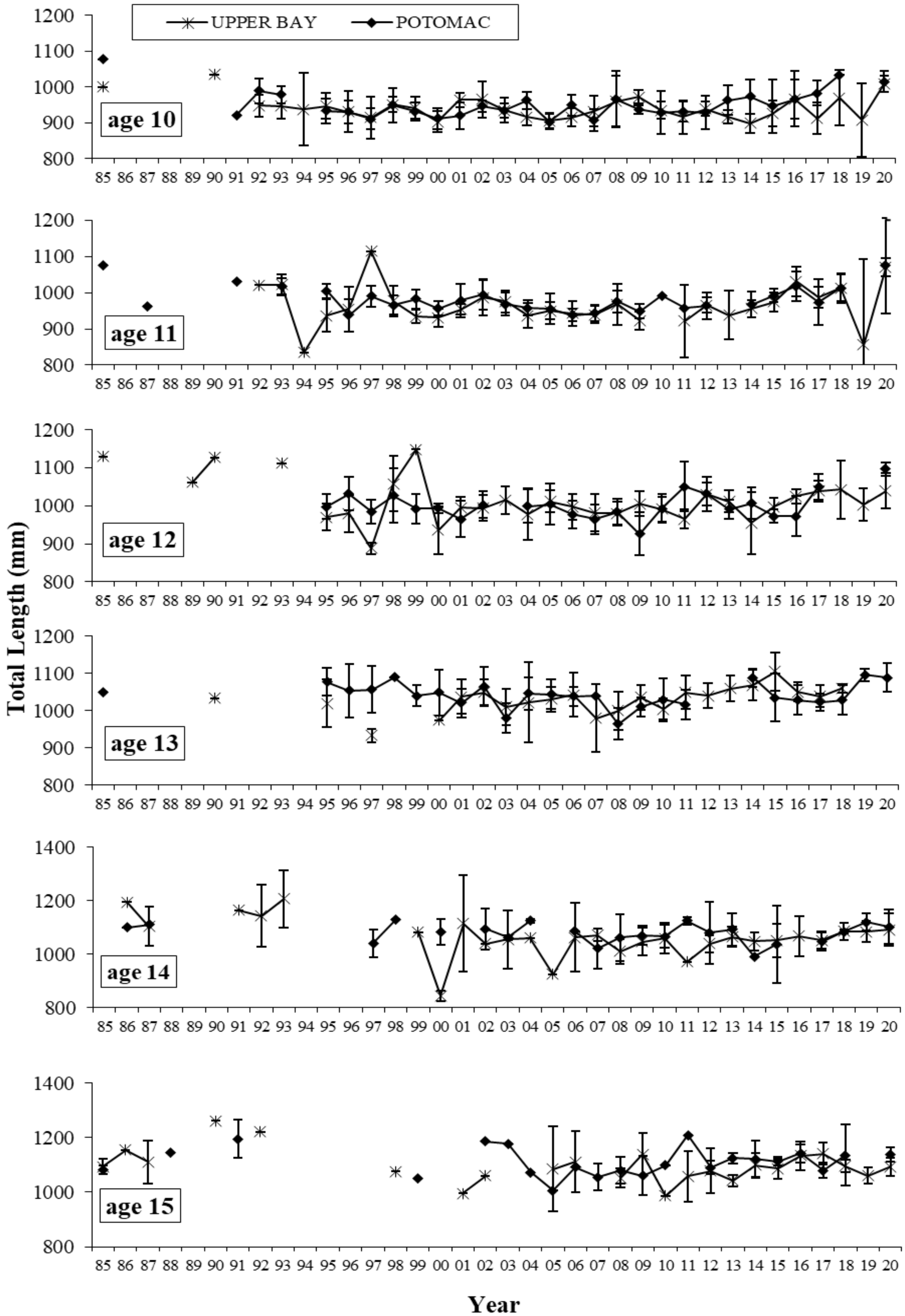


Figure 9. Maryland Chesapeake Bay spawning stock indices used in the coastal assessment. These are selectivity-corrected estimates of CPUE by year for ages 2 through 15+. Areas and sexes are pooled, although the contribution of sexes is shown in the stacked bars. Note different scales.

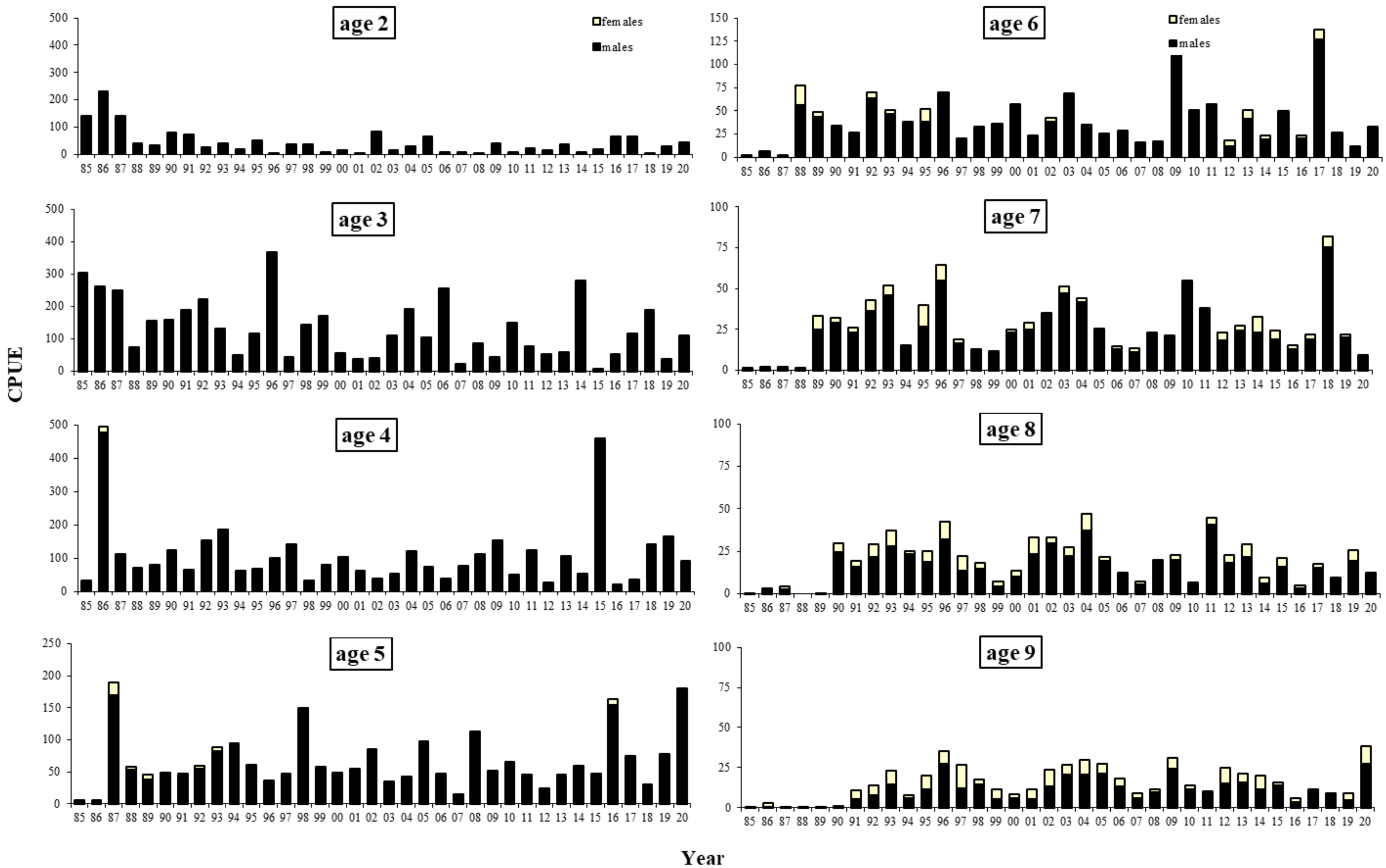


Figure 9. Continued.

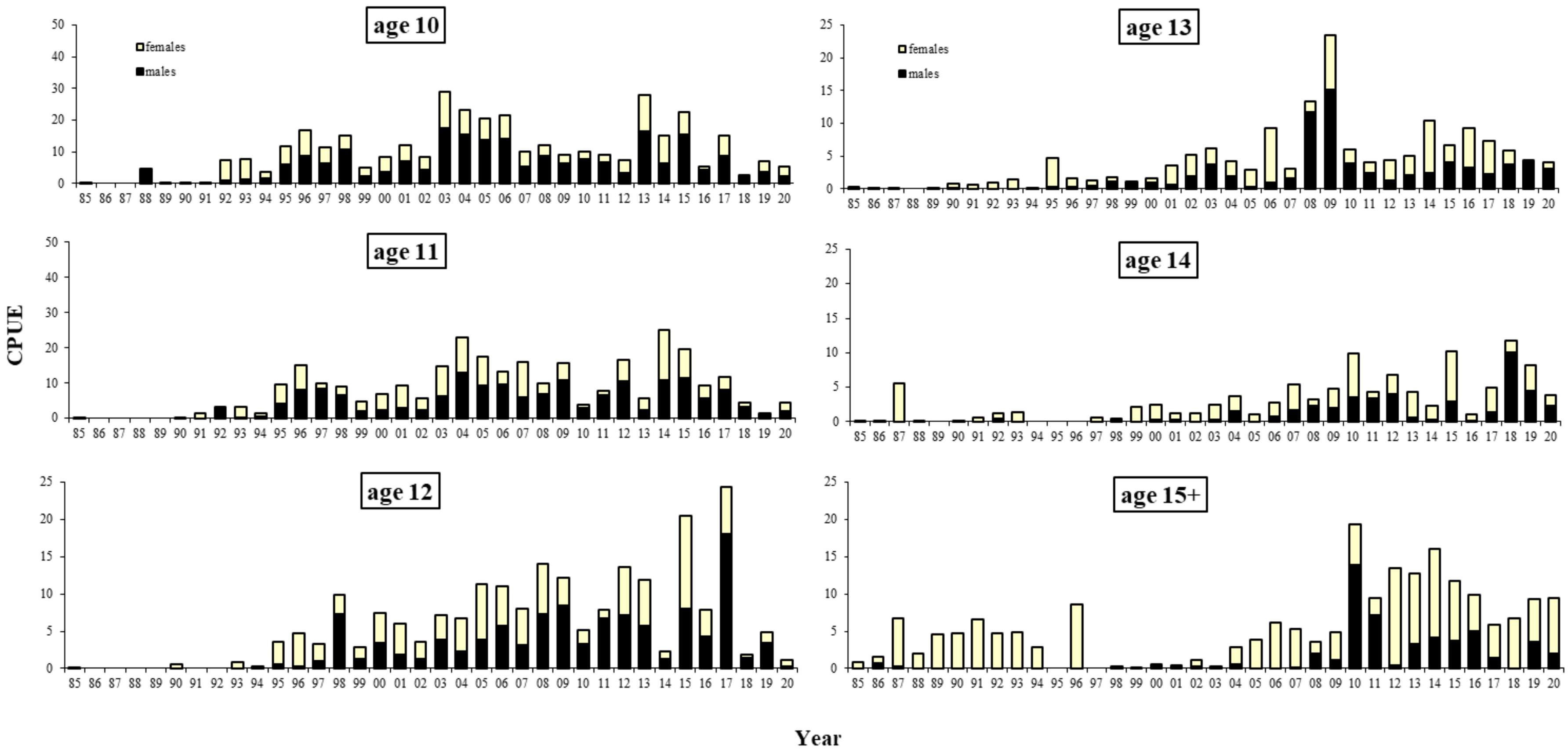
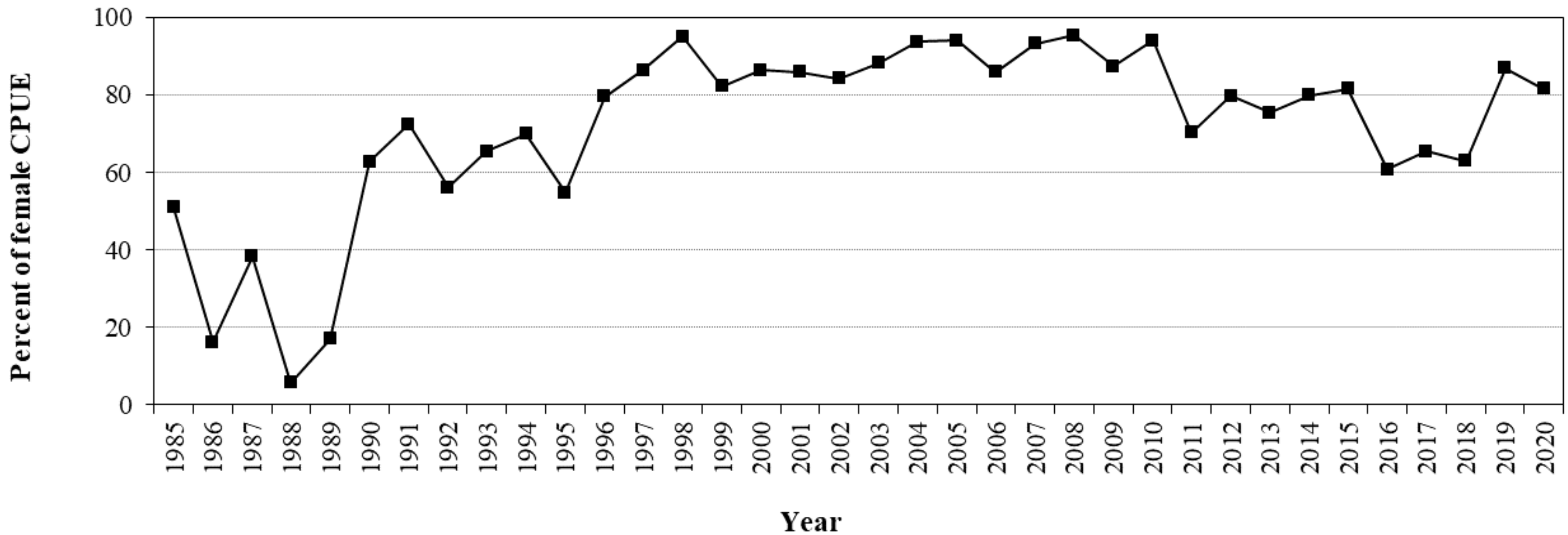
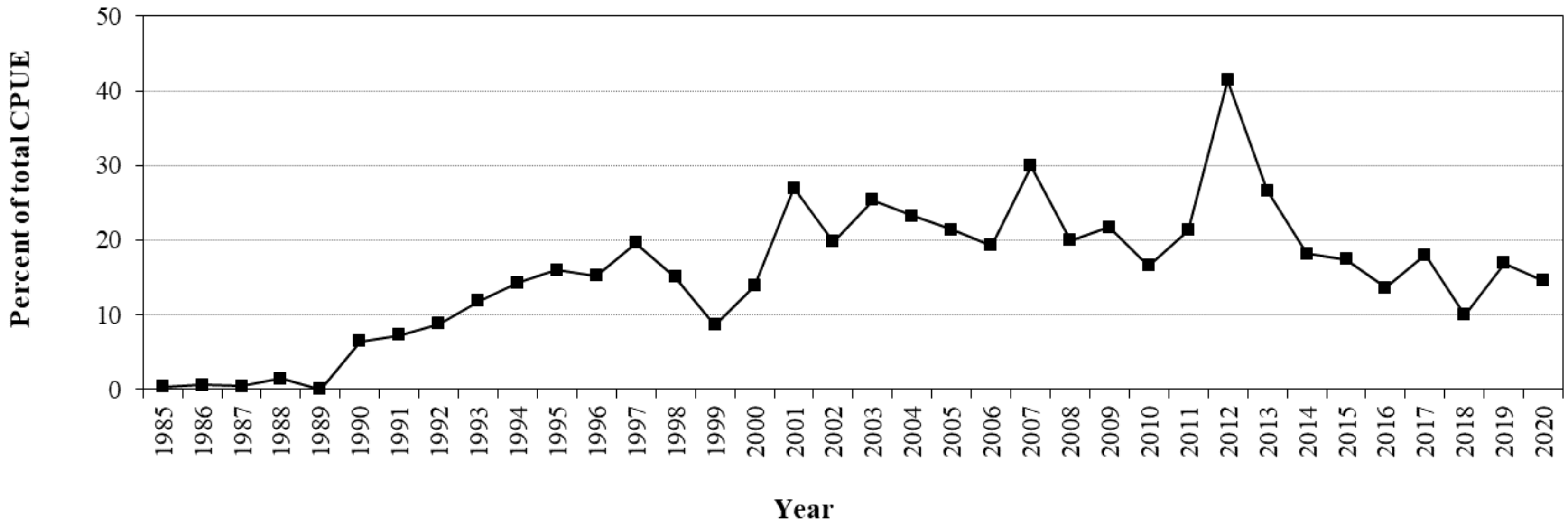


Figure 10. Percentage (selectivity-corrected CPUE) of female striped bass that were age 8 and older sampled from experimental drift gill nets set in spawning reaches of the Potomac River, Choptank River and the Upper Chesapeake Bay, March through May, 1985-2020 (Choptank River to 1996). Effort is standardized 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.



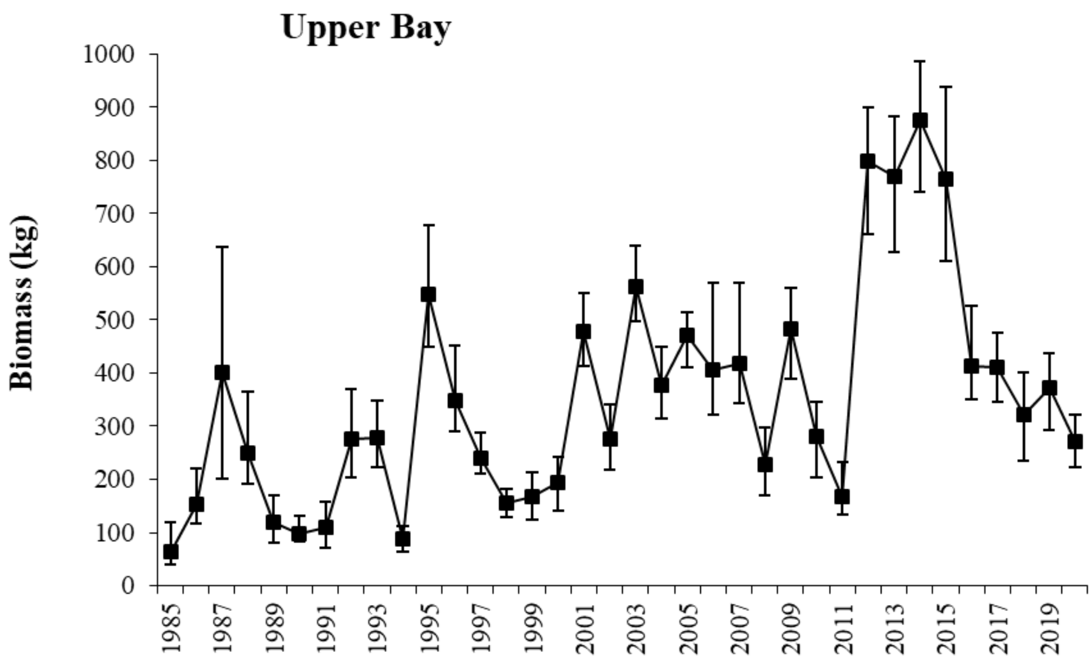
* Weights for spawning areas (1985 - 1996): Upper Bay=0.59; Potomac River=0.37; Choptank River=0.04.
(1997 - Present): Upper Bay=0.615; Potomac River=0.385. (Hollis 1967).

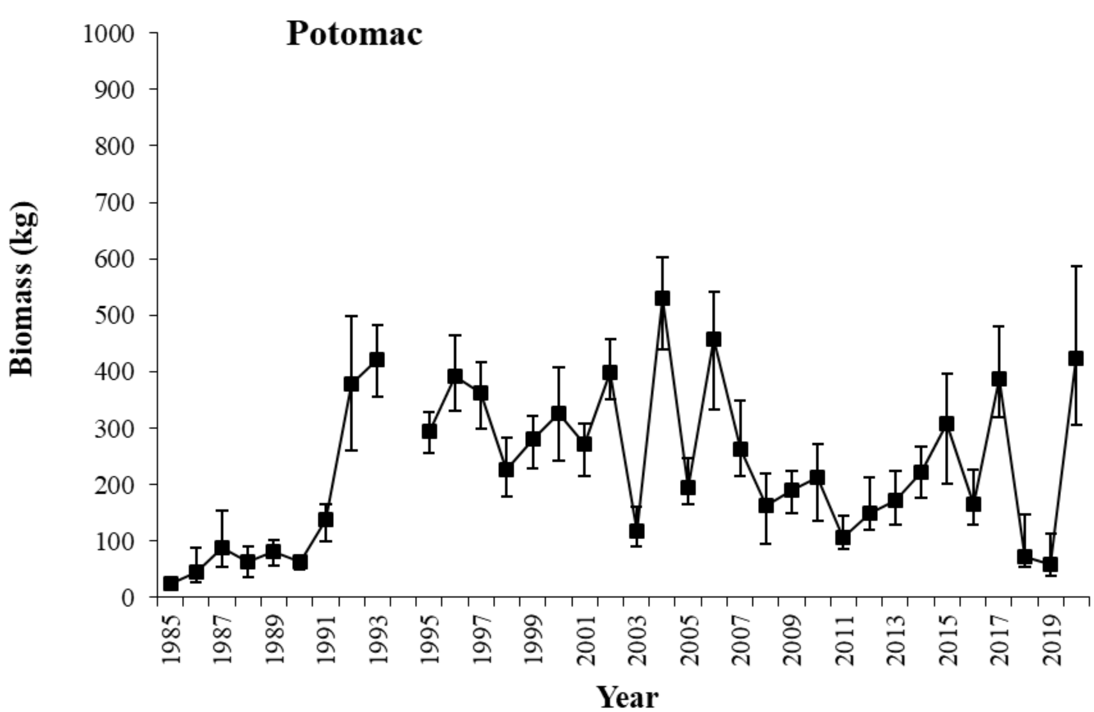
Figure 11. Percentage (selectivity-corrected CPUE) of male and female striped bass age 8 and over sampled from experimental drift gill nets set in spawning reaches of the Potomac River, Choptank River and the Upper Chesapeake Bay, March through May, 1985-2020 (Choptank River to 1996). Effort is standardized 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, 1985-2020. 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.

Construction of the new Governor Harry Nice Memorial Bridge across the Potomac River forced a change to the Aqualand Marina site (#163). Access to the marina property will be prohibited for at least 5 years, so a new site was established at Lower Cedar Point (#171) just 1.5 miles downstream. The auxiliary site on the Susquehanna Flats at Tyding’s Estate (#144) could not be sampled due to thick submerged aquatic vegetation and matted algae. Since no suitable replacements are available the Tyding's Estate site will be revisited in the future.

From 1954 to 1961, Maryland's juvenile survey included inconsistent stations and rounds. Sample sizes ranged from 34 to 46. Indices derived for this period include only stations which are consistent with subsequent years. In 1962, stations were standardized and a second sample round was added for a total of 88 samples. A third sample round, added in 1966, increased sample size to 132.

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

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

Sample Protocol

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

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

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

Estimators

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

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

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

Comparison of these three indices is one method of assessing their accuracy. Similar trends among indices create more certainty that indices reflect actual changes in juvenile abundance. Greatly diverging trends may identify error in one or more of the indices.

Bay-wide annual indices are compared to the target period average (TPA). The TPA is the average of indices from 1959 through 1972. These years have been suggested as a period of stable biomass and general stock health (ASMFC 1989) and "an appropriate stock rebuilding target" (Gibson 1993). The TPA provides a fixed reference representing an average index produced by a healthy population. A fixed reference is an advantage over a time-series average that is revised annually and may be significantly biased by long-term trends in annual indices.

Differences among annual means were tested with an analysis of variance (GLM; SAS 1990) on the $\log_e(x+1)$ transformed data. Means were considered significant at the α=0.05 level. Duncan's multiple range test was used to differentiate means.

RESULTS

Bay-wide Means

A total of 327 YOY striped bass was collected at permanent stations in 2020, with individual samples yielding between 0 and 42 fish. The AM (2.5) and GM (1.12) were both below their respective time-series averages and TPAs (Tables 2 and 3, Figures 2 and 3). The PPHL was 0.54, indicating that 54% 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 2020 log_e-mean was significantly smaller than 41 years of the time-series.

System Means

Head of Bay - In 42 samples, 147 juveniles were collected at the Head of Bay sites for an AM of 3.5, less than the time-series average (11.7) and the TPA (17.3) (Table 2, Figure 5). The GM of 1.95 was also less than the time-series average (5.74) 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 2020 Head of Bay log_e-mean greater than just four year-classes of the time-series.

Potomac River - A total of 126 juveniles was collected in 42 samples on the Potomac River. The AM of 3.0 was lower than both the time-series average (8.0) and TPA (9.2) (Table 2, Figure 5). The GM of 1.05 was also below the time-series average (3.51) 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 2020 Potomac River year-class significantly smaller than 30 years of the time-series.

Choptank River - A total of 4 juveniles was collected in 24 Choptank River samples. The AM of 0.2 was below the time-series average of 20.4 and the TPA (10.8) (Table 2, Figure 5). The GM of 0.11 was less than its time-series average (7.84) 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 2020 Choptank River year-class significantly smaller than 47 years of the time-series.

Nanticoke River - A total of 50 juveniles was collected in 24 samples on the Nanticoke River. The AM of 2.1 was below the time-series average (8.8) and the TPA (8.6) (Table 2, Figure 5). The GM of 1.41 was below its time-series average (4.03) 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 2020 index significantly less than 18 years of the time-series.

Auxiliary Indices

At the **Head of Bay auxiliary sites**, 72 juveniles were caught in 12 samples, resulting in an AM of 6.0, and a GM of 2.97. The AM was above the time-series average, and the GM was slightly below its time-series average (Table 5).

On the **Patuxent River**, 9 YOY striped bass were caught in 18 samples. The AM of 0.5 and GM of 0.30 were both less than their respective time-averages (Table 5).

DISCUSSION

Striped bass recruitment in Maryland's portion of Chesapeake Bay was poor in 2020 for the second consecutive year. Unlike 2019, however, the 2020 GM of 1.12 meets the definition of recruitment failure specified by Addendum II to Amendment 6 of the Interstate Fishery Management

Plan (ASMFC 2010). Recruitment failure in Maryland's portion of the Chesapeake Bay is defined as a GM index below 75% of the values from 1959 to 2009, or a GM less than 1.6. Addendum II goes on to describe how three consecutive years of recruitment failure as measured by juvenile indices will trigger conservation actions under the authority of ASMFC.

Recruitment in individual systems is often variable, but was consistently poor in 2020. Based on the percentile ranking of each system's GM, the Nanticoke performed best of all areas surveyed, with a GM ranked in the 34th percentile. The Choptank River GM ranked in the 3rd percentile of its time-series, making it the worst performing system surveyed.

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 58% of the variability (r^2 =0.58, $p \leq 0.001$) in the age 1 indices (Figure 10). The equation that best described this relationship was: C_1=(0.177)(C_0)- 0.0597, 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 (0.20) was greater than the predicted index of 0.13. Examination of residuals (Figure 11) shows that this regression equation can be often be used to predict subsequent yearling striped bass abundance with reasonable certainty in the case of average sized year-classes but predictions are less reliable with large or small year-classes. Lower than expected abundance of age 1 striped bass may be an indication of density-dependent processes operating at high levels of abundance, such as cannibalism, increased competition for food, increased spatial distribution, or overwintering mortality. Higher than expected abundance of age 1 striped bass may identify particularly good conditions that enhanced survival.

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LIST OF TABLES

LIST OF FIGURES

Table 1. Maryland juvenile striped bass survey sample sites.

Site Number	River or Creek	Area or Nearest Landmark
	HEAD OF CHESAPEAKE BAY SYSTEM	
* 168	Susquehanna Flats	North side Fishing Battery Light Island
* 130	Susquehanna Flats	North side of Plum Point
* 144	Susquehanna Flats	Tyding's Estate, west shore of flats
* 59	Northeast River	Carpenter Point, old K.O.A. Campground beach
3	Northeast River	Elk Neck State Park beach
31	Elk River	Oldfield Point
5	Elk River	Hyland Point Light
115	Bohemia River	Parlor Point
160	Sassafras River	Sassafras N.R.M.A., opposite Ordinary Point
10	Sassafras River	Howell Point, 500 yards east of point
164	Worton Creek	Handy Point, 0.3 miles west of Green Point Wharf
* 88	Chesapeake Bay	Beach at Tolchester Yacht Club
	POTOMAC RIVER SYSTEM	
139	Potomac River	Hallowing Point, VA
50	Potomac River	Indian Head, old boat basin
51	Potomac River	Liverpool Point, south side of pier
52	Potomac River	Blossom Point, mouth of Nanjemoy Creek
171	Potomac River	Lower Cedar Point
55	Wicomico River	Rock Point
56	Potomac River	St. George Island, south end of bridge

* Indicates auxiliary seining site

Table 1. Continued.

Site Number	River or Creek	Area or Nearest Landmark
		CHOPTANK RIVER SYSTEM
2	Tuckahoe Creek	Northeast side near mouth
148	Choptank River	North side of Jamaica Point
161	Choptank River	Dickinson Bay, 0.5 miles from Howell Point
29	Choptank River	Castle Haven, northeast side
		NANTICOKE RIVER SYSTEM
36	Nanticoke River	Sharptown, pulpwood pier
166	Nanticoke River	Opposite Red Channel Marker #26
38	Nanticoke River	Opposite Chapter Point, above light #15
39	Nanticoke River	Tyaskin Beach
		PATUXENT RIVER SYSTEM
* 85	Patuxent River	Selby Landing
* 86	Patuxent River	Nottingham, Windsor Farm
* 91	Patuxent River	Milltown Landing
* 92	Patuxent River	Eagle Harbor
* 106	Patuxent River	Sheridan Point
* 170	Patuxent River	Grammers Cove

* Indicates auxiliary seining site

Table 2. Maryland juvenile striped bass survey arithmetic mean (AM) catch per haul at permanent sites.

Year	Head of Bay	Potomac River	Choptank River	Nanticoke River	Bay-wide
1954	0.9	5.2	1.2	25.1	5.2
1955	4.4	5.7	12.5	5.9	5.5
1956	33.9	6.2	9.8	8.2	15.2
1957	5.4	2.5	2.1	1.3	2.9
1958	28.2	8.4	19.5	22.5	19.3
1959	1.9	1.6	0.1	1.8	1.4
1960	9.3	4.3	9.0	4.7	7.1
1961	22.1	25.8	6.0	1.5	17.0
1962	11.4	19.7	6.1	6.6	12.2
1963	6.1	1.1	5.4	4.1	4.0
1964	31.0	29.1	10.6	13.3	23.5
1965	2.2	3.4	9.5	21.6	7.4
1966	32.3	10.5	13.6	3.3	16.7
1967	17.4	1.9	5.3	4.1	7.8
1968	13.1	0.7	6.3	9.0	7.2
1969	26.6	0.2	4.8	6.2	10.5
1970	33.1	20.1	57.2	17.1	30.4
1971	23.7	8.5	6.3	2.0	11.8
1972	12.1	1.9	11.0	25.0	11.0
1973	24.5	2.1	1.3	1.1	8.9
1974	19.9	1.5	15.3	3.9	10.1
1975	7.6	7.8	4.7	5.2	6.7
1976	9.9	3.2	2.4	1.7	4.9
1977	12.1	1.9	1.2	1.0	4.8
1978	12.5	7.9	6.0	4.8	8.5
1979	8.3	2.2	2.8	0.9	4.0
1980	2.3	2.2	1.0	1.8	2.0
1981	0.3	1.4	1.3	2.4	1.2
1982	5.5	10.0	13.0	6.2	8.4
1983	1.2	2.0	0.9	1.0	1.4
1984	6.1	4.7	2.8	1.5	4.2
1985	0.3	5.6	3.7	2.1	2.9
1986	1.6	9.9	0.5	2.2	4.1
1987	1.3	6.4	12.1	2.5	4.8
1988	7.3	0.4	0.7	0.4	2.7
1989	19.4	2.2	97.8	2.9	25.2
1990	3.8	0.6	3.1	0.9	2.1
1991	3.9	2.5	12.2	1.1	4.4

Table 2. Continued.

Year	Head of Bay	Potomac River	Choptank River	Nanticoke River	Bay-wide
1992	1.3	22.1	4.3	4.3	9.0
1993	23.0	36.4	105.5	9.3	39.8
1994	23.4	3.9	19.3	21.5	16.1
1995	4.4	8.7	17.7	10.4	9.3
1996	25.0	48.5	154.4	43.7	59.4
1997	8.3	10.6	7.3	3.5	8.0
1998	8.3	10.8	32.6	3.8	12.7
1999	3.1	15.7	48.2	18.7	18.1
2000	13.3	7.8	21.2	17.6	13.8
2001	13.4	7.8	201.9	40.1	50.8
2002	3.1	7.0	0.7	7.8	4.7
2003	28.4	23.6	41.8	8.7	25.8
2004	7.8	4.0	22.8	19.5	11.4
2005	13.2	10.3	55.2	1.5	17.8
2006	1.5	6.7	5.8	3.2	4.3
2007	20.2	4.9	14.3	15.4	13.4
2008	5.9	3.3	0.5	1.0	3.2
2009	6.8	7.8	11.3	6.5	7.9
2010	7.3	5.7	3.3	4.6	5.6
2011	10.3	12.8	125.7	24.3	34.6
2012	0.7	1.7	0.1	0.6	0.9
2013	4.9	7.0	4.8	6.1	5.8
2014	15.2	2.3	12.5	17.3	11.0
2015	9.9	11.3	43.0	53.0	24.2
2016	2.0	3.7	1.1	0.9	2.2
2017	26.5	8.5	6.8	4.4	13.2
2018	24.2	5.5	20.3	8.9	14.8
2019	3.9	2.5	3.1	4.3	3.4
2020	3.5	3.0	0.2	2.1	2.5
Average	11.7	8.0	20.4	8.8	11.5
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
Average	5.74	3.51	7.84	4.03	4.25
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
Average	11.7	205.1	1.45	91.44	0.71	0.64	0.79	
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
Average	20.9	5.79		5.9	3.00	
Median	4.1	2.08		4.3	2.16	

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	N/A

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

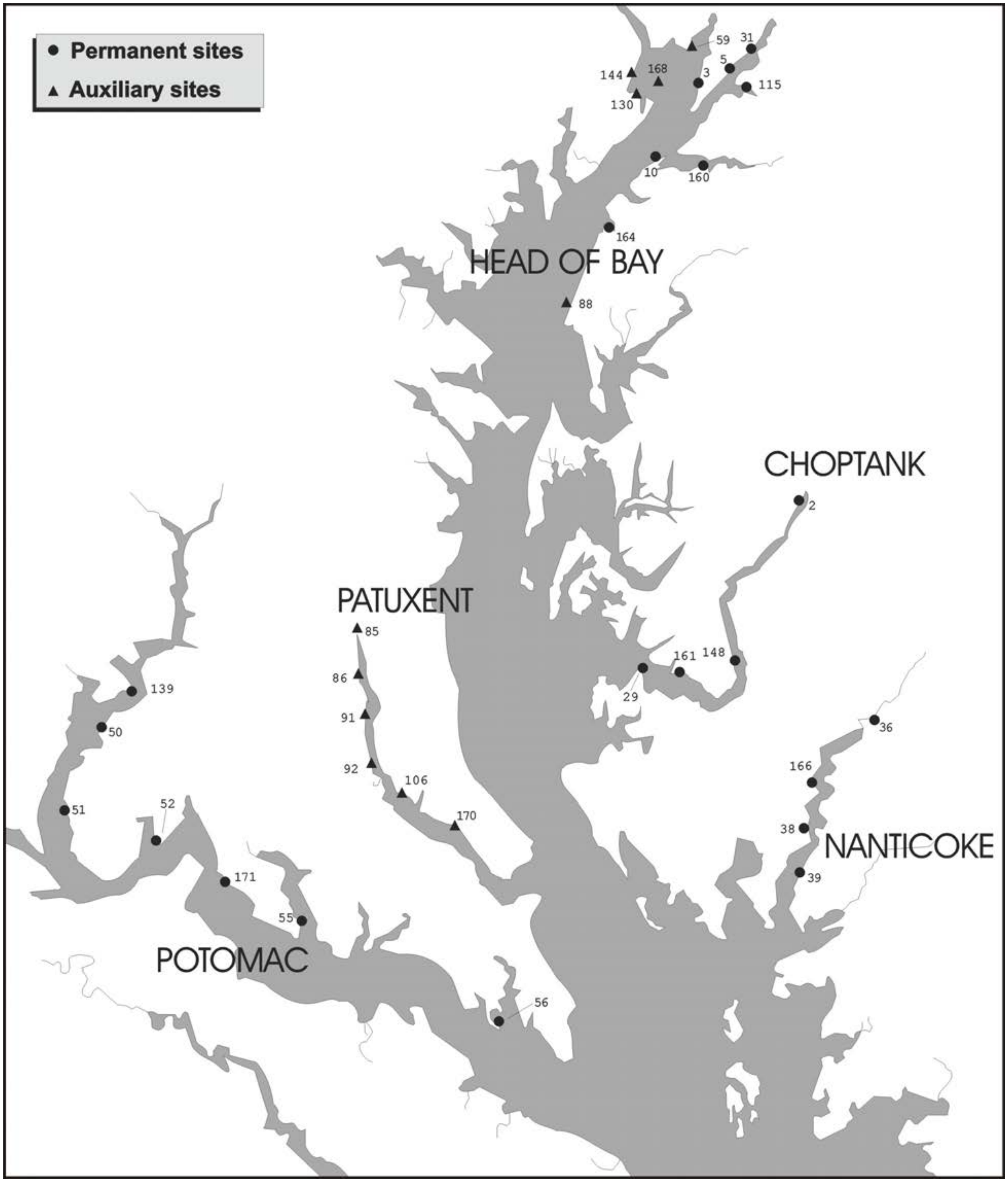


Figure 2. Maryland Chesapeake Bay arithmetic mean (AM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

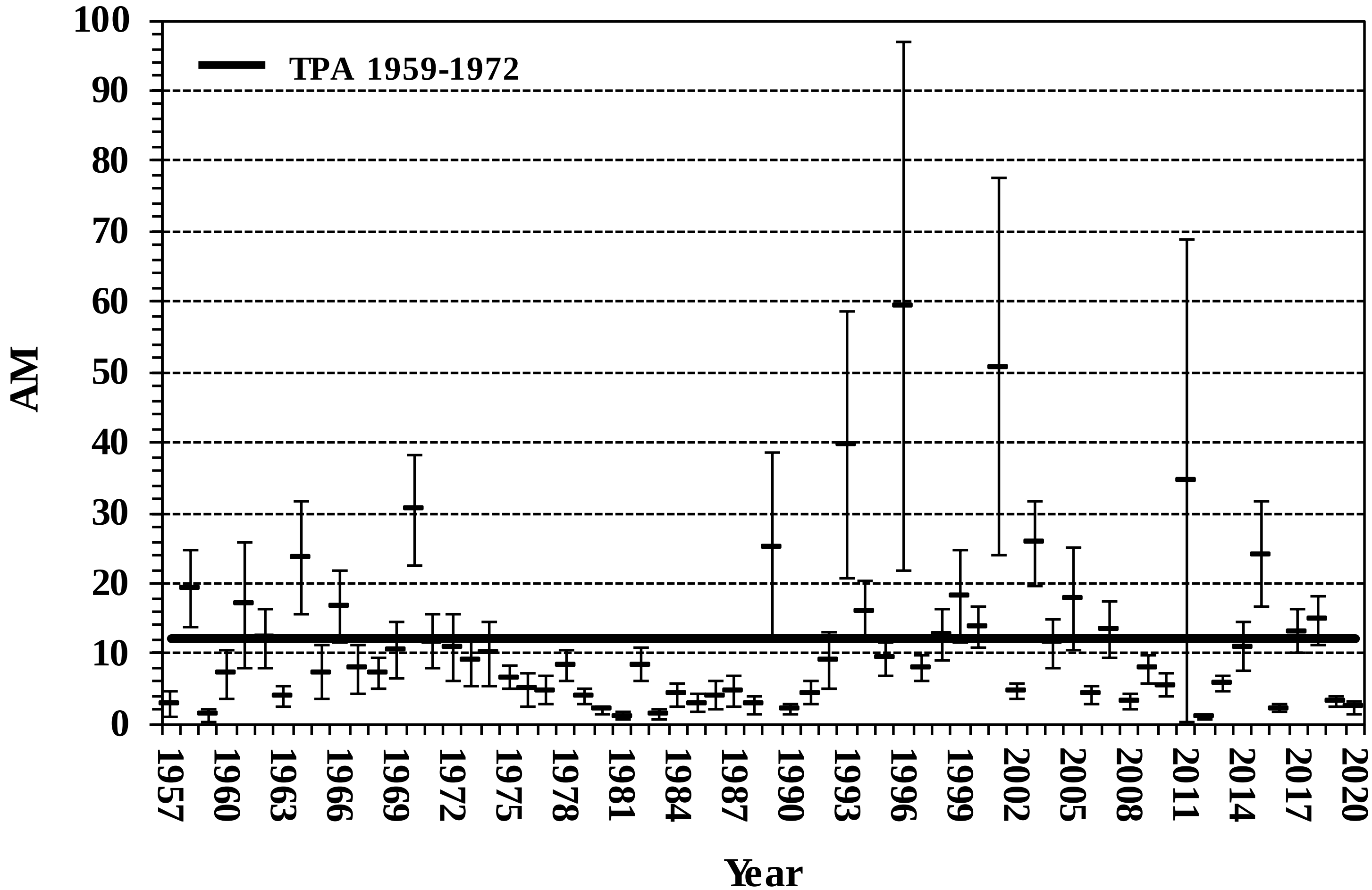


Figure 3. Maryland Chesapeake Bay geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

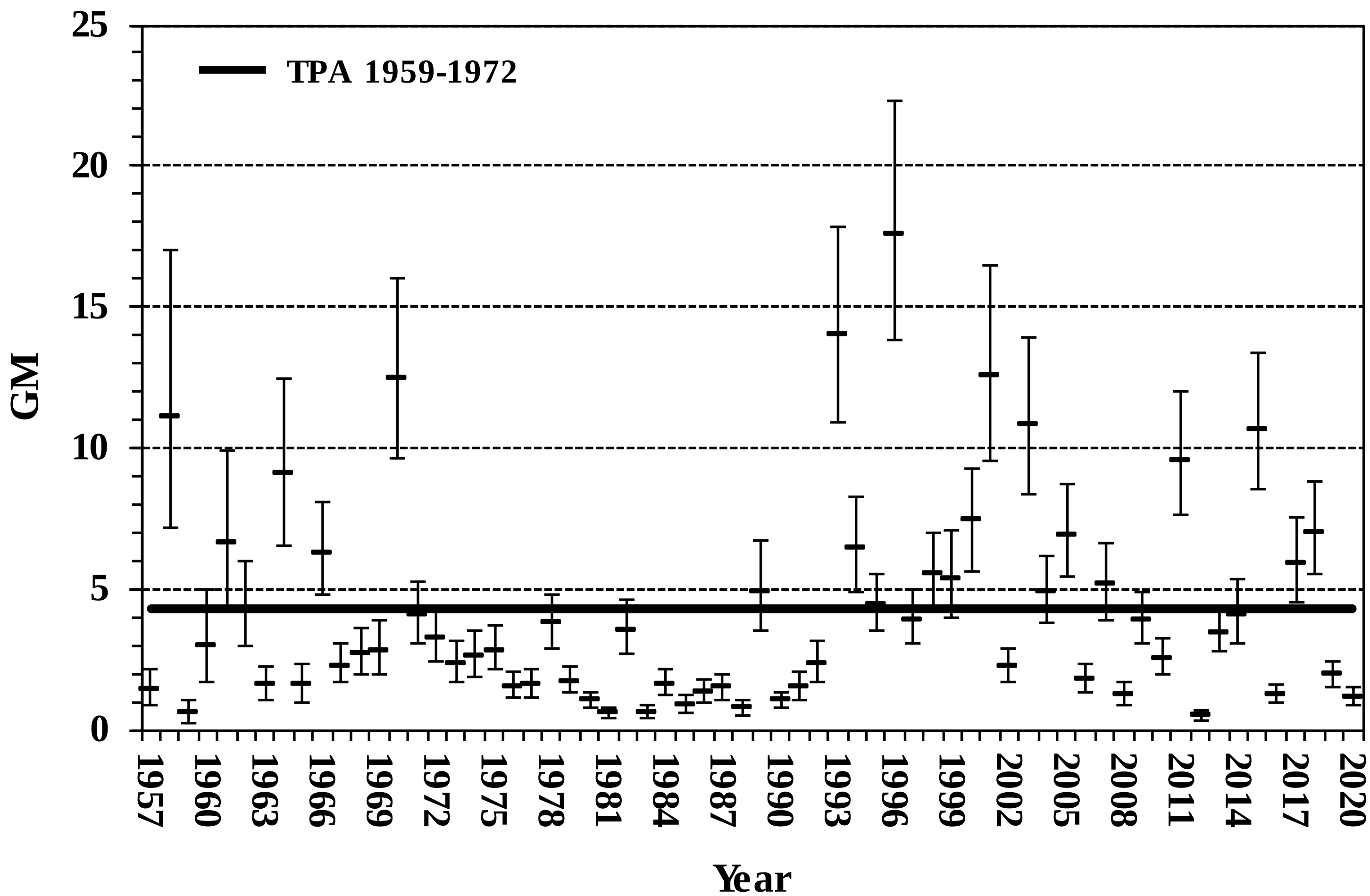


Figure 4. Maryland Chesapeake Bay juvenile striped bass indices. Arithmetic mean (AM), scaled geometric mean (GM)*, and proportion of positive hauls (PPHL) as percent.

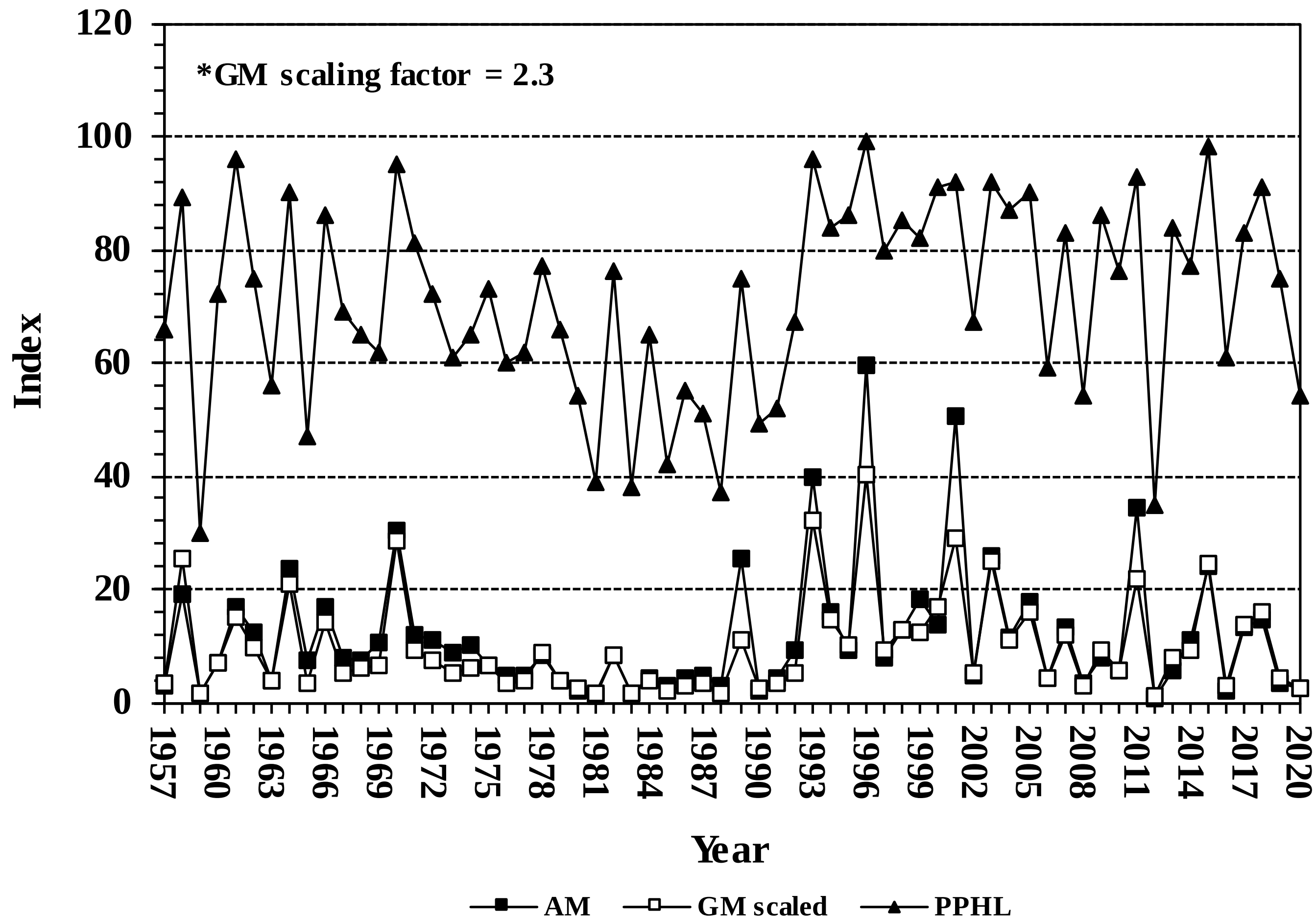


Figure 5. Arithmetic mean (AM) catch per haul by system for juvenile striped bass. Note different scales.

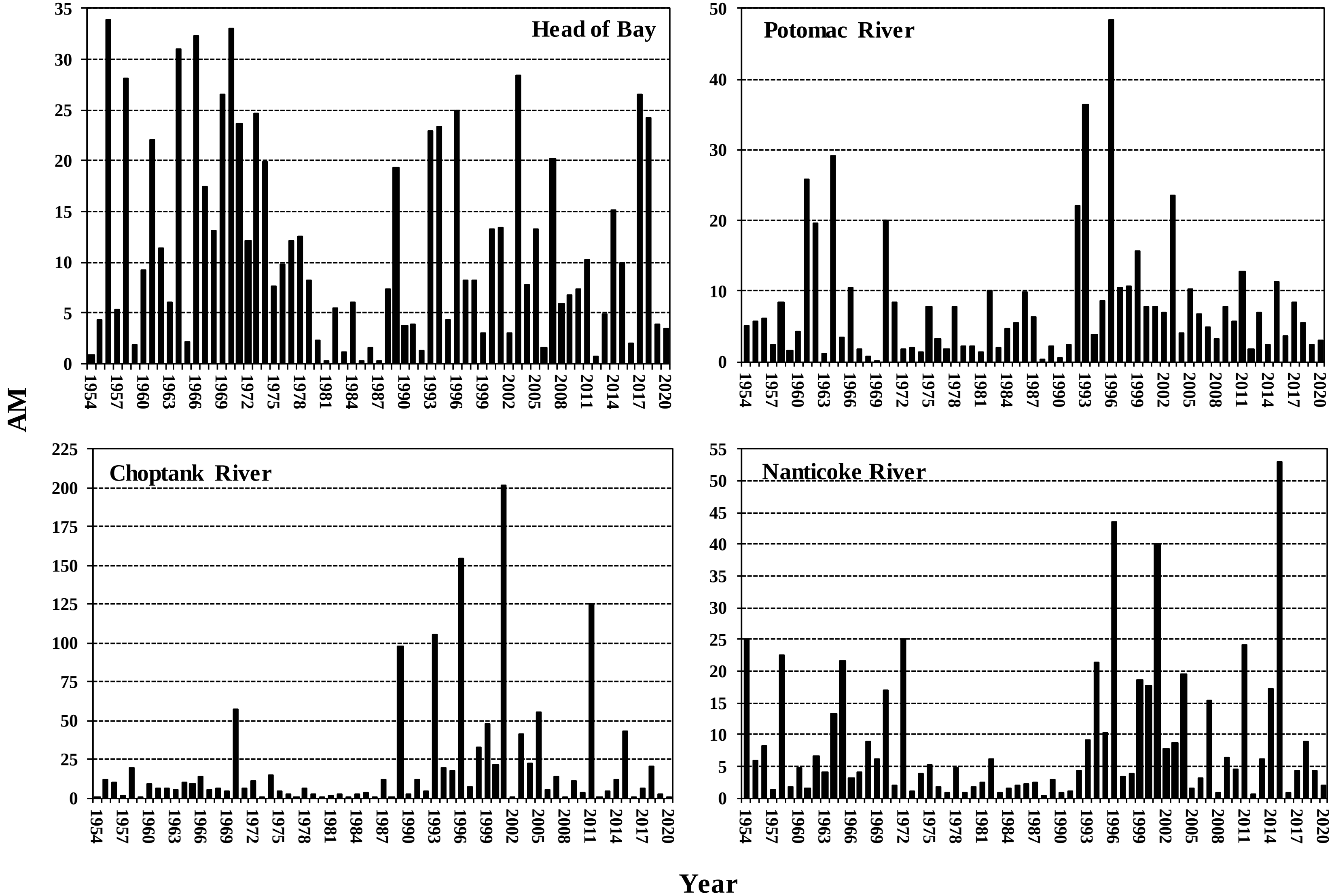


Figure 6. Head of Bay geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

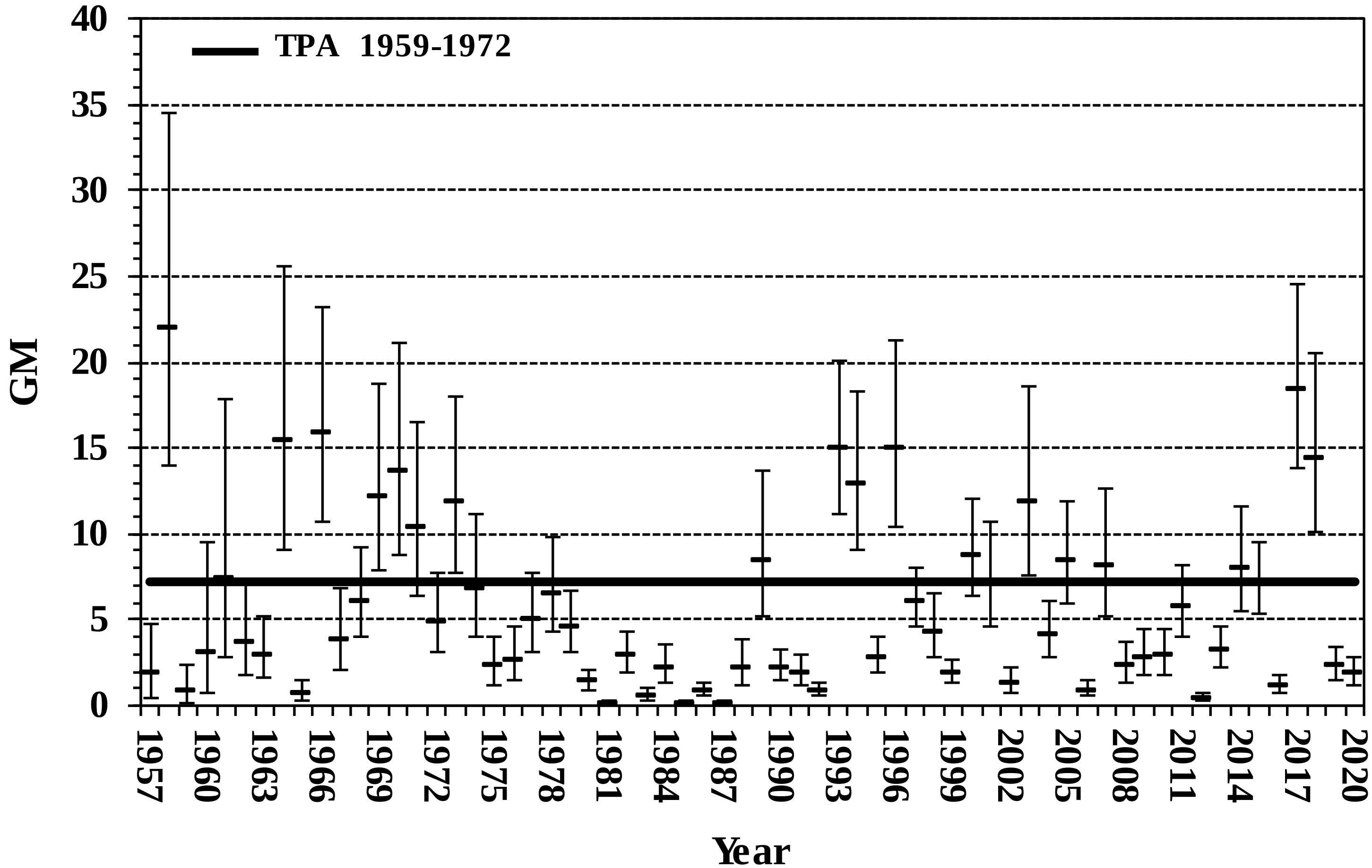
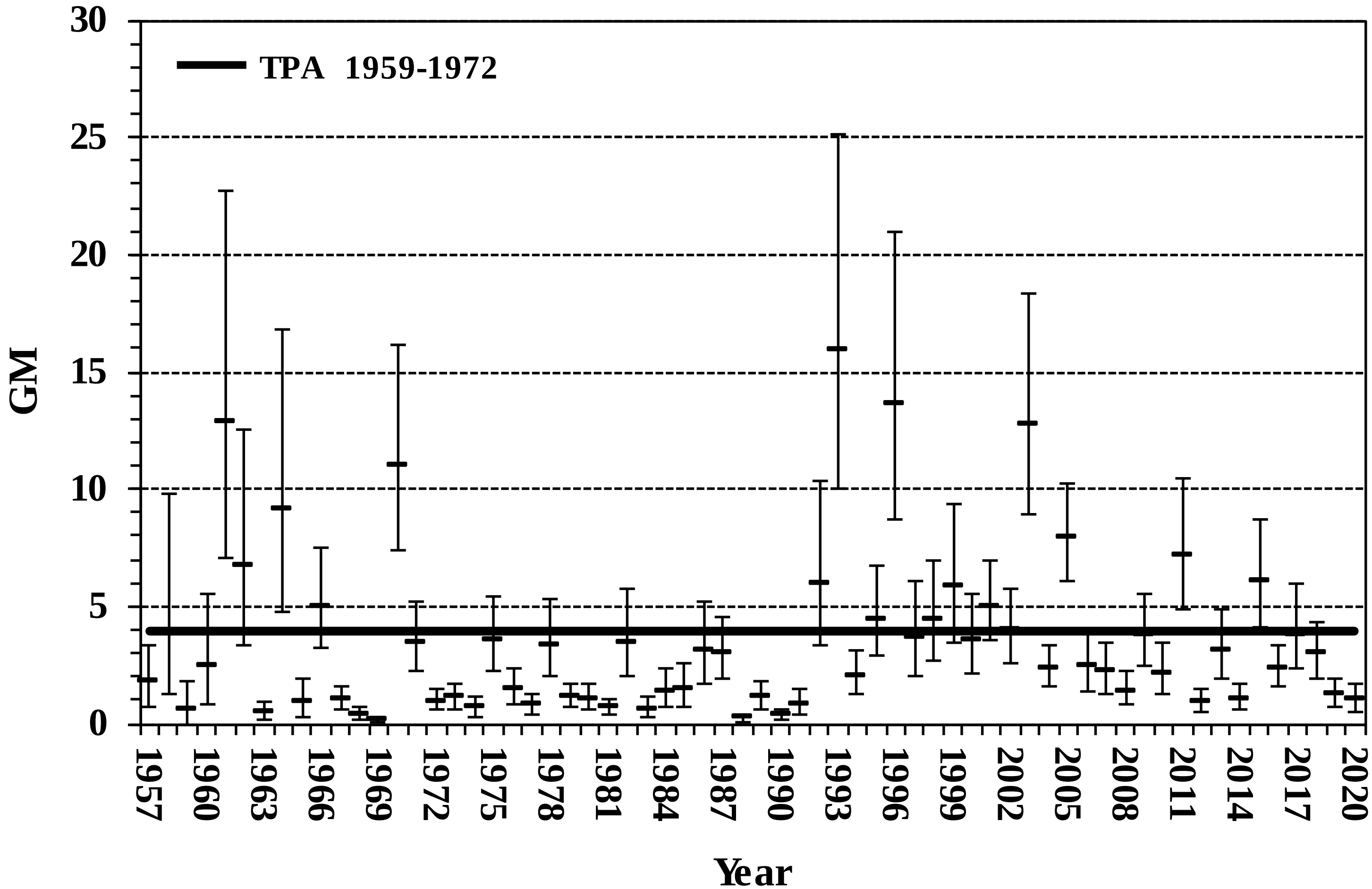


Figure 7. Potomac River geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).



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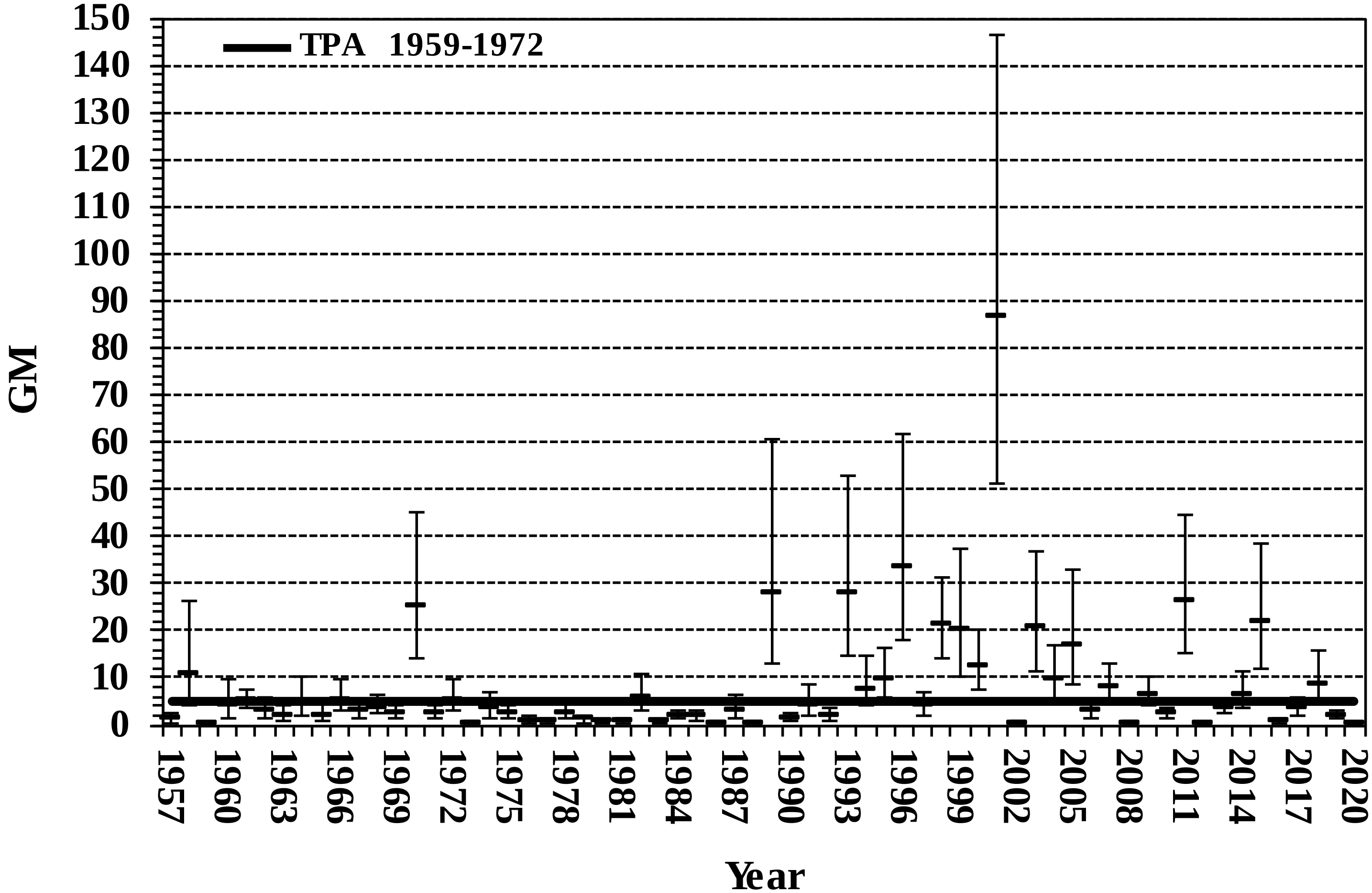

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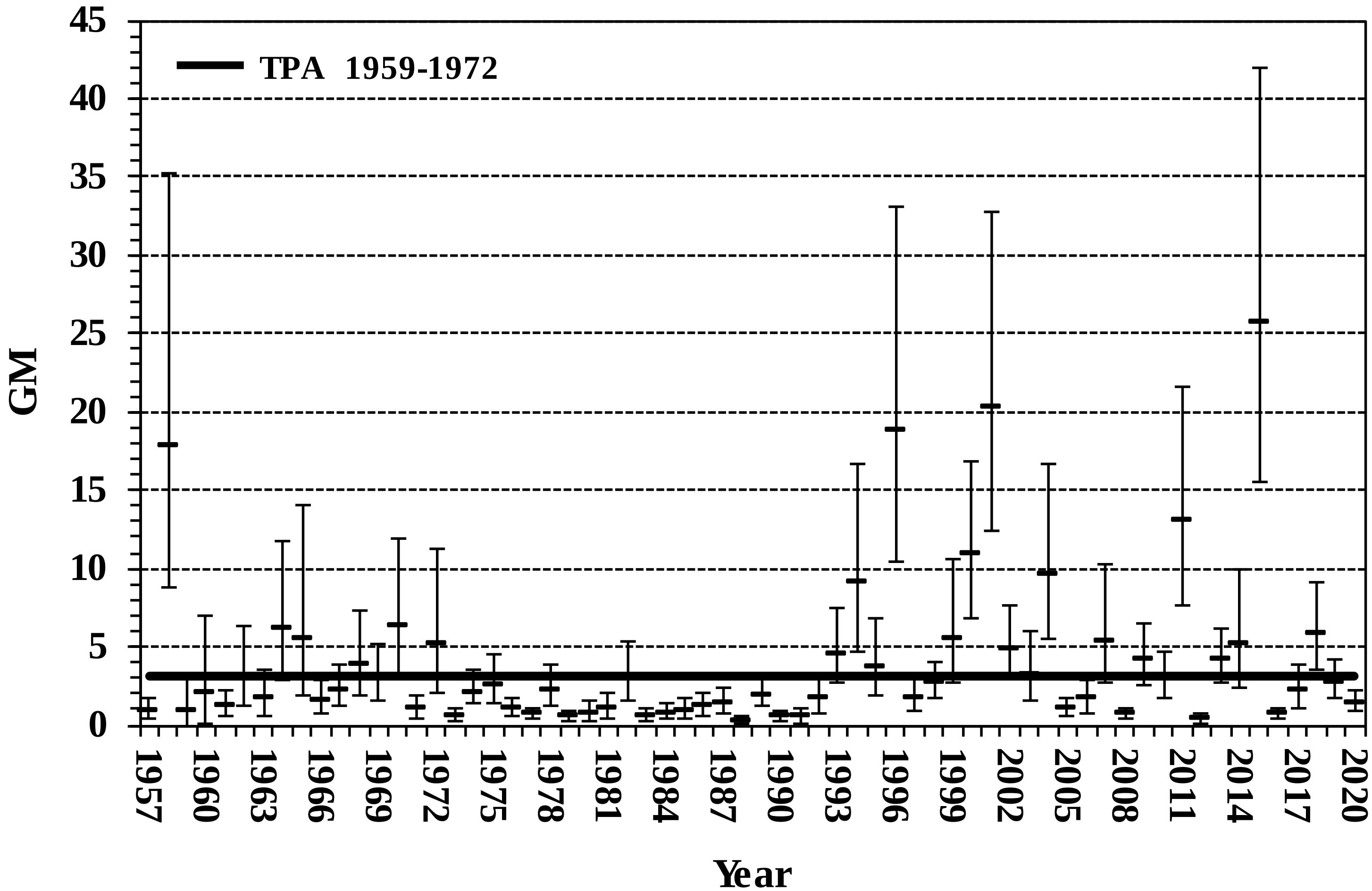

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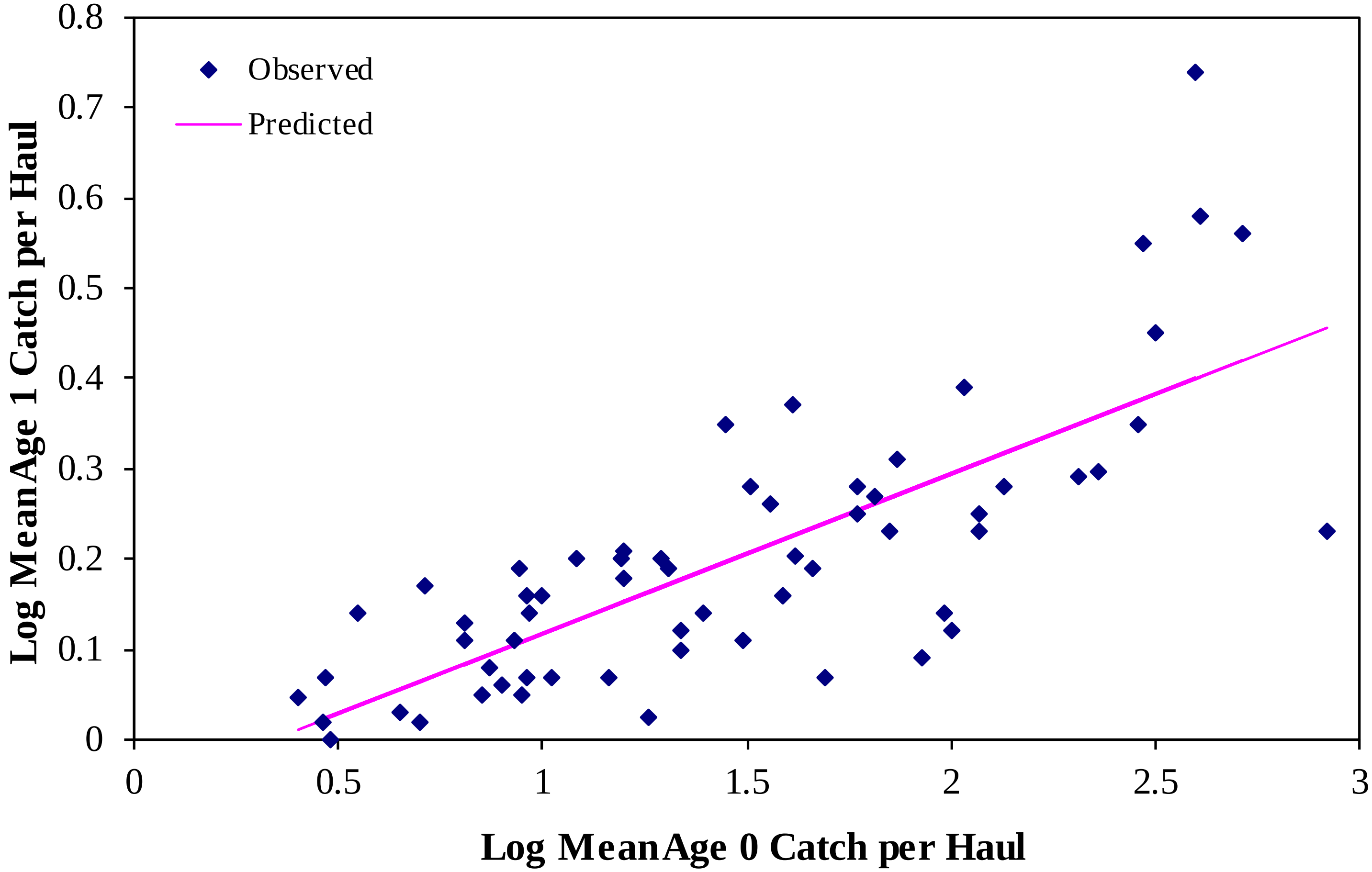

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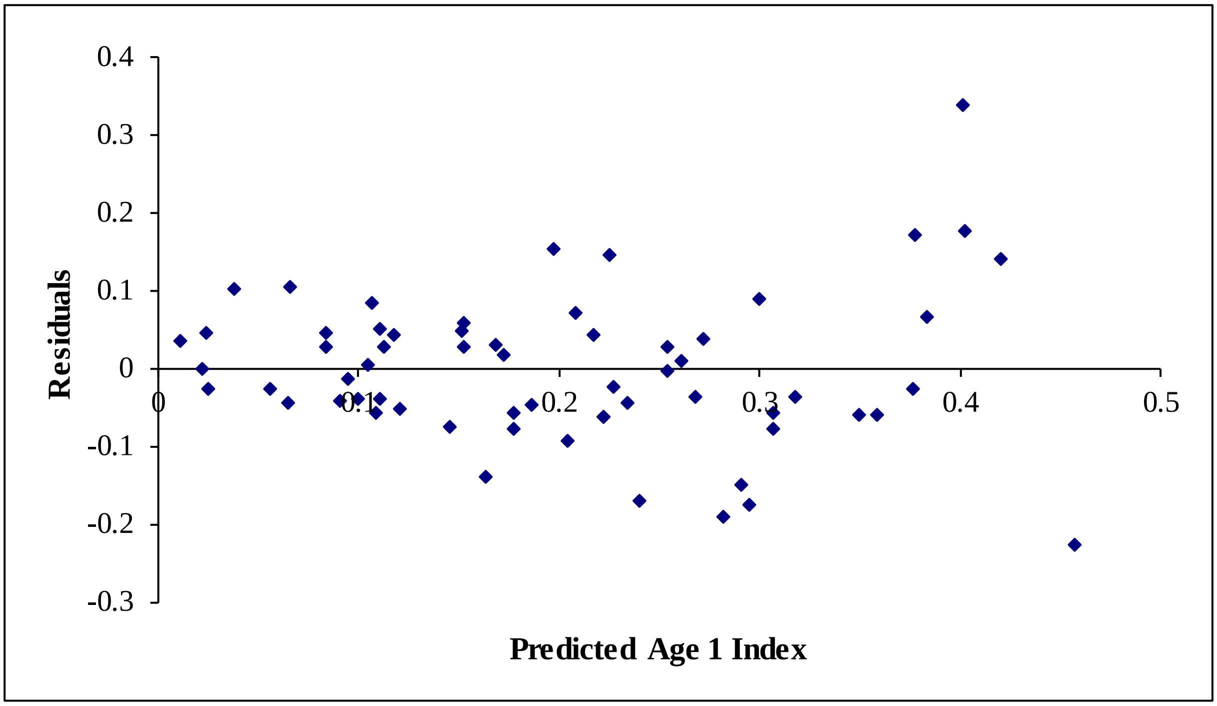

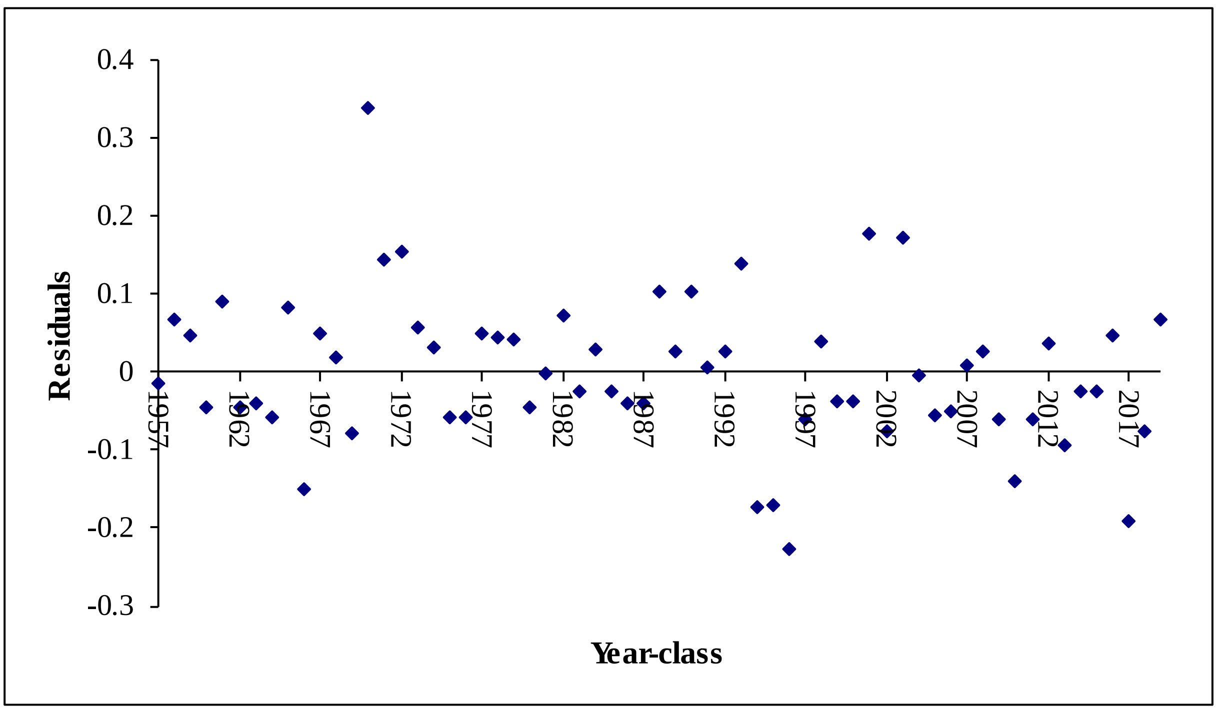

PROJECT NO. 2
JOB NO. 3
TASK NO. 4

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 2020 and to provide preliminary results for the 2021 tagging programs. Completed results for the 2021 tagging activities will be reported in the F-61-R-17 Chesapeake Bay Finfish Investigations report. The Maryland Department of Natural Resources (MD DNR) has been a key partner in the offshore cooperative winter tagging cruise and continues to maintain the long-term data set for the cruise. For these reasons, the offshore tagging activities were also summarized and included in this report.

MD DNR and partnering agencies tagged striped bass as part of the United States Fish and Wildlife Service's (USFWS) Cooperative Coastwide Striped Bass Tagging Program. Fish were tagged from the Chesapeake Bay resident/pre-migratory and spawning stocks, and from the Atlantic coastal stock. Subsequently, tag numbers and associated fish attribute data were forwarded to the USFWS, with the captor providing recovery information directly to the USFWS. These data are used to evaluate stock dynamics (mortality rates, survival rates, growth rates, etc.) of Chesapeake Bay resident and Atlantic coast striped bass stocks.

METHODS

Sampling procedures

The survey start was delayed due to COVID-19, but from mid-April through mid-May 2020, 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 2020, the offshore tagging cruise was conducted using hook and line, onboard a contracted sportfishing vessel departing from Virginia Beach, VA and Ocean City, MD. The goal was to tag as many coastal migratory striped bass as possible while they were wintering in the Atlantic Ocean off the mouth of Chesapeake Bay. Participants in the sampling effort included USFWS, North Carolina Division of Marine Fisheries (NC DMF), Atlantic States Marine Fisheries Commission (ASMFC), MD DNR, North Carolina Department of Environment and Natural Resources, North Carolina State University, Potomac River Fisheries Commission, Virginia Institute of Marine Science and National Oceanic and Atmospheric Administration.

Sampling was conducted during 13 fishing trips, between January 23 and February 18, 2020. Five lines with custom-made tandem parachute rigs were trolled at 3 to 3.5 knots, in depths of 80 to 103 feet (24 to 31 m).

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 from 400-800 mm TL, and from all striped bass less than 400 mm TL and greater than 800 mm TL.

Tagging procedures

For all surveys, internal anchor tags, supplied by the USFWS, were inserted through an incision made in the left side of the fish, slightly behind and below the tip of the pectoral fin. This small, shallow incision was made with a #12 curved scalpel after removing a few scales from the tag area. The incision was angled anteriorly through the musculature, encouraging the incision to fold together and the tag streamer to lie back along the fish's side. The tag anchor was then pushed through the remaining muscle tissue and peritoneum into the body cavity and checked for retention.

Analytical Procedures

Survival, fishing mortality and natural mortality rates from fish tagged during the spring in Maryland were estimated based on historic release and recovery data. The instantaneous rates – catch and release (IRCR) model is the primary model utilized and employs an age-independent form of the IRCR model developed by Jiang et al. (2007) to estimate survival, fishing mortality and natural mortality. The candidate models run in the IRCR model are formulated based on historical regulatory changes in striped bass management. Additional details on the methodologies can be found in the latest peer reviewed stock assessment report (Northeast Fisheries Science Center 2019), however it does not contain 2020 data.

Estimates for Maryland’s spawning stock are broken into two size groups: $\geq$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 2020 will not be completed until after March 27, 2021.

Estimates of fishing mortality for the Chesapeake Bay pre-migratory stock were developed using tag release and return data from spring male fish, ≥457 mm TL and <711 mm TL (18 – 28 inches TL). Male fish less than 28 inches are generally accepted to compose the majority of the Chesapeake Bay resident stock, while larger fish are predominantly coastal migrants. Release and recapture data from Maryland and Virginia (provided by Virginia Institute of Marine Science) were combined to produce a Baywide fishing mortality estimate. Similar to the coastwide methods, the IRCR model was utilized to calculate the Chesapeake Bay estimates. Further details on the methodologies and results can be found in the latest stock assessment report (Northeast Fisheries Science Center 2019).

Estimates of survival, fishing mortality and recovery rates for the cooperative offshore tagging data are calculated using the same methods as Maryland's spring tagging data and will be conducted by the USFWS.

For each study, t-tests were used to test for significant differences between the mean lengths of striped bass that were tagged and all striped bass measured for total length (SAS 1990). This was done to determine if the tagged fish were representative of the entire sample. Lengths were considered different at $P \leq 0.05$. Additionally a Kolmogorov-Smirnov test (K-S test) was used to test for differences between length distributions. Distributions were considered different at $P \leq 0.05$.

RESULTS AND DISCUSSION

Spring tagging

The spring sampling component monitored the size and sex characteristics of striped bass spawning in the Potomac River and the upper Chesapeake Bay. Sampling occurred between April 14 and May 22, 2020. A total of 1,990 striped bass were sampled and 864 (43%) were tagged as part of this long-term survey (Table 1).

On many occasions, large samples were caught in a short period of time which required fish to spend a considerable amount of time submerged in the gill net or in the boat, thereby increasing the potential for mortality. In these cases, biologists measured all fish but were only able to tag a sub-sample. Typically, these large concentrations of fish were of a smaller size and captured in small mesh panels. Larger fish were encountered less frequently, and therefore a higher proportion was tagged. This resulted in a significantly greater mean length of tagged fish than the mean length of all fish sampled. Mean total length of striped bass tagged during spring 2020 (549 mm TL) was significantly greater (t-value = -5.61, $P<0.0001$) than that of the sampled population (506 mm TL) (Figure 2). This was also evident in the significant difference of the two length frequencies ($D=0.112$, $P<0.0001$).

Tag releases and recaptures from both Maryland and Virginia's sampling (combined spring 2020 data) will be used to estimate an instantaneous fishing mortality rate on resident fish for the 2020-2021 recreational, charter boat, and commercial fisheries for the entire Chesapeake Bay. Estimates of survival and fishing mortality for the 2020 Chesapeake Bay spawning stock, as well as the resident stock, will be presented in a future report of the ASMFC Striped Bass Tagging Subcommittee.

Cooperative offshore tagging activities

The primary objective of the offshore tagging trips was to apply tags to as many striped bass as possible. Striped bass were only encountered on four trips in 2020 off the coast of Virginia. The majority of fish sampled in recent years were encountered in federal waters off the mouth of Chesapeake Bay.

In 2020, the survey encountered 202 striped bass and 199 (99%) were tagged (Table 2). The mean lengths of all fish sampled and of those tagged (1048 mm TL) were the same (Figure 3). The mean total length of striped bass tagged in 2020 (1048 mm TL) was not significantly different than the length of fish tagged from the 2019 hook and line trips (1034 mm TL, t-value = -1.12, P=0.265). Length distributions between the two years were also similar (D=0.121, P=0.332). Estimates of survival and mortality based on fish tagged in the 2020 offshore study will be presented in a future report of the ASMFC Striped Bass Tagging Subcommittee.

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

STRIPED BASS TAGGING

2021 PRELIMINARY RESULTS

Spring tagging

Sampling occurred between March 30 and May 18, 2021, with a break in the middle of the Upper Bay survey. A total of 755 striped bass were sampled and 494 (65 %) were tagged as part of this long-term survey. Mean total length of striped bass tagged during spring 2021 (572 mm TL) was significantly greater (t-value = -4.02, $P<0.0001$) than that of the sampled population (527 mm TL). Estimates of survival and fishing mortality for the 2021 Chesapeake Bay spawning stock, as well as the resident stock, will be presented in a future report of the ASMFC Striped Bass Tagging Subcommittee.

Cooperative offshore tagging activities

In 2021, hook and line sampling was conducted onboard a contracted sportfishing vessel departing from Ocean City, MD and Virginia Beach, VA. Sampling was conducted during 13 fishing trips, between January 7 and February 8, 2021.

While fishing with hook and line, 1,021 striped bass were encountered and 1,007 (99%) were tagged. The mean length of all fish sampled and of those tagged was 965 mm TL. Estimates of survival and fishing mortality based on fish tagged in the 2021 offshore tagging study will be presented in a future report of the ASMFC Striped Bass Tagging Subcommittee.

The final, complete analyses of the 2021 striped bass tagging activities will appear in the F-61-R-17 Chesapeake Bay Finfish Investigations report.

CITATIONS

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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 2020.

System	Inclusive Release Dates	Total Fish Sampled	Total Fish Tagged	Approximate Tag Sequences [a]
Potomac River	4/14/20 - 5/16/20	392 [b]	222	616001 – 616222
Upper Chesapeake Bay	4/14/20 - 5/22/20	1,598 [c]	642	611661 – 612000 612307 – 612608
Spring spawning survey totals:		1,990	864	

[a] Not all tags in reported sequences were applied; some were lost, destroyed, or applied out of order.
[b] Total sampled includes one USFWS recapture.
[c] Total sampled includes three USFWS recaptures.

Table 2. Summary of USFWS internal anchor tags applied to striped bass during the 2020 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	1/23/20 – 2/18/20	202	199	611001 – 611199

Figure 1. Tagging locations in spawning areas of the Upper Chesapeake Bay and the Potomac River, April - May 2020.

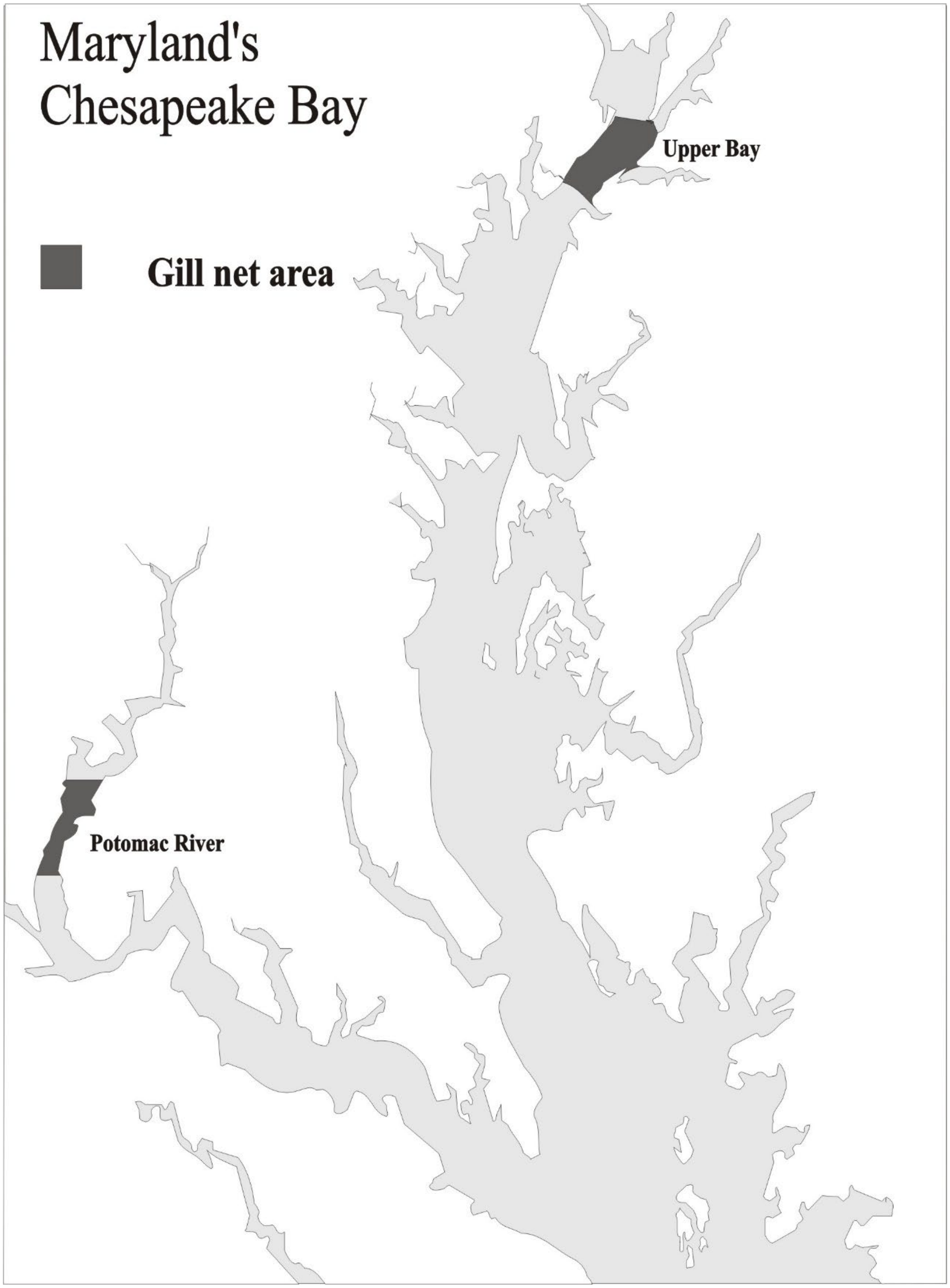


Figure 2. Length frequencies of striped bass measured and tagged during the spring in Chesapeake Bay, April - May 2020.

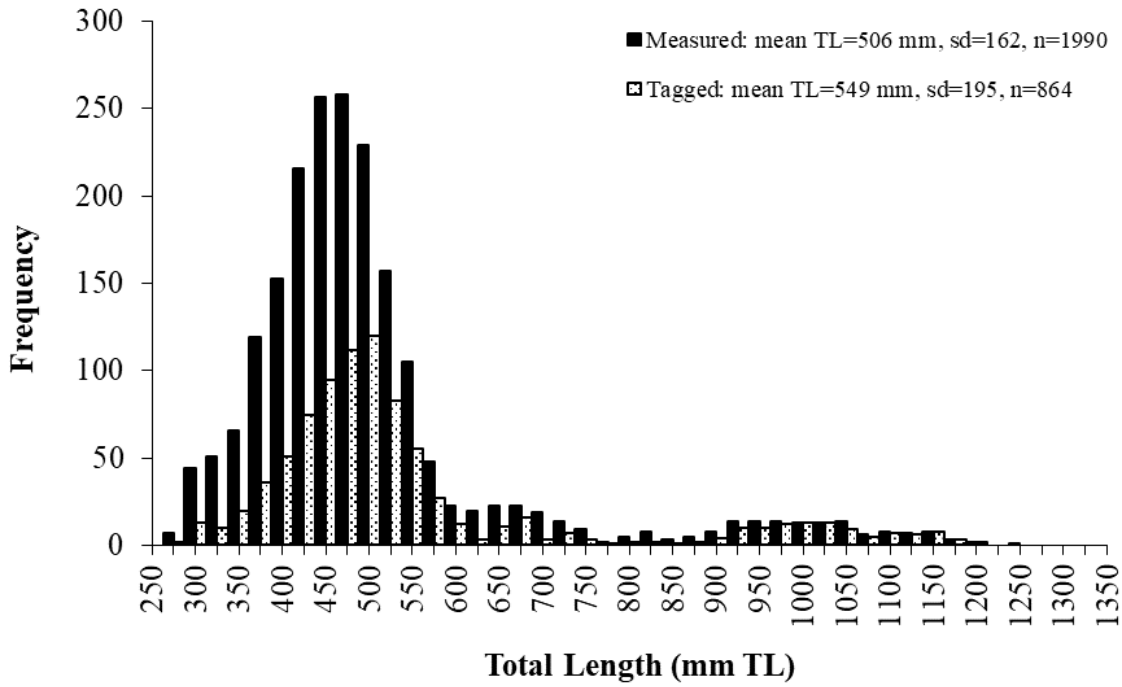
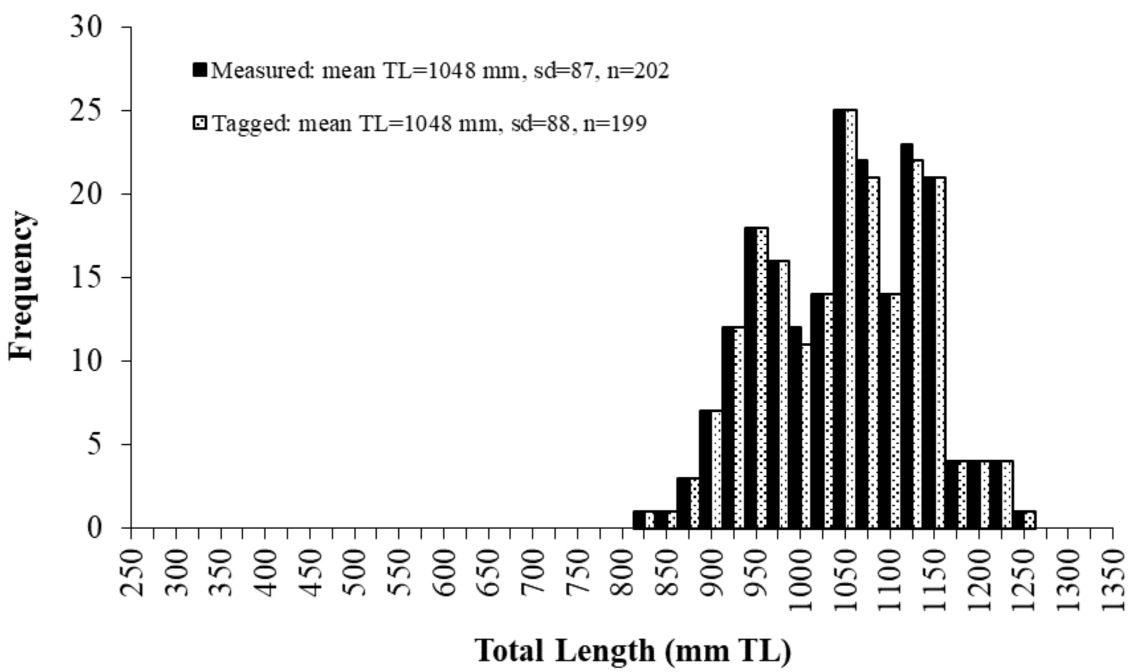


Figure 3. Length frequencies of striped bass measured and tagged during the cooperative offshore tagging trips, January – February 2020.



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 2019; describe the harvest monitoring conducted by the Maryland Department of Natural Resources (MD DNR); and present preliminary information regarding Maryland's 2020 commercial fishery monitoring. A final accounting of the 2020 commercial fishery and monitoring activities will be presented in the F-61-R-17 Chesapeake Bay Finfish Investigations report.

Maryland completed its twenty-ninth year of commercial fishing under the quota system since the striped bass fishing moratorium was lifted in 1990. The official 2019 commercial quota for Maryland's Chesapeake Bay and tributaries was 1,471,888 pounds, identical to 2018. 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 IV to Amendment 6 of the Atlantic Striped Bass Interstate Fisheries Management Plan, which prescribed a 20.5% reduction in quota (Atlantic States Marine Fisheries Commission, 2014). The Chesapeake Bay commercial fishery was subject to an 18 – 36 inch total length (TL) slot limit. There was a separate quota of 90,727 pounds for the Atlantic fishery, also mandated by Addendum IV 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

2019 commercial fishery operated on a combination of a Common Pool and the ITQ system, with 97% of the quota in the ITQ system. ITQ participants were assigned a share of the commercial quota based partly on their harvest history, and could fish any open season and legal gear. A portion of the commercial quota was reserved for commercial fishermen who opted to remain in the old, derby-style management system. The total Common Pool quota was 48,176 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 2019 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 2019 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 – Friday. The Common Pool fishery was open by public notice as follows: 5 days in January; 2 days each in February and June – September. 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

On the Chesapeake Bay and its tributaries, 1,475,162 pounds of striped bass were harvested in 2019 (Table 2). This harvest was 3,274 pounds, or 0.2%, over the 1,471,888 pound quota. As a result, the 2020 Bay quota will be reduced by 3,274 pounds to remain in compliance with the Atlantic States Marine Fisheries Commission Fisheries Management Plan.

The reported number of fish landed was 340,949 (Table 2). The pound net fishery landed 48% of the total landings by weight, followed by the drift gill net fishery at 45% and the hook-and-line fishery with 7% of the total Bay landings. No striped bass were harvested with haul seines.

Maryland’s Atlantic coast landings were reported at 3,270 striped bass, weighing 82,753 pounds (Table 2). The gill net fishery made up nearly 100% of the Atlantic harvest, by weight, with only 408 pounds harvested by the trawl fishery.

Comparisons of Average Weight

The mean weight per fish of striped bass harvested in Chesapeake Bay, regardless of gear type, was 4.33 pounds when calculated from the check station activity reports and 5.26 pounds when measured by biologists (Table 3). Mean weights by specific gear type or season ranged from 3.51 to 6.01 pounds from check station activity reports, and 3.39 to 6.25 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.

Striped bass were also sampled at Atlantic coast check stations to characterize coastal harvest (Project 2, Job 3, Task 1C, this report). Striped bass sampled from the Atlantic coast fisheries (combined gears) by MD DNR biologists averaged 26.38 pounds (Table 3), similar to the average weight calculated from the check station activity reports (25.31 pounds). Average weights calculated from check station reports indicate that fish harvested by gill net were heavier than those harvested by trawl. This could not be corroborated by biological sampling because harvest gear was not always discernible.

<u>Commercial Harvest Trends</u>

Commercial striped bass quotas and harvests have been relatively consistent in the Chesapeake Bay since the late-1990s (Figure 4). Gill nets have historically been responsible for most of the Bay striped bass harvest. In 2019, however, pound nets accounted for more harvest than gill nets for the second consecutive year. The hook-and-line fishery generally harvests the least of the three major Chesapeake Bay gears, and has been steadily decreasing since 2009. The 2019 hook-and-line harvest was the lowest observed since 1996 (Table 4, Figure 5).

Similar to the Chesapeake Bay fisheries, the Atlantic harvest increased in the early 1990s after the moratorium was lifted, but has been highly variable since 2000 (Figure 4). The drift gill net fishery continued to account for the majority of the Atlantic harvest in 2019, as it has in recent years (Table 4, Figure 5).

<u>Commercial CPUE Trends</u>

In Chesapeake Bay, pound net CPUE (492) declined slightly and drift gill net CPUE (505) increased slightly relative to 2018 to make these gears nearly equal in efficiency in 2019 (Table 5, Figure 6). The hook-and-line fishery CPUE (188) decreased relative to 2018 but has varied without trend for the last decade. Hook-and-line was the only Chesapeake Bay gear with CPUE below its respective time-series average in 2019 (Figure 6).

On the Atlantic coast, drift gill net was by far the most efficient harvest gear with a CPUE of 722 pounds per trip. The CPUE for trawlers (102) increased more than two-fold from the historic low of 2018 (Table 5, Figure 6). Since the Atlantic season was expanded to include May and October in 2016, large catches of striped bass have occurred by gill net in May (Figure 3). These large catches are responsible for the high Atlantic gill net CPUE for the third consecutive year (Table 5, Figure 6).

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

COMMERCIAL FISHERY HARVEST MONITORING

2020 PRELIMINARY REPORT - WORK IN PROGRESS

Maryland's initial 2020 commercial striped bass quota for Chesapeake Bay was established at 1,445,394 pounds, then adjusted to 1,442,120 pounds due to the 3,274 pound overage in 2019. A portion of that total (39,026 pounds) was designated for Common Pool participants and the rest was available to the ITQ fishery.

The 2020 ITQ commercial summer/fall fishery opened on June 1 and closed on December 31. Hook-and-line gear was permitted Monday – Thursday; haul seines were permitted Monday – Friday; and pound nets were permitted Monday – Saturday. The Chesapeake Bay 2020 ITQ drift gill net season was split, with the first segment from January 1 through February 28, and the second segment from December 1 through December 31. The Common Pool fishery was open by public notice for 3 days each in January and February, 2 days each June – October, 1 day in November, and 2 days in December. Chesapeake Bay fisheries were subject to an 18-36 inch (TL) slot limit.

Maryland's 2020 Atlantic coast quota was set at 89,094 pounds. The Atlantic fishery permitted two gear types, drift gill net and trawl, and the season occurred in two segments: January 1 through May 31, and October 1 through December 31. The Atlantic fishery was subject to a 24 inch (TL) minimum size limit.

Mandatory harvest reporting methods remained unchanged. MD DNR biologists continued fisheries-dependent surveys of the harvest. Landings were not finalized at the time of this writing but will be reported in the F-61-R-17 Chesapeake Bay Finfish Investigations report.

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Table 1. Striped bass commercial regulations by gear type for the 2019 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	206	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 48,176; No ITQ Quota	138	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 48,176; No ITQ Quota	265	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		**1,471,888**				
Atlantic Coast	Trawl and Gill Net	90,727	32	No trip limits for ITQ	24 in TL min	Monthly Harvest Report
Total Maryland Quota		**1,562,615**				

Table 2. Summary of striped bass commercial harvest statistics by gear type for the 2019 calendar year.

Area	Gear Type	Pounds[1]	Number of Fish[1]	Trips[2]
Chesapeake Bay[3]	Haul Seine	0	0	0
	Pound Net	711,730	202,579	1,448
	Hook-and-Line	99,245	27,823	692
	Gill Net	664,187	110,547	1,315
	Chesapeake Total	**1,475,162**	**340,949**	**3,455**
Atlantic Coast	Trawl	408	50	4
	Gill Net	82,345	3,220	114
	Atlantic Total	**82,753**	**3,270**	**118**
Maryland Totals		**1,557,915**	**344,219**	**3,573**

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 2019 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 Bay[3]	Haul Seine	N/A	N/A	N/A
	Pound Net	3.51	3.39 (3.30-3.47)	1,892
	Hook-and-Line	3.57		
	Gill Net	6.01	6.25 (6.17-6.33)	3,564
	Chesapeake Total Harvest	**4.33**	**5.26 (5.19-5.33)**	**5,456**
Atlantic Coast	Trawl	8.16	26.38 (25.52-27.23)	131
	Gill Net	25.57		
	Atlantic Total Harvest	**25.31**	**26.38 (25.52-27.23)**	**131**

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 2019.

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

Table 5. Striped bass average catch per trip (CPUE) in pounds by commercial gear type, 1990 to 2019.

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
Average	156	292	303	242	596
5 year avg	174	460	476	480	430

Figure 1. Map of the 2019 Maryland Chesapeake Bay authorized commercial striped bass check stations.

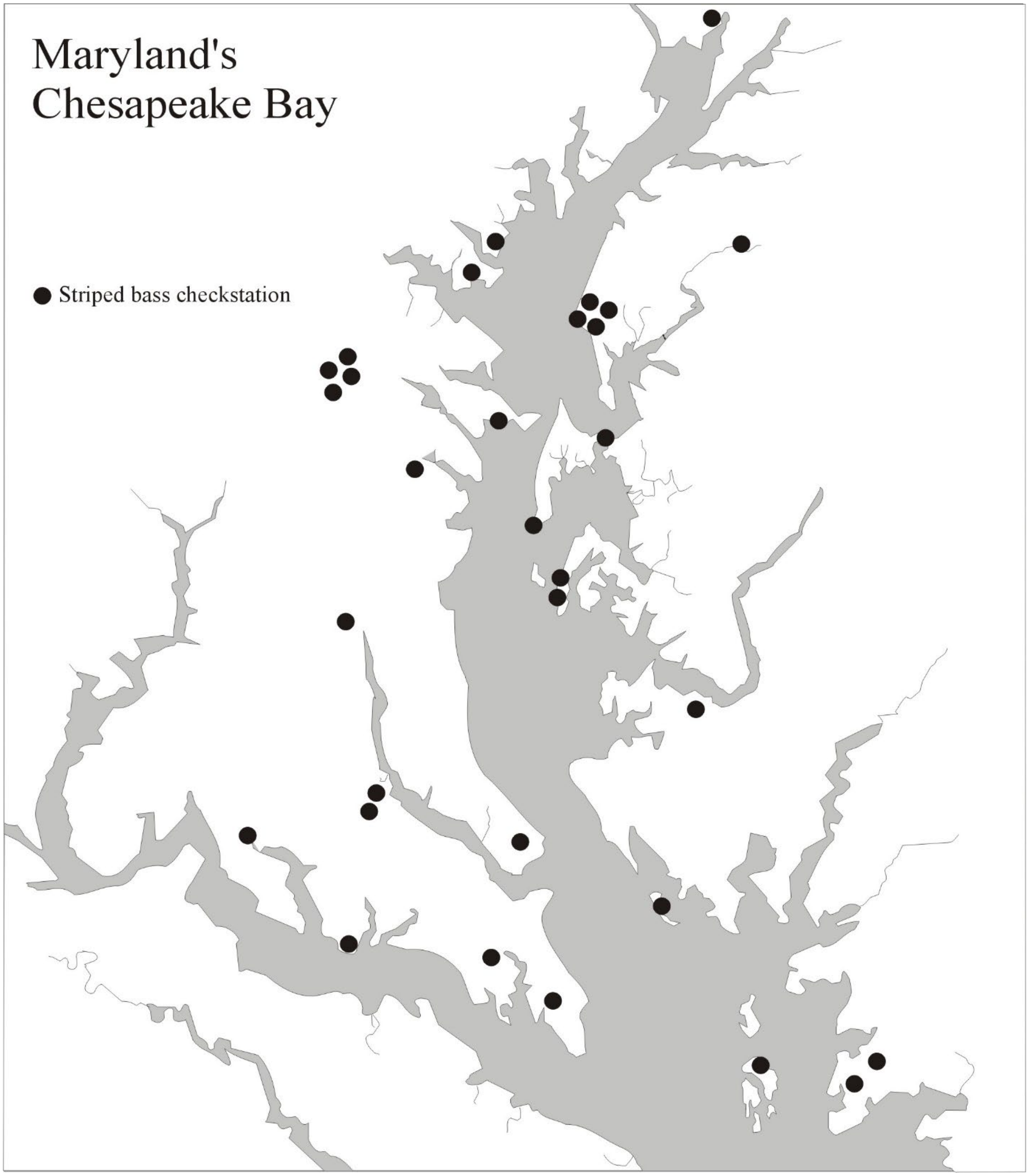
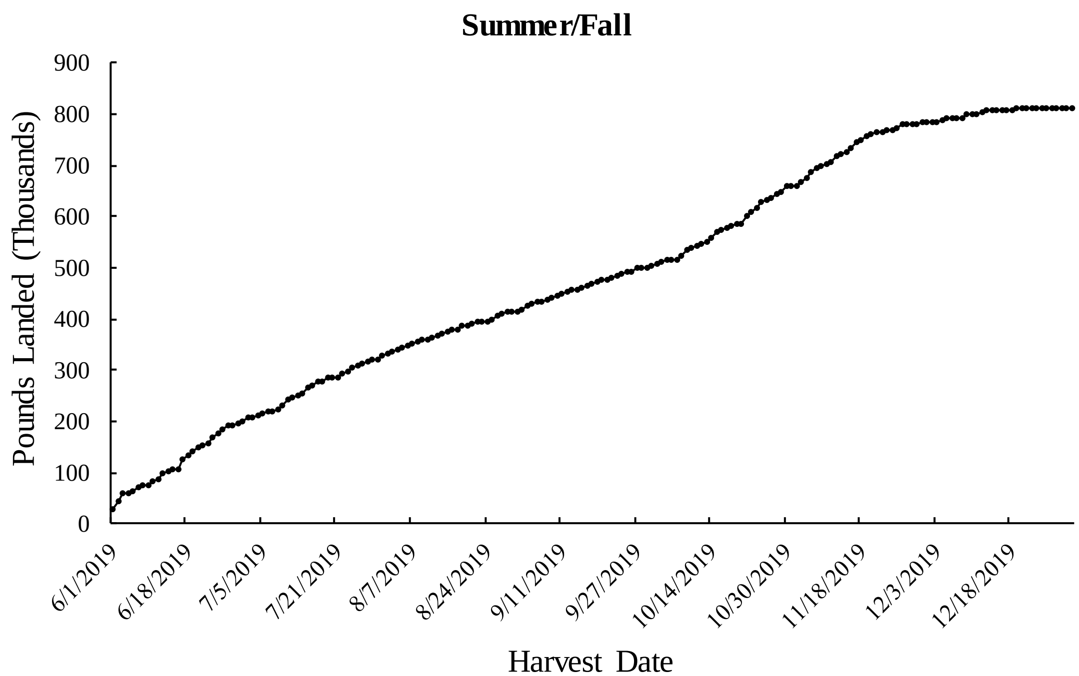


Figure 2. Maryland's Chesapeake Bay summer/fall (pound net and hook-and-line) and winter (gill net) fisheries cumulative striped bass landings from check station reports for calendar year 2019. Note different scales.



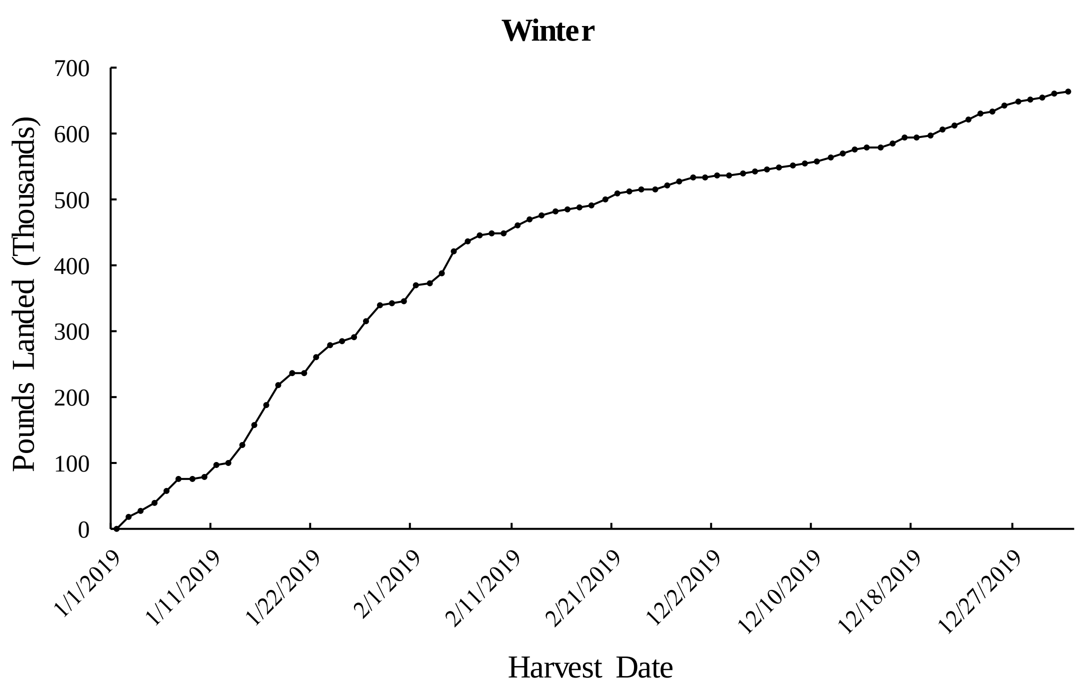


Figure 3. Maryland's Atlantic trawl and gill net fisheries (combined) cumulative striped bass landings from check station reports, January-May and October-December 2019.

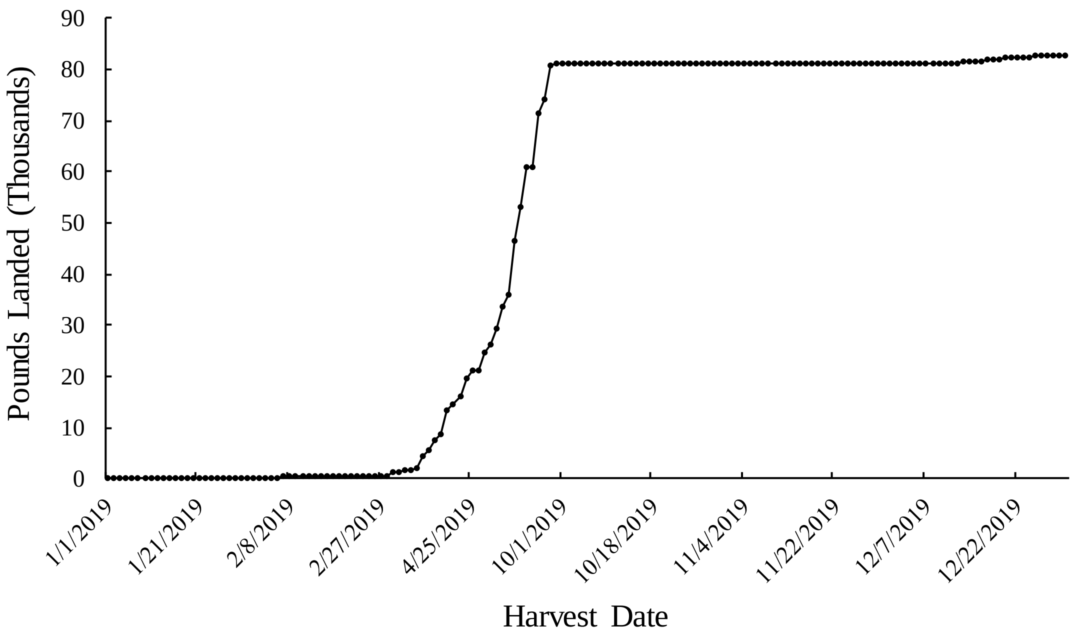
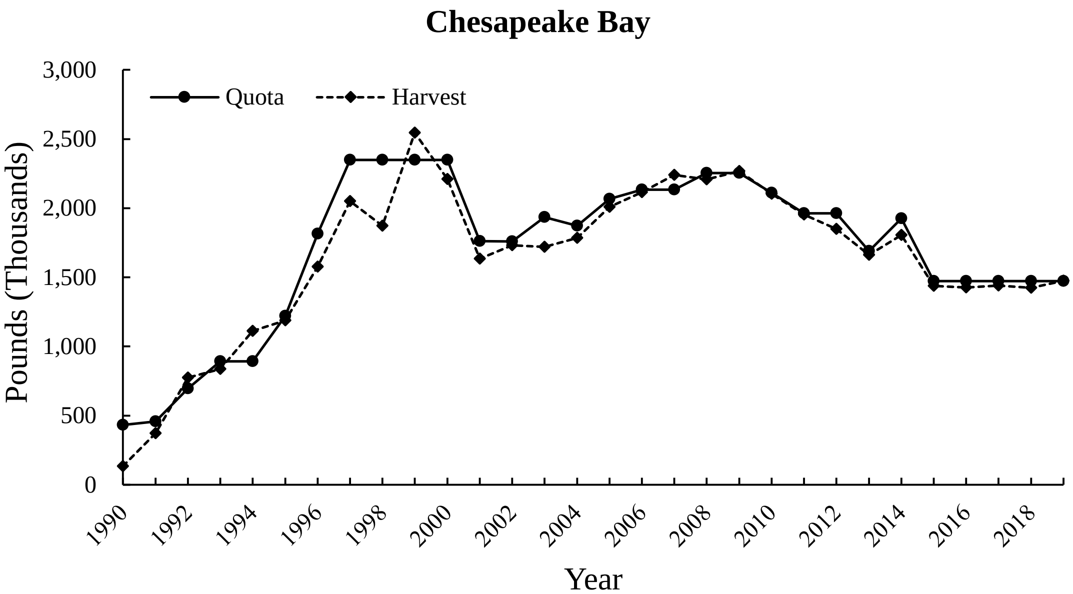


Figure 4. Maryland's Chesapeake Bay and Atlantic Ocean quotas (pounds) and harvests (pounds) for all gears, 1990-2019. Note different scales.



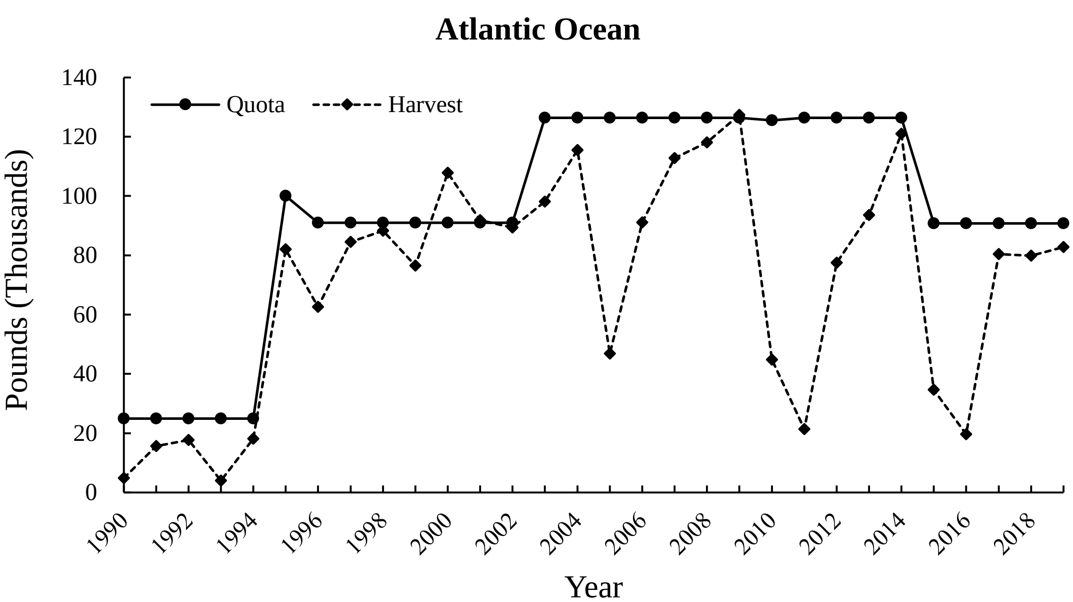
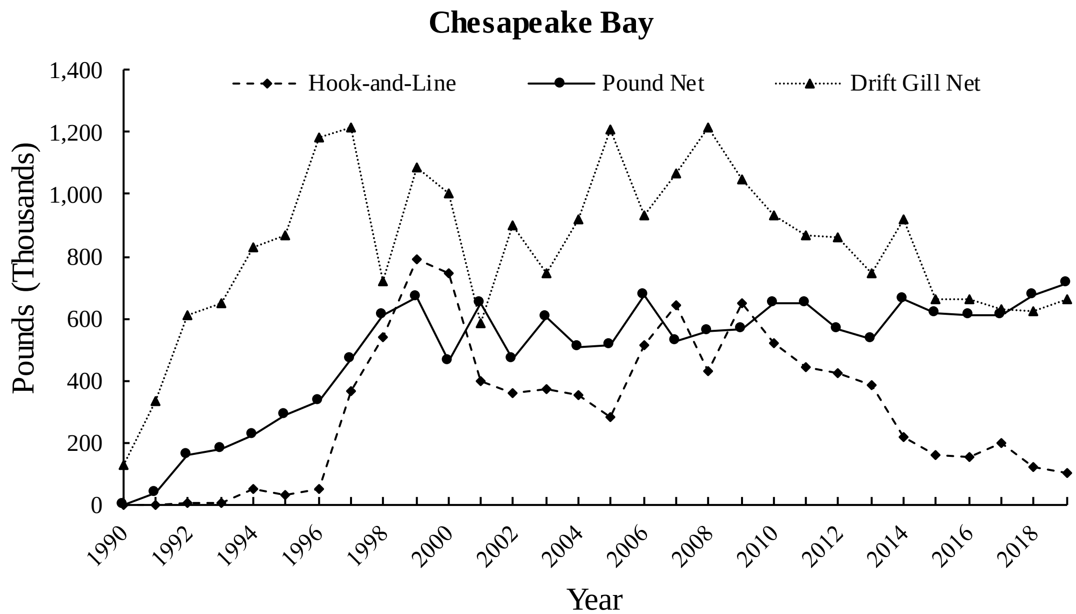


Figure 5. Maryland's Chesapeake Bay and Atlantic Ocean striped bass total harvest (thousands of pounds) per calendar year by commercial gear type, 1990-2019. Note different scales.



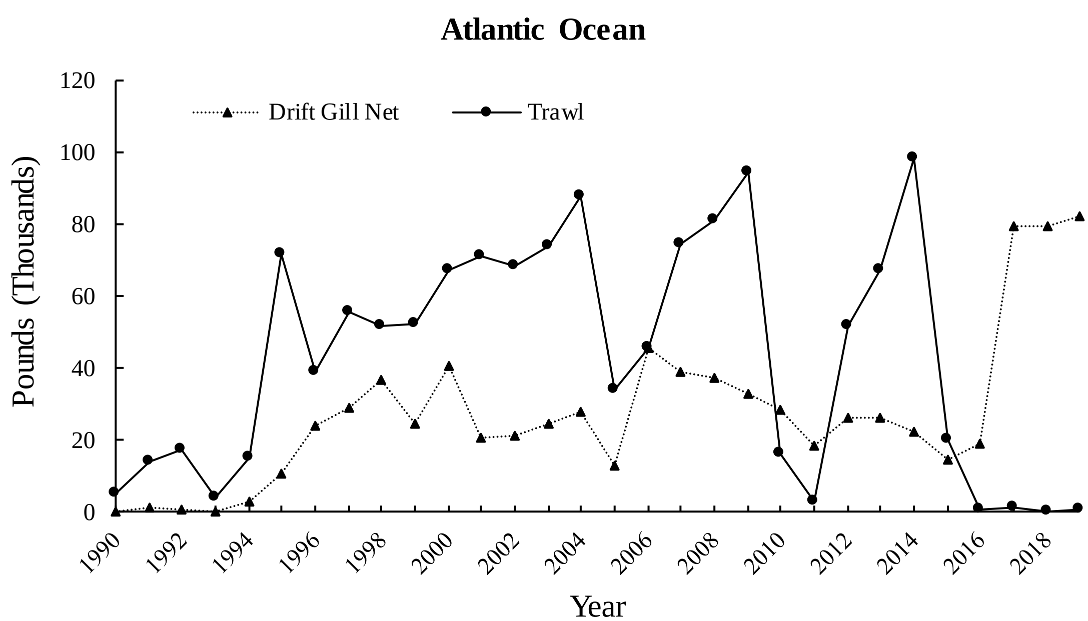
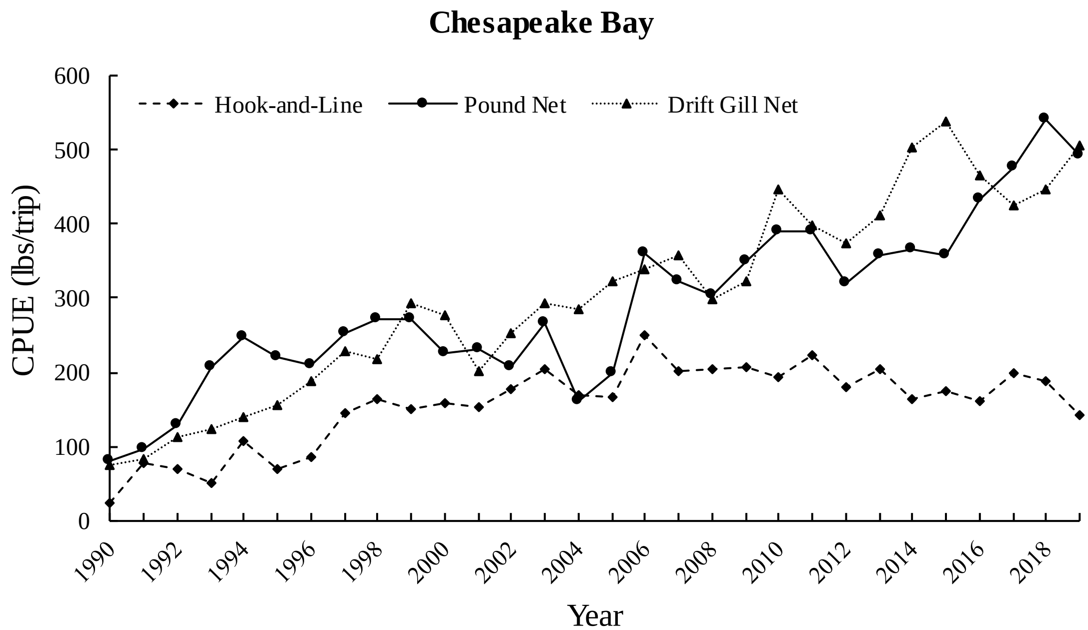
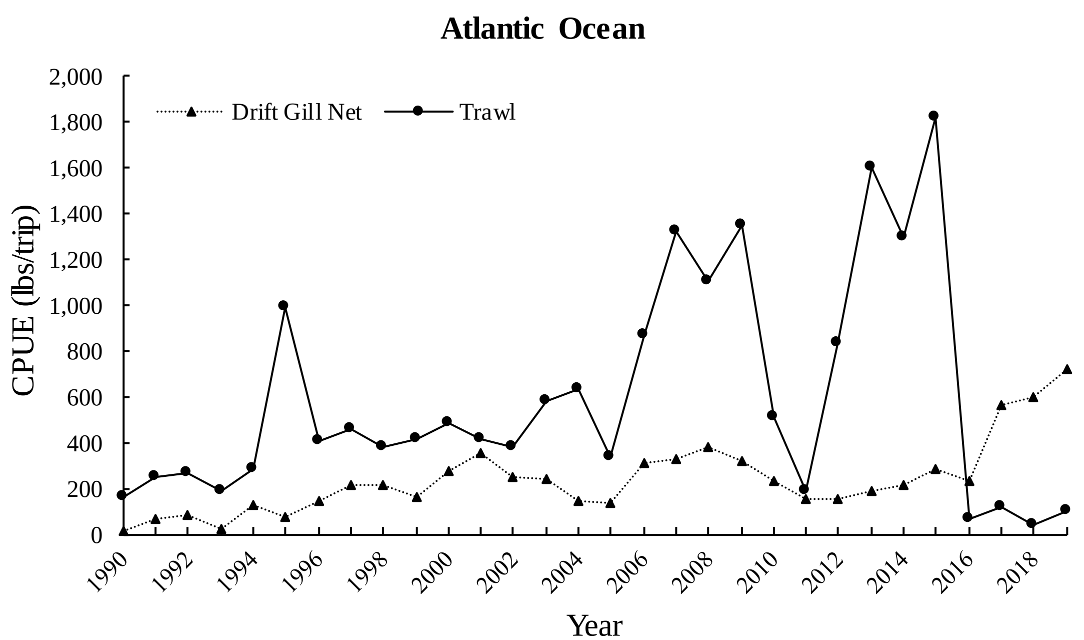


Figure 6. Maryland's Chesapeake Bay and Atlantic Ocean striped bass catch (pounds) per trip (CPUE) by commercial gear type, 1990-2019. Trips were defined as days on which striped bass were landed. Note different scales.





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

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

Prepared by Simon C. Brown

INTRODUCTION

The primary objective of Project 2, Job 3, Task 5B was to finalize the characterization of the size, age and sex composition of striped bass (*Morone saxatilis*) sampled from the 2020 spring recreational season, which began on Friday, May 1 and continued through May 15. The secondary objective was to estimate recreational harvest rates and catch per unit effort during the spring recreational season. Preliminary results as available for the 2021 spring recreational season are reported and complete results for the 2021 spring recreational season will be reported in the F61-R-17 Chesapeake Bay Finfish Investigations report.

A portion of the Atlantic migratory striped bass stock returns to Chesapeake Bay annually in the spring to spawn in the various tributaries (Pearson 1938; Merriman 1941; Tresselt 1952; Raney 1952; Raney 1957; Chapoton and Sykes 1961; Dovel 1971; Dovel and Edmunds 1971; Kernehan et al. 1981). Mansueti and Hollis (1963) reported that the spawning season runs from April through June. After spawning, migratory striped bass leave the tributaries and exit the bay to their summer feeding grounds in the Atlantic Ocean. Water temperatures can significantly influence the harvest of migratory striped bass in any one year, with coastal migrants remaining in Chesapeake Bay longer during cool springs (Jones and Sharov 2003). In some years, ripe, pre-spawn females have been captured as late as the end of June and early July (Pearson 1938; Raney

1952; Vladykov and Wallace 1952), although this has not been observed in recent years. Increasing water temperatures tend to trigger migrations out of the bay and northward along the Atlantic coast (Merriman 1941; Raney 1952; Vladykov and Wallace 1952).

Estimates indicate that in the mid-1970s, over 90% of the coastal striped bass harvested from southern Maine to Cape Hatteras were fish spawned in Chesapeake Bay (Berggren and Lieberman 1978; Setzler et al. 1980; Fay et al. 1983). Consequently, spawning success and young-of-year survival in the Chesapeake Bay and its tributaries have a significant effect on subsequent striped bass stock size and catch from North Carolina to Maine (Raney 1952; Mansueti 1961; Alperin 1966; Schaefer 1972; Austin and Custer 1977; Fay et al. 1983).

Maryland's post-moratorium spring striped bass season targets coastal migrant fish in the main stem of Chesapeake Bay. The first spring season opened in 1991 with a 16-day season, 36-inch minimum size, and a one fish per season creel limit (Speir et al. 1999). Spring season regulations became progressively more liberal since 1991 as stock abundance increased (Table 1).

In response to the results of the 2019 benchmark stock assessment indicating the stock is overfished with overfishing occurring, the ASMFC Management Board approved Addendum VI to Amendment 6 in October 2019. The Addendum implements measures to reduce total striped bass removals by 18% relative to 2017 levels in order to achieve the fishing mortality target in 2020. The 2020 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 2020 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 2020: 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 2002-2019, 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 main-stem of the Bay. Due to COVID-19, interview data from MRIP is not currently available for wave 3 (May/June) of 2020. 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.

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, α=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 (α=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

Due to COVID-19 MRIP data was not available for the spring trophy season in 2020. 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). 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 2020, estimates from the MRIP program were not available for the spring trophy period due to COVID-19.

In 2020, there were a total of 207 recorded logbook trips during the spring trophy season, with 10.6% excluded as multiple trips resulting in the analysis of 185 single trips. The total number of qualifying striped bass logbook trips has declined 88% compared with the mean of previous years (Table 10B).

The number of charter boats intercepted and number of striped bass examined each year are presented in Table 5B. Sampling was delayed for the 2-week trophy season due to the extra time required to develop and implement COVID-19 safety protocols. In 2020, a total of 30 fish were examined from 8 charter trips intercepted with nonzero striped bass harvest (Table 5B).

BIOLOGICAL DATA

Length and Weight

Length distribution

In the 2020 spring striped bass season, fish lengths measured from the harvest ranged from 678 mm TL to 1285 mm TL with a mean of 994 mm TL (n=30, Table 6A, Figure 2). The average size of harvested striped bass has increased since 2016 when regulatory changes increased the minimum size limit to 35 inches (Table 1). In 2020, the mean length estimate was above the long-term mean and is the fourth largest in the time series.

Mean length

The mean length of females (996 mm TL) was greater than the mean length of males (969 mm TL), which is typical of the biology of the species (Bigelow and Schroeder 1953). Only two male striped bass were encountered in 2020 and ranged from 935 to 1003 mm TL. Female striped bass length in 2020 was 6% 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 2020 was significantly different than 2018 which was the year female mean length was largest, but not significantly different than other years since the size limit increased in 2016 (Table 6A, Figure 3).

Due to the shortened season, the mean daily lengths of female striped bass harvested in 2020 showed no trend (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).

The Striped Bass Program receives supplemental length data from anglers who submit information through the online Volunteer Angler Survey. Data collected during the spring season through the Volunteer Angler Survey includes lengths of striped bass that were caught and released in addition to lengths of striped bass that were harvested. In 2020, anglers reported lengths for 29 striped bass caught during the trophy season and released. The mean length of fish caught and released reported by the Volunteer Angler Survey was 489 mm TL.

Mean weight

Not all fish measured were weighed due to filleting occurring prior to fish being intercepted on shore. Fish weights sampled during the 2020 spring striped bass season ranged from 7.4 kg to 16.1 kg. The mean weight in 2020 was 10.4 kg and 95% confidence intervals indicate it was similar to the mean weight in 2016, 2017, 2019, but smaller than the mean weight in 2018 (Table 6B, Figure 5).

The mean weight of females was 10.4 kg. Females tend to grow larger than males, and most striped bass over 13.6 kg (30.0 lb) are females (Bigelow and Schroeder 1953). ANOVA indicated significant differences in mean weight among years for females ($p<0.0001$). The weight of females in the harvest has generally increased from 2012 to 2018, but declined in 2020. Duncan's multiple range test for females ($\alpha=0.05$) found that the mean length in 2020 was significantly different than 2018 which was the year female mean weight was largest, but not significantly different than other years since the size limit increased in 2016 (Table 6B, Figure 5).

Age Structure

The number of scales aged from the creel survey has varied between years. In 2020, 74 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 2020 spring recreational harvest ranged from 7 to 17 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 2020 the above average 2011 year-class (Age 9) disproportionately contributed 53.4% to the harvest (Figure 6). This high contribution likely represents the complete maturation and fully migratory status of 9 year old females from the 2011 year-class. Similar disproportionate contributions from the 2003 year-class occurred in 2012-2014, also starting at age 9 (Figure 6). The next largest contribution was 12.5% from the 2012 year-class with all other year-classes each contributing less than 10% (Figure 6).

Sex Ratio

There were no striped bass which received an unknown sex designation in 2020 (Table 7A). As in past years, the 2020 spring season harvest was dominated by female striped bass, comprising 93% of the total sample (Table 7B). Since the minimum size limit increase in 2016, the proportion of females in the harvest has been above 90%, except in 2019 (Table 7B). Prior to 2016 (2002-2015), the mean proportion of females sampled in the harvest was around 84% (Table 7B).

<u>Spawning Condition</u>

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 – 2020 the percentage of pre-spawn females in the spring season harvest has declined from a maximum of 63% in 2005 to a minimum of 6% in 2018 (Table 8). Only two pre-spawn females were observed in 2020 out of a total of 28 females sampled (7%). 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=0.77). 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 2020, the proportion of pre-spawn females was lower than predicted by the average annual mean total length (mm) (Figure 7), which may be attributed to the starting date the trophy season moving from the third Saturday in April to May 1st in 2020.

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 2020. 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. 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 2020 according to charter boat data was 2.7 fish per trip (Table 9A) which was 36% below the long term mean charter boat HPT (4.2 fish per trip) but up from 1.5 fish per trip from the previous year. 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 2020 was 0.52 fish per person (Table 9B) which was a 25% reduction from the long-term mean (0.69 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 was unavailable to make a 2020 calculation due to COVID-19 (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 2020, MRIP data for private boats was unavailable due to COVID-19 to facilitate comparisons of catch rates with charter boats. Charter boats caught 3.0 fish per trip, which was 34% below the long-term average (5.8 fish per trip, Table 10B). The charter boat catch per hour (CPH) was 0.5 fish per hour.

Angler Characterization

States of residence

In 2020, MRIP angler interview data from wave 3 used to summarize angler state of residence was not available due to COVID-19.

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

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

2021 PRELIMINARY RESULTS

Data collected during the 2021 spring recreational season (May 1-May15) are currently being analyzed. In 2021, biological sampling of harvested striped bass from the charter boat fleet was conducted two or more days a week depending on the availability of fish from for a total of six sample days. The final, complete analyses of the spring 2021 recreational survey data will be available in the F-61-R-17 Chesapeake Bay Finfish Investigations report.

During the 2021 spring recreational season, 51 striped bass from 19 intercepted charter boat trips were measured, weighed, and internally examined for spawning condition. Biological samples collected from examined fish for aging studies include 51 scale samples and 10 otoliths. Female striped bass (n=47) were a mean Total Length of 988 mm and mean weight of 9.91 kg. Internal examination revealed 100% of female striped bass harvested had recently spawned. Male striped bass (n=4) were a mean Total Length of 951 mm and a mean weight of 8.39 kg. Scale samples are currently being processed and aged, therefore no age distribution of the 2021 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, 1991-2020.

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 larger than 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 larger than 40		
2016	**4/16-5/15**	35 inches or larger	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
2017	**4/15-5/15**			
2018	**4/21-5/15**			
2019	**4/20-5/15**			
2020	**5/01-5/15**			

Table 2. Survey sites for the Maryland striped bass spring season dockside creel survey, 2002-2020. 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, 2020.

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			

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

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)*
Mean	930 (909-954)	941 (919-963)	872 (852-896)

*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)*
Mean	8.5 (7.9-9.2)	8.8 (8.2-9.6)	6.8 (6.3-7.4)

*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

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
Mean	83	85	85

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.

	Pre-spawn Females		**Post-spawn Females**	
Year	**n**	**%**	**n**	**%**
2002	150	45	181	55
2003	231	58	168	42
2004	222	55	180	45
2005	144	63	85	37
2006	162	41	231	59
2007	142	59	97	41
2008	47	30	108	70
2009	81	49	83	50
2010	62	29	150	71
2011	79	42	107	58
2012	29	30	69	70
2013	46	29	114	71
2014	53	27	141	73
2015	34	24	109	76
2016	23	13	157	87
2017	17	12	120	88
2018	6	6	99	94
2019	2	10	18	90
2020	2	7	26	93
Mean	--	33 (25-41)	--	67 (59-75)

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
Mean	1,432	4.2 (3.6-4.8)	0.9 (0.6-1.1)	0.6 (0.4-0.7)

Table 9B. Mean harvest of striped bass per angler, per trip (HPA), with 95% confidence limits, calculated from Maryland charter boat logbook data, spring season creel survey interview data, and MRIP data, through May 15. SAFIS data were combined with the charter logbook data from 2011 through the present.

Year	Charter Trips	Charter Mean HPA	Private Creel Mean HPA	MRIP Mean HPA
2002	1,424	0.78 (0.76-0.79)	0.4 (0.3-0.6)	0.1 (<0.1-0.2)
2003	1,393	0.93 (0.92-0.94)	0.4 (0.3-0.5)	0.6 (0.3-0.8)
2004	1,591	0.88 (0.86-0.89)	0.7 (0.5-0.8)	0.4 (0.3-0.6)
2005	1,965	0.88 (0.87-0.89)	--	0.7 (0.5-0.8)
2006	1,934	0.86 (0.87-0.85)	0.5 (0.2-0.7)	0.5 (0.2-0.9)
2007	1,607	0.69 (0.68-0.71)	0.3 (0.2-0.3)	0.2 (0.1-0.3)
2008	1,755	0.79 (0.78-0.81)	0.2 (0.2-0.3)	0.5 (0.1-0.9)
2009	1,849	0.81 (0.80-0.82)	0.3 (0.3-0.4)	0.6 (0.4-0.8)
2010	1,986	0.76 (0.75-0.77)	0.4 (0.3-0.5)	0.3 (0.1-0.6)
2011	1,849	0.78 (0.77-0.80)	0.3 (0.3-0.3)	0.4 (0.2-0.5)
2012	1,546	0.67 (0.64-0.71)	0.2 (0.1-0.2)	0.3 (0.1-0.5)
2013	1,822	0.75 (0.74-0.77)	0.3 (0.3-0.4)	0.2 (0.1-0.4)
2014	1,481	0.82 (0.81-0.84)	0.3 (0.3-0.4)	0.7 (0.5-1.0)
2015	1,392	0.45 (0.43-0.47)	0.1 (0.0-0.1)	0.3 (0.2-0.5)
2016	1,380	0.65 (0.63-0.67)	0.2 (0.2-0.3)	0.4 (0.3-0.5)
2017	995	0.41 (0.39-0.42)	0.1 (<0.1-0.1)	0.2 (0.2-0.3)
2018	713	0.35 (0.33-0.37)	--	0.1 (<0.1-0.1)
2019	347	0.26 (0.23-0.29)	--	0.1 (<0.1-0.1)
2020	185	0.52 (0.48-0.57)	--	COVID-19
Mean	1,432	0.69 (0.6-0.77)	0.3 (0.2-0.4)	0.4 (0.3-0.5)

Table 10A. Private boat mean catch, effort, and catch per hour, with 95% confidence limits, from the Maryland striped bass spring season creel survey interview data and MRIP interview data, through May 15. Catch is defined as number of fish harvested plus number of fish released.

Year	Private Boat catch/trip	Private Boat hours/trip	Private Boat catch/hour	MRIP catch/trip	MRIP hours/trip	MRIP catch/hour
2002	1.6 (0.9-2.4)	4.9 (4.3-5.5)	0.3 (0.2-0.5)	0.9 (0.3-1.6)	5.5 (4.9-6.2)	0.1 (<0.1-0.2)
2003	1.8 (0.9-2.8)	5.4 (4.8-6.0)	0.5 (0.2-0.7)	1.9 (1.2-2.6)	4.5 (4.0-5.1)	0.4 (0.2-0.6)
2004	3.5 (2.0-4.9)	4.6 (3.8-5.3)	1.0 (0.6-1.4)	0.9 (0.6-1.2)	5.1 (4.7-5.5)	0.2 (0.1-0.2)
2005	--	2.5	--	1.9 (1.2-2.7)	3.8 (3.3-4.5)	0.6 (0.4-0.8)
2006	2.3 (1.1-3.5)	4.9 (4.2-5.7)	0.7 (0.3-1.1)	2.2 (1.3-3.3)	5.1 (4.1-6.2)	0.4 (0.3-0.6)
2007	1.6 (1.2-2.0)	5.0 (4.9-5.1)	0.3 (0.2-0.4)	0.8 (0.5-1.2)	4.9 (4.4-5.5)	0.2 (0.1-0.3)
2008	1.0 (0.7-1.3)	4.5 (4.2-4.7)	0.3 (0.2-0.4)	1.1 (0.3-1.9)	5.4 (4.2-6.6)	0.2 (0.1-0.3)
2009	1.6 (1.0-2.1)	4.7 (4.5-4.8)	0.4 (0.2-0.5)	1.4 (0.8-2.3)	4.8 (4.4-5.2)	0.3 (0.2-0.6)
2010	1.6 (1.2-2.0)	4.7 (4.5-4.9)	0.4 (0.3-0.5)	3.5 (1.0-6.7)	5.5 (4.9-6.1)	0.8 (0.2-1.6)
2011	1.2 (1.0-1.4)	4.4 (4.2-4.6)	0.3 (0.2-0.4)	1.3 (0.6-2.4)	4.0 (3.7-4.4)	0.3 (0.2-0.5)
2012	0.8 (0.5-1.1)	4.8 (4.6-5.1)	0.2 (0.1-0.3)	2.7 (0.8-5.7)	5.7 (4.8-6.5)	0.5 (0.1-1.0)
2013	1.3 (1.0-1.7)	4.4 (4.2-4.7)	0.3 (0.2-0.4)	2.0 (0.7-3.5)	4.3 (3.4-5.3)	0.5 (0.2-0.8)
2014	1.2 (1.0-1.4)	4.7 (4.4-4.9)	0.3 (0.2-0.4)	2.3 (1.1-3.9)	5.1 (4.5-5.7)	0.6 (0.3-1.0)
2015	0.7 (0.5-1.0)	6.3 (4.7-9.5)	0.2 (0.1-0.2)	1.2 (0.7-1.8)	5.2 (4.7-5.7)	0.2 (0.1-0.4)
2016	2.6 (1.5-4.0)	5.1 (4.9-5.3)	0.5 (0.3-0.8)	3.0 (1.4-5.0)	5.3 (4.8-5.8)	0.7 (0.3-1.3)
2017	0.7 (0.4-0.9)	4.6 (4.4-4.8)	0.2 (0.1-0.2)	1.4 (0.9-2.0)	5.7 (5.3-6.1)	0.3 (0.2-0.6)
2018	--	--	--	0.7 (0.4-1.0)	5.7 (5.3-6.0)	0.1 (0.1-0.2)
2019	--	--	--	0.6 (0.3-0.9)	5.5 (5.1-6.0)	0.1 (0.1-0.2)
2020	--	--	--	COVID-19	COVID-19	COVID-19
Mean	1.6 (1.2-2.0)	4.7 (4.3-5.0)	0.4 (0.3-0.5)	1.7 (1.3-2.0)	5.1 (4.8-5.3)	0.4 (0.3-0.5)

Table 10B. Charter boat mean catch, effort, and catch per hour, with 95% confidence limits, calculated from charter boat logbook data, through May 15. Catch is defined as number of fish harvested plus number of fish released. Mean hours per trip are from creel survey interview data until 2009 where the mean hours per trip are from mate interviews. SAFIS data were combined with the charter logbook data from 2011 through the present.

Year	**n**	**Mean catch/trip**	**Mean hours/trip** (From interview data)	**Mean catch/hour**
2002	1,487	5.5 (5.4-5.7)	5.5 (5.3-5.7)	1.0 (0.9-1.1)
2003	1,420	7.3 (7.0-7.6)	4.0 (3.7-4.4)	1.8 (1.7-1.9)
2004	1,629	7.4 (7.0-7.7)	4.0 (3.6-4.4)	1.8 (1.7-1.9)
2005	1,994	6.9 (6.6-7.1)	3.1 (2.6-3.5)	2.2 (2.1-2.3)
2006	1,990	8.0 (7.7-8.2)	3.6 (3.2-3.9)	2.2 (2.1-2.3)
2007	1,793	8.1 (7.8-8.4)	4.6 (4.1-5.0)	1.8 (1.7-1.8)
2008	1,755	6.4 (6.2-6.6)	--	--
2009	1,849	6.0 (5.9-6.2)	3.4 (2.9-4.0)	1.8 (1.7-1.8)
2010	1,986	5.7 (5.5-5.8)	4.4 (4.0-4.9)	1.3 (1.2-1.3)
2011	1,849	5.8 (5.6-6.0)	4.2 (3.5-4.9)	1.4 (1.3-1.4)
2012	1,546	5.0 (4.8-5.2)	5.5 (4.9-6.1)	0.9 (0.9-1.0)
2013	1,822	5.4 (5.3-5.6)	5.2 (4.7-5.7)	1.0 (1.0-1.1)
2014	1,481	5.9 (5.7-6.1)	4.8 (4.3-5.2)	1.2 (1.2-1.3)
2015	1,392	6.0 (5.7-6.4)	6.3 (6.0-6.7)	1.0 (0.9-1.0)
2016	1,380	5.2 (4.9-5.5)	5.7 (5.6-5.9)	0.9 (0.9-1.0)
2017	995	4.5 (3.9-5.1)	6.3 (6.1-6.5)	0.7 (0.6-0.8)
2018	713	4.4 (3.9-5.1)	5.8 (5.4-6.3)	0.8 (0.7-0.9)
2019	347	3.8 (3.3-4.3)	5.9 (5.5-6.4)	0.6 (0.6-0.7)
2020	185	3.0 (2.7-3.2)	6.0 (6.0-6.0)	0.5
Mean	1,432	5.8 (5.2-6.4)	4.8 (4.4-5.3)	1.3 (1.1-1.6)

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						

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 (2020).

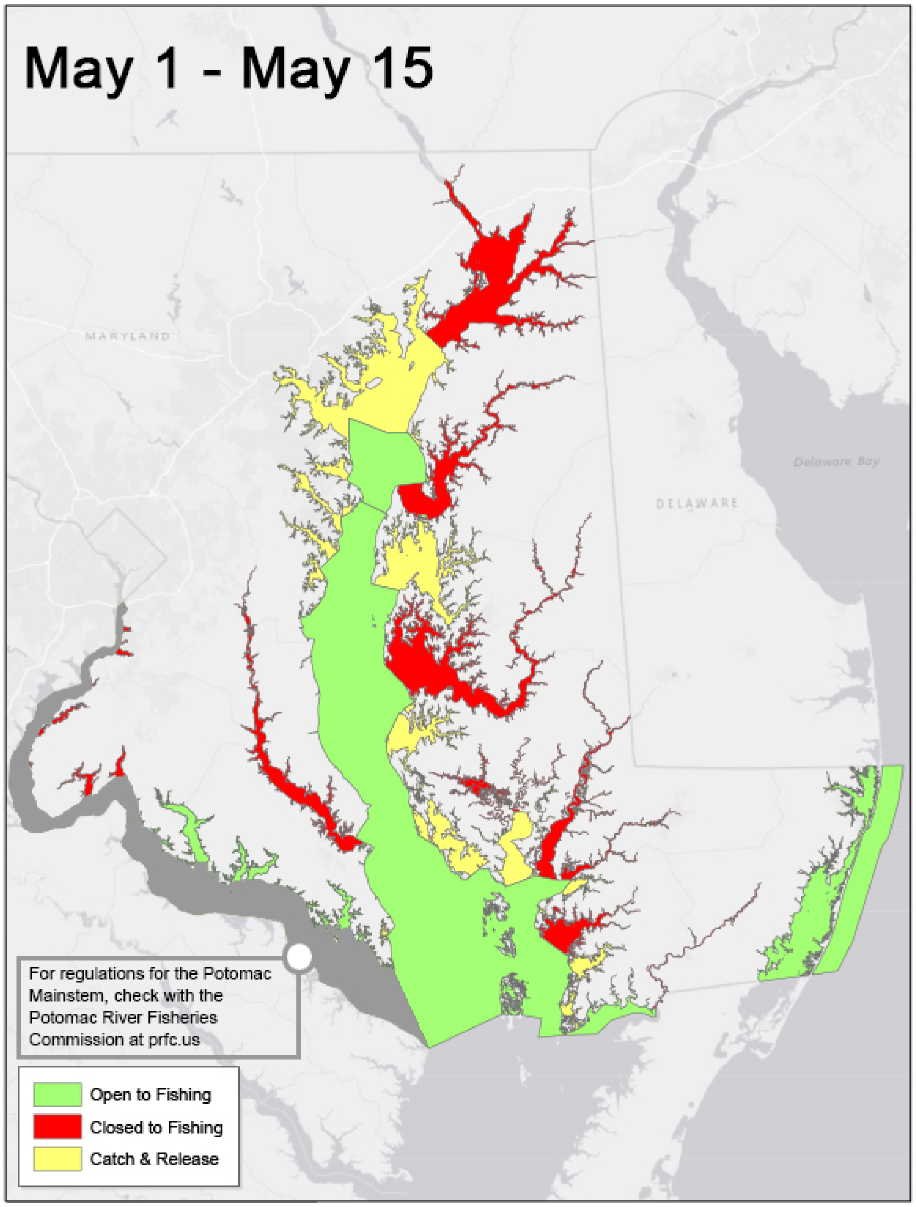


Figure 2. Length distribution of striped bass sampled by year, during the Maryland striped bass spring season creel survey, through May 15.

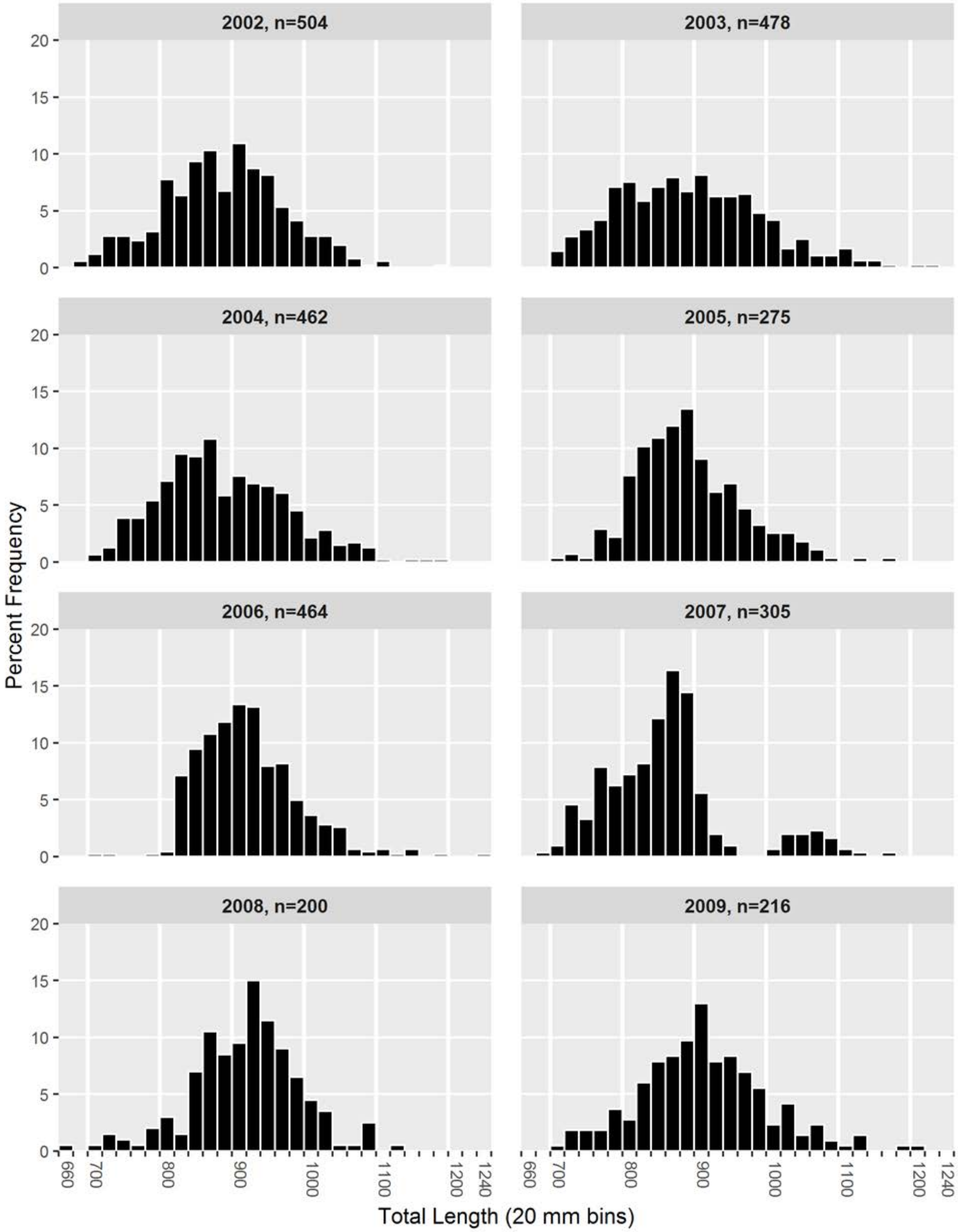


Figure 2. Continued.

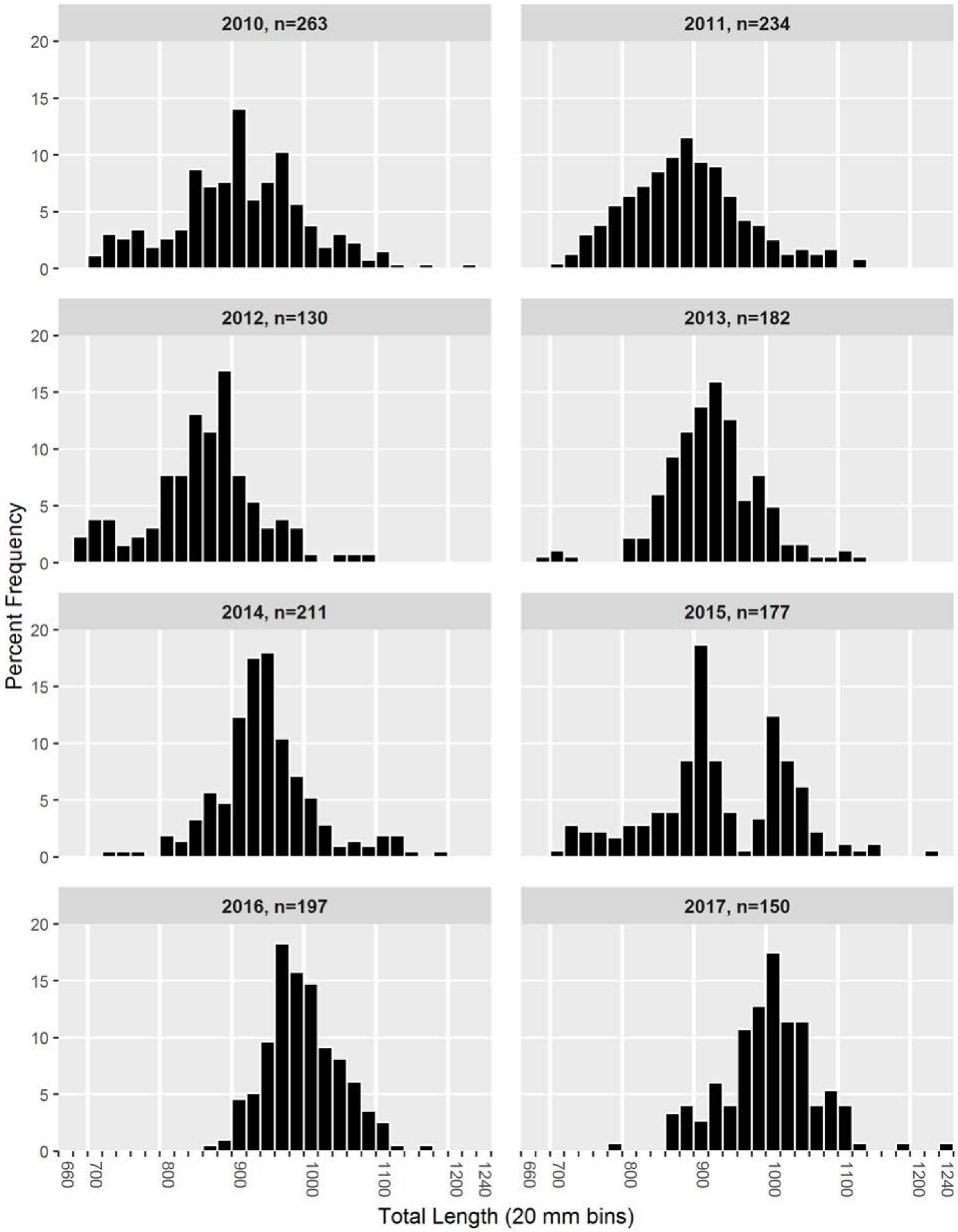


Figure 2. Continued.

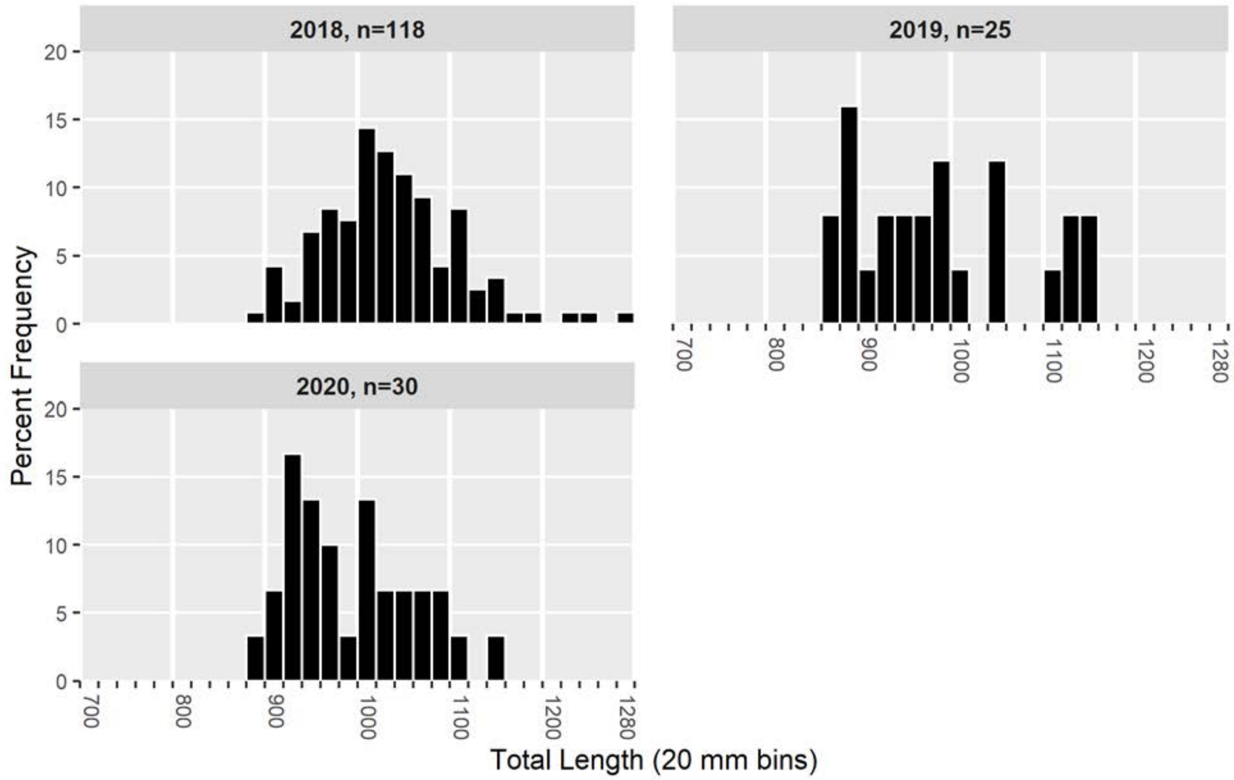


Figure 3. Mean length of female and male striped bass (mm TL) with 95% confidence intervals, sampled by the Maryland striped bass spring season creel survey, through May 15.

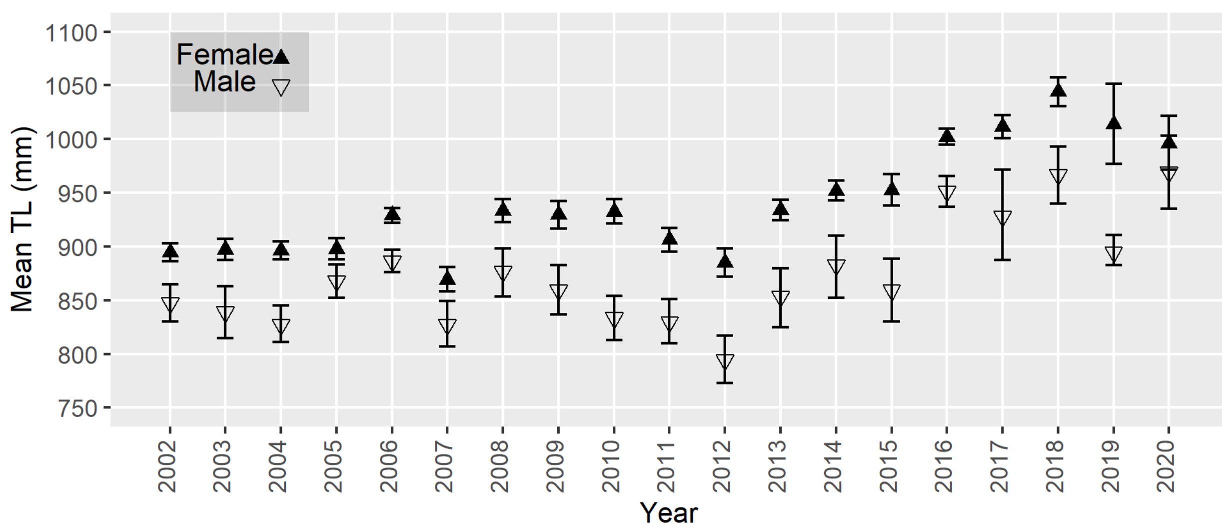


Figure 4. Mean daily length of female striped bass with 95% confidence intervals, sampled by the Maryland striped bass spring season creel survey, through May 15.

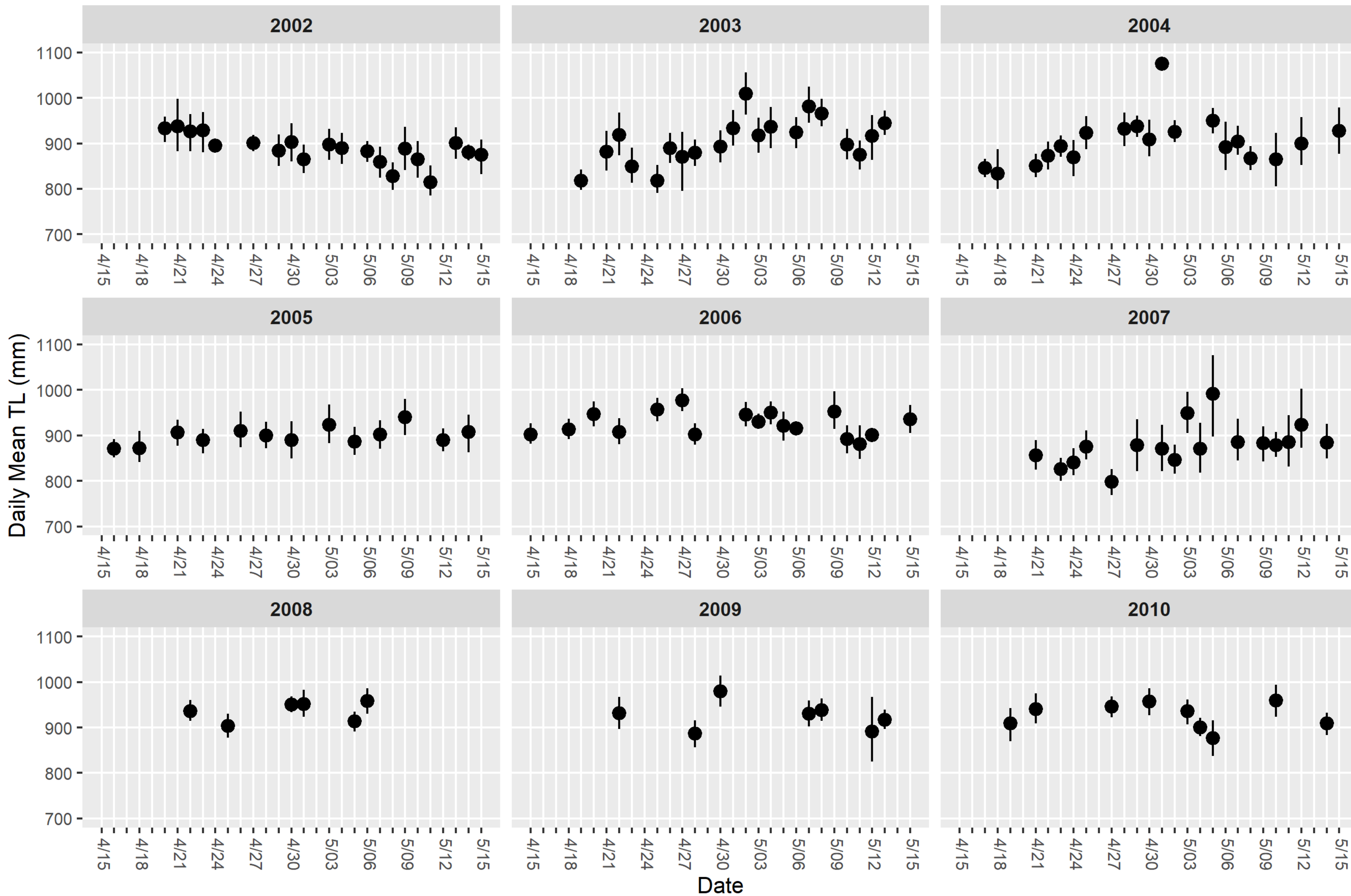


Figure 4. Continued.

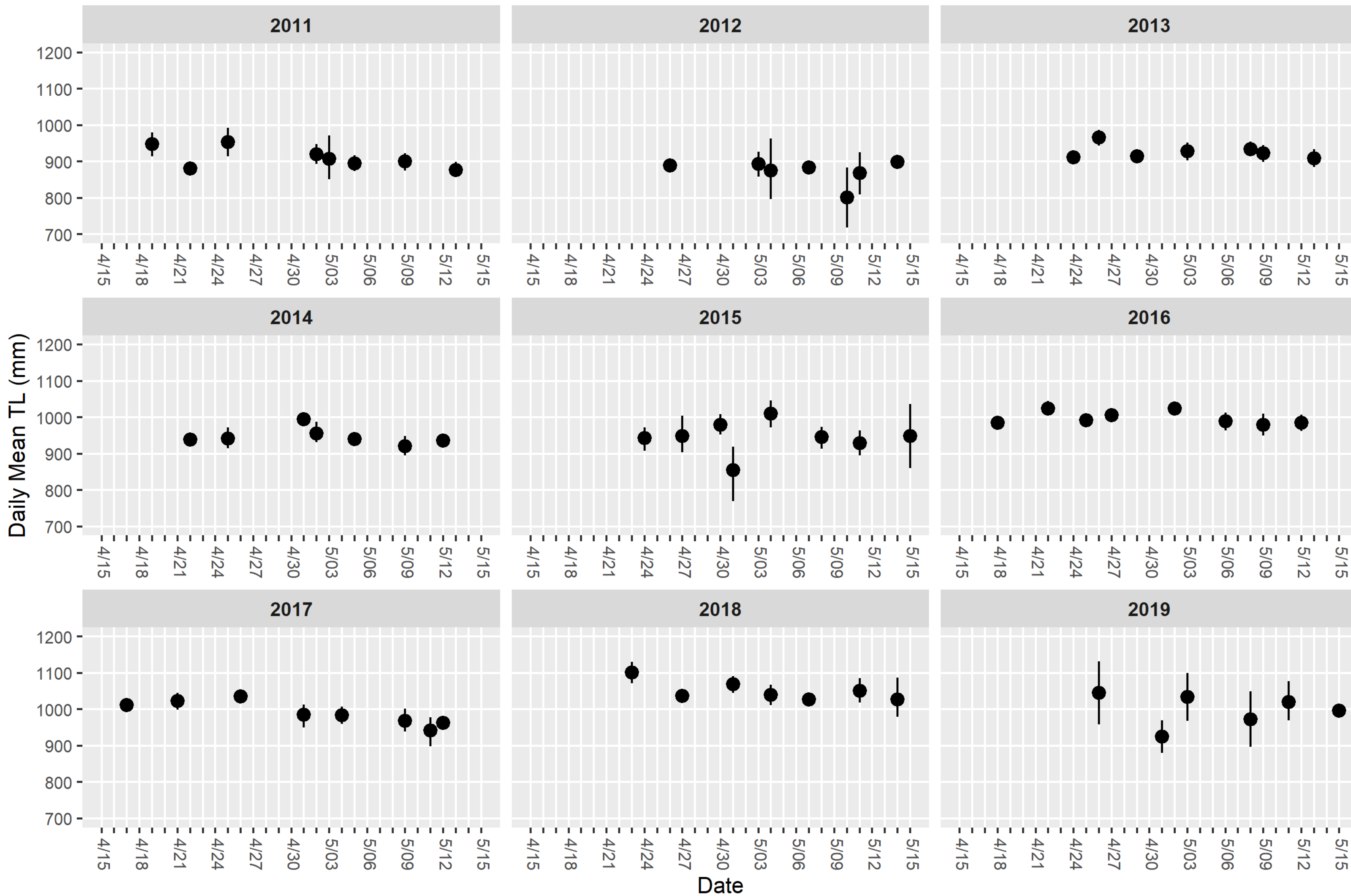


Figure 4. Continued.

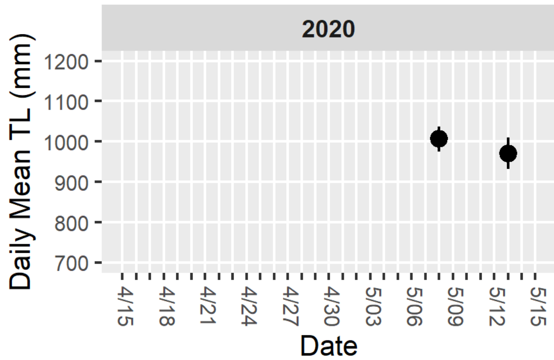


Figure 5. Mean weight of female and male striped bass (kg) with 95% confidence intervals sampled by the Maryland striped bass spring season creel survey, through May 15.

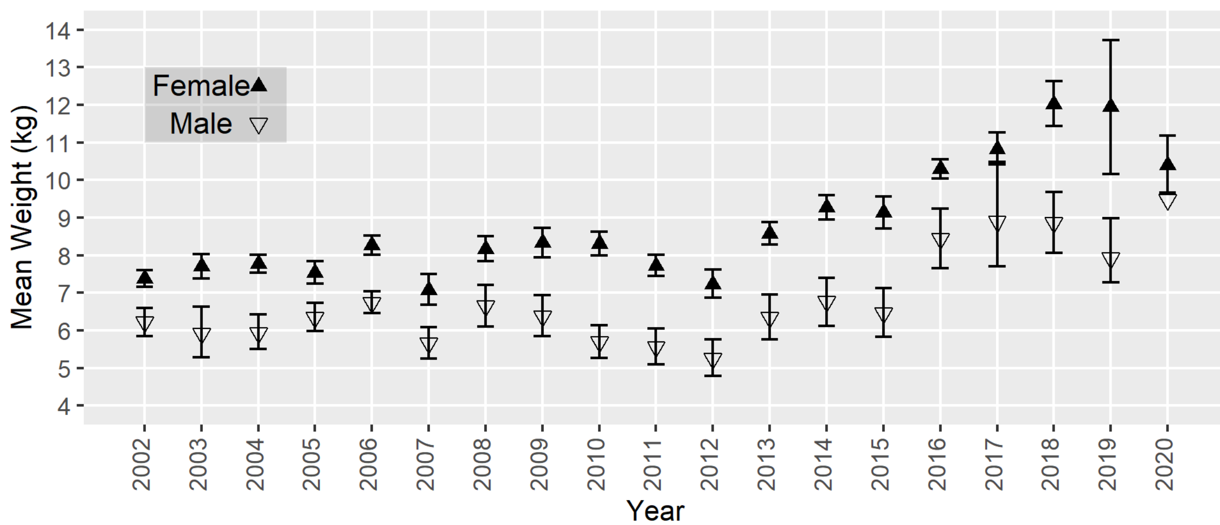


Figure 6. Estimated age distribution of striped bass sampled by the Maryland striped bass spring season creel survey, through May 15.

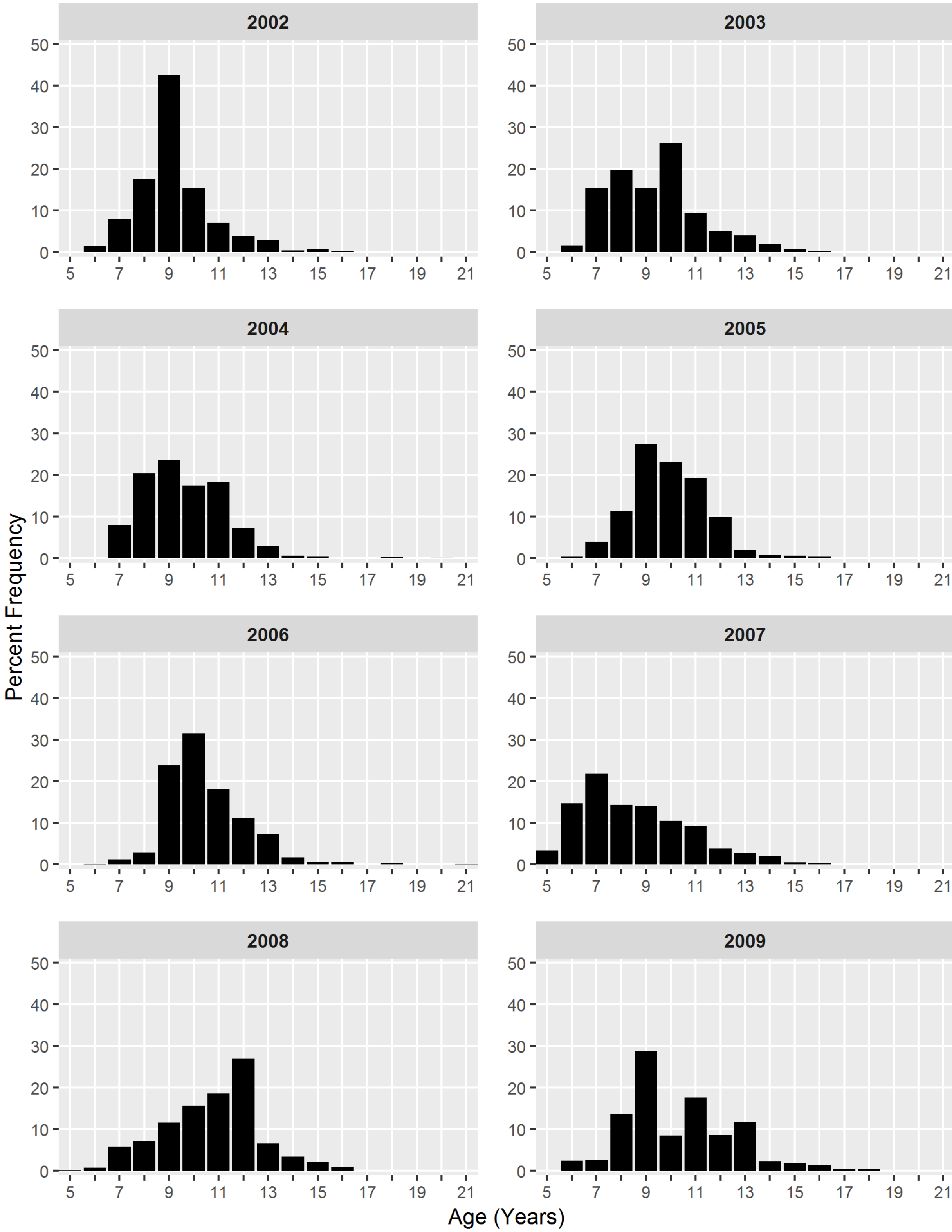


Figure 6. Continued.

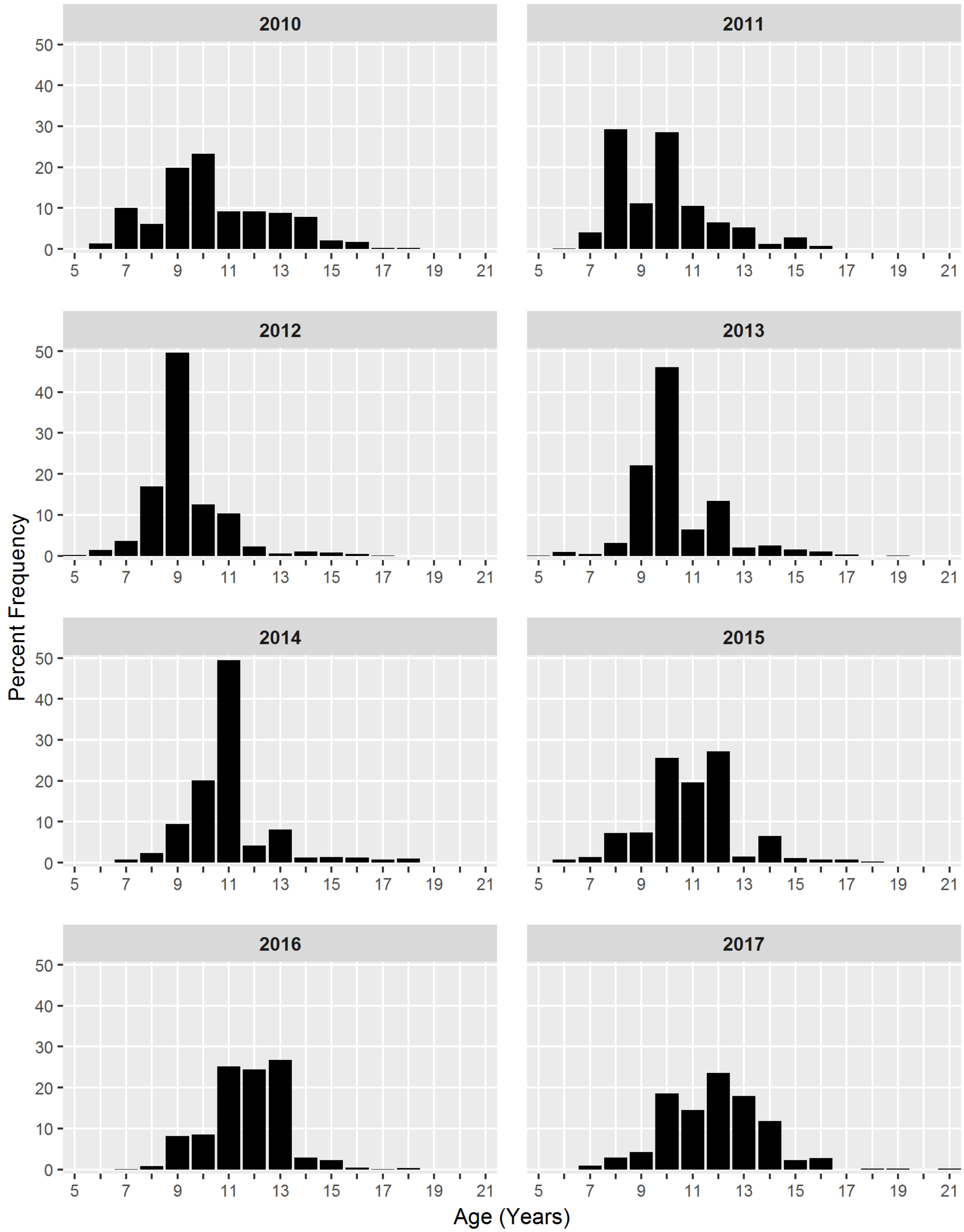


Figure 6. Continued.

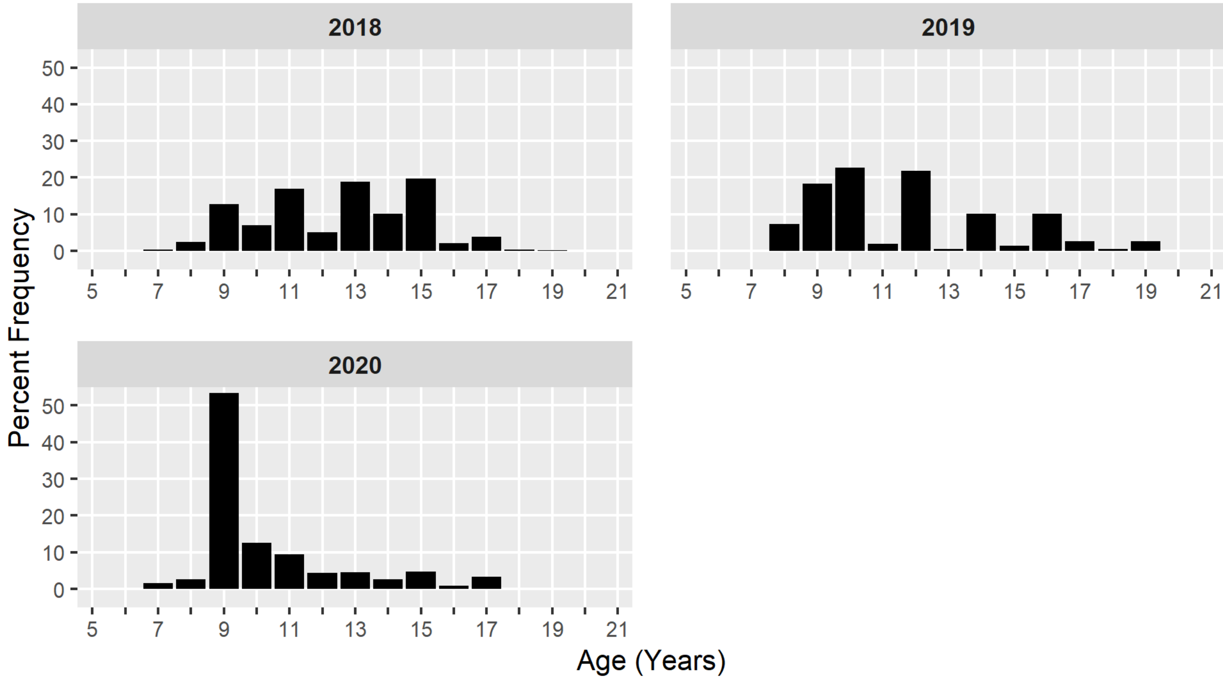


Figure 7. Proportion of pre-spawn females versus the annual mean total length (mm) of female striped bass sampled. Linear regression coefficients are intercept=339.27, slope=-0.32 (Adjusted R-squared=0.77, p<0.0001). Shading indicates 95% confidence intervals. Current year labeled for reference.

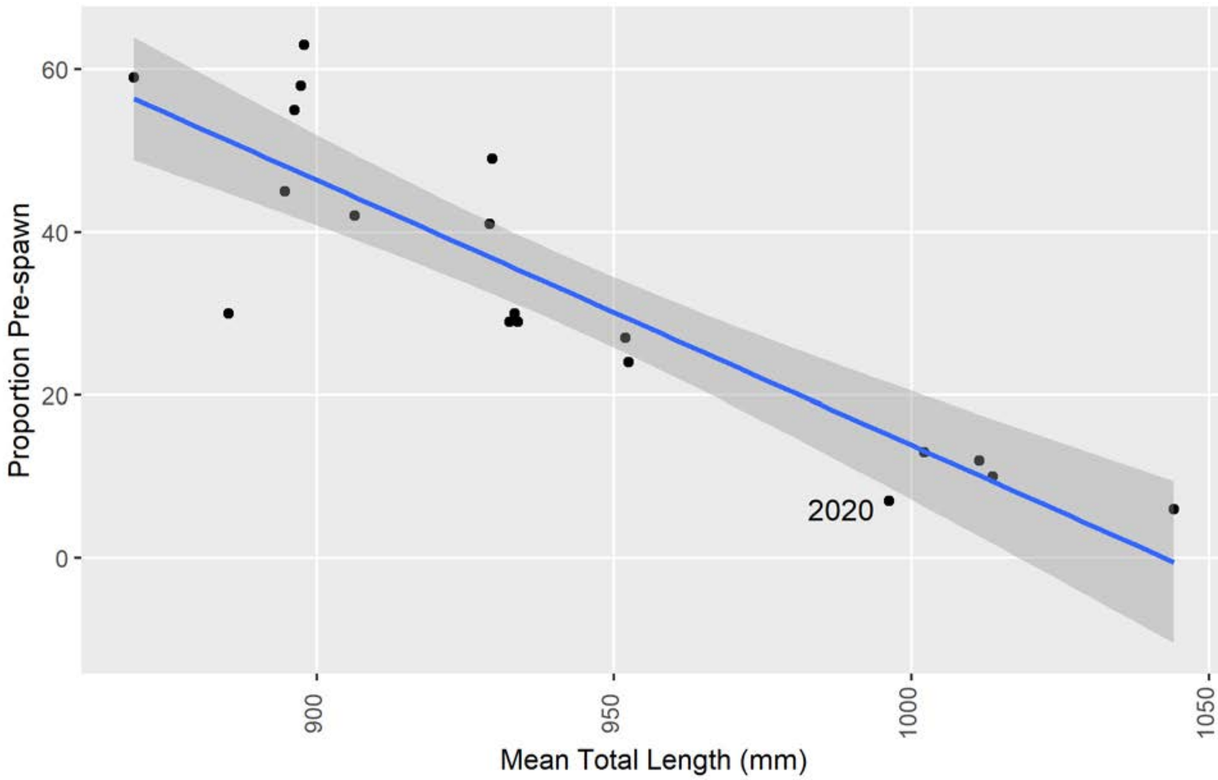


Figure 8. Daily percent of female striped bass in post-spawn condition sampled by the Maryland striped bass spring season creel survey, through May 15.

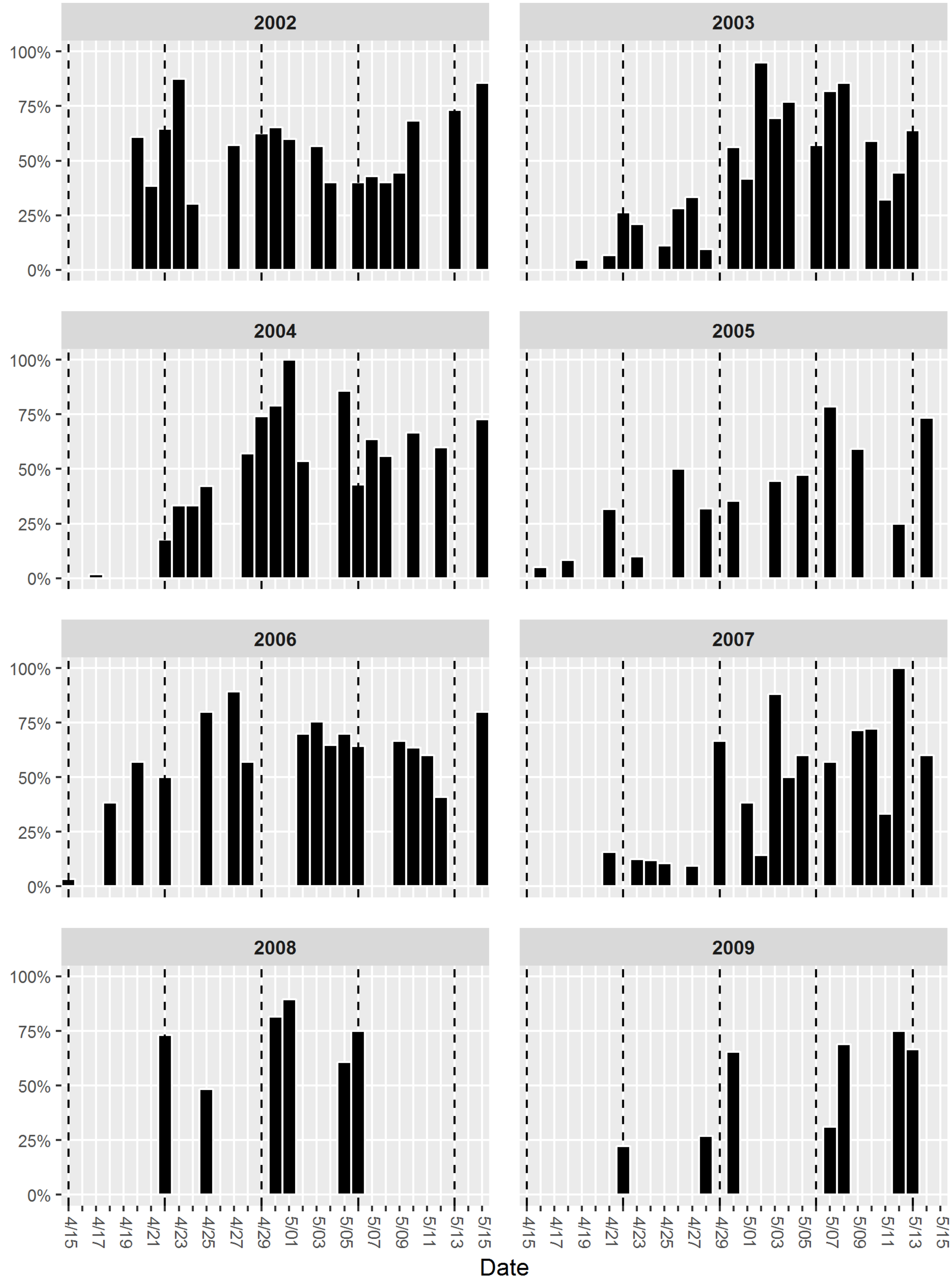


Figure 8. Continued.

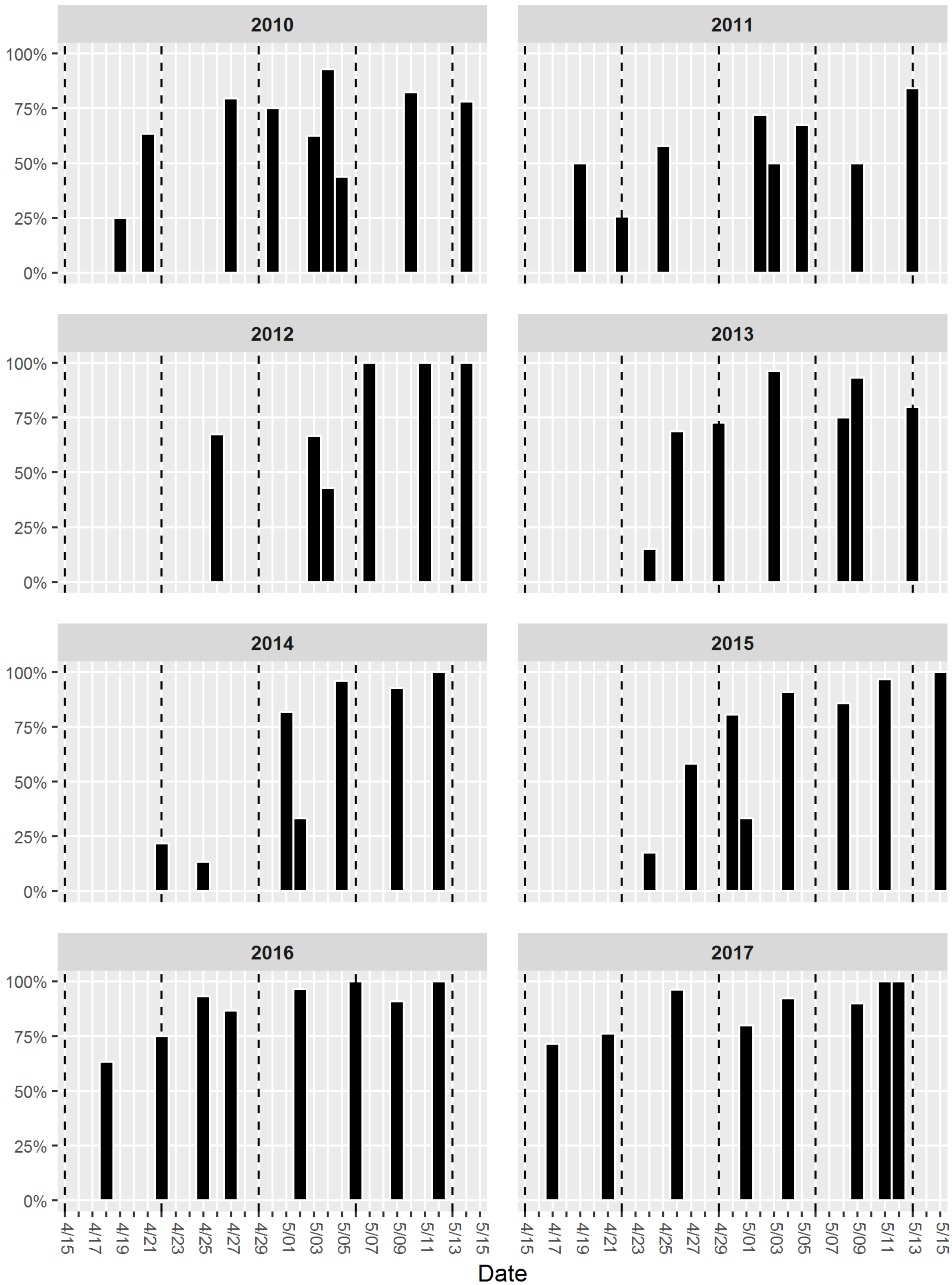


Figure 8. Continued.

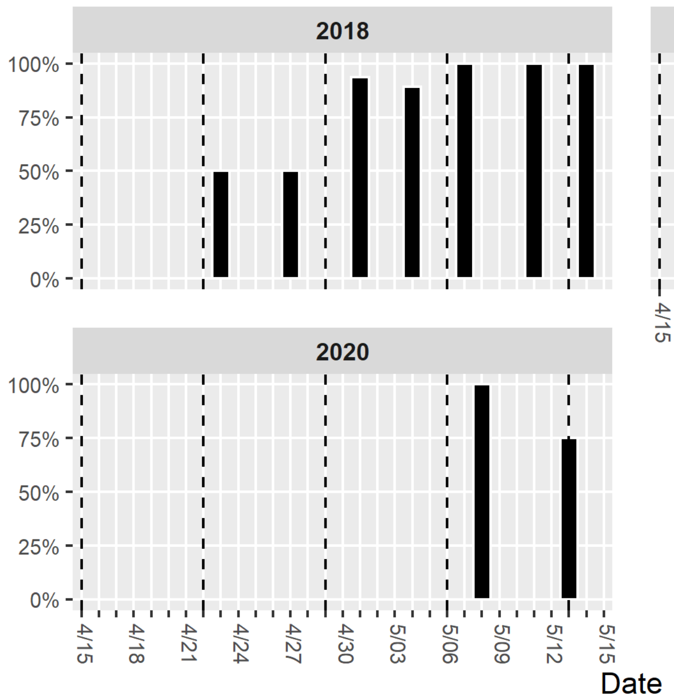
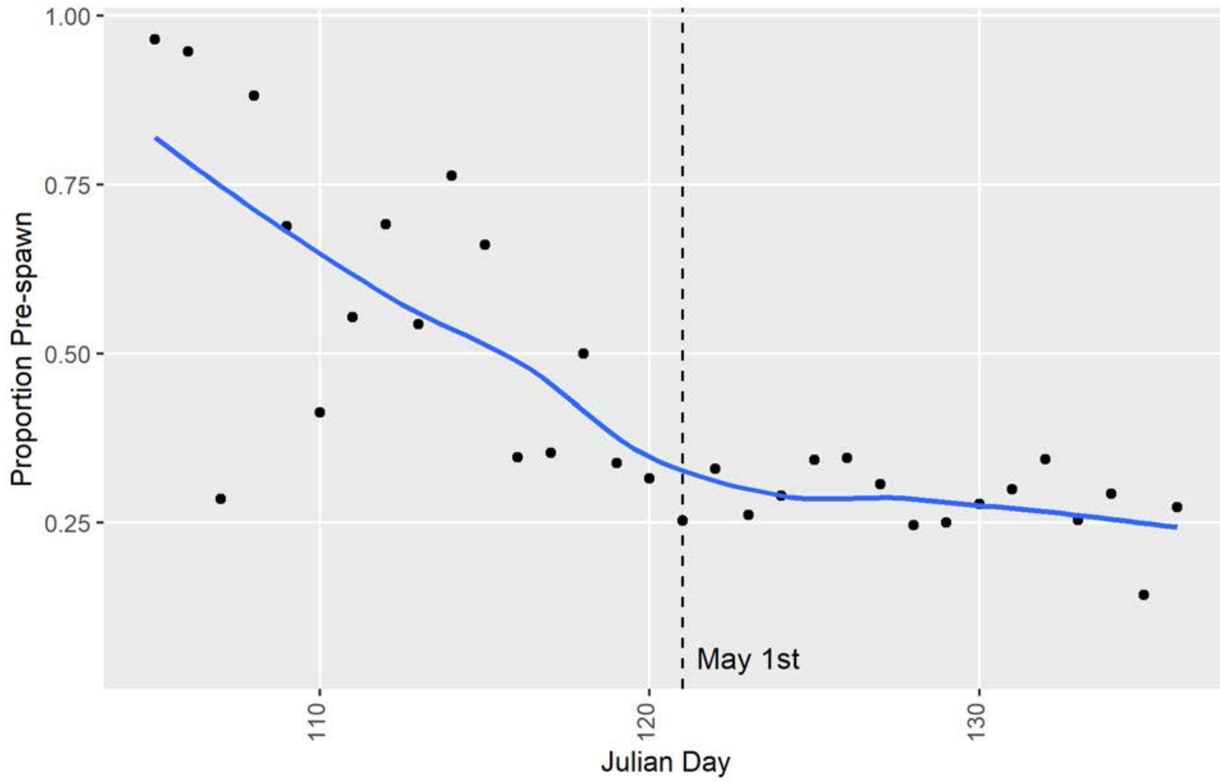


Figure 9. Proportion pre-spawn females sampled in all years of the charter creel survey summarized by sample date (Julian day). Locally weight smoothing line (loess) added for visual aid. Dashed reference line is May 1st.



PROJECT NO. 2
JOB NO. 4

INTER-GOVERNMENT COORDINATION

Prepared by Eric Q. Durell, Harry Rickabaugh, Robert J. Bourdon and Harry T. Hornick

The objective of Job 4 was to document and summarize participation of Survey personnel in various research and management forums regarding fifteen resident and migratory finfish species found in Maryland's Chesapeake Bay. With the passage of the Atlantic Coastal Fisheries Cooperative Management Act, various management entities such as the Atlantic States Marine Fisheries Commission (ASMFC), the Mid-Atlantic Migratory Fish Council (MAMFC), the Chesapeake Bay Living Resources Subcommittee (CBLRS), the Potomac River Fisheries Commission (PRFC), and the Susquehanna River Anadromous Fish Restoration Cooperative (SRAFRC), require current stock assessment information in order to assess management measures. The Survey staff also participated in ASMFC, US Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) fishery research and management forums.

Direct participation by Survey personnel as representatives to various management entities provided effective representation of Maryland interests through the development, implementation and refinement of management options for Maryland as well as coastal fisheries management plans. In addition, survey information was used to formulate management plans for thirteen finfish species as well as providing evidence of compliance with state and federal regulations. A summary of this participation and contributions is presented below.

Alosines:

Project staff attended SRAFRC meetings as Maryland representatives to discuss American shad and river herring stock status, restoration, and management in the Susquehanna River.

The ASMFC Technical Committee representative served as a member of the Plan Review Team, attended the American shad Technical Committee meetings, and prepared the annual American Shad and River Herring Compliance Report for Maryland. Alosine project staff prepared data, analyses, and a summary report for the American shad benchmark stock assessment. A staff member participated in multiple shad and river herring technical committee conference calls to develop improvements to Amendments 2 and 3.

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 2021 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 an addendum 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.

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 a conference call of the ASMFC red drum technical committee and stock assessment subcommittee and presented at the red drum simulation assessment data and methods workshop.

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 elected chair of the newly created Spot Technical Committee (TC) and prepared the ASMFC Annual Maryland Spot Compliance Report. Staff member was also assigned to the Traffic Light Analysis (TLA) Subgroup of the TC and the assisted in updating the 2021 TLA.

Spotted Seatrout:

Staff prepared the Maryland Spotted Seatrout Compliance Report required by ASMFC.

Striped Bass:

Staff also 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 and participated in one webinar of the TC to review sampling requirements required by the ASMFC Fisheries Management Plan for Weakfish.

PROJECT NO. 2
JOB NO. 4

INTER-GOVERNMENT COORDINATION

2021 PRELIMINARY RESULTS – WORK IN PROGRESS

A staff member served as Spot Technical Committee (TC) chair and led a webinar of the TC to finalize the 2021 Spot Traffic Light Analysis (TLA) and prepared a presentation to be given to the ASMFC Sciaenid Board. Staff also participated in webinar of the Atlantic Croaker TC to finalize the 2021 TLA. Staff also participated in multiple conference calls of the Susquehanna River Anadromous Fish Restoration Cooperative Technical Committee to discuss fish passage issues, invasive species, and dam relicensing. Staff participated in multiple webinars to continue work on draft Addendum I to Amendment III of the ASMFC Atlantic Menhaden FMP.

Staff served on the ASMFC Striped Bass Plan Development Team (PDT) working to develop Addendum 7 and assisted by completing analyses, drafting document sections, and attending multiple PDT webinars

Staff completed and submitted required ASMFC compliance reports for alewife herring, American shad, Atlantic croaker, Atlantic menhaden, black drum, blueback herring, bluefish, red drum and striped bass. Staff reviewed state compliance reports to ASMFC fisheries management plans for alewife herring, American shad, blueback herring, Atlantic Menhaden, and spot, and attended the corresponding conference calls, as members of the ASMFC plan review teams for those species.

Striped Bass Data Sharing and Web Page Development

To augment data sharing efforts, Striped Bass Program staff in 2002 developed a web page within the MD DNR web site presenting historical Juvenile Striped Bass Survey (Job 3) results. This effort has enabled the public to access Striped Bass Program data directly. In 2016, the Program's web presence was expanded to include individual pages for many surveys conducted by the Striped Bass Program. The new web pages added survey reports, species data, glossary, and information about the biologists. The new home page can be found at http://dnr.maryland.gov/fisheries/Pages/striped-bass/index.aspx.

Total page views to specific Striped Bass Program pages for the period January 2020 to December 2020 are provided in Table 1**.** The Juvenile Index survey page is still the most viewed page by visitors. A significant spike in page views occurred in late October coinciding with the issue of the striped bass juvenile index press release. Many large or complex data requests are still handled directly by Striped Bass Program staff. However, web page access to survey information has saved staff a considerable amount of time answering basic and redundant data requests.

Table 1. Visits to the Striped Bass Program's web pages (http://dnr.maryland.gov/fisheries/Pages/striped-bass/), January 2020 through December 2020.

Striped Bass Program Project Sites	Page Views
Juvenile Index (/juvenile-index.aspx)	1,704
Home Page (/index.aspx)	693
Volunteer Angler Survey (sb_survey.aspx)	653
Commercial (/commercial.aspx)	317
Adult Spawning Stock Survey (/studies.aspx)	290
Recreational (/recreational.aspx)	201
Glossary (/glossary.aspx)	177
Reports (/reports.aspx)	161
Species (/species.aspx)	103
Biologists (/biologists.aspx)	74
Total	4,373

Project staff also provided Maryland striped bass data and biological samples such as scale and finfish samples, to other state, federal, private and academic researchers. These included the National Marine Fisheries Service (NMFS), US Fish and Wildlife Service (USFWS), University of Maryland, University of Delaware, Virginia Institute of Marine Sciences, Georgetown University, and State management agencies. For the past contract year, (July 1, 2020 through June 30, 2021) the following specific requests for information have been accommodated:

-Atlantic States Marine Fisheries Commission (ASMFC).
Provision of striped bass juvenile index data; results from fishery dependent monitoring programs and age/length keys developed from results of fishery monitoring programs; updated striped bass fishery regulations; striped bass commercial fishery data, striped bass spawning stock CPUE data; current striped bass commercial fishery data. Staff also provided bluefish recruitment data to ASMFC.

Ms. Rachel Dixon, Virginia Institute of Marine Science. Provision of historic Juvenile Seine Survey data and striped bass age-length-keys.

Ms. Aditi Gupta, Department of Fisheries and Oceans, Ontario, Canada. Provision of historic Juvenile Seine Survey data.

Mr. Ethan Doyle, Boston University Department of Biology. Provision of Seine Survey data.

Ms. Karen Limburg, SUNY Department of Environment and Forest Biology, Syracuse, New York. Provision of historic Juvenile Seine Survey data.

Ms. Kontessa Roebuck, PELA Design Architectural Landscaping, Inc. Provision of historic Juvenile Seine Survey data.

Maryland Charterboat Association (MCA). Provision of striped bass fishery regulations, APAIS Survey background information, striped bass recreational harvest information and data.

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

-Mr. Marty Gary, Potomac River Fisheries Commission (PRFC).
Provision of striped bass juvenile survey data, commercial harvest data and commercial regulation information.

-Mr. David Sikorski, CCA, Maryland. Provision of striped bass harvest estimates, APAIS Survey background information and striped bass juvenile survey data.

-The Striped Bass Program staff also provided biological information and related reports to twelve (12) additional scientists, students, retired politician's and concerned stakeholders.

Atlantic Sturgeon, Shortnose Sturgeon and Sea Turtle Interaction Summary for Chesapeake Bay Finfish Investigations
Project No.: F-61-R-16

Prepared by Paul G. Piavis, Harry W. Rickabaugh, Eric Q. Durell, Robert J. Bourdon and Harry T. Hornick

Summary

The primary objective of the Chesapeake Bay Finfish Investigations Survey, F-61-R-16, was to monitor and biologically characterize resident and migratory finfish species in the Maryland portion of the Chesapeake Bay during the 2020 – 2021 sampling season. The F-61-R Survey provides a long-term series of annual reports that provide information regarding recruitment, relative abundance, age and size structure, growth, mortality, and migration patterns of finfish populations in Maryland's Chesapeake Bay. This intent of this report is to summarize any interactions of these biological surveys with endangered species such as Atlantic sturgeon, shortnose sturgeon, and sea turtles. During the 2020 – 2021 sampling season, there were no documented Atlantic sturgeon, shortnose sturgeon or sea turtle encounters.

CONTENTS:

PROJECT I: RESIDENT SPECIES STOCK ASSESSMENT

JOB 1: Population vital rates of resident finfish in selected tidal areas of Maryland's Chesapeake Bay.

JOB 2: Population assessment of white perch in select regions of Chesapeake Bay, Maryland.

PROJECT 2: INTERJURISDICTIONAL SPECIES STOCK ASSESSMENT

JOB 1: Alosa Species: Stock assessment of adult and juvenile anadromous *Alosa* species in the Chesapeake Bay and selected tributaries.

JOB 2: Migratory Species: Stock assessment of selected recreationally important adult migratory finfish in Maryland's Chesapeake Bay.

JOB 3: Striped Bass: Stock assessment of adult and juvenile striped bass in Maryland's Chesapeake Bay and selected tributaries.

Task 1: Summer-Fall stock assessment and commercial fishery monitoring.
Task 2: Characterization of striped bass spawning stocks in Maryland.
Task 3: Maryland juvenile striped bass survey.

<u>PROJECT I</u>: **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.

<u>Introduction</u>

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

<u>Atlantic Sturgeon Interactions</u>

No Atlantic sturgeon were sampled or observed in the Upper Chesapeake Bay Winter Trawl Survey during the Survey period of July 1, 2020, through June 30, 2021.

<u>Shortnose Sturgeon and Sea Turtle Interactions</u>

No shortnose sturgeon or sea turtles were sampled or observed in the Upper Chesapeake Bay Winter Trawl Survey during the Survey period of July 1, 2020, through June 30, 2021.

2. Fishery Dependent Yellow Perch Fyke Net Survey

<u>Atlantic Sturgeon Interactions</u>

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, 2020, through June 30, 2021.

<u>Shortnose Sturgeon and Sea Turtle Interactions</u>

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, 2020, through June 30, 2021.

3. Fishery Independent Choptank River Fyke Net Survey

<u>Atlantic Sturgeon Interactions</u>

No Atlantic sturgeon were sampled or observed in the Choptank River Fyke Net Survey during the Survey period of July 1, 2020, through June 30, 2021.

<u>Shortnose Sturgeon and Sea Turtle Interactions</u>

No shortnose sturgeon or sea turtles were sampled or observed in the Choptank River Fyke Net Survey during the Survey period of July 1, 2020, through June 30, 2021.

<u>PROJECT 2</u>: **INTERJURISDICTIONAL SPECIES STOCK ASSESSMENT**

<u>JOB 1</u>: Alosa Species: Stock assessment of adult and juvenile anadromous *Alosa* in the Chesapeake Bay and select tributaries.

Research Surveys:
1. Nanticoke River Pound/Fyke Net Survey
2. Nanticoke River Ichthyoplankton Survey
3. Conowingo Dam Tailrace Tag Recapture Survey
4. North East River Gill Net Survey

1. Nanticoke River Pound/Fyke Net Survey

The Nanticoke River Survey was not conducted due to COVID-19 restrictions.

<u>Atlantic Sturgeon Interactions</u>
No Atlantic sturgeon were sampled or observed during the Survey period of this project from July 1, 2020, through June 30, 2021.

<u>Shortnose Sturgeon and Sea Turtle Interactions</u>
No shortnose sturgeon or sea turtles were sampled or observed during the Survey period of this project from July 1, 2020, through June 30, 2021.

2. Nanticoke River Ichthyoplankton Survey

The Nanticoke River Survey was not conducted due to COVID-19 restrictions.

<u>Atlantic Sturgeon Interactions</u>
No Atlantic sturgeon were sampled or observed during the Survey period of July 1, 2020, through June 30, 2021.

<u>Shortnose Sturgeon and Sea Turtle Interactions</u>
No shortnose sturgeon or sea turtles were sampled or observed during the Survey period of July 1, 2020, through June 30, 2021.

3. Conowingo Dam Tailrace Tag Recapture Survey

<u>Atlantic Sturgeon Interactions</u>
No Atlantic sturgeon were sampled or observed during the Survey period of July 1, 2020, through June 30, 2021.

<u>Shortnose Sturgeon and Sea Turtle Interactions</u>
No shortnose sturgeon or sea turtles were sampled or observed during the Survey period of July 1, 2020, through June 30, 2010.

4. North East River Gill Net Survey

<u>Atlantic Sturgeon Interactions</u>
No Atlantic sturgeon were sampled or observed during the Survey period of July 1, 2020, through June 30, 2021.

<u>Shortnose Sturgeon and Sea Turtle Interactions</u>
No shortnose sturgeon or sea turtles were sampled or observed during the Survey period of July 1, 2020, through June 30, 2010.

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
No Atlantic sturgeon were sampled or observed during the Survey period of July 1, 2020, through June 30, 2021.

Shortnose Sturgeon and Sea Turtle Interactions
No shortnose sturgeon or sea turtles sampled or observed during the Survey period of July 1, 2020, through June 30, 2021.

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, 2020, through June 30, 2021.

Shortnose Sturgeon and Sea Turtle Interactions
No shortnose sturgeon or sea turtles sampled or observed during the Survey period of July 1, 2020, through June 30, 2021.

<u>PROJECT 2, JOB 3</u>: Striped Bass: Stock assessment of adult and juvenile striped bass in Maryland's Chesapeake Bay and selected tributaries.

<u>Task 1</u>: Summer-Fall stock assessment and commercial fishery monitoring.

Research Survey:

1. **Summer - Fall Pound Net Survey**

<u>Atlantic Sturgeon Interactions</u>

No Atlantic sturgeon were sampled or observed during this Survey for the period of July 1, 2020, through June 30, 2021.

<u>Shortnose Sturgeon and Sea Turtle Interactions</u>

No shortnose sturgeon or sea turtles were sampled or observed during this Survey for the period of July 1, 2020, through June 30, 2021.

<u>Task 2:</u> Characterization of striped bass spawning stocks in Maryland.

Research Survey:

1. Spring Striped Bass Experimental Drift Gill Net Survey

<u>Atlantic Sturgeon Interactions</u>

No Atlantic sturgeon were sampled or observed during this Survey for the period of July 1, 2020, through June 30, 2021.

<u>Shortnose Sturgeon and Sea Turtle Interactions</u>

No shortnose sturgeon or sea turtles were sampled or observed during this Survey for the period of July 1, 2020, through June 30, 2021.

PROJECT 2, Job 3,

Task 3: Maryland juvenile striped bass survey

Research Survey:

1. Juvenile Striped Bass Seine Survey

Atlantic Sturgeonn Interactions
No Atlantic sturgeon were sampled or observed during this Survey for the period of July 1, 2020, through June 30, 2021.

Shortnose Sturgeon and Sea Turtle Interactions
No shortnose sturgeon or sea turtles were sampled or observed during this Survey for the period of July 1, 2020, through June 30, 2021.