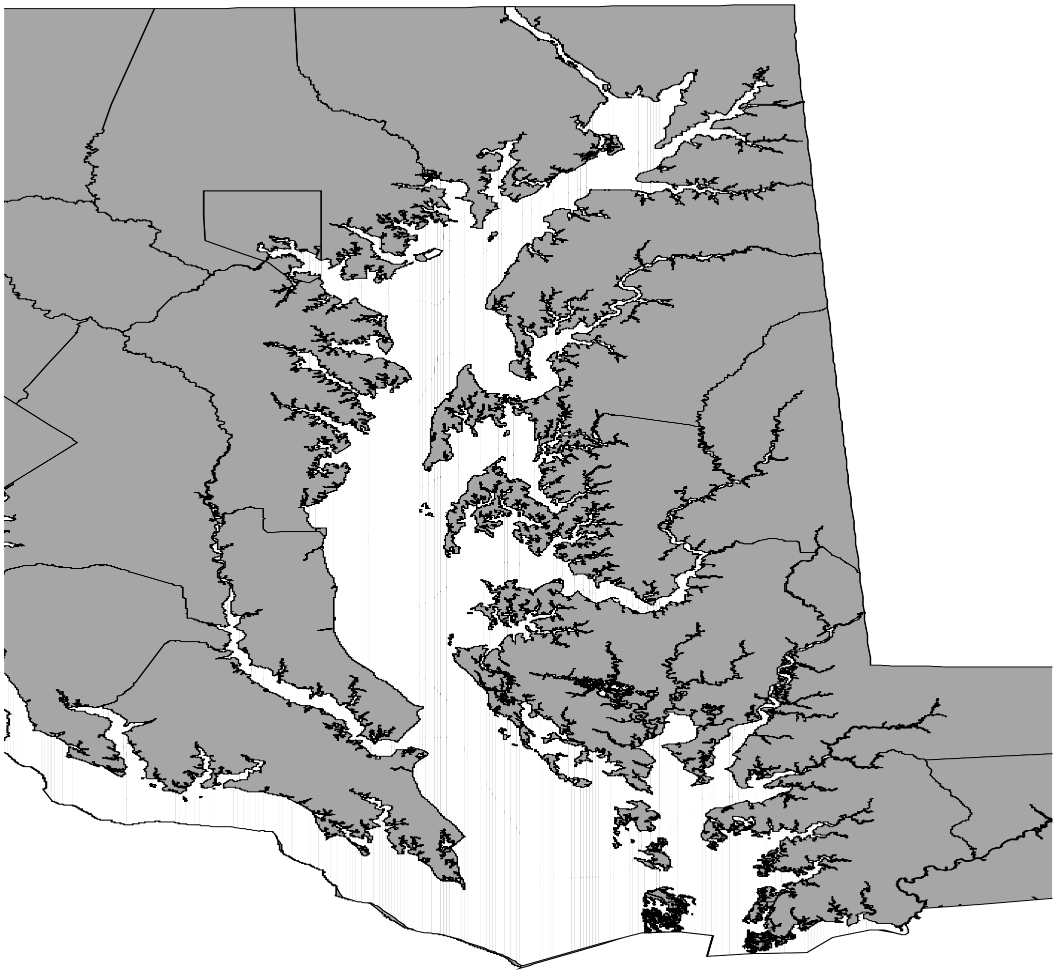

Chesapeake Bay Finfish Investigations

US FWS FEDERAL AID PROJECT
F-61-R-13
2016 - 2017

MARYLAND
DEPARTMENT OF
NATURAL RESOURCES

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

STATE: Maryland

PROJECT NO.: F-61-R-13

PROJECT TYPE: Research and Monitoring

PROJECT TITLE: Chesapeake Bay Finfish Investigations.

PROGRESS: ANNUAL X

PERIOD COVERED: July 1, 2017 through June 30, 2018

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 2017 indicated that white perch relative abundance declined relative to 2016, but remained at high levels. The 2011, 2014 and 2015 year-classes were particularly strong. Yellow perch relative abundance declined relative to 2016 and 2015. The 2011, 2014 and 2015 year-classes were strong. Channel catfish relative abundance also declined and was below the time-series average.

White perch relative abundance increased in the Choptank River Fyke Net Survey in 2017. Similar to the upper Bay trawl, the 2011, 2014, and 2015 year-classes were strong. Yellow perch relative abundance was low in 2017, but catches were impacted by the extra-ordinarily warm February and March time period. Channel catfish relative abundance continued a 3 year decline in

relative abundance and was below the time-series average. White catfish continued a four-year increase in relative abundance, and was above the time series average.

White perch population dynamics were modeled with a Catch Survey Analysis model for upper Chesapeake Bay and Choptank River stocks, separately. In the upper Chesapeake Bay, total population size exhibited a strong increasing trend in both pre-recruit and post-recruit abundance after 2014 and 2015, respectively. This increase was also validated by the Estuarine Juvenile Finfish Survey upper Bay young-of-year white perch index which discerned a very strong 2011 year-class and above average values for 2014 and 2015. Estimated fishing mortality (F) has declined since 2006 when F was at the limit. There was a zero percent probability that F exceeded the target, indicating that the stock was not overfished. The Choptank River assessment indicated that that total population abundance declined after reaching a peak in 2011 (time series = 1989 – 2016). 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. Instantaneous fishing mortality has been below the target since 2013.

White perch population dynamics were inferred from fishery dependent trends in the lower Chesapeake Bay. 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, followed by a decline. The decline persisted until around 2007 with the indices indicating an increasing population through 2016.

U.S. Atlantic coastwide 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. American shad were angled from the Susquehanna River below Conowingo dam from 20 April through 30 May 2017, and 266 were successfully scale-aged. The 2013 (age 4) year-class was the most abundant for male and the 2012 (age 5) year -class was most abundant for female American shad in 2017. Estimates of abundance for American shad in the lower Susquehanna River slightly decreased in 2017, and remain well below time-series peak values observed in the early 2000's. Relative abundance of American shad in the Potomac River has significantly increased over the time series (1996-2017), and remained above average in 2017. Relative abundance in the Nanticoke River declined in 2017, is highly variable and shows no significant trend over the time series. In 2017, the juvenile American shad abundance index increased in the Upper Chesapeake Bay, declined in the Nanticoke River and was similar to the 2016 estimate for the Potomac River The Potomac River American shad juvenile abundance index continues to be the highest index in Maryland's portion of Chesapeake Bay.

Previously, hickory shad age structure has remained relatively consistent, with a wide range of ages and a high percentage of older fish. However, the past seven years (2012-2017) have seen no hickory shad over the age of 7. This suggests the age structure of hickory shad has become truncated in recent years.

Biologists sampled alewife and blueback herring from commercial pound and fyke nets in the Nanticoke River from 3 March through 28 April 2017. River herring CPUE in the Nanticoke River has declined over the time series (1989-2017) and continues to be very low. Mean length continues to decline for blueback herring in this river. A multi-panel experimental anchored sinking gill net was deployed in the North East River from 2013-2017 to assess the river herring spawning stock in the upper Chesapeake Bay. The gill net was fished at four randomly chosen sites once a week from 6 March to 17 May 2017. Relative abundance of both species in the North East River declined in 2017. The 2014 year-class (age 3) was the most abundant for the spawning stock of both species. The juvenile abundance indices indicate alewife and blueback herring recruitment increased in the Nanticoke River in 2017, and that alewife recruitment declined in the Upper Bay region in 2017, while blue back herring recruitment increased.

Weakfish have experienced a sharp decline in abundance coast-wide. Recreational harvest estimates for inland waters by the NMFS for Maryland waters declined from 471,142 fish in 2000 to 754 in 2006, and has fluctuated at a very low level from 2007 through 2016, with an estimated 1013 weakfish harvested in 2016. The 2016 Maryland Chesapeake Bay commercial weakfish harvest of 61 pounds was well below the 1981 – 2016 Maryland Chesapeake Bay average of 43,676 pounds per year. The 2017 mean length for weakfish from the onboard pound net survey was 257 mm TL, the fourth lowest value of the time series. One weakfish measuring 338 mm TL was captured in the Choptank River gill net survey in 2017.

Summer flounder mean length from the pound net survey was 191 mm TL in 2017, which was the lowest value in the time series. The low value was due to a high proportion of juveniles that are evident in the 2017 length frequency distribution. Seventeen post-harvest summer flounder were measured during fish house sampling in 2017, with a mean total length of 392 mm and a mean weight of 636 grams. Only five summer flounder were captured in the Choptank River gill net survey in 2017. The NMFS 2016 coast wide stock assessment update concluded that summer flounder stocks were not overfished, but overfishing was occurring.

Mean length of bluefish from the onboard pound net survey in 2017 was 299 mm TL, and was the 10^{th} lowest value in the time-series. The length distribution indicated a shift back to smaller bluefish in 2016 and 2017. Bluefish sampled from seafood dealer sampling had a mean length of 405 mm TL, and a mean weight of 603 grams, indicated pound net fishermen are releasing smaller bluefish. Only three bluefish were captured in the Choptank River gill net survey in 2017. Bluefish have been encountered in low numbers all four years of the survey (3 – 24 fish per year). Reported Maryland bluefish commercial and charter boat harvest and inland recreational estimates in 2016 were all well below their time series means. The 2015 coast wide stock assessment update indicated the stock was not overfished and overfishing was not occurring.

The mean length of Atlantic croaker examined from the onboard pound net survey in 2017 was 258 mm TL, and was the fourth lowest value of the 25 year time series. Atlantic croaker sampled from seafood dealers had a mean total length and weight of 262 mm and 270 grams. Atlantic croaker age structure from pound net samples was truncated to age six, and was dominated by the 2012 year class (age 5). 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 in 2016 and 2017 with 32 and 53 fish being captured respectively. Maryland 2016 Atlantic croaker Chesapeake Bay commercial harvest, inland waters recreational harvest estimate and charter boat harvest values all declined from 2015, and all three were well below their long term means. The Atlantic croaker juvenile index had decreased steadily from 2012 to 2015. The juvenile index value increase in 2016 and 2017, and was near the 29 year time-series mean in 2017.

The 2017 spot mean length of 200 mm TL was near the 25 year time-series, and the length frequency distribution expanded in 2107. Spot aged from the onboard pound net survey were predominately age one, with very few age two fish. Spot catch in the Choptank River gill net survey was highest in 2014, similar in 2013, 2015 and 2017, and lowest in 2016. Chesapeake Bay commercial spot harvest was similar in 2013 and 2014, but declined sharply in 2015 and 2016. The inland waters recreational harvest estimate in 2016 was below the time-series mean. The spot juvenile index values in 2014, 2015 and 2016 were the 4th, 1st and 7th lowest values respectively, in the 29 year time-series. The 2017 index value increased, but was still below the time series mean.

Mean length for Atlantic menhaden sampled from the onboard pound net survey in 2017 was 217 mm FL, the third lowest value of the 14 year time-series. Pound net caught Atlantic menhaden from seafood dealer sampling had a mean length of 218 mm TL. The 2017 length frequency distribution was dominated by the 190 and 210 millimeter size groups, and was less evenly distributed than in 2016. 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 (2016) to 2,247 fish (2014). Mean lengths for all meshes combined displayed little inter-annual variation from 2013-2016, but did decrease slightly in 2017. 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 2016 season ranged in age from 1 to 11 years old. Five year old striped bass from the above average 2011 year-class dominated biological samples taken from pound nets and made up 32% of the sample. Check station sampling determined that the commercial summer/fall fishery harvest was comprised of four to twelve year-old striped bass from the 2004 through 2012 year-classes.

The December 2016 - February 2017 commercial drift gill net harvest consisted primarily of age 6,7, and 8 year-old striped bass from the 20011, 2010 and 2009 year-classes that composed 85% of the total harvest. The contribution of fish older than age 9 was 13% to the gill net fishery. The youngest fish observed in the 2016-2017 sampled harvest were age 5 from the 2012 year-class. Striped bass present in commercial drift gill net samples collected from check stations ranged in age from age 5 to 12 years old (2012 to 2005 year-classes).

Striped bass harvested during the 2016-2017 Atlantic coast commercial fishing season ranged from age 6 (2011 year-class) to age 16 (2001 year-class) with nine different year-classes represented in the sampled harvest. The most common age represented in the catch-at-age estimate was age 10, the 2007 year-class, which represented 25% of the sampled harvest. Age 6 (2011 year-class) and age 12 (2005 year-class) fish were also significant contributors to the sample population at 19% and 16% respectively. Striped bass sampled at Atlantic coast check stations during the 2016 – 2017 season had a mean length of 916 mm TL and mean weight of 9.9 kg.

The spring 2017 spawning stock survey indicated that there were 18 age-classes of striped bass present on the Potomac River and Upper Bay spawning grounds. These fish ranged in age from 2 to 21 years old. Male striped bass ranged in age from 2 to 16 years old and females ranged in age from 4 to 21. Age 6 females from the 2011 year-class were most commonly observed, followed by age 12 (2005 year-class) and age 13 (2004 year-class). The contribution of age 8+ females to the total female CPUE was 66%. The contribution of females age 8 and older to the spawning stock has been at or above 80% since 1996, with the exception of 2011, 2013, 2016 and 2017. The time-series average is 71%. The large numbers of females from the 2011 year-class entering the spawning stock and being encountered during the survey likely contributed to the lower values in recent years.

The striped bass young-of-year index, a measure of striped bass spawning success in Chesapeake Bay, was 13.2 in 2017. The 2017 index was slightly above the 64-year average of 11.7. MD DNR biologists have conducted the Young-of-Year Survey annually since 1954 to track the reproductive success of striped bass and help predict future population abundance. The largest spawning area, the Upper Bay, was also the most productive area surveyed in Maryland in 2017. In fact, the Upper Bay young-of-year index was the eighth highest on record. Strong reproduction in three of the past seven years is an encouraging sign for the coastal population and for future fishing opportunities. During the 2017 survey, biologists collected over 33,000 fish of 62 species, including 1,741 young-of-year striped bass. Results also showed high white perch reproduction in the Upper Bay and Nanticoke River. American shad reproduction was above average, primarily due to success in the Potomac River.

During the 2017 spring recreational trophy season, biologists intercepted 264 fishing trips, interviewed 501 anglers, and examined 150 striped bass. The average total length of striped bass sampled from the spring trophy fishery was 1005 mm total length. The average weight was 10.7 kg. Striped bass sampled from the spring trophy fishery ranged in age from 7 to 21 years old. The 2005 year-class (age 12) was the most frequently observed cohort, constituting 27% of the sampled harvest. In 2017, private boats caught an average of 0.7 fish per trip, similar to 2015 while charter boats caught 4.5 fish per trip. The private boat catch per hour (CPH) was 0.2 fish per hour while charter boats had a CPH of 0.7 fish per hour.

Maryland Department of Natural Resources biologists continued to tag and release striped bass in spring 2017 in support of the US FWS coordinated interstate, coastal population study. A total of 2,680 striped bass were sampled and a total of 1,515 striped bass were tagged and released with US FWS internal anchor tags March 30 through May 16, 2017 in Maryland. Of this sample, 392 were tagged in the Potomac River and 1,123 were tagged in the upper Chesapeake Bay area during the spring spawning stock assessment survey. A total of 881 striped bass were tagged during the US FWS cooperative offshore tagging cruise in 2017.

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 RMC Environmental Services 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, Brian Richardson 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 Rick Younger and crew of the *R/V Kerhin,* and Captain Michael Hulme and crew of the *R/V Rachel Carson,* for their 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 Gary Tyler and Steve Doctor. Experimental drift gill nets were operated by B. Owen Clark, III on the Upper Chesapeake Bay and Robert A. Boarman, on the Potomac River.

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CONTENTS

SURVEY TITLE: CHESAPEAKE BAY FINFISH/HABITAT INVESTIGATIONS

CONTENTS (Continued)

PROJECT NO. 1
JOB NO. 1

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

Prepared by Paul G. Piavis and Edward Webb, III

INTRODUCTION

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

METHODS

I. Field Operations

Upper Chesapeake Bay Winter Trawl

The upper Chesapeake Bay winter bottom trawl survey is designed to collect fishery-independent data for the assessment of population trends of white perch, yellow perch, channel catfish, and white catfish. Upper Chesapeake Bay was divided into five sampling areas; Sassafras River (SAS; 3 sites), Elk River (EB; 4 sites), upper Chesapeake Bay (UB; 6 sites), middle Chesapeake Bay (MB; 4 sites), and 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 2017 through February 2017.

Trawl sites have been consistent throughout the survey, but Chester River sites were added in 2011 and weather and operational issues caused incomplete sampling in some years. The 2003 survey was hampered by ice conditions such that only one of six rounds was completed. Retirement of the captain of the R/V Laidly during 2004 led to no rounds being completed. Only 1-½ rounds of the scheduled six rounds were completed in 2005 because of catastrophic engine failure. Ice-cover prevented the final two rounds of the 2007 survey and one round of the 2009 from being completed. Ice conditions also affected the 2010 and 2011 sample years where only 56 and 66 of the scheduled 108 trawls were completed, respectively. In 2013, ice-cover prevented the sampling of several Upper Bay sites allowing the completion of 86 of the scheduled 108 hauls. In 2014 and 2015, ice-cover once again prevented the sampling of several Upper Bay sites allowing the completion of 60 of the scheduled 108 hauls in 2014 and 107 of the

144 hauls in 2015. During 2017, 137 of the scheduled 138 trawls were completed.

Choptank River Fishery Independent Sampling

In 2017, six experimental fyke nets were set in the Choptank River to sample the four resident species from this system. 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 21 February through 30 March (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 and yellow perch were removed for age determination.

Upper Chesapeake Bay Fishery Dependent Sampling

Commercial fyke net catches were sampled for yellow perch on 11 February 2017 in the Patapsco/Middle River area (Figures 3, 4), 23 February 2017 in Gunpowder River (Figures 5), and 27 February 2017 in Bush River (Figure 6). 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

From 3 March 2017 to 28 April 2017, resident species were sampled from pound nets and fyke nets set by commercial fishermen on the Nanticoke River. This segment of the survey was completed in coordination with Project 2, Job 1 of this grant. Nets were set from Barren Creek (35.7 rkm) downstream to Monday’s Gut (30.4 rkm; Figure 7). Net sites and dates fished were at the discretion of the commercial fishermen. Thirty randomly selected white perch from the fyke nets were sexed and measured and a subsample was processed for age determination (otoliths). A bushel of unculled, mixed catfish species was randomly selected, identified as channel or white catfish and total lengths measured.

II. Data compilation

Population Age Structures

Population age structures were determined for yellow perch and white perch from Choptank River and upper Chesapeake Bay (trawl and commercial sampling separately). Population age structures were also determined for Nanticoke River white perch. Age-at-length keys for yellow perch and white perch (separated by sex) from the Choptank River fyke net survey, upper Bay commercial fyke net survey (yellow perch only), and Nanticoke River (white perch only) were constructed by determining the proportion-at-age per 20-mm length group and applying that proportion to the total number-at-length. For the upper Bay trawl survey, an age-length key was constructed in 10 mm increments and the age-at-length key was applied to individual hauls. Total number by sex were added together to get total numbers at age.

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 were investigated for yellow perch (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 the EJFS seine survey within each target system, by month.

Mortality

White perch instantaneous fishing mortality (F) estimates were determined in Piavis and Webb (2018; Job 2 of this Report) for Choptank River and upper Chesapeake Bay. Nanticoke River estimates of white perch mortality were determined from catch curves of $\log_e$ transformed catch-at-age data for ages 6 – 10+. The slope of the line was –Z and M was assumed to be 0.20. Instantaneous fishing mortality (F) was Z-M.

Choptank River yellow perch mortality was estimated catch curve analysis of $\log_e$ transformed catches of ages 4 – 8. The wildly unequal recruitment and annual changes in catchability proved difficult to overcome in estimating Choptank River mortality. Instantaneous mortality rates for yellow perch from the upper Bay commercial samples were calculated with a statistical catch-at-age model (Piavis and Webb 2017) 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 1+ abundance in the winter trawl survey. Any yellow perch < 130 mm, white perch < 110 mm, and channel catfish < 135 mm were assumed 1+. 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 Howell Pt., Sassafras River Natural Resources Management Area, Handy's Creek, Elk Neck Park, Parlor Pt., and Welch Pt. permanent sites were used to determine the yellow perch juvenile relative abundance index. The index is reported as an average $\log_e$ (catch+1) index. 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 new 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 18 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 1-3
Yellow perch	Tables 3-6

Population Length Structures

White perch	Tables 7-9 and Figures 8-10
Yellow perch	Tables 10-12 and Figures 11-13
Channel catfish	Tables 13-15 and Figures 14-16
White catfish	Tables 16-18 and Figures 17-19

Growth

White perch	Tables 19-20
Yellow perch	Tables 21-22

Mortality

White perch	Table 23
Yellow perch	Table 24

Recruitment

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

Relative Abundance

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

PROJECT NO. 1
JOB NO. 1

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

2017 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 129 of the 138 proposed tows. The trawl survey began January 15, 2018 and concluded on February 14, 2018. The survey collected 92,825 white perch, yielding 4,904 length measurements and 151 age samples (otoliths). Yellow perch numbered 933 with 544 length measurements and 139 age samples (otoliths). The catfish complex yielded 2,187 channel catfish (944 measurements) and 110 white catfish (108 measurements).

Three sampling days were allocated to characterize the commercial yellow perch fishery. However, 3,662 yellow perch were measured and 165 fish were sacrificed for age determination. Areas sampled included Gunpowder River (February 17 and 22, 2018), Patapsco rivers (February 17, 2017), and Bush River (February 28, 2018).

The Choptank River fyke net survey started February 20, 2018 and ended April 13, 2018. A total of 30,303 white perch were collected, yielding 3,114 length measurements and 176 age samples. Yellow perch numbered 3,513 (3,512 measurements and 210 ages); channel catfish numbered 643 (575 measurements) and white catfish numbered 1,467 (1,149 length measurements).

To date, all age samples have been processed, and all data were tabulated from all surveys for all species. General trends included increasing yellow perch and white perch relative abundance metrics, due largely to large year-classes in 2011, 2014 and 2015 for both species. Conversely, the 2016 and 2017 year-class for both species are particularly weak and will likely prevent population growth.

In addition to these surveys, Job 1 tabulates data from the Nanticoke River Alosid survey from white perch, channel 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. The data are currently being entered into a database and will be analyzed when available.

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Piavis, P. and E. Webb, III. 2018. Population assessment of white perch in select regions of Chesapeake Bay, Maryland. In, Chesapeake Bay Finfish Investigations. Maryland Department of Natural Resources Fisheries Service Report F-61-R. Annapolis, Maryland.

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Figure 1. Upper Chesapeake Bay winter trawl survey locations, January 2017 – February 2017. Different symbols indicate each of 6 different sampling rounds.

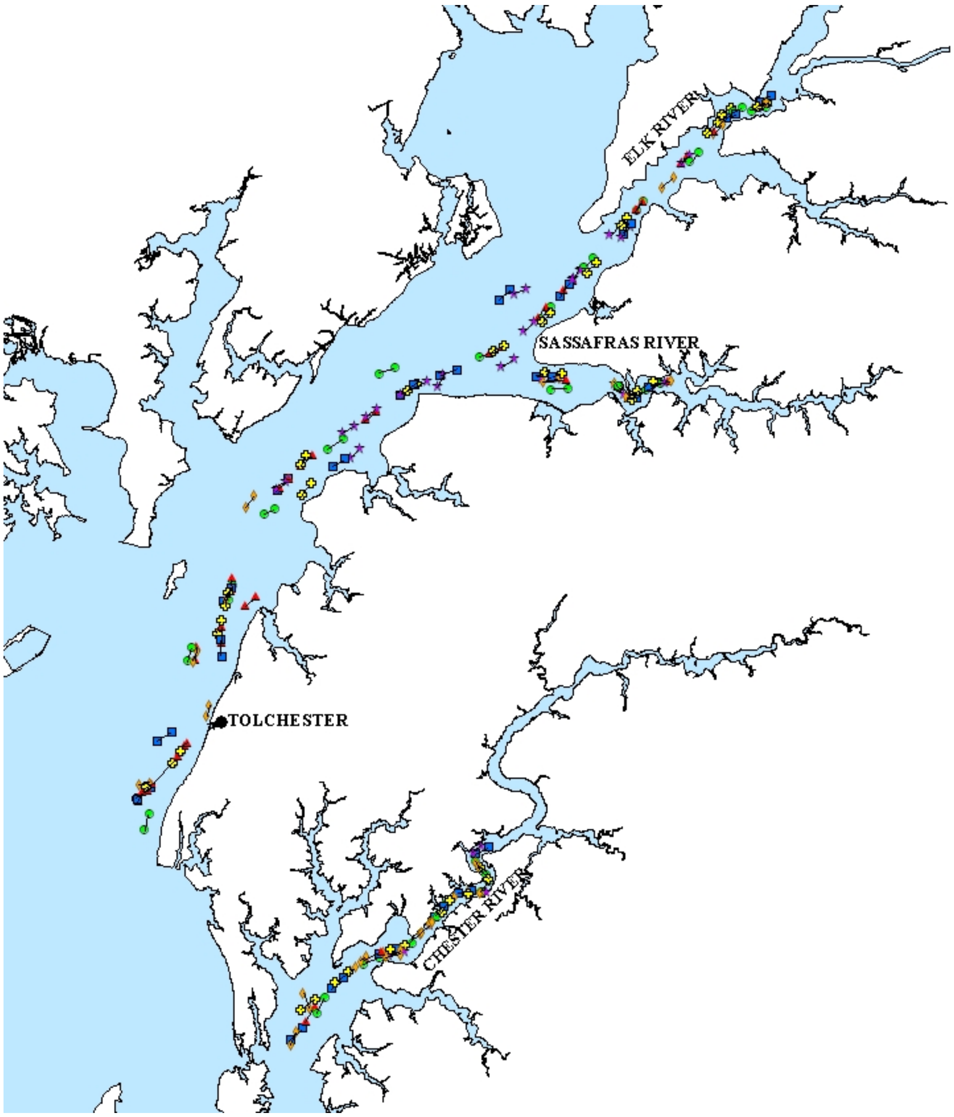


Figure 2. Choptank River fyke net locations, 2017. Circles indicate sites.

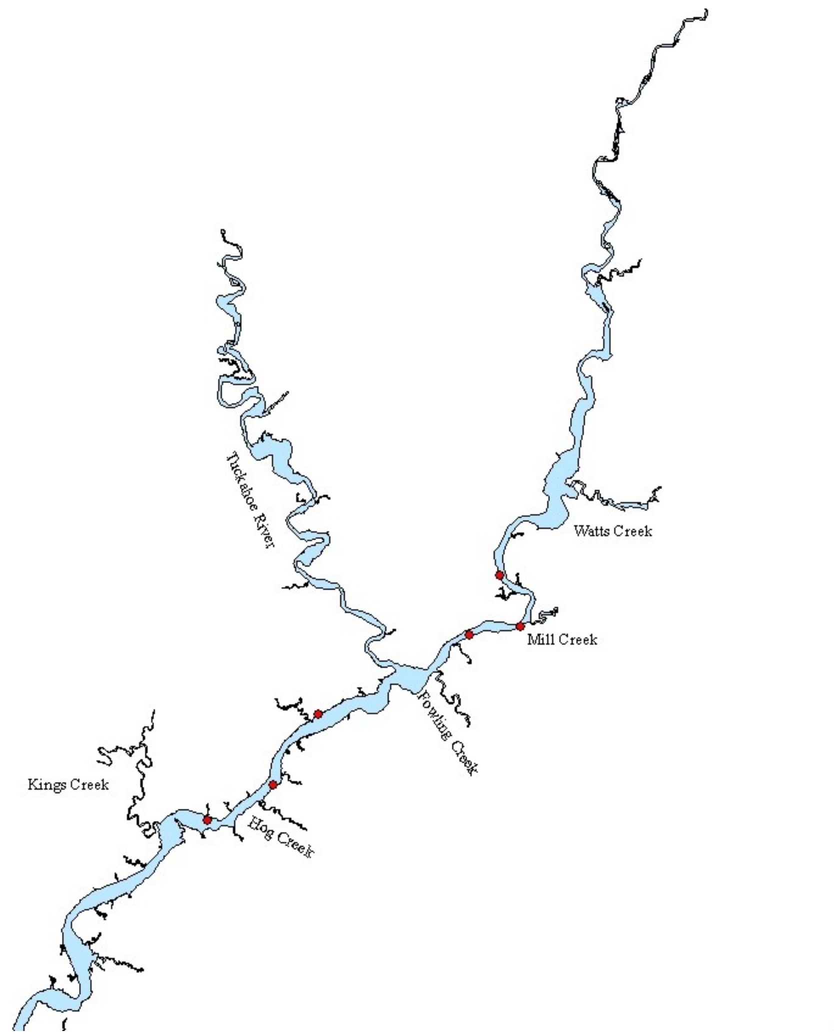


Figure 3. Commercial yellow perch fyke net sites sampled during 2017 in Bear Creek, tributary to Patapsco River. Circles indicate fyke net locations.

Figure 4. Commercial yellow perch fyke net sites sampled during 2017 in Middle River area. Circles indicate fyke net locations.

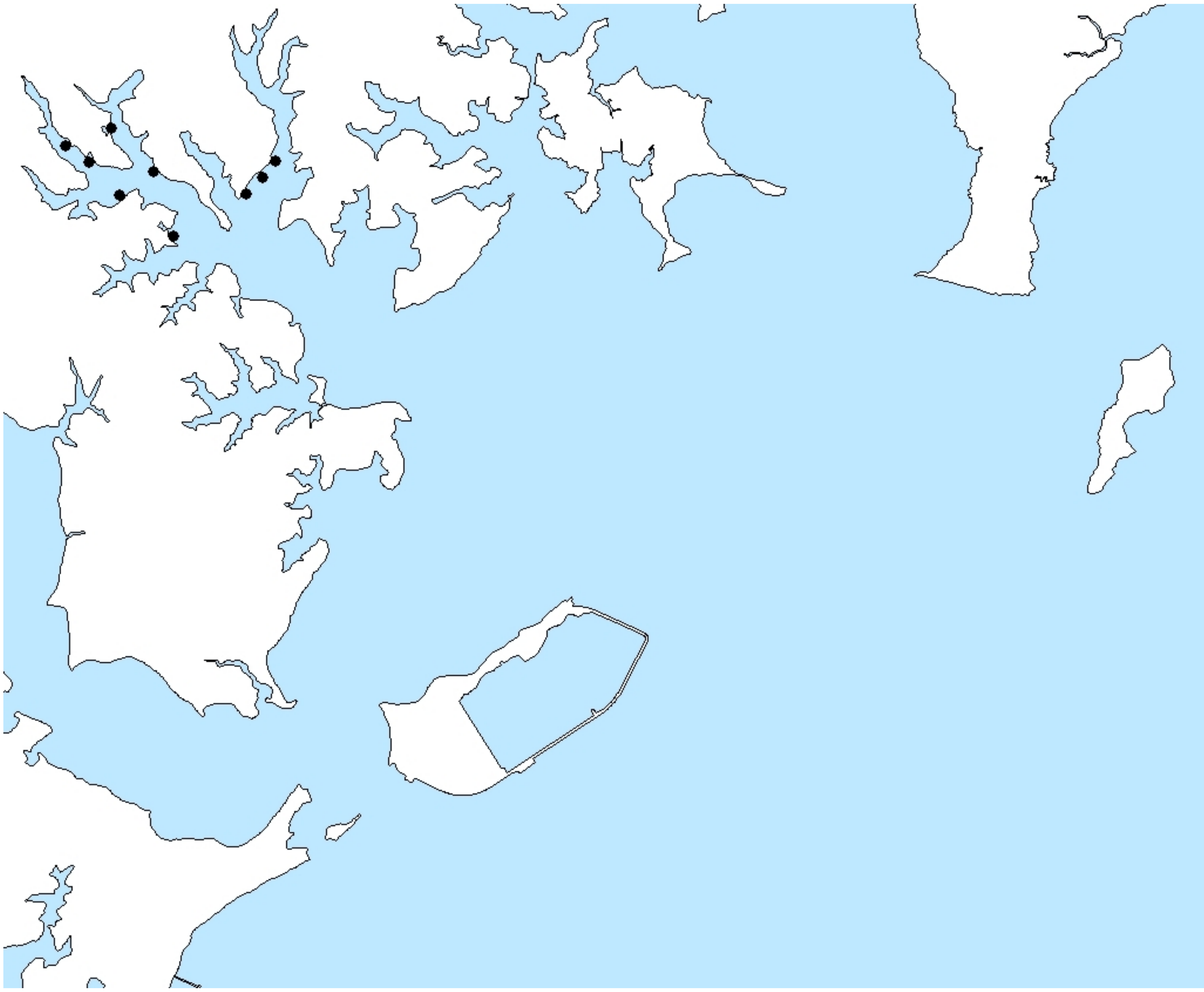


Figure 5. Commercial yellow perch fyke net sites sampled during 2017 in Gunpowder River. Circles indicate sites.

Figure 6. Commercial yellow perch fyke net sites sampled during 2017 in Bush River. Circles indicate fyke net locations.

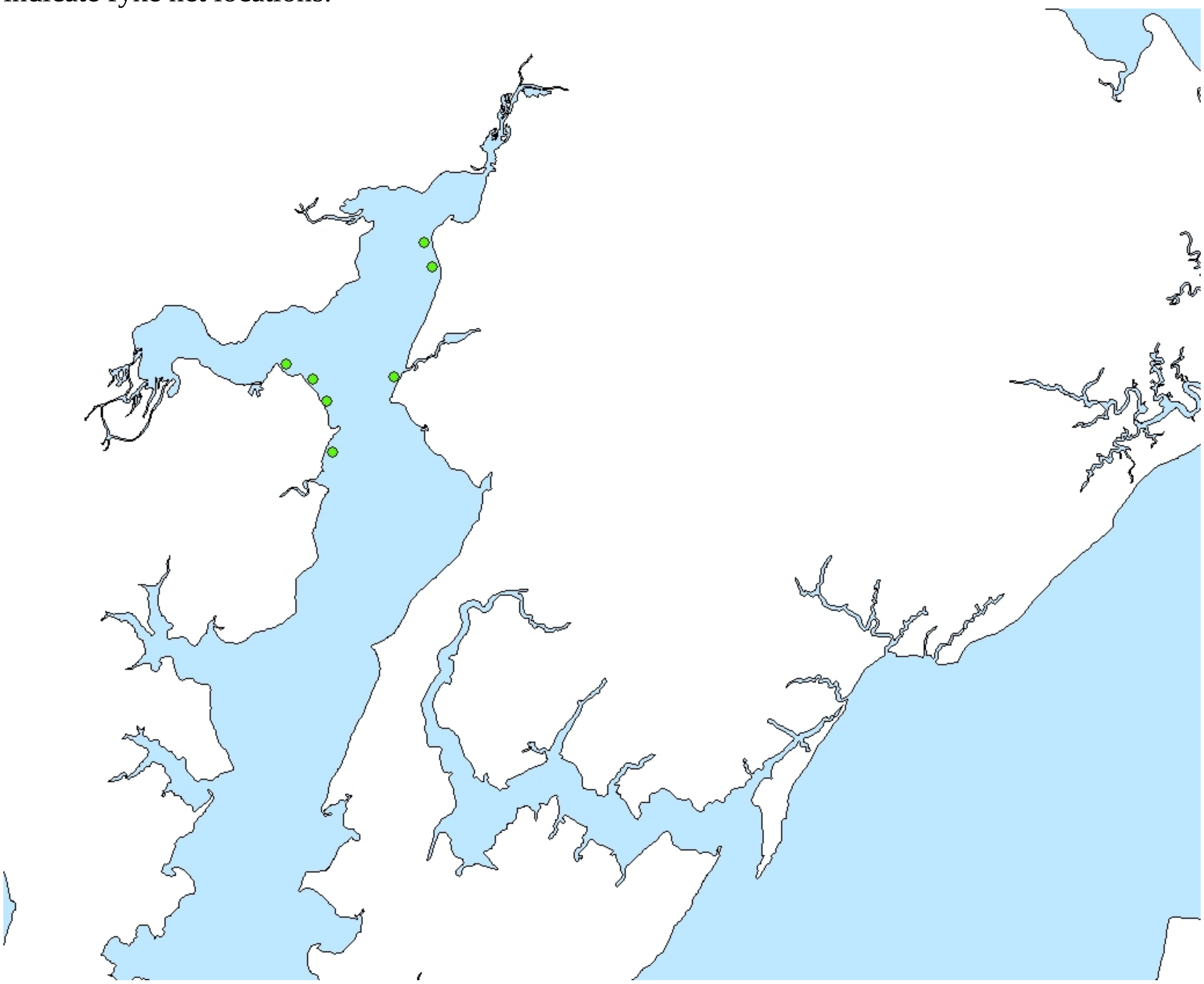


Figure 7. Commercial fyke net and pound net sites sampled during 2017 in the Nanticoke River. Black lines indicate the geographic range of fyke net locations.

Table 1. White perch catch-at-age matrix from upper Chesapeake Bay winter trawl survey, 2000 – 2017.

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

Table 2. White perch catch-at-age matrix from Choptank River fyke net survey, 2000 – 2017.

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

Table 3. White perch catch-at-age matrix from Nanticoke River fyke and pound net survey, 2000 – 2017. 2007 -- 2009 include Marshyhope River data.

YEAR	AGE									
	1	2	3	4	5	6	7	8	9	10+
2000	0	42	593	6,074	6,471	2,813	1,942	365	81	0
2001	0	0	681	796	3,262	1,822	689	785	94	38
2002	0	5	1,469	1,927	504	2,124	1,132	632	244	135
2003	0	97	318	2,559	1,567	446	994	652	180	175
2004	0	6,930	3,892	12,215	3,259	1,835	1,297	1,361	443	886
2005	0	826	1,302	5,847	3,903	5,288	2,400	1,237	1,497	2,582
2006	0	0	5,759	3,280	5,298	3,488	3,590	1,287	861	799
2007	0	497	1,948	12,876	727	6,236	2,260	2,716	977	1,573
2008	0	33	902	1,188	2,780	824	1,457	665	593	496
2009	0	70	1,351	4,135	2,117	6,216	1,188	1,651	889	1,470
2010	0	101	273	155	414	315	1,113	88	143	166
2011	0	933	1,625	7,817	1,167	4,433	1,750	5,133	1.050	3,034
2012	4	134	387	176	539	214	330	57	276	85
2013	5	418	1,342	1,587	270	615	433	671	207	723
2014	0	0	1,511	1,444	1,191	372	601	154	464	531
2015	NOT SAMPLED									
2016	10	630	2,627	140	12,472	2,982	1,410	128	266	693
2017	0	440	3,448	2,661	0	5,830	890	754	18	290

Table 4. Yellow perch catch at age matrix from upper Chesapeake Bay winter trawl survey, 2000 – 2017.

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

Table 5. Yellow perch catch at age matrix from Choptank River fyke net survey, 1988 – 2017.

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

Table 6. Yellow perch catch at age matrix from upper Chesapeake Bay commercial fyke net survey, 1999 – 2017.

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

Table 7. Relative stock densities (RSD's) of white perch from the upper Chesapeake Bay winter trawl survey, 2000 – 2017. 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

Figure 8. White perch length-frequency from 2017 upper Chesapeake Bay winter trawl survey.

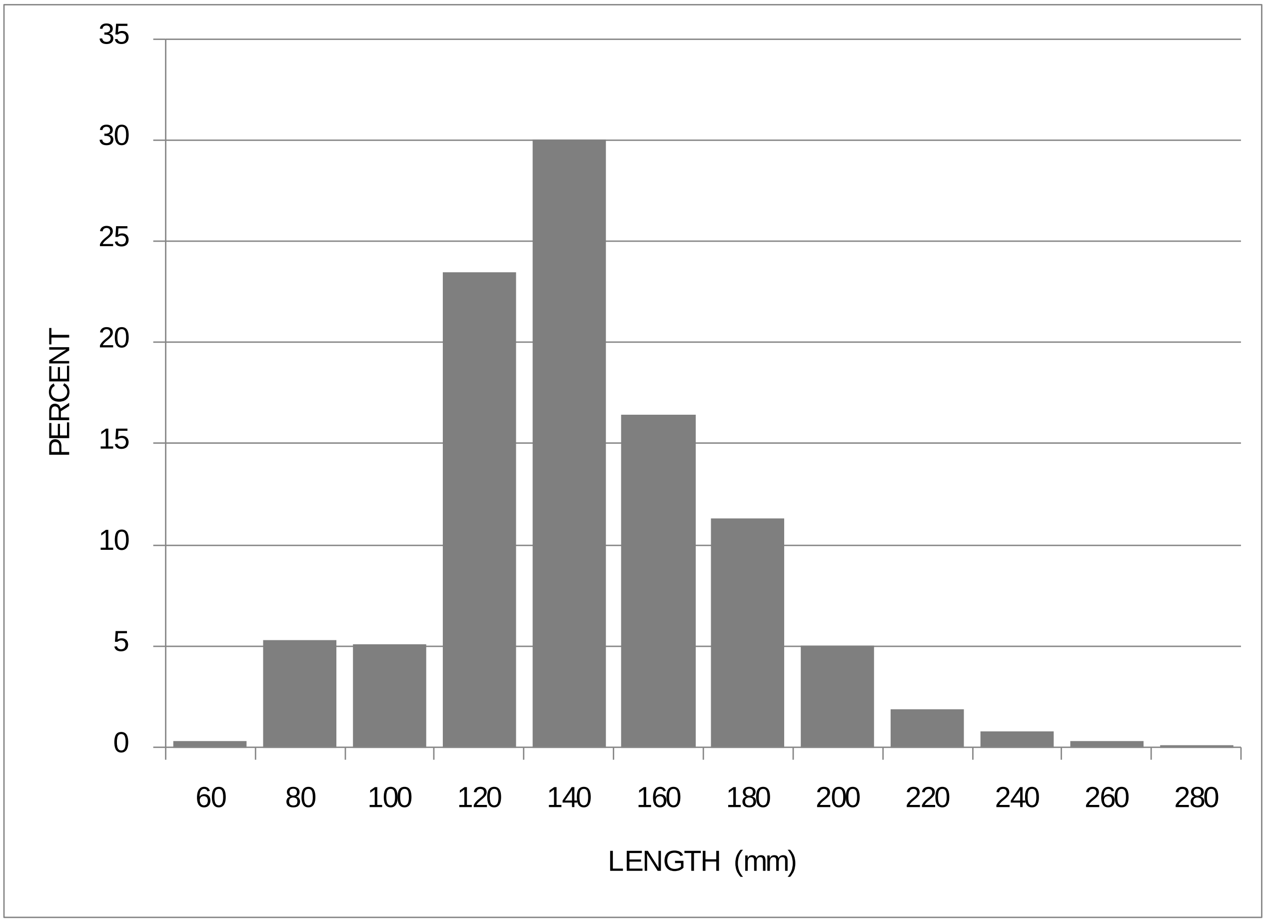


Table 8. Relative stock densities (RSD's) of white perch from the Choptank River fyke net survey, 1993 – 2017. Minimum length cut-offs in parentheses.

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

Figure 9. White perch length-frequency from 2017 Choptank River fyke net survey.

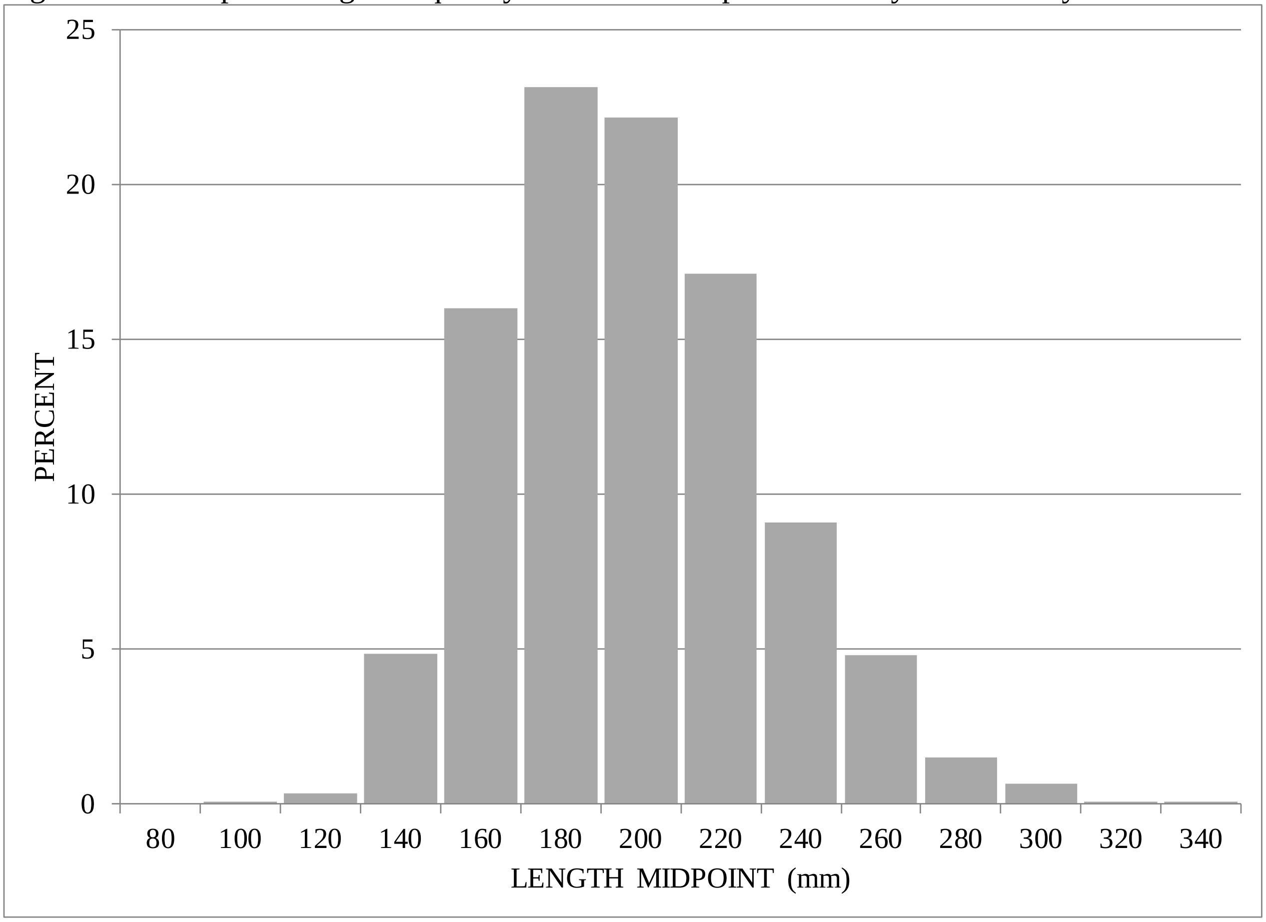


Table 9. Relative stock densities (RSD's) of white perch from the Nanticoke River fyke and pound net survey, 1995 – 2017. Minimum length cut-offs in parentheses. 2007 -- 2009 include Marshyhope River data.

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

Figure 10. White perch length-frequency from 2017 Nanticoke River fyke and pound net survey.

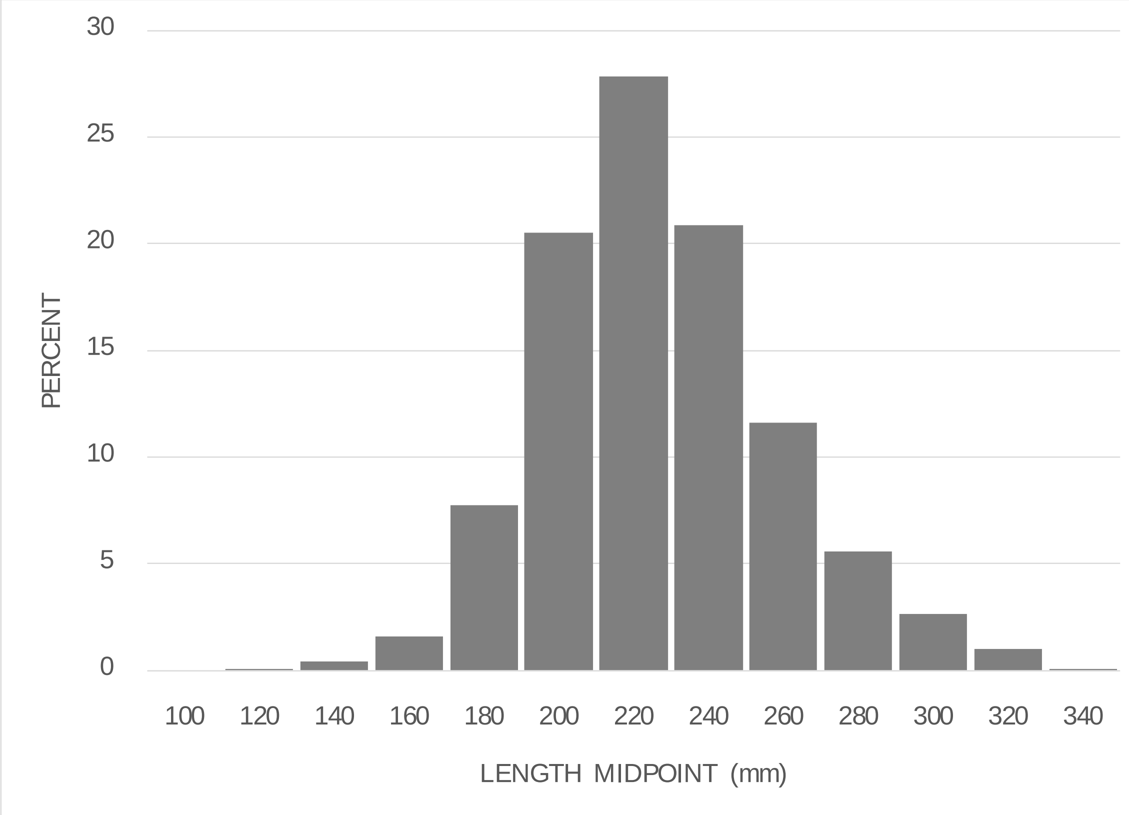


Table 10. Relative stock densities (RSD's) of yellow perch from the upper Chesapeake Bay winter trawl survey, 2000 – 2017. Minimum length cut-offs in parentheses.

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

Figure 11. Yellow perch length-frequency from the 2017 upper Chesapeake Bay winter trawl survey.

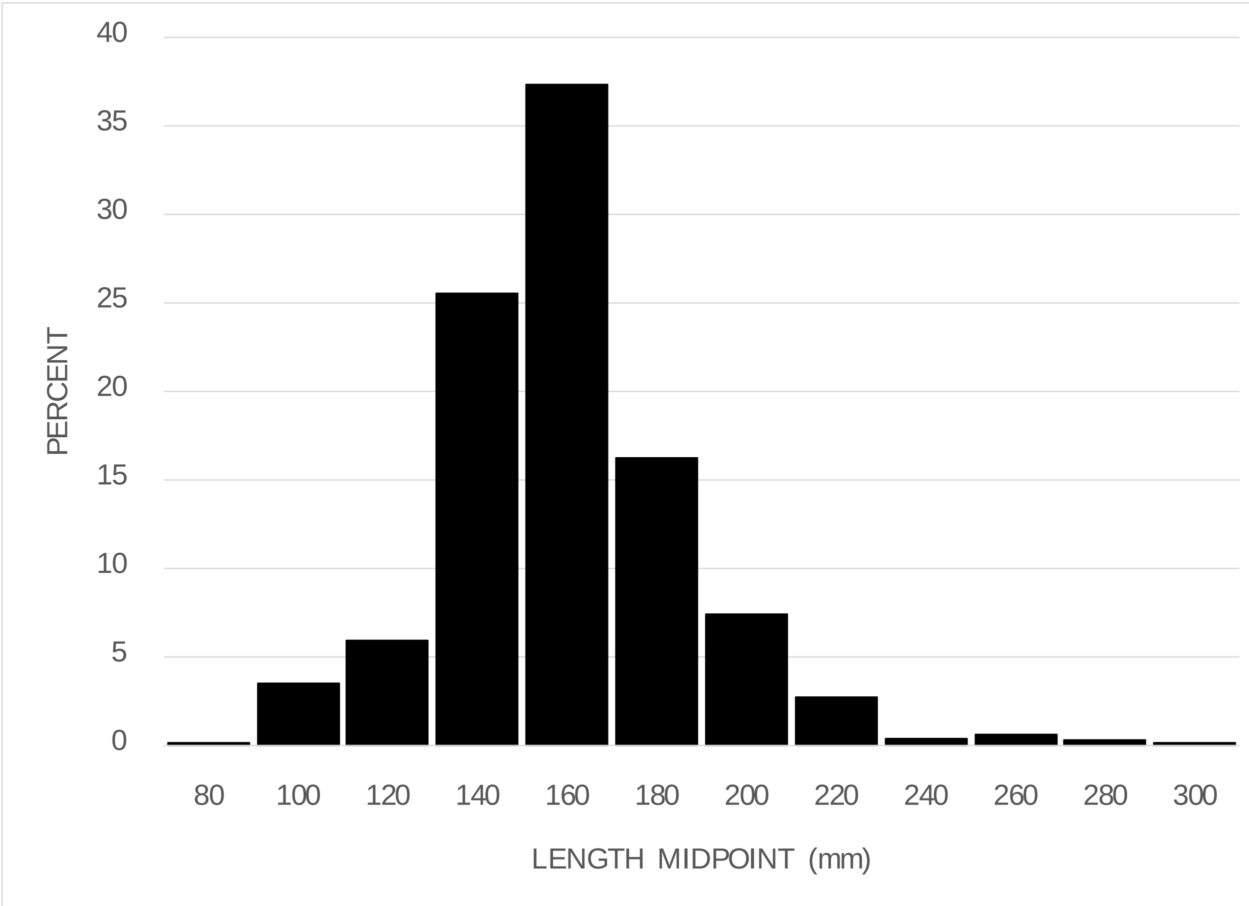


Table 11. Relative stock densities (RSD's) of yellow perch from the Choptank River fyke net survey, 1989 – 2017. Minimum length cut-offs in parentheses.

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

Figure 12. Yellow perch length-frequency from the 2017 Choptank River fyke net survey.

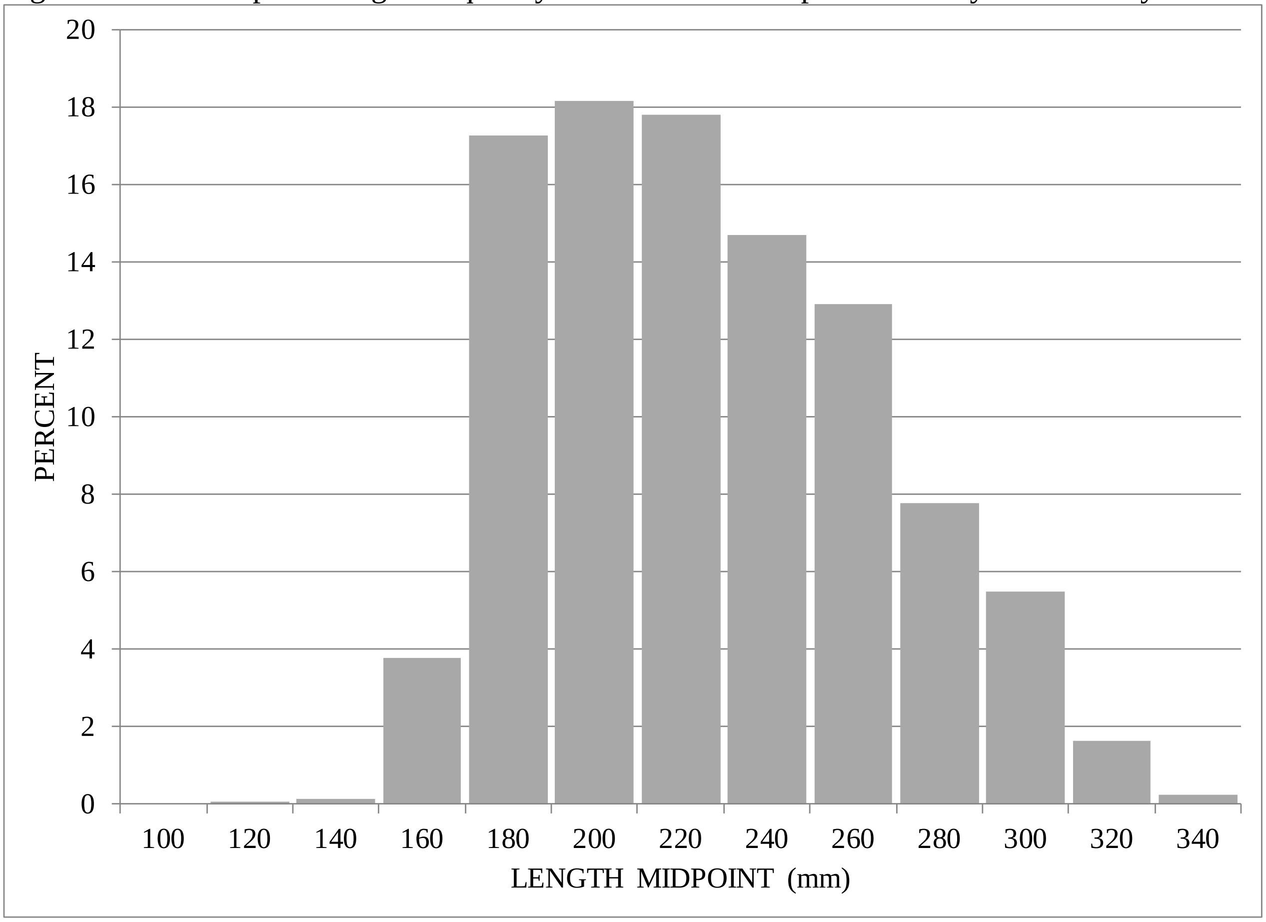


Table 12. Relative stock densities (RSD's) of yellow perch from the upper Chesapeake Bay commercial fyke net survey, 1988, 1990, 1998 – 2017. Minimum length cut-offs in parentheses.

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

Figure 13. Yellow perch length frequency from the 2017 upper Chesapeake commercial fyke net survey.

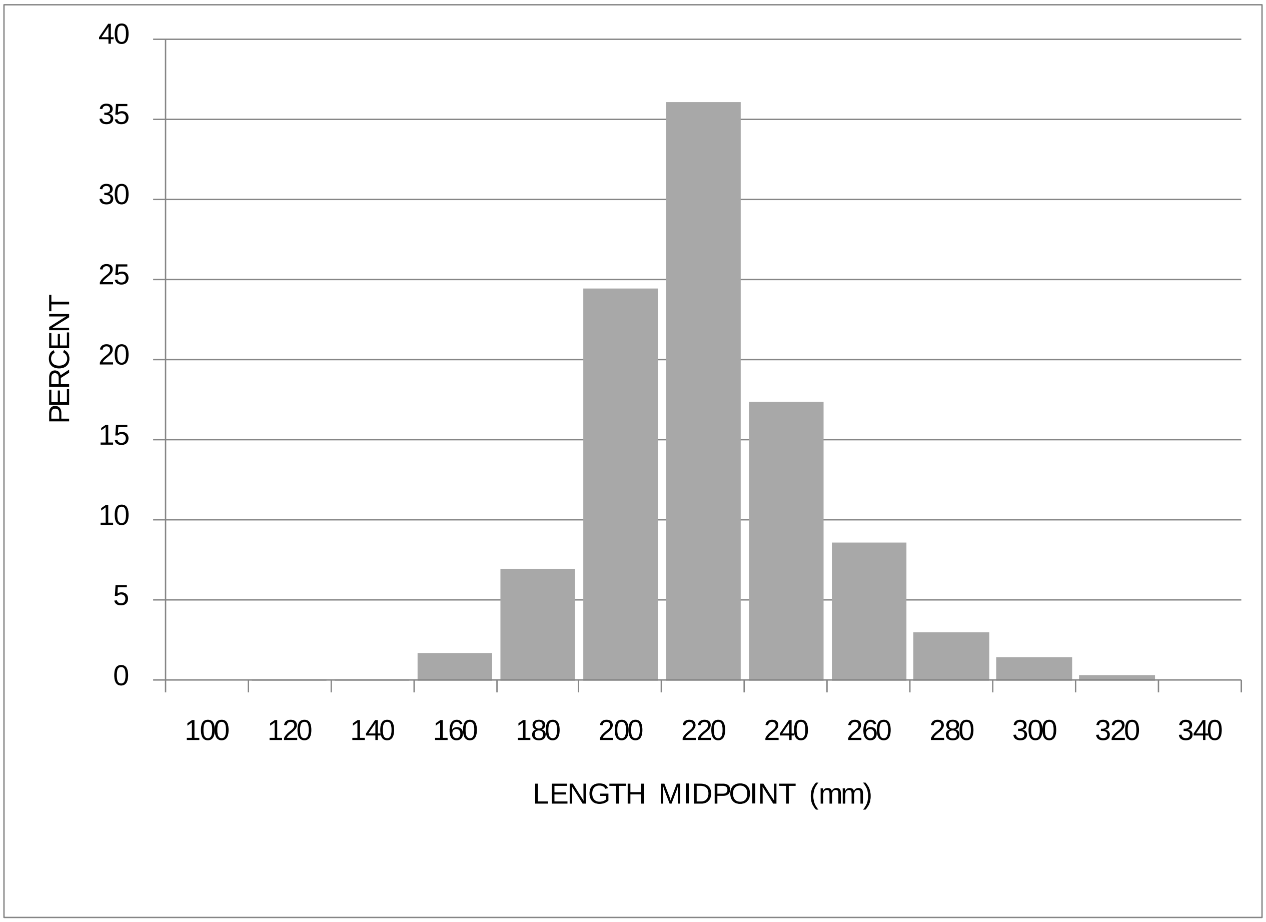


Table 13. Relative stock densities (RSD's) of channel catfish from the upper Chesapeake Bay winter trawl survey, 2000 – 2017. Minimum length cut-offs in parentheses.

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

Figure 14. Length frequency of channel catfish from the 2017 upper Chesapeake Bay winter trawl survey.

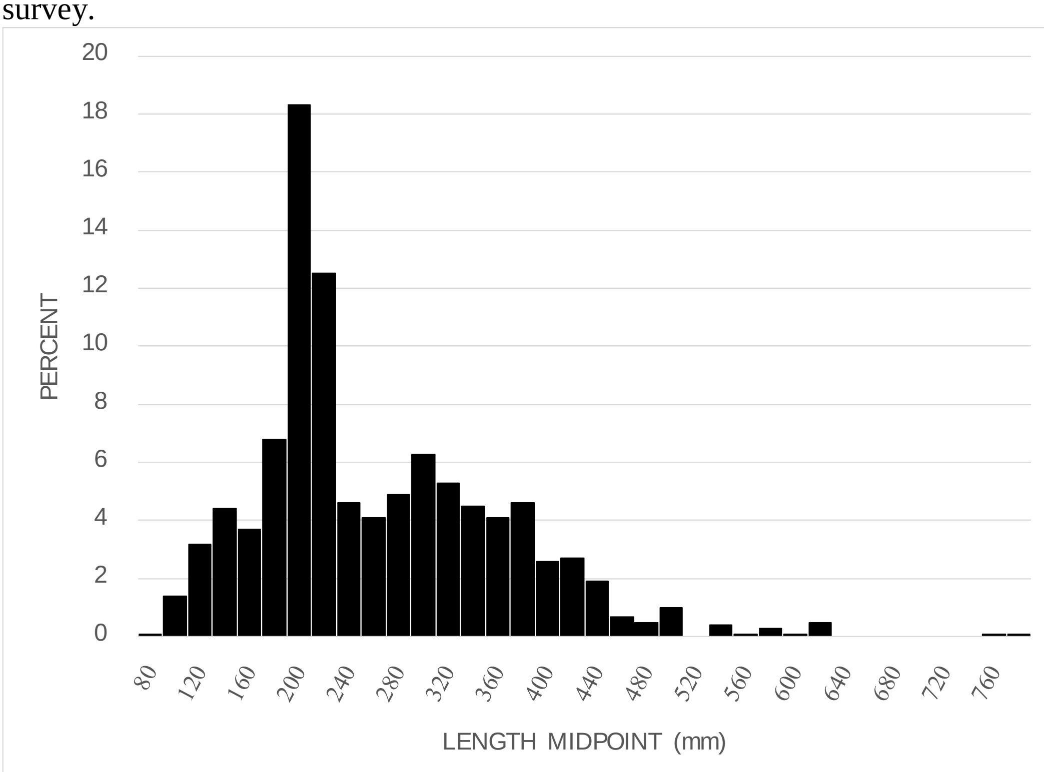


Table 14. Relative stock densities (RSD's) of channel catfish from the Choptank River fyke net survey, 1993 – 2017. Minimum length cut-offs in parentheses.

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

Figure 15. Channel catfish length frequency from the 2017 Choptank River fyke net survey.

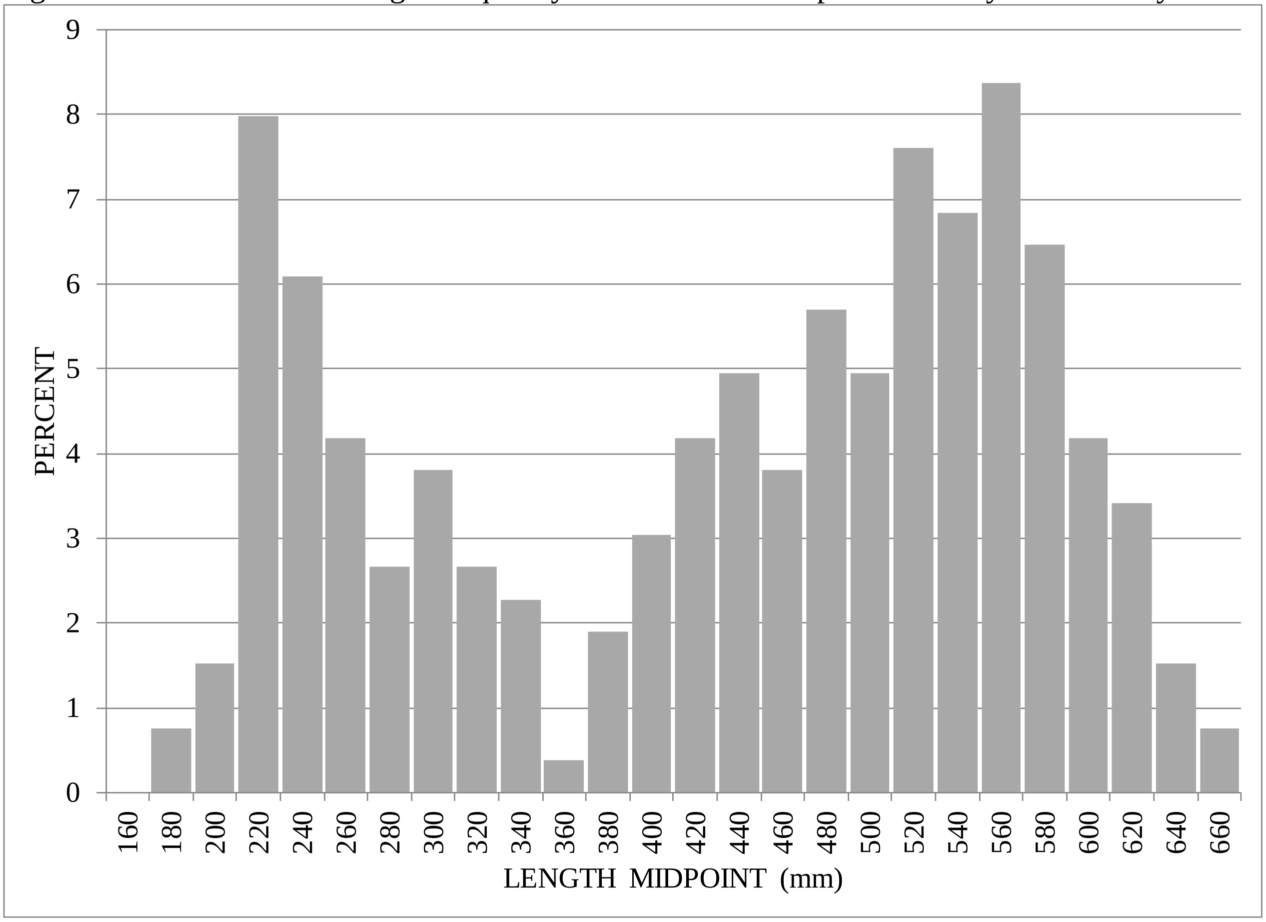


Table 15. Relative stock densities (RSD's) of channel catfish from Nanticoke River fyke and pound net survey, 1995 – 2017. 2007 -- 2009 include Marshyhope River fyke net data. Minimum length cut-offs in parentheses.

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

Figure 16. Channel catfish length frequency from the 2017 Nanticoke River fyke and pound net survey.

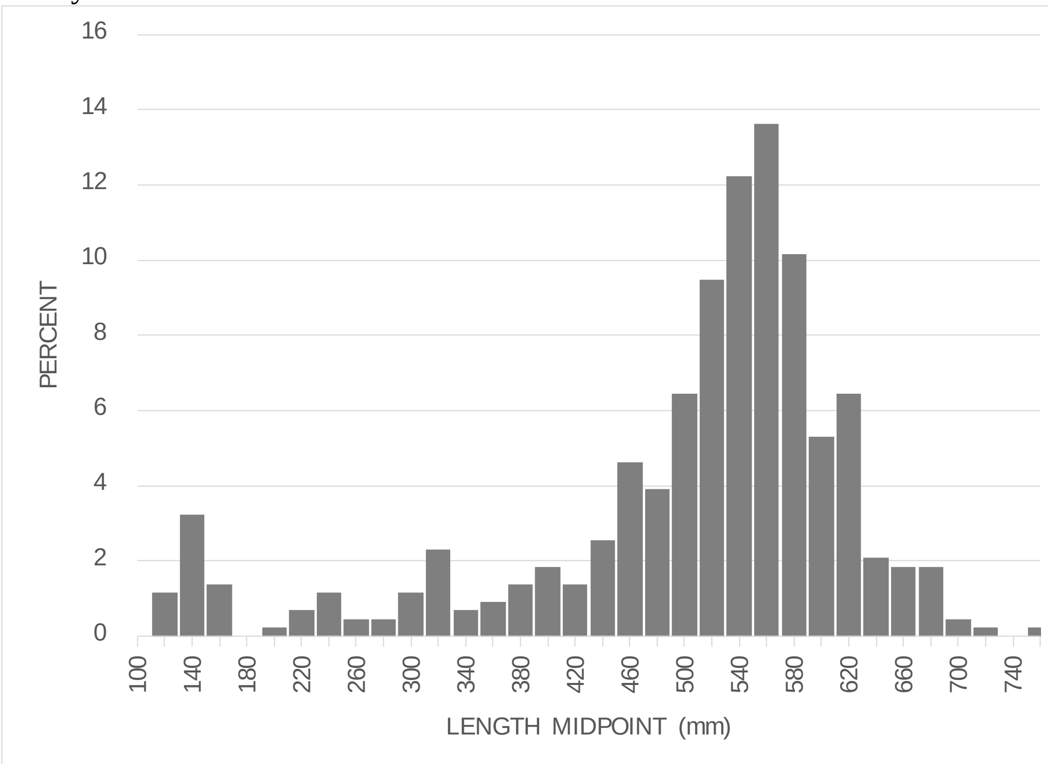


Table 16. Relative stock densities (RSD's) of white catfish from the upper Chesapeake Bay winter trawl survey, 2000 – 2017. Minimum length cut-offs in parentheses.

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

Figure 17. White catfish length frequency from the 2017 upper Chesapeake Bay winter trawl survey.

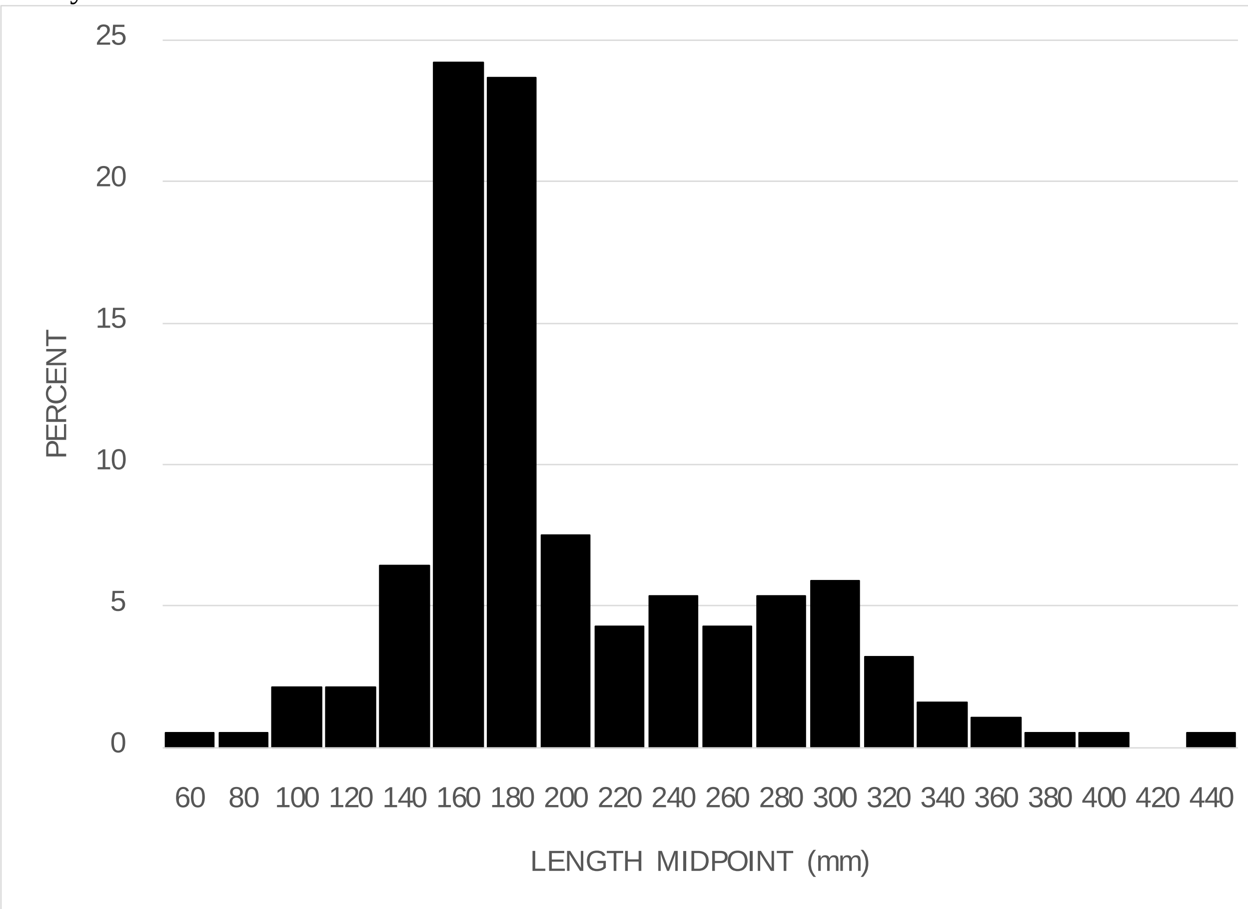


Table 17. Relative stock densities (RSD's) of white catfish from the Choptank River fyke net survey, 1993 – 2017. Minimum length cut-offs in parentheses.

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

Figure 18. White catfish length frequency from the 2017 Choptank River fyke net survey.

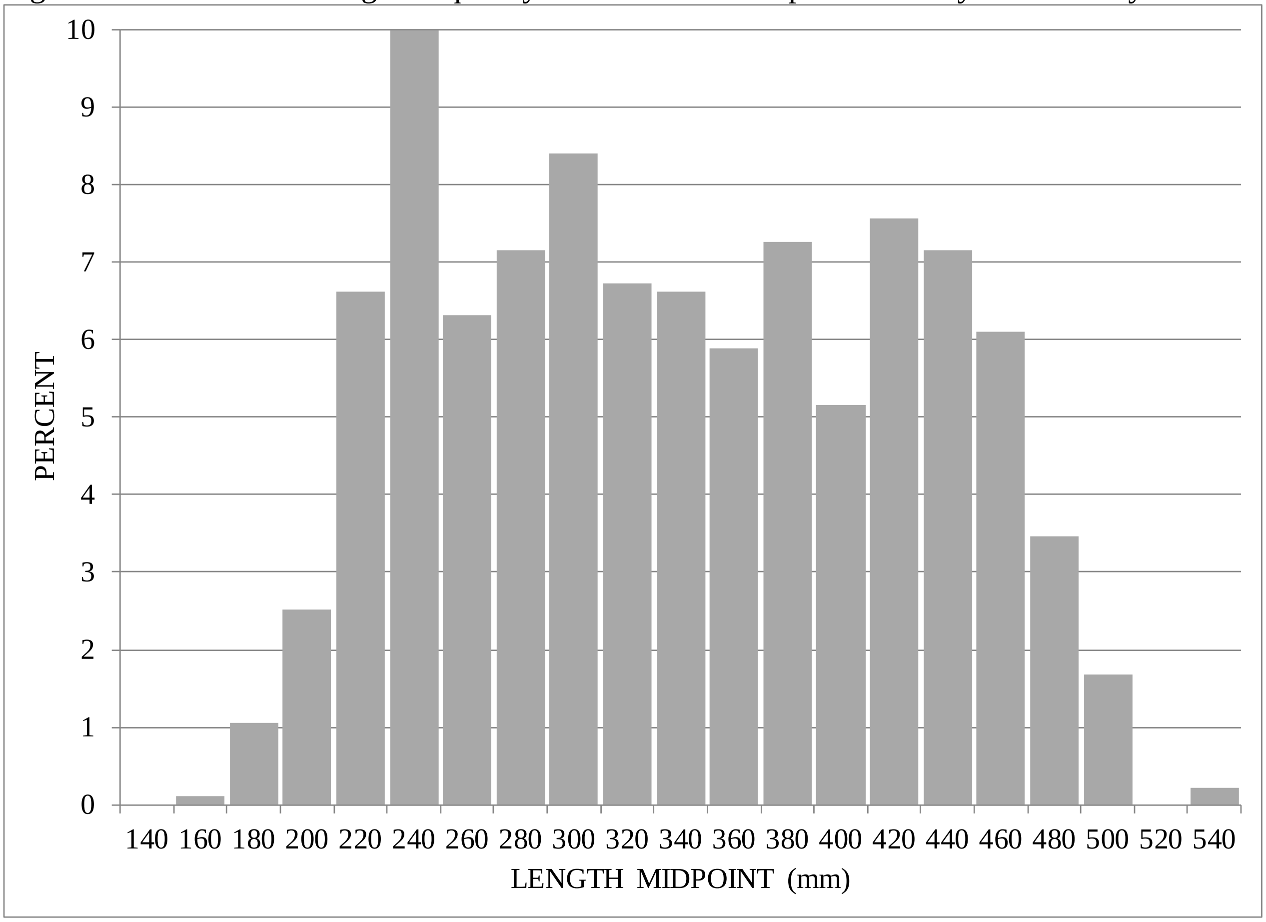


Table 18. Relative stock densities (RSD's) of white catfish from the Nanticoke River fyke and pound net survey, 1995 – 2017. 2007 -- 2009 include Marshyhope River fyke net data. Minimum length cut-offs in parentheses.

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

Figure 19. White catfish length frequency from the 2017 Nanticoke River fyke and pound net survey.

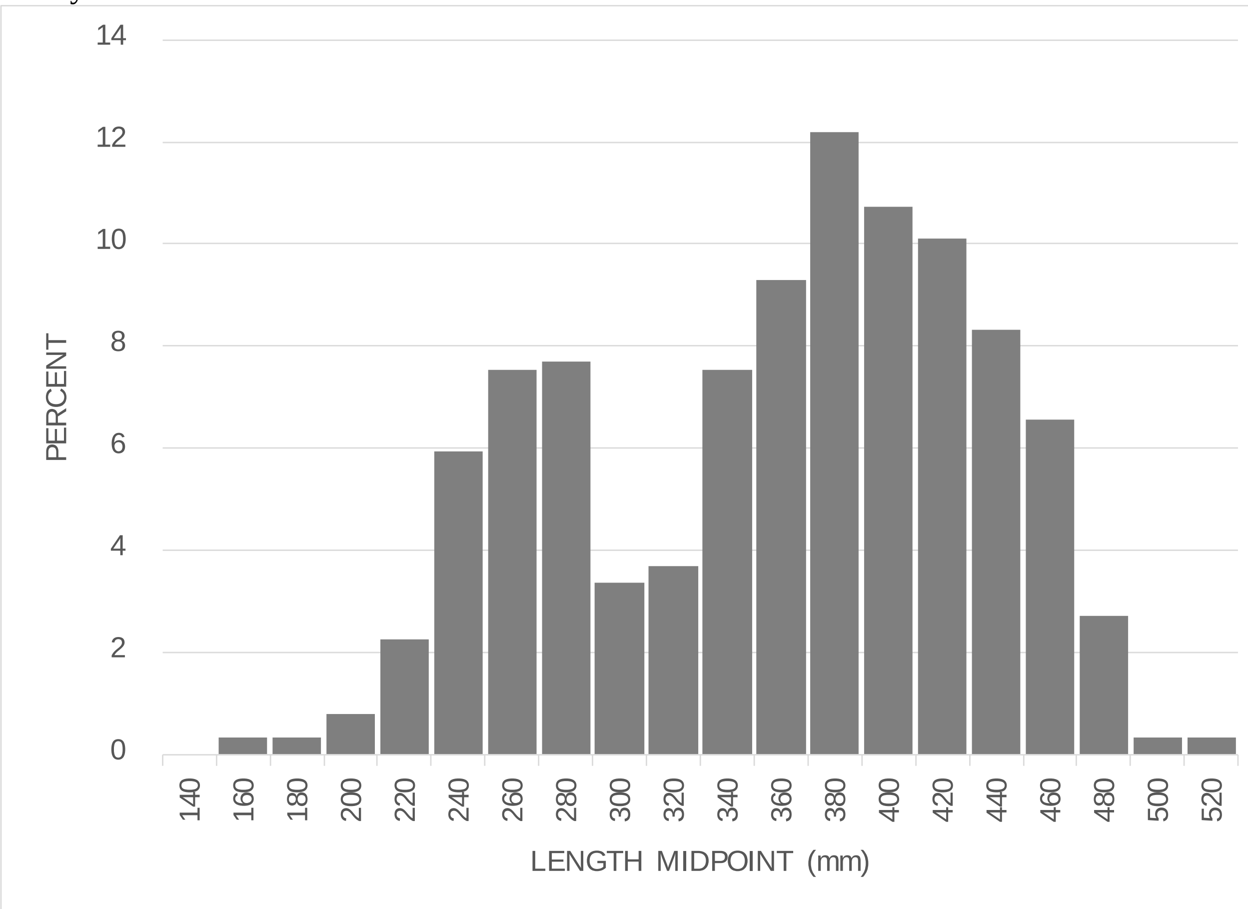


Table 19. White perch growth parameters from Choptank River for males, females, and sexes combined. NA=data not available NSF=no solution found or small sample size.

Sample Year	Sex	Allometry		von Bertalanffy		
		alpha	beta	L-inf	K	t_0
2009	F	2.8×10^{-6}	3.32	325	0.18	-0.48
	M	2.5×10^{-6}	3.32	238	0.25	-0.45
	Combined	1.9×10^{-6}	3.38	293	0.20	-0.35
2010	F	4.0×10^{-6}	3.26	302	0.22	-0.42
	M	4.2×10^{-6}	3.23	209	0.60	0.09
	Combined	2.6×10^{-6}	3.33	302	0.17	-1.29
2011	F	2.3×10^{-6}	3.35	324	0.18	-0.93
	M	2.4×10^{-6}	3.34	223	0.35	-0.43
	Combined	2.0×10^{-6}	3.38	326	0.15	-1.49
2012	F	6.9×10^{-6}	3.17	273	0.34	-0.02
	M	4.5×10^{-6}	3.23	229	0.36	-0.16
	Combined	3.1×10^{-6}	3.31	259	0.34	0.00
2013	F	8.9×10^{-6}	3.10	273	0.34	-0.39
	M	4.4×10^{-6}	3.21	228	0.42	-0.43
	Combined	3.8×10^{-6}	3.25	259	0.31	-0.82
2014	F	5.9×10^{-6}	3.18	278	0.33	-0.18
	M	1.2×10^{-6}	3.46	226	0.42	-0.16
	Combined	2.9×10^{-6}	3.30	259	0.35	-0.13
2015	F	2.3×10^{-6}	2.92	278	0.27	-0.57
	M	3.2×10^{-6}	3.23	228	0.29	-0.68
	Combined	1.3×10^{-5}	3.03	267	0.26	-0.78
2016	F	3.4×10^{-6}	3.29	334	0.19	-0.95
	M	7.9×10^{-7}	3.56	215	0.60	0.01
	Combined	3.2×10^{-6}	3.30	340	0.15	-1.80
2017	F	5.2×10^{-6}	3.21	338	0.16	-1.58
	M	2.4×10^{-6}	3.34	219	0.74	-0.16
	Combined	3.0×10^{-6}	3.31	310	0.15	-2.77
2000 – 2017	F	5.0×10^{-6}	3.21	290	0.26	-0.45
	M	5.0×10^{-6}	3.20	229	0.35	-0.41
	Combined	3.3×10^{-6}	3.29	277	0.25	-0.66

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

Sample Year	Sex	(allometry) alpha	beta	(von Bertalanffy) L-inf	K	t_0
2009	F	3.4×10^{-6}	3.28	285	0.33	0.80
	M	1.4×10^{-4}	2.58	259	0.53	-0.51
	Combined	5.9×10^{-6}	3.18	287	0.23	-0.16
2010	F	1.7×10^{-6}	3.41	345	0.16	-1.03
	M	3.4×10^{-5}	2.85	278	0.23	-0.25
	Combined	2.7×10^{-6}	3.32	313	0.19	-0.50
2011	F	1.6×10^{-6}	3.42	313	0.25	0.12
	M	7.8×10^{-6}	3.13	271	0.23	-0.38
	Combined	1.5×10^{-6}	3.43	297	0.23	-0.25
2012	F	4.5×10^{-6}	3.25		NSF	
	M	1.0×10^{-5}	3.08	306	0.18	-0.79
	Combined	2.9×10^{-6}	3.32	329	0.16	-1.04
2013	F	7.7×10^{-6}	3.14	307	0.28	-0.16
	M	1.7×10^{-5}	2.99	276	0.27	-0.35
	Combined	6.2×10^{-6}	3.18	295	.27	-0.29
2014	F	1.5×10^{-5}	2.60	311	0.25	-0.29
	M	6.5×10^{-5}	2.73	269	0.33	-0.09
	Combined	5.4×10^{-5}	2.77	295	0.27	-0.25
2015	F	NA	NA		NA	
	M	NA	NA		NA	
	Combined	NA	NA		NA	
2016	F	9.2×10^{-5}	2.70	302	0.33	0.25
	M	1.1×10^{-5}	3.07	288	0.27	-0.21
	Combined	2.9×10^{-5}	2.90	296	0.30	0.05
2017	F	5.2×10^{-6}	3.21	323	0.26	-0.25
	M	4.7×10^{-6}	3.21	308	0.21	-0.52
	Combined	3.1×10^{-6}	3.29	318	0.23	-0.49
2000 - 2017	F	1.1×10^{-5}	3.07	315	0.21	-0.80
	M	1.7×10^{-5}	2.98	273	0.25	-0.40
	Combined	7.4×10^{-6}	3.14	299	0.23	-0.47

Table 21. 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 alpha	beta	von Bertalanffy L-inf	K	t_0
2009	F	8.7×10^{-6}	3.06	314	0.32	-0.32
	M	2.8×10^{-6}	3.26	299	0.22	-0.69
	Combined	4.4×10^{-6}	2.18	296	0.29	-0.66
2010	F	1.3×10^{-5}	2.97		NSF	
	M	4.7×10^{-6}	3.16		NSF	
	Combined	9.9×10^{-6}	3.02		NSF	
2011	F	1.2×10^{-6}	3.02	276	0.58	0.03
	M	4.7×10^{-6}	3.17	232	0.57	-0.11
	Combined	3.2×10^{-6}	3.25	245	0.74	0.12
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 X 10-4	2.52	321	0.20	-1.90
	M	3.9 X 10-5	2.79	282	0.18	-2.74
	Combined	3.8 X 10-5	2.82	286	0.24	-1.59
2000 – 2017	F	1.4×10^{-6}	2.98	295	0.40	-0.32
	M	5.2×10^{-6}	3.15	268	0.26	-1.48
	Combined	7.6×10^{-6}	3.08	266	0.42	-0.54

Table 22. 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
2009	F	1.30×10^{-6}	3.43	294	0.34	-0.53
	M	6.09×10^{-6}	3.13	221	0.69	-0.13
	Combined	6.27×10^{-7}	3.56	248	0.57	-0.12
2010	F	1.62×10^{-4}	2.57	292	0.51	0.29
	M	1.92×10^{-6}	3.34	254	0.49	-0.21
	Combined	3.40×10^{-5}	2.84	274	0.49	-0.09
2011	F	3.1×10^{-7}	4.10		NSF	
	M	9.4×10^{-7}	3.47	242	0.97	0.20
	Combined	9.1×10^{-8}	3.90	245	0.23	0.25
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	1.4×10^{-6}	3.40	247	0.61	-0.04
	Combined	9.2×10^{-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
1998 – 2017	F	4.3×10^{-6}	3.21	313	0.28	-1.21
	M	3.4×10^{-6}	3.23	242	0.53	-0.22
	Combined	2.0×10^{-6}	3.34	265	0.52	-0.14

Table 23. Estimated instantaneous fishing mortality rates (F) for white perch. NR= not reliable; NA=not available; MIN= minimal, at or near M estimate.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Choptank[1]	0.16	0.12	0.21	0.38	0.68	0.33	0.35	0.27	0.54	NA
Nanticoke	0.16	0.12	0.66	NR	NR	0.08	MIN	NA	0.15	0.31
Upper Bay[1]	0.20	0.15	0.25	0.54	0.93	0.46	0.52	0.42	0.37	NA

[1]Estimated F from annual assessment. See Job 2 of this report.

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

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Choptank	0.31	NR	NR	MIN	0.03	MIN	NR	NR	NR	MIN
Upper Bay[1]	0.04	0.22	0.25	0.30	0.27	0.16	0.11	0.13	0.21	0.20

[1]Fully recruited F from annual update of Piavis and Webb (2017).

Figure 20. Baywide young-of-year relative abundance index for white perch, 1962 – 2017, based on EJFS data. Bold horizontal line=time series average. Error bars indicate 95% CI's.

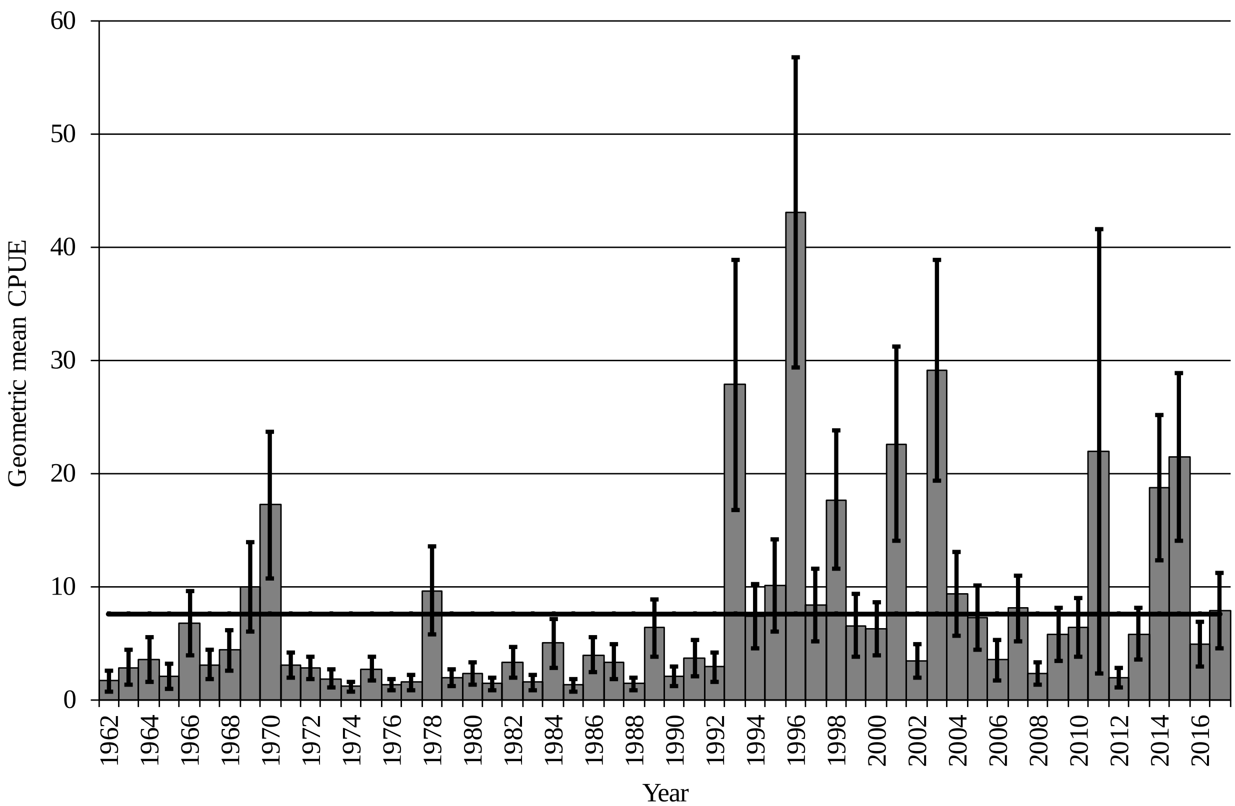


Figure 21. Age 1 white perch relative abundance from upper Chesapeake Bay winter trawl survey. Not sampled in 2004, small sample sizes 2003 and 2005. Error bars=95% CI.

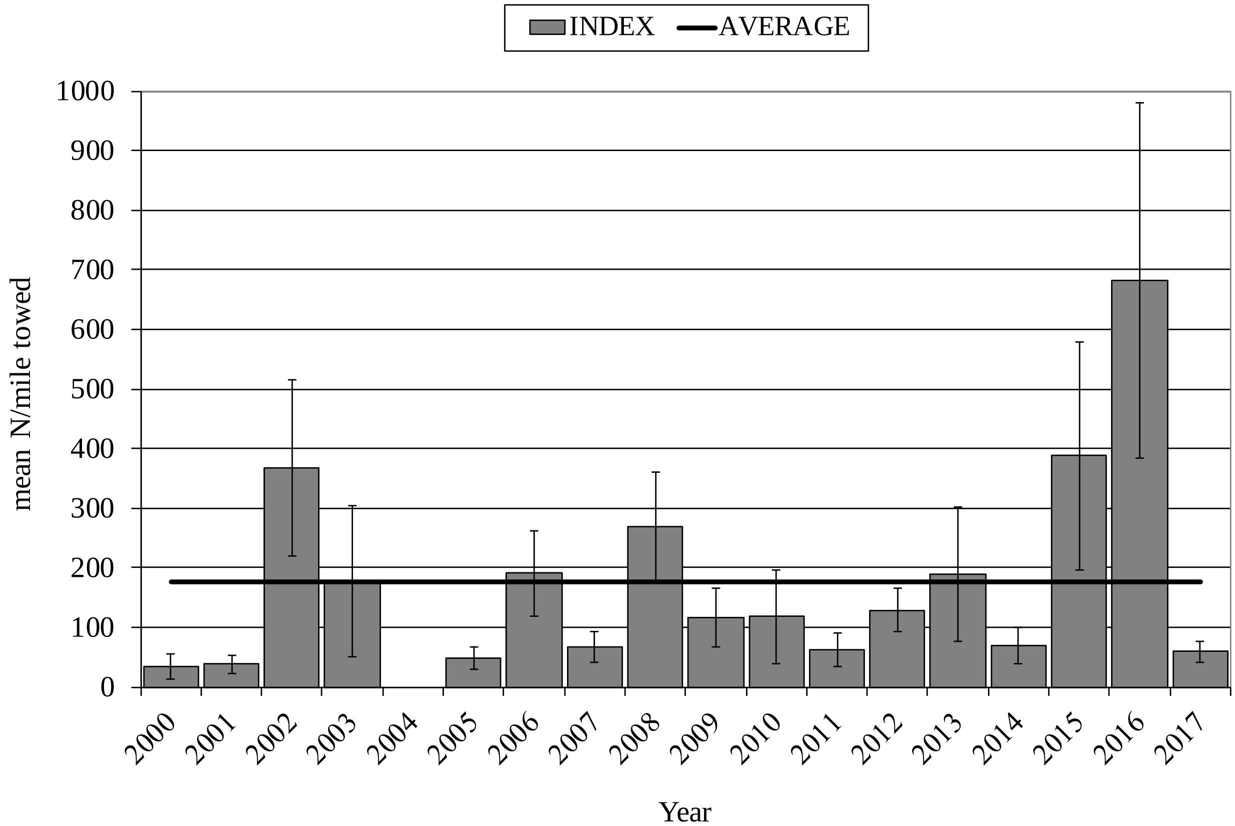


Figure 22. Head-of-Bay young-of-year relative abundance index for yellow perch, 1979 – 2017, based on Estuarine Juvenile Finfish Survey data. Horizontal line=time series average. Error bars indicate 95% confidence interval.

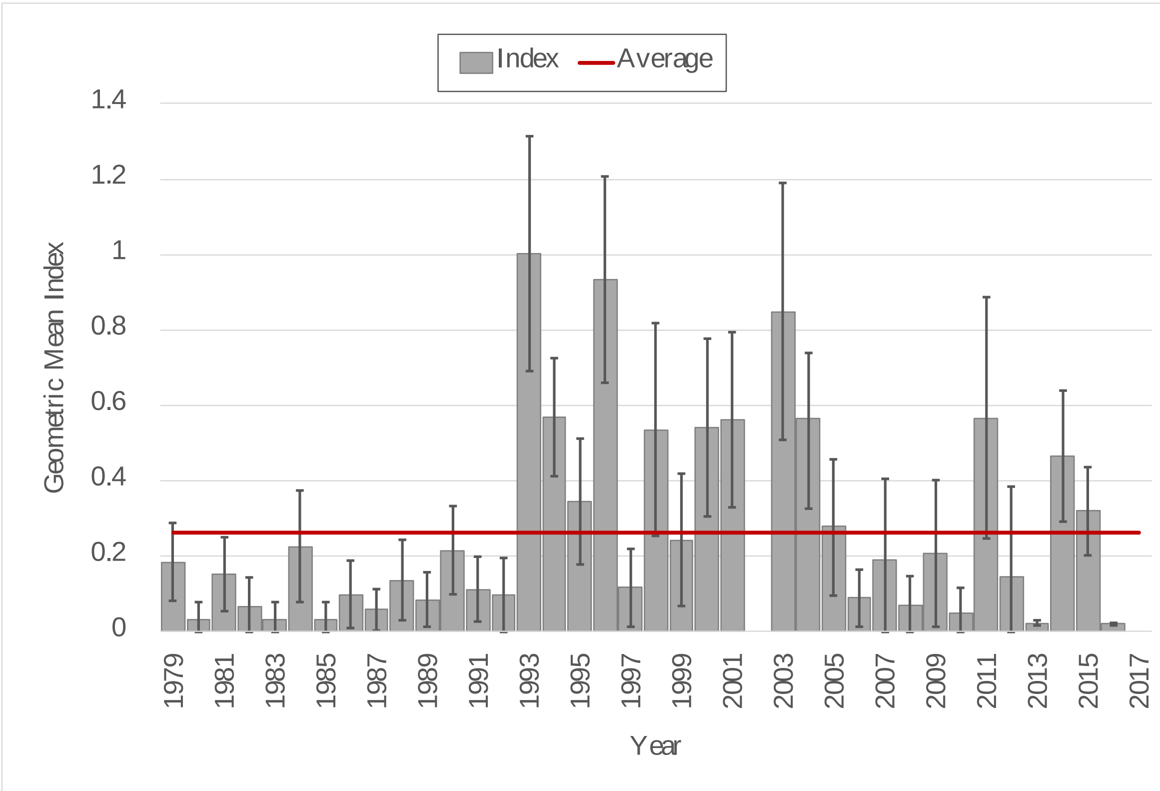


Figure 23. Age 1 yellow perch relative abundance from upper Chesapeake Bay winter trawl survey. Not sampled in 2004, small sample sizes 2003 and 2005. Error bars=95% CI.

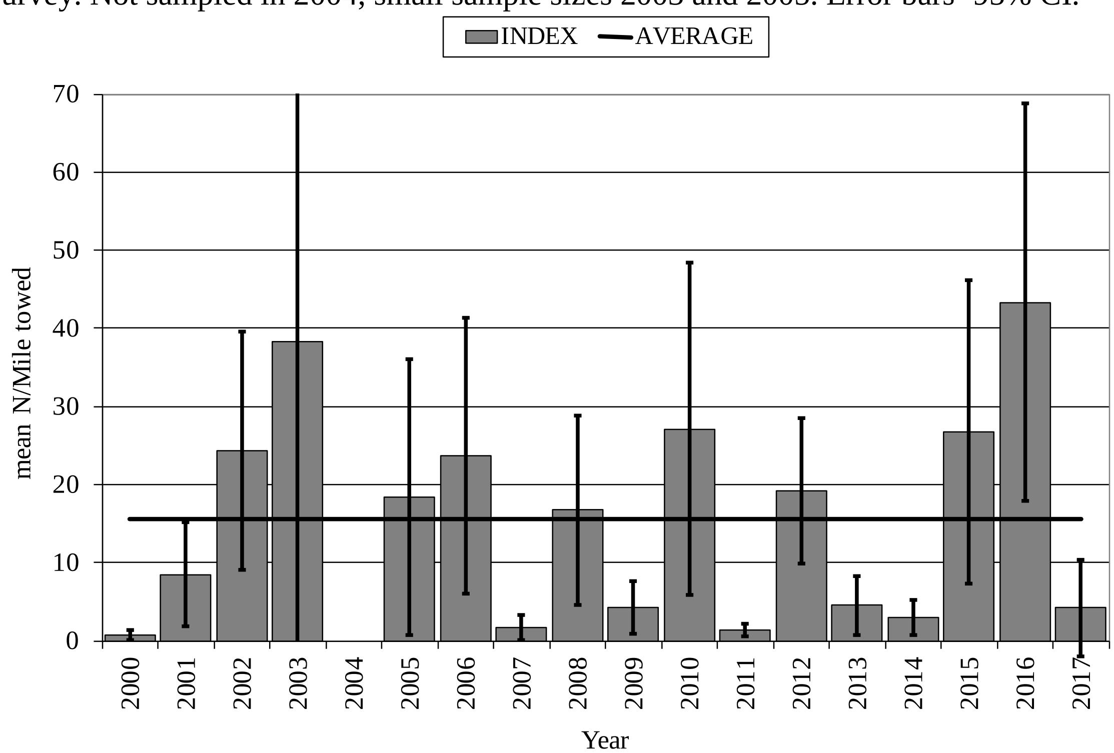


Figure 24. Age 1 channel catfish relative abundance from upper Chesapeake Bay winter trawl survey. Not sampled in 2004, small sample sizes 2003 and 2005.

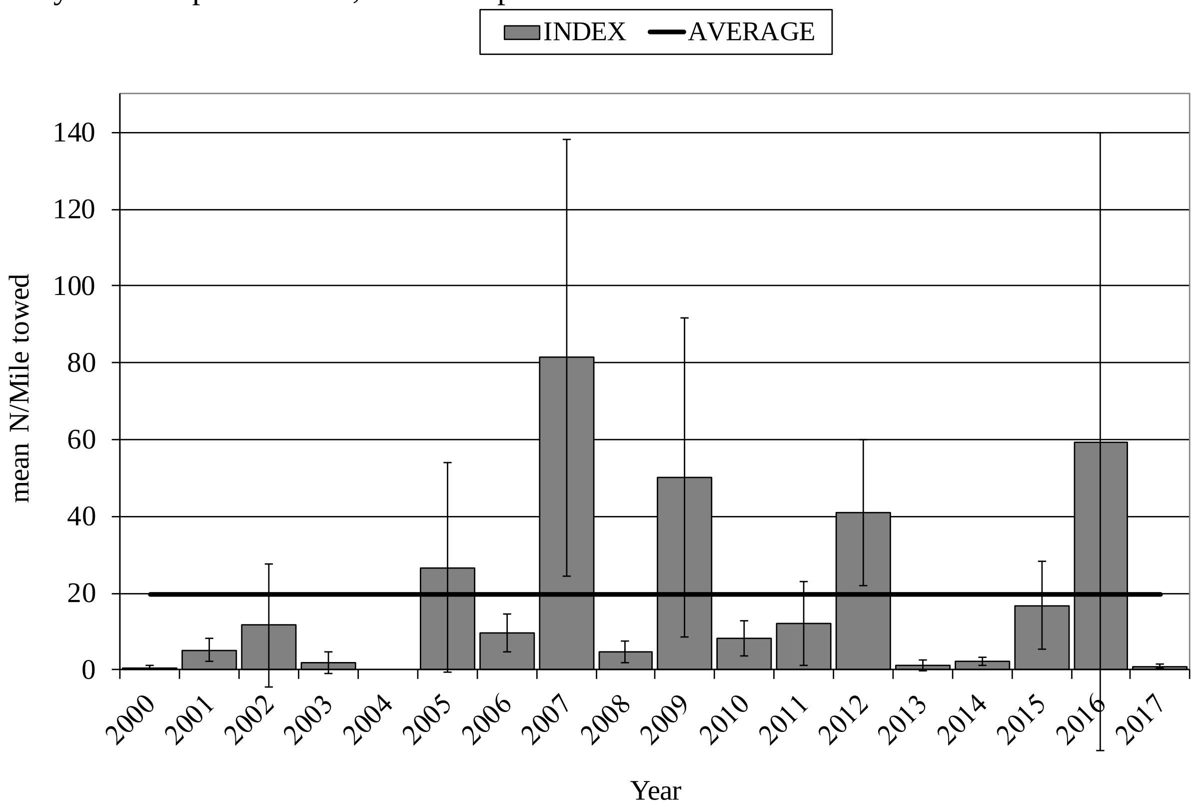


Table 25. White perch relative abundance (N/MILE TOWED) and number of tows from the upper Chesapeake Bay winter trawl survey, 2000 – 2017. Chester River sites included starting 2011.

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

Table 26. White perch relative abundance (N/net day) and total effort from the Choptank River fyke net survey, 2000 – 2017.

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	21.7	4.3	0.0	54.1	2.3	0.2	0.0	1.1	101.5	213

Table 27. Yellow perch relative abundance (N/MILE TOWED) and number of tows from the upper Chesapeake Bay winter trawl survey, 2000 – 2017.

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

Table 28. Yellow perch relative abundance (N/net day) and total effort from the Choptank River fyke net survey, 1988 – 2017.

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

Figure 25. Choptank River yellow perch relative abundance from fyke nets, 1988 – 2017. Effort standardized from 1 March – 95% total catch date. Trendline statistically significant at P<0.001.

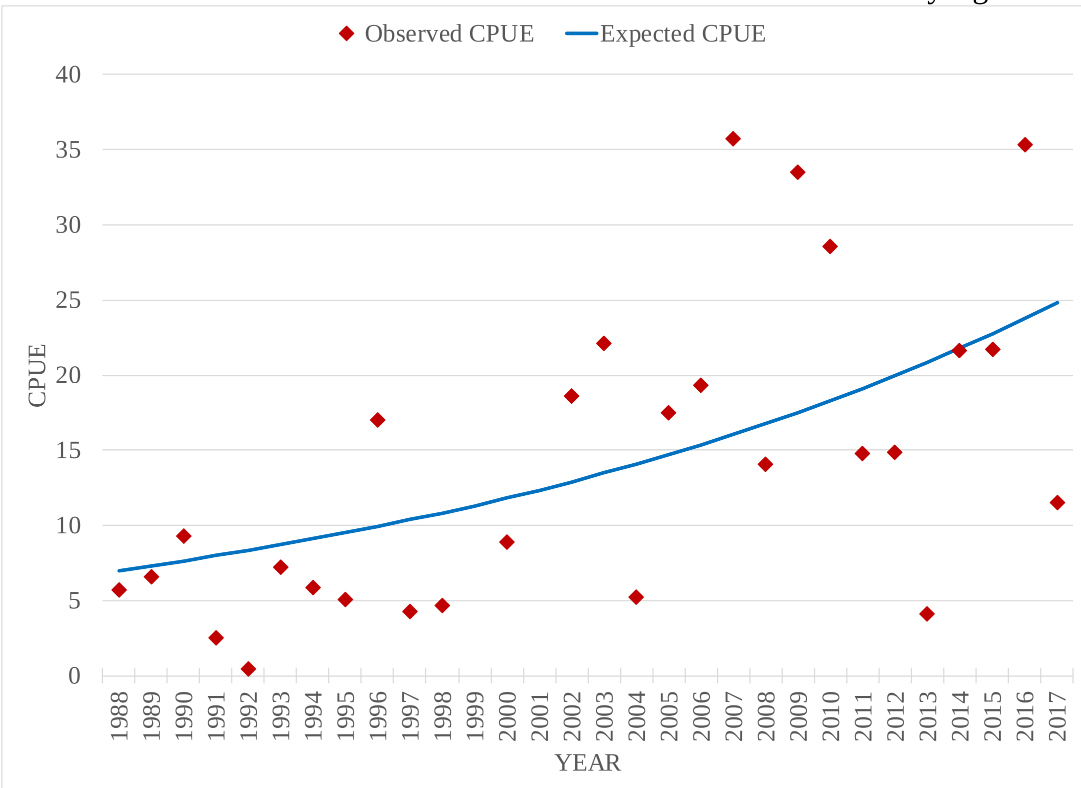


Figure 26. Channel catfish relative abundance (N/mile towed) from the upper Chesapeake Bay winter trawl survey, 2000-2017. Not surveyed in 2004, small sample sizes in 2003 and 2005.

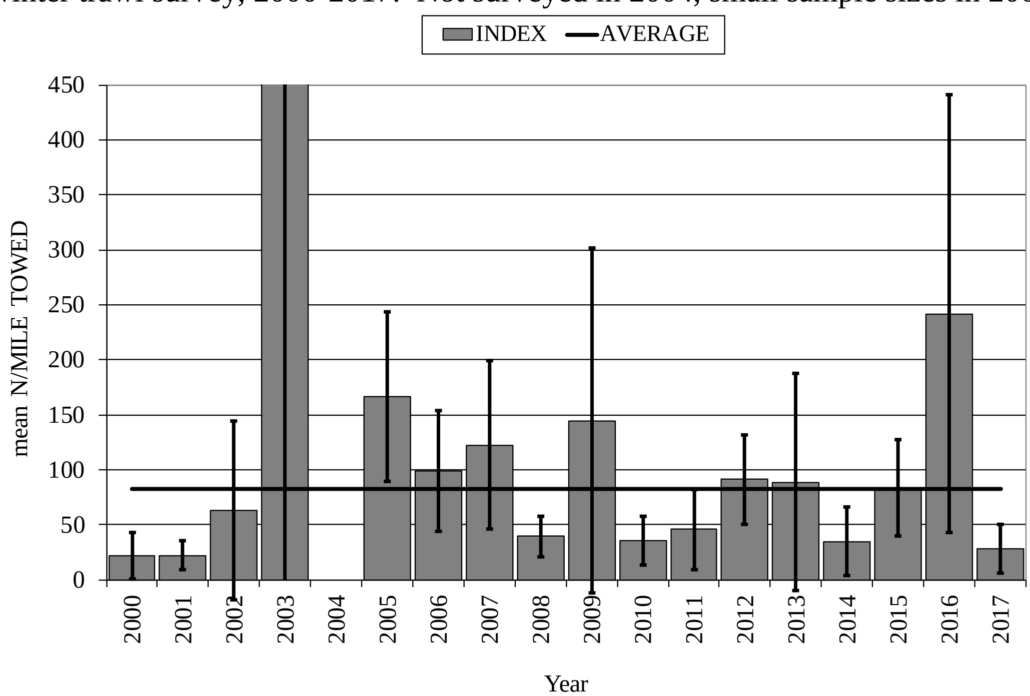


Figure 27. Channel catfish relative abundance (N/net day) from the Choptank River fyke net survey, 2000 – 2017. Horizontal line indicates time series average relative abundance.

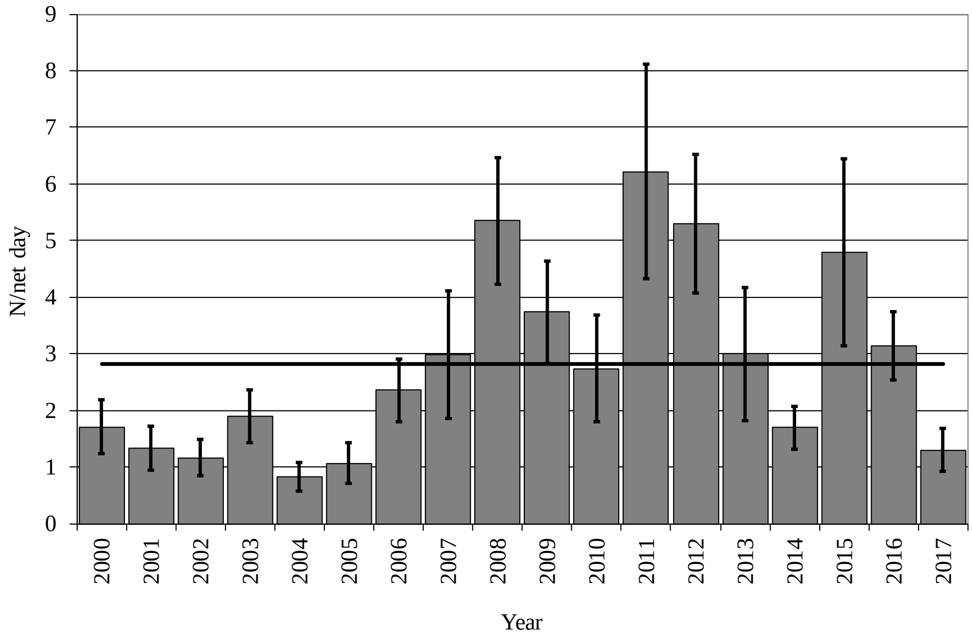
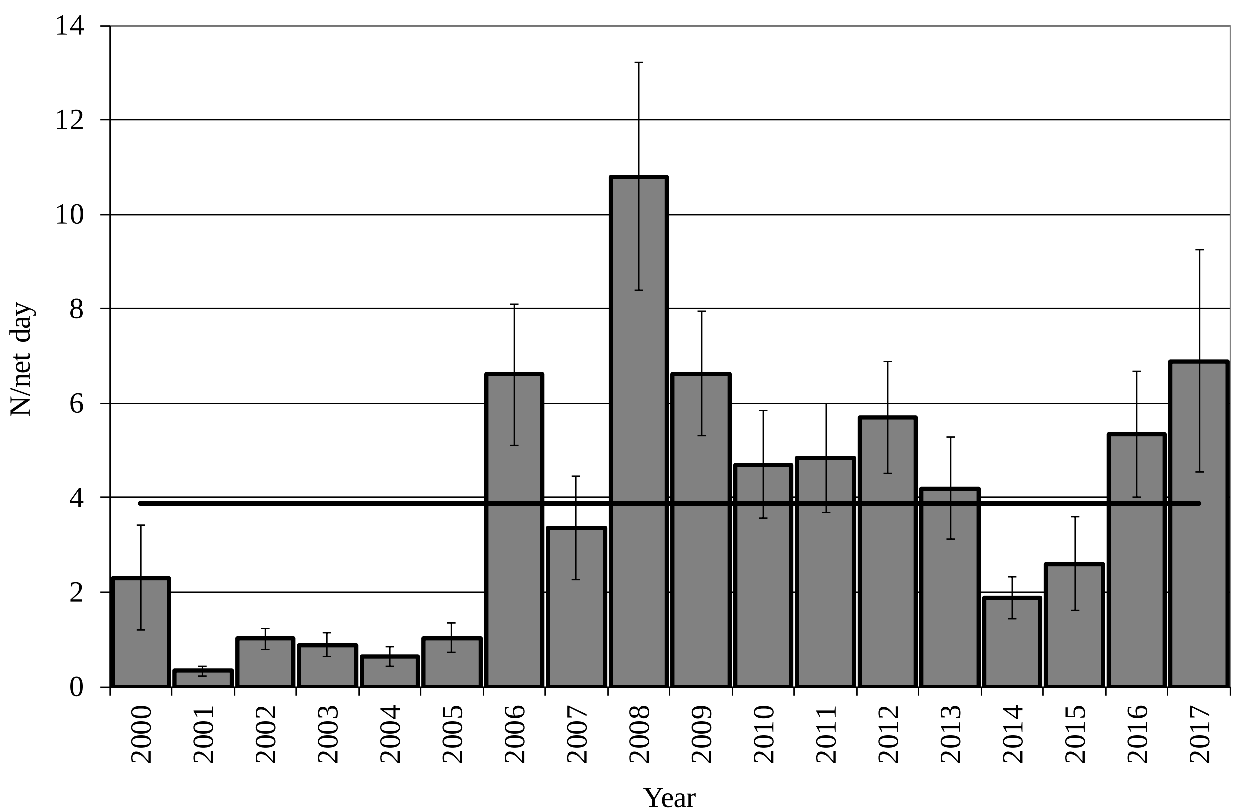


Figure 28. White catfish relative abundance (N/net day) from the Choptank River fyke net survey, 2000 – 2017. Horizontal line indicates time series average relative abundance.



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, personal communication), Maryland's 2016 recreational white perch landings (inland only) were 877,000 pounds, and averaged 672,000 pounds from 2012 – 2016. The 2013 recreational white perch harvest was the highest since a peak of > 1.2 million pounds in 2010, but landings decline to around 300,000 pounds annually in 2014. White perch also support a robust commercial fishery in Maryland. Commercial white perch landings were 1.85 million pounds in 2016 and averaged 1.65 million pounds from 2012 – 2016.

Maryland's white perch stocks were last assessed in 2014 (Piavis and Webb 2015). The 2014 assessment modeled upper Bay white perch dynamics with a Catch-

Survey Analysis (CSA) based on MDDNR winter trawl fishery independent data (see Job 1) for the years 2000 -- 2014. The CSA model was also utilized to describe the population dynamics of white perch in Choptank River based on fishery independent MDDNR fyke net survey data (1989 – 2014). 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 2014 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 were 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 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. In addition, retrospective analyses were conducted on the data by eliminating one year's data, running the model, then eliminating two year's data. The results for population size and F from each model run were plotted to determine the degree of precision that occurred in the final year's estimates.

Shortened Time-Series Model Run

As documented above, trawl indices were not available for 2003 and 2004. Although the model formulation allows for some missing data, consecutive years of no relative abundance data may confound results. A shortened time-series was modeled. This model incorporated identical inputs as the full term model, but covered only 2005 – 2017. Model results from the shortened time-series runs were graphically compared to the full time-series model.

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.

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 –2013 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. In addition, retrospective analyses were conducted on the data by eliminating one year's data, running the model, then eliminating two year's data. The results for population size and F from each model run were plotted to determine if biases occurred in the final year's estimates.

Lower Chesapeake Bay Relative Abundance Indices

Fishery Dependent

Fishery dependent relative abundance indices were calculated from the 3 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 – 2016.

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 +1 from all sites below the Bay Bridges from 1962 – 2017.

Fisheries Service has conducted a striped bass drift gill net survey in the Potomac River since 1985 (Project 2 Job 3). Catch data for 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 2.2 million white perch during 2000 – 2016. Landings declined from 2000 (2.8 million) to a time series low in 2008 of 1.1 million white perch (Figure 5). Landings rose rapidly to 2.9 million fish in 2010 and were 2.4 million white perch in 2016, almost 10 % greater than the time-series average. 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. 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 – 2017 than any other three year period.

Total population abundance (pre- and post-recruits combined) decreased from 6.9 million white perch in 2000 to 2.9 million fish in 2006 (Figure 8). Total abundance rose 19.4 million white perch in 2016. Pre-recruit abundance (185 mm TL – 202 mm TL) ranged from 1.3 million white perch in 2003 to over 9.5 million in 2016, and averaged 3.8 million during 2000 – 2016. Post-recruit white perch abundance ranged from 0.5 million white perch in 2004 to 13.7 million fish in 2017, and averaged 3.7 million fish. Instantaneous fishing mortality (F) varied throughout the time-series from F=0.14 (2016) to F=1.78 (2007; Figure 9). Final year F was 0.15 and averaged 0.62 during 2000 – 2016.

Plots of observed versus expected survey indices tracked well for the time-series (Figures 6, 7). Plots of residuals also illustrate these results. Pre-recruit residuals were generally acceptable, but the largest residuals (all positive and < 0.5) occurred in the last 2 years (Figure 10). The post-recruit residuals were also indicative of a good fit, but the final year estimate produced the largest negative residual (Figure 11).

A suite of biological reference points were 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 appear appropriate. Target F and limit F were 0.6 and 1.12, respectively. Estimated F marginally exceeded target F in 2007, and again in 2010 and 2011. Since that time, F was at or below target F (Figure 9).

Bootstrap evaluation of the model indicated precise results. Of the 5,000 bootstrap trials, 99.98 % were successful. Catchability was precisely estimated (CV=10.2 %). Pre-recruit abundance fit very well with CV's ranging from 13.4 % in 2007 to 28.4 % in 2002 (Table 1). Post-recruit white perch abundance estimates were slightly less precise than the pre-recruit estimates, but they were still regarded as precise (Range= 18.3 % -- 40.8 %). Confidence intervals (80%) of pre-recruit and post-recruit abundance were determined from bootstrap samples (Figures 12, 13). Abundance estimates were particularly unreliable for at least one year when the trawl survey was idled. Confidence intervals of fishing mortality indicated a slightly low bias, and were problematic for at least one year where the trawl survey was idled (Figure 14). These anomalous values when the fishery independent index was unavailable was the ultimate reason a shorter time series was also modeled.

Retrospective analysis indicated that the model was somewhat optimistic. Abundance estimates for both the pre-recruits and post-recruits were 24 % higher in the t-2 retrospective run than the 2017 model run (Figures 15, 16). Instantaneous fishing mortality (F) was underestimated by 18 % from the t-2 run to the 2017 run (Figure 17).

The shortened time series results indicated that there was little loss of information by starting the assessment with 2005 data. Pre-recruit abundance estimates were never greater than 3 % of the full model, post-recruit estimates were never greater than 4.5% of the full model, and F deviated less than 3.5 % (Figures 18, 19, 20).

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 21). Recently, removals have rebounded from 381,000 in 2009 to over 1 million fish in both 2011 and 2012. An estimated 935,000 white perch were harvested in the final year (2016). 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 22). Post-recruit white perch CPUE was flat from 1989 – 1998 (Figure 23). The post-recruit index exhibited an increasing trend from 1998 – 2010 before declining through 2017.

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 4.0 million fish in 2010 (Figure 24). Since 2010, abundance varied between 2.0 million and 3.4 million white perch. Pre-recruit abundance (185 mm – 202 mm) ranged from 417,000 white perch in 1989 to 1.8 million in 2015 before declining to 500,000 in 2016. Post-recruit white perch abundance ranged from 581,000 white perch in 1989 to 2.7 million fish annually during the five year period 2008 -- 2012. Terminal year (2017) estimate was 1.2 million fish. Instantaneous fishing mortality (F) increased through 1997 followed by a general decline through 2010 (Figure 25). Since 2010, F increased; final year F was 0.54.

Plots of observed versus expected survey indices tracked well for a large portion of the time series, but the model results failed to track an increasing pre-recruit index during 2006 – 2009 (Figure 22). The expected post-recruit CPUE tracked the upward trend of observed CPUE (1989 – 2009), and the subsequent decline later in the time-series (Figure 23). The pre-recruit residuals exhibited a pattern of largely negative residuals for the first 10 years and turned positive for the next fifteen (Figure 26). Post-recruit residuals were fairly evenly (Figure 27).

Comparing the derived F with the proposed biological reference points indicated that overfishing did occur for at least a small portion of the time-series. Target F was exceeded several years in the 1990's, and F was very near the limit in 1997. However, F has been below the target 2001 -- 2016, except for 2012 (Figure 25).

Bootstrap evaluation of the model indicated precise results. Of the 5,000 bootstrap trials, over 99% were successful. Catchability was very precisely estimated at 2.4 % (CV). Pre-recruit abundance fit very well with CV's, ranging from 18% 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 28, 29, 30).

Retrospective analysis indicated that the model was only slightly optimistic. Abundance estimate for pre-recruit white perch was overestimated by 9 % and the post-recruit abundance was under estimated by 10 % in the t-2 retrospective run (Figures 31, 32). Instantaneous fishing mortality (F) was overestimated by 7% from the t-2 run to the 2017 run (Figure 33).

Lower Chesapeake Bay Relative Abundance Indices

Fishery Dependent

Fishery dependent relative abundance indices produced mixed information. The fyke net index indicated a slight from 2013 through 2016, with the final year less than 10% below median values (Figure 34). 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 2013 – 2016 was of increasing relative abundance, ending slightly above median values (Figure 35). The drift gill net index was more similar to the pound net index with relative abundance measures increasing 2013 – 2016 (Figure 36). The increase over that time period was quite pronounced with the 2016 value the highest in the time series and 3X greater than the 2013 value.

Fishery Independent

An adult white perch relative abundance index was derived from a striped bass spawning stock survey (drift gill net) in 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 37). As with the fishery dependent relative abundance values, the fishery independent survey indicated higher relative abundance 2011 – 2017. Similar to the commercial metrics, four of the last five common years (2012 – 2016) were above median values.

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 38). 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 and 2015. 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 38).

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, upper Chesapeake Bay covering all areas north of the Preston Lane Memorial Bridges, and Choptank River. Upper Chesapeake Bay commercial white perch landings accounted for 32% of total Maryland Chesapeake Bay landings, and commercial landings from Choptank River accounted for 22% of total baywide landings in 2016 (52% of statewide total). Recreational removals in upper Bay accounted for, on average, 59% of the baywide recreational harvest over the 2 year period, 2015 and 2016. Recreational removals in

Choptank River accounted for, on average 6% of the baywide recreational harvest over the 2 year period (2015 and 2016). Therefore, these two systems accounted for 65% of the recreational harvest during that time period.

Upper Chesapeake Bay Assessment

The CSA model fit the fishery independent trawl data well. Coefficients of variation of pre-recruit and post-recruit N ranged from 13.4% to 40.8%. However, the only CV's greater than 28% occurred in years where the fishery independent trawl survey was idled. The secondary model run beginning with 2005 data agreed very precisely with the full dataset, indicating that although the 2003 -- 2004 estimates were relatively imprecise, the more recent and illustrative results were well estimated and quite robust.

Total population size exhibited a strong increasing trend in both pre-recruit and post-recruit abundance after 2014 and 2015, respectively. This increase was also validated by the Estuarine Juvenile Finfish Survey upper Bay young-of-year white perch index which discerned a very strong 2011 year-class and above average values for 2014 and 2015. The previous assessment (Piavis and Webb 2015) indicated a saddle-shaped pattern where the lowest abundance occurred midway through the time series (2004 – 2009). The dominant 2011 year-class would not have been accounted for in the earlier assessment. The recent population increase makes the previous saddle shape much less prominent (a matter of scale).

Estimated fishing mortality (F) has declined since 2006 when F was at the limit (67% chance of exceeding limit from bootstrap analysis). Since 2006, F was at or over target F in 2007, 2010, 2011, and 2013. Probability of exceeding the target in those years ranged from 62% to 94%, but the probability of exceeding limit F was slight. Since

2013, the probability of exceeding either the target or limit was 0%. Therefore, overfishing did not occur on the upper Bay white perch stock for the terminal year. Comparing the recent F estimates to the population growth indicates that even violating the 0.6 F target did not hamper population expansion.

Choptank River Assessment

The model run for Choptank River white perch indicated that total population abundance declined after reaching a peak in 2011 (time series = 1989 – 2016). 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.

Fishing mortality rates exhibited a declining trend since 1997 when F was above the proposed limit reference point. Recently, fishing mortality approached but did not exceed the target reference point in 2011, breeched it 2012, and declined to 0.27 in 2015. Terminal year F estimate was 0.54 (target F = 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. Stock specific estimates of F from age data or other methods need to be investigated for comparisons to biological reference points.

Diagnostics of model precision, bootstrap metrics, retrospective analysis, and residual plotting suggest that the model fit the data very well. However, the pattern of residuals in the pre-recruit index persisted; this pattern was evident in the 2008 assessment (Piavis and Webb 2009), in 2011 (Piavis and Webb 2012), and in 2014 (Piavis and Webb 2015). Alternate model runs were made by shortening the time series (due to increased DNR fyke effort after 1993) and up-weighting the pre-recruit index. These model runs did lessen the residual pattern and population estimates were generally within 10% of the base run. The 10% difference did fall within the confidence limits of the base model, so we adopted the base run of equal weighting and 1989 – 2017 data range for the current assessment. In addition, the observed values increased steadily over the first 20 years. The model fit the straight line of the uptrend which naturally had most negative residuals in the earliest portion, switching to positive residuals for the latter half of the time period.

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, followed by a decline. The decline persisted until around 2007 with the indices indicating an increasing population through 2016. The population bottom in 2007 and possible recovery through 2016 is almost identical to the upper Bay CSA results. The fyke net and gill net indices indicated high relative abundance (the highest in the time series) in 2015 (fyke net) and 2016 (gill net). The pound net index is more difficult to interpret, but a recent low index value in 2013 increased to the median by 2016. The pound net fishery is probably the most opportunistic fishery of the three. The drift gill net fishery and fyke net fishery are more likely targeting white perch and as such may be more indicative of population trends.

The fishery independent indices somewhat 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 2015. 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 8 year moving average, utilized as a proxy for population trends for 1 – 8 year old white perch, suggested that abundance did decline after 2003, but stabilized during the period 2010 – 2014. The 2016 and 2017 moving average was the highest since 2003.

PROJECT NO. 1
JOB NO. 2

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

2017 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 Bay assessment has utilized a surplus production model in the past, but Job 2 is also investigating whether a Catch Survey Analysis is appropriate. The most likely model results will be reported. Choptank River stocks are being assessed with a Catch Survey Analysis, utilizing data from Job 1's fyke net survey. The base models have been written and run. Choptank River channel catfish stocks are declining due to poor recent recruitment, although fishing mortality is relatively low. The upper Chesapeake Bay stocks are abundant and fishing mortality is not excessive, despite the commercial and recreational removal of 1.5 million pounds in 2016 and 1.3 million pounds in 2017. The lower Bay assessment will examine trends in fishery dependent relative abundance.

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<u>**LIST OF FIGURES**</u>

LIST OF FIGURES (cont'd)

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

Estimate/Parameter	Estimate	Mean	Median	CV	Bias[1]
q	8.71E-06	9.02E-06	8.98E-06	10.2	-3.0
Pre-Recruit N 2000	2,705,893	2,722,248	2,583,295	25.4	4.7
Pre-Recruit N 2001	3,222,565	3,214,423	3,124,885	22.8	3.1
Pre-Recruit N 2002	2,194,392	2,208,537	2,018,486	28.4	8.7
Pre-Recruit N 2003	1,321,119	2,701,094	2,713,633	13.5	-51.3
Pre-Recruit N 2004	4,261,873	3,118,280	3,143,250	19.1	35.6
Pre-Recruit N 2005	2,213,064	2,220,187	2,174,125	20.2	1.8
Pre-Recruit N 2006	1,554,777	1,575,656	1,538,184	19.5	1.1
Pre-Recruit N 2007	5,531,519	5,356,294	5,323,292	13.4	3.9
Pre-Recruit N 2008	2,175,981	2,148,035	2,050,712	23.9	6.1
Pre-Recruit N 2009	3,520,972	3,456,508	3,388,107	20.0	3.9
Pre-Recruit N 2010	2,900,987	2,897,668	2,828,869	20.3	2.5
Pre-Recruit N 2011	2,634,344	2,643,399	2,581,489	20.3	2.0
Pre-Recruit N 2012	2,113,927	2,100,889	2,030,012	22.5	4.1
Pre-Recruit N 2013	4,381,970	4,288,635	4,215,788	19.1	3.9
Pre-Recruit N 2014	5,936,813	5,754,459	5,602,233	22.4	6.0
Pre-Recruit N 2015	8,415,427	8,194,175	7,941,624	23.2	6.0
Pre-Recruit N 2016	9,521,307	9,365,458	8,882,770	25.3	7.2
Post-Recruit N 2000	4,154,738	3,934,800	3,925,056	22.4	5.9
Post-Recruit N 2001	3,017,554	2,850,874	2,808,120	24.5	7.5
Post-Recruit N 2002	2,955,570	2,812,438	2,751,209	27.6	7.4
Post-Recruit N 2003	2,297,284	2,191,678	2,099,929	40.8	9.4
Post-Recruit N 2004	500,005	1,543,371	1,504,831	34.1	-66.8
Post-Recruit N 2005	1,889,122	1,807,062	1,809,506	24.0	4.4
Post-Recruit N 2006	1,379,410	1,318,058	1,325,200	23.0	4.1
Post-Recruit N 2007	754,939	721,802	699,198	31.5	8.0
Post-Recruit N 2008	2,625,718	2,455,126	2,429,456	24.9	8.1
Post-Recruit N 2009	2,949,765	2,787,216	2,763,619	21.6	6.7
Post-Recruit N 2010	3,880,925	3,695,061	3,680,826	18.3	5.4
Post-Recruit N 2011	2,908,853	2,753,964	2,745,852	22.2	5.9
Post-Recruit N 2012	2,157,972	2,038,574	2,008,491	26.4	7.4
Post-Recruit N 2013	2,299,303	2,190,873	2,163,558	25.4	6.3
Post-Recruit N 2014	2,994,890	2,829,700	2,768,194	28.2	8.2
Post-Recruit N 2015	6,004,824	5,720,280	5,624,796	22.3	6.8
Post-Recruit N 2016	9,881,306	9,467,194	9,306,019	20.9	6.2
Post-Recruit N 2017	13,730,233	13,263,589	13,027,092	20.4	5.4

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

Estimate/Parameter	Estimate	Mean	Median	CV	Bias1
q	2.20E-05	2.25E-05	2.25E-05	2.4	-2.3
Pre-Recruit N 1989	417,524	432,969	416,802	30.6	0.2
Pre-Recruit N 1990	992,772	968,555	951,933	22.5	4.3
Pre-Recruit N 1991	521,405	537,856	516,442	30.1	1.0
Pre-Recruit N 1992	778,184	782,336	768,316	24.8	1.3
Pre-Recruit N 1993	780,155	788,967	775,371	24.0	0.6
Pre-Recruit N 1994	1,062,925	1,054,145	1,032,327	22.0	3.0
Pre-Recruit N 1995	1,050,705	1,056,935	1,031,042	23.3	1.9
Pre-Recruit N 1996	1,457,343	1,443,971	1,428,052	20.4	2.1
Pre-Recruit N 1997	1,543,326	1,543,215	1,532,114	18.6	0.7
Pre-Recruit N 1998	1,115,646	1,121,570	1,091,379	25.0	2.2
Pre-Recruit N 1999	1,671,596	1,633,177	1,615,649	20.7	3.5
Pre-Recruit N 2000	1,025,240	1,036,878	1,006,903	27.3	1.8
Pre-Recruit N 2001	1,371,952	1,358,778	1,331,622	24.2	3.0
Pre-Recruit N 2002	1,154,023	1,163,907	1,123,977	28.2	2.7
Pre-Recruit N 2003	1,606,568	1,582,443	1,540,752	25.5	4.3
Pre-Recruit N 2004	1,380,930	1,379,777	1,335,893	27.9	3.4
Pre-Recruit N 2005	1,516,683	1,493,539	1,449,706	27.5	4.6
Pre-Recruit N 2006	1,409,526	1,409,713	1,360,757	29.5	3.6
Pre-Recruit N 2007	1,567,597	1,529,688	1,475,508	28.5	6.2
Pre-Recruit N 2008	1,146,285	1,149,289	1,106,963	30.5	3.6
Pre-Recruit N 2009	1,002,256	1,011,297	971,488	30.9	3.2
Pre-Recruit N 2010	1,294,176	1,269,715	1,233,289	27.8	4.9
Pre-Recruit N 2011	683,540	703,122	674,966	31.5	1.3
Pre-Recruit N 2012	679,111	691,406	660,390	30.9	2.8
Pre-Recruit N 2013	981,405	986,992	960,362	27.7	2.2
Pre-Recruit N 2014	1,086,191	1,102,913	1,072,380	28.2	1.3
Pre-Recruit N 2015	1,846,080	1,820,460	1,785,126	23.1	3.4
Pre-Recruit N 2016	497,227	533,997	508,402	34.4	-2.2
Recruit N 1989	581,026	547,714	530,521	27.0	9.5
Recruit N 1990	592,682	578,053	567,368	22.6	4.5
Recruit N 1991	938,342	906,538	893,306	19.0	5.0
Recruit N 1992	797,665	785,095	774,300	19.8	3.0
Recruit N 1993	708,563	701,671	690,979	22.1	2.5
Recruit N 1994	545,138	546,710	530,351	26.0	2.8
Recruit N 1995	719,038	713,137	693,542	24.9	3.7
Recruit N 1996	754,525	754,795	736,921	25.1	2.4
Recruit N 1997	930,161	919,434	897,938	24.8	3.6
Recruit N 1998	679,653	670,779	650,054	27.5	4.6
Recruit N 1999	948,724	946,309	925,255	23.8	2.5
Recruit N 2000	1,128,525	1,095,094	1,076,309	22.7	4.9
Recruit N 2001	1,052,040	1,034,197	1,016,119	22.8	3.5
Recruit N 2002	1,281,054	1,255,658	1,227,014	21.4	4.4
Recruit N 2003	1,446,527	1,433,828	1,411,352	20.1	2.5
Recruit N 2004	1,722,402	1,692,253	1,667,961	20.0	3.3
Recruit N 2005	1,660,201	1,634,573	1,604,616	20.8	3.5
Recruit N 2006	2,018,198	1,978,266	1,951,542	18.4	3.4
Recruit N 2007	2,392,569	2,360,030	2,334,020	16.6	2.5
Recruit N 2008	2,714,849	2,657,170	2,633,739	15.2	3.1
Recruit N 2009	2,698,621	2,653,858	2,630,194	14.3	2.6
Recruit N 2010	2,692,162	2,662,916	2,644,393	13.3	1.8
Recruit N 2011	2,655,467	2,611,495	2,599,658	12.2	2.1
Recruit N 2012	1,781,240	1,761,271	1,748,388	15.1	1.9
Recruit N 2013	1,015,491	1,009,209	992,752	21.7	2.3
Recruit N 2014	1,179,374	1,178,804	1,160,405	20.1	1.6
Recruit N 2015	1,304,377	1,317,602	1,294,761	20.3	0.7
Recruit N 2016	1,965,069	1,954,920	1,919,844	17.1	2.4
Recruit N 2017	1,169,264	1,191,060	1,161,746	23.7	0.6

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

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

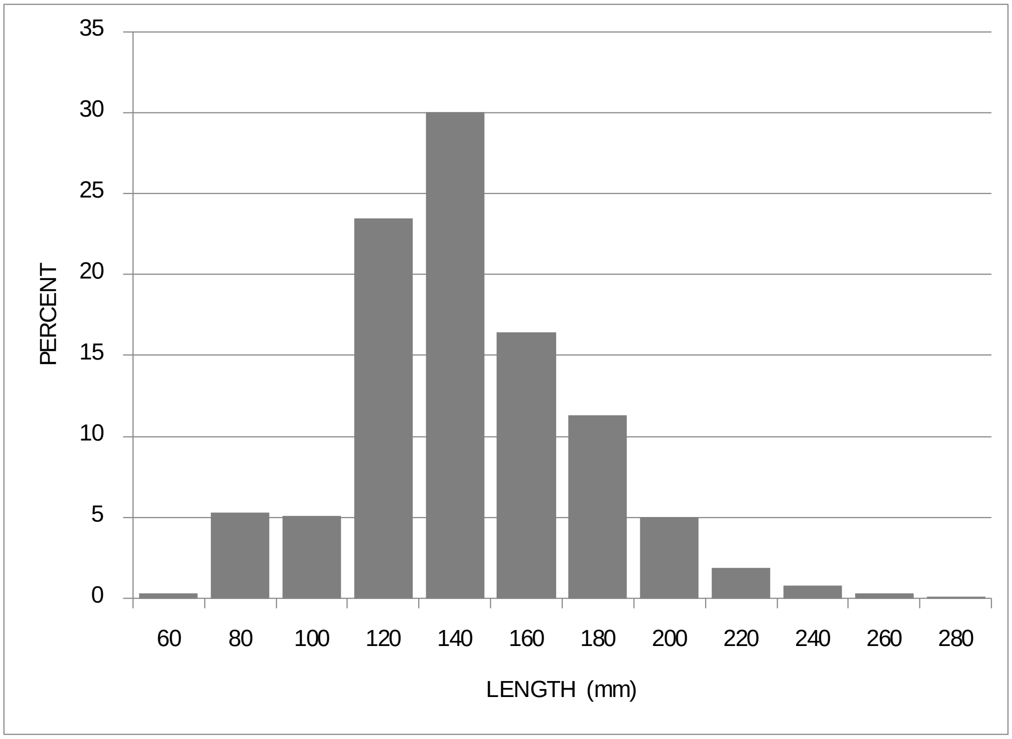


Figure 2. Length frequency of white perch from Choptank River fyke net survey, 2017.

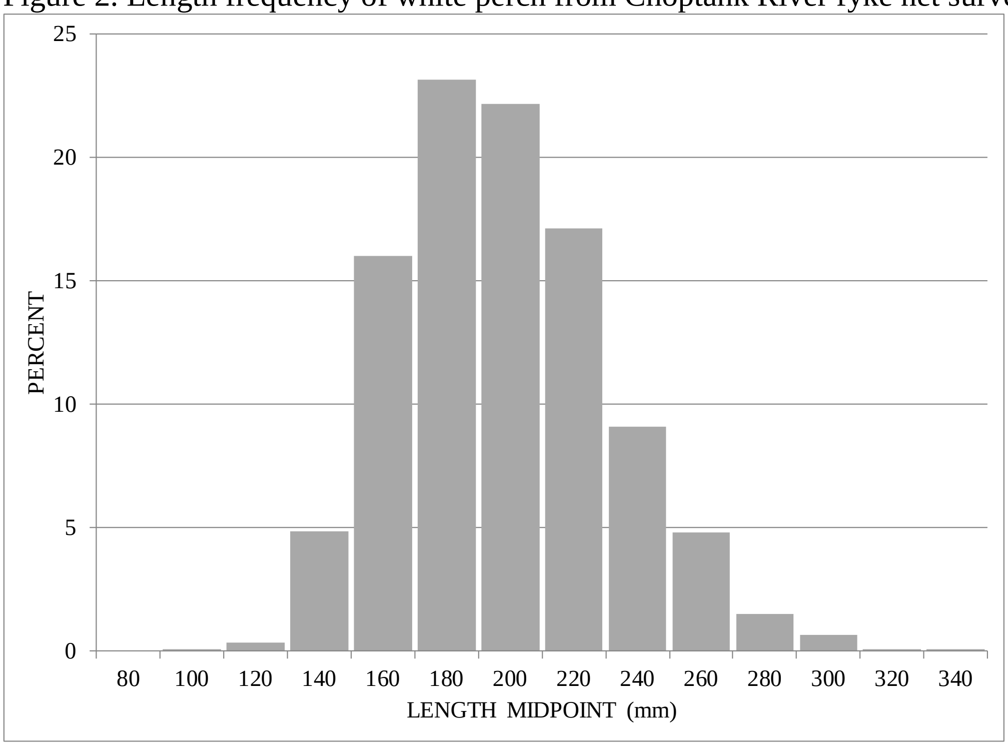


Figure 3. Upper Chesapeake Bay trawl sites, 2017.

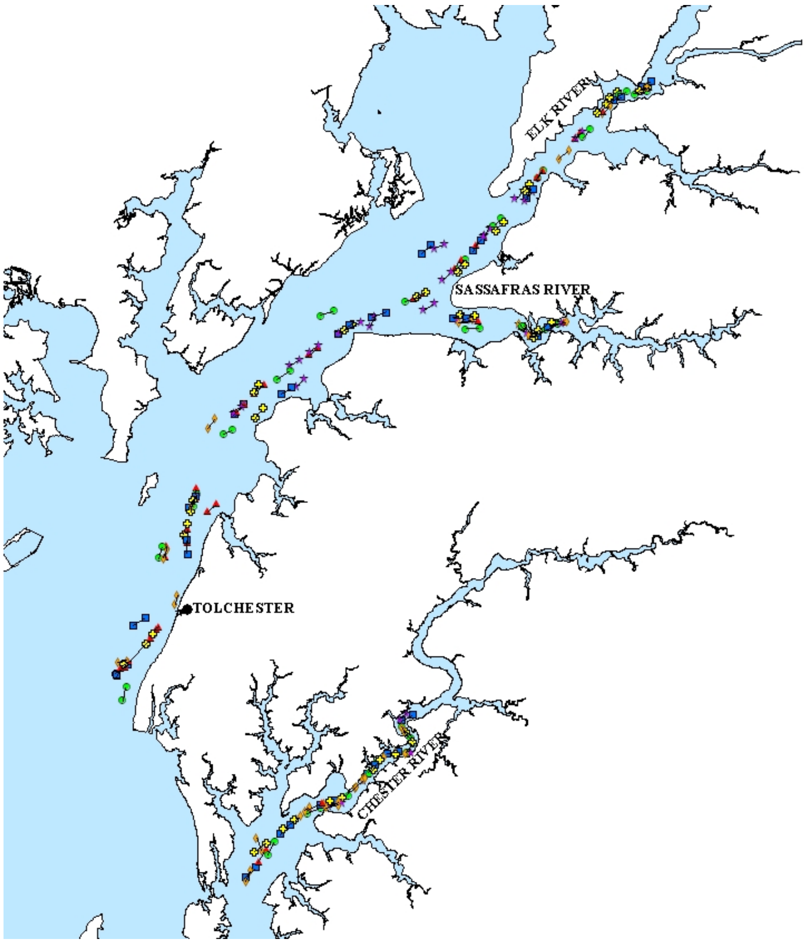


Figure 4. Choptank River fyke net sites (circles), 2017.

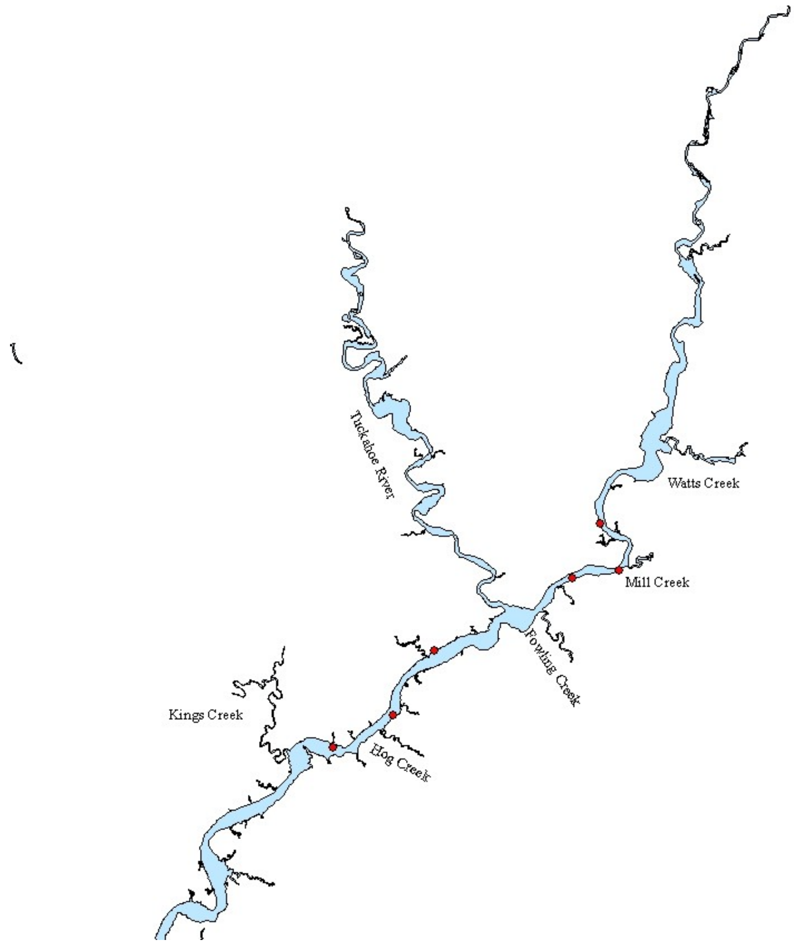


Figure 5. Estimated upper Chesapeake Bay white perch removals (commercial and recreational), 2000 – 2016.

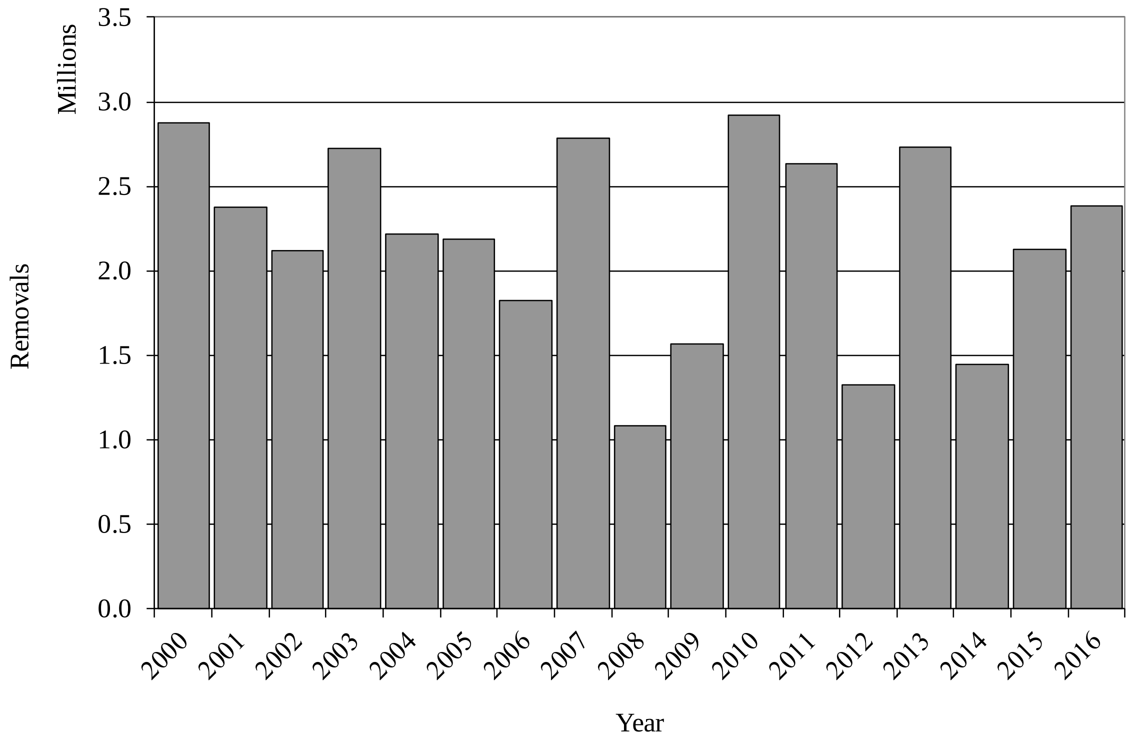


Figure 6. Observed and expected white perch pre-recruit indices from upper Chesapeake Bay trawl survey, 2000 – 2016.

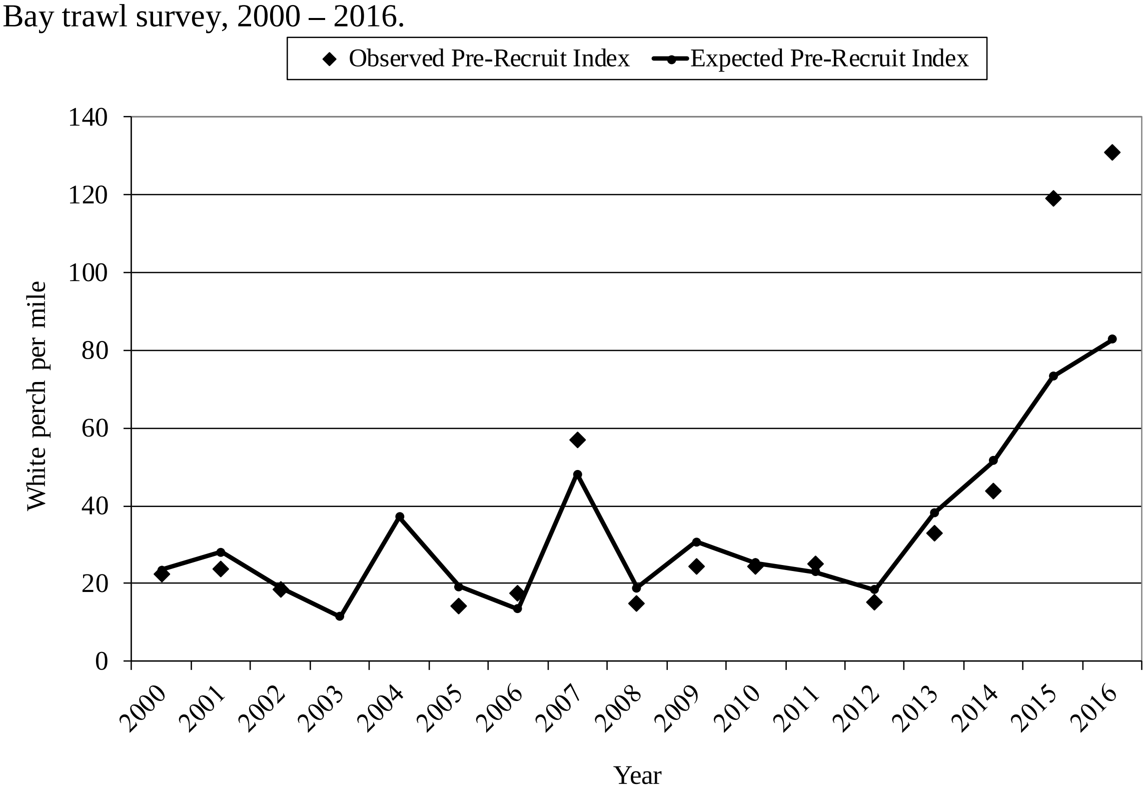


Figure 7. Observed and expected white perch post-recruit indices from upper Chesapeake Bay trawl survey, 2000 – 2017.

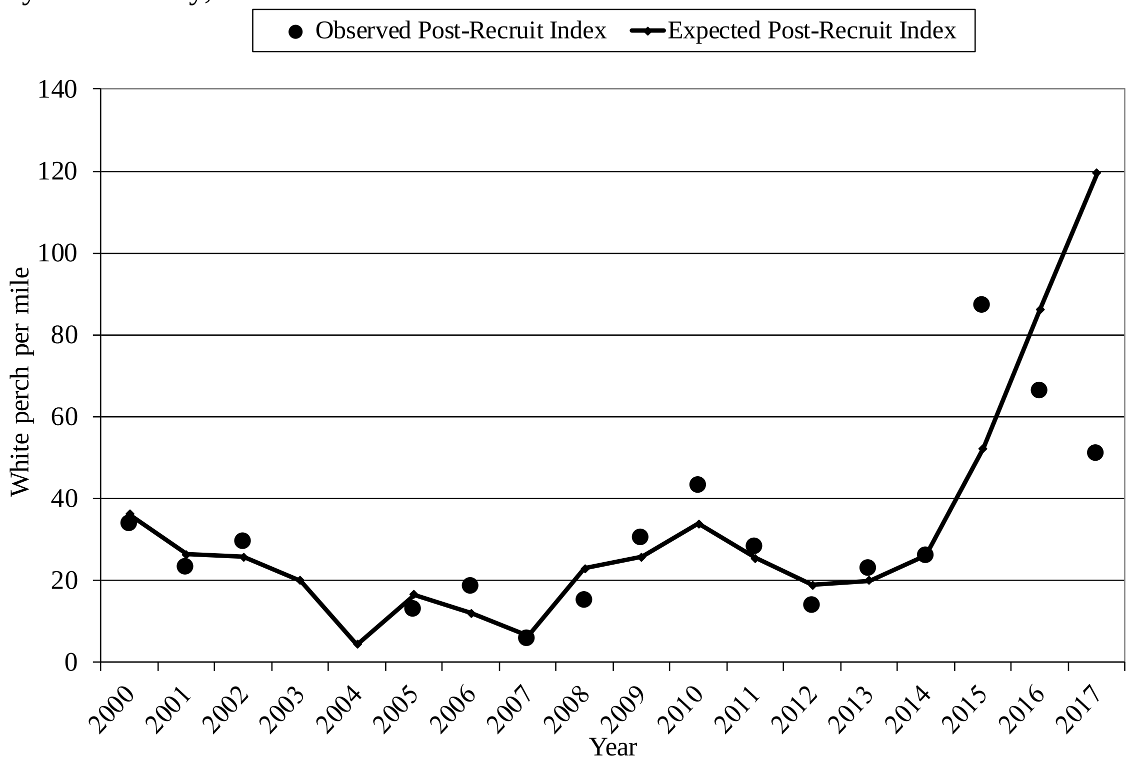


Figure 8. Total population estimate of upper Chesapeake Bay white perch from Catch Survey Analysis, 2000 – 2017.

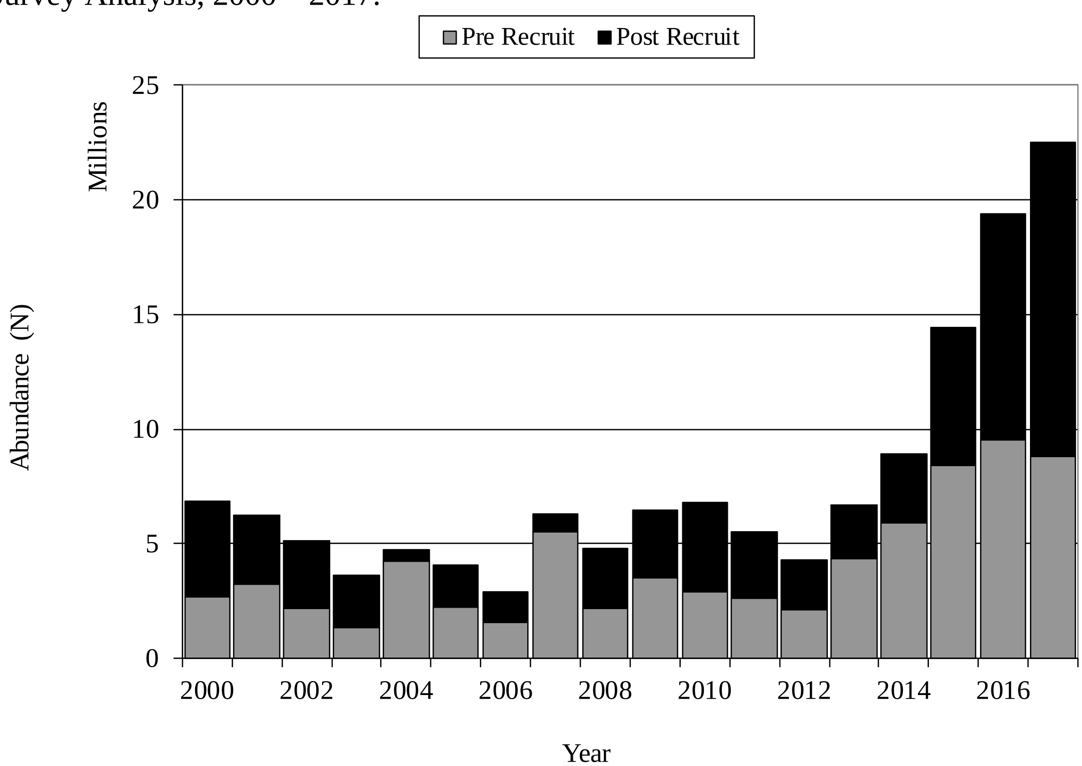


Figure 9. Instantaneous fishing mortality (F) of upper Chesapeake Bay white perch and proposed biological reference points for F, 2000—2016.

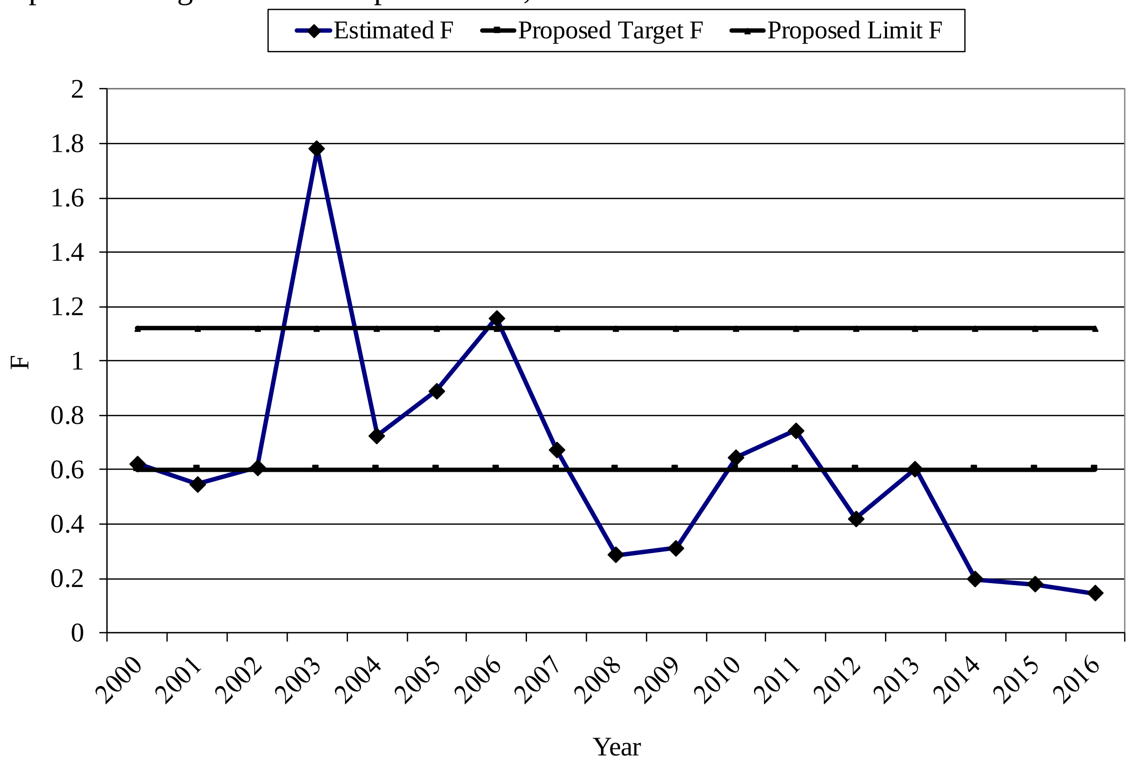


Figure 10. Pre-recruit residuals from upper Chesapeake Bay Catch Survey Analysis of white perch.

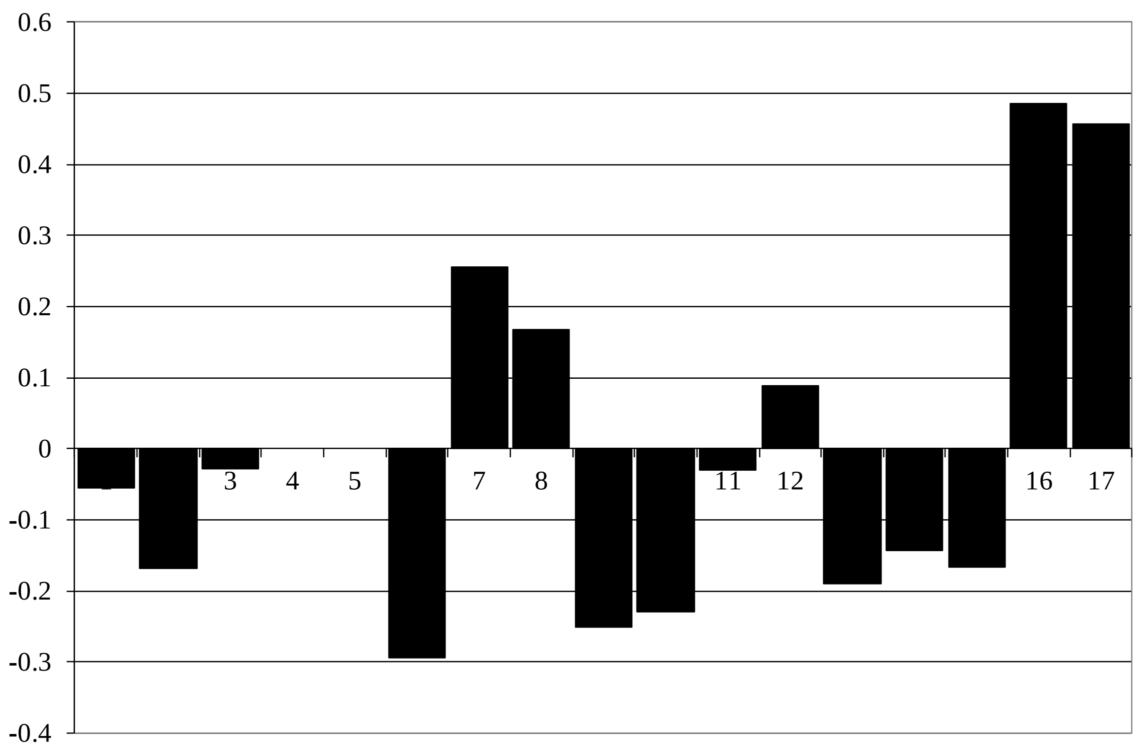


Figure 11. Post-recruit residuals from upper Chesapeake Bay Catch Survey Analysis of white perch.

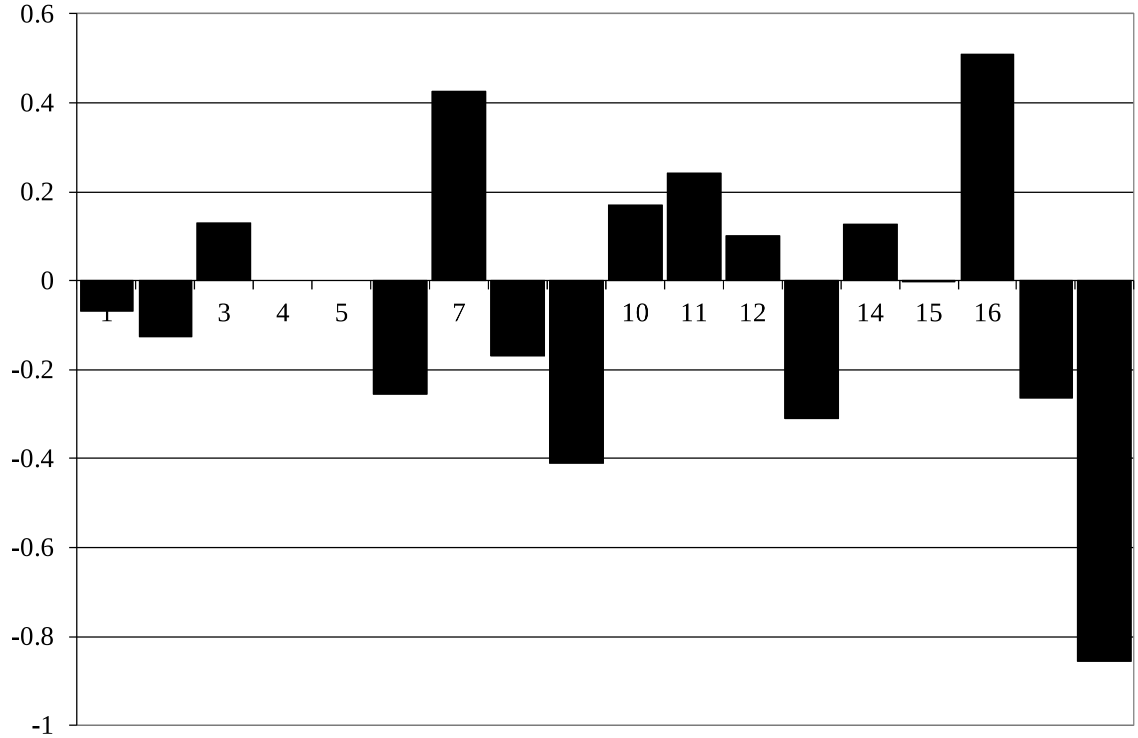


Figure 12. Bootstrap derived confidence intervals (80 %) for upper Chesapeake Bay pre-recruit white perch.

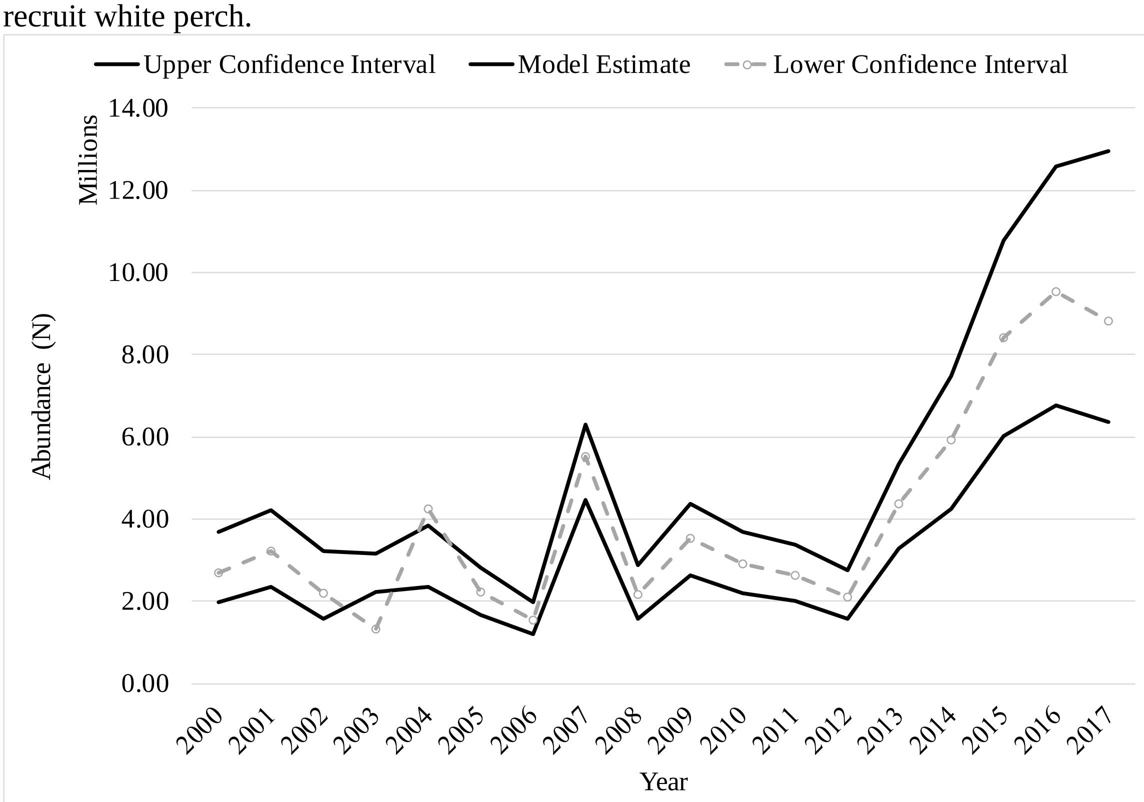


Figure 13. Bootstrap derived confidence intervals (80 %) for upper Chesapeake Bay post-recruit white perch.

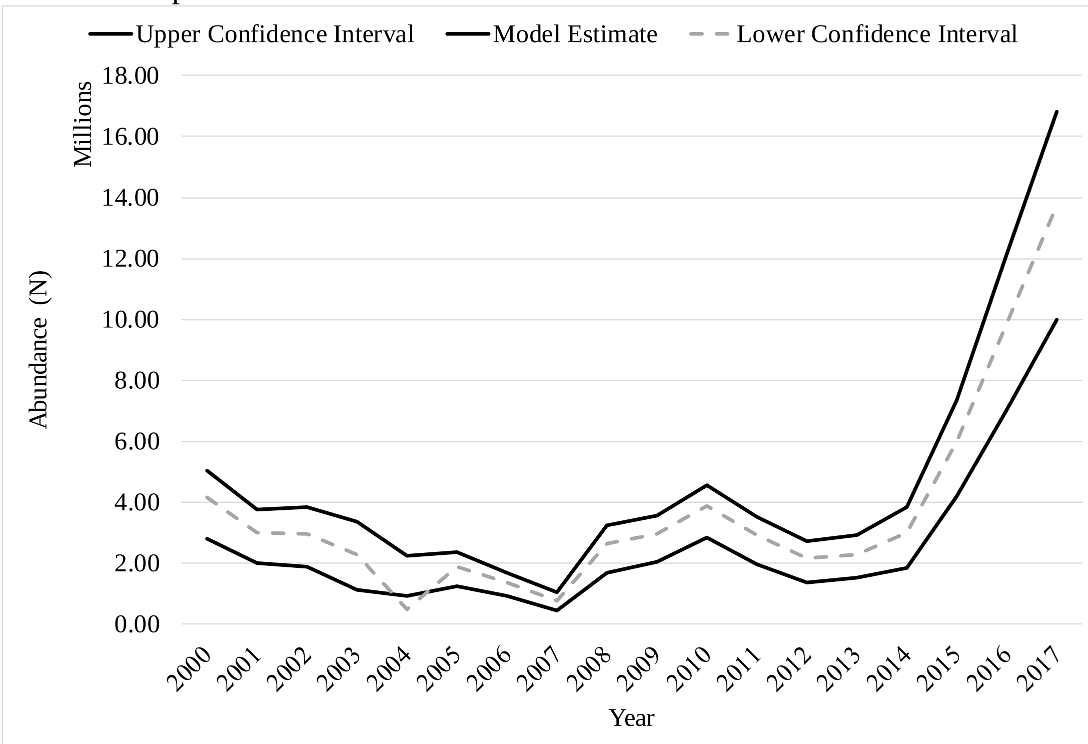


Figure 14. . Bootstrap derived confidence intervals (80 %) for upper Chesapeake Bay white perch instantaneous fishing mortality (F).

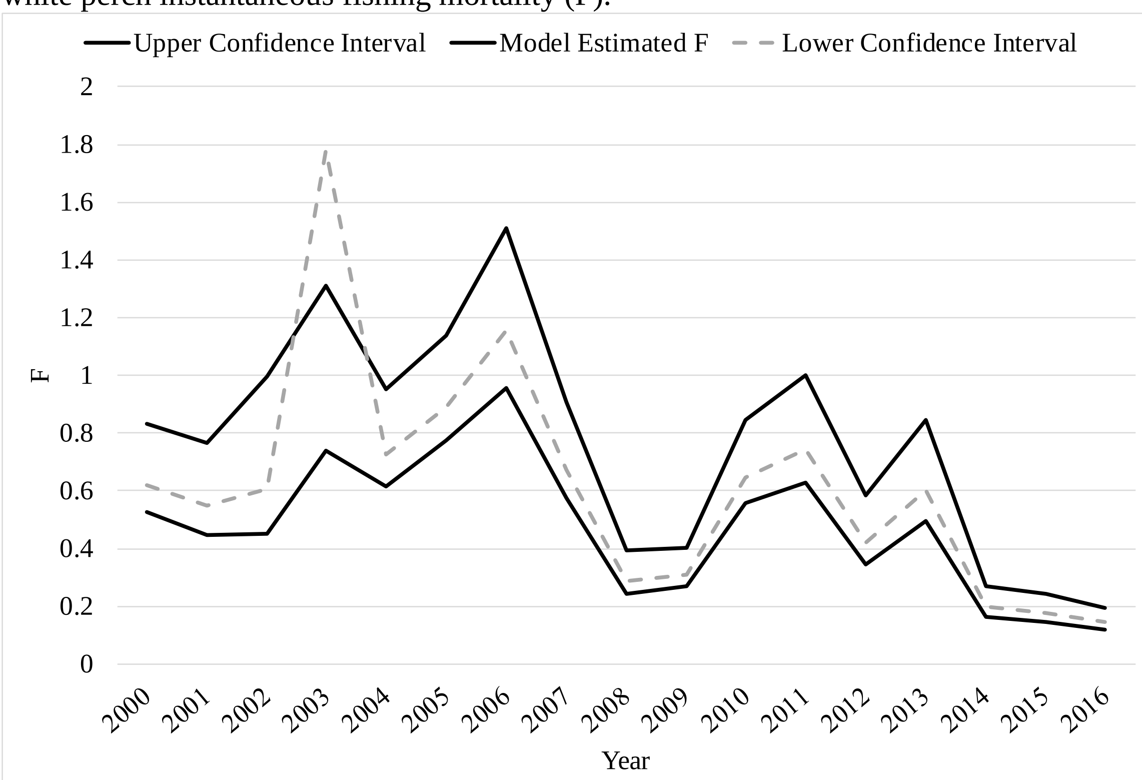


Figure 15. Retrospective analysis of upper Chesapeake Bay pre-recruit white perch estimates from Catch Survey Analysis.

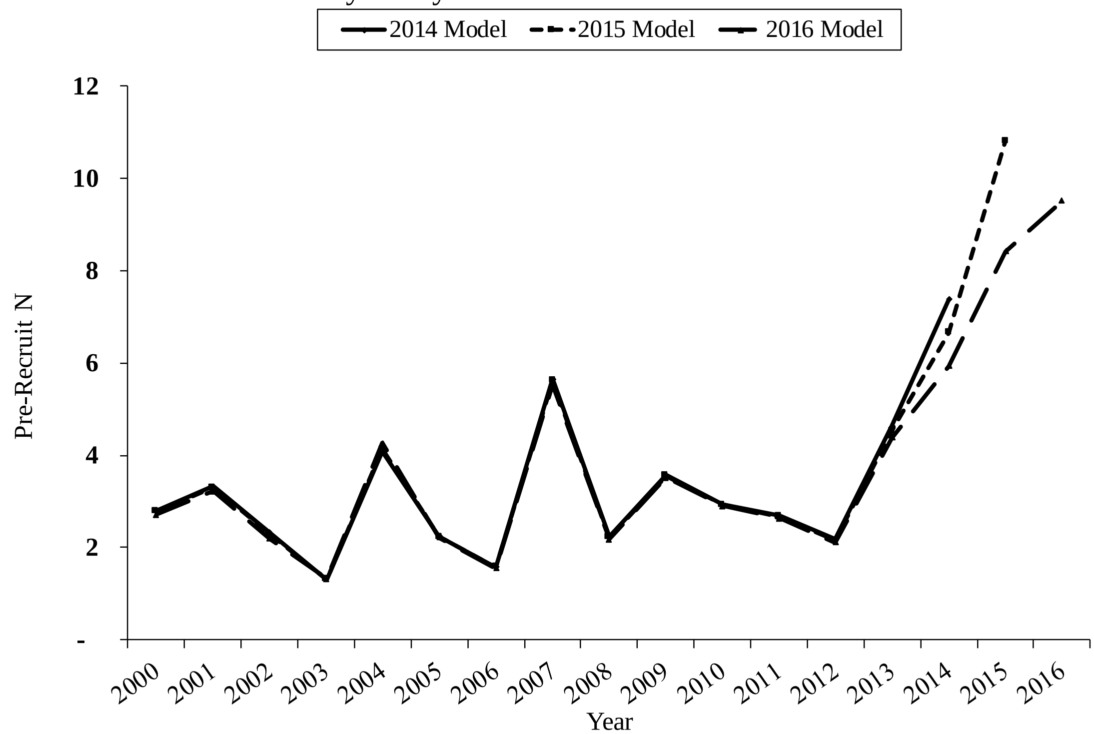


Figure 16. Retrospective analysis of upper Chesapeake Bay post-recruit white perch estimates from Catch Survey Analysis.

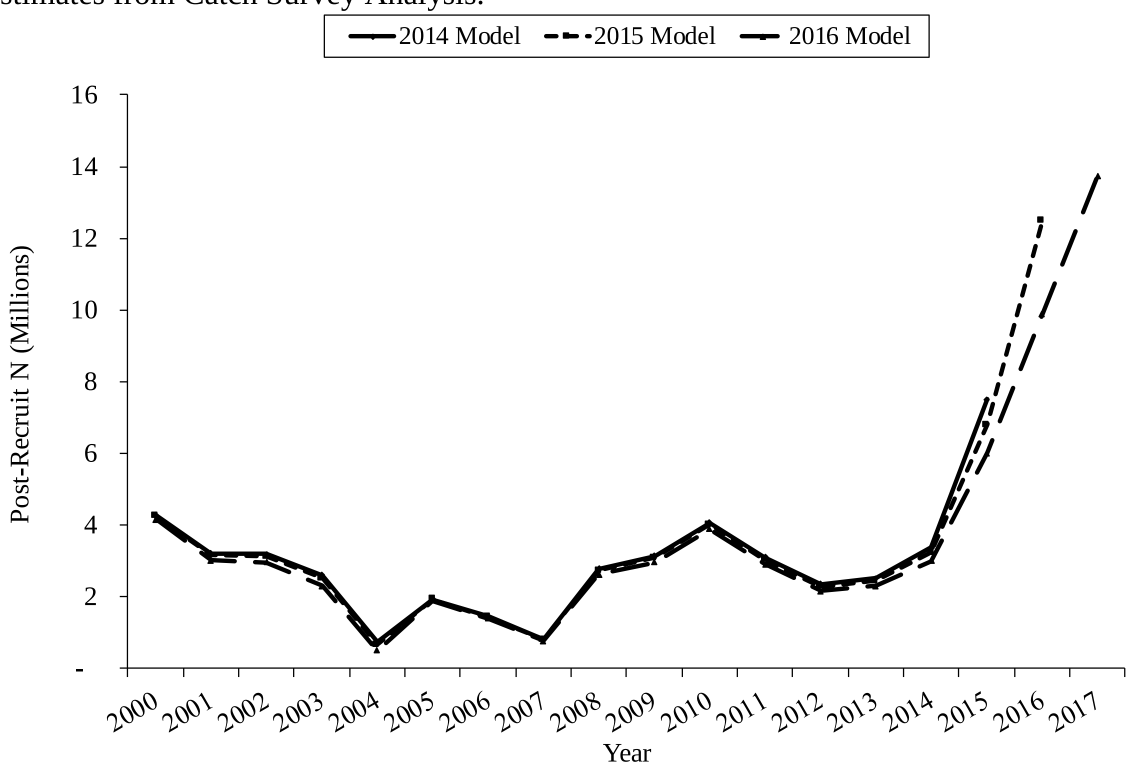


Figure 17. Retrospective analysis of upper Chesapeake Bay instantaneous fishing mortality estimates of white perch from Catch Survey Analysis.

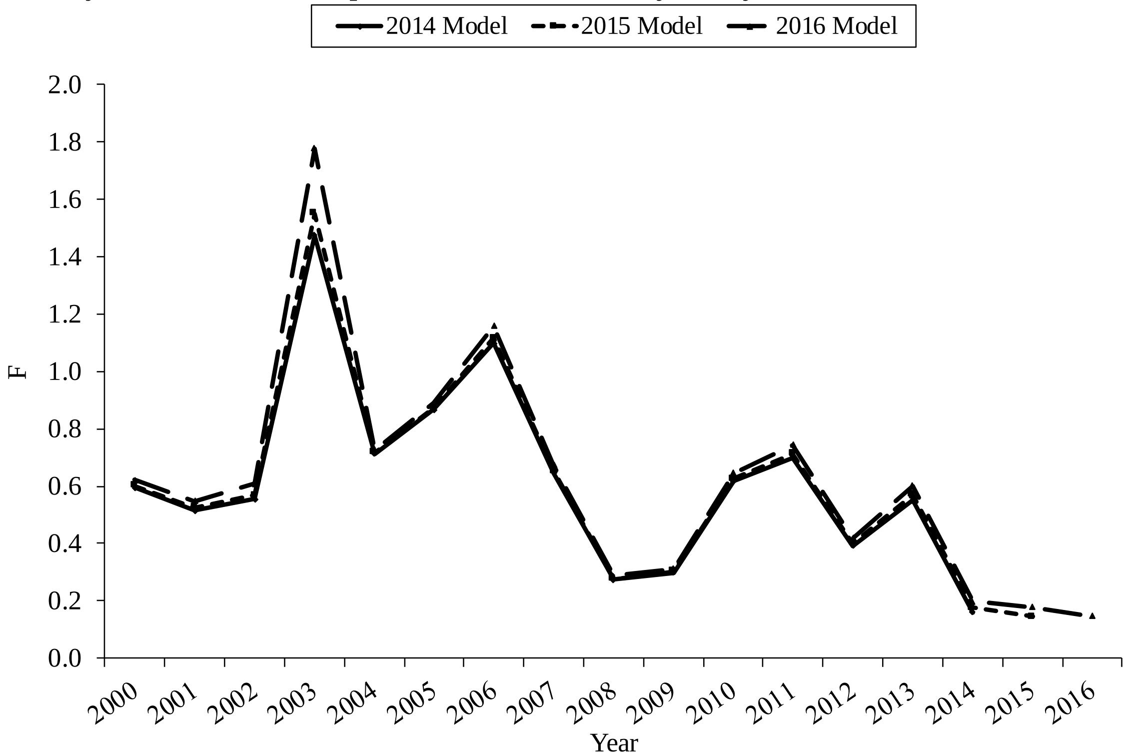


Figure 18. Estimated pre-recruit abundance for full time series and shortened time series from upper Chesapeake Bay white perch Catch Survey Analysis.

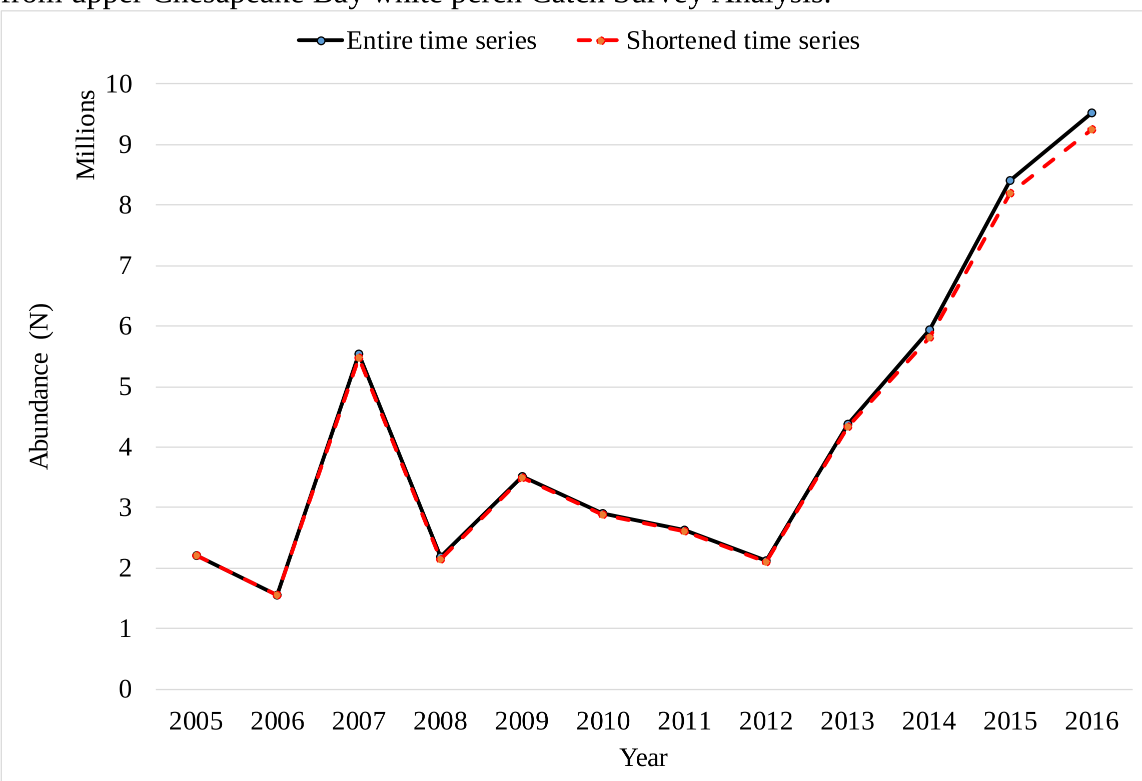


Figure 19. Estimated post-recruit abundance for full time series and shortened time series from upper Chesapeake Bay white perch Catch Survey Analysis.

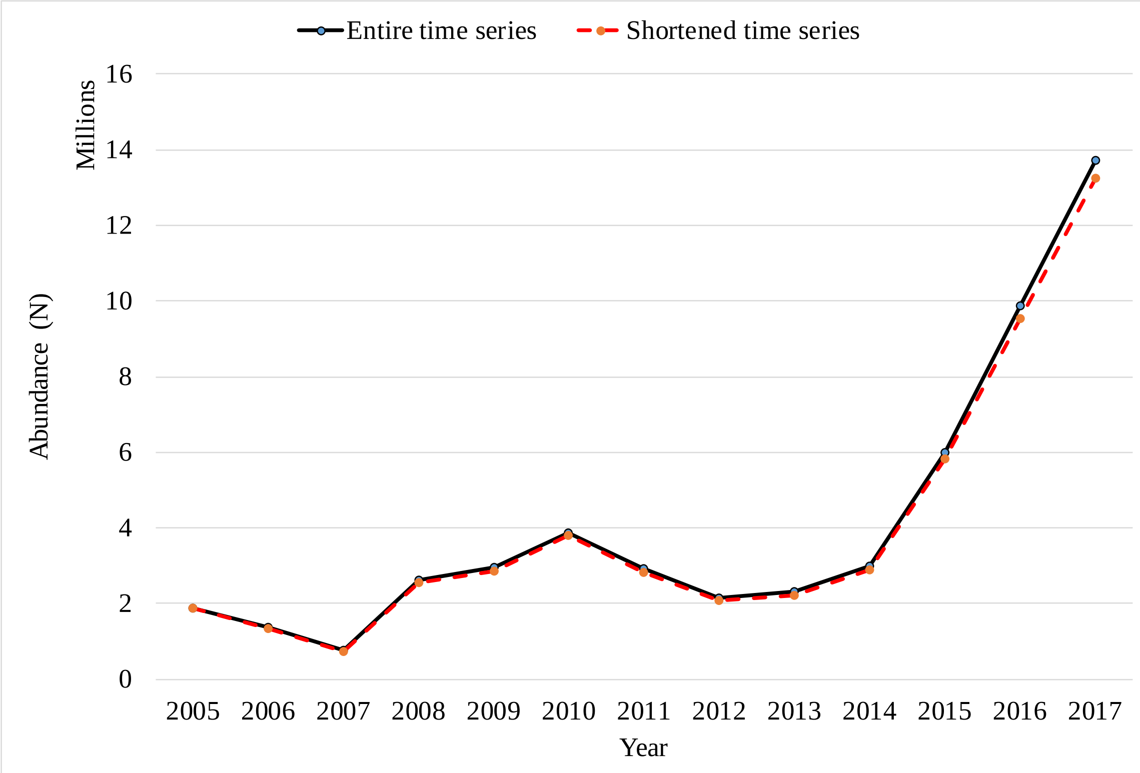


Figure 20. Estimated instantaneous fishing mortality for full time series and shortened time series from upper Chesapeake Bay white perch Catch Survey Analysis.

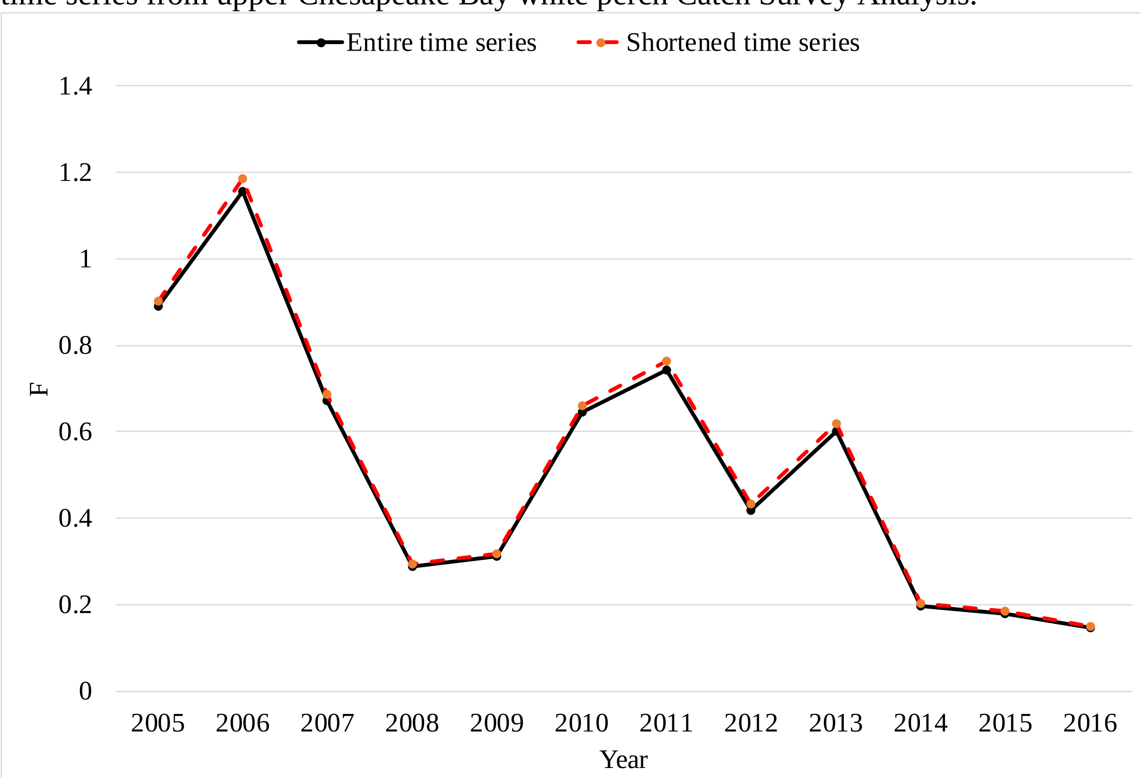


Figure 21. Estimated Choptank River white perch removals (commercial and recreational), 2000 – 2016.

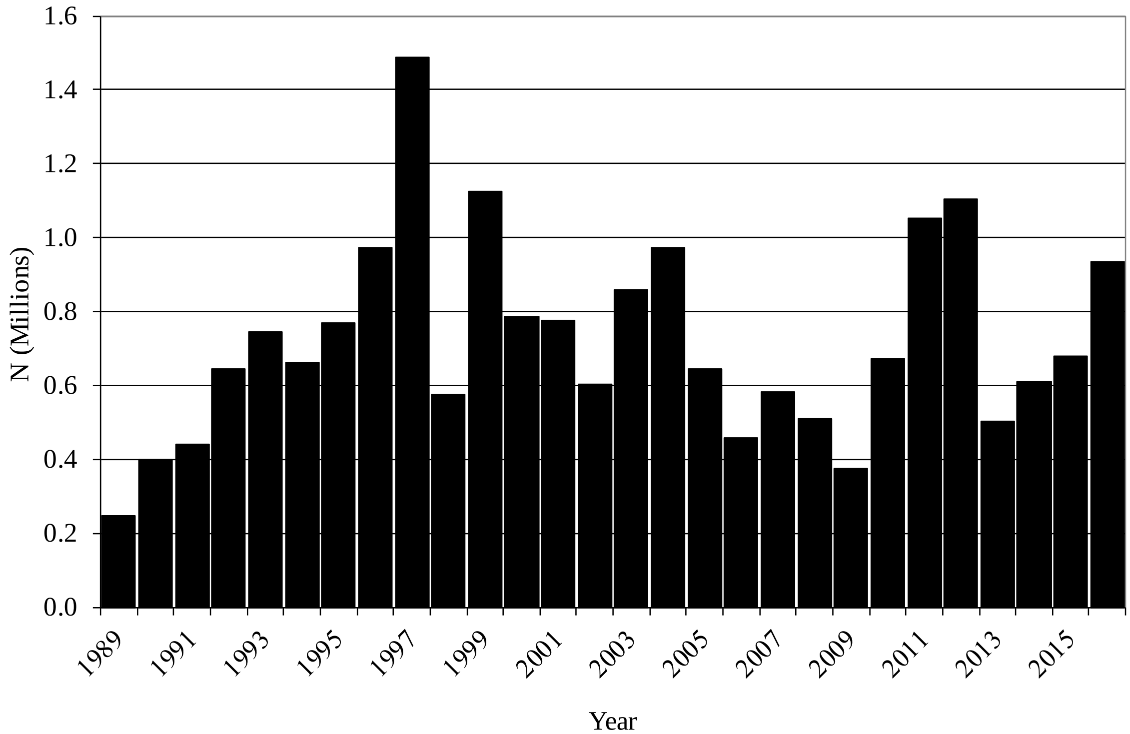


Figure 22. Observed and expected Choptank River pre-recruit white perch fyke indices, 1989—2016.

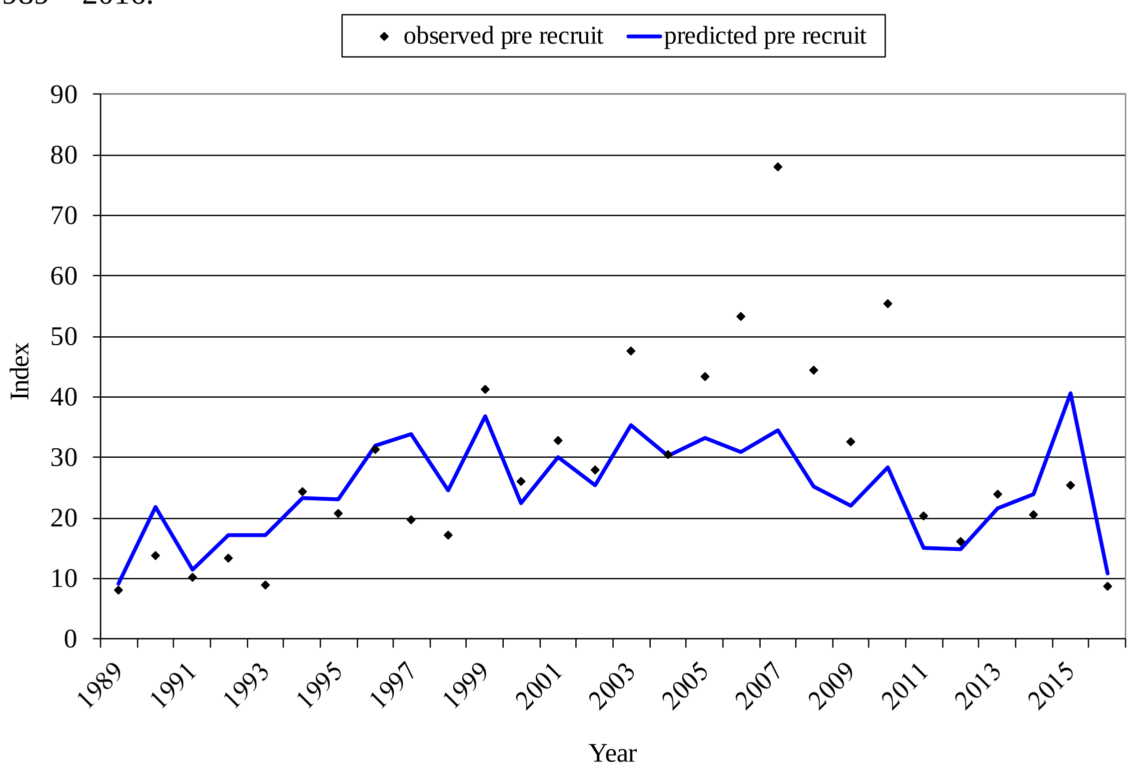


Figure 23. Observed and expected Choptank River post-recruit white perch fyke indices, 1989—2017.

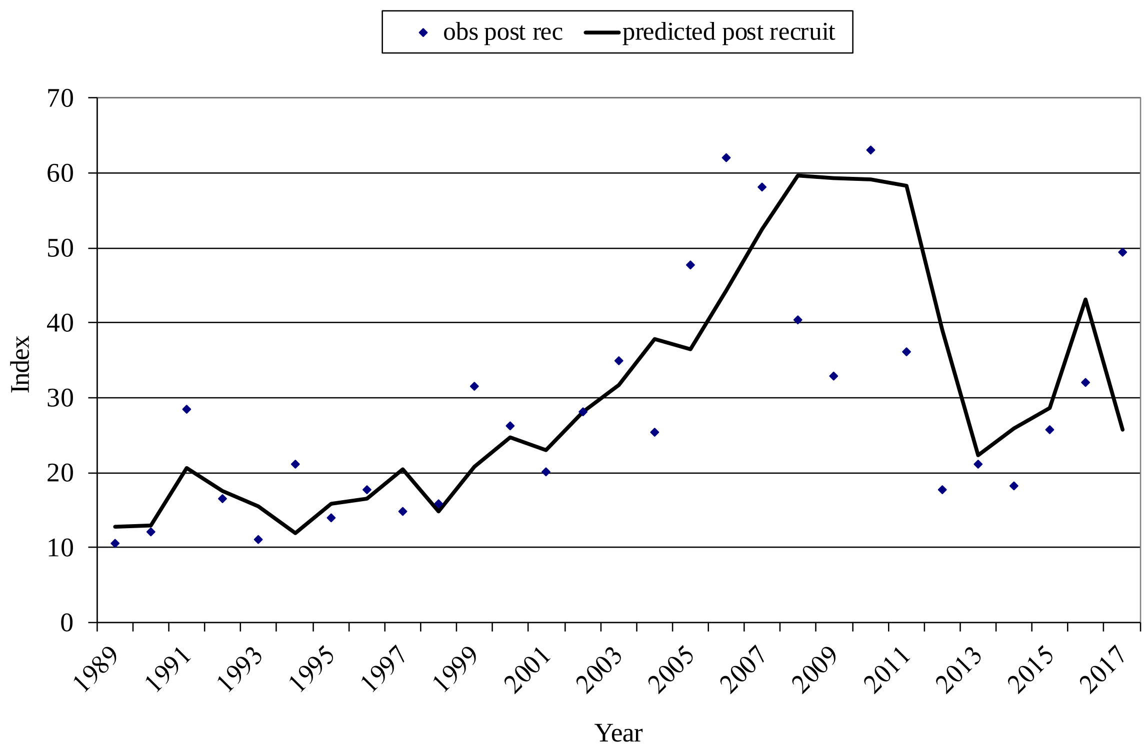


Figure 24. Estimated population abundance of pre-recruit and post-recruit white perch in the Choptank River, 1989 – 2017.

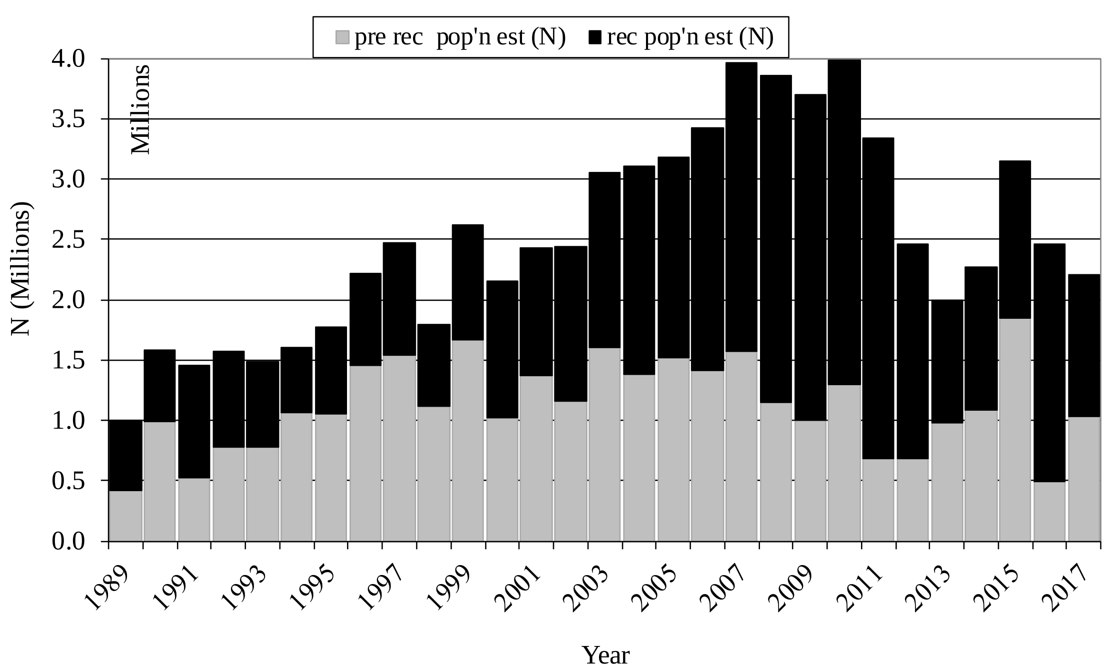


Figure 25. Instantaneous fishing mortality (F) of Choptank River white perch and proposed biological reference points for F, 2000—2016.

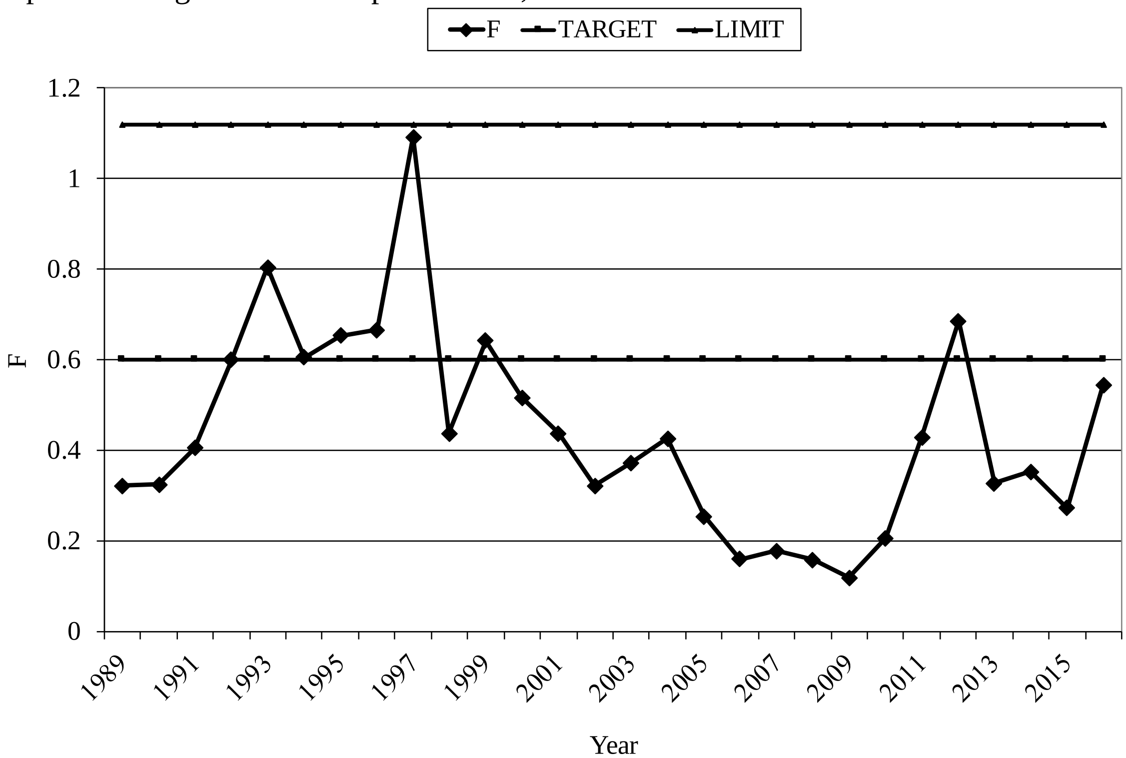


Figure 26. Pre-recruit residuals from Catch Survey Analysis of Choptank River white perch.

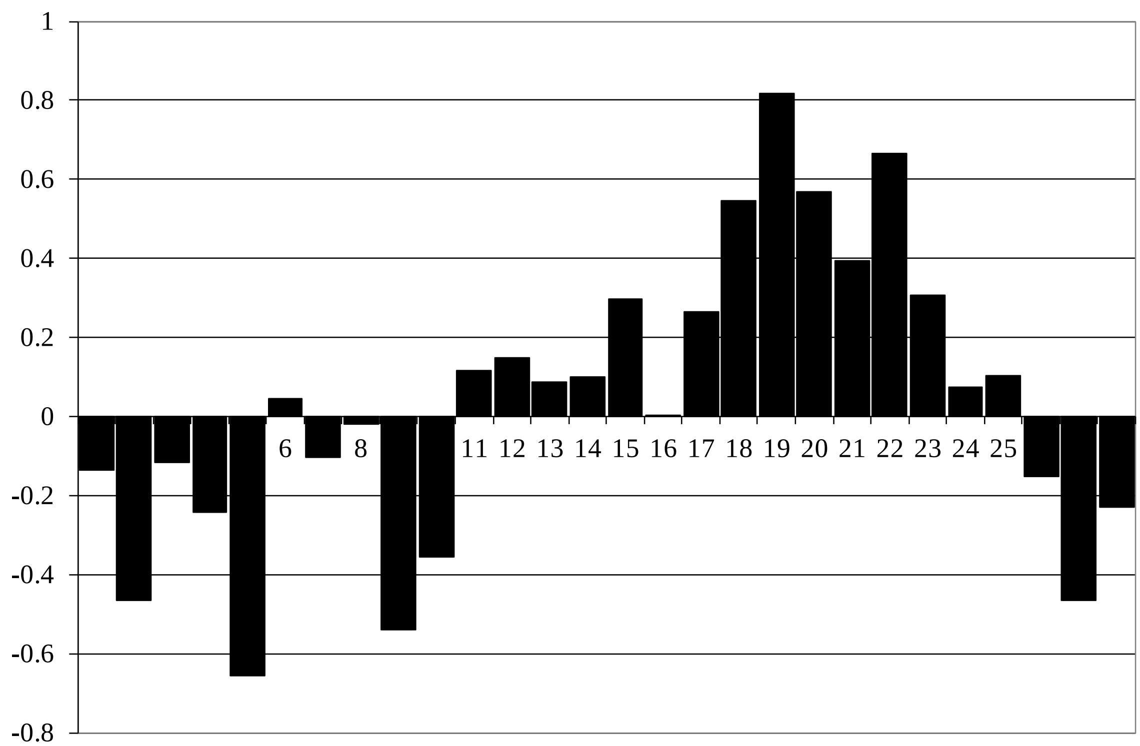


Figure 27. Post-recruit residuals from Catch Survey Analysis of Choptank River white perch.

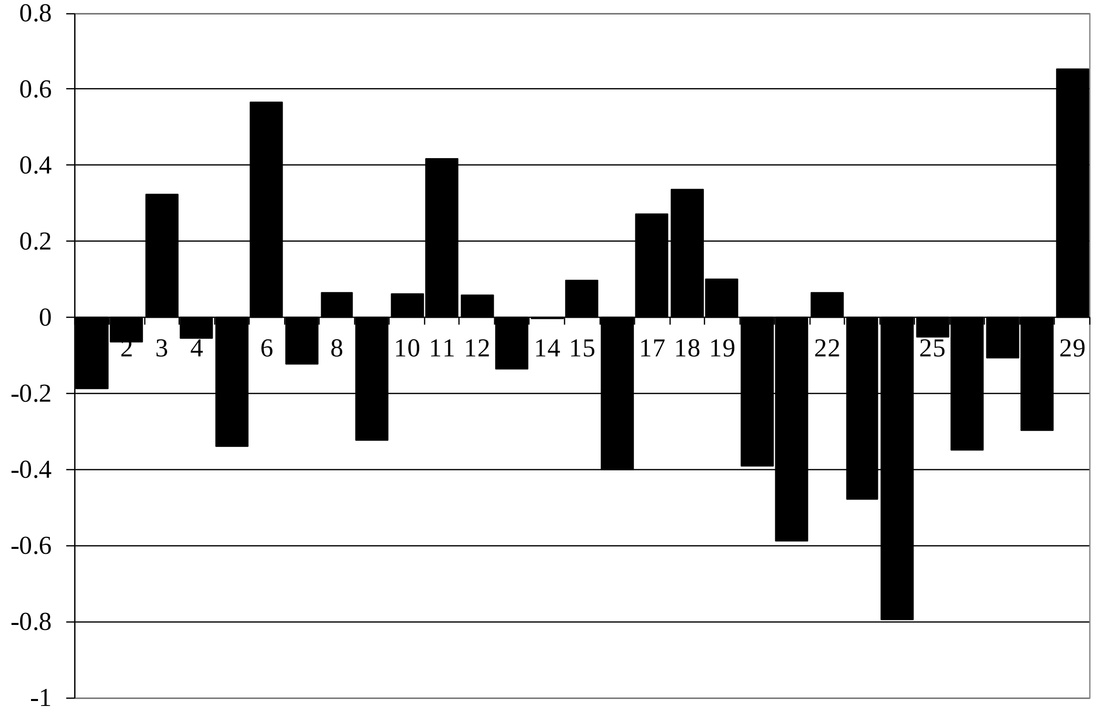


Figure 28. Bootstrap derived confidence intervals (80 %) for Choptank River pre-recruit white perch.

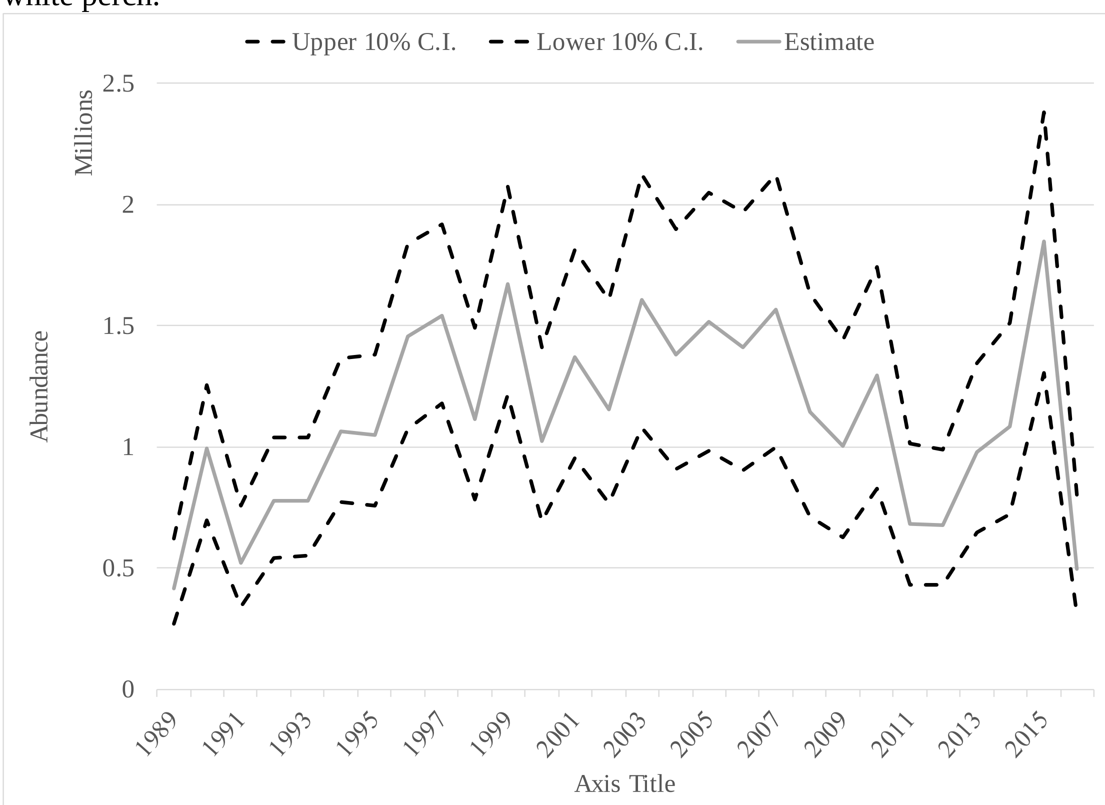


Figure 29. Bootstrap derived confidence intervals (80 %) for Choptank River post-recruit white perch.

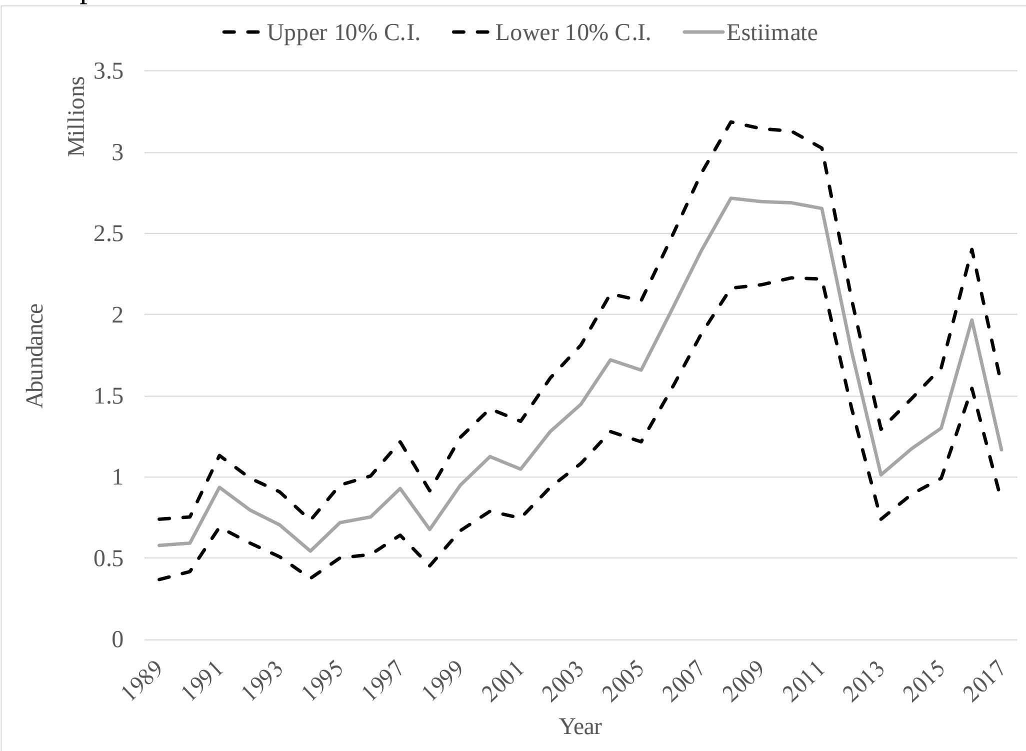


Figure 30. Bootstrap derived confidence intervals (80 %) for Choptank River white perch instantaneous fishing mortality.

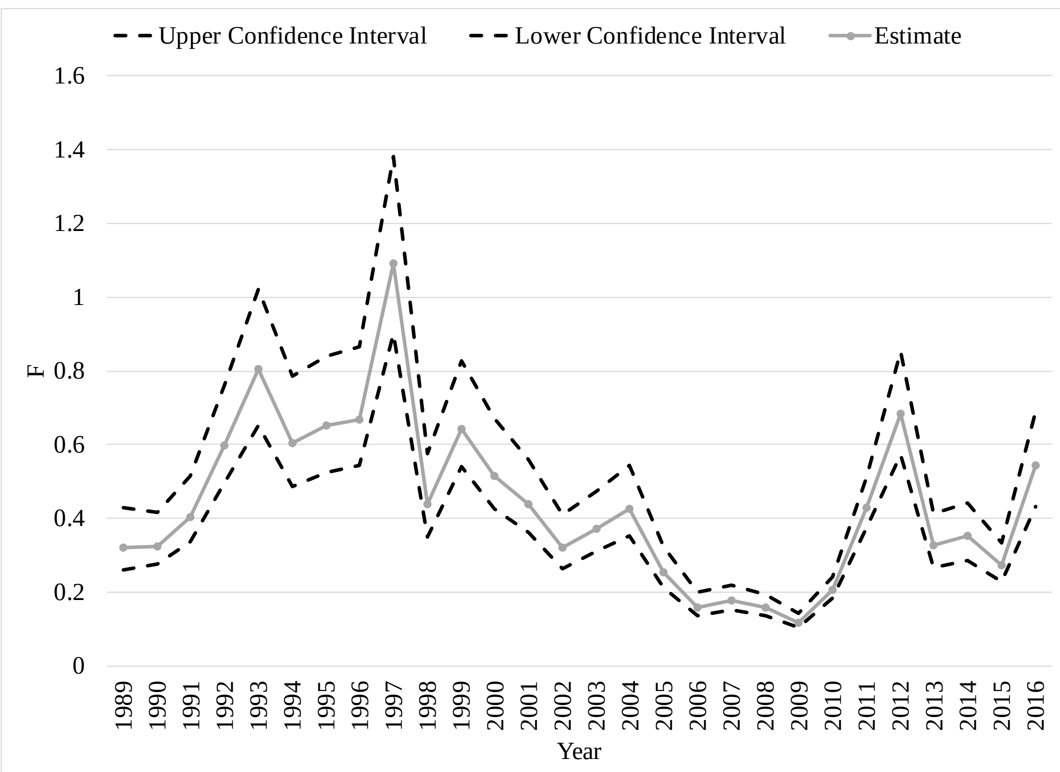


Figure 31. Retrospective analysis of Choptank River pre-recruit white perch estimates from Catch Survey Analysis.

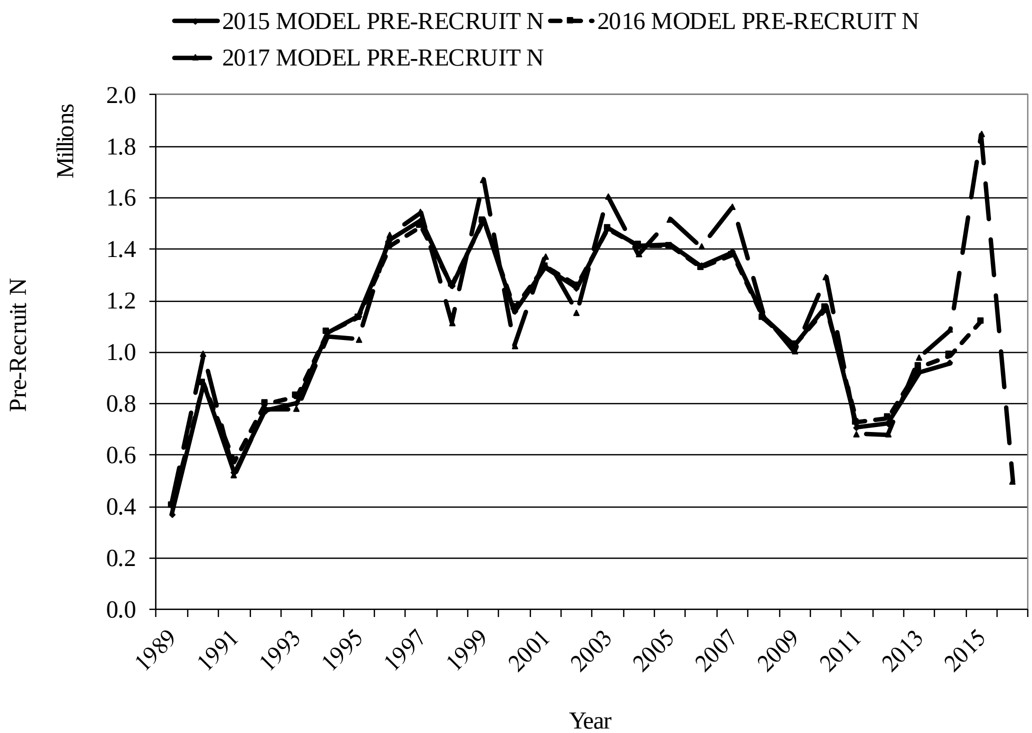


Figure 32. Retrospective analysis of Choptank River post-recruit white perch estimates from Catch Survey Analysis.

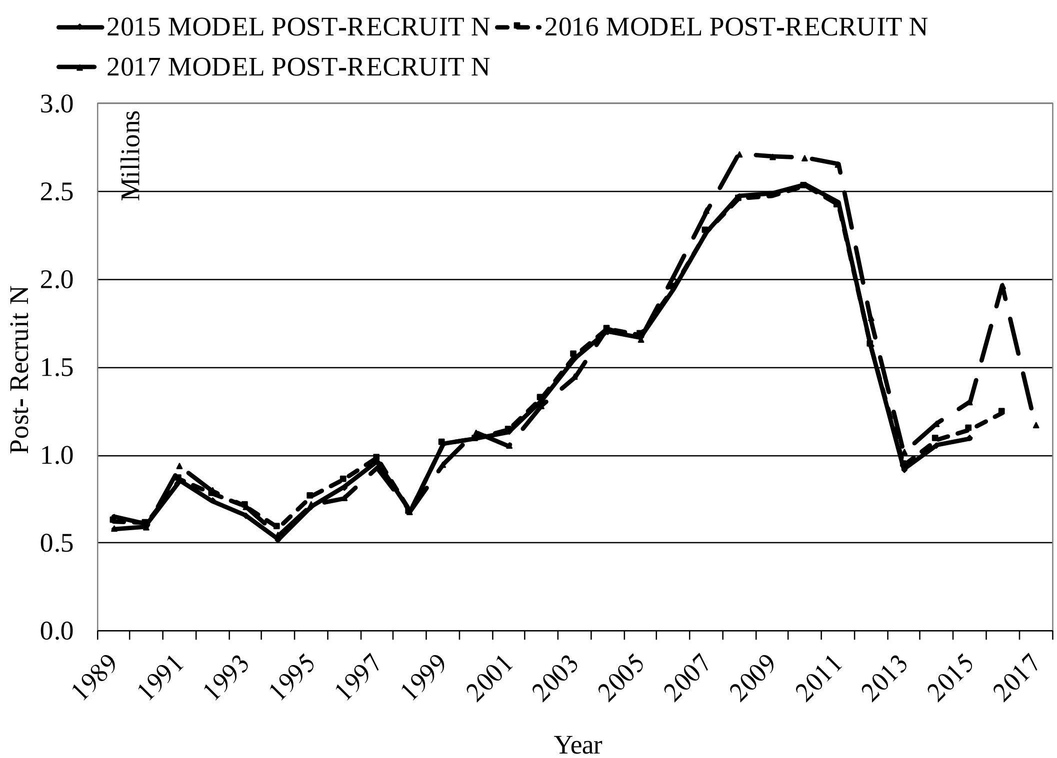


Figure 33. Retrospective analysis of Choptank River instantaneous fishing mortality estimates of white perch from Catch Survey Analysis.

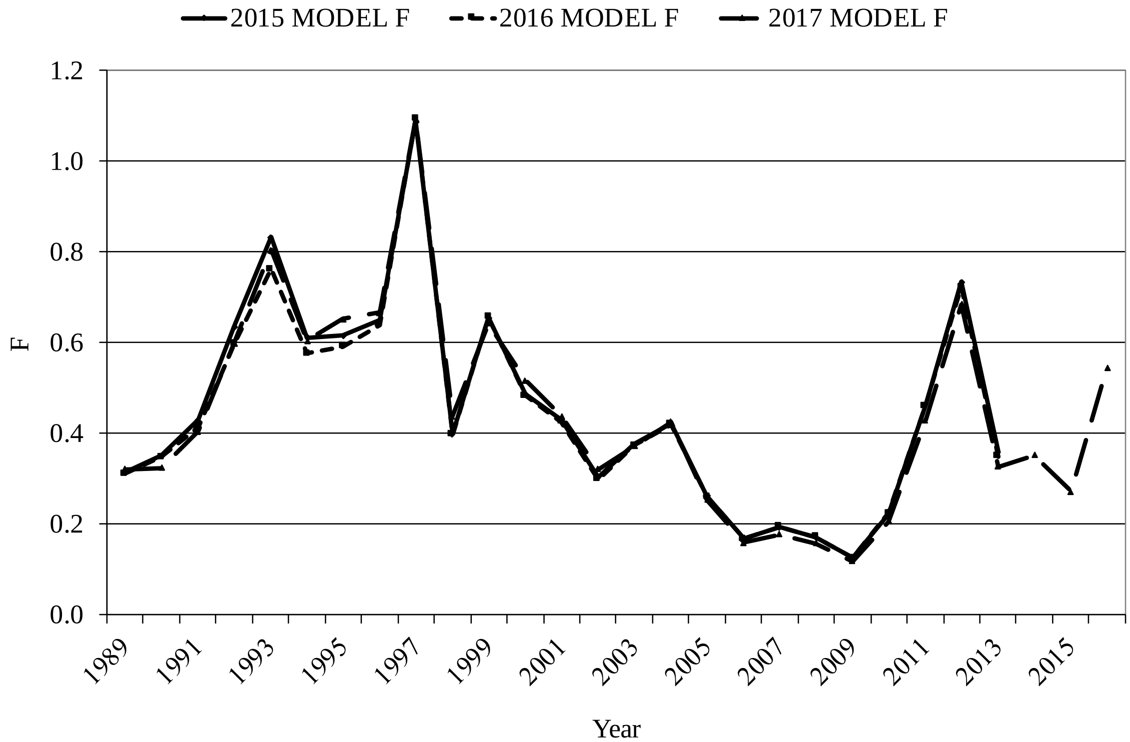


Figure 34. Lower Chesapeake Bay fishery dependent white perch fyke net index, 1980 – 2016. Horizontal line = time-series average.

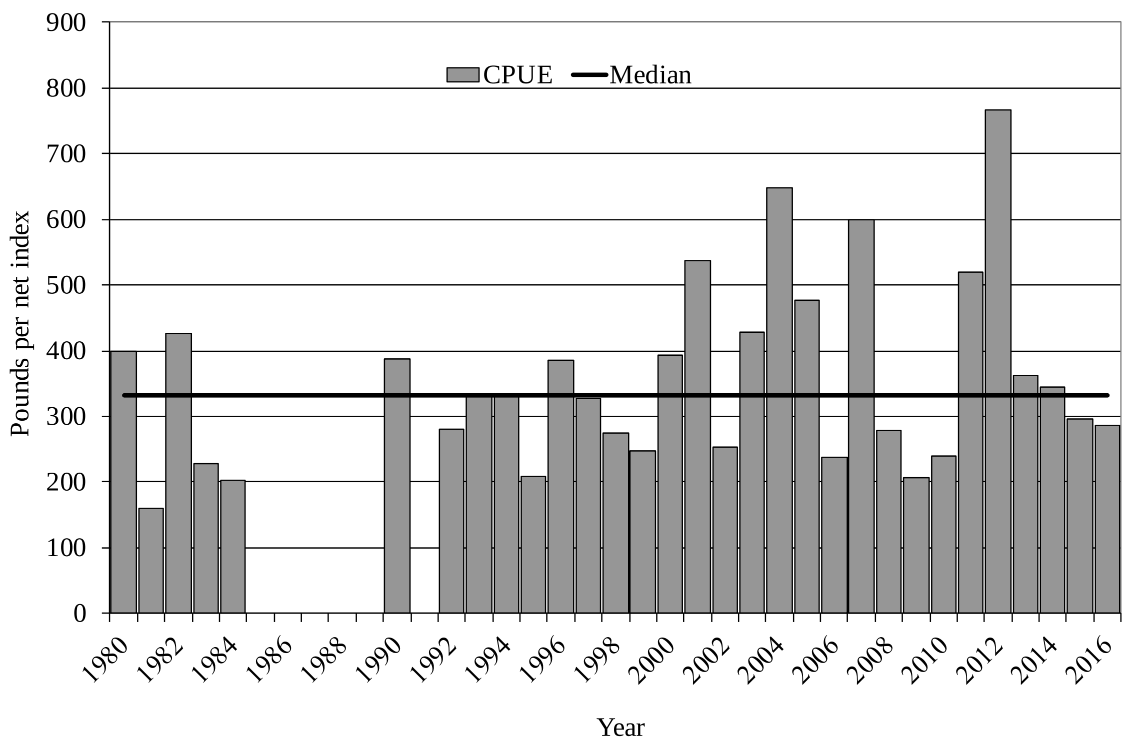


Figure 35. Lower Chesapeake Bay fishery dependent white perch pound net index, 1981 – 2016. Horizontal line = time-series average.

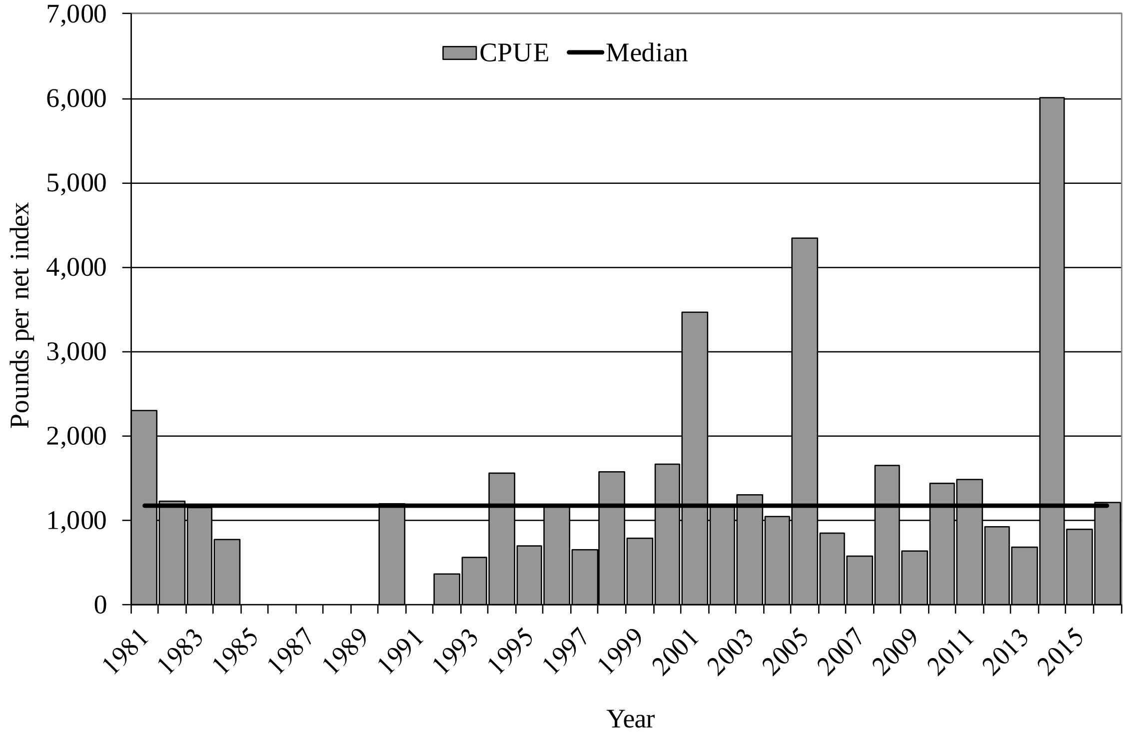


Figure 36. Lower Chesapeake Bay fishery dependent white perch gill net index, 1980 – 2016. Horizontal line = time-series average

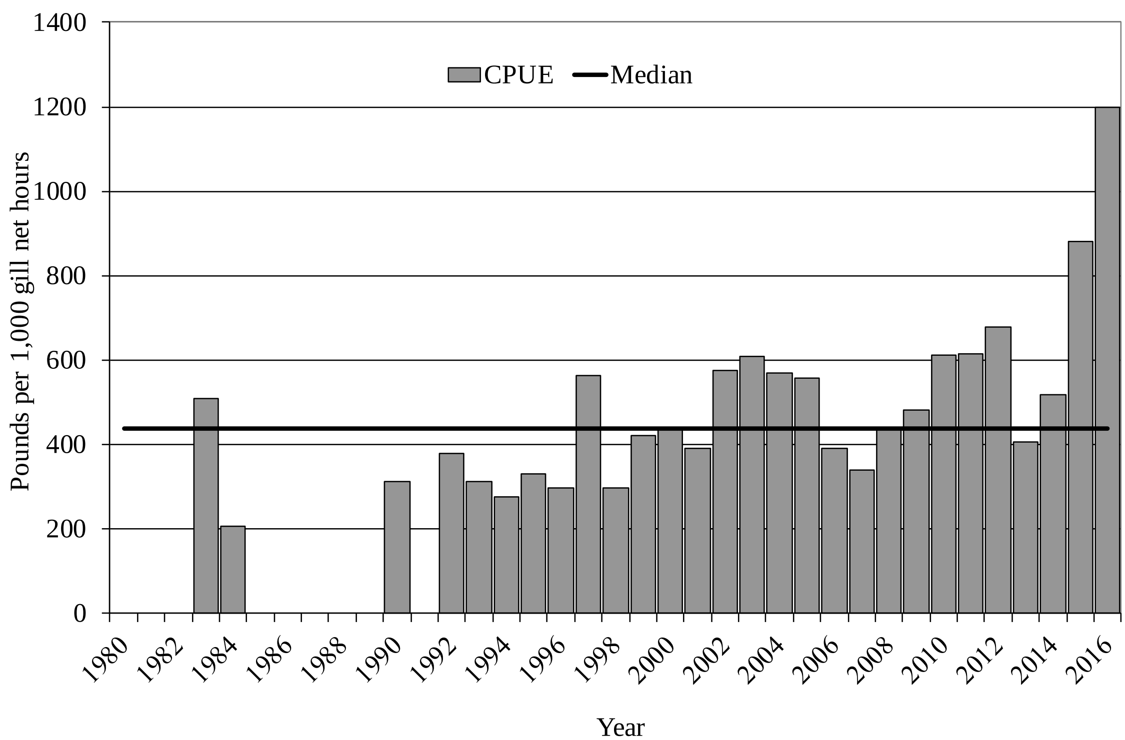


Figure 37. Potomac River fishery independent gill net survey white perch index, 1985—2017. Horizontal line = time-series average.

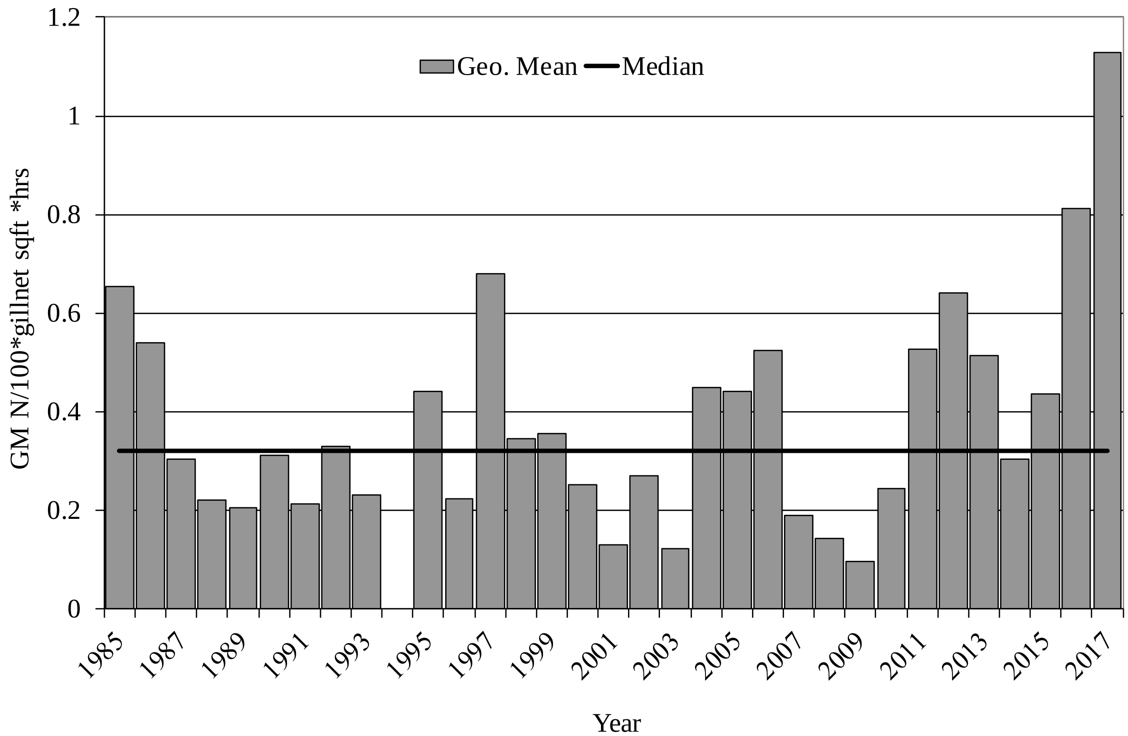
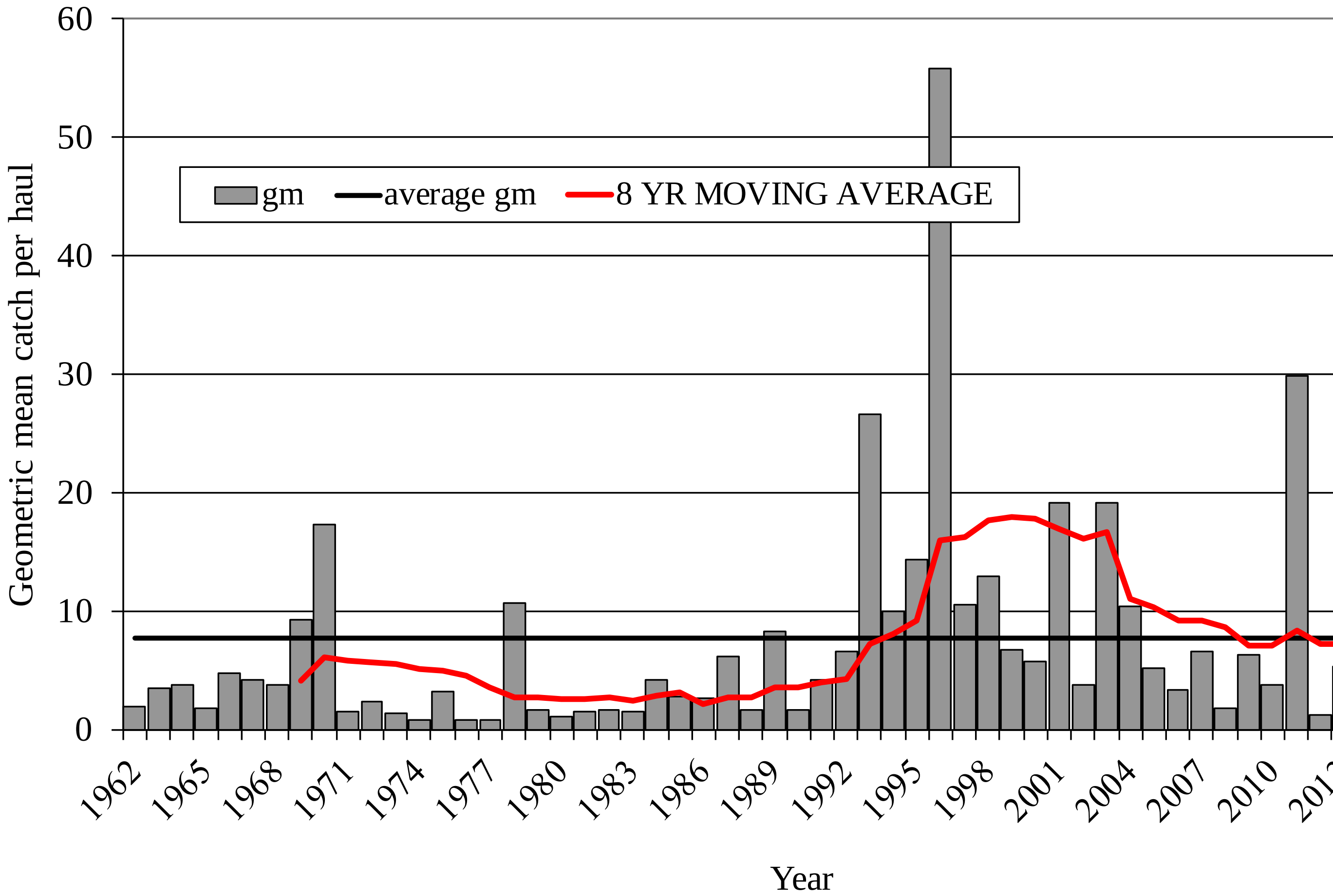


Figure 38. Lower Chesapeake Bay young-of-year white perch seine index, 1962 – 2017.



PROJECT NO. 2
JOB NO. 1

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

Prepared by
Genine L. McClair and Anthony A. Jarzynski

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. Information regarding adult alosine species and their subsequent spawning success in Maryland tributaries was collected for this project by the Maryland Department of Natural Resources utilizing both fishery independent and dependent sampling gear. On the Susquehanna River, biologists independently sampled adult American shad by hook and line fishing below the Conowingo Dam to collect stock composition data. Similar data was collected for adult American shad in the Potomac River utilizing fishery-independent gill nets (SBSSS; Project 2, Job 3, Task 2). In the Nanticoke River, fisheries dependent sampling was conducted where, biologists worked with commercial fishermen to collect stock composition data and to estimate relative abundance of adult American and hickory shad, and river herring. Hickory shad abundance was assessed in a tributary to the Susquehanna River (Deer Creek) by the Maryland Department of Natural Resources Restoration and Enhancement Program. River herring were independently sampled using an experimental gill net in the North East River. The 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), Susquehanna River Anadromous Fish Restoration Cooperative (SRAFRC), and Chesapeake Bay Program's Sustainable Fisheries Goal Implementation Team.

METHODS

Data Collection

Susquehanna River

Adult American shad were angled by Maryland Department of Natural Resources staff from the Conowingo Dam tailrace on the lower Susquehanna River two to four times per week from 20 April through 30 May 2017 (Figure 1). Two or three rods were fished simultaneously; each rod was rigged with two shad darts and lead weight was added when required to achieve proper depth. American shad were sexed (by expression of gonadal products), total length (TL) and fork length (FL) were measured to the nearest millimeter (mm), and scales were removed below the insertion of the dorsal fin for ageing and spawning history analysis. Fish in good physical condition, with the exception of spent or post-spawn fish, were tagged with Floy tags (color-coded to identify the year tagged) and released. A Maryland Department of Natural Resources hat was awarded for returned tags.

Normandeau Associates, Inc. was responsible for observing and/or collecting American shad at the Conowingo Dam fish lifts. American shad collected in the East Fish Lift (EFL) were deposited into a trough, directed past a 4' x 10' counting window, identified to species and counted by experienced technicians. American shad captured from the West Fish Lift (WFL) were counted and either used for experiments (e.g. hatchery brood stock, oxytetracycline [OTC] analysis, sacrificed for otolith extraction) or returned to the tailrace. For both lifts, tags were used to identify American shad captured in the Maryland Department of Natural Resources hook and line survey in the current and previous years.

A non-random roving creel survey provided catch and effort data from the recreational anglers in the Conowingo Dam tailrace, concurrent with the Maryland Department of Natural Resources American shad hook and line survey. Stream bank anglers were interviewed about

American shad catch that day and hours spent fishing. A voluntary logbook survey also provided location, catch and hours spent fishing for American shad in the lower Susquehanna River (including the Conowingo tailrace and Deer Creek) for each participating angler. The same information was collected for hickory shad in various locations throughout the Chesapeake Bay region. Beginning in 2014, anglers could participate in the logbook survey by recording fishing trips through the Volunteer Angler Shad Survey on Maryland Department of Natural Resources' website (http://dnrweb.dnr.state.md.us/fisheries/surveys/login.asp).

Due to the low number of hickory shad typically observed by this project, Maryland Department of Natural Resources' Restoration and Enhancement Program provided additional hickory shad data (2004-2017) from their brood stock collection. Hickory shad were collected in Deer Creek (a Susquehanna River tributary) for hatchery brood stock and were sub-sampled for age, repeat spawning marks, sex, length and weight. In 2004 and 2005, fish were collected using hook and line fishing. More recently fish have been collected by a combination of electrofishing and hook and line fishing (2006-2017). Scale samples were taken from the first 20 fish per day for age determination.

Nanticoke River

One commercial pound net and six commercial fyke nets were surveyed for American shad, hickory shad and river herring between 3 March and 28 April 2017 (Figure 2). Fish captured from these nets were sorted according to species and transferred to the survey boat for processing. All nets were sampled one to two days per week during the survey period. Fish were sexed (by expression of gonadal products), measured to the nearest mm (TL and FL), and scales were removed below the insertion of the dorsal fin for ageing and spawning history analysis. The first ten alewife and the first ten blueback encountered per sampling day were sacrificed to remove otoliths for ageing. Otoliths from dead adult American shad were removed and will be sent to the Delaware Division of Fish and Wildlife (DE DFW) for OTC analysis.

Ichthyoplankton sampling was conducted on the Nanticoke River in cooperation with the Fish Habitat and Ecosystem Program (Federal Aid Grant F-63-R, Segment 2, Job 1, Section 3) twice per week from 3 April to 28 April 2017. The presence/absence of alosine eggs or larvae was noted (time and field conditions prevented species identification of alosine eggs or larvae). These samples were collected following historical methodology: the river was divided into eighteen one-mile cells and ten of these cells were randomly selected during each sampling day (Figure 3). The ichthyoplankton net was constructed of 500 μm mesh net with a 500 mm metal ring opening. The net was towed with the tide for two minutes at approximately two knots. At the conclusion of the tow, the contents were flushed down into a mason jar for presence/absence determination.

Potomac River

The Striped Bass Spawning Stock Survey (SBSSS; Project 2, Job 3, Task 2) provided American shad scales from the Potomac River to compare age structure and repeat spawning of fish in this river with fish sampled in the Susquehanna and Nanticoke Rivers. American shad were captured in gill nets targeting striped bass that were fished from 30 March to 10 May 2017. All American shad were sexed, measured (TL and FL) to the nearest mm, and scales were removed below the insertion of the dorsal fin for ageing and spawning history analysis.

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. The gill net was fished at four randomly chosen sites once a week for 10 weeks from 6 March to 17 May 2017. Sampling did not occur the week of 17 March due to ice coverage on the river. Sampling locations were randomly assigned from a grid superimposed on a map of the system (Figure 4). The grid consisted of 112, 0.04 square mile quadrants. Sampling sites were subsequently randomized for depth, to determine if the net would be set in shallow or deeper water within the quadrant. Four alternate sites were also randomly chosen and used in cases where the chosen site was unable to be sampled. For example, if depth was below 6 feet at a given site, the next available alternate site was selected.

Individual net panels were 100 feet long and 6 feet deep. The net had a 1/2-3/8 inch poly-foamcore float line and a 50 pound lead line. Nets were hung with 200 feet of stretch netting for every 100 feet of net. From 2013 – 2014 the panels were constructed of 0.33 mm diameter monofilament twine in 2.5, 2.75 and 3 inch mesh. Beginning in 2015, the 3 inch mesh panel was replaced with a 2.25 inch mesh panel, as there was evidence the current mesh size selection was 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 tied together at the start of the survey for each year. Two nets were assembled annually and routine maintenance to mend holes in the net was conducted throughout the sampling season.

Following deployment of the net, water quality, 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 encountered per panel for ageing and spawning history analysis. The first ten alewife and the first ten blueback encountered per sampling day were sacrificed to remove otoliths for ageing. A variety of other important sport fish were also measured to the nearest mm TL.

Data Analysis

Ichthyoplankton

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

Sex, Age and Stock Composition

Male-female ratios were derived for American shad collected at the Conowingo Dam in the Susquehanna River, collected from pound and fyke nets in the Nanticoke River, and gill netted in the Potomac River. Hickory shad male-female ratios were derived from data provided by the Maryland Department of Natural Resources Restoration and Enhancement Program's brood stock collection on the Susquehanna River. Male-female ratios were also derived for alewife herring and blueback herring captured by experimental gill nets in the North East River and pound and fyke nets in the Nanticoke River.

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, random subsamples of 300 were processed for ageing and then applied to total catch using an age-length key.

Alosine scales collected from all rivers were aged following "Massachusetts Division of Marine Fisheries Age and Growth Laboratory: Fish Aging Protocols" (Elzey et al., 2015) as suggested by Atlantic states' ageing experts after ASMFC held the "2013 River Herring Ageing Workshop" (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 Bell and Howell MT-609 microfiche reader. The scale edge was counted as a year-mark due to the assumption that each fish had completed a full year's growth at the time of capture. Ages were not assigned to regenerated scales or to scales that were difficult to read. Repeat spawning marks were counted on all alosine scales during ageing. Ageing of otolith samples will be conducted as time allows.

Age determination from scales was attempted for all American shad and blueback herring samples. Age determination from scales was attempted for 300 randomly chosen samples for alewife herring from each system. Hickory shad scales from the Susquehanna River were aged by the Maryland Department of Natural Resources Restoration and Enhancement Program. Age determination for this project is made by two readers independently. When scale age and spawning mark determinations differ between readers, the scale sample is re-read jointly by the readers. If a consensus age or spawning mark cannot be determined the sample is eliminated from further analysis. In 2017, scale age agreement between readers after the first read was 68% for alewife, 81% for blueback and 80% for American shad. Spawning mark agreement between readers after the first read was 82% for alewife, 84% for blueback and 84% for American shad in 2017.

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 $\alpha = 0.05$.

All hatchery produced juvenile American shad stocked in Maryland, Delaware and the Susquehanna basin have unique fluorescent OTC marks. Otolith examination by the Pennsylvania Fish and Boat Commission (PFBC) and the DE DFW indicated the percent of non-hatchery fish present from American shad collected in the WFL and, when available, Maryland's portion of the Nanticoke River, respectively.

Adult Relative Abundance

Using catch-per-unit-effort (CPUE) as a measure of abundance is commonly used 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. A combined lift GM CPUE was calculated using the total number of adult fish lifted per hour of lifting at the EFL and WFL at Conowingo Dam. Catch-per-angler-hour (CPAH) for American shad angled in the Susquehanna River and hickory shad angled in the region were also calculated from the data collected by the logbook survey (i.e. paper logbook data and online angler reports were combined) and roving creel survey. Historically, the relative abundance (GM CPUE) of American shad in the Nanticoke River was calculated with data from all pound nets, but due to variability in the number and location of pound nets deployed each year, estimates from 1996 to present only utilize data from one pound net (Mill Creek) because it was consistently sampled over the time series. Similarly, alewife and blueback herring GM CPUE were only calculated with fyke net data because pound nets were not consistently set in ideal habitat for river herring. Only trips following the first observed fish of each species per year were used in the GM CPUE calculation. No CPUE was calculated for hickory shad in the Nanticoke River due to the low number encountered by both gear types over the time series. In the Potomac River, the SBSSS calculated CPUE as the number of fish caught per 1,000 square yards of experimental drift gill net per hour fished. There was a slight decrease in the fishing effort by the SBSSS in the Potomac River beginning in 2015. The program reduced the length of three mesh panels (3, 3.75, and 4.5 inches) from 150 feet to 75 feet in an attempt to catch fewer blue catfish.

The North East River gill net CPUE was estimated separately for alewife and blueback herring using catch from the 2.5 and 2.75 inch mesh panels, as these two panels were consistently sampled in all years. Alewife CPUE was calculated using summed catch and effort data from the first 8 weeks of the survey, as the run typically tails off in early May. Conversely, the last 6 weeks of catch and effort data were summed to calculate the blueback CPUE, since the run does not typically begin until early April. Catch was pooled across the mesh sizes indicated and a GM CPUE was reported as the number of fish caught per set of experimental gill net per hour fished. When using a gill net to capture fish, the mesh sizes utilized influence the size of fish that are captured. This can cause length bias in the sample, which is not completely eliminated even when multiple mesh sizes are fished simultaneously (Hamely 1975). Therefore, it is advised to estimate and correct for gill net selectivity by indirectly estimating selectivity curves for each mesh size fished (Millar and Fryer 1999). Selectivity corrections will be made to the length frequencies and CPUEs of the North East gill net survey as time allows for them to be developed.

While CPUE is one of the most commonly used measure of abundance, it can fluctuate year to year due to factors other than a change in abundance (e.g. temperature, flow, turbidity, etc.). Index standardization is a method that attempts to remove the influence other factors may have on a CPUE. Standardization is done by fitting statistical models to catch and effort data that incorporate the relationship of the covariates with catch (Maunder and Punt 2004). Due to the non-linear relationship of catch of American shad by hook and line in the Conowingo Dam tailrace, a generalized additive model (GAM) was used to standardize this index of abundance using relevant covariates. A GAM allows for smoothing functions as the link function between catch and covariates. The covariates explored for the model include: surface water temperature (°C), river flow in thousands of cubic feet per second as measured by the USGS Water Resources station 01578310 Susquehanna River at Conowingo, MD (USGS 2017), and day of the year. Variance Inflation Factors (VIFs) were used to assess collinearity of the covariates to determine which covariates to incorporate in the model (Zuur et al 2009). Several statistical distributions for the response variable were investigated and model selection was determined based on the model with dispersion closest to one, the highest deviance explained, and the lowest Akaike Information Criterion (AIC). All models were run in RStudio (R Core Team 2015) utilizing the mgcv package (Wood 2011).

Population Estimates

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

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

where N is the relative population estimate, C is the number of fish examined for tags at the EFL, M is the number of fish tagged minus 3% tag loss, and R is the number of tagged fish recaptured at the EFL excluding recaps of previous years' tags. C is corrected to include only fish that were lifted after tagging began in the tailrace. Prior to 2001, C was the number of fish examined for tags at both the EFL and WFL, and R was the number of tagged fish recaptured at both lifts excluding recaps of previous years' tags. Observations at the WFL were omitted to avoid double counting beginning in 2001, as it became protocol for some fish captured at the WFL to be returned to the tailrace. Calculation of 95% confidence limits (N*) for the Peteresen statistic were based on sampling error associated with recaptures in conjunction with Poisson distribution approximation (Ricker 1975):

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

where

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

Overestimation of abundance by the Petersen statistic (due to low recapture rates) necessitated the additional use of a biomass surplus production model (SPM; MacCall 2002, Weinrich et al. 2008):

$$N_t = N_{t-1} + [r\ N_{t-1}(1-(N_{t-1}/\ K))] - C_{t-1}$$

where N_t is the population (numbers) in year t, N_{t-1} is the population (numbers) in the previous year, r is the intrinsic rate of population increase, K is the maximum population size, and C_{t-1} is losses associated with upstream and downstream fish passage and estimated bycatch mortality in the previous year (equivalent to catch in a surplus production model). Fish passage mortalities are calculated as 100% of adult American shad emigrating back through Holtwood Dam (N_{Holt}) and 25% for adult American shad emigrating back through the Conowingo Dam (N_{Cono}). The estimated bycatch mortality is derived from ocean fisheries landings (L) known to encounter American shad as incidental catch (i.e. the Atlantic herring and mackerel fisheries). A bycatch coefficient (b) is estimated to fit the model to these fisheries' landings. Therefore losses in the previous year are calculated as:

$$C_{t-1} = N_{Holt} + 0.25 * (N_{Cono} - N_{Holt}) + b * L$$

Model parameters were estimated using a non-equilibrium approach that follows an observation-error fitting method (i.e., assumes that all errors occur in the relationship between true stock size and the index used to measure it). The model is fit to indices of abundance for American shad in the Conowingo dam tailrace. Assumptions include accurate adult American shad turbine mortality estimates and proportional bycatch of American shad in the ocean fisheries.

The SPM requires starting values for the initial population (B_0) in 1985, a carrying capacity estimate, an estimate of the intrinsic rate of growth, and a bycatch coefficient. For model development in 2015 the starting values were as follows: B_0 was set as 7,876, which was the Petersen statistic for 1985, K was set as 3,040,551 fish, which was three times the highest Petersen estimate of the time series, r was set as 0.50, and b was set at 0.032. These starting values were adjusted by the model during the fitting procedure using Evolver 4.0 for Windows that utilizes a genetic algorithm for optimization. The fitting procedure was constrained to search within r = 0.01 to 1.0, K = 100,000 to 30 million fish, B_0 = 5,682 (the lower confidence limit of the 1985 Petersen statistic) to 1 million fish and b = 0.001 to 1.0. The final estimates for each of these parameters in 2015 were then used as the starting values for model development in 2017 (B_0 = 54,176, K = 1,005,502, r = 0.57, and b = 0.51). The model was run multiple times varying the indices of abundance and the landings data from which bycatch mortality was derived. The run with the lowest sum of squares and best parameter estimates was chosen.

Mortality

Chapman-Robson methodology (1960) was used to estimate total instantaneous mortalities (Z) of adult American shad, hickory shad and river herring from all systems surveyed where species' data were available. Age composition data was 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 has less bias 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).

Juvenile Abundance

The Maryland Department of Natural Resources Estuarine Juvenile Finfish Seine Survey (EJFS; Project 2, Job 3, Task 3) provided juvenile indices (geometric mean catch per haul) for alewife herring and blueback herring from fixed stations within the Nanticoke River and the upper Chesapeake Bay, and for American shad in the Nanticoke and Potomac rivers, upper Chesapeake Bay and baywide. Hickory shad data are not reported by the EJFS due to small sample sizes.

RESULTS

Ichthyoplankton

Ichthyoplankton tows were conducted on six days in 2017. Fertilized alosine eggs and/or larvae were present at 40.4% of tow stations in 2017 (Figure 5). Salinity at tow stations ranged from 0.1 to 2.0 ppt. An absence of observed fertilized eggs and/or larvae occurred from 2006-2008, and in 2012.

American Shad

Sex, Age and Stock Composition

The male-female ratio of adult American shad captured by hook and line from the Conowingo tailrace was 1:1.4. Of the 286 fish sampled by this gear, 266 were successfully scale-aged (Table 1). Males were present in age groups 3-6 and females were found in age groups 4-6. No fish over the age of six were encountered by the gear in 2017. At least one seven year old has been encountered by this survey since 1989. The 2013 (age 4) year-class was the most abundant for males (47.8%) and the 2012 (age 5) year-class was the most abundant for females (60.1%; Table 1). Twenty percent of males and 43% of females were repeat spawners. The percentages of repeat spawners has declined since it peaked in 2014 (Figure 6). The arcsine-transformed proportion of these repeat spawners (sexes combined) has significantly increased over the time series (1984-2017; r^2 = 0.63, P < 0.001; Figure 7). Analysis by PFBC of 500 American shad otoliths collected from the WFL at Conowingo Dam showed that 58% were wild fish and 42% were hatchery produced fish in 2017. This is a decrease from hatchery contribution observed in 2016 (54%).

The male-female ratio for adult American shad captured in the Nanticoke River was 1:0.94. Thirty-eight American shad were collected from the Nanticoke pound and fyke nets in 2017 and 34 were subsequently aged (Table 1). Males and females were present in age groups 3-6. The 2013 year-class (age 4) was the most abundant year-class for males (44%; Table 1). The 2012 (age 5) was the most abundant year-classes for females (44%; Table 1). Thirty-nine percent of males and 38% of females were repeat spawners. The arcsine-transformed proportion of Nanticoke River repeat spawning American shad (sexes combined) has significantly increased over the time series, (1988-2017; $r^2 = 0.34$, $P < 0.001$; Figure 8). Analysis by DE DFW of American shad otoliths collected from the Nanticoke River have not been completed for the 2017 samples.

The male-female ratio for adult American shad captured in the Potomac River was 1:1.38. Of the 88 American shad collected, 85 were successfully aged (Table 1). Males were present in age groups 3-6, and females were present in age groups 4-7. The most abundant year-class for males was the 2012 (age 5) year-class (47%) and the 2011 (age 6) year-class for females (49%; Table 1). Thirty-five percent of males and 43% of females were repeat spawners. The arcsine-transformed proportion of Potomac River repeat spawning American shad (sexes combined) showed no significant trend over the time series (2002-2017; $r^2 < 0.01$, $P = 0.93$; Figure 9).

Adult Relative Abundance

Sampling at the Conowingo Dam occurred for 14 days in 2017. A total of 321 adult American shad were encountered by the gear; all of these fish were captured by Maryland Department of Natural Resources staff from a boat. No shore sampling occurred in 2017. Peak catch by hook and line (65 fish) occurred on 1 May 2017 at a surface water temperature of 18°C.

Maryland Department of Natural Resources staff tagged 284 (88%) of the sampled fish. Three American shad recaptures, two from the Conowingo Dam tailrace and one from the Potomac River were reported by recreational anglers in 2017.

The Conowingo EFL operated for 46 days between 12 April and 2 June 2017. Of the 16,265 American shad that passed at the EFL, 89% (7,373 fish) passed between 18 April and 2 May 2017. Peak passage was on 20 May; 1,715 American shad were recorded on this date. Twenty-six of the American shad counted at the EFL counting windows were identified as being tagged in 2017 (Table 2).

The Conowingo WFL operated for 13 days between 29 April and 27 May 2017. The 736 captured American shad were retained for hatchery operations, sacrificed for otolith data collection, or returned alive to the tailrace. Peak capture from the WFL was on 16 May, when 108 American shad were collected. Four tagged American shad were recaptured by the WFL in 2017, all were tagged in 2017 (Table 2).

The various model configurations explored for developing a GAM for the hook and line index and how each model performed are summarized in Table 3. Due to observed collinearity of day of the year with surface water temperature, day of the year was removed from the model. Since GAMs are highly sensitive to collinearity, a more stringent VIF cutoff may be necessary. For example, Booth et al. (1994) suggest a cutoff of 1.5. This more stringent cutoff would lead to the removal of the flow variable, leaving only surface water temperature. For this reason, models that included temperature and flow, and models that just included temperature were explored.

Overall, models that included both temperature and flow explained more deviance, but only slightly more than models with just temperature, which indicates temperature had a greater effect on catch than flow (Table 3). The model results also indicate that both models 2 and 3 are acceptable. Model 2 is slightly over-dispersed, while model 3 is slightly under-dispersed. It was suggested that being slightly under-dispersed would be better than being over-dispersed (Laura Lee, North Carolina Department of Environment and Natural Resources, pers. comm.), therefore model 3 was chosen as the best fit model.

The best fit model utilized temperature and flow as explanatory variables linked to catch using cubic spline regression, year as a factor level, with the log of effort as an offset, and a negative binomial response distribution. This model showed no obvious signs of pattern in the residuals (Figure 10). The annual hook and line CPUE generated using the best fit GAM shows abundance is variable from 2007-2017, and remains below the high indices observed from 1998-2002 (Figure 11).

The Conowingo Dam lifts provide another opportunity to measure American shad abundance in this region for comparison to the hook and line index. Both the count of fish lifted at Conowingo Dam and the combined lift GM CPUE mirror the hook and line index, for years when both the East and West Fish lift were operating (Figure 12). Like all relative measures of abundance there are caveats to accepting these indices as indicative of true abundance. Run counts at Conowingo Dam are affected by the lift efficiency and river flows, while the GM CPUE is affected by the number and frequency of lifts. All three indices measured in this region of the Susquehanna River show a broad general trend that abundance was low in the 1990s, increased to a peak in the early 2000s and has since declined to low levels of abundance (Figure 11 and 12).

Ninety-four interviews were conducted over nine days during the creel survey at the Conowingo Dam Tailrace. The CPAH has increased since 2013 (Table 4), and has no significant trend over the time series (2001-2017; $r^2 = 0.18$, $P = 0.09$).

Three anglers returned paper logbooks in 2017. Additionally, five anglers participated online by recording their trips through 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 declined in 2017 (Table 5). Online angler data was included in the CPAH calculation beginning in 2014. The logbook CPAH estimate of adult American shad relative abundance has decreased significantly over the time series (2000-2017; $r^2 = 0.45$, $P = 0.002$; Table 5).

The Nanticoke River pound net GM CPUE declined in 2017, is highly variable and shows no significant trend over the time series (1996-2017; $r^2 = 0.02$, $P = 0.58$, Figure 13). Only the indices from 1996-2017 were used in the trend analysis because prior to 1996 estimates were calculated using all pound net data, not just Mill Creek. The Potomac River CPUE significantly increased over the time series (1996-2017; $r^2 = 0.40$, $P < 0.01$, Figure 14).

Population Estimates

The Petersen statistic estimated 140,883 American shad in the Conowingo Dam tailrace in 2017 with an upper confidence limit of 203,028 fish and a lower confidence limit of 97,274 fish (Figure 15). The SPM with the lowest sum of squares that best represented American shad in the Conowingo Dam utilized the CPUE from the hook and line survey, the lift index, and used the Atlantic herring and mackerel combined landings to estimate bycatch losses. This run estimated a population of 79,549 American shad in the Conowingo Dam in 2017 and produced realistic estimates of the model parameters r, K and B_0 ($r = 0.56$, $K = 1,684,428$, $B_0 = 54,135$; Figure 16). The 2017 SPM estimate is just below the lower confidence interval of the Petersen estimate for 2017.

Despite differences in yearly estimates, the overall population trends derived from each population model are fairly similar (Figures 15 and 16). Specifically, the SPM showed an increasing population size from the beginning of the time series to a peak in 2001, followed by a decline through 2007 (Figure 16). Petersen estimates follow a similar pattern if the high levels of uncertainty in 2004 and 2008 (due to low recapture rates) are considered (Figure 15), and both models show a slight decline since 2009.

Mortality

The Conowingo Dam tailrace Chapman-Robson total instantaneous mortality estimate for male American shad resulted in Z = 1.09 in 2017. Total instantaneous mortality for females could not be calculated in 2017 because data was not available from at least three age-classes. Due to the change in estimation methodology, 2017 estimates will not be compared to previously reported estimates. A total instantaneous mortality estimate for American shad captured in the Nanticoke River was not calculated due to small sample size (n = 34).

Juvenile Abundance

In 2017 the juvenile American shad abundance index provided by the EJFS increased in the Upper Chesapeake Bay, declined in the Nanticoke River and was similar to the 2016 estimate for the Potomac River (Figures 17-20). Juvenile indices were not corrected for hatchery contribution.

Hickory Shad

Sex, Age and Stock Composition

The number of hickory shad captured from the Nanticoke River (n=7) was not large enough to draw meaningful conclusions about sex and age composition. In Deer Creek, 316 hickory shad were sampled by the broodstock collection survey. The male-female ratio was 1:0.65. Of the total fish captured by this survey, 59 were successfully aged. Males were present in age groups 3-6, and females were present in age groups 3-7 (Table 6). The most abundant year-class was the 2012 year-class (age 5) for males (42%) and the 2013 year class (age 4) for females (35%, Table 6). Since 2012 no hickory shad of ages greater than 7 have been observed (Table 7). The arcsine-transformed proportion of repeat spawners (sexes combined) has not changed significantly over the time series (2004-2017; $r^2 = 0.19$, $P = 0.12$; Figure 21).

Relative Abundance

Shad logbook and Volunteer Angler Shad Survey data indicated that hickory shad CPAH has declined over the time series (1998-2017; $r^2 = 0.27$, $P = 0.02$). Hickory shad CPAH in 2017 decreased from the 2016 value (3.92, Table 8). On the Nanticoke River, only 7 fish were captured by pound and fyke nets, which is below average for hickory shad encountered by this survey since its inception.

Mortality

Total instantaneous hickory shad mortality in the Susquehanna River (Deer Creek) was estimated as Z = 1.76. Due to the change in methodology for estimating Z, this value cannot be compared to previously reported estimates.

Alewife and Blueback Herring

Sex, Age and Stock Composition

The 2017 male-female ratio for Nanticoke River alewife herring was 1:2.02. Of the 801 alewives sampled, 282 were subsequently aged. An age-length key was generated to assign an age structure to the entire catch in 2017. Alewife were present from ages 2-7 and the 2012 year-class (age 5, sexes combined) was the most abundant, accounting for 34% of the total catch (Table 9). The 2017 male-female ratio for Nanticoke River blueback herring was 1:0.88. Of the 100 blueback herring sampled, 76 were subsequently aged. Blueback herring were present from ages 3-7 and the 2013 year-class (age 4, sexes combined) was the most abundant, accounting for 40% of the sample (Table 10). Blueback herring ages 9 – 11 have not been observed since 2000, which is evident in the decrease of the percent of blueback herring ages 6 and older observed in recent years (Table 10).

For the Nanticoke River, 48% of alewife herring and 36% of blueback herring were repeat spawners (sexes combined). There was no trend in the arcsine-transformed proportion of alewife herring repeat spawners over the time series (1990-2017; $r^2 = 0.06$ $P = 0.23$); however, blueback herring exhibited a decreasing trend over the same time series (1990-2017; $r^2 = 0.63$, $P < 0.001$; Figure 22).

Mean length (FL mm) of alewife herring from the Nanticoke River has varied without trend since the inception of this survey (1989-2017; $r^2 = 0.03$, $P = 0.41$) while, blueback herring mean length (FL mm) has significantly decreased across the time series (1989 – 2017; $r^2 = 0.56$, $P < 0.001$; Figure 23).

Since the inception of the North East River gill net survey, more female alewife herring have been encountered by the gear than male alewife herring. Male-female ratios for alewife herring in 2017 were 1:1.75. An age-length key was generated to assign an age structure to the entire alewife catch in 2017. Alewife herring of ages 3-7 were present in 2017. The 2014 alewife year-class was the most abundant in 2017 at the age of 3, comprising 39% of the sample (Figure 24).

Male-female ratios for blueback herring in 2017 were 1:1.63. Blueback herring were present from ages 3-7 from 2013 through 2017. The 2014 year-class for blueback herring was most abundant in 2017 (age 3) comprising 49% of the sample in 2017 (Figure 25). For the North East River in 2017, 29.9% of alewife herring and 33.7% of blueback herring were repeat spawners (sexes combined).

Adult Relative Abundance

Data from six fyke nets on the Nanticoke River were used to calculate relative abundance of river herring in 2017. The GM CPUE for Nanticoke River alewife herring captured in fyke nets has decreased over the time series (1990-2017; $r^2 = 0.20$, $P = 0.02$; Figure 26). The coefficient of determination from this analysis indicates the data only has a marginal fit to the predicted linear model, there is a lot of variability in the data, or perhaps a different model should be explored. The GM CPUE for blueback herring has also decreased over the time series (1989-2017; $r^2 = 0.59$, $P < 0.001$; Figure 26).

The gill net survey in the North East River caught increasingly more alewife and blueback herring each year from 2013 – 2015, but catch declined for both species in 2016 and 2017. The timing of the alewife and blueback herring run for 2017 can be seen in Figure 27. A majority of the alewife herring were caught in the 2.5 inch mesh for all years (Figure 28). Alewife ranged in size from 200-284 mm FL. A majority of the blueback herring were caught in the 2.25 inch mesh in 2017 (Figure 29). Blueback ranged in size from 204-266 mm FL.

Catch-per-unit-effort estimates made for alewife and blueback herring separately from the pooled 2.5 and 2.75 inch mesh catch indicate a decrease in abundance of both alewife and blueback herring in 2017 (Figure 30). Discretion should be used when interpreting these results as they have not been corrected for selectivity bias of the mesh sizes. Total catch of other important sport fish are noted in Table 11.

Mortality

Total instantaneous mortality for Nanticoke River alewife herring (sexes combined) was estimated as Z = 1.46. Total instantaneous mortality for Nanticoke River blueback herring (sexes combined) was Z = 0.83. The 2017 total instantaneous mortality estimates for alewife herring from the North East River was Z = 0.69, and the blueback herring estimate was Z = 0.70.

Juvenile Abundance

Data provided by the EJFS indicated that the upper bay juvenile GM CPUE for alewife declined, while the Nanticoke River juvenile GM CPUE for alewife increased in 2017. Both the upper bay and Nanticoke River juvenile GM CPUE for blueback herring increased in 2017 (Figures 31-32).

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 and pollution. 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. The American shad adult stock has shown some improvement since the inception of restoration efforts, although the 2007 ASMFC stock assessment indicated that stocks were still declining in most river systems along the east coast (ASMFC 2007).

The population size of American shad in the lower Susquehanna appears to be relatively stable over the past nine years (2009-2017; SPM estimate), although at a much lower level than the peak observed from 2000-2001 and compared to historical abundance. This follows a period (2001-2007) when calculated indices of abundance generally decreased (including the hook and line CPUE, lift CPUE, logbook CPAH and creel CPAH).

The Petersen estimate and the SPM are both useful techniques for providing estimates of American shad abundance at the Conowingo Dam. Both models show the population to be relatively stable (2007-2017), although both models indicate a slight decline in the population in recent years (2009-2017). The SPM likely underestimates American shad abundance, while the Petersen statistic likely overestimates the population, especially in years of low recapture of tagged fish. Trends, rather than the actual numbers, produced by the models should be emphasized when assessing the population at the Conowingo Dam in the Susquehanna River. The trends in these population estimates indicate that the population has stabilized at some low level, likely limited by the available spawning habitat below Conowingo and stocking success. The PFBC data currently estimates stocking contributes approximately 40% of the adult American shad population in the Conowingo tailrace.

There was disagreement in the calculated indices of abundance for the lower Susquehanna River in 2017, where the creel CPAH index and fish passage showed increases, but the hook and line index and the logbook CPAH showed similar values to 2016. The Potomac

River CPUE (1996-2015) has increased over time, which indicates there is some improvement in this river, while the Susquehanna River continues to be significantly impacted.

Peak capture of American shad in the Conowingo tailrace by hook and line occurred almost three weeks before peak passage was observed at the East Fish Lifts, and two weeks before peak capture at the West Fish Lift in 2017. Surface water temperature for peak capture by hook and line was within the optimal migration temperature for American shad (17-19°C, Leggett and Whitney 1972) at 18°C, whereas peak passage at the East Fish Lift occurred at 19.7°C; slightly above the optimal migration temperature, but within the optimal temperature for spawning (14-20°C, Stier and Crance 1985). Efficient and timely passage of American shad at Conowingo Dam is important to ensure migration and spawning occurs at the appropriate temperatures and in the appropriate habitats.

Ageing American shad using scales is common practice, as it the only non-lethal ageing structure for this fish. However, ageing accuracy has been called into question by many (ASMFC 2007). Ageing other hard structures such as otoliths produces higher age agreement between readers compared to scales (Duffy et al. 2012), but ageing from otoliths sacrifices repeat spawning information. We will remain consistent with historical ageing methods until alternative ageing structures or techniques can be implemented in our lab.

The percent of repeat spawning American shad below the Conowingo Dam has increased over time. The percent of repeat spawners was generally less than 10% in the early 1980s in the Conowingo Dam tailrace (Weinrich et al. 1982). In contrast, 33% of aged American shad at the Conowingo Dam were repeat spawners in 2017, and, on average, 50% of aged fish were repeat spawners over the past four years. Similar estimates of repeat spawning were observed in recent years for American shad collected from Virginia rivers (Hilton et al., 2015), and from the Potomac River, a free flowing river, unimpeded by dam construction. The average percent of repeat spawners from the Potomac River was 17% in the 1950s (Walburg and Sykes 1957), and is currently 40%. Increased repeat spawning in these river systems may indicate increased survival of adult fish. This could be due to decreased harvest in Atlantic Ocean fisheries, increased abundance leading to more fish reaching older ages, reductions in natural mortality, and/or reader bias. Additional river systems along the Atlantic coast that show increasing trends in repeat spawners include the Merrimack (1999-2005; ASMFC 2007), Nanticoke (Figure 8), and James Rivers (2000-2002; Olney et al., 2003).

Juvenile American shad indices increased baywide, in the upper Chesapeake Bay in 2017. Juvenile American shad indices in the Potomac River were in 2017 were similar to 2016 values, following the record high observed in 2015.

Hickory Shad

Hickory shad stocks have drastically declined due to the loss of habitat, overfishing, stream blockages and pollution. A statewide moratorium on the harvest of hickory shad in Maryland waters was implemented in 1981 and is still in effect today.

Adult hickory shad are difficult to capture due to their aversion to fishery independent (fish lifts) and dependent (pound and fyke net) gears. Very few hickory shad are historically observed using the EFL in the Susquehanna River. A notable exception was in 2011 when 20 hickory shad were counted at the EFL viewing window. Despite the traditionally low number of hickory shad observed passing the Conowingo Dam, Deer Creek (a tributary to the Susquehanna River) has the greatest densities of hickory shad in Maryland (Richardson et al. 2009). Catch rates exceed four fish per hour for all years except 2009, 2010, 2015 and 2017 according to shad logbook data collected from anglers (1998-2017).

Previously, hickory shad age structure has remained relatively consistent, with a wide range of ages and a high percentage of older fish, although the past seven years (2012-2017) have seen no hickory shad over the age of 7. This suggests the age structure of hickory shad has become truncated in recent years. Richardson et. al (2004) found ninety percent of hickory shad from the upper Chesapeake Bay had spawned by age four, and this stock generally consisted of few virgin fish. Percent repeat spawning values observed in 2014 and 2015 were the lowest of the time series, which coincided with fewer hickory shad reaching those older ages. Fewer older fish combined with a smaller proportion of repeat spawners may indicate poor year classes and/or an increase in natural mortality at older ages. Percent repeat spawning increased in 2016 and 2017, but the age structure has yet to expand.

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

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

Alewife and Blueback Herring

Alewife and blueback herring numbers have drastically declined for the same reasons discussed previously for American and hickory shad. The most recent stock assessment, released in 2017, showed the coastwide meta-complex of river herring stocks on the US Atlantic coast is 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 corresponds with the low indices of abundance for both species observed in the Nanticoke River by this project through 2017. Crecco and Gibson (1990) found alewife herring 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. However, relative abundance in the North East River showed signs of improvement for both blueback and alewife herring from 2013-2015. Without a reference point for this river, the significance of this improvement is unclear.

Amendment 2 of the ASMFC Interstate Fishery Management Plan for American Shad and River Herring required states to develop and implement a sustainable fishery plan for jurisdictions wishing to maintain an open commercial or recreational fishery. Due to the decline in and persistently low levels of river herring in Maryland, a moratorium on the possession of river herring went into effect on 26 December 2011. The moratorium on river herring eliminates any directed in-river mortality experienced by these species, and there are a number of efforts underway to reduce incidental catch mortality of river herring in ocean fisheries as well. Beginning in 2014, the Mid-Atlantic and New England Fisheries Management Councils placed incidental catch caps for river herring and shad on the Atlantic herring and mackerel fleets (Federal Register 2014a, 2014b). The expectation is that these efforts to reduce fishing mortality on river herring will lead to increased spawning stock, with a corresponding increase in production of juvenile river herring. While it is has only been a few years since these measures were enacted, the ASMFC 2017 stock assessment update did not indicate a change to the stock status for Maryland's river herring populations.

Mortality estimates in recent years for alewife and blueback herring in the North East and Nanticoke Rivers have been high. In 2017, the mortality estimate for alewife was higher in the Nanticoke River than the North East 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. Invasive catfish in the Chesapeake Bay region also pose a threat to these species, as river herring and shad are known prey items for flathead and blue catfish (Moran et al. 2016) that are spreading throughout the region.

The population age structure for the North East and Nanticoke Rivers is similar to that of other river herring populations in the region (Hilton et al. 2015), but should be interpreted with caution as the ASMFC River Herring Ageing Workshop (2013) found precision between states and even within ageing labs to be low and highly variable. 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 ageing 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

2017 PRELIMINARY RESULTS – WORK IN PROGRESS

Analysis of the data collected in 2018 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 and hickory shad, and river herring (i.e. alewife and blueback) in the Susquehanna, Nanticoke, Potomac and North East rivers.

Adult American shad were angled by staff from the lower Susquehanna River two to four times per week from 26 April through 1 June 2018. Biologists encountered 177 adult American shad and collected 162 scale samples for ageing and spawning history analysis. American shad ranged in size from 334 - 511 mm FL.

In 2018, biologists worked with commercial fishermen in the Nanticoke River to collect stock composition data and to estimate relative abundance of adult American and hickory shad, and river herring from 5 March through 30 April 2018. Data from this survey are still being entered into the database at this time. Biologists also completed 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 to compare age structure and repeat spawning of fish in this river with fish sampled in the Susquehanna and Nanticoke Rivers. A total of 95 American shad were encountered by this survey in 2018.

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 15 March to 16 May 2018. The gill net was set 40 times and encountered 465 alewife and 138 blueback herring. A total of 433 alewife scale samples and 130 blueback herring scale samples are being processed for ageing.

The complete analyses of the data collected in 2018 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 Conowingo Dam tailrace (hook and line) Nanticoke River (gears combined) and Potomac River (gill net) in 2017.

Conowingo Dam Tailrace

AGE	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
3	11	0	3	0	14	0
4	53	9	34	4	87	13
5	44	13	92	47	136	60
6	3	0	24	14	27	14
Totals	111	22	153	65	264	87
Percent Repeats	19.8%		42.5%		33.0%	

Nanticoke River

AGE	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
3	2	0	1	0	3	0
4	8	3	4	0	12	3
5	5	2	7	2	12	4
6	3	2	4	4	7	6
7	0	0	0	0	0	0
8	0	0	0	0	0	0
Totals	18	7	16	6	34	13
Percent Repeats	38.9%		37.5%		38.2%	

Potomac River

AGE	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
3	2	0	0	0	2	0
4	10	1	4	1	14	2
5	16	6	21	6	37	12
6	6	5	25	14	31	19
7	0	0	1	1	1	1
Totals	34	12	51	22	85	34
Percent Repeats	35.3%		43.1%		40.0%	

Table 2. Number of recaptured American shad in 2017 at the Conowingo Dam East and West Fish Lifts.

East Lift			West Lift		
Tag Color	Year Tagged	Number Recaptured	Tag Color	Year Tagged	Number Recaptured
Yellow	2017	26	Yellow	2017	4

Table 3. The six generalized additive model (GAM) configurations and performance statistics explored for standardizing the hook and line catch per unit effort index.

Model Number	Cofactor(s)	Response Variable Distribution	N	Effective Degrees of Freedom	Deviance Explained	Dispersion	AIC
1	Temp + Flow	Poisson	458	47.16	42.80%	10.38	6884.1
2	Temp + Flow	Tweedie	458	36.71	44.00%	2.47	3903.52
3	Temp + Flow	Negative Binomial	458	36.34	39.90%	0.85	3939.2
4	Temp	Poisson	458	38.17	39.70%	10.67	7117.02
5	Temp	Tweedie	458	34.14	42.20%	2.5	3912.2
6	Temp	Negative Binomial	458	39.98	37.70%	0.84	3949.25

Table 4. Catch, effort and catch-per-angler-hour (CPAH) from the recreational creel survey in the Susquehanna River below Conowingo Dam, 2001-2017. Due to sampling limitations, no data were available for 2011.

Year	Number of Interviews	Hours Fished for American Shad	American Shad Catch (numbers)	American Shad CPAH
2001	90	202.9	991	4.88
2002	52	85.3	291	3.41
2003	65	148.2	818	5.52
2004	97	193.3	233	1.21
2005	29	128.8	63	0.49
2006	78	227.3	305	1.34
2007	30	107.5	128	1.19
2008	16	32.5	24	0.74
2009	40	85.0	120	1.41
2010	36	64.0	114	1.78
2012	58	189.0	146	0.77
2013	63	161.8	107	0.66
2014	81	227.0	312	1.37
2015	64	158.9	263	1.65
2016	164	308.5	612	1.98
2017	94	185.0	483	2.61

Table 5. Catch, effort and catch-per-angler-hour (CPAH) from spring logbooks for American shad, 2000-2017. 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
2000	10	404.0	3,137	7.76
2001	8	272.5	1,647	6.04
2002	8	331.5	1,799	5.43
2003	9	530.0	1,222	2.31
2004	15	291.0	1035	3.56
2005	12	258.5	533	2.06
2006	16	639.0	747	1.17
2007	10	242.0	873	3.61
2008	14	559.5	1,269	2.27
2009	15	378.0	967	2.56
2010	16	429.5	857	2.00
2011	9	174.0	413	2.37
2012	5	180.5	491	2.77
2013	6	217.3	313	1.44
2014	16	228.0	467	2.05
2015	11	154.0	348	2.18
2016	14	284.0	687	2.42
2017	8	146.0	288	1.97

Table 6. Number of adult hickory shad and repeat spawners by sex and age sampled from the brood stock collection survey in Deer Creek (Susquehanna River tributary) in 2017.

AGE	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
3	7	0	3	0	10	0
4	9	6	9	7	18	13
5	14	14	8	8	22	22
6	3	3	5	5	8	8
7	0	0	1	1	1	1
Totals	33	23	26	21	59	44
Percent Repeats	69.7%		80.8%		74.6%	

Table 7. Percent of hickory shad by age and number sampled from the brood stock collection survey in Deer Creek (Susquehanna River tributary) by year, 2004-2017.

Year	N	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 8	Age 9
2004	80		7.5	23.8	27.5	18.8	18.8	3.8	
2005	80		6.3	17.5	28.8	33.8	11.3	1.3	1.3
2006	178	0.6	9.0	31.5	29.8	20.2	7.3	1.7	
2007	139		6.5	23.7	33.8	20.9	12.2	2.2	0.7
2008	149		9.4	29.5	33.6	20.1	5.4	2.0	
2009	118		7.6	16.9	44.9	19.5	10.2	0.8	
2010	240		12.5	37.9	31.3	11.3	6.7	0.4	
2011	216		30.1	30.1	27.3	8.8	2.8	0.9	
2012	200		26.5	39.5	24.5	7.5	2.0		
2013	193		21.2	45.6	23.8	8.3	1.0		
2014	100		11.0	37.0	40.0	12.0			
2015	113	0.9	30.1	43.4	20.4	5.3			
2016	120		20.8	30.8	35.8	11.7	0.8		
2017	59		16.9	30.5	37.3	13.6	1.7		

Table 8. Catch, effort and catch-per-angler-hour (CPAH) from logbooks for hickory shad, 1998-2017. Since 2014, data from Maryland's Volunteer Angler Shad Survey has been combined with logbook data.

Year	Number of Returned Logbooks	Total Reported Angler Hours	Total Number of Hickory Shad	Catch Per Angler Hour
1998	19	600	4,980	8.30
1999	15	817	5,115	6.26
2000	14	655	3,171	14.8
2001	13	533	2,515	4.72
2002	11	476	2,433	5.11
2003	14	635	3,143	4.95
2004	18	750	3,225	4.30
2005	19	474	2,094	4.42
2006	20	766	4,902	6.40
2007	17	401	3,357	8.37
2008	22	942	5,465	5.80
2009	15	561	2,022	3.60
2010	16	552	1,956	3.54
2011	9	224	1,802	8.03
2012	6	198	867	4.38
2013	6	259	1,679	6.49
2014	19	275	1,204	4.38
2015	15	197	371	1.88
2016	14	363	1,424	3.92
2017	12	230	548	2.38

Table 9. Percent catch-at-age for adult alewife herring sampled from the Nanticoke River from 1989 - 2017. Age 6+ includes all catch age 6 – 11. * indicates years where not all fish were aged and an age-length key was subsequently used to assign ages to those fish based on size.

		Age				
Year	N	2	3	4	5	6+
1989	435	0	5	37	38	20
1990	749	0	9	23	38	31
1991	850	0	3	48	26	23
1992	778	0	5	28	49	18
1993	637	0	3	24	38	35
1994	642	0	6	25	40	29
1995*	728	0	6	42	30	23
1996*	548	0	21	37	27	14
1997	256	0	9	47	31	13
1998	271	0	4	45	34	17
1999	317	0	9	21	40	30
2000	228	0	7	59	21	13
2001	239	0	7	36	43	14
2002	282	0	1	21	35	43
2003	168	0	4	19	35	42
2004	203	0	6	31	31	33
2005	169	0	4	40	25	31
2006	170	0	4	18	49	29
2007	218	0	7	40	27	26
2008	183	0	4	27	45	24
2009	216	0	4	38	35	22
2010	69	0	3	28	33	36
2011	182	0	4	36	28	31
2012*	527	0	13	31	33	23
2013	128	0	6	24	38	32
2014*	564	0	2	32	51	15
2015	0	0	0	0	0	0
2016*	1058	0	2	16	55	27
2017*	586	0	21	31	34	14

Table 10. Percent catch-at-age for adult blueback herring sampled from the Nanticoke River from 1989 - 2017. Age 6+ includes all catch age 6 – 11. * indicates years where not all fish were aged and an age-length key was subsequently used to assign ages to those fish based on size.

		Age				
Year	N	2	3	4	5	6+
1989	701	0	2	32	35	31
1990	732	0	2	15	29	54
1991	719	0	2	24	21	52
1992	258	0	3	21	24	52
1993	509	0	1	13	32	53
1994	452	0	6	29	38	27
1995	65	0	8	35	25	32
1996	223	0	3	38	42	17
1997	347	0	4	15	30	52
1998	232	0	3	26	27	44
1999	123	0	7	19	46	29
2000	198	0	6	51	25	18
2001	105	0	8	45	35	12
2002	146	0	6	35	44	15
2003	128	0	2	30	41	26
2004	132	0	12	37	33	17
2005	18	0	22	50	17	11
2006	68	0	3	28	54	15
2007	74	0	26	41	24	9
2008	82	0	10	51	30	9
2009	66	0	21	56	20	3
2010	26	0	8	58	23	12
2011	122	0	7	55	27	11
2012	136	1	15	38	37	10
2013	82	0	6	40	29	24
2014*	455	0	14	46	33	8
2015	0					
2016	147	0	10	37	39	14
2017	76	0	13	39	30	17

Table 11. Counts of species (other than alewife and blueback) captured in the North East River gill net survey from 2013-2017.

Species	2013	2014	2015	2016	2017
Striped Bass	39	39	42	50	42
White Perch	287	227	1273	813	257
Menhaden	145	145	476	908	145
Gizzard Shad	2,617	850	104	568	112
Goldfish	2	0	2	1	0
Carp	2	1	2	0	0
White Sucker	3	1	1	1	2
White Catfish	1	1	0	1	1
Brown Bullhead	66	132	78	123	15
Channel Catfish	17	45	50	7	6
Largemouth Bass	1	0	1	1	0
Pumpkinseed	1	1	2	4	1
Walleye	0	1	0	0	0
Hickory Shad	19	25	5	15	5
American Shad	0	2	0	0	0
Blue catfish	0	0	1	1	0
Golden shiner	0	0	1	0	4
Quilback	0	0	2	0	0
Bluegill	0	0	0	1	0
Redear Sunfish	0	0	0	0	1

Figure 1. Conowingo Dam Tailrace (Susquehanna River) hook and line sampling location for American shad in 2017.

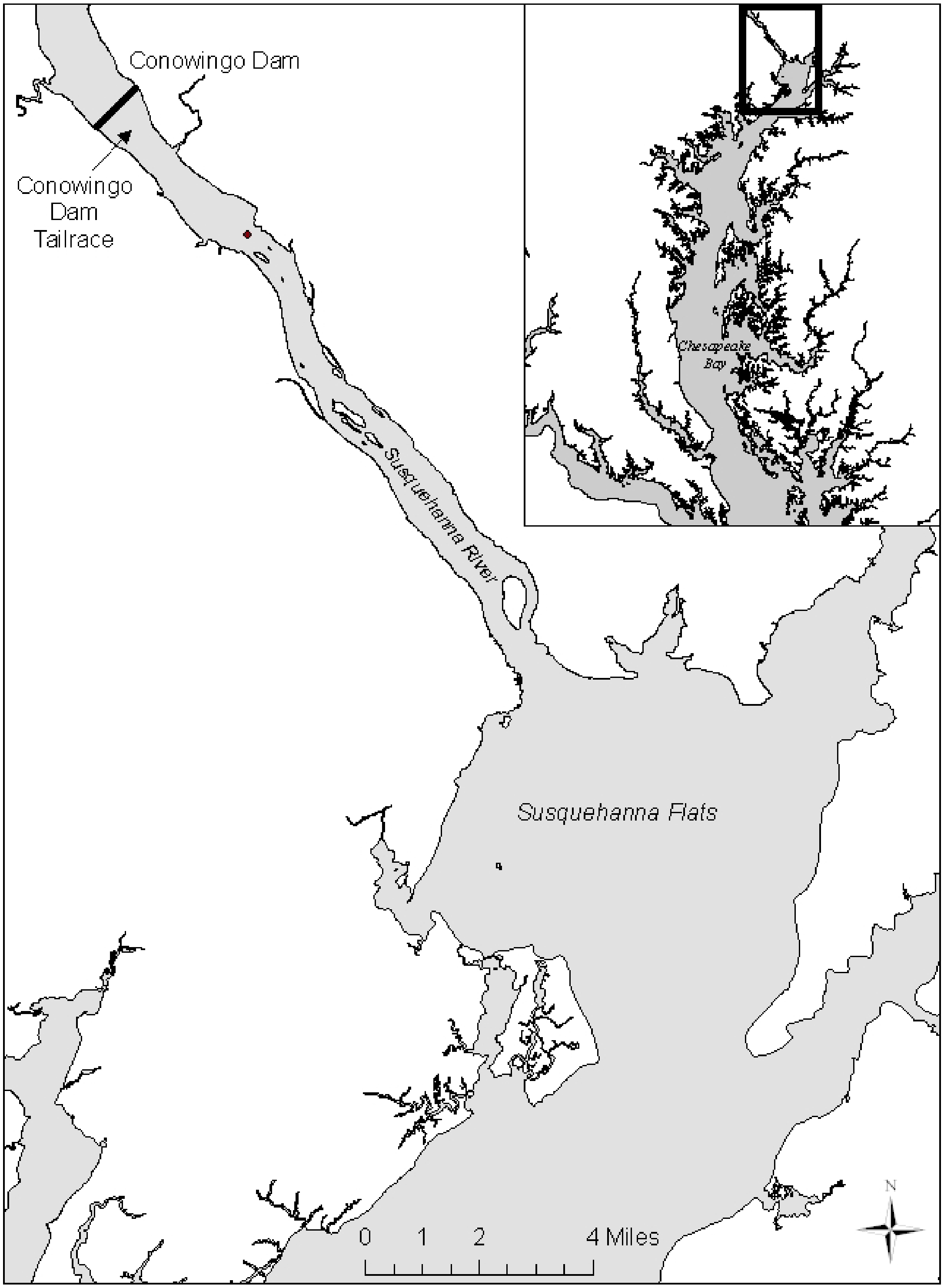


Figure 2. Nanticoke River pound and fyke net sites for adult alosine sampling in 2017. The Mill Creek pound net site used for calculating American shad CPUE is identified.

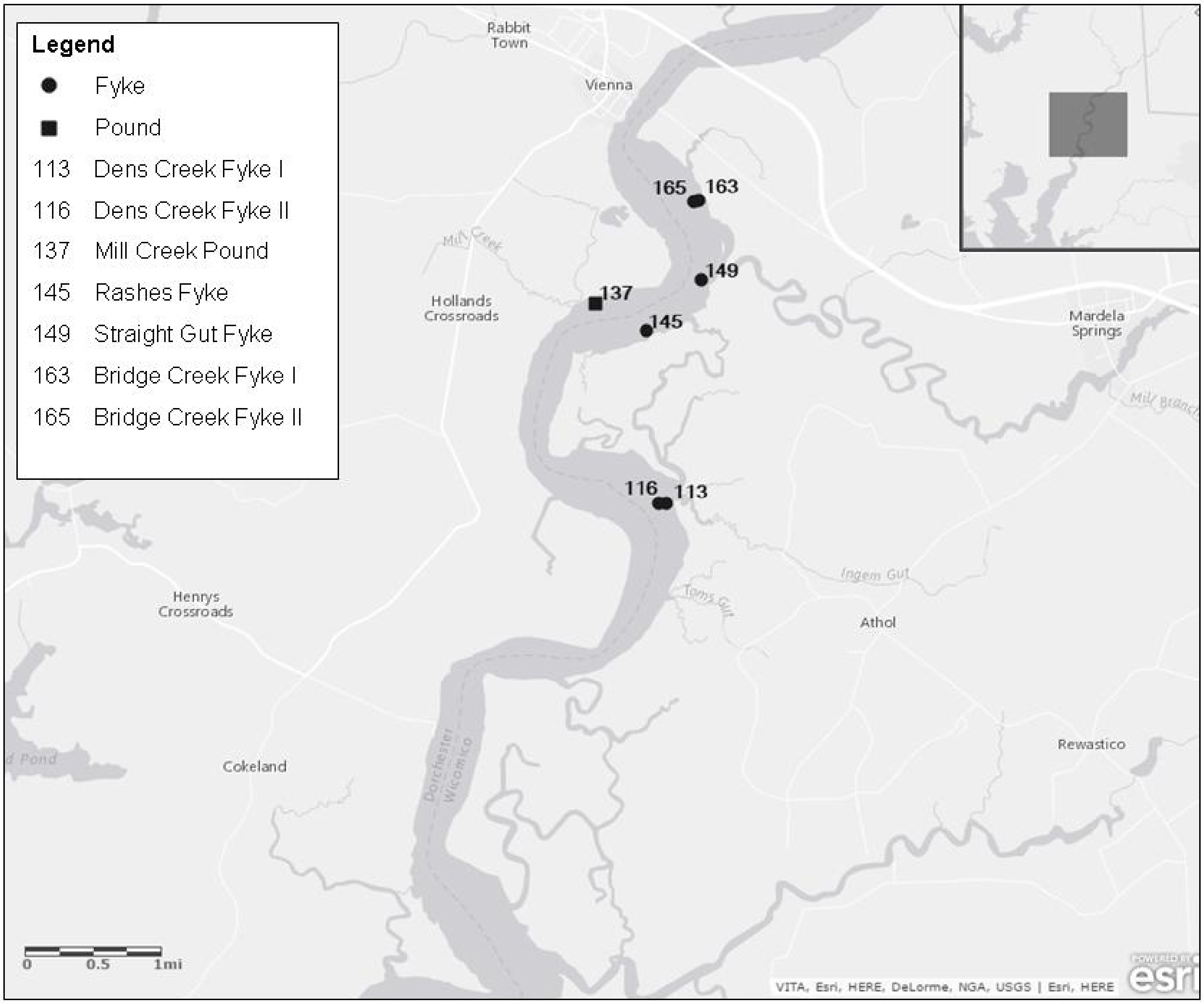


Figure 3. Nanticoke River sites for alosine ichthyoplankton sampling in 2017.

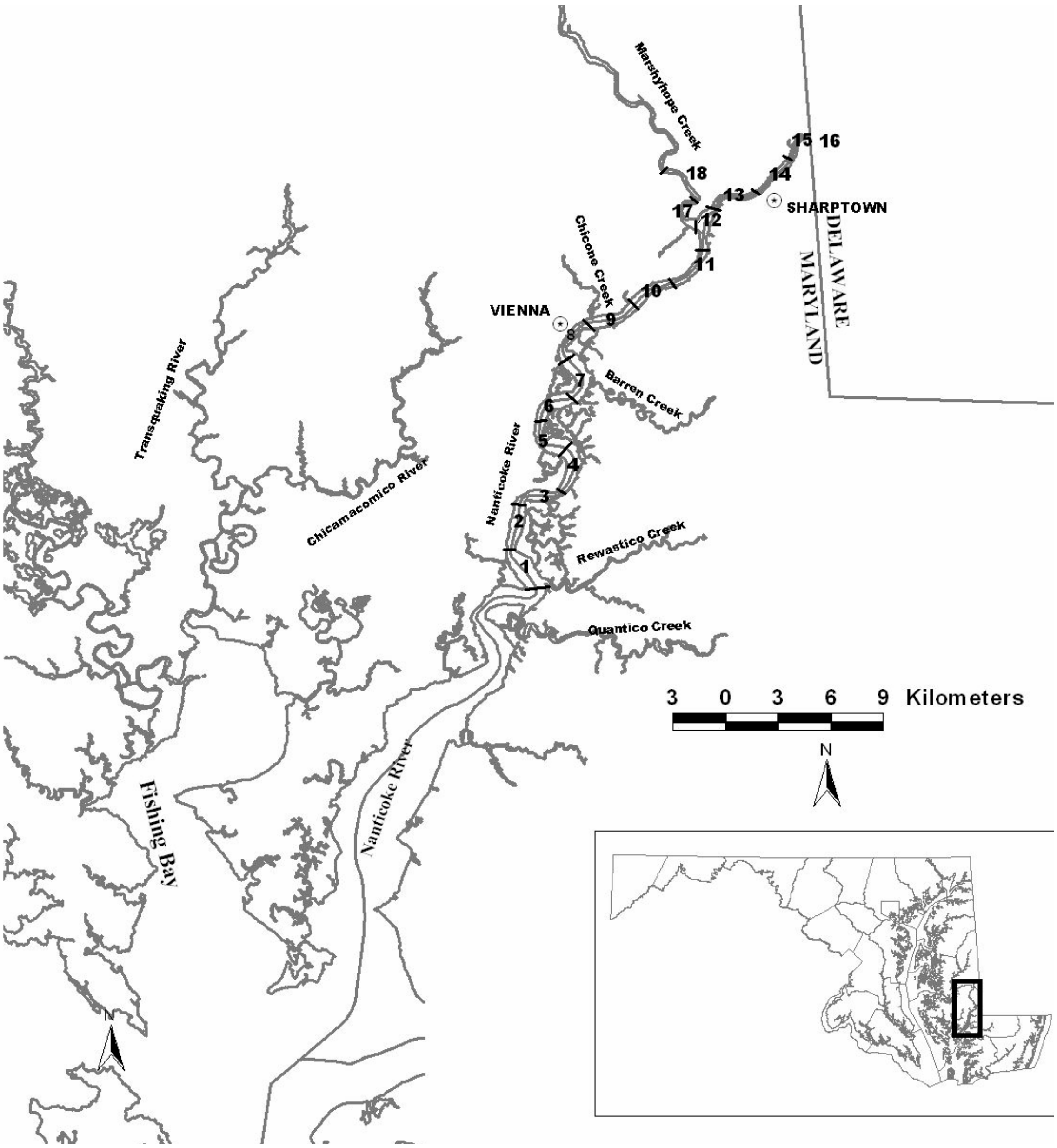


Figure 4. Grid of 1000ft x 1000ft squares overlaid on a map of the North East River from which sites were randomly chosen for the North East River sinking gill net survey, 2013-2017.

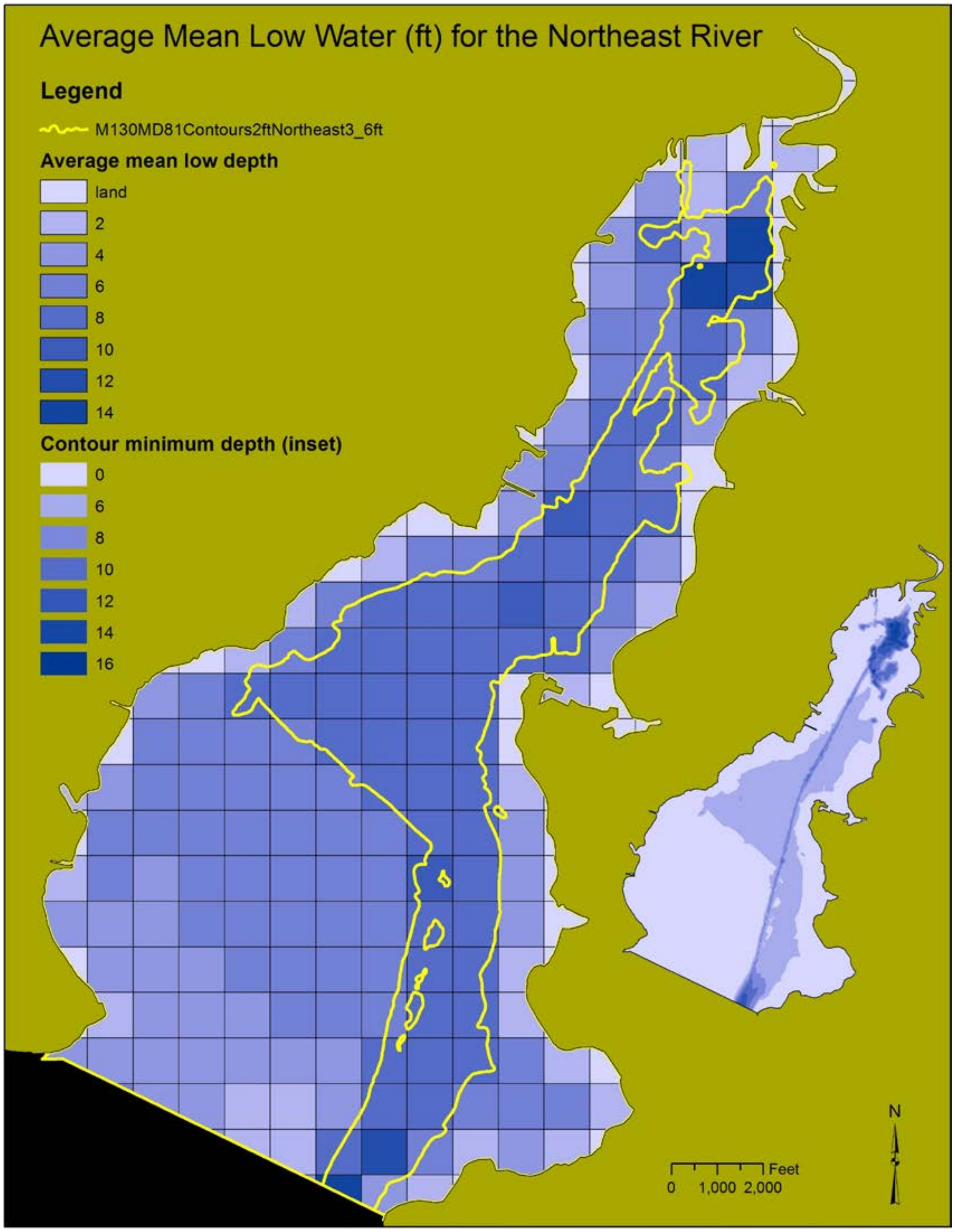


Figure 5. Percentage of sites with clupeid eggs or larvae in the Nanticoke River (2005-2017).

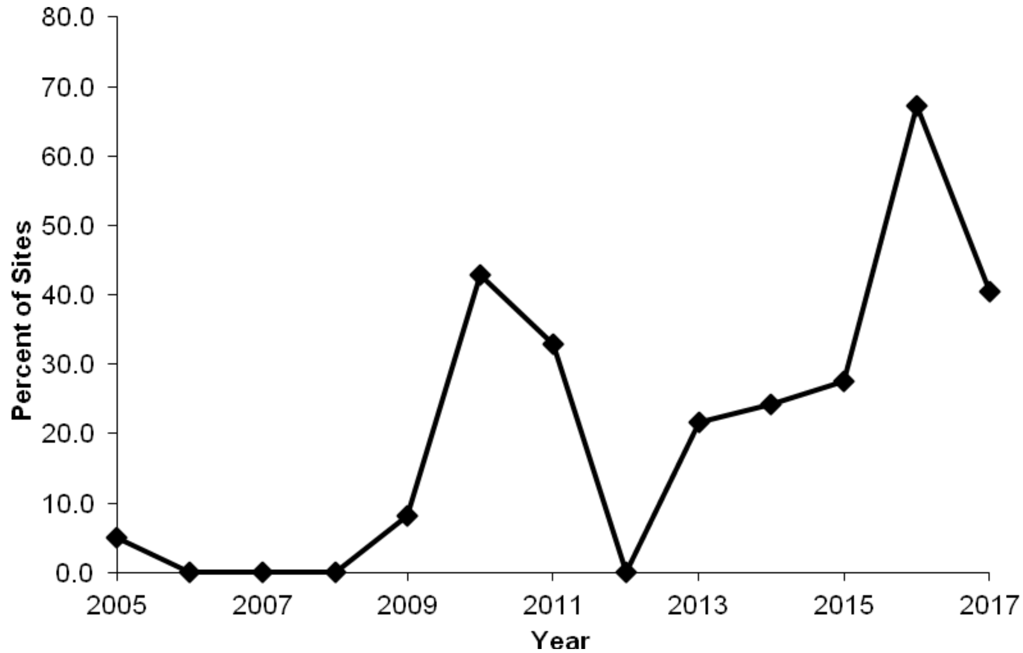


Figure 6. Percent of American shad repeat spawners by sex collected in the Conowingo Dam tailrace (1982-2017).

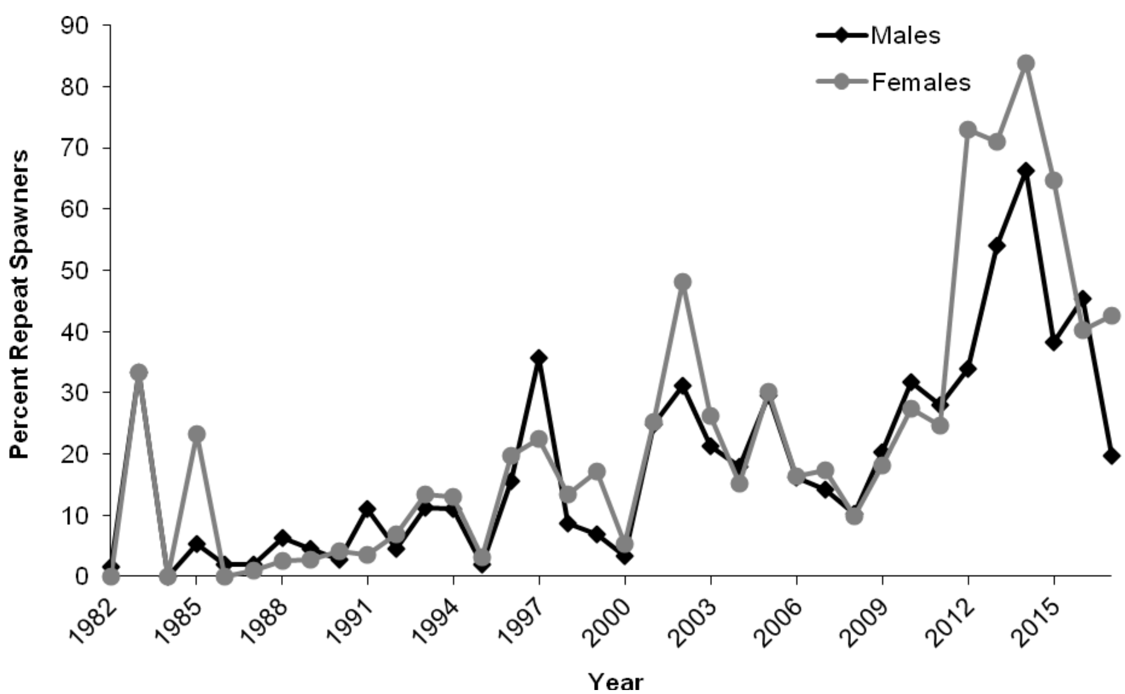


Figure 7. Arcsine-transformed percentages of repeat spawning American shad (sexes combined) collected from the Conowingo Dam tailrace, 1984-2017.

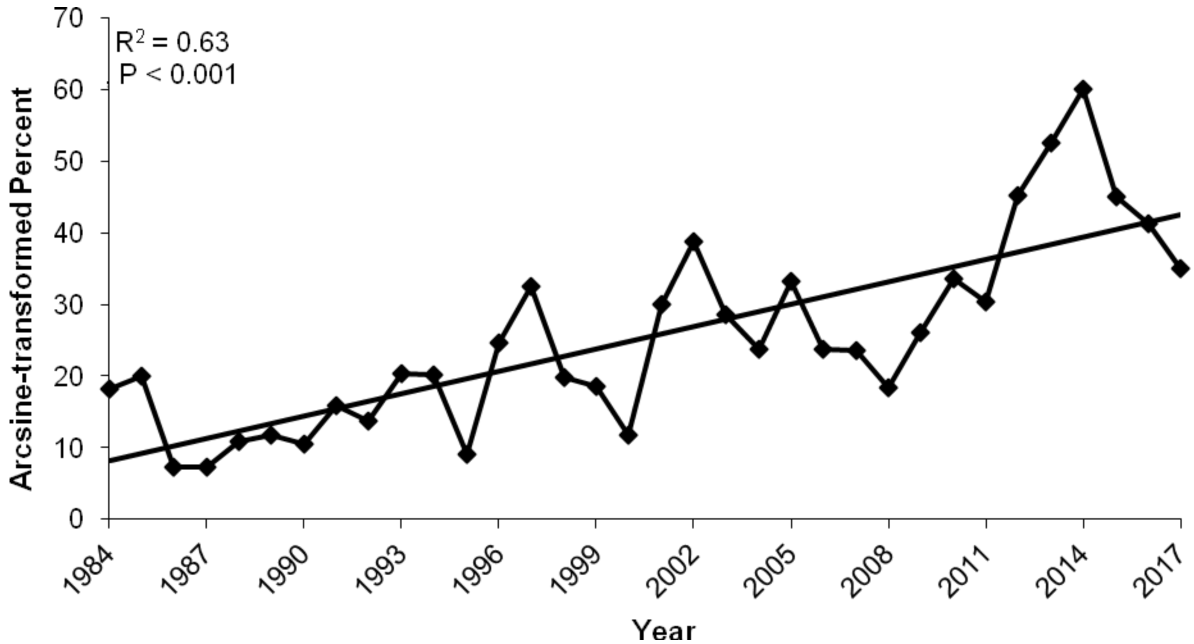


Figure 8. Arcsine-transformed percentages of repeat spawning American shad (sexes combined) collected from the Nanticoke River, 1988-2017.

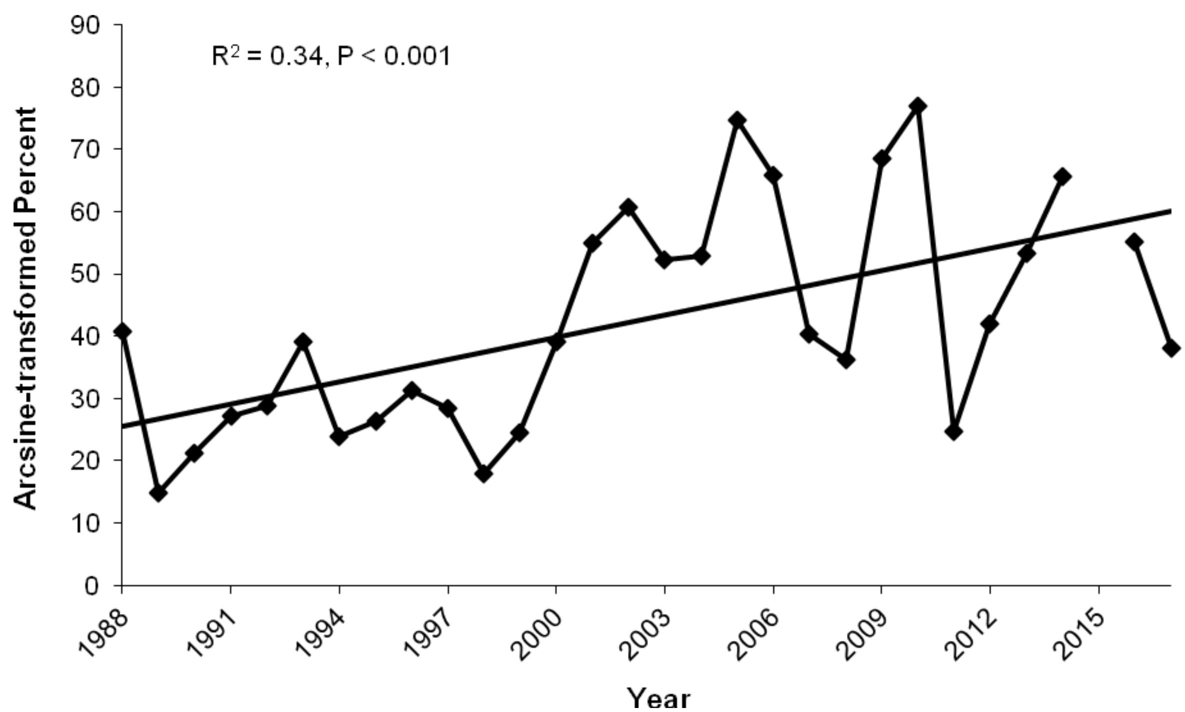


Figure 9. Trends in arcsine-transformed percentages of repeat spawning American shad (sexes combined) collected from the Potomac River, 2002-2017.

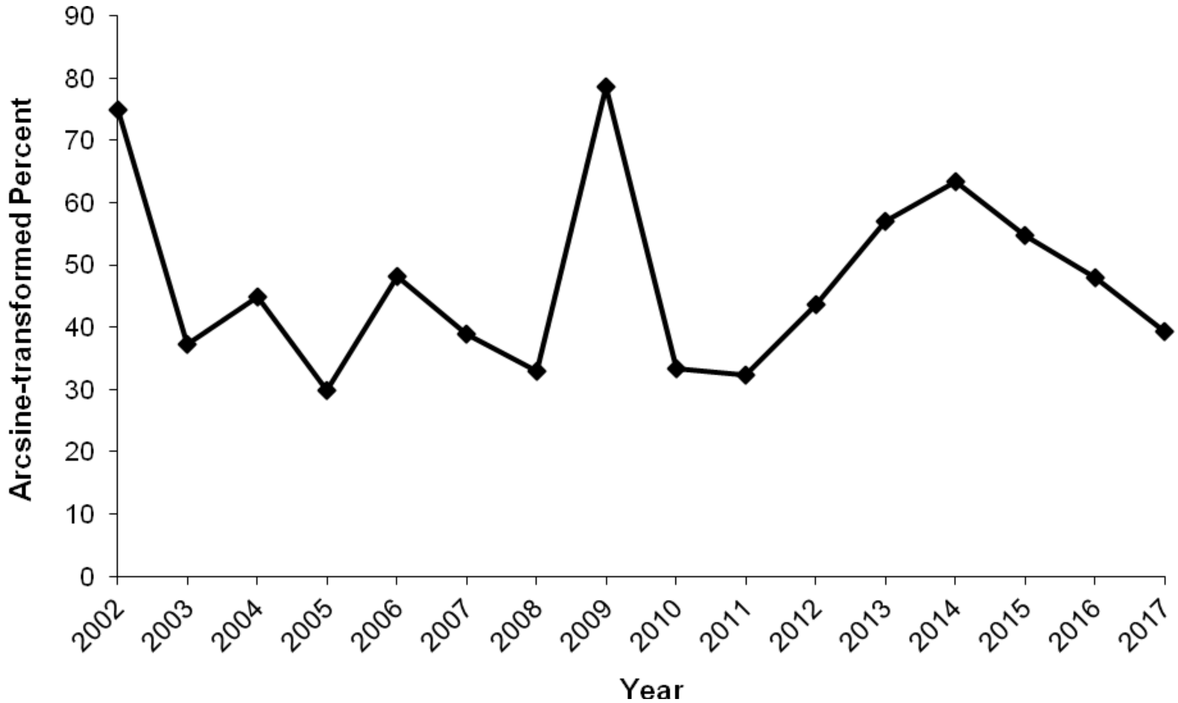


Figure 10. Pearson residuals from the best fit generalized additive model (GAM) in 2017 used to standardize the Susquehanna River hook and line catch per unit effort (CPUE) index.

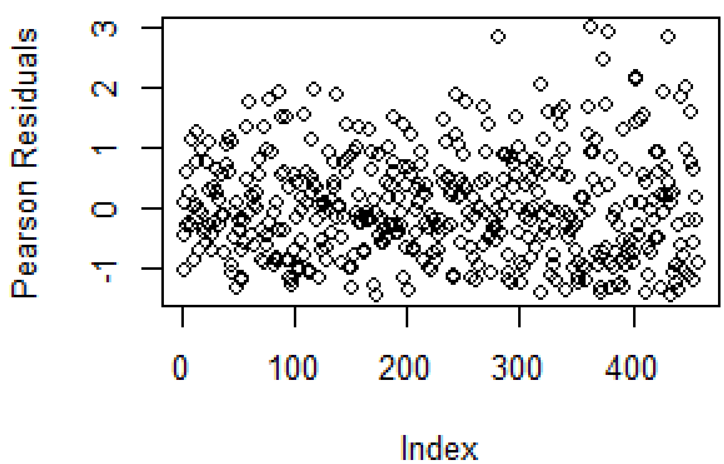


Figure 11. American shad standardized CPUE with 95% confidence intervals estimated by a generalized additive model for the Conowingo Dam tailrace hook and line sampling, 1987-2017.

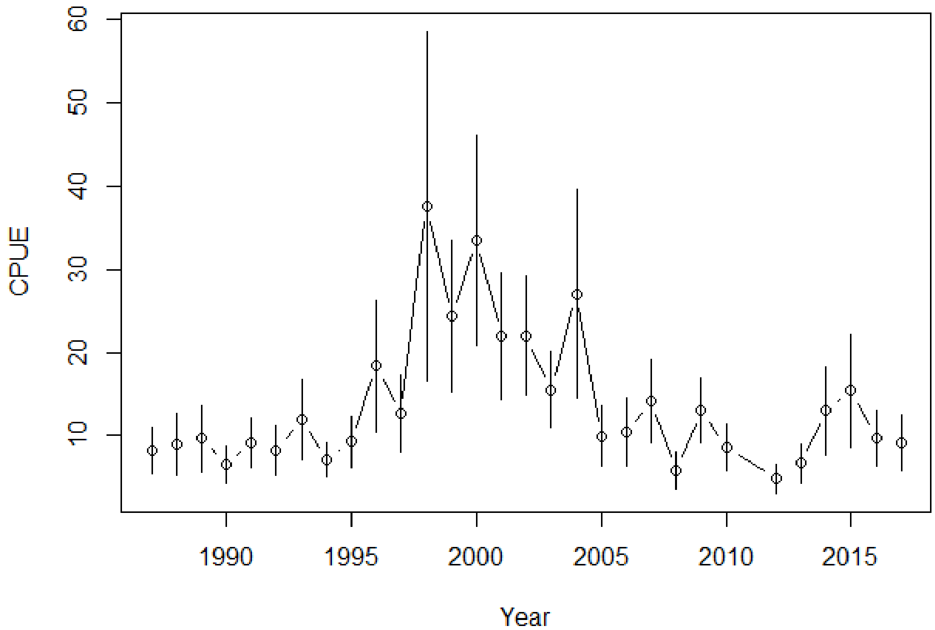


Figure 12. American shad geometric mean CPUE (fish per lift hour) and the total number of American shad lifted at the East and West Fish Lifts at the Conowingo Dam, 1991-2017.

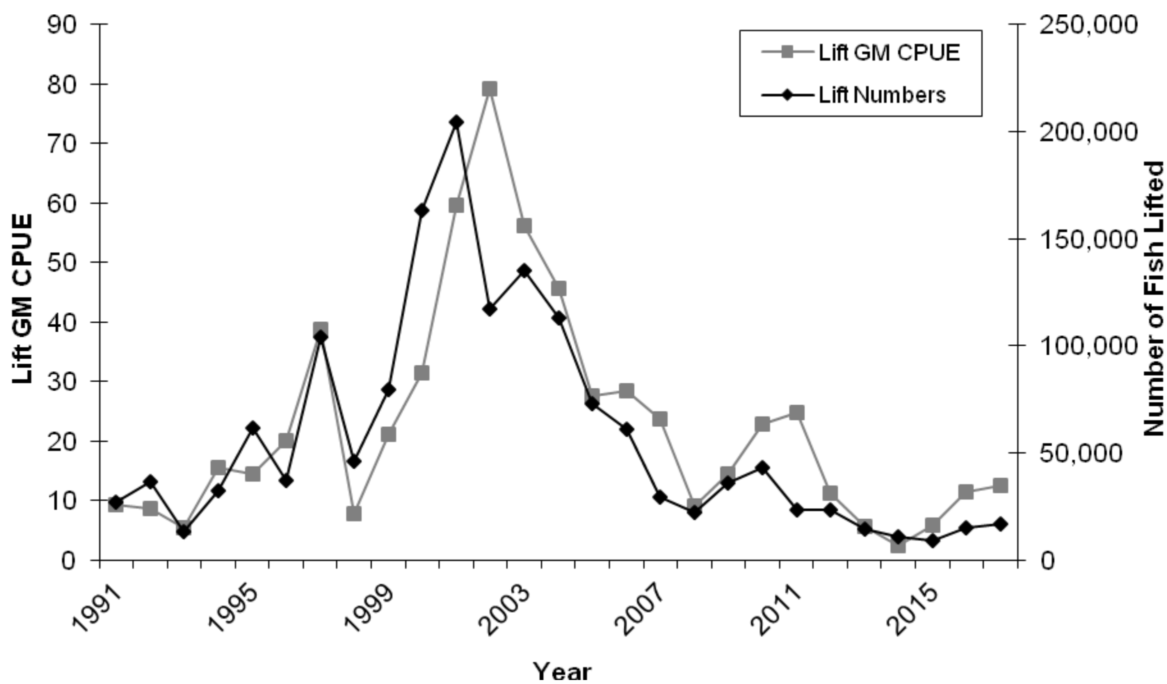


Figure 13. American shad geometric mean CPUE (fish per net day) from the Mill Creek pound net in the Nanticoke River, 1988-2017. No pound nets were fished in 2004 or 2015.

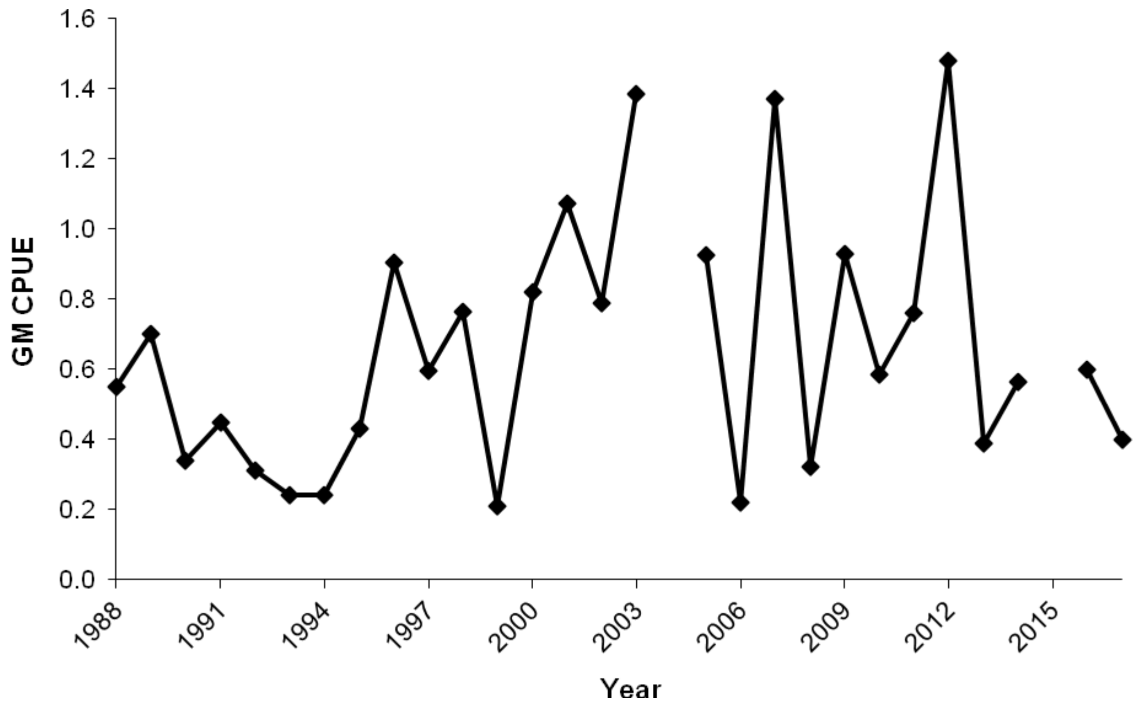


Figure 14. American shad mean CPUE (fish per 1,000 square yards of experimental drift gill net per hour fished) from the Potomac River, 1996-2017.

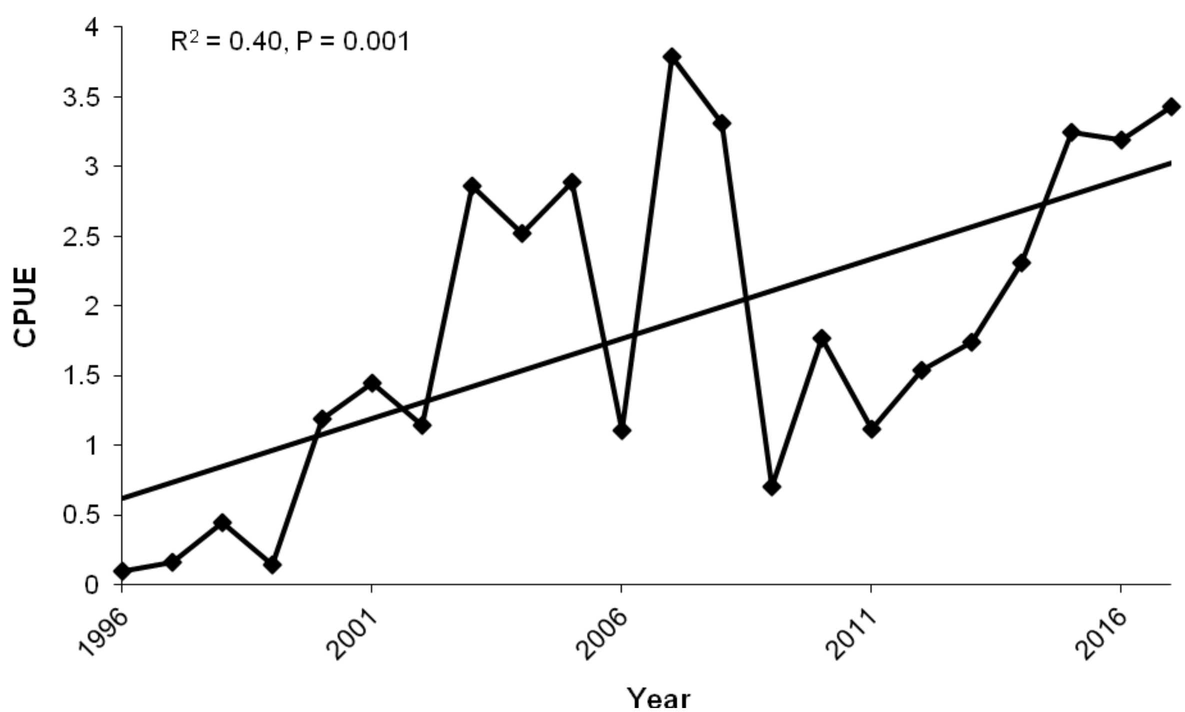


Figure 15. Conowingo Dam tailrace adult American shad abundance estimates from the Petersen statistic with 95% confidence limits, 1986-2017.

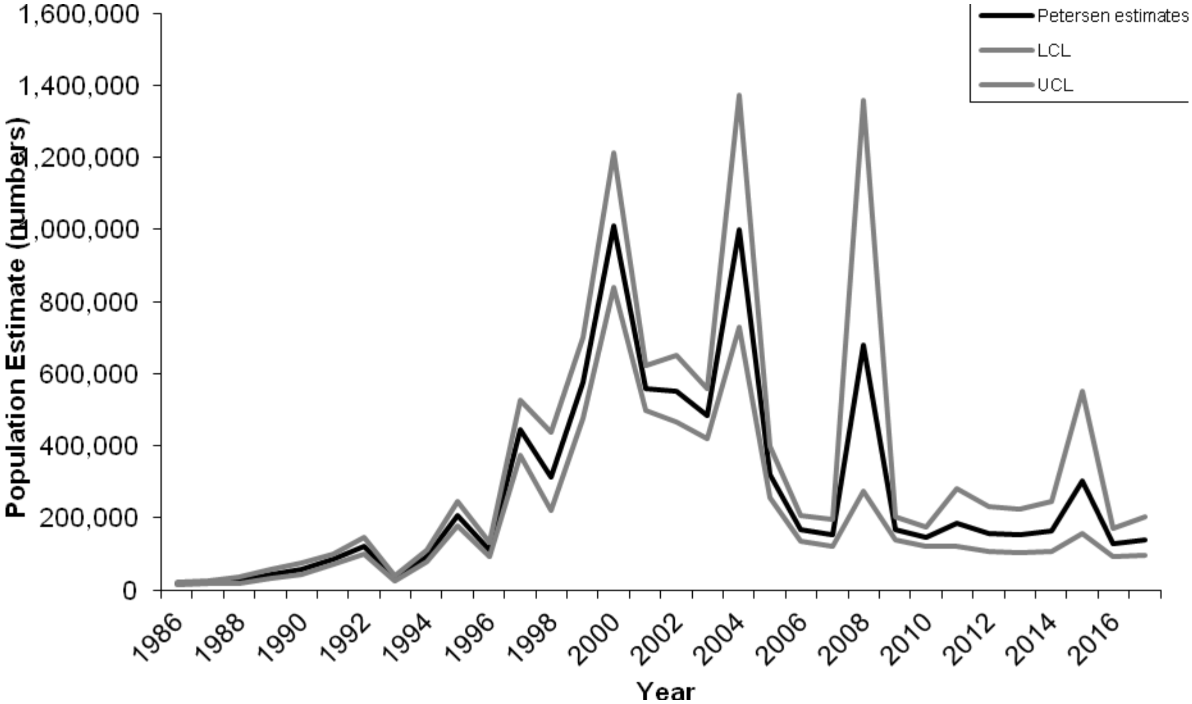


Figure 16. Conowingo Dam tailrace adult American shad abundance estimates from the surplus production model (SPM), 1986-2017.

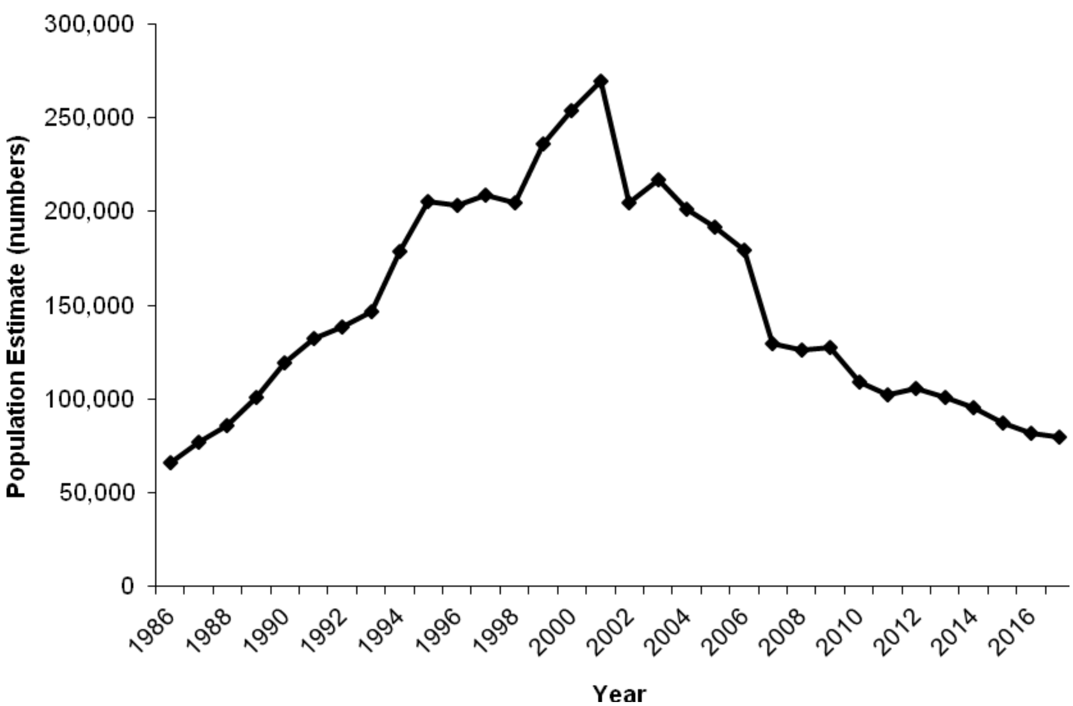


Figure 17. Baywide juvenile American shad geometric mean CPUE (catch per haul), 1959-2017.

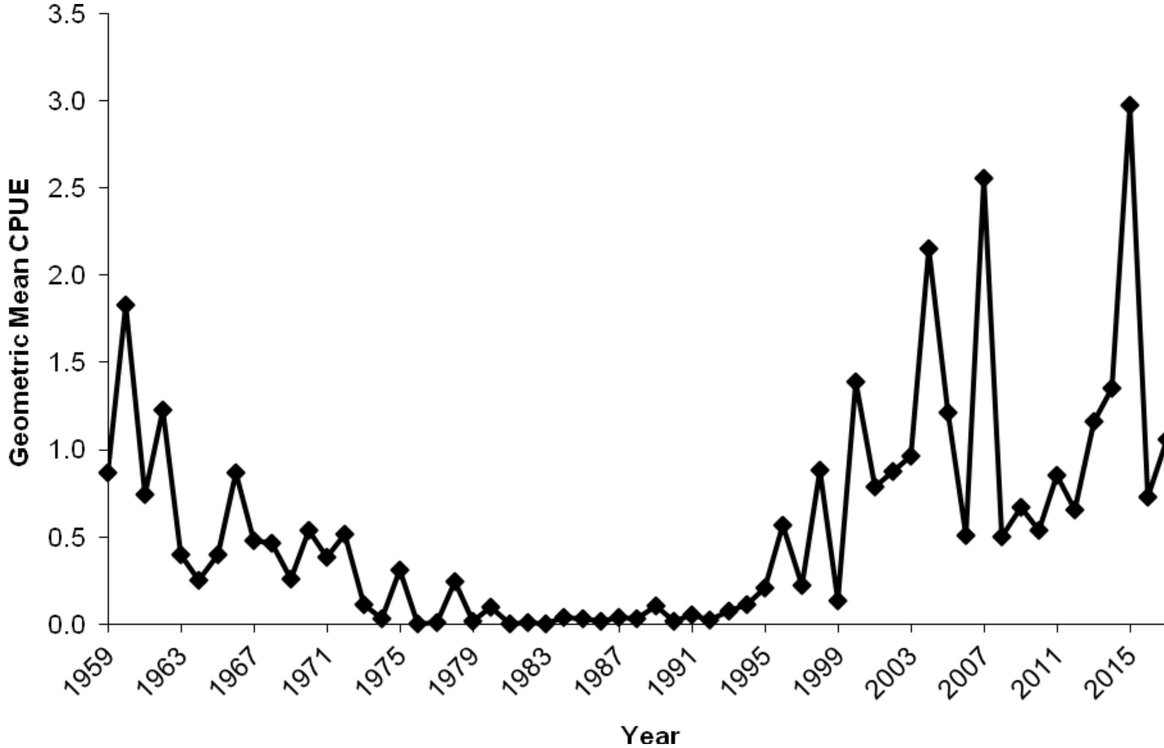


Figure 18. Upper Chesapeake Bay juvenile American shad geometric mean CPUE (catch per haul), 1959-2017.

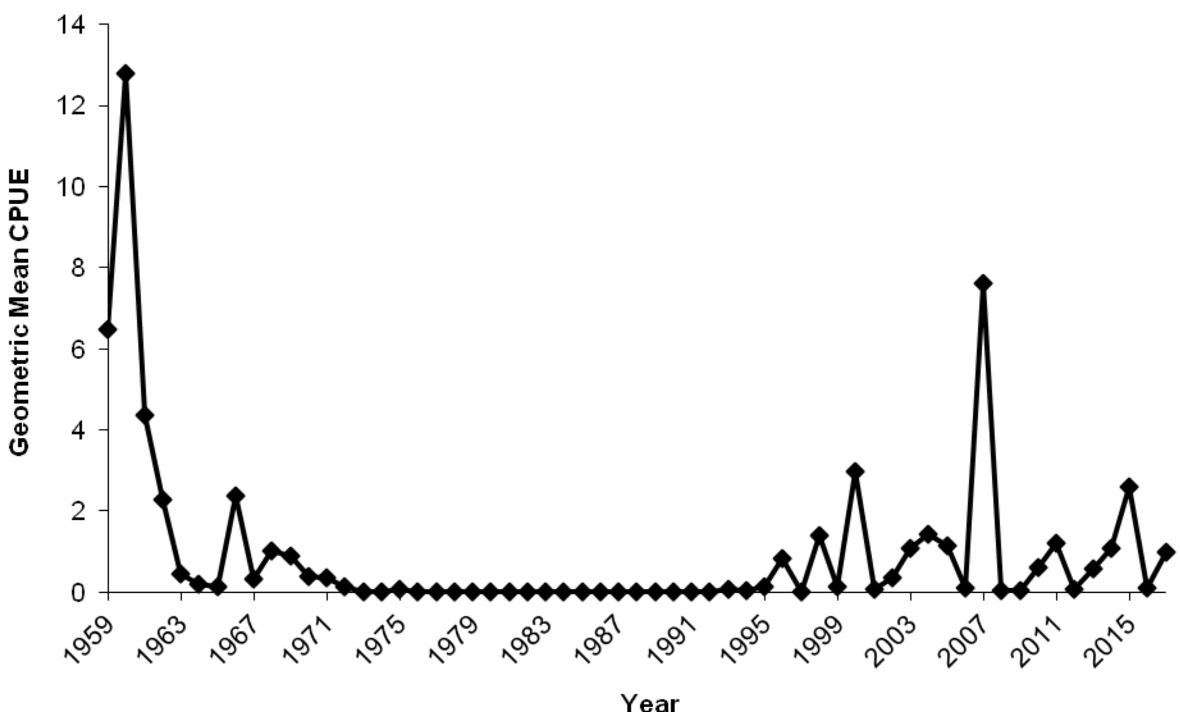


Figure 19. Potomac River juvenile American shad geometric mean CPUE (catch per haul), 1959-2017.

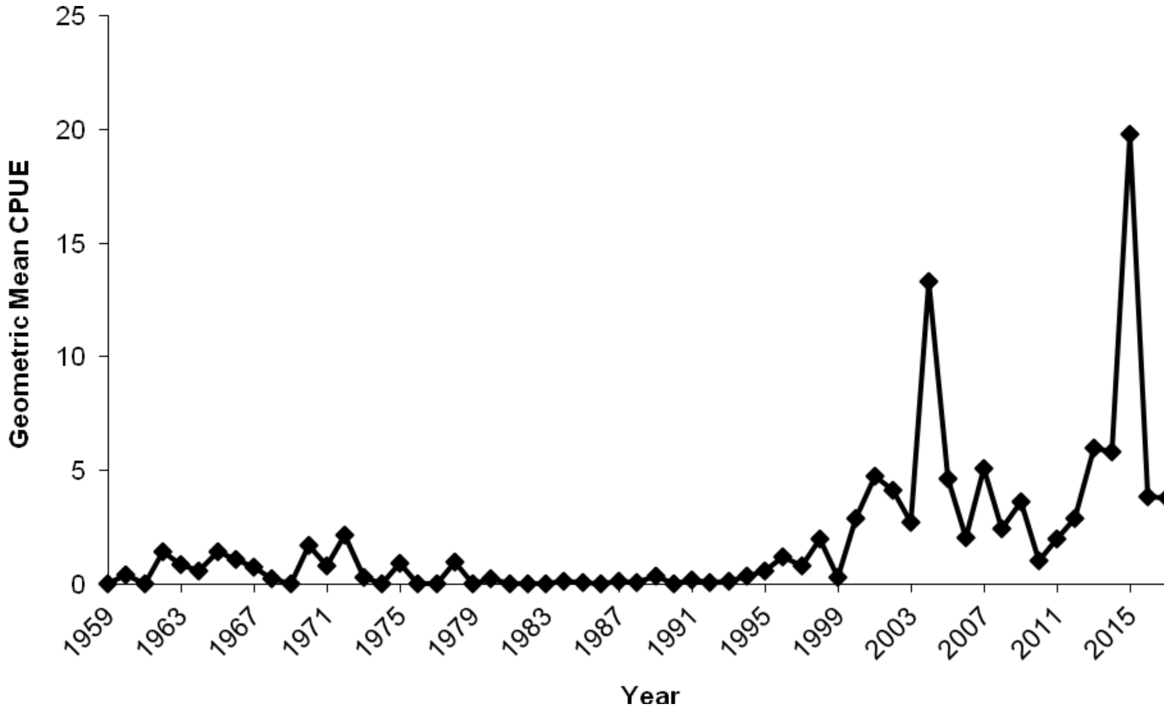


Figure 20. Nanticoke River juvenile American shad geometric mean CPUE (catch per haul), 1959-2017.

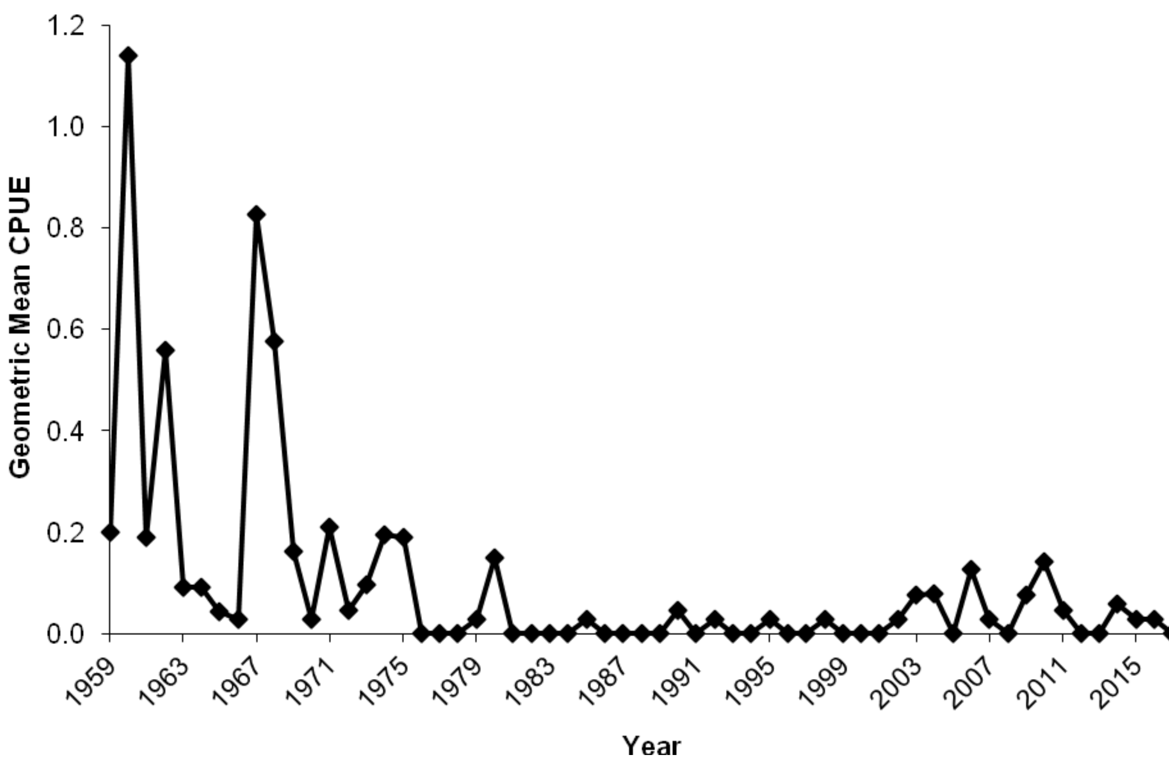


Figure 21. Arcsine-transformed percentages of repeat spawning hickory shad (sexes combined) collected from Deer Creek (Susquehanna River tributary), 2004-2017.

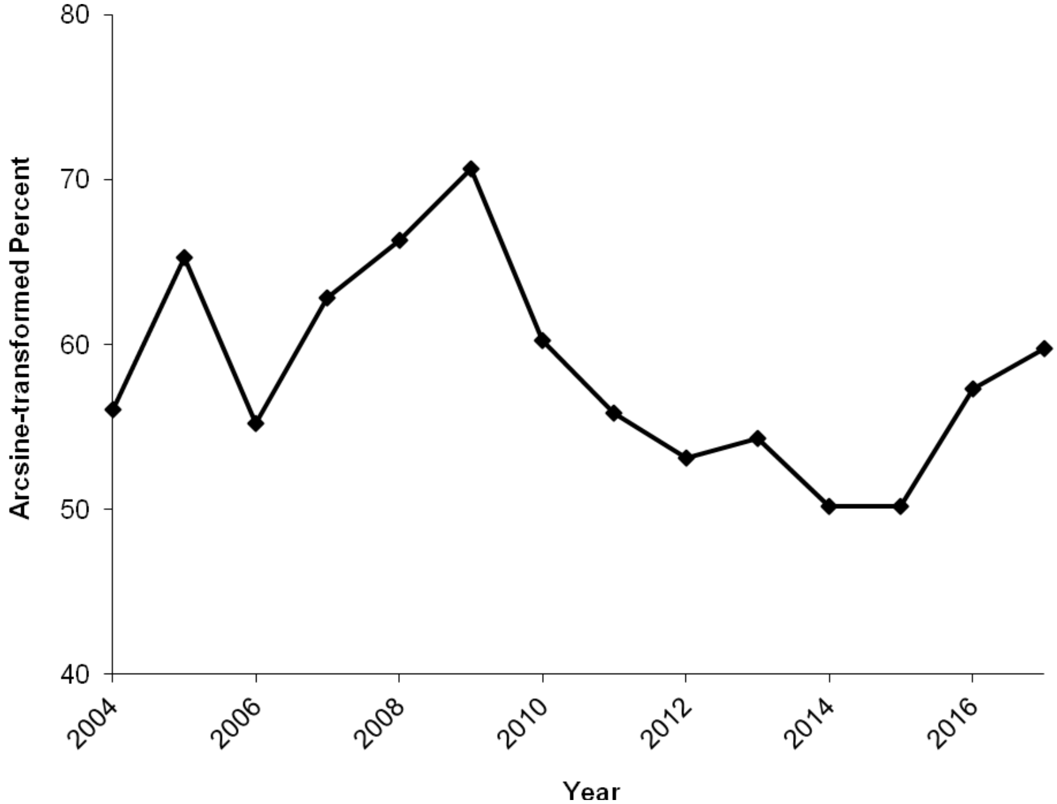


Figure 22. Arcsine-transformed percentage of repeat spawning alewife and blueback herring (sexes and gears combined) from the Nanticoke River, 1989-2017.

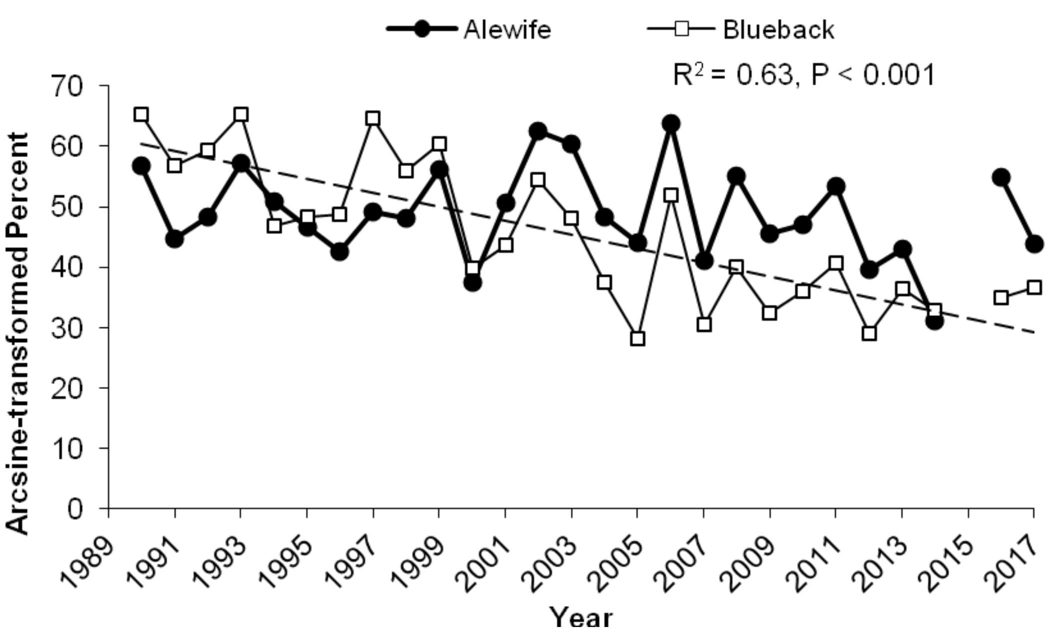


Figure 23. Mean fork length (mm) of adult alewife and blueback herring from the Nanticoke River, 1989-2017.

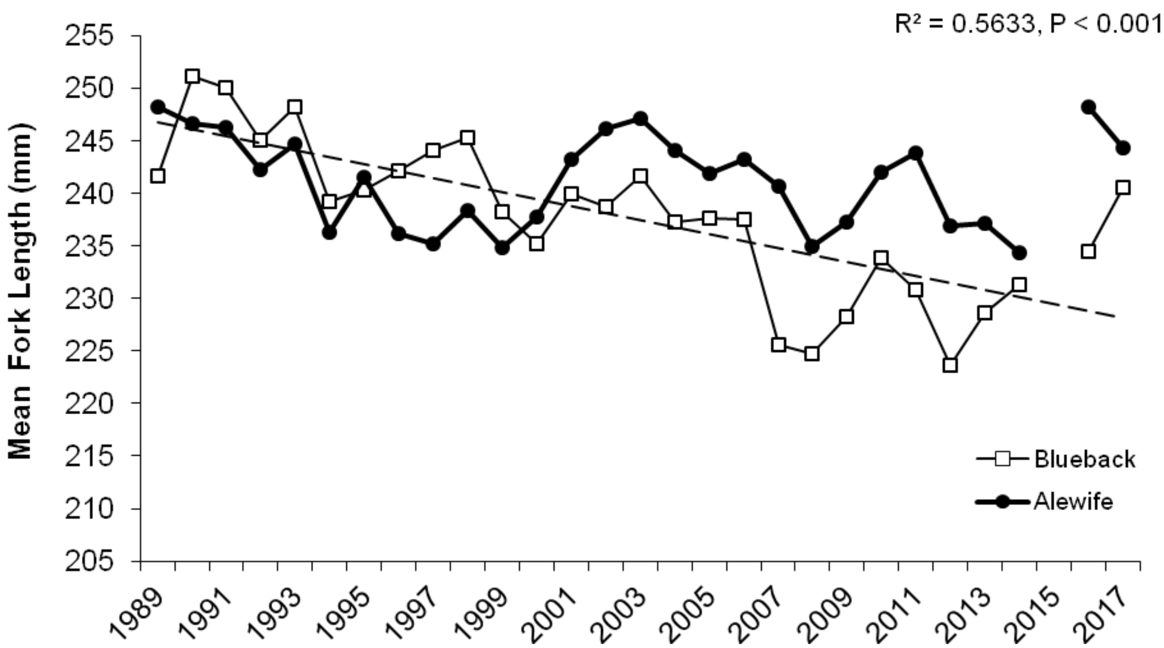


Figure 24. Percent catch-at-age by year of alewife herring from the North East River, 2013-2017.

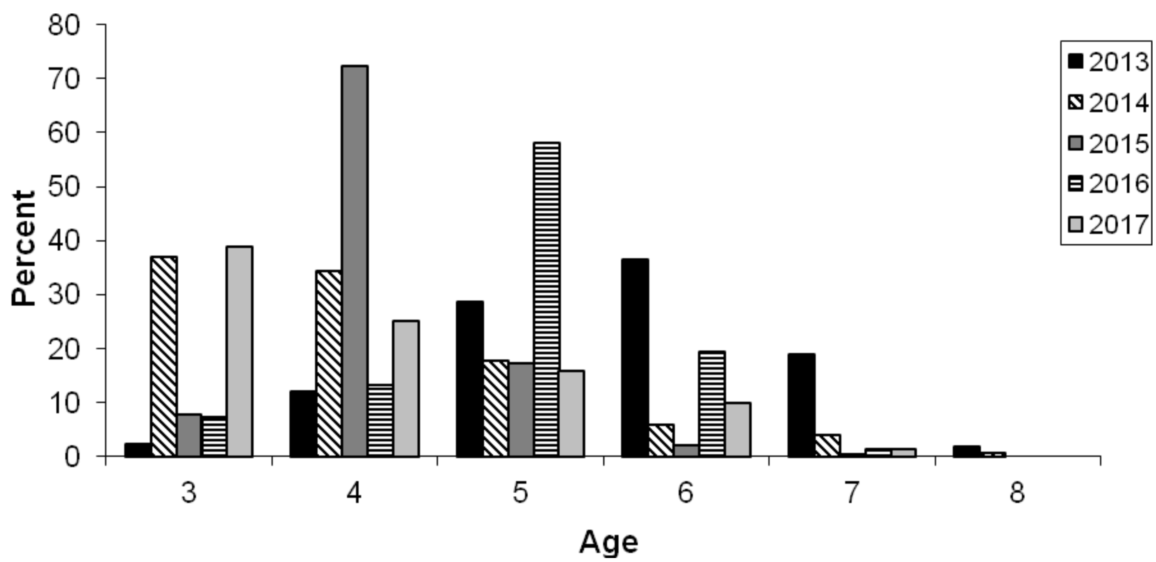


Figure 25. Percent catch-at-age by year of blueback herring from the North East River, 2013-2017.

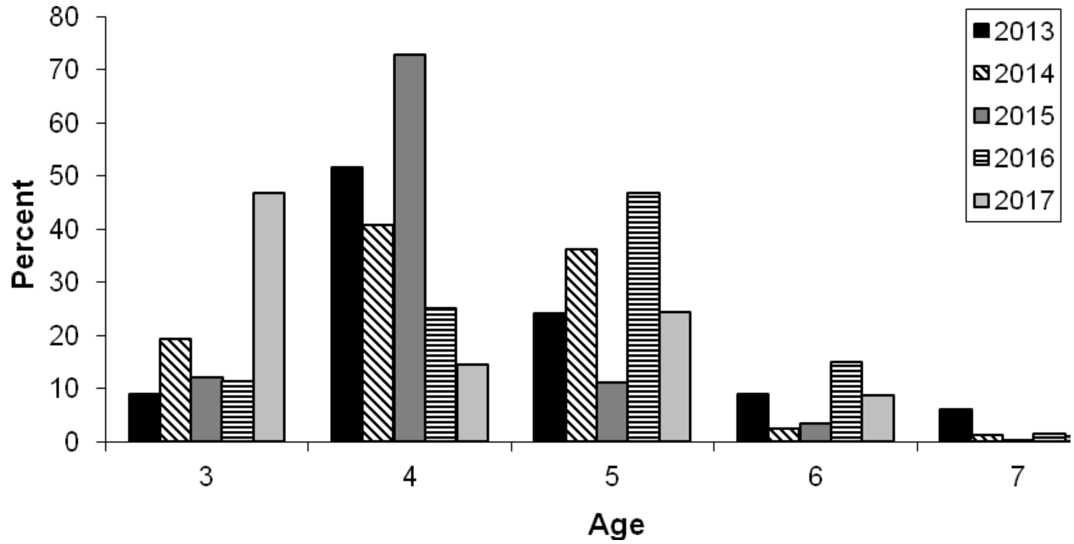


Figure 26. Geometric mean CPUE (catch per net day) of adult alewife and blueback herring from Nanticoke River fyke nets, 1989-2017. No fyke nets were fished in 2012 and 2015.

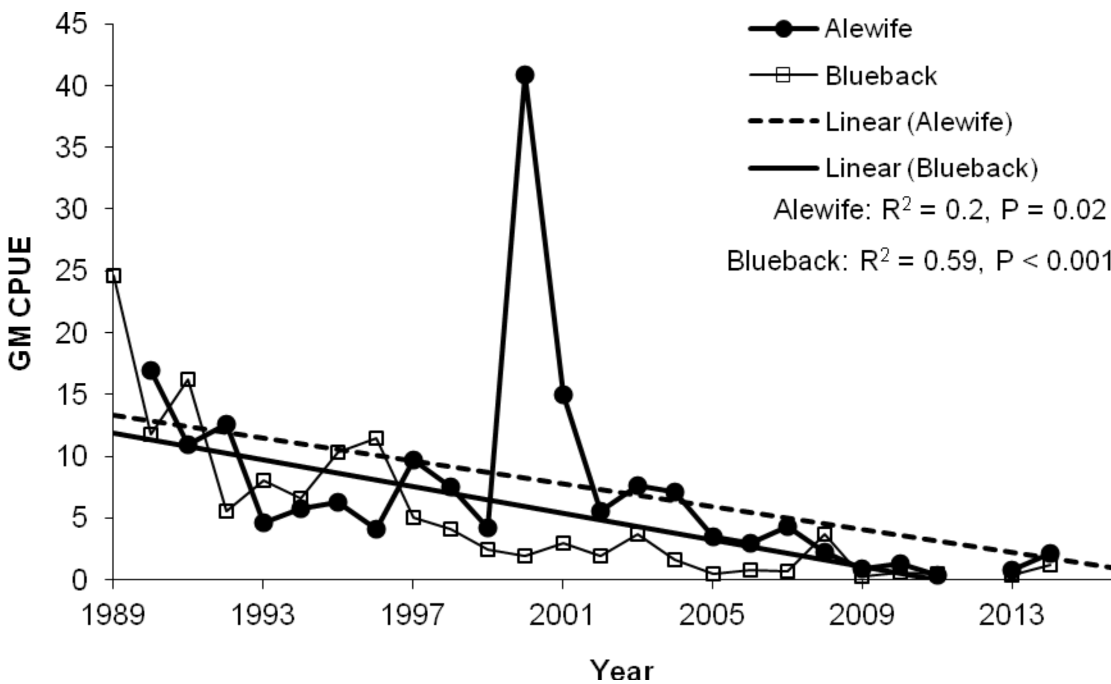


Figure 27. North East River catch per day of alewife and blueback herring, plotted with surface water temperature for 2017.

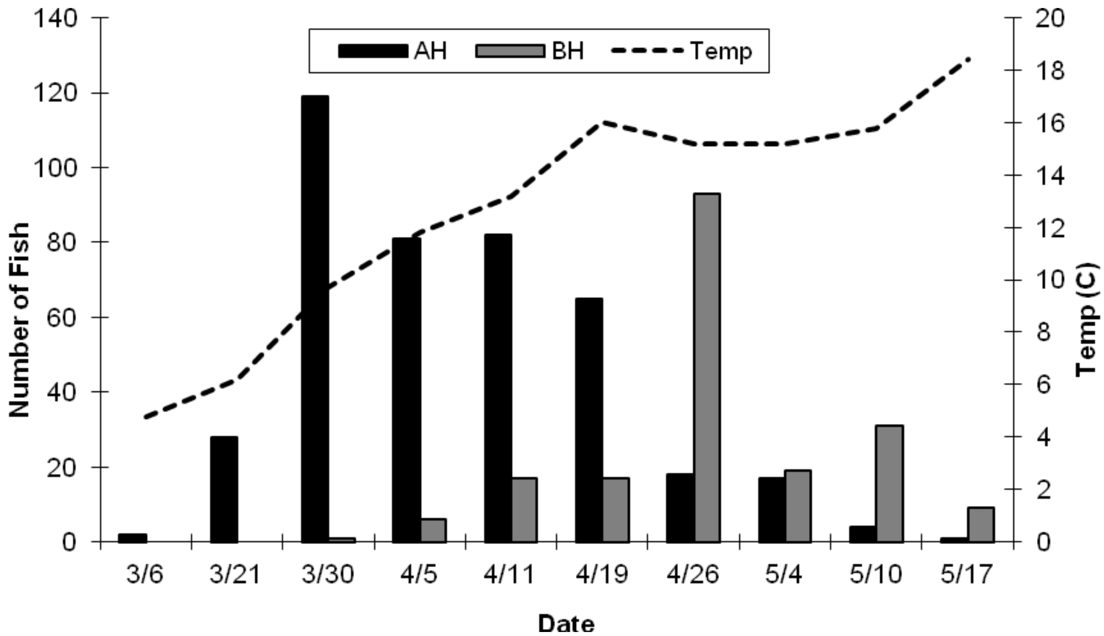


Figure 28. Percent of total catch by mesh size of alewife herring from the North East River, 2013-2017.

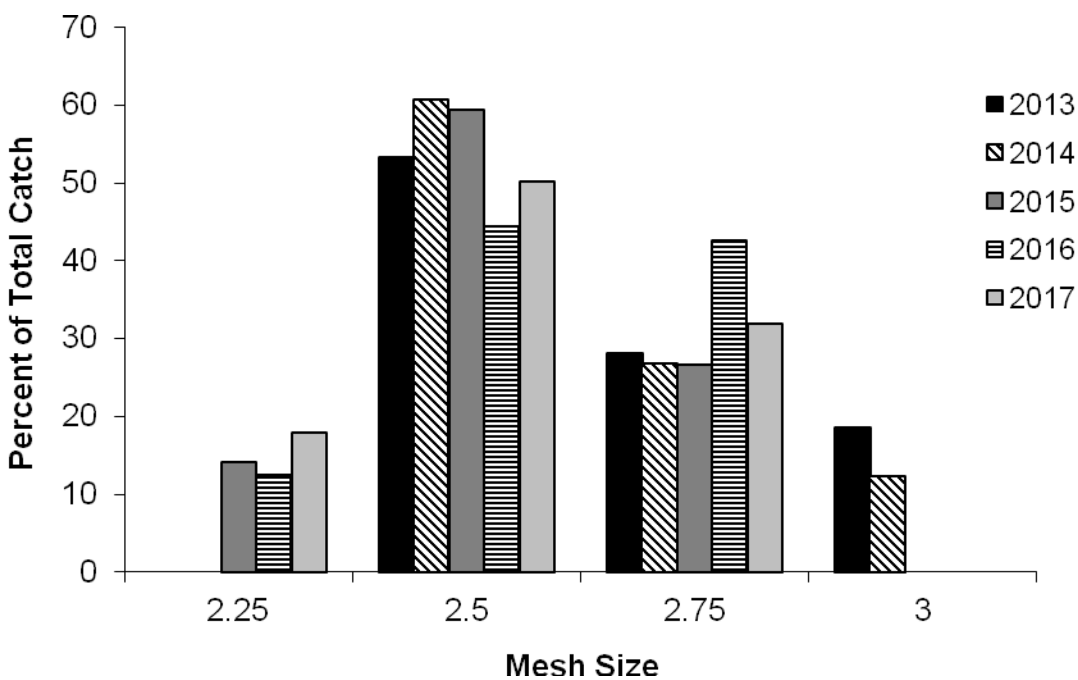


Figure 29. Percent of total catch by mesh size of blueback herring from the North East River, 2013-2017.

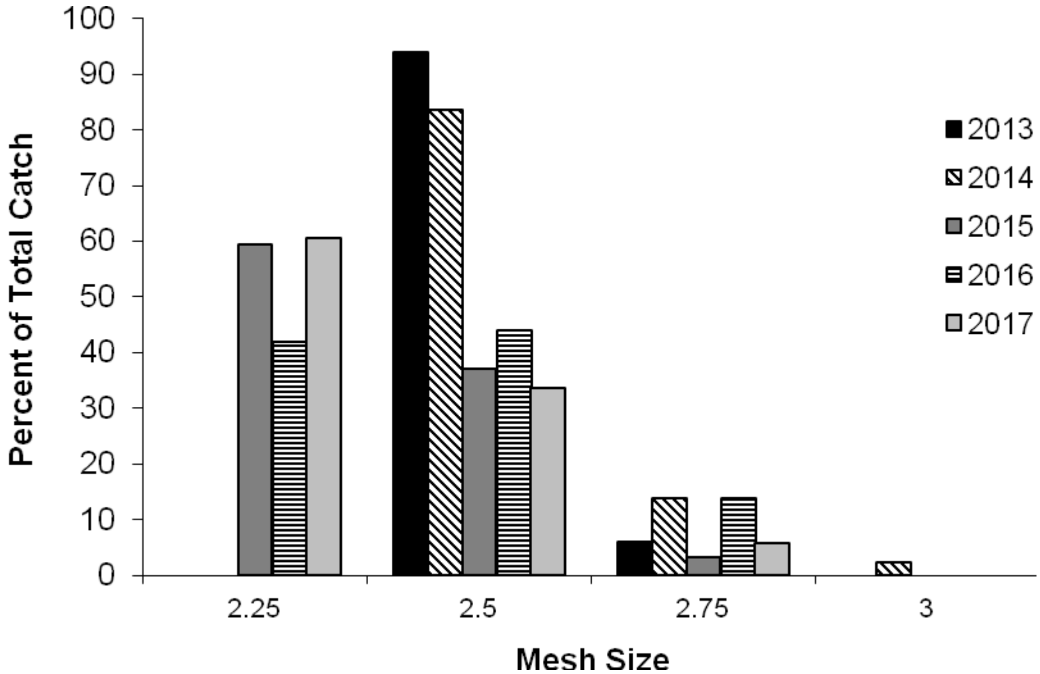


Figure 30. Alewife and blueback herring CPUE (number of fish caught per set of experimental gill net per hour fished) from the North East River gill net survey, 2013-2017. Catch was pooled across the 2.5 and 2.75" mesh panels for all years.

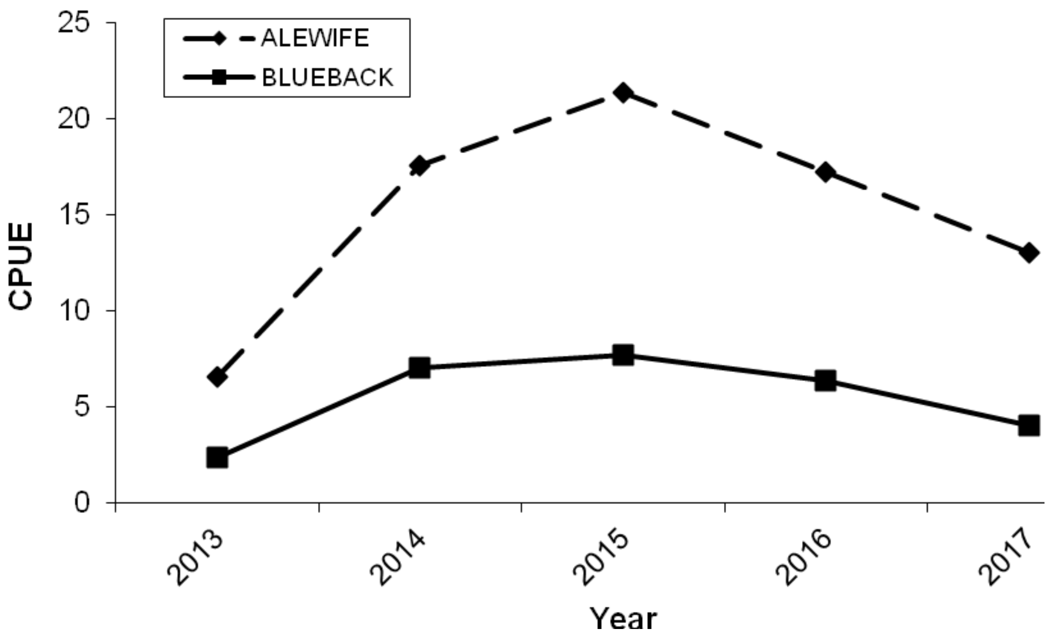


Figure 31. Upper Bay juvenile alewife and blueback herring geometric mean CPUE (catch per haul), 1959-2017.

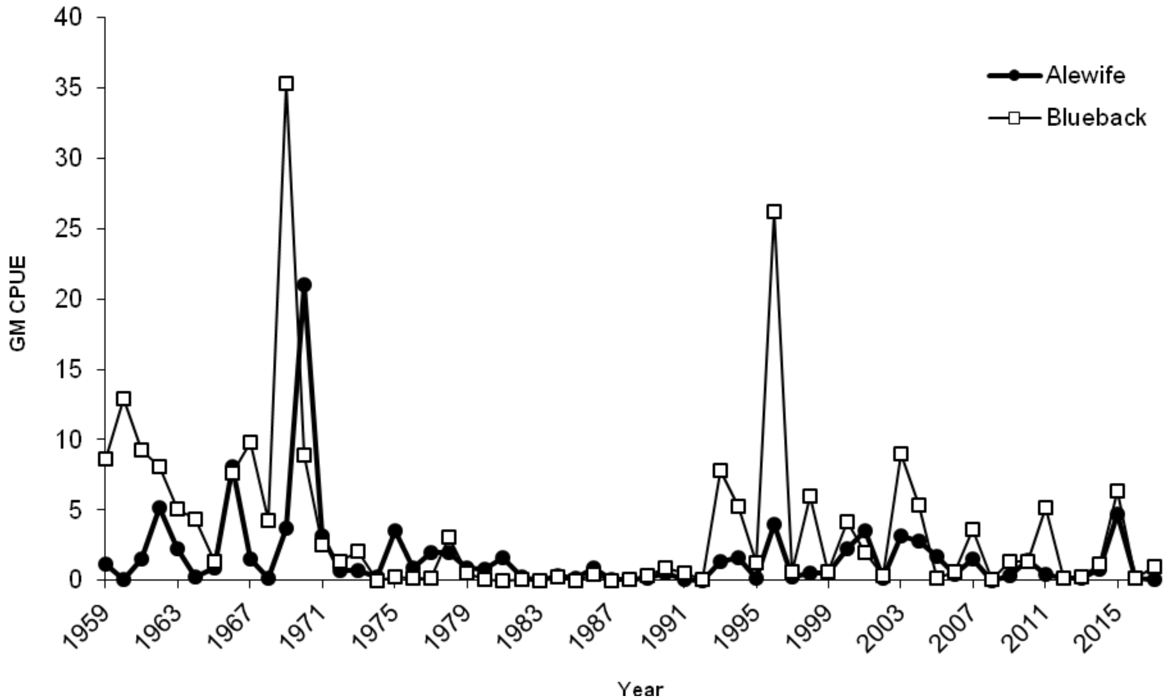
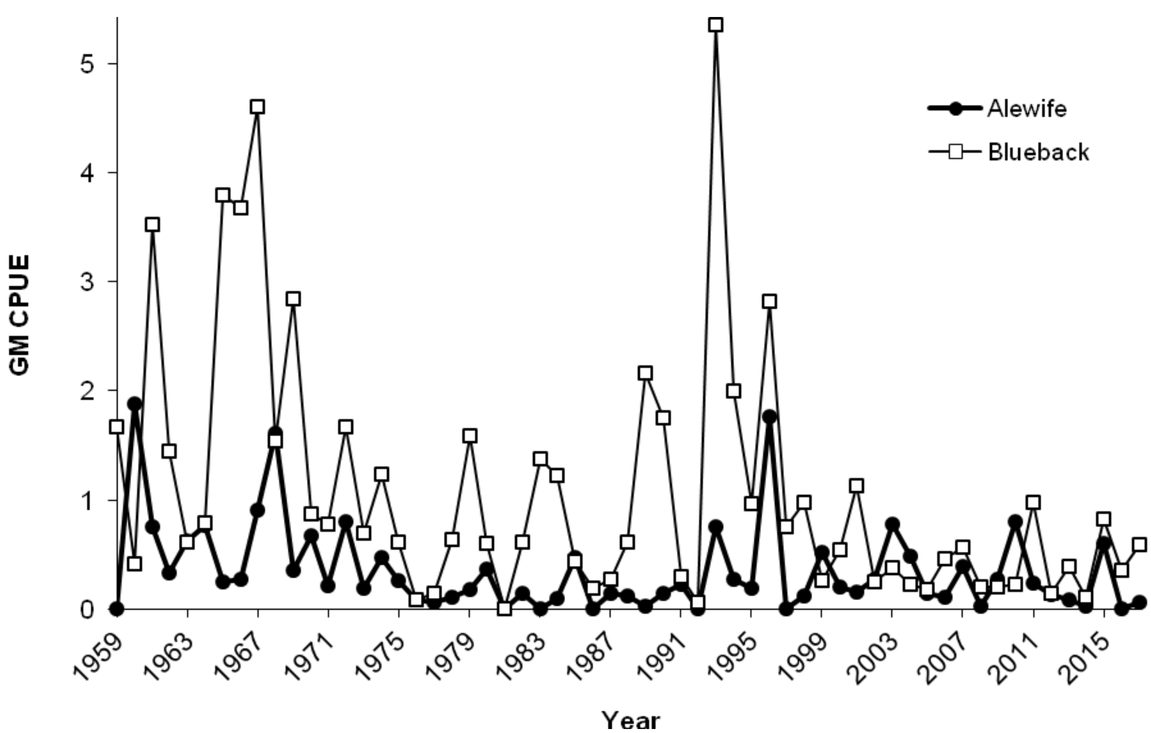


Figure 32. Nanticoke River juvenile alewife and blueback herring geometric mean CPUE (catch per haul), 1959-2017.



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 sport fish 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 sport fish (Hartman and Brandt 1995, Overton et al 2000).

The Maryland Department of Natural Resources (Department) has conducted summer pound net sampling for these species 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) and the Mid-Atlantic Fishery Management Council (MAFMC). This information is also utilized by the Department in managing the state's valuable migratory finfish resources through the regulatory/statutory process.

<u>METHODS</u>

<u>Data Collection</u>

The onboard pound net survey relies on cooperation of pound net fishermen. Pound nets from the lower Chesapeake Bay and Potomac River have been monitored throughout the 25 years of this survey (1993-2017). However, since no cooperating fishermen could be located on the lower Potomac River, sampling was not conducted in this area for 2009, but sampling resumed in 2010. In 2017 commercial pound nets were sampled inside the mouth of Potomac River and in Chesapeake Bay just north of the Potomac River (Figure 1). Each site was sampled once every two weeks, weather and fisherman's schedule permitting. The commercial fishermen set all nets sampled as part of their regular fishing routine. Net soak time and manner in which they were fished were consistent with the fisherman's day-to-day operations. There were no cooperating commercial fisherman on the eastern side of Chespaeke Bay in 2017, so fish dealer sampling was conducted on Hooper Island, from pound net harvested fish, to collect biological information from this area.

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 data base if the net was not emptied on the day of sampling or the previous day fished.

During seafood dealer sampling all specimens of the target species were measured to the nearest millimeter and weighed to the nearest gram when possible. Subsamples of 50 pound boxes of fish were sampled if sampling all individual fish was not practical. Date of capture, gear type and the location nets were set was also recorded when available.

A subsample of fish was retained and brought back to the lab for processing from both the onboard and seafood dealer sampling efforts. Otoliths were taken, and weight to the nearest gram, TL in 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 2017 were aged by Department biologists. All spot otoliths were processed and aged by the department. For all three species, the left otolith from each specimen was mounted to a glass slide for sectioning. If the left otolith was damaged, missing or miss cut the right otolith was substituted. Otoliths were mounted to a glass slide using Crystalbond® 509, and were sectioned with a Buehler IsoMet® low speed saw using two blades separated by a 0.4 mm spacer. The Buehler 15 HC diamond wafering blades are 101.6 millimeters in diameter and 0.305 millimeters thick. The 0.4 millimeter sections were then mounted on microscope slides and viewed under a microscope at five power to six power to determine the number of annuli. All age structures were read by two readers. If readers did not agree, both readers reviewed the structures together, and if agreement still could not be reached the sample was not assigned an age, except in 2013. In 2013 two readers made initial age evaluations, but due to logistical limitations only one reader reexamined structures in which annuli counts differed. 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 and spawning history using an Anacomp Inc. Micron 385 microfiche reader. In 2015 the ASMFC conducted an Atlantic menhaden aging workshop. It was determined 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 ages 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 from an imaginary line crossing from Howell Point to Jenkins Creek downstream to the river mouth (Figure 2). Sampling dates in 2013 were from mid-June to mid-September. Logistical issues in 2016 resulted in missing one week in June, one week in August and only completing two of the four sets one week in July. Sampling was extended one week into September in 2016 to help compensate for the lost sets. In 2017 only three sets were completed on one sampling day in June and one sampling day in August due to mechanical issues with the sampling vessel. The survey uses a simple random design in which the river has been divided into a block grid, with each block being a 457.2 meters 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 centimeter (2.5 inches), 7.6 centimeter (3.0 inches), 8.9 centimeter (3.5 inches) and 10.2 centimeter (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 is 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. Four sampling blocks were sampled each day beginning approximately 30 minutes prior to sunrise. A GPS unit was used to find 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 of nets the salinity (parts per thousand), secchi disk readings (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 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 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 13-millimeter-stretch-mesh cod end liner towed for six min at 4.0-4.8 kilometers/hour. The systems sampled included the Chester River, Choptank River, Eastern Bay, and 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 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, personal communication), respectively. MRIP data was downloaded on January 22, 2018. Since these data sets are not finalized until the spring of the following year, harvest data for this report are through 2016. 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. Inland waters are not separable in the MRIP online data query.

Beginning in 1993, Maryland 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. Trips in which a species was targeted but not caught could not be distinguished in the log books, since no indication of target species is given. Therefore, no CPUE was derived. All Maryland charter boat data was from Chesapeake Bay for the target species. Since the 2017 charter log book data had not been finalized, only data through 2016 was utilized for analysis.

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 millimeter TL and K= 0.08. L_c was 305 millimeter TL. Von Bertalanffy parameters for croaker mortality estimates were derived from pooled ages (otoliths; n = 3,125) determined from 2003-2017 Chesapeake Bay pound net survey data, and June through September 2003-2017 measurements of age zero croaker (n=333) from MD DNR Blue Crab Trawl Survey Tangier Sound samples (Chris Walstrum MD DNR personnel communication 2017). 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 2003-2017 were L_∞ = 384 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 coastwide 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 2017. 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 croaker in 2000 and 2002 through 2017, weakfish from 2003 through 2017 and Atlantic menhaden from 2005 through 2017. Age and length data for spot were assigned to 10 millimeter TL groups for spot then the length-at-age key was applied to the length frequency to determine the proportion at age by year for 2007 through 2017. 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.

Chesapeake Bay juvenile indices were calculated as the geometric mean (GM) catch per tow. 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 10.4 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 the Chesapeake Bay from May 23, 2017 through September 11, 2017 (Table 1). Black drum was the only target not encountered during this time period. Eighteen non-target species (Table 2) were also encountered in 2017. Seven seafood dealer sapling trips were conducted at a single dealer on the eastern shore of Chesapeake Bay from May 16, 2017 to September 7, 2017, eight of the target species were encountered. The Choptank River fisheries independent gill net survey was conducted once per week from June 7, 2017 to August 31, 2017. Six of the target species and eight non-target species were captured in 2017 (Table 3).

Weakfish

Twenty-seven weakfish were sampled in the 2017 pound net survey, a decrease from 2016 and similar to the very low 2014 and 2015 values, and well below the 25 year time series mean of 313 weakfish per year. Weakfish mean length in 2017 was 257 millimeters TL, the fourth lowest value of the time series (Table 4). The 2017 length frequency distribution remained truncated, with 74% of sampled weakfish being less than

270 millimeter TL (Figure 4). Females accounted for 67% of the 27 weakfish in which sex was determined, and had a mean length and weight of 258 millimeters TL and 177 grams. Males had a mean length and weight of 254 millimeters TL and 160g. No weakfish were encountered during seafood dealer sampling.

Chesapeake Bay weakfish length-frequencies were truncated during 1993 – 1998, while those for 1999 and 2000 contained considerably more weakfish greater than 380 millimeter TL. However, this trend reversed from 2001 to 2017, with far fewer large weakfish being encountered. Four percent of the 27 weakfish sampled in the 2017 pound net survey were above the recreational size limit of 331 millimeters TL (13 inches), and seven percent were above the commercial size limit of 305 millimeters TL (12 inches).

One weakfish measuring 338 millimeters TL was captured in the Choptank River gill net survey in 2017. Only one weakfish was captured in 2015, two in 2016 and none were encountered in 2013 or 2014 (Table 3). All four weakfish captured by the survey were in the 6.4 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 coastwide stock are likely causes of weakfish being rarely encountered by the survey.

The 2016 Maryland Chesapeake Bay commercial weakfish harvest of 61 pounds was well below the 1981 – 2016 Maryland Chesapeake Bay average of 43,676 pounds per year (Figure 5). Harvest was higher in the 1980s averaging 121,732 pounds per year, but has been extremely low the past seven years averaging 207 pounds per year. Maryland recreational anglers harvested an estimated 1,013 weakfish (PSE = 61.5) from inland waters during 2016, with an estimated weight of 635 pounds (PSE = 60.6; Figure 5). The number of weakfish harvested by the recreational fishery in 2016 was well below the time series mean harvest of 171,055 fish and, was the third lowest value of the 1981-2016 time series. According to the MRIP estimates, Maryland anglers released 80,986 (PSE = 84.1) weakfish from inland waters in 2016, a decrease compared to 2015 (117,505 PSE = 75.0), and still below the time series mean estimate of 169,137 fish per year. Estimated recreational harvest decreased steadily from 471,142 fish in 2000 to 754 in 2006, and has fluctuated at a very low level from 2007 through 2016. 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. The reported harvest from Maryland charter boat captains has ranged from 831 to 75,154 weakfish from 1993 to 2016 (Figure 6), with a sharp decline occurring in 2003, and the lowest value occurring in 2014. Reported charter boat harvest increased slightly in 2015 to 1,255 fish, was similar in 2016 at 1,154 fish, but was still the third lowest value of the 24 year time series.

The weakfish juvenile GM was stable from 2013 to 2015, with values just below the time series mean, but declined to the fourth and third lowest values of the 29 year time series in 2016 and 2017 respectively (Figure 7). Weakfish juvenile abundance generally increased from 1989 to 1996 in Pocomoke and Tangier sounds, remaining at a relatively high level through 2001, but generally decreased from 2003 to 2008, with moderate to low values since. The relatively low abundance of juvenile weakfish since 2003 is similar to that of the early 1990's, but harvest continues to be exceptionally low, unlike the higher harvest in the early 1990's.

Weakfish otoliths were collected from 27 fish in 2017. Seventy-eight percent of sampled weakfish were age one, and 22% were age two (Table 5). 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 zero to 30% age two plus fish and no age 3 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 (Table 5). The 2014 age sample size was too small to make valid comparisons (six fish). No age three plus fish were sampled in 2015 through 2017, but low sample size could have led to missed age classes.

Mortality estimates for 2006 through 2012 and 2014 through 2016 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 6), 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).

The most recent weakfish Stock Assessment Workshop, completed by ASMFC in 2016, utilized a Bayesian model with time-varying M and spatial heterogeneity (ASMFC 2016). This assessment indicated weakfish biomass was very low; F was low and M was high but decreasing in 2014, the terminal year of the assessment (ASMFC 2016). The stock was classified as depleted due to high M, not F. The stock assessment confirmed that the low commercial and recreational weakfish harvest in Maryland, and low abundance in the sampling surveys, is directly related to a very low coast wide stock abundance.

Summer flounder

Summer flounder pound net survey mean lengths have varied widely from 2004-2017. 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 4). The 2017 mean length was influenced by an unusually large number of small flounder. The length frequency distributions from the onboard sampling from 2004-2012 were either bimodal with peaks at the 130 to 150 and between 310 to 430 millimeter TL length groups, or more normal in distribution with a singular peak between the 310 to 430 millimeter TL length groups (Figure 8). 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 length distribution was bimodal, with 56% of sampled flounder below 150 millimeters TL (Figure 8). Recreational size limits have been adjusted annually, but comparing the onboard pound net survey catches to the 2017 recreational size limit of 407 millimeter TL indicated two percent of the 394 sampled flounder were of legal size in 2017, compared to none in 2016, 14% in 2015, 4% in 2014 and 11% in 2013.

Seventeen summer flounder were measured during fish house sampling in 2017, with a mean total length of 392 millimeters (Table 7). Weights were taken from 14 of the measured fish, with a mean weight of 636 grams. Smaller flounder were absent from the length frequency distribution, since these were post-harvest fish (Figure 9). All dealer measured fish were from a relatively narrow size band, with no 450 millimeter or larger fish present.

In 2017 five summer flounder were captured in the Choptank River gill net survey ranging in length from 170 to 259 millimeters TL. Three specimens were captured in the 6.4 centimeter mesh and one each in the 7.6 and 8.9 centimeter meshes. Only four summer flounder were encountered in the previous four years of the survey.

The 2016 Maryland Chesapeake Bay commercial summer flounder harvest totaled 910 pounds, the lowest value of the 1981 – 2016 time series (Figure 10). 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 Maryland Chesapeake Bay landings steadily decreased from 2005 to 2016, with the exception of an increase in 2014 (Figure 10). The recreational inland harvest estimate of 9,197 fish (PSE = 30.0) caught in 2016 was a decrease from the 2015 estimate of 21,392 fish (PSE = 26.3) fish, and the lowest value of the time series (Figure 10). The 2016 MRIP recreational inland waters release estimate of 347,558 fish (PSE = 31.1) increased compared to 2015 (200,760 fish, PSE = 31.9; Figure 10). The recreational inland fishery has primarily been from the Maryland coastal bays in recent years. Regulations have been more restrictive in the past 10 years than earlier in the time series.

Reported summer flounder charter boat harvest has been variable, but generally increased to the time series high of 14,371 fish in 2010 from the 2003 low of 1,051 fish (Figure 11). The harvest decreased and stabilized at just over 5,000 pounds from 2012 to 2016, except for slightly higher landings in 2015 (8,208 fish).

A coast wide stock assessment using the Age Structured Assessment Program (ASAP) was conducted in 2013, (NFSC 2013), with a terminal year of 2012. The NMFS assessment concluded that summer flounder stocks were not overfished, and overfishing was not occurring. An update of the 2013 assessment, with data through 2015, was conducted in 2016 (Terceiro 2016), and indicated the stock was not overfished, but overfishing was occurring. Projection analysis for 2016-2018 indicated if F is reduced to the target for 2016-2018 the stock would not become overfished, but would be right at the threshold value for 2016.

Bluefish

Bluefish sampled from the onboard pound net survey averaged 299 millimeters TL during 2017, the 10th lowest value of the 25 year time series (Table 4). The pound net survey length frequency distributions have been bimodal most years (Figure 12). The 2005-2007 pound net sampling indicated a small shift to a larger grade of bluefish, although small bluefish still dominated the population. This trend reversed in 2008 through 2011 when larger bluefish became scarce. The 2012-2015 length structure was similar to those of 2005-2007, but fewer larger fish were sampled in 2016 and 2017, which had distributions similar to those of 2008 and 2009. 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 sampled from seafood dealer sampling had a mean length of 405 millimeters Tl (n = 172; Table 7.), and a mean weight of 603 grams (n = 82). One blue fish with a length of 962mm could not be weighted do to exceeding the limits of the scale, so mean weight is biased slightly low. The seafood dealer length frequency indicates fishermen are selecting bluefish that are 330 millimeters or greater (Figure 13). Seventy-five percent of bluefish from onboard pound net sampling (pre-harvest) were below this selection limit, indicating a high discard rate for bluefish in the 2017 pound net fishery.

Bluefish have been captured in low numbers all five years of the Choptank River gill net survey, with only three being captured in 2016 and 2017 (Table 3). Catches were slightly higher in the first three years of the survey, ranging from seven to 21 per year. Bluefish lengths for all panels and years combined ranged from 218 to 500 millimeters TL (n=45), with the three from 2017 being toward the high end of the range (387 – 452 millimeters). Sample size was too small to make meaningful comparisons to length by net mesh size. Bluefish were most often captured in the 6.4 millimeter mesh panel in 2013 and 2015 with the 7.6 millimeter mesh panel accounting for the second highest catch in those years and all of the catch in 2016 (Figure 14). The three specimens in 2017 were captured in the 7.6 and 8.9 millimeter mesh panels.

Maryland bluefish Chesapeake Bay commercial harvest in 2016 was 5,026 pounds, the lowest value in the 1981-2016 time series, and below the average of 111,999 pounds per year (Figure 15). Chesapeake Bay commercial landings were higher in the 1980s averaging 321,402 pounds per year, but have been variable since and only averaging 43,999 from 1990 to 2016 (Figure 15). Recreational inland harvest estimates for bluefish were high through most of the 1980's, but have fluctuated at a lower level since 1991 (Figure 15). The 2016 estimate of 110,064 fish (PSE = 38.2) harvested increased compared to 2015, but was still the third lowest estimate of the 1981-2016 time series (Figure 15). Estimated inland recreational releases were 129,141 fish (PSE = 44.2) in 2016, well below the time series mean of 397,425 fish (Figure 15). Reported bluefish harvest from charter boat logs ranged from 12,692 – 134,828 fish per year from 1993 to 2016, with the 2016 harvest being the lowest of the 24 year time series (Figure 16).

A stock assessment of Atlantic coast bluefish utilized ASAP in 2015, a forward projecting catch at age model utilizing data through 2014 (NFSC 2015). The assessment indicated that F was high in the late 1980s and early 1990s, declined into the late 1990s, remained fairly stable through 2010, and has declined slightly through 2014. Spawning stock biomass decreased through the 1980s and early 1990s, and has generally increased since, in response to decreased fishing Mortality. The model indicated that overfishing is not occurring and that the stock is not overfished.

Atlantic croaker

Atlantic croaker mean length from the onboard pound net survey was 258 millimeters TL in 2017, and was the fourth lowest value of the 25 year time series (Table 4). The onboard pound net length frequency distribution for 2017 was very similar to the 2016 distribution, with 60% of all sampled fish in the 230 and 250 millimeter TL length groups combined, and less than one half of a percent of sampled croaker in the 350 millimeter and larger length groups combined (Figure 17).

Mean lengths and weights by sex for Atlantic croaker sampled from the onboard pound net survey increased in 2017, with values of 273 millimeters TL and 296 grams for females (n = 109) and 260 millimeters TL and 238 grams for males (n = 90). Pound net samples were 55% female and 45% male. Samples, in which sex determination and weight were taken, were not randomly selected; therefore sex specific data may be biased.

Atlantic croaker sampled from seafood dealers had a mean total length and weight of 262 millimeters (n = 767) and 270 grams (n = 737) respectively (Table 7). The length frequency distribution from the seafood dealer caught fish was very similar to the onboard sampling in 2017, except for fewer fish in the 210 millimeter and smaller size groups due to the nine inch minimum size limit (Figure 18).

Atlantic croaker catches from the Choptank River gill net survey declined through the first three years of the survey, 476 fish in 2013, 269 fish in 2014 and 21 fish in 2015. Atlantic croaker catches remained low in 2016 and 2017, with 32 and 53 fish being captured respectively. Anecdotal reports from commercial and recreational fishermen indicated croaker catches were unusually low from the Choptank River north in 2015 through 2017, but catches were not as poor in lower Tangier Sound and the Potomac River. The decreased catches since 2015, coupled with declining landings, indicate decreased abundance in the mid to upper bay in recent years. 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 19). 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 sized increased (Figure 20). Year to year length frequency comparisons were not made do to the low sample sizes in 2015 through 2017.

The 2016 Maryland Atlantic croaker Chesapeake Bay commercial harvest of 78,907 pounds was a 66% decrease from 2015, fell below the 1981 to 2016 mean of 390,502 pounds, and was the lowest value since 1992 (Figure 21). The 2016 recreational inland harvest estimate was 185,842 fish (PSE = 19.5) a 76% decrease from 2015, and well below the 1981-2016 average of 681,861 fish (Figure 21). The 2015 recreational release estimate of 244,461 fish decreased 60% compared to 2015 (Figure 21), and was well below the 1981-2016 average of 1,188,938 fish. Reported Atlantic croaker harvest from charter boats ranged from 12,491 – 448,789 fish per year during the 24 year time period (Figure 22), with the low value occurring in 2016. 2016 was the seventh consecutive year of declining reported charter boat harvest.

Since 1989, the Atlantic croaker juvenile indices have varied without trend, with the highest values occurring in the late 1990s. This index increased to the third highest value of the 29 year time series for 2008, but fell sharply in 2009 and remained low through 2011, before spiking again in 2012 (Figure 23). The GM steadily decreased the following three years to the 2^{nd} lowest value of the time series in 2015 (0.21 fish per tow). The index value increased to 2.35 fish per tow in 2017, which is near 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 onboard pound net survey caught Atlantic croaker otoliths in 2017 ranged from zero to six (n=230; Table 8). The number of Atlantic croaker sampled for length in 2017 (n=2,064) was applied to an age-length key for 2016 (Table 8). This application indicated that 47% of the fish were age five, 20% were age four, and 18% were age three. The remaining age groups each accounted for six percent or less of the fish sampled (Table 8). Age structure in 2017 was truncated to younger fish, with no age seven plus fish and 66% of sampled fish coming from the 2012 and 2013 year classes. Atlantic croaker typically recruit to the fishery at age two, with full recruitment occurring at age three or four. The contribution of strong year classes (1998, 2002, 2006, 2008 and 2012) to the catch can be seen in Table 8. Age was determined for 112 croaker from seafood dealer sampling, with ages one through six being present. The age structure of the seafood dealer sampled fish was applied to the seafood dealer length frequencies. After this application, age five accounted for 53% of sampled fish, age four 20%, age three 15% and age one 5%, with all other ages accounting for 3% or less of sampled fish (Table 9).

Instantaneous total mortality estimates in 2017 using Maryland growth parameters and ASMFC stock assessment growth parameters were Z = 1.45 and Z = 1.00, respectively (Table 6). Both sets of estimates indicate the same trend, with the Maryland only growth parameters indicating a larger range of values (Figure 24). Total mortality estimates were relatively stable at a low level from 1999 through 2009. From 2010 to 2014 estimates of Z increased rapidly and have been more variable, but generally increasing, since 2014. Recruitment has generally been poor in recent years, leading to increase mortality rates on recent year classes, and fewer fish reaching older age, or larger lengths.

In 2017, the ASMFC Atlantic Croaker Technical Committee completed a stock assessment using a statistical catch at age model using 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 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 has tasked the Atlantic Croaker Technical Committee to explore revisions to the TLA following the assessment. That work should be completed in 2018.

Spot

The 2017 spot mean length from the onboard sampling of 200 millimeters TL was near the time series mean of 202 millimeters, and increased from the lowest value of the 25 year time series in 2016 (Table 4). Sixty-five percent of spot encountered in the onboard pound net survey in 2017 were between 190 and 229 millimeters TL, a shift to larger sizes and an overall all expansion of the length frequency distribution (Figure 25). Only two jumbo spot (>254 millimeter TL) were present in the 2017 onboard sampling (total measured = 1,063). Abundance of jumbo spot in the survey has been low for the past several years (0-3% of sample, 2005-2017). This followed good catches in the early part of the decade (10% in 2003, 13% in 2004).

The length frequency distribution and mean length from seafood dealer sampling indicated larger croaker are being harvested by the pound net fishery than observed during onboard sampling (Figure 18, Table 7). This would be expected as smaller spot are not desirable as marketable as food fish.

Spot catch in the Choptank River gill net survey was highest in 2014 (749 fish) and similar in 2013, 2015 and 2017 (272, 222 and 298 fish, respectively), and lowest in 2016 (109 fish). The 6.4 centimeter mesh captured the majority of spot each year (Figure 26), accounting for over 95% of catch in 2013, 2014 and 2016, and accounted for 73% and 78% 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 three spot were captured in the 8.9 centimeter mesh in 2013, 2015 and 2017, and no spot were captured in the 10.5 centimeter mesh through the five year time series. Length frequency distribution was similar in 2013 and 2014 with the 200 and 210 millimeter length groups combined accounting for over 60% of catch each of those years (Figure 27). The distribution shifted toward larger fish in 2015, with only 24% of captured fish in the 200 and 210 millimeter length groups combined. The length distribution shifted to smaller fish in 2016 with 74% of captured spot being less than 200 millimeter TL, but returned to a broader distribution in 2017. These shifts are likely driven by a decrease in availability of younger spot in 2015 and older spot in 2016 due to below average recruitment, as discussed below. Large shifts in length distribution are not uncommon in short lived species, such as spot.

Commercial harvest from Maryland's portion of Chesapeake Bay remained stable in 2013 and 2014, 257,881 and 254,443 pounds respectively (Figure 28), but declined to 62,251 pounds in 2015, and to 17,760 pounds in 2016, the fourth lowest value of the 36 year time series. Maryland recreational inland harvest estimates from the MRIP indicated that spot catches since 1981 have been highly variable (Figure 28). Recreational harvest ranged from 277,964 fish in 1988 to 3,766,055 fish in 1986, while the number released fluctuated from 208,897 in 1996 to 2,615,298 in 2013 (Figure 28). The 2016 recreational inland waters harvest estimate of 466,856 fish (PSE = 38.1) was below the time series mean estimate of 1,483,039 fish. The release estimate of 228,912 fish (PSE = 37.1) was below the time series mean of 1,002,025 fish (Figure 28). Reported spot charter boat logbook harvest from 1993 to 2016 ranged from 121,411 to 848,492 fish per year (Figure 29). The 2016 reported harvest was the lowest of the time series, well below the time series mean of 455,637 fish.

Spot juvenile trawl index values from 1989-2016 were quite variable (Figure 30). 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 26 year time series, and the 2012 value increased to nearly the time series mean (Figure 30). The index values have declined since 2012 to the time series low in 2015 (0.29 fish per tow). The index values increased in 2016 and 2017 (2.02 fish per tow in 2017), but were still below average.

In 2017 80.5% of spot sampled from the onboard pound net survey were age one, 19.1% were age zero, and 0.3% were age two (228 ages and 1,063 lengths; Table 10). Age two spot were not encountered in 2016 and remained rare in 2017. Age one spot dominated the pound net catch from 2007 to 2011, accounting for 75% to 99% of sampled fish. During this same time period, age zero and age two fish were present every year, with age zero accounting for 0.4% to 24.3% of sampled spot and age two accounting for 0.2% to 3.3%. Two fish, sampled for length only, in both 2007 and 2011 were in length groups four to six centimeters larger than available Maryland DNR samples. In both cases age length information from spot aged by VMRC were used. These were the only fish in the three and four year old age classes throughout the time series. Spot ages from the seafood dealer sampling indicated 98.6 % of harvested spot were age one, with the reaming 1.4 % being age zero.

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, decrease in mean size and reduction in percent jumbo spot observed in 2005 through 2016 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, and the continued low abundance of age two fish, and lack of age three plus fish, is likely due to below average year classes since 2012. The 2017 year class did improve compared to 2015 and 2016, but was still below average and will likely lead to continued lower availability of adult spot in 2018.

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 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 has tasked the Spot Plan Review Team to explore revisions to the TLA following the assessment. That work should be completed in 2018.

<u>Red Drum</u>

Red drum have been encountered sporadically through the 25 years of the onboard pound net survey, with none being measured in nine years and 458 being measured in 2012 (Table 4). Nineteen red drum were measured in 2017 averaging 549 millimeters TL and ranging from 333 to 655 millimeters TL. Recreational anglers in Maryland are allowed one red drum between 18 and 27 inches in length. Fourteen of the pound net caught fish fell within the slot limit, indicating there likely was a greater than normal opportunity, although still very limited, for anglers to encounter a legal size fish in 2017. Two red drum were encounter during fish dealer sampling with a mean length of 598 millimeters TL (Table 7).

Maryland Chesapeake Bay commercial fishermen reported harvesting 70 pounds of red drum in 2016, compared to the 2013 spike of 2,923 pounds, and the 1981 to 2016 mean of 500 pounds per year (Figure 31). The high 2013 landings value was likely due to a large year class growing into the 18 – 25 inch slot limit.

The MRIP 2016 Maryland inland waters recreational harvest and release estimates were zero and 15,414 (PSE = 50.2) red drum respectively (Figure 31). Recreational harvest estimates have been extremely variable with zero harvest estimates for 27 of the 37 years, and very high PSE values. 2012 recreational release estimates 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, but catches returned to lower levels beginning in 2013.

Maryland charter boat captains reported harvesting red drum in every year from 1993-2016, except for 1996. Harvest was low for all years, ranging from zero to a high of 271 fish in 2012, with nineteen red drum being harvested in 2016 (Figure 32). 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 for red drum and catches of legal size fish would be expected to increase if the stock expands in response to the current Atlantic coast stock recovery plan (ASMFC 2002).

Black Drum

Black drum are only occasionally encountered during the Department onboard pound net sampling, with none being sampled in 2017 (Table 4). Lengths throughout the time series have ranged from 244 to 1,330 millimeters TL. Commercial harvest of black drum was banned for Maryland's portion of Chesapeake Bay in 1999 (Figure 33). Recreational inland water harvest and release estimates from 1981 to 2016 have been variable, with harvest ranging from zero (20 years) to 13,308 fish in 1983 (Figure 33). In 2015, MRIP estimated 190 black drum were harvested (PSE = 70.3), and 107 were released (PSE = 100.6). 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. Charter boat logs indicated black drum were harvested in all years of the 1993-2016 time series, with a mean catch of 369 fish per year (range = 20 – 905; Figure 34). Twenty black drum were reported as harvested in 2016.

Spanish Mackerel

Spanish mackerel have been measured for FL, TL or both each year of the onboard pound net sampling. Since 2001, however, the majority of samples have been FL only, 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 – 681 millimeters. Only nine Spanish mackerel were encountered in 2017. The number of mackerel measured has been low for most years with the largest samples occurring from 2005-2007 and in 2013 (Table 4). Thirty-five Spanish mackerel were sampled during fish house sampling with a mean length of 455 millimeters FL. No Spanish mackerel were encountered in the gill net survey in 2017.

The 2016 commercial harvest of Spanish mackerel in Maryland’s portion of Chesapeake Bay was 1,916 pounds (Figure 35), and below the 1981 to 2016 mean of 4,820 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 peaked in 1993 and 1994 with approximately 43,000 fish harvested both years (Figure 35). This followed a period of eight out of twelve annual estimates with zero fish captured. Harvest estimates for 1998 – 2016 were variable, ranging from 0 – 20,049 fish with an average of 7,873 fish taken. The 2016 estimated recreational Spanish mackerel harvest of 11,465 fish (PSE = 51.2) was similar to the 2015 estimate of 11,366 fish (Figure 35). Most years have a high PSE values, these estimates are considered tenuous. Spanish mackerel charter boat harvest from 1993 to 2016 ranged from 53 – 10,653 fish per year, with a harvest of 732 fish in 2016 (Figure 36). 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 rarely encountered during sampling, with annual observations ranging from zero (11 years) to 23 fish. Three were measured from the onboard pound net survey in 2017 ranging from 426 to 522 millimeters TL (Table 4). Commercial harvest of spotted seatrout in Maryland's portion of Chesapeake Bay averaged 2,949 pounds from 1981-2016, however, 11 of 12 years had zero harvest from 1981-1992 (Figure 37). Reported 2016 commercial harvest was 12 pounds. Recreational harvest estimates for inland waters indicated a modest variable fishery during the mid-1980s through the mid-1990s. Estimated harvest averaged 19,602 fish per year from 1986 to 1999, but was low from 2000 to 2016, including six years of zero harvest, and averaged 2,538 fish per year (Figure 37). The 2016 harvest estimate was 2,813 fish (PSE 102.8). The high PSE values from 2009 to 2016 indicate the MRIP survey does not provide reliable estimates for this species in Maryland.

Spotted seatrout harvest from 2016 charter boats was 10 fish. Reported harvest ranged from 10 – 20,030 fish per year and averaged 3,081 fish per year for the 22 year time series (Figure 38). 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 approximated the time series mean coinciding with zero value estimates by MRIP.

Atlantic Menhaden

Mean length for Atlantic menhaden sampled onboard commercial pound nets in 2017 was 217 millimeters FL, the third lowest value of the 14 year time series (Table 4). Menhaden from seafood dealer sample averaged 218 millimeters FL in 2017 (Table 7). Menhaden length frequencies from onboard sampling have varied annually (Figure 39). The 2016 onboard pound net sampling distribution was more evenly distributed than previous years, but the 2017 distribution was dominated by the 190 and 210 millimeter size groups (Figure 40). Seafood dealer sampling distribution was more evenly distributed in 2017 than the onboard sampling, even though the mean lengths were nearly identical.

Menhaden was the most common species captured by the Choptank River gill net survey, with annual catches ranging from 1,171 fish (2016) to 2,247 fish (2014; Table 3). The 7.6 centimeter mesh and the 6.4 centimeter mesh combined accounted for over 70% of the catch annually (Figure 41). The 7.6 centimeter mesh caught the highest proportion of menhaden from 2014 through 2015, and the 6.4 centimeter mesh the highest in 2016 and

2017. Length frequency distributions from the Choptank River gill net survey indicated the gear selects slightly larger menhaden than the pound net survey (Figure 42), with the 230 and 250 millimeter length groups combined accounting for over 60% of the catch annually. There was a shift to smaller lengths in 2017 compared to previous years. Mean lengths for all meshes combined displayed little inter annual variation from 2013-2016: 2013 = 254 millimeters FL (n = 278), 2014 = 256 millimeters FL (n = 459), 2015 = 258 millimeters FL (n = 420) and 2016 = 254 millimeters FL (n = 308). Mean length did decrease to 243 millimeters (n = 361) in 2017.

Atlantic menhaden scale samples were taken from 300 fish in 2017 from the onboard pound net survey and fish dealer samples from the pound net fishery, but ages could only be assigned to 295 fish (Table 11). After applying the annual length frequencies (1,058 lengths) to the corresponding age length keys, 44% of sampled fish were age two, 43% were age one, and ages three through five were also present. Corrections in Maryland's assigning of annuli following the 2015 ASMFC Atlantic menhaden aging workshop likely have reduced the age estimates of some fish from 2015 to 2017 compared to the method used in previous years. One hundred sixty-seven scale samples were taken for age from the Choptank River gill net survey in 2017, but age could only be assigned to 163 individuals. Age two accounted for 53% of sampled fish, age three accounted for 29%, age four accounted 9%, age one accounted for 7% and age five accounted for 2% of sampled menhaden (Table 12). Commercial pound nets and gill nets used in the Choptank River survey select slightly different ages. The gill net survey had fewer age one fish all years, and a higher proportion of age three plus fish in all years.

Average annual Atlantic menhaden commercial harvest in Maryland's portion of Chesapeake Bay was 6.7 million pounds from 1981 to 1989, 3.2 million pounds from 1990 to 2004 and 7.9 million pounds from 2005 to 2016 (Figure 43). 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. Maryland's 2015 Chesapeake Bay landings of 5,346,563 pounds likely would have been higher if trip limits had not been placed on the fishery, to satisfy the ASMFC requirement. Prior to 2013 the menhaden fishery in Maryland had no restrictions, aside from general commercial fishing license requirements and regulations, including a prohibition on purse seining.

A benchmark ASMFC Atlantic menhaden stock assessment was conducted in 2014, with data through 2013, using the Beaufort Assessment Model, which is a forward-projecting statistical catch-at-age model (SEDAR 2015). Additional data sources were explored to make more accurate selectivity and catchability assumptions, and more accurate life history information was used to inform the model. These changes led to the determination that that the stock is not experiencing overfishing and was not overfished. This is in contrast to the 2009 benchmark assessments determination of an overfished status.

PROJECT NUMBER 2
JOB NUMBER 2

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

2017 PRELIMINARY RESULTS – WORK IN PROGRESS

Onboard pound net survey sampling, through the 2018 portion of the reporting period, began on May 31, 2018, and continued through June 26, 2018, with three separate sampling days and five nets sampled. During this time period the survey took length measurements from one Atlantic croaker, 228 Atlantic menhaden, eight bluefish, one cobia, one Spanish mackerel, 281 spot and seven summer flounder. Subsamples for aging were collected from one Atlantic croaker, 71 Atlantic menhaden and 39 spot. Sampling continued into the next reporting period.

In 2018 no cooperating fisherman could be located for the lower Eastern Shore area. Seafood dealer sampling was conducted on June 8, 2018, with sampling continuing into the season beyond the reporting period. This dealer purchased almost all of its fish from pound netters operating in the Hooper's Island area. No measurements were recorded on the sampling day due to no boats arriving at the fish house.

The Choptank River gill net survey was conducted on four days for a total of 16 sites form June 7, 2018 to June 27, 2018. The survey caught one Atlantic croaker, 342 Atlantic menhaden, 26 blue crabs, two bluefish, one butterfish, one channel catfish, eight harvestfish, one hogchoker, and 37 spot. Sampling continued into the next reporting period.

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Table 1. Areas sampled number of sampling trips, mean surface water temperature and mean surface salinity by month for the onboard pound net survey in 2017.

Area	Month	Number of Samples	Mean Water Temp. C	Mean Salinity (ppt)
Point Lookout	May	1	19.9	10.6
Point Lookout	June	4	25.6	11.6
Point Lookout	July	3	27.6	14.1
West Bay	July	1	28.6	13.1
Point Lookout	August	5	28.7	20.5
West Bay	August	2	28.6	13.1
West Bay	September	2	26.5	14.7

Table 2. List of non-target species observed during the 2017 onboard pound net survey.

Common Name	Scientific Name
American eel	*Anguilla rostrata*
Atlantic needlefish	*Strongylura marina*
Atlantic thread herring	*Opisthonema oglinum*
Blueback Herring	*Alosa aestivalis*
Blue catfish	*Ictalurus furcatus*
Butterfish	*Peprilus triacanthus*
Channel catfish	*Ictalurus punctatus*
Cobia	*Rachycentron canadum*
Cownose ray	*Rhinoptera bonasus*
Gizzard shad	*Dorosoma cepedianum*
Harvestfish	*Peprilus alepidotus*
Hogchoker	*Trinectes maculates*
Northern Snakehead	*Channa argus*
Northern puffer	*Sphoeroides maculatus*
Southern stingray	*Dasyatis americana*
Striped bass	*Morone saxatilis*
Striped burrfish	*Chilomycterus schoepfi*
White perch	*Morone americana*

Table 3. Total catch by species in numbers from the Choptank River gill net survey, 2013 – 2017.

Common Name	2013	2014	2015	2016	2017
Atlantic Croaker	476	269	21	32	53
Atlantic Menhaden	1,584	2,247	1,782	1,171	1,292
Black Drum	0	0	0	1	0
Blue Crab	34	44	165	127	107
Bluefish	11	22	7	3	3
Butterfish	0	2	2	0	0
Gizzard Shad	180	231	188	36	28
Harvestfish	0	0	0	2	2
Hickory Shad	0	0	0	0	1
Hogchoker	3	39	6	6	14
Northern Kingfish	1	9	0	1	1
Spanish Mackerel	0	0	0	1	0
Spot	272	749	222	109	298
Striped Bass	16	33	14	50	76
Summer Flounder	2	0	0	2	5
Weakfish	0	0	1	3	1
White Perch	18	41	55	64	67
Total Catch	2,597	3,686	2,463	1,608	1,948

Table 4. Mean length (millimeter TL, unless otherwise noted), standard deviation, and sample size of summer migrant fishes from Chesapeake Bay onboard pound net sampling, 1993-2017.

	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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
Spotted Seatrout																									
mean length		448	452			541	460								414	464	262		361	436	456	499	487	625	464
std. dev.		86	42				134								43	72	22		142	112	29	70			51
n	0	4	6	0	0	1	2	0	0	0	0	0	0	0	3	10	23	0	4	8	5	4	1	1	3
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	
std. dev.		175	454	20		182				190	20	212		228	95	238	84	345	188		236	150	171	429	
n	0	2	3	2	0	12	0	0	0	7	4	44	1	8	9	5	13	3	3	1	4	14	4	4	0

Table 4. 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
Red Drum																									
mean length						302	332	648		316	506	647	353	366	658	361			678	318	469	954		340	549
std. dev.							71			44		468		21	40	57			18	71	39			10	105
n	0	0	0	0	0	1	16	1	0	177	1	2	1	16	2	21	0	0	2	458	16	1		3	19
Spanish Mackerel (Total Length)																									
mean length	261	391	487	481	520	418	468	455													508		343	404	
std. dev.	114	55	38	55		45	82	66													37			53	
n	3	78	39	27	1	4	45	35													124		1	10	
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
std. dev.			34	62				34	34	81	63	95	33	35	51	59	53			74	36		41	16	54
n			44	27	1	1		49	19	20	11	8	373	445	158	18	7	0	0	107	331	1	3	10	9
Menhaden (Fork Length)																									
mean length												262	282	238	243	246	245	232	213	243	251	223	219	208	217
std. dev.												28	36	42	41	29	40	36	39	25	31	38	28	42	24
n												213	1,052	826	854	826	366	836	773	755	762	775	864	732	723

Table 5. 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 2003-2017.

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

Table 6. Weakfish and Atlantic croaker instantaneous total mortality rate estimates (Z) from Chesapeake Bay pound net data, 1999–2017.

	Growh parameters From MD only	Growh parameters From MD only	Growh parameters From ASMFC SA
Year	Weakfish	Atlantic Croaker	Atlantic Croaker
1999	0.74	0.37	0.34
2000	0.4	0.29	0.36
2001	0.62	0.25	0.28
2002	0.58	0.21	0.27
2003	0.73	0.37	0.40
2004	1.29	0.29	0.32
2005	1.44	0.25	0.27
2006	*	0.21	0.24
2007	*	0.24	0.31
2008	*	0.25	0.29
2009	*	0.40	0.38
2010	*	0.56	0.47
2011	*	0.69	0.55
2012	*	0.69	0.89
2013	1.55	0.76	0.83
2014	*	1.45	1.02
2015	*	1.27	0.87
2016	*	1.64	1.11
2017	*	1.45	1.00

* Insufficient sample size to calculate 2006 – 2012, 2014 - 2017 weakfish estimates.

Table 7. Mean length (millimeter TL, unless otherwise noted), standard deviation, and sample size of summer migrant fishes from Chesapeake Bay onboard seafood dealer sampling in 2017.

Species	Mean Length	SD	n
Summer flounder	392	28	17
Bluefish	405	71	172
Atlantic croaker	262	26	761
Spot	213	19	425
Spotted Seatrout	381	52	7
Red Drum	598	45	2
Spanish Mackerel (Fork Length)	455	59	35
Menhaden (Fork Length)	218	27	285

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, 1999-2017.

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

Table 9. Percentage of Atlantic croaker by age and number of age samples using seafood dealer sampling length and age data from 2017.

Age	0	1	2	3	4	5	6	7
n	23	39	5	120	149	398	26	0
%	2.99	5.16	0.71	15.83	19.64	52.28	3.40	0.00

Table 10. 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, 2007-2017.

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

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, 2005-2017.

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

Table 12. Atlantic menhaden percentage at age, number of age samples and number of length samples by year using, gill net length and age data, 2015-2017.

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

Figure 1. Onboard pound net survey and fish house sampling site locations for 2017.

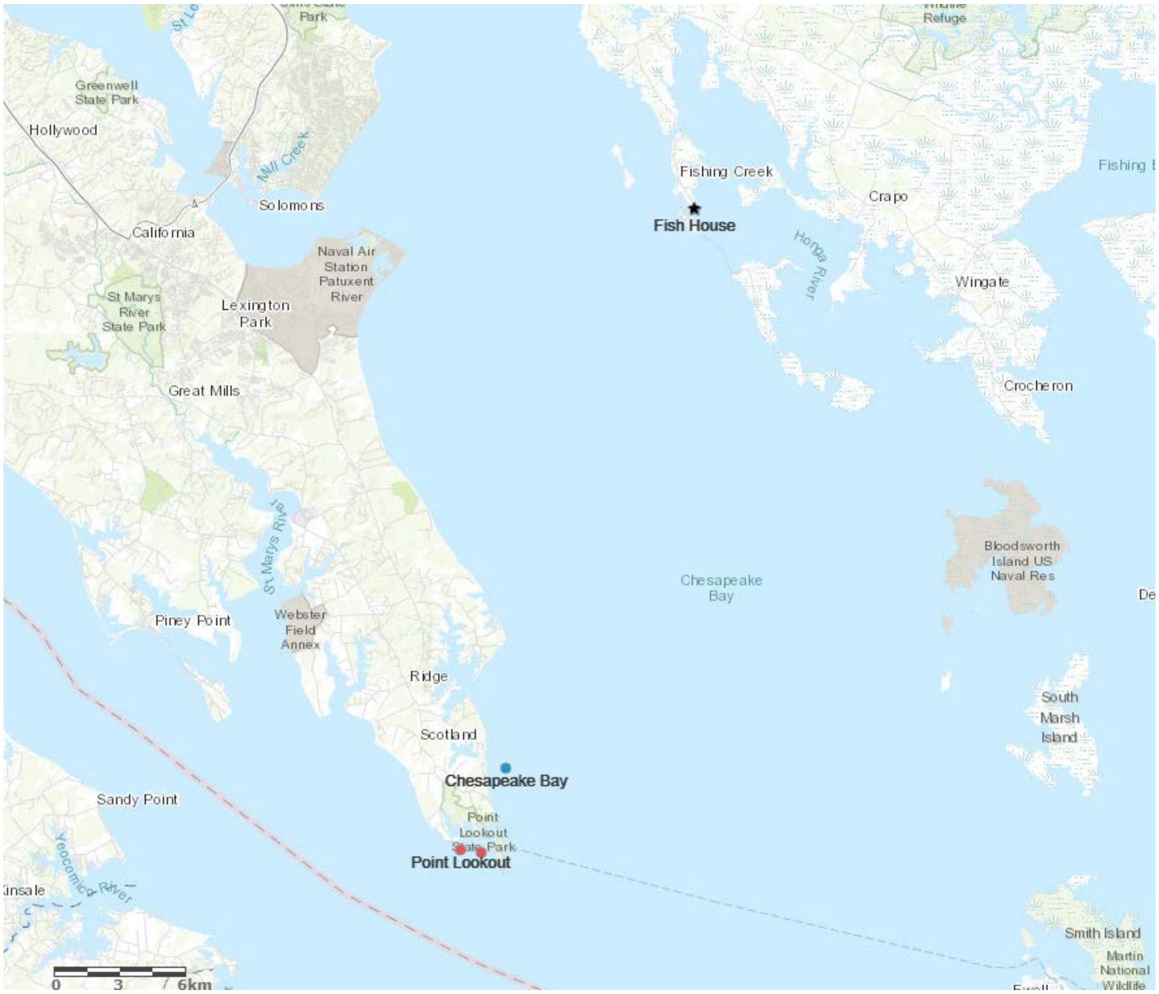


Figure 2. Choptank River gill survey net sampling site locations for 2017.

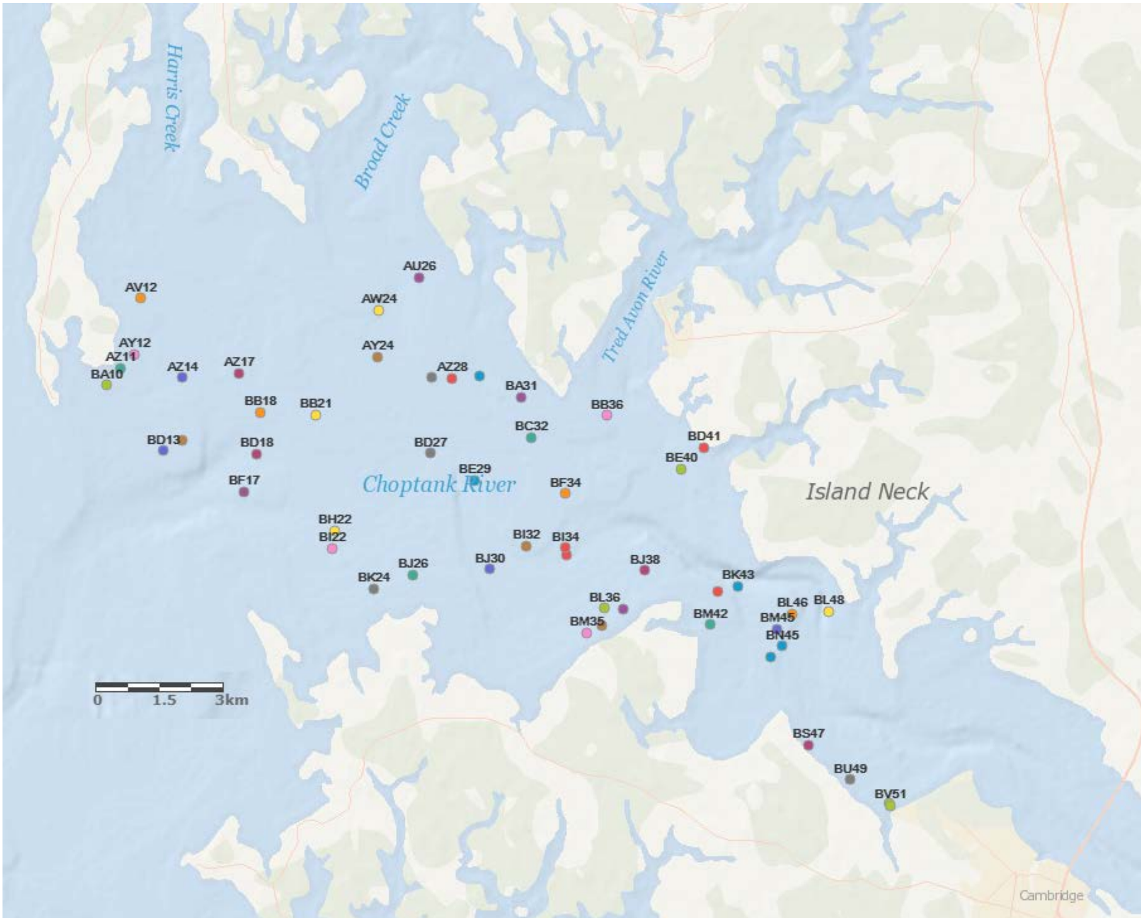


Figure 3. Choptank River gill net survey sampling grid and grid names used in all years of the survey.

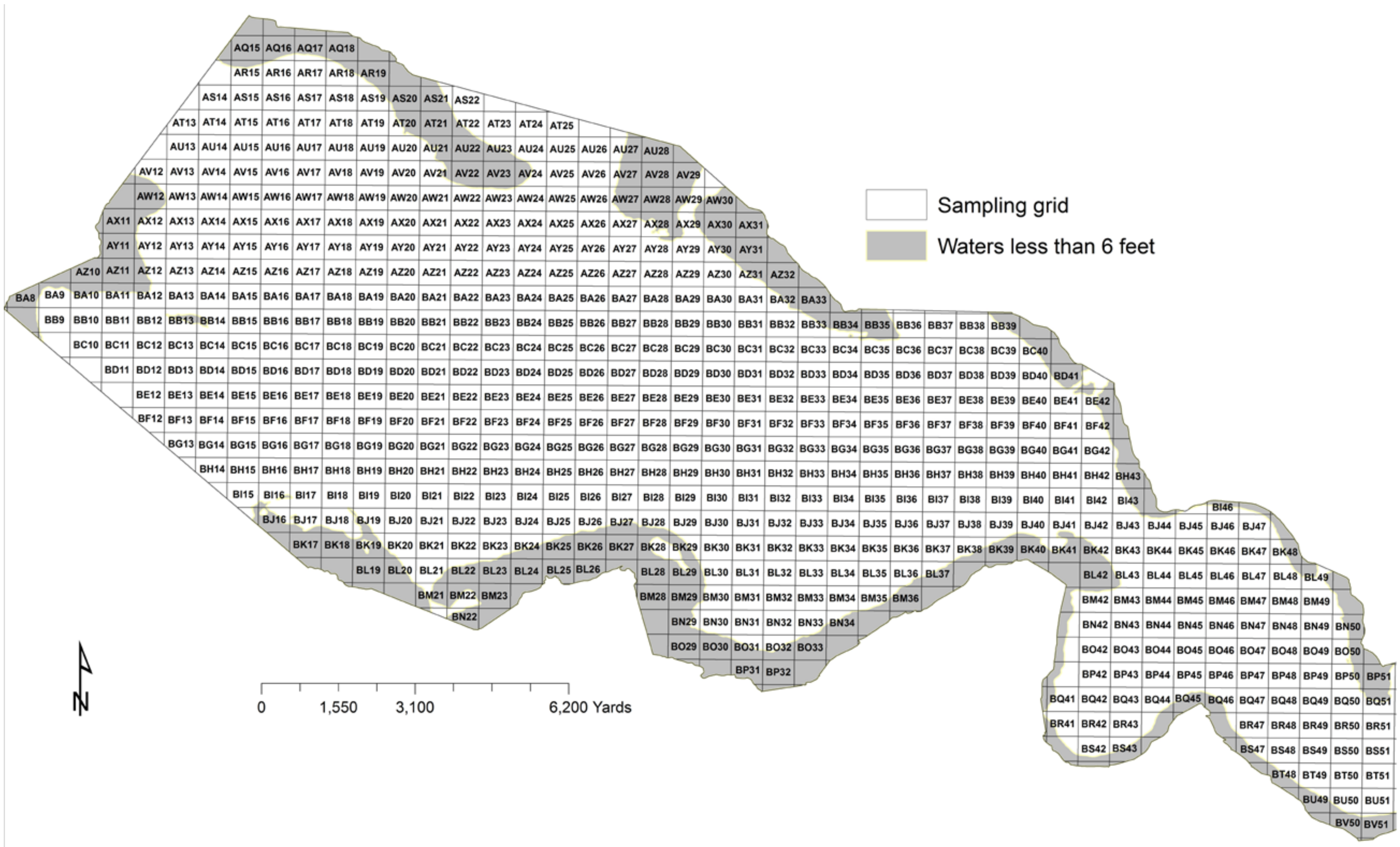


Figure 4. Weakfish length frequency distributions from onboard pound net sampling, 2008-2017. Note: 2011 210 millimeter length group was truncated to preserve scale, actual value is 50%.

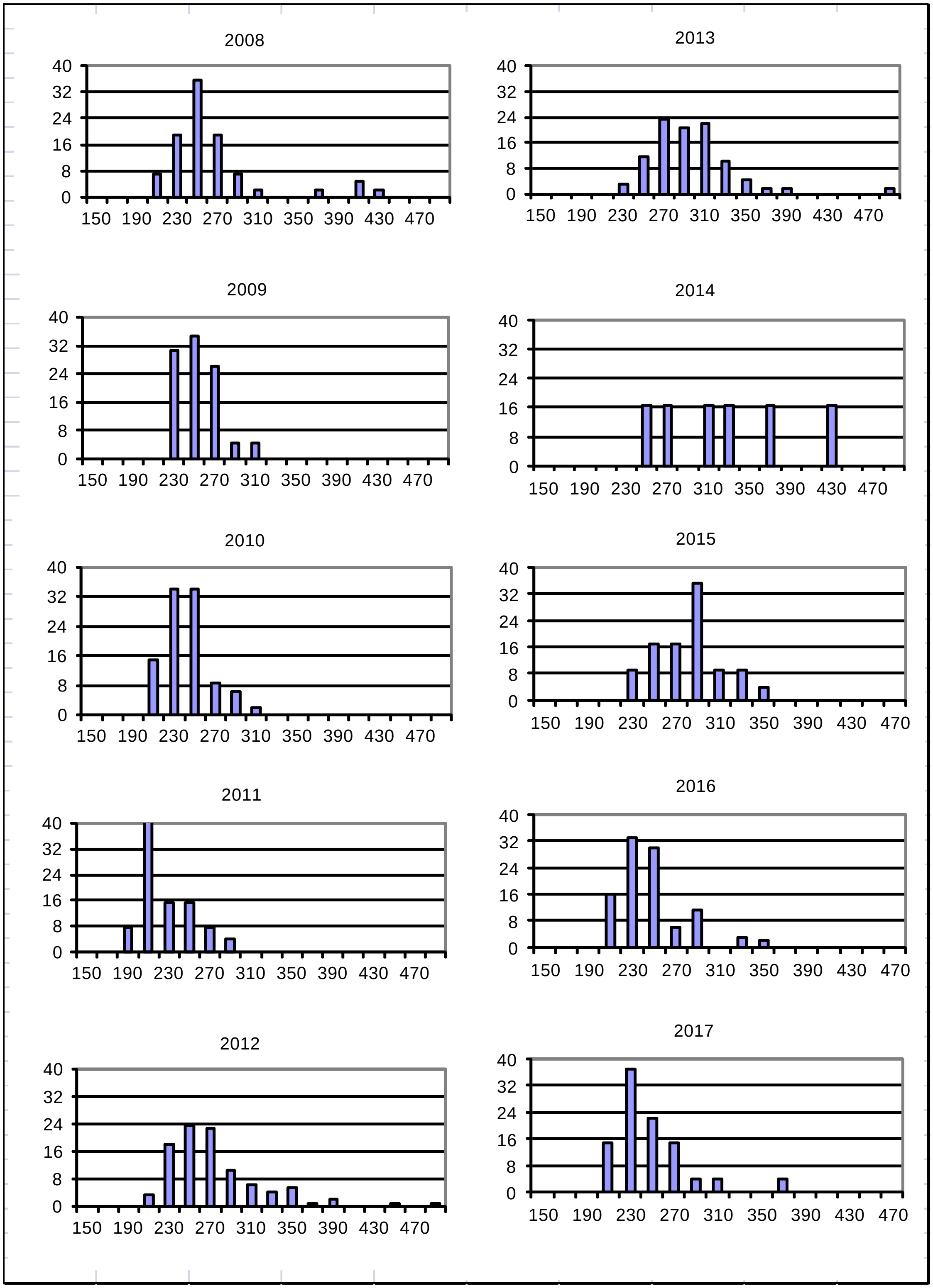


Figure 5. Maryland's commercial landings of weakfish in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational weakfish harvest and release estimates in numbers from 1981-2016.

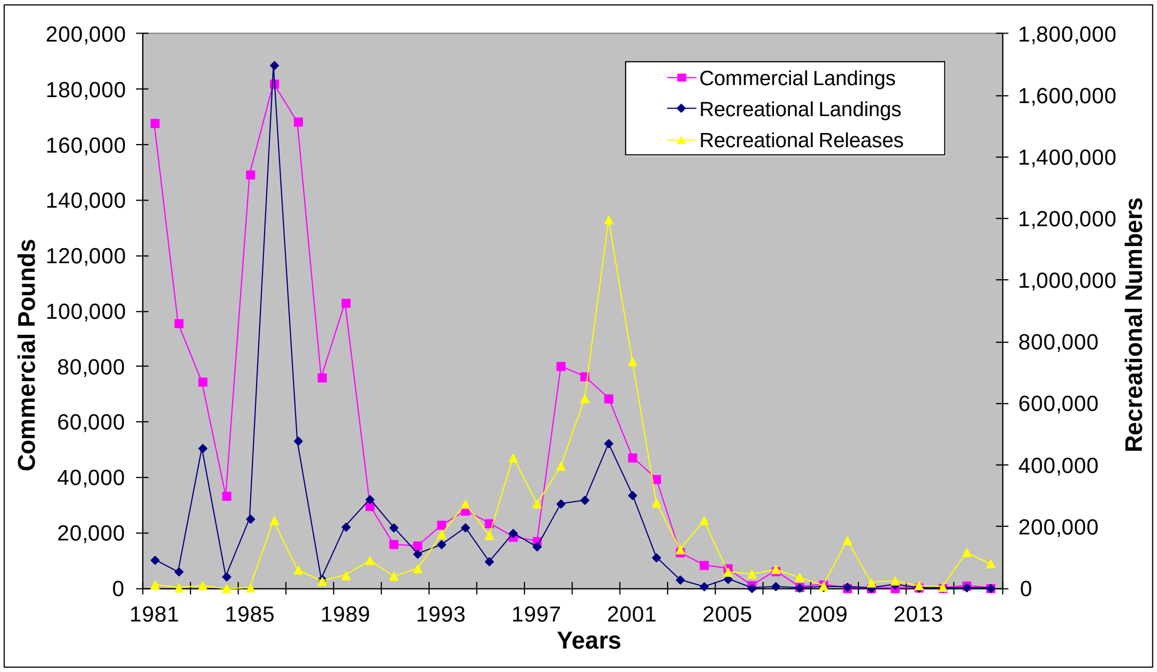


Figure 6. Maryland Charter boat log book weakfish harvest in numbers and the number of anglers participating in trips catching weakfish, 1993-2016.

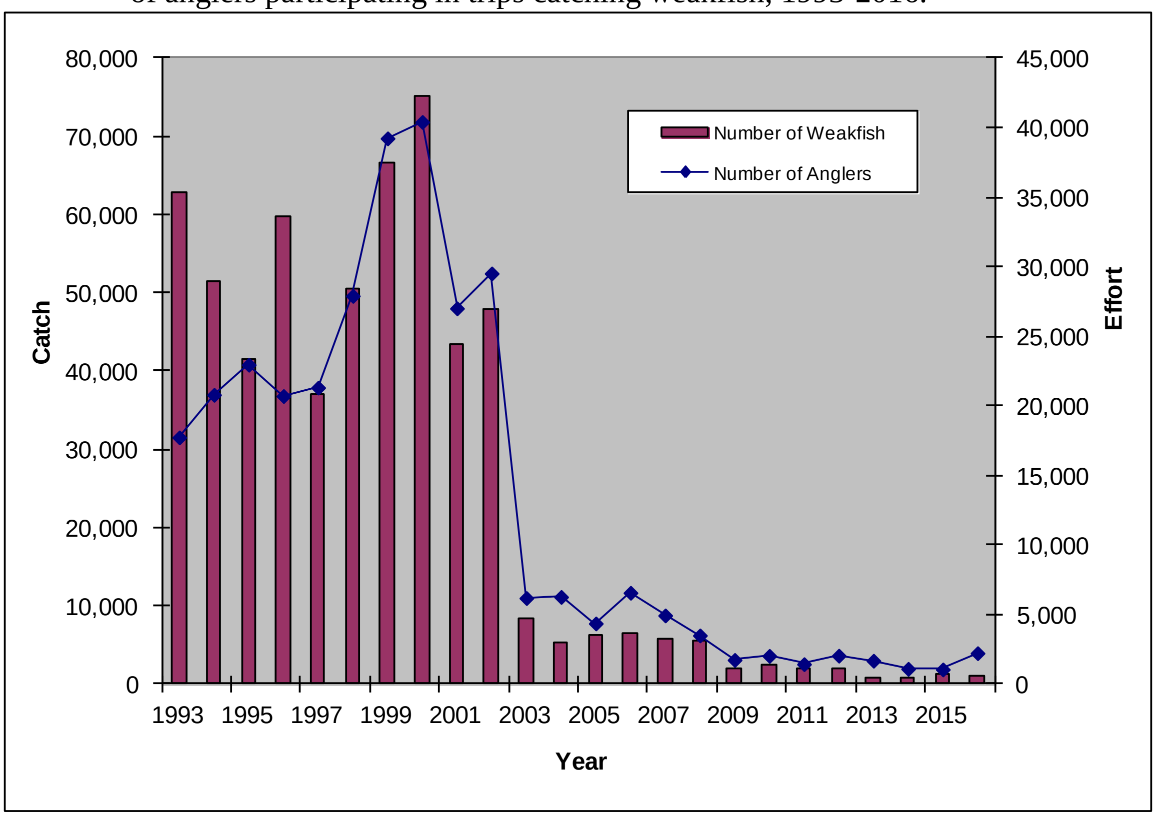


Figure 7. Maryland juvenile weakfish geometric mean catch per trawl and 95% confidence intervals for Maryland's lower Chesapeake Bay, 1989-2017.

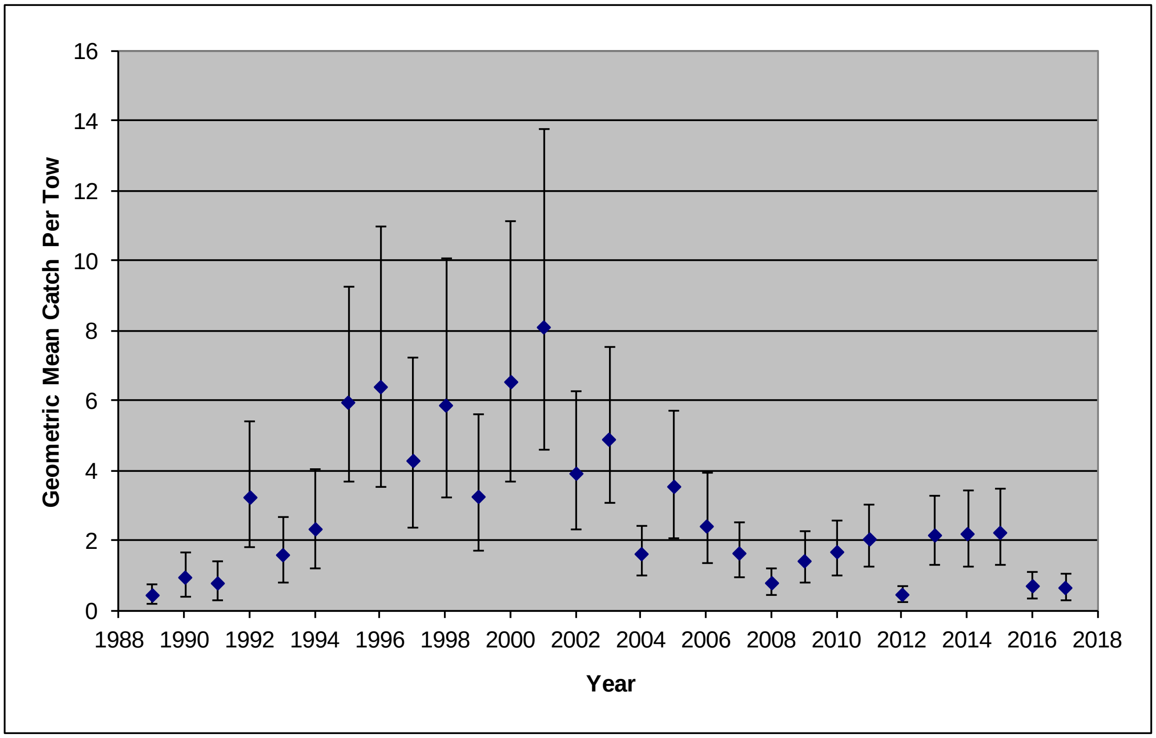


Figure 8. Summer flounder length frequency distributions from onboard pound net sampling, 2008-2017.

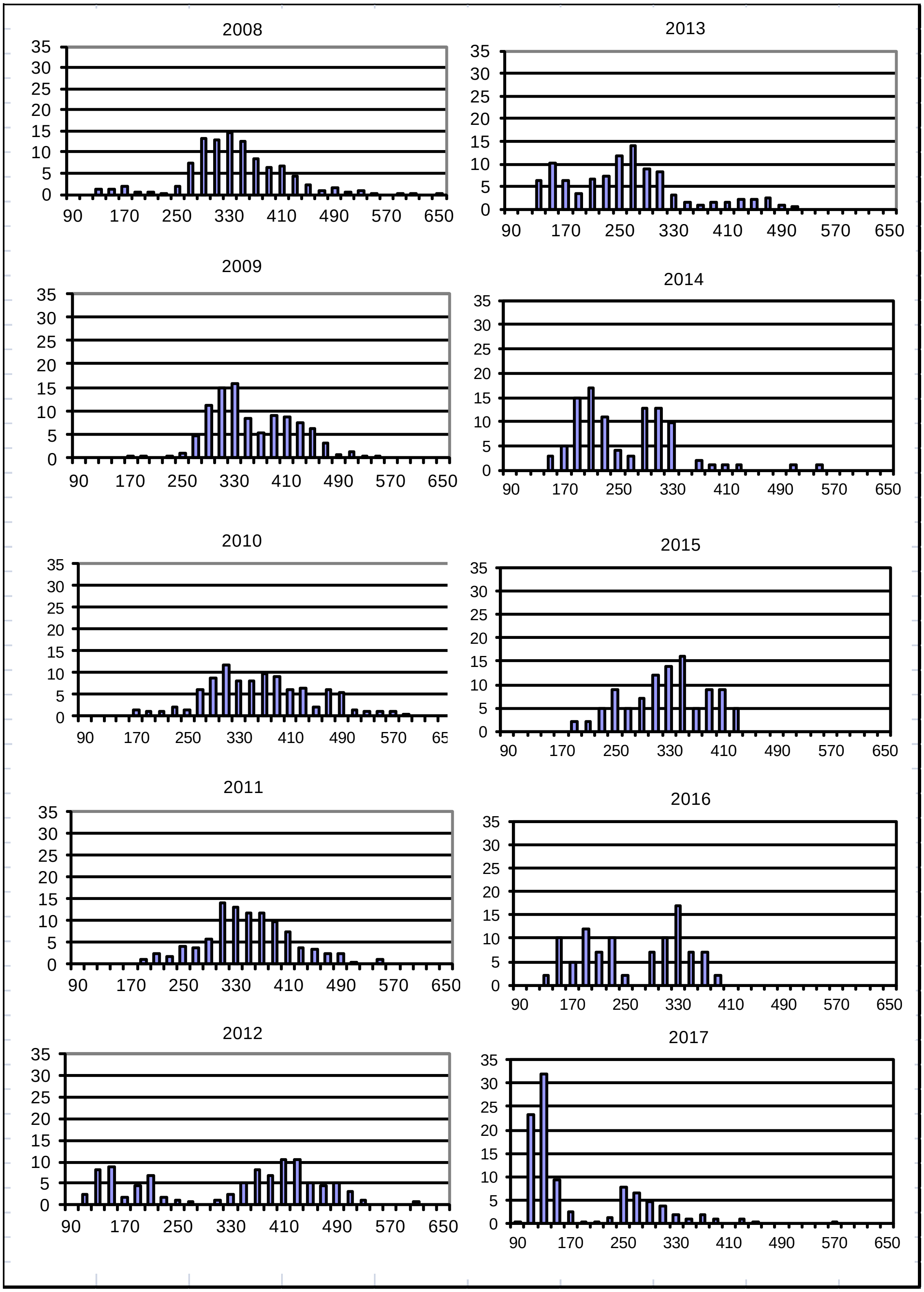


Figure 9. Summer flounder length frequency distributions from seafood dealer sampling in 2017.

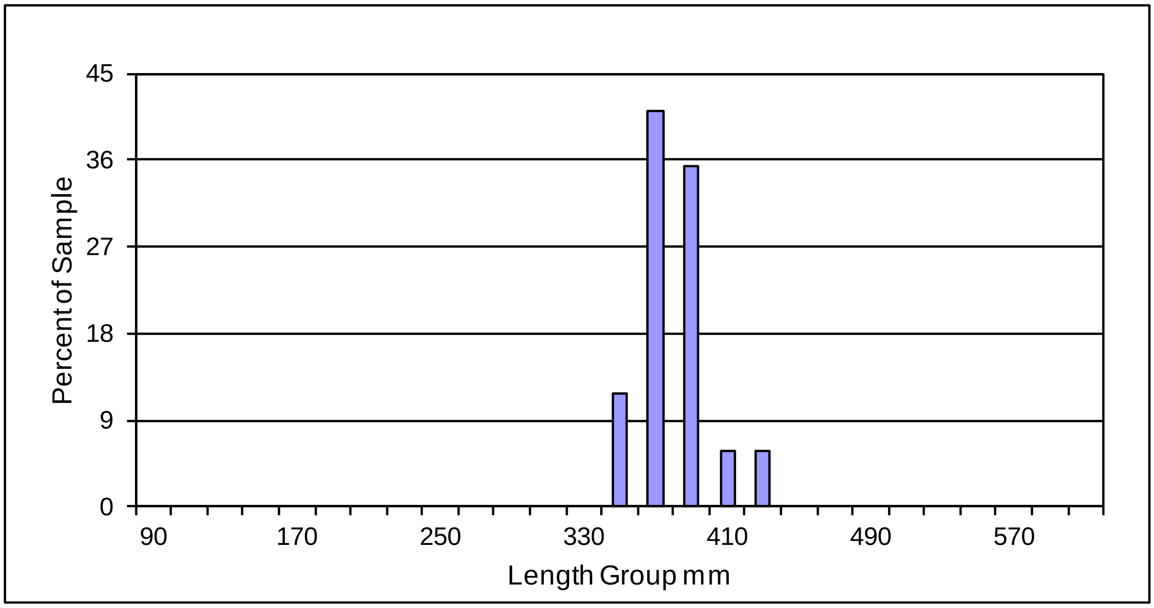


Figure 10. Maryland's commercial landings of summer flounder in pounds from the Chesapeake Bay and the MRIP Maryland summer flounder inland recreational harvest and release estimates in numbers from 1981-2016.

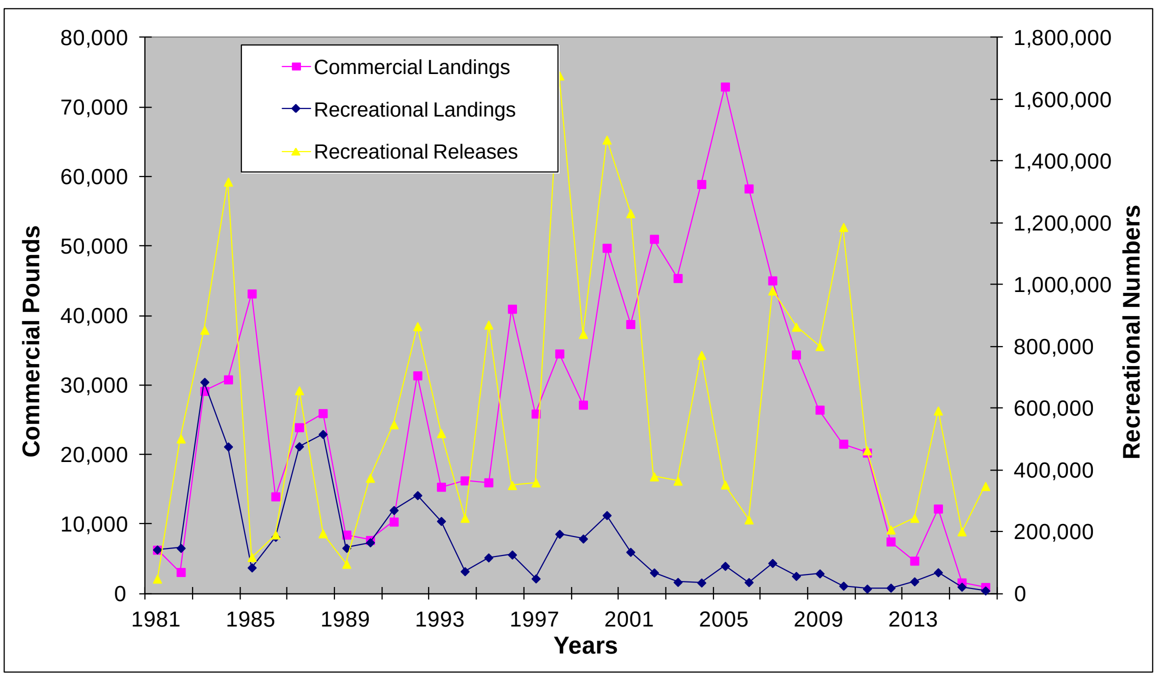


Figure 11. Maryland Charter boat log book summer flounder harvest in numbers and the number of anglers participating in trips catching summer flounder, 1993-2016.

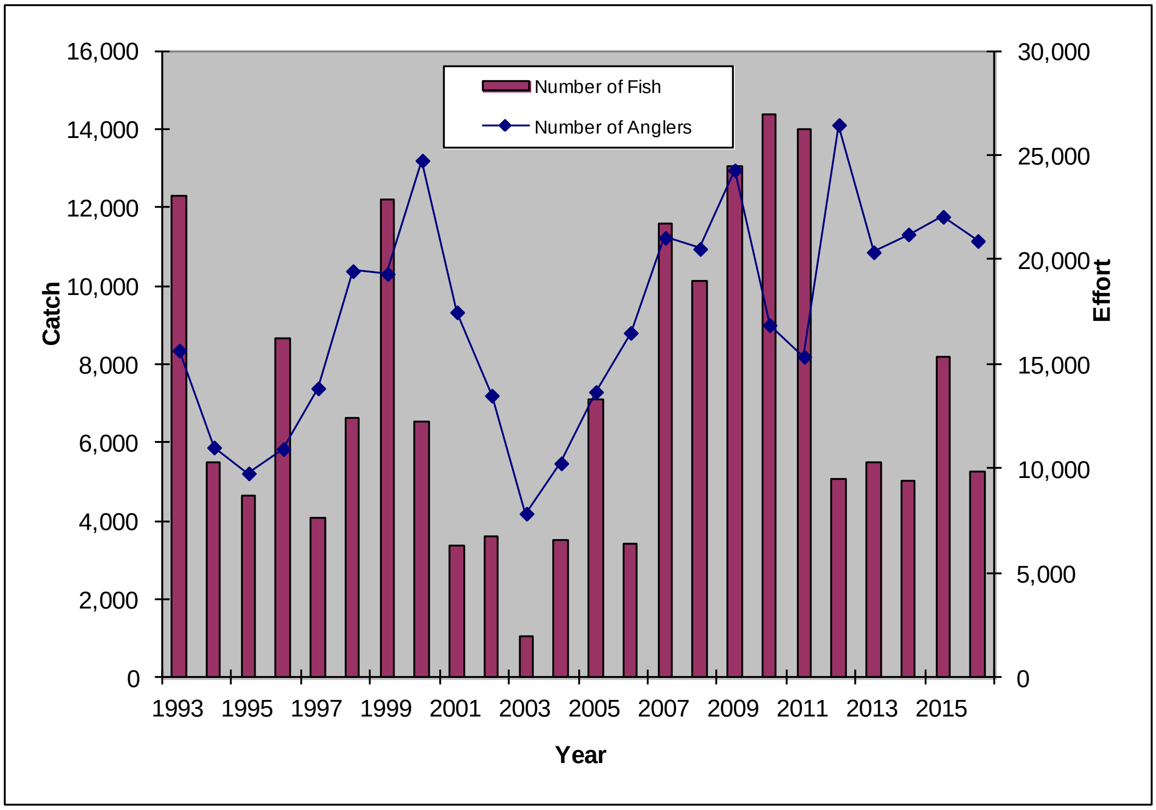


Figure 12. Bluefish length frequency distributions from onboard pound net sampling, 2008-2017.

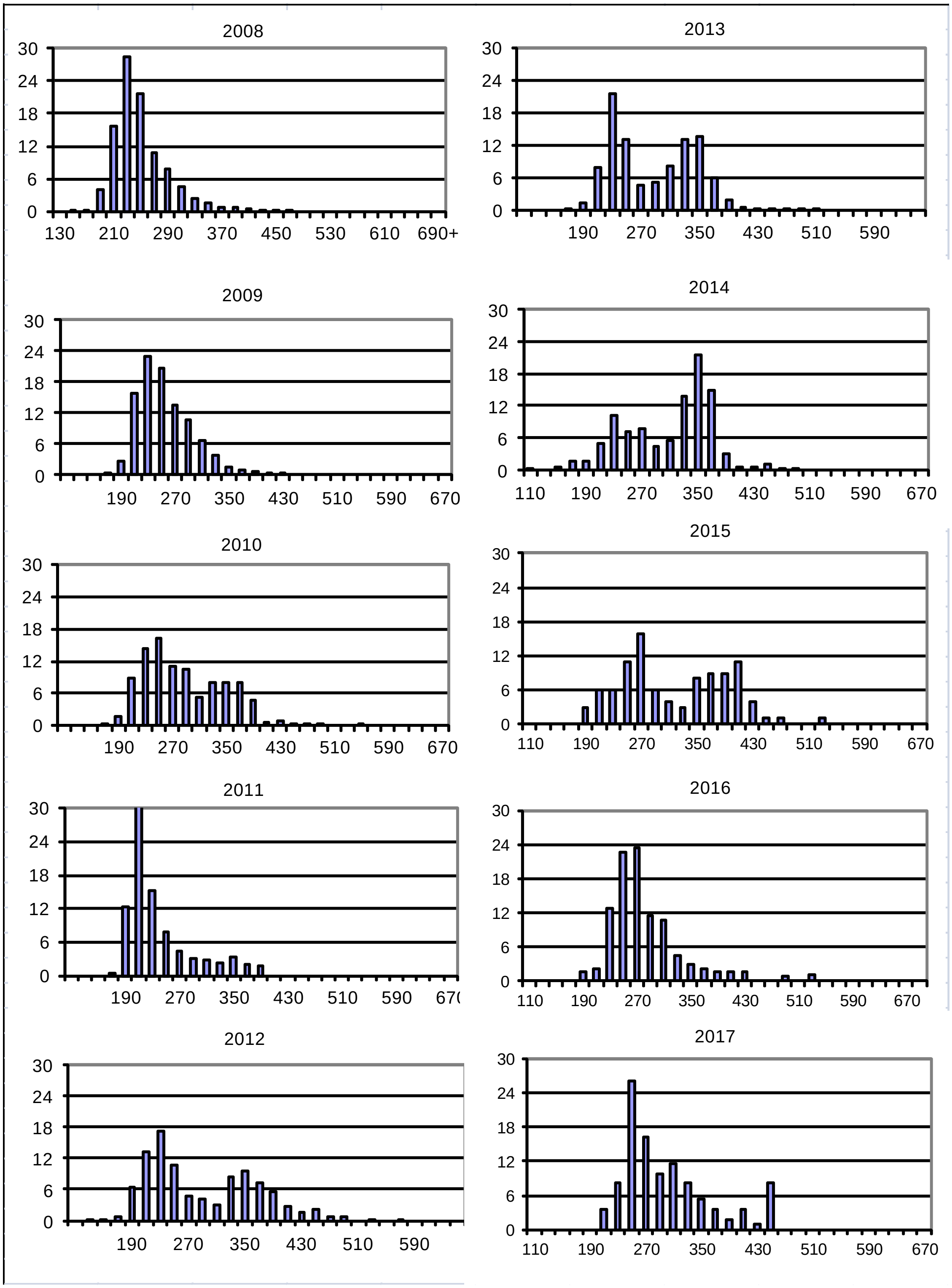


Figure 13. Summer flounder length frequency distributions from seafood dealer sampling in 2017.

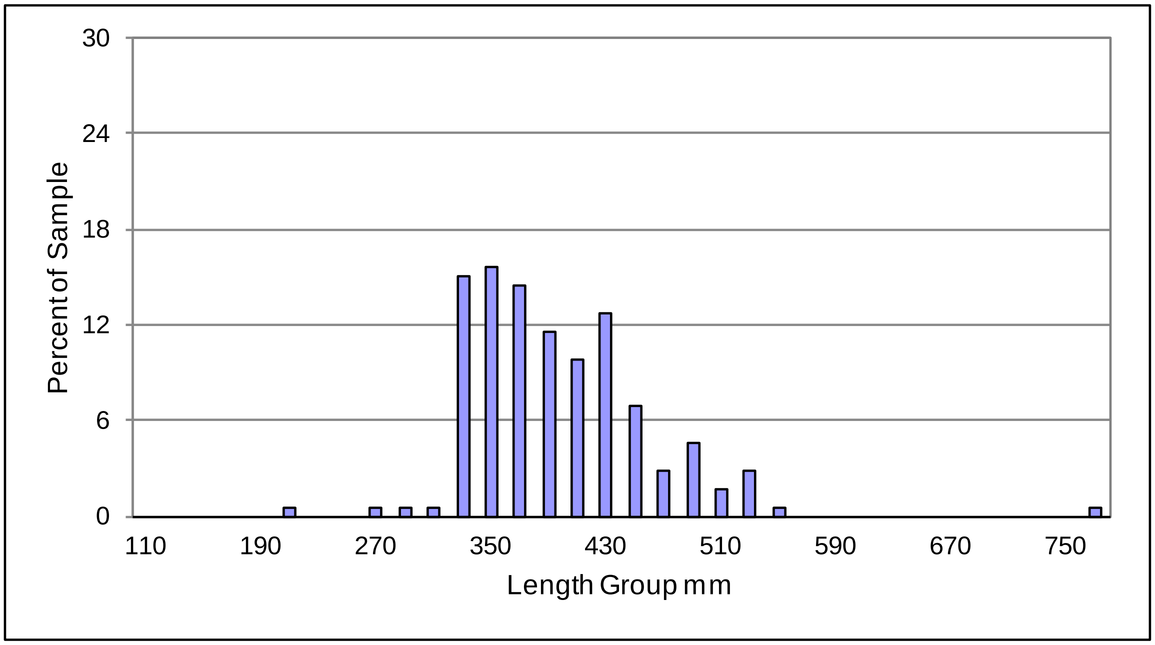


Figure 14. Proportion of bluefish catch by mesh size and year for the Choptank River gill net survey, 2013-2017.

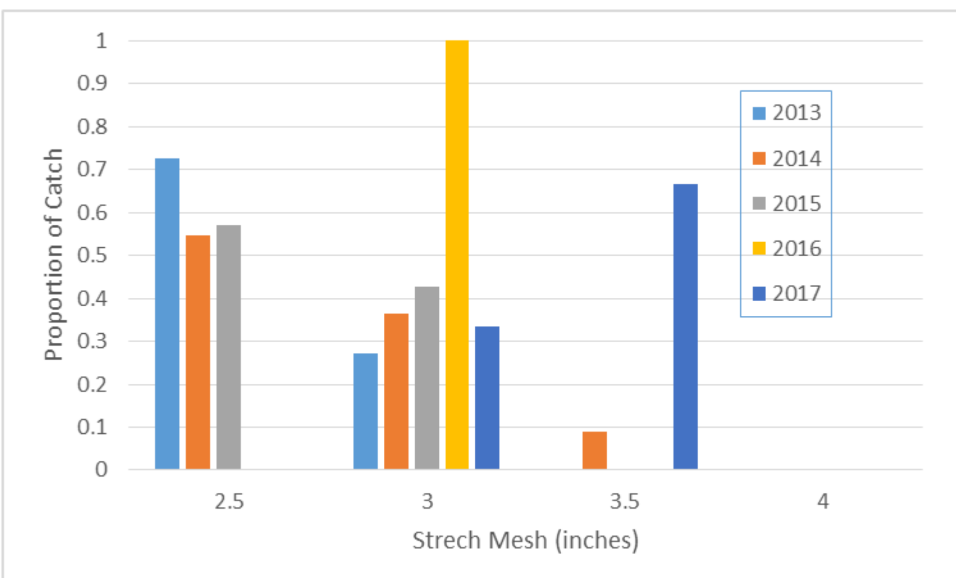


Figure 15. Maryland's commercial landings of bluefish in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational bluefish harvest and release estimates in numbers from 1981-2016.

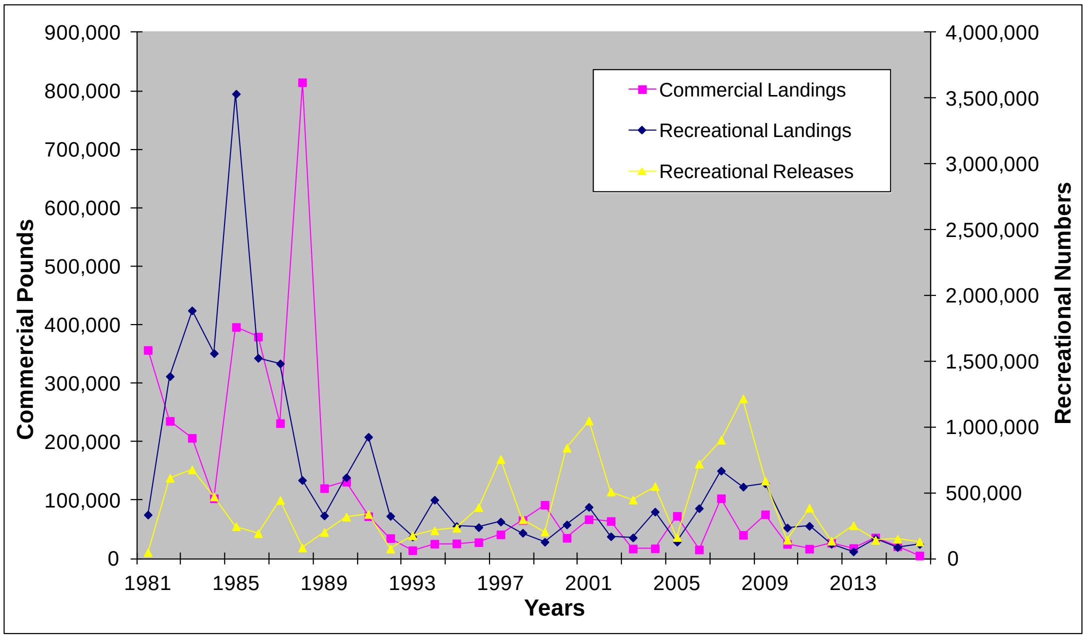


Figure 16. Maryland Charter boat log book bluefish harvest in numbers and the number of anglers participating in trips catching bluefish, 1993-2016.

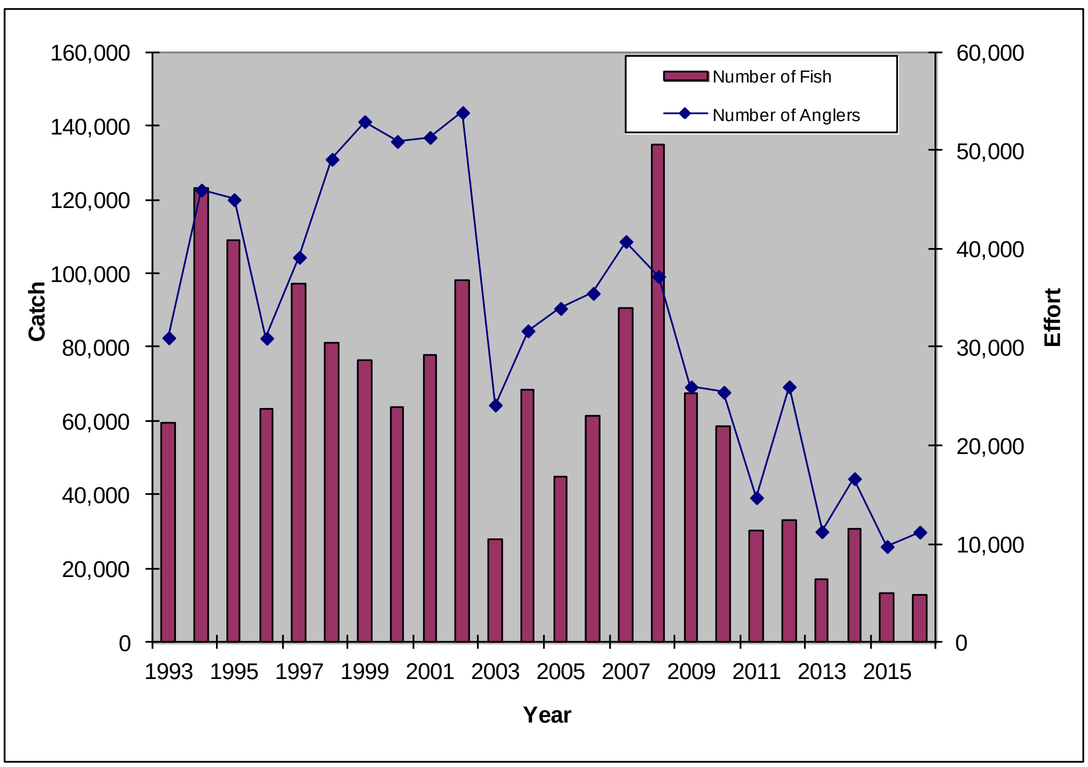


Figure 17. Atlantic croaker length frequency distributions from onboard pound net sampling, 2008-2017.

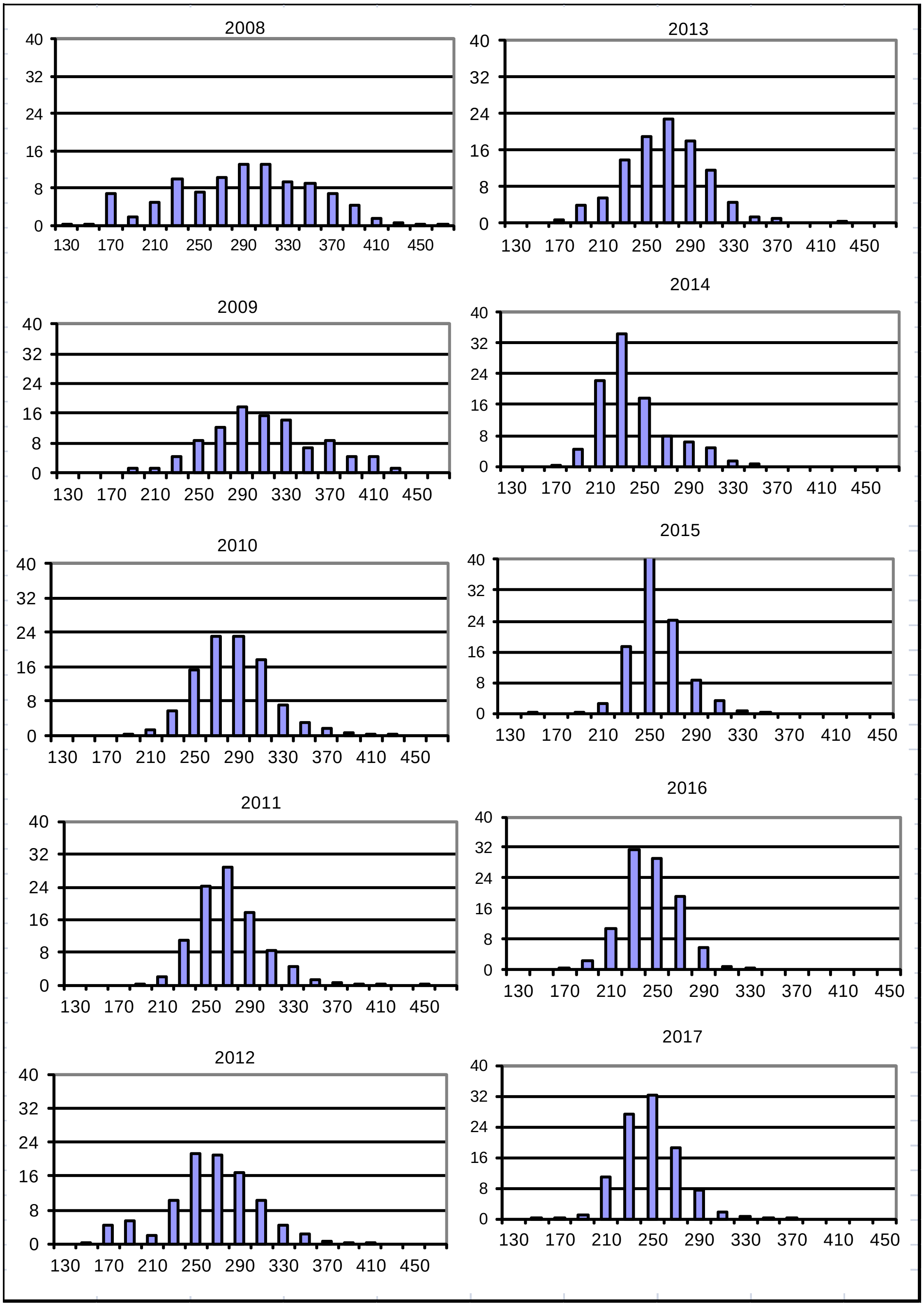


Figure 18. Atlantic croaker length frequency distributions from seafood dealer sampling in 2017.

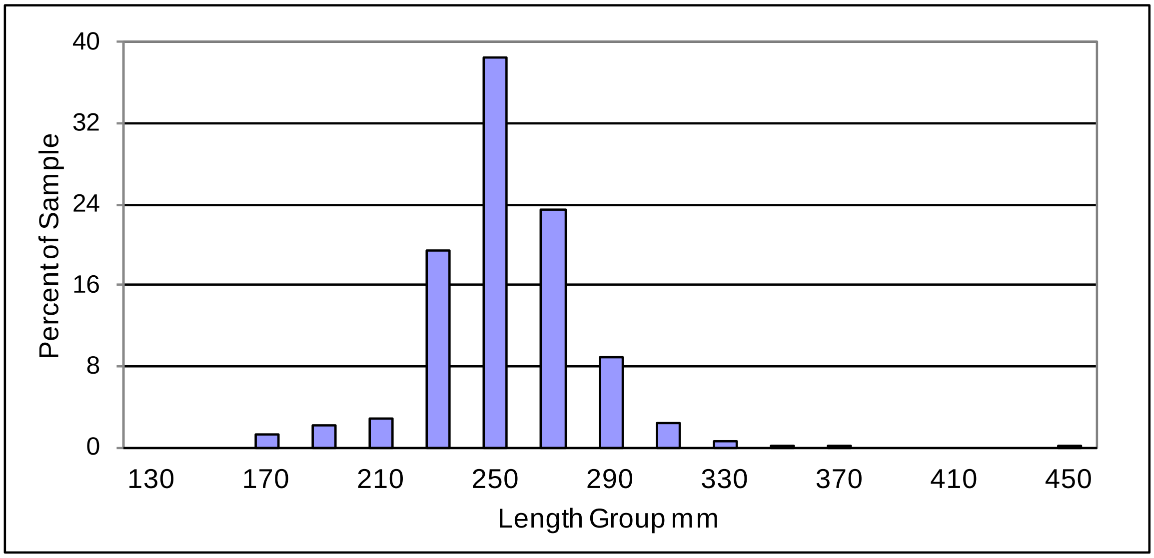


Figure 19. Proportion of Atlantic croaker catch by mesh size and year for the Choptank River gill net survey, 2013-2017.

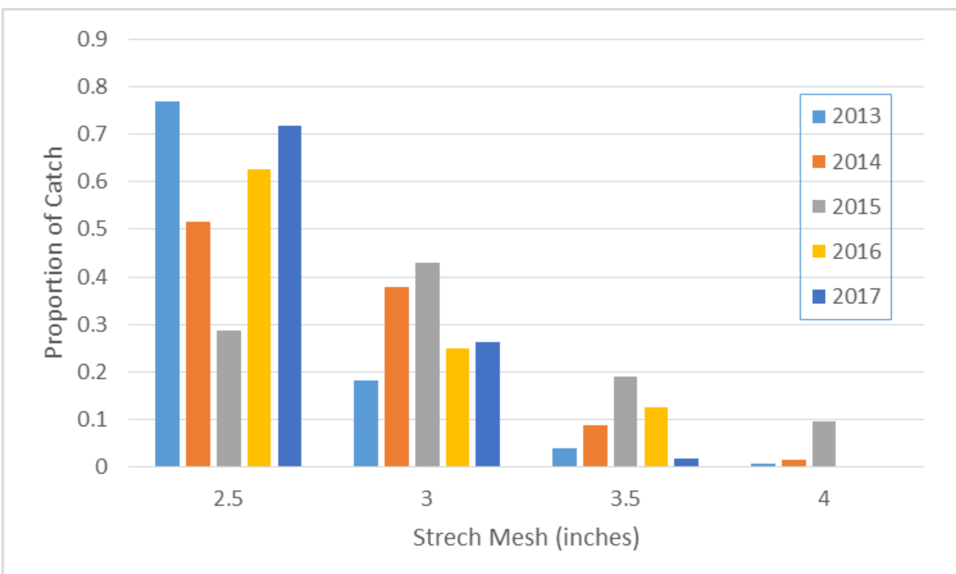


Figure 20. Atlantic croaker length frequency distribution from the Choptank River gill net survey by stretched mesh size in inches, 2013-2017 combined.

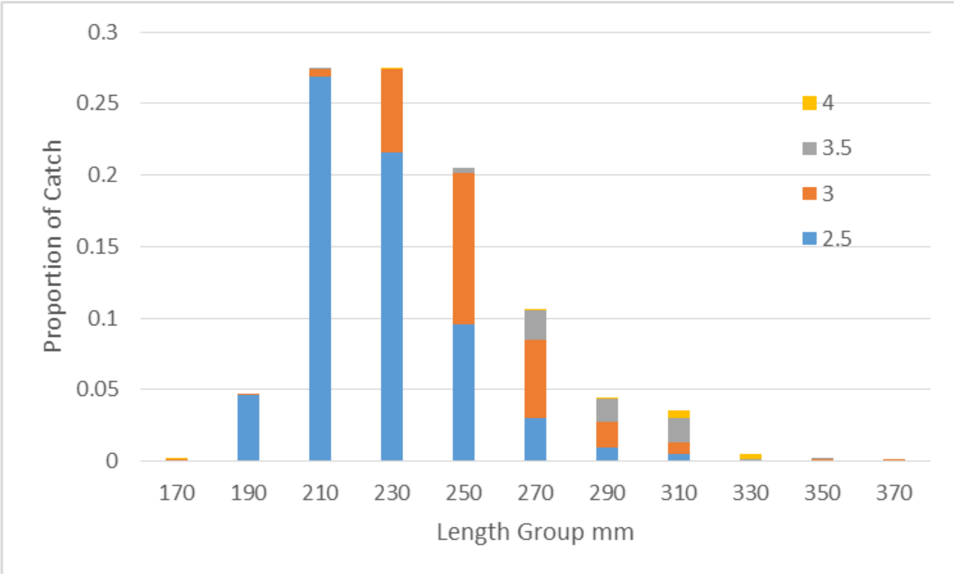


Figure 21. Maryland's commercial landings of Atlantic croaker in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational Atlantic croaker harvest and release estimates in numbers from 1981-2016.

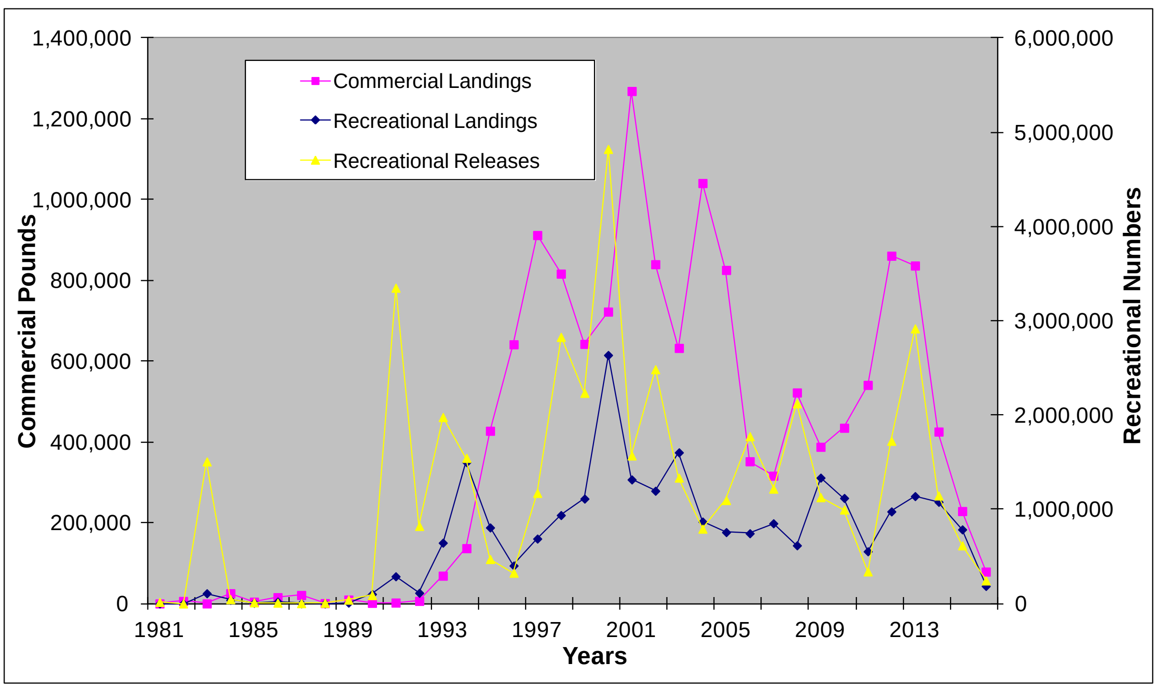


Figure 22. Maryland Charter boat log book Atlantic croaker harvest in numbers and the number of anglers participating in trips catching Atlantic croaker, 1993-2016.

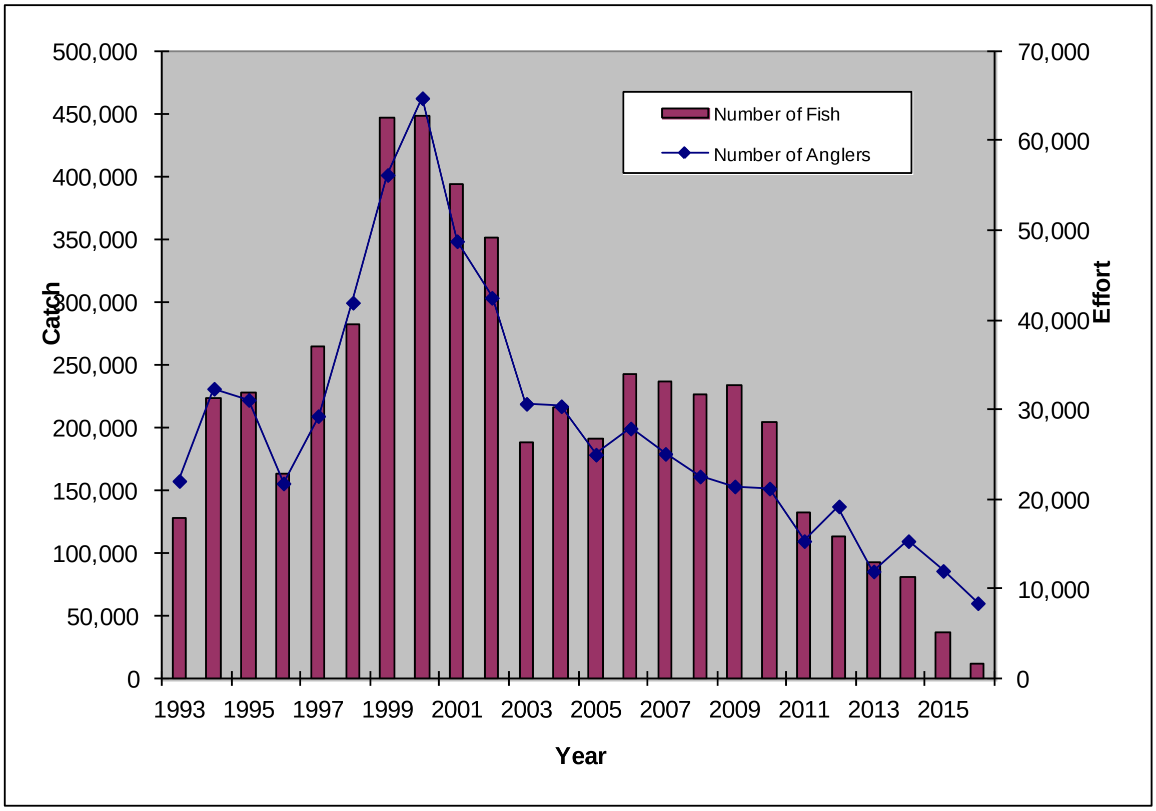


Figure 23. Maryland juvenile Atlantic croaker geometric mean catch per trawl and 95% confidence intervals for Maryland's lower Chesapeake Bay, 1989-2017. 1998 data point was omitted for scale (GM 1998 = 30.05 -9.02, +12.72).

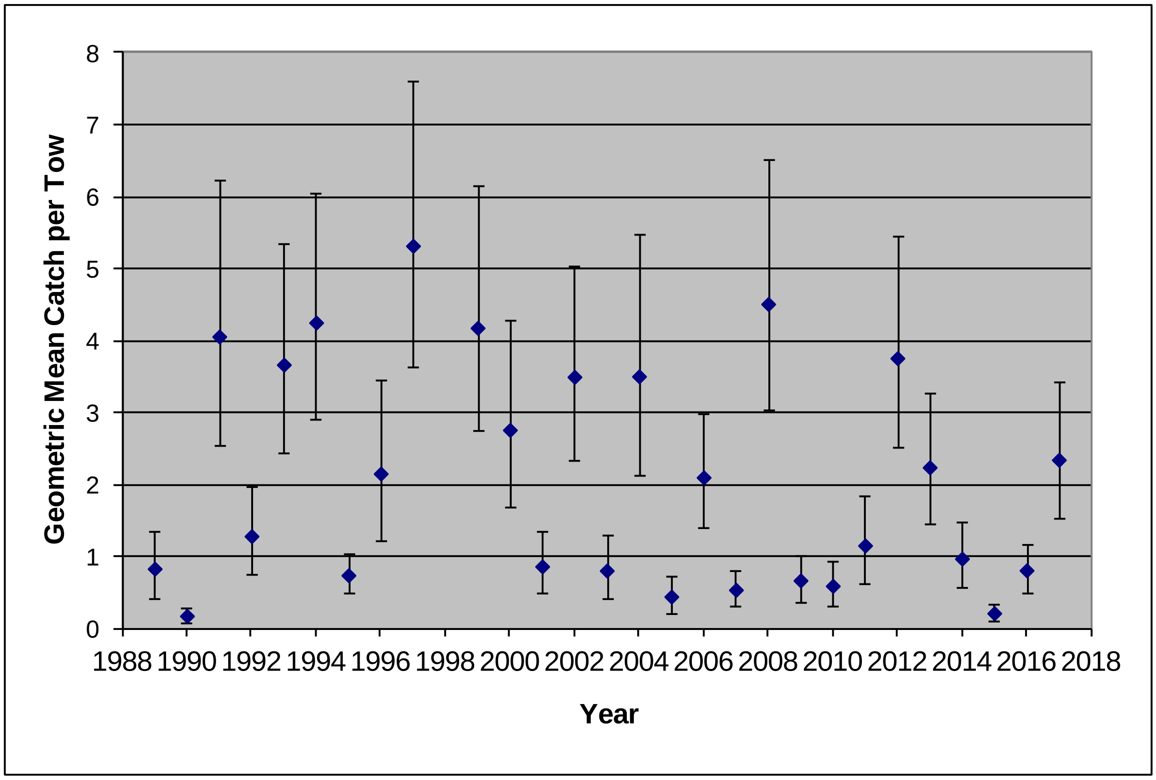


Figure 24. Atlantic croaker total mortality estimates using Maryland age date to derive growth parameters and using the growth parameters from the ASMFC 2017 stock assessment, 1999 - 2017.

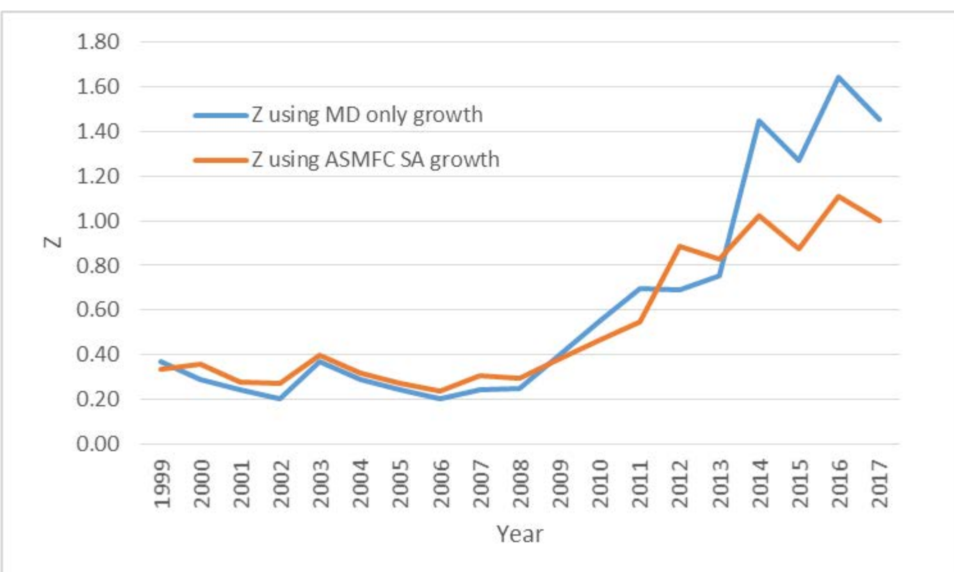


Figure 25. Spot length frequency distributions from onboard pound net sampling, 2008-2017.

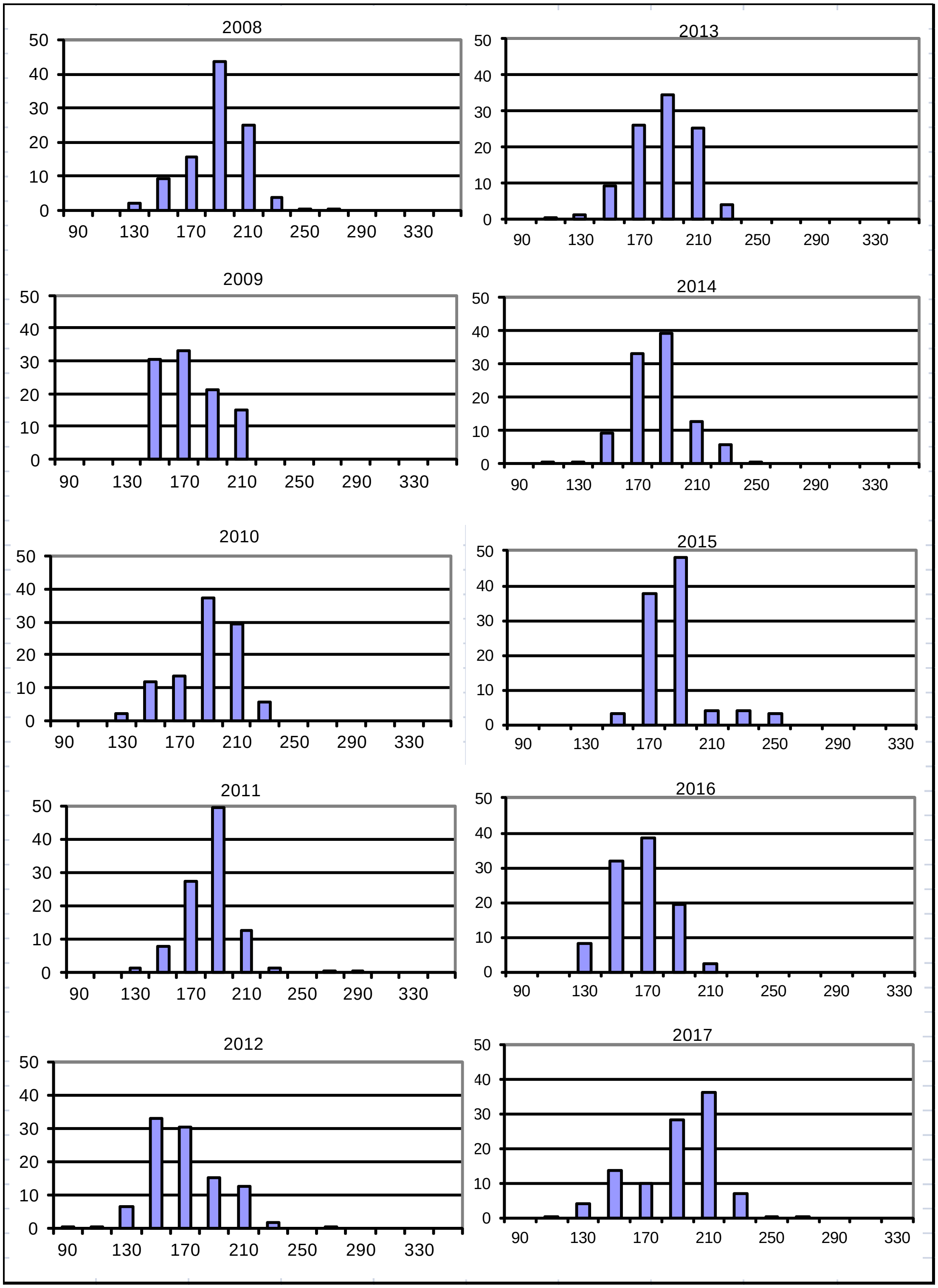


Figure 26. Proportion of spot captured in the Choptank River gill net survey by mesh size and year, 2013-1017.

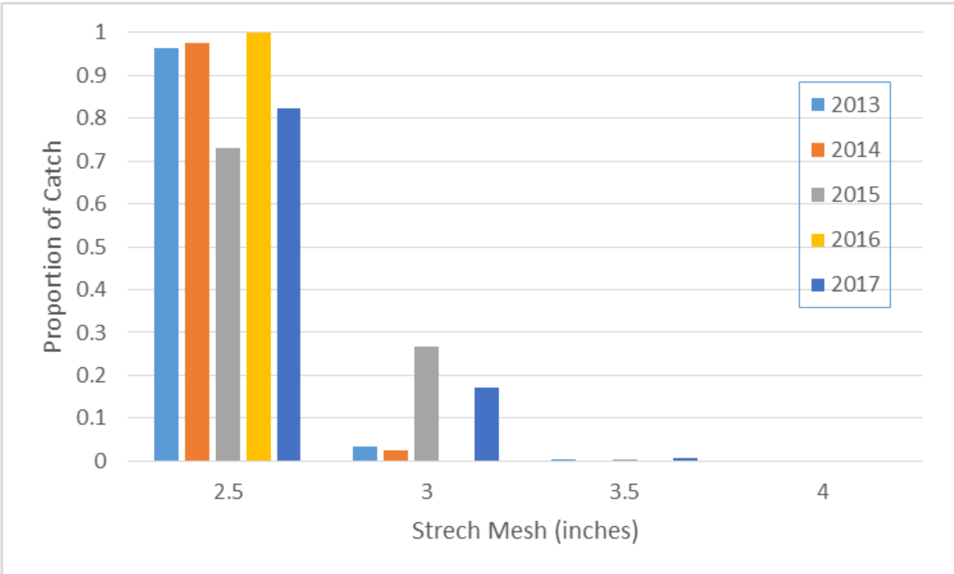


Figure 27. Spot length frequency distributions from the Choptank River gill net survey for 2013-2017.

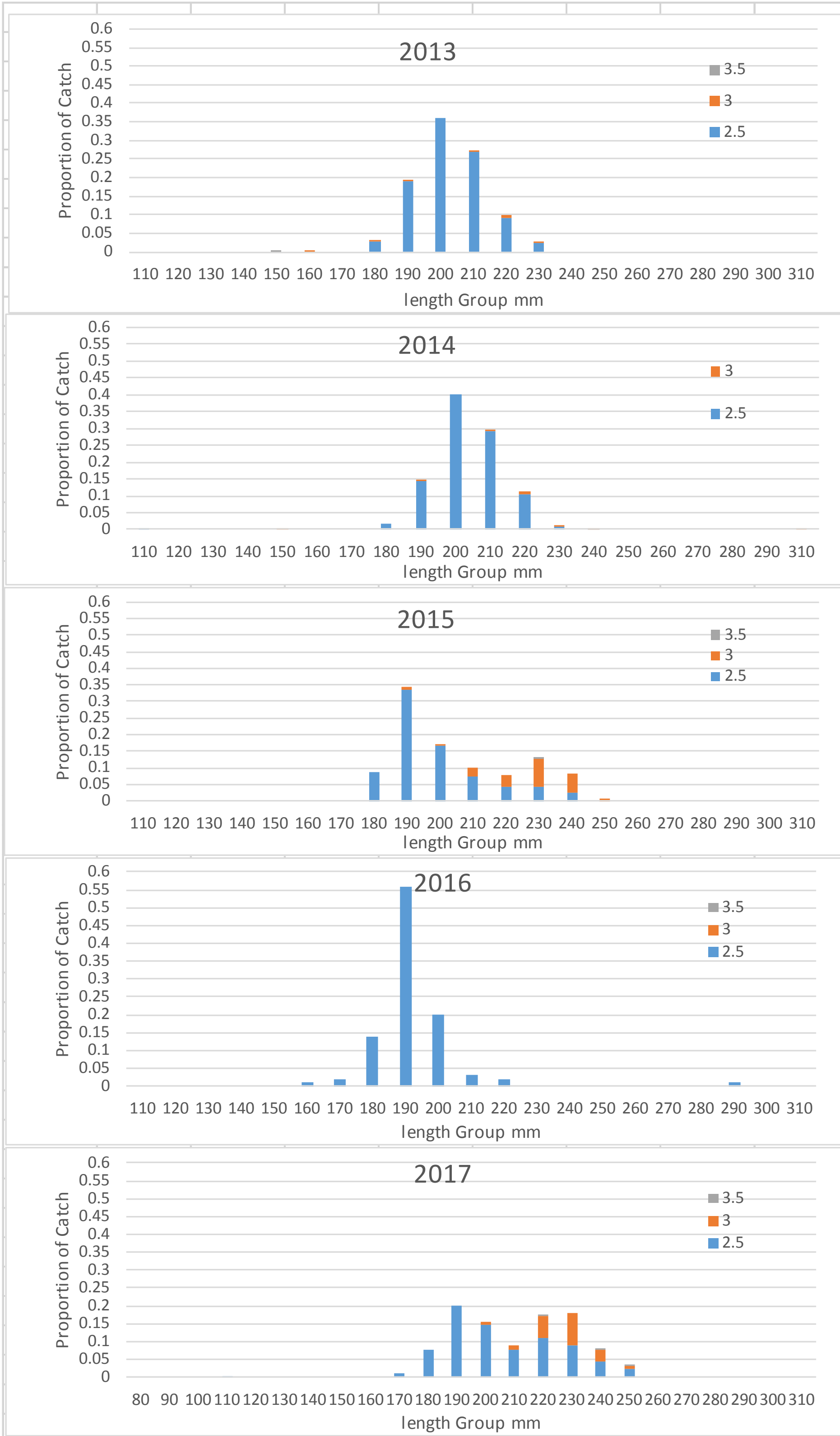


Figure 28. Maryland's commercial landings of spot in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational spot harvest and release estimates in numbers from 1981-2016.

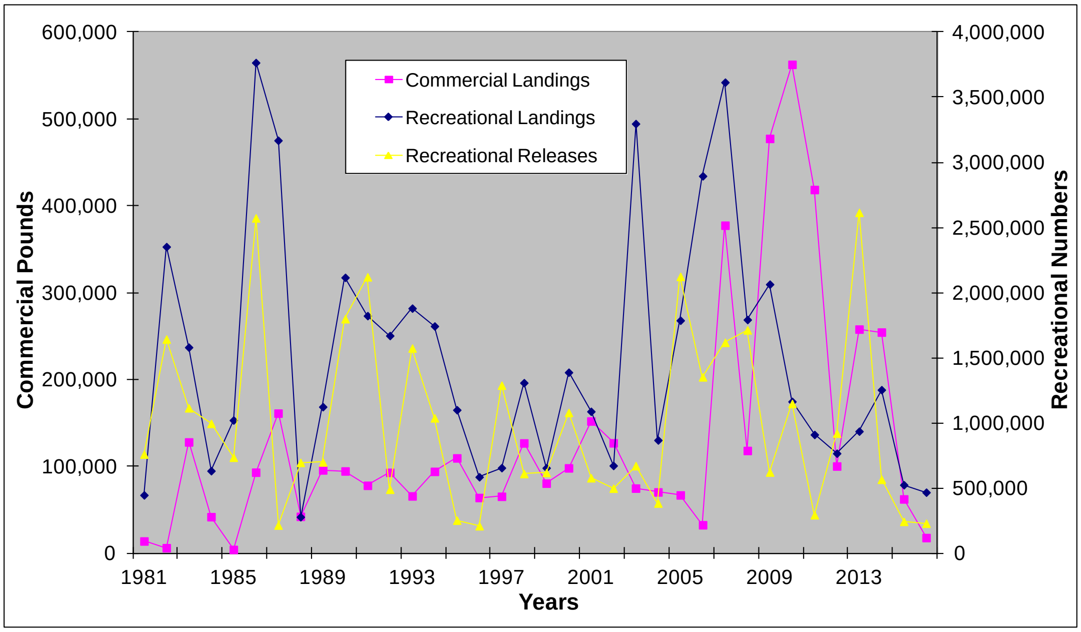


Figure 29. Maryland Charter boat log book spot harvest in numbers and the number of anglers participating in trips catching spot, 1993-2016.

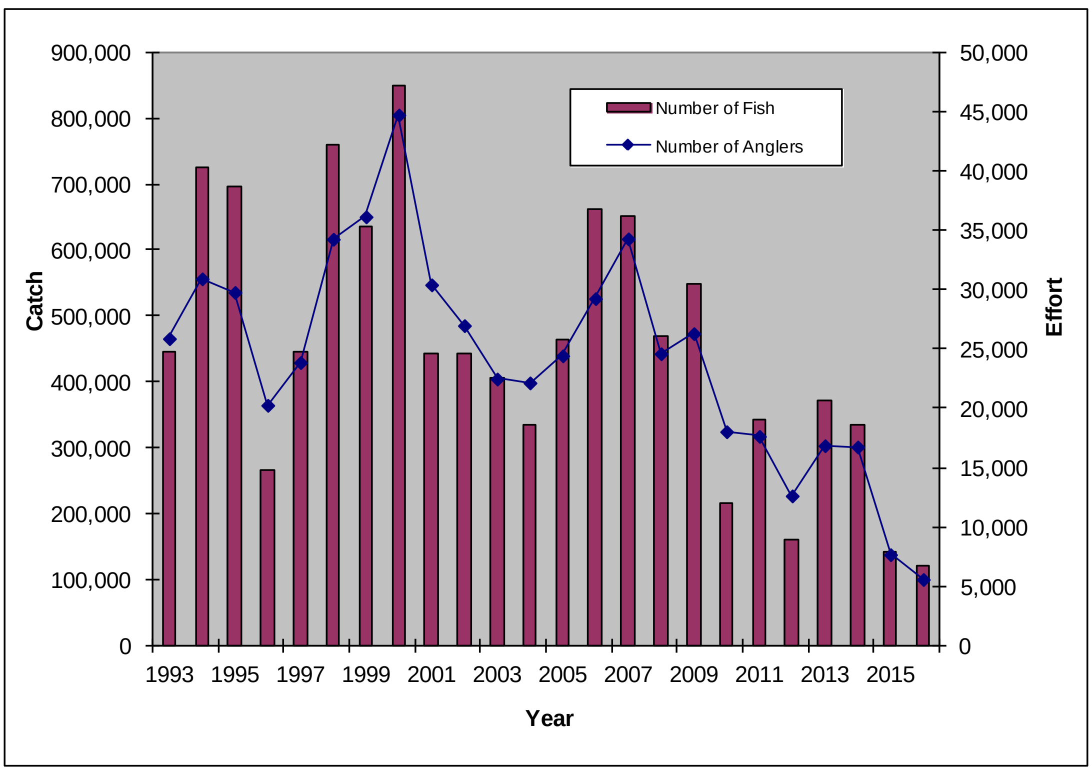


Figure 30. Maryland juvenile spot geometric mean catch per trawl and 95% confidence intervals for Maryland's lower Chesapeake Bay, 1989-2017.

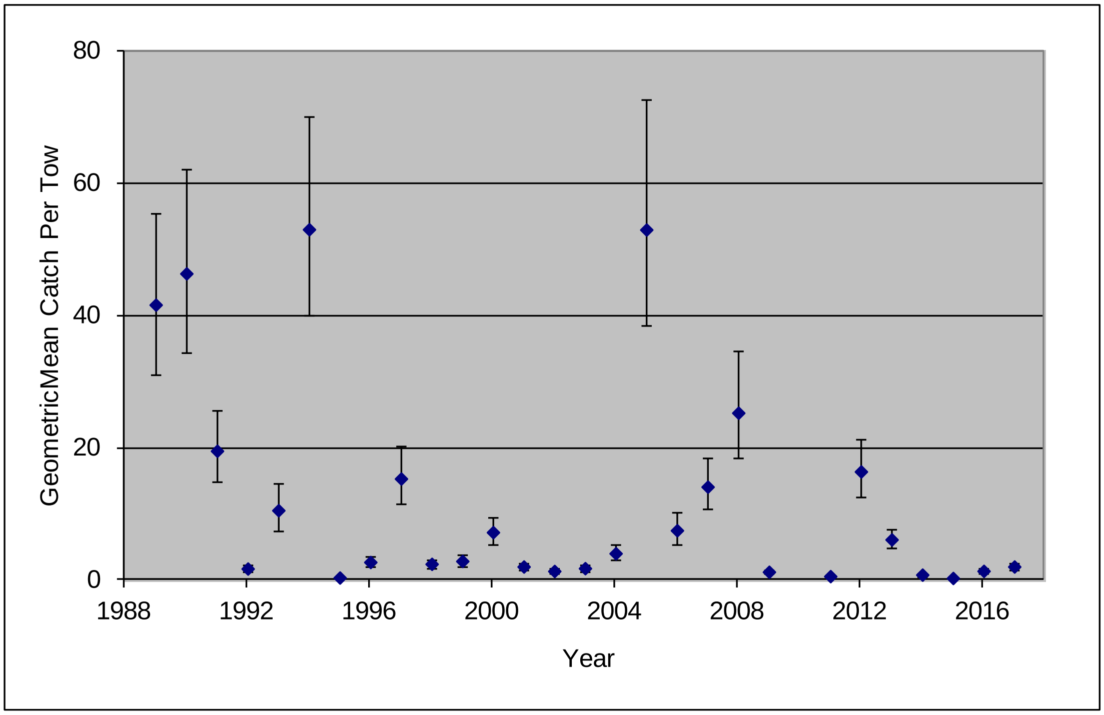


Figure 31. Maryland's commercial landings of red drum in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational red drum harvest and release estimates in numbers from 1981-2016.

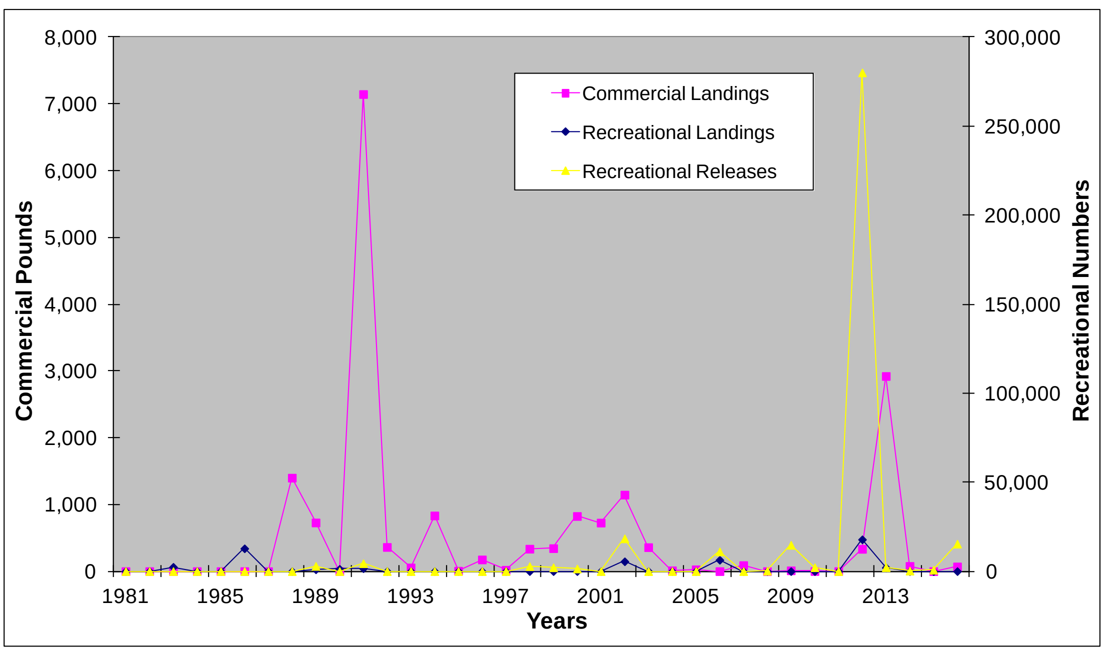


Figure 32. Maryland Charter boat log book red drum harvest in numbers and the number of anglers participating in trips catching red drum, 1993-2016.

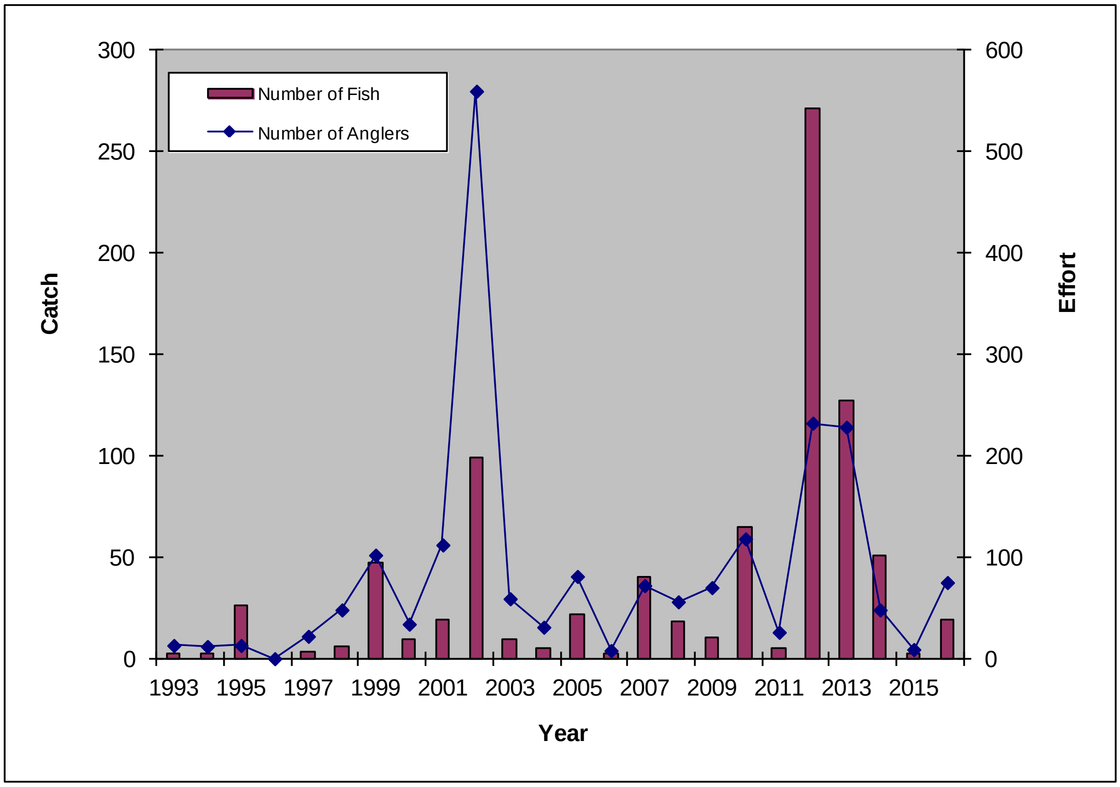


Figure 33. Maryland's commercial landings of black drum in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational black drum harvest and release estimates in numbers from 1981-2016.

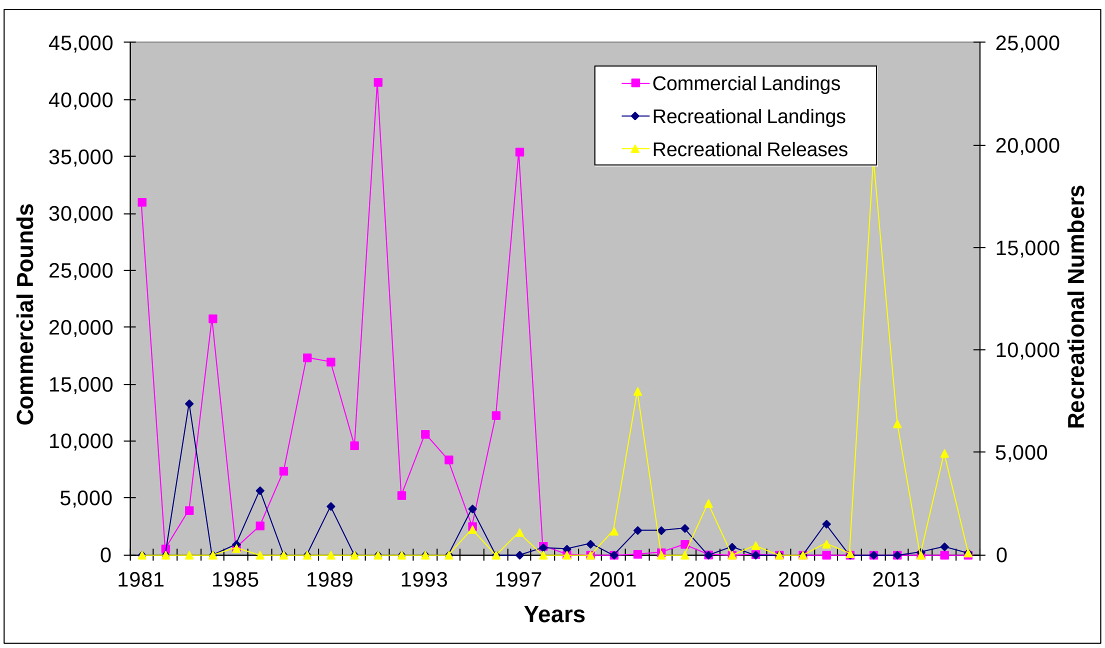


Figure 34. Maryland Charter boat log book black drum harvest in numbers and the number of anglers participating in trips catching black drum, 1993-2016.

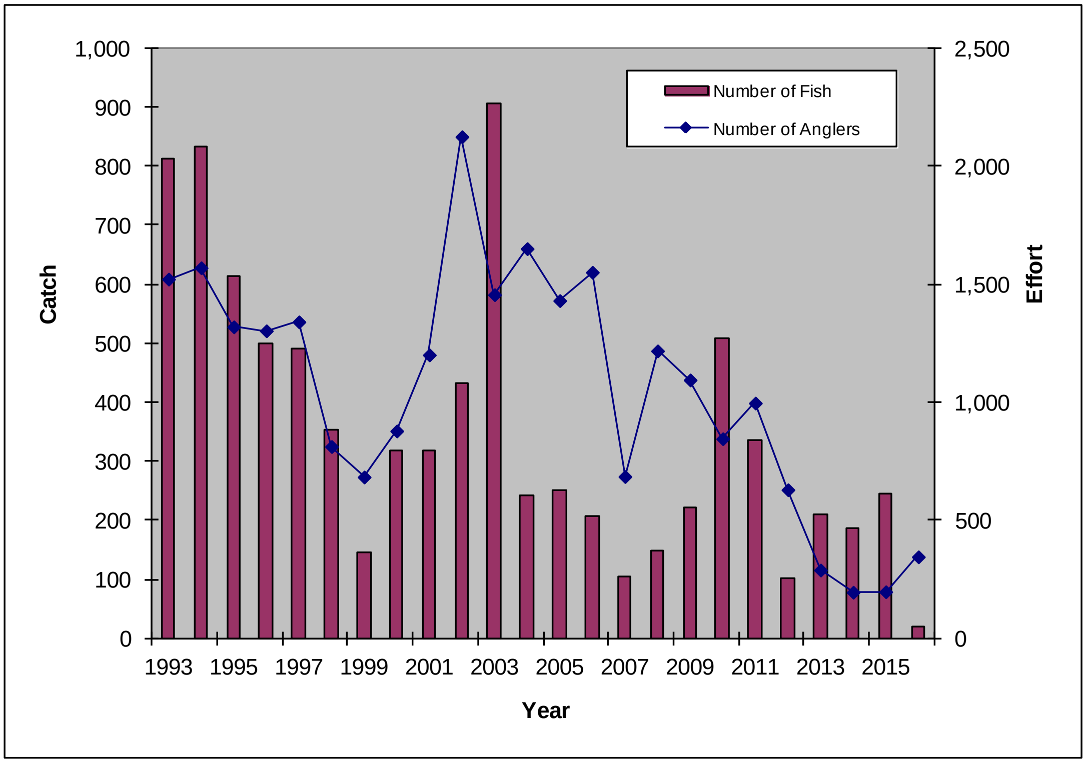


Figure 35. Maryland's commercial landings of Spanish mackerel in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational Spanish mackerel harvest and release estimates in numbers from 1981-2016.

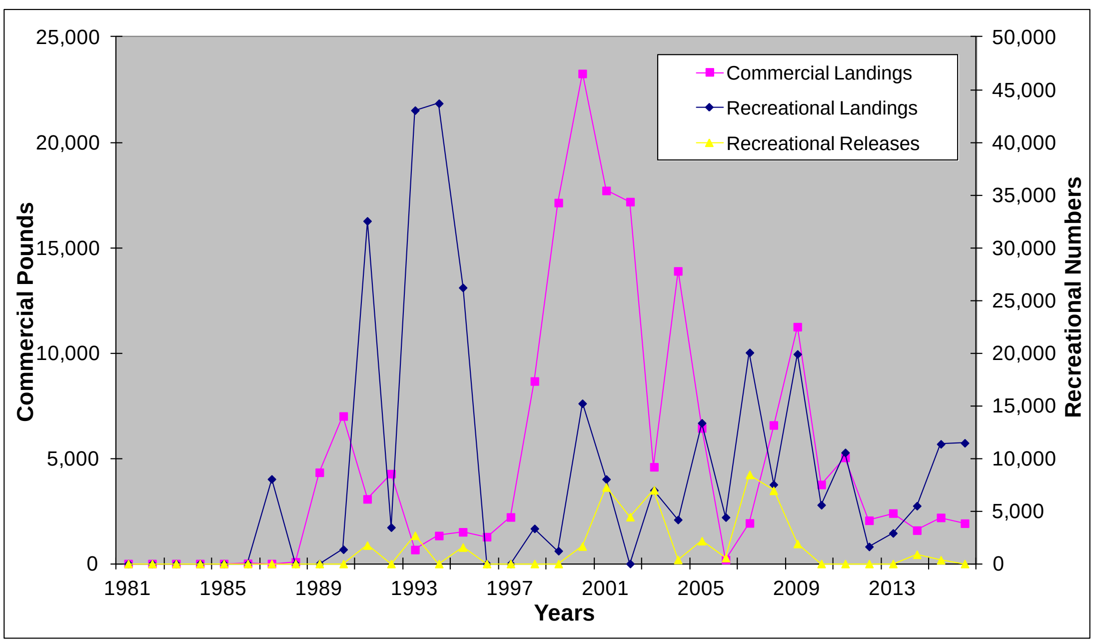


Figure 36. Maryland Charter boat log book Spanish mackerel harvest in numbers and the number of anglers participating in trips catching Spanish mackerel, 1993-2016.

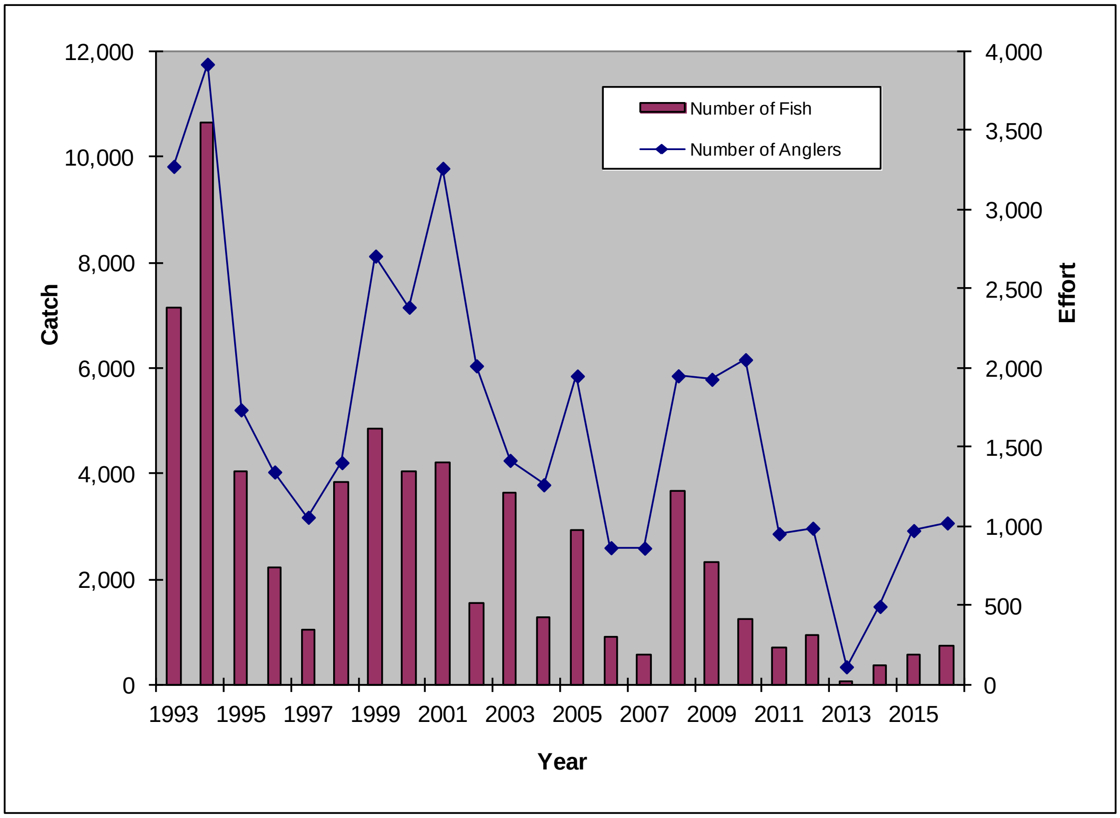


Figure 37. Maryland's commercial landings of spotted seatrout in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational spotted seatrout harvest and release estimates in numbers from 1981-2016.

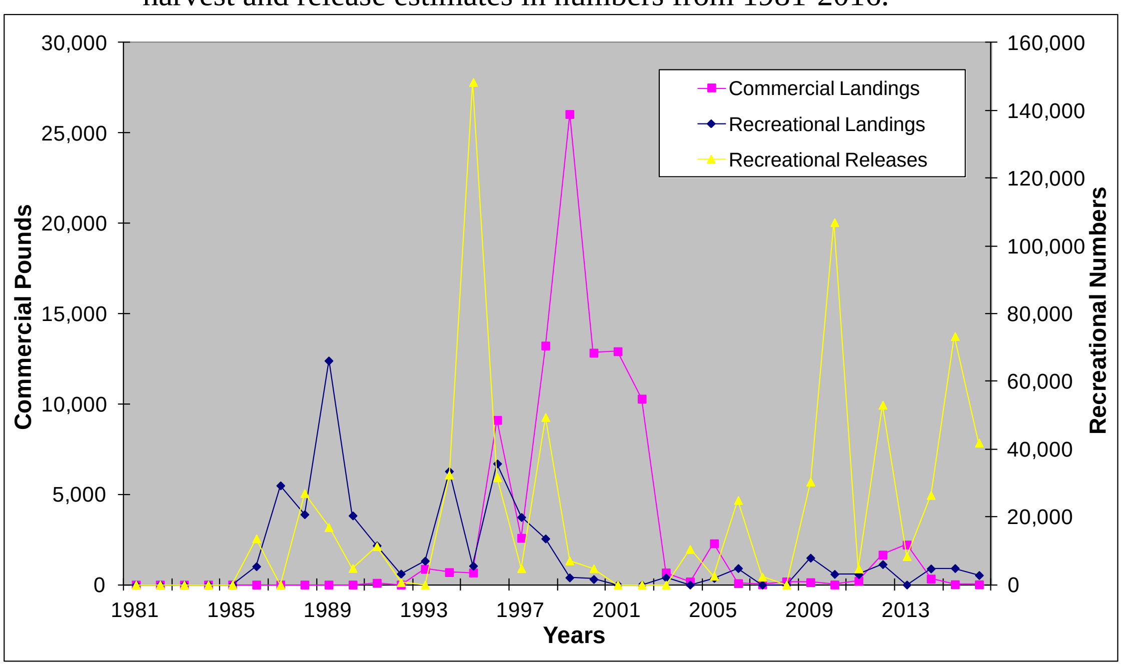


Figure 38. Maryland Charter boat log book spotted seatrout harvest in numbers and the number of anglers participating in trips catching spotted seatrout, 1993-2016.

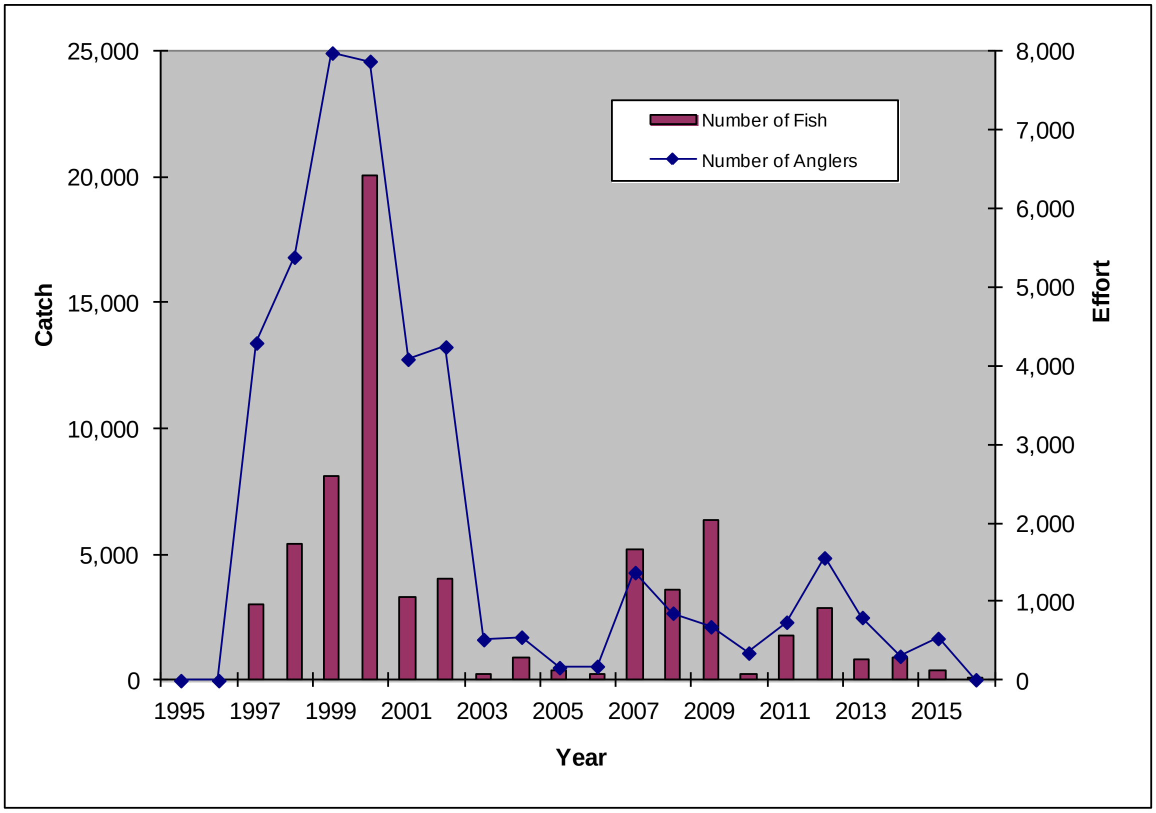


Figure 39. Atlantic menhaden length frequency distributions from onboard pound net sampling, 2008-2017.

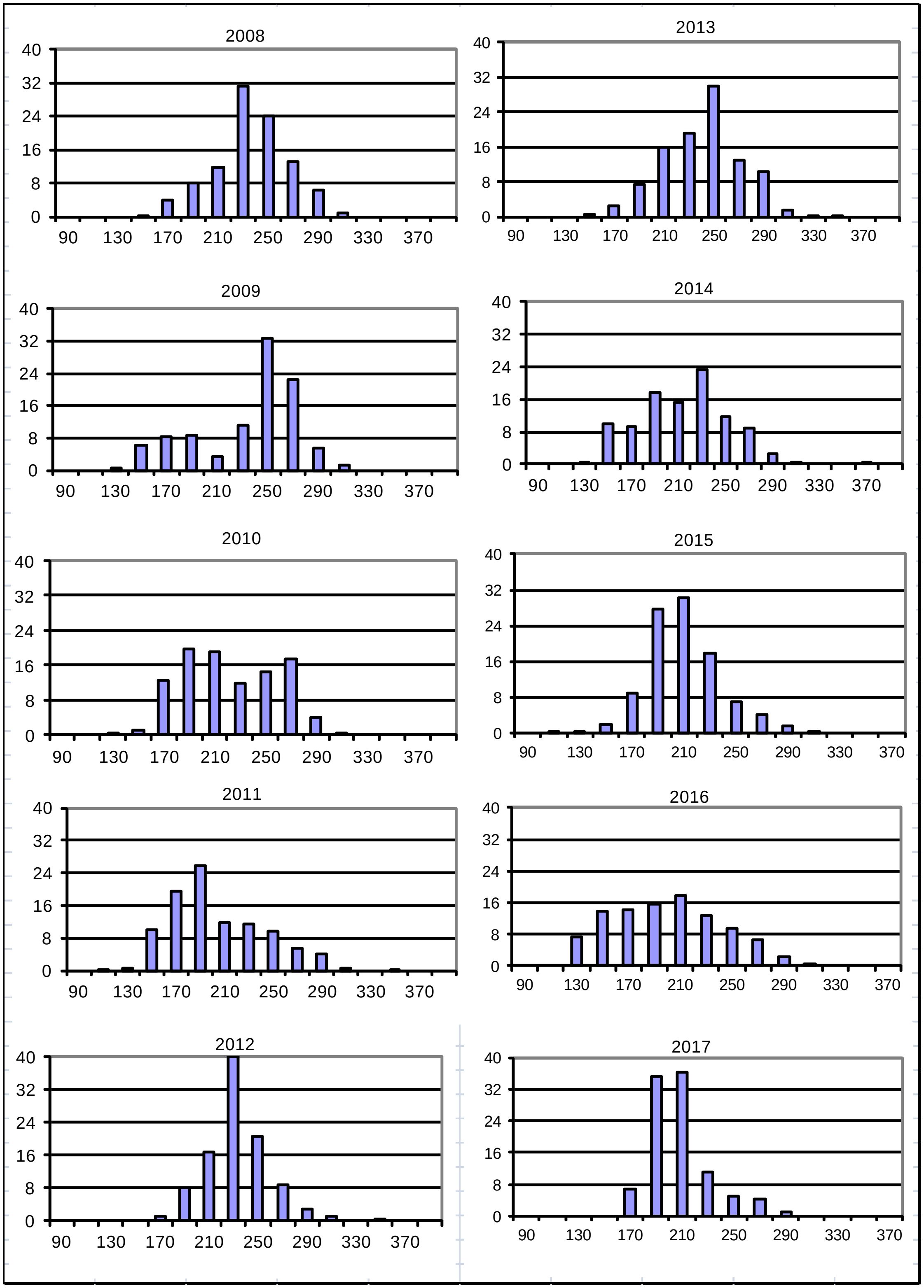


Figure 40. Atlantic menhaden length frequency distributions from the seafood dealer sampling in 2017.

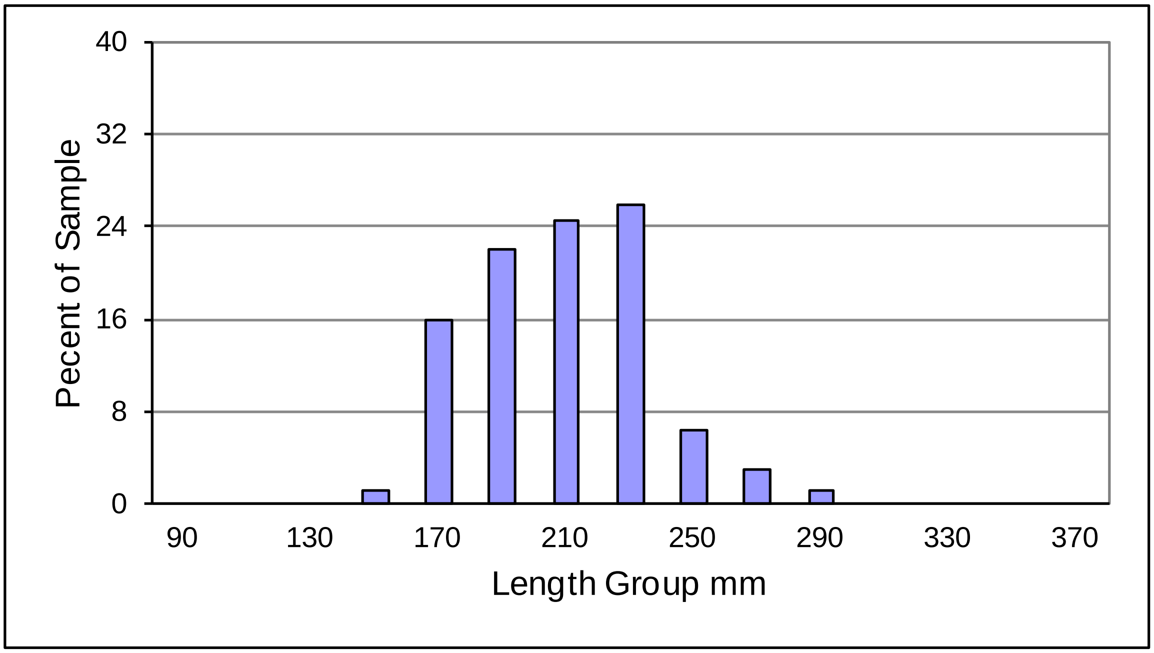


Figure 41. Atlantic menhaden proportion of catch by panel and year from the Choptank River gill net survey, 2013-2017.

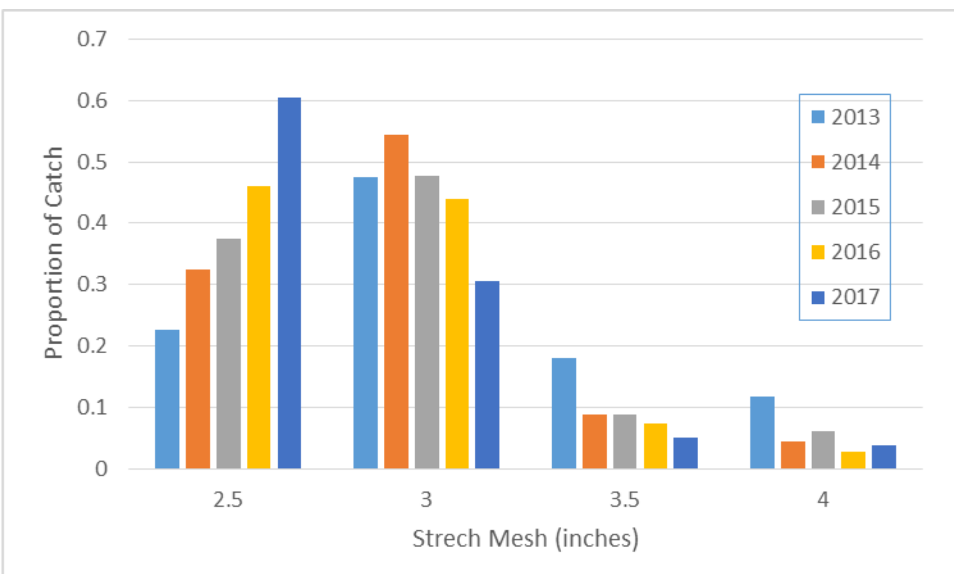


Figure 42. Atlantic menhaden length frequency distributions from the Choptank River gill net survey by year, 2013-2017.

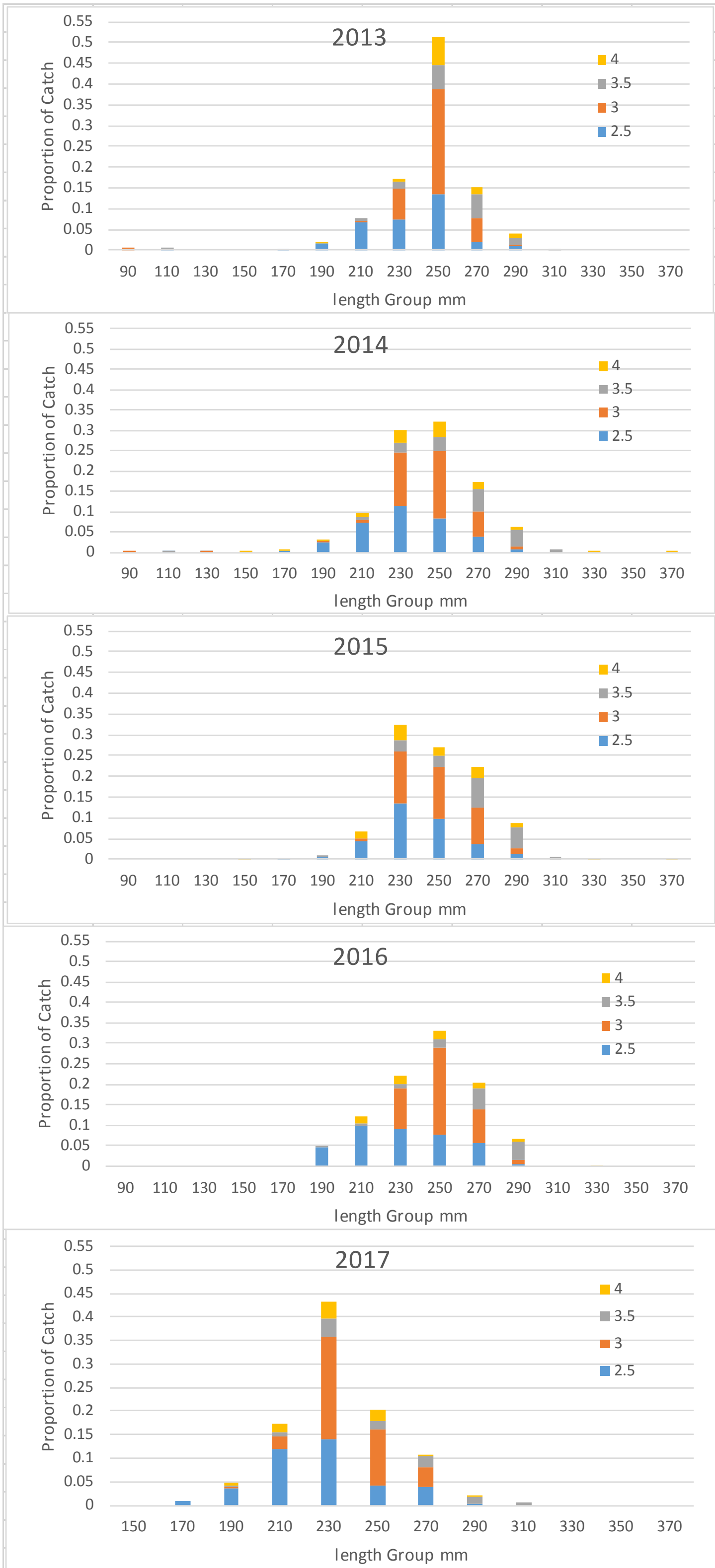
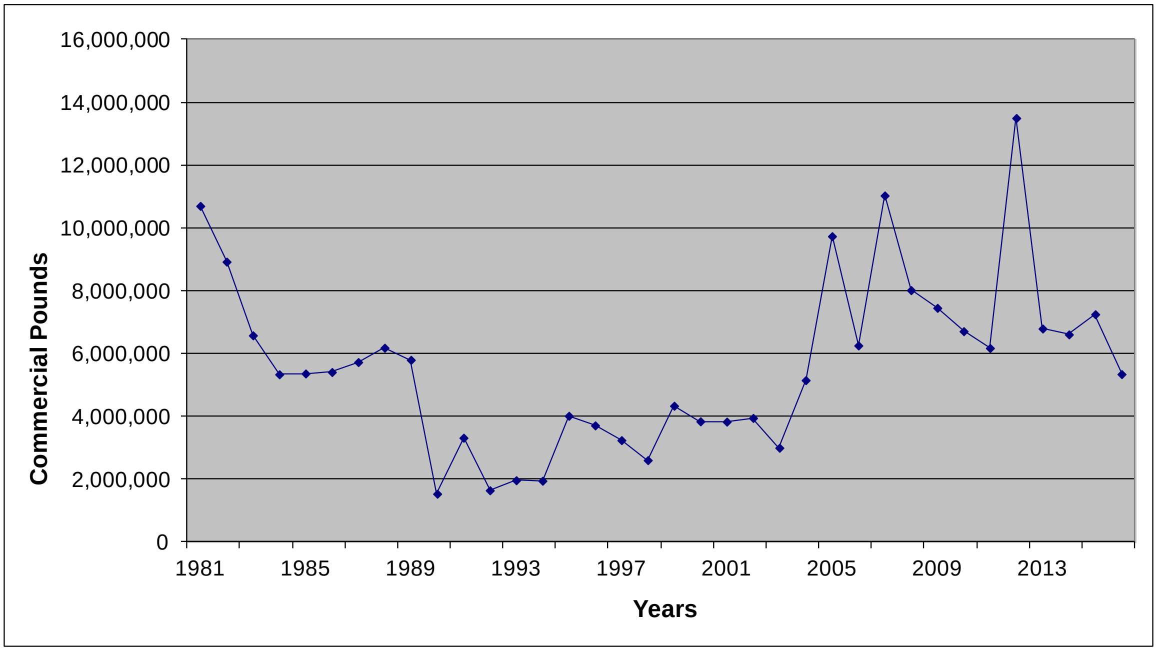


Figure 43. Maryland's Chesapeake Bay commercial landings for Atlantic menhaden from 1981-2016.



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 characterize the size and age structures of the 2016 Maryland striped bass *Morone saxatilis* commercial summer/fall fishery. The commercial fishery during the summer/fall in 2016 operated on a combination of a common pool fishery and individual transferable quota (ITQ) system (see Project 2, Job 3, Task 5A). The 2016 ITQ commercial summer/fall fishery was open from 1 June through 30 November, with an extension for pound net gear to 31 December. The season typically runs from 1 June to 30 November, but was extended to allow fishermen the opportunity to catch their entire quota. The common pool fishery was open two days each in June, July, August, September, 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 structure of the commercial harvest, 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 2016 commercial fishery season were used to characterize the length and age structure of the entire 2016 Chesapeake Bay commercial harvest and the majority of the recreational harvest.

METHODS

Commercial pound net monitoring

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

Pound net sampling occurred one to four times per month from June through November 2016 (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 2016, striped bass were sampled from pound nets in the upper and lower Bay. Whenever possible, all striped bass in each pound net were measured in order to investigate by-catch. A full net sample was not possible when pound nets contained too many fish to be transferred to 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 striped bass 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 2016 (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 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 dispersed 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 650 mm TL (maximum three samples per length group per month) and from all fish greater than 650 mm TL. A subsample of five fish per 10 mm length group per trip was used if a high number of large fish 650 to 700 mm TL were encountered. All scales from fish >700 mm TL were taken.

<u>Analytical Procedures</u>

Scale ages from the pound net and check station surveys were combined and applied to all fish sampled. The decision to apply ages from the pound net fishery to hook and line fish was based on the study by Fegley (2001) in which striped bass sampled from pound nets and from commercial hook-and-line check stations were examined for possible differences in length at age. An analysis of covariance (Sokal and Rohlf 1995) test failed to detect an age*gear interaction ($P>0.05$, $F=0.8532$). Striped bass harvested by each gear exhibited statistically indistinguishable and nearly identical age-length relationships; therefore ages derived from one fishery could be applied to the other. This is not surprising since both fisheries are concurrent within Maryland, and minimum and maximum size regulations are identical.

Age composition of the summer/fall fishery was estimated via two-stage sampling (Kimura 1977, Quinn and Deriso 1999). In the first stage, total length and scale samples were taken based on

10 mm length groups, which were assumed to be a random sample of the commercial harvest. In stage two, a fixed sub-sample of scales were randomly chosen to be aged based on 20 mm length groups. Scales from check station surveys and pound net monitoring were combined to create the ALK. Approximately twice as many scales as ages per length group were selected to be read based on the variance of ages per length group (Barker et al. 2004). Target sample sizes were: length group<300 mm=3 scales per length group; 300-400 mm=4 scales per length group; 400-700 mm=5 scales per length group; >700 mm=10 scales per length group. In some cases, the actual number of scales aged was limited by the number of samples available per length group.

Year-class was determined by reading 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 recruitment into the summer/fall fishery, the age structure of the harvest over time was examined. The age structure of the harvest for the 2016 summer/fall fishery was also compared to previous years. An ANOVA with a Duncan's multiple range test (SAS 2006) was performed to compare lengths and weights of striped bass harvested between months in 2016.

Mean lengths- and weights-at-age of striped bass landed in the summer/fall fishery were derived by applying ages to all sampled fish, and weighting the means on the length distribution at each age. Mean lengths- and weights-at-age were calculated by year-class for the aged sub-sample of fish. Mean lengths-at-age and weights-at-age were also estimated for each year-class using an expansion method. Expanded means were calculated with an age-length key and a probability table which applied ages from the sub-sample of aged fish to all sampled fish. Age-specific length distributions based on the aged sub-sample are often different than the age-specific length distribution based on the entire length sample. Bettoli and Miranda (2001) suggested that the sub-sample means-at-age are often biased. The two calculation methods would result in equal means only if the length distributions for each age-class were normal, which rarely occurs in these data. Finally, length frequencies from the pound net monitoring and check station samples were examined.

RESULTS and DISCUSSION

Commercial pound net monitoring

During the 2016 striped bass pound net study, a total of 5,727 striped bass were sampled from eight pound nets in the upper Bay and three pound nets in the lower Bay. The eleven nets were sampled a total of 23 times during the study (Table 1).

Striped bass sampled from pound nets ranged from 195-960 mm TL, with a mean length of 485 mm TL (Figure 2). In 2016, 47% of striped bass collected from full net samples were less than the commercial minimum legal size of 18 inches (457 mm) TL, while 32% of fish from partially sampled nets were sub-legal. Mean total lengths of the aged sub-sample from pound nets are presented in Table 2.

Striped bass sampled from pound nets ranged from 1 to 12 years of age when the combined age length key was applied to the entire sample (Table 3, Figure 2). Age 5 fish from the above average 2011 year-class contributed 32% in 2016, which was lower than the contribution in 2015 (54%). Striped bass age 6 and comprised 10% of the sample, which was higher than their contribution in 2015 (7%) and 2014 (7%; Figure 3). Length frequencies of legal sized striped bass (n=3,571) sampled at pound nets were almost identical to length distributions from the check stations (Figure 4).

Commercial summer/fall check station monitoring

A total of 2,217 striped bass were sampled at summer/fall check stations in 2016. The mean length of sampled striped bass was 556 mm TL. Striped bass sampled from the summer/fall fishery ranged from 446 to 901 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 for the 2016 summer/fall fishery are shown in Tables 4 and 5.

The combined length frequency and ages of the sampled fish were applied to the total summer/fall fishery harvest. Striped bass in the 450-550 mm length groups accounted for 66% of the summer/fall harvest (Figure 5). As in past years, few large fish were available to the summer/fall fishery. Striped bass over 700 mm TL were harvested throughout the season (Figure 6), but contributed only 9% to the overall harvest. Historically, these fish have not been available in large numbers during the summer (MD DNR 2002).

The 2016 summer/fall reported harvest accounted for 54%, by weight, of the Maryland Chesapeake Bay total commercial harvest in 2016 with 765,313 pounds landed (see Project 2, Job 3, Task 5A). Landings reported by the MD DNR commercial reporting section were 154,238 pounds for hook and line gear and 611,075 pounds for pound net gear. The estimated 2016 catch-at-age in pounds and numbers of fish for the summer/fall fishery is presented in Table 6. A three year old fish (2013 year class) was not encountered in the subsample, however, the combined age length key showed this year class was present in pound nets. Mean weight-at-age was obtained for these fish from the ASMFC Compliance report (Durell 2016). By weight, the majority (90%) of the harvest was composed of four to six year-old striped bass. Striped bass from the above average 2011 (age 5) year class contributed 48% to the harvest and were the highest contribution to the fishery. Striped bass from the 2012 year class (age 4) contributed the second highest percentage to the harvest (30%). Striped bass age 8 and older contributed 6% to the overall harvest in 2016, which was similar to 2015 (6%).

Monitoring summary

Striped bass ranging from 457 to 550 mm TL composed 66% of the 2016 summer/fall harvest. A higher percentage of fish >630 mm TL were harvested in 2016 (18%) compared to 2015 (16%; Figure 5). In 2016, 127 fish from pound net monitoring and 96 fish from check station sampling were aged. Younger fish (age 4 to 6) were abundant, accounting for the majority of the harvest (Figure 7). Length frequencies of legal-sized fish sampled from pound nets and all fish from check stations were almost identical (Figure 4). Mean lengths-at-age have remained nearly the same since 2000 (Figure 8).

A Duncan's multiple range test (SAS 2006) was performed on lengths and weights of striped bass harvested between months (p=0.05). Striped bass were significantly largest (TL= 574 mm and WT=2.02 kg) in November and smallest in October and September (TL=543 and 539 mm and WT=1.59 and 1.49 kg, respectively). 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

2017 PRELIMINARY RESULTS – WORK IN PROGRESS

Commercial pound net monitoring

During the 2017 striped bass pound net study, a total of 6,023 striped bass were sampled and 706 scale samples were collected for ageing from four pound nets in the upper Bay and two pound nets in the lower Bay. The six nets were sampled a total of 19 times during the study.

Striped bass sampled from pound nets ranged from 277-902 mm TL, with a mean length of 475 mm TL. In 2017, 39% of striped bass collected from full net samples were less than the minimum legal size of 18 inches (457 mm) TL, while 52% of fish from partially sampled nets were sub-legal. A breakdown of catch by age will be available in the next F-61 Chesapeake Bay Finfish Investigations report.

Commercial summer/fall check station monitoring

A total of 1,988 striped bass were sampled and 588 scale samples were collected for ageing at summer/fall check stations in 2017. The mean length of sampled striped bass was 581 mm TL. Striped bass sampled from the summer/fall fishery ranged from 444 to 920 mm TL. Less than 1% of the sampled harvest was sub-legal (<457 mm TL). Mean lengths-at-age and weights-at-age will be available in the next F-61 Chesapeake Bay Finfish Investigations report.

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Table 1. Summary of sampling areas, sampling dates, surface temperature, surface salinity and numbers of fish encountered during the 2016 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	3	23.6	9.9	1110
	Middle	-	-	-	-
	Lower	1	23.3	13.6	164
July	Upper	1	28.0	-	237
	Middle	-	-	-	-
	Lower	1	30.0	-	173
August	Upper	2	27.8	11.1	670
	Middle	-	-	-	-
	Lower	1	28.5	15.4	269
September	Upper	3	24.4	5.1	562
	Middle	-	-	-	-
	Lower	1	23.0	16.4	312
October	Upper	3	17.7	7.3	704
	Middle	-	-	-	-
	Lower	1	17.3	17.1	233
November	Upper	3	13.3	3.3	409
	Middle	-	-	-	-
	Lower	3	13.4	15.1	884

Table 2. Mean length-at-age (mm TL) of striped bass sampled from pound nets in Maryland's Chesapeake Bay, June through November 2016.

Year-class	Age	n	Mean Length (mm TL)	Lower CL	Upper CL
2015	1	15	257	230	284
2014	2	26	345	326	364
2013	3	16	418	403	433
2012	4	10	498	453	543
2011	5	22	594	555	633
2010	6	17	673	636	711
2009	7	5	732	698	765
2008	8	6	779	702	856
2007	9	6	815	773	831
2006	10	2	824	*	*
2005	11	2	883	*	*

*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 2016.

Year-class	Age	Pound Net Monitoring	
		Number Sampled at Age (n)	Percent of Total
2015	1	165	2.9
2014	2	992	17.3
2013	3	847	14.8
2012	4	1,324	23.1
2011	5	1,830	32.0
2010	6	450	7.9
2009	7	40	0.7
2008	8	30	0.5
2007	9	37	0.6
2006	10	7	0.1
2005	11	4	0.1
2004	12	1	0.0
Total*		**5,727**	**100.0**

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

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 2016.

Year-class	Age	n	Mean Length (mm TL)	Lower CL	Upper CL
2012	4	8	491	475	507
2011	5	23	591	565	617
2010	6	11	686	634	737
2009	7	8	764	740	787
2008	8	10	781	742	821
2007	9	20	809	786	831
2006	10	8	833	803	863
2005	11	7	845	829	861
2004	12	1	886	-	-

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 2016.

Year-class	Age	n	Mean Weight (kg)	Lower CL	Upper CL
2012	4	8	1.07	0.91	1.24
2011	5	23	2.11	1.77	2.45
2010	6	11	3.46	2.66	4.25
2009	7	8	4.60	4.30	4.91
2008	8	10	4.94	4.23	5.65
2007	9	20	5.38	4.87	5.89
2006	10	8	6.11	5.30	6.92
2005	11	7	6.35	5.92	6.78
2004	12	1	7.26	-	-

Table 6. Estimated catch-at-age of striped bass landed by Maryland Chesapeake Bay commercial summer/fall fishery, June through November 2016.

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**
2013**	3	19,216	2.5	9,905	4.9
2012	4	231,861	30.3	98,290	48.2
2011	5	366,282	47.9	78,741	38.6
2010	6	89,614	11.7	11,748	5.8
2009	7	14,794	1.9	1,459	0.7
2008	8	12,473	1.6	1,145	0.6
2007	9	20,283	2.7	1,710	0.8
2006	10	6,118	0.8	454	0.2
2005	11	4,442	0.6	317	0.2
2004	12	230	0.0	14	0.0
Total*		**765,313**	**100.0**	**203,784**	**100.0**

* Sum of columns may not equal totals due to rounding.
** 2013 year class fish were not encountered in the subsample. Mean weight at age was obtained from ASMFC 2016 Compliance Report to calculate landings in pounds of fish and numbers of fish.

Table 7. Duncan's multiple range test for mean length by month for the Maryland Chesapeake Bay commercial summer/fall fishery, June through November 2016. Months with the same Duncan grouping letter are not significantly different in mean length.

Duncan Grouping	Month	Mean Length (mm)	Number of Fish Sampled
A	November	574	270
A,B	July	567	339
A,B	June	561	332
B	August	559	426
C	October	543	477
C	September	539	373

Table 8. Duncan's multiple range test for mean weight by month for the Maryland Chesapeake Bay commercial summer/fall fishery, June through November 2016. Months with the same Duncan grouping letter are not significantly different in mean weight.

Duncan Grouping	Month	Mean Weight (kg)	Number of Fish Sampled
A	November	2.02	270
A,B	July	1.96	339
A,B	June	1.89	332
B	August	1.82	426
C	October	1.59	474
C	September	1.49	372

Figure 1. Locations of Chesapeake Bay commercial summer/fall check stations sampled from June through November 2016.

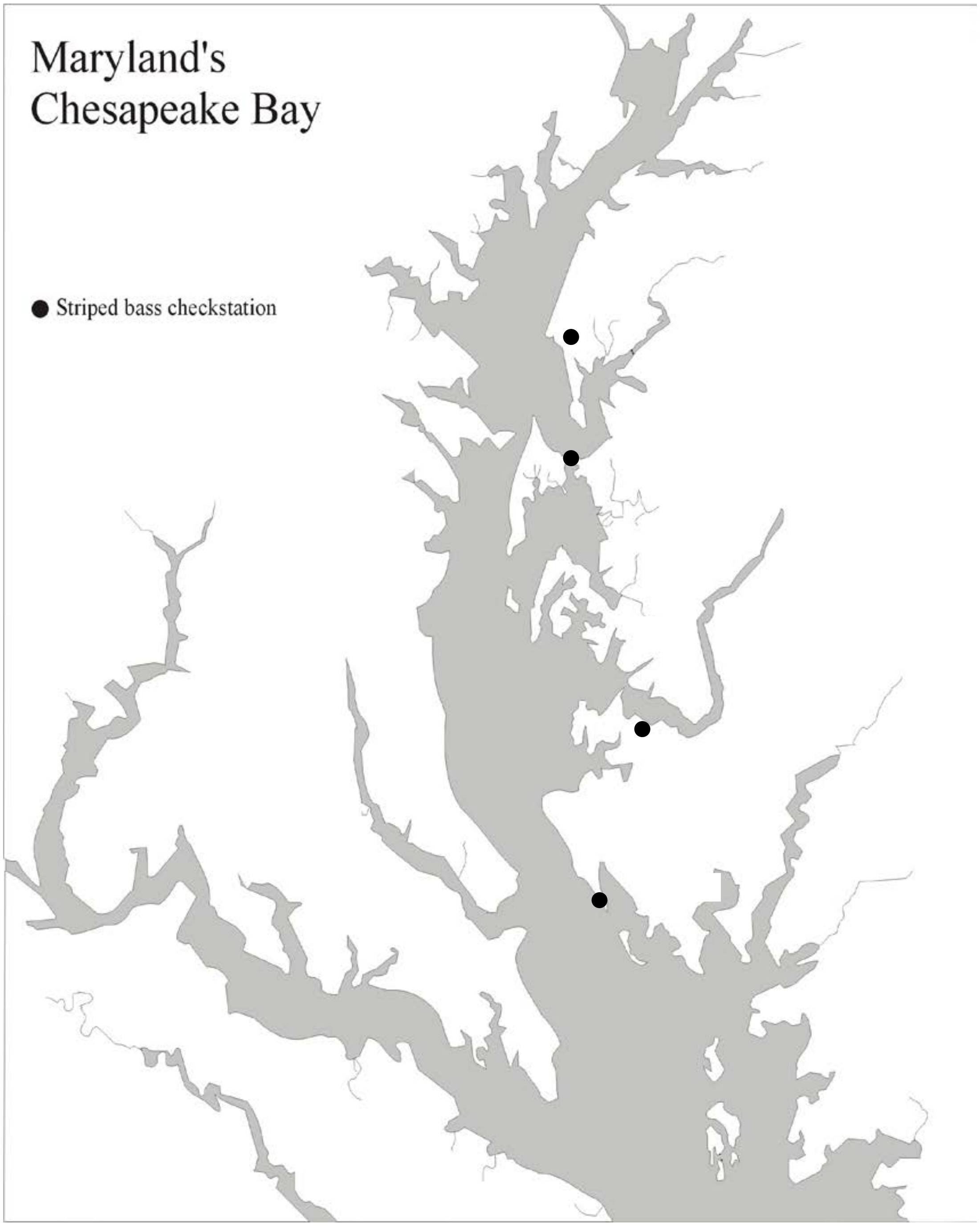
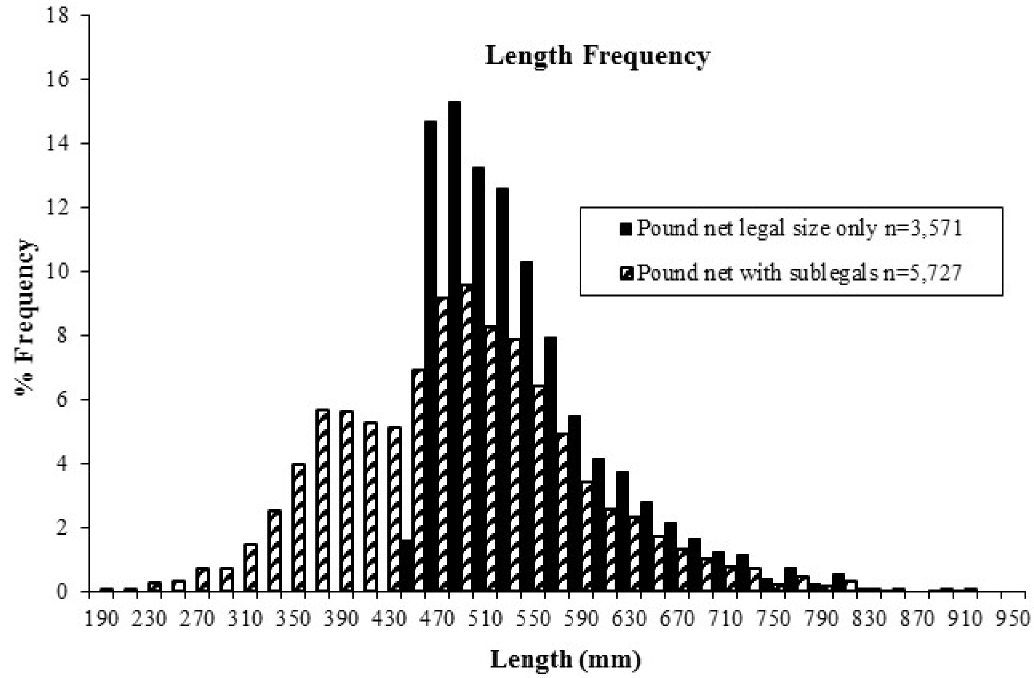


Figure 2. Age and length (mm TL) frequencies of striped bass sampled during Maryland Chesapeake Bay pound net monitoring study, June through November 2016.



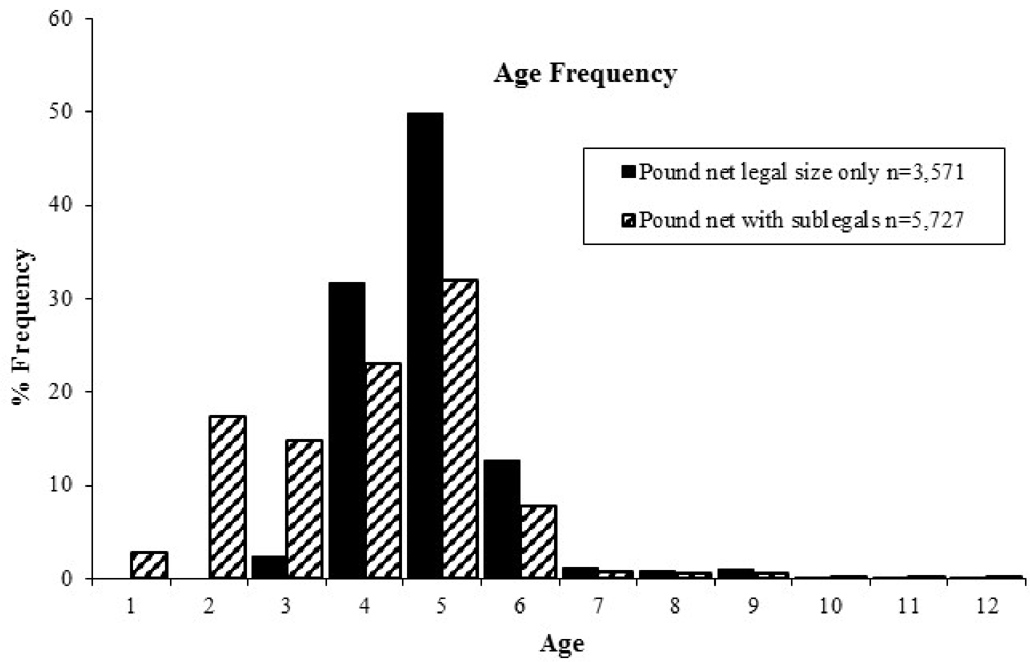


Figure 3. Age structure of striped bass sampled from Maryland Chesapeake Bay commercial pound net monitoring study from 1996 through 2016. *Note partial net sampling for legal sized fish was conducted from 1996 to 1999. Full net samples started in 2000.

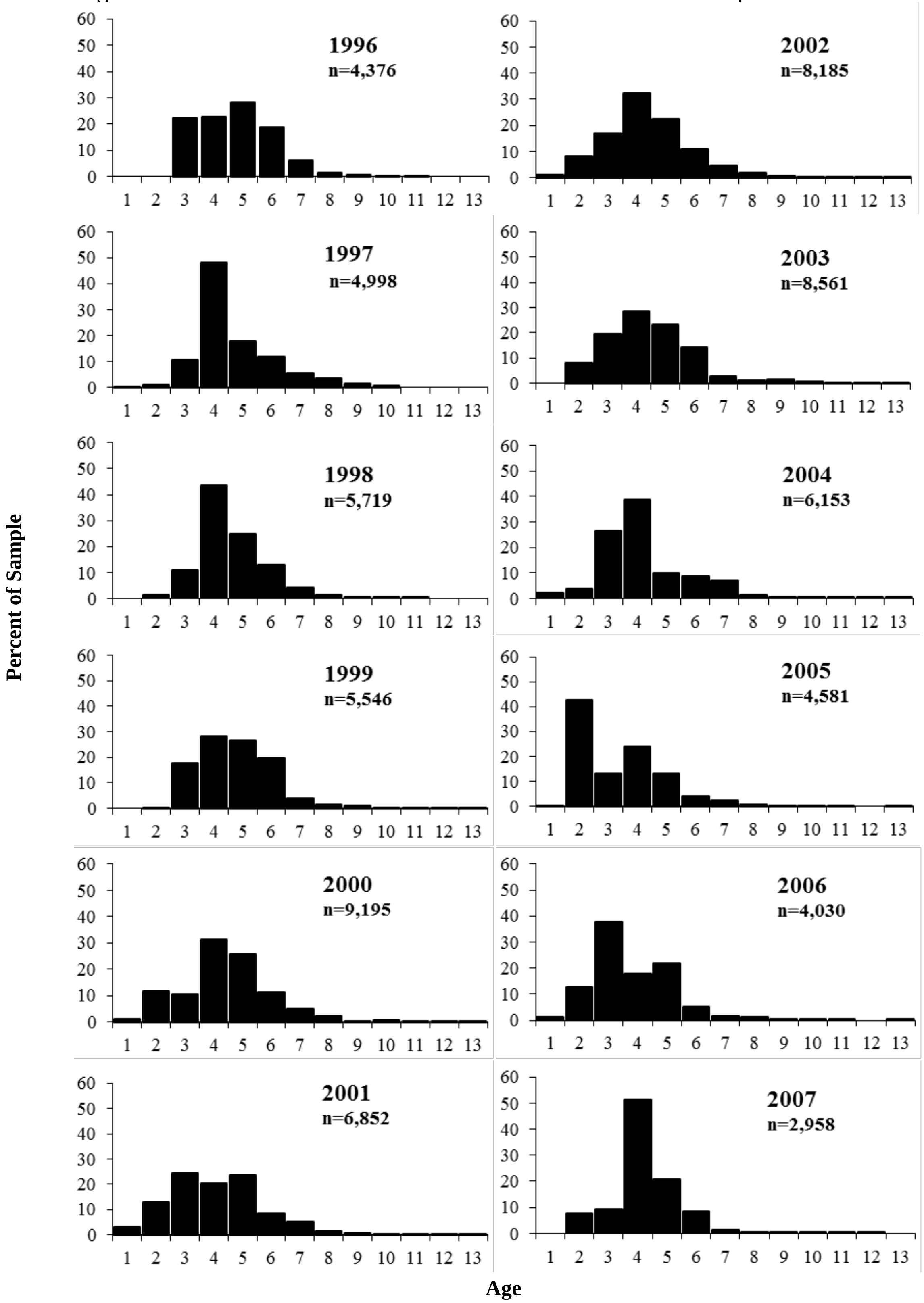


Figure 3. Continued.

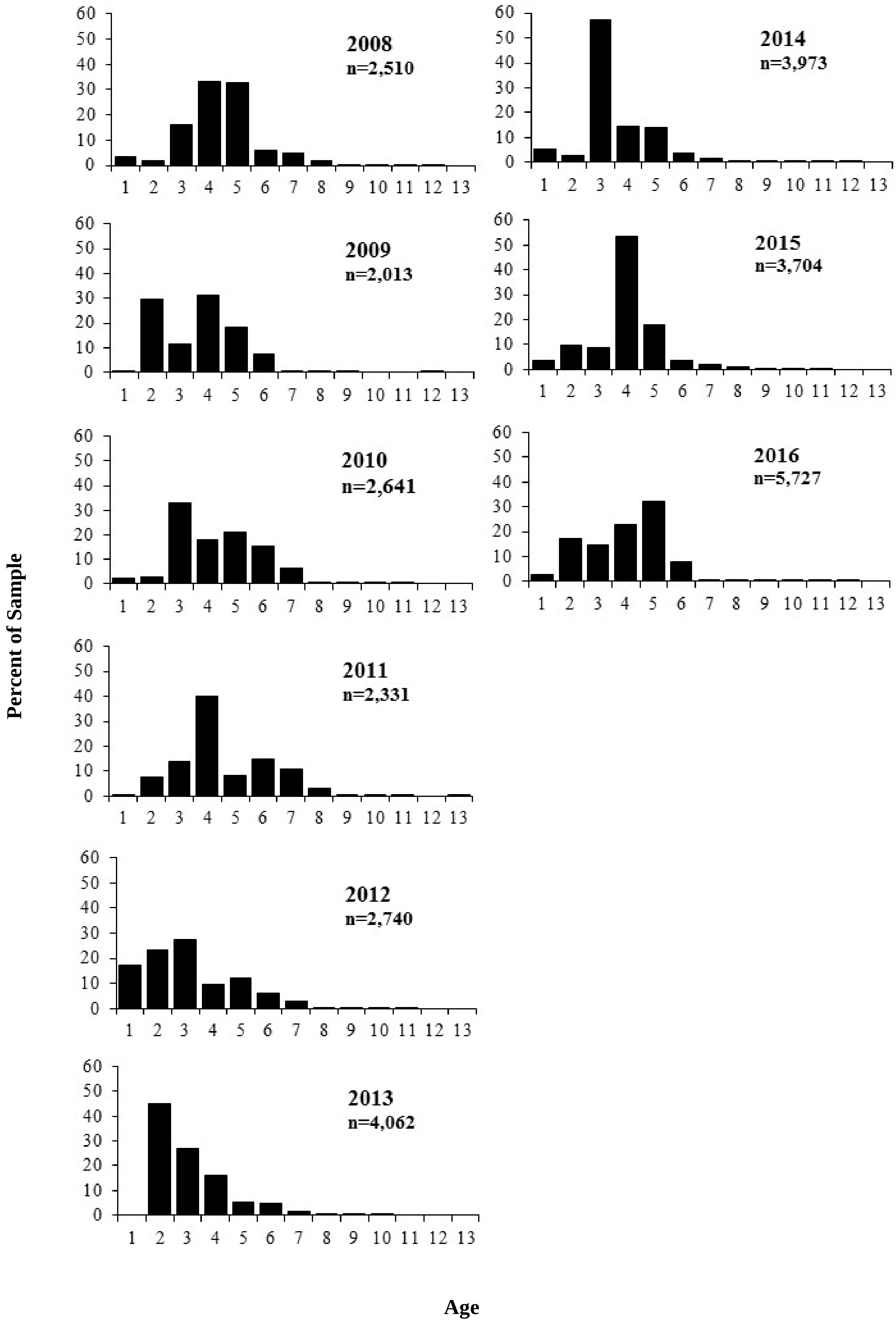


Figure 4. Length frequency of striped bass sampled during the 2016 pound net monitoring and the summer/fall check station surveys. All fish were sampled from June through November 2016. Pound net monitoring length frequency is for legal-size fish only (≥457 mm TL/18 in TL).

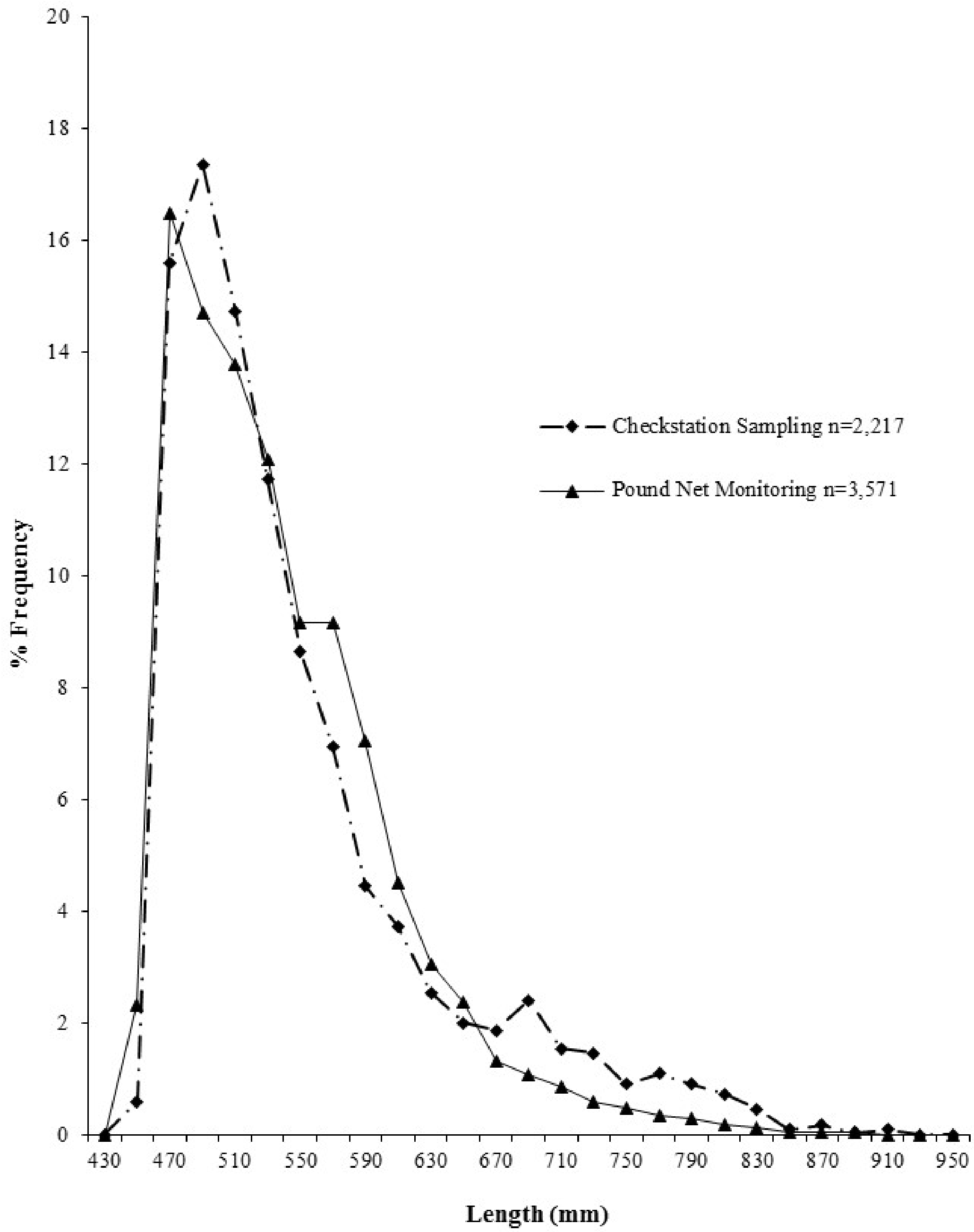
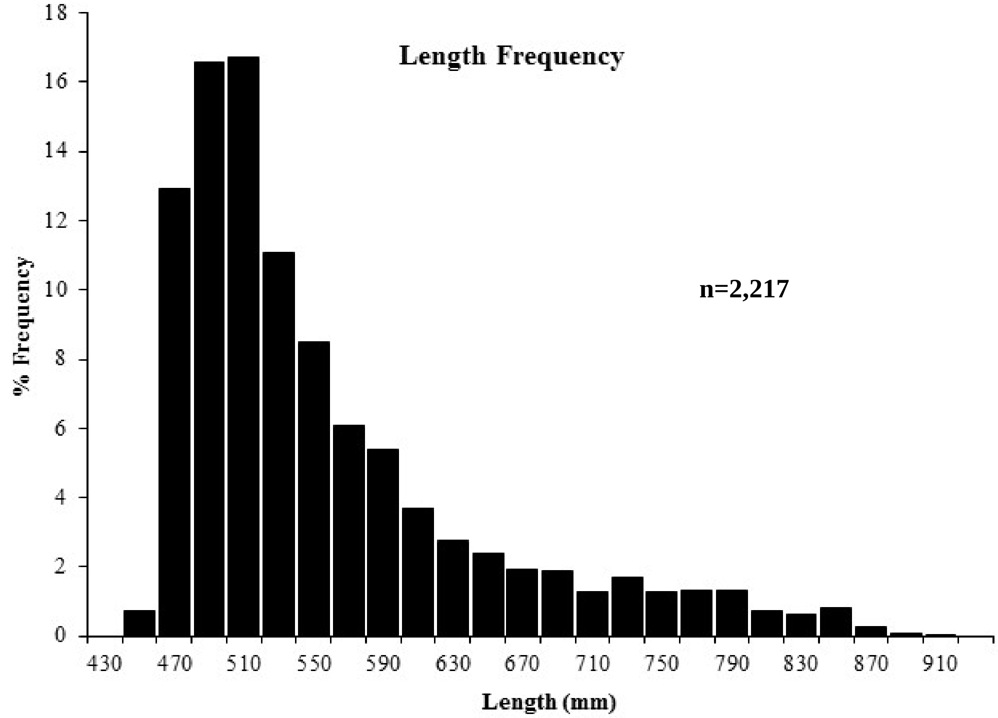


Figure 5. Age and length frequencies of striped bass sampled from Maryland Chesapeake Bay commercial summer/fall check stations, June through November 2016.



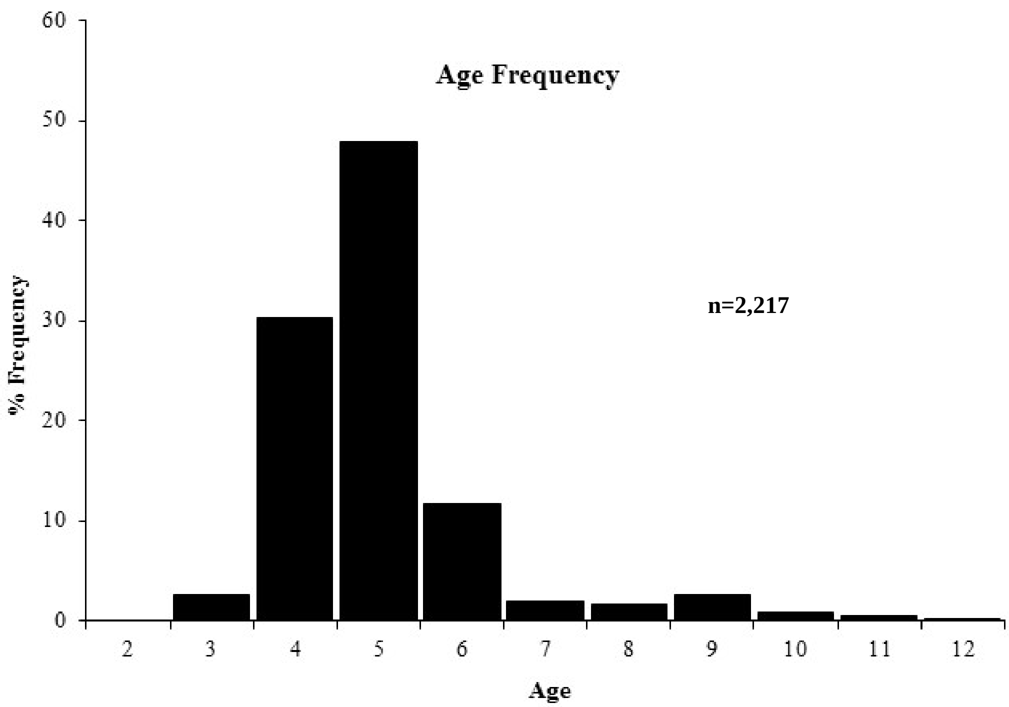


Figure 6. Month-specific length distributions of striped bass sampled from Maryland Chesapeake Bay commercial summer/fall check stations, June through November 2016.

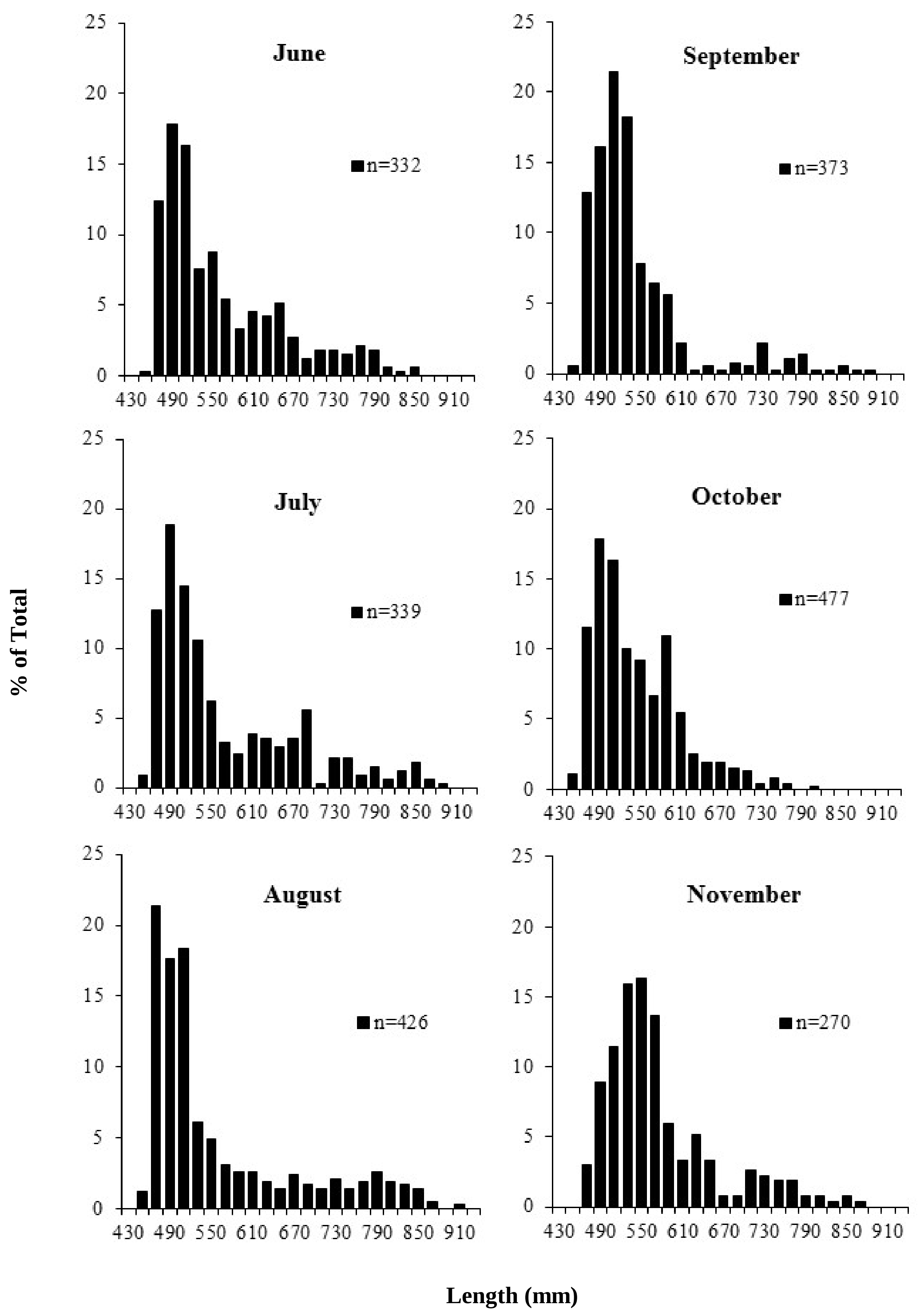
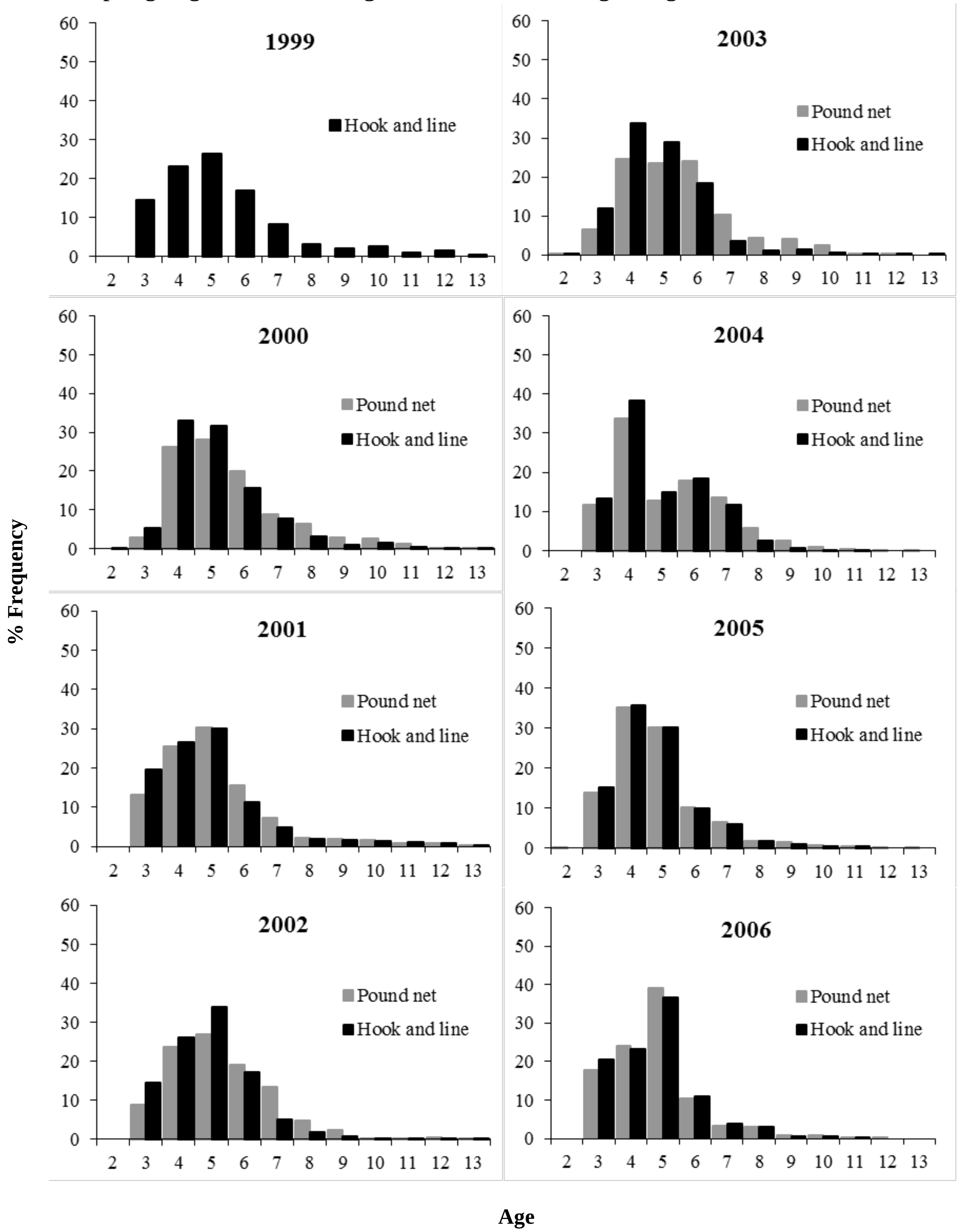


Figure 7. Age structure of striped bass sampled from Maryland Chesapeake Bay commercial summer/fall check stations, 1999 through 2016. Note-pound net check station sampling began in 2000 and gears are combined beginning in 2014.



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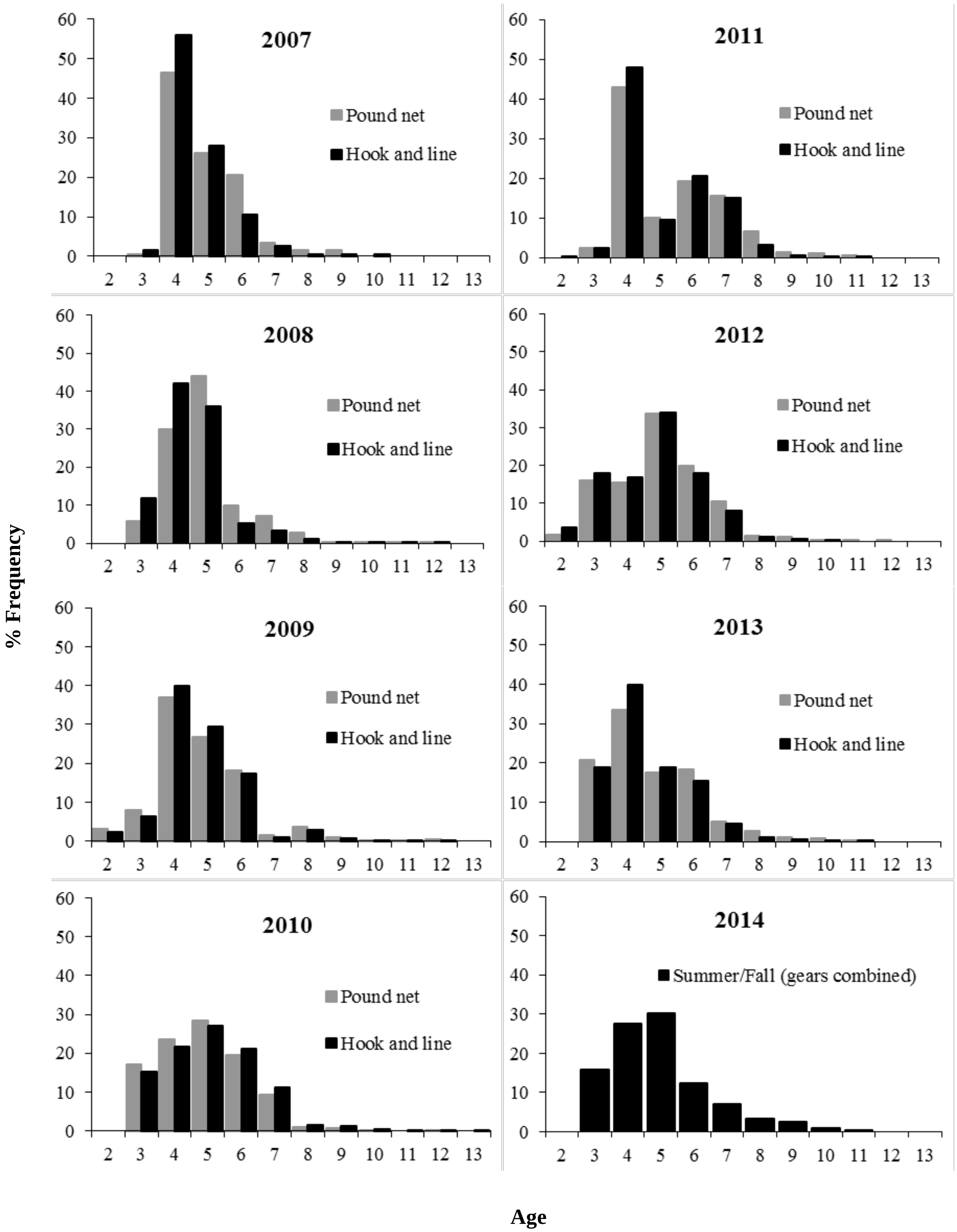
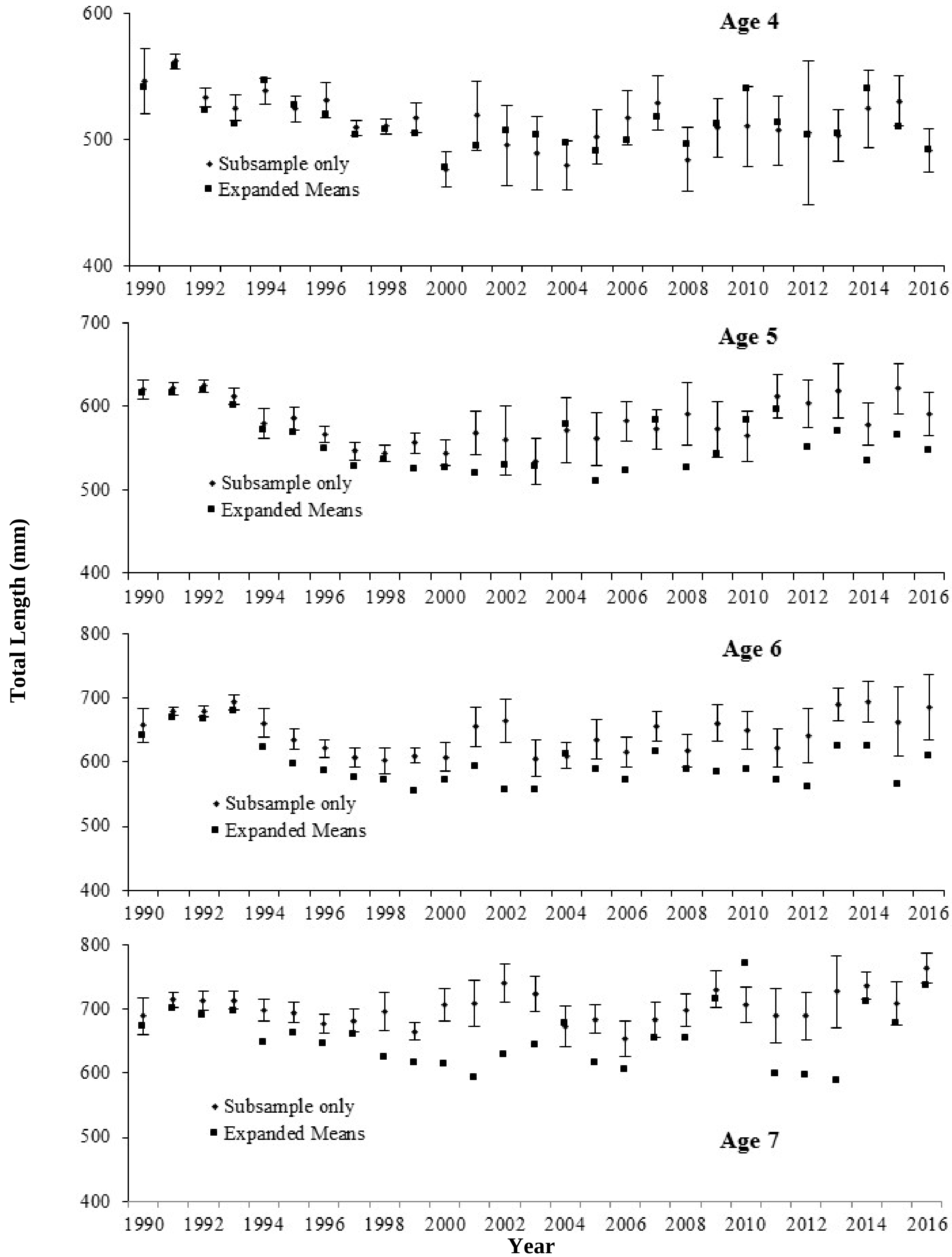


Figure 7. Continued

Figure 8. Mean lengths for legal-size striped bass (≥457 mm TL) by year for age 4, 5, 6, and 7 striped bass sampled from Maryland Chesapeake Bay pound nets and commercial summer/fall check stations, 1990 through 2016. 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 characterize the size and age structure of striped bass (*Morone saxatilis*) sampled from the December 1, 2016 – February 28, 2017 commercial drift gill net fishery. 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.

In 2014, Maryland's Chesapeake Bay commercial fisheries switched to an individual transferable quota (ITQ) system (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. This fishery was only open for one day in December, three days in January and two days in February.

METHODS

Data collection procedures

All striped bass harvested in Maryland's commercial striped bass fishery are required to pass through a Maryland Department of Natural Resources (MD DNR) approved check station. Striped bass check stations were sampled for the winter stock assessment according to a stratified random sampling design. Strata were defined as either high-use, medium-use, or low-use check stations based on landings from the previous year. Individual check stations that processed 8% or greater of the entire 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 were measured (mm TL) and weighed (kg). On days when fewer than 300 fish were checked in, all individuals were sampled. For fish less than 700 mm TL, scales were taken randomly from two fish per 10 mm length group per visit. For fish between 700 mm TL and 799 mm TL, scales were taken randomly from three fish per 10 mm length group per visit and scales were taken from all fish greater than or equal to 800 mm TL.

Analytical procedures

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

Ages were assigned to scales by viewing acetate impressions in a microfiche reader. The resulting age-length key was applied to the sample length-frequency to generate a sample age distribution. Finally, the age distribution of the total 2016-2017 winter gill net harvest was estimated by applying the sample age distribution to the total reported landings. Because the winter gill net season straddles two calendar years, ages were calculated by subtracting year-class (assigned by scale readers) from the year in which the fishery ended. For example, for the December 2016 – February 2017 gill net season, the year used for age calculations was 2017.

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

To examine recruitment into the winter drift gill net fishery and the age-class structure of the harvest over time, the expanded age structure of the 2016-2017 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 3,596 striped bass were sampled and 167 striped bass were aged from the harvest between December 2016 - February 2017. 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 Tilghman Island (Figure 1). Check stations were visited by biologists four times in December, eight times in January, and five 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 (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.

The number of fish landed for the 2016-2017 season was estimated by dividing reported monthly harvest weight by the mean monthly weight of check station samples. Total reported landings were 582,741 pounds and the estimated number of fish was 71,731 (Table 1). According to the catch-at-age analysis, the 2016-2017 commercial drift gill net harvest consisted primarily of age 6 striped bass from the 2011 year-class (36%; Table 2). The 2010 to 2008 year-classes (ages 7 to 9) composed an additional 59% of the total harvest. The contribution of fish older than age 9 (2%) was similar to the 2015-2016 harvest (3%). The youngest fish observed in the 2016-2017 sampled harvest were age 5 from the 2012 year class (4%).

Mean lengths and weights-at-age of the aged subsample and the estimated means from the expansion technique are presented in Tables 3 and 4. Expanded mean lengths and weights-at-age were generally slightly higher than subsample means for 5-7 year old fish and slightly lower for fish age 8 and older. Striped bass were recruited into the winter gill net fishery beginning at age 5 (2012 year-class), with an expanded mean length and weight of 545 mm TL and 1.98 kg, respectively. The 2011 year-class (age 6) was most commonly observed in the sampled landings and had an expanded mean length and weight of 625 mm TL and 3.10 kg, respectively. The expanded mean length and weight of the oldest fish in the aged subsample (age 12, 2004 year-class) were 862 mm TL and 7.82 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 570-750 mm length groups. Sub-legal fish have occasionally been sampled in previous years and two less than 18 inches were observed in 2016-2017 sampling.

Time series of subsampled and expanded mean lengths and weights for the period 1994-2017 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 and 7 have become less variable as the ITQ system has encouraged the harvest of larger, more profitable fish. Mean length-at-age and weight-at-age for ages 4, 5, 8, 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

2017-2018 WINTER STOCK ASSESSMENT AND COMMERCIAL FISHERY MONITORING

2017-2018 SEASON PRELIMINARY RESULTS

A total of 2,720 striped bass were sampled and 784 scale samples were collected from the harvest between December 2017 - February 2018. 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 on Tilghman Island. Check stations were visited by biologists five times in December, five times in January, and eight 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 of harvest-, length-, and weight-at-age will be provided in the next F-61 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 2016 - February 2017.

Month	**Harvest (lbs)**	**Check station average wt. (lb)**	**Estimated # harvested**
December 2016	113,902	7.876	14,445
January 2017	265,247	8.778	30,181
February 2017	203,592	7.502	27,106
Total*	**582,741**		**71,731**

Table 2. Estimated catch-at-age of striped bass (numbers of fish) landed by the Maryland Chesapeake Bay commercial drift gill net fishery, December 2016 - February 2017.

Year-class	**Age**	**Catch**	**Percentage of the catch**
2012	5	2,580	4
2011	6	25,815	36
2010	7	20,130	28
2009	8	14,911	21
2008	9	6,925	10
2007	10	788	1
2006	11	483	1
2005	12	100	0
Total*		**71,731**	**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 2016 - February 2017.

Year-class	Age	n fish aged	Mean TL (mm) of aged subsample	Estimated # at-age in sample	Expanded mean TL (mm)
2012	5	9	510	129	545
2011	6	45	582	1,294	625
2010	7	26	634	1,009	651
2009	8	33	747	748	706
2008	9	26	782	347	710
2007	10	14	838	40	810
2006	11	10	847	24	810
2005	12	4	872	5	862
Total*		**167**		**3,596**	

* 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 2016 - February 2017.

Year-class	Age	n fish aged	Mean weight (kg) of aged subsample	Estimated # at-age in sample	Expanded mean weight (kg)
2012	5	9	1.65	129	1.98
2011	6	45	2.64	1,294	3.10
2010	7	26	3.63	1,009	3.46
2009	8	33	5.26	748	4.36
2008	9	26	5.79	347	4.46
2007	10	14	7.14	40	6.42
2006	11	10	7.39	24	6.48
2005	12	4	8.20	5	7.82
Total*		**167**		**3,596**	

* 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 2016 - February 2017.

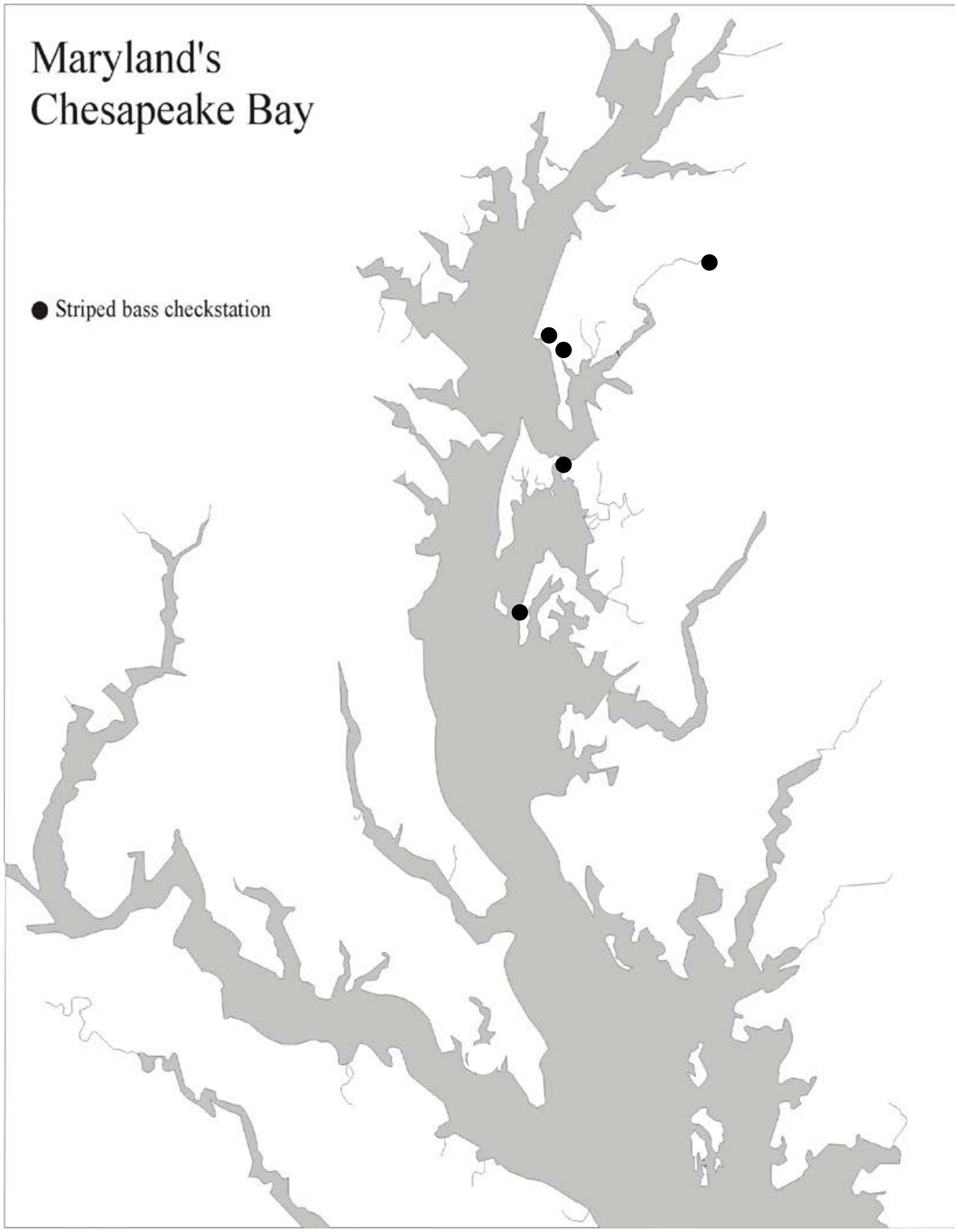
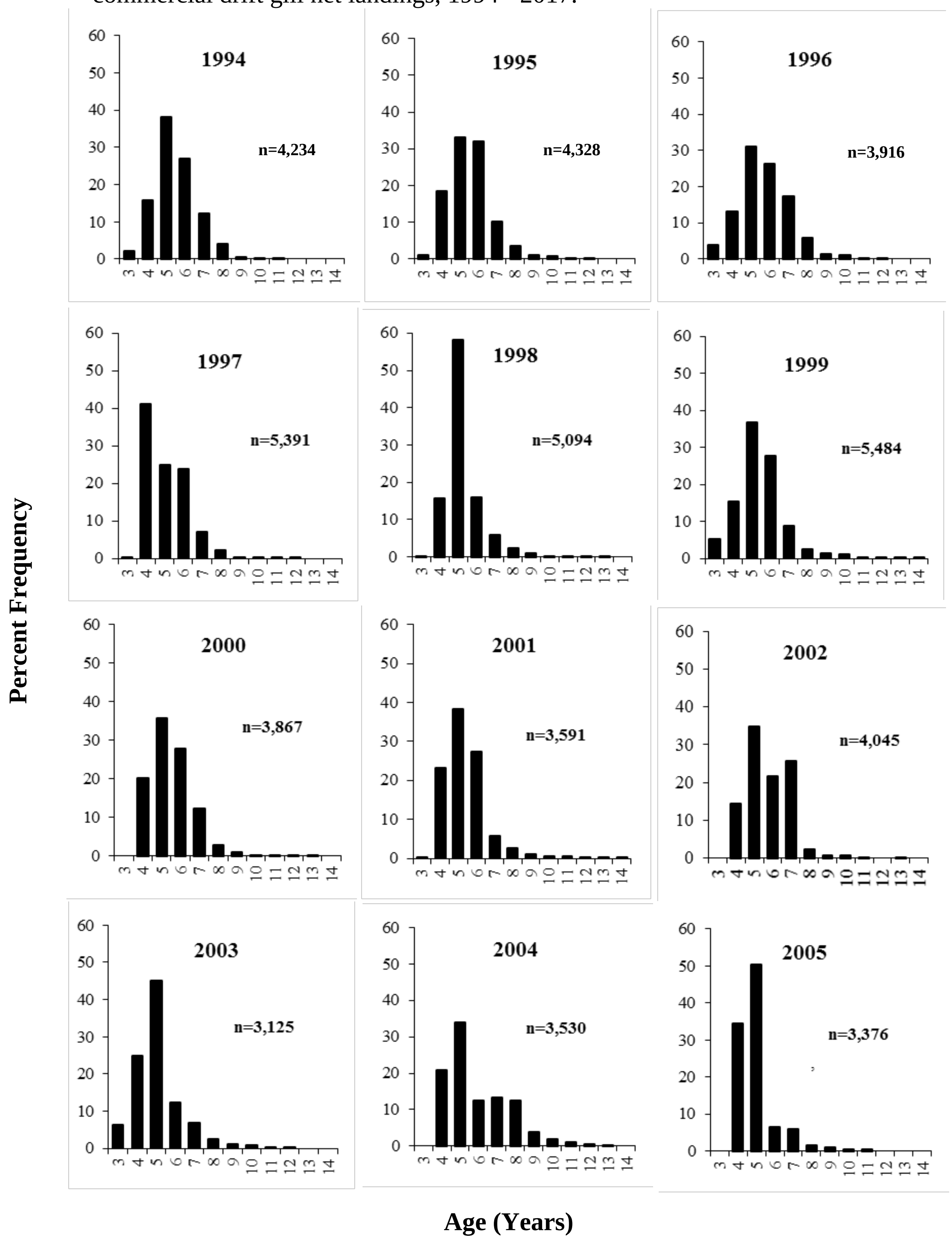


Figure 2. Age distribution of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, 1994 - 2017.



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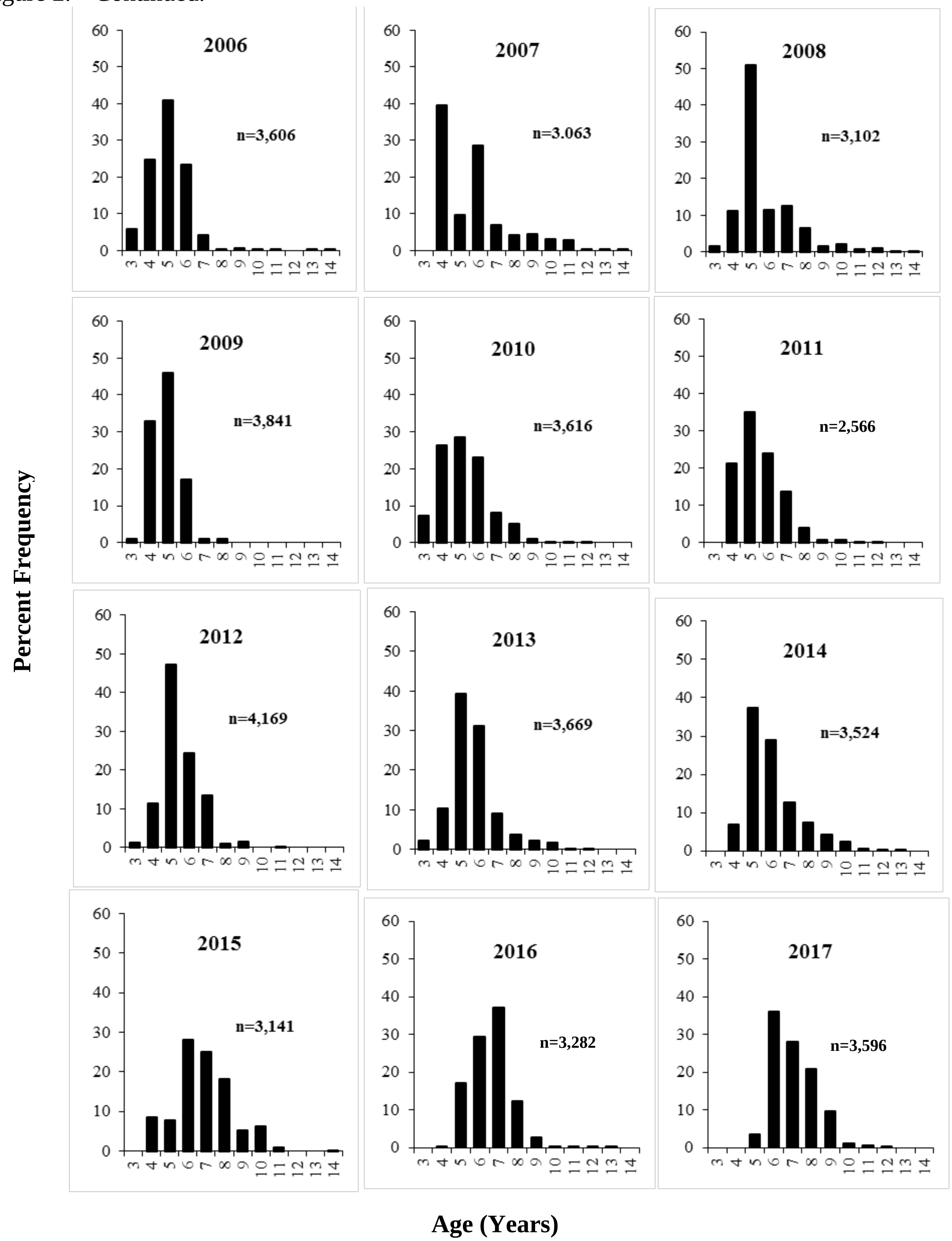


Figure 3. Length frequency distribution of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, December 2016 - February 2017.

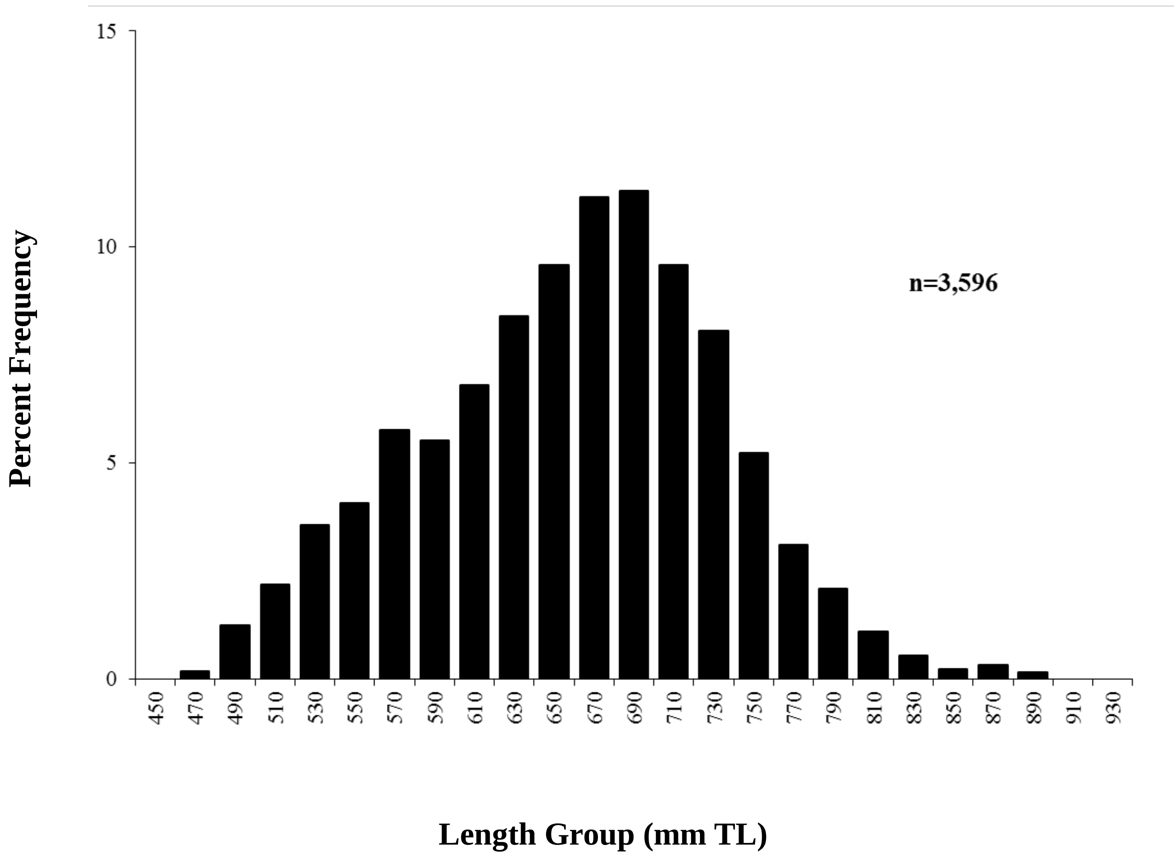
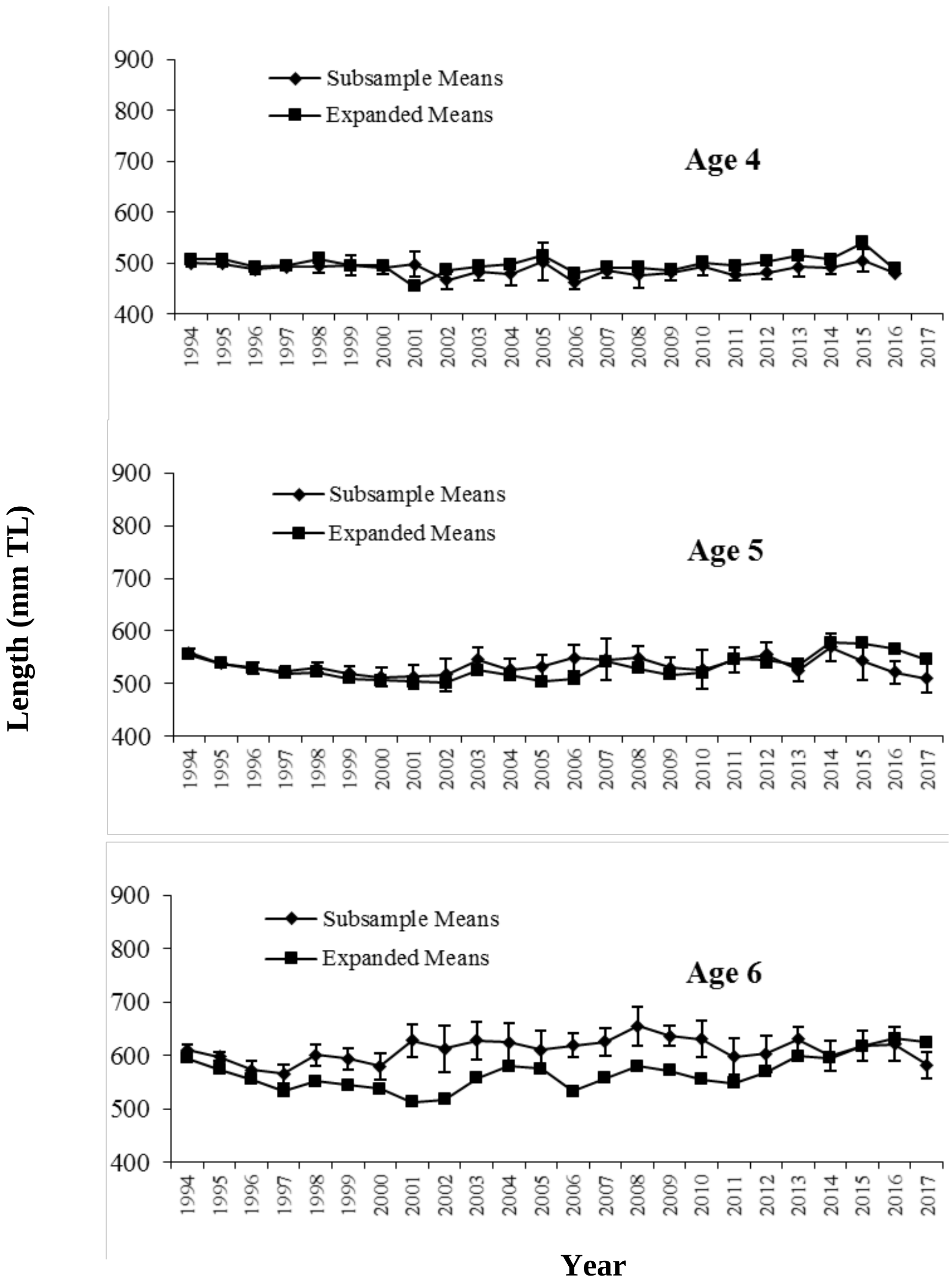


Figure 4. Mean total lengths (mm TL) of the aged subsample, by year, for individual age-classes of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, 1994 - 2017 (95% confidence intervals are shown around each point). Expanded means (estimated from entire sample) are also shown. Year refers to the year in which the season ended.



--No Age 4 fish in sample for 2017.

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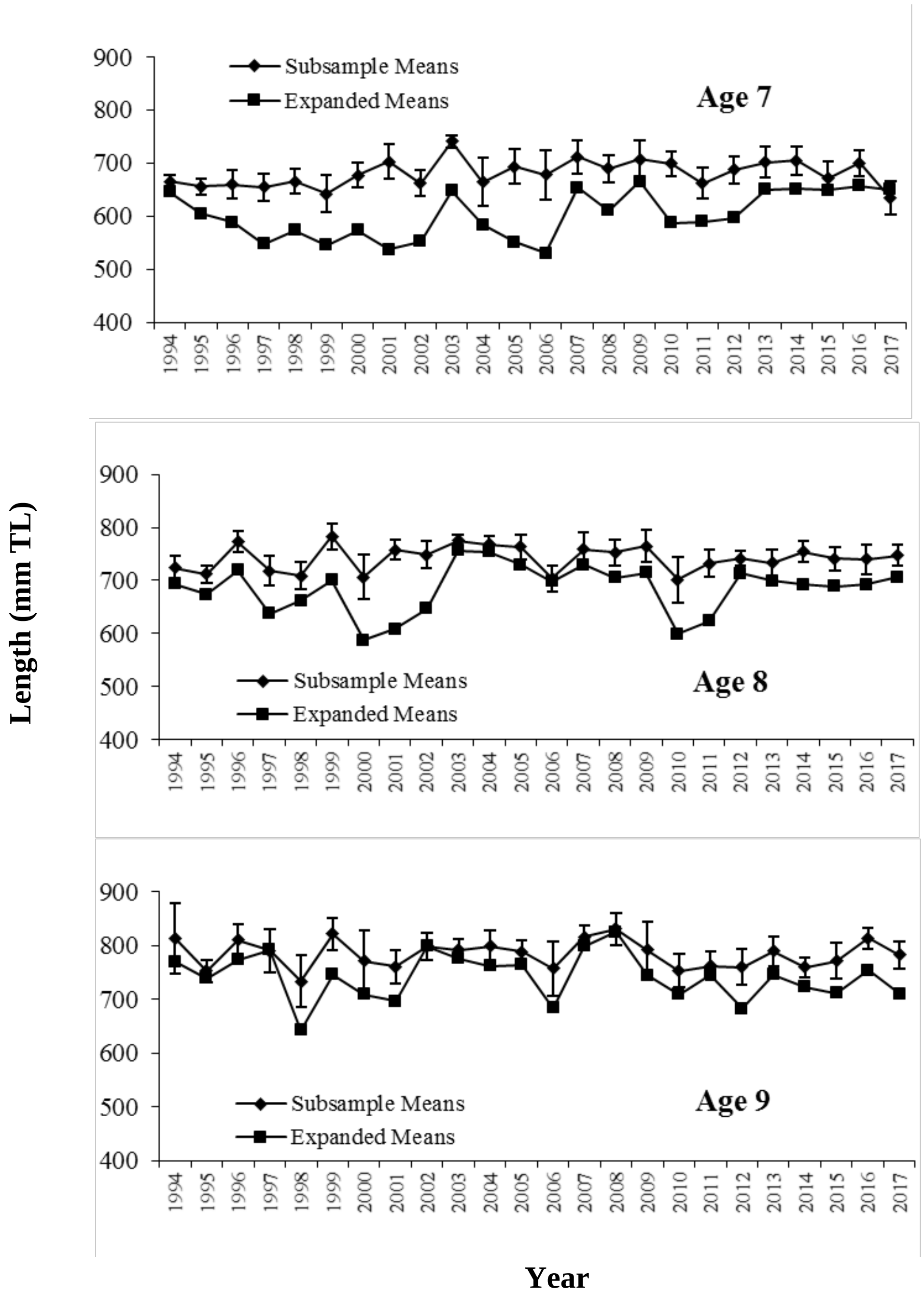
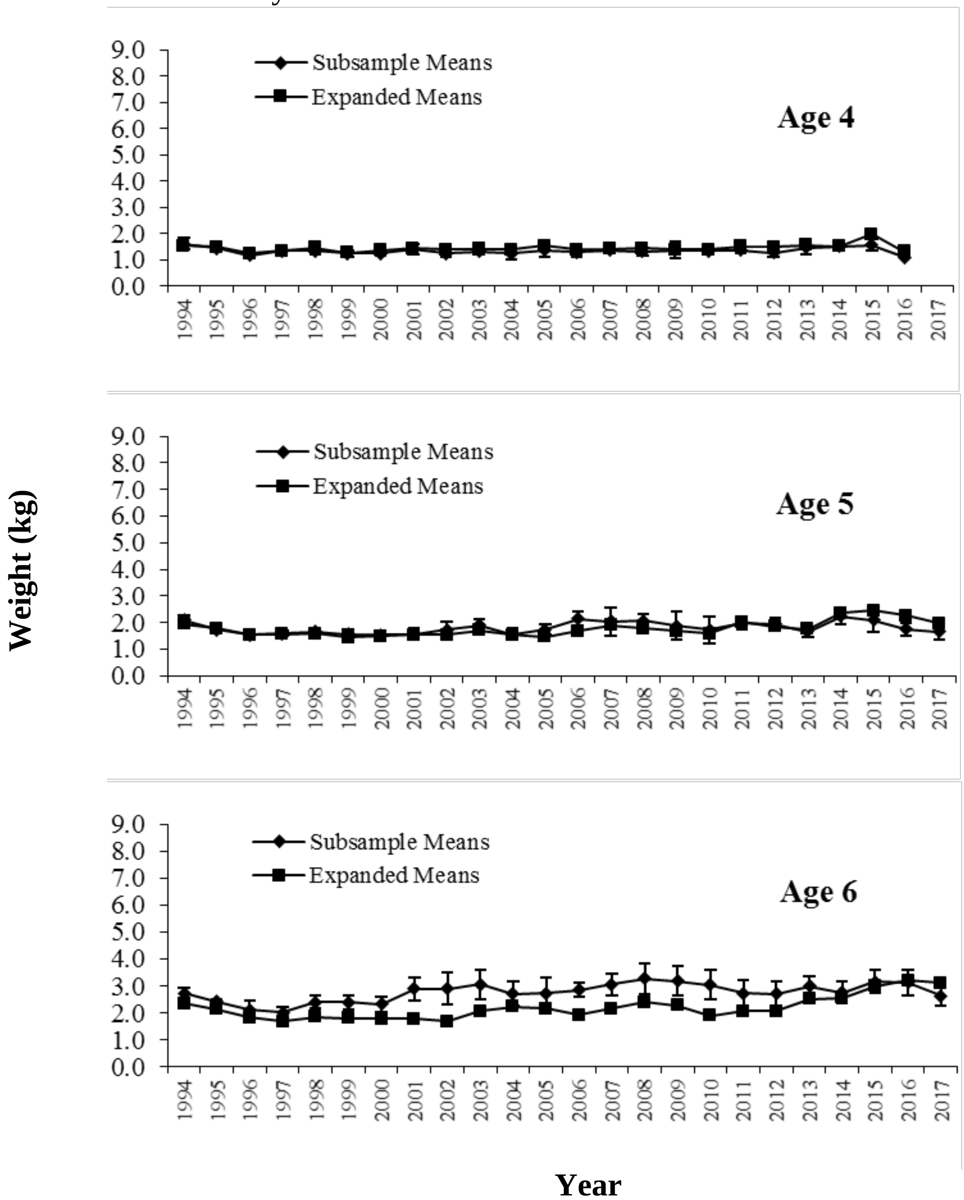
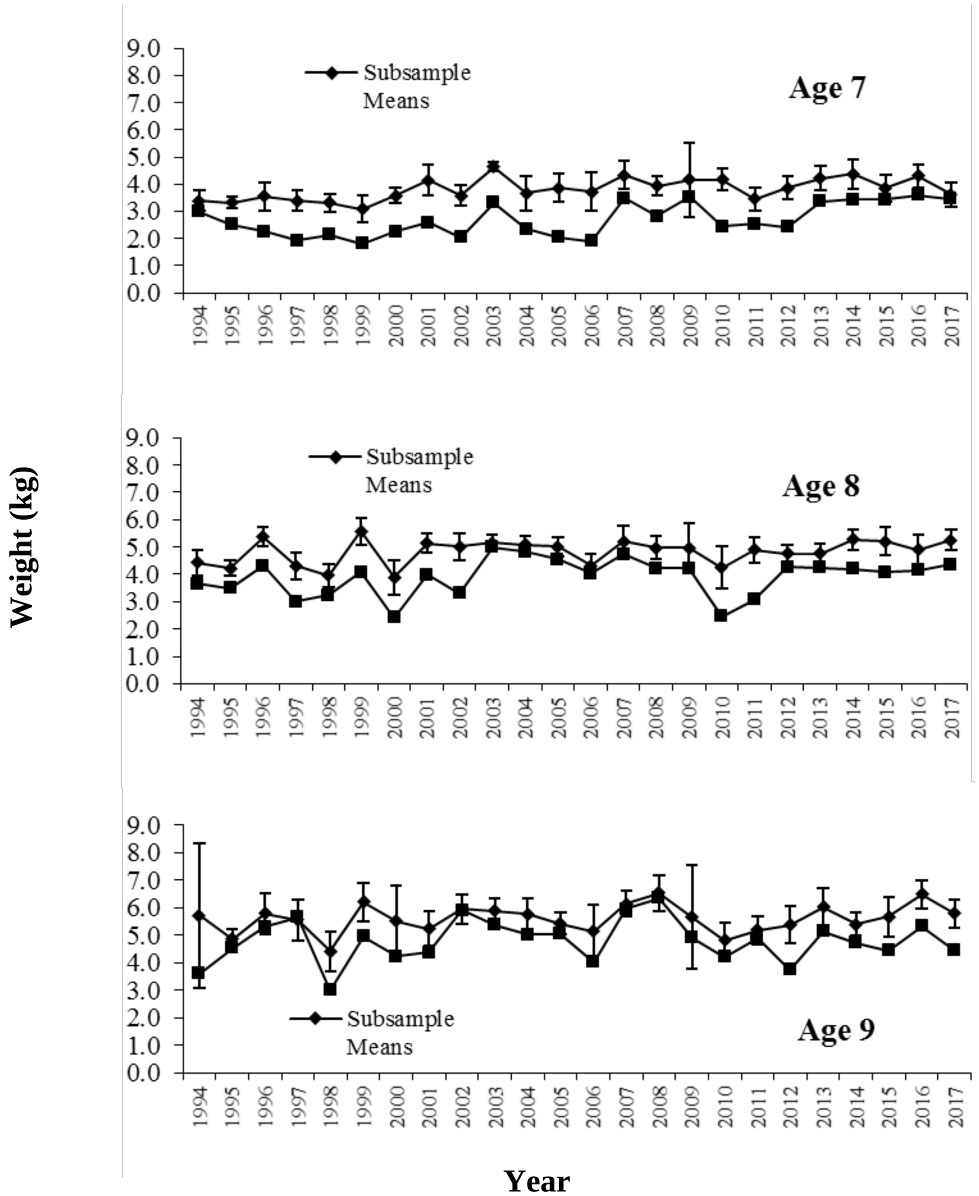


Figure 5. Mean weights (kg) of the aged subsample, by year, for individual age-classes of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net fishery, 1994 - pogo2017 (95% confidence intervals are shown around each point). Expanded means (estimated from entire sample) are also shown. Year refers to the year in which the season ended.



--No Age 4 fish in sample for 2017.

Figure 5. Continued.



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

ATLANTIC COAST STOCK ASSESSMENT AND COMMERCIAL HARVEST MONITORING

Prepared by Robert J. Bourdon

INTRODUCTION

The primary objective of Project 2, Job 3, Task 1C was to characterize the size and age structure of commercially harvested striped bass from Maryland's Atlantic coast. Trawls and gill nets were permitted during the Atlantic season within state waters (to 3 miles offshore). The 2017 season opened October 1, 2016 and ended May 31, 2017. The 2017 Atlantic striped bass season continued to be managed with a reduced annual quota under Addendum IV to Amendment 6 of the Atlantic Striped Bass Interstate Fishery Management Plan (Giuliano et al. 2014). Although this report covers the October 2016 – May 2017 fishing season, the quota is managed by calendar year. This fishery was managed with a 24 inch total length (TL) minimum size limit and an annual quota of 90,727 pounds. Maryland's Atlantic coast fishery is not as large as the Chesapeake Bay commercial fishery and its annual quota composes only 6% of Maryland's ocean and bay quotas combined. Monitoring of the coastal fishery began for the 2007 fishing season (November 1, 2006 – April 29, 2007) to improve Maryland's catch-at-age and weight-at-age estimates used in the annual compliance report to the Atlantic States Marine Fisheries Commission, as well as the coast-wide stock assessment.

METHODS

Data collection procedures

All striped bass commercially harvested in Maryland are required to pass through a Maryland Department of Natural Resources (MD DNR) approved check station. Check stations are typically cooperating fish dealers who report daily landings to MD DNR. A review of 2005

– 2015 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 for November, December, and January, because a previous analysis of check station logs showed that 90% of the harvest occurred during these months. 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

In all seasons prior to 2016 – 2017, 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. However, as a consequence of the observed length distribution and low sample size, all scale samples were chosen to be aged for the 2016 – 2017 season.

Year-class was determined by reading acetate 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 2016 – May 2017 Atlantic fishery, the year used for age calculations was 2017. These ages were then used to construct the age-length key (ALK). In seasons prior to 2016 – 2017 where only a sub-sample of scales was analyzed, the resulting ALK was applied to the sample length frequency to generate a sample age distribution for all fish sampled at check stations. 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.

In seasons prior to 2016 – 2017, 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

Sampling at coastal check stations was conducted on five days between November 2016 and May 2017. A total of 32 fish were measured for length and weight, and fish ages were determined directly from all 32 scale samples. Commercial fishermen have a limited area to harvest striped bass (~62 square miles) within Maryland waters. During the 2017 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.

Check stations reported 3,072 fish landed during the 2016 – 2017 Atlantic coast season (Table 1) (Chris Jones, Data Management and Quota Monitoring Program, Personal Communication). This is the third lowest number of striped bass reported at Atlantic check stations in the time series (Figure 1). The catch-at-age estimate determined that nine year-classes were represented in the sampled harvest, ranging from age 6 (2011 year-class) to age 16 (2001 year-class) (Table 1; Figure 2). The most common age represented in the catch-at-age estimate was age 10, the 2007 year-class, which represented 25% 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 6 (2011 year-class) and age 12 (2005 year-class) fish were also significant contributors to the sample population at 19% and 16% respectively (Table 1).

Striped bass sampled at Atlantic coast check stations during the 2016 – 2017 season had a mean length of 916 mm TL and mean weight of 9.9 kg. The sample length distribution ranged from 615 to 1079 mm TL (Figure 3). The weight of fish sampled ranged from 2.3 to 15.4 kg. Age 10 striped bass (2007 year-class), the most abundant age group sampled, had a mean length of 960 mm TL and mean weight of 11.4 kg (Tables 2 and 3, Figures 4 and 5).

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Table 1. Estimated catch-at-age of striped bass (numbers of fish) landed by the Maryland Atlantic coast commercial fishery, October 2016 – May 2017.

Year-Class	**Age**	**Number of Fish**	**Percent**
2011	6	576	18.8
2010	7	96	3.1
2009	8	96	3.1
2007	10	768	25.0
2006	11	288	9.4
2005	12	480	15.6
2004	13	192	6.3
2003	14	288	9.4
2001	16	288	9.4
Total*	-	3,072	100

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

Table 2. Mean total lengths (mm TL) by year-class of striped bass sampled from Atlantic coast fishery, October 2016 – May 2017. Includes the lower and upper 95% confidence limits (LCL and UCL, respectively).

Year-Class	Age	n Fish Aged	Mean TL (mm)	LCL	UCL
2011	6	6	665	618	713
2010	7	1	680	-	-
2009	8	1	792	-	-
2007	10	8	960	917	1003
2006	11	3	995	894	1095
2005	12	5	1001	951	1051
2004	13	2	973	610	1335
2003	14	3	1008	981	1034
2001	16	3	1069	1046	1093
Total		**32**			

Table 3. Mean weights (kg) by year-class of striped bass sampled from Atlantic coast fishery, October 2016 – May 2017. Includes the lower and upper 95% confidence limits (LCL and UCL, respectively).

Year-Class	Age	n Fish Aged	Mean Weight (kg)	LCL	UCL
2011	6	6	3.4	2.4	4.4
2010	7	1	3.7	-	-
2009	8	1	4.4	-	-
2007	10	8	11.4	10.2	12.5
2006	11	3	10.9	10.0	11.7
2005	12	5	11.7	10.3	13.1
2004	13	2	11.0	4.9	17.1
2003	14	3	13.1	12.4	13.9
2001	16	3	15.1	14.3	16.0
Total		**32**			

Figure 1. Number of striped bass landed at Atlantic check stations by the Maryland Atlantic coast commercial fishery by fishing season.

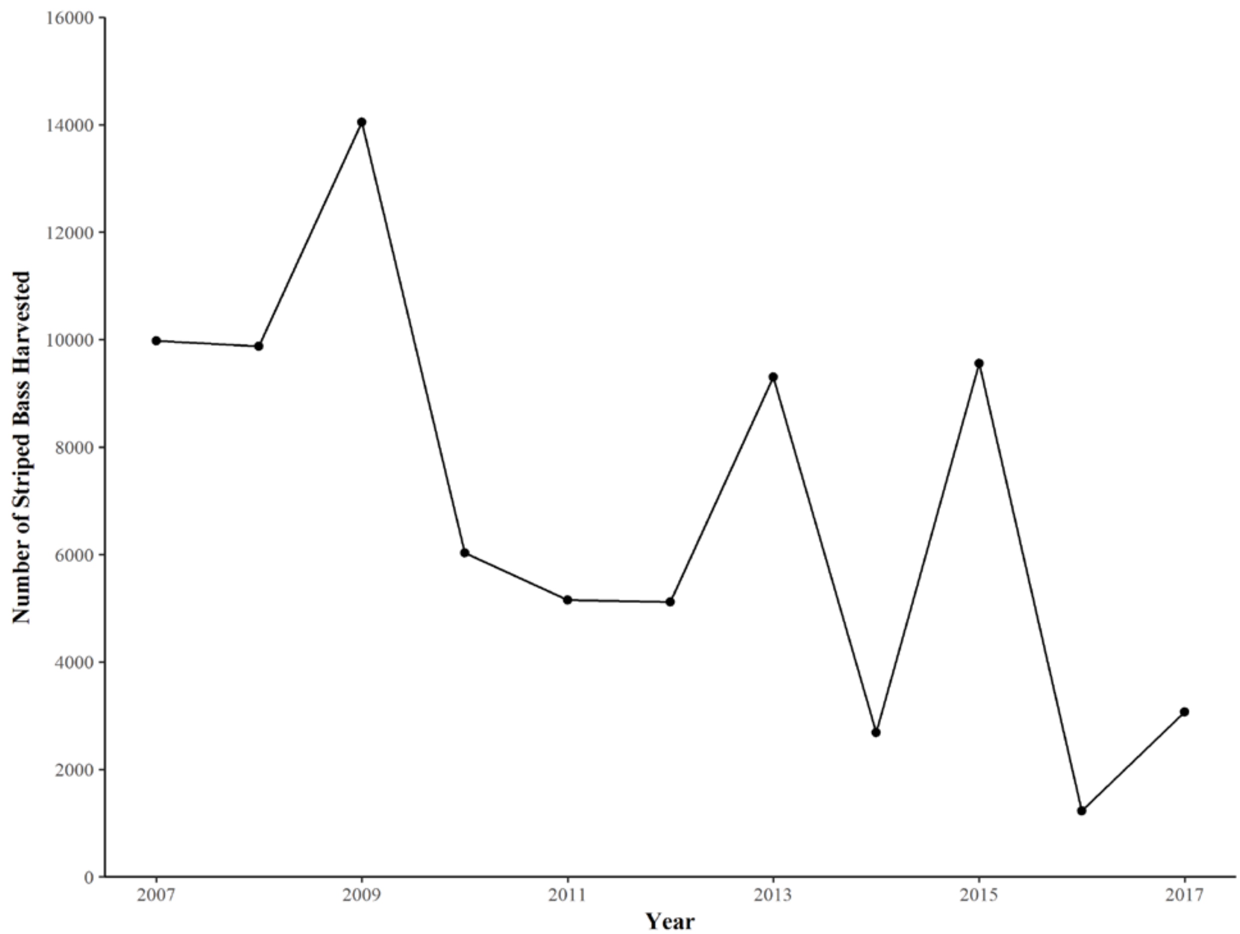


Figure 2. Age distribution of striped bass sampled from the Atlantic coast fishery, 2007 – 2017 seasons.

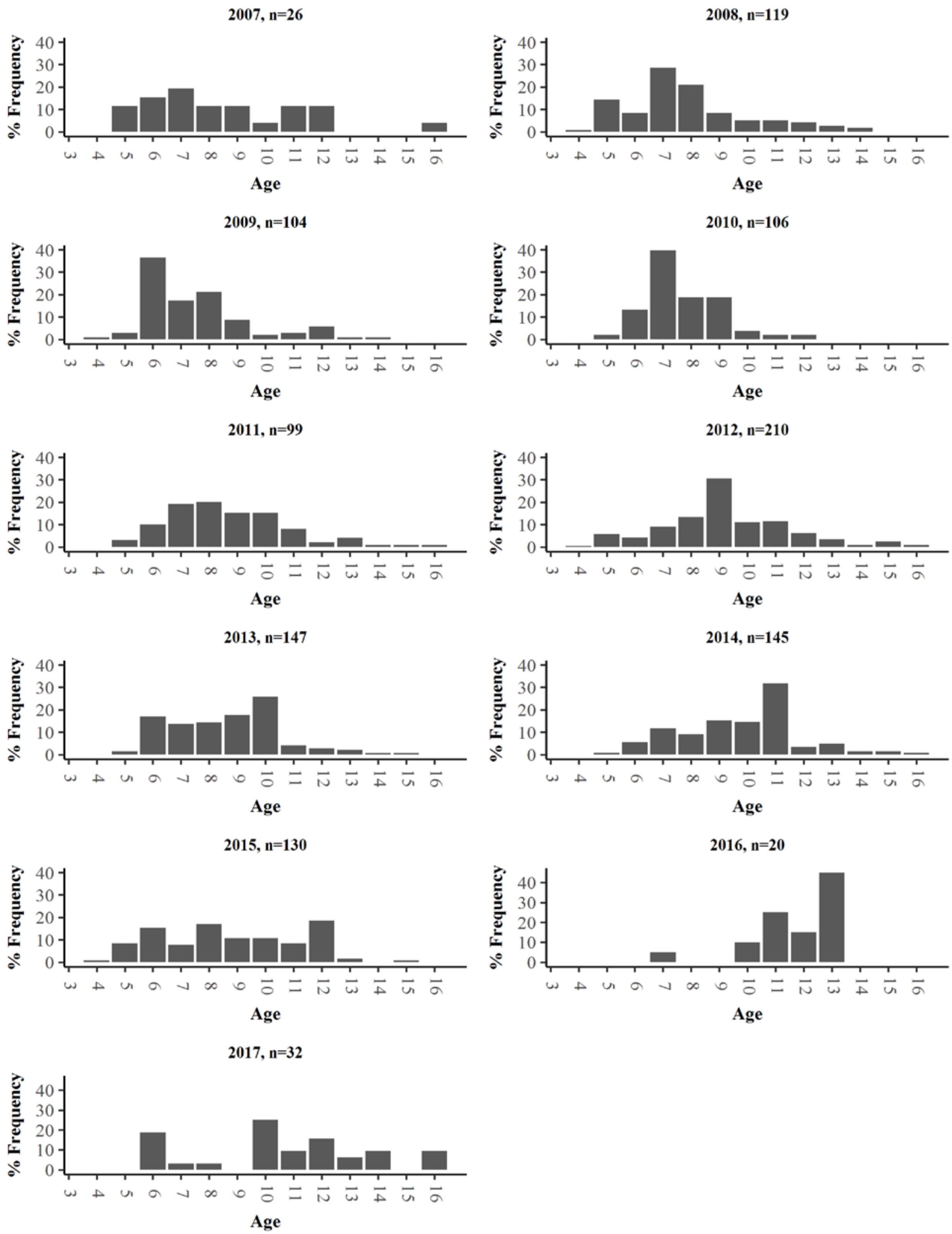


Figure 3. Length distribution of striped bass sampled from the Atlantic coast fishery, 2007 – 2017 seasons. *Note different y-axis scales.

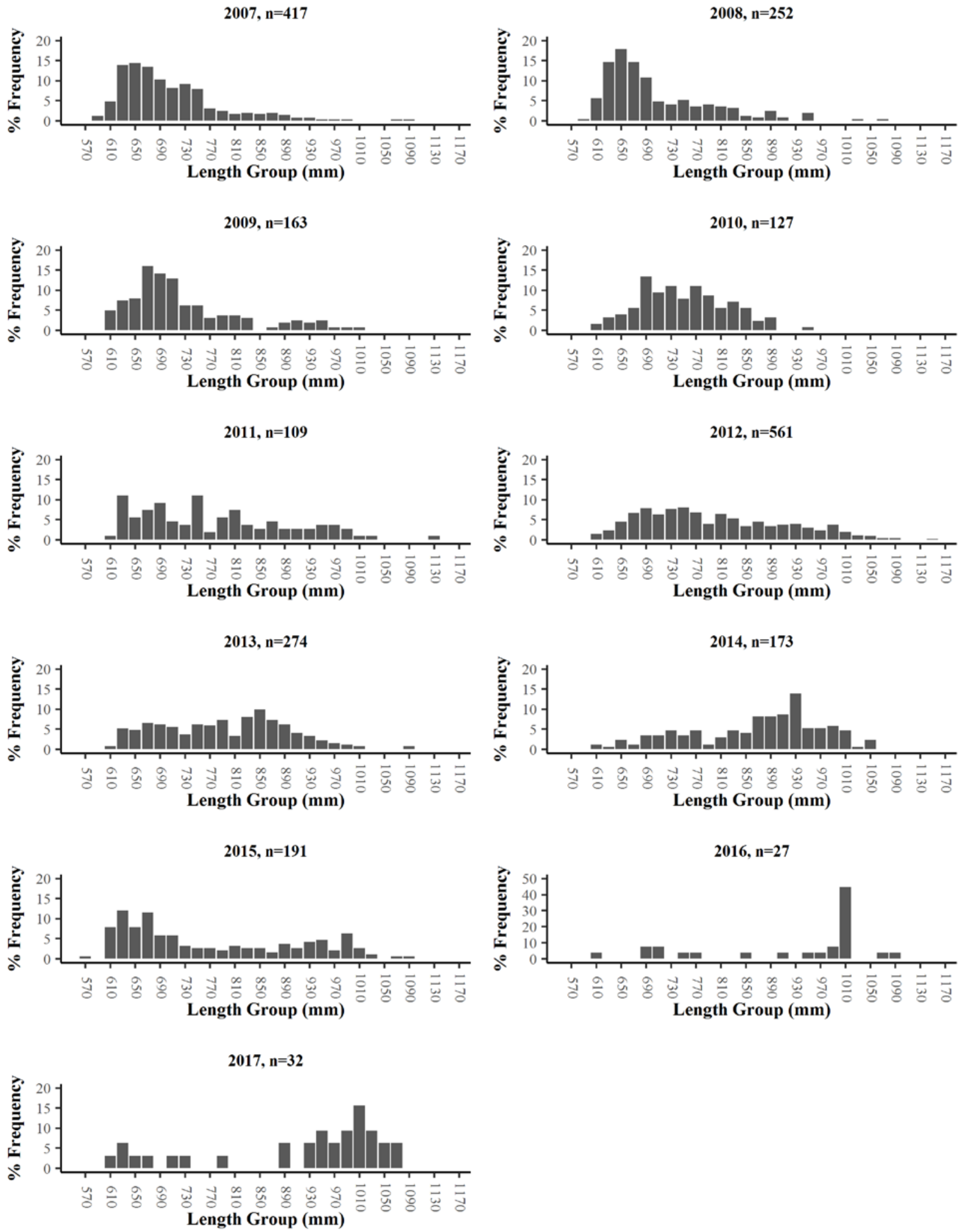
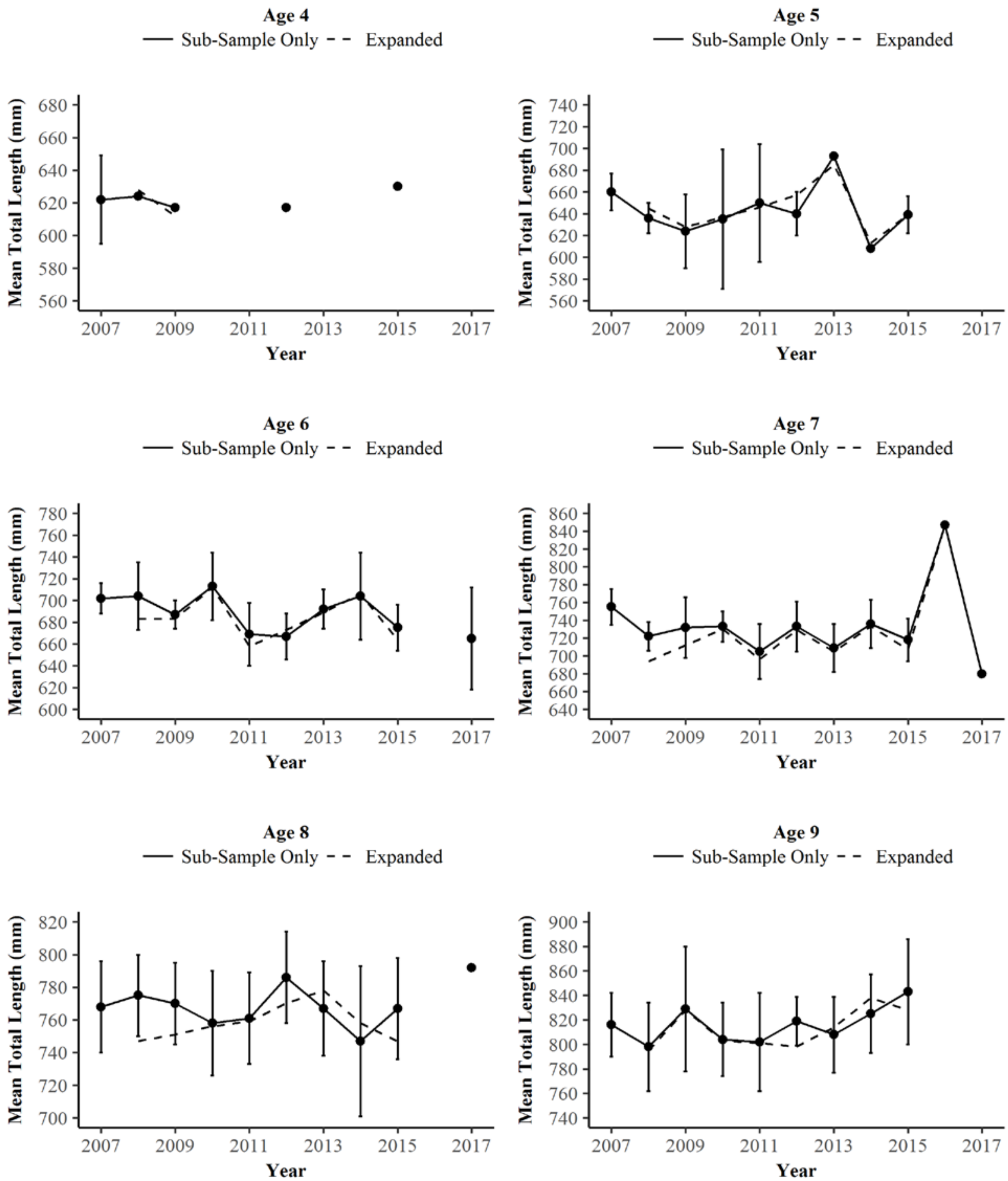


Figure 4. Mean total lengths (mm TL) of the aged sub-sample, by year, for individual age-classes of striped bass (through age 12) sampled from the Maryland Atlantic coast trawl and gill net landings, 2007 – 2017 (95% confidence intervals included when permitted by sample size). Expanded means (estimated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



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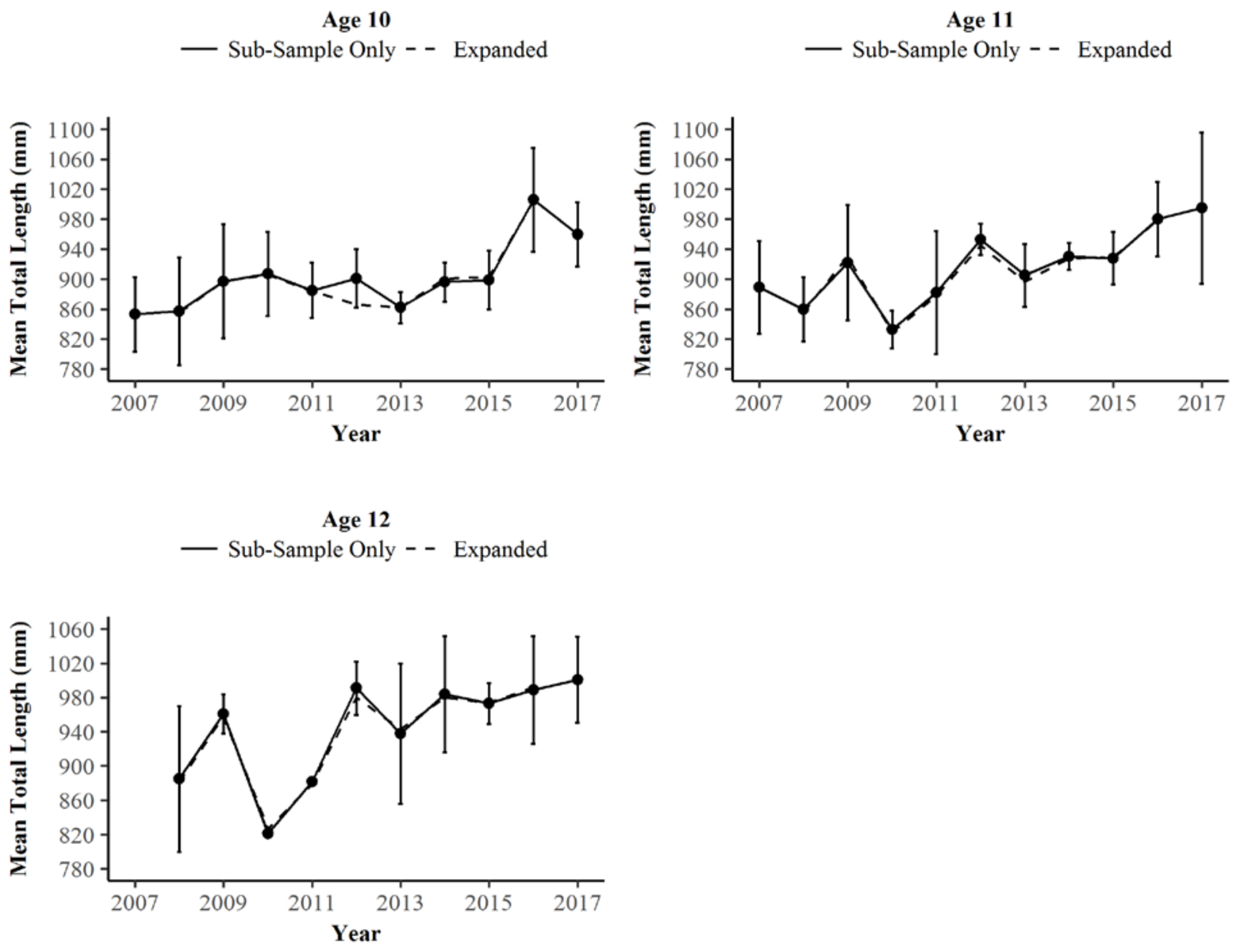
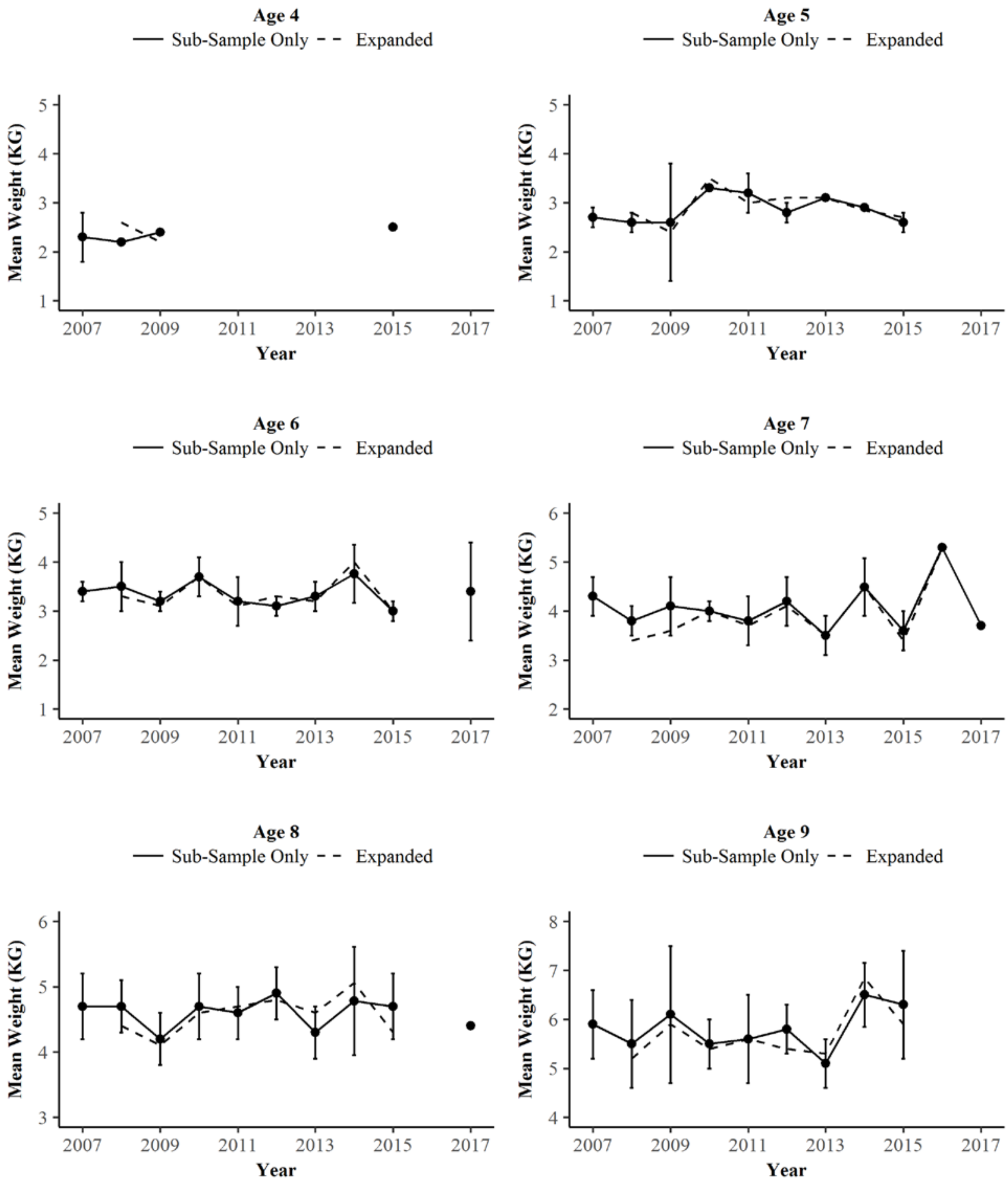


Figure 5. Mean weight (kg) of the aged sub-sample, by year, for individual age-classes of striped bass (through age 12) sampled from the Maryland Atlantic coast trawl and gill net landings, 2007 – 2017 (95% confidence intervals included when permitted by sample size). Expanded means (estimated from entire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



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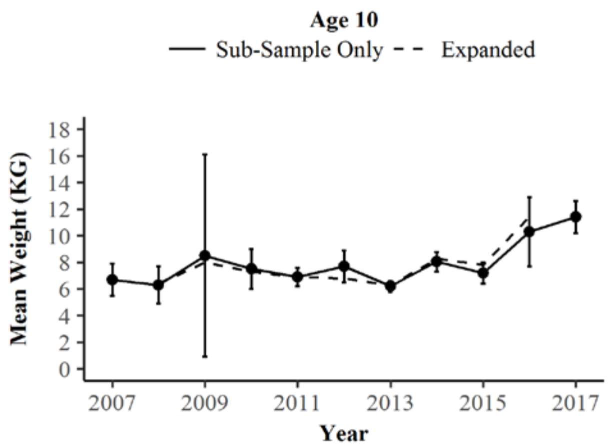

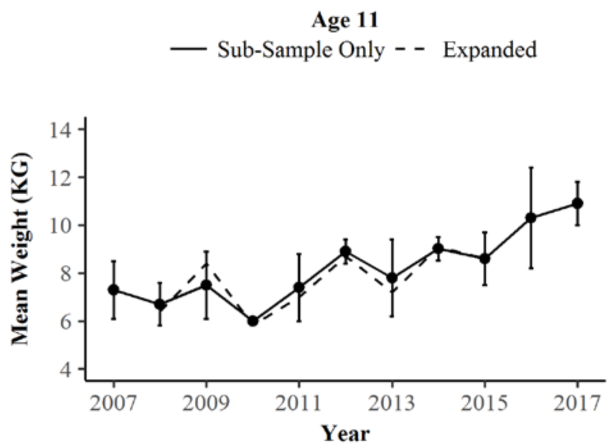

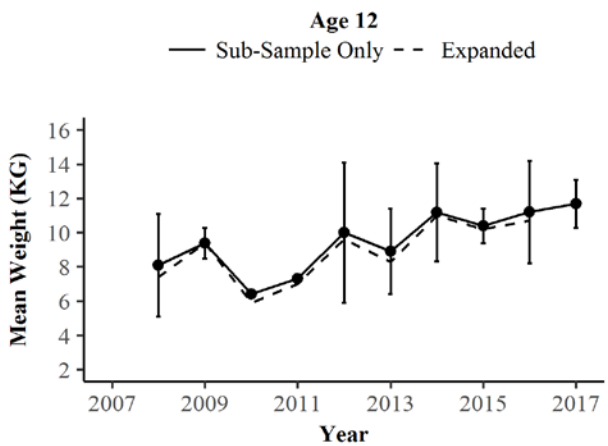

PROJECT NO. 2
JOB NO. 3
TASK NO. 2

CHARACTERIZATION OF STRIPED BASS SPAWNING STOCKS IN MARYLAND

Prepared by Beth A. Versak

INTRODUCTION

The primary objective of Project 2, Job 3, Task 2 was to estimate relative abundance-at-age for striped bass in Chesapeake Bay during the 2017 spring spawning season. 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 2017 (Figure 1). Gill nets were fished 6 days per week, weather permitting, in April and May. In the Potomac River, sampling was conducted from March 30 to May 10 for a total of 33 sample days. In the Upper Bay, sampling was conducted from April 3 to May 16 for a total of 34 sample days.

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. 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. Between each panel, there were gaps of 5 to 10 feet. Overall soak times for each panel ranged from 7 to 158 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, per week, for a maximum of 10 scale samples per length group over the entire season. Scales were also 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). In 2017 three additional scale samples from concurrent spring surveys were also used to fill gaps in the ALK in smaller female length groups (Table 1). These fish were assumed to be similar to striped bass sampled from the gill net and recreational creel surveys, but due to small sample sizes this assumption could not be tested.

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 patterns and 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

CPUEs and variance

A total of 619 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.

The 2017 un-weighted CPUEs increased for both sexes, in both systems, compared to 2016. The 2017 un-weighted CPUE for Potomac females (44) was double the previous year's value and above the series average of 27 (Table 2). This was the sixth highest value in the 32 years of sampling the Potomac River. The un-weighted CPUE for Potomac males (510) was also double last year's value and above average (430) (Table 3). The Upper Bay female CPUE (53) was above the time-series average (43) for the sixth consecutive year and ranked seventh in the 33 years of the survey (Table 4). The un-weighted CPUE for Upper Bay males (488) was above the average of 456 (Table 5). The abundant 2011 year-class (age 6 fish) held the highest 2017 age-class CPUE values for both sexes, in both systems. Age 3 males from the 2014 year-class were also very abundant. 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 annual coastwide striped bass stock assessment. These indices are presented in a time-series for ages one through 15+ (Table 8). The 2017 selectivity-corrected, total, weighted CPUE (546) ranked 10th in the 33 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 2017 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 are similar for the un-weighted and weighted CPUEs. Unless otherwise noted, all CPUEs and percentages discussed here are the weighted values.

The above-average 2011 year-class was the most prevalent cohort in the spawning stock this year, composing 25% of the total CPUE, followed closely by the 2014 year-class at 21%. Upper Bay fish made up 61% of the total CPUE. Males were most frequently encountered, composing 91% of the total CPUE. This was due to the large contribution of the 2014 and 2011 year-class males.

The 2011 year-class made the largest contributions to the male CPUE in the Potomac River at 28%, followed by the 2014 year-class at 23%. In the Upper Bay, those two year-classes contributed equally to the male CPUE (24%). Older males were not frequently encountered. In both systems, 83% of the male CPUE was made up of fish ages 6 and younger.

Historically the female contribution has been less than 10% to each system's CPUE. The female contribution to the Upper Bay CPUE was 10%, and 8% to the Potomac CPUE. Female CPUEs were distributed across many year-classes in both systems, with 6 year-old female fish from the 2011 year-class contributing the most to each system's female CPUE (16% in Potomac, 24% in Upper Bay). Age 10 females from the 2007 year-class were the next largest contributor on the Potomac (15% of the female CPUE), and age 12 females in the Upper Bay (13% of the female CPUE).

Temperature and catch patterns

Daily surface water temperature on the Potomac River was 10°C at the start of the survey, gradually increased through April to a high of 22°C on May 2, then decreased slightly through the end of the survey. Female CPUEs were fairly consistent through the first part of April. Three consecutive days of large females catches occurred as water temperature approached 18°C in the third week of April (Figure 2). The largest peaks in male CPUE were observed in mid-April, as water temperatures warmed and passed the 14°C mark necessary to initiate spawning (Fay et al., 1983).

Upper Bay surface water temperatures began at 8°C, and slowly increased to a high of 18.6°C on May 1. Water temperatures remained near 18°C for about a week, then decreased to approximately 14°C for the remainder of the survey. The highest catches of females occurred on April 12, April 22 and May 1, which coincided with the highest observed water temperature (Figure 3). The largest peak in male CPUE occurred on April 15. Daily female and male CPUEs were generally higher in April as the water warmed.

Length composition of the stock

In 2017, 2,466 male and 214 female striped bass were measured. On the Potomac River, 847 male and 72 female striped bass were measured; 1,619 males and 142 females were measured from the Upper Bay (Figure 4). The mean length of female striped bass (954 ± 24 mm TL) was significantly larger than the mean length of male striped bass (512 ± 5 mm TL, $P < 0.0001$), consistent with the known biology of the species. Mean lengths are presented with 2 standard errors.

Mean lengths of male striped bass collected from the Potomac River (514 ± 9 mm TL) and Upper Bay (511 ± 6 mm TL) were not significantly different (P=0.593). The length distributions of male fish are very similar (Figure 4).

Male striped bass on the Potomac ranged from 235 to 1080 mm TL. Males between 330 and 610 mm TL composed 80% of the Potomac River male catch in 2017, representing fish from the above average 2015, 2014 and 2011 year-classes (Figure 4). The influence of these young fish was evident in the large uncorrected and selectivity-corrected CPUE peaks between 270 and 610 mm TL (Figure 5).

Male striped bass on the Upper Bay ranged from 249 to 1094 mm TL, with a peak in the length frequency between 390-530 mm TL (58% of catch; Figure 4). Similar to the Potomac, male CPUE in the Upper Bay was dominated by small fish, representing the 2015, 2014 and 2011 year-classes (Figure 5). The selectivity correction increased the contribution of the 310 length group in the Upper Bay because all of those fish were caught in the 3-inch mesh, which only partially selects for that length group.

Female striped bass sampled from the Potomac River (996 ± 33 mm TL) in 2017 were significantly larger than those in the Upper Bay (933 ± 31 mm TL; P=0.006). Female striped bass sampled from the Potomac ranged from 500 to 1185 mm TL, while females sampled in the Upper Bay ranged from 481 to 1226 mm TL (Figure 4). The peaks in both systems between 590 and 690 are young females from the 2011 year-class. The larger peaks between 990 and 1070 mm TL likely represent the 2005 through 2003 year-classes.

Female CPUE in the Potomac River was generally low and sporadic with several large selectivity corrected peaks at 670, 810 and 950 mm TL (Figure 6). These resulted from a few fish caught in meshes that had low selectivities for their size group. Because of this, the selectivity correction increased the CPUE to better approximate the relative abundance of those size fish in the spawning population.

In the Upper Bay, female CPUEs covered a wide range of length groups, representing 13 year-classes (Figure 6). Application of the selectivity model to the data corrected the catch upward in the lower and upper ends of the length distribution where fewer fish were available and likely not captured efficiently. The peaks in the uncorrected CPUEs at 630 and 1010 mm TL represented the above-average 2011 and 2005 year-classes, respectively.

Length at age (LAA)

Based on previous investigations which indicated no influence of area on mean LAA, samples from the Potomac River, Upper Bay, the spring recreational creel sampling (Project 2, Job 3, Task 5B), and other concurrent spring surveys were again combined in 2017 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 2017 ($\alpha > 0.05$). Age 10 female fish were significantly shorter on the Upper Bay (912 mm TL) than the Potomac River (983 mm TL, P=0.0204). Age 3 males were significantly shorter on the Upper Bay (354 mm TL) than the Potomac River (399 mm TL, P=0.0132).

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 2016 and 2017 for all ages except for age 11 (P=0.0273). Mean lengths of females were similar in 2016 and 2017 for all ages except age 8 (P=0.038).

Age composition of the stock

Eighteen age-classes, ranging from 2 to 21 were encountered (Tables 14 and 15). Of the 283 male fish aged from the survey (Table 1), ages 3 and 6 (2014 and 2011 year-classes) were the most commonly encountered. On the Potomac River, the males encountered ranged from age 2 through 15, while on the Upper Bay, males ages 2 through 16 were captured. Females ranged in age from 4 to 21 on the Potomac River, and 5 to 17 on the Upper Bay. Of the 158 aged female scales (Table 1), age 6 females from the dominant 2011 year-class were most commonly observed, followed by age 12 females (2005 year-class).

The abundance of ages 2 to 5 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 2016, most of the age-specific CPUEs for 2017 increased, except for ages 2, 5, 13 and 15+. The contribution of the 15+ age group had been strong over the previous seven years (Figure 9).

The contribution of age 8+ females to the total female CPUE increased slightly from last year to 66% (Figure 10). The contribution of females age 8 and older to the spawning stock has been at or above 80% since 1996, with the exception of 2011, 2013, 2016 and 2017. The time-series average is 71%. The large numbers of females from the 2011 year-class entering the spawning stock and being encountered during the survey likely contributed to the lower values in recent years.

The percentage of the overall sample (males and females combined) age 8 and older has been variable since 1997 (Figure 11). The 2017 value of 18% is a slight increase from 2016. The percentage of age 8+ fish is heavily influenced by strong year-classes and shows cyclical variations (Figure 9). The lower values in recent years of age 8+ fish was due to the high number of young fish (from the 2015, 2014, 2013, and 2011 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 2016), but Maryland's Chesapeake Bay estimates showed an increase from 2011 to 2015. 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 2017 ISP value of 411 was well below the high values of that previous period, but similar to the 2016 value, and above the time-series average of 354 (Table 16, Figure 12). The Potomac River female ISP dropped in 2016, but increased to 387 in 2017. This was above the time-series average of 234 and the highest value since 2006.

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

CHARACTERIZATION OF STRIPED BASS SPAWNING STOCKS IN MARYLAND

2018 PRELIMINARY RESULTS

Data collected during the 2018 spring spawning season are currently being analyzed. In the Potomac River in 2018, sampling was conducted from April 2 to May 10 for a total of 31 sample days. In the Upper Bay, sampling was conducted from April 5 to May 18 for a total of 37 sample days.

Scale samples are currently being processed and aged, therefore no CPUE estimates are available at this time. A total of 834 scales were collected for use in creating the sex-specific ALKs. In the Potomac River, a total of 771 striped bass were sampled, 749 males and 22 females. Of those 771 fish, 369 (48%) were tagged with U. S. Fish and Wildlife Service internal anchor tags. In the Upper Bay, at total of 1,656 striped bass were captured, 1,563 males and 93 females. Of the 1,656 fish encountered, 711 (43%) were tagged.

Male striped bass on the Potomac ranged from 260 to 1122 mm TL, with a mean of 433 mm TL. Male striped bass on the Upper Bay ranged from 284 to 1070 mm TL, with a mean of 467 mmd TL. Female striped bass sampled from the Potomac ranged from 673 to 1224 mm TL, with a mean of 958 mm TL. Upper Bay female striped bass ranged from 497 to 1263 mm TL, and had a mean of 963 mm TL.

The final, complete analyses of the spring 2018 spawning stock survey data will appear in the next F-61 Chesapeake Bay Finfish Investigations report.

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Table 1. Number of scales aged per sex, area, and survey, by length group (mm TL).

	MALES				FEMALES				
Length group (mm)	Upper Bay	Potomac River	Creel	Male Total	Upper Bay	Potomac River	Creel	Other Surveys	Female Total
250	1	0	0	**1**	0	0	0	0	**0**
270	1	0	0	**1**	0	0	0	0	**0**
290	5	2	0	**7**	0	0	0	0	**0**
310	3	2	0	**5**	0	0	0	0	**0**
330	3	3	0	**6**	0	0	0	0	**0**
350	3	3	0	**6**	0	0	0	0	**0**
370	4	3	0	**7**	0	0	0	0	**0**
390	2	3	0	**5**	0	0	0	0	**0**
410	3	4	0	**7**	0	0	0	0	**0**
430	3	2	0	**5**	0	0	0	0	**0**
450	3	3	0	**6**	0	0	0	0	**0**
470	4	2	0	**6**	0	0	0	0	**0**
490	3	3	0	**6**	1	1	3	0	**5**
510	3	3	0	**6**	1	0	7	0	**8**
530	3	3	0	**6**	1	0	2	0	**3**
550	3	3	0	**6**	1	0	9	0	**10**
570	6	7	0	**13**	0	0	4	1	**5**
590	4	4	0	**8**	5	0	5	0	**10**
610	6	4	0	**10**	4	0	6	0	**10**
630	4	5	0	**9**	8	2	1	1	**12**
650	6	5	0	**11**	3	2	3	0	**8**
670	4	5	0	**9**	1	1	9	0	**11**
690	6	5	0	**11**	5	1	3	0	**9**
710	5	6	5	**16**	3	0	3	0	**6**
730	6	5	4	**15**	2	0	2	0	**4**
750	5	6	4	**15**	1	0	4	0	**5**
770	6	4	3	**13**	0	0	0	0	**0**
790	6	5	5	**16**	1	0	2	0	**3**
810	5	2	3	**10**	1	1	1	1	**4**
830	4	3	1	**8**	0	0	2	0	**2**
850	4	2	1	**7**	0	0	0	0	**0**
870	3	1	3	**7**	2	0	4	0	**6**
890	3	1	4	**8**	1	3	4	0	**8**
910	4	1	2	**7**	2	1	2	0	**5**
930	8	3	0	**11**	1	2	9	0	**12**
950	4	2	0	**6**	4	1	5	0	**10**
970	4	1	2	**7**	7	3	6	0	**16**
990	2	1	2	**5**	5	5	4	0	**14**
1010	3	1	0	**4**	4	6	5	0	**15**
1030	3	0	0	**3**	6	4	5	0	**15**
1050	1	0	0	**1**	5	5	5	0	**15**
1070	3	1	0	**4**	5	7	5	0	**17**
1090	2	0	1	**3**	6	2	5	0	**13**
1110	0	0	0	**0**	5	3	6	0	**14**
1130	0	0	0	**0**	0	4	1	0	**5**
1150	0	0	0	**0**	3	0	0	0	**3**
1170	0	0	0	**0**	3	3	0	0	**6**
1190	0	0	0	**0**	1	1	1	0	**3**
1210	0	0	0	**0**	0	0	0	0	**0**
1230	0	0	0	**0**	0	0	0	0	**0**
1250	0	0	0	**0**	0	0	1	0	**1**
1270	0	0	0	**0**	2	0	1	0	**3**
Total	**164**	**119**	**40**	**323**	**100**	**58**	**135**	**3**	**296**

Table 2. Estimates of selectivity-corrected age-class CPUE by year for female striped bass captured in the Potomac River during the 1985-2017 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**
Average																**27**

Table 3. Estimates of selectivity-corrected age-class CPUE by year for male striped bass captured in the Potomac River during the 1985-2017 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	**1166**
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**
Average																**430**

Table 4. Estimates of selectivity-corrected age-class CPUE by year for female striped bass captured in the Upper Bay during the 1985-2017 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**
Average																**43**

Table 5. Estimates of selectivity-corrected age-class CPUE by year for male striped bass captured in the Upper Bay during the 1985-2017 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**
Average																**456**

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	**1399**
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	**1029**
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	**1457**
1993	0.0	291.3	128.8	1156.4	193.5	158.8	161.5	147.3	45.9	11.3	3.5	0.0	0.0	0.0	0	**2298**
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	**2191**
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	**1794**
Average																**1279**

Table 8. Mean values of the annual, pooled, weighted, age-specific CPUEs (1985–2017) 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	**1007**
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**
Average																**494**

Table 9. Lower confidence limits (95%) of the annual, pooled, weighted, age-specific CPUEs (1985–2017) 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	*

* 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 (1985–2017) 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	*

* 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 (1985–2017) 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	*

* 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, March through May 2017. 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
2016	1	0.0	0.0	0.0	0.0	0.0	0.0
2015	2	126.1	11.5	0.0	0.0	59.4	66.7
2014	3	232.3	21.2	0.0	0.0	116.3	116.0
2013	4	66.8	6.1	0.3	2.4	32.9	31.1
2012	5	148.4	13.5	0.3	2.6	70.8	74.6
2011	6	278.7	25.4	7.1	12.6	141.7	117.2
2010	7	45.3	4.1	3.8	3.0	20.9	17.5
2009	8	35.9	3.3	2.8	1.8	15.9	15.3
2008	9	23.3	2.1	0.8	1.4	11.7	9.4
2007	10	30.7	2.8	6.9	5.9	9.8	8.0
2006	11	23.2	2.1	3.6	3.6	7.4	8.5
2005	12	49.3	4.5	5.7	6.7	20.2	16.7
2004	13	13.9	1.3	4.7	5.1	0.8	3.3
2003	14	9.9	0.9	3.4	3.6	1.7	1.2
≤2002	15+	11.6	1.1	4.9	4.3	0.4	2.1
Total		1095.2		44.3	53.1	510.1	487.7
% of Total				4.0	4.9	46.6	44.5
% of Sex				45.5	54.5	51.1	48.9
% of System				8.0	9.8	92.0	90.2

Table 13. Striped bass catch per unit effort (CPUE) by year-class, weighted by spawning area*, March through May 2017. 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
2016	1	0.0	0.0	0.0	0.0	0.0	0.0
2015	2	63.9	11.7	0.0	0.0	22.9	41.0
2014	3	116.1	21.3	0.0	0.0	44.8	71.3
2013	4	33.5	6.1	0.1	1.5	12.7	19.1
2012	5	74.9	13.7	0.1	1.6	27.3	45.9
2011	6	137.2	25.1	2.7	7.8	54.6	72.0
2010	7	22.2	4.1	1.5	1.9	8.1	10.8
2009	8	17.8	3.3	1.1	1.1	6.1	9.4
2008	9	11.5	2.1	0.3	0.9	4.5	5.8
2007	10	15.0	2.7	2.6	3.6	3.8	4.9
2006	11	11.7	2.1	1.4	2.2	2.9	5.2
2005	12	24.3	4.5	2.2	4.1	7.8	10.3
2004	13	7.3	1.3	1.8	3.2	0.3	2.0
2003	14	4.9	0.9	1.3	2.2	0.6	0.8
≤2002	15+	5.9	1.1	1.9	2.6	0.2	1.3
Total		546.1		17.1	32.7	196.6	299.7
% of Total				3.1	6.0	36.0	54.9
% of Sex				34.3	65.7	39.6	60.4
% of System				8.0	9.8	92.0	90.2

* 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, March through May 2017.

YEAR-CLASS	AGE	AREA	N	MEAN	LCL	UCL	SD	SE
2015	2	POTOMAC	7	328	289	367	42	16
		UPPER	8	294	269	319	29	10
		COMBINED	15	310	288	331	39	10
2014	3	POTOMAC	14	399	368	429	53	14
		UPPER	16	354	333	374	39	10
		COMBINED	30	375	356	394	51	9
2013	4	POTOMAC	5	435	415	455	16	7
		UPPER	4	449	371	527	49	24
		COMBINED	9	441	416	467	33	11
2012	5	POTOMAC	8	532	454	611	94	33
		UPPER	12	482	454	509	43	12
		COMBINED	20	502	469	535	71	16
2011	6	POTOMAC	36	616	588	644	83	14
		UPPER	39	621	597	645	74	12
		COMBINED	75	619	601	636	78	9
2010	7	POTOMAC	13	729	687	772	70	20
		UPPER	13	735	669	801	109	30
		COMBINED	26	732	696	768	90	18
2009	8	POTOMAC	16	737	706	769	60	15
		UPPER	12	784	733	835	81	23
		COMBINED	28	757	729	785	72	14
2008	9	POTOMAC	7	804	707	900	105	40
		UPPER	15	791	745	837	83	21
		COMBINED	22	795	756	834	88	19
2007	10	POTOMAC	6	861	777	944	79	32
		UPPER	16	857	816	898	77	19
		COMBINED	22	858	825	892	76	16
2006	11	POTOMAC	2	969	689	1249	31	22
		UPPER	6	941	846	1035	90	37
		COMBINED	8	948	883	1013	78	28
2005	12	POTOMAC	3	964	854	1074	44	26
		UPPER	14	947	893	1000	92	25
		COMBINED	17	950	906	993	85	21
2004	13	POTOMAC	1	841	-	-	-	-
		UPPER	2	1017	*	*	*	*
		COMBINED	3	958	642	1275	127	74
2003	14	POTOMAC	0	-	-	-	-	-
		UPPER	4	966	846	1086	75	38
		COMBINED	4	966	846	1086	75	38
2002	15	POTOMAC	1	1080	-	-	-	-
		UPPER	0	-	-	-	-	-
		COMBINED	1	1080	-	-	-	-
2001	16	POTOMAC	0	-	-	-	-	-
		UPPER	3	1061	986	1136	30	17
		COMBINED	3	1061	986	1136	30	17

* 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, March through May 2017.

YEAR-CLASS	AGE	AREA	N	MEAN	LCL	UCL	SD	SE
2013	4	POTOMAC	1	500	-	-	-	-
		UPPER	0	-	-	-	-	-
		COMBINED	1	500	-	-	-	-
2012	5	POTOMAC	0	-	-	-	-	-
		UPPER	3	529	402	657	51	30
		COMBINED	3	529	402	657	51	30
2011	6	POTOMAC	6	653	627	679	25	10
		UPPER	30	640	621	660	52	10
		COMBINED	36	643	626	659	49	8
2010	7	POTOMAC	0	-	-	-	-	-
		UPPER	3	704	574	834	52	30
		COMBINED	3	704	574	834	52	30
2009	8	POTOMAC	1	819	-	-	-	-
		UPPER	2	919	*	*	*	*
		COMBINED	3	885	687	1084	80	46
2008	9	POTOMAC	2	966	445	1487	58	41
		UPPER	1	797	-	-	-	-
		COMBINED	3	910	647	1173	106	61
2007	10	POTOMAC	10	983	944	1022	55	17
		UPPER	8	912	860	964	62	22
		COMBINED	18	951	918	985	67	16
2006	11	POTOMAC	6	973	891	1055	78	32
		UPPER	4	987	941	1033	29	14
		COMBINED	10	979	935	1022	61	19
2005	12	POTOMAC	7	1050	1009	1091	44	17
		UPPER	18	1039	1010	1069	59	14
		COMBINED	25	1042	1020	1065	55	11
2004	13	POTOMAC	5	1024	992	1055	26	11
		UPPER	15	1039	1009	1070	56	14
		COMBINED	20	1035	1012	1059	50	11
2003	14	POTOMAC	8	1046	1006	1086	48	17
		UPPER	7	1052	1013	1091	42	16
		COMBINED	15	1049	1025	1073	44	11
2002	15	POTOMAC	5	1080	1042	1117	30	13
		UPPER	2	1140	886	1394	28	20
		COMBINED	7	1097	1060	1134	40	15
2001	16	POTOMAC	5	1147	1120	1175	22	10
		UPPER	6	1171	1130	1211	38	16
		COMBINED	11	1160	1138	1182	33	10
2000	17	POTOMAC	0	-	-	-	-	-
		UPPER	1	1226	-	-	-	-
		COMBINED	1	1226	-	-	-	-
1999	18	POTOMAC	1	1175	-	-	-	-
		UPPER	0	-	-	-	-	-
		COMBINED	1	1175	-	-	-	-
1996	21	POTOMAC	1	1185	-	-	-	-
		UPPER	0	-	-	-	-	-
		COMBINED	1	1185	-	-	-	-

* 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
Average	**354**	**234**

Figure 1. Drift gill net sampling locations in spawning areas of the Upper Chesapeake Bay and the Potomac River, spring 2017.

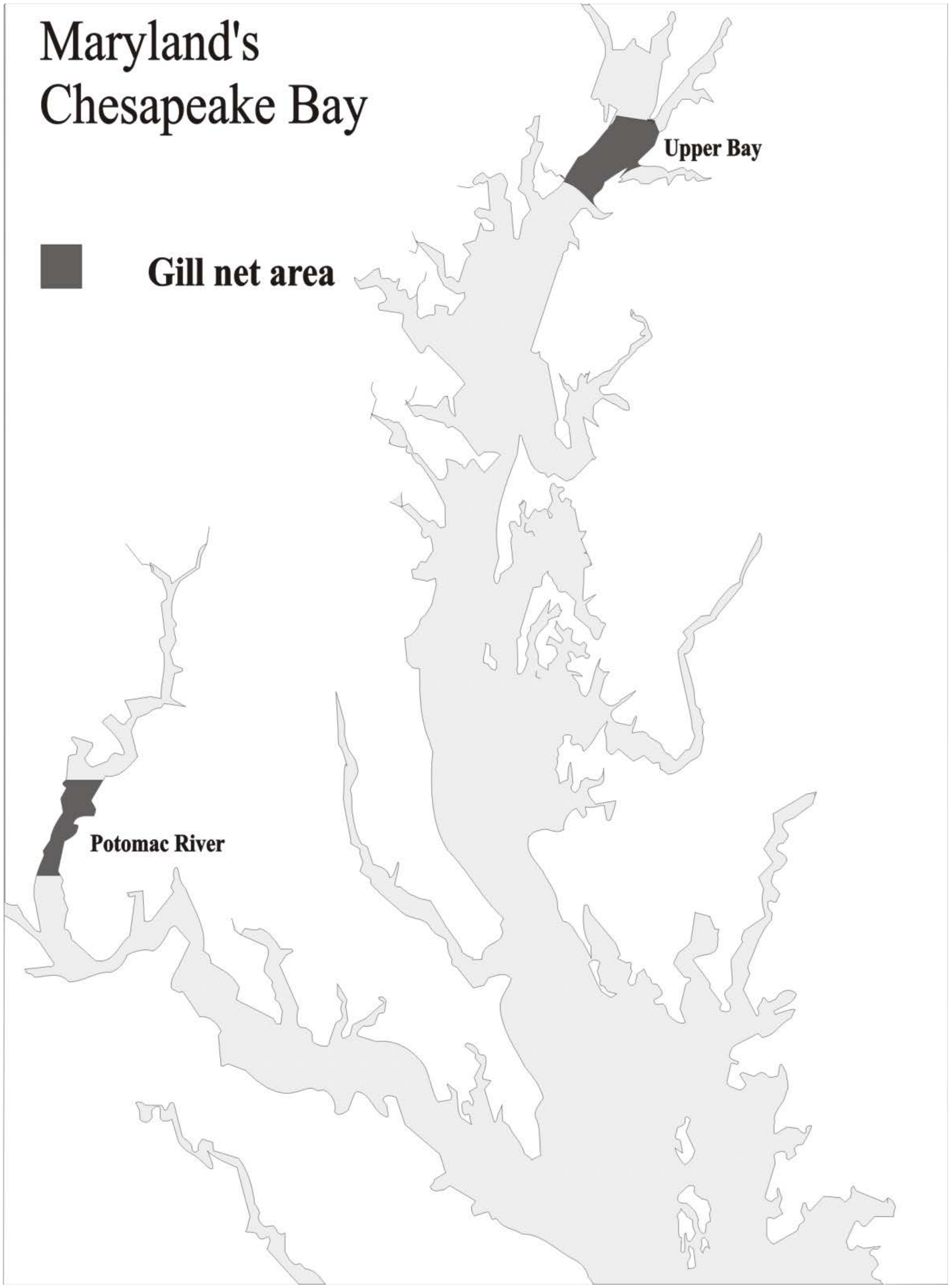
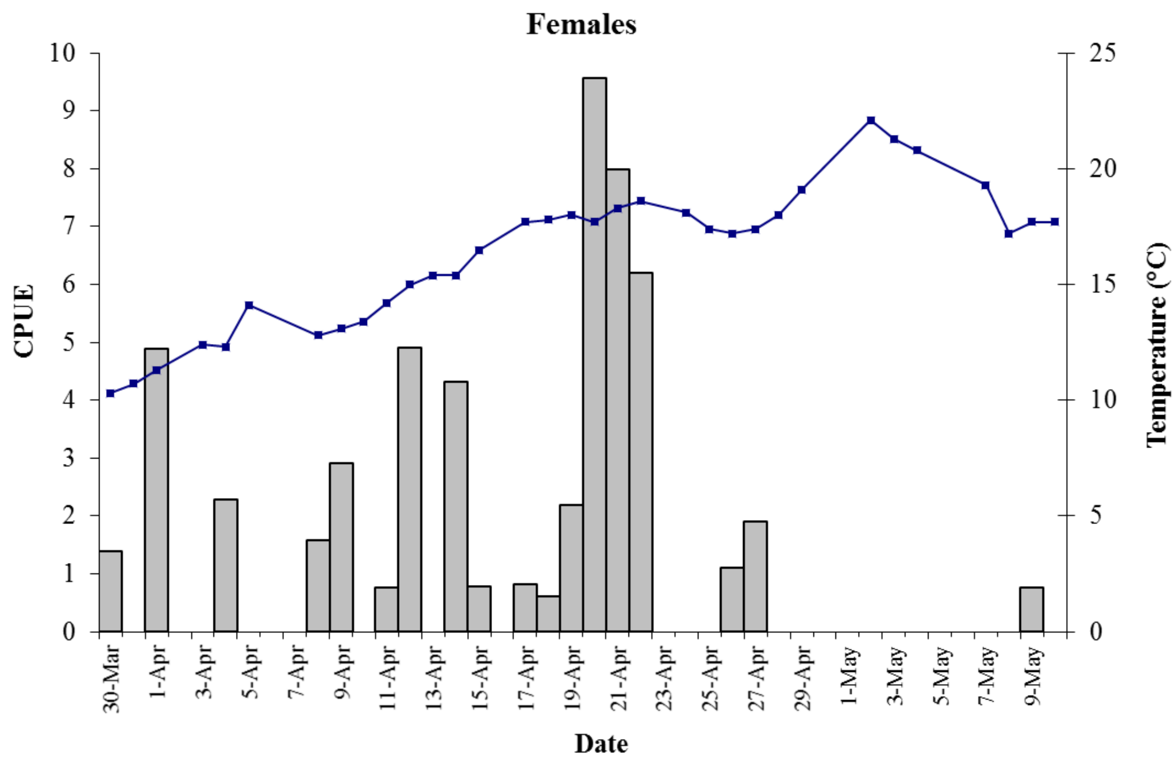


Figure 2. Daily effort-corrected catch of female and male striped bass, with surface water temperature in the spawning reach of the Potomac River, March through May 2017. Effort is standardized as 1000 square yards of experimental gill net per hour. Note different scales.



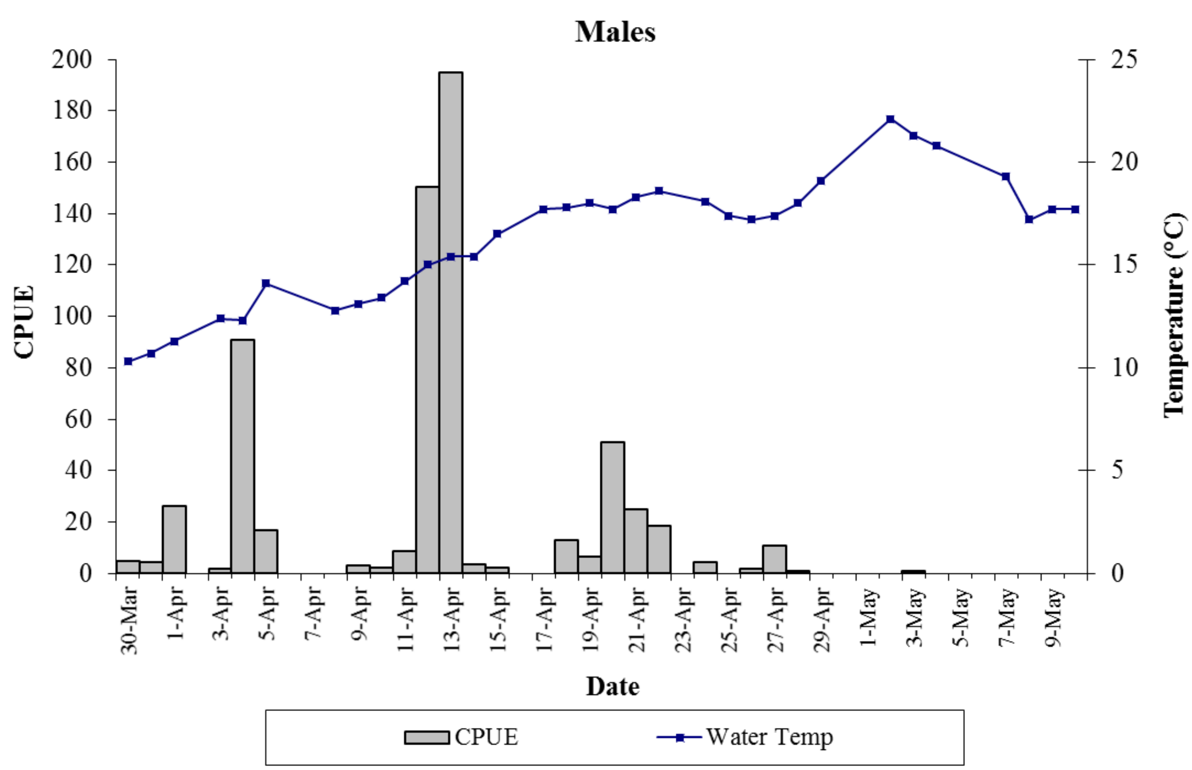


Figure 3. Daily effort-corrected catch of female and male striped bass, with surface water temperature in the spawning reach of the Upper Chesapeake Bay, April through May 2017. Effort is standardized as 1000 square yards of experimental drift gill net per hour. Note different scales.

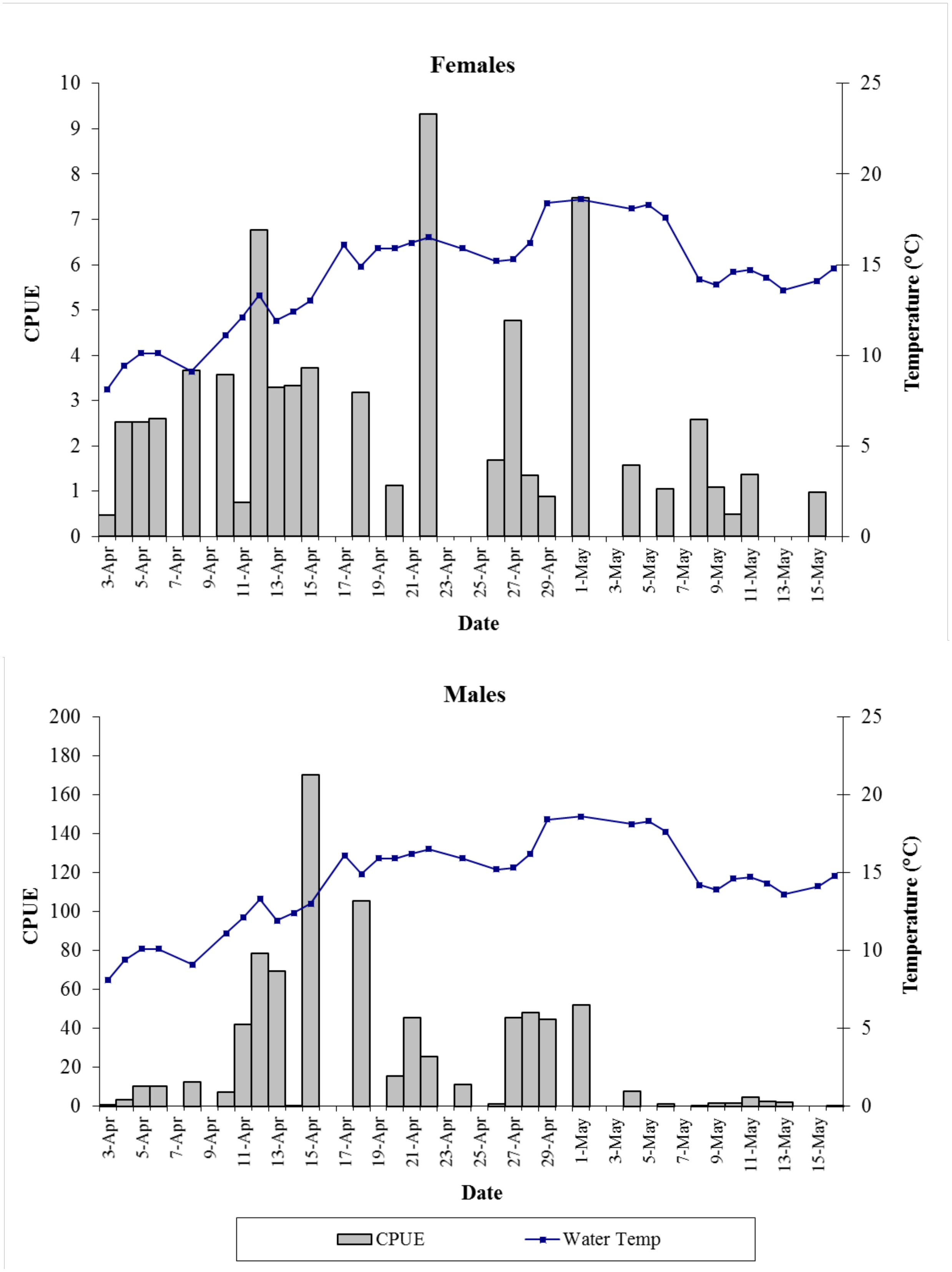
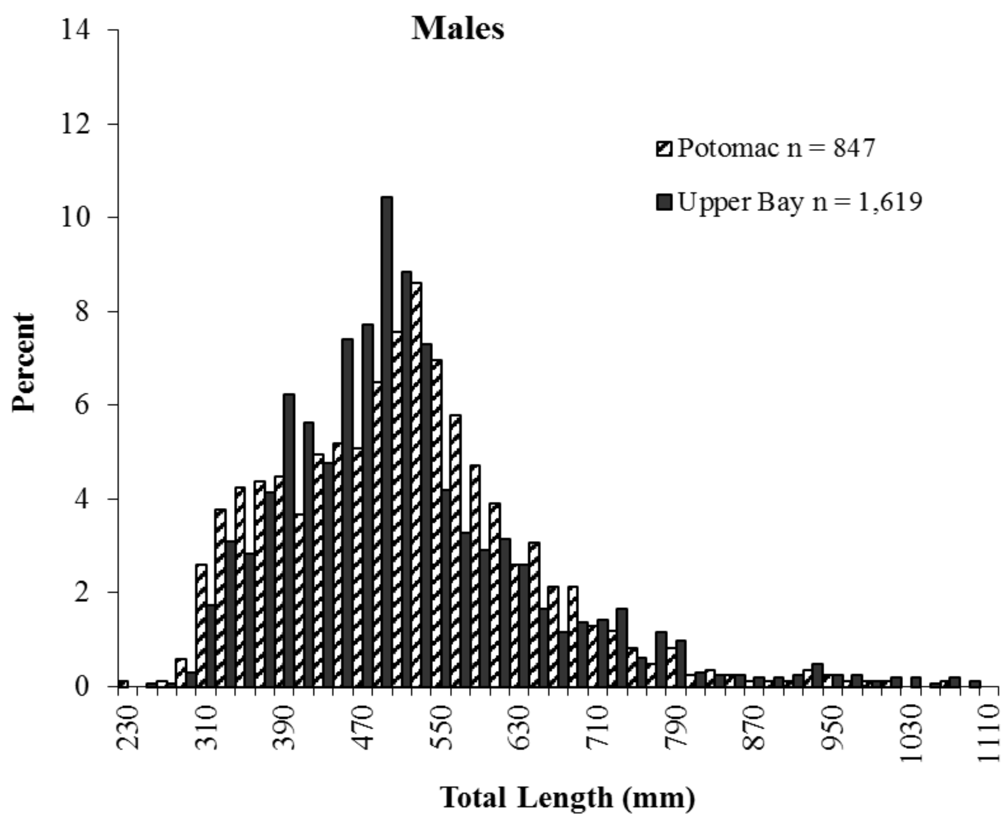


Figure 4. Length frequency of male and female striped bass from the spawning areas of the Upper Chesapeake Bay and Potomac River, March through May 2017. Note different x-axis scale.



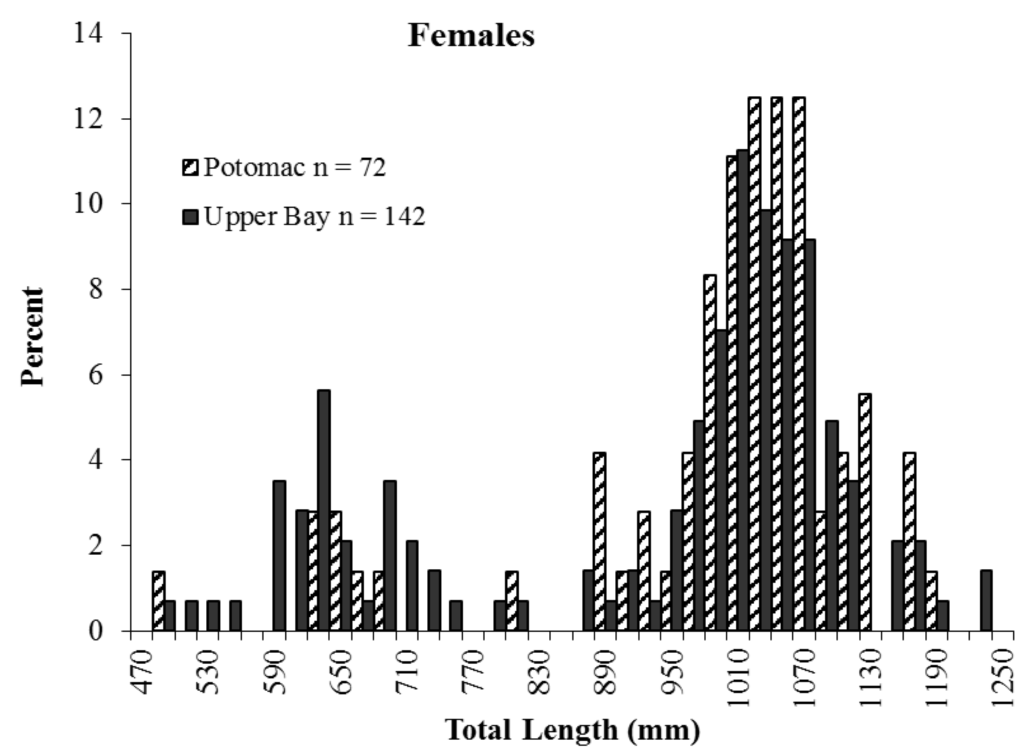
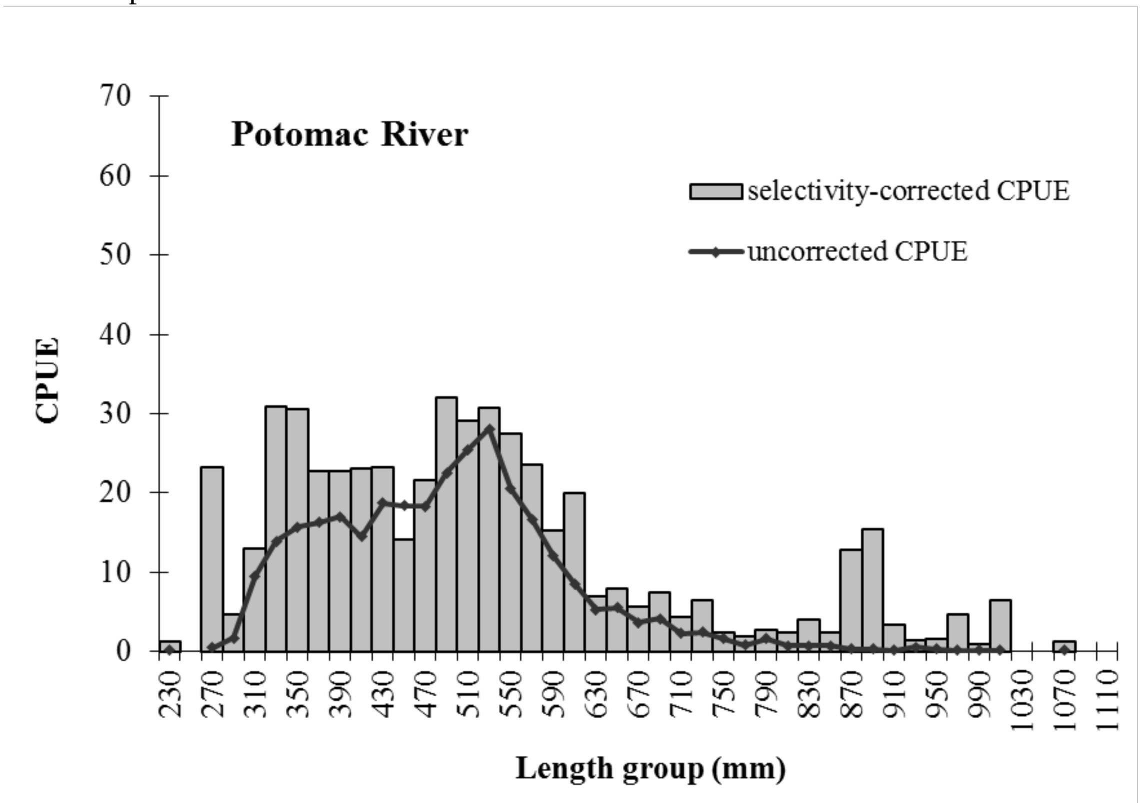


Figure 5. Length group CPUE (uncorrected and corrected for gear selectivity) of male striped bass collected from spawning areas of the Upper Bay and Potomac River, March - May 2017. CPUE is the number of fish captured per hour in 1000 square yards of experimental drift net.



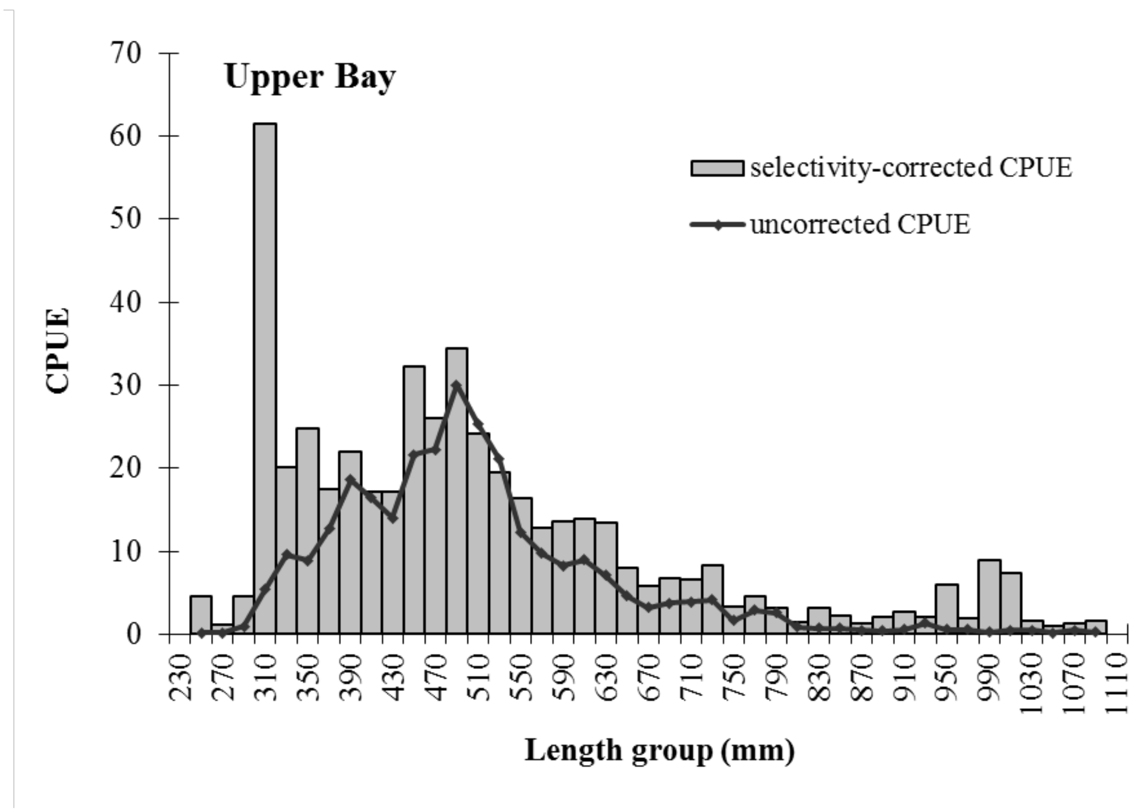
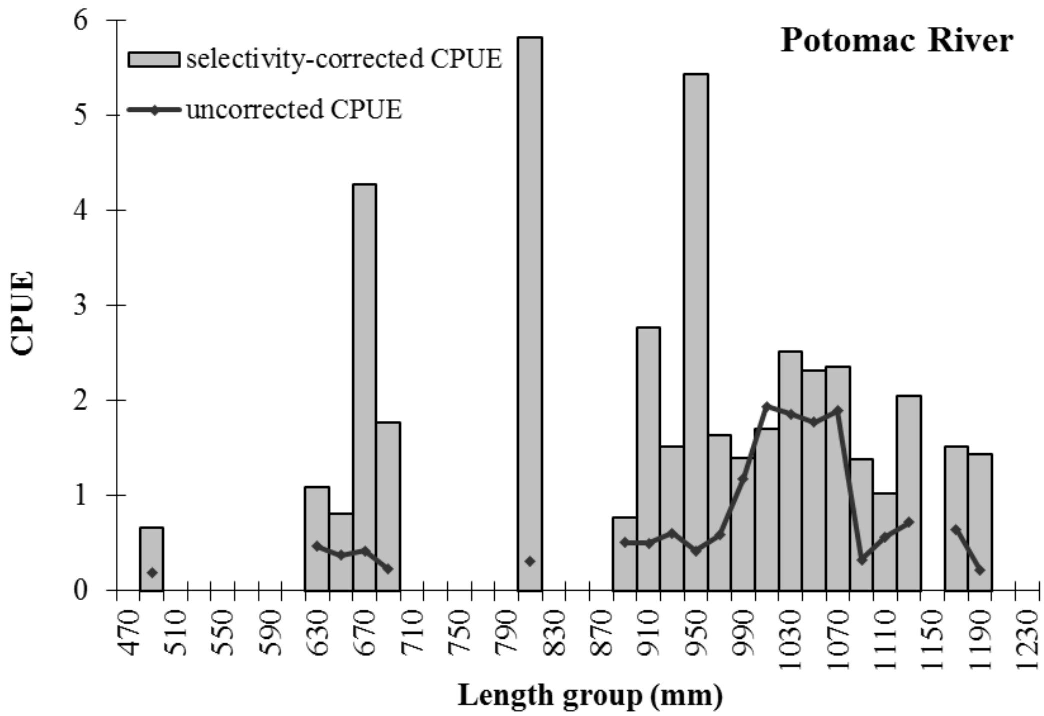


Figure 6. Length group CPUE (uncorrected and corrected for gear selectivity) of female striped bass collected from spawning areas of the Upper Bay and Potomac River, March - May 2017. CPUE is the number of fish captured per hour in 1000 square yards of experimental drift net.



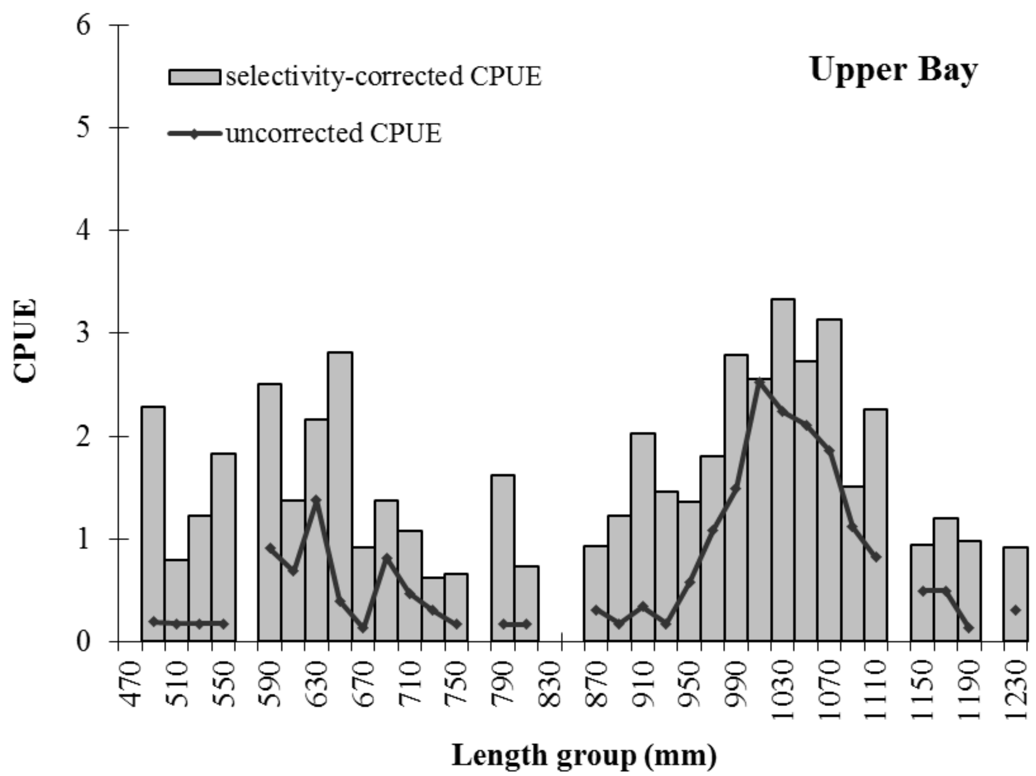
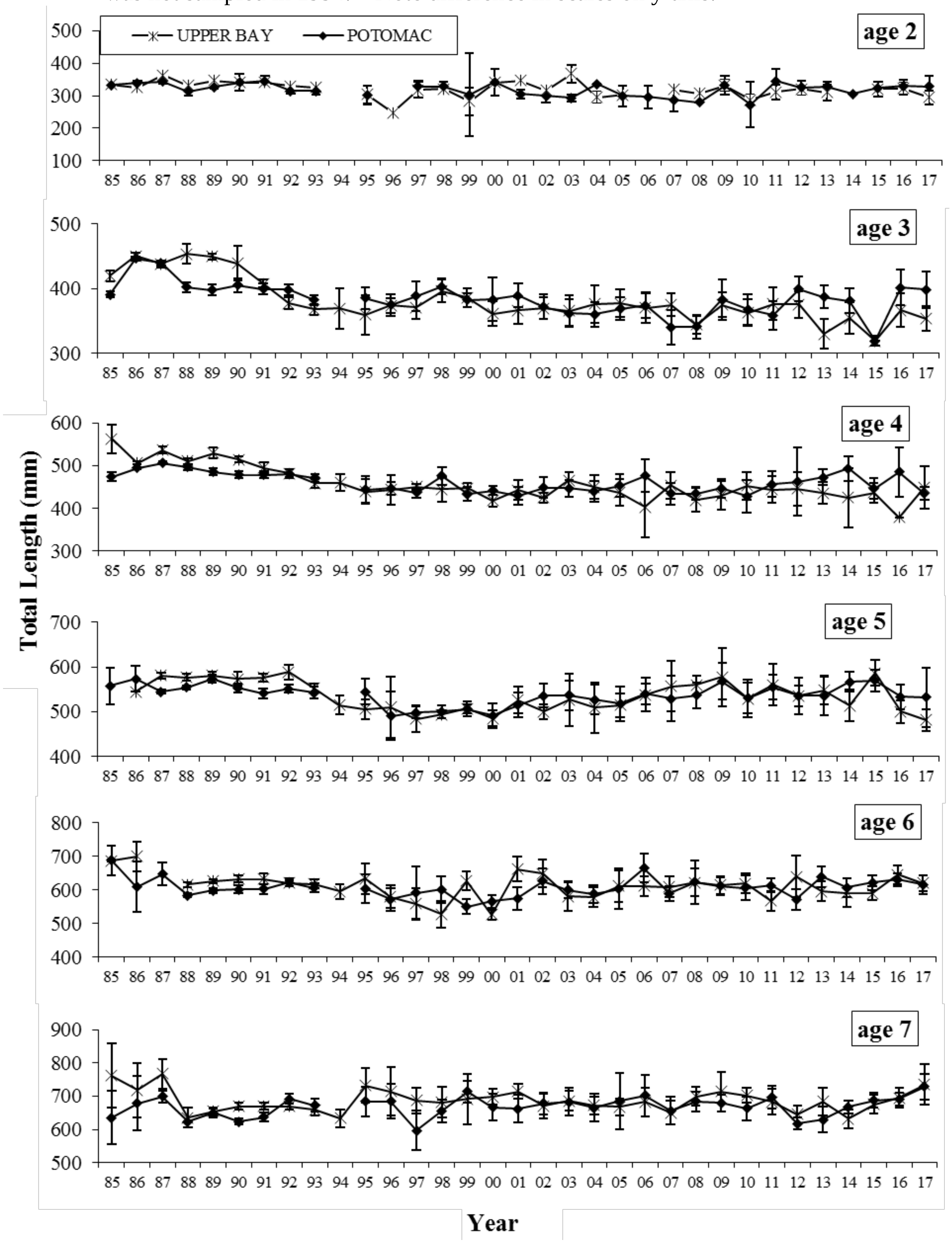


Figure 7. Mean length (mm TL) by year for individual ages of male striped bass sampled from spawning areas of the Potomac River and Upper Chesapeake Bay during March through May, 1985-2017. Error bars are ± 2 standard errors (SE). The Potomac River was not sampled in 1994. *Note difference in scales on y-axis.



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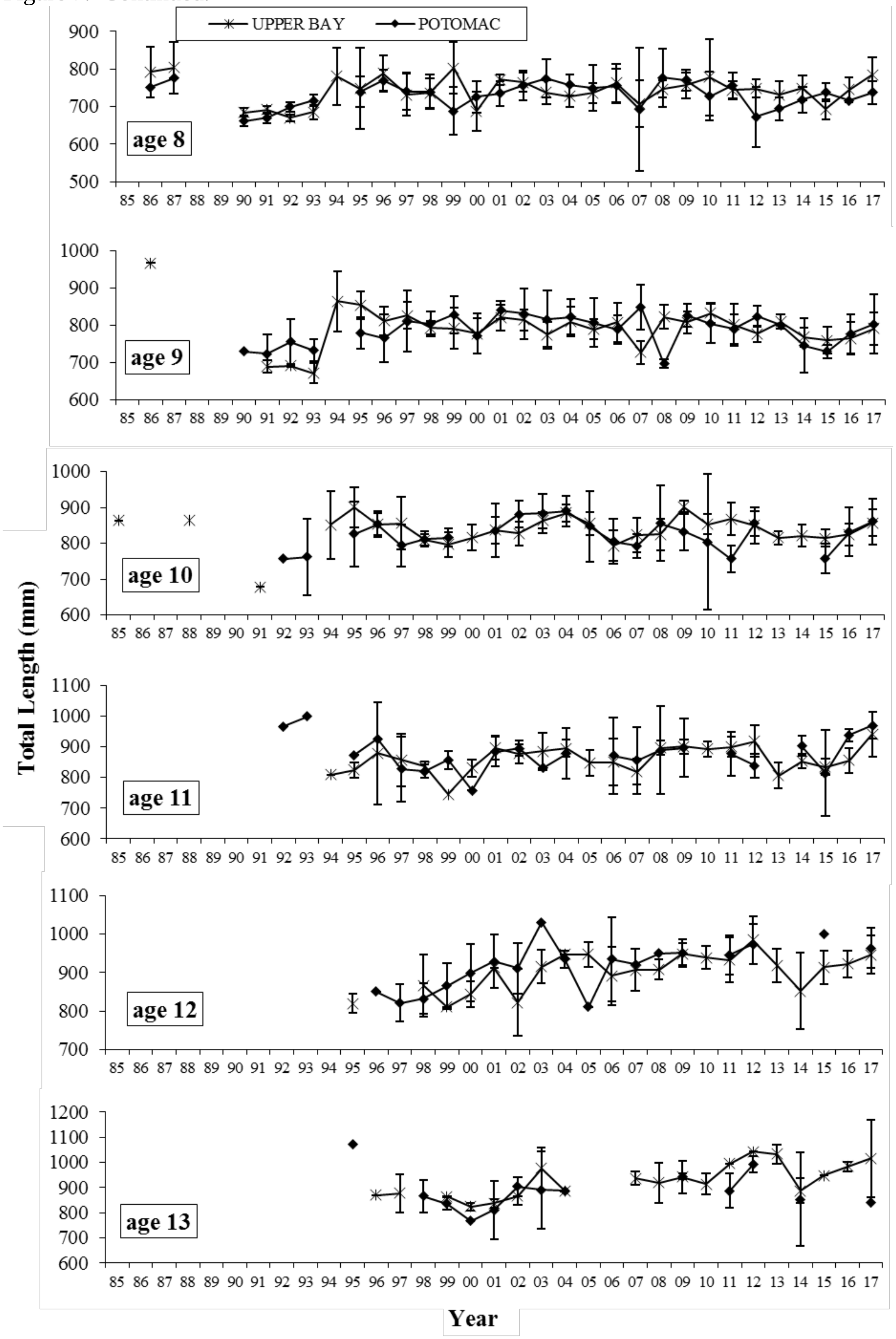
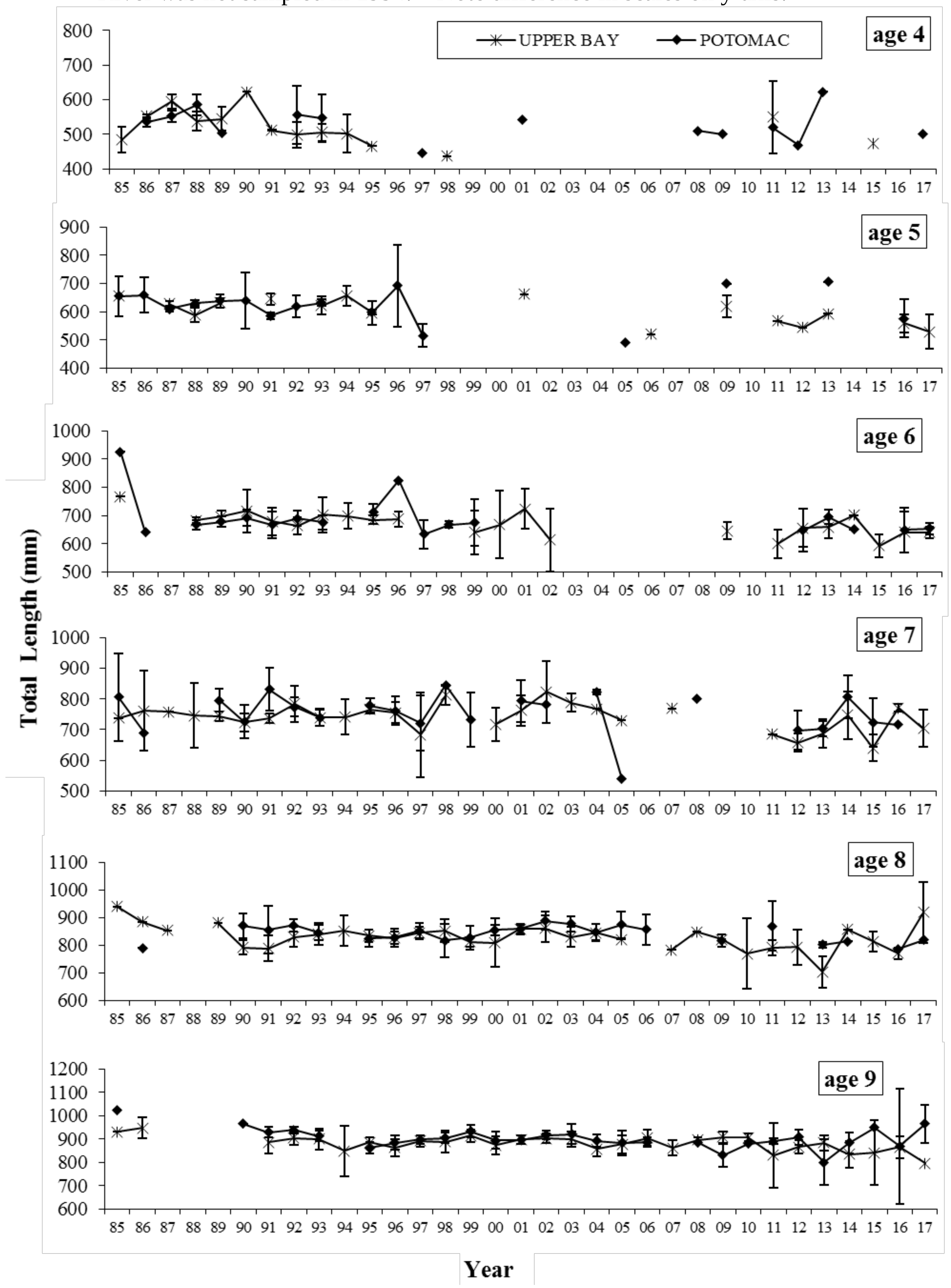


Figure 8. Mean length (mm TL) by year for individual ages of female striped bass sampled from spawning areas of the Potomac River and Upper Chesapeake Bay during March through May, 1985–2017. Error bars are ± 2 standard errors (SE). Note the Potomac River was not sampled in 1994. *Note difference in scales on y-axis.



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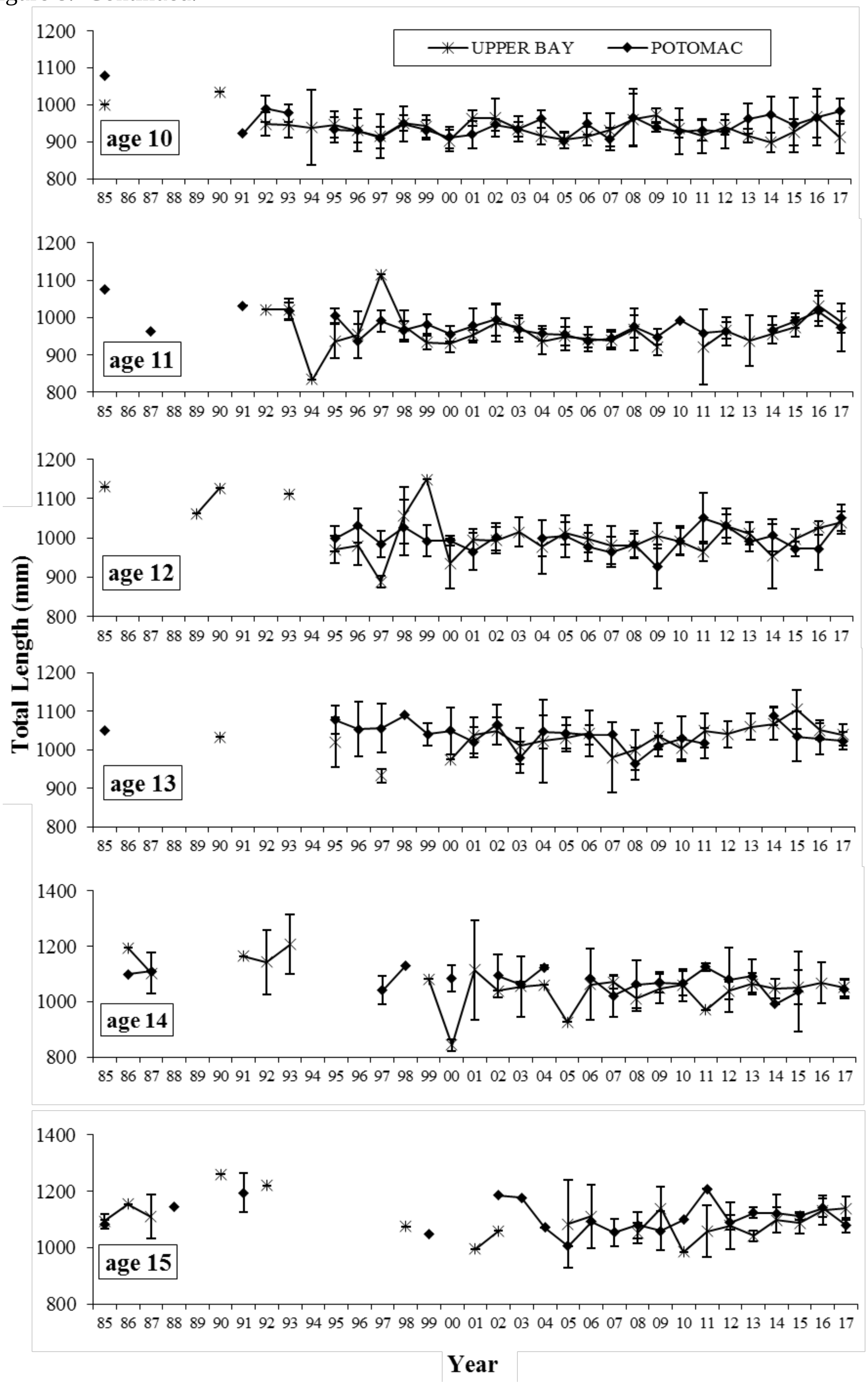
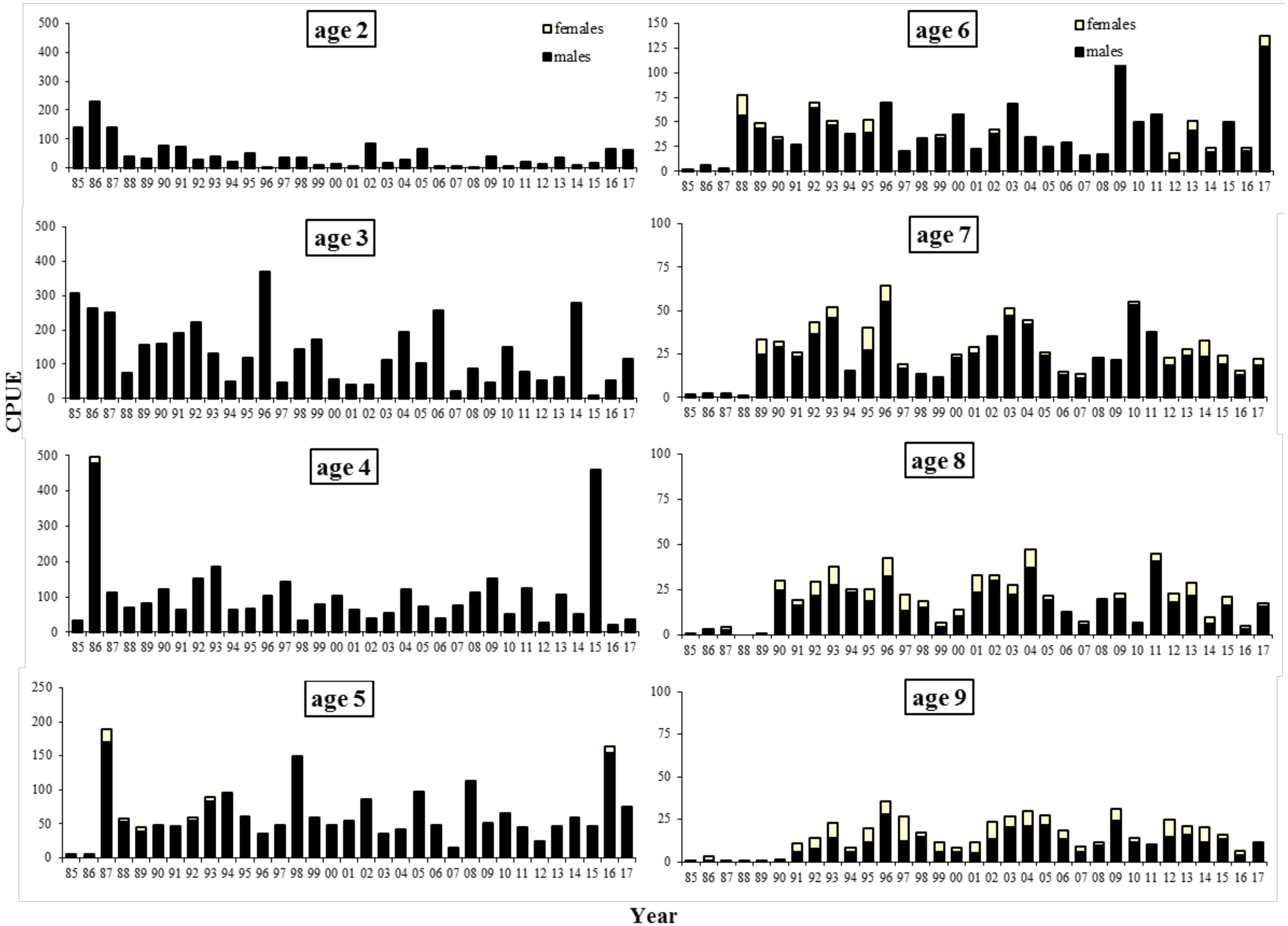


Figure 9. Maryland Chesapeake Bay spawning stock indices used in the coastal assessment. These are selectivity-corrected estimates of CPUE by year for ages 2 through 15+. Areas and sexes are pooled, although the contribution of sexes is shown in the stacked bars. Note different scales.



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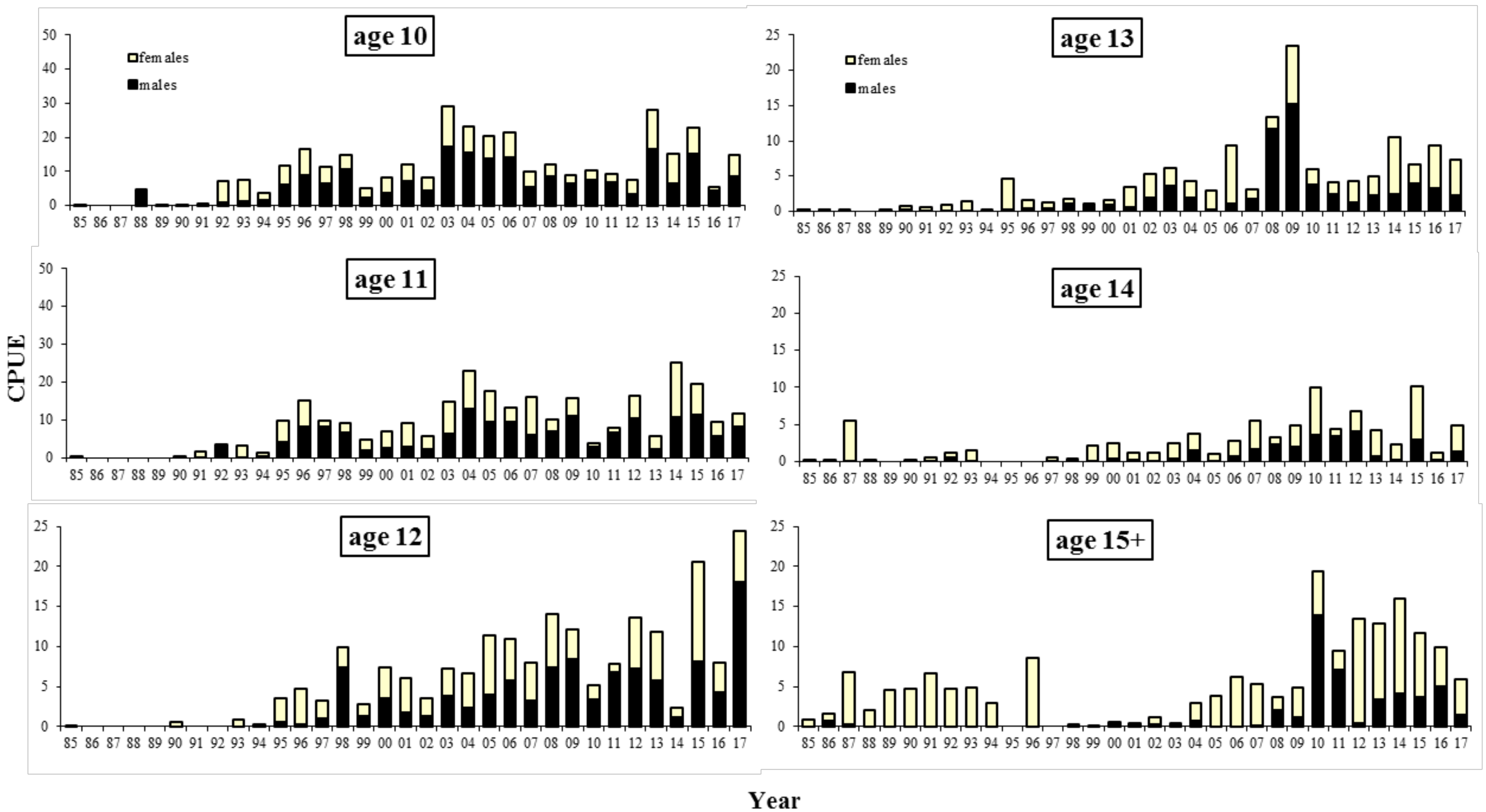
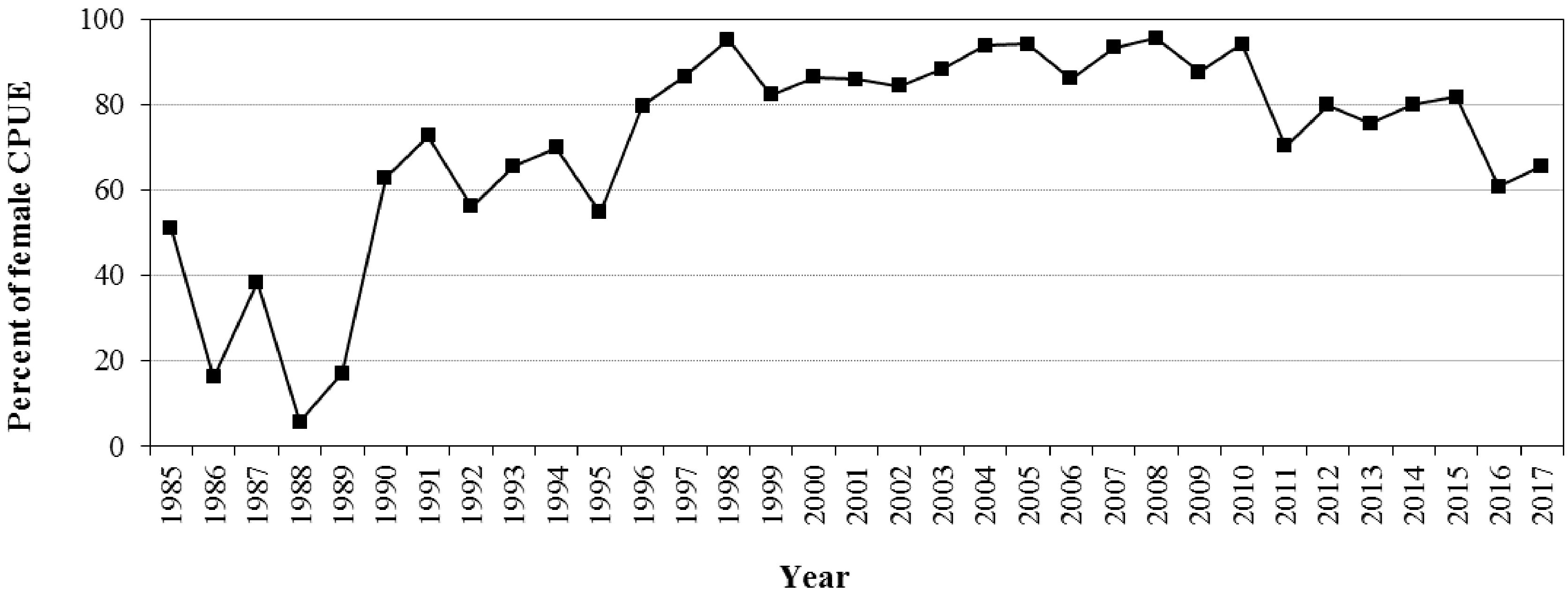
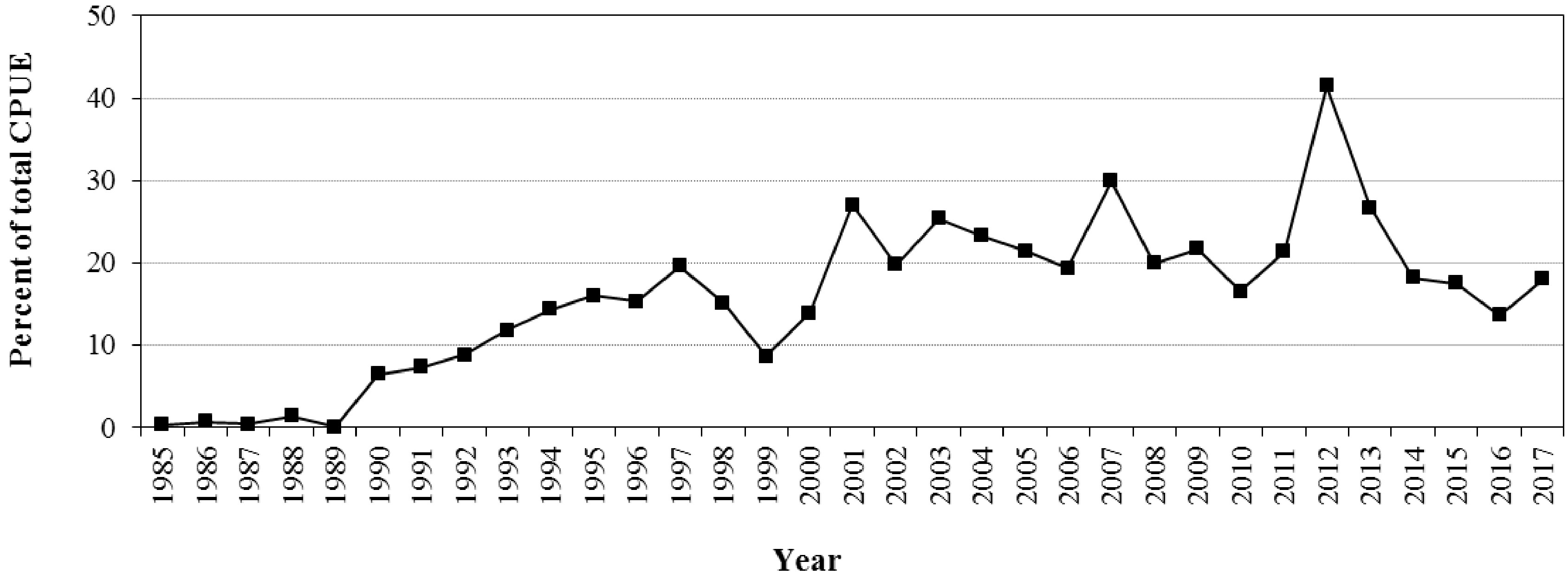


Figure 10. Percentage (selectivity-corrected CPUE) of female striped bass that were age 8 and older sampled from experimental drift gill nets set in spawning reaches of the Potomac River, Choptank River and the Upper Chesapeake Bay, March through May, 1985-2017 (Choptank River to 1996). Effort is standardized 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.



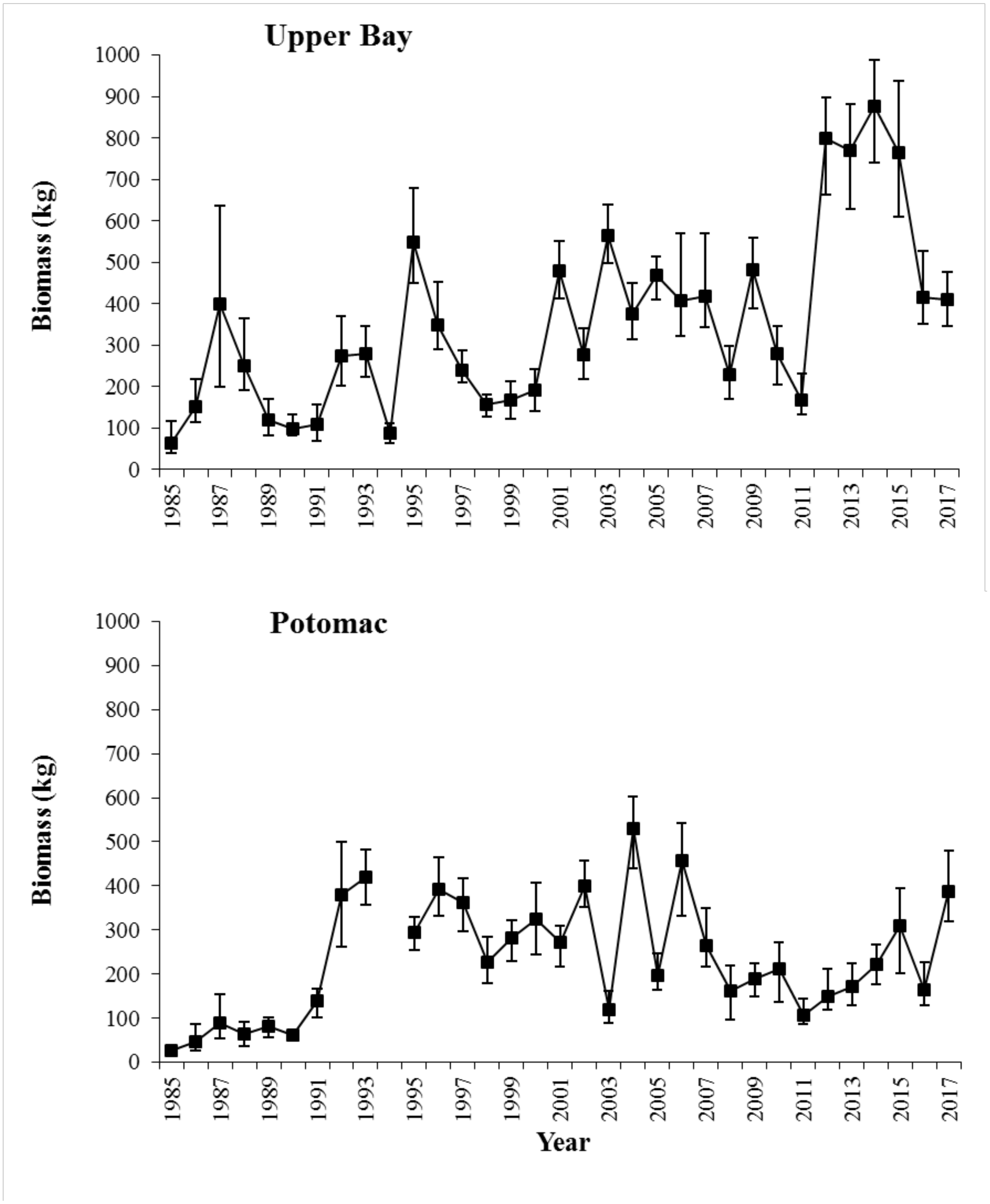
* Weights for spawning areas (1985 - 1996): Upper Bay=0.59; Potomac River=0.37; Choptank River=0.04.
(1997 - Present): Upper Bay=0.615; Potomac River=0.385. (Hollis 1967).

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, 1985-2017 (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, 1985-2017. 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.

From 1954 to 1961, Maryland’s juvenile surveys 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. The area swept was previously reported as a 729 m^2 quadrant, based on the area of a quarter-circle with a radius of 30.5 m. However, recent field trials showed that 492 m^2 is a more realistic estimate under ideal field conditions. When depths of 1.6 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 does not exist (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 population 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 $p=0.05$ level. Duncan's multiple range test was used to differentiate means.

RESULTS

Bay-wide Means

A total of 1,741 YOY striped bass was collected at permanent stations in 2017, with individual samples yielding between 0 and 101 fish. The AM (13.2) and GM (5.88) were both above their respective time-series averages and TPAs (Tables 2 and 3, Figures 2 and 3). The PPHL was

0.83, indicating that 83% of samples produced juvenile striped bass. The PPHL was greater than 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 ($p=0.05$) found that the 2017 $\log_e$-mean was significantly smaller than just nine years of the time-series.

System Means

Head of Bay - In 42 samples, 1,114 juveniles were collected at the Head of Bay sites for an AM of 26.52, greater than the time-series average (11.7) and the TPA (17.3) (Table 2, Figure 5). The GM of 18.52 was greater than the time-series average (5.72) 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 2017 Head of Bay $\log_e$-mean indiscernible from the best 11 year-classes of the time-series and significantly greater than the remaining 49 year-classes in the time-series.

Potomac River - A total of 358 juveniles was collected in 42 samples on the Potomac River. The AM of 8.5 fell between its time-series average (8.2) and TPA (9.2) (Table 2, Figure 5). The GM of 3.82 also fell between the time-series average (3.60) 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 ($p=0.05$) ranked the 2017 Potomac River year-class significantly smaller than just 6 other years, but indiscernible from 30 years of the time-series. The 2017 Potomac year-class was significantly greater than 24 years of the time-series.

Choptank River - A total of 164 juveniles was collected in 24 Choptank River samples. The AM of 6.8 was less than the time-series average of 21.0 and the TPA (10.8) (Table 2, Figure 5). The

GM of 3.40 was also less than its time-series average (8.04) and TPA (5.00) (Table 3, Figure 8). Differences among years were significant (ANOVA: P<0.0001). Duncan's multiple range test (p=0.05) found the 2017 Choptank River year-class significantly smaller than 15 years of the time-series, and significantly larger than only 12 years of the time-series.

Nanticoke River - A total of 105 juveniles was collected in 24 samples on the Nanticoke River. The AM of 4.4 was less than the time-series average (9.0) and TPA (8.6) (Table 2, Figure 5). The GM of 2.23 was also less than its time-series average (4.07) 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 (p=0.05) found the 2017 index significantly greater than only two years of the time-series, indiscernible from 49 years of the time-series and significantly less than nine years of the time-series.

Auxiliary Indices

At the **Head of Bay auxiliary sites**, 173 juveniles were caught in 14 samples, resulting in an AM of 12.4, and a GM of 6.62. Both indices exceeded their respective time-series averages (Table 5). The September sample could not be collected from Site #144 (Tydings Estate) this year due to prolific growth of macroalgae in the vicinity of the beach.

On the **Patuxent River**, 142 YOY striped bass were caught in 18 samples. The AM of 7.9 and GM of 2.08 were both less than their respective time-series averages, but greater than or equal to their respective time-series medians (Table 5).

DISCUSSION

Striped bass recruitment in Maryland's portion of Chesapeake Bay was slightly above average in 2017. The GM ranks in the 77th percentile of the time-series, and YOY striped bass were wide-spread, occurring in 83% of samples collected. This marks the second time in the past three years that the survey has documented above-average striped bass recruitment.

Recruitment in individual systems was variable. The Head of Bay indices were among the best in the history of the survey. Potomac River performance was approximately average. Indices in the Choptank and Nanticoke rivers were below-average.

Recruitment was highest in the Head of Bay spawning area, where YOY striped bass were captured in 100% of samples collected. The Head of Bay GM ranked in the 98th percentile of the time series, second only to the large year-class of 1958. Duncan's multiple range test ($p=0.05$) found recruitment in this area to be indistinguishable from the 11 largest year-classes ever measured.

Recruitment in the Choptank and Nanticoke rivers was below average. GM indices in these spawning areas were below their average benchmarks but equal to their respective time-series medians.

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% ($P \leq 0.001$) 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 61% of the variability ($r^2 = 0.61$, $p \leq 0.001$) in the age 1 indices (Figure 10). The equation that best described this relationship was: $C_1 = (0.1838)(C_0) - 0.0662$, 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 (0.13) was higher than the predicted index of 0.08. The relatively small, positive residual indicates that survival during the first winter of the 2016 year-class was slightly better than expected. Examination of residuals (Figure 11) shows that this regression equation can be used to predict subsequent yearling striped bass abundance with reasonable certainty in the case of small and average sized year-classes. Estimates of future abundance of age 1 striped bass are less reliable for dominant 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	
* 58	Susquehanna Flats	North side Spoil Island, 1.9 miles south of Tyding's Park
* 130	Susquehanna Flats	North side of Plum Point
* 144	Susquehanna Flats	Tyding's Estate, west shore of flats
* 132	Susquehanna Flats	0.2 miles east of Poplar Point
* 59	Northeast River	Carpenter Point, K.O.A. Campground beach
3	Northeast River	Elk Neck State Park beach
4	Elk River	Welch Point, Elk River side
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
163	Potomac River	Aqualand Marina
56	Potomac River	St. George Island, south end of bridge
55	Wicomico River	Rock Point

* 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
* 90	Patuxent River	Peterson Point

* 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
Average	11.7	8.2	21.0	9.0	11.7
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
Average	5.72	3.60	8.04	4.07	4.29
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
Average	11.9	207.2	1.46	91.77	0.71	0.64	0.78	
TPA*	12.0	194.8	1.52	93.18	0.71	0.62	0.80	

* TPA (target period average) is the average from 1959 through 1972.

Table 5. Maryland juvenile striped bass survey arithmetic (AM) and geometric (GM) mean catch per haul and number of seine hauls per year (n) for auxiliary sample sites.

	Patuxent River			Head of Bay		
Year	AM	GM	n	AM	GM	n
1983	0.1	0.04	18	0.6	0.33	12
1984	0.6	0.39	18	0.9	0.43	12
1985	3.2	1.95	18	1.0	0.24	12
1986	2.4	1.17	18	0.9	0.54	12
1987	2.9	0.94	17	0.3	0.26	9
1988	0.6	0.40	17	1.6	1.07	21
1989	1.4	0.92	18	10.4	1.91	21
1990	0.3	0.17	18	5.0	2.24	21
1991	0.9	0.53	18	2.2	0.98	20
1992	9.5	1.85	18	0.5	0.26	20
1993	104.3	47.18	18	28.0	11.11	21
1994	4.1	2.82	18	6.3	2.31	21
1995	7.3	3.46	18	3.0	1.15	21
1996	420.4	58.11	18	12.4	4.69	20
1997	7.3	2.72	18	2.7	2.18	20
1998	13.2	7.58	18	3.0	1.51	16
1999	7.3	5.39	18	3.6	2.13	13
2000	9.7	5.03	18	8.6	5.68	15
2001	17.3	10.01	18	19.5	6.62	15
2002	1.2	0.69	18	1.0	0.42	15
2003	61.1	22.17	18	16.1	11.79	16
2004	2.1	1.29	18	7.7	4.40	15
2005	8.9	3.91	18	5.5	4.35	15
2006	1.0	0.66	18	0.7	0.31	15
2007	15.2	6.07	18	5.3	2.72	15
2008	0.3	0.24	18	3.5	2.02	15
2009	3.0	1.87	18	2.1	1.14	15

Table 5. Continued.

	Patuxent River			Head of Bay		
Year	**AM**	**GM**	**n**	**AM**	**GM**	**n**
2010	3.3	2.49	18	3.7	1.45	15
2011	42.5	13.41	18	12.3	5.75	21
2012	0.1	0.04	18	1.9	0.71	21
2013	6.0	2.63	18	4.9	2.82	15
2014	5.1	2.70	18	5.3	4.34	15
2015	11.5	4.15	18	6.3	4.15	15
2016	1.4	0.83	18	1.5	0.90	15
2017	7.9	2.08	18	12.4	6.62	14
Average	22.4	6.17		5.7	2.84	
Median	4.1	2.08		3.6	2.02	

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	N/A

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

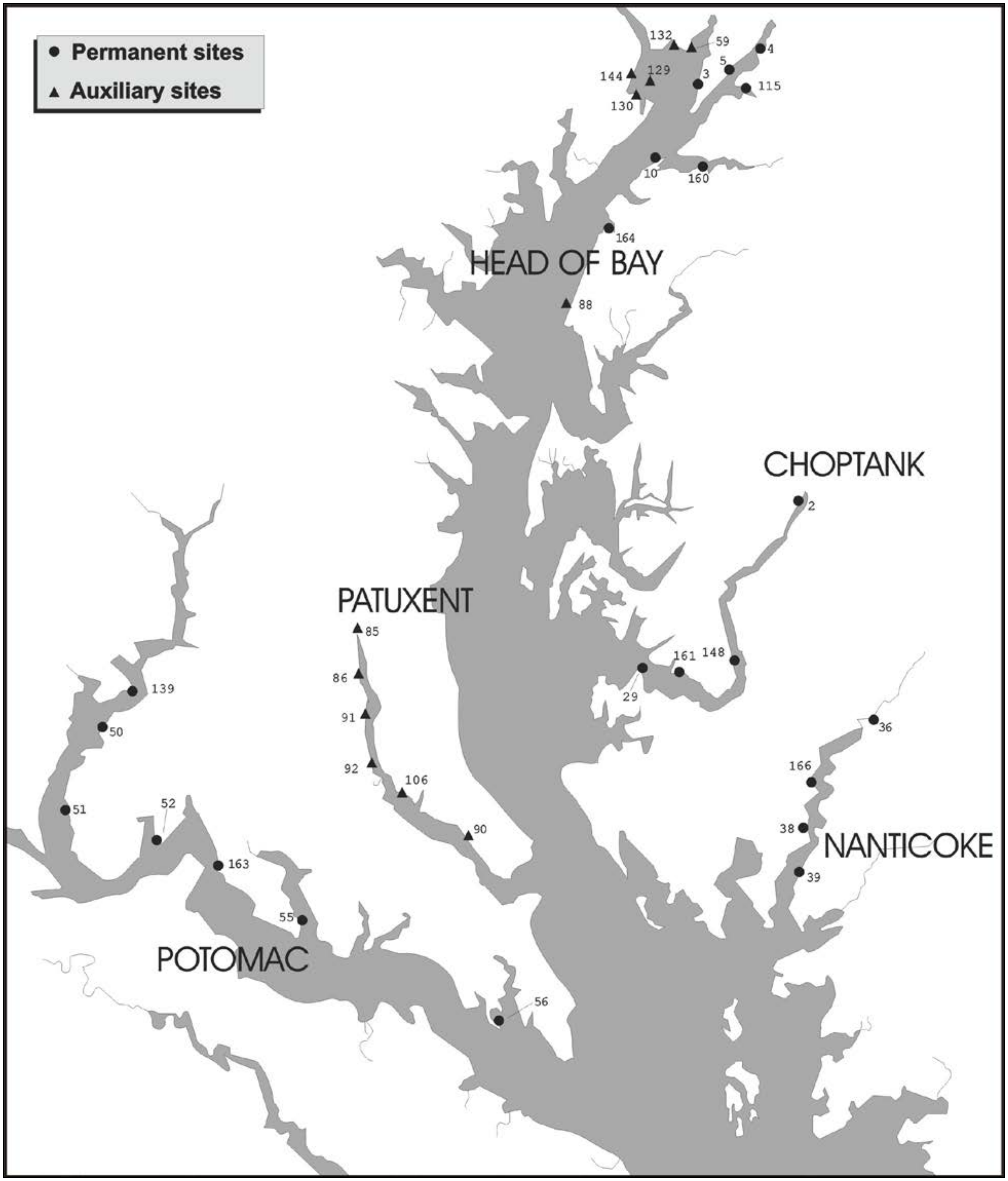


Figure 2. Maryland Chesapeake Bay arithmetic mean (AM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

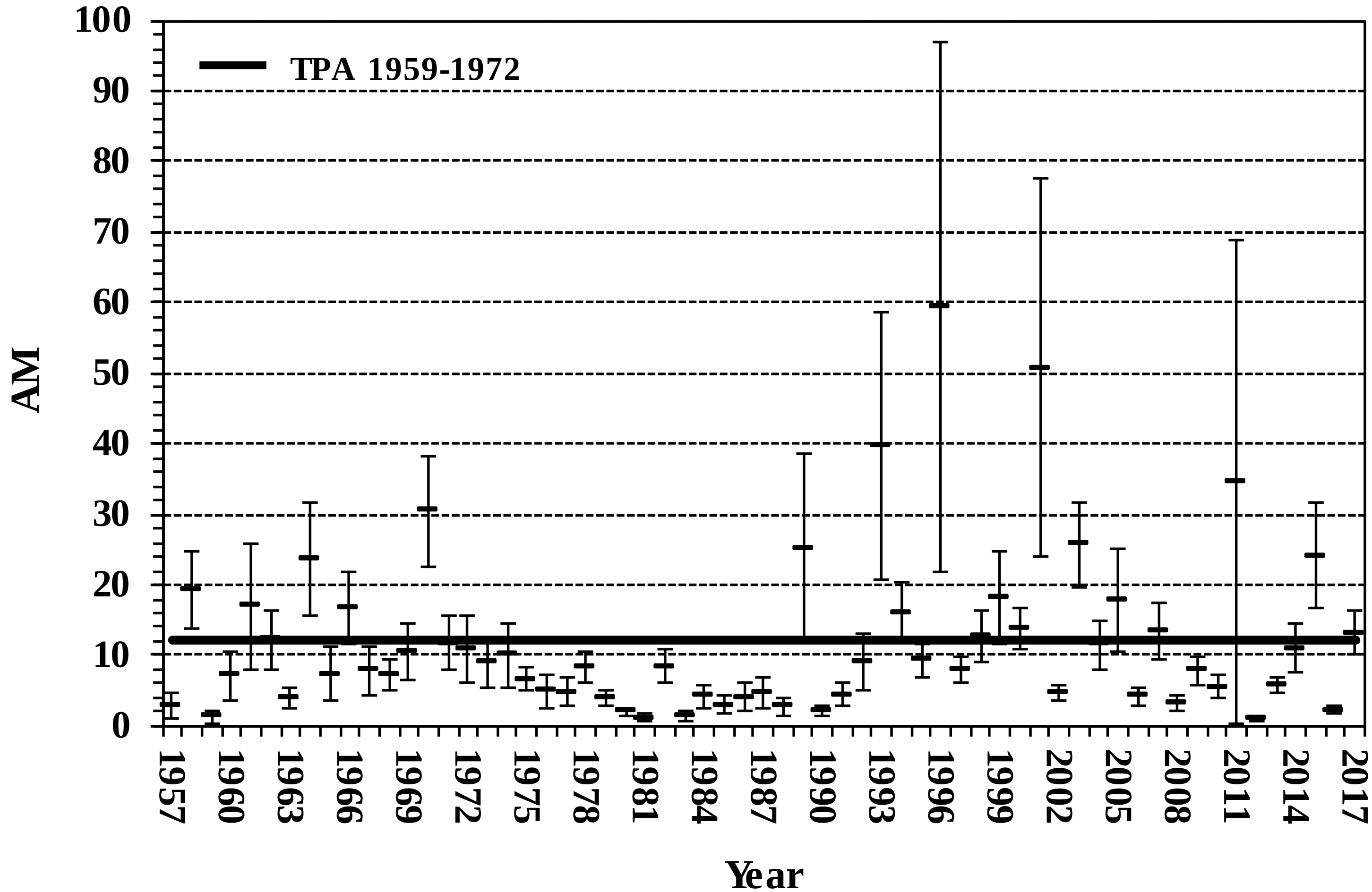


Figure 3. Maryland Chesapeake Bay geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

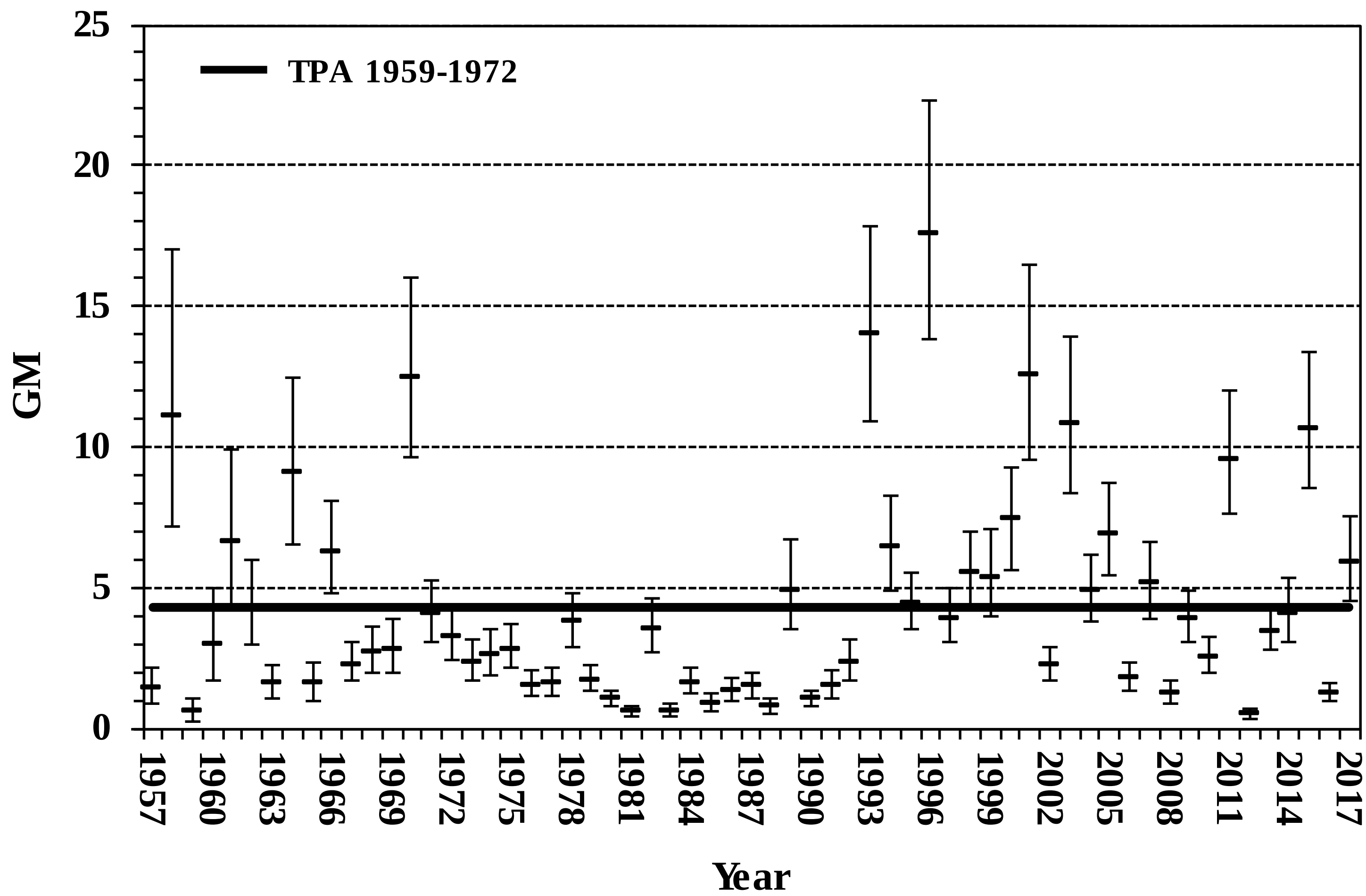


Figure 4. Maryland Chesapeake Bay juvenile striped bass indices. Arithmetic mean (AM), scaled geometric mean (GM)*, and proportion of positive hauls (PPHL) as percent.

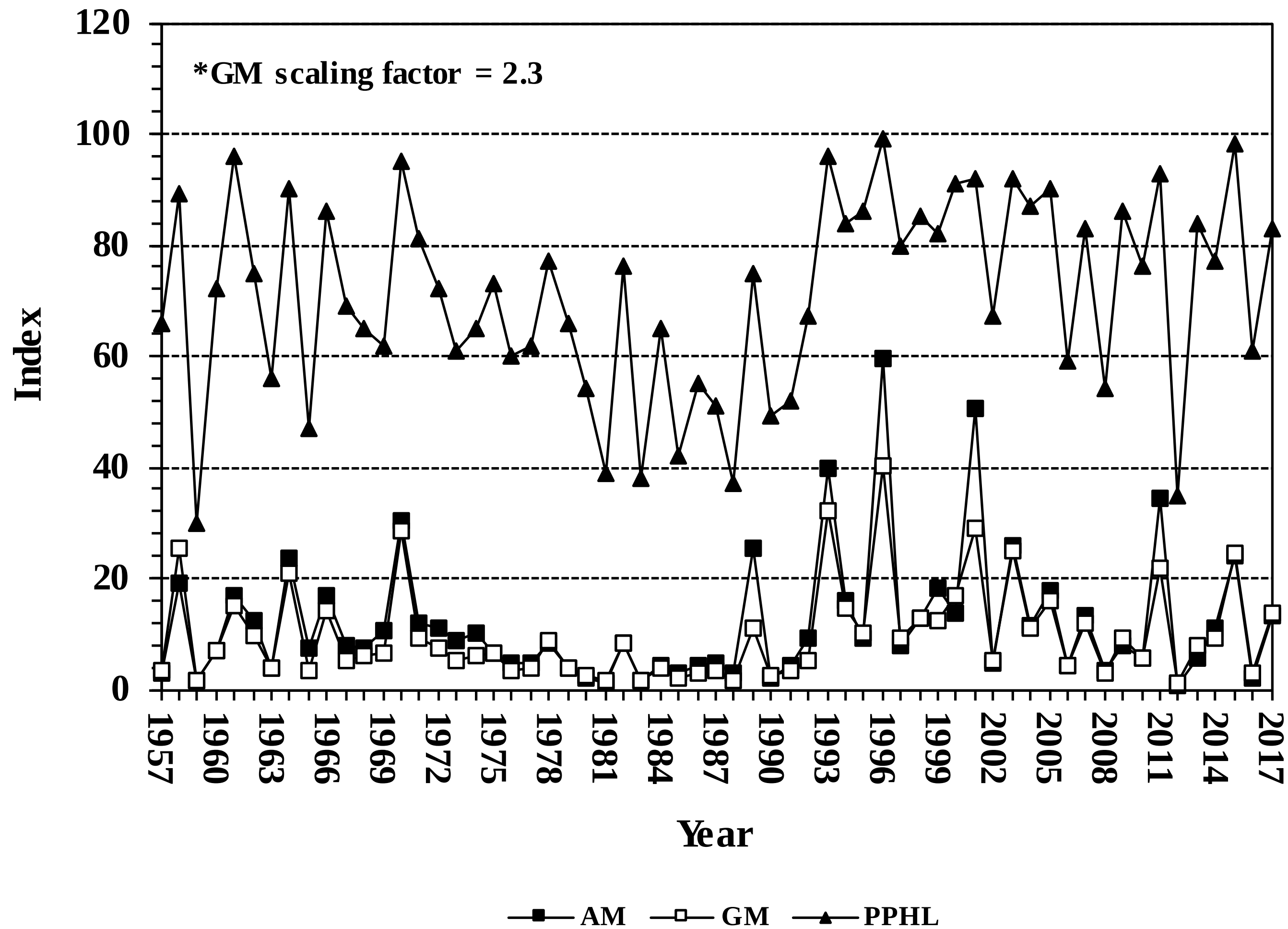


Figure 5. Arithmetic mean (AM) catch per haul by system for juvenile striped bass. Note different scales.

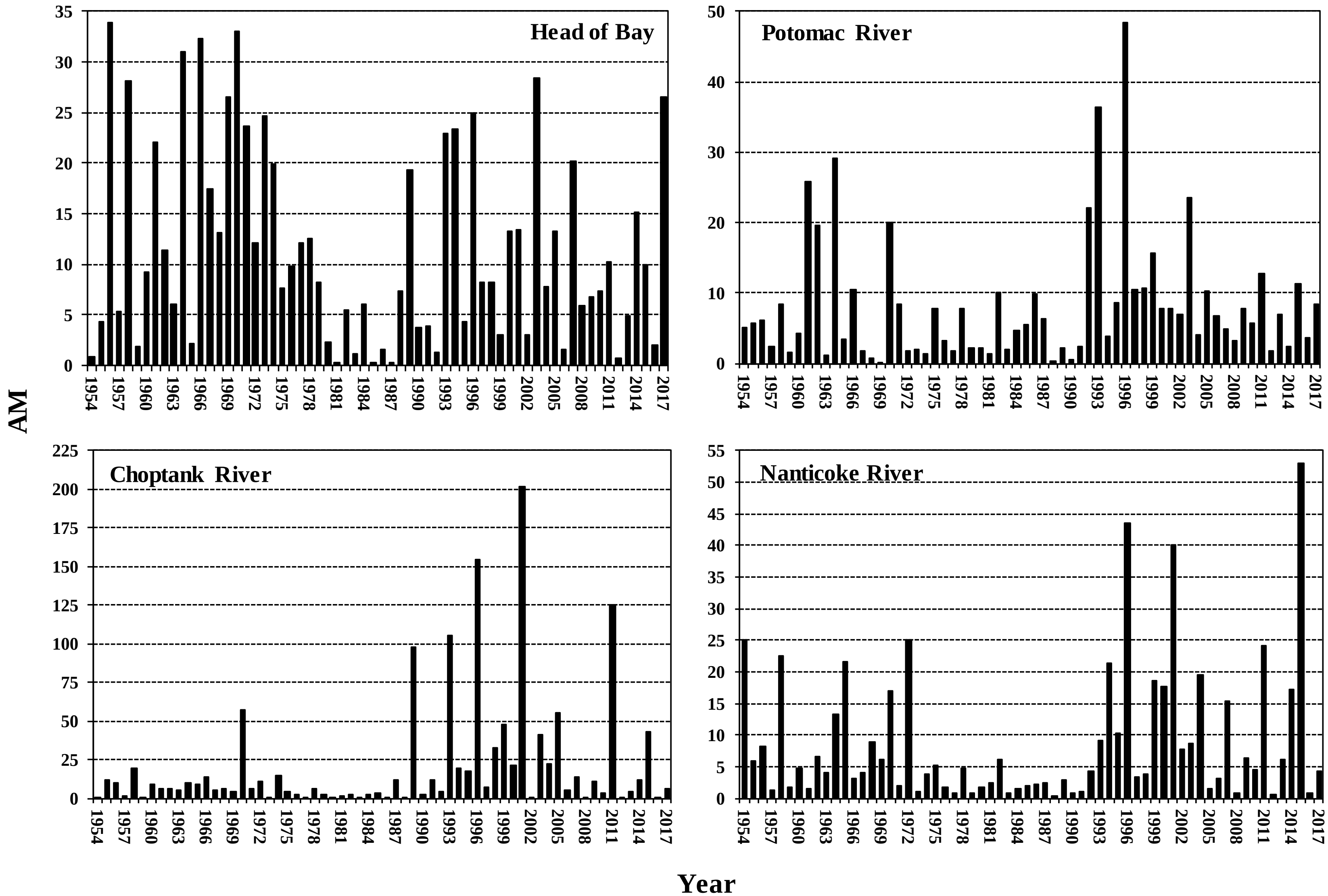


Figure 6. Head of Bay geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

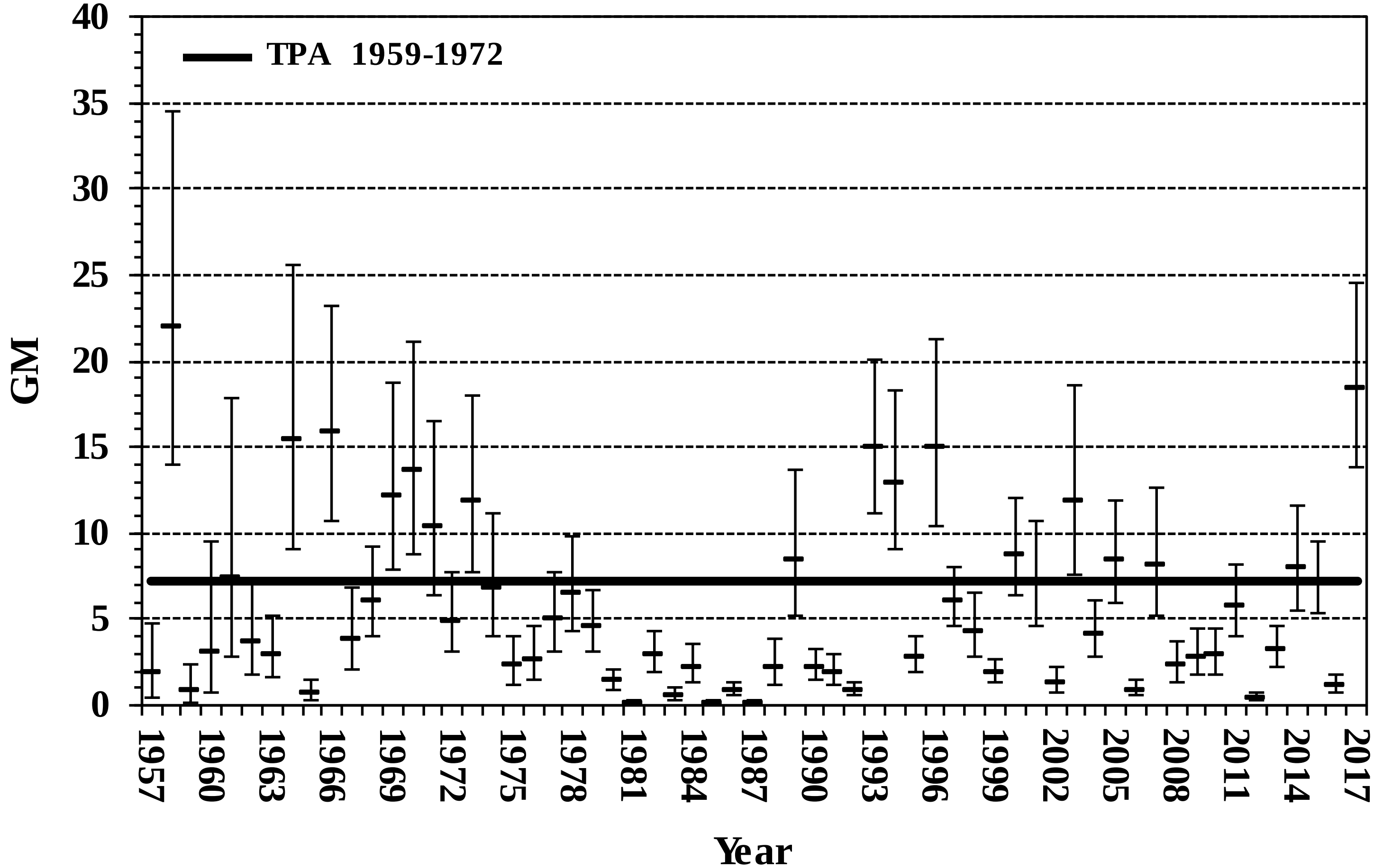


Figure 7. Potomac River geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

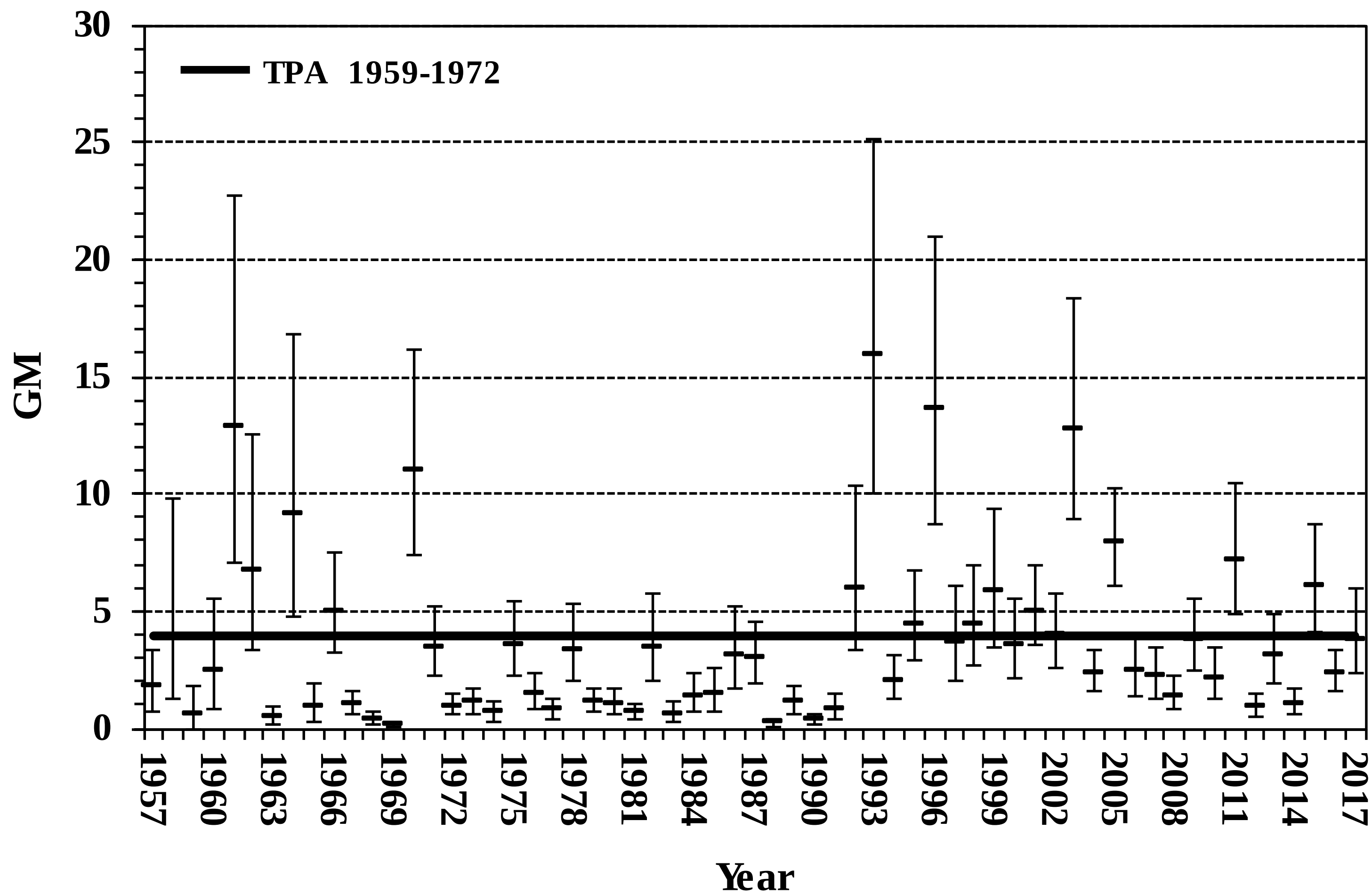


Figure 8. Choptank River geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

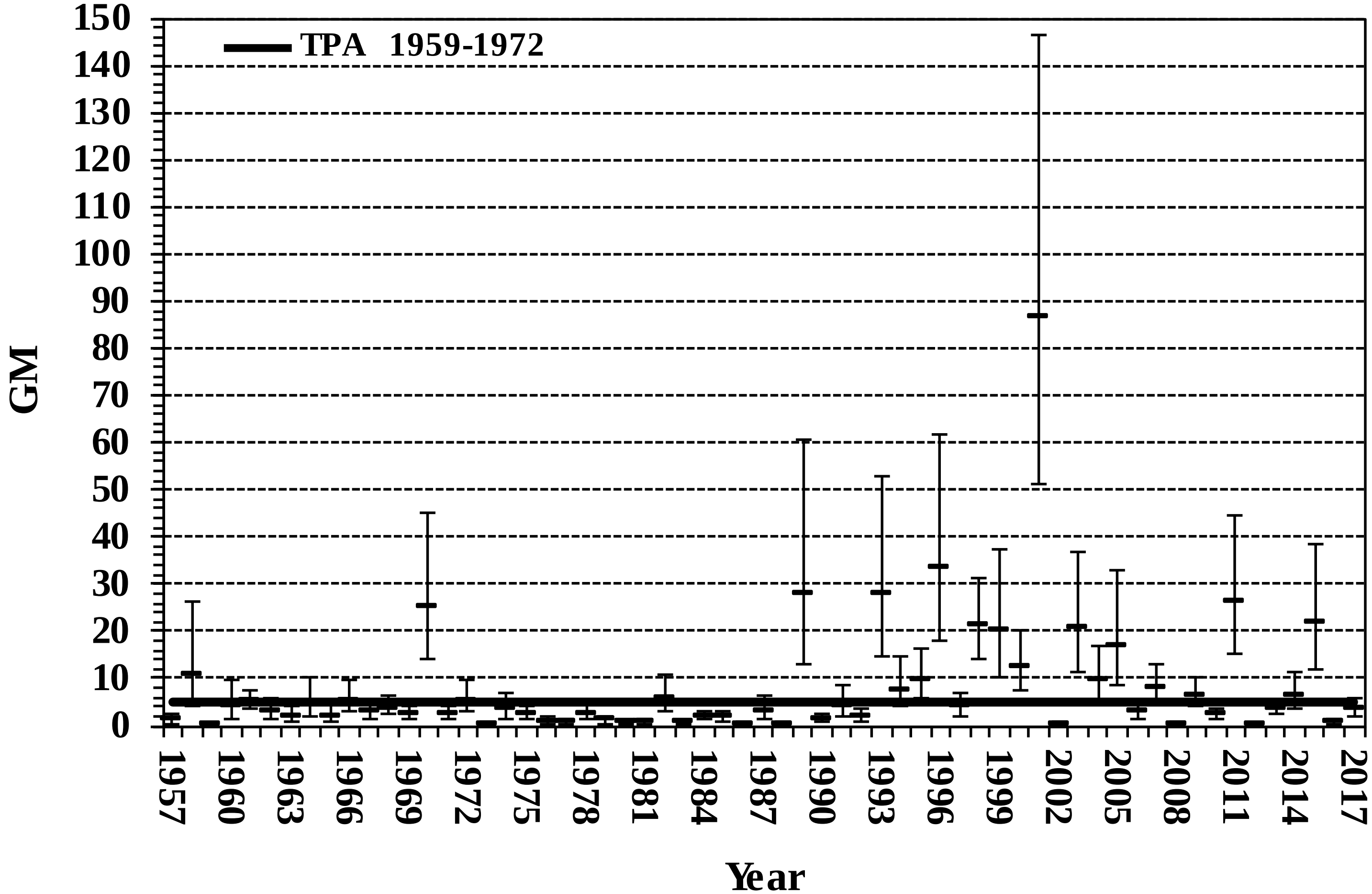


Figure 9. Nanticoke River geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

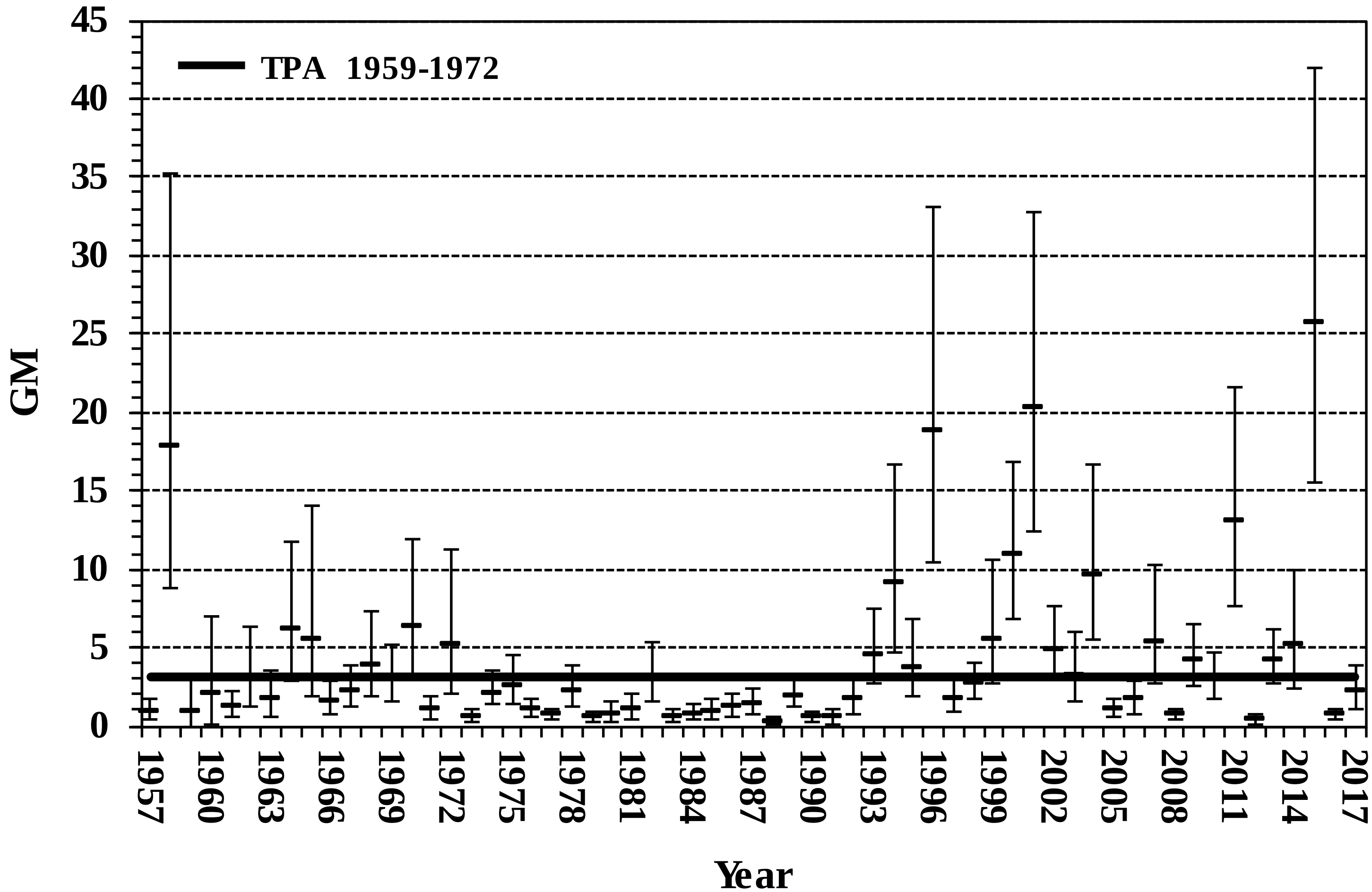


Figure 10. Relationship between age 0 and subsequent age 1 striped bass indices.

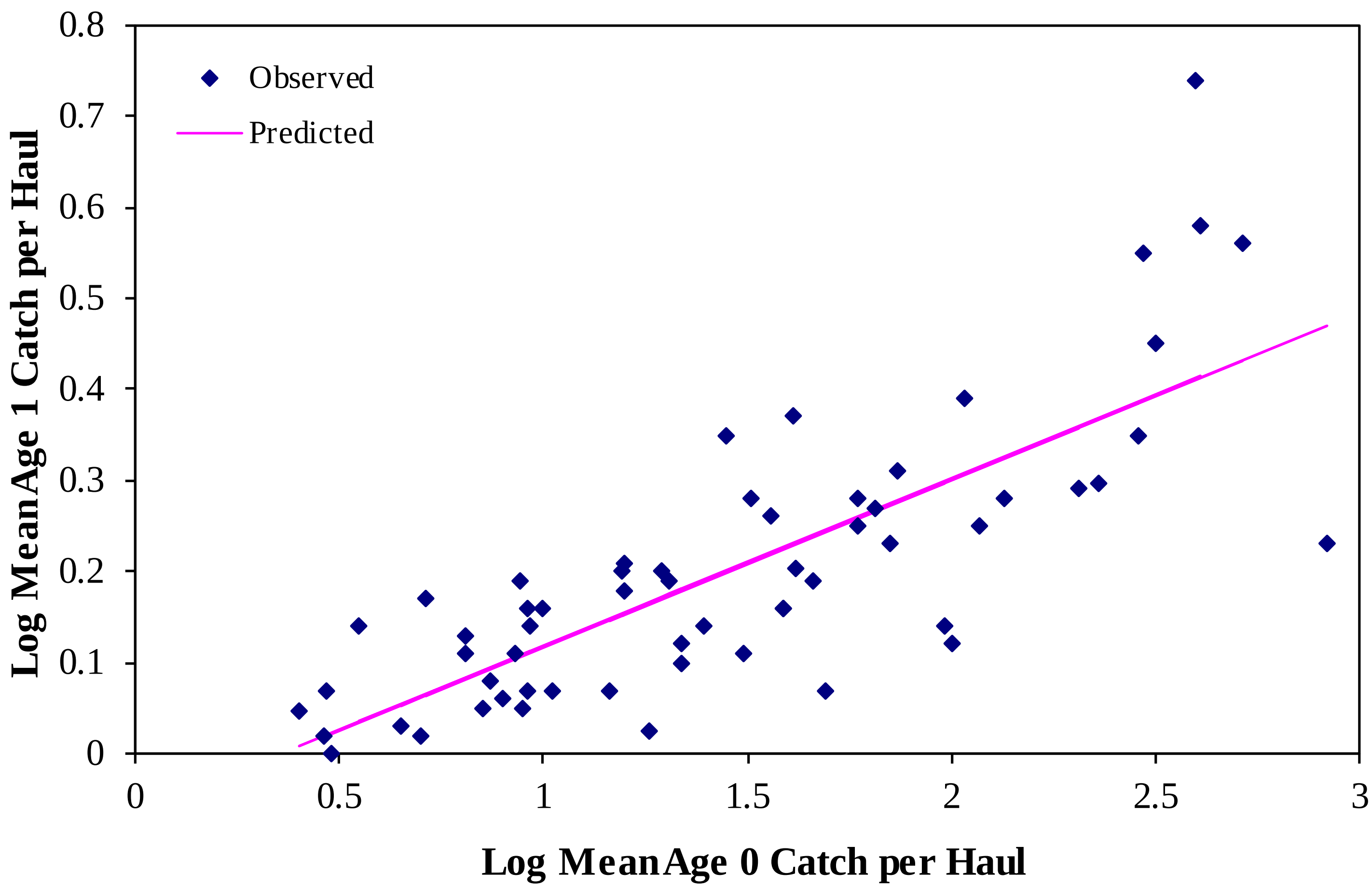
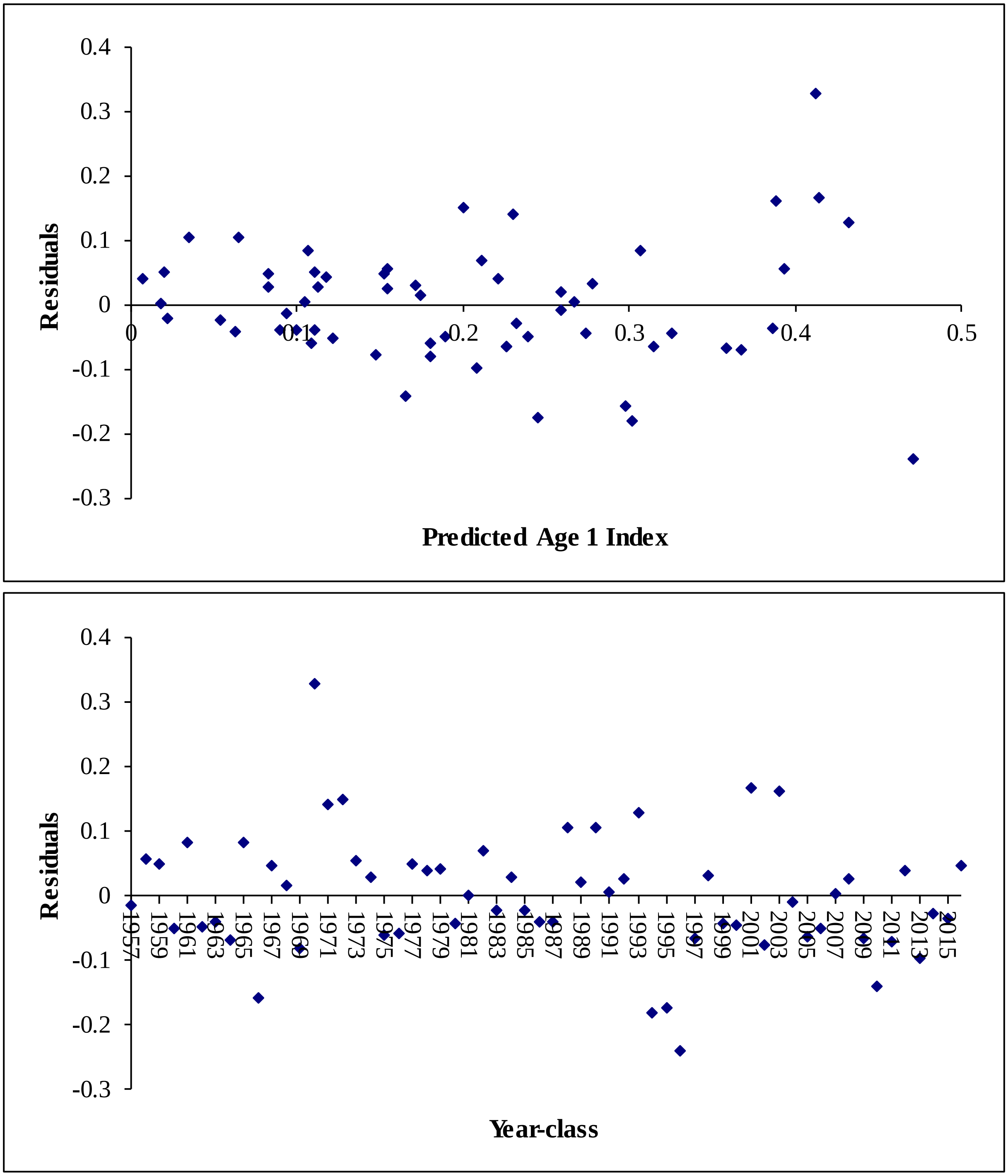


Figure 11. Residuals of age 1 and age 0 striped bass regression.



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

STRIPED BASS TAGGING

Prepared by Beth A. Versak

INTRODUCTION

The primary objective of Project 2, Job 3, Task 4 was to summarize striped bass tagging activities in Maryland's portion of the Chesapeake Bay in 2017. The Maryland Department of Natural Resources (MD DNR) has been a key partner in the North Carolina cooperative winter tagging cruise and continues to maintain the long-term data set for the cruise. For these reasons, the offshore tagging cruise 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

From the end of March through mid-May 2017, 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 (TL) to the nearest millimeter (mm) 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. No more than 10 scale samples per 10-mm length group were taken 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 2017, funding was obtained to conduct only the hook and line component of the offshore North Carolina tagging cruise. The goal was to tag as many coastal migratory striped bass as possible while they were wintering in the Atlantic Ocean off northeastern North Carolina and/or Virginia (state and federal waters). Participants in the sampling effort included USFWS, North Carolina Division of Marine Fisheries (NC DMF), North Carolina Department of Environmental Quality, MD DNR, South Atlantic and Mid-Atlantic Fisheries Management Councils, Atlantic States Marine Fisheries Commission (ASMFC), U. S. Coast Guard, Potomac River Fisheries Commission, North Carolina Wildlife Resources Commission, Virginia Department of Game and Inland Fisheries, North Carolina State Cooperative Extension and Delaware State University.

Fishing was conducted onboard a contracted sportfishing vessel departing from Virginia Beach, VA. Sampling was conducted during 10 fishing trips, between January 21 and February 5, 2017. Between six and seven lines with custom-made tandem parachute rigs were trolled, at 2 to 3 knots, in depths of 60 to 105 feet (18.3 to 32 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 similar in structure to the models previously used in Program MARK, and are formulated based on historical changes in striped bass management. Three models were run in Program MARK as a check on the calculated total mortality (Z). Additional details on the methodologies can be found in the latest peer reviewed stock assessment report (Northeast Fisheries Science Center 2013). Further details on Program MARK methodologies can be found in Versak (2007).

Estimates for Maryland's spawning stock are broken into two size groups: $\geq$457 mm TL (18 inches) and $\geq$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 2017 will not be completed until after March 27, 2018.

Tag release and return data from spring male fish, $\geq$457 mm TL and <711 mm TL (18 – 28 inches TL), are used to develop annual estimates of fishing mortality for the Chesapeake Bay pre-migratory stock. 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 2013).

Estimates of survival, fishing mortality and recovery rates for the North Carolina cooperative tagging cruise data were calculated using the same methods as Maryland's spring tagging data. These calculations will be conducted by the USFWS.

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

RESULTS AND DISCUSSION

Spring tagging

The spring sampling component monitored the size and sex characteristics of striped bass spawning in the Potomac River and the upper Chesapeake Bay. Sampling occurred between March 30 and May 16, 2017. A total of 2,680 striped bass were sampled and 1,515 (57%) 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 on 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 2017 (593 mm TL) was significantly greater (t-value = -7.20, $P<0.0001$) than that of the sampled population (548 mm TL) (Figure 2). This was also evident in the significant difference of the two length frequencies ($D=0.094$, $P<0.0001$).

Tag releases and recaptures from both Maryland and Virginia's sampling (combined spring 2017 data) will be used to estimate an instantaneous fishing mortality rate on resident fish for the 2017-2018 recreational, charter boat, and commercial fisheries for the entire Chesapeake Bay. Estimates of survival and fishing mortality for the 2017 Chesapeake Bay spawning stock, as well as the resident stock, will be presented in the next report of the ASMFC Striped Bass Tagging Subcommittee. A benchmark stock assessment is planned for 2018.

North Carolina cooperative offshore tagging activities

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

In 2017, 904 striped bass were encountered and 881 (97%) were tagged (Table 2). The mean length of all fish sampled during the hook and line sampling was 1023 mm TL. The mean total length of striped bass tagged (1022 mm TL) was almost identical (Figure 3).

The mean total length of striped bass tagged on the 2017 hook and line cruise (1022 mm TL) was significantly greater than the length of fish tagged from the 2016 hook and line cruise (984 mm TL , t-value = -11.1, $P<0.0001$, Figure 3). Length distributions between the two years were also different ($D=0.244$, $P<0.0001$).

The NC DMF is presently completing age determination for the 2017 cruise via scale analysis. Estimates of survival and fishing mortality based on fish tagged in the 2017 North Carolina study will be presented in the next report of the ASMFC Striped Bass Tagging Subcommittee.

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

STRIPED BASS TAGGING

2018 PRELIMINARY RESULTS

Spring tagging

Sampling occurred between April 2 and May 18, 2018. A total of 2,427 striped bass were sampled and 1,080 (44%) were tagged as part of this long-term survey. Mean total length of striped bass tagged during spring 2018 (540 mm TL) was significantly greater (t-value = -9.11, $P<0.0001$) than that of the sampled population (480 mm TL).

Tag releases and recaptures from both Maryland and Virginia's sampling (combined spring 2018 data) will be used to estimate an instantaneous fishing mortality rate on resident fish for the 2018-2019 recreational, charter boat, and commercial fisheries for the entire Chesapeake Bay. Estimates of survival and fishing mortality for the 2018 Chesapeake Bay spawning stock, as well as the resident stock, will be presented following the ASMFC Benchmark Stock Assessment in 2018.

North Carolina cooperative offshore tagging activities

In 2018, funding was obtained to conduct only the hook and line component of the offshore North Carolina tagging cruise. Fishing was conducted onboard a contracted sportfishing vessel departing from Virginia Beach, VA. Sampling was conducted during 10 fishing trips, between January 24 and February 15, 2018. Fish were difficult to locate during the 2018 sampling timeframe.

While fishing with hook and line, 695 striped bass were encountered and 667 (96%) were tagged. The mean length of all fish sampled and of those tagged was 1046 mm TL.

The NC DMF is presently completing age determination for the 2018 cruise via scale analysis. Estimates of survival and fishing mortality based on fish tagged in the 2018 North Carolina study will be following the ASMFC Benchmark Stock Assessment in 2018.

The final, complete analyses of the 2018 striped bass tagging activities will appear in the next F-61 Chesapeake Bay Finfish Investigations report.

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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, March - May 2017.

System	**Inclusive Release Dates**	**Total Fish Sampled**	**Total Fish Tagged**	**Approximate Tag Sequences** [a]
Potomac River	3/30/17 - 5/10/17	919	392	535866 – 536000 542997 – 543254
Upper Chesapeake Bay	4/3/17 - 5/16/17	1,761[b]	1,123	537701 – 538500 602001 – 602324
Spring spawning survey totals:		2,680	1,515	

[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.

Table 2. Summary of USFWS internal anchor tags applied to striped bass during the 2017 cooperative offshore tagging cruise.

System	**Gear**	**Inclusive Release Dates**	**Total Fish Sampled**	**Total Fish Tagged**	**Approximate Tag Sequences**
Nearshore Atlantic Ocean (Near MD, VA, NC coasts)	Hook & Line	1/21/17 – 2/5/17	904	881	598501 – 599381

Figure 1. Tagging locations in spawning areas of the Upper Chesapeake Bay and the Potomac River, March - May 2017.

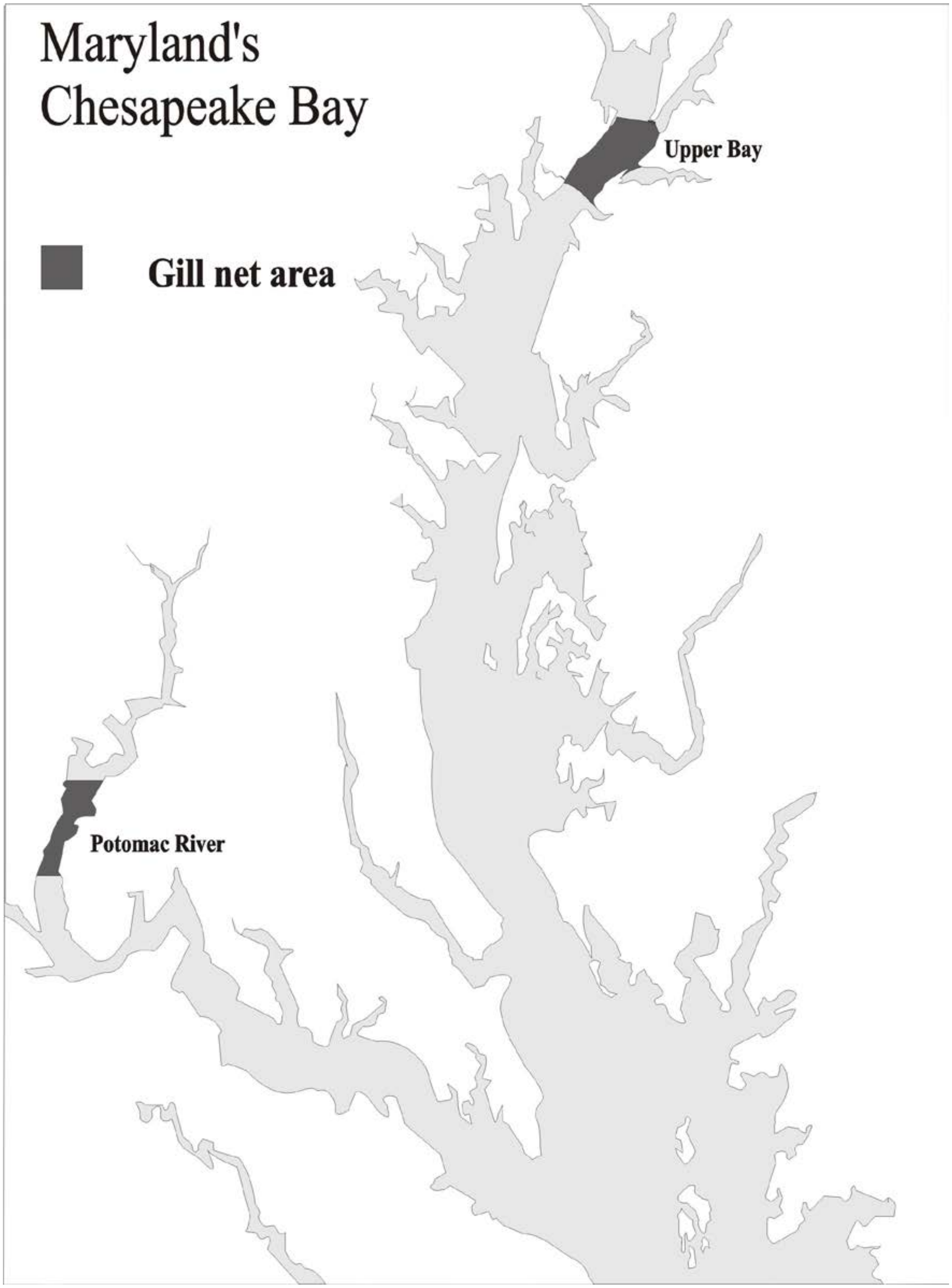


Figure 2. Length frequencies of striped bass measured and tagged during the spring in Chesapeake Bay, March - May 2017.

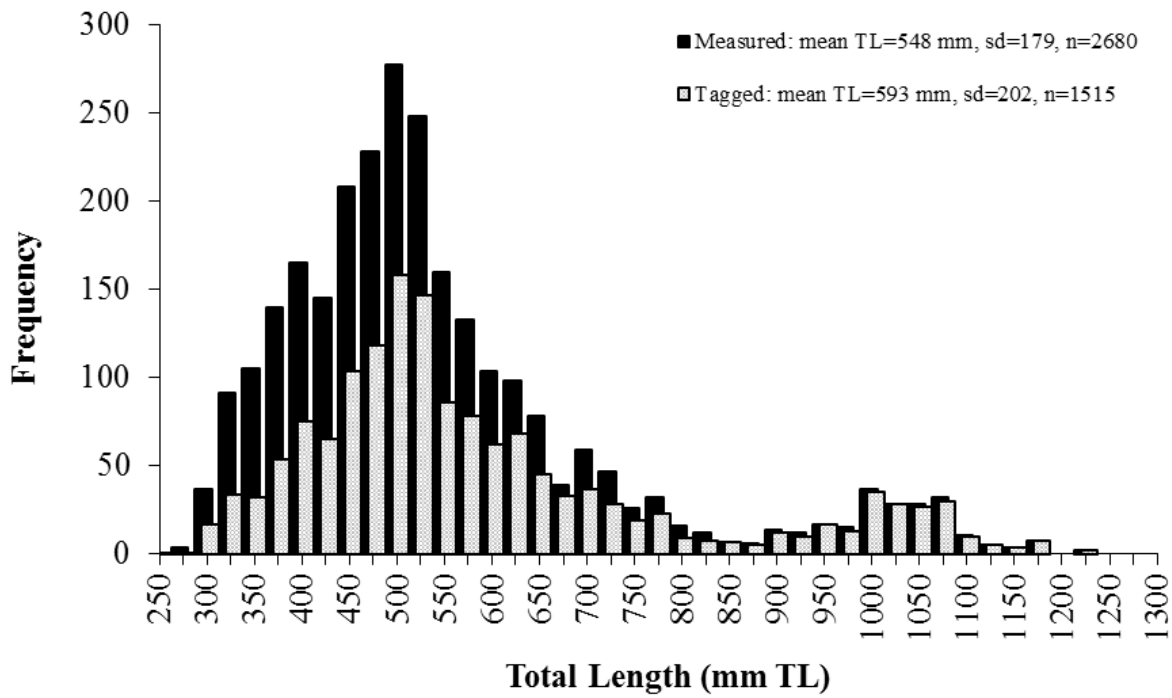
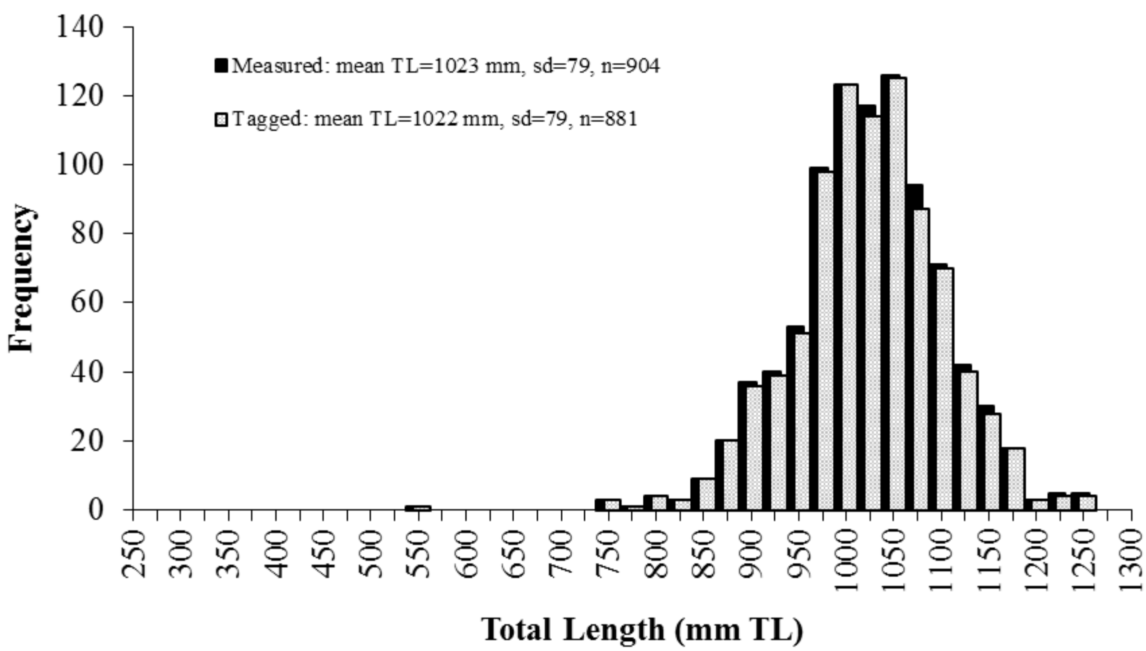


Figure 3. Length frequency of striped bass tagged during the cooperative offshore tagging cruise, January – February 2017.



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

COMMERCIAL FISHERY HARVEST MONITORING

Prepared by Robert J. Bourdon

INTRODUCTION

The primary objectives of Project 2, Job 3, Task 5A were to quantify the commercial striped bass harvest in 2016 and describe the harvest monitoring conducted by the Maryland Department of Natural Resources (MD DNR). Maryland completed its twenty-seventh year of commercial fishing under the quota system since the striped bass fishing moratorium was lifted in 1990. The commercial fishery receives 42.5% of the state's total annual Chesapeake Bay striped bass quota. The commercial quota system is based on a calendar year.

The official 2016 commercial quota for Maryland's Chesapeake Bay and tributaries was 1,471,888 pounds. This quota was identical to 2015 and 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.

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 2016 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 45,672 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 2016 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 2016 ITQ drift gill net season was split, with the first segment from January 1 through February 29, 2016 and the second segment from December 1 through December 31, 2016, Monday – Friday. The hook-and-line Common Pool fishery was open for two days each month from June – November. The gill net Common Pool fishery was open for three days in January, three days in February, and one day in December. The Atlantic coast fishery permitted two gear types, drift gill net and trawl, and the season occurred in two segments: January 1 through May 31, 2016 and October 1 through December 31, 2016, 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

Beginning in July 2008, commercial finfish license holders were notified by MD DNR that participation in the striped bass fishery required a declaration of intent to fish using a specified legal gear. In 2014, license holders were instead required to declare their intent to participate in the striped bass ITQ or Common Pool system. The period of August 1 – September 30 was allotted for receipt of declaration; this process is repeated for every year in which the license holder intends to fish. ITQ participants may transfer their permits and quota to other fishermen, or receive transfers, at any time during the fishing season.

MD DNR charged a fee to participants based upon the type of license held. Participants who held an Unlimited Tidal Fishing License (TFL) were required to pay $300. Participants who held an Unlimited Finfish Harvester License (FIN) were required to pay $150 and the Hook-and-Line Only License (HLI) were required to pay $100. Participants were also required to purchase a striped bass permit in addition to their license; TFL holders were required to pay $150, FIN and HLI holders were required to pay $200. Starting in August 2013, all commercial watermen are required to pay a $215 Harvester's Registration fee (Chris Jones, Pers. Comm). In addition, striped bass permittees are required to pay for their mandated commercial harvest tags.

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). These reports allowed MD DNR to monitor the daily reported 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.

In addition, individual fishermen were required to report their striped bass harvest on a monthly fishing report (MFR). MFRs were required to be returned by the 10th of the following month on a monthly basis, regardless of fishing activity. Fishermen who did not return a MFR were considered late. The names of those individuals with late reports appeared on the "Late Reports" list on the MD DNR commercial fisheries website. If the report was still not received by MD DNR 50 days after the due date, the licensee received an official violation. Two or more official violations in a 12-month period may result in a license suspension. The following information was compiled from each commercial fisherman's MFR: 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 log sheets, 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 log sheets, 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.

RESULTS AND DISCUSSION

On the Chesapeake Bay and its tributaries, 1,425,461 pounds of striped bass were harvested in 2016; which was 46,427 pounds under the quota. The reported number of fish landed was 326,584 (Table 2). The Chesapeake drift gill net fishery landed 46% of the total landings by weight, followed by the pound net fishery at 43%. The hook-and-line fishery accounted for 11% of the total Bay landings.

Maryland's Atlantic coast landings were reported at 1,191 striped bass, weighing 19,675 pounds (Table 2). The gill net fishery made up 98% of the Atlantic harvest, by weight, with the remainder from the trawl fishery.

Comparisons of Average Weight

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 log sheets. 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 did not allow biologists to discern 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 mean weight per fish of striped bass harvested in Chesapeake Bay, regardless of gear type, was 4.36 pounds when calculated from the check station log sheets and 6.10 pounds when measured by biologists (Table 3). Mean weights by specific gear type or season ranged from 3.43 to 5.97 pounds from check station log sheets, and 3.91 to 7.42 pounds when measured by biologists. By either method 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, with an average weight of 3.43 pounds, according to check station log sheets. No commercial fishermen participated in the haul seine fishery for the 2016 season.

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 17.95 pounds (Table 3). The average weight calculated from the check station log sheets was 16.52 pounds. Fish caught in the Atlantic trawl fishery averaged 7.36 pounds according to MD DNR check station survey estimates, and were smaller on average than those caught in the gill net fishery (20.79 pounds). The average weights of fish from the Atlantic trawl and gill net fisheries, as calculated from check station log sheets, were 28.12 and 16.35 pounds, respectively. The disparity between average weight estimates of Atlantic fish is likely due to the small sample size (n=25) surveyed by biologists during check station surveys.

Commercial Harvest Trends

Commercial striped bass quotas and harvests have been relatively consistent in the Chesapeake Bay since the late-1990s (Figure 4). The majority of the commercial striped bass harvest in Chesapeake Bay has historically been by drift gill net. The hook-and-line fishery generally harvests the least of the three major Chesapeake Bay gears. (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 variable since 2000. The Atlantic fishery has not reached its quota since 2009 (Figure 4). In contrast to most years since 1990, the 2016 Atlantic harvest was dominated by the drift gill net fishery (Table 4, Figure 5).

Commercial CPUE Trends

Weight harvested by year and gear type was taken from check station log sheets. The number of fishing trips in which striped bass were landed was determined from the MFRs

(Table 2). The pounds landed were divided by the number of trips to calculate an estimate of CPUE.

The Chesapeake Bay pound net fishery exhibited an increase in CPUE relative to 2015 and was the highest in the time-series. The hook-and-line fishery showed marginal decreases in CPUE. Despite a decrease from 2015, the drift gill net fishery still had the highest CPUE of all Chesapeake Bay gears in 2016 at 465 pounds per trip. Pound net CPUE ranked second at 433 pounds per trip. Consistent with historic trends, the hook-and-line fishery CPUE of 162 pounds per trip was the lowest of all Bay gear types. All three bay fisheries had CPUEs above the time series average, and both pound net and gill net CPUE is trending upwards since records began being kept in 1990 (Table 5, Figure 6).

After peaking at 1,819 pounds per trip in 2015, the Atlantic trawl CPUE dropped to 68 pounds per trip. The Atlantic drift gill net CPUE dropped from 287 pounds per trip in 2015 to 231 pounds per trip in 2016. The Atlantic gill net CPUE was slightly above the time series average, while the trawl CPUE was the lowest in the time-series and well below average (Table 5; Figure 6)). Low catches in recent years have sparked speculation that fish are concentrating farther offshore and outside the permitted fishing zone (commercial harvest is limited to state waters, within 3 miles of shore).

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Table 1. Striped bass commercial regulations by gear type for the 2016 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	300	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 45,672; No ITQ Quota	189	Common Pool – 300 lbs/license/week, 600 lbs/vessel/day; No trip limits for ITQ	18-36 in TL slot	Monthly Harvest Report
	Gill Net	Included in Common Pool 45,672; No ITQ Quota	189	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	Atlantic Trawl and Gill Net	90,727	56	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 2016 calendar year.

Area	Gear Type	Pounds[1]	Number of Fish[1]	Trips[2]
Chesapeake Bay[3]	Haul Seine	0	0	0
	Pound Net	611,075	177,919	1,412
	Hook-and-Line	154,238	38,094	951
	Gill Net	660,148	110,571	1,419
	Chesapeake Total	**1,425,461**	**326,584**	**3,782**
Atlantic Coast	Trawl	478	17	7
	Gill Net	19,197	1,174	83
	Atlantic Total	**19,675**	**1,191**	**90**
Maryland Totals		**1,445,136**	**327,775**	**3,872**

1. Data from check station log sheets.

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 (lbs) by gear type for the 2016 calendar year. Average weights calculated by MD DNR biologists include 95% confidence intervals.

<table>
<tr><th>Area</th><th>Gear Type</th><th>Average Weight from Check Station Logs (pounds)[1]</th><th>Average Weight from Biological Sampling (pounds)[2]</th><th>Sample Size from Biological Sampling[2]</th></tr>
<tr><td rowspan="5">Chesapeake Bay[3]</td><td>Haul Seine</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Pound Net</td><td>3.43</td><td rowspan="2">3.91 (3.80-4.02)</td><td rowspan="2">2,213</td></tr>
<tr><td>Hook-and-Line</td><td>4.05</td></tr>
<tr><td>Gill Net</td><td>5.97</td><td>7.42 (7.33-7.51)</td><td>3,661</td></tr>
<tr><td>Chesapeake Total Harvest</td><td>4.36</td><td>6.10 (6.02-6.18)</td><td>5,874</td></tr>
<tr><td rowspan="3">Atlantic Coast</td><td>Trawl</td><td>28.12</td><td>7.36 (6.36-8.36)</td><td>7</td></tr>
<tr><td>Gill Net</td><td>16.35</td><td>20.79 (17.25-24.33)</td><td>18</td></tr>
<tr><td>Atlantic Total Harvest</td><td>16.52</td><td>17.95 (13.52-21.33)</td><td>25</td></tr>
</table>

1. Data from check station log sheets, pounds divided by the number of fish reported.

2. Data from check station sampling by MD DNR biologists, all months combined.

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 2016.

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

Table 5. Striped bass average catch per trip (CPUE) in pounds by commercial gear type, 1990 to 2016.

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
27 year avg	154	268	285	200	653
5 year avg	177	368	458	217	1,123

Figure 1. Map of the 2016 Maryland authorized commercial striped bass check stations.

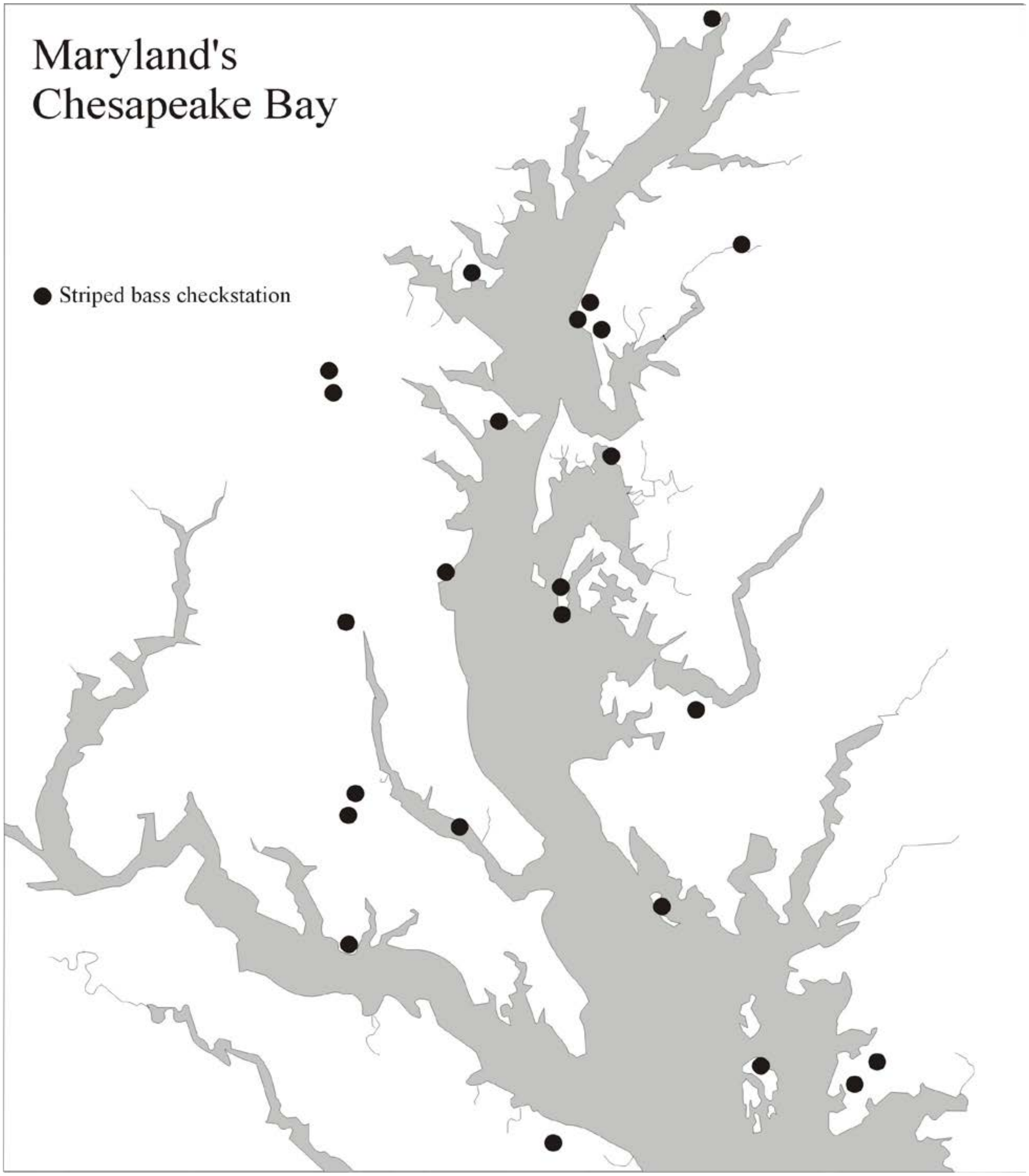
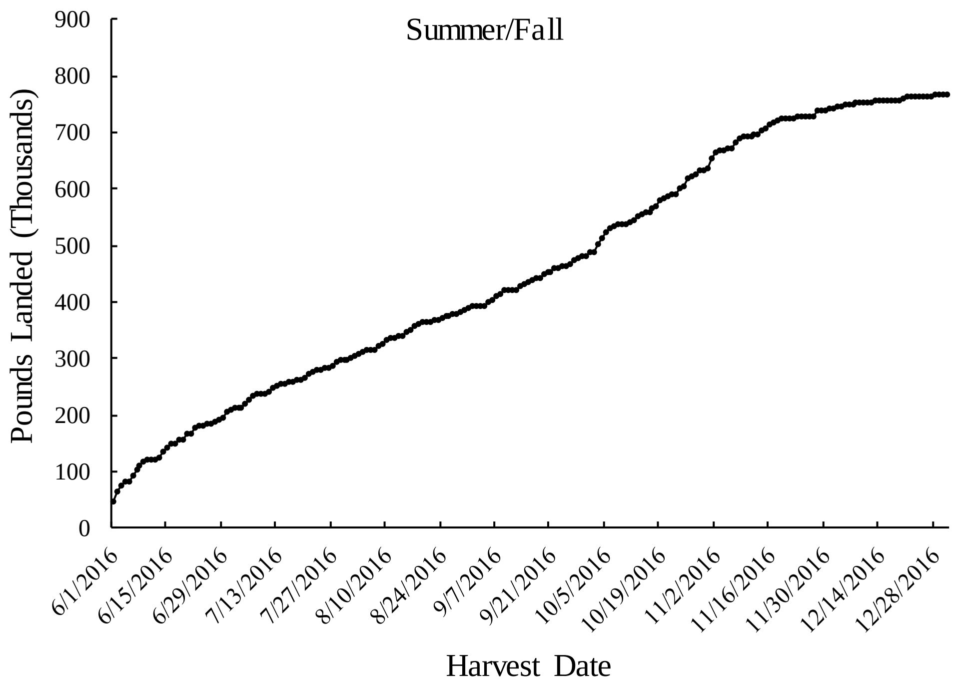


Figure 2. Maryland's Chesapeake Bay summer/fall (pound net and hook-and-line) and winter (gill net) fisheries cumulative striped bass landings from check station reports for calendar year 2016. Note different x-axis scales.



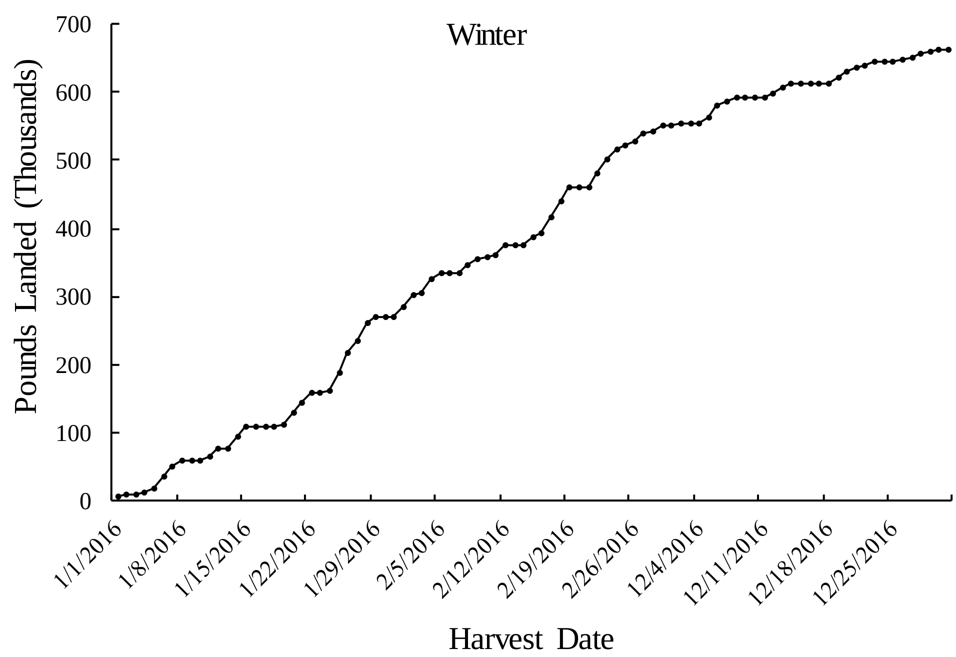


Figure 3. Maryland's Atlantic trawl and gill net fisheries (combined) cumulative striped bass landings from check station reports, January-December 2016.

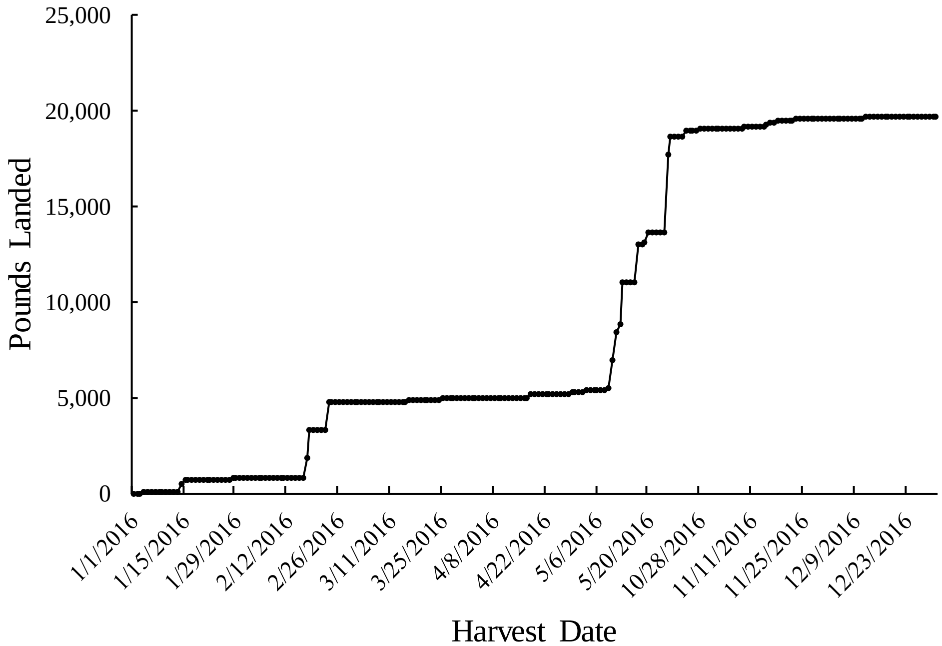
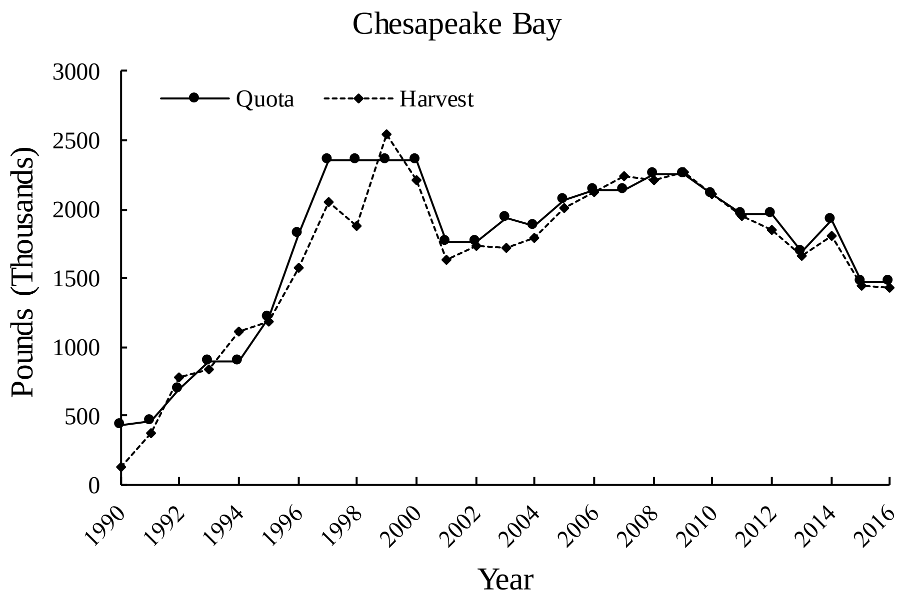


Figure 4. Maryland's Chesapeake Bay and Atlantic Ocean quotas (pounds) and harvests (pounds) for all gears, 1990-2016. Note different scales.



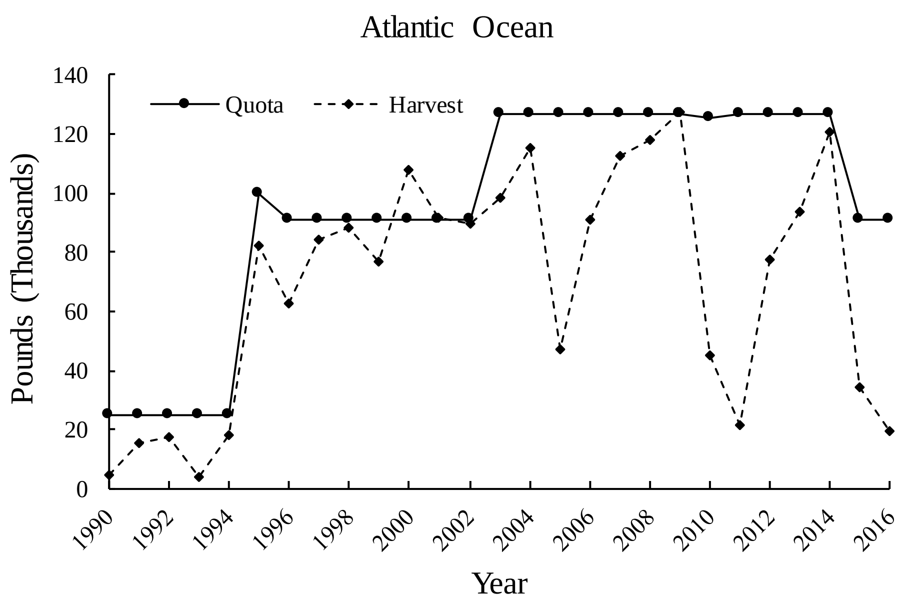
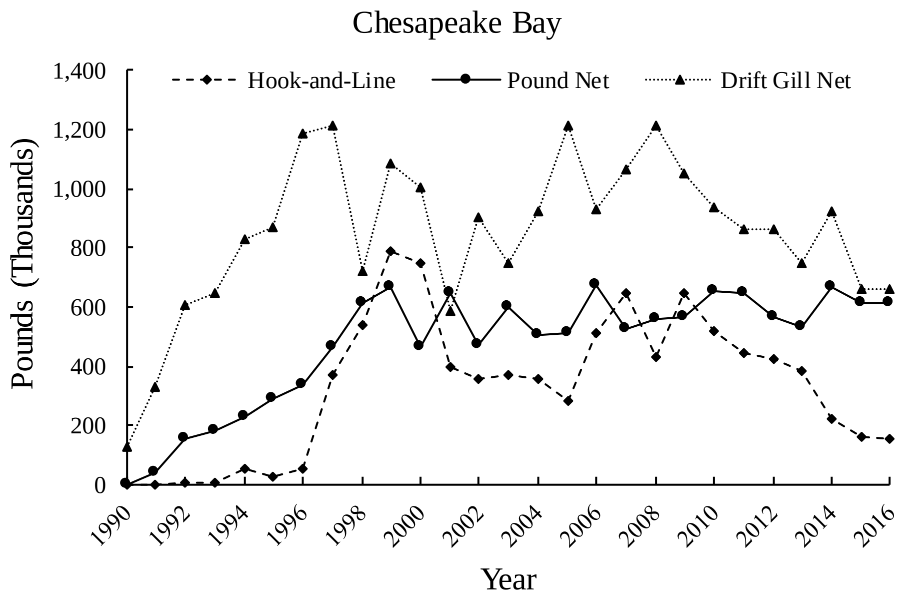


Figure 5. Maryland's Chesapeake Bay and Atlantic Ocean striped bass total harvest (thousands of pounds) per calendar year by commercial gear type, 1990-2016. Note different scales.



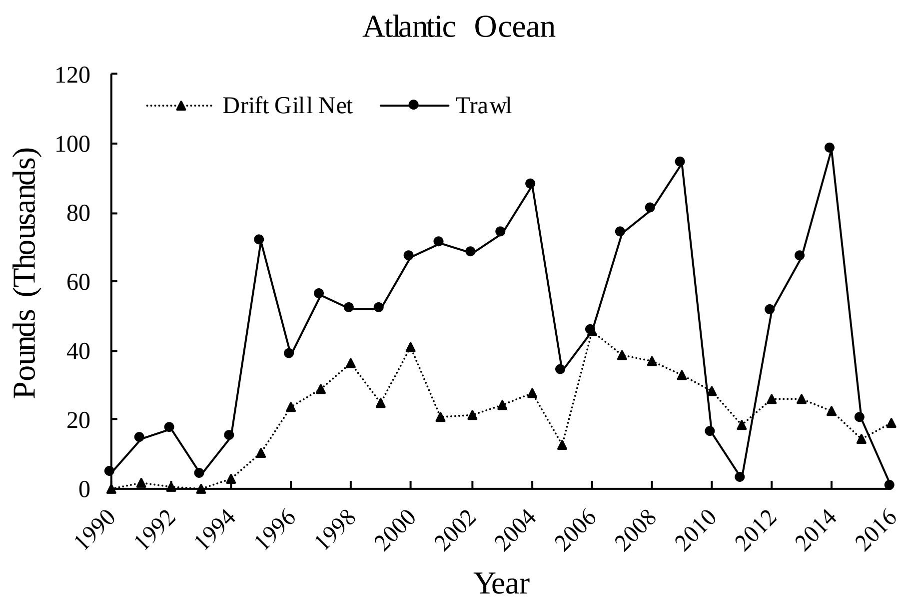
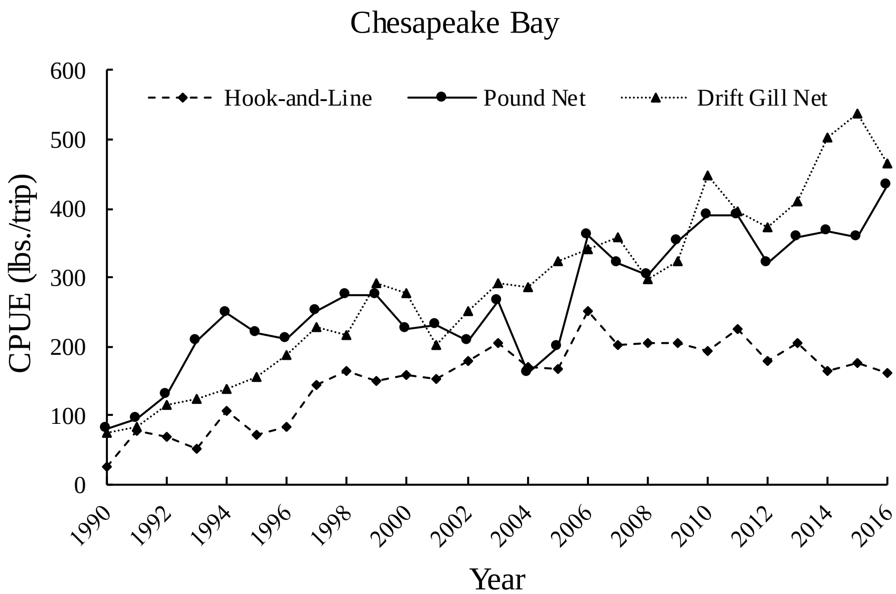
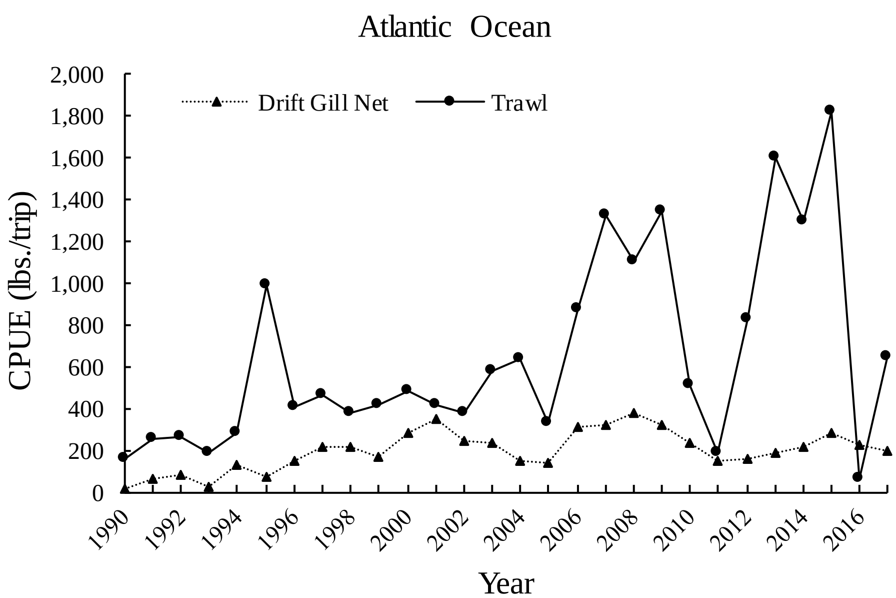


Figure 6. Maryland's Chesapeake Bay and Atlantic Ocean striped bass catch (pounds) per trip (CPUE) by commercial gear type, 1990-2016. Trips were defined as days on which striped bass were landed. Note different scales.





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 characterize the size, age and sex composition of striped bass (*Morone saxatilis*) sampled from the 2017 spring recreational season, which began on Saturday, April 15 and continued through May 15. The secondary objective was to conduct a dockside creel survey to characterize the angler population. Data collected includes catch and demographic information.

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). 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 have become progressively more liberal since 1991 as stock abundance increased (Table 1).

In response to the results of the 2013 benchmark assessment indicating a steady decline in the spawning stock biomass, the ASMFC Management Board approved Addendum IV to Amendment 6 in October 2014. The Addendum established new fishing mortality reference points (F target and threshold). In order to reduce F to a level at or below the new target, the coastal states and the Chesapeake Bay states/jurisdictions were required to implement a 25% harvest reduction of coastal migrant fish from 2013 levels. The 2017 spring season was 31 days long (April 15 – 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 2017 Maryland and Virginia spring harvest of coastal migrant striped bass in Chesapeake Bay are reported annually to ASMFC and are attached as Appendix III.

The 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 2A) 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. Charter boats sometimes caught their limit and returned to the dock as early as 10:00 AM. 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 three major charter fishing ports in 2017: Kentmorr Marina, Chesapeake Beach/Rod & Reel, and Deale/Happy Harbor (Table 2A). In previous years biologists also intercepted charter trips at Solomon's Island/Bunky's Charter, however, in 2017 the lack of trips booked during weekdays at this location precluded successful sampling visits. 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 to allow staff more time to survey private boat anglers. 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 catch rates could be calculated.

A separate creel survey was conducted at public boat ramps to specifically target private boat and shore anglers. Access sites were randomly selected from a list of five public boat ramps (Table 2B). Sites were categorized as high- or medium-use based on the experiences of creel interviewers in previous years. High- and medium-use sites were given relative weights of 2:1 for a probability-based random draw. Low-use sites have not been sampled since 2008. Public boat ramps were visited on one randomly selected weekday and one randomly selected weekend day per week. Interviewers were stationed at two sites per selected day and remained on-site from 10:00 AM–3:00 PM or until 20 trips were intercepted, whichever came first. If no boat trailers were present and no shore anglers were encountered within 2.5 hours, the sampling day was concluded and the site was characterized as having no fishing activity. Private boat and shore anglers were only interviewed after their trip was completed.

Biological Data Collection

Biologists approached mates of charter boats and requested permission to collect data from the catch (Table 3). Total length (mm TL) and weight (kg) were measured. 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 number of scales aged from the creel survey has varied between years. In 2017, 184 scale samples were aged. The age structure of fish sampled by the creel survey was estimated using the 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.

In 2014, a female striped bass maturity study was added in order to update the female maturity schedule used in the coastwide stock assessment. The 2012 and 2013 age-length keys were used to develop sampling targets at various lengths in order to adequately characterize the maturity ogive. Sample collection for this study was completed in 2016 and results of the study are presented in Appendix II.

Scales, otoliths, and ovaries were collected from female fish sampled on the creel survey. Both ovaries were removed and weighed to the nearest gram. One of the ovaries was randomly selected for fixation in 10% buffered formalin. Once fixed, a 4 mm cross-section from the center of the ovary was sectioned and placed in labeled tissue cassettes. The cassettes were placed in 70% ethanol for storage until histological preparation. In addition, an approximately 5 cm section of ovary was placed in 70% ethanol for later fecundity analysis. All females used in the maturity study were aged using scales, and otoliths were collected, where possible, for later age validation.

Calculation of Harvest and Catch Rates

Survey personnel interviewed private boat and shore anglers to obtain information from which to develop estimates of Harvest Per Trip (HPT), Harvest Per Angler (HPA), Catch Per Trip (CPT), and Catch Per Hour (CPH) (Table 4). The interview questions are provided in Appendix I. HPT was defined as the number of fish kept (harvested) for each trip. HPA was calculated by dividing the number of fish harvested on a trip by the number of anglers in the fishing party. CPT was defined as number of fish kept (harvest), plus number of fish released, for each trip. CPH was calculated by dividing the total catch by the number of hours fished for each trip.

HPT, HPA and CPT were also calculated from charter boat logbook data (downloaded 12/19/2017). 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 now submit their data to MD DNR through the Standard Atlantic Fisheries Information System (SAFIS), coordinated by the Atlantic Coastal Cooperative Statistics Program (ACCSP). This submission method has become more commonly used in recent years, and by 2017 comprised 51% of the trophy season charter data. 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, but sample sizes have still exceeded 1,000 trips per year. In 2017, 20% of the charter data was excluded resulting in 995 trips.

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 number of private and charter boats intercepted, number of anglers interviewed, and number of striped bass examined each year are presented in Table 5A. In 2017, there were 501 anglers interviewed comprised of anglers intercepted from 180 private boat trips, 77 charter boat trips, and seven shore angler fishing parties (Table 5A,B). A total of 150 fish were examined from 74 intercepted charter trips. Fishing activity during the spring season was highest in the middle bay, specifically the region between the Chesapeake Bay Bridge and the mouth of the Patuxent River.

BIOLOGICAL DATA

Length and Weight

Length distribution

In the 2017 spring striped bass season, fish lengths measured from the harvest ranged from 785 mm TL to 1265 mm TL with a mean of 1005 mm TL (n=150, Table 6A). For the past five consecutive years, the average size of harvested striped bass has increased (Table 6A). This could be, in part, due to an increase in the minimum size limit starting in 2015 (Table 1), however, the size distribution of harvested striped bass in 2017 displays symmetry with a central tendency away from the minimum size limit (Figure 2). This suggests that in addition to the minimum size limit, the availability of larger sized striped bass in the stock contributed to the higher frequency of larger sized of striped bass harvested in 2017.

Mean length

The mean length of females (1011 mm TL) was greater than the mean length of males (928 mm TL), which is typical of the biology of the species. Male striped bass lengths in 2017 were approximately 8% larger than the long-term average but due to the low sample size (n=12) statistical comparison across years was not conducted. 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 for female fish in 2017 (1011 mm TL) was similar to 2016 (

mm TL) but significantly different than all other years in the time series (Table 6A, Figure 3). Thus, the mean Total Length of female striped bass harvested in the most recent two spring seasons were larger than any previous years.

The mean daily lengths of female striped bass harvested in 2017 showed no trend as the season progressed (Figure 4). This is in contrast to mean daily length data for 2002 and 2011 and other studies, when 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 that submit information through the online Volunteer Angler Survey (http://dnr.maryland.gov/Fisheries/Pages/survey/index.aspx). 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 2017, anglers reported lengths for only 19 striped bass caught during the trophy season. The mean reported length of fish caught and released was 503 mm TL (n=17). Too few measurements of striped bass caught and harvested were reported through the Volunteer Angler Survey in 2017 to estimate a mean length.

Mean weight

Fish weights sampled during the 2017 spring striped bass season ranged from 6.0 kg to 16.4 kg. The mean weight of striped bass harvested in the spring season has increased over the last five years from 6.7 kg in 2012 to 10.7 kg in 2017 (Table 6B, Figure 5).

The mean weight of females (10.8 kg) was greater than the mean weight of males (8.9 kg), consistent with data from previous years. Females tend to grow larger than males, and most striped bass over 13.6 kg (30.0 lb) are females (Bigelow and Schroeder 1953). Mirroring mean length data, the ANOVA indicated significant differences in mean weight among years for females (p<0.0001). Duncan's multiple range test (α =0.05) found that the mean weight of female fish sampled in 2017 (10.8 kg) was significantly greater than all other years (Table 6B, Figure 5). The low sample size of male striped bass (n=12) precluded significance testing, but qualitatively the mean weight of males (8.9 kg) in 2017 was similar to 2016 (8.4 kg) and larger than the long-term average (6.5 kg, Table 6B, Figure 5).

Age Structure

The age distribution estimated from the combined age-length key applied to lengths of striped bass sampled from the 2017 spring recreational harvest ranged from 7 to 21 years old (Figure 6). The 2005 year-class (age 12) was the most frequently observed cohort, constituting 27% of the sampled harvest. The oldest striped bass in the harvest was estimated to come from the 1996 year class (age 21).

Sex Ratio

The data included three designations for sex: female, male and unknown. As in past years, the 2017 spring season harvest was dominated by female striped bass (Table 7A). Sex ratios (% of females in the harvest) were calculated using three methods: 1) including fish of unknown sex in total, 2) using only known-sex fish, and 3) assuming that the unknown fish were female (Table 7B).

Calculation method did not significantly alter the proportion of females in the sampled harvest as there was only one fish of unknown sex in 2017. Similar to the previous year, females constituted 92% of the sampled harvest. This is above the long-term average of 85% (Table 7B).

Spawning Condition

Percent pre-spawn females

The need to understand spawning condition of the female portion of the catch helped initiate this study in 2002. Goshorn et al. (1992) studied the spawning condition of large female striped bass in the upper Chesapeake Bay spawning area during the 1982-1991 spawning seasons. Their results suggested that most large females spawn before mid-May in the upper Chesapeake Bay spawning area, indicating a high potential to harvest gravid females in the spring fishery during the first two weeks of May. From 2002 – 2017 the percentage of pre-spawn females in the spring season harvest has declined from a maximum of 63% in 2005 to a minimum of 12% in 2017 (Table 8). Despite the opening day of the spring season occurring on the third Saturday in April since 2002, the 5-year average percentage of pre-spawn females in the spring season harvest was 52% in 2002-2006, 42% in 2007-2011, and 25% in 2012-2016. The onset of striped bass spawning is related to spring increases in water temperature, and alterations to the timing of spring warming from year-to-year could alter the timing of striped bass spawning in warm versus cold years (Peer and Miller 2014). Changing demographics of the spawning stock could also alter the average time of spawning since larger, older individuals spawn earlier in the season than smaller, younger individuals (Cowan et al 1993). Analysis of spring water temperature data concurrent with spawning condition and size/age data collected during the harvest of striped bass during the spring recreational season should be considered in future years.

Daily spawning condition of females

The percent of post-spawn females ranged from >50% in the first week of the spring season to >75% for the remainder of the season (Figure 7). By the last two dates of sampling (5/11 - 5/12/2017) 100% of the females sampled were in post-spawn condition. This pattern suggests that most female fish harvested in the spring season in 2017 had spawned by the last week of April and were subsequently captured as they migrated back to the coast from spawning grounds.

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 2017. Because of increased focus on improving our understanding of private boat fishing effort, all trips intercepted during the trophy season in 2017 for interviews were private boat trips. Creel survey interview data were used to obtain harvest rate estimates for private vessels. 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.

Because of the Addendum IV requirements in place since 2015 to reduce harvest, HPT was expected to be lower as compared to previous years. The mean HPT in 2017 according to charter boat data was 2.4 fish per trip (Table 9A) which was 48% below the long term mean charter boat HPT (4.6 fish per trip) and the lowest in the time series. Mean HPT from private boat interviews (0.2 fish per trip) was similar to 2015, and 78% below the long-term mean private boat HPT (0.9 fish per trip).

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 2017 was 0.41 fish per person (Table 9B) which was a 45% reduction from the long-term mean (0.74 fish per trip). HPA for private anglers, calculated from interview data, was 0.1 fish per person which is similar to 2015 and lowest in the time series (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 2017, private boats caught an average of 0.7 fish per trip, similar to 2015 and lower than other years (Table 10A). Charter boats caught 4.5 fish per trip, which is lower than all other years and 27% below the long-term average (6.2 fish per trip, Table 10B). The private boat catch per hour (CPH) was 0.2 fish per hour while charter boats had a CPH of 0.7 fish per hour. The private boat CPH was similar to previous years, whereas the charter boat CPH was the lowest in the time series.

Angler Characterization

States of residence

In 2017, 501 anglers were interviewed during the period April 15-May 15 (Table 5A). Thirteen states of residence were represented in 2017 (Table 11). Most anglers were from Maryland (82%), Virginia (6%), and Pennsylvania (6%), similar to previous years.

Proportion of License Exempt Anglers

Under current license regulations, a person can purchase a boat license which allows anyone aboard the boat to fish without purchasing an individual Maryland tidal fishing license. This creates a potentially significant, but indeterminate amount of unlicensed fishing effort. Consequently, a question was added to the dockside creel survey in 2008 to determine how many anglers on each boat were license-exempt by virtue of the boat license or other reason in order to determine the amount of license-exempt effort during the spring striped bass season. In 2017, there were on average 2.6 anglers per boat and of these anglers, 1.2 were license-exempt (Table 12). These results were consistent with previous years.

Number of Lines Fished

To further characterize fishing effort, a question was added to the creel survey in 2006 and 2010-2017 about the number of fishing lines used. In 2006, six lines were fished on average per private boat and the maximum number encountered on a boat was 15. In 2017, the average number of lines fished per private boat was 8 and ranged from 1 to 23 lines (Table 13). This was more lines, on average, than in 2006 (6 lines) but similar to recent years.

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

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

2018 PRELIMINARY RESULTS

Data collected during the 2018 spring recreational season (April 21-May15) are currently being analyzed. In 2018, 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 April 21 to May 15 for a total of eight sample days.

During the 2018 spring recreational season, a total of 118 striped bass from 41 intercepted charter boat trips were measured, weighed, and internally examined for spawning condition. Biological samples collected from examined fish for aging and reproductive studies include 111 scale samples, 25 otoliths, 4 dorsal fin spines and 3 ovary samples. Female striped bass (n=105) were a mean Total Length of 1044 mm and mean weight of 12.1 kg. Internal examination revealed 94% of female striped bass harvested had recently spawned. Male striped bass (n=11) were a mean Total Length of 967 mm and a mean weight of 8.9 kg. Scale samples are currently being processed and aged, therefore no age distribution of the 2018 spring recreational harvest is available at this time.

The final, complete analyses of the spring 2018 recreational survey data will appear in the next F-61 Chesapeake Bay Finfish Investigations report.

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Table 1. History of changes made to MD DNR-Fisheries Service regulations for Maryland striped bass spring trophy seasons, 1991-2017.

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**			

Table 2A. Survey sites for the Maryland striped bass spring season dockside creel survey, 2002-2017. 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 2B. Survey sites for the Maryland striped bass spring angler-intercept survey, 2017.

Relative Use	Access Intercept Site
High	Sandy Pt. State Park Boat Ramp and Beach
	Solomons Island Boat Ramp
Medium	Matapeake Boat Ramp
	Breezy Point Fishing Center and Ramp
	Chesapeake Beach Boat Ramp

Table 3. Biological data collected by the Maryland striped bass spring season creel survey, 2017.

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 4. Angler and catch information collected by the Maryland striped bass spring season creel survey, 2017.

Angler and Catch Data Collected
Number of hours fished
Fishing type: private boat or shore
Number of anglers on boat
Area fished: upper, middle, lower
Number of lines fished
Number of fish kept
Number of fish released
Number of anglers license exempt
State of residence

Table 5A. Numbers of trips intercepted, anglers interviewed, and fish examined by the Maryland striped bass spring season creel survey, through May 15.

Year	Trips Intercepted	Anglers Interviewed	Fish Examined
2002	187	458	503
2003	181	332	478
2004	138	178	462
2005	54	93	275
2006	139	344	464
2007	542	809	301
2008	305	329	200
2009	303	747	216
2010	238	601	263
2011	362	824	234
2012	209	447	130
2013	207	456	182
2014	258	580	211
2015	261	546	177
2016	279	585	197
2017	264	501	150

Table 5B. Number of trips, by type (fishing mode), intercepted by the Maryland striped bass spring season creel survey, through May 15.

Year	Charter Boat	Private Boat	Shore	Not Specified	Total
2002	140	45	0	2	187
2003	114	65	0	2	181
2004	88	42	1	7	138
2005	53	1	0	0	54
2006	101	28	10	0	139
2007	50	483	9	0	542
2008	34	265	6	0	305
2009	27	275	1	0	303
2010	45	193	0	0	238
2011	63	299	0	0	362
2012	37	172	0	0	209
2013	35	169	3	0	207
2014	48	209	1	0	258
2015	57	201	3	0	261
2016	58	221	0	0	279
2017	77	180	7	0	264

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)
Mean	**916** (898-935)	**926** (908-946)	**860** (842-878)

Table 6B. Mean weights 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)
Mean	**8.1** (7.6-8.6)	**8.4** (7.9-8.9)	**6.5** (6.0-6.9)

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 (Assume U were Female)
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

Table 7B. Percent females, using three different calculation methods, sampled by the Maryland striped bass spring season creel survey, through May 15. Means include 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
Mean	**83** (80-86)	**85** (82-88)	**85** (82-88)

Table 8. Spawning condition of the female portion of catch, sampled by the Maryland striped bass spring season creel survey, through May 15. Females of unknown spawning condition are excluded.

	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
Mean	**150**	**40**	**132**	**60**

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

Year	Charter Trips (n)	Charter Mean HPT	Private Creel Int. Trips (n)	Private Creel Int. Mean HPT
2002	1,424	**4.7** (4.6-4.8)	44	**1.1** (0.6-1.4)
2003	1,393	**5.7** (5.6-5.8)	64	**1.1** (0.7-1.4)
2004	1,591	**5.4** (5.3-5.5)	42	**2.2** (1.7-2.8)
2005	1,965	**5.5** (5.4-5.6)	1	N/A
2006	1,934	**5.3** (5.2-5.4)	28	**1.4** (0.6-2.1)
2007	1,607	**4.3** (4.2-4.4)	483	**0.7** (0.6-0.8)
2008	1,755	**4.9** (4.8-5.1)	260	**0.6** (0.5-0.7)
2009	1,849	**5.0** (4.9-5.1)	275	**0.9** (0.7-1.0)
2010	1,986	**4.8** (4.7-4.9)	193	**1.1** (0.9-1.3)
2011	1,849	**5.0** (4.9-5.1)	298	**0.9** (0.7-1.0)
2012	1,546	**4.2** (4.0-4.4)	172	**0.5** (0.3-0.6)
2013	1,822	**4.9** (4.8-5.1)	165	**0.9** (0.7-1.1)
2014	1,481	**5.5** (5.3-5.6)	207	**0.9** (0.8-1.1)
2015	1,392	**2.8** (2.7-3.0)	206	**0.2** (0.1-0.3)
2016	1,380	**3.9** (2.8-4.1)	221	**0.5** (0.4-0.7)
2017	995	**2.4** (2.3-2.5)	180	**0.2** (0.1-0.3)
Mean	1,623	**4.6** (4.1-5.1)	177	**0.9** (0.7-1.1)

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

Year	Charter Trips (n)	Charter Mean HPA	Private Creel Int. Trips (n)	Private Creel Int. Mean HPA
2002	1,424	**0.78** (0.76-0.79)	43	**0.4** (0.3-0.6)
2003	1,393	**0.93** (0.92-0.94)	64	**0.4** (0.3-0.5)
2004	1,591	**0.88** (0.86-0.89)	42	**0.7** (0.5-0.8)
2005	1,965	**0.88** (0.87-0.89)	1	N/A
2006	1,934	**0.86** (0.87-0.85)	27	**0.5** (0.2-0.7)
2007	1,607	**0.69** (0.68-0.71)	483	**0.3** (0.2-0.3)
2008	1,755	**0.79** (0.78-0.81)	260	**0.2** (0.2-0.3)
2009	1,849	**0.81** (0.80-0.82)	275	**0.3** (0.3-0.4)
2010	1,986	**0.76** (0.75-0.77)	193	**0.4** (0.3-0.5)
2011	1,849	**0.78** (0.77-0.80)	298	**0.3** (0.3-0.3)
2012	1,546	**0.67** (0.64-0.71)	172	**0.2** (0.1-0.2)
2013	1,822	**0.75** (0.74-0.77)	165	**0.3** (0.3-0.4)
2014	1,481	**0.82** (0.81-0.84)	207	**0.3** (0.3-0.4)
2015	1,392	**0.45** (0.43-0.47)	206	**0.1** (0.0-0.1)
2016	1,380	**0.65** (0.63-0.67)	221	**0.2** (0.2-0.3)
2017	995	**0.41** (0.39-0.42)	180	**0.1** (0.0-0.1)
Mean	1,623	**0.74** (0.67-0.81)	177	**0.3** (0.2-0.4)

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, through May 15. Catch is defined as number of fish harvested plus number of fish released.

Year	n	Mean catch/trip	Mean hours/trip	Mean catch/hour
2002	41	**1.6** (0.9-2.4)	**4.9** (4.3-5.5)	**0.3** (0.2-0.5)
2003	63	**1.8** (0.9-2.8)	**5.4** (4.8-6.0)	**0.5** (0.2-0.7)
2004	42	**3.5** (2.0-4.9)	**4.6** (3.8-5.3)	**1.0** (0.6-1.4)
2005	1	**NA**	**2.5**	**NA**
2006	28	**2.3** (1.1-3.5)	**4.9** (4.2-5.7)	**0.7** (0.3-1.1)
2007	483	**1.6** (1.2-2.0)	**5.0** (4.9-5.1)	**0.3** (0.2-0.4)
2008	260	**1.0** (0.7-1.3)	**4.5** (4.2-4.7)	**0.3** (0.2-0.4)
2009	275	**1.6** (1.0-2.1)	**4.7** (4.5-4.8)	**0.4** (0.2-0.5)
2010	193	**1.6** (1.2-2.0)	**4.7** (4.5-4.9)	**0.4** (0.3-0.5)
2011	298	**1.2** (1.0-1.4)	**4.4** (4.2-4.6)	**0.3** (0.2-0.4)
2012	172	**0.8** (0.5-1.1)	**4.8** (4.6-5.1)	**0.2** (0.1-0.3)
2013	165	**1.3** (1.0-1.7)	**4.4** (4.2-4.7)	**0.3** (0.2-0.4)
2014	207	**1.2** (1.0-1.4)	**4.7** (4.4-4.9)	**0.3** (0.2-0.4)
2015	205	**0.7** (0.5-1.0)	**6.3** (4.7-9.5)	**0.2** (0.1-0.2)
2016	221	**2.6** (1.5-4.0)	**5.1** (4.9-5.3)	**0.5** (0.3-0.8)
2017	180	**0.7** (0.4-0.9)	**4.6** (4.4-4.8)	**0.2** (0.1-0.2)
Mean	177	**1.6** (1.2-2.0)	**4.7** (4.4-5.1)	**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 was 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)	N/A	N/A
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)
Mean	1,648	**6.2** (5.7-6.7)	**4.7** (4.2-5.2)	**1.4** (1.2-1.7)

Table 11. State of residence and number of anglers interviewed by the Maryland striped bass spring season creel survey, through May 15.

State	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
AK	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
AL	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	0
AZ	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
CA	1	0	1	0	0	2	0	0	0	0	0	0	0	1	0	0
CO	0	0	1	0	1	1	0	0	1	0	1	0	0	0	2	0
DC	6	1	1	0	1	2	1	0	6	1	0	1	0	0	0	1
DE	6	7	3	0	9	8	1	0	3	1	2	0	5	2	2	10
FL	0	0	1	1	2	0	1	0	3	1	0	1	0	1	1	4
GA	1	1	0	2	2	0	0	0	0	0	0	0	0	0	0	1
IL	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
KY	0	1	0	0	0	0	0	0	1	0	0	0	0	1	0	0
KS	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0
MA	0	1	1	0	0	0	0	1	1	0	0	0	0	0	1	0
MD	**353**	**260**	**107**	**66**	**227**	**679**	**266**	**651**	**482**	**491**	**381**	**407**	**484**	**483**	**474**	**413**
MI	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
MN	0	0	1	0	0	0	0	0	0	4	0	0	0	0	0	0
MT	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0
NC	0	2	0	1	0	1	1	0	0	0	3	0	1	0	1	0
NJ	2	2	6	0	3	2	4	0	0	1	3	0	2	0	0	2
NV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
NY	4	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0
OH	0	0	0	0	0	3	1	0	1	0	1	0	1	0	0	0
PA	**27**	**19**	**17**	**4**	**22**	**32**	**16**	**46**	**18**	**19**	**23**	**21**	**30**	**24**	**25**	**32**
RI	2	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
SC	0	0	1	0	0	1	0	0	0	0	0	0	0	3	0	0
TN	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
TX	0	1	0	0	0	0	0	0	0	0	1	2	0	0	1	0
VA	**48**	**31**	**30**	**13**	**56**	**71**	**29**	**44**	**42**	**23**	**26**	**20**	**39**	**27**	**49**	**31**
VT	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
WA	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
WI	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1
WV	0	1	0	2	6	3	2	4	4	0	4	2	10	3	5	1
Intl.	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0	0
Unknown	0	0	0	0	0	0	0	0	36	0	0	0	0	0	2	0

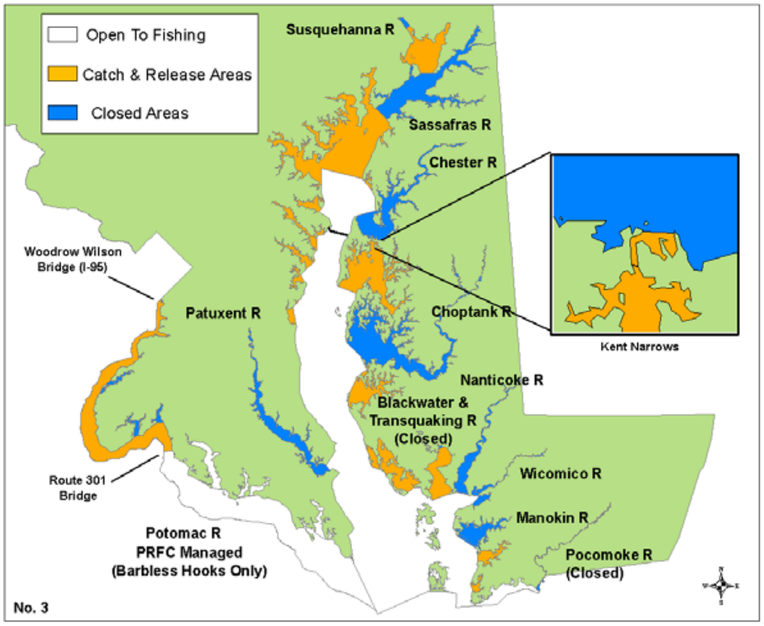
Table 12. The average number of anglers and average number of unlicensed anglers, per boat, with 95% confidence intervals, from the 2008-2017 Maryland striped bass spring season creel survey interview data.

Year	Number of Trips Interviewed	Average Number of Anglers per Boat	Average Number of Unlicensed Anglers per Boat
2008	261	**2.8** (2.7-2.9)	**1.5** (1.3-1.6)
2009	276	**2.7** (2.6-2.8)	**1.3** (1.2-1.5)
2010	193	**2.8** (2.6-2.9)	**1.4** (1.2-1.5)
2011	298	**2.7** (2.6-2.9)	**1.5** (1.3-1.6)
2012	172	**2.6** (2.4-2.8)	**1.3** (1.1-1.5)
2013	165	**2.7** (2.6-2.9)	**1.2** (1.0-1.4)
2014	207	**2.7** (2.5-2.9)	**1.2** (1.1-1.4)
2015	206	**2.6** (2.5-2.8)	**1.3** (1.1-1.4)
2016	223	**2.6** (2.5-2.8)	**1.3** (1.1-1.4)
2017	183	**2.6** (2.5-2.8)	**1.2** (1.0-1.4)

Table 13. Number of lines fished by private boats.

Year	Minimum	Maximum	Mean
2006	3	15	6
2010	1	19	8
2011	2	22	8
2012	2	18	7
2013	1	25	8
2014	2	21	8
2015	1	20	7
2016	1	25	8
2017	1	23	8

Figure 1. MD DNR maps showing legal open and closed striped bass fishing areas in Chesapeake Bay during the spring season, April 15-May 3, 2017 (top) and May 4-May 15, 2017 (bottom)



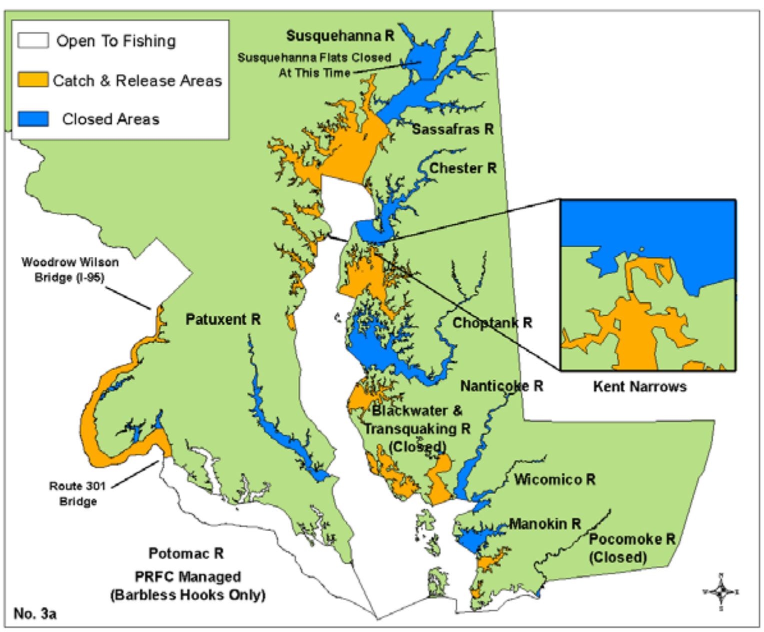


Figure 2. Length distribution of striped bass sampled by year, during the Maryland striped bass spring season creel survey, through May 15.

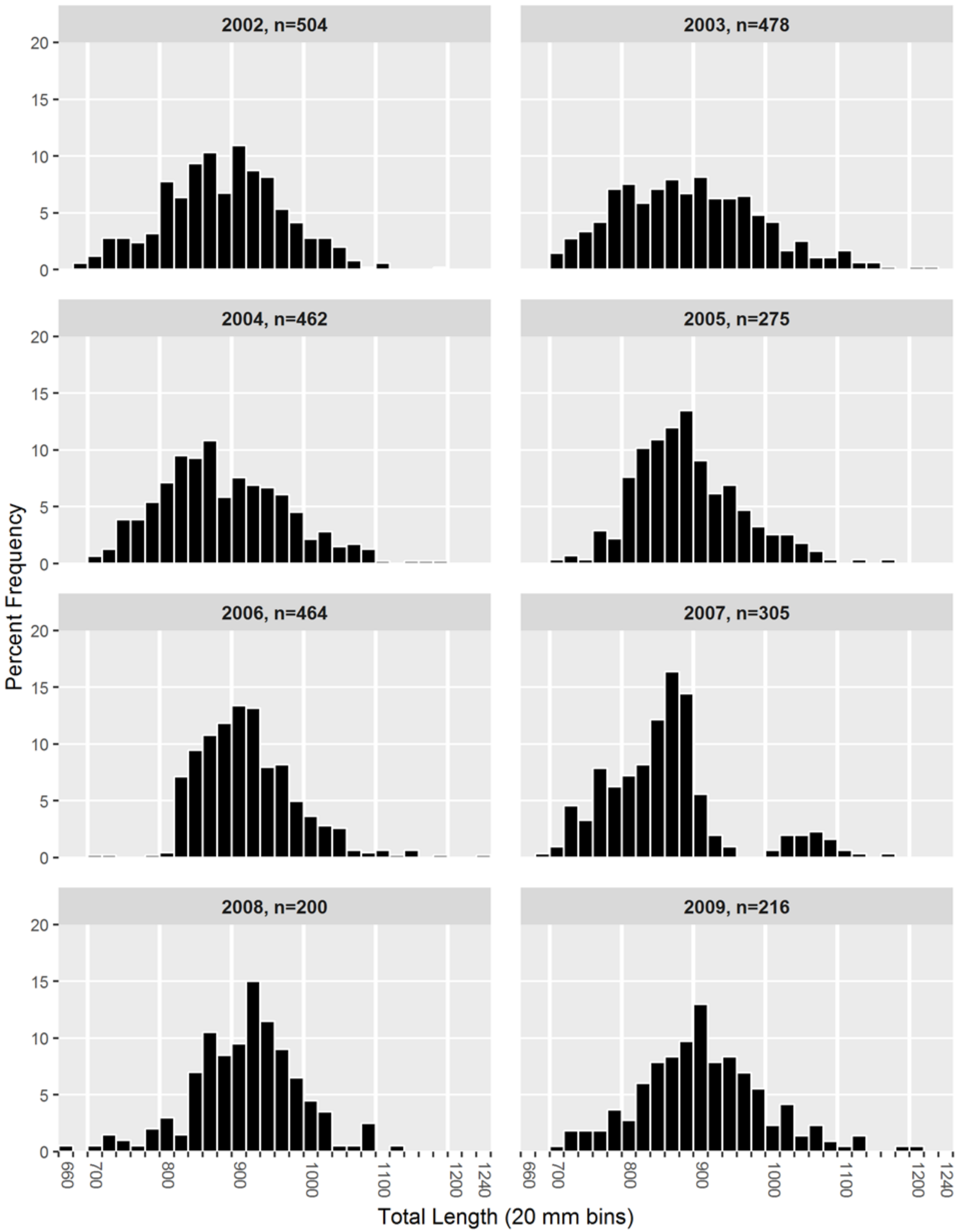


Figure 2. Continued.

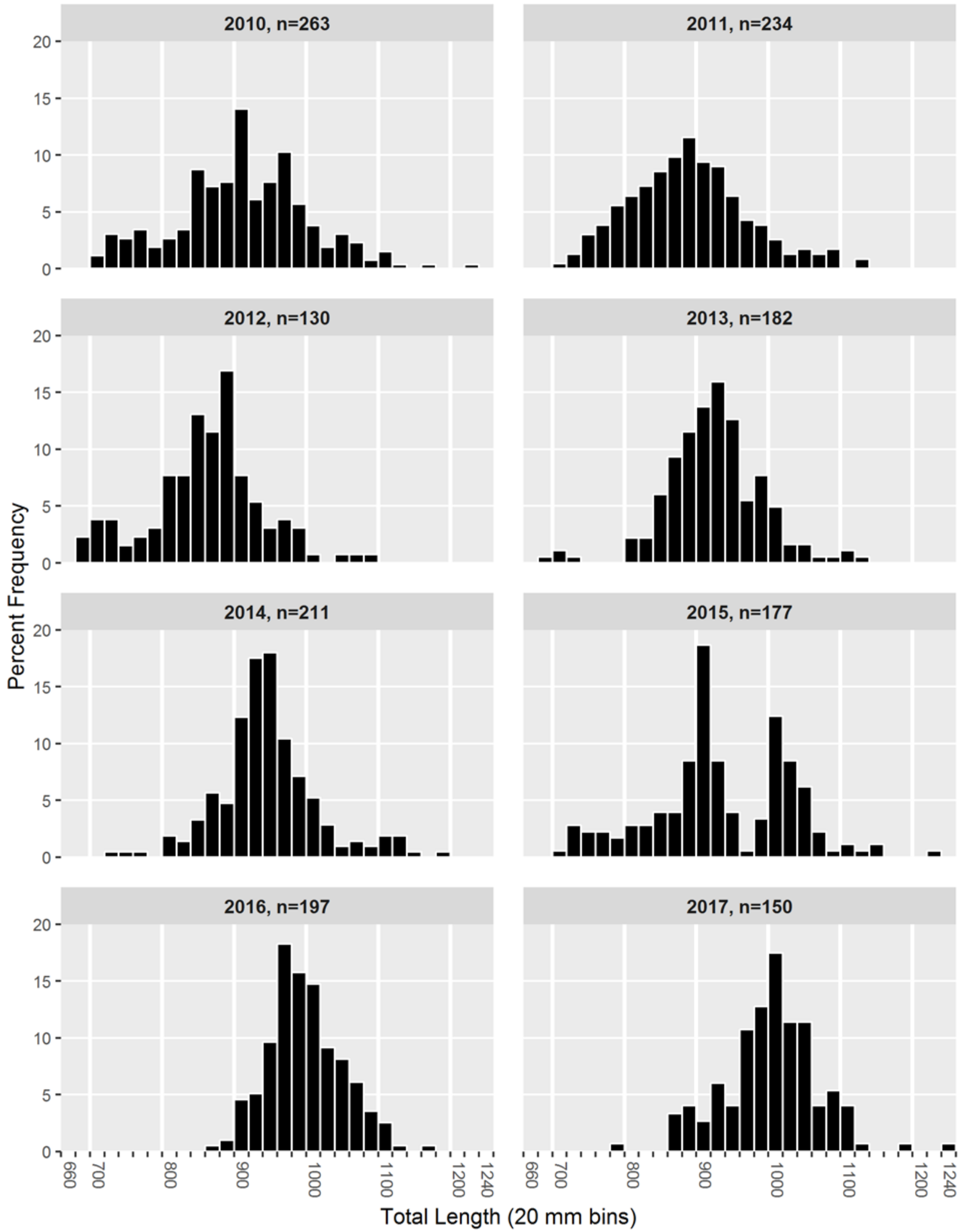


Figure 3. Mean length of striped bass (mm TL) with 95% confidence intervals, sampled by the Maryland striped bass spring season creel survey, through May 15. Lower case letters indicate pairwise differences among years (Duncan's multiple range test, α=0.05).

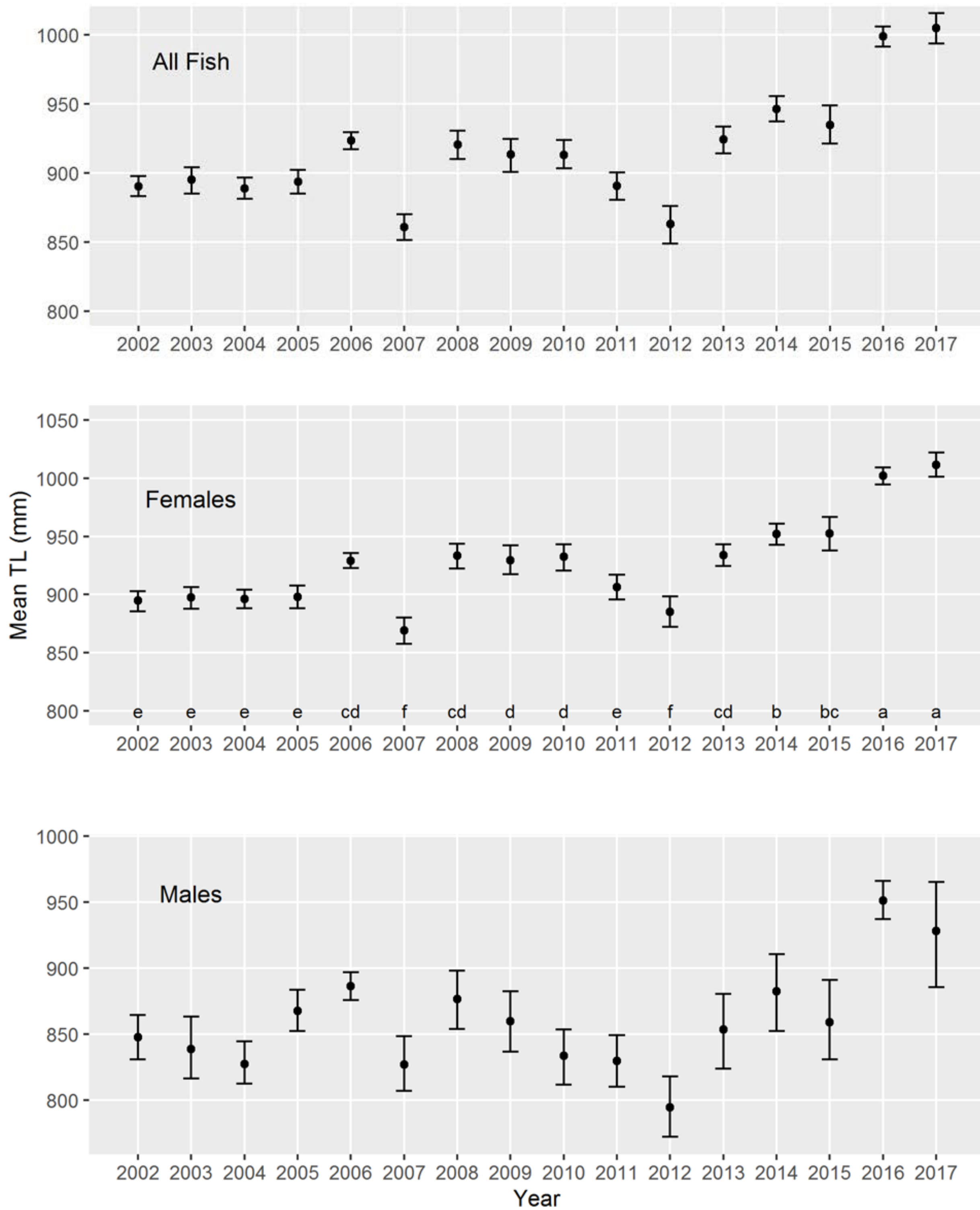


Figure 4. Mean daily length of female striped bass with 95% confidence intervals, sampled by the Maryland striped bass spring season creel survey, through May 15.

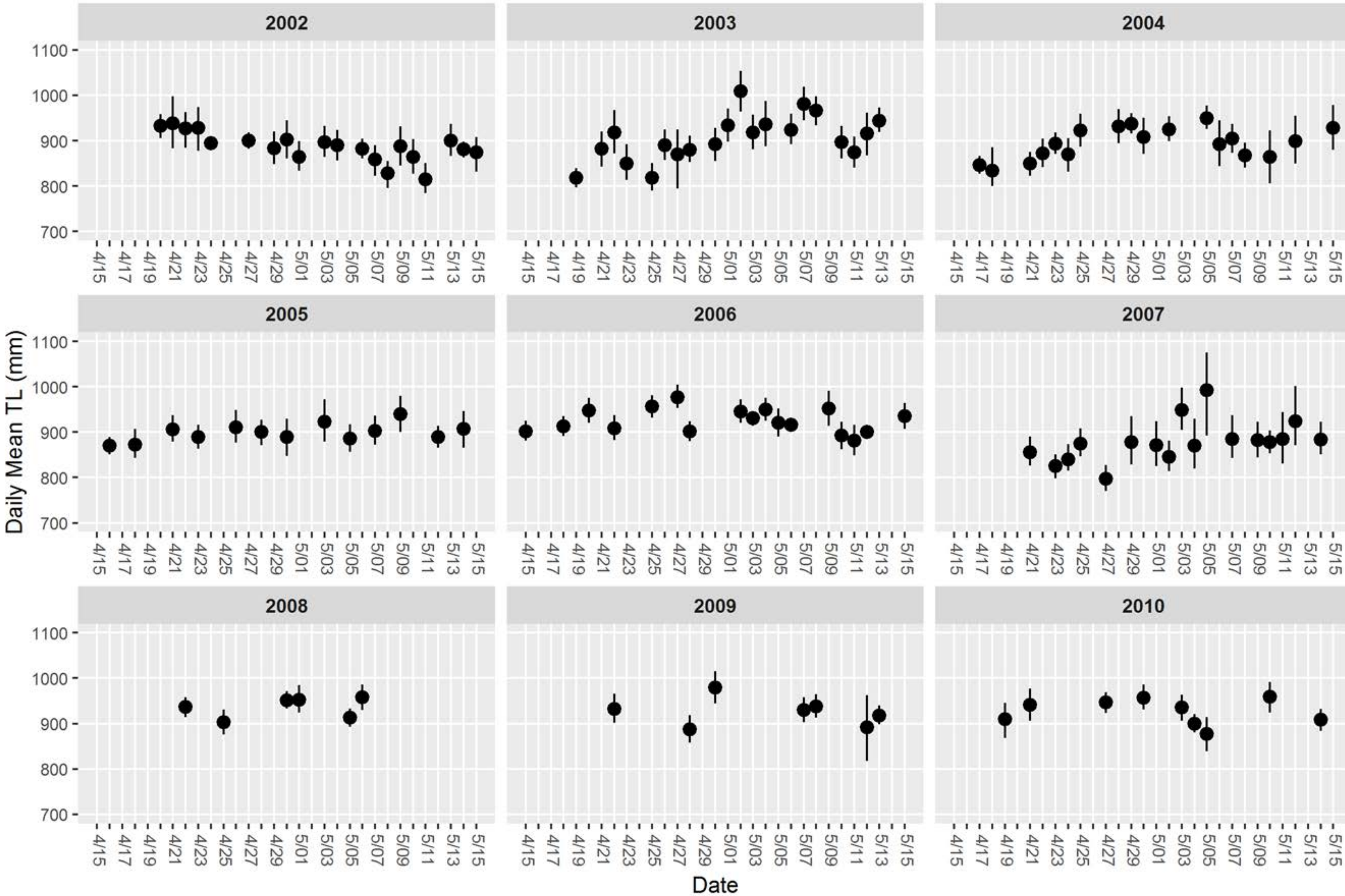


Figure 4. Continued.

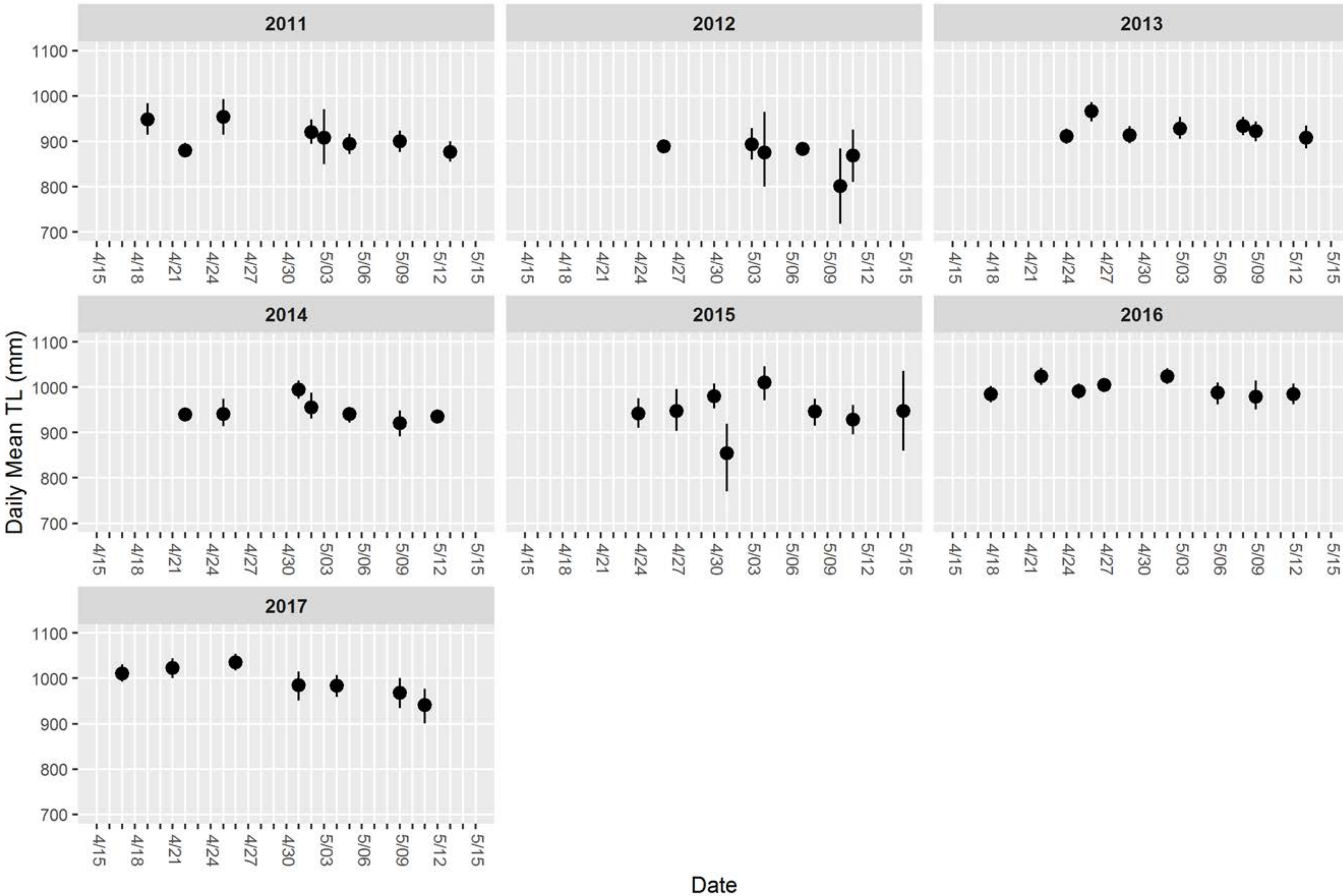


Figure 5. Mean weight of striped bass (kg) with 95% confidence intervals, sampled by the Maryland striped bass spring season creel survey, through May 15. Lower case letters indicate pairwise differences among years (Duncan's multiple range test, α=0.05).

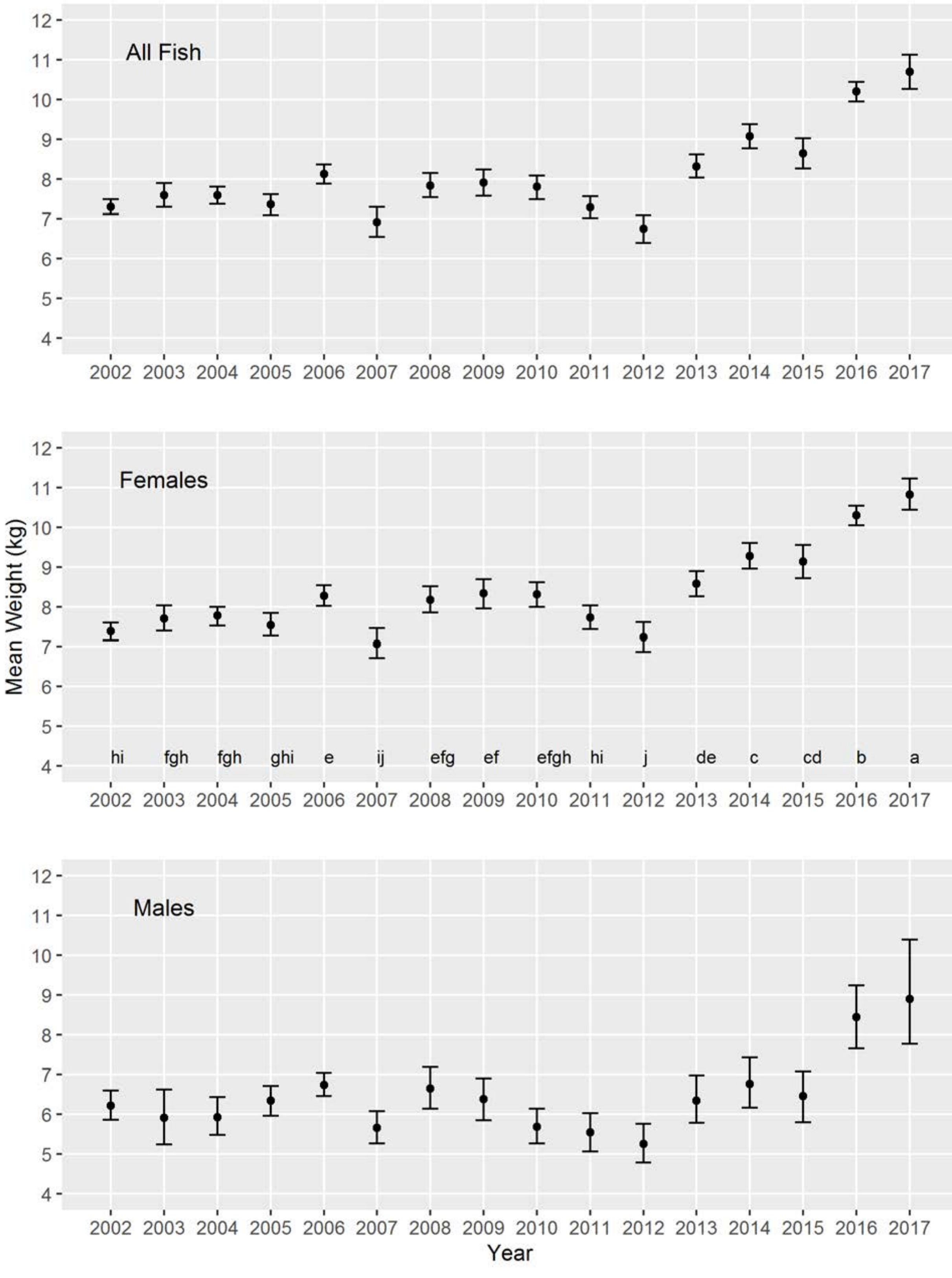


Figure 6. Estimated age distribution of striped bass sampled by the Maryland striped bass spring season creel survey, through May 15.

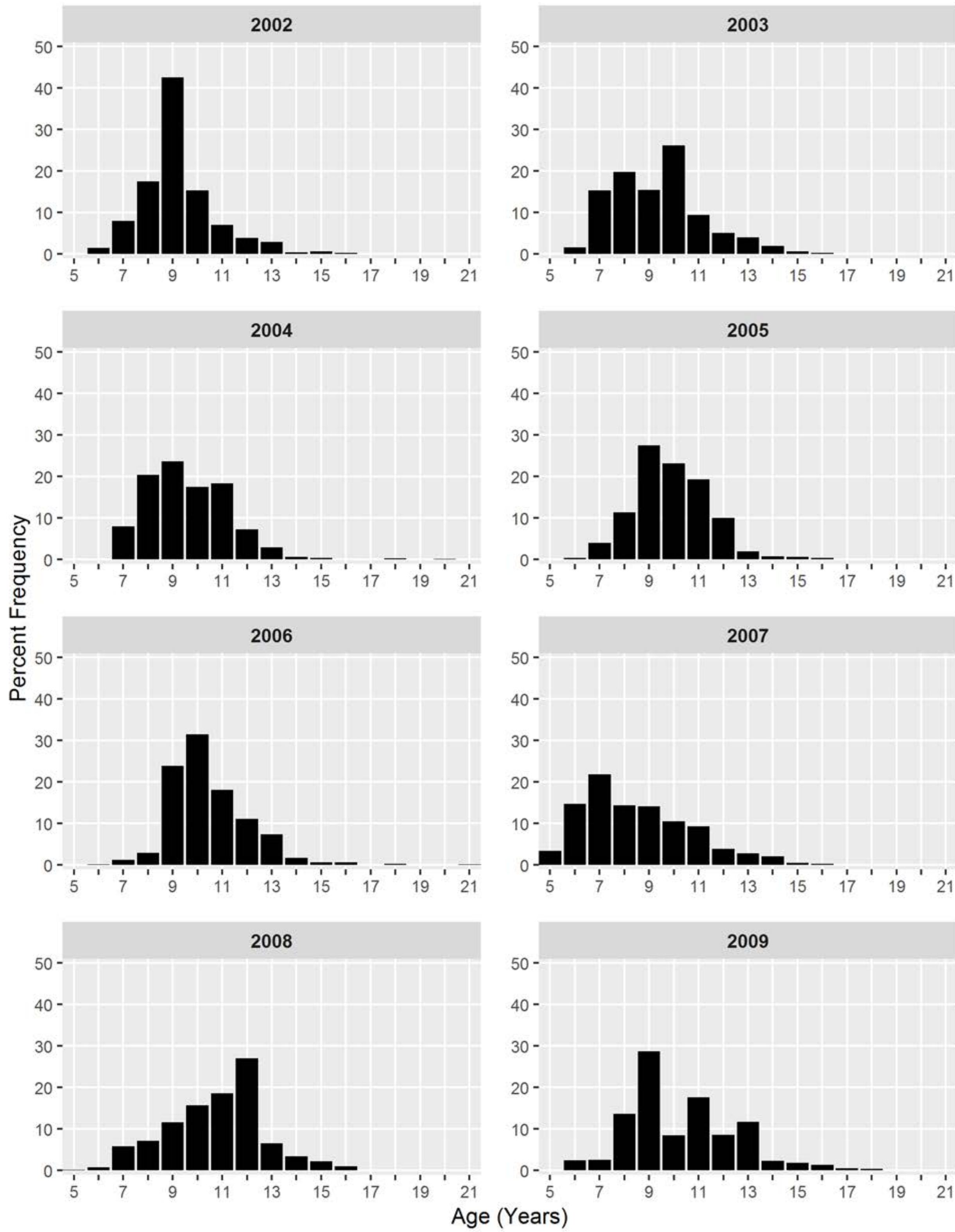


Figure 6. Continued.

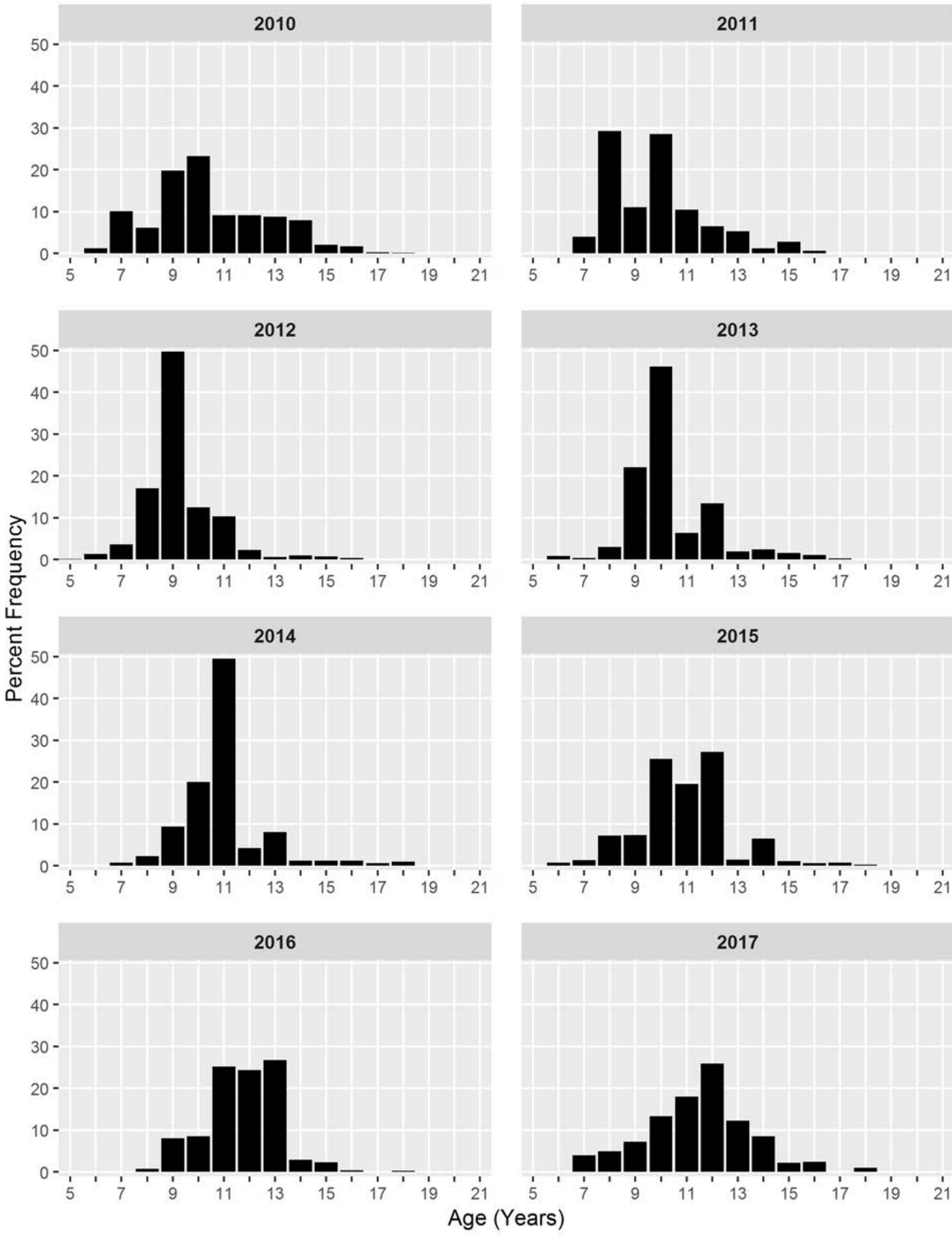


Figure 7. Daily percent of female striped bass in post-spawn condition sampled by the Maryland striped bass spring season creel survey, through May 15.

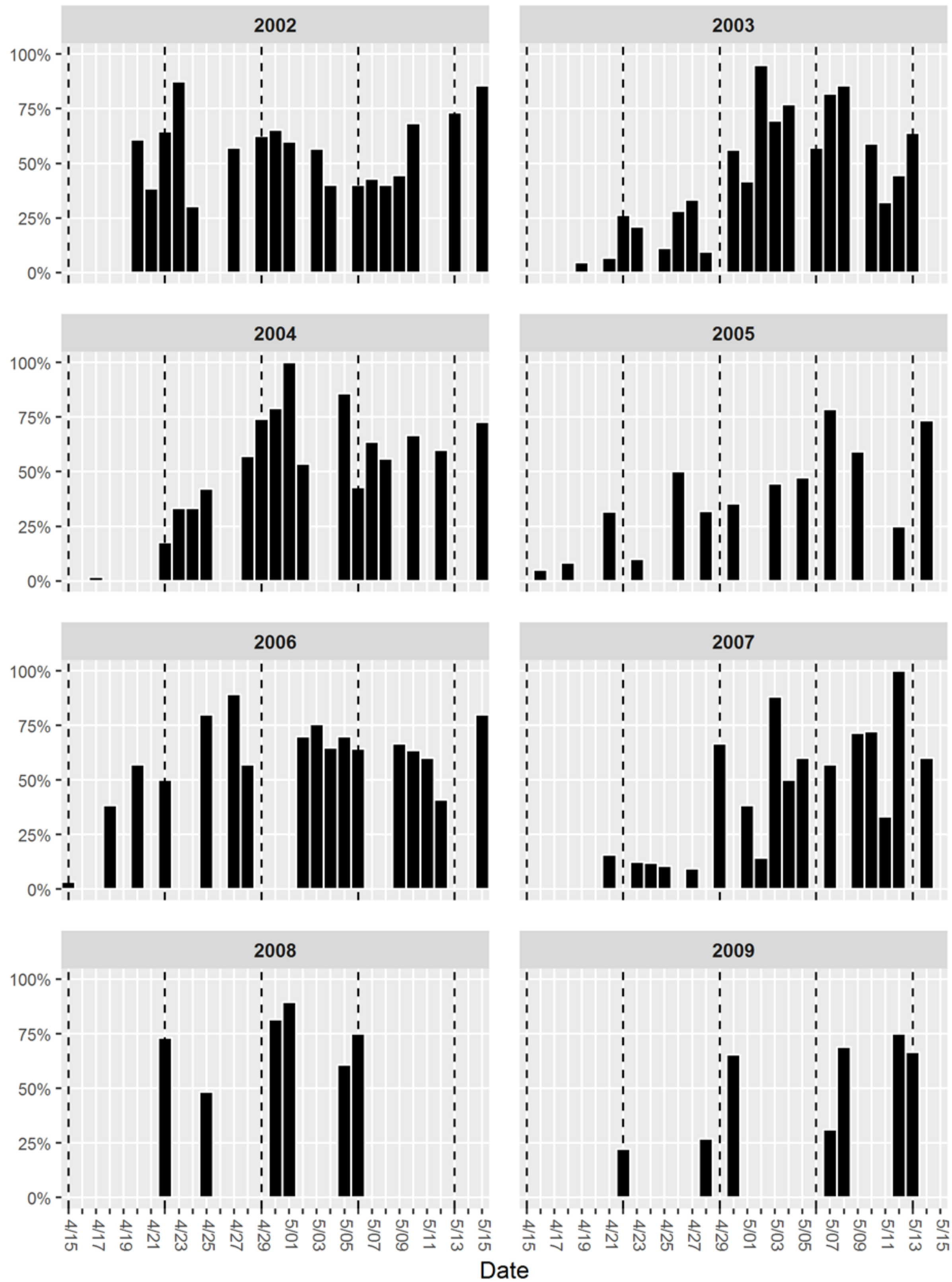
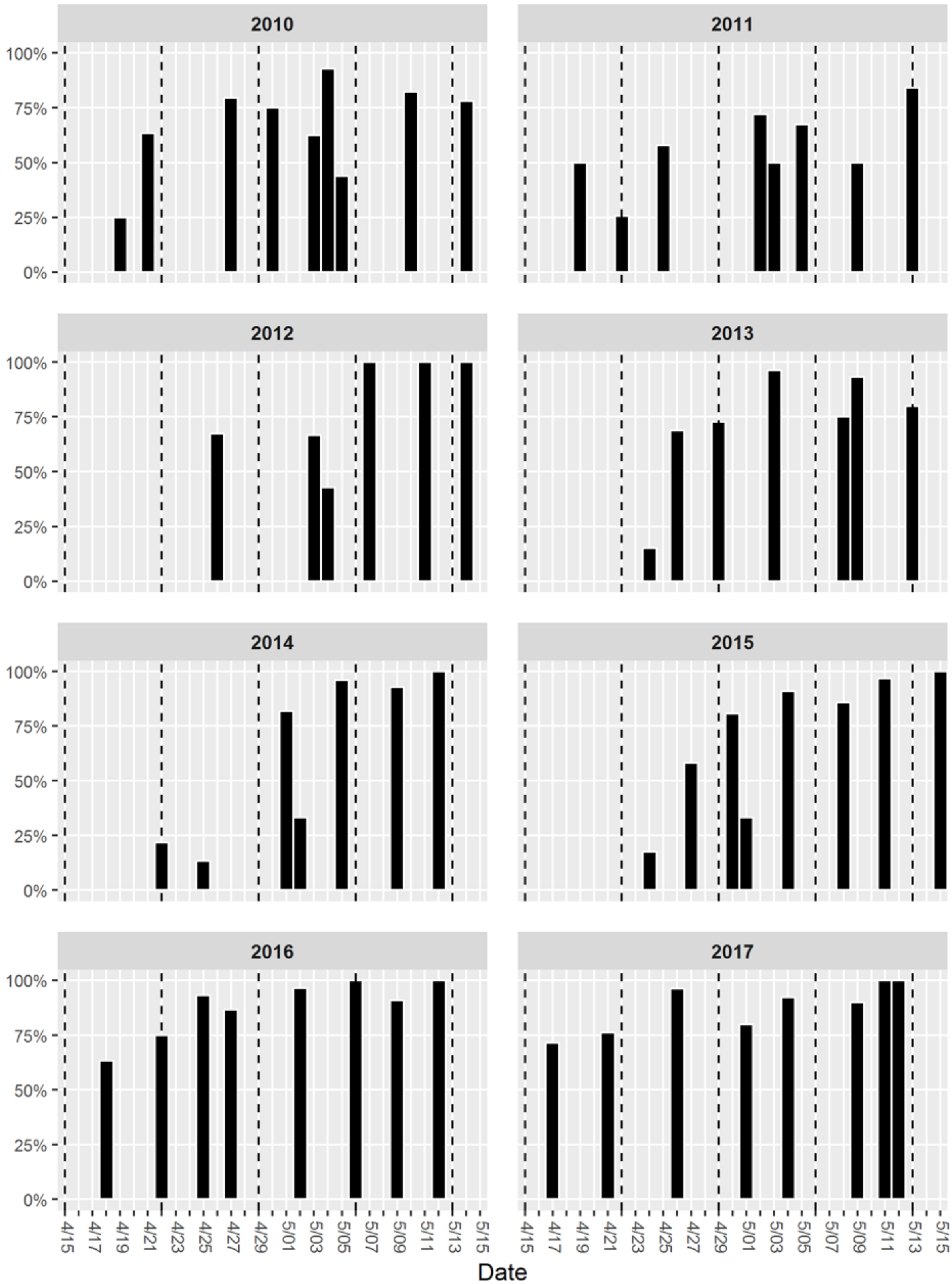


Figure 7. Continued.



APPENDIX I

INTERVIEW FORMAT AND QUESTIONS
MARYLAND STRIPED BASS SPRING SEASON CREEL SURVEY
MARYLAND DEPARTMENT OF NATURAL RESOURCES-FISHERIES SERVICE

1. How many anglers were on your boat today?
2. How many striped bass were kept by your party?
3. How many striped bass were released by your party?
4. How many hours did you fish today? (lines in until lines out)
5. How many lines were you fishing?
6. Where did you spend most of your time fishing today? **U**, **M**, or **L** Bay: Upper Bay = above Bay Bridge, Middle Bay = Bay Bridge to Cove Point, Lower Bay = Cove Point to MD/VA line at Smith Point (Maps will be provided)
7. What is your state of residence?
8. Licenses:
    a. Do you have a boat license? Yes/No
    b. How many anglers in your party also have their own individual licenses?

APPENDIX II

Update to the Female Striped Bass Maturity Schedule

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Maryland Department of Natural Resources

Introduction

The 2013 striped bass benchmark stock assessment (Northeast Fisheries Science Center 2013) lists development of maturity ogives applicable to coastal migratory stocks as a moderate level research priority. The current female striped bass maturity schedule used in the stock assessment is based on a 1987 white paper by Phil Jones (Table 1).

In the white paper, data for ages 4-6 were from the Maryland spawning stock gill net survey from 1985-1987, while data for ages 7-8 appear to be from a Texas Instruments study (Texas Instruments Inc. 1980) done on the Hudson River from 1976-1979. The Maryland study estimated maturity at age by dividing female CPUE from the spawning stock survey by male CPUE while assuming the natural and fishing mortality were the same between the sexes and that all males were mature. The assumption of equivalent mortality between the sexes was valid during the time period of the study due to the moratorium. The Texas Instruments study used a gonadosomatic index (ovary weight divided by fish weight) to separate immature from mature female fish.

Both methods use an indirect, rather than histological approach, to estimate female maturity at age and the work has not been updated since the stock was rebuilt. The estimated female maturity at age is improved by using newer, standardized, and more detailed histological techniques that reflect the dynamics of a restored stock.

This report summarizes the work conducted from 2014-2016 to update the maturity schedule. The secondary goal of calculating fecundity estimates will be completed at a later date.

Methods

Determining Sampling Targets

In an attempt to sample all ages of females in the population, length group targets were established after reviewing past female age frequencies (Table 2) and length frequencies (Figure 1) from the Maryland spring creel survey. Based on sample sizes from five years of creel survey sampling, it was determined that three years of sampling (2014-2016) would be required to achieve adequate sample sizes.

The majority of the sampling effort (68%) was on fish between 520-879 mm TL. Using Maryland's 2012 and 2013 spring age-length keys, these fish should be between 5-8 years old. Sampling was focused on this size/age range to adequately characterize the steepest part of the current maturity ogive (Figure 2). However, samples were also collected at smaller and larger sizes where fish were expected to be mostly immature or all mature, respectively. The proposed target sample sizes, by 20 mm length group, as well as the number sampled, are shown in Table 3 and Figure 3. The length groups in this table and figure are midpoints (i.e. the 610 length group goes from 600-619 mm).

Sample Collection Procedures

The primary source of fish was the Maryland Department of Natural Resources (MDNR) spring creel survey, since all fish encountered were already dead and the harvest over the April through June survey included both resident and migratory fish within the spawning period (Table 4). Additional fish from the Chesapeake Bay spawning stock were collected from the spawning stock survey and other surveys in Maryland's portion of the Bay.

While the low sample sizes in the 590-830 mm length groups observed in the spring creel survey sampling (Figure 1) could be due to the two different regulatory periods during the spring (trophy season through May 15 and summer/fall season after) and angler behavior, it is also possible that fish in this size range are immature migratory females that have not yet returned to the Chesapeake Bay to spawn. By using only samples from the Chesapeake Bay, the results may be biased towards immature, premigratory fish and mature, migratory fish, while lacking immature migratory females that remain on the coast. To minimize this bias, complementary sampling was conducted by coastal states to fill in missing length groups. The New Jersey Bureau of Marine Fisheries, Rhode Island Division of Fish and Wildlife, and the Northeast Area Monitoring and Assessment Program (NEAMAP) contributed samples from their routine surveys (Table 4). Ovaries were collected from the various surveys in the months of March through July and September through December during pre-spawn, spawning and post-spawn periods (Table 5). Total length (mm TL), weight (kg), visual (macroscopic) maturity stage, and external anomalies were recorded from all fish. Scales were collected to assign ages to fish sampled, as scale ages for striped bass are generally accurate through age ten (ASMFC 2013). Maryland does not have the ability to process and read striped bass otoliths, however, otoliths were collected for future validation.

Histological procedures followed the methods from Boyd (2011). Both ovaries were carefully removed from the body cavity and weighed. One ovary was retained in cold 10% buffered formalin for up to two weeks, depending on ovary size. Formalin was used for preservation on all surveys with the exception of NEAMAP where Normalin was used. Large ovaries were cut in half and remained in formalin for a longer time to ensure complete fixation.

After fixation was complete, a 4 mm thick ovary cross-section was placed into one or more labeled, standard histological cassettes and stored in 70% ethanol.

Histological Procedures

The MDNR Diagnostics & Histology Laboratory at the Cooperative Oxford Laboratory prepared MH&E-stained histological slides of ovary tissues. Detailed laboratory procedures for the processing of ovary slides can be found in Boyd (2011).

Slides were viewed under 40X or 100X magnification through a dissecting scope, and maturity stages were assigned according to the categories defined in Brown-Peterson et al. (2011) (Table 6). Slides were examined by three biologists to determine the final maturity stage. If there was disagreement between the readers, the slides were viewed and discussed until a final stage was agreed upon.

Analytical Procedures

Brown-Peterson et al. (2011) defines immature fish as a gonadotropin independent phase and “fish enter the reproductive cycle when gonadal growth and gamete development first become gonadotropin dependent (i.e., the fish become sexually mature and enter the developing phase)” (Figure 4). While a striped bass may enter the developing phase and be physiologically mature, it does not necessarily indicate that the fish will spawn in the upcoming spawning season (Olsen and Rulifson 1992; Berlinsky et al. 1995; Boyd 2011). For this reason, the data were analyzed in two ways: as the percent mature (with developing through regenerating phases designated as mature) and as percent spawning (spawning capable through regressing phases indicating spawning is imminent or completed).

Ovary slides from fish collected in the fall/winter were essentially all immature or developing fish, with 89% of samples in the developing phase. As stated above, these fish may or may not spawn in the following spawning season. For this reason, the data were also analyzed using a subset of data from the spring and summer, a time period when spawning was occurring or just completed and the full dataset.

For samples collected from March through July, ages were calculated as the sample year minus the assigned year class. Calculation of ages for fish collected in the fall and winter (September through December) were done slightly differently. If a fish was determined to be immature in the fall/winter, it was immature the previous spring and age was calculated as above. Similarly, if a fish was regressing or regenerating in the fall/winter, it was assumed to have spawned the previous spring and age was also calculated as sample year minus year class. Difficulty arose with fish in the developing phase in the fall/winter with no readily apparent indications of previous spawning (e.g. thickened ovarian walls and/or muscle bundles). Therefore, if a fish was in the developing phase, it may or may not have spawned in the previous year. For these fish, we make the assumption that the observed developing phase is in preparation for the upcoming spawning season. For this reason, ages of fish in the developing phase from the fall and winter were advanced one year.

The maturity at age data were analyzed using logistic regression by specifying the logit link in a binomial generalized linear model (GLM) in R (R Core Team 2016).

Results

Over three years, 428 ovary samples were collected and were useable for this study (Figure 3). Of these, 307 were from Maryland's Chesapeake Bay (71.7%) and 121 were from coastal surveys (28.3%, Table 4). Lengths of all females sampled ranged from 350 to 1223 mm TL (mean=697 mm, SE=8.7 mm). Chesapeake Bay fish ranged from 350 to 1223 mm TL (mean=731 mm, SE=10.8 mm) and females sampled on the coast ranged from 350 to 1030 mm TL (mean=610 mm, SE=10.6 mm).

Ages ranged from 2 to 16, with 31% of fish from the above average 2011 year-class. The majority of fish sampled were between ages 4 and 6 (54.2%, Table 7). Sampling targets put the most sampling effort on fish approximately ages 5-8 (68%) in order to characterize the steepest part of the maturity ogive. For our dataset, 59.6% of the samples were from this age range.

Of the 428 fish sampled, 32 were immature (7.5%), 157 were developing (36.7%), 84 were spawning capable (19.6%), 12 were actively spawning (2.8%), 117 were regressing (27.3%), and 26 were regenerating (6.1%).

March-July Dataset

Most studies that examine maturity collect samples during the months of spawning. This data subset used data from March-July as spawning in Chesapeake Bay, where most of these samples were from, is known to occur into early June (Mansueti and Hollis 1963; Hollis 1967). Additionally, through July, fish that had spawned the previous spring were easily identified as being in the regressing and regenerating phases and more samples of small, immature fish were collected from pound nets. Of the 343 fish sampled in this time period, 302 were from Chesapeake Bay and 41 were from coastal states (16 from Delaware Bay, 9 from the New Jersey Ocean Trawl, and 16 from NEAMAP).

When developing fish were identified as mature, the age at 50% maturity was 3.59 years old (Figure 5). When developing fish were identified as not spawning imminently, the age at 50% maturity was 5.27 years old (Figure 6).

Full Dataset

The final dataset analyzed used data from throughout the year (March through December). This dataset included more fish from the coast, specifically samples from Rhode Island, but had the complication of how to define developing fish. Of the 428 fish sampled, 307 were from Chesapeake Bay and 121 were from coastal areas (see Table 4 for more information on sample sizes from specific surveys).

When developing fish were classified as mature, the age at 50% maturity was 3.63 years old (Figure 7). When developing fish were identified as not imminently spawning, the age at 50% maturity was 5.84 years old (Figure 8).

Discussion

The methods recommended in Brown-Peterson et al. (2011) were put forward in an effort to standardize terminology and reproductive phases across a wide variety of fish species. While the inclusion of developing fish as mature makes sense from a physiological standpoint (in the sense that that is the first reproductive phase to be gonadotropin dependent), it does not make sense from a stock assessment perspective for striped bass. Boyd (2011) specifies that for striped bass, fish in the developing phase may not necessarily spawn in the upcoming spawning season and therefore, we believe it makes more sense to treat these fish as not yet part of the spawning stock. Additionally, when developing fish were considered mature, the age of 50% maturity was very low, ranging from 3.6 -3.9 years old depending on the dataset used. This age at 50% maturity is much lower than the age that the Maryland spawning stock survey starts seeing any females on the spawning grounds. Since 1994, no females younger than age four have been caught in the spawning stock survey and only 12 four year olds have been caught in that time. We recommend using a maturity curve where developing fish are considered immature/not imminently spawning.

In general, the logistic regression equations estimate higher maturity-at-age up through age 6 as compared to the maturity schedule currently used in the stock assessment and similar maturity at age for ages 7 and above. The observed proportions mature at age for ages 4-6 are also higher than the values used currently (Table 8). Some of these differences are likely due to methodology. The previous estimates of maturity-at-age were calculated using CPUE data from the Maryland spawning stock survey and a GSI developed from fish on the Hudson River. This study utilizes histology to determine maturity which is known to be more accurate (West 1990). Additionally, those studies were conducted in the mid- to late-1980s and may have been reflective of a depressed stock. However, our observed proportions mature at age for ages 4 and 5 using the full dataset are similar to Berlinsky et al. (1995).

Despite our best efforts to include fish from the coast, it is also possible that some bias was still introduced. First, we continued to observe a bimodal distribution in our length samples (Figure 3). While this could partially be due to poor recruitment in the year classes that would span those sizes, it is also possible that we are still missing some migratory, immature fish. Second, as most of the fish were collected from the Maryland spring creel survey, these fish were subject to the minimum recreational sizes in the Chesapeake Bay (18” minimum in 2014 and 20” minimum in 2015 and 2016). To assess whether the samples were biased by the recreational size limits, comparisons were made to the length frequency sampled from Maryland’s summer/fall pound net and checkstation surveys in 2014-2016. These surveys should provide some estimate of the overall size distribution of age 4 and 5 fish in the Bay as pound nets are not size selective and the pound net survey samples both legal and sublegal fish in proportion to their availability in the net. The size frequencies, though, are sexes-combined as sex cannot be determined at that time of year and it is known that female striped bass tend to be larger at age than male striped bass after age 3 (Mansueti 1961; Mansueti and Hollis 1963; ASMFC 2013). Comparing the size frequency of samples at age from the maturity study to those collected in the pound net survey, it appears that age 4 fish sampled on the coast were larger than those sampled in the Bay (Figure 9). Most of the coastal fish were sampled in the fall from Rhode Island and may be indicative of larger age 4 fish migrating to the coast while smaller age 4 fish remain in the Bay (Dorazio et al. 1994). The Bay samples, however, generally align with the pound net survey samples indicating that the Bay sampling was not biased by the recreational size limits. Sampling of age 5 fish also showed no evidence of bias though differences in the length frequencies sampled were still observed between the Bay and coast with coastal age 5 fish being larger than Chesapeake Bay age 5 fish.

Assuming the Striped Bass Technical Committee and Stock Assessment Subcommittee (SAS) agrees with our suggestion to use a maturity curve where developing fish are considered immature/not imminently spawning, decisions would still need to be made on which dataset and results to use. Studies are often recommended to be done either prior to spawning (Hunter and Macewicz 2003) or prior to and during the spawning season (Murua et al. 2003). This would align best with our March-July data subset or possibly even a smaller subset. However, consideration must also be given to the distribution of fish across the study area, particularly when immature and mature individuals occur in different areas (Berlinsky et al. 1995; Hunter and Macewicz 2003; Murua et al. 2003). It is for this reason that Berlinsky et al. (1995) sampled during the spring and fall feeding migrations even though this required an assumption that maturations rates were not significantly different among stocks.

The March-July dataset includes more immature fish and spans the entire spawning season in Chesapeake Bay which is known to occur into June. However, using this smaller dataset reduces the overall sample size and the number of coastal fish included in the dataset. Use of the full dataset includes all of the fish collected coastwide, including those immature migratory females we may be missing within the Bay; however, some error is likely added by classifying older, developing fish as not imminently spawning. An examination of Figure 8, however, indicates that this is likely not an issue as most of the fish sampled above age 6 were classified as spawning capable or regressing/regenerating. This is likely due to our focus on smaller coastal fish that were between ages 5-8. To aid in deciding which dataset and results to use, a comparison of the logistic regression estimates of maturity-at-age for these two datasets as well as a comparison of the observed proportions mature-at-age in shown in Figure 10. <u>We would recommend using the full dataset.</u>

<u>Acknowledgements</u>

This study was a joint effort that included several state agencies and other programs within MD DNR. First we would like to thank Jacob Boyd of the North Carolina Division of Marine Fisheries for his consultation, advice, and histology slide expertise as we started on this project. We'd also like to thank Heather Corbett and her staff at New Jersey Department of Environmental Protection - Bureau of Marine Fisheries, Nicole Lengyel and her staff at Rhode Island Department of Environmental Management - Division of Fish and Wildlife, and Virginia Institute of Marine Science staff that run the NEAMAP cruises (Jameson Gregg, James Gartland, Rob Latour) for helping us collect additional ovaries from fish along the Atlantic coast. Additional thanks go to the MD Fish and Wildlife Health Program staff, Mark Matsche and Kevin Rosemary, for their demonstrations and knowledge on dissection and histology techniques. Finally we are very grateful for Chris Dungan and his staff (former lab manager Jud Blazek and current manager Laurinda Serafin) in the Diagnostics and Histology Laboratory for

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Table 1. Current female maturity schedule used for the striped bass stock assessment.

Age	4	5	6	7	8	9
Proportion Mature	0.04	0.13	0.45	0.89	0.94	1.0

Table 2. Number of female striped bass, by age and year, collected during the Maryland spring creel survey, 2009-2013.

Age	2009	2010	2011	2012	2013	Average
3	1	6	1	0	1	2
4	7	6	33	17	17	16
5	7	7	19	25	9	13
6	7	3	3	31	26	14
7	4	17	7	16	3	9
8	18	12	42	13	6	18
9	40	29	14	30	18	26
10	11	27	39	3	28	22
11	10	15	15	8	4	10
12	8	13	6	1	11	8
13	12	12	6	0	3	7
14	6	19	2	0	2	6
15	3	4	6	2	1	3

16	3	3	1	0	0	1
17	1	0	0	1	1	1
18	1	0	0	0	0	0
Totals	139	173	194	147	130	157

Table 3. Targets and sample sizes for maturity schedule survey, along with deficits when targets were not met.

Length Group	Target	2014 Samples	2015 Samples	2016 Samples	Total Samples	Deficit
350		1	2	0	3	
370		1	1	0	2	
390		0	0	0	0	
410		2	6	3	11	
430	10	1	4	1	6	4
450	10	2	0	1	3	7
470	10	7	1	3	11	
490	10	6	1	3	10	
510	10	4	5	3	12	
530	15	2	5	10	17	
550	15	8	10	7	25	
570	15	6	20	4	30	
590	15	4	22	7	33	
610	15	1	19	9	29	
630	15	3	10	4	17	
650	15	6	10	3	19	
670	15	4	4	4	12	3
690	15	2	7	2	11	4
710	15	2	4	3	9	6
730	15	4	4	1	9	6
750	15	0	3	3	6	9
770	15	3	4	2	9	6
790	15	0	5	4	9	6
810	15	4	4	0	8	7
830	15	2	4	3	9	6
850	15	5	6	2	13	2
870	15	5	7	4	16	
890	10	6	5	0	11	
910	10	7	5	0	12	
930	10	7	4	0	11	
950	10	7	4	0	11	
970	10	6	1	5	12	
990	10	5	3	3	11	
1010	3	1	3	1	5	
1030	3	2	0	2	4	
1050	3	0	3	1	4	
1070	3	0	3	0	3	
1090	3	1	1	1	3	
1110		0	1	0	1	
1130		0	0	0	0	

1150		0	0	0	0	
1170		0	0	0	0	
1190		0	0	0	0	
1210		0	0	0	0	
1230		0	1	0	1	
Totals	395	127	202	99	428	66

Table 4. Number of fish sampled by state and survey.

State	Survey	Months Sampled	n	Percent
Maryland				
	Spring Creel Survey	April-June	252	58.9%
	Spring Gill Net Survey	April-May	15	3.5%
	Striped Bass Pound Net Sampling	June-July	19	4.4%
	Nanticoke Spring Pound Net and Fyke Net Survey	March	2	0.5%
	Commercial Check Station Sampling	March	3	0.7%
	Fish Health Hook & Line Survey	September-November	5	1.2%
	Patapsco Gill Net Survey	June	3	0.7%
	Shad Gill Net Survey (USFWS)	April-May	8	1.9%
New Jersey				
	Delaware Bay Gill Net Survey	March-May	15	3.5%
	Ocean Trawl Survey	April-May	9	2.1%
		October	1	0.2%
	Headboat Sampling	December	13	3.0%
	Herring Survey	May	1	0.2%
Rhode Island				
	Fish Trap Survey	September-October	59	13.8%
NEAMAP				
	Ocean Trawl Survey	May	16	3.7%
		September-October	7	1.6%
Total			428	

Table 5. Number of fish sampled by month.

Month	n	Percent
March	15	3.5%
April	80	18.7%

May	151	35.3%
June	84	19.6%
July	13	3.0%
September	16	3.7%
October	54	12.6%
November	2	0.5%
December	13	3.0%
Total	428	

Table 6. Macroscopic and histological description of maturity phases used in the analysis. From Table 2 of Brown-Peterson et al. (2011). Abbreviations used in descriptions: CA = cortical alveolar; GVBD = germinal vesicle breakdown; GVM = germinal vesicle migration; OM = oocyte maturation; PG = primary growth; POF = postovulatory follicle complex; Vtg1 = primary vitellogenic; Vtg2 = secondary vitellogenic; Vtg3 = tertiary vitellogenic.

Phase	Macroscopic and Histological Features
Immature (never spawned)	Small ovaries, often clear, blood vessels indistinct. Only oogonia and PG oocytes present. No atresia or muscle bundles. Thin ovarian wall and little space between oocytes.
Developing (ovaries beginning to develop but not yet ready to spawn)	Enlarging ovaries, blood vessels becoming more distinct. PG, CA, Vtg1, and Vtg2 oocytes present. Not evidence of POFs or Vtg3 oocytes. Some atresia can be present. *Early Developing subphase*: PG and CA oocytes only.
Spawning Capable (fish are developmentally and physiologically able to spawn in this cycle)	Large ovaries, blood vessels prominent. Individual oocytes visible macroscopically. Vtg3 oocytes present or POFs present in batch spawners. Atresia of vitellogenic and/or hydrated oocytes may be present. Early stages of OM can be present. *Actively Spawning subphase*: oocytes undergoing late GVM, GVBD, hydration, or ovulation.
Regressing (cessation of spawning)	Flaccid ovaries, blood vessels prominent. Atresia (any stage) and POFs present. Some CA and/or vitellogenic (Vtg1, Vtg2) oocytes present.
Regenerating (sexually mature, reproductively inactive)	Small ovaries, blood vessels reduced but present. Only oogonia and PG oocytes present. Muscle bundles, enlarged blood vessels, thick ovarian wall and/or gamma/delta atresia or old, degenerating POFs may be present.

Table 7. Number of fish sampled by age. Ages were calculated as for the full dataset analysis (e.g. fall developing fish had their ages advanced one year).

Age	n	Percent
2	3	0.7%
3	13	3.0%
4	45	10.5%
5	131	30.6%
6	56	13.1%
7	32	7.5%
8	36	8.4%
9	13	3.0%
10	28	6.5%
11	44	10.3%
12	14	3.3%
13	8	1.9%
14	4	0.9%
16	1	0.2%
Total	428	

Table 8. Comparison of maturity at age estimates from various studies. The current maturity-at-age estimates used in the stock assessment are bolded.

Study	Merriman (1941) a	Texas Instruments (1980) b	Specker et al. (1987) b	**Jones (1987)**	Berlinsky et al. (1995)	Data Subset (this study)	Full Dataset (this study)
Area	New England	Hudson	Coastwide	**MD and Hudson**	Rhode Island	Coastwide	Coastwide
Timing	April-Nov				May-June, Sept-Nov	March-July	March-July, Sept-Dec
Age							
3	0%			**0%**	0%	0%	0%
4	27%	4%	5%	**4%**	12%	7%	9%
5	74%	21%	15%	**13%**	34%	51%	32%
6	93%	60%	45%	**45%**	77%	66%	45%
7	100%	89%	100%	**89%**	100%	90%	84%
8	100%	94%	100%	**94%**	100%	94%	89%
9	100%	100%	100%	**100%**	100%	100%	100%

a: From Berlinksy et al 1995

b: From Jones 1987

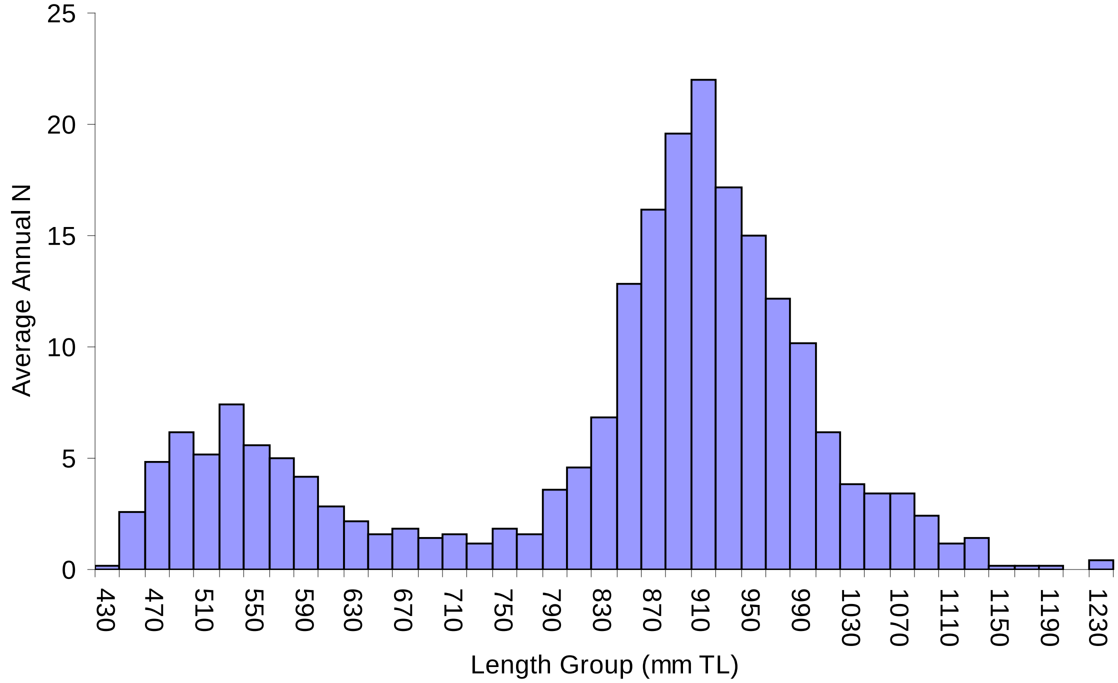


Figure 1. Average annual sample size of female fish by length group from the Maryland spring creel survey, 2009-2013.

Figure 2. Current maturity ogive for female striped bass. The highlighted area indicates the age range where sampling effort was focused.

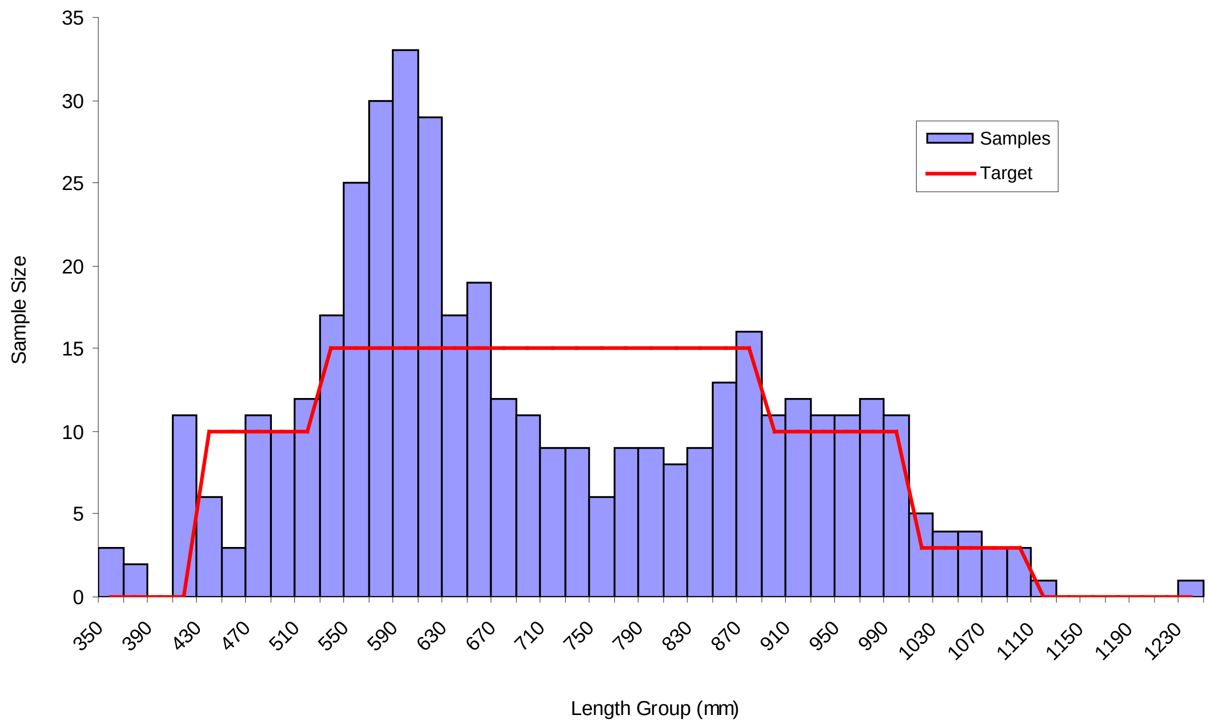


Figure 3. Samples collected vs. targets.

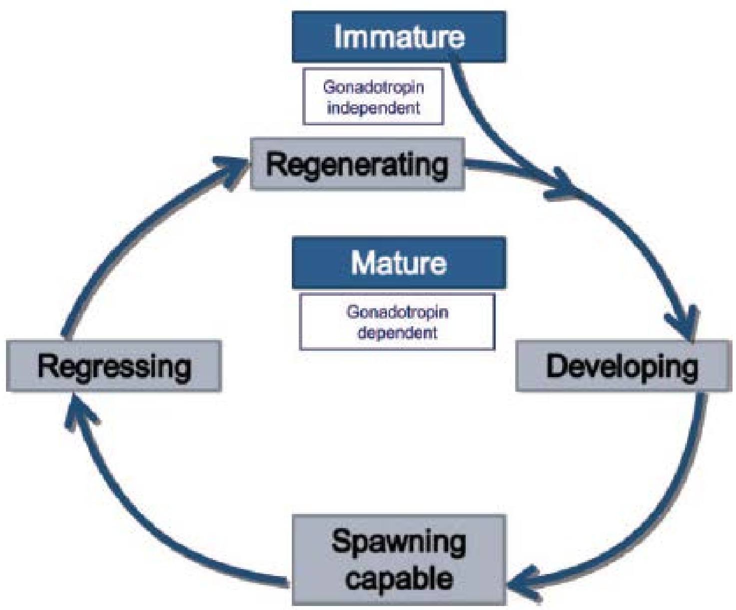


Figure 4. Conceptual model of fish reproductive phase terminology. Figure from Brown-Peterson et al. 2011.

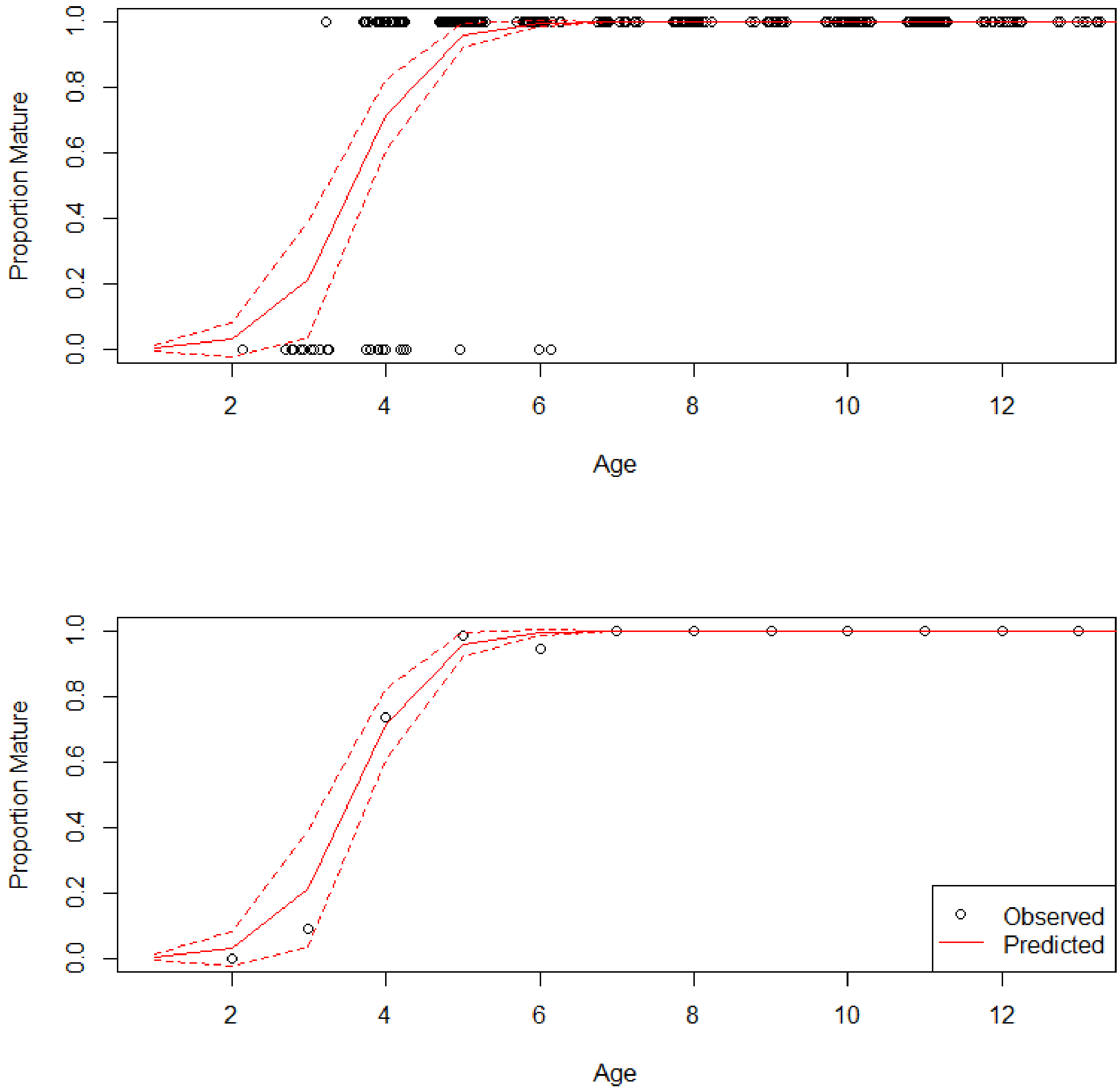


Figure 5. Estimated proportions mature, by age, for the March-July dataset when developing fish are considered mature. Top figure shows the sample size and maturity status for each fish sampled, by age, and bottom figure shows the overall observed proportion mature.

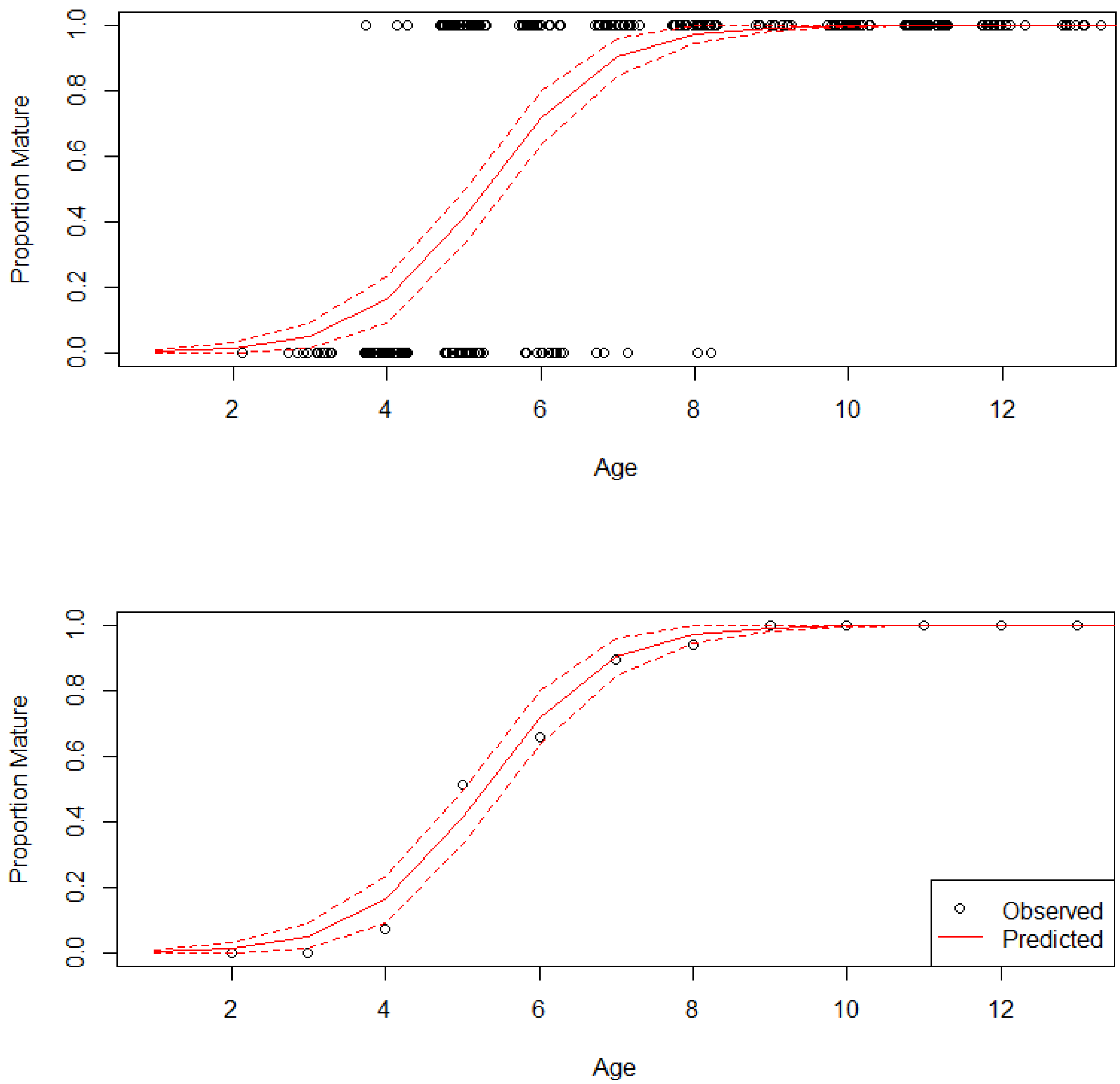
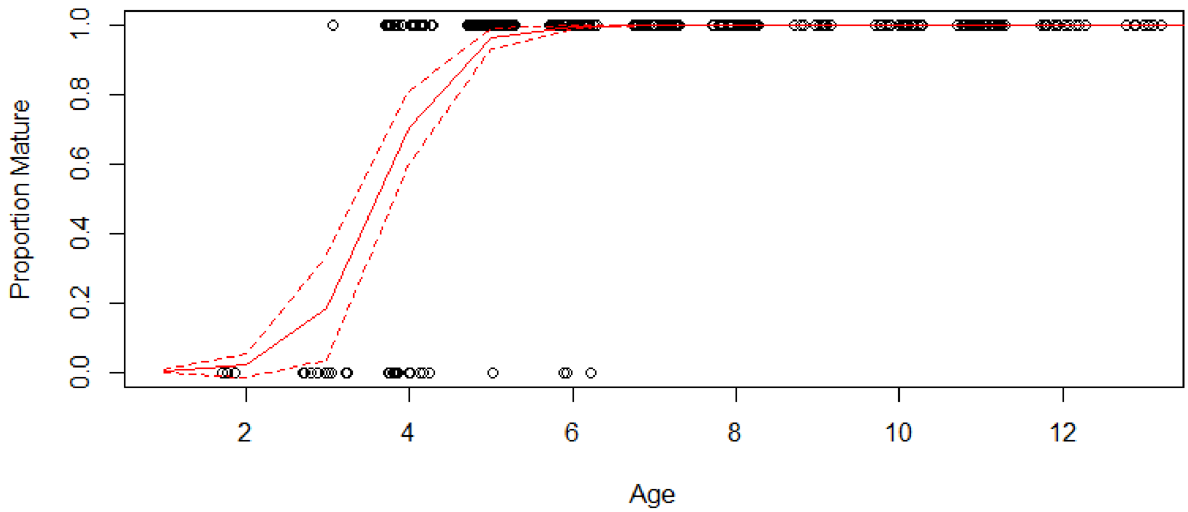


Figure 6. Estimated proportions mature, by age, for the March-July dataset when developing fish are considered not imminently spawning. Top figure shows the sample size and maturity status for each fish sampled, by age, and bottom figure shows the overall observed proportion mature.



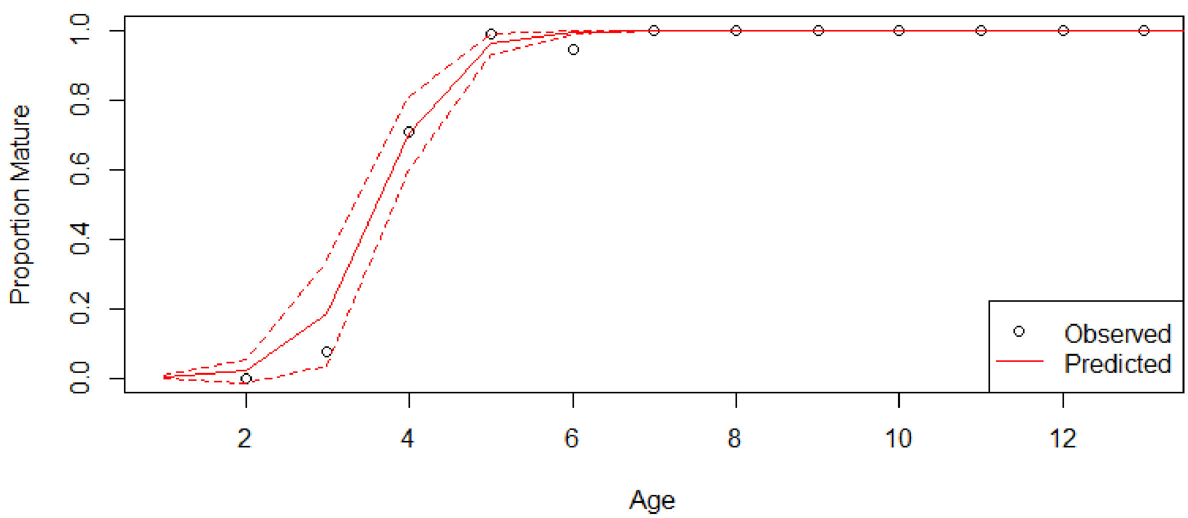


Figure 7. Estimated proportions mature, by age, for the full dataset when developing fish are considered mature. Top figure shows the sample size and maturity status for each fish sampled, by age, and bottom figure shows the overall observed proportion mature.

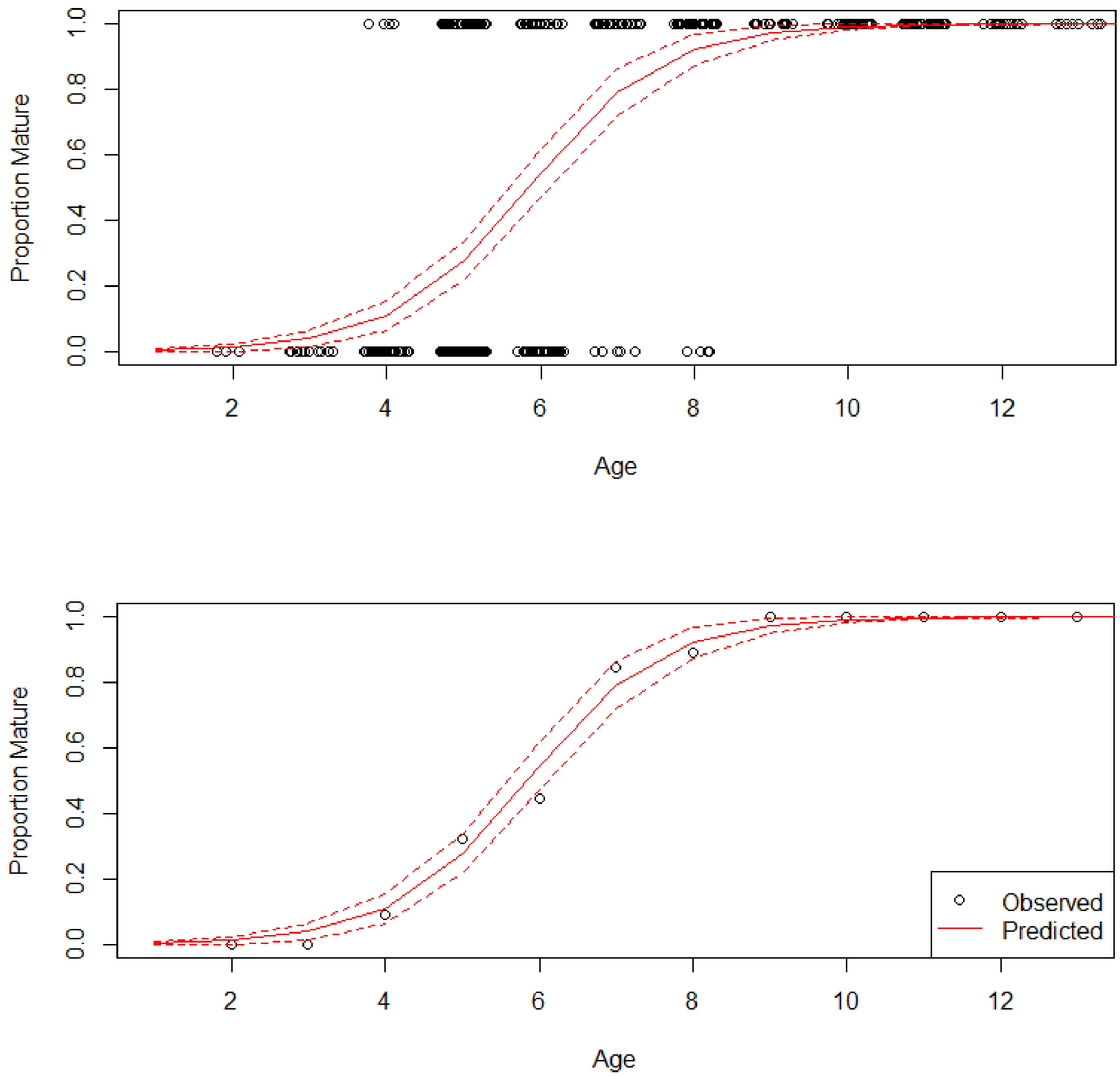


Figure 8. Estimated proportions mature, by age, for the full dataset when developing fish are considered not imminently spawning. Top figure shows the sample size and maturity status for each fish sampled, by age, and bottom figure shows the overall observed proportion mature.

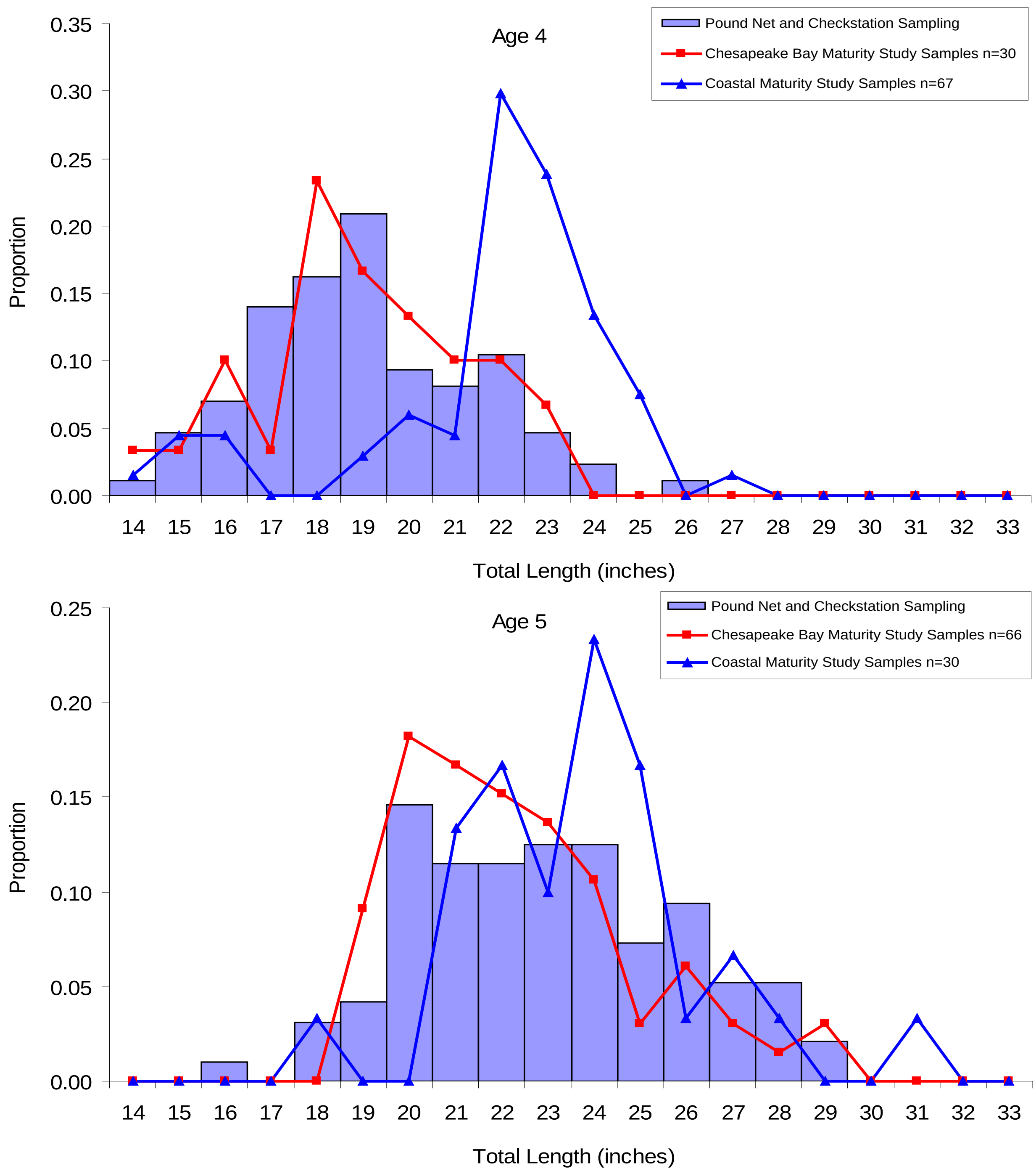


Figure 9. Comparison of the length frequencies, at age, from the summer/fall pound net and checkstation surveys (2014-2016, sexes combined) and fish sampled for the maturity study (2014-2016).

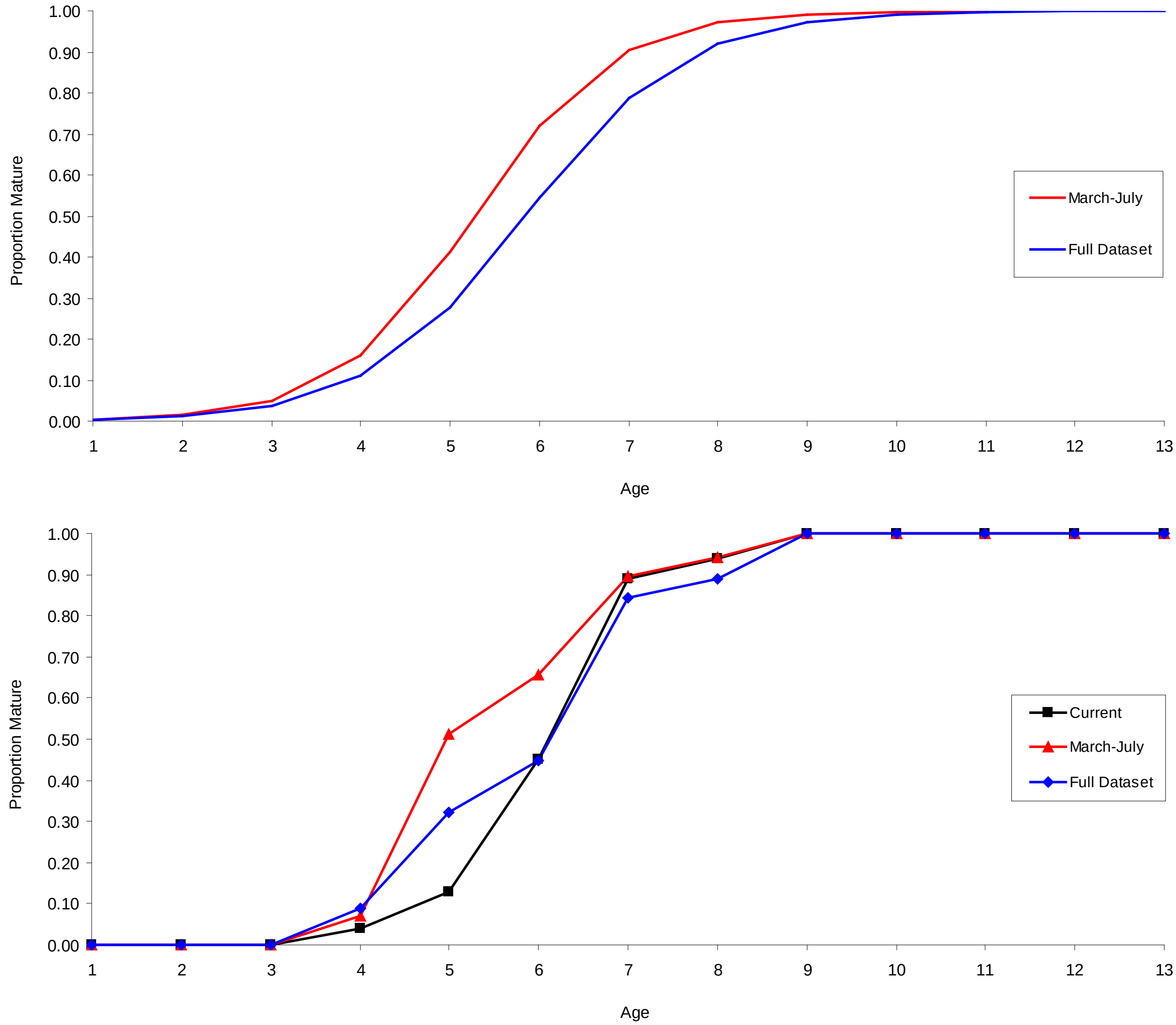


Figure 10. Comparison of the maturity at age estimates between the different data subsets when developing fish are classified as not imminently spawning. Top panel compares the logistic regression estimates. Bottom panel compares the observed proportions.

APPENDIX III

Final Estimate for 2017 of

Spring Harvest of Coastal Migrant Striped Bass in Chesapeake Bay

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May 24, 2018

INTRODUCTION

This report presents the final estimates of the 2017 Maryland and Virginia spring harvest of coastal migrant striped bass in Chesapeake Bay (Table 1). The method used to determine coastal migrants in Maryland was presented in detail in Jones (2003), Barker and Sharov (2004), and Sharov et al. (2005). This report is submitted yearly to the Atlantic States Marine Fisheries Commission (ASMFC) as an appendix to the annual compliance reporting, and as an appendix to the recreational fishing section of the Chesapeake Bay Finfish Investigations Federal Aid Report to the U. S. Fish and Wildlife Service (USFWS).

ASMFC implemented Addendum IV to the Striped Bass Management Plan in 2014 in order to reduce fishing mortality to a level at or below the target. Addendum IV manages the trophy season as part of the coastal fishery and required a 25% reduction in harvest for 2017. Therefore, Maryland raised the minimum size limit to 35 inches from April 15 to May 15. Addendum IV also required a Chesapeake Bay reduction of 20.5% in the summer/fall fishery. The regulations were two fish $\geq$ 20 inches (only one over 28 inches) from May 16 to December 20th.

METHODS

Estimation of harvest

Maryland Department of Natural Resources (MD DNR) charter boat logbook reports provided the census values of daily charter boat harvest in numbers of fish (Table 1). Due to increased online reporting of charter boat logbook data, Standard Atlantic Fisheries Information System (SAFIS) data were also used for the charter calculation. The NOAA Marine Recreational Information Program (MRIP) survey provided final estimates of harvest for Maryland private and rental boats, in numbers of fish, for Wave 2 (March/April) and Wave 3 (May/June; Table 1). The Virginia Marine Resources Commission (VMRC) provided mandatory spring season striped bass reporting data.

Harvest apportioned by time

The migrant harvest season overlaps parts of both Waves 2 and 3 of the MRIP survey. Length distribution of the harvest is known to change over this time period, so total harvest was apportioned into 2-week intervals between April 16 and June 15. All Wave 2 landings for striped bass occurred in the last 2 weeks of the wave. The 2-week interval proportions for Wave 3 landings were developed as the proportions of the harvest recorded in the Maryland charter boat logbook and SAFIS reports (Table 1). Total Maryland striped bass harvest per interval was calculated as charter boat harvest (MD DNR) + private and rental harvest (MRIP; Table 1).

Harvest apportioned by length

Data from the MD DNR Volunteer Charter Boat Survey and Charter Creel Survey were used to develop the length frequency distribution of the Maryland charter boat catch for each 2-week interval (Table 2). Data from the Volunteer Charter Boat Survey were also used to develop the length frequency distribution for the Maryland private angler catch due to small samples of fish reported in the Volunteer Angler Survey. Harvest in each interval was distributed by the length frequency distribution for each 2-week interval. The number of migrants harvested in Maryland during the spring trophy season was determined by applying length-specific migration probabilities. These probabilities were derived from the estimate of the number of striped bass tagged on the spawning grounds in Maryland that migrate to the Atlantic coast before December of the first year at large (Dorazio et al. 1994). The result was a migrant and resident harvest estimate for each 2-week interval, distributed among interval-specific length groups (Table 3). The total 2017 Maryland spring harvest of coastal migrant striped bass in Chesapeake Bay was calculated as the sum of migrants over all length groups and 2-week intervals from both sectors (charter and private). The estimate of the migrant harvest for Virginia's portion of Chesapeake

Bay was calculated by applying the same length-specific migration probabilities to the length frequency data provided by VMRC, based on mandatory reporting by recreational anglers and charter boat captains.

RESULTS and DISCUSSION

MD DNR charter boat estimates of harvest were queried on 11/17/17. The total charter boat harvest was 2,847 fish from April 15 to April 30, 1,042 fish from May 1 to May 15, 6,592 fish from May 16 to May 31 and 6,886 fish from June 1 to June 15. Final MRIP private and rental boat estimates were downloaded on 5/22/18. Private and rental boat total harvest was 8,574 fish from April 15 to April 30, 6,817 fish from May 1 to May 15, 39,541 fish from May 16 to May 31 and 40,904 fish from June 1 to June 15 (Table 1).

The final estimate of the 2017 Chesapeake Bay spring migrant harvest is 22,892 fish, a decrease compared to 2016 and below the 2006-2017 average of 42,973 fish (Table 4). The Maryland portion of the Chesapeake Bay migrant harvest is 22,853 migrants (Table 1). The Maryland charter boat migrant harvest is 4,370 fish. The Maryland private boat migrant harvest is 18,483 fish. The estimate of the spring 2017 migrant harvest in Virginia is 39 fish. Annual spring migrant harvest by length group has shifted to slightly smaller fish compared to 2015 and 2016, however, fish are larger than 2014 (Figure 1). As required by ASMFC Addendum IV, an increased minimum size limit of 35 inches for April 15 to May 15 and a new minimum size of 20 inches for May 16 to December 20th was in place for 2017. The length frequency distribution and Volunteer Charter Boat Survey data reflected this change in regulations (Table 2, Figure 1).

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LIST OF FIGURES

Table 1. 2017 Chesapeake Bay spring striped bass migrant harvest, distributed among 2-week intervals, based on data from Maryland charter boat logbook reports, MRIP Maryland recreational harvest estimate and VA calculated migrant harvest.* Shaded time intervals outside of the April 15th to June 15th season are shown to demonstrate partitioning of the total harvest.

	Interval	Charter Harvest (% by interval)[1]	MD Charter Harvest[1]	MD Private Harvest[2]	MD Total Harvest	MD Charter Migrants	MD Private Migrants	MD Total Migrants	VA Migrants[3]	Bay Total Migrants
Wave 2	Apr 1-14	0	0	0	0	0	0	0		
	Apr 15-30	100	2,847	8,574	11,421	2,757	8,304	11,061		
Wave 3	May 1-15	5	1,042	6,817	7,859	955	6,250	7,205		
	May 16-31	29	6,592	39,541	46,133	365	2,190	2,555		
	June 1-15	30	6,886	40,904	47,790	293	1,739	2,032		
	June 16-30	36	8,247	49,085	57,332					
	Wave 3 total	*100*	*22,767*	*136,347*	*159,114*					
Season total (Apr 15 – June 15)			17,367	95,836	113,203	4,370	18,483	**22,853**	**39**	**22,892**

* – Numbers may not sum due to rounding
1 – Data from MD DNR charter logbooks and SAFIS (11/17/17)
2 – Data from MRIP (retrieved from NOAA NMFS website 5/22/18)
3 – Data from VMRC (Alex Aspinwall, VMRC, Pers. Comm. 11/17/17)

Table 2. Length distribution, in inches, of the 2017 Maryland striped bass spring season harvest as voluntarily reported by charter boat captains and supplemented with fish sampled at charter boat docks (May 1-15 only), by 2-week intervals between April 15 and June 15. Shaded areas represent no-take size groups.

Length Group	April 15-30	May 1-15	May 16-31	June 1-15	Total
17	0	0	0	0	0
18	0	0	0	0	0
19	0	0	1	0	1
20	0	0	45	37	82
21	0	0	46	40	86
22	0	0	62	57	119
23	0	0	36	38	74
24	0	0	27	47	74
25	0	0	25	17	42
26	0	0	19	20	39
27	0	0	21	12	33
28	0	0	5	13	18
29	0	0	9	4	13
30	0	0	4	1	5
31	0	1	9	2	12
32	0	0	3	2	5
33	0	0	2	1	3
34	0	7	1	1	9
35	6	5	2	0	13
36	9	9	0	1	19
37	16	7	0	1	24
38	33	14	0	0	47
39	50	14	0	0	64
40	48	12	0	0	60
41	37	5	0	0	42
42	31	5	0	0	36
43	15	0	0	0	15
44	15	0	0	0	15
45	3	0	0	0	3
46	5	0	0	0	5
47	0	0	0	0	0
48	1	0	0	0	1
49	0	0	0	0	0
50	0	0	0	0	0
51	0	0	0	0	0
52	0	0	0	0	0
53	0	0	0	0	0
54	0	0	0	0	0
55	0	0	0	0	0
56	0	0	0	0	0
n	**269**	**79**	**317**	**294**	**959**

Table 3. 2017 Maryland spring striped bass migrant harvest, distributed among 1 inch length groups (length as total length).*

Length Group	Apr 15-30			May 1-15		
	Charter	**Private**	**Total**	**Charter**	**Private**	**Total**
17	0	0	0	0	0	0
18	0	0	0	0	0	0
19	0	0	0	0	0	0
20	0	0	0	0	0	0
21	0	0	0	0	0	0
22	0	0	0	0	0	0
23	0	0	0	0	0	0
24	0	0	0	0	0	0
25	0	0	0	0	0	0
26	0	0	0	0	0	0
27	0	0	0	0	0	0
28	0	0	0	0	0	0
29	0	0	0	0	0	0
30	0	0	0	0	0	0
31	0	0	0	5	33	38
32	0	0	0	0	0	0
33	0	0	0	0	0	0
34	0	0	0	67	441	508
35	52	156	208	54	351	405
36	84	252	335	104	681	785
37	156	469	625	85	556	641
38	332	999	1,330	175	1,147	1,323
39	512	1,543	2,056	179	1,170	1,349
40	498	1,500	1,998	155	1,015	1,170
41	387	1,165	1,552	65	426	491
42	326	981	1,306	65	428	494
43	158	476	634	0	0	0
44	158	477	635	0	0	0
45	32	96	127	0	0	0
46	53	159	212	0	0	0
47	0	0	0	0	0	0
48	11	32	42	0	0	0
49	0	0	0	0	0	0
50	0	0	0	0	0	0
51	0	0	0	0	0	0
52	0	0	0	0	0	0
53	0	0	0	0	0	0
54	0	0	0	0	0	0
55	0	0	0	0	0	0
56	0	0	0	0	0	0
n	**2,757**	**8,304**	**11,061**	**955**	**6,250**	**7,205**

*Note: numbers may not sum due to rounding.

Table 3. 2017 Maryland spring striped bass migrant harvest, distributed among 1 inch length groups (length as total length).* Continued.

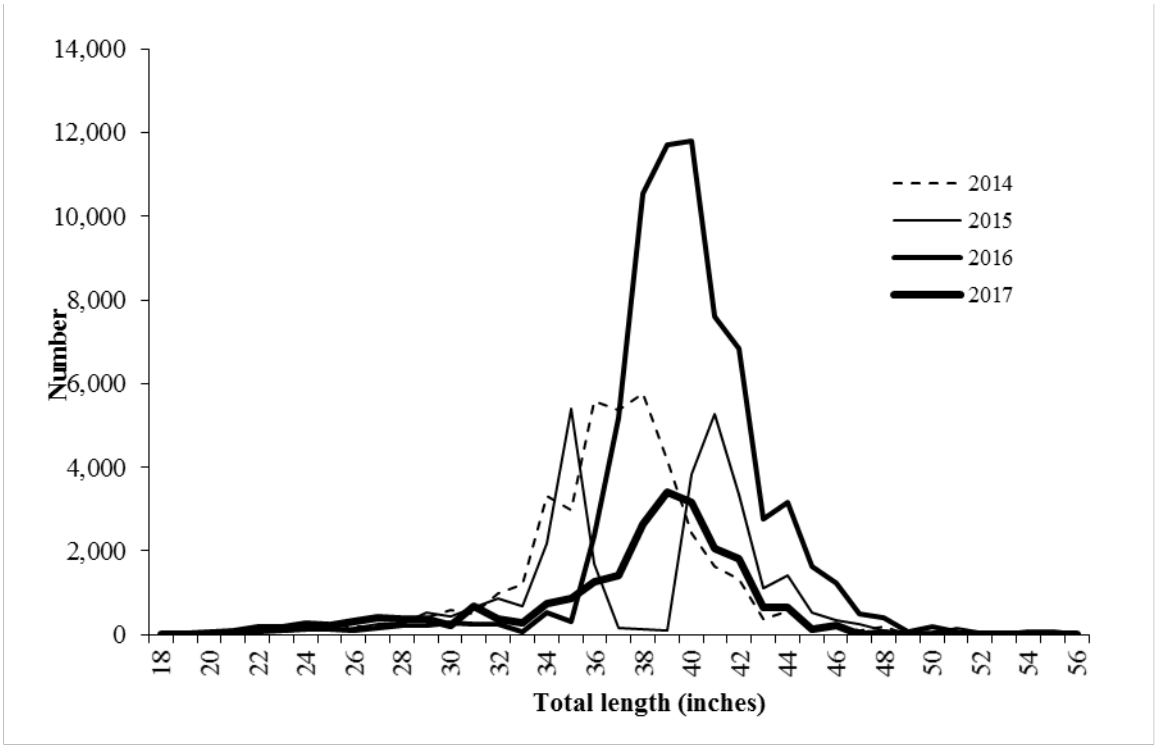
Length Group	May 16-31			June 1-15		
	Charter	**Private**	**Total**	**Charter**	**Private**	**Total**
17	0	0	0	0	0	0
18	0	0	0	0	0	0
19	0	0	0	0	0	0
20	3	17	20	3	16	18
21	5	28	33	5	27	32
22	10	61	72	11	63	74
23	10	58	67	11	68	79
24	12	70	81	23	135	158
25	17	104	121	13	79	92
26	21	125	146	25	147	172
27	36	218	254	23	139	162
28	13	80	93	39	232	271
29	36	217	253	18	107	125
30	23	140	163	7	39	45
31	72	434	507	18	108	126
32	32	189	221	24	141	165
33	26	156	182	15	87	102
34	15	91	106	17	102	119
35	34	203	237	0	0	0
36	0	0	0	21	122	143
37	0	0	0	22	128	150
38	0	0	0	0	0	0
39	0	0	0	0	0	0
40	0	0	0	0	0	0
41	0	0	0	0	0	0
42	0	0	0	0	0	0
43	0	0	0	0	0	0
44	0	0	0	0	0	0
45	0	0	0	0	0	0
46	0	0	0	0	0	0
47	0	0	0	0	0	0
48	0	0	0	0	0	0
49	0	0	0	0	0	0
50	0	0	0	0	0	0
51	0	0	0	0	0	0
52	0	0	0	0	0	0
53	0	0	0	0	0	0
54	0	0	0	0	0	0
55	0	0	0	0	0	0
56	0	0	0	0	0	0
n	**365**	**2,190**	**2,555**	**293**	**1,739**	**2,032**

*****Note: numbers may not sum due to rounding.

Table 4. Harvest of migrant striped bass in the spring fishery from 1992-2017 (Individual estimates not available for all sectors prior to 2006). Average was only calculated for 2006-2017 due to techniques used to calculate migrant harvest.

Year	MD Charter Migrant Harvest	MD Private Migrant Harvest	VA Migrant Harvest	Total Migrant Harvest
1992				1,013
1993				2,719
1994				3,672
1995				42,634
1996				11,613
1997				21,222
1998				10,021
1999				17,051
2000				26,748
2001				25,728
2002				14,839
2003	43,248		242	43,900
2004	31,218		186	31,404
2005	64,345		1,319	65,664
2006	15,570	47,878	4,323	67,771
2007	9,359	26,229	740	36,328
2008	13,106	22,785	275	36,166
2009	12,740	77,799	243	90,782
2010	12,504	7,261	82	19,847
2011	13,673	22,616	145	36,434
2012	9,335	8,796	77	18,208
2013	13,724	34,810	23	48,557
2014	12,311	26,599	11	38,921
2015	5,771	24,725	37	30,533
2016	9,524	64,615	169	74,308
2017	4,370	18,483	39	22,892
Avg (2006-17)	**10,999**	**31,460**	**514**	**42,973**

Figure 1. Comparison of Maryland's 2014 through 2017 spring striped bass migrant harvests, apportioned by length.



PROJECT NO. 2
JOB NO. 4

INTER-GOVERNMENT COORDINATION

Prepared by Eric Q. Durell, Harry Rickabaugh 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 (SRAFRAC), 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.

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. Provided data, analysis and attended the ASMFC Benchmark Stock Assessment data work shop.

Project staff served as Maryland's representative for the Technical Expert Working Group for river herring, attending 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 reprehensive is also a member of the Stock Assessment Subcommittee for the current benchmark stock assessment, and attended the Assessment Review Workshop and all conference calls associated with finalizing the assessment. Staff member was also assigned to the Traffic Light Analysis (TLA) Subgroup of the TC to analyze potential modifications of the TLA.

Atlantic Menhaden:

Project staff provided served on the ASMFC Plan Review Team and Plan Development team, and prepared the Annual Maryland Atlantic Menhaden Compliance Report required by ASMFC.

Black Drum:

ASMFC Technical Committee representative prepared the Annual Black Drum Compliance Report for Maryland, and currently serves as Chair of the Technical Committee. Staff also sat on the Plan Development Team for Amendment 1 of the ASMFC Black Drum FMP, providing analysis for potential Maryland regulation changes.

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:

ASMFC Technical Committee representative prepared the Annual Red Drum Status Compliance Report for Maryland.

Spanish Mackerel:

Staff prepared the Maryland Spanish Mackerel Compliance Report required by ASMFC.

Spot:

Project staff served on the Spot Plan Review Team, and prepared the ASMFC Annual Maryland Spot Compliance Report. The Plan Review Team member also served on the Stock Assessment Subcommittee for the most recent benchmark stock assessment, and attended the Review Workshop and all conference calls associated with the assessment. Staff member was also assigned to the Traffic Light Analysis (TLA) Subgroup of the TC to analyze potential modifications of the TLA.

Spotted Seatrout:

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

Striped Bass:

Project staff served on the ASMFC Striped Bass Tagging Sub Committee, the Interstate Tagging Committee, the ASMFC Bluefish Technical Committee, and as Maryland representatives to the Potomac River Fisheries Commission (PRFC) Finfish Advisory Board.

Project staff served as Maryland alternate representatives to the ASMFC Striped Bass Scientific and Statistical Committee, the Striped Bass Stock Assessment Subcommittee, and produced Maryland's Annual Striped Bass Compliance Report to the ASMFC.

Weakfish:

ASMFC Weakfish Technical Committee representative for Maryland participated in Weakfish Technical Committee conference calls, and prepared the ASMFC Annual Maryland Weakfish Compliance Report.

Aging:

A staff member attended an ASMFC sponsored aging workshop to compare aging methods and reader agreement between jurisdictions for Atlantic menhaden, Atlantic croaker, bluefish and summer flounder.

PROJECT NO. 2
JOB NO. 4

INTER-GOVERNMENT COORDINATION

2017 PRELIMINARY RESULTS – WORK IN PROGRESS

A staff member served on the Atlantic States Marine Fisheries Commission (ASMFC) Black Drum Plan Development Team writing and editing sections of Amendment 1 to the Fisheries Management Plan. This responsibility required participating in one conference call in the reporting period. A staff member also served on both the Atlantic Croaker Technical committee and Spot Plan Review Team to analyze data in development of revised Traffic Light Analysis (TLA) used to manage croaker and spot. Fulfilling this commitment required participation in two webinars and assignment to the ASMFC Plan Development Team for these species, which required participating in an additional webinar. Staff also participated in two calls of the Susquehanna River Anadromous Fish Restoration Cooperative Technical Committee to discuss fish passage issues, including passage of invasive species.

Staff completed and submitted ASMFC required compliance reports for alewife herring, American shad, Atlantic croaker, Atlantic menhaden, black drum, blueback herring and red drum. Staff reviewed state compliance to ASMFC fisheries management plans for alewife herring, American shad, blueback herring, Atlantic Menhaden and spot, 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 2017 to December 2017 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 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 2017 through December 2017.

Striped Bass Program Project Sites	Page Views
Juvenile Index (/juvenile-index.aspx)	2,021
Adult Spawning Stock Survey (/studies.aspx)	356
Home Page (/index.aspx)	431
Glossary (/glossary.aspx)	279
Recreational (/recreational.aspx)	148
Reports (/reports.aspx)	117
Commercial (/commercial.aspx)	128
Biologists (/biologists.aspx)	152
Species (/species.aspx)	77
Total	3,709

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), Morgan State University, University of Maryland, University of Delaware, Virginia Institute of Marine Sciences, Georgetown University, and State management agencies from Delaware, Massachusetts, New York and Virginia. For the past contract year, (July 1, 2017 through June 30, 2018) the following specific requests for information have been accommodated:

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

-Mr. Alex Aspinwall, VMRC. Provision of seasonal length frequencies and age-length keys from commercial and recreational fishery monitoring.

-Mr. Andrew Carr-Harris, NOAA NEFSC. Provision of Volunteer Angler Survey data, current seasonal age-length keys, and recreational catch at age estimates.

- Ms. Ellen Cosby, Potomac River Fisheries Commission. Provision of American shad and river herring data from Potomac River spring spawning stock survey.

- Maryland Charterboat Association (MCA)
Provision of striped bass fishery regulations, striped bass recreational, and charter boat harvest data.

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

-Mr. Joseph Grist, VMRC.
Provision of striped bass juvenile survey data and recreational fishery regulations information.

-Dr. Edward Hale, Delaware Division of Fish and Wildlife. Provision of current striped bass length and age data from pound net and commercial fishery monitoring surveys.

-Dr. Matthew Hamilton, Georgetown University.
Provision of juvenile striped bass biological samples for genetic research and abundance indices.

-Dr. Thomas Ihde, Assistant Professor, Morgan State University. Provision of historical Juvenile Seine Survey data.

-Mr. Ryan J. Woodland, Associate Professor, Chesapeake Biological Laboratory. Provision of Juvenile Seine Survey data from the Patuxent River.

-The Interjurisdictional Species Stock Assessment staff also provided biological information and related reports to twenty-eight (28) additional scientists, students and concerned stakeholders.

Atlantic Sturgeon, Shortnose Sturgeon and Sea Turtle Interaction Summary for Chesapeake Bay Finfish Investigations
Project No.: F-61-R-13

Prepared by Paul G. Piavis, Harry W. Rickabaugh, Eric Q. Durell, Genine K. Lipkey and Harry T. Hornick

Summary

The primary objective of the Chesapeake Bay Finfish Investigations Survey, F-61-R-11, was to monitor and biologically characterize resident and migratory finfish species in the Maryland portion of the Chesapeake Bay during the 2016 – 2017 sampling season. The F-61-R Survey specifically provides 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 particular report is to summarize any interactions of these biological surveys with endangered species such as Atlantic sturgeon, shortnose sturgeon, and sea turtles. During the 2016 – 2017 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.

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.

Introduction

The objective of Project 1, Job 1 is to determine population vital rates (relative abundance, age, growth, mortality, and recruitment) of yellow perch, white perch, and catfish species in tidal regions of Chesapeake Bay. Job 2 is a rotational, triennial stock assessment of yellow perch (integrated analysis), white perch (catch survey analysis) or channel catfish (surplus production modeling). However, all data collections and surveys are performed under Job1.

Research Surveys:

1. Upper Chesapeake Bay Winter Trawl
2. Fishery Dependent Yellow Perch Fyke Net Survey
3. Fishery Independent Choptank River Fyke Net Survey

1. Upper Chesapeake Bay Winter Trawl Survey

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed in the Upper Chesapeake Bay Winter Trawl Survey during the Survey period of July 1, 2017 through June 30, 2018.

Shortnose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed in the Upper Chesapeake Bay Winter Trawl Survey during the Survey period of July 1, 2017 through June 30, 2018.

2. Fishery Dependent Yellow Perch Fyke Net Survey

Atlantic Sturgeon Interactions

This survey is performed with the cooperation of commercial fishermen and the objective is to collect commercial catch at age and length data of yellow perch. No data on other species are collected. However, no Atlantic sturgeon were sampled or observed in the Commercial Fyke Net Survey during the Survey period of July 1, 2017 through June 30, 2018.

Shortnose Sturgeon and Sea Turtle Interactions

This survey is performed with the cooperation of commercial fishermen and the objective is to collect commercial catch at age and length data of yellow perch. No data on other species are collected. However, no shortnose sturgeon or sea turtles were sampled or observed in the Commercial Fyke Net Survey during the Survey period of July 1, 2017 through June 30, 2018.

3. Fishery Independent Choptank River Fyke Net Survey

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed in the Choptank River Fyke Net Survey during the Survey period of July 1, 2017 through June 30, 2018.

Shortnose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed in the Choptank River Fyke Net Survey during the Survey period of July 1, 2017 through June 30, 2018.

<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

1. Nanticoke River Pound/Fyke Net Survey

<u>Atlantic Sturgeon Interactions</u>

No Atlantic sturgeon were sampled or observed during the Survey period of this project from July 1, 2017 through June 30, 2018.

<u>Shornose 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, 2017 through June 30, 2018.

2. Nanticoke River Ichthyoplankton Survey

<u>Atlantic Sturgeon Interactions</u>

No Atlantic sturgeon were sampled or observed during the Survey period of July 1, 2017 through June 30, 2018.

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

No shortnose sturgeon or sea turtles were sampled or observed during the Survey period of July 1, 2017 through June 30, 2018.

PROJECT 2:

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

Research Survey:

1. **Summer Pound Net Survey**

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed during the Survey period of July 1, 2017 through June 30, 2018.

Shortnose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles sampled or observed during the Survey period of July 1, 2017 through June 30, 2018.

<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, 2017 through June 30, 2018.

<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, 2017 through June 30, 2018.

<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, 2017 through June 30, 2018.

<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, 2017 through June 30, 2018.

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, 2017 through June 30, 2018.

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, 2017 through June 30, 2018.