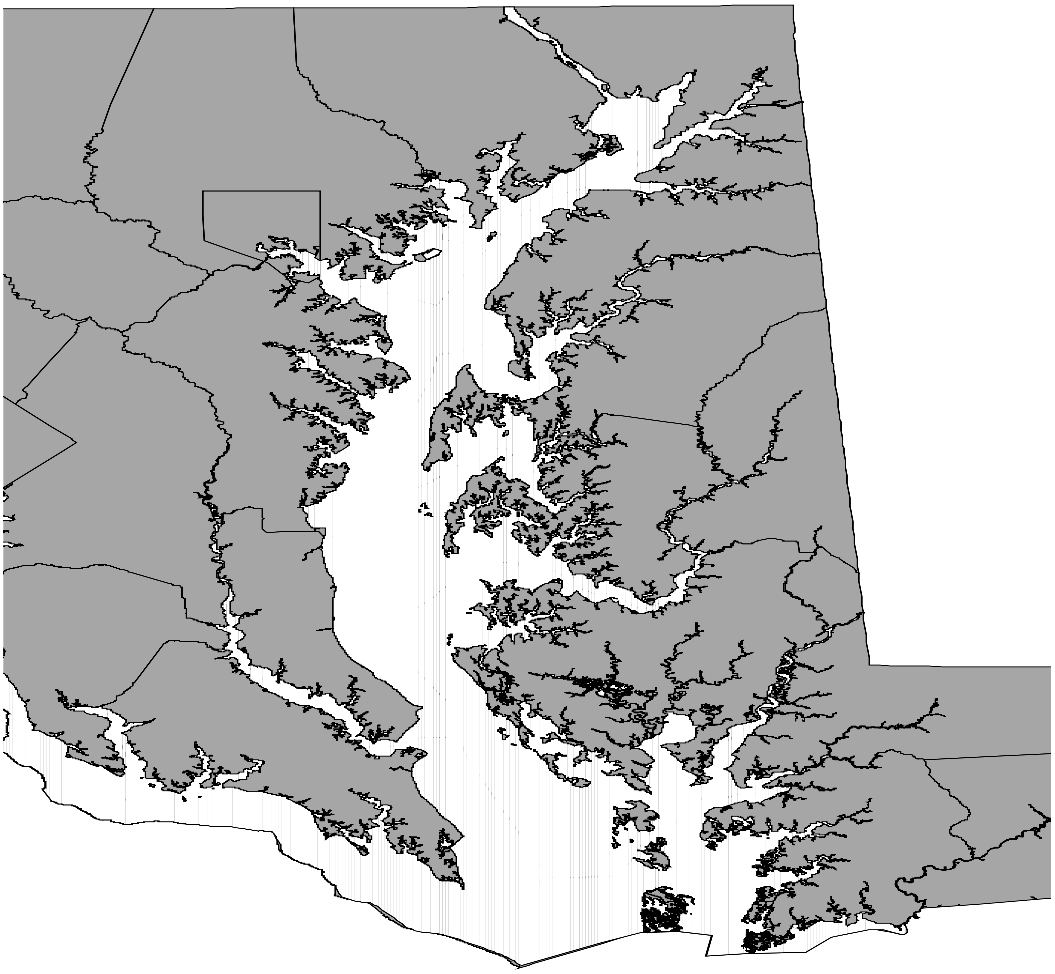

Chesapeake Bay Finfish Investigations

US FWS FEDERAL AID PROJECT
F-61-R-12
2015 - 2016

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-12

PROJECT TYPE: Research and Monitoring

PROJECT TITLE: Chesapeake Bay Finfish Investigations.

PROGRESS: ANNUAL X

PERIOD COVERED: February 1, 2016 through June 30, 2017

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 a reference point for future fisheries management considerations**.**

Annual winter trawl efforts in upper Chesapeake Bay indicated a continued surge in white perch relative abundance, reaching a 16 year high. The 2011, 2014 and 2015 year-classes were especially large and contributed to the total population increase. Yellow perch relative abundance also rebounded from lower values to much higher levels in 2015 and 2016. Channel catfish relative abundance was the second highest in the time series in 2016 and continued the increasing trend that began in 2014. Recruitment of the 2015 year-class for all three species was particularly strong.

White perch relative abundance declined in the Choptank River Fyke Net Survey in 2016. However the 2014 and 2011 year-classes were very abundant. Yellow perch relative abundance was high in 2016, dominated by the 2011 year-class. Channel catfish relative abundance in Choptank

River declined in 2016 relative to 2015, but remained above the 17 year average. White catfish relative abundance increased in 2016 and was also above the 17 year average.

Yellow perch population dynamics were assessed for upper Chesapeake Bay stock with a statistical catch at age model, while the Choptank River stock was assessed by analyzing relative abundance data from a fyke net survey spanning 29 years. The upper Bay assessment indicated that abundance continued to increase from relatively low levels seen during 2009 – 2011 and abundance estimates were above the 19 year average. Fully recruited F was above F_{target} and recruitment (abundance of age 1 yellow perch) was particularly high for the 2011, 2014 and 2015 year-classes, but markedly poor for the 2012 and 2013 year-classes. Comparing F rates to the target and incorporating uncertainty, suggested that over-fishing was not occurring.

The Choptank River yellow perch stock was analyzed with a non-linear regression of catch-per-unit-effort and year that provided a statistically significant fit. Results indicated that relative abundance increased from 6.2 fish per net day in 1988 to 24.1 fish per net day in 2106. Estimated fishing mortality was below target levels and, as such, over-fishing was not occurring.

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 15 April through 31 May 2016, and 366 were successfully scale-aged. The 2011 (age 5) year class was the most abundant for male and female American shad in 2016. Estimates of abundance for American shad in the lower Susquehanna River slightly decreased in 2016, and remain well below time-series peak values observed in the early 2000's. Relative abundance of American shad in the Nanticoke (1989-2016) and Potomac (1996-2016) rivers has significantly increased over the time series, and remained above average in 2016. American shad juvenile abundance indices decreased baywide in 2016. The Potomac River American shad juvenile abundance index continues to be the highest index in Maryland's portion of Chesapeake Bay.

The age structure of hickory shad from the Susquehanna River was previously very consistent, containing a wide range of ages, however, since 2011 a smaller percentage of older fish have been present, suggesting it may be truncating. The arcsine-transformed proportion of repeat spawners (sexes combined) has not changed significantly over the time series (2004-2016), but has been below average the past six years (2011-2016).

Biologists sampled alewife and blueback herring from commercial pound and fyke nets in the Nanticoke River from 3 March through 29 April 2016. River herring CPUE in the Nanticoke River has declined over the time series (1989-2016) 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 2013-2016 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 16 March to 17 May 2016. Relative abundance of both species in the North East River declined in

2016. The strong 2011 year-class (age 5) continues to dominate the spawning stock. The juvenile abundance indices indicate alewife and blueback herring recruitment decreased baywide in 2016.

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 2015, with an estimated 3,093 weakfish harvested in 2015. The 2015 Maryland Chesapeake Bay commercial weakfish harvest of 983 pounds was well below the 1981 – 2015 Maryland Chesapeake Bay average of 44,922 pounds per year. The 2016 mean length for weakfish from the onboard pound net survey was 256 mm TL (n=64), the third lowest value of the time series. Two weakfish measuring 292 and 299 mm TL were captured in the Choptank River gill net survey in 2016, and only one was encountered from 2013 to 2015.

Summer flounder mean length from the pound net survey was 273 mm TL (n=41) in 2016, and was below the long term mean. The 2016 length frequency distribution shifted back toward smaller fish after a slight increase in large fish in 2015. Only two summer flounder were captured in the Choptank River gill net survey in 2016. The NMFS 2014 coast wide stock assessment concluded that summer flounder stocks were not overfished, but overfishing was occurring.

Mean length of bluefish from the pound net survey in 2016 was 289 mm TL (n=132), and was below the time-series mean. The length distribution indicated a shift back to smaller bluefish in 2016. Only three bluefish were captured in the Choptank River gill net survey in 2016. Bluefish have been encountered in low numbers all four years of the survey (3 – 24 fish per year). Recreational and commercial bluefish harvest in 2015 were both 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 pound net survey in 2016 was 254 mm TL (n=2,239), and was the third lowest value of the 24 year time series. Atlantic croaker age structure from pound net samples (n=175) expanded back to age 8, but was still dominated by age 4 and younger fish. 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 with 32 fish being captured. Maryland 2015 Atlantic croaker Chesapeake Bay commercial harvest and inland waters recreational harvest estimate values declined from 2014. The commercial harvest fell below the long term mean, while the recreational harvest estimate remained above its long term mean. The Atlantic croaker juvenile index had decreased steadily from 2012 to 2015. The juvenile index value increase in 2016, but was still below the 28 year time-series mean.

The 2015 spot mean length of 175 mm TL (n=135) was the lowest of the 24 year time-series, and the length frequency distribution was truncated. Spot aged from the onboard pound net survey (n=111) were predominately age zero, with no fish over age one. 2016 was only the second year no age two fish were sampled, and the first in which age zero was dominant. Spot catch in the

Choptank River gill net survey was highest in 2014, similar in 2013 and 2015 and lowest in 2016 (109 spot captured). The length structure shifted to smaller fish in 2016. Chesapeake Bay commercial spot harvest was similar in 2013 and 2014, but declined fourfold in 2015. The inland waters recreational harvest estimate in 2015 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 28 year time-series.

Mean length for Atlantic menhaden sampled from commercial pound nets in 2016 was 208 mm FL, the lowest value of the 13 year time-series. The 2016 length frequency distribution was more evenly distributed than previous years. Atlantic Menhaden was the most common species captured by the Choptank River gill net survey, with annual catches ranging from 1,171 fish (2016) to 2,247 fish. Mean lengths for all meshes combined displayed little inter annual variation, and length frequency distributions from the Choptank River gill net survey indicated the gear selects slightly larger menhaden than the pound net survey. Age samples from the onboard pound net survey (n=241) and Choptank River gill net survey (n=140) select slightly different ages. The gill net survey had fewer age one fish in both 2015 and 2016, and a higher proportion of age three plus fish.

Resident/premigratory striped bass sampled from pound nets in the Chesapeake Bay during the summer – fall 2015 season ranged in age from 1 to 11 years old. Four year old (2011 year-class) striped bass dominated biological samples taken from pound nets and contributed 54% of the sample. Check station sampling determined that the majority of the commercial pound net and hook-and-line fishery harvest was composed of three to eleven year old striped bass from the 2004 through 2012 year-classes.

The December 2015 - February 2016 commercial drift gill net harvest consisted primarily of age 7 striped bass from the 2009 year-class (37%). The 2011, 2010 and 2008 year-classes (ages 5, 6, and 8) composed an additional 59% of the total harvest. The contribution of fish older than age 9 (3%) was lower than in the 2014-2015 harvest (13%). The youngest fish observed in the 2015-2016 sampled harvest were age 4 from the 2012 year-class. Striped bass present in commercial drift gill net samples collected from check stations ranged in age from age 4 to 13 years old (2003 to 2012 year-classes).

Fish harvested during the 2015-2016 Atlantic coast fishing season ranged from age 4 (2012 year-class) to age 15 (2001 year-class). Twelve year-classes were represented in the sampled harvest. Approximately 92% of striped bass harvested were ages 5 through 12.

The spring 2016 spawning stock survey indicated that there were 17 age-classes of striped bass present on the Potomac River and Upper Bay spawning grounds. These fish ranged in age from 2 to 18 years old. Male striped bass ranged in age from 2 to 17 years old and females ranged in age from 5 to 18, with age 13 (2003 year-class) females the year-class most commonly observed. During the spring 2016 spawning season, age 8 and older females made up 61% of the female spawning stock. Females from the 1998 year-class are still present and contributing to the spawning stock in both the Upper Bay and the Potomac River.

The striped bass juvenile index, a measure of striped bass spawning success in Chesapeake Bay, was 2.2 in 2016. MD DNR biologists have conducted the Young-of-Year Survey annually since 1954 to track the reproductive success of striped bass, which can vary greatly from year to year, and help predict future population abundance. During the 2016 survey, biologists collected 291 juvenile striped bass at 22 survey sites in the four major spawning systems: the Choptank, Nanticoke, and Potomac rivers, and the Upper Bay. Juvenile indices are calculated as the average catch of young-of-year fish per sample. In 2011 and 2015, biologists documented very strong striped bass year-classes and these fish are currently very abundant in the Chesapeake Bay.

Survey data documented below-average recruitment for several other anadromous species, notably American shad, white perch, and yellow perch. Decreased production for a range of anadromous species indicates large scale environmental conditions as a possible influence. The Chesapeake Bay region was experiencing significant drought conditions during spring 2016, a crucial time for the survival of sensitive life stages of many anadromous species in the Chesapeake Bay. Cumulative spring flow from four Chesapeake tributaries (Susquehanna, Patuxent, Potomac, and Choptank rivers) was the third lowest since 1985.

During the 2016 spring recreational trophy season, biologists intercepted 279 fishing trips, interviewed 585 anglers, and examined 197 striped bass. The average total length of striped bass sampled was 999 mm total length. The average weight was 10.2 kg. Striped bass sampled from the trophy fishery ranged in age from 8 to 18 years old. The 2003 (age 13), 2004 (age 12) and 2005 (age 11) year-classes were the most frequently observed cohorts sampled from the spring recreational fishery. In 2016, the average private boat catch rate based on angler interviews was 0.50 fish per hour, while charter boat mean catch per hour was 0.90 fish per hour.

Maryland Department of Natural Resources biologists continued to tag and release striped bass in spring 2016 in support of the US FWS coordinated interstate, coastal population study for growth and mortality. Approximately 1,938 striped bass were sampled and a total of 1,300 striped bass were tagged and released with USFWS internal anchor tags between March through May 2016 in Maryland. Of this sample, 237 were tagged in the Potomac River and 1,063 were tagged in the upper Chesapeake Bay area during the spring spawning stock assessment survey. A total of 1,350 striped bass were tagged during the 2016 cooperative USFWS / SEAMAP Atlantic Ocean tagging cruise.

APPROVAL

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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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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; 4 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 24 sampling stations were approximately 2.6 km (1.5 miles) in length and variable in width (Figure 1). 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 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 December 2015 through February 2016.

Trawl sites have been consistent throughout the survey, but 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 2016, 112 of the scheduled 144 trawls were completed.

Choptank River Fishery Independent Sampling

In 2016, 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 22 February through 11 April (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 20 February 2016 in Gunpowder River (Figure 3), 20 February 2016 in the Patapsco/Back/Middle River area (Figures 4, 5), and 27 February 2016 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 2016 to 29 April 2016, 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)^3) 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, Excel Solver (Microsoft Corporation 1993), or Evolver genetic tree algorithms (Palisades Corporation 2001). 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

Catch curves for Choptank River, Nanticoke River and upper Chesapeake Bay white perch were based on $\log_e$ transformed catch-per-unit-effort (CPUE) data for ages 6 -10 for males and females. 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 with a ratio method to determine survivorship (S), where S = (CPUE ages 4 – 10+ in year t)/(CPUE ages 3-10+ in year t-1). Total instantaneous mortality (Z) was $-\log_e$ (S), and F=Z-M where M was assumed to be 0.25. The only exception to this method was the 2002 estimate where all age-classes were used for the survivorship estimate. Instantaneous mortality rates for yellow perch from the upper Bay commercial samples were calculated with a statistical catch-at-age model which is updated annually to produce a total allowable catch for the fishery, and are documented in Job 2 of this grant report.

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.

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 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
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PROJECT NO. 1
JOB NO. 1

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

2017 PRELIMINARY RESULTS

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 137 of the 138 proposed tows. The uppermost Sassafras River was discontinued. This decision improved efficiency and it was a marginal site at best. The trawl survey began January 4, 2017 and concluded on February 15, 2017. The survey collected 81,933 white perch, yielding 5,169 length measurements and 225 age samples (otoliths). Yellow perch numbered 2,125 with 714 length measurements and 117 age samples (otoliths). The catfish complex yielded 1,783 channel catfish (777 measurements) and 298 white catfish (187 measurements).

Three sampling days were allocated to characterize the commercial yellow perch fishery. However, 3,917 yellow perch were measured and 199 fish were sacrificed for age determination. Areas sampled included Gunpowder River (February 23, 2017), Middle and Patapsco rivers (February 11, 2017), and Bush River (February 27, 2017).

The Choptank River fyke net survey started February 24, 2017 and ended March 30, 2017. A total of 23,988 white perch were collected, yielding 2,211 length measurements and 165 age samples. Yellow perch numbered 1,964 (1,964 measurements and 201 ages); channel catfish numbered 264 (263 measurements) and white catfish numbered 1,419 (951 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.

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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Figure 1. Upper Chesapeake Bay winter trawl survey locations, January 2016 – February 2016. Different symbols indicate each of 5 different sampling rounds.

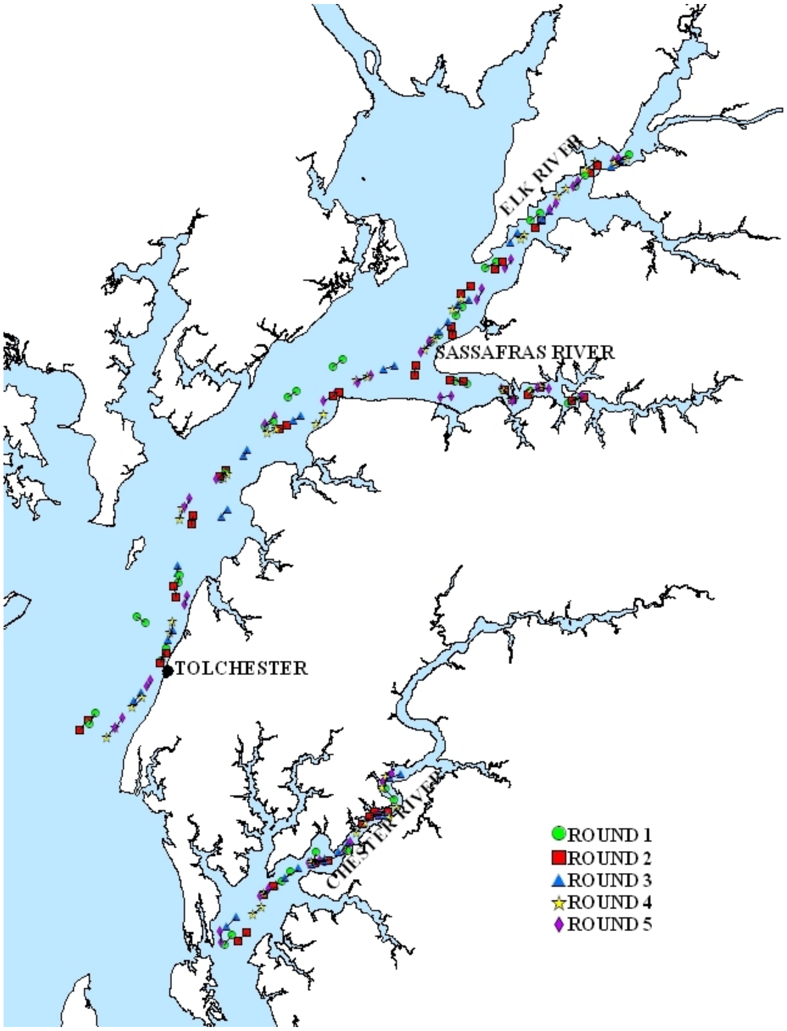


Figure 2. Choptank River fyke net locations, 2016. Circles indicate sites.

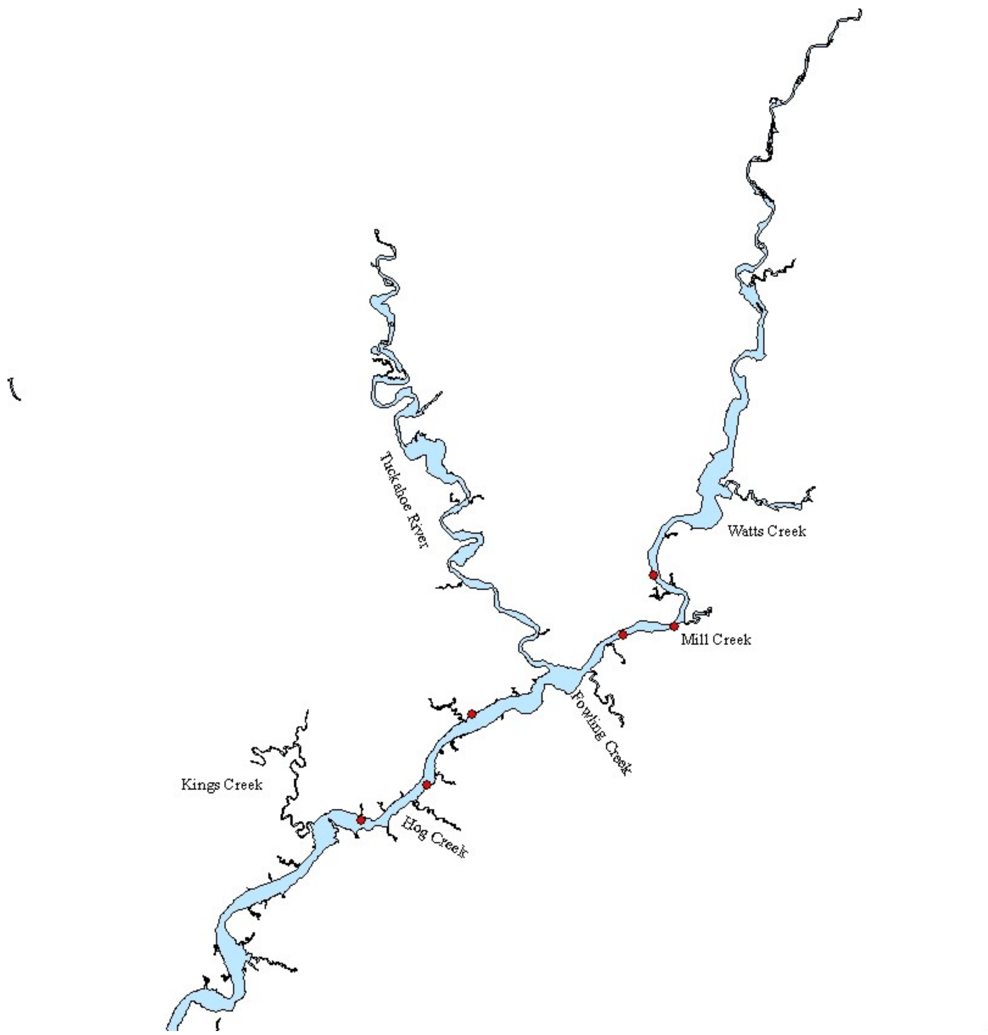


Figure 3. Commercial yellow perch fyke net sites sampled during 2016 in Gunpowder River. Circles indicate sites.

Figure 4. Commercial yellow perch fyke net sites sampled during 2016 in Bear Creek, tributary to Patapsco River. Circles indicate fyke net locations.

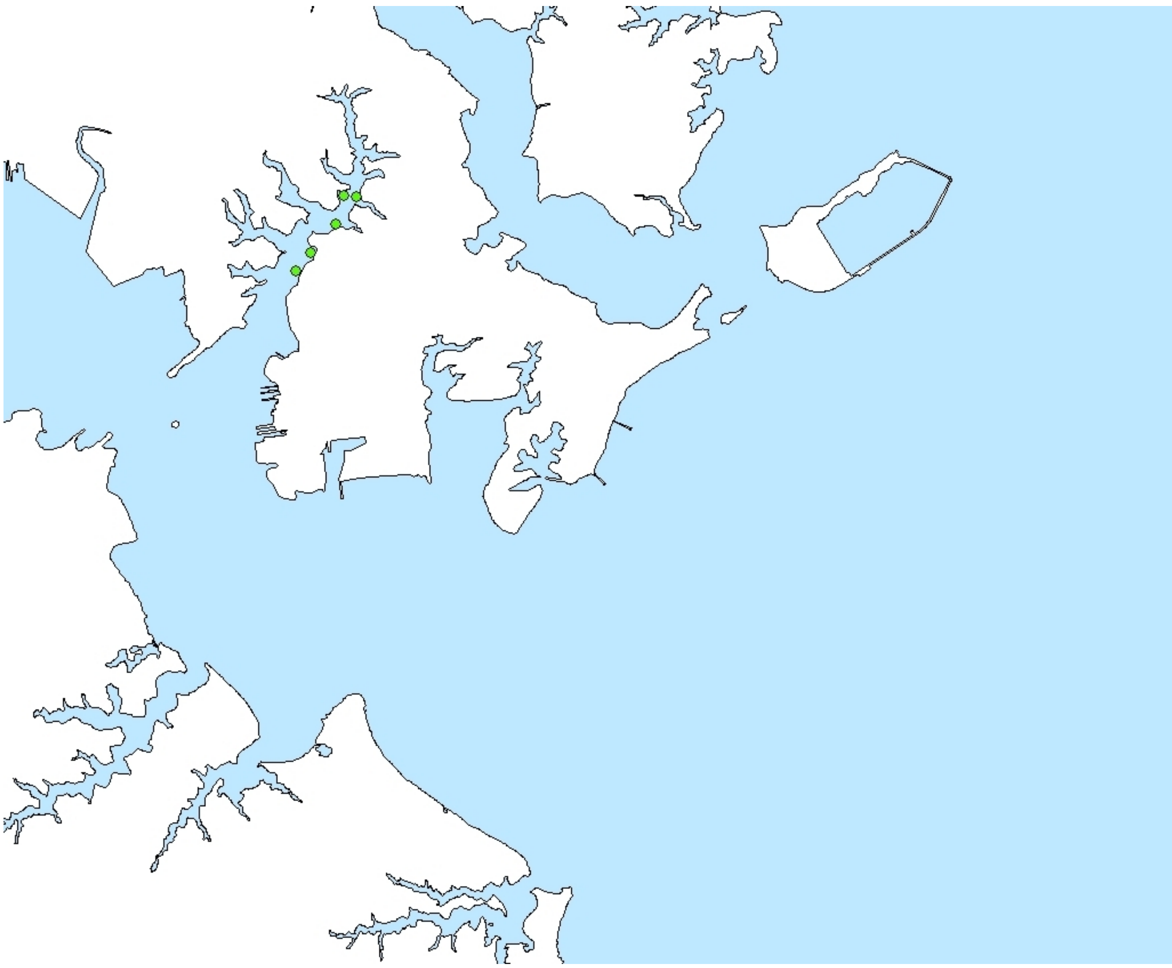


Figure 5. Commercial yellow perch fyke net sites sampled during 2016 in Middle River area. Circles indicate fyke net locations.

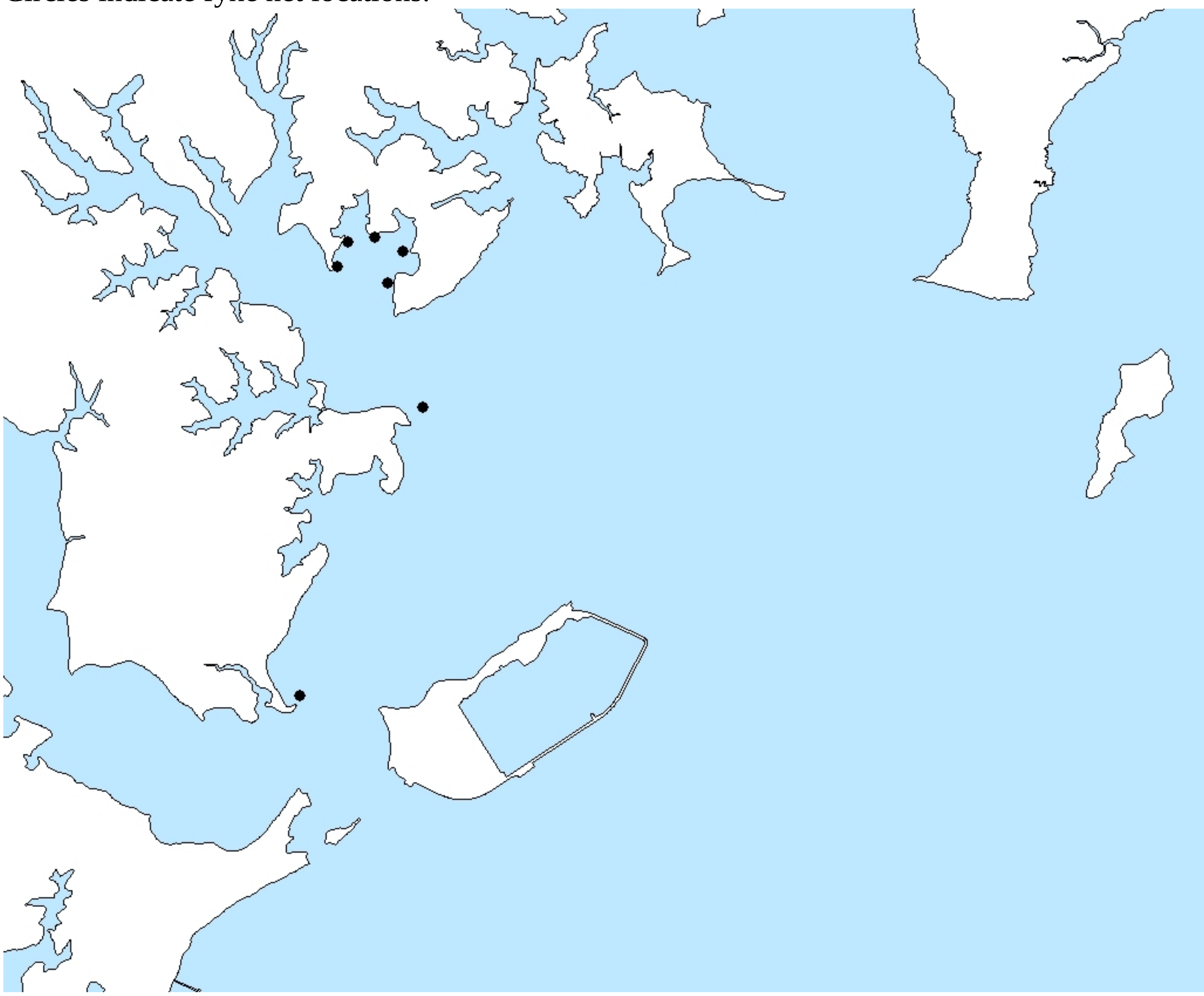


Figure 6. Commercial yellow perch fyke net sites sampled during 2016 in Bush River. Circles indicate fyke net locations.

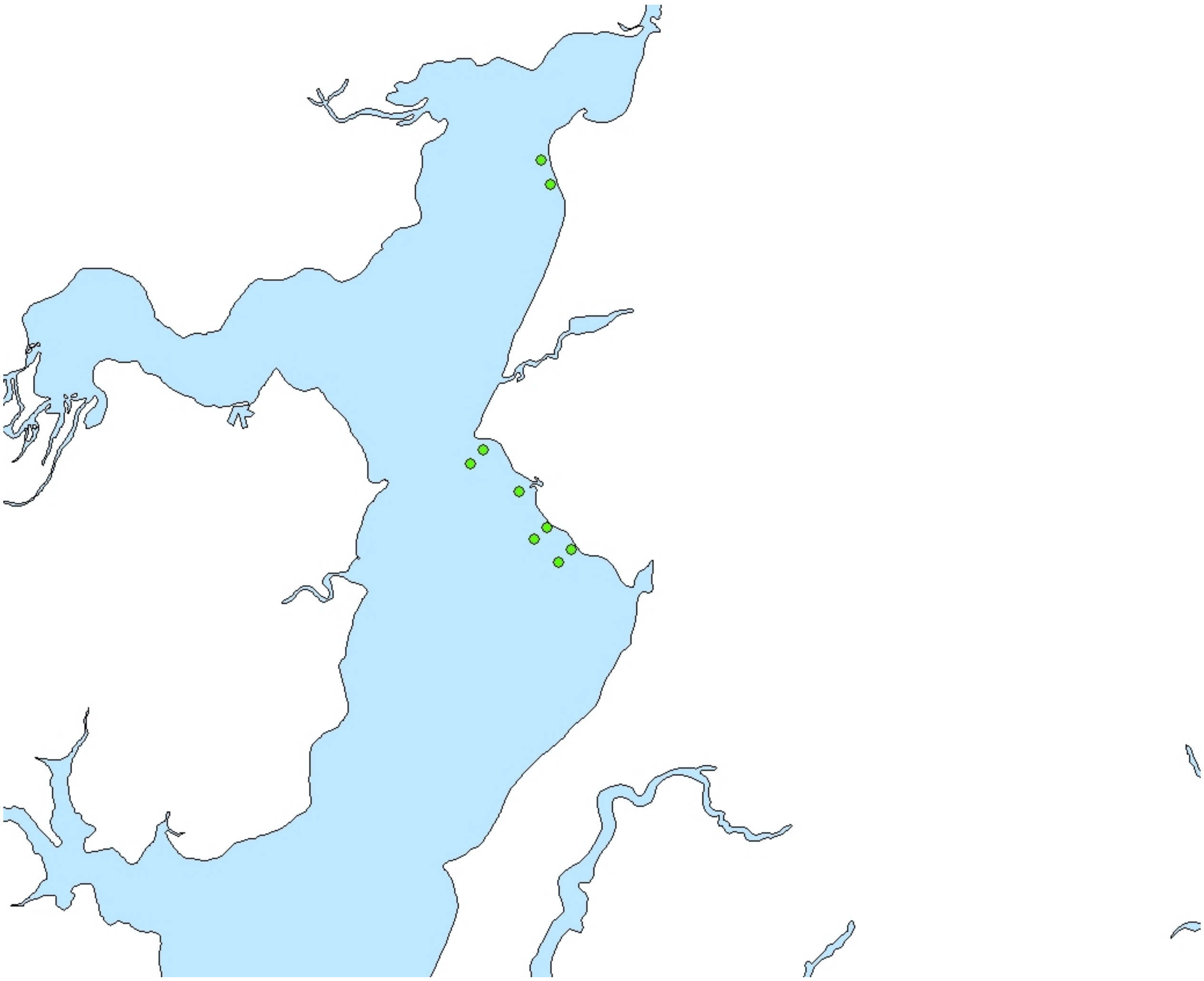


Figure 7. Commercial fyke net and pound net sites sampled during 2014 in the Nanticoke River. Black lines indicate the geographic range of fyke net locations.

Table 1. White perch catch-at-age matrix from upper Chesapeake Bay winter trawl survey, 2000 – 2016.

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

Table 2. White perch catch-at-age matrix from Choptank River fyke net survey, 2000 – 2016.

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

Table 3. White perch catch-at-age matrix from Nanticoke River fyke and pound net survey, 2000 – 2016. 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

Table 4. Yellow perch catch at age matrix from upper Chesapeake Bay winter trawl survey, 2000 – 2016.

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

Table 5. Yellow perch catch at age matrix from Choptank River fyke net survey, 1988 – 2016.

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

Table 6. Yellow perch catch at age matrix from upper Chesapeake Bay commercial fyke net survey, 1999 – 2016.

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

Table 7. Relative stock densities (RSD's) of white perch from the upper Chesapeake Bay winter trawl survey, 2000 – 2016. 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

Figure 8. White perch length-frequency from 2016 upper Chesapeake Bay winter trawl survey.

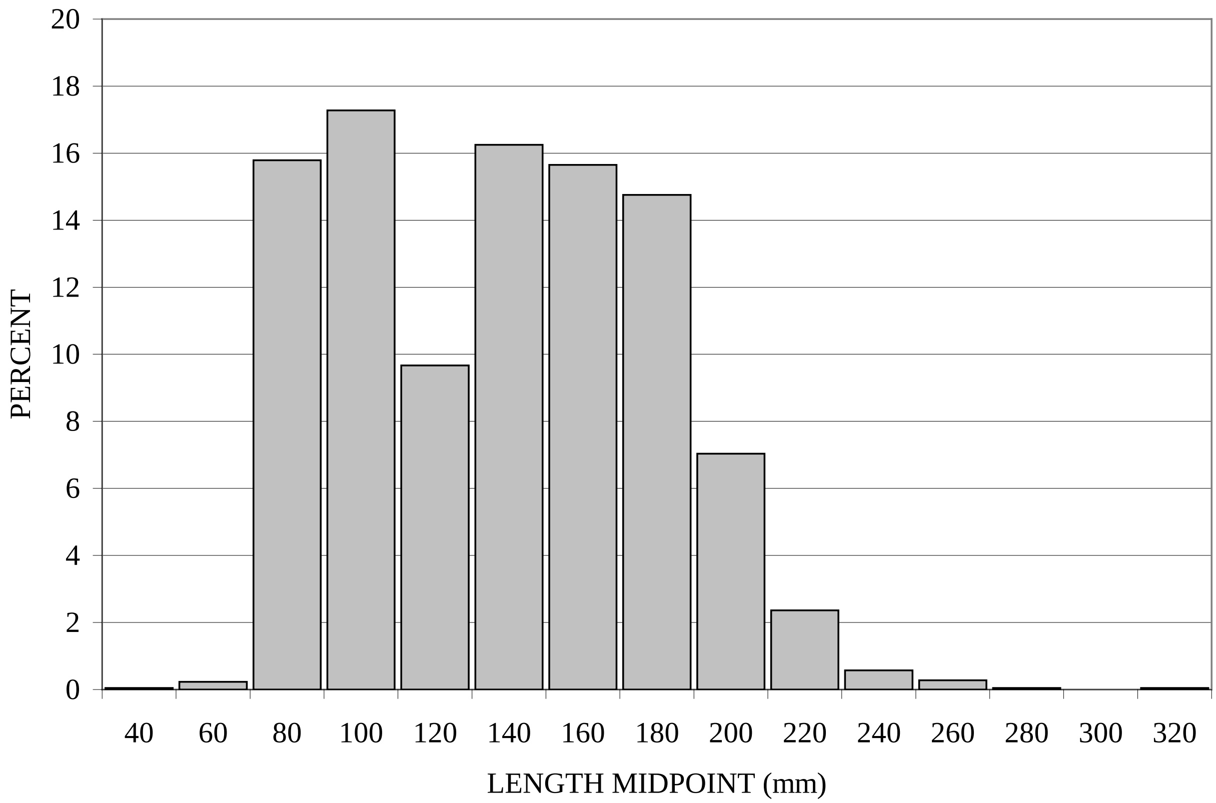


Table 8. Relative stock densities (RSD's) of white perch from the Choptank River fyke net survey, 1993 – 2016. Minimum length cut-offs in parentheses.

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

Figure 9. White perch length-frequency from 2016 Choptank River fyke net survey.

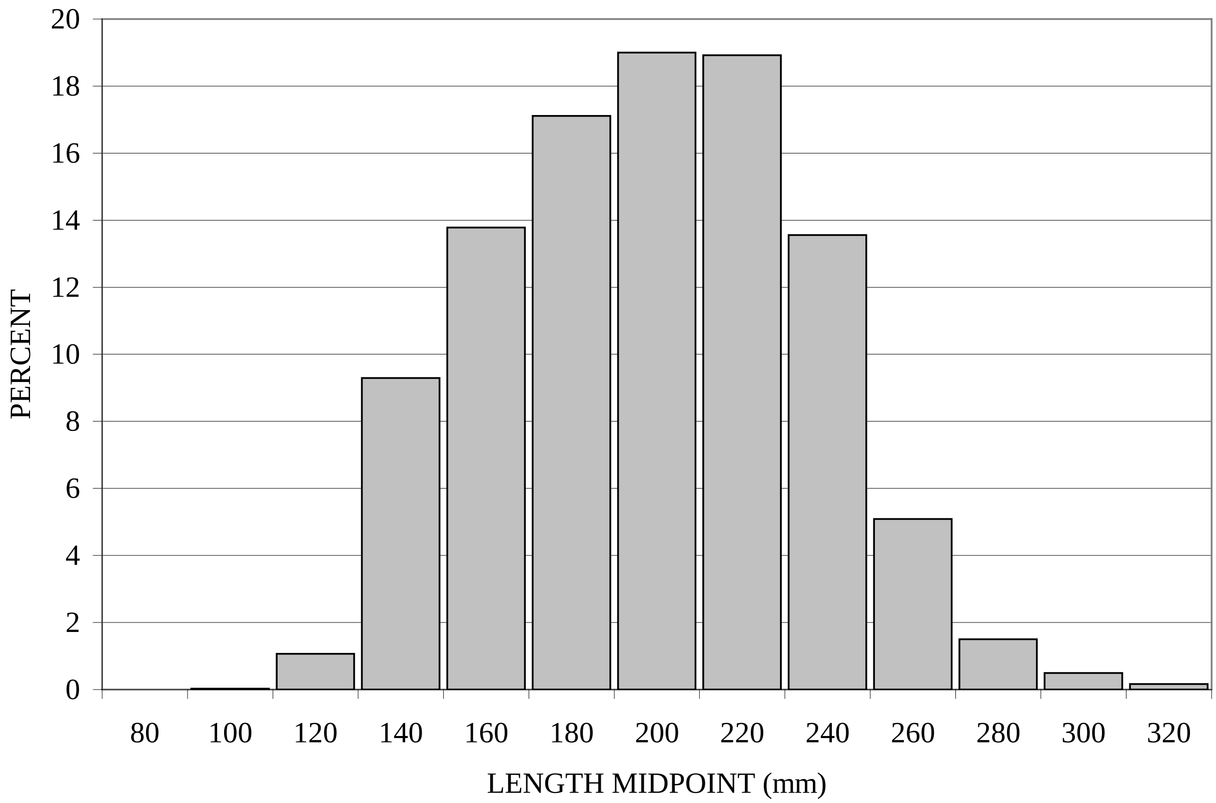


Table 9. Relative stock densities (RSD's) of white perch from the Nanticoke River fyke and pound net survey, 1995 – 2016. Minimum length cut-offs in parentheses. 2007 -- 2009 include Marshyhope River data.

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

Figure 10. White perch length-frequency from 2016 Nanticoke River fyke and pound net survey.

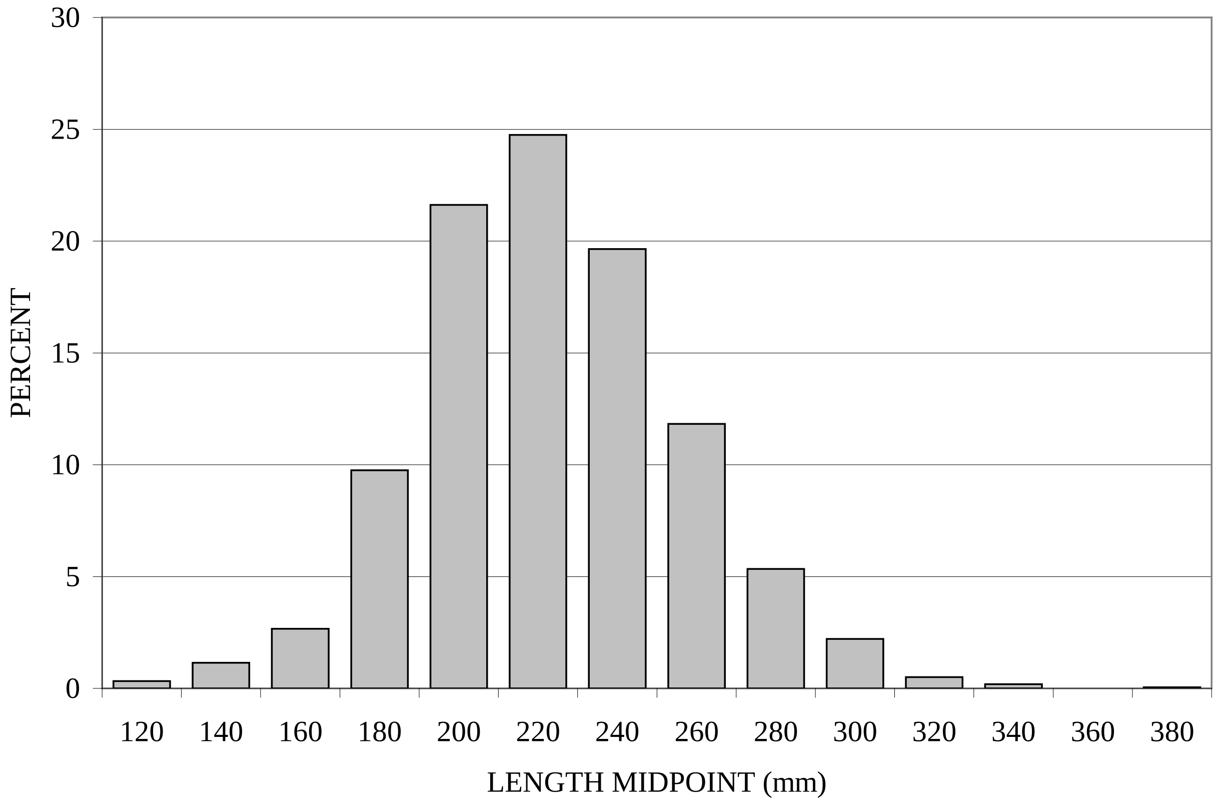


Table 10. Relative stock densities (RSD's) of yellow perch from the upper Chesapeake Bay winter trawl survey, 2000 – 2016. Minimum length cut-offs in parentheses.

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

Figure 11. Yellow perch length-frequency from the 2016 upper Chesapeake Bay winter trawl survey.

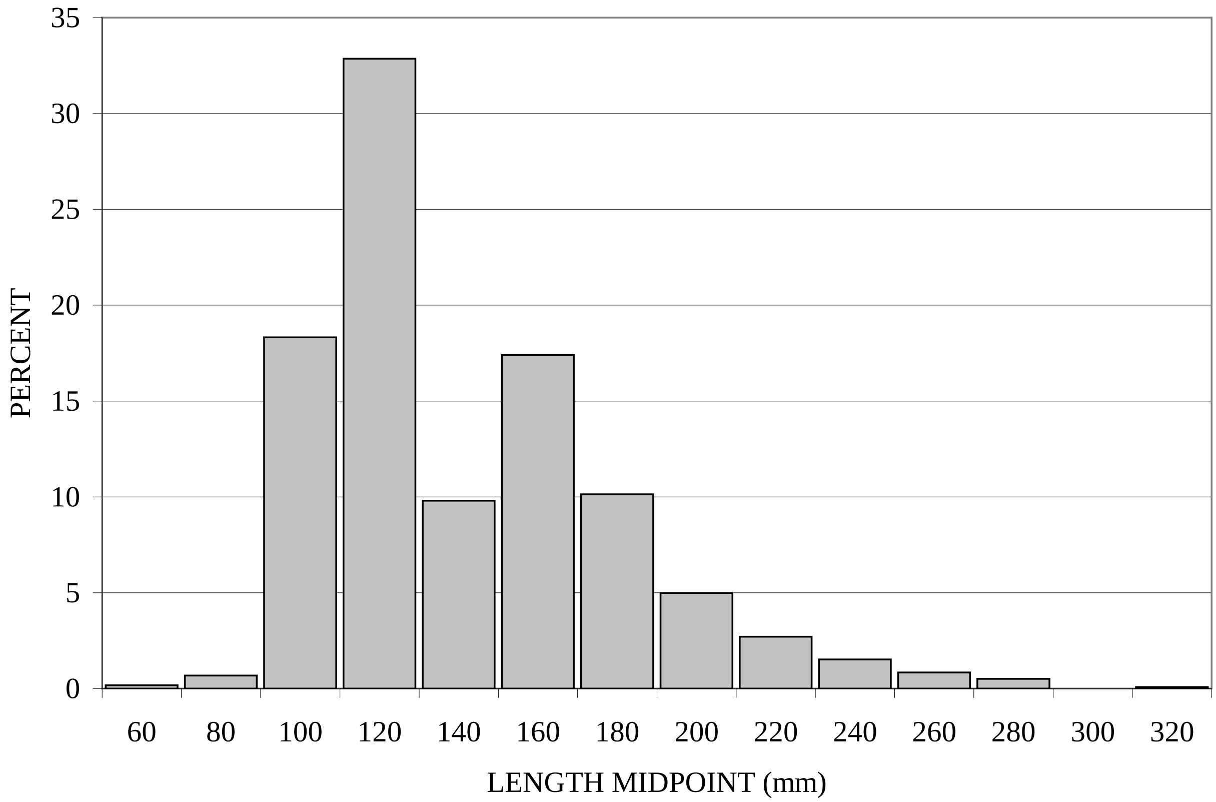


Table 11. Relative stock densities (RSD's) of yellow perch from the Choptank River fyke net survey, 1989 – 2016. Minimum length cut-offs in parentheses.

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

Figure 12. Yellow perch length-frequency from the 2016 Choptank River fyke net survey.

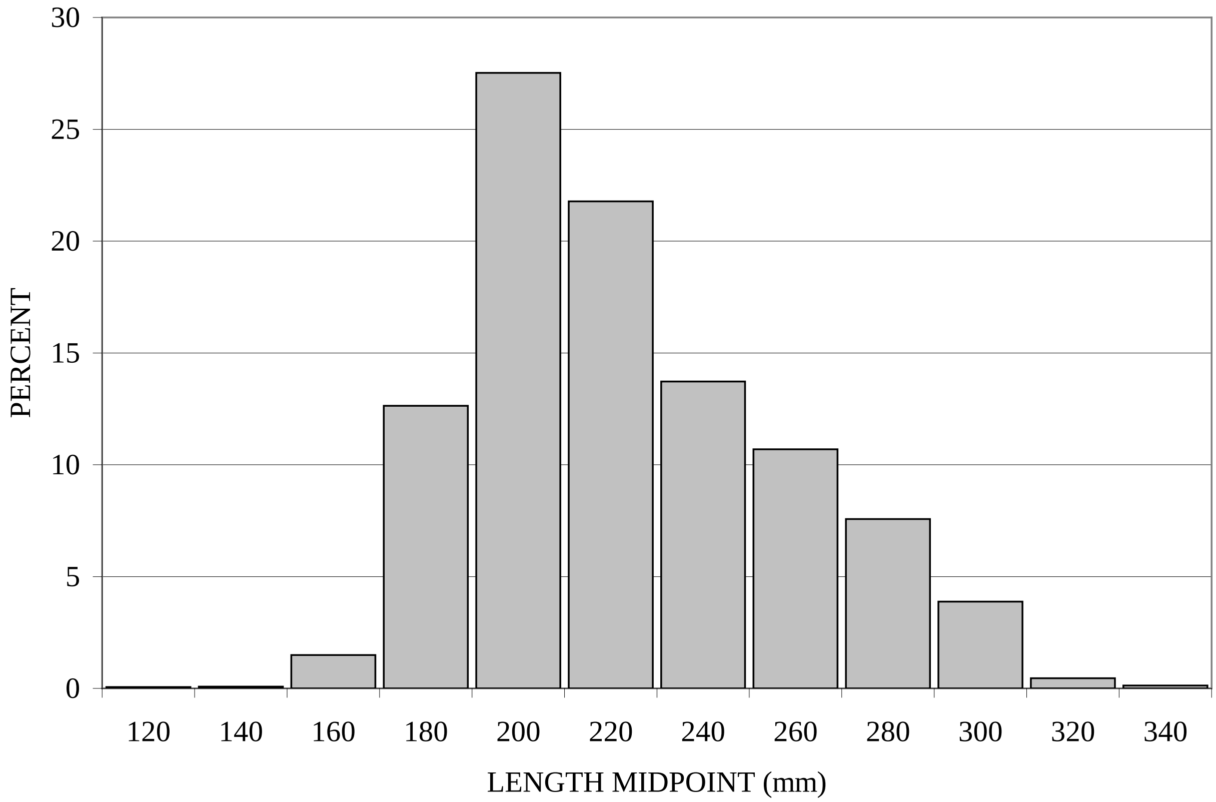


Table 12. Relative stock densities (RSD's) of yellow perch from the upper Chesapeake Bay commercial fyke net survey, 1988, 1990, 1998 – 2016. Minimum length cut-offs in parentheses.

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

Figure 13. Yellow perch length frequency from the 2016 upper Chesapeake commercial fyke net survey.

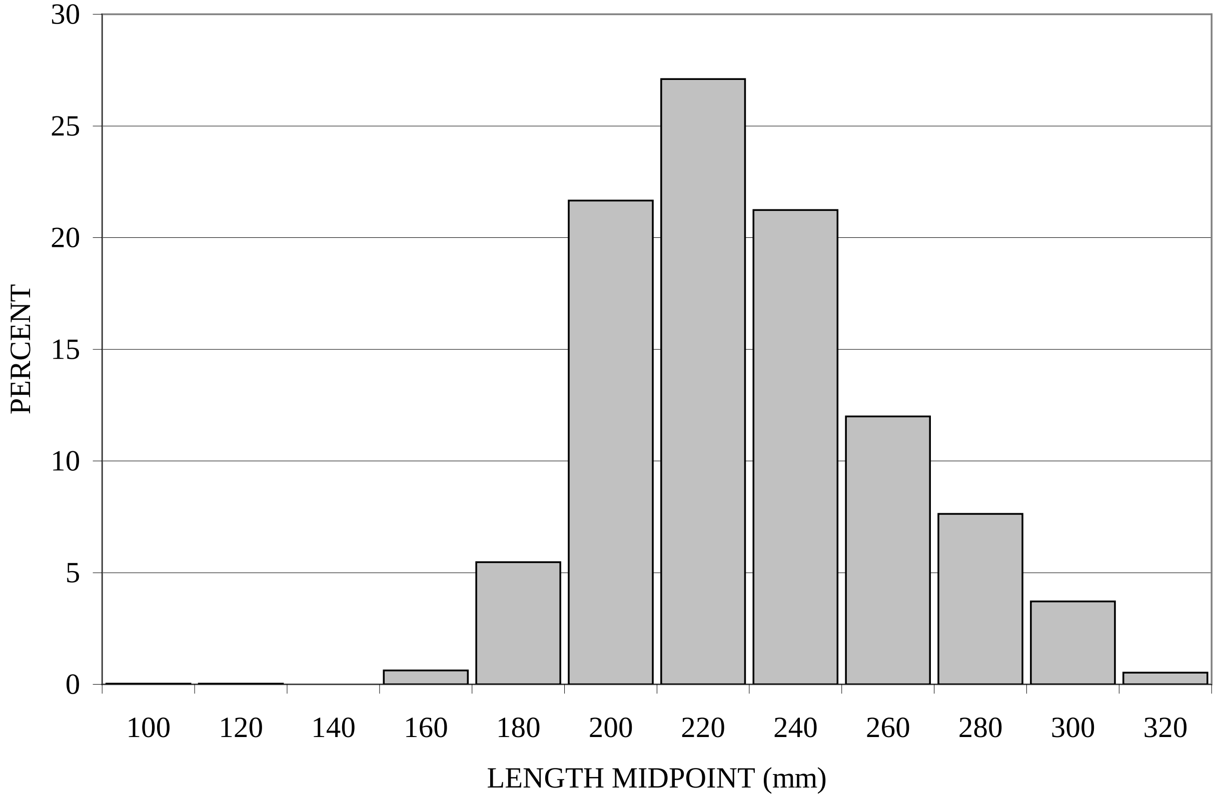


Table 13. Relative stock densities (RSD's) of channel catfish from the upper Chesapeake Bay winter trawl survey, 2000 – 2016. Minimum length cut-offs in parentheses.

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

Figure 14. Length frequency of channel catfish from the 2016 upper Chesapeake Bay winter trawl survey.

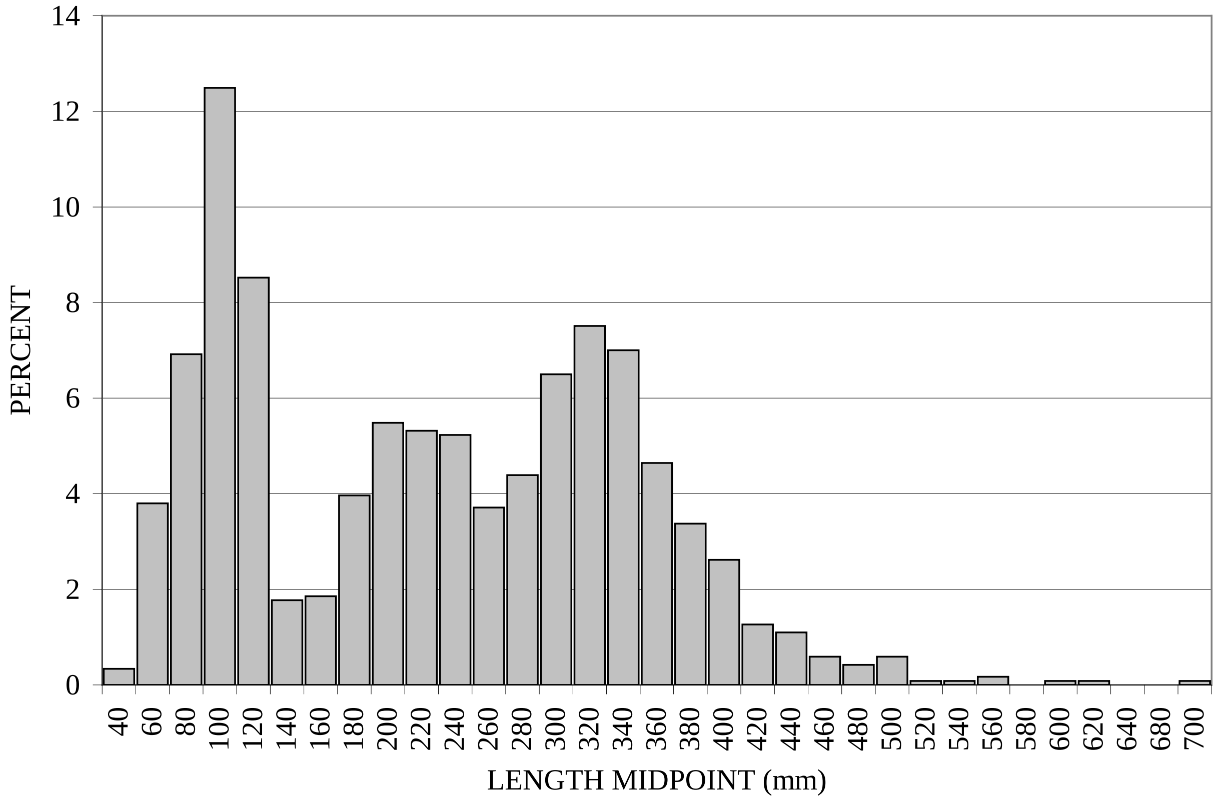


Table 14. Relative stock densities (RSD's) of channel catfish from the Choptank River fyke net survey, 1993 – 2016. Minimum length cut-offs in parentheses.

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

Figure 15. Channel catfish length frequency from the 2016 Choptank River fyke net survey.

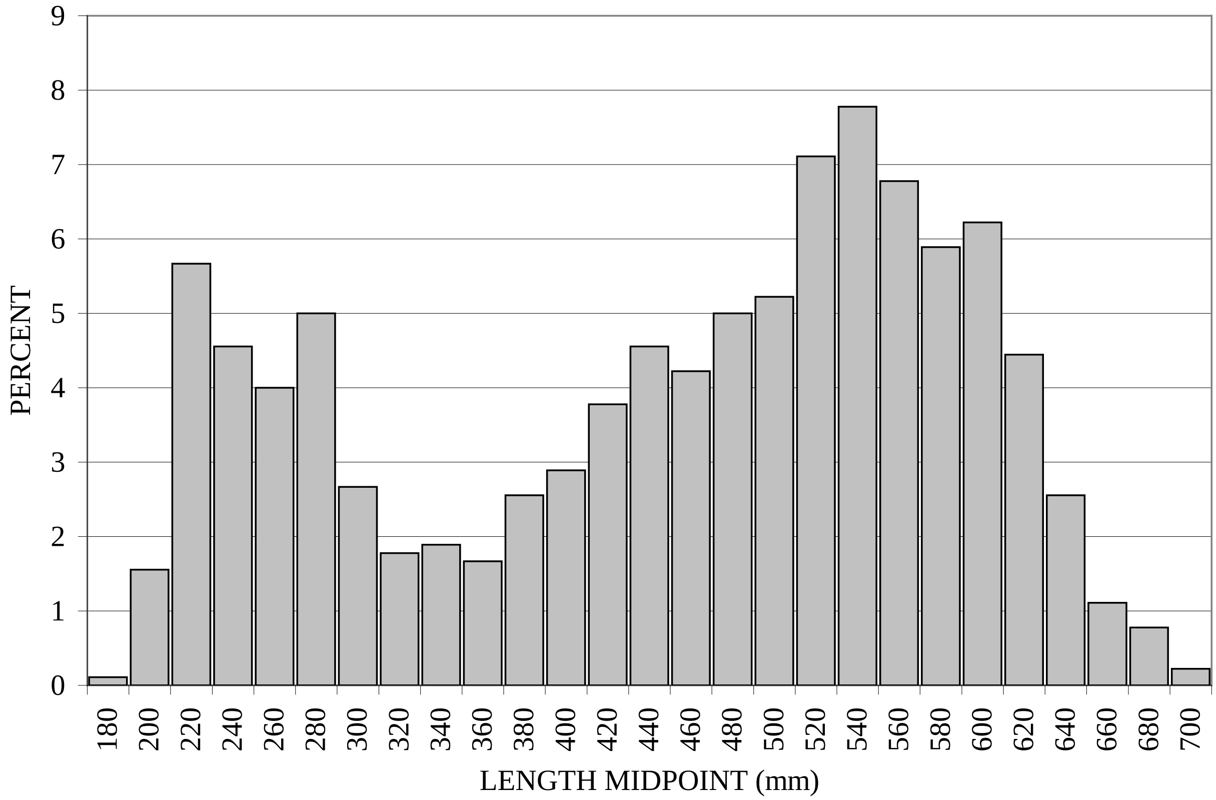


Table 15. Relative stock densities (RSD's) of channel catfish from Nanticoke River fyke and pound net survey, 1995 – 2016. 2007 -- 2009 include Marshyhope River fyke net data. Minimum length cut-offs in parentheses.

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

Figure 16. Channel catfish length frequency from the 2016 Nanticoke River fyke and pound net survey.

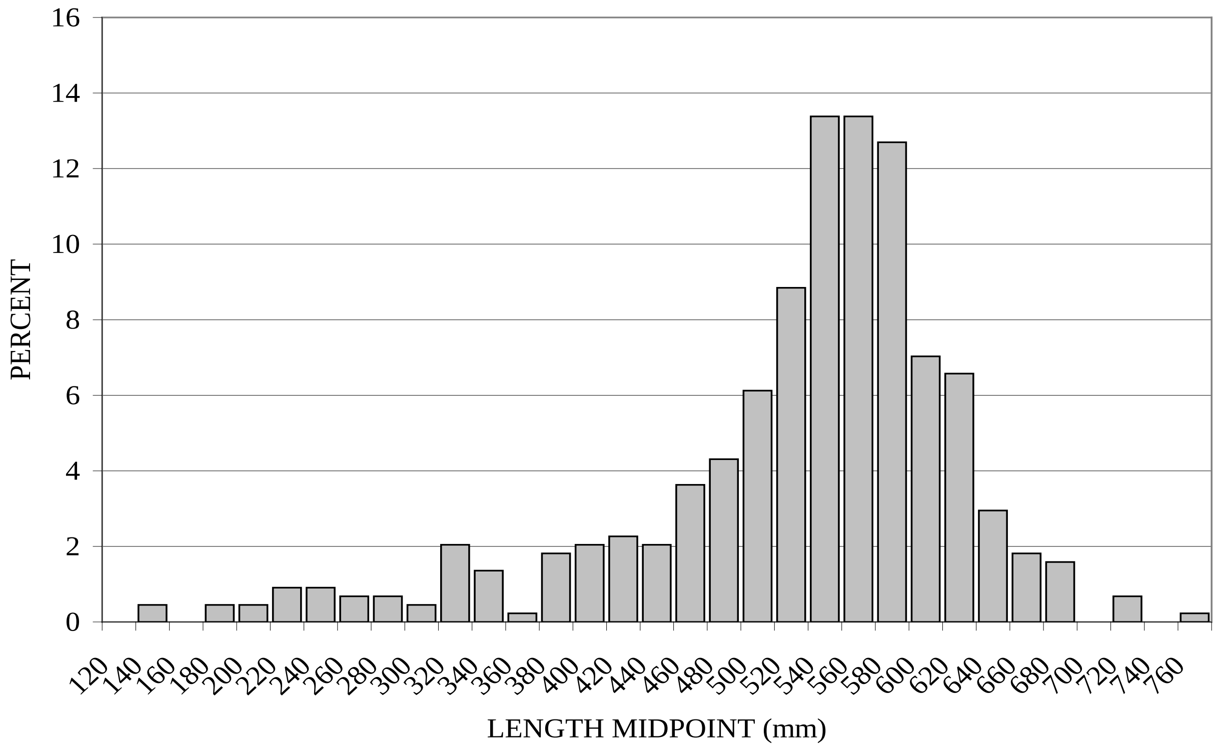


Table 16. Relative stock densities (RSD's) of white catfish from the upper Chesapeake Bay winter trawl survey, 2000 – 2016. Minimum length cut-offs in parentheses.

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

Figure 17. White catfish length frequency from the 2016 upper Chesapeake Bay winter trawl survey.

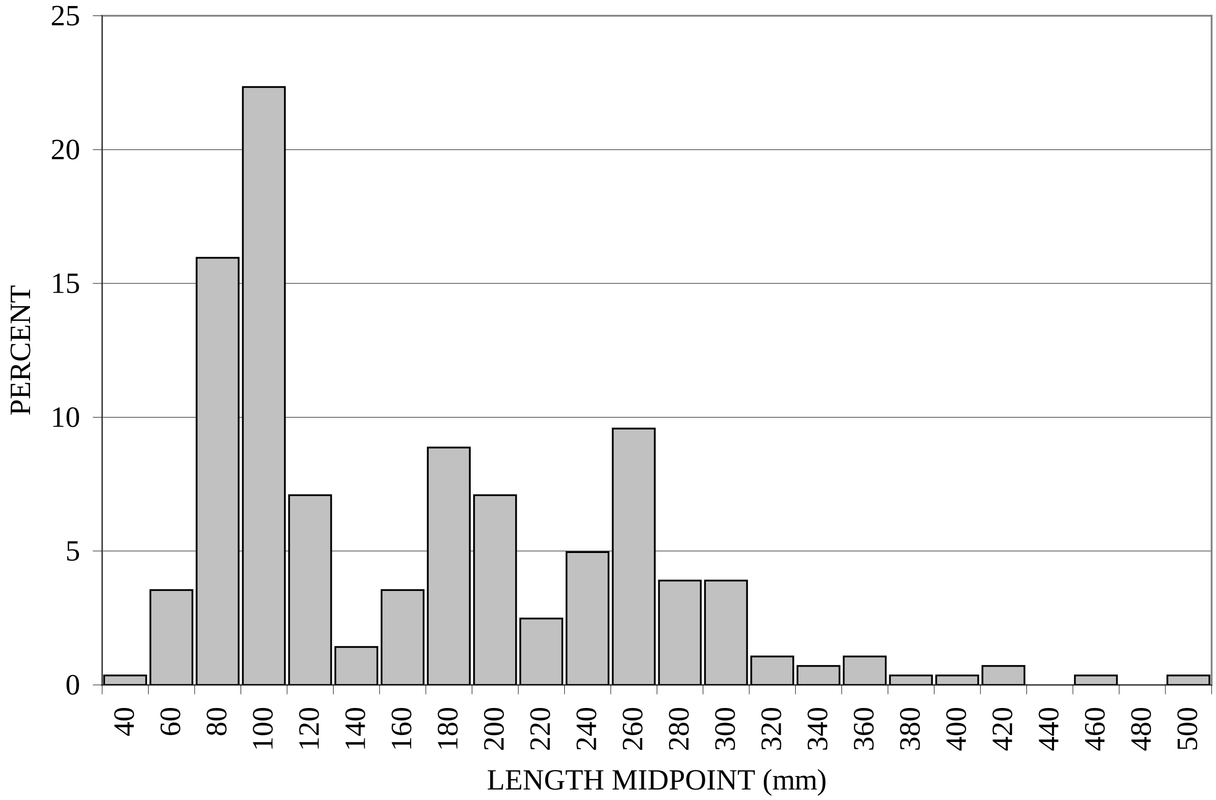


Table 17. Relative stock densities (RSD's) of white catfish from the Choptank River fyke net survey, 1993 – 2016. Minimum length cut-offs in parentheses.

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

Figure 18. White catfish length frequency from the 2016 Choptank River fyke net survey.

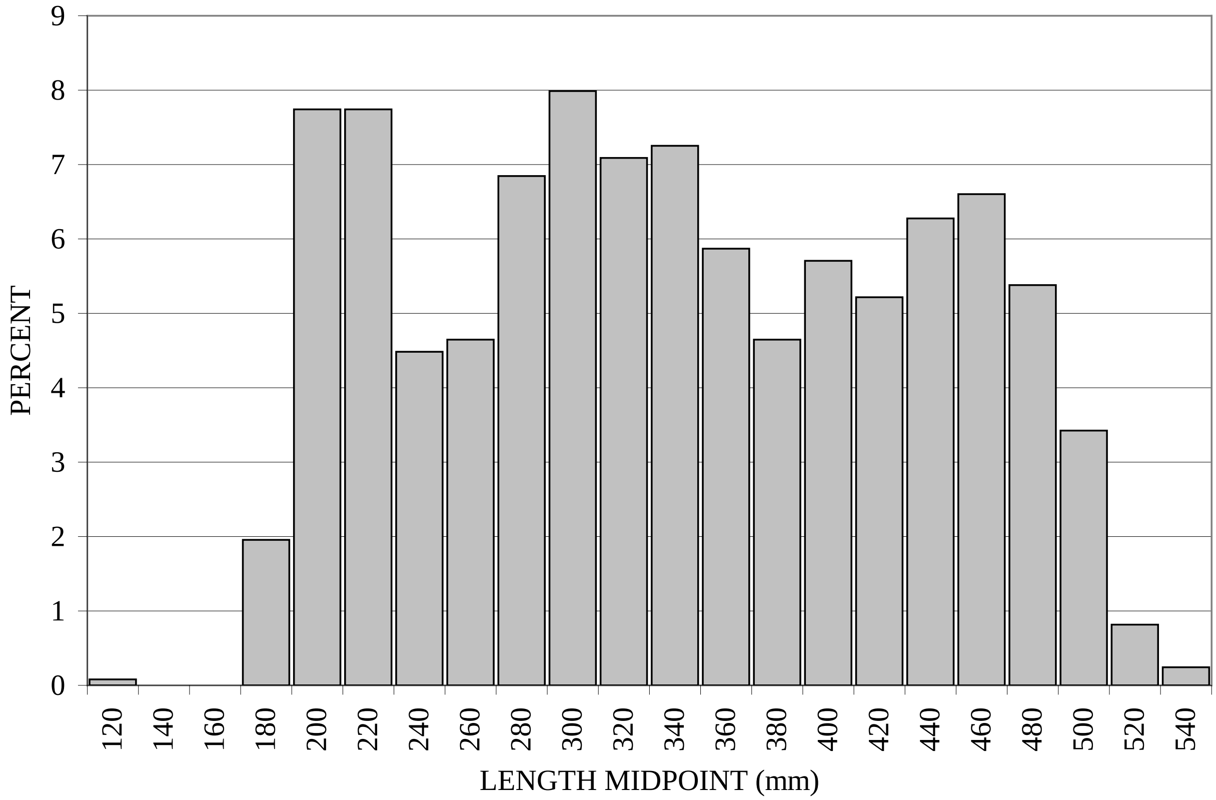


Table 18. Relative stock densities (RSD's) of white catfish from the Nanticoke River fyke and pound net survey, 1995 – 2016. 2007 -- 2009 include Marshyhope River fyke net data. Minimum length cut-offs in parentheses.

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

Figure 19. White catfish length frequency from the 2016 Nanticoke River fyke and pound net survey.

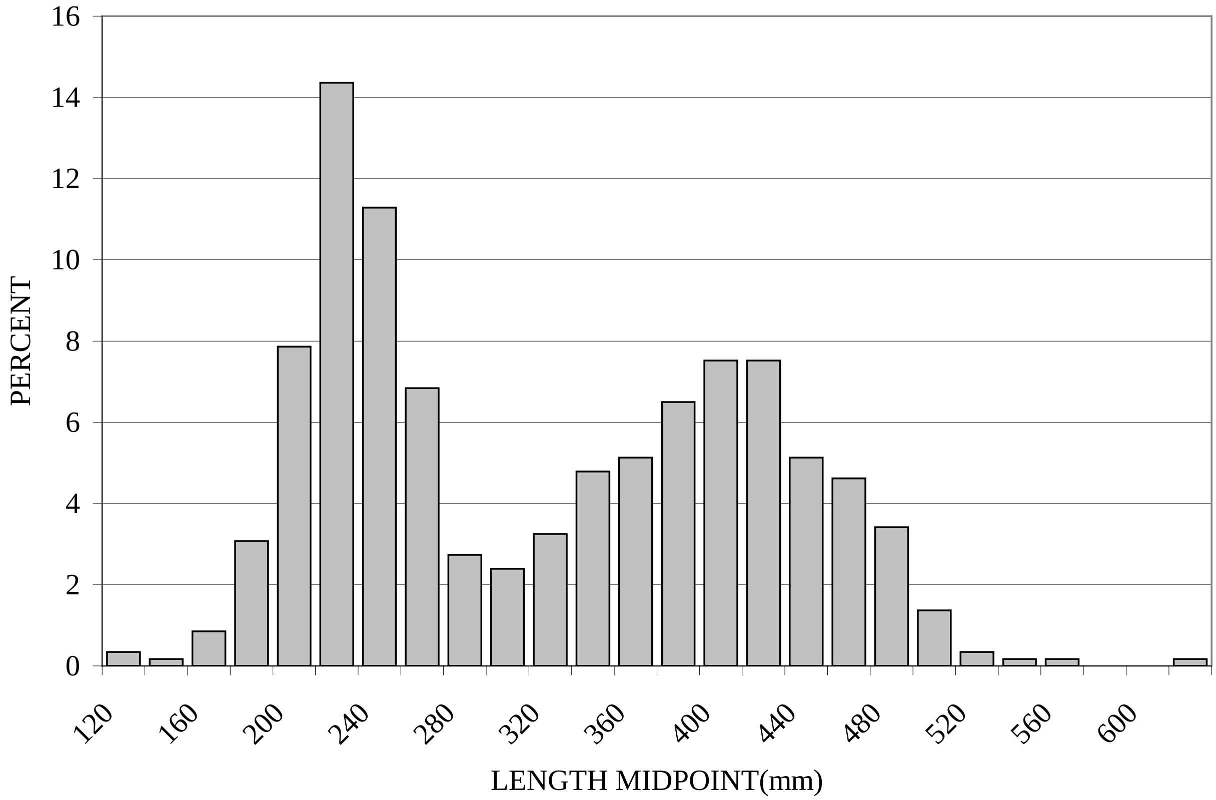


Table 19. White perch growth parameters from Choptank River for males, females, and sexes combined. NA=data not available NSF=no solution found or small sample size.

Sample Year	Sex	Allometry		von Bertalanffy		
		alpha	beta	L-inf	K	t_0
2008	F	3.0×10^{-6}	3.29	306	0.21	0.51
	M	3.7×10^{-6}	3.25	218	0.36	-0.36
	Combined	2.2×10^{-6}	3.35	282	0.23	-0.50
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
2000 – 2016	F	5.0 X 10-6	3.21	290	0.26	-0.44
	M	5.0 X 10-6	3.20	231	0.34	-0.37
	Combined	3.3 X 10-6	3.29	277	0.25	-0.58

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)		(von Bertalanffy)		
		alpha	beta	L-inf	K	t_0
2008	F	4.1×10^{-6}	3.25	295	0.27	0.56
	M	8.0×10^{-6}	3.12	258	0.27	-0.14
	Combined	3.6×10^{-6}	3.27	292	0.23	-0.06
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
2000 - 2016	F	1.2×10^{-5}	3.07	314	0.21	-0.78
	M	1.8×10^{-5}	2.97	271	0.26	-0.42
	Combined	7.6×10^{-6}	3.14	298	0.23	-0.50

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		von Bertalanffy		
		alpha	beta	L-inf	K	t_0
2008	F	5.8×10^{-6}	3.12	322	0.34	0.23
	M	1.1×10^{-5}	3.00	**253**	**0.20**	**-2.57**
	Combined	8.1×10^{-6}	3.06	288	0.31	-0.34
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
2000 – 2016	F	8.6×10^{-6}	3.06	306	0.36	-0.45
	M	3.6×10^{-6}	3.21	270	0.26	-1.47
	Combined	6.0×10^{-6}	3.12	269	0.41	-0.61

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
2008	F	7.83×10^{-6}	3.11	310	0.30	-0.73
	M	3.32×10^{-6}	3.24	231	0.61	-0.28
	Combined	3.89×10^{-6}	3.23	263	0.48	-0.38
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
1998 – 2016	F	4.4×10^{-6}	3.21	297	0.38	-0.36
	M	3.3×10^{-6}	3.23	240	0.54	-0.20
	Combined	2.1×10^{-6}	3.34	264	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.

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Choptank	0.18	0.16	0.12	0.20	0.38	0.54	0.32	MIN	0.17	0.34
Nanticoke	0.18	0.16	0.12	0.66	NR	NR	0.08	MIN	NA	0.15
Upper Bay	0.72	0.22	0.22	0.42	0.42	0.22	0.35	MIN	MIN	MIN

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

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Choptank[1]	MIN	NR	0.17	MIN	0.56	0.12	MIN	MIN	0.26	NR
Upper Bay[2]	0.18	0.04	0.22	0.25	0.30	0.27	0.16	0.11	0.13	0.21

[1]Based on ratio of CPUE of ages 4-10+ (year t) to CPUE of ages 3 – 10+ (year t-1) except 2009, 2014 and 2015 estimate where ratio of ages 5 - 10 and 4 - 10 were used.
[2]Fully recruited F from Piavis and Webb see Job 2.

Figure 20. Baywide young-of-year relative abundance index for white perch, 1962 – 2016, based on EJFS data. Bold horizontal line=time series average. Error bars indicate 95% CI's.

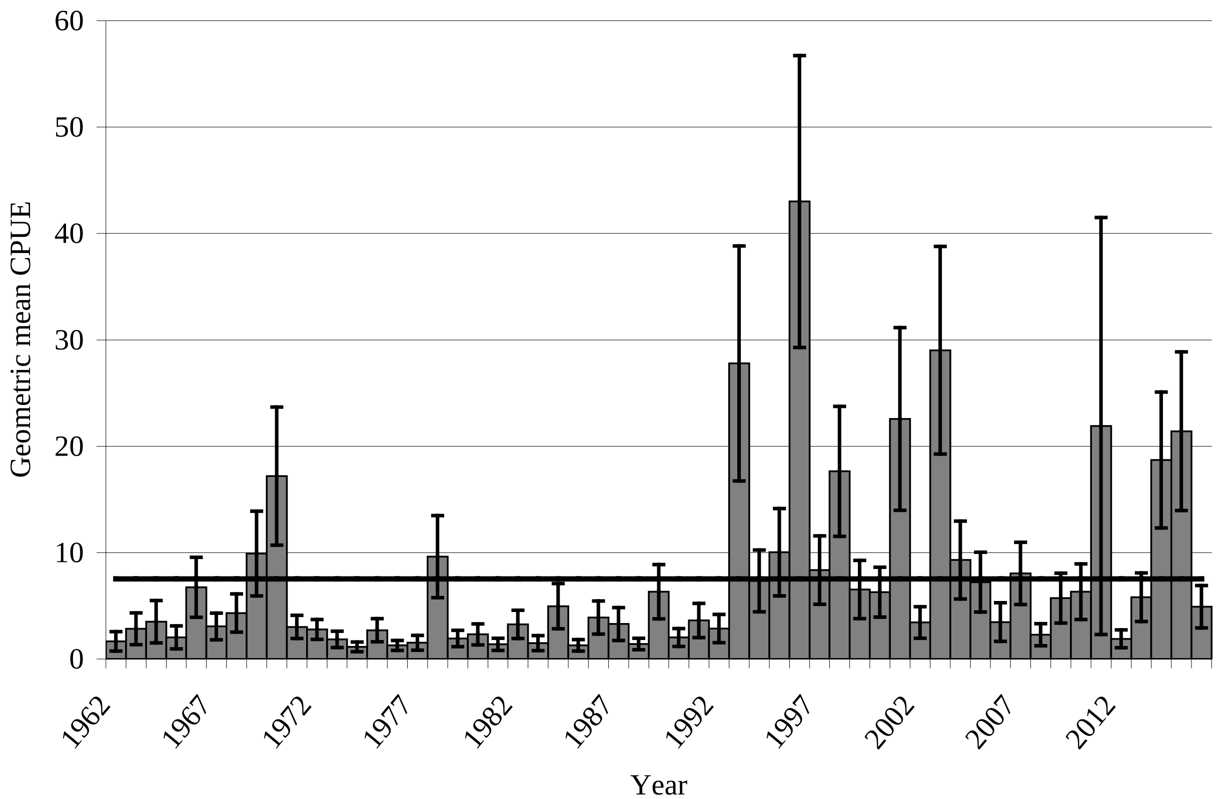


Figure 21. Age 1 white perch relative abundance from upper Chesapeake Bay winter trawl survey. Not sampled in 2004, small sample sizes 2003 and 2005. Error bars=95% CI.

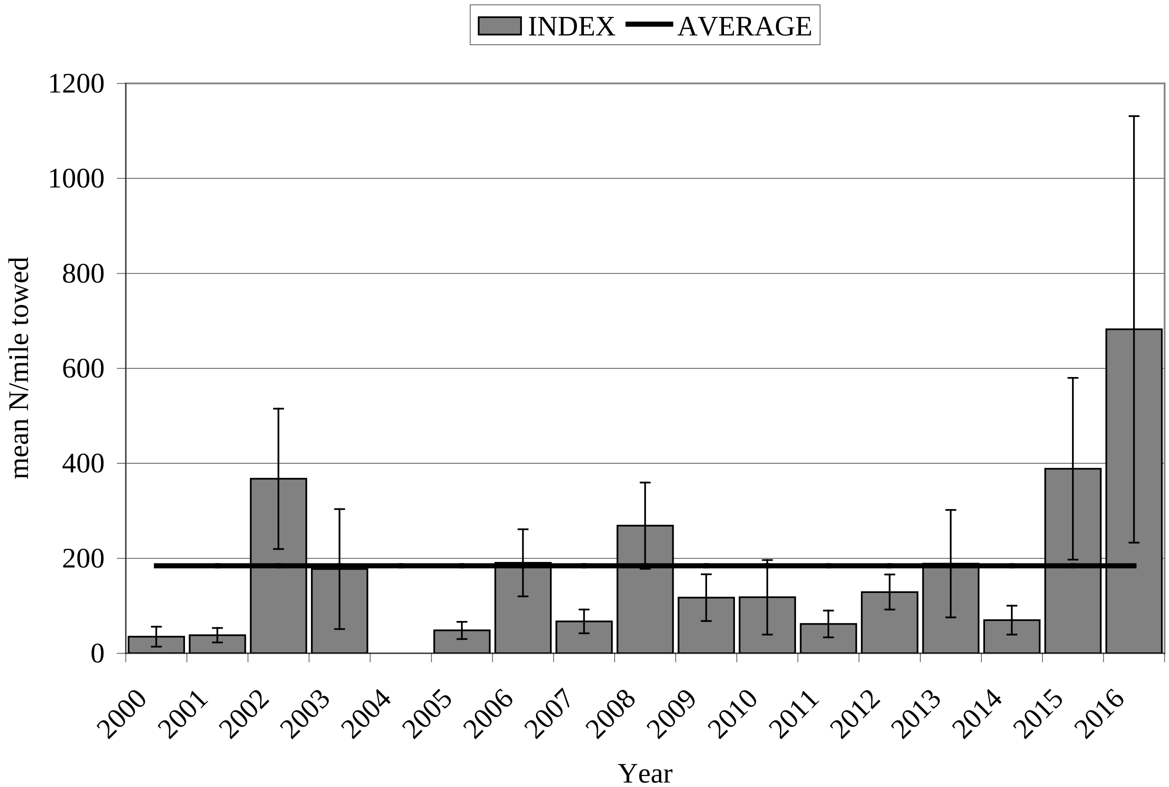


Figure 22. Head-of-Bay young-of-year relative abundance index for yellow perch, 1979 – 2016, based on Estuarine Juvenile Finfish Survey data. Horizontal line=time series average. Error bars indicate 95% confidence interval.

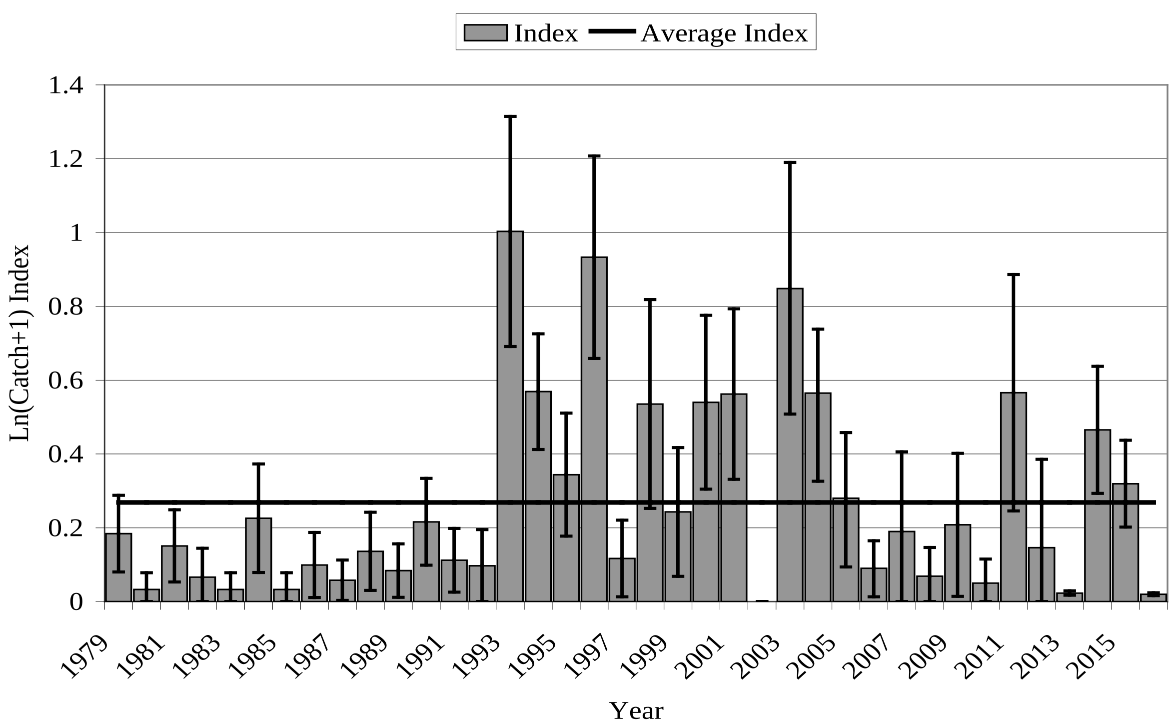


Figure 23. Age 1 yellow perch relative abundance from upper Chesapeake Bay winter trawl survey. Not sampled in 2004, small sample sizes 2003 and 2005. Error bars=95% CI.

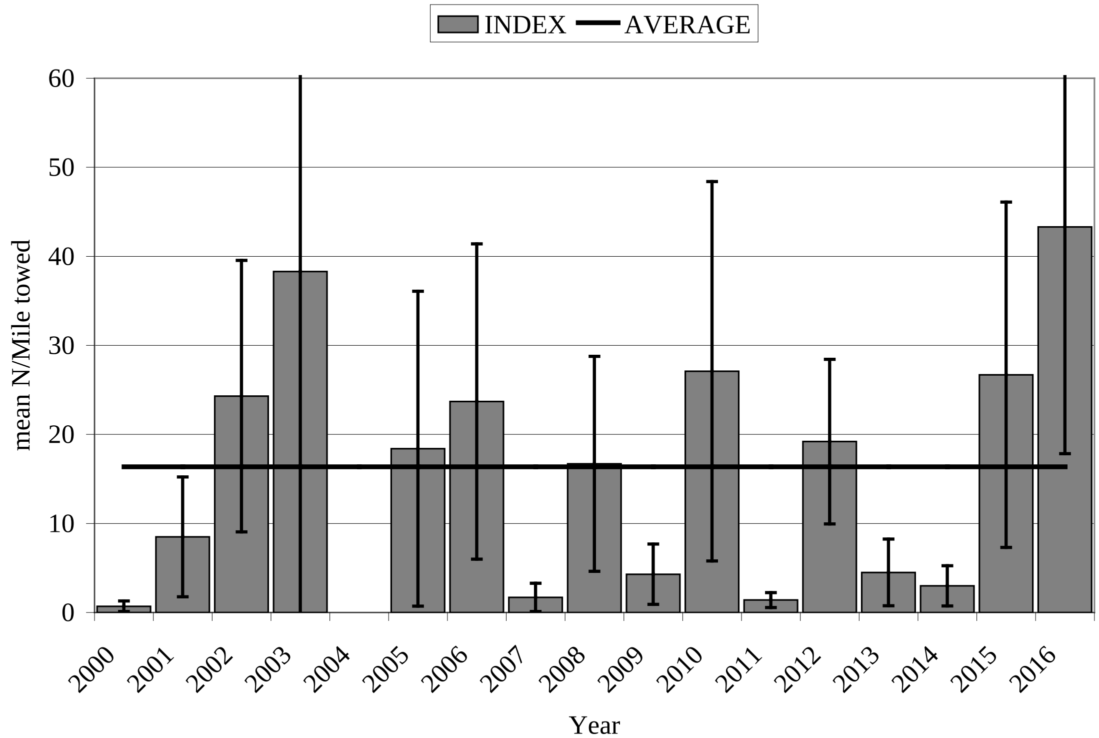


Figure 24. Age 1 channel catfish relative abundance from upper Chesapeake Bay winter trawl survey. Not sampled in 2004, small sample sizes 2003 and 2005.

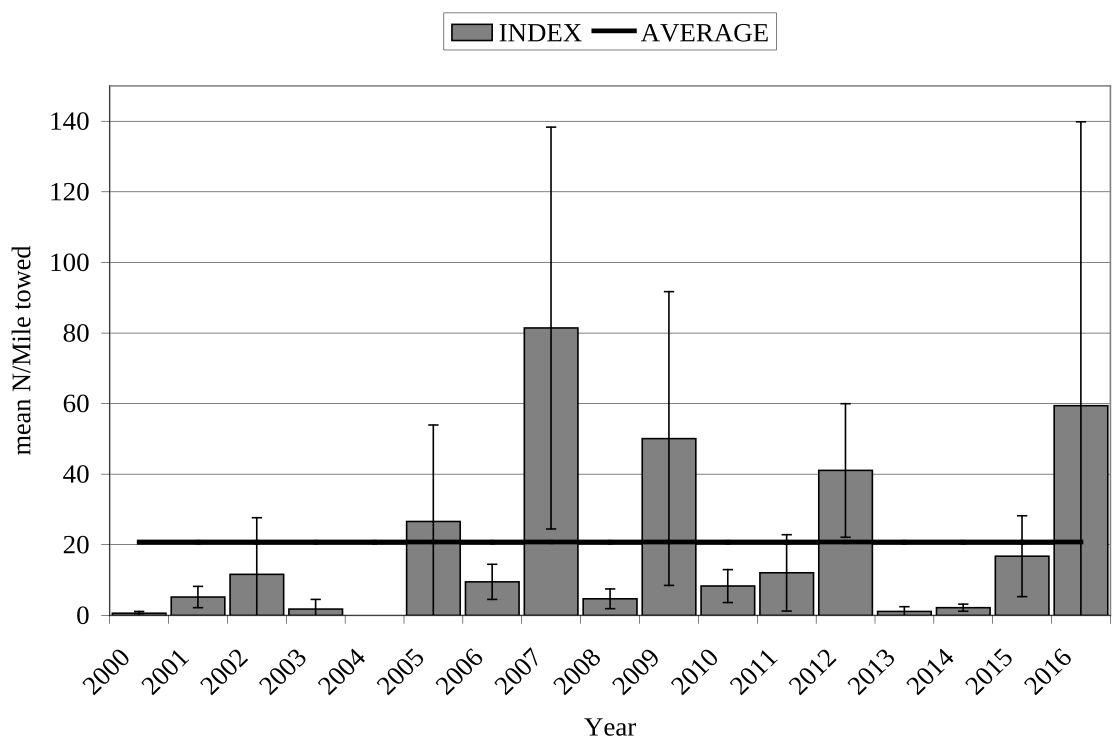


Table 25. White perch relative abundance (N/MILE TOWED) and number of tows from the upper Chesapeake Bay winter trawl survey, 2000 – 2016. Chester River sites included starting 2011.

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

Table 26. White perch relative abundance (N/net day) and total effort from the Choptank River fyke net survey, 2000 – 2016.

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

Table 27. Yellow perch relative abundance (N/MILE TOWED) and number of tows from the upper Chesapeake Bay winter trawl survey, 2000 – 2016.

YEAR	AGE											
	1	2	3	4	5	6	7	8	9	10+	Sum CPE	No. Trawls
2000	0.7	1.5	0.2	1.6	0.1	0.3	0.1	0.0	0.0	0.1	4.5	79
2001	8.5	0.6	1.0	0.2	0.6	<0.1	0.0	<0.1	0.0	0.0	10.9	115
2002	24.3	17.2	1.7	3.6	0.3	1.8	0.0	0.2	0.1	0.0	49.1	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	18.4	13.4	<0.1	3.1	0.4	<0.1	<0.1	0.0	<0.1	0.0	35.3	43
2006	23.7	34.3	15.8	0.0	3.3	0.4	0.0	0.4	0.0	0.0	78.0	108
2007	1.7	3.3	8.4	2.4	1.5	0.6	0.1	<0.1	0.0	0.0	18.0	71
2008	16.7	4.1	9.1	8.0	2.1	0.0	0.0	0.0	0.0	0.0	40.0	108
2009	4.3	21.2	1.1	2.4	2.1	0.5	<0.1	0.0	0.0	0.0	31.6	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	19.1	6.5	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	3.0	0.0	15.5	6.8	0.8	0.0	0.1	0.1	0.1	0.0	26.3	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	43.3	31.6	6.1	0.3	4.3	0.5	0.2	0.0	0.0	0.0	86.4	83

Table 28. Yellow perch relative abundance (N/net day) and total effort from the Choptank River fyke net survey, 1988 – 2016.

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

Figure 25. Choptank River yellow perch relative abundance from fyke nets, 1988 – 2016. Effort standardized from 1 March – 95% total catch date. Trendline statistically significant at P<0.001.

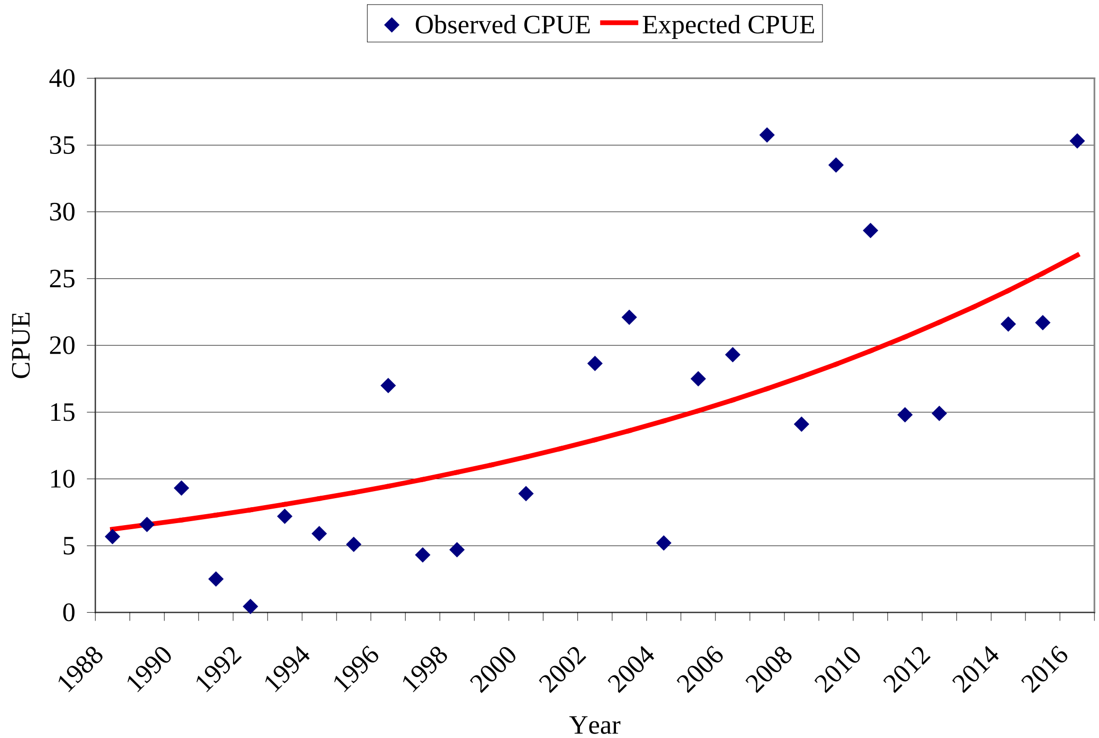


Figure 26. Channel catfish relative abundance (N/mile towed) from the upper Chesapeake Bay winter trawl survey, 2000-2016. Not surveyed in 2004, small sample sizes in 2003 and 2005.

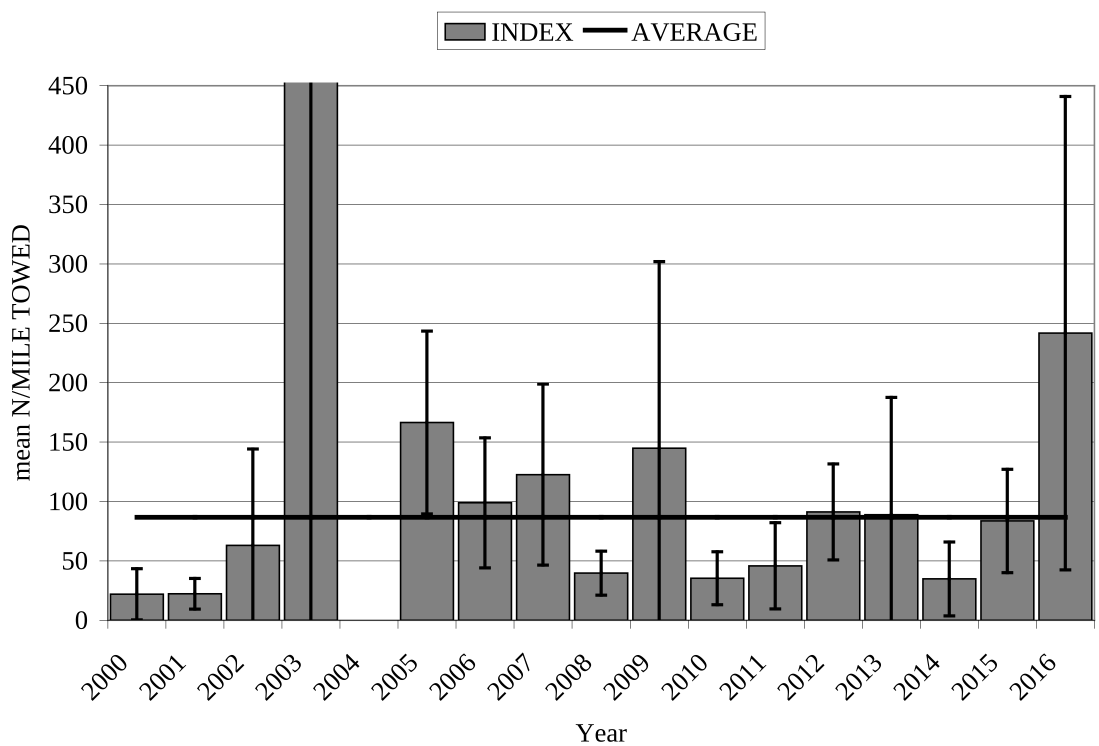


Figure 27. Channel catfish relative abundance (N/net day) from the Choptank River fyke net survey, 2000 – 2016. Horizontal line indicates time series average relative abundance.

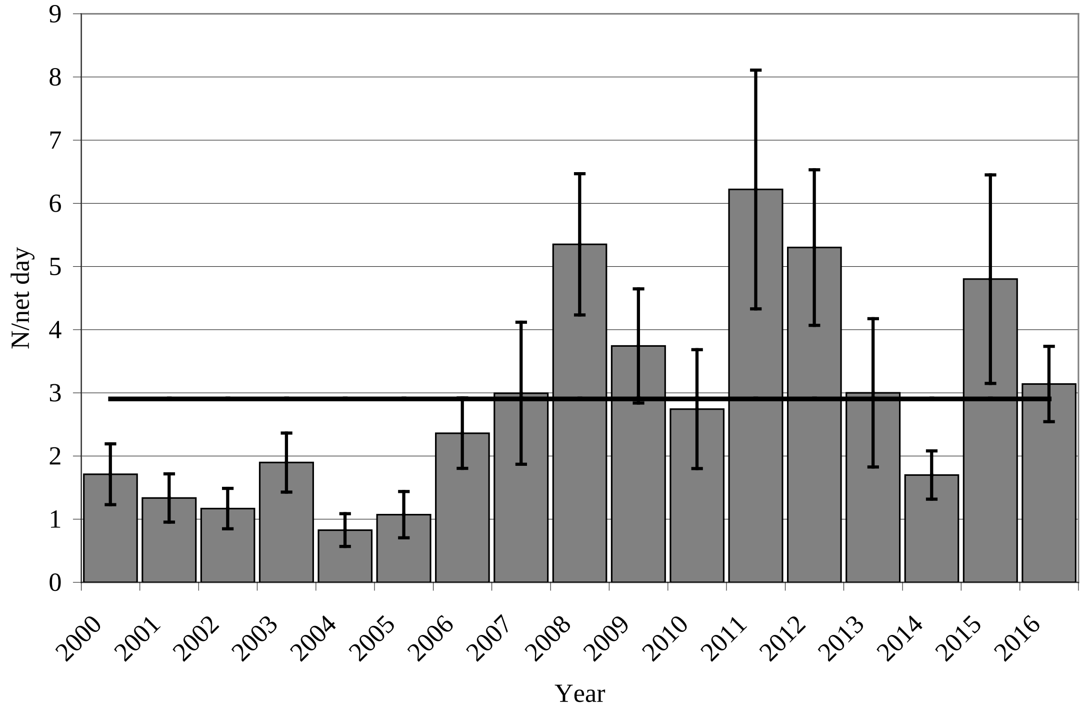
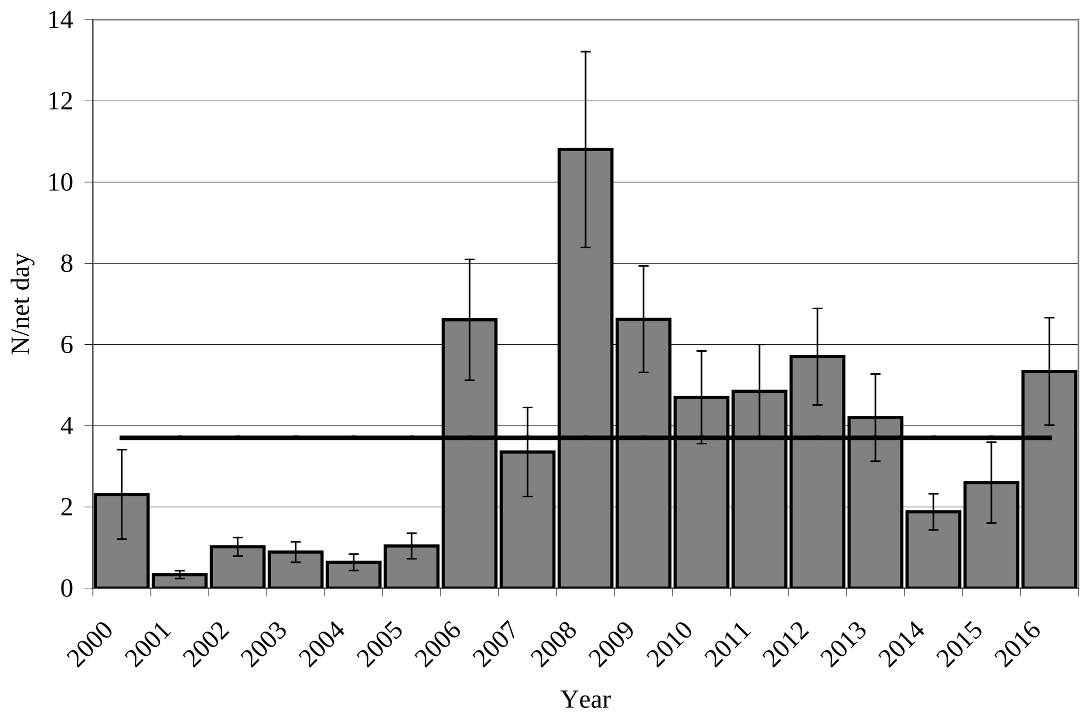


Figure 28. White catfish relative abundance (N/net day) from the Choptank River fyke net survey, 2000 – 2016. Horizontal line indicates time series average relative abundance.



PROJECT NO. 1
JOB NO. 2

POPULATION ASSESSMENT OF YELLOW PERCH IN MARYLAND WITH SPECIAL EMPHASIS ON HEAD-OF-BAY STOCKS

Prepared by Paul G. Piavis and Edward Webb, III

INTRODUCTION

Yellow perch (*Perca flavescens)* are an important finfish resource in Maryland's tidewater region. The dense aggregation during the late February – March spawning period offers recreational anglers the earliest opportunity to fish. Yellow perch are similarly an important seasonal fishery for commercial fishers. The modest commercial fishery occurs during a slack season between striped bass (*Morone saxatilis)* and white perch *(M. americana)* gill netting and the white perch spawning run. Over the 10 year period 2007 -- 2016, annual commercial harvest in Maryland ranged from 8,854 kg in 2008 to 28,878 kg in 2016 and averaged 19,480 kg. Since 1929, landings averaged 44,100 kg annually. However, changes in regulations, population abundance, and commercial effort drastically influence landings history.

The commercial fishery is predominately a fyke net fishery located above the Preston Lane Memorial Bridges in the upper Chesapeake Bay region. Fyke net harvest accounted for > 99% of the total yellow perch commercial harvest over the five year period 2012 – 2016. From 1988 – 1999, commercial fishers in the upper Bay had a closed season in February, and an 8 ½" minimum size limit (no maximum size limit). During 2000 – 2007, the commercial fishery had a closed season in February, and an 8½" – 11" slot limit in order to preserve larger spawning females and to enhance population age structure (Uphoff and Piavis 1999). Regulations changed for the 2008 fishing season due to a legislative mandate that caused a closure of the commercial yellow perch fishery from 1 January 2008 through 15 March 2008. The January – mid March closure encompassed a significant part of the commercial yellow perch season. Completion of a suitable stock assessment in late 2008 prompted the establishment of a total allowable catch (TAC) for the upper Bay commercial yellow perch fishery. Hard caps on the upper Chesapeake Bay commercial fishery were determined annually from 2009 – 2016 (Table 1).

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

Prior to 2009, tidal yellow perch management in Maryland focused on managing fishing mortality (F) to produce 35% maximum spawning potential (%MSP). Targets and limits were developed for yellow perch recreational and commercial fisheries using growth estimates, fishery selectivity, and partial recruitment estimates in a spawning stock biomass per recruit model (Piavis and Uphoff 1999; Yellow Perch Workgroup 2002). However, managing based solely on F was problematic because fishing mortality estimates were based on catch curves that capture a generational history of F, but not the true annual F. Over time, data sufficiently matured to assess upper Chesapeake Bay yellow perch population dynamics with a statistical catch-at-age model with data through 2006 (Piavis and Webb 2008); the assessment was last updated in 2013 (Piavis and Webb 2014).

This report updated and refined the statistical catch-at-age model to estimate fishing mortality, abundance in both biomass and numbers, and recruitment of upper Bay yellow perch. The update included three more years of data (2014 -- 2016) and the model was refined by revisiting fishery independent indices and weightings, and expanding the range of ages that were modeled from ages 2 – 8+ to ages 1 – 8+. Selectivity parameters for the trawl survey were also determined to provide a better statistical fit of the age-specific tuning indices.

In addition, we updated the spawning stock biomass per recruit model (SSB/R) that was used to set biological reference points contained in the current Fisheries Management Plan (Piavis and Uphoff 1999; Yellow Perch Workgroup 2002). The $F_{0.1}$ reference point from a yield per recruit model (YPR) was also determined. We incorporated the fishery selectivity vector produced from the current assessment along with updated growth parameters into the new SSB/R model.

Data from an on-going fishery independent fyke net survey in the Choptank River were also analyzed. The Choptank River is located in the mid-Bay region on Maryland's eastern shore. The watershed encompasses 371,000 acres. The Choptank River has an active recreational-only yellow perch fishery (9" minimum size limit, 10 fish creel limit). The fyke net survey provided a time-series of relative abundance estimates spanning 29 years. This survey provides the only dataset of adult yellow perch relative abundance outside of the upper Chesapeake Bay.

METHODS

Upper Chesapeake Bay statistical catch-at-age model

Data

Fishery dependent data

The area assessed included the Chesapeake Bay north of the Preston Lane Memorial Bridges and all tributaries except the Chester River (Figure 1). Data supported an assessment covering 1998 – 2016. Commercial landings and effort were needed for the assessment. Commercial fishermen are obligated to submit monthly catch reports and effort (number of nets) by gear and area for each day fished (Lewis 2010). Effort was calculated as the number of fyke nets utilized by watermen that landed more than 100 pounds of yellow perch during the commercial season, multiplied by the number of days the gear were deployed.

No estimates of recreational harvest prior to 2008 were available from creel surveys specifically designed to estimate yellow perch harvest, but we assumed recreational harvest to be a minor component of the total removals. Directed creel surveys conducted in the upper Bay during 2008 and 2009 estimated that recreational harvest in the Bush River was only 242 yellow perch in 2008 and 234 in 2009, and 1,480 yellow perch in Northeast River in 2009 (Wilberg and Humphrey 2008, 2009). The MRIP federal program samples tidal-fresh areas, but in many years encounter rates are insufficient to produce informative recreational estimates. Estimates from MRIP coinciding with the assessment time frame provided relatively precise estimates for only five of 18 years (Personal communication, National Marine Fisheries Service, Fisheries Statistics Division, 2017).

Biological samples were taken from cooperating commercial fyke net fishermen, from 1998 – 2016. Not all regions were sampled in every year, but biologists generally visited at least two areas per year. These included the Middle River, Back River, Bush River, Gunpowder River, Sassafras River and Northeast River. Random samples were taken from pre-culled catches (Table 2). Yellow perch were measured (mm TL) and sex was determined by examining external gonadal exudation. A non-random subsample was procured for otolith extraction and subsequent age determination. Ages were determined by counting annular rings on otoliths submersed in glycerin under a dissecting microscope with direct light. Weights and lengths were also taken for these specimens. Ages were mostly determined by one individual (experienced) reader. Percent agreement and precision were recently determined between the two age readers with percent agreement at 97% and mean CV of 0.56% (see Appendix A in Piavis and Webb 2011). These values compared favorably with estimates of precision from a yellow perch population in Pennsylvania (Niewinski and Ferreri 1999) and a population in Lake Erie (Vandergoot et al. 2008).

We formulated a commercial catch-at-age (CAA) matrix for each sample year by sex, for ages 2 – 8+. Length and weight data were disaggregated by sex into 20 mm length intervals. Average weight, by sex, in each interval was multiplied by the number of yellow perch (by sex) in each interval to get a total interval weight. Sample weights of all intervals were summed to get total sample weight by sex. Total landings by sex were calculated by multiplying reported commercial landings by the proportion of sex-specific sample weights. Total number of harvested yellow perch was determined by multiplying the sex-specific landings estimates by the number of sex-specific yellow perch in the sample divided by the total sex-specific sample weight. Total number harvested by sex and age-class was determined by formulating annual sex-specific age-length keys in 20 mm increments for legal sized fish only. The estimated total number harvested by sex was multiplied by the sex-specific proportion catch-at-age to get the number at age and sex harvested. Male and female CAA matrices were added together to arrive at a final annual CAA matrix. We substituted the lowest annual catch for an age-group if there was no representation of an age-class in any particular year (Table 3).

Fishery independent data

We also incorporated data from fishery-independent surveys into the model. The upper Bay winter trawl survey, initiated in December 1999, provided age-specific relative abundance data. Weather, logistic, and mechanical problems led to either no data or very small sample sizes during 2003 through 2005. Therefore, trawling effort was sufficient to generate a relative abundance index of 1 and 2 year-old yellow perch and an aggregated age 3+ abundance index for the years 2000 – 2002 and 2006 – 2016.

The upper Chesapeake Bay winter bottom trawl survey is designed to collect fishery-independent data for the assessment of population trends of white perch and yellow perch and channel catfish (*Ictalururs puntatus*). Six sampling rounds were scheduled from December through February. The Chesapeake Bay 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; Figure 2). Six sites in Chester River were added in 2015, but are not included in the assessment. Sites were approximately 2.6 km in length and variable in width. Each sampling station was divided into west/north or east/south halves by drawing a line parallel to the shipping channel, and sampling depth was divided into two strata; shallow water (<6m) and deep water (>6 m). Each site visit was randomized for depth strata and the north/south or east/west directional components.

The trawl was a 7.6 m bottom trawl consisting of 7.6 cm stretch-mesh wings and body, 1.9 cm stretch-mesh cod end and a 1.3 cm stretch-mesh liner. Following the 10-minute tow at approximately 3 kts, the trawl was retrieved into the boat by winch and the catch was emptied into either a culling board or a large tub if catches were large. A minimum of 50 fish per species were sexed and measured. Non-random sub-samples of yellow perch were sacrificed for otolith extraction and subsequent age determination. An annual age-length key (10 mm intervals) was created and applied to the length structure of each individual haul. The age-length key was not sex-specific because male yellow perch were not routinely ripe, making sex determination difficult. The age 1, age 2, and age 3+ trawl indexes were geometric mean catch per statute mile towed.

Another age 1 index was developed from the Estuarine Juvenile Finfish Survey (EJFS; Durrell 2016). The EJFS is a seine survey in several areas of the Chesapeake

Bay. Previous yellow perch assessments indicated that a suite of selected upper Bay seine sites provided a good index of age 0 abundance. Therefore, only the Howell Pt., Ordinary Pt., Tim's Creek, Elk Neck State Park, Parlor Pt. and Welch Pt. permanent sites were used to index abundance. The index was the age 0 geometric mean catch per seine haul, lagged one year (in reality, a six-month lag at worst). So the 1997 survey indexed age 1 abundance in 1998, the 1998 survey indexed age 1 abundance in 1999, *et cetera*.

Model formulation

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

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

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

$$SSR = \Sigma\lambda_F[\mathrm{Ln}(E_y \bullet q_{comm}) - \mathrm{Ln}(F_{y\ pred})]^2 + \Sigma\lambda_C[\mathrm{Ln}(C_{a,y\ obs}) - \mathrm{Ln}(C_{a,y\ pred})]^2$$

$$+ \Sigma\lambda_S[\mathrm{Ln}(I_{\mathrm{seine}\ 0,y-1\ obs}) - \mathrm{Ln}(I_{\mathrm{seine}\ 0,y-1\ pred})]^2 + \Sigma\lambda_{T1}[\mathrm{Ln}(I_{\mathrm{trwl}\ 1,y\ obs}) - \mathrm{Ln}(I_{\mathrm{trwl}\ 1,y\ pred})]^2$$

$$\Sigma\lambda_{T2}[\mathrm{Ln}(I_{\mathrm{trwl}\ 2,y\ obs}) - \mathrm{Ln}(I_{\mathrm{trwl}\ 2,y\ pred})]^2 + \Sigma\lambda_{T3+}[\mathrm{Ln}(I_{\mathrm{trwl}\ 3+,y\ obs}) - \mathrm{Ln}(I_{\mathrm{trwl}\ 3+,y\ pred})]^2$$

where E_y is the commercial fishing effort index in year y, q_{comm} is catchability of the commercial fyke net fishery, F_y is instantaneous fishing mortality in year y, $C_{a,y}$ is the catch of age a yellow perch in year y, $I_{seine\ 0,\ y-1}$ is the seine index, $I_{trwl\ 1,y}$ $I_{trwl\ 2,y}$ and $I_{trwl\ 3+,y}$ are the trawl indexes of ages 1, 2 and 3+ yellow perch in year y, and λ_F, λ_C, λ_Y, λ_S, λ_{T1}, λ_{T2} and λ_{T3+} are weighting factors. The fishery independent indexes were weighted by the inverse variance. The final weighting scheme was unity for the CAA and F, and weights of the fishery independent tuning indexes were 1.00 for the for the age 1 seine index, 1.06 for the age 2 trawl index, 1.41 for the age 1 trawl index, and 1.73 for the age 3+ trawl index.

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

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

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

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

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

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

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

The model needs information other than the CAA matrix to scale the abundance estimates to the correct level (Haddon 2001). Predicted F and fishery independent indexes were used. An F_{pred} vector was produced from the model runs, and F_{obs} was the q_{comm} multiplied by the annual commercial fishing effort index (E_y). In essence, this is a "semi-observed F" because the fitted parameter q_{comm} was used to calculate F_{obs} (Haddon 2001). Gear saturation may affect the tuning ability of the model. In order to assure that gear saturation was not an issue, landings were regressed against effort. The predicted age 1 trawl index was $N_{1,y}*q_{trwl}*s_{trwl\ 1}$. Similarly the predicted age 2 and age 3+ trawl indices were $N_{2,y}*q_{trwl}*s_{trwl\ 2}$ and $N_{3+,y}*q_{trwl}*s_{trwl\ 3+}$, respectively. The predicted age 1 seine index was $N_{0,y-1} * q_{seine}$.

Model run

The model requires estimation of $N_{2\ldots8+,\ 1998}$, $R_{1998\ldots2016}$ (where R is recruitment or abundance at age 1), F_y, q_{comm}, $q_{trawl,1}$, $q_{trawl,2}$, $q_{trawl,3+}$, $q_{seine,t-1}$ and age specific selectivities (s_a) for the trawl and CAA matrix. To obtain initial estimates of abundance ($N_{2\ldots8+,\ 1998}$), a Gulland style virtual population analysis (Megrey 1989) was performed on the CAA matrix in an earlier assessment (Piavis and Webb 2008) and estimates for $N_{2\ldots8+,\ 1998}$ were utilized here. We held initial recruitment constant initial recruitment value of 50 yellow perch ($R_{1998\ldots2016}$). Starting values of catchability were 0.1 for the commercial fishery and 0.0002 for seine and trawl surveys. Initial values of F were set at 0.2 for all years. In addition, fishery selectivity was estimated for two time periods because commercial regulations changed over the course of the assessment. A 9" minimum size limit was enforced during 1998 – 1999, suggesting a flat-topped selectivity pattern. During 2000 – 2016, the commercial fishery had an 8 ½" – 11" slot limit which should produce a dome-shaped selectivity pattern. For the first time period, selectivity was constrained to a maximum of 1. For the second time period (slot limit), selectivity for each age-class was divided by the maximum selectivity to ensure that at least one age class was fully selected (Quinn and Deriso, 1999). Selectivity of age 1, 2 and 3+ yellow perch in the trawl was initially run = 1.0. Previous model runs indicated that the model fit was quite insensitive to starting values of N, R, *q*, and F (Piavis and Webb 2011). We assumed a constant instantaneous natural mortality (M) = 0.25.

The model was implemented in an Excel spreadsheet, and all fitting was done with the Microsoft Excel Solver algorithm. Uncertainty was quantified by bootstrapping. Residuals were randomized and added back to the fishery independent indexes, and the model was rerun. Early runs demonstrated occasional fits that produced unrealistically low F and high N estimates. Therefore a penalty term was invoked for F < 0.075 for years not impacted by ice conditions. The model was bootstrapped 4,000 times and 80% confidence intervals were determined from the cumulative percent distribution for F, R, N, and biomass. In addition, coefficients of variation (CV) were produced for parameters of interest. Retrospective analyses over the last 3 years were performed to help assess the stability of the model.

<u>Spawning stock biomass per recruit and biological reference points</u>

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

Thompson-Bell modification determines the number (N_{ts}) and weight (W_{ts}) available at spawning as

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

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

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

where c is the fraction of F before spawning, p is the fraction vulnerable to harvest at age (selectivity), d is the fraction of M that occurs before spawning, fr_{ts} is the fraction mature at age t, and W_t is the mean weight at age (Table 4). We used an arbitrary initial cohort of 100,000 at age 0. The assessment was run for 12 age-classes. Female yellow perch growth rate was modeled with vonBertalanffy growth parameters (L_∞ = 297 mm K = 0.38 t_0 = -0.36) and an allometric length-weight relationship (α = 4.4 X 10^{-6} β = 3.21) from upper Bay yellow perch during 1998 -- 2016 (see Project 1 Job1). The fishery selectivity vector for a fishery with an 8 1/2” to 11” slot limit was taken from the current assessment. This models the SSB/R for a predominantly commercial fishery. For a predominantly recreational fishery (9” minimum size limit) selectivity was the same as an earlier assessment (Piavis and Uphoff 1999).

The Thompson-Bell SSB/R analysis was constructed as a Microsoft Excel spreadsheet. An initial run with F = 0 determined the unfished (virgin) spawning stock biomass. We selected $F_{35\%}$ and $F_{25\%}$ as target and limit reference points, consistent with the current Yellow Perch Fisheries Management Plan (Yellow Perch Workgroup 2002). These reference points are the level of F that produce the reproductive output of stock sizes that are 35% and 25% of virgin stock size, respectively.

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

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

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

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

The fishery specific selectivity-at-age vectors (p_t) were the same as the SSB/R model. Yield was determined for F's ranging from 0 - 1.2 in increments of 0.1, except the yield at F=0.01 was determined in order to find the slope of the line at the origin in order to assess $F_{0.1}$.

Choptank River relative abundance analysis

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

Catch per unit effort since 1988 was modeled with SAS PROC NLIN procedure. An exponential increase was assumed, and therefore, a power function was used:

$$CPUE = \alpha \bullet e^{\beta \bullet y}$$

where y is year from 1 to 29 (corresponding to 1988 – 2016) and α and β are fitted parameters. The nonlinear regression was analyzed for outliers by inspecting studentized residuals. Residuals that were outside of the range of -2.5 to 2.5 were omitted from analysis and the regression was rerun. The regression was considered significant at the $\alpha = 0.05$ level.

RESULTS

Upper Chesapeake Bay statistical catch-at-age model

Landings were regressed against effort to determine if gear saturations occurred, which would compromise the selection of effort as a tuning index. No gear saturation was evident ($R^2 = 0.55$ P=0.0002; Figure 3). Selectivity at age was estimated for 2 time periods corresponding to different commercial regulations. The model fit the 1998 – 1999 time period with a flat-topped selectivity pattern with 5-year old yellow perch being fully recruited. Selectivity for age 3 yellow perch was 0.20. The model fit the 2000 – 2016 time period with a dome-shaped selectivity pattern, as was expected given the adoption of the slot limit during 2000. Yellow perch were fully recruited at age 5 and s_{8+} was 0.20 (Figure 4). Catchability for the commercial fyke net fishery was estimated as 2.20 X 10^{-5}, catchability of the trawl survey was 3.92 X 10^{-6} and the selectivity at age for the trawl survey was 1.0 for ages 1 and 2 and 0.32 for age 3+. Catchability of the seine survey was 7.78 X 10^{-5}.

Abundance estimates (all ages) averaged 1.7 million yellow perch during 1998 – 2016, and averaged 1.8 million yellow perch in the last five years of the assessment

(Figure 5). Abundance ranged from 1.15 million in 2003 to 3.0 million in 1998. The terminal year (2016) abundance was estimated at 2.2 million yellow perch. Biomass was at a time series low in 2004 (138,000 kg). The biomass estimate rose in 2016 to 212,000 kg, and the time series average was 202,000 kg (Figure 6). Maximum biomass was 343,000 kg in 1998.

Instantaneous fishing mortality (fully selected F) ranged from 0.04 – 1.1 during 1998 – 2016. Fishing mortality peaked in 2002 at 1.1. Since a total allowable catch was instituted in 2009, F averaged 0.20. Fully recruited F was 0.21 in the terminal year (Figure 7).

Estimated recruitment (abundance of age 1 yellow perch) ranged from 21,400 yellow perch in 2003 (2002 year-class) to 1.133 million yellow perch in 2012 (2011 year-class) and averaged 441,300 yellow perch, 1998 – 2016 (Figure 8). Yellow perch recruitment was poor in 2003, 2009, 2013 and 2014 (2002, 2008, 2012 and 2013 year-classes, respectively). Recently, above average recruitment occurred in 2008, 2012, 2015, and 2016 (2007, 2011, 2014 and 2015 year-classes, respectively)

Observed and expected indexes were plotted to illustrate both the model fit and provide an indication of the magnitude and pattern of residuals. As expected, the indexes that were weighted highest had the best fit. The age 3+ trawl index ($\lambda = 1.73$) and age 1 trawl index ($\lambda = 1.41$) fit particularly well. There were no residuals >1.0 or <-1.0 for the age 1 trawl index and only one residual <-1.0 for the aggregate age 3+ index (Figures 9, 10). The age 2 trawl index ($\lambda = 1.06$) generally alternated between +/- residuals with low to moderate absolute values (Figure 11). The age 1 seine index ($\lambda = 1.00$) exhibited the poorest fit, but most of the residual error was accumulated in 3 of the 19 years (2 negative residuals and 1 positive residual; Figure 12).

Bootstrapping provided confidence intervals and quantified uncertainty. Of the 4,000 bootstrap trials, 96.4 % were successful runs. Analysis of 80% confidence intervals indicated that N was fairly well estimated with a slightly low bias (Figure 13). Biomass exhibited a similar pattern (Figure 14), which is to be expected since biomass was estimated as the N matrix multiplied by survey sample weights at age. Recruitment estimates exhibited high precision, but the estimates for 2015 and 2016 were relatively imprecise (Figure 15). Instantaneous fishing mortality (F) estimates were suitable, but biased somewhat low (Figure 16).

Coefficients of variation (CV) for survey and the commercial CAA were below 30% (Table 5). Estimates of F exhibited CV's generally around 30%, while CV's of abundance were very good, with the latest 2 years having the highest CV's due to more uncertainty in the age 1 estimates (see R in Table 6). Biomass estimates had CV's that largely mimicked abundance (Table 6).

Retrospective analysis was performed on the dataset in order to quantify the stability of the model. Estimates of abundance (Figure 17), recruitment (Figure 18), and F (Figure 19) were all particularly stable. Commercial catchability showed an increasing trend in the retrospective analysis whereby q increased from 1.8×10^{-5} in the t-2 model to 2.2×10^{-5} in the base model. The catchabilty of each fishery independent survey remained stable through the three retrospective runs.

Spawning stock biomass per recruit and biological reference points

Spawning stock biomass per recruit modeling produced percent maximum spawning potential (%MSP) at F curves for a fishery with an 8 ½" – 11" slot limit (commercial fishery; Figure 20) and a fishery with a 9" minimum size limit (recreational fishery; Figure 21). For the upper Bay, which is a predominately commercial fishery, the target reference point ($F_{35\%}$) was 0.54 and the limit reference point ($F_{25\%}$) was 0.84. Yield per recruit modeling produced $F_{0.1}$ and F_{max} reference points of 0.65 and 1.8, respectively. Fully selected F in 2016 (0.21) produced a %MSP of 62%. For a predominately recreational fishery (9" minimum size limit), the target reference point ($F_{35\%}$) was 0.37 and the limit reference point ($F_{25\%}$) was 0.55. Yield per recruit modeling produced $F_{0.1}$ reference point of 0.37, and F_{max} was 0.87. The bootstrap distribution of F indicated that there was a 0.05 % chance that F exceeded $F_{35\%}$ in the upper Chesapeake Bay during 2016.

<u>Choptank River relative abundance analysis</u>

Non-linear regression of CPUE and year provided a statistically significant fit. However, two data points were identified as possible outliers. Exclusion of the CPUE values for 1999 and 2001 greatly improved the fit and corrected a bias toward negative residuals. The final equation, $CPUE = 5.92 \cdot e^{(0.052 \cdot yr)}$, was highly statistically significant ($P<0.0001$). The resultant curve indicated that CPUE increased from 6.2 fish/net day in 1988 to 24.1 fish/net day in 2016 (Figure 22).

DISCUSSION

Statistical catch-at-age models incorporate many advances in fisheries science into an analytical framework, often relaxing sometimes onerous assumptions associated with virtual population analysis. One major assumption that is relaxed is that the CAA matrix is measured without error. However, certain assumptions are common between the two families of population assessments. Common assumptions include that M is constant and accurately assigned; that there is no net immigration or emigration; and in the current model, that q does not vary over time. Severe violations of these assumptions may confound the model results.

The model assumed constant natural mortality (M) = 0.25. Total instantaneous mortality in areas closed to commercial and recreational fishing produced estimates of Z near 0.25 – 0.30, which in the absence of F would approximate M (Piavis et al. 1993; Piavis and Webb 2008). Over a nearly 30 year period of monitoring yellow perch in Chesapeake Bay, 10 year old yellow perch were not rare, and the oldest captured yellow perch was 14 years old, consistent with a lower M (Yellow Perch Workgroup 2002).

Recently, research in the Laurentian Great Lakes assumed a higher M than our model. Wilberg et al. (2005) utilized M=0.37 for a Bayesian statistical catch at age model for Lake Michigan yellow perch. Ecosystem differences could cause lower natural mortality in Chesapeake Bay yellow perch relative to Great Lakes yellow perch. Abundance of gizzard shad (*Dorosoma cepedianum*), white perch, alosids (*Alosa spp.*) and other forage fish likely reduce predation pressure on Chesapeake Bay yellow perch. Yellow perch over-winter mortality was negatively correlated with gizzard shad abundance in Oneida Lake, NY because gizzard shad provided a buffer against predation (Fitzgerald et al. 2006). Alternatively, large abundance of gizzard shad could cause increased mortality if interspecific competition for zooplankton is intense. However, Roseman et al. (1996) noted no overlap of yellow perch and gizzard shad diets. Generally, young-of-year yellow perch exhibited an ontogenetic shift to benthic prey items before annual decreases in *Daphnia* spp occurred.

A longer growing season in the Chesapeake Bay region may also significantly decrease predation risk, thus reducing M by increasing growth rates of juvenile yellow perch. Headley and Lauer (2008) determined an average length of about 75 mm for age 1 Southern Lake Michigan yellow perch. Age 1 yellow perch collected in the upper Bay trawl survey averaged 103 mm in 2012 and 121 mm in 2013, and 110 mm for the survey duration (2000 – 2013).

The concept of a unit stock must also be established such that there is no net gain or loss from immigration or emigration. Two recent investigations have helped satisfy this assumption, one on the molecular level and one at the individual level. The assessment area is characterized by an increasing salinity gradient from north to south, ostensibly acting as a barrier to movement into or out of the study area. The assessment excluded the Chester River population which is the lowest eastern shore tributary above the Bay Bridges. The Chester River has historically been excluded from upper Bay assessments because of high salinities at the river mouth. Recent genetic analysis indicates that a salinity barrier exists that inhibits gene flow. Yellow perch genetics within the Chesapeake Bay exhibited genetic profiles such that yellow perch were separated into distinct lines among the Bush River (in the assessment area), Severn River, Choptank River, and Nanticoke River (Grzybowski et al. 2010). However, the Severn River yellow perch were most closely related to the Bush River samples, and the largest divergences were the Nanticoke River population and the Choptank River population from themselves and the upper Bay yellow perch. These results validate the hypothesis that gene flow from the upper Bay is limited.

In 2008, we conducted an *ad hoc* yellow perch tagging survey in the Chester, Bush, Gunpowder, and Northeast rivers. The latter three systems are within the assessment area. Tags from each particular system were a unique color. Tag returns indicated that yellow perch were at large for 2 – 383 days. Commercial and recreational tag returns indicated significant movement among rivers in the assessment area but not the Chester River. Out of system recaptures of yellow perch tagged in the Northeast River accounted for 86% of the tag returns, and none were from outside of the assessment area. Gunpowder River source yellow perch had 29% of the returns from outside of the tagging system, with none from outside of the assessment area. There were only three recaptures of yellow perch tagged in the Bush River and all were recaptured within the system. However, commercial fishermen reported catching Bush River fish (as verified by the unique tag color) in the Chesapeake Bay just outside of the Bush River. No recaptures were reported from outside of the assessment area. Yellow perch tagged in the Chester River showed very limited immigration to the upper Bay, with only one tag encountered outside of the system (79 reported recaptures or 1.3%). At least for 2008 and 2009, no movement out of the upper Bay was noted, and very minimal emigration from the Chester River to the upper Bay was evident.

The assessment assumed constant catchability for the commercial fishery and all of the fishery independent surveys. Recent fishery literature has explored the folly of assuming that catchability is constant among both fishery-dependent and fishery-independent data sources. Wilberg et al. (2010) identified several factors that may influence catchability, including density dependent changes in q, environmental variability, and changes in fisher behavior. Density dependent changes in catchability are possible, but at least for the time period encompassed by this assessment, large variations in q are unlikely. In addition, fisher behavior is unlikely to have caused large-scale variations in q over the assessment period because the largest harvesters have maintained relatively consistent sites, gear, and fishing techniques. Gear saturation could also have an effect on the ability of the model to accurately determine q. This is particularly important when a model is selected that uses effort to tune F to influence abundance estimates. A plot of landings and effort did not indicate that gear saturation occurred.

Environmental variation in the upper Chesapeake Bay may be the most confounding of the three influences on q. Commercial fishers suggested that yellow perch migration differs in year with ice cover, in that larger fish will ascend to upper river stretches earlier in the season when ice cover is present. In addition, increased submerged aquatic vegetation could decrease q, which has been noted by at least one commercial yellow perch fisher. The relatively short time span of the assessment likely buffers against error in assuming a constant q. The retrospective analysis indicated that q rose from 1.79 X 10-5 with data through 2014 to 2.19 X 10-5 with data through 2016. However, previous model runs indicated that q fell from the 2007 assessment through the current assessment, and q was stable in 2016 compared to the 2013 analysis.

Interpretation of these values is difficult because the model changed somewhat drastically over time as data matured.

Given the available data, the model performed well and appears to have captured the population dynamics of yellow perch in the upper Chesapeake Bay. Upper Chesapeake Bay yellow perch populations were quite large in 1998 and 1999 due to the recruitment of the dominant 1996 year-class. The lack of another large year-class combined with high mortalities in 2002 caused the population to decline, but stabilize around 1.7 million fish from 2002 – 2009. Poor recruitment then caused the population to decline during 2010 – 2012, before rebounding in 2013 due to the recruitment of the 2011 year-class. Recent successful year-classes in 2014 and 2015 appear to have pushed abundance over 2 million fish, but this abundance relies heavily on age 1 and 2 fish. These age-classes are generally the least reliable estimates in this model.

Recruitment was a prime contributor to population abundance, even when F varied from 0.04 – 0.97. Two year-old yellow perch contributed 23% on average to total population abundance. However, 2 year-old yellow perch comprised 56% of the population in years with the largest three year-classes, and only 3% in the 3 years with the smallest year-classes. Piavis et al. (1993) suggested that dominant year-classes were important for yellow perch populations in the Chesapeake Bay region. A strong 1985 year-class in the Choptank River sustained the population over a period of low recruitment from 1986 – 1992. Similarly, the strong 1984 year-class in the upper Chesapeake Bay was responsible for higher commercial landings during the late 1980's, followed by a period of low recruitment and declining commercial harvest.

Commercial yellow perch regulations changed from a minimum size limit only to a slot limit in 2000. Uphoff and Piavis (1999) simulated population responses for several management scenarios ranging from *status quo* to high minimum size limits and slot limits. Slot limits provided more diversity in the age composition of the spawning stock over a wider range of F. The statistical catch-at-age model produced annual survival estimates at age. During the period before the slot limit was enacted (1998 – 1999), survival of age 8+ yellow perch averaged 52%, but when the slot limit was in effect (2000 – 2016) average annual survival increased to 73%. Variation in fishing effort could confound the interpretation of the increased annual survival at age. From 1998 – 1999, fishing effort averaged approximately 20,000 fyke net days, compared to 11,000 for the period 2000 – 2016. Undoubtedly, both factors (decreased effort and establishment of a maximum size limit) caused the increased survival of age 8+ yellow perch.

Instantaneous fishing mortality estimates and variability of the estimates from bootstrapping determined the probability that overfishing was occurring on yellow perch stocks in the upper Chesapeake Bay. Point estimates of F indicated that since biological reference points were adopted for management (2002), the F_{limit} was exceeded in 2002 (97% probability) . F_{target} was never exceeded (except 2002, of course) but uncertainty analysis indicated that there was a 50% probability and a 62% probability that F_{target} was exceeded in 2003 and 2004, respectively. There was an 8% chance that the target was exceeded in 2016 and 0% probably that the limit was exceeded in 2016. Given the low probability of exceeding F-based biological reference points, we determined that overfishing was not occurring in the upper Chesapeake Bay. Currently, no biomass based targets or limits have been determined so assessment of over-fished status cannot be determined.

Choptank River yellow perch relative abundance has increased significantly after 2000. Estimated fishing mortality averaged F=0.15 (Project 1 Job 1). In addition, recruitment, as defined by relative abundance of 3 year old yellow perch was relatively high during 2006 – 2009, 2012 and 2014, balanced by low 3 year-old relative abundance in 2010, 2011, 2013, and 2015 (Project 1 Job 1). Based on recent F estimates and results from the SSB/R analysis utilizing a 9” minimum size limit selectivity pattern, over 60% MSP can be achieved. The calculated MSP is considerably higher than the current target (35% MSP), and as such, over-fishing is not occurring.

PROJECT NO. 1
JOB NO. 2

POPULATION ASSESSMENT OF YELLOW PERCH IN MARYLAND WITH SPECIAL EMPHASIS ON HEAD-OF-BAY STOCKS

2017 PRELIMINARY RESULTS

Job 2 is designed to assess white perch, yellow perch, and channel catfish on a rotating, triennial basis. The white perch assessment is currently in progress. The upper Bay assessment (relying on Project 1’s trawl survey) and Choptank River assessment (relying on Job 1’s fyke net survey) both utilized a Catch Survey Analysis. The base models have been written and will be completed once commercial and recreational harvest data are finalized. The lower Bay assessment will examine trends in fishery dependent relative abundance.

LIST OF TABLES

LIST OF FIGURES

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

YEAR	TAC	ADJUSTED TAC	HARVEST
2009	38,000		49,951
2010	44,900	39,949	49,629
2011	47,200	37,520	37,543
2012	38,973	38,950	36,975
2013	29,800	29,800	19,352
2014	27,200	27,200	19,305
2015	30,489	30,489	34,478
2016	46,098	42,109	56,501

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

Year	Length sample size	Age sample size	
		Females	Males
1998	890	131	67
1999	1,453	231	42
2000	1,670	187	59
2001	4,45	79	19
2002	1,440	79	43
2003	1,078	69	35
2004	964	70	39
2005	973	56	45
2006	1,015	56	44
2007	1,386	53	34
2008	8,927	272	89
2009	1,321	69	42
2010	1,322	56	49
2011	1,031	58	59
2012	1,057	64	38
2013	1,127	80	48
2014	871	65	31
2015	1,379	35	27
2016	1,861	54	48

Table 3 Catch-at age matrix for upper Chesapeake Bay yellow perch, 1998 –2016. Entries in bold were lowest value to substitute for 0 estimated catch.

Year	2	3	4	5	6	7	8+
1998	5,460	3,086	51,318	151,407	**127**	**1,437**	**414**
1999	0	224,304	7,503	65,241	79,448	6,984	794
2000	0	876	162,415	4,826	9,278	15,570	**414**
2001	0	27,708	11,273	169,957	3,936	4,546	7,441
2002	4,902	24,777	119,202	11,544	211,205	4,101	27,478
2003	231	45,646	1,400	34,692	4,621	37,693	3,612
2004	0	55,005	70,522	8,333	8,088	**1,437**	6,462
2005	0	377	99,246	24,017	3,068	1,437	4,127
2006	1,735	24,636	580	31,575	7,688	**1,437**	580
2007	0	5,604	54,280	1,564	20,722	6,972	1,173
2008	0	1,643	5,076	7,509	127	1,551	414
2009	1,596	1,746	34,940	27,300	29,895	1,681	3,194
2010	268	31,845	11,182	24,510	25,136	23,258	2,057
2011	874	2,498	37,262	11,092	15,746	13,532	7,413
2012	282	25,352	1,313	40,802	1,126	15,353	14,779
2013	659	8,741	25,652	3,250	7,555	1,757	1,889
2014	0	23,789	12,008	6,035	1,410	4,073	1,699
2015	412	412	49,496	14,831	11,300	**1,437**	4,708
2016	6,083	2,151	1,780	87,015	22,180	16,320	2,448

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

Age	f_{rs}	selectivity pattern (p)		c	d	M
		Slot limit	9"msl			
1	0.00	0.00	0.00	0.95	0.15	0.25
2	0.35	0.01	0.18	0.95	0.15	0.25
3	0.80	0.22	0.50	0.95	0.15	0.25
4	1.00	0.67	0.80	0.95	0.15	0.25
5	1.00	1.00	1.00	0.95	0.15	0.25
6	1.00	0.97	1.00	0.95	0.15	0.25
7	1.00	1.00	1.00	0.95	0.15	0.25
8	1.00	0.12	1.00	0.95	0.15	0.25
9	1.00	0.09	1.00	0.95	0.15	0.25
10	1.00	0.00	1.00	0.95	0.15	0.25
11	1.00	0.00	1.00	0.95	0.15	0.25
12	1.00	0.00	1.00	0.95	0.15	0.25

Table 5. Coefficient of variation of catchability (q), instantaneous fishing mortality (F), population abundance (N) and exploitable abundance (ages 3 and older; Ne) for upper Chesapeake Bay yellow perch statistical catch at age model.

Parameter	**C.V.**	**Parameter**	**C.V.**	**Parameter**	**C.V.**
q comm	28.6	N 1998	13.2	Ne 1998	8.8
q trwl	21.0	N 1999	6.5	Ne 1999	7.8
q seine	22.5	N 2000	8.7	Ne 2000	10.2
F 1998	18.0	N 2001	14.7	Ne 2001	10.0
F1999	20.3	N 2002	20.6	Ne 2002	12.9
F2000	19.7	N 2003	23.7	Ne 2003	22.1
F2001	19.1	N 2004	25.3	Ne 2004	25.6
F2002	20.7	N 2005	25.9	Ne 2005	30.9
F2003	28.2	N 2006	25.2	Ne 2006	29.6
F2004	32.7	N 2007	25.4	Ne 2007	28.7
F2005	36.2	N 2008	24.3	Ne 2008	28.3
F2006	36.5	N 2009	24.3	Ne 2009	28.0
F2007	37.0	N 2010	24.9	Ne 2010	27.1
F2008	33.5	N 2011	25.5	Ne 2011	30.5
F2009	30.3	N 2012	25.0	Ne 2012	30.4
F2010	31.3	N 2013	25.7	Ne 2013	30.3
F2011	32.0	N 2014	25.8	Ne 2014	26.7
F2012	33.6	N 2015	28.7	Ne 2015	27.5
F2013	32.9	N 2016	30.3	Ne 2016	28.8
F2014	31.5				
F2015	29.7				
F2016	30.1				

Table 6. Coefficient of variation of total yellow perch biomass estimates (B) and exploitable biomass (ages 3 and older; Be) for upper Chesapeake Bay yellow perch statistical catch at age model.

Parameter	**C.V.**	**Parameter**	**C.V.**	**Parameter**	**C.V.**
B 1998	10.2	Be 1998	9.1	R 1998	38.0
B 1999	7.4	Be 1999	7.9	R 1999	15.3
B 2000	9.9	Be 2000	10.8	R 2000	19.9
B 2001	10.7	Be 2001	10.5	R 2001	31.7
B 2002	15.9	Be 2002	13.6	R 2002	27.6
B 2003	23.7	Be 2003	23.3	R 2003	29.5
B 2004	25.8	Be 2004	26.3	R 2004	27.5
B 2005	28.2	Be 2005	31.6	R 2005	26.5
B 2006	28.5	Be 2006	30.7	R 2006	24.4
B 2007	28.1	Be 2007	29.9	R 2007	23.7
B 2008	28.4	Be 2008	29.8	R 2008	23.9
B 2009	26.8	Be 2009	29.0	R 2009	26.2
B 2010	27.8	Be 2010	28.7	R 2010	27.1
B 2011	29.1	Be 2011	32.0	R 2011	27.3
B 2012	28.3	Be 2012	32.3	R 2012	27.4
B 2013	27.6	Be 2013	32.2	R 2013	32.1
B 2014	27.3	Be 2014	27.6	R 2014	35.0
B 2015	27.0	Be 2015	28.0	R 2015	42.1
B 2016	27.6	Be 2016	29.3	R 2016	49.1

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

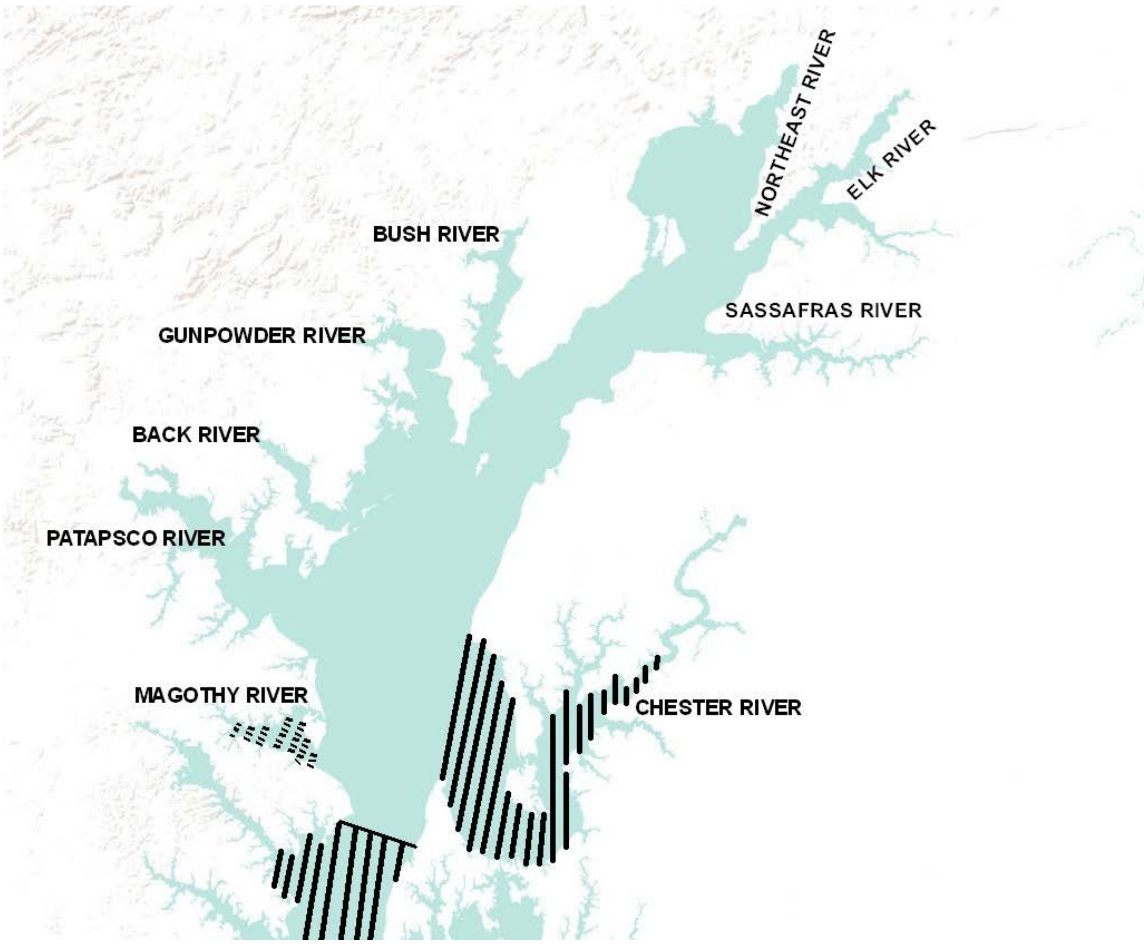


Figure 2. Upper Chesapeake Bay winter trawl survey locations for the 2016 sampling season.

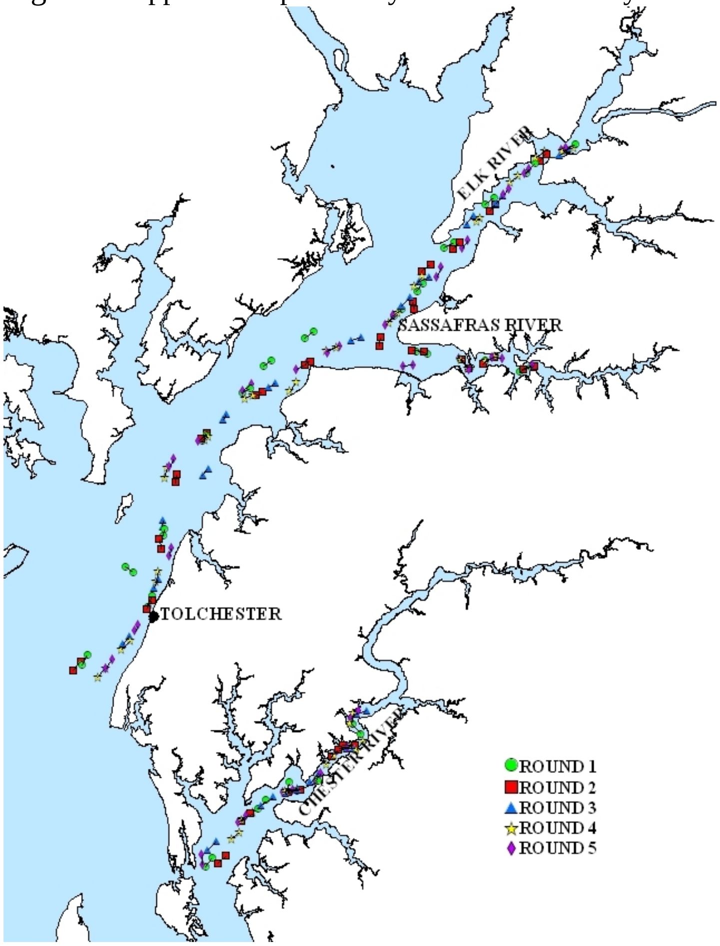


Figure 3. Commercial yellow perch landings v. fyke net effort for upper Chesapeake Bay yellow perch fishery with statistically significant linear trend line.

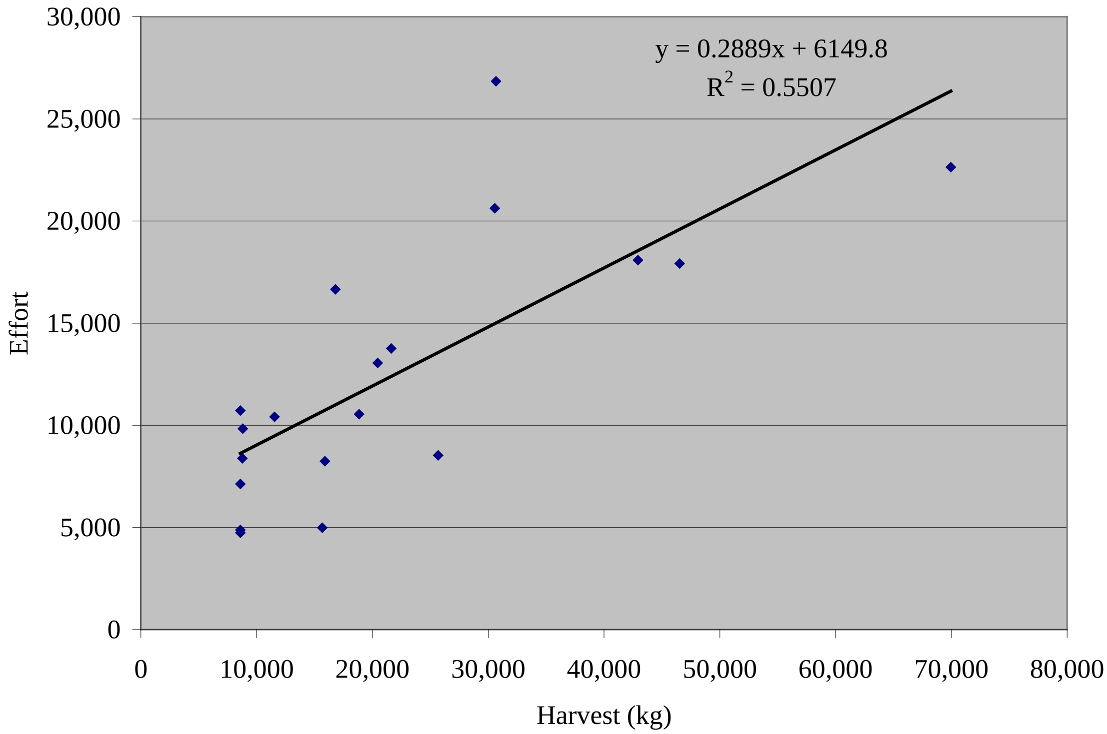


Figure 4. Yellow perch commercial fyke net selectivity ogives for 2 time periods, 1998-1999 and 2000-2016.

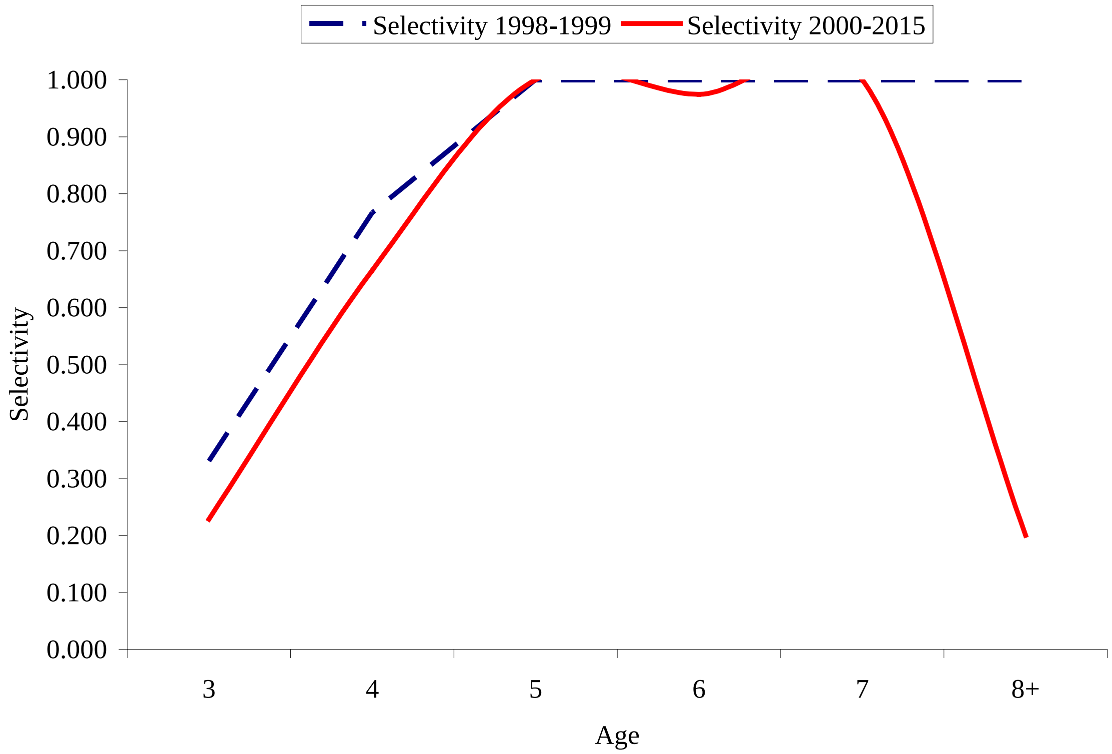


Figure 5. Upper Chesapeake Bay yellow perch abundance estimates (N, all ages), 1998 – 2016.

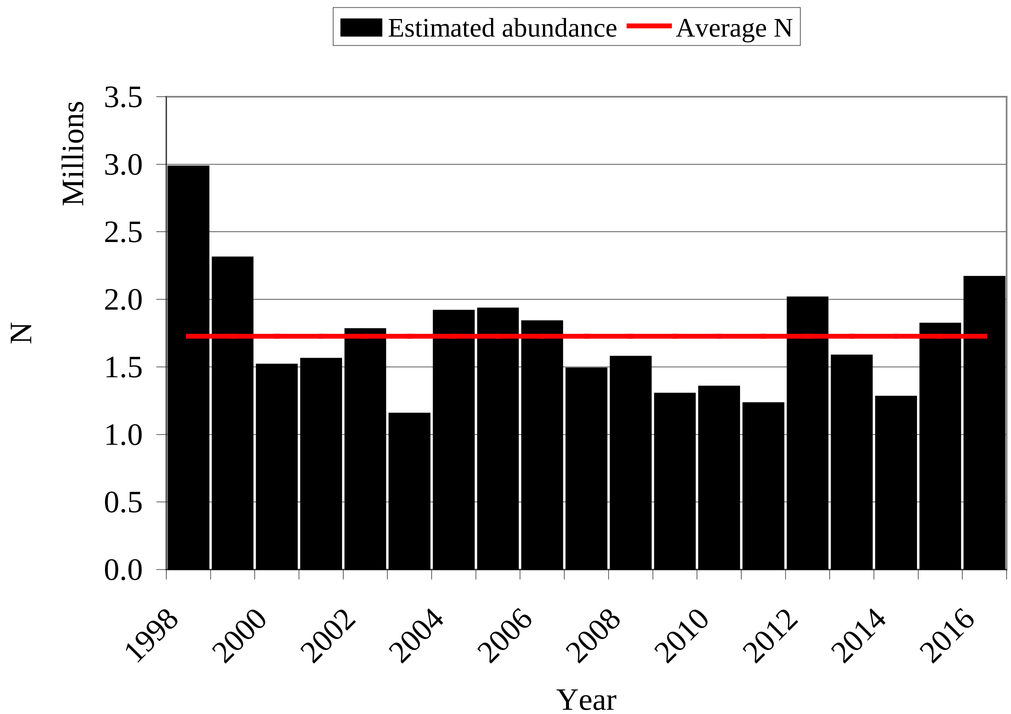


Figure 6. Upper Chesapeake Bay yellow perch biomass (kg, all ages) estimates, 1998 – 2016.

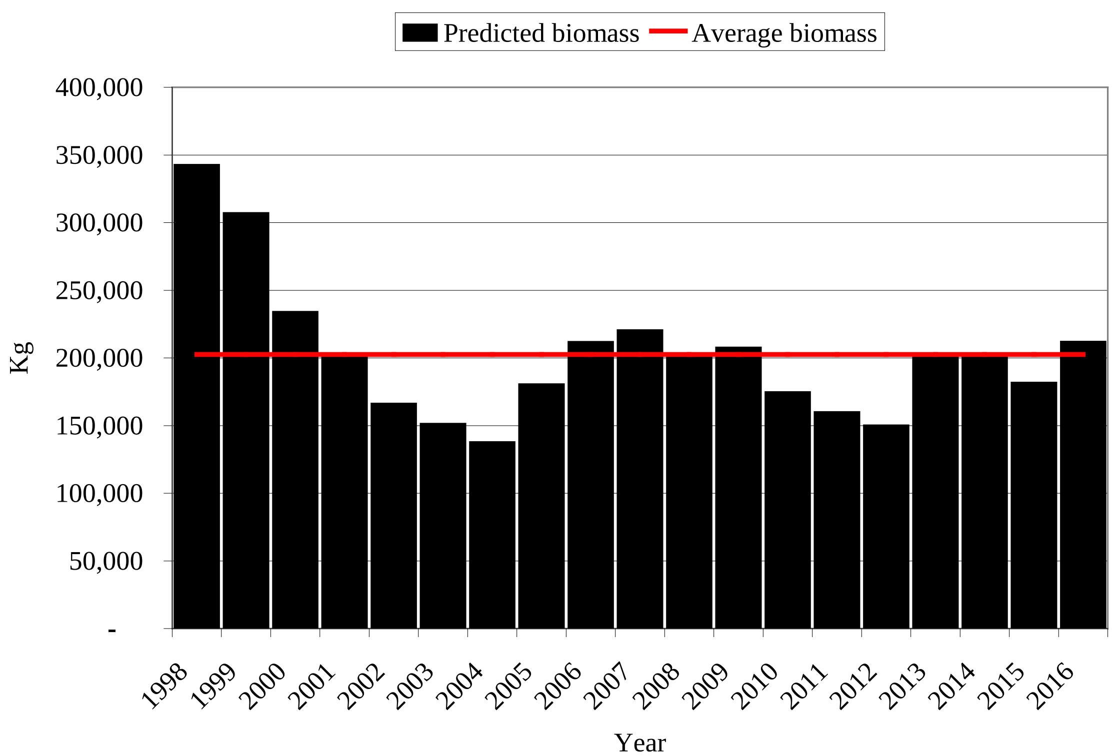


Figure 7. Upper Chesapeake Bay yellow perch fully recruited instantaneous fishing mortality (F) estimates, 1998 – 2016.

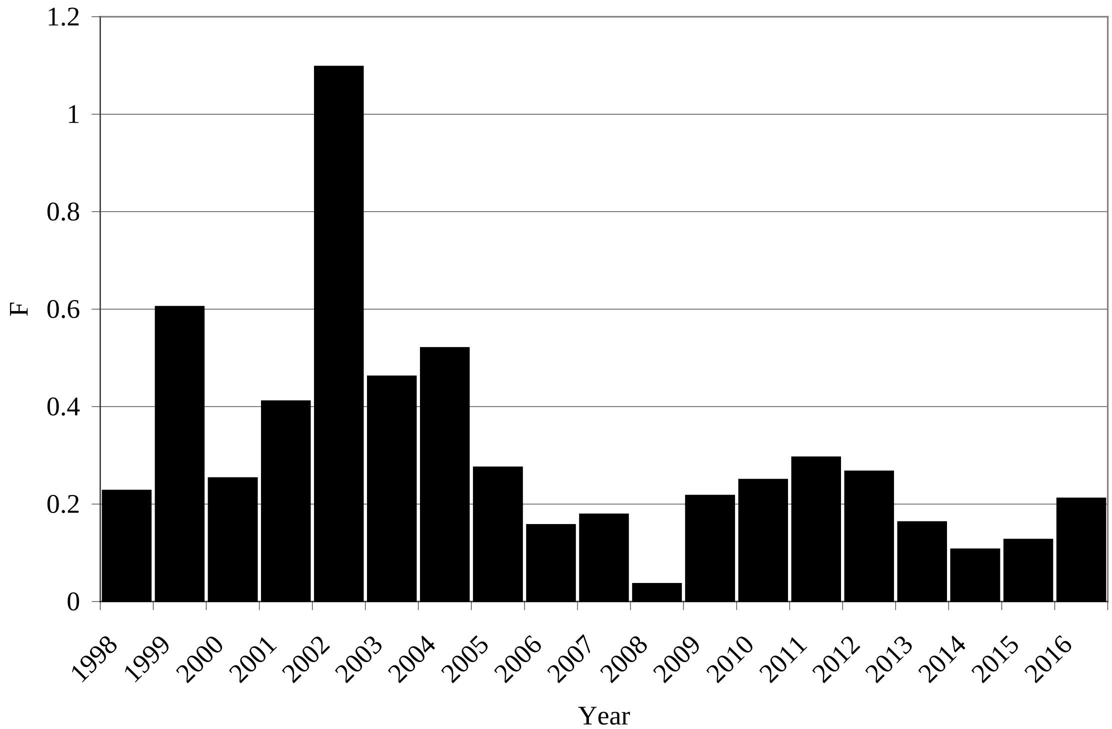


Figure 8. Upper Chesapeake Bay yellow perch recruitment (R, age 1) estimates, 1998 – 2016. Horizontal line indicates time series average.

Figure 9. Age 3+ trawl index residuals from upper Chesapeake Bay yellow perch population model.

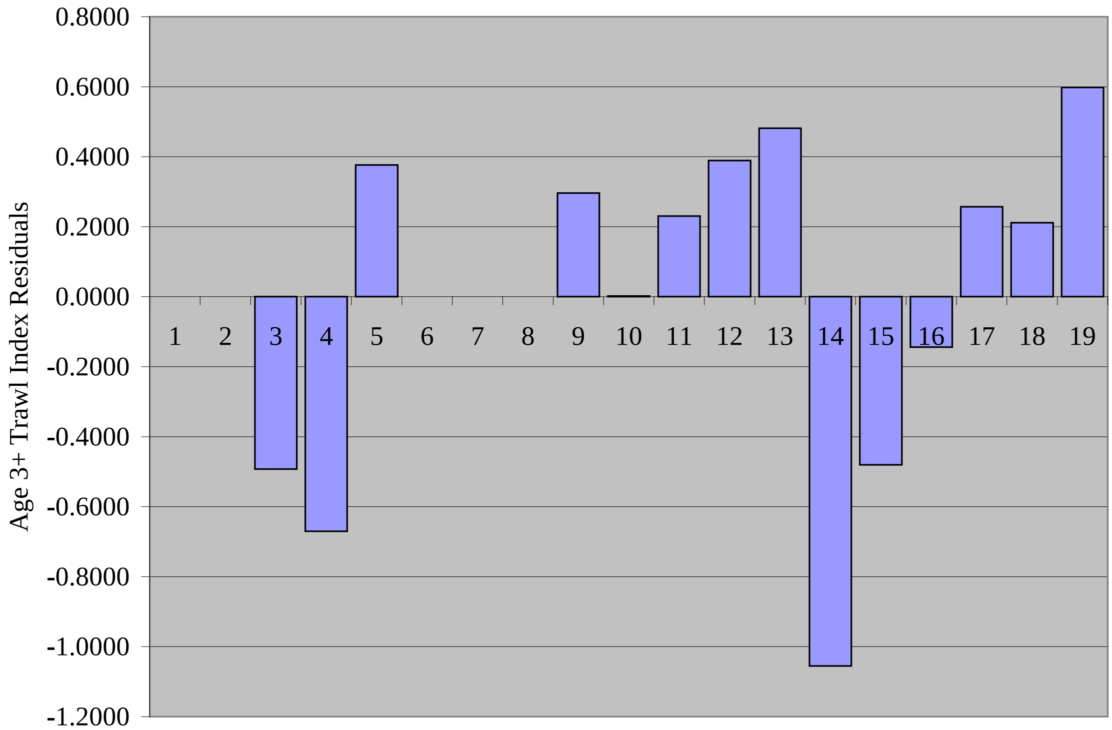


Figure 10. Age 1 trawl index residuals from upper Chesapeake Bay yellow perch population model.

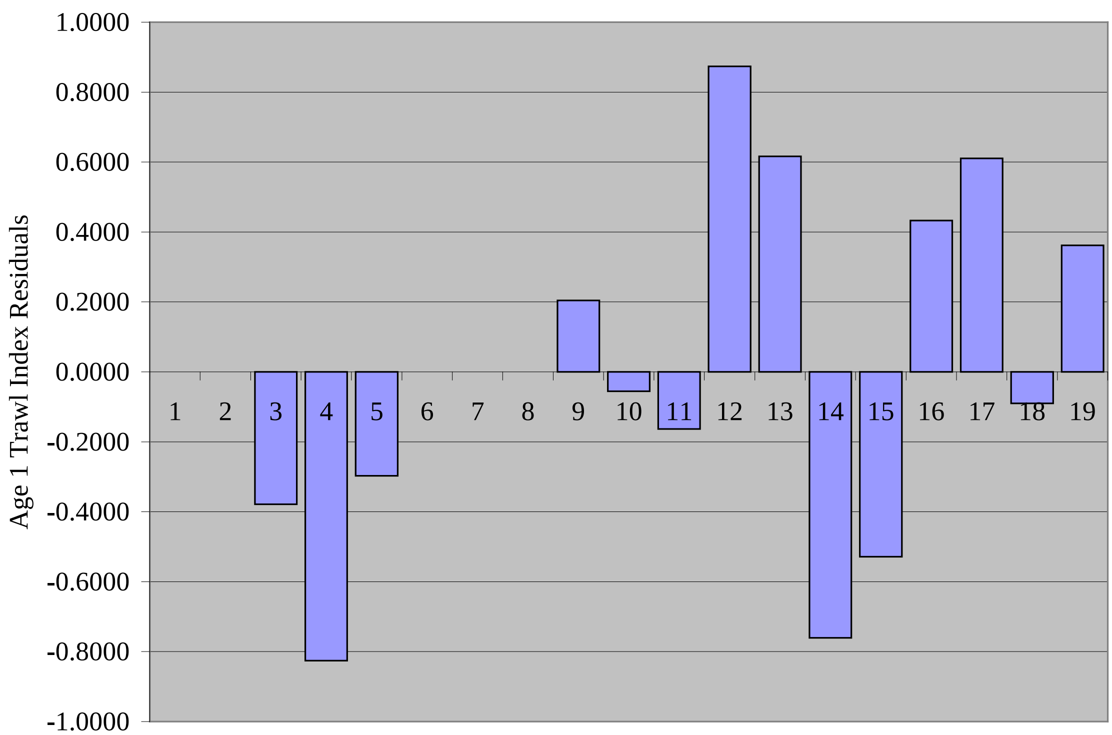


Figure 11. Age 2 trawl index residuals from upper Chesapeake Bay yellow perch population model.

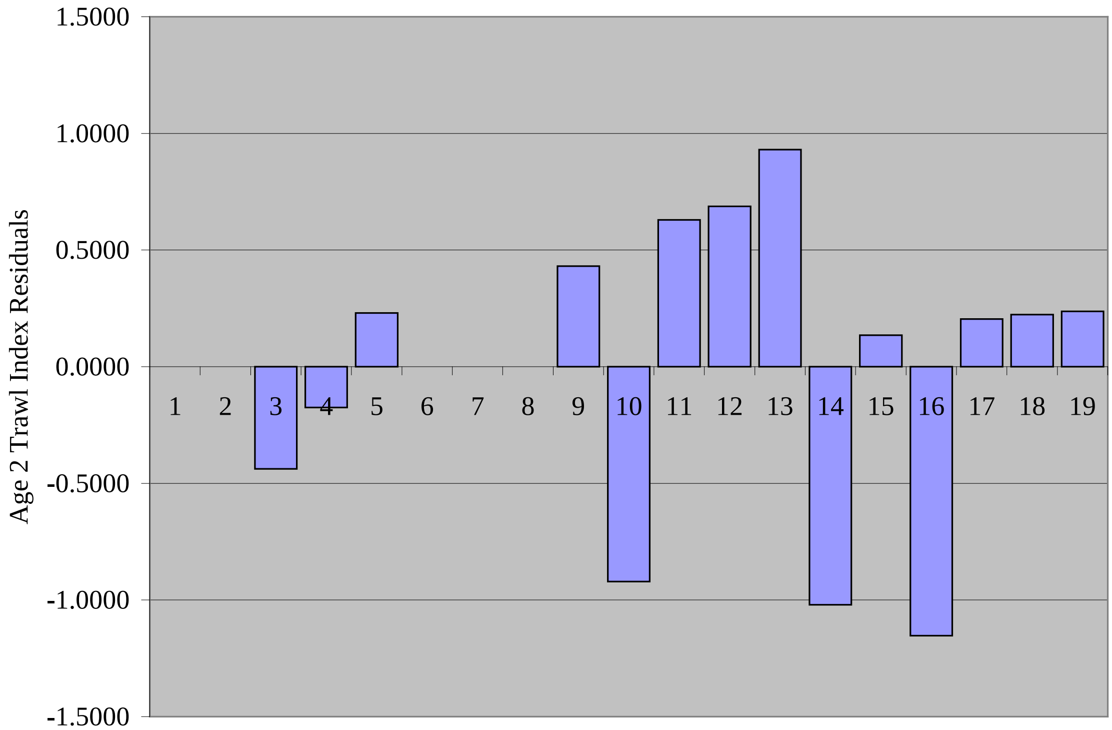


Figure 12. Age 1 seine index residuals from upper Chesapeake Bay yellow perch population model.

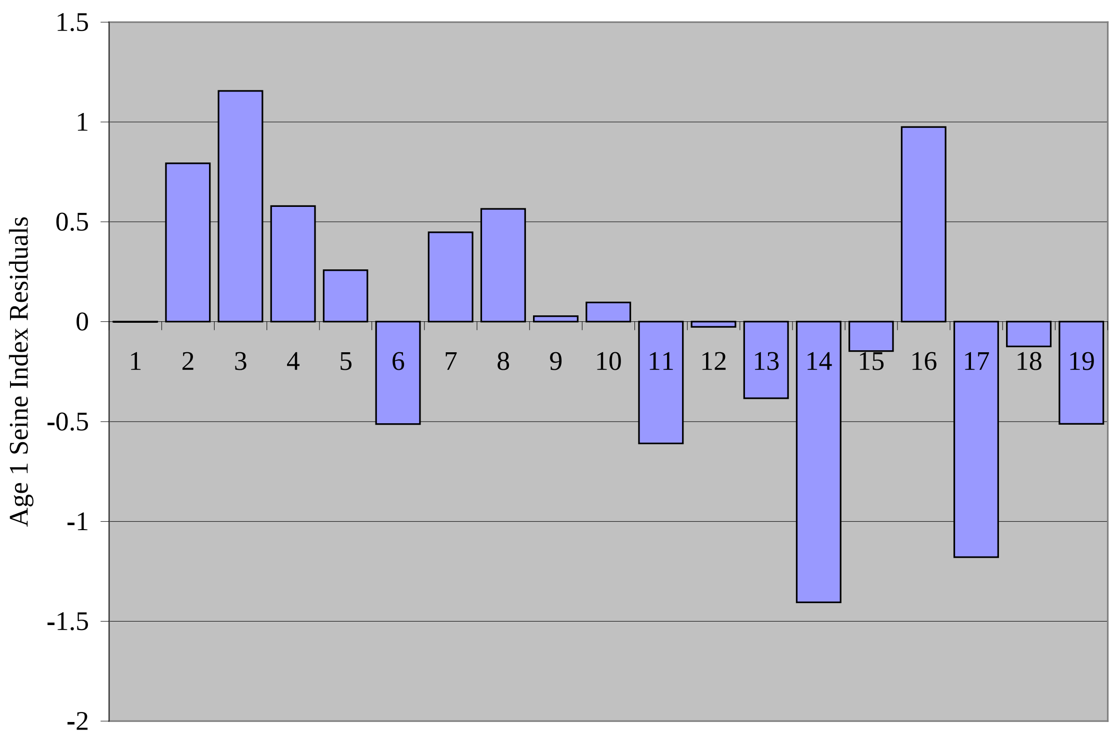


Figure 13. 80% confidence intervals of abundance (N) estimates from upper Chesapeake Bay yellow perch population model.

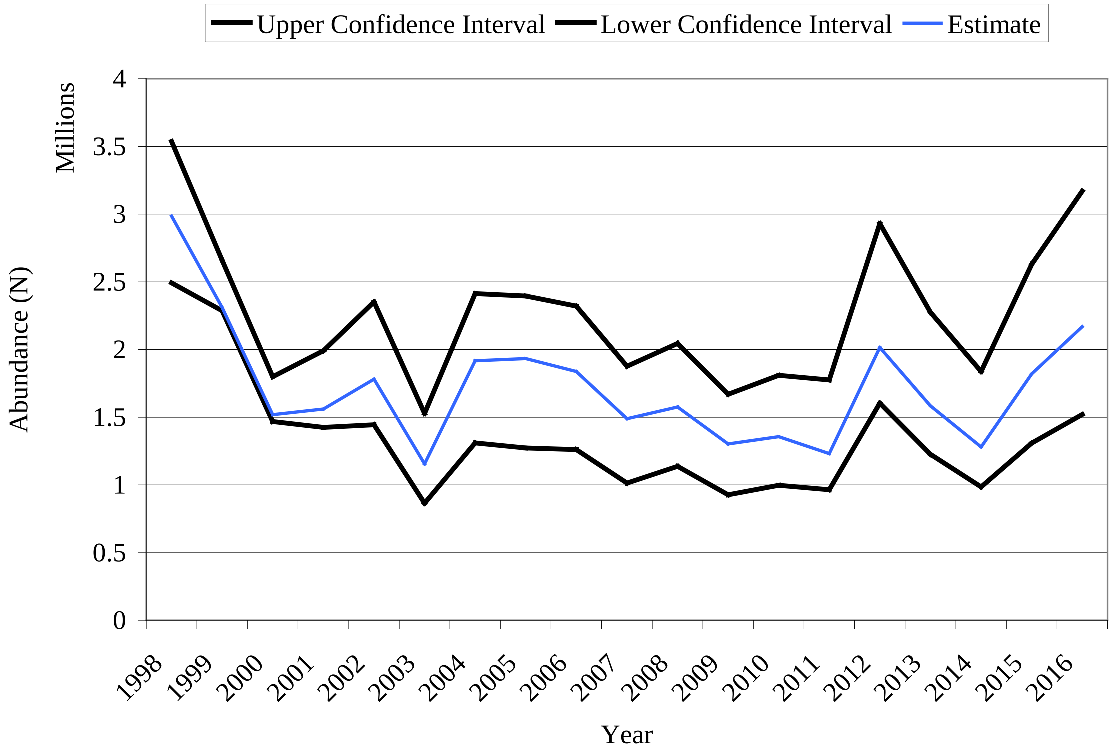


Figure 14. 80% confidence intervals of exploitable biomass estimates (kg, ages 3+) from upper Chesapeake Bay yellow perch population model.

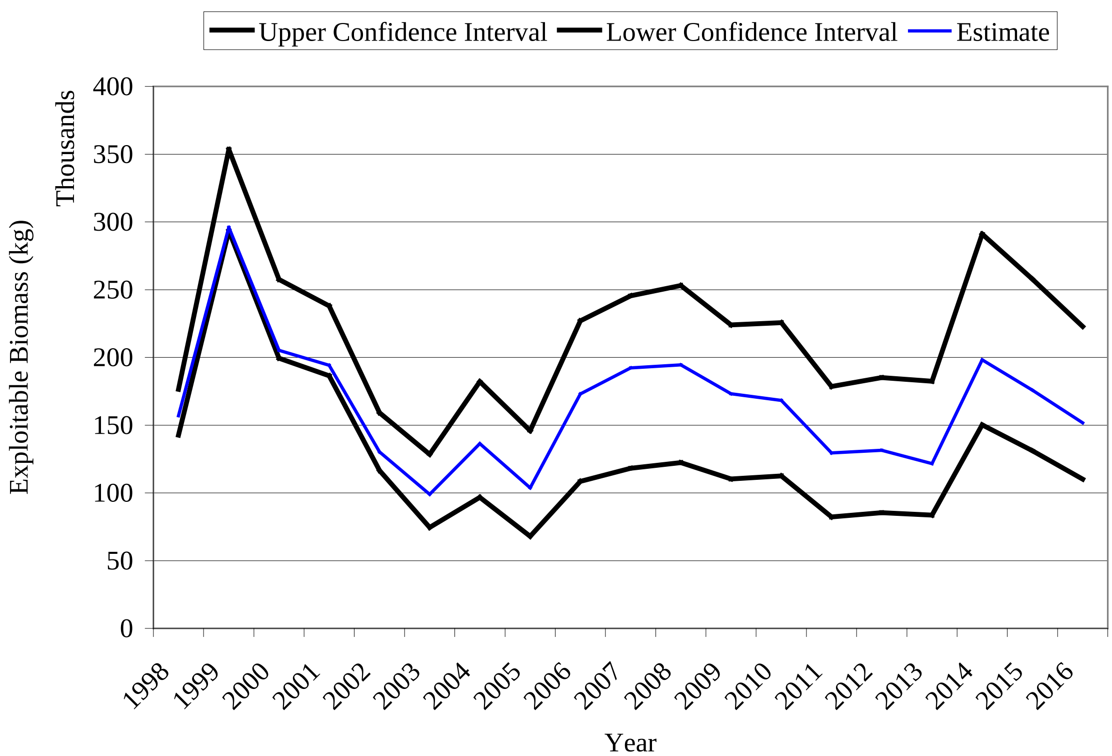


Figure 15. 80% confidence intervals of recruitment (age 1, R) estimates from upper Chesapeake Bay yellow perch population model.

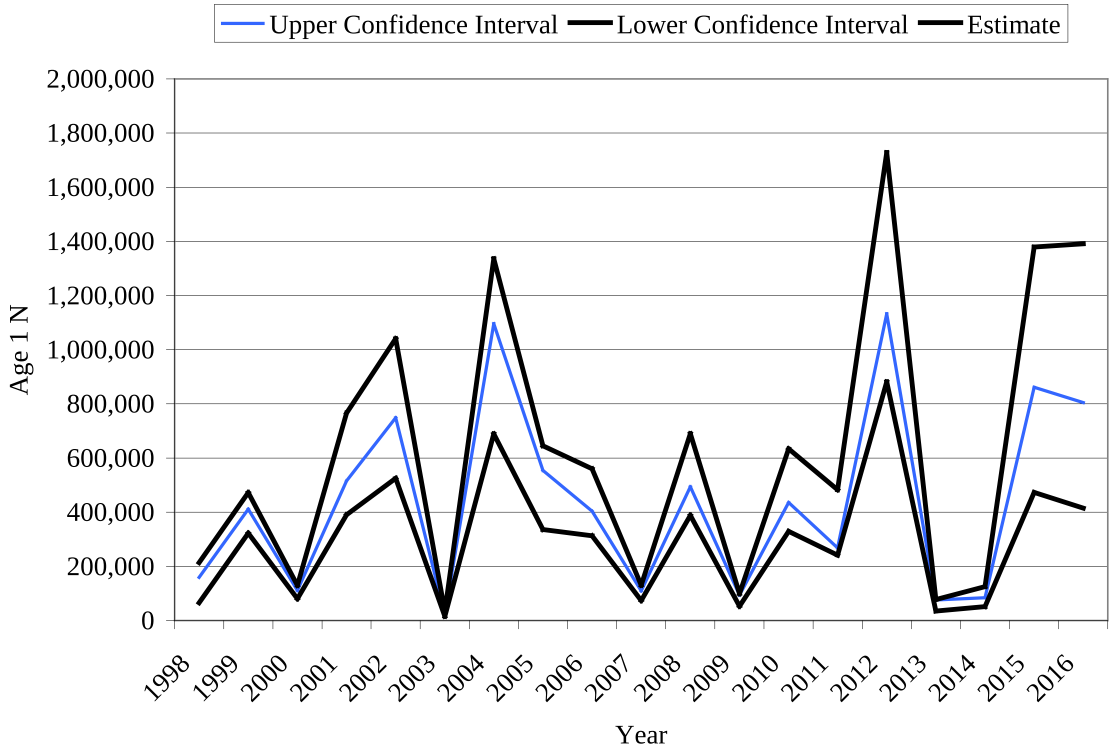


Figure 16. 80% confidence intervals of fully recruited F estimates from upper Chesapeake Bay yellow perch population model.

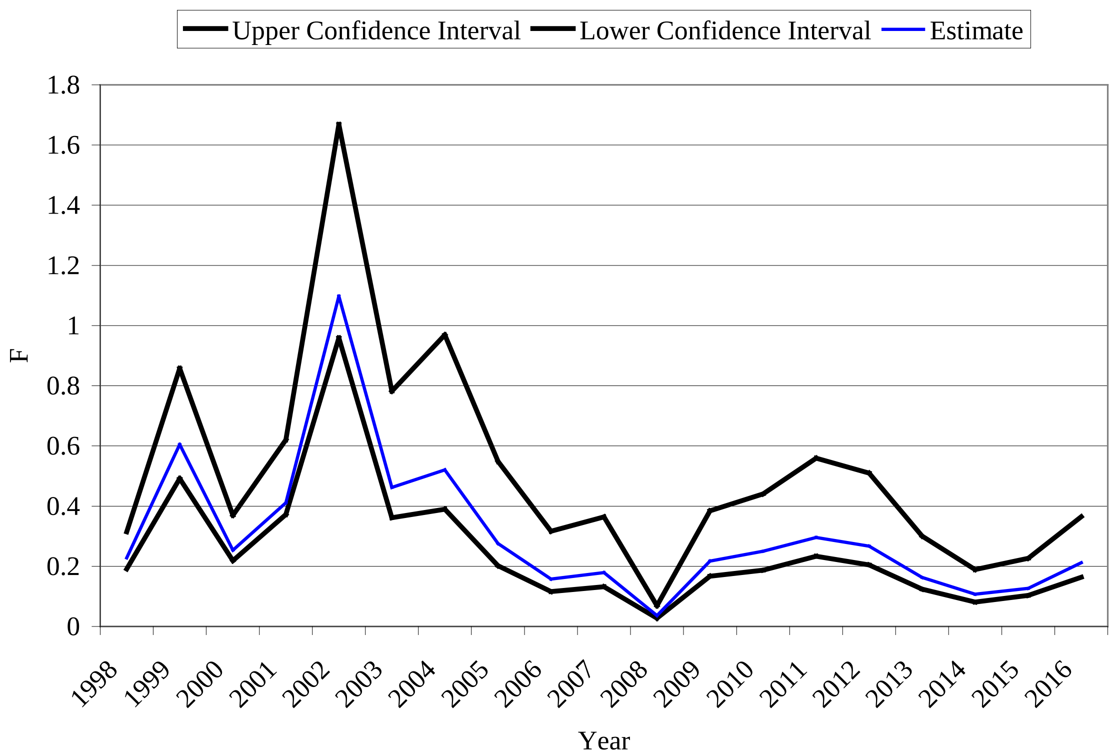


Figure 17. Retrospective analysis of abundance estimates from upper Chesapeake Bay yellow perch population model.

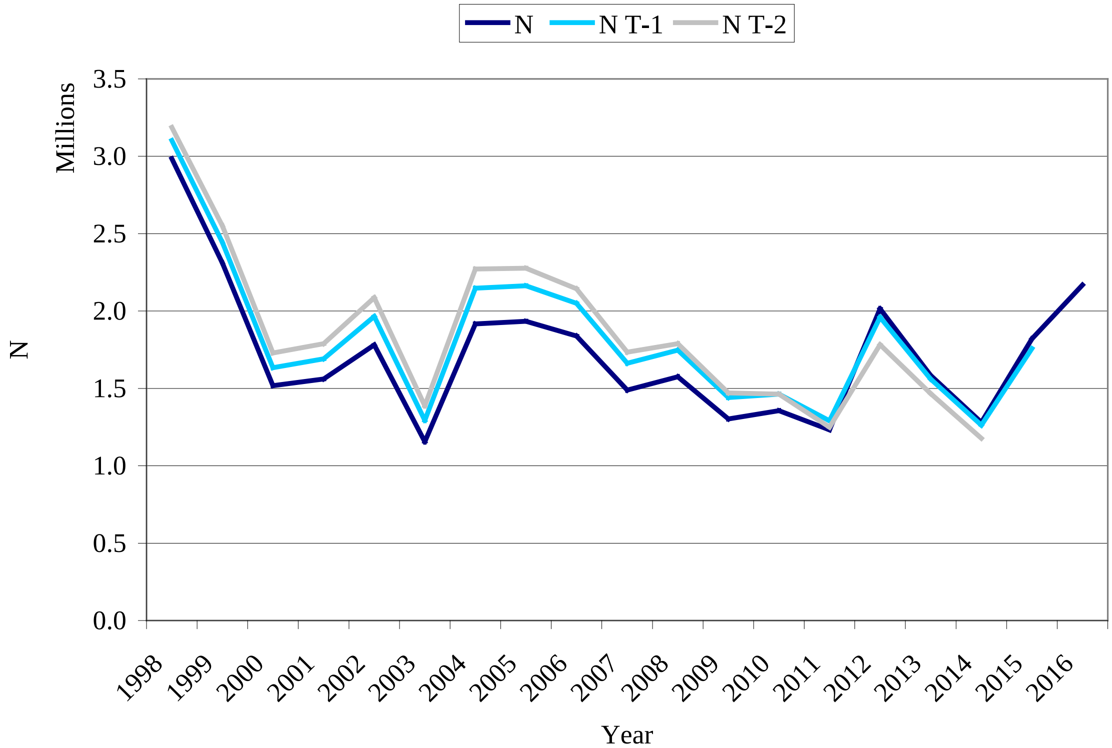


Figure 18. Retrospective analysis of recruitment estimates (R) from upper Chesapeake Bay yellow perch population model.

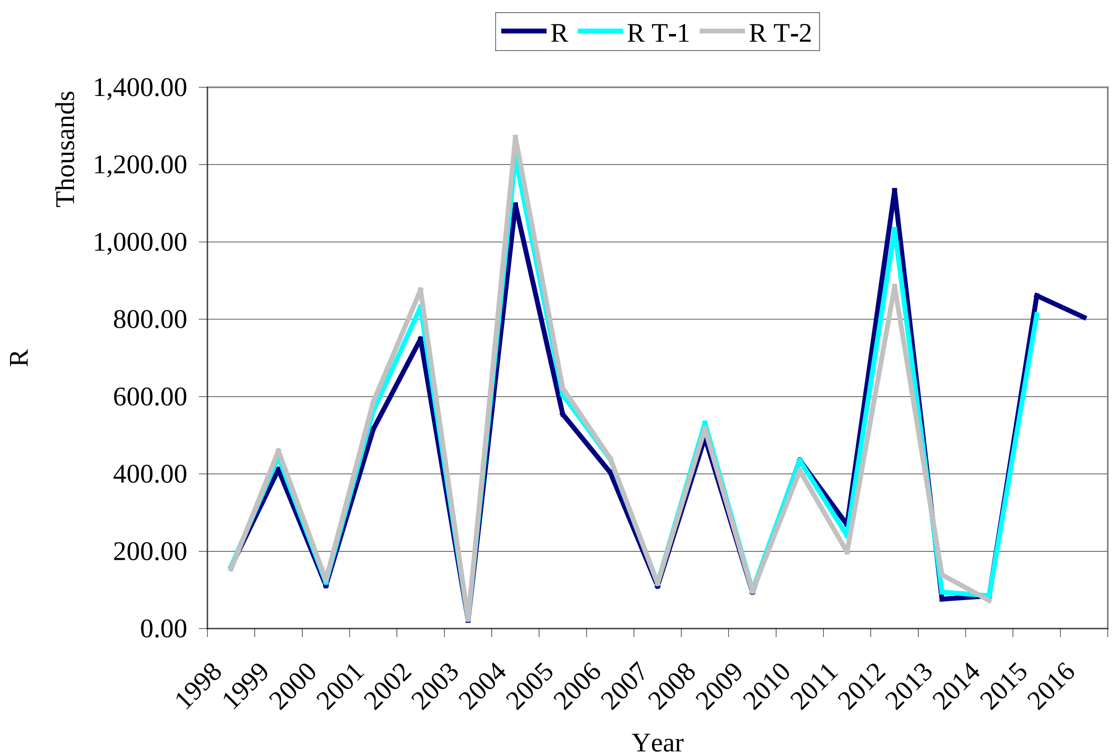


Figure 19. Retrospective analysis of F estimates from upper Chesapeake Bay yellow perch population model.

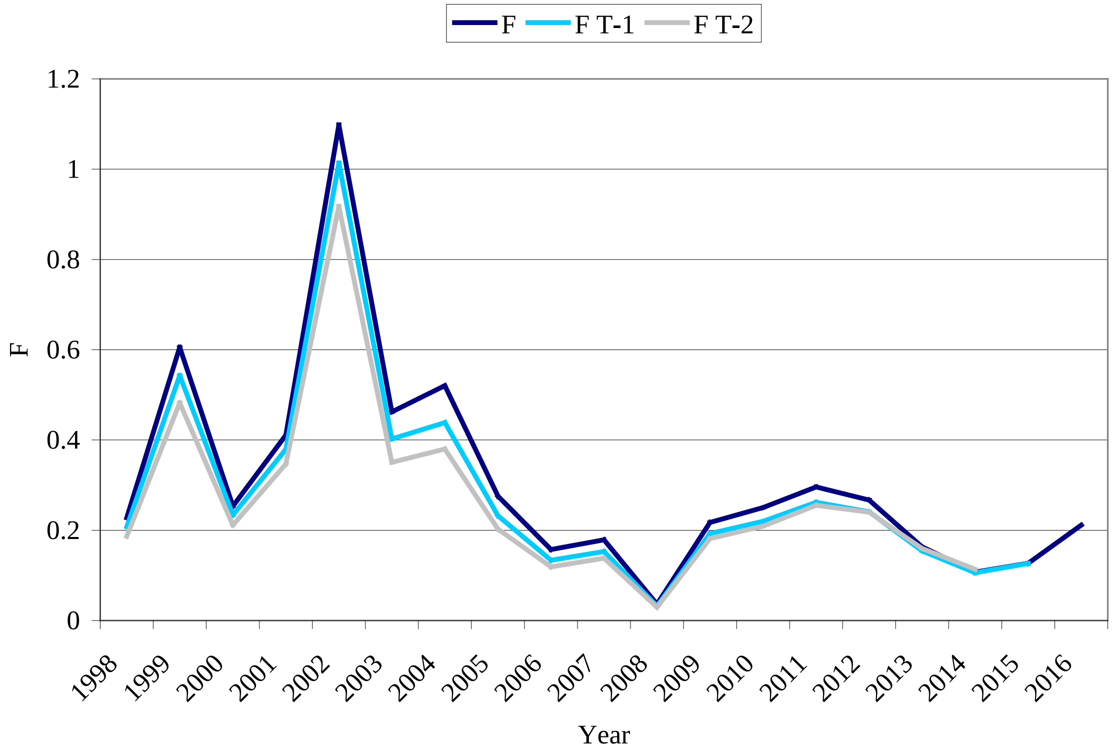


Figure 20. Percent maximum spawning potential (%MSP) versus F from Chesapeake Bay yellow perch spawning stock biomass/recruit model for 8 1/2” – 11” slot limit.

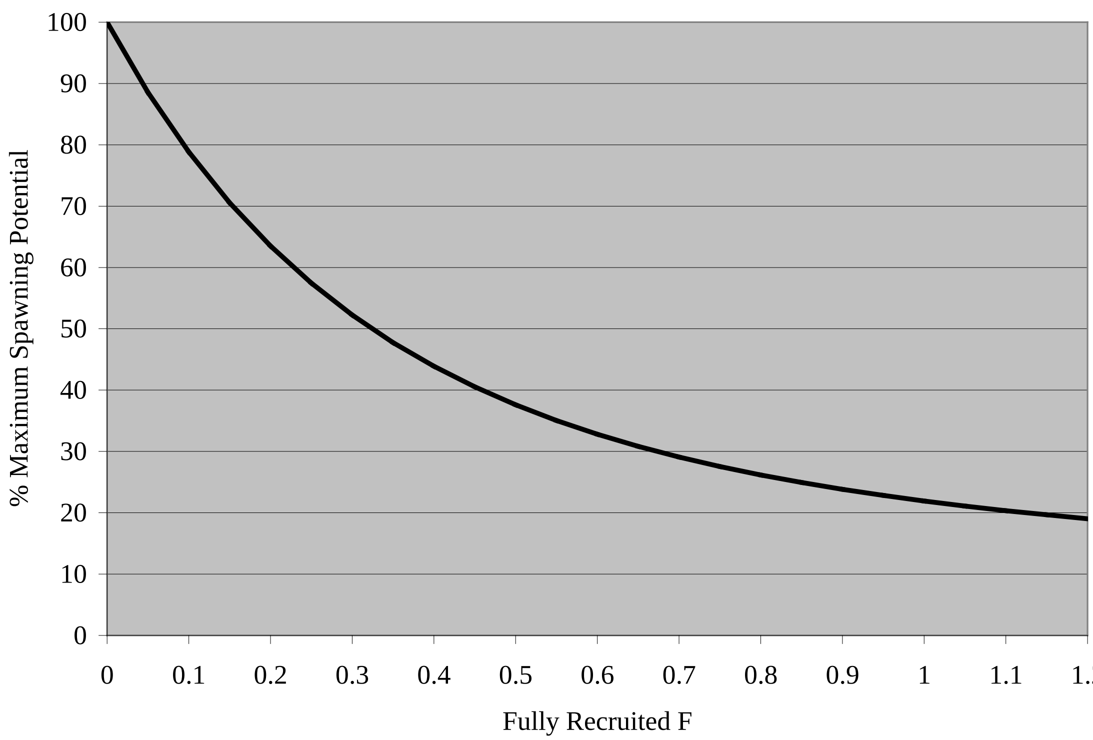


Figure 21. Percent maximum spawning potential (%MSP) versus F from Chesapeake Bay yellow perch spawning stock biomass/recruit model for 9" minimum size limit.

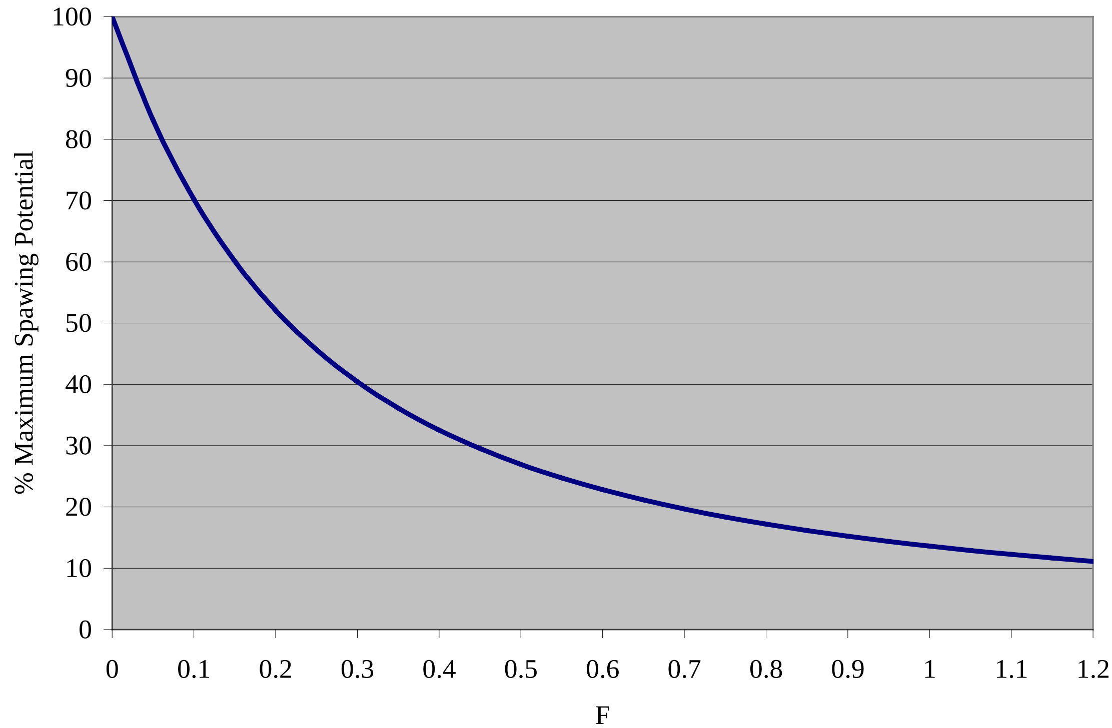
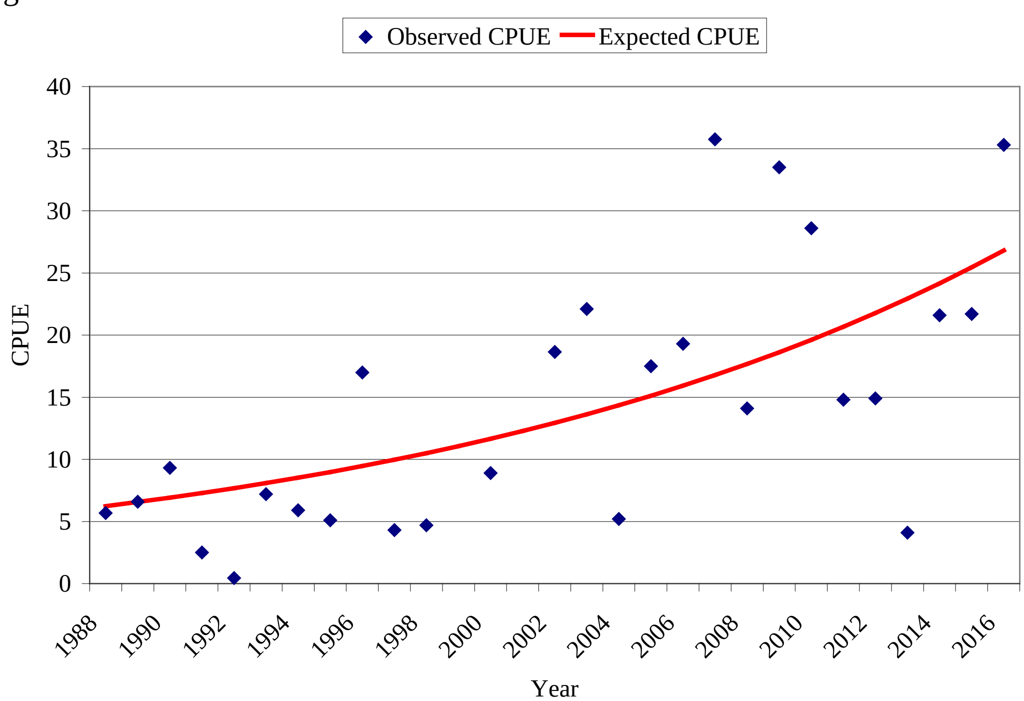


Figure 22. Yellow perch relative abundance (fish/net day) from Choptank River fishery independent fyke net survey, 1988 – 2016. Predicted CPUE curve is statistically significant at $P < 0.0002$.



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 15 April through 31 May 2016 (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 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 (2004-2016) 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 (2006-2016). 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 29 April 2016 (Figure 2). Fish captured from these nets were sorted according to species and transferred to the survey boat for processing. All nets were sampled 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. Beginning in 2016, the first five alewife and the first five 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 4 April to 29 April 2016. 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 1 April to 14 May 2016. 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 16 March to 17 May 2016. 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. Beginning in 2016, the first seven alewife and the first seven 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, 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). 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. 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. Hickory shad scales from the Susquehanna River were aged by the Maryland Department of Natural Resources Restoration and Enhancement Program. Repeat spawning marks were counted on all alosine scales during ageing. Ageing of otolith samples will be conducted as time allows.

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. The relative abundance (GM CPUE) of American shad, alewife herring and blueback herring in the Nanticoke River was calculated for each net day by gear type. 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. Gill net surveys that specifically target American shad typically use mesh sizes of 5 to 5.5 inches (Richardson et al., 2009), so the changes made to the SBSSS gill net should have minimal affect on American shad catch and therefore CPUE moving forward.

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 2016), the number of small generation units operating, the number of large generation units operating, 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 2016 (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

Catch curve analysis was used to estimate total instantaneous mortality (Z) of adult American shad, hickory shad and river herring from all systems surveyed where species' data were available. The number of repeat spawning marks was used in this estimation instead of age because ageing techniques for American shad scales are tenuous (McBride et al. 2005). Therefore, the Z calculated for these fish represents mortality associated with repeat spawning. Assuming that consecutive spawning occurred, the ln-transformed spawning group frequency was plotted against the corresponding number of times spawned:

$$\ln(S_{fx} + 1) = a + Z * W_{fx}$$

where S_{fx} is number of fish with 1,2,...f spawning marks in year x, a is the y-intercept, and W_{fx} is frequency of spawning marks (1,2,...f) in year x. Using Z, annual mortality (A) for American

Shad was obtained from a table of exponential functions and derivatives (Ricker 1975). This calculation of Z may bias mortality high if skip spawning is occurring (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 seven days in 2016. Fertilized alosine eggs and/or larvae were present at 67.2% of tow stations in 2016, which is the highest value of the time series (Table 1). Salinity at tow stations ranged from 0.1 to 2.7 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 1:0.6. Of the 382 fish sampled by this gear, 366 were successfully scale-aged (Table 2). Males were present in age groups 3-7 and females were found in age groups 4-7. The 2011 (age 5) year-class was the most abundant for males and females, accounting for 62% of males and 55% of females (Table 2). Forty-five percent of males and 40% of females were repeat spawners. The percentages of repeat spawners for females decreased in 2016, after a steady increase from 2008-2014 (Figure 5). The arcsine-transformed proportion of these repeat spawners (sexes combined) has significantly increased over the time series (1984-2015; $r^2 = 0.63$, $P < 0.001$; Figure 6). Analysis by PFBC of 556 American shad otoliths collected from the WFL at Conowingo Dam showed that 46.3% were wild fish and 53.7% were hatchery produced fish in 2016. This is an increase from hatchery contribution observed in 2015 (40%).

The male-female ratio for adult American shad captured in the Nanticoke River was 1:0.49. Sixty-four American shad were collected from the Nanticoke pound and fyke nets in 2016 and 49 were subsequently aged (Table 2). Males were present in age groups 3-8 and females were found in age groups 5-8. The 2011 year-class (age 5) was the most abundant year-class for males (41%; Table 2). The 2009 (age 7) and 2011 (age 5) were the most abundant year-classes for females (33%; Table 2). Sixty-two percent of males and 80% 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, (1988-2016; $r^2 = 0.40$, $P < 0.001$; Figure 7). Analysis by DE DFW of American shad otoliths collected from the Nanticoke River have not been completed for the 2016 samples.

The male-female ratio for adult American shad captured in the Potomac River was 1:1.12. Of the 142 American shad collected, 140 were successfully aged (Table 2). Males were present in age groups 4-7, and females were present in age groups 4-8. The most abundant year-class for males and females was the 2011 (age 5) year-class (60% and 48%, respectively). Fifty-six percent of males and 53% 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 (2002-2016; r^2 = 0.01, P = 0.74; Figure 8).

Adult Relative Abundance

Sampling at the Conowingo Dam occurred for 18 days in 2016. A total of 436 adult American shad were encountered by the gear; all of these fish were captured by Maryland Department of Natural Resources staff from a boat. Shore sampling occurred on 11 May 2016, and three additional American shad were caught. Peak catch by hook and line (109 fish) occurred on 28 April 2016 at a surface water temperature of 18°C. Maryland Department of Natural Resources staff tagged 367 (84%) of the sampled fish. One American shad recapture from the Conowingo Dam tailrace was reported by a recreational angler on 30 April 2016.

The EFL operated for 55 days between 1 April and 3 June 2016. Of the 14,276 American shad that passed at the EFL, 89% (7,415 fish) passed between 21 April and 5 May 2016. Peak passage was on 21 April; 1,487 American shad were recorded on this date. Thirty-nine of the American shad counted at the EFL counting windows were identified as being tagged in 2016 and three were identified as being tagged in 2015 (Table 3).

The Conowingo WFL operated for 11 days between 23 April and 15 May 2016. The 861 captured American shad were retained for hatchery operations, sacrificed for characterization data collection, or returned alive to the tailrace. Peak capture from the WFL was on 1 May, when 197 American shad were collected. Three tagged American shad were recaptured by the WFL in 2016, all were tagged in 2016.

The various model configurations explored for developing a GAM for the hook and line index and how each model performed are summarized in Table 4. Due to observed collinearity of day of the year with surface water temperature, day of the year was removed from the model.

The number of small generation units operating and the number of large generation units operating had large VIF values (>3) and were also 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 has a greater effect on catch than flow (Table 4). 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. A bootstrap procedure could be used to test the predictive ability of models 2 and 3, and evaluate model performance by fitting a linear regression to the observed versus predicted values. A bootstrap evaluation will be further developed as time allows.

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 9). The annual hook and line CPUE generated using the best fit GAM shows abundance is variable from 2007-2016, with a slight decrease in 2016, and remains below the high indices observed from 1999-2002 (Figure 10).

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 run count of fish lifted at Conowingo Dam and the combined lift GM CPUE, for years when both the East and West Fish lift were operating, mirror the hook and line index (Figure 11). 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 10 and 11). However, the increase observed in the hook and line index in recent years is not apparent in the other two indices.

One hundred and sixty-four interviews were conducted over 13 days during the creel survey at the Conowingo Dam Tailrace. The CPAH continued to increase in 2016 (Table 5), but has decreased over the time series (2001-2016; $r^2 = 0.28$, $P = 0.04$). 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.

Only one angler returned a paper logbook in 2016. Additionally, 13 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 was slightly larger than the 2015 CPAH estimate (2.18; Table 6). 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 (2000-2016; $r^2 = 0.45$, $P = 0.003$; Table 6).

The 2016 Nanticoke River pound net GM CPUE was similar to 2014. The GM CPUE, is highly variable and shows no significant trend over the time series (1988-2016; $r^2 = 0.14$, $P =$

0.054, Figure 12). The Potomac River CPUE significantly increased over the time series (1996-2016; $r^2 = 0.34$, $P < 0.01$), and was above the time series mean for the past three years (Figure 13).

Population Estimates

The Petersen statistic estimated 127,190 American shad in the Conowingo Dam tailrace in 2016 with an upper confidence limit of 172,322 fish and a lower confidence limit of 93,667 fish (Figure 14). 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, and used the Atlantic herring and mackerel combined landings to estimate bycatch losses. This run estimated a population of 153,171 American shad in the Conowingo Dam in 2016 and produced realistic estimates of the model parameters r, K and B_0 ($r = 0.57$, $K = 1{,}119{,}186$, $B_0 = 52{,}778$; Figure 15). The 2016 SPM estimate is within the confidence intervals if the Petersen estimate for 2016.

Despite differences in yearly estimates, the overall population trends derived from each population model are fairly similar (Figures 14 and 15). 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. Since 2007 the population size has shown a slight increase in recent years (2012-2015; Figure 15). Petersen estimates follow a similar pattern if the high levels of uncertainty in 2004 and 2008 (due to low recapture rates) are considered (Figure 14), although they show a decline in 2016, differing from the SPM estimate.

Mortality

The Conowingo Dam tailrace total instantaneous mortality estimate from catch curve analysis (using repeat spawning instead of age) resulted in Z = 0.97 (A = 62.1%) in 2016, which is higher than both the 2013 (Z = 0.67) and the 2014 (Z = 0.71) estimates. A total instantaneous mortality estimate for American shad captured in the Nanticoke River was not calculated due to small sample size (n = 49).

Juvenile Abundance

The juvenile American shad abundance index provided by the EJFS declined in all sampled tributaries in 2016, following a record high in 2015 (Figures 16-19). 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=20) was not large enough to draw meaningful conclusions about sex and age composition. In Deer Creek, 459 hickory shad were sampled by the broodstock collection survey. The male-female ratio was 1:0.87. Of the total fish captured by this survey, 120 were successfully aged. Males were present in age groups 3-6, and females were present in age groups 3-7 (Table 7). The most abundant year-class was the 2013 year-class (age 3) for males (33%) and the 2012 year class (age 4) for females (47%, Table 8). Since 2012 no hickory shad of ages greater than 7 have been observed (Table 8). The arcsine-transformed proportion of repeat spawners (sexes combined) has not changed significantly over the time series (2004-2016; r^2 = 0.27, P = 0.07; Figure 20). The total percent of repeat spawners in 2016 (70.8%) increased from the record lows observed in 2014 and 2015 (Table 9).

Relative Abundance

Shad logbook and Volunteer Angler Shad Survey data indicated that hickory shad CPAH did not vary significantly over the time series (1998-2016; $r^2 = 0.04$, $P = 0.4$). Hickory shad CPAH in 2016 was the second highest year on record since 1998 when this survey began (Table 10). On the Nanticoke River, only 20 fish were captured by pound and fyke nets, but this is the fourth highest number of 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 = 0.70. This estimate is similar to the 2013 and 2015 Z estimates (Z = 0.78 and 0.68, respectively), but much higher than the 2014 estimate (Z = 0.36).

Alewife and Blueback Herring

Sex, Age and Stock Composition

The 2016 male-female ratio for Nanticoke River alewife herring was 1:2.06. Of the 1,066 alewives sampled, 286 were subsequently aged. An age-length key was generated to assign an age structure to the entire in 2016. Ages 3-7 were present and the 2011 year-class (age 5, sexes combined) was the most abundant, accounting for 55% of the total catch (Table 11). The 2016 male-female ratio for Nanticoke River blueback herring was 1:1.07. Of the 257 blueback herring sampled, 147 were subsequently aged. Blueback herring were present from ages 3-7 and the 2011 year-class (age 5, sexes combined) was the most abundant, accounting for 39% of the sample (Table 12). 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 12).

For the Nanticoke River, 67% of alewife herring and 33% 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 (1989-2016; $r^2 = 0.04$ $P = 0.31$); however, blueback herring exhibited a decreasing trend over the same time series (1989-2016; $r^2 = 0.64$, $P < 0.001$; Figure 21). For male alewife and blueback herring, 41% and 70% were first time spawners, respectively. Twenty-nine percent of female alewife and 65% of female blueback herring were first time spawners.

Mean length (FL mm) of alewife herring from the Nanticoke River has varied without trend since the inception of this survey (1989 – 2016; $r^2 = 0.05$, $P = 0.26$) while, blueback herring mean length (FL mm) has significantly decreased across the time series (1989 – 2016; $r^2 = 0.68$, $P < 0.001$; Figure 22). The mean length for alewife herring in 2016 was the largest recorded mean by this survey.

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 2016 were 1:1.6. An age-length key was generated to assign an age structure to the entire alewife catch in 2016. Alewife herring of ages 3-7 were present in 2016. The 2011 alewife herring year-class began to return to the North East River to spawn beginning in 2014 at the age of 3 (mostly males). This year-class was the most abundant in 2015 at the age of 4, comprising 72.2% of the sample, and continued to be the most abundant year class in 2016 at the age of 5 (58.3%; Figure 23).

Male-female ratios for blueback herring in 2016 were 1:2.8. Blueback herring were present from ages 3-7 from 2013 through 2016, and age 4 (sexes combined) was the most abundant age for all years, with the exception of 2016, where age 5 was the most abundant age. Similar to alewife herring, the 2011 year-class for blueback herring was most abundant in 2015 (age 4) and continued to be the most abundant year class at 46.9% in 2016 (age 5, Figure 24). For the North East River in 2016, 69% of alewife herring and 56.8% of blueback herring were repeat spawners (sexes combined).

Adult Relative Abundance

Data from five fyke nets on the Nanticoke River were used to calculate relative abundance of river herring in 2016. The GM CPUE for Nanticoke River alewife herring captured in fyke nets has decreased over the time series (1990-2016; $r^2 = 0.19$, $P = 0.03$; Figure 25). The GM CPUE for blueback herring has also decreased over the time series (1989-2016; $r^2 = 0.60$, $P < 0.001$; Figure 25).

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. The timing of the alewife and blueback herring run for 2015 can be seen in Figure 26, which indicates the alewife run may have begun prior to our sampling start date. This could account for the decline in catch of alewife herring for 2016. A majority of the alewife herring were caught in the 2.5 inch mesh for all years (Figure 27). Alewife ranged in size from 210-282 mm FL. A majority of the blueback herring were caught in the 2.5 inch mesh in 2016 (Figure 28). Blueback ranged in size from 204-269 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 2016 (Figure 29). 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 13.

Mortality

Total instantaneous mortality for Nanticoke River alewife herring (sexes combined) was estimated as Z = 1.17 (A = 68.96%). Total instantaneous mortality for Nanticoke River blueback herring (sexes combined) was Z = 0.77 (A = 53.7%). Table 14 shows the total instantaneous mortality for North East River alewife and blueback herring (sexes combined) for all years of the gill net survey. Sample size for blueback herring in 2013 was too small to calculate a reliable mortality estimate. The 2016 total instantaneous mortality estimates for alewife herring from the North East River was high (Z = 1.5), while the blueback herring estimate was much lower than previously observed (Z = 0.63).

Juvenile Abundance

Data provided by the EJFS indicated that both the upper bay and Nanticoke River juvenile GM CPUE for alewife and blueback herring decreased in 2016 (Figures 30-31).

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 (2007-2015; 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 (2007-2016), although the Petersen shows a decline in the population in 2016. 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 2016, where the recreational fishery indices (logbook CPAH and creel CPAH) and fish passage showed increases, but the hook and line index showed a decline. The Potomac River CPUE (1996-2015) and the Nanticoke River CPUE (1989-2016) have increased over time, which indicates there is some improvement in these rivers, while the Susquehanna River continues to be significantly impacted.

Peak capture of American shad in the Conowingo tailrace by hook and line occurred a week after peak passage was observed at the East Fish Lifts, but the same week as peak capture at the West Fish Lift in 2016. 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 16.3°C; slightly below 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, 43% of aged American shad at the Conowingo Dam were repeat spawners in 2016, and, on average, 58% 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., 2014), 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 55%. 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 7), and James Rivers (2000-2002; Olney et al., 2003).

Historically, calculated Z for American shad in the lower Susquehanna River has been above the target Z_{30} (1984 – 2005; ASMFC 2007). The 2016 mortality estimate continues this pattern, with a calculated Z for American shad in the Conowingo Dam tailrace (Z=0.97) being above the Z_{30} established for rivers in neighboring states (range=0.54−0.76, ASMFC 2007). As previously mentioned these calculated mortality estimates may be high if skip spawning is occurring (ASMFC 2012).

Juvenile American shad indices decreased baywide, in the upper Chesapeake Bay and the Potomac River in 2016, following the record high observed in 2015. The spring of 2016 was very dry resulting in low flows that were likely not conducive for successful American shad spawning and/or hatching. Bilkovic et al. (2002) found American shad spawning reaches to be characterized by relatively high velocities (0.3 – 1 m/s) in two Virginia rivers.

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 counting 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 and 2015 according to shad logbook data collected from anglers (1998-2016).

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 five years (2012-2016) 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. In 2016, percent repeat spawning increased, but remains below average for the time series.

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 2012, 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 2012). This assessment corresponds with the low indices of abundance for both species observed in the Nanticoke River by this project through 2016. 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 show 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.

Mortality estimates in recent years for alewife and blueback herring in the North East and Nanticoke Rivers have been high. A decline in mortality estimates for blueback herring in both rivers in 2016 is encouraging. 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

Analysis of the data collected in 2017 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 20 April through 1 June 2017. Biologists encountered 321 adult American shad and collected 288 scale samples for ageing and spawning history analysis. Male American shad ranged in size from 320 - 459 mm FL, and female American shad ranged in size from 386 - 580 mm FL.

In 2017, 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 3 March through 28 April 2017. 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 88 American shad were encountered by this survey in 2017.

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 6 March to 17 May 2017. The gill net was set 40 times and encountered 416 alewife and 169 blueback herring. A total of 300 alewife scale samples and 169 blueback herring scale samples are being processed for ageing.

The complete analyses of the data collected in 2017 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. Percentage of sites with clupeid eggs or larvae and number of sites sampled in the Nanticoke River (2005-2016).

Year	Total Sites	Percent of Sites with Clupeid Eggs/Larvae
2005	80	5.0
2006	80	0.0
2007	78	0.0
2008	109	0.0
2009	97	8.2
2010	70	42.9
2011	73	32.9
2012	86	0.0
2013	69	21.7
2014	62	24.2
2015	76	27.6
2016	58	67.2

Table 2. 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 2016.

Conowingo Dam Tailrace

AGE	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
3	5	0	0	0	5	0
4	43	13	11	1	54	14
5	140	66	77	27	217	93
6	37	23	47	25	84	48
7	2	1	4	3	6	4
Totals	227	103	139	56	366	159
Percent Repeats	45.4%		40.3%		43.4%	

Nanticoke River

AGE	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
3	1	0	0	0	1	0
4	7	1	0	0	7	1
5	14	9	5	3	19	12
6	8	7	4	3	12	10
7	3	3	5	5	8	8
8	1	1	1	1	2	2
Totals	34	21	15	12	49	33
Percent Repeats	61.8%		80.0%		67.3%	

Potomac River

AGE	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
4	13	7	7	0	20	7
5	40	20	35	10	75	30
6	11	9	24	22	35	31
7	3	2	6	6	9	8
8	0	0	1	1	1	1
Totals	45	29	75	51	120	80
Percent Repeats	56.7%		53.4%		55.0%	

Table 3. Number of recaptured American shad in 2016 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
Blue	2015	3	Blue	2015	0
Orange	2016	39	Orange	2016	3

Table 4. 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	445	45.73	43.2%	10.41	6723.61
2	Temp + Flow	Tweedie	445	37.30	45.2%	2.77	3784.46
3	Temp + Flow	Negative Binomial	445	34.97	40.3%	0.83	3830.11
4	Temp	Poisson	445	36.88	40.5%	10.63	6916.50
5	Temp	Tweedie	445	35.36	44.7%	2.81	3785.20
6	Temp	Negative Binomial	445	33.47	39.2%	0.83	3834.39

Table 5. Catch, effort and catch-per-angler-hour (CPAH) from the recreational creel survey in the Susquehanna River below Conowingo Dam, 2001-2016. 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

Table 6. Catch, effort and catch-per-angler-hour (CPAH) from spring logbooks for American shad, 2000-2016. 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

Table 7. 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 2016.

AGE	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
3	20	0	5	0	25	0
4	22	15	15	13	37	28
5	18	18	25	24	43	42
6	7	7	7	7	14	14
7	0	0	1	1	1	1
Totals	67	40	53	45	120	85
Percent Repeats	59.7%		84.9%		70.8%	

Table 8. Percent of hickory shad by age and number sampled from the brood stock collection survey in Deer Creek (Susquehanna River tributary) by year, 2004-2016.

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		

Table 9. Percent repeat spawning hickory shad (sexes combined) by year from the brood stock collection survey in Deer Creek (Susquehanna River tributary), 2004-2016.

Year	N	Percent Repeats
2004	80	68.8
2005	80	82.5
2006	178	67.4
2007	139	79.1
2008	149	83.9
2009	118	89.0
2010	240	75.4
2011	216	68.5
2012	200	64.0
2013	193	74.1
2014	100	59.0
2015	113	59.3
2016	120	70.8

Table 10. Catch, effort and catch-per-angler-hour (CPAH) from logbooks for hickory shad, 1998-2016. 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	1424	11.67

Table 11. Percent catch-at-age for adult alewife herring sampled from the Nanticoke River from 1989 - 2016. Age 6+ includes all catch age 6 – 11.

Year	N	Age				
		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

[*] Indicates years where not all fish were aged. An age-length key was subsequently used to assign ages to those fish based on size.

Table 12. Percent catch-at-age for adult blueback herring sampled from the Nanticoke River from 1989 - 2016. Age 6+ includes all catch age 6 – 11.

		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

* Indicates years where not all fish were aged. An age-length key was subsequently used to assign ages to those fish based on size.

Table 13. Counts of species (other than alewife and blueback) captured in the North East River gill net survey from 2013-2016.

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

Table 14. Total instantaneous mortality for North East River alewife and blueback herring (sexes combined) for 2013-2016. Sample size for blueback herring in 2013 was too small to calculate a reliable mortality estimate.

Species	2013	2014	2015	2016
Alewife Herring	0.81	1.10	1.31	1.5
Blueback Herring	-	0.98	1.71	0.63

Figure 1. Conowingo Dam Tailrace (Susquehanna River) hook and line sampling location for American shad in 2016.

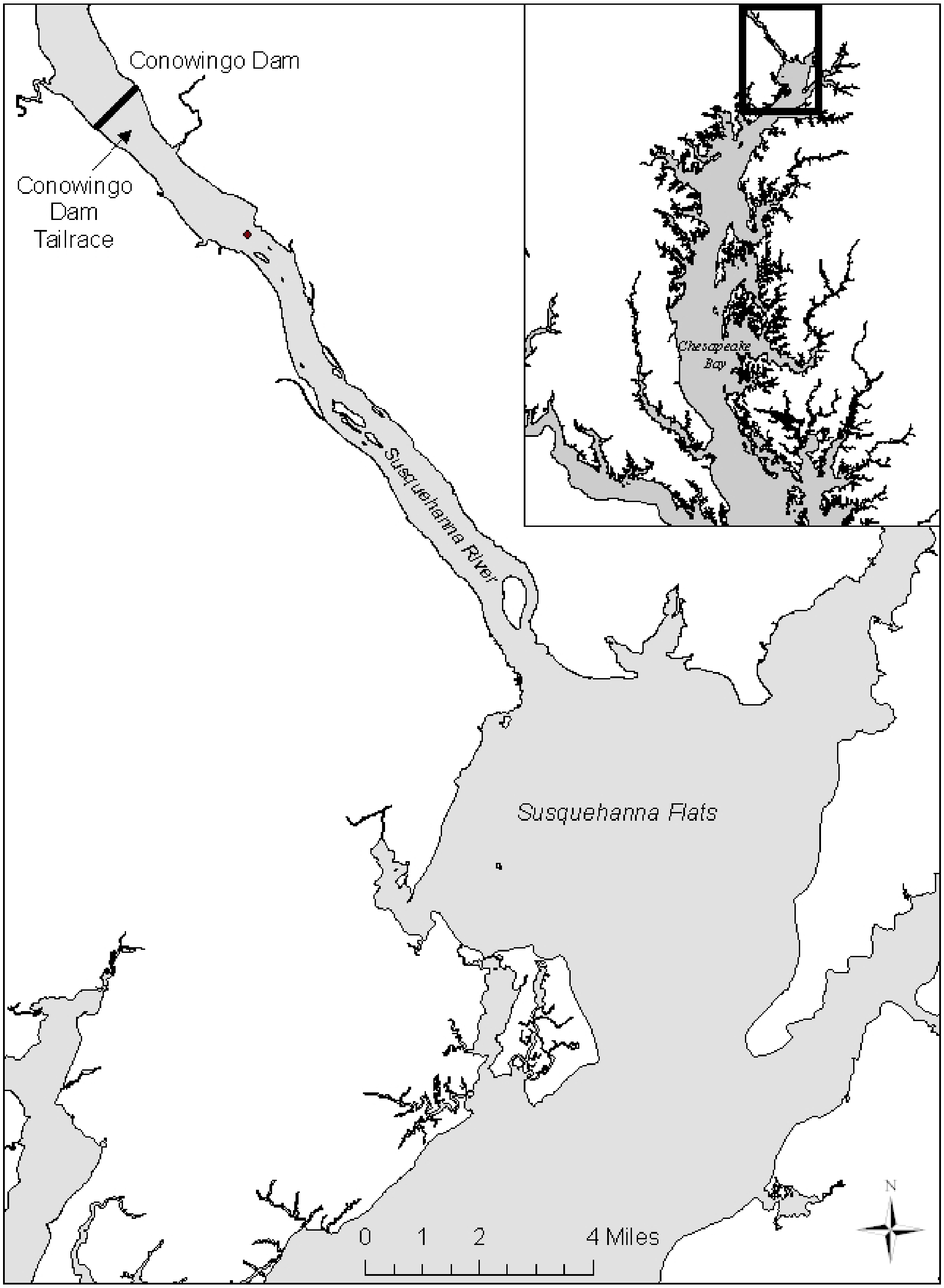


Figure 2. Nanticoke River pound and fyke net sites for adult alosine sampling in 2016. The Mill Creek pound net site used for calculating American shad CPUE is identified.

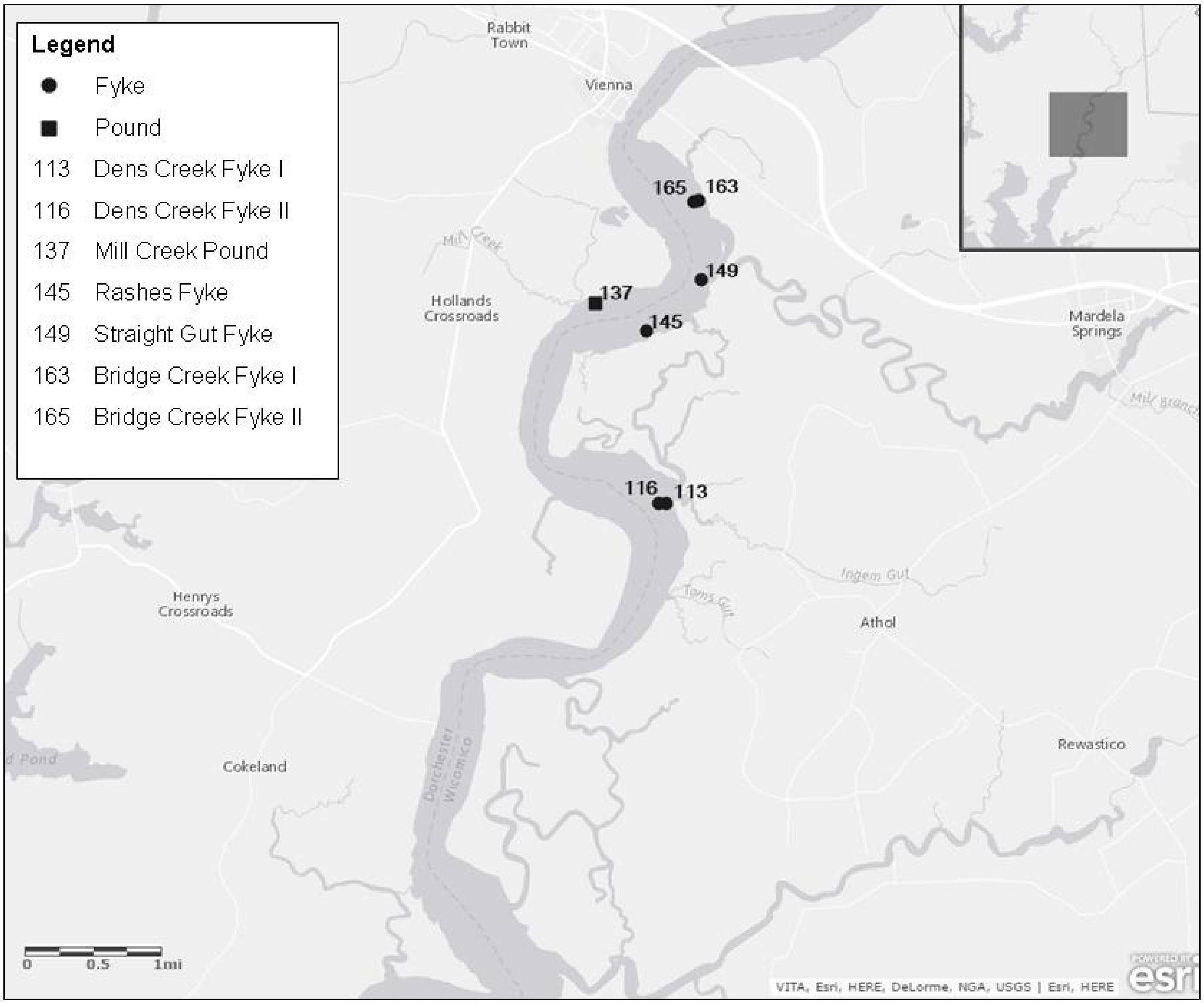


Figure 3. Nanticoke River sites for alosine ichthyoplankton sampling in 2016.

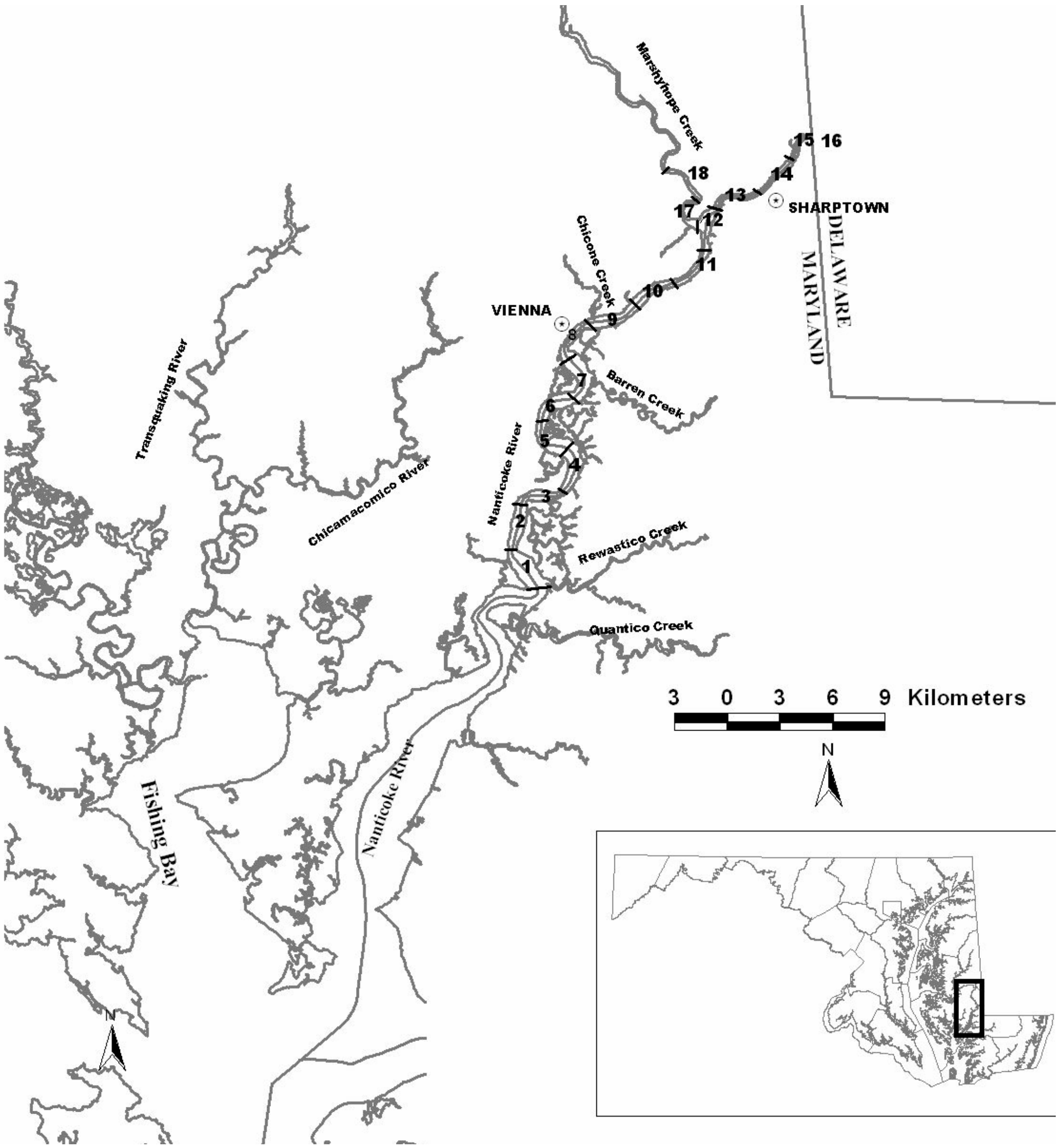


Figure 4. Grid of 1000ft x 1000ft squares overlaid on a map of the North East River from which sites were randomly chosen for the North East River sinking gill net survey, 2013-2016.

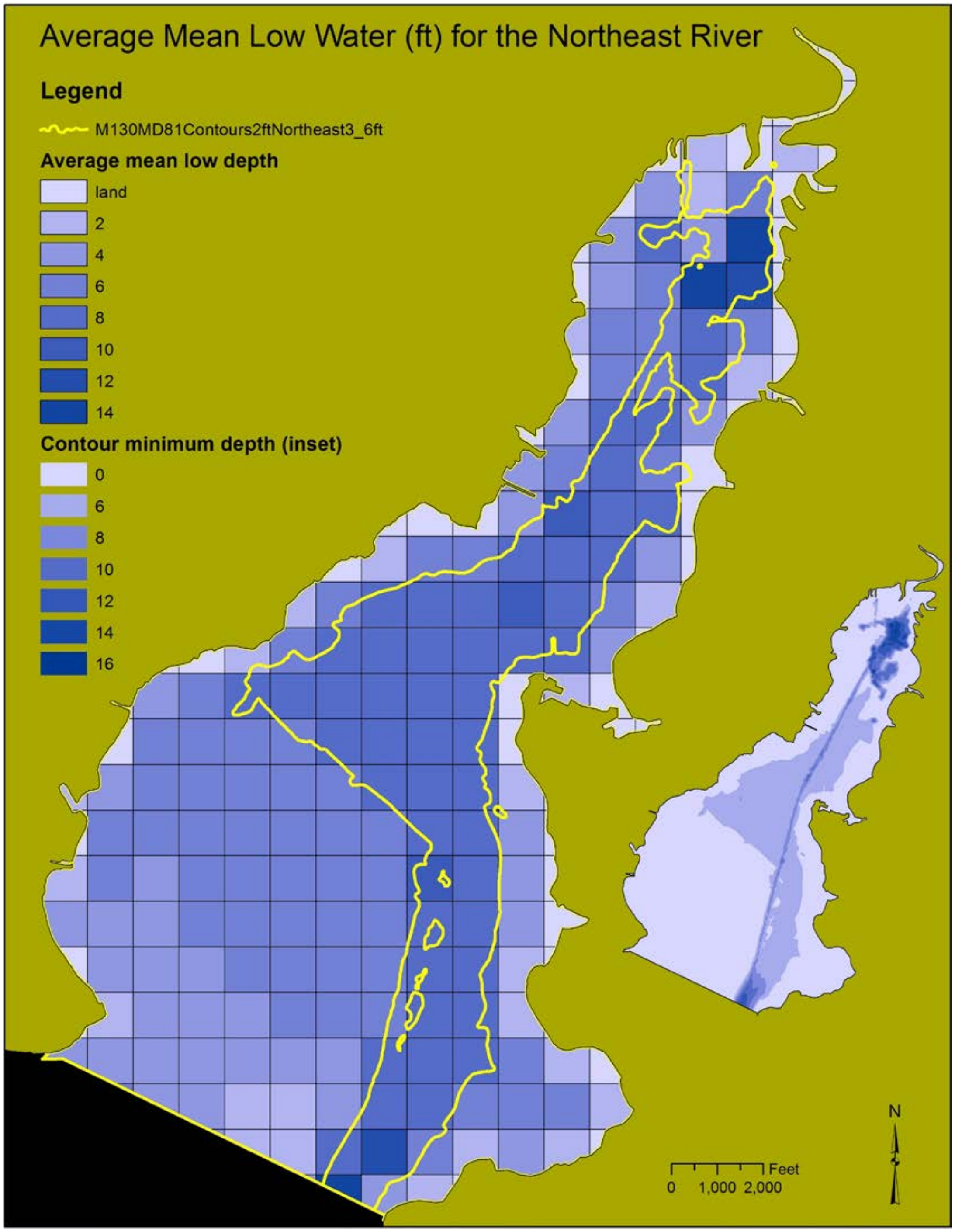


Figure 5. Percent of American shad repeat spawners by sex collected in the Conowingo Dam tailrace (1982-2016).

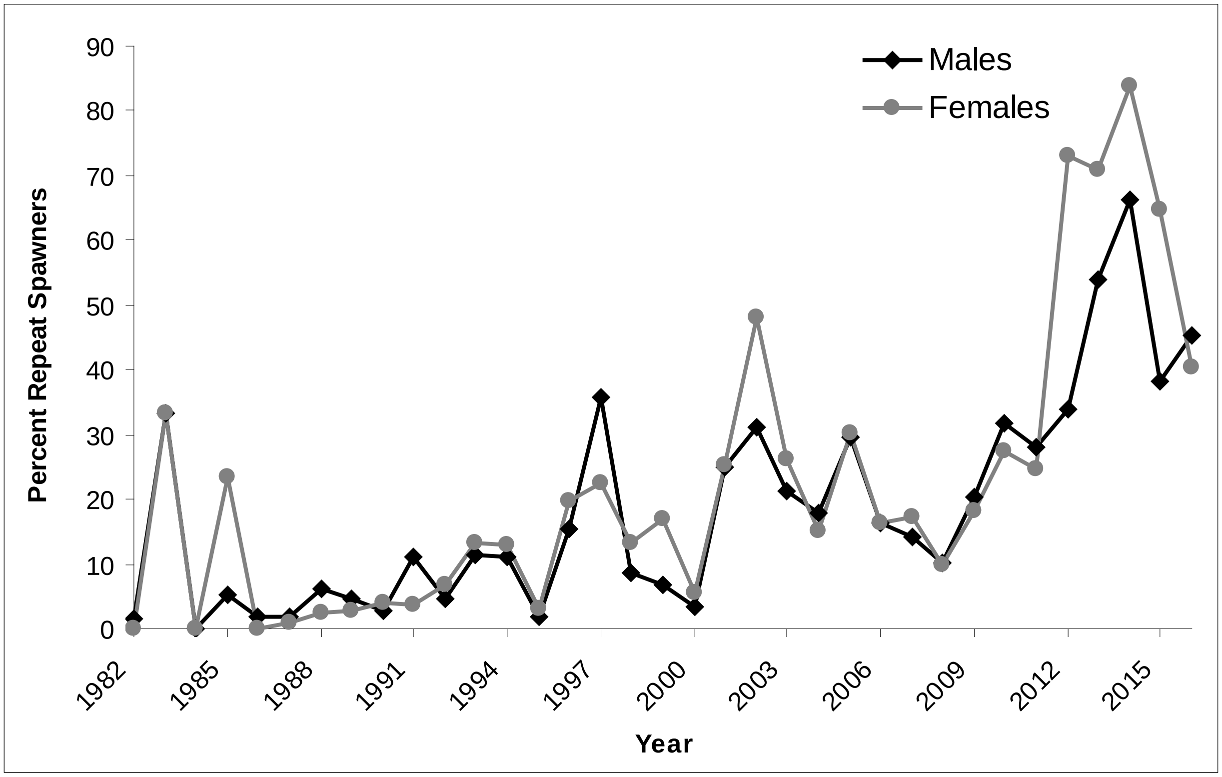


Figure 6. Arcsine-transformed percentages of repeat spawning American shad (sexes combined) collected from the Conowingo Dam tailrace, 1984-2016.

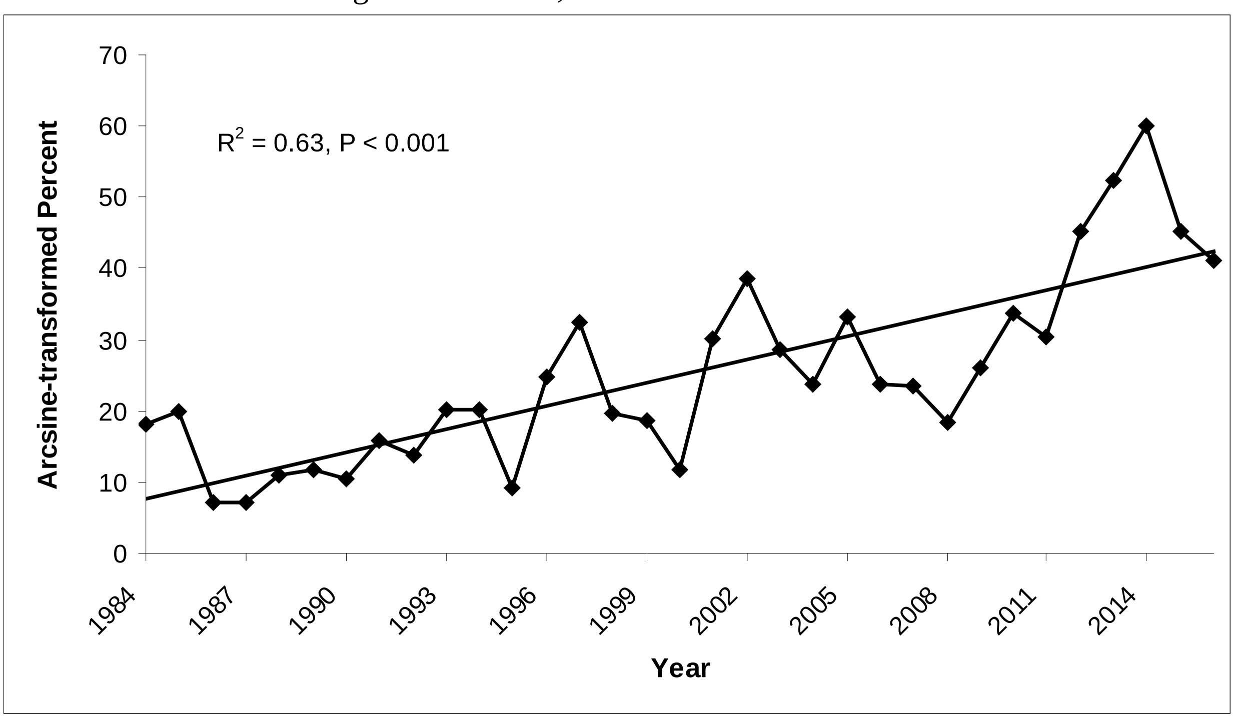


Figure 7. Arcsine-transformed percentages of repeat spawning American shad (sexes combined) collected from the Nanticoke River, 1988-2016.

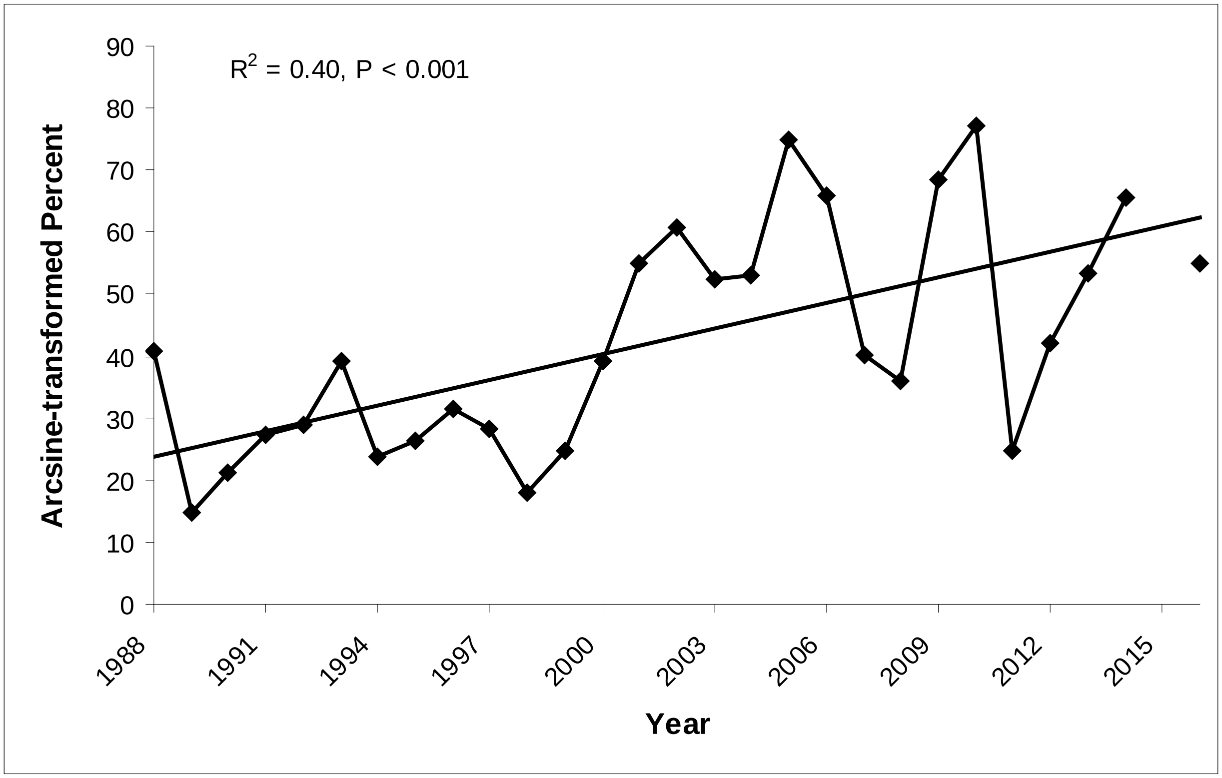


Figure 8. Trends in arcsine-transformed percentages of repeat spawning American shad (sexes combined) collected from the Potomac River, 2002-2016.

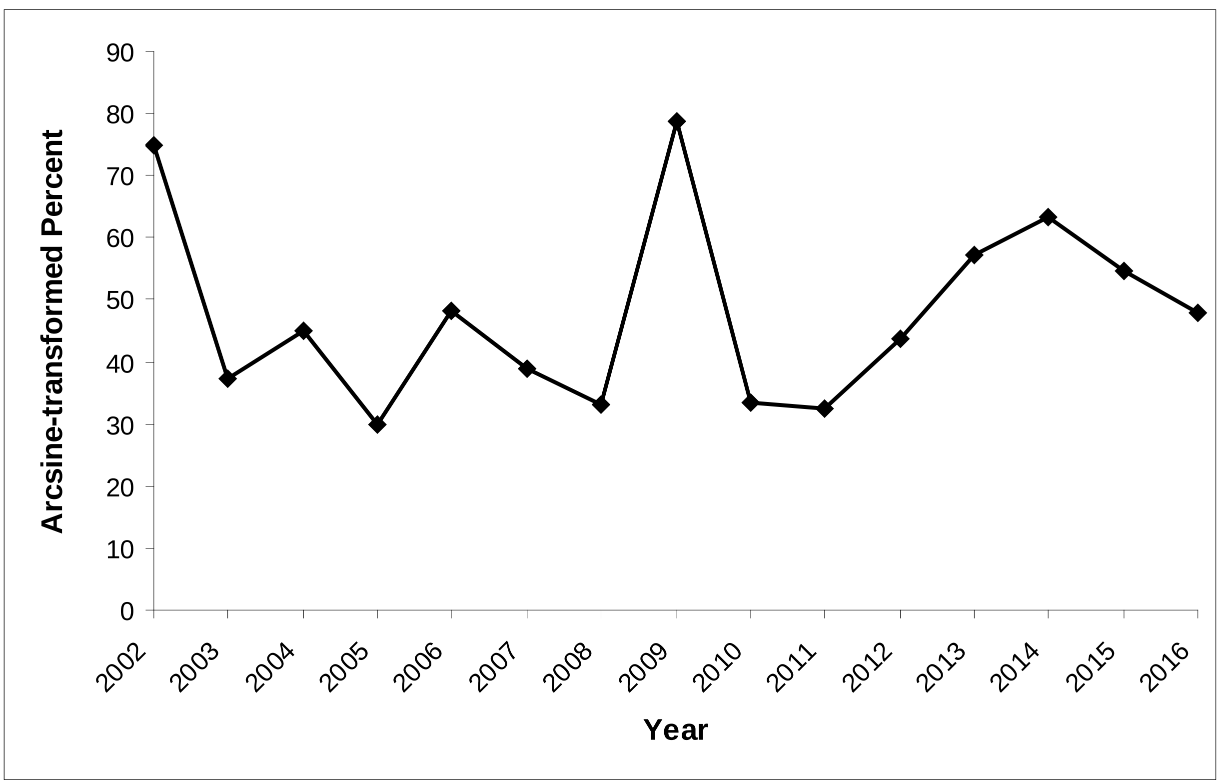


Figure 9. Pearson residuals from the best fit generalized additive model (GAM) used to standardize the Susquehanna River hook and line catch per unit effort (CPUE) index.

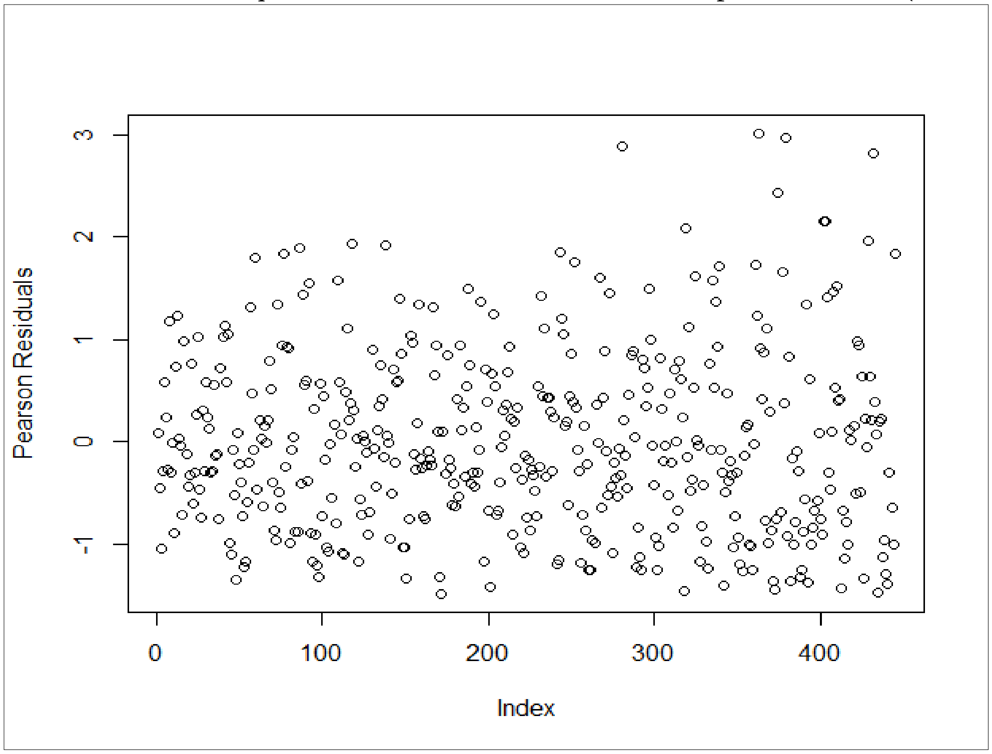


Figure 10. American shad standardized CPUE with 95% confidence intervals estimated by a generalized additive model for the Conowingo Dam tailrace hook and line sampling, 1987-2016.

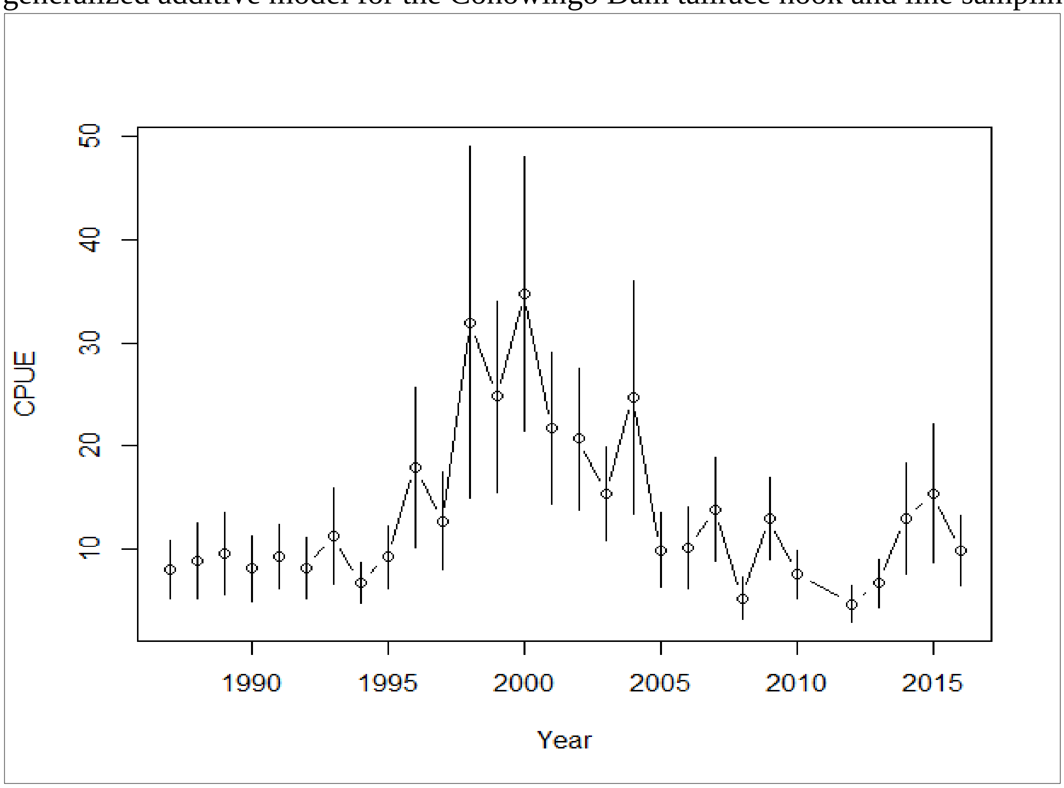


Figure 11. American shad geometric mean CPUE (fish per lift hour) and the total number of American shad lifted at the East and West Fish Lifts at the Conowingo Dam, 1991-2016.

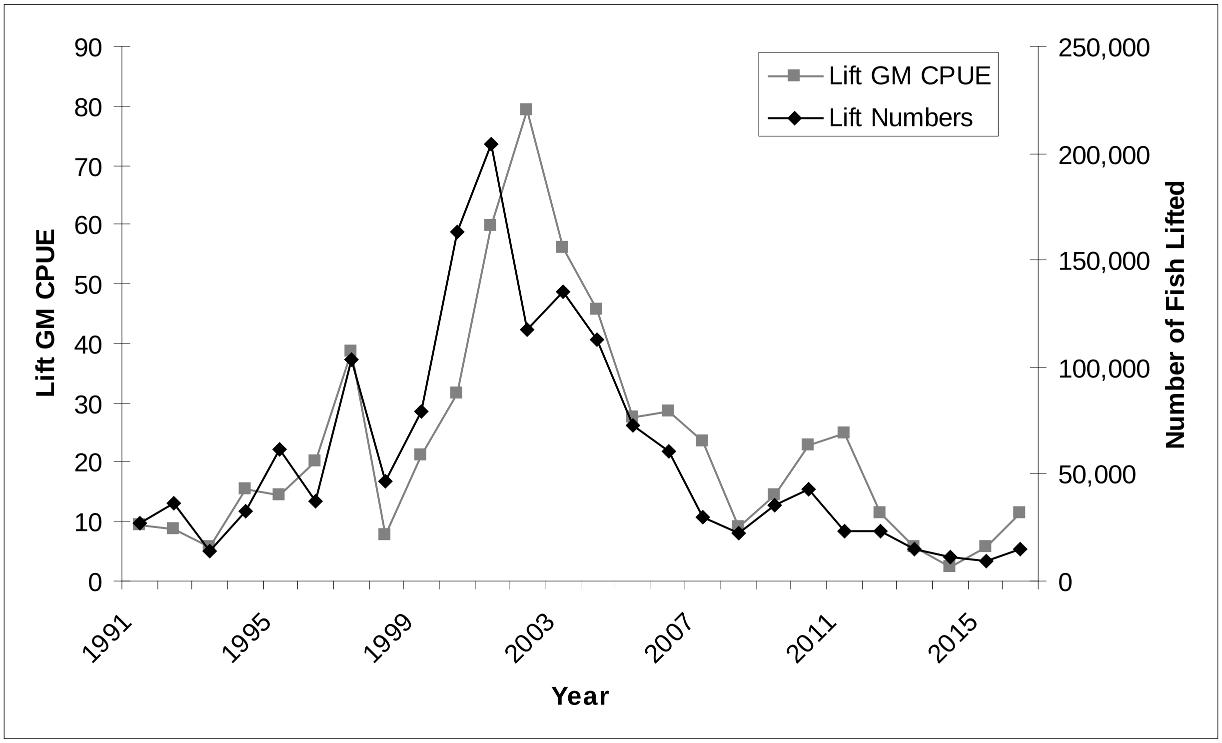


Figure 12. American shad geometric mean CPUE (fish per net day) from the Mill Creek pound net in the Nanticoke River, 1988-2016. No pound nets were fished in 2004 or 2015.

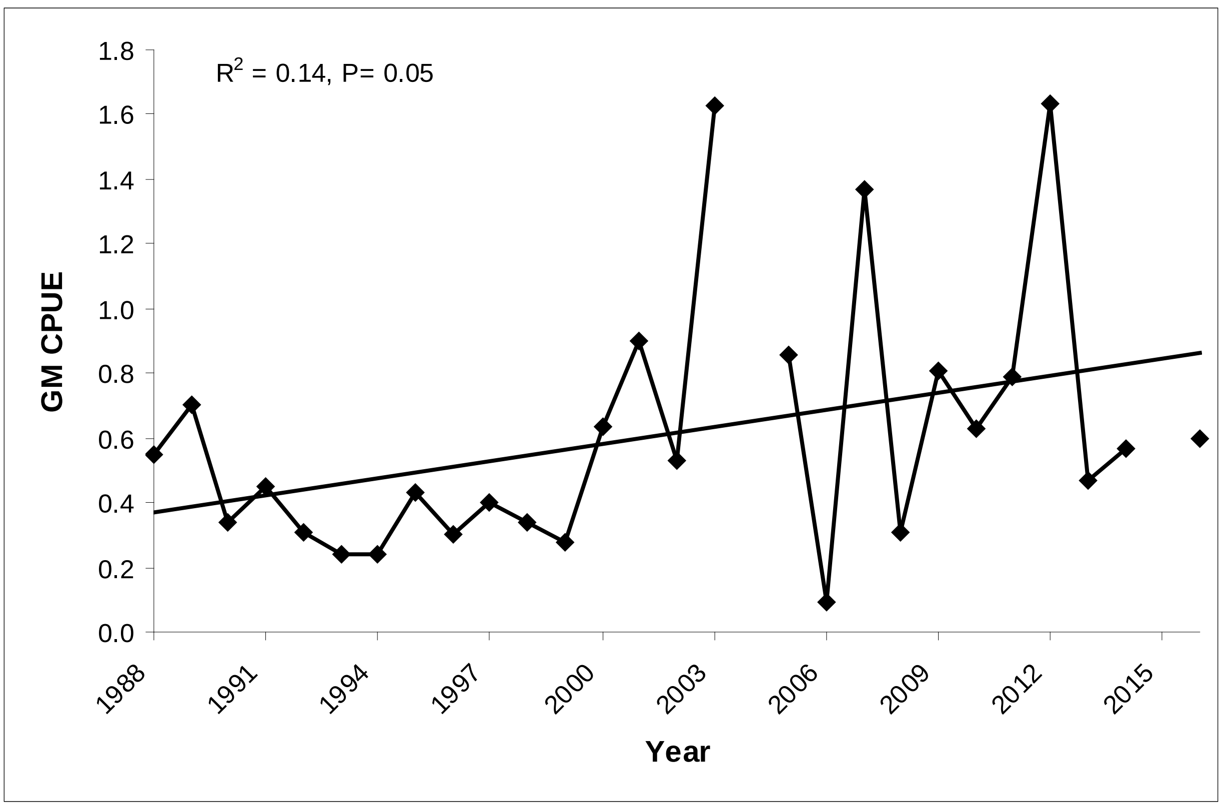


Figure 13. American shad geometric mean CPUE (fish per 1,000 square yards of experimental drift gill net per hour fished) from the Potomac River, 1996-2016.

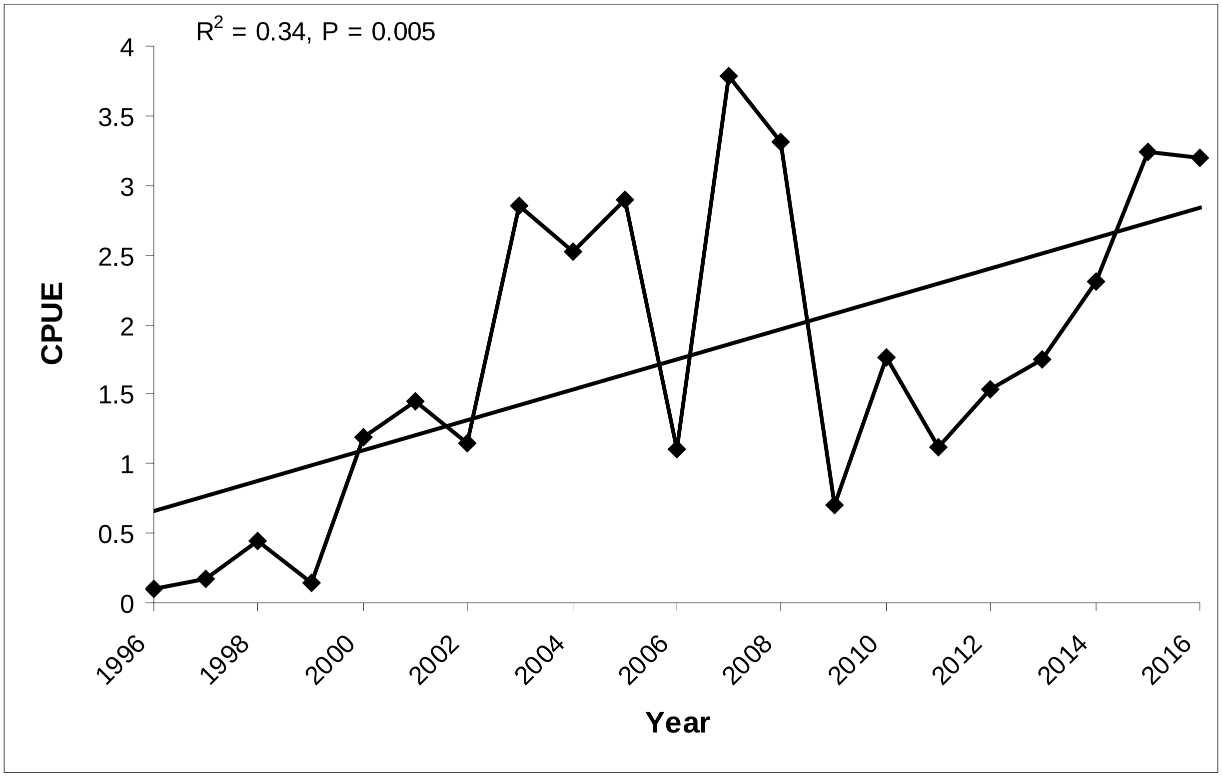


Figure 14. Conowingo Dam tailrace adult American shad abundance estimates from the Petersen statistic with 95% confidence limits, 1986-2016.

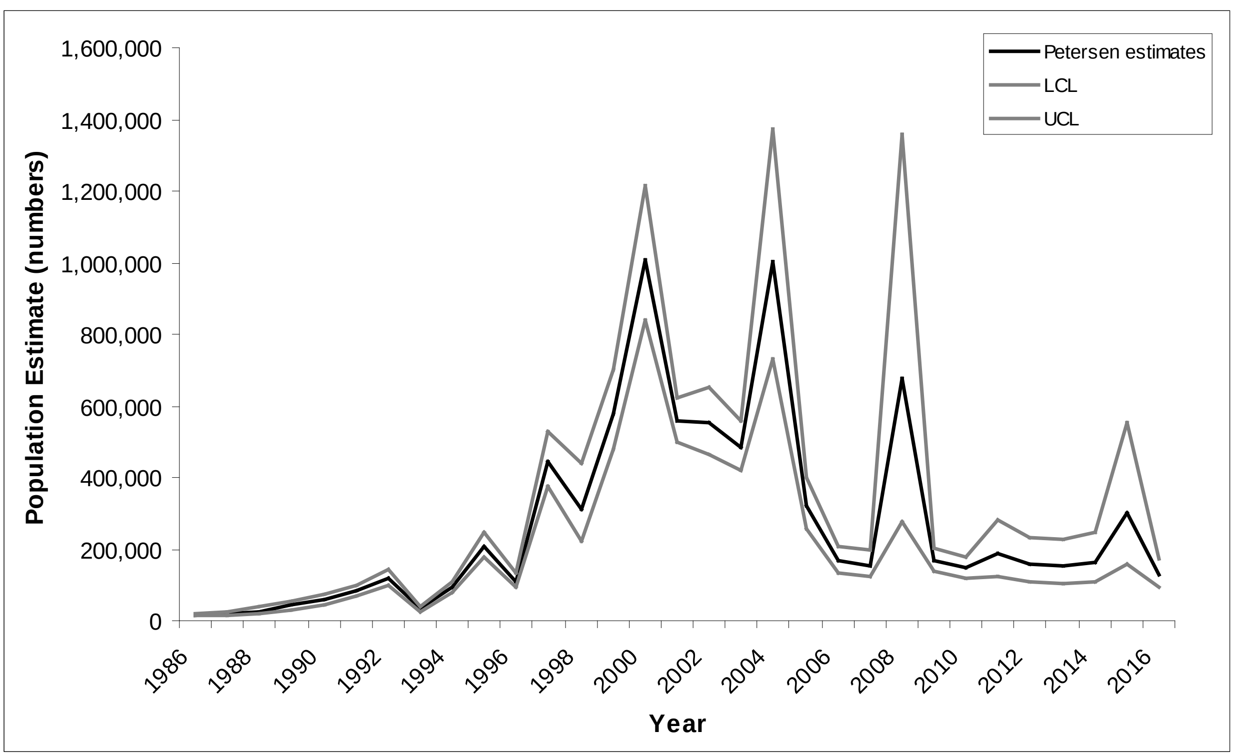


Figure 15. Conowingo Dam tailrace adult American shad abundance estimates from the surplus production model (SPM), 1986-2016.

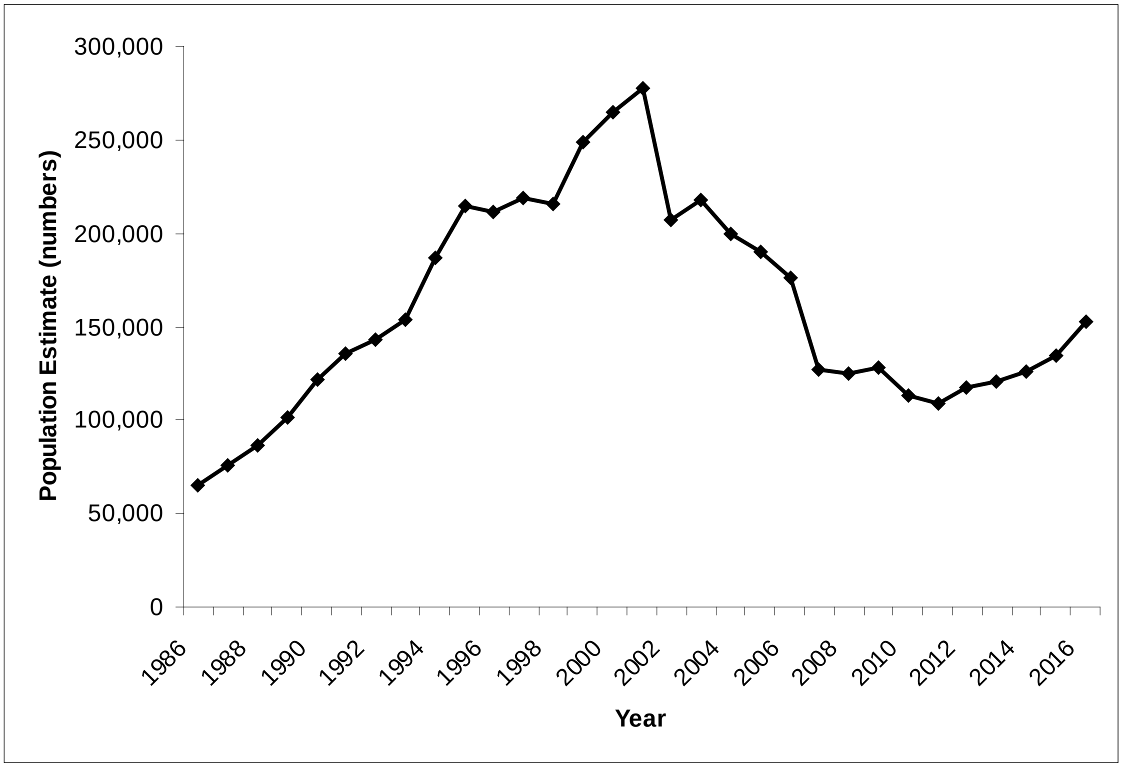


Figure 16. Baywide juvenile American shad geometric mean CPUE (catch per haul), 1959-2016.

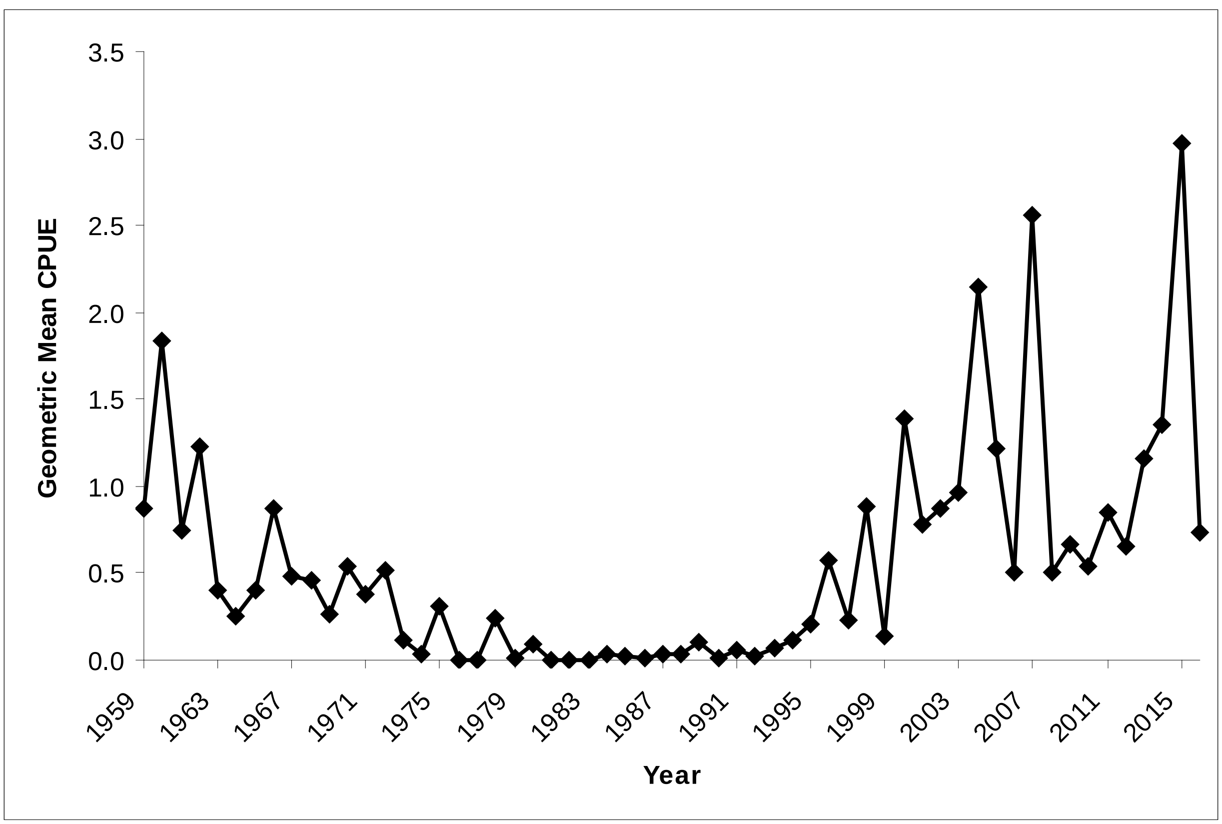


Figure 17. Upper Chesapeake Bay juvenile American shad geometric mean CPUE (catch per haul), 1959-2016.

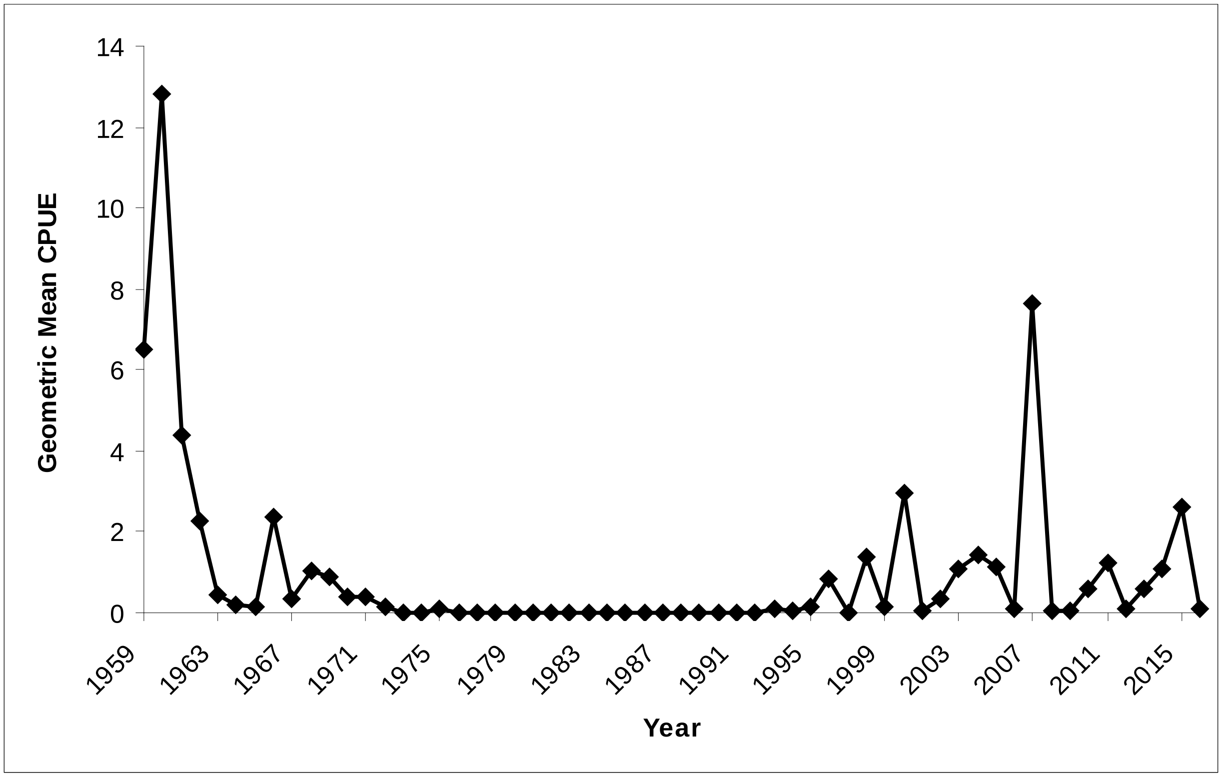


Figure 18. Potomac River juvenile American shad geometric mean CPUE (catch per haul), 1959-2016.

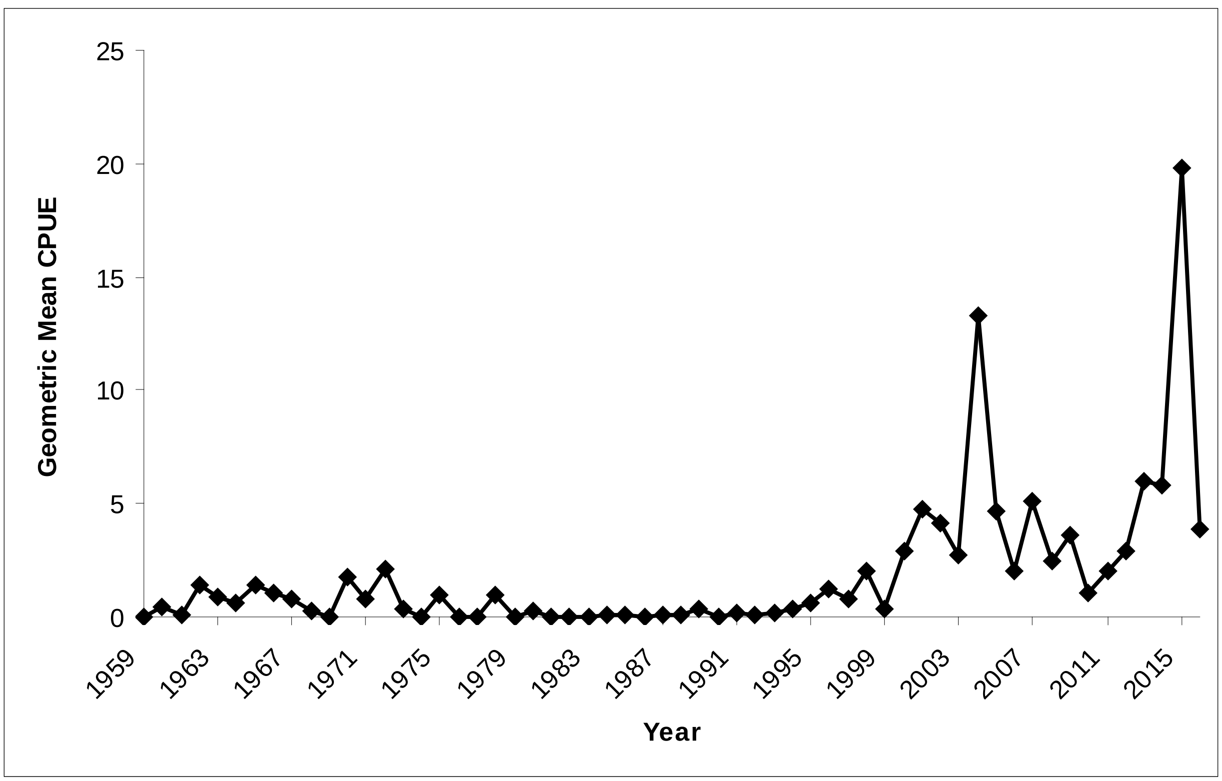


Figure 19. Nanticoke River juvenile American shad geometric mean CPUE (catch per haul), 1959-2016.

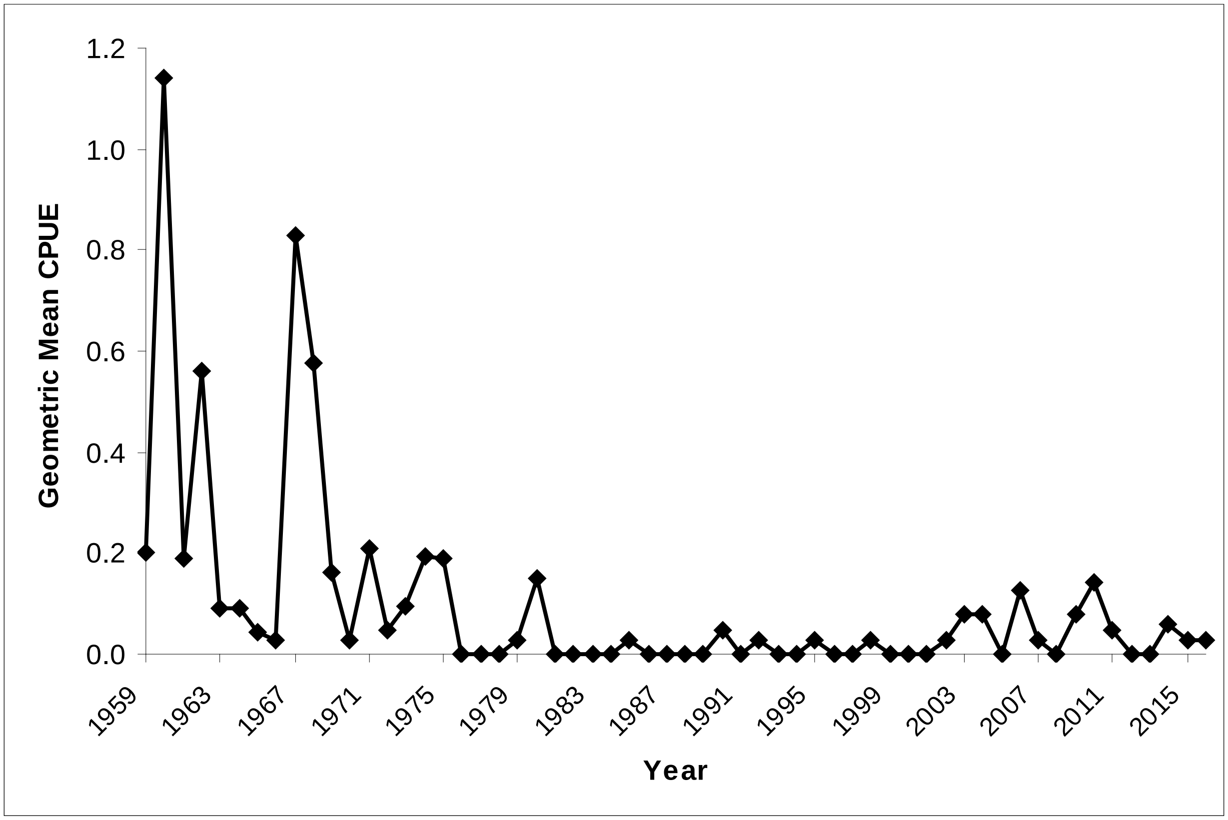


Figure 20. Arcsine-transformed percentages of repeat spawning hickory shad (sexes combined) collected from Deer Creek (Susquehanna River tributary), 2004-2016.

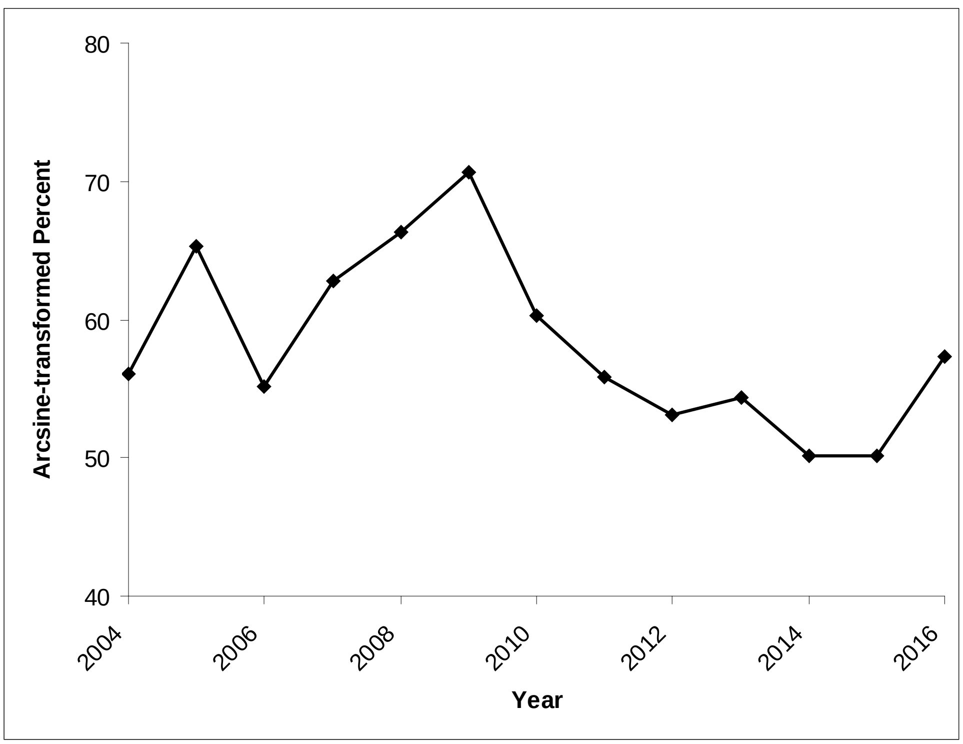


Figure 21. Arcsine-transformed percentage of repeat spawning alewife and blueback herring (sexes and gears combined) from the Nanticoke River, 1989-2016.

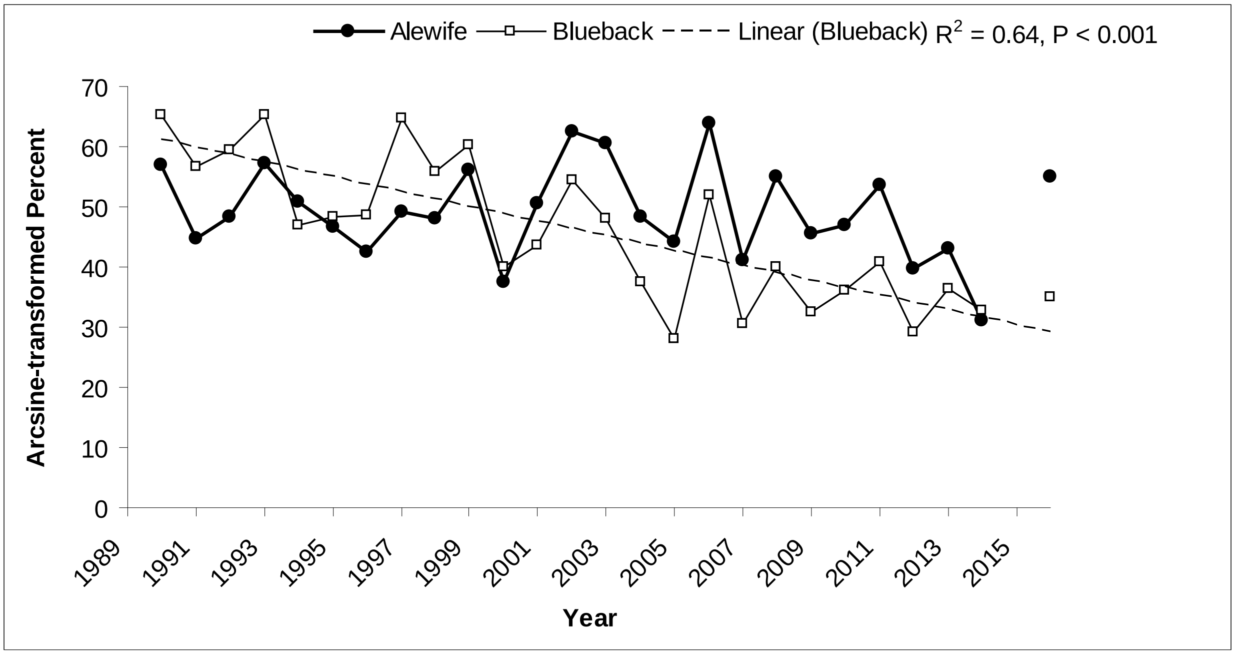


Figure 22. Mean fork length (mm) of adult alewife and blueback herring from the Nanticoke River, 1989-2016.

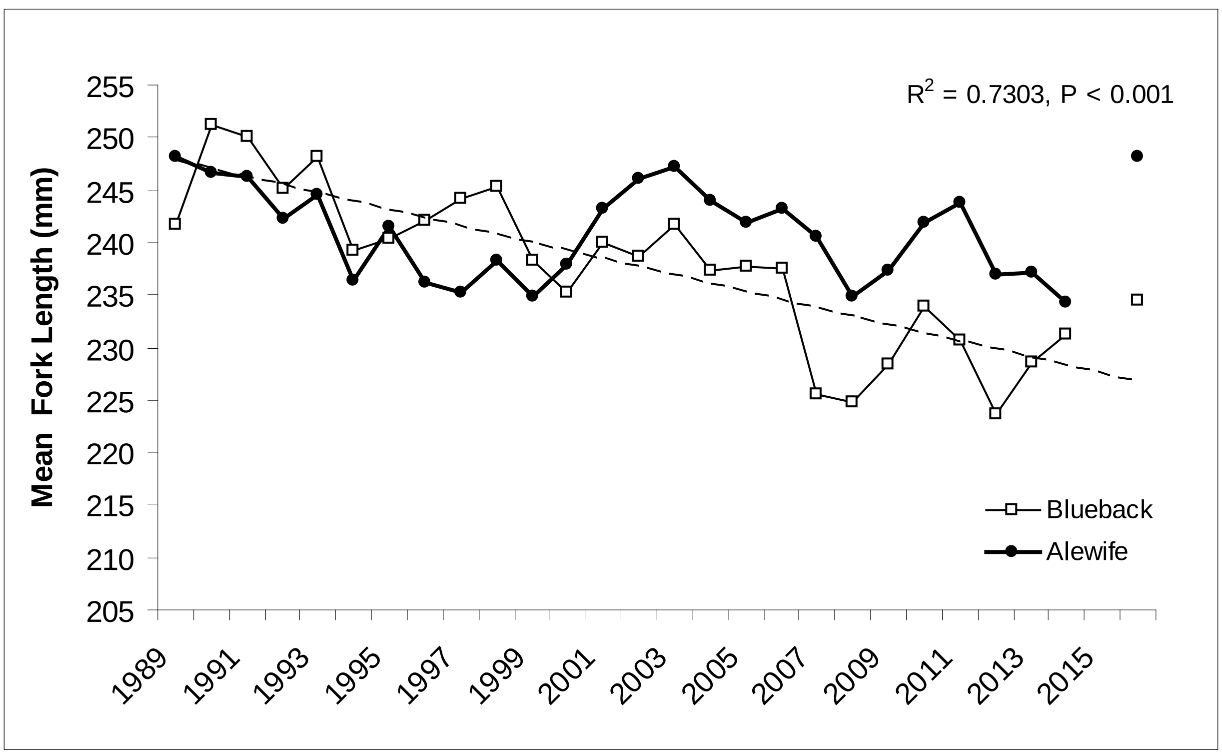


Figure 23. Percent catch-at-age by year of alewife herring from the North East River, 2013-2016.

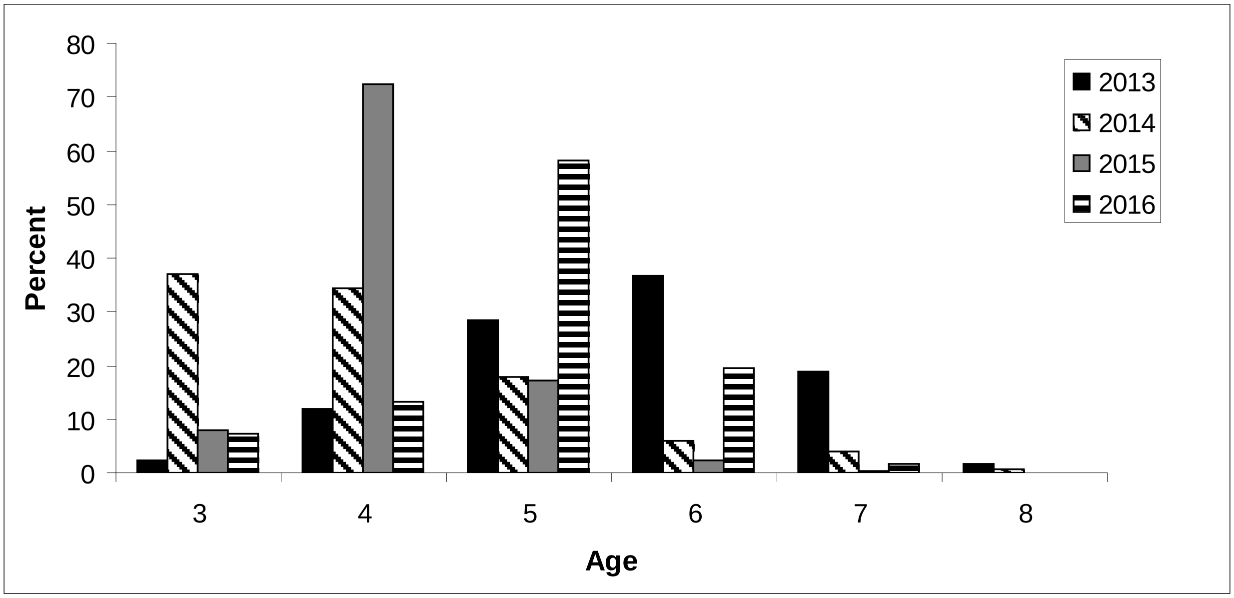


Figure 24. Percent catch-at-age by year of blueback herring from the North East River, 2013-2016.

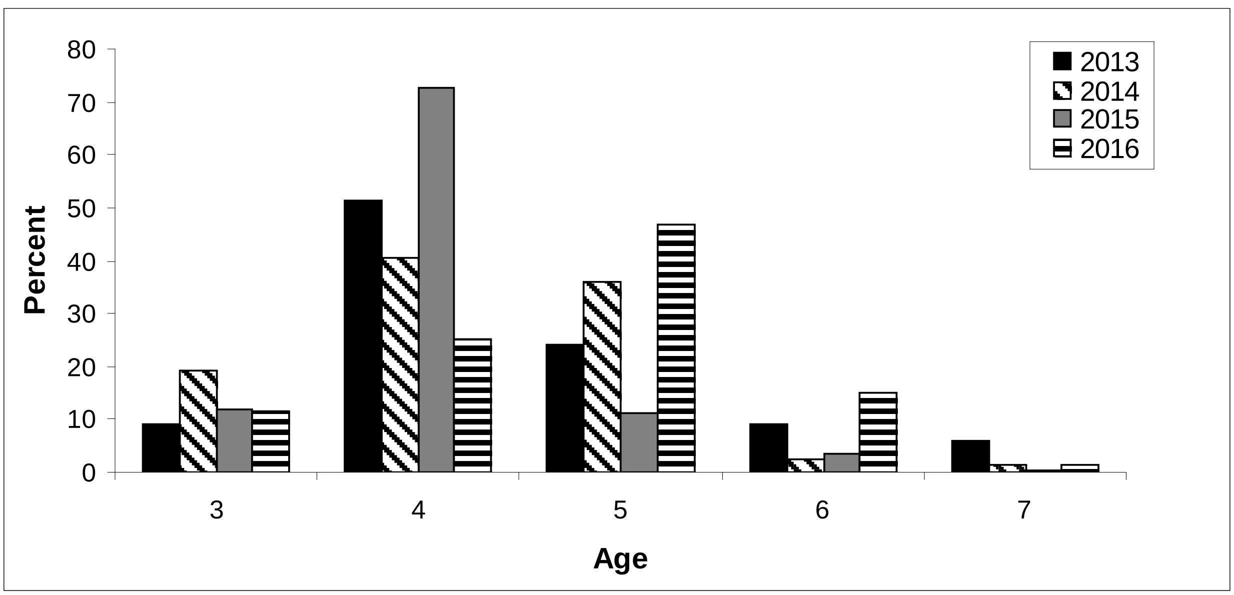


Figure 25. Geometric mean CPUE (catch per net day) of adult alewife and blueback herring from Nanticoke River fyke nets, 1989-2016. No fyke nets were fished in 2012 and 2015.

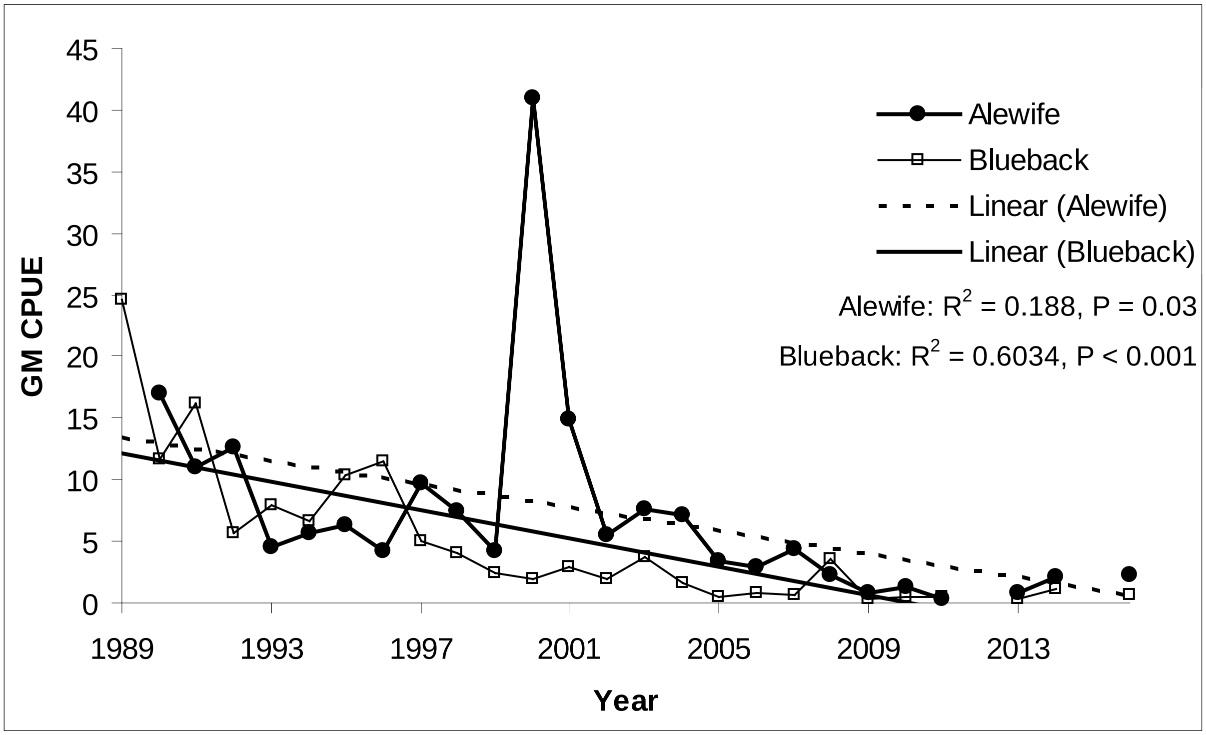


Figure 26. North East River catch per day of alewife and blueback herring, plotted with surface water temperature for 2016.

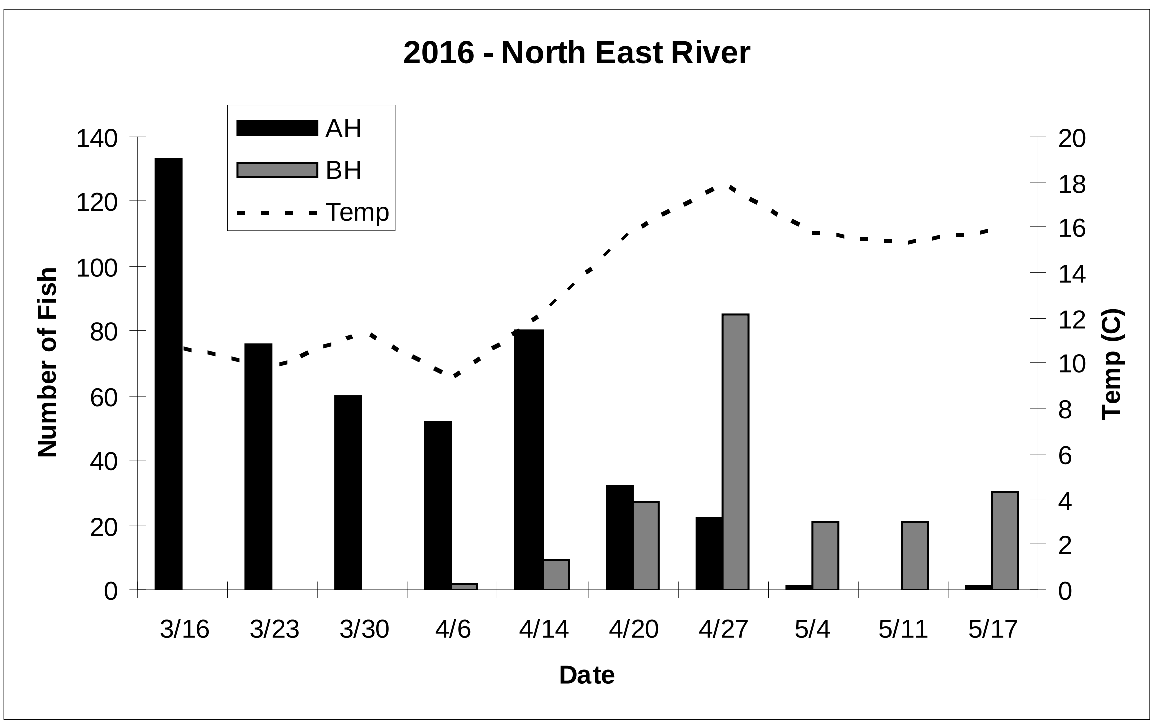


Figure 27. Percent of total catch by mesh size of alewife herring from the North East River, 2013-2016.

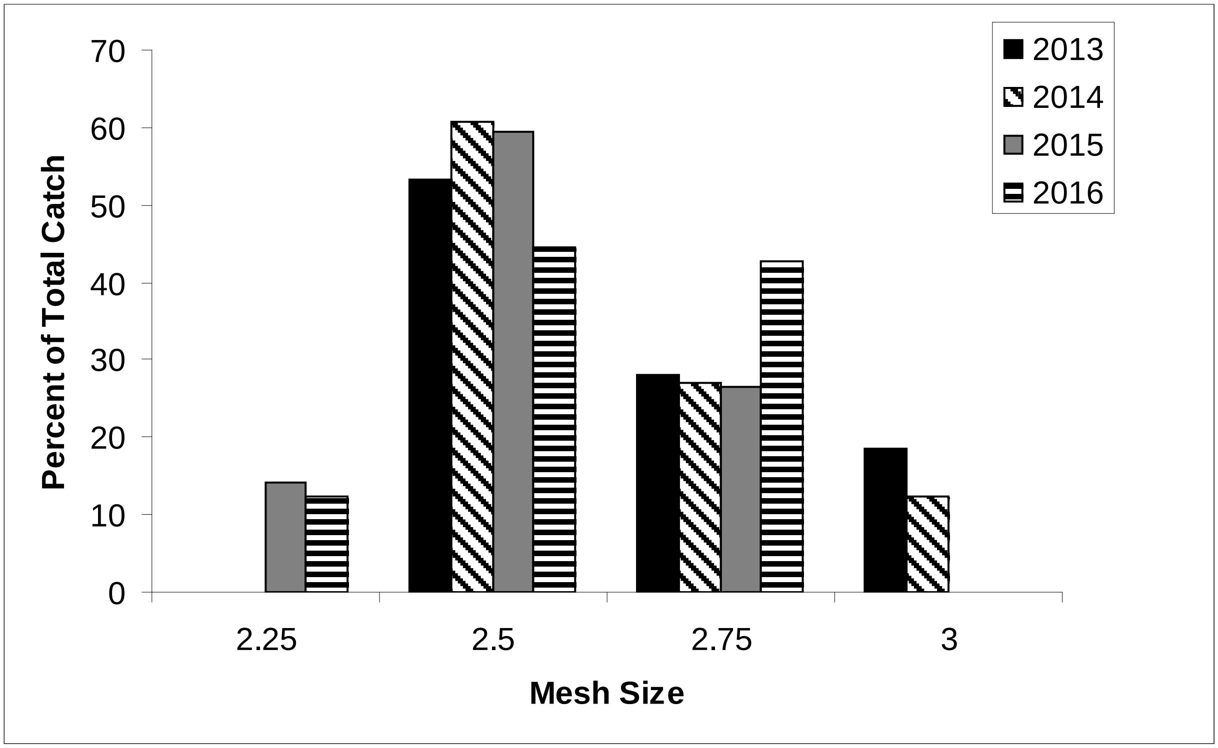


Figure 28. Percent of total catch by mesh size of blueback herring from the North East River, 2013-2016.

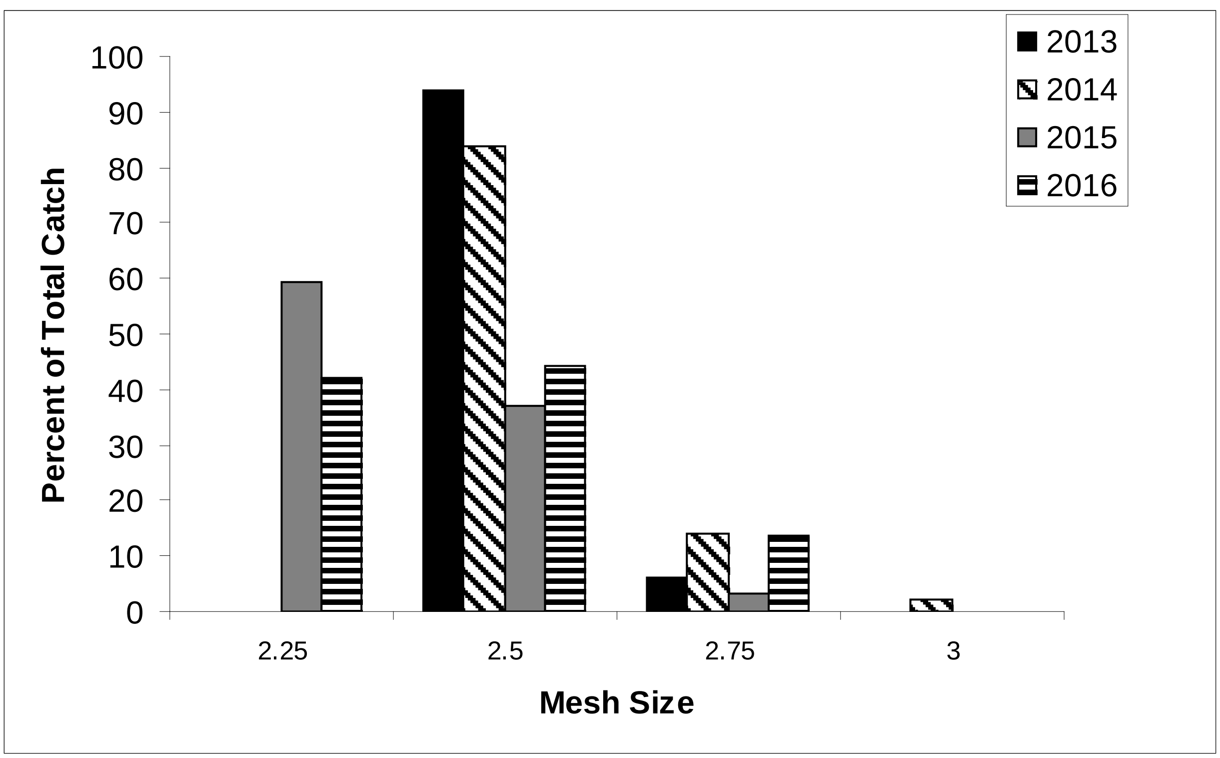


Figure 29. Alewife and blueback herring CPUE (number of fish caught per set of experimental gill net per hour fished) from the North East River gill net survey, 2013-2016. Catch was pooled across the 2.5 and 2.75” mesh panels for all years.

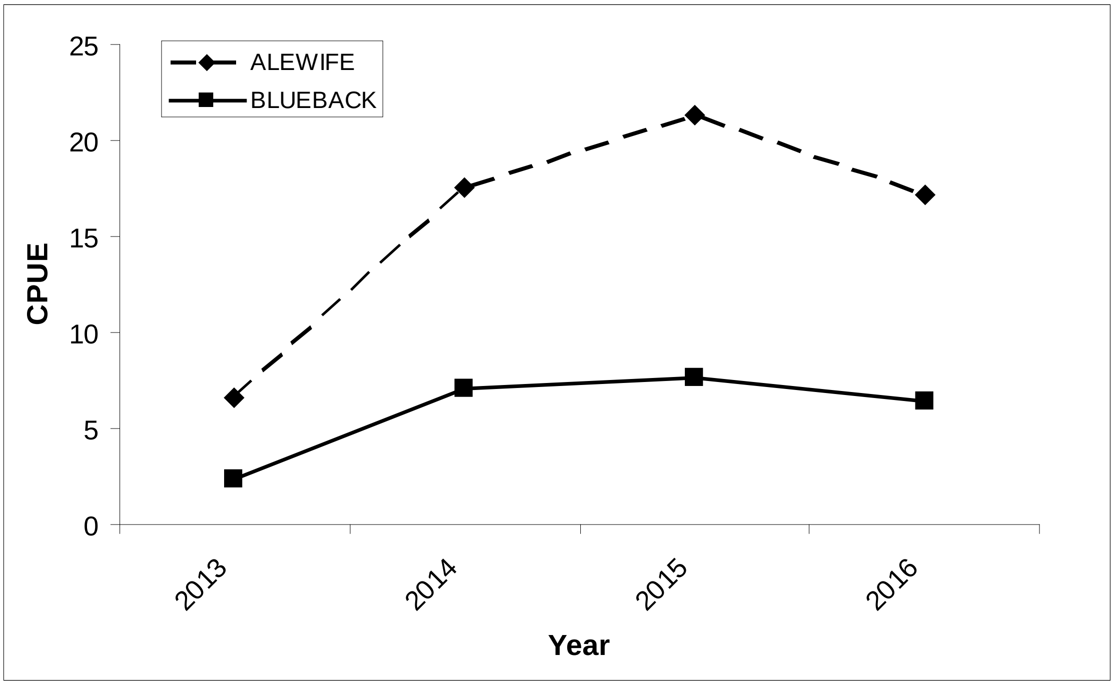


Figure 30. Upper Bay juvenile alewife and blueback herring geometric mean CPUE (catch per haul), 1959-2016.

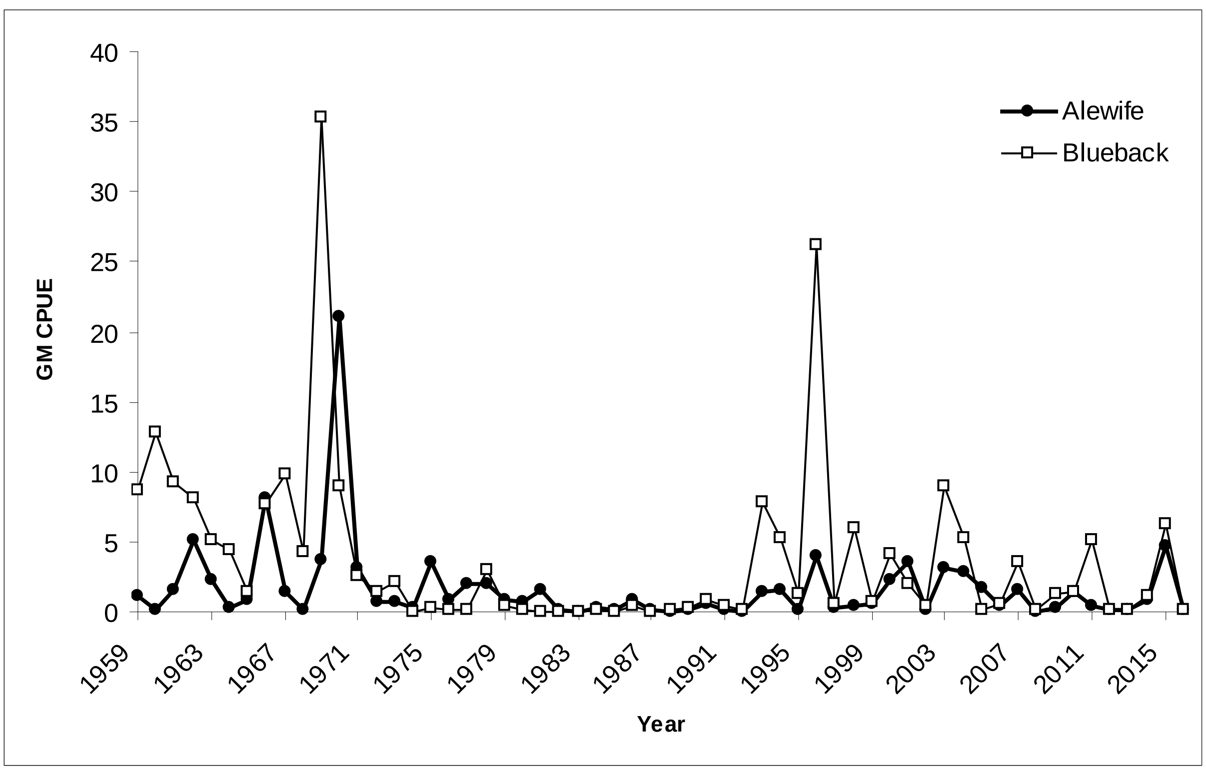
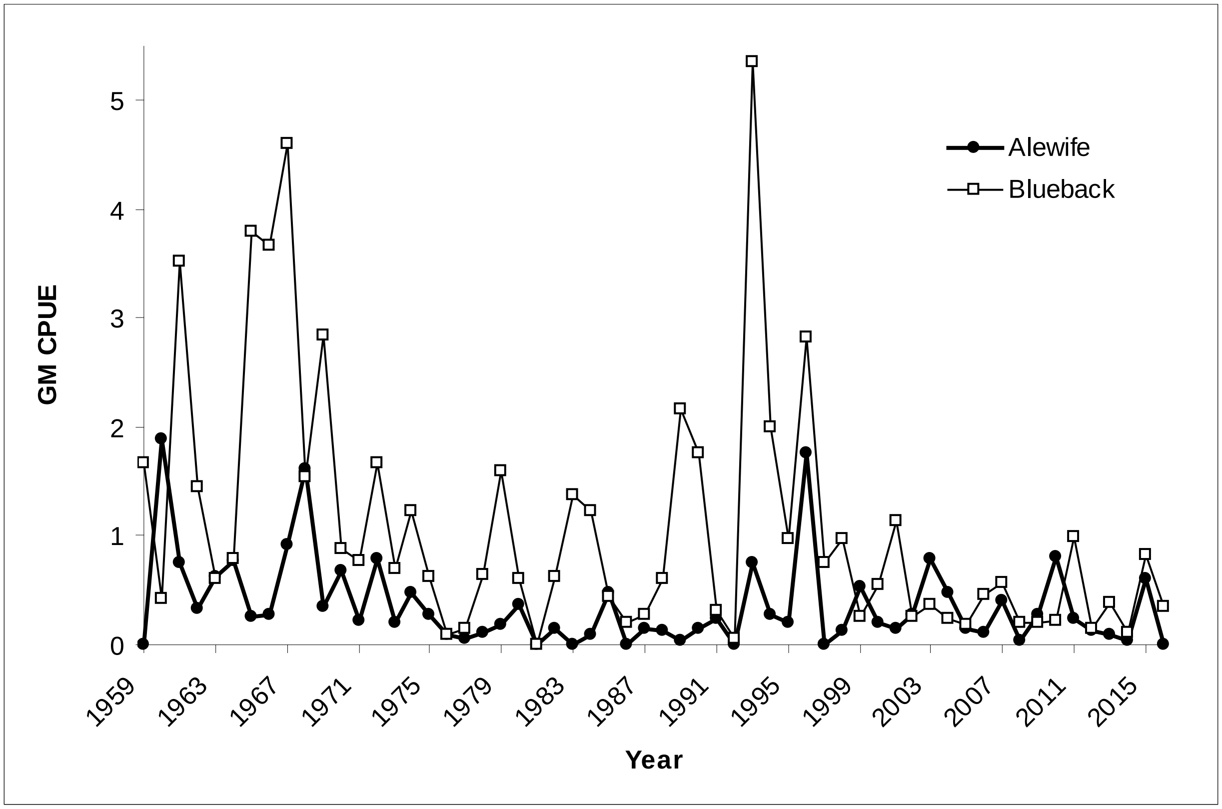


Figure 31. Nanticoke River juvenile alewife and blueback herring geometric mean CPUE (catch per haul), 1959-2016.



PROJECT NO. 2
JOB NO. 2

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

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

INTRODUCTION

The primary objective of Project 2 Job 2 was to characterize recreationally important migratory finfish stocks in Maryland's Chesapeake Bay by age, length, weight, growth and sex. Weakfish (*Cynoscion regalis*), bluefish (*Pomatomus saltatrix*), Atlantic croaker (*Micropogonias undulates*), summer flounder (*Paralichthys dentatus*) and spot (*Leiostomus xanthurus*) are very important sport fish in Maryland's Chesapeake Bay. Red drum (*Sciaenops ocellatus*), black drum (*Pogonias cromis*), spotted seatrout (*Cynoscion nebulosus*) and Spanish mackerel (*Scomberomorus maculates*) 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 (MD DNR) 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 for the Chesapeake Bay, the Atlantic States Marine Fisheries Commission (ASMFC) and the Mid-Atlantic Fishery Management Council (MAFMC).

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

METHODS

Data Collection

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 23 years of this survey (1993-2016). 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 2016 commercial pound nets were sampled at the mouth of Potomac River, Hooper Straight, the lower Nanticoke River and Tangier Sound (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.

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 (ppt), 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.

Otoliths were taken and weight (g), TL (mm) and sex were determined from a sub sample of weakfish, spot and Atlantic croaker. Prior to 2011, Atlantic croaker and weakfish otoliths were processed and aged by the South Carolina Department of Natural Resources (SC DNR). Otoliths from 2011 to 2016 were aged by MD DNR biologists. All spot otoliths were processed and aged by MD DNR. 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 mm in diameter and 0.3048 mm thick. The 0.4 mm sections were then mounted on microscope slides and viewed under a microscope at 5X to 6X 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 MD DNR 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 Atlantic States marine Fisheries Commission (ASMFC) conducted an Atlantic menhaden aging workshop. It was determined that MD DNR 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 2016, therefore Atlantic menhaden ages prior to 2015 may be biased high.

A fishery independent gill net survey targeting adult Atlantic croaker, spot, bluefish and Atlantic menhaden 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. 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 m square (Figure 3). An experimental gill net constructed of four 30.5m by 1.8m net panels with stretch mesh sizes of 6.4 cm (2.5 inches), 7.6 cm (3.0 inches), 8.9 cm (3.5 inches) and 10.2 cm (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 1.2m gap. Nets were rigged to sink using 5/8 inch float core line and 65 lb. lead core line and mesh constructed of number 8 monofilament netting, except for the 6.4 cm mesh which was constructed of number 4 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 1.5m 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 time, weather, wind speed (knots), wind direction, tidal stage, water temperature (°C), salinity (ppt) and secchi disk readings (meters) were recorded. All fish were enumerated by species and mesh size in which they were captured. All Atlantic croaker, spot, bluefish, white perch, striped bass, weakfish and summer founder 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 for the first five fish for each mesh panel each day (not each site).

Juvenile indices were calculated for weakfish, Atlantic croaker and spot from the MD DNR Blue Crab Trawl Survey data. This survey utilizes a 4.9 m semi-balloon otter trawl with a body and cod end of 25-mm-stretch-mesh and a 13-mm-stretch-mesh cod end liner towed for 6 min at 4.0-4.8 km/h. The systems sampled included the Chester River, Eastern Bay, Choptank River 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 - 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 December 20, 2016. Since these data sets are not finalized until the spring of the following year, harvest data for this report are through 2015. 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 2016 charter log book data had not been finalized, only data through 2015 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 mm TL and K= 0.08. L_c was 305 mm TL. Von Bertalanffy parameters for croaker mortality estimates were derived from pooled ages (otoliths; n = 2,850) determined from 2003-2015 Chesapeake Bay pound net survey data, and June through September 2003-2015 measurements of age zero croaker (n=333) from MD DNR Blue Crab Trawl Survey Tangier Sound samples (Chris Walstrum MD DNR personnel communication 2015). 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 2003-2015 were L_∞ = 389.40 mm TL and K= 0.40, while L_c for Atlantic croaker was 229 mm TL.

Annual length frequency distributions were constructed when sample size was sufficient for summer flounder, Atlantic croaker, weakfish, bluefish, spot and Atlantic menhaden, utilizing 20 mm length groups for both the onboard pound net and Choptank River gill net surveys. Length-at-age keys were constructed for weakfish, Atlantic croaker and Atlantic menhaden using age samples through 2016. Age and length data were assigned to 20 mm groups for each species and then the length-at-age key was applied to the length frequency by year to determine the proportion at age for croaker in 2000 and 2002 through 2016, weakfish from 2003 through 2016 and Atlantic menhaden from 2005 through 2016. Age length keys for spot were constructed for 2007 through 2016. Age and length data were assigned to 10 mm TL groups for spot and then the length-at-age key was applied to the length frequency to determine the proportion at age by year. It was necessary to supplement MD DNR spot ages with Virginia Marine Recourses Commission (VMRC) spot age data for a small number of fish greater than 270 mm 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 24, 2016 through September 7, 2016 (Table 1). All target species were encountered during this time period. Twenty-two non-target species (Table 2) were also encountered in 2016. The Choptank River fisheries independent gill net survey was conducted once per week from June 14, 2016 to September 8, 2016, with the following exceptions due to mechanical problems with the sampling vessel: the first week in August, the First week of June and two of the four sets in the third week of July. Eight of the target species and seven non-target species were captured in 2016 (Table 3).

Weakfish

Sixty-four weakfish were sampled in the 2016 pound net survey, an increase from the very low 2014 and 2015 values, but still well below the 24 year time series mean of 325 weakfish per year. Weakfish mean length in 2016 was 256 mm TL, the third lowest value of the time series (Table 4). The 2016 length frequency distribution remained truncated, with 78% of sampled weakfish being less than 270 mm TL (Figure 4). Females accounted for 74% of the 61 weakfish in which sex was determined, and had a mean length and weight of 258 mm TL and 173 g. Males had a mean length and weight of 250 mm TL and 161g.

Chesapeake Bay weakfish length-frequencies were truncated during 1993 – 1998, while those for 1999 and 2000 contained considerably more weakfish greater than 380 mm TL. However, this trend reversed from 2001 to 2016, with far fewer large weakfish being encountered. Five percent of the 64 weakfish sampled in the 2016 pound net survey were above the recreational size limit of 331 mm TL (13 inches), and 13% were above the commercial size limit of 305 mm TL (12 inches).

Two weakfish measuring 292 and 299 mm TL were captured in the Choptank River gill net survey in 2016. Only one weakfish measuring 157 mm TL was captured in 2015, and none were encountered in 2013 or 2014 (Table 3). All three weakfish captured were in the 6.4 cm 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 2015 Maryland Chesapeake Bay commercial weakfish harvest of 983 pounds was well below the 1981 – 2015 Maryland Chesapeake Bay average of 44,922 pounds per year (Figure 5). Harvest was higher in the 1980s averaging 121,732 pounds per year, but has been extremely low the past six years averaging 231 pounds per year. Maryland recreational anglers harvested an estimated 3,093 weakfish (PSE = 55.5) from inland waters during 2015, with an estimated weight of 1,695 pounds (PSE = 53.3; Figure 5). The number of weakfish harvested by the recreational fishery in 2015 was well below the time series mean harvest of 175,413 fish and, was the sixth lowest value of the 1981-2015 time series. According to the MRIP estimates, Maryland anglers released 117,550 (PSE = 75.0) weakfish from inland waters in 2015, a substantial increase compared to 2014 (4,134, PSE = 66.0), but still below the time series mean estimate of 171,657 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 2015. 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 2015 (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, but was still the third lowest value of the 23 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 third lowest value of the 28 year time series in 2016 (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 63 fish in 2016, and an additional fish was measured. Eighty-six percent of sampled weakfish were age one, and 14% 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 0 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 or 2016, 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 2004-2016. Mean total lengths have ranged from the time series high of 374 mm TL in 2005 and 2010 to the time series low of 268 mm TL in 2013 and 2014 (Table 4). The 2015 mean length of 336 mm TL was similar to the 23 year time series mean of 331 mm TL, but the 2016 value declined to 273mm TL. 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 mm TL length groups, or more normal in distribution with a singular peak between the 310 to 430 mm TL length groups (Figure 8). The 2013 and 2014 length frequency distributions were heavily skewed toward smaller fish, with 66% and 58% below 290 mm TL in length respectively. The 2015 distribution shifted to larger fish, but reverted back to smaller fish in 2016. The number of summer flounder sampled in 2015 (n=43) and 2016 (n=41) were the lowest of the 24 years surveyed (Table 4), and well below the average annual number sampled of 681. Recreational size limits have been adjusted annually, but comparing the onboard pound net survey catches to the 2016 recreational size limit of 407 mm TL indicated none of the sampled flounder were of legal size in 2016, compared to 14% in 2015, 4% in 2014 and 11% in 2013. In 2016 only two summer flounder were captured in the Choptank River gill net survey measuring 177 and 242 mm TL. Both specimens were captured in the 6.4 cm mesh.

The 2014(2015) Maryland Chesapeake Bay commercial summer flounder harvest totaled 1,566, the lowest value of the 1981 – 2014 time series (Figure 9). 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 2015, with the exception of an increase in 2014 (Figure 9). The recreational inland harvest estimate of 21,392 (PSE = 26.3) fish caught in 2015 was a decrease from the 2014 estimate of 68,277 (PSE = 65.2) fish (Figure 9). The 2015 MRIP recreational inland waters release estimate of 200,760 (PSE = 31.9) also decreased compared to 2014 (592,097 fish, PSE = 38.3; Figure 9). The recreational inland fishery is primarily 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 10). The harvest decreased and stabilized at just over 5,000 pounds from 2012 to 2014, before increasing to 8,208 pounds in 2015.

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 2014, was conducted in 2015 (Terceiro 2015), and indicated the stock was not overfished, but overfishing was occurring. Projection analysis for 2015-2018 indicated that overfishing was likely to occur in 2015, but if F is reduced to the target for 2016-2018 the stock would not become overfished.

Bluefish

Bluefish sampled from the onboard pound net survey averaged 289 mm TL during 2016, the 5th lowest value of the 24 year time series (Table 4). The pound net survey length frequency distributions have been bimodal most years (Figure 11). 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, which had a distribution more similar to 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 have been captured in low numbers all four years of the Choptank River gill net survey, with only three being captured in 2016 (Table 3). Bluefish lengths for all panels and years combined ranged from 218 to 500 mm TL (n=42). Sample size was too small to make meaningful comparisons to length by net mesh size. Bluefish were most often captured in the 6.4 mm mesh panel in 2013 and 2015 with the 7.6 mm mesh panel accounting for the second highest catch in those years and all of the catch in 2016 (Figure 12).

Maryland bluefish Chesapeake Bay commercial harvest in 2015 was 20,985 pounds, well below the 1981-2015 average of 115,052 pounds per year (Figure 13). Chesapeake Bay commercial landings were higher in the 1980s averaging 321,402 pounds per year, but have been variable since and only averaging 45,494 from 1990 to 2015 (Figure 13). Recreational inland harvest estimates for bluefish were high through most of the 1980's, but have fluctuated at a lower level since 1991 (Figure 13). The 2016 estimate of 89,989 (PSE = 27.3) fish harvested decreased compared to 2014, and was the second lowest estimate of the 1981-2015 time series (Figure 13). Estimated inland recreational releases were 149,739 (PSE = 41.0) fish in 2015, well below the time series mean of 405,091 fish (Figure 13). Reported bluefish harvest from charter boat logs ranged from 13,124 – 134,828 fish per year from 1993 to 2015. The 2015 harvest of fish was the lowest of the 23 year time series (Figure 14).

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 1980 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 254 mm TL in 2016, and was the third lowest value of the 24 year time series (Table 4). The onboard pound net length frequency distribution for 2016 indicated a continued shift to smaller croaker, with 60% of all sampled fish in the 230 and 250 mm TL length groups combined and no croaker in the 350 mm and larger length groups (Figure 15).

Mean lengths and weights by sex for Atlantic croaker sampled from pound nets decreased in 2016, with values of 264 mm TL and 254 g for females (n = 88) and 254 mm TL and 231 g for males (n = 48). Pound net samples were 65% female and 35% male. Samples in which sex determination and weight were taken, were not randomly selected; therefore sex specific data may be biased.

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, with 32 fish being captured. Anecdotal reports from commercial and recreational fishermen indicated croaker catches were unusually low from the Choptank River north in 2015 and 2016, but catches were more normal in lower Tangier sound and the Potomac River. The large decreased catches in 2015 and 2016 may be a localized low abundance event and not an indication of availability in Maryland waters in general. The 6.4 cm mesh net caught the highest proportion of Atlantic croaker in 2013, 2014 and 2016 with proportion of catch declining with increased mesh size (Figure 16). In 2015 the 7.6 cm 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 17). Year to year length frequency comparisons were not made do to the low sample sizes in 2015 and 2016.

The 2015 Maryland Atlantic croaker Chesapeake Bay commercial harvest of 228,819 pounds was a 46.2% decrease from 2014, and fell below the 1981 to 2015 mean of 309,405 pounds (Figure 18). The 2015 recreational inland harvest estimate was 768,197 fish (PSE = 22.1) a 28.8% decrease from 2014, but still above the 1981-2015 average of 696,033 fish (Figure 18). The 2015 recreational release estimate of 616,942 fish decreased 46.2% compared to 2014 (Figure 18), and was below the 1981-2015 average of 1,215,923 fish. Reported Atlantic croaker harvest from charter boats ranged from 36,495 – 448,789 fish per year during the 23 year time period (Figure 19), with the low value occurring in 2015. 2015 was the sixth 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 24 year time series for 2008, but fell sharply in 2009 and remained low through 2011, before spiking again in 2012 (Figure 20). The GM steadily decreased the following three years to the 2nd lowest value of the 27 year time series in 2015 (0.21 fish per tow). The index value increased in 2016 to 0.81, but remains relatively low. 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 pound net caught Atlantic croaker otoliths in 2016 ranged from zero to eight (n=175; Table 7). The number of Atlantic croaker sampled for length in 2016 (n=2,239) was applied to an age-length key for 2016 (Table 7). This application indicated that 64% of the fish were age four, 20% were age three, and 5% were age two. The remaining age groups each accounted for four percent or less of the fish sampled (Table 7). Age structure in 2016 expanded slightly, but still was predominately age 4 or less (94%). 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 7. Instantaneous total mortality in 2016 was Z = 1.82 (Table 6). Total mortality estimates had been fairly stable from 2011 through 2013, after increasing steadily from the time series low in 2006 through 2011. The high 2014 to 2016 total mortality estimates from the length based approach are likely somewhat inflated by the sudden influx of the strong 2012 year class, which dominated the length frequency distribution. However the lack of older larger fish does indicate increased mortality and/or poor recruitment of year classes prior to 2012. The fishery is currently being supported primarily by a single year class.

In 2010, the ASMFC Atlantic Croaker Technical Committee completed a stock assessment using a statistical catch at age model using data through 2008 (ASMFC 2010). The assessment indicated decreasing F and rising SSB since the late 1980's. Estimated values of F, SSB and biological reference points were too uncertain to be used to determine stock status. However, the ratio of F to F_{MSY} (the F needed to produce maximum sustainable yield) was deemed reliable and was used to determine that overfishing is not occurring. It is not possible to be confident with regard to stock status, particularly a biomass determination until the discards of Atlantic croaker from the South Atlantic shrimp trawl fishery can be adequately estimated and incorporated into the stock assessment (ASMFC 2010). A benchmark coastwide stock assessment has been initiated by ASMFC, with projected completion in early 2017.

Spot

The 2016 spot mean length from the onboard sampling of 175 mm TL was the lowest of the 24 year time series (Table 4). Seventy percent of spot encountered in the onboard pound net survey in 2016 were between 150 and 189 mm TL, the length frequency distribution remained truncated relative to the distributions of the early to mid-2000s and shifted further toward smaller fish (Figure 21). No jumbo spot (>254 mm TL) were present in the 2016 onboard sampling. Abundance of jumbo spot in the survey has been low for the past several years (0-3% of sample, 2005-2014). This followed good catches in the early part of the decade (10% in 2003, 13% in 2004).

Spot catch in the Choptank River gill net survey was highest in 2014 (749 fish) and similar in 2013 and 2015 (272 and 222 fish, respectively), and lowest in 2016 (109 fish). The 6.4 cm mesh captured the majority of spot each year (Figure 22), accounting for over 95% of catch in 2013, 2014 and 2016. The 6.4 cm mesh accounted for 73% of the catch in 2015, and the 7.6 cm mesh 27% of the catch. Only one spot was captured in the 8.9 cm mesh in 2013 and 2015, and no spot were captured in the 10.5 cm mesh. Length frequency distribution was similar in 2013 and 2014 with the 200 and 210 mm length groups accounting for over 60% of catch each of those years (Figure 23). The distribution shifted toward larger fish in 2015, with only 24% of captured fish in the 200 and 210 mm length groups combined. The length distribution shifted to smaller fish in 2016 with 74% of captured spot being less than 200 mm TL. 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 24), but declined to 62,251 pounds in 2016, below the 1981-2015 mean of 134,487 pounds. Gill net landings for spot have been higher since 2006 than in previous years. This would seem to indicate an increased effort directed at spot, likely triggered by market demand and/or the decreased availability of other more desirable species. An increase in fish pot harvest in 2011 is likely a result of charter fishermen with commercial licenses' reporting spot caught in pots to use as live bait. In 2015 gill nets and fish pots accounted for 57% of harvest and 8% of harvest, respectively.

Maryland recreational inland harvest estimates from the MRIP indicated that spot catches since 1981 have been highly variable (Figure 24). 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 24). The 2015 recreational inland waters harvest estimate of 525,079 fish (PSE = 24.2) was below the time series mean estimate of 1,541,132 fish. The release estimate of 565,679 fish (PSE = 31.6) was below the time series mean of 1,024,119 fish (Figure 24). Reported spot charter boat logbook harvest from 1993 to 2015 ranged from 141,999 to 848,492 fish per year (Figure

25). The 2015 reported harvest was the lowest of the time series, well below the time series mean of 470,168 fish.

Spot juvenile trawl index values from 1989-2016 were quite variable (Figure 26). 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 26). The index values have declined since 2012 to the time series low in 2015 (0.29 fish per tow). The 2016 value increased to 1.36 fish per tow, but was still the 7th lowest value of the 28 year time series.

In 2016 57% of sampled fish were age zero and 43% were age one, with no age two plus fish being sampled (111 ages and 137 lengths; Table 8). 2016 was the first year that age one spot did not account for a majority of the age distribution, and only the second year no age two plus spot were sampled. 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.

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 2012 are likely due to the very poor 2011 year class and influx of the stronger 2012 years class. This is further supported by the very large number of fish estimated to be released by MRIP in 2013, which would have been age 1 fish, and the highest percentage of age two fish from the pound net survey occurring in 2014. Very weak year classes in 2014 and 2015 lead to the length structure sifting to smaller fish and the majority of spot being age zero. The below average 2016 year class will likely lead to continued lower availability of adult spot in 2017. In 2014 the ASMFC adopted a traffic light approach to monitor the stock and initiate management, as an interim measure, until a stock assessment can be completed. An evaluation of ASMFC traffic light indicator in 2015, using data through 2014, did not indicate the stock was in need of management action, but levels of red were nearing the threshold in which action would be needed. The traffic light was not updated with 2015 data due to the initiation of the first coastwide bench mark stock assessment, which is tentatively scheduled for completion in early 2017.

Red Drum

Red drum have been encountered sporadically through the 24 years of the onboard pound net survey, with none being measured in nine years and 458 being measured in 2012 (Table 4). Three red drum were measured in 2016 ranging from 333 to 352 mm TL. Pound net sampling indicated more red drum were available to anglers in 2012 and 2013 than in most other years, but this trend ended in 2014. The two year increased availability is like from a very strong year class using the bay as sub-adults.

Maryland Chesapeake Bay commercial fishermen reported harvesting no red drum in 2015, compared to the 2013 spike of 2,923 pounds, and the 1981 to 2015 mean of 513 pounds per year (Figure 27). The high 2013 landings value was likely due to a large year class growing into the 18 – 25 inch slot limit.

The MRIP 2015 Maryland inland waters recreational harvest and release estimates were zero and 779 (PSE = 101.8) red drum respectively (Figure 27). Recreational harvest estimates have been extremely variable with zero harvest estimates for 26 of the 35 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 1993-2015, except for 1996. Harvest was low for all years, ranging from zero to a high of 271 fish in 2012, with 2 red drum being harvested in 2015 (Figure 28). 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 MD DNR onboard pound net sampling, with four being sampled in 2016 ranging from 308 to 1,175 mm TL (Table 4). Lengths throughout the time series have ranged from 244 to 1,330 mm TL. Commercial harvest of black drum was banned for Maryland's portion of Chesapeake Bay in 1999 (Figure 29). Recreational inland water harvest and release estimates from 1981 to 2015 have been variable, with harvest ranging from zero (20 years) to 13,308 fish in 1983 (Figure 29). In 2015, MRIP estimated 733 black drum were harvested (PSE = 91.2), and 4,969 were released (PSE = 101.5). 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 1993-2015 time series, with a mean catch of 369 fish per year (range = 101 – 905; Figure 30). Two hundred forty-five black drum were reported as harvested in 2015.

Spanish Mackerel

Spanish mackerel have been measured for FL, TL or both in 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 mm. Only ten Spanish mackerel were encountered in 2016. The number of mackerel measured has been low for most years with the largest samples occurring from 2005-2007 and in 2013 (Table 4). One Spanish mackerel was measured from the gill net survey in 2016 measuring 435 mm FL (Table 4).

The 2015 commercial harvest of Spanish mackerel in Maryland’s portion of Chesapeake Bay was 2,190 pounds (Figure 31), and below the 1981 to 2015 mean of 4,903 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 31). This followed a period of eight out of twelve annual estimates with zero fish captured. Harvest estimates for 1998 – 2015 were variable, ranging from 0 – 20,049 fish with an average of 7,873 fish taken. The 2015 estimated recreational Spanish mackerel harvest of 11,366 fish (PSE = 26.6) was slightly more than double the 2014 estimate of 5,494 fish (Figure 31). Most years have a high PSE values, these estimates are considered tenuous. Spanish mackerel charter boat harvest from 1993 to 2015 ranged from 53 – 10,653 fish per year, with a harvest 578 fish in 2015 (Figure 32). 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. One was measured from the onboard pound net survey in 2016 measuring 625 mm TL (Table 4). Commercial harvest of spotted seatrout in Maryland's portion of Chesapeake Bay averaged 2,949 pounds from 1981-2015, however, 11 of 12 years had zero harvest from 1981-1992 (Figure 33). Reported 2015 harvest was 16 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 2015, including six years of zero harvest, and averaged 2,521 fish per year (Figure 33). The 2015 harvest estimate was 4,870 fish (PSE 66.5). The high PSE values from 2009 to

2015 indicate the MRIP survey does not provide reliable estimates for this species in Maryland.

Spotted seatrout harvest from 2015 charter boats was 396 fish. Reported harvest ranged from 224 – 20,030 fish per year and averaged 3,567 fish per year for the 19 year time series (Figure 34). 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 from commercial pound nets in 2016 was 208 mm FL, the lowest value of the 13 year time series (Table 4). Menhaden length frequencies from onboard sampling have varied annually (Figure 35). The 2016 distribution was more evenly distributed than previous years. 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 cm mesh and the 6.4 cm mesh combined accounted for over 70% of the catch annually (Figure 36). The 7.6 cm mesh caught the highest proportion of menhaden through 2015 and the 6.4 cm mesh the highest in 2016. Length frequency distributions from the Choptank River gill net survey indicated the gear selects slightly larger menhaden than the pound net survey (Figure 37), with the 230 and 250 mm length groups combined accounting for over 60%

of the catch annually. Mean lengths for all meshes combined displayed little inter annual variation: 2013 = 254 mm FL (n = 278), 2014 = 256 mm FL (n = 459), 2015 = 258 mm FL (n = 420) and 2016 = 254 mm FL (n = 308).

Atlantic menhaden scale samples were taken from 247 fish in 2016 from the onboard pound net survey, but ages could only be assigned to 241 fish (Table 9). After applying the annual length frequencies to the corresponding age length keys, age one was the dominate year-class in 2010 and 2011, accounting for 43% and 38% of pound net caught menhaden, respectively (Table 9). In 2012 age two menhaden accounted for 57% of pound net caught menhaden and age seven fish were present for the first time since aging began in 2005. Menhaden ages were more evenly distributed in 2013, with ages one, two and three accounting for 24%, 28% and 24% of pound net caught fish, respectively. The 2014 through 2016 age distributions were skewed toward younger fish. In 2016 43% of sampled fish were age one and 30% were age two, and ages three through five were also present. Corrections in Maryland's assigning of annuli following the 2015 ASMFC Atlantic menhaden aging workshop would have reduced the age estimates of some fish in 2015 and 2016 compared to the method used in previous years. One hundred fourty-seven scale samples were taken for age from the Choptank River gill net survey in 2016, but age could only be assigned to 140 individuals. Age three accounted for 45% of sampled fish, age two accounted for 29%, ages four and one accounted 12% and age five accounted for 2% or of sampled menhaden (Table10). The gill net survey had a lower proportion of age two menhaden in 2016 than in 2015, with a corresponding increase in age one and three fish. The onboard pound net survey and gill net survey select slightly different ages. The gill net survey had fewer age one fish both years, and a higher proportion of age three plus fish.

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 8.1 million pounds from 2005 to 2015 (Figure 38). 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 7,252,026 pounds 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 using 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 NO. 2
JOB NO. 2

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

2017 PRELIMINARY RESULTS

Onboard pound net survey sampling, through the 2017 portion of the reporting period, began on May 23, 2017, and continued through June 27, 2017, with three separate sampling days and six nets sampled. During this time period the survey took length measurements from 57 Atlantic croaker, 50 Atlantic menhaden, 15 bluefish, three Spanish mackerel, 210 spot and 293 summer flounder. Subsamples for aging were collected from 11 Atlantic croaker, 15 Atlantic menhaden and 47 spot. Sampling continued into the next reporting period.

In 2017 no cooperating fisherman could be located for the lower Eastern Shore area. Seafood dealer sampling was conducted on June 16, 2017, 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. Length and weight measurements were taken from five Atlantic croaker, two bluefish, two northern kingfish, 122 spot, two spotted seatrout and three summer flounder.

The Choptank River gill net survey was conducted on four days for a total of 16 sites form June 7, 2017 to June 28, 2017. The survey caught three Atlantic croaker, 44 Atlantic menhaden, 27 blue crabs, one bluefish, seven gizzard shad, one hickory shad, one hogchoker, 33 spot, 12 striped bass and 42 white perch. 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 2016.

Area	Month	Number of Samples	Mean Water Temp. C	Mean Salinity (ppt)
Point Lookout	May	1	16.6	14.4
Point Lookout	June	3	24.0	14.2
Hooper Strait	June	1	25.4	15.0
Nanticoke	June	3	24.6	13.0
Tanger Sound	June	2	24.0	13.5
Point Lookout	July	4	26.4	15.8
Hooper Strait	July	1	27.1	16.5
Point Lookout	August	4	28.7	20.5
Tanger Sound	August	1	27.2	20.3
Tanger Sound	September	1	24.6	23.9

Table 2. List of non-target species observed during the 2016 onboard pound net survey.

Common Name	Scientific Name
American eel	*Anguilla rostrata*
Atlantic needlefish	*Strongylura marina*
Atlantic spadefish	*Chaetodipterus faber*
Atlantic thread herring	*Opisthonema oglinum*
Blueback Herring	*Alosa aestivalis*
Blue runner	*Caranx crysos*
Butterfish	*Peprilus triacanthus*
Common Carp	*Cyprinus carpio*
Cownose ray	*Rhinoptera bonasus*
Florida pompano	*Trachinotus carolinus*
Gizzard shad	*Dorosoma cepedianum*
Harvestfish	*Peprilus alepidotus*
Ladyfish	*Bodianus rufus*
Longnose gar	*Lepisosteus osseus*
Northern puffer	*Sphoeroides maculatus*
Oyster toadfish	*Opsanus tau*
Silver perch	*Bairdiella chrysoura*
Southern kingfish	*Menticirrhus americanus*
Southern stingray	*Dasyatis americana*
Striped bass	*Morone saxatilis*
Striped burrfish	*Chilomycterus schoepfi*
White catfish	*Ameiurus catus*

Table 3. Total catch by species in numbers from the Choptank River gill net survey, 2013 - 2016.

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

Table 4. Mean length (mm TL, unless otherwise noted), standard deviation, and sample size of summer migrant fishes from Chesapeake Bay onboard pound net sampling, 1993-2016.

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
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
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
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
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
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
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
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
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
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
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
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
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
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
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
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
Spotted Seatrout																								
mean length		448	452			541	460								414	464	262		361	436	456	499	487	625
std. dev.		86	42				134								43	72	22		142	112	29	70		
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
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

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
Red Drum																								
mean length						302	332	648		316	506	647	353	366	658	361			678	318	469	954		340
std. dev.							71			44		468		21	40	57			18	71	39			10
n	0	0	0	0	0	1	16	1	0	177	1	2	1	16	2	21	0	0	2	458	16	1		3
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
std. dev.			34	62				34	34	81	63	95	33	35	51	59	53			74	36		41	16
n			44	27	1	1		49	19	20	11	8	373	445	158	18	7	0	0	107	331	1	3	10
Menhaden (Fork Length)																								
mean length												262	282	238	243	246	245	232	213	243	251	223	219	208
std. dev.												28	36	42	41	29	40	36	39	25	31	38	28	42
n												213	1,052	826	854	826	366	836	773	755	762	775	864	732

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 2003-2016.

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

Table 6. Weakfish and Atlantic croaker instantaneous total mortality rate estimates (Z) from Chesapeake Bay pound net data, 1999–2016.

	Species	
Year	Weakfish	Atlantic Croaker
1999	0.74	0.38
2000	0.4	0.42
2001	0.62	0.33
2002	0.58	0.33
2003	0.73	0.46
2004	1.29	0.36
2005	1.44	0.30
2006	*	0.26
2007	*	0.31
2008	*	0.31
2009	*	0.48
2010	*	0.65
2011	*	0.80
2012	*	0.80
2013	1.55	0.86
2014	*	1.61
2015	*	1.41
2016	*	1.82

* Insufficient sample size to calculate 2006 – 2012, 2014 - 2016 weakfish estimates.

Table 7. 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, 1999-2016.

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

Table 8. 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, 2007-2016.

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

Table 9. Atlantic menhaden percentage at age, number of age samples and number of length samples by year using, pound net length and age data, 2005-2016.

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

Table 10. Atlantic menhaden percentage at age, number of age samples and number of length samples by year using, gill net length and age data, 2015-2016.

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

Figure 1. Onboard pound net survey sampling site locations for 2016.

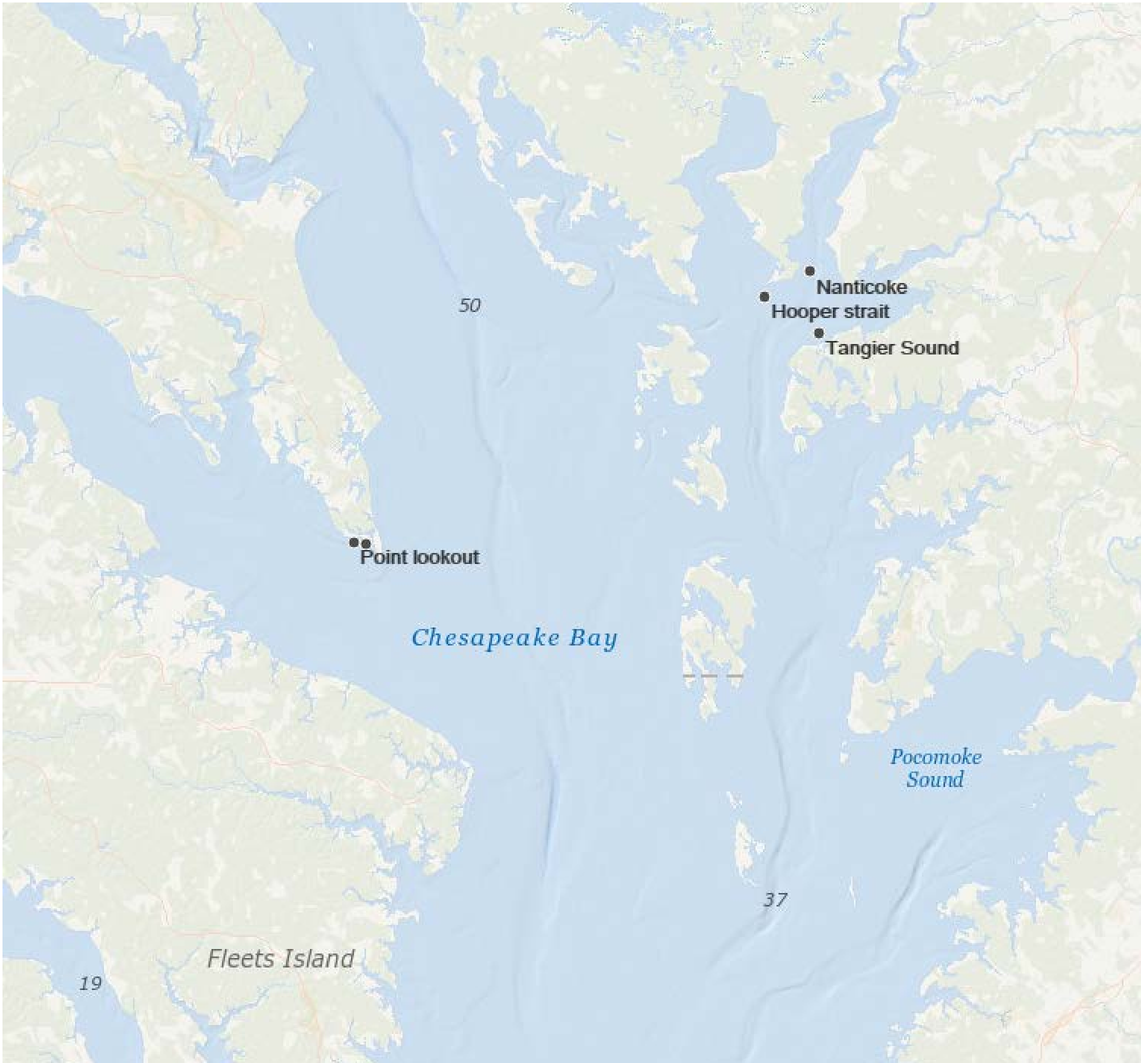


Figure 2. Choptank River gill survey net sampling site locations for 2016.

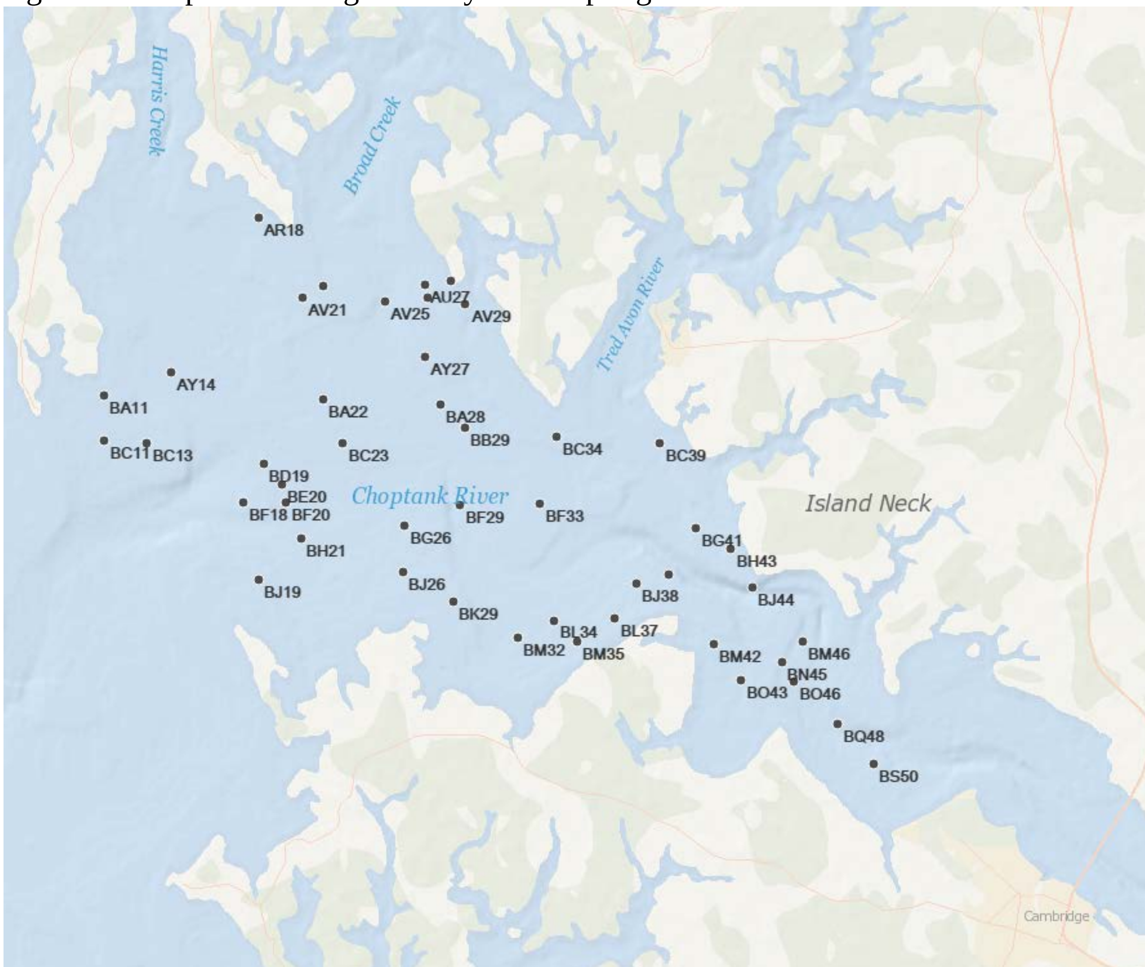


Figure 3. Choptank River gill net survey sampling grid and grid names used in all years of the survey.

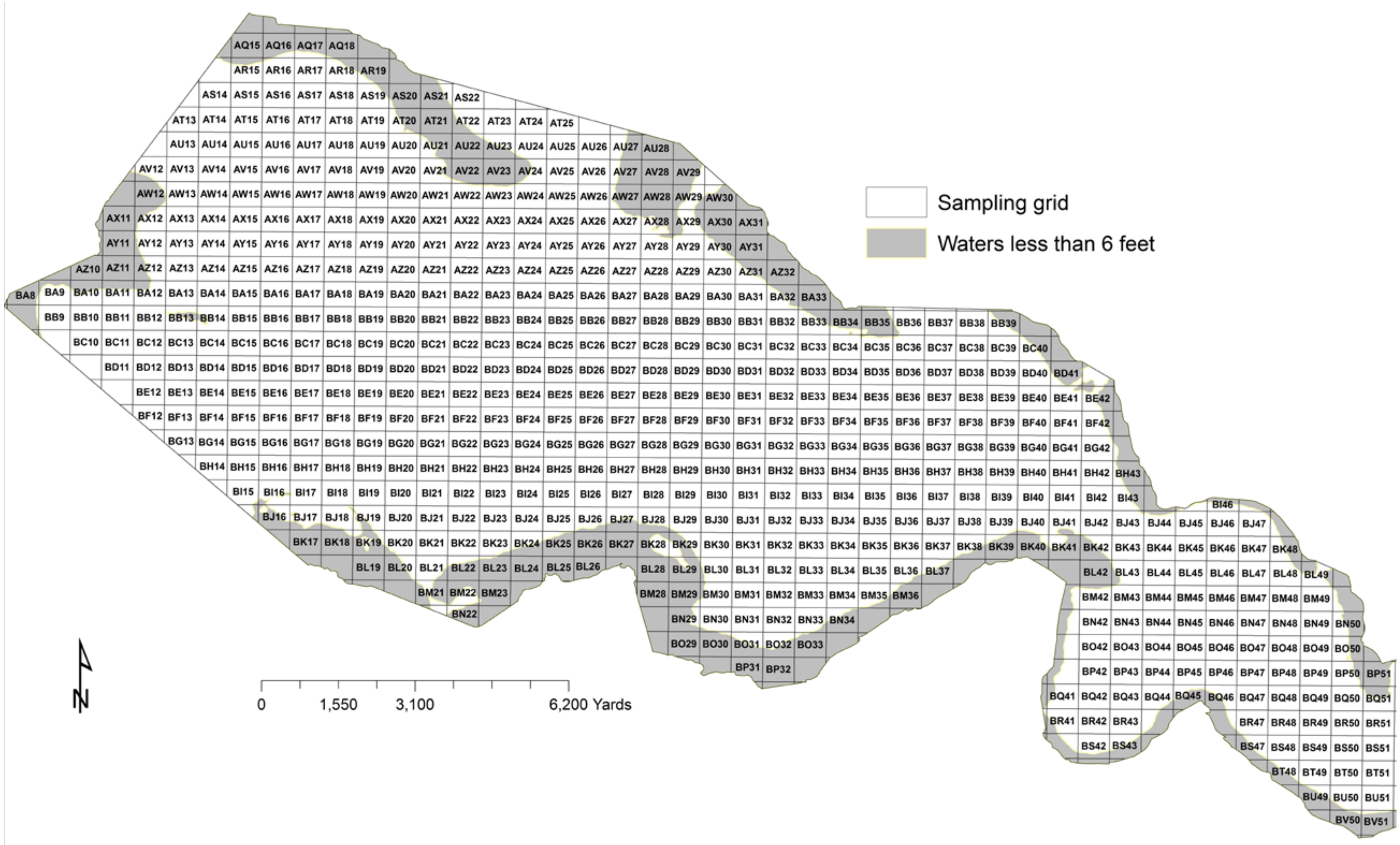


Figure 4. Weakfish length frequency distributions from onboard pound net sampling, 2007-2016. Note: 2011 210 mm length group was truncated to preserve scale, actual value is 50%.

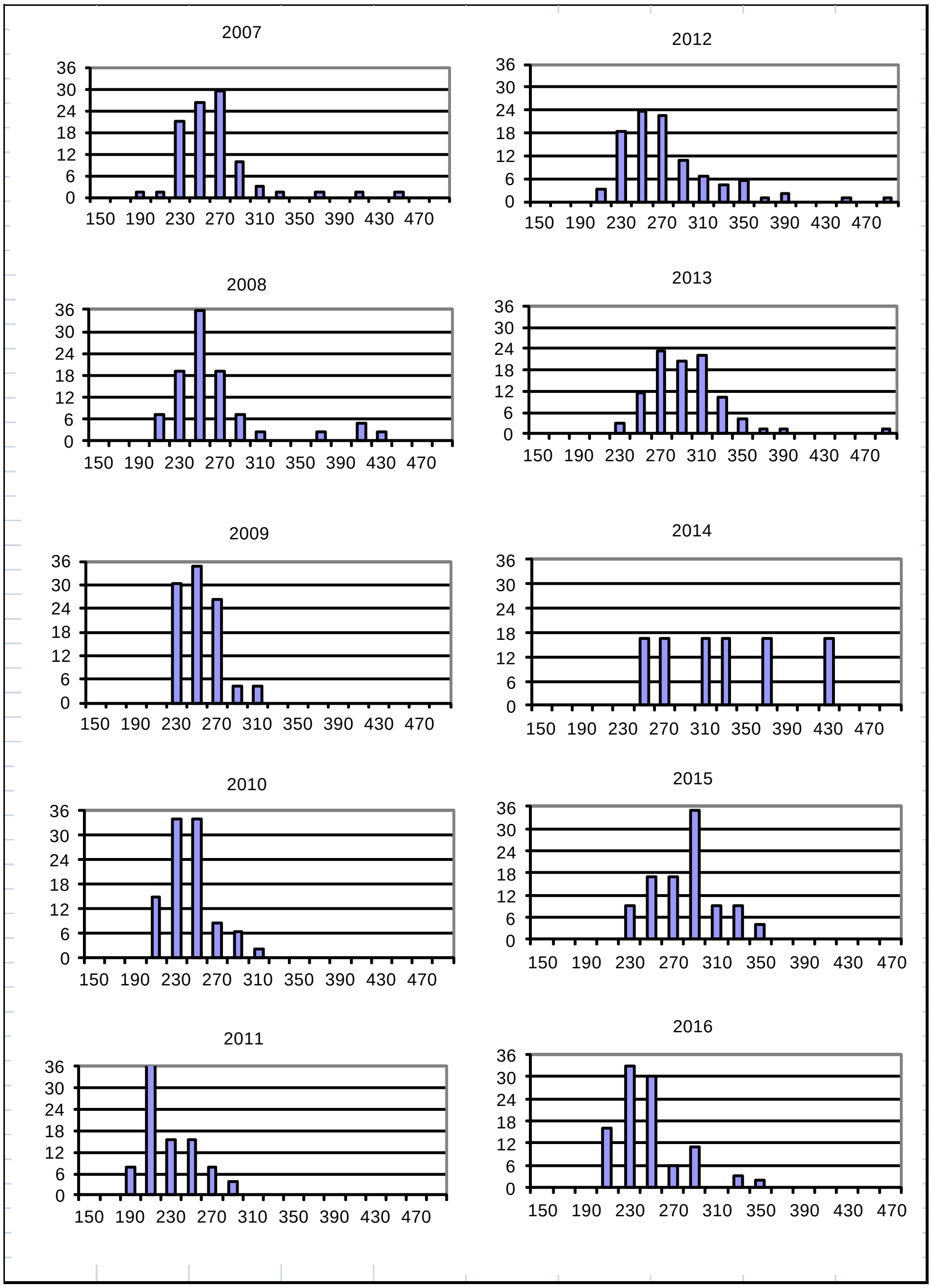


Figure 5. Maryland's commercial landings of weakfish in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational weakfish harvest and release estimates in numbers from 1981-2015.

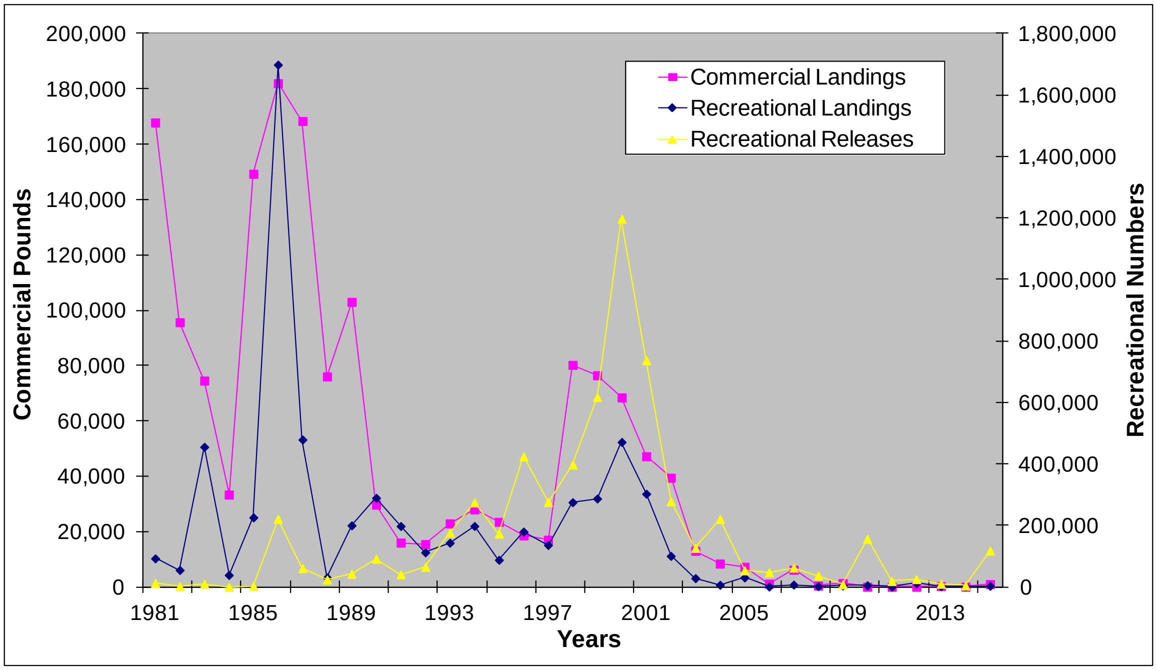


Figure 6. Maryland Charter boat log book weakfish harvest in numbers and the number of anglers participating in trips catching weakfish, 1993-2015.

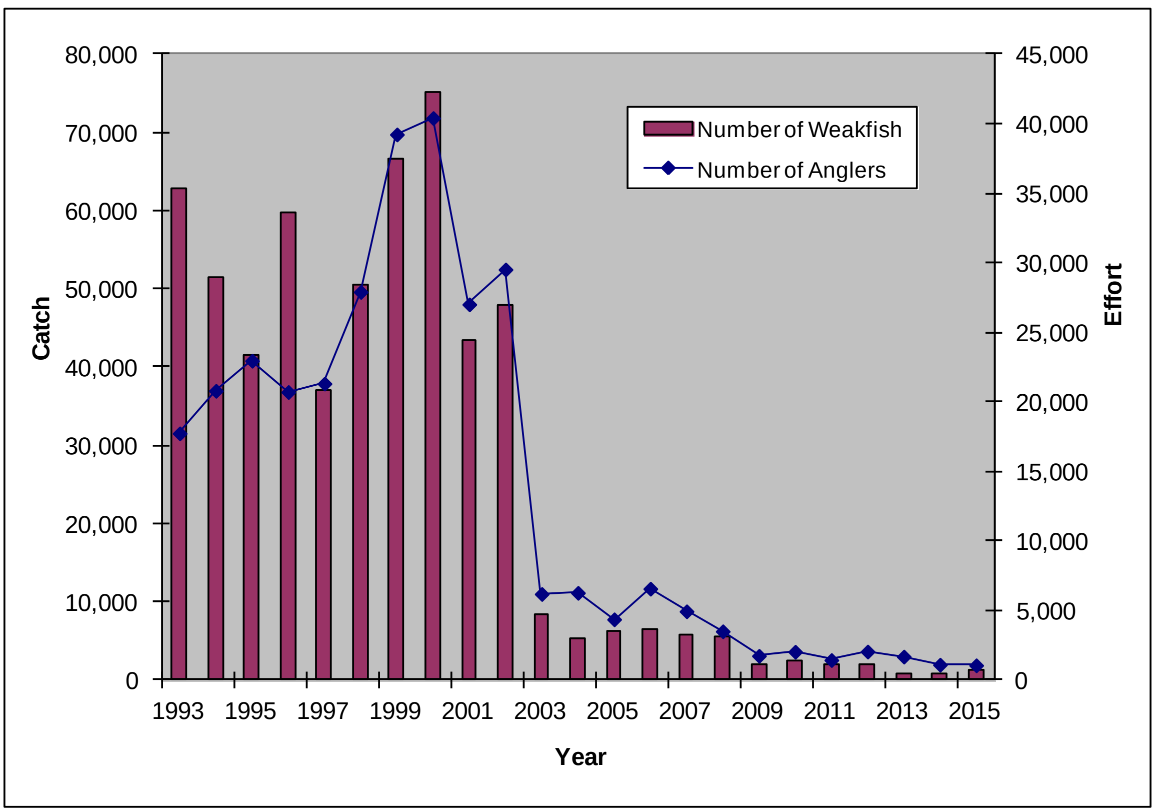


Figure 7. Maryland juvenile weakfish geometric mean catch per trawl and 95% confidence intervals for Maryland's lower Chesapeake Bay, 1989-2016.

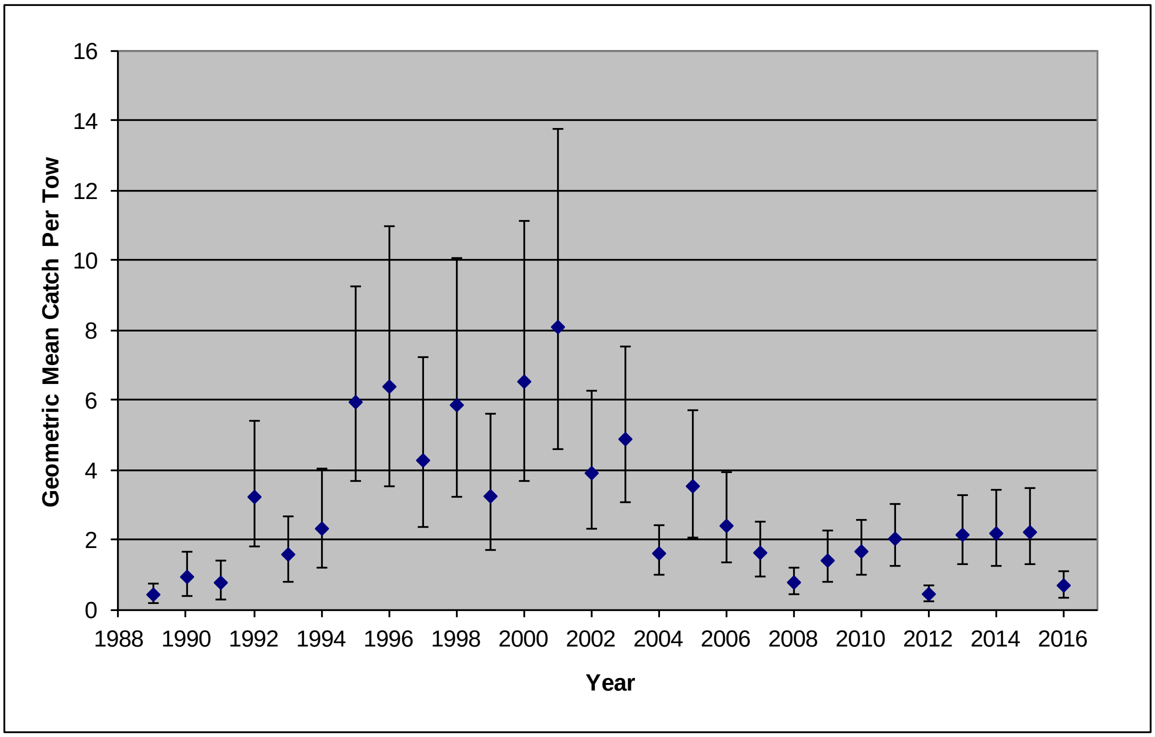


Figure 8. Summer flounder length frequency distributions from onboard pound net sampling, 2007-2016.

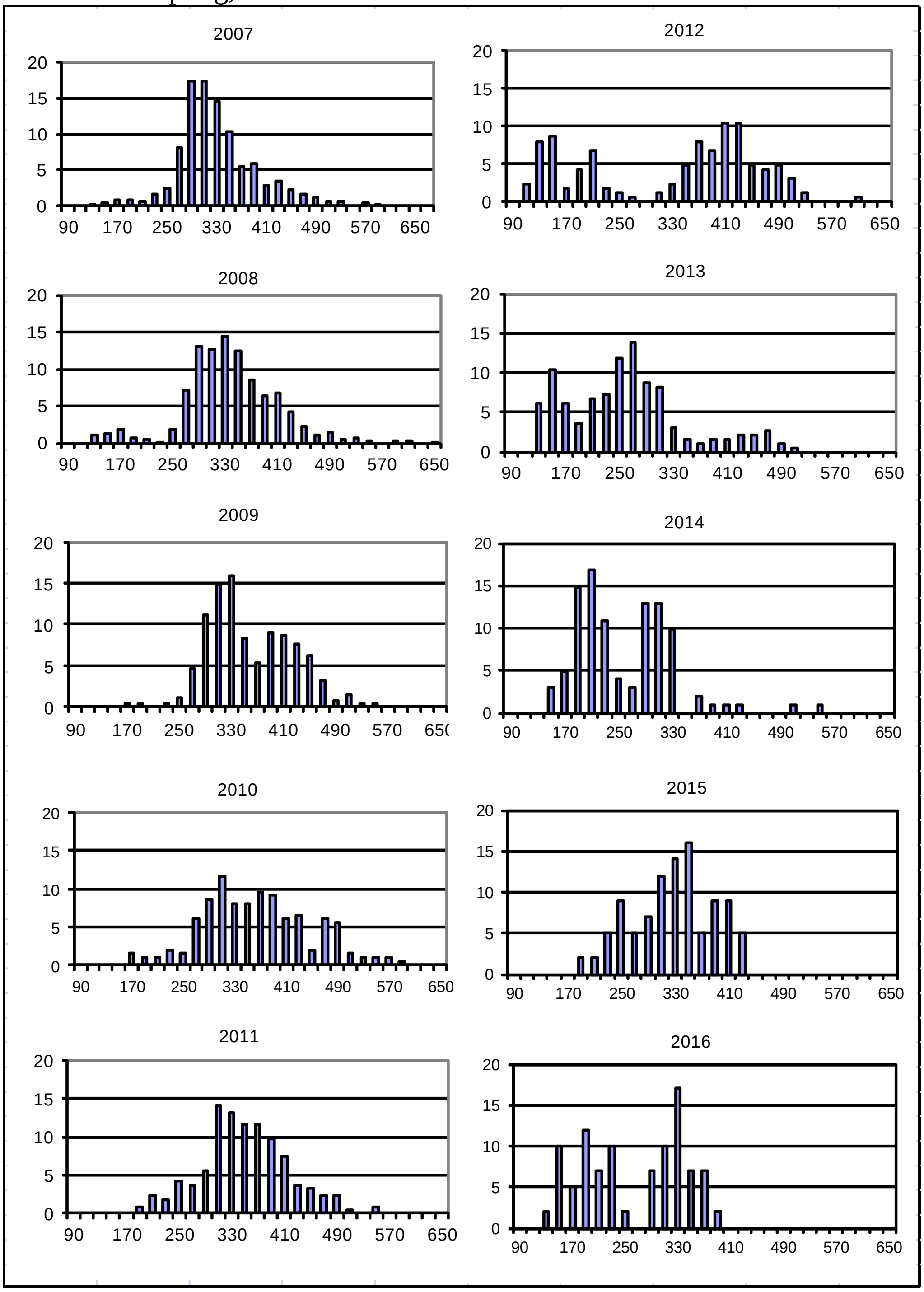


Figure 9. Maryland's commercial landings of summer flounder in pounds from the Chesapeake Bay and the MRIP Maryland summer flounder inland recreational harvest and release estimates in numbers from 1981-2015.

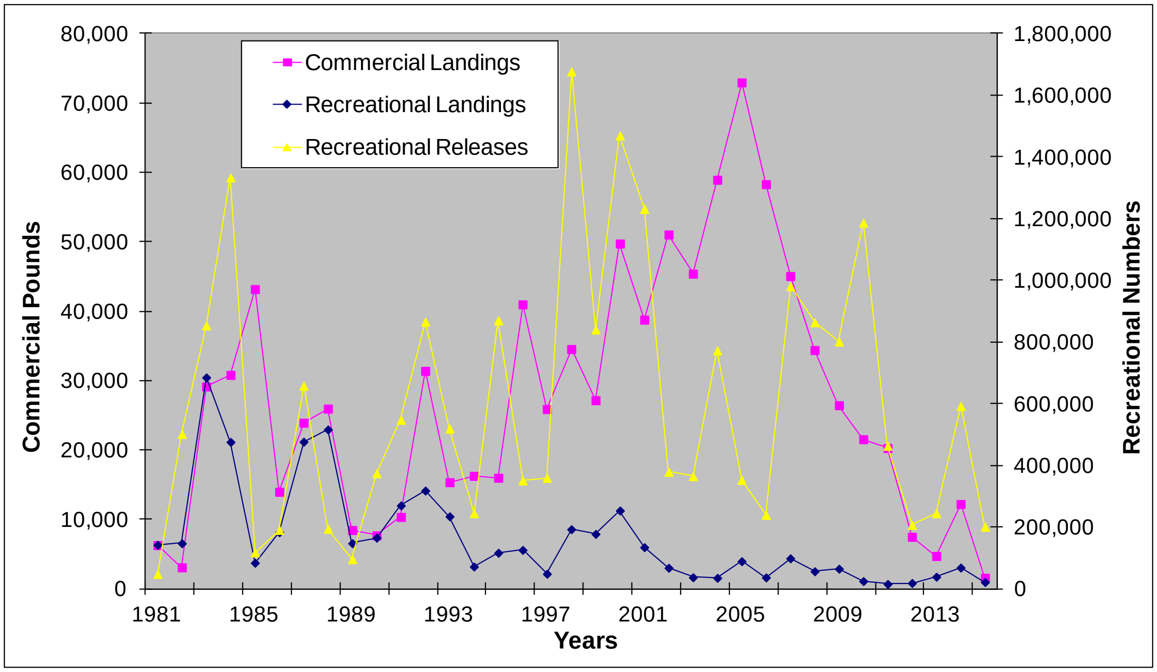


Figure 10. Maryland Charter boat log book summer flounder harvest in numbers and the number of anglers participating in trips catching summer flounder, 1993-2015.

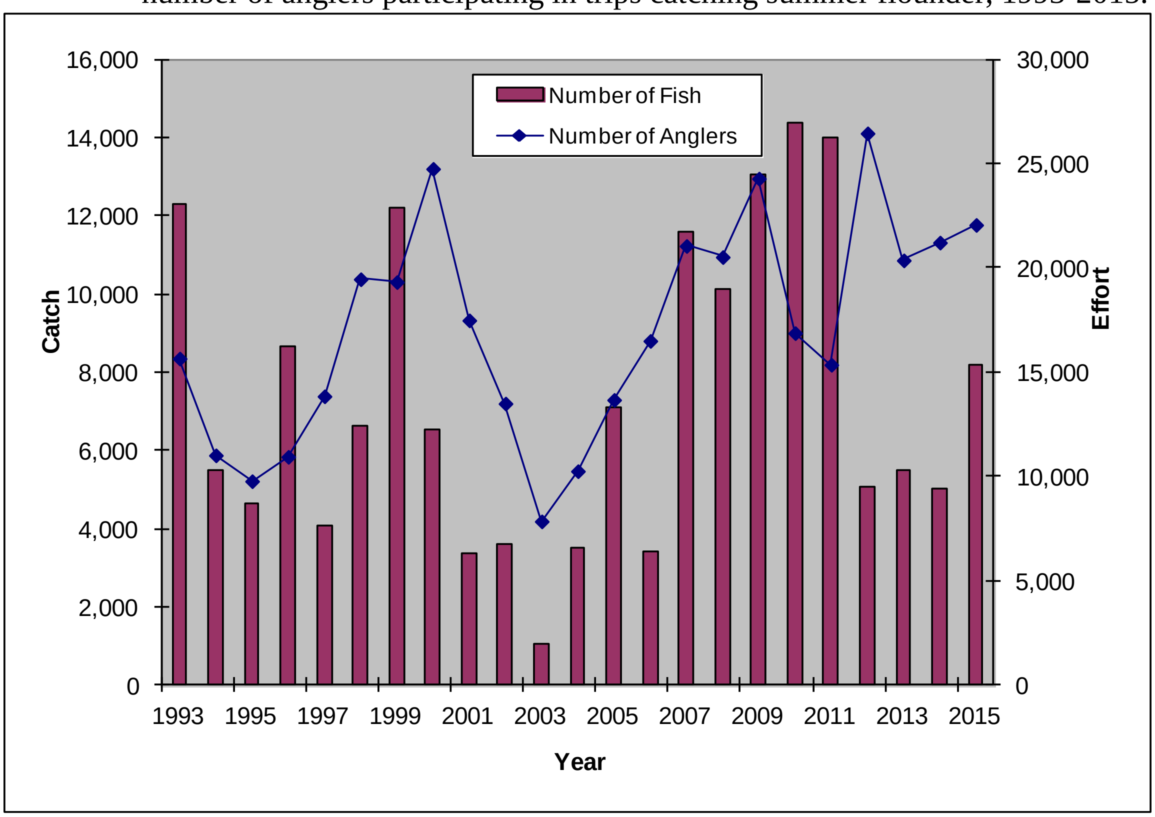


Figure 11. Bluefish length frequency distributions from onboard pound net sampling, 2007-2016.

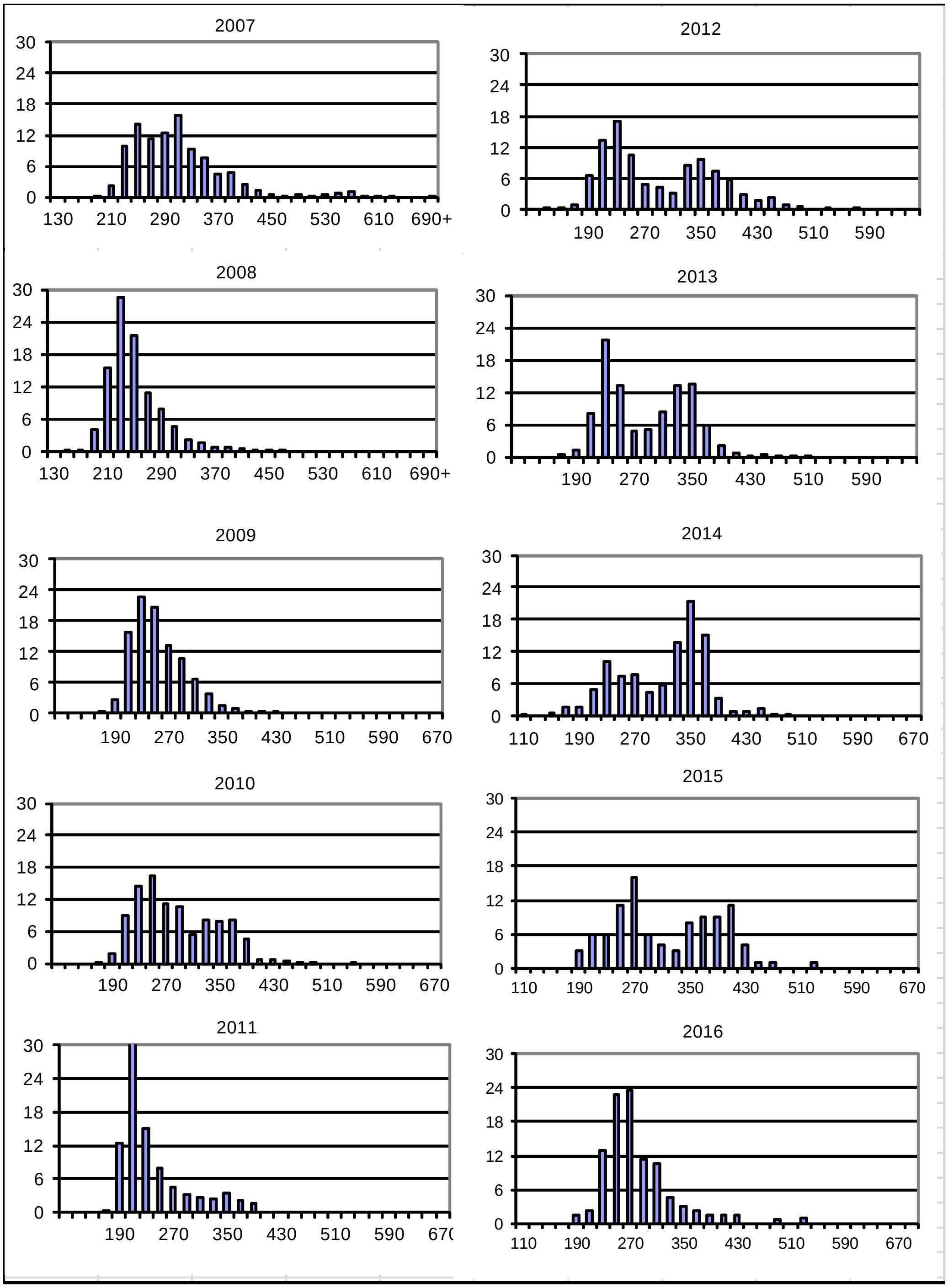


Figure 12. Proportion of bluefish catch by mesh size and year for the Choptank River gill net survey, 2013-2016.

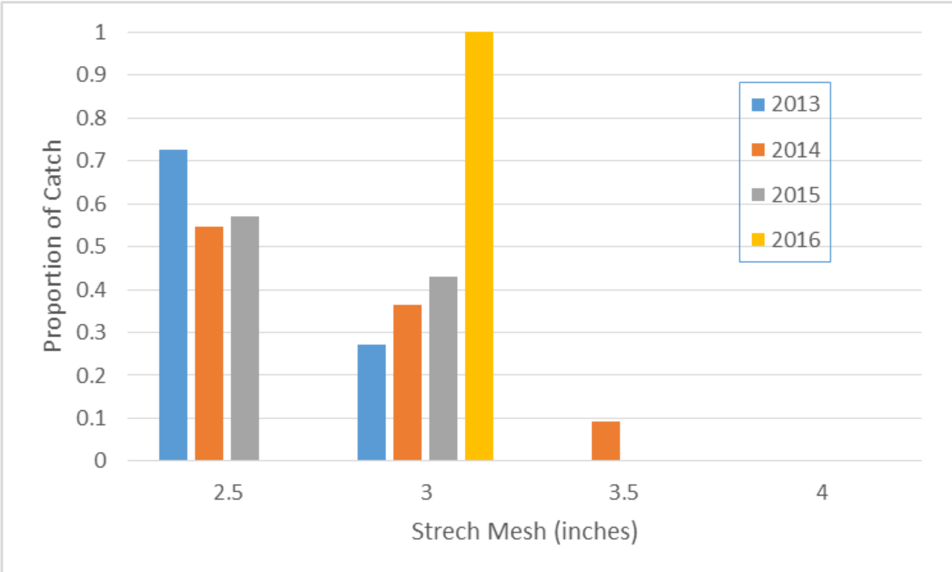


Figure 13. Maryland's commercial landings of bluefish in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational bluefish harvest and release estimates in numbers from 1981-2015.

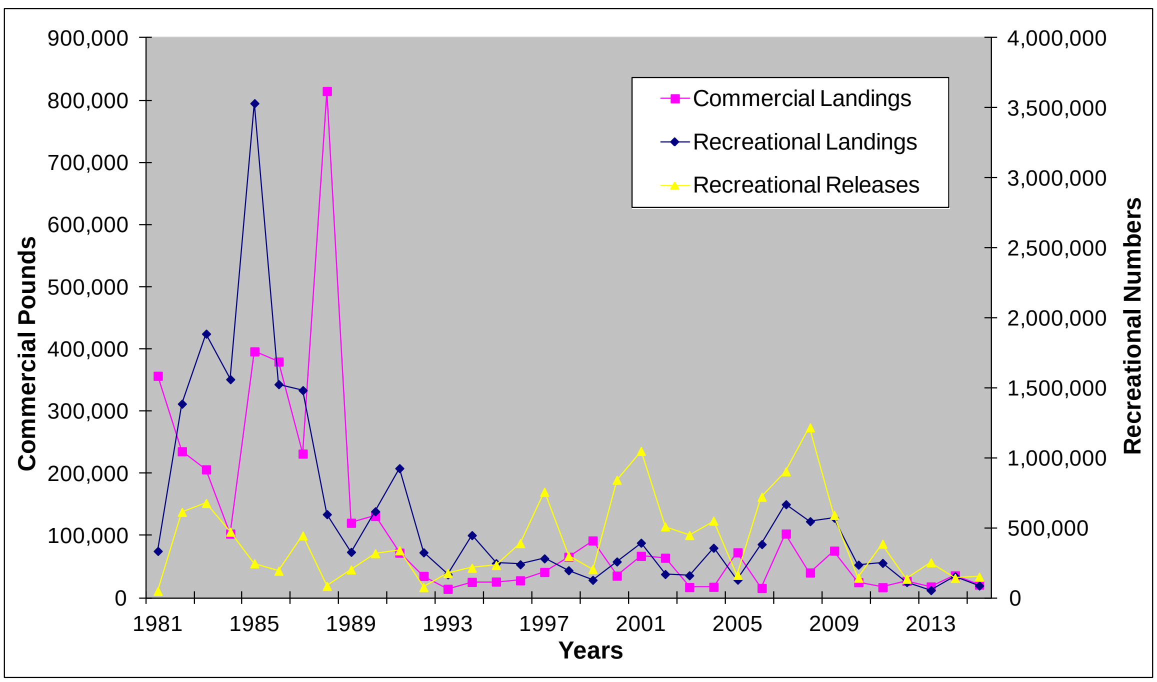


Figure 14. Maryland Charter boat log book bluefish harvest in numbers and the number of anglers participating in trips catching bluefish, 1993-2015.

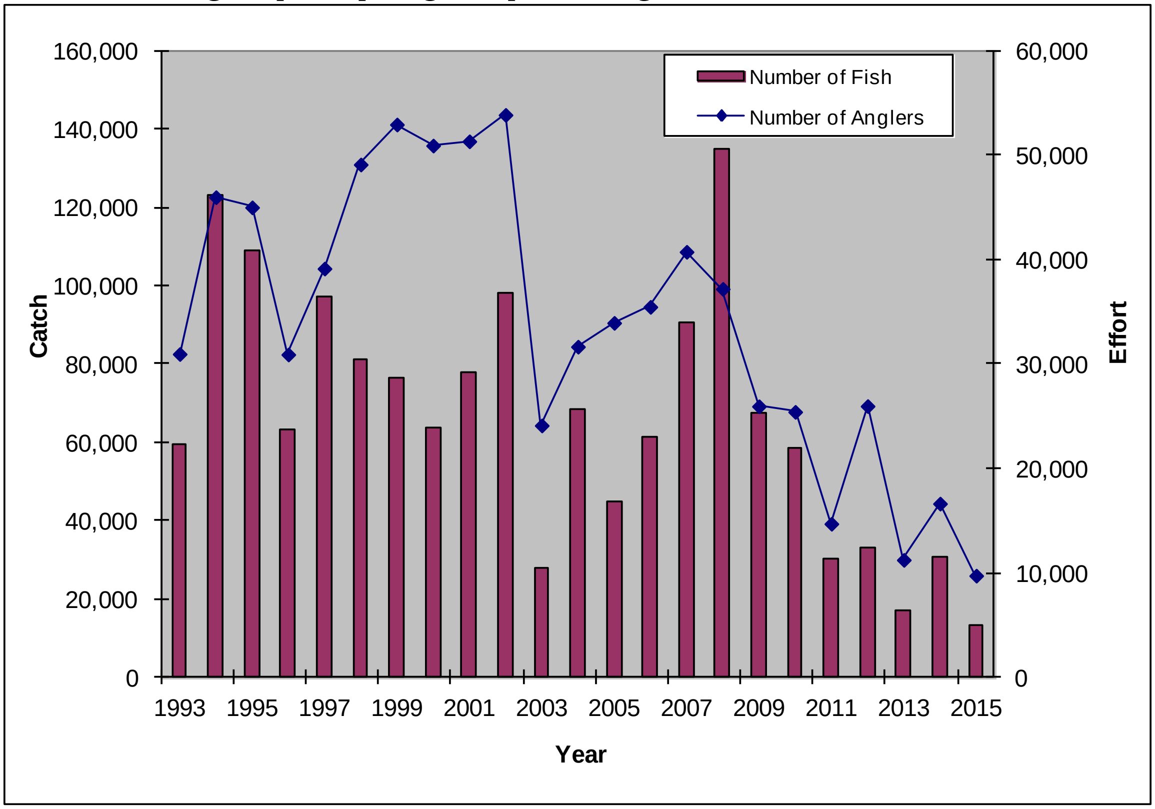


Figure 15. Atlantic croaker length frequency distributions from onboard pound net sampling, 2007-2016.

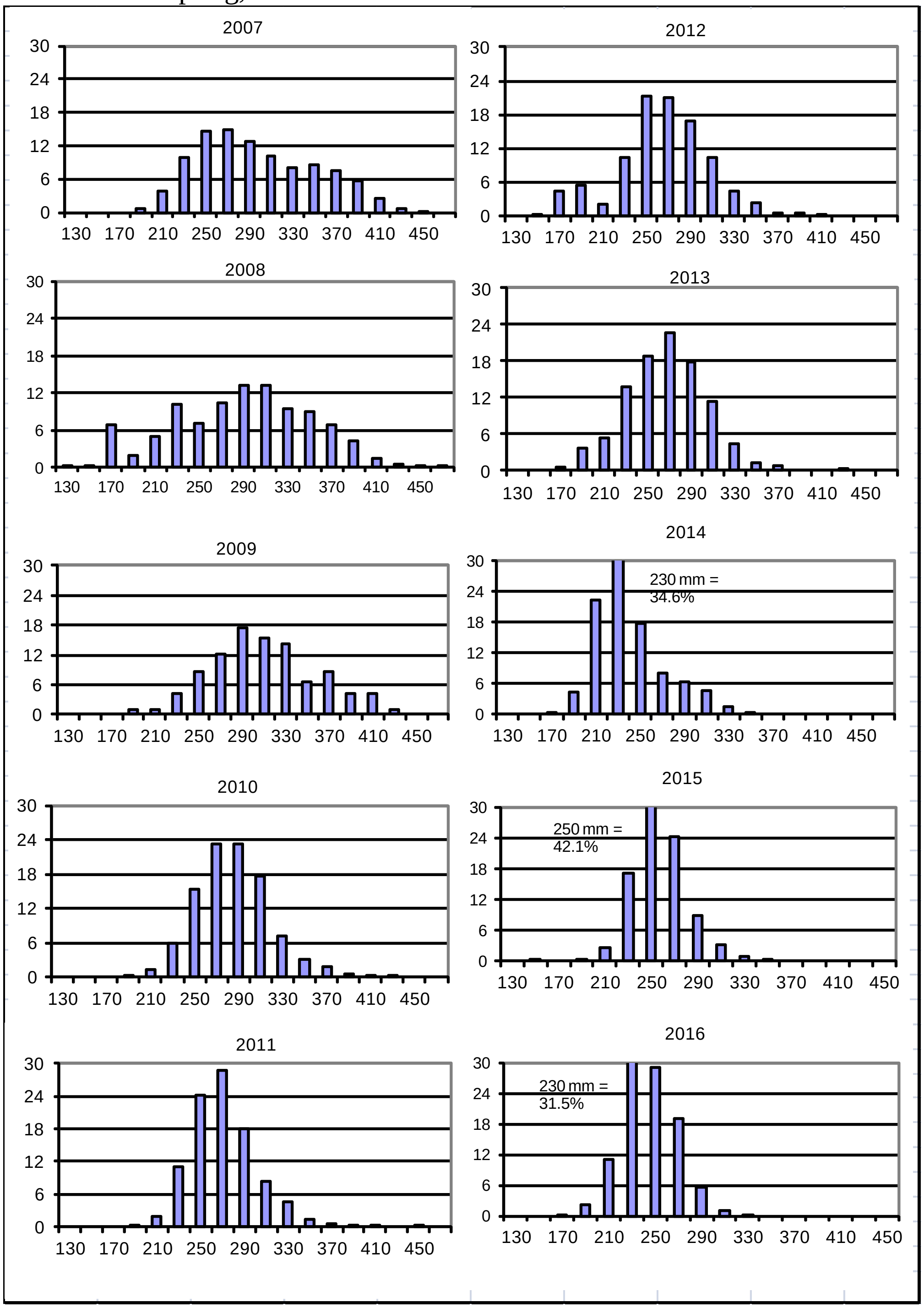


Figure 16. Proportion of Atlantic croaker catch by mesh size and year for the Choptank River gill net survey, 2013-2016.

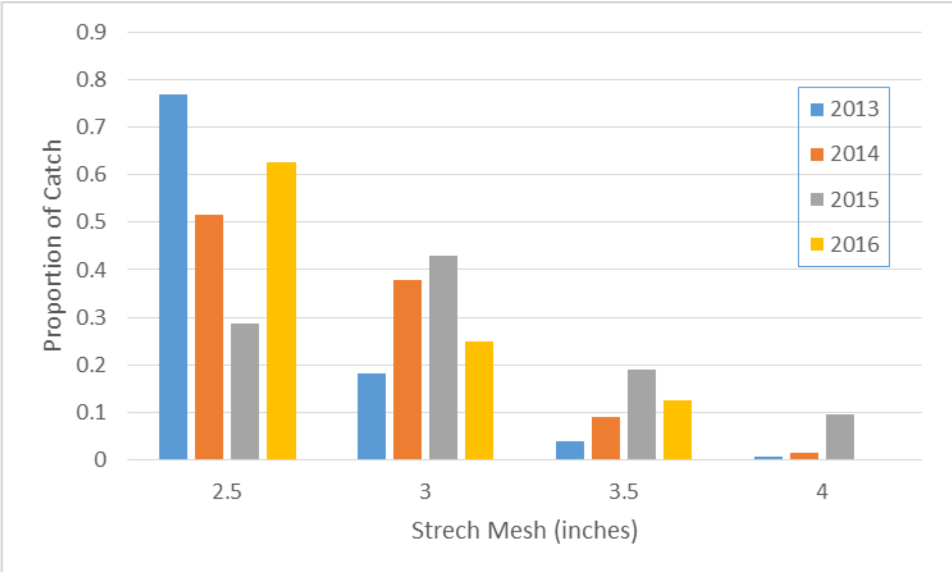


Figure 17. Atlantic croaker length frequency distribution from the Choptank River gill net survey by stretched mesh size in inches, 2013-2016 combined.

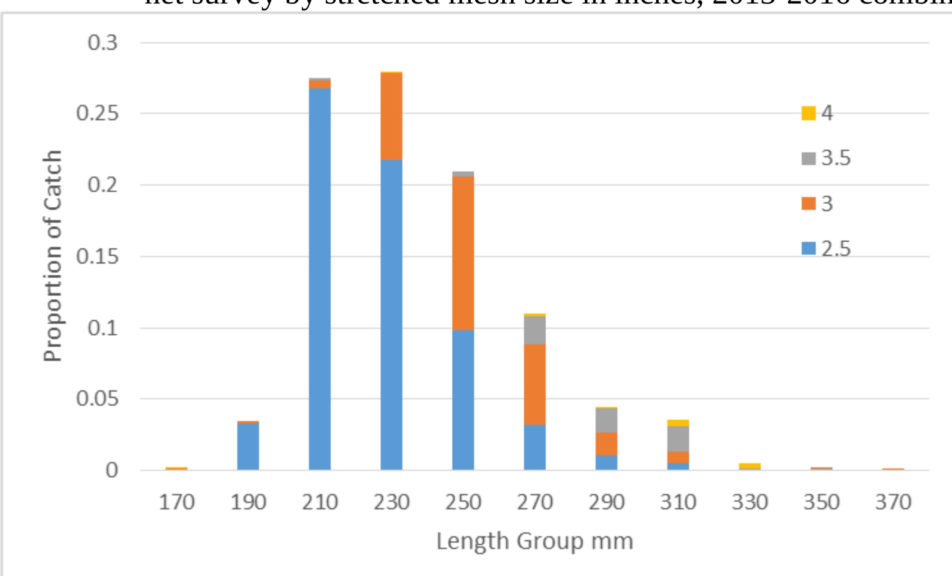


Figure 18. Maryland's commercial landings of Atlantic croaker in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational Atlantic croaker harvest and release estimates in numbers from 1981-2015.

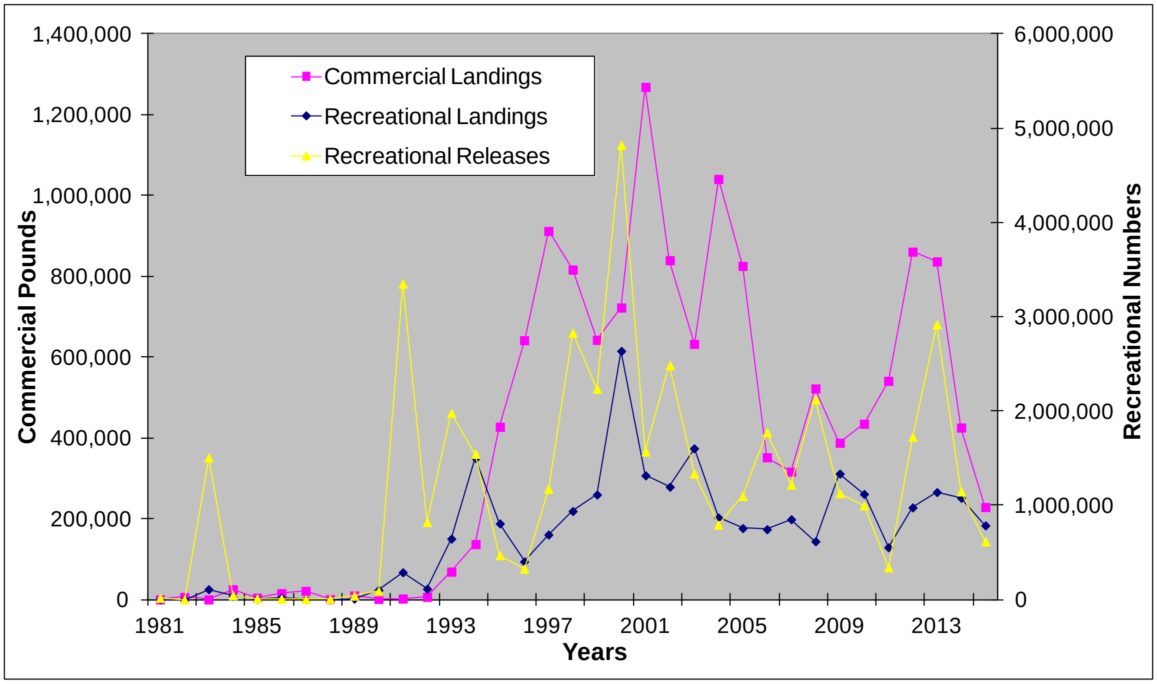


Figure 19. Maryland Charter boat log book Atlantic croaker harvest in numbers and the number of anglers participating in trips catching Atlantic croaker, 1993-2015.

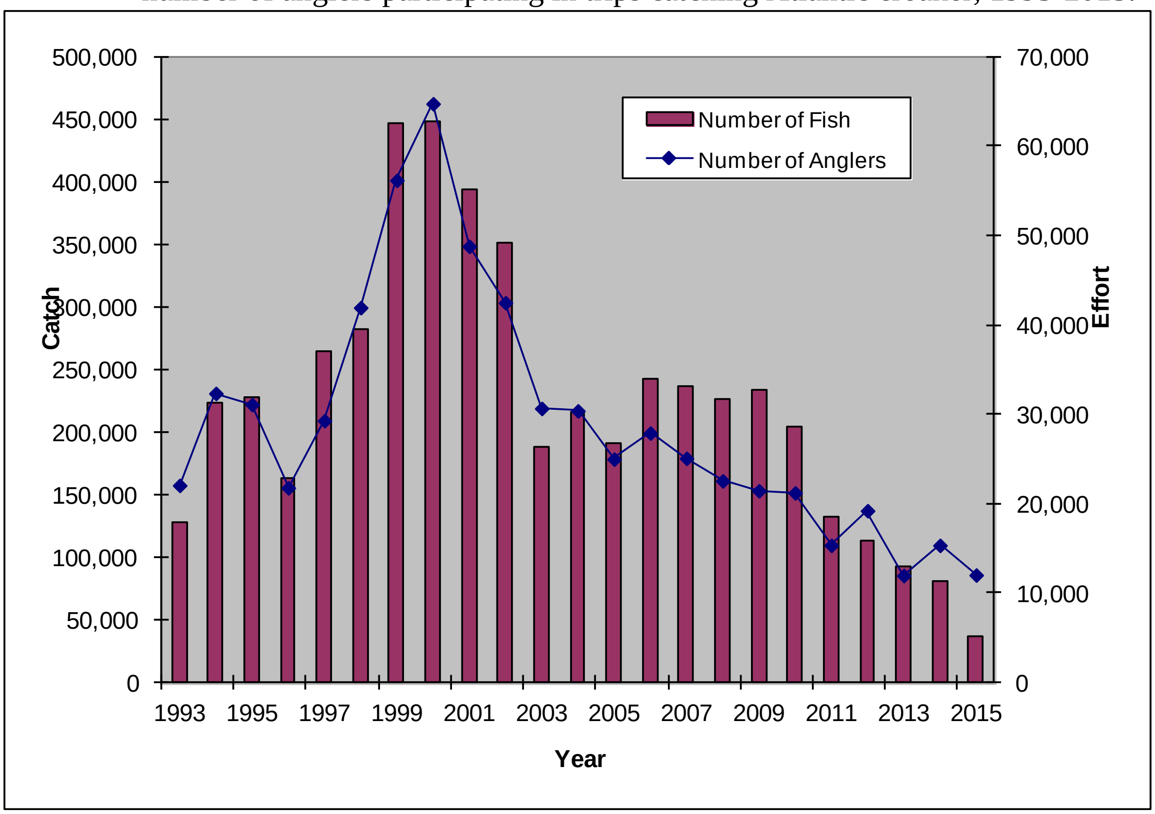


Figure 20. Maryland juvenile Atlantic croaker geometric mean catch per trawl and 95% confidence intervals for Maryland's lower Chesapeake Bay, 1989-2016. 1998 data point was omitted for scale (GM 1998 = 30.05 -9.02, +12.72).

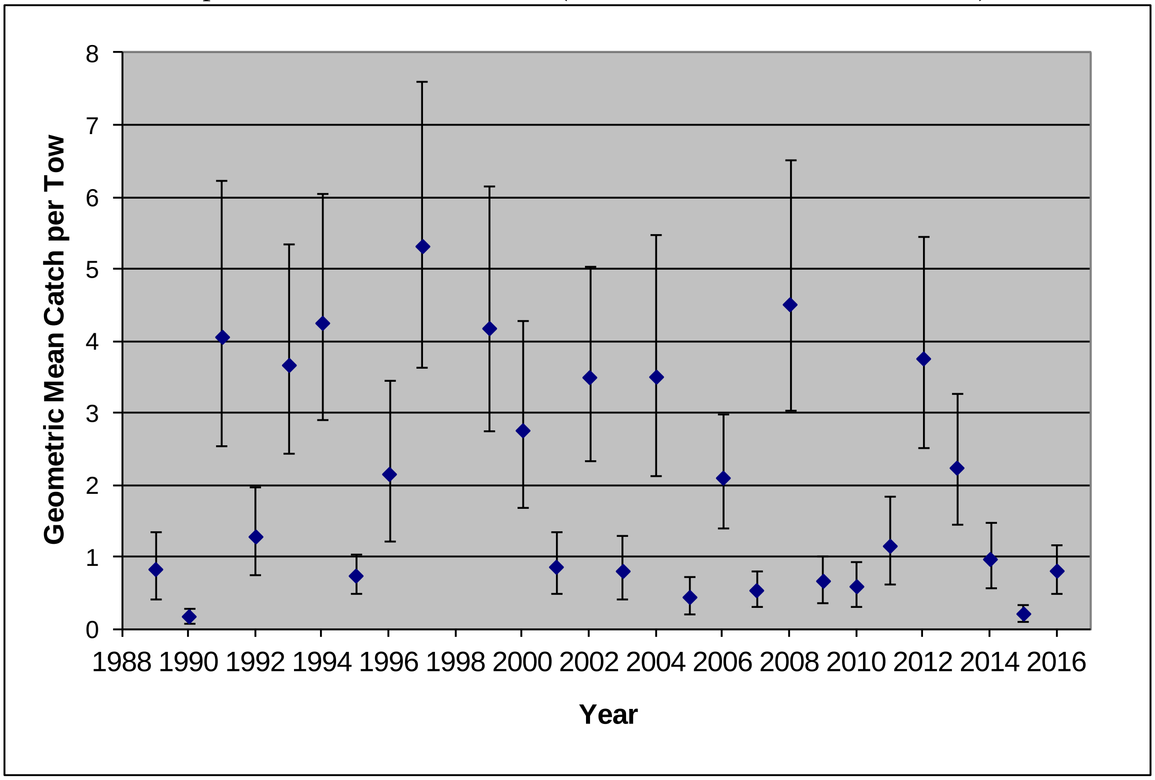


Figure 21. Spot length frequency distributions from onboard pound net sampling, 2007-2016.

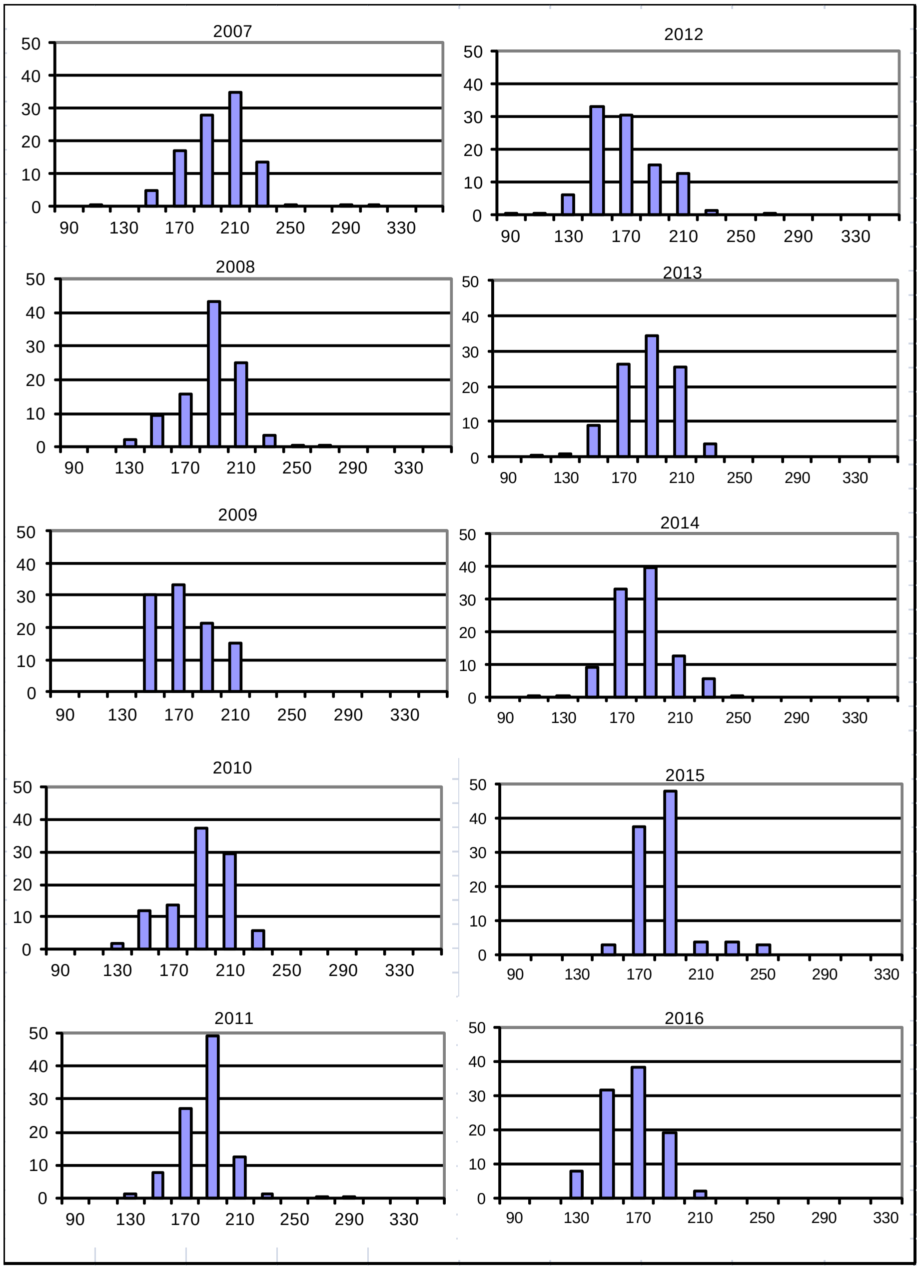


Figure 22. Proportion of spot captured in the Choptank River gill net survey by mesh size and year, 2013-1016.

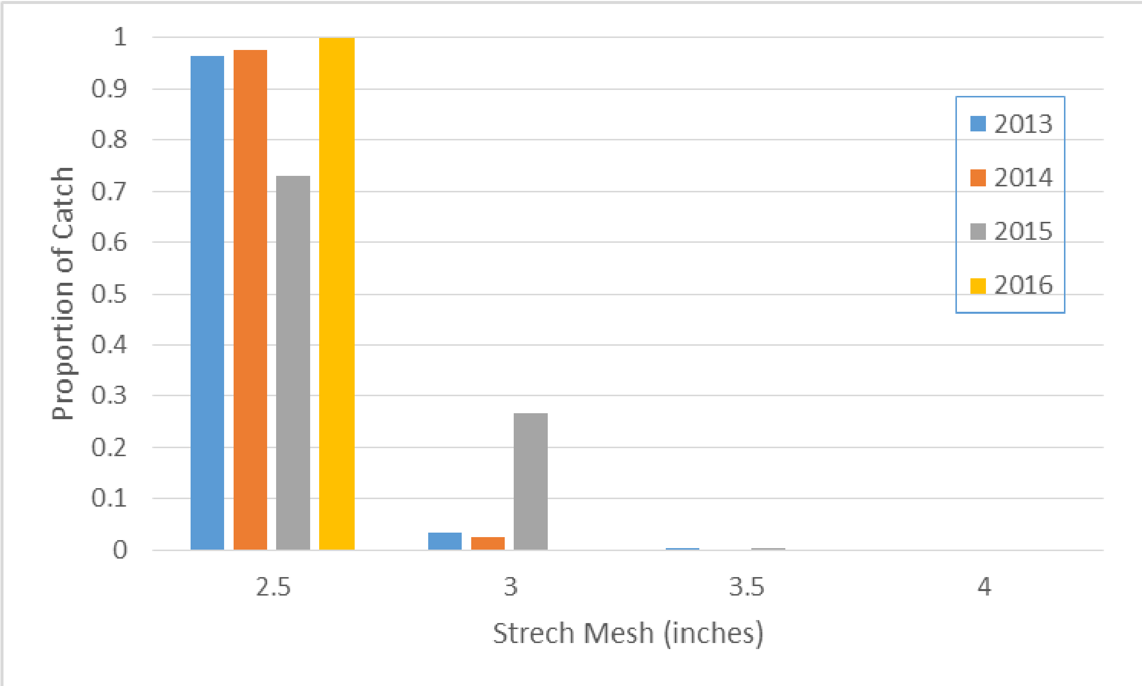


Figure 23. Spot length frequency distributions from the Choptank River gill net survey for 2013-2016.

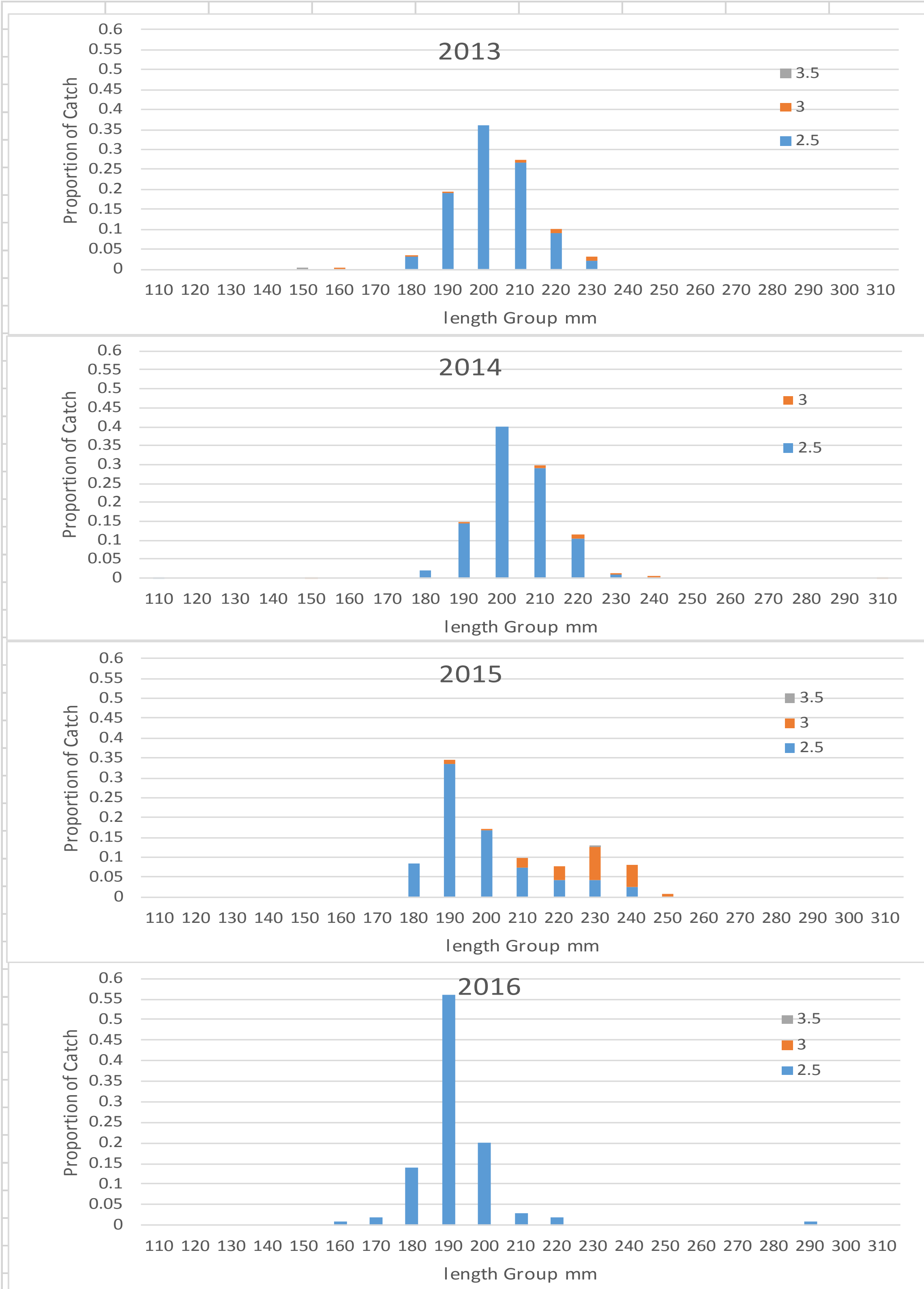


Figure 24. Maryland's commercial landings of spot in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational spot harvest and release estimates in numbers from 1981-2015.

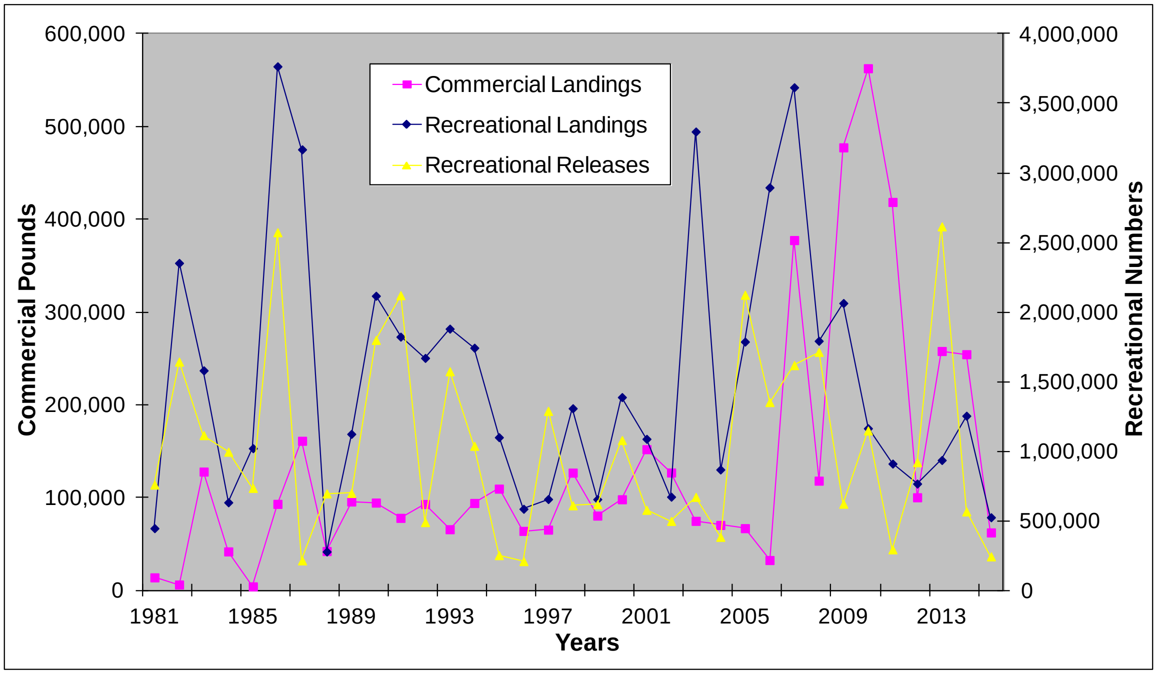


Figure 25. Maryland Charter boat log book spot harvest in numbers and the number of anglers participating in trips catching spot, 1993-2015.

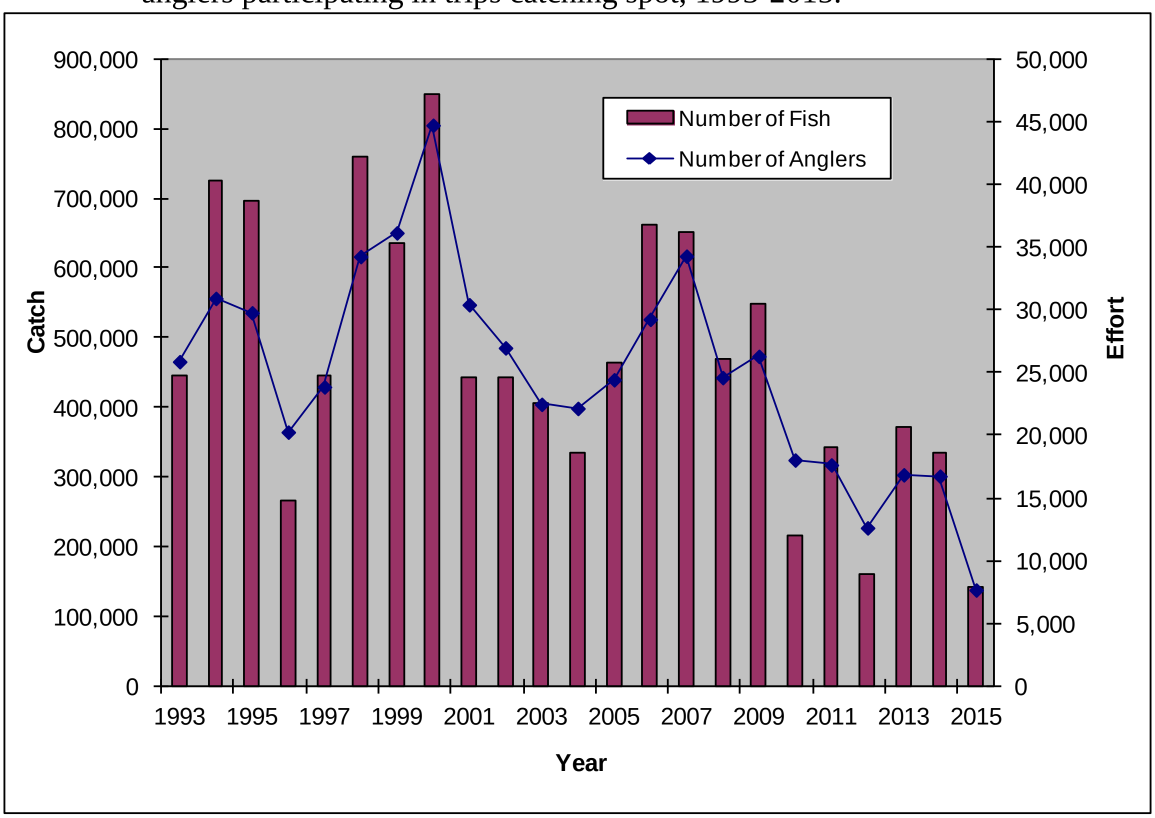


Figure 26. Maryland juvenile spot geometric mean catch per trawl and 95% confidence intervals for Maryland's lower Chesapeake Bay, 1989-2016.

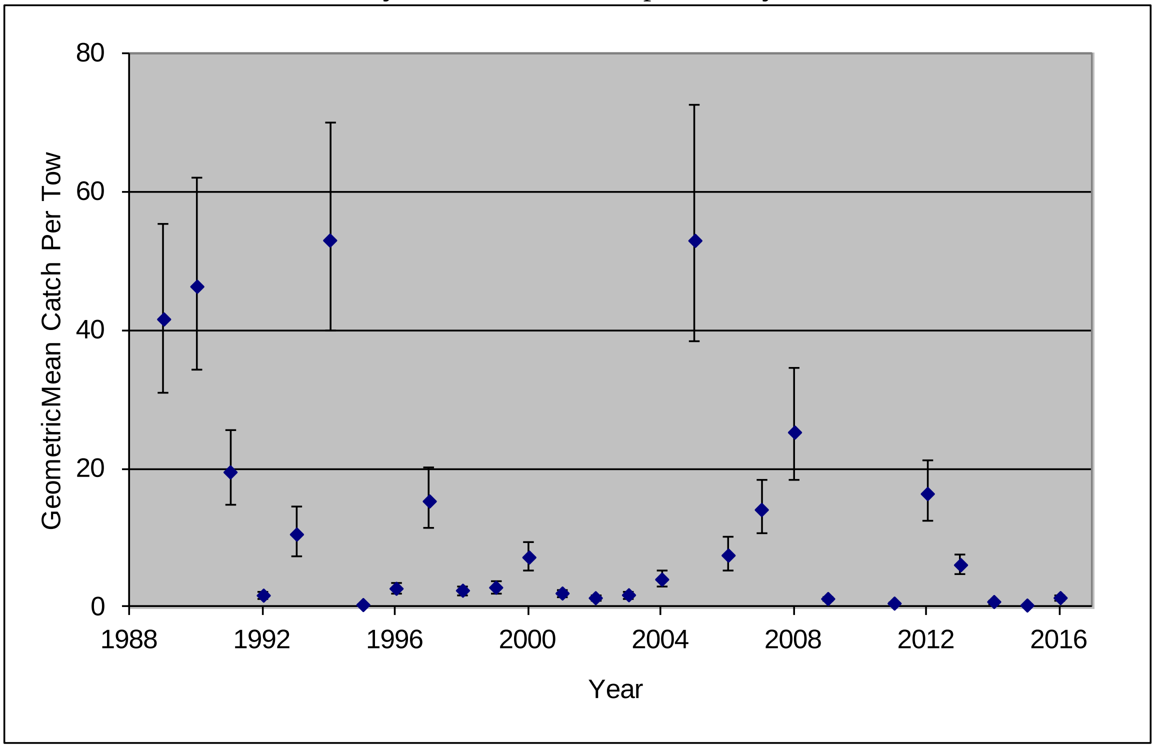


Figure 27. Maryland's commercial landings of red drum in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational red drum harvest and release estimates in numbers from 1981-2015.

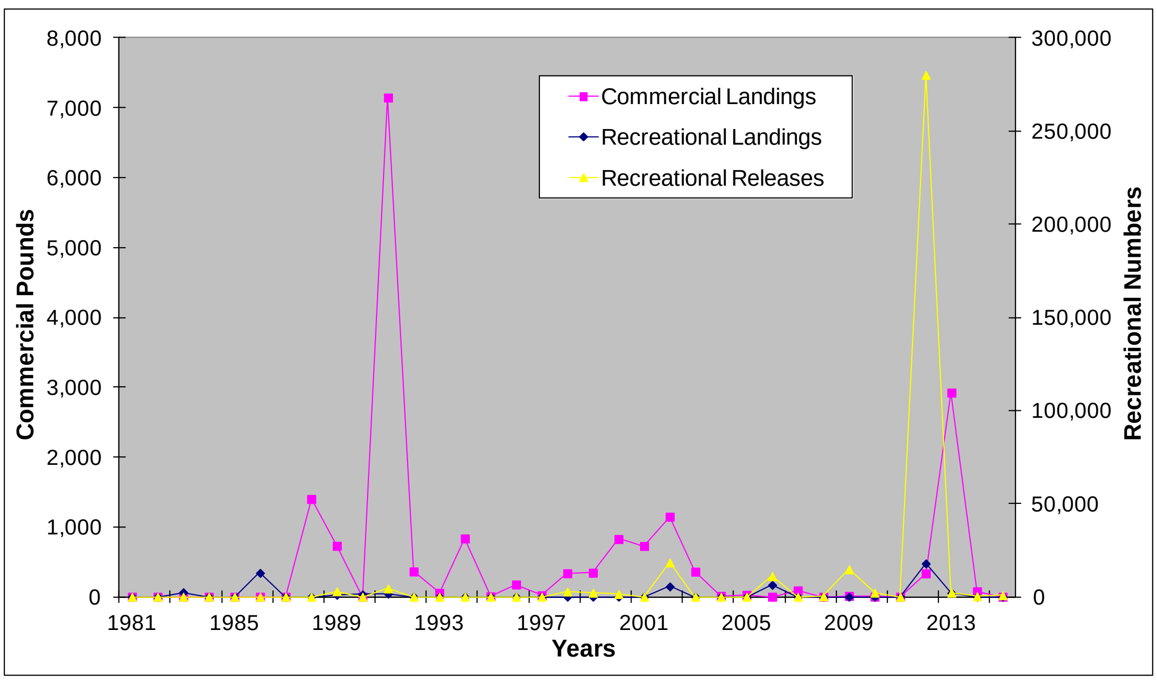


Figure 28. Maryland Charter boat log book red drum harvest in numbers and the number of anglers participating in trips catching red drum, 1993-2015.

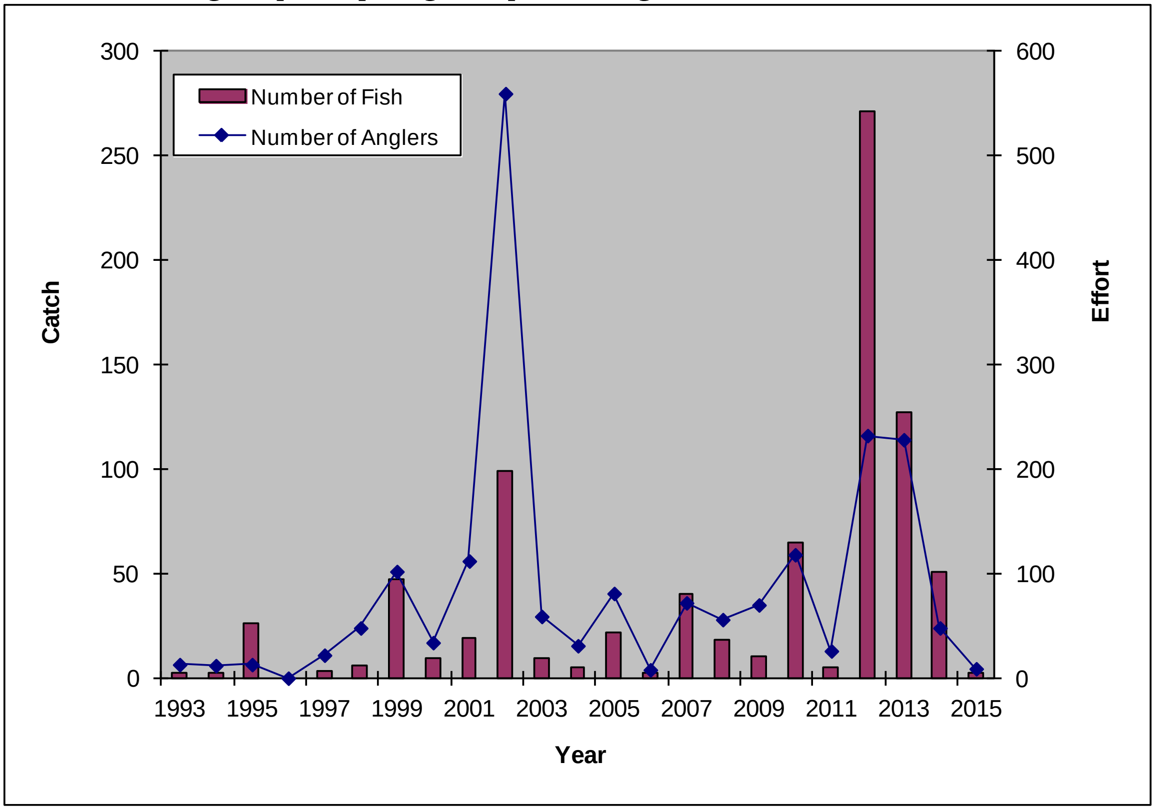


Figure 29. Maryland's commercial landings of black drum in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational black drum harvest and release estimates in numbers from 1981-2015.

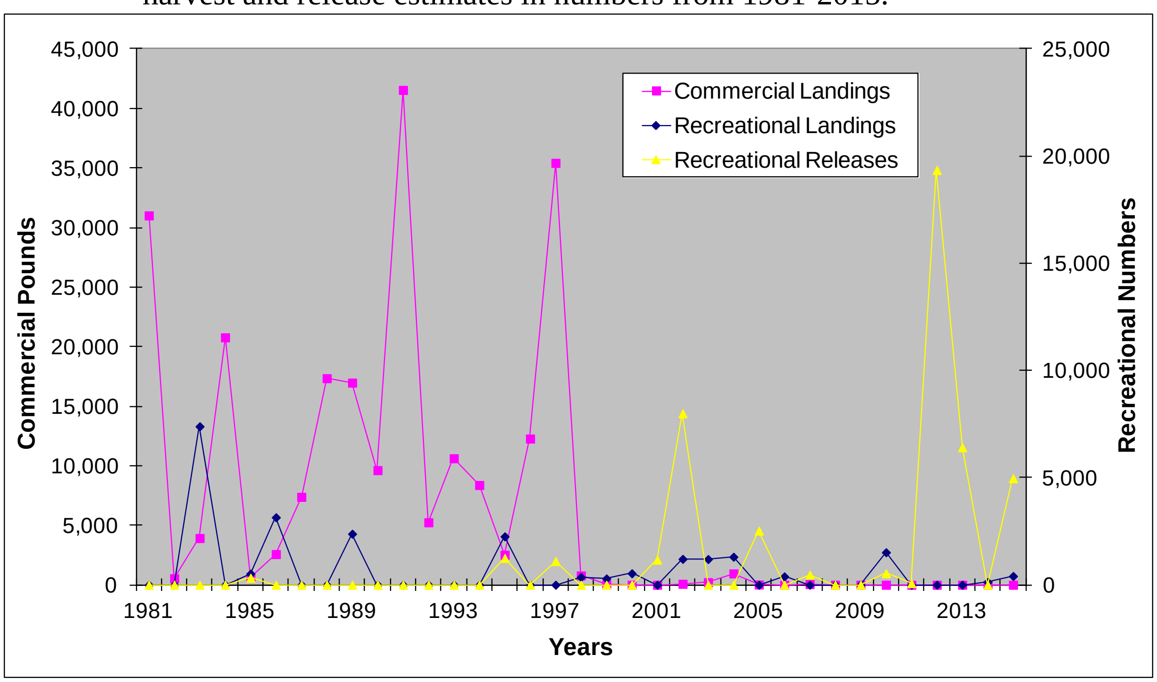


Figure 30. Maryland Charter boat log book black drum harvest in numbers and the number of anglers participating in trips catching black drum, 1993-2015.

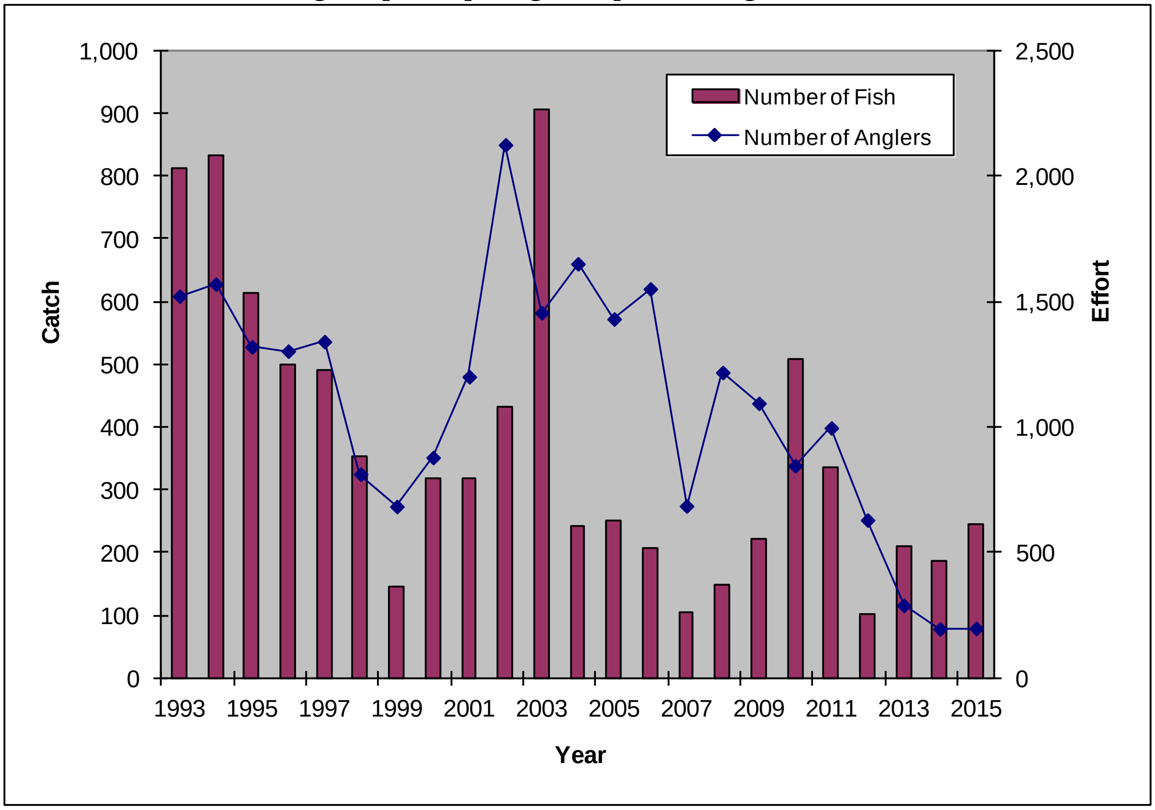


Figure 31. Maryland's commercial landings of Spanish mackerel in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational Spanish mackerel harvest and release estimates in numbers from 1981-2015.

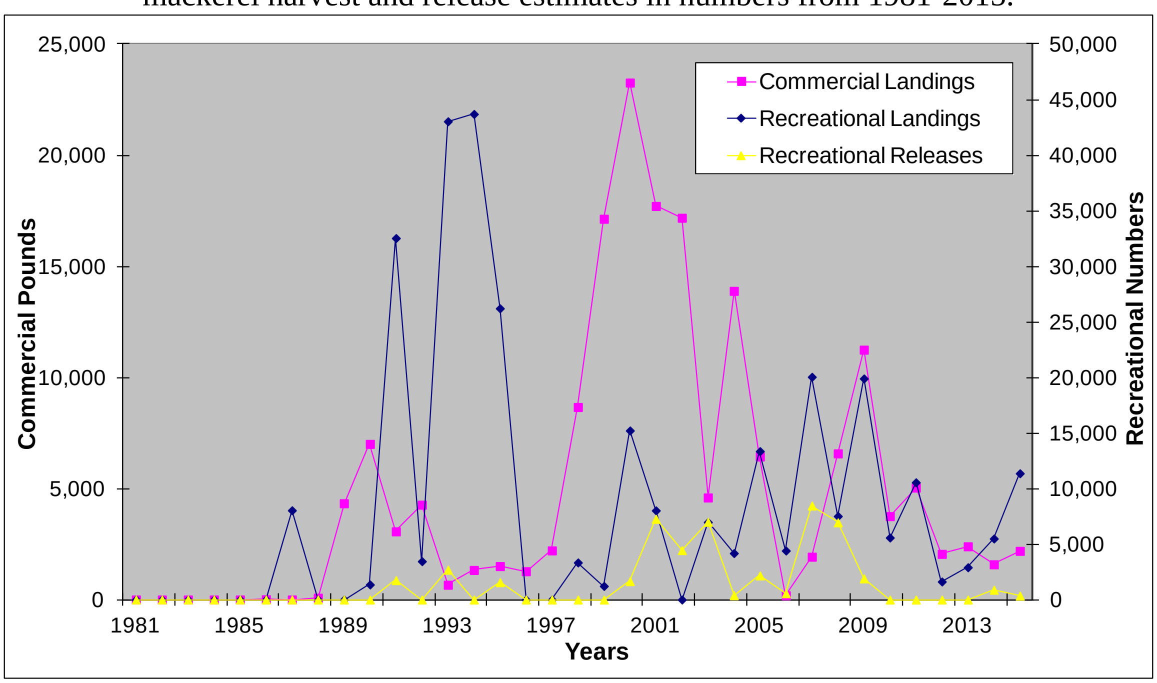


Figure 32. Maryland Charter boat log book Spanish mackerel harvest in numbers and the number of anglers participating in trips catching Spanish mackerel, 1993-2015.

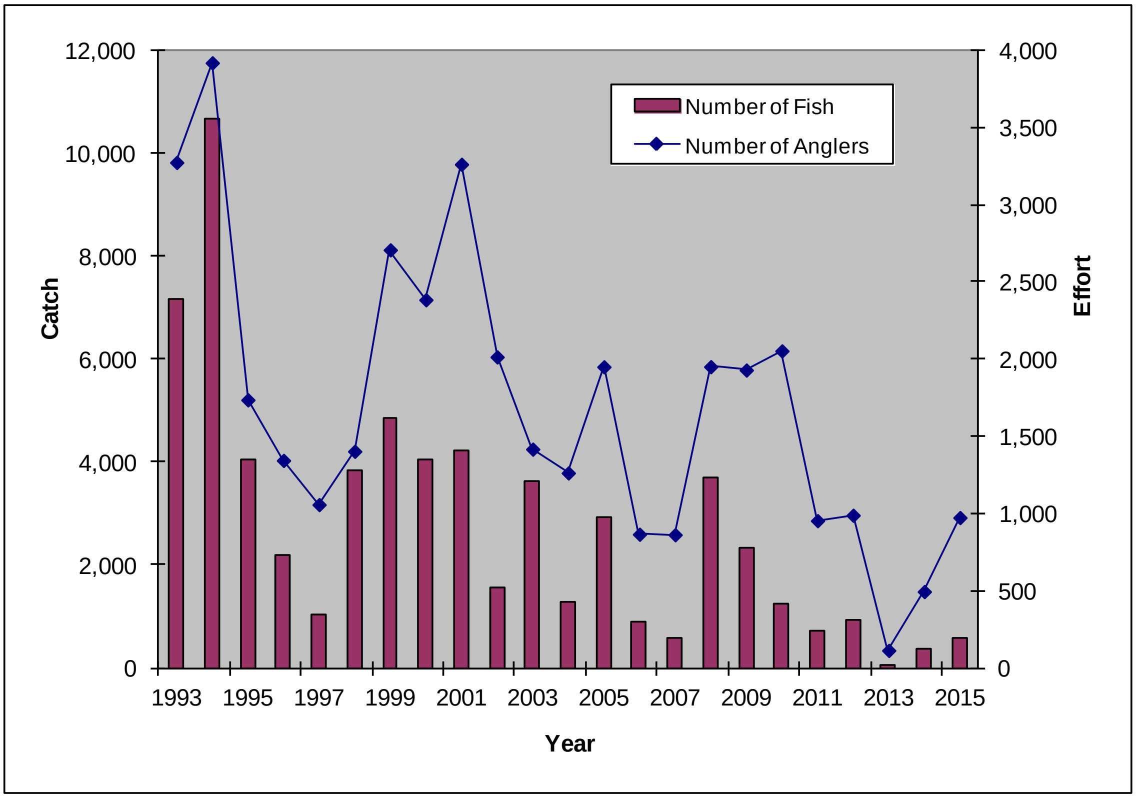


Figure 33. Maryland's commercial landings of spotted seatrout in pounds from the Chesapeake Bay and the MRIP Maryland inland recreational spotted seatrout harvest and release estimates in numbers from 1981-2015.

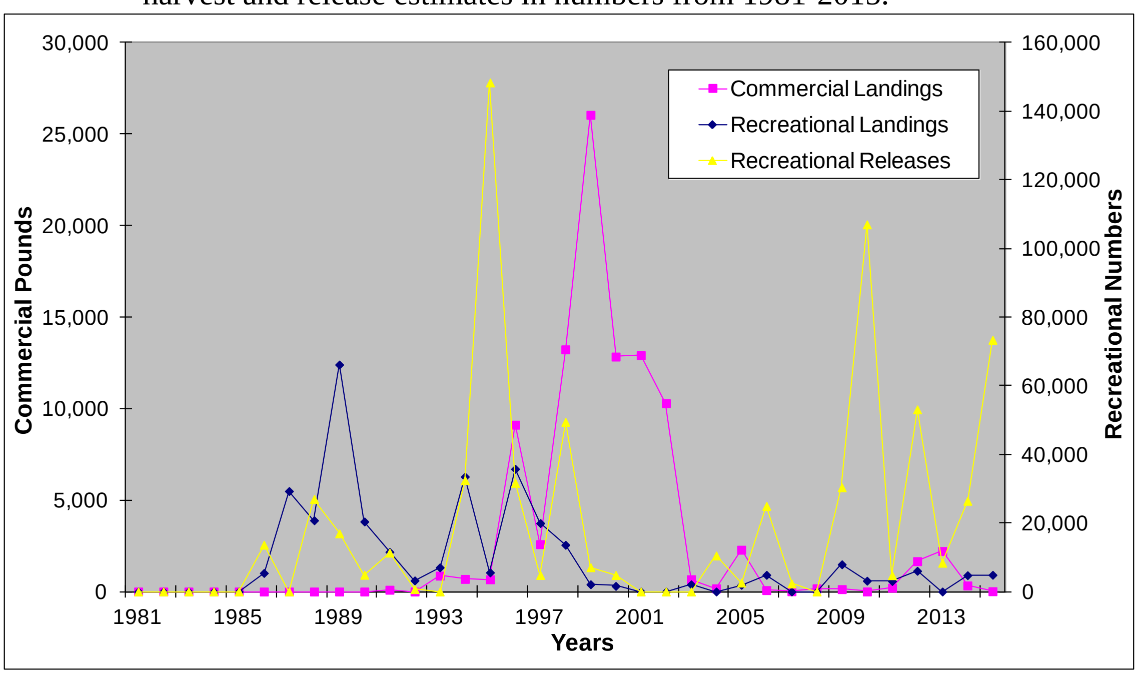


Figure 34. Maryland Charter boat log book spotted seatrout harvest in numbers and the number of anglers participating in trips catching spotted seatrout, 1993-2015.

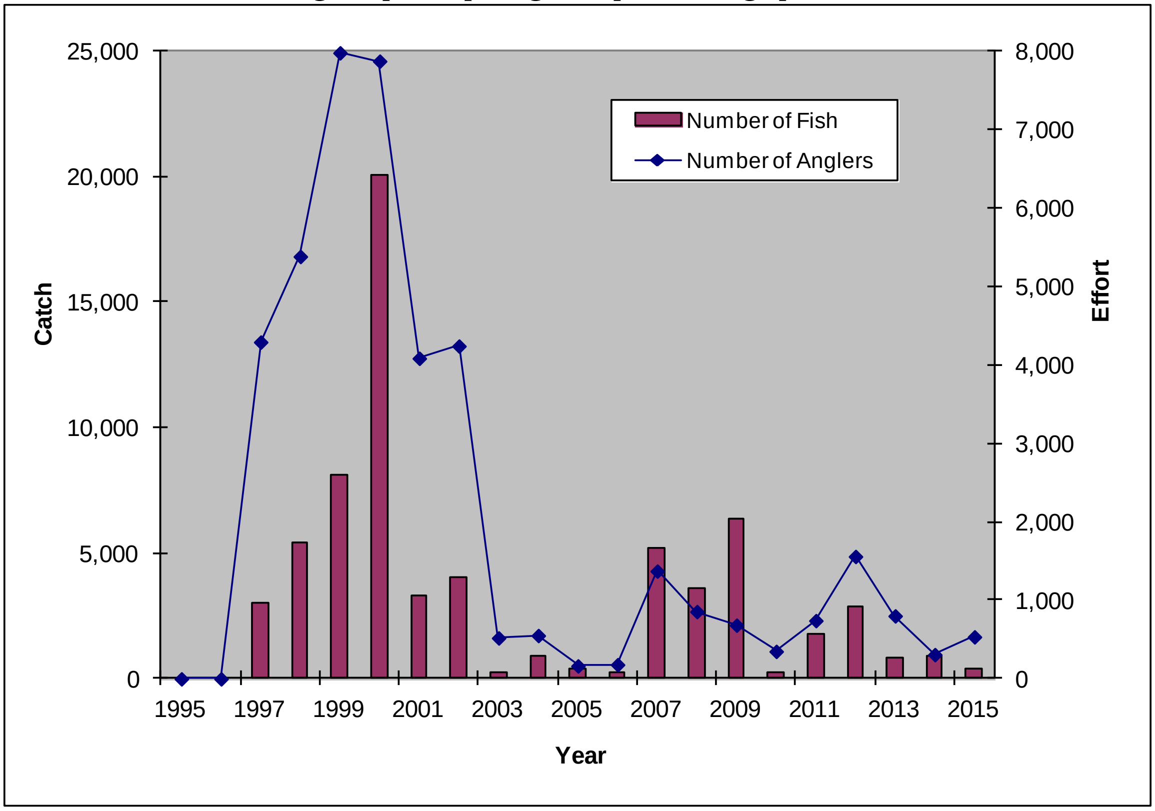


Figure 35. Menhaden length frequency distributions from onboard pound net sampling, 2007-2016.

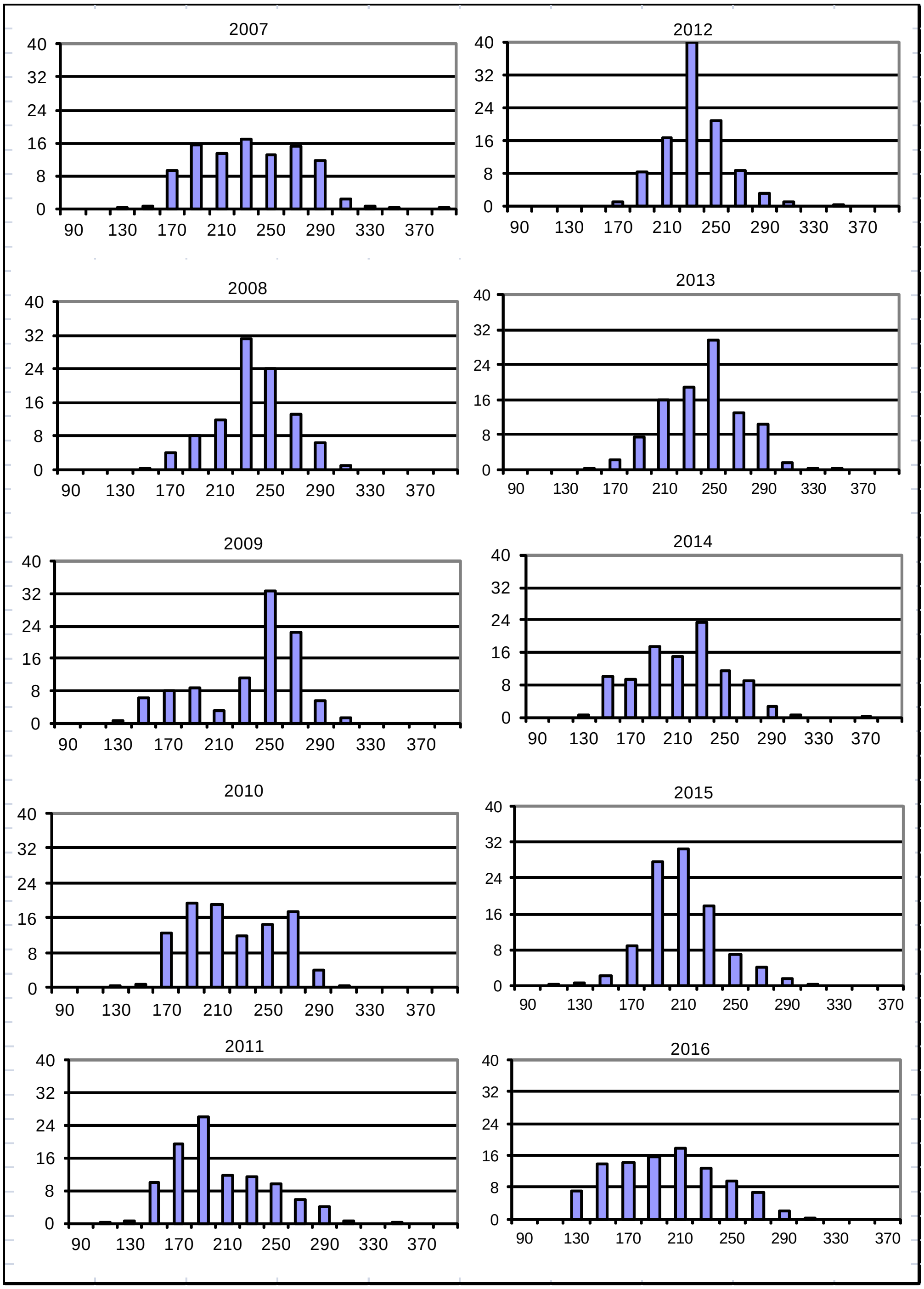


Figure 36. Atlantic menhaden proportion of catch by panel and year from the Choptank River gill net survey, 2013-2016.

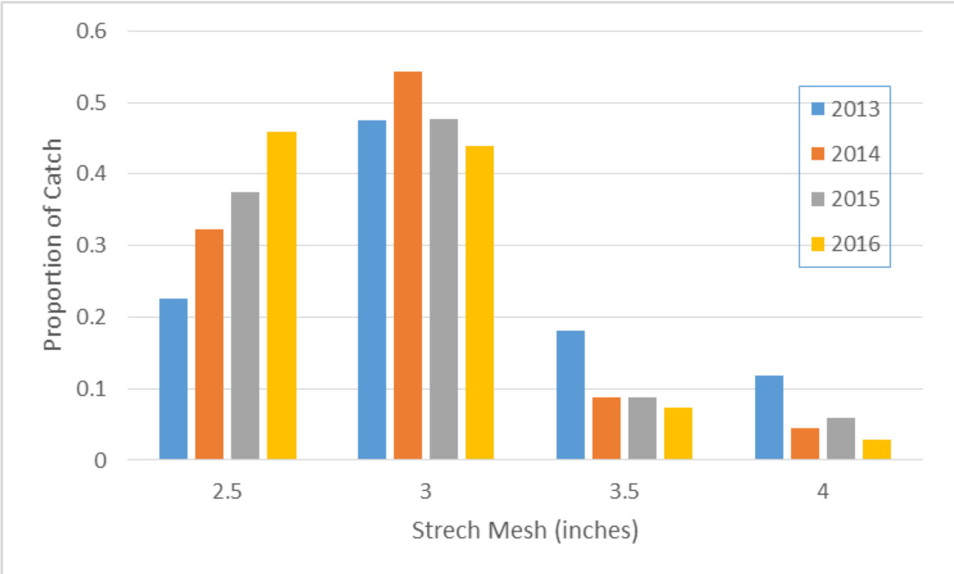


Figure 37. Atlantic menhaden length frequency distributions from the Choptank River gill net survey by year, 2013-2016.

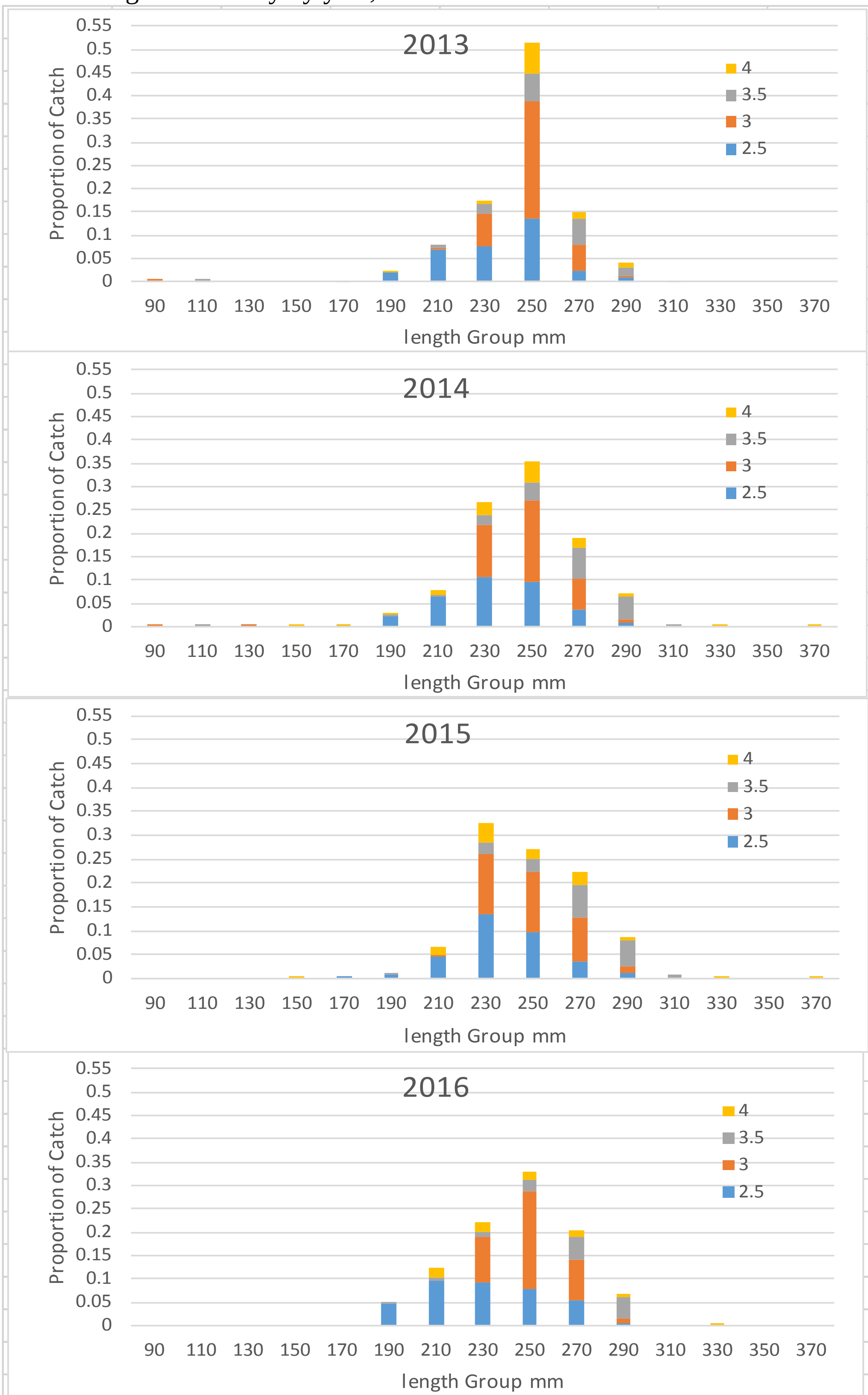
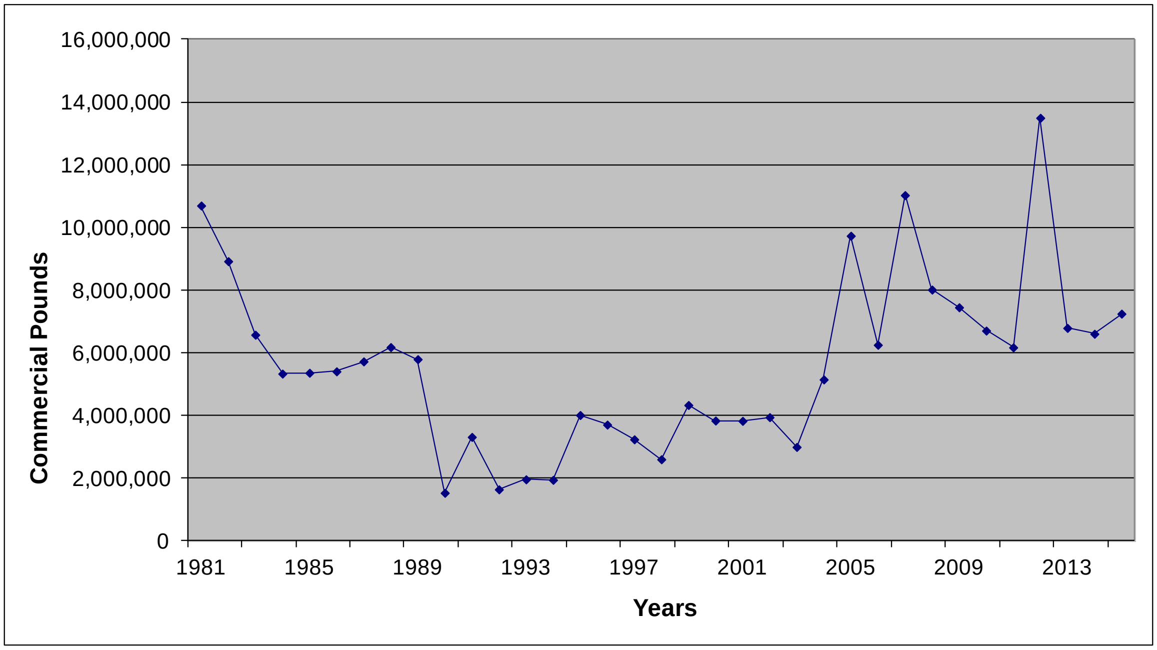


Figure 38. Maryland's Chesapeake Bay commercial landings for Atlantic menhaden from 1981-2015.



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 2015 Maryland striped bass *Morone saxatilis* commercial summer/fall fishery. The commercial fishery during the summer/fall in 2015 operated on a combination of a common pool fishery and individual transferable quota (ITQ) system (see Project 2, Job 3, Task 5A). The 2015 ITQ commercial summer/fall fishery was open from 1 June through 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 four days in June, two days in July, two days in August, four days in September, three days in October, and three days in 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 2015 commercial fishery season were used to characterize the length and age structure of the entire 2015 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 Fisheries Service (FS) 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 2015 (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 2015, 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 Fisheries Service 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 three 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 December 2015 (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 monthly 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 four 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 >700 mm TL).

Analytical Procedures

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, 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. 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 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 2015 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 2015.

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. The 2012 year class was not encountered in the sub-sample of fish but were present in the ALK. Mean weight-at-age was used from the ASMFC Compliance report to calculate landings in pounds and numbers of fish for the 2012 year class (Durell 2015). 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 2015 striped bass pound net study, a total of 3,704 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 20 times during the study (Table 1).

Striped bass sampled from pound nets ranged from 259-883 mm TL, with a mean length of 488 mm TL (Figure 2). In 2015, 44% of striped bass collected from full net samples were less than the minimum legal size of 18 inches (457 mm) TL, while 27% 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 11 years of age (Table 3, Figure 2). Age 4 fish from the above average 2011 year-class contributed 54% in 2015, which was higher than the contribution in 2014 (15%). Striped bass age 6 and over accounted for 7% of the sample, which was similar to their contribution in 2014 (7%) and 2013 (7%; Figure 3). Length frequencies of legal sized striped bass (n=2,329) 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 2,202 striped bass were sampled at summer/fall check stations in 2015. The mean length of sampled striped bass was 549 mm TL. Striped bass sampled from the summer/fall fishery ranged from 455 to 904 mm TL and from 3 to 11 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 2015 summer/fall fishery are shown in Tables 4 and 5.

The 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 69% 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 8% to the overall harvest. Historically, these fish have not been available in large numbers during the summer (MD DNR 2002).

The 2015 summer/fall reported harvest accounted for 54%, by weight, of the Maryland Chesapeake Bay total commercial harvest in 2015 with 775,228 pounds landed (see Project 2, Job 3, Task 5A). Landings reported by the MD DNR commercial reporting section were 160,750 pounds for hook and line gear and 614,478 pounds for pound net gear. The combined length frequency for the summer/fall fishery was applied to the reported total catch. The estimated 2015 catch-at-age in pounds and numbers of fish for the summer/fall fishery is presented in Table 6. The majority of the harvest in pounds of fish was composed of four to six year-old striped bass (91%). Striped bass from the above average 2011 (age 4) year class contributed 57% to the harvest and were the highest contribution to the fishery. Striped bass from the 2010 year class (age 5) contributed the second highest percentage to the harvest (28%). Striped bass age 8 and older contributed 6% to the overall harvest in 2015, which was similar to 2014 (7%).

Monitoring summary

Striped bass ranging from 457 to 550 mm TL composed 68% of the 2015 summer/fall harvest. A smaller percentage of fish >630 mm TL were harvested in 2015 (16%) compared to 2014 (20%; Figure 5). In 2015, 95 fish from pound net monitoring and 109 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=602 mm and WT=2.43 kg) in June and smallest in August and September (TL=517 and 508 mm and WT=1.23 and 1.20 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

2016 PRELIMINARY RESULTS

Commercial pound net monitoring

During the 2016 striped bass pound net study, a total of 5,727 striped bass were sampled and 695 scale samples were collected for ageing 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.

Striped bass sampled from pound nets ranged from 195-960 mm TL, with a mean length of 485 mm TL. In 2016, 47% of striped bass collected from full net samples were less than the minimum legal size of 18 inches (457 mm) TL, while 32% 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 2,217 striped bass were sampled and 599 scale samples were collected for ageing 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. 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 2015 Maryland Chesapeake Bay commercial pound net monitoring survey.

Month	**Area**	**Number of Nets Sampled**	**Mean Water Temp (°C)**	**Mean Salinity (ppt)**	**Number of Fish Sampled**
June	Upper	2	25.0	8.4	969
	Middle	-	-	-	-
	Lower	1	25.9	11.8	9
July	Upper	2	25.9	6.1	618
	Middle	-	-	-	-
	Lower	2	27.9	11.8	155
August	Upper	1	26.5	8.6	141
	Middle	-	-	-	-
	Lower	2	25.9	13.5	187
September	Upper	-	-	-	-
	Middle	-	-	-	-
	Lower	1	24.6	14.8	197
October	Upper	3	18.6	5.6	243
	Middle	-	-	-	-
	Lower	2	16.7	14.6	708
November	Upper	3	14.1	5.7	248
	Middle	-	-	-	-
	Lower	1	14.1	17.5	229

Table 2. Mean length-at-age (mm TL) of striped bass sampled from pound nets in Maryland's Chesapeake Bay, June through November 2015.

Year-class	Age	n	Mean Length (mm TL)	Lower CL	Upper CL
2014	1	12	307	286	328
2013	2	15	351	327	374
2012	3	6	435	415	455
2011	4	31	461	440	482
2010	5	5	573	506	640
2009	6	7	635	619	651
2008	7	4	703	652	754
2007	8	7	759	717	800
2006	9	5	818	758	877
2005	10	2	799	614	983
2004	11	1	821	-	-

*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 2015.

Year-class	Age	Pound Net Monitoring	
		Number Sampled at Age (n)	Percent of Total
2014	1	135	3.7
2013	2	352	9.5
2012	3	326	8.8
2011	4	1,990	53.7
2010	5	661	17.8
2009	6	125	3.4
2008	7	64	1.7
2007	8	30	0.8
2006	9	8	0.2
2005	10	11	0.3
2004	11	3	0.1
Total*		**3,704**	**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 December 2015.

Year-class	Age	n	Mean Length (mm TL)	Lower CL	Upper CL
2011	4	21	530	509	551
2010	5	25	621	589	653
2009	6	9	663	599	726
2008	7	12	709	671	747
2007	8	21	773	749	798
2006	9	8	811	766	855
2005	10	16	795	772	819
2004	11	6	839	776	901

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 December 2015.

Year-class	Age	n	Mean Weight (kg)	Lower CL	Upper CL
2011	4	21	1.38	1.18	1.57
2010	5	25	2.57	2.08	3.05
2009	6	9	2.93	2.07	3.79
2008	7	12	3.72	3.18	4.25
2007	8	21	4.66	4.23	5.10
2006	9	8	5.62	4.59	6.65
2005	10	16	5.22	4.74	5.70
2004	11	6	6.36	4.65	8.07

Table 6. Estimated catch-at-age of striped bass landed by Maryland Chesapeake Bay commercial summer/fall fishery, June through December 2015.

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
2012**	3	1,526	0.2	870	0.4
2011	4	443,024	57.1	145,618	73.3
2010	5	213,816	27.6	37,738	19.0
2009	6	45,577	5.9	7,056	3.6
2008	7	27,703	3.6	3,378	1.7
2007	8	22,334	2.9	2,174	1.1
2006	9	6,642	0.9	536	0.3
2005	10	11,157	1.4	969	0.5
2004	11	3,450	0.4	246	0.1
Total*		**775,228**	**100.0**	**198,584**	**100.0**

* Sum of columns may not equal totals due to rounding.
** 2012 year class fish were not encountered in the subsample. Mean weight at age was obtained from ASMFC 2015 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 at Maryland Chesapeake Bay commercial summer/fall fishery, June through December 2015. 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	June	602	372
B	December	565	156
B,C	November	559	352
B,C	July	555	232
C	October	547	396
D	August	517	140
D	September	508	554

Table 8. Duncan's multiple range test for mean weight by month at Maryland Chesapeake Bay commercial summer/fall fishery, June through December 2015. 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	June	2.43	371
B	December	2.14	156
C	November	1.86	311
C	July	1.77	232
D	October	1.56	396
E	August	1.23	140
E	September	1.20	554

Figure 1. Locations of Chesapeake Bay commercial summer/fall check stations sampled from June through November 2015.

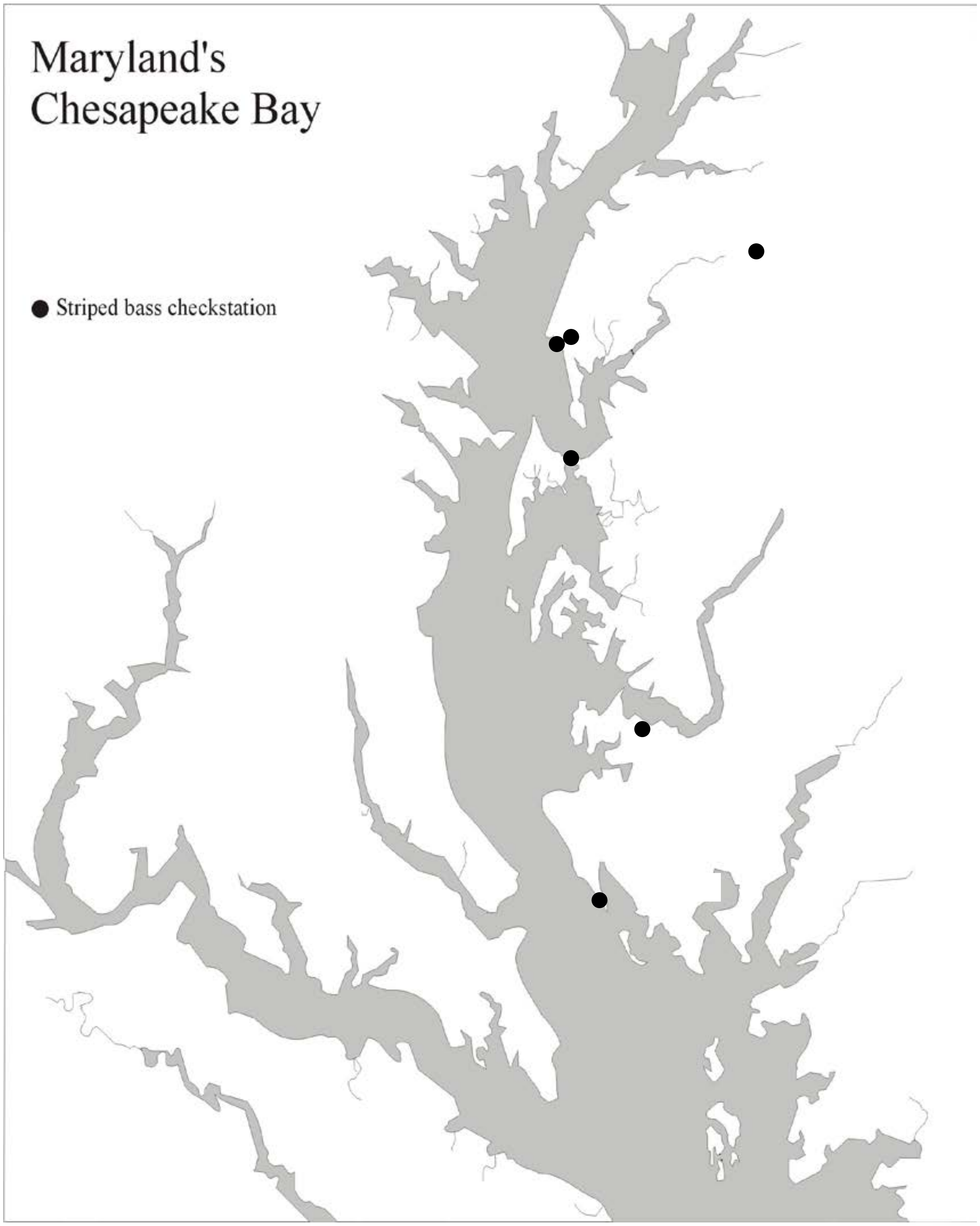
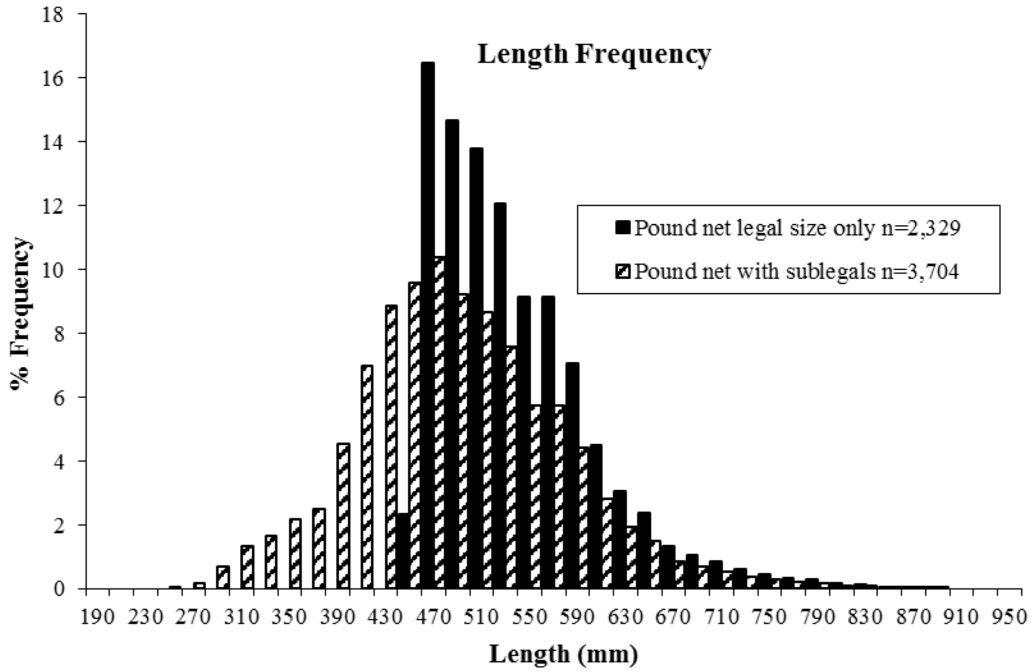


Figure 2. Age and length (mm TL) frequencies of striped bass sampled during Maryland Chesapeake Bay pound net monitoring study, June through November 2015.



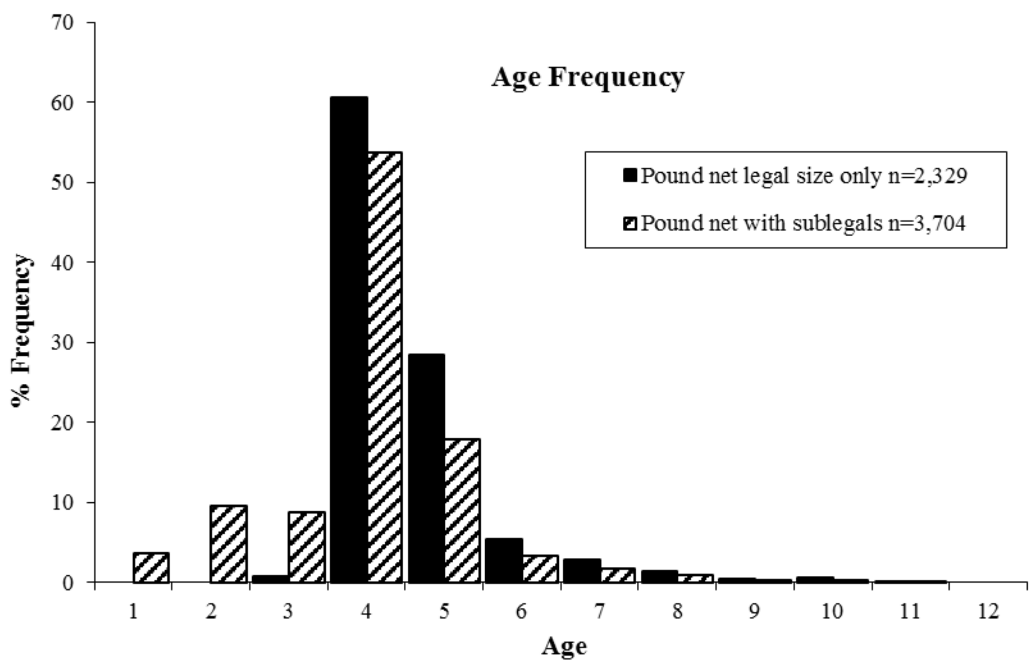


Figure 3. Age structure of striped bass sampled from Maryland Chesapeake Bay commercial pound net monitoring study from 1996 through 2015. *Note partial net sampling for legal sized fish was conducted from 1996 to 1999. Full net samples started in 2000.

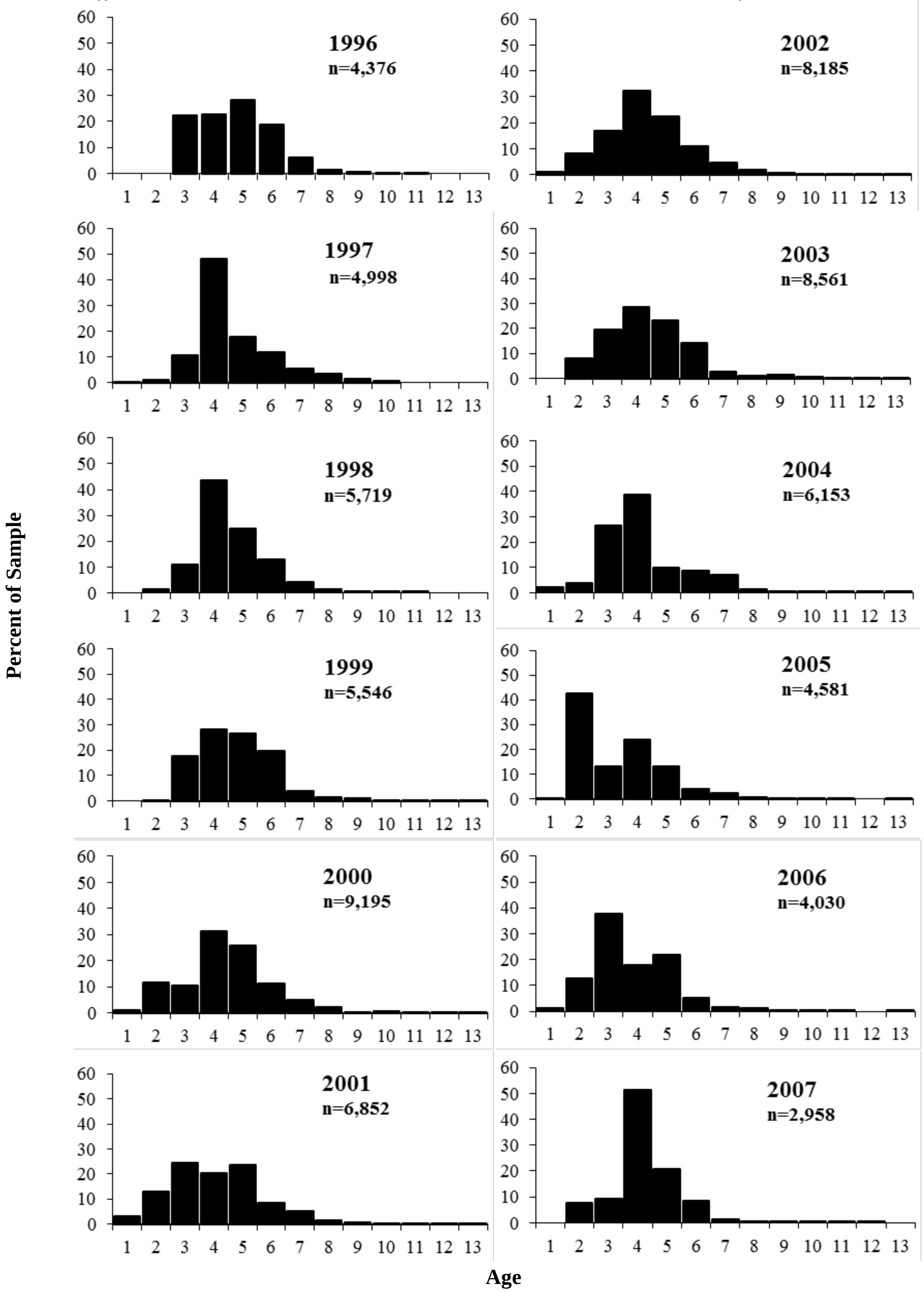


Figure 3. Continued.

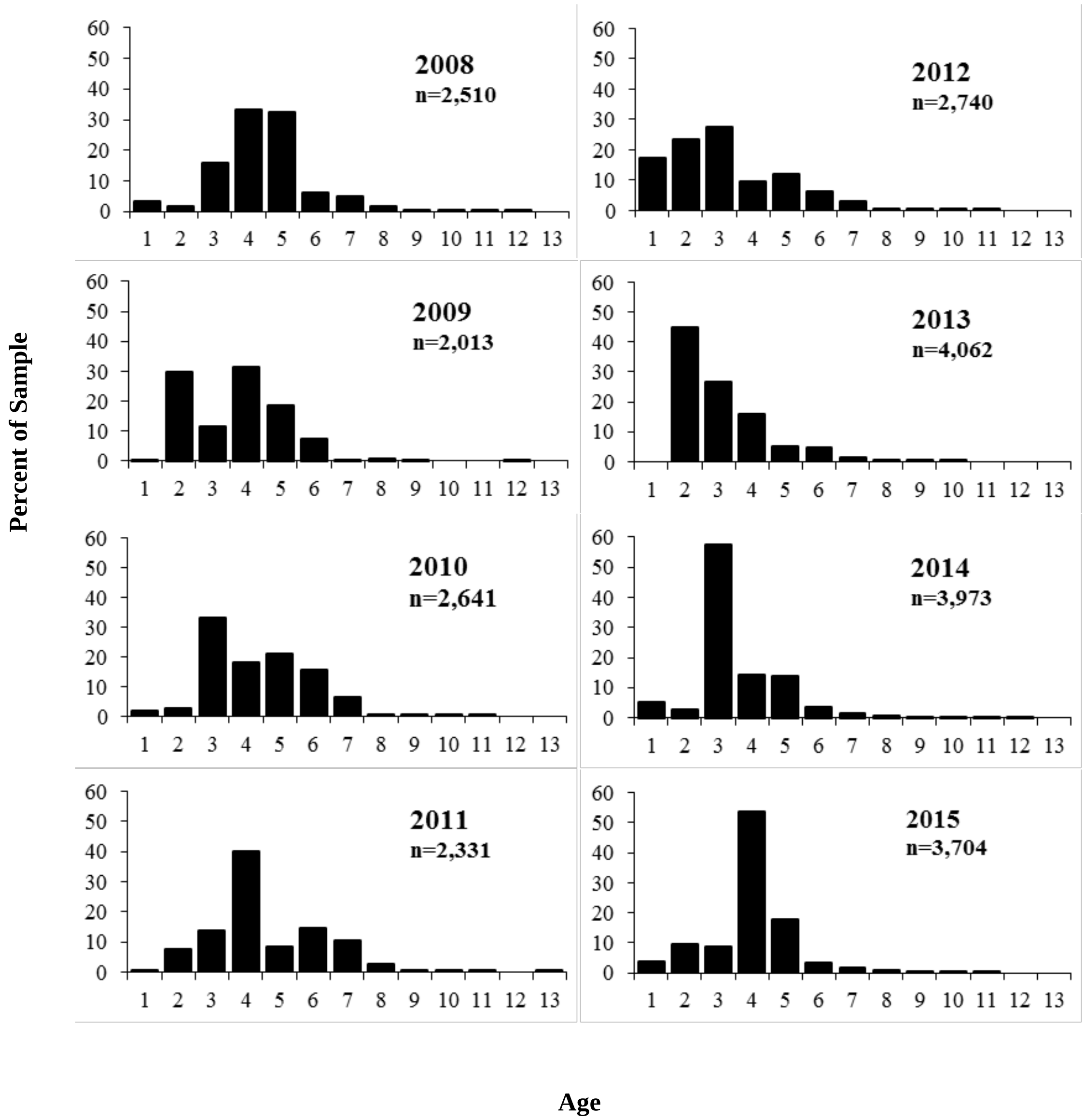


Figure 4. Length frequency of striped bass sampled during the 2015 pound net monitoring and the summer/fall check station surveys. All fish were sampled from June through December 2015. Pound net monitoring length frequency is for legal-size fish only (≥457 mm TL/18 in TL).

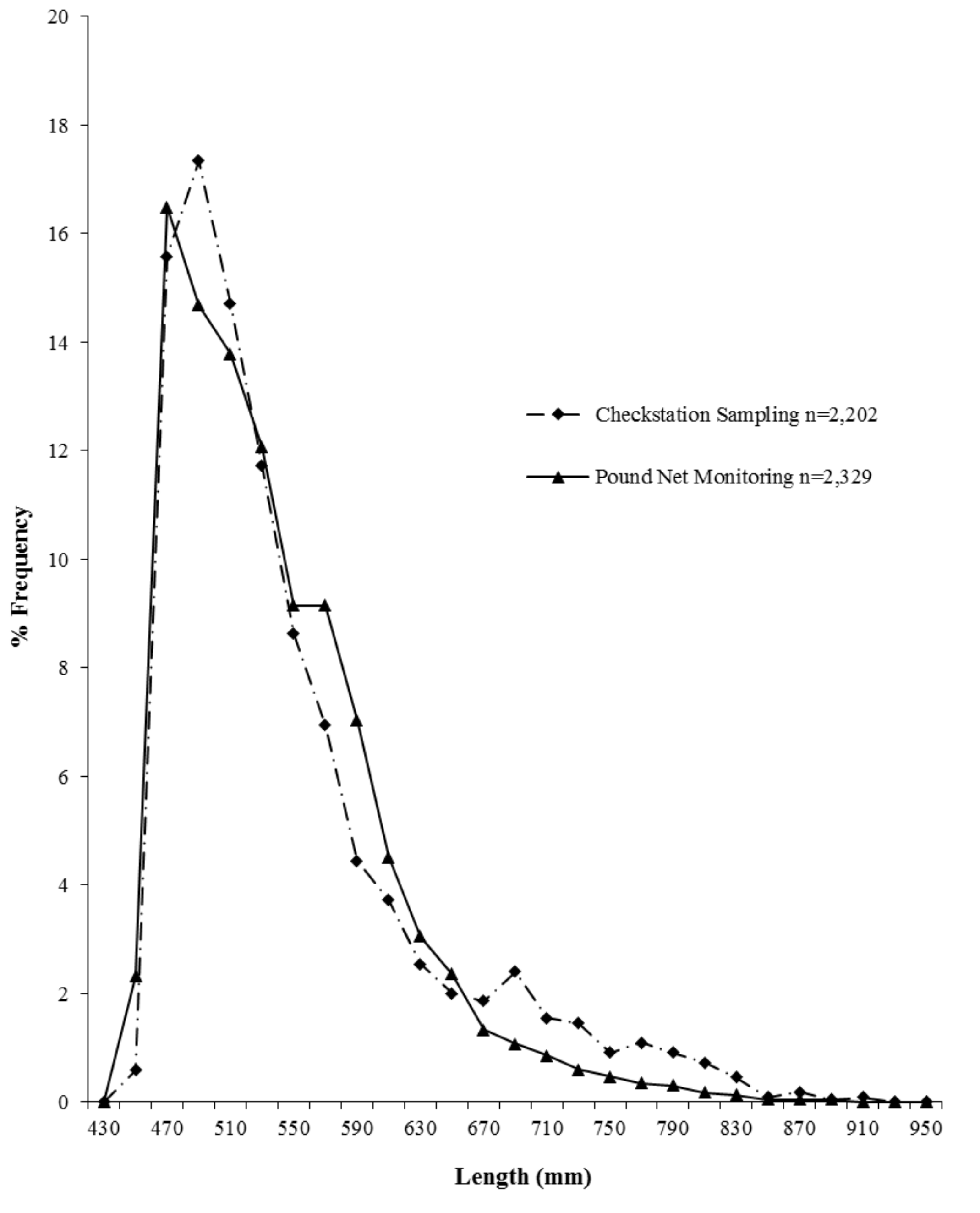
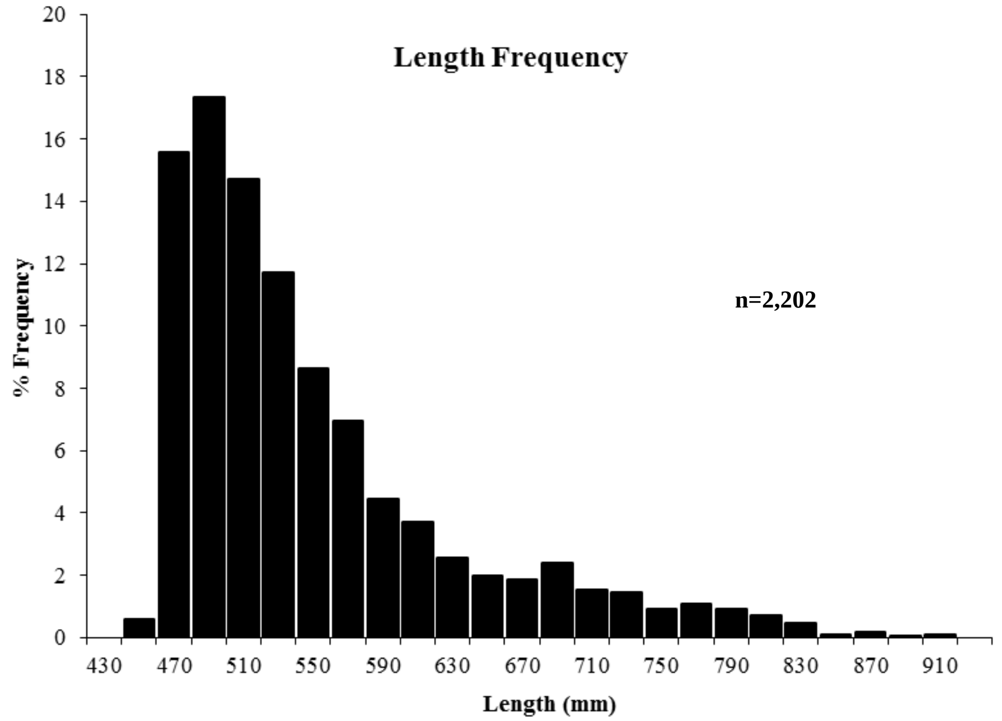


Figure 5. Age and length frequencies of striped bass sampled from Maryland Chesapeake Bay commercial summer/fall check stations, June through December 2015.



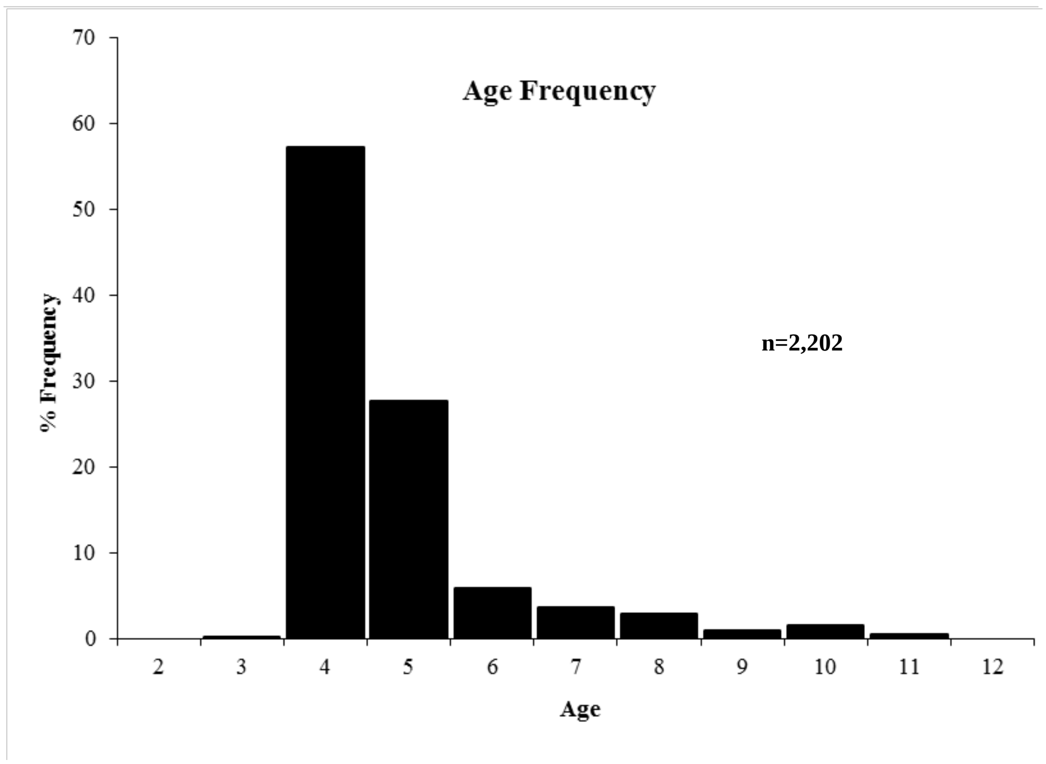


Figure 6. Month-specific length distributions of striped bass sampled from Maryland Chesapeake Bay commercial summer/fall check stations, June through December 2015.

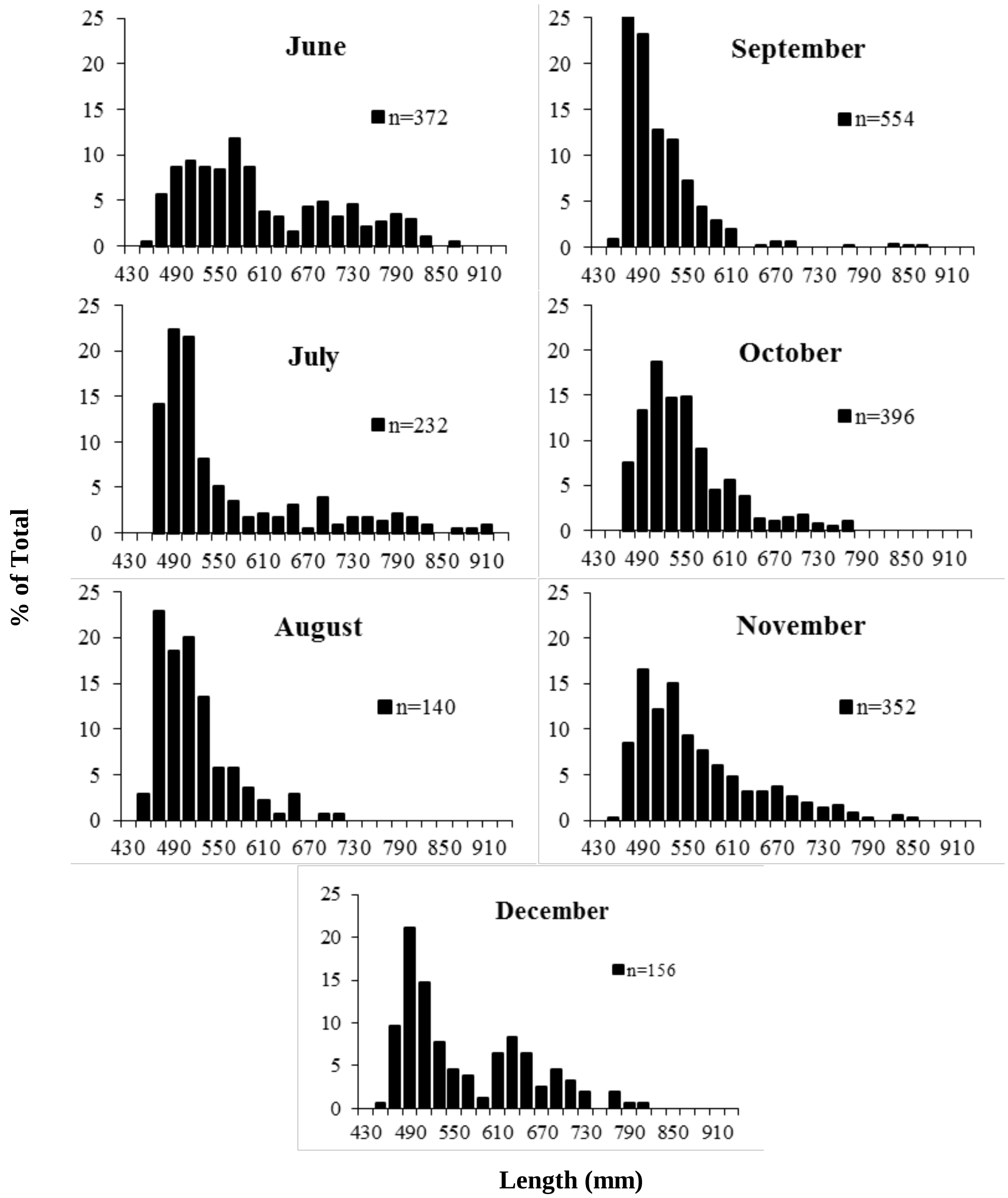


Figure 7. Age structure of striped bass sampled from Maryland Chesapeake Bay commercial summer/fall check stations, 1999 through 2015. Note-pound net check station sampling began in 2000.

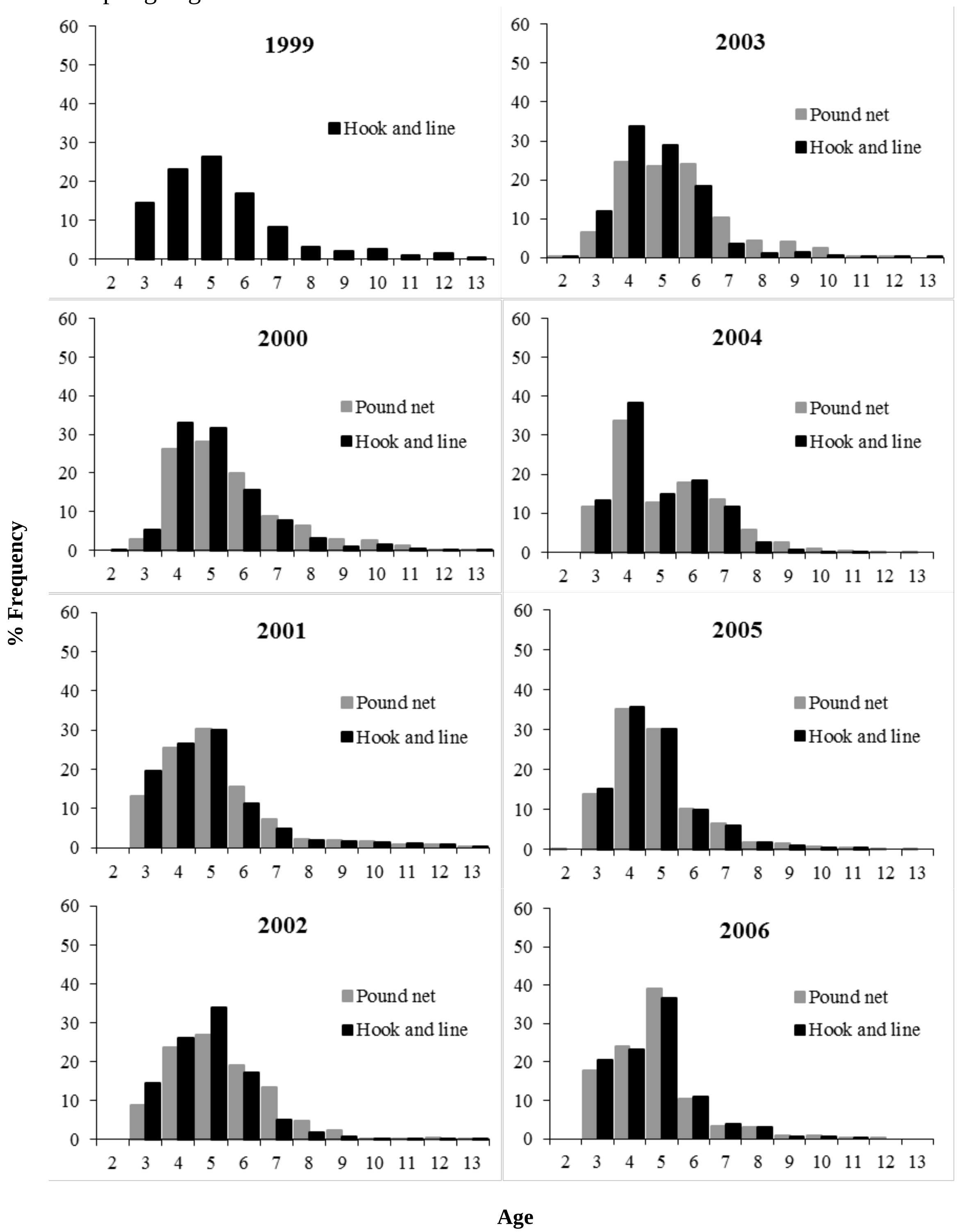


Figure 7. Continued.

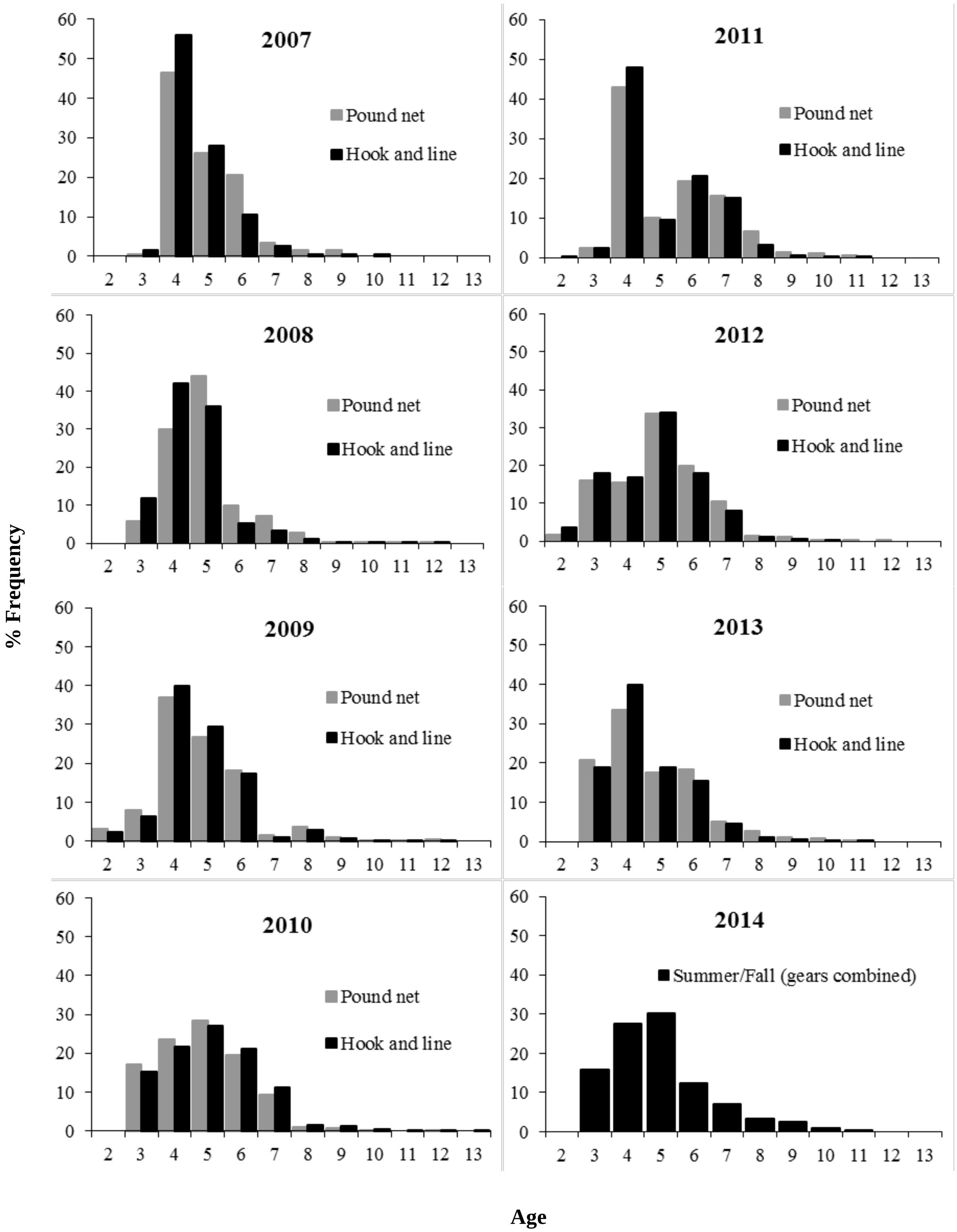


Figure 7. Continued

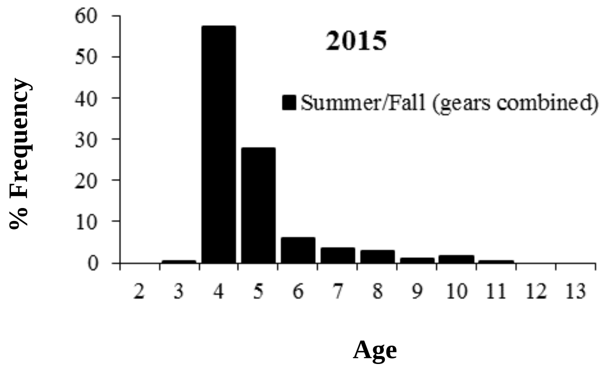
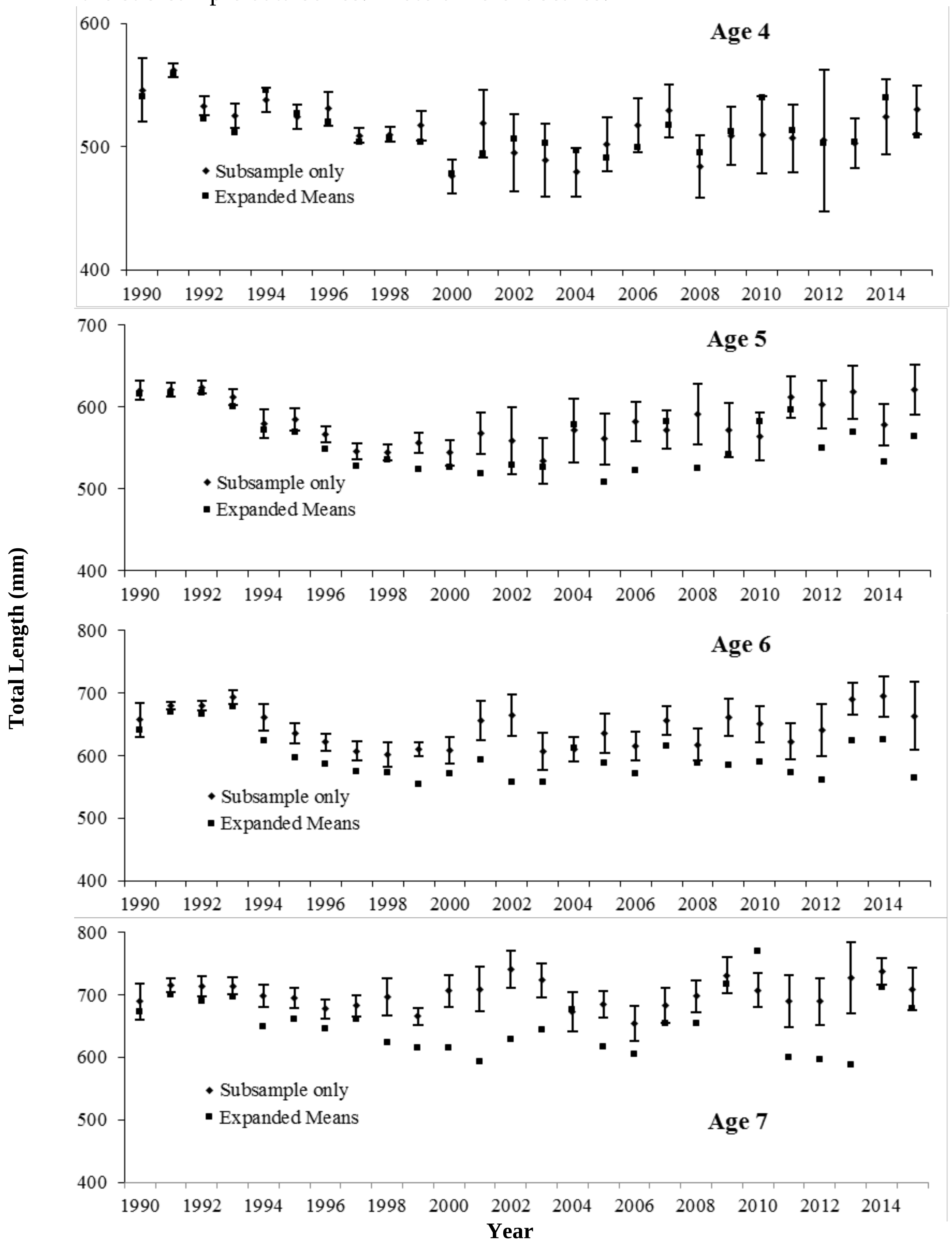


Figure 8. Mean lengths for legal-size striped bass (≥457 mm TL) by year for age 4, 5, 6, and 7 striped bass sampled from Maryland Chesapeake Bay pound nets and commercial summer/fall check stations, 1990 through 2015. Mean lengths were calculated by using sub-sampled ages only and by expanding ages to 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, 2015 – February 29, 2016 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 three days in February.

METHODS

Data collection procedures

All striped bass harvested in Maryland's commercial striped bass fishery are required to pass through a Maryland Department of Natural Resources (MD DNR) approved check station. Striped bass check stations were sampled for the winter stock assessment according to a stratified random sampling design. Strata were defined as either high-use, medium-use, or low-use check stations based on landings from the previous year. Individual check stations that processed 8% or greater of the 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). 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 2015-2016 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 2015 – February 2016 gill net season, the year used for age calculations was 2016.

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 2015-2016 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 3,282 striped bass were sampled and 159 striped bass were aged from the harvest between December 2015 - February 2016. 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 five times in December, four times in January, and six 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 2015-2016 season was estimated by dividing reported monthly harvest weight by the mean monthly weight of check station samples. Total reported landings were 662,247 pounds and the estimated number of fish was 89,613 (Table 1). According to the catch-at-age analysis, the 2015-2016 commercial drift gill net harvest consisted primarily of age 7 striped bass from the 2009 year-class (37%; Table 2). The 2011, 2010 and 2008 year-classes (ages 5, 6, and 8) composed an additional 59% of the total harvest. The contribution of fish older than age 9 (3%) was lower than in the 2014-2015 harvest (13%). The youngest fish observed in the 2015-2016 sampled harvest were age 4 from the 2012 year class (0.4%).

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 4-5 year old fish and slightly lower for fish age 6 and older. Striped bass were recruited into the winter gill net fishery beginning at age 4 (2012 year-class), with an expanded mean length and weight of 489 mm TL and 1.33 kg, respectively. The 2009 year-class (age 7) was most commonly observed in the sampled landings and had an expanded mean length and weight of 657 mm TL and 3.60 kg, respectively. The expanded mean length and weight of the oldest fish in the aged subsample (age 13, 2003 year-class) were 865 mm TL and 7.70 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 590-710 mm length groups. Sub-legal fish have occasionally been sampled in previous years and four were observed in 2015-2016 sampling.

Time series of subsampled and expanded mean lengths and weights for the period 1994-2016 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 due to larger sample sizes from the ITQ fishery. 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

2016-2017 WINTER STOCK ASSESSMENT AND COMMERCIAL FISHERY MONITORING

2016-2017 SEASON PRELIMINARY RESULTS

A total of 3,596 striped bass were sampled and 895 scale samples were collected 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. Check stations were visited by biologists four times in December, seven 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. 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 2015 – February 2016.

Month	Harvest (lbs)	Check station average wt. (lb)	Estimated # harvested
December 2015	118,121	8.311	14,213
January 2016	263,150	7.198	36,559
February 2016	280,976	7.234	38,841
Total*	**662,247**		**89,613**

Table 2. Estimated catch-at-age of striped bass (numbers of fish) landed by the Maryland Chesapeake Bay commercial drift gill net fishery, December 2015 - February 2016.

Year-class	Age	Catch	Percentage of the catch
2012	4	364	0
2011	5	15,484	17
2010	6	26,456	30
2009	7	33,358	37
2008	8	10,980	12
2007	9	2,398	3
2006	10	325	0
2005	11	164	0
2004	12	41	0
2003	13	41	0
Total*		**89,613**	**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 2015-February 2016.

Year-class	**Age**	**n fish aged**	**Mean TL (mm) of aged subsample**	**Estimated # at-age in sample**	**Expanded mean TL (mm)**
2012	4	1	480	13	489
2011	5	28	522	567	566
2010	6	28	621	968	632
2009	7	45	700	1,221	657
2008	8	23	740	402	692
2007	9	21	813	88	754
2006	10	7	827	12	814
2005	11	4	846	6	827
2004	12	1	866	2	865
2003	13	1	862	2	865
Total*		**159**		**3,282**	

* 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 2015-February 2016.

Year-class	**Age**	**n fish aged**	**Mean weight (kg) of aged subsample**	**Estimated # at-age in sample**	**Expanded mean weight (kg)**
2012	4	1	1.12	13	1.33
2011	5	28	1.75	567	2.27
2010	6	28	3.13	968	3.21
2009	7	45	4.31	1,221	3.60
2008	8	23	4.91	402	4.16
2007	9	21	6.50	88	5.33
2006	10	7	7.42	12	6.54
2005	11	4	7.62	6	7.02
2004	12	1	7.57	2	7.70
2003	13	1	7.83	2	7.70
Total*		**159**		**3,282**	

* 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 2015-February 2016.

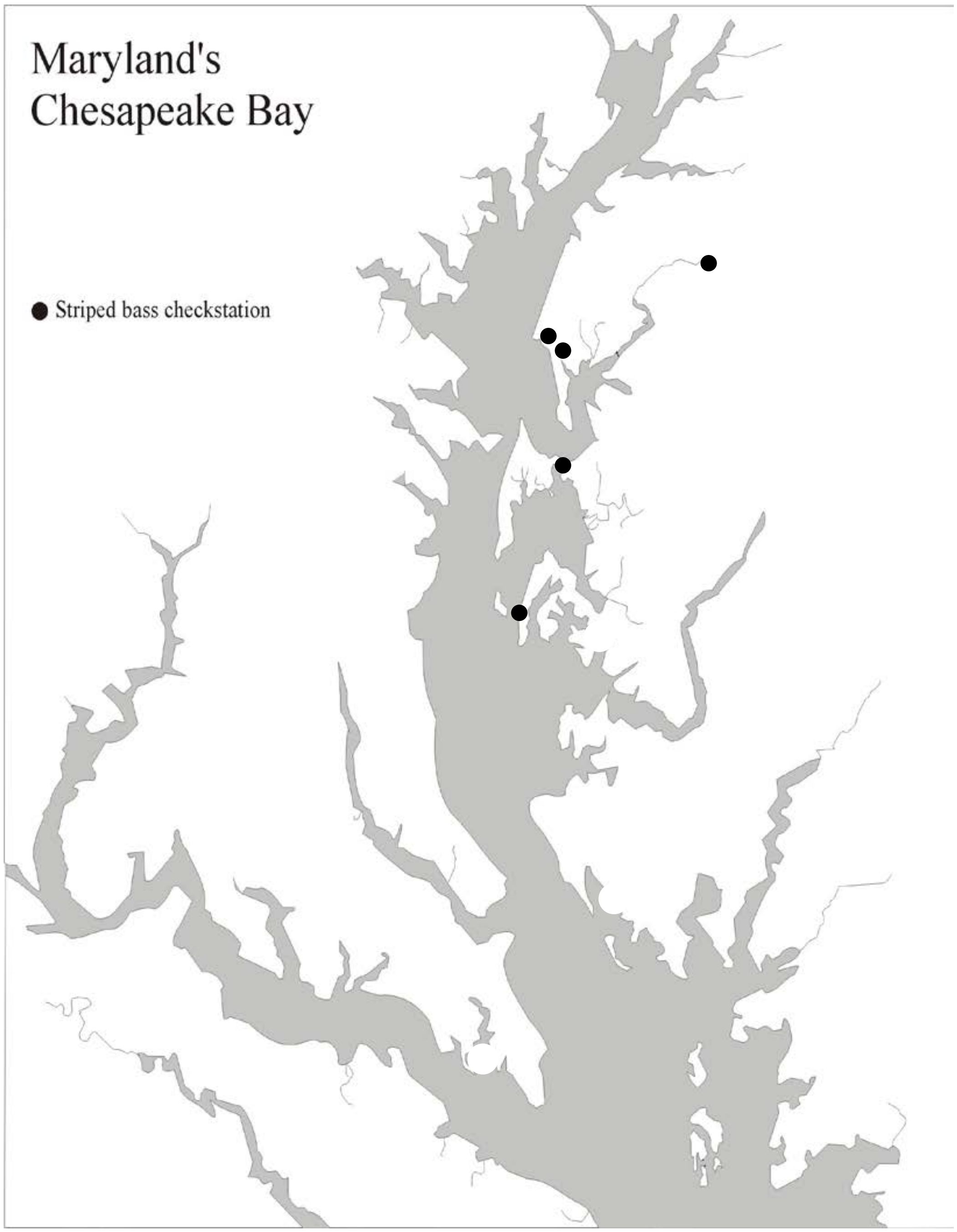
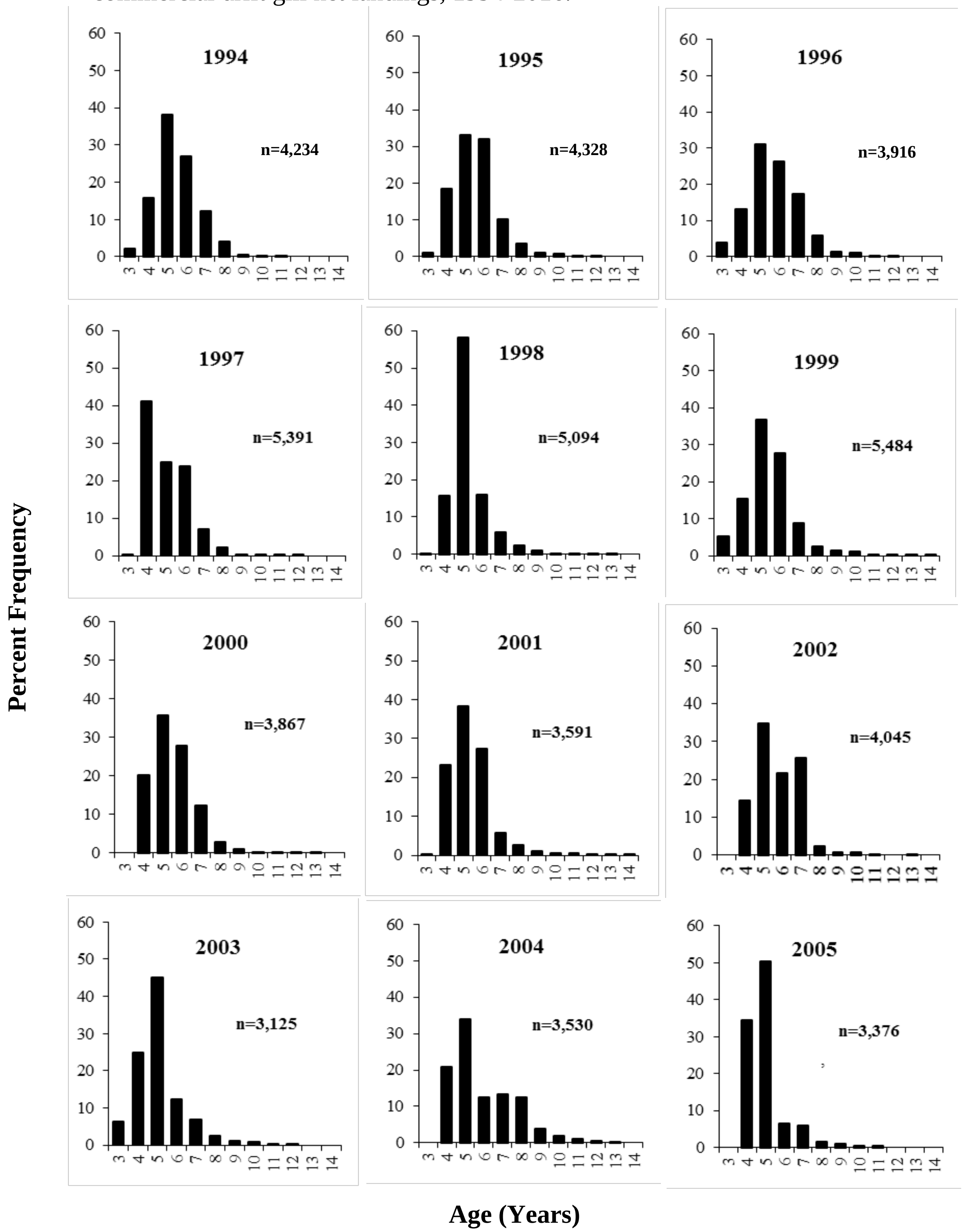


Figure 2. Age distribution of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, 1994-2016.



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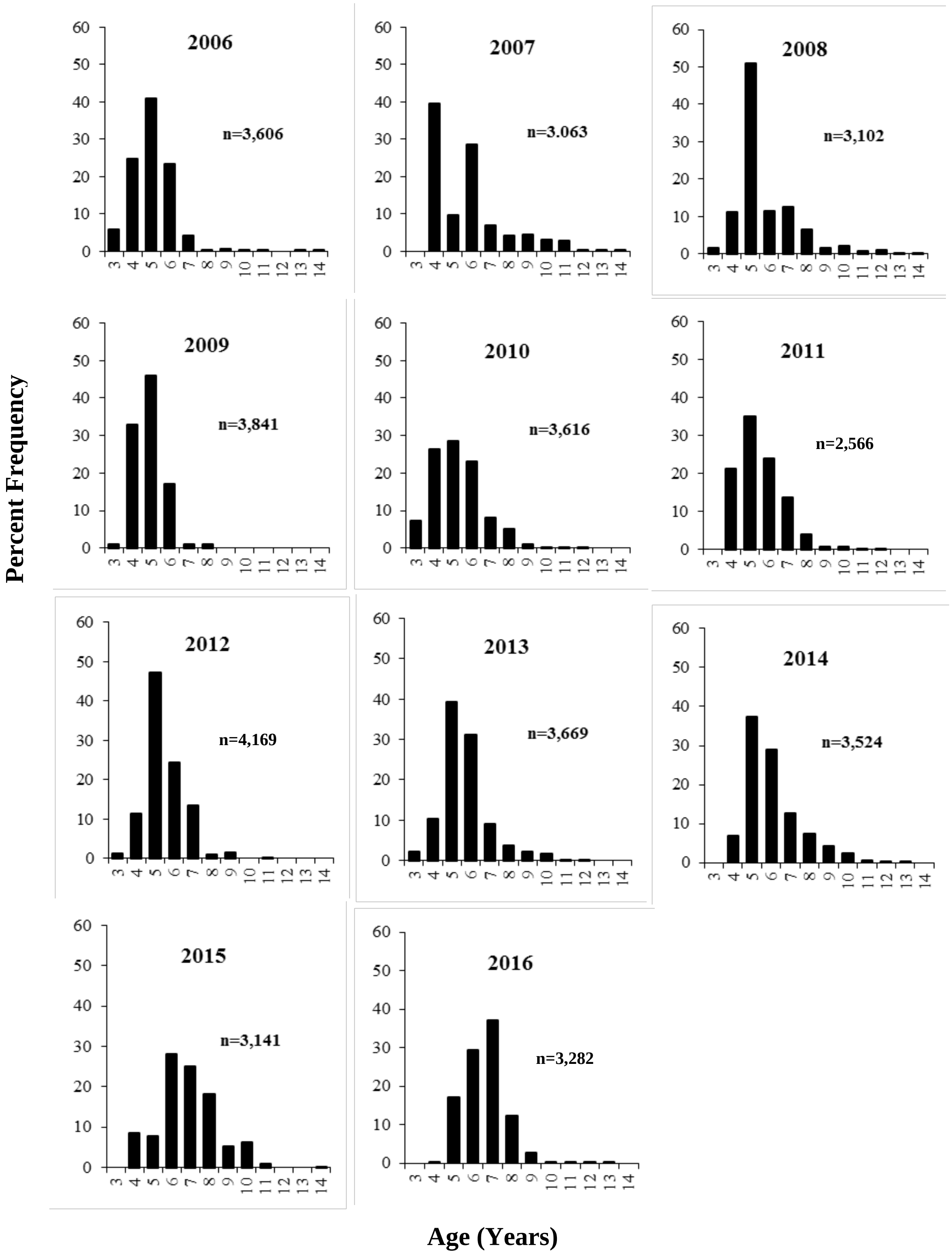


Figure 3. Length frequency distribution of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, December 2015-February 2016.

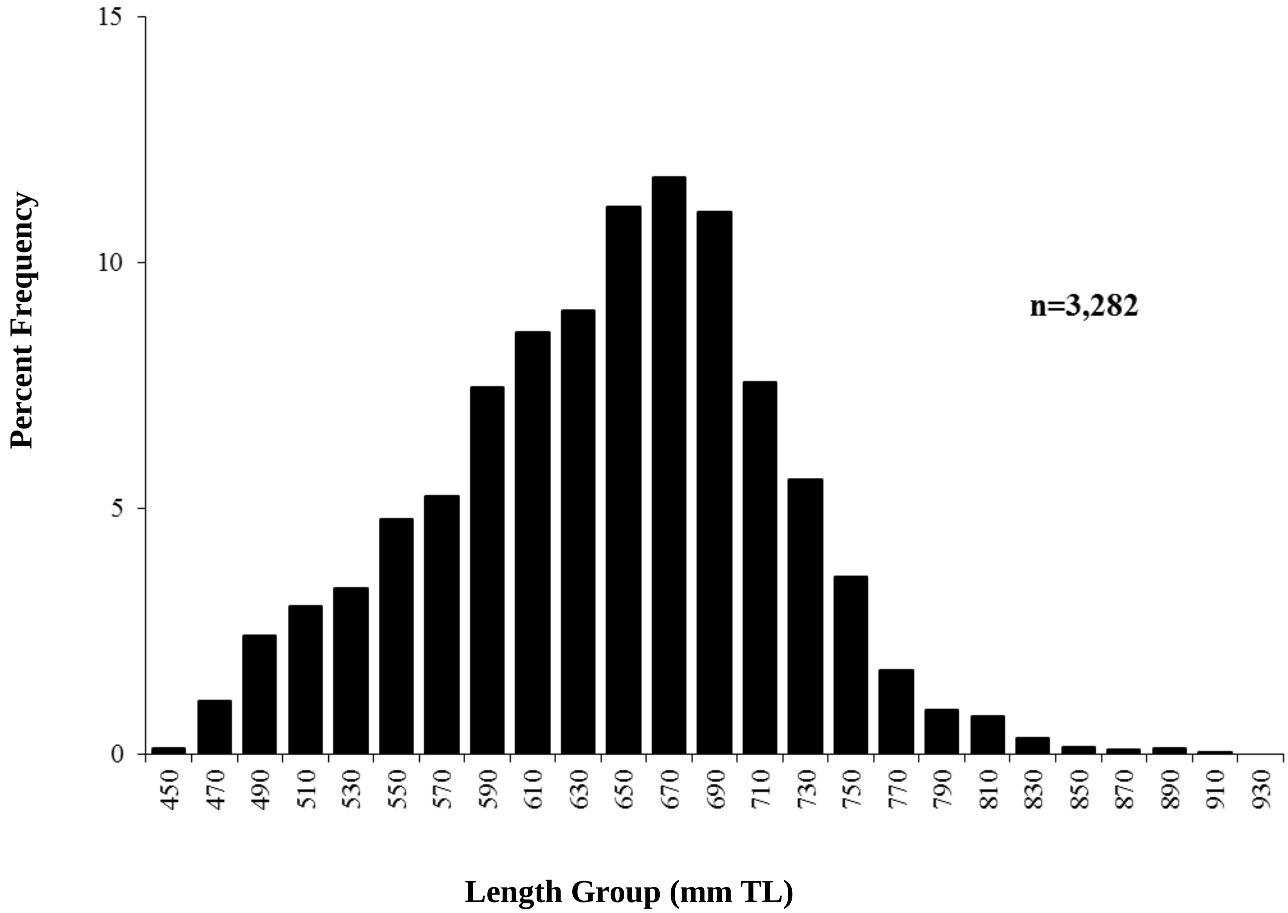
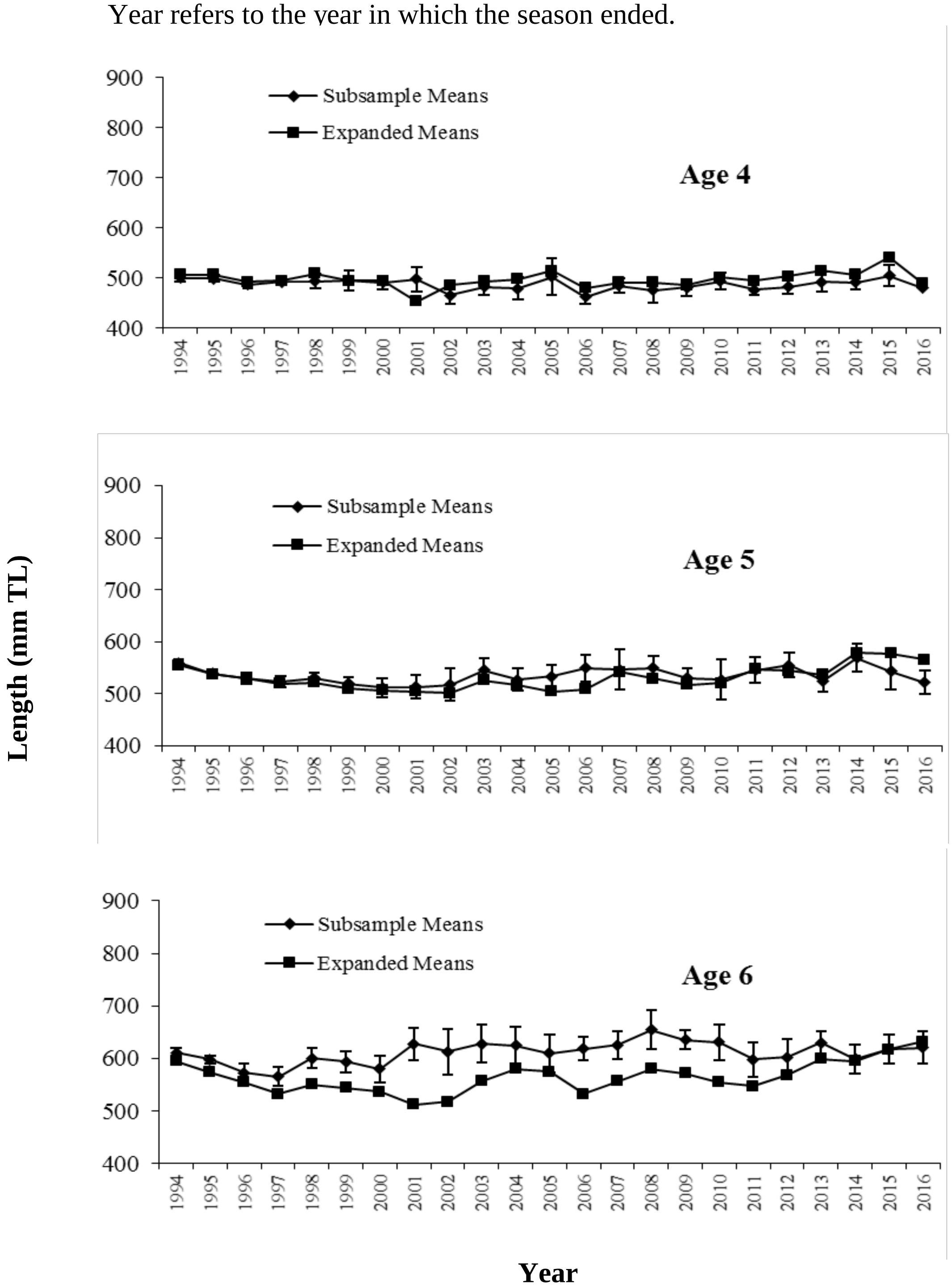


Figure 4. Mean total lengths (mm TL) of the aged subsample, by year, for individual age-classes of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, 1994-2016 (95% confidence intervals are shown around each point). Expanded means (estimated from entire sample) are also shown. Year refers to the year in which the season ended.



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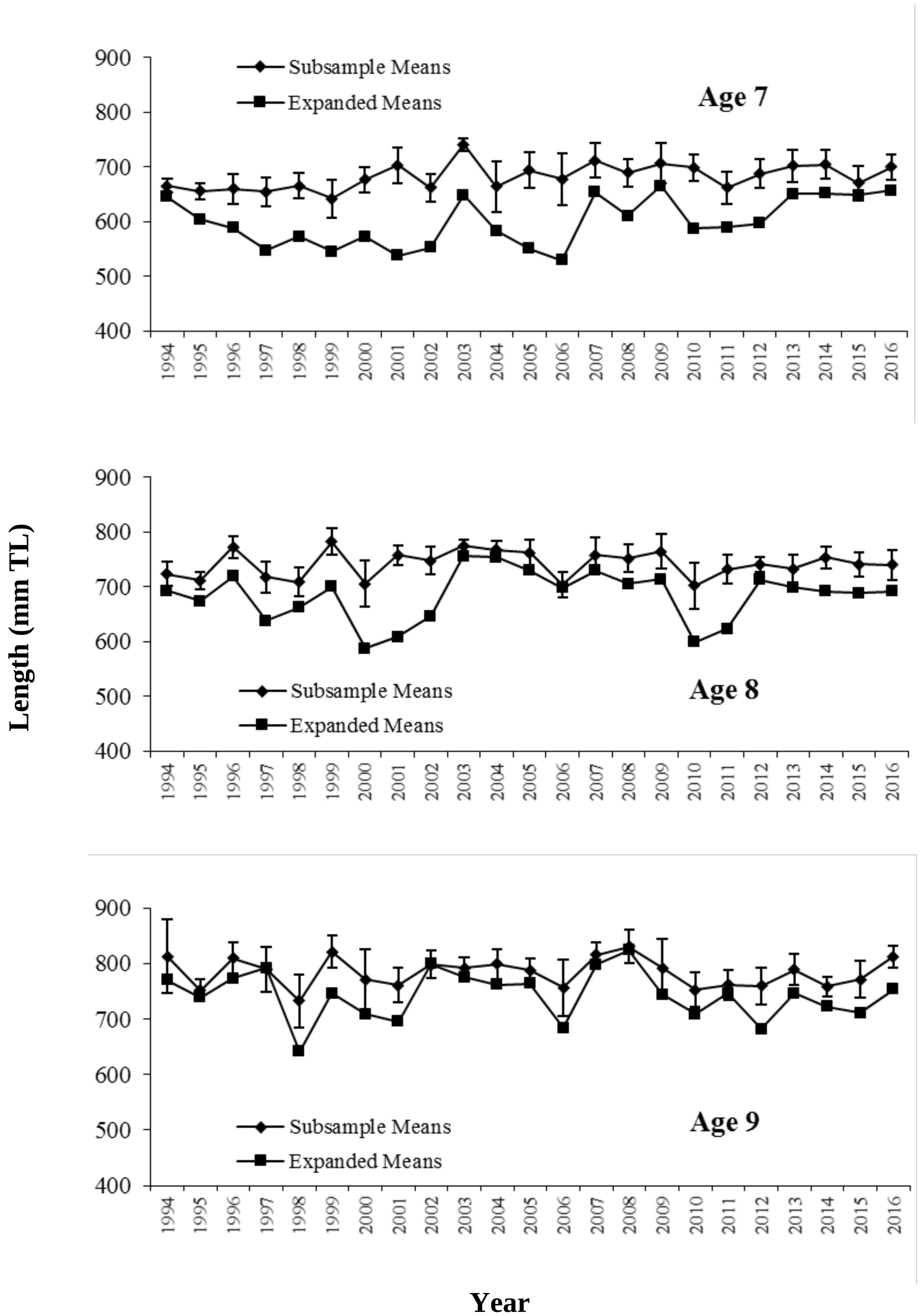
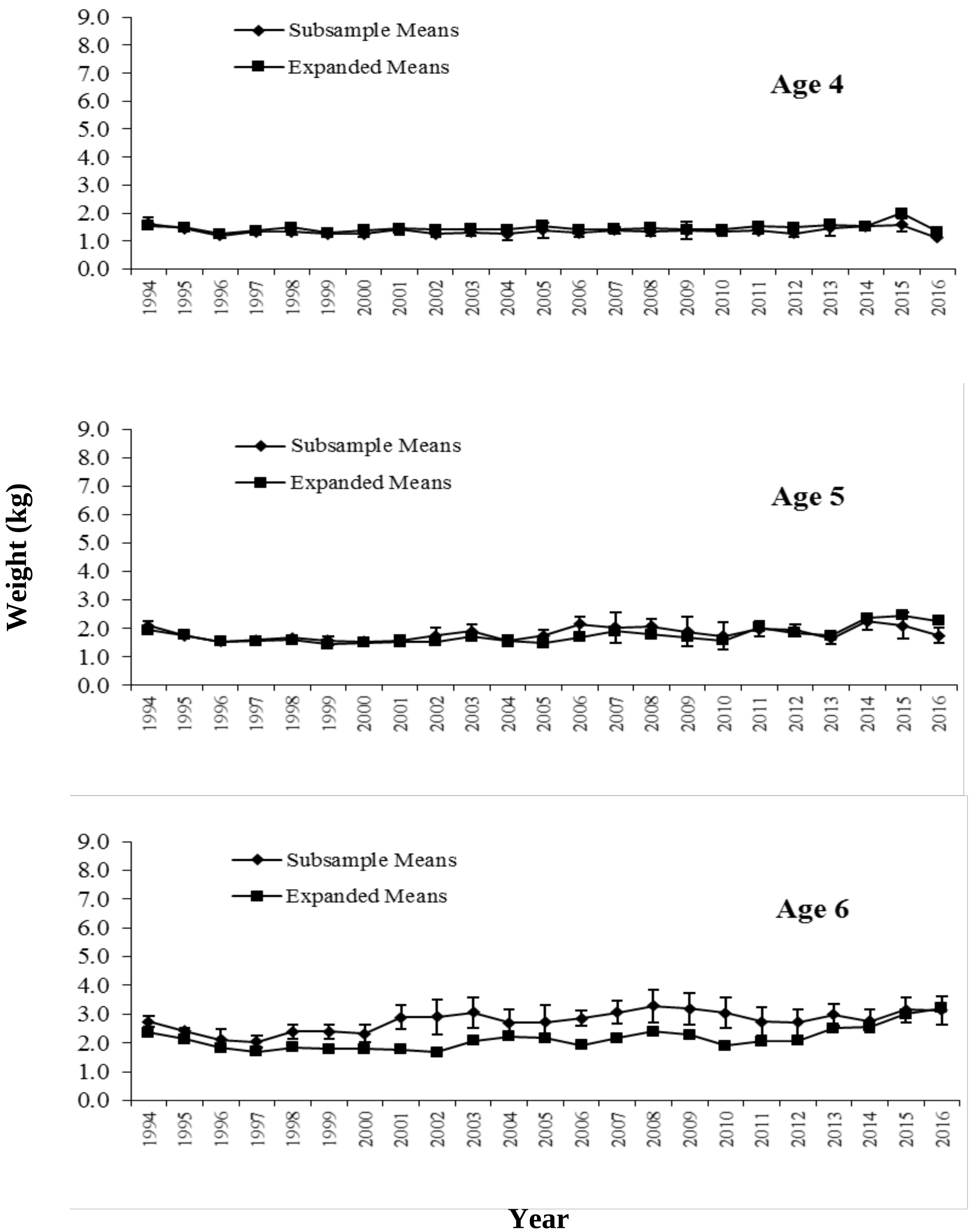


Figure 5. Mean weights (kg) of the aged subsample, by year, for individual age-classes of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net fishery, 1994-2016 (95% confidence intervals are shown around each point). Expanded means (estimated from entire sample) are also shown. Year refers to the year in which the season ended.



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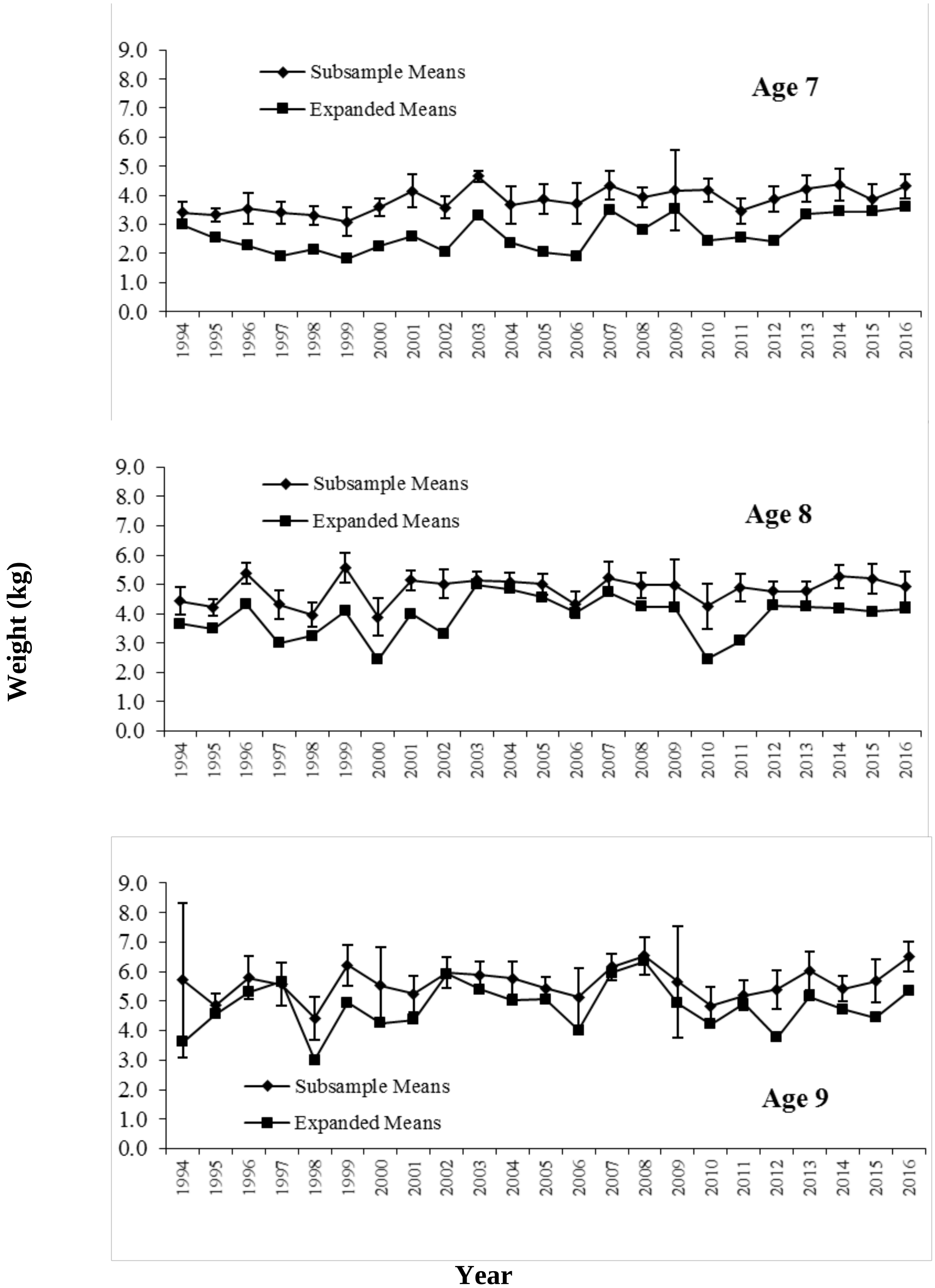

.PROJECT NO. 2
JOB NO. 3
TASK NO. 1C

ATLANTIC COAST STOCK ASSESSMENT AND COMMERCIAL HARVEST MONITORING

Prepared by Ryan P. Hastings

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 out). The 2016 season opened October 1, 2015 and ended May 31, 2016. The 2016 Atlantic striped bass season was subject to 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 2015-May 2016 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 in 2006 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 occured 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

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

Year-class was determined by reading acetate impressions of the scales placed 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 2015-May 2016 Atlantic fishery, the year used for age calculations was 2016. These ages were then used to construct the age-length key (ALK). The 2016 Atlantic fishery ALK was supplemented with the 2015 Atlantic fishery ALK due to low sample size. 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 from October 2015 through May 2016 was estimated by applying the sample age distribution to the total landings as reported from the check stations.

Mean lengths- and weights-at-age were calculated by year-class for the sub-sample of fish. Mean lengths-at-age and mean weights-at-age were also estimated for each year-class using an expansion method. 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

The Atlantic striped bass fishery is largely by-catch from the commercial spiny dogfish fishery. Sampling at coastal check stations was conducted on three days between December 2015 and May 2016. A total of 27 fish were measured and weighed and fish ages were estimated from 20 scale samples. Statistical analysis of the fish sampled was not possible due to low sample size. This is the smallest sample in the Atlantic fishery time series. Commercial fishermen have a limited area to harvest striped bass (~62 square miles) within Maryland waters. During the 2016 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 1,225 fish landed during the 2015-2016 Atlantic coast season (Table 1) (Chris Jones, Data Management and Quota Monitoring Program, Personal Communication). This is the lowest number of striped bass reported at Atlantic checkstations in the time series (Figure 1). The catch-at-age estimate determined that landings ranged from age 4 (2012 year-class) to age 15 (2001 year-class) (Table 1). Most (97.6%) striped bass harvested were ages 5 through 13 (Table 1). The most common age represented in the catch-at-age estimate was age 6, the 2010 year class (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.

Five year-classes were represented in the sampled harvest and ranged from age 7 (2009 year-class) to age 13 (2003 year-class) (Figure 2). The most common age sampled during the 2015-2016 Atlantic coast fishery was age 13 (2003 year-class), which represented only 5.2% of the landings (Table 1).

Striped bass sampled at Atlantic coast check stations during the 2015-2016 seasons had a mean length of 920 mm TL and mean weight of 8.8 kg. The sample length distribution ranged from 615 to 1096 mm TL (Figure 3). The weight distribution from the sample of fish harvested ranged from 2.3 to 13.4 kg.

Since most of the sampled fish were aged, the expanded mean lengths- and weights-at-age were similar to means of the aged sub-sample, and within the 95% confidence limits (Tables 2 and 3, Figures 4 and 5). Age 13 striped bass (2003 year-

class) were the most abundant age group sampled, with an expanded mean length of 1021 mm TL and expanded mean weight of 11.5 kg (Figures 4 and 5). Age 11 striped bass, the next most abundant year-class sampled had an expanded mean length of 979 mm TL and expanded mean weight of 10.3 kg (Tables 2 and 3).

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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 2015-May 2016. Number of fish are calculated on combined 2016 and 2015 age length key.

Year-Class	**Age**	**Number of Fish**	**Percent**
2012	4	23	1.9
2011	5	183	14.9
2010	6	257	21.0
2009	7	88	7.2
2008	8	162	13.2
2007	9	91	7.4
2006	10	95	7.7
2005	11	92	7.5
2004	12	164	13.4
2003	13	64	5.2
2002	14	0	0.0
2001	15	6	0.5
Total*	-	1,225	100

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

Table 2. Sub-sample and expanded mean total lengths (mm TL) by year-class of striped bass sampled from Atlantic coast fishery, October 2015-May 2016. Includes the lower and upper 95% confidence limits (LCL and UCL, respectively).

Year-Class	**Age**	**n Fish Aged**	**Mean TL (mm) of Aged Sub-sample**	**LCL**	**UCL**	**Estimated # at-age in Sample**	**Expanded Mean TL (mm)**
2009	7	1	847	-	-	1	847
2006	10	2	1006	937	1076	3	1005
2005	11	5	980	930	1029	7	979
2004	12	3	989	926	1052	4	992
2003	13	9	1021	992	1049	12	1021
Total		**20**				**27**	

Table 3. Sub-sample and expanded mean weights (kg) by year-class of striped bass sampled from Atlantic coast fishery, October 2015-May 2016. Includes the lower and upper 95% confidence limits (LCL and UCL, respectively).

Year-Class	**Age**	**n Fish Aged**	**Mean Weight (kg) of Aged Sub-sample**	**LCL**	**UCL**	**Estimated # at-age in Sample**	**Expanded Mean Weight (kg)**
2009	7	1	5.3	-	-	1	5.3
2006	10	2	10.3	7.7	12.9	3	11.4
2005	11	5	10.3	8.2	12.5	7	10.3
2004	12	3	11.2	8.2	14.3	4	10.7
2003	13	9	11.5	10.6	12.6	12	11.5
Total		**20**				**27**	

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

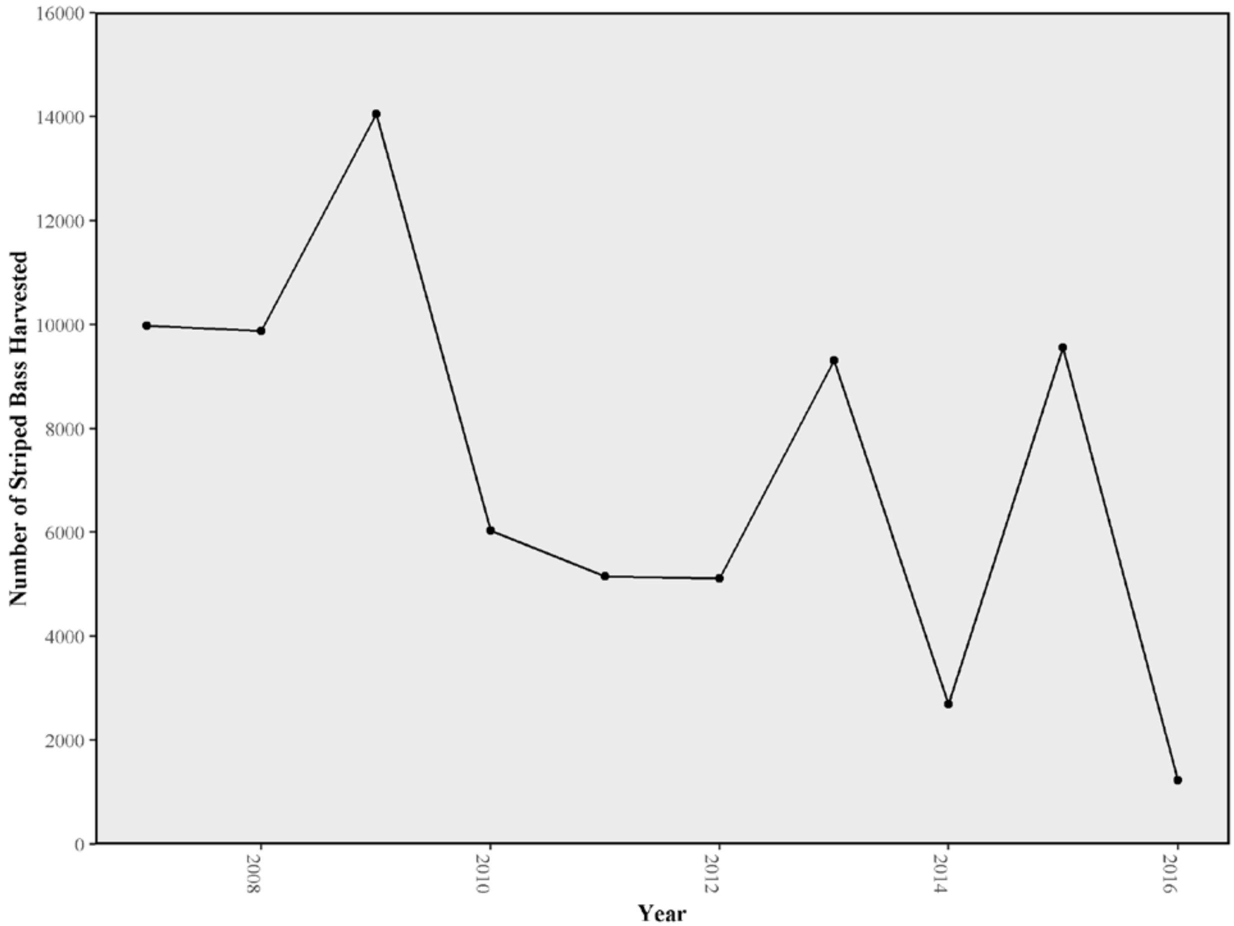


Figure 2. Age distribution of striped bass sampled from the Atlantic coast fishery, 2006-2016 seasons.

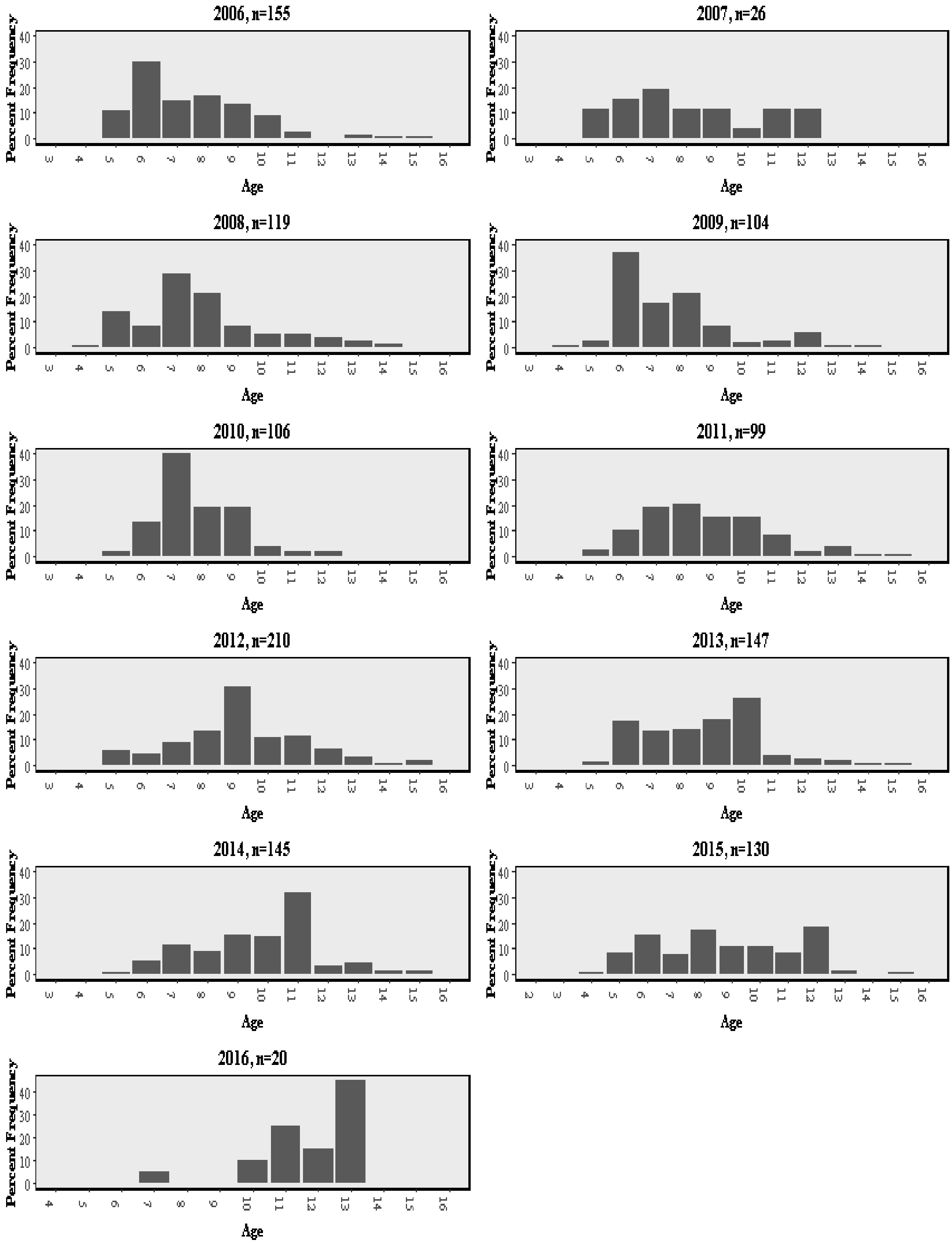


Figure 3. Length distribution of striped bass sampled from the Atlantic coast fishery, 2006-2016 seasons.

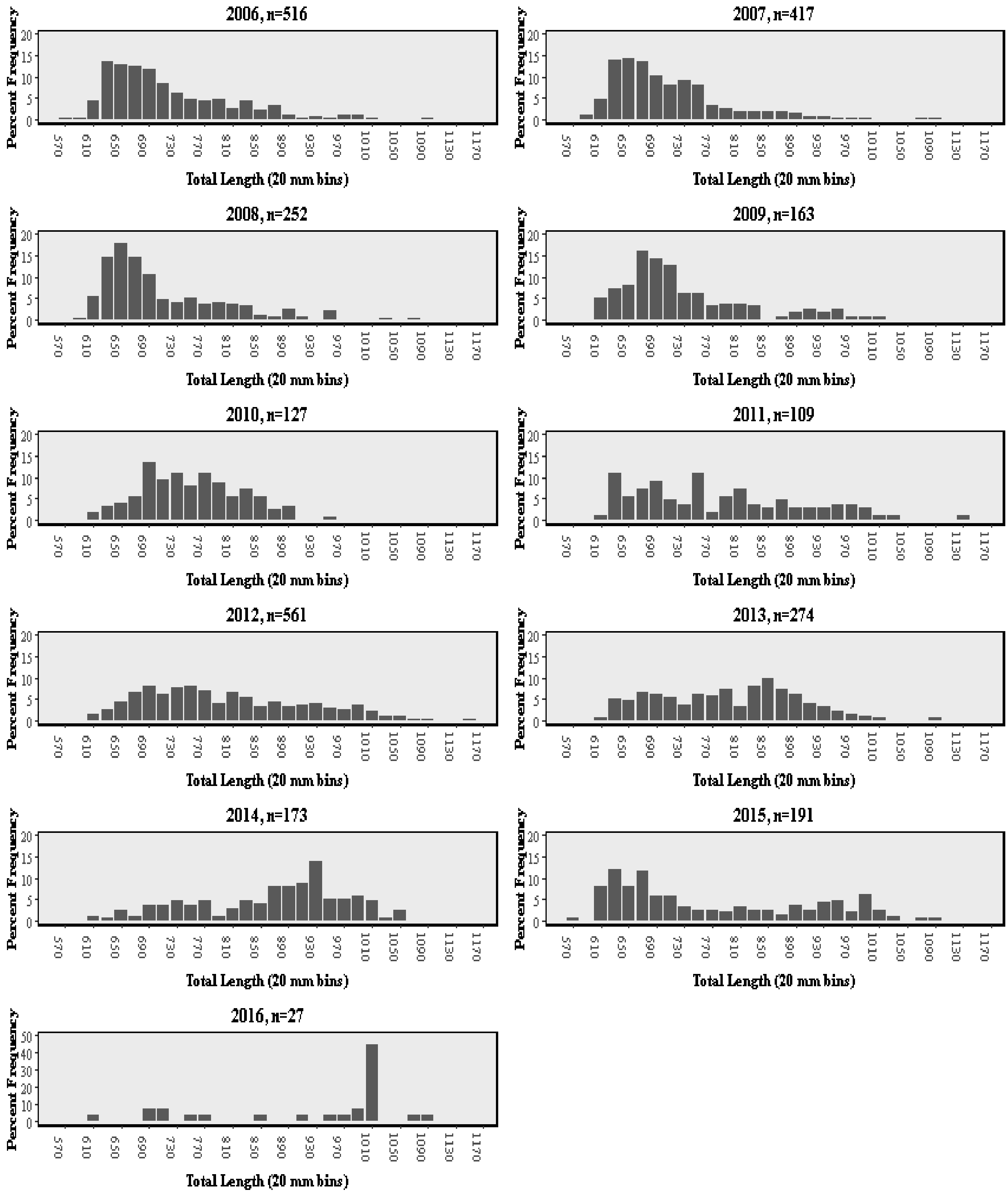
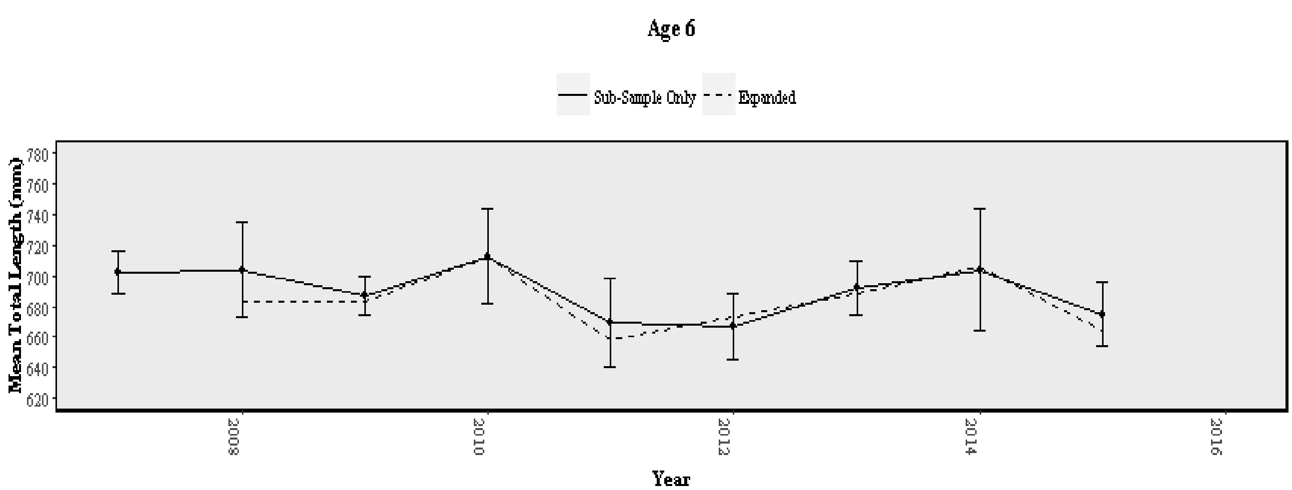


Figure 4. Mean total lengths (mm TL) of the aged sub-sample, by year, for individual age-classes of striped bass (through age 12) sampled from the Maryland Atlantic coast trawl and gill net landings, 2007`-2016 (95% confidence intervals are shown around each point). Expanded means (estimated from entire sample) are also shown. *Note differences in scales on the y-axis.



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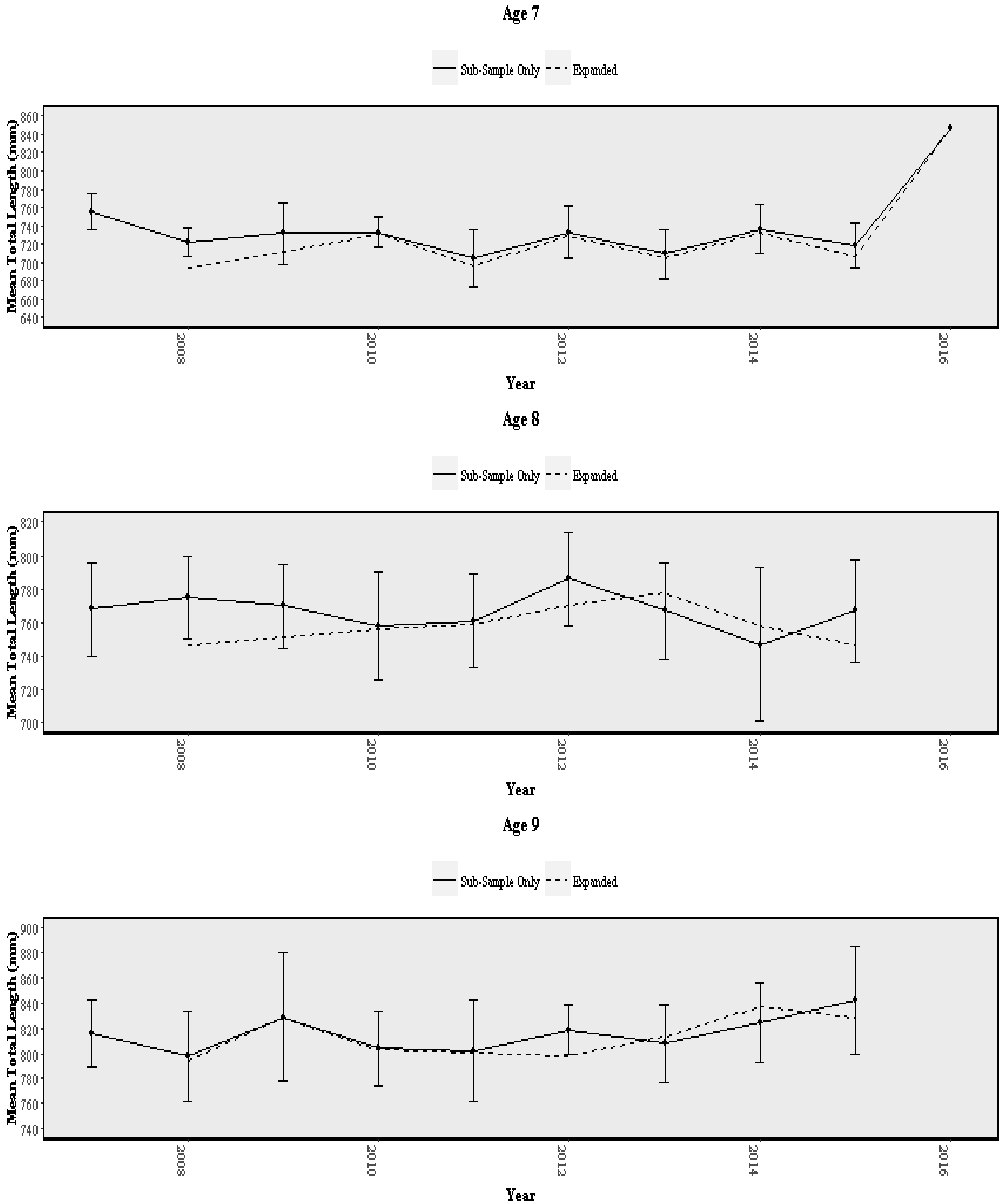

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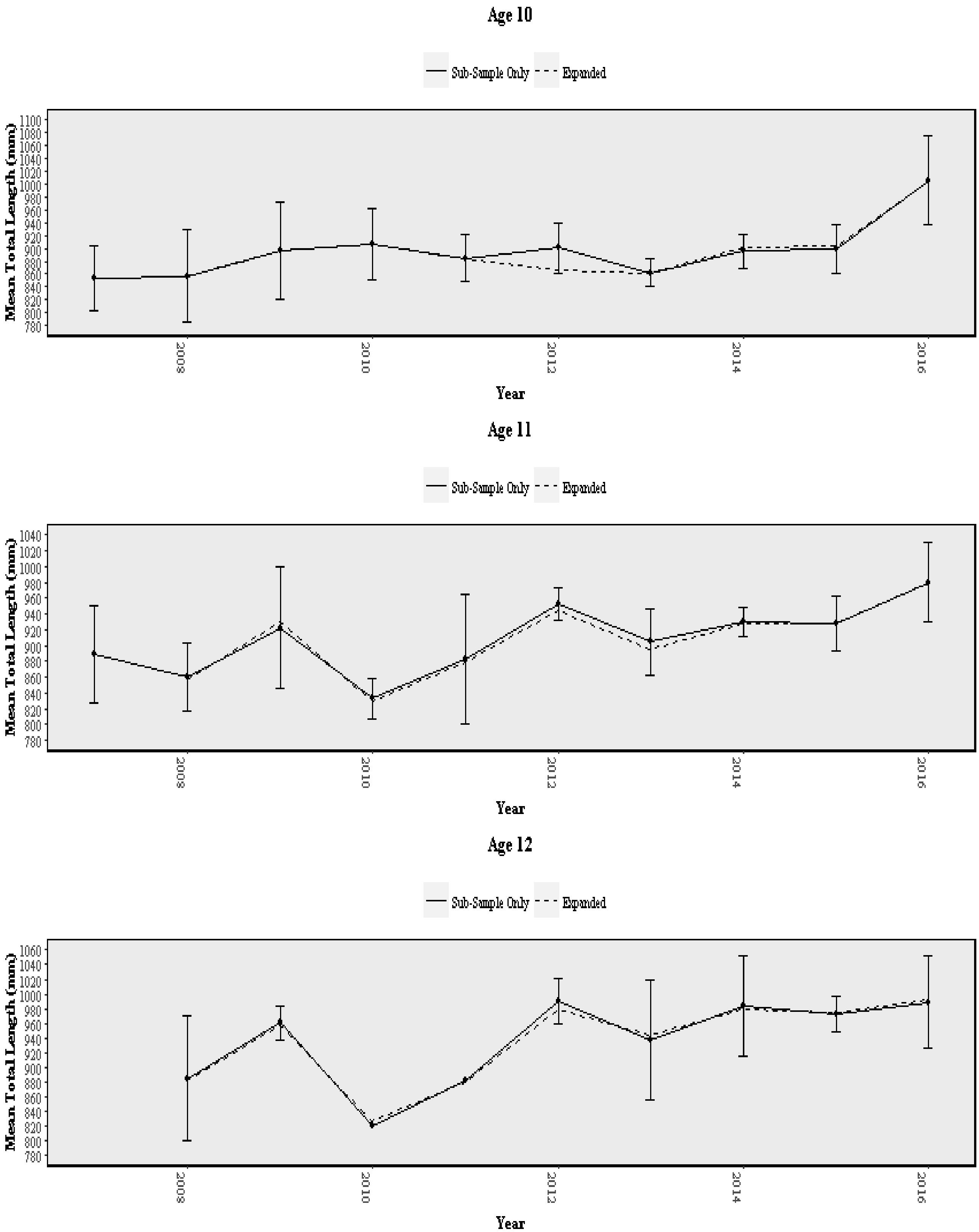
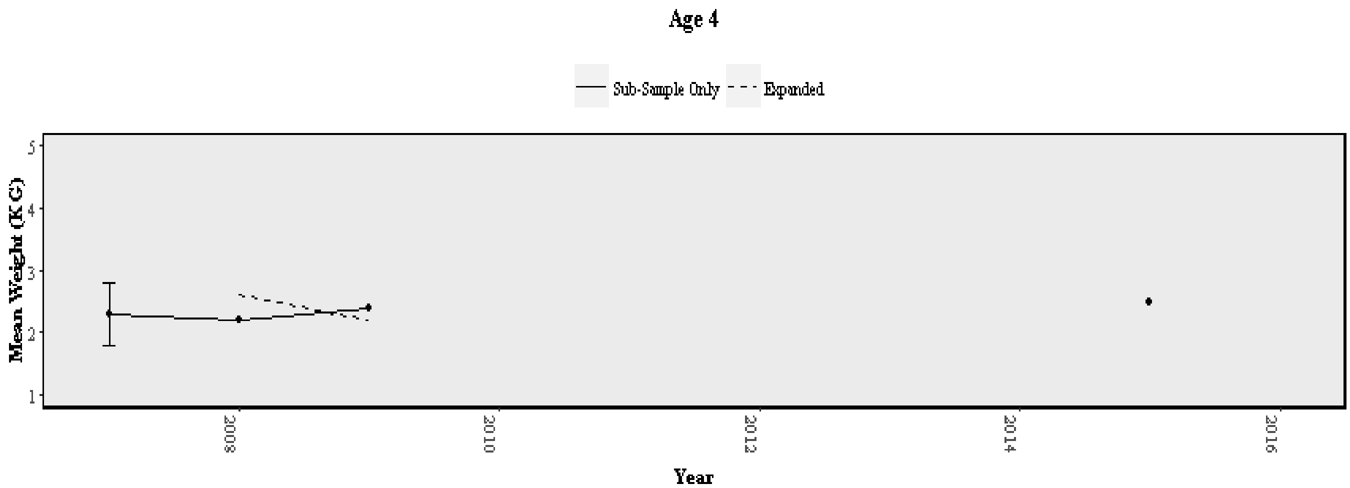


Figure 5. Mean weight (kg) of the aged sub-sample, by year, for individual age-classes of striped bass (through age 12) sampled from the Maryland Atlantic coast trawl and gill net landings, 2007-2016 (95% confidence intervals are shown around each point). Expanded means (estimated from entire sample) are also shown. *Note differences in scales on the y-axis.



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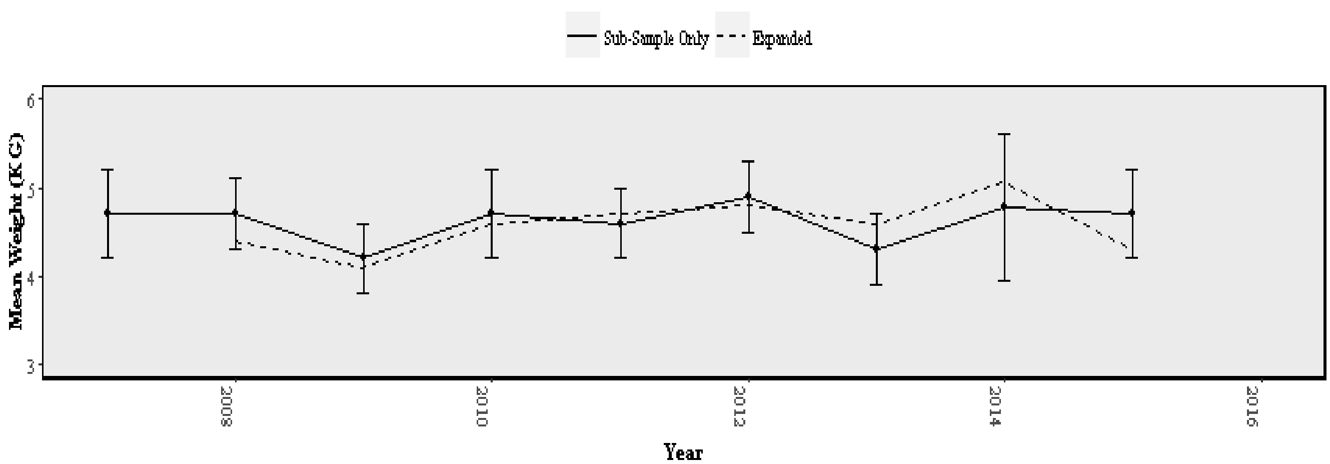
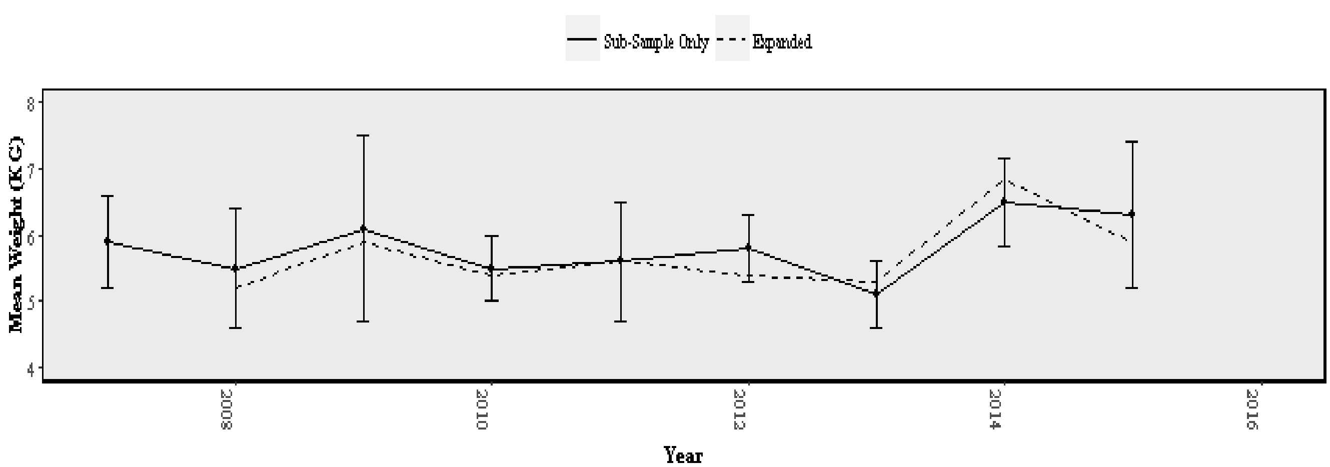
Age 7

Age 8



Age 9



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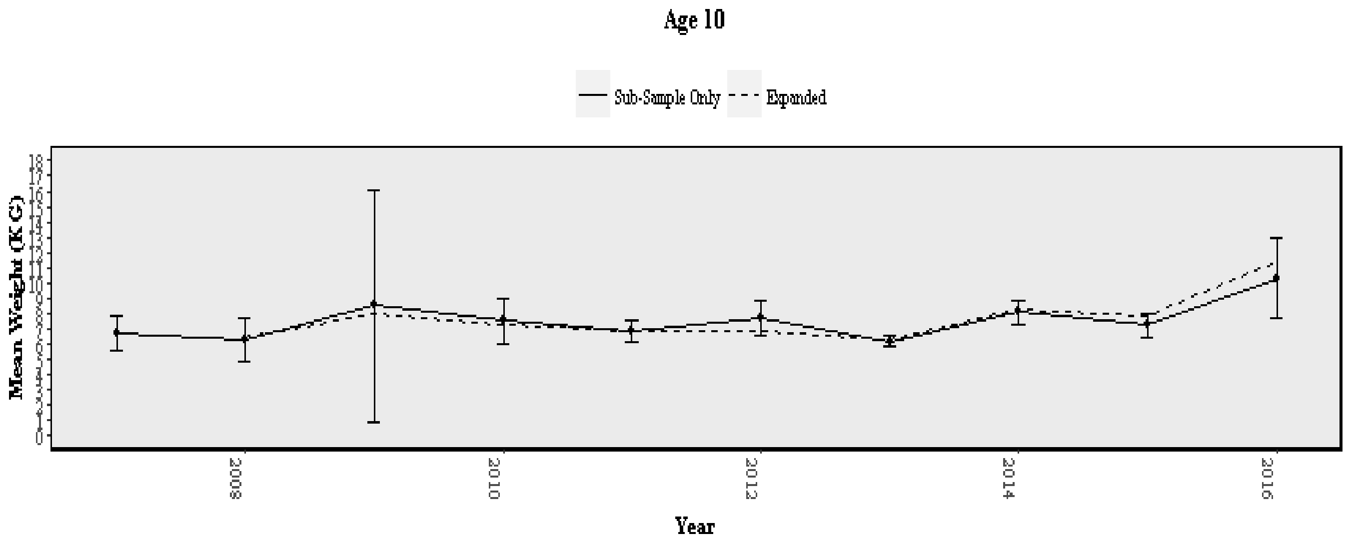

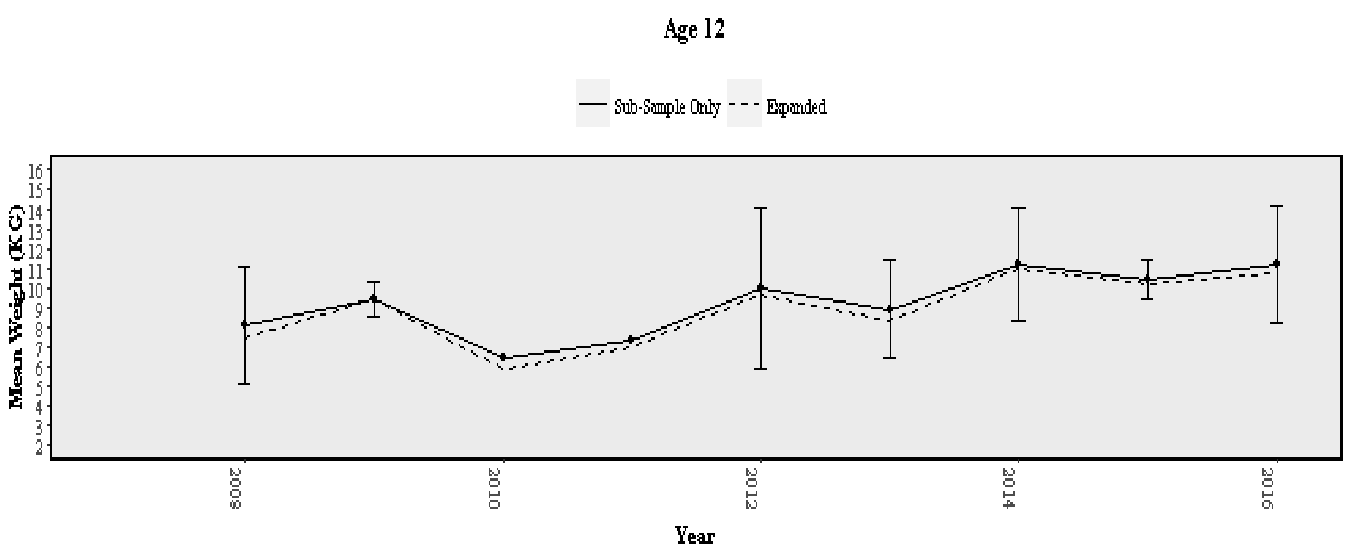

PROJECT NO. 2
JOB NO. 3
TASK NO. 2

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 2016 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 produce up to 90% of the Atlantic coastal stock (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 2016 (Figure 1). Gill nets were fished 6 days per week, weather permitting, in April and May. In the Potomac River, sampling was conducted from April 1 to May 14 for a total of 34 sample days. In the Upper Bay, sampling was conducted from April 4 to May 14 for a total of 30 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 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 159 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 2016 five additional scale samples from concurrent spring surveys were also used to fill gaps in the ALK in larger 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 612 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 2016 un-weighted CPUEs decreased for both sexes, in both systems, compared to 2015. The 2016 un-weighted CPUE for Potomac females (21) was below the series average of 26 (Table 2). The un-weighted CPUE for Potomac males (256) was also below average (428) and much lower than the near-record high value in 2015 (Table 3). The Upper Bay female CPUE (52) was above the time-series average (43) for the fifth consecutive year and ranked ninth in the 32 years of the survey (Table 4). The un-weighted CPUE for Upper Bay males (419) was slightly below the average of 455 (Table 5). The abundant 2011 year-class (age 5 fish) held the highest 2016 age-class CPUE values for both sexes, in both systems. The Choptank River has not been sampled since 1996, but the results are included here for the historical record (Tables 6 and 7).

Area- and sex-specific, weighted CPUE values were pooled for use in the annual coastwide striped bass stock assessment. These indices are presented in a time-series for ages one through 15+ (Table 8). The 2016 selectivity-corrected, total, weighted CPUE (396) ranked 26th in the 32 year survey, well below the time-series average of 493.

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 2016 age-specific

CPUEs were all at or below 0.15 indicating a small variance in CPUE. Historically, 82% 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 un-weighted CPUEs by year-class, and those 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, comprising 41% of the total CPUE. Upper Bay fish dominated the total CPUE, making up 73% of the total. Males were most frequently encountered, composing 90% of the total CPUE. This again was due to the large contribution of the 2011 year-class males.

The 2011 year-class made the largest contributions to the male CPUE for each system (48% in the Upper Bay, 31% on the Potomac River). Older males were not frequently encountered. In the Potomac River, 90% of the male CPUE was made up of fish ages 5 and younger. Similarly in the Upper Bay, 79% of the male CPUE was from ages 5 and younger.

Historically the female contribution has been less than 10% to each system's CPUE. The female contribution in the Upper Bay CPUE was 11% and 8% to the Potomac CPUE. Female CPUEs were distributed across many year-classes in both systems, with the young, 5 year-old female fish from the 2011 year-class contributing the most to each system's female CPUE (25% in Potomac, 24% in Upper Bay). Age 13 females from the above-average 2003 year-class were the next largest contributor (15% of the female CPUE in both systems), followed by age 15+ (14% in Potomac, 12% in Upper Bay).

Temperature and catch patterns

Daily surface water temperature on the Potomac River was near 14°C at the start of the survey, then decreased to 10.7°C by April 11. The water slowly warmed to 17.8°C on April 27, and remained fairly constant through the survey's end. Female CPUE showed one large peak on April 12, just after the lowest recorded temperature, then remained low but steady for the remainder of sampling (Figure 2). Several large peaks in male CPUE were observed during the second half of 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 11.1°C, then decreased to a low of 8.9°C on April 6. The water temperature increased slowly to a peak of 18.5°C on April 27, then remained near 16°C through the end of the survey. The highest catch of females and second highest catch of males occurred on April 27, coinciding with the highest observed water temperature (Figure 3). Daily female and male CPUEs were generally higher in April as the water warmed, but the largest peak in male CPUE occurred in the second week of May.

Length composition of the stock

In 2016, 1,767 male and 170 female striped bass were measured. On the Potomac River, 444 male and 46 female striped bass were measured; 1,322 males and 124 females were measured from the Upper Bay (Figure 4). The mean length of female striped bass (934 ± 29 mm TL) was significantly larger than the mean length of male striped bass (507 ± 6 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 (463 ± 11 mm TL) and Upper Bay (522 ± 7 mm TL) were significantly different ($P<0.0001$). The higher catches of small fish on the Potomac River are evident in the length distributions of male fish (Figure 4).

Male striped bass on the Potomac ranged from 272 to 956 mm TL. Males between 310 and 510 mm TL composed 75% of the Potomac River male catch in 2016, representing fish from the 2014, 2013 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 490 mm TL (Figure 5).

Male striped bass on the Upper Bay ranged from 292 to 1084 mm TL, with a peak in the length frequency between 430-510 mm TL (59% of catch; Figure 4). Male CPUE in the Upper Bay was dominated by these small fish, representing the 2011 year-class (Figure 5). The selectivity correction increased the contribution of the abundant age 5 fish in both systems because these fish were caught in a variety of mesh sizes, including some with a low selectivity for their size.

Female striped bass sampled from the Potomac River and Upper Bay in 2016 were not significantly different in mean total length (P=0.694). Female striped bass sampled from the Potomac ranged from 485 to 1189 mm TL (mean=924 ± 57 mm TL), while females sampled in the Upper Bay ranged from 490 to 1218 mm TL (mean=937 ± 34 mm TL; Figure 4). The peaks in both systems between 970 and 1070 mm TL likely represent the 2003 year-class.

Female CPUE in the Potomac River was low, and distributed over several length groups (Figure 6). The largest selectivity corrected peaks at 710 and 1110 mm TL 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, corrected and uncorrected 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 peak in the uncorrected CPUE from 990 to 1150 mm TL represented the above-average 2005 and 2003 year-classes. The largest selectivity corrected peak at 710 mm TL resulted from one fish caught in a mesh that had a low selectivity for its size group.

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 2016 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 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 2016 ($\alpha > 0.05$). Age 7 female fish were significantly shorter on the Potomac River (715 mm TL) than the Upper Bay (770 mm TL, P=0.026). Age 12 females were significantly shorter on the Potomac River (972 mm TL) than the Upper Bay (1025 mm TL, P=0.04). In both instances, sample sizes of the Potomac fish were small. Lengths-at-age for male fish were statistically similar between the two areas.

Mean lengths-at-age were compared between years for each sex, areas combined (ANOVA, α=0.05). Male and female LAA has been relatively stable since the mid-1990s

(Figures 7 and 8). Mean lengths of males were similar in 2015 and 2016 for all ages except for age 3 (P=0.002), age 5 (P=0.0004) and age 6 (P=0.013). Age 5 males in 2016 were from the above average 2011 year-class, and their mean length was significantly shorter than 5 year old fish in 2015. This could be due to density dependent factors related to large year-classes. Mean lengths of females were similar in 2015 and 2016 for all ages except age 7 (P=0.003) and age 11 (P=0.01).

Age composition of the stock

Seventeen age-classes, ranging from 2 to 18 were encountered (Tables 14 and 15). Of the 282 male fish aged from the survey (Table 1), ages 5 and 6 (2011 and 2010 year-classes) were the most commonly encountered. On the Potomac River, the males encountered ranged from age 2 through 11, while on the Upper Bay, males ages 2 through 17 were captured. Females ranged in age from 5 to 18 in both systems. Of the 141 aged female scales (Table 1), age 13 (2003 year-class) was most commonly observed. Young females from the dominant 2011 year-class began to contribute to the spawning stock.

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 2015, most of the age-specific CPUEs for 2016 decreased, except for ages 2, 3, 5 and 13 (2014, 2013, 2011 and 2003 year-classes, respectively). The contribution of the 15+ age group has been strong over the last seven years (Figure 9).

The contribution of age 8+ females to the total female CPUE decreased sharply to 61% (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 and 2016. Some decline is expected based on the results of the most recent coastwide stock assessment update, which showed that female spawning stock biomass has been declining coastwide (ASMFC 2016). The large numbers of age 5 females encountered during the 2016 survey likely contributed to the decrease this year.

The percentage of the overall sample (males and females combined) age 8 and older has been variable since 1997 (Figure 11). The 2016 value decreased to 14%, after a time-series high of 41% in 2012. The percentage of age 8+ fish is heavily influenced by strong year-classes and shows cyclical variations (Figure 9). The decline in age 8+ fish this year was due to the high number of young fish (from the 2014, 2013, 2011 and 2010 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 previous four years. The 2016 ISP value of 414 was well below the high values of the previous four years, but still above the time-series average of 352 (Table 16, Figure 12). The Potomac River female ISP increased from 2011 to 2015, but decreased to 165 in 2016. This was below the time-series average of 229.

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

CHARACTERIZATION OF STRIPED BASS SPAWNING STOCKS IN MARYLAND

2017 PRELIMINARY RESULTS

Data collected during the 2017 spring spawning season are currently being analyzed. In the Potomac River in 2017, 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.

Scale samples are currently being processed and aged, therefore no CPUE estimates are available at this time. A total of 1,078 scales were collected for use in creating the sex-specific ALKs. In the Potomac River, a total of 919 striped bass were sampled, 847 males and 72 females. Of those 919 fish, 392 (43%) were tagged with U. S. Fish and Wildlife Service internal anchor tags. In the Upper Bay, at total of 1,761 striped bass were captured, 1,619 males and 142 females. Of the 1,761 fish encountered, 1,123 (64%) were tagged.

Male striped bass on the Potomac ranged from 235 to 1080 mm TL, with a mean of 514 mm TL. Male striped bass on the Upper Bay ranged from 249 to 1094 mm TL, with a mean of 511 mmd TL. Female striped bass sampled from the Potomac ranged from 500 to 1185 mm TL, with a mean of 996 mm TL. Upper Bay female striped bass ranged from 481 to 1226 mm TL, and had a mean of 933 mm TL.

The final, complete analyses of the spring 2017 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**
290	3	2	0	**5**	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	3	0	**6**	0	0	0	0	**0**
430	3	4	0	**7**	0	0	0	0	**0**
450	5	1	0	**6**	0	0	0	0	**0**
470	3	5	0	**8**	0	0	0	0	**0**
490	3	2	0	**5**	3	1	0	1	**5**
510	4	3	2	**9**	4	0	6	0	**10**
530	2	3	2	**7**	2	0	12	0	**14**
550	3	3	2	**8**	1	1	6	1	**9**
570	5	5	1	**11**	0	2	7	0	**9**
590	6	7	1	**14**	2	2	5	0	**9**
610	6	3	3	**12**	3	0	3	1	**7**
630	4	5	3	**12**	1	0	1	1	**3**
650	4	5	2	**11**	1	1	0	0	**2**
670	5	5	4	**14**	1	1	2	0	**4**
690	6	5	4	**15**	0	0	1	1	**2**
710	6	6	1	**13**	1	1	1	0	**3**
730	12	0	3	**15**	1	0	1	0	**2**
750	12	2	1	**15**	3	1	2	0	**6**
770	9	2	6	**17**	3	2	1	0	**6**
790	7	1	0	**8**	3	1	2	0	**6**
810	6	0	3	**9**	0	0	1	0	**1**
830	5	0	0	**5**	2	0	3	0	**5**
850	4	0	0	**4**	1	0	2	0	**3**
870	4	2	0	**6**	2	0	4	0	**6**
890	2	0	0	**2**	0	0	3	0	**3**
910	6	0	1	**7**	0	3	7	0	**10**
930	6	2	2	**10**	1	1	7	0	**9**
950	10	1	2	**13**	3	0	12	0	**15**
970	5	0	3	**8**	8	0	7	0	**15**
990	7	0	2	**9**	5	5	5	0	**15**
1010	3	0	0	**3**	5	5	5	0	**15**
1030	4	0	0	**4**	8	4	7	0	**19**
1050	0	0	0	**0**	7	1	3	0	**11**
1070	2	0	0	**2**	7	3	6	0	**16**
1090	1	0	0	**1**	5	0	7	0	**12**
1110	0	0	0	**0**	7	1	5	0	**13**
1130	0	0	0	**0**	1	2	1	0	**4**
1150	0	0	0	**0**	2	2	0	0	**4**
1170	0	0	0	**0**	2	0	1	0	**3**
1190	0	0	0	**0**	2	1	0	0	**3**
1210	0	0	0	**0**	3	0	0	0	**3**
Total	**191**	**91**	**48**	**330**	**100**	**41**	**136**	**5**	**282**

Table 2. Estimates of selectivity-corrected age-class CPUE by year for female striped bass captured in the Potomac River during the 1985-2016 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**
Average																**26**

Table 3. Estimates of selectivity-corrected age-class CPUE by year for male striped bass captured in the Potomac River during the 1985-2016 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**
Average																**428**

Table 4. Estimates of selectivity-corrected age-class CPUE by year for female striped bass captured in the Upper Bay during the 1985-2016 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**
Average																**43**

Table 5. Estimates of selectivity-corrected age-class CPUE by year for male striped bass captured in the Upper Bay during the 1985-2016 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**
Average																**455**

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 (1985–2016) 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**
Average																**493**

Table 9. Lower confidence limits (95%) of the annual, pooled, weighted, age-specific CPUEs (1985–2016) 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	*

* 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 (1985–2016) 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	*

* 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 (1985–2016) 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	*

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

Table 12. Un-weighted striped bass catch per unit effort (CPUE) by year-class, April through May 2016. 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
2015	1	0.0	0.0	0.0	0.0	0.0	0.0
2014	2	134.9	18.0	0.0	0.0	71.0	63.9
2013	3	112.2	15.0	0.0	0.0	66.5	45.7
2012	4	34.7	4.6	0.0	0.1	11.9	22.7
2011	5	297.9	39.8	5.2	12.5	79.8	200.3
2010	6	44.0	5.9	2.3	3.9	11.1	26.7
2009	7	28.5	3.8	1.5	3.3	6.7	17.0
2008	8	8.7	1.2	0.4	2.1	1.6	4.6
2007	9	10.9	1.5	0.8	3.5	1.4	5.1
2006	10	9.4	1.3	0.6	1.5	1.2	6.1
2005	11	16.8	2.3	1.8	4.9	2.6	7.5
2004	12	14.0	1.9	1.9	4.8	1.1	6.2
2003	13	16.6	2.2	3.1	7.9	0.6	4.9
2002	14	2.1	0.3	0.6	1.2	0.0	0.3
≤2001	15+	17.2	2.3	2.8	6.2	0.2	8.0
Total		747.7		21.0	51.7	255.8	419.1
% of Total				2.8	6.9	34.2	56.1
% of Sex				28.9	71.1	37.9	62.1
% of System				7.6	11.0	92.4	89.0

Table 13. Striped bass catch per unit effort (CPUE) by year-class, weighted by spawning area*, April through May 2016. 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
2015	1	0.0	0.0	0.0	0.0	0.0	0.0
2014	2	66.6	16.8	0.0	0.0	27.4	39.3
2013	3	53.7	13.6	0.0	0.0	25.6	28.1
2012	4	18.6	4.7	0.0	0.1	4.6	13.9
2011	5	163.6	41.3	2.0	7.7	30.7	123.1
2010	6	24.0	6.1	0.9	2.4	4.3	16.4
2009	7	15.6	3.9	0.6	2.0	2.6	10.5
2008	8	4.9	1.2	0.1	1.3	0.6	2.8
2007	9	6.2	1.6	0.3	2.1	0.5	3.2
2006	10	5.4	1.4	0.2	0.9	0.5	3.8
2005	11	9.3	2.4	0.7	3.0	1.0	4.6
2004	12	7.9	2.0	0.7	2.9	0.4	3.8
2003	13	9.3	2.4	1.2	4.8	0.2	3.0
2002	14	1.1	0.3	0.2	0.7	0.0	0.2
≤2001	15+	9.9	2.5	1.1	3.8	0.1	4.9
Total		396.1		8.1	31.8	98.6	257.6
% of Total				2.0	8.0	24.9	65.0
% of Sex				20.3	79.7	27.7	72.3
% of System				7.6	11.0	92.4	89.0

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

Table 14. Mean length-at-age (mm TL) statistics for male striped bass collected in the Potomac River and the Upper Bay, and areas combined, April through May 2016.

YEAR-CLASS	AGE	AREA	N	MEAN	LCL	UCL	SD	SE
2014	2	POTOMAC	10	330	309	351	29	9
		UPPER	9	322	301	343	27	9
		COMBINED	19	326	313	340	28	6
2013	3	POTOMAC	11	402	371	432	46	14
		UPPER	9	367	336	397	40	13
		COMBINED	20	386	365	407	46	10
2012	4	POTOMAC	4	485	394	576	57	29
		UPPER	1	379	-	-	-	-
		COMBINED	5	464	379	549	68	31
2011	5	POTOMAC	23	534	505	562	66	14
		UPPER	29	500	475	526	67	12
		COMBINED	52	515	496	534	68	9
2010	6	POTOMAC	22	631	612	650	42	9
		UPPER	19	646	617	674	60	14
		COMBINED	41	638	622	654	51	8
2009	7	POTOMAC	10	692	671	713	29	9
		UPPER	28	695	664	726	80	15
		COMBINED	38	694	671	717	70	11
2008	8	POTOMAC	1	716	-	-	-	-
		UPPER	12	745	709	781	57	16
		COMBINED	13	742	709	776	55	15
2007	9	POTOMAC	5	777	704	851	59	26
		UPPER	9	765	714	815	66	22
		COMBINED	14	769	734	805	62	16
2006	10	POTOMAC	2	831	*	*	*	*
		UPPER	20	825	793	858	69	15
		COMBINED	22	826	796	855	67	14
2005	11	POTOMAC	3	937	895	979	17	10
		UPPER	19	855	812	898	89	20
		COMBINED	22	866	827	905	87	19
2004	12	POTOMAC	0	-	-	-	-	-
		UPPER	16	922	886	958	68	17
		COMBINED	16	922	886	958	68	17
2003	13	POTOMAC	0	-	-	-	-	-
		UPPER	14	983	961	1004	37	10
		COMBINED	14	983	961	1004	37	10
2002	14	POTOMAC	0	-	-	-	-	-
		UPPER	1	1027	-	-	-	-
		COMBINED	1	1027	-	-	-	-
2001	15	POTOMAC	0	-	-	-	-	-
		UPPER	4	1023	920	1125	65	32
		COMBINED	4	1023	920	1125	65	32
1999	17	POTOMAC	0	-	-	-	-	-
		UPPER	1	1084	-	-	-	-
		COMBINED	1	1084	-	-	-	-

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

Table 15. Mean length-at-age (mm TL) statistics for female striped bass collected in the Potomac River and the Upper Bay, and areas combined, April through May 2016.

YEAR-CLASS	AGE	AREA	N	MEAN	LCL	UCL	SD	SE
2011	5	POTOMAC	4	576	469	683	67	34
		UPPER	14	559	524	593	60	16
		COMBINED	18	563	533	592	60	14
2010	6	POTOMAC	6	649	547	751	97	40
		UPPER	7	641	553	730	96	36
		COMBINED	13	645	589	701	93	26
2009	7	POTOMAC	1	715	-	-	-	-
		UPPER	5	770	752	788	15	7
		COMBINED	6	761	734	789	26	11
2008	8	POTOMAC	1	786	-	-	-	-
		UPPER	3	770	729	811	17	10
		COMBINED	4	774	749	799	16	8
2007	9	POTOMAC	2	870	*	*	*	*
		UPPER	5	866	801	930	52	23
		COMBINED	7	867	790	944	83	31
2006	10	POTOMAC	3	966	847	1085	48	28
		UPPER	4	967	846	1089	76	38
		COMBINED	7	967	911	1023	61	23
2005	11	POTOMAC	7	1018	969	1067	53	20
		UPPER	8	1031	984	1078	56	20
		COMBINED	15	1025	995	1055	53	14
2004	12	POTOMAC	3	972	859	1085	46	26
		UPPER	16	1025	1006	1045	37	9
		COMBINED	19	1017	997	1037	42	10
2003	13	POTOMAC	9	1029	983	1075	60	20
		UPPER	23	1051	1024	1077	61	13
		COMBINED	32	1045	1023	1067	61	11
2002	14	POTOMAC	0	-	-	-	-	-
		UPPER	4	1068	950	1186	74	37
		COMBINED	4	1068	950	1186	74	37
2001	15	POTOMAC	4	1142	1090	1193	33	16
		UPPER	8	1133	1073	1193	72	26
		COMBINED	12	1136	1098	1174	60	17
2000	16	POTOMAC	0	-	-	-	-	-
		UPPER	2	1161	582	1739	64	46
		COMBINED	2	1161	582	1739	64	46
1998	18	POTOMAC	1	1160	-	-	-	-
		UPPER	1	1218	-	-	-	-
		COMBINED	2	1189	821	1557	41	29

* 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
Average	**352**	**229**

Figure 1. Drift gill net sampling locations in spawning areas of the Upper Chesapeake Bay and the Potomac River, April - May 2016.

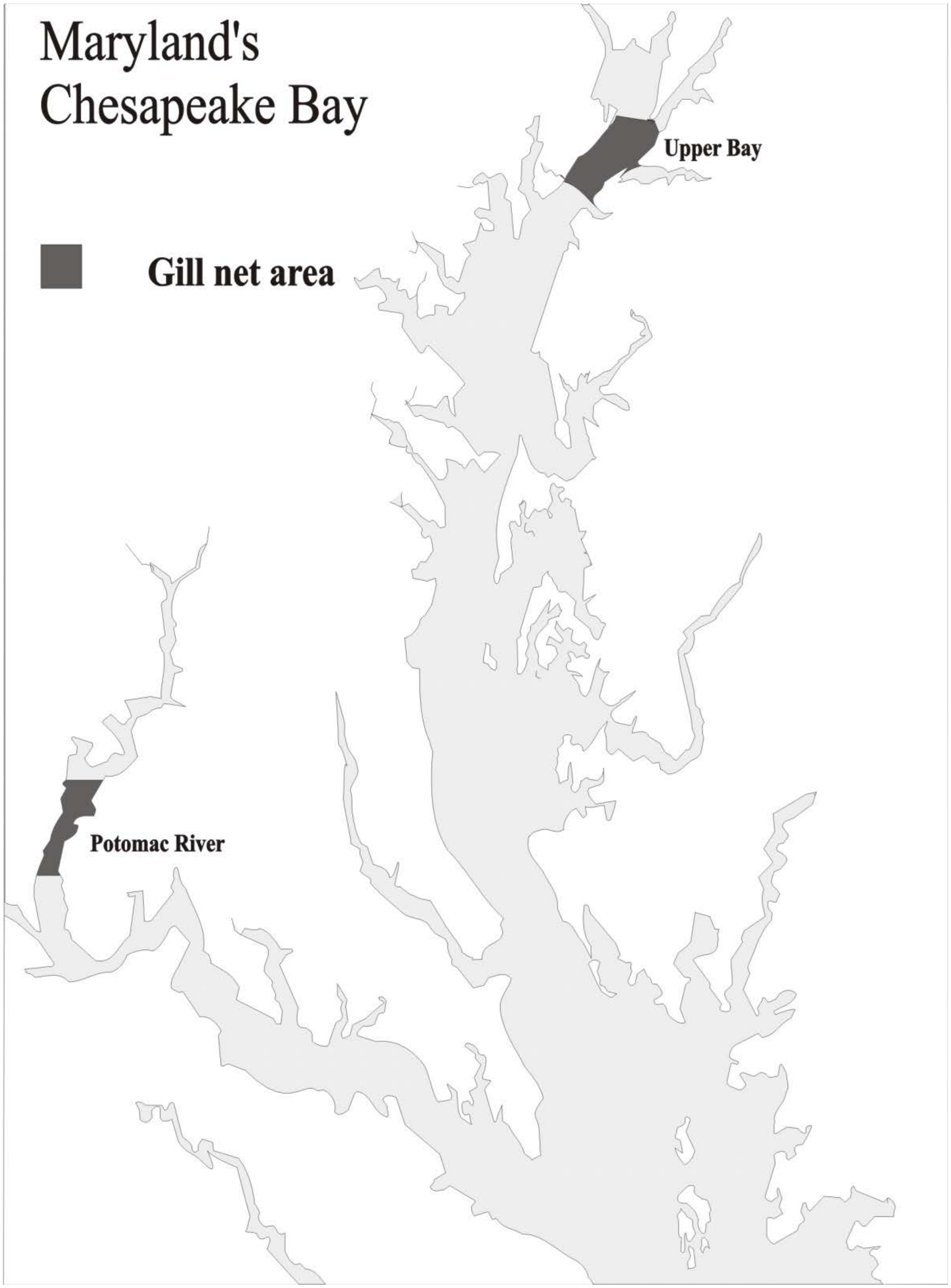
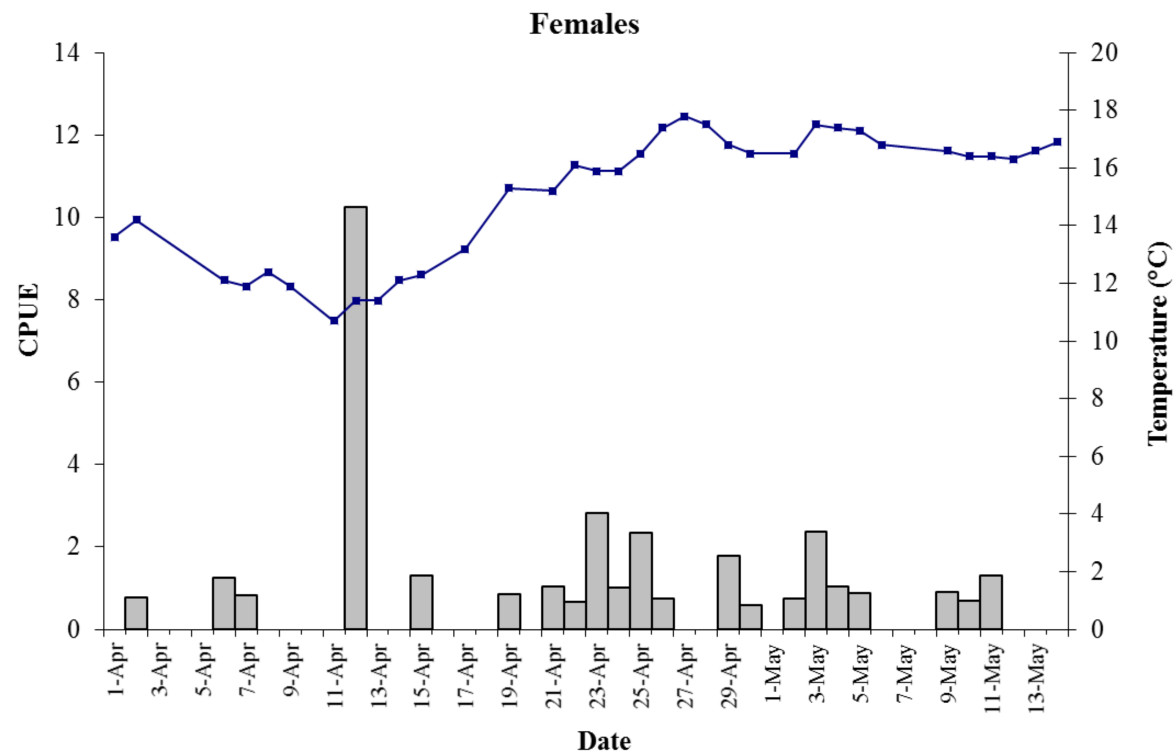


Figure 2. Daily effort-corrected catch of female and male striped bass, with surface water temperature in the spawning reach of the Potomac River, April through May 2016. Effort is standardized as 1000 square yards of experimental gill net per hour. Note different scales.



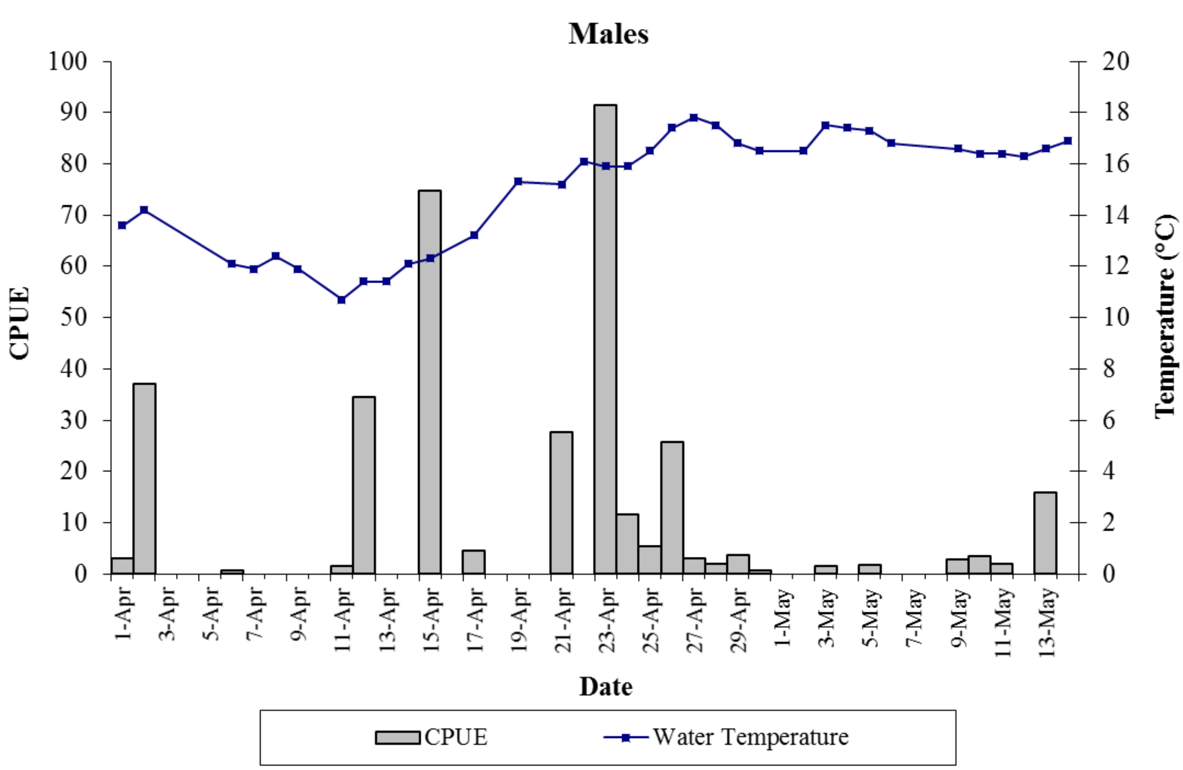


Figure 3. Daily effort-corrected catch of female and male striped bass, with surface water temperature in the spawning reach of the Upper Chesapeake Bay, April through May 2016. Effort is standardized as 1000 square yards of experimental drift gill net per hour. Note different scales.

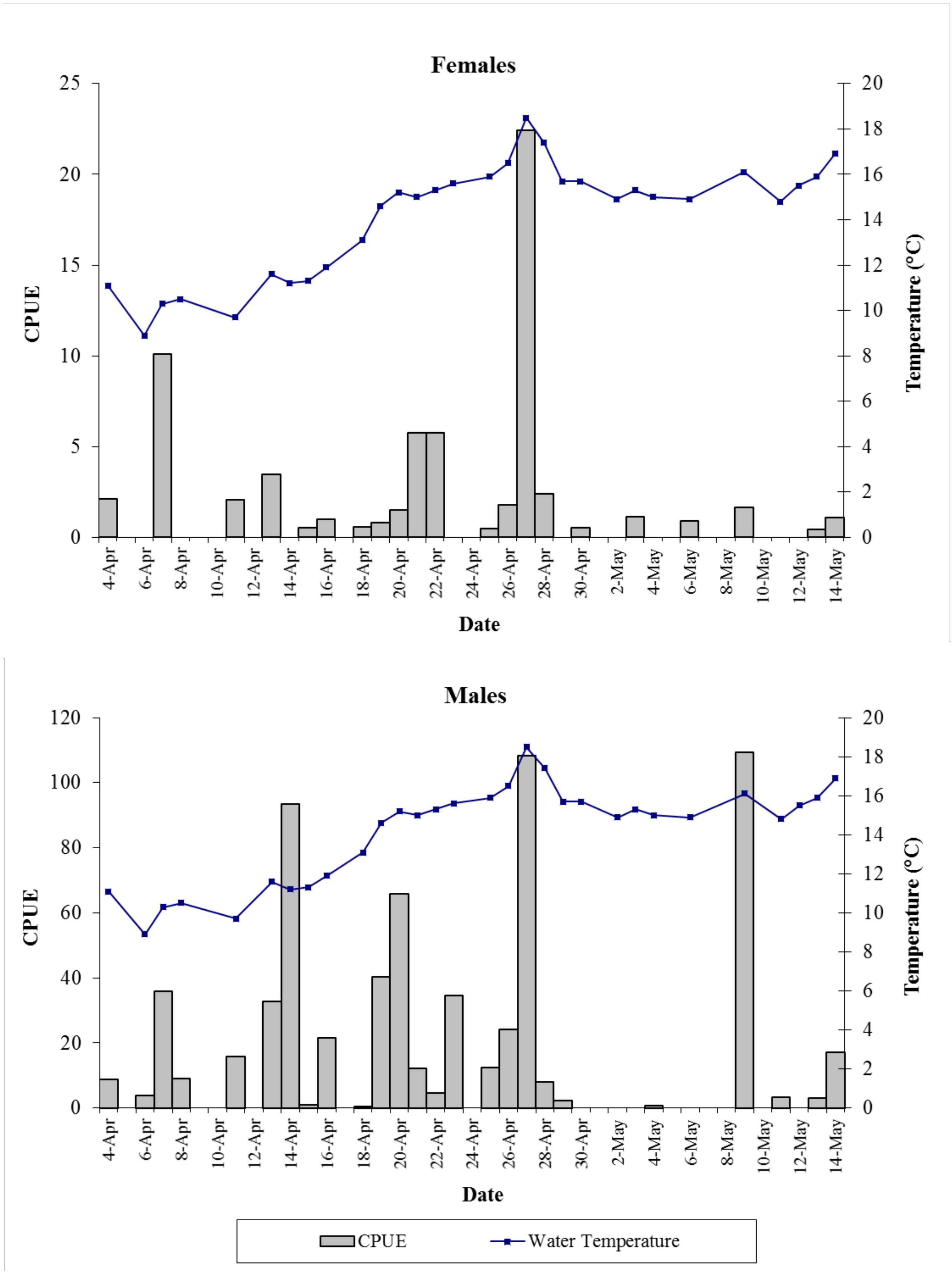
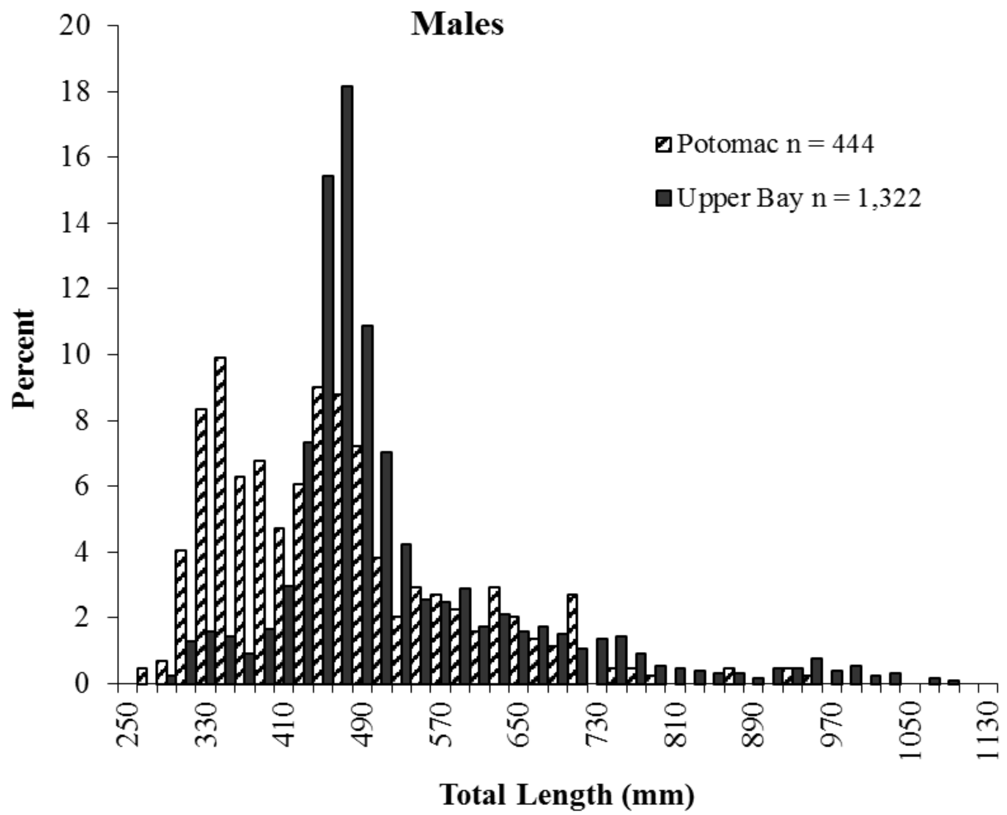


Figure 4. Length frequency of male and female striped bass from the spawning areas of the Upper Chesapeake Bay and Potomac River, April through May 2016. Note different x-axis scale.



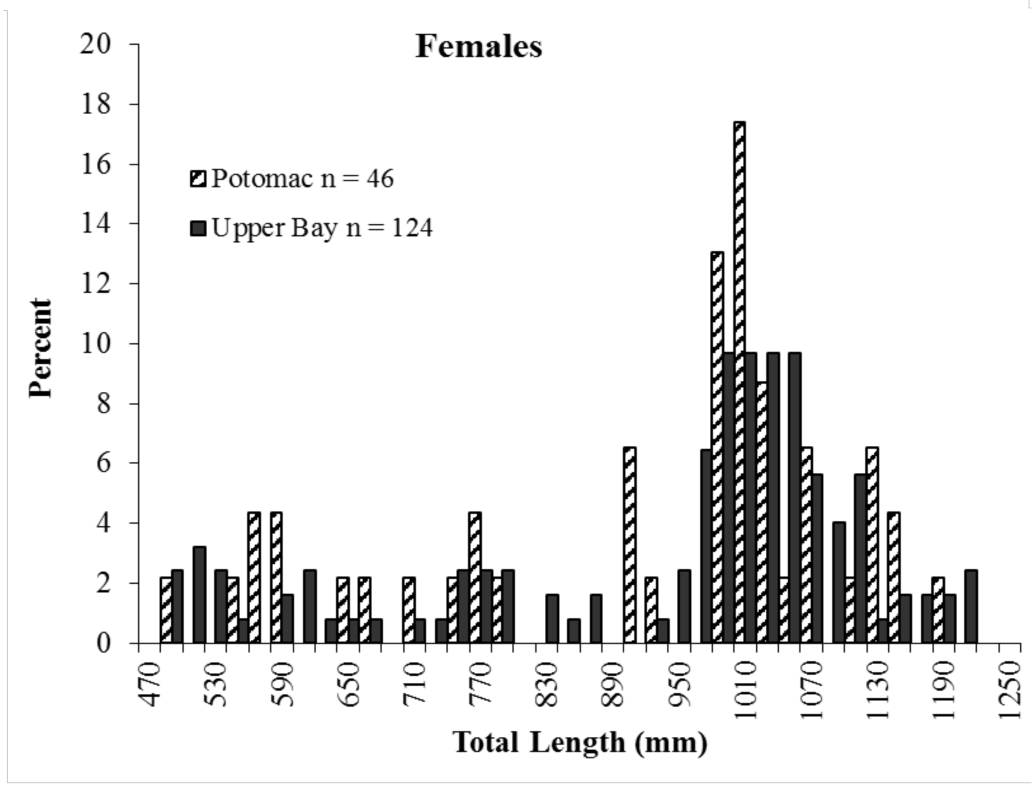
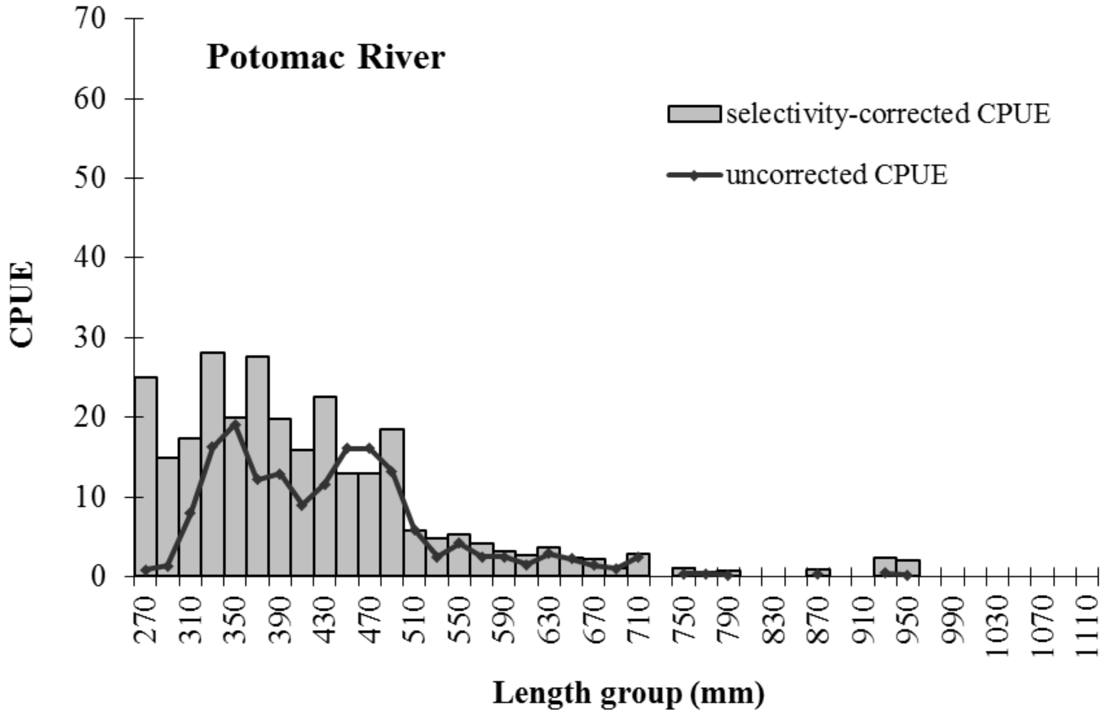


Figure 5. Length group CPUE (uncorrected and corrected for gear selectivity) of male striped bass collected from spawning areas of the Upper Bay and Potomac River, April - May 2016. CPUE is the number of fish captured per hour in 1000 square yards of experimental drift net.



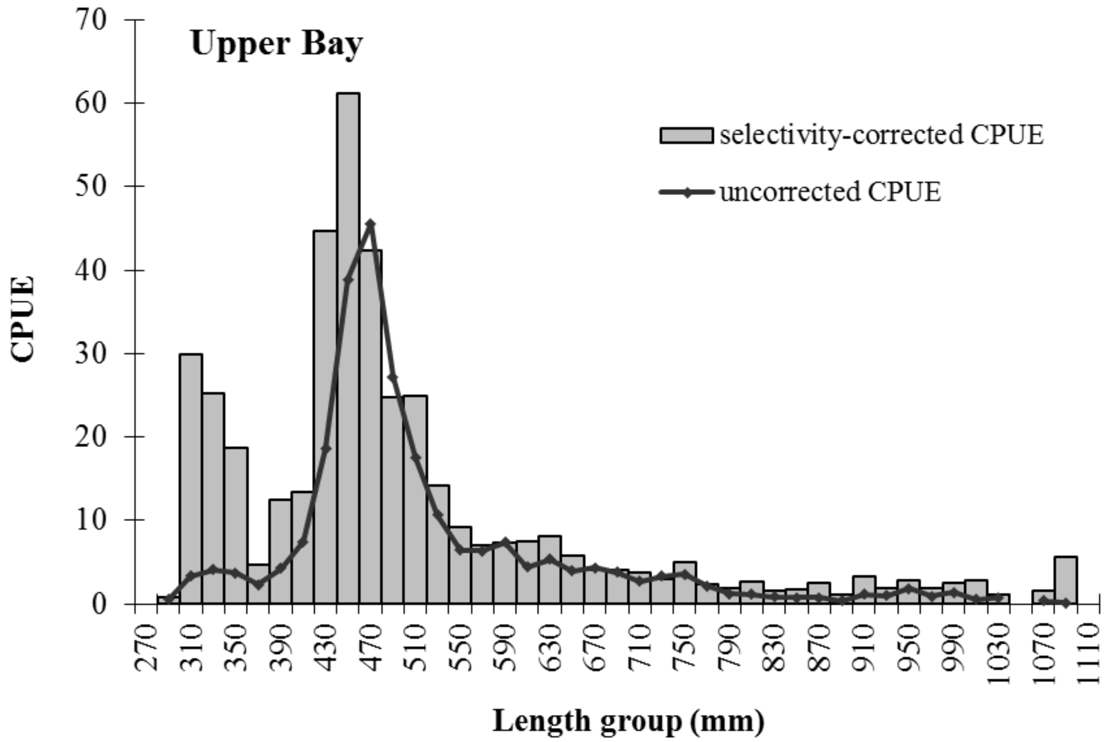
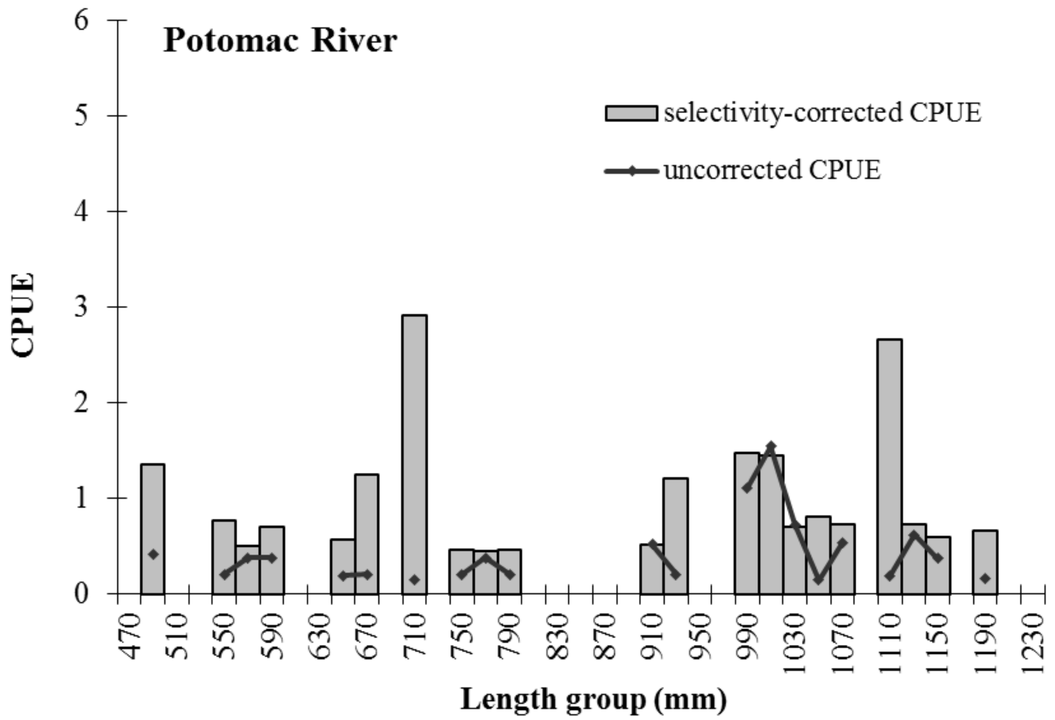


Figure 6. Length group CPUE (uncorrected and corrected for gear selectivity) of female striped bass collected from spawning areas of the Upper Bay and Potomac River, April - May 2016. CPUE is the number of fish captured per hour in 1000 square yards of experimental drift net.



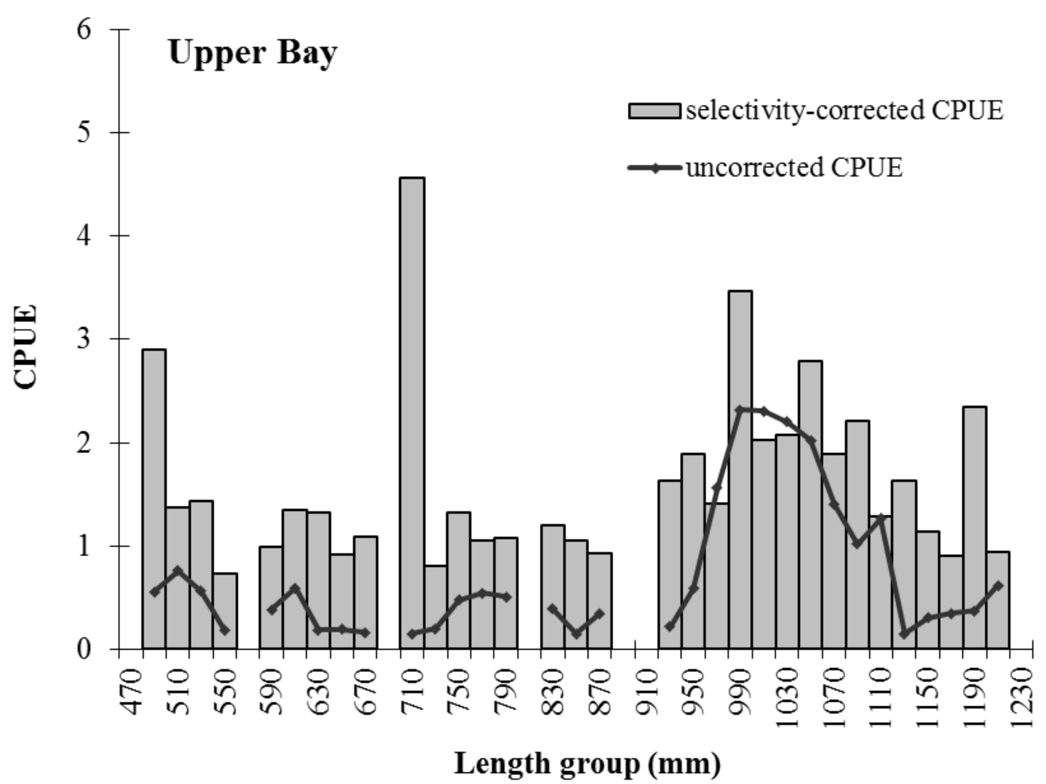


Figure 7. Mean length (mm TL) by year for individual ages of male striped bass sampled from spawning areas of the Potomac River and Upper Chesapeake Bay during April through May, 1985-2016. Error bars are ± 2 standard errors (SE). The Potomac River was not sampled in 1994. *Note difference in scales on y-axis.

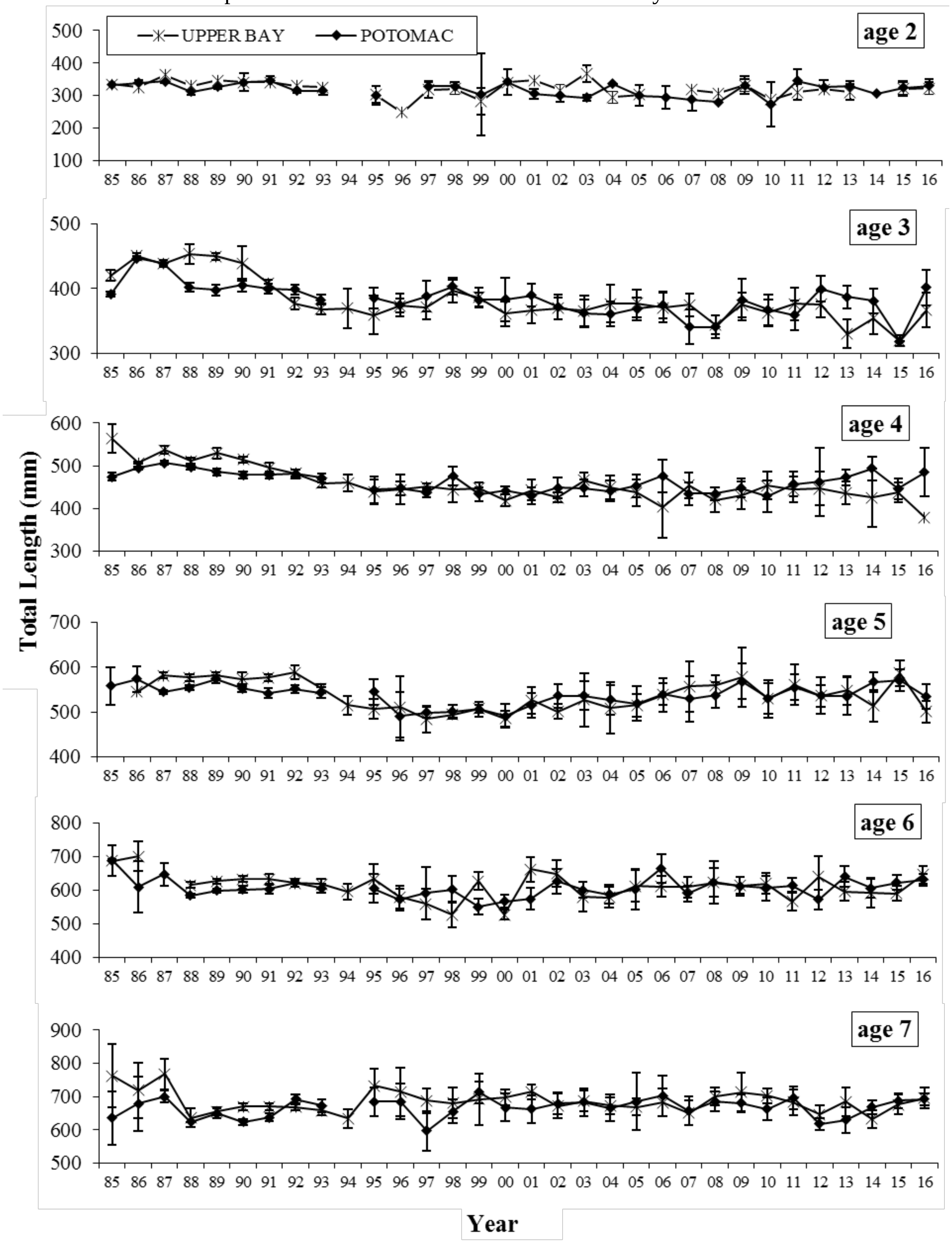


Figure 7. Continued.

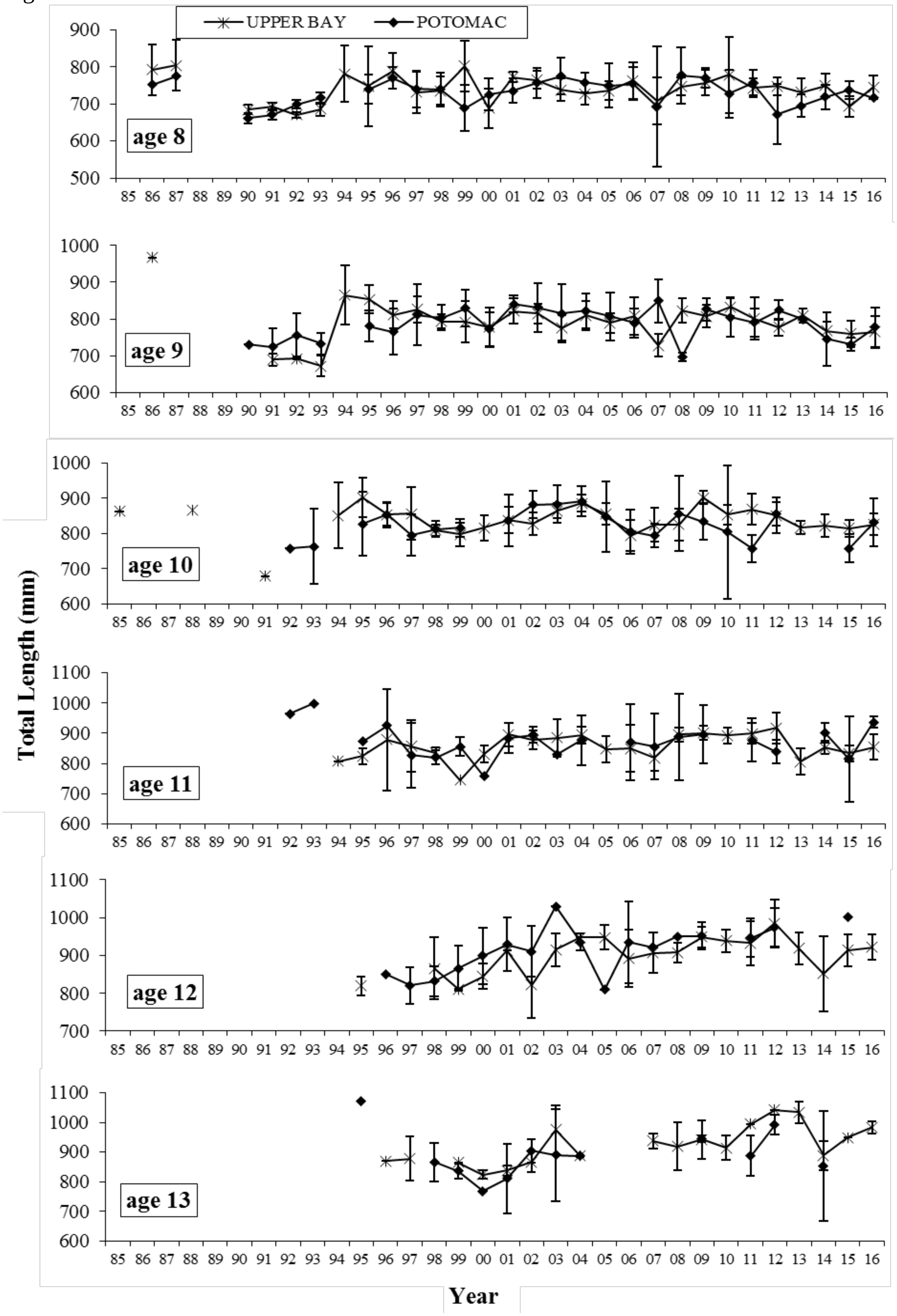


Figure 8. Mean length (mm TL) by year for individual ages of female striped bass sampled from spawning areas of the Potomac River and Upper Chesapeake Bay during April through May, 1985–2016. Error bars are ± 2 standard errors (SE). Note the Potomac River was not sampled in 1994. *Note difference in scales on y-axis.

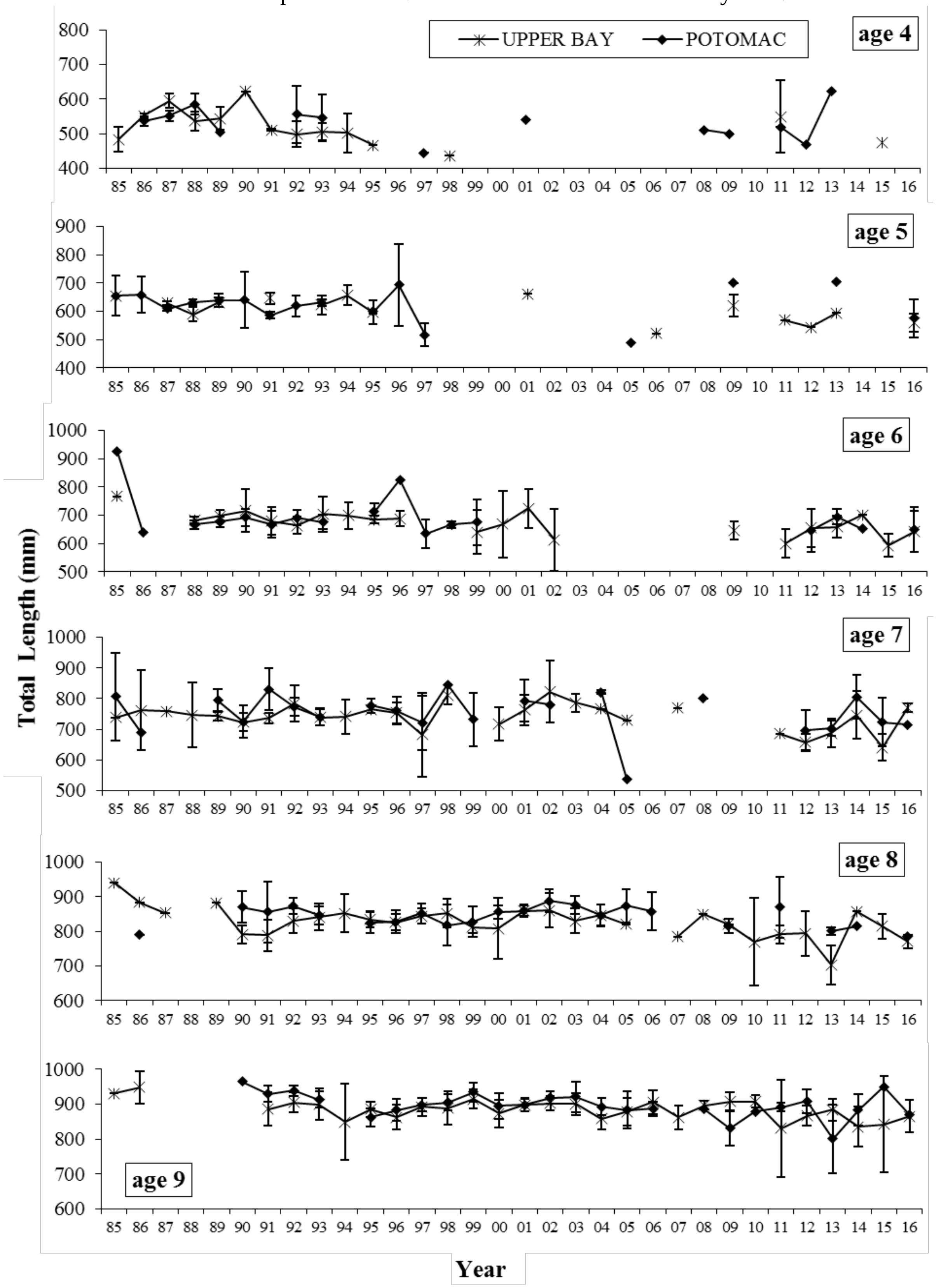


Figure 8. Continued.

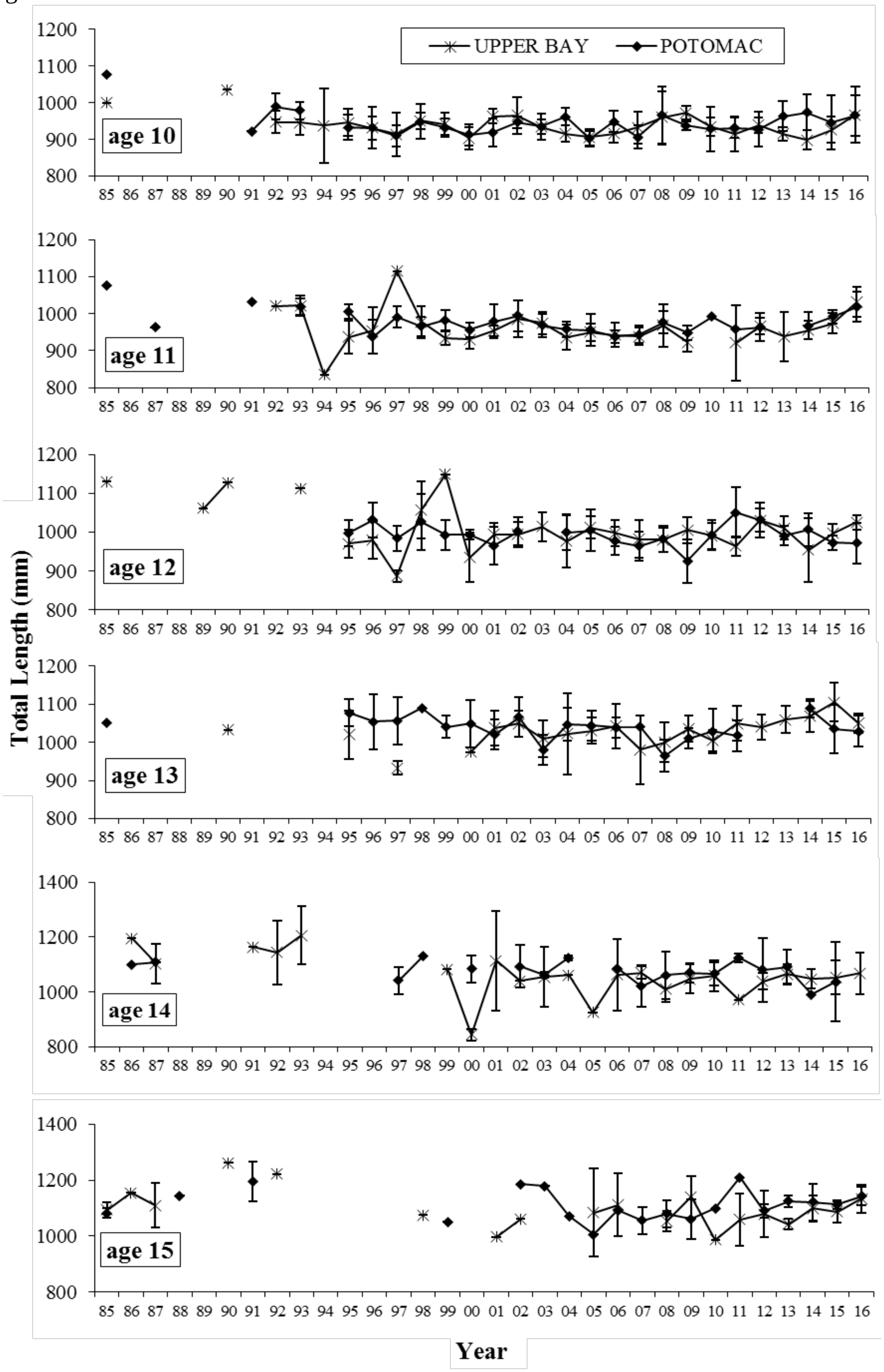


Figure 9. Maryland Chesapeake Bay spawning stock indices used in the coastal assessment. These are selectivity-corrected estimates of CPUE by year for ages 2 through 15+. Areas and sexes are pooled, although the contribution of sexes is shown in the stacked bars. Note different scales.

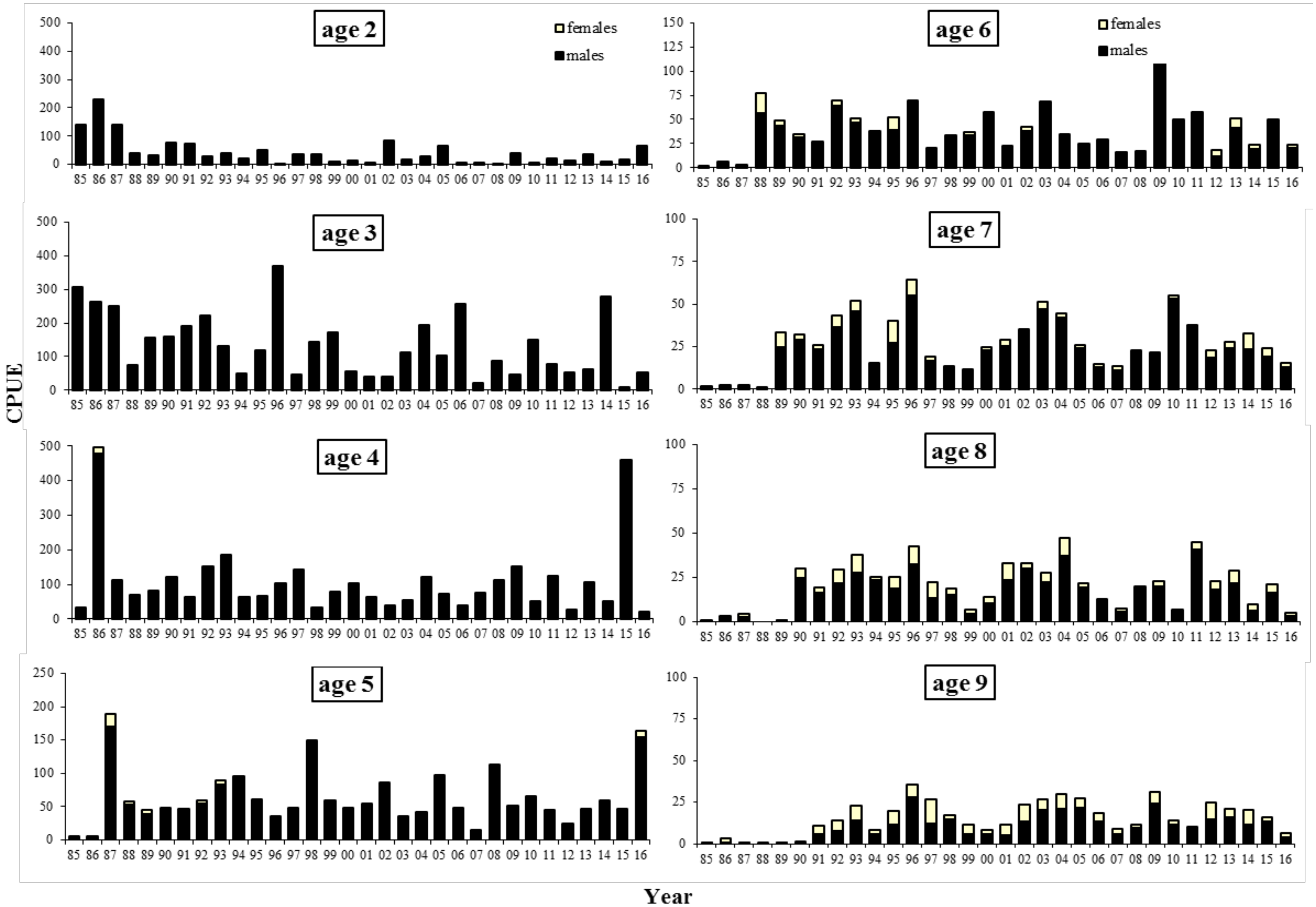


Figure 9. Continued.

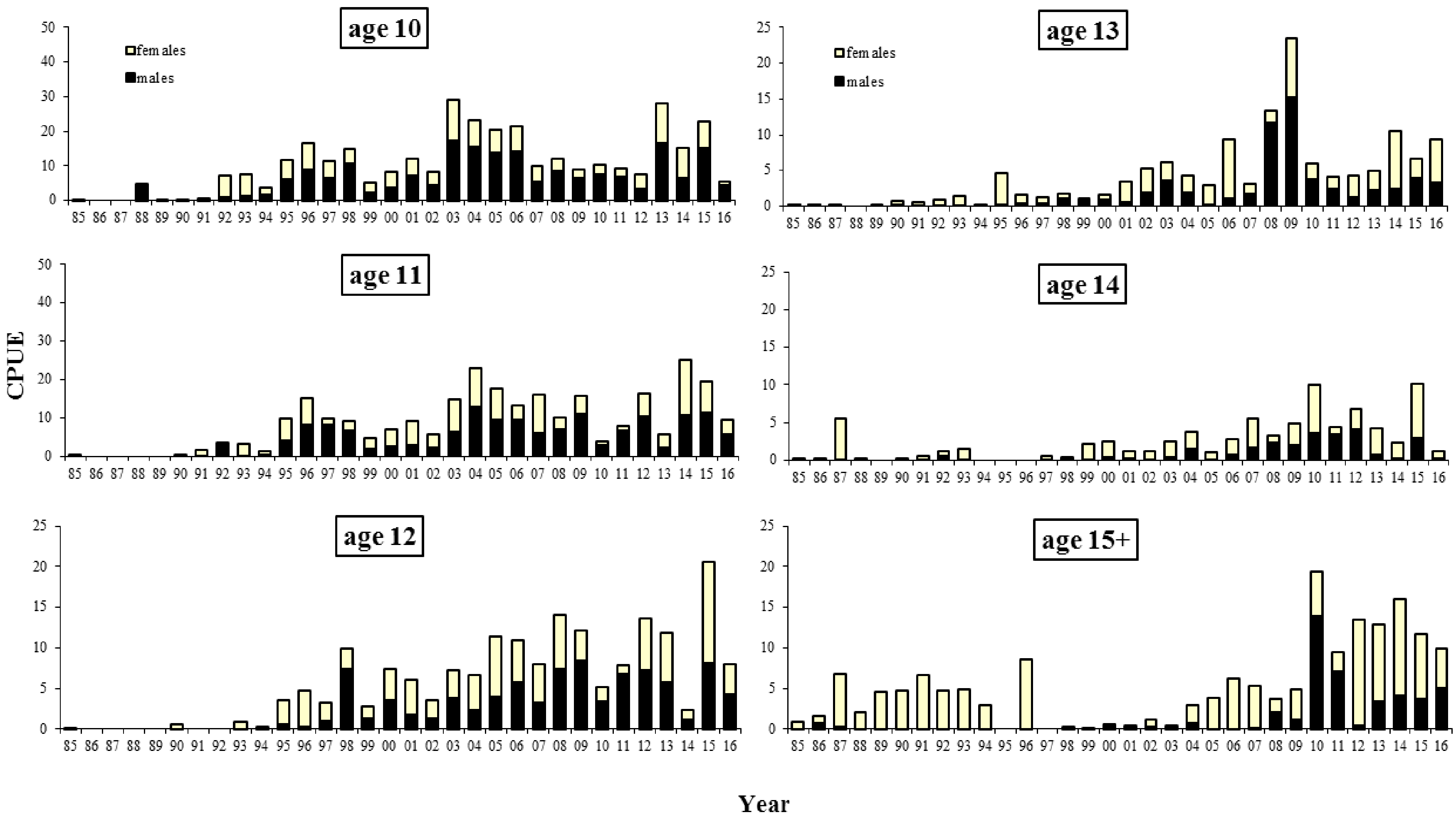


Figure 10. Percentage (selectivity-corrected CPUE) of female striped bass that were age 8 and older sampled from experimental drift gill nets set in spawning reaches of the Potomac River, Choptank River and the Upper Chesapeake Bay, April through May, 1985-2016 (Choptank River to 1996). Effort is standardized 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.

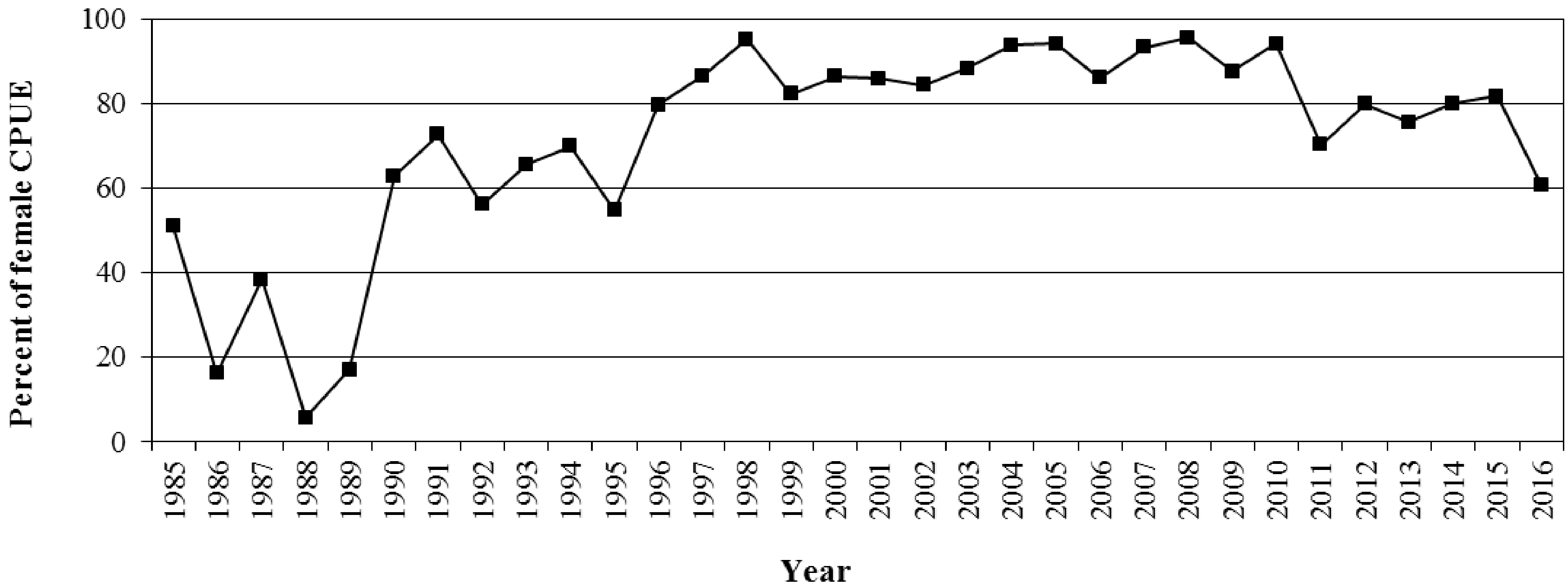


Figure 11. Percentage (selectivity-corrected CPUE) of male and female striped bass age 8 and over sampled from experimental drift gill nets set in spawning reaches of the Potomac River, Choptank River and the Upper Chesapeake Bay, April through May, 1985-2016 (Choptank River to 1996). Effort is standardized 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.

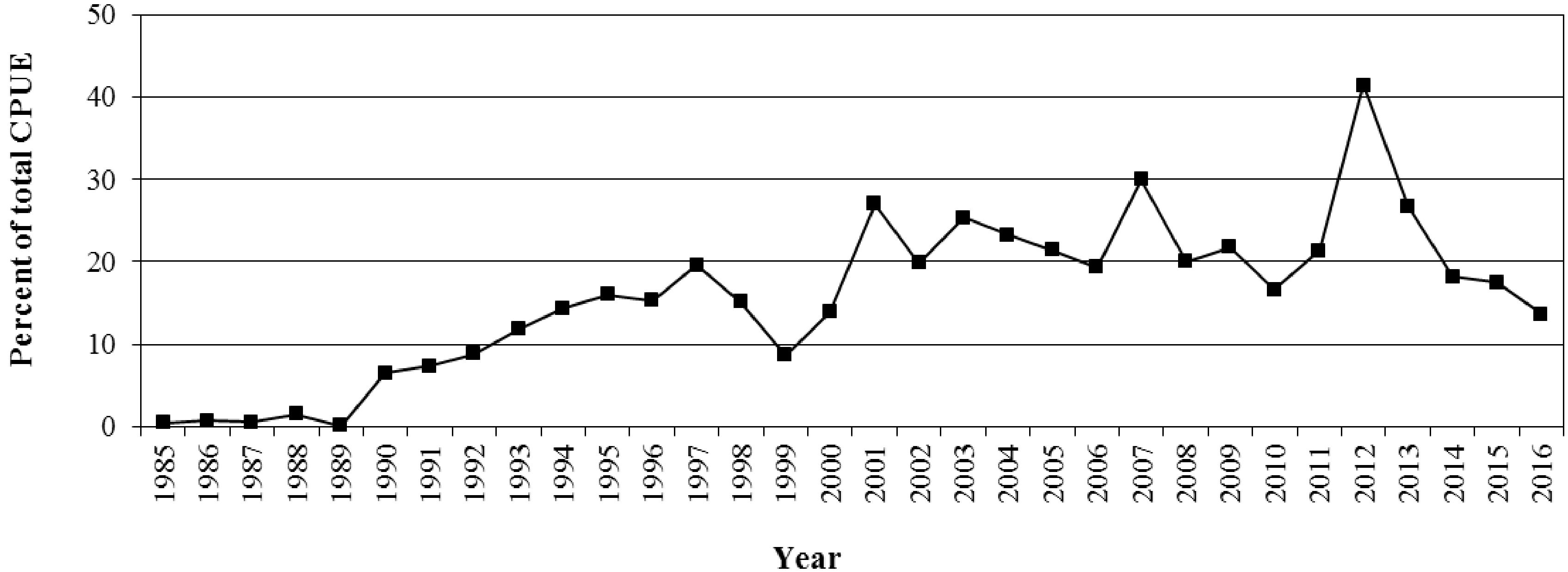
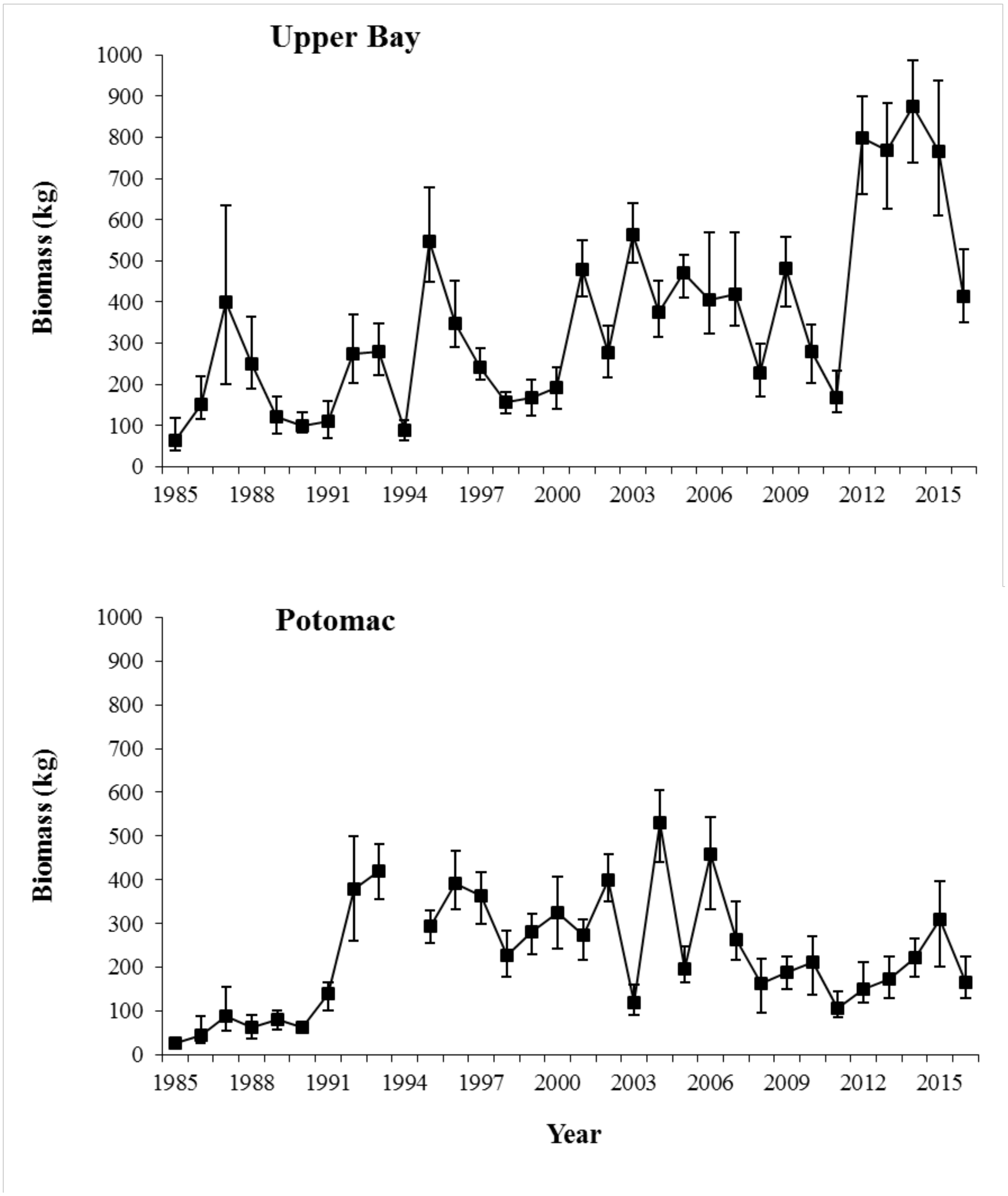


Figure 12. Index of spawning potential, expressed as biomass (kg), of female striped bass greater than or equal to 500 mm TL collected from experimental drift gill nets fished in two spawning areas of the Maryland Chesapeake Bay during April through May, 1985-2016. The index is corrected for gear selectivity, 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 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 291 YOY striped bass was collected at permanent stations in 2016, with individual samples yielding between 0 and 16 fish. The AM (2.2) and GM (1.25) were both below their respective time-series averages and TPAs (Tables 2 and 3, Figures 2 and 3). The PPHL was 0.61, indicating that 61% of samples produced juvenile striped bass. The PPHL was less 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 2016 $\log_e$-mean was significantly greater than just 1 year of the time-series (2012), and less than 37 years of the time-series. The 2016 year-class was indiscernible from 21 other year-classes.

System Means

Head of Bay - In 42 samples, 86 juveniles were collected at the Head of Bay sites for an AM of 2.0, less than the time-series average (11.5) and the TPA of 17.3 (Table 2, Figure 5). The GM of 1.14 was less than the time-series average (5.51) 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 2016 Head of Bay $\log_e$-mean significantly less than 33 years of the time-series and indiscernible from the 26 other year-classes in the time-series.

Potomac River - A total of 156 juveniles was collected in 42 samples on the Potomac River. The AM of 3.7 was less than its TPA (9.2) and time-series average (8.2) (Table 2, Figure 5). The GM of 2.36 was also less than the TPA (3.93) and time-series average (3.59) (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 2016 Potomac River year-class significantly smaller than 12 years, and significantly greater than 9 years of the time-series. The 2016 Potomac year-class was indiscernible from the remaining 38 years of the time-series.

Choptank River - A total of 27 juveniles was collected in 24 Choptank River samples. The

AM of 1.1 was less than the time-series average of 21.2 and the TPA of 10.8 (Table 2, Figure 5). The GM of 0.64 was also less than its time-series average (8.11) 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 2016 Choptank River year-class significantly smaller than 32 years of the time-series, and indiscernible from the remaining 27 years of the time-series.

Nanticoke River - A total of 22 juveniles was collected in 24 samples on the Nanticoke River. The AM of 0.9 was less than the time-series average (9.0) and TPA (8.6) (Table 2, Figure 5). The GM of 0.68 was also less than its time-series average (4.10) 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) ranked the 2016 index significantly less than 26 years of the time-series and indiscernible from the remaining 33 years of time-series.

Auxiliary Indices

At the **Head of Bay auxiliary sites**, 23 juveniles were caught in 15 samples, resulting in an AM of 1.5, and a GM of 0.90. Both indices were less than their respective time-series averages (Table 5).

On the **Patuxent River**, 25 YOY striped bass were caught in 18 samples. The AM of 1.4 and a GM of 0.83 were less than their respective time-series averages (Table 5).

DISCUSSION

Striped bass recruitment in Maryland's portion of Chesapeake Bay was poor in 2016. In sharp contrast to the successful year-class of 2015 when YOY fish occurred in 98% of samples, YOY striped bass captured in just 61% of samples (PPHL=0.61) in 2016. Another indication of a small year-class is the tight confidence intervals around abundance indices which were a result of the narrow range of individual striped bass catches. Duncan's multiple range test found the 2016year-class significantly greater than only the record-low index of 2012.

The 2016 bay-wide GM of 1.25 ranks in the 13th percentile of the time-series and meets the ASMFC definition of recruitment failure. Amendment 6, Addendum II, to the Interstate Fisheries Management Plan for Atlantic Striped Bass defines recruitment failure in Maryland as a GM index that falls below the 25th percentile of all values from 1957-2009, or a GM of 1.60.

Recruitment in individual systems was uniformly low. GM indices for the Head of Bay, Choptank, and Nanticoke were all below the first quartile. The Potomac River GM ranked slightly higher, but was still below the median time-series value.

Survey data documented below-average recruitment for several other anadromous species, notably American shad, white perch, and yellow perch. Decreased production for a range of anadromous species indicates large-scale environmental conditions as a possible influence. The Chesapeake Bay region was experiencing significant drought conditions during spring 2016, a crucial time for the survival of sensitive life stages of many anadromous species. Cumulative spring flow from four Chesapeake tributaries (Susquehanna, Patuxent, Potomac, and Choptank rivers) was the third lowest since 1985 (personal communication, Renee Karrh, MDDNR, Tidewater Ecosystem Assessment).

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: $C_1=(0.18511)(C_0)- 0.06887$, 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 (0.35) was slightly lower than the index of 0.39 predicted by the regression analysis. The small, negative residual indicates that survival during the first winter of the 2015 year-class was slightly higher 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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<u>**LIST OF TABLES**</u>

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
Average	11.5	8.2	21.2	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
Average	5.51	3.59	8.11	4.10	4.27
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
Average	11.9	208.4	1.45	92.20	0.71	0.63	0.78	
TPA*	12.0	194.8	1.52	93.18	0.71	0.62	0.80	

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

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

	Patuxent River			Head of Bay		
Year	AM	GM	n	AM	GM	n
1983	0.06	0.04	18	0.58	0.33	12
1984	0.61	0.39	18	0.92	0.43	12
1985	3.17	1.95	18	1.00	0.24	12
1986	2.44	1.17	18	0.92	0.54	12
1987	2.94	0.94	17	0.33	0.26	9
1988	0.59	0.40	17	1.62	1.07	21
1989	1.39	0.92	18	10.43	1.91	21
1990	0.28	0.17	18	4.95	2.24	21
1991	0.94	0.53	18	2.15	0.98	20
1992	9.50	1.85	18	0.50	0.26	20
1993	104.30	47.18	18	28.00	11.11	21
1994	4.10	2.82	18	6.30	2.31	21
1995	7.28	3.46	18	2.95	1.15	21
1996	420.39	58.11	18	12.40	4.69	20
1997	7.33	2.72	18	2.70	2.18	20
1998	13.22	7.58	18	2.94	1.51	16
1999	7.28	5.39	18	3.62	2.13	13
2000	9.67	5.03	18	8.60	5.68	15
2001	17.28	10.01	18	19.47	6.62	15
2002	1.22	0.69	18	1.00	0.42	15
2003	61.11	22.17	18	16.06	11.79	16
2004	2.11	1.29	18	7.73	4.40	15
2005	8.94	3.91	18	5.53	4.35	15
2006	1.00	0.66	18	0.67	0.31	15
2007	15.22	6.07	18	5.33	2.72	15
2008	0.33	0.24	18	3.47	2.02	15
2009	3.00	1.87	18	2.13	1.14	15

Table 5. Continued.

	Patuxent River			Head of Bay		
Year	**AM**	**GM**	**n**	**AM**	**GM**	**n**
2010	3.33	2.49	18	3.67	1.45	15
2011	42.50	13.41	18	12.29	5.75	21
2012	0.06	0.04	18	1.86	0.71	21
2013	6.00	2.63	18	4.93	2.82	15
2014	5.11	2.70	18	5.33	4.34	15
2015	11.56	4.15	18	6.33	4.15	15
2016	1.39	0.83	18	1.53	0.90	15
Average	22.81	6.29		5.54	2.73	
Median	3.72	2.22		3.55	1.97	

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	N/A

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

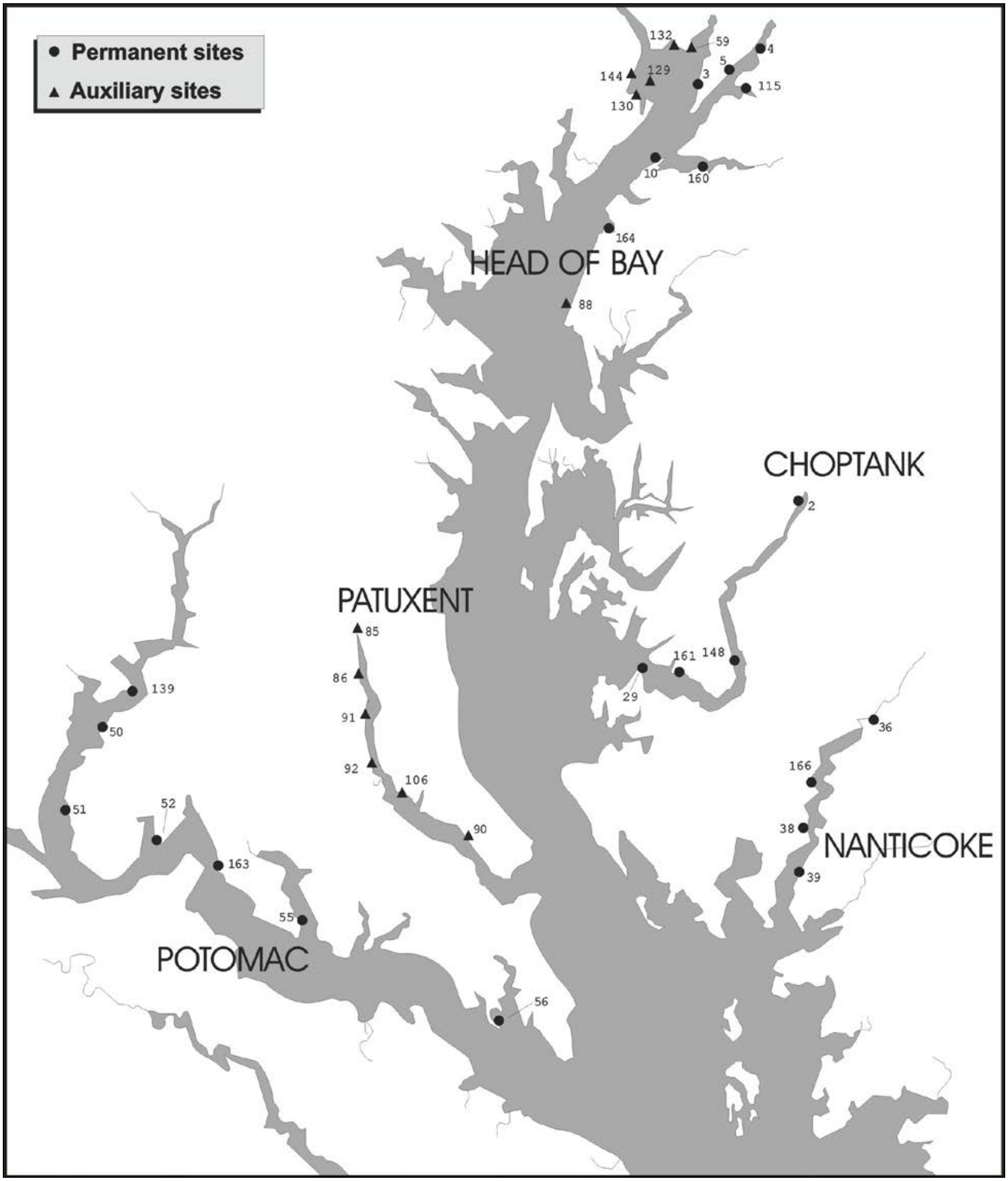


Figure 2. Maryland Chesapeake Bay arithmetic mean (AM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

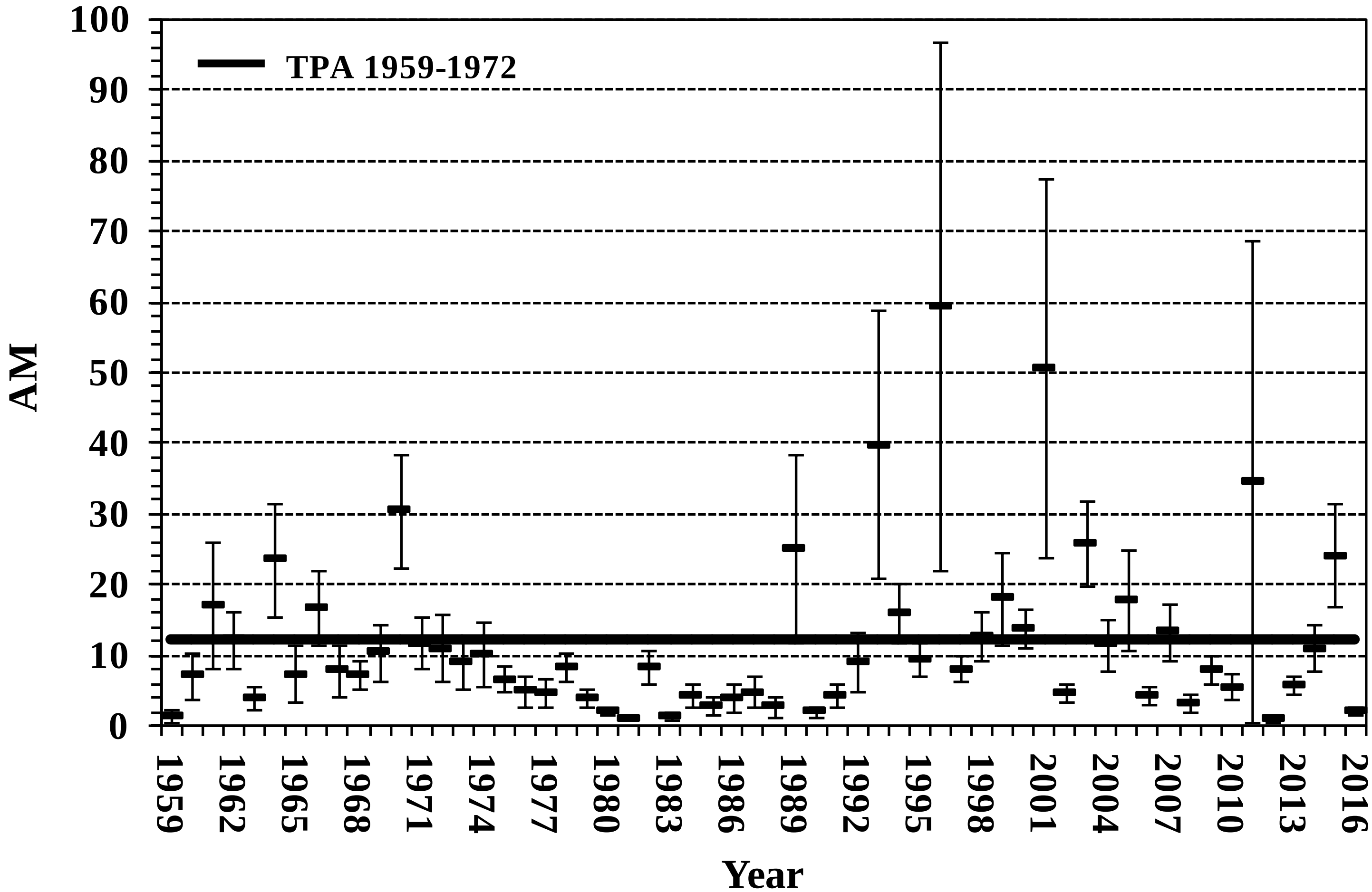


Figure 3. Maryland Chesapeake Bay geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

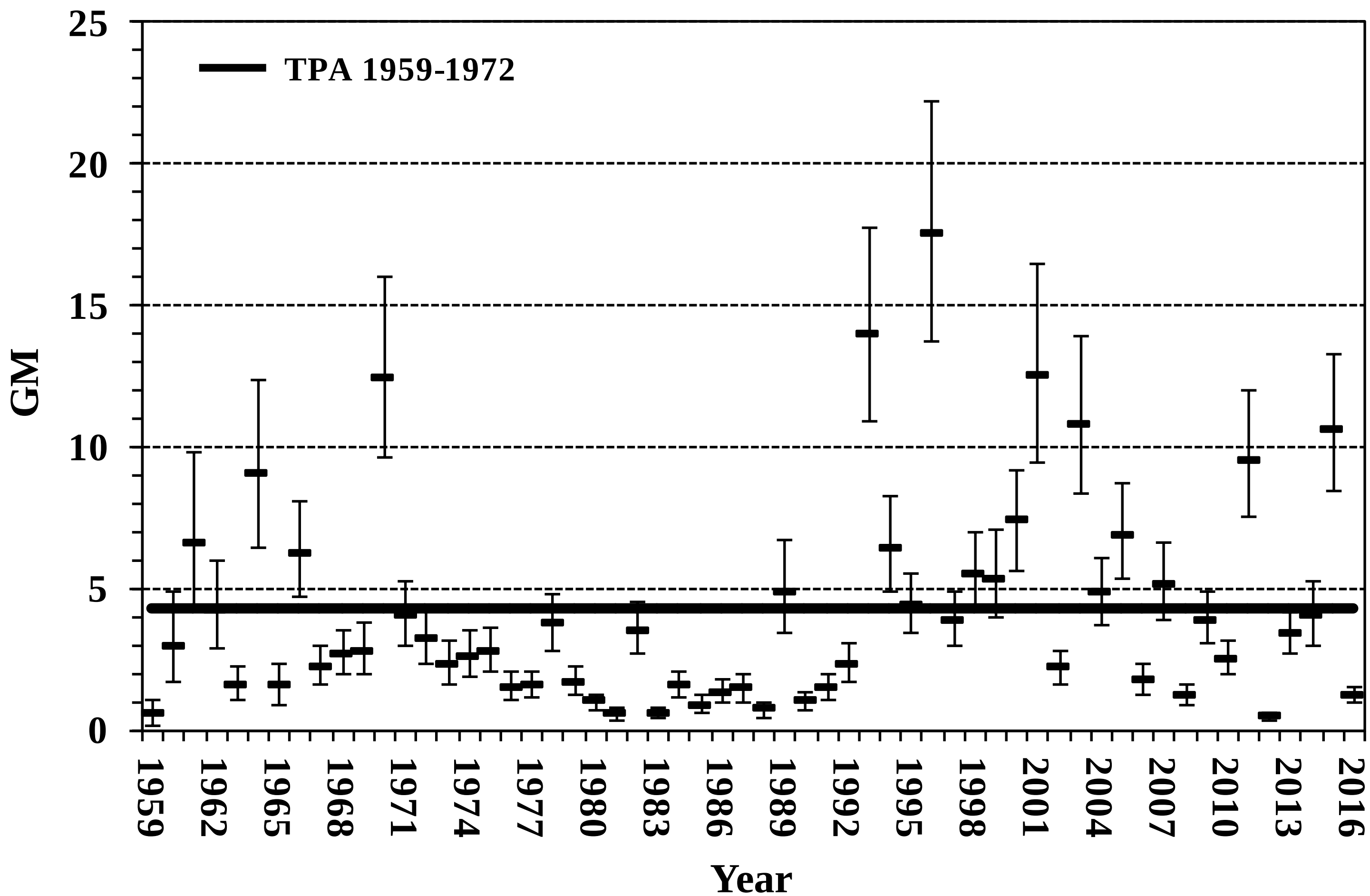


Figure 4. Maryland Chesapeake Bay juvenile striped bass indices. Arithmetic mean (AM), scaled geometric mean (GM)*, and proportion of positive hauls (PPHL) as percent.

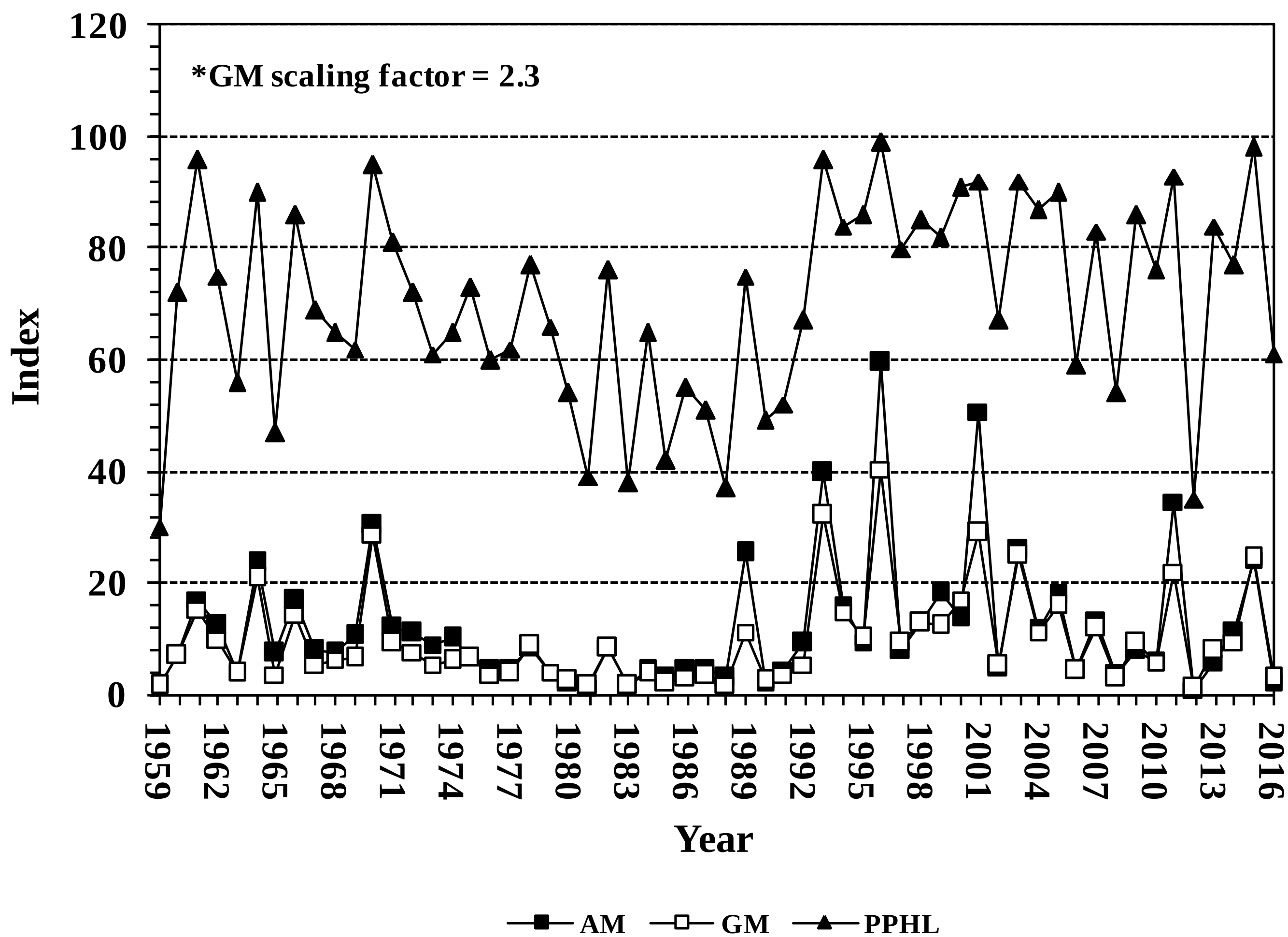


Figure 5. Arithmetic mean (AM) catch per haul by system for juvenile striped bass. Note different scales.

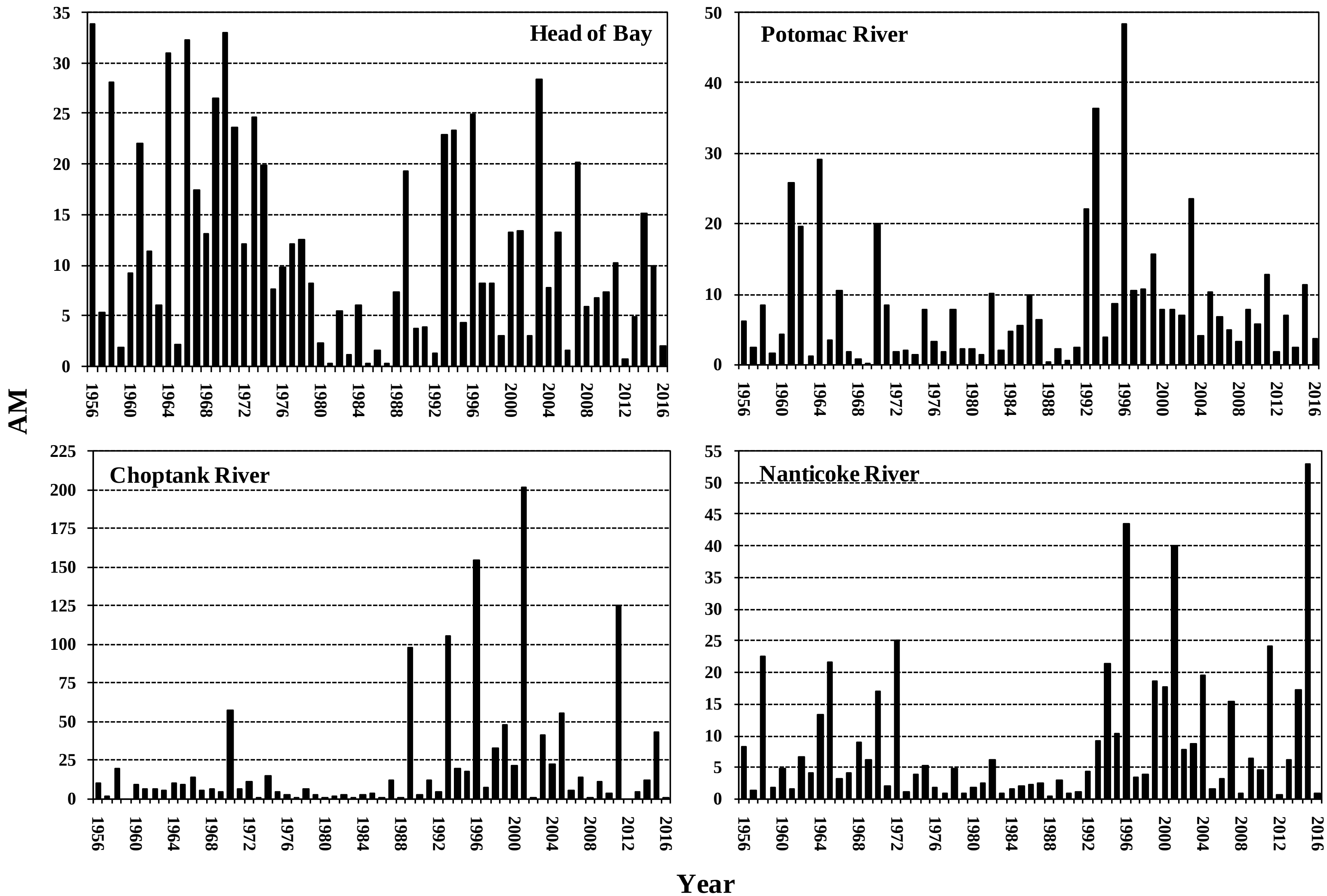


Figure 6. Head of Bay geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

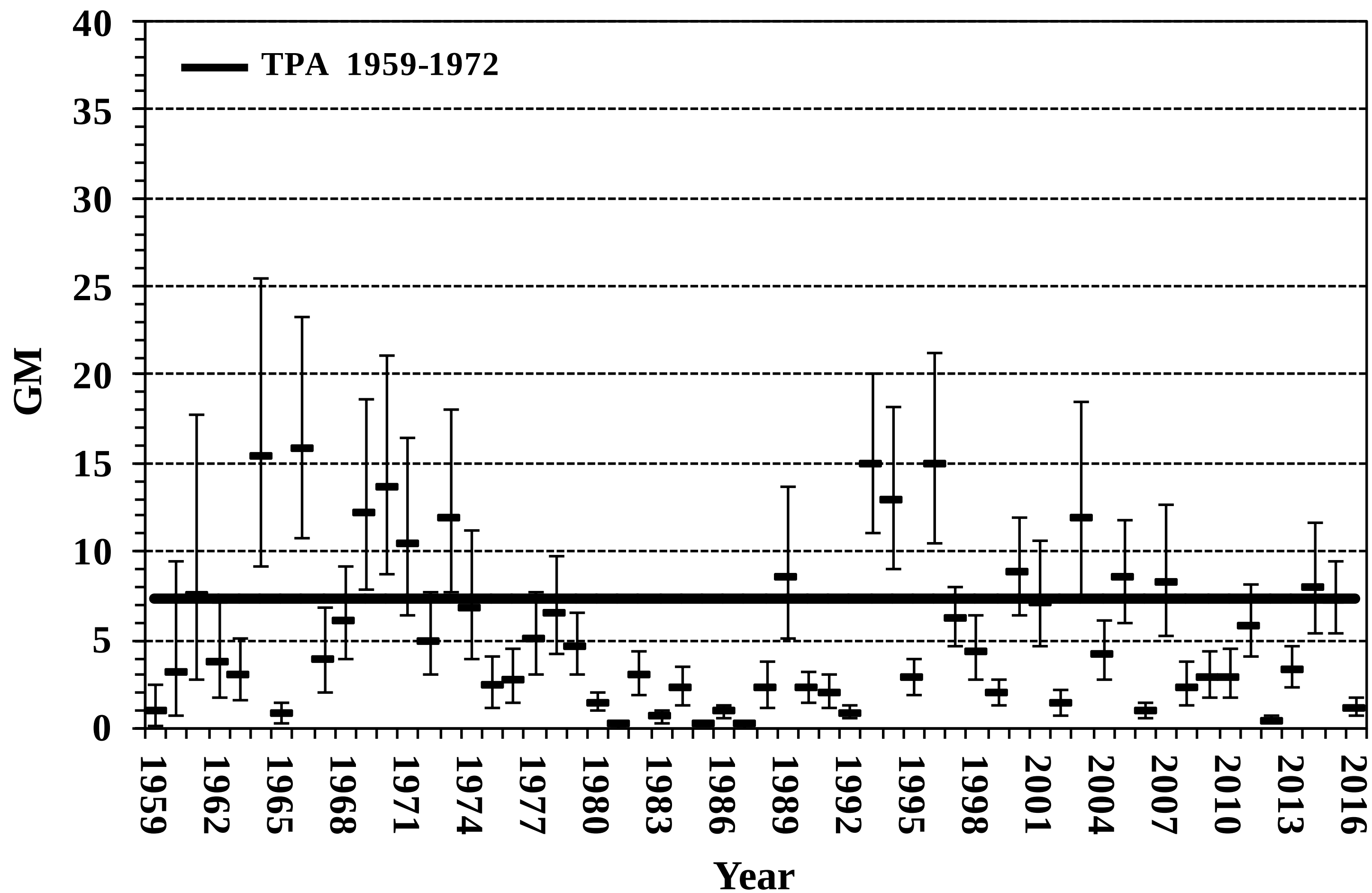


Figure 7. Potomac River geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

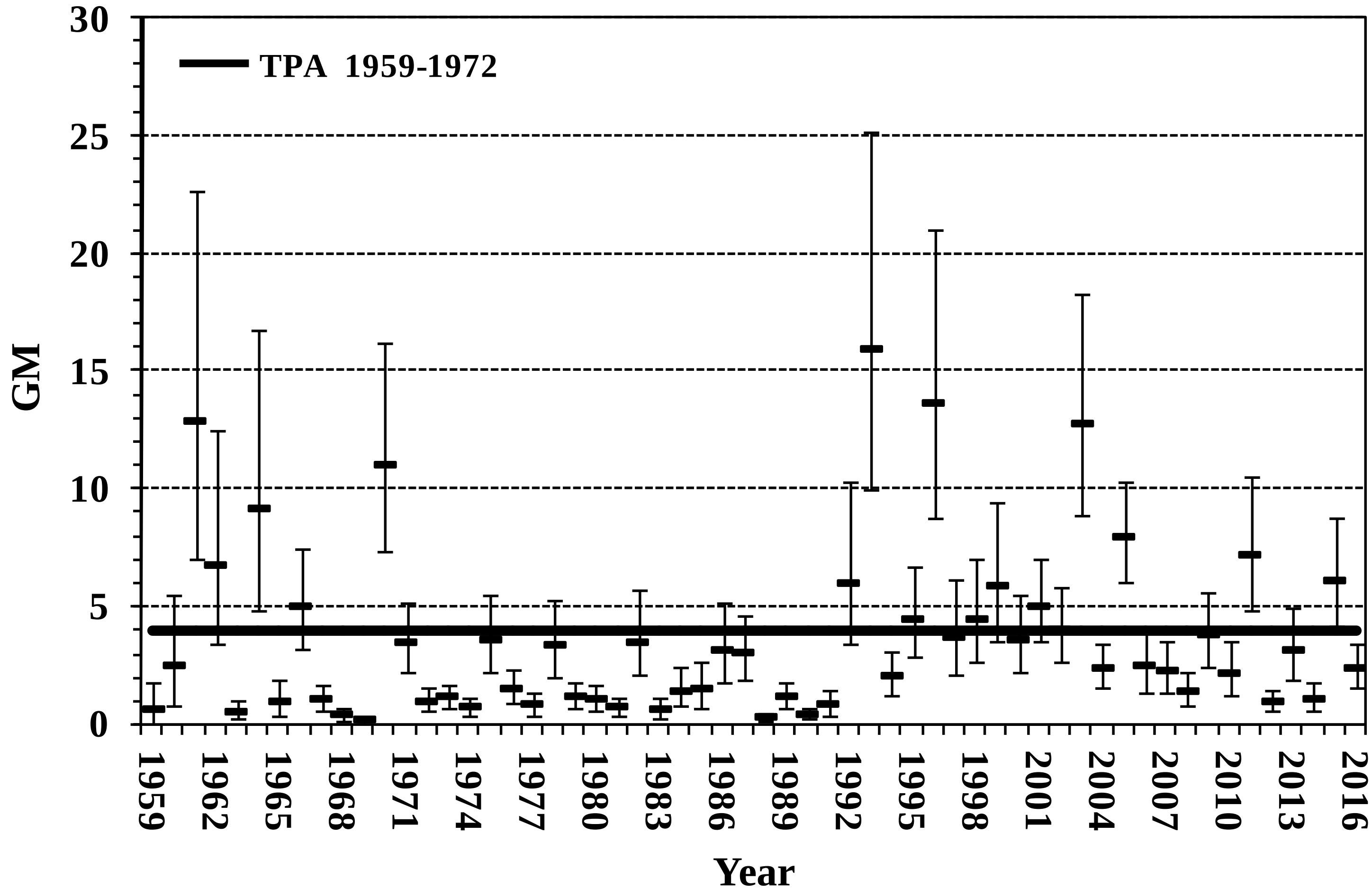


Figure 8. Choptank River geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

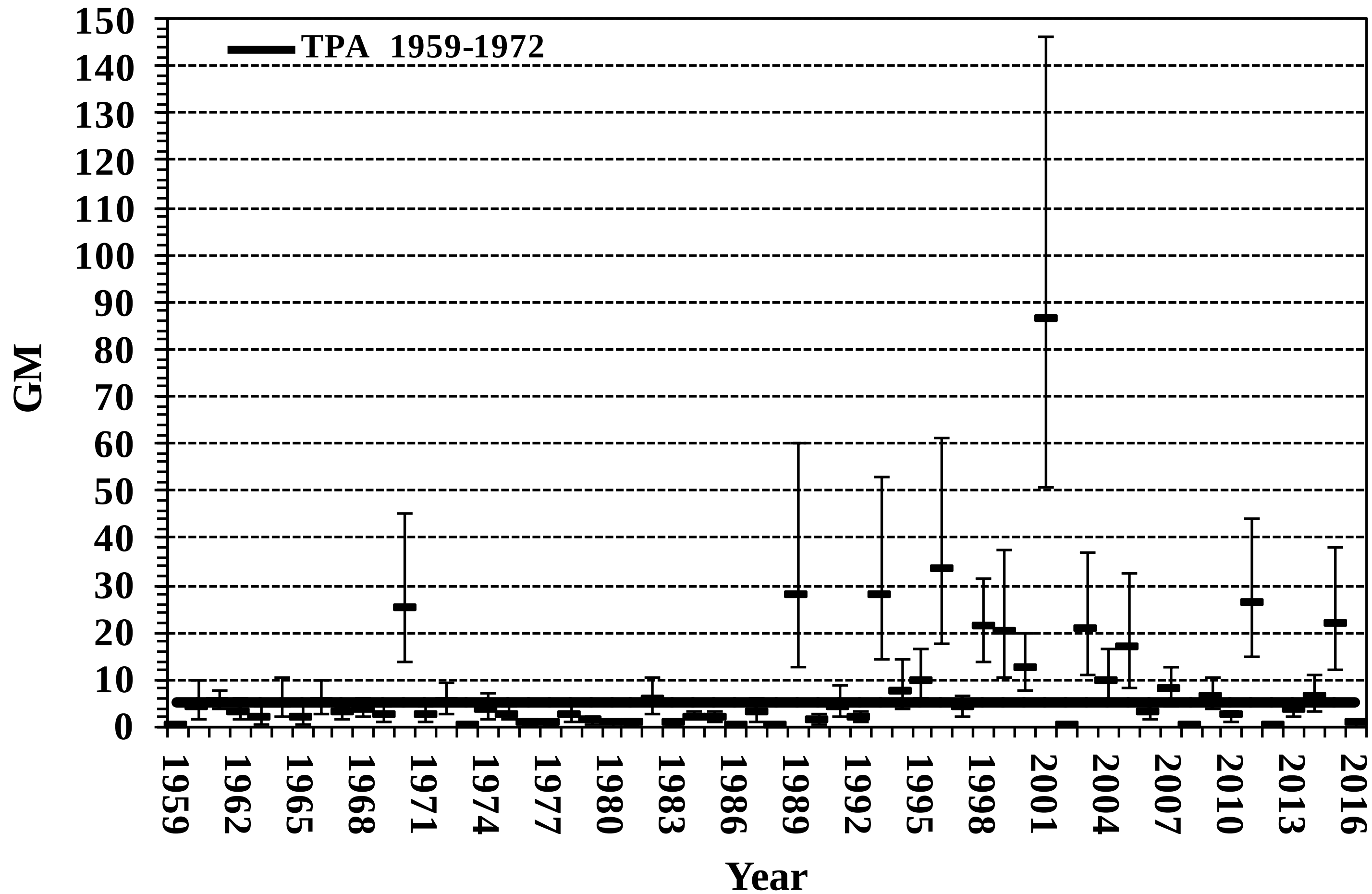


Figure 9. Nanticoke River geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

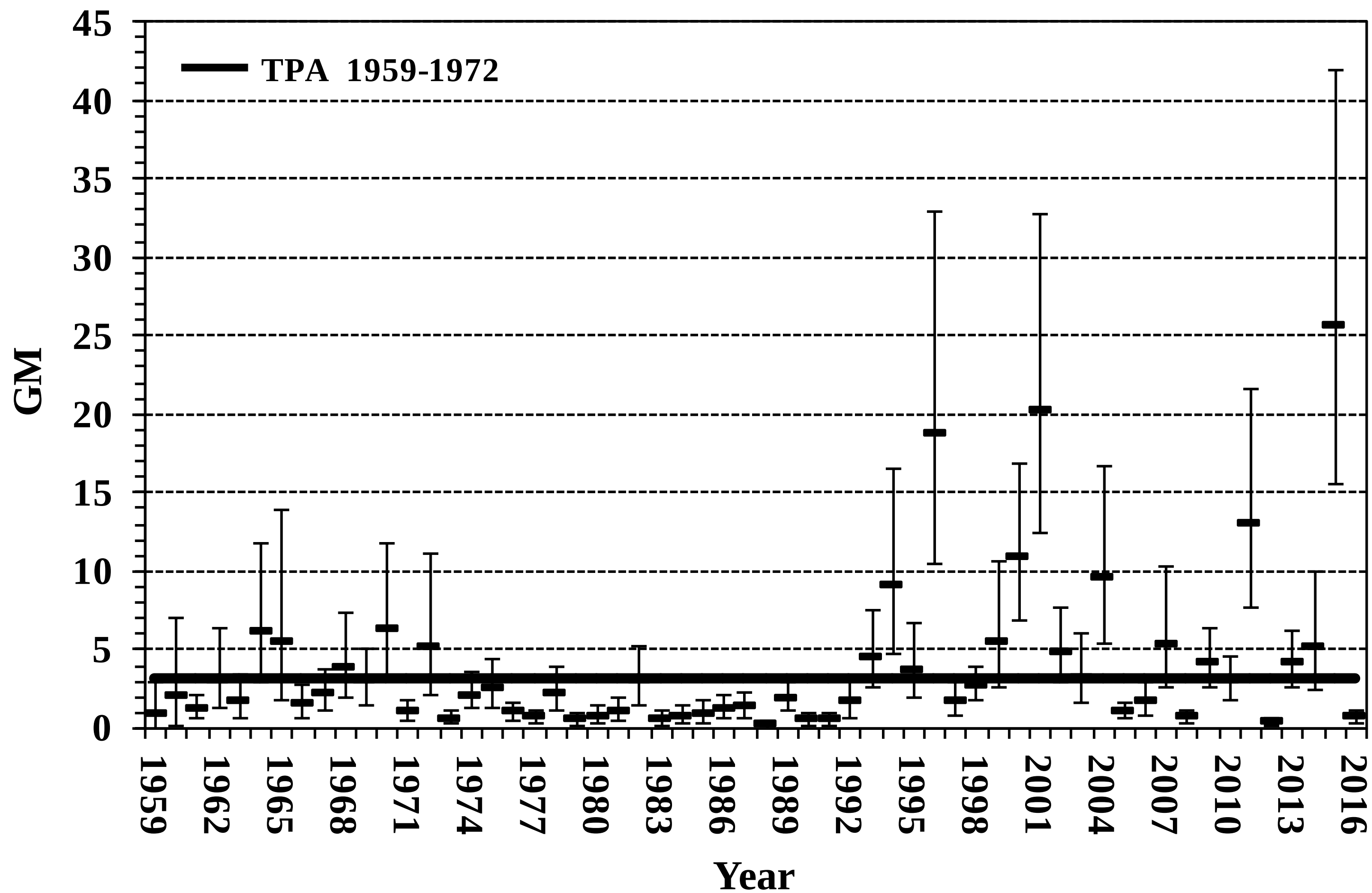


Figure 10. Relationship between age 0 and subsequent age 1 striped bass indices.

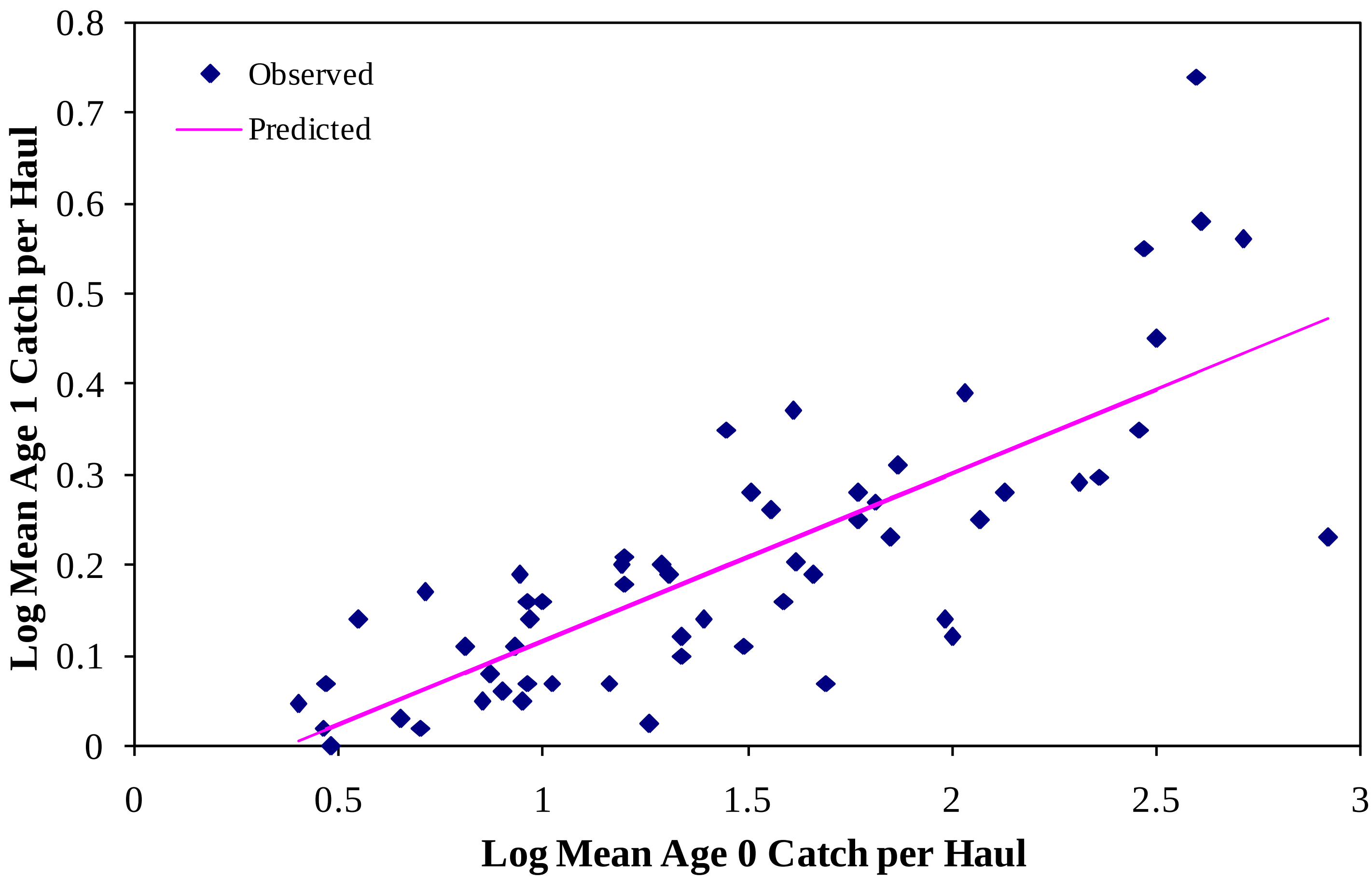
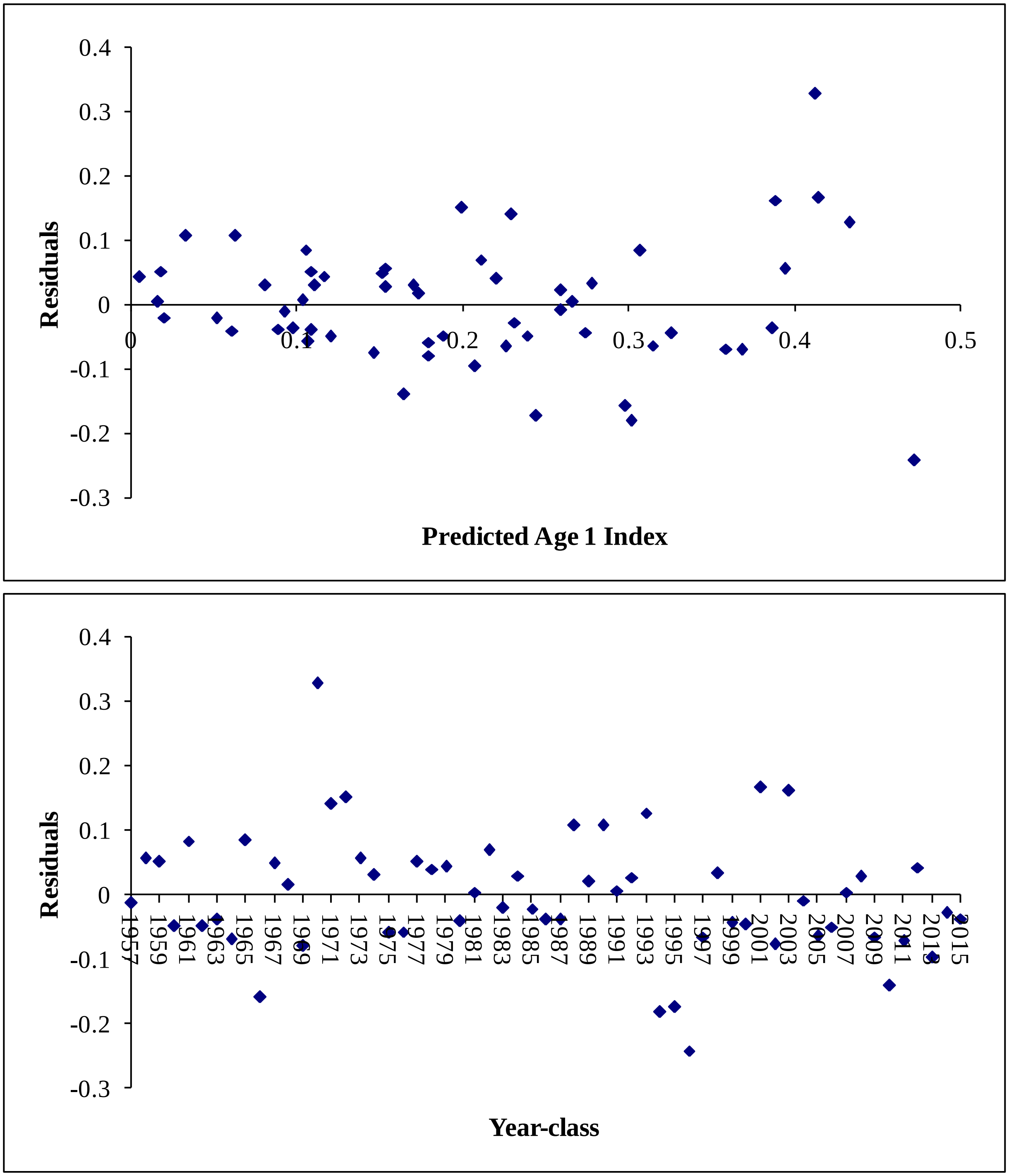


Figure 11. Residuals of age 1 and age 0 striped bass regression.



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 2016. 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

During April through mid-May 2016, 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 2016, funding was obtained to conduct both a trawl and 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 southeastern Virginia (state and federal waters). Participants in the two sampling components included USFWS, North Carolina Division of Marine Fisheries (NC DMF), East Carolina University, MD DNR, North Carolina Department of Environment and Natural Resources, National Marine Fisheries Service, South Atlantic and Mid-Atlantic Fisheries Management Councils, Atlantic States Marine Fisheries Commission (ASMFC), U. S. Coast Guard, Virginia Department of Game and Inland Fisheries, Virginia Commonwealth University and Delaware State University.

The first phase of the tagging cruise took place from January 12 to January 18, 2016. Trawling was conducted 24 hours per day aboard the Skidaway Institute of Oceanography's Research Vessel Savannah. One 65-foot (19.7 m) head-rope Mongoose trawl was towed 102 times at speeds ranging from 2.8 to 3.5 knots at depths of 24 to 111 feet (7.3 – 33.8 m) for 0.03 to 0.33 hours.

The hook and line fishing was conducted onboard a contracted sportfishing vessel departing from Virginia Beach, VA. Sampling was conducted during 10 fishing trips, between January 26 and February 12, 2016. Between five and seven lines with custom-made tandem parachute rigs were trolled, at 2 to 3 knots, in depths of 52 to 110 feet (15.9 to 33.5 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 in 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: ≥457 mm TL (18 inches) and ≥711 mm TL (28 inches). The recovery year began on the first day of spring tagging in the time series (March 28) and continued until March 27 of the following year. Survival and mortality estimates for fish tagged in spring 2016 will not be completed until after March 27, 2017.

Tag release and return data from spring male fish, ≥457 mm TL and <711 mm TL (18 – 28 inches TL), were used to develop annual estimates of fishing mortality for the Chesapeake Bay pre-migratory stock. Male fish 18 to 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 April 1 and May 14, 2016. A total of 1,938 striped bass were sampled and 1,300 (67%) 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 2016 (572 mm TL) was significantly greater (t-value = -3.94, $P<0.0001$) than that of the sampled population (545 mm TL) (Figure 2). This was also evident in the significant difference of the two length frequencies ($D=0.053$, $P=0.0237$).

Tag releases and recaptures from both Maryland and Virginia's sampling (combined spring 2016 data) will be used to estimate an instantaneous fishing mortality rate on resident fish for the

2016-2017 recreational, charter boat, and commercial fisheries for the entire Chesapeake Bay. Estimates of survival and fishing mortality for the 2016 Chesapeake Bay spawning stock, as well as the resident stock, will be presented in the next report of the ASMFC Striped Bass Tagging Subcommittee. Stock assessments are currently being conducted every two years.

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.

During the 2016 trawling portion of the cruise, 110 striped bass were captured and all were tagged (Table 2). The majority of these fish were encountered off Maryland's coast – farther north than other years. The mean length of all fish captured and tagged on the 2016 trawling cruise was 960 mm TL. While fishing with hook and line, 1,273 striped bass were encountered and 1,240 (97%) were tagged (Table 2). The mean length of all fish sampled during the hook and line sampling was 985 mm TL. The mean total length of striped bass tagged on the hook and line portion of the cruise (984 mm TL) was significantly greater than the length of fish tagged from the trawling component (960 mm TL , t-value=3.19, P=0.0015, Figure 3). This could be a result of the bait sizes used during the hook and line component, the ability of larger fish to swim faster to avoid the trawl, or for larger fish to outcompete the smaller fish for the trolled baits. Similarly, the KS-test results showed a significant difference in length distributions (D=0.15, P=0.0177).

The mean total length of striped bass tagged on the 2016 hook and line cruise (984 mm TL) was significantly greater than the length of fish tagged from the 2015 hook and line cruise (975 mm TL , t-value = -2.95, P=0.0032, Figure 3). Length distributions between the two years were also different ($D=0.11$, $P<0.0001$).

The NC DMF is presently completing age determination for the 2016 cruise via scale analysis. Estimates of survival and fishing mortality based on fish tagged in the 2016 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

2017 PRELIMINARY RESULTS

Spring tagging

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. 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).

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 following the ASMFC Benchmark Stock Assessment in 2018.

North Carolina cooperative offshore tagging activities

In 2017, 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 21 and February 5, 2017.

While fishing with hook and line, 904 striped bass were encountered and 881 (97%) were tagged (Table 2). The mean length of all fish sampled was 1023 mm TL and the mean total length of striped bass tagged was 1022 mm TL.

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 following the ASMFC Benchmark Stock Assessment in 2018.

The final, complete analyses of the 2017 striped bass tagging activities will appear in the next F-61 Chesapeake Bay Finfish Investigations report.

CITATIONS

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Table 1. Summary of USFWS internal anchor tags applied to striped bass in Maryland's portion of Chesapeake Bay and Potomac River, April - May 2016.

System	Inclusive Release Dates	Total Fish Sampled	Total Fish Tagged	Approximate Tag Sequences [a]
Potomac River	4/1/16 - 5/14/16	492 [b]	237	535627 – 535865
Upper Chesapeake Bay	4/4/16 - 5/14/16	1,446	1,063	436951 – 437000 539651 – 540000 541333 – 541500 542501 – 542996
Spring spawning survey totals:		1,938	1,300	

[a] Not all tags in reported sequences were applied; some were lost, destroyed, or applied out of order.
[b] Total sampled includes two fish with no total length recorded.

Table 2. Summary of USFWS internal anchor tags applied to striped bass during the 2016 cooperative offshore tagging cruises.

System	Gear	Inclusive Release Dates	Total Fish Sampled	Total Fish Tagged	Approximate Tag Sequences [a]
Nearshore Atlantic Ocean (Near MD, VA, NC coasts)	Trawl	1/12/16 – 1/18/16	110	110	592001 – 592110
Nearshore Atlantic Ocean (Near MD, VA, NC coasts)	Hook & Line	1/26/16 – 2/12/16	1,273 [b]	1,240 [c]	573801 – 574850 590334 – 590528
Cooperative tagging cruise totals:			1,383	1,350	

[a] Not all tags in reported sequences were applied; some were lost, destroyed, or applied out of order.
[b] Total sampled includes four USFWS recaptures, one Hudson River Foundation recapture, and one fish with no total length recorded.
[c] Total tagged includes one fish with no total length recorded.

Figure 1. Tagging locations in spawning areas of the Upper Chesapeake Bay and the Potomac River, April - May 2016.

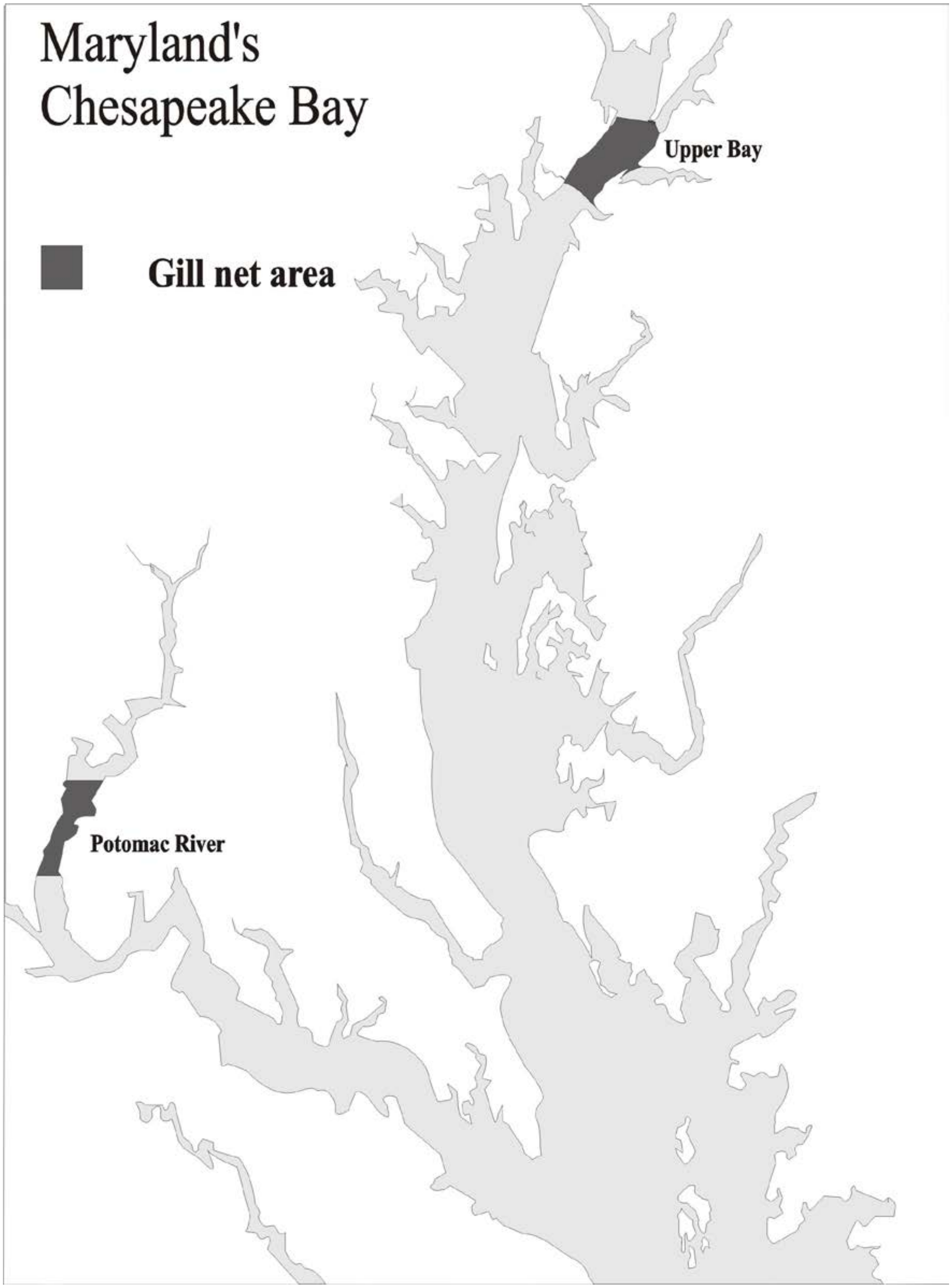
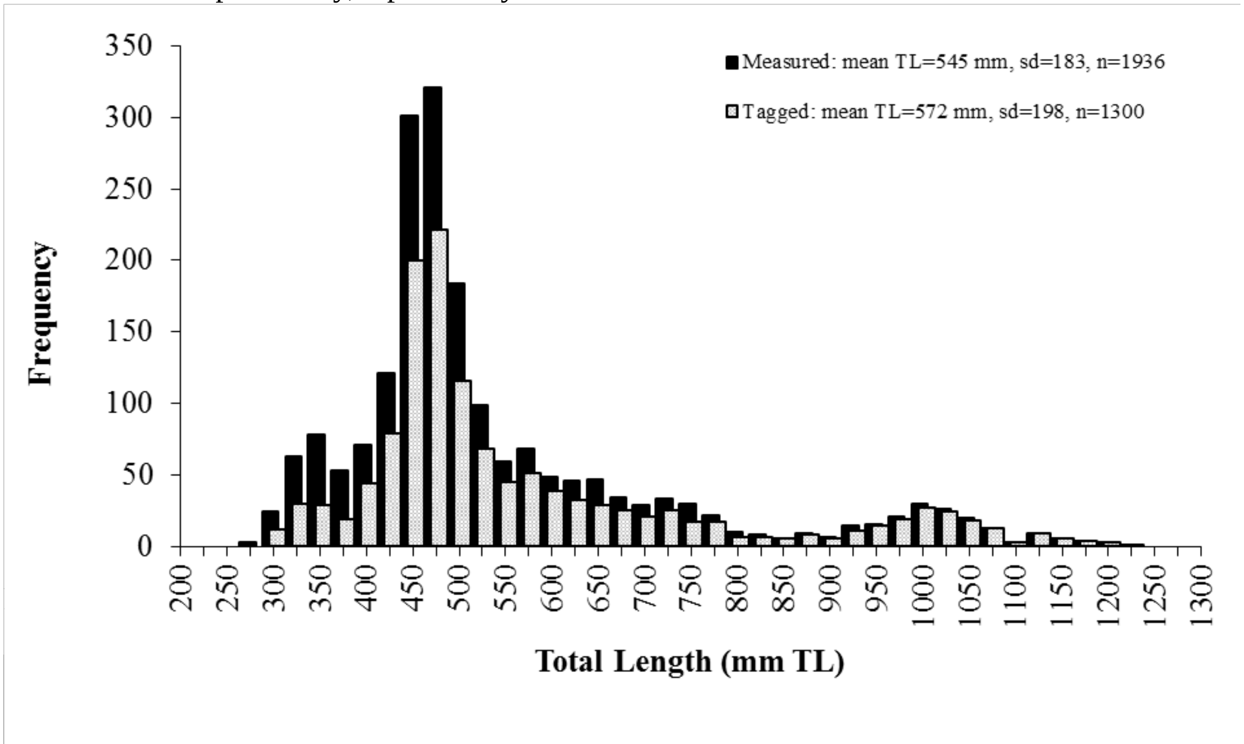
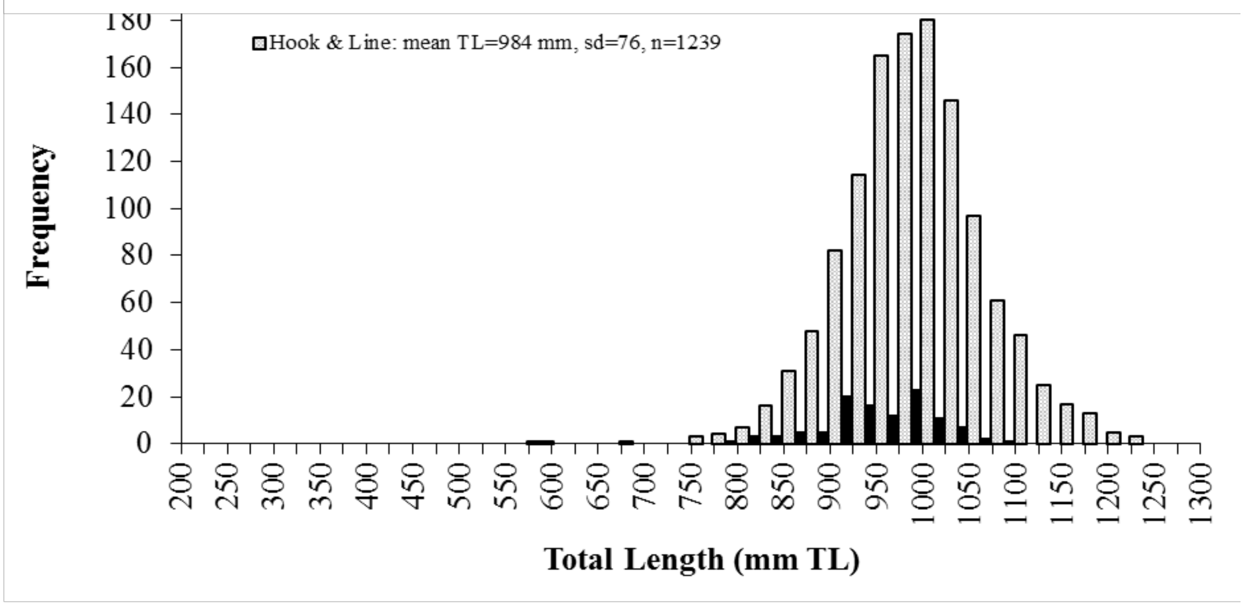


Figure 2. Length frequencies of striped bass measured and tagged during the spring in Chesapeake Bay, April - May 2016.





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

COMMERCIAL FISHERY HARVEST MONITORING

Prepared by Ryan P. Hastings

INTRODUCTION

The primary objectives of Project 2, Job 3, Task 5A were to quantify the commercial striped bass harvest in 2015 and describe the harvest monitoring conducted by the Maryland Department of Natural Resources (MD DNR). Maryland completed its twenty-fifth 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 2015 commercial quota for Maryland's Chesapeake Bay and tributaries was 1,471,888 pounds, a decrease of 24%, relative to the 2014 quota (1,925,421 pounds). The 2015 reduction was mandated by Addendum IV to Amendment 6 of the Atlantic Striped Bass Interstate Fisheries Management Plan, which prescribed a 20.5% reduction to commercial quota relative to the 2012 harvest (Atlantic States Marine Fisheries Commission, 2014). The Chesapeake Bay commercial fishery was also subject to an 18-36 inch total length (TL) slot limit. There was a separate quota of 90,757 for the Atlantic fishery, also mandated by Addendum IV though a conservation equivalency. 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 2015 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 total commercial quota was reserved for commercial fishermen who opted to remain in the old, derby-style management system. The total Common Pool quota was determined by combing 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 2015 ITQ commercial summer/fall fishery (hook-and-line, haul seine, and pound net) opened on June 1, and closed on November 26, November 27, and December 31, respectively. The Chesapeake Bay 2015 ITQ drift gill net season was split, with the first segment from January 1 through March 13, 2015 and the second segment from December 1 through December 31, 2015, Monday through Friday. The hook-and-line Common Pool fishery was open four days in June, two days in July, two days in August, four days in September, three days in October, and three days in November. The gill net Common Pool fishery was open six days in January, two days in February, and one day in December. The Atlantic coast fishery permitted of two gear types, drift gill net and trawl, and the season occurred in two segments: January 1 through April 30, 2015 and October 1 through December 31, 2015, Monday through 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) for 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 1-31 was established 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 permitees are required to pay for their mandated commercial harvest tags.

All commercially harvested striped bass were required to be tagged by the 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 by gear or fishery type through multiple of the following systems: 1) Daily phone reports from check stations operated by volunteers holding fish dealer licenses; 2) daily reporting from the Atlantic Coastal Cooperative Statistics Program's (ACCSP) Standard Atlantic Fisheries Information System (SAFIS); 3) weekly written log reports form designated check stations, 4) the Fishing Activity and Catch Tracking System (FACTS) (Figures 2 and 3). These reports allowed MD DNR to monitor the fisheries' and fishemen's daily reported progress towards their respective quotas. Check stations were required to keep daily written logs detailing the activity of each fisherman, which were returned weekly by mail to MD DNR. Individual fishermen were then required to return their striped bass permit 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 have more timely data, the pounds landed have come from the daily check station telephone reports, online SAFIS reports, and the weekly check station log sheets. However, all three 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, 1,436,867 pounds of striped bass were harvested in 2015; which was 35,021 pounds under the quota. The reported number of fish landed was 340,318 (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 2,601 striped bass, weighing 34,626 pounds (Table 2). The trawl fishery made up 58% of the Atlantic harvest, by weight, with the remainder from the gill net 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).

The mean weight per fish of striped bass harvested in Chesapeake Bay, regardless of gear type, was 4.22 pounds when calculated from the check station log sheets and 6.19 pounds when measured by biologists (Table 3). Mean weights by specific gear type ranged from 3.25 to 5.61 pounds from check station log sheets, and 3.76 to 8.00 pounds when measured by biologists. By either method of estimation, the largest striped bass landed in the Chesapeake Bay were taken by the drift gill net fishery. The smallest fish harvested in the Bay were taken by pound nets, with an average weight of 3.25 pounds, according to check station log sheets. No commercial fishermen participated in the haul seine fishery for the 2015 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 18.81 pounds (Table 3). The average weight calculated from the check station log sheets was 13.31 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 (24.59 pounds). The average weights of fish from the Atlantic trawl and gill net fisheries, as calculated from check station log sheets, were 15.04 and 11.50 pounds, respectively. The disparity between average weight estimates of Atlantic fish is likely due to the small sample size (n=27) collected during check station surveys.

Commercial Harvest Trends

Commercial striped bass harvests and quotas 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 1990's after the moratorium was lifted, but has been variable since 2000 (Figure 6). The Atlantic fishery has not reached its quota since 2009 (Figure 4). In almost all years since 1990, the Atlantic trawl fishery harvest has been greater than the Atlantic drift gill net harvest (Table 4, Figure 6).

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.

Chesapeake Bay gill nets and hook-and-line fisheries experienced an increase in CPUE relative to 2014. The pound net fishery showed a slight decrease in CPUE relative to 2014. The Chesapeake Bay drift gill net fishery had the highest CPUE of the Bay fisheries at 537 pounds per trip. Pound net CPUE ranked second at 359 pounds per trip. Consistent with historic trends, the hook-and-line fishery CPUE of 176 pounds per trip was the lowest of all Bay gear types (Table 5, Figure 7).

The Atlantic trawl fishery CPUE increased to the highest value in the time-series in to 1,819 pounds per trip. The Atlantic gill net fishery CPUE was 287 pounds per trip, an increase from the 2014 CPUE of 221 (Table 5, Figure 8).

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Table 1. Striped bass commercial regulations by gear type for the 2015 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	230	No trip limits for ITQ; 4 Nets/license	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 50,142; No ITQ Quota	196	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 50,142; No ITQ Quota	274	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	25	1,700 lbs/licensee/season	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 2015 calendar year.

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Area	Gear Type	Pounds[1]	Number of Fish[1]	Trips[2]
Chesapeake Bay[3]	Haul Seine	0	0	0
	Pound Net	614,478	188,929	1,710
	Hook-and-Line	160,750	33,396	913
	Gill Net	661,639	117,993	1,233
	Chesapeake Total Harvest	**1,436,867**	**340,318**	**3,856**
Atlantic Coast	Trawl	20,005	1,330	11
	Gill Net	14,621	1,271	51
	Atlantic Total Harvest	**34,626**	**2,601**	**62**
Maryland Totals		**1,471,493**	**342,919**	**3,918**

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 2015calendar year. Average weights calculated by MD DNR biologists include 95% confidence intervals.

Area	**Gear Type**	**Average Weight from Check Station Logs (pounds)[1]**	**Average Weight from Biological Sampling (pounds)[2]**	**Sample Size from Biological Sampling[2]**
Chesapeake Bay[3]	Haul Seine	N/A	N/A	N/A
	Pound Net	3.25	3.76 (3.66-3.86)	2,160
	Hook-and-Line	4.81		
	Gill Net	5.61	8.00 (7.91-8.09)	2,908
	Chesapeake Total Harvest	**4.22**	**6.19 (6.10-6.28)**	**5,110**
Atlantic Coast	Trawl	15.04	7.36 (6.10-8.61)	13
	Gill Net	11.50	24.59 (23.10-26.07)	14
	Atlantic Total Harvest	**13.31**	**18.81 (14.92-22.76)**	**27**

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 2015.

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

Table 5. Striped bass average catch per trip (CPUE) in pounds by commercial gear type, 1990 to 2015.

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
26 yr avg	**153**	**262**	**278**	**199**	**675**
5 yr avg	**190**	**359**	**444**	**202**	**1147**

Figure 1. Map of the 2015Maryland authorized commercial striped bass check stations.

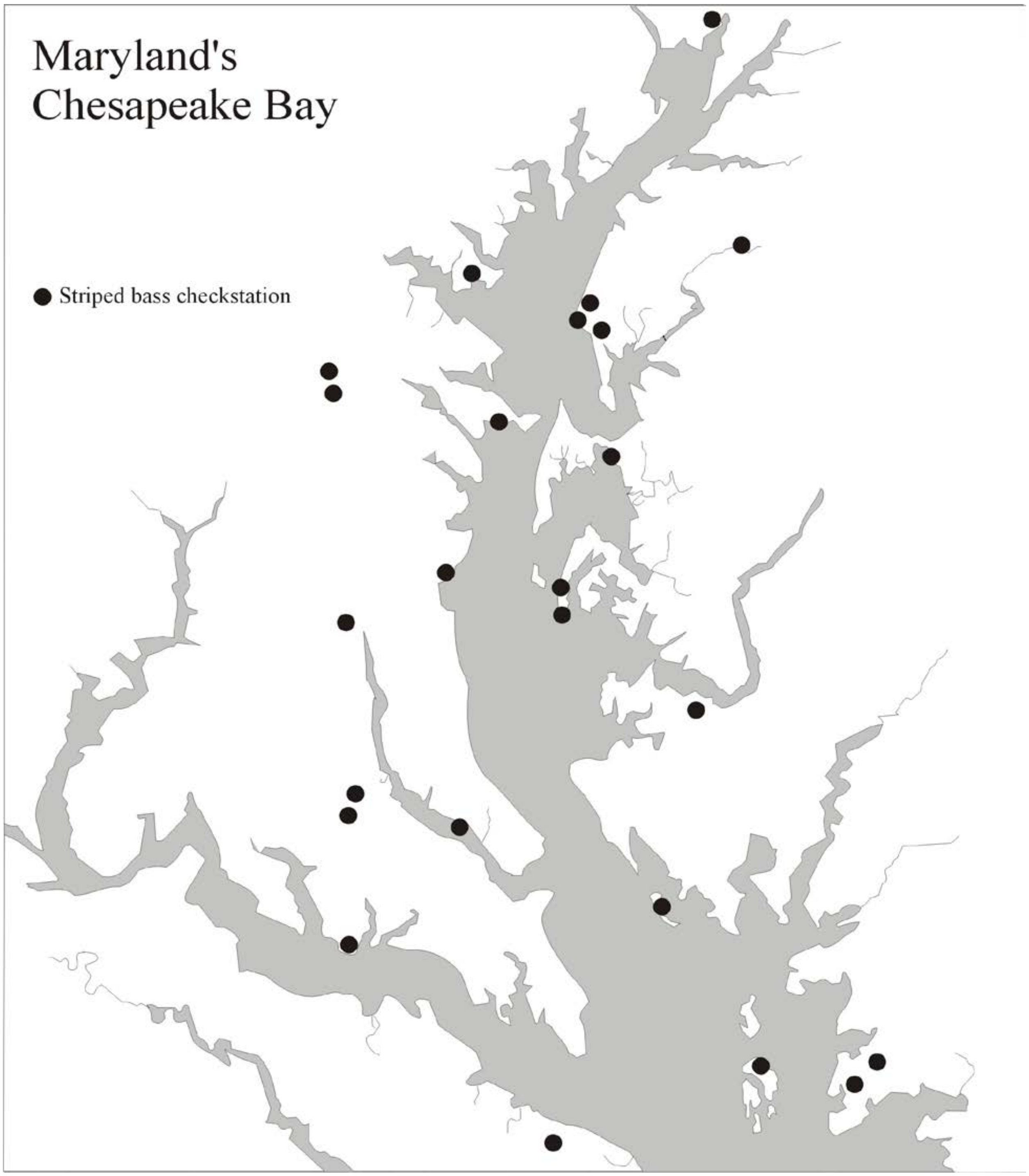


Figure 2. Maryland's Chesapeake Bay summer/fall (pound net and hook-and-line) fisheries cumulative striped bass landings from check stations reports, June-December 2015.

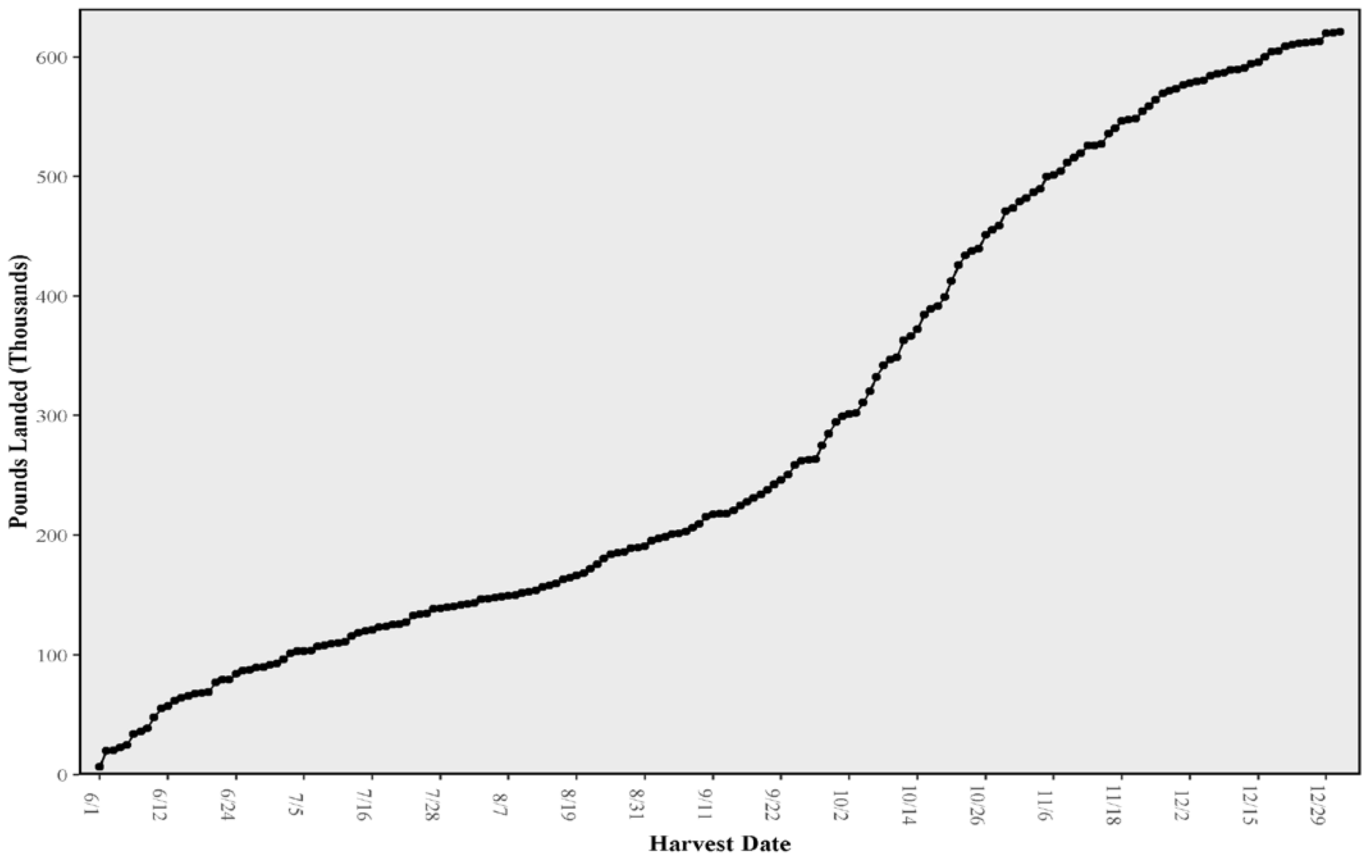
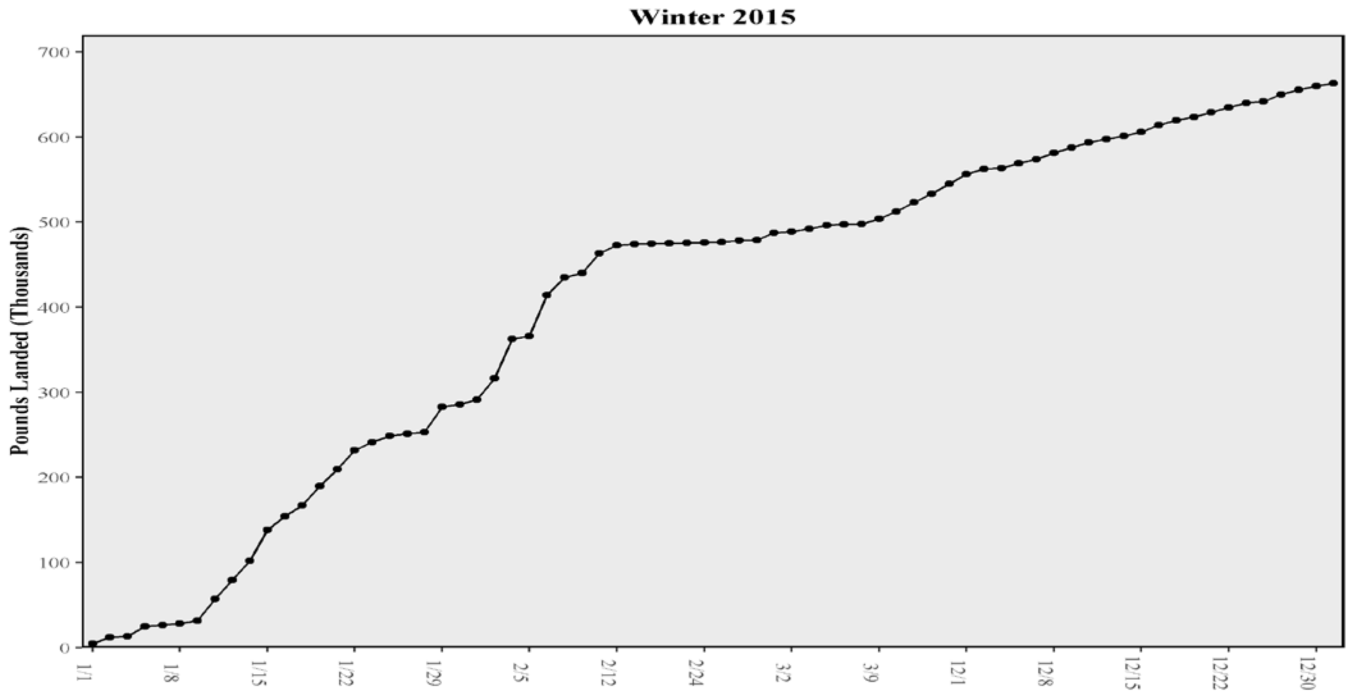


Figure 3. Maryland's Chesapeake Bay winter (gill net) and the Atlantic trawl and gill net fisheries (combined) cumulative striped bass landings from check stations reports, January-December 2015. Note different scales.



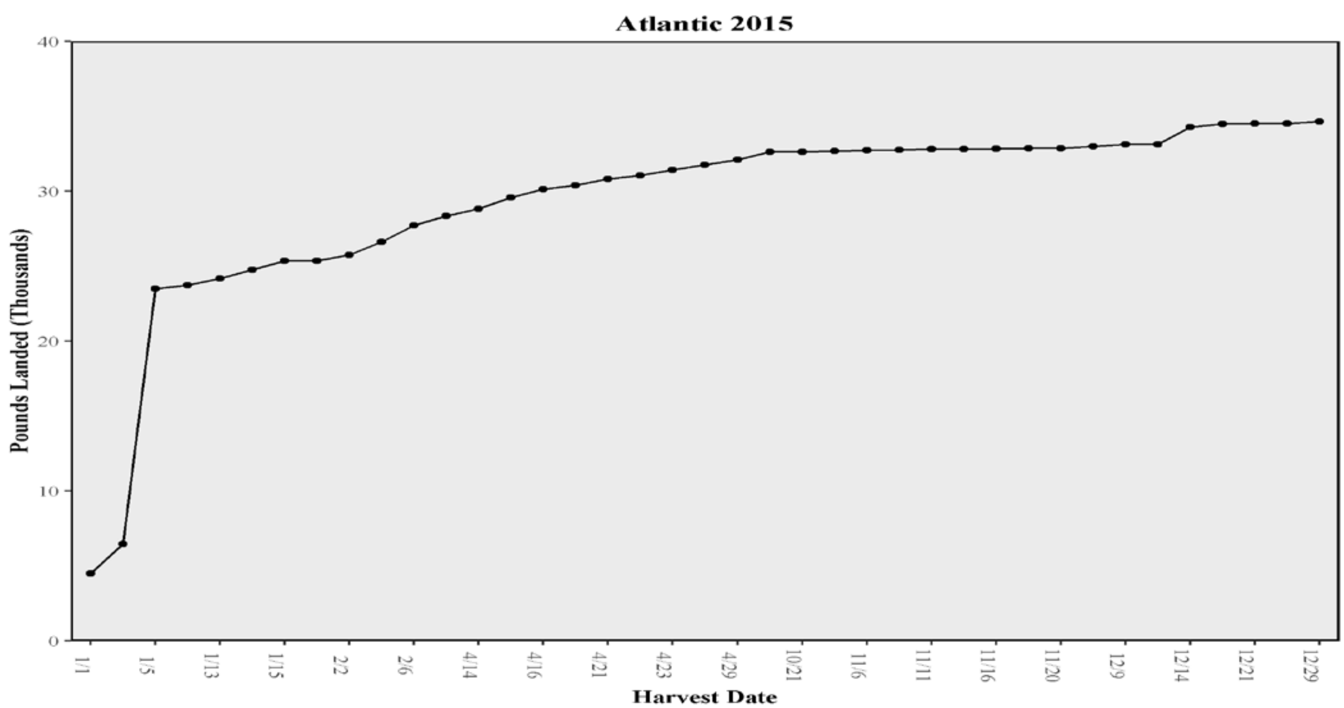
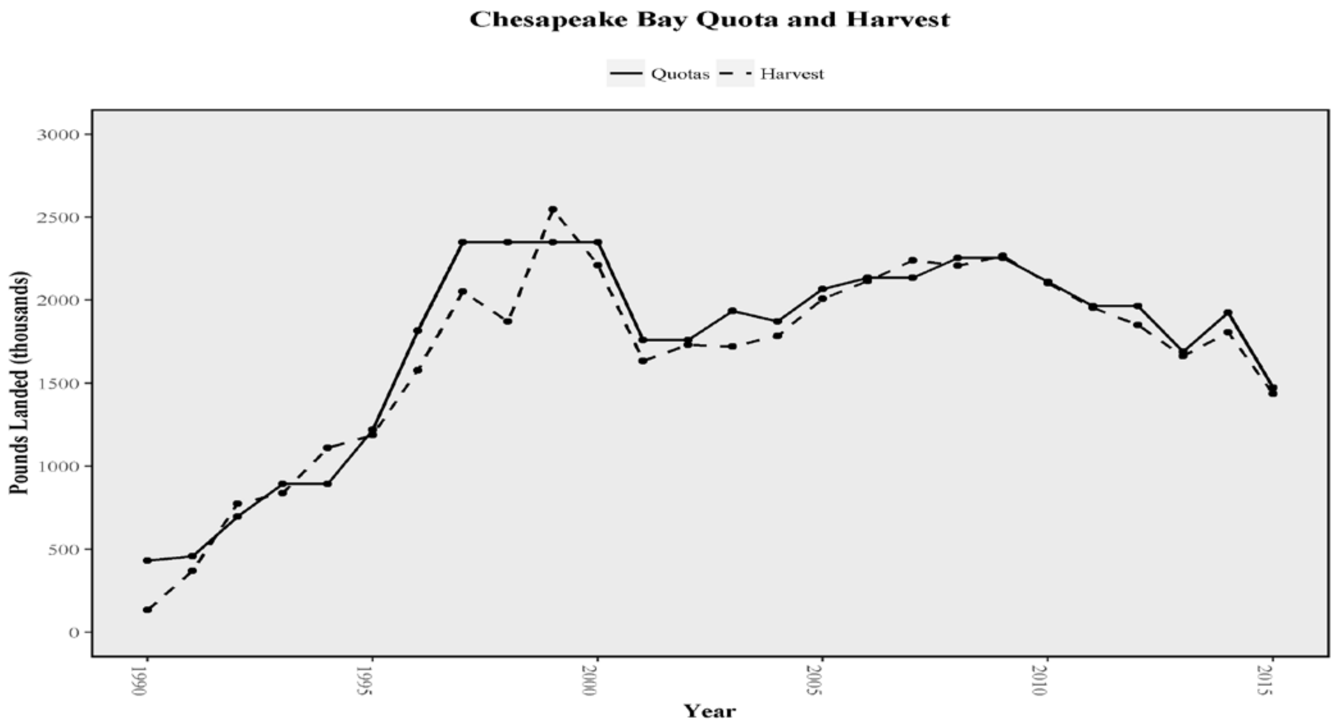


Figure 4. Maryland's Chesapeake Bay and Atlantic Ocean harvests (lbs) and quotas (lbs) for all gears, 1990-2015. Note different scales.



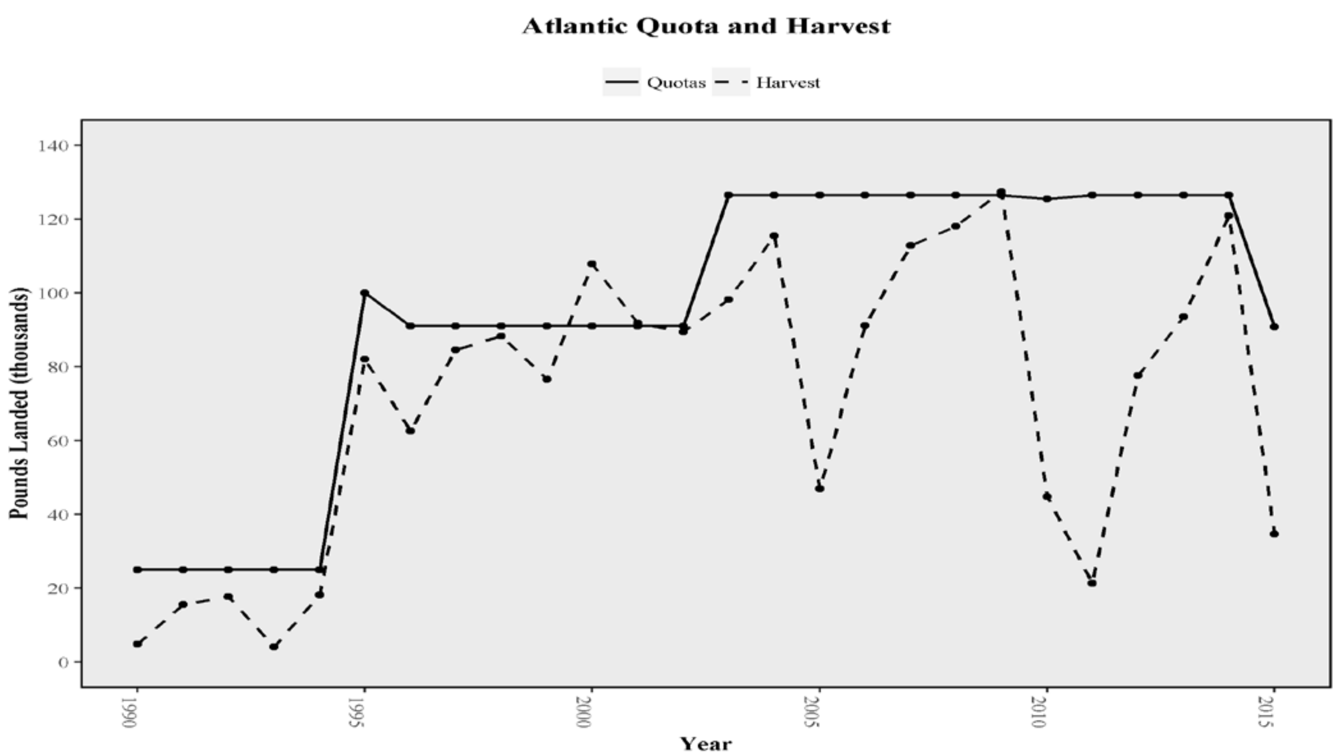


Figure 5. Maryland's Chesapeake Bay striped bass total harvest (thousands of pounds) per calendar year by commercial gear type, 1990-2015.

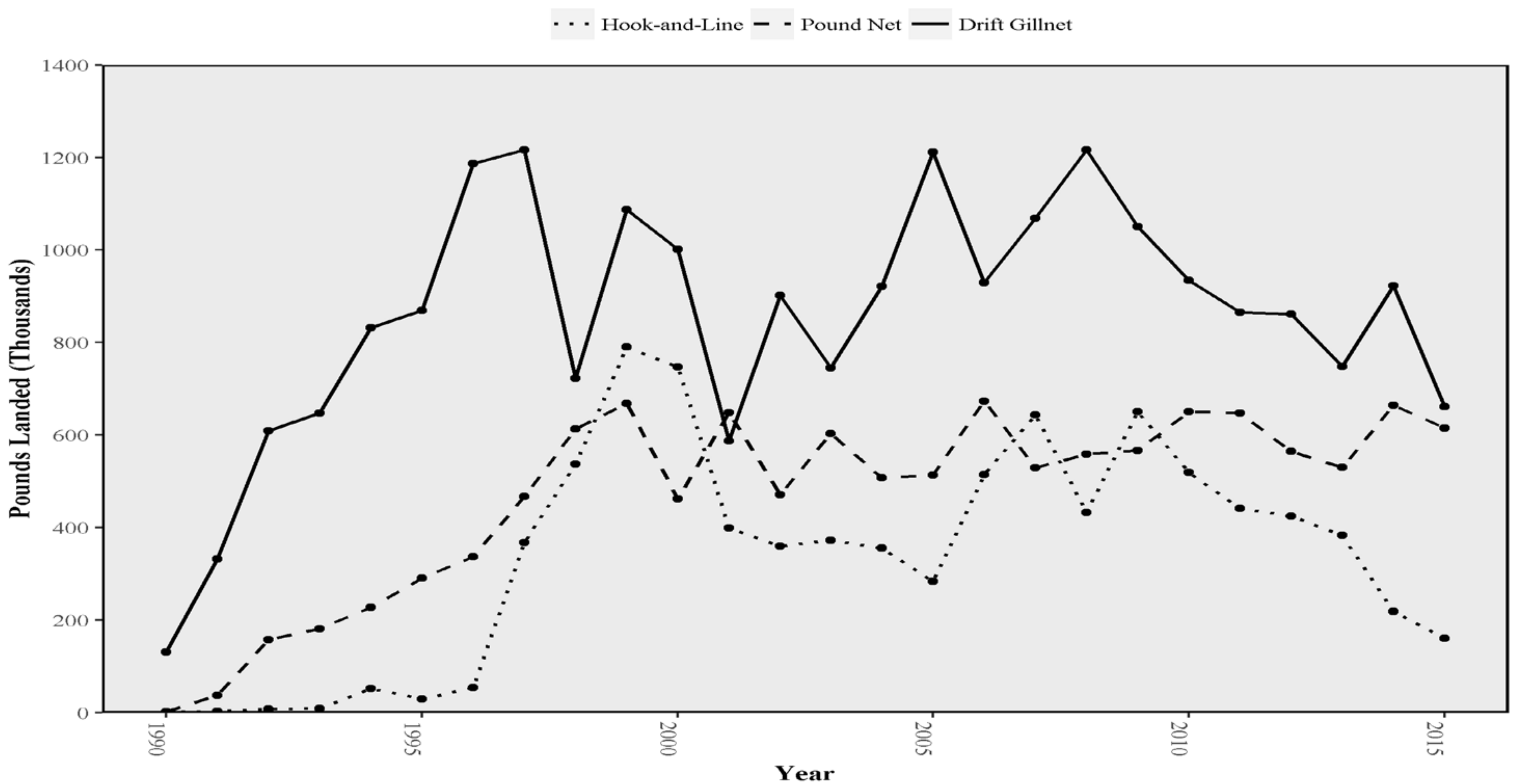


Figure 6. Maryland's Atlantic gill net and trawl fisheries total striped bass harvest (thousands of pounds) per calendar year by commercial gear type, 1990-2015.

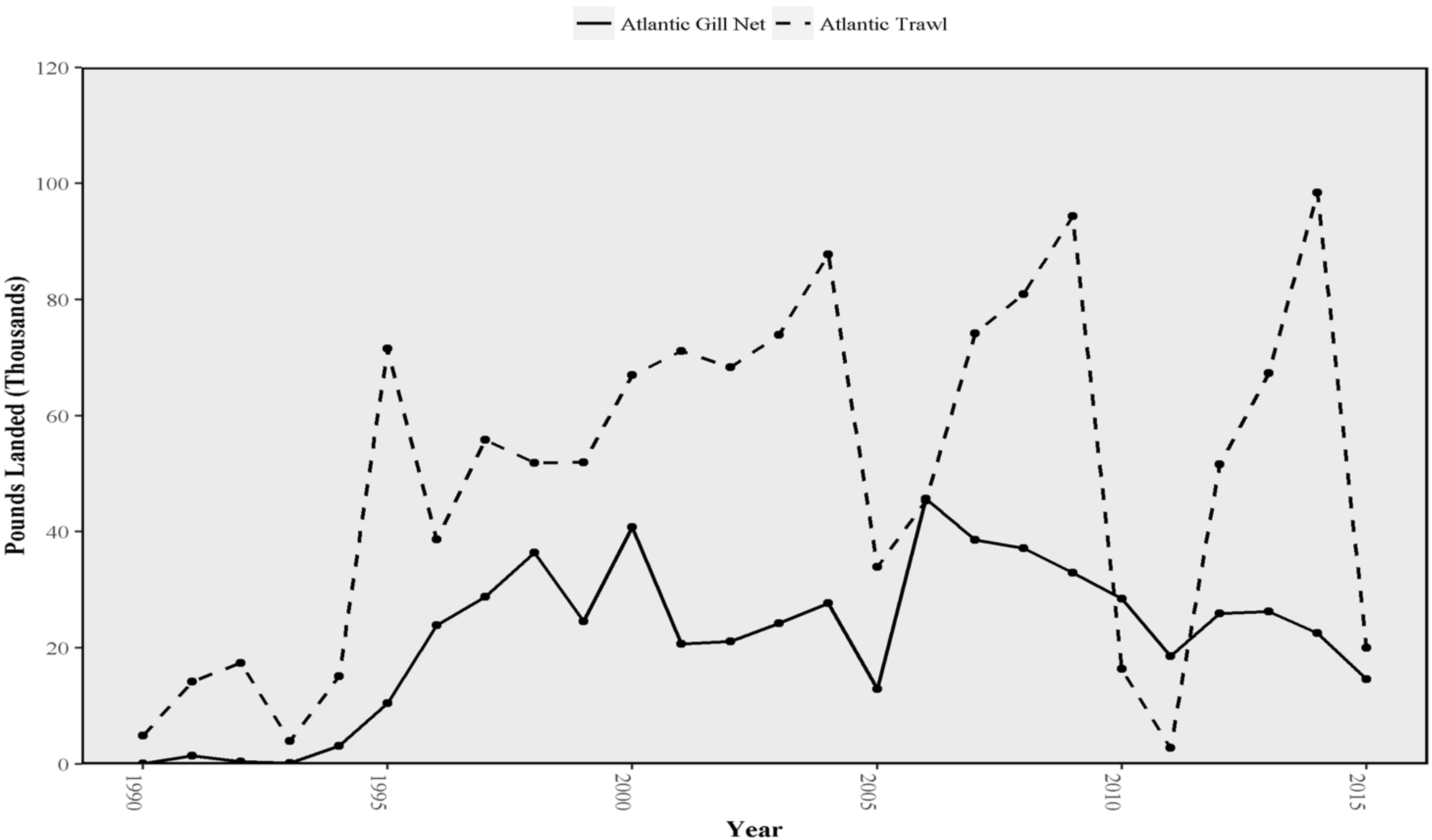


Figure 7. Maryland's Chesapeake Bay striped bass catch (pounds) per trip (CPUE) by commercial gear type, 1990-2015. Trips were defined as days fished when striped bass catch was reported.

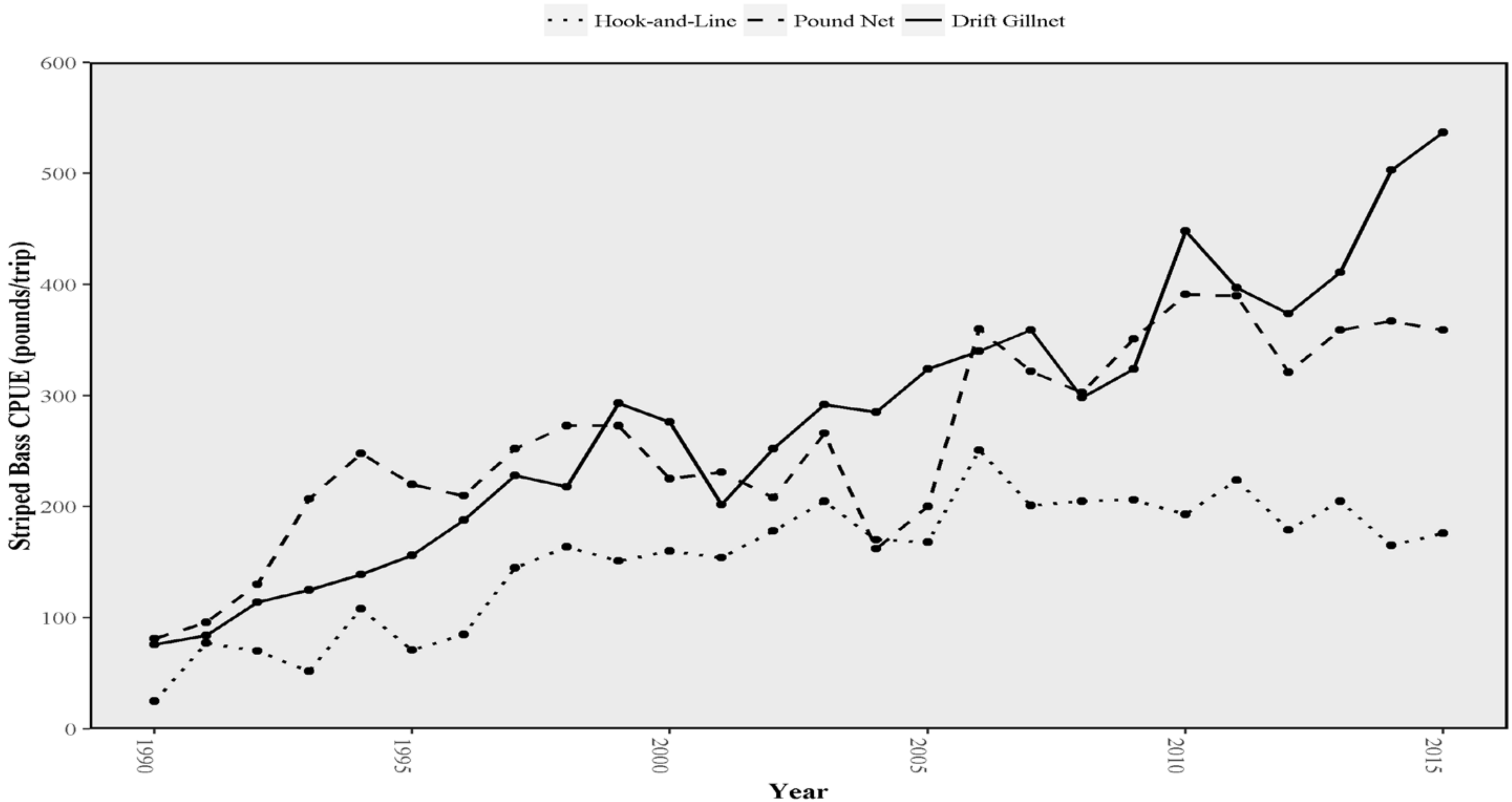
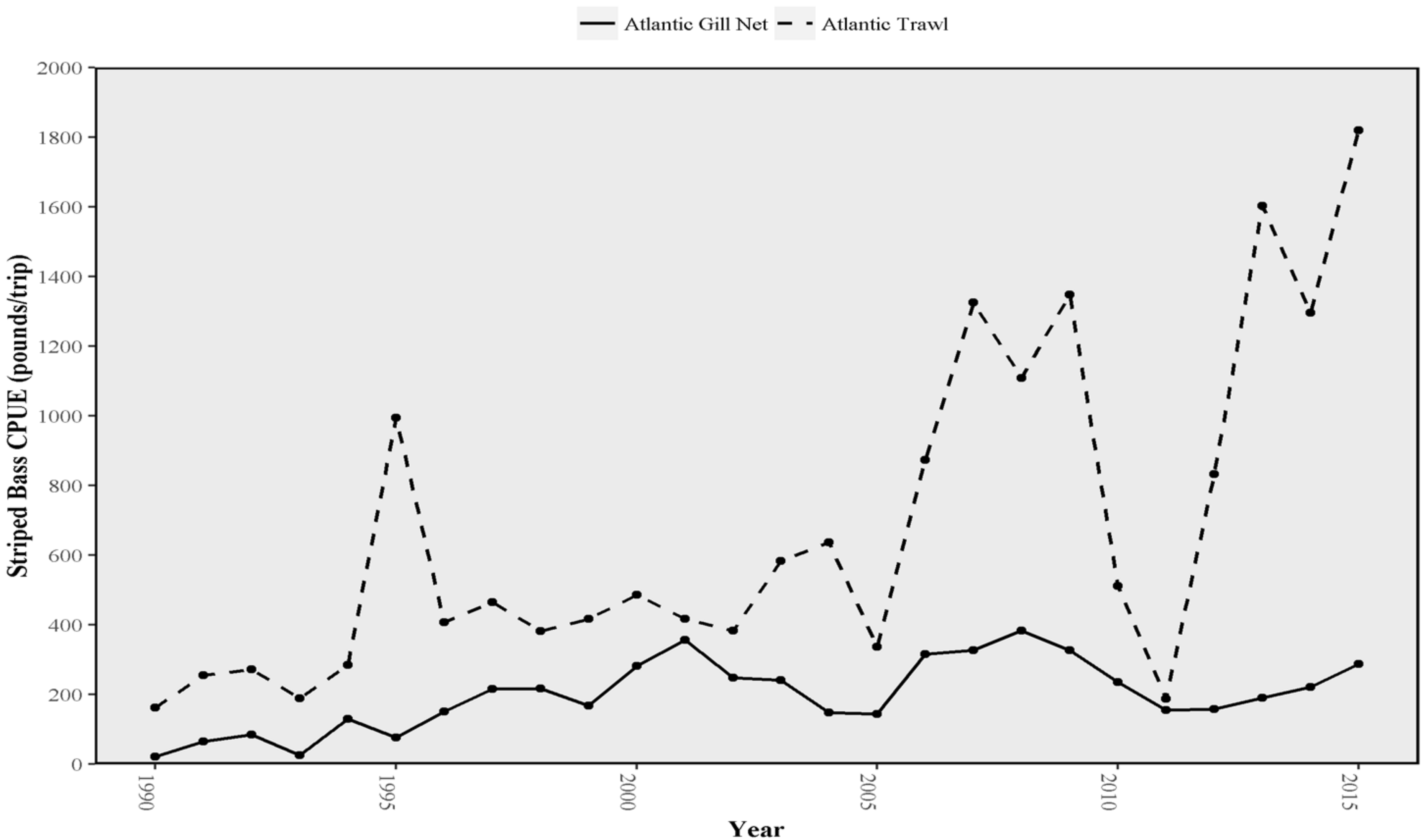


Figure 8. Maryland's Atlantic gill net and trawl fisheries striped bass catch (pounds) per trip (CPUE), 1990-2015. Trips were defined as days fished when striped bass catch was reported.



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 2016 spring recreational season, which began on Saturday, April 16 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 2016 spring season was 30 days long (April 16 – May 15), with a one fish ($\geq$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 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 four major charter fishing ports in 2016: Solomons Island/Bunky's Charter Boats, Kentmorr Marina, Chesapeake Beach/Rod & Reel, and Deale/Happy Harbor (Table 2A). 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 they 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 2016, 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 continued in 2016.

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 taken for 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. This is a multi-year study, and while the scale ages were included in the combined spring age-length key, the maturity and fecundity results are not available at this time.

Beginning in 2014, spleen samples were collected during the creel survey for mycobacteriosis monitoring and prevalence studies conducted and independently reported by the Cooperative Oxford Laboratory. Spleens were collected from striped bass 28 inches TL and greater that are considered part of the Atlantic coastal migratory population. Spleens were fixed in 10% buffered formalin. Once fixed, six randomly selected 4 mm cross-sections of the spleen were placed in labeled tissue cassettes. The cassettes were placed in 70% ethanol for storage until taken for histological preparation.

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 10/28/2016). 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 2016 comprised 49% 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 2016, 19% of the charter data was excluded.

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 2016, there were 585 anglers interviewed comprised of anglers intercepted from 221 private boats trips and 58 charter boat trips (Table 5A,B). A total of 197 fish were sampled from 58 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 2016 spring striped bass season, fish lengths measured from the harvest ranged from 878 mm TL to 1175 mm TL with a mean of 999 mm TL (n=197, Table 6A). Harvested striped bass were larger on average than previous years and the long-term average (910 mm TL) which could be due in part to the 35 inch (889 mm) minimum size limit (Table 1, Table 6A). However, the size distribution of harvested striped bass in 2016 shows 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 2016.

Mean length

The mean length of females (1002 mm TL) was greater than the mean length of males (951 mm TL), which is typical of the biology of the species. Male striped bass lengths in 2016 were

~12% larger than the long-term average but due to the low sample size (n=13) 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 2016 (1002 mm TL) was 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 spring 2016 season was larger than any previous year.

The mean daily lengths of female striped bass harvested in 2016 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 2016, anglers reported lengths for 127 striped bass caught during the trophy season. The mean reported length of fish released was 413 mm TL (n=101). The mean length of striped bass harvested from the Volunteer Angler Survey was 982 mm TL (n=26) which is similar to the mean length from the creel survey (999 mm TL) given that volunteer anglers measure and report lengths in inches (1 inch = 25.4 mm).

Mean weight

Fish weights sampled during the 2016 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 5 years from 6.7 kg in 2012 to a maximum of 10.2 kg in 2016 (Table 6B, Figure 5).

The mean weight of females (10.3 kg) was greater than the mean weight of males (8.4 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 ($\alpha = 0.05$) found that the mean weight of female fish sampled in 2016 (10.3 kg) was significantly greater than all other years and was 26% greater than the long-term mean of 8.2 kg (Table 6B, Figure 5). The low sample size of male striped bass (n=13) precluded significance testing, but qualitatively the mean weight of males (8.4 kg) in 2016 was the largest value in the time-series and 33% greater than the long-term mean (6.3 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 2016 spring recreational harvest ranged from 8 to 18 years old (Figure 6). The 2003 (13 years old), 2004 (12 years old) and 2005 (11 years old) year-classes were the most frequently observed cohorts, constituting 27%, 24%, and 25% of the of the sampled harvest, respectively. The oldest striped bass in the harvest were estimated to come from the 1998 year class (18 years old).

Sex Ratio

The data included three designations for sex: female, male and unknown. As in past years, the 2016 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 affect the proportion of females in the sampled harvest as there were no fish of unknown sex in 2016. Females constituted 93% 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 – 2016 the percentage of pre-spawn females in the spring season harvest has declined over-all from a maximum of 63% in 2005 to a minimum of 13% in 2016 (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 date of sampling (5/12/2016) 100% of the females sampled were in post-spawn condition. This pattern suggests that most female fish harvested in the spring season in 2016 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 2016. Because of increased focus on improving our understanding of private boat fishing effort, all trips intercepted during the trophy season in 2016 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 2016 according to charter boat data was 3.9 fish per trip (Table 9A) which was 19% below the long term mean charter boat HPT (4.8 fish per trip) and the second lowest in the time series after 2015. Mean

HPT from private boat interviews (0.5 fish per trip) was also the second lowest in its time series after 2015 and 44% 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 2016 was 0.65 fish per person (Table 9B) which was a 16% reduction from the long-term mean (0.77 fish per trip). HPA for private anglers, calculated from interview data, was 0.2 fish per person which is similar to previous years (2007-2014) and higher than 2015 (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 2016, private boats caught an average of 2.6 fish per trip, higher than any previous year except 2004 (3.5 fish per trip), and similar to 2006 (2.3 fish per trip, Table 10A). The high mean catch per trip rate in 2016, despite a corresponding low harvest rate, could be due in part to catch and release fishing trips that target abundant sub-legal sized individuals from the 2011 year-class. Three catch and release trips were encountered during private boat interviews in which the numbers of fish caught and released using gear not suitable for larger fish (e.g. jigging with light tackle) ranged from 60 to 100 fish per trip. Charter boats caught 5.2 fish per trip, which is slightly lower than the long-term average (6.3 fish per trip) but similar to 2012 and 2013 (Table 10B). The private boat catch per hour (CPH) was 0.5 fish per hour while charter boats had a CPH of 0.9 fish per hour. The 2016 private boat CPH was greater than any recent year since 2006 mirroring the catch per trip, while the charter boat CPH was similar to previous years.

Angler Characterization

States of residence

In 2016, 585 anglers were interviewed during the period April 16-May 15 (Table 5A). Twelve states of residence were represented in 2016 (Table 11). Most anglers were from Maryland (81%), Virginia (8%), and Pennsylvania (4%), 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 2016, there were on average 2.6 anglers per boat and of these anglers, 1.3 were license-exempt (Table 12). These results were consistent with previous years.

Angler Gender

In 2016, 91% of anglers interviewed by the creel survey were male and 9% were female (Table 13). These values are similar for all years surveyed in which the percentage of male anglers is consistently above 90%. The highest proportion of female anglers was encountered in 2016 (9%) while the lowest was encountered in 2005 (3%).

Number of Lines Fished

To further characterize fishing effort, a question was added to the creel survey in 2006 and 2010-2016 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 2016, the average number of lines fished per private boat was 8 and ranged from 1 to 25 lines (Table 13). This was more lines, on average, than in 2006 (6 lines) but similar to more recent years.

Dollars Spent per Day

Anglers spent an average of $83 per trip in 2016 (Table 15). Dollars spent by anglers is expected to vary each year due to fluctuations in the price of fuel and other commodities. The decrease in the dollars spent since 2006 is due in part to the fact that fewer or no charter boat anglers were interviewed. Private boat anglers would mainly be paying for gas, food, bait, etc. while charter boat fees are generally higher per person.

Anglers' Years of Experience Fishing and Trips per Year

Anglers interviewed during the 2016 creel survey had been fishing for striped bass in Chesapeake Bay an average of 21 years (Table 16). This is consistent estimates from previous years which had a mean ranging from 13 years (2002) to 27 years (2013). In 2016, the range of anglers' fishing experience for striped bass during the trophy season ranged from 1 to 70 years.

In 2016, anglers were asked approximately how many fishing trips they take per year specifically during the spring trophy season (Table 17). Answers ranged from one trip to 40 trips per year during the spring trophy season with a mean of 7 trips per year.

Angler Satisfaction with Regulations

Anglers were asked if they were satisfied with three aspects of the current spring trophy season regulations: 1) size limits, 2) creel limits, and 3) season length. In 2016, 80%, 81%, and 80% of the respondents said they were satisfied with the current striped bass size limits, creel, limits, and season length regulations respectively (Table 18). A small percentage of respondents were dissatisfied with either size limits (6%), creel limits (9%), or season length (8%). Although a majority of anglers were satisfied with the current regulations based on their confidence in the management system, they nonetheless shared comments and suggestions for regulation changes that they perceived to improve aspects of the striped bass fishery that they value (i.e. increased conservation, increased fishing opportunities, increased harvest, etc).

The high diversity of comments about current and previous regulations received from anglers can be broadly summarized into two categories: 1) suggestions intended to increase conservation of the striped bass stock through protection of spawners, and 2) suggestions intended to increase striped bass fishing success during the spring season. Of the first category, suggestions included: ending pre-season catch and release fishing due to the potential for discard mortality, delaying the start of trophy season to protect pre-spawn females, increasing the minimum size limit, and eliminating the spring trophy season entirely. Of the second category, suggestions included: an earlier opening date for the trophy season, an earlier opening date for area closures (i.e. allowing harvest in rivers), a decreased minimum size limit, and increasing the creel limit to 2 fish per person per day. Some respondents also commented on the trade-offs of changing different aspects of the regulations. For example, one comment suggested delaying the start of the spring trophy season, but then eventually increasing the creel limit to two fish per person per day. Several comments also stressed a strong desire for more simplicity and consistency in regulations along with dissatisfaction of the previous year (2015) slot limit which was viewed as overly complicated.

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

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

2017 PRELIMINARY RESULTS

Data collected during the 2017 spring recreational season (April 15-May15) are currently being analyzed. In 2017, two creel clerks performed dockside creel interviews twice a week with private anglers from April 15 to May 15 for a total of seven sample days. 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 15 to May 15 for a total of nine sample days.

During the 2017 spring recreational season, a total of 500 anglers were interviewed from 190 intercepted private boat trips. Among all anglers interviewed only 38 striped bass were reported harvested. Private angler catch and harvest rates of striped bass during the 2017 spring recreational season were historically low. For private boat anglers, mean catch and harvest rates were 0.43 per angler trip and 0.07 per angler trip respectively.

During the 2017 spring recreational season, a total of 149 striped bass from 74 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 143 scale samples, 43 otoliths, 6 dorsal fin spines and 10 ovary samples. Female striped bass (n=137) were a mean Total Length of 1011 mm and mean weight of 10.8 kg. Internal examination revealed 88% of female striped bass harvested had recently spawned. Male striped bass (n=12) were a mean Total Length of 928 mm and a mean weight of 8.9 kg. Scale samples are currently being processed and aged, therefore no age distribution of the 2017 spring recreational harvest is available at this time.

The final, complete analyses of the spring 2017 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, 1991-2016.

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**

Table 2A. Survey sites for the Maryland striped bass spring season dockside creel survey, 2002-2016. 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, 2016.

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, 2016.

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, 2016.

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

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

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)
Mean	**910** (894-928)	**920** (905-938)	**855** (838-875)

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)
Mean	**7.9** (7.5-8.3)	**8.2** (7.8-8.6)	**6.3** (6.0-6.7)

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

Table 7B. Percent females, using three different calculation methods, sampled by the Maryland striped bass spring season creel survey, through May 15.

Year	%F (Include U)	%F (Exclude U)	%F (Assume U were Female)
2002	68	83	86
2003	84	92	92
2004	88	90	90
2005	85	86	86
2006	85	86	86
2007	80	83	84
2008	78	78	78
2009	77	78	78
2010	81	81	81
2011	79	79	79
2012	75	75	75
2013	88	88	88
2014	92	92	92
2015	81	81	81
2016	93	93	93
Mean	**82** (79-86)	**84** (82-87)	**85** (82-87)

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
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)
Mean	1,665	**4.8** (4.4-5.1)	190	**0.9** (0.7-1.2)

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)
Mean	1,665	**0.77** (0.70-0.82)	190	**0.3** (0.3-0.4)

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)
Mean	190	**1.6** (1.3-2.1)	**4.9** (4.7-5.1)	**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)
Mean	1,665	**6.3** (5.8-6.8)	**4.6** (4.1-5.0)	**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**
AL	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
AZ	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
CA	1	0	1	0	0	2	0	0	0	0	0	0	0	1	0
CO	0	0	1	0	1	1	0	0	1	0	1	0	0	0	2
DC	6	1	1	0	1	2	1	0	6	1	0	1	0	0	0
DE	6	7	3	0	9	8	1	0	3	1	2	0	5	2	2
FL	0	0	1	1	2	0	1	0	3	1	0	1	0	1	1
GA	1	1	0	2	2	0	0	0	0	0	0	0	0	0	0
IL	0	0	0	0	1	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
KS	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0
MA	0	1	1	0	0	0	0	1	1	0	0	0	0	0	1
MD	**353**	**260**	**107**	**66**	**227**	**679**	**266**	**651**	**482**	**491**	**381**	**407**	**484**	**483**	**474**
MI	1	0	0	0	1	1	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
MT	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0
NC	0	2	0	1	0	1	1	0	0	0	3	0	1	0	1
NJ	2	2	6	0	3	2	4	0	0	1	3	0	2	0	0
NV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
NY	4	0	0	1	1	0	0	0	1	1	0	0	0	0	0
OH	0	0	0	0	0	3	1	0	1	0	1	0	1	0	0
PA	**27**	**19**	**17**	**4**	**22**	**32**	**16**	**46**	**18**	**19**	**23**	**21**	**30**	**24**	**25**
RI	2	0	1	0	0	0	0	0	0	0	1	0	0	0	0
SC	0	0	1	0	0	1	0	0	0	0	0	0	0	3	0
TN	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
TX	0	1	0	0	0	0	0	0	0	0	1	2	0	0	1
VA	**48**	**31**	**30**	**13**	**56**	**71**	**29**	**44**	**42**	**23**	**26**	**20**	**39**	**27**	**49**
VT	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
WA	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
WI	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
WV	0	1	0	2	6	3	2	4	4	0	4	2	10	3	5
Intl.	0	0	1	0	0	0	0	0	0	1	0	0	0	1	0
Unknown	0	0	0	0	0	0	0	0	36	0	0	0	0	0	2

Table 12. The average number of anglers and average number of unlicensed anglers, per boat, with 95% confidence intervals, from the 2008-2016 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)

Table 13. Percent of male and female anglers interviewed by the Maryland striped bass spring season creel survey.

Year	% Male	% Female
2002	95	5
2003	96	4
2004	96	4
2005	97	3
2006	92	8
2007	93	7
2010	95	5
2013	93	7
2016	91	9

Table 14. 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

Table 15. Dollars spent (per day) by anglers on striped bass fishing trips during the Maryland spring striped bass season.

Year	Minimum	Maximum	Median	Mean
2002	$0	$500	$100	$104
2003	$0	$1,300	$80	$90
2004	$0	$1,000	$100	$114
2005	$0	$1,200	$100	$148
2006	$0	$1,000	$100	$111
2007	$0	$3,000	$50	$63
2010	$0	$500	$76	$89
2013	$0	$600	$80	$119
2016	$0	$400	$50	$83

Table 16. Interviewed anglers' experience (years) fishing for striped bass in Chesapeake Bay.

Year	Minimum	Maximum	Median	Mean
2002	0	60	10	13
2003	0	75	20	20
2004	0	68	12	16
2005	0	64	20	23
2006	0	60	15	18
2007	0	70	21	23
2010	1	60	20	24
2013	0	60	29	27
2016	1	70	20	21

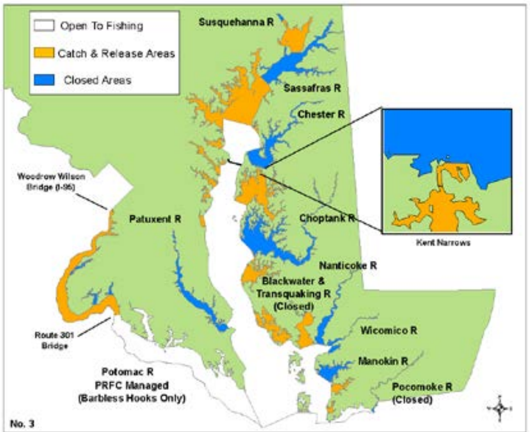
Table 17. Number of fishing trips anglers take per year in Chesapeake Bay. Data in 2016 are number of fishing trips anglers take per year specifically during the spring trophy season.

Year	Minimum	Maximum	Median	Mean
2010	1	100	15	22
2013	2	365	20	28
2016	1	40	5	7

Table 18. Percent of interviewed anglers expressing satisfaction with Maryland Chesapeake Bay striped bass fishing regulations. In 2016, anglers were asked about satisfaction with the current size limit, creel limit, and season length separately.

<table>
<tr><th>Year</th><th colspan="3">Satisfied (%)</th><th colspan="3">Neutral (%)</th><th colspan="3">Not Satisfied (%)</th></tr>
<tr><td>2002</td><td colspan="3">68</td><td colspan="3">NA</td><td colspan="3">32</td></tr>
<tr><td>2003</td><td colspan="3">84</td><td colspan="3">NA</td><td colspan="3">16</td></tr>
<tr><td>2004</td><td colspan="3">70</td><td colspan="3">NA</td><td colspan="3">30</td></tr>
<tr><td>2005</td><td colspan="3">59</td><td colspan="3">NA</td><td colspan="3">41</td></tr>
<tr><td>2006</td><td colspan="3">70</td><td colspan="3">NA</td><td colspan="3">30</td></tr>
<tr><td>2007</td><td colspan="3">64</td><td colspan="3">NA</td><td colspan="3">36</td></tr>
<tr><td>2010</td><td colspan="3">75</td><td colspan="3">NA</td><td colspan="3">25</td></tr>
<tr><td>2013</td><td colspan="3">80</td><td colspan="3">NA</td><td colspan="3">20</td></tr>
<tr><td>2016</td><td>Size Limit: 80</td><td>Creel Limit: 81</td><td>Season Length: 80</td><td>Size Limit: 14</td><td>Creel Limit: 10</td><td>Season Length: 12</td><td>Size Limit: 6</td><td>Creel Limit: 9</td><td>Season Length: 8</td></tr>
</table>

Figure 1. MD DNR maps showing legal open and closed striped bass fishing areas in Chesapeake Bay during the spring season, April 16-May 3, 2016 and May 4-May 15,, 2016



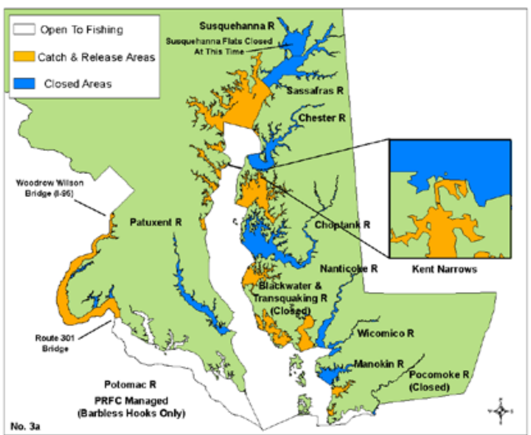


Figure 2. Length distribution of striped bass sampled by year, during the Maryland striped bass spring season creel survey, through May 15.

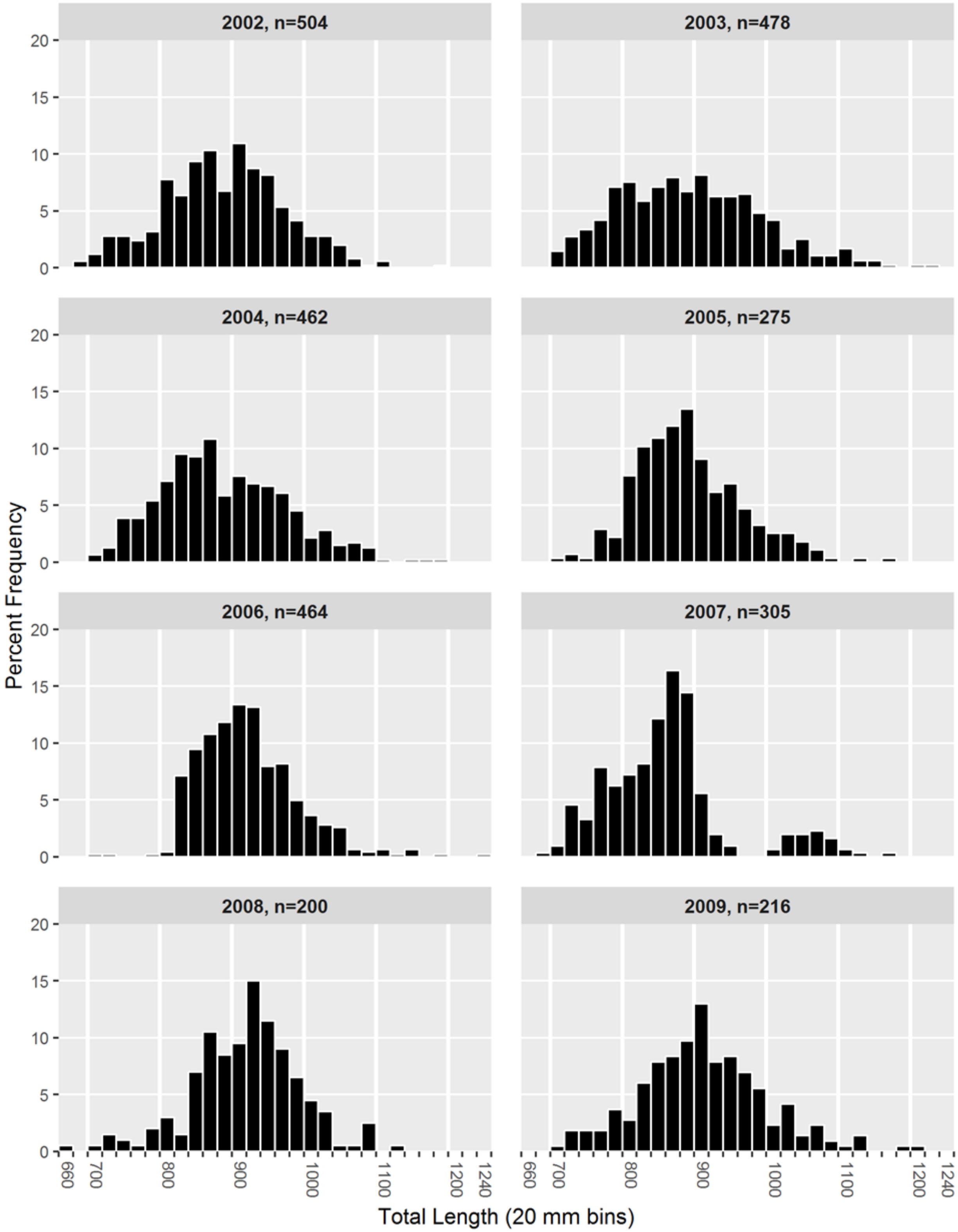


Figure 2. Continued.

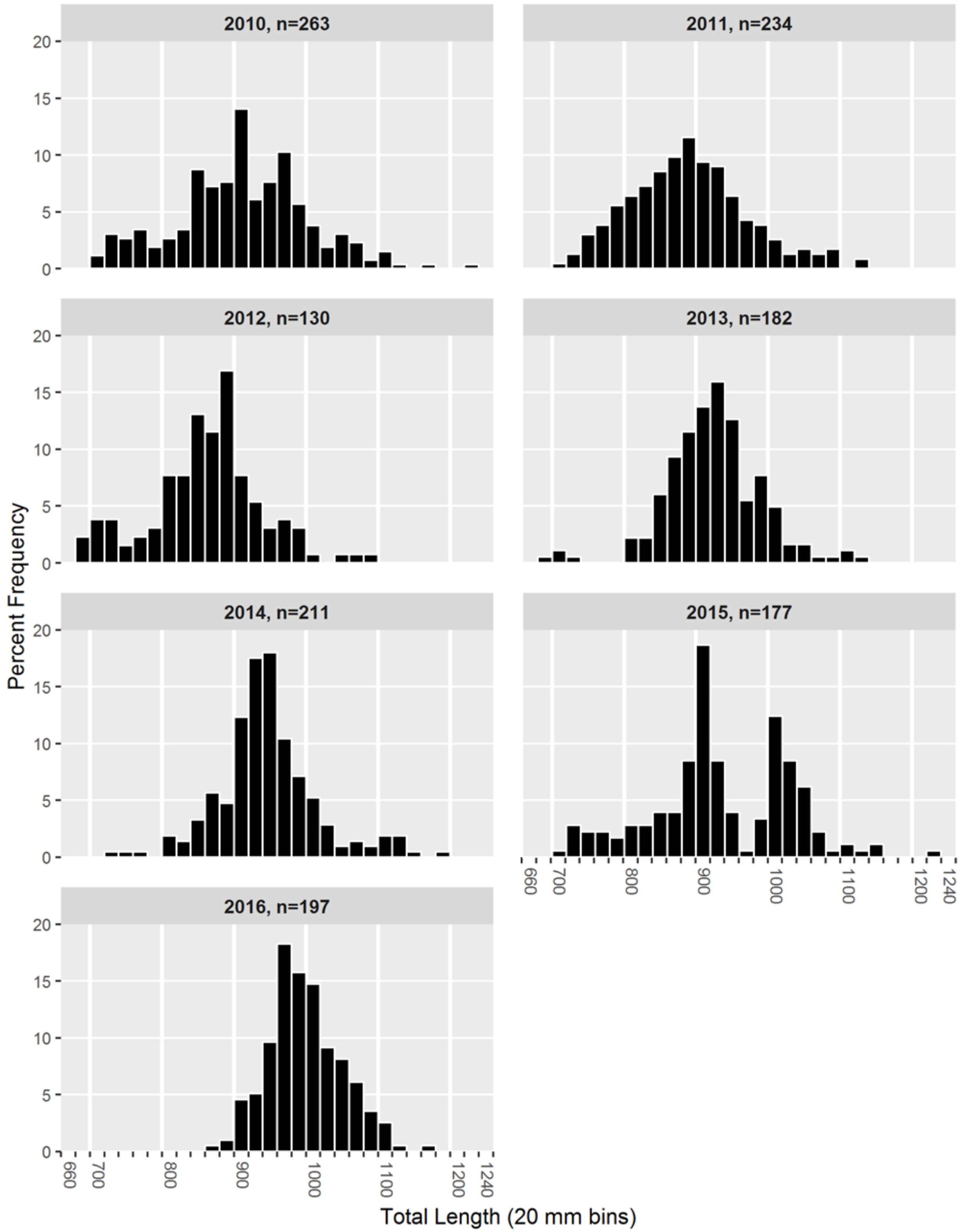


Figure 3. Mean length of striped bass (mm TL) with 95% confidence intervals, sampled by the Maryland striped bass spring season creel survey, through May 15. Lower case letters indicate pairwise differences among years (Duncan's multiple range test, α=0.05).

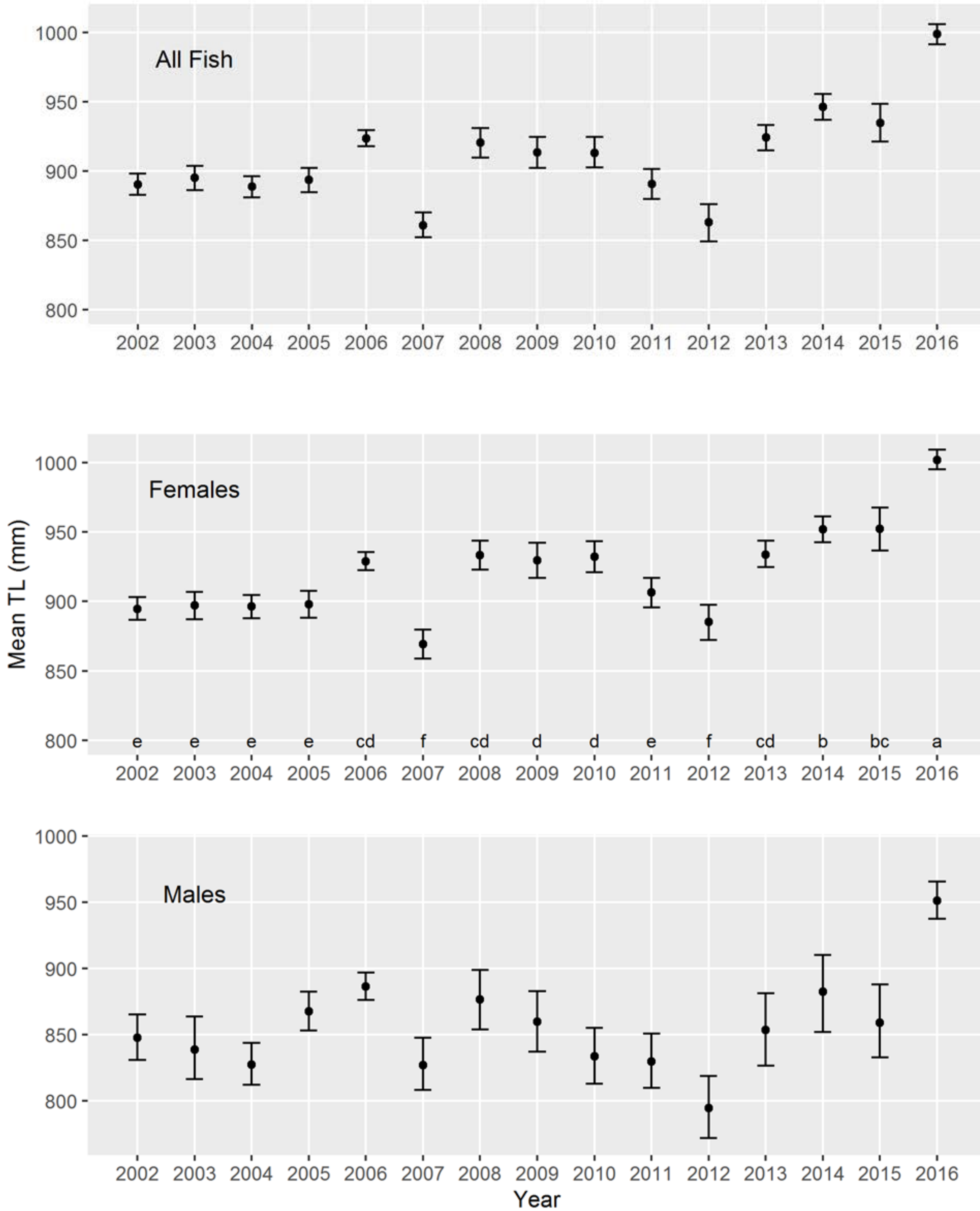


Figure 4. Mean daily length of female striped bass with 95% confidence intervals, sampled by the Maryland striped bass spring season creel survey, through May 15.

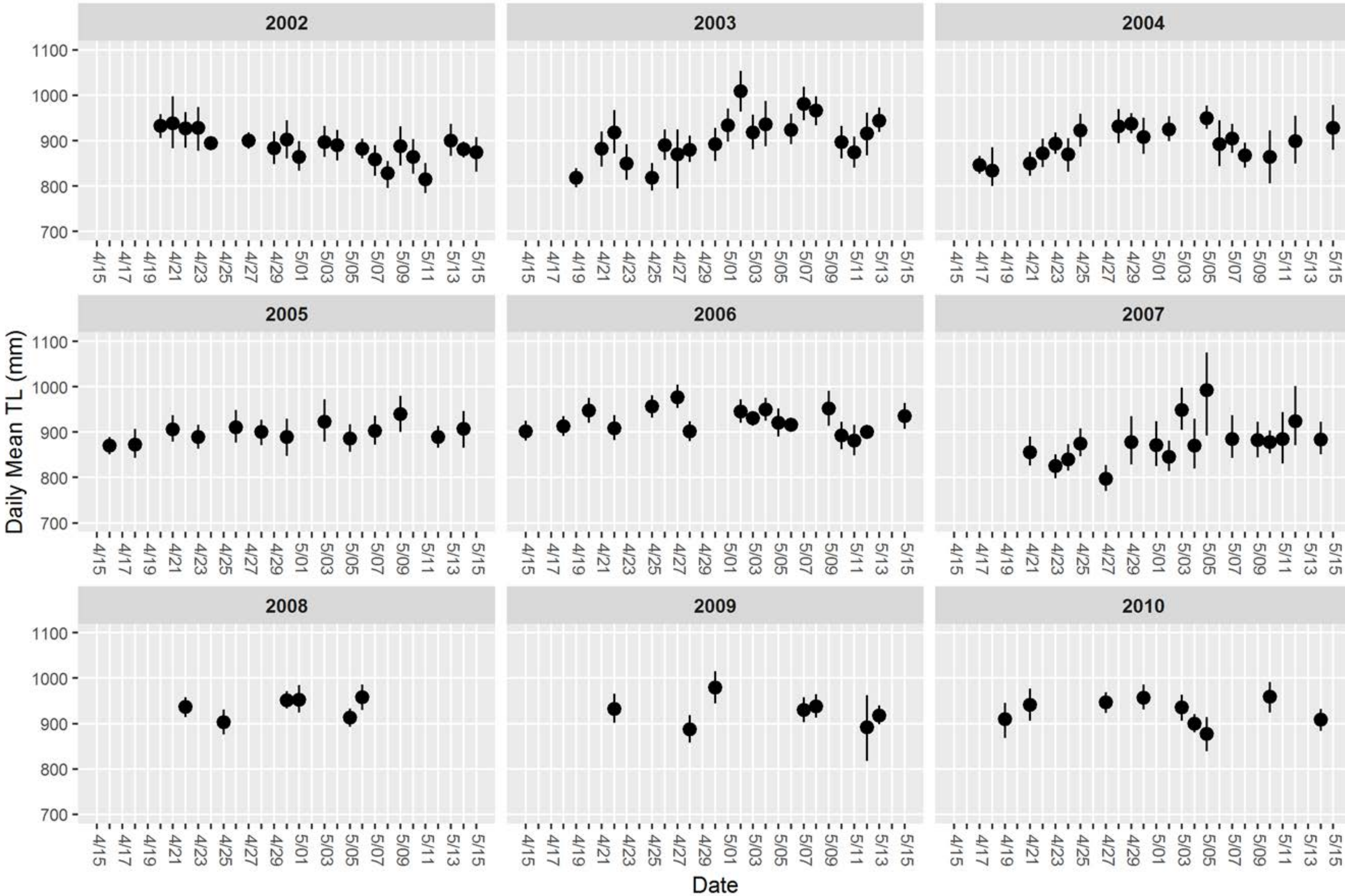


Figure 4. Continued.

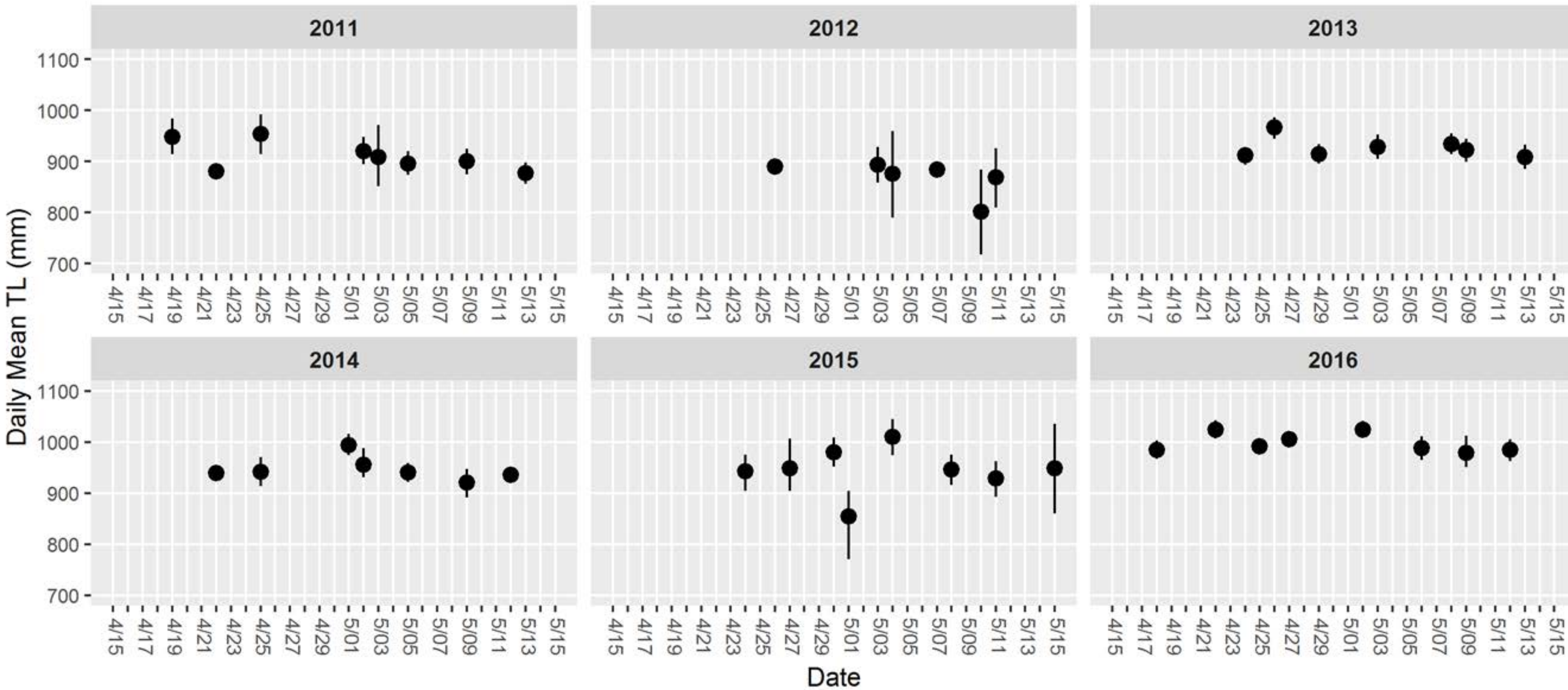


Figure 5. Mean weight of striped bass (kg) with 95% confidence intervals, sampled by the Maryland striped bass spring season creel survey, through May 15. Lower case letters indicate pairwise differences among years (Duncan's multiple range test, α=0.05).

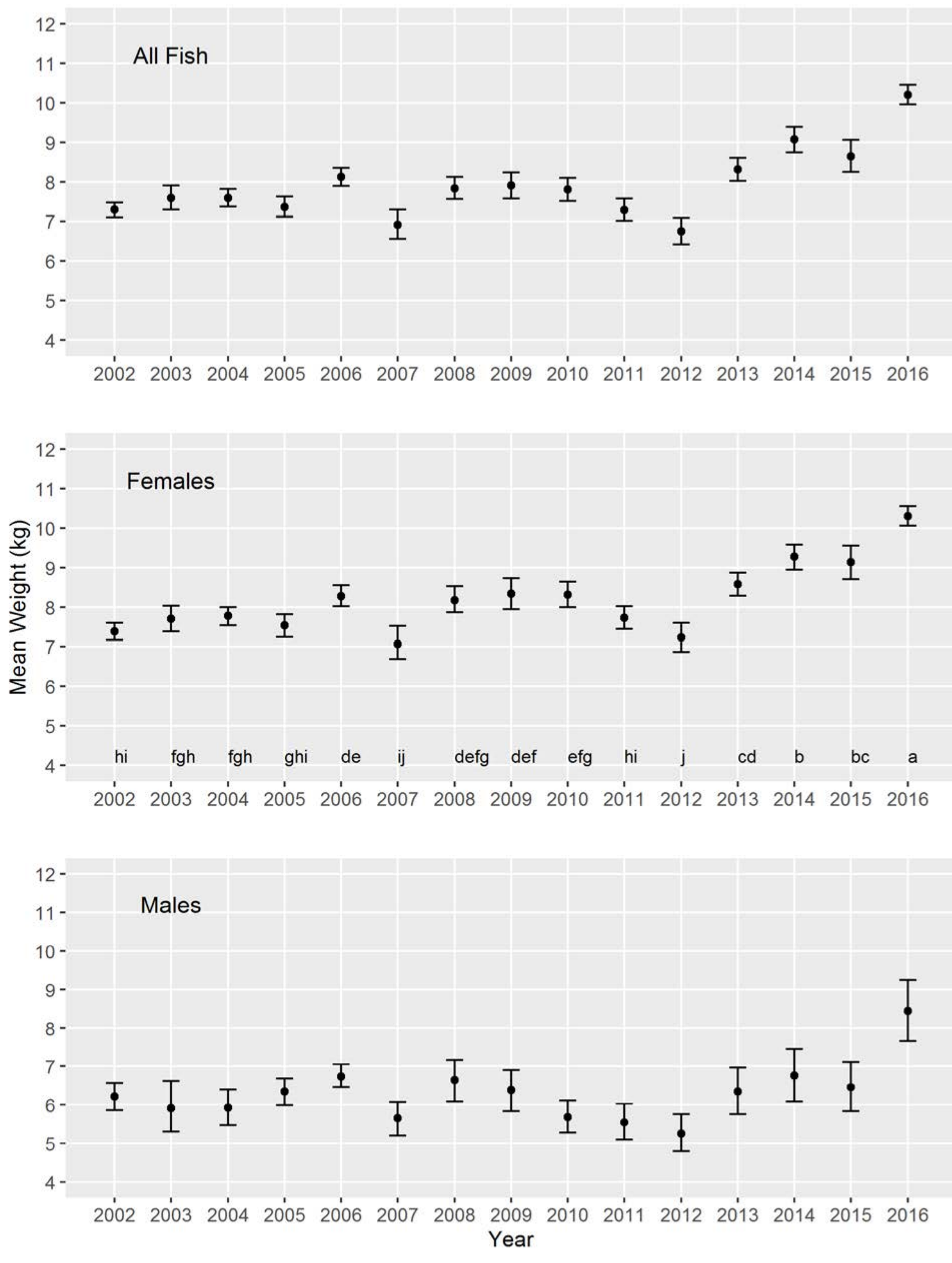


Figure 6. Estimated age distribution of striped bass sampled by the Maryland striped bass spring season creel survey, through May 15.

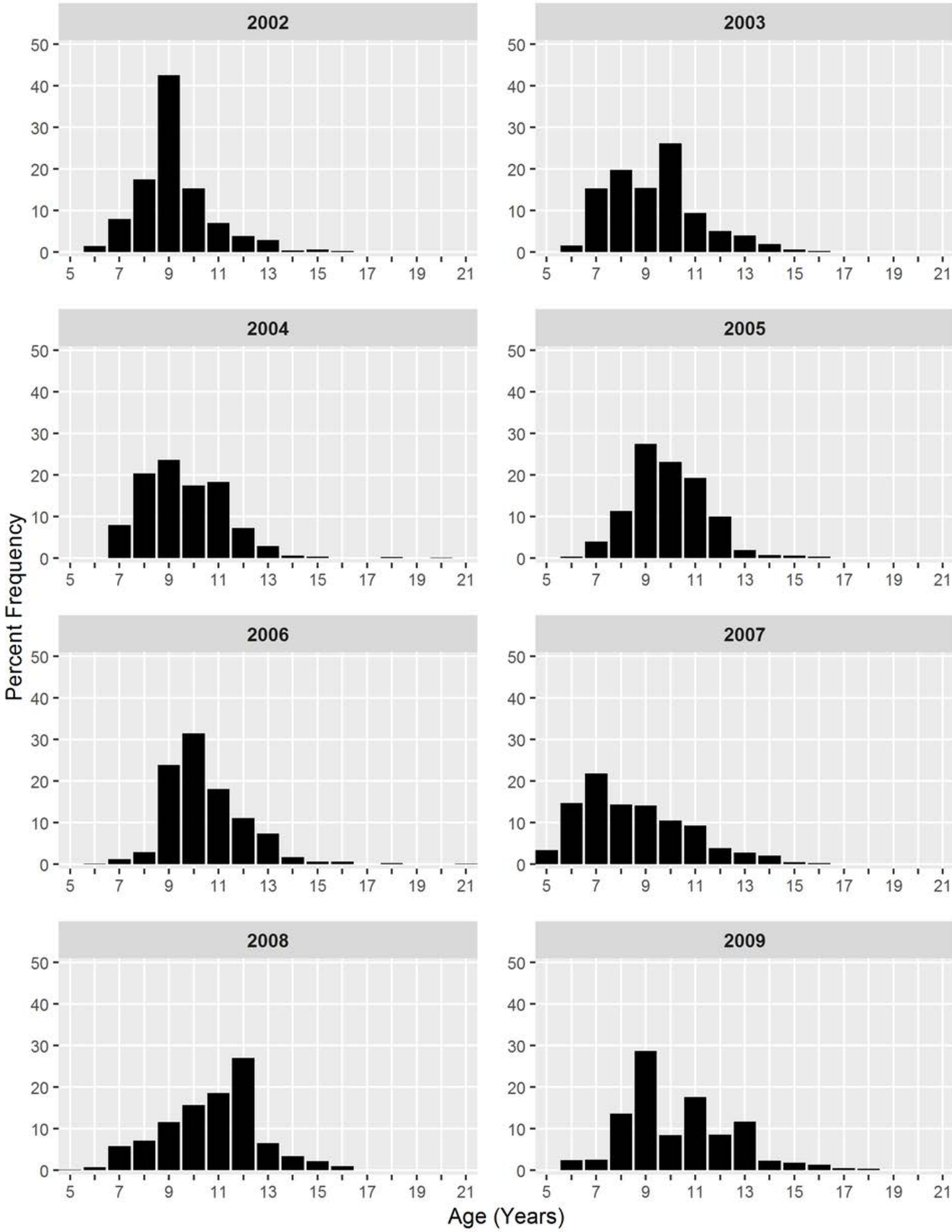


Figure 6. Continued.

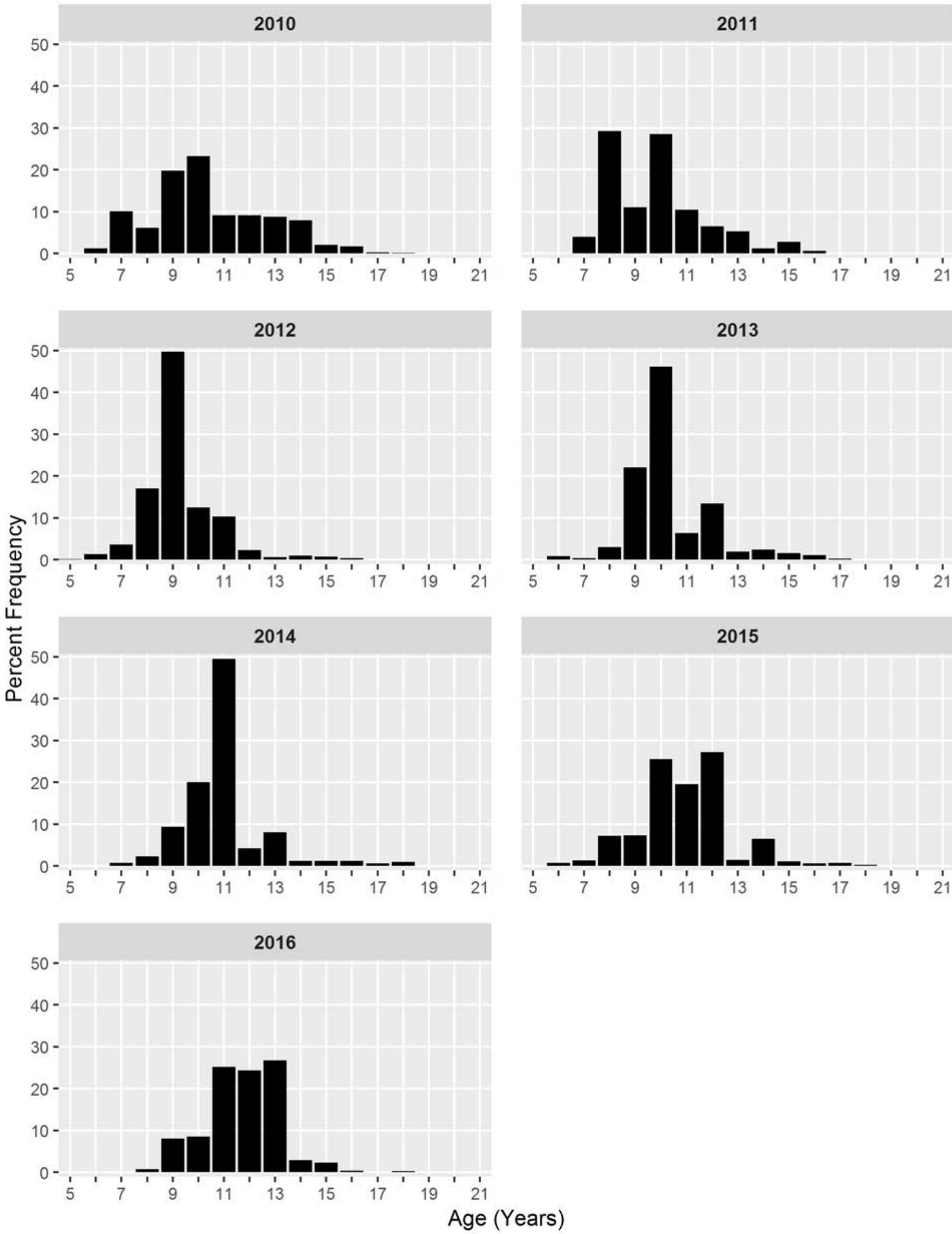


Figure 7. Daily percent of female striped bass in post-spawn condition sampled by the Maryland striped bass spring season creel survey, through May 15.

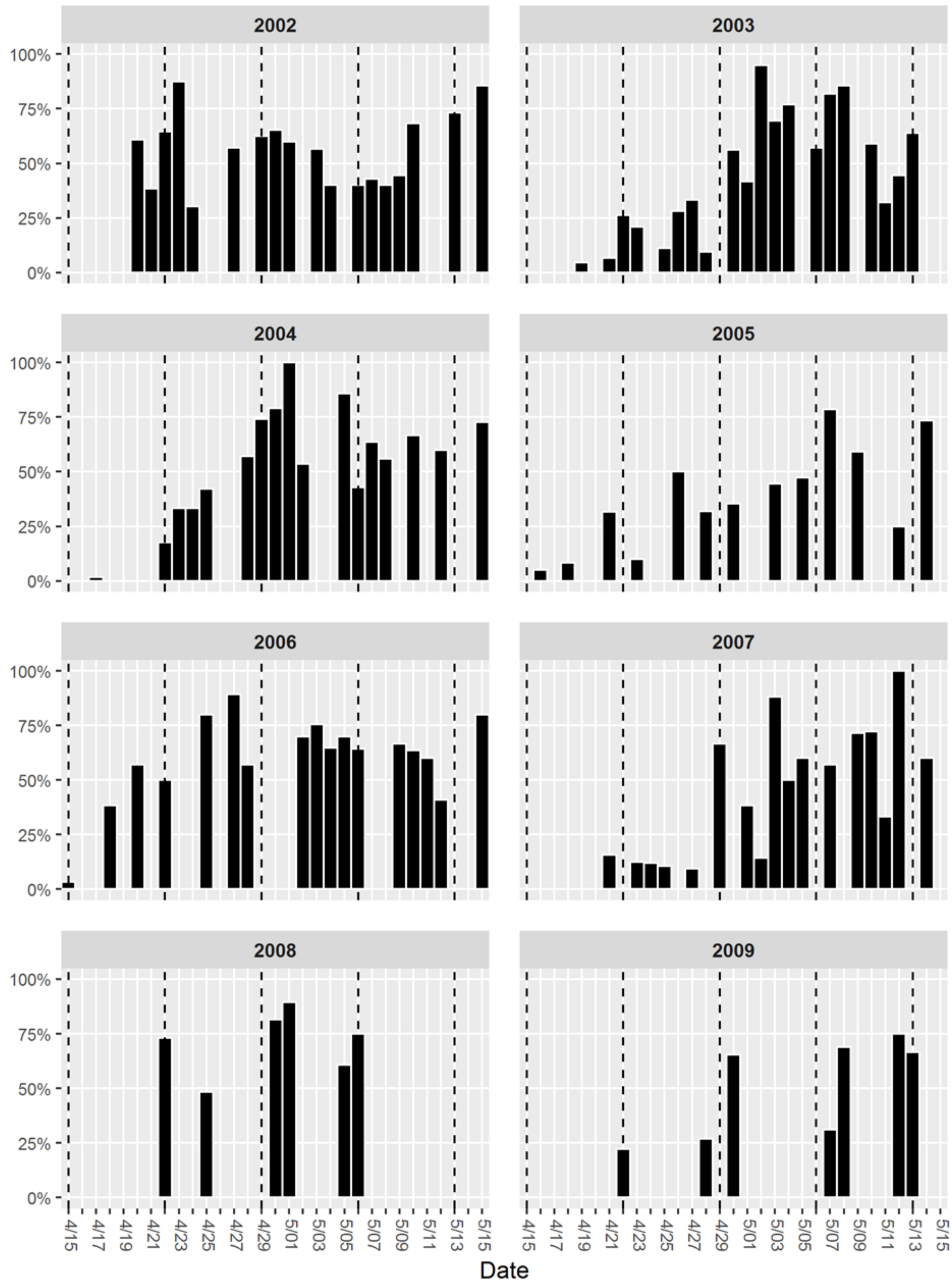
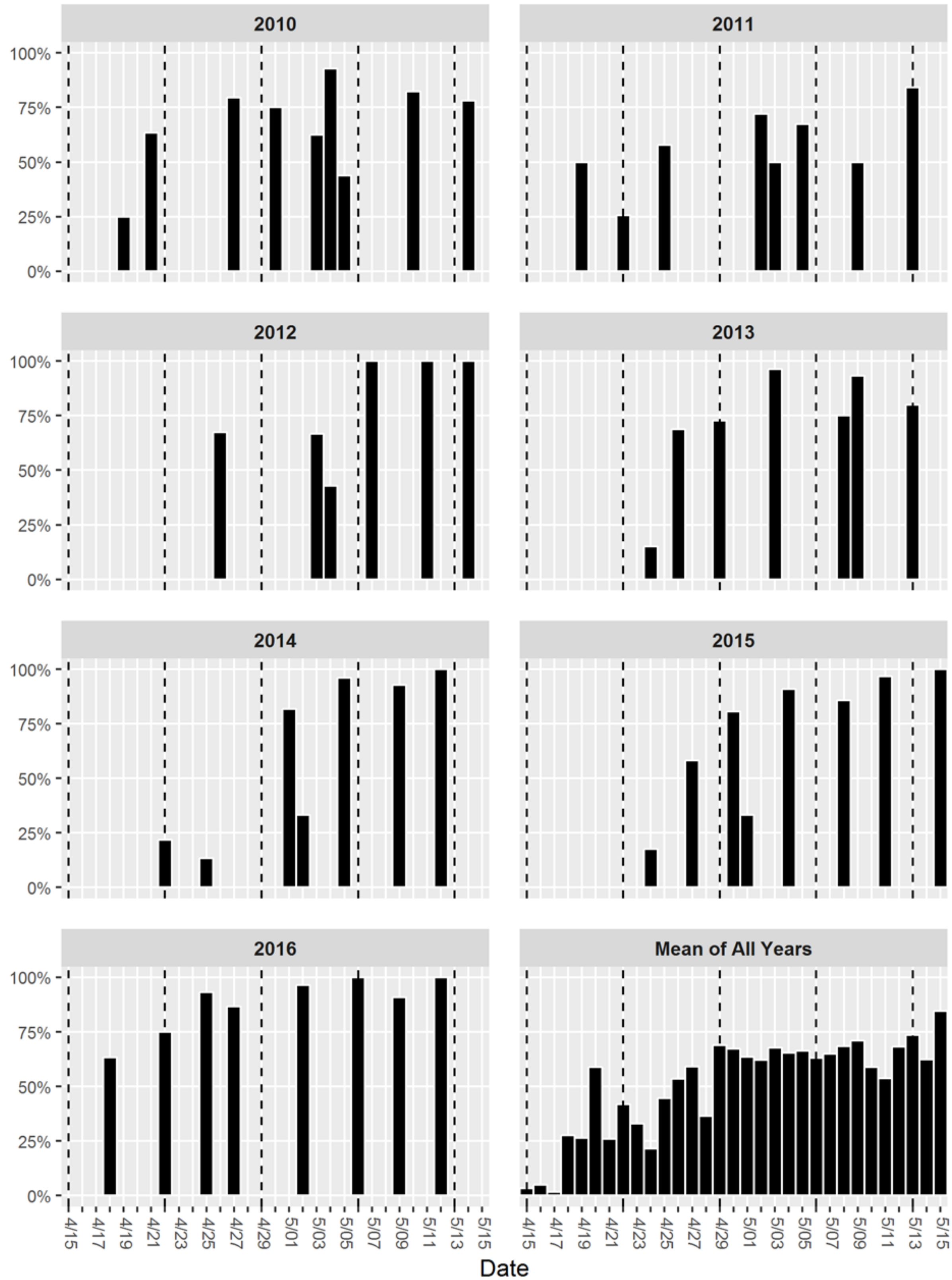


Figure 7. Continued.



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. Gender of Anglers
8. What is your state of residence?
9. Approximately how much money did you spend today to go fishing? (Gas, food, tackle, fare, tip; **excluding the cost of the license**)
10. How many years have you been fishing for striped bass?
11. Approximately how many fishing trips do you take per year?
12. Licenses:
    a. Do you have a boat license? Yes/No
    b. How many anglers in your party also have their own individual licenses?
13. What is your level of satisfaction with the **current** (trophy season April 18-May15 OR summer/fall May 16-Dec15) MD Bay striped bass regulations? (Scale: 1. Very satisfied; 2. Somewhat satisfied; 3. No opinion; 4. Somewhat dissatisfied; 5. Very dissatisfied)
    a. Size limits (1-5)
    b. Creel limits (1-5)
    c. Season length (1-5)

PROJECT NO. 2
JOB NO. 4

INTER-GOVERNMENT COORDINATION

Prepared by Eric Q. Durell, Harry Rickabaugh, Genine K. Lipkey 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 support and update 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:

A staff member participated in three conference calls as a member of the ASMFC Shad and River Herring Technical Committee to review six sustainable fishery management plans and the River Herring Stock Assessment update. 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. The ASMFC Technical Committee representative also continues to serve 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. Staff reviewed state compliance to ASMFC fisheries management plans for alewife herring, American shad, and blueback herring as members of the ASMFC Plan Review Teams for those species.

Atlantic Croaker:

Project staff served on the Atlantic Croaker Technical Committee, and prepared the ASMFC Annual Maryland Atlantic Croaker Compliance Report. A staff member also served on both the Atlantic Croaker and Spot Stock Assessment Sub-Committees to complete and present portions of the ASMFC stock assessments. Fulfilling this commitment required participation in three webinars and the Peer Review workshop in Raleigh, North Carolina.

Atlantic Menhaden:

Project staff provided Atlantic menhaden data utilized for stock assessments, FMP’s and shared coastal management activities with ASMFC, NMFS, USFWS and various academic institutions, and prepared the Annual Maryland Atlantic Menhaden Compliance Report required by ASMFC. A staff member served on the ASMFC Atlantic Menhaden Plan Development Team writing and editing sections of Draft Amendment 3 to the Fisheries Management Plan. This responsibility required participating in five webinars.

Black Drum:

ASMFC Technical Committee representative prepared the Annual Black Drum Status Compliance Report for Maryland, and currently serves as the Chair of the Technical Committee.

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. Staff served on the Stock Assessment Life History and Tagging Subgroups, and the Stock Assessment Sub Committee.

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 Atlantic Croaker Compliance Report. The Plan Review Team member also serves on the Stock Assessment Sub Committee for the current benchmark stock assessment, and attended the data workshop and all conference calls associated with the assessment. Staff reviewed state compliance to ASMFC fisheries management plans for spot as a member of the ASMFC Plan Review Team for spot.

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 and support staff 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. A staff member is also a member of the Stock Assessment Subcommittee, and participated in all meetings and conference calls pertaining to current stock assessment activities.

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 programs 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 dnr.maryland.gov/fisheries/Pages/striped-bass/index.aspx.

Total page views to specific Striped Bass Program pages for the period January 2016 to December 2016 are provided in Table 1**.** The Juvenile Index survey page is still the most viewed page by visitors. A significant spike in Juvenile Index 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, January 2016 through December 2016. dnr.maryland.gov/fisheries/Pages/striped-bass.

Striped Bass Program Project Sites	**Page Views**
Juvenile Index (/juvenile-index.aspx)	1,356
Adult Spawning Stock Survey (/studies.aspx)	738
Home Page (/index.aspx)	447
Glossary (/glossary.aspx)	220
Recreational (/recreational.aspx)	175
Reports (/reports.aspx)	109
Commercial (/commercial.aspx)	83
Biologists (/biologists.aspx)	72
Species (/species.aspx)	45
Total	3,245

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), the University of Maryland, Virginia Institute of Marine Sciences, Towsan State University, and State management agencies from Delaware, Massachusetts, New York and Virginia. For the past contract year, (November 1, 2014 through January 31, 2016) the following specific requests for information have been accommodated:

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

- Mr. Jim Cummins, Interstate Commission for the Potomac River Basin, (ICPRB).
Provision of updated striped bass juvenile survey data.

- Dr. Mary Fabrizio,VIMS, Department of Marine Sciences.
Provision of current striped bass juvenile survey information.

-Ms. Alexandra Fries, UMCES.
Provision of annual bay anchovy abundance data from the striped bass juvenile survey.

- Maryland Charterboat Association members (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 Robert Graham, Dominion Virginia Power Company
Provision of Potomac River fish community data from the juvenile striped bass seine survey.

Dr. Barbara Hutniczak, NOAA
Provision of current and historical Maryland striped bass compliance reports

-Mr. Steve Minkkinen, USFWS.
Provision of shad and herring recruitment data from the striped bass juvenile survey.

- National Marine Fisheries Service, NOAA, Chesapeake Bay Program Staff.
Provision of results from fishery dependent monitoring programs, striped bass juvenile index data, and Atlantic menhaden juvenile survey data.

-Dr. Jay Nelson, Towson University Department of Biological Sciences
Provision of data and biological samples from the striped bass juvenile survey.

-Dr. Matthew Ogburn, Smithsonian Environmental Research Center
Provision of juvenile herring abundance indices and supporting data from the juvenile striped bass survey.

-Ms. Olivia Phillips, VIMS
Provision of data and biological samples from the striped bass juvenile survey.

Ms. Jill Ramsey, Virginia Marine Resources Commission
Provision of striped bass fishery dependent and independent striped bass data and seasonal age-length-keys.

Mr. Zachary Whitener, Gulf of Maine Research Institute
Provision of current and historical striped bass spawning survey data.

-The Interjurisdictional Project also provided related biological information, scientific literature and reports to twenty three (23) additional scientists, students and concerned stakeholders.

<u>Atlantic Sturgeon, Shortnose Sturgeon and Sea Turtle Interaction Summary for Chesapeake Bay Finfish Investigations</u>
<u>Project No.: F-61-R-12</u>

Prepared by Paul G. Piavis, Harry W. Rickabaugh, Eric Q. Durell, Genine K. Lipkey and Harry T. Hornick

<u>Summary</u>

The primary objective of the Chesapeake Bay Finfish Investigations Survey, F-61-R-12, was to monitor and biologically characterize resident and migratory finfish species in the Maryland portion of the Chesapeake Bay during the 2015 – 2016 sampling season. The F-61-R, Chesapeake Bay Finfish Investigations 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 2015 – 2016 sampling season, there were no documented Atlantic sturgeon, shortnose sturgeon or sea turtle encounters.

<u>CONTENTS</u>:

<u>PROJECT I</u>: RESIDENT SPECIES STOCK ASSESSMENT
JOB 1: Population vital rates of resident finfish in selected tidal areas of Maryland's Chesapeake Bay.

JOB 2: Population assessment of yellow perch in Maryland with special emphasis on the Head-of-Bay stocks.

<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.

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

<u>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.
<u>Task 2</u>: Characterization of striped bass spawning stocks in Maryland.
<u>Task 3</u>: Maryland juvenile striped bass survey.

<u>PROJECT I</u>: **RESIDENT SPECIES STOCK ASSESSMENT**

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

JOB 2: Population assessment of yellow perch in Maryland with special emphasis on the Head-of-Bay stocks.

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**

For the first time in 19 years, three Atlantic Sturgeon and four shortnose sturgeon were captured in the upper Bay winter trawl survey. No apparent morbidity/barotrauma, etc were noted.

TABLE 1. SHORTNOSE STURGEON ENCOUNTERS

Date	Total Length (mm)	Salinity (ppt)	Water T (ºC)	Depth (ft)	Location	Latitude	Longitude
1/27/2016	813	3.6	1.3	39	Elk River	39 28.741min	75 57.202 min
1/27/2016	991	4.1	1.1	39	Elk River	39 30.637min	75 53.692 min
2/1/2016	606	0.5	2.2	39	Ches. Bay near Sassafras River	39 22.92 min	76 05.931 min
2/1/2016	846	1.8	2.1	41	Elk River	39 27.919 min	75 58.333 min

TABLE 2. ATLANTIC STURGEON ENCOUNTERS

Date	Total Length (mm)	Salinity (ppt)	Water T (ºC)	Depth (ft)	Location	Latitude	Longitude
1/27/2016	626	3.6	1.3	39	Elk River	39 28.741min	75 57.202 min
2/1/2016	675	1.8	2.1	41	Elk River	39 27.919 min	75 58.333 min
2/1/2016	583	1.8	2.1	41	Elk River	39 27.919 min	75 58.333 min

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 February 1, 2016 through June 30, 2017

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 February 1, 2016 through June 30, 2017.

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 February 1, 2016 through June 30, 2017.

Shornose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed during the Survey period of February 1, 2016 through June 30, 2017

PROJECT 2: **INTERJURISDICTIONAL SPECIES STOCK ASSESSMENT**

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

Research Surveys:

1. Nanticoke River Pound/Fyke Net Survey
2. Nanticoke River Ichthyoplankton Survey

1. Nanticoke River Pound/Fyke Net Survey

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed during the Survey period of this project from February 1, 2016 through June 30, 2017.

Shornose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed during the Survey period of this project from February 1, 2016 through June 30, 2017.

2. Nanticoke River Ichthyoplankton Survey

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed during the Survey period of February 1, 2016 through June 30, 2017.

Shornose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed during the Survey period of this project from February 1, 2016 through June 30, 2017.

<u>PROJECT 2</u>:

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

Research Survey:

1. **Summer Pound Net Survey**

<u>Atlantic Sturgeon Interactions</u>

No Atlantic sturgeon were sampled or observed during the Survey period of February 1, 2016 through June 30, 2017.

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

No shortnose sturgeon or sea turtles sampled or observed during the Survey period of February 1, 2016 through June 30, 2017.

Project 2,

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

Task 1: Summer-Fall stock assessment and commercial fishery monitoring.

Research Survey:

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

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed during this Survey for the period of February 1, 2016 through June 30, 2017.

Shortnose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed during this Survey for the period of February 1, 2016 through June 30, 2017.

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

Research Survey:

1. Spring Striped Bass Experimental Drift Gill Net Survey

<u>Atlantic Sturgeon Interactions</u>

There was one (1) Atlantic sturgeon sampled during this Survey for the period of February 1, 2016 through June 30, 2017.

<u>ESA Report Information:</u>

Observer's Name: Beth Versak, MD Department of Natural Resources, Fisheries Service
Reporter's Name: Same as above
Survey: Striped Bass Spawning Stock Survey
Species Identification: Atlantic Sturgeon
How documented: Identified to species by biologists and photos taken
Type of gear and length of deployment: Experimental, multifilament, nylon drift gill net, ten different mesh sizes, soak time varies – see specific details below.

Encounter # 1:

Date: April 29, 2016 Time: 8:40 AM
Location: Upper Chesapeake Bay, just west of main shipping channel off Still Pond, N 39 21.45 W 76 09.40
Water temp: 15.7 C Salinity: 0.6 ppt
Air temp: 9 C
Water depth: 28 feet Tide: end of ebb tide
Gear: drift gill net, 4.5 inch stretch mesh, soak time = 23 minutes
Total length: 646 mm Fork length: 565 mm
Condition/description: Appeared healthy and robust, no visible marks, released unharmed
Photograph taken: Yes, see below
Genetic sample taken: Yes, clip from caudal fin
Genetic sample given to: Chuck Stence On date: TBD
Scanned for PIT tag: No
PIT tag inserted: No

<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 February 1, 2016 through June 30, 2017.

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 February 1, 2016 through June 30, 2017.

Shortnose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed during this Survey for the period of February 1, 2016 through June 30, 2017.