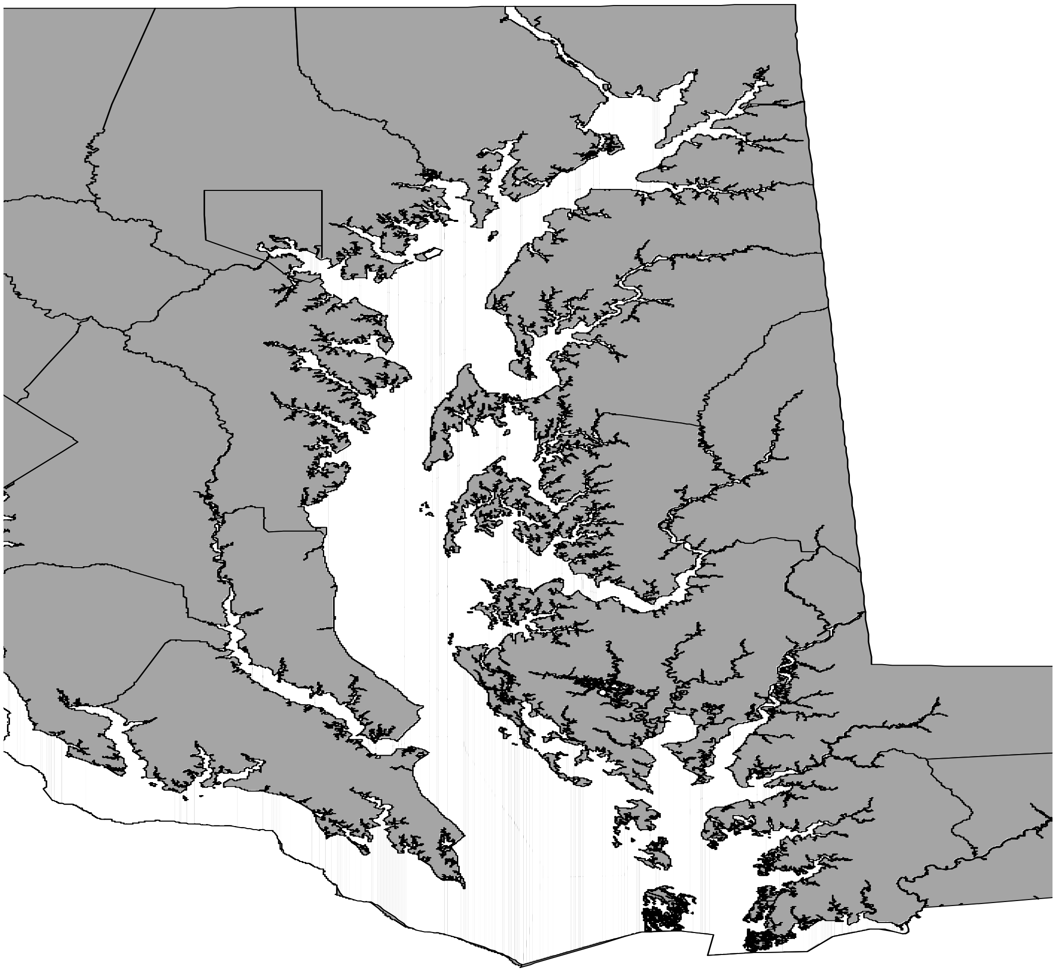

Chesapeake Bay Finfish Investigations

US FWS FEDERAL AID PROJECT
F-61-R-9
2012 - 2013

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-9

PROJECT TYPE: Research and Monitoring

PROJECT TITLE: Chesapeake Bay Finfish Investigations.

PROGRESS: ANNUAL X

PERIOD COVERED: November 1, 2012 through October 31, 2013

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.

Yellow perch population abundance, biomass, instantaneous fishing mortality (F) and recruitment (N at age 2) were determined using a statistical catch at age model for Head-of-Bay (HOB) yellow perch. In addition, biological reference points were updated using a spawning stock biomass per recruit model. Target ($F_{35\%}$) and limit ($F_{25\%}$) fishing mortality (F) were defined as F=0.55 and 0.85, respectively. HOB population abundance (age 2 and older) declined from 2.61 million fish in 1998 to 879,000 fish in 2004. A gradual decline from 2006 – 2012 occurred followed by the recruitment of the strong 2011 year-class in 2013. As such, population abundance increased to 887,000 fish in 2013. Biomass was estimated at 146,000 kg in 2013. The time series low was 110,000 kg in 2012. Instantaneous fishing mortality ranged from 0.05 to 0.97 over the time period

1998 – 2013. Fishing mortality has generally been around F=0.30 since 2009 when a Total Allowable Catch was initiated. Fishing mortality was below the target in 2013 (0.23 vs. 0.55) and bootstrap analysis indicated only a 3% chance that F exceeded the target. Therefore, overfishing was not occurring in the HOB. No biomass or abundance reference points have been determined.

Choptank River yellow perch were assessed with relative abundance indices from a fishery independent fyke net survey (1988 – 2013). Time-series analysis showed an increasing trend, suggesting continual expansion of Choptank River yellow perch population. Exploitation was estimated to be at very low levels. Mortality was also below target levels in the Choptank River.

Predation, bycatch, turbine mortality, and limited access to prime spawning habitat continue to impact American shad populations in Maryland's portion of Chesapeake Bay and its tributaries. All measures of abundance for American Shad in the lower Susquehanna River show declining trends from 2001-2013. However, relative abundance of American shad in the Potomac (1996-2013) and Nanticoke Rivers (1988-2013) have significantly increased over the time series. Juvenile abundance indices in the Potomac River have improved since 2000 and continue to be the highest in Maryland's portion of Chesapeake Bay.

Hickory shad age structure in the Susquehanna River has previously been very consistent with a wide range of ages, however since 2011 a smaller percentage of older fish have been present, suggesting it may be truncating. In 2013, 90% of the fish encountered were age 5 or younger. The arcsine-transformed proportion of repeat spawners (sexes combined) has not changed significantly over the time series (2004-2013; $r^2 = 0.09$, $P = 0.39$; Figure 18), and this year's estimate is similar to the 2011 and 2012 estimates.

According to the most recent ASMFC stock assessment, the coastwide meta-complex of river herring stocks on the U.S. Atlantic coast is depleted to near historic lows. River herring age structure in the Nanticoke River appears to be truncating, especially for blueback herring. Observed declines in length-at-age generally occur toward the end of the time series. The GM CPUE for juvenile alewife herring decreased in 2013 in all Maryland tributaries, but increased for blueback herring in all Maryland tributaries, expect the Potomac River. Due to Amendment 2 to the ASMFC FMP for American shad and river herring, it is not legal to harvest river herring within the jurisdiction of Maryland. This moratorium on river herring should promote an increased spawning stock, leading to increased production of juvenile river herring.

Weakfish have experienced a sharp decline in abundance coast wide. Recreational catch estimates by the NMFS for Maryland declined from 475,348 fish in 2000 to 237 fish in 2011, before increasing to 11,401 fish in 2012. Maryland's commercial weakfish harvest increased from the time series low of 378 pounds in 2011 to 1,358 pounds in 2012, but was still well below the mean harvest of 612,564 pounds. The 2013 mean length for weakfish from the onboard pound net survey was 304mm TL. The 2013 length frequency distribution indicated a shift to larger weakfish in Maryland waters. The charter boat CPUE value was the lowest of the time series, and has significantly declined form 1993-2012.

Summer flounder mean length from the pound net survey was 268 mm TL in 2012, the lowest mean value the 21 year survey. The 2013 length frequency distribution was skewed toward smaller fish, possibly indicating a strong year class entering the fishery. Charter boat CPUE declined from 1993 - 2003, but was relatively stable form 2004 to 2011 before declining again in 2012. The NMFS 2011 coast wide stock assessment concluded that summer flounder stocks were not overfished, overfishing was not occurring and the rebuilding target was met in 2010.

Mean length of bluefish from the pound net survey in 2012 was 297 mm TL, below the time series mean. Length distribution indicated a slight shift to larger bluefish in 2012. Recreational and commercial bluefish harvest gave conflicting signals in 2012, with commercial harvest doubling and the recreational harvest estimate declining by more than 50%. The 2012 coast wide stock assessment update indicated the stock was not overfished and overfishing is not occurring.

The mean length of Atlantic croaker examined from the pound net survey in 2013 was 276 mm TL; this was the fourth lowest value of the 21 year time series. Maryland Atlantic croaker total commercial harvest and recreational harvest estimate increased in 2012 to 908,619 pounds and 979,216 fish, respectively. The 2011 charter boat geometric catch per angler increased to 4.73 fish per angler, and was above the long term mean.

Spot mean length increased in 2013, but was still below the long term mean. The spot juvenile index spiked to the time series high in 2010, declined to near the time series low in 2011, rose in 2012 to the eighth highest value in the 25 year time series, and declined again in 2013. Commercial harvests declined sharply in 2013 after high values for the previous three years. The recreational decreased again in 2012 remaining well bellow the time series mean. The charter boat geometric mean catch per angler increased in 2011, but declined to a very low value in 2012.

Resident / premigratory striped bass sampled from pound nets in the Chesapeake Bay during the summer – fall 2012 ranged in age from 1 to 13 years old. One year old (2011 year-class), two year old (2010 year-class), Three year old (2009 year-class), four year old (2008 year-class), and five year old (2007 year-class) striped bass dominated biological samples taken from pound nets. These five year-classes comprised 90% 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 seven year old striped bass from the 2005 through 2009 year-classes and comprised 95% of the sampled harvest.

The 2012-2013 commercial striped bass drift gill net fishery harvest was comprised primarily of fish 4, 5, 6 and 7 years old from the 2006 through 2009 year-classes. Striped bass from the 2008 year-class (five year old fish) composed 39% of the total drift gill net harvest. The 2009 and 2007 (ages 4 and 6) cohorts accounted for 41% of the total harvest while age groups 8 to 12 year-old fish contributed 8% to the total. Striped bass present in commercial drift gill net samples collected from check stations ranged in age from age 3 to 12 years old (2001 to 2010 year-classes).

Fish harvested during the 2012-2013 Atlantic coast fishing season ranged from age 5 (2008 year-class) to age 15 (1998 year-class). Eleven year-classes were represented in the sampled harvest. Approximately 89% of striped bass harvested were ages 6 through 10. Striped bass were recruited into the Atlantic coast fishery as young as age 5. However, due to the 24 inch minimum size limit, few fish younger than age 6 were harvested, similar to previous years. Based on the estimated catch-at-age, the most common age harvested during the 2012-2013 Atlantic coast harvest was age 10 (2003 year-class), which represented 25% of the fishery. Large contributions were also made by the 2004 year-class (age 9) and the 2007 year- class (age 6), which represented 18.6% and 18.1% of the fishery, respectively.

The spring 2013 spawning stock survey indicated that there were 18 age-classes of striped bass present on the Potomac River and Upper Bay spawning grounds. These fish ranged in age from 2 to 19 years old. Male striped bass ranged in age from 2 to 17 years old, with age 9 and age 10 fish (2004 and 2003 year-classes) being the most abundant component of the male striped bass spawning stock. The majority of females were ages 6 to 14, with most female striped bass collected being age 10 (2003 year-class). During the spring 2013 spawning season, age 8 and older females made up 75% of the female spawning stock.

The 2013 striped bass juvenile index, a measure of striped bass spawning success in Chesapeake Bay, was 5.8. This was below the 60-year average of 11.7 but an improvement over the 2012 juvenile index. Although young-of-year striped bass did not occur in high abundance, they occurred in a high proportion of samples (84%), indicating that they were widely distributed. Highly variable spawning success is a hallmark of striped bass populations. Typically, several years of average reproduction are interspersed with occasional large and small year-classes. Spawning success is heavily influenced by environmental conditions such as flow rates and water temperature. In 2011, biologists documented one of the most successful striped bass spawns on record and these 2-year-old fish are currently very abundant in the Chesapeake Bay. The successful spawning years of 1989, 1996, and 2001 were also followed by below-average or poor years of reproduction. American shad reproduction in the Potomac River was very successful in 2013, at approximately 4 times the long-term average, while resident white perch experienced near-average reproduction.

MD DNR biologists have monitored the reproductive success of striped bass and other species in Maryland’s portion of the Chesapeake Bay annually since 1954. During this year’s juvenile striped bass survey, biologists collected over 34,540 fish of 51 different species, including 759 juvenile striped bass. DNR biologists have conducted this survey and use these data to assess spawning success of striped bass and other important species

During the 2013 spring recreational trophy season, biologists intercepted 207 fishing trips, interviewed 456 anglers, and examined 182 striped bass. The average total length of striped bass sampled was 924 mm total length (mm TL) (36.4 inches). The average weight was 8.3 kg (18.2 lbs). Striped bass sampled from the trophy fishery ranged in age from 5 to 19 years old. The 2003 (age 10) and 2004 (age 9) year-classes were the most frequently observed cohorts sampled from the spring fishery. Average private boat catch rate based on angler interviews was 0.3 fish per hour.

Maryland Department of Natural Resources biologists continued to tag and release striped bass in spring, 2013 in support of the US FWS coordinated interstate, coastal population study for growth and mortality. A total of 970 striped bass were tagged and released with USFWS internal anchor tags between March through May 2013 in Maryland. Of this sample, 272 were tagged in the Potomac River and 698 were tagged in the upper Chesapeake Bay area during the spring spawning stock assessment survey. A total of 2007 striped bass were tagged during the cooperative USFWS / SEAMAP Atlantic Ocean tagging cruise.

APPROVAL

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Maryland Department of Natural Resources

ACKNOWLEDGEMENTS

The Maryland Department of Natural Resources (MD DNR) would like to thank the Maryland Watermen's Association commercial captains and their crews who allowed us to sample their commercial catches. 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 collected for portions of this study from commercial pound nets owned and operated by Maryland Watermen's Association commercial captains and their crews. 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 William L. Rice, on the Potomac River, and Bobby Owen Clark, III, on the Upper Chesapeake Bay.

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CONTENTS

SURVEY TITLE: **CHESAPEAKE BAY FINFISH/HABITAT INVESTIGATIONS**

CONTENTS (Continued)

IPROJECT 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 four sampling areas; Sassafras River (SAS), Elk River (EB), upper Chesapeake Bay (UB), and middle Chesapeake

Bay (MB). Eighteen sampling stations, each approximately 2.6 km (1.5 miles) in length and variable in width, were created throughout the study area (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 3 knots, the trawl was retrieved into the boat by winch and the catch emptied into either a culling board or large tub if catches were large. 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 2012 through February 2013.

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. During 2012, 107 of the scheduled 108 hauls were completed. In 2013, ice-cover prevented the sampling of several Upper Bay sites allowing the completion of 86 of the scheduled 108 hauls.

Choptank River Fishery Independent Sampling

In 2013, 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 25 February through 15 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 16 February 2013 in Northeast River, 19 February 2013 in Bush River, 23 February 2013 in and around Middle River and 3 March 2013 in Gunpowder River (Figures 3, 4, 5, 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 21 February 2013 to 23 March 2013, 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. All yellow perch caught were sexed, measured for total length and a non-random sample of otoliths removed for age determination. 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.

The 2011 sampling season was severely truncated due to snow and ice conditions. As such, the yellow perch run had finished before sampling was initiated. In addition, sample sizes for channel catfish and white catfish were also very low.

II. Data compilation

Population Age Structures

Population age structures were determined for yellow perch and white perch from the Choptank and Nanticoke rivers and the upper Chesapeake Bay (trawl and commercial sampling separately). Age-at-length keys for yellow perch and white perch (separated by sex) from the Choptank River, Nanticoke River, and upper Bay commercial fyke net surveys 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 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.

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. Current Nanticoke River yellow perch rates were not estimated because of unequal recruitment rates, varying annual sample sizes, and an inability to assign associated effort data to catches. Instantaneous mortality rates for yellow perch from upper Bay commercial samples were calculated with a statistical catch-at-age model (see Project 1, Job2).

Recruitment

Recruitment data were provided from age 1+ 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 which provided a good index of juvenile abundance. Therefore, only the Howell Pt., Ordinary Pt., Tim's Creek, Elk Neck Park, Parlor Pt., and Welch Pt. permanent sites were used to determine the yellow perch juvenile relative abundance index. However, the Ordinary Pt. seine site was lost because of bulkhead construction and the replacement site was not included in the index. This index is reported as an average $\log_e$ (catch+1) index. White perch and channel catfish 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 target species was determined as the grand mean abundance from all surveys where reliable effort data were available. For white perch and yellow perch, relative abundance as CPUE at age was determined from the catch-at-age matrices. Fyke net effort for yellow perch 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, CPUE from 1 March to the 95% catch end time was utilized for time-trend analysis.

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 4-7

Population Length Structures

White perch	Tables 8-10 and Figures 8-10
Yellow perch	Tables 11-14 and Figures 11-14
Channel catfish	Tables 15-17 and Figures 15-17
White catfish	Tables 18-20 and Figures 18-20

Growth

White perch	Tables 21-22
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Mortality

White perch	Table 26
Yellow perch	Table 27

Recruitment

White perch	Figures 21-22
Yellow perch	Figures 23-24
Channel catfish	Figure 25

Relative Abundance

White perch	Tables 28-29
Yellow perch	Tables 30-31 and Figure 26
Channel catfish	Figures 27-28
White catfish	Figure 29

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Figure 1. Upper Chesapeake Bay winter trawl survey locations, December 2012 – February 2013. Different symbols indicate each of 6 different sampling rounds.

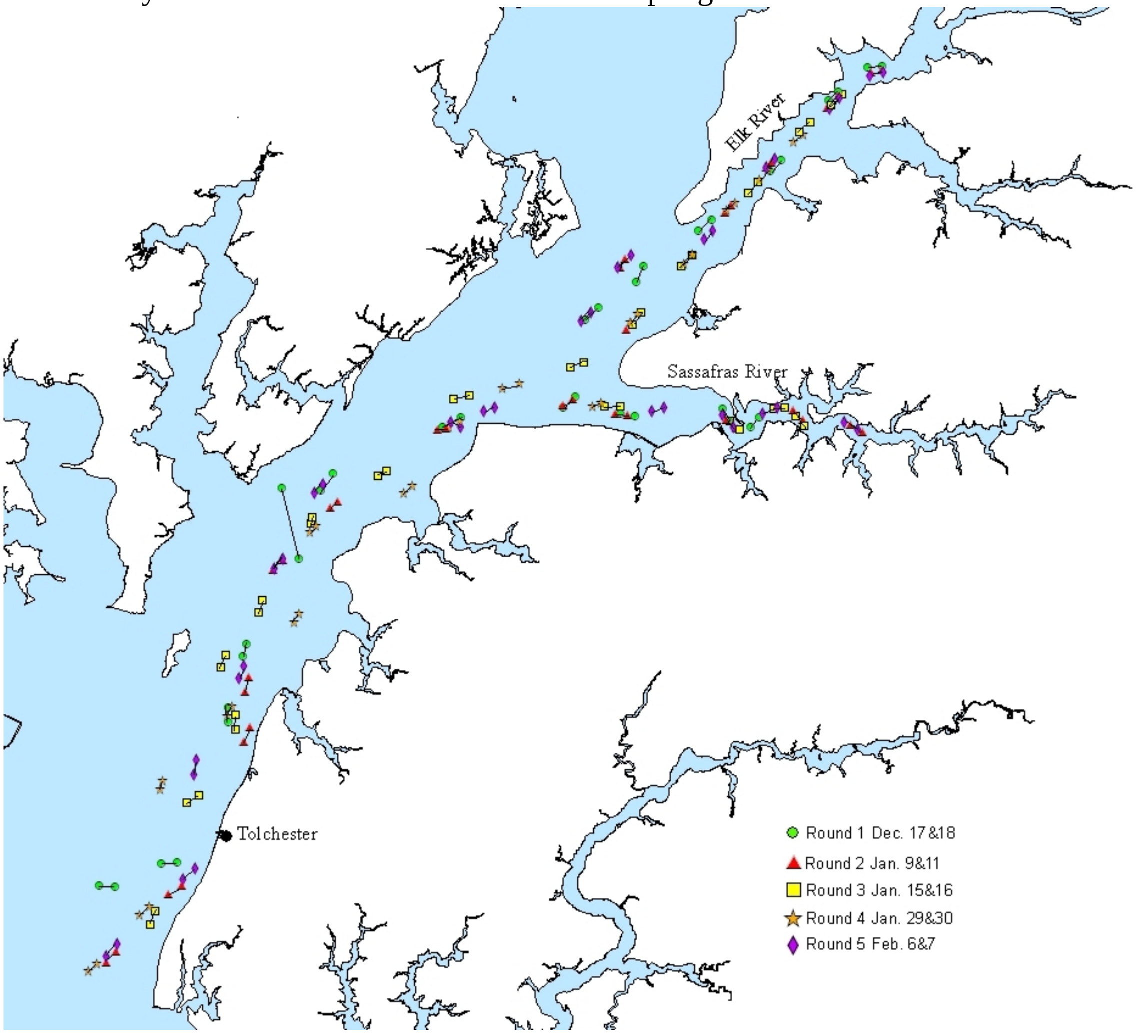


Figure 2. Choptank River fyke net locations, 2013. Circles indicate sites.

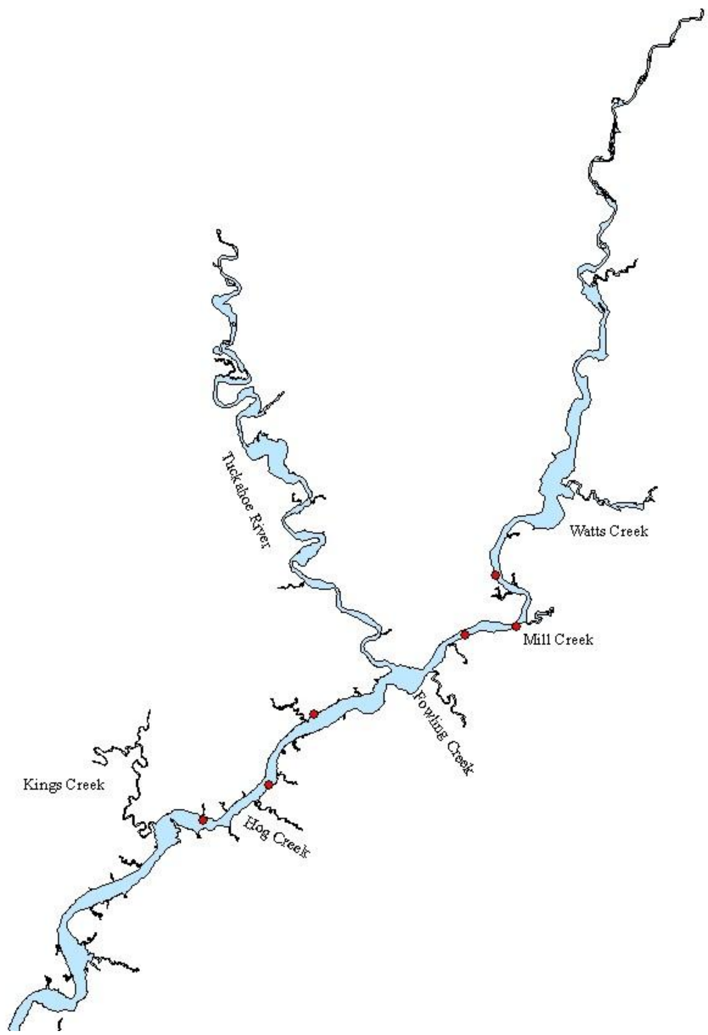


Figure 3. Commercial yellow perch fyke net sites sample during 201 in Northeast River. Circles indicate sites.

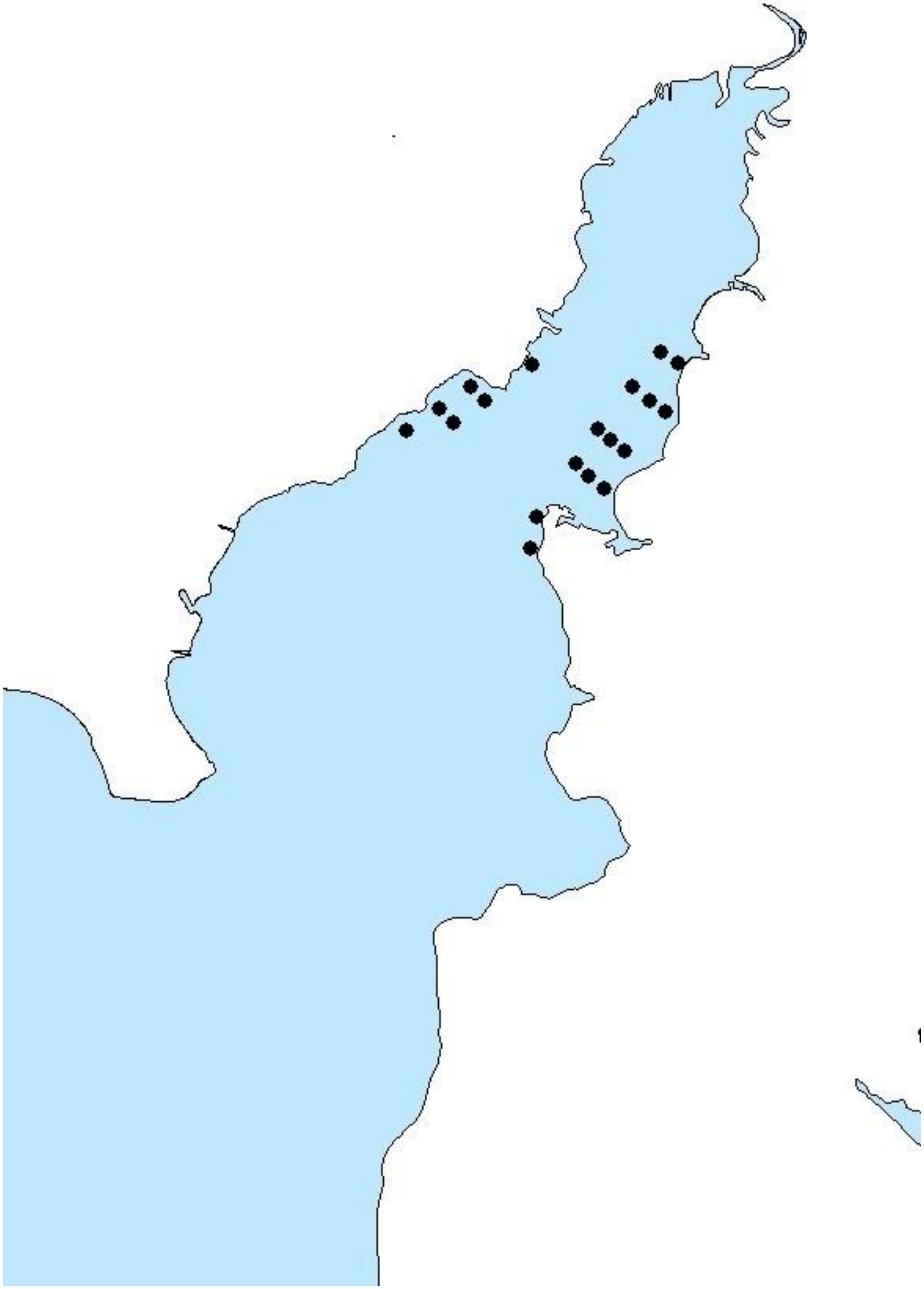


Figure 4. Commercial yellow perch fyke net sites sample during 2013 in Bush River. Circles indicate fyke net locations.

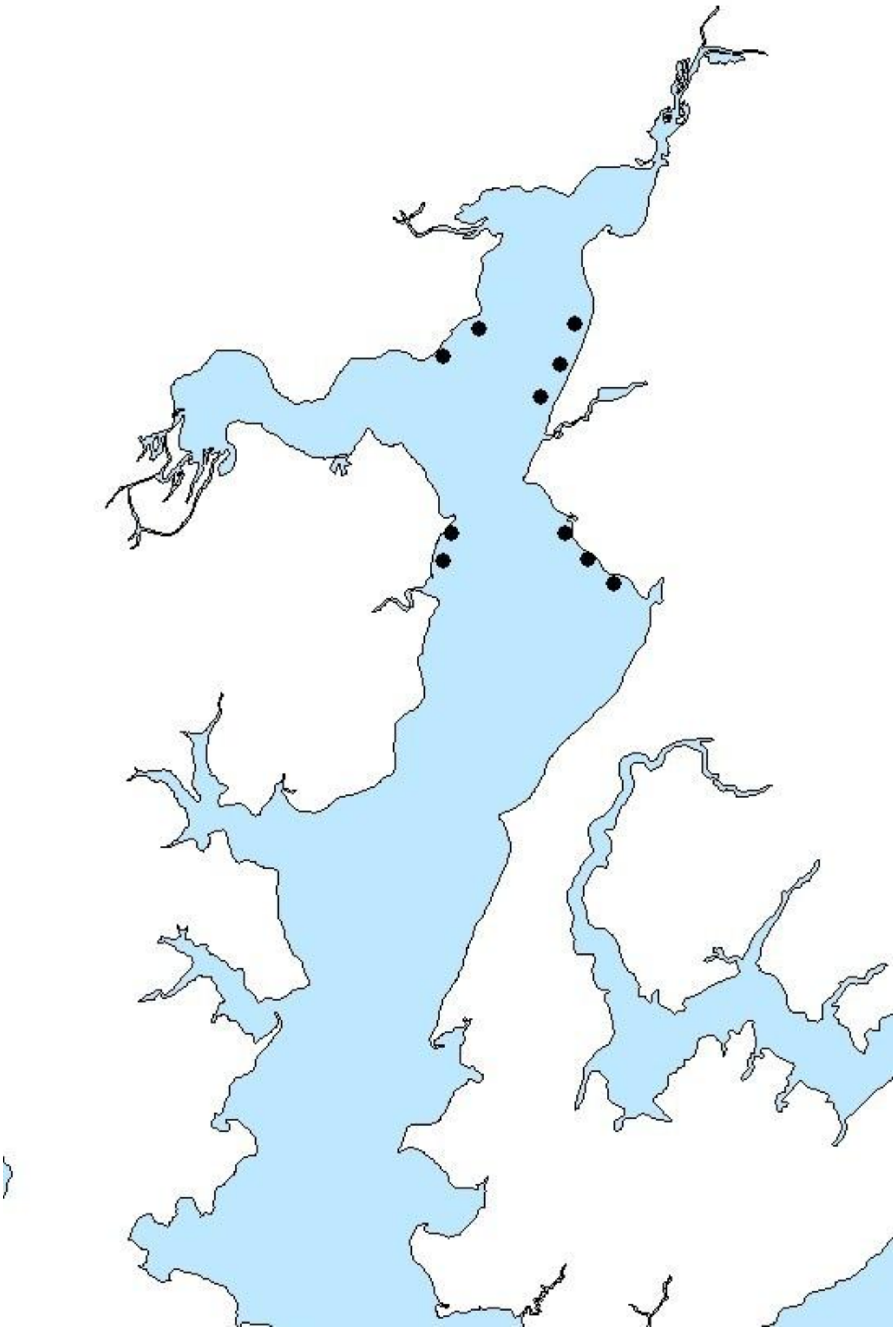


Figure 5. Commercial yellow perch fyke net sites sample during 2013 in Middle River. Black circles indicate fyke net locations.

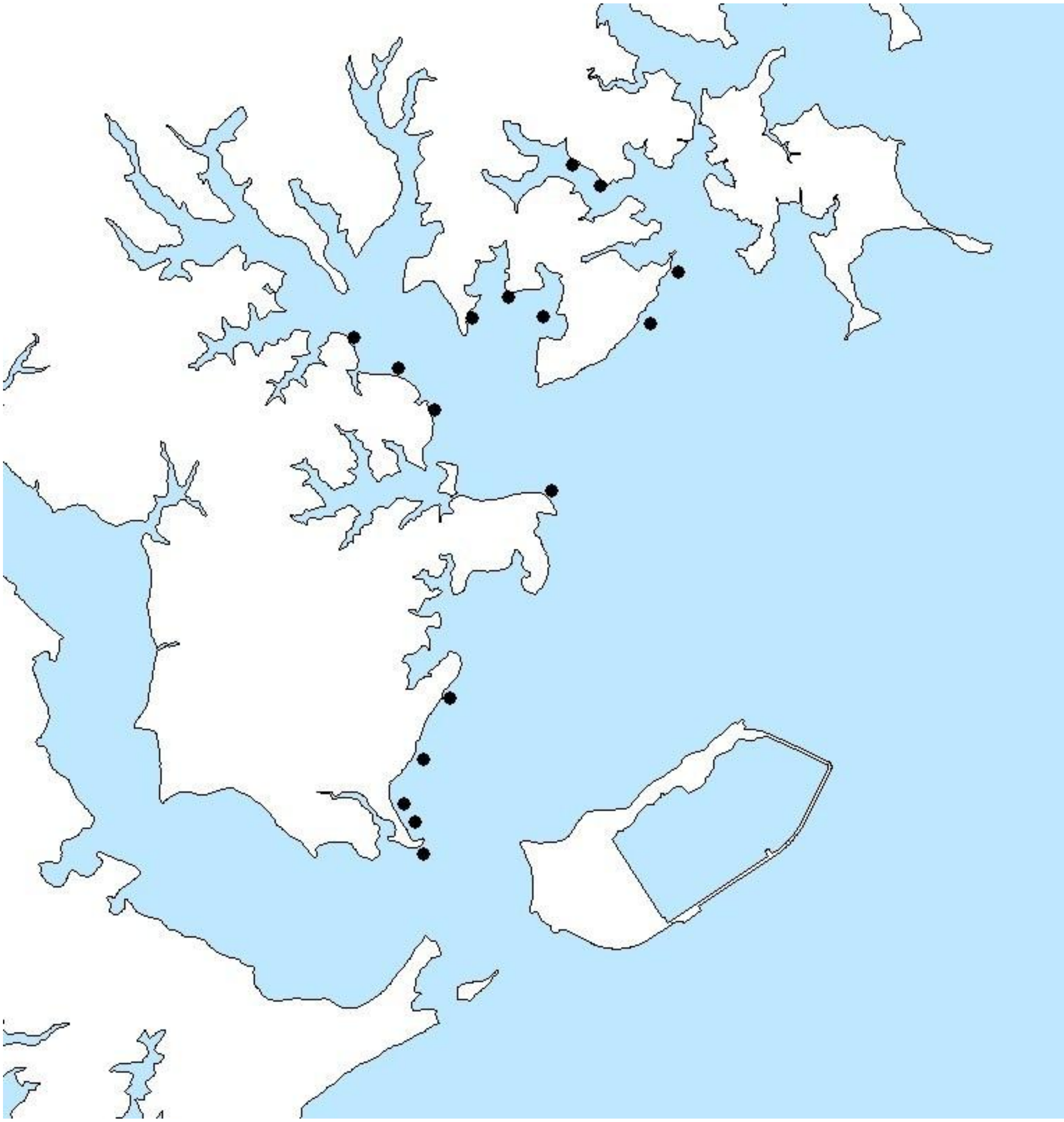


Figure 6. Commercial yellow perch fyke net sites sample during 2013 in Gunpowder River. Black lines indicate the geographic range of fyke net locations.

Figure 7. Commercial fyke net and pound net sites sample during 2013 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 – 2013.

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

Table 2. White perch catch-at-age matrix from Choptank River fyke net survey, 2000 – 2013.

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

Table 3. White perch catch-at-age matrix from Nanticoke River fyke and pound net survey, 2000 – 2013. 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

Table 4. Yellow perch catch at age matrix from upper Chesapeake Bay winter trawl survey, 2000 – 2013.

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

Table 5. Yellow perch catch at age matrix from Choptank River fyke net survey, 1988 – 2013.

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

Table 6. Yellow perch catch at age matrix from upper Chesapeake Bay commercial fyke net survey, 1999 – 2013.

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

Table 7. Yellow perch catch at age matrix from Nanticoke River fyke and pound net survey, 1999 – 2013. 2007 -- 2009 include Marshyhope River data.

YEAR	AGE									
	1	2	3	4	5	6	7	8	9	10+
1999	0	10	1,072	323	295	22	0	4	14	22
2000	0	0	16	561	78	83	7	0	0	0
2001	0	2	36	114	737	48	36	3	0	0
2002	0	128	9	60	36	940	39	24	6	0
2003	0	17	123	2	49	2	45	1	2	0
2004	0	7	58	93	0	1	10	21	1	0
2005	0	59	6	34	35	0	1	0	4	0
2006	0	56	381	18	34	50	4	3	6	5
2007	0	38	244	291	37	32	16	0	0	2
2008	0	36	238	144	148	25	9	4	2	7
2009	0	37	374	660	336	126	9	0	11	0
2010	0	0	0	3	6	5	0	0	0	0
2011	0	2	6	31	22	20	10	2	0	0
2012	0	28	12	8	11	15	14	4	1	0
2013	0	17	42	25	4	4	8	4	1	0

Table 8. Relative stock densities (RSD's) of white perch from the upper Chesapeake Bay winter trawl survey, 2000 – 2013. 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

Figure 8. White perch length-frequency from 2013 upper Chesapeake Bay winter trawl survey.

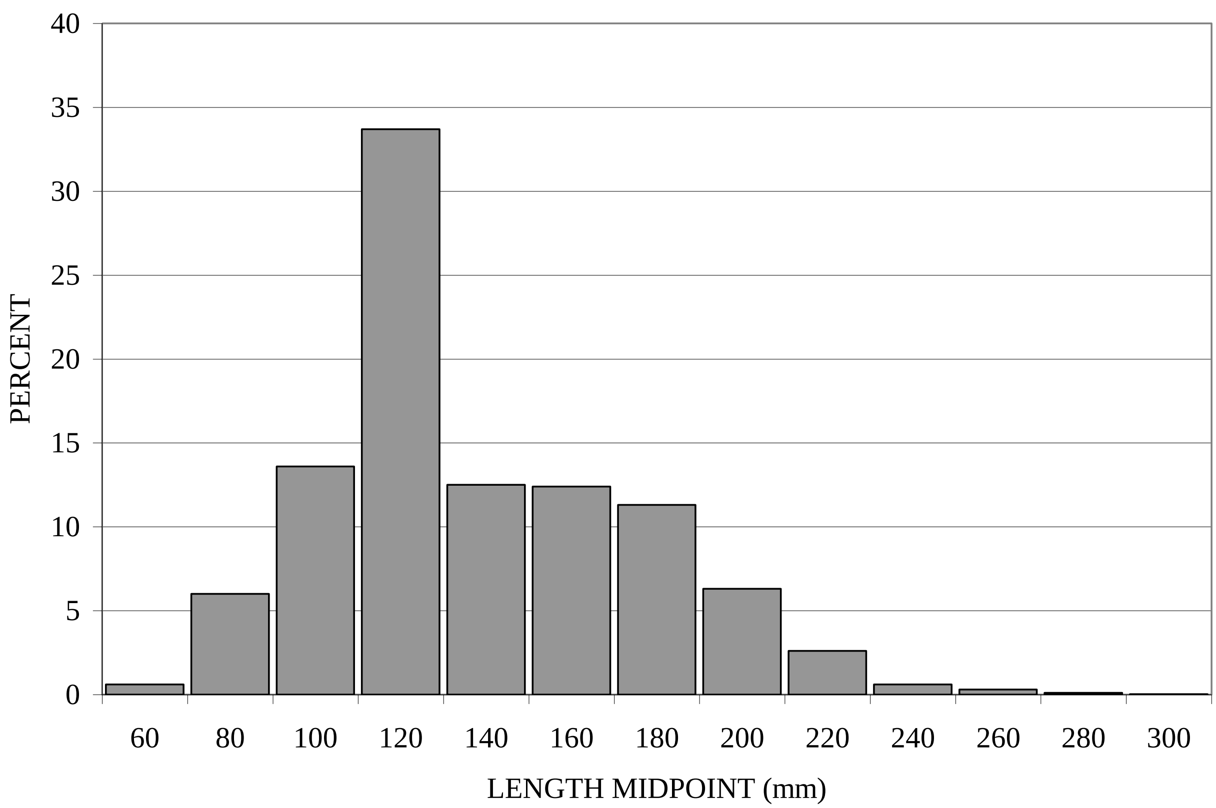


Table 9. Relative stock densities (RSD's) of white perch from the Choptank River fyke net survey, 1993 – 2013. Minimum length cut-offs in parentheses.

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

Figure 9. White perch length-frequency from 2013 Choptank River fyke net survey.

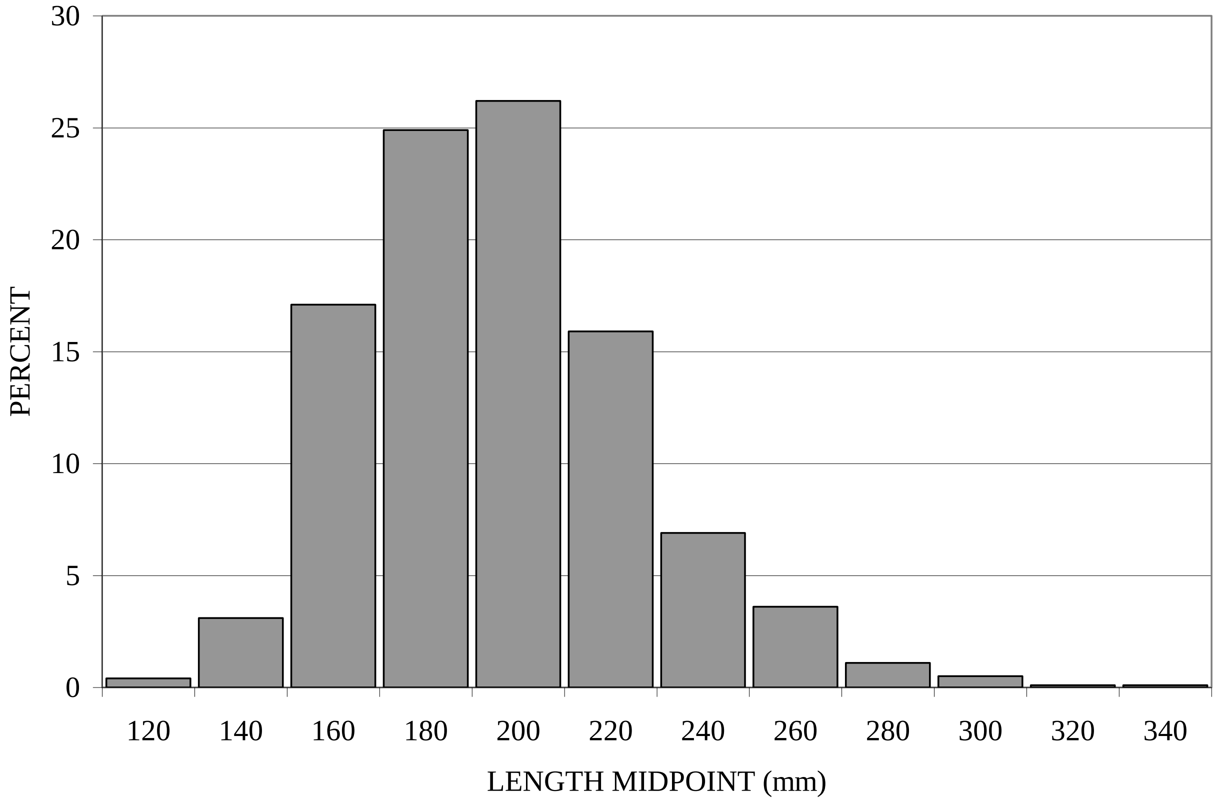


Table 10. Relative stock densities (RSD's) of white perch from the Nanticoke River fyke and pound net survey, 1995 – 2013. Minimum length cut-offs in parentheses. 2007 -- 2009 include Marshyhope River data.

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

Figure 10. White perch length-frequency from 2013 Nanticoke River fyke and pound net survey.

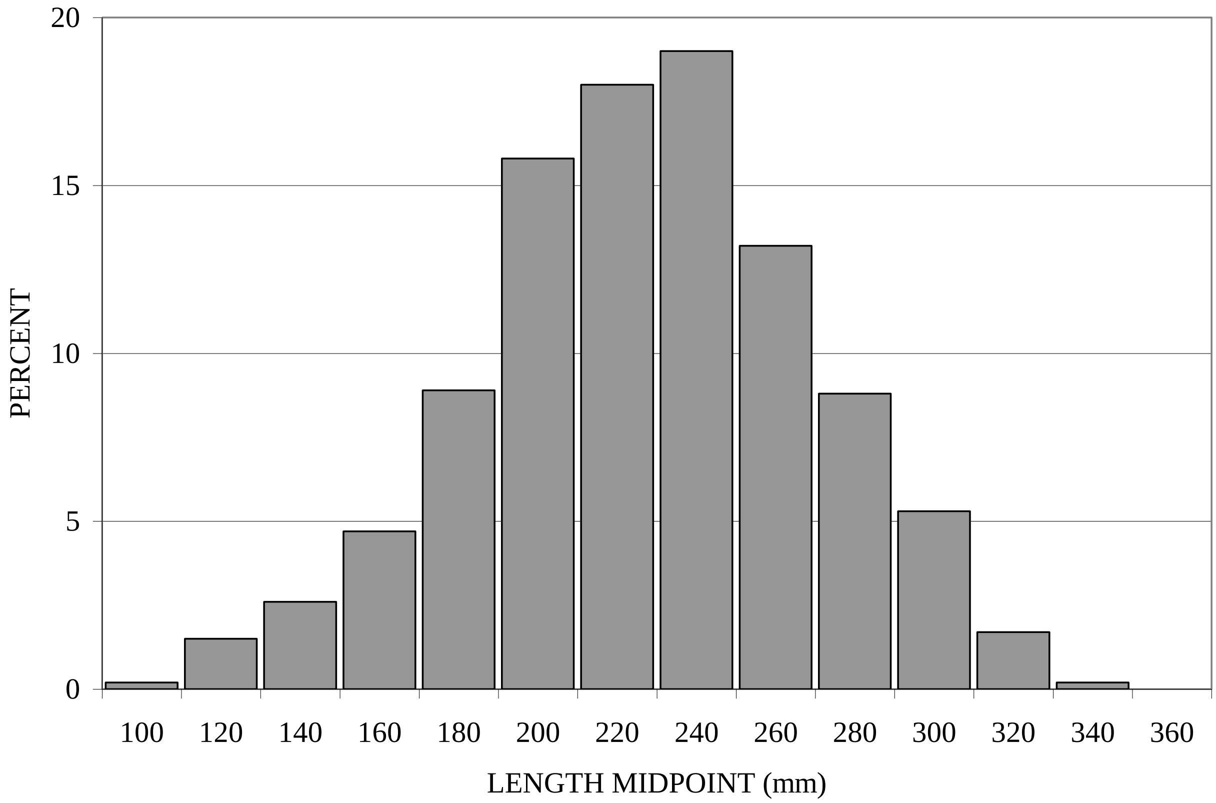


Table 11. Relative stock densities (RSD's) of yellow perch from the upper Chesapeake Bay winter trawl survey, 2000 – 2013. Minimum length cut-offs in parentheses.

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

Figure 11. Yellow perch length-frequency from the 2013 upper Chesapeake Bay winter trawl survey.

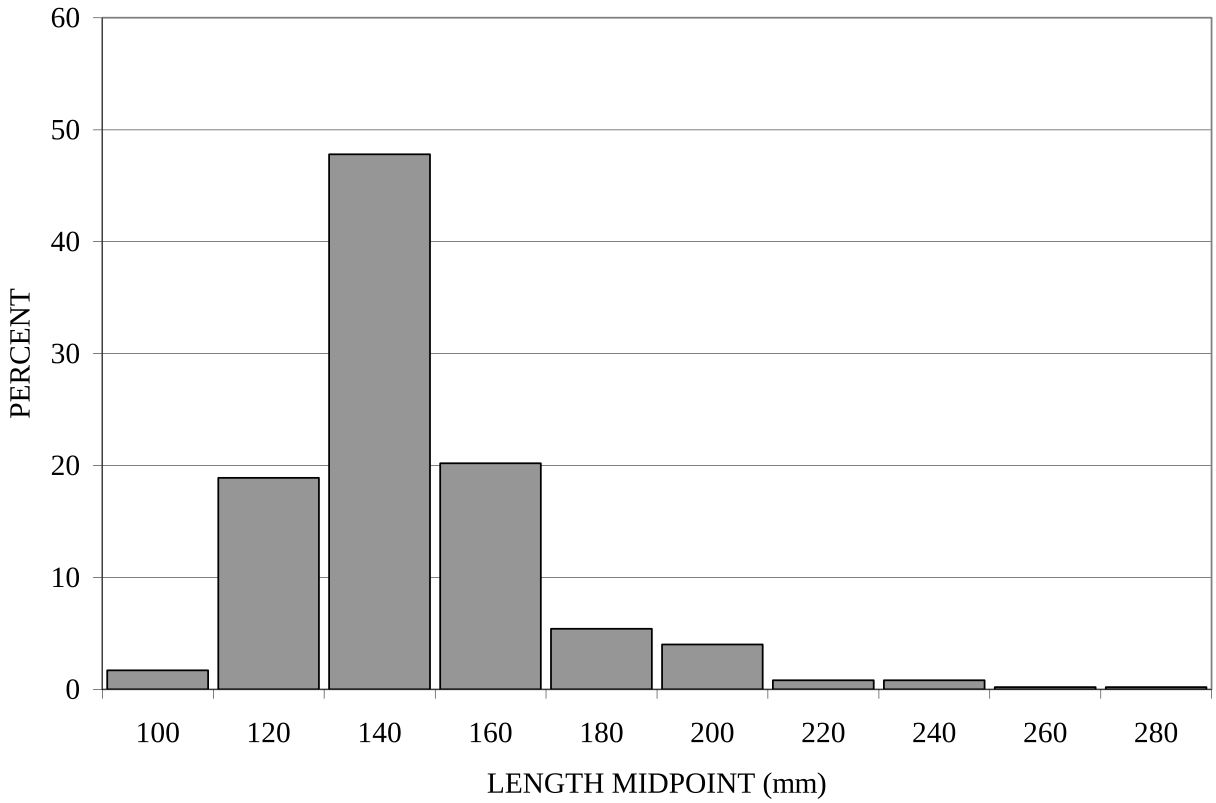


Table 12. Relative stock densities (RSD's) of yellow perch from the Choptank River fyke net survey, 1989 – 2013. Minimum length cut-offs in parentheses.

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

Figure 12. Yellow perch length-frequency from the 2013 Choptank River fyke net survey.

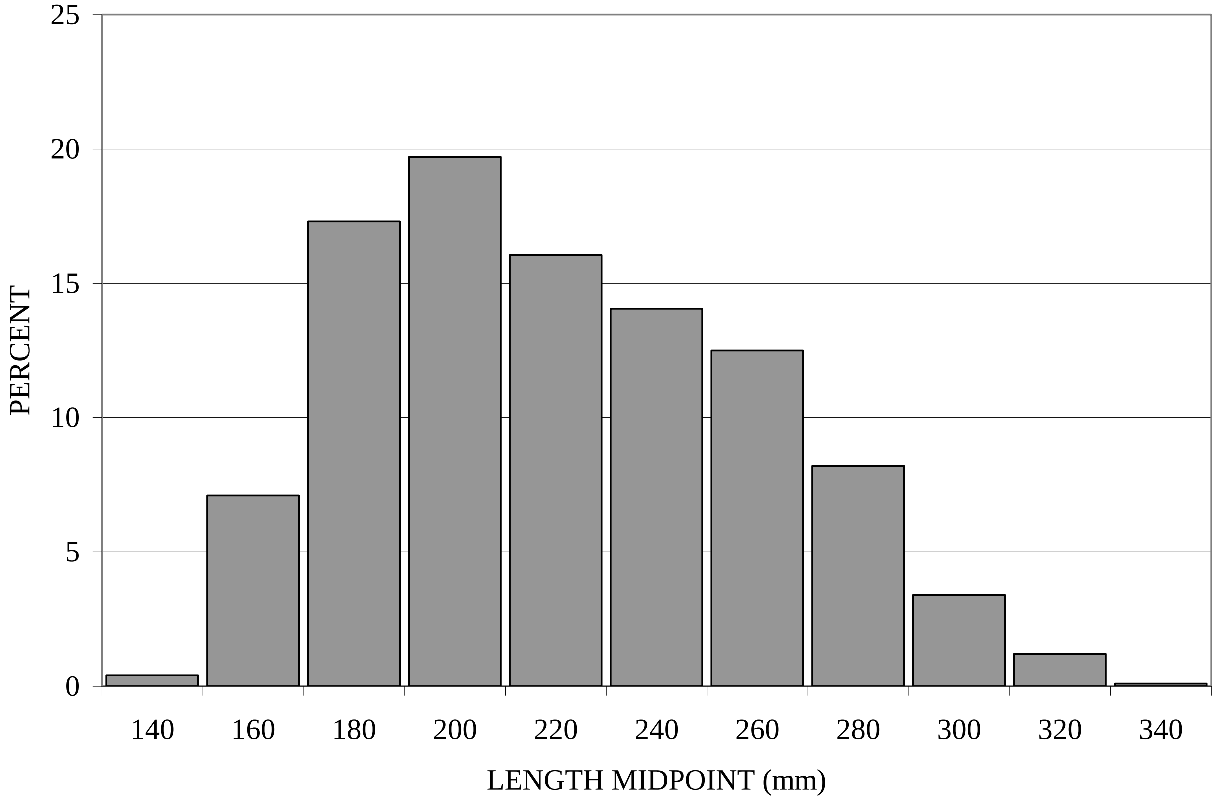


Table 13. Relative stock densities (RSD's) of yellow perch from the upper Chesapeake Bay commercial fyke net survey, 1988, 1990, 1998 – 2013. Minimum length cut-offs in parentheses.

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

Figure 13. Yellow perch length frequency from the 2013 upper Chesapeake commercial fyke net survey.

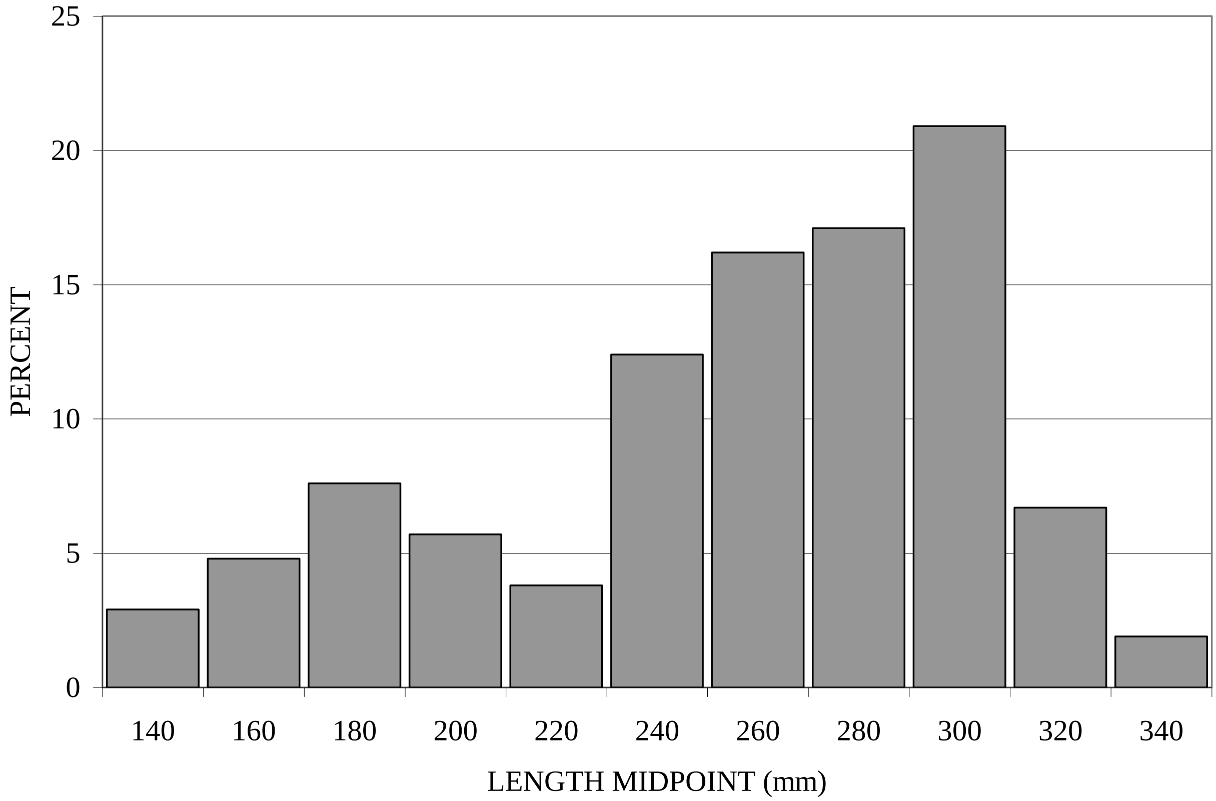


Table 14. Relative stock densities (RSD's) of yellow perch from the Nanticoke River fyke and pound net survey, 1999 – 2013. Minimum length cut-offs in parentheses; 2007-- 2009 includes Marshyhope River data.

Year	**Stock** (140 mm)	**Quality** (216 mm)	**Preferred** (255 mm)	**Memorable** (318 mm)	**Trophy** (405 mm)
1999	12.4	28.8	55.6	3.2	0.0
2000	3.1	19.5	72	5.2	0.0
2001	2.4	22.2	66.6	8.9	0.0
2002	2.9	18.9	62.5	15.7	0.0
2003	10.9	46.6	36.3	6.2	0.0
2004	1.6	27.2	60.7	10.5	0.0
2005	16.2	33.8	38.7	11.3	0.0
2006	4.1	34.1	57.1	4.7	0.0
2007	15.7	21.8	57.1	5.4	0.0
2008	27.4	25.0	42.1	5.5	0.0
2009	9.0	28.0	53.9	9.0	0.0
2010	0.0	14.3	78.6	7.1	0.0
2011	2.2	15.0	75.3	7.5	0.0
2012	24.7	16.1	44.1	15.0	0.0
2013	22.9	15.2	57.1	4.8	0.0

Figure 14. Yellow perch length frequency from the 2013 Nanticoke River survey fyke and pound net survey.

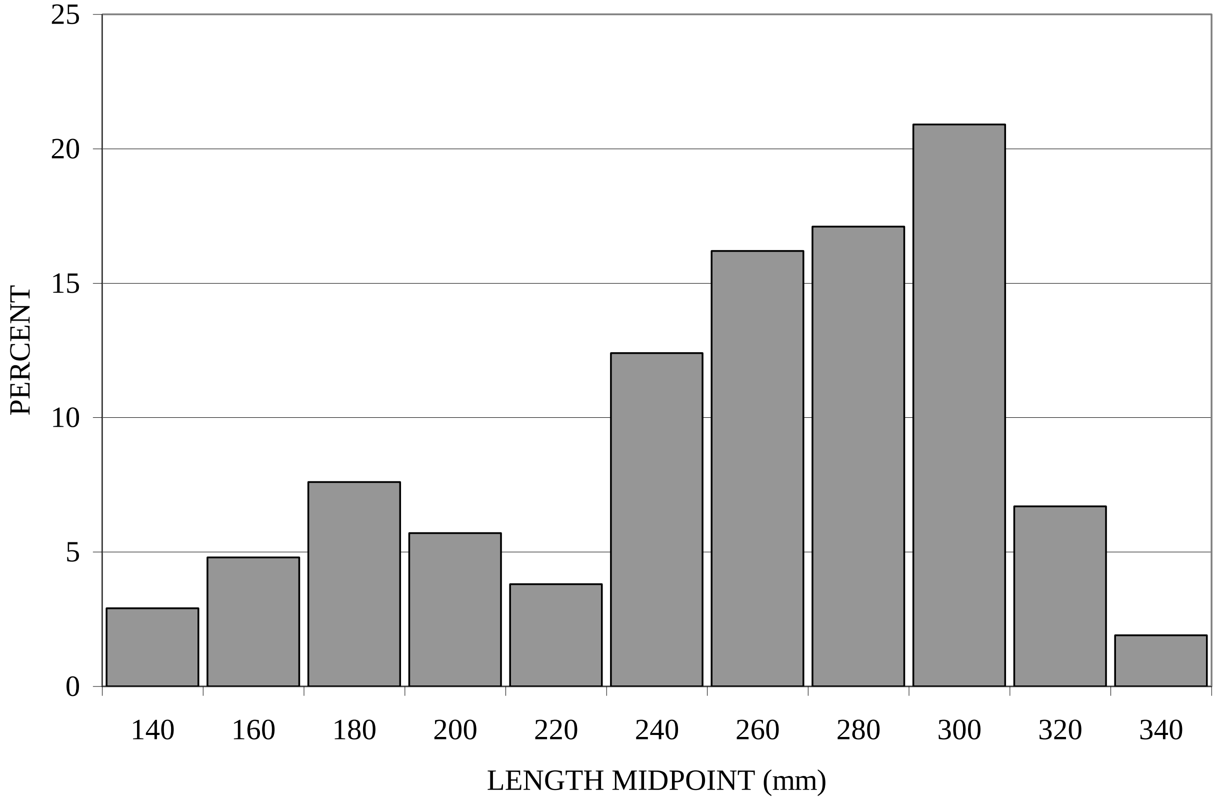


Table 15. Relative stock densities (RSD's) of channel catfish from the upper Chesapeake Bay winter trawl survey, 2000 – 2013. Minimum length cut-offs in parentheses.

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

Figure 15. Length frequency of channel catfish from the 2013 upper Chesapeake Bay winter trawl survey.

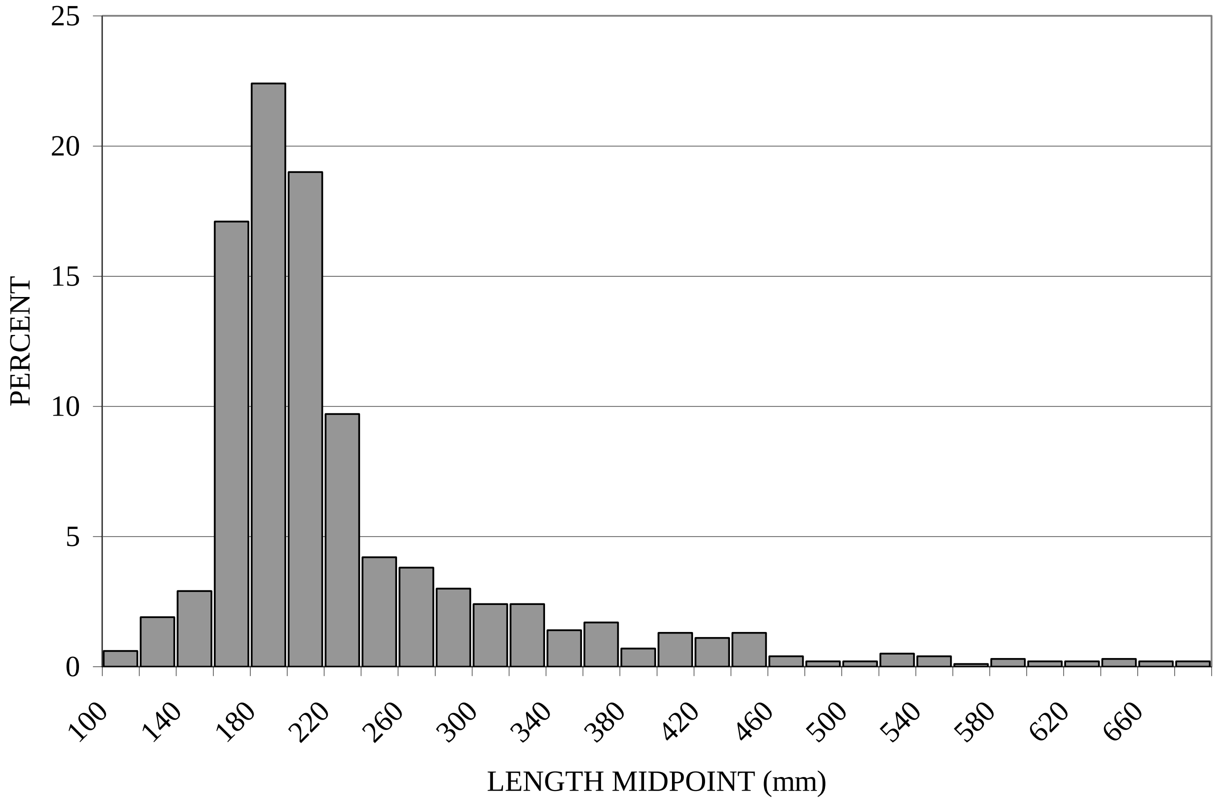


Table 16. Relative stock densities (RSD's) of channel catfish from the Choptank River fyke net survey, 1993 – 2013. Minimum length cut-offs in parentheses.

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

Figure 16. Channel catfish length frequency from the 2013 Choptank River fyke net survey.

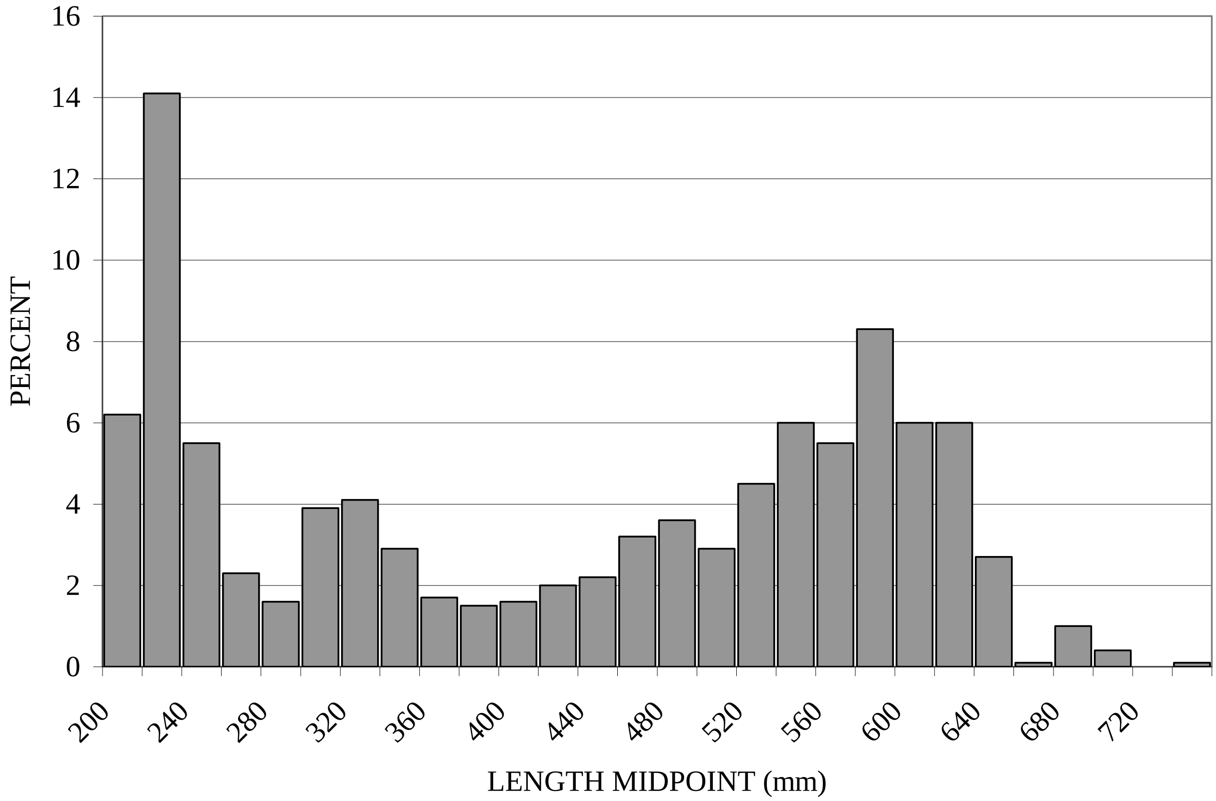


Table 17. Relative stock densities (RSD's) of channel catfish from Nanticoke River fyke and pound net survey, 1995 – 2013. 2007 -- 2009 include Marshyhope River fyke net data. Minimum length cut-offs in parentheses.

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

Figure 17. Channel catfish length frequency from the 2013 Nanticoke River fyke and pound net survey.

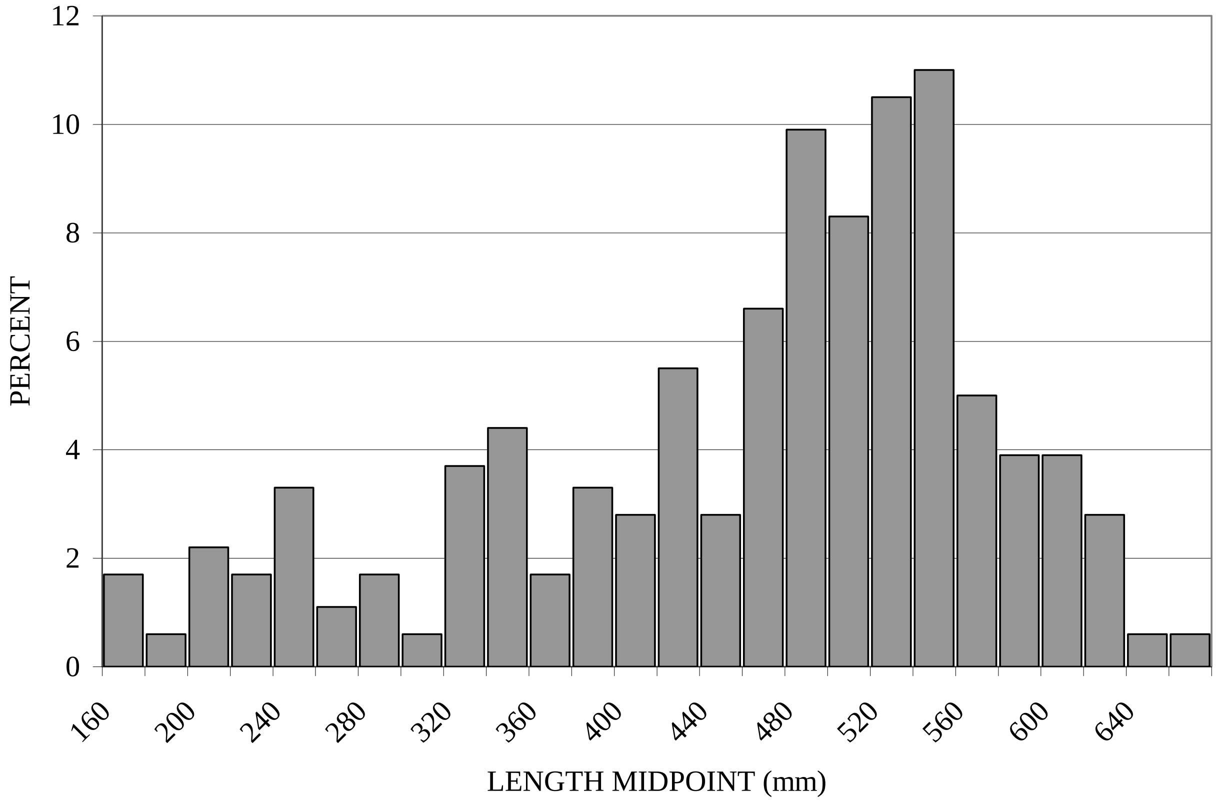


Table 18. Relative stock densities (RSD's) of white catfish from the upper Chesapeake Bay winter trawl survey, 2000 – 2013. Minimum length cut-offs in parentheses.

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

Figure 18. White catfish length frequency from the 2013 upper Chesapeake Bay winter trawl survey.

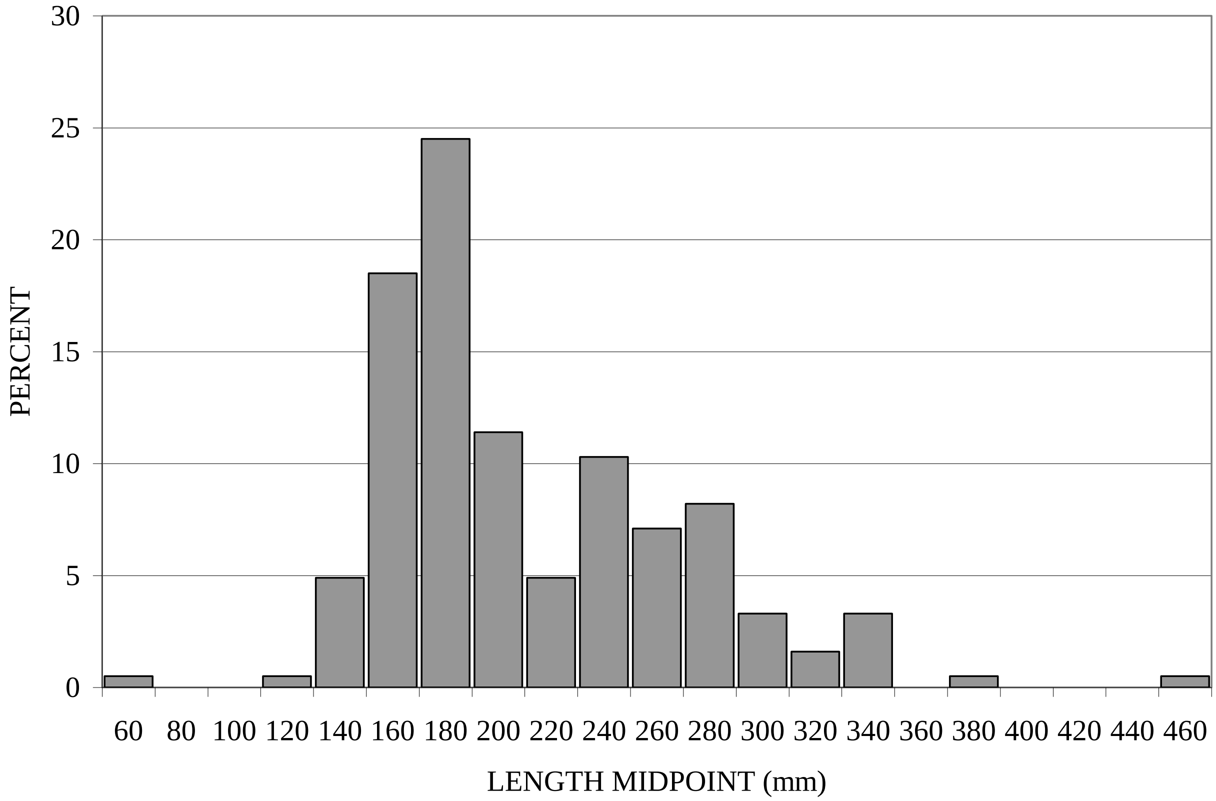


Table 19. Relative stock densities (RSD's) of white catfish from the Choptank River fyke net survey, 1993 – 2013. Minimum length cut-offs in parentheses.

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

Figure 19. White catfish length frequency from the 2013 Choptank River fyke net survey.

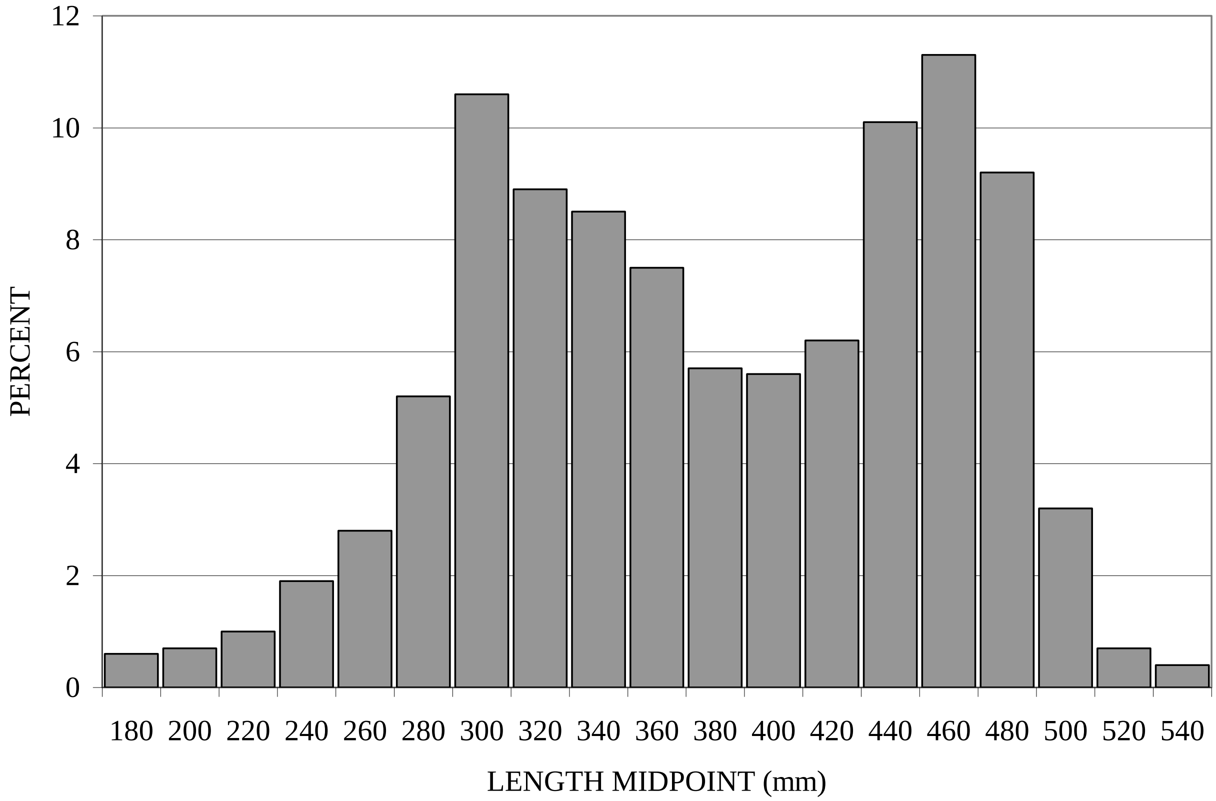


Table 20. Relative stock densities (RSD's) of white catfish from the Nanticoke River fyke and pound net survey, 1995 – 2013. 2007 -- 2009 include Marshyhope River fyke net data. Minimum length cut-offs in parentheses.

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

Figure 20. White catfish length frequency from the 2013 Nanticoke River fyke and pound net survey.

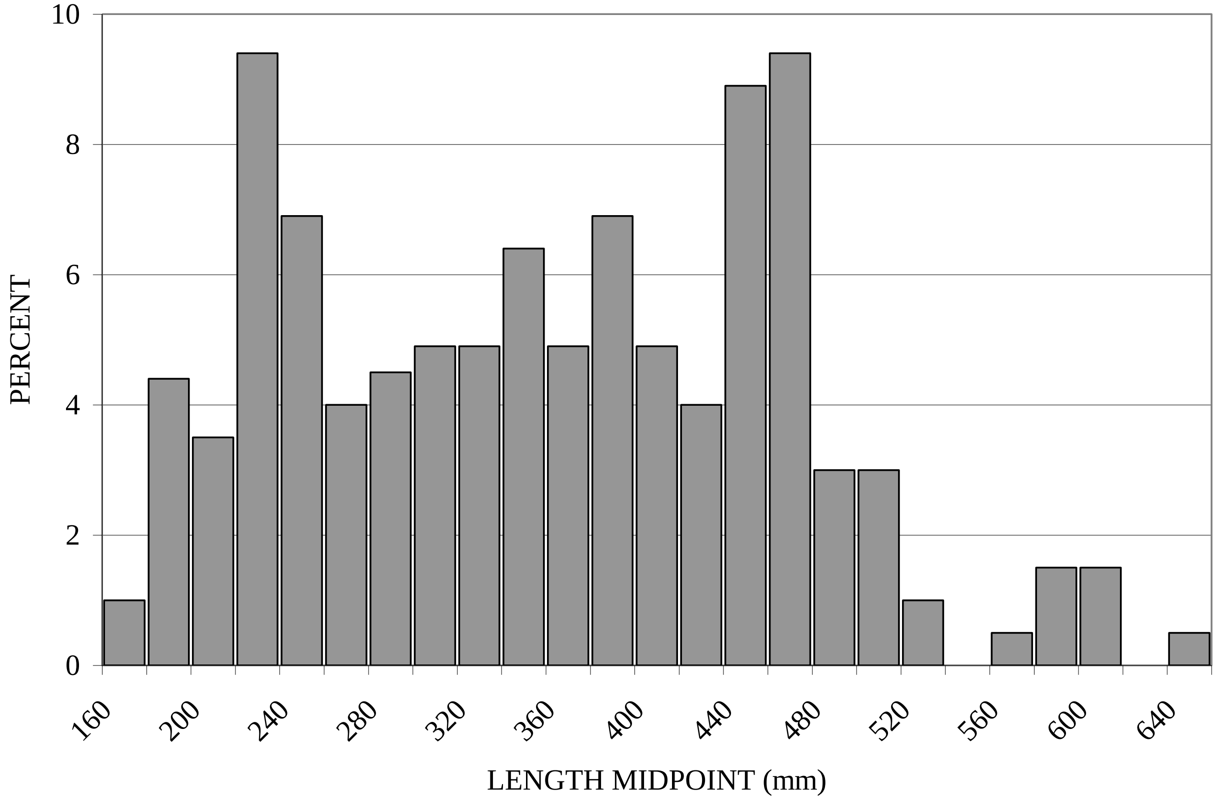


Table 21. White perch growth parameters from Choptank River for males, females, and sexes combined. NA=data not available NSF=no solution found or small sample size.

Sample Year	Sex	Allometry		von Bertalanffy		
		alpha	beta	L-inf	K	t_0
2005	F	4.8×10^{-6}	3.23	288	0.36	0.00
	M	4.8×10^{-6}	3.22	374	0.10	-2.10
	Combined	3.8×10^{-6}	3.27	304	0.25	-1.60
2006	F	NSF	285	0.36	0.40	
	M	NSF	275	0.42	0.60	
	Combined	7.8×10^{-5}	2.69	273	0.4	0.60
2007	F	1.6×10^{-5}	3.00	269	0.33	0.28
	M	5.8×10^{-5}	2.74	247	0.32	0.06
	Combined	1.9×10^{-5}	2.96	265	0.31	0.15
2008	F	3.0×10^{-6}	3.29	317	0.23	-1.44
	M	3.7×10^{-6}	3.25	227	0.32	-1.98
	Combined	2.2×10^{-6}	3.35	284	0.28	-0.89
2009	F	2.8×10^{-6}	3.32	338	0.20	-1.33
	M	2.5×10^{-6}	3.32	225	0.49	-0.77
	Combined	1.9×10^{-6}	3.38	281	0.32	-0.17
2010	F	4.0×10^{-6}	3.26	312	0.18	-1.38
	M	4.2×10^{-6}	3.23		NSF	
	Combined	2.6×10^{-6}	3.33		NSF	
2011	F	2.3×10^{-6}	3.35		NSF	
	M	2.4×10^{-6}	3.34	217	0.49	0.44
	Combined	2.0×10^{-6}	3.38		NSF	
2012	F	6.9×10^{-6}	3.17	264	0.47	0.81
	M	4.5×10^{-6}	3.23	227	0.39	-0.21
	Combined	3.1×10^{-6}	3.31	251	0.46	0.68
2013	F	8.9×10^{-6}	3.10	320	0.13	-4.78
	M	4.8×10^{-6}	3.19	245	0.20	-3.64
	Combined	3.8×10^{-6}	3.25	284	0.16	-3.66
2000 – 2013	F	4.9×10^{-6}	3.22	308	0.18	-1.88
	M	5.7×10^{-6}	3.17	247	0.22	-2.07
	Combined	3.2×10^{-6}	3.29	293	0.19	-1.74

Table 22. 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
2005	F	2.3×10^{-6}	3.36	313	0.23	-0.53
	M	NSF	313	0.14	-2.65	
	Combined	1.50×10^{-6}	3.44	321	0.17	-1.60
2006	F		311	0.22	-1.41	
	M	NA		279	0.19	-2.54
	Combined			321	0.16	-2.60
2007	F	6.2×10^{-6}		2.76	299	0.23
	M	1.0×10^{-6}		3.08	282	0.24
	Combined	3.4×10^{-6}	2.87	297	0.23	-0.70
2008	F	4.1×10^{-6}	3.25	295	0.35	0.23
	M	8.0×10^{-6}	3.12	254	0.38	-0.20
	Combined	3.6×10^{-6}	3.27	288	0.32	-0.16
2009	F	3.4×10^{-6}	3.28	285	0.33	0.47
	M	1.4×10^{-4}	2.58	273	0.18	-1.70
	Combined	5.9×10^{-6}	3.18	284	0.25	-0.33
2010	F	1.7×10^{-6}	3.41	345	0.16	-1.36
	M	3.4×10^{-5}	2.85	275	0.25	-0.46
	Combined	2.7×10^{-6}	3.32	318	0.18	-1.03
2011	F	1.6×10^{-6}	3.42	313	0.25	-0.20
	M	7.8×10^{-6}	3.13	265	0.26	-0.31
	Combined	1.5×10^{-6}	3.43	293	0.24	-0.39
2012	F	4.5×10^{-6}	3.25	NSF		
	M	1.0×10^{-5}	3.08	318	0.16	-1.56
	Combined	2.9×10^{-6}	3.32	344	0.14	-1.83
2013	F	7.7×10^{-6}	3.14	307	0.28	-0.49
	M	1.7×10^{-5}	2.99	285	0.22	-1.19
	Combined	6.2×10^{-6}	3.18	300	0.24	-0.91
2000 - 2013	F	5.2×10^{-6}	3.20	315	0.20	-1.15
	M	1.7×10^{-5}	2.99	280	0.21	-1.32
	Combined	4.6×10^{-6}	3.23	306	0.20	-1.22

Table 23. 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.

Sample Year	Sex	allometry		von Bertalanffy		
		alpha	beta	L-inf	K	t_0
2004	F	NA		306	0.41	-0.4
	M	NA		253	0.34	-1.2
	Combined	NA		259	0.51	-0.5
2005	F	NA		293	0.64	-0.5
	M	NA		244	0.63	0.1
	Combined	NA		258	0.45	-1.6
2006	F	NA		297	.36	-1.05
	M	NA		291	.24	-1.09
	Combined	NA		290	.26	-2.00
2007	F	2.3×10^{-5}	2.88	308	0.52	0.19
	M	1.3×10^{-5}	2.97	279	0.29	-1.40
	Combined	1.1×10^{-5}	3.02	277	0.54	-0.01
2008	F	5.8×10^{-6}	3.12	322	0.43	-0.12
	M	1.1×10^{-5}	3.00	253	0.26	-2.82
	Combined	8.1×10^{-6}	3.06	289	0.40	-0.59
2009	F	8.7×10^{-6}	3.06	315	0.40	-0.63
	M	2.8×10^{-6}	3.26	288	0.35	-0.24
	Combined	4.4×10^{-6}	2.18	308	0.29	-1.71
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		NSF	
	M	4.7×10^{-6}	3.17		NSF	
	Combined	3.2×10^{-6}	3.25		NSF	
2012	F	7.0×10^{-6}	3.08	374	0.18	-2.22
	M	1.5×10^{-6}	3.37	257	0.29	-2.62
	Combined	6.7×10^{-6}	3.09	295	0.32	-1.38
2013	F	9.2×10^{-6}	3.02	294	0.53	-0.28
	M	1.7×10^{-5}	2.92	322	0.10	-6.35
	Combined	1.5×10^{-5}	2.94	267	0.53	-0.48
2000 – 2013	F	1.0×10^{-5}	3.03	313	0.32	-1.06
	M	3.5×10^{-6}	3.22	298	0.15	-3.60
	Combined	6.8×10^{-6}	3.10	270	0.36	-1.29

Table 24. Yellow perch growth parameters from upper Chesapeake Bay fyke nets for males, females, and sexes combined. NA=data not available NSF=no solution found.

Sample Year	Sex	allometry		von Bertalanffy		
		alpha	beta	L-inf	K	t_0
2004	F	1.18×10^{-6}	3.43	297	0.75	1.14
	M	NSF		256	0.37	-2.5
	Combined	7.08×10^{-7}	3.52	273	1.04	1.35
2005	F	4.40×10^{-7}	3.62	358	0.25	-0.7
	M	5.61×10^{-7}		3.55	244	0.41
	Combined	1.69×10^{-7}	3.79	256	0.64	0.32
2006	F	5.15×10^{-5}	2.75	288	0.34	-2
	M	4.75×10^{-5}	2.73	240	0.41	-2
	Combined	4.72×10^{-5}	2.75	244	0.6	-2
2007	F	1.96×10^{-6}	3.35	325	0.34	-0.09
	M	4.38×10^{-6}	3.18	240	0.61	0.61
	Combined	6.68×10^{-7}	3.54	267	0.64	0.55
2008	F	7.83×10^{-6}	3.11	339	0.26	-2.14
	M	3.32×10^{-6}	3.24		NSF	
	Combined	3.89×10^{-6}	3.23	275	0.41	-1.97
2009	F	1.30×10^{-6}	3.43	294	0.43	-0.78
	M	6.09×10^{-6}	3.13	220	0.97	-0.14
	Combined	6.23×10^{-6}	3.56	245	0.90	0.13
2010	F	1.62×10^{-4}	2.57	392	0.51	0.04
	M	1.92×10^{-6}	3.34	247	0.88	0.99
	Combined	3.40×10^{-5}	2.84	296	0.66	0.40
2011	F	3.1×10^{-8}	4.10		NSF	
	M	9.4×10^{-7}	3.47		NSF	
	Combined	9.1×10^{-6}	3.90	245	0.66	-1.93
2012	F	1.4×10^{-6}	3.39	294	0.44	-0.31
	M	7.8×10^{-6}	3.06	253	0.89	1.22
	Combined	7.7×10^{-6}	3.50	269	0.73	0.53
2013	F	2.5×10^{-6}	3.31	393	0.15	-2.27
	M	1.5×10^{-5}	2.95	257	0.38	-0.02
	Combined	1.2×10^{-6}	3.44	304	0.24	-1.76
1998 – 2013	F	4.3×10^{-6}	3.21	314	0.27	-1.54
	M	4.1×10^{-6}	3.19	250	0.32	-2.34
	Combined	2.0×10^{-6}	3.34	266	0.48	-0.58

Table 25. Yellow perch growth parameters from upper 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
2004	F			326	0.43	-1.1
	M	NA	284	0.32	-3.4	
	Combined			290	0.68	-0.5
2005	F	NSF	332	0.56	-0.1	
	M	3.40×10^{-5}	2.84	286	0.68	0.1
	Combined	NSF	342	0.35	-1.1	
2006	F	NA	313	0.73	0.3	
	M			297	0.57	-0.1
	Combined			301	0.78	0.4
2007	F	1.80×10^{-6}	3.38	346	0.35	-0.8
	M	7.37×10^{-6}	3.10		NSF	
	Combined	1.18×10^{-6}	3.45	308	0.42	-0.8
2008	F	3.37×10^{-6}	3.26	325	0.63	0.28
	M	6.79×10^{-6}	3.10	259	0.92	0.45
	Combined	9.96×10^{-7}	3.46	285	0.90	0.55
2009	F	3.0×10^{-5}	2.87	NSF		
	M	7.5×10^{-5}	2.67	292	0.40	-0.01
	Combined	1.1×10^{-5}	3.05	317	0.32	-1.10
2010	F	NSF			NSF	
	M	NSF			NSF	
	Combined	NSF			NSF	
2011	F	5.4×10^{-5}	2.74		NSF	
	M	3.3×10^{-6}	3.23		NSF	
	Combined	1.6×10^{-5}	2.95		NSF	
2012	F	1.9×10^{-6}	2.93	327	.053	0.08
	M	1.8×10^{-6}	3.34	311	.034	-0.41
	Combined	8.6×10^{-6}	3.07	312	.063	0.43
2013	F	1.3×10^{-5}	3.00	321	0.69	0.78
	M	2.6×10^{-6}	3.29	294	0.43	0.15
	Combined	9.5×10^{-6}	3.06	308	0.80	0.93
2000 –2013	F	9.3×10^{-6}	3.07	343	0.33	-0.99
	M	9.9×10^{-6}	3.04	292	0.36	-0.90
	Combined	4.0×10^{-6}	3.22	306	0.42	-0.69

Table 26. Estimated instantaneous fishing mortality rates (F) for white perch. Based on catch curve analysis of ages 6 – 10+. NR= not reliable; NA=not available; MIN= minimal, at or near M estimate.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Choptank	0.1	0.58	0.58	0.40	MIN	0.35	0.99	0.29	0.08	MIN
Nanticoke	NR	NR	0.22	0.18	0.16	0.12	0.66	NR	NR	0.08
Upper Bay trawl	NA	0.50	0.12	0.19	0.26	0.54	0.76	0.51	0.08	0.03

Table 27. Estimated instantaneous fishing mortality rates (F) for yellow perch. NR= not reliable; MIN=minimal, at or near M estimate.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Choptank[1]	NR	0.08	MIN	0	NR	0.17	MIN	0.56	0.12	MIN
Upper Bay[2]	0.23	0.14	0.13	0.12	0.04	0.17	0.24	0.21	0.21	0.11

[1]Based on ratio of CPUE of ages 4-10+ (year t) to CPUE of ages 3 – 10+ (year t-1) except 2002 estimate where all available ages were used, and 2009 estimate where ratio of ages 5 - 10 and 4 - 10 were used.

[2]N-weighted population F from Piavis and Webb in publ.

Figure 21. Baywide young-of-year relative abundance index for white perch, 1962 – 2013, based on EJFS data. Bold horizontal line=time series average. Error bars indicate 95% CI's.

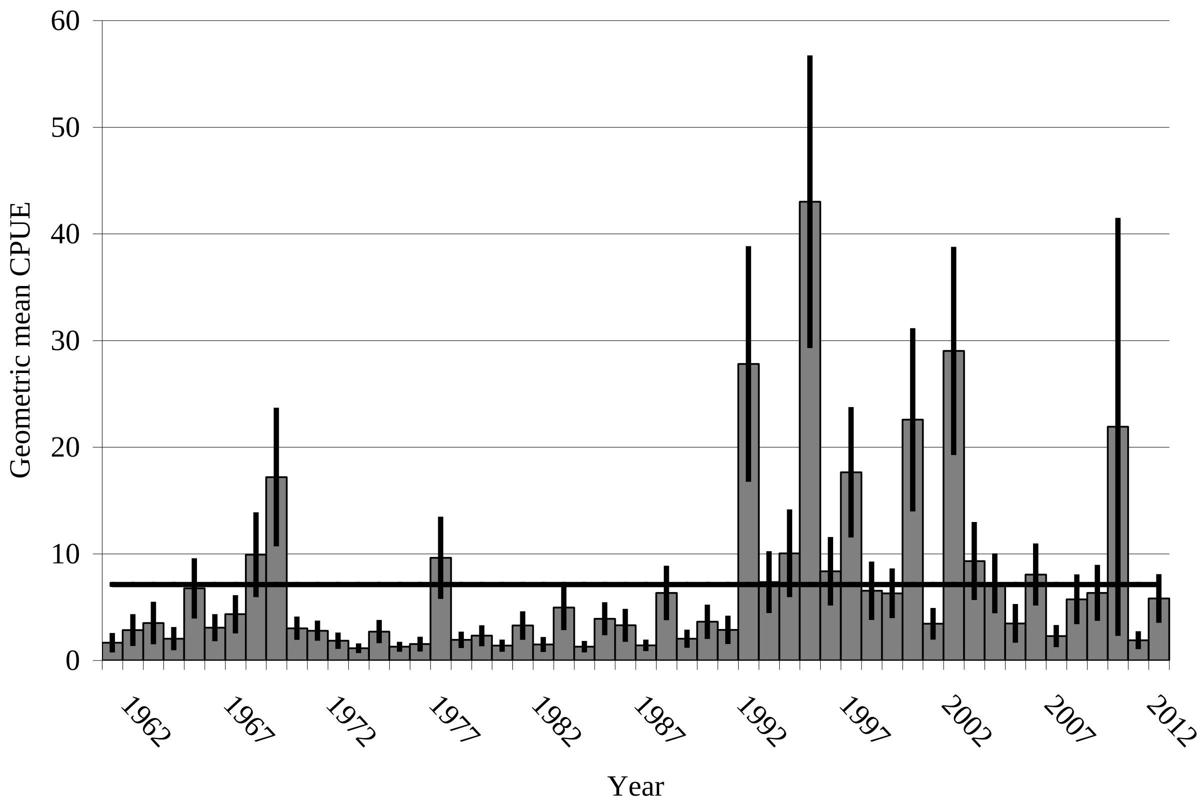


Figure 22. Age 1 white perch relative abundance from upper Chesapeake Bay winter trawl survey. Not sampled in 2004, small sample sizes 2003 and 2005.

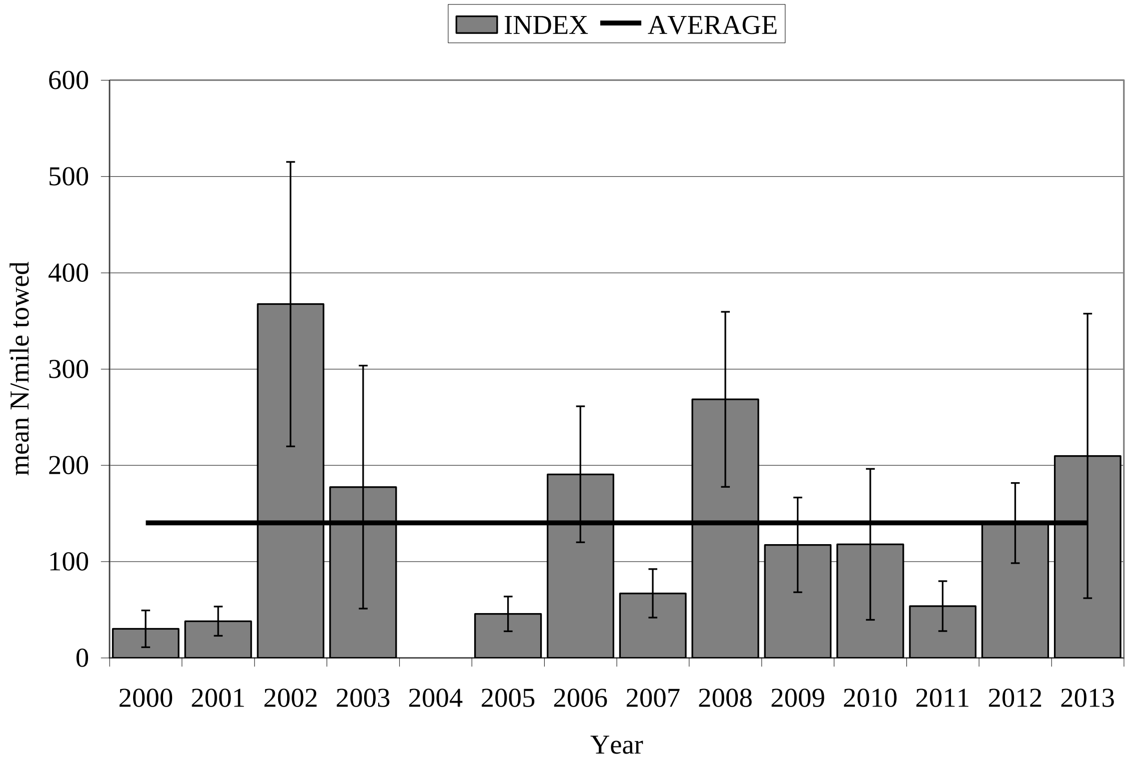


Figure 23. Head-of-Bay young-of-year relative abundance index for yellow perch, 1979 – 2013, based on Estuarine Juvenile Finfish Survey data. Horizontal line=time series average. Error bars indicate 95% confidence interval.

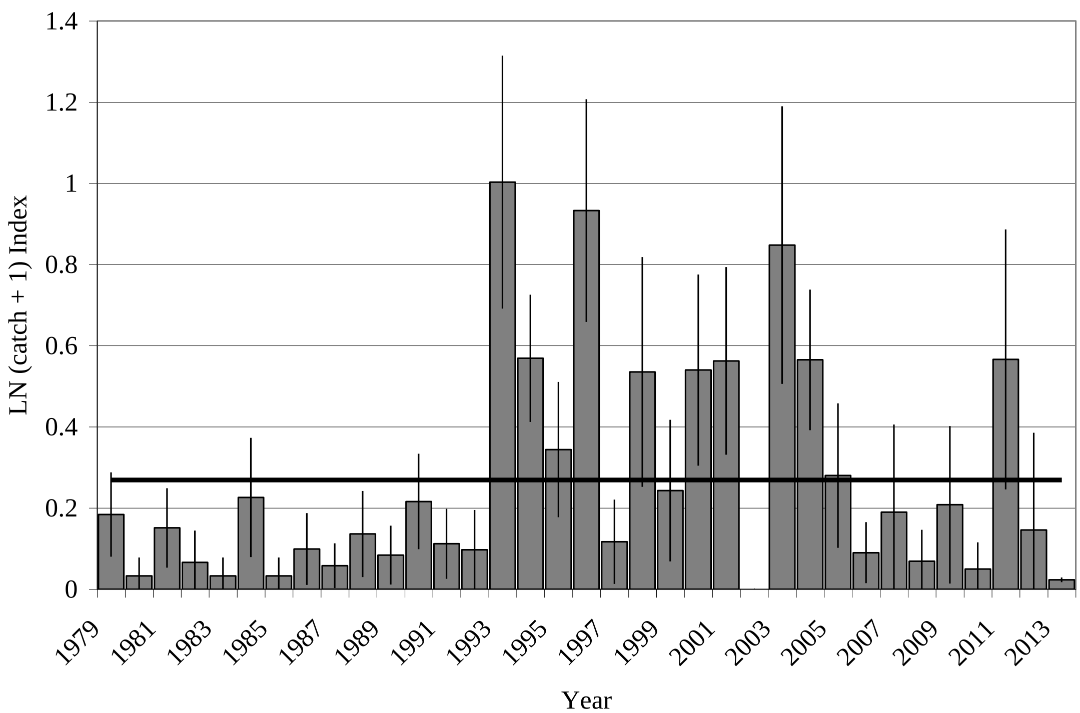


Figure 24. Age 1 yellow perch relative abundance from upper Chesapeake Bay winter trawl survey. Not sampled in 2004, small sample sizes 2003 and 2005.

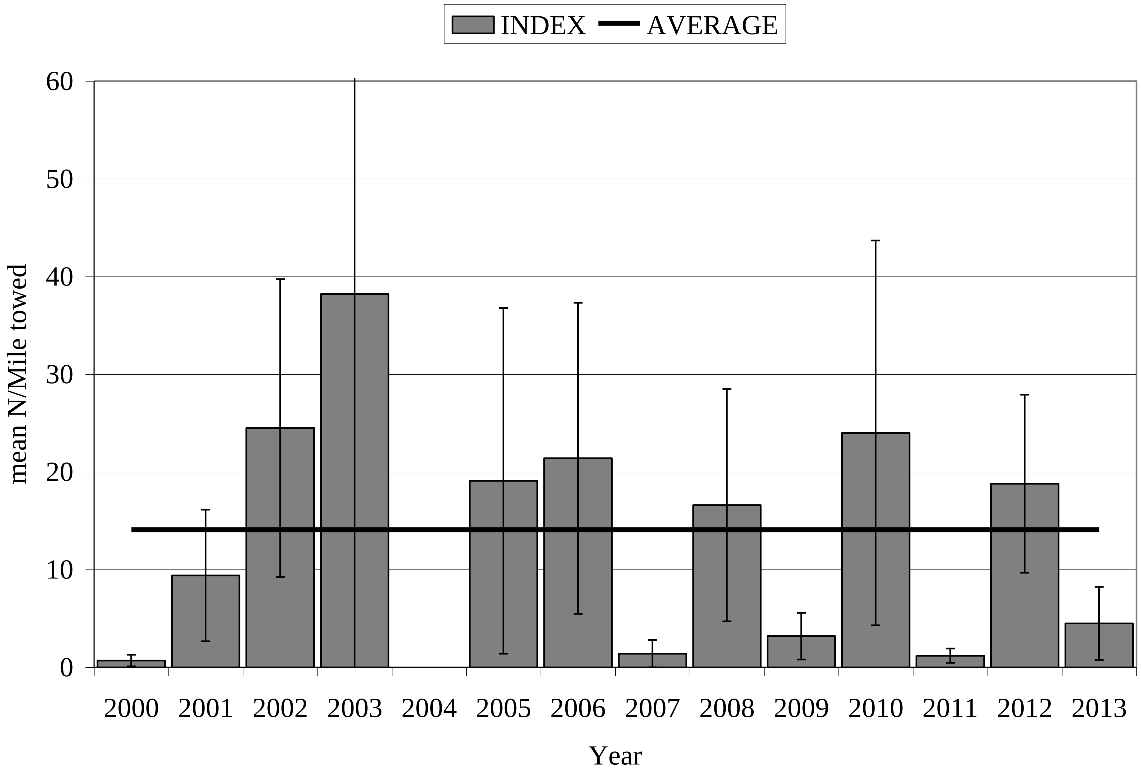


Figure 25. Age 1 channel catfish relative abundance from upper Chesapeake Bay winter trawl survey. Not sampled in 2004, small sample sizes 2003 and 2005.

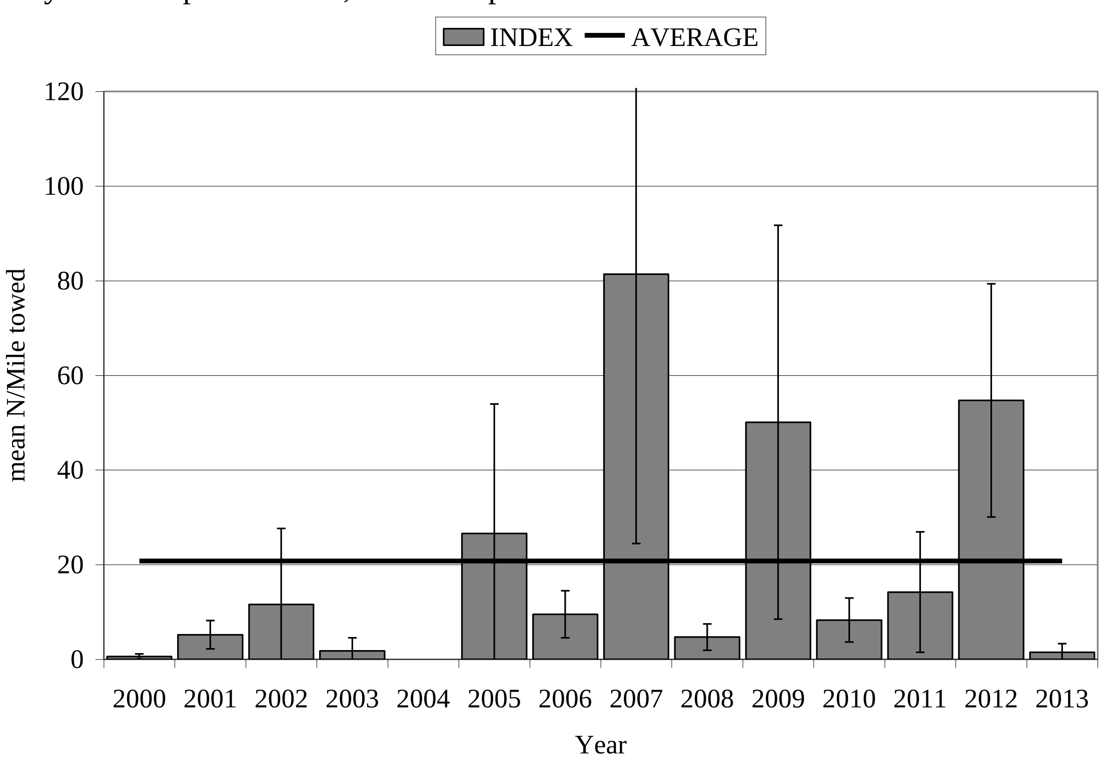


Table 28. White perch relative abundance (N/MILE TOWED) and number of tows from the upper Chesapeake Bay winter trawl survey, 2000 – 2013.

YEAR	AGE											
	1	2	3	4	5	6	7	8	9	10+	Sum CPE	No. Tows
2000	34.5	227.3	102.0	65.8	24.7	14.8	20.3	2.2	2.2	1.4	495.2	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	367.2	2.9	71.1	28.8	44.5	19.0	36.8	20.5	5.3	12.3	608.4	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	45.5	80.7	22.1	40.3	10.2	3.6	1.2	11.4	1.3	0.6	216.9	56
2006	192.1	63.2	153.2	47.2	36.7	10.2	6.3	6.1	1.5	2.7	519.2	108
2007	67.0	44.3	31.8	61.6	34.9	8.4	9.2	0.8	0.6	3.0	261.6	149
2008	268.5	44.7	113.3	84.5	25.7	8.8	3.5	3.8	1.4	1.4	555.6	108
2009	118.5	324.6	13.7	59.4	112.1	95.2	2.3	33.4	7.2	1.4	767.8	90
2010	178.0	138.5	163.4	5.6	52.6	41.7	68.9	5.8	9.5	13.9	677.9	56
2011	53.7	70.5	51.2	68.9	16.9	38.9	21.6	22.9	1.3	4.6	350.5	66
2012	139.9	45.9	19.9	8.6	9.6	9.8	16.7	7.3	10.3	3.1	271.1	107
2013	209.7	301.8	35.8	79.0	71.9	362.8	41.5	49.8	11.7	29.6	1,193.6	86

Table 29. White perch relative abundance (N/net day) and total effort from the Choptank River fyke net survey, 2000 – 2013.

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

Table 30. Yellow perch relative abundance (N/MILE TOWED) and number of tows from the upper Chesapeake Bay winter trawl survey, 2000 – 2013.

YEAR	AGE											
	1	2	3	4	5	6	7	8	9	10+	Sum CPE	No. Trawls
2000	0.9	1.5	0.2	1.6	0.1	0.3	0.1	0.0	0.0	0.1	4.8	79
2001	9.4	0.6	1.0	0.2	0.6	<0.1	0.0	<0.1	0.0	0.0	12.0	114
2002	24.3	17.3	1.7	3.6	0.3	1.8	0.0	0.2	0.1	0.0	49.3	110
2003	38.3	135.7	422.1	46.3	61.6	4.0	24.8	0.0	2.0	0.0	734.8	20
2004	NOT SAMPLED											
2005	18.8	13.7	<0.1	3.1	0.4	<0.1	<0.1	0.0	<0.1	0.0	36.4	43
2006	23.8	34.3	15.8	0.0	3.3	0.4	0.0	0.4	0.0	0.0	78.0	108
2007	3.6	3.3	8.4	2.4	1.5	0.6	0.1	<0.1	0.0	0.0	20.0	71
2008	17.0	4.1	9.1	8.0	2.1	0.0	0.0	0.0	0.0	0.0	40.3	108
2009	4.3	21.2	1.1	2.4	2.1	0.5	<0.1	0.0	0.0	0.0	31.7	90
2010	27.1	3.3	8.5	0.6	0.9	0.4	0.2	0.0	0.1	0.0	41.1	56
2011	1.4	4.6	0.7	2.9	0.0	0.4	0.1	0.0	0.0	0.0	10.1	66
2012	19.1	6.5	2.2	0.1	0.1	0.1	0.0	0.7	0.0	0.0	28.8	107
2013	4.7	9.4	2.7	1.1	0.1	<0.1	<0.1	0.0	0.1	0.0	18.3	86

Table 31. Yellow perch relative abundance (N/net day) and total effort from the Choptank River fyke net survey, 1988 – 2013.

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

Figure 26. Choptank River yellow perch relative abundance from fyke nets, 1988 – 2013. Effort standardized from 1 March – 95% total catch date. Log-transformed trendline statistically significant at P<0.002.

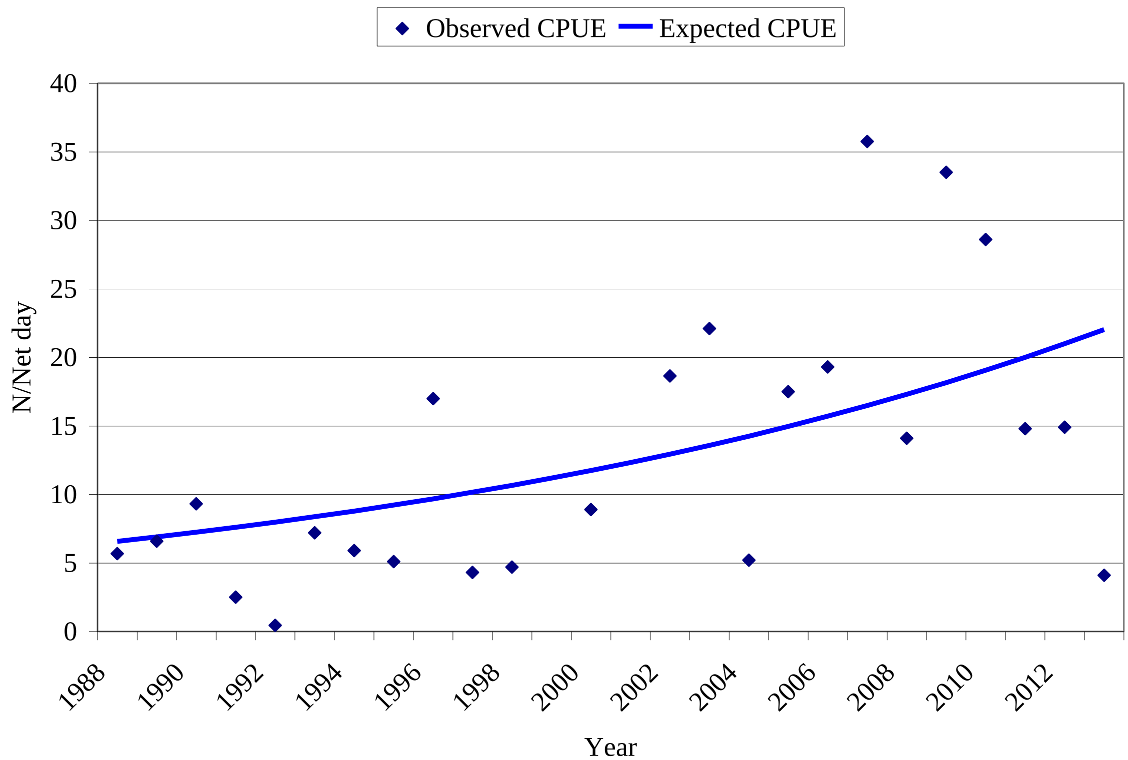


Figure 27. Channel catfish relative abundance (N/mile towed) from the upper Chesapeake Bay winter trawl survey, 2000-2013. Not surveyed in 2004, small sample sizes in 2003 and 2005.

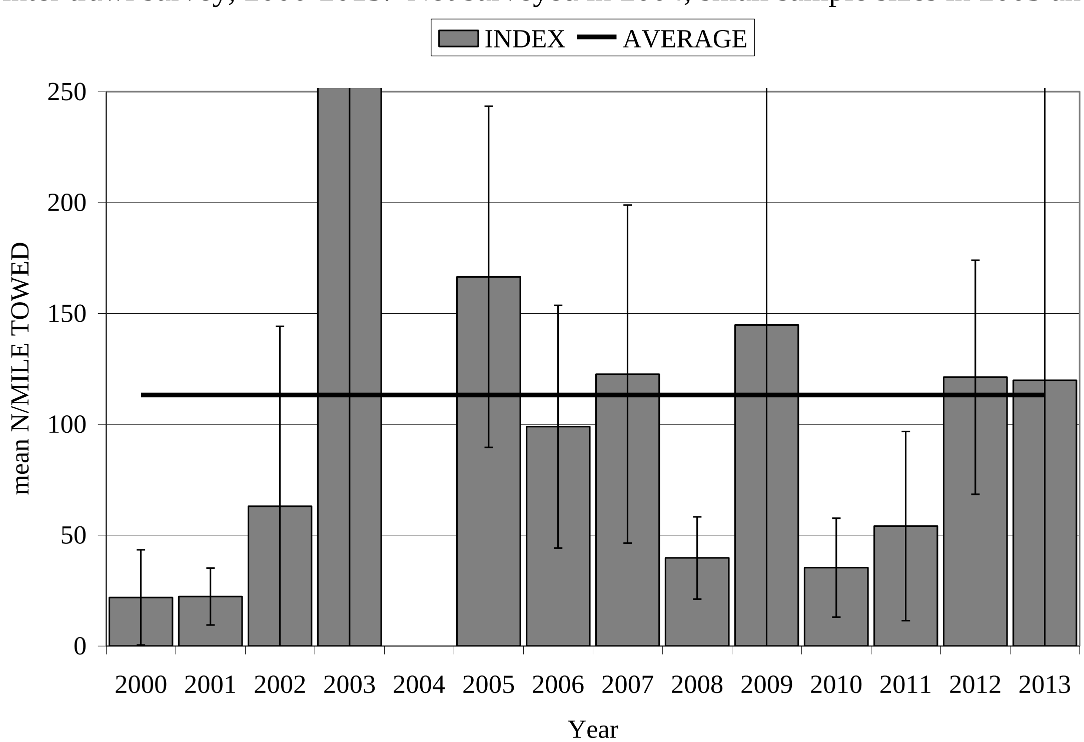


Figure 28. Channel catfish relative abundance (N/net day) from the Choptank River fyke net survey, 2000 – 2013. Horizontal line indicates time series average relative abundance.

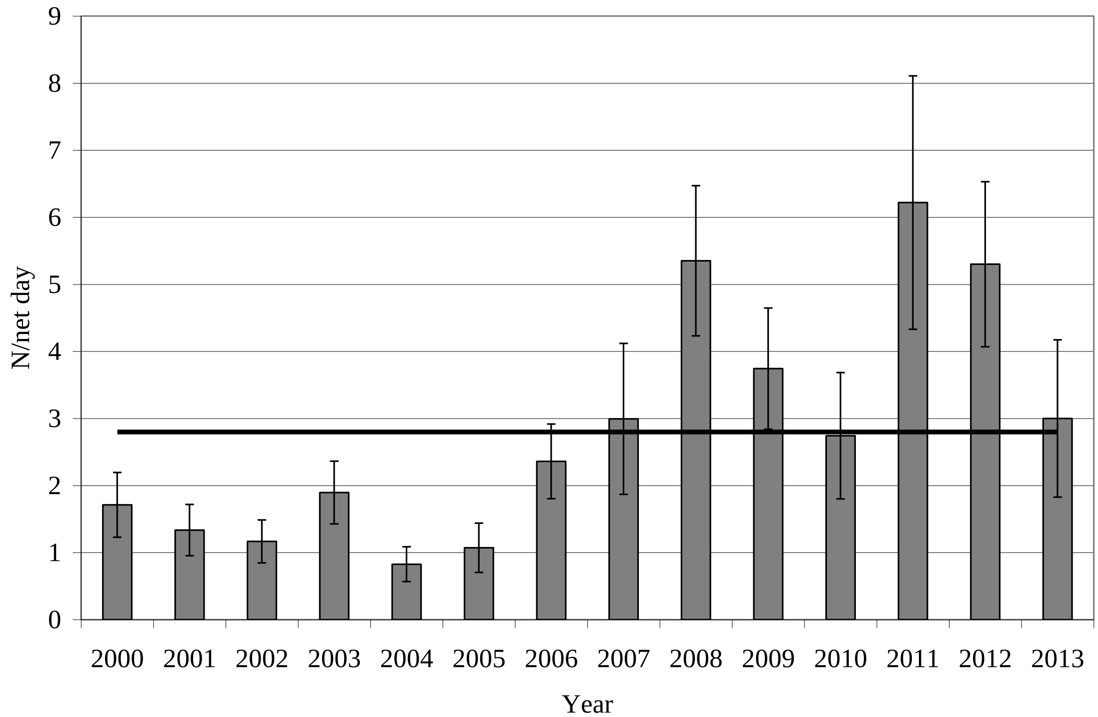
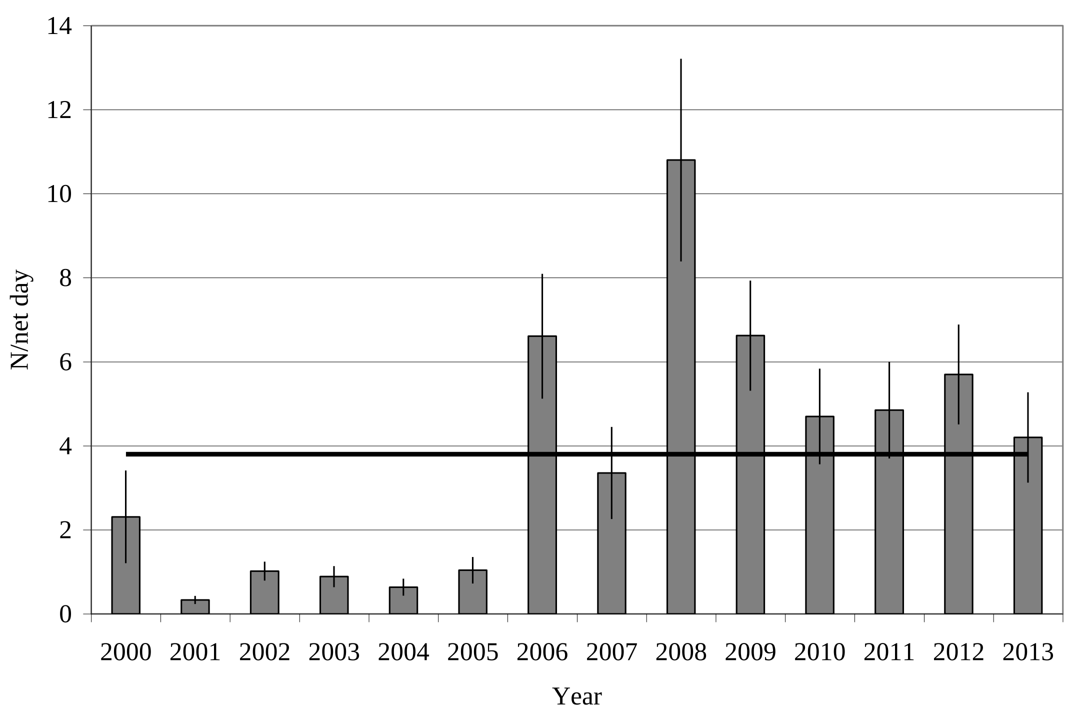


Figure 29. White catfish relative abundance (N/net day) from the Choptank River fyke net survey, 2000 – 2013. Horizontal line indicates time series average relative abundance.



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 2004 – 2013, annual commercial harvest in Maryland ranged from 30,600 kg in 2004 to 8,800 kg in 2008, and averaged 45,000 kg since 1929. 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 (Chesapeake Bay Bridge) in the upper Chesapeake Bay region. Fyke net harvest accounted for 99% of the total yellow perch commercial harvest over the five year period 2008 – 2012. 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). From 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 – 2013, and the historical proportion of Chester River landings to upper Bay landings was used to formulate a Chester River quota. Conservative historical landings from Patuxent River were also used to determine a quota (Table 1). All areas maintained the slot limit and in addition, the season opened 1 January of each year.

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). During the late 1950s and early 1960s, one creel survey indicated that yellow perch harvest in the uppermost reach of the Susquehanna River in Maryland ranged from 4,500 – 6,000 yellow perch (McCauley et al. 2007). 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.

From 1988 – 2008, recreational fishers in the upper Bay had a 5 fish daily creel limit and a 9” minimum size limit (msl) with no closed season. During these years, the 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 with a 9” msl and a 10 fish daily creel limit.

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, 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 updated again in 2010 (Piavis and Webb 2011). The previous %MSP target and limit remained consistent with the earlier time periods (target=35% limit=25%).

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 (2011 – 2013) and the model was refined by revisiting fishery independent indices and weightings, and expanding the range of ages that were modeled from ages 3 – 8+ to ages 2 – 8+.

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 as a comparison to our targets and limits. We incorporated the fishery selectivity vector produced from the statistical catch-at-age model 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 26 years. This survey provided the only adult yellow perch relative abundance dataset 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 Chesapeake Bay Bridge and all tributaries except the Chester River (Figure 1). Data supported an assessment covering 1998 – 2013. 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 fished (Lewis 2010). Effort was calculated as the number of fyke nets utilized by watermen that landed more than 100 pounds of yellow perch in any month, multiplied by the number of days in the month to get a total number of net days. The only exception was the month of April where 15 days were ascribed as the effort multiplier since the yellow perch spawning run and down-running activity is largely completed early in the month. The 2008 yellow perch season began on 15 March 2008, so the effort multiplier was 16 days for March and 15 days for April. The commercial fishing season had variable closing dates during 2009 – 2013, dependent upon quota attainment. The effort multipliers were adjusted to the actual closing date of the fishery during those years.

No estimates of recreational harvest prior to 2008 were available, but we assumed recreational harvest to be a minor component of the total removals. 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 the Northeast River in 2009 (Wilberg and Humphrey 2008, 2009). Given the lack of recreational harvest characterization, no recreational removals were considered in the catch-at-age matrix.

Biological samples were taken from cooperating commercial fyke net fishermen, from 1998 – 2013. Not all regions were sampled in every year, but biologists generally visited 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 an upper Bay 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 some data in spite of weather and mechanical problems (Piavis and Webb 2014). Trawling effort was sufficient to generate a relative abundance index of 2 and 3 year-old yellow perch and an aggregated age 4+ abundance index for the years 2000 – 2002 and 2006 – 2013.

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). 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 2, age 3, and age 4+ trawl indexes were geometric mean catch per mile towed.

Another age 2 index was developed from the Estuarine Juvenile Finfish Survey (EJFS; Durrell 2013). 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 two years. So the 1996 survey indexed age 2 abundance in 1998, the 1997 survey indexed age 2 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 occurring simultaneously, but essentially the model searches for the correct annual F (instantaneous fishing mortality), abundance starting values, annual recruitment levels (age 2 abundance) and fishery selectivity and fishery and survey catchability 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

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

$$+ \Sigma\lambda_S[\mathrm{Ln}(I_{seine\ 0,y\text{-}2\ obs}) - \mathrm{Ln}(I_{seine\ 0,y\text{-}2\ pred})]^2 + \Sigma\lambda_{T2}[\mathrm{Ln}(I_{trwl\ 2,y\ obs}) - \mathrm{Ln}(I_{trwl\ 2,y\ pred})]^2$$

$$\Sigma\lambda_{T3}[\mathrm{Ln}(I_{trwl\ 3,y\ obs}) - \mathrm{Ln}(I_{trwl\ 3,y\ pred})]^2 + \Sigma\lambda_{T4+}[\mathrm{Ln}(I_{trwl\ 4+,y\ obs}) - \mathrm{Ln}(I_{trwl\ 4+,y\ pred})]^2$$

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, $I_{seine\ 0,\ y\text{-}2}$ is the seine index, $I_{trwl\ 2,y}$ $I_{trwl\ 3,y}$ and $I_{trwl\ 4+,y}$ are the trawl indexes of ages 2, 3 and 4+ yellow perch in year y, and λ_F, λ_C, λ_Y, $\lambda_{S,}$ $\lambda_{T2,}$ λ_{T3} and λ_{T4+} 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 4+ trawl index, 1.07 for the age 2 trawl index, 1.57 for the age 2 seine index, and 2.21 for the age 3 trawl index.

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

$$N_{\ a+1,\ y+1} = N_{\ a,\ y}\, e^{\ -(M+s_a F)} \qquad \text{for a = 2 to 7}$$

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

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.

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

$$CAA_{pred} = (F_y/Z_y)*N_{a,y}*(1-S_{a,y})$$

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

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 2 trawl index was $N_{2,y}*q_{trawl,2,y}$. Similarly the predicted age 3 and age 4+ trawl indices were $N_{3,y}*q_{trawl,3+,y}$ and $N_{4+,y}*q_{trawl,4+,y}$, respectively. The predicted age 2 seine index was $N_{0,y-2} * q_{seine}$.

Model run

The model requires estimation of $N_{4…8+, 1998}$, $R_{1998…2013}$ (where R is recruitment or abundance at age 2), F_y, q_{comm}, $q_{trawl,2}$, $q_{trawl,3}$, $q_{trawl,4+}$ and $q_{seine,t-2}$. To obtain initial estimates of abundance ($N_{4…8+, 1998}$), a Gulland style virtual population analysis (Megrey 1989) was performed on the CAA matrix. This analysis provided estimates for $N_{4…8+, 1998}$. This model used a constant initial recruitment value of 50 yellow perch ($R_{1998…2010}$). 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, 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 – 2013, 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). Previous model runs indicated that the model fit was quite insensitive to starting values of 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 0.1< F and F>1.1 for terminal year F (2013). The model was bootstrapped 10,000 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 all parameters.

<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

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

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

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

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_∞ = 314 mm K = 0.27 t_0 = -1.54) and an allometric length-weight relationship (α = 4.34 X 10^{-6} β = 3.21) from upper Bay yellow perch during 1998 -- 2013 (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). These biological reference points can be used to assess recreational fishing mortality status in areas open solely to recreational fishing (eg, Choptank River).

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

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

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

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 $F_{0.1}$.

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

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:

$$CPUE = a \bullet e^{(b \bullet yr)}$$

where yr is year from 1 to 26 (corresponding to 1988 – 2013) and a and b 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 ($R^2 = 0.49$ P=0.005; 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 0.26. The model fit the 2000 – 2013 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 0.15 (Figure 4). Catchability for the commercial fyke net fishery was estimated as 2.19 X 10 $^{-5}$, catchability of the trawl survey was 8.02 X 10 $^{-6}$ for age 2 yellow perch, 6.32 X $^{10-6}$ for age 3 yellow perch, and 1.50 X 10 $^{-6}$ for aggregated age 4+ yellow perch, and catchability of the seine survey was 1.26 X 10 $^{-6}$.

Abundance estimates were greater than 1,000,000 yellow perch from 1998 through 2003 (Figure 5). Abundance then declined to 634,500 yellow perch by 2012. Terminal year abundance was estimated at 886,700 yellow perch. Biomass was at a time series low 110,000 kg (2012). The biomass estimate rose in 2013 to 146,000 kg, less than the time series average of 215,000 kg (Figure 6). Maximum biomass was 463,000 kg in 1998.

Instantaneous fishing mortality (fully selected F) ranged from 0.05 – 0.97 during 1998 – 2013. Fishing mortality peaked in 2002 at 0.97, and then declined to 0.16 in 2006. In 2008, the F was 0.05 due to the closure of the commercial fishery that year. Since 2009, F averaged 0.30. Fully recruited F was 0.23 in the terminal year (Figure 7).

Estimated recruitment (abundance of age 2 yellow perch) ranged from 17,800 yellow perch in 2004 (2002 year-class) to 1,758,000 yellow perch in 1998 (1996 year-class) and averaged 367,000 yellow perch, 1998 – 2013 (Figure 8). Yellow perch recruitment was poor in 1999, 2004, 2008 and 2010 (1997, 2002, 2006, and 2008 year-classes, respectively). Recently, above average recruitment occurred in 2006, 2009, and 2013 (2004, 2007, and 2011 year-classes, respectively). The largest recruitment event occurred in 1998 (1996 year-class) at an estimated 1.76 million 2 year old yellow perch produced.

Log-$_e$ transformed 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 (λ = 2.21) and age 2 seine index (λ = 1.57) fit particularly well with all residuals < 1.0 (or > – 1.0 for negative residuals) with no apparent pattern (Figures 9 and 10). The age 2 trawl index ($\lambda = 1.07$) generally alternated between +/- residuals with low to moderate absolute values (Figure 11). The age 4+ aggregated trawl index ($\lambda = 1.00$) exhibited the poorest fit, but residuals were generally < 1.0 (or > – 1.0 for negative residuals), with limited contrast in the final few years (Figure 12).

Bootstrapping provided confidence intervals and quantified uncertainty. Of the 10,000 bootstrap trials, 95.5% 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 and F estimates were well estimated with slightly low bias for 2011 and 2012 (Figures 15, 16).

Coefficients of variation for all parameters and estimates were higher than in previous assessments. Survey and commercial fishery catchabilities were very well estimated (Table 5). Other parameters and estimates CV's were quite good early in the time series (<0.30). More recent values were generally in the 0.3 -- 0.35 range for most estimates.

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 17) and a fishery with a 9" minimum size limit (recreational fishery; Figure 18). For the upper Bay, which is a predominately commercial fishery, the target reference point ($F_{35\%}$) was 0.55 and the limit reference point ($F_{25\%}$) was 0.85. Yield per recruit modeling produced $F_{0.1}$ reference point of 0.12. Fully selected F in 2013

(0.23) produced a %MSP of 59%, less than the $F_{35\%}$ reference point indicating overfishing is not occurring. The bootstrap distribution of F indicated that there was only a 3 % chance that F exceeded $F_{35\%}$ in the upper Chesapeake Bay during 2013.

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 points of 0.16. Based on results from Project 1 Job 1, overfishing was not occurring in the Choptank River recreational fishery in 2013.

Choptank River relative abundance analysis

Non-linear regression of CPUE and year provided a statistically significant fit (P = 0.0002) . However, two data points were identified as possible outliers. Exclusion of the CPUE values for 1999 and 2001 improved the fit and corrected a bias toward negative residuals. The final equation, $CPUE = 6.26 \bullet e^{(0.048 \bullet yr)}$, was highly statistically significant ($P<0.0001$). The resultant curve indicated that predicted CPUE increased from 6.6 fish/net day in 1988 to 22.0 fish/net day in 2013 (Figure 19).

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 a decreasing salinity gradient from south to north, 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 due to the short-term nature of the assessment. 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, influencing 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, but future updates need to be inspected for any serial trends in q estimates. For example, a consistently significant decline or increase in q or an increase in CV’s of q could indicate that the assumption of constancy was violated.

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 1.2 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.

Recruitment was a prime contributor to population abundance, even when F varied from 0.04 – 0.97. Two year-old yellow perch contributed 28% on average to total population abundance. However, 2 year-old yellow perch comprised 55% 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 55%, but when the slot limit was in effect (2000 – 2013) average annual survival increased to 67%. 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 13,100 for the period 2000 – 2013. 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 that the probability was low 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 (83% probability) and F_{target} was exceeded in 2005 (64% probability). There was a 3% chance that the target was exceeded in 2013 and 0% probably that the limit was exceeded in 2013. 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 overfished status cannot be determined.

Choptank River yellow perch relative abundance has increased significantly over the past 10 years. Estimated fishing mortality has generally been below F=0.1 and in 2013 was minimal, meaning calculated Z was at or near assumed M (Project 1 Job 1). In addition, recruitment to the fishery, as defined by relative abundance of 3 year old yellow perch was relatively high during 2006 – 2009 and 2012, balanced by low 3 year-old relative abundance in 2010, 2011 and 2013 (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 80% MSP can be achieved. The calculated MSP is considerably higher than the current target (35% MSP), and as such, overfishing is not occurring.

LIST OF TABLES

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

YEAR	TAC	HARVEST	ADJUSTED TAC
2009	38,000	49,951	
2010	44,900	49,629	32,949
2011	47,200	37,543	37,520
2012	38,973	36,975	38,950
2013	29,800	19,352	29,800

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

Table 3 Catch-at age matrix, and harvest (N), for upper Chesapeake Bay yellow perch, 1998 –2013. Entries in bold were lowest value to substitute for 0 estimated catch.

Year	2	3	4	5	6	7	8+	Harvest
1998	5,460	3,086	51,318	151,407	**127**	**1,437**	**414**	210,896
1999	**231**	224,304	7,503	65,241	79,448	6,984	794	384,274
2000	**231**	876	162,415	4,826	9,278	15,570	**414**	193,545
2001	**231**	27,708	11,273	169,957	3,936	4,546	7,441	224,860
2002	4,902	24,777	119,202	11,544	211,205	4,101	27,478	398,308
2003	231	45,646	1,400	34,692	4,621	37,693	3,612	127,665
2004	**231**	55,005	70,522	8,333	8,088	**1,437**	6,462	149,848
2005	**231**	377	99,246	24,017	3,068	1,437	4,127	132,272
2006	1,735	24,636	580	31,575	7,688	**1,437**	580	66,496
2007	**231**	5,604	54,280	1,564	20,722	6,972	1,173	90,315
2008	**231**	1,643	5,076	7,509	127	1,551	414	16,320
2009	1,596	1,746	34,940	27,300	29,895	1,681	3,194	100,351
2010	268	39,285	11,182	22,652	20,086	20,335	1,386	118,256
2011	874	2,498	37,262	11,092	15,746	13,532	7,413	88,416
2012	282	25,352	1,313	40,802	1,126	15,353	14,779	99,007
2013	659	8,741	25,652	3,250	7,555	1,757	1,889	49,503

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	0.26	0.50	0.95	0.15	0.25
4	1.00	0.70	0.83	0.95	0.15	0.25
5	1.00	1.00	1.00	0.95	0.15	0.25
6	1.00	0.88	1.00	0.95	0.15	0.25
7	1.00	0.87	1.00	0.95	0.15	0.25
8	1.00	0.15	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), initial N in 1998, recruitment (R), instantaneous fishing mortality (F), population abundance (N) and biomass (B) for upper Chesapeake Bay yellow perch statistical catch at age model.

Parameter	**C.V.**	**Parameter**	**C.V.**
q comm	0.335	F2009	0.319
q index 3 trwl	0.210	F2010	0.333
Ln q index 2 seine	0.218	F2011	0.362
q index 4+ trwl	0.334	F2012	0.391
q index 2 trwl	0.258	F2013	0.393
N 1998 3	0.176	N 1998	0.162
N 1998 4	0.148	N 1999	0.171
N 1998 5	0.237	N 2000	0.199
N 1998 6	0.273	N 2001	0.216
N 1998 7	0.272	N 2002	0.255
N 1998 8	0.272	N 2003	0.315
R2 1998	0.169	N 2004	0.339
R2 1999	0.192	N 2005	0.352
R2 2000	0.194	N 2006	0.334
R2 2001	0.217	N 2007	0.323
R2 2002	0.254	N 2008	0.331
R2 2003	0.301	N 2009	0.292
R2 2004	0.320	N 2010	0.314
R2 2005	0.306	N 2011	0.329
R2 2006	0.285	N 2012	0.354
R2 2007	0.264	N 2013	0.348
R2 2008	0.242	B 1998	0.211
R2 2009	0.253	B 1999	0.178
R2 2010	0.276	B 2000	0.221
R2 2011	0.303	B 2001	0.222
R2 2012	0.323	B 2002	0.280
R2 2013	0.383	B 2003	0.381
F 1998	0.256	B 2004	0.345
F1999	0.286	B 2005	0.431
F2000	0.253	B 2006	0.376
F2001	0.242	B 2007	0.375
F2002	0.260	B 2008	0.353
F2003	0.352	B 2009	0.343
F2004	0.406	B 2010	0.328
F2005	0.434	B 2011	0.374
F2006	0.417	B 2012	0.381
F2007	0.406	B 2013	0.402
F2008	0.357		

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

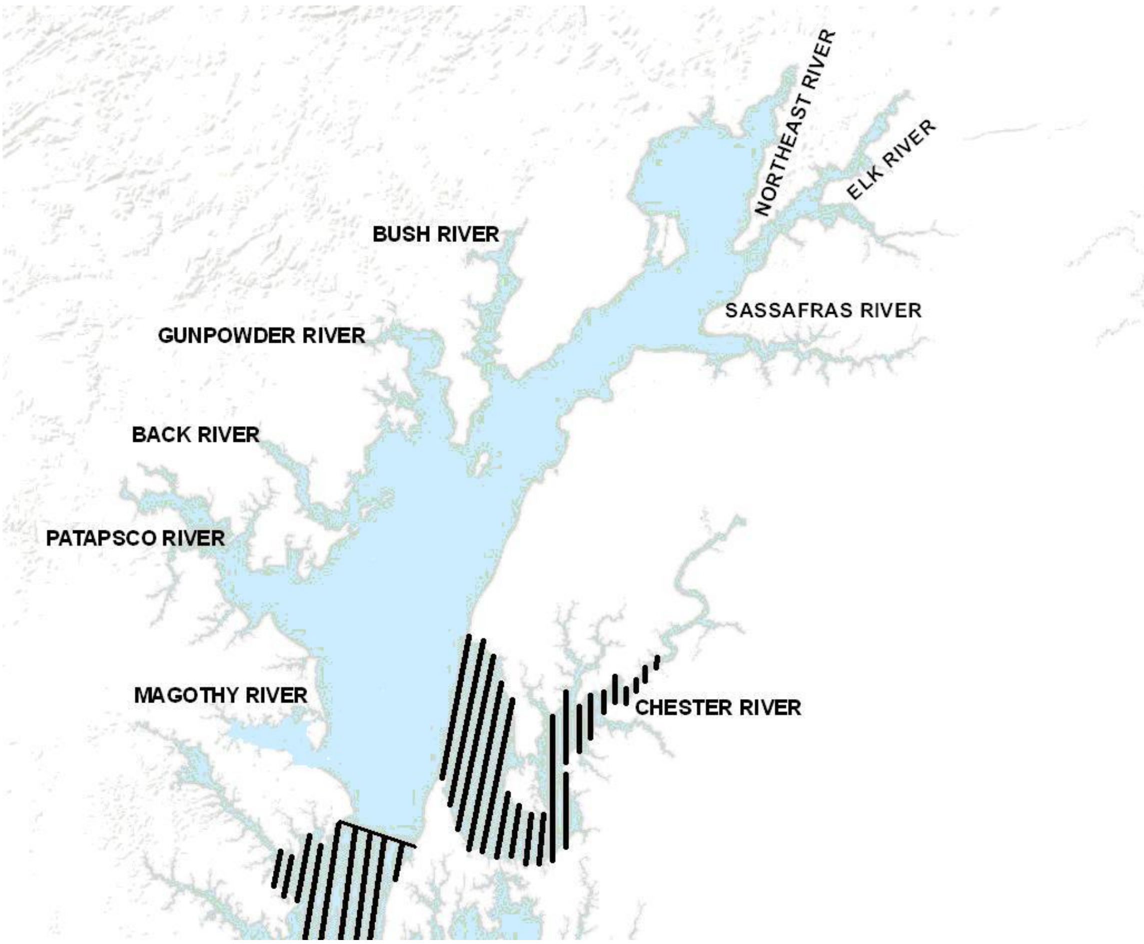


Figure 2. Upper Chesapeake Bay winter trawl survey locations for the 2013 sampling season.

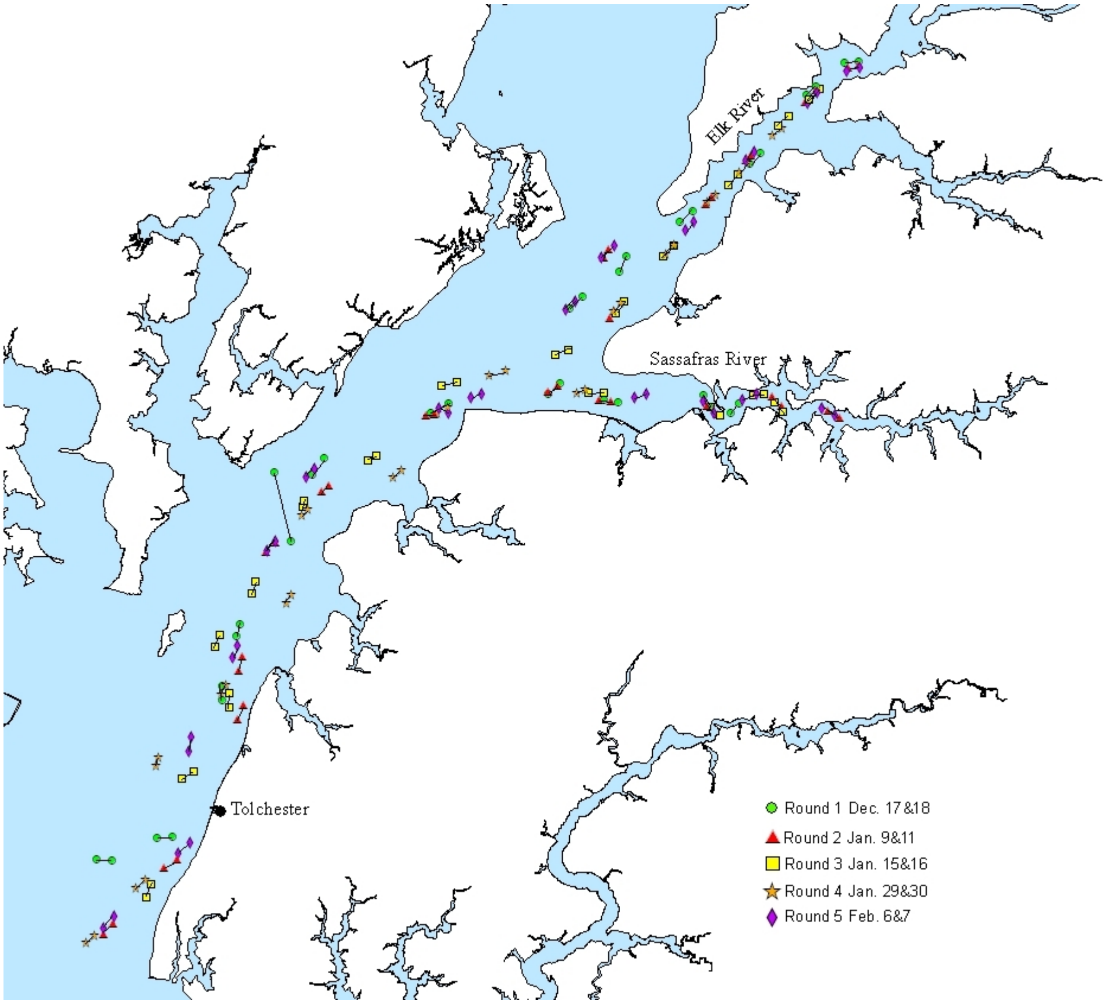


Figure 3. Commercial yellow perch landings v. fyke net effort for upper Chesapeake Bay yellow perch fishery with statistically significant linear trend line.

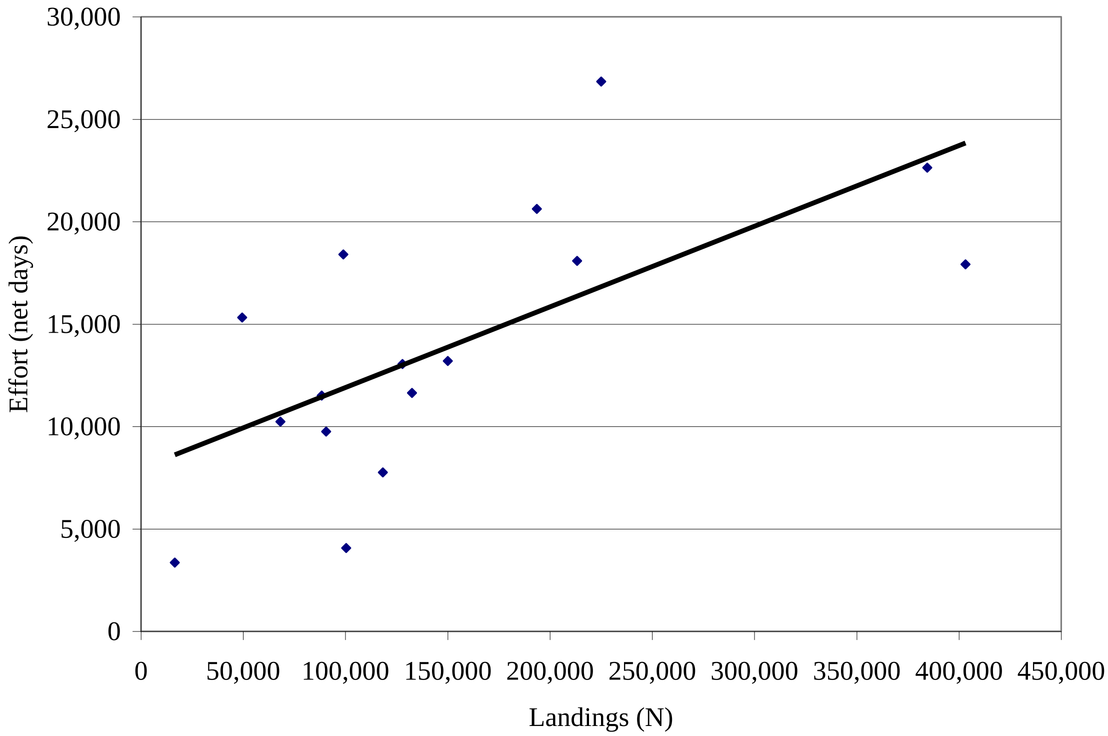


Figure 4. Yellow perch commercial fyke net selectivity ogives for 2 time periods, 1998-1999 and 2000-2013.

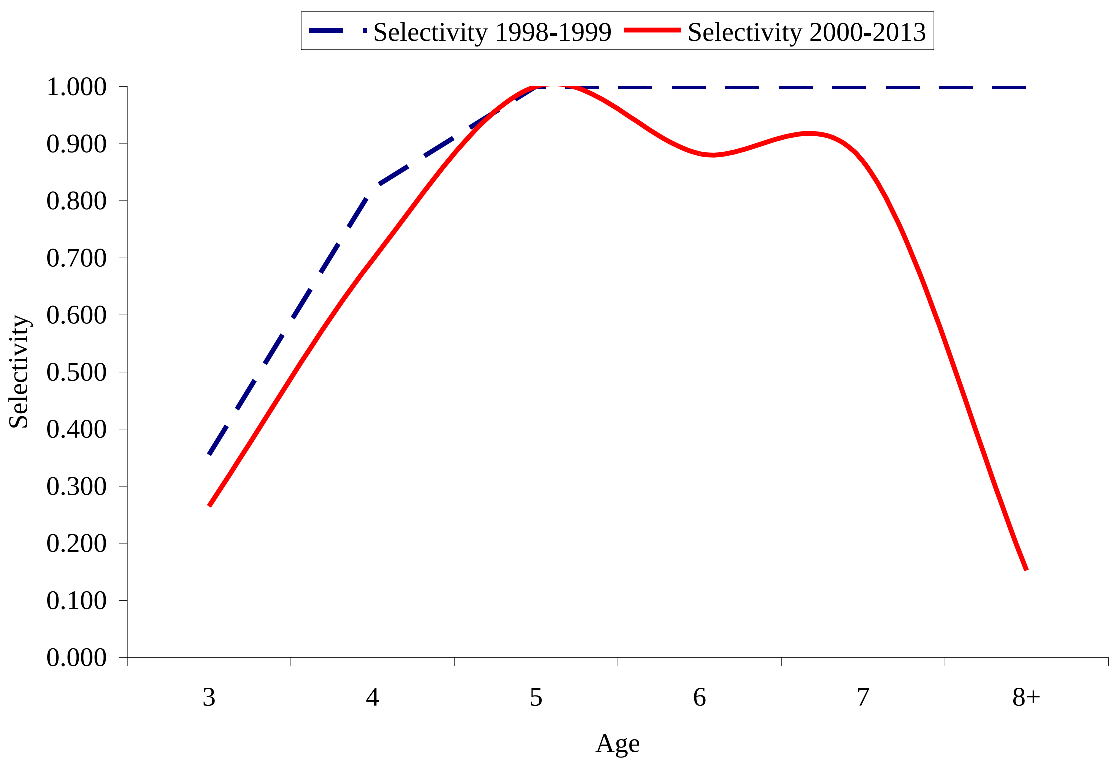


Figure 5. Upper Chesapeake Bay yellow perch abundance estimates (N, ages 2+), 1998 – 2013.

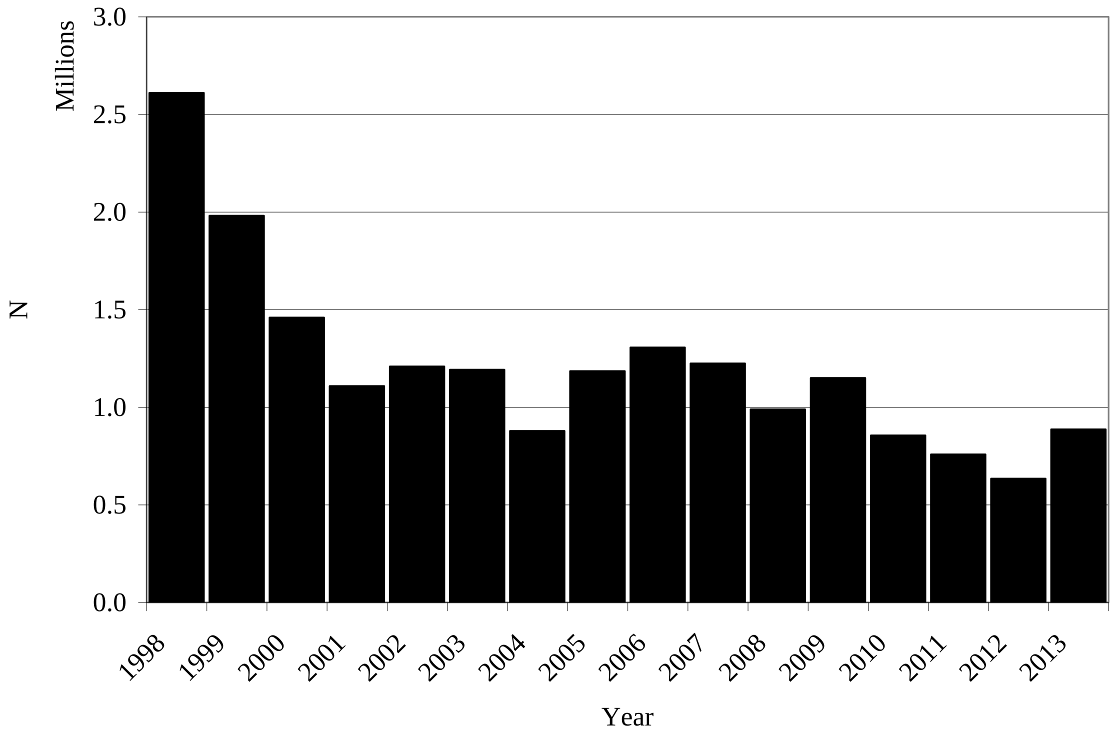


Figure 6. Upper Chesapeake Bay yellow perch biomass (kg, ages 2+) estimates, 1998 – 2013.

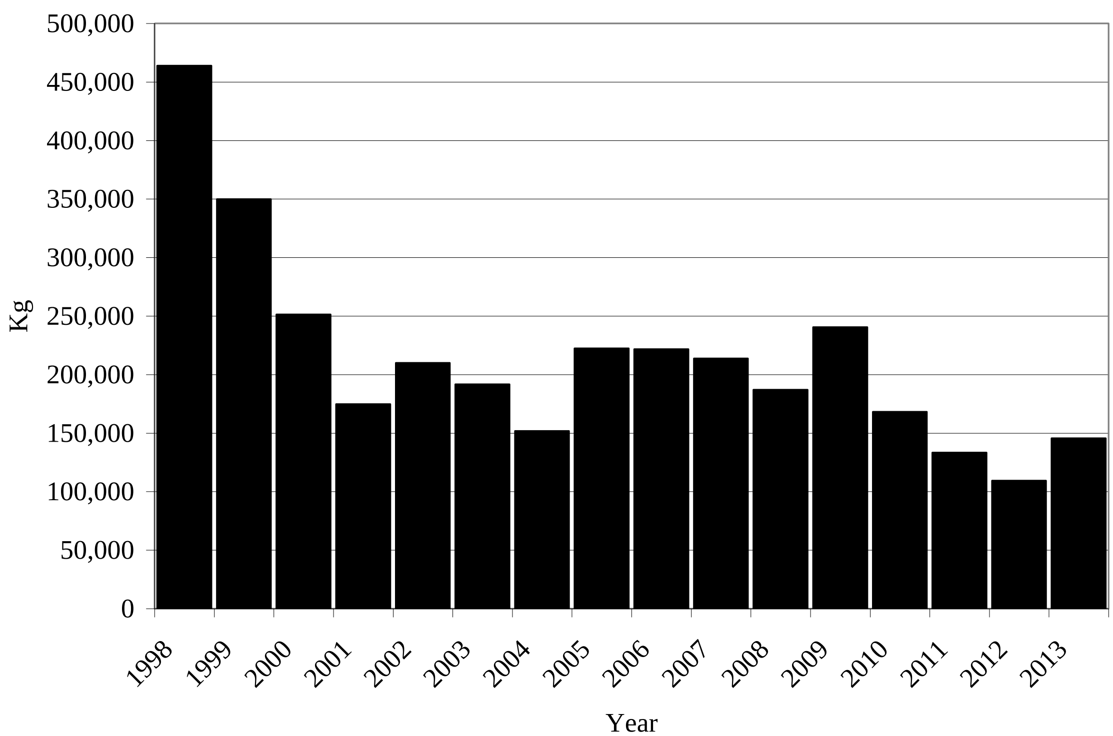


Figure 7. Upper Chesapeake Bay yellow perch fully recruited instantaneous fishing mortality (F) estimates, 1998 – 2013.

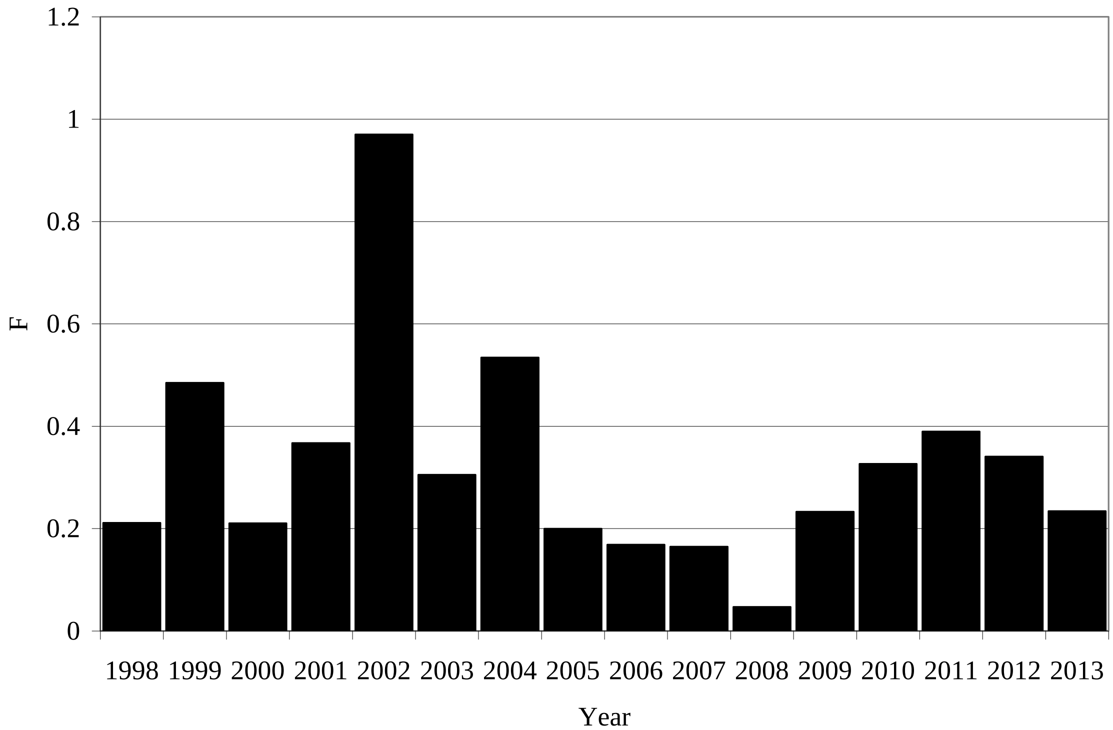


Figure 8. Upper Chesapeake Bay yellow perch recruitment (R, age 2) estimates, 1998 – 2013. Horizontal line indicates time series average.

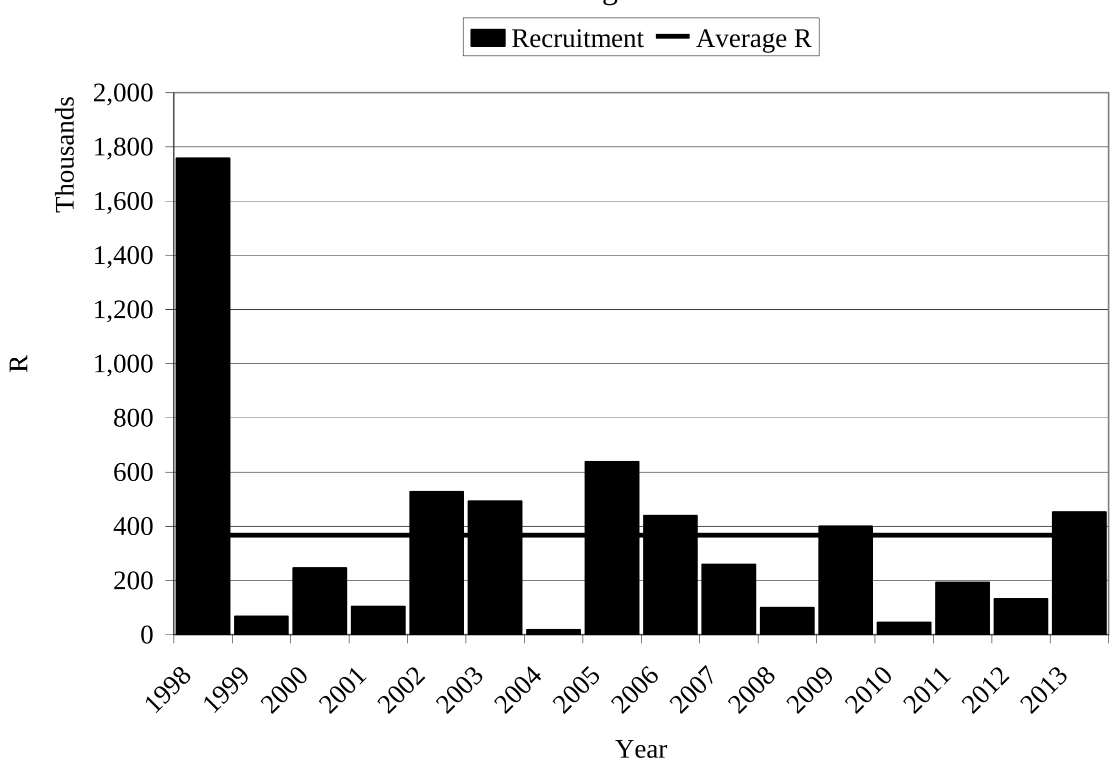


Figure 9. Age 3 observed and expected trawl index from upper Chesapeake Bay yellow perch population model.

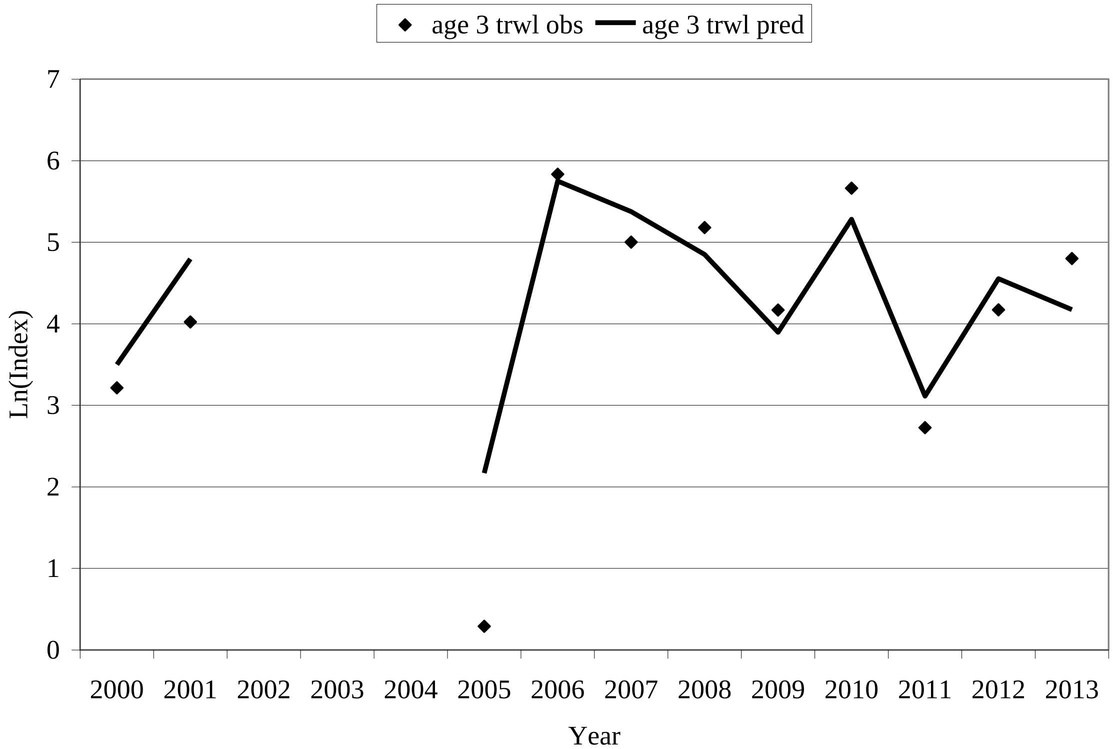


Figure 10. Age 2 observed and expected seine index from upper Chesapeake Bay yellow perch population model.

Figure 11. Age 2 observed and expected trawl index from upper Chesapeake Bay yellow perch population model.

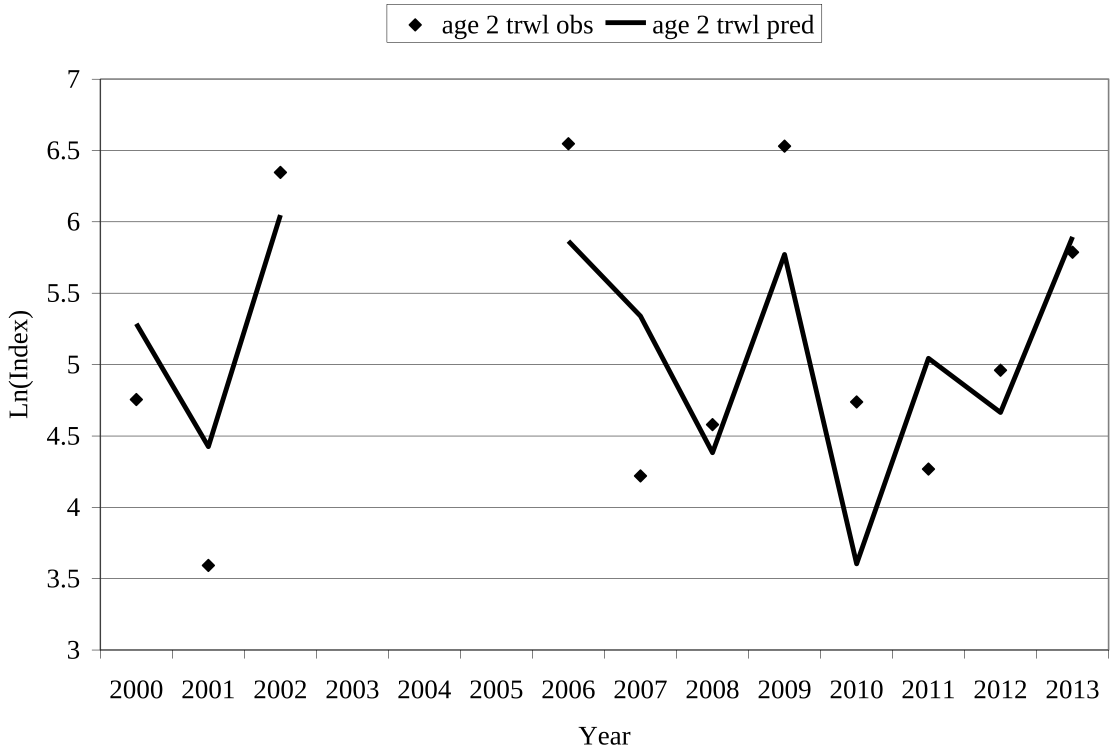


Figure 12. Age 4+ observed and expected trawl index from upper Chesapeake Bay yellow perch population model.

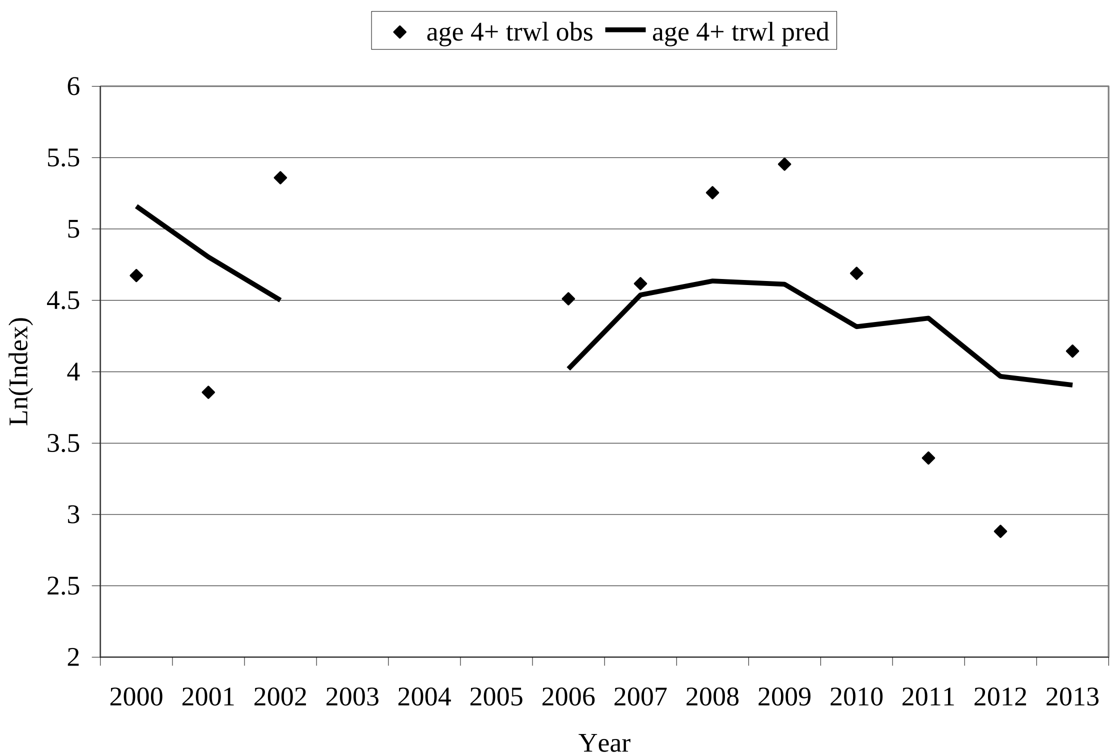


Figure 13. 80% confidence intervals of abundance (N, ages 2+) estimates from upper Chesapeake Bay yellow perch population model.

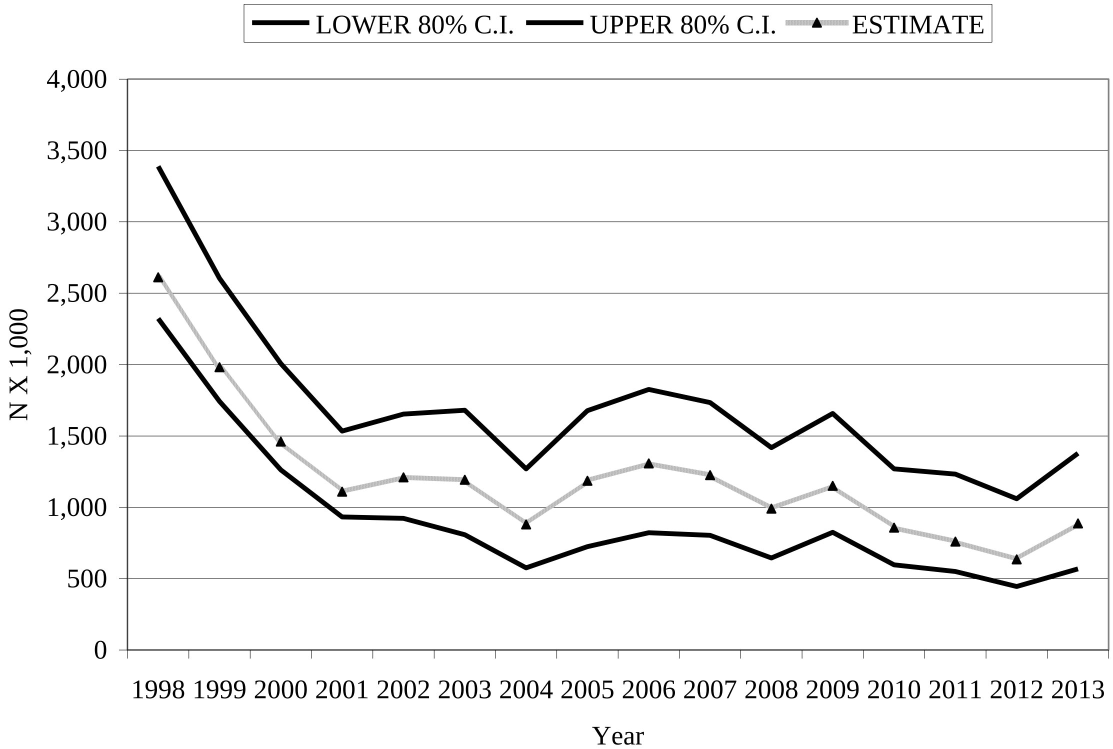


Figure 14. 80% confidence intervals of biomass (kg, ages 2+) estimates from upper Chesapeake Bay yellow perch population model.

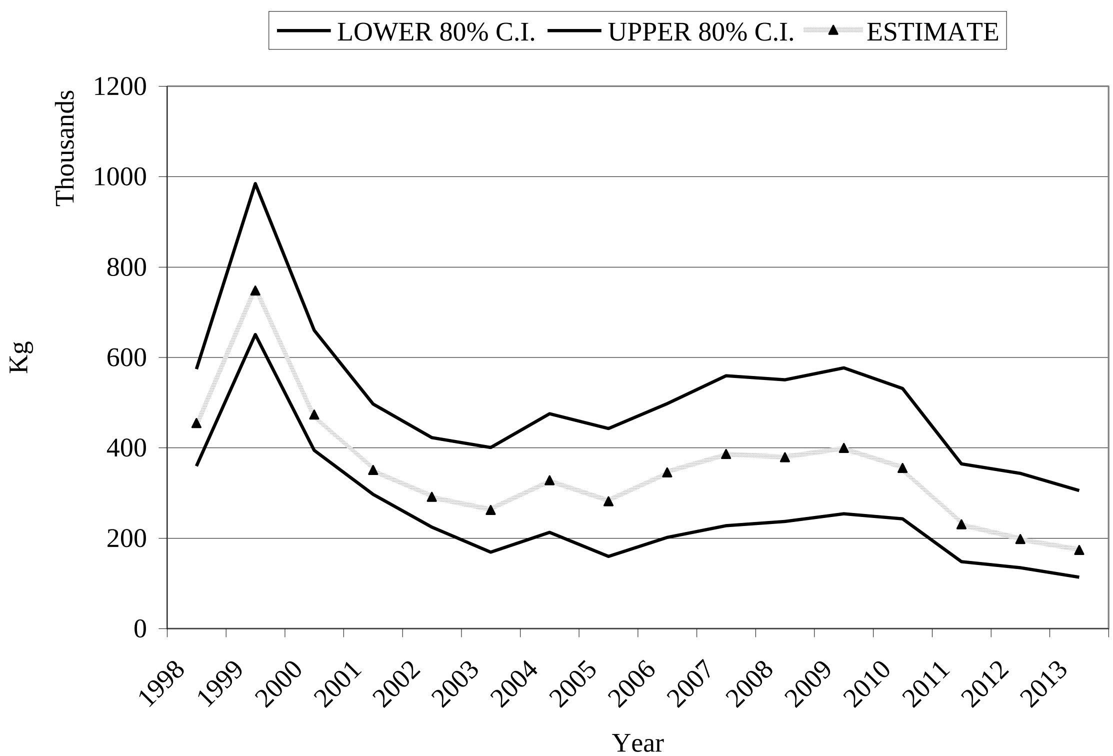


Figure 15. 80% confidence intervals of recruitment (age 2, R) estimates from upper Chesapeake Bay yellow perch population model.

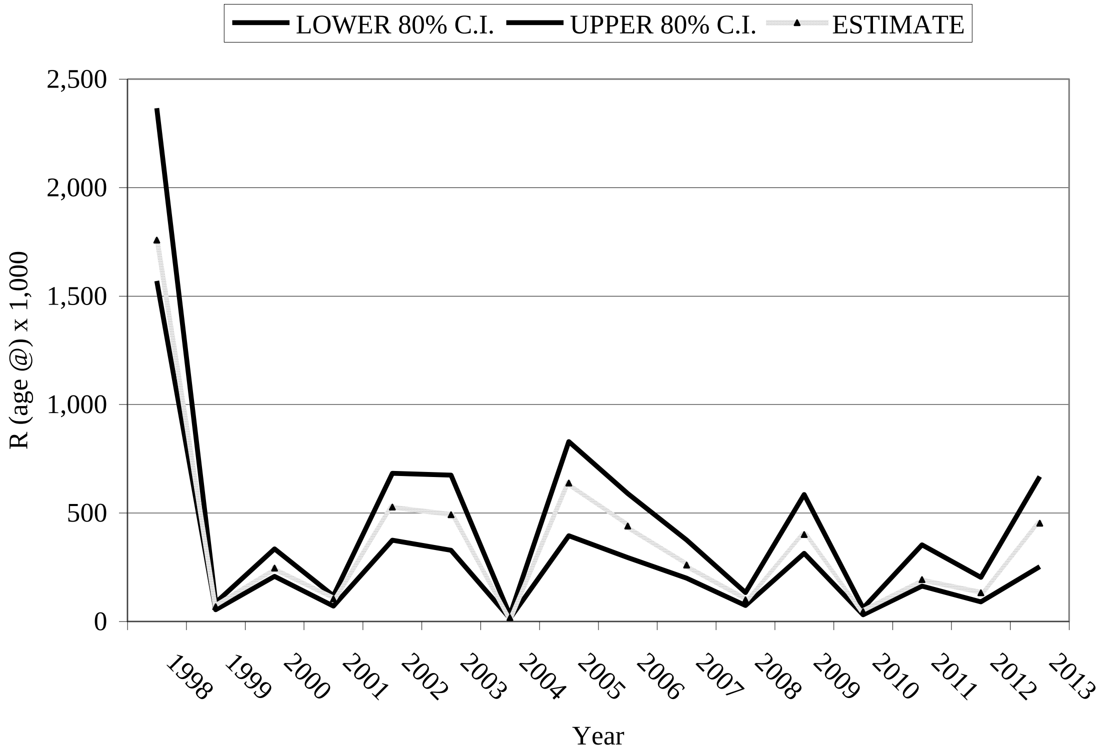


Figure 16. 80% confidence intervals of fully recruited F estimates from upper Chesapeake Bay yellow perch population model.

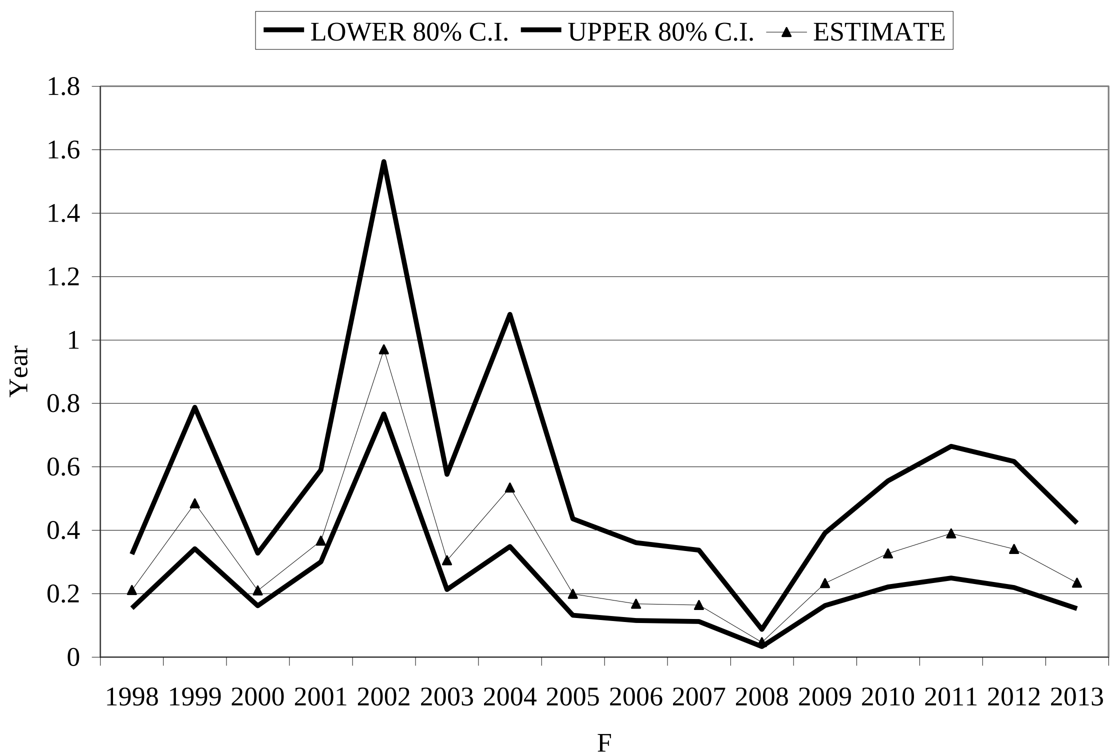


Figure 17. Percent maximum spawning potential (%MSP) versus F from Chesapeake Bay yellow perch spawning stock biomass/recruit model for 8 1/2” – 11” slot limit.

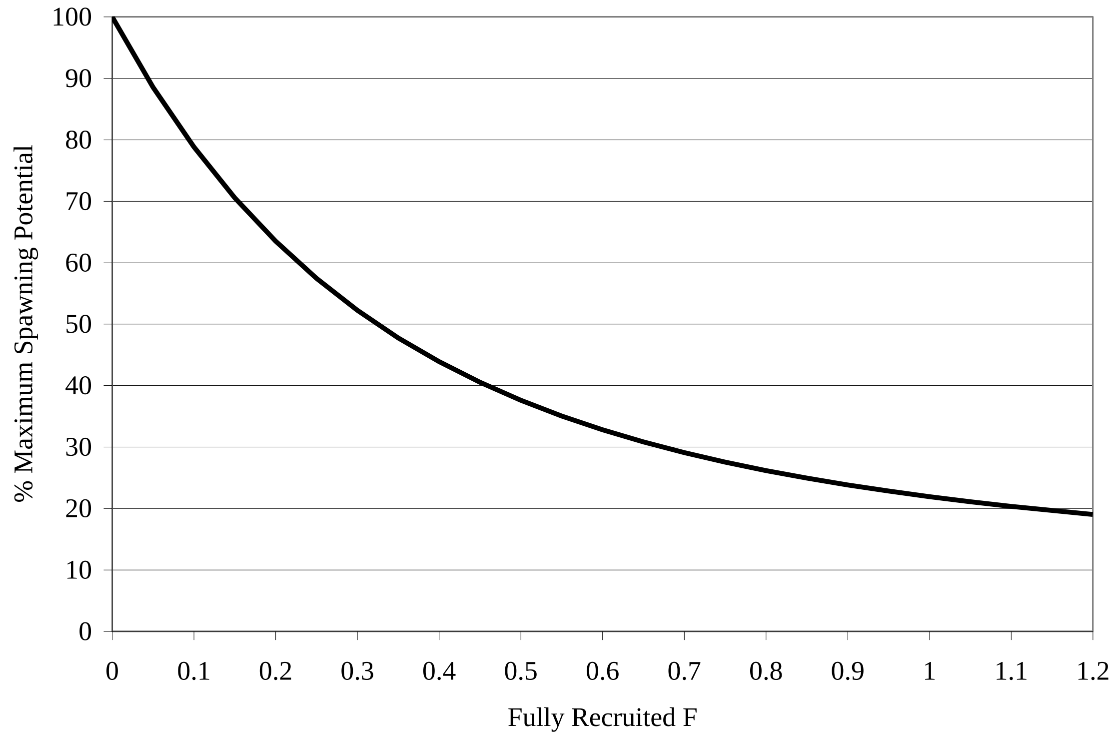


Figure 18 Percent maximum spawning potential (%MSP) versus F from Chesapeake Bay yellow perch spawning stock biomass/recruit model for 9” minimum size limit.

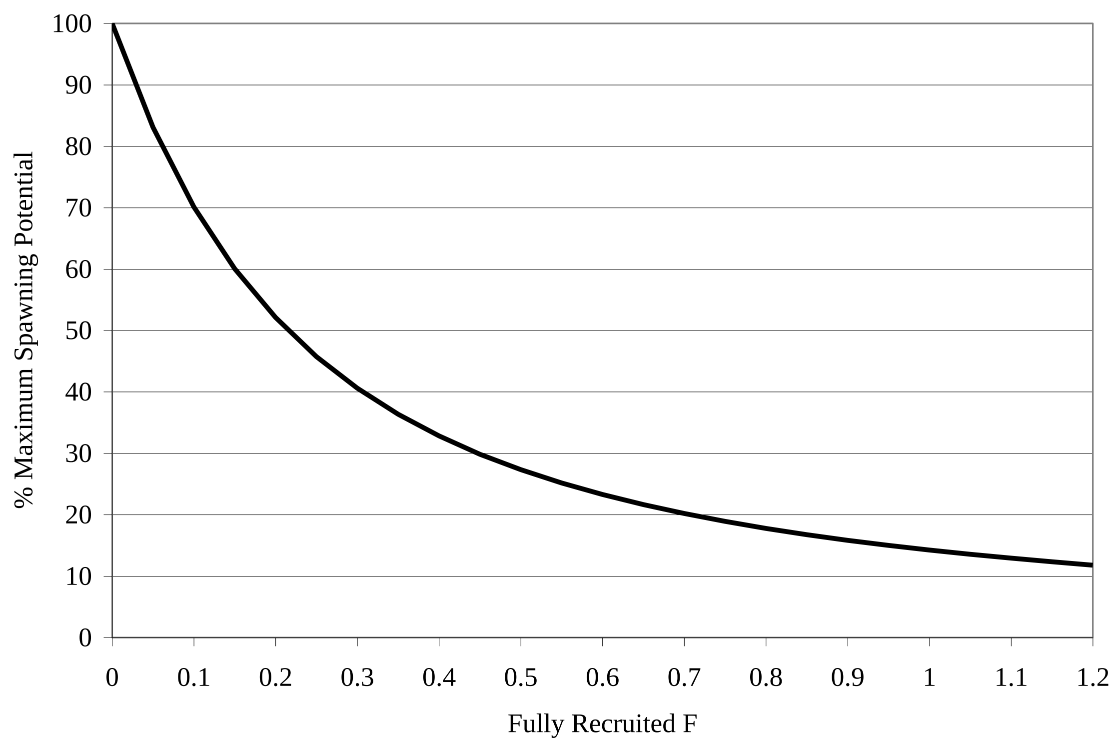
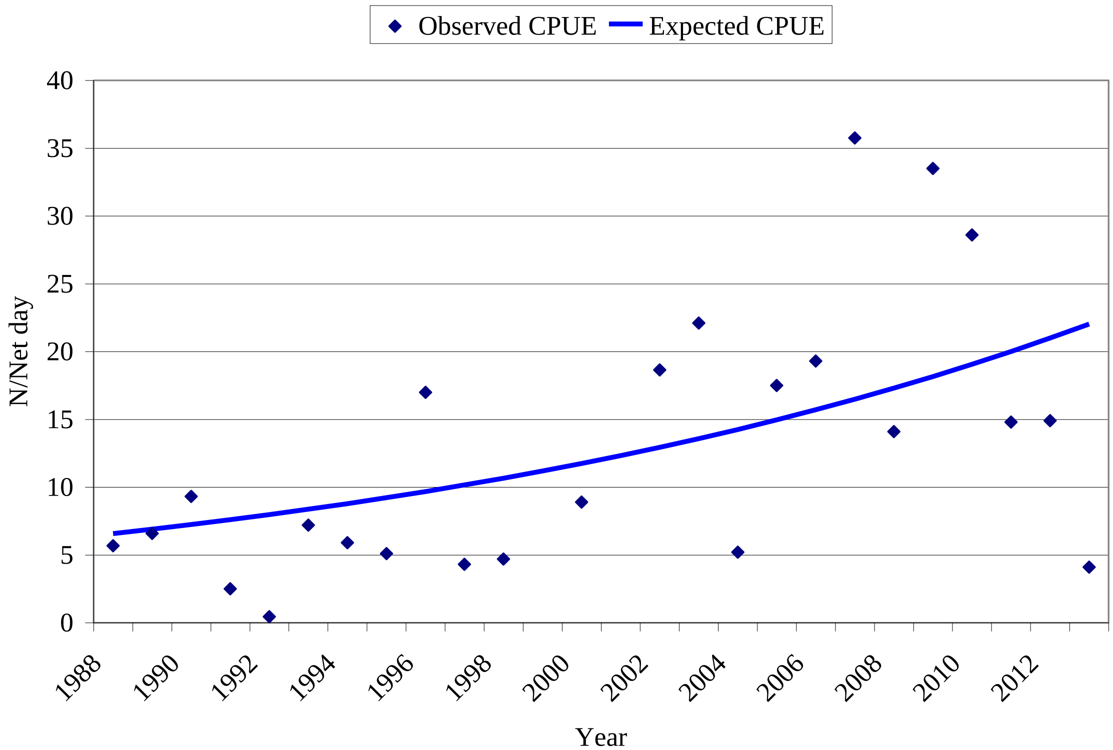


Figure 19. Yellow perch relative abundance (fish/net day) from Choptank River fishery independent fyke net survey, 1988 – 2013. Predicted CPUE curve is statistically significant at $P < 0.0001$.



PROJECT NO. 2
JOB NO. 1

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

Prepared by
Genine K. Lipkey 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 (MDNR) utilizing both fishery dependent and independent sampling gear. On the Nanticoke River, biologists worked with commercial fishermen to collect sex, age and stock composition data and to estimate relative abundance of adult American shad, hickory shad and river herring. Survey biologists also independently sampled ichthyoplankton. Similar data were collected for adult American shad in the lower Susquehanna River below the Conowingo Dam, and hickory shad abundance was assessed in a tributary to the Susquehanna River (Deer Creek).

The data collected during this study 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), Chesapeake Bay Program's Living Resources Committee and Maryland Sea Grant Ecosystem-Based Fisheries Management Program.

METHODS

Data Collection

Susquehanna River

Adult American shad were angled by MDNR staff from the Conowingo Dam tailrace on the lower Susquehanna River two to four times per week from 23 April through 31 May 2013 (Figure 1). Two rods were fished simultaneously; each rod was rigged with two shad darts and lead weight was added when required to achieve proper depth. All 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 (including unspent or ripe females) were tagged with Floy tags (color-coded to identify the year tagged) and released. A MDNR hat was awarded for returned tags.

Scales collected from all rivers for American shad, hickory shad and river herring were aged using Cating's method (Cating 1953). 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 Restoration and Enhancement Program. Repeat spawning marks were counted on all alosine scales during ageing.

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 MDNR hook and line survey in the current and previous years.

Recreational data from a non-random roving creel survey were collected from anglers in the Conowingo Dam tailrace during the MDNR American shad hook and line survey. In this survey, stream bank anglers were interviewed about American shad catch 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 the Susquehanna River (including the Conowingo tailrace and Deer Creek) and North East Creek.

Due to the low number of hickory shad typically observed by this project, MDNR's Susquehanna Restoration and Enhancement Program provided additional hickory shad data (2004-2013) from their brood stock collection. Hickory shad were collected in Deer Creek (a Susquehanna River tributary) for hatchery brood stock and were subsampled for age, repeat spawning marks, sex, length and weight. In 2004 and 2005, fish were collected using hook and line fishing; fish have been collected using electrofishing gear from 2006 to present.

Nanticoke River

Three commercial pound nets and one commercial fyke net were surveyed for American shad, hickory shad and river herring between 21 February and 30 April 2013 (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. Otoliths from dead adult American shad were removed and sent to the Delaware Division of Fish and Wildlife (DE DFW) for OTC analysis.

Ichthyoplankton sampling was conducted in cooperation with the Fish Habitat & Ecosystem Program (Federal Aid Grant F-63-R, Segment 2, Job 1, Section 3) twice per week from 3 April to 30 April 2013 in the Nanticoke River. 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 for two minutes at approximately two knots. At the conclusion of the tow, the contents were flushed down into a masonry jar for presence/absence determination.

Chester River

The Chester River juvenile alosine survey was discontinued beginning in 2013 due to historically low catches of alosine species by this survey as seen in Table 1. Alosine species juvenile abundance indices are provided by the MDNR Estuarine Juvenile Finfish Seine Survey (EJFS; Project 2, Job 3, Task 3) from fixed stations within the Nanticoke River, upper Chesapeake Bay, and Potomac River.

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 from 28 March to 13 May 2013. All American shad were sexed, measured (TL and FL), and scales were removed below the insertion of the dorsal fin for ageing and spawning history analysis.

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, captured in pound and fyke nets in the Nanticoke River and gill netted in the Potomac River. Male-female ratios were also derived for alewife herring and blueback herring captured by pound and fyke nets in the Nanticoke River. Due to the low number of hickory shad captured in the Nanticoke River survey, hickory shad male-female ratios were derived from data provided by the MDNR Restoration and Enhancement Program's brood stock collection on the Susquehanna River.

Age determination from scales was attempted for all American shad and river herring samples collected from the Susquehanna, Nanticoke, and Potomac Rivers. 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 α = 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 Maryland's portion of the Nanticoke River, respectively.

Adult Relative Abundance

Catch-per-unit-effort (CPUE) from the Conowingo Dam tailrace was calculated as the number of adult fish captured per boat hour. We computed a combined lift CPUE as the total number of adult fish lifted per hour of lifting at the EFL and WFL. The geometric mean (GM) of adult American shad CPUE for both the tailrace area and the lifts was then calculated as the average LN (CPUE + 1) for each fishing/lifting day, transformed back to the original scale. In addition, the relative abundance (GM CPUE) of American shad, alewife herring and blueback herring in the Nanticoke River was calculated as the average LN (CPUE + 1) for each net day by gear type, transformed back to the original scale. 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; instead, the number of hickory shad captured by gear type is reported. 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. Catch-per-angler-hour (CPAH) for American shad angled in the Susquehanna River and hickory shad angled in the Susquehanna and North East Rivers were also calculated from the shad logbooks. The roving creel survey was used to calculate a CPAH for American shad in the Conowingo Dam tailrace.

Historically, CPUE for American shad from the Nanticoke was only calculated with data from one pound net that was most consistently sampled over the time series (Mill Creek).

Similarly, alewife and blueback herring CPUE were only calculated with fyke net data because pound nets were not consistently set in ideal habitat for river herring. Therefore, the number and location of fyke nets used for this calculation varies across the time series. This report follows these historical protocols.

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 and WFL, M is the number of fish tagged minus 3% tag loss, and R is the number of tagged fish recaptured. 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; Macall 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 bycatch mortality in the Atlantic herring fishery in the previous year (equivalent to catch in a surplus production model). The dynamics of this population are governed by the logistic growth curve. 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). Assumptions include proportional bycatch of American shad in the Atlantic herring fishery and accurate adult American shad turbine mortality estimates. The SPM required starting values for the initial population (B_0) in 1985 (set as 7,876 by the Petersen statistic for this year; calculation described above), a carrying capacity estimate (set as 3,040,551 fish, which was three times the highest Petersen estimate of the time series, and an estimate of the intrinsic rate of growth (set as 0.50). These starting values were the same in 2012 and were adjusted by the model during the fitting procedure using Evolver 4.0 for Windows. The fitting procedure was constrained to search within r = 0.01 to 1.0, K = 100,000 to 30 million fish and B_0 = 5,682 (the lower confidence limit of the 1985 Petersen statistic) to 1 million fish.

Mortality

Catch curve analysis was used to estimate total instantaneous mortality (Z) of adult American shad and river herring in the Nanticoke River. Additionally, Z was calculated for American and hickory shad in the Susquehanna River. 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).

Natural and fishing mortality were not estimated for any alosine species because American shad, hickory shad and river herring fisheries are closed in Maryland. Commercial landings, commercial and recreational bycatch, and EFL and WFL mortalities were considered when estimating the minimum total losses of adult American shad in Maryland waters.

Juvenile Abundance

The MDNR 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 8 days in 2013 (Table 2). Fertilized alosine eggs and/or larvae were present at 21.7% of tow stations in 2013. Salinity at tow stations ranged from 0.1 to 3.0 ppt. An absence of observed fertilized eggs and/or larvae occurred from 2006-2008, and in 2012. The available data indicate that clupeid egg and/or larvae presence was highest in 2010 (43%).

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 1:0.83. Of the 302 fish sampled by this gear, 298 were successfully scale-aged (Table 3). Males were present in age groups 4-9 and females were found in age groups 4-10. The 2008 (age 5) and 2007 (age 6) year-classes were the most abundant for males and females, respectively, accounting for 41% of males and 38% of females (Table 3). Fifty-four percent of males and 71% of females were repeat spawners. The percentages of repeat spawners for both males and females have steadily increased since 2008 (Figure 4), and the arcsine-transformed proportion of these repeat spawners (sexes combined) has significantly increased over the time series (1984-2013; $r^2 = 0.47$, $P < 0.001$; Figure 5). Of the readable adult Analysis by PFBC of American shad otoliths collected from the WFL at Conowingo Dam in 2013 was not complete prior to the submission of this report.

The male-female ratio for adult American shad captured in the Nanticoke River was 1:0.75. All 31 American shad collected from the Nanticoke pound and fyke nets in 2013 were subsequently aged (Table 3). Males were present in age groups 5-8 and females were found in age groups 5-9. The 2007 year-class (age 6) was the most abundant year-class for both males (56%) and females (42%; Table 3). Fifty six percent of males and 75% 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, (1988-2013; $r^2 = 0.35$, $P = 0.001$; Figure 6). Analysis by DE DFW of American shad otoliths collected from the Nanticoke River in 2013 was not complete prior to the submission of this report.

The male-female ratio for adult American shad captured in the Potomac River was 1:0.69. All of the 105 American shad collected were successfully aged (Table 3). Males were present in age groups 4-10 and females were present in age groups 4-8. The most abundant year-class for males was the 2008 (age 5) year-class (55%). For females, both the 2008 (age 5) and 2007 (age 6) year-classes were the most abundant (both 42%). Seventy four percent of males and 65% 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 (2002-2013; $r^2 = 0.0093$, $P = 0.77$; Figure 7).

Adult Relative Abundance

Sampling at the Conowingo Dam occurred for 14 days in 2013. A total of 336 adult American shad were encountered by the gear; 282 of these fish were captured by MDNR staff from a boat and the remaining 54 were captured by shore anglers. MDNR staff tagged 297 (88%) of the sampled fish. To remain consistent with historical calculations, only the 282 fish captured from the boat were used to calculate the hook and line CPUE. No tagged American shad recaptures were reported from either commercial fishermen or recreational anglers in 2013.

The EFL operated for 60 days between 1 April and 3 June 2013. Of the 12,733 American shad that passed at the EFL, 86% (10,957 fish) passed between 25 April and 12 May 2013. Peak passage was on 2 May; 1,758 American shad were recorded on this date. Twenty-three of the American shad counted at the EFL counting windows were identified as being tagged in 2013 (Table 4).

The Conowingo WFL operated for 24 days between 24 April and 24 May 2013. The 2,030 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 9 May when 264 American shad were collected. The eleven tagged American shad recaptured by the WFL were fish tagged in 2013 (Table 4).

The Petersen statistic estimated 121,908 American shad in the Conowingo Dam tailrace in 2013 with an upper confidence limit of 168,485 fish and a lower confidence limit of 87,947 fish. The SPM estimated a population of 80,910 fish in 2013. Despite differences in yearly estimates, the overall population trends derived from each method are similar (Figures 8 and 9). Specifically, the SPM showed an increasing population size from the beginning of the time series to a peak in 2000, followed by a decline from 2001 to 2007. Since 2007 the population size has showed no specific trend (2008-2013; Figure 9). Petersen estimates follow a similar pattern if the high levels of uncertainty in 2004 and 2008 (due to low recapture rates) are considered (Figure 8).

Estimates of hook and line GM CPUE vary without trend over the time series (1984-2013; r^2 = 0.07, P = 0.15). Abundance is particularly variable from 2007-2013 and remains below the high indices observed from 1999 to 2002 (Figure 10). The Conowingo Dam combined lift GM CPUE significantly increased over the time series (1980-2013; r^2 = 0.26, P = 0.002), but has decreased since 2011 (Figure 11).

Sixty-three interviews were conducted over three days during the creel survey at the Conowingo Dam Tailrace. The CPAH in 2013 was the second lowest since the start of the survey in 2001 (Table 5), and CPAH has decreased over the time series (2001-2013; $r^2 = 0.47$, $P = 0.01$). Six anglers returned logbooks in 2013; all six logbooks contained information from fishing trips in the lower Susquehanna River. American shad CPAH calculated from shad logbook data was the second lowest in the time series and CPAH has decreased significantly over the time series (2000-2013; $r^2 = 0.52$, $P = 0.003$; Table 6). It should be noted that for years 2000 through 2002, which report the highest CPAH (Table 6), two separate logbooks were used for American and hickory shad, and not all anglers returned both logbooks. Beginning in 2003, to allow anglers to record data on both shad species if encountered, a combined logbook was distributed.

The 2013 Nanticoke River pound net GM CPUE was considerably less than 2012. However, the GM CPUE significantly increased over the time series (1988-2013; $r^2 = 0.19$, $P = 0.03$, Figure 12). The Potomac River CPUE also increased significantly over the time series (1996-2013; $r^2 = 0.21$, $P = 0.059$), although CPUE in each of the past five years has been lower than the CPUE in 2007 and 2008 (Figure 13).

Mortality

The Conowingo Dam tailrace total instantaneous mortality estimate from catch curve analysis (using repeat spawning instead of age) resulted in Z = 0.68 (A = 49.3%). The Nanticoke River mortality estimate was suspect as a result of small sample size (n=31), therefore it is not reported here. Estimated American shad mortalities (in numbers) from Maryland waters are presented in Table 7.

Juvenile Abundance

Data provided by the EJFS indicated that juvenile American shad indices increased in 2013 baywide, in the upper Chesapeake Bay, and in the Potomac River (Figures 14-16), but decreased in the Nanticoke River (Figure 17). The Potomac River index remains above the time series mean (Figure 16) and is greater than all other system indices (Figures 14-17). 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=9) was not large enough to draw meaningful conclusions about sex and age composition. However, 779 hickory shad were sampled by the brood stock collection survey in Deer Creek. The male-female ratio was 1:0.68. Of the total fish captured by this survey, 193 were successfully aged. Males were present in age groups 3-7 and females were found in age groups 3-6 (Table 8). The most abundant year-class by sex was the 2008 year-class (age 4) for both males (43%) and females (48.4%; Table 9). The 2012 and 2013 sampling years are the only years in the times series where hickory shad of ages greater than 7 were not observed (Table 9). The arcsine-transformed proportion of repeat spawners (sexes combined) has not changed significantly over the time series (2004-2013; r^2 = 0.09, P = 0.39; Figure 18). The total percent of repeat spawners in 2012 (64.0%) was the lowest of the time series, and increased in 2013 (2004-2013; Table 10).

Relative Abundance

Shad logbook data indicated that hickory shad CPAH did not vary significantly over the time series (1998-2013; $r^2 = 0.11$, $P = 0.22$); however, hickory shad CPAH increased in 2013 (Table 11). On the Nanticoke River, only 9 fish were captured by pound and fyke nets.

Mortality

Total instantaneous mortality in the Susquehanna River (Deer Creek) was estimated as Z = 0.78. This estimate is greater than the 2012 Z estimate (Z = 0.68) but similar to the 2010 Z estimate (Z = 0.74). Annual mortality in 2013 was estimated as A = 54.2%.

Juvenile Abundance

The MDNR Estuarine Juvenile Finfish Seine Survey (EJFS; Project 2, Job 3, Task 3) do not report juvenile indices for hickory shad because they are caught in such low numbers. Therefore, there is no data available on hickory shad juvenile abundance to report for 2013.

Alewife and Blueback Herring

Sex, Age and Stock Composition

The 2013 male-female ratio for Nanticoke River alewife herring was 1:1.8. Of the 157 alewives sampled, 134 were subsequently aged. Age groups 3-8 were present and the 2008 year-class (age 5, sexes combined) was the most abundant, accounting for 37.3% of the total catch (Table 12). The 2013 male-female ratio for Nanticoke River blueback herring was 1:0.53. Of the 91 blueback herring sampled, 83 were subsequently aged. Blueback herring were present from ages 3-8 and the 2009 year-class (age 4, sexes combined) was the most abundant, accounting for 39.8% of the sample (Table 12).

For the Nanticoke River, 46.6% of alewife herring and 35.4% of blueback herring were repeat spawners (sexes combined; Table 12). There was no trend in the arcsine-transformed proportion of alewife herring repeat spawners over the time series (1989-2013; $r^2 < 0.016$ P = 0.54); however, blueback herring exhibited a decreasing trend over the same time series (1989-2013; $r^2 = 0.60$, $P < 0.001$; Figure 19). For male alewife and blueback herring, 71.1% and 61.8% were first time spawners, respectively. Forty four percent of female alewife and 70% of female blueback herring were first time spawners.

Mean length-at-age for female alewife herring from the Nanticoke River are greater than the corresponding male mean length-at-age (Table 13). Female blueback herring mean length-at-age are also greater than the corresponding male mean length-at-age (Table 14). Age structure appears to be truncating, especially for blueback herring. The mean lengths for female alewife herring at ages 4-8 and male alewife herring at ages 4 -7 have decreased significantly since 1989 (Table 15). Mean length for female blueback herring at ages 3-8 and males blueback herring at ages 3-7 have significantly decreased since 1989 (Table 15). Observed declines in mean length generally occur toward the end of the time series.

Adult Relative Abundance

Only data from one fyke net is available from the Nanticoke River survey in 2013. The GM CPUE for Nanticoke River alewife herring captured in fyke nets has varied without trend over the time series (1990-2013; $r^2 = 0.16$, $P = 0.06$; Figure 20); in contrast, the GM CPUE for blueback herring has decreased over the time series (1989-2011; $r^2 = 0.63$ $P < 0.001$; Figure 20). The herring fishery closed on 26 December 2011. As of 31 December 2013, 305 pounds of river herring were landed in Maryland waters**.** Prior to the closure of the fishery, total commercial landings for river herring in Maryland waters were at multi-decadal lows (Figure 21). Due to the difficult nature of discerning alewife from blueback, there was no differentiation between species in the commercial river herring fishery.

Mortality

Total instantaneous mortality for Nanticoke River alewife herring (sexes combined) was estimated as Z = 0.91 (A = 59.8%). Total instantaneous mortality for Nanticoke River blueback herring (sexes combined) was Z = 0.72 (A = 51.3%).

Juvenile Abundance

Data provided by the EJFS indicated that the Nanticoke River and upper bay alewife and blueback herring juvenile GM CPUE remained low in 2013 (Figure 22-23). Over the past five years the highest juvenile GM CPUE for alewife and blueback herring were observed in 2010 and 2011, respectively for both of these systems.

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 six years (2007-2013; SPM estimate). 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). Despite this trend in abundance, there is no significant trend in CPUE over time. Additionally, the 2013 calculated indices of abundance in the lower Susquehanna River are all less than 2012 values, with the exception of the hook and line CPUE. Gizzard shad are increasing in abundance in the Susquehanna drainage and may reduce the number of lifted American shad by using the lifts themselves, thus affecting lift CPUE, which has been decreasing since 2011. The Potomac River CPUE (1996-2013) and the Nanticoke River CPUE (1988-2013) have both increased over time. However, the Nanticoke River CPUE declined in 2013. These trends suggest there is some improvement in the Nanticoke and Potomac Rivers, while the Susquehanna River continues to be significantly impacted.

The Petersen estimate and the SPM are both useful techniques for providing estimates of American shad abundance at the Conowingo Dam. The SPM likely underestimates American shad abundance. For example, the SPM estimated population size in 2003 and 2004 were both lower than the number of fish lifted at the Conowingo Dam. In those years the population size would have to be at least the number of fish lifted, if not more, as it is unlikely the Conowingo Dam lift efficiency is 100%. The Petersen statistic likely overestimates the population, especially in years of low recapture of tagged fish. Therefore, the 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.

Scales are the only validated ageing structures for determining the age of American shad (Judy 1960, McBride et al. 2005). However, Cating's method of using transverse grooves is no longer recommended: comparisons of American shad scales from different populations show different groove frequencies to the freshwater zone and first three annuli (Duffy et al. 2011). We will remain consistent with historical ageing methods until alternative ageing structures or techniques are investigated.

The percent of repeat spawning American shad below the Conowingo Dam has increased over time, particularly since the truck and transport to locations above Safe Harbor Dam ceased in 1997 when the EFL was automated. 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, 63% of aged American shad at the Conowingo Dam were repeat spawners in 2013, and, on average, 33% of aged fish were repeat spawners over the past five years. Turbine mortality for dams above the Conowingo Dam is considered to be 100%, and the end of truck and transport in 1997 may have resulted in more fish surviving to return in following years, which also indicates that fewer adults are reaching optimal spawning habitat above Safe Harbor Dam. However, the same trend occurs in the Potomac River, where there is no history of truck and transport and associated turbine mortality: the average percent of repeat spawners was 17% in the 1950s (Walburg and Sykes 1957), and is currently 71%. Increased repeat spawning in both 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, and/or reductions in natural mortality.

Historically, calculated Z for American shad in the lower Susquehanna River has been well above the target Z_{30} (1984 – 2005; ASMFC 2007). The 2013 mortality estimate continues this pattern, with a calculated Z for American shad in the Conowingo Dam tailrace (Z=0.68) being above the Z_{30} established for rivers in neighboring states (range=0.54−0.64), with the exception of Albemarle Sound, NC (Z_{30}=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 increased baywide, in the upper Chesapeake Bay and the Potomac River in 2013. Only the juvenile index in the Nanticoke River decreased in 2013. The Potomac River juvenile American shad index has been greater than all other systems since 2007. This suggests weather conditions were more favorable for successful recruitment in 2013. Fish lifted above the Conowingo Dam may reduce the number of potential spawners due to turbine mortality, and inefficient lift facilities above the Conowingo Dam may also prevent spawners from reaching optimal spawning habitat above the York Haven Dam, thus affecting juvenile production. Predation by apex predators, particularly striped bass and the invasive flathead and blue catfish, may also affect juvenile survival.

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. Only one hickory shad was observed in the EFL in 2013. 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 and 2010 according to shad logbook data collected from Deer Creek anglers (1998-2013). Hickory shad are sensitive to light and generally strike artificial lures more frequently when flows are somewhat elevated and the water is slightly turbid. Consequently, the low CPAH for hickory shad in 2009 may be directly related to the low flow and clear water conditions encountered by Deer Creek anglers and observed by MDNR staff during that spring season.

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 two years (2012-2013) have seen no hickory shad over the age of 7, and in 2013 90% of fish were age 5 or younger. This suggests the age structure of hickory shad has become truncated in recent years. Ninety percent of hickory shad from the upper Chesapeake Bay spawn by age four, and this stock generally consists of few virgin fish (Richardson et. al 2004). Repeat spawning has remained relatively consistent over the 2004-2013 time series, with the percent of repeat spawners ranging between 64-89%.

Hickory shad relative abundance metrics in the Nanticoke River (pound and fyke net CPUE) are tenuous, presumably because of gear avoidance. Therefore, relative abundance analysis for hickory shad in the Nanticoke River was discontinued. Extensive spring electrofishing conducted in conjunction with Maryland stocking efforts in the Nanticoke River watershed concluded that stocks increased in this system from 2002-2009 (Richardson 2009). Maryland stocking and sampling of American shad in the Nanticoke River ended in 2009.

Estimates of Z are primarily attributed to M because only a catch and release fishery exists for hickory shad in Maryland. The high percent of repeat spawners is also indicative of very low bycatch mortality. 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. Sampling would need to be initiated prior to 1 June in order to accurately assess hickory shad juvenile production.

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 the mean length of at least one age were observed in most rivers examined (ASMFC 2012). This assessment corresponds with the low indices of abundance in the Nanticoke River. Specifically, the truncating age structure for river herring may be a sign of excessive mortality rates.

Juvenile alewife and blueback production in the Nanticoke River and upper bay has generally been erratic, with frequent declines in abundance to very low levels. In 2013, alewife herring CPUE decreased for juveniles in both of these regions, while blueback herring CPUE increased slightly in both of these regions. Generally, abundance for both species remains at low levels.

Because river herring landings along the east coast have decreased significantly, ASMFC passed Amendment 2 of the ASMFC Interstate Fishery Management Plan for American Shad and River Herring. This amendment 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. It is no longer legal to possess river herring within the jurisdiction of Maryland unless the possessor has a bill of sale identifying the river herring were legally caught in waters not under Maryland jurisdiction. The expectation is that the moratorium on river herring will lead to increased production of juvenile river herring, and (in three to five years) an increase in the spawning stock.

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Table 1. Number of juvenile alosines captured by species in seines and trawls on the Chester River, 2007-2012.

Seine

	2007	2008	2009	2010	2011	2012
American Shad	0	0	0	0	0	0
Hickory Shad	0	0	0	5	9	0
Alewife	1	1	18	2	19	0
Blueback	334	36	19	28	1,214	0

Trawl

	2007	2008	2009	2010	2011	2012
American Shad	0	0	0	0	0	0
Hickory Shad	3	0	1	0	6	0
Alewife	33	12	27	11	6	0
Blueback	1	0	5	0	0	0

Table 2. Percentage of sites with clupeid eggs or larvae and number of sites sampled in the Nanticoke River (2005-2013).

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

Table 3. 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 in 2013.

Conowingo Dam Tailrace

AGE	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
4	11	1	4	0	15	1
5	66	25	23	8	89	33
6	48	32	51	40	99	72
7	32	26	38	34	70	60
8	4	3	14	14	18	17
9	1	1	5	5	6	6
10	0	0	1	1	1	1
Totals	161	87	135	96	291	183
Percent Repeats	54.0%		71.1%		62.9%	

Nanticoke River

AGE	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
5	3	0	2	0	5	0
6	9	5	5	4	14	9
7	2	2	2	2	4	4
8	2	2	2	2	4	4
9	0	0	1	1	1	1
Totals	16	9	12	9	28	18
Percent Repeats	56.3%		75.0%		64.3%	

Potomac River

AGE	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
4	1	0	0	0	1	0
5	9	3	2	1	11	4
6	34	27	18	9	52	36
7	13	11	18	13	31	24
8	4	4	5	5	9	9
10	1	1	0	0	1	1
Totals	62	46	43	28	105	74
Percent Repeats	74.2%		65.1%		70.5%	

Table 4. Number of recaptured American shad in 2013 at the Conowingo Dam East and West Fish Lifts by tag color and year.

East Lift		
Tag Color	Year Tagged	Number Recaptured
Pink	2013	23
West Lift		
Tag Color	Year Tagged	Number Recaptured
Pink	2013	11

Table 5. Catch (numbers), effort (hours fished) and catch-per-angler-hour (CPAH) from the recreational creel survey in the Susquehanna River below Conowingo Dam, 2001-2013. Due to sampling limitations, no data were available for 2011.

Year	Number of Interviews	Hours Fished for American Shad	American Shad Catch	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
2011				
2012	58	189.0	146	0.77
2013	63	161.8	107	0.66

Table 6. Catch (numbers), effort (hours fished) and catch-per-angler-hour (CPAH) from spring logbooks for American shad, 2000-2013. Multiple logbooks were used from 2000 until 2003, when a single logbook was utilized to collect data on both shad species.

Year	Number of Returned Logbooks	Total Reported Angler Hours	Total Number of American Shad	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

Table 7. Estimated adult American shad mortalities (in numbers) in Maryland waters (1997-2013). Lower Susquehanna River (below the Conowingo Dam) abundance estimates are derived from the surplus production model. West Fish Lift mortality includes mortality due to day-to-day operations.

Year	Total Commercial Landings in Maryland's Portion of Chesapeake Bay	Conowingo Dam East Fish Lift Mortality[1]	Conowingo Dam West Fish Lift Mortality	Estimated Commercial Chesapeake Bay Bycatch Mortality [2]	Recreational Bycatch Mortality	Ocean Commercial Landings [3]	Minimum Total Losses	Conowingo Dam Tailrace Abundance Estimate
1997	0	43,790	2,274	4,200	Unknown	24,859	75,123	161,162
1998	0	16,152	1,300	4,200	Unknown	18,526	39,908	162,044
1999	0	43,455	3,136	4,200	Unknown	13,623	64,414	192,232
2000	0	60,452	3,102	4,200	Unknown	4,834	72,588	202,516
2001	0	130,876	2,607	4,200	Unknown	2,347	140,030	199,217
2002	0	40,142	2,837	4,200	Unknown	1,882	49,061	124,230
2003	0	50,224	2,160	4,200	Unknown	621	57,205	117,980
2004	0	29,911	1,218	4,200	Unknown	220	35,549	99,311
2005	0	42,873	1,412	4,200	Unknown	0	48,485	96,498
2006	0	41,201	1,696	4,200	Unknown	0	95,582	79,303
2007	0	14,120	1,737	4,200	Unknown	0	20,057	57,393
2008	0	7,075	1,477	4,200	Unknown	0	12,752	57,201
2009	0	15,490	1,566	4,200	Unknown	0	21,256	64,088
2010	0	21,793	1,219	4,200	Unknown	0	27,212	65,286
2011	0	5,159	1,038	4,200	Unknown	0	10,397	60,578
2012	0	8,714	710	4,200	Unknown	0	13,952	70,872
2013	0	5,341	447	4,200	Unknown	0	9,541	80,910

1 Estimated to be 100% of fish passing above Holtwood Dam and 25% turbine mortality of fish passing back through Conowingo Dam.

2 Extrapolated from American shad observed mortalities from pound nets in the upper Chesapeake Bay.

3 Reported numbers were calculated by multiplying total pounds by an estimated four pounds per fish.

Table 8. 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 2013.

AGE	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
3	23	0	18	0	41	23
4	43	32	45	24	88	56
5	23	23	23	23	46	46
6	9	9	7	7	16	16
7	2	2	0	0	2	2
Totals	100	89	93	54	193	143
Percent Repeats	66.0%		58.1%		74.1%	

Table 9. Percent of hickory shad by age and number sampled from the brood stock collection survey in Deer Creek (Susquehanna River tributary) by year, 2004-2013.

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	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	
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	0.93	
2012	200		26.5	39.5	24.5	7.5	2.0		
2013	193		21.2	45.6	23.8	8.3	1.0		

Table 10. Percent repeat spawning hickory shad (sexes combined) by year from the brood stock collection survey in Deer Creek (Susquehanna River tributary), 2004-2013.

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

Table 11. Catch (numbers), effort (hours fished) and catch-per-angler-hour (CPAH) from spring logbooks for hickory shad, 1998-2013. Multiple logbooks were used from 1998 until 2003, when a single logbook was utilized to collect data on both shad species.

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	252	1,679	6.67

Table 12. Catch-at-age and repeat spawners by sex and age for adult alewife and blueback herring sampled from the Nanticoke River in 2013.

Alewife Herring

AGE	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
3	6	0	3	0	9	0
4	12	0	20	0	32	0
5	17	4	32	18	49	22
6	9	8	21	19	30	27
7	1	1	11	11	12	12
8	0	0	1	1	1	1
9	0	0	0	0	0	0
Totals	45	13	88	49	133	62
Percent Repeats	28.9%		55.7%		46.6%	

Blueback Herring

AGE	Male		Female		Total	
	N	Repeats	N	Repeats	N	Repeats
3	4	0	1	0	5	0
4	22	2	11	0	33	2
5	17	10	7	2	24	12
6	11	8	4	2	15	10
7	1	1	1	1	2	2
8	0	0	3	3	3	3
Totals	55	21	27	8	82	29
Percent Repeats	38.2%		29.6%		35.4%	

Table 13. Mean length-at-age by sex for alewife herring sampled from the Nanticoke River, 1989-2013.

Males

Year	Age								
	2	3	4	5	6	7	8	9	10
1989		230	236	243	256	261			
1990		221	231	244	250	263	264		
1991		224	234	240	251	260	243		
1992		216	228	238	247	254			
1993		208	225	239	246	248	246		
1994		207	219	231	239	246			
1995		214	226	238	246	251	244		
1996	212	219	228	238	242	263			
1997		213	228	233	240		252		
1998		217	225	238	243	254			
1999		211	222	233	238	244			
2000		220	228	238	258				
2001		225	234	240	247				
2002		225	233	241	244	248			
2003		228	239	245	251				
2004		228	242	251	250				
2005		214	226	236	252	252			
2006		219	223	235	242				
2007		219	227	235	248				
2008		216	217	229	235	278			
2009		221	224	231	241				
2010		221	224	232	248				
2011		215	229	233	244				
2012		215	217	230	241				
2013		208	222	232	241	245			

Females

Year	Age								
	2	3	4	5	6	7	8	9	10
1989		229	244	253	267	277	286		
1990		225	238	253	261	274	283	286	
1991		227	243	251	263	270	273	286	
1992		223	240	248	256	265	276	279	
1993		225	233	247	256	265	277		
1994		219	228	243	254	258	270		
1995		221	235	252	263	268	274		280
1996		219	231	250	257	267	268	260	
1997		228	234	242	253	267	271		
1998		224	235	245	255	264		277	
1999		220	229	242	250	260	272		
2000		237	237	250	257	270			
2001		239	243	249	256	266	270		
2002		226	238	248	255	260	263		
2003		240	239	250	260	263			
2004		235	249	259	262	270			
2005			233	243	257	267	272		
2006		228	240	247	256	264	277		
2007		220	236	247	256	265	269		
2008		217	231	238	248	256	276	279	
2009		215	231	242	252	261			
2010			234	245	257	251			
2011		226	236	247	256	268	275		
2012		218	233	249	260	263			
2013		233	232	240	249	262	269		

Table 14. Mean length-at-age by sex for blueback herring sampled from the Nanticoke River, 1989-2013.

Males

Year	Age								
	2	3	4	5	6	7	8	9	10
1989		218	227	234	245	259	262	279	
1990		218	232	239	249	258	263	270	
1991		217	229	237	247	258	260	273	
1992		212	224	235	245	251	260	256	
1993		205	224	237	247	256	262	261	
1994		213	223	238	250	256			
1995		220	226	233	247	256			
1996	205	219	230	240	244	270	261		
1997		212	225	238	241	247	257		
1998		212	225	233	245	253			
1999		200	222	232	239	251			
2000		219	225	235	246	249			
2001		218	231	235	250				
2002		217	229	234	243				
2003	215	230	240	238					
2004	216	231	234	245	250				
2005		222	226	238					
2006		209	224	235	236	270			
2007		207	221	227	266				
2008		206	216	220					
2009		214	219	231					
2010		219	227		228				
2011		206	220	226	234				
2012	212	207	217	229	229				
2013		216	222	225	231	226			

Females

Year	Age								
	2	3	4	5	6	7	8	9	10
1989		227	236	244	257	271	279	297	
1990			241	252	262	271	281	286	291
1991		228	238	251	260	264	273	285	
1992		230	230	250	260	264	272	281	
1993		220	236	246	259	269	277	290	296
1994		215	226	245	260	272	282	277	
1995		228	235	248	260	264	270		
1996		218	238	249	257	275	278		
1997		226	242	247	254	268	276	290	
1998			233	246	257	265	281		
1999		219	236	244	253	273			
2000		227	231	243	260	269	275		
2001		219	242	248	260	273			
2002		220	235	246	257	260			
2003	224	235	248	252	264	283			
2004		236	245	254	262	262			
2005		241	236	248	264				
2006		204	235	242	246				
2007		217	221	246	247	266			
2008		213	227	234	252	251	261		
2009		227	232	242	260	278			
2010			243	238	247				
2011		201	240	238	251	262			
2012		213	230	244	249	256			
2013		232	226	240	244	233	256		

Table 15. Regression statistics for length by age and sex over time for alewife and blueback herring (1989-2013). Only ages with consistent representation over time were considered. Bolded values indicate significant changes in length-at-age over time.

Alewife	Males				Females			
Age	N	Slope	r^2	P	N	Slope	r^2	P
3	396	-0.155	0.0083	0.069	125	-0.104	0.0053	0.42
4	1401	-0.385	0.0599	< **0.001**	1296	-0.31	0.0455	< **0.001**
5	1154	-0.387	0.0601	< **0.001**	1741	-0.289	0.0416	< **0.001**
6	482	-0.382	0.0641	< **0.001**	1113	-0.285	0.043	< **0.001**
7	71	-0.851	0.178	**<0.001**	364	-0.359	0.0759	< **0.001**
8					97	-0.507	0.0762	**0.006**

Blueback	Males				Females			
Age	N	Slope	r^2	P	N	Slope	r^2	P
3	220	-0.291	0.0602	**<0.001**	58	-0.441	0.126	**0.006**
4	927	-0.326	0.0582	< **0.001**	801	-0.159	0.00877	**0.008**
5	983	-0.328	0.0414	< **0.001**	962	-0.280	0.0350	< **0.001**
6	668	-0.629	0.1	< **0.001**	703	-0.473	0.0473	< **0.001**
7	282	-0.732	0.0510	**<0.001**	342	-0.474	0.0483	**<0.001**
8	90	-0.259	0.00247	0.641	114	-0.702	0.1	**<0.001**
9	21	-4.561	0.258	**0.019**	33	-0.006	<0.0001	0.996

Figure 1. Conowingo Dam Tailrace (Susquehanna River) hook and line sampling location for American shad in 2013.

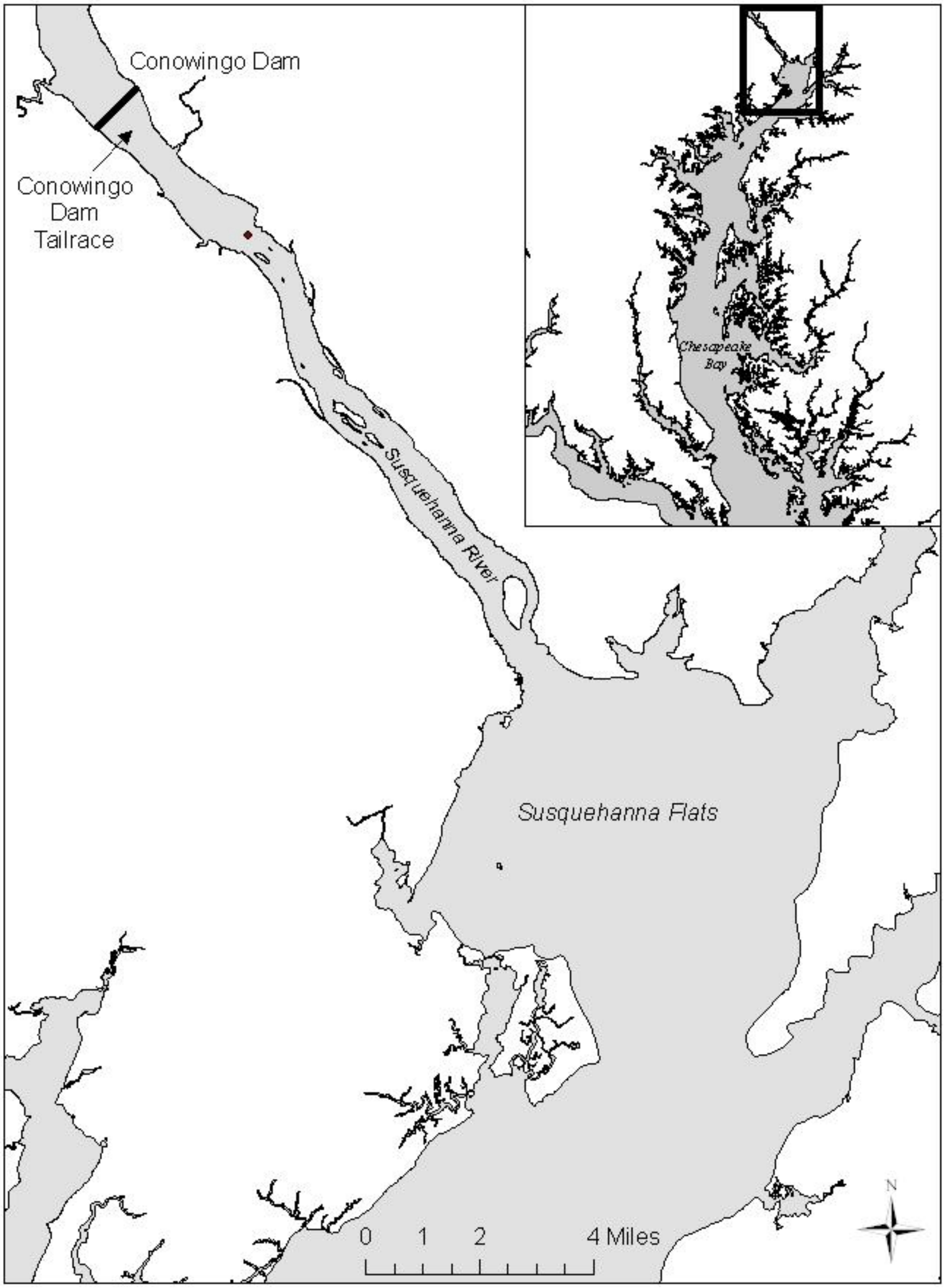


Figure 2. Nanticoke River pound and fyke net sites for adult alosine sampling in 2013. The Mill Creek pound net site used for calculating American shad CPUE is identified.

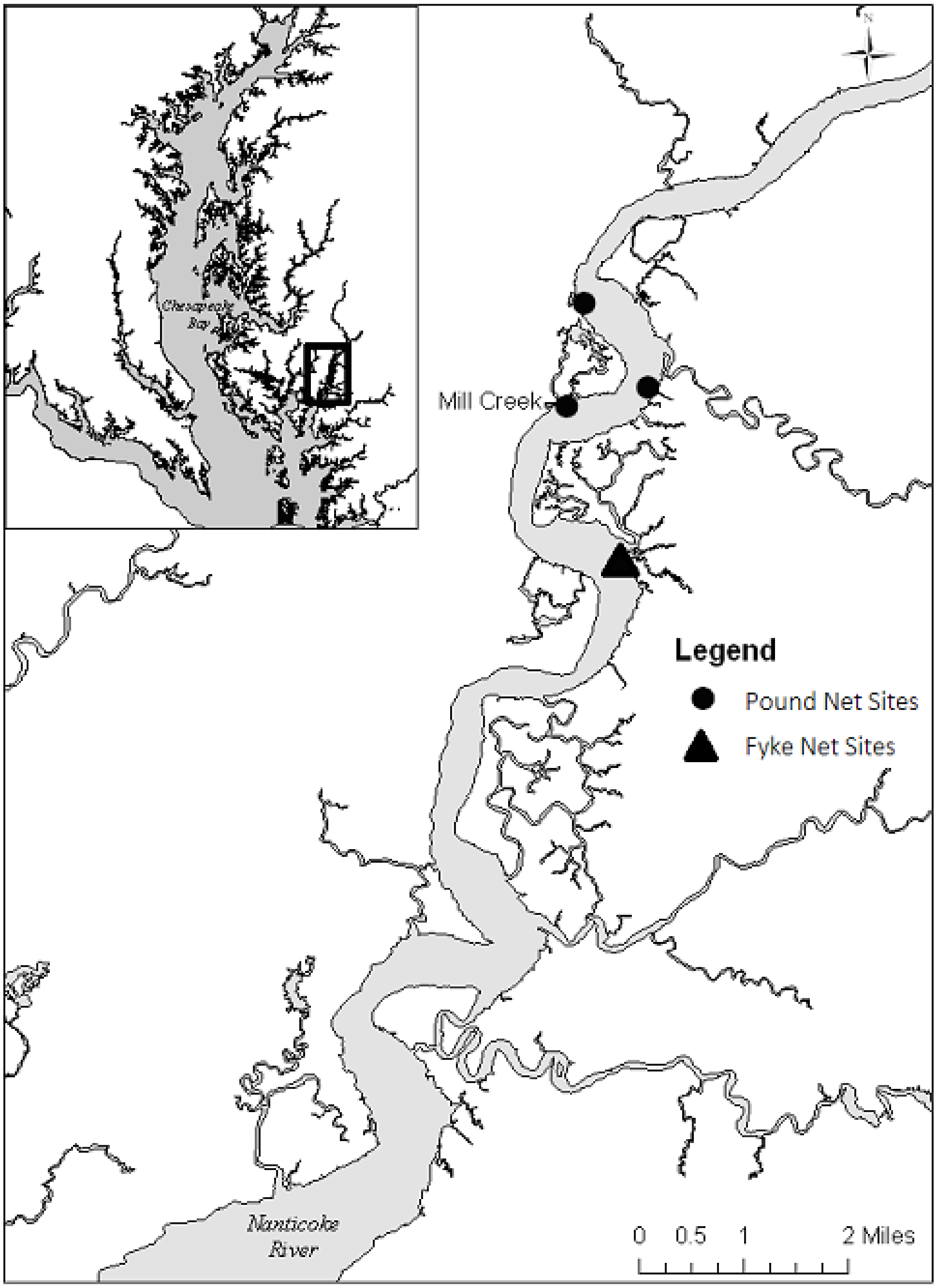


Figure 3. Nanticoke River sites for alosine ichthyoplankton sampling in 2013.

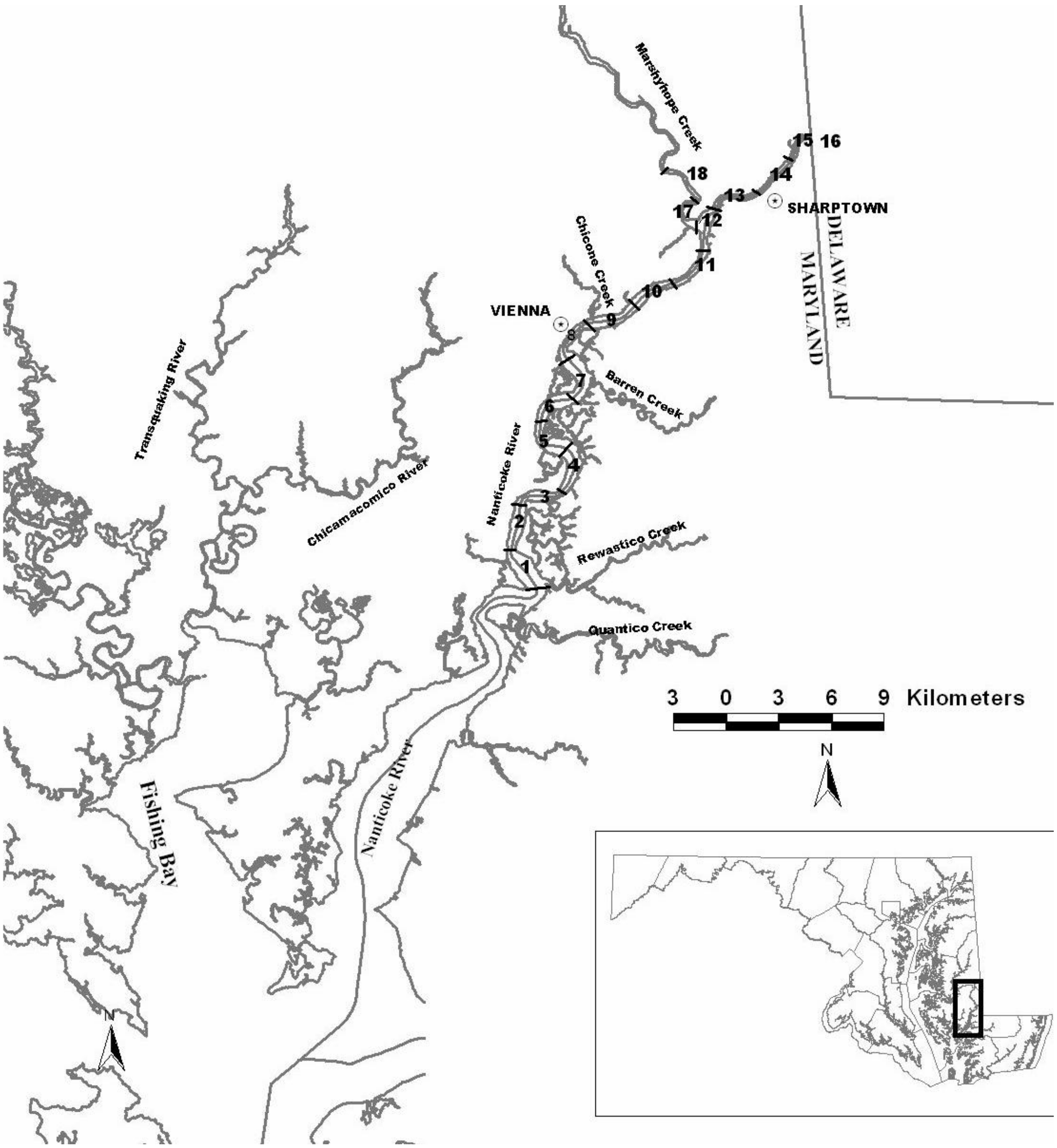


Figure 4. Percent of American shad repeat spawners by sex collected in the Conowingo Dam tailrace (1982-2013).

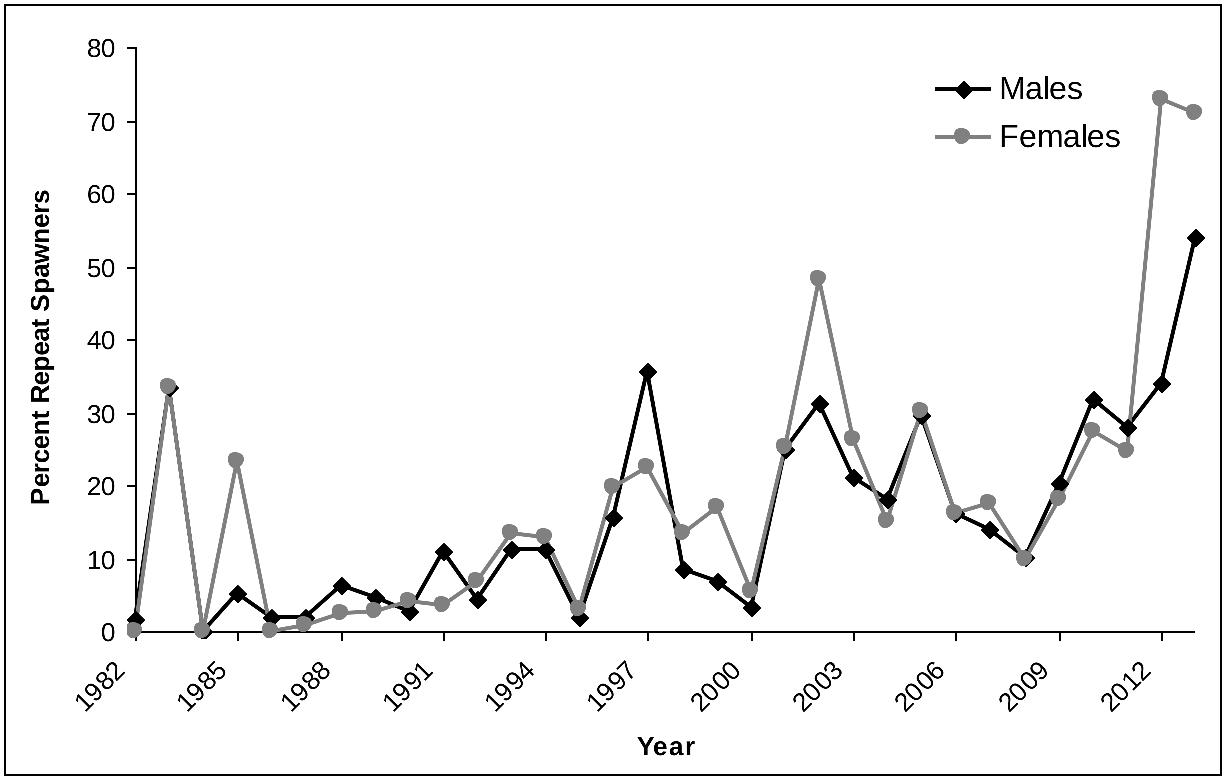


Figure 5. Arcsine-transformed percentages of repeat spawning American shad (sexes combined) collected from the Conowingo Dam tailrace, 1984-2013.

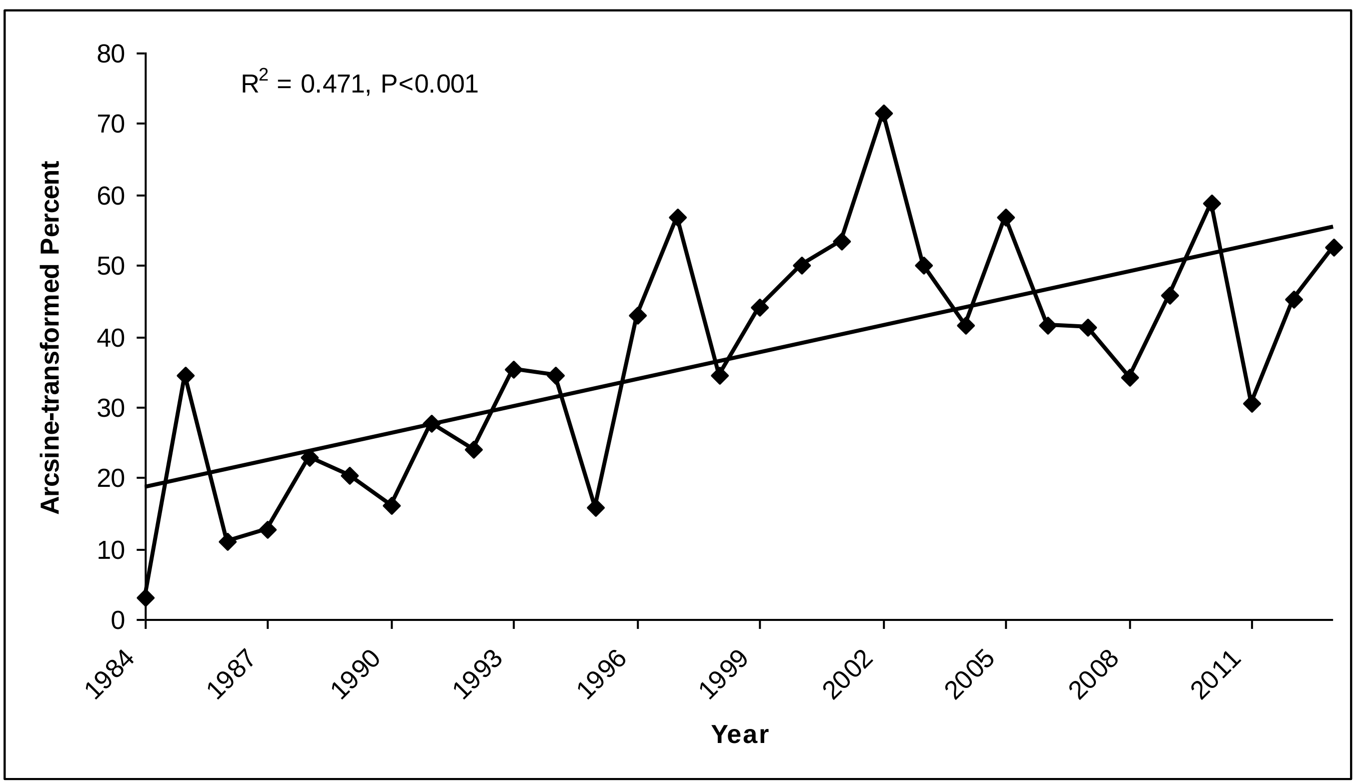


Figure 6. Arcsine-transformed percentages of repeat spawning American shad (sexes combined) collected from the Nanticoke River, 1988-2013.

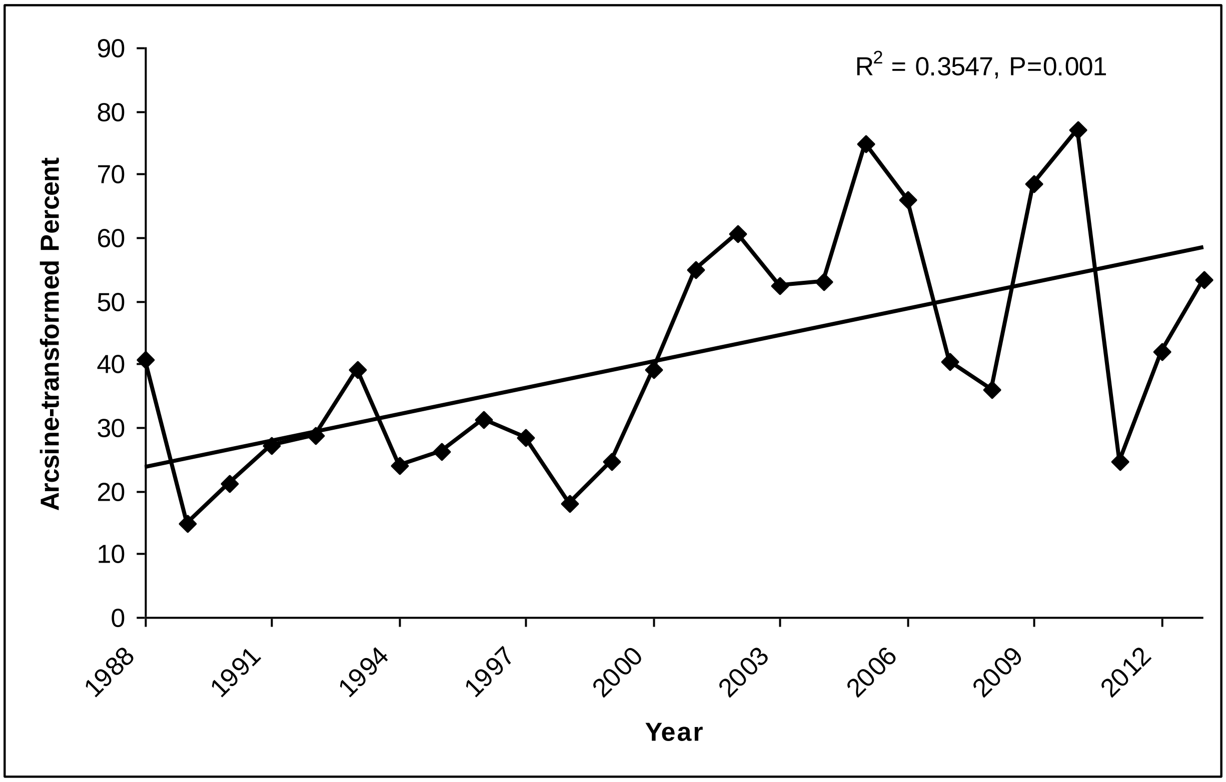


Figure 7. Trends in arcsine-transformed percentages of repeat spawning American shad (sexes combined) collected from the Potomac River, 2002-2013.

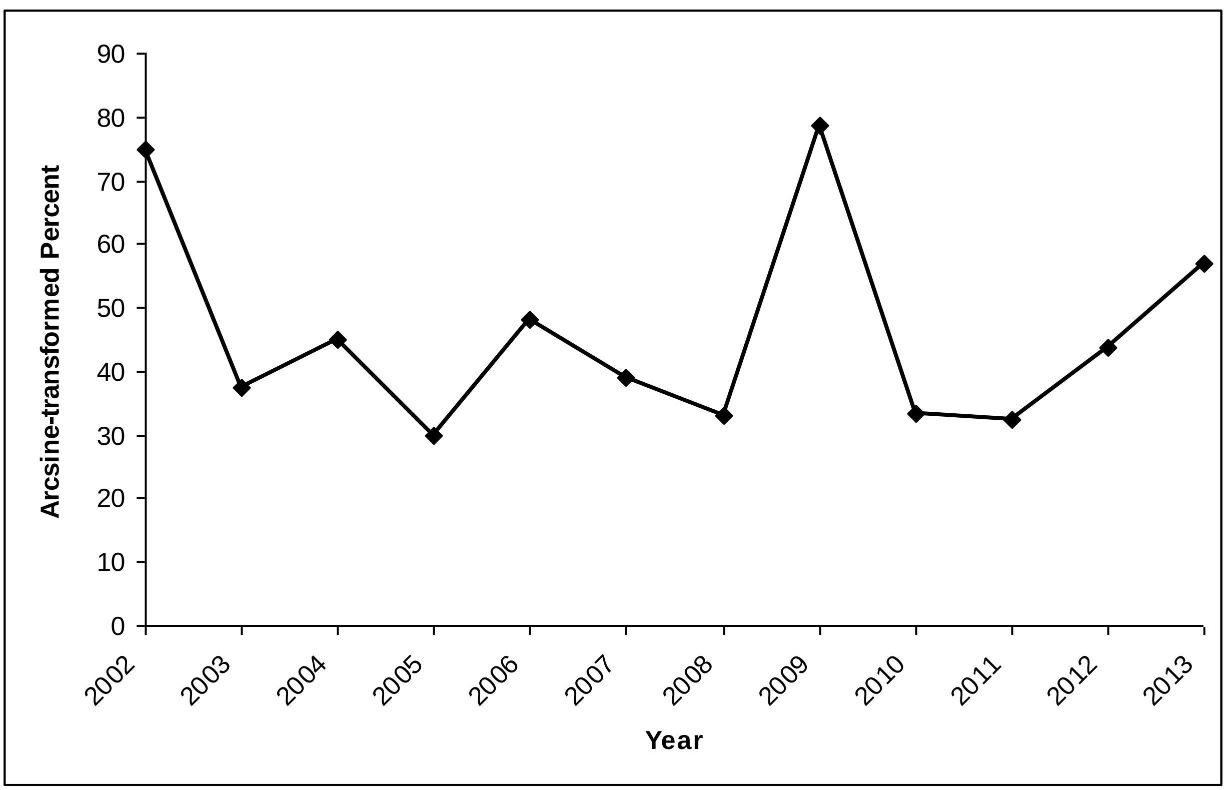


Figure 8. Conowingo Dam tailrace adult American shad abundance estimates from the Petersen statistic with 95% confidence limits, 1986-2013.

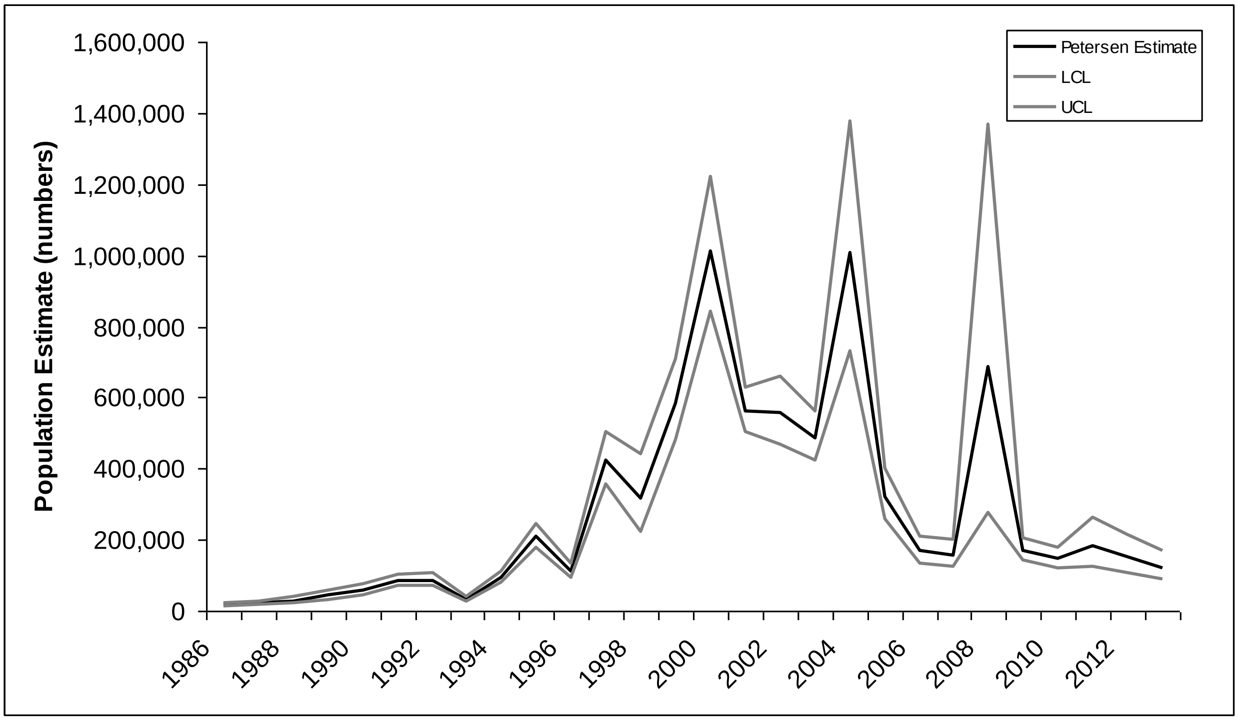


Figure 9. Conowingo Dam tailrace adult American shad abundance estimates from the surplus production model (SPM), 1986-2013.

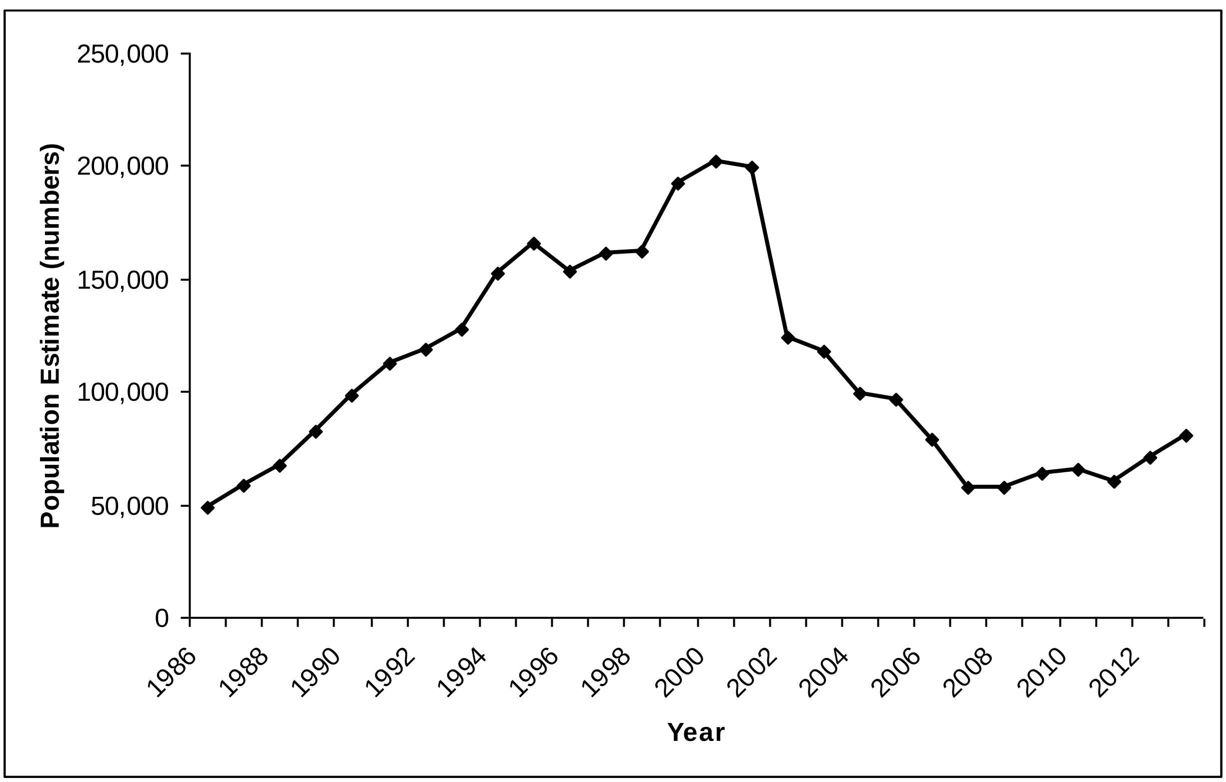


Figure 10. American shad geometric mean CPUE (fish per boat hour) from the Conowingo Dam tailrace hook and line sampling, 1984-2013.

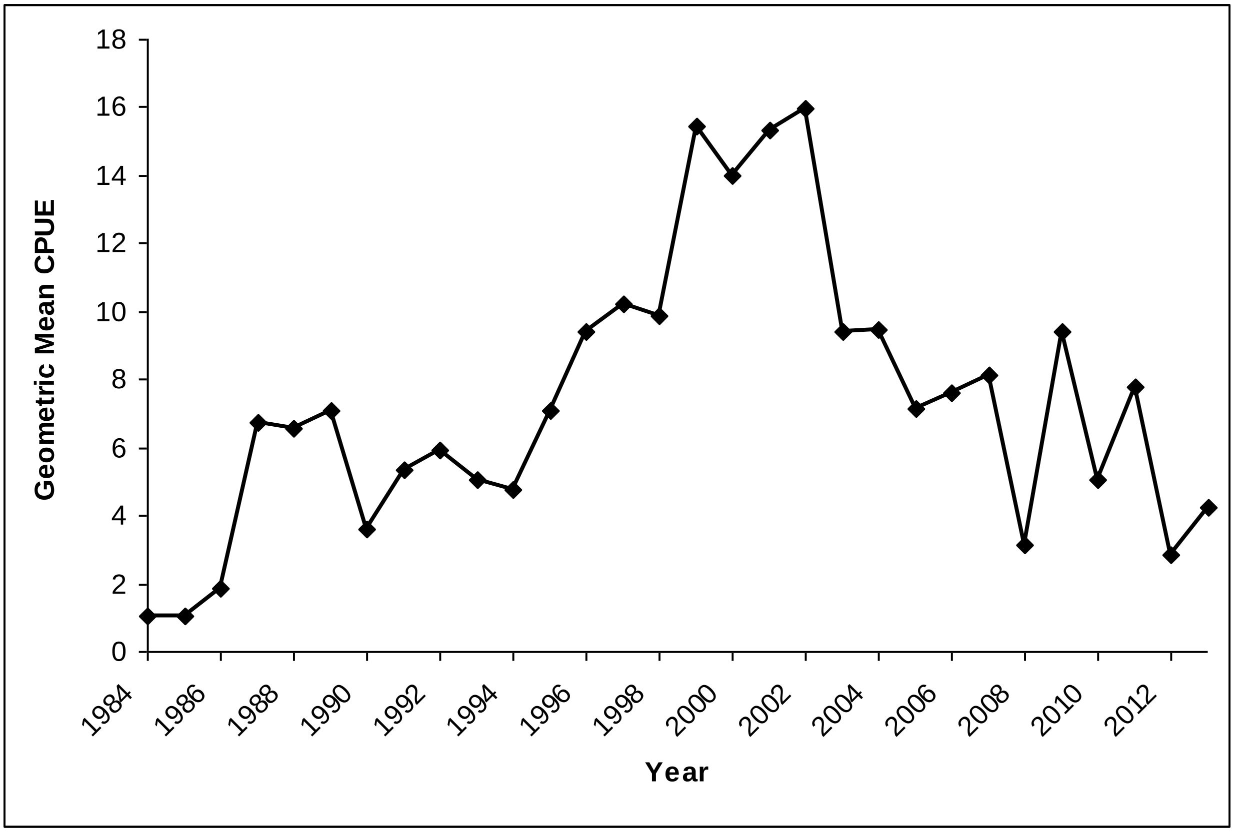


Figure 11. American shad geometric mean CPUE (fish per lift hour) from the East and West Fish Lifts at the Conowingo Dam, 1980-2013.

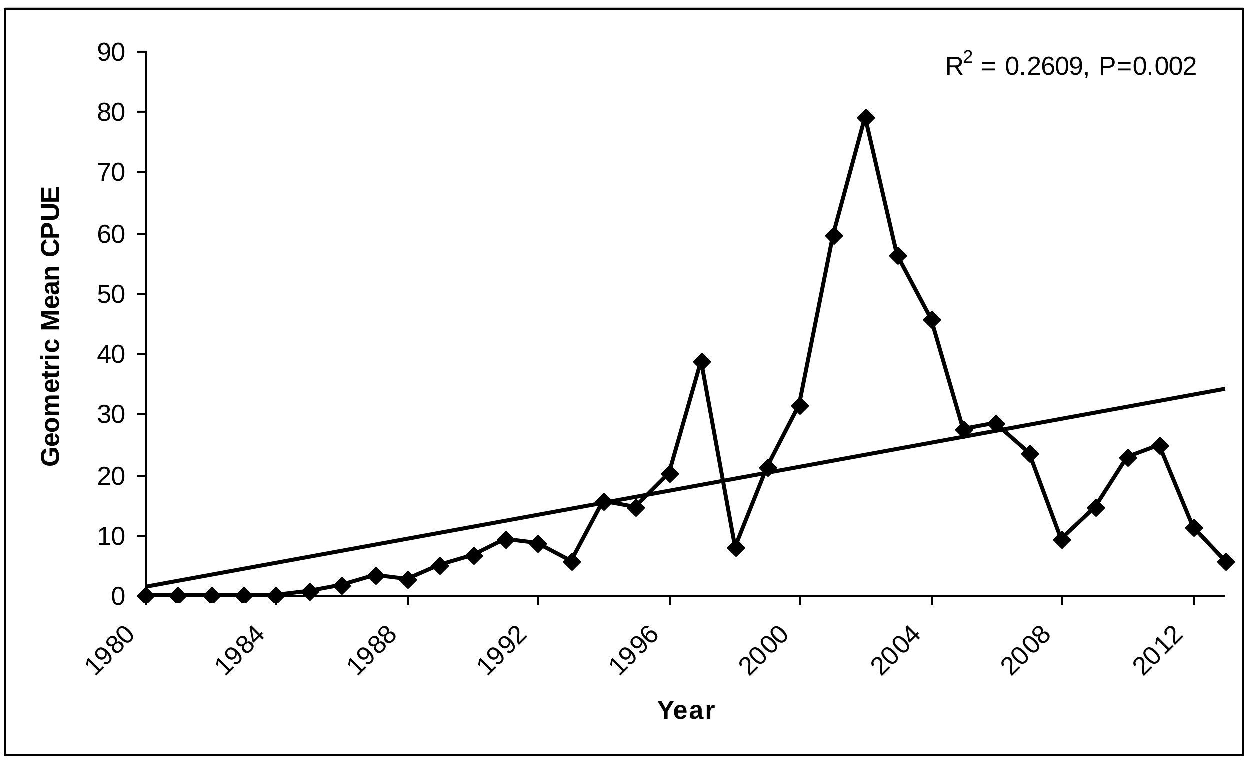


Figure 12. American shad geometric mean CPUE (fish per net day) from the Mill Creek pound net in the Nanticoke River, 1988-2013. No pound nets were fished in 2004.

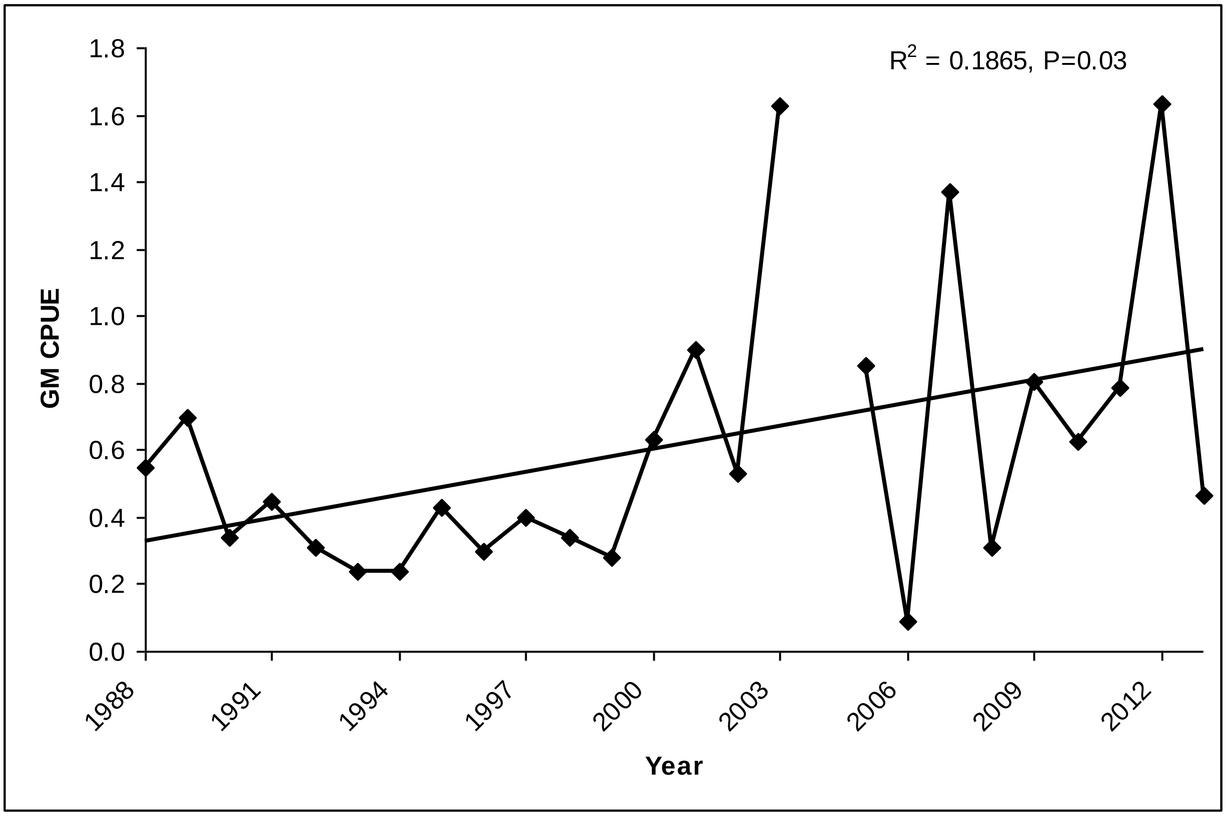


Figure 13. American shad geometric mean CPUE (fish per 1,000 square yards of experimental drift gill net per hour fished) from the Potomac River, 1996-2013.

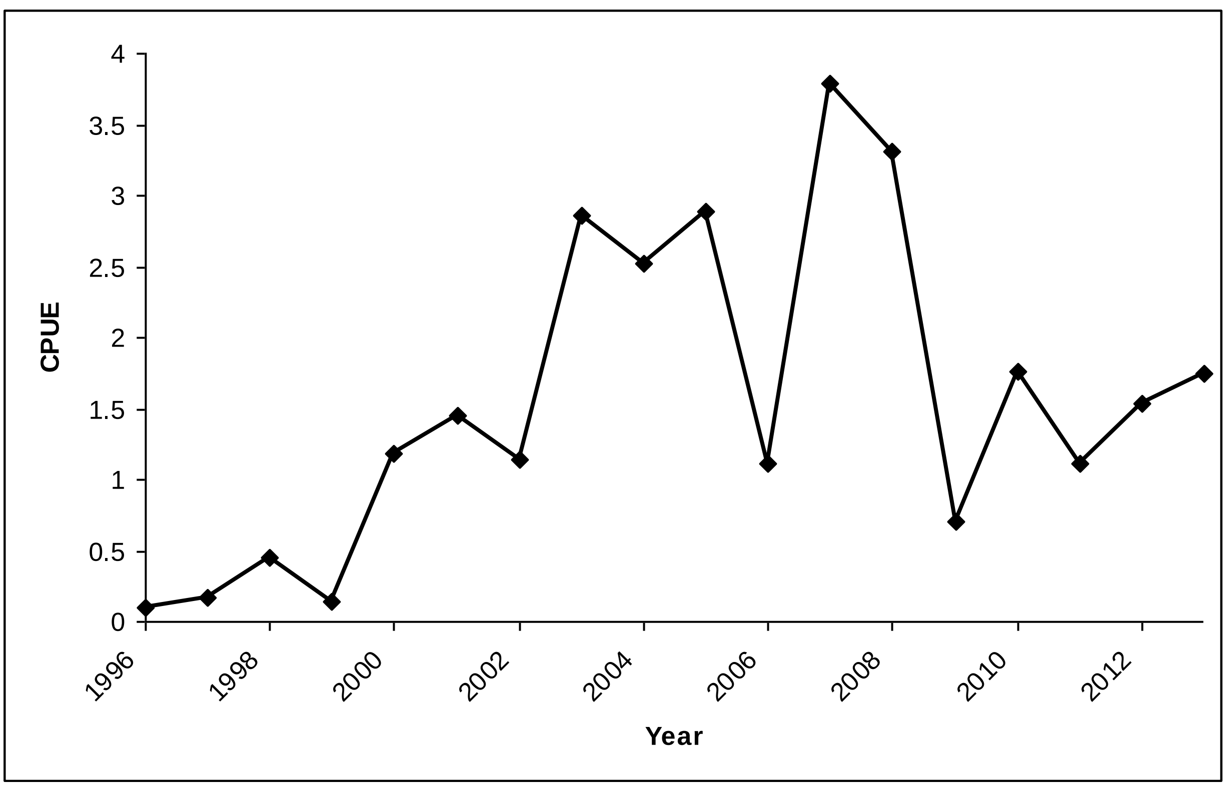


Figure 14. Baywide juvenile American shad geometric mean CPUE (catch per haul), 1959-2013.

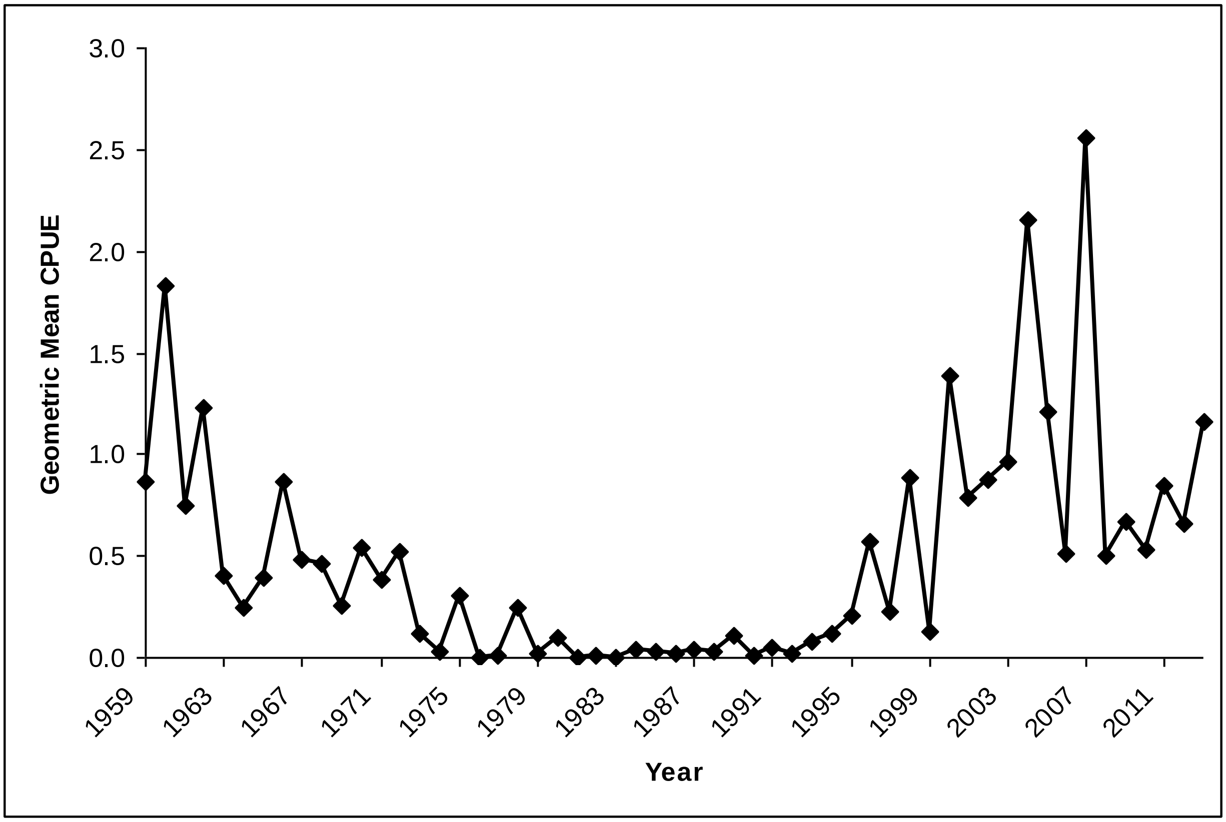


Figure 15. Upper Chesapeake Bay juvenile American shad geometric mean CPUE (catch per haul), 1959-2013.

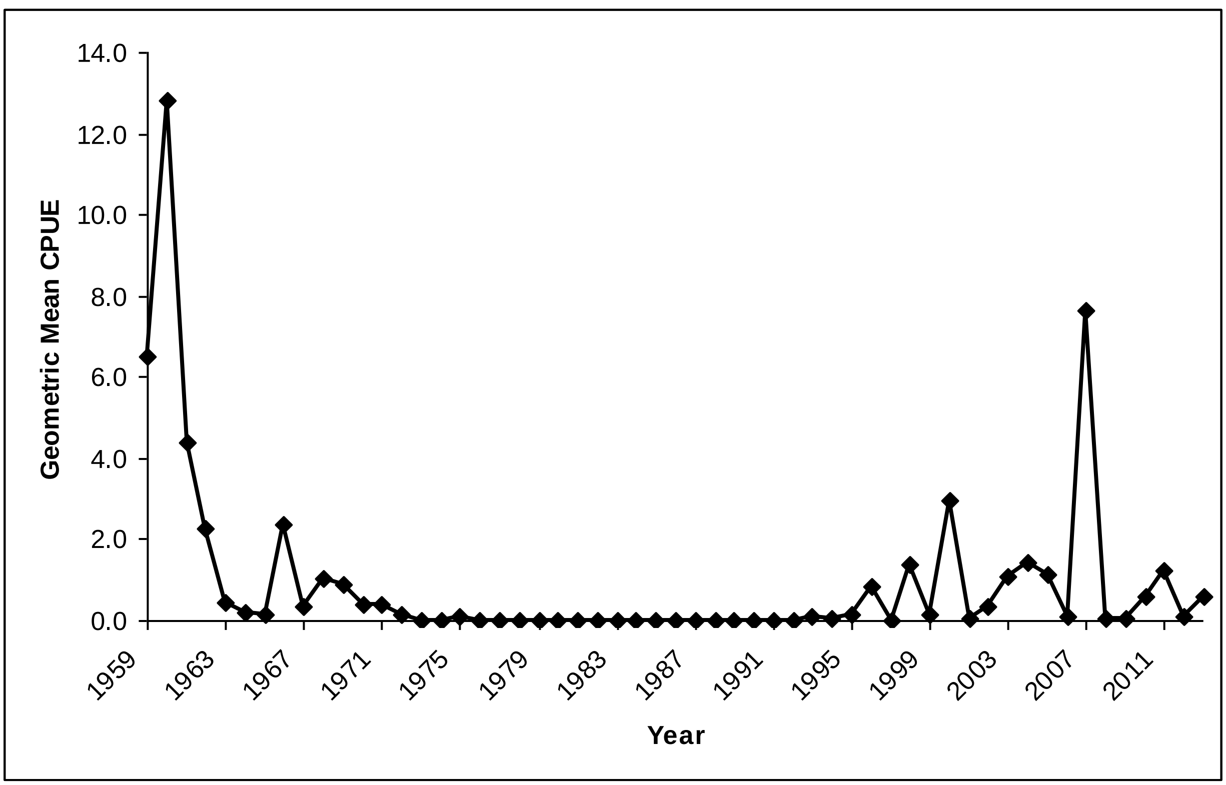


Figure 16. Potomac River juvenile American shad geometric mean CPUE (catch per haul), 1959-2013.

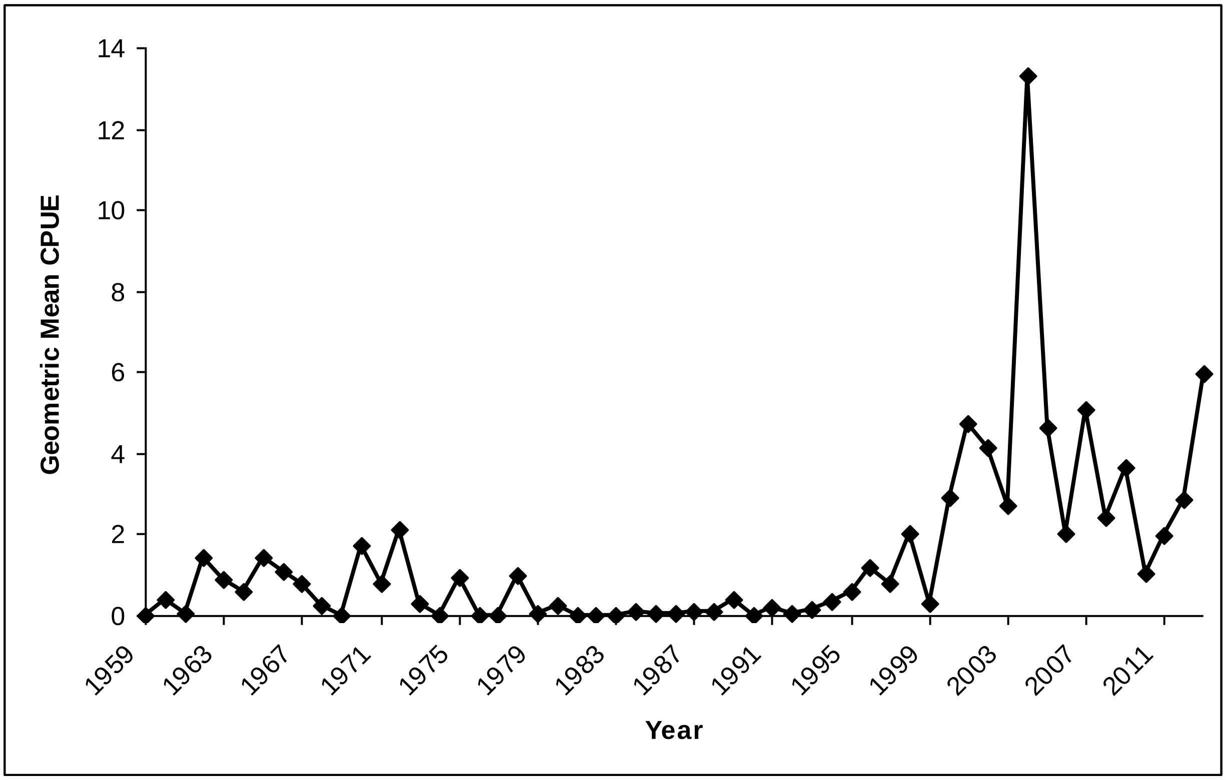


Figure 17. Nanticoke River juvenile American shad geometric mean CPUE (catch per haul), 1959-2013.

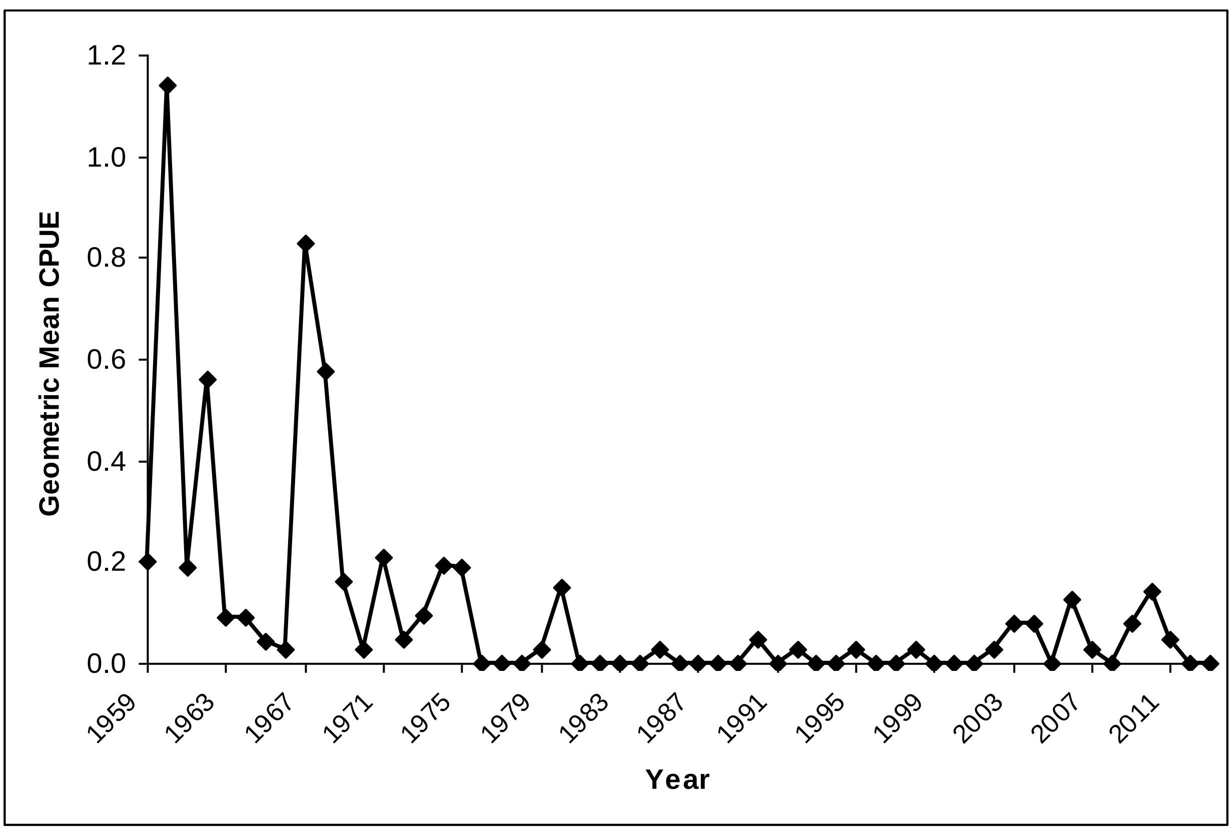


Figure 18. Arcsine-transformed percentages of repeat spawning hickory shad (sexes combined) collected from Deer Creek (Susquehanna River tributary), 2004-2013.

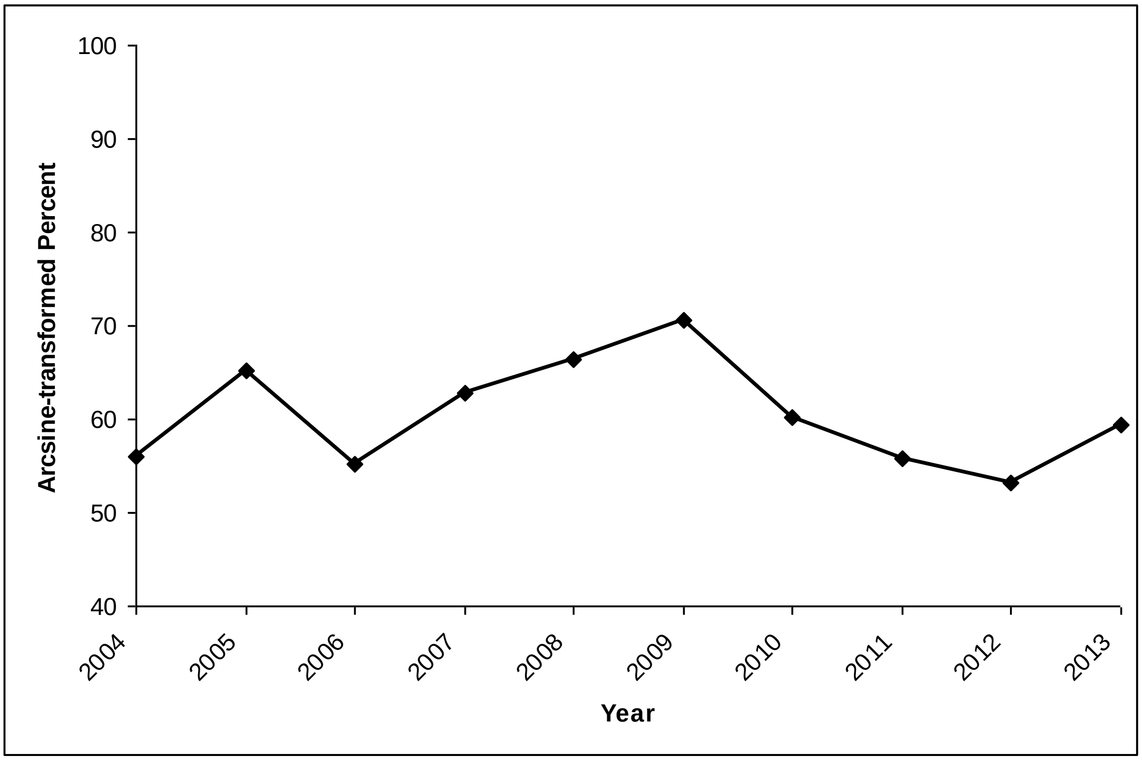


Figure 19. Arcsine-transformed percentages of repeat spawning alewife and blueback herring (sexes and gears combined) from the Nanticoke River, 1989-2013.

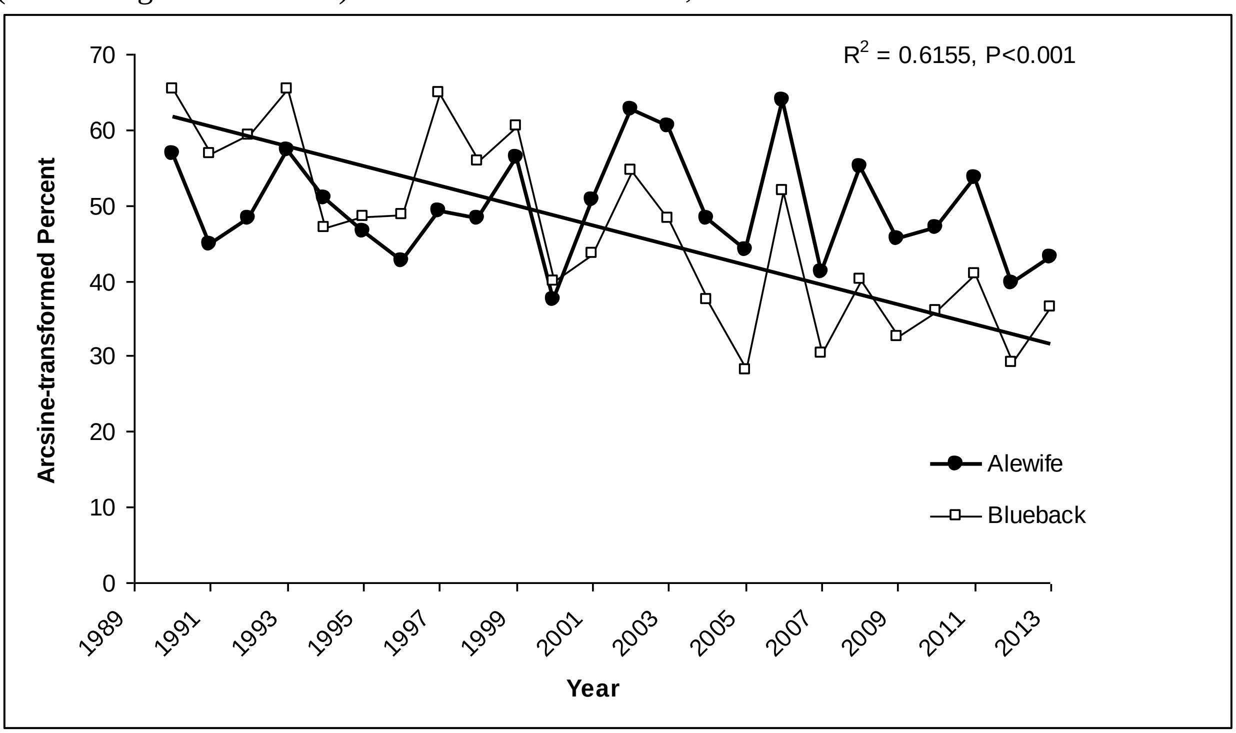


Figure 20. Geometric mean CPUE (catch per net day) of adult alewife and blueback herring from Nanticoke River fyke nets, 1989-2013. No fyke nets were fished in 2012.

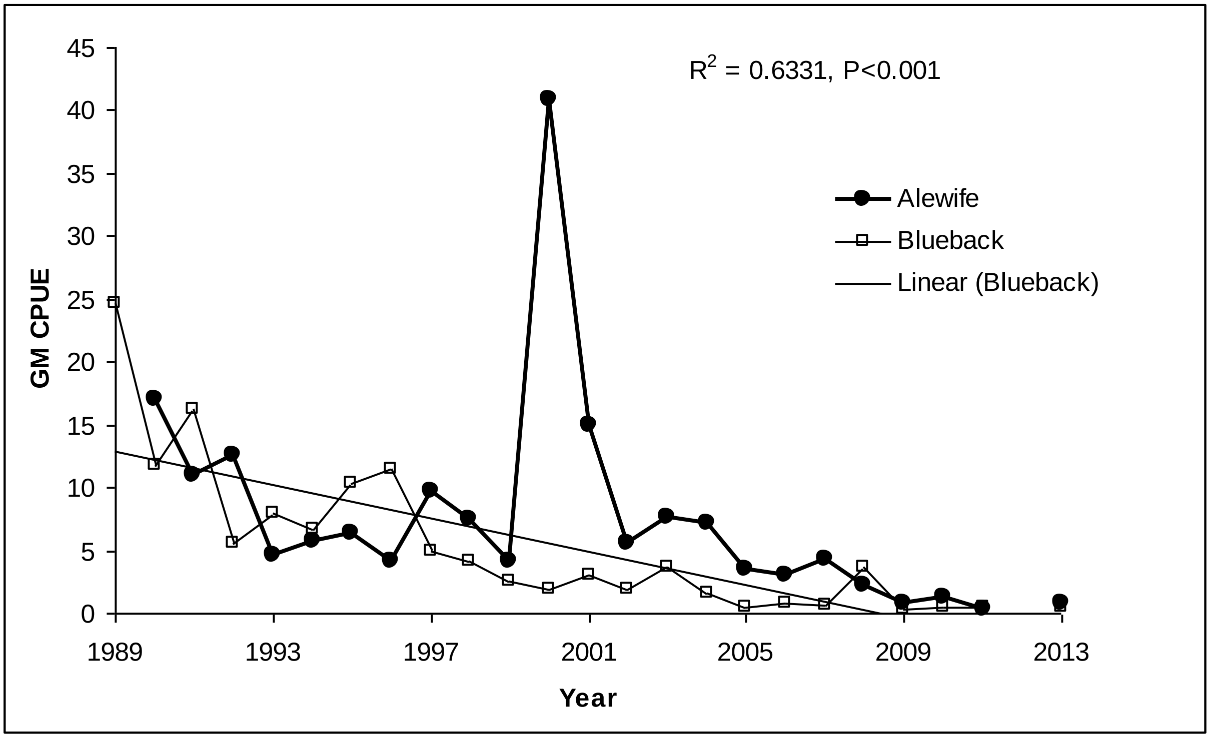


Figure 21. Maryland's commercial river herring landings, 1929-2013.

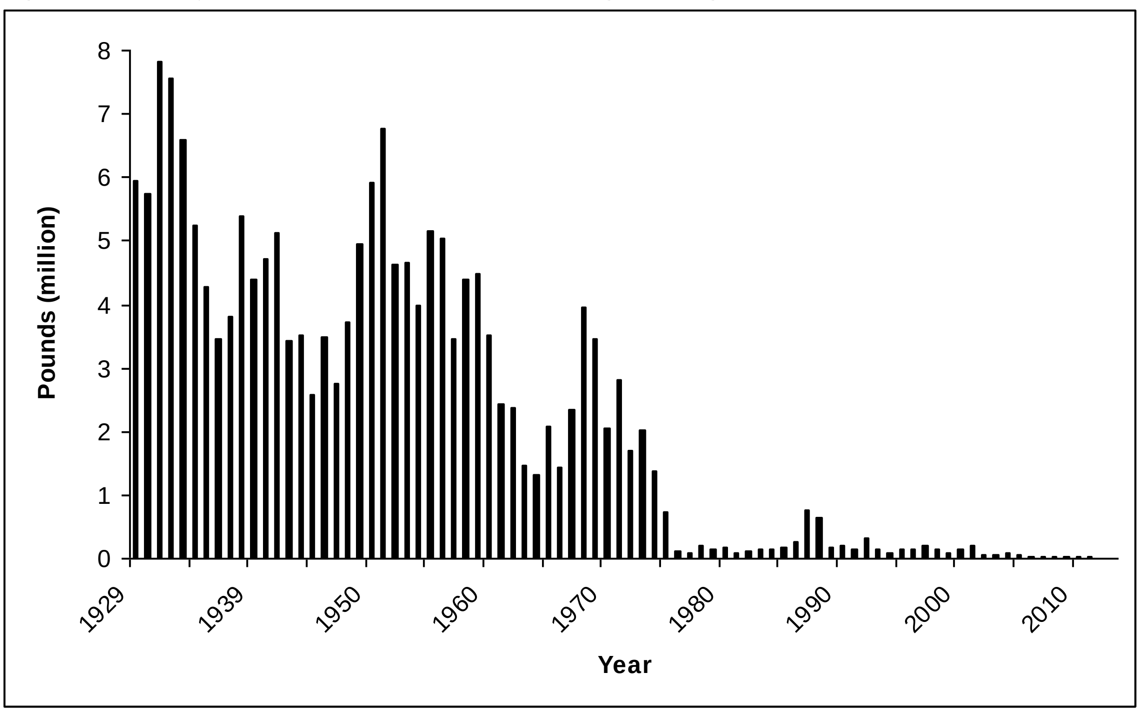


Figure 22. Nanticoke River juvenile alewife and blueback herring geometric mean CPUE (catch per haul), 1959-2013.

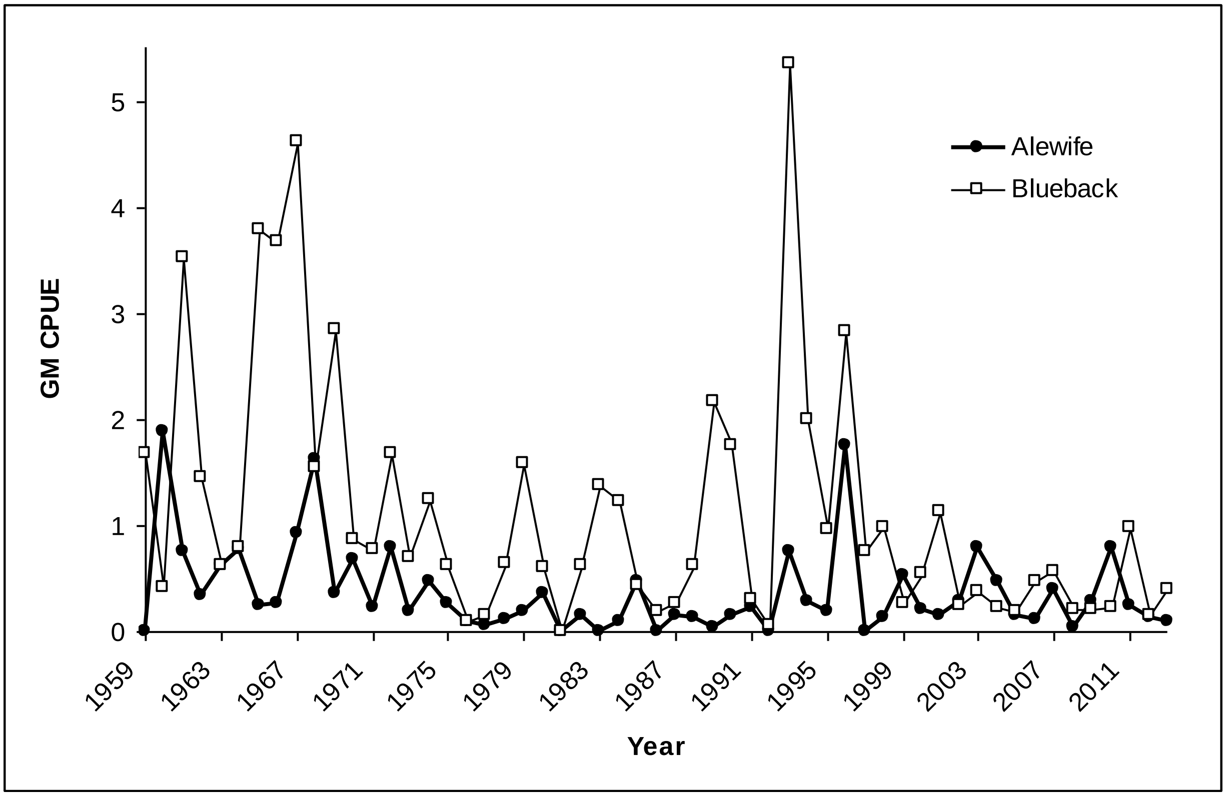
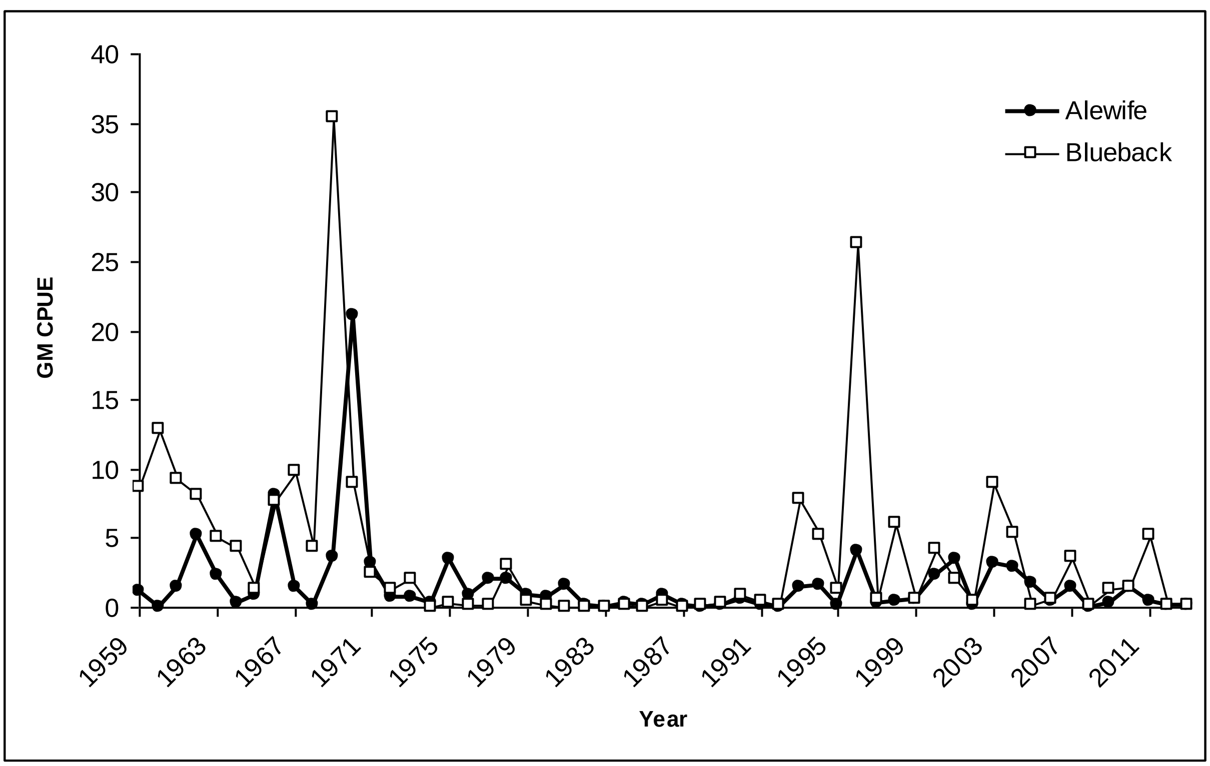


Figure 23. Upper Bay juvenile alewife and blueback herring geometric mean CPUE (catch per haul), 1959-2013.



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. The data collected from this effort 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 voluntary cooperation of pound net fishermen. Pound nets from the lower Chesapeake Bay and Potomac River have been consistently monitored throughout the 21 years of this survey (1993-2013). 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. Five commercial pound nets were sampled at the Potomac River and Chesapeake Bay between Cove Point and Point No Point in 2013 (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 mm total length (TL) except for Spanish mackerel, which were measured to the nearest mm fork length (FL). Fifty randomly selected menhaden were measured to the nearest mm FL each day, when available, and scale samples were taken from 10 to 25 of the measured fish. Menhaden scales were aged by two MD DNR biologists. Water temperature (°C), salinity (ppt), GPS coordinates (NAD 83), date and hours fished were also recorded at each net.

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 2013 were aged by MD DNR biologists. All spot otoliths from 2013 were processed and aged by MD DNR, as in previous years. 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 in 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. 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.

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 harvest 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 6, 2013. Since these data sets are not finalized until the spring of the following year, harvest data for this report are through 2012. Harvest from Maryland's commercial reporting system was divided by area into Chesapeake Bay, Atlantic Ocean (including coastal bays) and unknown areas.

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. Chesapeake Bay geometric mean catch per angler (CPA) indices were derived for eight of the ten target species. No indices were calculated for red drum due to small sample size, or menhaden, since it is not recreationally harvested. Geometric mean catch / angler trip compared to year was analyzed using linear regression to identify significant trends in relative abundance. The statewide MRIP estimates include all anglers (private and for hire) and all areas (Chesapeake Bay, Coastal Bays and Atlantic Ocean). All Maryland charter boat data was from Chesapeake Bay for the target species. The MRIP for hire inland only estimates do not include the Atlantic Ocean and are only for anglers that paid another individual to take them fishing, and may be more comparable to the charter boat log data. Numbers of fish harvested by charter boats for each species was compared to statewide MRIP recreational catch estimates (numbers), MRIP inland only for hire estimates (numbers), and reported Chesapeake Bay commercial landings (pounds), using linear regression, with P values of 0.01 or less were considered significant. Since the 2013 charter log book data had not been finalized, only data through 2012 was utilized for analysis.

Instantaneous total mortality rates 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 over the last decade. 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 = 2,284) determined from 2003-2012 Chesapeake Bay pound net survey data, and June through September 2003-2012 measurements of age zero croaker (n=197) from MD DNR Blue Crab Trawl Survey Tangier Sound samples (Chris Walstrum MD DNR personnel communication 2012). 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 2003-2012 were L_∞ = 413.7 mm TL and K= 0.321, while L_c for Atlantic croaker was 229 mm TL.

Length frequency distributions were constructed for summer flounder, Atlantic croaker, weakfish, bluefish, spot and Atlantic menhaden, utilizing onboard sampling length data divided into 20 mm length groups. Length-at-age keys were constructed for weakfish, Atlantic croaker and Atlantic menhaden using age samples through 2013. Age and length data were assigned to 20mm 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 2013, weakfish from 2003 through 2013 and Atlantic menhaden from 2005 through 2013. Age length keys for spot were constructed for 2007 through 2013. Age and length data were assigned to 10mm 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).

RESULTS and DISCUSSION

The Potomac River and the Cheasapeake Bay were sampled from May 28, 2013 through September 3, 2013 (Table 1). All target species, and twenty six non-target species (Table 2) were encountered during this time period.

Weakfish

Sixty seven weakfish were sampled in the 2013 pound net survey, the seventh lowest catch of the 21 year time series. Weakfish mean length in 2013 was 304 mm TL, an increase from the 2012 mean length of 284 mm TL, just above the time series annual mean length of 296 mm TL (Table 3). The 2013 onboard pound net survey length frequency distribution indicated a shift to larger sizes compared to 2012, with 66% of sampled weakfish in the 270 to 310 mm TL groups (Figure 2).

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 2011, with far fewer large weakfish being encountered. All of the weakfish sampled in the 2011 pound net survey were below the recreational size limit of 331 mm TL (13 inches) and the commercial size limit of 305 mm TL (12 inches). This trend ended in 2012, with 15% and 24% of 93 weakfish above the recreational and commercial size limits, respectively. Larger weakfish remained available in 2013 with 15% and 46% of 67 weakfish above the recreational and commercial size limits, respectively.

In 2013, females accounted for 58% of fish sampled from the pound net survey (n=52). Female mean TL and mean weight were 315 mm TL and 302g, respectively, while males averaged 292 mm TL and 233g. In 2012, females averaged 289 mm TL and 250g and accounted for 74% of fish sampled, while male mean length and weight were 282 mm TL and 212g, respectively.

Total Maryland commercial weakfish harvest (Chesapeake Bay and Atlantic Ocean combined) in 2012 increased six fold to 1,358 pounds, with the Chesapeake Bay portion only accounting for 31 pounds (Figures 3 and 4). The 2012 total harvest was still the second lowest of the 83 year time series and was well below Maryland's average of 612,564 pounds per year. Maryland recreational anglers harvested an estimated 11,401 weakfish (PSE = 94) during 2012, with an estimated weight of 6,192 pounds (PSE = 94; Figure 5). The number of weakfish harvested by the recreational fishery in 2012 was the highest value since 2005, but was still the seventh lowest value of the 1981-2011 time series, and well below the time series mean harvest of 285,918 fish. According to the MRIP estimates, Maryland anglers released 24,898 (PSE = 58) weakfish in 2012, an increase compared to 2011 (18,500, PSE = 47). Estimated recreational harvest decreased steadily from 475,348 fish in 2000 to near zero in 2006, and has fluctuated at a very low level from 2007 through 2012. 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 3 fish to 1 fish per 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 1,915 to 75,154 weakfish from 1993 to 2012 (Figure 6), with a dramatic decline occurring in 2003 and the lowest value in 2012. The reported charter boat harvest had the same trend as the reported commercial harvest ($R^2 = 0.65$, $P < 0.001$), the statewide MRIP estimate ($R^2 = 0.82$, $P < 0.001$) and the inland for hire only MRIP estimate ($R^2 = 0.32$, $P = 0.0096$). Of the 27,734 entries reported, only one was not included in this analysis since the CPA exceeded 200. The 2012 geometric mean of 0.54 weakfish per angler was the lowest value of the time series (Figure 7). The geometric mean CPA has declined significantly from 1993 – 2011 ($R^2 = 0.81$, $P < 0.001$).

The weakfish juvenile GM in 2013 increased compared to 2012, and was the 12th lowest value in the 25 year time series (Figure 8). 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. This lack of recruitment may explain poor commercial and recreational harvest in recent years. 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 52 fish in 2013. 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 4).

Mortality estimates for 2006 through 2012 could not be calculated because of extremely low sample size, while instantaneous total mortality estimates calculated for 2004, 2005 and 2013 were $Z=1.29$, $Z = 1.35$ and $Z = 1.55$, respectively (Table 5), 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 conducted by ASMFC in 2009 utilized various models to determine natural mortality (M), fishing mortality (F) and current biomass (NFSC 2009). This assessment indicated weakfish biomass was extremely low; F was moderate and M was high and increasing (NFSC 2009). 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 coast wide stock decline.

Summer flounder

Summer flounder pound net survey mean lengths have varied widely from 2004-2013. 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 (Table 3). The 2013 mean length was the lowest of the 21 year time series. 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 9). The 2013 length frequency distribution was heavily skewed toward smaller fish, with 25% of sampled fish in the 250 and 270 mm TL length groups and 66% below 290 mm in length. The 250 and 270 mm TL length groups have not been well represented in previous years accounting for 1 – 11% of summer flounder sampled. This shift to smaller fish may indicate a strong year class in 2013. The number of summer flounder sampled in 2013 was the second lowest of the 21 years surveyed (Table 3). Recreational size limits have been adjusted annually, but comparing the onboard pound net survey catches to the 2013 recreational size limit of 407 mm TL indicated a lower proportion of legal fish in Maryland's portion of Chesapeake Bay during 2013 (11%) compared to 2012 (41%) and 2011 (22%).

Maryland's commercial summer flounder harvest totaled 81,287 pounds in 2012, the 3rd lowest in the 51 year time series (Figure 10). The long-term (1962 – 2011) commercial harvest average is 406,446 pounds. In recent years the commercial flounder fishery has been managed by quota, with varying regulations and season closures to ensure the quota was not exceeded. The majority of the Maryland commercial flounder harvest comes from the Atlantic Ocean and coastal bays (Figures 10 and 11). The recreational harvest estimate of 22,617 (PSE = 32) fish caught in 2012 ranked 31st out of the 32 year time series, and increased 47% from the 2012 time series low estimate of 15,347 (PSE = 45) fish (Figure 12). The 2012 MRIP recreational release estimate of

213,558 (PSE = 37) fish ranked 28th in the 1981- 2011 time series (Figure 12). The recreational fishery has been subject to increasingly restrictive regulations in the past several years, which most likely contributed to reduced harvest rates.

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 13). The harvest decreased in 2012 to 5,060 fish, the eighth lowest value in the 20 year time series. Linear regression indicated no significant trend between the charter boat catch and the statewide MRIP estimate, the commercial landings or the for hire inland only MRIP estimate. This is not surprising, since the majority of the commercial harvest occurs in the Atlantic Ocean, and the MRIP inland estimate includes both the coastal bays and the Chesapeake Bay, and the charter logs are all from the Chesapeake Bay. The geometric mean index significantly declined ($R^2 = 0.51$, $P < 0.001$) over the entire time series (Figure 14), but was relatively stable from 2004 to 2009.

A coast wide stock assessment using the Age Structured Assessment Program (ASAP) was conducted in 2008, and updated in 2011 and 2012 (NFSC 2008, Terceiro 2011, Terceiro 2012), with data from 2010 and 2011, respectively. The assessment indicated that summer flounder recruitment along the Atlantic coast declined from a peak in 1983 to the time series low in 1988 (NFSC 2008). The ASAP model estimated recruitment for 2009 at 47 million fish, above the long term mean of 42 million fish, but both the 2010 and 2011 recruitment were estimated to be below average (NFSC 2008, Terceiro 2012). The NMFS coastal assessment found that F varied from F = 1.1 to F = 2.0 from 1982 to 1996, but has remained below 1.0 since 1996. The 2011 update estimated F to be 0.22 in 2010, below the threshold, with an estimated 2010 SSB of 132.8

million pounds, slightly above the target level of 132.4 million pounds, leading to a determination that the rebuilding target had been met (Terceiro 2011). The 2012 stock assessment update estimated F to be 0.24, and SSB to be 125.7 million pounds. Both values are within the adopted threshold reference points, but not within the target reference points (Terceiro 2012). The NMFS assessment concluded that summer flounder stocks were not overfished, and overfishing was not occurring, (NFSC 2008, Terceiro 2012).

Bluefish

Bluefish sampled from the onboard pound net survey averaged 297 mm TL during 2013, which was nearly identical to the 2012 mean of 298 mm TL (Table 3). The 2013 mean length was below the 21 year time series mean of 301 mm. The pound net survey length frequency distribution shifted to larger size bluefish in 2012, lengths were mostly distributed between the 190 to 370 mm TL groups with peaks in the 230 and 350 mm TL groups (Figure 15). The 2013 distribution was similar to 2012 in range of lengths, but was a little more centralized around peaks at the 230 and 350 mm TL length groups.

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 and 2013 length structure was similar to those of 2005 – 2007. 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.

Maryland bluefish commercial harvest more than doubled in 2012 to 166,786 pounds, and was near the 1929-2012 average of 171,352 pounds per year (Figure 16). The 2012 catch ranked 27th in the 83 year time series. Total commercial landings fluctuated without trend from 42,662 to 166,786 pounds from 1993 – 2012 (Figure 16). The majority of Maryland's commercial bluefish harvest from 1972 through 1988 came from the Chesapeake Bay. However, Chesapeake Bay catches declined after 1988 while Atlantic Ocean and coastal bay catches remained somewhat stable through the 1990s. Harvest in both regions has fluctuated since 2000. Recreational harvest estimates for bluefish were high through most of the 1980's, but have fluctuated at a lower level since 1991 (Figure 17). The 2012 estimate of 113,698 (PSE = 36) fish harvested was less than half of the 2011 estimate (259,286 fish, PSE = 26), and was well below the time series average of 829,510 fish. Estimated recreational releases decreased 66% in 2012 to 138,495 fish (PSE = 58) compared to 2011 (408,323 fish PSE = 28), well below the time series mean of 529,315 fish (Figure 17).

Reported bluefish harvest from charter boat logs ranged from 27,667 – 134,828 fish per year from 1993 to 2012. The 2012 harvest of 33,188 fish was similar to 2011 (30,176 fish; Figure 18). Harvest from charter boat logs generally tracked with state wide MRIP estimates, but regression analysis indicated no significant trend with statewide or for hire recreational estimates or commercial landings. Two of the 70,182 entries were not used in indices calculations because of excessively high CPA's (>300). The geometric mean catch per angler varied in a narrow range from 1993 to 2007, increased to the time series high in 2008, but then declined from 2009 to 2012 (Figure 19).

A stock assessment of Atlantic coast bluefish utilized ASAP in 2010, a forward projecting catch at age model (Shepherd and Nieland 2010), which was updated in 2012 (Wood 2013). The assessment indicated that F was steady at a low rate since 2000. Recruitment estimated in the ASAP model has remained relatively constant since 2000 at around 20 million age-0 bluefish, with the exception of a relatively large 2006 cohort estimated as 35.1 million fish. Recruitment during 2010 and 2011 was below average (Shepherd and Nieland 2010, NMFS 2012). The model indicated that overfishing is not occurring and that the stock is not overfished, but projected spawning stock biomass declines over the next few years due to recent poor recruitment.

Atlantic croaker

Atlantic croaker mean length from the onboard pound net survey was 276 mm TL in 2013, was similar to the 2012 value of 274 mm TL, and was the fourth lowest value of the 21 year time series (Table 3). The onboard pound net length frequency distribution for 2013 indicated a decrease in larger croaker, with no croaker in the 390 and 410 mm length groups (Figure 20).

Mean lengths and weights by sex for Atlantic croaker sampled from pound nets in 2013 were 284 mm TL and 324 g for females (n = 146) and 275 mm TL and 280 g for males (n = 103). Pound net samples were 59% female and 41% male. Pound net samples, in which sex determination and weight were taken, were not randomly selected; therefore sex specific data may be biased.

During 2012, the Maryland Atlantic croaker total commercial harvest of 908,619 pounds (Chesapeake Bay and Atlantic Ocean combined) increased for the third consecutive year (Figure 21). The 2012 harvest was still below the 1929-2012 average of 1,041,084 pounds, but was well above the 1950-2012 average of 514,040 pounds. The 2012 recreational harvest estimate was 979,216 fish (PSE = 26) a 57% increase from 2011, the 12th highest value of the time series, and was above the 1981-2012 average of 763,145 fish (Figure 22). The 2012 recreational release estimate of 1,731,079 fish increased over 4 fold compared to 2011 (Figure 22), and was above the 1981-2012 average of 1,256,449 fish.

Reported Atlantic croaker harvest from charter boats ranged from 127,664 – 448,789 fish during the 20 year time period (Figure 23). The charter boat log book harvest trended with the statewide MRIP estimates (R^2 = 0.39, P = 0.0033), but not with the Chesapeake Bay commercial landings or for hire inland only MRIP estimates. The MRIP for hire inland only estimates did, however, follow the same general trend. Twelve of the 51,044 entries were not used to calculate the GM because of CPA values exceeding 200 fish. The geometric mean catch per angler increased (R^2 = 0.44, P = 0.0013) from 1993 to 2012, with relatively stable values prior to 2004 and generally increasing values since 2004 (Figure 24). Following three years of steadily increasing values, the 2011 GM decreased compared to 2010. The 2012 GM of 4.73 increased slightly from 2011, and both 2011 and 2012 values were still above the long term mean.

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 (Figure 25). The 2013 GM decreased to 2.2 fish per tow, but was still equal to the 25 year time series mean of 2.2 fish per tow, and was the 12th highest value of the time series. 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 2013 ranged from 0 to 10 (n=247; Table 6). The number of Atlantic croaker sampled for length in 2013 (n=2,320) was applied to an age-length key for 2013 (Table 6). This application indicated that 28% of the fish were age five, 25% were age three, 22% were age four, 14% were age one, 5% were age seven, and no age zero or nine fish were present. The remaining age groups each accounted for four percent or less of the fish sampled (Table 6). Atlantic croaker greater than six years old have become less abundant in recent years compared to the mid 2000s. The contribution of strong year classes (1998, 2002, 2006, 2008 and 2012) to the catch can also been seen in Table 6. Instantaneous total mortality in 2013 was Z = 0.85 (Table 5). Total mortality estimates have been fairly stable the past three years after increasing steadily from 2006, the time series low, through 2011.

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).

<u>Spot</u>

Spot mean length from the onboard sampling increased in 2013 to 196 mm TL (n=1,302), and was slightly below the mean value of 204 mm TL for the 21 year time series (Table 3). The onboard sampling length frequency distribution in 2013 shifted back toward larger length fish, but remained truncated compared to the distributions of the early to mid 2000s (Figure 26). The 170 and 190 mm TL groups accounted for 60 % of sampled spot. No jumbo spot (>254 mm TL) were present in the 2013 onboard sampling. Abundance of jumbo spot in the survey has been low for the past several years (0-3% of sample, 2005-2012). This followed good catches in the early part of the decade (10% in 2003, 13% in 2004).

Commercial harvest in 2011 decreased sharply to 100,406 pounds (Figure 27), the 5th highest catch of the 82 year time series. Commercial harvest peaked in the 1950's with catches nearing 600,000 pounds. Harvest then fell sharply and remained low, except for a few spikes, rebounding to moderate levels from the mid 1980s through the late 2000s, and returning to near time series high values in 2009-2011. Chesapeake Bay commercial harvest had been fairly steady from 2003-2005 ranging from 66,865 to 74,722 pounds before declining to 23,500 pounds in 2006. An unusually sharp increase in 2007 and 2009 through 2011 can be attributed to a large increase in gill net harvest, which accounted for 95% of the 2007 spot harvest (380,648 pounds), 90% of the 2009 harvest (467,595 pounds), 87% of the 2010 harvest (507,091 pounds) and 61% in 2011 (388,533 pounds), compared to 43% of the 2006 harvest (16,420 pounds). The reported spot harvest, excluding gill net landings, for 2007 (19,703 pounds) was similar to the 2006 non-gill net harvest of 21,354 pounds. In 2008 gill nets accounted for 48% of commercial harvest, with an increasing catch in non-gill net fisheries (62,934 pounds). The 2009 non-gill net harvest was similar to 2008 (52,556 pounds), but the 2011 non-gill net harvest increased and was primarily from fish pots (134,058 pounds, 24% of total harvest). This would seem to indicate the recent spike in gill net landings was due to increased effort directed at spot, likely triggered by market demand and/or the decreased availability of other more desirable species. The 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 2012 gill nets and fish pots accounted for 60,023 pounds (60% of harvest) and 21,954 pounds (22% of harvest), respectively.

Maryland recreational harvest estimates from the MRIP indicated that spot catches since 1981 have been variable (Figure 28). Recreational harvest ranged from 377,964 fish in 1988 to 3,789,769 fish in 1986, while the number released fluctuated from 208,897 in 1996 to 2,720,343 in 1986 (Figure 28). The 2012 recreational harvest estimate (776,145 fish; PSE = 28) decreased 22% compared to 2011, remaining well below the time series mean estimate of 1,620,289 fish, and marked the 6th lowest value of the 32 year time series. The release estimate of 919,816 fish (PSE = 24) increased compared to 2010, and was the just below the time series mean of 1,048,770 fish (Figure 28).

Reported spot charter boat logbook harvest from 1993 to 2010 ranged from 160,881 to 848,492 fish per year (Figure 29). The 2012 reported harvest was the lowest of the 20 year time series. The charter boat log book harvest did not significantly trend with the MRIP for hire inland only estimates, the Chesapeake Bay commercial landings or statewide MRIP estimates. This is not surprising, since charter boat captains sometimes have clients catch spot to use as bait for larger predatory species. MRIP surveys may not accurately account for spot used as bait, while the commercial harvest tends to be more incidental some years and directed in others. Twenty-four of the 44,056 charter log book entries were not utilized because of greatly inflated CPA values (>300). The geometric mean CPA was highest in 1995, stable at a relatively low level from 1999 – 2002, generally increased from 2002 – 2007, and remained above average in 2008 and 2010 (Figure 30). The CPA alternated between very low values in 2010 and 2012 and a very high value in 2011.

Spot juvenile trawl index values from 1989-2013 were quite variable (Figure 31). The 2010 GM value of 104.5 spot per tow was the highest value of the time series, declined to the second lowest value of the 25 year time series in 2011, and increased to nearly the time series mean in 2012 (Figure 31). The 2013 index value declined to 6.11 fish per tow.

In 2013 96% of sampled fish were age one and the remaining 4% were age zero, with no fish over age one sampled (n = 167; Table 7). In 2012 age one spot accounted for 60% of the sample with 39% being age zero and the remaining 1% being age two.

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.

In a relatively short-lived species such as spot, population dynamics 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 2013 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. Virginia and North Carolina voiced concern over decreasing spot harvests in their waters, and ASMFC's spot Plan Review Team continues to monitor catch and biological information to determine if additional management action is necessary. Given the popularity of spot as a recreational finfish, other indicators of stock status should be developed to ensure production is exceeding harvest and losses due to natural mortality. No stock assessment has been completed for spot; primarily do to lack of necessary data.

Red Drum

Red drum have been encountered sporadically through the 21 years of the onboard pound net survey, with none being measured in 8 years and 458 being measured in 2012 (Table 3). Sixteen red drum were measured in 2013 with a mean length of 469 mm TL, indicating the fish were primarily immature sub-adults. Eleven of the sampled red drum were within the recreational and commercial size limit slots of 18 - 27 and 18-25 inches respectively, and the remaining five were below the 18 inch minimum size limit. Pound net sampling indicated fewer red drum were available to anglers in 2013 compared to 2012, but many of the available fish were of legal size in 2013, compared to none of the fish sampled in 2012.

Maryland commercial fishermen reported harvesting 334 pounds of red drum in 2012, the first year harvest exceed 90 pounds since 2003 (Figure 32). Average harvest from 2004 to 2011 was 27 pounds per year, compared to 700 pounds per year from 1998 to 2003. However, lower harvest since 2003 may not reflect an actual decline in abundance, since more liberal regulations were in effect during previous years. Prior to the regulation change to an 18 – 25 inch slot limit with a 5 fish bag limit in 2003, Maryland commercial fishermen were allowed to harvest one fish over 27 inches per day. Most of these fish were much larger than 27 inches which consequently led to higher harvest values by weight.

The MRIP estimated that recreational fishermen harvested and released 17,869 (PSE = 101) and 280,171 (PSE = 48) red drum respectively in 2012, both values were time series highs (Figures 33 and 34). Recreational harvest estimates have been extremely variable with zero harvest estimates for 23 of the 32 years, and very high PSE values. 2012 recreational harvest and 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.

Maryland charter boat captains reported harvesting red drum in every year from 1993 - 2010, except for 1996. Catches were low for all years, ranging from zero to a high of 271 fish in 2012, with a mean of 33 red drum per year (Figure 35). The low reported catch indicated red drum were available in Maryland's portion of Chesapeake Bay, but the low numbers confirm the species limited availability to recreational anglers, as also indicated by the annual MRIP estimates. No annual indices were generated because of low sample sizes. 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).

<u>Black Drum</u>

Black drum are only occasionally encountered during the MD DNR onboard pound net sampling, with only four being sampled in 2013 (Table 3). Lengths throughout the time series have ranged from 244 to 1,330 mm TL. The mean length in 2013 was 882 mm TL. Commercial harvest of black drum was banned for Maryland's portion of Chesapeake Bay in 1999, but some fish are still harvested along the Atlantic coast (Figure 36). Recreational harvest and release estimates from 1981 to 2012 have been variable, ranging from zero to over 13,000 fish in 1983 (Figure 37). In 2012, MRIP estimated no black drum were harvested and 19,351 (PSE = 94) were released by recreational anglers. 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.

Examination of the charter boat logs revealed black drum were harvested in all years of the 1993-2011 time series, with a mean catch of 392 fish per year (range = 101 –

905; Figure 38). Charter harvest had no significant trend to either the state wide or inland for hire only MRIP estimates. The geometric mean significantly declined ($R^2 = 0.68$, $P < 0.001$) throughout the time series, but most of the decline occurred from 1993 through 2002, with values varying in a narrower range in the past 10 years (Figure 39).

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. Four hundred eleven Spanish mackerel were encountered in 2013, with 331 FL measurements and 124 TL measurements, some individuals were measured for both FL and TL. Mean lengths were 428 mm FL and 508 mm TL (Table 3). The number of mackerel measured has been low for most years with the largest samples occurring from 2005-2007 and in 2013 (Table 3).

The 2012 commercial harvest of Spanish mackerel in Maryland was 3,664 pounds, a 28% decrease from 2011 (5,054 pounds; Figure 40), and below the 1965 to 2012 mean of 6,303 pounds per year. Commercial harvest was very low from 1965 – 1986 with no catches greater than 3,600 pounds including six years of zero harvest. Commercial harvest has been somewhat more stable since 1987 with a peak of 62,688 pounds in 1991. Since 1996, the majority of Spanish mackerel harvest has come from Chesapeake Bay, but during the 1987 – 1995 time period Atlantic Ocean catches dominated. Recreational harvest estimates peaked in the early to mid 1990's with three years of approximately 40,000 fish harvested (Figure 41). This followed a period of seven out of ten annual estimates with zero fish captured. Harvest estimates for 1998 – 2012 were variable, ranging from 0 – 20,049 fish with an average of 8,305 fish taken. In 2012, an estimated 2,962 (PSE = 58) Spanish mackerel were harvested, less then a third of the 2011 estimate of 10,554 fish (PSE = 53, Figure 41). Due to the high PSE values, these estimates are considered tenuous.

Spanish mackerel charter boat harvest from 1993 to 2012 ranged from 563 – 10,653 fish per year (Figure 42). The charter boat log book harvest did trend significantly with the MRIP for hire inland only estimates ($R^2 = 0.58$, $P < 0.01$) and the statewide MRIP estimates ($R^2 = 0.51$, $P < 0.01$), but not the Chesapeake Bay commercial landings. The geometric mean CPA was variable with a declining trend ($R^2 = 0.36$, $P = 0.0053$; Figure 43). It would appear that Spanish mackerel are providing a small but somewhat consistent opportunity for recreational anglers in Chesapeake Bay.

<u>Spotted Seatrout</u>

Spotted seatrout are rarely encountered during sampling, with annual observations ranging from zero (11 years) to 23 fish. Five were measured from the onboard sampling in 2013 with a mean of 456 mm TL (Table 3). Commercial harvest of spotted seatrout in Maryland averaged 44,921 pounds from 1944-1954, zero pounds from 1955 – 1990 and 6,288 pounds from 1991-2012 (Figure 44). Reported 2012 harvest was 1,903 pounds, well below the 1991- 2011 mean. Recreational harvest estimates indicated a modest fishery during the mid 1980’s and mid 1990’s. However, catches became very low to nonexistent from the late 1990’s to 2005, with a slight upswing in 2006 before returning to zero in 2007 and 2008. Catches increased in 2009 to 11,680 fish, the highest value since 1998 (Figure 45). The 2010 and 2011 estimates were around 3,100 fish, and 2012 estimates increased to 6,032 (PSE = 78), but the high PSE values from 2009 to 2012 indicate the MRIP survey does not provide reliable estimates for this species in Maryland.

Spotted seatrout harvest from 2012 charter boats was 2,874 fish. Reported harvest ranged from 224 – 20,030 fish per year and averaged 4,187 fish per year for the 15 year time series (Figure 46). No harvest was reported from 1993 to 1996, but it is not clear if spotted seatrout were not reported at that time or none were captured. The charter boat log book harvest did not trend significantly with the MRIP for hire inland only estimates, the statewide MRIP estimates or the Chesapeake Bay commercial landings. The geometric mean CPA varied without significant trend, but did increase in 2012 after declining for the previous three years (Figure 47). 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 the MRIP.

Atlantic Menhaden

Mean length for Atlantic menhaden sampled from commercial pound nets in 2013 was 251 mm FL, near the mean of 246 mm FL for the 2004 to 2013 time series (Table 3). Menhaden length frequencies from onboard sampling for 2006 and 2007 were very similar and robust compared to 2005. However, the 2008 length frequency distribution was more concentrated around the mean, with a lower proportion of smaller and larger fish than the previous two years. In 2009 the distribution expanded, but was still dominated by larger fish (Figure 48). The 2010 and 2011 length distribution indicated a shift to smaller fish, and a more even distribution of lengths. The 2012 distribution returned to a more truncated distribution similar to 2008, with 40% of sampled fish in the 230 mm FL size group. The 2013 distribution broadened slightly peaking in the 250 mm FL size group.

Atlantic menhaden scale samples were taken from 340 fish in 2013, but ages could only be assigned to 315 fish (Table 8). 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 8). 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. All ages from one through seven were present in 2013.

Atlantic menhaden commercial harvest in Maryland increased from 7,000 pounds in 1935 to over 8 million pounds in 1965 (Figure 49). Commercial harvest remained above 3 million pounds until 1990 when harvest dropped to 1.7 million pounds, slowly increased, and spiked in 2005 to 12.6 million pounds. Average commercial harvest from 1935-2011 was 4.2 million pounds. The 2012 commercial harvest increased to the time series high of 13.7 million pounds, with 98% of harvest from the Chesapeake Bay (Figure 49).

An update of the ASMFC Atlantic menhaden stock assessment was conducted in 2012 using data through 2011 (ASMFC 2012a). The assessment indicated that recruitment was generally low and population fecundity declined since the late 1990s.

Fishing mortality increased in 2010 and 2011 and the population is currently experiencing overfishing when compared to the population benchmarks. Amendment 2 of the ASMFC Fisheries Management Plan for Atlantic menhaden (ASMFC 2012b) was adopted and requires a 20% reduction in harvest from a 2009 to 2011 reference period, to end overfishing and increase the abundance of this important prey species.

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Table 1. Areas sampled number of sampling trips, mean water temperature and mean salinity by month for 2013.

Area	Month	Number of Samples	Mean Water Temp. C	Mean Salinity (ppt)
Point Lookout	May	1	20.5	13.2
Central Bay	May	1	24.5	12.3
East Bay	May	1	24.3	9.2
Point Lookout	June	2	22.7	10.2
Central Bay	June	2	24.2	9.8
East Bay	June	1	23.6	8.1
Point Lookout	July	2	28.0	14.2
Central Bay	July	2	27.6	12.6
West Bay	July	3	27.3	12.4
Point Lookout	August	2	27.0	16.2
Central Bay	August	1	27.1	15.3
East Bay	August	1	27.1	15.1
West Bay	August	2	27.6	15.7
Point Lookout	September	1	25.0	16.7
Central Bay	September	1	27.1	15.1
East Bay	September	1	27.2	15.1
West Bay	September	2	27.0	15.3

Table 2. List of non-target species observed during the 2013 onboard pound net survey.

Common Name	*Scientific Name*
American shad	*Alosa sapidissima*
Atlantic cutlassfish	*Trichiurus lepturus*
Atlantic herring	*Clupea harengus*
Atlantic needlefish	*Strongylura marina*
Atlantic thread herring	*Opisthonema oglinum*
Bull shark	*Carcharhinus leucas*
Butterfish	*Peprilus triacanthus*
Channel catfish	Ictalurus punctatus
Cobia	*Rachycentron canadum*
Common Carp	*Cyprinus carpio*
Cownose ray	*Rhinoptera bonasus*
Crevalle jack	*Caranx hippos*
Florida pompano	*Trachinotus carolinus*
Gizzard shad	*Dorosoma cepedianum*
Harvestfish	*Peprilus alepidotus*
Hogchoker	*Trinectes maculates*
Northern kingfish	*Menticirrhus saxatilis*
Northern puffer	*Sphoeroides maculatus*
Northern searobin	*Prionotus carolinus*
Oyster toadfish	*Opsanus tau*
Silver perch	*Bairdiella chrysoura*
Southern stingray	*Dasyatis americana*
Striped bass	*Morone saxatilis*
Striped mullet	*Mugil cephalus*
White perch	*Morone americana*
Windowpane flounder	*Scophthalmus aquosus*

Table 3. Mean length (mm TL, unless otherwise noted), standard deviation, and sample size of summer migrant fishes from Chesapeake Bay onboard pound net sampling, 1993 - 2013.

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Weakfish																					
mean length	276	291	306	293	297	337	334	361	334	325	324	273	278	290	275	276	262	253	236	284	304
std. dev.	46	50	54	54	39	37	53	83	66	65	68	32	39	30	42	52	22	24	24	48	33
n	435	642	565	1,431	755	1,234	851	333	76	196	129	326	304	62	61	42	23	47	26	93	67
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
std. dev.	58	104	62	65	91	53	63	46	50	93	56	101	76	92	66	72	64	84	67	130	89
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
Bluefish																					
mean length	312	316	323	307	330	343	306	303	307	293	320	251	325	311	318	260	265	297	245	298	297
std. dev.	75	55	54	50	74	79	65	40	41	45	58	60	92	71	70	41	43	60	48	77	59
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
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
std. dev.	35	34	42	31	39	40	54	45	37	73	55	43	48	66	54	62	50	34	31	42	36
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
Spot																					
mean length	184	207	206	235	190	230	213	230	239	184	216	208	197	191	208	198	185	201	193	179	196
std. dev.	28	21	28	28	35	16	25	21	33	36	30	36	37	29	23	21	21	22	18	24	20
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
Spotted Seatrout																					
mean length		448	452			541	460								414	464	262		361	436	456
std. dev.		86	42				134								43	72	22		142	112	29
n	0	4	6	0	0	1	2	0	0	0	0	0	0	0	3	10	23	0	4	8	5
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
std. dev.		175	454	20		182				190	20	212		228	95	238	84	345	188		236
n	0	2	3	2	0	12	0	0	0	7	4	44	1	8	9	5	13	3	3	1	4

Table 3. Continued.

	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Red Drum																					
mean length						302	332	648		316	506	647	353	366	658	361			678	318	469
std. dev.							71			44		468		21	40	57			18	71	39
n	0	0	0	0	0	1	16	1	0	177	1	2	1	16	2	21	0	0	2	458	16
Spanish Mackerel (Total Length)																					
mean length	261	391	487	481	520	418	468	455													508
std. dev.	114	55	38	55		45	82	66													37
n	3	78	39	27	1	4	45	35													124
Spanish Mackerel (Fork Length)																					
mean length			418	401	437	379		386	406	422	405	391	422	439	436	407	418			393	428
std. dev.			34	62				34	34	81	63	95	33	35	51	59	53			74	36
n			44	27	1	1		49	19	20	11	8	373	445	158	18	7	0	0	107	331
Menhaden (Fork Length)																					
mean length												262	282	238	243	246	245	232	213	243	251
std. dev.												28	36	42	41	29	40	36	39	25	31
n												213	1,052	826	854	826	366	836	773	755	762

Table 4. 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 2003-2013.

Year	Age 1	Age 2	Age 3	Age 4	# of Ages	# of Lengths
2003	8.81	72.57	15.69	2.94	48	129
2004	55.90	39.20	4.90		59	326
2005	39.80	55.20	4.80	0.30	109	304
2006	70.10	22.20	7.60	0.10	62	62
2007	67.80	24.20	7.90	0.10	61	61
2008	85.71	7.14	7.14		41	42
2009	77.27	22.73			22	22
2010	100.00				45	47
2011	80.77	15.38			26	27
2012	54.18	42.34	3.47		71	93
2013	34.71	51.93	13.36		52	67

Table 5. Weakfish and Atlantic croaker instantaneous total mortality rate estimates (Z) from Chesapeake Bay pound net data, 1999 – 2013.

	Species	
Year	Weakfish	Atlantic Croaker
1999	0.74	0.45
2000	0.4	0.46
2001	0.62	0.36
2002	0.58	0.36
2003	0.73	0.52
2004	1.29	0.42
2005	1.44	0.35
2006	*	0.30
2007	*	0.37
2008	*	0.37
2009	*	0.52
2010	*	0.67
2011	*	0.81
2012	*	0.80
2013	1.55	0.85

* Insufficient data to calculate 2006 - 2012 weakfish estimates.

Table 6. 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, 1999-2013.

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	0.0	34.0	22.5	3.3	9.4	4.2	16.0	6.0	4.2	0.4					180	1,399
2000	0.0	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	0.0	3.0	0.5	0.6				66	771
2003	0.0	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	0.0	0.6	54.9	5.0	5.4	6.9	23.3	3.1	0.0	0.2	0.0	0.6			161	1,653
2005	0.0	10.1	4.8	51.5	7.6	1.5	7.3	11.4	5.6	0.0	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	0.0	0.0	0.0	0.1	253	1,295
2007	0.0	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	0.0	30.9	8.5	37.4	11.1	7.8	1.8	2.2	0.3						222	1,381
2010	0.0	1.2	25.7	8.7	36.5	15.8	9.4	0.9	1.3	0.3	0.0	0.3			267	2,516
2011	0.0	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	0.0	13.5	2.3	24.7	22.2	27.9	4.1	4.9	0.1	0.0	0.2				247	2,320

Table 7. 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, 2007-2013.

Year	Age 0	Age 1	Age 2	Age 3	Age 4	Ages	Lengths
2007	21.3	75.0	3.3	0.0	0.4	98	519
2008	20.8	78.6	0.6	0.0	0.0	206	1,201
2009	7.7	90.7	1.6	0.0	0.0	232	614
2010	5.9	90.1	4.0	0.0	0.0	91	300
2011	0.4	99.4	0.2	0.0	0.0	173	582
2012	39.5	59.8	0.7	0.0	0.0	230	1,408
2013	3.6	96.4	0.0	0.0	0.0	167	1,285

Table 13. Atlantic menhaden proportion at age in percentage, using pound net length and age data, number of age samples and number of length samples by year, 2005-2013.

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

Figure 1. Summer pound net sampling area map for 2013.

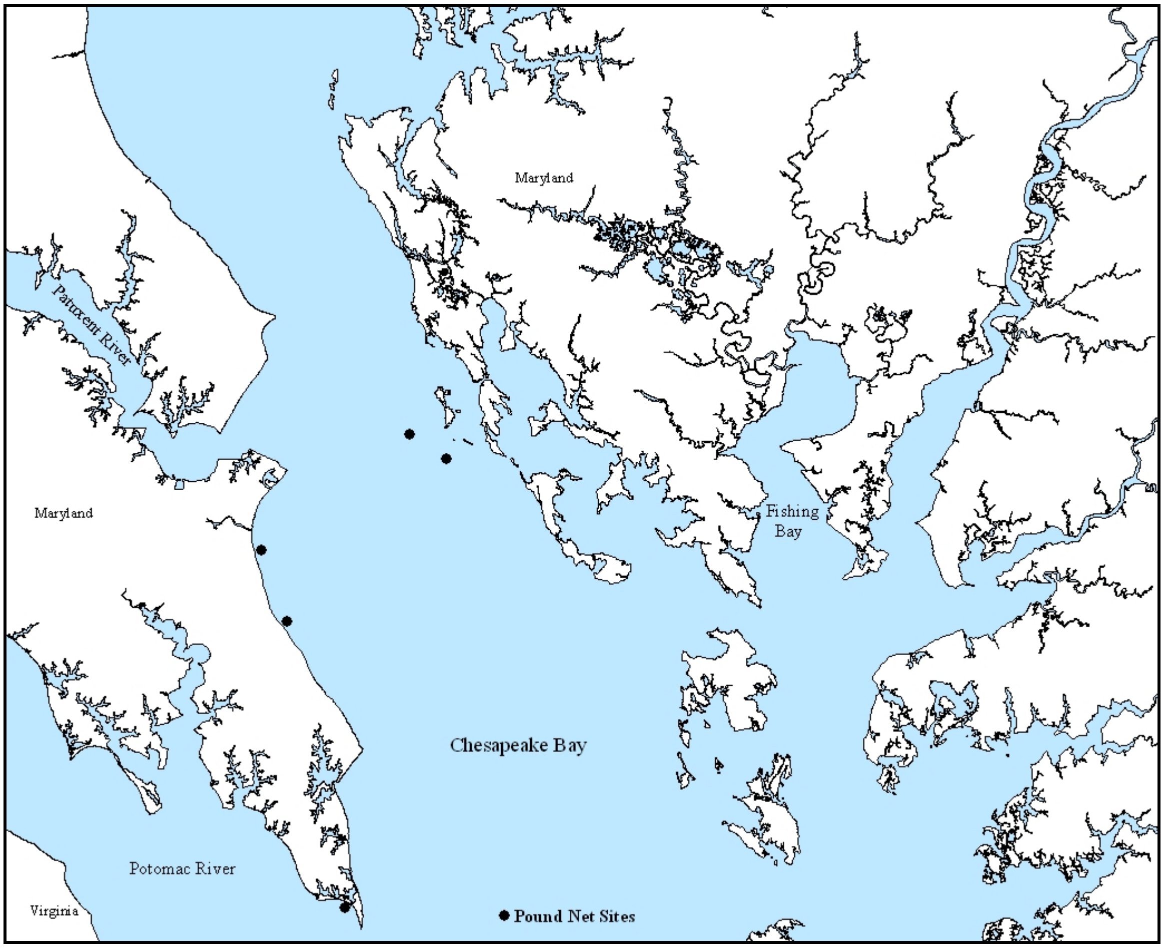


Figure 2. Weakfish length frequency distributions from onboard pound net sampling, 2004-2013. Note: 2011 210 mm length group was truncated to preserve scale, actual value is 50%.

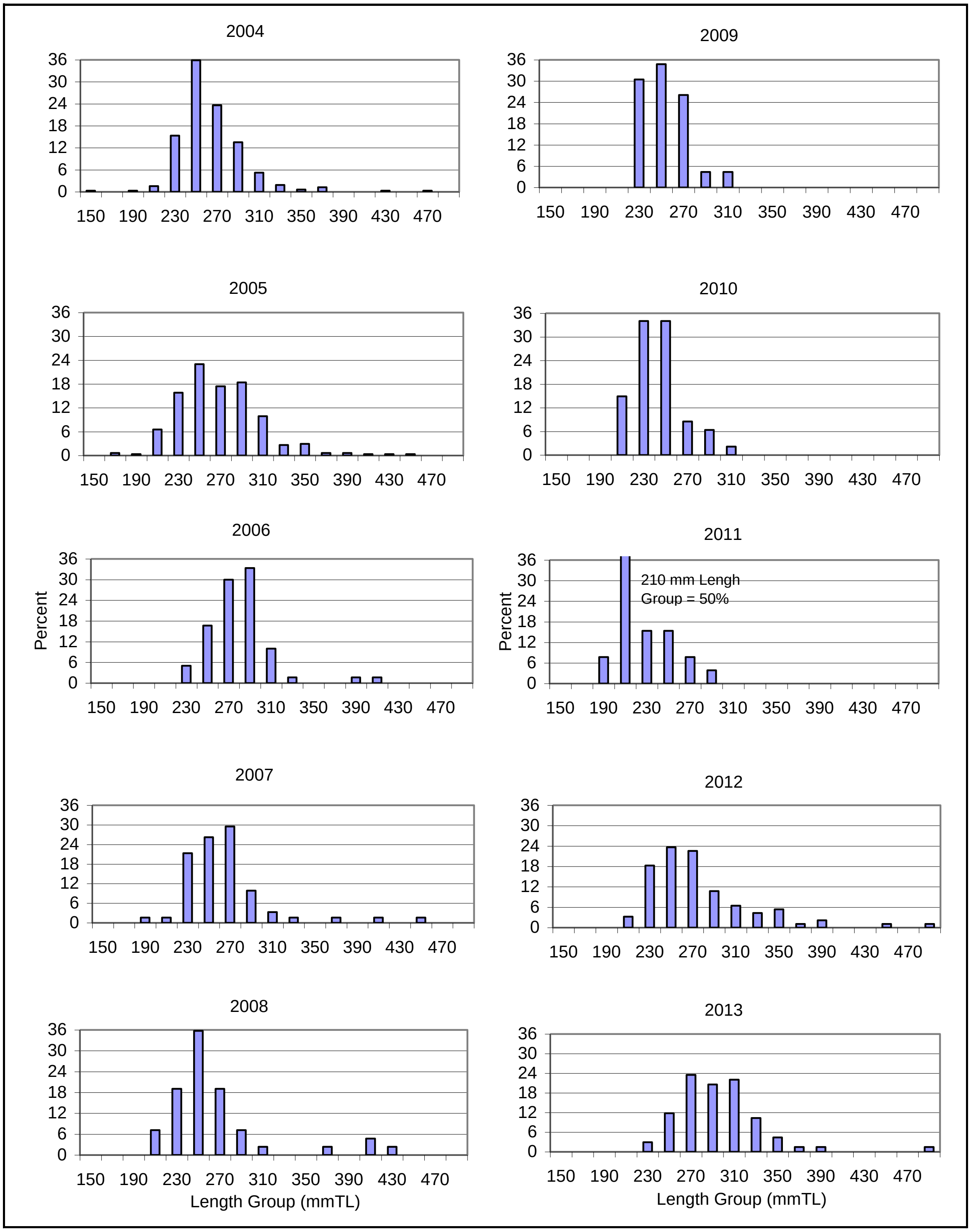


Figure 3. Maryland commercial weakfish harvest by area, 1929-2012.

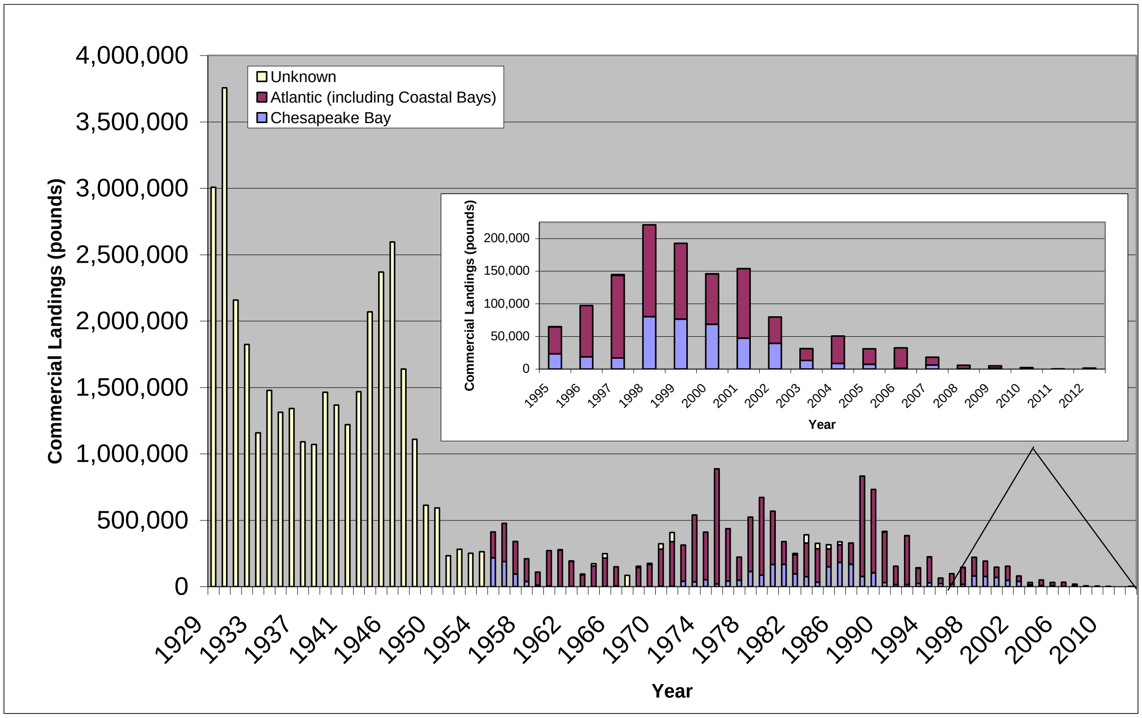


Figure 4. Maryland commercial weakfish harvest in the Chesapeake Bay, 1955-2012.

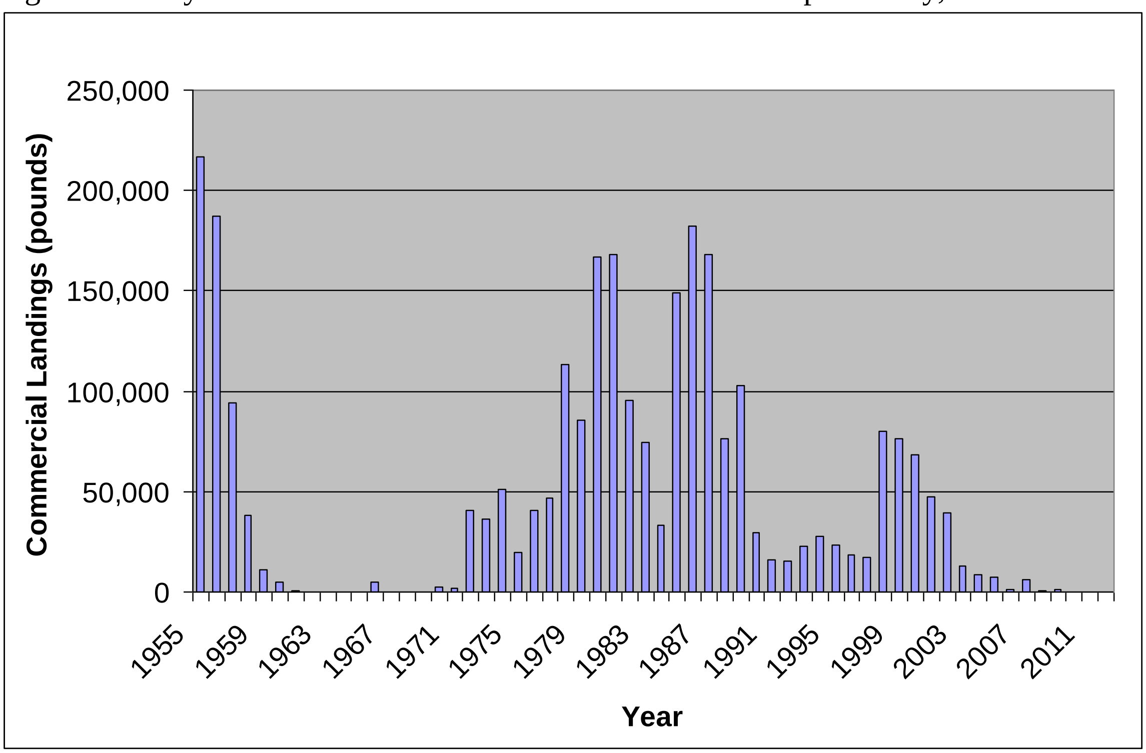


Figure 5. Estimated Maryland recreational weakfish harvest and releases for 1981-2012 (Source: MRIP, 2014).

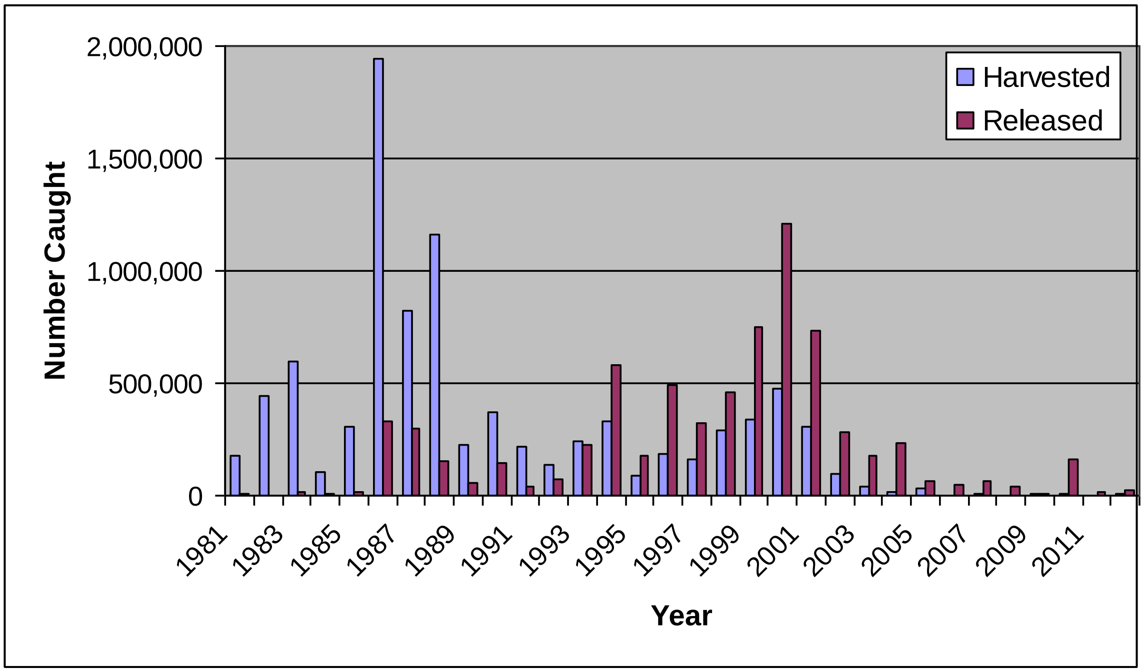


Figure 6. Weakfish statewide MRIP harvest in numbers, Maryland reported charter boat harvest in numbers and Maryland commercial harvest in pounds, 1993-2012.

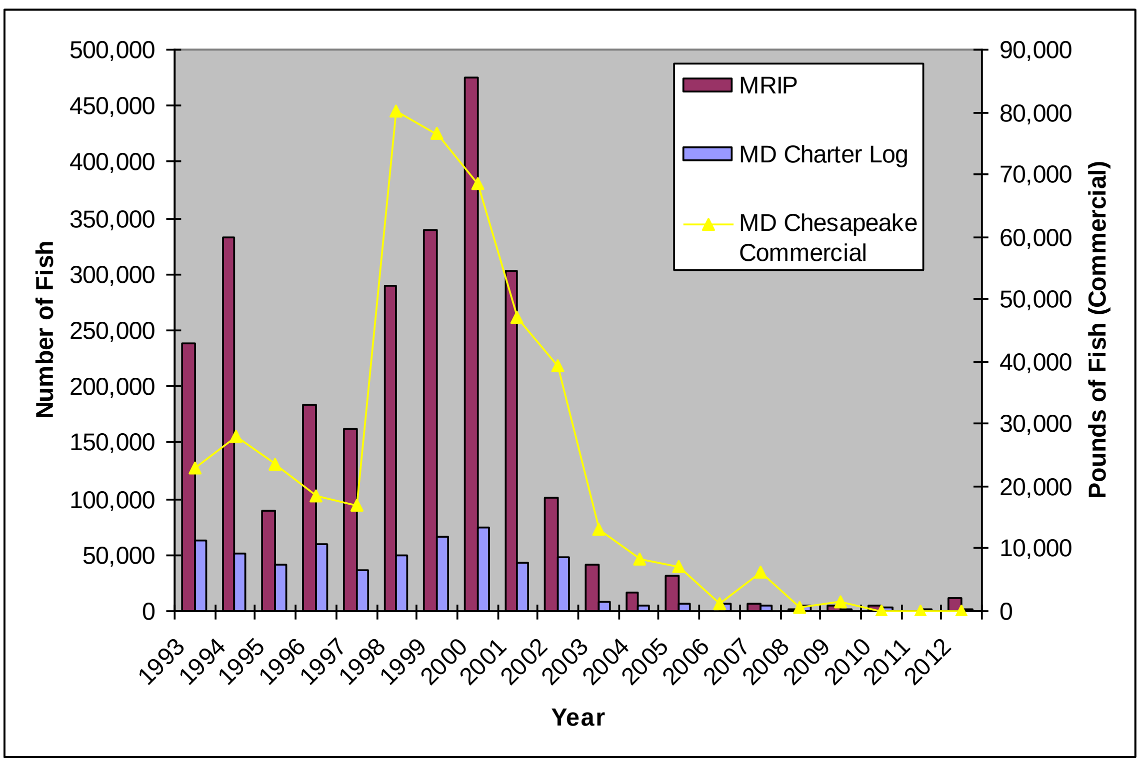


Figure 7. Weakfish geometric mean catch per angler from Maryland charter boat logs, with 95% confidence intervals, 1993-2012.

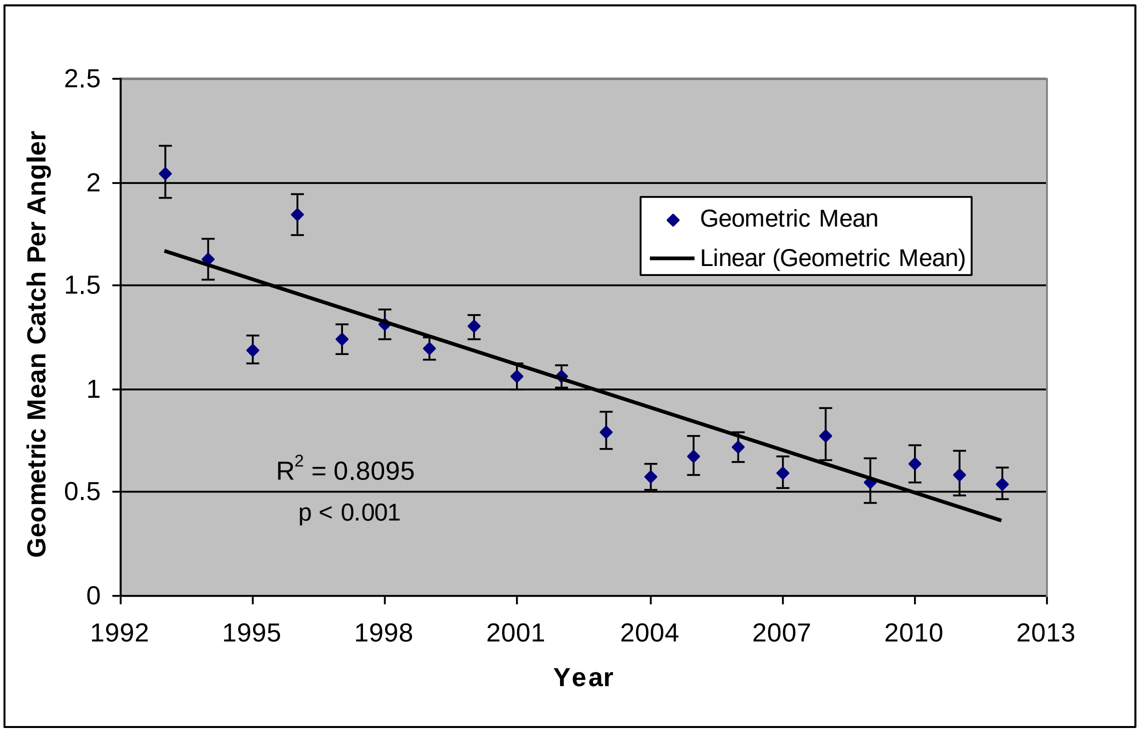


Figure 8. Maryland juvenile weakfish geometric mean catch per trawl and 95% confidence intervals for Maryland's lower Chesapeake Bay, 1989 – 2013.

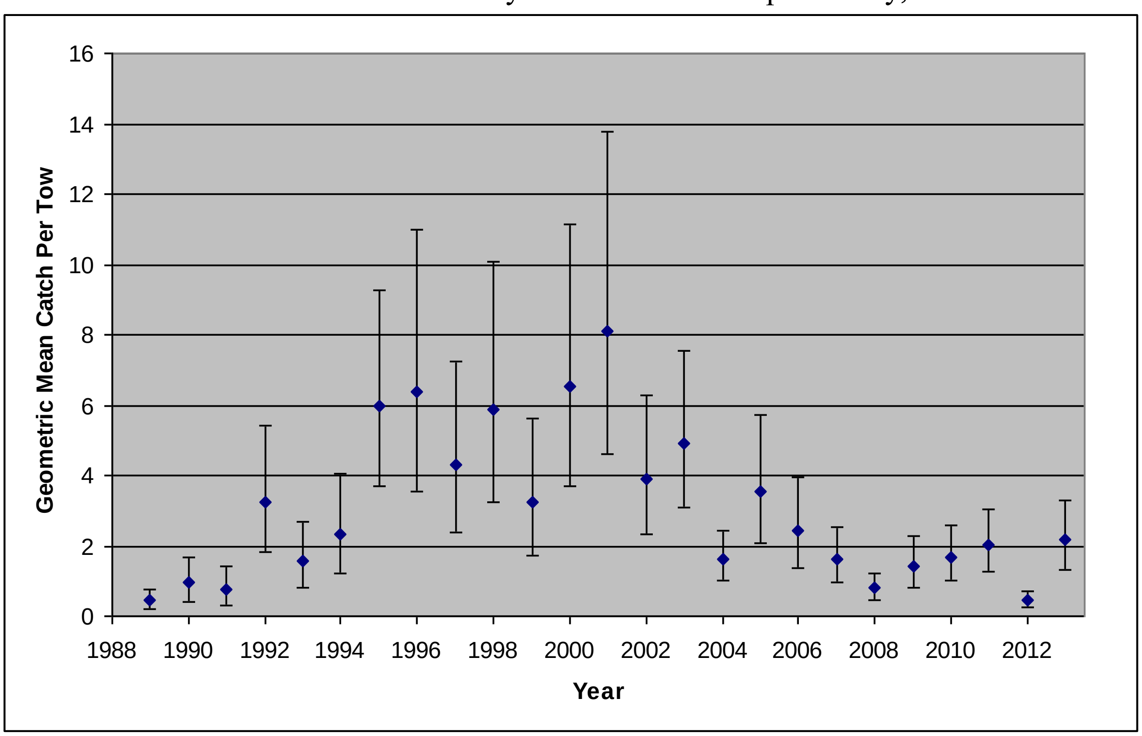


Figure 9. Summer flounder length frequency distributions from onboard pound net sampling, 2004-2013.

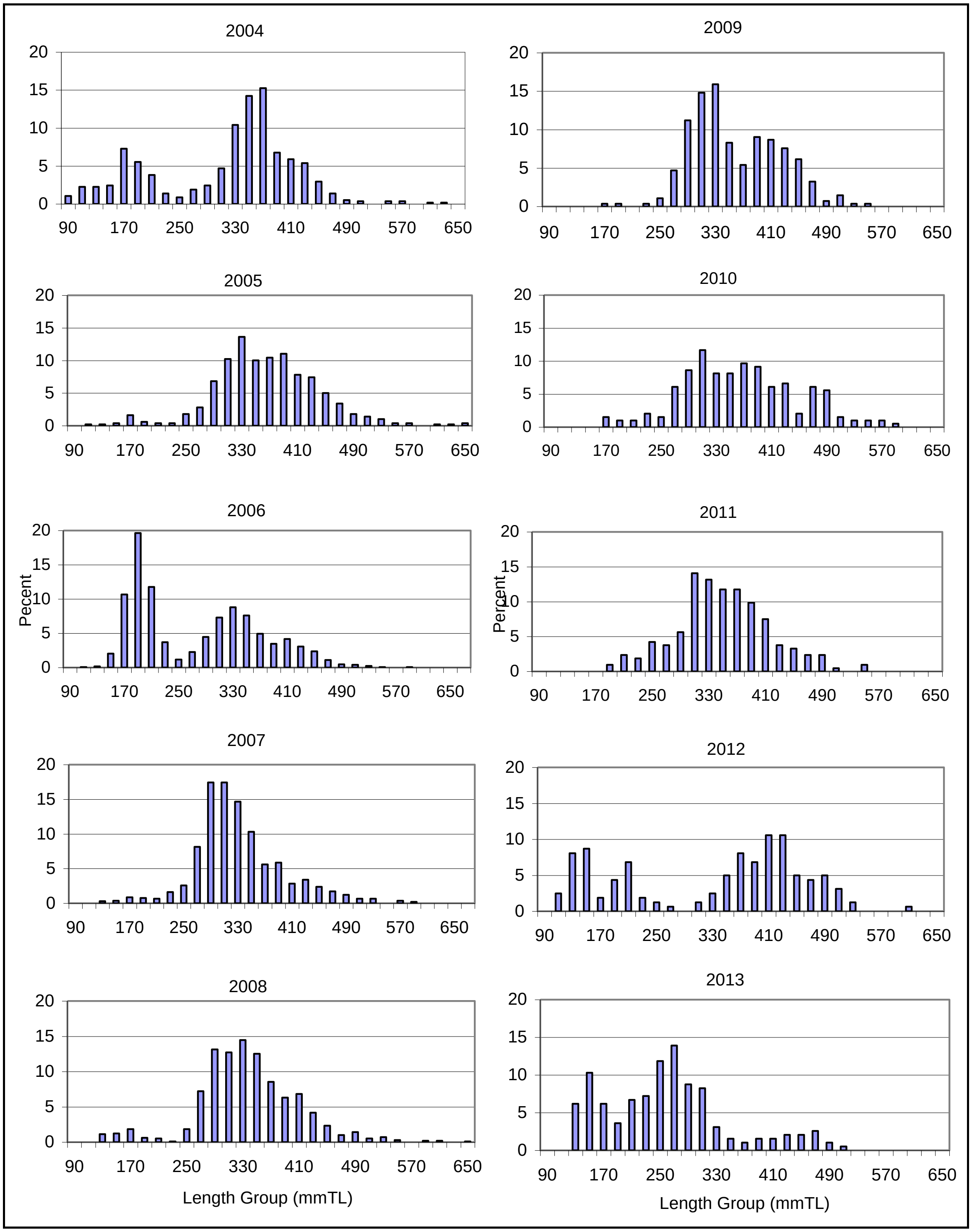


Figure 10. Maryland commercial summer flounder harvest by area, 1962-2012.

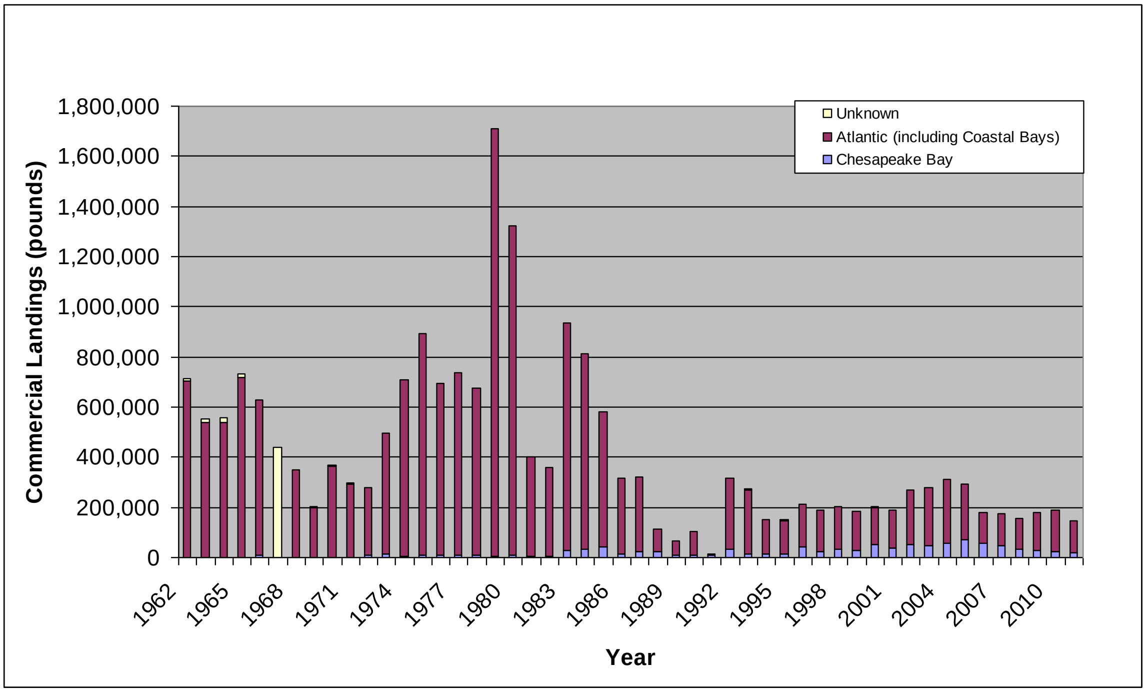


Figure 11. Maryland commercial summer flounder harvest in the Chesapeake Bay, 1962-2013.

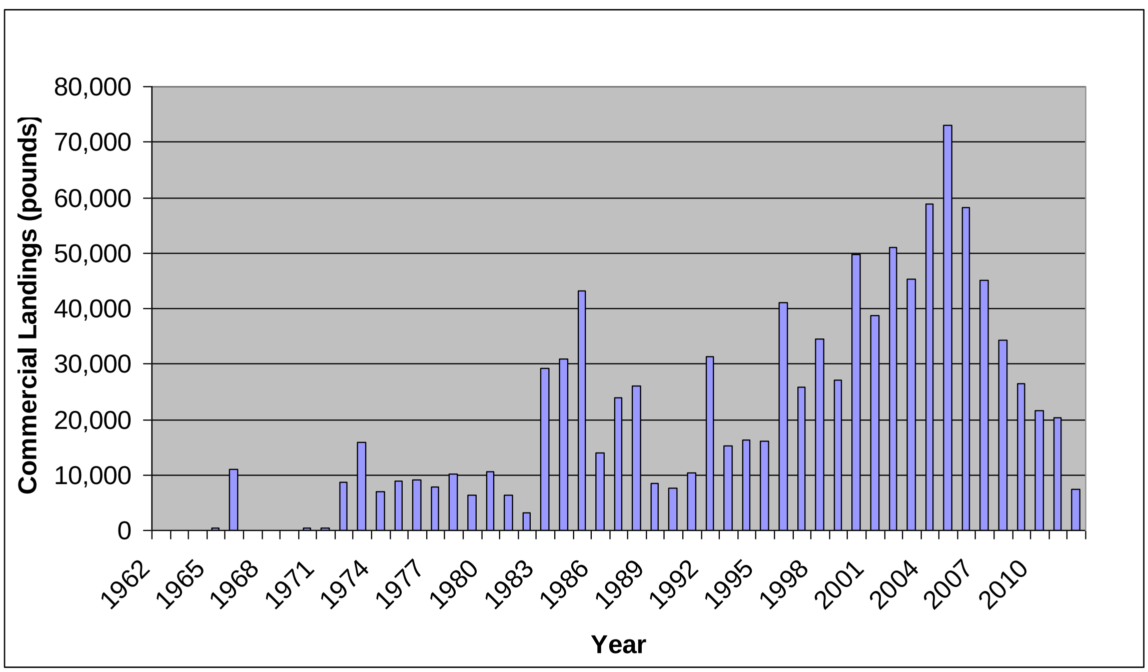


Figure 12. Estimated Maryland recreational summer flounder harvest and releases for 1981-2012 (Source: MRIP, 2014).

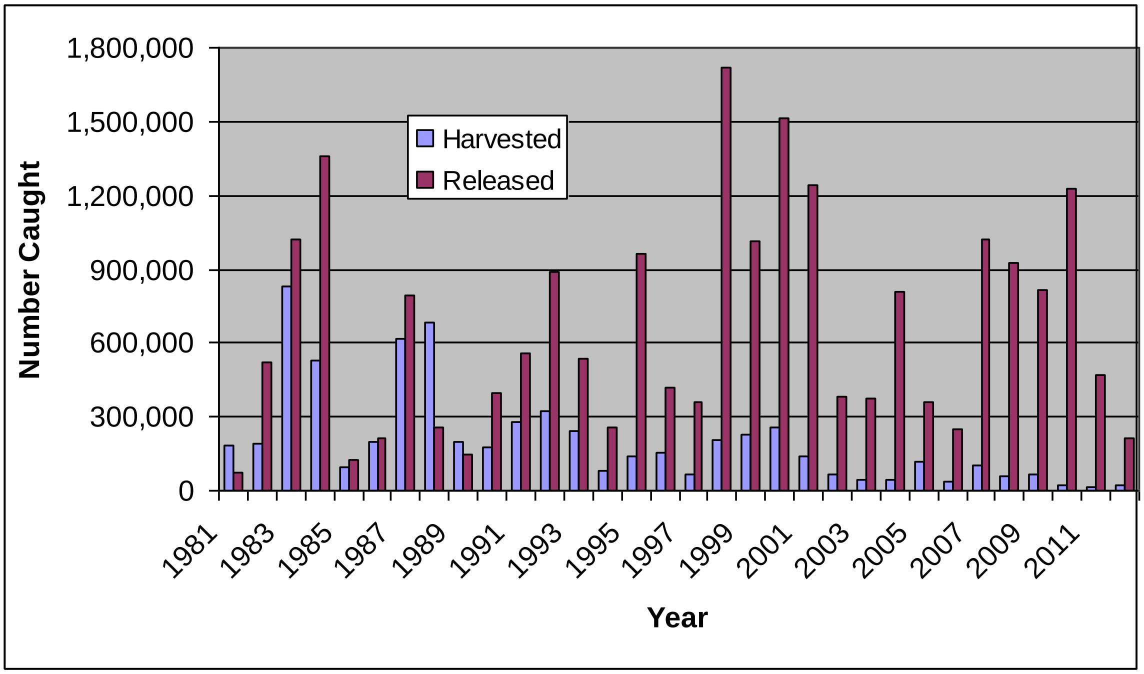


Figure 13. Summer Flounder statewide MRIP harvest and reported charter boat harvest from Maryland logbooks in numbers, 1993-2012.

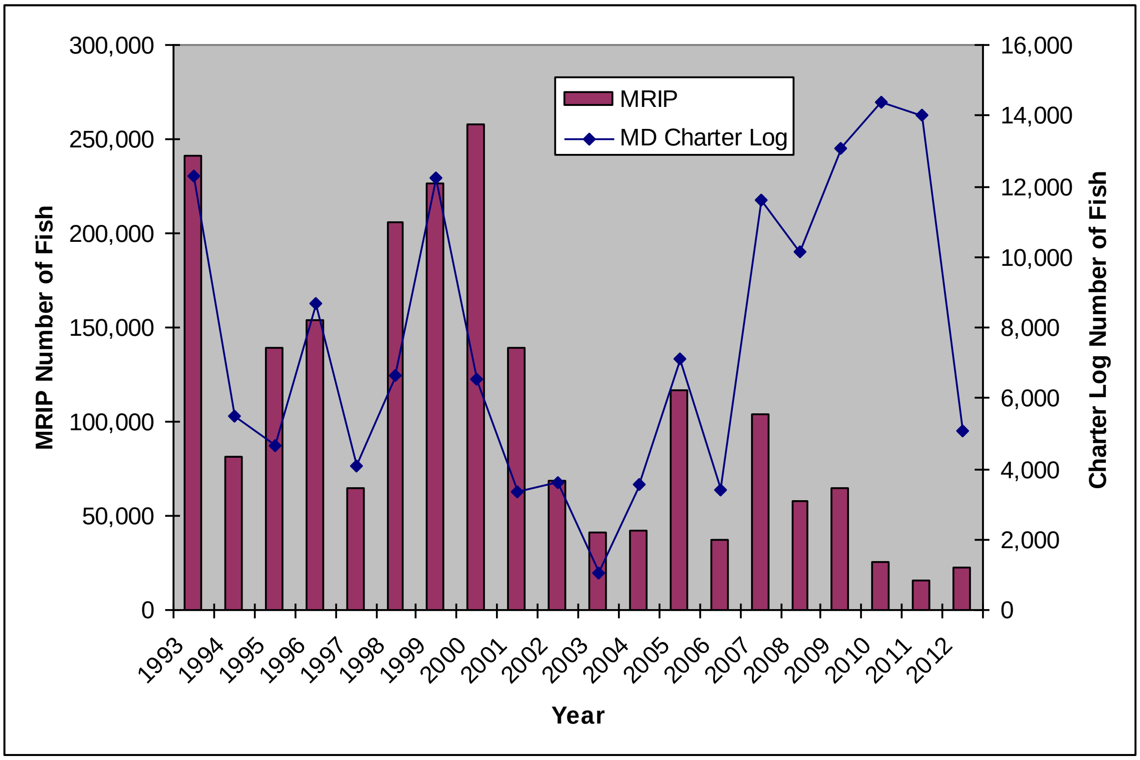


Figure 14. Summer flounder geometric mean catch per angler from Maryland charter boat logs, with 95% confidence intervals, 1993-2012.

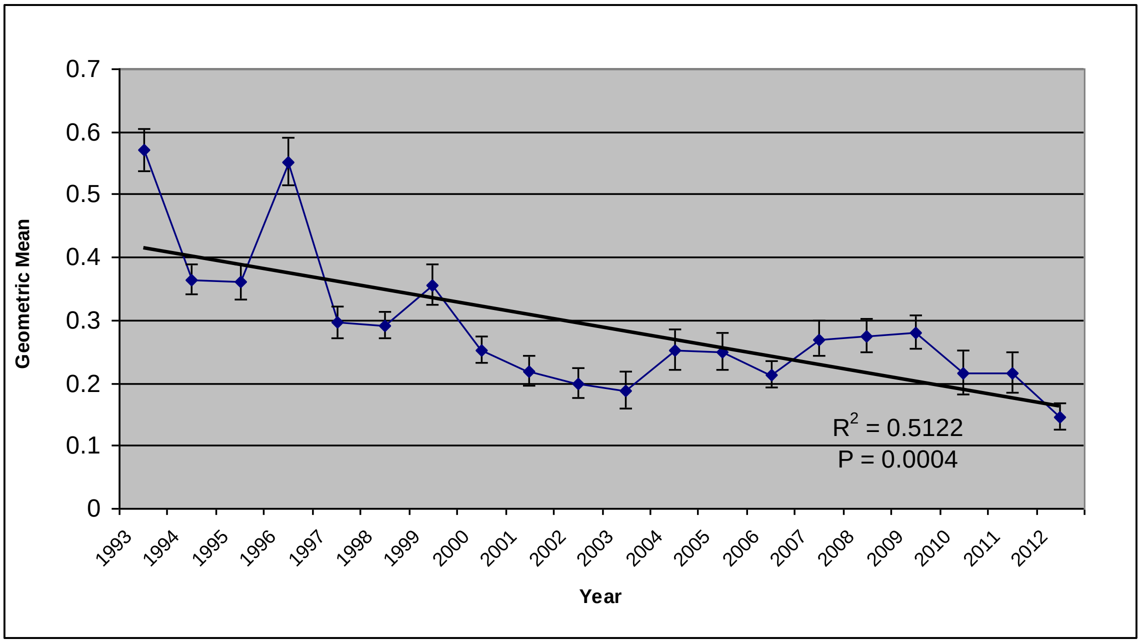


Figure 15. Bluefish length frequency distributions from onboard pound net sampling, 2004-2013.

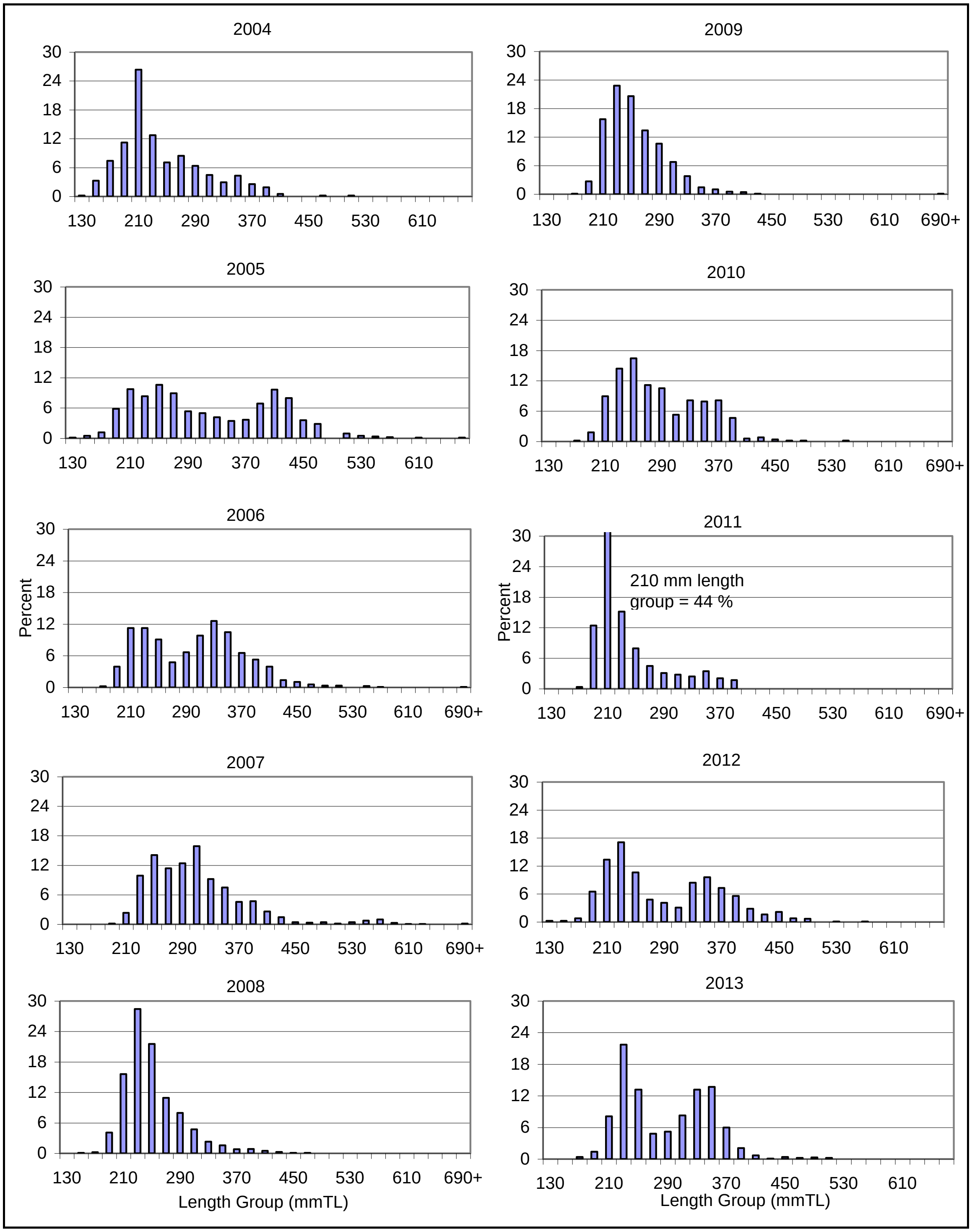


Figure 16. Maryland commercial bluefish harvest by area, 1929-2012.

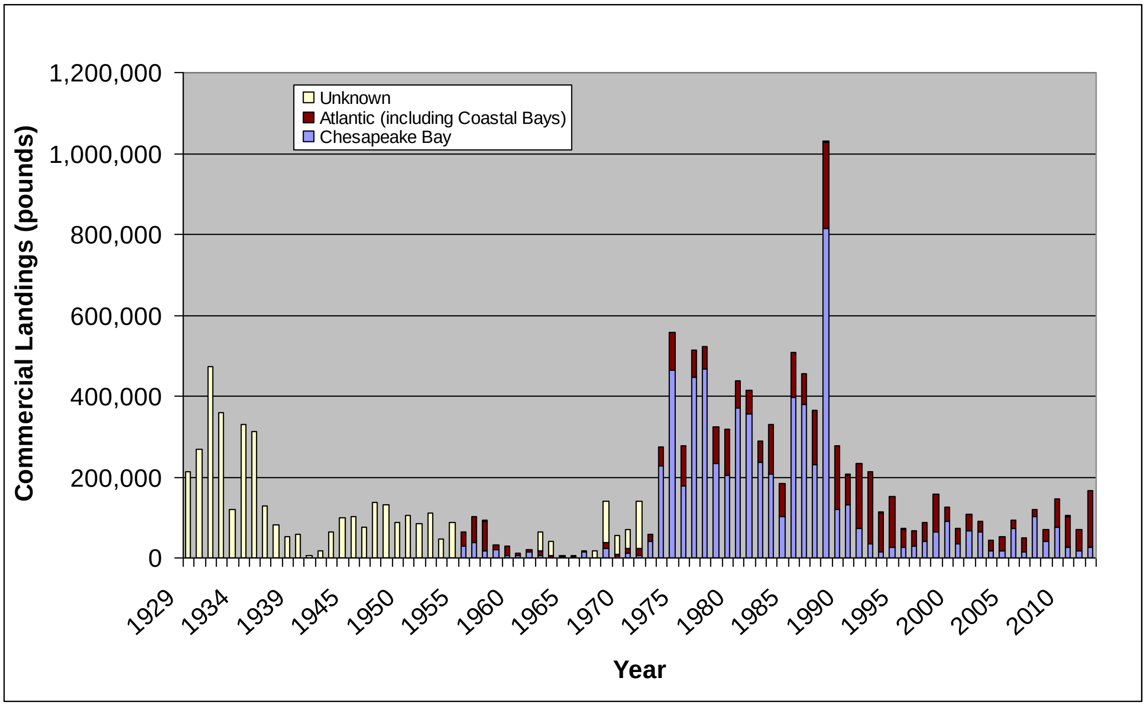


Figure 17. Estimated Maryland recreational bluefish harvest and releases for 1981-2012 (Source: MRIP, 2014).

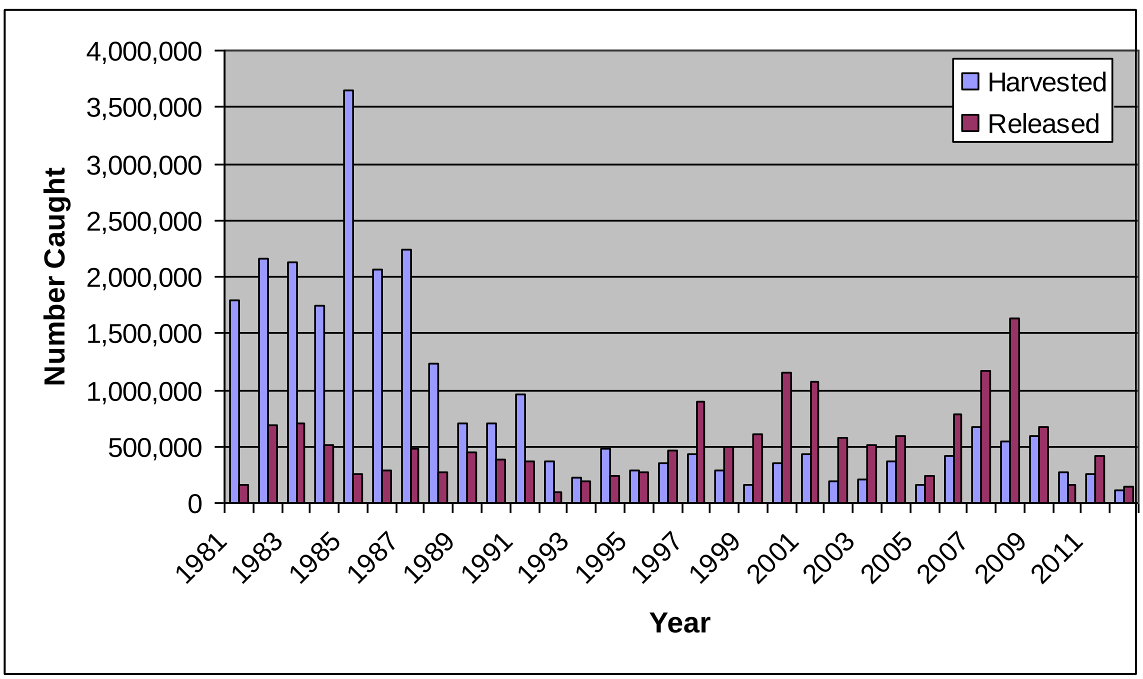


Figure 18. Bluefish statewide MRIP harvest in numbers, Maryland reported charter boat harvest in numbers and Maryland commercial harvest in pounds, 1993-2012.

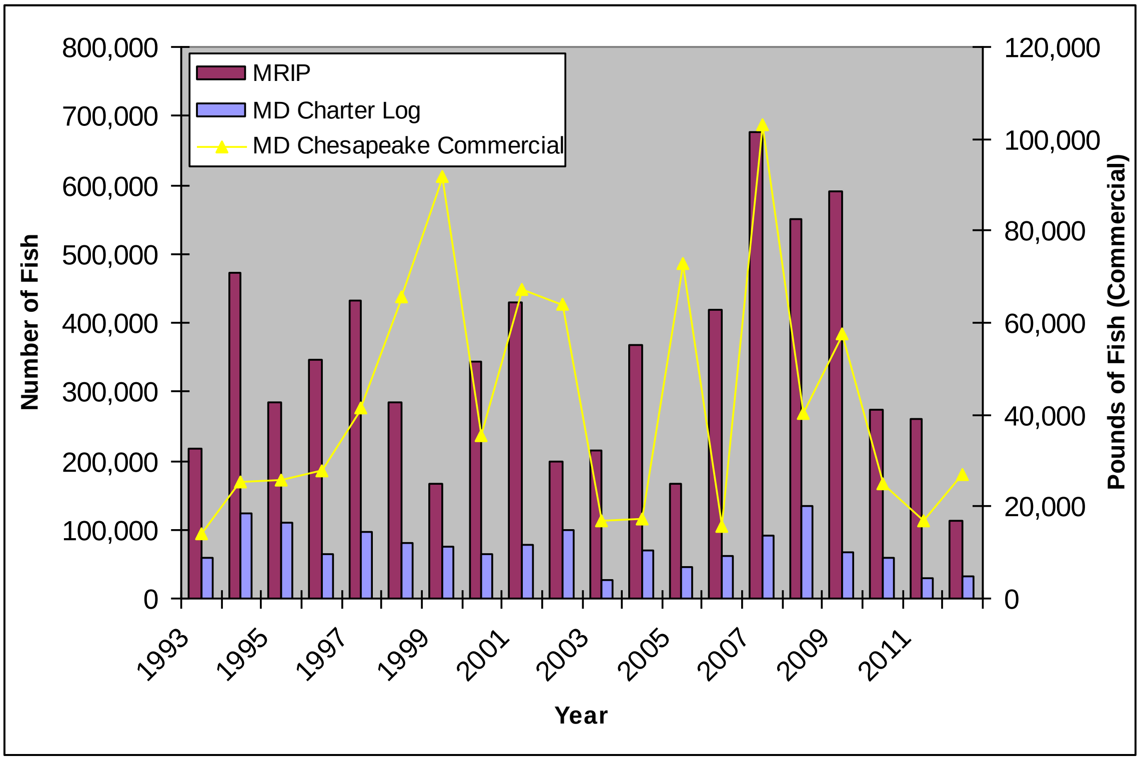


Figure 19. Bluefish geometric mean catch per angler from Maryland charter boat logs, with 95% confidence intervals, 1993-2012.

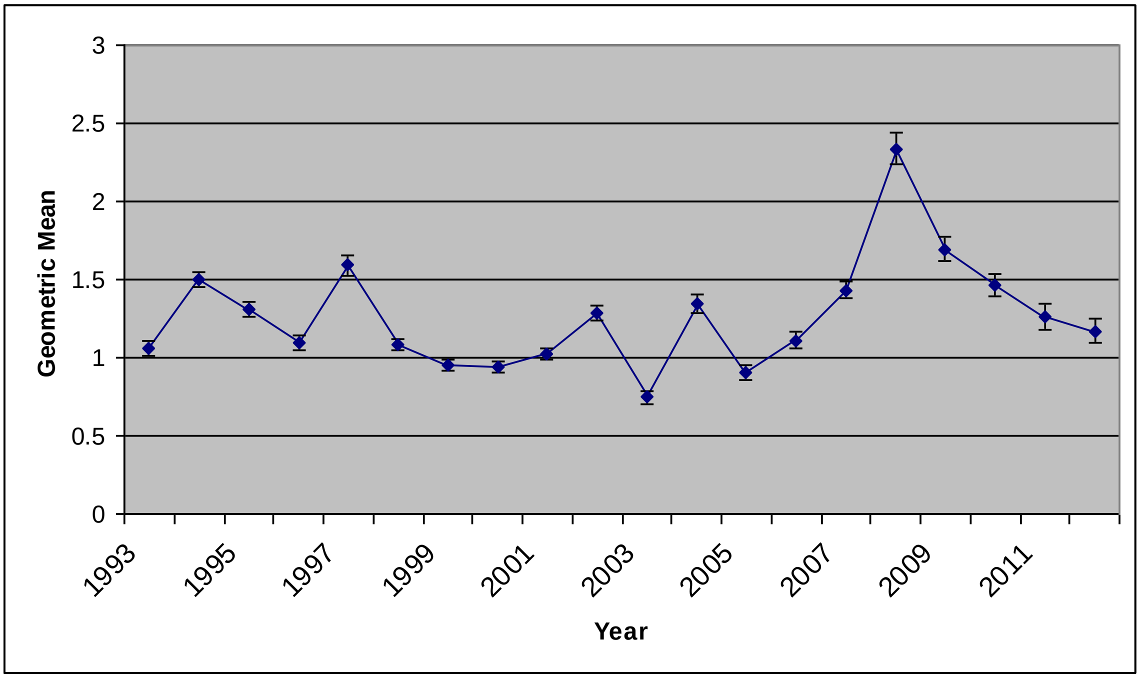


Figure 20. Atlantic croaker length frequency distributions from onboard pound net sampling, 2004-2013.

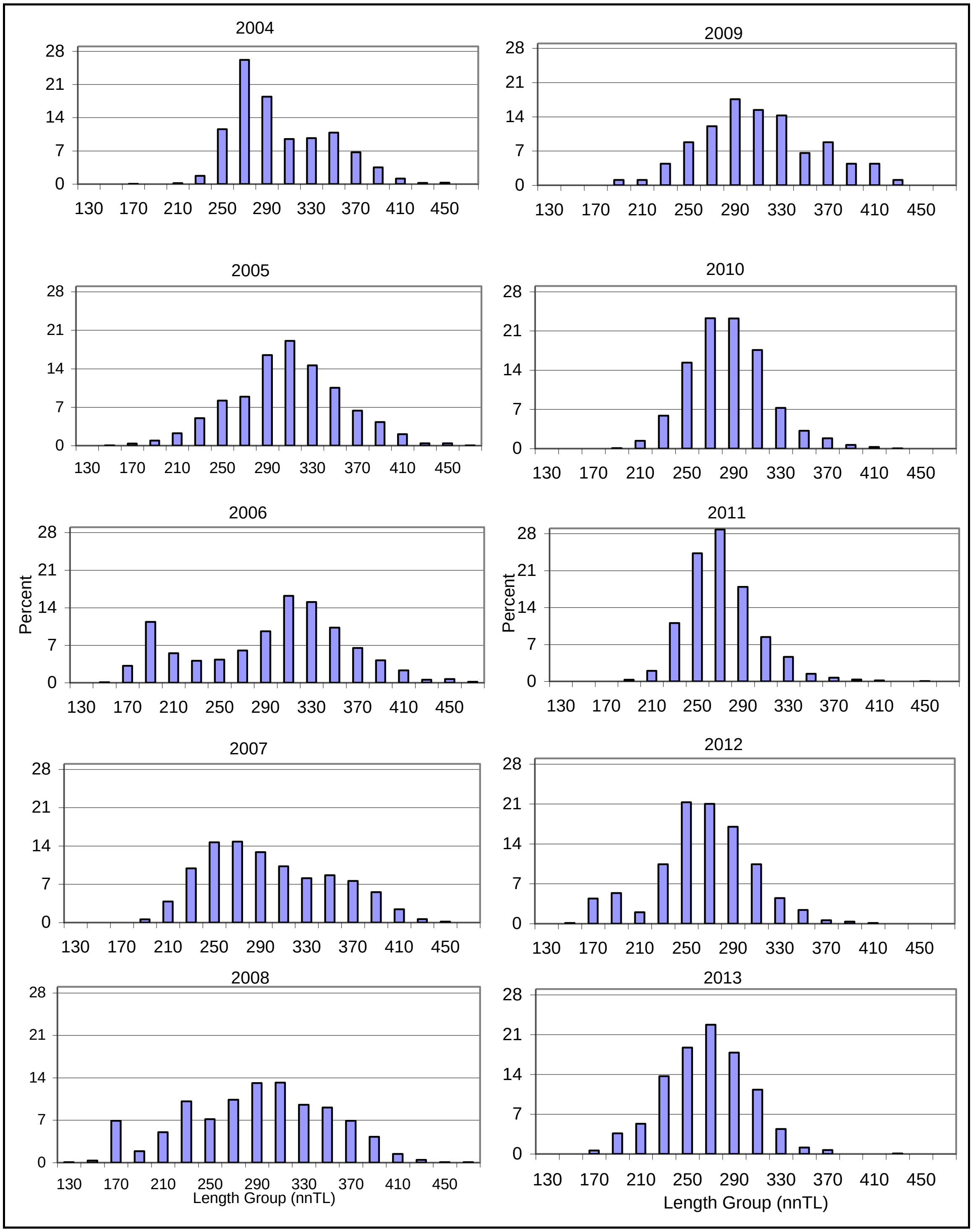


Figure 21. Maryland commercial Atlantic croaker harvest by area, 1929-2012.

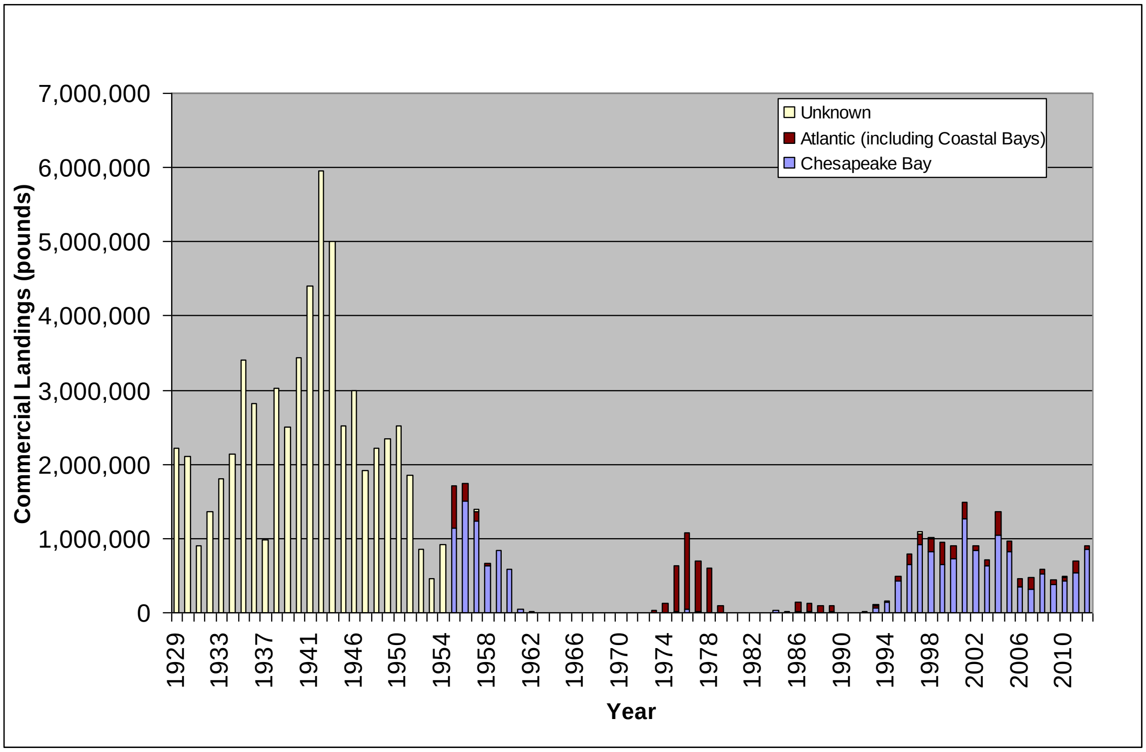


Figure 22. Estimated Maryland recreational Atlantic croaker harvest and releases for 1981-2012 (Source: MRIP, 2014).

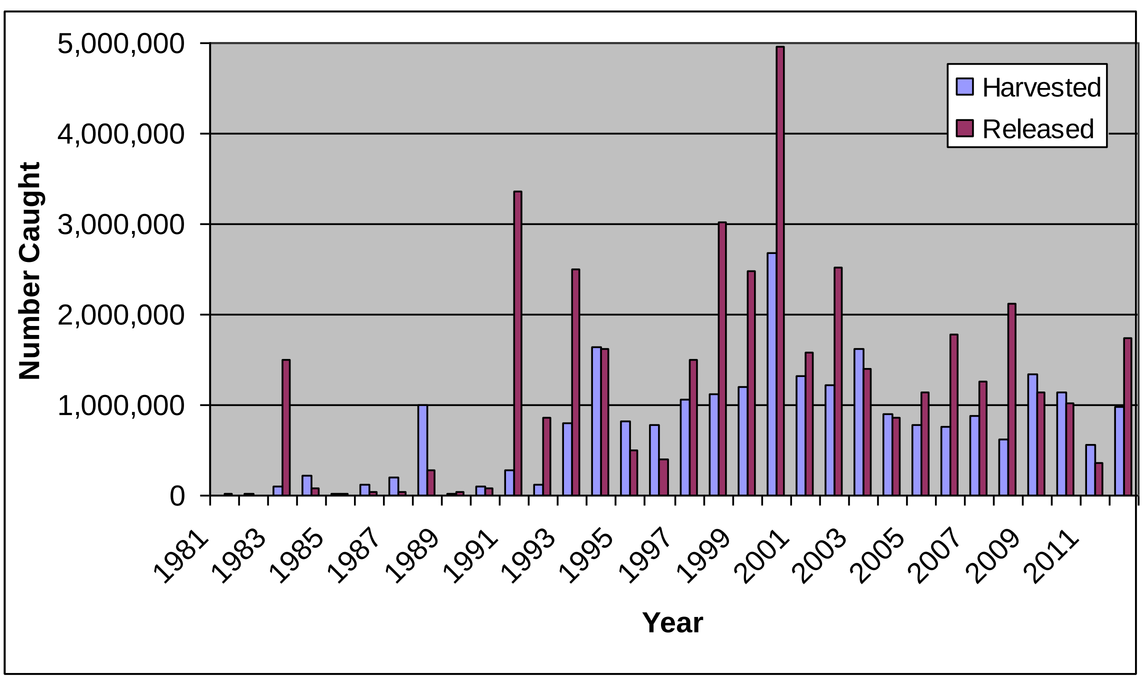


Figure 23. Atlantic croaker statewide MRIP harvest, MRIP for hire inland harvest and Maryland reported charter boat harvest in numbers, 1993-2012.

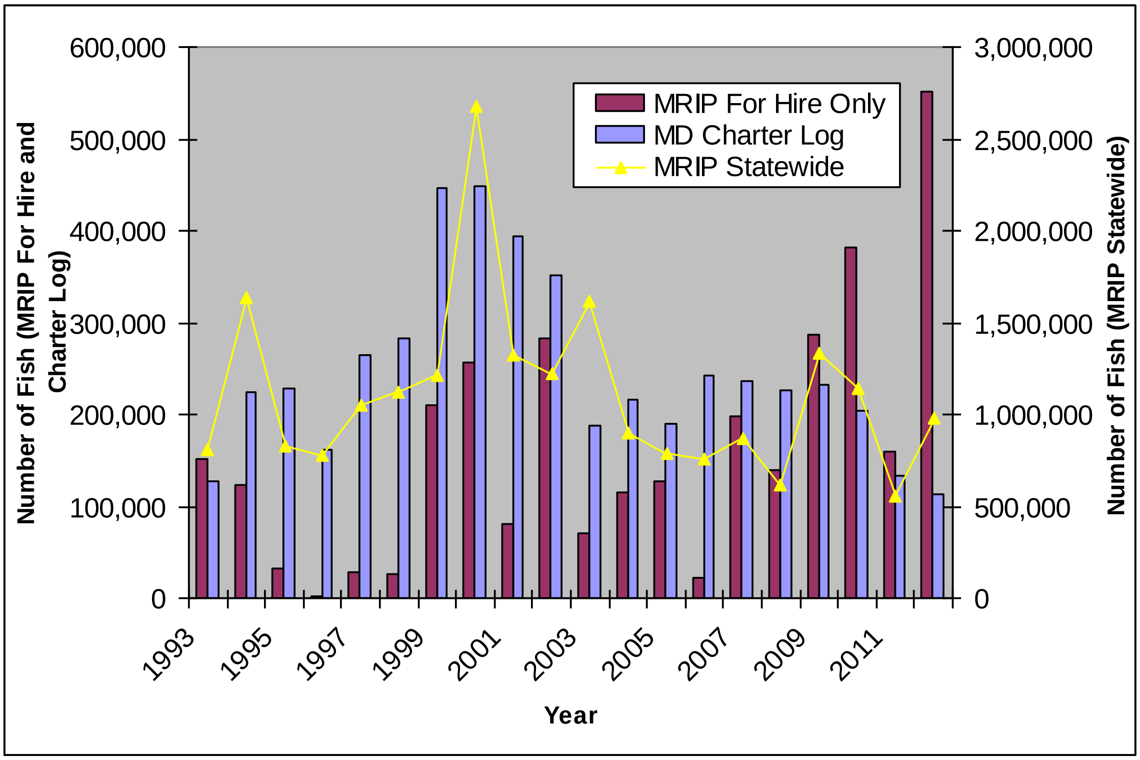


Figure 24. Atlantic croaker geometric mean catch per angler from Maryland charter boat logs, with 95% confidence intervals, 1993-2012.

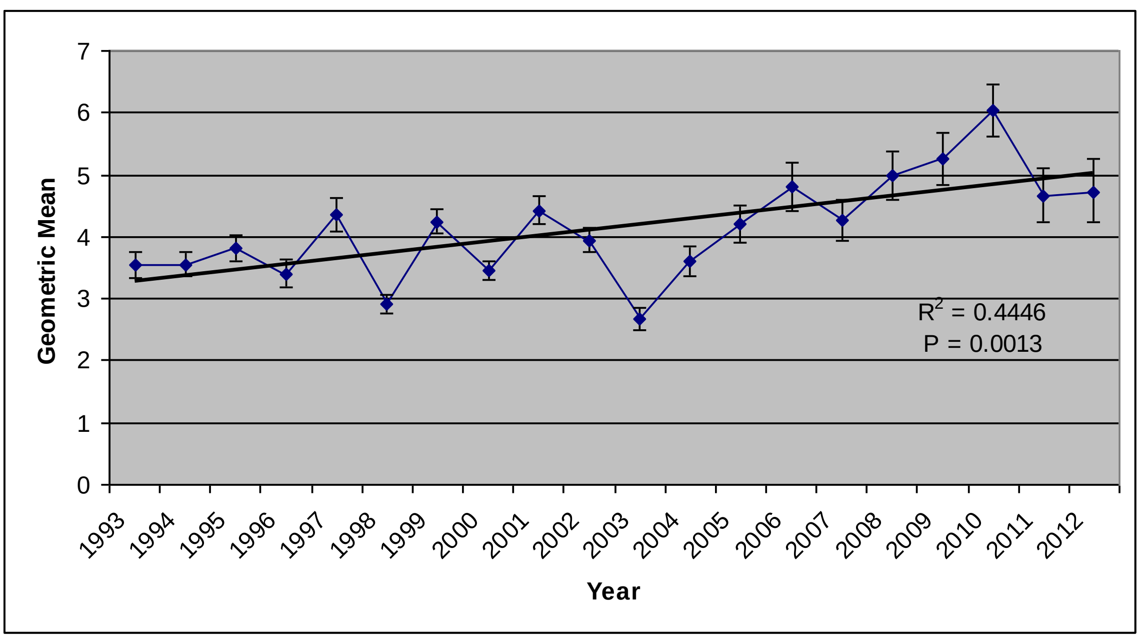


Figure 25. Maryland juvenile Atlantic croaker geometric mean catch per trawl and 95% confidence intervals for Maryland's lower Chesapeake Bay, 1989 – 2013. 1998 data point was omitted for scale (GM 1998 = 30.05 -9.02, +12.72).

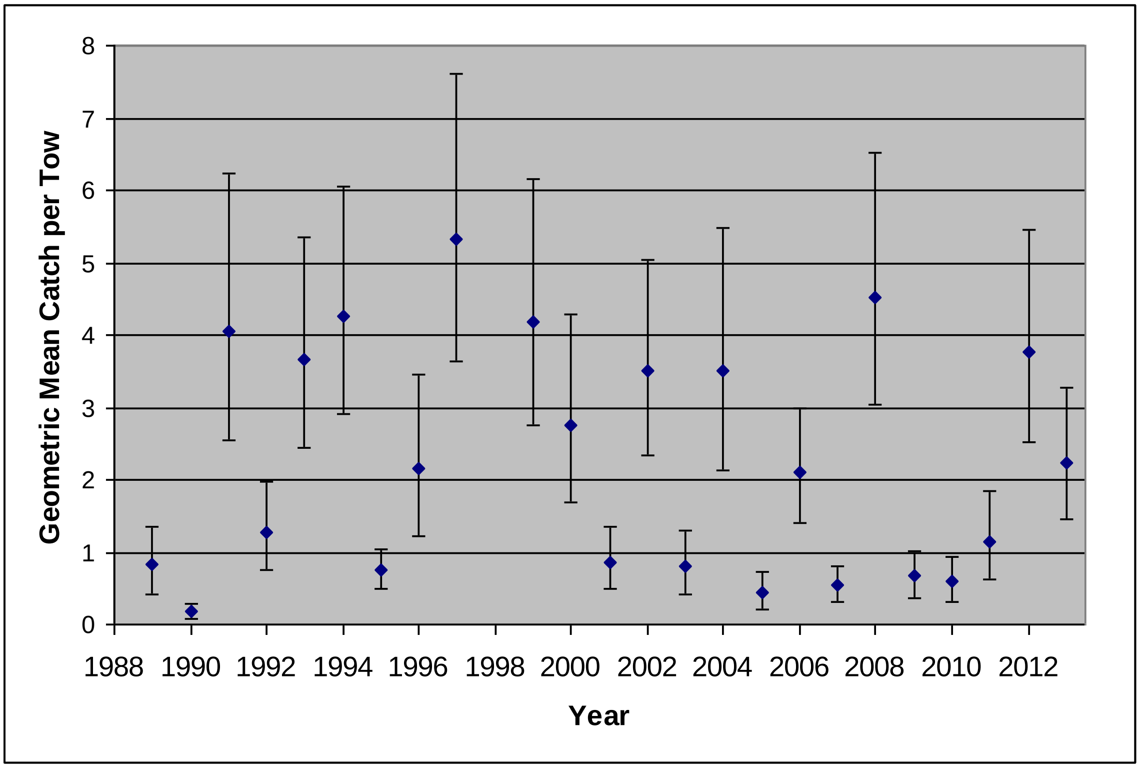


Figure 26. Spot length frequency distributions from onboard pound net sampling, 2004-2013.

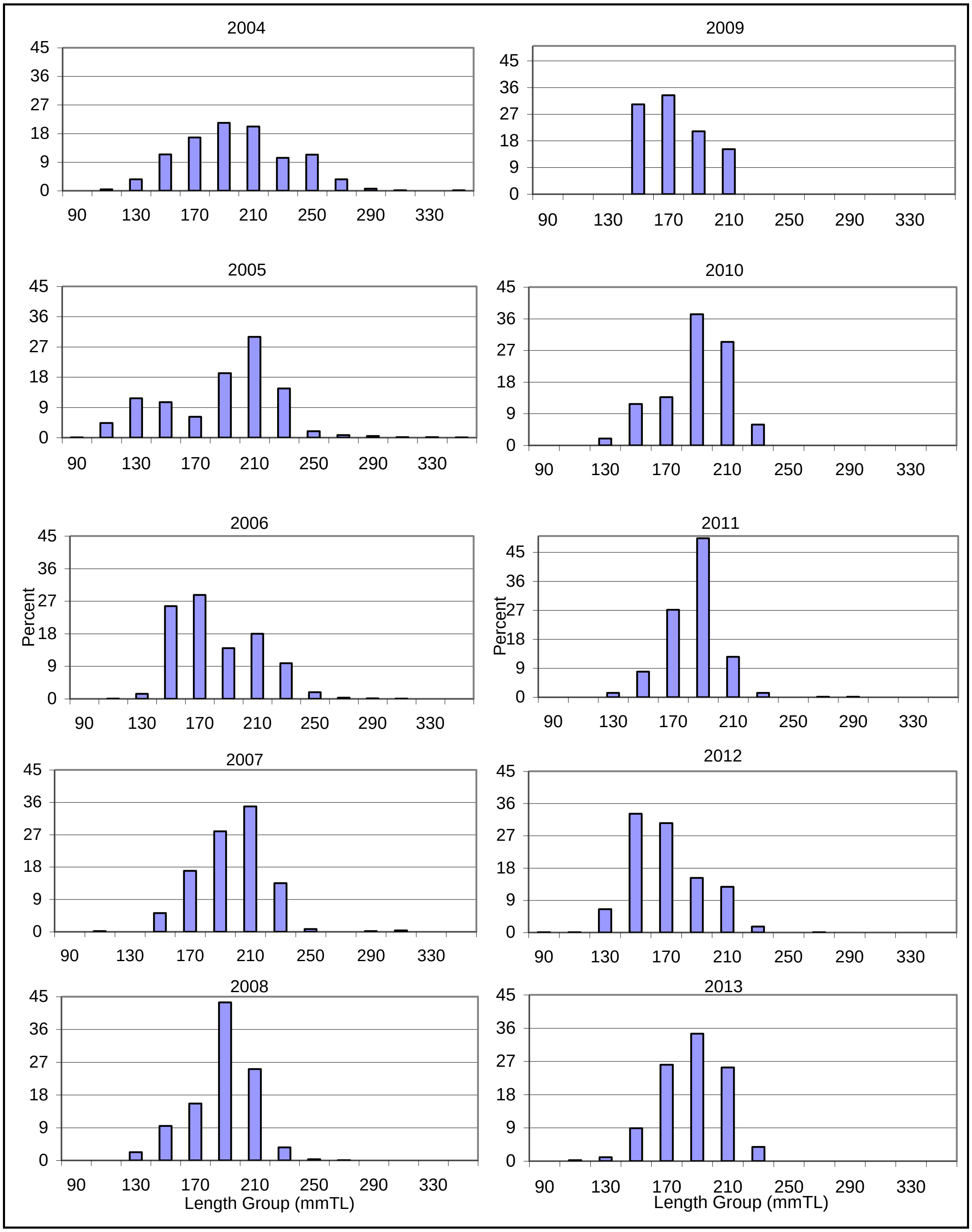


Figure 27. Maryland commercial spot harvest by area, 1929-2012.

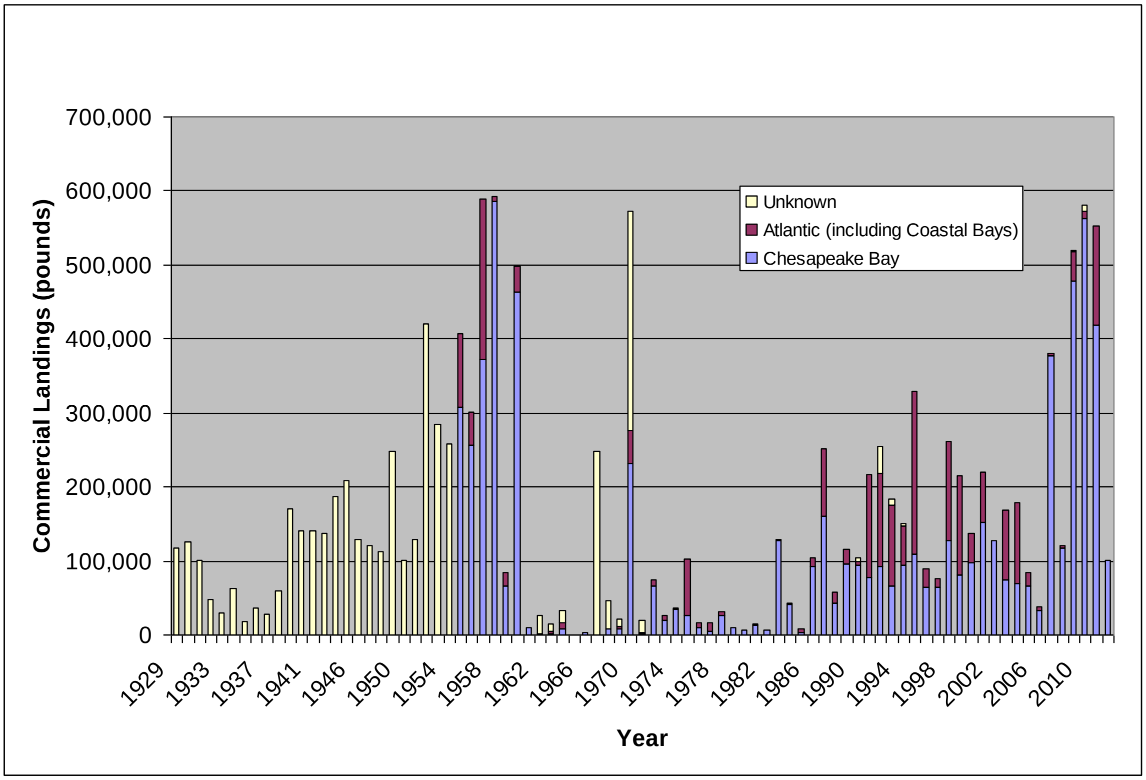


Figure 28. Estimated Maryland recreational spot harvest and releases for 1981-2012 (Source: MRIP, 2014).

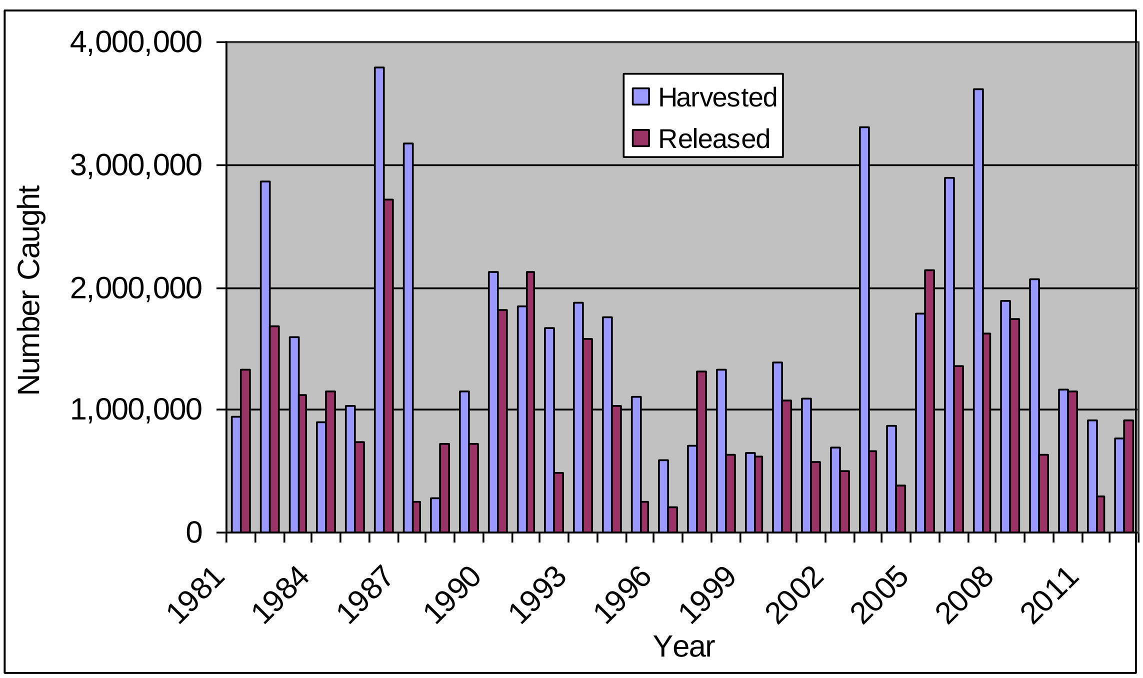


Figure 29. Spot statewide MRIP harvest in numbers, Maryland reported charter boat harvest in numbers and Maryland commercial harvest in pounds, 1993-2012.

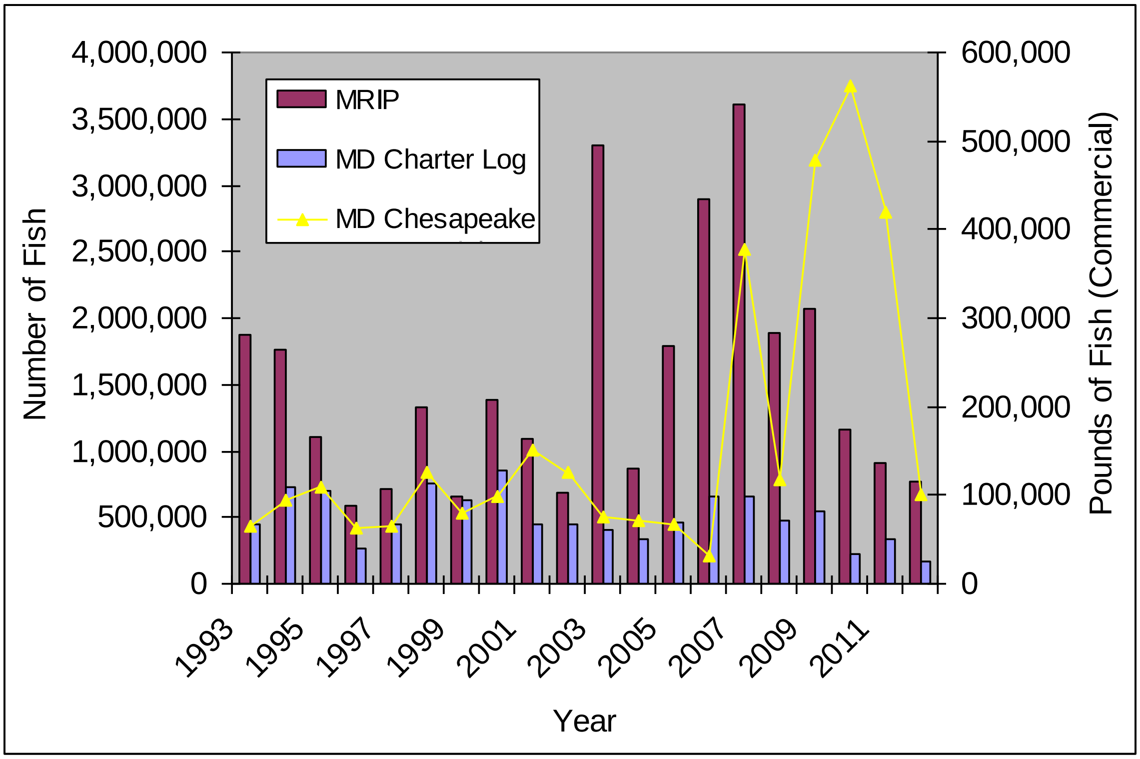


Figure 30. Spot geometric mean catch per angler from Maryland charter boat logs, with 95% confidence intervals, 1993-2012.

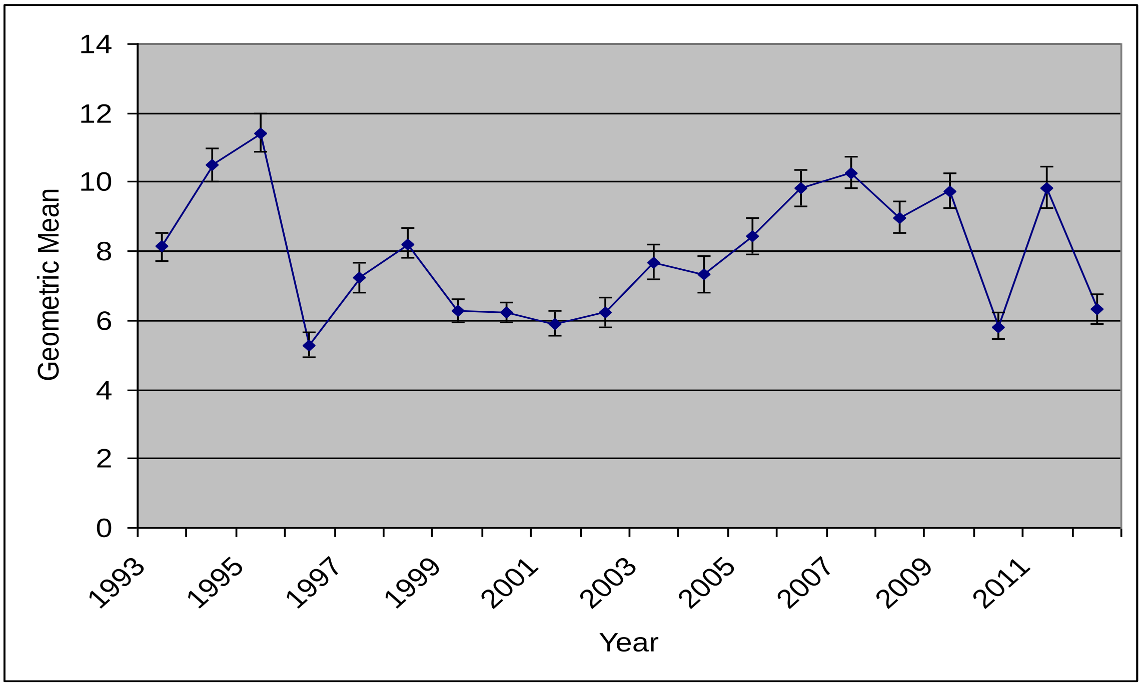


Figure 31. Maryland juvenile spot geometric mean catch per trawl and 95% confidence intervals for Maryland's lower Chesapeake Bay, 1989 – 2013.

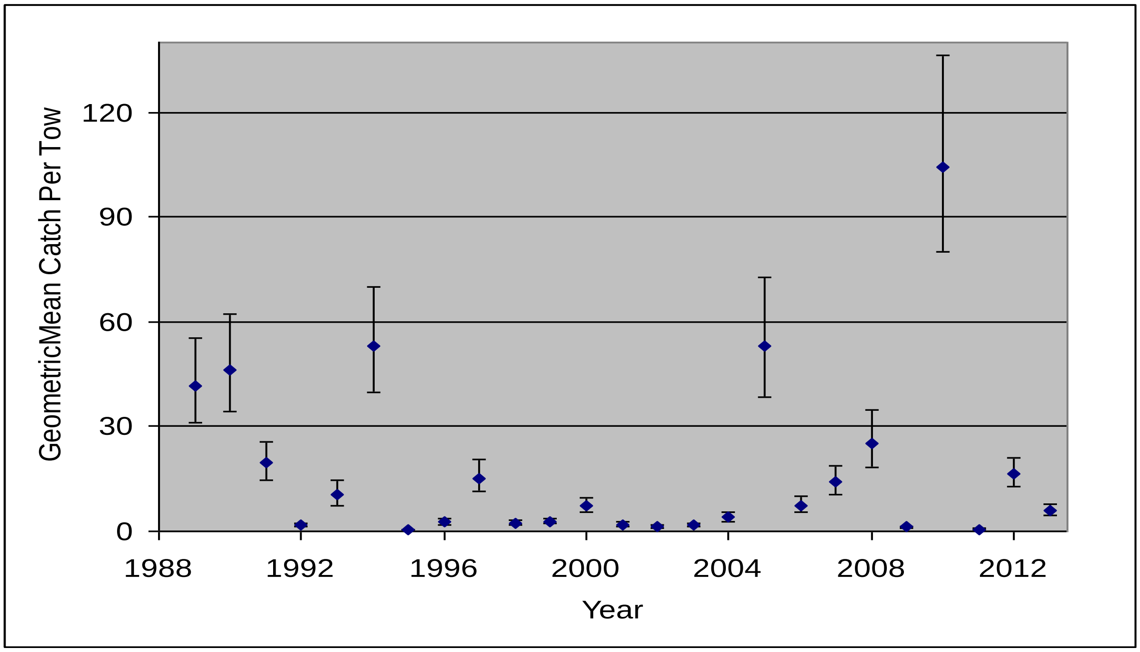


Figure 32. Maryland commercial red drum harvest by area, 1958-2012.

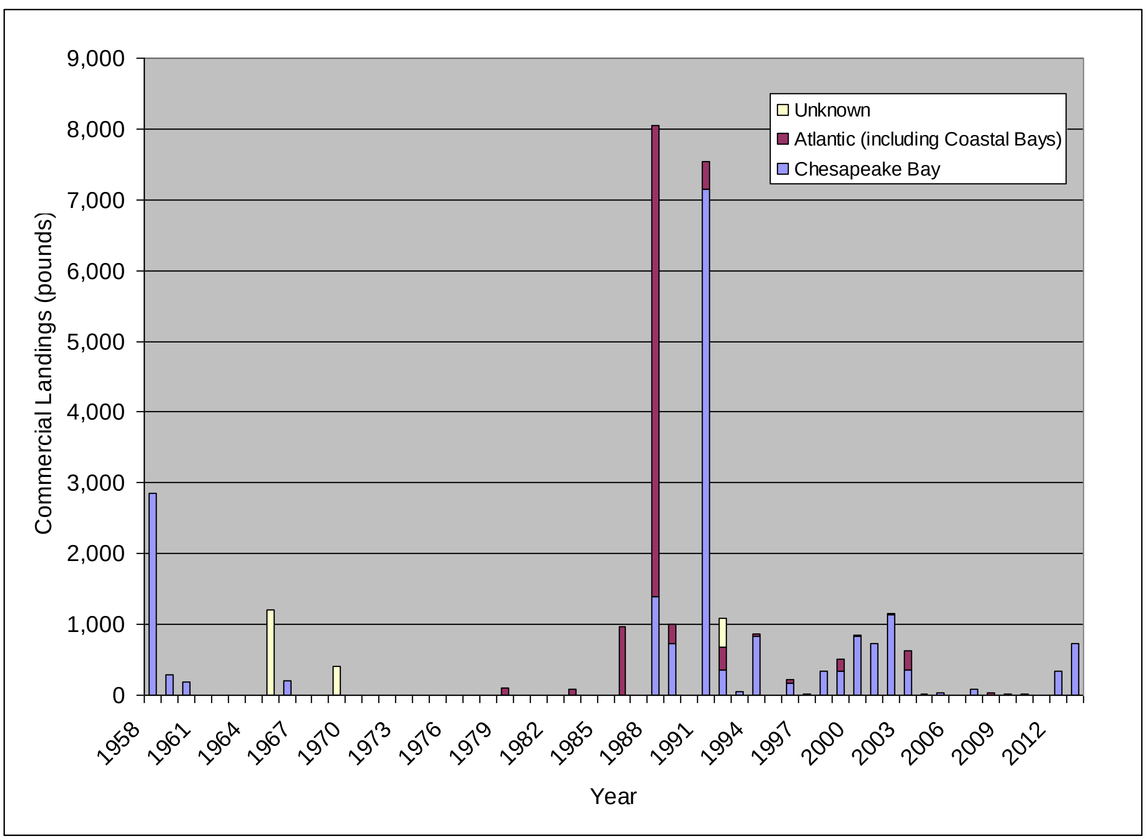


Figure 33. Estimated Maryland recreational red drum harvest for 1981-2012 (Source: MRIP, 2014).

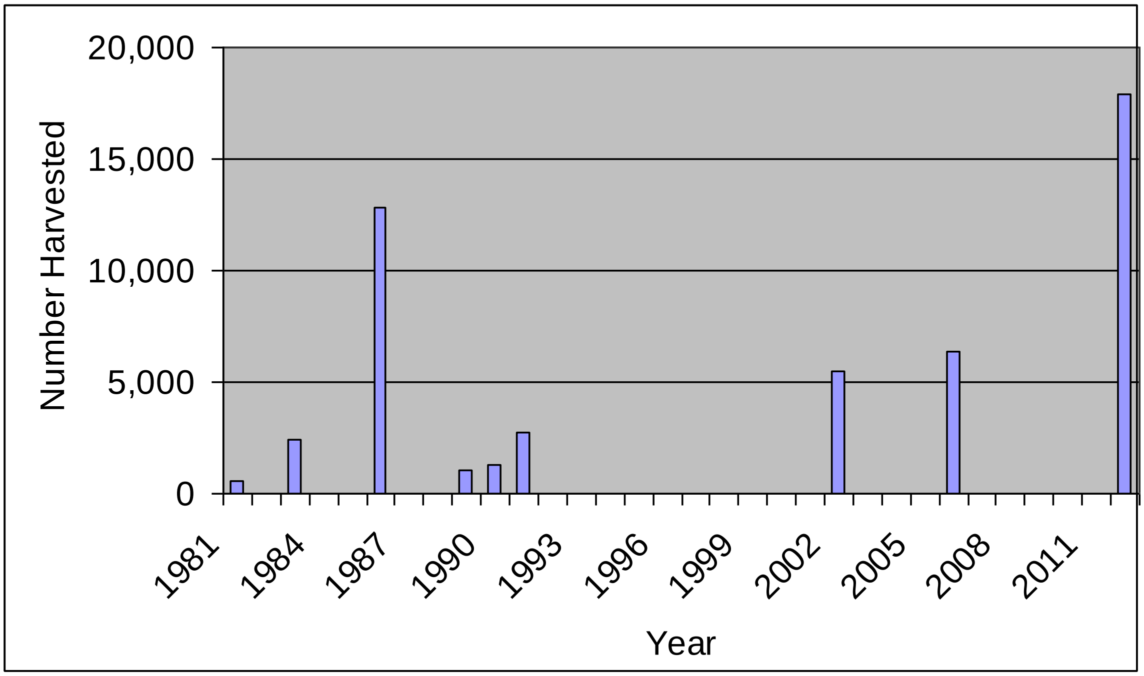


Figure 34. Estimated Maryland recreational red drum released for 1981-2012 (Source: MRIP, 2014). 2012 vale of 280,171 was truncated to preserve scale.

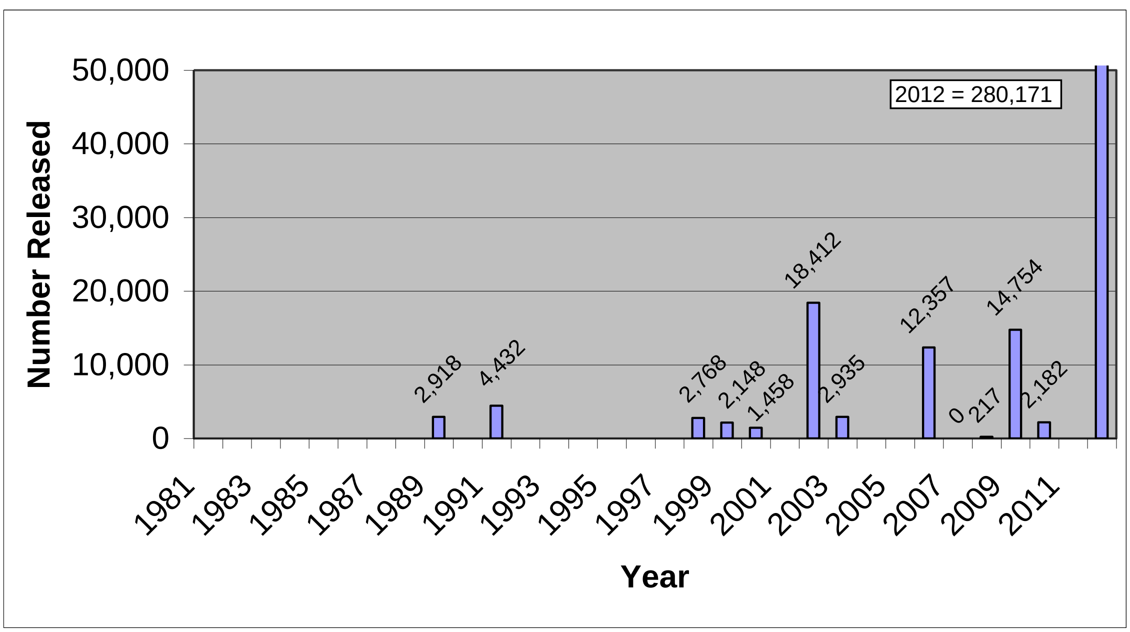


Figure 35. Number of red drum harvested and the number of anglers catching red drum from the Maryland Charter boat logs, 1993-2012.

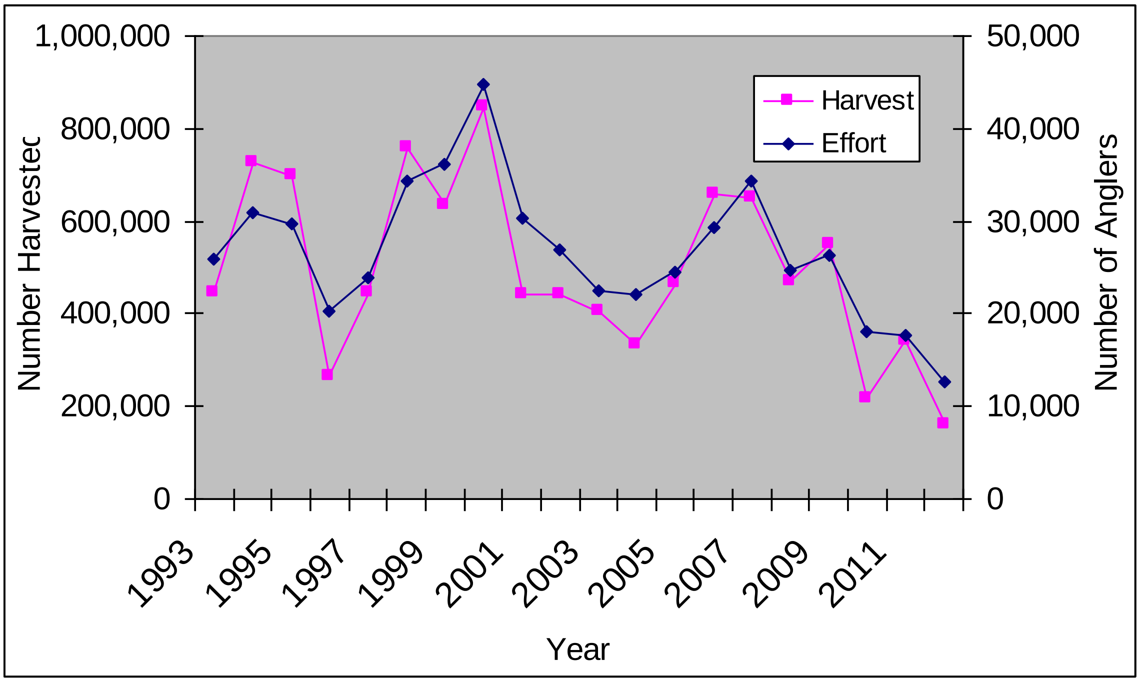


Figure 36. Maryland commercial black drum harvest by area, 1929-2012.

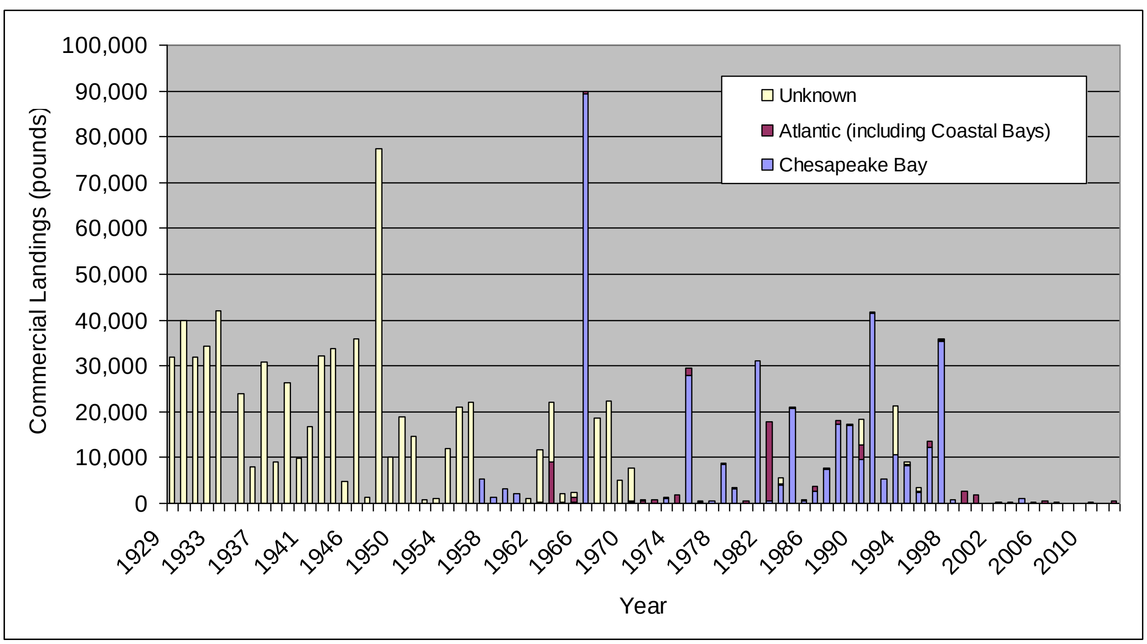


Figure 37. Estimated Maryland recreational black drum harvest and releases for 1981-2012 (Source: MRIP, 2014).

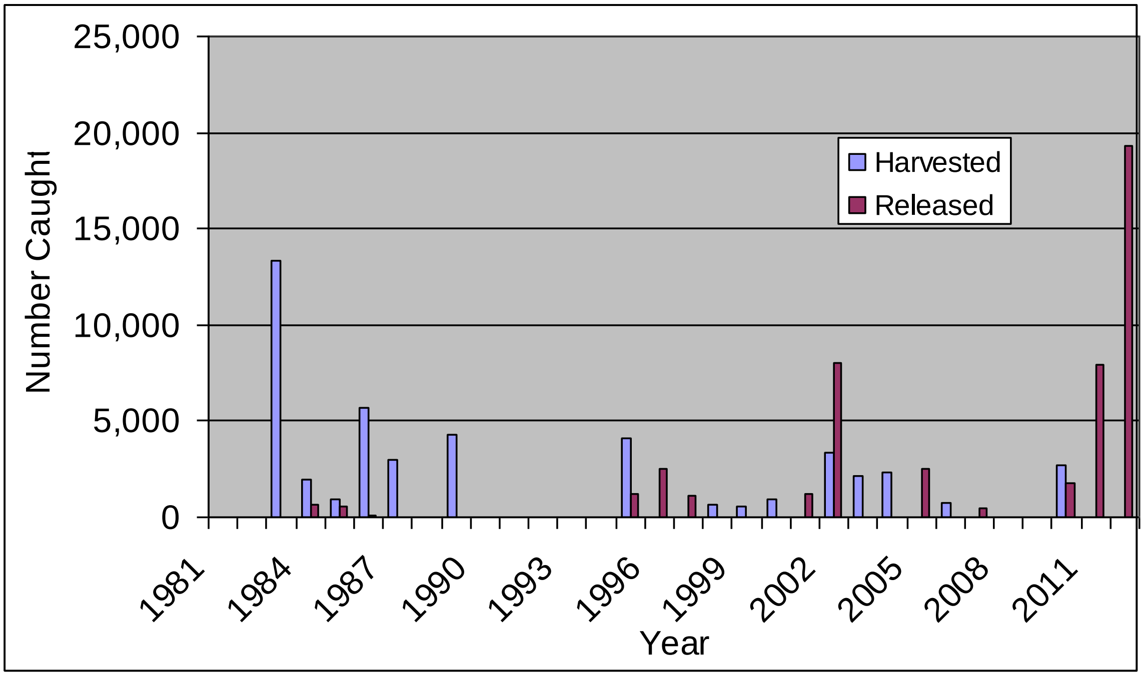


Figure 38. Reported Maryland charter boat harvest for black drum in numbers, 1993-2012.

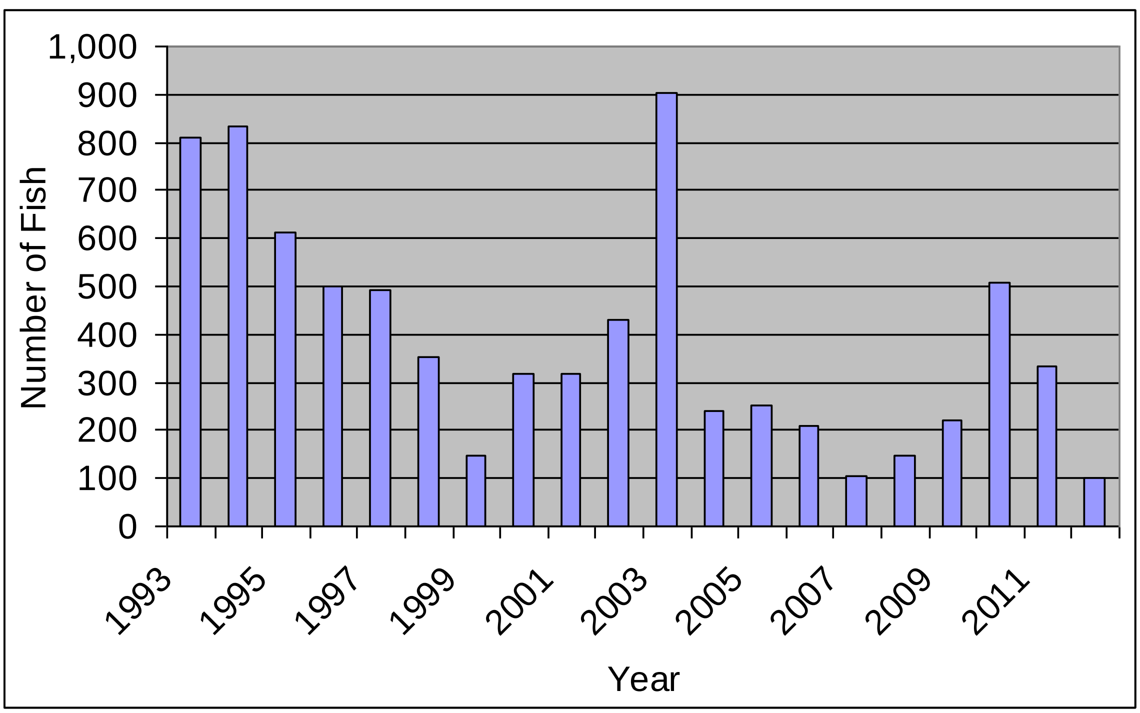


Figure 39. Black drum geometric mean catch per angler from Maryland charter boat logs, with 95% confidence intervals, 1993-2012.

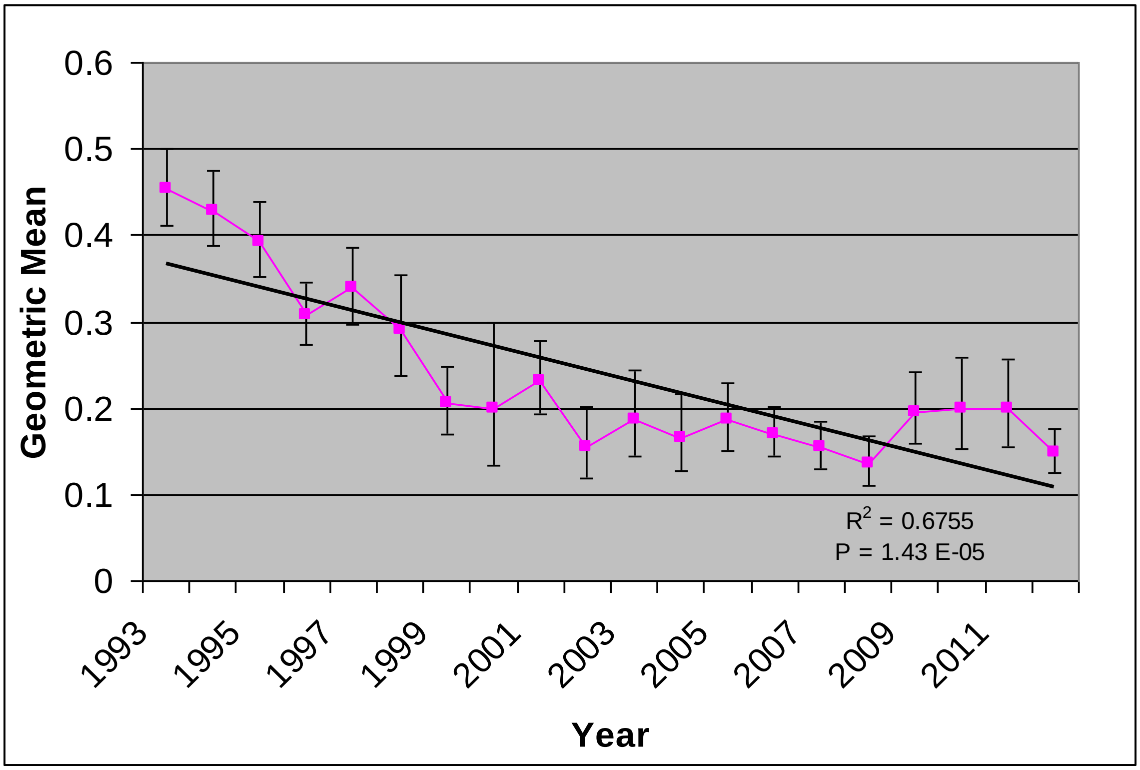


Figure 40. Maryland commercial Spanish mackerel harvest by area, 1965-2012.

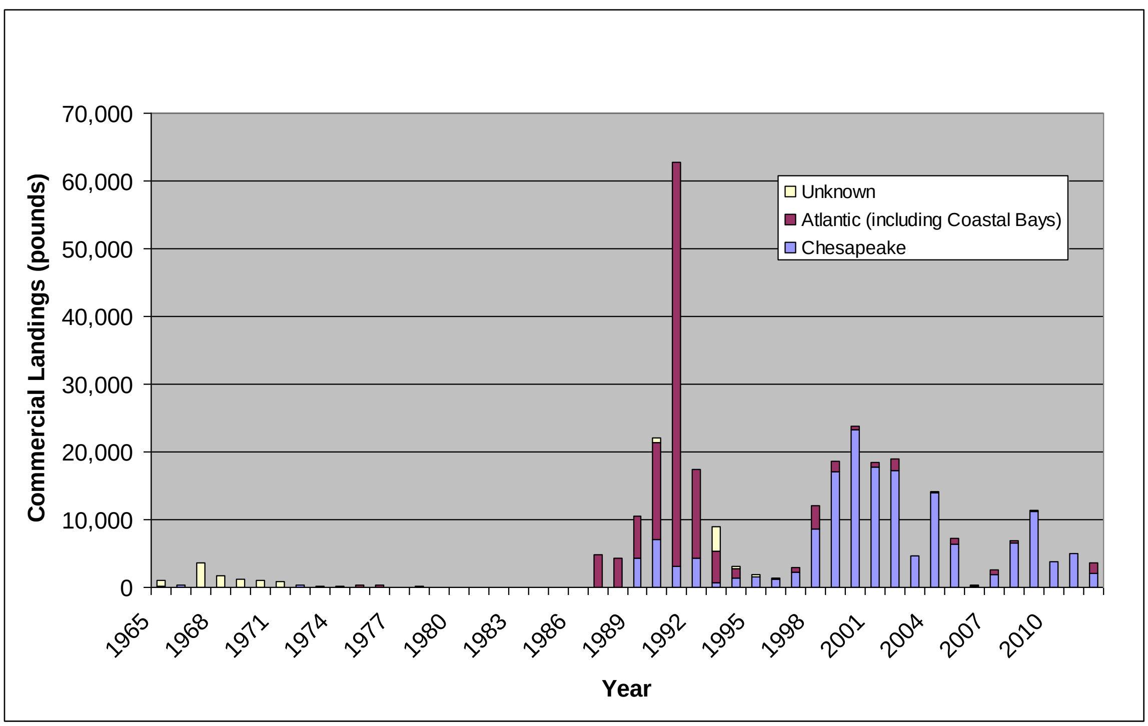


Figure 41. Estimated Maryland recreational Spanish mackerel harvest and releases for 1981-2012 (Source: MRIP, 2014).

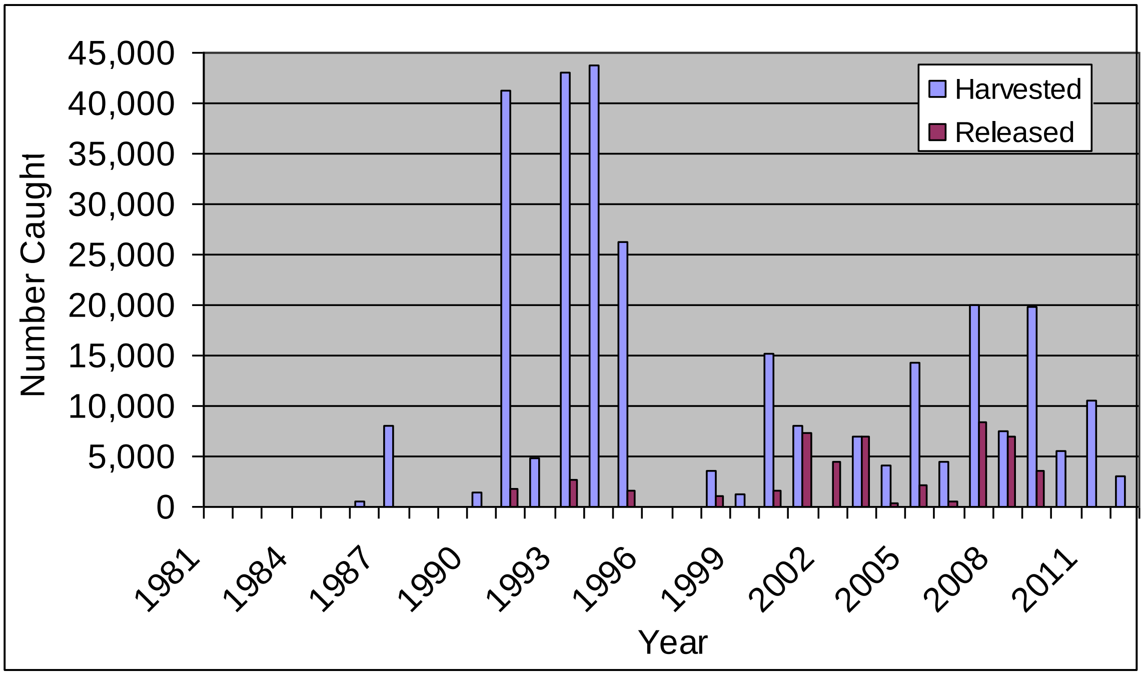


Figure 42. Spanish mackerel statewide MRIP harvest, MRIP for hire inland harvest and Maryland reported charter boat harvest in numbers, 1993-2012.

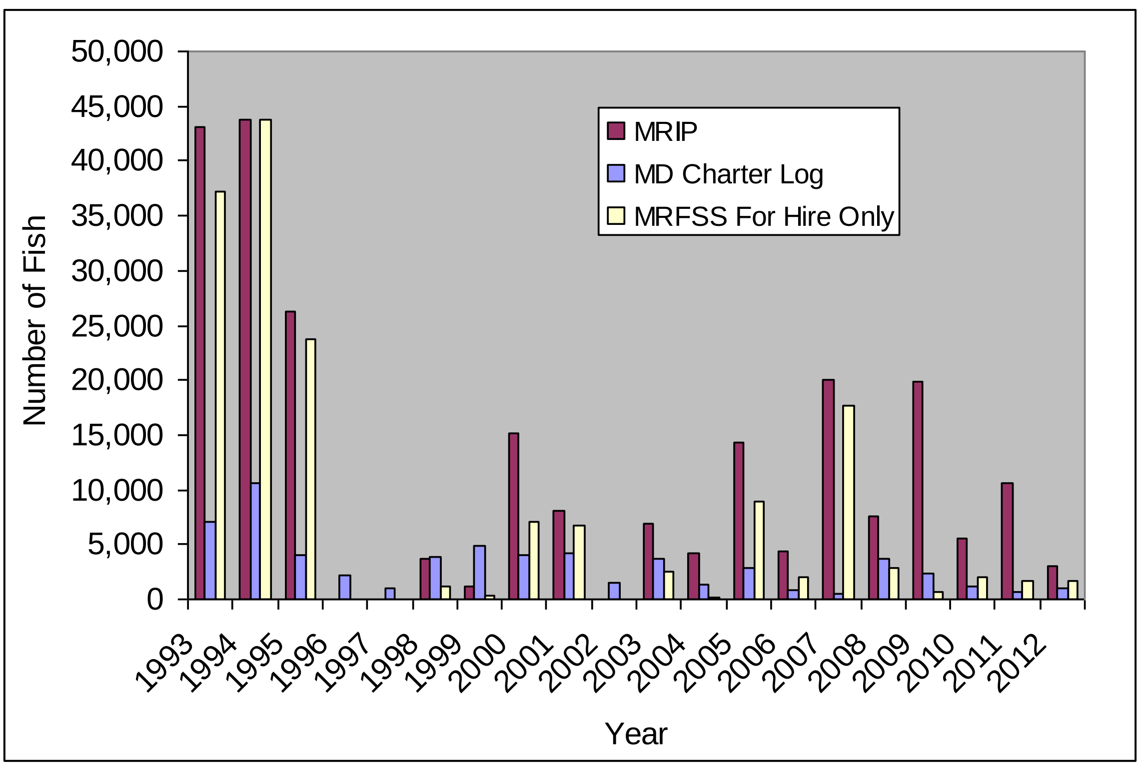


Figure 43. Spanish mackerel geometric mean catch per angler from Maryland charter boat logs, with 95% confidence intervals, 1993-2012.

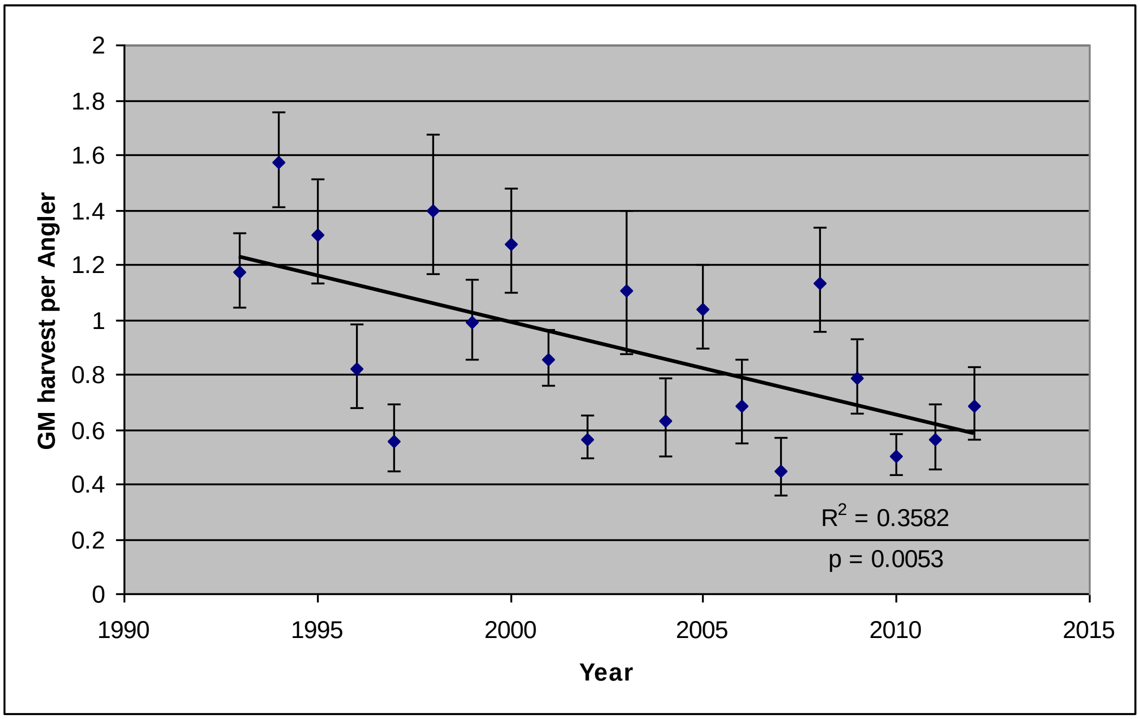


Figure 44. Maryland commercial spotted seatrout harvest by area, 1944-2012.

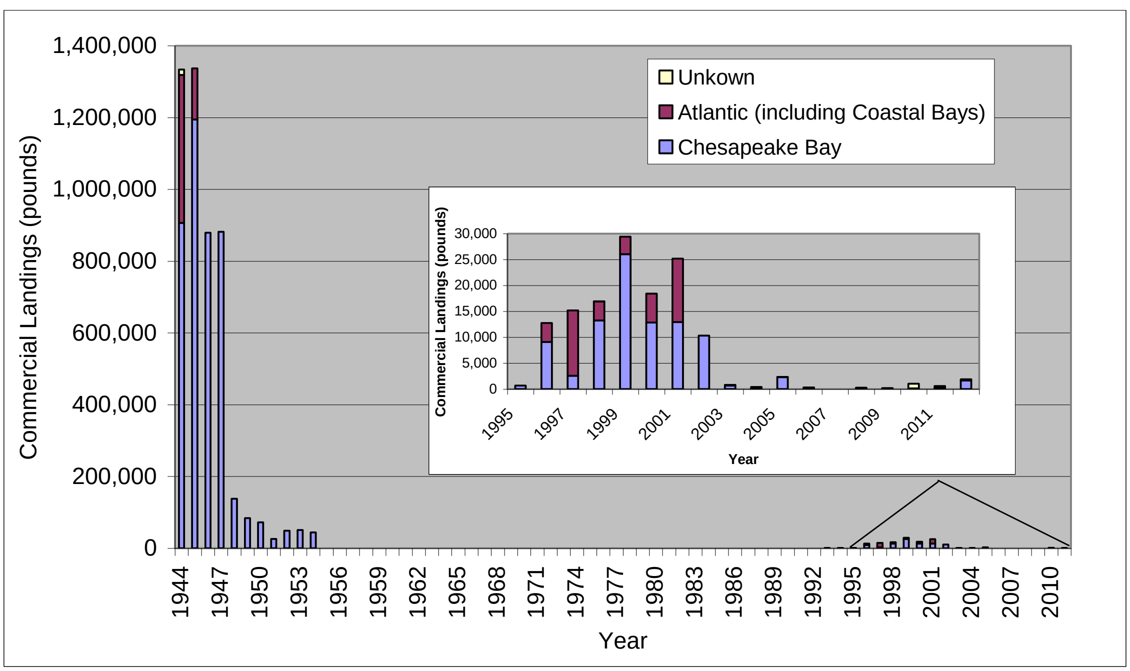


Figure 45. Estimated Maryland recreational spotted seatrout harvest and releases for 1981-2012 (Source: MRIP, 2014).

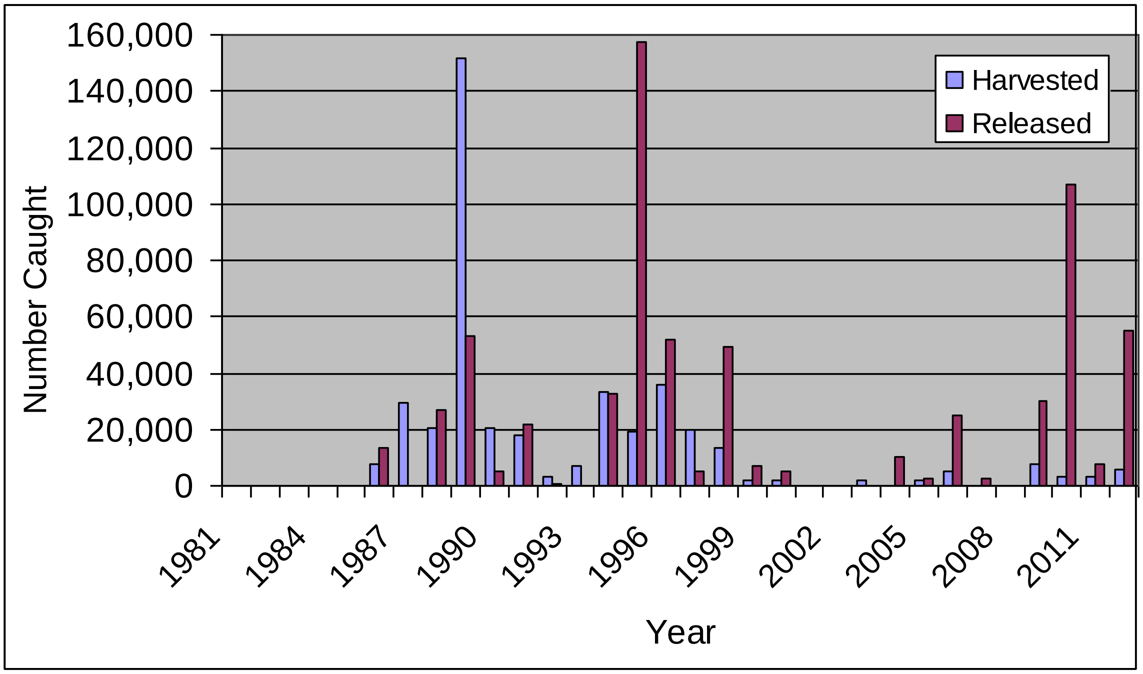


Figure 46. Reported Maryland charter boat harvest for spotted seatrout in numbers, 1993-2012.

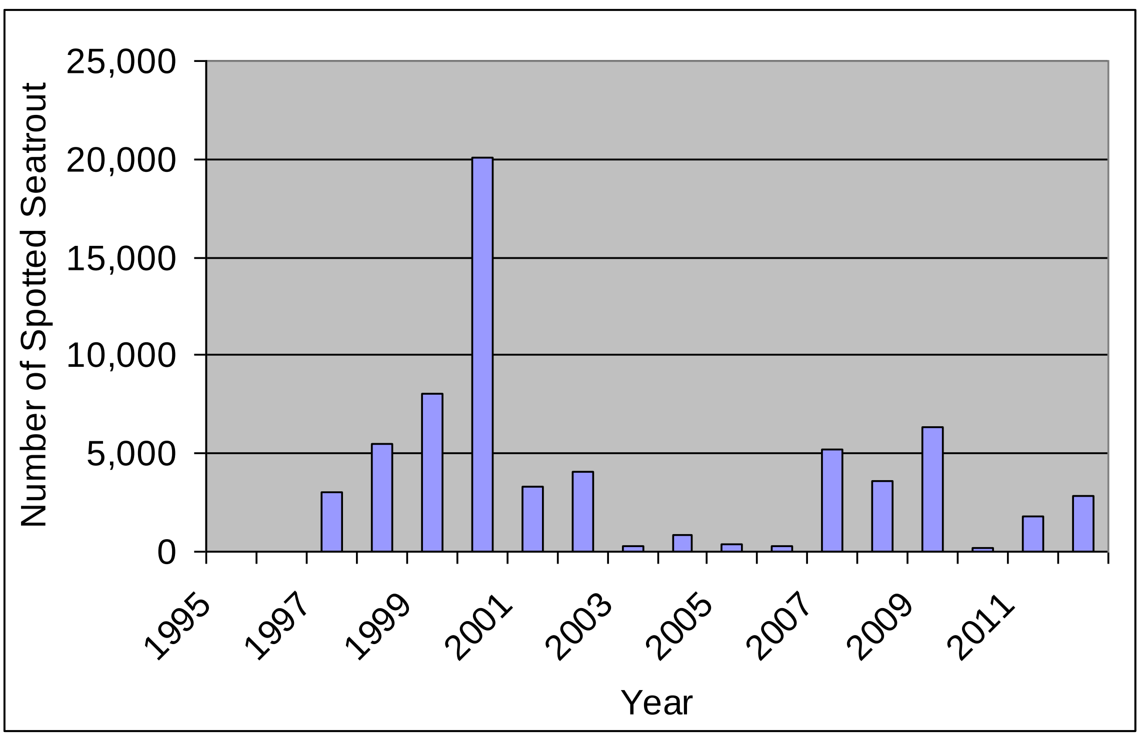


Figure 47. Spotted seatrout geometric mean catch per angler from Maryland charter boat logs, with 95% confidence intervals, 1993-2012.

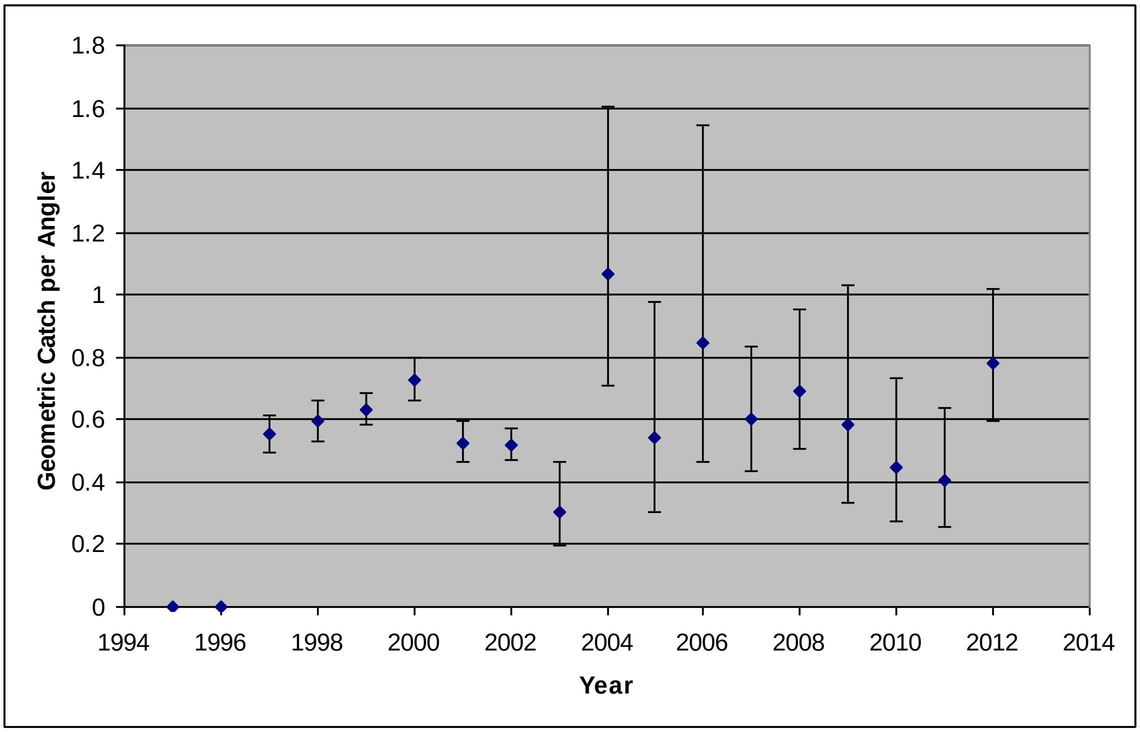


Figure 48. Menhaden length frequency distributions from onboard pound net sampling, 2004-2013.

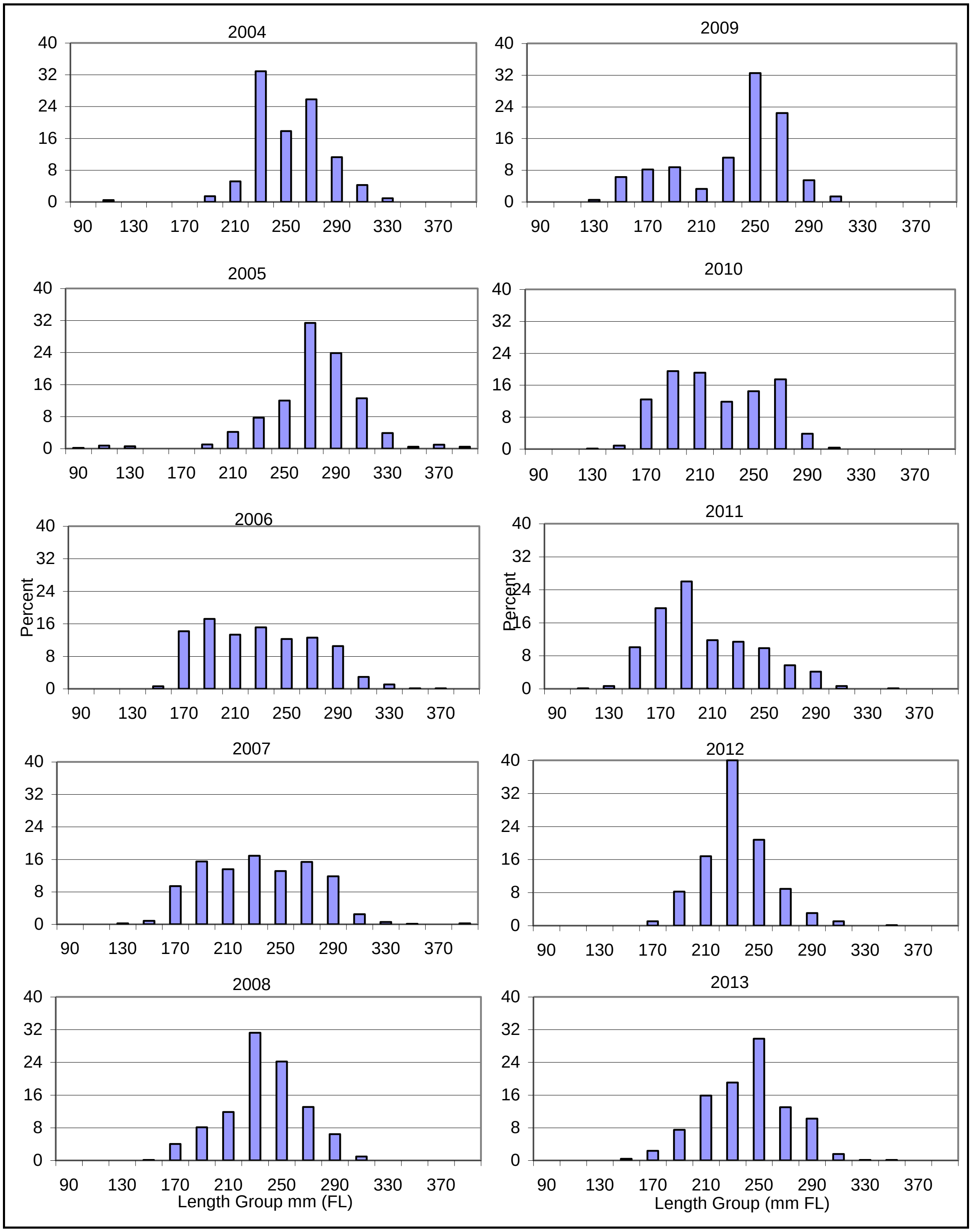
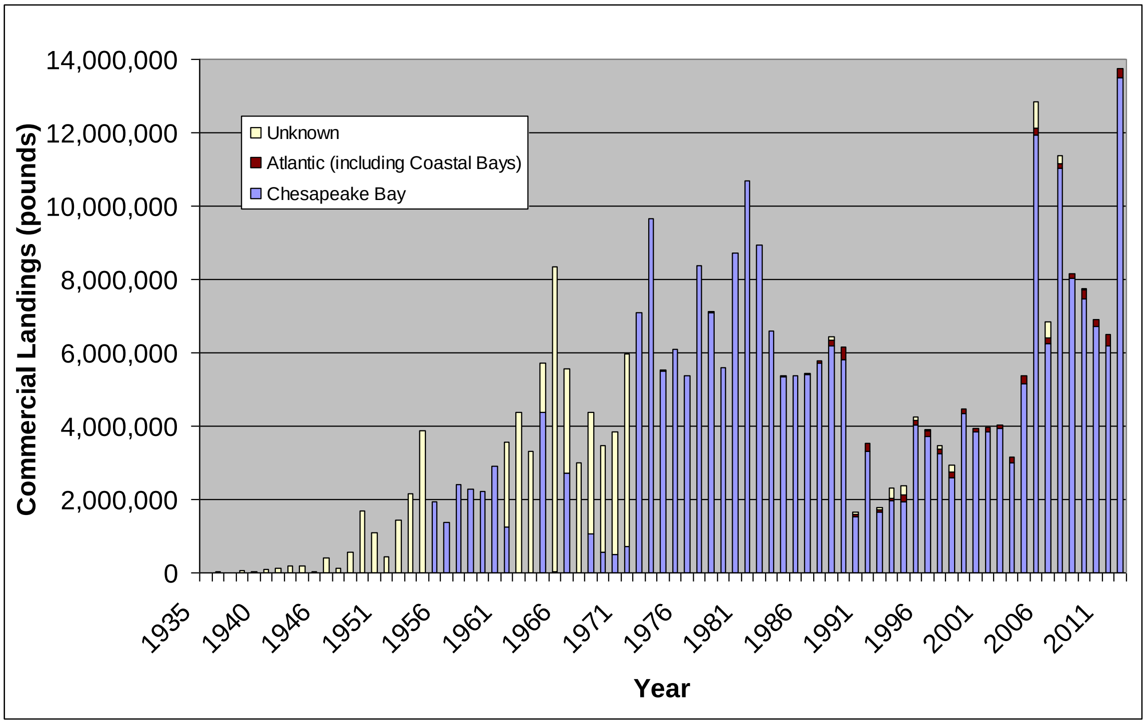


Figure 49. Maryland commercial Atlantic menhaden harvest by area, 1935-2012.



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 2012 Maryland striped bass (Morone saxatilis) commercial pound net and hook-and-line harvest. The 2012 pound net season ran from 1 June through 30 November while the commercial hook-and-line fishery was open from 7 June through 29 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 2012 commercial fisheries seasons were used to characterize the length and age structure of the entire 2012 Chesapeake Bay commercial harvest and the majority of the recreational harvest (Fegley 2001).

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 structure.

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 monthly from June through November 2012 (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 2012, 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. Full net sampling was not possible when pound nets contained too many fish to be transferred to FS boats. If a full net could not be sampled, a random sub-sample was taken.

At each net sampled, all 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-millimeter 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.

<u>Commercial pound net/hook-and-line fisheries monitoring (check station)</u>

All striped bass harvested in Maryland's commercial striped bass fisheries are required to pass through a MD DNR approved check station (see Project 2, Job 3, Task 5A). Check stations across Maryland were sampled for pound net and hook-and-line harvested fish each month from June through November 2012 (Figure 1). For the pound net fishery, sample targets were established of 100 fish per month from June through August and 200 fish per month for September through November. This monthly allocation reflects consistent historic patterns of harvest levels, which normally increase in the fall to twice summer levels. For the hook-and-line fishery, a sample target of 400 fish per month was established over the six-month season, since historical landings exhibited no clear monthly pattern. Target sample sizes for both fisheries were based on sample sizes and age-length keys derived from the 1997 and 1998 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-millimeter length group from striped bass less than 650 mm TL and from all striped bass greater than 650 mm TL from pound net and hook-and-line harvested fish. Scales taken from the pound net monitoring survey were combined with check station scales for ageing.

Analytical Procedures

Scale ages from the pound net and check station surveys were applied to all fish sampled. The number of scales read per length group varied depending on the size of the fish. 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 indicated no age*gear interaction ($P>F=0.8532$). Striped bass harvested by each gear exhibited 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 length size regulations are identical.

Age composition of the pound net and hook-and-line 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. Scales from check station surveys and pound net monitoring were combined to create the age-length key. 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 age-length key. The catch-at-age for each fishery was calculated by applying the age-length key to the hook-and-line and pound net length frequencies, and expanding the resulting age distribution to the landings. Landings are derived from mandatory reports submitted by commercial fisherman to MD DNR (see Project 2, Job 3, Task 5a).

In order to examine recruitment into the pound net and hook-and-line fisheries, the age structure of the harvest over time was examined. The age structure of the harvest for the 2012 hook-and-line and pound net fisheries 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 fisheries and months in 2012.

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

RESULTS and DISCUSSION

Pound net monitoring

During the 2012 striped bass pound net study, a total of 2,740 striped bass were sampled from two pound nets in the upper Bay and five pound nets in the lower Bay. The seven nets were sampled a total of 12 times during the study.

Striped bass sampled from pound nets ranged from 189-883 mm TL, with a mean length of 421 mm TL (Figure 2). In 2012, 72% of striped bass collected from full net samples were less than the minimum legal size of 18 inches TL, while 49% 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 1 fish from the above-average 2011 year-class contributed 17% of the sample. Age 3 fish contributed 27% in 2012, which was higher than the contribution in 2011 (14%). Five year-old fish from the above-average 2007 year-class contributed 12% in 2012. This was fewer age 5 fish than in 2011 (40%) and 2010 (31%). Age 6 fish from the below-average 2006 year-class contributed only 6% of the sample (Table 3). Striped bass age 6 and over were less common in 2012 accounting for

10% of the sample; less than their contribution in 2011 (30%) and 2010 (23%; Figure 3). Fish age 8 and older composed 1% of the sample in 2012, which was lower than 2011 (4%) and similar to 2010 (1%). Length frequencies of legal sized striped bass (n=1,013) sampled at pound nets were almost identical to length distributions from the check stations (Figure 4).

Hook-and-line check station sampling

A total of 1,988 striped bass were sampled at hook-and-line check stations in 2012. The mean length of sampled striped bass was 539 mm TL. Striped bass sampled from the hook-and-line fishery ranged from 450 to 836 mm TL and from 2 to 10 years of age (Figure 5).

The length frequency and ages of the sampled fish were applied to the total harvest. Striped bass in the 470-550 mm length groups accounted for 69% of the hook-and-line harvest, higher than 2011 (59%; Figure 5). Fish >630 mm TL contributed 9% to the total harvest. As in past years, few large fish were available to the hook-and-line fishery. Striped bass over 700 mm TL were harvested throughout the season, but contributed only 2% to the overall harvest (Figure 6). Historically, these fish have not been available in large numbers during the summer (MDDNR 2002). Approximately 1% of the harvest was sub-legal (<457 mm TL). Mean lengths-at-age and weights-at-age for the 2012 combined hook-and-line and pound net fisheries are shown in Tables 4 and 5.

The 2012 hook-and-line harvest accounted for 23%, by weight, of the Maryland Chesapeake Bay total commercial harvest in 2012 (see Project 2, Job 3, Task 5A). Total weight landed for the hook-and-line fishery was 424,657 pounds. The estimated 2012 catch-at-age of the hook-and-line fishery is presented in Table 6. The majority of the harvest was composed of three to seven year-old striped bass (95%). Striped bass from the above-average 2007 (age 5) year-class contributed the highest percentage at 34%. Fish from the strong 2003 year-class (age 9) accounted for less than 1%

of the total, less than in 2011 (3%). Striped bass age 8 and older contributed 2% to the overall harvest in 2012, less than in 2011 (4%). Age 2 striped bass from the 2010 year-class contributed 4% in 2012 (Figure 7).

Pound net check station sampling

A total of 788 striped bass were sampled at pound net check stations in 2012. Striped bass sampled ranged from 458 to 919 mm TL (Figure 5). Striped bass sampled from the pound net fishery ranged from 2 to 12 years of age. Striped bass in the 450-550 mm TL length groups accounted for 63% of the 2012 pound net harvest, which is more than 2011 (51%; Figure 5). The contribution of striped bass in the 570-630 mm TL length groups decreased from 32% in 2011 to 28% in 2012. Fish >630 mm TL composed 9% of the sample, half that of 2011 (17%). A number of large fish were available to the 2012 pound net fishery at certain times of the year, but fewer than previous years (Figure 6). Mean lengths-at-age and weights-at-age from the combined 2012 hook-and-line and pound net fisheries are shown in Tables 4 and 5, respectively.

The pound net fishery accounted for 31%, by weight, of the Maryland Chesapeake Bay 2012 commercial harvest (see Proj. 2, Job 3, Task 5A). Total weight landed for the pound net fishery was 565,600 pounds. The estimated 2012 catch-at-age for the pound net fishery is presented in Table 6. Fish age three to seven contributed 96% of the 2012 total pound net harvest. Two year old striped bass (2010 year class), which occur rarely in this fishery, contributed 2% of the harvest (Figure 7). The contribution of nine year-old fish from the 2003 year-class was lower in the pound net harvest in 2012 than in 2011, contributing 1% to the total harvest (Figure 7). Striped bass age 8 and over composed 3% of the 2012 harvest, much lower than the contribution in 2011 (10%). Sub-legal striped bass (< 457 mm TL) were not encountered in the sample.

Monitoring summary

Striped bass ranging from 457 to 550 mm TL composed 63% and 70% of the 2012 pound net and hook-and-line fisheries, respectively. There were fewer large fish (>630 mm) harvested in 2012 compared to 2011 (6% for hook-and-line and 9% for pound net; Figure 5). In 2012, 105 fish from pound net monitoring and 93 fish from check station sampling were aged. Younger fish (age 3 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).

The mean lengths of 4, 5, and 6 year-old legal-sized striped bass (≥457 mm TL) decreased during the period 1990 to 2000 (Figure 8). Since 2001, there was no apparent trend for mean lengths of striped bass aged 4 to 6.

A Duncan's multiple range test (SAS 2006) performed on lengths and weights of striped bass harvest between fisheries and months indicated that fish were significantly ($P<0.05$) longer and heavier from the pound net fishery than the hook-and-line fishery. During the hook-and-line fishery, the longest and heaviest fish were sampled in June and the smallest in August, September and October. Striped bass sampled in June were significantly longer than all other months. July fish were significantly longer than August, September, October, and November. Striped bass sampled in June were significantly heavier than fish harvested in any other month. Striped bass harvested in July and November were significantly heavier than those in August, September and October.

In the pound net check station monitoring, the longest and heaviest fish were harvested in June and November and the smallest in August and September. Striped bass in July and October were significantly longer and heavier than those in August and September, but smaller and lighter than June and November.

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Table 1. Summary of sampling areas, sampling dates, surface temperature, surface salinity and numbers of fish encountered during the 2012 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	-	-	-	-
	Middle	-	-	-	-
	Lower	1	23.2	13.5	92
July	Upper	1	26.7	9.3	98
	Middle	-	-	-	-
	Lower	1	27.3	14.9	191
August	Upper	1	26.4	12.3	284
	Middle	-	-	-	-
	Lower	-	-	-	-
September	Upper	-	-	-	-
	Middle	-	-	-	-
	Lower	1	22.5	17.1	218
October	Upper	1	17.3	13.2	294
	Middle	-	-	-	-
	Lower	4	19.0	17.2	1202
November	Upper	1	7.6	11.9	85
	Middle	-	-	-	-
	Lower	1	14.3	14.3	276

Table 2. Mean length-at-age (mm TL) of striped bass sampled from pound nets in Maryland's Chesapeake Bay, June through November 2012.

Year-class	Age	n	Mean length (mm TL)	STD	STDERR	Lower CL	Upper CL
2011	1	19	249	45	10	227	271
2010	2	16	355	46	12	330	380
2009	3	20	436	74	17	401	471
2008	4	10	513	83	26	454	573
2007	5	10	643	75	24	590	696
2006	6	7	648	77	29	577	719
2005	7	11	682	62	19	640	723
2004	8	5	771	61	27	696	847
2003	9	6	783	45	18	736	830
2002	10	-	-	-	-	-	-
2001	11	1	883	-	-	-	-

Table 3. Number of striped bass, by age, sampled from pound nets, in Maryland's Chesapeake Bay, June through November 2012.

Year-class	Age	Pound Net Monitoring	
		Number sampled at age (n)	Percent of Total
2011	1	477	17.39
2010	2	638	23.28
2009	3	752	27.45
2008	4	262	9.56
2007	5	333	12.16
2006	6	166	6.08
2005	7	86	3.14
2004	8	13	0.47
2003	9	11	0.38
2002	10	1	0.04
2001	11	1	0.04
Total		**2,740**	**100.00**

Table 4. Mean length-at-age (mm TL) of legal-size striped bass (≥457 mm TL/18 in TL) sampled from commercial pound net and hook-and-line fisheries in Maryland's Chesapeake Bay, June through November 2012.

Year-class	Age	n	Mean Length (mm TL)	STD	STDERR	Lower CL	Upper CL
2010	2	2	472	6	5	414	529
2009	3	6	480	24	10	455	506
2008	4	3	505	51	29	380	631
2007	5	27	603	77	15	573	634
2006	6	16	641	85	21	596	687
2005	7	16	689	75	19	649	729
2004	8	10	747	75	24	693	800
2003	9	8	757	64	23	703	810
2002	10	3	799	46	26	685	912
2001	11	1	919	-	-	-	-
2000	12	1	744	-	-	-	-

Table 5. Mean weight-at-age (kg) of legal-size striped bass (≥457 mm TL/18 in TL) sampled from commercial pound net and hook-and-line fisheries in Maryland's Chesapeake Bay, June through November 2012. Mean weights are weighted by the sample n-at-length in each age.

Year-Class	Age	n Aged	Weighted Mean weight* (kg)
2010	2	2	1.0
2009	3	6	1.0
2008	4	3	1.2
2007	5	27	2.2
2006	6	16	2.6
2005	7	16	3.3
2004	8	10	4.3
2003	9	8	4.6
2002	10	3	5.4
2001	11	1	7.4
2000	12	1	4.6

* Mean weights-at-age were calculated based on the age-length key and length and weight measurements of individual fish.

Table 6. Estimated catch-at-age of striped bass landed by Maryland Chesapeake Bay commercial hook-and-line and pound net fisheries, June through November 2012.

Year-class	Age	Hook and Line		Pound Net	
		Landings in Pounds of Fish	**Percent of Total**	**Landings in Pounds of Fish**	**Percent of Total**
2010	2	15,099	3.6	8,848	1.6
2009	3	76,474	18.0	90,393	16.0
2008	4	71,346	16.8	87,344	15.4
2007	5	144,015	33.9	190,016	33.6
2006	6	76,570	18.0	113,308	20.0
2005	7	33,616	7.9	59,251	10.5
2004	8	4,361	1.0	8,346	1.5
2003	9	2,990	0.7	5,972	1.1
2002	10	187	0.1	688	0.1
2001	11	0	0.0	717	0.1
2000	12	0	0.0	717	0.1
Total*		**424,657**	**100.0**	**565,600**	**100.0**

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

Figure 1. Locations of Chesapeake Bay commercial pound net and hook-and-line check stations sampled from June through November 2012.

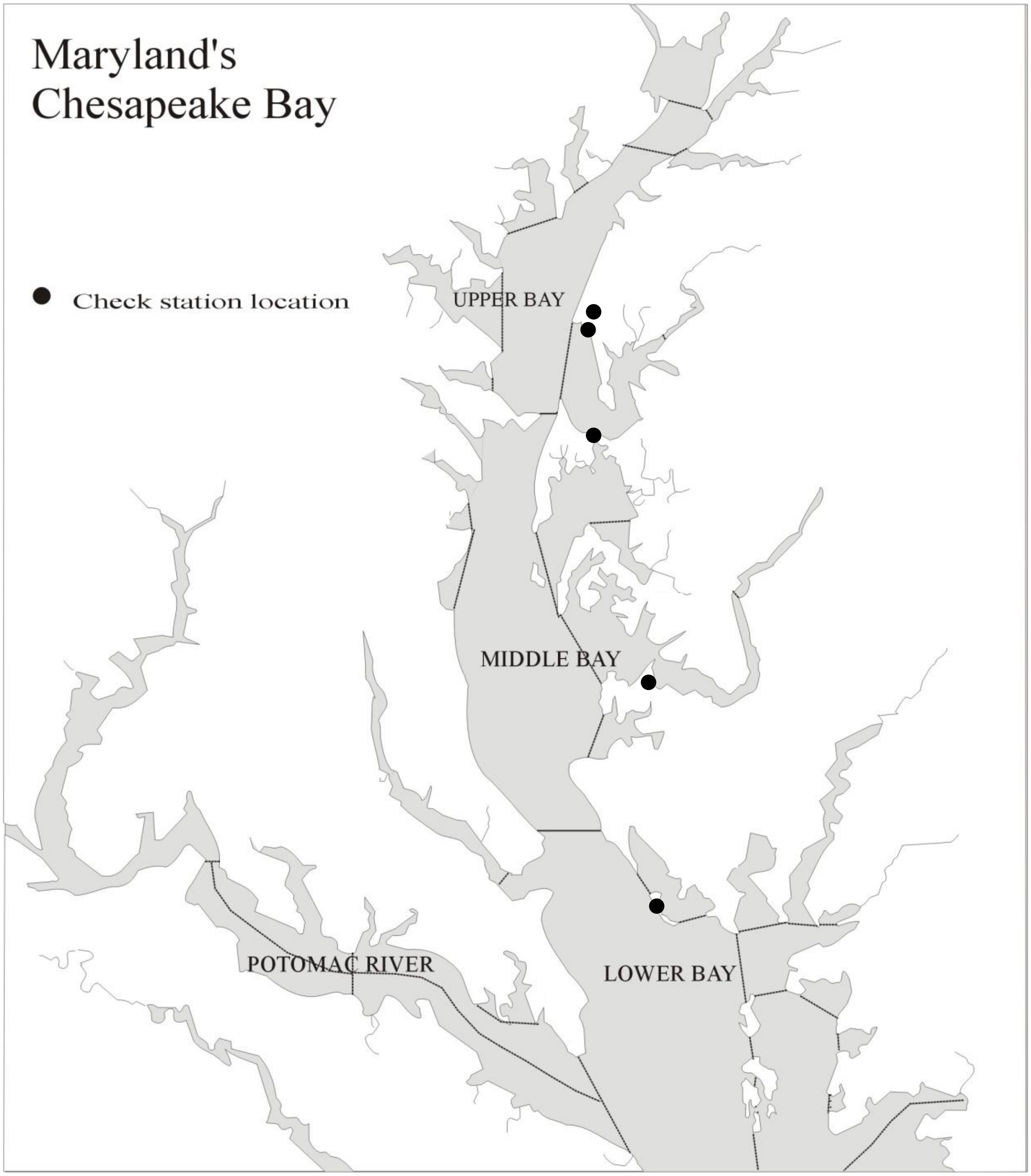
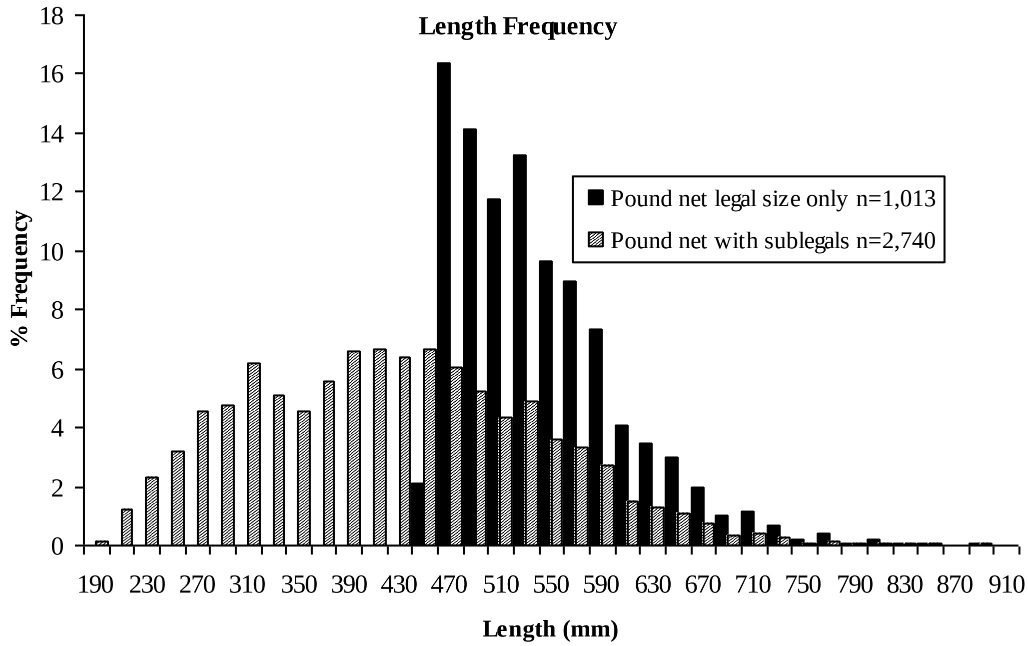


Figure 2. Age and length (mm TL) frequencies of striped bass sampled during Maryland Chesapeake Bay pound net monitoring study, June through November 2012.



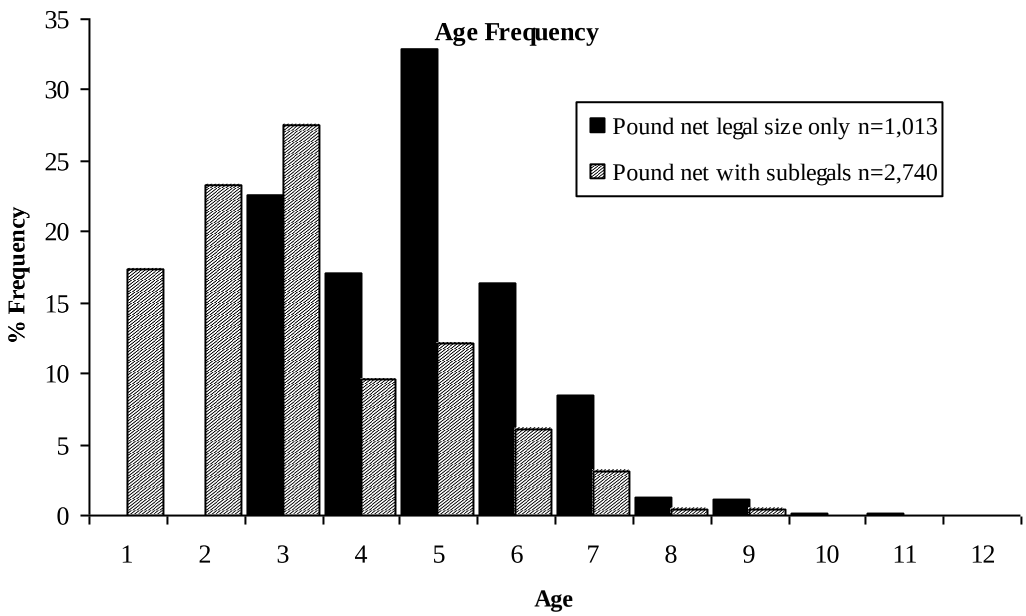


Figure 3. Age structure of striped bass (≥457 mm TL/18 in TL) sampled from Maryland Chesapeake Bay commercial pound net monitoring study from 1996 through 2012.

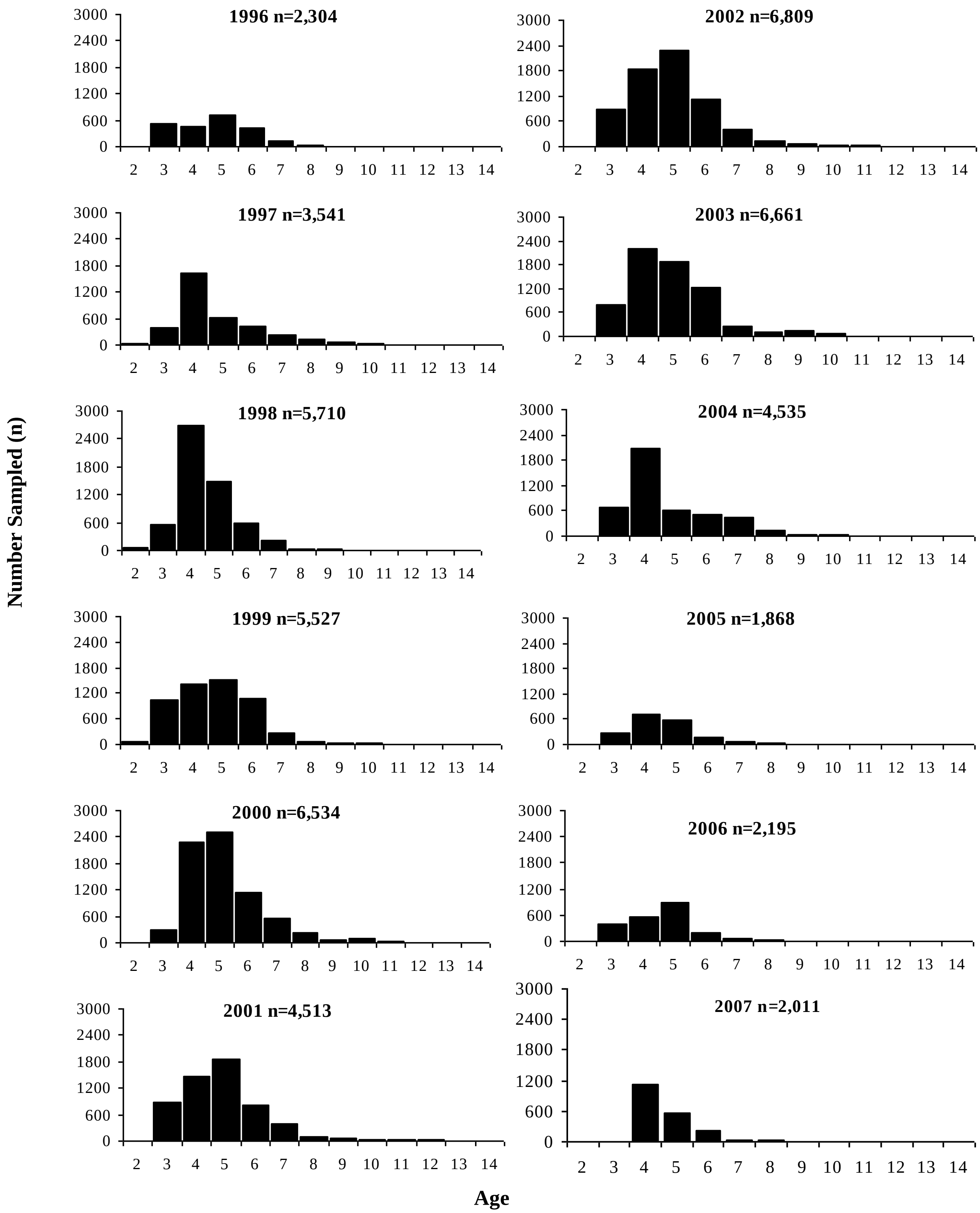


Figure 3. Continued.

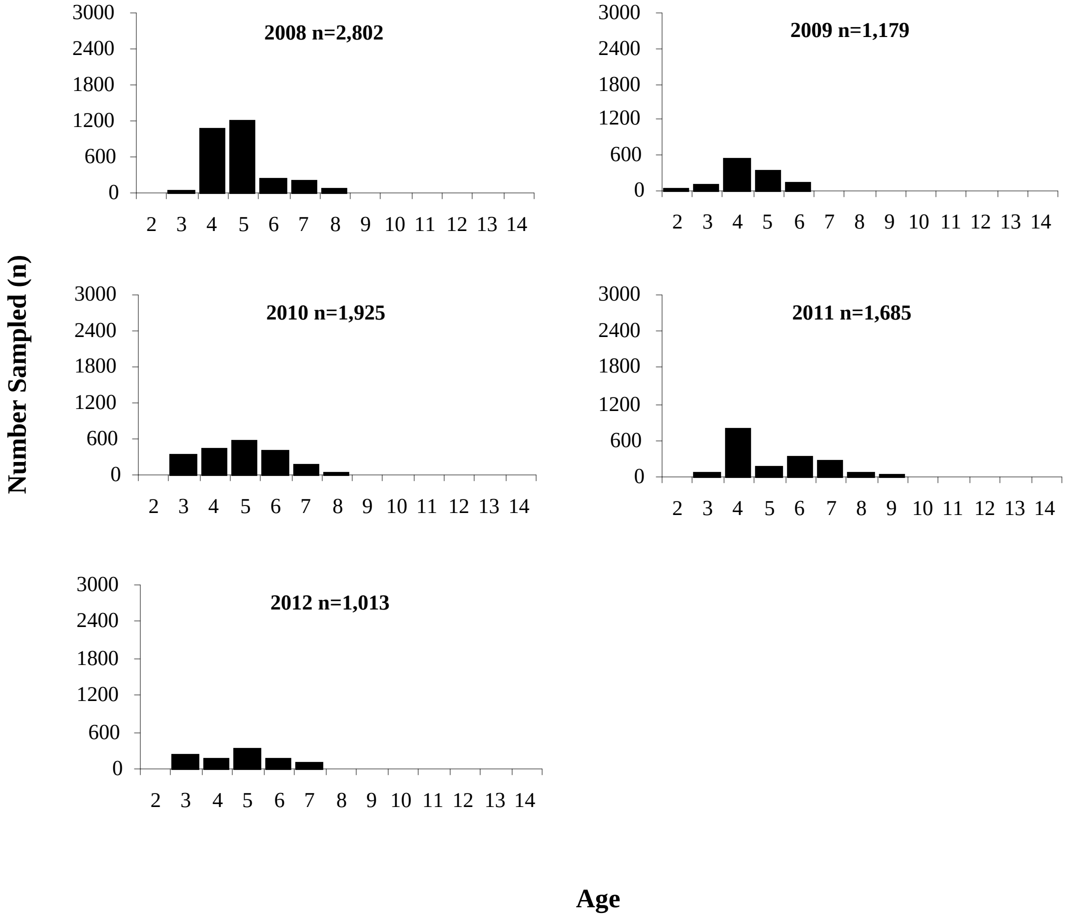


Figure 4. Length frequency of striped bass sampled during the 2012 pound net monitoring, pound net check station and hook-and-line check station surveys. All fish were sampled from June through November 2012. Pound net monitoring length frequency is for legal-size fish only (≥457 mm TL/18 in TL).

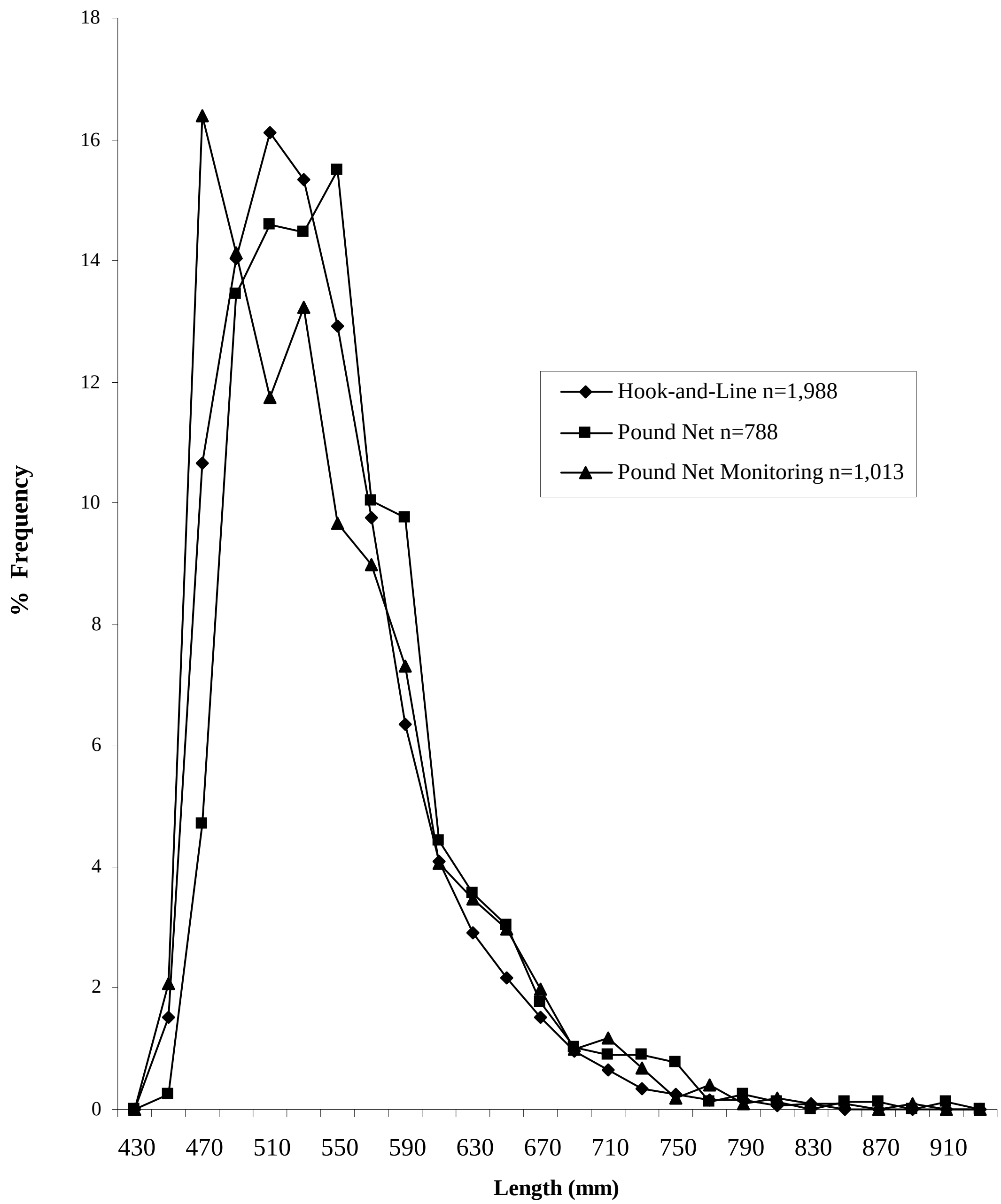
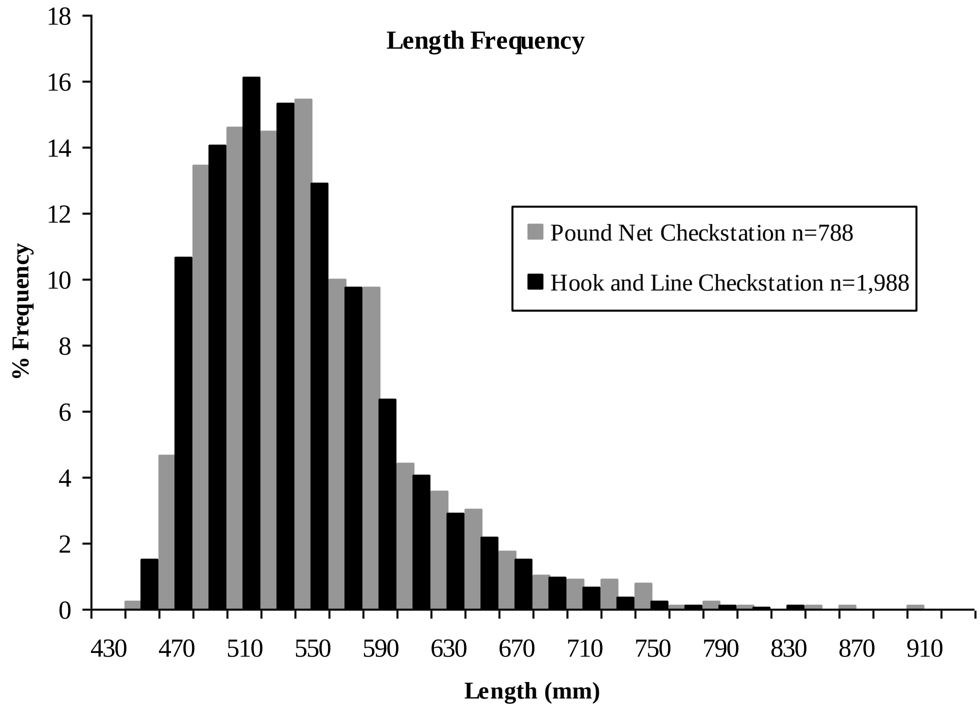


Figure 5. Age and length frequencies of striped bass sampled from Maryland Chesapeake Bay commercial hook-and-line and pound net check stations, June through November 2012.



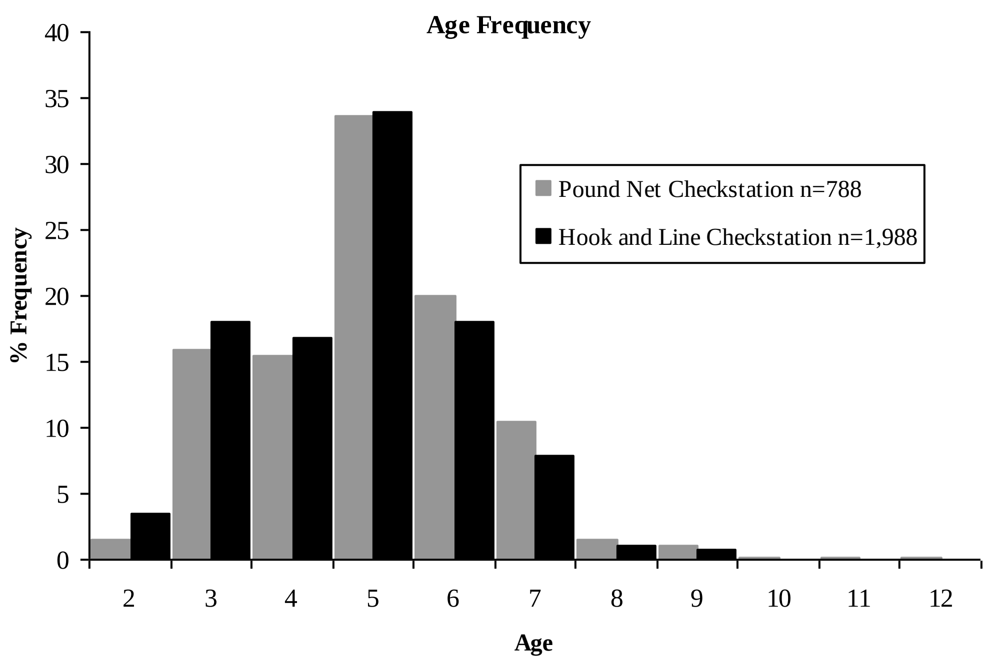


Figure 6. Month-specific length distributions of striped bass sampled from Maryland Chesapeake Bay commercial hook-and-line and pound net fisheries, June through November 2012.

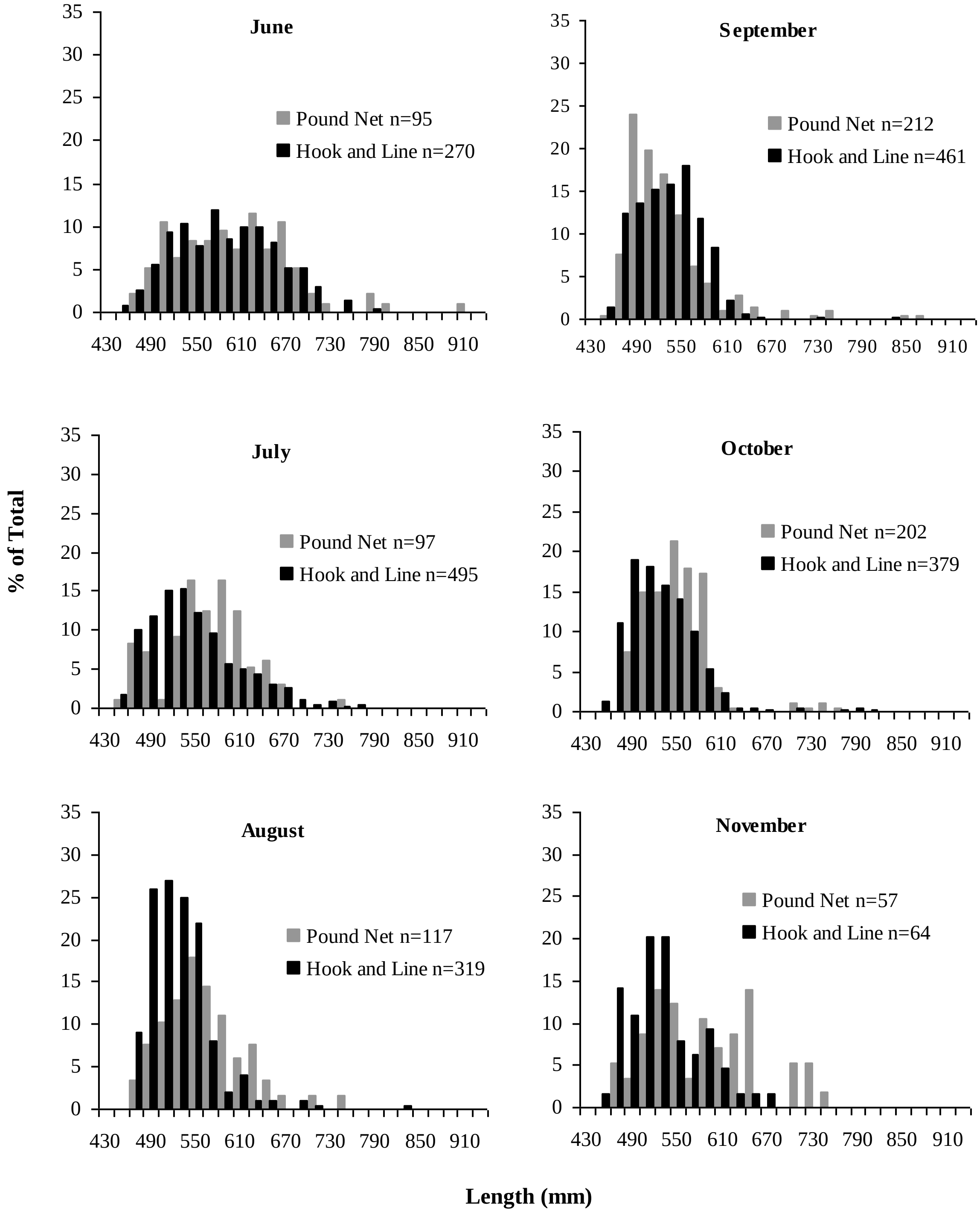


Figure 7. Age structure of striped bass sampled from Maryland Chesapeake Bay commercial hook-and-line and pound net check stations, 1999 through 2012. Note-pound net check station sampling began in 2000.

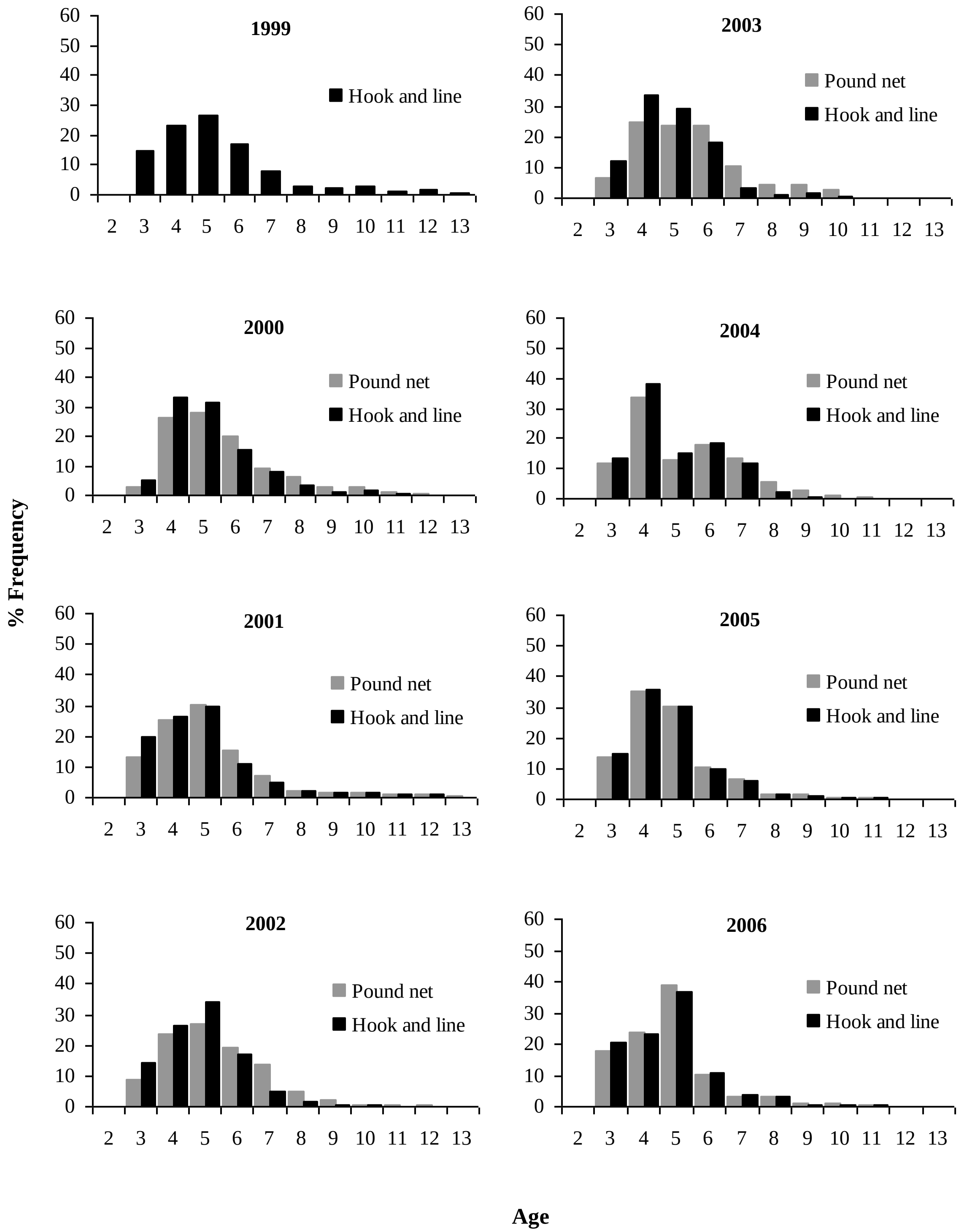


Figure 7. Continued.

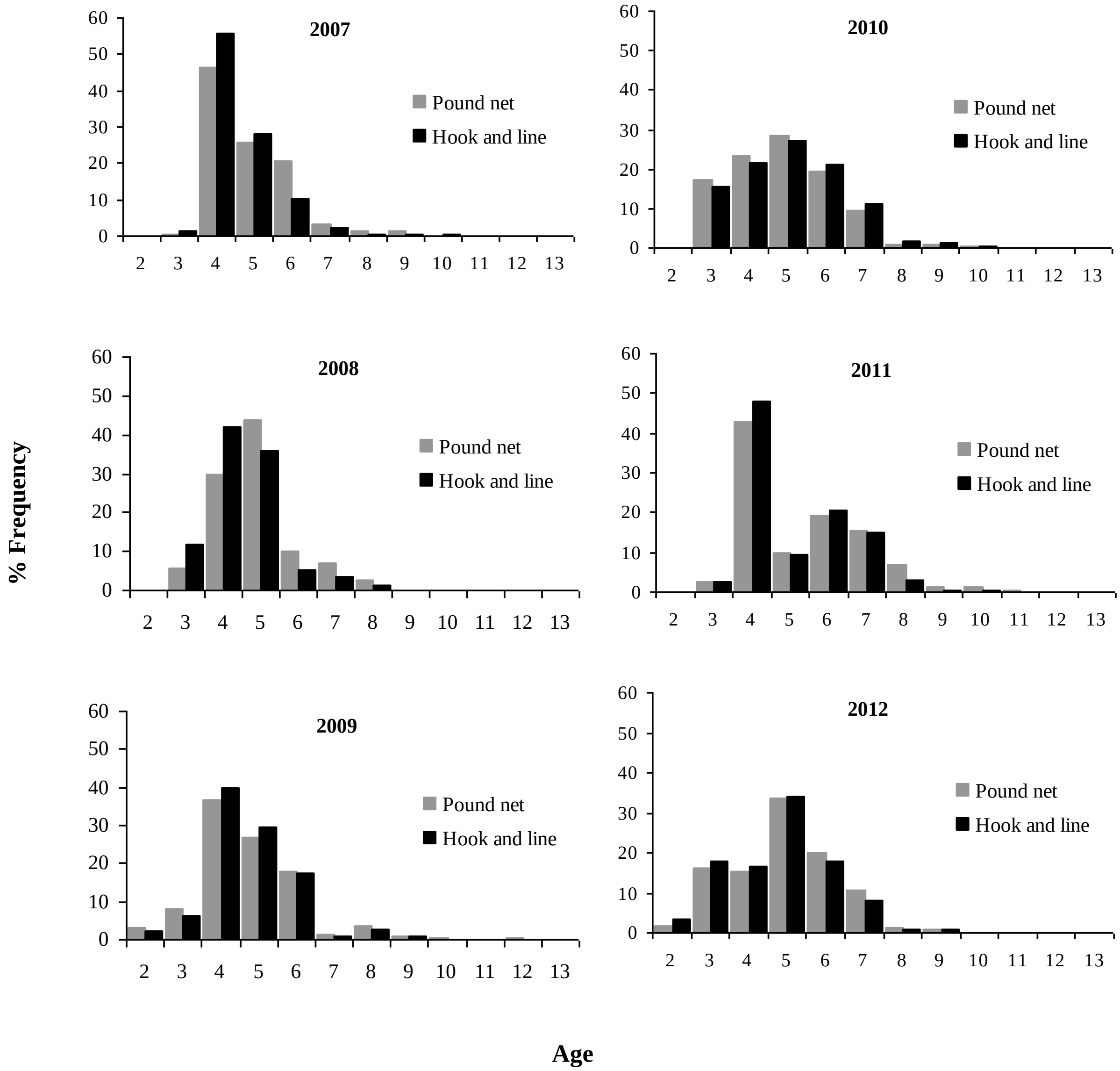
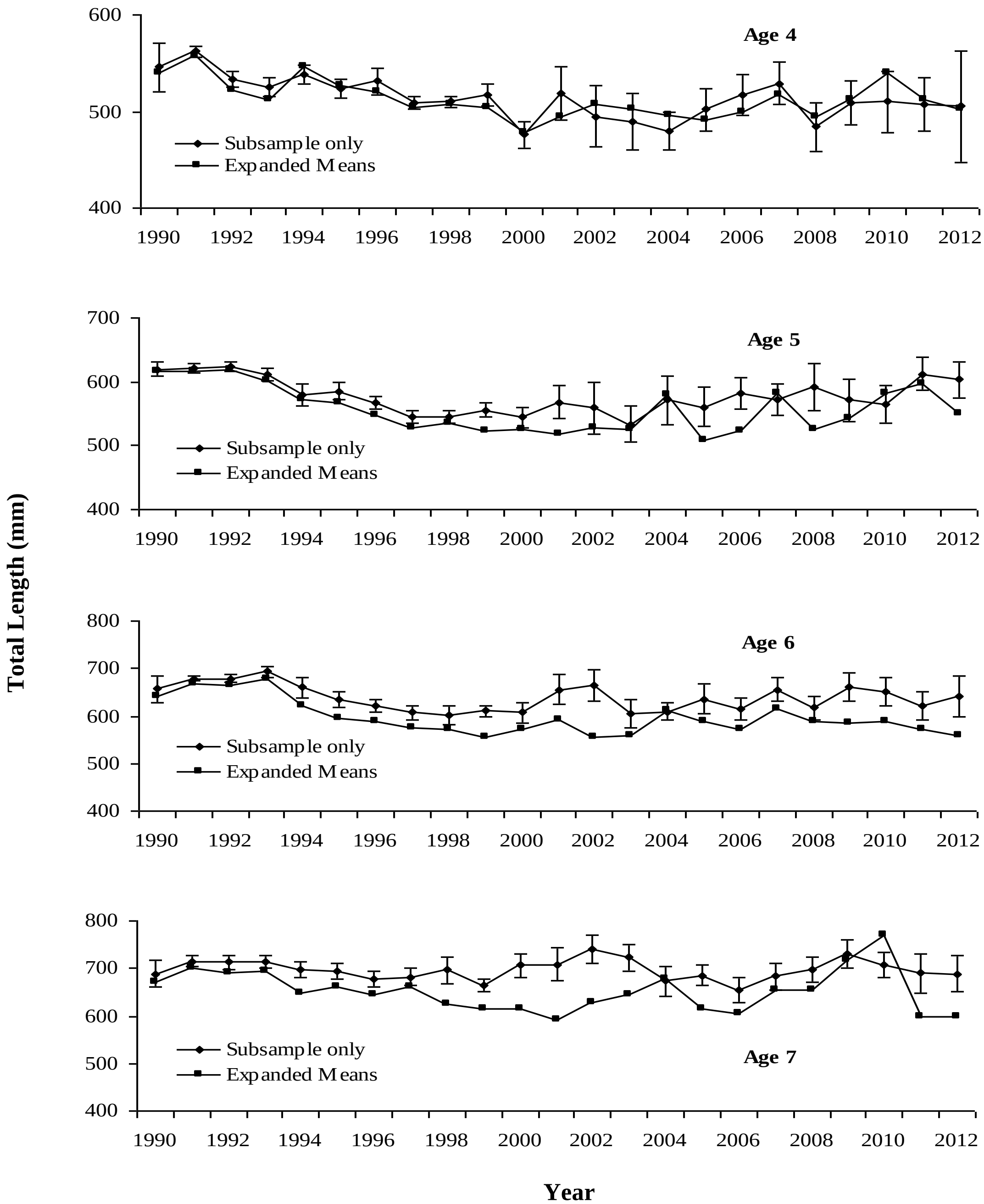


Figure 8. Mean lengths for legal-size striped bass (≥457 mm TL) by year for 4, 5, 6, and 7 year-old striped bass sampled from Maryland Chesapeake Bay pound nets and commercial hook-and-line and pound net check stations, 1990 through 2012. Mean lengths were calculated by using sub-sampled ages only and 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 11, 2012 - February 27, 2013 commercial drift gill net fishery. This fishery targets resident/pre-migratory Chesapeake Bay striped bass and accounts for approximately 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 (ASMFC) coastal striped bass stock assessment.

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; one medium-use station was sampled for every three visits to a high-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. Sampling was distributed as evenly as possible between northern and eastern geographic areas of the Chesapeake Bay. The northern-most check station sampled in this survey was located in Millington, while the southern-most station was located on Hooper's Island (Figure 1).

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 at least 300 striped bass per visit 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, but scales were taken from all fish greater than or equal to 700 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 2012-2013 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 2012 – February 2013 gill net season, the year used for age calculations was 2013.

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 2012-2013 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 3,669 striped bass were sampled and 139 striped bass were aged from the harvest between December 2012 - February 2013. The gill net season was open for 9 days in December, 10 days in January, and 6 days in February due to high catch rates.

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 between years based on year-class strength. The number of fish landed for the 2012-2013 season was estimated by dividing reported monthly harvest weight by the mean monthly weight of checkstation samples. Total landings were 829,238 pounds and 159,660 fish. According to the estimated catch-at-age analysis, the 2012-2013 commercial drift gill net harvest consisted primarily of age 5 striped bass from the 2008 year-class (39%; Table 1). The 2009 and 2007 year-classes (ages 4 and 6) composed an additional 41% of the total harvest, while ages 8 and older contributed 8% to the total. The contribution of fish older than 8 years was higher than in the 2011-2012 harvest (2%) and the 2010-2011 harvest (6%). The youngest fish observed in the 2012-2013 sampled harvest were age 3.

Mean lengths and weights-at-age of the aged subsample and the estimated means from the expansion technique are presented in Tables 2 and 3. Expanded mean lengths and weights-at-age were generally slightly higher than subsample means for smaller fish and slightly lower for larger fish. Striped bass were recruited into the winter gill net fishery beginning at age 3 (2010 year-class), with an expanded mean length and weight of 511 mm TL and 1.51 kg, respectively. The 2008 year-class (age 5) was most commonly observed in the sampled landings and had an expanded mean length and weight of 536 mm TL and 1.75 kg, respectively. The expanded mean length and weight of the oldest fish in the aged subsample (age 12, 2001 year-class) were 847 mm TL and 7.54 kg, respectively.

The length frequency of the check station samples are presented in Figure 3. The length frequency distributions were dominated by fish in the 490-610 mm TL range. Sub-legal fish (<457 mm) composed less than 1% of the Bay-wide sampled harvest.

Time series of subsampled and expanded mean lengths and weights for the period 1994-2013 are shown in Figures 4 and 5 for fish ages 4 through 9, which generally make up 95% or more of the harvest. Mean length-at-age and weight-at-age for age 4 and 5 striped bass have been relatively constant. Mean length-at-age and weight-at-age for ages 6, 7, 8, and 9 are more variable, likely due to smaller sample sizes or greater range of lengths and weights for each age group.

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Table 1. Estimated catch-at-age of striped bass (numbers of fish) landed by the Maryland Chesapeake Bay commercial drift gill net fishery, December 2012 - February 2013.

Year-class	**Age**	**Catch**	**Percentage of the catch**
2010	3	3,281	2
2009	4	16,537	10
2008	5	62,886	39
2007	6	49,786	31
2006	7	14,579	9
2005	8	6,079	4
2004	9	3,294	2
2003	10	2,657	2
2002	11	387	0
2001	12	174	0
Total*		**159,660**	**100**

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

Table 2. Mean total lengths (mm TL) by year-class of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, December 2012-February 2013.

Year-class	Age	n fish aged	Mean TL (mm) of aged subsample	Estimated # at-age in sample	Expanded mean TL (mm)
2010	3	1	503	75	511
2009	4	9	493	380	515
2008	5	21	525	1,445	536
2007	6	23	630	1,144	599
2006	7	17	702	335	651
2005	8	14	733	140	699
2004	9	22	789	76	746
2003	10	23	811	61	762
2002	11	6	826	9	799
2001	12	3	844	4	847
Total*		**139**		**3,669**	

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

Table 3. Mean weights (kg) by year-class of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, December 2012-February 2013.

Year-class	Age	n fish aged	Mean weight (kg) of aged subsample	Estimated # at-age in sample	Expanded mean weight (kg)
2010	3	1	1.42	75	1.51
2009	4	9	1.47	380	1.58
2008	5	21	1.65	1,445	1.75
2007	6	23	2.98	1,144	2.51
2006	7	17	4.22	335	3.36
2005	8	14	4.76	140	4.24
2004	9	22	6.04	76	5.15
2003	10	23	6.71	61	5.51
2002	11	6	6.95	9	6.14
2001	12	3	8.13	4	7.54
Total*		**139**		**3,669**	

* 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 2012-February 2013.

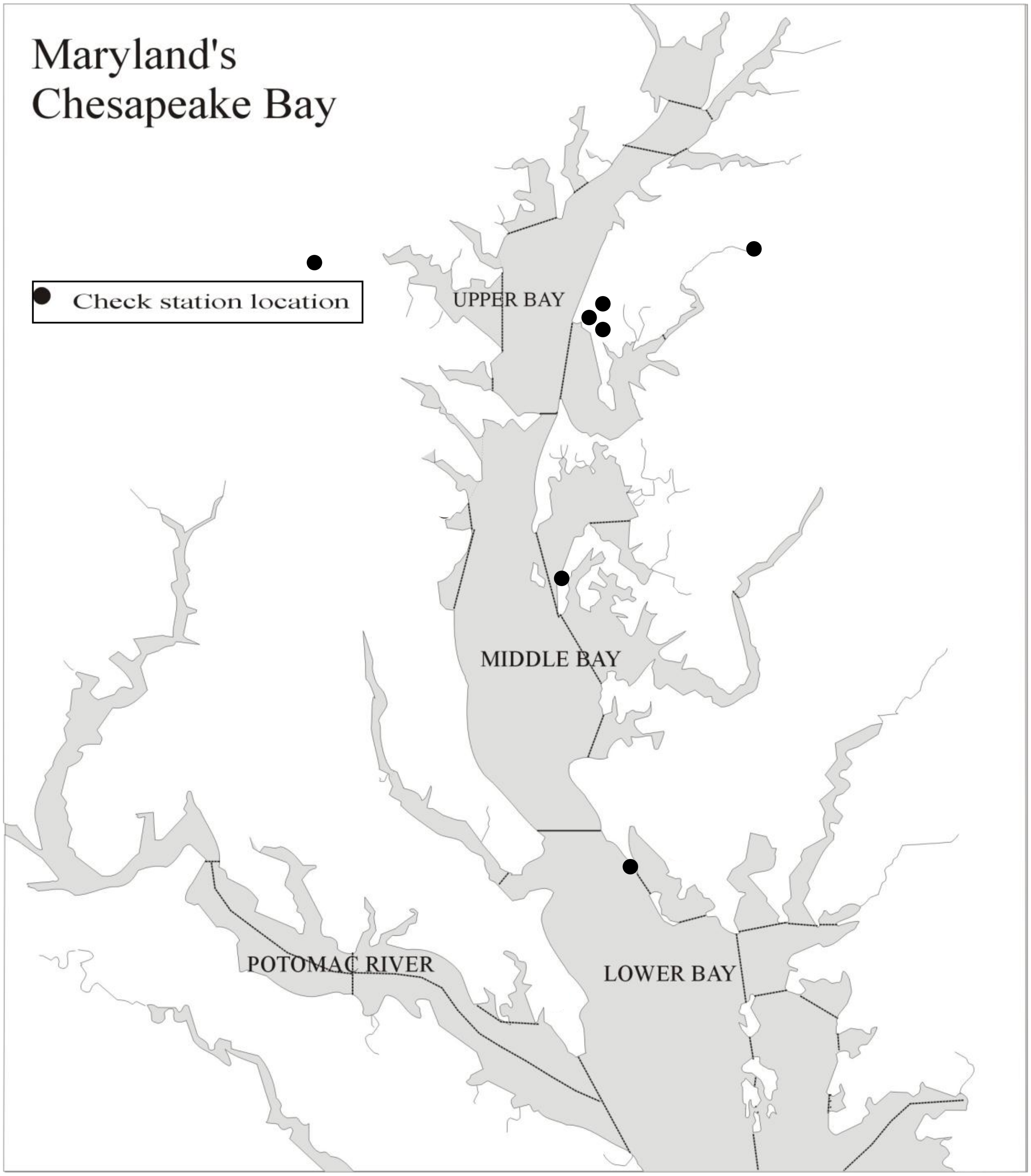
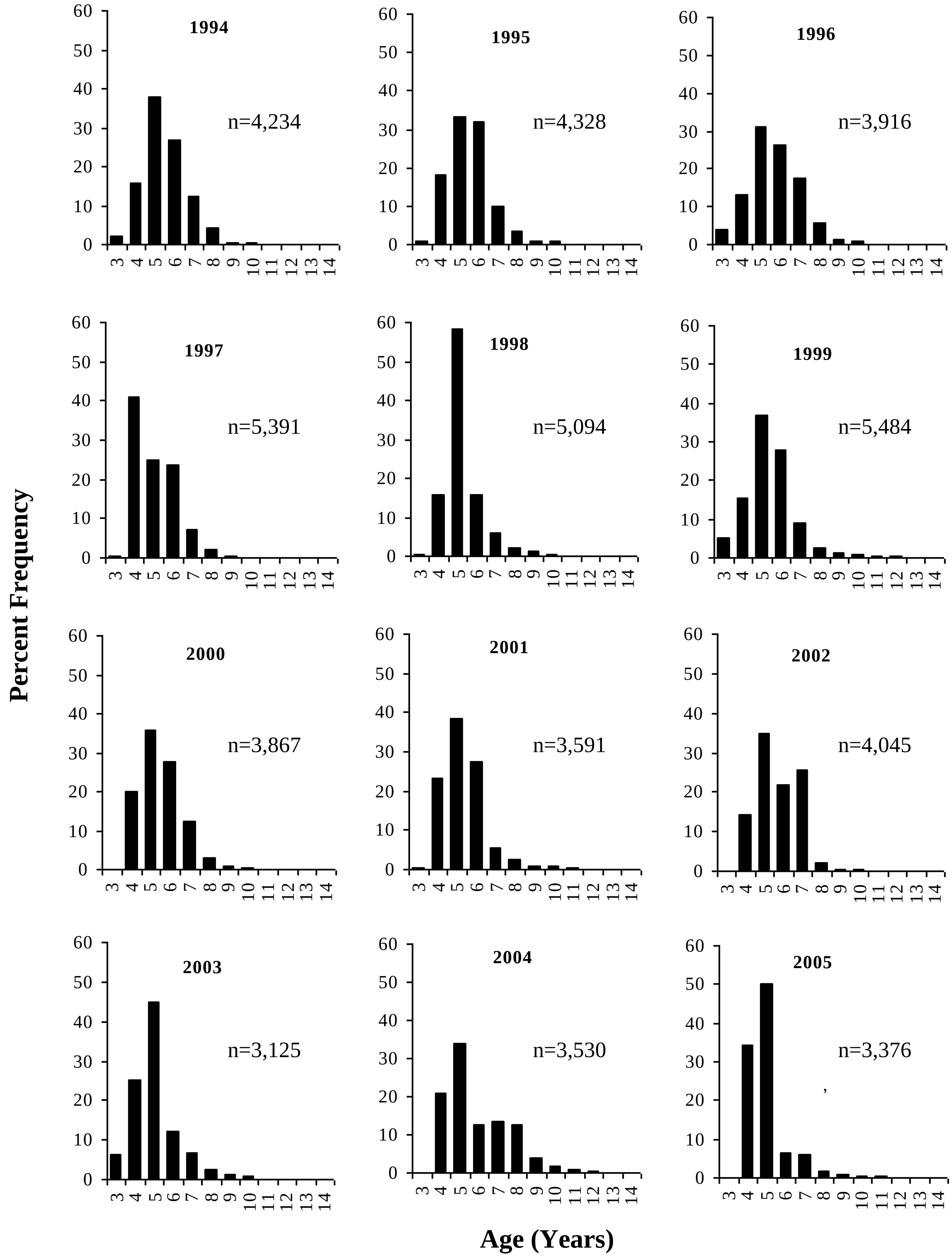


Figure 2. Age distribution of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, 1994-2013.



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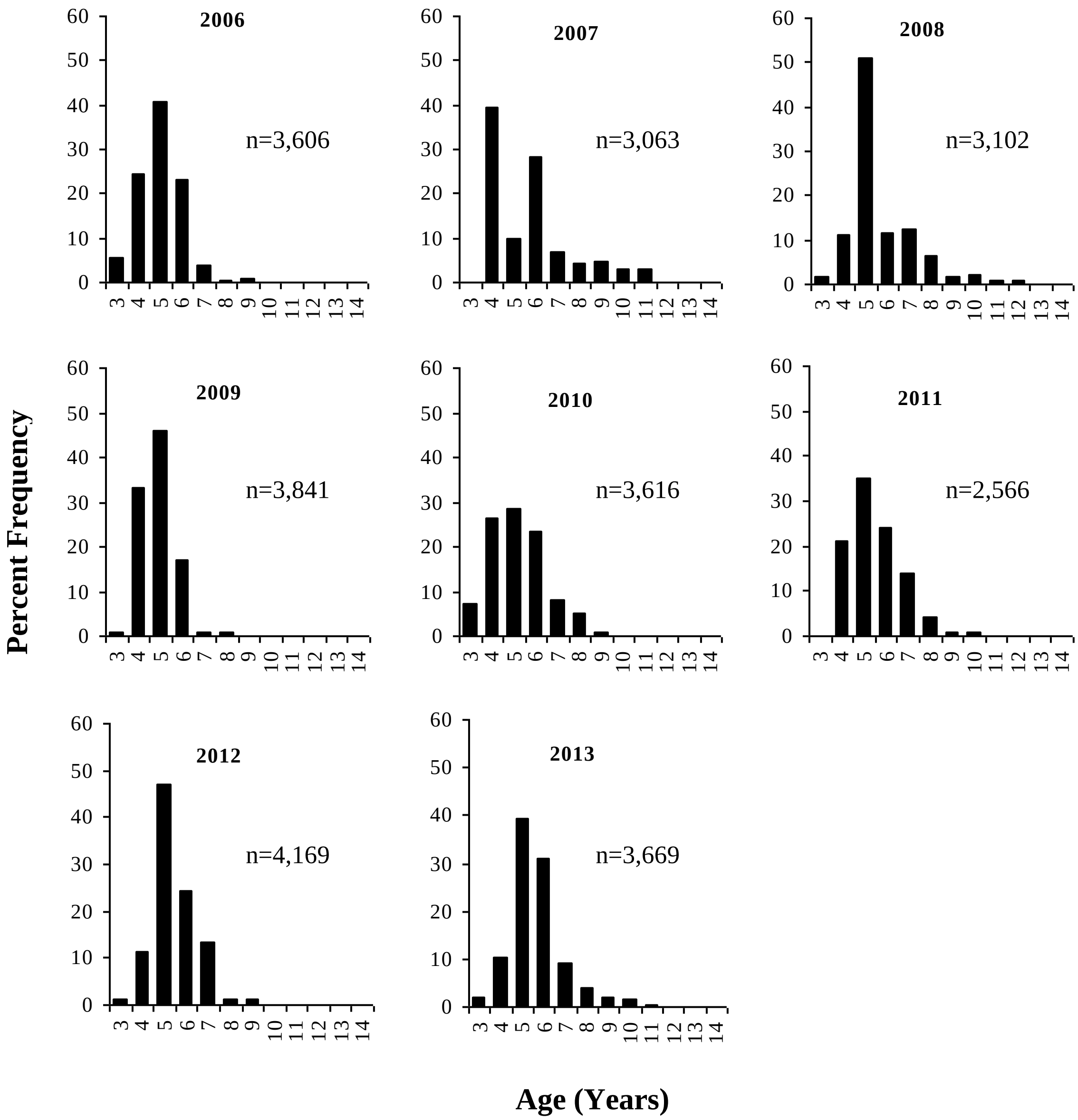


Figure 3. Length frequency distribution of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, December 2012-February 2013.

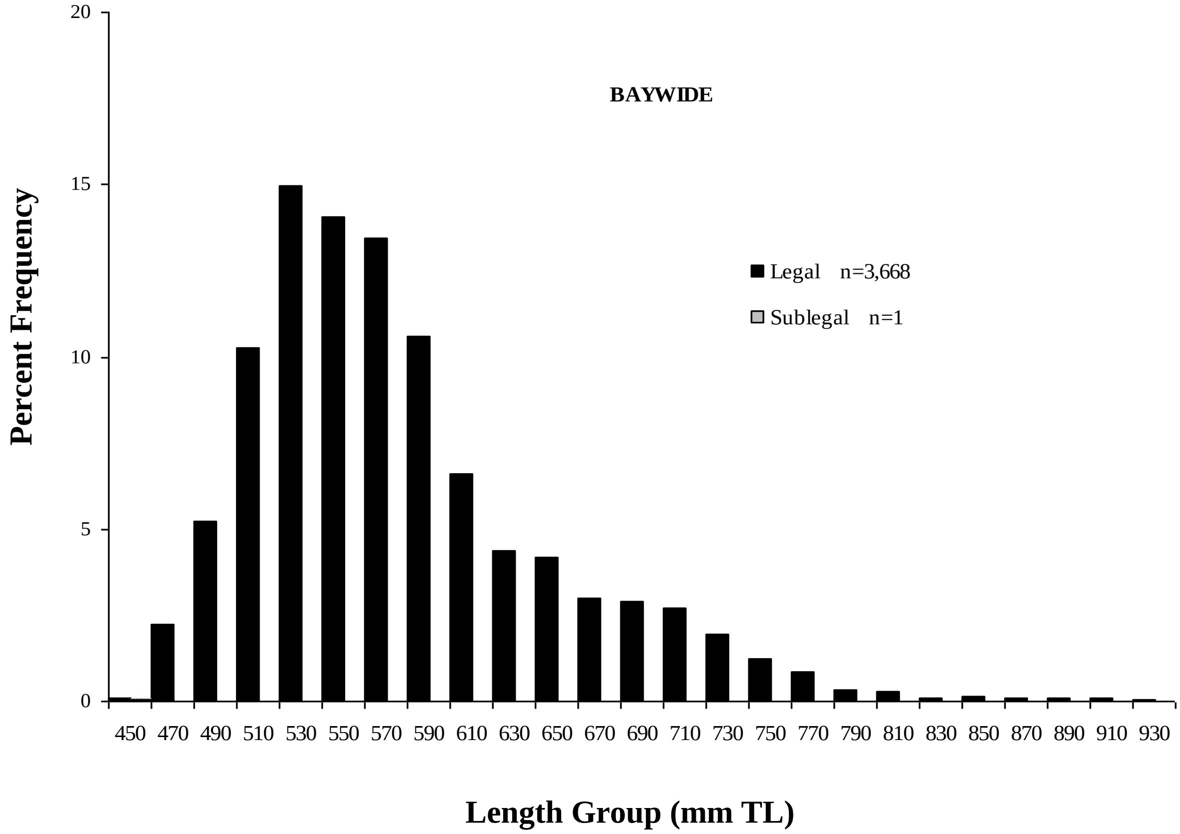
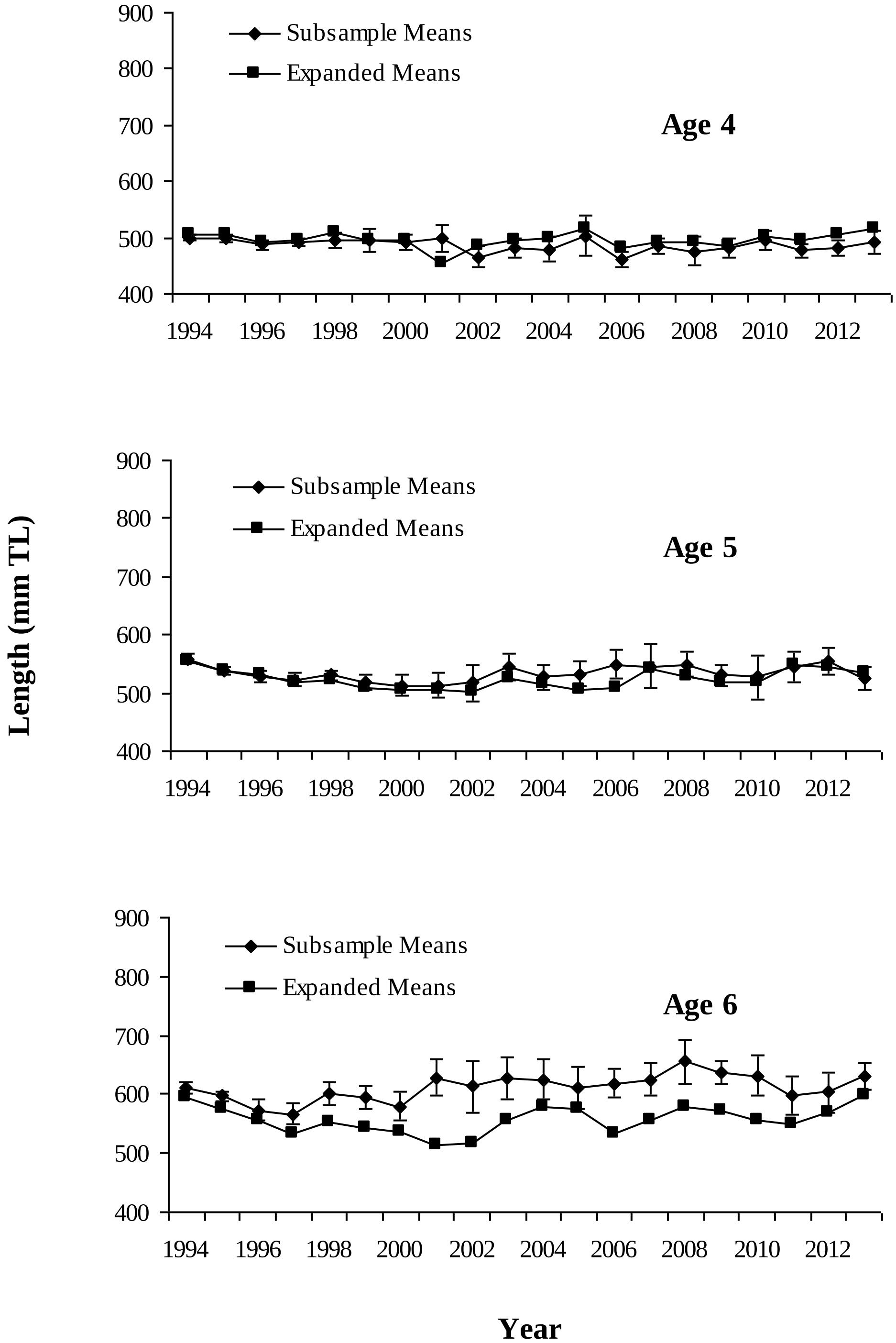


Figure 4. Mean total lengths (mm TL) of the aged subsample, by year, for individual age-classes of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net landings, 1994-2013 (95% confidence intervals are shown around each point). Expanded means (estimated from entire sample) are also shown. Year refers to the year in which the season ended.



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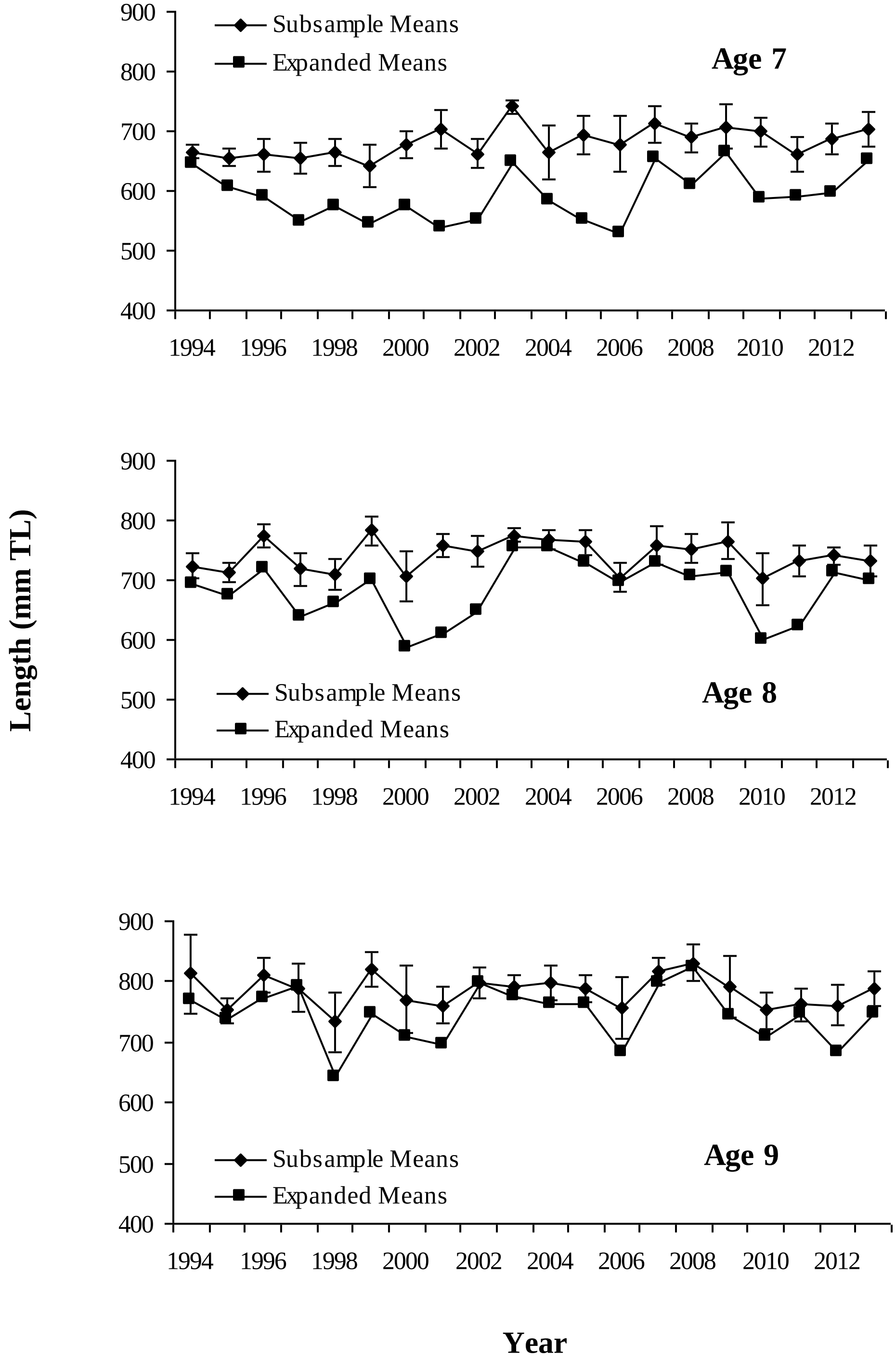
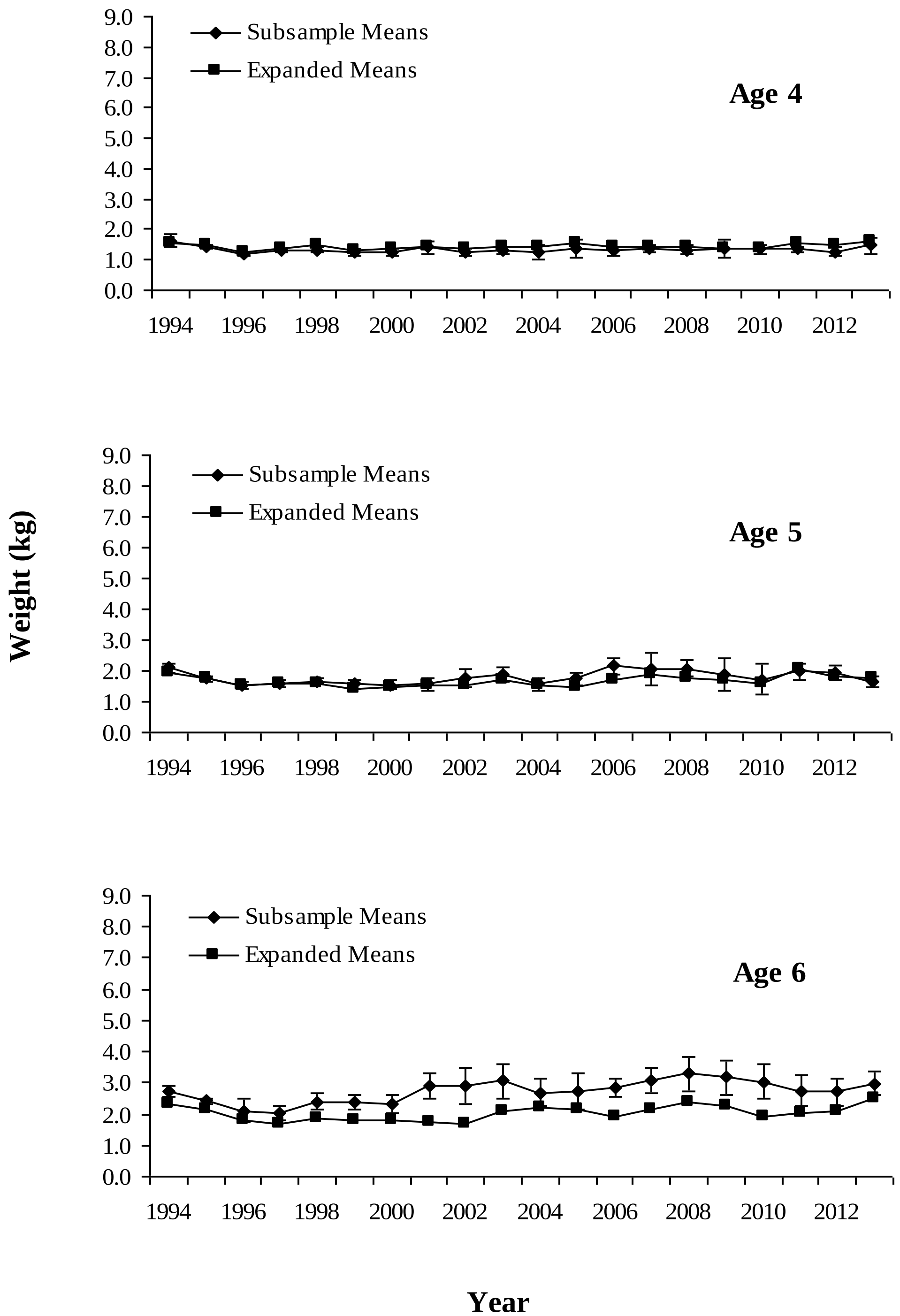


Figure 5. Mean weights (kg) of the aged subsample, by year, for individual age-classes of striped bass sampled from the Maryland Chesapeake Bay commercial drift gill net fishery, 1994-2013 (95% confidence intervals are shown around each point). Expanded means (estimated from entire sample) are also shown. Year refers to the year in which the season ended.



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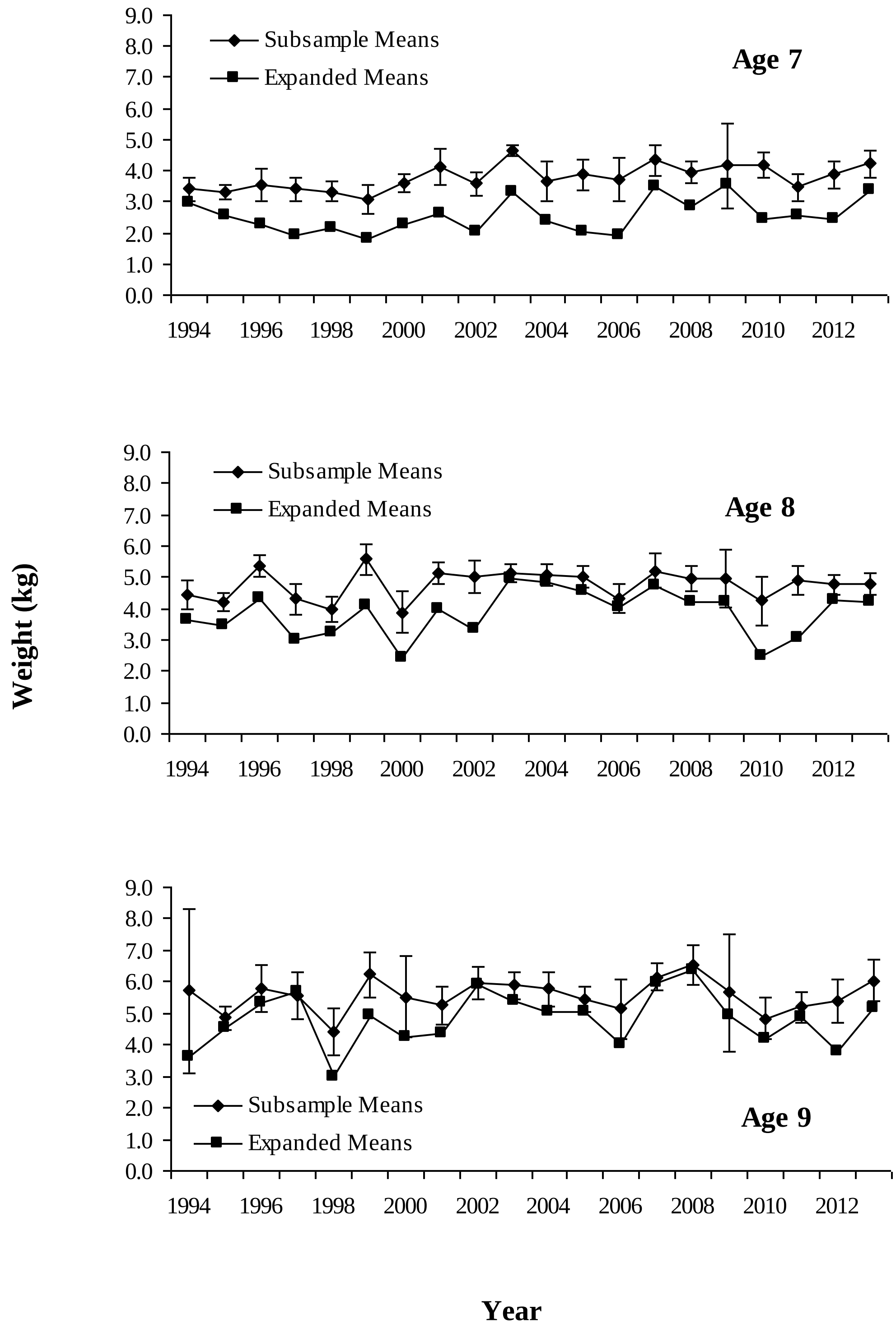

PROJECT NO. 2
JOB NO. 3
TASK NO. 1C

ATLANTIC COAST STOCK ASSESSMENT AND COMMERCIAL HARVEST MONITORING

Prepared by Amy Batdorf

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, which occurred between November 1, 2012 and April 30, 2013. This fishery was managed with a 24 inch total length (TL) minimum size limit and an annual quota of 126,396 pounds. Although this report covers the November 2012-April 2013 fishing season, the quota is managed by calendar year. Maryland's Atlantic coast fishery is not as large as the Chesapeake Bay commercial fishery and its annual quota composes only 6% of Maryland's total commercial harvest quota. 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 2005-2010 check station activity indicated that 81% 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 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 96% of the harvest occurs 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 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 November 2012-April 2013 Atlantic fishery, the year used for age calculations was 2013. These ages were then used to construct the age-length key (ALK). 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 November 2012 through April 2013 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

This fishery is largely a by-catch fishery based on commercial spiny dogfish harvest; consequently fish were harvested intermittently and are often difficult to intercept at the check stations. Sampling at coastal check stations was conducted on eight days between November 2011 and April 2012. A total of 274 fish were measured and weighed and the ALK was developed from 147 scale samples.

Check stations reported 9,306 fish landed during the 2012-2013 Atlantic coast season (Table 1). The catch-at-age estimate determined that landings ranged from age 5 (2008 year-class) to age 15 (1998 year-class) (Figure 1). Most (89%) striped bass harvested were ages 6 through 10 (Table 1). Striped bass recruited into the Atlantic coast fishery as young as age 5, but due to the 24 inch minimum size limit, few fish younger than age 6 were harvested, which is similar to previous years.

Eleven year-classes were represented in the sampled harvest. Based on the estimated catch-at-age, the most common age harvested during the 2012-2013 Atlantic coast harvest was age 10 (2003 year-class), which represented 25% of the landings (Table 1). Large contributions were also made by the 2004 year class (age 9) and the 2005 year class (age 8), which represented 19% and 15% of the fishery, respectively.

Striped bass sampled at Atlantic coast check stations during the 2012-2013 season had a mean length of 799 mm TL and mean weight of 5.1 kg. The sample length distribution ranged from 610 to 1097 mm TL (Figure 2). The weight distribution from the sample of fish harvested ranged from 2.1 to 13.8 kg.

Due to a high proportion of the total sample being 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 3 and 4). Recently recruited age 6 fish had an expanded mean length of 689 mm TL and expanded mean weight of 3.2 kg (Figure 3 and 4). Age 10 striped bass, the most abundant age harvested, had an expanded mean length of 862 mm TL and expanded mean weight of 6.3 kg (Figure 3 and 4). Age 9 striped bass, the next most abundant year-class harvested, had an expanded mean length of 814 mm TL and an expanded mean weight of 5.3 kg (Figure 3 and 4).

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Table 1. Estimated catch-at-age of striped bass (numbers of fish) landed by the Maryland Atlantic coast commercial fishery, November 2012-April 2013.

Year-Class	Age	Catch	Percent
2008	5	124	1.3
2007	6	1,686	18.1
2006	7	1,200	12.9
2005	8	1,360	14.6
2004	9	1,733	18.6
2003	10	2,324	25.0
2002	11	326	3.5
2001	12	218	2.3
2000	13	204	2.2
1999	14	68	0.7
1998	15	62	0.7
	Total	**9,305**	**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, November 2012-April 2013. 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)
2008	5	2	693	---	---	4	685
2007	6	25	692	674	710	50	689
2006	7	20	709	682	735	35	705
2005	8	21	767	738	796	40	778
2004	9	26	808	777	839	50	814
2003	10	38	862	841	883	68	862
2002	11	6	905	863	948	10	896
2001	12	4	938	856	1020	7	943
2000	13	3	1027	877	1177	6	1024
1999	14	1	969	---	---	2	965
1998	15	1	855	---	---	3	848
Total		**147**				**275**	

Table 3. Sub-sample and expanded mean weights (kg) by year-class of striped bass sampled from Atlantic coast fishery, November 2012-April 2013. 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)
2008	5	2	3.1	---	---	4	3.1
2007	6	25	3.3	3.0	3.5	50	3.2
2006	7	20	3.5	3.1	3.9	35	3.5
2005	8	21	4.3	3.9	4.8	40	4.6
2004	9	26	5.1	4.6	5.6	50	5.3
2003	10	38	6.2	5.8	6.7	68	6.3
2002	11	6	7.8	6.2	9.3	10	7.2
2001	12	4	9.0	6.4	11.5	7	8.3
2000	13	3	11.2	5.3	17.1	6	10.6
1999	14	1	9.2	---	---	2	9.2
1998	15	1	8.2	---	---	3	8.2
Total		**147**				**275**	

*Due to low sample sizes, the UCL and LCL listed as --- exceed known biological limits.

Figure 1. Age distribution of striped bass sampled from the Atlantic coast fishery, 2006-2013 seasons.

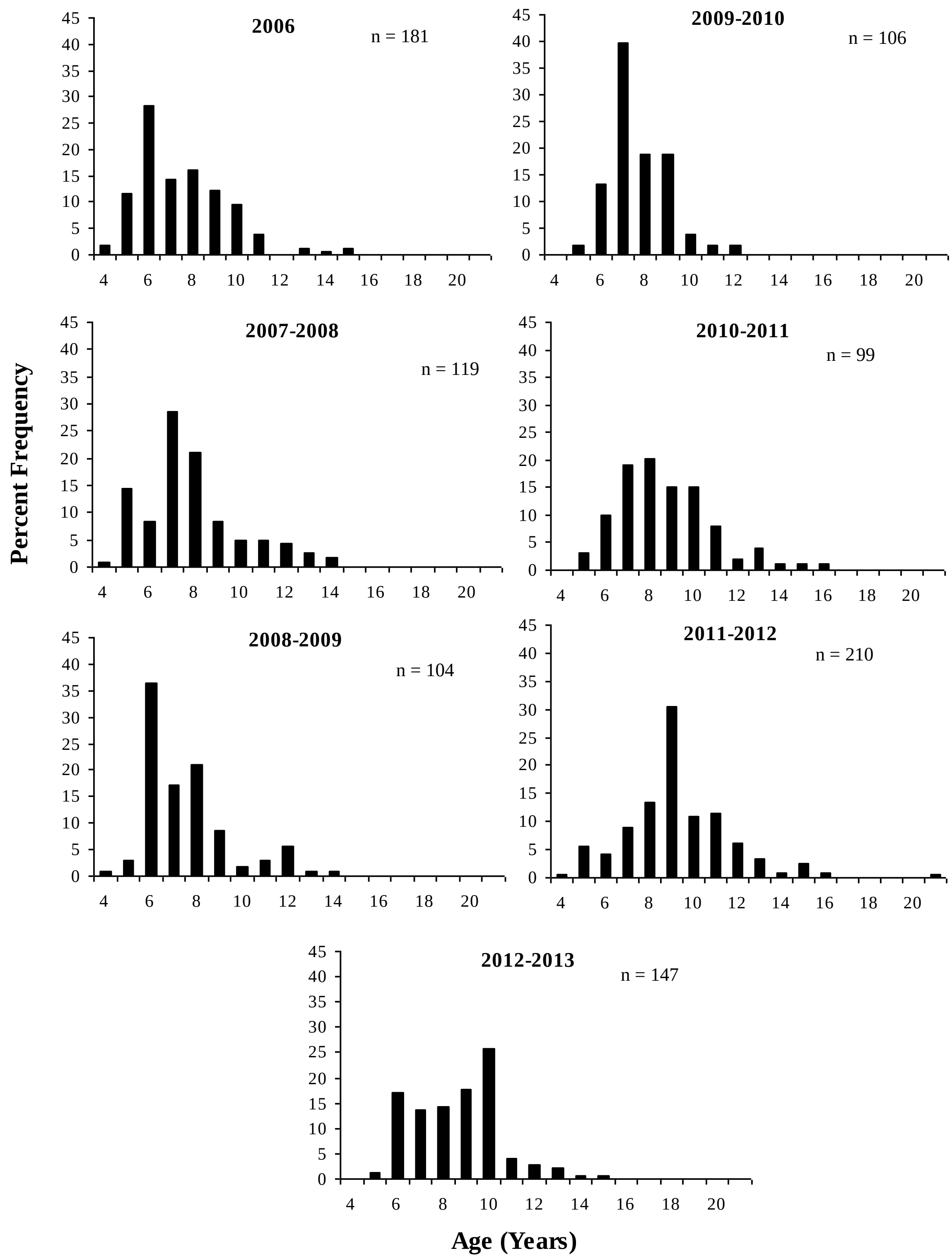


Figure 2. Length distribution of striped bass sampled from the Atlantic coast fishery, 2006-2013 seasons.

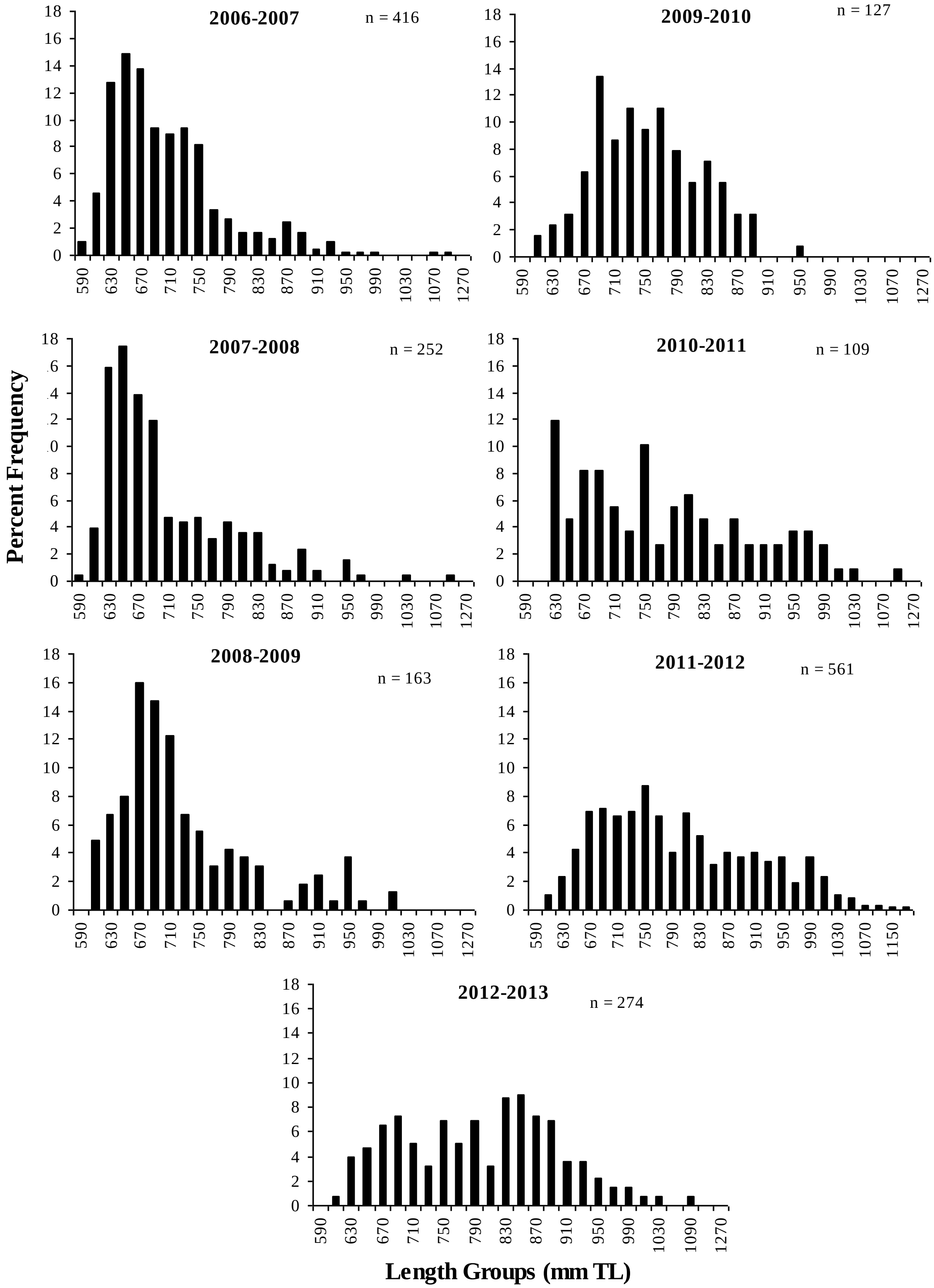
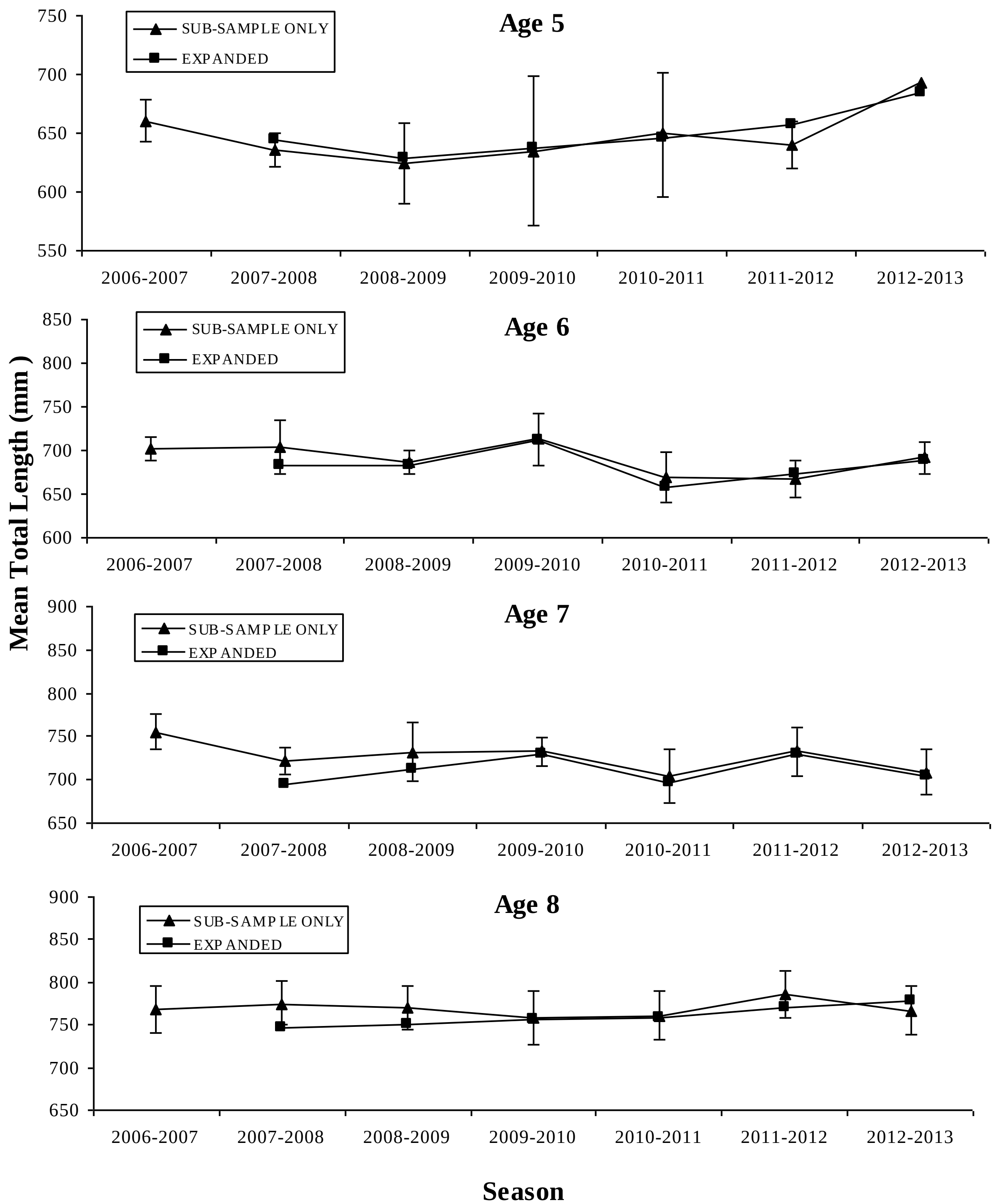


Figure 3. Mean total lengths (mm TL) of the aged sub-sample, by year, for individual age-classes of striped bass (through age 12) sampled from the Maryland Atlantic coast trawl and gill net landings, 2006-2013 (95% confidence intervals are shown around each point). Expanded means (estimated from entire sample) are also shown. *Note differences in scales on the y-axis.



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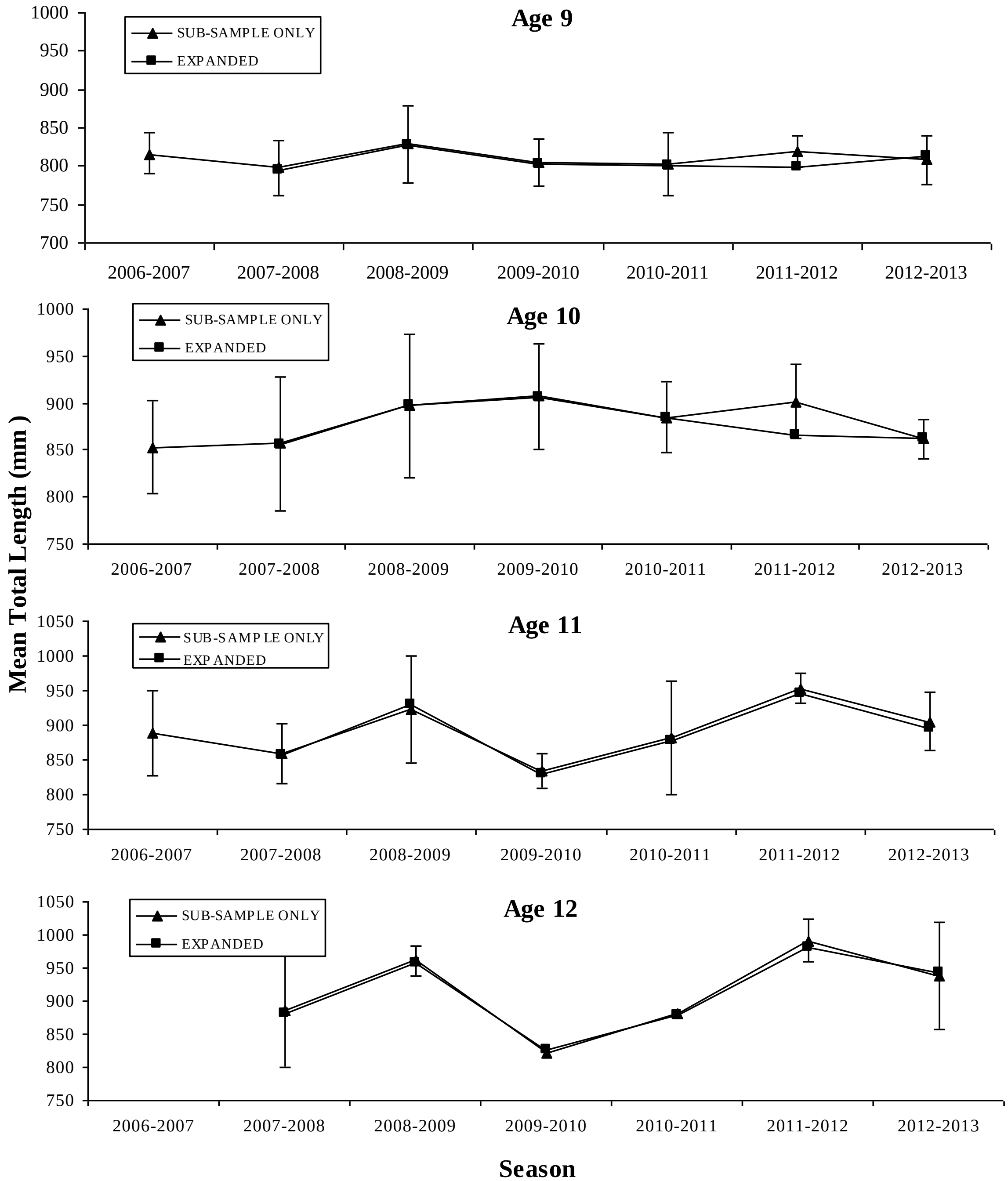

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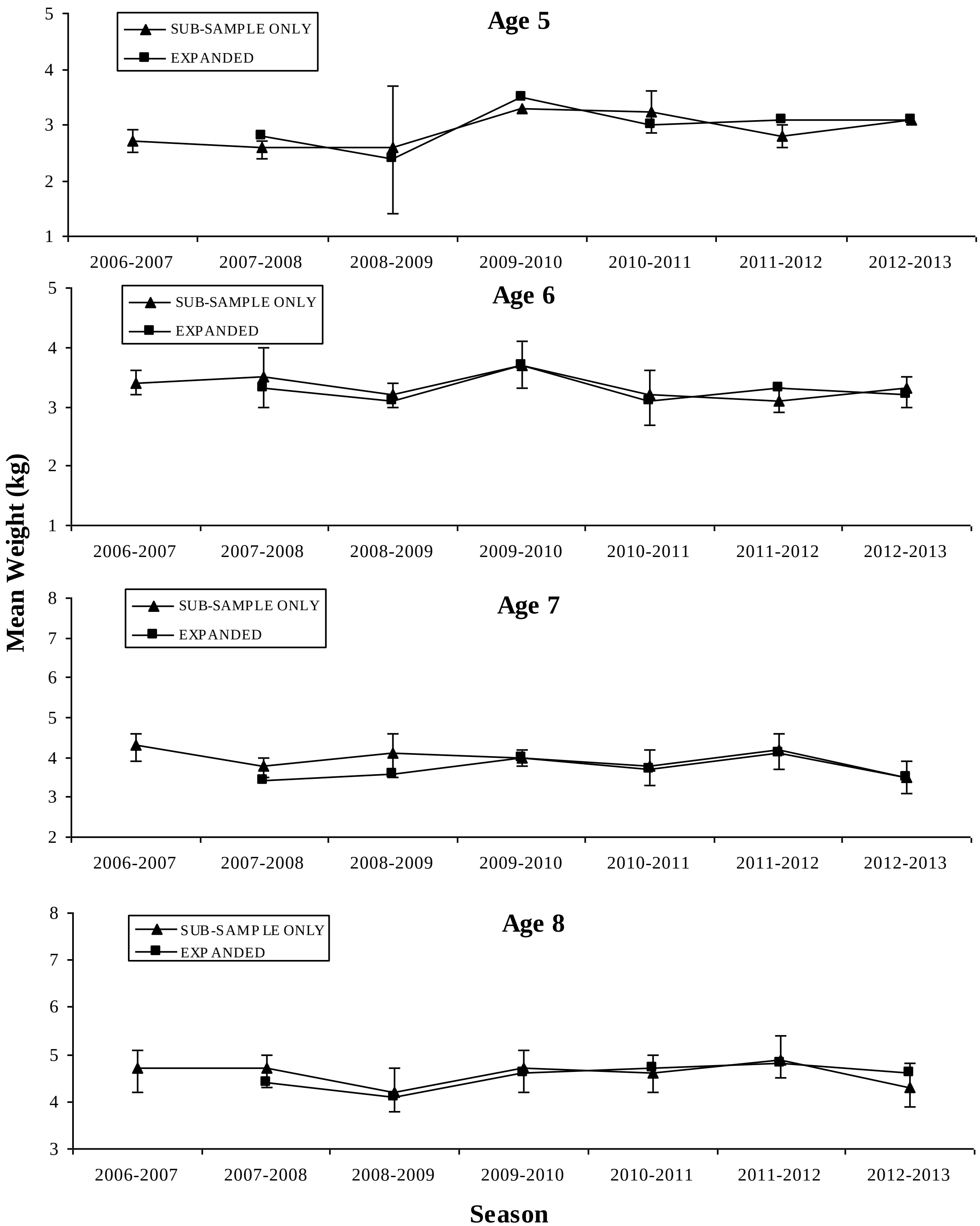

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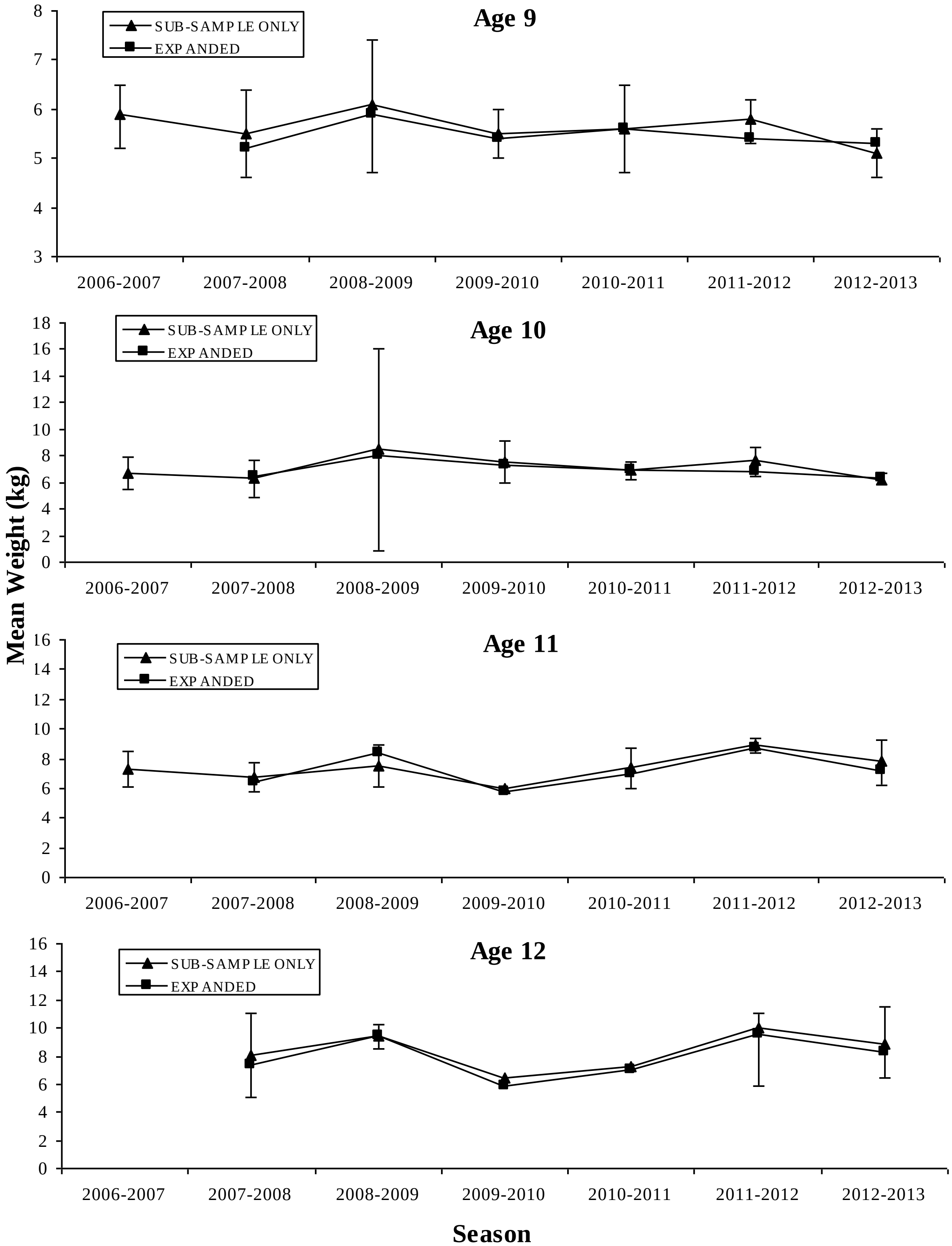

PROJECT NO. 2
JOB NO. 3
TASK NO. 2

CHARACTERIZATION OF STRIPED BASS SPAWNING STOCKS IN MARYLAND

Prepared by Angela Giuliano and Beth A. Versak

INTRODUCTION

The primary objective of Project 2, Job 3, Task 2 was to generate estimates of relative abundance-at-age for striped bass in Chesapeake Bay during the 2013 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 2013 (Figure 1). Gill nets were fished 4 to 6 days per week, weather permitting, from late March through May. In the Potomac River, sampling was conducted from March 28 to May 13 for a total of 33 sample days. In the Upper Bay, sampling was conducted from April 3 to May 14 with a total of 26 sample days.

Individual net panels were 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. 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 13 to 108 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 quadrants, while the upper Bay grid consisted of 31, 1-square-mile quadrants. GPS equipment, buoys, and landmarks were used to locate the appropriate quadrant in the field. Once in the designated quadrant, 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, between the lateral line and the first dorsal fin. 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).

<u>Analytical Procedures</u>

Development of age-length keys

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

Development of selectivity-corrected CPUEs and variance estimates

CPUEs for individual mesh sizes and length groups were calculated for each spawning area. CPUE was standardized as the number of fish captured in 1000 square yards of experimental drift gill net per hour. Mesh-specific CPUEs were calculated by summing the catch in each length group across days and meshes, and dividing the result by the total effort for each mesh. This ratio of sums approach was assumed to provide the most accurate characterization of the spawning population, which exhibits a high degree of emigration and immigration from the sampling area during the two-month sampling interval. The dynamic state of the spawning population precludes obtaining an instantaneous, representative sample on a given day, whereas a sum of the catches absorbs short-term variability and provides a cumulative 'snap-shot' 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. These two sex-specific selectivity coefficients have been used since 2000.

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 pooled 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 and air 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):

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

  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 624 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 2013 un-weighted CPUE for Potomac females (18) ranked eighteenth of 28 years in the time series, below the series average of 26 (Table 2). The un-weighted CPUE for Potomac males (136) ranked twenty-fourth in the time-series, and was less than half of the average (423). Potomac male CPUEs have been below the time-series average for 13 of the last 14 years (Table 3). The Upper Bay female CPUE (96) was, for the second year, the highest in the 29 year time series and well above the time series average of 39 (Table 4). The un-weighted CPUE for Upper Bay males (526) was also high, ranking ninth in the time series, and above the time series average of 448 (Table 5). 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 2013 selectivity-corrected, total, weighted CPUE (442) was nineteenth in the 29 year time series and slightly below the time series average of 486.

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 2013 age-specific CPUEs were all below 0.10 indicating a small variance in CPUE. Historically, 81% of the CV values were less than 0.10 and 90% 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 and those weighted by spawning area. In most cases, the percentages are very 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 entered the spawning stock this year, comprising 8% of the total CPUE. Upper Bay fish dominated the total CPUE, making up 86% of the total. Males were also more frequently encountered, comprising 85% of the total CPUE. Four year old males from the 2009 year-class were the largest contributors (24%) to the total CPUE in 2013.

Males dominated the total CPUEs for each system. For the second consecutive year, the 2009 year-class was the largest contributor to male CPUE (26% in the Upper Bay, 37% on the Potomac River). In the Potomac River, 87% of the male CPUE was made up of fish age 6 and younger. The Upper Bay male CPUE was more evenly distributed over a wide range of ages, but still had 74% of the male CPUE from ages 6 and younger.

Historically the female contribution is less than 10% in each system. In 2013 however, the female contribution in the Upper Bay was 15% of the total. On the Potomac, females contributed 11% to the total CPUE. Female CPUEs were distributed across many year-classes in both systems. Three and four year old females were present in the Upper Bay, but not in the Potomac River. In the Upper Bay, female fish age 7 and younger made up 26% of that system's female CPUE, while on the Potomac River these young females contributed only 15%. Age 10 females from the above-average 2003 year-class were the largest contributor (17%) to the female Upper Bay CPUE, followed by the 15+ age group (14%), which includes the record 1996 year-class. In the Potomac River, the contribution of the 15+ females to the female CPUE was highest at 22%, followed closely by the age 10 fish from the 2003 year-class, which contributed 19%.

Temperature and catch patterns

In both systems, wide fluctuations in air temperatures were observed, likely due to differences in daily sampling time.

Daily surface water temperatures on the Potomac River ranged from 6.8°C to 19°C. The survey started with the water temperature at 6.8°C, the lowest starting temperature in the 28 year time series. Water temperatures steadily climbed through April 18, then stabilized around 17°C for the remainder of the survey. Female CPUE did not show any large spikes during the survey, but instead there were a series of small peaks between March 29 and May 2 (Figure 2). Male CPUE was low throughout the survey except for one large peak on April 11 when water temperatures reached 13°C, approaching the 14°C mark necessary to initiate spawning (Fay et al., 1983).

Surface water temperatures on the Upper Bay during the spawning survey ranged from 7.6°C to 18.4°C. Upper Bay water temperatures increased gradually during the survey period. Water temperatures surpassed 14°C on April 15. There were several peaks in female CPUE, spread throughout April and May (Figure 3). The highest catches of males occurred during the first two weeks of April, as water temperatures neared 14°C. Male CPUEs slowly tapered off, with two smaller peaks occurring in the third week of April and first week of May. These observations suggest spawning activity occurred throughout the timeframe of the survey.

Length composition of the stock

In 2013, 1,517 male and 170 female striped bass were measured. On the Potomac River, 452 male and 45 female striped bass were sampled; 1,065 males and 125 females were sampled from the Upper Bay (Figure 4). The mean length of female striped bass in 2013 (918 ± 23 mm

TL) was larger than the mean length of male striped bass (558 ± 7 mm TL, $P < 0.0001$), consistent with the known biology of the species. Mean lengths are reported with 2 standard errors.

Mean lengths of male striped bass collected from the Potomac River (503 ± 9 mm TL) and Upper Bay (581 ± 10 mm TL) were significantly different ($P<0.0001$) in 2013. The majority of males caught on the Potomac River in 2013 were between 390 and 570 mm TL. While the Upper Bay male length distribution had a similar mode as the Potomac River, the Upper Bay length distribution had a larger range and included many more fish above 610 mm TL (Figure 4).

Male striped bass on the Potomac ranged from 302 to 800 mm TL. The length distribution was heavily influenced by the contribution of striped bass from the 2007 through 2010 year-classes. Male striped bass between 390 and 570 mm TL composed 74% of the Potomac River male catch in 2013 (Figure 4). The uncorrected Potomac male CPUE peaked between 450 and 490 mm TL, representing a combination of the 2008 and 2009 year-classes (Figure 5). Similarly, the selectivity-corrected Potomac male CPUE peaked between 430 and 470 mm TL.

Male striped bass on the Upper Bay ranged from 275 to 1092 mm TL, with a peak in the length frequency between 430-470 mm TL (Figure 4). Male selectivity-corrected CPUE in the Upper Bay was high across a wide range of sizes, whereas the entirety of the Potomac River male CPUE occurred between 310 and 790 mm TL (Figure 5). The large selectivity-corrected CPUE in the 430 mm length group represents the below-average 2009 year-class. Many year-classes are present in the Upper Bay male CPUEs, including the record 1996 year-class. The selectivity correction increased the contribution of the younger age 2 and 3 fish, as evident by the peaks in the 290 and 330 mm length groups. This could indicate that the smaller fish are not captured efficiently in the sampling gear.

Female striped bass sampled from the Potomac River and Upper Bay in 2013 were not significantly different in mean total length (P=0.74). Female striped bass sampled from the Potomac ranged from 622 to 1167 mm TL (mean=912 ± 50 mm TL), while females sampled in the Upper Bay ranged from 538 to 1196 mm TL (mean=920 ± 26 mm TL; Figure 4).

There were several small peaks in female CPUE by length group the Potomac River in 2013. The selectivity-corrected CPUE peaks in the 810, 970, 1090, and 1170 mm length groups (Figure 6) cover a wide range of ages.

In the Upper Bay, corrected and uncorrected female CPUEs covered a wide range of length groups. Application of the selectivity model to the data corrected the catch upward in the extreme ends of the length distribution where fewer fish were encountered and likely not captured efficiently. Large numbers of females were again captured in 2013, resulting in higher than normal CPUEs. Peaks in selectivity-corrected CPUEs between 650 and 690 mm TL were composed of fish from the 2005, 2006 and 2007 year-classes. The highest peak at 810 mm TL represented one fish from the 2005 year-class. This particular fish was caught in a small mesh with low selectivity for its size group. Because of this, the selectivity correction increased the CPUE to better approximate the relative abundance of fish this size in the spawning population. The peaks in the uncorrected CPUE between 910 and 1030 mm TL represent the above-average 2003 and 2001 year-classes. The CPUEs in the larger size groups were a combination of 11 to 19 year old fish from the 2002 through 1994 year-classes.

<u>Length at age (LAA)</u>

Based on previous investigations which indicated no influence of area on mean LAA, samples from the Potomac River, Upper Bay and the spring recreational creel sampling (Project 2, Job 3, Task 5B) were again combined in 2013 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 small 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 two-way analysis of variance was performed, where possible, to determine differences in LAA between areas (Upper Bay and Potomac). Few differences between sample areas were detected in LAA for either sex in 2013 ($P>0.05$). The exceptions were 10 and 15 year old females and 3 and 6 year old males. For males, the three year olds were significantly shorter on the Upper Bay (330 mm TL) than the Potomac River (387 mm TL, $P=0.007$) and the six year olds were significantly longer on the Potomac River (640 mm TL) than the Upper Bay (597 mm TL, $P=0.05$). Ten year old females were significantly longer on the Potomac (963 mm TL) than the Upper Bay (916 mm TL, $P=0.05$). Fifteen year old females were also significantly longer on the Potomac River (1124 mm TL) than the Upper Bay (1042 mm TL, $P=0.004$).

Lengths-at-age were compared between years for each sex. Male and female LAA has been relatively stable since the mid 1990s (Figures 7 and 8). Mean lengths of males were similar in 2012 and 2013 for all ages except for age 11 (ANOVA, $\alpha=0.05$, $P=0.02$). Mean lengths of females were similar in 2012 and 2013 for all ages that could be tested (ANOVA, $\alpha=0.05$).

Age composition of the stock

During the 2013 survey, eighteen age-classes, ranging from 2 to 19 were encountered (Tables 14 and 15). Male striped bass ranged from ages 2 to 17, with ages 9 and 10 fish (2004 and 2003 year-classes) being the most abundant male cohorts. On the Potomac River, the males encountered ranged from age 2 through 9, while on the Upper Bay males through age 17 were captured. Females ranged in age from 4 to 19, with the most females encountered at age 10 (2003 year-class). A large number of age 6 females from the above-average 2007 year-class were captured suggesting that they are beginning to recruit 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). In 2013, the largest increase in age-specific CPUE was observed for the age 4 (below average 2009 year-class) cohort. Nine of the 14 age-specific CPUEs presented showed an increase. The contribution 15+ age group has been strong over the last four years (Figure 9).

In 2013, the contribution of age 8+ females to the total female CPUE decreased slightly to 75% (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 and 2013. Some decline is expected based on the results of the most recent coastwide stock assessment, which showed that female spawning stock biomass has been declining coastwide (Northeast Fisheries Science Center 2013).

The percentage of the overall sample (males and females combined) age 8 and older has been variable since 1997 (Figure 11). The 2013 value decreased to 27%, 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 a combination of factors. A large number of younger males from the 2009 and 2007 year-classes and females from the 2007 year-class were encountered. In addition, males from the above-average 2011 year-class started recruiting into the spawning stock.

Historically, Chesapeake Bay estimates of ISP, expressed as biomass, have followed trends similar to the coastal estimates. Recent estimates of spawning stock biomass (SSB) for coastal females have shown a decline over the past several years (Northeast Fisheries Science

Center 2013). The MD DNR estimate of ISP generated from the Upper Bay has been variable, but in 2013 the ISP value of 770 was the second highest on record, and more than double the time-series average of 317 (Table 16, Figure 12). The 2013 Potomac River female ISP increased slightly to 172, but was still below the time series average of 229.

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Table 1. Number of scales aged per sex, area, and survey, by length group (mm TL), in 2013.

	MALES				FEMALES			
Length group (mm)	**Upper Bay**	**Potomac River**	**Creel**	**Male Total**	**Upper Bay**	**Potomac River**	**Creel**	**Female Total**
270	1	0	0	**1**	0	0	0	**0**
290	3	0	0	**3**	0	0	0	**0**
310	4	2	0	**6**	0	0	0	**0**
330	3	3	0	**6**	0	0	0	**0**
350	3	3	0	**6**	0	0	0	**0**
370	3	3	0	**6**	0	0	0	**0**
390	3	3	0	**6**	0	0	0	**0**
410	3	3	0	**6**	0	0	0	**0**
430	3	3	0	**6**	0	0	0	**0**
450	3	3	0	**6**	0	0	1	**1**
470	3	3	0	**6**	0	0	1	**1**
490	3	3	0	**6**	0	0	3	**3**
510	3	3	0	**6**	0	0	1	**1**
530	3	3	0	**6**	1	0	7	**8**
550	3	3	0	**6**	0	0	7	**7**
570	5	5	0	**10**	0	0	5	**5**
590	5	5	0	**10**	3	0	6	**9**
610	5	5	0	**10**	1	0	6	**7**
630	5	5	0	**10**	1	2	6	**9**
650	5	5	0	**10**	1	0	3	**4**
670	5	5	0	**10**	2	2	4	**8**
690	5	5	0	**10**	3	2	2	**7**
710	8	3	4	**15**	5	5	2	**12**
730	7	3	5	**15**	1	2	1	**4**
750	12	2	1	**15**	2	1	2	**5**
770	10	2	3	**15**	3	0	2	**5**
790	13	1	1	**15**	1	1	0	**2**
810	9	1	5	**15**	0	1	1	**2**
830	13	0	2	**15**	2	0	1	**3**
850	12	0	3	**15**	3	1	7	**11**
870	11	0	4	**15**	4	1	10	**15**
890	14	0	1	**15**	6	0	9	**15**
910	5	0	3	**8**	10	0	5	**15**
930	3	0	1	**4**	7	3	5	**15**
950	2	0	2	**4**	10	0	5	**15**
970	3	0	0	**3**	7	1	7	**15**
990	2	0	0	**2**	5	5	5	**15**
1010	5	0	0	**5**	6	4	5	**15**
1030	3	0	1	**4**	6	1	3	**10**
1050	1	0	0	**1**	5	1	3	**9**
1070	1	0	0	**1**	7	0	1	**8**
1090	4	0	0	**4**	1	1	1	**3**
1110	0	0	0	**0**	2	2	1	**5**
1130	0	0	0	**0**	4	3	1	**8**
1150	0	0	0	**0**	2	2	1	**5**
1170	0	0	0	**0**	2	1	0	**3**
1190	0	0	0	**0**	1	0	0	**1**
1210	0	0	0	**0**	0	0	0	**0**
Total	**217**	**85**	**36**	**338**	**114**	**42**	**130**	**286**

Table 2. Estimates of selectivity-corrected age-class CPUE by year for female striped bass captured in the Potomac River during the 1985-2013 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**
Average																**26**

Table 3. Estimates of selectivity-corrected age-class CPUE by year for male striped bass captured in the Potomac River during the 1985-2013 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	151	103	65.	19.	10.	6.9	3.8	4.4	3.1	1.9	0.0	0.0	**696**

			.9	.2	.6	4	1	3								
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**
Average																**423**

Table 4. Estimates of selectivity-corrected age-class CPUE by year for female striped bass captured in the Upper Bay during the 1985-2013 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.	0.0	0.0	0.5	0.5	3.8	0.0	0.0	0.0	0.0	0.0	0.3	**30**

				3												
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**
Average																**39**

Table 5. Estimates of selectivity-corrected age-class CPUE by year for male striped bass captured in the Upper Bay during the 1985-2013 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**
Average																**448**

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 CPE 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 (1985–2013) 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**
Average																**486**

Table 9. Lower confidence limits (95%) of the annual, pooled, weighted, age-specific CPUEs (1985–2013) 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.	75.	39.	38.	83.	40.	33.	32.	22.	7.4	5.4	3.3	3.7	0.3	*

	0	7	3	8	3	4	9	2	0						
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	*

* 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 (1985–2013) 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.	43.	157	53.	143	21.	23.	33.	9.4	16.	13.	26.	5.3	*

		7	6	.6	5	.3	8	4	1		7	5	2		
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	*

* 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 (1985–2013) 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	*

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

Table 12. Un-weighted striped bass catch per unit effort (CPUE) by year-class, late March through May 2013. 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
2012	1	0.0	0.0	0.0	0.0	0.0	0.0
2011	2	60.4	7.8	0.0	0.0	6.7	53.7
2010	3	101.4	13.1	0.0	0.3	19.9	81.2
2009	4	191.8	24.7	0.0	2.4	50.9	138.5
2008	5	82.7	10.7	0.2	1.8	23.7	56.9
2007	6	90.9	11.7	1.5	15.2	17.6	56.6
2006	7	48.3	6.2	0.7	5.2	8.6	33.9
2005	8	49.7	6.4	2.0	10.8	5.0	31.9
2004	9	35.1	4.5	0.7	8.1	1.5	24.9
2003	10	47.5	6.1	3.3	16.7	1.9	25.7
2002	11	10.3	1.3	2.0	4.5	0.2	3.6
2001	12	19.8	2.6	1.5	9.0	0.1	9.2
2000	13	8.6	1.1	1.1	3.9	0.0	3.5
1999	14	7.2	0.9	0.8	5.3	0.0	1.1
≤1998	15+	22.3	2.9	3.9	13.0	0.0	5.4
Total		776.1		17.5	96.2	136.1	526.2
% of Total				2	12	18	68
% of Sex				15	85	21	79
% of System				11	15	89	85

Table 13. Striped bass catch per unit effort (CPUE) by year-class, weighted by spawning area*, late March through May 2013. 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
2012	1	0.0	0.0	0.0	0.0	0.0	0.0
2011	2	35.6	8.1	0.0	0.0	2.6	33.0
2010	3	57.8	13.1	0.0	0.2	7.7	49.9
2009	4	106.2	24.0	0.0	1.5	19.6	85.1
2008	5	45.3	10.3	0.1	1.1	9.1	35.0
2007	6	51.5	11.7	0.6	9.3	6.8	34.8
2006	7	27.6	6.2	0.3	3.2	3.3	20.9
2005	8	28.9	6.6	0.8	6.6	1.9	19.6
2004	9	21.1	4.8	0.3	5.0	0.6	15.3
2003	10	28.0	6.3	1.3	10.2	0.7	15.8
2002	11	5.8	1.3	0.8	2.8	0.1	2.2
2001	12	11.8	2.7	0.6	5.6	0.1	5.7
2000	13	5.0	1.1	0.4	2.4	0.0	2.2
1999	14	4.3	1.0	0.3	3.3	0.0	0.6
≤1998	15+	12.8	2.9	1.5	8.0	0.0	3.3
Total		441.7		6.7	59.1	52.5	323.4
% of Total				2	13	12	73
% of Sex				10	90	14	86
% of System				11	15	89	85

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

Table 14. Mean length-at-age (mm TL) statistics for male striped bass collected in the Potomac River and the Upper Bay, and areas combined, late March through May 2013.

YEAR-CLASS	AGE	AREA	N	MEAN	LCL	UCL	SD	SE
2011	2	POTOMAC	6	329	310	348	18	7
2011	2	UPPER	6	310	279	341	30	12
2011	2	COMBINED	12	319	303	335	26	7
2010	3	POTOMAC	12	387	368	407	30	9
2010	3	UPPER	8	330	304	357	31	11
2010	3	COMBINED	20	365	345	384	41	9
2009	4	POTOMAC	10	473	451	494	30	9
2009	4	UPPER	22	436	409	463	61	13
2009	4	COMBINED	32	448	428	468	55	10
2008	5	POTOMAC	11	535	488	582	70	21
2008	5	UPPER	10	548	511	585	51	16
2008	5	COMBINED	21	541	514	569	61	13
2007	6	POTOMAC	18	640	607	673	65	15
2007	6	UPPER	17	597	567	627	58	14
2007	6	COMBINED	35	619	597	641	65	11
2006	7	POTOMAC	15	629	588	670	74	19
2006	7	UPPER	9	684	635	733	63	21
2006	7	COMBINED	24	650	619	681	74	15
2005	8	POTOMAC	12	694	661	728	52	15
2005	8	UPPER	19	731	692	770	81	19
2005	8	COMBINED	31	717	690	744	73	13
2004	9	POTOMAC	1	800	-	-	-	-
2004	9	UPPER	44	810	790	829	63	9
2004	9	COMBINED	45	809	791	828	62	9
2003	10	POTOMAC	0	-	-	-	-	-
2003	10	UPPER	50	816	797	835	66	9
2003	10	COMBINED	50	816	797	835	66	9
2002	11	POTOMAC	0	-	-	-	-	-
2002	11	UPPER	6	806	751	861	53	21
2002	11	COMBINED	6	806	751	861	53	21
2001	12	POTOMAC	0	-	-	-	-	-
2001	12	UPPER	14	918	872	965	81	22
2001	12	COMBINED	14	918	872	965	81	22
2000	13	POTOMAC	0	-	-	-	-	-
2000	13	UPPER	6	1033	985	1082	46	19
2000	13	COMBINED	6	1033	985	1082	46	19
1999	14	POTOMAC	0	-	-	-	-	-
1999	14	UPPER	1	1000	-	-	-	-
1999	14	COMBINED	1	1000	-	-	-	-
1998	15	POTOMAC	0	-	-	-	-	-
1998	15	UPPER	4	1050	947	1153	65	32
1998	15	COMBINED	4	1050	947	1153	65	32
1997	16	POTOMAC	0	-	-	-	-	-
1997	16	UPPER	2	1005	840	1170	18	13
1997	16	COMBINED	2	1005	840	1170	18	13
1996	17	POTOMAC	0	-	-	-	-	-
1996	17	UPPER	1	1027	-	-	-	-
1996	17	COMBINED	1	1027	-	-	-	-

Table 15. Mean length-at-age (mm TL) statistics for female striped bass collected in the Potomac River and the Upper Bay, and areas combined, late March through May 2013. * Values were omitted for being biologically unreasonable.

YEAR-CLASS	AGE	AREA	N	MEAN	LCL	UCL	SD	SE
2009	4	POTOMAC	1	622	-	-	-	-
		UPPER	0	-	-	-	-	-
		COMBINED	1	622	-	-	-	-
2008	5	POTOMAC	1	705	-	-	-	-
		UPPER	1	593	-	-	-	-
		COMBINED	2	649	*	*	79	56
2007	6	POTOMAC	7	695	663	726	34	13
		UPPER	11	659	616	702	64	19
		COMBINED	18	673	645	701	56	13
2006	7	POTOMAC	4	703	665	741	24	12
		UPPER	3	688	588	787	40	23
		COMBINED	7	696	669	724	30	11
2005	8	POTOMAC	2	802	732	871	8	6
		UPPER	5	704	625	782	63	28
		COMBINED	7	732	667	797	70	27
2004	9	POTOMAC	2	801	172	1429	70	50
		UPPER	12	884	849	918	54	16
		COMBINED	14	872	836	907	62	16
2003	10	POTOMAC	7	963	912	1013	54	21
		UPPER	34	916	897	935	55	9
		COMBINED	41	924	906	942	57	9
2002	11	POTOMAC	0	-	-	-	-	-
		UPPER	9	938	861	1015	100	33
		COMBINED	9	938	861	1015	100	33
2001	12	POTOMAC	6	991	959	1023	30	12
		UPPER	12	1011	979	1043	50	14
		COMBINED	18	1004	982	1027	45	11
2000	13	POTOMAC	0	-	-	-	-	-
		UPPER	7	1060	1017	1102	46	17
		COMBINED	7	1060	1017	1102	46	17
1999	14	POTOMAC	5	1092	1008	1176	68	30
		UPPER	7	1064	1018	1111	50	19
		COMBINED	12	1076	1040	1112	57	16
1998	15	POTOMAC	2	1124	997	1251	14	10
		UPPER	6	1042	1017	1067	24	10
		COMBINED	8	1062	1026	1099	43	15
1997	16	POTOMAC	5	1095	1010	1180	68	31
		UPPER	3	1141	1087	1194	22	12
		COMBINED	8	1112	1064	1160	58	20
1996	17	POTOMAC	0	-	-	-	-	-
		UPPER	1	1141	-	-	-	-
		COMBINED	1	1141	-	-	-	-
1995	18	POTOMAC	0	-	-	-	-	-
		UPPER	2	1185	1109	1261	8	6
		COMBINED	2	1185	1109	1261	8	6
1994	19	POTOMAC	0	-	-	-	-	-
		UPPER	1	1130	-	-	-	-
		COMBINED	1	1130	-	-	-	-

Table 16. Index of spawning biomass 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	64.93	25.90
1986	151.95	45.70
1987	400.49	88.84
1988	250.32	63.60
1989	120.29	80.54
1990	98.42	62.52
1991	109.38	138.65
1992	274.95	379.35
1993	278.52	420.88
1994	87.26	Not Sampled
1995	547.66	293.77
1996	347.87	391.57
1997	240.42	362.33
1998	155.86	226.78
1999	168.44	280.82
2000	192.75	325.22
2001	479.14	272.49
2002	276.46	398.94
2003	563.41	118.46
2004	376.19	530.23
2005	469.68	195.80
2006	406.22	458.23
2007	418.54	263.27
2008	228.60	162.78
2009	482.52	189.77
2010	279.71	212.79
2011	167.56	105.43
2012	799.21	149.96
2013	769.50	172.31
Average	**317.46**	**229.18**

Figure 1. Drift gill net sampling locations in spawning areas of the Upper Chesapeake Bay and the Potomac River, late March - May 2013.

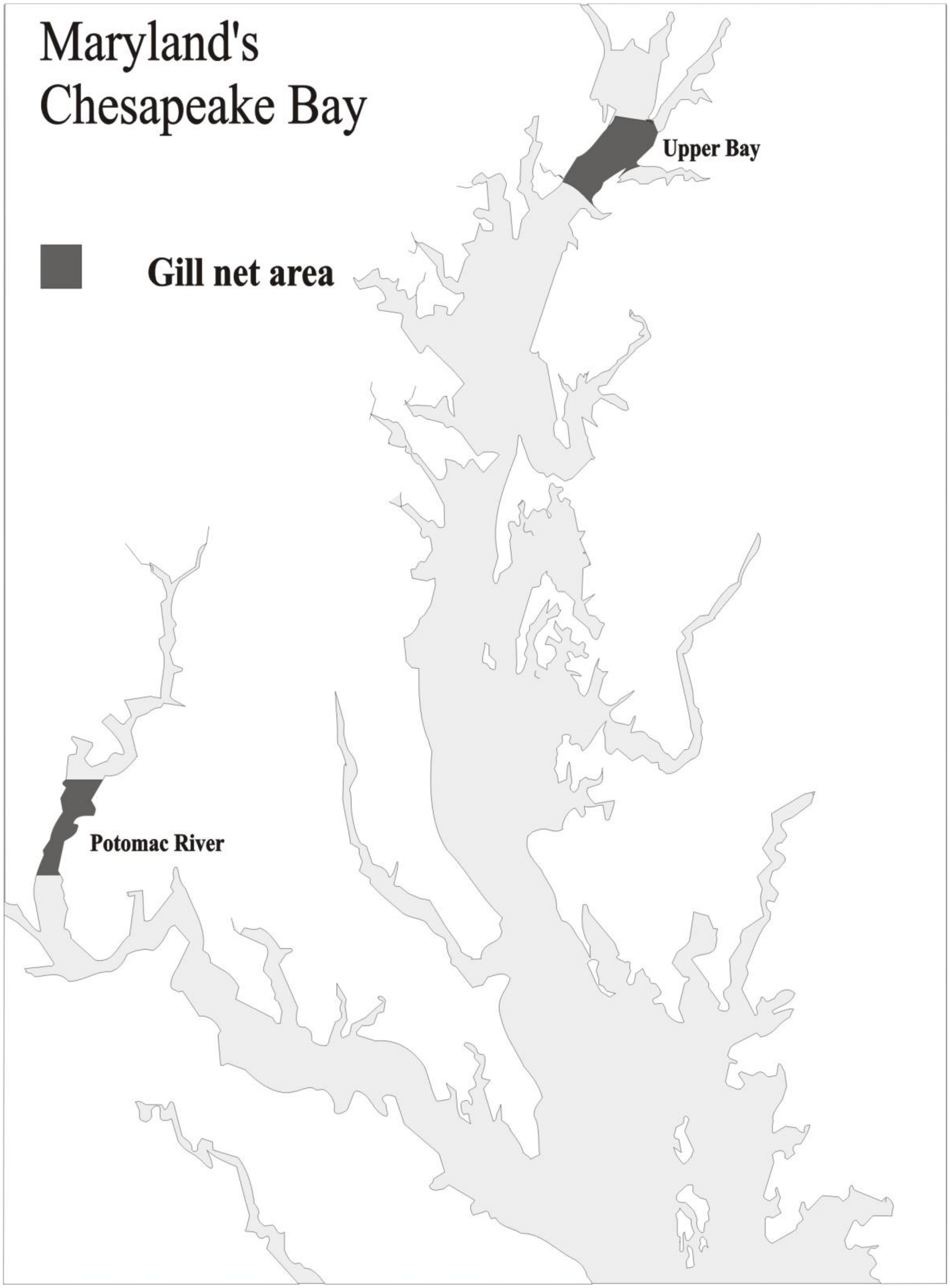


Figure 2. Daily effort-corrected catch of female and male striped bass, with surface water and air temperatures in the spawning reach of the Potomac River, late March through May 2013. Effort is standardized as 1000 square yards of experimental gill net per hour. Note different scales.

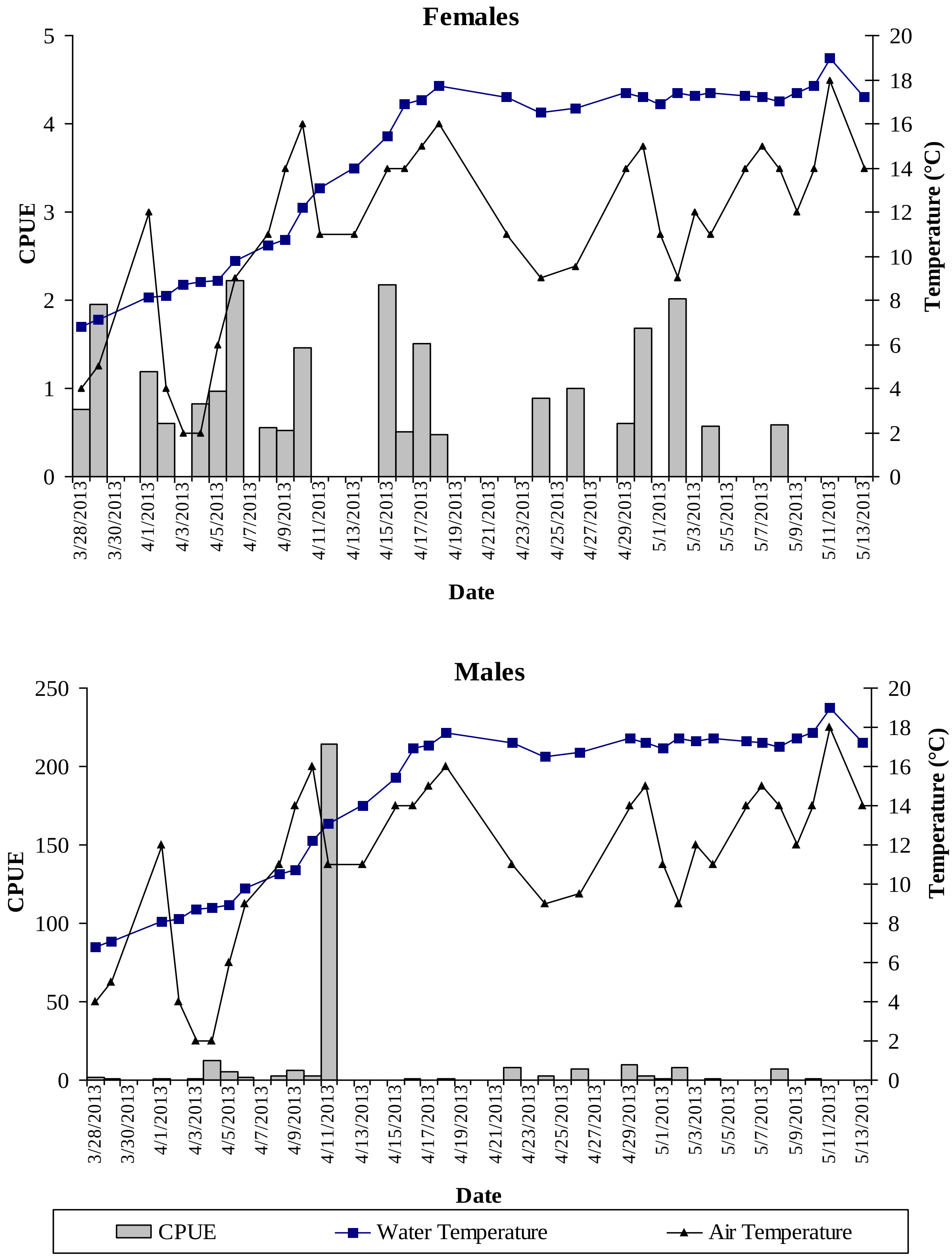


Figure 3. Daily effort-corrected catch of female and male striped bass, with surface water and air temperatures in the spawning reach of the Upper Chesapeake Bay, late March through May 2013. Effort is standardized as 1000 square yards of experimental drift gill net per hour. Note different scales.

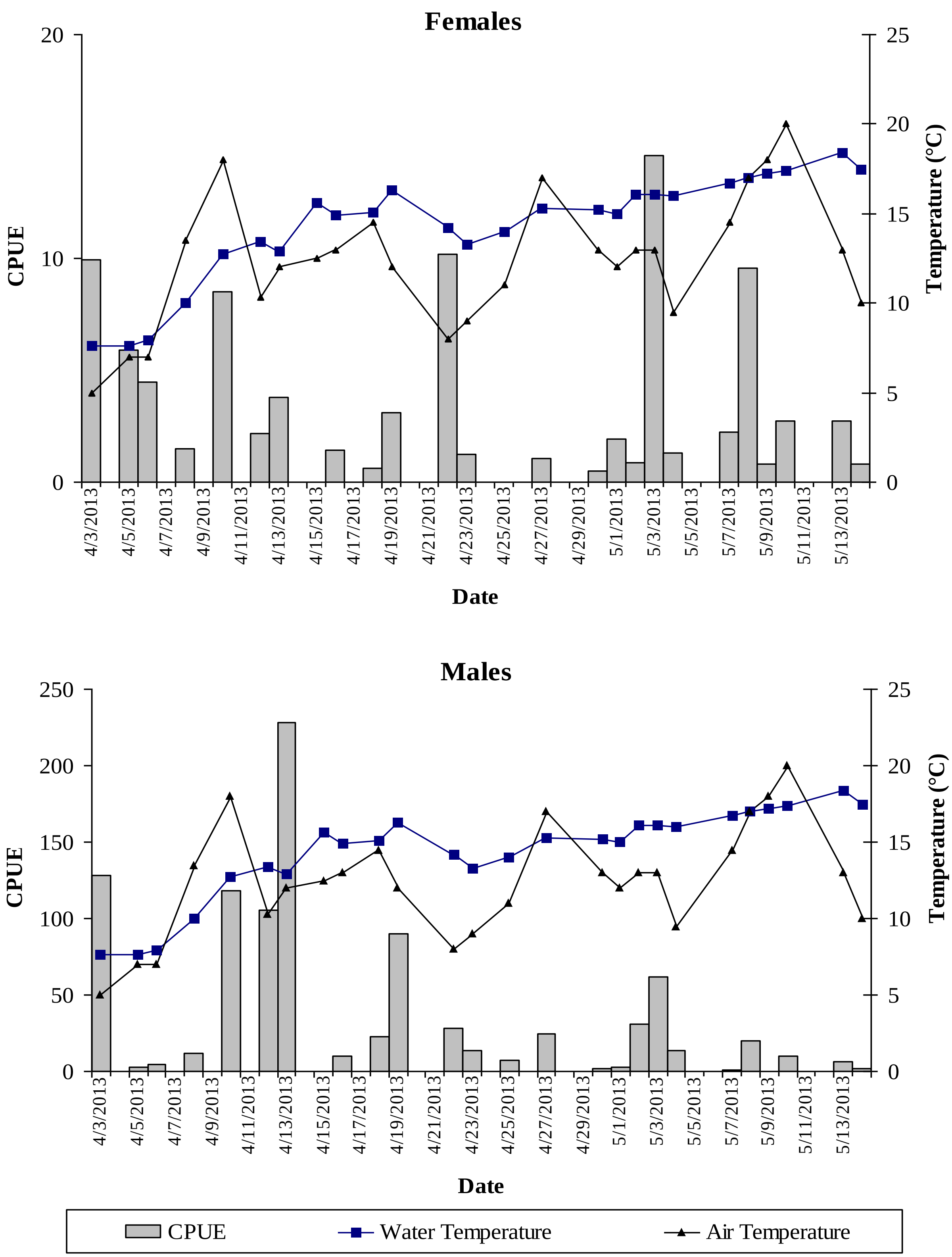
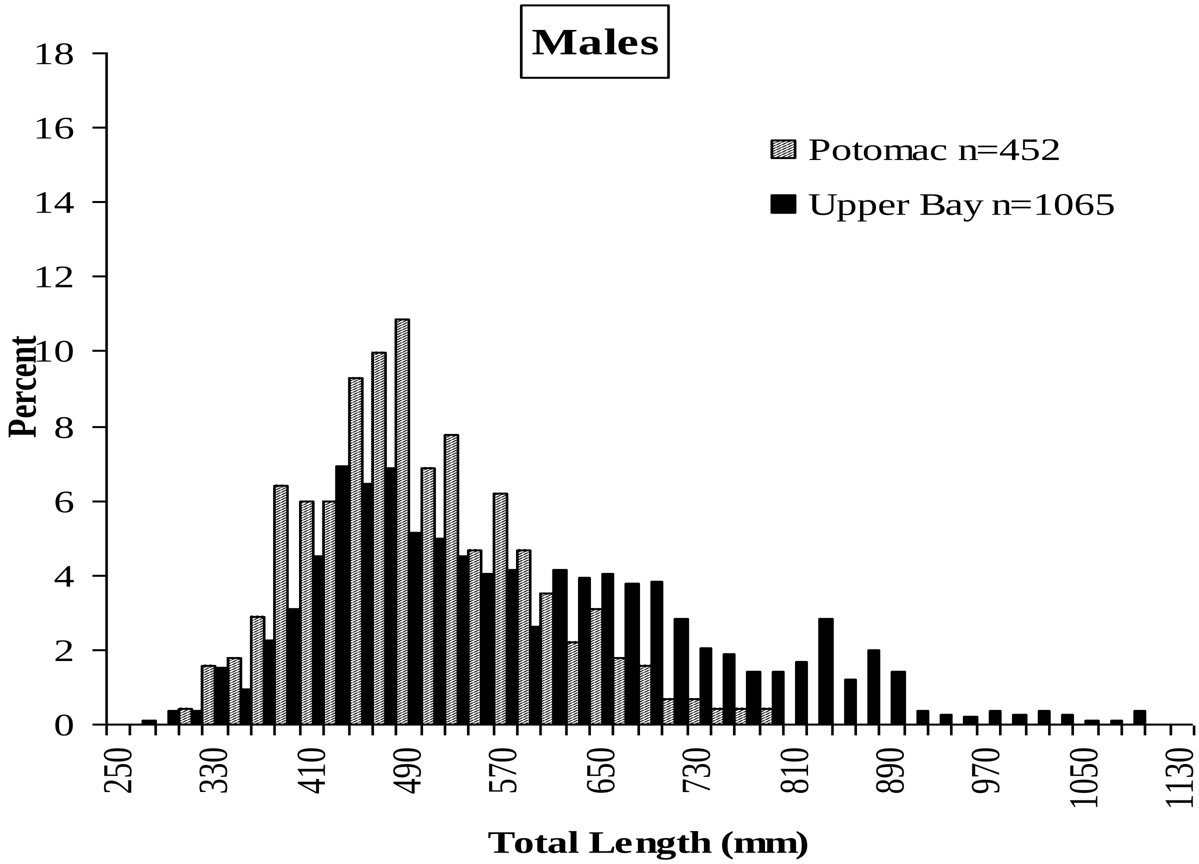


Figure 4. Length frequency of male and female striped bass from the spawning areas of the Upper Chesapeake Bay and Potomac River, late March through May 2013. Note different scales.



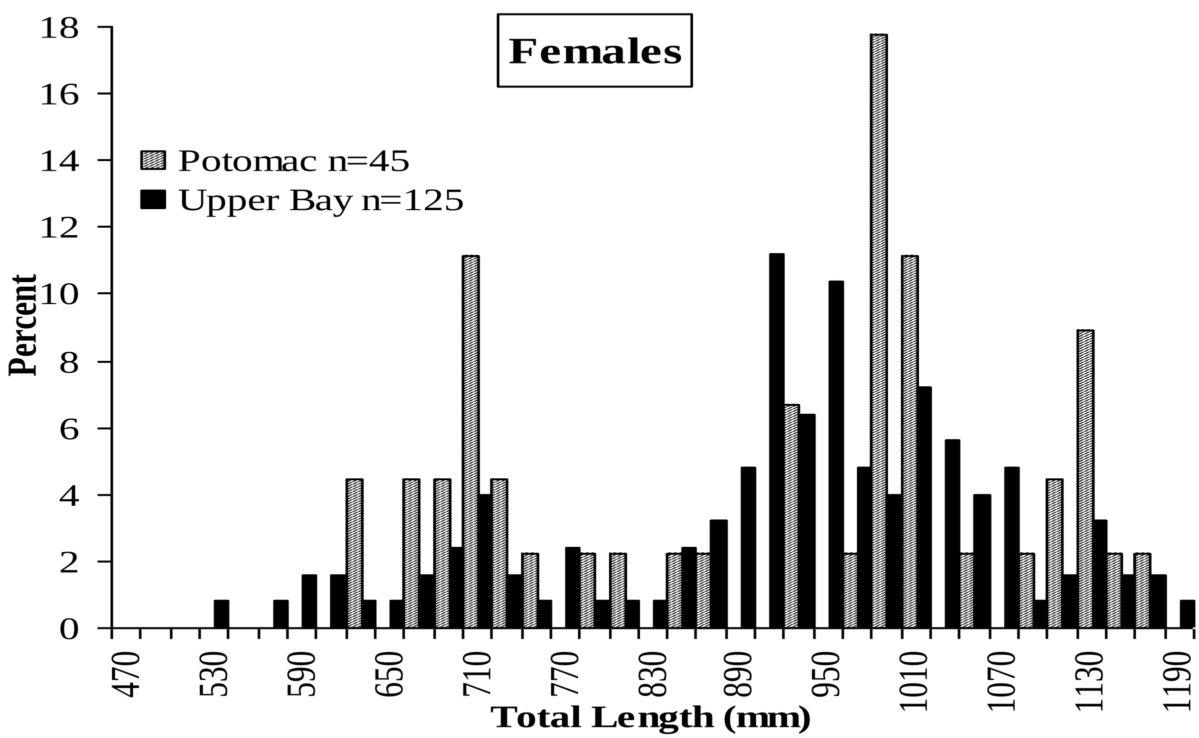
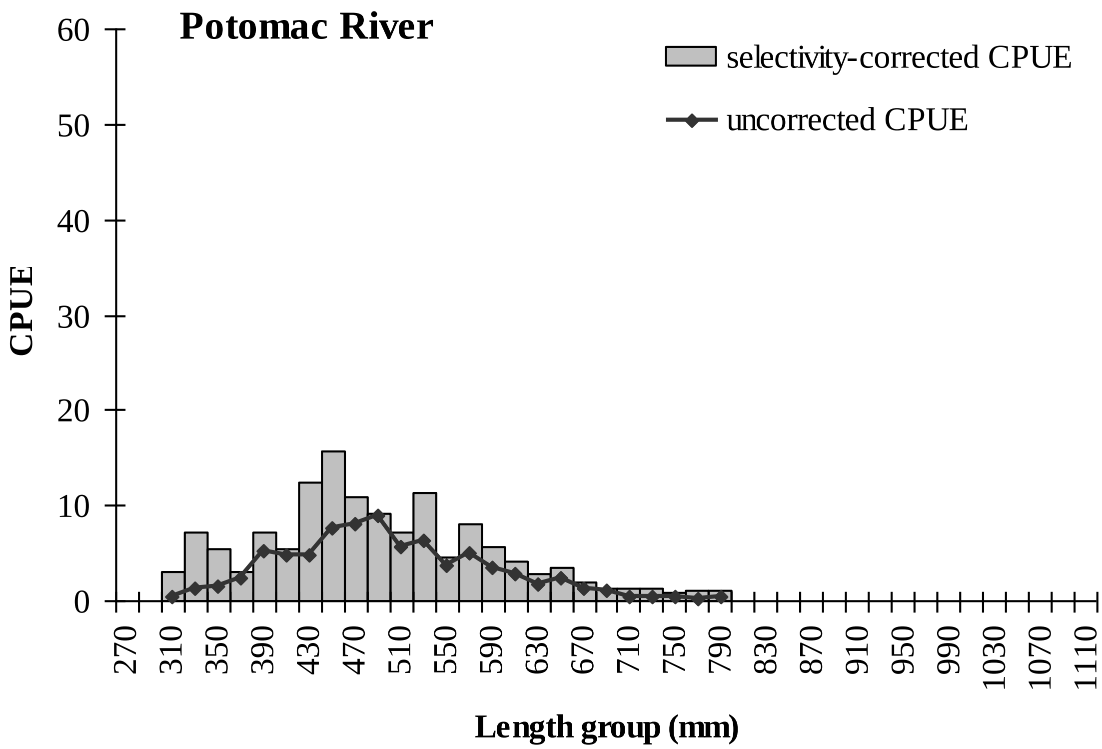


Figure 5. Length group CPUE (uncorrected and corrected for gear selectivity) of male striped bass collected from spawning areas of the Upper Bay and Potomac River, late March - May 2013. CPUE is the number of fish captured per hour in 1000 square yards of experimental drift net.



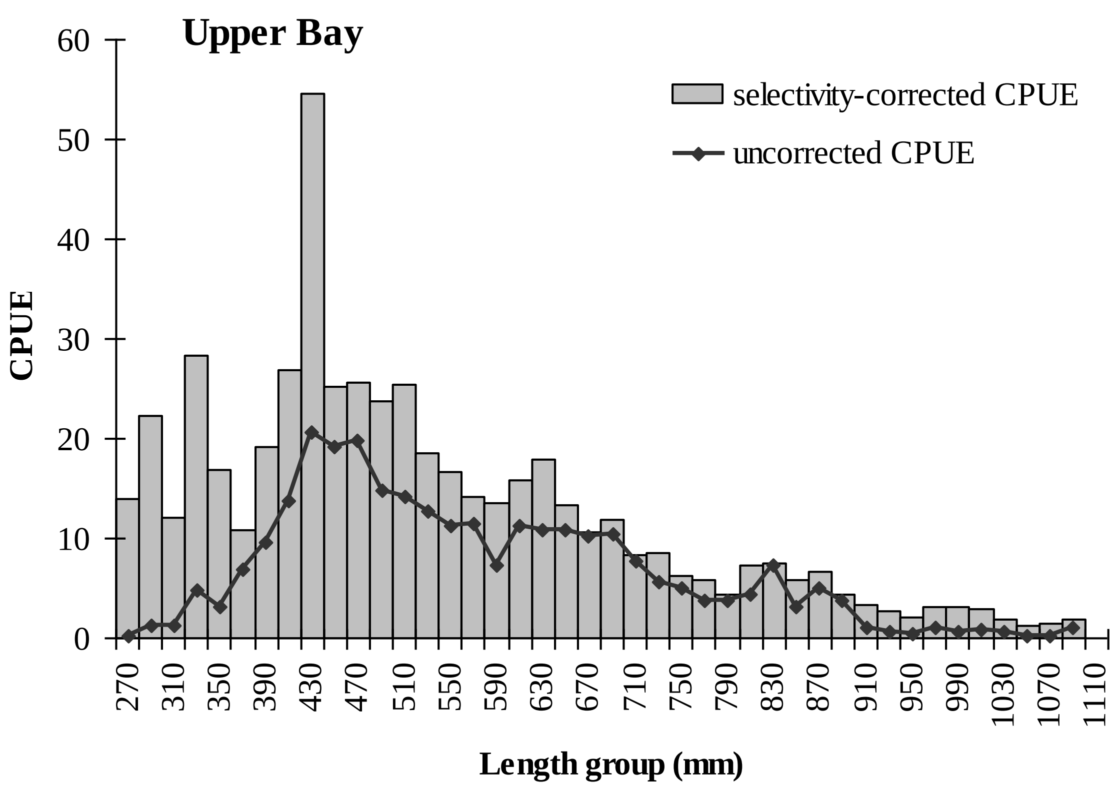


Figure 6. Length group CPUE (uncorrected and corrected for gear selectivity) of female striped bass collected from spawning areas of the Upper Bay and Potomac River, late March - May 2013. CPUE is the number of fish captured per hour in 1000 square yards of experimental drift net.

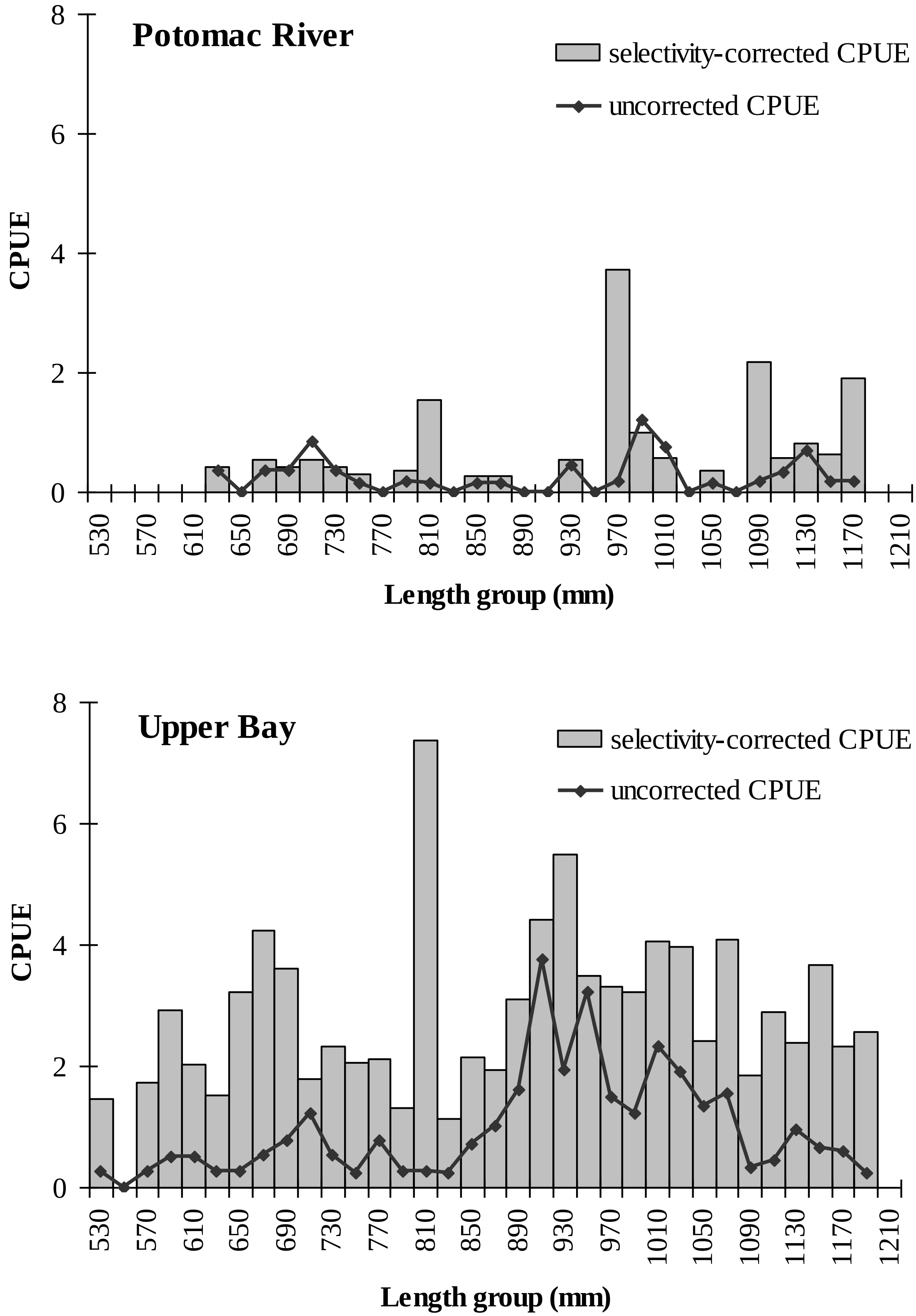


Figure 7. Mean length (mm TL) by year for individual ages of male striped bass sampled from spawning areas of the Potomac River and Upper Chesapeake Bay during late March through May, 1985-2013. Error bars are ± 2 standard errors (SE). The Potomac River was not sampled in 1994. *Note difference in scales on y-axis.

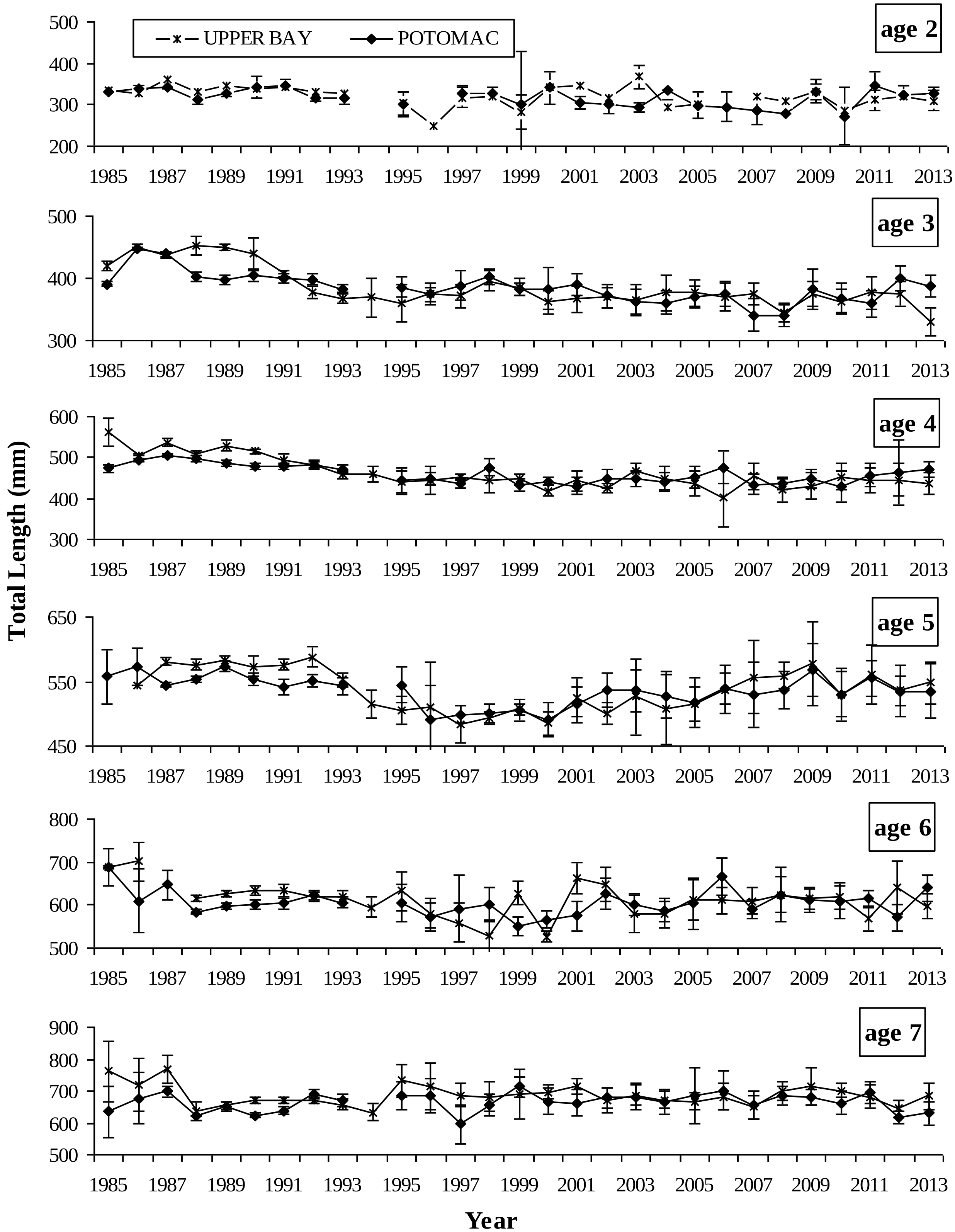


Figure 7. Continued.

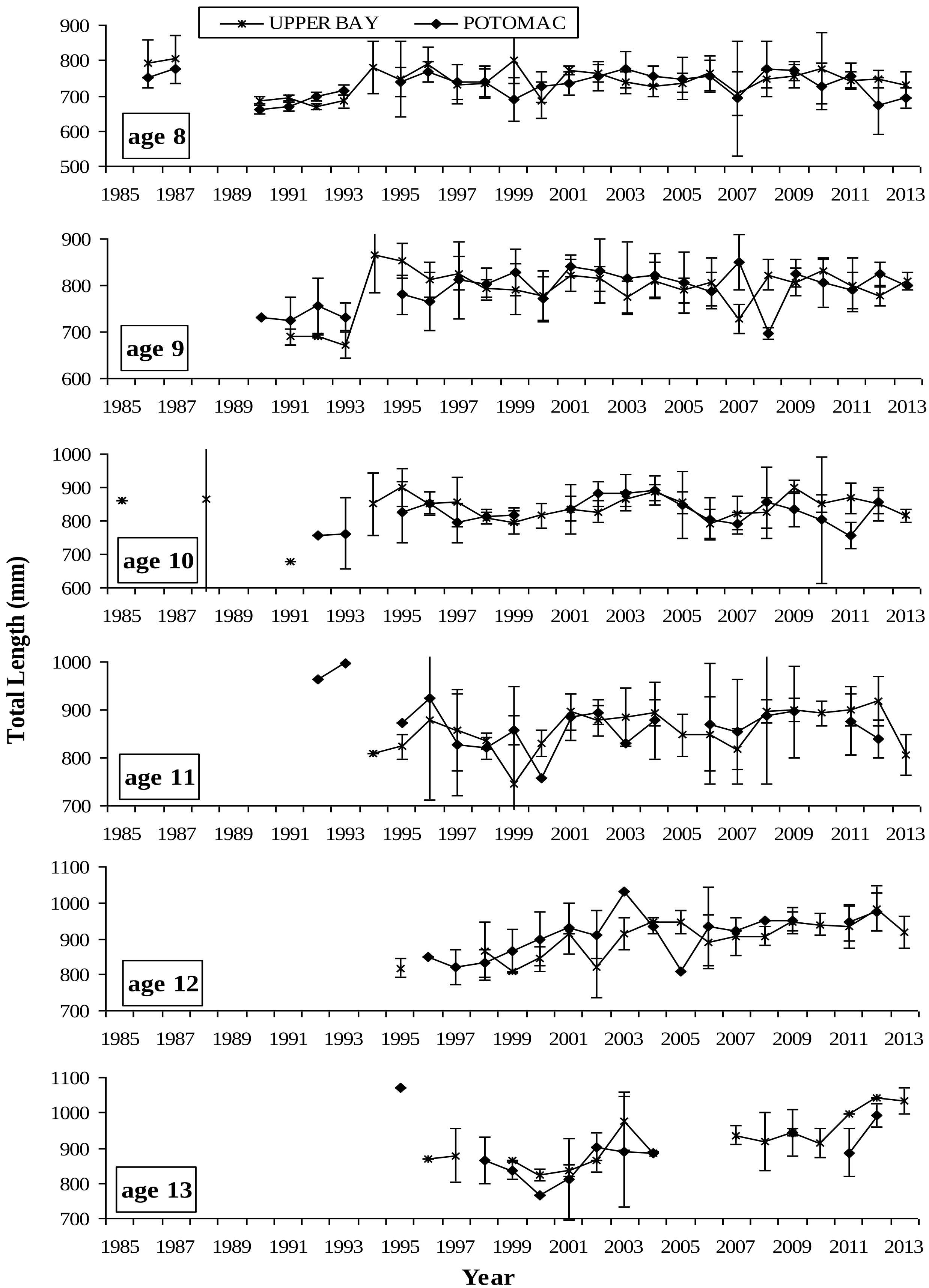


Figure 8. Mean length (mm TL) by year for individual ages of female striped bass sampled from spawning areas of the Potomac River and Upper Chesapeake Bay during late March through May, 1985–2013. Error bars are ± 2 standard errors (SE). Note the Potomac River was not sampled in 1994. *Note difference in scales on y-axis.

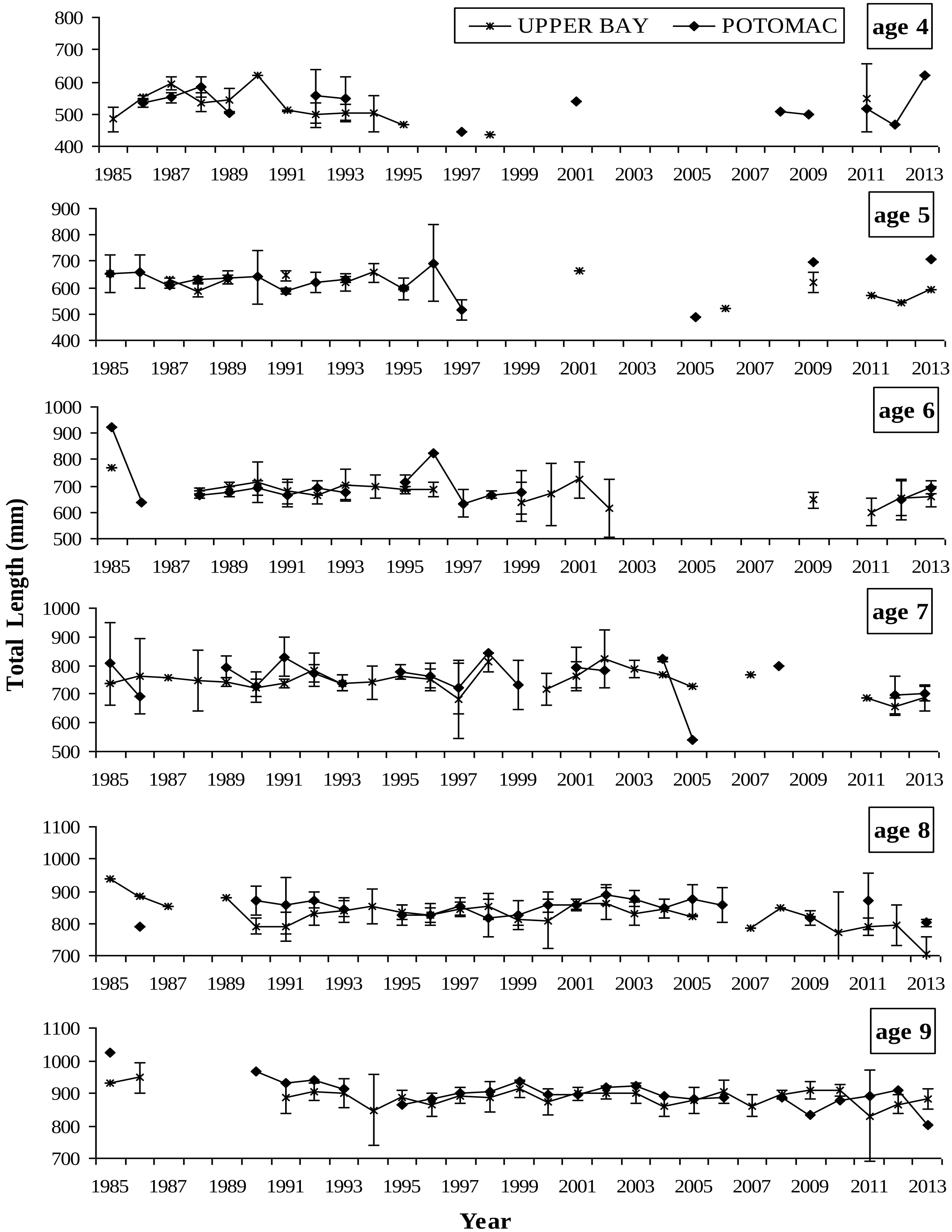


Figure 8. Continued.

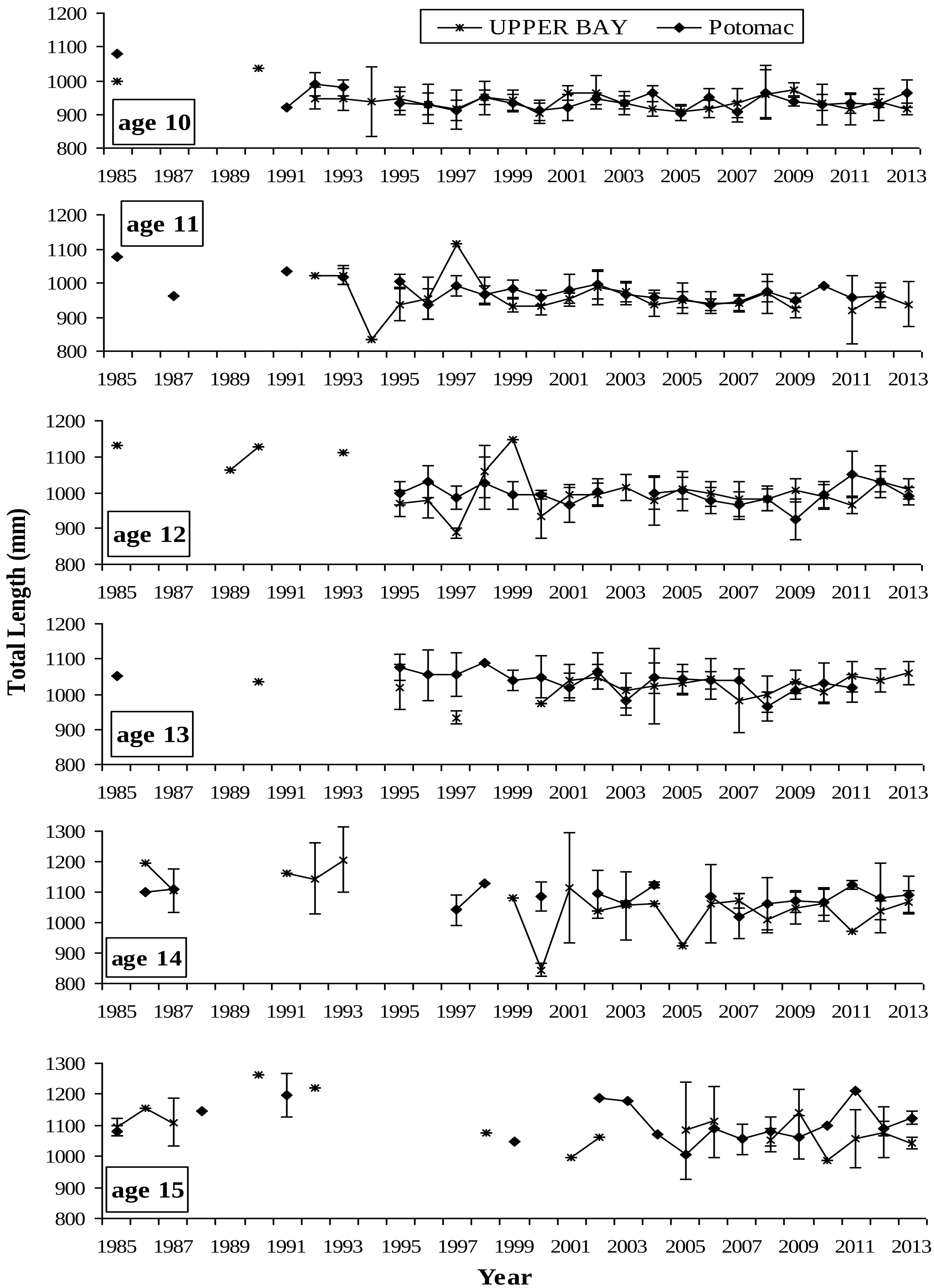


Figure 9. Maryland Chesapeake Bay spawning stock indices used in the coastal assessment. These are selectivity-corrected estimates of CPUE by year for ages 2 through 15-plus. Areas and sexes are pooled, although the contribution of sexes is shown in the stacked bars. Note different scales.

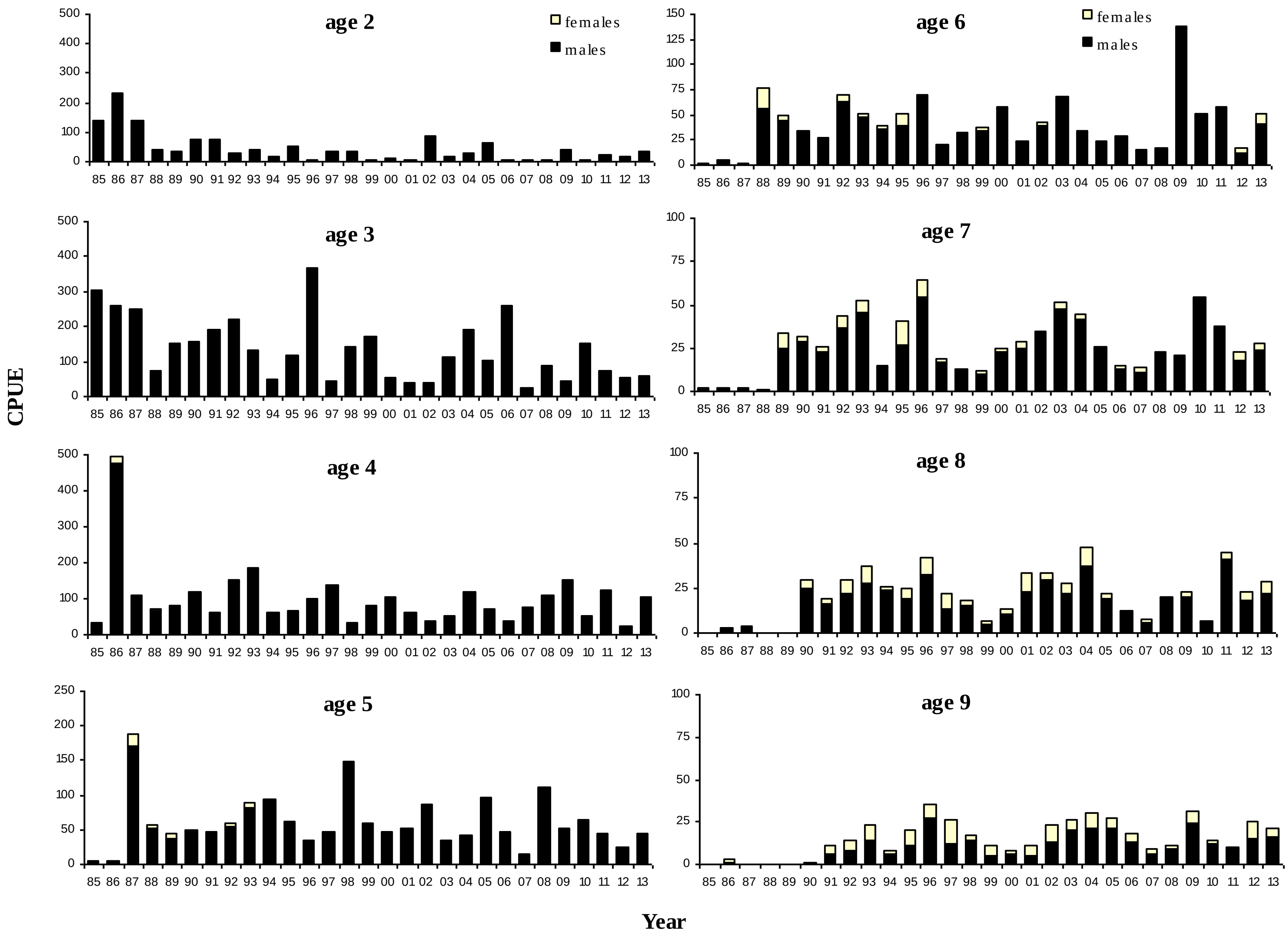


Figure 9. Continued.

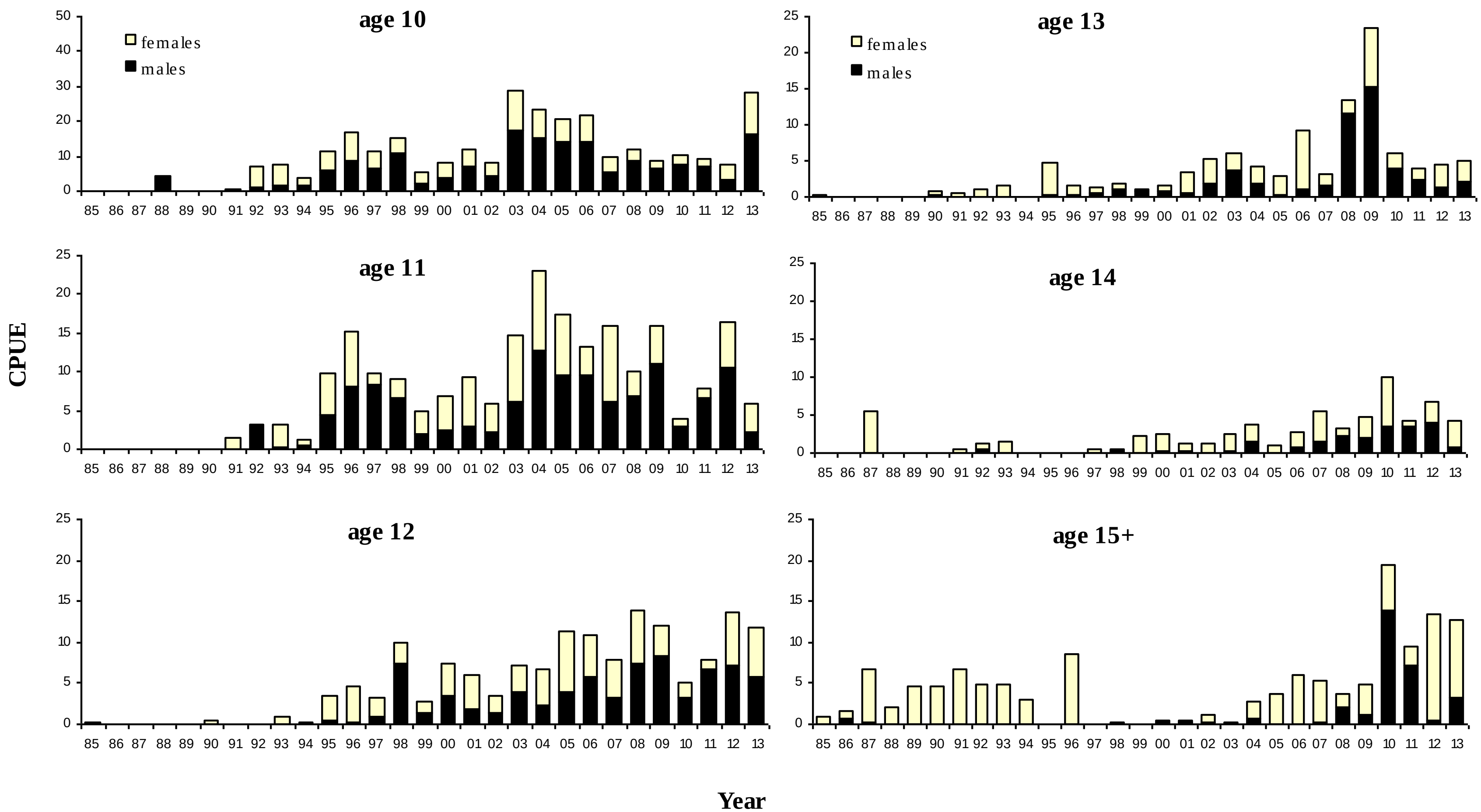
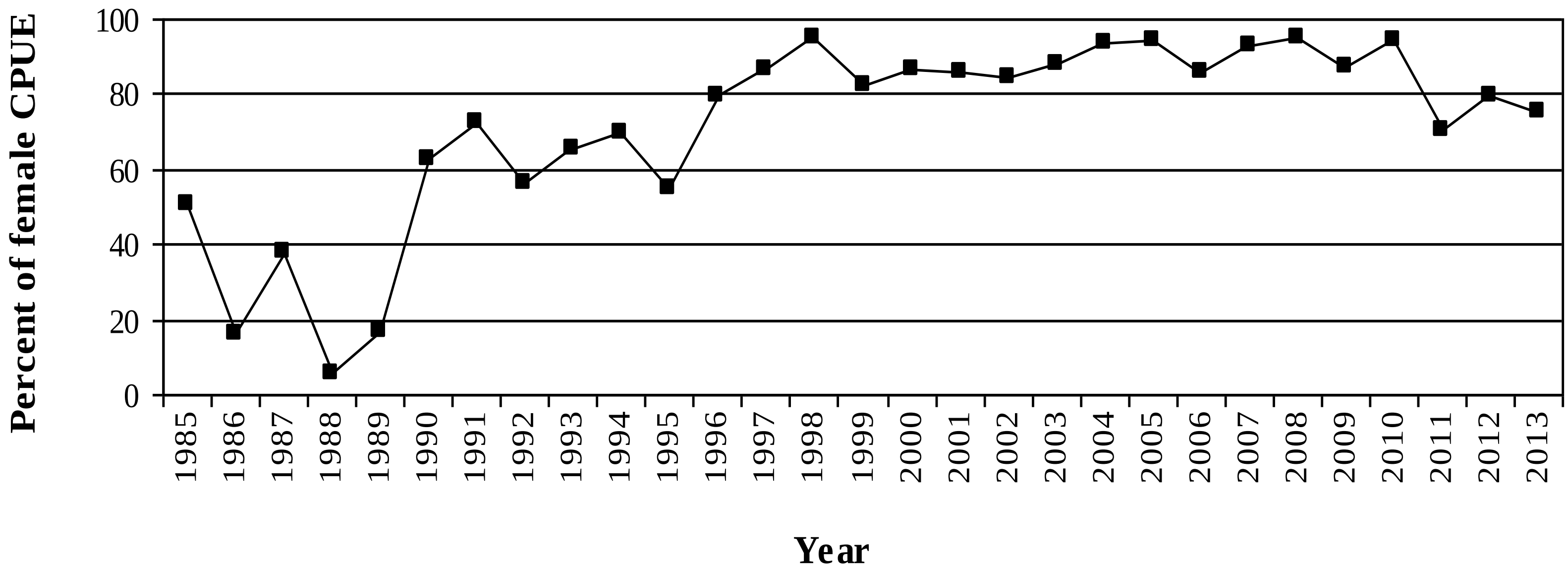
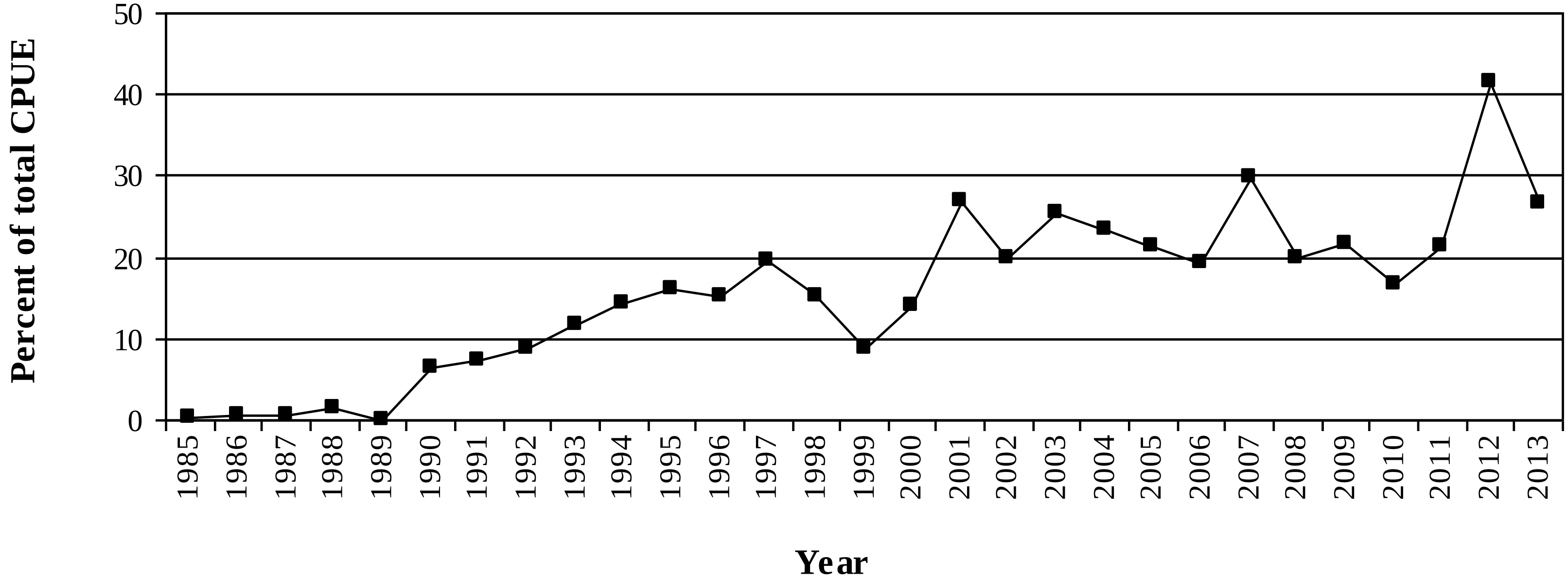


Figure 10. Percentage (selectivity-corrected CPUE) of female striped bass that were age 8 and older sampled from experimental drift gill nets set in spawning reaches of the Potomac River, Choptank River and the Upper Chesapeake Bay, late March through May, 1985-2013 (Choptank River to 1996). Effort is standardized as 1000 square yards of net per hour. Area-specific indices were weighted based on the relative size of the spawning areas* before area-specific indices were pooled.



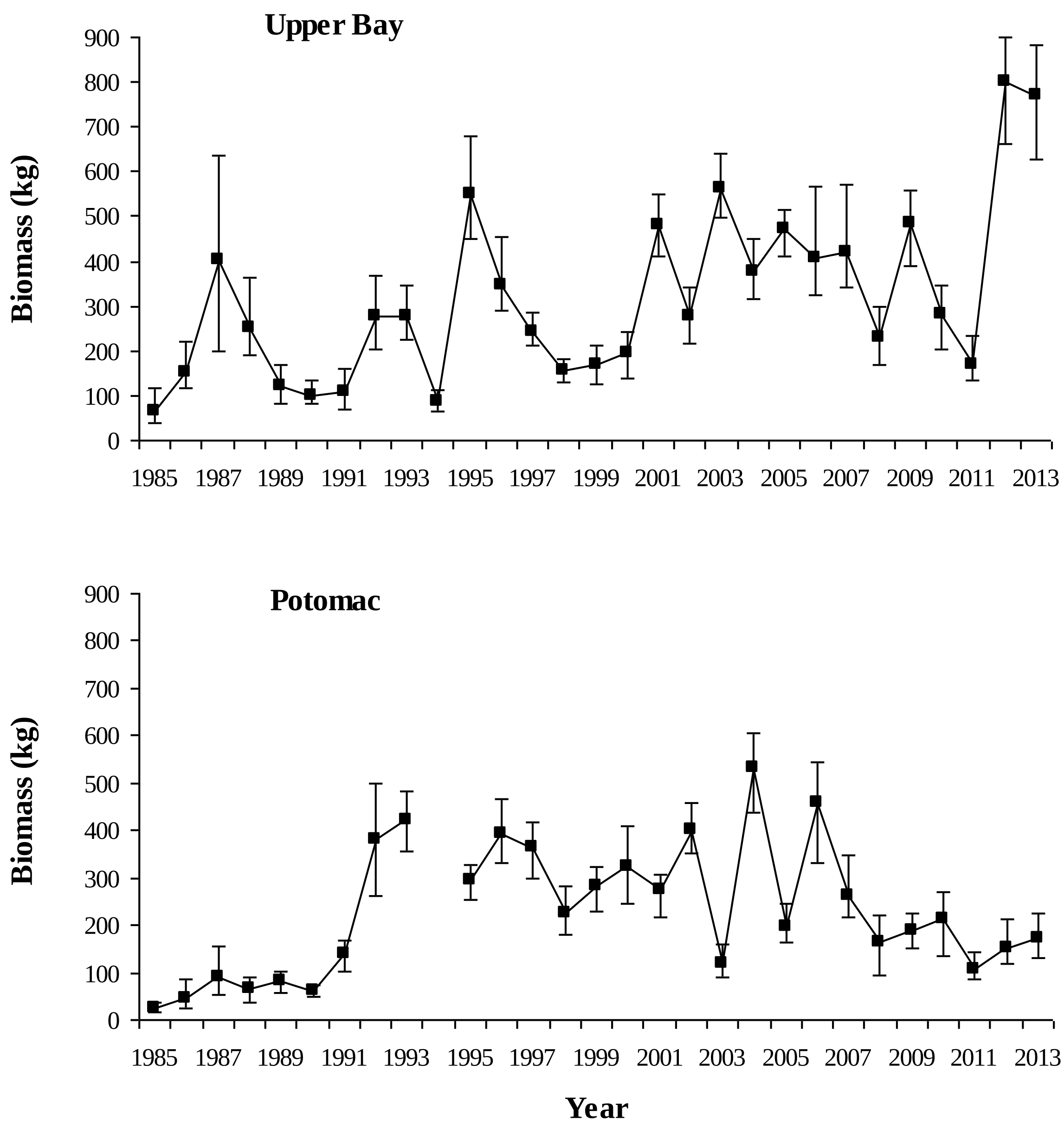
* Weights for spawning areas (1985 - 1996): Upper Bay=0.59; Potomac River=0.37; Choptank River=0.04.
(1997 - Present): Upper Bay=0.615; Potomac River=0.385. (Hollis 1967).

Figure 11. Percentage (selectivity-corrected CPUE) of male and female striped bass age 8 and over sampled from experimental drift gill nets set in spawning reaches of the Potomac River, Choptank River and the Upper Chesapeake Bay, late March through May, 1985-2013 (Choptank River to 1996). Effort is standardized as 1000 square yards of net per hour. Area-specific indices were weighted based on the relative size of the spawning areas* before area-specific indices were pooled.



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

Figure 12. 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 late March through May, 1985-2013. 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.

Stations have been sampled continuously since 1954, with changes in some station locations. Continued erosion at the Worton Creek site (#11) in the Head of Bay area made sampling there impossible in 2013. The nearby Handy Point site (#164) was elevated from auxiliary to permanent status as a replacement.

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 other river systems. 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 759 YOY striped bass was collected at permanent stations in 2013, with individual samples yielding between 0 and 40 fish. The AM (5.8) and GM (3.42) were both below their respective time-series averages and TPAs (Table 2 and 3, Figures 2 and 3). The PPHL was 0.84, indicating that 84% of samples produced juvenile striped bass. The PPHL was greater than the time-series average of 0.70 (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 2013 $\log_e$-mean was significantly lower than 14 years of the time-series, and greater than 20 years of the time-series. The 2013 year-class was indiscernible from 22 other year-classes.

System Means

Head of Bay - In 42 samples, 207 juveniles were collected at the Head of Bay sites for an AM of 4.93, less than the time-series average (11.6) and the TPA of 17.3 (Table 2, Figure 5). The GM of 3.29 was also below the time-series average (5.51) and 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 2013 Head of Bay $\log_e$-mean significantly less than 16 years of the time-series and significantly greater than 10 years of the time-series. The 2013 Head of Bay index was indiscernible from 30 other year-classes in the time-series.

Potomac River - A total of 292 juveniles was collected in 42 samples on the Potomac River. The AM of 6.95 was less than the TPA (9.2) and the time-series average (8.3) (Table 2, Figure 5). The GM of 3.13 was also less than the time-series average (3.61) and TPA (3.93) (Table 3, Figure 7).

Analysis of variance of $\log_e$-means indicated significant differences among years (ANOVA: P<0.0001). Duncan's multiple range test (p=0.05) ranked the 2013 Potomac River year-class significantly smaller than eight years, and significantly larger than 19 year of the time-series. It was not significantly different than the 29 other years of the time-series.

Choptank River - A total of 114 juveniles was collected in 24 Choptank River samples. The AM of 4.75 was lower than the time-series average of 21.3 and the TPA of 10.8 (Table 2, Figure 5). The GM of 3.53 was also lower than its time-series average (8.04) and TPA (5.00) (Table 3, Figure 8). Differences among years were significant (ANOVA: P<0.0001). Duncan's multiple range test (p=0.05) found the 2013 Choptank River year-class significantly smaller than 14 years, significantly larger than 12 years of the time-series, and indiscernible from 30 other years of the time-series.

Nanticoke River - A total of 146 juveniles was collected in 24 samples on the Nanticoke River. The AM of 6.08 was below the time-series average (8.3) and TPA (8.6) (Table 2, Figure 5). The GM of 4.14 exceeded its time-series average (3.77) and TPA (3.12) (Table 3, Figure 9). The Nanticoke River also exhibited significant differences among years (ANOVA: P<0.0001). Duncan's multiple range test (p=0.05) ranked the 2013 index significantly smaller than five years of the time-series and larger than 20 years of time-series. The 2013 Nanticoke River index was statistically indiscernible from the remaining 31 years of the time-series.

Auxiliary Indices

At the **Head of Bay auxiliary sites**, 74 juveniles were caught in 15 samples, resulting in an AM of 4.93, which was less than its time-series average of (5.65). The GM of 2.82 was greater than the time-series average of 2.69 (Table 5).

On the **Patuxent River**, 108 YOY striped bass were caught in 18 samples for an AM of 6.0 and a GM of 2.63. Both Patuxent River indices were less than their time-series averages but greater than their respective time-series medians (Table 5).

DISCUSSION

Although improved from the record low level of 2012, striped bass recruitment in Maryland's Chesapeake Bay was below average in 2013. Young-of-year striped bass did not occur in high abundance, but were captured in a high proportion of samples (PPHL=0.84), indicating that they were widely distributed.

Only one of the four systems surveyed showed above-average recruitment. The Nanticoke River GM was above its time-series average and TPA. The Nanticoke GM ranked in the 72nd percentile of the time-series. A Duncan's multiple range test found Nanticoke River recruitment lower than only the best five years of the time-series.

Recruitment in the remaining systems was uniformly low. GMs in the Head of Bay system, and Potomac and Choptank rivers, were at or near their respective time-series median values, but all indices from these systems were below average.

In contrast to the permanent Head of Bay sites, the GM at Head of Bay auxiliary sites, located primarily on the Susquehanna Flats, was above average.

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: $C_1=(0.187156)(C_0)- 0.06895$, 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 (0.05) was greater than the index of 0.01 predicted by the regression analysis. Examination of residuals (Figure 11) shows that this regression equation can be used to predict subsequent yearling striped bass abundance with reasonable certainty in the case of small and average sized year-classes. Estimates of future abundance of age 1 striped bass are less reliable for dominant year-classes. Lower than expected abundance of age 1 striped bass may be an indication of density-dependent processes operating at high levels of abundance, such as cannibalism, increased competition for food, increased spatial distribution, or overwintering mortality. Higher than expected abundance of age 1 striped bass may identify particularly good conditions that enhanced survival.

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LIST OF TABLES

LIST OF FIGURES

Table 1. Maryland juvenile striped bass survey sample sites.

Site Number	River or Creek	Area or Nearest Landmark
	HEAD OF CHESAPEAKE BAY SYSTEM	
* 58	Susquehanna Flats	North side Spoil Island, 1.9 miles south of Tyding's Park
* 130	Susquehanna Flats	North side of Plum Point
* 144	Susquehanna Flats	Tyding's Estate, west shore of flats
* 132	Susquehanna Flats	0.2 miles east of Poplar Point
* 59	Northeast River	Carpenter Point, K.O.A. Campground beach
3	Northeast River	Elk Neck State Park beach
4	Elk River	Welch Point, Elk River side
5	Elk River	Hyland Point Light
115	Bohemia River	Parlor Point
160	Sassafras River	Sassafras N.R.M.A., opposite Ordinary Point
10	Sassafras River	Howell Point, 500 yards east of point
164	Worton Creek	Handy Point, 0.3 miles west of Green Point Wharf
* 88	Chesapeake Bay	Beach at Tolchester Yacht Club
	POTOMAC RIVER SYSTEM	
139	Potomac River	Hallowing Point, VA
50	Potomac River	Indian Head, old boat basin
51	Potomac River	Liverpool Point, south side of pier
52	Potomac River	Blossom Point, mouth of Nanjemoy Creek
163	Potomac River	Aqualand Marina
56	Potomac River	St. George Island, south end of bridge
55	Wicomico River	Rock Point

* Indicates auxiliary seining site

Table 1. Continued.

Site Number	River or Creek	Area or Nearest Landmark
		CHOPTANK RIVER SYSTEM
2	Tuckahoe Creek	Northeast side near mouth
148	Choptank River	North side of Jamaica Point
161	Choptank River	Dickinson Bay, 0.5 miles from Howell Point
29	Choptank River	Castle Haven, northeast side
		NANTICOKE RIVER SYSTEM
36	Nanticoke River	Sharptown, pulpwood pier
37	Nanticoke River	0.3 miles above Lewis Landing
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
Average	11.6	8.3	21.3	8.3	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
Average	5.51	3.61	8.04	3.77	4.21
TPA*	7.27	3.93	5.00	3.12	4.32

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

Table 4. Maryland Chesapeake Bay arithmetic mean (AM) and log mean with coefficients of variation (CV), proportion of positive hauls (PPHL) with 95% confidence intervals (CI), and number of seine hauls (n) for juvenile striped bass.

Year	AM	CV (%) of AM	Log Mean	CV (%) of Log Mean	PPHL	Low CI	High CI	n
1957	2.9	205.5	0.87	100.72	0.66	0.52	0.80	44
1958	19.3	94.2	2.50	48.56	0.89	0.79	0.99	36
1959	1.4	198.3	0.47	171.23	0.30	0.14	0.45	34
1960	7.1	149.2	1.39	86.32	0.72	0.58	0.87	36
1961	17.0	183.3	2.03	61.04	0.96	0.90	1.02	46
1962	12.2	160.8	1.66	82.85	0.75	0.66	0.84	88
1963	4.0	182.6	0.96	111.85	0.56	0.45	0.66	88
1964	23.5	162.3	2.31	60.35	0.90	0.83	0.96	88
1965	7.4	247.7	0.94	140.06	0.47	0.36	0.57	88
1966	16.7	184.8	1.98	67.16	0.86	0.80	0.92	132
1967	7.8	263.9	1.19	100.40	0.69	0.61	0.77	132
1968	7.2	175.3	1.31	94.10	0.65	0.57	0.73	132
1969	10.5	224.0	1.34	104.40	0.62	0.54	0.70	132
1970	30.4	157.5	2.60	52.73	0.95	0.91	0.99	132
1971	11.8	187.0	1.61	80.43	0.81	0.74	0.88	132
1972	11.0	250.8	1.45	91.54	0.72	0.64	0.80	132
1973	8.9	229.2	1.20	110.90	0.61	0.53	0.70	132
1974	10.1	261.9	1.29	102.42	0.65	0.57	0.74	132
1975	6.7	152.2	1.34	86.76	0.73	0.66	0.81	132
1976	4.9	279.4	0.95	113.88	0.60	0.51	0.68	132
1977	4.8	236.4	1.96	113.00	0.62	0.54	0.70	132
1978	8.5	145.6	1.56	77.24	0.77	0.69	0.84	132
1979	4.0	182.1	1.00	100.24	0.66	0.58	0.74	132
1980	2.0	174.8	0.70	114.68	0.54	0.45	0.62	132
1981	1.2	228.2	0.46	150.34	0.39	0.30	0.47	132
1982	8.4	160.1	1.51	79.73	0.76	0.68	0.83	132
1983	1.4	268.0	0.48	152.37	0.38	0.30	0.46	132
1984	4.2	228.2	0.97	106.58	0.65	0.57	0.73	132
1985	2.9	253.0	0.65	152.02	0.42	0.33	0.50	132
1986	4.1	272.2	0.85	121.40	0.55	0.47	0.64	132
1987	4.8	262.1	0.90	124.54	0.51	0.42	0.59	132
1988	2.7	313.8	0.55	170.46	0.37	0.29	0.45	132
1989	25.2	309.1	1.77	90.18	0.75	0.68	0.82	132
1990	2.1	174.8	0.71	120.74	0.49	0.41	0.58	132
1991	4.4	203.8	0.93	120.27	0.52	0.43	0.60	132

Table 4. Continued.

Year	AM	CV (%) of AM	Log Mean	CV (%) of Log Mean	PPHL	Low CI	High CI	n
1992	9.0	267.0	1.20	105.19	0.67	0.59	0.75	132
1993	39.8	279.1	2.71	49.53	0.96	0.93	0.99	132
1994	16.1	150.4	2.00	66.96	0.84	0.78	0.90	132
1995	9.3	153.3	1.69	66.42	0.86	0.80	0.92	132
1996	59.4	369.2	2.92	45.50	0.99	0.96	1.00	132
1997	8.0	135.6	1.59	70.98	0.80	0.74	0.87	132
1998	12.7	164.8	1.87	65.72	0.86	0.78	0.92	132
1999	18.1	208.4	1.85	77.45	0.80	0.75	0.88	132
2000	13.8	120.8	2.13	53.69	0.91	0.86	0.96	132
2001	50.8	308.9	2.61	57.22	0.92	0.88	0.97	132
2002	4.7	141.3	1.16	91.89	0.67	0.59	0.75	132
2003	25.8	136.9	2.47	55.42	0.92	0.88	0.97	132
2004	11.4	177.8	1.77	67.01	0.87	0.81	0.93	132
2005	17.8	237.3	2.07	59.12	0.90	0.86	0.95	132
2006	4.3	178.6	1.02	103.67	0.59	0.51	0.67	132
2007	13.4	177.3	1.81	71.92	0.83	0.76	0.89	132
2008	3.2	213.1	0.81	119.32	0.54	0.45	0.62	132
2009	7.9	154.3	1.59	66.66	0.86	0.80	0.92	132
2010	5.6	175.0	1.26	82.49	0.77	0.69	0.84	132
2011	34.6	580.4	2.36	51.94	0.93	0.89	0.97	132
2012	0.9	197.5	0.40	152.53	0.35	0.27	0.43	132
2013	5.8	115.7	1.49	63.93	0.84	0.78	0.90	132
Average	11.8	210.6	1.44	93.04	0.70	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	42.5	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
Average	24.44	6.65		5.65	2.69	
Median	3.33	1.95		3.47	1.91	

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	N/A

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

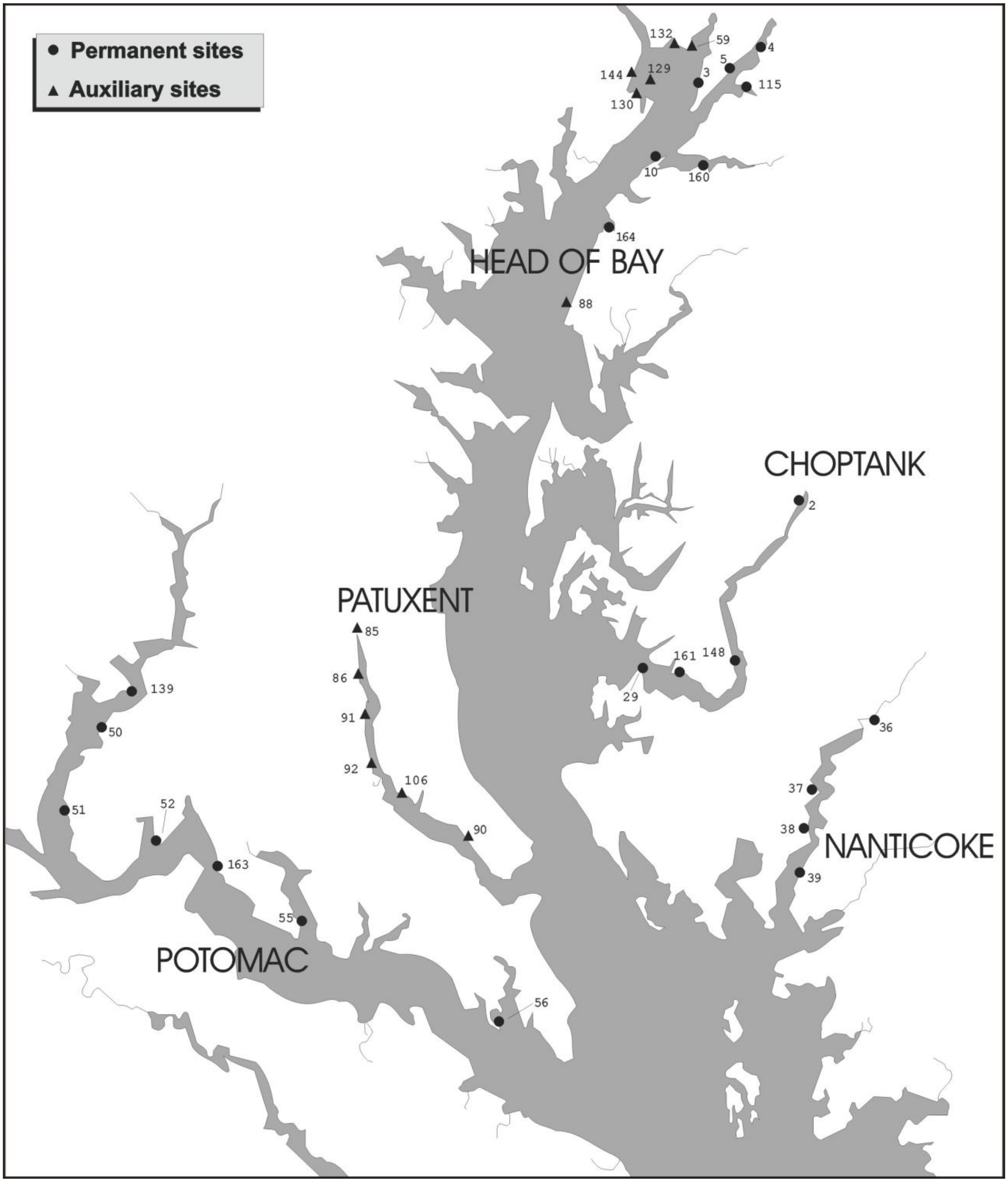


Figure 2. Maryland Chesapeake Bay arithmetic mean (AM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

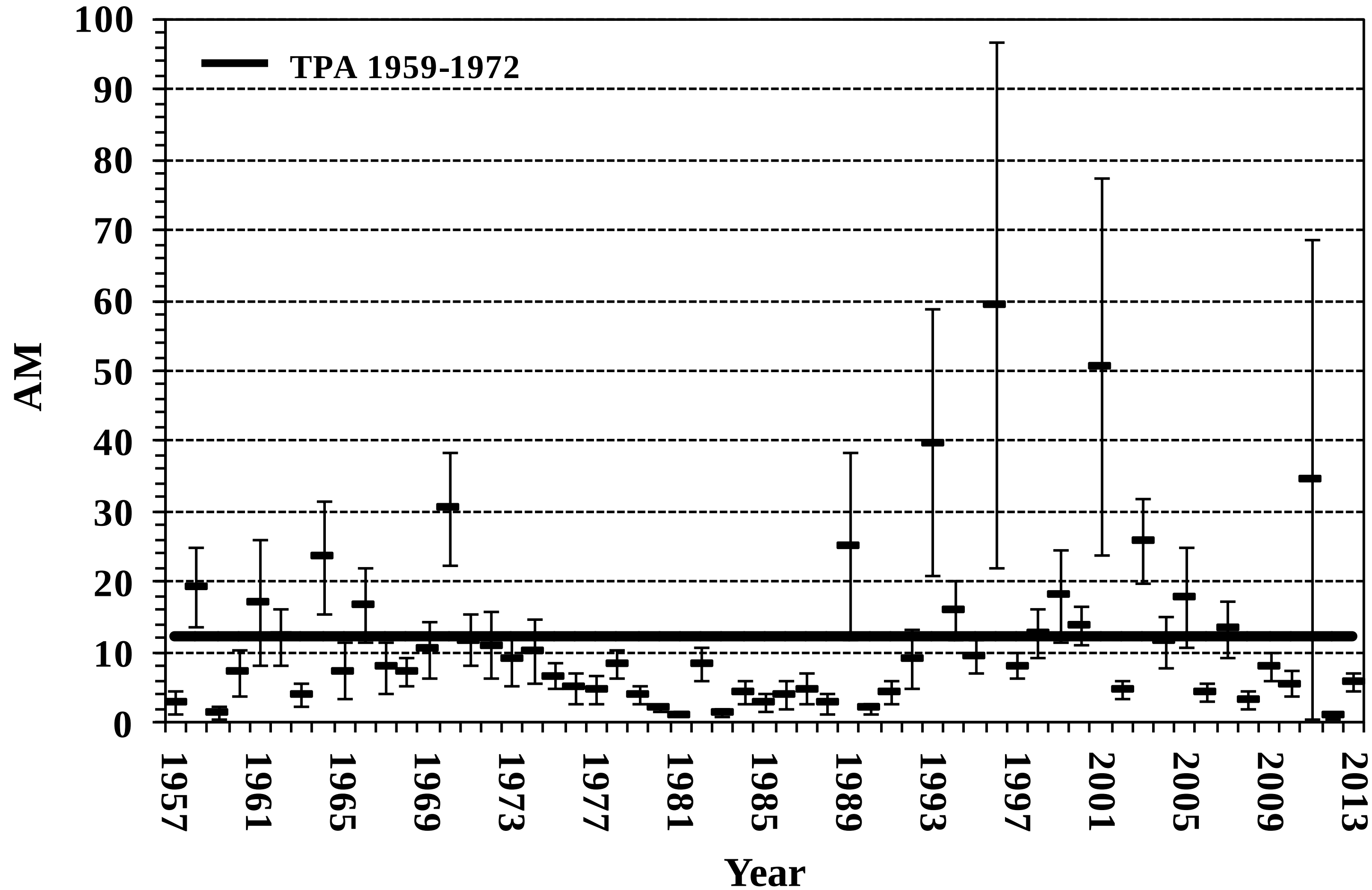


Figure 3. Maryland Chesapeake Bay geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

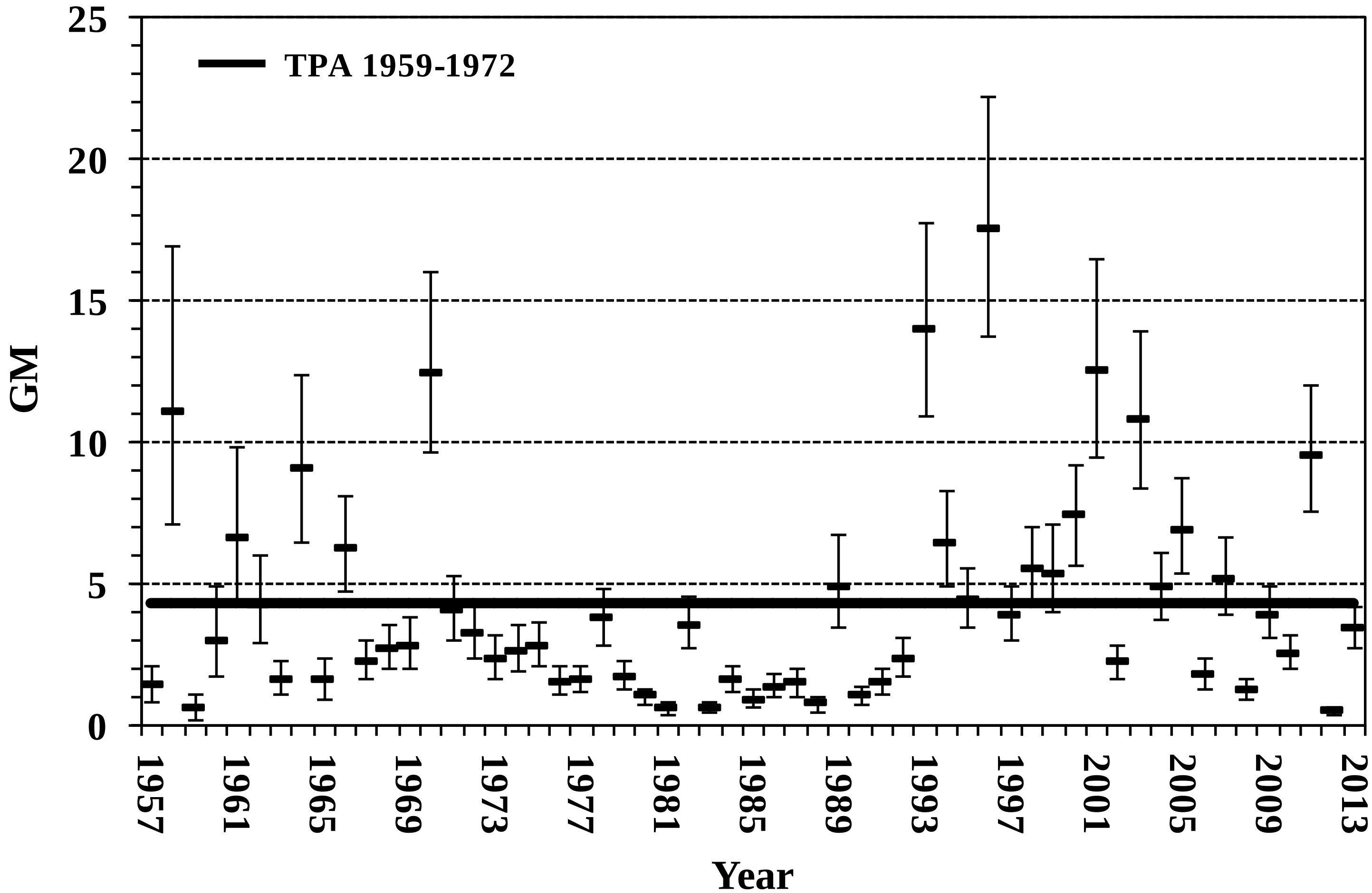


Figure 4. Maryland Chesapeake Bay juvenile striped bass indices. Arithmetic mean (AM), scaled geometric mean (GM)*, and proportion of positive hauls (PPHL) as percent.

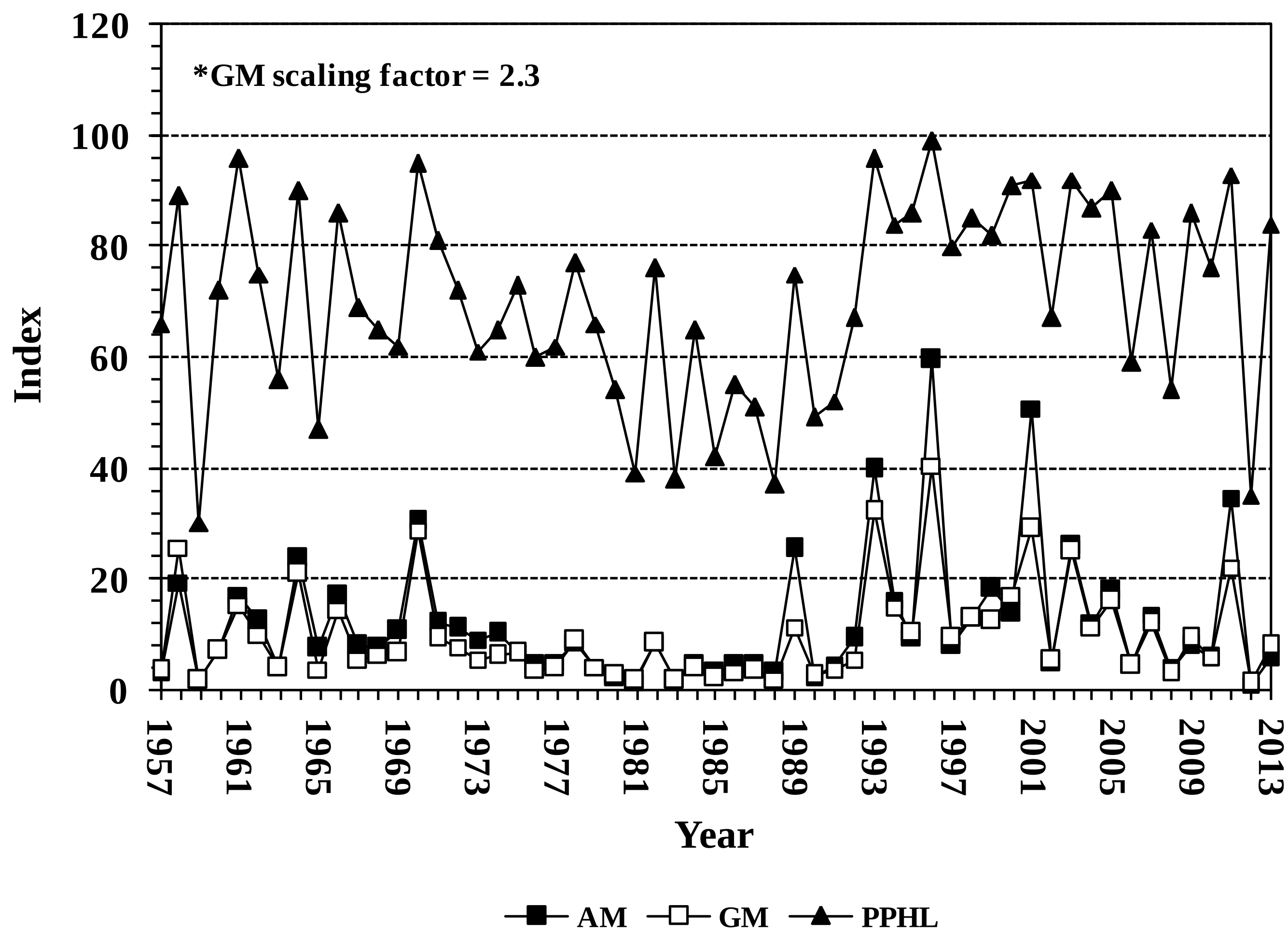


Figure 5. Arithmetic mean (AM) catch per haul by system for juvenile striped bass. Note different scales.

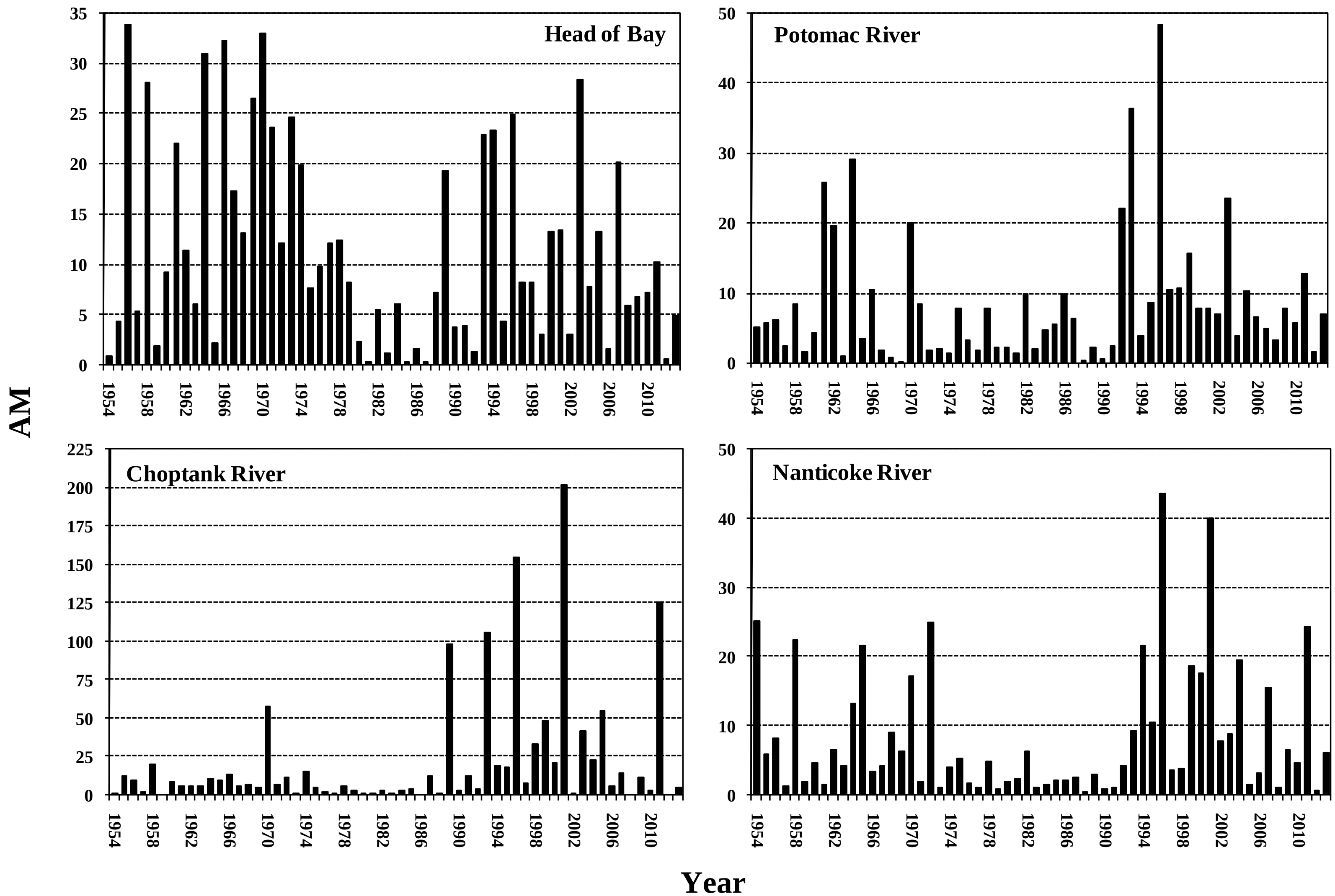


Figure 6. Head of Bay geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

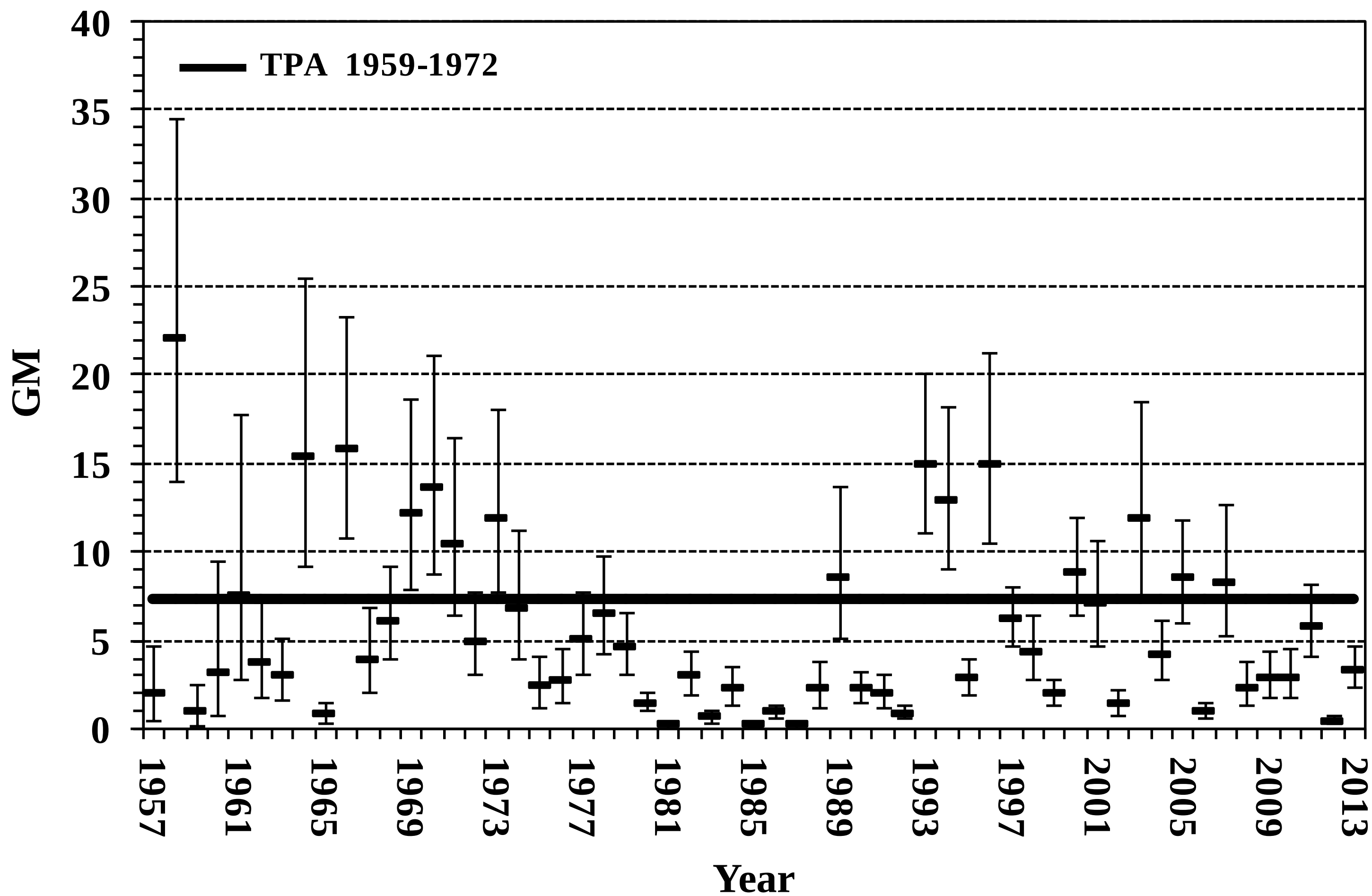


Figure 7. Potomac River geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

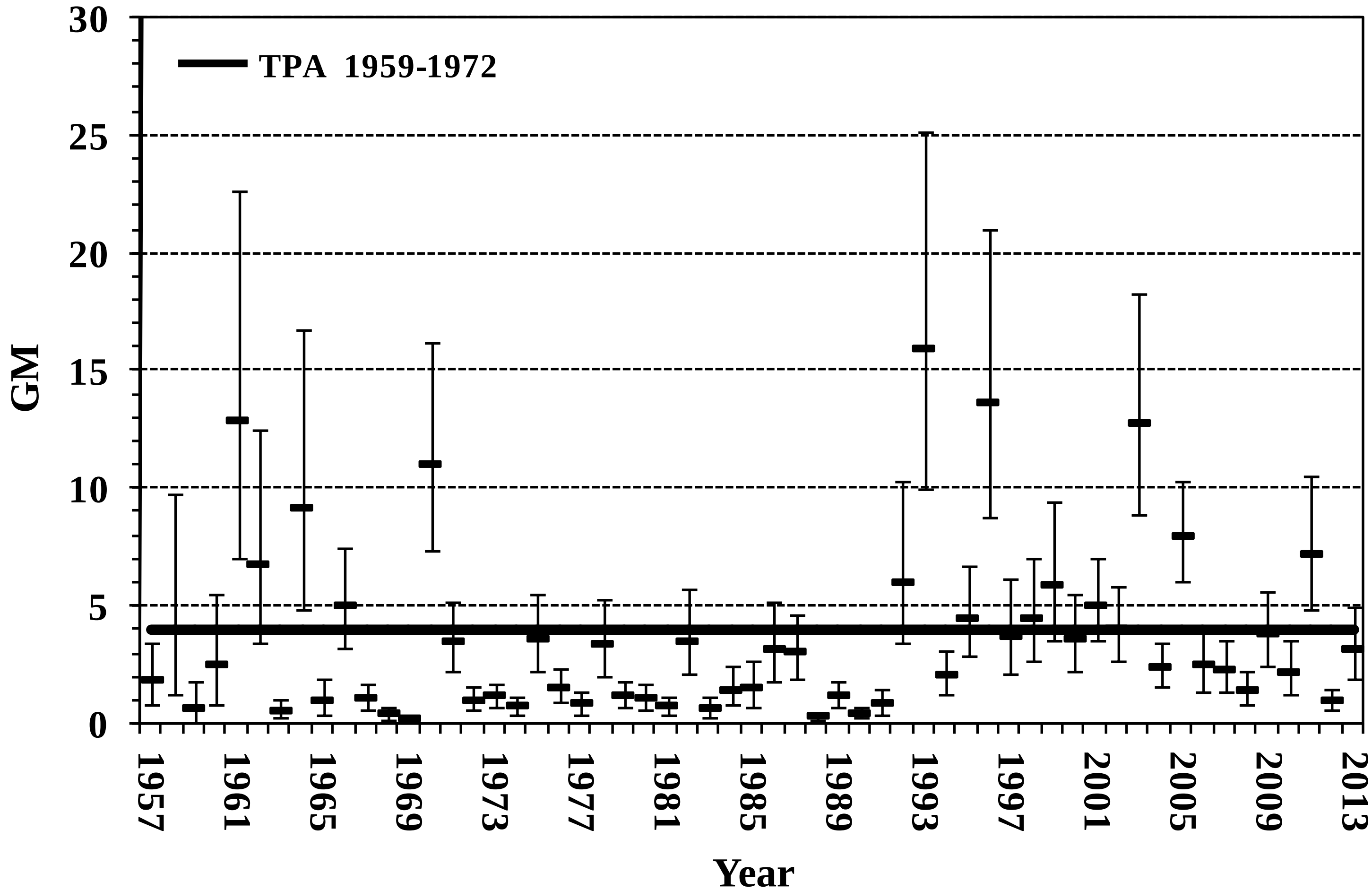


Figure 8. Choptank River geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

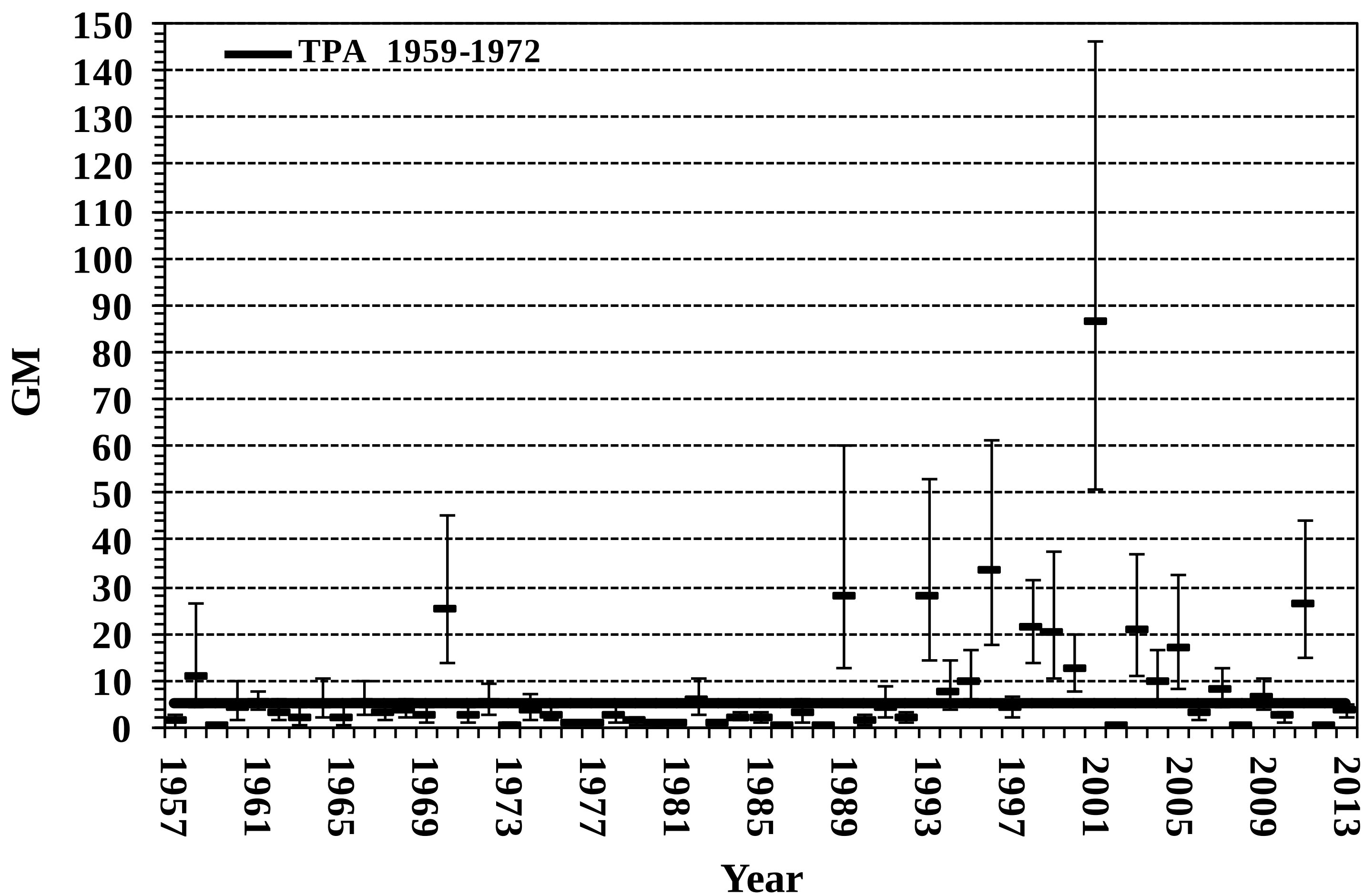


Figure 9. Nanticoke River geometric mean (GM) catch per haul and 95% confidence intervals (± 2 SE) for juvenile striped bass with target period average (TPA).

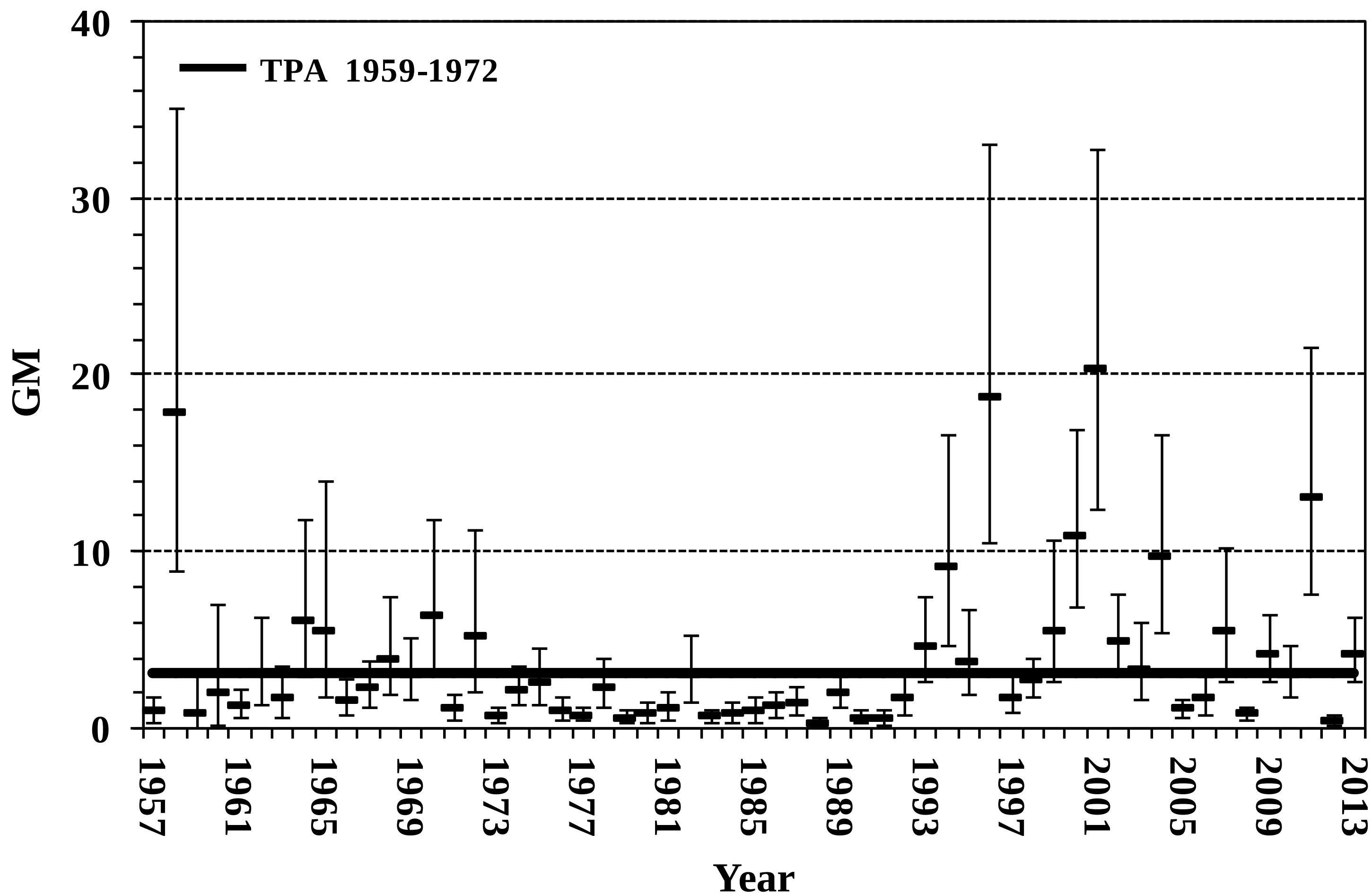


Figure 10. Relationship between age 0 and subsequent age 1 striped bass indices.

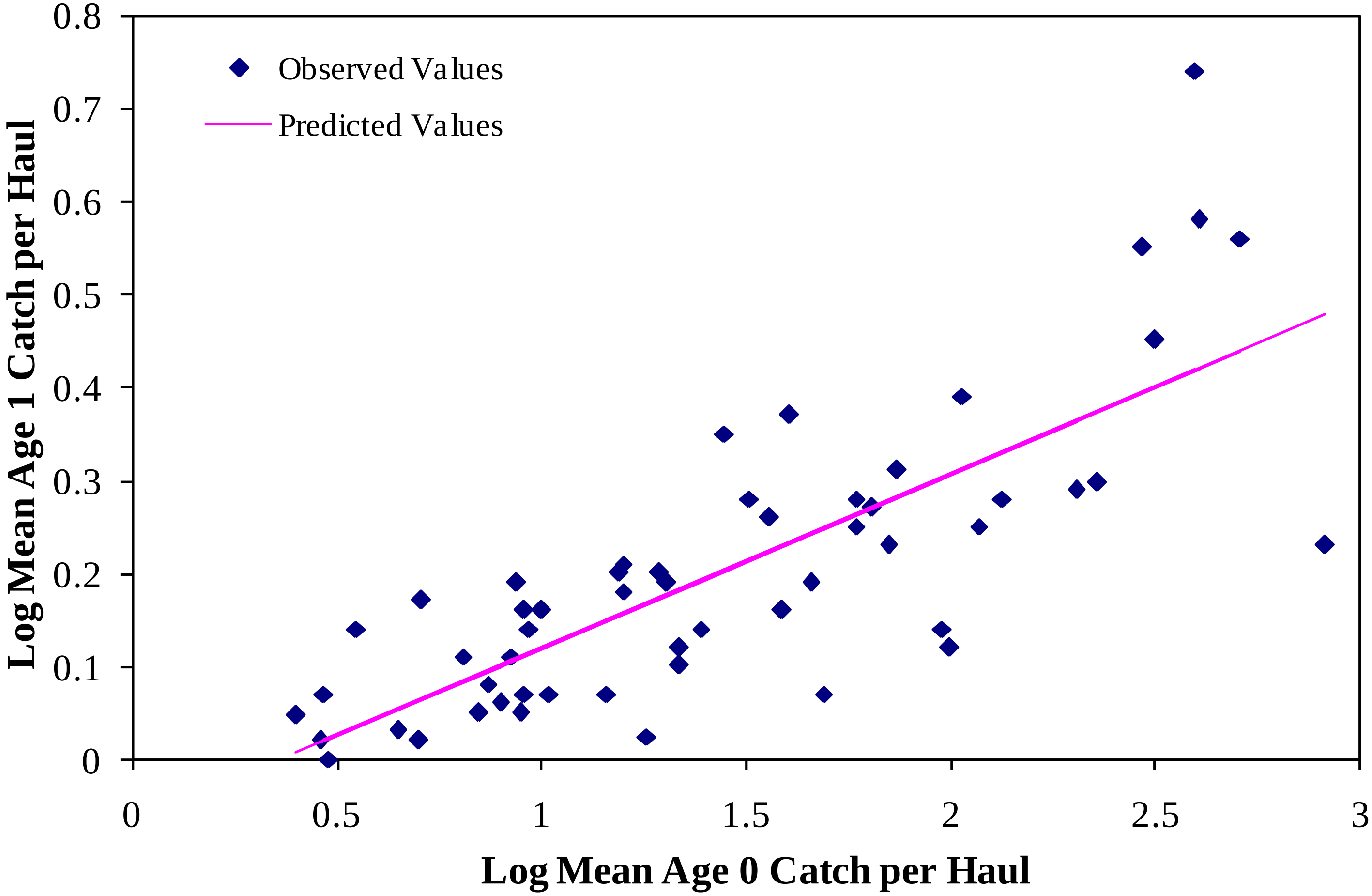
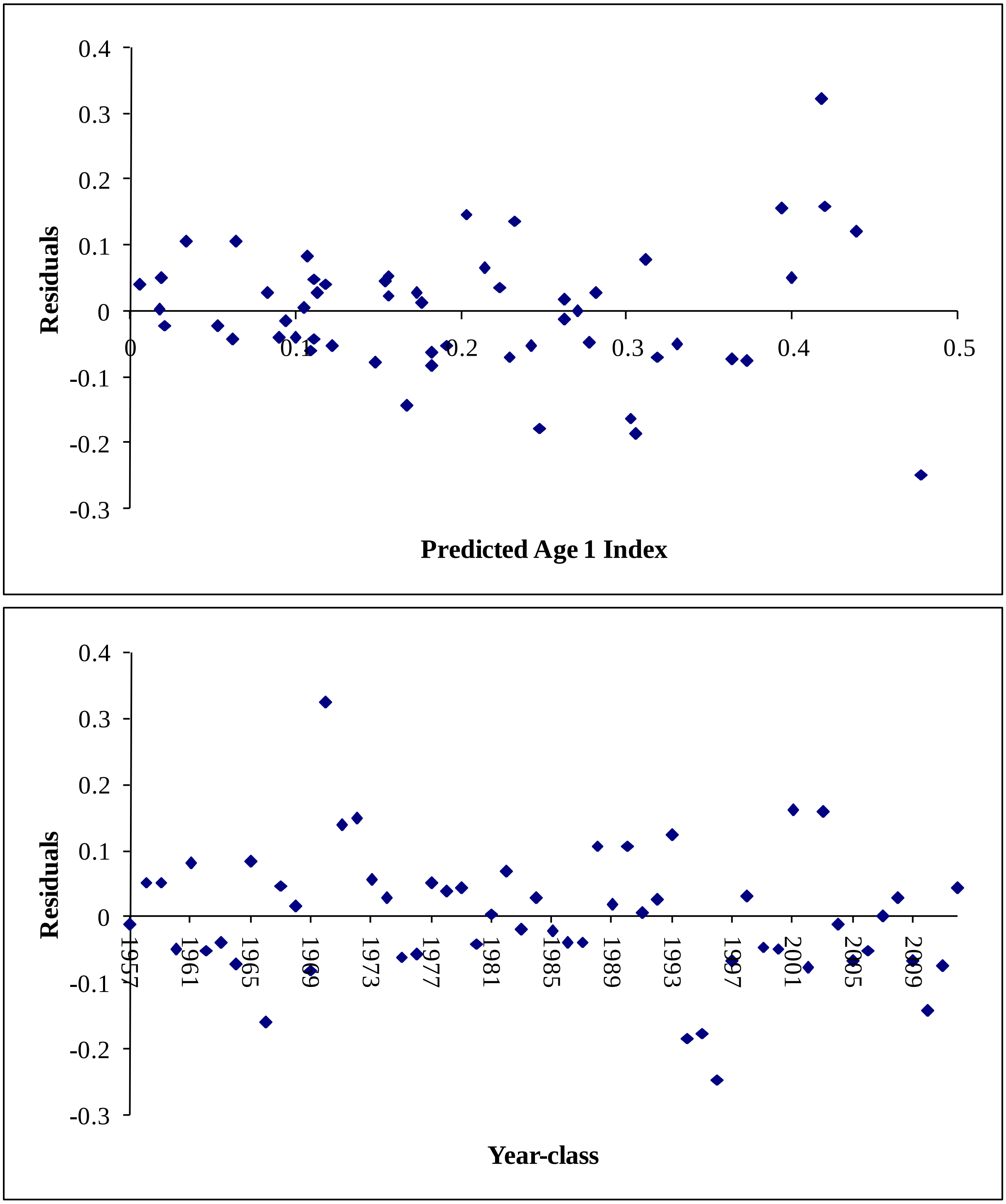


Figure 11. Residuals of age 1 and age 0 striped bass regression.



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 all striped bass tagging activities in Maryland's portion of the Chesapeake Bay and the North Carolina cooperative tagging cruise that occurred during winter and spring of 2013. The Maryland Department of Natural Resources (MD DNR) and partnering agencies tagged striped bass as part of the United States Fish and Wildlife Service's (USFWS) Cooperative Coastal 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 Atlantic coast striped bass stocks.

METHODS

Sampling procedures

During late March through mid-May 2013, 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, maturation 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 and all female fish. Tagging stopped when catches dropped off or water temperature exceeded 70°F.

In 2013, 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 wintering in the Atlantic Ocean off northeastern North Carolina and/or southeastern Virginia (state and federal waters), using two different gears. While the future of funding for the trawl portion remains uncertain, there is the potential for side by side comparisons to be done on these data, such as survival estimates and mean lengths. Participants in the two sampling components included USFWS, Southeast Area Monitoring and Assessment Program, North Carolina Division of Marine Fisheries (NC DMF), East Carolina University, MD DNR, Atlantic States Marine Fisheries Commission (ASMFC), National Marine Fisheries Service, North Carolina Wildlife Resources Commission, North Carolina Division of Coastal Management, Potomac River Fisheries Commission, North Carolina State University, Virginia Commonwealth University and Delaware State University.

The first phase of the tagging cruise took place from January 8 to January 16, 2013. Trawling was conducted 24 hours per day aboard the Duke University Research Vessel Cape Hatteras. One 65-foot (19.7 m) head-rope Mongoose trawl was towed 245 times at speeds ranging from 1.8 to 4.2 knots at depths of 35 to 90 feet (10.7 – 27.4 m) for 0.08 to 0.52 hours.

The hook and line portion of the tagging cruise was conducted on three contracted sportfishing vessels departing from Virginia Beach, VA. Sampling was conducted during 10 fishing trips, between January 21 and February 13, 2013. Between four and ten lines containing custom-made tandem parachute rigs were trolled, at 2 to 5 knots, in depths of 42 to 88 feet (12.8 to 26.8 m).

In both components of the cruise, captured fish were placed in holding tanks equipped with an ambient water flow-through system for observation prior to tagging. Vigorous fish with no external anomalies 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 ventral side of healthy 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 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 formerly used in Program MARK. 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).

The recovery year began on the first day of tagging in the time series (March 28) and continued until March 27 of the following year. Since survival and F estimates for fish released in spring 2013 will not be completed until after March 27, 2014, these estimates will not appear in this report.

Tag release and return data from spring male fish, ≥457 mm TL and <711 mm TL (18 – 28 inches TL), were used to develop the 2012-2013 estimate of F for Chesapeake Bay (unpublished data). Male fish 18 to 28 inches are generally accepted to compose 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 estimate of F. Similar to the coastwide methods, the IRCR model was utilized to calculate the Chesapeake Bay F. Further details on the methodologies 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 $P \leq 0.05$.

RESULTS AND DISCUSSION

Spring tagging

The spring sampling component monitored the size and sex characteristics of striped bass spawning in the Potomac River and the upper Chesapeake Bay. Sampling occurred between March 28 and May 14, 2013. A total of 1,702 striped bass were sampled and 970 (57%) were tagged as part of this long-term survey (Table 1).

In 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 2013 (645 mm TL) was significantly greater ($P<0.0001$) than that of the sampled population (593 mm TL) (Figure 2).

Tag releases and recaptures from both Maryland and Virginia's sampling (combined spring 2012 data) were used to estimate an instantaneous fishing mortality rate (F) for the 2012-2013 recreational, charter boat, and commercial fisheries for the entire Chesapeake Bay. Fishing mortality estimates were below the target $F=0.27$ set by ASMFC (unpublished data).

Estimates of survival and fishing mortality for the 2013 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 tagging cruise

The primary objective of both components was to apply tags to as many striped bass as possible. The majority of fish sampled were in federal waters off the mouth of Chesapeake Bay.

During the 2013 trawling portion of the cruise, 895 striped bass were captured and 893 (99.8%) were tagged (Table 2). The mean length of all fish captured and tagged on the 2013 trawling cruise was 834 mm TL. While fishing with hook and line, 1,129 striped bass were encountered and 1,114 (99%) were tagged (Table 2). The mean length of all fish captured and tagged during the hook and line sampling was 931 mm TL. The mean total length of striped bass tagged on the hook and line portion of the cruise (931 mm TL) was significantly greater than the length of fish tagged from the trawling component (834 mm TL , $P<0.0001$, Figure 3). This could be a result of the bait sizes used during the hook and line component or the ability of larger fish to swim faster to avoid the trawl and/or outcompete the smaller fish for the trolled baits.

The NC DMF is presently completing age determination for the 2013 cruise via scale analysis. Estimates of survival and fishing mortality based on fish tagged in the 2013 North Carolina study will be presented in the next report of the ASMFC Striped Bass Tagging Subcommittee.

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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, late March - May 2013.

System	Inclusive Release Dates	Total Fish Sampled	Total Fish Tagged	Approximate Tag Sequences [a]
Potomac River	3/28/13 - 5/13/13	500	272	524248 – 524522
Upper Chesapeake Bay	4/3/13 - 5/14/13	1,202	698	518457 – 519000 532501 – 532654
Spring spawning survey totals:		1,702 [b]	970	

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

Table 2. Summary of USFWS internal anchor tags applied to striped bass during the 2013 cooperative offshore tagging cruise.

System	Gear	Inclusive Release Dates	Total Fish Sampled	Total Fish Tagged	Approximate Tag Sequences [a]
Nearshore Atlantic Ocean (Near VA-NC line)	Trawl	1/8/13 – 1/16/13	895	893	462230 – 462500 561089 – 561500 565651 – 565843 566851 – 566919
Nearshore Atlantic Ocean (Near VA-NC line)	Hook & Line	1/21/13 – 2/13/13	1,129	1,114	565844 – 565850 566920 – 567500 568001 – 568927
Cooperative tagging cruise totals:			2,024 [b, c]	2,007 [b]	

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

Figure 1. Tagging locations in spawning areas of the Upper Chesapeake Bay and the Potomac River, late March - May 2013.

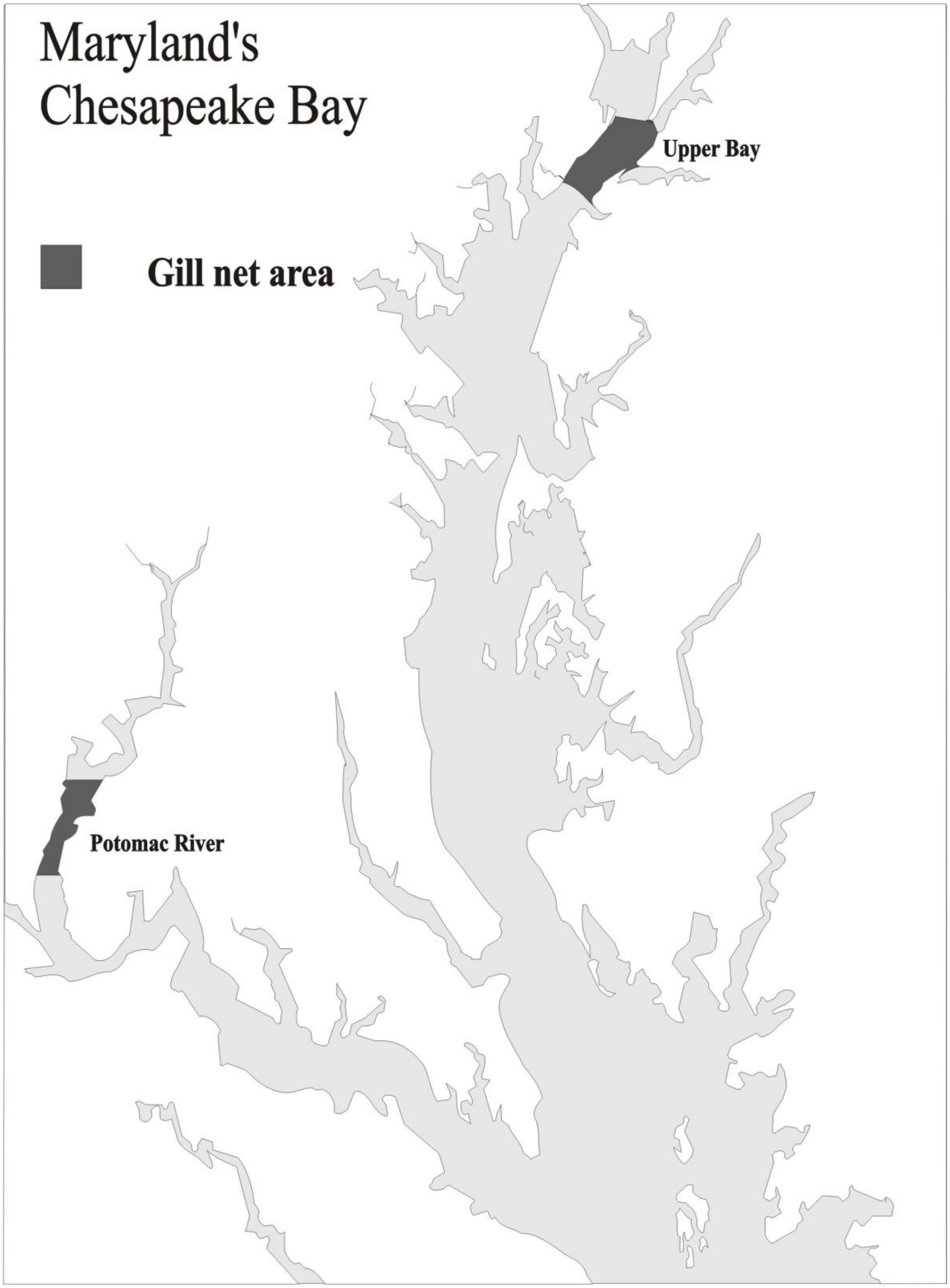


Figure 2. Length frequencies of striped bass measured and tagged during the spring in Chesapeake Bay, late March - May 2013.

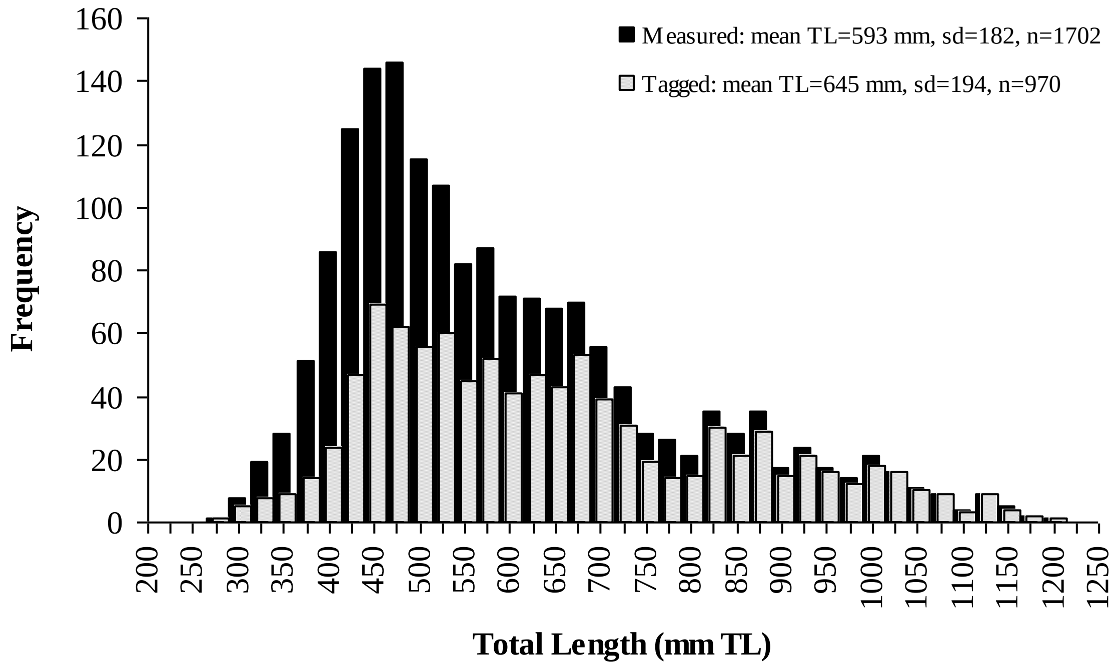
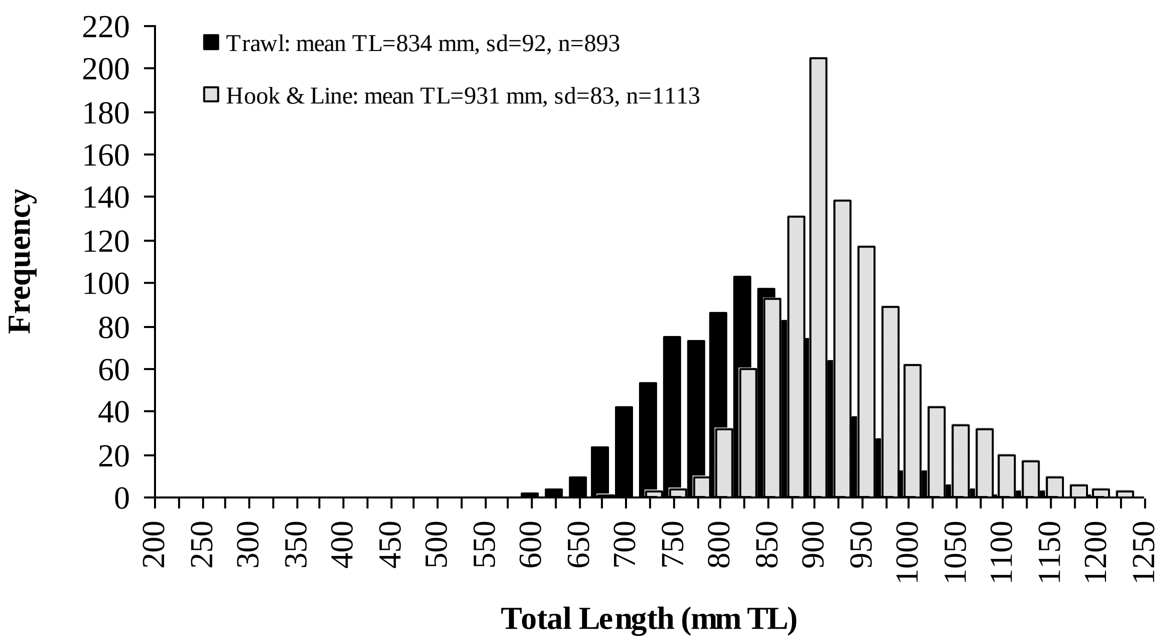


Figure 3. Length frequencies of striped bass tagged during the two components (trawl and hook and line) of the cooperative offshore tagging cruise, January 2013.



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

COMMERCIAL FISHERY HARVEST MONITORING

Prepared by Amy Batdorf

INTRODUCTION

The primary objectives of Project 2, Job 3, Task 5A were to quantify the commercial striped bass harvest in 2012 and describe the harvest monitoring conducted by the Maryland Department of Natural Resources (MD DNR). MD DNR changed the organization of its commercial quota system from a seasonal to a calendar year system in 1999. Maryland completed its twenty-third year of commercial fishing under the quota system since the striped bass fishing moratorium was lifted in 1990. The commercial fishery received 42.5% of the state's total Chesapeake Bay striped bass quota. The 2012 commercial quota for the Chesapeake Bay and its tributaries was 1,963,873 pounds, unchanged from 2011, with an 18 to 36 inch total length (TL) slot limit. In 2012, 5% of the quota was withheld due to uncertainty in harvest reporting, therefore the effective Chesapeake Bay striped bass quota was 1,865,680 pounds. There was a separate quota of 126,396 pounds, with a 24-inch (TL) minimum size for the state's jurisdictional waters off the Atlantic coast.

The Chesapeake Bay commercial quota was further divided by gear type (Table 1). The hook-and-line and drift gill net fisheries were combined and allotted 75% of the commercial quota. The pound net and haul seine fisheries were allotted the remaining 25%. When the allotted quota for a fishery (gear type) was not landed, it was transferred to another commercial fishery.

Each fishery was managed with specific seasons that could be modified by MD DNR as necessary. The hook-and-line fishery was open from June 7 through November 30, 2012, Monday through Thursday only. The pound net fishery was open from June 1 through November 30, 2012, Monday through Saturday. The haul seine fishery was open from June 7 through November 30, 2012, Monday through Friday. The Chesapeake Bay drift gill net season was split, with the first segment from January 1 through February 28, 2012 and the second segment from December 1 through December 31, 2012, Monday through Friday. The Atlantic coast fishery consisted of two gear types, drift gill net and trawl. Both gear types were permitted during the Atlantic season, which occurred in two segments: January 1 through April 30, 2012 and November 1 through December 31, 2012, 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. A deadline of August 31 was established for receipt of declaration; this process is repeated for every year in which the license holder intends to fish. 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 to pay $100 and the Hook-and-Line only License (HLI) were required to pay $37.50 Daily allocations were established to distribute harvest over as many days as was practical, in an effort to avoid flooding the market (Table 1). Individual allocations were printed on each striped bass permit issued by MD DNR.

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 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. Each morning following a harvest day, the check station was required to telephone MD DNR and report the total pounds of striped bass checked the previous day (Figures 2, 3). These reports allowed MD DNR to monitor the fisheries' 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 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 10^{th} 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 commercial fisheries website. If the report was still not received by DNR 50 days after the report due date, the licensee received an official violation. Two or more official violations for any of the report types 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, 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 pounds of striped bass presented in this report were supplied by the Data Management and Quota Monitoring Program of the MD DNR Fisheries Service. 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 telephone 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 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, 1,851,432 pounds of striped bass were harvested in 2012; 15,059 pounds under the 2012 quota. The estimated number of fish landed was 494,979 (Table 2). The Chesapeake drift gill net fishery landed 46% of the total landings by weight, followed by the pound net fishery at 31%. The hook-and-line fishery contributed 23% of the total landings and there were zero fish harvested by the haul seine fishery.

Maryland’s Atlantic coast landings were estimated at 6,871 striped bass, weighing 77,551 pounds (Table 2). The trawl fishery made up 67% 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 mean weight per fish of striped bass harvested in Chesapeake Bay, regardless of gear type, was 3.74 pounds when calculated from the check station log sheets and 4.04 pounds when measured by biologists (Table 3), a decrease from the 2011 season. Mean weights by specific gear type ranged from 3.19 to 4.18 pounds from check station log sheets, and were 3.32 to 4.50 pounds when measured by biologists. The largest striped bass landed in the Chesapeake Bay were taken by the drift gill net fishery. The average weight of fish harvested by gill net was 4.18 pounds when calculated using the log sheet data and 4.50 pounds when calculated using the MD DNR measurements.

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 by MD DNR biologists averaged 10.87 pounds (Table 3). The average weight calculated from the check station log sheets was 11.29 pounds. Fish caught in the Atlantic trawl fishery averaged 12.18 pounds according to MD DNR estimates, and were larger on average than those caught in the gill net fishery (9.72 pounds). The average weights of fish from the Atlantic trawl and gill net fisheries, as calculated from check station log sheets, were 11.91 and 10.22 pounds, respectively.

Commercial Harvest Trends

Since the moratorium was lifted in 1990, striped bass harvests and quotas have become relatively consistent in the Chesapeake Bay (Figure 4). The majority of the commercial striped bass harvest in Chesapeake Bay has historically been by drift gill net. Since the late 1990s, however, an increasing portion of the harvest has come from the pound-net and hook-and-line fisheries (Figure 7). The hook-and-line fishery generally harvests the least of the three major Chesapeake Bay gears. The pound net fishery harvest increased through the early 1990s and by 1998 averaged approximately 600,000 pounds of striped bass harvested per year between 1998-2012 (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 during the 2009-2012 seasons (Figure 6). In almost all years since 1990, the Atlantic trawl fishery harvest has been greater than the Atlantic drift gill net harvest with the exception of 2010 and 2011 (Table 4, Figure 6). Though the Atlantic drift gill net fishery harvested very little initially after the moratorium was lifted, the harvest began to increase in 1994, likely due to increased interest in the fishery as increased abundance of the stock led to increased quotas (Figure 4).

Commercial CPUE Trends

Weight harvested by year and gear type was taken from check station log sheets. The number of fishing trips in which striped bass were landed was determined from the MFRs (Table 2). The pounds landed were divided by the number of trips to calculate an estimate of CPUE.

The pound net fishery CPUE was 321 pounds per trip, an 18% decrease from last season. The Chesapeake Bay drift gill net fishery CPUE was 374 pounds per trip, a 6% decrease from 2011. The hook-and-line fishery CPUE was 179 pounds per trip, a 20% decrease from the previous year (Table 5, Figure 7). With the exception of 2004, the hook-and-line fishery continues to have the lowest CPUE of all the Chesapeake Bay fisheries. Over the past five years, the gill net fishery had the highest average CPUE value (368 lbs per trip), followed closely by the pound net fishery (351 lbs per trip) and the hook-and-line fishery (201 lbs per trip) (Table 6, Figure 7).

The Atlantic trawl fishery CPUE was 832 pounds per trip in 2012, a 55% increase from the 2011 CPUE and well above the twenty-three year average of 558 pounds per trip. The 2012 CPUE for the Atlantic drift gill net fishery was 157 pounds per trip, similar to 2011 CPUE, but still below the twenty-three year average of 194 pounds per trip (Table 5, Figure 8).

In general, all Chesapeake Bay commercial striped bass fisheries have exhibited positive trends in CPUE estimates since the lifting of the moratorium in 1990 (Figure 7). The

Atlantic drift gill net fishery has been variable with a downward trend since 2009 and exhibited a small increase in the 2012 season (Figure 8). The Atlantic trawl fishery has also been variable, with several spikes in harvest in 1995 and from 2006-2009.

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Table 1. Striped bass commercial regulations by gear type for the 2012 calendar year.

Area	Gear Type	Annual Quota (pounds)	Number of Participants	Trip Limit	Minimum Size	Reporting Requirement
Bay and Tributaries	Pound Net	616,420	100	single permit holders: 800 lbs/day; multiple permit holders 1,600 lbs/day	18-36 in TL slot	Monthly Harvest Report
	Haul Seine	included in Pound Net	3	750 lbs/license/day; 1,100 lbs/license/net/season	18-36 in TL slot	Monthly Harvest Report
	Hook-and-Line	447,205	147	500 lbs/license/day; 1,500 lbs/license/week; max 4 people/boat; 2 crew/licensee	18-36 in TL slot	Monthly Harvest Report
	Gill Net	802,056	621*	300 lbs/licensee/day; max 4 licenses/boat	18-36 in TL slot	Monthly Harvest Report
Total Bay Quota		**1,865,681**				
Atlantic Coast	Atlantic Trawl	126,396		1,600 lbs/license/season for both Atlantic gears	24 in TL min	Monthly Harvest Report
	Atlantic Gill Net	included in Trawl				
Total Maryland Quota		**1,992,077**				

*Dual registered as gill net and hook and line.

Table 2. Summary of striped bass commercial harvest statistics by gear type for the 2012 calendar year.

Area	Gear Type	Pounds[1]	Estimated[1] Number of Fish	Trips[2]
Chesapeake Bay[3]	Haul Seine	0	0	0
	Pound Net	565,600	155,933	1,759
	Hook & Line	424,657	132,897	2,368
	Gill Net	861,174	206,149	2,304
	Chesapeake Total Harvest	**1,851,432**	**494,979**	**6,431**
Atlantic Coast	Atlantic Trawl	51,609	4,333	62
	Atlantic Gill Net	25,942	2,538	165
	Atlantic Total Harvest	**77,551**	**6,871**	**227**
Maryland Totals		**1,928,982**	**501,850**	**6,658**

1. Data from check station log sheets.

2. Trips were determined 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 2012 calendar year. Average weights calculated by MD DNR biologists include 95% confidence intervals.

Area	Gear Type	Average Weight from Check Station Logs (pounds)[1]	Average Weight from Biological Sampling (pounds)[2]	Sample Size from Biological Sampling[2]
Chesapeake Bay[3]	Haul Seine	N/A	N/A	N/A
	Pound Net	3.62	3.63 (3.50-3.75)	788
	Hook-and-Line	3.19	3.32 (3.26-3.38)	1,988
	Gill Net	4.18	4.50 (4.45-4.54)	3,799
	Chesapeake Total Harvest	**3.74**	**4.04 (3.99-4.08)**	**6,575**
Atlantic Coast	Trawl	11.91	12.18 (11.61-12.75)	292
	Gill Net	10.22	9.72 (9.36-10.07)	334
	Atlantic Total Harvest	**11.29**	**10.87 (10.52-11.21)**	**626**

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 2012.

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	424,657	565,600	861,174	25,942	51,609

Table 5. Striped bass average catch per trip (CPUE) in pounds by commercial gear type, 1990 to 2012.

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	1325
2008	205	303	298	383	1108
2009	206	351	324	326	1348
2010	193	391	448	235	511
2011	224	390	397	155	187
2012	179	321	374	157	832
23 yr avg	**150**	**249**	**252**	**194**	**558**
5 yr avg (2012-2009)	**201**	**351**	**368**	**251**	**797**

Figure 1. Map of the 2012 Maryland authorized commercial striped bass check stations.

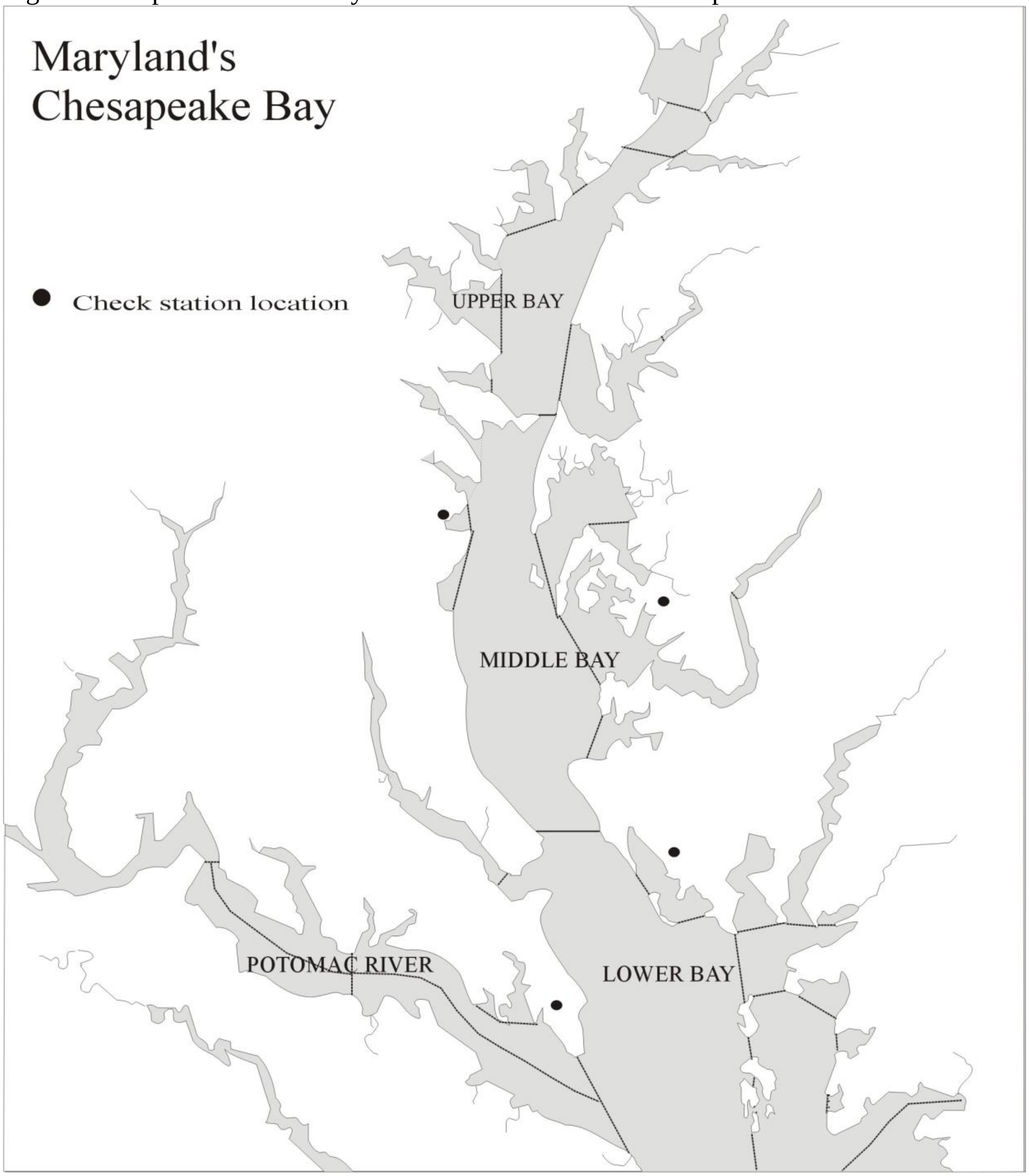


Figure 2. Maryland's Chesapeake Bay pound net and hook-and-line fisheries cumulative striped bass landings from check stations daily call-in reports, June-December 2012.

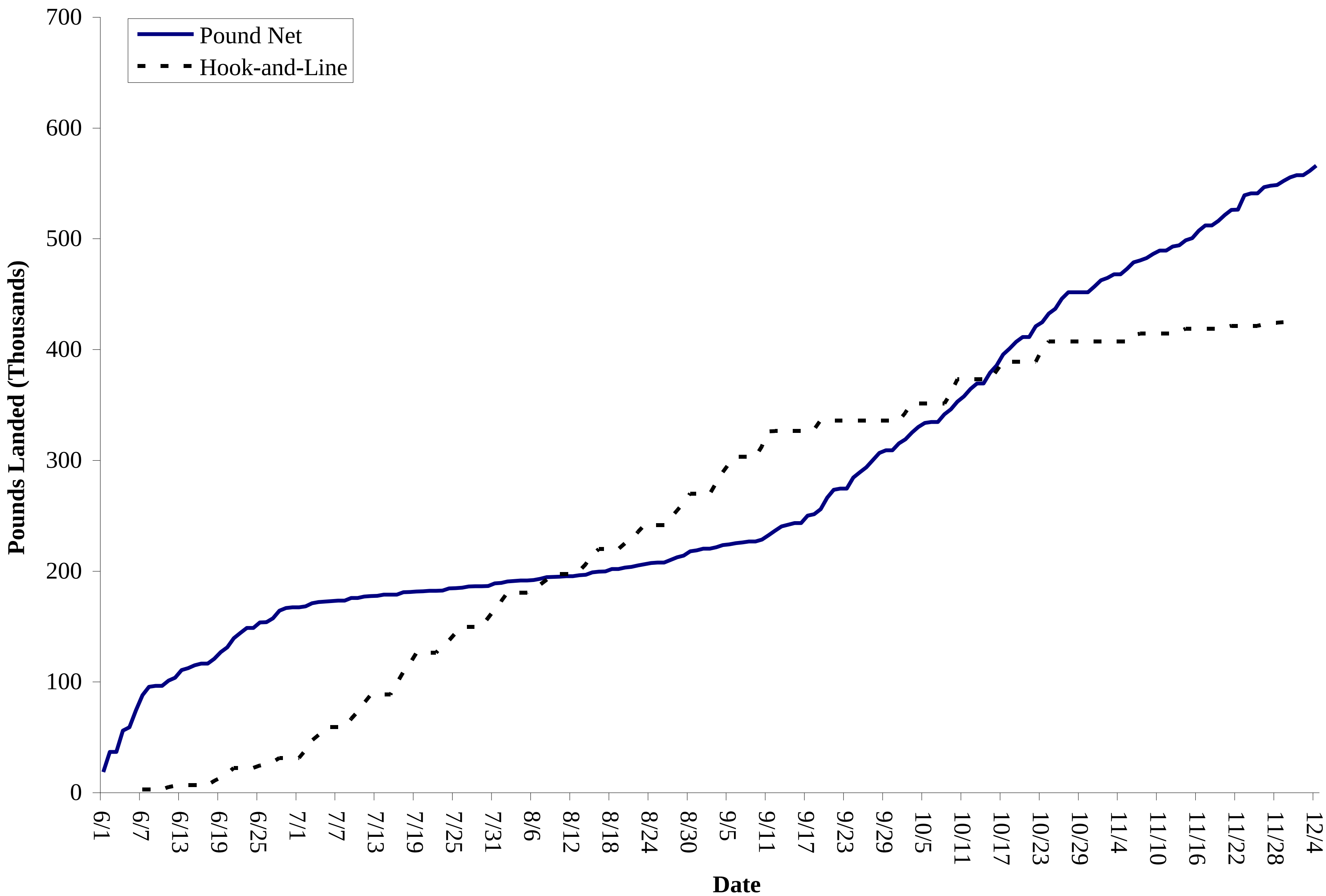
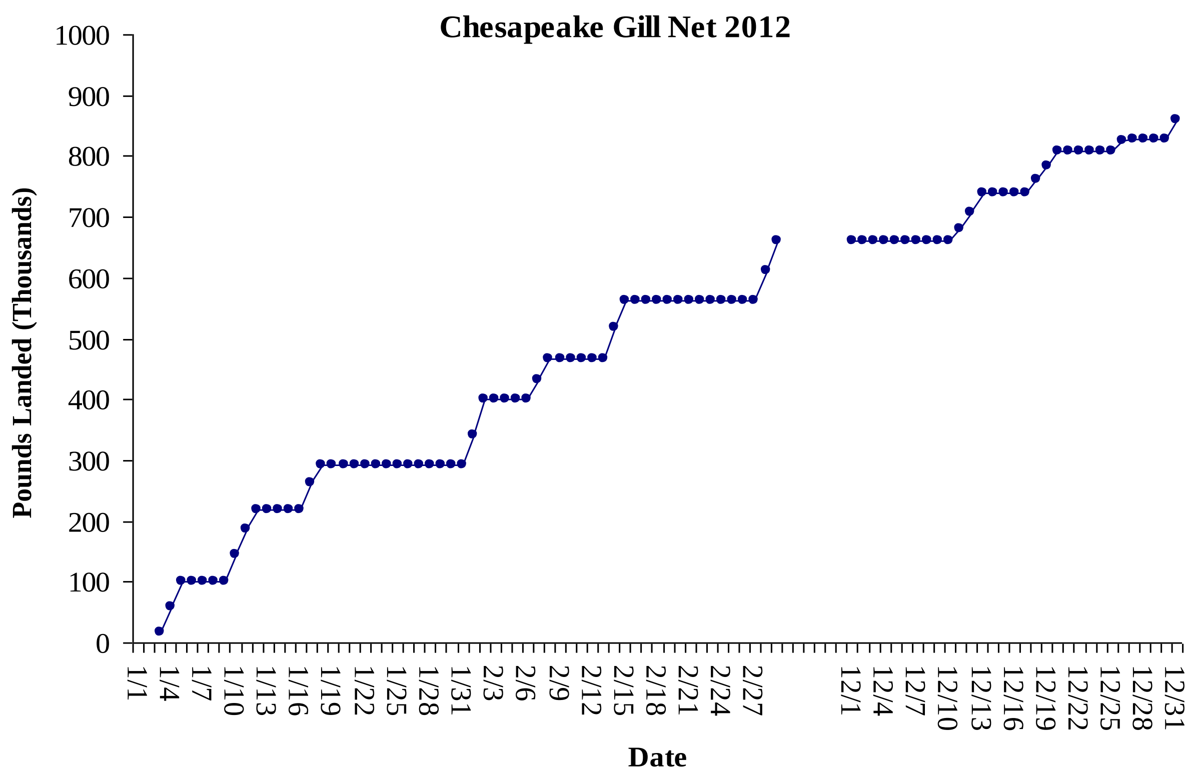


Figure 3. Maryland's Chesapeake Bay gill net and the Atlantic trawl and gill net fisheries (combined) cumulative striped bass landings from check stations' daily call-in reports, January-December 2012. Note different scales.



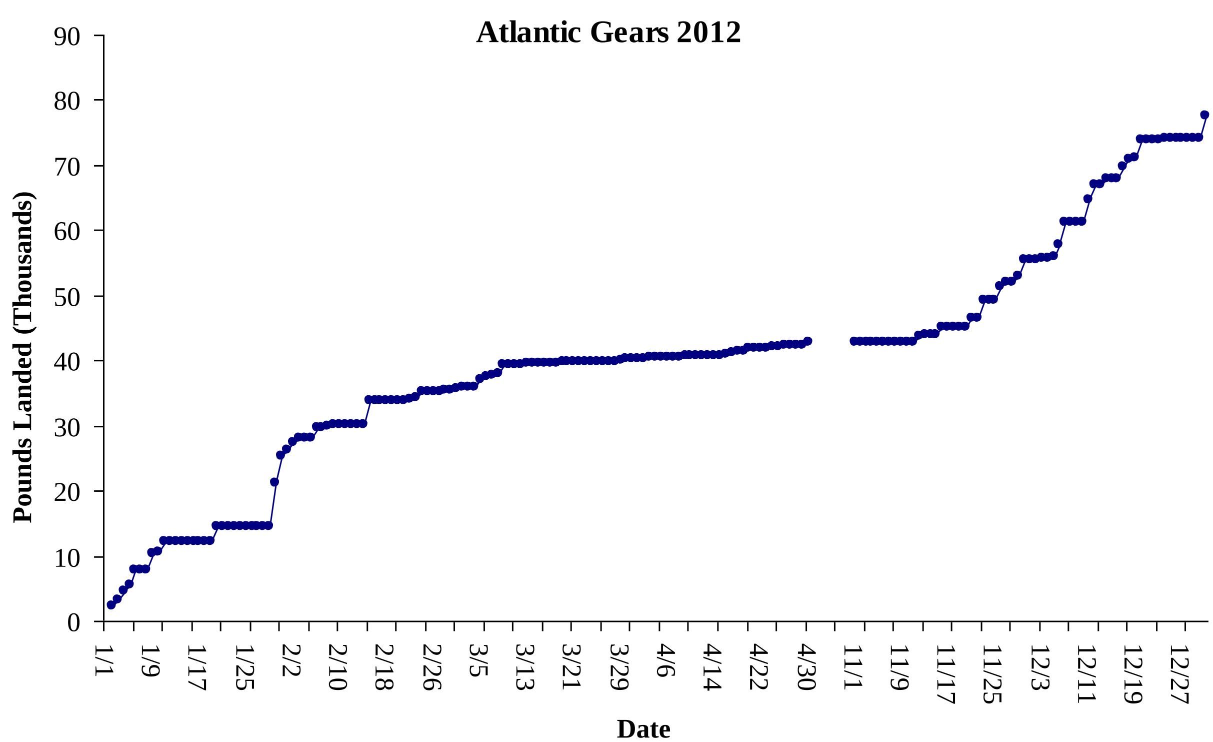
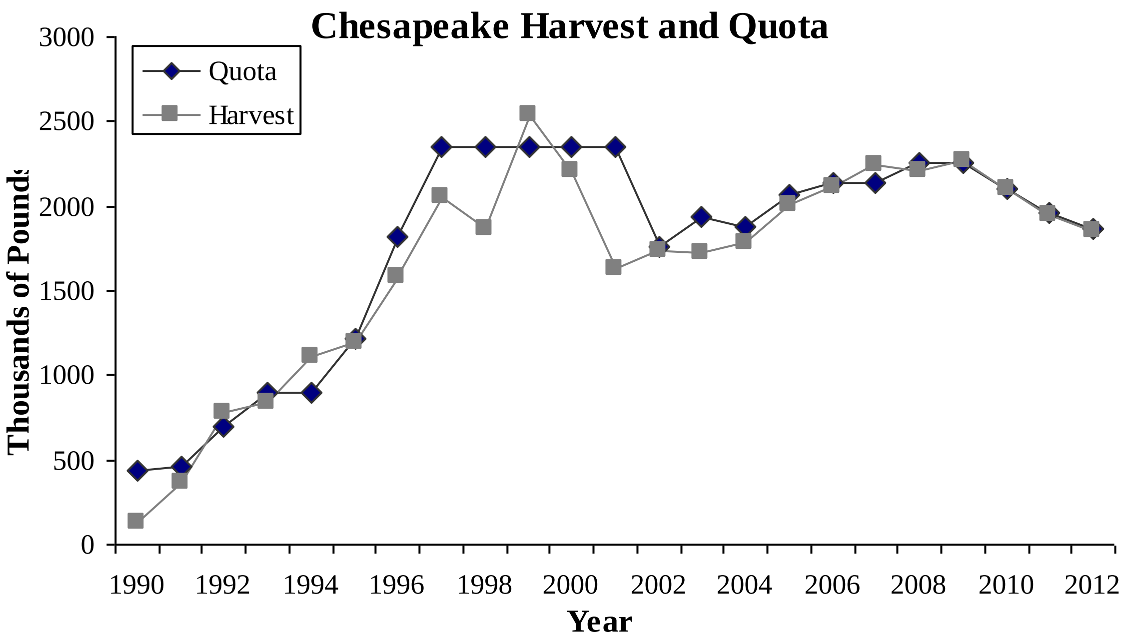


Figure 4. Maryland's Chesapeake Bay and Atlantic Ocean harvests (lbs) and quotas (lbs) for all gears, 1990-2012. Note different scales.



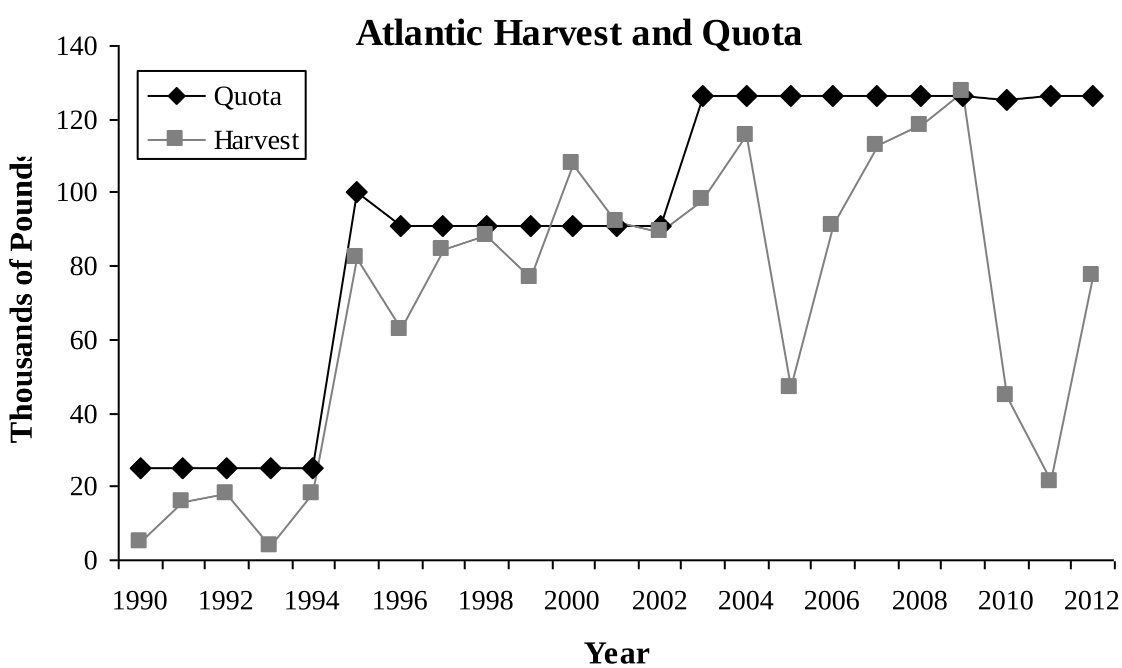


Figure 5. Maryland's Chesapeake Bay striped bass total harvest (thousands of pounds) per calendar year by commercial gear type, 1990–2012.

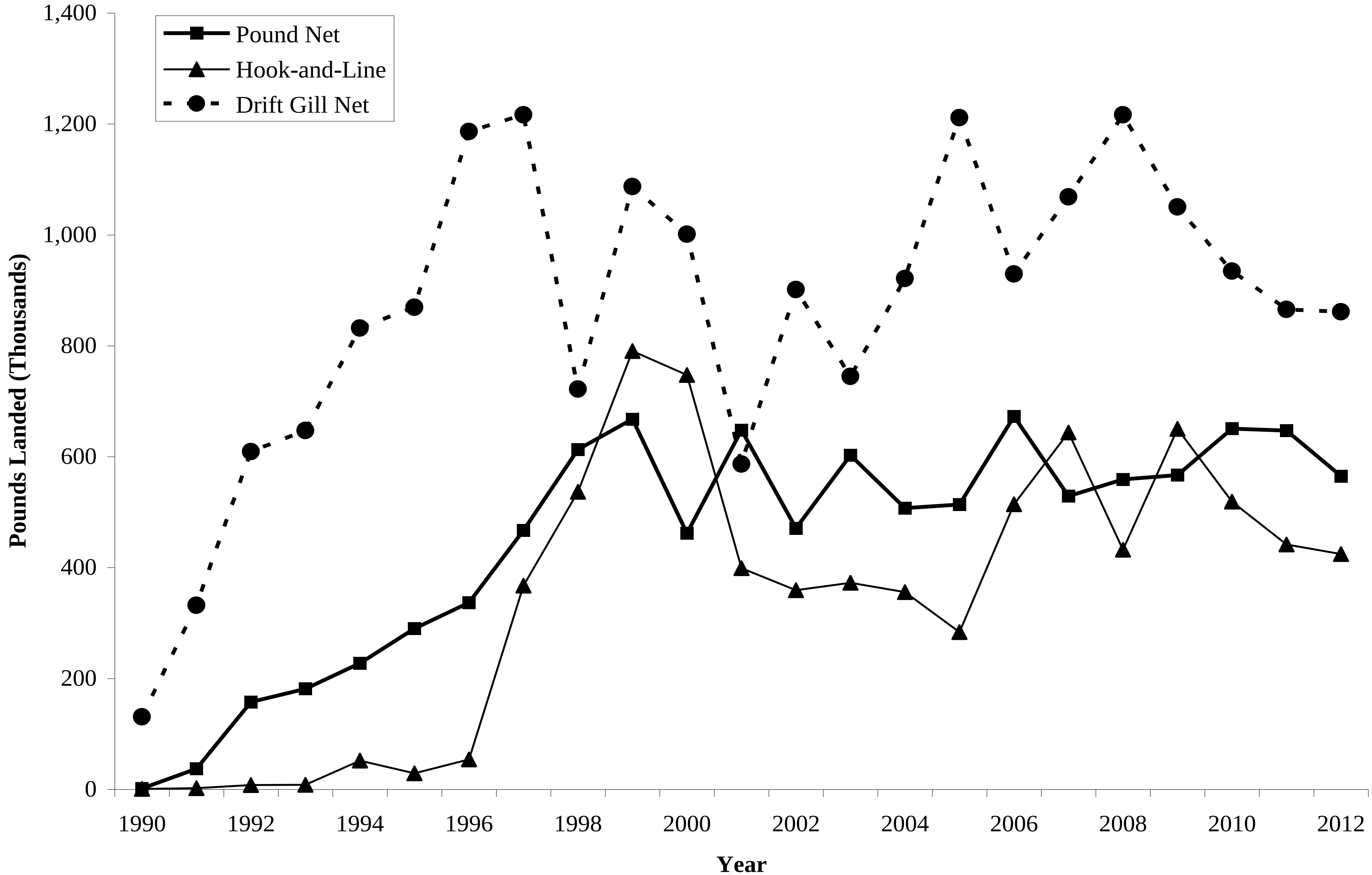


Figure 6. Maryland's Atlantic gill net and trawl fisheries total striped bass harvest (thousands of pounds) per calendar year by commercial gear type, 1990-2012.

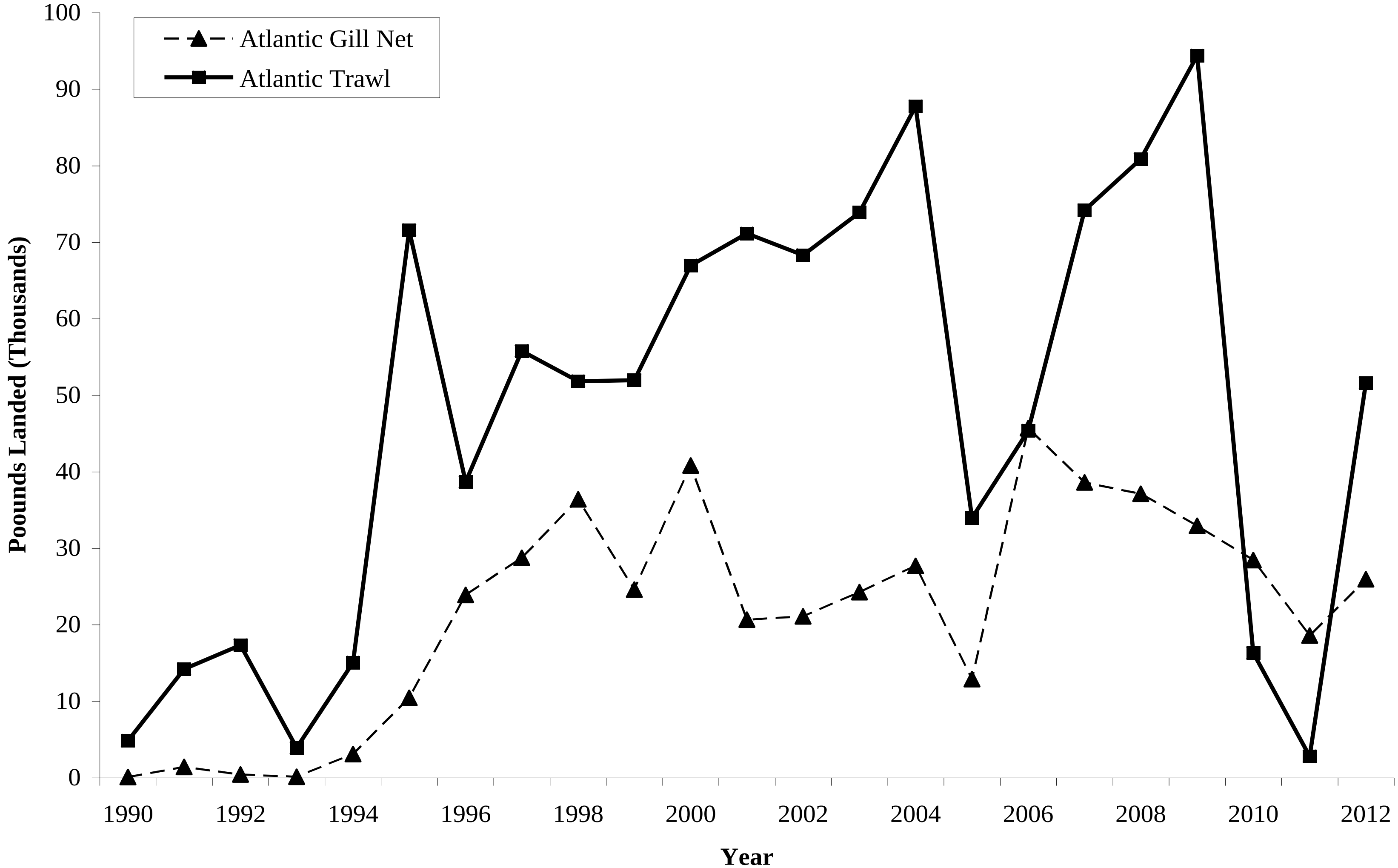


Figure 7. Maryland's Chesapeake Bay striped bass catch (pounds) per trip (CPUE) by commercial gear type, 1990- 2012. Trips were determined as days fished when striped bass catch was reported.

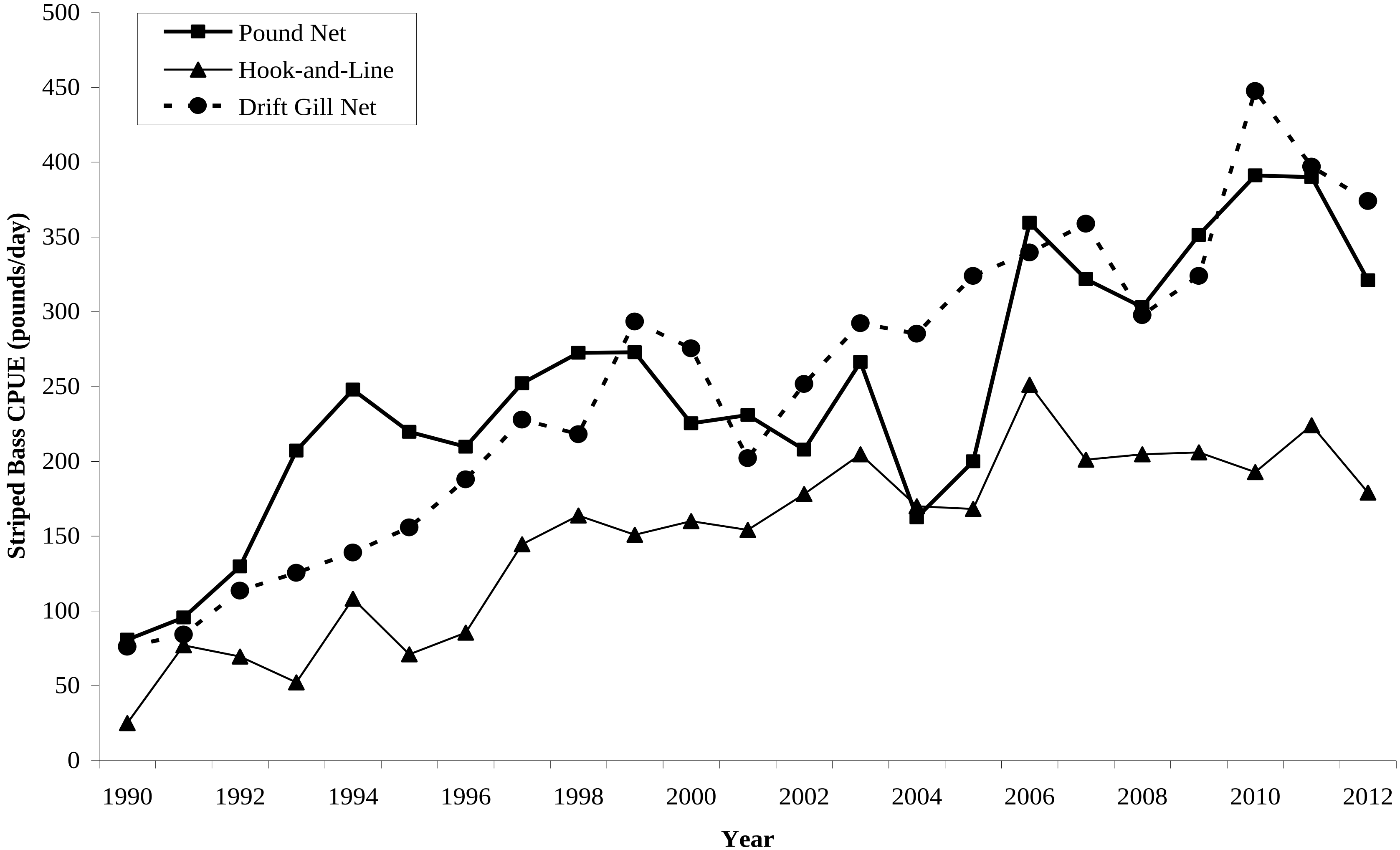
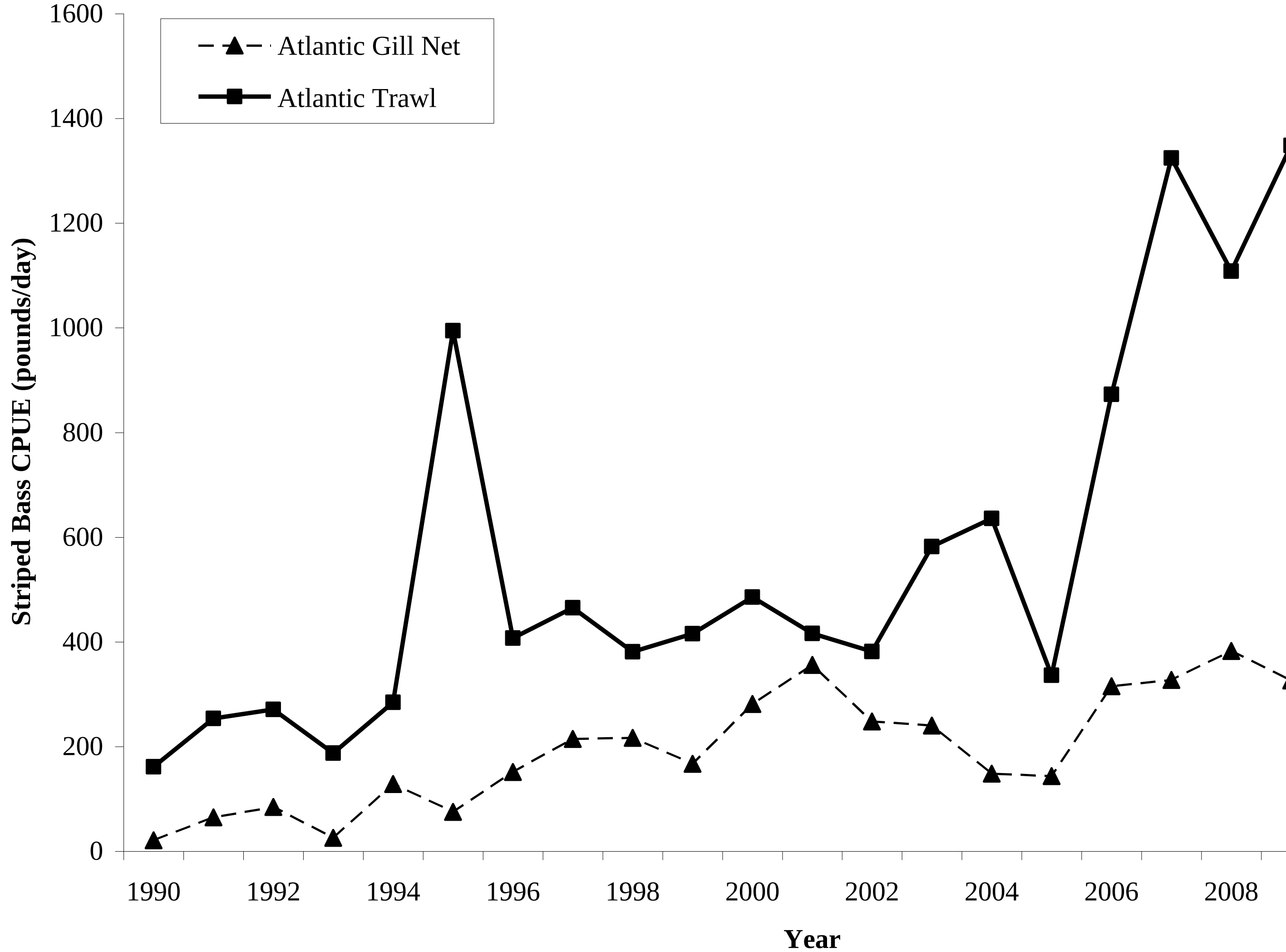


Figure 8. Maryland's Atlantic gill net and trawl fisheries striped bass catch (pounds) per trip (CPUE), 1990-2012. Trips were determined as days fished when striped bass catch was reported.



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

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

Prepared by Angela Giuliano

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 2013 spring recreational season, which began on Saturday, April 20 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 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). The 2013 season was 26 days long (April 20 – May 15), with a one fish (≥ 28 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 Maryland Department of Natural Resources (MD DNR) Striped Bass Program initiated a dockside creel survey for the spring fishery in 2002. The main objectives are:

1. Develop a time-series of relative abundance of the Chesapeake Bay spawning stock harvested during 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 five major charter fishing ports in 2013: Solomons Island/Calvert Marina, 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). When significant differences were found, a Duncan's multiple range test was used to determine which years were significantly different from each other.

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 read from the creel survey has varied between years. In 2013, 166 scale samples were read. 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 a small amount of milt were considered post-spawn.

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 log data. CPH was calculated using the charter boat log data and the average duration of charter boat trips from mate interview data. Charter boat captains are required to submit data to MD DNR indicating the days and areas fished, number of anglers fishing, and numbers of striped bass caught and released. In place of a paper logbook, captains can 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 2013 had become a significant proportion (39%) of the trophy season charter data. From this point forward, SAFIS data will be combined with charter logbook data to produce a complete charter boat data set. The SAFIS data were not included in 2011 and 2012 and the calculations for these years have been updated in this report. 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 2013, 16% 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 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 2013, 165 private boat trips and 3 shore trips were intercepted for interviews. Fish were sampled from 35 intercepted charter trips (Table 5B). 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

Although the minimum size limit for the 2013 spring striped bass season was 28 inches (711 mm) TL, lengths ranged from 685 mm TL to 1140 mm TL. The catch was dominated by fish between 880 and 940 mm TL (34 to 37 inches, Figure 2).

Mean length

In 2013, the mean length for all fish (924 mm TL) was significantly larger than the previous two years (Table 6A, Figure 3). The mean length of females (934 mm TL) was greater than the mean length of males (853 mm TL), which is typical of the biology of the species. The mean total length of females in 2013 was significantly larger than most years but similar to that observed in 2006 and 2008-2010. For males, the mean length was significantly larger than last year but in the middle of the range of observed values.

The mean daily lengths of female striped bass harvested in 2013 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).

Mean weight

The mean weight of fish sampled in 2013 (8.3 kg) was significantly larger than the past two years (Table 6B). The mean weight of females (8.6 kg) was statistically larger than the past two years but similar to 2008-2010 (Figure 5). The mean weight of males (6.3 kg) in 2013 was significantly larger than the past two years but statistically similar to seven previous years. The mean weight of females (8.6 kg) was greater than the mean weight of males (6.3 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).

Age Structure

The age distribution of striped bass from the sampled harvest in 2013 ranged from 5 to 19 years old (Figure 6). Most fish harvested were between 9 and 12 years old. The 2003 (10 years old in 2013) and 2004 (9 years old) year-classes were the most frequently observed cohorts, each constituting 46% and 22% of the sampled harvest, respectively. The strong 2003 year-class has increased annually in the harvest since 2008 and dominated the harvest since 2012. The record 1996 year-class (17 years old in 2013), which dominated catches in 2005, 2006, and 2008, constituted just 0.3% of the sample harvest.

Sex Ratio

The data included three designations for sex: female, male and unknown. As in past years, the 2013 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 2013. Females constituted 88% of the sampled harvest. This is one of the highest proportions of females harvested in the time-series, though similar to 2004.

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. Data from the 2013 creel survey indicated that 29% of the females caught between April 20 and May 15 were in pre-spawn condition (Table 8). This percentage is lower than the average of the past eleven years and one of the lowest percentages in the time-series indicating that most fish caught had already spawned.

Daily spawning condition of females

The percent of pre-spawn females harvested ranged from 4% to 85% on any given day (Figure 7). The highest percentage of pre-spawn females occurred on the first day of sampling and sharply dropped off after that. After the first sampling day, 19% of the females, on average, were in pre-spawn condition.

CATCH RATES AND FISHING EFFORT

Harvest Per Trip Unit Effort

Charter boat activity can be accurately characterized from existing reporting methods so no interviews of charter boat anglers were conducted during the trophy season in 2013. Because of increased focus on improving our understanding of private boat fishing effort, all trips intercepted during the trophy season in 2013 for interviews were private boat and shore 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.

The mean HPT in 2013 according to charter boat data was 4.9 fish per trip (Table 9A). While higher than 2012, it was similar to other years. Mean HPT from private boat interviews (0.9 fish per trip) was much lower than HPT from charter boats. Like the charter boat HPT, private boat HPT was also higher than last year but similar to other years.

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. HPA from charter boat data in 2013 was 0.75 fish per person (Table 9B). While not the lowest value in the time-series, it is lower than six years of the twelve year time-series. HPA for private anglers, calculated from interview data, was 0.3 fish per person, similar to many years of the time-series (Table 9B).

Catch Per Unit Effort

In all years, charter boats caught more fish per trip and per hour than 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 2013, private boats caught an average of 1.3 fish per trip, while charter boats caught 5.4 fish per trip. While the 2013 private boat catch per trip (CPT) was similar to many past years, the charter boat mean CPT was lower than seven years in the thirteen year time-series. The private boat catch per hour (CPH) was 0.3 fish per hour while charter boats had a CPH of 1.0 fish per hour. The 2013 private boat CPH was similar to many years of the time-series. The charter boat mean CPH was improved from 2012 but was still lower than much of the time-series, particularly 2003-2008.

Mean Daily Catch Per Hour

Anecdotal information from anglers and charter boat captains in most years indicates a decrease in catch rates during the latter portion of the spring season. Interview data showed that mean daily CPH declined slightly over time in some years, but has generally varied without trend since 2002 (Figure 8). Though there were not enough observations to make a definitive conclusion, it appears that daily CPH in 2013 varied without trend. CPH values have decreased since 2007 due to the lack of charter boat interview data. Comparing 2008-2013, however, it appears that the 2013 daily CPH values are higher than 2012 but similar to all other years.

Angler Characterization

States of residence

In 2013, 172 private boat and shore trips were intercepted for interviews and 456 anglers were interviewed during the period April 20-May 15 (Table 5A and Table 5B). Nine states of residence were represented in 2013 (Table 11). Most anglers were from Maryland (89%), Virginia (4%), and Pennsylvania (5%), 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 2013, there were on average 2.7 anglers per boat and of these anglers, 1.2 were license-exempt (Table 12). These results are remarkably consistent with previous years.

Angler Gender

In 2013, 93% of anglers interviewed by the creel survey were male and 7% were female (Table 13). These values are similar to the long term average for all years surveyed. The highest proportion of female anglers was encountered in 2006 (8%) while the lowest was encountered in 2005 (3%).

Number of Lines Fished

In order to determine fishing effort, a question was added to the creel survey in 2006 and 2010 to present 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 2013, the average number of lines fished per private boat was eight and ranged from one to 25 lines (Table 14). This was more lines, on average, than in 2006 (6 lines) but similar to 2010 and 2011.

Dollars Spent per Day

Anglers spent an average of $119 per trip in 2013 (Table 15). This is higher than the mean in 2007 and 2010 but similar to other years. The decrease in 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 2013 creel survey had been fishing for striped bass in Chesapeake Bay an average of 27 years (Table 16). The average and median (29) values are the highest in the time-series. The range of anglers' fishing experience for striped bass during the trophy season ranged from zero to 60 years.

For the second time during the angler intercept survey, anglers were asked approximately how many fishing trips they take per year (Table 17). Answers ranged from two trips to 365 trips per year with a mean of 28 trips per year.

Angler Satisfaction with Regulations

Anglers were also asked if they were satisfied with the current regulations. In 2013, 80% of the respondents said they were satisfied with the current striped bass regulations (Table 18). Of those that were dissatisfied (33 responses), most people had issue with the use of gill nets in the Bay and wanted stricter consequences for poaching (27%). Other comments included either raising or lowering the creel limit for striped bass, starting the spring trophy season earlier, and dissatisfaction with recent price increases in license and boat fees.

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Table 1. History of MD DNR-Fisheries Service regulations for Maryland striped bass spring trophy seasons, 1991-2013.

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	36	1 per person, per season, with permit	Main stem Chesapeake Bay, Annapolis Bay Bridge-VA State line
1993	5/01-5/31	36	1 per person, per season	Main stem Chesapeake Bay, Annapolis Bay Bridge-VA State line
1994	5/01-5/31	34	1 per person, per day, 3 per season	Main stem Chesapeake Bay, Annapolis Bay Bridge-VA State line
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	32	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
1997	4/25-5/31	32	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
1998	4/24-5/31	32	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
1999	4/23-5/31	28	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
2000	4/25-5/31	28	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
2001	4/20-5/31	28	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
2002	4/20-5/15	28	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
2003	4/19-5/15	28	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
2004	4/17-5/15	28	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
2005	4/16-5/15	28	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
2006	4/15-5/15	33	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
2007	4/21-5/15	28-35 or larger than 41	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
2008	4/19-5/13	28	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
2009	4/18-5/15	28	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
2010	4/17-5/15	28	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
2011	4/16-5/15	28	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
2012	4/21-5/15	28	1 per person, per day	Main stem Chesapeake Bay, Brewerton Channel-VA State line
2013	4/20-5/15	28	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, 2002-2013. 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, 2013.

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, 2013.

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, 2013.

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
Angler gender
Years of fishing experience
Number of fishing trips per year
Money spent on fishing trip
Satisfaction with current regulations

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

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

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	TL (mm) - All fish	TL (mm) - Females	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)

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)

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

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
Mean	**81**	**83**	**84**

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
Mean	**116**	**44**	**131**	**56**

*Two female fish (1% of females sampled) were of unknown spawning condition.

Table 9A. Mean harvest of striped bass per trip (HPT), with 95% confidence limits, calculated from Maryland charter boat data and spring season creel survey interview data, through May 15. SAFIS data was 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	**0.0**
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)

Table 9B. Mean harvest of striped bass per angler, per trip (HPA), with 95% confidence limits, calculated from Maryland charter boat data and spring season creel survey interview data, through May 15. SAFIS data was 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	**0.0**
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)

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	**0.0**	**2.5**	**0.0**
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)

Table 10B. Charter boat mean catch, effort, and catch per hour, with 95% confidence limits, calculated from charter boat 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 creel 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)

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

State of residence	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
AL	0	0	0	0	1	0	0	0	0	0	0	1
AZ	0	0	0	0	0	0	0	0	0	1	0	0
CA	1	0	1	0	0	2	0	0	0	0	0	0
CO	0	0	1	0	1	1	0	0	1	0	1	0
DC	6	1	1	0	1	2	1	0	6	1	0	1
DE	6	7	3	0	9	8	1	0	3	1	2	0
FL	0	0	1	1	2	0	1	0	3	1	0	1
GA	1	1	0	2	2	0	0	0	0	0	0	0
IL	0	0	0	0	1	0	0	0	0	0	0	0
KY	0	1	0	0	0	0	0	0	1	0	0	0
KS	0	0	1	0	0	0	0	0	0	0	0	0
MA	0	1	1	0	0	0	0	1	1	0	0	0
MD	353	260	107	66	227	679	266	651	482	491	381	407
MI	1	0	0	0	1	1	0	0	0	0	0	0
MN	0	0	1	0	0	0	0	0	0	4	0	0
MT	0	0	0	0	0	0	0	1	2	0	0	0
NC	0	2	0	1	0	1	1	0	0	0	3	0
NJ	2	2	6	0	3	2	4	0	0	1	3	0
NY	4	0	0	1	1	0	0	0	1	1	0	0
OH	0	0	0	0	0	3	1	0	1	0	1	0
PA	27	19	17	4	22	32	16	46	18	19	23	21
RI	2	0	1	0	0	0	0	0	0	0	1	0
SC	0	0	1	0	0	1	0	0	0	0	0	0
TN	0	0	0	0	0	0	0	0	0	0	1	0
TX	0	1	0	0	0	0	0	0	0	0	1	2
VA	48	31	30	13	56	71	29	44	42	23	26	20
VT	0	0	0	0	0	0	0	0	0	0	0	1
WA	0	0	1	0	0	0	0	0	0	0	0	0
WI	0	0	0	1	0	0	0	0	0	0	0	0
WV	0	1	0	2	6	3	2	4	4	0	4	2
Outside U.S.	0	0	1	0	0	0	0	0	0	1	0	0
Unknown	0	0	0	0	0	0	0	0	36	0	0	0

Table 12. The average number of anglers and average number of unlicensed anglers, per boat, with 95% confidence intervals, from the 2008-2013 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)

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

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

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

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

Table 17. Average number of fishing trips anglers take per year in Chesapeake Bay.

Year	Minimum	Maximum	Median	Mean
2010	1	100	15	22
2013	2	365	20	28

Table 18. Percent of interviewed anglers expressing satisfaction with Maryland Chesapeake Bay striped bass fishing regulations.

Year	Satisfied (%)	Not Satisfied (%)
2002	68	32
2003	84	16
2004	70	30
2005	59	41
2006	70	30
2007	64	36
2010	75	25
2013	80	20

Figure 1. MD DNR map showing legal open and closed striped bass fishing areas in Chesapeake Bay during the spring season, April 20-May 15, 2013.

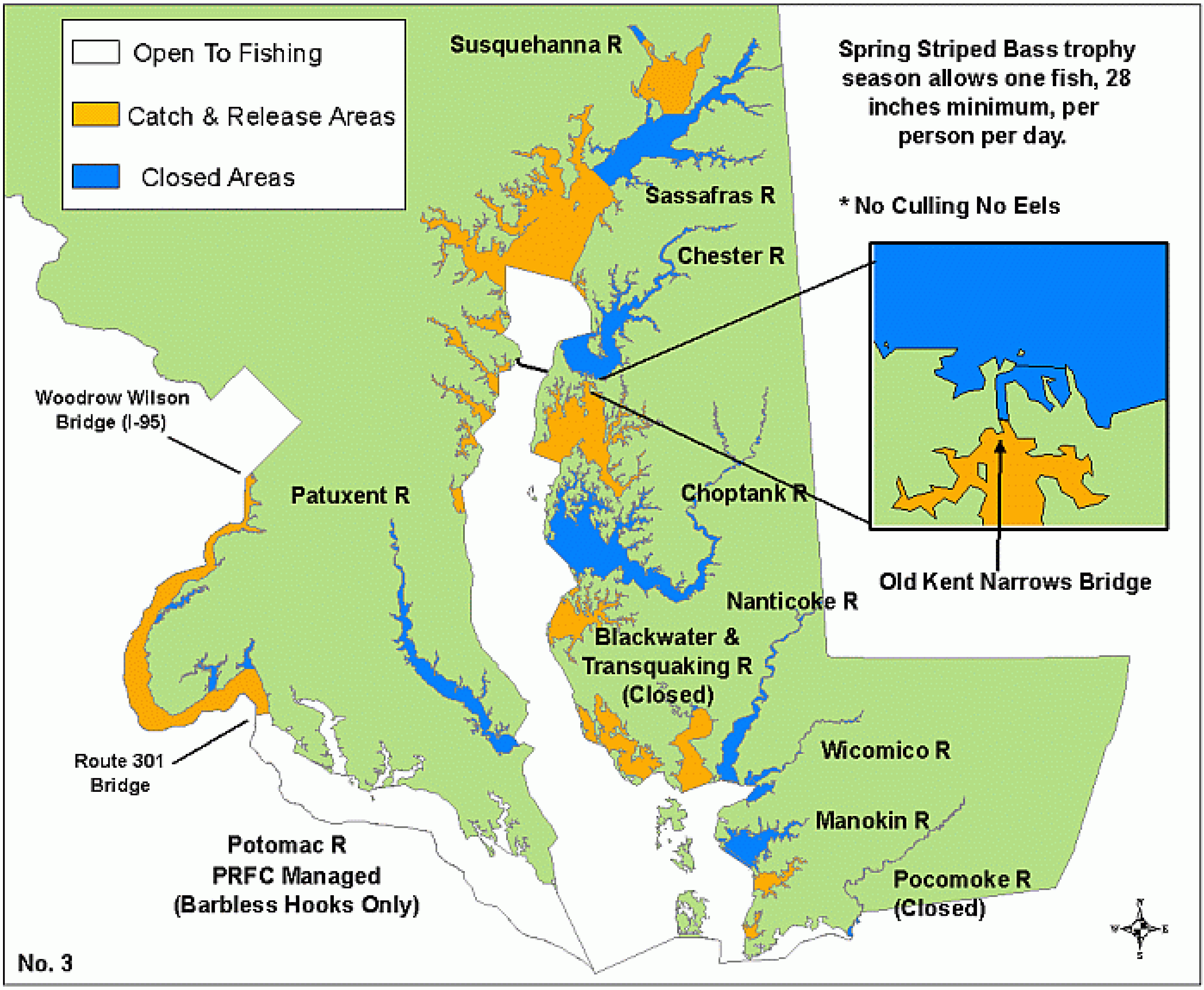


Figure 2. Length distribution of striped bass sampled by year, during the Maryland striped bass spring season creel survey, through May 15.

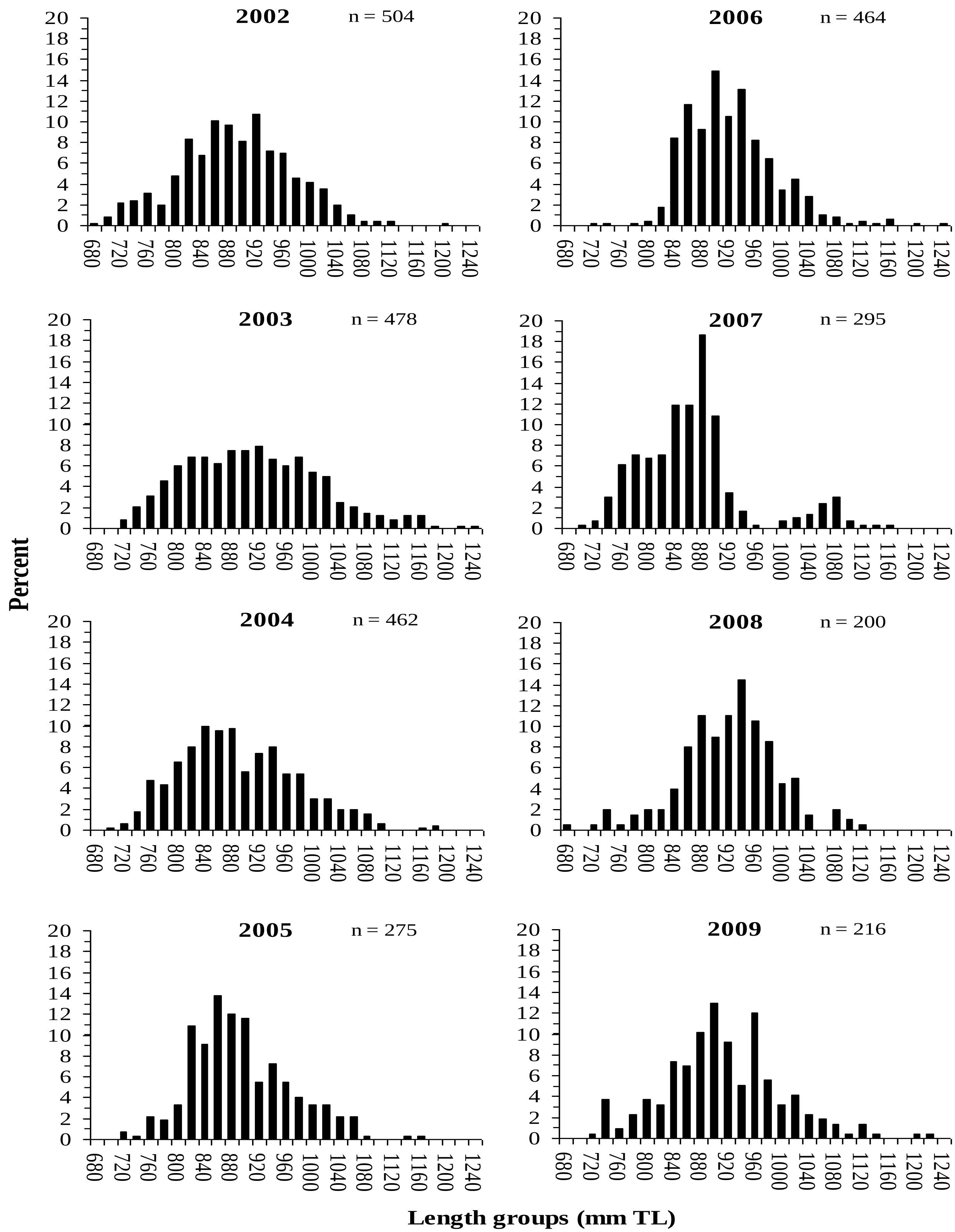


Figure 2. Continued.

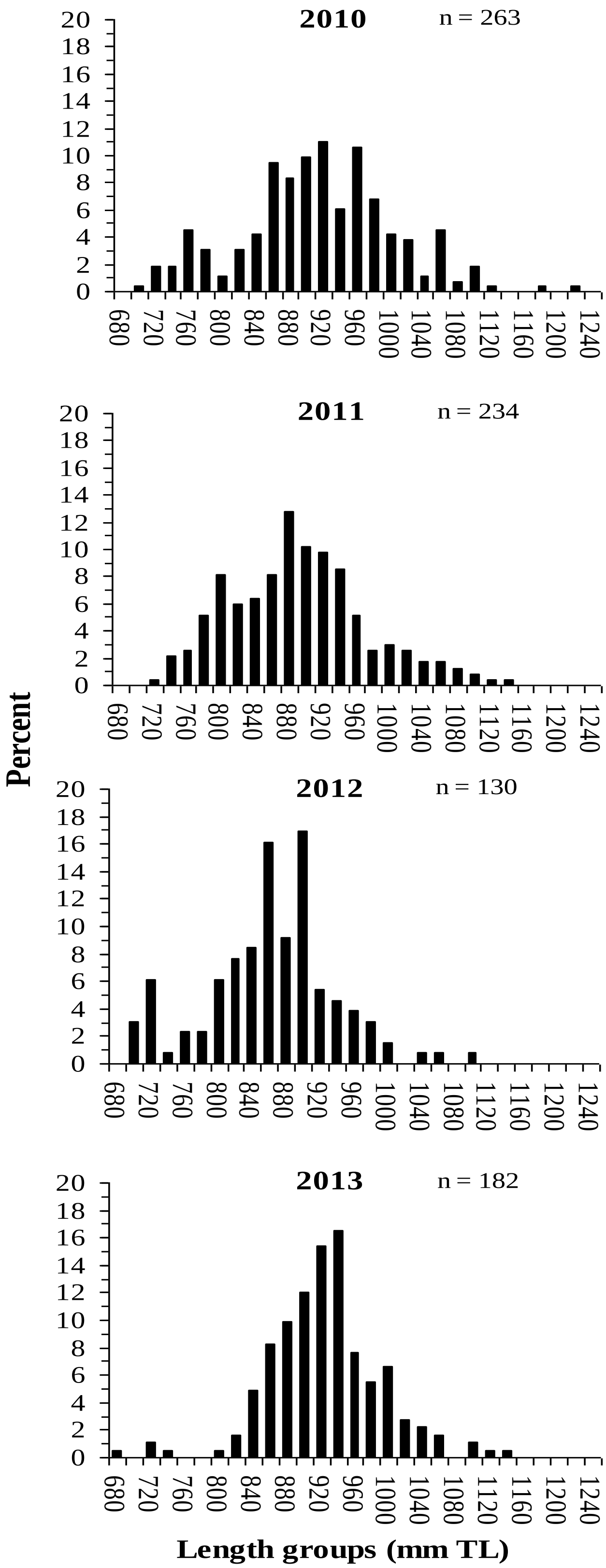


Figure 3. Mean length of striped bass (mm TL) with 95% confidence intervals, sampled by the Maryland striped bass spring season creel survey, through May 15.

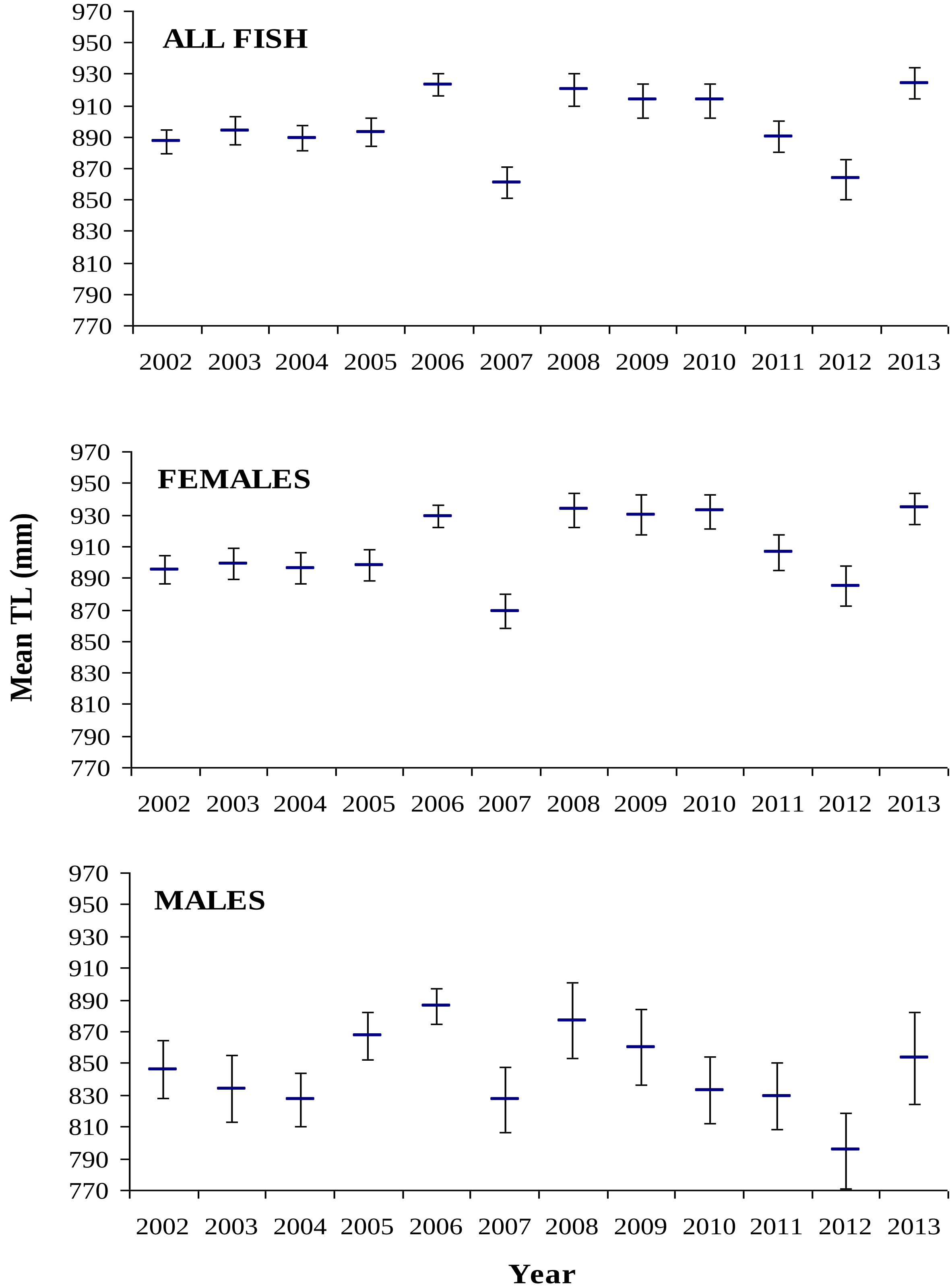


Figure 4. Mean daily length of female striped bass with 95% confidence intervals, sampled by the Maryland striped bass spring season creel survey, through May 15.

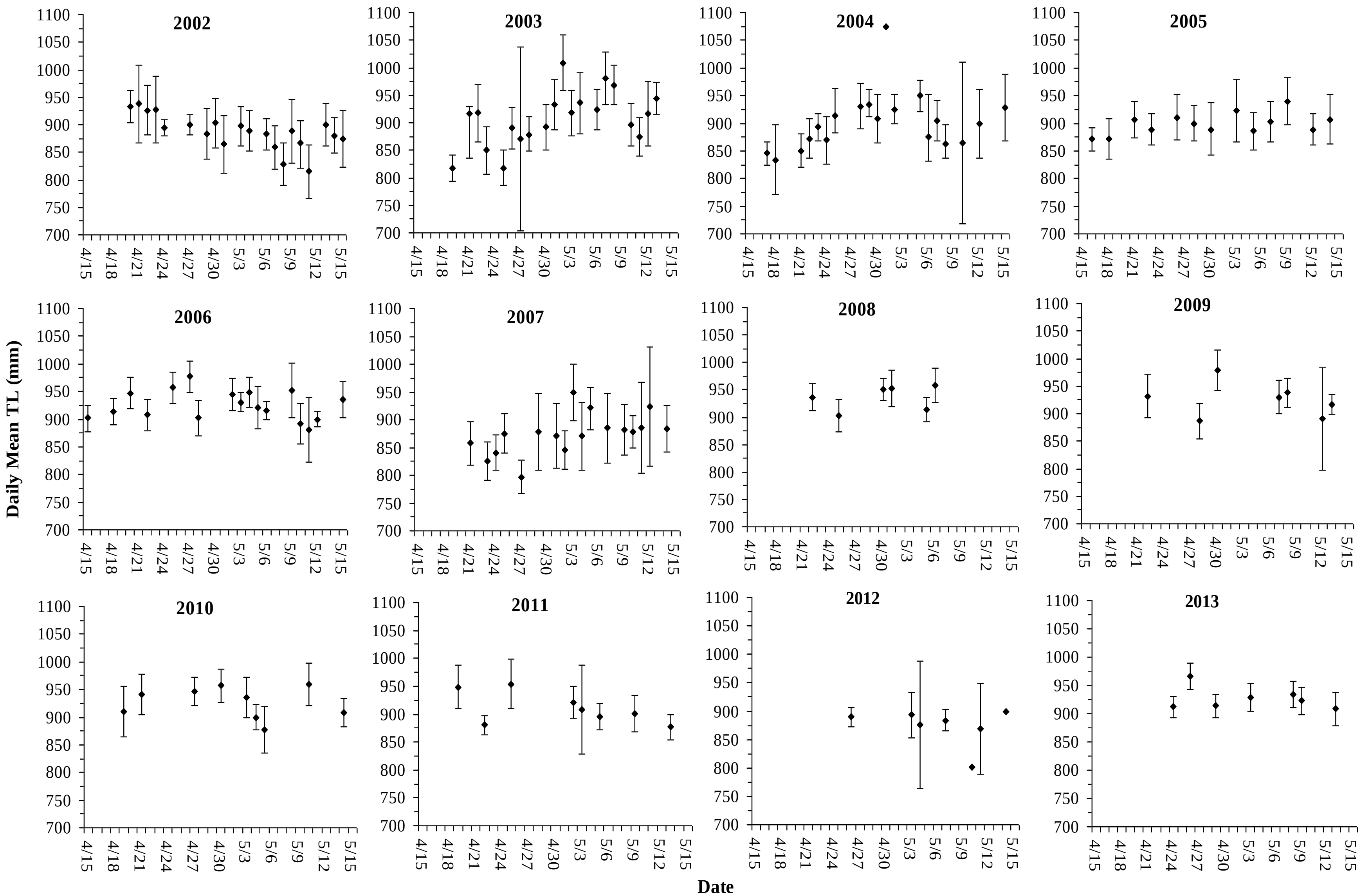


Figure 5. Mean weight of striped bass (kg) with 95% confidence intervals, sampled by the Maryland striped bass spring season creel survey, through May 15.

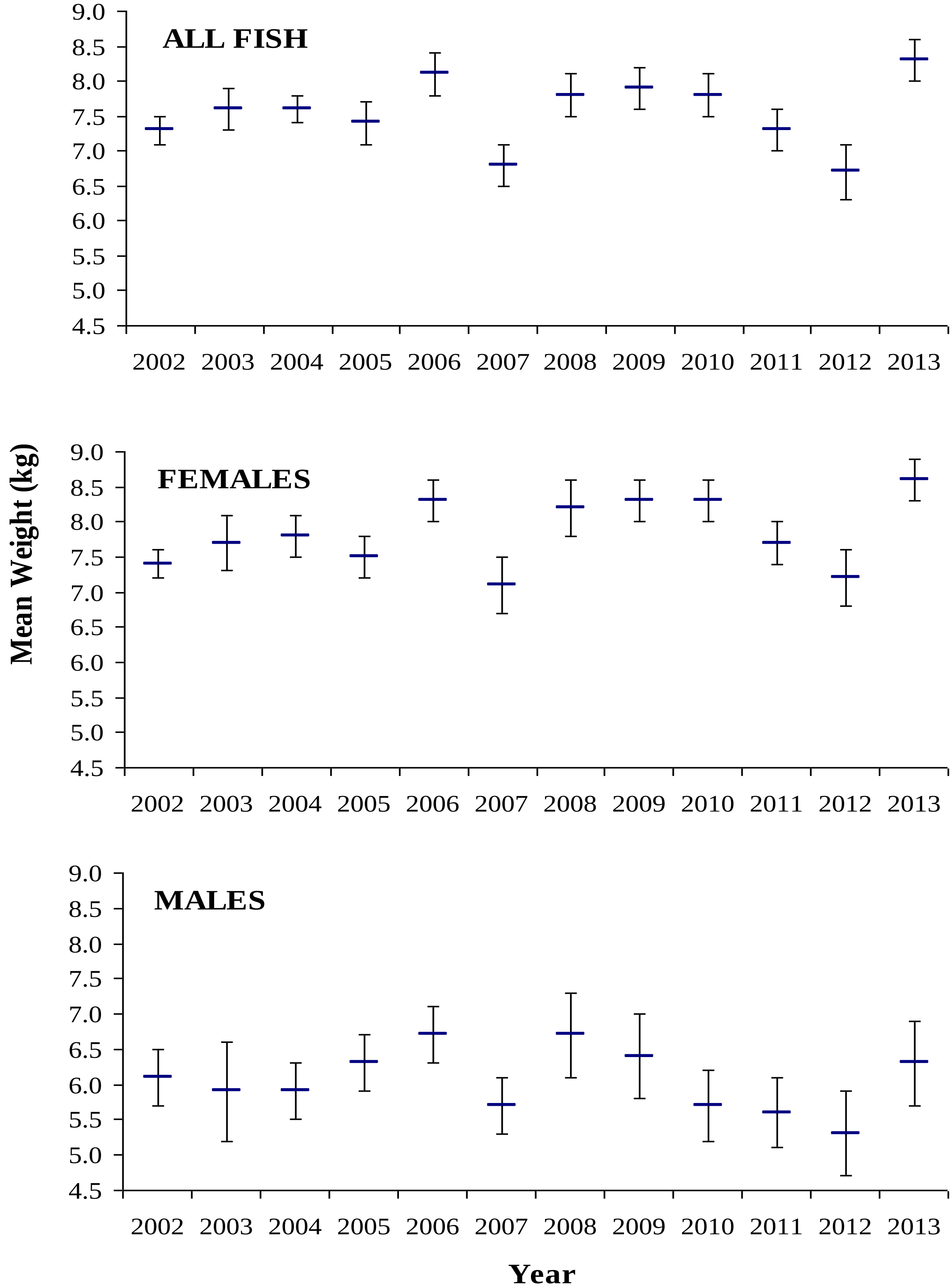


Figure 6. Age distribution of striped bass sampled by the Maryland striped bass spring season creel survey, through May 15.

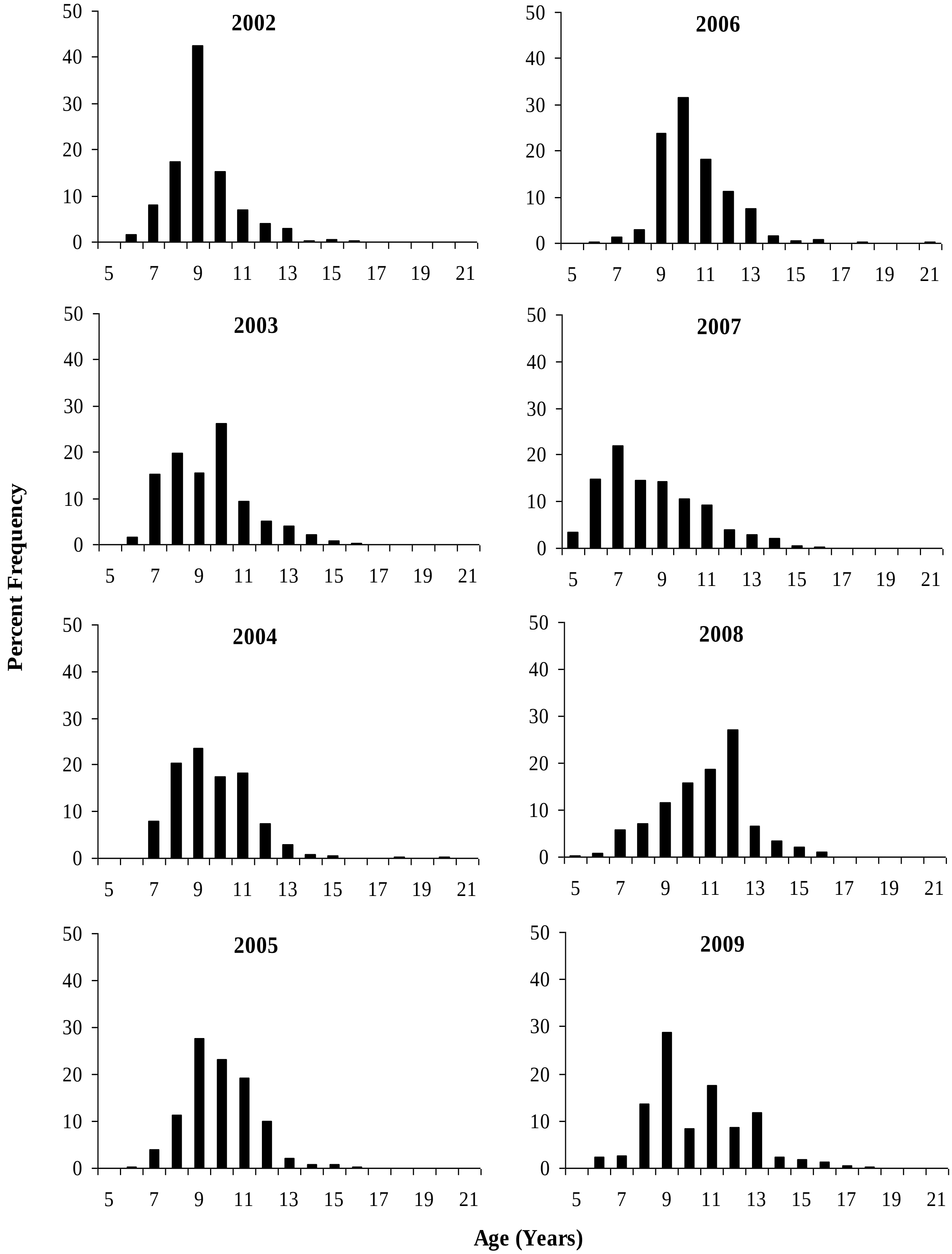


Figure 6. Continued.

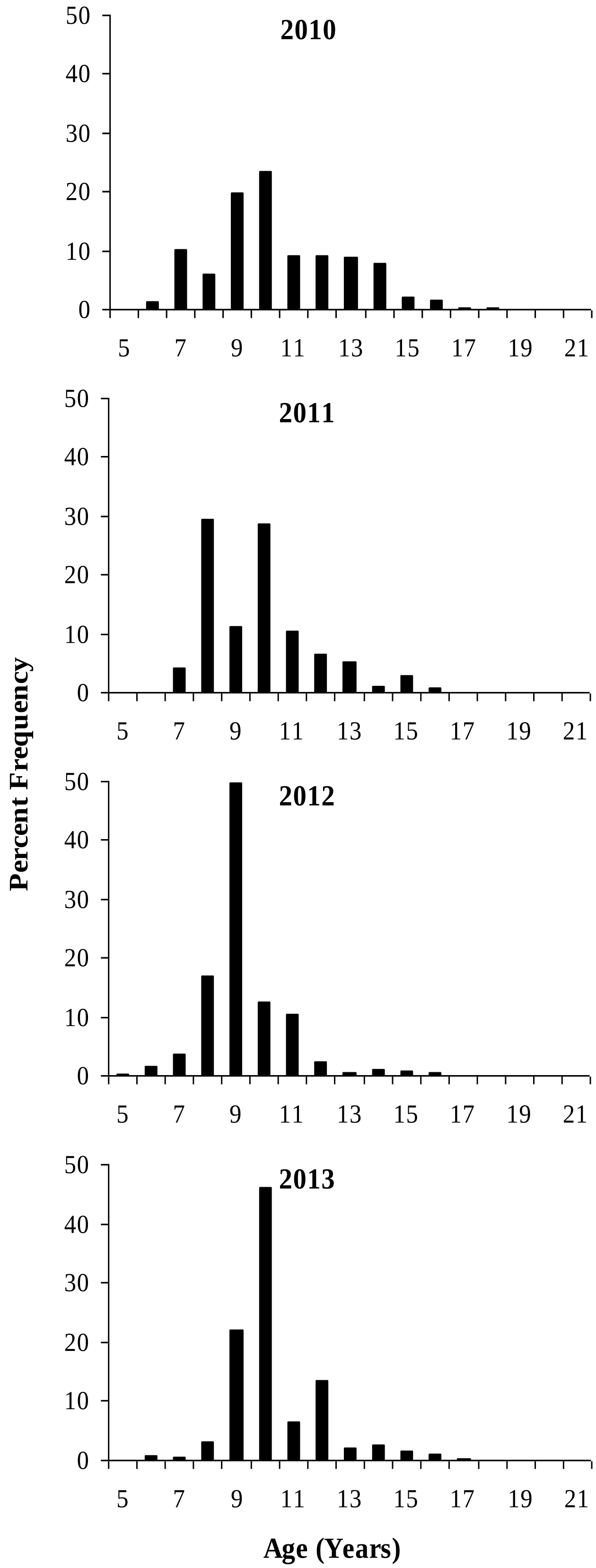


Figure 7. Daily percent of female striped bass in pre-spawn condition sampled by the Maryland striped bass spring season creel survey, through May 15.

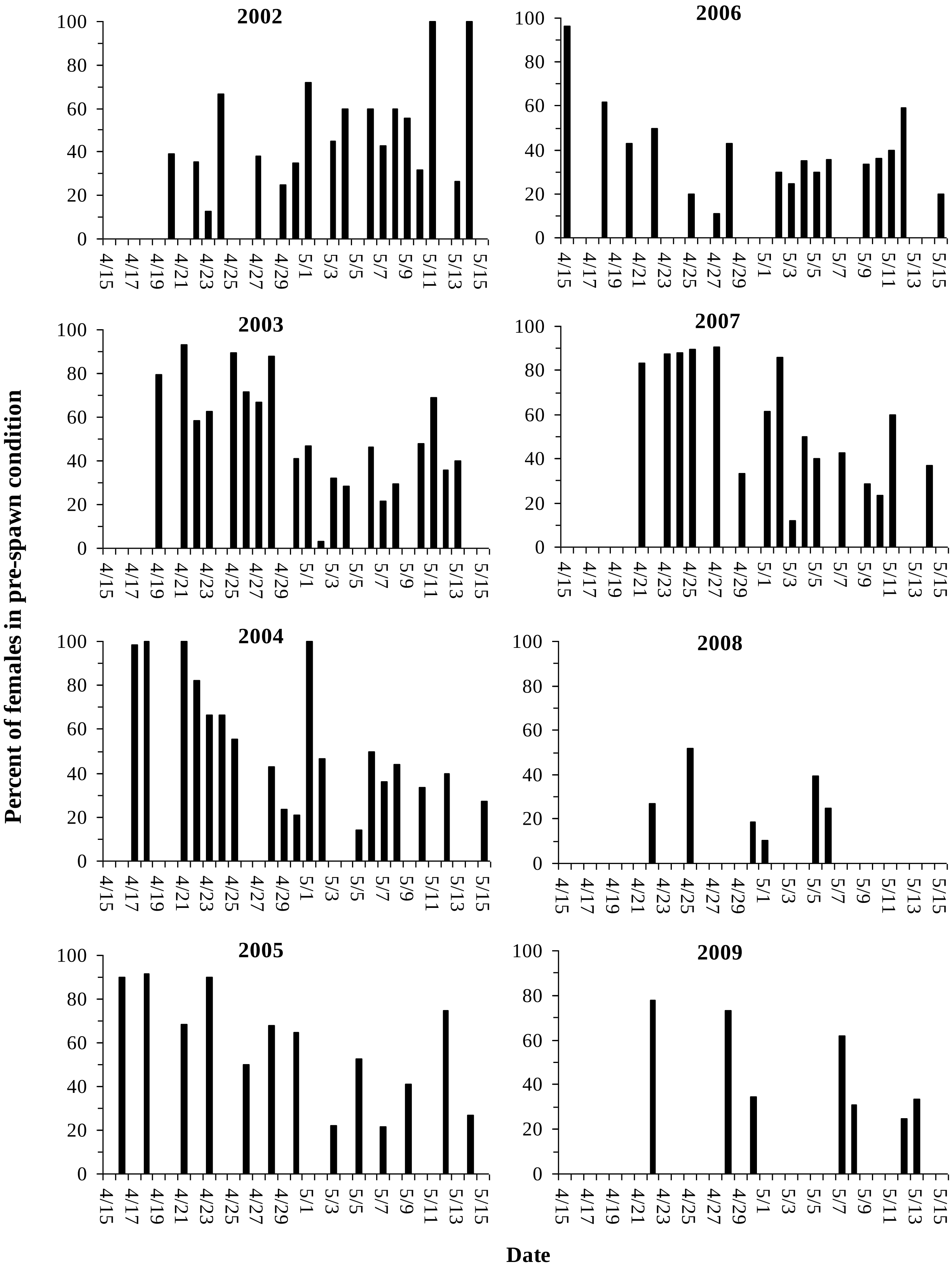


Figure 7. Continued.

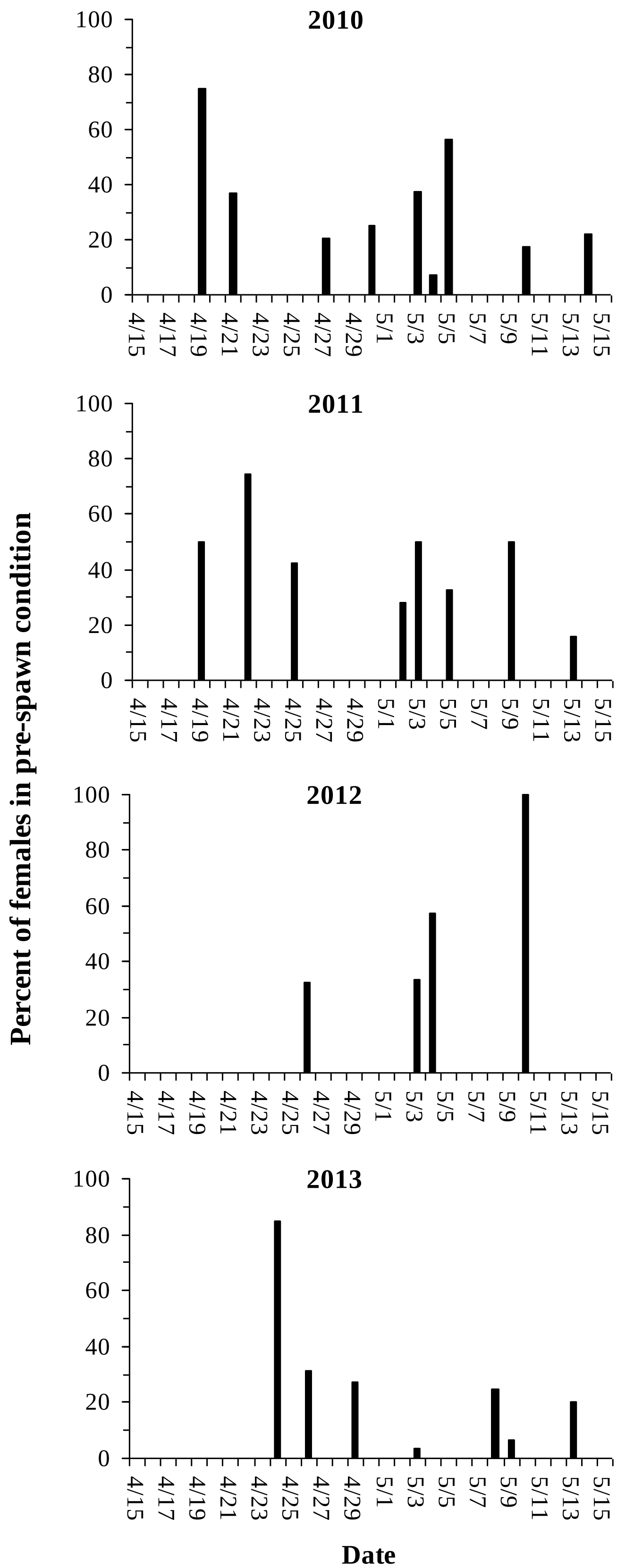
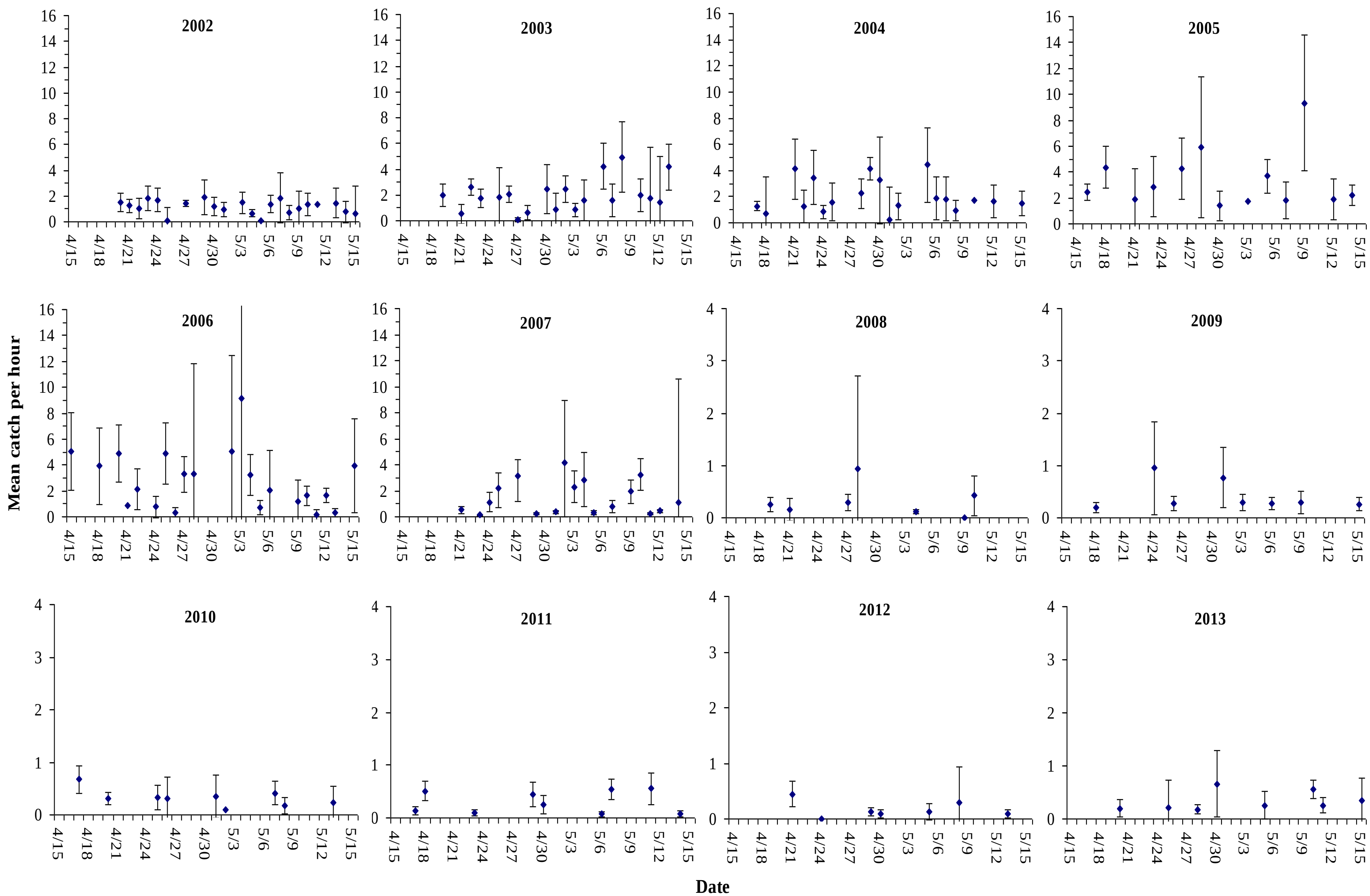


Figure 8. Daily mean catch per hour (CPH) of striped bass with 95% confidence intervals, calculated from angler interview data collected by the Maryland striped bass spring season creel survey, through May 15. Note different scale since 2008.



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? (Line 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 Pt., Lower Bay = Cove Pt. to MD/VA line at Smith Pt.

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.) a. Do you have a boat license?

b. How many anglers in your party were fishing under the boat license? (Or, how many anglers in the party have their own individual licenses?)

13.) Are you happy with the current MD Bay striped bass regulations? If not, what changes would you like to see?

PROJECT NO. 2
JOB NO. 4

INTER-GOVERNMENT COORDINATION

Prepared by Harry T. Hornick and Eric Q. Durell

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

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

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.

Alosines:

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

ASMFC Technical Committee representative attended the American shad Technical Committee meetings to approve the annual state compliance report, examine the current population abundance estimates and discuss the ocean and river-specific fisheries, and prepared the Annual American Shad Status Compliance Report for Maryland.

Bluefish:

The ASMFC Bluefish Technical Committee representative prepared the ASMFC Annual Bluefish Status Compliance Report for Maryland and provided Chesapeake Bay juvenile bluefish data to the Mid-Atlantic Fishery Management Council.

Red Drum:

ASMFC Technical Committee representative prepared the Annual Red Drum Status Compliance Report for Maryland.

Weakfish:

ASMFC Weakfish Technical Committee representative for Maryland attended annual Weakfish Technical Committee meetings and prepared the ASMFC Annual Weakfish Status Compliance report

Striped Bass:

Project staff served on the ASMFC Striped Bass Tagging Sub Committee, the Interstate Tagging Committee, the ASMFC Bluefish Technical Committee, and as Maryland representatives to the Potomac River Fisheries Commission (PRFC) Finfish Advisory Board.

Project staff served as Maryland alternate representatives to the ASMFC Striped Bass Scientific and Statistical Committee, the Striped Bass Stock Assessment Subcommittee, and produced Maryland's Annual Striped Bass Compliance Report to the ASMFC.

Striped Bass Data Sharing and Web Page Development

To augment data sharing efforts, Striped Bass Stock Assessment program staff in 2002 developed a web page within the MD DNR web site presenting historic Juvenile Striped Bass Survey (Job 3) results. This effort has enabled the public to access SBSA program data directly. The web page, http://dnr.maryland.gov/fisheries/Pages/striped-bass/juvenile-index.aspx, is updated annually in October.

Monthly individual visits to the Juvenile Striped Bass Survey web page by individual IP address for the period August 2012 to December 2013 are provided in Table 1**.** An increase in volume in October, 2012 and October, 2013 coincided with publication of the juvenile survey results in the media and advertisement on the main Fisheries Service page. Many large or complex data requests are still handled directly by Striped Bass Stock Assessment 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. Monthly visits to the Juvenile Striped Bass Survey web page, August 2012 to December 2013.

Date	**Visits**
August, 2012	195
September	217
October	402
November	202
December	164
January, 2013	163
February	162
March	131
April	184
May	194
June	148
July	188
August	138
September	204
October	375
November	177
December, 2013	118
TOTAL	3362

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), Duke University, the University of Maryland, University of Massachusetts, Virginia Institute of Marine Sciences, Georgetown University, the Pennsylvania State University, Syracuse University, and State management agencies from Delaware, Massachusetts, New York and Virginia. For the past contract year, (November 1, 2012 through October 31, 2013) the following specific requests for information have been accommodated:

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

-Dr. Jeffrey Buckel, North Carolina State University
Provision of historical striped bass juvenile survey data and survey protocols.

-Ms. Melissa Cichantele, Potomac Conservancy.
Provision of white perch and striped bass juvenile survey data.

-Mr. Jim Cummins, Interstate Commission for the Potomac River Basin,(ICPRB).
Provision of current striped bass recreational, charter, and commercial fishery data, and American shad and striped bass juvenile survey data.

- Maryland Charterboat Association (MCA)
Provision of striped bass fishery regulations, striped bass recreational, and charter boat harvest data.

-Ms. Diane Embry, Johns Hopkins University.
Provision of historic striped bass juvenile survey data.

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

-Dr. Matthew Hamilton, Georgetown University.
Provision of juvenile striped bass biological samples for genetic research and abundance indices

-Mr. Ken Hastings.
Provided striped bass commercial fishery monitoring and budget information, and ASMFC Striped Bass Compliance Report information.

-Mr. Mike Hendricks, Pennsylvania Fish & Boat Commission (PFBC).
Provision of American shad juvenile survey data from Juvenile Striped Bass Survey.

-Dr. Desmond Kahn, Delaware Division of Fish and Wildlife.
Provision of historic striped bass juvenile survey data.

- 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.

-Ms. Anne-Marie Pelletier, Ministry of Natural Resources, Quebec, Canada
Provision of striped bass juvenile survey data and survey protocols.

-Mr. Jason Schaffler, Virginia Marine Resources Commission .
Provision of juvenile striped bass abundance indices.

-Ms. Catherine Schlick, George Mason University.
Provision of historic juvenile herring abundance indices. Provided herring young-of-year samples from the Juvenile Survey.

-Ms. Allison Watts, Virginia Marine Resources Commission.
Provision of current and historical striped bass commercial fishery data; Striped bass Volunteer Angler Survey data, results of fishery dependent monitoring programs and striped bass juvenile survey data.

-Dr. Peter Wimberger, University of Puget Sound.
Provision of biological data from Juvenile Index survey for Atlantic menhaden, and striped bass. Also provided biological data on striped bass and Atlantic menhaden from pound net survey and commercial harvest monitoring

-University of Maryland (U MD - CEES), Chesapeake Biological Laboratory and Horn Point Environmental Laboratory.
Provided six (5) staff and students with current striped bass juvenile index data, Atlantic menhaden juvenile index data, recreational and commercial landings data, and biological samples.

-The Interjurisdictional Project also provided related biological information and reports to twenty five (25) additional scientists, students and concerned stakeholders.

Atlantic Sturgeon, Shortnose Sturgeon and Sea Turtle Interaction Summary for Chesapeake Bay Finfish Investigations
Project No.: F-61-R-9

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

Summary

The primary objective of the Chesapeake Bay Finfish Investigations Survey, F-61-R-9 was to monitor and biologically characterize resident and migratory finfish species in the Maryland portion of the Chesapeake Bay. The F-61-R Survey provides information regarding recruitment, relative abundance, age and size structure, growth, mortality, and migration patterns of finfish populations in Maryland's Chesapeake Bay. This document will summarize any interactions of these biological surveys with endangered species such as Atlantic sturgeon, shortnose sturgeon, and sea turtles. There were three (3) documented Atlantic sturgeon encounters during the 2013 Striped Bass Spawning Stock Survey (Project 2, Job 3, Task 2) on the Potomac River.

CONTENTS:

PROJECT I: RESIDENT SPECIES STOCK ASSESSMENT

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

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

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.

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

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

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

PROJECT I: RESIDENT SPECIES STOCK ASSESSMENT

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

JOB 2: Population assessment of 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

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed in the Upper Chesapeake Bay Winter Trawl Survey during the Survey period of November 1, 2012 through October 31, 2013.

Shortnose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed in the Upper Chesapeake Bay Winter Trawl Survey during the Survey period of November 1, 2012 through October 31, 2013.

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 November 1, 2012 through October 31, 2013.

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 November 1, 2012 through October 31, 2013.

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 November 1, 2012 through October 31, 2013.

Shortnose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed in the Choptank River Fyke Net Survey during the Survey period of November 1, 2012 through October 31, 2013.

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 November 1, 2012 through October 31, 2013.

Shornose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed during the Survey period of this project from November 1, 2012 through October 31, 2013..

2. Nanticoke River Ichthyoplankton Survey

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed during the Survey period of November 1, 2012 through October 31, 2013.

Shornose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles were sampled or observed during the Survey period of November 1, 2012 through October 31, 2013.

PROJECT 2:

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

Research Survey:

1. Summer Pound Net Survey:

1. Summer Pound Net Survey

Atlantic Sturgeon Interactions

No Atlantic sturgeon were sampled or observed during the Survey period of November 1, 2012 through October 31, 2013.

Shortnose Sturgeon and Sea Turtle Interactions

No shortnose sturgeon or sea turtles sampled or observed during the Survey period of November 1, 2012 through October 31, 2013..

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

1. Summer - Fall Pound Net Survey

Atlantic Sturgeon Interactions
No Atlantic sturgeon were sampled or observed during this Survey for the period of November 1, 2012 through October 31, 2013.

Shortnose Sturgeon and Sea Turtle Interactions
No shortnose sturgeon or sea turtles were sampled or observed during this Survey for the period of November 1, 2012 through October 31, 2013.

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

Research Survey:
1. Spring Striped Bass Experimental Drift Gill Net Survey

1. Spring Striped Bass Experimental Drift Gill Net Survey

Atlantic Sturgeon Interactions
Three Atlantic sturgeon were encountered in this assessment project on the Potomac River (Figure 1) during the survey period of November 1, 2012 through October 31, 2013. Incident Reports follow below.

Shortnose Sturgeon and Sea Turtle Interactions
No shortnose sturgeon or sea turtles were sampled or observed during this Survey for the period of November 1, 2012 through October 31, 2013.

Incident Report: ESA Listed Species Take

Observer's full name: Eric Q. Durell, MD Department of Natural Resources

Reporter's full name: same

Survey: Striped Bass Spawning Stock Survey

Species Identification: Atlantic Sturgeon

How documented: identified to species by biologist and photos taken

Type of gear and length of deployment: experimental drift gill net, mesh sizes and soak time variable, see below

Encounter #1:

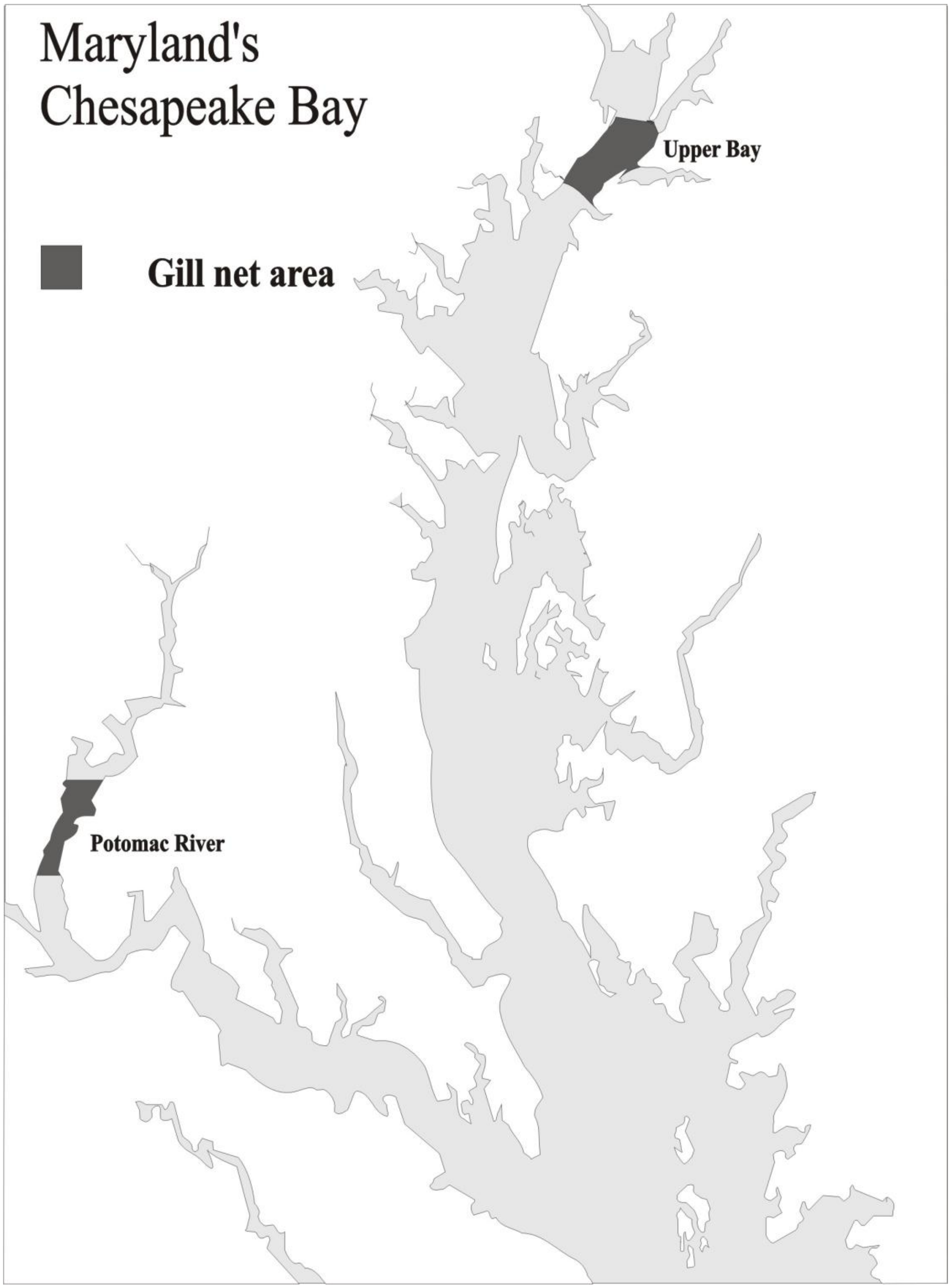
Date: April 1, 2013
Time: 12:59 PM
Location: Potomac River, near Mallows Bay, N 38 28.65, W 77 16.6
Water Temp: 8.1° C
Env Conditions: salinity 0.1 ppt, airtemp 12° C, ebb tide
Gear: drift gill net, multifilament nylon 4.5 inch stretch mesh, soak time 1 hour 16 min
Total Length: 605 mm
Condition/description of specimen: robust, released unharmed
Photograph taken? YES
Genetics sample taken? NO

Encounter #2:
Date: April 17, 2013
Time: 7:56 AM
Location: Potomac River, near Quantico Marine Base, N 38 30.20, W 77 17.8
Water Temp: 17.1° C
Env Conditions: salinity 0.1 ppt, airtemp 15° C, flood tide
Gear: drift gill net, multifilament nylon 10 inch stretch mesh, soak time 52 min
Total Length: 952 mm
Condition/description of specimen: healing injury to snout, robust, released unharmed
Photograph taken? YES
Genetics sample taken? NO

Encounter #3:

Date: May 1, 2013
Time: 8:16 AM
Location: Potomac River, near Indian Head Navy Base, N 38 34.40, W 77 13.3
Water Temp: 16.9° C
Env Conditions: salinity 0.1 ppt, airtemp 11° C, flood tide
Gear: drift gill net, multifilament nylon 6.5 inch stretch mesh, soak time 32 min
Total Length: 893 mm
Condition/description of specimen: scar on back, robust, released unharmed
Photograph taken? YES
Genetics sample taken? NO

Figure 1. Drift gill net sampling locations in spawning areas of the upper Chesapeake Bay and the Potomac River, late March – May, 2013.



Project 2, Job 3,
Task 3: Maryland juvenile striped bass survey

Research Survey:
1. Juvenile Striped Bass Seine Survey

1. Juvenile Striped Bass Seine Survey

Atlantic Sturgeonn Interactions
No Atlantic sturgeon were sampled or observed during this Survey for the period of November 1, 2012 through October 31, 2013.

Shortnose Sturgeon and Sea Turtle Interactions
No shortnose sturgeon or sea turtles were sampled or observed during this Survey for the period of November 1, 2012 through October 31, 2013.