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Estimation of Juvenile Striped Bass Relative Abundance in the Virginia Portion of Chesapeake Bay

ANNUAL PROGRESS REPORT: 2014 - 2015

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EXECUTIVE SUMMARY

The 2014 Striped Bass juvenile abundance index was 11.30 and was not significantly higher than the historic average of 8.56. Abundance indices from individual rivers in 2014 varied compared with their respective historic averages, and significantly higher recruitment was observed in the York and Rappahannock rivers. Average recruitment occurred in the James River. Increased catches of young-of-the-year Striped Bass at upriver and downriver auxiliary sites suggest an expansion of Striped Bass nursery grounds in 2014. Similar to Striped Bass, juvenile White Perch abundance indices in 2014 were above the historic average for this species. A weak year class for Atlantic Croaker appears to have occurred in 2014. Average to above-average indices for forage fishes suggest adequate prey resources for populations of commercial and recreational piscivores in Virginia waters.

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PREFACE

The primary objective of the Virginia Institute of Marine Science juvenile Striped Bass survey is to monitor the relative annual recruitment of juvenile Striped Bass in the principal Virginia nursery areas of Chesapeake Bay. The U.S. Fish and Wildlife Service initially funded the survey from 1967 to 1973. Beginning in 1980, funds were provided by the National Marine Fisheries Service under the Emergency Striped Bass Study program. Commencing with the 1989 annual survey, the work was jointly supported by Wallop-Breaux funds (Sport Fish Restoration Act),administered through the U.S. Fish and Wildlife Service, and the Virginia Marine Resources Commission. This report summarizes the results of the 2014 sampling period and compares these results with previous years.

INTRODUCTION

Striped Bass (*Morone saxatilis*) is one of the most commercially and recreationally sought-after fish species on the east coast of the United States. Decreases in the commercial harvest of Striped Bass in the 1970s paralleled the steady decline in abundance of Striped Bass along the east coast; Chesapeake Bay stock abundances were particularly depressed. Declines in commercial harvests mirrored declines in juvenile recruitment (Goodyear 1985). Because the tributaries of Chesapeake Bay were identified as primary spawning and nursery areas, fishery managers enacted regulations intended to halt and reverse the decline of Striped Bass in Chesapeake Bay and elsewhere within its native range (ASMFC 2003).

In 1981, the Atlantic States Marine Fisheries Commission (ASMFC) developed the Atlantic Coast Striped Bass Interstate Fisheries Management Plan (FMP), which included recommendations aimed to improve the stock status. The Virginia Marine Resources Commission (VMRC) adopted the plan in March 1982 (Regulation 450-01-0034), but the ASMFC did not have regulatory authority for fisheries management in individual states at that time. As Striped Bass populations continued to decline, Congress passed the Atlantic Striped Bass Conservation Act (PL 98-613) in 1984, which required states to follow and enforce management measures in the FMP or face a moratorium on Striped Bass harvests. Since 1981 the FMP has been amended six times to address changes in the management of the stocks. Amendment VI to the plan, adopted in February 2003, requires "producing states" (i.e., Virginia, Maryland, Delaware and New York) to develop and support programs monitoring Striped Bass recruitment.

In 1967, before the FMP requirement, Virginia began monitoring the annual recruitment of juvenile Striped Bass using funding from the Commercial Fisheries Development Act of 1965 (PL88-309). This monitoring continued until 1973 when funding was discontinued. Monitoring of striped bass recruitment was re-instituted in 1980 using Emergency Striped Bass Study funds (PL 96-118, 16 U.S.C. 767g, the "Chafee Amendment"), and since 1989, the annual survey has been funded by the Wallop-Breaux expansion of the Sport Fish Restoration and Enhancement Act of 1988 (PL 100-448, “the Dingle-Johnson Act”). Funds are administered through the VMRC.

Initially, the Virginia program used a 6 ft. x 100 ft. x 0.25 in. mesh (2 m x 30.5 m x 6.4 mm) bag seine, but comparison hauls with Maryland gear (4 ft. x 100 ft. x 0.25 in. mesh; 1.2m x 30.5m x 6.4mm mesh) showed virtually no statistical differences in catch, and Virginia adopted the "Maryland seine" after 1987 (Colvocoresses 1987). The gear comparison study aimed to standardize methods and promote a bay-wide recruitment estimate (Colvocoresses and Austin 1987). This was never realized due to remaining differences in the methods of estimation of means (MD: arithmetic index; VA: geometric index). A bay-wide index using a geometric mean weighted by spawning area in each river was proposed in 1993 (Austin et al. 1993) but has not been implemented. Recent computations of a bay-wide geometric mean juvenile abundance index (JAI) were found to be correlated with fishery-independent monitoring (Woodward 2009).

Objectives for the 2014 program were to:

1. estimate the relative abundance of the 2014 year class of Striped Bass in the James, York and Rappahannock river systems,

2. quantify environmental conditions at the time of collection, and

3. examine relationships between juvenile Striped Bass abundance and environmental and biological data.

METHODS

Field sampling was conducted during five biweekly periods (rounds) from 25 June through 2 September 2014. During each round, seine hauls were conducted at 18 index stations and 21 auxiliary stations in the James, York and Rappahannock river systems (Figure 1). Auxiliary sites were added to the survey in 1989 to provide better geographic coverage and increase sample sizes within each river system. Such monitoring was desirable in light of increases in stock size during the 1980s and hypothesized expansion of the nursery ground in years of high recruitment.

Collections were made by deploying a 100 ft. (30.5 m) long, 4 ft. (1.2 m) deep, 0.25 in (6.4 mm) mesh minnow seine perpendicular to the shoreline until either the net was fully extended or a depth of approximately 4 ft. (1.2 m) was encountered and then pulling the offshore end down-current and back to the shore. During each round a single haul was made at each auxiliary station and duplicate hauls, with a 30-minute interlude, were made at each index station. Every fish collected during a haul was removed from the net and placed into water-filled buckets. All Striped Bass were measured to the nearest mm fork length (FL), and for all other species, a sub-sample of up to 25 individuals was measured to the nearest mm FL (or total length if appropriate). At index stations, fish collected during the first haul were held in a water-filled bucket until the second haul was completed. All captured fish, except those preserved for life

history studies, were returned to the water at the conclusion of sampling. Sampling time, tidal stage, and weather conditions were recorded at each sampling location. Salinity, water temperature and dissolved oxygen concentrations were measured after the first haul using a YSI water quality sampler.

In this report, comparisons of Striped Bass recruitment indices with prior years are made for the "primary nursery" area only (Colvocoresses 1984), using data collected from months and areas sampled during all years (i.e., index stations). Catch data from auxiliary stations are not included in the calculation of the annual indices. The index of relative abundance for young-of-the-year Striped Bass is calculated as the adjusted overall mean catch per seine haul such that

$$\text{Index} = (\exp(\ln(\text{totnum} + 1)) - 1) \times 2.28$$

where *totnum* is the total number of Striped Bass per seine haul; catches from the first and second seine haul at each index station are included in this calculation. Because the frequency distribution of the catch is skewed (Colvocoresses 1984), a logarithmic transformation (ln(*totnum*+1)) was applied to the data prior to analysis (Sokal and Rohlf 1981). Mean values are back-transformed and scaled up arithmetically ($\times 2.28$) to allow comparisons with Maryland indices. Thus, a "scaled" index refers to an index that is directly comparable with the Maryland index.

In accordance with suggestions made by Rago et al. (1995), the Virginia juvenile Striped Bass index has also been recomputed using only the first haul at each index station. Additionally, the rehabilitation of Chesapeake Bay Striped Bass stocks, and subsequent relaxation of commercial and recreational fisheries regulations in

Chesapeake Bay in 1990 (ASMFC 2003) allows examination of the recruitment of Striped Bass during three distinct periods:

- 1967 – 1973: an early period of monitoring;
- 1980 – 1989: a decade reflecting severe population depression during which temporary fishing moratoria were in place; and,
- 1990 – Present: a period of post-recovery and regulation targeting the development of a sustainable fishery.

An average index value for 1990 – 2013 was calculated using only the first haul at each index site to provide a benchmark for interpreting recruitment strength during the post-recovery period and was compared with the 2014 annual index.

In previous years, the historic average was calculated as the geometric mean across all stations. However, survey effort has not been equal through time. The number of hauls completed annually ranged from 42 (1967) to 180 (post-1988) resulting in an estimate of the historic average that was biased by recruitment years with higher effort (i.e., more recent years). The historic average should instead be calculated as the mean of the annual abundance estimates (n = 42, one estimate per year). Equal weight is thus given to years of lower sampling effort (which in this time series happen to be years of low abundance), and years with higher sampling effort (which occurred during the latter part of the time series and included years of higher abundance).

Throughout this report, mean catch rates are compared using 95% confidence intervals. Reference to "significant" differences between geometric means in this context will be restricted to cases of non-overlapping confidence intervals. Because

standard errors are calculated from transformed (logarithmic) values, confidence intervals for the back-transformed and scaled indices are non-symmetrical.

RESULTS AND DISCUSSION

Juvenile Index of Abundance for Virginia

We collected 2,293 young-of-the-year Striped Bass in 2014 from 180 seine hauls at index stations and 1,261 individuals from 105 hauls at auxiliary stations (Table 1). Using index-station catches from both hauls, the estimated Striped Bass recruitment index in 2014 was 11.30 (LCI = 8.98, UCI = 14.09; Table 2), which was not significantly different than the historic average of 8.56 (LCI = 6.86, UCI = 10.26; Figure 2).

Even with a 30-minute interlude between hauls at index stations, second hauls cannot be considered independent samples and their use violates a key assumption necessary for making inferences from a sample mean (Rago et al. 1995). Previous reports consistently documented fewer catches in the second haul (e.g. Hewitt et al. 2007, 2008), a result which artificially lowers the geometric mean when data from both hauls are included in the index computation. Thus, the annual and historic indices were recalculated using only the first haul at each index station. In 2014, 1,401 young-of-the-year Striped Bass were collected in the first haul resulting in an index of 14.81 (LCI = 10.87, UCI = 19.93, Table 3), which is not significantly different from the recomputed first-haul historic index of 10.32 (LCI = 9.14, UCI =11.50). All annual Striped Bass abundance estimates presented in Table 3 are based on single hauls. The 2014 Virginia-wide index of 14.81 (LCI = 10.87, UCI = 19.93) is similar to the mean index estimated for the post-recovery period (index = 13.53; LCI = 12.57, UCI = 14.49).

Prior to 2011, annual recruitment indices were derived from all collections made during a sampling year. From 1967 to 1973, seine sampling extended into October and occasionally into December (1973). Current sampling concludes in mid-September because after this time, sampling efficiency decreases due to mortality of juveniles, increased avoidance of the sampling gear, and the dispersal of juveniles into deeper waters. Indices calculated from data that include catches after mid-September are therefore biased low. Starting in 2011, recruitment calculations were made using catch data from the currently established sampling season (July through mid-September) to permit uniform comparisons of annual recruitment (Tables 2– 4).

Striped Bass recruitment success in the Virginia portion of Chesapeake Bay is variable among years and among nursery areas within years. Average to above-average recruitment years occurred between 2003 and 2011, and in 2013 and 2014 (Figure 2). The highest recruitment index observed by the Virginia seine survey occurred in 2011. Since the termination of the Striped Bass fishing moratorium in 1990, strong year classes have been observed approximately every decade (1993, 2003, and 2011). Similarly, single years of low recruitment have occurred approximately every ten years (1991, 1999, 2002, and 2012). Individual years of poor recruitment after the moratorium (i.e., since 1990) were followed by years of average or above-average recruitment and that pattern was repeated in 2013 and 2014 (Figure 2). Under current ASMFC regulations (ASMFC 2010), management action is triggered after three consecutive years of below-average recruitment in producing states.

Continued monitoring of regional recruitment success will be important in identifying management strategies to protect the spawning stock of Chesapeake Bay Striped Bass. Research suggests that a Chesapeake Bay-wide index, computed from Virginia and Maryland data combined, will provide a better estimate of recruitment strength and serve as a better predictor of subsequent adult Striped Bass abundance within the Bay (Woodward 2009). This may be particularly appropriate in years when individual state JAIs provide divergent estimates of year-class strength; such differences may arise due to annual changes in the spatial distribution and contribution of nursery areas throughout Chesapeake Bay.

Juvenile Index of Abundance for Individual Watersheds

Recruitment indices observed in the three Virginia watersheds during 2014 were considered average (James) or significantly above-average (York and Rappahannock rivers) compared with their respective historic means. The 2014 JAI for the James River drainage was 8.56 (LCI = 5.80, UCI = 12.26), compared with the historic James River index of 8.96 (LCI = 6.82, UCI = 11.61; Table 4). The 2014 JAI value for the York River drainage was 10.30 (LCI = 7.36, UCI = 14.14), compared with the historic York River index of 5.38 (LCI = 4.16, UCI = 6.83). The 2014 JAI value for the Rappahannock River was 17.54 (LCI = 10.70, UCI = 27.96), compared with the historic Rappahannock River index of 7.14 (LCI = 5.36, UCI = 9.32).

Mid-river index stations contributed to a greater proportion of the catches in the James River watershed (Machut and Fabrizio 2011, 2012), with 38% of all young-of-the-

year Striped Bass occurring in the core nursery zone (C1, C3, and J46). Most of the remaining striped bass were captured at upriver sites (48%).

The 2014 York River JAI of 10.30 (LCI = 7.36, UCI = 14.14) was significantly greater than the historic average of 5.38 (LCI = 4.16, UCI = 6.83) for this river (Table 4; Figure 3). No index sites are located along the main stem of the York River although three auxiliary stations are sampled; the watershed JAI is compiled from sites located within the two principle York River tributaries, the Mattaponi and Pamunkey rivers. The 2014 Pamunkey River JAI of 19.43 (LCI = 13.21, UCI = 28.13) was significantly higher than the historic index of 6.04 (LCI = 4.33, UCI = 8.19), but the 2014 Mattaponi River index of 5.96 (LCI = 3.58, UCI = 9.31) was not significantly different from the historic average of 4.92 (4.92; LCI = 3.91, UCI = 6.09). About 60% of York River Striped Bass were collected from the Pamunkey River and 28% from the Mattaponi River, the remainder were from the York River auxiliary stations (Table 1).

The 2014 Rappahannock River index of 17.54 (LCI = 10.70, UCI = 27.96) was significantly higher than the historic average of 7.14 (LCI = 5.36, UCI = 9.32; Table 4). In 2014, 85% of the total Rappahannock River catch was taken from the three uppermost index sites (R44, R50, R55; Table 1); these three sites have dominated the catches in this drainage for several years.

Weak year classes in 1991, 1999, 2002, and 2012 were all followed by average or above-average recruitment in the following year or years (Figure 2). Large changes in young-of-the-year abundance estimates are typical of estuarine-dependent species. Catches of young-of-the-year Striped Bass from individual watersheds in Virginia during

2014 indicate an average year class was produced throughout Virginia waters. After the moratorium was lifted in 1990, individual years of poor recruitment have occurred sporadically and were usually driven by poor recruitment within a single watershed except for 2012, when recruitment was poor in all three watersheds.

Striped Bass Collections from Auxiliary Stations

Figures 4 – 7 illustrate the spatial distribution of the 2014 year class throughout the nursery area. Note that scaling is not constant across figures. The 1989 addition of auxiliary stations has provided increased spatial coverage for the James, York and Rappahannock drainages and the upriver and downriver auxiliary sites allow delineation of the upper and lower limits of the nursery. These auxiliary stations reveal spatial changes in the nursery areas that occur due to annual changes in river flow. Additionally, in years of low or high juvenile abundance, the nursery area may contract or expand spatially. Inter-annual changes in the occurrence of young-of-the-year Striped Bass at auxiliary sites was particularly evident in 2014: we observed increased catches at upriver and downriver auxiliary stations which we interpret as expansion in the spatial extent of Striped Bass nursery grounds.

Juvenile Striped Bass were captured at all auxiliary stations in the James River during 2014, though catches were lowest at upper- and lower-most stations (Table 1; Figure 4). The greatest number of Striped Bass collected from stations in the James River was from an upriver auxiliary station (J62, n = 338 Striped Bass; Tables 1 and 5). The nursery grounds also extended downstream in 2014 (to J22 and J12; Table 1).

Striped Bass were collected from all auxiliary sites in the Pamunkey and Mattaponi rivers in 2014 (Tables 1 and 5; Figures 5 and 6). Additionally, Striped Bass were collected from all three auxiliary stations within the York River watershed (Table 1). The greatest number of Striped Bass captured in the York River system in 2014 was at P36, a downriver auxiliary station (Table 5).

We previously suggested that the lack of Striped Bass at upriver auxiliary stations in the York River watershed may have been due to the inability to accurately sample in the dense hydrilla vegetation that occurs at these sites (Machut and Fabrizio 2010). In 2014, we detected juvenile Striped Bass at the York River auxiliary sites (Table 1), but not all fish may have been detected due to low capture efficiencies associated with hauling a seine net through dense aquatic vegetation. Furthermore, recent catches at P55, and to a lesser extent at M52, may have been affected by the altered state of the near-shore zone at these sites. Striped Bass may have been forced into deeper waters by the dense hydrilla beds; alternatively, Striped Bass may preferentially use hydrilla habitats but remain unavailable to the sampling gear. The continued sampling difficulties at these stations suggest a need to examine alternative collection methods within this region to determine the abundance of juvenile Striped Bass in near-shore areas where hydrilla is present.

Striped Bass were collected at all upriver Rappahannock River auxiliary stations during 2014. In recent years, few fish have been collected at the lower auxiliary stations in the Rappahannock River (R12, R21) even though these sites have favorable substrate and no obstructions to compromise seining. The consistent low capture rates at R12

and R21 suggest these sites may have lower value as nursery areas in the Rappahannock River. The same is not true for upstream auxiliary locations. Historic JAI values at auxiliary stations upstream of Tappahannock (near R37) appear comparable to JAIs at index stations R28, R37, and R44 (Table 5).

The occurrence of young-of-the-year Striped Bass at downstream and upstream auxiliary sites throughout tidal tributaries in Virginia further supports the observation of an average recruitment year in 2014. Direct comparisons between auxiliary and index sites are problematic due to slightly different sampling protocols (index station catches are reported as an average of two hauls, whereas only a single haul is made at auxiliary stations). Past analyses demonstrate that catches are consistently greater in the first of two hauls at a given site. Because only one haul is completed at auxiliary sites, abundance estimates at these sites may be biased high relative to abundances estimated at index sites.

Comparison among Sampling Rounds

The largest number of young-of-the-year Striped Bass were collected during rounds 1 and 2 in 2014, with fewer recorded in subsequent rounds (Table 6). Historically, 21% fewer Striped Bass are observed in the second round relative to the first round, however in 2014, there was an increase of 12.3% of young-of-the-year Striped Bass between rounds 1 and 2 (Table 6).

Environmental Conditions and Potential Relationships to Juvenile Striped Bass Abundance

In Virginia tidal tributaries, water temperatures follow a well-defined pattern of high temperatures in July followed by declining temperatures towards the end of the sampling season in mid September. In 2014, this pattern was slightly altered: water temperatures peaked during July (rounds 1 and 2), and remained above 25^{o}C throughout August (except for four sites; rounds 3 and 4) and into early September (round 5; Table 7). A more traditional temperature pattern occurred in 2009 and 2010 (Machut and Fabrizio 2010, 2011) when temperatures in September were below 25^{o}C. In September 2014 (round 5), only one site exhibited water temperatures below 25^{o}C compared with about 50% of sites in 2010. This slightly altered pattern has now occurred in consecutive years with similar water temperatures observed in 2013. This unusual temperature pattern did not seem to affect catches, however. Catch rates in 2014 followed the historic pattern with respect to water temperature: most fish (99%) were captured at temperatures between 25.0 and 34.9^{o}C (Table 8). Water temperatures in tidal tributaries reflect not only long-term, regional climate patterns, but also significant day-to-day and local variation. Shallow shoreline areas are easily affected by local events such as thunderstorms and small-scale spatial and temporal variations associated with time of sampling (e.g., morning versus afternoon, riparian shading, tidal stage). As noted in previous reports, the relationship between declining catches and decreasing temperature is considered to be largely the result of a coincident downward decline in catch rates and water temperatures as the season

progresses (beyond early August) rather than any direct effect of water temperature on juvenile fish distribution.

In 2014, average salinity at all stations was lower than that observed historically except for J68 (Table 5). As observed in the past, greater catches of young-of-the-year Striped Bass in 2014 were obtained at sites exhibiting low salinities within the primary nursery area (Table 9). No index station exceeded 10.0 ppt salinity, although salinity as high as 15.4 ppt was observed at one auxiliary site in the York River (Table 10). In 2014, the percentage of catch observed in low salinities (0.0 – 4.9 ppt) was similar to that observed historically (98.8% in 2014 vs. 93% all years; Table 9). Conversely, the catch in mid-range salinities (5.0 – 9.9 ppt) was below the historic average (1% in 2014 vs. 6%, all years). Although juvenile Striped Bass were captured at downstream sites with average salinities up to 14 ppt, catches were distinctly lower at such sites compared with catches in lower salinity areas.

Dissolved oxygen (DO) concentrations were lower in 2014 at many sites compared with the historic average (Table 11). Within the nursery area, almost half of the measurements (87 of 190 measurements) exhibited DO levels that were more than one standard error (SE) less than the site's historic average (Table 11). Two sites exhibited low DO levels during 2014 (all occurring in the York River system). Correlations between DO and juvenile Striped Bass catches are difficult to ascertain. Lower-than-average values occurred inconsistently through time and across sampling sites. DO values more than one SE less than the mean at a given station (shaded values in Table 11) do not necessarily correspond with low catches at that station (Table 1).

High seasonal catches at index stations occurred during periods when DO was more than one SE below the historic average and when DO measures were within one SE of the historic average.

Striped Bass recruitment variability may be partially explained by regional climate patterns during winter and spring (Wood 2000). For example, abundance of young Striped Bass has been positively associated with high river flows during the preceding winter (Wingate and Secor 2008). One of the strongest Striped Bass year classes was produced in 2011, which was characterized by above normal precipitation in winter and spring (Machut and Fabrizio 2012). Precipitation in the winter and spring of 2014 (December 2013 - May 2014) was "above normal" in Maryland and Virginia (NCDC 2015). These regional precipitation conditions resulted in our observation that salinities were below the historic averages at most Virginia seine sites (Table 5). However, recruitment of Striped Bass was average in 2014. Clearly, other factors, aside from regional climate patterns, influence variation in recruitment of juvenile Striped Bass.

Additional Abundance Indices Calculated from the Seine Survey

A variety of species are collected by the juvenile Striped Bass seine survey annually due to a sampling regime that spans the euryhaline to freshwater zone. The five most common species encountered in 2014 were White Perch (*Morone americana*), Atlantic Silverside (*Menidia menidia*), Spottail Shiner (*Notropis hudsonius*), Striped Bass (*Morone saxatilis*), and Blueback Herring (*Alosa aestivalis* ; Table 12). In 2014, more than 40,000 individuals comprising 60 species were collected (Table 12).

Several additional indices of abundance derived from seine survey collections are reported for species of management importance to fulfill commonwealth compliance requirements to the ASMFC; these species include American Shad (Watkins et al. 2011) and Atlantic Menhaden (VMRC 2010). Abundance estimates for juvenile American Shad from the seine survey were highly correlated with those from push-net sampling (Wilhite et al. 2003), providing support for the seine survey-based index. Additionally, requests for an index of abundance or raw catch data occur throughout the year on an *ad hoc* basis.

One of the most common species annually captured by the seine survey, White Perch, supports important recreational and commercial fisheries in Chesapeake Bay (Murdy et al. 1997, NMFS 2012). The general overlap in spawning time and use of nursery grounds by White Perch and Striped Bass suggest that the seine survey may adequately sample juvenile White Perch and that calculation of a recruitment index for this species is appropriate. Colvocoresses (1988) found a strong correlation between a young-of-the-year White Perch index (geometric mean) calculated from seine survey data and an index obtained for harvest-sized White Perch from a trawl survey. In years of low abundance (e.g., 1985) the proportion of hauls containing White Perch may be as low as 40%; whereas in years of high abundance (e.g., 2011), White Perch may be found in 95% of hauls. A delta-lognormal index was developed to address this inter-annual variation and to accommodate data with a high proportion of zero hauls. We used Cox's method (Fletcher 2008) to estimate the mean abundance based on the delta-lognormal distribution, and calculated 95% confidence intervals from 1,000 bootstrap samples as

described by Fletcher (2008). This approach remains under development, so we report only the means here.

From July through September 2014, 5,412 young-of-the-year White Perch were collected from 149 sampling stations during five sampling rounds. Because White Perch movement among Virginia tributaries is unlikely (Mulligan and Chapman 1989), we presume each tributary supports a distinct stock and report juvenile abundance for each river separately (Figures 9 - 13). Generally, 2014 river-specific JAIs for White Perch suggest average to above-average recruitment for this species throughout Virginia. Numerically, the highest 2014 JAI values for White Perch were observed in the Pamunkey, James, and Mattaponi rivers. Below average recruitment occurred in the Rappahannock River in 2014, where the index was down 27% from the historic average for this river. At present, development of river-specific indices for White Perch is incomplete. Although we feel confident in the estimation of annual mean relative abundance, alternative approaches for estimating confidence intervals should be examined. The White Perch JAI developed by the seine survey compliments the juvenile White Perch index currently reported by the Juvenile Fish Trawl Survey (Tuckey and Fabrizio 2012); however, unlike the index reported by the trawl survey, the seine survey index is based on catches from tidal brackish and freshwater zones.

Atlantic Croaker (*Micropogonias undulatus*) is another commercially and recreationally important fish (Murdy et al. 1997, NMFS 2012) regularly collected by the seine survey. Young-of-the-year Atlantic Croaker are collected at predominately mesohaline sampling sites during July and early August (rounds 1, 2 and 3) before fish

are able to avoid the net and affect their detection probability (Williams and Fabrizio 2011). Murdy et al. (1997) report peak spawning of Atlantic Croaker from August – October; thus, young-of-the-year fish collected during 2014 were spawned during the fall of 2013. Similar to White Perch, Atlantic Croaker raw catch data exhibit high annual variability in the proportion of non-zero hauls. To address this variation and accommodate data with a high proportion of zero hauls we developed a delta-lognormal index for Atlantic Croaker. Estimation of confidence intervals for the mean of the delta-lognormal distribution remains under development, so only means are reported here.

From July through early August 2014, we encountered at total of 9 young-of-the-year Atlantic Croaker and these fish were observed at only 2 sampling locations. Because Atlantic Croaker are coastal shelf spawners with larval migration into Chesapeake Bay, we report a Virginia-wide estimate of juvenile abundance (Figure 14). An extremely weak year class for Atlantic Croaker appears to have occurred during 2014. Periods of strong recruitment from 1991 – 1995, 1997 – 1998, and 2008 – 2009 correspond with patterns observed by the VIMS Juvenile Fish Trawl Survey (Tuckey and Fabrizio 2012).

Spot (*Leiostomus xanthurus*), like Atlantic Croaker, is another commercially and recreationally important fish that is collected by the seine survey and reported as a Virginia-wide estimate of juvenile abundance (Figure 8). From July through early August 2014, 400 young-of-the-year Spot were collected from 49 sampling locations. A below-average year class for Spot was observed in 2014. The spatial proximity of sites sampled

by the seine and trawl surveys provides a more complete picture of fish distribution in estuarine areas. Near-shore shallow zones are sampled by the seine survey whereas the trawl survey samples adjacent benthic main stem sections. Indices of abundance for common forage species within the tidal near-shore zone have been computed for: Spottail Shiner (*Notropis hudsonius*; Table 13), Atlantic Silverside (*Menidia menidia*; Table 14), Inland Silverside (*Menidia beryllina*; Table 15), and Banded Killifish (*Fundulus diaphanus*; Table 16). The 2014 Spottail Shiner geometric mean of 11.82 (LCI = 9.08, UCI = 15.30) was similar to the historic average (Index = 9.07, LCI = 7.43, UCI = 11.04). The 2014 Atlantic Silverside index of 12.86 (LCI = 7.51, UCI = 21.57) was also similar to the historic average of 10.17 (LCI = 8.10, UCI 12.71; Table 14). The 2014 Inland Silverside abundance index of 5.49 (LCI = 4.04, UCI = 7.35; Table 15) was significantly higher than the historic geometric mean of 1.79 (LCI = 1.41, UCI = 2.23; Table 16). The 2014 Banded Killifish abundance index of 3.05 (LCI = 2.27, UCI = 4.02) was similar to the historic average of 2.02 (LCI = 1.46, UCI = 2.72). Average to above-average indices for all four of these species in 2014 suggest that a robust population of forage fishes was available for commercially and recreationally important piscivores in Virginia waters.

CONCLUSION

The 2014 juvenile abundance index (JAI) for Striped Bass (11.30) was not significantly higher than the historic average (8.56) for Virginia waters. Compared with historic averages, we observed significantly higher recruitment in the Rappahannock and York Rivers (particularly in the Pamunkey River), but average recruitment in the

James River. Continued evaluation of juvenile Striped Bass recruitment is important in predicting recruitment to the commercial and recreational Striped Bass fisheries in the Chesapeake Bay and along the Atlantic coast. A critical characteristic of the long-term annual seine survey conducted in the Chesapeake Bay is the ability to identify years of poor recruitment which, if persistent, serve as an early warning to managers of potential declines in Striped Bass standing stock biomass. Coinciding with Striped Bass, juvenile White Perch abundance indices in 2014 were average to above-average compared with the historic average for this species. Forage fish abundance index values were average or significantly above average in 2014.

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LITERATURE CITED

ASMFC (Atlantic States Marine Fisheries Commission). 2003. Amendment #6 to the Interstate Fishery Management Plan for Atlantic Striped Bass. Fisheries Management Report 41. Atlantic States Marine Fisheries Commission, Washington, D.C. 63 p.

ASMFC (Atlantic States Marine Fisheries Commission). 2010. Addendum II to Amendment #6 to the Interstate Fishery Management Plan: definition of recruitment failure. Atlantic States Marine Fisheries Commission, Washington, D.C. 18 p.

Austin, H.M., J.A. Colvocoresses and T.A. Mosca III. 1993. Develop a Chesapeake Bay-wide young-of-the-year Striped Bass index. Final Report, CBSAC Cooperative Agreement NA16FUO393-01, 59 p. + 2 app.

Colvocoresses, J. A. 1984. Striped Bass research, Virginia. Part I: Juvenile Striped Bass seining program. Annual Report 1987-88. Virginia Institute of Marine Science, Gloucester Point, Virginia.64 p.

Colvocoresses, J. A. 1987. Intercalibration and refinement of estimates of abundance of Chesapeake Bay juvenile Striped Bass.NOAA Tech. Rept. TRS-SAC-91-010, 28 p.

Colvocoresses, J. A. 1988. Comparisons among York River White Perch stock abundance measures. NOAA Tech. Rept. TRS-SAC-91-021, 18 p.

Colvocoresses, J.A. and H.M. Austin. 1987. Development of an index of juvenile Striped Bass abundance for the Chesapeake Bay System: I. An evaluation of present measures and recommendations for future studies. Special Science Report 120. Virginia Institute of Marine Science, Gloucester Point, VA. 108 p.

Fletcher, D. 2008. Confidence intervals for the mean of the delta-lognormal distribution. Environmental and Ecological Statistics 15: 175 – 189.

Goodyear, C. P. 1985. Relationship between reported commercial landings and abundance of young Striped Bass in Chesapeake Bay, Maryland. Transactions of the American Fisheries Society 114: 92 – 96.

Hewitt, A. H., J.K. Ellis and M.C. Fabrizio. 2007. Estimation of juvenile Striped Bass relative abundance in the Virginia portion of Chesapeake Bay. Annual Report 2006.Virginia Institute of Marine Science, Gloucester Point, VA.31 p.

Hewitt, A. H.,L. S. Machut and M.C. Fabrizio. 2008. Estimation of juvenile Striped Bass relative abundance in the Virginia portion of Chesapeake Bay. Annual Report 2007.Virginia Institute of Marine Science, Gloucester Point, VA.28 p.

Machut, L. S., and M.C. Fabrizio. 2010. Estimation of juvenile Striped Bass relative abundance in the Virginia portion of Chesapeake Bay. Annual Report 2009.Virginia Institute of Marine Science, Gloucester Point, VA.45 p.

Machut, L. S., and M.C. Fabrizio. 2011. Estimation of juvenile Striped Bass relative abundance in the Virginia portion of Chesapeake Bay. Annual Report 2010.Virginia Institute of Marine Science, Gloucester Point, VA.47 p.

Machut, L. S., and M.C. Fabrizio. 2012. Estimation of juvenile Striped Bass relative abundance in the Virginia portion of Chesapeake Bay. Annual Report 2011.Virginia Institute of Marine Science, Gloucester Point, VA.55 p.

Mulligan, T. J., and R. W. Chapman. 1989. Mitochondrial DNA analysis of Chesapeake Bay White Perch, *Morone americana*. Copiea 3: 679 – 688.

Murdy, E. O., R. S. Birdsong, and J.A. Musick. 1997. Fishes of Chesapeake Bay. Smithsonian Institution Press, Washington, D. C. 324 p.

NCDC (National Climate Data Center). 2014. http://www.ncdc.noaa.gov/oa/ncdc.html. Site accessed March 2015.

NMFS (National Marine Fisheries Service. 2012. http://www.st.nmfs.noaa.gov/st1/commercial/landings/annuallandings.html. Site accessed March 2012.

Rago, P., D. Stephan, and H. Austin. 1995. ASMFC Special Report 48. Report of the juvenile indices abundance workshop, January 1992, Kent Island, MD. 83 p.

Sokal, R.R. and F.J.Rohlf. 1981. Biometry. W.H. Freeman and Co., San Francisco, CA. 851 p.

Tuckey, T.D., and M.C. Fabrizio. 2012. Estimating relative juvenile abundance of ecologically important finfish in the Virginia portion of Chesapeake Bay. Final Report to the Virginia Marine Resources Commission.

Watkins, B.J. Olney, and R. O'Reilly. 2011. A summary of Virginia's American Shad fisheries in 2010 and results of monitoring and restoration programs: annual compliance report to the Atlantic States Marine Fisheries Commission American Shad Technical Committee, Virginia Institute of Marine Sciences, Gloucester Point, VA.43 pp.

Wilhite, M.L., K. L. Maki, J. M. Hoenig, and J. E. Olney. 2003. Towards validation of a juvenile index of abundance for American Shad in the York River, Virginia. Pages 285 - 294 *in* K. E. Limburg and J. A. Waldman (eds.) Biodiversity Status and Conservation of the World's Shads.American Fisheries Society Symposium 35, Bethesda, MD.

Williams, B. D. and M. C. Fabrizio. 2011. Detectability of estuarine fishes in a beach seine survey of tidal tributaries of lower Chesapeake Bay. Transactions of the American Fisheries Society 140: 1340-1350.

Wingate, R. L., and D. H. Secor. 2008. Effects of winter temperature and flow on a summer-fall nursery fish assemblage in the Chesapeake Bay, Maryland. Transactions of the American Fisheries Society 137: 1147 – 1156.

Wood, R.J. 2000.Synoptic scale climatic forcing of multispecies fish recruitment patterns in Chesapeake Bay. Ph.D. Dissertation.College of William and Mary, Williamsburg, VA.

Woodward, J.R. 2009. Investigating the relationships between recruitment indices and estimates of adult abundance for Striped Bass, Weakfish, and Atlantic Croaker.Mastersthesis.College of William and Mary, Williamsburg, VA.

VMRC (Virginia Marine Resources Commission).2010. Atlantic Menhaden compliance report for Virginia: Report to the Atlantic States Marine Fisheries Commission. Fisheries Management Division, Newport News, VA.16 pp.

Table 1. Catch of young-of-the-year Striped Bass per seine haul in 2014. Two hauls were completed at each index station (bold). Sampling was completed in July (rounds 1 and 2), August (rounds 3 and 4), and September (round 5).

Drainage															Round
JAMES		Station	J12	J22	**J29**	**J36**	J42	**C1**	**C3**	**J46**	J51	**J56**	J62	J68	J78	Total
	Round	1	2	1	8/0	9/7	16	53/30	13/16	2/2	41	12/1	168	0	1	382
		2	5	13	0/1	16/2	30	72/99	3/5	4/13	13	5/5	120	1	1	408
		3	1	13	3/5	0/1	7	29/27	7/1	4/2	20	4/8	10	0	3	145
		4	0	2	0/0	4/0	0	9/6	3/4	0/1	43	10/8	32	0	1	123
		5	0	3	0/0	3/1	3	5/3	2/3	0/1	10	4/0	8	0	1	47
														James Total		**1,105**
YORK		Station	Y15	Y21	Y28	P36	**P42**	**P45**	**P50**	P55						
	Round	1	0	4	3	88	13/28	63/26	35/6	1						267
		2	1	10	7	132	9/12	26/11	23/18	1						250
		3	11	0	18	68	4/8	12/13	4/3	0						141
		4	0	3	53	19	11/0	15/2	8/3	0						114
		5	0	0	39	4	4/3	12/10	5/10	0						87
		Station				**M33**	M37	**M41**	**M44**	**M47**	M52					
	Round	1				49/3	18	26/18	10/3	0/0	1					128
		2				65/10	54	4/2	6/1	2/0	0					144
		3				11/5	8	3/0	3/0	5/0	0					35
		4				2/0	0	2/3	7/5	2/2	0					23
		5				1/0	0	1/2	1/1	0/1	0					7
														York Total		**1,196**
RAPPAHANNOCK		Station	R12	R21	**R28**	**R37**	R41	**R44**	**R50**	**R55**	R60	R65	R69	R76		
	Round	1	0	0	3/0	4/2	15	111/69	36/38	45/9	13	2	1	5		353
		2	0	0	4/1	4/0	0	124/58	96/63	65/13	39	22	3	5		497
		3	0	0	2/1	0/1	3	64/22	32/45	18/58	16	1	1	6		270
		4	0	0	1/1	3/3	4	3/1	27/15	14/9	0	4	1	3		89
		5	0	0	4/2	0/0	1	4/0	7/17	2/3	4	0	0	0		44
														Rappahannock Total		**1,253**
														2014 Catch		**3,554**

Table 2. Catch of young-of-the-year Striped Bass in the primary nursery areas of Virginia (index stations) summarized by year, where x = total fish, Index = $(\exp(\ln(x+1)) - 1) \times 2.28$, SD = Standard Deviation, and SE = Standard Error.

Year	Total Fish (x)	Mean ln (x+1)	SD	Index	C.I. (± 2 SE)	N (hauls)
1967	191	1.18	1.00	5.17	3.20-7.86	42
1968	184	1.04	0.92	4.15	2.68-6.06	50
1969	193	0.97	0.94	3.73	2.39-5.46	55
1970	345	1.39	1.11	6.88	4.52-10.06	56
1971	165	0.90	0.90	3.34	2.17-4.81	60
1972	84	0.45	0.59	1.28	0.87-1.75	90
1973	133	0.60	0.82	1.86	1.12-2.76	70
1980	228	0.74	0.90	2.52	1.68-3.53	89
1981	165	0.52	0.69	1.56	1.10-2.09	116
1982	323	0.78	0.97	2.71	1.85-3.74	106
1983	296	0.91	0.83	3.40	2.53-4.42	102
1984	597	1.09	1.06	4.47	3.22-6.02	106
1985	322	0.72	0.86	2.41	1.78-3.14	142
1986	669	1.12	1.04	4.74	3.62-6.06	144
1987	2191	2.07	1.23	15.74	12.40-19.80	144
1988	1348	1.47	1.13	7.64	6.10-9.45	180
1989	1978	1.78	1.12	11.23	9.15-13.70	180
1990	1249	1.44	1.10	7.34	5.89-9.05	180
1991	667	0.97	0.95	3.76	2.96-4.68	180
1992	1769	1.44	1.24	7.35	5.72-9.31	180
1993	2323	2.19	0.98	18.11	15.35-21.30	180
1994	1510	1.72	1.03	10.48	8.66-12.60	180
1995	926	1.22	1.05	5.45	4.33-6.75	180
1996	3759	2.41	1.23	23.00	18.80-28.10	180
1997	1484	1.63	1.10	9.35	7.59-11.40	180
1998	2084	1.92	1.14	13.25	10.80-16.10	180
1999	442	0.80	0.86	2.80	2.19-3.50	180
2000	2741	2.09	1.24	16.18	13.06-19.92	180
2001	2624	1.98	1.27	14.17	11.33-17.60	180
2002	813	1.01	1.09	3.98	3.05-5.08	180
2003	3406	2.40	1.18	22.89	18.84-27.71	180
2004	1928	1.88	1.04	12.70	10.54-15.22	180
2005	1352	1.61	1.05	9.09	7.45-11.02	180
2006	1408	1.69	1.04	10.10	8.31-12.18	180
2007	1999	1.83	1.18	11.96	9.66-14.70	180
2008	1518	1.50	1.17	7.97	6.33-9.93	180
2009	1408	1.55	1.10	8.42	6.80-10.32	180
2010	1721	1.61	1.25	9.07	7.14-11.40	180
2011	4189	2.56	1.19	27.09	22.30-32.80	178
2012	408	0.78	0.83	2.68	2.10-3.33	179
2013	1620	1.76	1.08	10.94	8.97-13.25	180
2014	2293	1.78	1.26	11.30	8.98-14.09	180
Overall (1967-2013)	52760	1.41	0.55	8.56	6.86-10.26	41 (years)

Table 3. Catch of young-of-the-year Striped Bass in the primary nursery areas of Virginia using only the 1st haul (Rago et al. 1995) summarized by year, Index = $(\exp(\ln(x + 1)) - 1) \times 2.28$, SD = Standard Deviation, and SE = Standard Error.

Year	Total Fish (x)	Mean ln (x+1)	SD	Index	C.I. (± 2 SE)	N (hauls)
1967	191	1.18	1.00	5.17	3.20-7.86	42
1968	184	1.04	0.92	4.15	2.68-6.06	50
1969	193	0.97	0.94	3.73	2.39-5.46	55
1970	345	1.39	1.11	6.88	4.52-10.06	56
1971	165	0.90	0.90	3.34	2.17-4.81	60
1972	84	0.45	0.59	1.28	0.87-1.75	90
1973	133	0.60	0.82	1.86	1.12-2.76	70
1980	216	0.82	0.96	2.90	1.85-4.21	72
1981	112	0.64	0.74	2.05	1.28-2.99	58
1982	172	0.86	0.96	3.10	1.86-4.71	54
1983	185	0.99	0.94	3.86	2.44-5.71	51
1984	377	1.27	1.09	5.81	3.72-8.63	53
1985	216	0.94	0.92	3.54	2.4-4.97	71
1986	449	1.35	1.07	6.53	4.56-9.06	72
1987	1314	2.27	1.22	19.77	14.25-27.13	72
1988	820	1.57	1.21	8.66	6.2-11.85	90
1989	1427	2.06	1.18	15.68	11.71-20.77	90
1990	720	1.58	1.12	8.76	6.44-11.7	90
1991	462	1.17	1.05	5.04	3.59-6.85	90
1992	1143	1.65	1.31	9.63	6.76-13.41	90
1993	1241	2.34	0.89	21.36	17.31-26.25	90
1994	969	1.93	1.09	13.37	10.17-17.4	90
1995	559	1.37	1.07	6.71	4.89-8.99	90
1996	2326	2.60	1.27	28.29	21.11-37.69	90
1997	931	1.83	1.14	11.92	8.9-15.76	90
1998	1365	2.12	1.22	16.66	12.35-22.23	90
1999	274	0.92	0.91	3.43	2.43-4.64	90
2000	1528	2.22	1.23	18.70	13.91-24.9	90
2001	1671	2.16	1.32	17.52	12.7-23.89	90
2002	486	1.17	1.13	5.03	3.48-7.01	90
2003	2042	2.50	1.26	25.61	19.09-34.13	90
2004	1129	2.07	1.04	15.75	12.19-20.19	90
2005	835	1.79	1.07	11.42	8.64-14.9	90
2006	767	1.76	1.06	11.02	8.34-14.36	90
2007	1271	2.09	1.21	16.07	11.95-21.39	90
2008	867	1.70	1.11	10.15	7.56-13.42	90
2009	861	1.72	1.11	10.47	7.81-13.83	90
2010	994	1.75	1.26	10.83	7.78-14.82	90
2011	2397	2.70	1.17	31.69	24.29-41.16	90
2012	265	0.92	0.87	3.47	2.50-4.63	90
2013	877	1.82	1.10	11.85	8.92-15.54	90
2014	1401	2.01	1.24	14.81	10.87-19.93	90
(1967- 2013)	32563	1.54	0.59	10.32	9.14-11.50	41 (years)
(1990-2013)	27381	1.84	0.48	13.53	12.57-14.49	24 (years)

Table 4. Catch of young-of-the-year Striped Bass per seine haul in the primary nursery area in 2014 summarized by drainage and river.

	2014				All Years Combined (1967-2013)			
Drainage River	Total Fish	Index	C.I. (±2 SE)	N (hauls)	Total Fish	Index	C.I. (±2 SE)	N (years)
JAMES	536	8.56	5.80 – 12.26	60	21161	8.96	6.82 – 11.61	41
James	146	4.95	3.14 – 7.36	40	12974	8.17	6.01 – 10.90	41
Chickahominy	390	22.09	12.38 – 38.22	20	8187	11.15	8.38 – 14.64	41
YORK	653	10.30	7.36 – 14.14	70	15411	5.38	4.16 – 6.83	41
Pamunkey	397	19.43	13.21 – 28.13	30	7643	6.04	4.33 – 8.19	41
Mattaponi	256	5.96	3.58 – 9.31	40	7768	4.92	3.91 – 6.09	41
RAPPAHANNOCK	1104	17.54	10.70 – 27.96	50	16188	7.14	5.36 – 9.32	41
Overall	2293	11.30	8.98-14.09	180	52760	8.56	6.86 – 10.26	41

Table 5. Site specific Striped Bass indices and average site salinity during 2014 compared to historic (1967 – 2014) index values with corresponding average salinities (Avg. Sal., ppt). The York drainage includes Pamunkey and Mattaponi rivers. Index stations are indicated by bold font.

Drainage														
JAMES		Station	J12	J22	**J29**	**J36**	J42	**C1**	**C3**	**J46**	J51	**J56**	J62	J68	J77
	1967-2013	Avg. Sal.	14.4	7.8	4.8	2.5	1.6	1.5	1.3	0.6	0.3	0.2	0.2	0.1	0.2
		Index	1.8	14.3	7.2	12.4	13.6	17.2	7.5	19.2	17.4	6.4	11.0	6.3	2.6
	2014	Avg. Sal.	12.9	7.2	3.3	1.4	0.6	0.6	0.6	0.2	0.1	0.1	0.1	0.1	0.1
		Index	2.39	10.0	1.9	5.8	13.7	45.8	10.1	4.3	49.4	10.0	81.5	0.3	3.0
YORK		Station	Y15	Y21	Y28	P36	**P42**	**P45**	**P50**	P55					
	1967-2013	Avg. Sal.	16.6	13.9	10.7	4.2	1.7	0.7	0.4	0.3					
		Index	1.3	1.9	5.8	12.5	4.4	9.1	12.6	4.3					
	2014	Avg. Sal.	14.5	11.7	8.5	3.1	1.1	0.3	0.2	0.1					
		Index	2.0	4.4	35.9	85.0	12.0	32.6	19.2	0.7					
		Station				**M33**	M37	**M41**	**M44**	**M47**	M52				
	1967-2013	Avg. Sal.				4.6	2.4	1.2	0.4	0.3	0.1				
		Index				6.1	8.1	6.8	5.6	4.6	1.4				
	2014	Avg. Sal.				3.8	1.6	0.4	0.1	0.1	0.0				
		Index				11.5	11.9	7.6	6.1	1.8	0.3				
RAPPAHANNOCK		Station	R12	R21	**R28**	**R37**	R41	**R44**	**R50**	**R55**	R60	R65	R69	R75	
	1967-2013	Avg. Sal.	14.2	12.9	10.0	5.4	3.2	2.0	1.0	0.6	0.2	0.2	0.1	0.1	
		Index	0.5	0.7	2.8	3.2	5.7	8.2	13.6	38.9	6.0	4.1	3.0	2.6	
	2014	Avg. Sal.	11.3	10.2	8.4	4.0	1.4	0.8	0.2	0.1	0.0	0.0	0.0	0.0	
		Index	0.0	0.0	3.7	2.7	6.0	38.6	68.9	33.3	17.4	6.2	2.3	6.8	

Table 6. Catch of young-of-the-year Striped Bass in the primary nursery areas of Virginia in 2014 summarized by sampling round and month.

	2014					All Years Combined (1967-2013)				
Month (Round)	N (hauls)	Total Fish	Scaled Mean	C.I. (± 2 SE)	Change From Previous Round	N (years)	Total Fish	Scaled Mean	C.I. (± 2 SE)	Change From Previous Round
July (1st)	36	750	22.38	13.51 – 36.22		41	16329	11.17	8.72 – 14.16	
(2nd)	36	842	20.41	11.93 – 33.95	+12.3%	41	12956	8.30	6.40 – 10.62	-20.7%
Aug. (3rd)	36	405	10.89	6.52 – 17.42	-51.9%	41	9556	6.53	5.05 – 8.30	-26.2%
(4th)	36	184	7.14	4.66 – 10.52	-54.6%	37	8175	6.13	4.69 – 7.88	-14.5%
Sept. (5th)	36	112	4.37	2.76 – 6.49	-39.1%	34	5744	4.95	3.82 – 6.29	-29.7%

Table 7. Water temperature (°C) recorded at seine survey stations in 2014. The York drainage includes the Pamunkey and Mattaponi rivers. Index stations are indicated by bold font. Red colors denote temperatures over 30°C; blue colors denote temperatures below 25°C.

Drainage															
JAMES		Station	J12	J22	**J29**	**J36**	J42	**C1**	**C3**	**J46**	J51	**J56**	J62	J68	J78
	Round	1	30.3	31.4	30.1	26.2	29.1	27.6	27.5	29.6	28.3	27.3	30.3	30.3	29.4
		2	27.8	29.2	30.9	27.9	29.6	28.9	28.5	29.5	27.1	26.2	27.4	28.8	28.6
		3	27.0	25.3	28.0	24.8	25.7	26.1	26.4	26.8	27.4	26.0	28.8	30.3	29.0
		4	26.5	26.9	28.6	24.8	27.5	27.0	26.4	27.5	27.2	26.9	28.4	28.9	28.4
		5	28.5	29.1	27.9	25.5	27.3	26.8	26.4	28.4	26.0	25.3	27.3	28.2	27.5
YORK		Station	Y15	Y21	Y28	P36	**P42**	**P45**	**P50**	P55					
	Round	1	28.3	28.3	26.3	27.8	28.3	29.3	29.3	29.9					
		2	26.8	26.5	26.4	27.5	27.7	28.1	28.3	28.5					
		3	24.8	24.7	24.6	26.2	26.3	27.0	27.0	27.6					
		4	25.9	24.9	24.9	25.7	25.6	26.2	26.9	27.8					
		5	27.4	26.1	25.3	26.4	26.3	26.9	26.9	28.8					
		Station				**M33**	M37	**M41**	**M44**	**M47**	M52				
	Round	1				28.0	28.1	28.7	29.7	31.6	31.5				
		2				27.4	27.3	27.6	28.6	28.8	28.5				
		3				26.5	26.3	26.5	27.0	27.9	27.2				
		4				26.4	26.4	26.4	27.0	27.1	27.4				
		5				27.4	27.7	28.1	28.8	29.8	31.0				
RAPPAHANNOCK		Station	R12	R21	**R28**	**R37**	R41	**R44**	**R50**	**R55**	R60	R65	R69	R76	
	Round	1	31.2	32.3	27.2	28.6	29.1	29.9	27.8	27.9	27.8	28.9	28.9	28.1	
		2	30.0	29.3	27.1	27.4	28.6	28.9	27.8	28.1	28.2	28.6	29.7	28.7	
		3	28.1	28.4	26.2	27.3	27.4	28.5	28.0	28.0	28.5	27.9	28.4	28.2	
		4	27.4	27.2	25.8	26.6	26.5	26.7	26.8	27.3	27.3	27.5	27.9	28.0	
		5	27.5	27.5	24.3	25.4	26.6	27.1	25.8	26.2	26.1	26.1	26.5	26.5	

Table 8. Catch of young-of-the-year Striped Bass per seine haul in the primary nursery areas of Virginia in 2014 summarized by water temperature.

	2014				All Years Combined (1967-2013)			
Temp. (°C)	Total Fish	Scaled Mean	C.I. (± 2 SE)	N (sites)	Total Fish	Scaled Mean	C.I. (± 2 SE)	N (sites)
15.0 - 19.9	N/A			0	54	2.30	0.66 – 4.85	20
20.0 - 24.9	11	2.98	0.61 – 7.28	6	2,653	3.97	3.50 – 4.49	645
25.0 - 29.9	2,273	12.43	9.86 – 15.54	168	40,022	8.59	8.21 – 8.99	4,389
30.0 - 34.9	9	1.41	-0.49 – 5.32	6	9,656	9.62	8.70 – 10.62	931
Overall	2,293	11.30	8.98 – 14.09	180	52,760	8.56	6.86 – 10.26	6,050

Table 9. Catch of young-of-the-year Striped Bass per seine haul in the primary nursery areas of Virginia in 2014 summarized by salinity.

	2014				All Years Combined (1967-2014)			
Salinity (ppt)	Total Fish	Scaled Mean	C.I. (± 2 SE)	N (sites)	Total Fish	Scaled Mean	C.I. (± 2 SE)	N (sites)
0.0 - 4.9	2,265	12.88	10.16 – 16.20	162	49,042	9.28	8.90 – 9.68	5,023
5.0 - 9.9	28	2.72	1.51 – 4.32	18	3,294	4.35	3.88 – 4.85	755
10.0 - 14.9	N/A			0	422	2.16	1.75 – 2.61	244
15.0 - 19.9	N/A			0	2	0.12	0.00 – 0.29	28
Overall	2,293	11.30	8.98 – 14.09	180	52,760	8.56	6.86 – 10.26	6,050

Table 10. Salinity (ppt) recorded at seine survey stations in 2014. The York drainage includes the Pamunkey and Mattaponi rivers. Index stations are indicated by bold font.

Drainage															
JAMES		Station	J12	J22	**J29**	**J36**	J42	**C1**	**C3**	**J46**	J51	**J56**	J62	J68	J78
	Round	1	9.5	4.7	1.8	0.5	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
		2	15.3	6.4	2.7	0.6	0.5	0.3	0.3	0.1	0.1	0.1	0.0	0.1	0.1
		3	10.3	7.6	4.6	0.9	0.5	0.5	0.5	0.1	0.1	0.1	0.2	0.1	0.1
		4	14.6	8.5	5.9	2.9	1.3	1.4	1.3	0.3	0.2	0.1	0.2	0.1	0.2
		5	15.0	8.6	1.5	1.9	0.7	0.9	1.0	0.5	0.2	0.1	0.2	0.1	0.1
YORK		Station	Y15	Y21	Y28	P36	**P42**	**P45**	**P50**	P55					
	Round	1	11.7	8.8	6.1	0.9	0.2	0.1	0.1	0.1					
		2	15.0	12.5	8.4	3.7	0.9	0.2	0.1	0.1					
		3	15.4	12.7	10.1	3.1	1.2	0.3	0.1	0.1					
		4	15.4	11.9	10.2	4.6	1.9	0.5	0.2	0.1					
		5	15.1	12.8	7.9	3.4	1.4	0.6	0.3	0.3					
		Station				**M33**	M37	**M41**	**M44**	**M47**	M52				
	Round	1				1.1	0.2	0.0	0.0	0.0	0.0				
		2				4.0	1.3	0.2	0.1	0.0	0.0				
		3				3.7	1.4	0.3	0.1	0.1	0.0				
		4				5.3	2.6	0.6	0.2	0.1	0.0				
		5				5.0	2.4	0.7	0.3	0.2	0.1				
RAPPAHANNOCK		Station	R12	R21	**R28**	**R37**	R41	**R44**	**R50**	**R55**	R60	R65	R69	R76	
	Round	1	10.9	8.9	5.7	1.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	
		2	13.3	11.3	9.0	3.3	0.8	0.2	0.1	0.0	0.0	0.0	0.0	0.0	
		3	12.7	11.3	8.7	4.3	1.1	0.5	0.1	0.1	0.0	0.0	0.0	0.0	
		4	12.7	11.3	9.7	6.0	2.5	1.5	0.3	0.2	0.1	0.0	0.1	0.1	
		5	6.9	8.4	9.1	4.9	2.5	1.6	0.7	0.3	0.1	0.1	0.1	0.0	

Table 11. Dissolved oxygen concentrations (mg/L) at seine survey stations in 2014. The York drainage includes the Pamunkey and Mattaponi rivers. Blue shaded values are more than one standard error (SE) less than the mean dissolved oxygen concentrations recorded at that station from 1989 to 2013. Yellow shaded values denote particularly low dissolved oxygen values (also more than 1 SE below the long-term mean). Index stations are indicated by bold font.

Drainage															
JAMES		Station	J12	J22	**J29**	**J36**	J42	**C1**	**C3**	**J46**	J51	**J56**	J62	J68	J78
	Round	1	5.9	7.3	6.2	5.7	6.8	6.7	5.3	6.1	6.2	6.2	9.9	6.4	6.0
		2	7.2	7.7	6.6	6.3	7.5	7.4	6.4	6.5	5.7	5.2	6.2	5.5	5.2
		3	6.6	7.6	6.5	6.4	7.9	6.9	6.1	7.7	6.1	6.3	8.0	7.5	6.0
		4	4.4	5.6	6.9	6.0	8.0	6.3	5.8	5.5	5.8	6.1	7.0	6.7	6.5
		5	5.3	6.9	7.4	5.8	8.5	6.4	5.7	7.4	6.3	6.6	8.2	6.5	5.8
YORK		Station	Y15	Y21	Y28	P36	**P42**	**P45**	**P50**	P55					
	Round	1	6.2	5.7	5.8	4.7	5.9	6.2	5.7	7.2					
		2	6.6	4.1	5.0	4.7	4.9	5.0	5.0	5.6					
		3	5.2	5.0	5.0	5.3	6.1	6.4	5.8	6.6					
		4	4.6	3.7	4.4	4.3	5.1	5.2	5.2	8.1					
		5	5.0	4.3	4.8	5.1	5.8	5.9	5.6	11.1					
		Station				**M33**	M37	**M41**	**M44**	**M47**	M52				
	Round	1				4.5	4.6	4.9	4.8	6.6	5.3				
		2				4.3	4.2	4.6	5.3	5.4	5.0				
		3				4.3	4.7	5.2	5.2	7.0	5.8				
		4				4.1	3.9	4.2	4.6	5.0	6.1				
		5				5.1	4.9	4.6	4.8	5.1	6.0				
RAPPAHANNOCK		Station	R12	R21	**R28**	**R37**	R41	**R44**	**R50**	**R55**	R60	R65	R69	R76	
	Round	1	6.6	5.9	5.7	6.0	6.5	6.6	7.0	6.7	7.0	8.3	6.1	5.5	
		2	6.9	5.7	5.1	5.9	7.8	8.0	7.4	6.7	6.7	7.9	8.2	6.3	
		3	6.4	6.3	5.4	6.0	7.4	8.0	6.4	6.3	7.1	5.3	6.4	5.3	
		4	6.7	6.5	5.0	5.0	7.0	6.9	5.5	6.6	4.4	4.8	7.3	7.5	
		5	8.1	6.9	6.5	6.8	7.2	6.6	6.3	6.9	5.3	6.3	6.7	6.3	

Table 12. Species collected during the 2014 seine survey (index and auxiliary stations).

Scientific Name	Common Name	Total Caught
Morone americana	White Perch	8,359
Menidia menidia	Atlantic Silverside	6,194
Notropis hudsonius	Spottail Shiner	4,214
Morone saxatilis	Striped Bass	3,573
Alosa aestivalis	Blueback Herring	3,522
Menidia beryllina	Inland Silverside	2,670
Trinectes maculatus	Hogchoker	2,376
Fundulus heteroclitus	Mummichog	2,180
Brevoortia tyrannus	Atlantic Menhaden	1,423
Anchoa mitchilli	Bay Anchovy	1,070
Fundulus diaphanus	Banded Killifish	962
Alosa sapidissima	American Shad	793
Leiostomus xanthurus	Spot	400
Dorosoma cepedianum	Gizzard Shad	371
Notropis analostanus	Satinfin Shiner	346
Hybognathus regius	Eastern Silvery Minnow	333
Ictalurus furcatus	Blue Catfish	288
Fundulus majalis	Striped Killifish	258
Etheostoma olmstedi	Tessellated Darter	233
Cynoscion regalis	Weakfish	121
Menticirrhus americanus	Southern Kingfish	84
Perca flavescens	Yellow Perch	75
Bairdiella chrysoura	Silver Perch	62
Alosa pseudoharengus	Alewife	61
Anchoa hepsetus	Striped Anchovy	49
Lepomis gibbosus	Pumpkinseed	48
Membras martinica	Rough Silverside	41
Strongylura marina	Atlantic Needlefish	40
Dorosoma petenense	Threadfin Shad	36
Enneacanthus gloriosus	Bluespotted Sunfish	26
Ictalurus punctatus	Channel Catfish	22
Lepomis auritus	Redbreast Sunfish	21
Lepomis macrochirus	Bluegill	20
Anguilla rostrata	American Eel	18
Pomatomus saltatrix	Bluefish	18
Micropterus punctulatus	Spotted Bass	17
Gambusia affinis	Mosquitofish	16

Table 12. (cont'd.)

Scientific Name	Common Name	Total Caught
Hemiramphus brasiliensis	Ballyhoo	15
Ictalurus catus	White Catfish	14
Micropogonias undulatus	Atlantic Croaker	11
Notropis bifrenatus	Bridle Shiner	11
Notemigonus crysoleucas	Golden Shiner	10
Micropterus salmoides	Largemouth Bass	8
Mugil curema	White Mullet	8
Ictalurus nebulosus	Brown Bullhead	7
Alosa mediocris	Hickory Shad	7
Symphurus plagiusa	Blackcheek Tonguefish	7
Mugil cephalus	Striped Mullet	6
Lepisosteus osseus	Longnose Gar	5
Paralichthys dentatus	Summer Flounder	5
Menticirrhus saxatilis	Northern Kingfish	5
Syngnathus fuscus	Northern Pipefish	3
Cynoscion nebulosus	Spotted Seatrout	3
Pomoxis nigromaculatus	Black Crappie	2
Lepomis microlophus	Redear Sunfish	2
Moxostoma macrolepidotum	Shorthead Redhorse	1
Cyprinodon variegatus	Sheepshead minnow	1
Hypentelium nigricans	Northern Hog Sucker	1
Rhinoptera bonasus	Cownose Ray	1
Sphoeroides maculatus	Northern Puffer	1
	Total	40,576

Table 13. Preliminary catch of Spottail Shiner from select juvenile Striped Bass seine survey stations using only the 1st haul (Rago et al. 1995) summarized by year, where x = total fish, Index = $(\exp(\ln(x + 1)) - 1)$, SD = Standard Deviation, and SE = Standard Error.

Year	Total Fish (x)	Mean ln (x+1)	SD	Index	C.I. (± 2 SE)	N (hauls)
1989	2940	2.64	1.15	12.99	10.34-16.25	121
1990	2068	2.12	1.30	7.35	5.62-9.54	124
1991	1429	1.87	1.24	5.49	4.17-7.14	119
1992	2357	2.02	1.40	6.50	4.83-8.65	123
1993	1713	1.96	1.27	6.13	4.65-8.01	118
1994	2498	2.29	1.34	8.91	6.77-11.66	120
1995	2216	2.10	1.36	7.16	5.37-9.46	120
1996	2280	2.28	1.27	8.74	6.72-11.29	119
1997	3605	2.17	1.53	7.77	5.67-10.53	125
1998	2092	2.12	1.32	7.36	5.53-9.72	114
1999	1252	1.48	1.30	3.38	2.48-4.52	126
2000	4882	2.73	1.43	14.39	10.92-18.86	125
2001	2848	2.39	1.33	9.92	7.64-12.82	128
2002	1541	1.30	1.40	2.67	1.86-3.70	128
2003	2972	2.42	1.40	10.21	7.76-13.34	129
2004	5113	3.25	1.13	24.72	19.98-30.54	123
2005	3585	2.63	1.40	12.85	9.71-16.91	119
2006	3451	2.47	1.51	10.85	7.96-14.68	117
2007	3823	2.58	1.47	12.22	9.09-16.33	118
2008	2152	1.97	1.46	6.16	4.51-8.31	124
2009	3033	2.21	1.54	8.10	5.89-11.02	122
2010	3983	2.38	1.54	9.79	7.16-13.26	121
2011	6194	3.20	1.41	23.50	17.84-30.85	117
2012	3997	2.40	1.58	10.03	7.27-13.71	121
2013	4502	2.77	1.38	14.98	11.49-19.44	125
2014	3343	2.55	1.35	11.82	9.08-15.30	126
Overall (1989-2013)	76,526	2.31	0.45	9.07	7.43-11.04	25 (years)

Table 14.Preliminary catch of Atlantic Silverside from select juvenile Striped Bass seine survey stations using only the 1st haul (Rago et al. 1995) summarized by year, where x = total fish, Index = $(\exp(\ln(x + 1)) - 1)$, SD = Standard Deviation, and SE = Standard Error.

Year	Total Fish (x)	Mean ln (x+1)	SD	Index	C.I. (± 2 SE)	N (hauls)
1989	881	1.49	1.57	3.42	1.93-5.68	58
1990	1430	1.47	1.46	3.33	1.97-5.31	60
1991	2532	2.53	1.71	11.51	6.89-18.84	55
1992	5564	2.88	2.08	16.79	9.39-29.45	60
1993	2166	2.21	1.80	8.12	4.71-13.56	59
1994	2174	1.98	1.73	6.26	3.64-10.35	60
1995	2701	2.43	1.81	10.39	6.11-17.26	59
1996	4666	2.50	2.17	11.24	5.96-20.52	59
1997	973	1.83	1.48	5.26	3.24-8.23	58
1998	2182	2.61	1.60	12.64	8.02-19.64	60
1999	6227	3.37	1.50	28.03	18.49-42.23	57
2000	2936	2.83	1.72	15.99	9.81-25.71	58
2001	3487	2.92	1.69	17.48	11.02-27.41	62
2002	4582	3.48	1.53	31.38	20.82-47.04	60
2003	3470	2.16	2.15	7.63	3.95-14.04	60
2004	1473	1.76	1.79	4.78	2.64-8.19	60
2005	1843	2.48	1.50	10.97	7.18-16.52	62
2006	2613	2.56	1.68	11.96	7.52-18.72	64
2007	2021	2.68	1.51	13.61	8.84-20.70	58
2008	3107	2.04	1.78	6.71	3.93-11.06	63
2009	2618	2.76	1.68	14.80	9.35-23.13	63
2010	1347	2.38	1.26	9.78	6.87-13.78	64
2011	2953	2.63	1.80	12.94	7.87-20.92	63
2012	1079	1.86	1.46	5.42	3.43-8.31	62
2013	5745	2.50	2.14	11.17	6.12-19.79	64
2014	4244	2.63	1.95	12.86	7.51-21.57	64
Overall (1989-2013)	70,770	2.41	0.51	10.17	8.10-12.71	25 (years)

Table 15. Preliminary catch of Inland Silverside from select juvenile Striped Bass seine survey stations using only the 1st haul (Rago et al. 1995) summarized by year, where x = total fish, Index = $(\exp(\ln(x + 1)) - 1)$, SD = Standard Deviation, and SE = Standard Error.

Year	Total Fish (x)	Mean ln (x+1)	SD	Index	C.I. (± 2 SE)	N (hauls)
1989	471	1.15	0.96	2.17	1.63-2.81	107
1990	574	1.09	1.14	1.97	1.39-2.70	110
1991	285	0.86	0.87	1.37	1.00-1.81	105
1992	326	0.67	0.90	0.96	0.65-1.33	110
1993	368	0.76	0.97	1.14	0.77-1.59	106
1994	166	0.53	0.76	0.70	0.46-0.97	106
1995	104	0.44	0.62	0.56	0.38-0.75	107
1996	772	0.82	1.13	1.27	0.83-1.83	107
1997	175	0.54	0.76	0.71	0.48-0.98	110
1998	204	0.69	0.80	0.99	0.70-1.33	104
1999	298	0.72	0.93	1.06	0.73-1.45	113
2000	718	1.06	1.19	1.89	1.31-2.62	113
2001	626	0.96	1.15	1.61	1.10-2.24	115
2002	447	0.78	1.04	1.18	0.80-1.66	114
2003	545	1.21	0.99	2.37	1.80-3.06	113
2004	753	1.23	1.17	2.44	1.75-3.29	113
2005	368	0.93	0.94	1.53	1.11-2.03	110
2006	1161	1.32	1.32	2.73	1.90-3.79	112
2007	807	1.06	1.20	1.88	1.29-2.62	111
2008	658	1.15	1.11	2.14	1.56-2.87	114
2009	1691	1.88	1.29	5.56	4.16-7.35	114
2010	908	1.19	1.30	2.29	1.57-3.21	111
2011	1334	1.32	1.27	2.76	1.95-3.79	110
2012	901	1.45	1.10	3.26	2.49-4.25	113
2013	1608	1.82	1.34	5.15	3.79-6.89	115
2014	1793	1.87	1.36	5.49	4.04-7.35	116
Overall (1989-2014)	16,268	1.03	0.37	1.79	1.41-2.23	25 (years)

Table 16. Preliminary catch of Banded Killifish from select juvenile Striped Bass seine survey stations using only the 1st haul (Rago et al. 1995) summarized by year, where x = total fish, Index = $(\exp(\ln(x + 1)) - 1)$, SD = Standard Deviation, and SE = Standard Error.

Year	Total Fish (x)	Mean ln (x+1)	SD	Index	C.I. (± 2 SE)	N (hauls)
1989	231	0.56	0.82	0.75	0.49 - 1.05	106
1990	235	0.65	0.88	0.92	0.63 - 1.28	109
1991	247	0.59	0.93	0.80	0.50 - 1.16	104
1992	153	0.46	0.77	0.59	0.37 - 0.84	108
1993	258	0.59	0.95	0.80	0.49 - 1.17	103
1994	200	0.53	0.84	0.70	0.44 - 1.01	105
1995	287	0.66	1.01	0.93	0.59 - 1.35	105
1996	600	1.14	1.20	2.12	1.46 - 2.94	104
1997	365	0.88	1.00	1.41	0.99 - 1.92	110
1998	304	0.92	0.94	1.52	1.07 - 2.05	95
1999	335	0.79	1.01	1.20	0.81 - 1.68	107
2000	312	0.81	0.95	1.24	0.86 - 1.69	105
2001	374	0.99	0.95	1.68	1.23 - 2.22	108
2002	478	0.82	1.12	1.26	0.83 - 1.80	109
2003	841	1.16	1.24	2.18	1.50 - 3.03	109
2004	1388	1.79	1.31	5.00	3.63 - 6.77	103
2005	721	1.29	1.22	2.64	1.86 - 3.65	100
2006	498	0.93	1.18	1.53	0.99 - 2.21	97
2007	677	1.32	1.18	2.73	1.94 - 3.74	98
2008	1017	1.62	1.19	4.05	3.00 - 5.37	105
2009	1202	1.74	1.29	4.72	3.43 - 6.39	102
2010	1927	2.15	1.37	7.63	5.57 - 10.34	101
2011	1920	1.95	1.95	6.00	4.25-8.32	97
2012	1831	2.11	1.33	7.22	5.32-9.70	102
2013	653	1.24	1.19	2.45	1.74-3.36	105
2014	684	1.40	1.10	3.05	2.27-4.02	105
Overall (1989-2013)	17,054	1.11	0.52	2.02	1.46-2.72	25 (years)

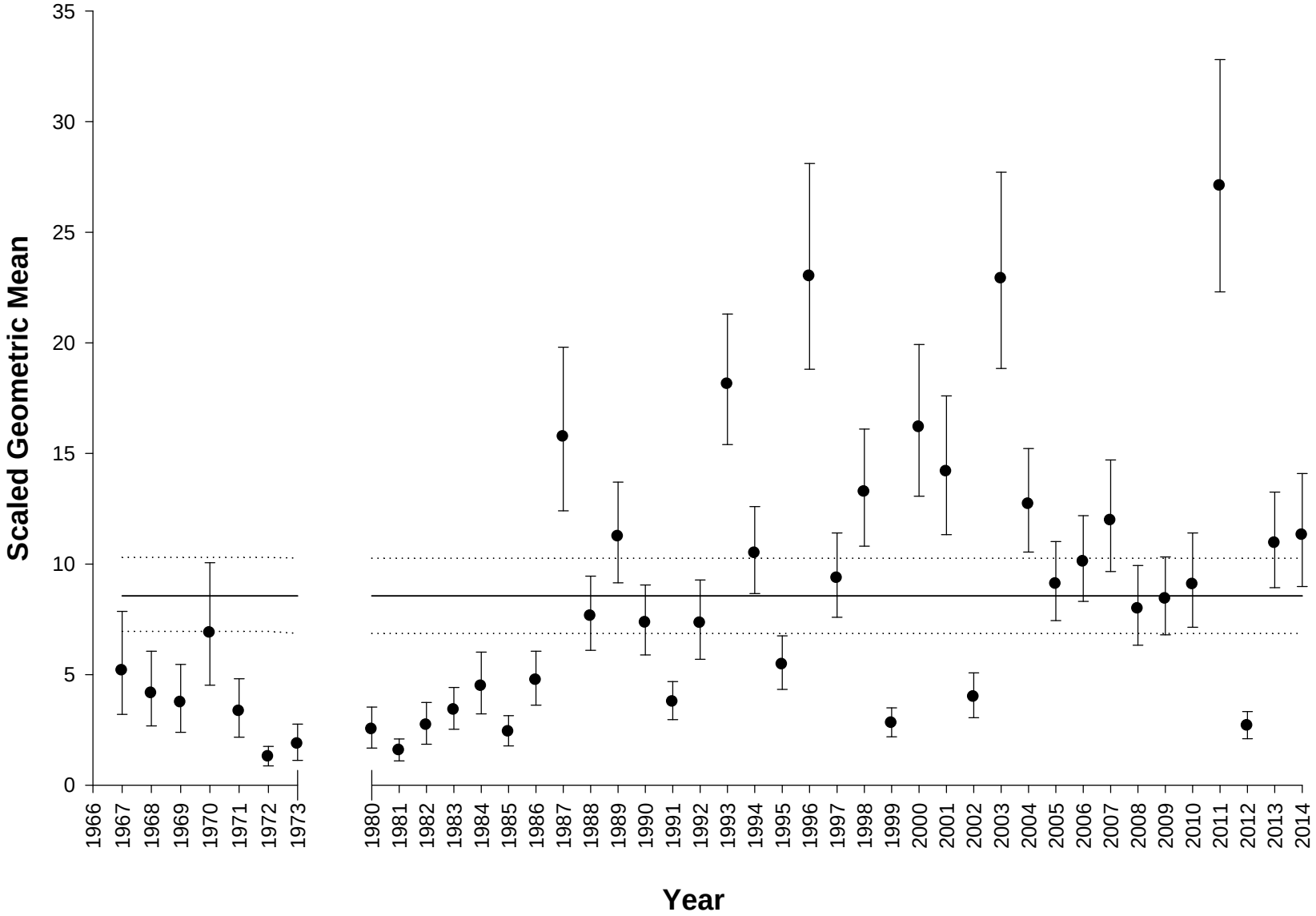

Figure 2. Scaled geometric mean of young-of-the-year Striped Bass in the primary nursery areas of Virginia (index stations) by year. Vertical bars are 95% confidence intervals as estimated by ± 2 standard errors of the mean. Horizontal lines indicate the historical arithmetic mean (solid) and confidence intervals (dotted) for 1967-2013.

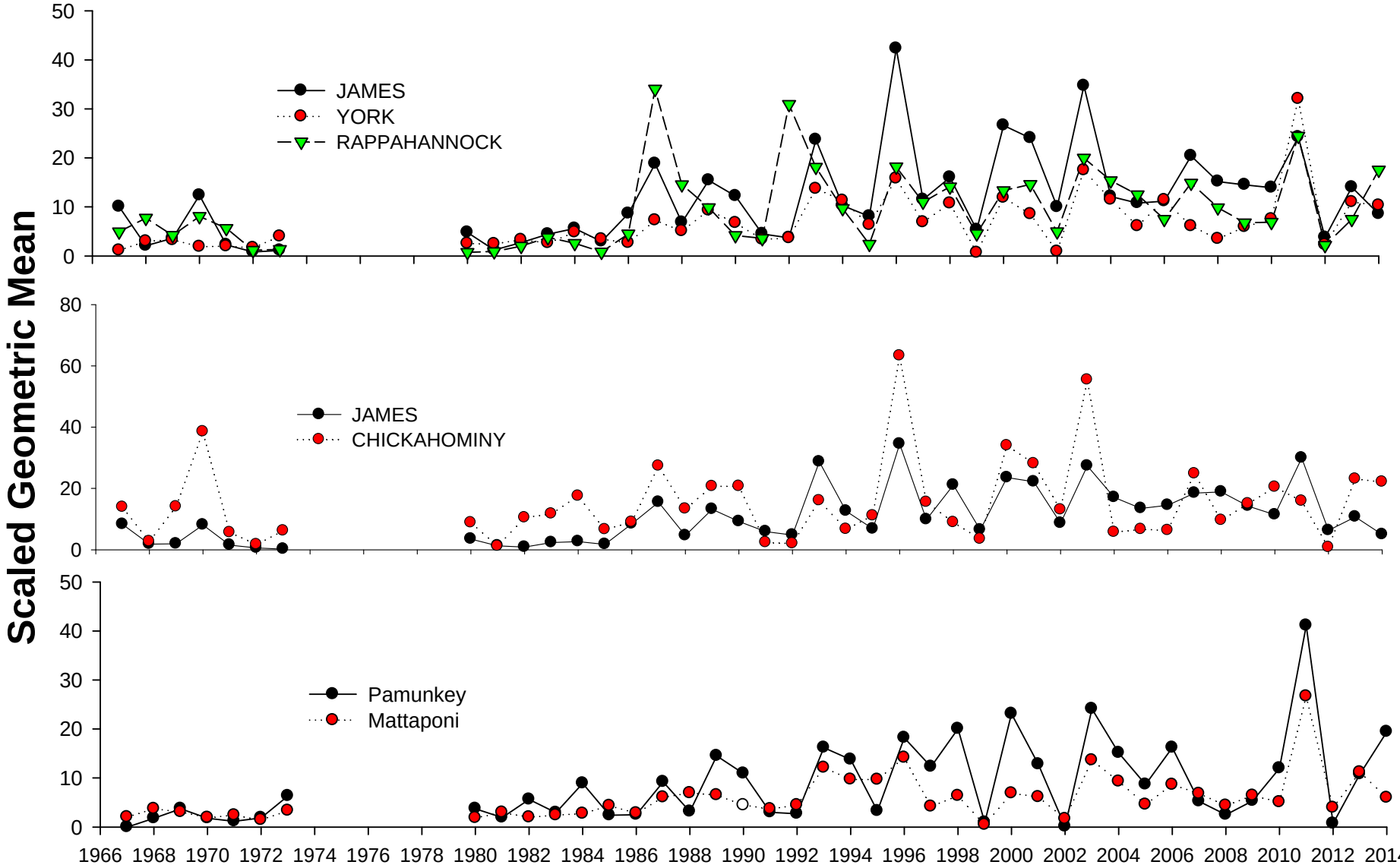

Figure 3. Scaled geometric mean of young-of-the-year Striped Bass in the primary nursery areas of Virginia (index stations) by drainage and river.

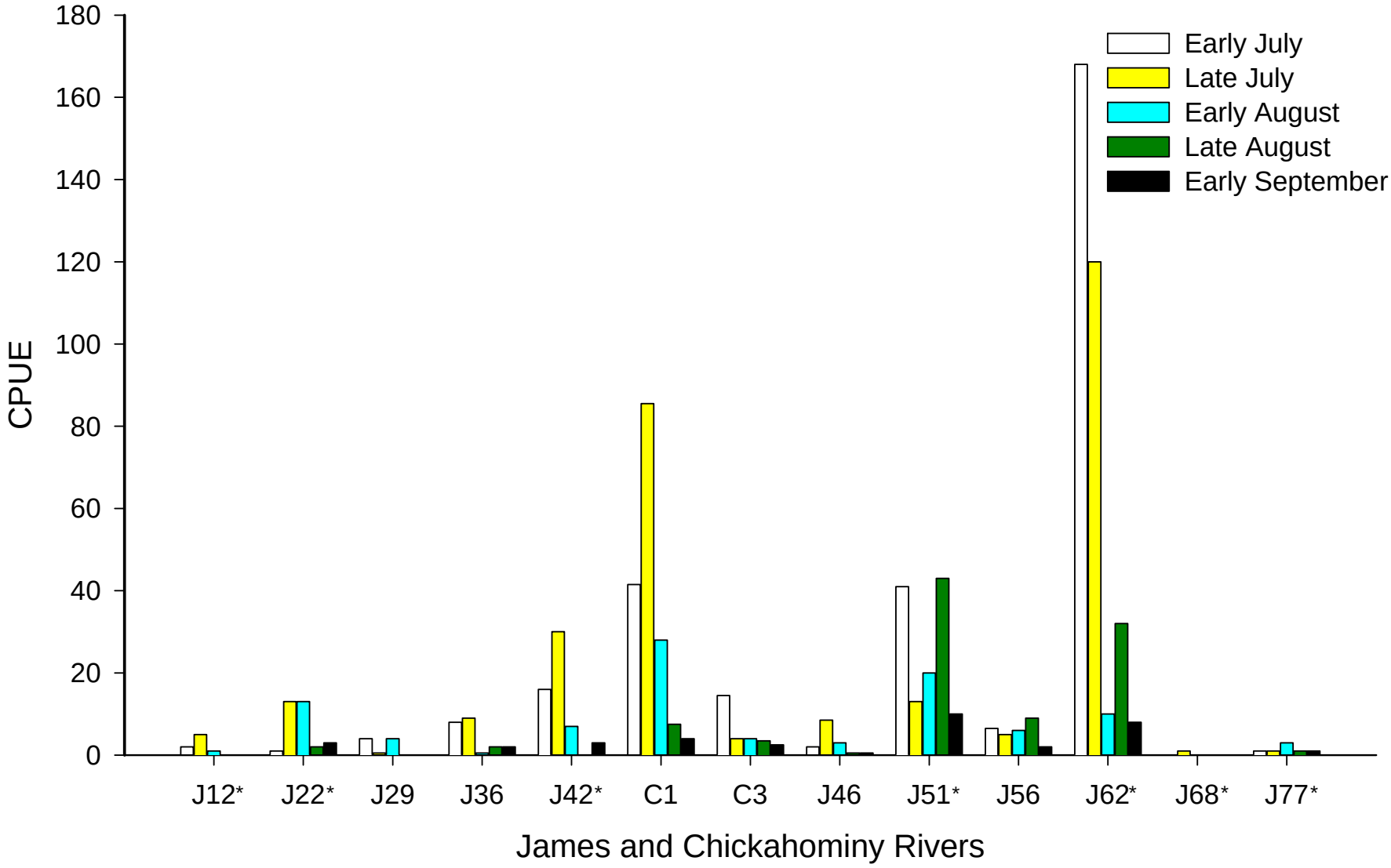

Figure 4. Catch of young-of-the-year Striped Bass by station in the James River drainage in 2014. Index station catch represents an average of two hauls; auxiliary station (starred) catch represents one haul. Hauls were completed at all stations during all rounds in 2014.

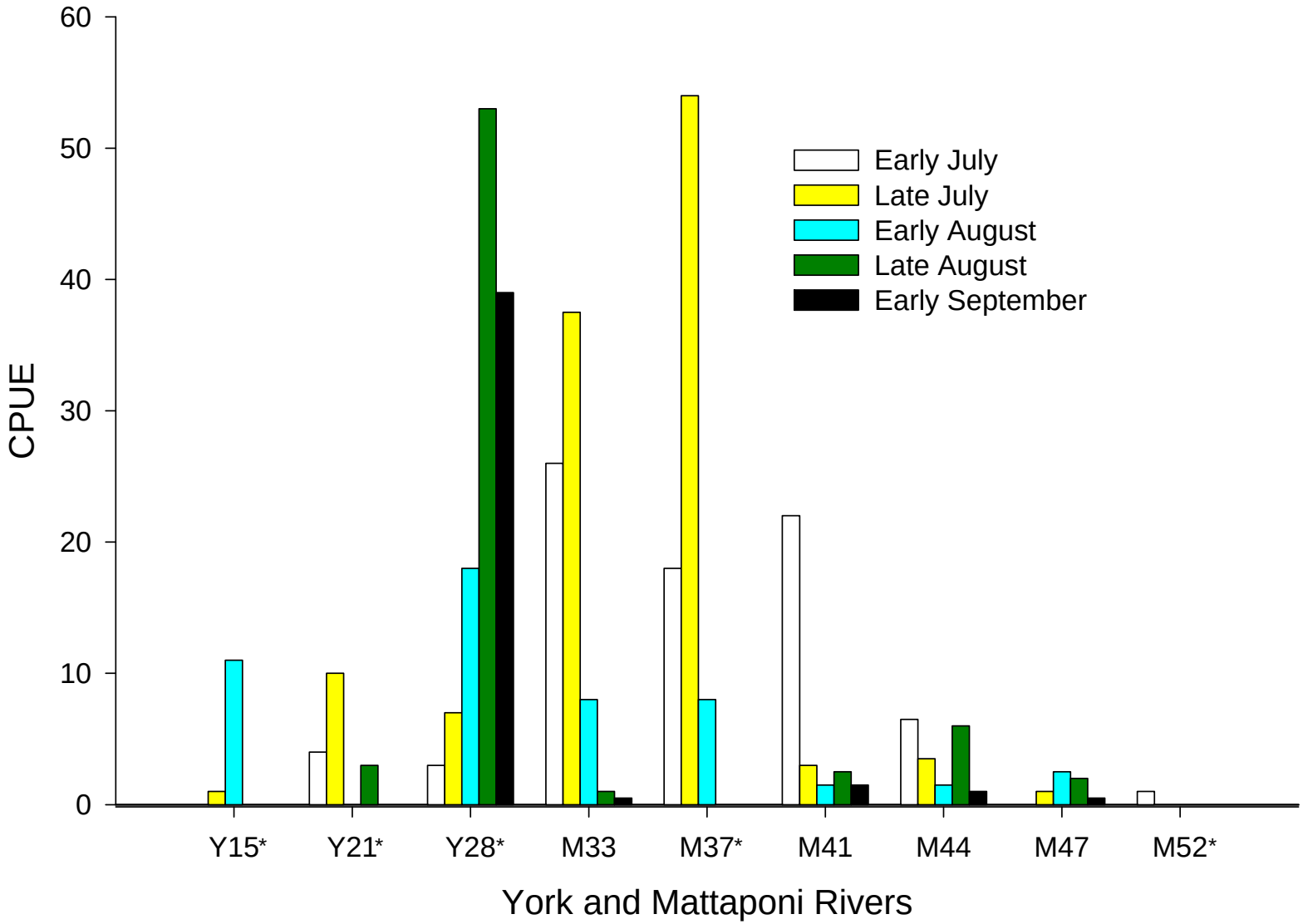

Figure 5. Catch of young-of-the-year Striped Bass by station in the York and Mattaponi rivers in 2014. Index station catch represents an average of two hauls; auxiliary station (starred) catch represents one haul. Hauls were completed at all stations during all rounds in 2014.

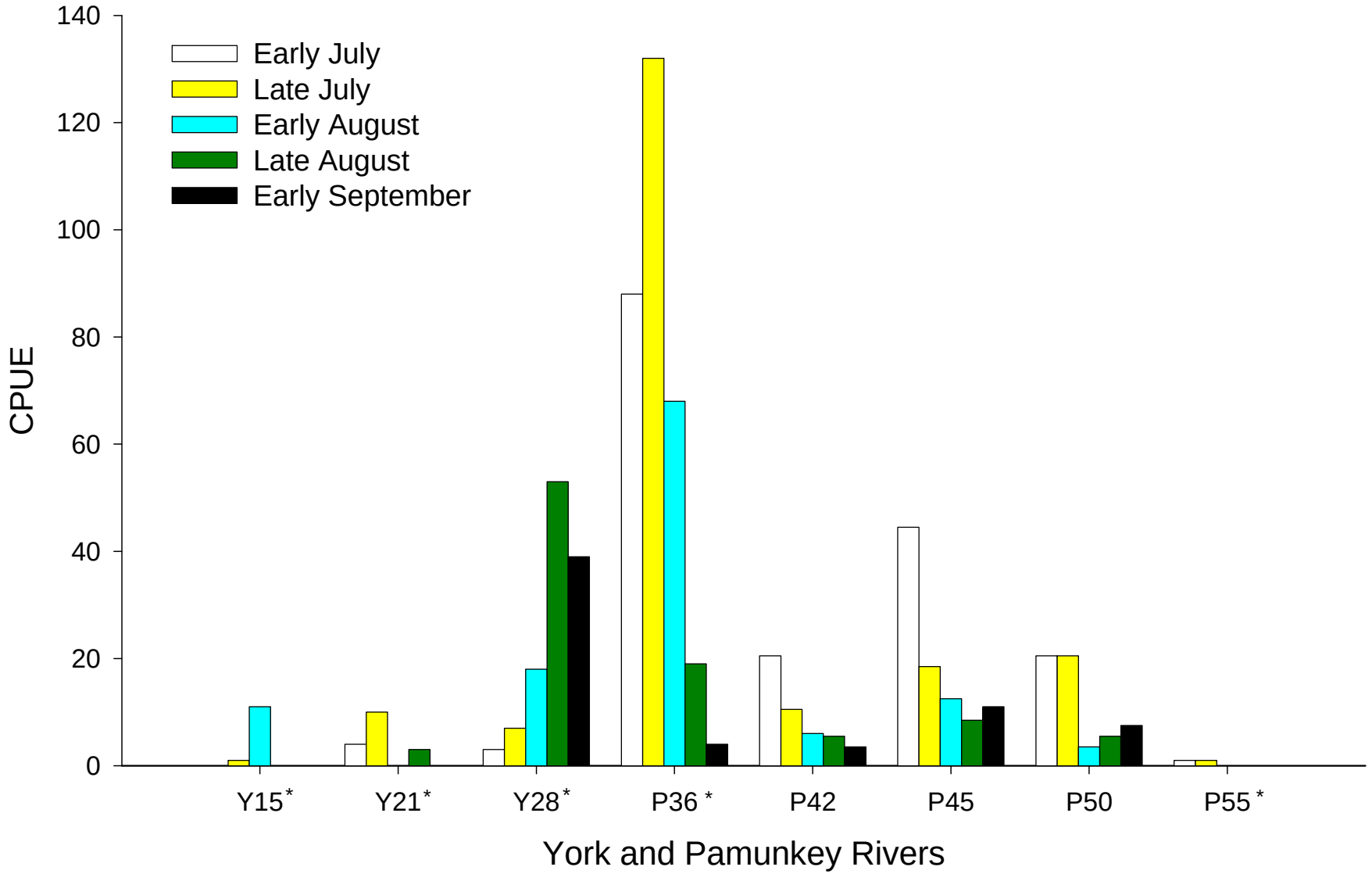

Figure 6. Catch of young-of-the-year Striped Bass by station in the York and Pamunkey rivers in 2014. Index station catch represents an average of two hauls; auxiliary station (starred) catch represents one haul. Hauls were completed at all stations during all rounds in 2014.

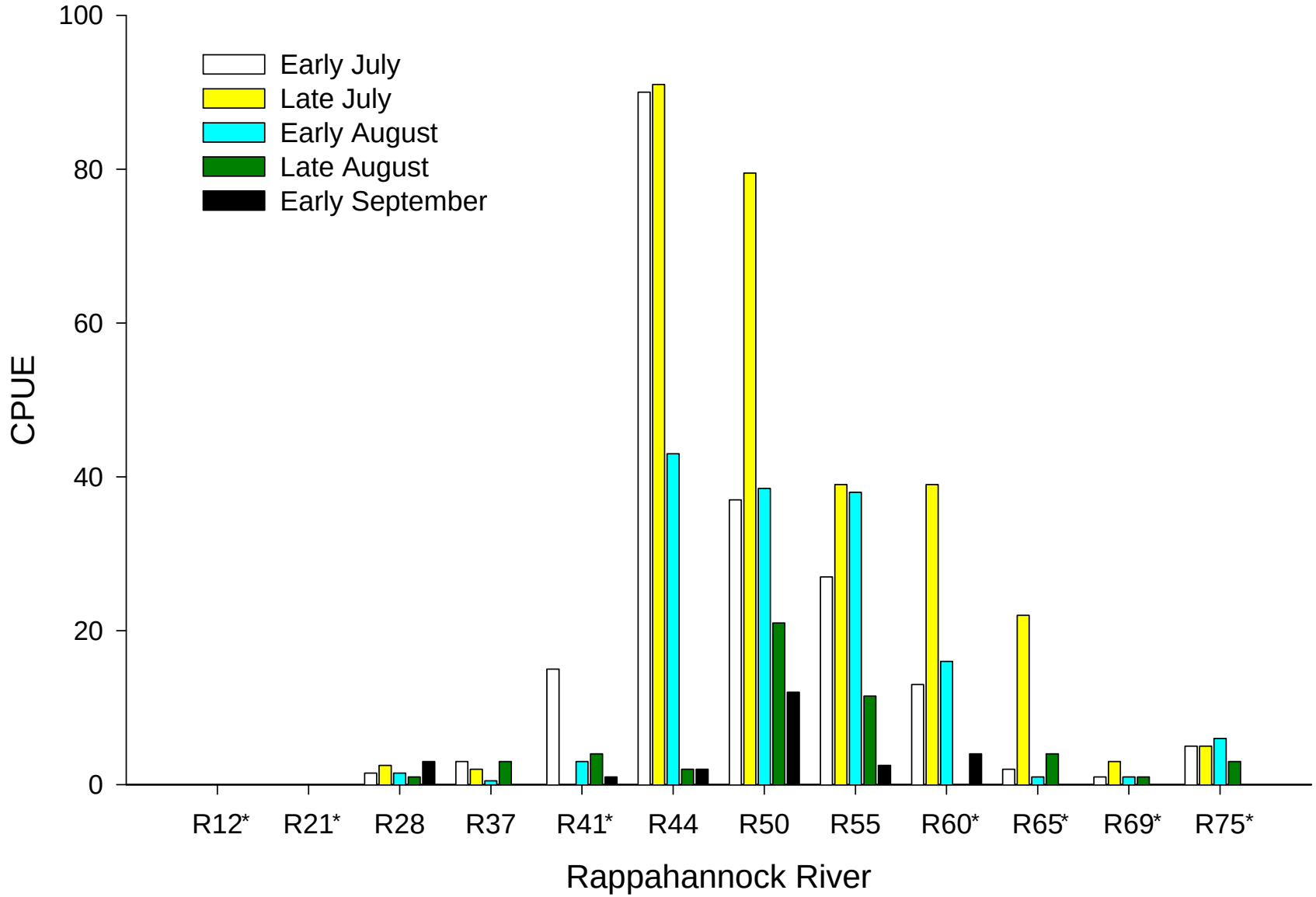

Figure 7. Catch of young-of-the-year Striped Bass by station in the Rappahannock River in 2014. Index station catch represents an average of two hauls; auxiliary station (starred) catch represents one haul. Hauls were completed at all stations during all rounds in 2014.

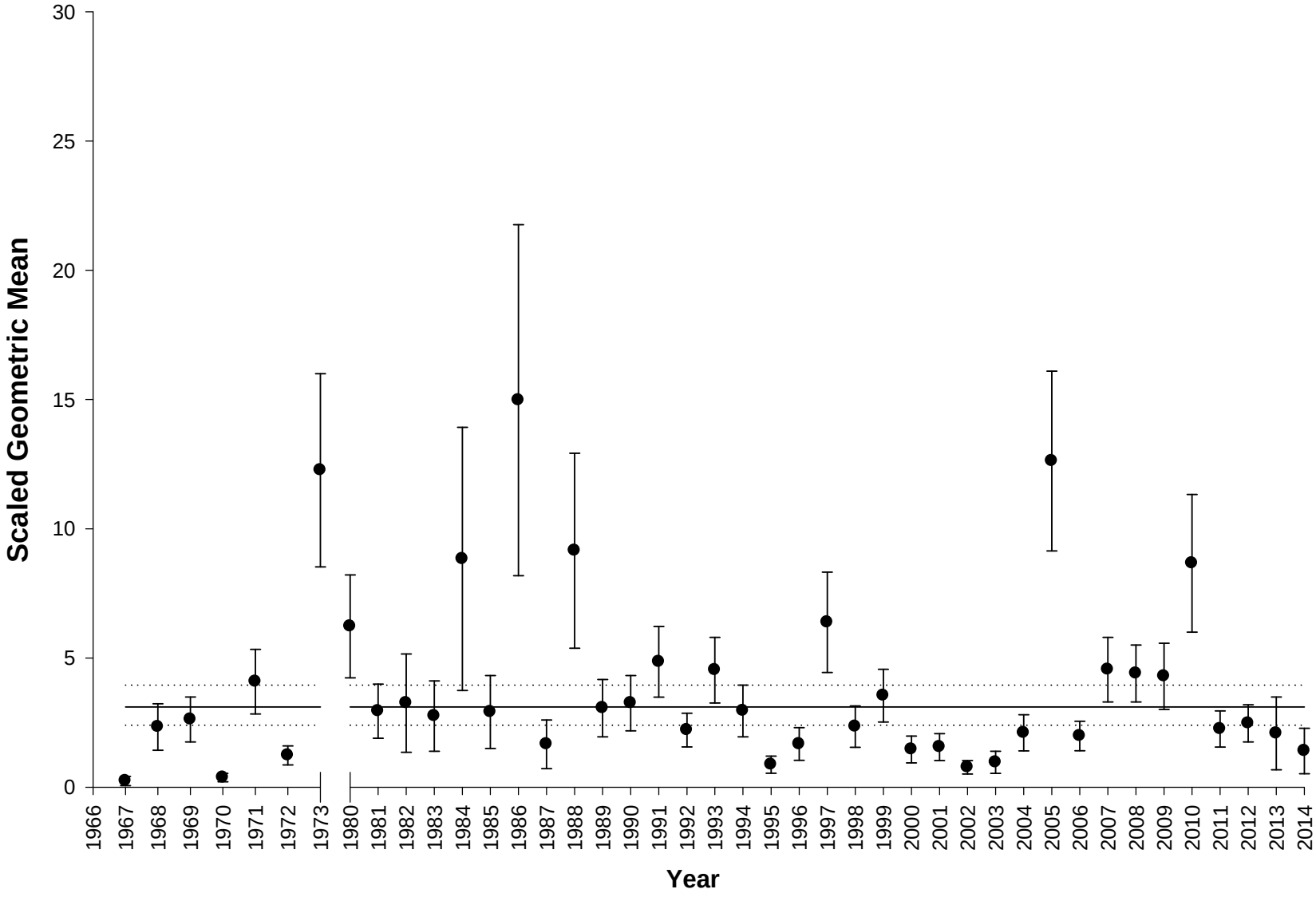

Figure 8. Scaled geometric mean of young-of-the-year Spot by year from select seine survey stations in Virginia tributaries of Chesapeake Bay. The vertical bars are 95% confidence intervals as estimated by 2 standard errors of the mean. Horizontal lines indicate the historical geometric mean (solid) and confidence intervals (dotted) for 1967-2013

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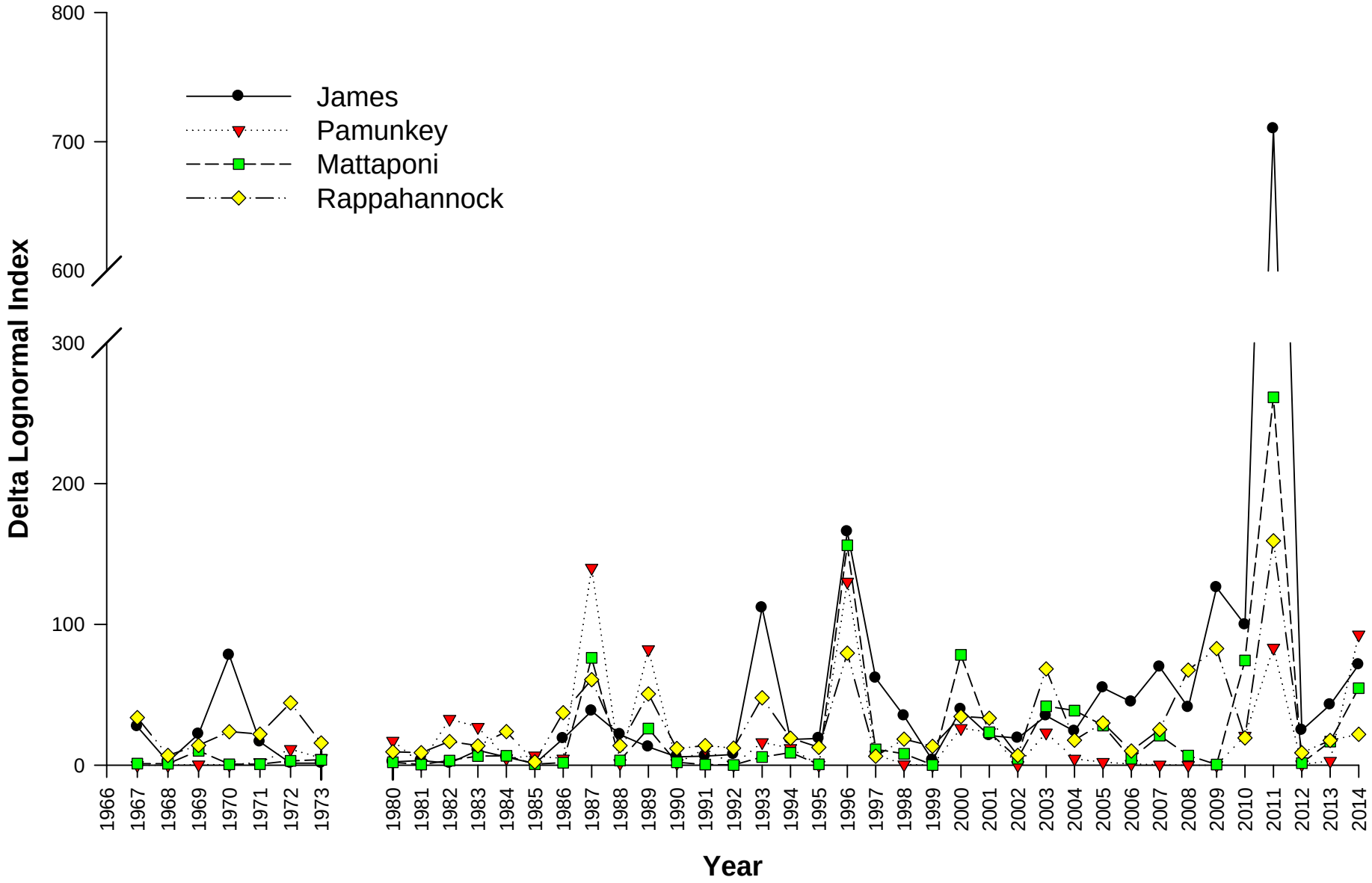

Figure 9. Delta-lognormal mean of young-of-the-year White Perch from select seine survey stations by river and year.

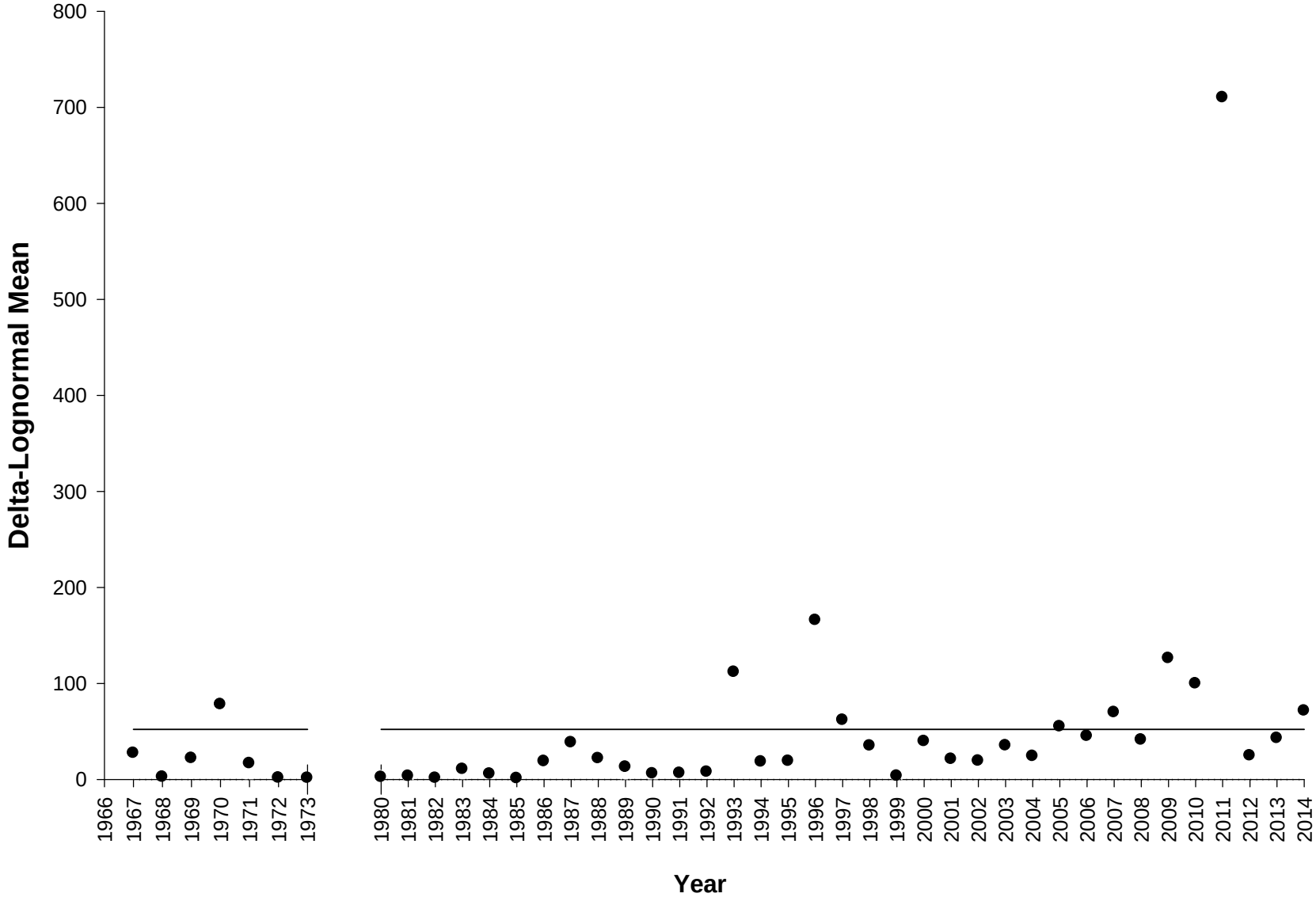

Figure 10. Delta-lognormal mean of young-of-the-year White Perch from the James River nursery area by year. The horizontal line indicates the historical mean for 1967-2013.

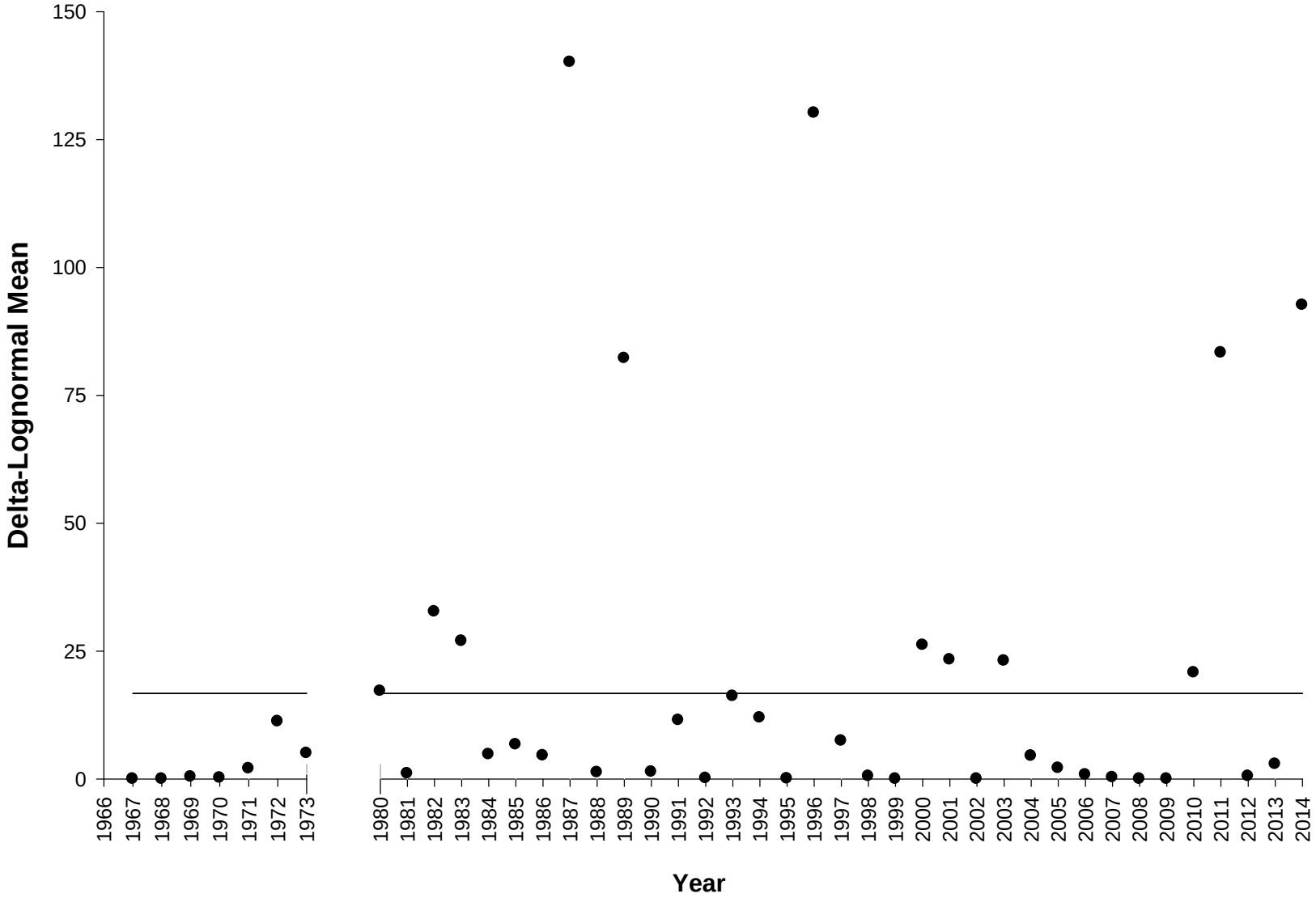

Figure 11. Delta-lognormal mean of young-of-the-year White Perch from the Pamunkey River nursery area by year. The horizontal line indicates the historical mean for 1967-2013.

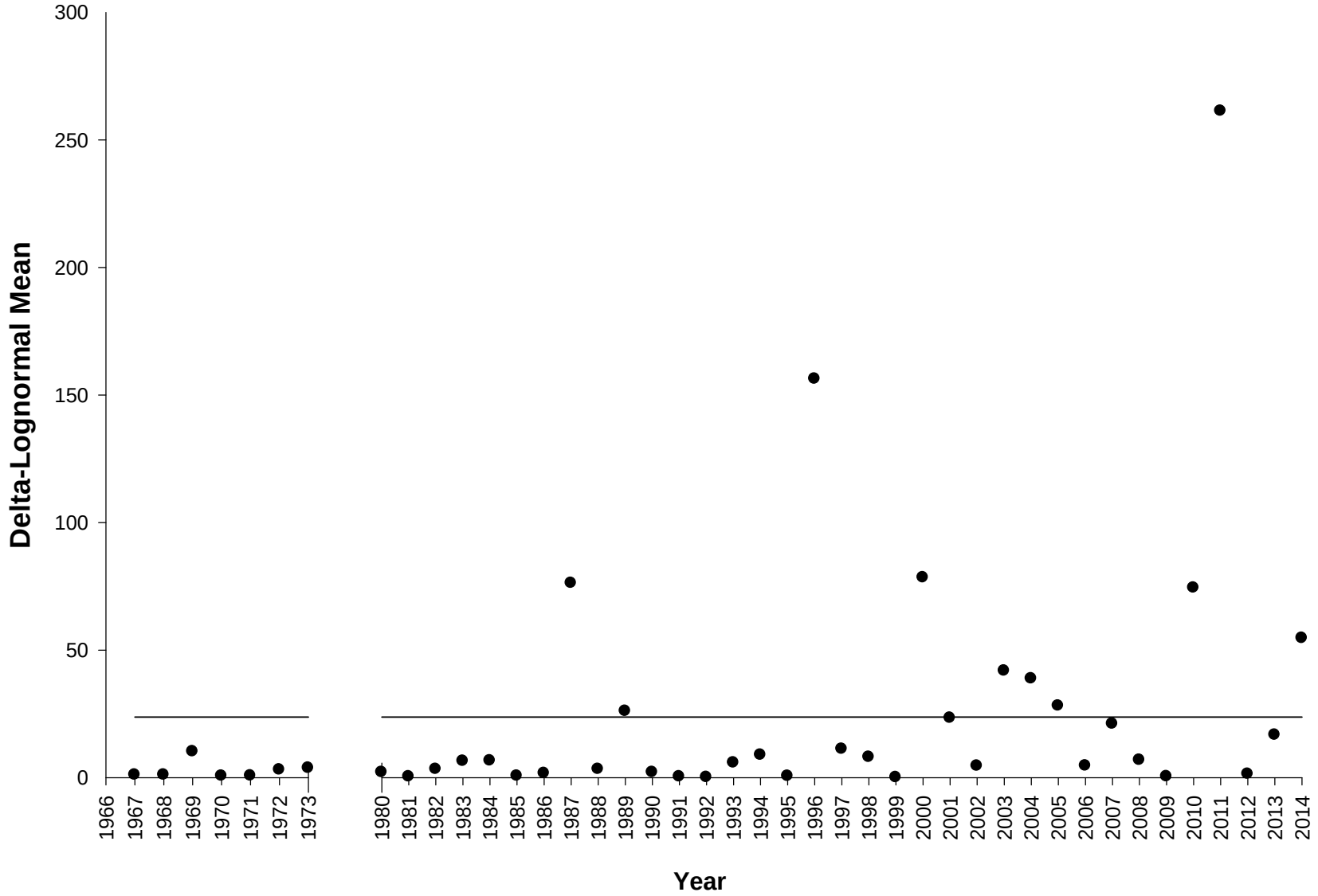

Figure 12. Delta-lognormal mean of young-of-the-year White Perch from the Mattaponi River nursery area by year. The horizontal line indicates the historical mean for 1967-2013

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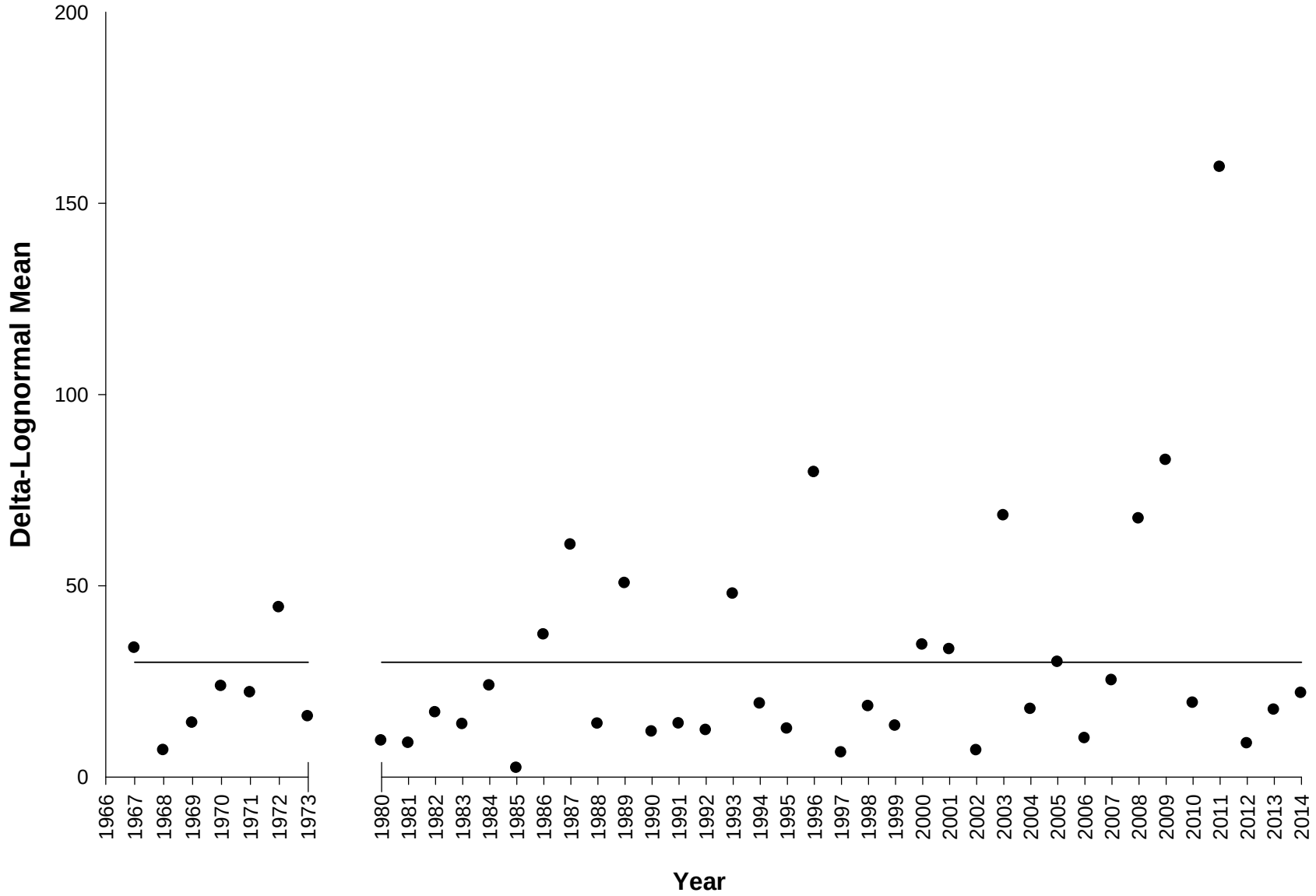

Figure 13. Delta-lognormal mean of young-of-the-year White Perch from the Rappahannock River nursery area by year. The horizontal line indicates the historical mean for 1967-2013.

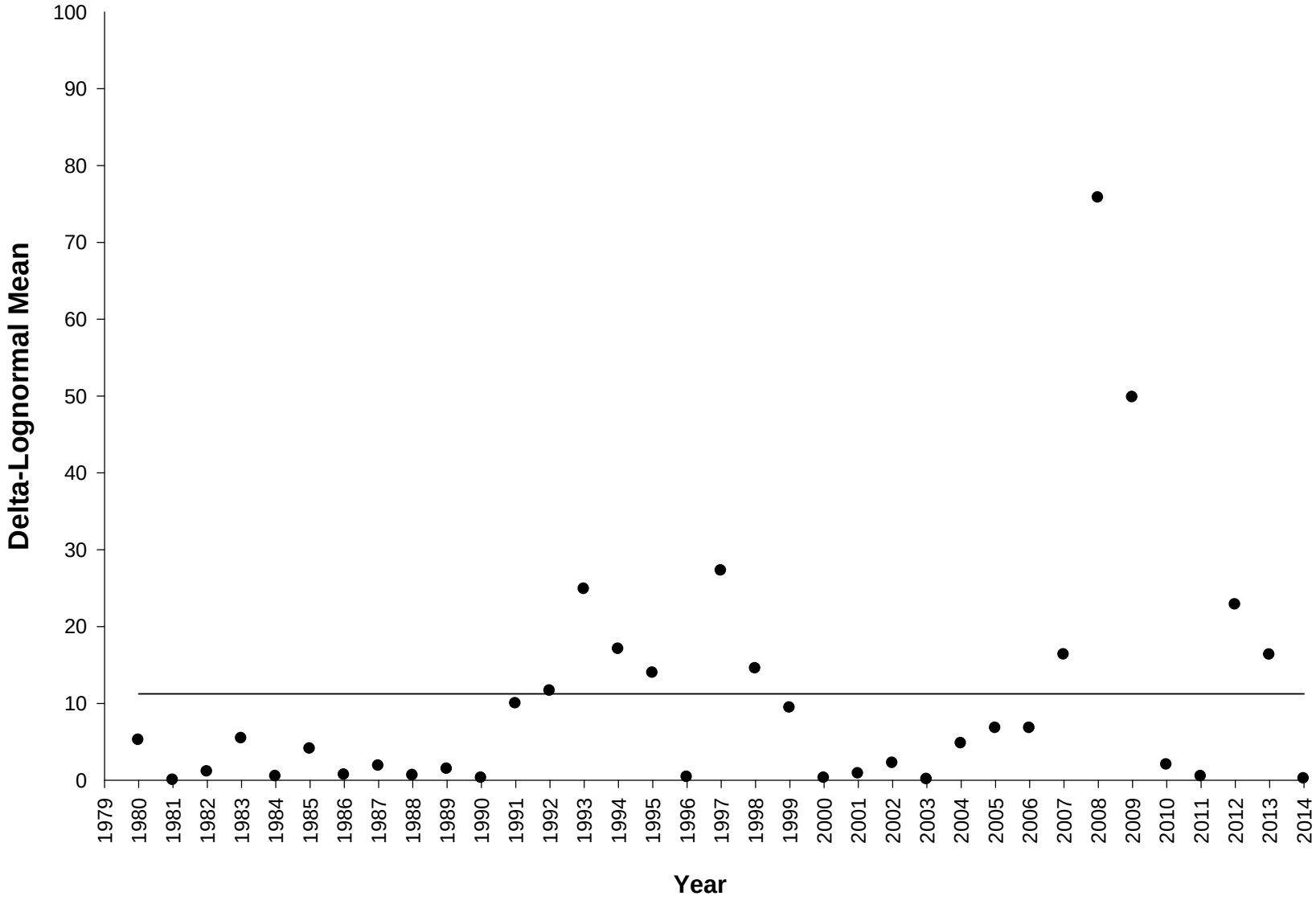

Figure 14. Delta-lognormal mean of young-of-the-year Atlantic Croaker from select seine survey stations in Virginia tributaries of Chesapeake Bay by year. The horizontal line indicates the historical mean for 1980-2013.