

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

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Cover image

Young-of-the-Year Striped Bass collected in a seine haul on the James River.

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EXECUTIVE SUMMARY

The 2024 juvenile Striped Bass abundance index was 3.43 and was significantly lower than the reference mean of 7.77 for the period 1980 to 2009. Abundance indices were below average in the James River and average in the York and Rappahannock rivers in 2024 compared with the river-specific reference means (1980-2009). With the exception of the James River, where the majority of juvenile Striped Bass were collected at upriver sites, relatively low catches of young-of-the-year Striped Bass from sites upriver and downriver of core nursery areas suggest juvenile Striped Bass largely remained within core nursery areas in 2024.

Juvenile indices of abundance were calculated for three additional economically and recreationally important fishes in Virginia waters. Juvenile White Perch abundance indices in 2024 were below historic averages in the James, York, and Rappahannock river systems. In 2024, the juvenile abundance index for Atlantic Croaker was similar to its historic average, while the juvenile abundance index for Spot was below its historic average in Virginia waters.

Indices of abundance were calculated for eight common forage species within the tidal nearshore zone of Virginia waters. Abundance indices for Atlantic Silverside and Spottail Shiner were generally below their historic averages in 2024. The abundance indices for Banded Killifish, Inland Silverside, and Mummichog were generally similar to their historic averages in 2024. For the third consecutive year, the abundance index for American Shad was greater than its historic average in the Rappahannock River. In contrast, the abundance indices for American Shad were below average in the James, Chickahominy, Mattaponi, Pamunkey, and York rivers. The abundance indices for Alewife were average in the James and York rivers, but below average in the Rappahannock River. Abundance indices for Blueback Herring were average in the James, York, and Rappahannock rivers. Together, these results suggest adequate production of forage fish prey for piscivores in Virginia.

PREFACE

The primary objective of the Virginia Institute of Marine Science Striped Bass Seine 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 with funds from the Commercial Fisheries Development Act of 1965 (PL88-309). Beginning in 1980, funds were provided by the National Marine Fisheries Service under the Emergency Striped Bass Study program (PL96-118, 16 U.S.C. 767g, the “Chafee Amendment”). Commencing with the 1989 annual survey, the work was jointly supported by Wallop-Breaux funds (Sport Fish Restoration and Enhancement Act of 1988 PL100-488, the “Dingell-Johnson Act”), administered through the U.S. Fish and Wildlife Service, and the Virginia Marine Resources Commission. This report summarizes the results of the 2024 sampling period and compares these results with previous years.

INTRODUCTION

Striped Bass (*Morone saxatilis*) is one of the most recreationally sought-after fish species on the east coast of the United States. Decreases in the harvest of Striped Bass in the 1970s paralleled the decline in abundance of Striped Bass along the east coast; Chesapeake Bay stock abundances were particularly depressed. Declines in coastwide harvests mirrored declines in juvenile recruitment in Chesapeake Bay (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 stock status. The Virginia Marine Resources Commission (VMRC) adopted the plan in March 1982 (Regulation 450-01-0034). 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 seven times to address changes in the management of the stocks. Amendment 6 to the plan, adopted in February 2003, requires "producing states" (i.e., Virginia, Maryland, Delaware and New York) to develop and support programs that monitor Striped Bass recruitment. In 2019, Addendum VI to Amendment 6 called for an 18% reduction in removals relative to 2017 removals to reduce fishing mortality rates on the stock, because the 2018 benchmark assessment found that the Striped Bass stock was experiencing overfishing. The estimated spawning stock biomass (SSB) has been below the SSB threshold since 2013 and hence, the stock has been overfished according to the 2018 benchmark stock assessment. This finding required ending overfishing within one year and rebuilding the stock by 2029. In 2022, Amendment 7 to the FMP was approved, which established new requirements for management triggers, conservation equivalency, recreational release mortality

measures, and a stock rebuilding plan (ASMFC 2022a). Results from the 2022 benchmark stock assessment indicated that the stock was no longer experiencing overfishing but remained overfished (ASMFC 2022b). Since 2022, multiple measures, including slot and bag limits, gear restrictions, and commercial quota reductions, have been instituted to reduce fishing mortality and support Striped Bass stock rebuilding by 2029. The 2024 stock assessment update reaffirmed that the Striped Bass stock remains overfished (ASMFC 2024). While overfishing is not currently occurring, low recruitment in recent years remains a major concern. In response, ASMFC implemented a 31-inch maximum size limit in 2023 to protect large, spawning females.

Initially, juvenile Striped Bass abundance was assessed in Virginia with 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 the 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 method used to estimate the index (MD: arithmetic mean; VA: geometric mean). 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. In 2009, computations of a bay-wide geometric mean juvenile abundance index (JAI) were found to be correlated with abundance estimates of adult fish from fishery-independent monitoring (Woodward 2009), suggesting that a bay-wide geometric mean would be reasonable.

Primary objectives for the 2024 study were to:

1. estimate the relative abundance of the 2024-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 3 July to 11 September 2024. Pilot sampling at three sites spanning the James and Mattaponi rivers in early to mid-June revealed that juvenile Striped Bass were relatively small and unlikely to be fully recruited to the gear (number of hauls = 7; number of fish = 8; median = 38 mm fork length (FL); range = 21-50 mm), which suggested that sampling did not need to be initiated in mid-June, as was done in 2017, 2019, 2021, and 2023 (Buchanan et al. 2024).

During each round, seine hauls were conducted at 18 index stations and 23 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 Striped Bass stock size during the 1980s and hypothesized expansion of the nursery grounds in years of high juvenile abundance. In 2024, the presence of construction prevented access to site J12 on the James River for the duration of the survey. Extensive growth of underwater vegetation (mostly *Hydrilla*) at site P56 in round 2 resulted in a modified haul to reduce the impact of vegetation on the capture efficiency of the seine. Additionally, the second haul at site J29 in round 5 was jettisoned due to the capture of a large school of Atlantic Menhaden (4,000+ individuals) that could not be brought on land. Since the haul was not properly conducted, the haul was not included in analyses.

As in previous years, collections were conducted with a 100-ft. (30.5 m) long, 4-ft. (1.2 m) deep, and 0.25-inch (6.4 mm) mesh minnow seine. In 2024, a mudline was installed along the lead line of the seine net to prevent mud accumulation while hauling. The seine net was deployed perpendicular to the shoreline until either the net was fully extended, or a depth of 4 ft. (1.2 m) was encountered, and then pulling the offshore end down-current and back to shore. During each round, a single haul was conducted at each auxiliary station, whereas duplicate hauls with an interlude of at least 30 minutes were completed at each index station. Fish were removed from the net and placed into

a water-filled bucket. All Striped Bass were measured to the nearest mm FL, and for all other species, a subsample 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 with an aerator until the second haul was completed to eliminate the possibility of duplicate counting. All captured fish were returned to the capture site at the conclusion of sampling. Sampling time, tidal stage, and weather conditions were recorded at each sampling location. Salinity, water temperature, dissolved oxygen concentration, pH, and turbidity (Formazin Nephelometric Unit or FNU) were measured after the first haul was completed using a YSI water-quality sampler. To ensure continuity with previous years, turbidity was also measured using a Secchi disk.

From 1999 to 2015, the VIMS seine survey used a net comprised of 0.25-inch knotless oval mesh. However, this netting was no longer available from the manufacturer in 2015, so a new net was constructed from 0.25-inch knotless rhomboid mesh material. To determine if the change in mesh material influenced the relative catch efficiency of the net, paired hauls of old and new nets were conducted during the 2015 sampling season, and these data were used to estimate species-specific calibration factors for juvenile Striped Bass and White Perch (Fabrizio et al. 2017). The estimated calibration factor was 0.5175 for Striped Bass and 0.6537 for White Perch, implying that the new net captured more Striped Bass and White Perch than the old net (i.e., catches in the new net were adjusted by multiplying by the calibration factor; Fabrizio et al. 2017). Due to low sample sizes ($n < 30$), these calibration factors were considered preliminary (Gallagher et al. 2017) and additional paired hauls were conducted during the 2017 sampling season. The addition of the 2017 data markedly increased sample sizes ($n > 70$) and resulted in calibration factors that were not significantly different from 1 for either species. Therefore, Striped Bass and White Perch catch data were not adjusted to estimate indices of abundance from the new net.

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). Thus, 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 considered in this calculation. Because the frequency distribution of the catch is skewed (Colvocoresses 1984), a logarithmic transformation ($\ln(\text{totnum})+1$) was applied to the data prior to analysis (Sokal and Rohlf 1981). Mean values are back-transformed and scaled 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 (which is based on the arithmetic mean).

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 lower catches on average 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. In accordance with suggestions made by Rago et al. (1995), the Virginia juvenile Striped Bass index was also recomputed using only the first haul at each index station.

Prior to 2011, annual recruitment indices were calculated from all collections made during a sampling year including fish captured before July and after mid-September. In particular from 1967 to 1973, seine sampling extended into October and occasionally into December (1973). Current protocols conclude sampling in late August or mid-September because after this time, sampling efficiency decreases due to increased avoidance of the sampling gear and movement of juveniles into deeper waters. Indices calculated from data that included 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, or

late-June through August) to permit uniform comparisons of annual recruitment (Tables 2-4).

The 2024 annual index calculated from both hauls was compared with the average index from 1980-2009 (hereafter referred to as the reference period) to reflect the fixed-time period used in the definition of recruitment failure in Virginia, as stipulated by Addendum II to Amendment 6 of the Striped Bass fishery management plan (ASMFC 2010). In addition, the 2024 annual index was calculated using only the first haul at each index site and compared with the average index value for 1990-2012 (using the first haul only) to provide a benchmark for interpreting recruitment strength during the period when the stock was recovering and was not overfished.

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.

Environmental conditions during each round in 2024 were compared graphically with long-term average conditions to assess changes in habitat condition for juvenile Striped Bass in Virginia’s nursery areas. For temperature and salinity, the long-term average was calculated using observations from 1989 to 2023; this allowed us to include all years when auxiliary stations were sampled, thereby maximizing and standardizing the spatial extent of sampling (Figure 1). Dissolved oxygen and Secchi depth were measured since 1992, so long-term averages were calculated using observations from 1992 to 2023. pH was measured from 1992 to 2006 and was reinstated in 2023, so the long-term average was calculated using observations from 1992 to 2006 and 2023. In all cases, conditions in 2024 were compared with those in the period 1989 to 2023 (water temperature, salinity), 1992 to 2023 (dissolved oxygen and Secchi), or 1992 to 2006 and 2023 (pH).

RESULTS AND DISCUSSION

Juvenile Striped Bass Index of Abundance for Virginia

We collected 585 young-of-the-year Striped Bass in 2024 from 179 seine hauls at index stations and 181 individuals from 110 hauls at auxiliary stations (Table 1). Using index-station catches from both hauls, the estimated Striped Bass recruitment index in 2024 was 3.43 (lower confidence interval [LCI] = 2.66, upper confidence interval [UCI] = 4.32; Table 2), which was significantly less than the average of 7.77 during the reference period (LCI = 6.01, UCI = 9.89; Figure 2). Using index-station catches from only the first haul in 2024, 356 young-of-the-year Striped Bass were collected, resulting in an index of 4.38 (LCI = 3.11, UCI = 5.94, Table 3), which was significantly less than the first-haul reference period index of 9.57 (LCI = 7.43, UCI = 12.17). The first-haul index was also significantly less than the mean index estimated for the post-recovery period from 1990-2012 during which the population was not overfished (post-recovery index = 11.91; LCI = 9.25, UCI = 15.17, Table 3).

Striped Bass recruitment success in the Virginia portion of Chesapeake Bay was variable among years and among nursery areas within years. Since the termination of the Striped Bass fishing moratorium in 1990, strong year classes have been observed approximately every decade (1993, 2003, and 2011). The highest recruitment index observed by the Virginia seine survey occurred in 2011. Average to above-average recruitment years occurred between 2003 and 2011, and more recently from 2013 to 2022 (Figure 2). Below-average year classes were observed in 1991, 1999, 2002, 2012, and 2023 (Figure 2). In the past decade, recruitment has been average or above average every year, except in 2023 when recruitment was below average, indicating production has been relatively consistent in Virginia nurseries during this time. Under current ASMFC regulations (ASMFC 2010), management action is triggered after three consecutive years of low recruitment in producing states (i.e., the index value is below the first quartile in the time series; Figure 2). Such periods of persistently low recruitment have previously occurred in Virginia from 1971-1973 and 1980-1983 (Figure 2).

Continued monitoring of regional recruitment success will be important in identifying management strategies to protect the spawning stock of Chesapeake Bay Striped Bass, particularly now that the spawning stock biomass is below the threshold. 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 indices from Virginia and Maryland provide divergent estimates of year-class strength (such as 2022, when Virginia reported average recruitment and Maryland reported below-average recruitment for Striped Bass); such differences may arise due to annual changes in the relative contribution of nursery areas throughout Chesapeake Bay.

Juvenile Striped Bass Index of Abundance for Individual Watersheds

Using index-station catches from both hauls, the estimated Striped Bass recruitment indices in the three Virginia watersheds during 2024 varied relative to their individual means from the 1980-2009 reference period (Table 4; Figure 3). The 2024 JAI for the James River drainage was 1.17 (LCI = 0.54, UCI = 1.94), which was significantly lower than the reference period index of 10.41 (LCI = 7.83, UCI = 13.64; Table 4). The 2024 JAI for the York River drainage was 5.11 (LCI = 3.87, UCI = 6.61), which was not significantly different from the reference period index of 5.85 (LCI = 4.50, UCI = 7.48; Table 4). The 2024 JAI for the Rappahannock River drainage was 4.93 (LCI = 2.85, UCI = 7.85), which was not significantly different from the reference period index of 7.90 (LCI = 5.63, UCI = 10.82, Table 4).

The core nursery area within the James River drainage consists of seven mid-river stations: four in the James River (J36, J42, J46, J51) and three in the Chickahominy River (C1, C3, C4). Historically, these seven stations tend to exhibit relatively high and stable abundance. In 2024, 8% of all young-of-the-year Striped Bass collected from the James River drainage were captured from this core nursery area (Table 1). The remaining Striped Bass were captured at upriver (69%) or downriver sites (22%; Table 1). The James River drainage includes the James River proper and the Chickahominy

River. Differences were not observed between indices from the James River main stem and the Chickahominy River. The 2024 JAI for the James River main stem (excluding the Chickahominy River) was 1.91 (LCI = 0.88, UCI = 3.28), which was significantly lower than the reference period index of 9.72 (LCI = 7.06, UCI = 13.12; Table 4). Similarly, the 2024 JAI for the Chickahominy River was 0.08 (LCI = -0.08, UCI = 0.25), which was significantly lower than the reference period index of 11.95 (LCI = 8.70, UCI = 16.15; Table 4). In fall 2020, shoreline modifications, including tree removal and shoreline stabilization through the installation of sills with bank grading and marsh creation, were made to a campground between two index sites in the Chickahominy River (C1 and C3). Historically, these sites exhibit a pattern of three to five years of average to above-average recruitment, followed by one to two years of below-average recruitment. In 2024, low recruitment was observed at sites C1 and C3 (Table 5). We will continue to monitor catches at these sites to determine if the recent shoreline modifications have influenced relative abundance in the Chickahominy River.

No index sites are located along the main stem of the York River; thus, the watershed JAI is estimated from catches at sites located within the two principle York River tributaries, the Pamunkey and Mattaponi rivers. The 2024 Pamunkey River JAI of 6.17 (LCI = 4.24, UCI = 8.67) was not significantly different than the reference period index of 6.90 (LCI = 4.90, UCI = 9.44; Table 4), and the 2024 Mattaponi River index of 4.41 (LCI = 2.90, UCI = 6.35) was also not significantly different from the reference period average of 5.16 (LCI = 4.06, UCI = 6.45; Table 4). Distinct core nursery areas are found within the Pamunkey (P45, P50) and Mattaponi rivers (M33, M37, M41, M44), and these areas generally exhibit high and stable catches compared with other sites in these rivers. This pattern held true in 2024, as the majority of Striped Bass were captured within the core nursery area in the Pamunkey (70%) and Mattaponi (56%) rivers. Overall, approximately 45% of Striped Bass in the York River drainage were collected from the Pamunkey River and 53% from the Mattaponi River in 2024; the remainder (2%) were from the York River auxiliary stations (Table 1).

The 2024 JAI for the Rappahannock River drainage was 4.93 (LCI = 2.85, UCI = 7.85), which was not significantly different from the reference period index of 7.90 (LCI = 5.63, UCI = 10.82, Table 4). The core nursery area within the Rappahannock River consists of the three uppermost index sites (R44, R50, R55) that have consistently dominated the catches in this drainage for more than two decades. In 2024, 71% of the total Rappahannock River catch was taken within the core nursery area (Table 1). The remaining Striped Bass were captured at upriver (28%) or downriver sites (1%; Table 1).

Striped Bass Collections from Auxiliary Stations

Figures 4-6 illustrate the spatial distribution of the 2024-year class of Striped Bass throughout the areas sampled by this survey. Note that the scaling of CPUE is not constant across these figures. The 1989 addition of auxiliary stations provided increased spatial coverage in the James, York, and Rappahannock drainages, and the upriver and downriver auxiliary sites allowed delineation of the upper and lower limits of the nursery. These auxiliary stations help reveal spatial changes in the nursery areas that may occur due to annual changes in river flow and other factors. Additionally, in years of low or high juvenile abundance, the nursery area may contract or expand spatially. For the York and Rappahannock rivers, we observed relatively low catches of young-of-the-year Striped Bass at upriver and downriver auxiliary sites in 2024, which suggests that fish occurred primarily within the core nursery area in these rivers. In the James River, we observed low catches of juvenile striped bass within the core nursery area, but relatively high catches at upriver sites in 2024.

During 2024, juvenile Striped Bass were captured at all auxiliary sites in the James River except for site C4 (Table 1 and 5; Figure 4). In the Appomattox River, where exploratory sampling began in 2022, 3 Striped Bass were collected in 2024 at auxiliary site A1 (Table 1; Figure 4), compared with 20 Striped Bass collected at site A1 in 2023. Striped Bass were collected from all downstream and upstream auxiliary sites in the Pamunkey and Mattaponi rivers in 2024 (Tables 1 and 5; Figure 5). In the York River main stem, relatively few Striped Bass were collected from the three auxiliary stations (Table 5).

We previously suggested that the lack of juvenile Striped Bass at auxiliary stations in the upper reaches of the York River watershed may have been due to the inability to accurately sample in the dense *Hydrilla* vegetation that typically occurs at these sites (Machut and Fabrizio 2010; Buchanan et al. 2024). In 2024, one juvenile Striped Bass was detected at the uppermost auxiliary site in the Pamunkey (P56; Table 1), but fish may not have been detected in the area due to low capture efficiencies associated with hauling a seine net through dense aquatic vegetation. Catches in recent years at site P56 may have been affected by the altered state of the nearshore area. For example, Striped Bass may be using habitats in deeper waters at site P56 due to the presence of dense *Hydrilla* stands along the shoreline; alternatively, Striped Bass may utilize *Hydrilla* habitats but remain unavailable to the sampling gear. The continued sampling difficulties at this station suggest a need to examine alternative collection methods within this region to determine the abundance of juvenile Striped Bass in nearshore areas where *Hydrilla* is present. In 2023, dense stands of *Hydrilla* were encountered at sites on the James (J46), Chickahominy (C3), Pamunkey (P56), and Rappahannock rivers (R65, R69, and R76). However, in 2024, dense stands of *Hydrilla* were only encountered at sites J46, C3, and P56 suggesting conditions were less favorable for *Hydrilla* in Virginia's waters.

Relatively high numbers of juvenile Striped Bass were collected at upriver Rappahannock sites (R60, R65, R69, R76) in 2024 (Tables 1 and 5; Figure 6). In recent years, few fish have been collected at downriver auxiliary sites in the Rappahannock River (R12, R21) even though these sites have favorable substrate and no obstructions to compromise seining. A similar pattern was observed in 2024 with one individual collected at sites R12 and R21 (Table 1; Figure 6).

Juvenile Striped Bass Indices by Sampling Round

Indices of juvenile abundance calculated by sampling round in 2024 were not significantly different from the averages calculated during the 1980-2009 reference period for rounds 1 and 2. For rounds 3, 4, and 5, the indices of juvenile abundance were significantly less than their reference period indices (Table 6). The largest number

of young-of-the-year Striped Bass was collected during round 1 in 2024, with fewer observed in other rounds, except for round 5, where an increase in catch was observed (Table 6). This generally follows the pattern observed during the reference period, in which the largest number of Striped Bass were collected during rounds 1 and 2, with fewer observed in subsequent rounds. In 2024, 32% of all juvenile Striped Bass were captured in round 1; this was followed by a modest decline (-22%) in the number of Striped Bass captured in round 2, a pattern that was similar to average declines observed between rounds 1 and 2 during the reference period (-22%). There was a moderate decline in catches during the third round (-31%), which is similar to average declines observed between rounds 2 and 3 during the reference period (-26%). During the fourth round, catches declined by -36%, which is greater than the average decline observed between rounds 3 and 4 during the reference period (-12%). A 31% increase in catches was observed during the fifth round in 2024, which differs from the average decline observed between rounds 4 and 5 during the reference period (-31%; Table 6).

Environmental Conditions and Potential Relationships to Striped Bass Abundance

Historically, water temperatures tended to follow a well-defined pattern of high temperatures in rounds 1 and 2, followed by declining temperatures as the sampling season progressed (rounds 3, 4, and 5; Figure 7). A similar pattern was observed in 2024: mean water temperatures were generally similar to or above historic averages during rounds 1, 2, and 3 ranging between 26.7 and 34.1°C (Figure 7). During rounds 4 and 5, mean water temperatures were below historic averages. The high temperatures observed in rounds 1, 2, and 3 were largely consistent with statewide average air temperatures from July to September of 2024, which were “above average” in Virginia (NCDC 2024). Relatively high-water temperatures in Striped Bass nursery areas have now occurred during 12 consecutive years, with a similarly high range of temperatures observed since 2013 (Buchanan et al. 2024). This temperature pattern did not seem to affect catches in previous years, however. Similarly, catch rates in 2024 followed the historic pattern with respect to water temperature: 95% of juvenile Striped Bass from index sites were captured at temperatures exceeding 25°C (Table 7). 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 typically observed prior to 2024 between declining Striped Bass catches and decreasing temperatures during rounds 3, 4, and 5 is considered to be largely the result of a coincident downward decline in catch rates and water temperatures as the season progresses (after early-August) rather than any direct effects of water temperature on juvenile fish distribution.

Across years, mean salinity tended to increase steadily from rounds 1 to 3, then stabilized during rounds 4 and 5 (Figure 8). In 2024, average salinities were generally similar to or below historical averages for all rivers, except in the Chickahominy River, where salinity was above historical averages during rounds 1 and 2 (Figure 8). As observed in the past, greater catches of young-of-the-year Striped Bass in 2024 were obtained at salinities less than 5 ppt on average (Table 5). In 2024, salinities at downriver stations were higher than historic averages. Only one index site in the Rappahannock River (R28) exhibited mean salinities exceeding 10.0 ppt in 2024, although mean salinities as high as 17.8 ppt were observed at one auxiliary station in the York River (Y15; Table 5). While juvenile Striped Bass were captured at downstream sites with average salinities up to 14.6 ppt, catches were distinctly lower at such sites compared with catches in lower salinity areas.

Historically, mean dissolved oxygen (DO) concentrations tended to decrease from rounds 1 to 4, then increase slightly in round 5 (Figure 9). Mean DO concentrations in 2024 were generally greater than long-term averages during all rounds (Table 8; Figure 9). Relationships between instantaneous measures of DO concentrations and juvenile Striped Bass catches are difficult to ascertain, as lower-than-average DO conditions occur inconsistently through time and across sampling sites. In previous years, high seasonal catches at index stations occurred during periods when DO concentrations were more than one standard error (SE) below the historic average,

as well as when DO concentrations were within one SE of the historic average. However, DO concentrations are typically greater than 4 mg/L and not likely limiting Striped Bass habitats. Thus, instantaneous measures of DO concentrations do not appear to affect juvenile Striped Bass abundance estimates in this survey. Dixon et al. (2022), however, concluded that DO is an important environmental factor for delineating suitable habitat for juvenile Striped Bass in Chesapeake Bay.

Historically, mean pH tended to increase slightly from rounds 1 to 2, decrease from rounds 2 to 3, increase during rounds 3 and 4, then decrease in round 5 (Figure 10). Mean pH in 2024 was generally similar to or greater than long-term averages during all rounds (Table 9; Figure 10). In 2024, a relationship between site-based mean pH and juvenile Striped Bass abundance is not evident as high and low abundances were recorded in both acidic and basic (alkaline) conditions (Table 9).

Turbidity was measured using a Secchi disk and a YSI water quality sampler. Historically, mean Secchi depth tended to generally increase from rounds 1 to 4, then decrease slightly in round 5 for all rivers, except for the Rappahannock River where mean Secchi values decreased from rounds 1 to 3, then increased in rounds 4 and 5 (Figure 11). In 2024, mean Secchi was generally similar to or less than the historical mean during rounds 1-4 for all rivers (Table 10; Figure 11). During round 5, mean Secchi was greater than the historical mean for all rivers, except in the Mattaponi River, where the mean Secchi was less than the historical mean. In 2024, mean turbidity (FNU) was generally higher at midriver sites than down-river or upriver sites (Table 11).

Regional climate patterns during winter and spring may partially explain Striped Bass recruitment variability in Chesapeake Bay (Wood 2000). For example, the abundance of young Striped Bass in the Patuxent River is positively associated with high freshwater flow during the preceding winter (Wingate and Secor 2008). One of the strongest Striped Bass year classes in Virginia was produced in 2011, a year characterized by relatively high freshwater flow in winter and spring (Machut and Fabrizio 2012). Freshwater flow in Virginia tidal tributaries varies seasonally, with monthly averages since 1967 showing relatively high flow during the winter, peaks in

early-spring (March-April), followed by steady declines through the late-spring and summer (Figure 12; USGS 2024). In 2024 and in most Virginia rivers, freshwater flow was generally similar to or below average from January to September, with peaks in January and March (Figure 12). Statewide precipitation during the winter and spring of 2024 (December 2023-May 2024) was “much above average” in Virginia relative to historical conditions since 1895 (NCDC 2024). Although these regional precipitation conditions were “above average,” salinities were generally similar to or above historic averages at most Virginia sample sites (Table 5). The effect of such seasonal changes in precipitation and flow on annual variations in recruitment of juvenile Striped Bass remain unclear.

Abundance Indices for Other Fishes

A variety of fish species are encountered annually by the juvenile Striped Bass seine survey due to a sampling regime that spans the euryhaline to freshwater zone. In 2024, more than 32,000 individuals comprising 66 species of fishes were collected (Table 12). The five most common species encountered in 2024 were Threadfin Shad (*Dorosoma petenense*), Atlantic Menhaden (*Brevoortia tyrannus*), Spottail Shiner (*Hudsonius hudsonius*), Mummichog (*Fundulus heteroclitus*), and Inland Silverside (*Menidia beryllina*) (Table 12). This was different from 2023, when Atlantic Silverside (*M. menidia*), Bay Anchovy (*Anchoa mitchilli*), and White Perch (*Morone americana*) were among the top five species captured, and Inland Silverside, Mummichog, and Threadfin Shad were not among the top five. Indices of abundance were estimated for 11 commonly occurring species (in addition to juvenile Striped Bass) based on catches from only the first haul at a subset of index and auxiliary stations, except for American Shad, where both hauls at index sites were included. A different subset of stations was used for each species based on the range of sites where the species was commonly encountered within each tributary from 1967 to 2010. In 2024, the methodology for calculating indices of abundance for 11 commonly occurring species was updated to reflect the survey’s sampling structure of five rounds. The effect of this alteration is most pronounced for earlier years (1967-1973) when sampling extended up to nine

rounds. A similar alteration was made to calculate the juvenile Striped Bass recruitment index in 2011 (see the Methods section for more information).

One of the most common species captured annually by the seine survey, White Perch, supports important recreational fisheries in Chesapeake Bay (Murdy et al. 1997, NMFS 2017). 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 the 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 collections and an index obtained for harvest-sized White Perch from a trawl survey. In years of low abundance (e.g., 1985), the proportion of seine 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 up to 95% of seine 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.

During the 2024 sampling period, 1,418 young-of-the-year White Perch were collected from 110 seine hauls at 31 sites (12 sites in the James, 10 in the York, and 9 in the Rappahannock rivers). 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 system separately (Table 13; Figures 13-16). River-specific JAIs for White Perch suggest below-average recruitment in the James, York, and Rappahannock rivers in 2024 (Figures 14-16). Although we feel confident in the estimation of annual mean relative abundance of White Perch, alternative approaches for estimating confidence intervals need to be examined. The White Perch JAI developed by the seine survey complements the juvenile White Perch index currently reported by the VIMS Juvenile Finfish Trawl Survey (Tuckey and Fabrizio

2024); 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 economically and recreationally important fish (Murdy et al. 1997, NMFS 2017) regularly collected by the seine survey. Young-of-the-year Atlantic Croaker are collected at predominantly mesohaline regions during rounds 1 to 3, before fish are able to avoid capture by the net (Williams and Fabrizio 2011). Murdy et al. (1997) report peak spawning of Atlantic Croaker from August to October; thus, young-of-the-year fish collected during 2024 were spawned during fall 2023. Similar to White Perch, Atlantic Croaker catches exhibit high annual variability in the proportion of nonzero hauls. To address this variation and accommodate data with a high proportion of zero hauls, we developed a delta-lognormal index for Atlantic Croaker (as described above). Atlantic Croaker are coastal shelf spawners, and their larvae migrate into Chesapeake Bay and enter nursery areas in the tributaries (Murdy et al. 1997). Therefore, we report a Virginia-wide estimate of juvenile abundance. Based on 2024 catches from 21 stations during rounds 1 to 3, we encountered 568 young-of-the-year Atlantic Croaker in 41 seine hauls (Table 14; Figure 17). Periods of strong recruitment from 1992-1995, 1997-1998, and 2007-2009 correspond with patterns observed by the VIMS Juvenile Finfish Trawl Survey (Tuckey and Fabrizio 2024). In 2024, an average year class for Atlantic Croaker was observed.

Spot (*Leiostomus xanthurus*), like Atlantic Croaker, is another economically and recreationally important species that is collected by the seine survey and reported as a Virginia-wide estimate of juvenile abundance (Table 15; Figure 18). Based on catches from 21 stations during 5 rounds in 2024, 639 young-of-the-year Spot were collected in 72 seine hauls. Using the delta-lognormal approach, we observed below-average relative abundance for Spot in 2024, similar to estimates for the previous eight years (Table 15; Figure 18).

Indices of relative abundance for common forage species within the tidal nearshore zone were computed for Spottail Shiner (*H. hudsonius*; 33 stations; Table 16), Atlantic Silverside (*M. menidia*; 25 stations; Table 17), Inland Silverside (*M. beryllina*; 37

stations; Table 18), Banded Killifish (*F. diaphanus*; 33 stations; Table 19), and Mummichog (*F. heteroclitus*; 25 stations; Table 20). Catches from all five rounds were used to estimate abundance indices for these species. The 2024 Spottail Shiner delta-lognormal mean of 17.0 was below the historic average of 28.8 (Table 16). The 2024 Atlantic Silverside delta-lognormal mean of 7.6 was below the historic average of 48.4 (Table 17). The 2024 Inland Silverside delta-lognormal mean of 7.8 was similar to the historic average of 5.9 (Table 18). The 2024 Banded Killifish delta-lognormal mean of 5.3 was similar to the historic average of 6.1 (Table 19). The 2024 Mummichog delta-lognormal mean of 26.2 was similar to the historic average of 25.5 (Table 20). Together, these results suggest adequate production of forage fish prey was available for piscivores in Virginia waters in 2024. In addition, we note that abundance indices for the four freshwater forage species (Banded Killifish, Inland Silverside, Mummichog, and Spottail Shiner) have been increasing since 1989.

Indices of abundance derived from seine survey collections are reported for species of management concern to fulfill Commonwealth compliance requirements to the ASMFC; these species include American Shad (Hilton et al. 2011), Alewife, Blueback Herring, 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. These indices are provided to VMRC when requested and are also reported here. Alosids contribute to the dynamics of freshwater, estuarine, and marine habitats serving as prey for many large, predatory fishes and consuming large amounts of plankton. Many stocks of alosid species are currently at record lows or of unknown status because of a lack of data to assess populations accurately, especially within riverine environments. Data collected on American Shad, Alewife, and Blueback Herring from the seine survey are critical for assessing populations in the James, York, and Rappahannock rivers. The 2024 geometric mean abundance index for American Shad was above average in the Rappahannock River, but below average in the James, Chickahominy, Mattaponi, Pamunkey, and York rivers (Figure 19). For Alewife, the 2024

geometric mean abundance indices were average in the James and York rivers, but below average in the Rappahannock River (Figure 20). The 2024 geometric mean abundance indices for Blueback Herring were average in the James, York, and Rappahannock rivers (Figure 21).

CONCLUSION

The 2024 juvenile abundance index (JAI) for Striped Bass (3.43) was significantly lower than the average for the reference period (7.77) for Virginia waters. Compared with reference period averages, we observed below-average recruitment in the James River and average recruitment in the York and Rappahannock rivers. Continued monitoring of juvenile Striped Bass abundance is important in predicting recruitment to the 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 below-average recruitment which, if persistent, serve as an early warning to managers of potential declines in Striped Bass spawning stock biomass, deteriorating conditions in nursery areas, or both. The juvenile White Perch abundance index in 2024 was lower than the historic average. The Atlantic Croaker juvenile abundance index was similar to the historic average, while the Spot juvenile abundance index was below the historic average in 2024. The abundance indices for Banded Killifish, Inland Silverside, and Mummichog were generally similar to their historic averages in 2024. Conversely, for Atlantic Silverside and Spottail Shiner, abundance indices were generally below average in Virginia waters in 2024, relative to historic averages. Abundance indices for three alosid species were generally average or below average in the James and York rivers and average in the Rappahannock River in 2024, relative to index values in previous years.

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TABLES

Table 1. Catch of young-of-the-year Striped Bass per seine haul in 2024. 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). A hyphen (-) indicates a haul was not completed (See methods).

Drainage																		Round
JAMES	Station	J12	J26	J29	J36	J42	C1	C3	C4	J46	J51	J56	J62	A1	J68	J77	Total	
Round	1	-	6	6/5	1/0	0	0/0	0/0	0	0/0	2	19/9	2	2	1	8	61	
	2	-	0	1/0	0/0	0	0/0	0/0	0	0/1	0	14/3	0	1	1	1	22	
	3	-	1	3/2	1/0	0	1/0	0/0	0	0/0	0	8/2	1	0	2	0	21	
	4	-	1	0/0	0/0	0	0/0	0/0	0	0/0	0	1/0	2	0	0	2	6	
	5	-	1	0/-	0/0	4	0/0	0/0	0	0/0	0	3/0	0	0	0	0	8	
																James Total	118	
YORK	Station	Y15	Y21	Y28	P36	P42	P45	P50	P56									
Round	1	0	2	0	2	5/3	7/1	5/11	0									36
	2	0	1	0	1	2/2	2/0	11/4	0									23
	3	0	0	0	3	2/3	4/3	4/5	0									24
	4	0	0	2	1	5/3	3/0	5/1	1									21
	5	0	0	0	1	1/0	2/0	12/3	0									19
Round	Station				M33	M37	M41	M44	M47	M52								
	1				5/3	1	0/0	3/1	2/3	0								18
	2				6/5	2	12/1	11/3	5/14	8								67
	3				1/0	1	2/0	3/9	10/3	4								30
	4				0/1	0	0/0	2/4	2/4	1								14
	5				2/0	0	1/1	1/1	1/3	1								11
																York Total	263	
RAPPAHANNOCK	Station	R12	R21	R28	R37	R41	R44	R50	R55	R60	R65	R69	R76					
Round	1	0	0	0	1/0	0	17/20	24/11	9/17	3	21	1	0					124
	2	1	1	0	0/0	0	5/7	14/5	8/10	34	21	0	0					106
	3	0	0	0	0/0	0	1/1	2/0	17/17	7	4	0	0					49
	4	0	0	0	0/0	0	3/2	1/2	21/5	0	2	0	0					36
	5	0	0	0	1/0	1	2/0	1/1	26/23	1	8	3	3					70
														Rappahannock Total		385		
														2024 Catch		766		

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	CI (± 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	2,191	2.07	1.23	15.74	12.40-19.83	144
1988	1,348	1.47	1.13	7.64	6.10-9.45	180
1989	1,978	1.78	1.12	11.23	9.15-13.68	180
1990	1,249	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	1,769	1.44	1.24	7.35	5.72-9.31	180
1993	2,323	2.19	0.98	18.11	15.35-21.30	180
1994	1,510	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	3,759	2.41	1.23	23.00	18.77-28.07	180
1997	1,484	1.63	1.10	9.35	7.59-11.41	180
1998	2,084	1.92	1.14	13.25	10.82-16.12	180
1999	442	0.80	0.86	2.80	2.19-3.50	180
2000	2,741	2.09	1.24	16.18	13.06-19.92	180
2001	2,624	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	3,406	2.40	1.18	22.89	18.84-27.71	180
2004	1,928	1.88	1.04	12.70	10.54-15.22	180
2005	1,352	1.61	1.05	9.09	7.45-11.02	180
2006	1,408	1.69	1.04	10.10	8.31-12.18	180
2007	1,999	1.83	1.18	11.96	9.66-14.70	180
2008	1,518	1.50	1.17	7.97	6.33-9.93	180
2009	1,408	1.55	1.10	8.42	6.80-10.32	180
2010	1,721	1.61	1.25	9.07	7.14-11.40	180
2011	4,189	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	1,620	1.76	1.08	10.94	8.97-13.25	180
2014	2,293	1.78	1.26	11.30	8.98-14.09	181
2015	1,879	1.84	1.13	12.00	9.78-14.64	179
2016	1,557	1.58	1.17	8.74	6.98-10.84	180
2017	2,060	1.61	1.28	9.17	7.18-11.57	180
2018	1,875	1.74	1.19	10.72	8.61-13.24	180
2019	1,624	1.65	1.14	9.54	7.69-11.74	180
2020	1,836	1.96	1.15	13.89	11.08-17.29	145
2021	1,512	1.33	1.22	6.30	4.88-8.01	180
2022	2,236	1.50	1.38	7.95	6.05-10.29	180
2023	707	1.05	1.00	4.26	3.36-5.31	180
2024	585	0.92	0.97	3.43	2.66-4.32	179
Reference (1980-2009)	43,527	1.48	0.53	7.77	6.01-9.89	30 (years)

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

Year	Total Fish (x)	Mean $\ln(x+1)$	SD	Index	CI (± 2 SE)	N (Hauls)
1967	191	1.18	1.00	5.17	3.20-7.86	42
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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	0.97	0.94	3.74	2.36-5.54	52
1984	377	1.27	1.09	5.81	3.72-8.63	53
1985	216	0.94	0.92	3.54	2.40-4.97	71
1986	449	1.35	1.07	6.53	4.56-9.06	72
1987	1,314	2.27	1.22	19.77	14.25-27.13	72
1988	820	1.57	1.21	8.66	6.20-11.85	90
1989	1,427	2.06	1.18	15.68	11.71-20.77	90
1990	720	1.58	1.12	8.76	6.44-11.70	90
1991	462	1.17	1.05	5.04	3.59-6.85	90
1992	1,143	1.65	1.31	9.63	6.76-13.41	90
1993	1,241	2.34	0.89	21.36	17.31-26.25	90
1994	969	1.93	1.09	13.37	10.17-17.40	90
1995	559	1.37	1.07	6.71	4.89-8.99	90
1996	2,326	2.60	1.27	28.29	21.11-37.69	90
1997	931	1.83	1.14	11.92	8.90-15.76	90
1998	1,365	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	1,528	2.22	1.23	18.70	13.91-24.90	90
2001	1,671	2.16	1.32	17.52	12.70-23.89	90
2002	486	1.17	1.13	5.03	3.48-7.01	90
2003	2,042	2.50	1.26	25.61	19.09-34.13	90
2004	1,129	2.07	1.04	15.75	12.19-20.19	90
2005	835	1.79	1.07	11.42	8.64-14.90	90
2006	767	1.76	1.06	11.02	8.34-14.36	90
2007	1,271	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	2,397	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	900	1.83	1.11	11.99	9-15.76	90
2014	1,401	2.01	1.24	14.81	10.87-19.93	90
2015	978	1.92	1.09	13.21	10.02-17.22	90
2016	783	1.60	1.16	9.06	6.60-12.21	90
2017	1,200	1.69	1.29	10.09	7.13-13.96	90
2018	1,072	1.80	1.24	11.54	8.37-15.66	90
2019	880	1.70	1.18	10.24	7.49-13.77	90
2020	1,256	2.04	1.17	15.29	11.43-20.24	89
2021	954	1.46	1.30	7.54	5.18-10.64	90
2022	1,485	1.72	1.44	10.42	7.09-14.92	90
2023	435	1.14	1.09	4.83	3.37-6.67	90
2024	356	1.07	1.00	4.38	3.11-5.94	90
1980-2009	26,735	1.65	0.54	9.57	7.43-12.17	30 (years)
1990-2012	25,103	1.83	0.50	11.91	9.25-15.17	23 (years)

Table 4. Catch of young-of-the-year Striped Bass per seine haul at index stations in 2024 summarized by drainage and river.

Drainage River	<u>2024</u>				<u>Reference Period</u> (1980-2009)			
	Total Fish	Index	C.I. ($\pm$ 2 SE)	N (hauls)	Total Fish	Index	C.I. ($\pm$ 2 SE)	N (years)
JAMES	80	1.17	0.54-1.94	59	17,650	10.41	7.83-13.64	30
James	79	1.91	0.88-3.28	39	10,727	9.72	7.06-13.12	30
Chickahominy	1	0.08	-0.08-0.25	20	6,923	11.95	8.70-16.15	30
YORK	231	5.11	3.87-6.61	70	12,470	5.85	4.50-7.48	30
Pamunkey	109	6.17	4.24-8.67	30	6,442	6.90	4.90-9.44	30
Mattaponi	122	4.41	2.9-6.35	40	6,028	5.16	4.06-6.45	30
RAPPAHANNOCK	274	4.93	2.85-7.85	50	13,407	7.90	5.63-10.82	30
Overall	585	3.43	2.66-4.32	179	43,527	7.77	6.01-9.89	30

Table 5. Striped Bass indices and average site salinity during 2024 compared to average index values during the auxiliary monitoring period (1989-2023), with corresponding average salinities (Avg. Sal., ppt). The York drainage includes Pamunkey and Mattaponi rivers. Index stations are indicated by bold font. Indices are calculated using only the 1st haul (Rago et al. 1995). A hyphen indicates a haul was not completed (See methods).

Drainage			J12	J26	J29	J36	J42	C1	C3	C4	J46	J51	J56	J62	J68	J77
JAMES		Station														
1989-2023	Avg. Sal.	14.5	6.1	4.7	2.3	1.2	1.3	1.1	0.7	0.4	0.2	0.2	0.2	0.1	0.1	
	Index	1.4	7.2	10.5	15.0	10.2	20.1	10.8	13.2	21.6	18.1	12.1	11.3	5.8	3.0	
2024	Avg. Sal.	-	7.7	6.0	3.0	1.2	1.4	1.2	0.9	0.3	0.1	0.1	0.1	0.1	0.1	
	Index	-	2.8	2.8	0.7	0.9	0.3	0.0	0.0	0.0	0.6	14.5	1.8	1.5	2.8	
YORK		Station	Y15	Y21	Y28	P36	P42	P45	P50	P56						
1989-2023	Avg. Sal.	16.6	13.8	10.6	4.1	1.7	0.7	0.4	0.1							
	Index	1.2	2.7	6.7	10.2	5.1	12.3	18.0	0.7							
2024	Avg. Sal.	17.8	14.5	11.7	5.0	2.0	0.5	0.2	0.1							
	Index	0.0	1.0	0.6	3.4	6.0	7.5	15.4	0.3							
1989-2023	Station					M33	M37	M41	M44	M47	M52					
	Avg. Sal.					4.6	2.2	1.0	0.4	0.2	0.1					
	Index					10.0	10.9	7.1	9.4	5.9	1.4					
2024	Avg. Sal.					4.6	1.5	0.2	0.1	0.1	0.0					
	Index					4.6	1.5	3.2	8.9	7.1	4.2					
RAPPAHANNOCK			R12	R21	R28	R37	R41	R44	R50	R55	R60	R65	R69	R76		
1989-2023	Avg. Sal.	14.2	12.8	10.0	5.2	2.8	1.7	0.7	0.4	0.2	0.1	0.1	0.1			
	Index	0.6	0.7	3.9	2.9	5.1	12.3	23.2	49.2	6.4	4.9	2.5	0.8			
2024	Avg. Sal.	14.6	12.8	10.3	5.3	3.0	1.8	0.6	0.3	0.1	0.1	0.0	0.1			
	Index	0.3	0.3	0.0	0.7	0.3	8.7	10.0	33.6	8.4	18.7	1.2	0.7			

Table 6. Catch of young-of-the-year Striped Bass at index stations in 2024 summarized by sampling round.

Month (Round)	N (hauls)	<u>2024</u>				<u>Reference Period (1980-2009)</u>				
		Total Fish	Index	C.I. (± 2 SE)	Change From Previous Round	N (years)	Total Fish	Index	C.I. (± 2 SE)	Change From Previous Round
July (1 st)	36	188	5.73	3.25-9.32		30	13,467	11.97	9.15-15.48	
(2 nd)	36	146	4.88	2.81-7.80	-22.3%	30	10,535	9.11	6.84-11.95	-21.8%
Aug. (3 rd)	36	101	3.30	1.85-5.25	-30.8%	30	7,838	7.26	5.44-9.50	-25.6%
(4 th)	36	65	2.04	1.03-3.35	-35.6%	26	6,907	6.88	5.12-9.04	-11.9%
Sept. (5 th)	35	85	2.09	0.96-3.60	30.8%	23	4,780	6.04	4.73-7.61	-30.8%

Table 7. Catch of young-of-the-year Striped Bass per seine haul in the primary nursery areas of Virginia in 2024 summarized by water temperature.

Temp (°C)	<u>2024</u>				<u>Reference Period</u> (1980-2009)			
	Total Fish	Index	C.I. (± 2 SE)	N (sites)	Total Fish	Index	C.I. (± 2 SE)	N (sites)
15.0-19.9	-	-	-	-	47	1.98	0.46-4.34	19
20.0-24.9	28	1.55	0.57-2.86	22	2,430	4.13	3.61-4.70	568
25.0-29.9	320	2.80	1.99-3.77	115	33,808	9.11	8.66-9.57	3,588
> 30.0	237	7.42	4.81-10.97	42	6,871	9.66	8.60-10.82	679

Table 8. Striped Bass indices and average site dissolved oxygen during 2024 compared to average index values during the auxiliary monitoring period (1992-2023), with corresponding average dissolved oxygen (Avg. DO, mg/L). The York drainage includes Pamunkey and Mattaponi rivers. Index stations are indicated by bold font. Indices are calculated using only the 1st haul (Rago et al. 1995). A hyphen indicates a haul was not completed (See methods).

Drainage		Station	J12	J26	J29	J36	J42	C1	C3	C4	J46	J51	J56	J62	J68	J77	
JAMES	1992-2023	Avg. DO.	6.9	7.1	7.1	6.2	7.8	7.1	6.1	7.7	6.9	6.2	6.8	8.8	6.5	6.3	
		Index	1.2	7.2	10.2	15.7	10.2	19.7	10.9	13.2	21.6	19.7	12.8	12.9	6.3	2.9	
	2024	Avg. DO.	-	8.4	8.5	6.3	9.1	7.3	6.9	8.6	8.3	6.8	7.1	10.3	6.5	6.7	
		Index	-	2.8	2.8	0.7	0.9	0.3	0.0	0.0	0.0	0.6	14.5	1.8	1.5	2.8	
	YORK		Station	Y15	Y21	Y28	P36	P42	P45	P50	P56						
	1992-2023	Avg. DO.	6.0	5.8	5.5	5.0	5.6	5.7	5.4	6.9							
Index		1.4	3.1	7.1	9.9	5.1	11.5	18.9	0.7								
2024	Avg. DO.	6.6	7.1	5.6	5.2	6.5	6.8	6.4	9.1								
	Index	0.0	1.0	0.6	3.4	6.0	7.5	15.4	0.3								
YORK		Station				M33	M37	M41	M44	M47	M52						
	1992-2023	Avg. DO.				4.4	4.5	4.8	5.1	5.9	5.6						
		Index				9.9	11.4	7.0	10.2	6.2	1.5						
	2024	Avg. DO.				4.6	4.9	5.4	5.9	8.1	6.6						
		Index				4.6	1.5	3.2	8.9	7.1	4.2						
	RAPPAHANNOCK			R12	R21	R28	R37	R41	R44	R50	R55	R60	R65	R69	R76		
1992-2023	Avg. DO.	7.1	6.8	6.5	6.5	6.8	7.5	6.6	6.8	6.4	7.3	6.4	6.4				
	Index	0.6	0.7	4.3	3.2	5.3	12.5	25.7	49.0	6.2	5.3	2.7	0.8				
2024	Avg. DO.	7.9	8.3	7.5	8.1	9.0	10.4	7.4	7.5	7.2	8.2	8.4	6.9				
	Index	0.3	0.3	0.0	0.7	0.3	8.7	10.0	33.6	8.4	18.7	1.2	0.7				

Table 9. Striped Bass indices and average site pH during 2024 compared to average index values during the auxiliary monitoring period (1992-2006 & 2023), with corresponding average pH (Avg. pH). The York drainage includes Pamunkey and Mattaponi rivers. Index stations are indicated by bold font. Indices are calculated using only the 1st haul (Rago et al. 1995). A hyphen (-) indicates a haul was not completed (See methods). An asterisk (*) indicates a site that was not sampled during the 1992-2006 auxiliary monitoring period.

Drainage			J12	J26	J29	J36	J42	C1	C3	C4	J46	J51	J56	J62	J68	J77
JAMES		Station														
1992-2006 & 2023	Avg. pH	7.6	*	7.7	7.5	8.2	7.8	7.4	*	7.8	7.5	7.8	8.1	7.5	7.7	
	Index	2.4	*	12.8	21.8	7.9	22.2	10.1	*	23.1	17.0	9.7	9.9	6.2	3.6	
2024	Avg. pH	-	7.9	7.9	7.5	8.3	7.6	7.4	7.6	8.0	7.6	7.7	8.2	7.3	7.6	
	Index	-	2.8	2.8	0.7	0.9	0.3	0.0	0.0	0.0	0.6	14.5	1.8	1.5	2.8	
YORK		Station	Y15	Y21	Y28	P36	P42	P45	P50	P56						
1992-2006 & 2023	Avg. pH	7.5	7.4	7.1	7.0	7.0	7.1	7.1	*							
	Index	1.3	2.1	5.3	10.7	5.1	13.9	22.2	*							
2024	Avg. pH	7.7	7.7	7.3	7.2	7.2	7.3	7.2	7.7							
	Index	0.0	1.0	0.6	3.4	6.0	7.5	15.4	0.3							
1992-2006 & 2023	Station				M33	M37	M41	M44	M47	M52						
	Avg. pH				6.8	6.8	6.8	6.8	6.8	6.7						
	Index				10.9	11.3	8.4	7.8	5.3	1.6						
2024	Avg. pH				7.0	6.9	6.7	6.8	7.1	6.9						
	Index				4.6	1.5	3.2	8.9	7.1	4.2						
RAPPAHANNOCK			R12	R21	R28	R37	R41	R44	R50	R55	R60	R65	R69	R76		
1992-2006 & 2023	Avg. pH	7.8	7.7	7.6	7.5	7.3	7.7	7.3	7.4	7.4	7.8	7.3	*			
	Index	0.6	1.1	4.4	4.2	4.4	13.2	19.9	47.6	6.9	5.0	3.3	*			
2024	Avg. pH	7.9	7.9	7.7	7.8	7.8	8.3	7.4	7.4	7.3	7.6	7.1	7.0			
	Index	0.3	0.3	0.0	0.7	0.3	8.7	10.0	33.6	8.4	18.7	1.2	0.7			

Table 10. Striped Bass indices and average site Secchi during 2024 compared to average index values during the auxiliary monitoring period (1992-2023), with corresponding average Secchi (Avg. Secchi, depth in meters). The York drainage includes Pamunkey and Mattaponi rivers. Index stations are indicated by bold font. Indices are calculated using only the 1st haul (Rago et al. 1995). A hyphen (-) indicates a haul was not completed (See methods).

Drainage		Station	J12	J26	J29	J36	J42	C1	C3	C4	J46	J51	J56	J62	J68	J77
JAMES	1992-2023	Avg. Secchi Index	0.5 1.2	0.6 7.2	0.5 10.2	0.5 15.7	0.5 10.2	0.4 19.7	0.5 10.9	0.6 13.2	0.5 21.6	0.5 19.7	0.5 12.8	0.4 12.9	0.6 6.3	0.7 2.9
	2024	Avg. Secchi Index	- -	0.6 2.8	0.6 2.8	0.5 0.7	0.4 0.9	0.5 0.3	0.4 0.0	0.5 0.0	0.4 0.0	0.5 0.6	0.6 14.5	0.4 1.8	0.5 1.5	0.5 2.8
	YORK		Station	Y15	Y21	Y28	P36	P42	P45	P50	P56					
	1992-2023	Avg. Secchi Index	0.6 1.4	0.4 3.1	0.3 7.1	0.3 9.9	0.4 5.1	0.5 11.5	0.5 18.9	0.5 0.7						
2024	Avg. Secchi Index	0.5 0.0	0.4 1.0	0.3 0.6	0.2 3.4	0.3 6.0	0.5 7.5	0.6 15.4	0.4 0.3							
YORK		Station				M33	M37	M41	M44	M47	M52					
	1992-2023	Avg. Secchi Index				0.4 9.9	0.4 11.4	0.6 7.0	0.6 10.2	0.6 6.2	0.8 1.5					
		2024	Avg. Secchi Index				0.4 4.6	0.4 1.5	0.4 3.2	0.5 8.9	0.4 7.1	0.4 4.2				
	RAPPAHANNOCK		R12	R21	R28	R37	R41	R44	R50	R55	R60	R65	R69	R76		
	1992-2023	Avg. Secchi Index	0.8 0.6	0.6 0.7	0.5 4.3	0.3 3.2	0.4 5.3	0.4 12.5	0.5 25.7	0.5 49.0	0.4 6.2	0.4 5.3	0.5 2.7	0.8 0.8		
		2024	Avg. Secchi Index	0.6 0.3	0.5 0.3	0.4 0.0	0.3 0.7	0.4 0.3	0.4 8.7	0.5 10.0	0.6 33.6	0.5 8.4	0.7 18.7	0.7 1.2	0.5 0.7	

Table 11. Striped Bass indices and average site turbidity (Avg. Turbidity, FNU) during 2024. The York drainage includes Pamunkey and Mattaponi rivers. Index stations are indicated by bold font. Indices are calculated using only the 1st haul (Rago et al. 1995). A hyphen (-) indicates a haul was not completed (See methods).

Drainage		J12	J26	J29	J36	J42	C1	C3	C4	J46	J51	J56	J62	J68	J77
JAMES	Station														
	Avg. Turbidity	-	27.9	16.1	16.3	31.2	17.0	68.4	19.3	18.9	16.7	9.5	22.3	35.1	14.0
	Index	-	2.8	2.8	0.7	0.9	0.3	0.0	0.0	0.0	0.6	14.5	1.8	1.5	2.8
YORK	Station	Y15	Y21	Y28	P36	P42	P45	P50	P56						
	Avg. Turbidity	18.8	18.6	49.2	177.2	57.6	16.6	11.2	25.3						
	Index	0.0	1.0	0.6	3.4	6.0	7.5	15.4	0.3						
	Station				M33	M37	M41	M44	M47	M52					
	Avg. Turbidity				22.1	16.5	16.8	20.3	34.1	14.2					
	Index				4.6	1.5	3.2	8.9	7.1	4.2					
RAPPAHANNOCK	Station	R12	R21	R28	R37	R41	R44	R50	R55	R60	R65	R69	R76		
	Avg. Turbidity	12.2	10.7	14.0	49.3	20.9	29.4	13.8	27.7	15.2	8.2	7.8	10.9		
	Index	0.3	0.3	0.0	0.7	0.3	8.7	10.0	33.6	8.4	18.7	1.2	0.7		

Table 12. Fish species collected during the 2024 seine survey (index and auxiliary stations).

Scientific Name	Common Name	Total Caught
<i>Dorosoma petenense</i>	Threadfin Shad	6350
<i>Brevoortia tyrannus</i>	Atlantic Menhaden	4536
<i>Hudsonius hudsonius</i>	Spottail Shiner	2955
<i>Fundulus heteroclitus</i>	Mummichog	2778
<i>Menidia beryllina</i>	Inland Silverside	2204
<i>Morone americana</i>	White Perch	2089
<i>Trinectes maculatus</i>	Hogchoker	1476
<i>Fundulus diaphanus</i>	Banded Killifish	1239
<i>Anchoa mitchilli</i>	Bay Anchovy	1224
<i>Menidia menidia</i>	Atlantic Silverside	976
<i>Alosa sapidissima</i>	American Shad	898
<i>Leiostomus xanthurus</i>	Spot	887
<i>Morone saxatilis</i>	Striped Bass	766
<i>Micropogonias undulatus</i>	Atlantic Croaker	753
<i>Alosa aestivalis</i>	Blueback Herring	386
<i>Dorosoma cepedianum</i>	Gizzard Shad	295
<i>Notemigonus crysoleucas</i>	Golden Shiner	289
<i>Cyprinella analostanus</i>	Satinfin Shiner	270
<i>Hybognathus regius</i>	Eastern Silvery Minnow	238
<i>Bairdiella chrysoura</i>	Silver Perch	159
<i>Etheostoma olmstedii</i>	Tessellated Darter	152
<i>Lepomis macrochirus</i>	Bluegill	147
<i>Enneacanthus gloriosus</i>	Bluespotted Sunfish	128
<i>Micropterus salmoides</i>	Largemouth Bass	122
<i>Fundulus majalis</i>	Striped Killifish	117
<i>Mugil cephalus</i>	Striped Mullet	112
<i>Lepomis auritus</i>	Redbreast Sunfish	68
<i>Gambusia affinis</i>	Mosquitofish	46
<i>Lepomis microlophus</i>	Redear Sunfish	45
<i>Membras martinica</i>	Rough Silverside	38
<i>Notropis bifrenatus</i>	Bridle Shiner	32
<i>Ictalurus furcatus</i>	Blue Catfish	30
<i>Strongylura marina</i>	Atlantic Needlefish	25
<i>Anguilla rostrata</i>	American Eel	24
<i>Micropterus punctulatus</i>	Spotted Bass	20
<i>Sciaenops ocellatus</i>	Red Drum	18
<i>Anchoa hepsetus</i>	Striped Anchovy	18
<i>Menticirrhus americanus</i>	Southern Kingfish	15
<i>Morone saxatilis</i> age 1+	Striped Bass Age 1+	13
<i>Perca flavescens</i>	Yellow Perch	12
<i>Cynoscion regalis</i>	Weakfish	10
<i>Lepomis gibbosus</i>	Pumpkinseed	9

Table 12. (continued).

Scientific Name	Common Name	Total Caught
<i>Cynoscion nebulosus</i>	Spotted Seatrout	9
<i>Pomoxis nigromaculatus</i>	Black Crappie	8
<i>Ictalurus punctatus</i>	Channel Catfish	8
<i>Ameiurus catus</i>	White Catfish	7
<i>Alosa pseudoharengus</i>	Alewife	5
<i>Hemiramphus brasiliensis</i>	Ballyhoo	5
<i>Cyprinus carpio</i>	Common Carp	5
<i>Alosa mediocris</i>	Hickory Shad	5
<i>Lepisosteus osseus</i>	Longnose Gar	5
<i>Hypentelium nigricans</i>	Northern Hog Sucker	5
<i>Syngnathus louisianae</i>	Chain Pipefish	4
<i>Micropterus dolomieu</i>	Smallmouth Bass	4
<i>Paralichthys dentatus</i>	Summer Flounder	4
<i>Syngnathus fuscus</i>	Northern Pipefish	3
<i>Scomberomorus maculatus</i>	Spanish Mackerel	3
<i>Symphurus plagiusa</i>	Blackcheek Tonguefish	2
<i>Synodus foetens</i>	Inshore Lizardfish	2
<i>Lucania parva</i>	Rainwater Killifish	2
<i>Chaetodipterus faber</i>	Atlantic Spadefish	1
<i>Pomatomus saltatrix</i>	Bluefish	1
<i>Nocomis raneyi</i>	Bull Chub	1
<i>Peprilus paru</i>	Harvestfish	1
<i>Gobiosoma ginsburgi</i>	Seaboard Goby	1
<i>Moxostoma macrolepidotum</i>	Shorthead Redhorse	1
<i>Noturus gyrinus</i>	Tadpole Madtom	1
Total		32,062

Table 13. Delta-lognormal mean of young-of-the-year White Perch from select seine survey stations by river system and year.

Year	James River		York River		Rappahannock River		N (hauls)
	# of Fish	Delta Mean	# of Fish	Delta Mean	# of Fish	Delta Mean	
1967	341	24.6	6	0.7	256	35.4	26
1968	48	2.5	10	0.7	125	7.0	19
1969	446	21.5	106	7.2	242	14.0	39
1970	1,582	78.8	7	0.5	267	24.1	48
1971	334	16.6	17	1.5	311	23.1	44
1972	38	1.4	247	7.2	392	43.0	57
1973	34	1.3	71	4.1	296	16.0	53
1980	62	2.3	211	14.9	145	9.4	34
1981	97	2.0	18	0.7	133	9.2	41
1982	18	1.3	292	20.7	126	16.4	28
1983	162	10.8	175	10.0	128	13.9	40
1984	94	5.7	100	5.3	156	25.2	44
1985	23	1.0	88	3.2	31	2.3	25
1986	421	19.3	79	3.0	336	37.9	49
1987	712	38.9	880	61.6	1,177	60.2	63
1988	457	21.5	69	2.3	287	13.9	61
1989	424	13.0	807	28.6	1,349	49.1	104
1990	235	5.9	70	1.7	487	11.8	84
1991	296	6.3	169	4.1	387	13.3	91
1992	338	7.6	4	0.1	395	11.8	67
1993	3,812	112.2	344	7.6	1,177	46.8	113
1994	608	18.0	420	9.4	655	19.3	125
1995	741	18.9	17	0.3	418	12.3	93
1996	4,784	164.7	1,654	65.3	2,294	79.4	126
1997	1,703	59.7	305	8.0	248	6.4	102
1998	1,432	35.4	195	4.7	457	17.8	108
1999	159	3.4	1	0.0	486	13.2	67
2000	1,540	39.8	1,363	39.7	1,184	34.5	121
2001	948	20.9	799	21.0	1,126	31.6	123
2002	790	19.2	129	2.8	275	7.0	83
2003	1,364	34.8	1,132	27.6	1,849	67.4	120
2004	1,030	24.0	799	21.9	670	17.9	130
2005	1,871	55.5	579	15.6	834	28.6	122
2006	2,064	44.8	95	2.9	388	10.2	99
2007	2,896	68.4	417	22.3	830	24.8	113
2008	1,627	41.4	184	4.1	1,512	67.1	107
2009	3,825	126.6	10	0.2	1,813	79.9	90
2010	3,085	98.6	1,632	43.4	728	19.2	130
2011	15,805	694.4	4,112	136.1	4,169	164.2	140
2012	1,233	24.7	47	1.0	338	8.7	99
2013	1,640	45.0	433	10.7	623	17.2	119
2014	2,198	72.1	2,373	64.1	841	22.0	120
2015	1,518	32.6	1,621	53.4	1,017	25.3	139
2016	1,474	32.6	980	31.1	1,286	40.3	121
2017	3,804	112.8	460	10.6	2,576	101.5	126
2018	4,757	112.2	1,025	31.8	1,976	55.9	136
2019	2,961	64.6	1,746	41.4	2,529	70.3	141
2020	3,658	87.3	867	20.8	1,780	64.2	133
2021	762	17.1	867	19.8	2,205	89.2	131
2022	1,947	47.8	1,085	28.7	1,660	46.4	137
2023	1,196	23.1	166	3.5	840	20.9	117
2024	624	10.7	216	4.8	578	15.0	110

Table 14. Delta-lognormal mean of young-of-the-year Atlantic Croaker from select seine survey stations in Virginia tributaries of Chesapeake Bay by year.

Year	Total Fish	Delta Mean	N (hauls)
1980	160	5.6	18
1981	0	0	0
1982	52	1.1	5
1983	114	5.3	10
1984	17	0.5	4
1985	129	4.1	14
1986	9	0.7	4
1987	46	2.0	9
1988	10	0.6	4
1989	112	1.4	16
1990	20	0.3	2
1991	636	10.0	48
1992	717	11.5	41
1993	1,115	29.9	47
1994	862	16.7	39
1995	598	13.7	36
1996	18	0.4	3
1997	955	27.4	48
1998	840	14.5	43
1999	519	9.3	38
2000	21	0.3	10
2001	35	0.8	11
2002	146	2.2	29
2003	8	0.1	4
2004	185	4.7	20
2005	177	6.9	24
2006	399	6.7	37
2007	329	16.3	21
2008	1,306	71.9	52
2009	1,724	50.2	46
2010	76	2.0	13
2011	36	0.5	10
2012	953	22.9	49
2013	771	16.4	36
2014	9	0.2	2
2015	7	0.1	2
2016	483	13.1	23
2017	230	6.4	24
2018	65	0.6	13
2019	68	1.6	13
2020	749	11.5	40
2021	191	4.9	18
2022	229	7.3	32
2023	1,357	27.6	46
2024	568	7.7	41
Overall (1980-2023)	16,483	9.8	44 (years)

Table 15. Delta-lognormal mean of young-of-the-year Spot from select seine survey stations in Virginia tributaries of Chesapeake Bay by year.

Year	Total Fish	Delta Mean	N (hauls)
1967	73	2.3	14
1968	655	11.5	38
1969	528	9.7	50
1970	57	0.7	25
1971	704	12.1	58
1972	443	2.5	54
1973	2,306	49.0	72
1980	2,033	25.6	66
1981	739	15.8	33
1982	608	93.8	16
1983	130	5.6	17
1984	899	30.2	19
1985	406	12.3	26
1986	1,338	60.4	33
1987	161	5.1	15
1988	943	20.9	37
1989	1,319	22.4	52
1990	1,050	11.0	62
1991	1,069	12.8	74
1992	525	5.9	65
1993	961	10.8	74
1994	990	10.0	60
1995	237	2.3	40
1996	728	11.5	44
1997	1,900	25.2	78
1998	881	15.7	55
1999	888	10.9	78
2000	465	6.1	46
2001	484	6.5	53
2002	185	1.7	44
2003	470	5.9	27
2004	581	6.2	51
2005	2,711	27.5	87
2006	471	5.0	66
2007	977	16.9	77
2008	906	9.7	84
2009	1,208	14.1	73
2010	2,801	30.4	87
2011	669	12.5	60
2012	581	6.6	66
2013	635	11.8	58
2014	566	12.6	45
2015	44	0.5	11
2016	113	1.4	27
2017	221	2.6	42
2018	294	3.1	34
2019	316	3.5	43
2020	305	3.0	50
2021	547	6.4	59
2022	732	9.7	60
2023	770	8.0	65
2024	639	7.3	72
Overall (1967-2023)	39,623	13.9	51 (years)

Table 16. Delta-lognormal mean of Spottail Shiner from select seine survey stations in Virginia tributaries of Chesapeake Bay by year.

Year	Total Fish	Delta Mean	N (hauls)
1989	2,932	22.4	119
1990	2,029	15.0	107
1991	1,406	10.6	97
1992	2,357	17.3	103
1993	1,711	12.7	101
1994	2,289	18.2	112
1995	2,221	17.8	107
1996	2,195	18.0	112
1997	3,574	25.0	106
1998	2,100	15.8	101
1999	1,240	8.8	86
2000	4,886	38.9	117
2001	2,852	21.8	117
2002	1,436	10.0	75
2003	3,078	22.9	128
2004	5,271	41.4	131
2005	3,597	30.7	112
2006	3,464	28.9	107
2007	3,837	33.7	111
2008	2,156	17.9	99
2009	3,035	24.2	101
2010	3,989	27.0	105
2011	6,284	58.3	122
2012	4,022	30.8	103
2013	4,357	32.5	115
2014	3,401	25.3	125
2015	4,457	33.8	130
2016	3,407	24.9	122
2017	5,436	43.5	112
2018	6,528	60.7	125
2019	8,169	72.6	124
2020	3,436	26.0	121
2021	6,146	49.1	120
2022	6,248	45.1	118
2023	2,924	24.8	101
2024	2,196	17.0	117
Overall (1989-2023)	126,470	28.8	35 (years)

Table 17. Delta-lognormal mean of Atlantic Silverside from select seine survey stations in Virginia tributaries of Chesapeake Bay by year.

Year	Total Fish	Delta Mean	N (Hauls)
1989	1,089	10.9	41
1990	2,917	50.4	51
1991	2,855	41.0	68
1992	6,087	125.2	58
1993	2,364	31.9	59
1994	2,305	32.1	52
1995	3,079	41.2	59
1996	4,871	81.2	52
1997	1,160	13.3	55
1998	2,434	26.3	66
1999	6,822	69.4	88
2000	3,778	44.2	65
2001	4,015	54.2	73
2002	5,387	66.9	96
2003	3,351	55.1	35
2004	1,503	21.5	39
2005	1,979	22.2	69
2006	2,847	31.7	67
2007	2,067	29.5	68
2008	3,454	36.9	58
2009	2,916	37.3	72
2010	1,723	18.4	86
2011	3,585	47.7	75
2012	1,381	13.8	68
2013	6,814	93.5	59
2014	4,891	68.6	67
2015	7,542	103.0	74
2016	2,397	26.5	56
2017	5,259	80.1	73
2018	8,071	134.4	46
2019	2,561	32.1	54
2020	2,500	30.8	53
2021	1,790	19.7	61
2022	7,330	74.4	61
2023	2,621	28.9	79
2024	788	7.6	51
Overall (1989-2023)	125,745	48.4	35 (years)

Table 18. Delta-lognormal mean of Inland Silverside from select seine survey stations in Virginia tributaries of Chesapeake Bay by year.

Year	Total Fish	Delta Mean	N (Hauls)
1989	495	2.9	86
1990	594	3.7	78
1991	286	1.8	66
1992	343	1.7	62
1993	389	2.2	60
1994	174	1.0	50
1995	109	0.6	48
1996	809	5.4	62
1997	201	1.2	57
1998	214	1.3	62
1999	307	1.9	58
2000	731	5.0	79
2001	661	4.0	67
2002	498	2.9	67
2003	580	3.3	100
2004	1,125	6.7	84
2005	419	2.5	78
2006	1,184	7.7	88
2007	861	5.4	78
2008	704	3.8	92
2009	1,751	9.9	113
2010	1,507	8.6	78
2011	1,476	7.6	89
2012	962	5.2	111
2013	1,671	10.2	111
2014	1,849	10.9	107
2015	1,618	10.4	108
2016	2,160	10.9	119
2017	1,627	9.3	117
2018	1,095	6.3	105
2019	1,277	8.1	105
2020	1,686	10.3	105
2021	1,169	7.2	103
2022	3,528	20.7	131
2023	1,344	7.4	103
2024	1,546	7.8	86
Overall (1989-2023)	35,404	5.9	35 (years)

Table 19. Delta-lognormal mean of Banded Killifish from select seine survey stations in Virginia tributaries of Chesapeake Bay by year.

Year	Total Fish	Delta Mean	N (Hauls)
1989	236	1.5	47
1990	238	1.6	50
1991	263	1.9	42
1992	153	1.1	35
1993	264	2.0	41
1994	203	1.4	43
1995	287	2.1	38
1996	654	5.0	64
1997	365	2.6	60
1998	311	2.2	61
1999	297	2.1	49
2000	252	1.7	54
2001	355	2.3	70
2002	364	2.7	49
2003	802	5.7	68
2004	1,383	9.6	89
2005	715	5.6	68
2006	498	3.9	48
2007	692	5.0	75
2008	1,025	6.8	87
2009	1,208	9.0	85
2010	1,965	14.9	97
2011	1,958	13.7	88
2012	1,865	13.3	97
2013	638	4.5	70
2014	715	4.6	87
2015	879	5.5	93
2016	1,834	13.2	108
2017	697	4.6	105
2018	849	5.8	94
2019	1,714	11.4	108
2020	1,232	9.0	91
2021	1,603	11.5	102
2022	3,143	18.5	109
2023	1,134	7.8	89
2024	839	5.3	75
Overall (1989-2023)	30,791	6.1	35 (years)

Table 20. Delta-lognormal mean of Mummichog from select seine survey stations in Virginia tributaries of Chesapeake Bay by year.

Year	Total Fish	Delta Mean	N (Hauls)
1989	230	2.4	29
1990	354	3.5	30
1991	759	8.4	55
1992	797	8.1	56
1993	997	9.8	66
1994	741	8.8	45
1995	673	7.8	45
1996	1,241	13.6	60
1997	1,182	11.9	49
1998	2,039	25.0	58
1999	893	8.9	40
2000	620	5.7	51
2001	875	7.6	68
2002	5,692	100.8	56
2003	1,016	10.4	57
2004	1,539	18.1	63
2005	1,601	15.9	77
2006	1,800	21.4	55
2007	999	11.0	53
2008	1,366	11.7	64
2009	860	8.5	61
2010	2,466	25.6	75
2011	3,883	34.2	81
2012	23,115	176.6	80
2013	798	7.9	54
2014	2,034	19.8	50
2015	1,146	11.3	62
2016	14,902	178.7	73
2017	1,594	17.3	63
2018	1,142	12.3	48
2019	1,449	13.8	68
2020	1,398	17.1	55
2021	2,665	29.6	72
2022	2,630	23.1	76
2023	730	5.9	55
2024	2,313	26.2	60
Overall (1989-2023)	86,226	25.5	35 (years)

FIGURES

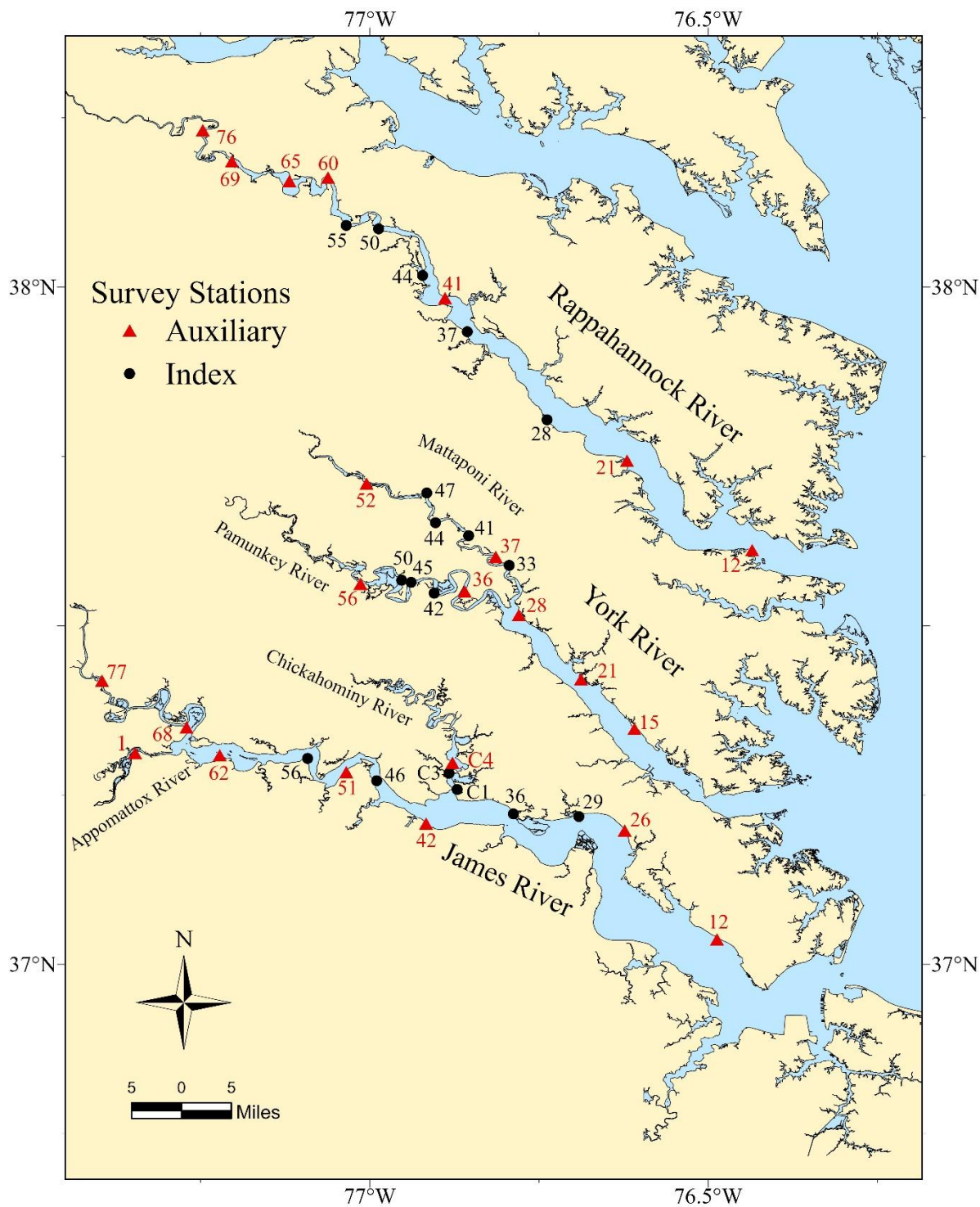


Figure 1. Juvenile Striped Bass seine survey stations. Station numbers denote the approximate river mile from the mouth.

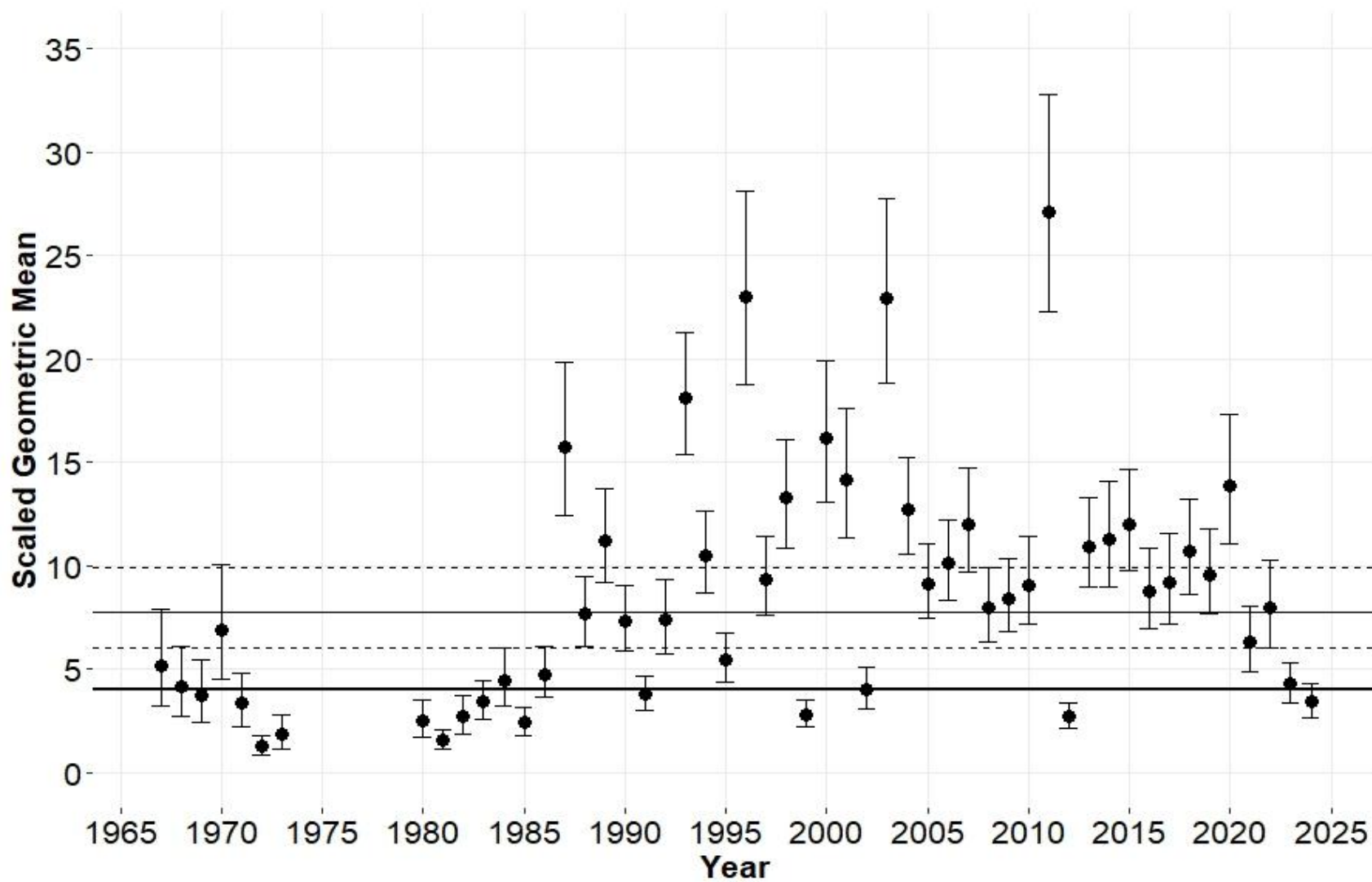


Figure 2. Scaled geometric mean of young-of-the-year Striped Bass in the primary nursery areas of Virginia (index stations) by year. Vertical bars are 95% confidence intervals as estimated by ± 2 standard errors of the mean. Horizontal lines indicate the arithmetic mean (thin solid), confidence intervals (dashed) and 1st quartile (thick solid) during the reference period from 1980-2009 (ASMFC 2010).

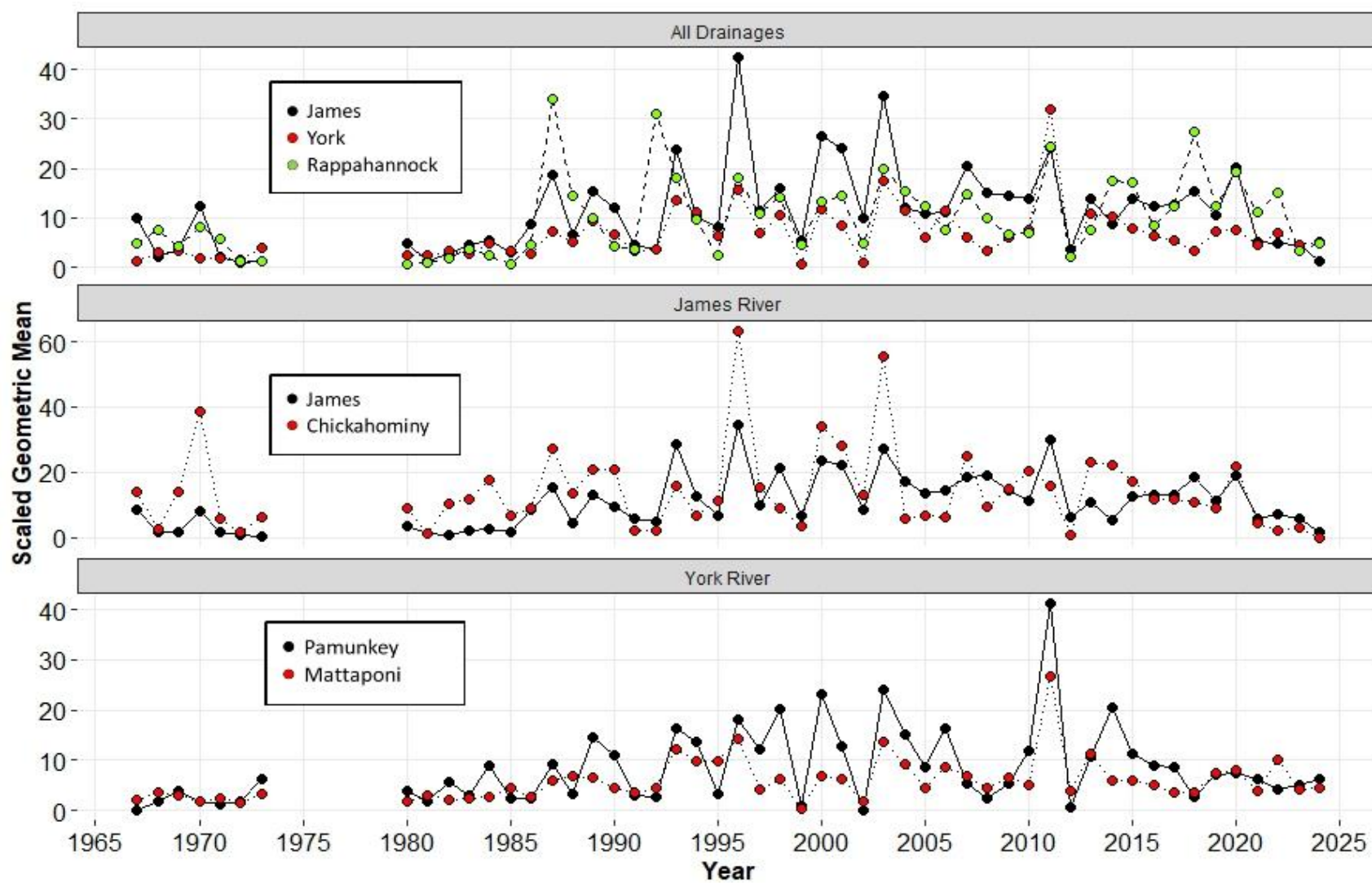


Figure 3. Scaled geometric mean of young-of-the-year Striped Bass in the primary nursery areas of Virginia (index stations) by drainage and river.

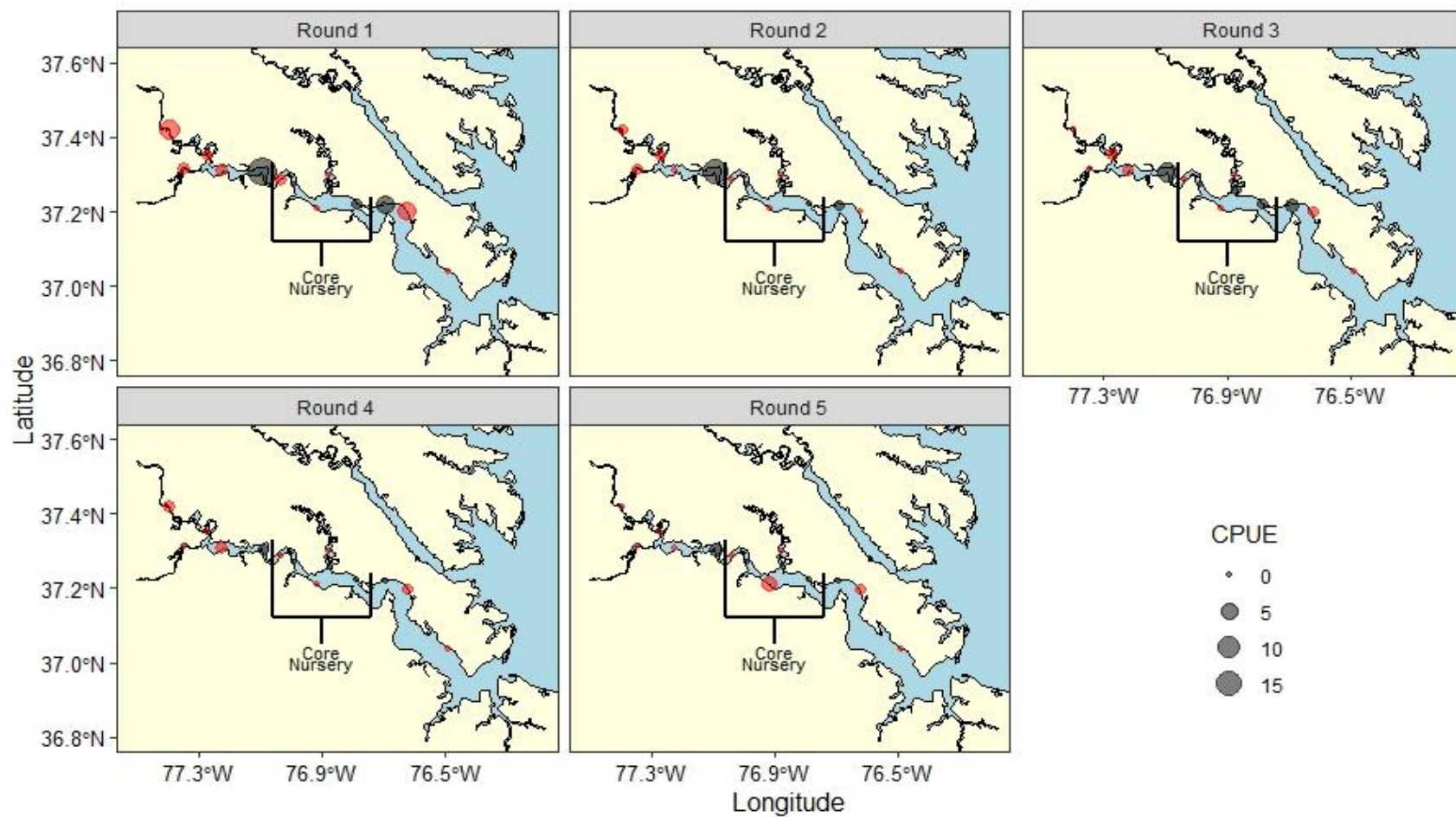


Figure 4. Catch per unit effort of juvenile Striped Bass by station in the James River drainage during each round in 2024. Data are shown for index (black) and auxiliary (red) stations, using the first haul only. The core nursery area is delineated by thick black lines.

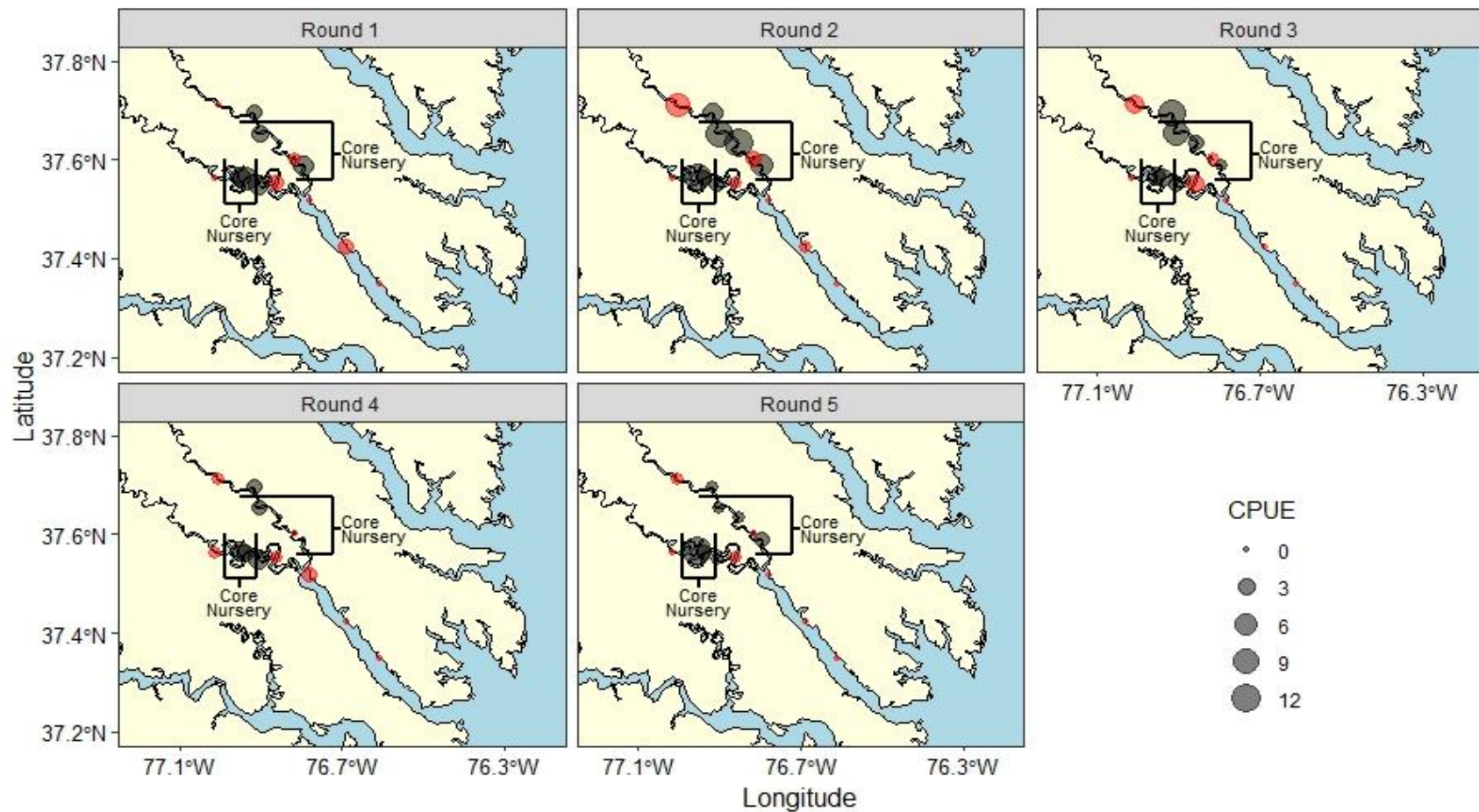


Figure 5. Catch per unit effort of juvenile Striped Bass by station in the York River drainage during each round in 2024. Data are shown for index (black) and auxiliary (red) stations, using the first haul only. Core nursery areas in the Pamunkey and Mattaponi rivers are delineated by thick black lines.

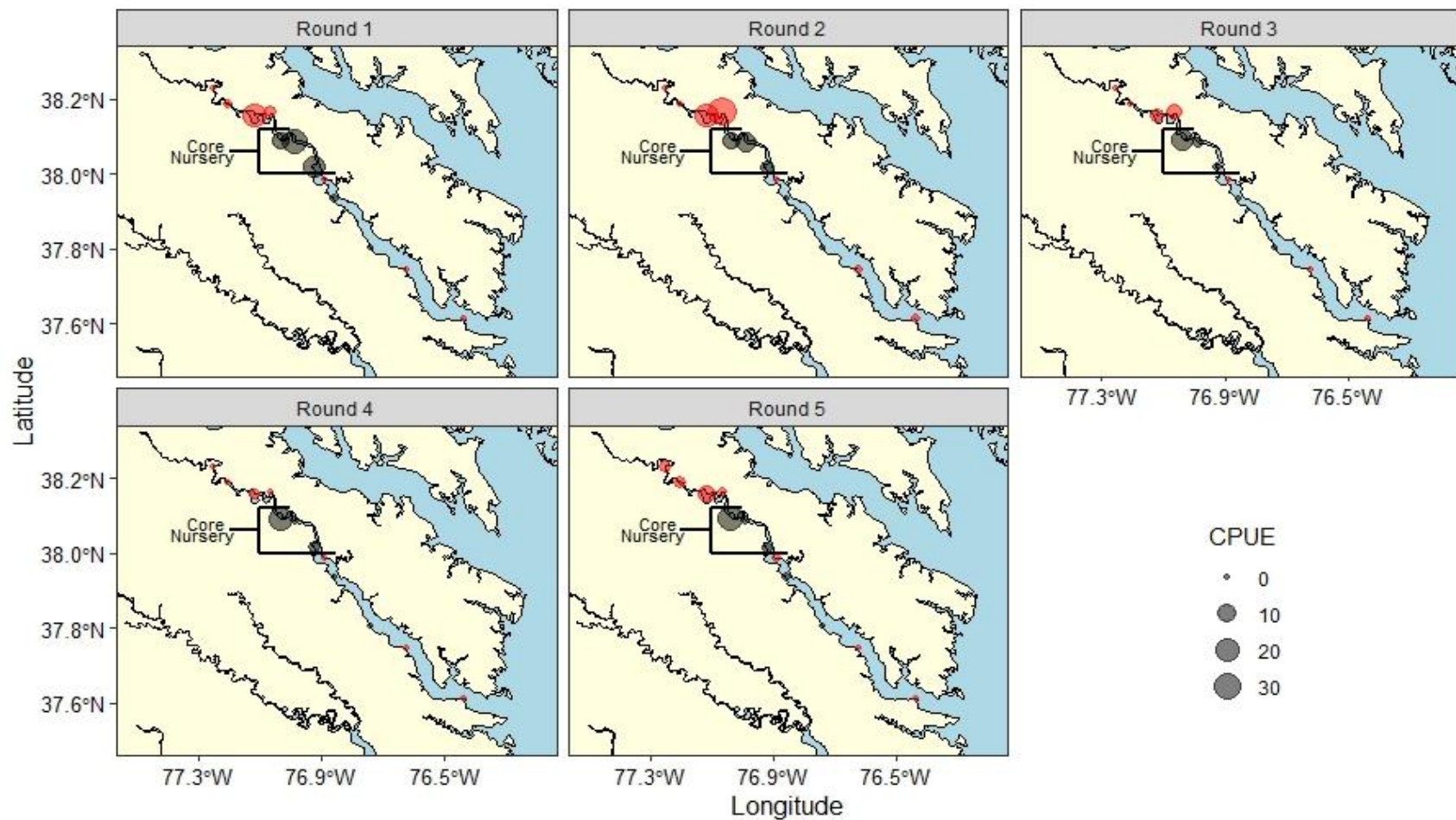


Figure 6. Catch per unit effort of juvenile Striped Bass by station in the Rappahannock River drainage during each round in 2024. Data are shown index (black) and auxiliary (red) stations, using the first haul only. The core nursery area is delineated by thick black lines.

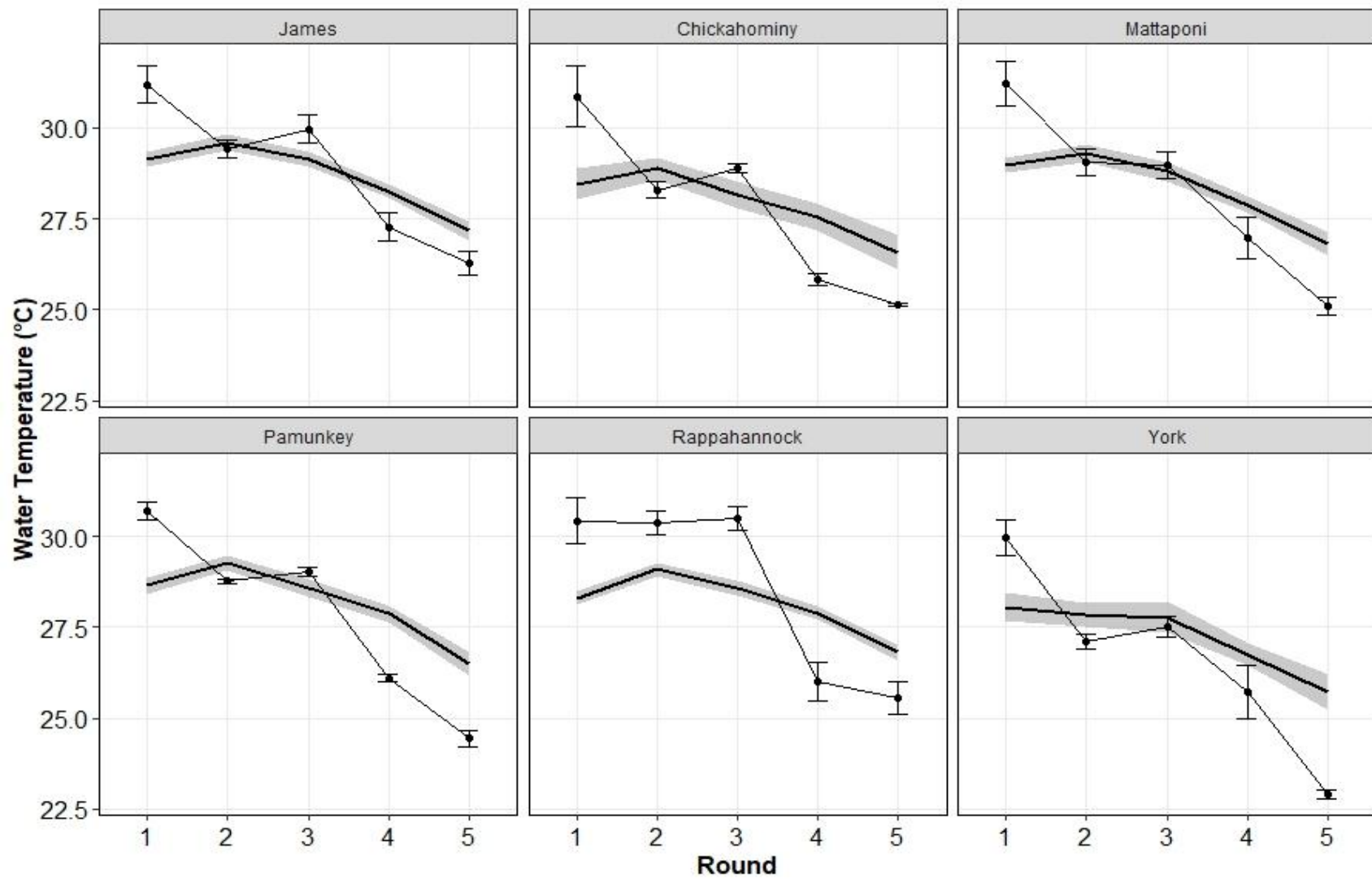


Figure 7. Mean water temperature and 95% confidence intervals during each round (x-axis) in each river during 2024 (thin line and error bars) and the auxiliary monitoring period from 1989-2023 (thick line and shaded region).

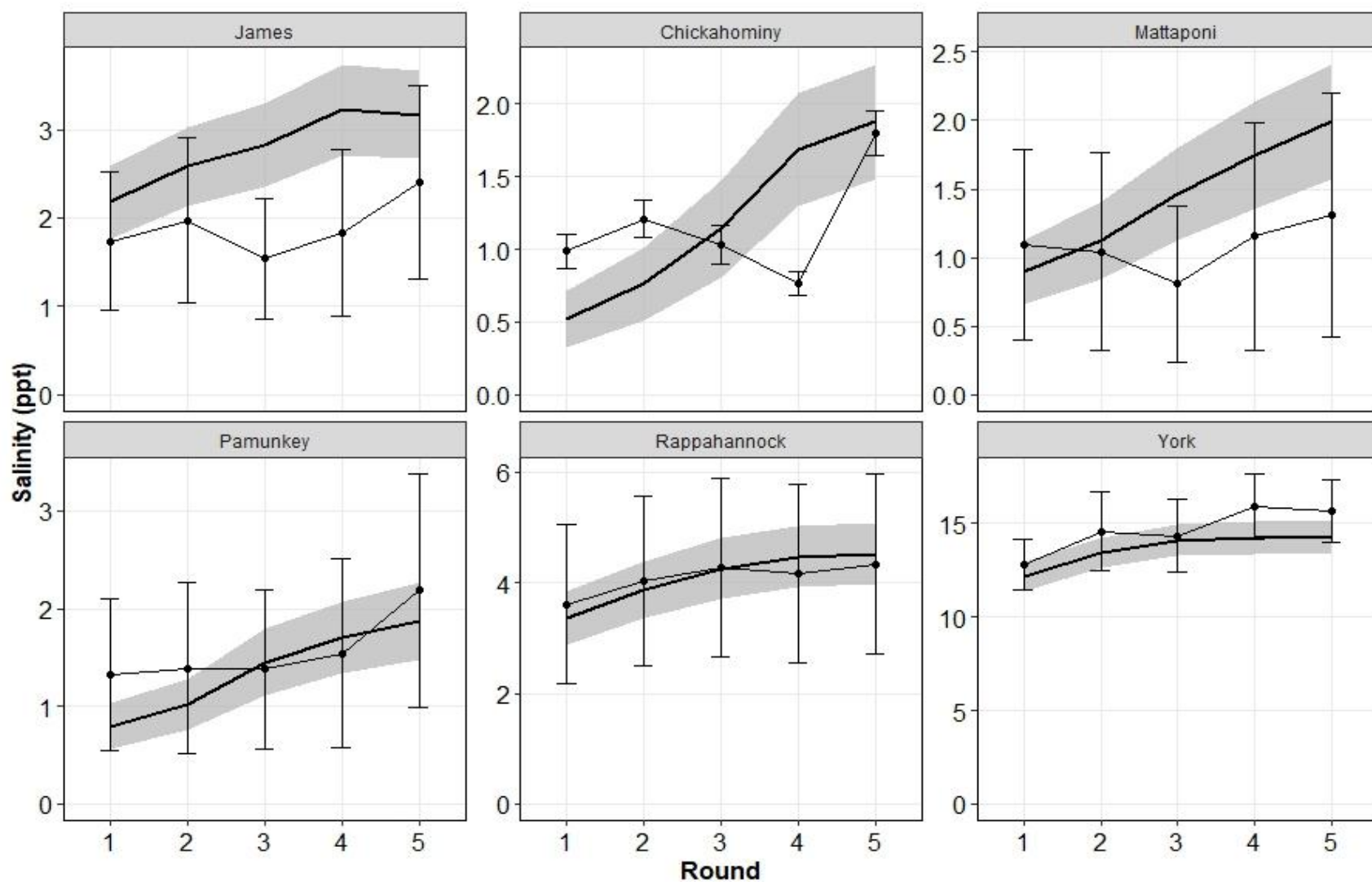


Figure 8. Mean salinity and 95% confidence intervals during each round (x-axis) in each river during 2024 (thin line and error bars) and the auxiliary monitoring period from 1989-2023 (thick line and shaded region). Note that the scale of the y-axis varies by river.

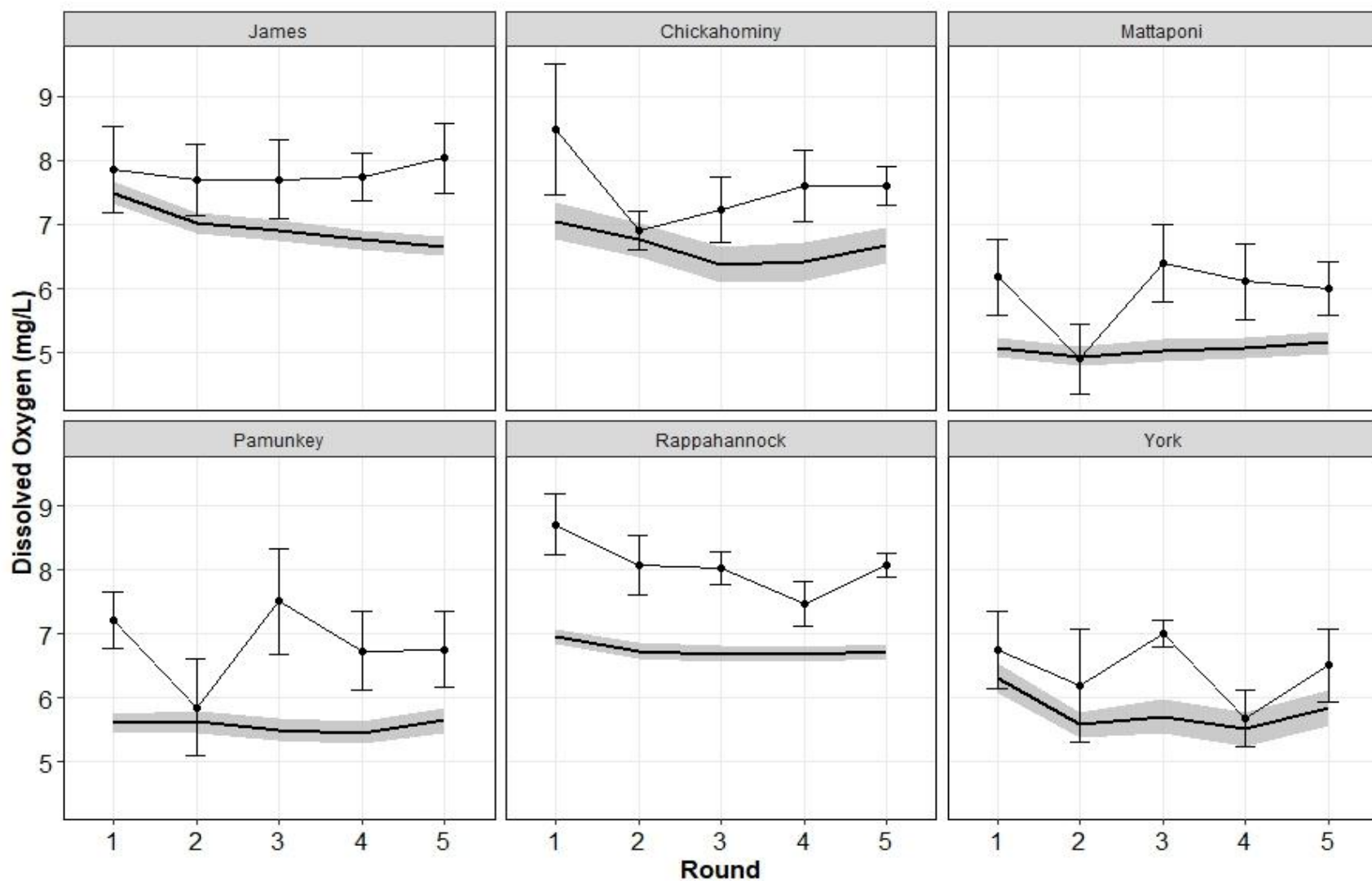


Figure 9. Mean dissolved oxygen and 95% confidence intervals during each round (x-axis) in each river during 2024 (thin line and error bars) and the monitoring period from 1992-2023 (thick line and shaded region). Note that dissolved oxygen was not measured on the seine survey before 1992.

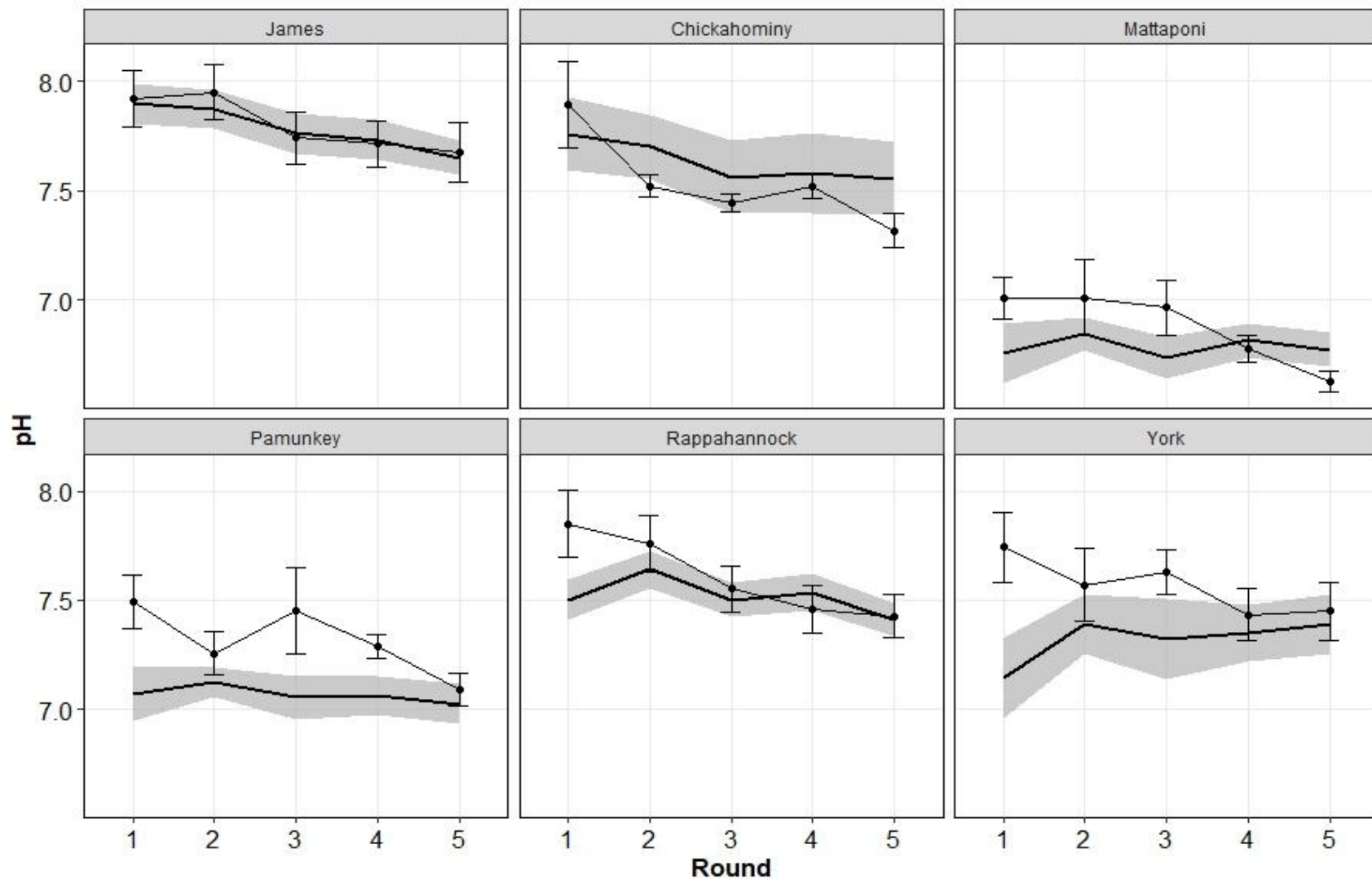


Figure 10. Mean pH and 95% confidence intervals during each round (x-axis) in each river during 2024 (thin line and error bars) and the monitoring period from 1992-2006 & 2023 (thick line and shaded region). Note that pH was not measured on the seine survey before 1992 and was stopped during 2006.

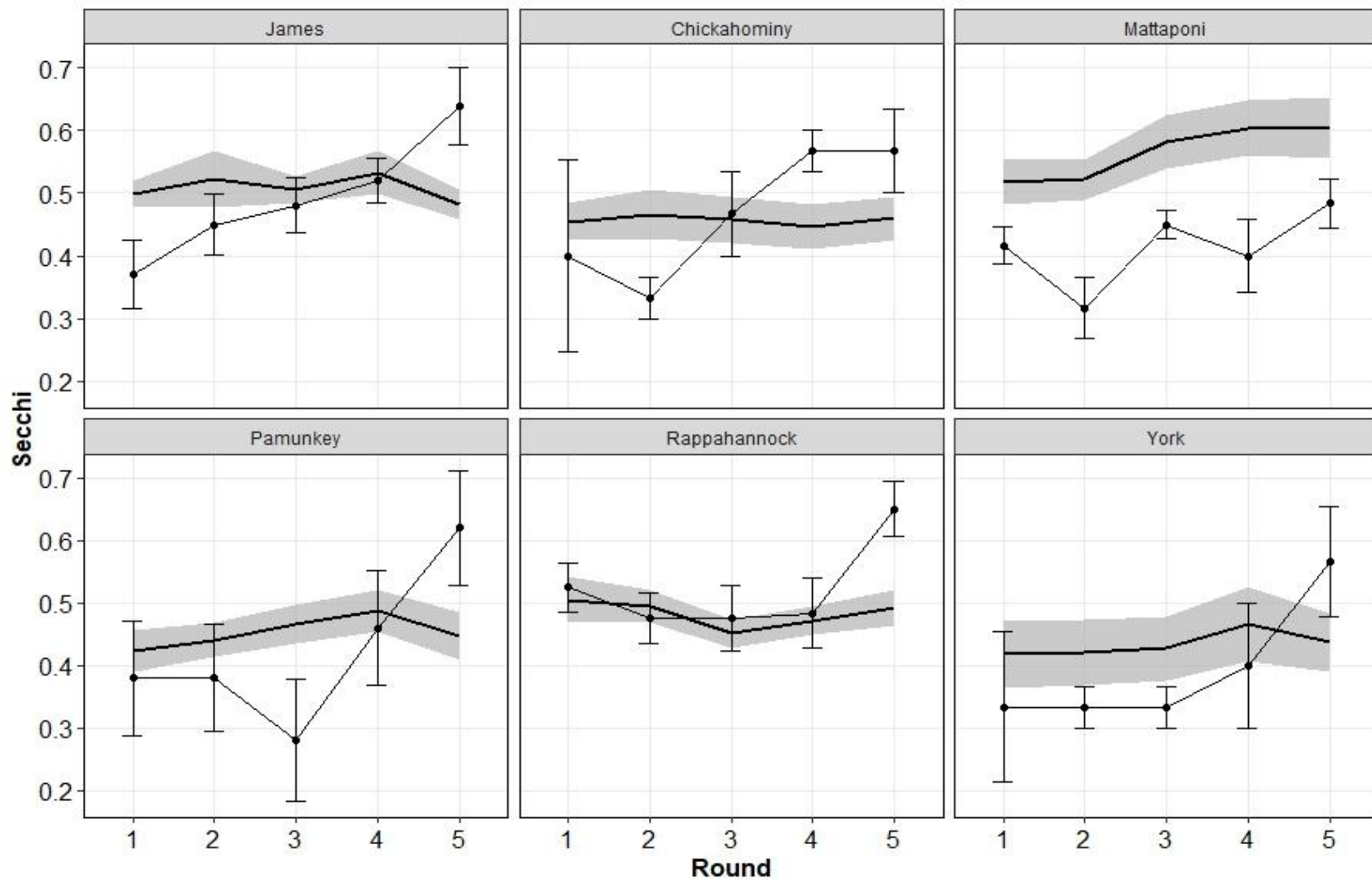


Figure 11. Mean Secchi and 95% confidence intervals during each round (x-axis) in each river during 2024 (thin line and error bars) and the monitoring period from 1992-2023 (thick line and shaded region). Note that Secchi was not measured on the seine survey before 1992.

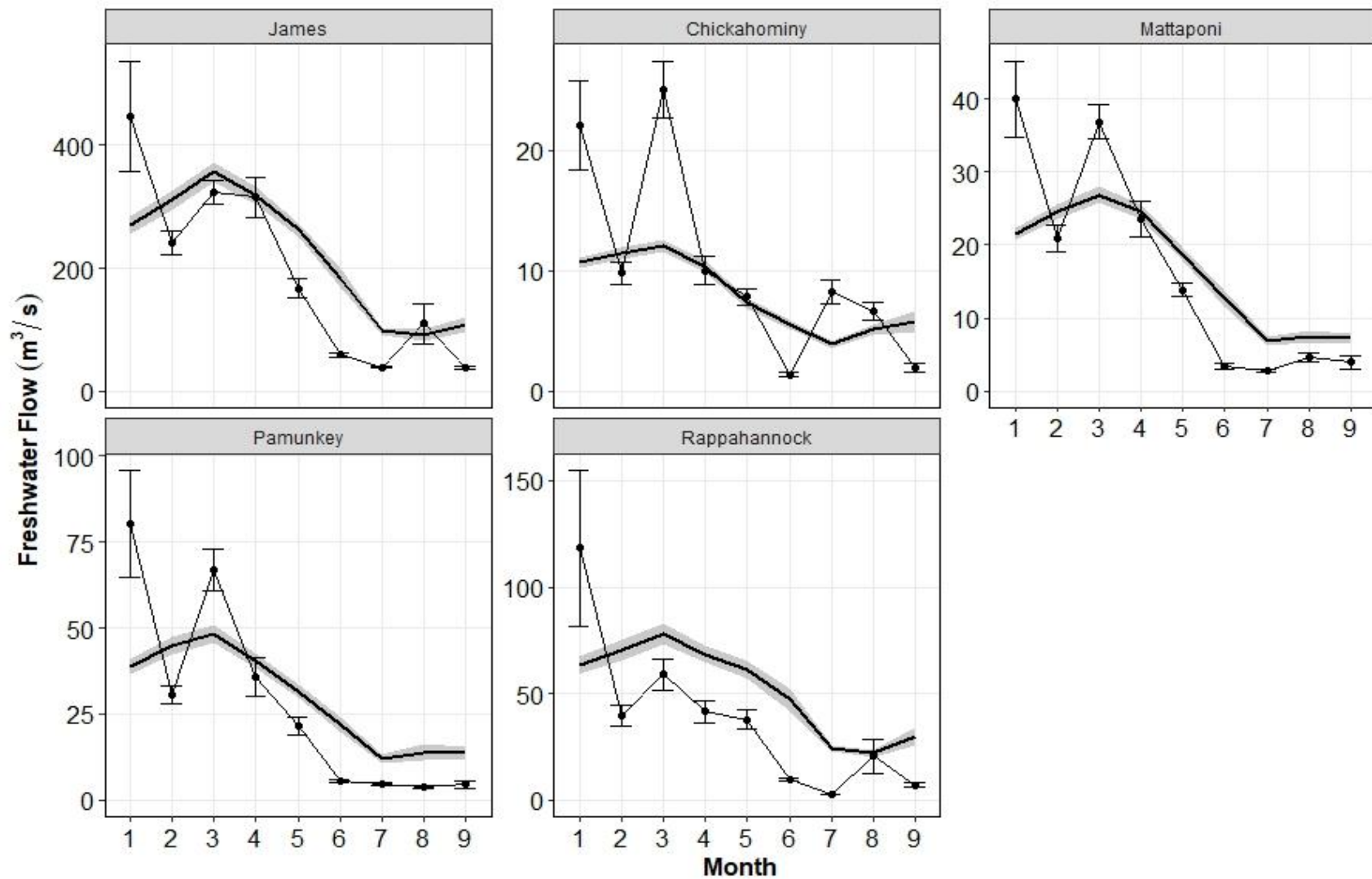


Figure 12. Mean freshwater flow and 95% confidence intervals during each month from January to September (x-axis) in each river during 2024 (thin line and error bars) and the historical monitoring period from 1967-2023 (thick line and shaded region). Note that the scale varies by river. Data are from USGS (2024).

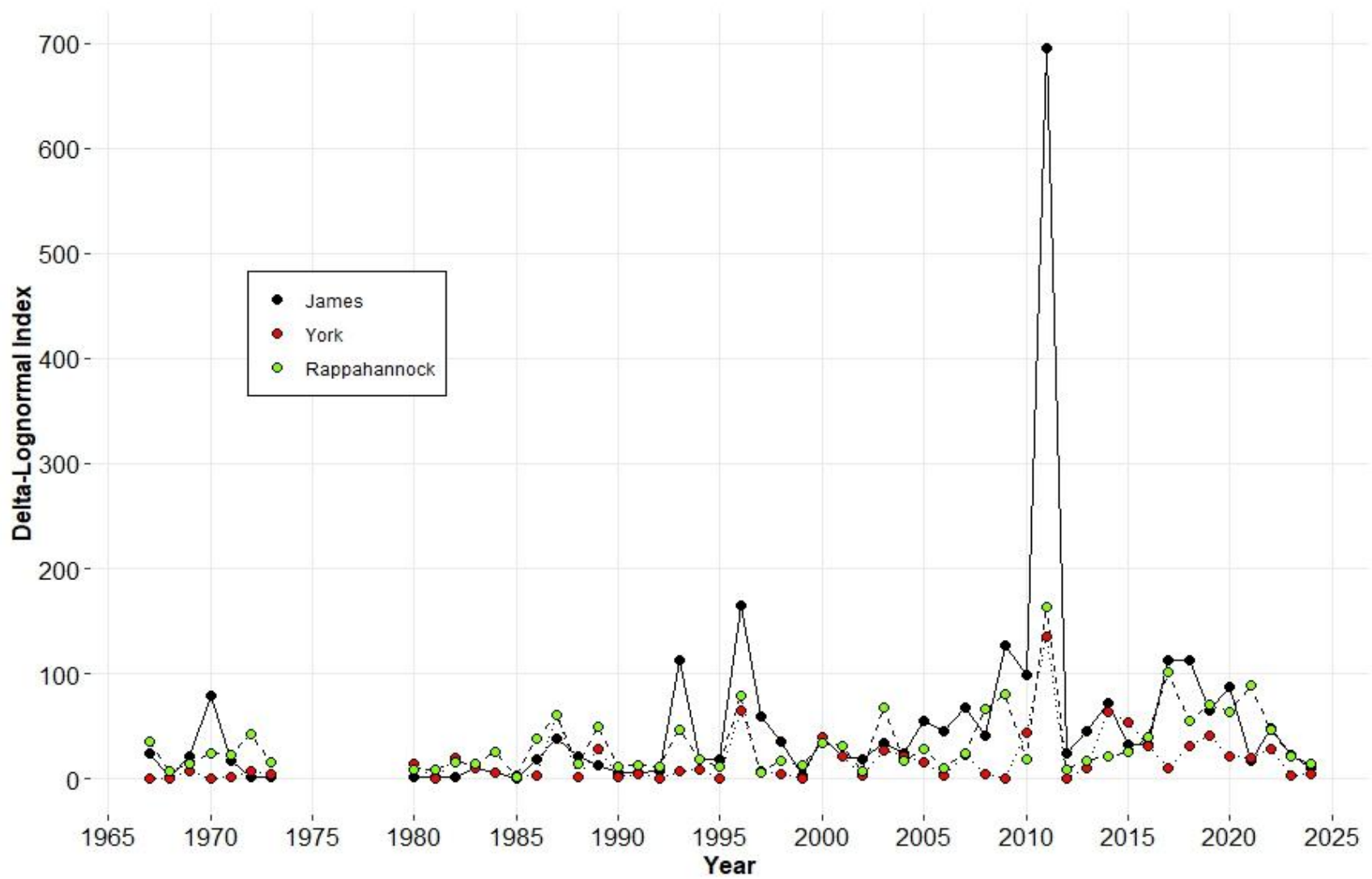


Figure 13. Delta-lognormal mean of young-of-the-year White Perch from select seine survey stations by drainage and year.

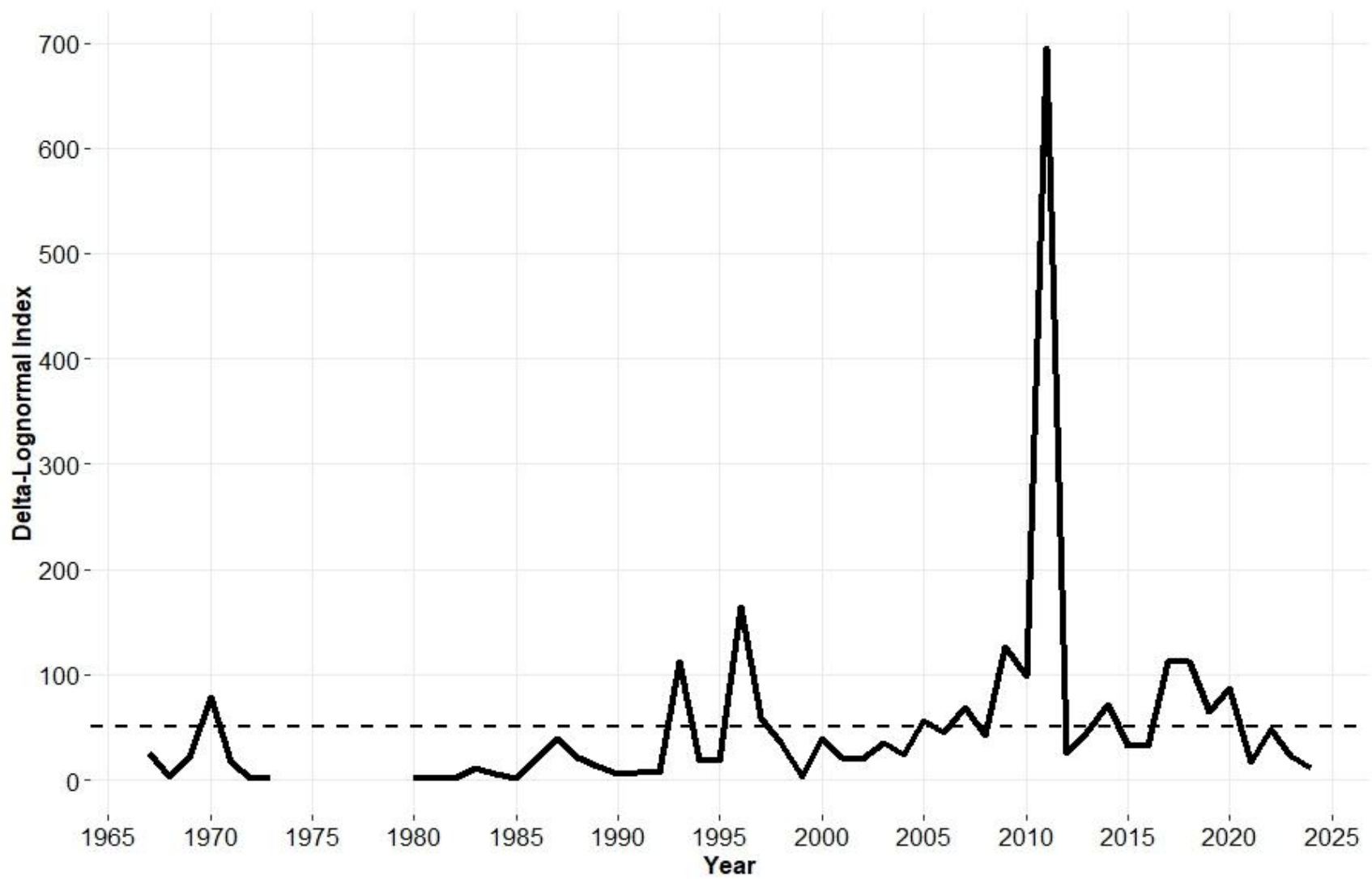


Figure 14. Delta-lognormal mean of young-of-the-year White Perch from the James River nursery area from 1967-2024. The time series average is shown by the horizontal line.

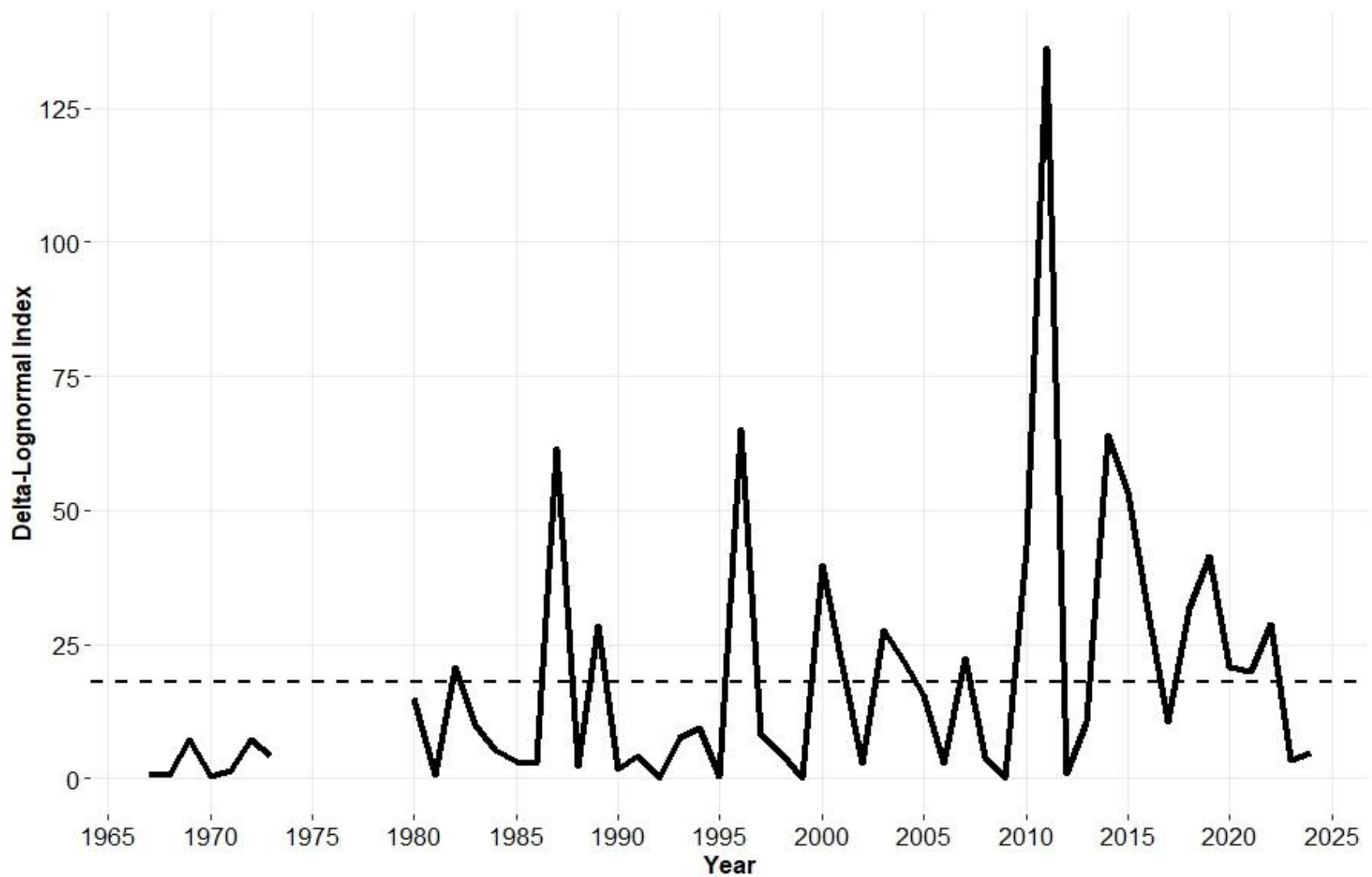


Figure 15. Delta-lognormal mean of young-of-the-year White Perch from the York River nursery area from 1967-2024. The time series average is shown by the horizontal line.

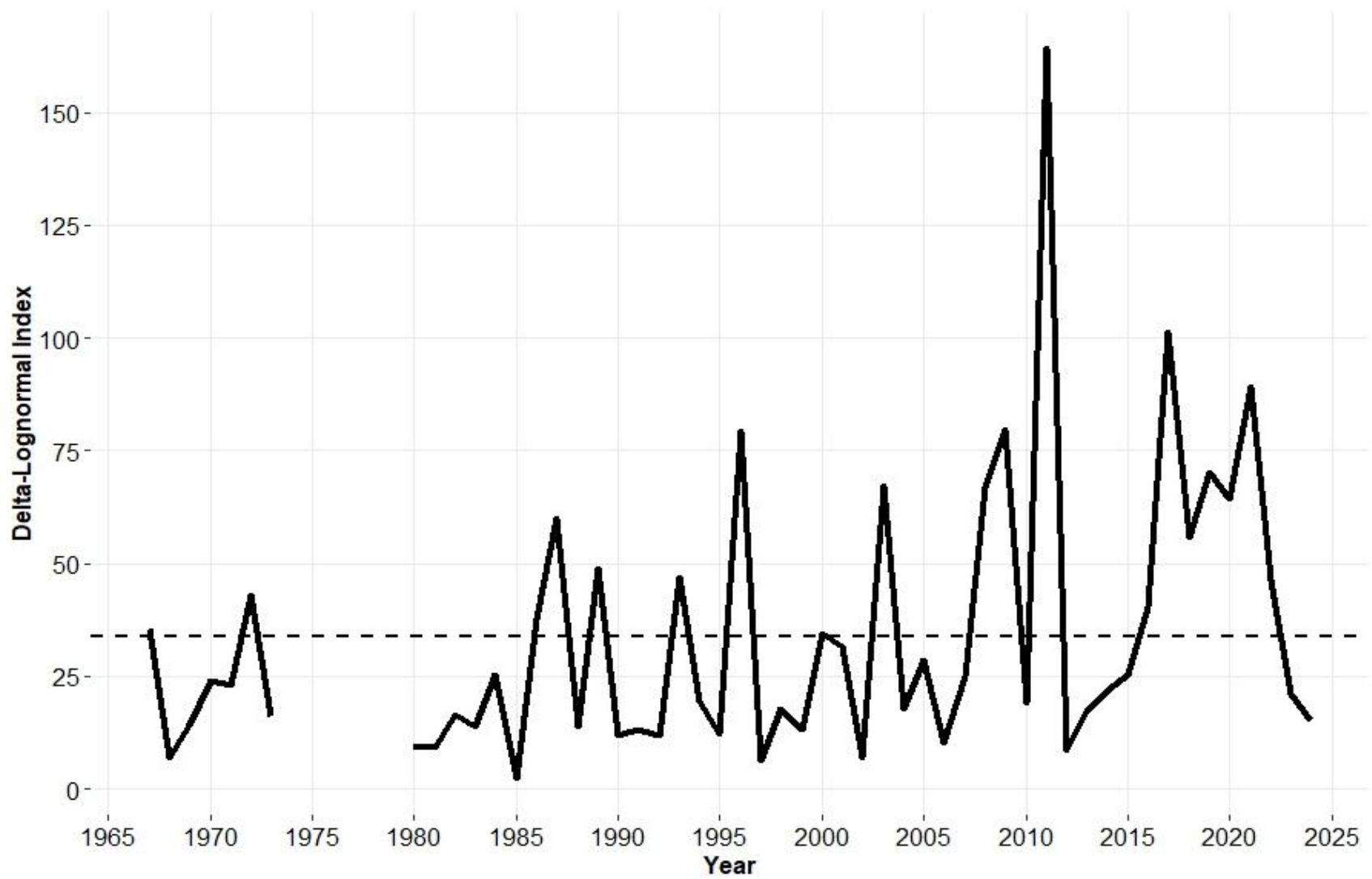


Figure 16. Delta-lognormal mean of young-of-the-year White Perch from the Rappahannock River nursery area from 1967-2024. The time series average is shown by the horizontal line.

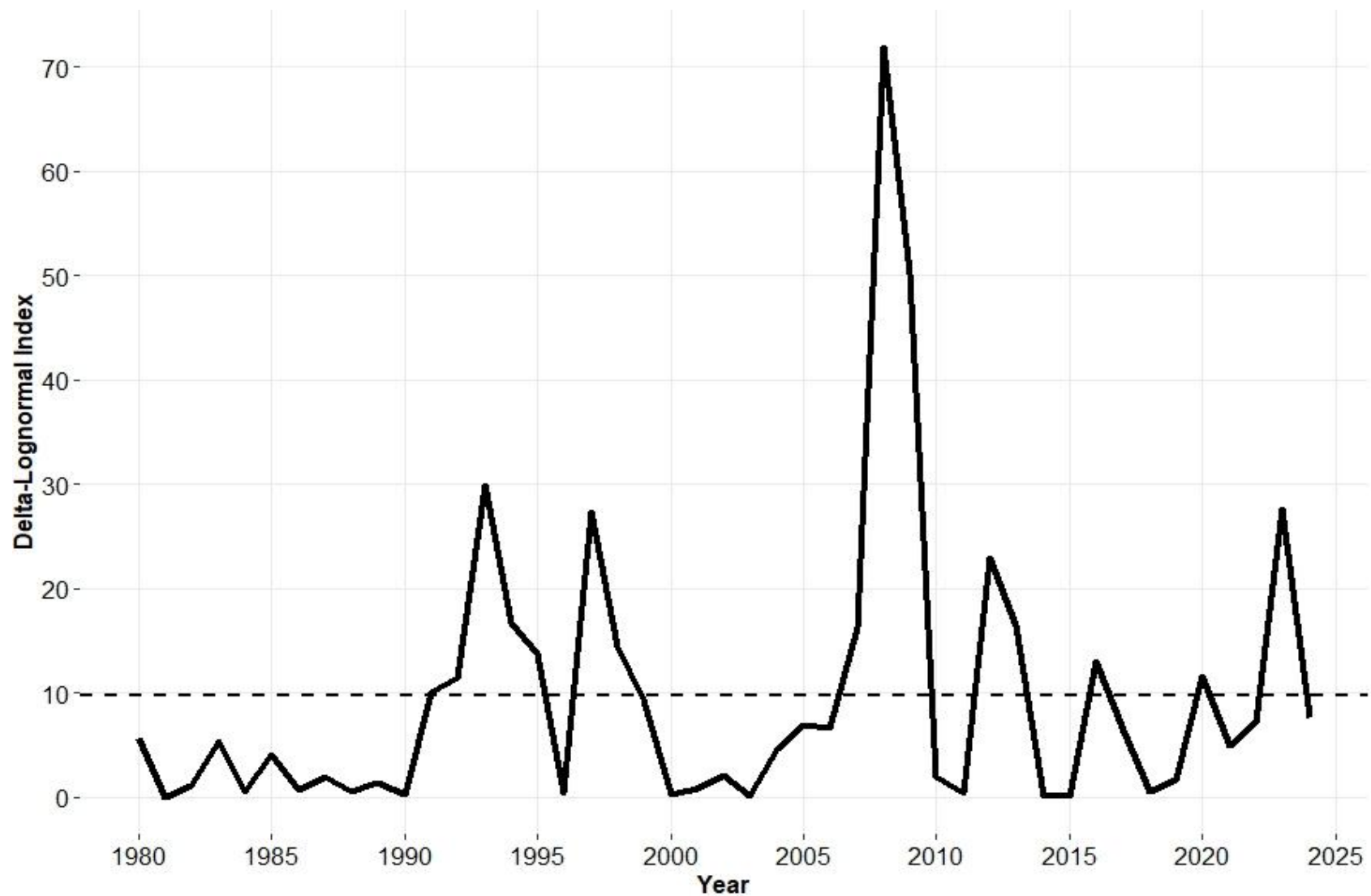


Figure 17. Delta-lognormal mean of young-of-the-year Atlantic Croaker from select seine survey stations in Virginia tributaries of Chesapeake Bay from 1980-2024. The time series average is shown by the horizontal line.

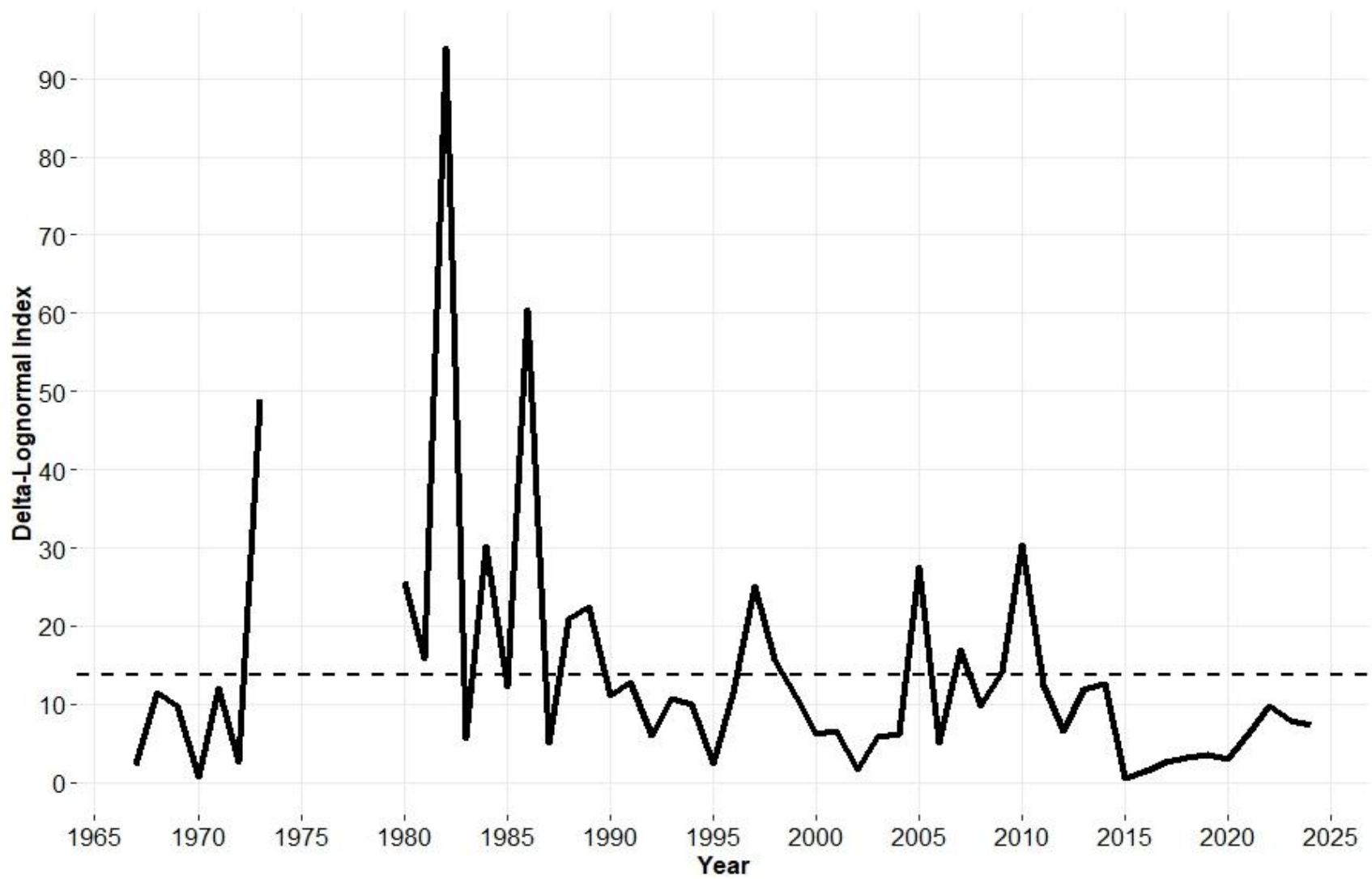


Figure 18. Delta-lognormal mean of young-of-the-year Spot from select seine survey stations in Virginia tributaries of Chesapeake Bay from 1967-2024. The time series average is shown by the horizontal line.

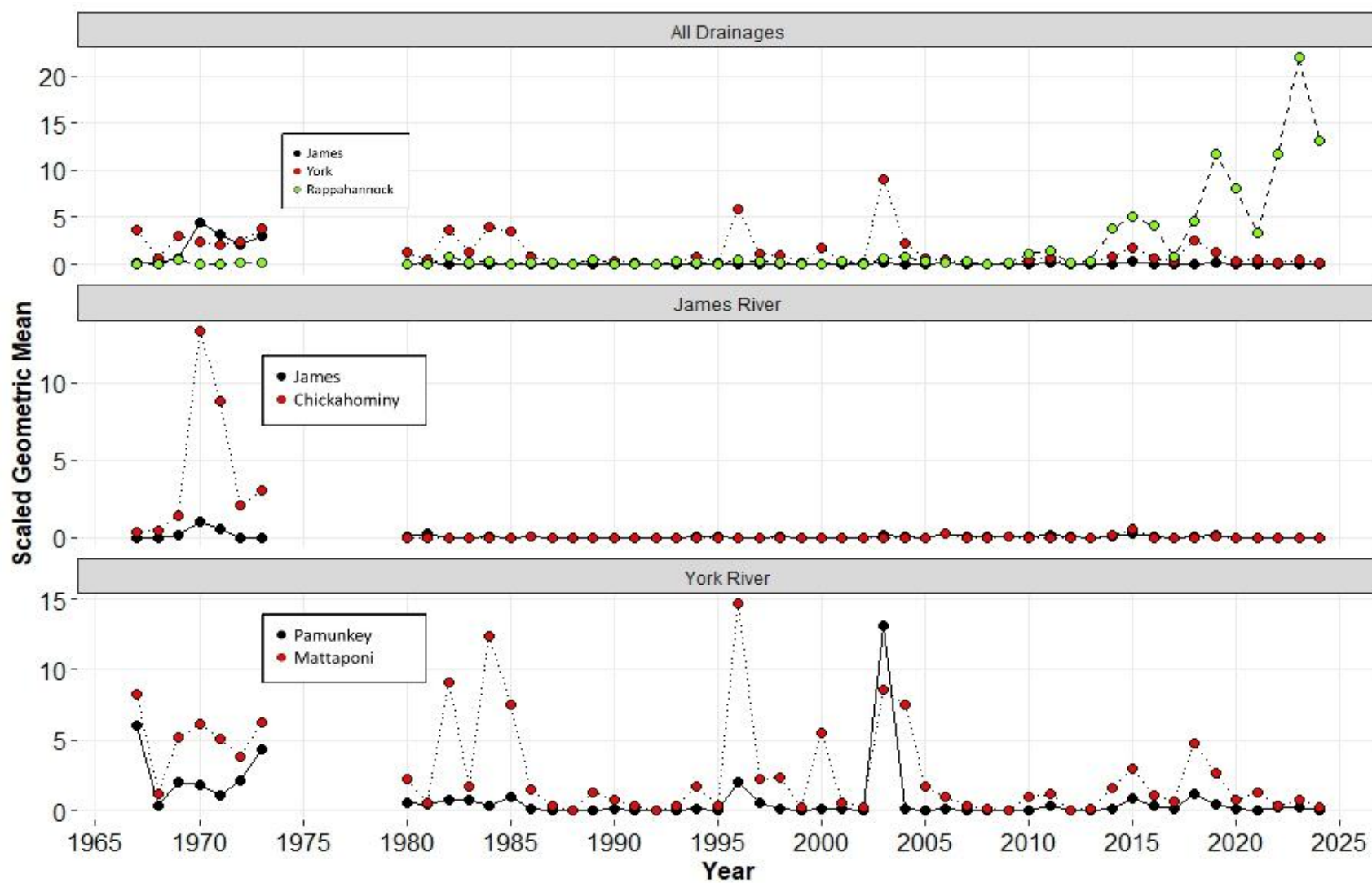


Figure 19. Scaled geometric mean of American Shad in the primary nursery areas of Virginia by drainage and river.

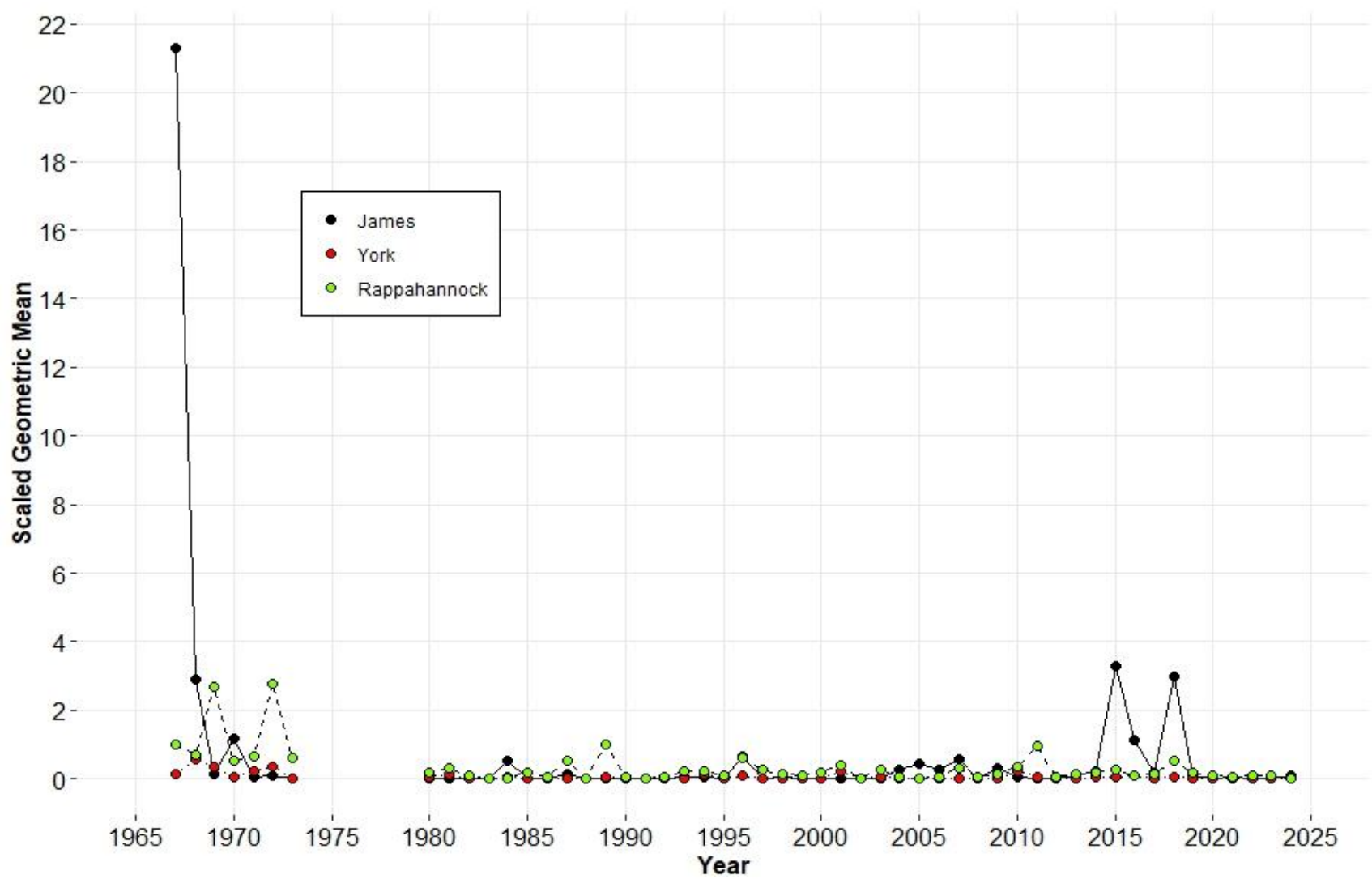


Figure 20. Scaled geometric mean of Alewife in the primary nursery areas of Virginia by drainage, using the first haul only.

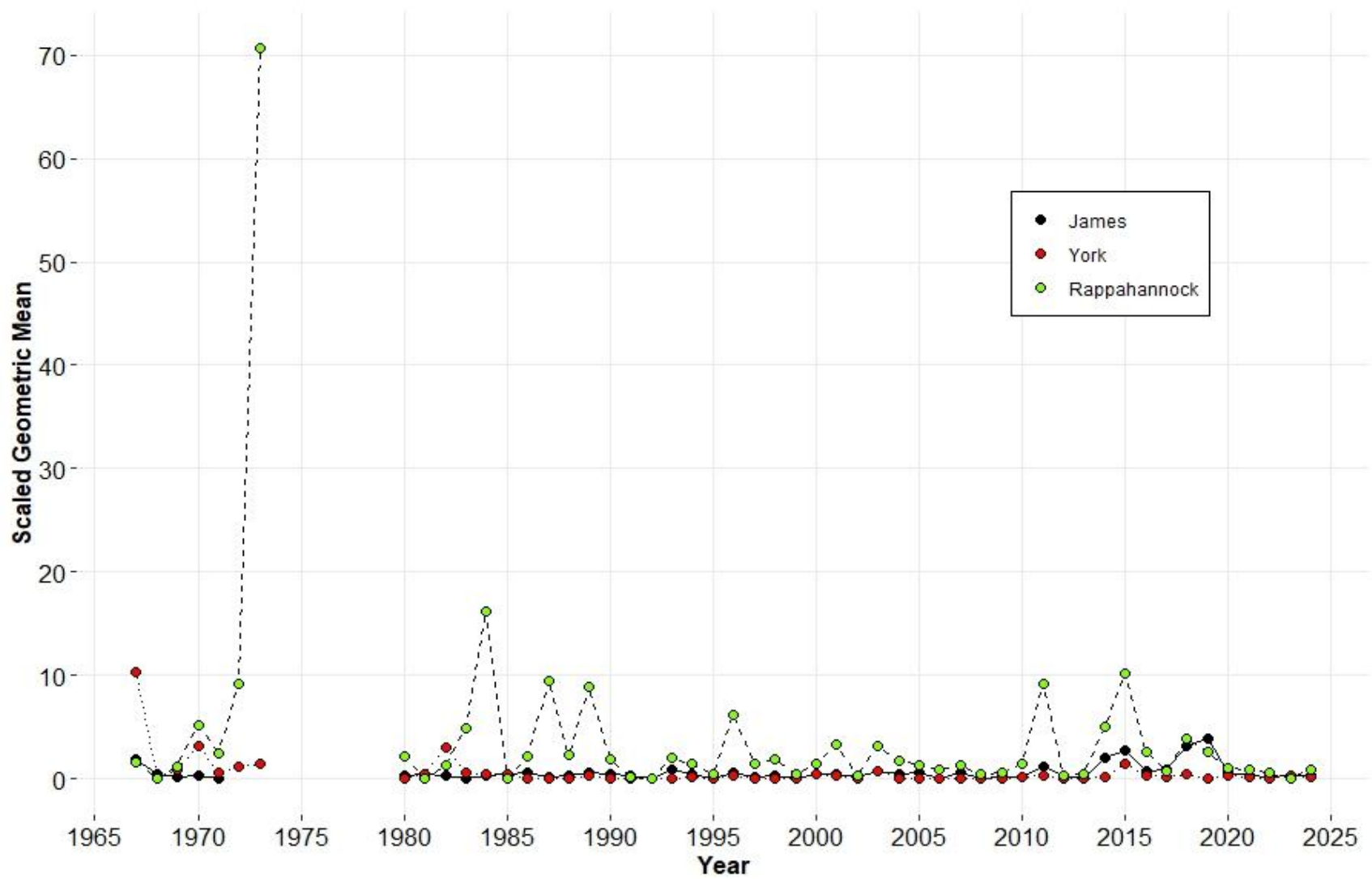


Figure 21. Scaled geometric mean of Blueback Herring in the primary nursery areas of Virginia by drainage, using the first haul only.