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2014 ANNUAL REPORT

Estimating Relative Juvenile Abundance of Ecologically Important Finfish in the Virginia Portion of Chesapeake Bay

Prepared by:
Troy D. Tuckey
Mary C. Fabrizio

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Virginia Institute of Marine Science

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Estimating Relative Juvenile Abundance of Ecologically Important Finfish in the Virginia Portion of Chesapeake Bay (1 June 2013 – 31 May 2014)

Project Number: F-104-R-18

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This project was supported by the Virginia Marine Resources Commission, Project No. F-104-R-18.

DISCLAIMER

Some of the results contained in this report are preliminary and may therefore contain errors and/or need further refinement.

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EXECUTIVE SUMMARY

June 2013 – May 2014

The juvenile fish trawl survey conducted by the Virginia Institute of Marine Science (VIMS) is the oldest continuing monitoring program (59 years) for marine and estuarine fishes in the United States. This survey provides a monthly assessment of abundance of juvenile marine and estuarine fishes and crustaceans in the tidal rivers and main stem of Chesapeake Bay. The survey provides crucial data to state, regional, and national fisheries management agencies, including the Virginia Marine Resources Commission (VMRC), the Atlantic States Marine Fisheries Commission (ASMFC), the Mid-Atlantic Fisheries Management Council (MAFMC), and the National Marine Fisheries Service (NMFS). The MAFMC recognizes the VIMS Juvenile Trawl Survey as one of the key predictors of Summer Flounder recruitment.

Several annual indices of juvenile abundance have been generated from Trawl Survey data for species of key recreational, ecological, and commercial importance in the Virginia portion of Chesapeake Bay. These include Spot, Atlantic Croaker, Weakfish, Summer Flounder, Black Sea Bass, Scup, Striped Bass, White Perch, White Catfish, Channel Catfish, Blue Catfish, Silver Perch, American Eel, and Bay Anchovy. Historically, four estimates of relative abundance were developed and reported for each species in the survey. However, only the unconverted indices (Random Stratified Index – RSI, 1988 to present) for the target species are the focus of this report. We chose to use this index because it is based on data collected from a random stratified survey design with consistent spatial and temporal domains over the time period 1988 - present. Furthermore, gear changes since 1988 were minor and inconsequential (replacement of standard trawl doors with China-V doors in 1991), thus, the index can be calculated without the use of gear-conversion factors.

We completed all planned tows (n = 1,224 tows) in 2013–2014. We collected 488,344 fishes and Bay Anchovy continue to be the most abundant species observed in the survey, accounting for 55.4% of all fishes collected. Of the target species for which we provide indices of relative abundance, 8 species categories (considering YOY and Age 1+ as separate categories) exhibited below-average abundance in 2013 – 2014 (American Eel, Atlantic Croaker, Black Sea Bass, Channel Catfish - juveniles and age 1+, Scup, and White Catfish - juveniles and age 1+), 6 exhibited average abundances (Bay Anchovy, Silver Perch, Spot, Summer Flounder, White Perch – juveniles and age 1+), and 3 species categories exhibited above-average abundance (Blue Catfish juveniles in all three tributaries, Striped Bass, and Weakfish). Adult Blue Catfish indices exhibited near-record levels of abundance in the York River for the third year in a row and lower-than-average levels in the James and Rappahannock rivers.

INTRODUCTION

Relative abundance estimates of early juvenile (age-0) fishes and invertebrates generated from fishery-independent survey programs provide a reliable and early indicator of year-class strength (Goodyear, 1985), and may be used to evaluate the efficacy of management actions. The Chesapeake Bay Stock Assessment Committee (CBSAC) reviewed available indices of juvenile abundance for important fishery resources in Chesapeake Bay (hereafter referred to as the "Bay") and recommended that "a unified, consistent trawl program should be one of the primary monitoring tools for finfish and crab stock assessment" (Chesapeake Bay Program Stock Assessment Plan, Chesapeake Executive Council, 1988). Subsequently, pilot studies directed at developing a comprehensive trawl survey for the Chesapeake Bay began at VIMS with monthly trawl sampling in the main stem of the lower Bay. This effort complemented and expanded the monthly trawl sampling conducted in major Virginia tributaries (James, York, and Rappahannock rivers) by the Virginia Institute of Marine Science (VIMS).

The present sampling program, which includes the Bay and its tributaries, ensures that data are of sufficient geographic coverage to generate relative abundance indices for recreationally, commercially, and ecologically important finfishes and invertebrates. The National Marine Fisheries Service Marine Recreational Information Program shows that recent recreational catches in Virginia are dominated by Atlantic Croaker (*Micropogonias undulatus*), Summer Flounder (*Paralichthys dentatus*), Spot (*Leiostomus xanthurus*), Striped Bass (*Morone saxatilis*), Black Sea Bass (*Centropristis striata*), Bluefish (*Pomatomus saltatrix*), Pigfish (*Orthopristis chrysoptera*), Weakfish (*Cynoscion regalis*), and Kingfishes (*Menticirrhus* spp.). These species depend on the lower Chesapeake Bay and its tributaries as nursery areas and, with the exception of Bluefish, are highly vulnerable to bottom trawls. Additional species of recreational interest, such as Scup (*Stenotomus chrysops*), White Perch (*Morone americana*), Silver Perch *(Bairdiella chrysoura)*, White Catfish (*Ameiurus catus)*, Channel Catfish (*Ictalurus punctatus)* and Blue Catfish (*I. furcatus*), are also taken with sufficient regularity during trawling operations to provide information suitable for the generation of juvenile abundance indices. Many species of interest are captured in significant numbers across several year classes. As a result, both juvenile and age 1+ (i.e., all fish older than age 0) indices are reported for White Perch, White Catfish, Channel Catfish, and Blue Catfish.

Although annual juvenile indices are the primary focus of this project, survey results can be used to address other aspects of finfish population biology, such as habitat utilization, early growth and survival, environmental effects on recruitment, or disease prevalence. For example, episodic climatic events, such as hurricanes, affect recruitment of shelf-spawning species such as Atlantic Croaker (Montane and Austin, 2005). Additionally, Tuckey and Fabrizio (2013) used trawl survey data to examine the influence of survey design on fish assemblages comparing fishes captured from fixed sites with those captured at random sites.

The development of juvenile indices requires a continuous time series of data to determine the most appropriate area-time sequences for index calculations. Provisional annual juvenile abundance indices were developed for Spot, Weakfish, Atlantic Croaker, Summer Flounder, and Black Sea Bass (Colvocoresses and Geer, 1991), followed by Scup (Colvocoresses et al., 1992), White Perch and Striped Bass (Geer et al., 1994), and White Catfish, Channel Catfish, and Silver Perch (Geer and Austin, 1994). More recently, Blue Catfish, American Eel (*Anguilla rostrata*), and Bay Anchovy (*Anchoa mitchilli*) indices were developed. Through the use of gear conversion factors and post stratification, a time series of index values can be produced back to 1955 for many species (Geer and Austin, 1997).

This report summarizes the activity of the VIMS Juvenile Finfish Trawl Survey from June 2013 through May 2014. Abundance indices are provided from 1988 to the present, along with the mean value estimated across the time series; indices for years prior to 1988 are available in previous reports.

METHODS

Field Sampling

A 30' (9.14m) semi-balloon otter trawl, with 1.5" (38.1mm) stretched mesh and 0.25" (6.35mm) cod-end liner, is towed along the bottom for 5 minutes during daylight hours. Sampling in the Bay occurs monthly except during January and March, when few target species are available. Sampling in the tributaries occurs monthly, at both the random stratified and historical fixed (mid-channel) stations. The stratification system is based on depth and latitudinal regions in the Bay, or depth and longitudinal regions in the rivers. Each Bay region spans 15 latitudinal minutes and consists of six strata: western and eastern shore shallow (4-12 ft), western and eastern shoal (12-30 ft), central plain (30-42 ft), and deep channel ($\geq$ 42 ft). Each tributary is partitioned into four regions of approximately ten longitudinal minutes, with four depth strata in each (4-12 ft, 12-30 ft, 30-42 ft, and $\geq$ 42 ft; Figure 1). Strata are collapsed in areas where certain depths are limited. Fixed stations were assigned to a stratum according to their location and depth. Additional details of the field sampling protocol are described in Lowery and Geer (2000).

With the exception of the fixed stations in the rivers, trawling sites within strata are selected randomly from the National Ocean Service's Chesapeake Bay bathymetric grid, a database of depth records measured or calculated at 15-cartographic-second intervals. Between two and four trawling sites are randomly selected for each Bay stratum each month, and the number varies seasonally. Exceptions include the shallow-water strata where only a single station is sampled each month. For most river strata, one to two random stations are selected per month. Sampling in the York River has been altered slightly as of 1991 to make the deeper depth strata (30 ft +) similar to those in the James and Rappahannock rivers and main stem Bay. The stratification scheme for the tributaries was modified in January 1996 to further partition the deep strata into two strata of 30-42 ft and ≥ 42 ft (Geer and Austin, 1996). Because tributary sampling had occurred at these depths prior to 1996, samples collected previously were reassigned to the strata established in 1996.

Fixed stations were sampled monthly (nearly continuously) since 1980 with sites in each tributary spaced at approximately 5-mile intervals from the river mouth up to the freshwater interface. From the mid-1950's (York River) and early-1960's (James and Rappahannock rivers) to 1972, fixed stations were sampled monthly using an unlined 30' trawl (gear code 010). During 1973-79, semi-annual random stratified sampling was performed by the VIMS Ichthyology Department, while the VIMS Crustaceology Department continued monitoring the fixed tributary stations on a limited monthly basis (May-November). Area-based weightings for the tributaries were previously assigned by dividing each river into two approximately equal length 'strata' by assuming that the stations in each stratum were representative of the channel areas in those reaches (see Lowery and Geer, 2000). As of 1996, all three tributaries were sampled with a random stratified design; the fixed stations were assigned to a stratum based on location and depth. The current design (combined fixed and random stations) provides greater spatial coverage and a long-term historical reference (Tuckey and Fabrizio 2013).

At the completion of each tow, all fishes are identified to species, counted, and measured to the nearest millimeter fork length (FL), total length (TL), or total length centerline (TLC, Black Sea Bass only). Species that have varying size ranges are measured and counted by size class and large catches of a particular species are randomly subsampled, measured, and the remaining unmeasured catch is counted. In instances of extremely large catches (e.g., Bay Anchovy), subsampling is performed volumetrically.

Juvenile Index Computations

Many of the target species of this study are migratory and abundance estimation presents special difficulties, particularly if the timing and duration of migration varies annually. Juvenile fishes that use estuarine nursery areas are especially vulnerable to the vagaries of the environment, as many rely on wind-driven and tidal circulation patterns for transport into the estuaries as larvae and early juveniles (Norcross, 1983; Bodolus, 1994; Wood, 2000). The outward migration of some species from the nursery area may follow annually variable environmental cues (e.g., temperature). Ideally, juvenile abundance should be measured when young fish are fully recruited to the nursery area under study. In practice, however, this can only be accomplished if the time of maximal abundance and size at recruitment to the gear can be predicted (and surveys timed accordingly), or if surveys can be conducted with high frequency over the season of potential maximal abundance. Neither of these two approaches is practical. The period of maximal abundance and the spatial extent of the area occupied by juvenile fish have proven to be variable among years and among species. This observation, coupled with multi-species monitoring objectives, precludes temporally intense surveys. Consequently, the survey is operated with a regular periodicity (monthly) and sample-site selection is performed using a standard sampling design for multispecies resource surveys.

A monthly size threshold value is applied to the length-frequency information collected for each target species to partition the catch data into young-of-year and older components for index calculation (Table 1). Threshold values vary among months for each species and are based on modal analyses of historical, composite length-frequency data and on reviews of ageing studies (Colvocoresses and Geer, 1991). For earlier months of the biological year, threshold values are somewhat arbitrary and fall between completely discrete modal size ranges. In the later part of the biological year, when the size of early spawned, rapidly growing individuals of the most recent year class may approach that of later spawned, slower growing individuals of the previous year class, threshold values were selected to preserve the numeric proportionality between year classes despite the potential misclassification of some individuals (Table 1). The extent of overlapping lengths and the proportion within that range attributable to each year class were estimated based on the shapes of the modal curve during the months prior to the occurrence of overlap. A length value was then selected, which preserves the proportional separation of year classes. Although this process involved considerable subjectivity and ignored possible interannual variability in average growth rates, the likelihood of significant error is small, because only a small fraction of the total number of young-of-year individuals falls within the zone of overlap, and furthermore, with a few exceptions, most of the data used to construct juvenile indices were drawn from months when no overlap was present.

After removing non-target individuals from consideration, monthly stratum-specific abundances and occurrence rates are calculated for each target species. Numbers of individuals captured are natural-log transformed (ln(n+1)) prior to abundance calculations following Chittenden (1991). Average catch rates (and the approximate 95% confidence intervals as estimated by $\pm$ 2 standard errors of the mean) are then back-transformed to geometric means. The stratum-specific coefficient of variation is expressed as the standard deviation divided by the log-transformed mean catch: STD/ $E[Y_{st}]$ (Cochran, 1977). The catch data were examined for area-time combinations that provided the best basis for juvenile index calculations. Criteria applied during the selection process included identification of maximal abundance levels, uniformity of distribution, minimization of overall variance, and avoidance of periods during which distribution patterns indicated migratory behavior. Although identification of areas most suitable for index calculations (primary nursery zones) was generally clear, selection of appropriate time windows was more complex. Surveys are timed on regular monthly intervals that may or may not coincide with periods of maximal recruitment to the nursery areas. The use of a single (maximal) month's survey result is therefore inappropriate and would decrease sample size, increase confidence intervals, and increase the risk of sampling artifacts. Conversely, the temporal series of data incorporated into index calculations should not be longer than necessary to capture the period of maximal juvenile use of the nursery area. With this approach, three- or four-month periods (but 6 months for Bay Anchovy) that provided reasonable abundance data for each species were identified (Table 1).

Using catch data from area-time combinations, an annual juvenile index is currently calculated as the weighted geometric mean catch per tow (Random Stratified Index, RSI_{GM}) for all species except American Eel, Atlantic Croaker, and Blue Catfish. This is accomplished by calculating stratum-specific means and variances and combining the stratum-specific estimates using weights based on stratum area (Cochran, 1977). Because stratum areas are not uniform, a weighted mean provides an index that more closely approximates actual population abundance. For American Eel, Atlantic Croaker, and Blue Catfish, whose catches follow a lognormal distribution, an index is calculated assuming a delta lognormal approach (RSI_{Delta}). The delta lognormal index method calculates stratum-specific means on log-transformed positive values only and adjusts the stratum means by the proportion of positive tows. The stratified mean is then calculated in the usual manner. We are currently developing confidence interval estimates for the annual relative abundance index, but these are not available for this report.

Appropriate indices are produced for each species for 1988 to the present and may include: an index based on the current Bay strata plus the fixed tributary stations (Bay & River Index – BRI), an index based on the fixed tributary stations only (River Only – RO), and a random stratified index using all spatially appropriate data (Random Stratified Index – RSI_{GM} or RSI_{Delta}; in previous reports, this index was called the Random Stratified Converted Index, RSCI). Data collected prior to 1988 are excluded from this report because results from the longer time series are considered provisional (i.e., indices prior to 1988 require both gear and vessel conversion factors, and concerns about conversion factors for this period have not yet been addressed). Multiple indices are presented in this report for completeness, but usually only the RSI will be described in detail.

RESULTS

A summary of tows completed from 1988 through May 2014 (Table 2) provides a comprehensive synopsis of the sampling completed for this report. For the 2013-2014 project year (June through May), 1,224 sites were sampled resulting in 488,344 fishes identified and enumerated from 107 species (Table 3). Bay Anchovy, Hogchoker, and Atlantic Croaker accounted for 78.8% of the catch by numbers. Ignoring Bay Anchovy and Hogchoker, six species – Atlantic Croaker, Spot, White Perch, Weakfish, Blue Catfish, and Spotted Hake – represented 82.9% of the catch numerically (Table 3).

Indices were calculated and described for the following species: American Eel, Atlantic Croaker, Bay Anchovy, Black Sea Bass, Blue Catfish**,** Channel Catfish, Scup, Silver Perch, Striped Bass, Spot, Summer Flounder, Weakfish, White Catfish, and White Perch. Length frequency distributions for each species are shown in Appendix Figure 1 with index-sized fish indicated in gray. Actual relative abundance indices are calculated on a subset of the data as described below.

American Eel (*Anguilla rostrata*) – American Eel are present along the Atlantic and Gulf coasts of North America and inland in the St. Lawrence Seaway and Great Lakes (Murdy et al*.,* 1997). This catadromous species is panmictic and supported throughout its range by a single spawning population (Haro et al., 2000). Spawning takes place during winter to early spring in the Sargasso Sea. The eggs hatch into leaf-shaped, ribbon-like larvae called leptocephali, which are transported by ocean currents (over 9-12 months) in a generally northwesterly direction. Within a year, metamorphosis into the next life stage (glass eel) occurs in the Western Atlantic near the east coast of North America. Coastal currents and active migration transport the glass eels into rivers and estuaries from February to June in Virginia and Maryland. As growth continues, eels become pigmented (elver stage) and within 12 –14 months they acquire a dark color with underlying yellow (yellow eel stage). Many eels migrate upriver into freshwater rivers, streams, lakes, and ponds, while others remain in estuaries. Most of the eel's life is spent in these habitats as a yellow eel. Age at maturity varies greatly with location and latitude, and in Chesapeake Bay may range from 8 to 24 years, with most eels in the Bay area less than 7 years old (Owens and Geer, 2003). Eels from

Chesapeake Bay mature and migrate at an earlier age than eels from northern areas (Hedgepeth, 1983). Metamorphosis into the silver eel stage occurs during the seaward migration that occurs from late summer through autumn, as mature eels migrate back to the Sargasso Sea to spawn and die (Haro et al., 2000).

The current American Eel index includes all eels (> 152 mm TL) collected in each of the major tributaries (Figure 1) during April through September (Fenske et al. 2011). American Eel indices exhibited above-average abundance in the Rappahannock River (mean RSI_{Delta} = 2.24) and the James River (mean RSI_{Delta} = 2.03) in the late 1980's and early 1990's and below-average abundance thereafter (Table 4; Figure 2). In the York River, below-average abundance (mean RSI_{Delta} = 0.61) has been observed since 1992. During the index period, American Eel are more abundant in the Rappahannock River compared with the James and York rivers (Figure 3).

Atlantic Croaker (*Micropogonias undulatus*) – Atlantic Croaker are typically captured in high abundance and are widely distributed throughout the survey area (Figure 4, bottom). Spawning takes place over a protracted period, such that small juveniles (<30 mm TL) can be present in catches year-round (Norcross, 1983; Colvocoresses and Geer, 1991; Colvocoresses et al., 1992; Geer et al., 1994). For some year classes, peak abundance occurs in the fall at lengths less than 100 mm TL, but for other year classes, the peak occurs the following spring. Previously, we provided two estimates of the index: a juvenile fall index (October - December) based on catches in the tributaries, and a spring recruit index (May - August) based on catches in the Bay and tributaries combined. Because the fall index does not reflect over-winter mortality, only the modified spring index, after Woodward (2009), is presented. The spring index is calculated using a delta lognormal model with juvenile Atlantic Croaker collected from all regions of the Bay and tributaries from April to June. During the early portion of the time series, the Atlantic Croaker spring RSI_{Delta} remained average to above-average from 1989 to 1991, dropped below average for most years between 1992 and 2005 (except for 1997 and 1998), and has been above average for six of the past nine years (Table 5 and Figure 4, top; mean RSI_{Delta} = 12.07). The 2014 RSI_{Delta} (for the 2013 year-class) is 1.55, among the lowest values observed for this species.

Bay Anchovy (*Anchoa mitchilli*) – Bay Anchovy are the most abundant finfish in Chesapeake Bay and its tributaries, and are found in salinities ranging from 1-33 psu (Murdy et al*.,* 1997). Bay Anchovy feed mostly on zooplankton and are an important prey of other Bay fishes (Murdy et al*.,* 1997). In years of average freshwater inflow (e.g., 1997-2000), Atlantic Menhaden, Bay Anchovy, and Atlantic Croaker often dominate fish biomass in Chesapeake Bay (Jung, 2002). Bay Anchovy abundance has increased in recent years from a period of low recruitment observed during 2001 - 2007 (Table 6; Figure 5, top). However, in 2013, Bay Anchovy exhibited a below-average year of abundance (RSI_{GM} = 23.76, long-term mean RSI_{GM} = 27.76). As expected, Bay Anchovy are ubiquitous in trawl survey catches with many stations having more than 2,000 individuals and one station having 8,191 individuals in a single tow (Figure 5, bottom).

Black Sea Bass (*Centropristis striata*) – Black Sea Bass are seldom taken in large numbers but regularly occur in survey catches. Young-of-year Black Sea Bass occur throughout the Bay and appear occasionally in the lower portions of the tributaries. Index calculations are based on all Bay strata and the lower James stratum from May through July only (Figure 6, bottom). Although some early juveniles appear in the Bay during their first summer and fall, more young-of-year enter the estuary during the following spring. Black Sea Bass spawn in the summer in the Mid-Atlantic Bight (Musick and Mercer, 1977). Thus, the index is calculated for the year class spawned the previous calendar year (i.e., the index for the 2012 year class is based on catches from May to July 2013). The Black Sea Bass RSI_{GM} was generally above average (mean RSI_{GM} = 0.70) prior to 1995, but fell below average the following years with the exception of 2000 – 2001, 2007, and 2010 (Table 7; Figure 6, top). The Black Sea Bass index for 2012 was below average at 0.19.

Blue Catfish (*Ictalurus furcatus*) – The Blue Catfish, one of Virginia's largest freshwater fishes (Jenkins and Burkhead, 1993), was introduced to the Chesapeake Bay area as a sportfish in the James, Rappahannock, and Mattaponi rivers between 1974 and 1989 (Virginia Department of Game and Inland Fisheries, 1989 as reported by Connelly, 2001). The Blue Catfish is a carnivorous bottom feeder that inhabits the main channels and backwaters of rivers (Murdy et al., 1997). Blue Catfish are distributed from the mesohaline portions of the major tributaries upstream into freshwater habitats, beyond the limits of the trawl survey (Figures 8; Schloesser et al. 2011). Because Blue Catfish are restricted in their distribution, an index of abundance is calculated for each tributary incorporating strata from portions of the lower river and all upper river strata. The James River typically has the highest juvenile Blue Catfish index with above-average recruitment (mean RSI_{Delta} = 3.93) in 1996, 1997, 2003 – 2006, 2009, and 2013 (Table 8; Figure 7). Recruitment of Blue Catfish juveniles in the Rappahannock River in 2011 (RSI_{Delta} = 17.21) was more then 25 times higher than the previous record (RSI_{Delta} = 0.67 in 2003); the 2013 index showed above-average levels (RSI_{Delta} = 3.06). In the York River, Blue Catfish juveniles in 2011 (RSI_{Delta} = 6.57) were nearly 4 times more abundant than the previous record (RSI_{Delta} = 1.68 in 2004; Figure 7), and the 2013 index (RSI_{Delta} = 0.81) remained above average in this system. The James and Rappahannock rivers each had individual samples that contained more than 100 juvenile Blue Catfish in a single tow (Figure 8).

Age 1+ Blue Catfish reside in mesohaline portions of the Rappahannock, York and James rivers (as well as freshwater habitats not sampled by the survey; Figure 10). The abundance index for age 1+ Blue Catfish in the Rappahannock River (RSI_{Delta} = 1.77) was below average in 2014 (mean long-term RSI_{Delta} = 10.72; Table 9; Figure 9). In the York River, abundance indices for age 1+ Blue Catfish have been average or above average since 2005 (mean long-term RSI_{Delta} = 0.71; Table 9; Figure 9). Age 1+ Blue Catfish abundance estimates form the York River have been among the highest abundance estimates observed in this system. Above-average abundance estimates for age 1+ Blue Catfish have been observed for six of the past nine years in the James River though 2014 was below average (mean long-term RSI_{Delta} = 13.73; Table 9; Figure 9).

Blue Catfish indices have been increasing since 1989 and the ecosystem effects of this invasive species are unknown (Schloesser et al., 2011); the objectives and results of several studies currently underway or recently completed have been summarized in a draft report submitted to the Sustainable Fisheries Goal Implementation Team. Diets of small Blue Catfish are dominated by invertebrates (mostly amphipods, isopods and mud crabs), whereas larger Blue Catfish consume invertebrates, Atlantic Menhaden (*Brevoortia tyrannus*), and Gizzard Shad (*Dorosoma cepedianum*; Parthree et al., 2008). Other catfishes (White and Channel) have similar diets and may be competing with the introduced Blue Catfish for the same prey resources (Schloesser et al., 2011).

Channel Catfish *(Ictalurus punctatus)* and **White Catfish** *(Ameiurus catus)* – Channel Catfish and White Catfish are usually found in the upper portions of the tributaries (Figures 12, 14, 22, and 24). Although each river system is unique, spawning typically occurs in late May through early July in Virginia (Menzel, 1945); consequently, June was selected as the start of the biological year. The survey typically catches both species up to 600 mm FL with young-of-the-year fish (≤ 50 mm FL) first recruiting to the gear in June. In most years, juvenile recruitment occurs from January to April for both species in the upriver strata only.

The Channel Catfish was introduced to Virginia in the late 1800s (Jenkins and Burkhead, 1993). Juvenile Channel Catfish exhibited low or failed recruitment in most years with a few notable peaks. In the past six years, only seven juvenile Channel Catfish have been captured by the trawl survey (Table 10, Figures 11 and 12). The age 1+ Channel Catfish RSI_{GM} has exhibited below-average values in the Rappahannock and James rivers since 2000 and index values have been consistently below average in the York River since 2003 (Table 11; Figures 13 and 14).

Similarly, RSI_{GM}'s for juvenile White Catfish indicate average or above-average recruitment most years prior to 1998 in the York and James rivers, and variable recruitment in the Rappahannock River (Table 18; Figures 21 and 22). Failed recruitment occurred annually in all three rivers after 1998 with a few exceptions (2003 and 2009). Fifty-eight juvenile White Catfish were collected during the recruitment window in 2014 (most from the James River; Figure 22). Abundance indices for age 1+ White Catfish were below-average since 2000 in the James River (average = 0.26), below-average since 2001 in the York River (average = 0.13), and below-average since 2005 in the Rappahannock River (average = 0.15; Table 19; Figures 23 and 24).

Scup (*Stenotomus chrysops*) – Scup are primarily a marine, summer spawning species that use the Bay in a manner similar to Black Sea Bass. The estuary is rarely used as a nursery area by early juveniles (25-40 mm FL), which occasionally appear in survey catches in June. Older juveniles can be found in the Bay during their second summer and first appear in catches in May; by June, they range from 50 to 215 mm FL. Using the original length threshold for Scup that was based on ageing studies (Morse, 1978), trawl survey catches were found to typically include three age groups (age 0, age 1, and age 2+). Because catches of age 1 and age 2+ Scup are highly variable and low, index calculations using trawl survey catches are based on age-0 individuals only. Age-0 fish are present in the Bay and available to the gear for the entire summer and early fall.

During index months, Scup are predominantly collected in the lower Bay (Figure 15, bottom). Catch rates for Scup usually peak in July, and the index is calculated from catches taken in June to September. Scup indices have been above average in several recent years (2005, 2006, 2008 and 2009), and below average most other years since 1993 (mean long-term RSI_{GM} = 1.38; Table 12; Figure 15, top). Scup abundance in 2013 (2012 year-class; RSI_{GM} = 0.74; Table 12) was below average.

Silver Perch *(Bairdiella chrysoura)* – Silver Perch are found in all sampling strata (Figure 16, bottom). Spawning occurs in the deep waters of the Bay and offshore from May to July, and juveniles (≤ 100 mm TL) enter the Bay by July (Chao and Musick, 1977; Rhodes, 1971). Abundance indices for Silver Perch are consistent and stable (Table 13; Figure 16, top). The time series average RSI_{GM} index for Silver Perch is 0.65 and the 2013 RSI_{GM} index is 0.59.

Spot (*Leiostomus xanthurus*) – Spot are widely distributed throughout the Bay and tributaries (Figure 17, bottom); abundance indices for this species are calculated using all strata from July to October. Spot is often one of the most abundant recreational species captured by the survey and recent catches of Spot are similar to catches observed in the late 1980s and early 1990s, with below-average abundance between 1992 - 2007 (Table 14; Figure 17, top). The RSI_{GM} index in 2013 was slightly below average (mean long-term RSI_{GM} = 14.73).

Striped Bass (*Morone saxatilis*) – Striped Bass use the upper tributaries of the Bay as spawning and nursery grounds; spawning occurs from early to mid-April through the end of May, in tidal freshwater areas just above the salt wedge. Juvenile Striped Bass often appear in catches from May to July in size classes less than 50 to 100 mm FL during years of high abundance, but then diminish in occurrence in trawl catches until the following winter. A second, stronger and more consistent period of juvenile abundance occurs in December and continues through February in the upper regions of the rivers. The trawl survey index for Striped Bass is based on this winter recruitment period. Index calculations are from those juvenile Striped Bass captured in the major tributaries only (Figure 18, bottom), although Striped Bass are encountered in other areas throughout the year.

Juvenile Striped Bass showed strong recruitment peaks for the 1989, 1993 and 2000 year classes but recruitment has declined in recent years (Table 15; Figure 18, top). The index value for the 2013 year class (RSI_{GM} = 1.33) is above the time-series average (mean RSI_{GM} = 0.82) and is consistent with results from the VIMS Seine Survey (Fabrizio et al. 2014).

Summer Flounder (*Paralichthys dentatus*) – Summer Flounder spawn on the continental shelf from September through January with a peak occurring in October and November (Murdy et al., 1997). Summer Flounder larvae enter the Bay and other Virginia estuaries from October through May with juveniles using shallow fine-substrate areas adjacent to seagrass beds (Murdy et al., 1997; Wyanski, 1990). Low water temperatures can have significant effects on growth and survival of individuals that enter the estuary in the winter (Able and Fahay, 1998). Juvenile Summer Flounder first appear in catches in late March, which is used as the beginning of the biological year. Juvenile Summer Flounder abundance continues to increase steadily throughout the summer and early fall to a late fall peak, and then trawl catches decline, presumably reflecting emigration of young fish during December. For our trawl survey, September, October, and November usually encompass the months of greatest abundance of juvenile Summer Flounder. Juvenile Summer Flounder are broadly distributed throughout the Bay and lower rivers. Consequently, index calculations are based on catches from the Bay and lower river strata during September, October, and November.

Juvenile Summer Flounder indices were greater during the early 1990s compared with recent years with notable peaks in 2004, 2008, and 2012 (Table 16; Figure 19, top). The 2011 index (RSI_{GM} = 0.17) was the lowest index value observed in the time series, whereas recruitment in 2012 (RSI_{GM} = 2.03) was the fourth highest index value observed since 1988. The 2013 Summer Flounder index (RSI_{GM} = 0.82) was below average (mean RSI_{GM} = 1.01). During index months, juvenile Summer Flounder were captured throughout the Bay and lower portions of the rivers (Figure 19, bottom), though juvenile Summer Flounder often occur upriver.

Weakfish (*Cynoscion regalis*) – Weakfish are one of the dominant species in trawl survey catches, and juveniles are found throughout the Bay and tributaries (Figure 20, bottom). Juveniles have occurred in catches in late May and June, with June considered the beginning of the biological year. Overall, the Weakfish index is consistent and indicates steady recruitment since 1988 (mean RSI_{GM} = 6.71; Table 17; Figure 20, top); we observed above-average recruitment in 2013 (RSI_{GM} = 9.41).

White Perch (*Morone americana*) – Spawning of White Perch occurs in the upper tributaries (Figure 26) from March to July with a peak occurring from late April to early May. Index months include December to February for juveniles and November to February for age 1+. Index stations are from the upper river strata and a separate index is calculated for each river.

Juvenile White Perch recruitment has been stable in each of the rivers with high and low periods of recruitment (Table 20; Figure 25). The three rivers show different time series averages with greater numbers of juvenile White Perch occurring in the James River (mean RSI_{GM} = 3.02) followed by the Rappahannock River (mean RSI_{GM} = 0.73) and the York River (mean RSI_{GM} = 0.20). Recruitment was below average in the Rappahannock River and above average in the James and York rivers in 2013 (Figure 25).

Abundance of age 1+ White Perch has been average in the Rappahannock River (mean RSI_{GM} = 1.31) for most of the time series (Table 21; Figure 27). In the York River, abundance of age 1+ White Perch was average or above average (mean RSI_{GM} = 0.39) prior to 1997 and below-average values have been observed since 1998 (Table 21; Figure 27). Abundance of age 1+ White Perch has been average in the James River (mean RSI_{GM} = 3.53) with notable peaks in 1988, 1989, 1991, and 1994 (Table 21; Figure 27). White Perch are collected throughout the upper rivers (Figure 28).

DISCUSSION

Juvenile indices contribute to the assessment and management of important recreational and commercial species in Chesapeake Bay and the mid-Atlantic Bight. For example, the VIMS Trawl Survey was recognized by the Mid-Atlantic Fisheries Management Council (MAFMC) as an important source of the Summer Flounder recruitment index; the VIMS index was instrumental in shaping protective harvest regulations in Virginia for this species. Other indices utilized by management agencies include those for American Eel, Atlantic Croaker, Spot, and Weakfish. Although a bottom trawl is not the preferred gear with which to sample American Eel, Eel indices from the Trawl Survey played an important role in the 2006 ASMFC American Eel FMP (ASMFC, 2006). In addition to management needs, the VIMS Trawl Survey also fulfills data and specimen requests from a variety of agencies, institutes, and individuals for research and educational purposes (e.g., Woodland et al. 2012; Sobocinski et al. 2013; Nys 2014) and we responded to 143 requests between June 2013 and May 2014 (Appendix Table 1).

Efforts to improve recruitment indices continue and include evaluation of the size ranges and months (the index period) used in index calculations. A VIMS Master's thesis addressed the distributional assumptions of the catch of YOY Weakfish and Atlantic Croaker (Woodward, 2009). The results showed that the nonzero catch data for Weakfish can be described by a gamma distribution and those for Atlantic Croaker appear to follow a lognormal distribution. Such findings indicate that indices of abundance calculated for these species could benefit from further refinements. In addition, the use of different index months for Weakfish and Atlantic Croaker may improve YOY indices by ensuring fewer age 1+ fish are included in YOY index calculations. Additional work may address potential effects of depth on the distribution and catch of these species (Woodward, 2009; Tuckey and Fabrizio 2013).

The Trawl Survey provides more than relative abundance indices used to tune stock assessments and aid in management activities. The data can also be used to investigate factors that influence species abundance that operate on time periods beyond annual recruitment cycles. For example, using fishery-independent survey data from 1968 – 2004 for estuarine-dependent species, Wood and Austin (2009) found that recruitment of anadromous species was negatively correlated with recruitment of species that spawn on the continental shelf. Furthermore, recruitment patterns favored one group over the other for periods greater than a decade and shifts between recruitment regimes occurred within a short period of time (2-3 years; Wood and Austin, 2009). Understanding that long-term recruitment cycles dominate for decades is an important development that could inform management options. For example, effects of regulations aimed at improving recruitment will be difficult to observe if regulations are enacted during a cycle of low recruitment.

Information from the Trawl Survey also provides a basis for monitoring species interactions. For example, annual catch rates of Channel Catfish and White Catfish have declined since 1991, while catches of the introduced Blue Catfish have increased dramatically (Schloesser et al. 2011). Because diets and distributions of these species overlap, the observed trends may be due to competition and thus, species interactions warrant further study. Furthermore, the shift in diet of older Blue Catfish to include other fishes may affect ecosystem function (Schloesser et al. 2011). An effort is underway in Chesapeake Bay to understand the biology and ecology of Blue Catfish and coordinate management throughout the bay through the Sustainable Fisheries Goal Implementation Team (coordinated by NOAA, Chesapeake Bay Office, and the EPA Chesapeake Bay Program).

Changes in catches of important recreational species may be associated with degradation of estuarine nursery habitats, overfishing, poor recruitment, or a combination of these factors (Murdy et al., 1997). Although it is not possible to determine the cause of recruitment variability from trawl survey data alone, some general observations are possible. Spot recruitment indices have declined greatly over the past 50 years, but year-class strength of this oceanic spawner appears to be controlled by environmental factors occurring outside the Bay (Homer and Mihursky, 1991; Bodolus, 1994). Three of the largest Spot recruitment indices from the past 20 years have been observed within the past six years indicating favorable conditions for this species in recent years. Atlantic Croaker recruitment indices show significant interannual variability with fluctuations possibly related to environmental conditions that vary annually. Norcross (1983) found that cold winters increased mortality in overwintering juvenile Atlantic Croaker and during some years may "push" the spawning population further south, preventing access to nursery areas in Chesapeake Bay. The warm winter during 2011-2012 may have contributed to greater overwinter survival and the highest index of abundance for this species. Weakfish recruitment indices have remained stable since 1988, though a decline in adult abundance has been observed and may be attributed to increased total mortality (ASMFC, 2012). Observed declines in Summer Flounder abundance may have been due to overfishing or year-class failure (Terceiro, 2006), but spawning stock biomass has been steadily increasing in response to the rebuilding plan and now exceeds the target. In 2013 however, recruitment of Summer Flounder was low. Striped Bass display great recruitment variability and one or two strong year classes may dominate the population at any one time (Richards and Rago, 1999). Finally, White Catfish and Channel Catfish indices, while variable, have decreased over the past 20 years, possibly due to competition with the introduced Blue Catfish.

The VIMS trawl survey program supplies critical data for management of fishery resources that use Chesapeake Bay as a spawning or nursery ground. Because the Bay serves as a nursery area for many coastal migratory fish, annual recruitment data are critical for multi-state management efforts along the Atlantic Coast. Furthermore, the trawl survey serves as a foundation to conduct research on basic biological characteristics of Bay and tributary fishes, as well as a platform from which emerging issues may be addressed.

LITERATURE CITED

Able, K. W. and M. P. Fahay. 1998. The first year in the life of estuarine fishes in the middle Atlantic Bight. Rutgers University Press, New Jersey.

ASMFC. 2006. Terms of Reference and Advisory Report to the American Eel Stock Assessment Peer Review. ASMFC American Eel Stock Assessment Review Panel. Stock Assessment Report No. 06-01 of the Atlantic States Marine Fisheries Commission.

ASMFC. 2012. Review of the Atlantic States Marine Fisheries Commission Fishery Management Plan for Weakfish. Weakfish Plan Review Team. Atlantic States Marine Fisheries Commission.

Bodolus, D. A. 1994. Mechanisms of larval Spot transport and recruitment to the Chesapeake Bay. Ph. D. Dissertation. College of William and Mary, Williamsburg, VA.

Chao, L. N. and J. A. Musick. 1977. Life history, feeding habits, and functional morphology of juvenile sciaenid fishes in the York River estuary, Virginia. Fishery Bulletin 75:657-702.

Chesapeake Executive Council. 1988. Chesapeake Bay Program Stock Assessment Plan. Agreement Commitment Report. Annapolis, MD.

Chittenden, M. E., Jr. 1991. Evaluation of spatial/temporal sources of variation in nekton catch and the efficacy of stratified sampling in the Chesapeake Bay. Final report to Chesapeake Bay Stock Assessment Committee & NOAA/NMFS. Virginia Institute of Marine Science, Gloucester Point, VA.

Cochran, W. G. 1977. Sampling techniques. John Wiley & Sons. New York.

Colvocoresses, J. A. and P. J. Geer. 1991. Estimation of relative juvenile abundance of recreationally important finfish in the Virginia portion of Chesapeake Bay. Annual report to VMRC/USFWS Sportfish Restoration Project F104R1. July 1990 to June 1991. Virginia Institute of Marine Science, Gloucester Point, VA.

Colvocoresses, J. A., P. J. Geer and C. F. Bonzek. 1992. Estimation of relative juvenile abundance of recreationally important finfish in the Virginia portion of Chesapeake Bay. Annual report to VMRC/USFWS Sportfish Restoration Project F104-2. July 1991 to June 1992. Virginia Institute of Marine Science, Gloucester Point, VA.

Connelly, W. J. 2001. Growth patterns of three species of catfish (*Ictaluridae*) from three Virginia tributaries of the Chesapeake Bay. Master's Thesis. College of William and Mary, Williamsburg, VA.

Fabrizio, M. C., T. D. Tuckey, and C. Davis. 2014. Estimation of juvenile striped bass relative abundance in the Virginia portion of Chesapeake Bay. Annual Report to the Virginia Marine Resources Commission.

Fenske, K. H., M. J. Wilberg, D. H. Secor, and M. C. Fabrizio. 2011. An age- and sex-structured assessment model for American eels (*Anguilla rostrata*) in the Potomac River, Maryland. Canadian Journal of Fisheries and Aquatic Sciences 68: 1024-1037.

Geer, P. J. and H. M. Austin. 1994. Estimation of relative abundance of recreationally important finfish in the Virginia portion of Chesapeake Bay. Annual report to VMRC/USFWS Sportfish Restoration Project F104R4. July 1993 to June 1994. Virginia Institute of Marine Science, Gloucester Point, VA.

Geer, P. J. and H. M. Austin. 1996. Estimation of relative abundance of recreationally important finfish in the Virginia portion of Chesapeake Bay. Annual report to VMRC/USFWS Sportfish Restoration Project F104R6. July 1995 to June 1996. Virginia Institute of Marine Science, Gloucester Point, VA.

Geer, P. J. and H. M. Austin. 1997. Estimation of relative abundance of recreationally important finfish in the Virginia portion of Chesapeake Bay. Annual report to VMRC/USFWS Sportfish Restoration Project F104R7. July 1996 to June 1997. Virginia Institute of Marine Science, Gloucester Point, VA.

Geer, P. J., C. F. Bonzek, and H. M. Austin. 1994. Juvenile finfish and blue crab stock assessment program bottom trawl survey annual data summary report series. Volume 1993. Virginia Institute of Marine Science Special Scientific Report No. 124. Virginia Institute of Marine Science, Gloucester Point, VA.

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.

Haro, A., W. Richkus, K. Whalen, W. D. Busch, S. Lary, T. Brush, and D. Dixon. 2000. Population decline of the American Eel: Implications for Research and Management. Fisheries 25(9): 7-16.

Hedgepeth, M.Y. 1983. Age, growth and reproduction of American Eels, *Anguilla rostrata* (Lesueur), from the Chesapeake Bay area. Master's Thesis. College of William and Mary, Williamsburg, VA.

Homer, M. L. and J. A. Mihursky. 1991. Spot. Pages 11.1-11.19 *in* S.L. Funderburk, J.A. Mihursky, S. J. Jordan, and D. Reiley, eds., Habitat requirements for Chesapeake Bay Living Resources, 2nd Edition. Living Resources Subcommittee, Chesapeake Bay Program. Annapolis, MD.

Jenkins, R. E. and N. M. Burkhead. 1993. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, MD.

Jung, S. 2002. Fish community structure and the temporal variability in recruitment and biomass production in Chesapeake Bay. Ph.D. Dissertation. University of Maryland, College Park, MD.

Lowery, W. A. and P. J. Geer. 2000. Juvenile finfish and blue crab stock assessment program bottom trawl survey annual data summary report series. Volume 1999. Virginia Institute of Marine Science Special Scientific Report No. 124. Virginia Institute of Marine Science, Gloucester Point, VA.

Menzel, R.W. 1945. The catfishery of Virginia. Transactions of the American Fisheries Society 73: 364-372.

Montane, M. M. and H. M. Austin. 2005. Effects of hurricanes on Atlantic Croaker (*Micropogonias undulatus*) recruitment to Chesapeake Bay. Pages 185-192 *in* K. Sellner, ed., Hurricane Isabel in Perspective. Chesapeake Research Consortium, CRC Publication 05-160, Edgewater, MD.

Morse, W. W. 1978. Biological and fisheries data on Scup, *Stenotomus chrysops* (Linnaeus). National Marine Fisheries Service, Sandy Hook Laboratory, Technical Series Report No. 12.

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

Musick, J. A. and L. P. Mercer. 1977. Seasonal distribution of Black Sea Bass, *Centropristis striata*, in the Mid-Atlantic Bight with comments on the ecology and fisheries of the species. Transactions of the American Fisheries Society 106:12-25.

Norcross, B. L. 1983. Climate scale environmental factors affecting year-class fluctuations of Atlantic Croaker, *Micropogonias undulatus* in the Chesapeake Bay, VA. Ph.D Dissertation. College of William & Mary, Williamsburg, VA.

Nys, L. N. 2014. Factors influencing growth and year-class strength of young-of-the-year Summer Flounder. Master's Thesis. College of William & Mary, Williamsburg, VA.

Owens, S. J. and P. J. Geer. 2003. Size and age structure of American Eels in tributaries of the Virginia portion of the Chesapeake Bay. Pages 117-124 *in* D. A. Dixon (Editor), Biology, Management and Protection of Catadromous Eels. American Fisheries Society Symposium Series 33, Bethesda, MD.

Parthree, D. J., C. F. Bonzek and R. J. Latour. 2008. Chesapeake Bay Trophic Interactions Laboratory Services. Project NA06NMF4570299. VIMS, Gloucester Point, VA.

Rhodes, S. F. 1971. Age and growth of the Silver Perch *Bairdiella chrysoura*. Master's Thesis. College of William & Mary, Williamsburg, VA.

Richards, R. A., and P. J. Rago. 1999. A case history of effective fishery management: Chesapeake Bay Striped Bass. North American Journal of Fisheries Management 19:356-375.

Schloesser, R. W., M. C. Fabrizio, R. J. Latour, G. C. Garman, B. Greenlee, M. Groves, and J. Gartland. 2011. Ecological role of Blue Catfish in Chesapeake Bay communities and implications for management. In P. Michaletz and V. Travnichek, eds., Conservation, ecology, and management of worldwide catfish populations and habitats. American Fisheries Society Symposium 77:369-382, Bethesda, MD.

Sobocinski, K. L., R. J. Orth, M. C. Fabrizio, and R. J. Latour. 2013. Historical comparison of fish community structure in lower Chesapeake Bay seagrass habitats. Estuaries and Coasts 36:775-794.

Terceiro, M. 2006. Summer Flounder assessment and biological reference point update for 2006. Northeast Fisheries Science Center Reference Document.

Tuckey, T. D. and M. C. Fabrizio. 2013. Influence of survey design on fish assemblages: implications from a study in Chesapeake Bay tributaries. Transactions of the American Fisheries Society 142:957-973.

Wojcik, F. J. and W. A. Van Engel. 1988. A documentation of Virginia trawl surveys, 1955 – 1984, listing pertinent variables. Volume II – York River. College of William and Mary, VIMS, Gloucester Point, VA. 198 p. (cited in Table 2)

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

Wood, R. J. and H. M. Austin. 2009. Synchronous multidecadal fish recruitment patterns in Chesapeake Bay, USA. Canadian Journal of Fisheries and Aquatic Sciences 66:496-508.

Woodland, R. J., D. H. Secor, M. C. Fabrizio, and M. J. Wilberg. 2012. Comparing the nursery role of inner continental shelf and estuarine habitats for temperate marine fishes. Estuarine, Coastal, and Shelf Science 99: 61-73.

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

Wyanski, D. M. 1990. Patterns of habitat utilization in 0-age Summer Flounder (*Paralichthys dentatus*). Master's Thesis. College of William and Mary, Williamsburg, VA.

TABLES

Table 1. Spatial, temporal, and length (mm) criteria used to calculate recruitment indices. Highlighted boxes indicate strata, months and sizes used to calculate indices. Cross-hatched boxes indicate that only a portion of those strata are used in index calculations.

	VIMS Trawl Survey - Area / Time / Size Values by Species																					
Species - Age	VIMS	Strata Used									Month											
	SP. CODE	Bay			James		York		Rapp		Size Cut-off Values (mm) - Darkened Areas Represent Index Months											
		BOTTOM	LOWER	UPPER	LOWER	UPPER	LOWER	UPPER	LOWER	UPPER	January	February	March	April	May	June	July	August	September	October	November	December
American Eel 1+	0060										---	---	---	>152	>152	>152	>152	>152	>152	---	---	---
Atlantic Croaker (spring)	0005										0-100	0-100	0-100	0-110	0-135	0-160	0-180	0-220	0-50	0-80	0-100	0-100
Bay Anchovy Y-O-Y	0103										0-77	0-80	0-80	0-80	0-80	0-80	0-44	0-51	0-56	0-61	0-65	0-70
Black Seabass Y-O-Y	0002										0-110	0-110	0-110	0-110	0-110	0-150	0-175	0-70	0-85	0-100	0-105	0-110
Blue Catfish Y-O-Y	0314										0-165	0-165	0-165	0-175	0-225	0-250	0-250	0-115	0-125	0-140	0-150	0-165
Blue Catfish 1+	0314										>165	>165	>165	>175	>225	>250	>250	>115	>125	>140	>150	>165
Channel Catfish Y-O-Y	0040										0-130	0-130	0-130	0-140	0-150	0-50	0-80	0-105	0-120	0-130	0-130	0-130
Channel Catfish 1+	0040										>130	>130	>130	>140	>150	>50	>80	>105	>120	>130	>130	>130
Scup	0001										90-170	90-170	90-170	90-170	35-90	40-100	50-125	60-145	75-160	85-170	90-170	90-170
Silver Perch Y-O-Y	0213										0-160	0-160	0-160	0-160	0-165	0-170	0-100	0-130	0-150	0-160	0-160	0-160
Spot Y-O-Y	0033										0-200	0-200	0-50	0-75	0-100	0-135	0-160	0-180	0-200	0-200	0-200	0-200
Striped Bass Y-O-Y	0031										0-200	0-200	0-200	0-200	0-50	0-80	0-100	0-120	0-135	0-150	0-175	0-190
Summer Flounder Y-O-Y	0003										0-290	0-290	0-60	0-100	0-140	0-170	0-200	0-225	0-250	0-275	0-290	0-290
Weakfish Y-O-Y	0007										0-200	0-200	0-200	0-225	0-240	0-90	0-120	0-150	0-180	0-200	0-200	0-200
White Catfish Y-O-Y	0039										0-110	0-110	0-110	0-110	0-120	0-50	0-65	0-80	0-90	0-100	0-110	0-110
White Catfish 1+	0039										>110	>110	>110	>110	>120	>50	>65	>80	>90	>100	>110	>110
White Perch Y-O-Y	0032										0-85	0-85	0-85	0-95	0-35	0-65	0-73	0-80	0-85	0-85	0-85	0-85
White Perch 1+	0032										>86	>86	>86	>96	>36	>66	>74	>81	>86	>85	>86	>86

Table 2. Sample collection history of the VIMS Trawl Survey, 1988 – May 2014. Each entry in the table represents the number of completed tows for the regular survey (not including Mobjack Bay); YR is year, TOT is total, STAT. TYPE is station type. Other codes are below and are based on Wojcik and Van Engel (1988), Appendices A – C.

YR	TOT	MONTH												WATER SYSTEM						Vessel			Gear		STAT. TYPE		TOW DURATION/DISTANCE		
		J	F	M	A	M	J	J	A	S	O	N	D	CL	JA	PO	RA	YK	ZZ	FH	JS	LN	070	108	F	R	5	OT	DIS
1988	889	69	69	62	48	82	82	82	82	82	82	80	69	576	97	0	105	111	0	0	889	0	889	0	313	576	885	0	4
1989	840	61	61	61	66	76	76	76	76	76	76	76	59	479	108	0	124	129	0	0	840	0	840	0	361	479	840	0	0
1990	827	61	61	61	61	76	76	77	75	76	69	76	58	473	108	0	119	127	0	279	548	0	827	0	354	473	826	0	1
1991	930	61	25	61	61	73	94	95	95	97	97	97	74	411	108	0	120	291	0	930	0	0	0	930	357	573	928	1	1
1992	982	79	47	79	79	97	88	88	88	89	88	88	72	404	110	0	124	344	0	982	0	0	0	982	361	621	975	7	0
1993	915	40	73	40	71	88	89	88	88	88	88	87	75	370	110	0	126	309	0	915	0	0	0	915	365	550	914	1	0
1994	911	40	73	40	73	88	88	88	88	88	88	88	69	368	110	0	124	309	0	911	0	0	0	911	363	548	906	5	0
1995	993	40	73	40	73	92	88	88	88	105	105	99	102	411	96	0	201	285	0	993	0	0	0	993	314	679	984	9	0
1996	1176	52	91	71	106	106	107	108	108	107	108	107	105	435	228	0	258	255	0	1176	0	0	0	1176	279	897	1168	6	2
1997	1220	68	105	66	98	110	111	111	112	111	112	111	105	425	265	0	264	266	0	1220	0	0	0	1220	302	918	1217	3	0
1998	1262	66	105	66	105	111	111	128	59	138	124	130	119	388	265	0	256	264	89	1262	0	0	0	1262	322	940	1261	1	0
1999	1382	79	122	80	122	120	118	119	118	122	124	131	127	402	264	0	264	265	187	1382	0	0	0	1382	363	1019	1380	2	0
2000	1367	52	129	85	101	158	111	128	125	121	141	111	105	433	250	17	266	265	136	1367	0	0	0	1367	363	1004	1367	0	0
2001	1122	30	30	30	75	112	144	111	112	135	136	111	96	384	230	35	230	230	13	1017	0	105	0	1122	277	845	1119	1	2
2002	1090	66	90	66	90	96	106	96	97	95	96	96	96	288	264	0	264	264	10	1090	0	0	0	1090	300	790	1089	1	0
2003	1191	66	96	66	96	96	111	111	111	111	111	111	105	399	264	0	264	264	0	1191	0	0	0	1191	300	891	1191	0	0
2004	1224	66	105	66	105	111	111	111	111	111	111	111	105	432	264	0	264	264	0	1224	0	0	0	1224	300	924	1224	0	0
2005	1211	66	105	66	105	111	111	111	111	113	111	111	90	419	264	0	264	264	0	1211	0	0	0	1211	300	911	1211	0	0
2006	1193	66	105	66	105	111	111	111	111	113	111	78	105	423	242	0	264	264	0	1193	0	0	0	1193	292	901	1193	0	0
2007	1224	66	105	66	105	111	111	111	111	111	111	111	105	432	264	0	264	264	0	1224	0	0	0	1224	300	924	1224	0	0
2008	1224	66	105	66	105	111	111	111	111	111	111	111	105	432	264	0	264	264	0	1224	0	0	0	1224	300	924	1224	0	0
2009	1224	66	105	66	105	111	111	111	111	111	111	111	105	432	264	0	264	264	0	1224	0	0	0	1224	300	924	1224	0	0
2010	1224	66	105	66	105	111	111	111	111	111	111	111	105	432	264	0	264	264	170	1224	0	0	0	1224	300	924	1224	0	0
2011	1224	66	105	66	105	111	111	111	111	111	111	111	105	432	264	0	264	264	204	1224	0	0	0	1224	300	924	1224	0	0
2012	1205	66	105	66	105	111	111	111	111	111	111	92	105	432	264	0	264	264	148	1205	0	0	0	1205	300	905	1205	0	0
2013	1224	66	105	66	105	111	111	111	111	111	111	111	105	432	264	0	264	264	0	1224	0	0	0	1224	300	924	1224	0	0
2014	453	66	105	66	105	111								123	110		110	110	0	453				453	125	328	453		
TOT	29,727	1,656	2,405	1,700	2,480	2,802	2,710	2,704	2,632	2,755	2,755	2,657	2,471	11,067	5,605	52	5,859	6,728	957	27,345	2,277	105	2,556	27,171	8,411	21,316	29,680	37	10

System: CL Lower Chesapeake Bay (Virginia Portion)
- JA James River
- PO Potomac River
- RA Rappahannock River
- YK York River
- ZZ includes: Atlantic Ocean (AT) - 1971, 78-79, 2002; Piankatank R. (PK) - 1970-71, 98-00; Mobjack Bay (MB) - 1970-73, 98-01, 10-12; Pocomoke Sound (CP) -1973-81, 98-01; Great Wicomico R. (GW) - 1998-00.

Vessel: FH Fish Hawk
- JS John Smith
- LN Langley II

Gear Code:

30' Gears
- 070 Lined, tickler chain, 60' bridle, 54"x24" doors
- 108 Lined, tickler chain, 60' bridle, metal china-v doors

Station Type: F - Fixed
- R - Random

Tow Type: OT is tow duration in minutes for those not listed. DIS is distance.

Table 3. VIMS trawl survey pooled catch for June 2013 to May 2014 from 1,224 tows.

Adjusted Percent of Catch Excludes Bay Anchovy and Hogchoker

Species	Number of Fish (All)	Frequency	Percent of Catch	Catch Per Trawl	Adjusted Percent of Catch	Number of Fish YOY	Average Length (mm)	Standard Error (length)	Minimum Length (mm)	Maximum Length (mm)
Bay Anchovy	270,704	1025	55.43	221.16	.	207,549	52	0.07	20	95
Hogchoker	68,832	731	14.09	56.24	.	24,456	80	0.18	13	196
Atlantic Croaker	45,334	743	9.28	37.04	30.46	27,864	134	0.43	13	374
Spot	25,905	601	5.30	21.16	17.41	17,456	139	0.20	11	228
White Perch	16,912	310	3.46	13.82	11.36	4,238	131	0.48	21	285
Weakfish	15,644	472	3.20	12.78	10.51	14,895	89	0.43	17	337
Blue Catfish	10,234	252	2.10	8.36	6.88	3,319	211	1.28	20	805
Spotted Hake	9,399	294	1.92	7.68	6.32	9,371	108	0.49	31	308
Northern Searobin	3,318	244	0.68	2.71	2.23	3,243	91	0.55	23	170
Atlantic Menhaden	2,466	245	0.50	2.01	1.66	787	95	1.85	23	298
Blackcheek Tonguefish	2,369	339	0.49	1.94	1.59	542	128	0.55	39	190
Silver Perch	2,009	259	0.41	1.64	1.35	1,582	129	0.59	17	187
Southern Kingfish	1,787	259	0.37	1.46	1.20	1,223	141	1.47	25	354
Gizzard Shad	1,692	181	0.35	1.38	1.14	635	219	2.39	73	383
Striped Anchovy	1,435	129	0.29	1.17	0.96	1,424	80	0.62	31	128
Striped Bass	1,068	182	0.22	0.87	0.72	850	149	2.85	19	597
Smallmouth Flounder	971	156	0.20	0.79	0.65	913	81	0.54	33	137
Summer Flounder	927	344	0.19	0.76	0.62	705	195	2.48	17	543
Kingfish spp	768	113	0.16	0.63	0.52	737	62	1.47	21	272
Blueback Herring	652	110	0.13	0.53	0.44	649	81	0.49	40	216
Alewife	535	126	0.11	0.44	0.36	525	110	1.06	47	273
Harvestfish	505	100	0.10	0.41	0.34	469	65	1.59	13	163
American Shad	453	114	0.09	0.37	0.30	453	97	0.60	74	160
Scup	453	57	0.09	0.37	0.30	440	76	0.97	26	149
Oyster Toadfish	450	143	0.09	0.37	0.30	.	169	3.27	25	342
Windowpane	336	130	0.07	0.27	0.23	330	123	1.83	38	258
White Catfish	272	108	0.06	0.22	0.18	58	203	5.22	34	458
Threadfin Shad	257	39	0.05	0.21	0.17	.	88	0.66	53	131
Butterfish	232	75	0.05	0.19	0.16	202	94	2.27	19	185
Northern Pipefish	204	122	0.04	0.17	0.14	.	128	2.29	63	251
American Eel	185	84	0.04	0.15	0.12	.	279	7.13	121	609
Pigfish	152	34	0.03	0.12	0.10	.	132	1.73	38	193
Northern Puffer	144	79	0.03	0.12	0.10	112	99	3.42	15	209
Striped Searobin	140	78	0.03	0.11	0.09	.	72	2.70	25	173
Naked Goby	134	72	0.03	0.11	0.09	.	36	0.68	17	59
Black Sea Bass	129	74	0.03	0.11	0.09	83	112	4.27	39	238
Atlantic Silverside	128	50	0.03	0.10	0.09	128	87	1.04	54	114
Clearnose Skate	95	47	0.02	0.08	0.06	.	431	4.32	227	505
Red Hake	94	16	0.02	0.08	0.06	.	130	3.19	57	202
Banded Drum	69	22	0.01	0.06	0.05	.	51	5.92	18	210
Seaboard Goby	65	24	0.01	0.05	0.04	.	35	0.69	24	52
Atlantic Cutlassfish	64	35	0.01	0.05	0.04	.	411	18.27	105	688
Atlantic Thread Herring	63	23	0.01	0.05	0.04	.	86	6.43	36	181
Atlantic Spadefish	57	35	0.01	0.05	0.04	.	81	5.24	21	157
Bluefish	53	36	0.01	0.04	0.04	.	201	6.80	77	337
Feather Blenny	48	29	0.01	0.04	0.03	.	71	3.07	37	128
Inshore Lizardfish	46	28	0.01	0.04	0.03	36	156	8.36	55	290
Longnose Gar	38	22	0.01	0.03	0.03	.	748	28.68	370	1030
Hickory Shad	35	26	0.01	0.03	0.02	.	119	6.01	44	273
Skilletfish	35	24	0.01	0.03	0.02	.	44	2.02	23	64
Lined Seahorse	31	28	0.01	0.03	0.02	.	71	5.09	29	128
Atlantic Moonfish	31	18	0.01	0.03	0.02	.	79	3.05	42	111
Star Drum	29	11	0.01	0.02	0.02	.	67	2.70	38	97
Silver Hake	25	11	0.01	0.02	0.02	.	128	5.00	77	162
Bluntnose Stingray	22	17	0	0.02	0.01	.	450	32.16	202	750
Spotted Seatrout	21	18	0	0.02	0.01	.	197	30.66	35	543
Northern Kingfish	20	13	0	0.02	0.01	8	128	9.38	67	191
Atlantic Stingray	19	18	0	0.02	0.01	.	285	23.48	174	545

Table 3 (continued)

Adjusted Percent of Catch Excludes Bay Anchovy and Hogchoker

Species	Number of Fish (All)	Frequency	Percent of Catch	Catch Per Trawl	Adjusted Percent of Catch	Number of Fish YOY	Average Length (mm)	Standard Error (length)	Minimum Length (mm)	Maximum Length (mm)
Pinfish	19	7	0	0.02	0.01	.	116	4.39	84	160
Sea Lamprey	18	10	0	0.01	0.01	.	152	2.68	131	173
Spottail Shiner	17	6	0	0.01	0.01	.	80	3.43	52	96
Silver Seatrout	14	6	0	0.01	0.01	.	219	6.16	148	243
Fringed Flounder	13	12	0	0.01	0.01	.	94	3.67	76	116
Smooth Butterfly Ray	13	11	0	0.01	0.01	.	457	38.38	302	865
Sheepshead	11	8	0	0.01	0.01	.	308	66.75	84	570
Black Drum	10	9	0	0.01	0.01	.	189	10.25	157	273
Winter Flounder	10	8	0	0.01	0.01	.	64	2.74	52	80
Chain Pipefish	9	8	0	0.01	0.01	.	255	9.68	208	298
Red Drum	9	6	0	0.01	0.01	.	290	73.66	57	537
Spiny Butterfly Ray	7	7	0	0.01	0	.	560	33.54	472	740
Bullnose Bay	7	6	0	0.01	0	.	360	17.90	305	440
Channel Catfish	6	5	0	0	0	4	147	50.52	29	343
Green Goby	6	5	0	0	0	.	44	2.17	39	52
Striped Cusk-eel	6	5	0	0	0	.	163	14.66	136	230
Striped Burrfish	6	5	0	0	0	.	209	13.35	147	243
Brown Bullhead	5	5	0	0	0	.	170	38.85	88	302
Common Carp	5	4	0	0	0	.	511	50.72	377	615
Spiny Dogfish	4	4	0	0	0	.	713	5.58	698	722
Atlantic Herring	3	3	0	0	0	.	178	62.05	59	268
Southern Stingray	3	3	0	0	0	.	552	14.71	523	569
Conger Eel	3	3	0	0	0	.	353	9.87	335	369
Northern Sand Lance	3	3	0	0	0	.	129	10.73	108	144
Northern Stargazer	3	3	0	0	0	.	44	9.17	34	62
Round Herring	3	2	0	0	0	.	74	5.70	67	85
Striped Blenny	3	2	0	0	0	.	75	2.96	71	81
Red Goatfish	3	2	0	0	0	.	55	1.45	52	57
Tautog	2	2	0	0	0	.	368	192.50	175	560
Tessellated Darter	2	2	0	0	0	.	72	4.50	67	76
Bluegill	2	2	0	0	0	.	51	1.00	50	52
Cownose Ray	2	2	0	0	0	.	515	115.50	399	630
Striped Mullet	2	2	0	0	0	.	202	11.50	190	213
Gobie spp	2	2	0	0	0	.	21	0.50	20	21
Southern Flounder	2	2	0	0	0	.	515	0	515	515
Roughtail Stingray	2	1	0	0	0	.	394	4.50	389	398
Fourspot Flounder	2	1	0	0	0	.	86	2.00	84	88
Spanish Mackerel	1	1	0	0	0	.	108	.	108	108
Atlantic Mackerel	1	1	0	0	0	.	277	.	277	277
Florida Pompano	1	1	0	0	0	.	170	.	170	170
Shorthead Redhorse	1	1	0	0	0	.	31	.	31	31
Sandbar Shark	1	1	0	0	0	.	527	.	527	527
Winter Skate	1	1	0	0	0	.	420	.	420	420
Eastern Mudminnow	1	1	0	0	0	.	48	.	48	48
Atlantic Sturgeon	1	1	0	0	0	.	664	.	664	664
Blue Runner	1	1	0	0	0	.	121	.	121	121
Lookdown	1	1	0	0	0	.	58	.	58	58
Atlantic Bumper	1	1	0	0	0	.	35	.	35	35
Gray Snapper	1	1	0	0	0	.	66	.	66	66
All Species Combined	488,344									

Table 4. American Eel indices (RSI_{Delta}, 1988–2013).

Year	Rappahannock			York			James		
	Index	Prop. pos.	N	Index	Prop. pos.	N	Index	Prop. pos.	N
1988	2.31	0.20	35	1.27	0.33	40	2.32	0.30	30
1989	11.82	0.37	43	3.50	0.27	49	6.08	0.37	38
1990	13.34	0.40	43	4.90	0.30	50	9.69	0.42	38
1991	4.89	0.38	42	0.64	0.18	49	1.82	0.26	38
1992	1.95	0.28	43	0.83	0.19	47	8.99	0.42	38
1993	1.87	0.30	43	0.33	0.16	49	5.74	0.42	38
1994	3.45	0.40	43	0.33	0.16	49	2.21	0.37	38
1995	2.83	0.37	43	0.33	0.18	49	1.74	0.37	46
1996	2.54	0.36	128	0.58	0.25	126	3.90	0.41	126
1997	2.71	0.45	132	0.47	0.19	132	1.77	0.36	132
1998	2.02	0.31	124	0.48	0.19	132	1.91	0.35	132
1999	0.71	0.23	132	0.23	0.14	133	1.16	0.31	132
2000	1.38	0.32	133	0.24	0.16	133	0.87	0.28	132
2001	0.58	0.18	133	0.16	0.14	133	0.58	0.23	134
2002	0.28	0.16	132	0.24	0.15	132	0.73	0.23	132
2003	0.61	0.20	132	0.14	0.11	132	0.57	0.23	132
2004	0.44	0.25	132	0.14	0.11	132	0.46	0.16	132
2005	0.14	0.11	132	0.09	0.05	132	0.26	0.17	132
2006	0.08	0.05	132	0.04	0.04	132	0.14	0.11	132
2007	0.20	0.11	132	0.08	0.06	132	0.11	0.10	132
2008	0.47	0.22	132	0.21	0.17	132	0.17	0.13	132
2009	0.48	0.17	132	0.14	0.12	132	0.33	0.16	132
2010	0.51	0.21	132	0.16	0.14	132	0.19	0.11	132
2011	0.85	0.30	132	0.10	0.10	132	0.34	0.17	132
2012	0.85	0.27	132	0.12	0.11	132	0.18	0.09	132
2013	0.96	0.25	132	0.16	0.12	132	0.43	0.14	132
Average	2.24			0.61			2.03		

Table 5. Spring Atlantic Croaker indices (RSI_{Delta}; 1988–2013).

Year Class	Year	Mean all	LCI all	UCI all	Mean Rivers	LCI Rivers	UCI Rivers
1987	1988	0.95	0.274	2.304	3.65	1.202	9.063
1988	1989	14.14	1.435	36.264	51.13	5.047	144.659
1989	1990	6.40	0.605	12.010	27.11	2.369	48.067
1990	1991	28.39	4.934	113.383	100.66	13.001	442.548
1991	1992	2.80	2.175	3.514	10.73	8.305	13.533
1992	1993	7.22	3.274	13.371	28.63	12.278	53.007
1993	1994	0.52	0.259	0.826	1.18	0.433	2.074
1994	1995	2.06	1.253	3.050	7.25	4.435	10.891
1995	1996	0.03	0.010	0.047	0.11	0.040	0.181
1996	1997	65.51	8.666	218.296	257.41	35.231	870.941
1997	1998	12.68	8.419	23.212	49.39	32.740	85.845
1998	1999	4.98	2.458	10.372	18.97	9.146	36.983
1999	2000	1.17	0.695	1.699	4.65	2.771	6.745
2000	2001	1.55	0.210	6.370	5.99	0.770	24.206
2001	2002	7.64	4.610	10.793	29.53	17.484	43.250
2002	2003	0.90	0.068	2.394	0.63	0.177	1.099
2003	2004	4.36	2.897	5.951	17.15	11.105	24.095
2004	2005	2.72	1.594	4.843	9.60	5.344	16.408
2005	2006	9.46	5.793	16.172	37.93	23.095	64.650
2006	2007	6.36	4.176	9.659	24.87	15.929	37.573
2007	2008	28.06	22.206	36.081	109.34	86.692	142.396
2008	2009	10.21	6.581	15.749	33.85	23.112	50.371
*		114.71	7.323	555.358			
2009	2010	29.07	6.633	73.246	80.83	21.237	202.500
2010	2011	4.43	1.364	8.357	8.83	2.347	16.763
2011	2012	56.20	39.680	84.441	165.47	111.742	234.917
2012	2013	16.67	10.421	24.651	50.40	31.652	69.685
2013	2014	1.55	0.609	2.33	4.08	0.882	6.342
Average		12.07			42.20		

Table 6. Bay Anchovy indices (RSI_{GM}; 1988–2013).

	Random Stratified Index (RSI)				Original Index			
Year	Geo. Mean	95% C.I.'s	C.V.	N	Bay & River (BRI)	N	River Only (RO)	N
1988	18.25	12.17 - 27.15	6.42	346	18.06	346	32.66	128
1989	52.47	36.27 - 75.71	4.54	374	51.59	374	22.74	128
1990	6.79	4.41 - 10.22	8.89	369	6.65	369	8.78	124
1991	22.51	15.05 - 33.43	6.04	491	22.83	350	33.41	125
1992	40.14	27.17 - 59.09	5.10	448	40.79	355	14.53	128
1993	43.31	28.80 - 64.89	5.23	449	42.71	360	28.93	132
1994	14.67	9.93 - 21.46	6.54	444	14.36	354	19.86	130
1995	18.36	12.84 - 26.07	5.66	540	18.52	362	18.57	138
1996	15.31	11.20 - 20.82	5.21	607	16.91	363	5.11	135
1997	18.96	13.63 - 26.23	5.19	625	17.33	378	12.64	150
1998	30.26	20.75 - 43.93	5.27	579	30.47	336	9.70	146
1999	15.47	11.20 - 21.22	5.35	606	14.38	360	21.26	150
2000	36.58	26.69 - 49.99	4.21	619	40.36	369	16.24	147
2001	9.55	6.93 - 13.04	6.06	627	9.23	377	4.56	150
2002	5.51	3.58 - 8.24	9.36	540	4.09	294	9.30	150
2003	18.03	13.17 - 24.56	5.01	624	20.65	378	3.41	150
2004	23.06	16.71 - 31.70	4.82	624	21.45	377	7.02	149
2005	22.27	16.01 - 30.85	4.98	613	21.26	367	8.43	150
2006	19.31	14.00 - 26.50	5.03	592	16.99	360	10.59	142
2007	23.76	17.33 - 32.44	4.69	624	21.15	378	10.27	150
2008	50.29	36.21 - 69.68	4.07	624	43.11	378	49.06	150
2009	30.12	22.30 - 40.55	4.21	624	25.64	378	25.09	150
2010	84.92	61.27 - 117.54	3.61	624	79.68	378	41.60	150
2011	26.56	19.20 - 36.59	4.68	624	24.10	378	24.37	150
2012	51.53	36.84 - 71.92	4.14	611	47.59	365	31.94	150
2013	23.76	16.92 - 33.19	5.03	624	23.03	378	14.45	150
Average	27.76							

Table 7. Black Sea Bass indices (RSI_{GM}; 1988–2012).

	Random Stratified Index (RSI)				Original Index			
	Geo.				Bay & River		River Only	
Year class	Mean	95% C.I.'s	C.V.	N	(BRI)	N	(RO)	N
1988	0.84	0.59 - 1.13	11.89	138	0.83	138	1.04	12
1989	2.36	1.70 - 3.17	8.93	138	2.36	138	1.52	12
1990	1.12	0.78 - 1.53	11.63	128	1.12	128	0.50	12
1991	1.28	0.91 - 1.72	10.76	129	1.29	129	2.35	12
1992	0.22	0.13 - 0.32	18.86	129	0.22	129	0.19	12
1993	1.05	0.74 - 1.42	11.46	129	1.04	129	0.76	12
1994	1.06	0.74 - 1.45	11.85	129	1.06	129	0.60	12
1995	0.50	0.33 - 0.69	14.47	151	0.54	127	0.62	12
1996	0.36	0.22 - 0.52	17.99	152	0.35	128	0.38	12
1997	0.46	0.31 - 0.63	14.63	153	0.47	129	0.23	12
1998	0.57	0.35 - 0.82	16.40	135	0.59	111	0.32	12
1999	0.58	0.41 - 0.77	12.22	146	0.60	122	0.48	12
2000	0.74	0.50 - 1.02	13.39	153	0.78	129	0.93	12
2001	1.29	0.85 - 1.84	12.89	108	1.33	84	1.31	12
2002	0.64	0.41 - 0.90	15.16	138	0.69	114	0.57	12
2003	0.12	0.06 - 0.18	25.11	153	0.11	129	0.12	12
2004	0.06	0.02 - 0.10	34.69	153	0.05	129	0.06	12
2005	0.19	0.12 - 0.26	17.66	153	0.20	129	0.06	12
2006	0.44	0.30 - 0.60	14.14	153	0.48	129	0.06	12
2007	0.83	0.53 - 1.18	14.68	153	0.90	129	0.49	12
2008	0.41	0.27 - 0.57	14.90	153	0.45	129	0.43	12
2009	0.32	0.19 - 0.47	19.23	153	0.35	129	0.16	12
2010	1.11	0.83 - 1.43	9.41	153	1.21	129	0.81	12
2011	0.65	0.47 - 0.85	11.61	153	0.71	129	0.43	12
2012	0.19	0.11 - 0.28	19.21	153	0.18	129	0.12	12
Average	0.70							

Table 8. Blue Catfish juvenile indices (RSI_{Delta}; 1989–2013).

	Rappahannock			York			James		
Year Class	Index	Prop. pos.	N	Index	Prop. pos.	N	Index	Prop. pos.	N
1989	0.00	0.00	28	0.00	0.00	28	1.12	0.15	20
1990	0.25	0.04	28	0.00	0.00	27	2.13	0.10	20
1991	0.00	0.00	26	0.00	0.00	28	0.00	0.00	22
1992	0.00	0.00	28	0.00	0.00	28	0.04	0.04	24
1993	0.59	0.17	29	0.00	0.00	28	0.65	0.17	24
1994	0.00	0.00	27	0.00	0.00	28	1.58	0.13	23
1995	0.09	0.04	55	0.00	0.00	52	1.20	0.23	31
1996	0.44	0.09	64	0.00	0.00	60	6.99	0.35	60
1997	0.30	0.02	64	0.00	0.00	60	4.35	0.32	57
1998	0.00	0.00	64	0.00	0.00	60	0.25	0.08	59
1999	0.00	0.00	64	0.00	0.00	60	0.02	0.02	51
2000	0.00	0.00	46	0.02	0.02	45	0.02	0.02	45
2001	0.00	0.00	64	0.02	0.02	60	0.00	0.00	60
2002	0.00	0.00	64	0.02	0.02	60	0.33	0.13	60
2003	0.67	0.14	64	0.41	0.12	60	20.24	0.50	60
2004	0.05	0.03	64	1.68	0.12	60	13.50	0.47	60
2005	0.03	0.03	64	0.11	0.05	60	5.27	0.28	60
2006	0.60	0.05	64	1.17	0.07	60	21.60	0.33	60
2007	0.00	0.00	64	0.00	0.00	60	0.78	0.08	60
2008	0.00	0.00	64	0.00	0.00	60	0.78	0.07	60
2009	0.18	0.06	64	0.00	0.00	60	7.09	0.40	60
2010	0.17	0.03	64	0.05	0.03	60	0.80	0.10	60
2011	17.21	0.05	64	6.57	0.18	60	2.82	0.32	60
2012	0.14	0.02	64	0.62	0.10	60	1.52	0.10	60
2013	3.06	0.14	64	0.81	0.22	60	5.10	0.40	60
Average	0.95			0.46			3.93		

Table 9. Blue Catfish age 1+ indices (RSI_{Delta}; 1988 –2014).

	Rappahannock			York			James		
Year	Index	Prop. pos.	N	Index	Prop. pos.	N	Index	Prop. pos.	N
1988	0.00	0.00	12	0.00	0.00	18	0.00	0.00	15
1989	0.00	0.00	26	0.00	0.00	25	0.00	0.00	22
1990	0.14	0.04	28	0.00	0.00	28	0.83	0.20	20
1991	3.11	0.11	28	0.00	0.00	27	3.13	0.20	20
1992	0.18	0.08	26	0.00	0.00	28	1.40	0.18	22
1993	0.33	0.18	28	0.00	0.00	28	2.63	0.17	24
1994	0.68	0.14	29	0.00	0.00	28	7.29	0.29	24
1995	2.32	0.15	27	0.00	0.00	28	3.24	0.30	23
1996	3.74	0.07	55	0.00	0.00	52	0.64	0.19	31
1997	8.10	0.30	64	0.05	0.03	60	2.08	0.33	60
1998	34.54	0.31	64	0.00	0.00	60	16.55	0.56	57
1999	64.21	0.20	64	0.00	0.00	60	22.81	0.39	59
2000	39.84	0.22	64	0.12	0.07	60	5.69	0.29	51
2001	0.75	0.09	46	0.29	0.04	45	2.02	0.27	45
2002	2.59	0.17	64	0.03	0.03	60	3.83	0.20	60
2003	0.56	0.05	64	0.02	0.02	60	0.44	0.23	60
2004	11.05	0.14	64	0.28	0.12	60	4.52	0.45	60
2005	13.09	0.39	64	1.50	0.15	60	12.72	0.68	60
2006	6.58	0.31	64	2.34	0.22	60	62.83	0.68	60
2007	13.53	0.36	64	2.94	0.30	60	92.31	0.62	60
2008	14.73	0.31	64	1.18	0.17	60	30.05	0.57	60
2009	8.48	0.13	64	1.08	0.18	60	21.90	0.52	60
2010	4.34	0.19	64	0.83	0.22	60	28.90	0.63	60
2011	18.73	0.20	64	0.68	0.23	60	5.22	0.47	60
2012	31.76	0.75	64	2.91	0.42	60	22.25	0.70	60
2013	4.32	0.27	64	2.35	0.25	60	10.02	0.63	60
2014	1.77	0.20	64	2.59	0.32	60	7.47	0.68	60
Average	10.72			0.71			13.73		

Table 10. Channel Catfish juvenile indices (RSI_{GM}, 1988–2013).

	Rappahannock				York				James			
Year class	RSI	N	CV	95% C.I.	RSI	N	CV	95% C.I.	RSI	N	CV	95% C.I.
1988	0.00	16	100.00	0.00 - 0.01	0.00	20		0	0.02	16	100.00	0.00 - 0.05
1989	0.02	16	69.87	0.00 - 0.04	0.05	19	58.09	0.00 - 0.11	1.74	16	17.94	0.91 - 2.94
1990	0.01	16	69.15	0.00 - 0.02	0.00	20	100.00	0.00 - 0.01	0.03	16	100.00	0.00 - 0.09
1991	0.00	16		0	0.00	20		0	0.03	16	100.00	0.00 - 0.09
1992	0.00	16		0	0.00	20		0	0.00	16		0
1993	0.00	16	100.00	0.00 - 0.01	0.00	20	100.00	0.00 - 0.01	0.04	16	88.50	0.00 - 0.11
1994	0.00	16		0	0.01	20	51.64	0.00 - 0.02	0.04	16	69.39	0.00 - 0.10
1995	0.00	41	68.31	0.00 - 0.01	0.01	40	82.13	0.00 - 0.04	0.20	28	36.13	0.05 - 0.38
1996	0.01	40	78.78	0.00 - 0.02	0.00	40		0	0.12	40	48.23	0.00 - 0.24
1997	0.00	40		0	0.00	40		0	0.05	40	65.74	0.00 - 0.11
1998	0.00	40	100.00	0.00 - 0.01	0.00	40	67.42	0.00 - 0.01	0.05	40	56.55	0.00 - 0.11
1999	0.00	40		0	0.00	40		0	0.00	34		0
2000	0.00	40		0	0.01	40	53.58	0.00 - 0.02	0.01	40	67.42	0.00 - 0.01
2001	0.00	40		0	0.00	40		0	0.00	40	100.00	0.00 - 0.01
2002	0.00	40	100.00	0.00 - 0.01	0.00	40		0	0.00	40		0
2003	0.01	40	68.89	0.00 - 0.02	0.02	40	39.07	0.00 - 0.04	0.28	40	26.13	0.13 - 0.46
2004	0.00	40		0	0.00	40	67.42	0.00 - 0.01	0.19	40	29.41	0.07 - 0.31
2005	0.00	40		0	0.00	40		0	0.02	40	56.41	0.00 - 0.05
2006	0.00	40		0	0.00	40		0	0.01	40	83.74	0.00 - 0.02
2007	0.00	40		0	0.00	40		0	0.00	40	100.00	0.00 - 0.01
2008	0.00	40		0	0.00	40		0	0.00	40		0
2009	0.00	40		0	0.00	40		0	0.01	40	100.00	0.00 - 0.02
2010	0.00	40	100.00	0.00 - 0.01	0.00	40		0	0.00	40		0
2011	0.00	40		0	0.00	40	100.00	0.00 - 0.01	0.00	40		0
2012	0.00	40		0	0.00	40		0	0.00	40		0
2013	0.00	40		0	0.00	40		0	0.00	40		0
Average	0.00				0.00				0.11			

Table 11. Channel Catfish age 1+ indices (RSI_{GM}; 1988–2014).

	Rappahannock				York				James			
Year	RSI	N	CV	95% C.I.	RSI	N	CV	95% C.I.	RSI	N	CV	95% C.I.
1988	0.03	16	100.00	0.00 - 0.08	0.05	20	100.00	0.00 - 0.17	0.80	16	28.49	0.29 - 1.51
1989	0.08	16	35.63	0.02 - 0.14	0.00	20		0	1.22	16	9.35	0.91 - 1.58
1990	0.07	16	22.35	0.04 - 0.10	0.03	19	58.97	0.00 - 0.06	0.92	16	24.75	0.39 - 1.64
1991	0.67	16	5.09	0.58 - 0.76	0.01	20	67.42	0.00 - 0.01	1.19	16	17.22	0.67 - 1.86
1992	0.77	16	21.49	0.38 - 1.26	0.02	20	51.73	0.00 - 0.05	1.59	16	9.21	1.17 - 2.09
1993	0.72	16	4.41	0.64 - 0.80	0.00	20		0	0.81	16	19.59	0.44 - 1.29
1994	0.07	16	25.11	0.03 - 0.10	0.00	20	100.00	0.00 - 0.01	0.71	16	39.39	0.12 - 1.61
1995	0.22	16	9.19	0.17 - 0.26	0.01	20	54.14	0.00 - 0.03	0.49	16	25.42	0.22 - 0.83
1996	0.12	41	27.05	0.05 - 0.19	0.00	40	69.46	0.00 - 0.01	0.50	28	22.58	0.25 - 0.80
1997	0.21	40	37.27	0.05 - 0.40	0.01	40	49.51	0.00 - 0.02	0.70	40	20.53	0.37 - 1.12
1998	0.22	40	38.53	0.05 - 0.42	0.00	40	69.46	0.00 - 0.01	0.50	40	19.83	0.28 - 0.77
1999	0.13	40	28.36	0.06 - 0.22	0.01	40	57.60	0.00 - 0.03	0.55	40	21.67	0.28 - 0.88
2000	0.03	40	57.14	0.00 - 0.06	0.03	40	34.14	0.01 - 0.05	0.26	34	34.05	0.08 - 0.47
2001	0.07	40	72.44	0.00 - 0.18	0.00	40	67.42	0.00 - 0.01	0.16	40	22.63	0.09 - 0.25
2002	0.03	40	78.01	0.00 - 0.08	0.00	40	100.00	0.00 - 0.01	0.14	40	44.96	0.01 - 0.27
2003	0.13	40	24.80	0.06 - 0.20	0.01	40	52.22	0.00 - 0.02	0.20	40	41.61	0.03 - 0.40
2004	0.07	40	44.48	0.01 - 0.13	0.00	40	100.00	0.00 - 0.01	0.20	40	26.76	0.09 - 0.33
2005	0.02	40	69.54	0.00 - 0.06	0.00	40	67.42	0.00 - 0.01	0.28	40	28.65	0.11 - 0.48
2006	0.01	40	57.12	0.00 - 0.02	0.00	40	100.00	0.00 - 0.01	0.27	40	31.74	0.09 - 0.48
2007	0.04	40	51.20	0.00 - 0.07	0.00	40		0	0.17	40	29.20	0.07 - 0.28
2008	0.00	40		0	0.00	40		0	0.06	40	32.35	0.02 - 0.11
2009	0.00	40	100.00	0	0.00	40	100.00	0.00 - 0.01	0.05	40	35.13	0.02 - 0.09
2010	0.00	40		0	0.00	40		0	0.06	40	57.37	0.00 - 0.13
2011	0.01	40	100.00	0.00 - 0.02	0.00	40	100.00	0.00 - 0.01	0.02	40	41.84	0.00 - 0.04
2012	0.00	40		0	0.00	40		0	0.04	40	37.82	0.01 - 0.08
2013	0.00	40		0	0.00	40		0	0.01	40	61.47	0.00 - 0.03
2014	0.00	40		0	0.00	40		0	0.00	40		0
Average	0.14				0.01				0.44			

Table 12. Scup indices (RSI_{GM}; 1988–2012).

	Random Stratified Index (RSI)			
Year-class	Geo. Mean	95% C.I.'s	C.V.	N
1988	3.06	2.05 - 4.41	10.20	112
1989	4.92	3.14 - 7.45	10.03	112
1990	1.90	1.11 - 2.99	14.99	103
1991	0.65	0.41 - 0.93	15.67	104
1992	3.36	2.16 - 5.01	10.90	104
1993	0.90	0.53 - 1.35	16.67	104
1994	0.39	0.21 - 0.59	21.36	104
1995	0.54	0.29 - 0.83	20.37	104
1996	0.21	0.09 - 0.35	28.00	104
1997	0.50	0.27 - 0.75	19.83	79
1998	0.27	0.06 - 0.52	37.91	88
1999	0.13	0.02 - 0.25	41.14	105
2000	1.34	0.88 - 1.90	12.80	111
2001	0.24	0.11 - 0.37	24.52	64
2002	0.96	0.58 - 1.42	15.89	104
2003	0.46	0.28 - 0.67	17.38	104
2004	1.11	0.71 - 1.59	13.89	104
2005	1.58	0.99 - 2.36	13.77	104
2006	2.99	2.07 - 4.19	9.47	104
2007	0.20	0.09 - 0.31	25.12	104
2008	2.97	2.07 - 4.13	9.28	104
2009	4.11	2.79 - 5.89	9.14	104
2010	0.82	0.51 - 1.20	15.70	104
2011	0.22	0.07 - 0.39	33.06	104
2012	0.74	0.46 - 1.06	15.48	104
Average	1.38			

Table 13. Silver Perch indices (RSI_{GM}; 1988–2013).

	Random Stratified Index (RSI)				Original Index			
	Geo.				Bay & River		River Only	
Year	Mean	95% C.I.'s	C.V.	N	(BRI)	N	(RO)	N
1988	0.61	0.35 - 0.92	18.30	172	0.65	172	1.02	65
1989	0.53	0.33 - 0.76	16.32	189	0.56	189	1.63	63
1990	0.69	0.49 - 0.92	11.94	185	0.75	185	4.08	59
1991	0.35	0.21 - 0.51	17.33	179	0.40	179	1.47	62
1992	0.81	0.49 - 1.18	15.80	178	0.86	178	1.95	61
1993	0.45	0.29 - 0.63	16.01	180	0.45	180	0.60	63
1994	0.25	0.11 - 0.40	25.42	180	0.26	180	0.37	63
1995	0.58	0.34 - 0.87	15.65	180	0.65	180	1.81	67
1996	0.59	0.38 - 0.84	15.63	304	0.58	183	1.18	66
1997	0.71	0.50 - 0.94	12.07	316	0.79	192	1.43	75
1998	0.24	0.15 - 0.33	16.77	316	0.24	192	0.53	75
1999	0.70	0.49 - 0.94	12.42	309	0.74	186	2.51	75
2000	0.68	0.46 - 0.93	13.56	317	0.76	192	2.12	74
2001	0.70	0.47 - 0.97	13.77	327	0.85	200	3.17	75
2002	0.44	0.24 - 0.67	20.16	269	0.41	146	1.67	75
2003	0.63	0.40 - 0.90	15.49	315	0.66	192	0.71	75
2004	0.34	0.22 - 0.48	16.50	315	0.36	192	0.80	75
2005	0.76	0.52 - 1.03	12.64	315	0.77	192	2.20	75
2006	1.21	0.84 - 1.64	11.31	283	1.22	174	4.45	67
2007	0.75	0.50 - 1.03	13.53	315	0.68	192	2.26	75
2008	0.49	0.34 - 0.66	13.31	315	0.46	192	0.84	75
2009	1.00	0.72 - 1.32	10.83	315	0.92	192	1.74	75
2010	1.27	0.95 - 1.65	9.29	315	1.12	192	3.52	75
2011	0.77	0.53 - 1.04	12.41	315	0.77	192	1.75	75
2012	0.80	0.55 - 1.08	12.38	302	0.80	179	3.65	75
2013	0.59	0.41 - 0.79	13.16	315	0.40	192	1.95	75
Average	0.65							

Table 14. Spot indices (RSI_{GM}; 1988–2013).

	Random Stratified Index (RSI)				Original Index			
Year	Geo. Mean	95% C.I.'s	C.V.	N	Bay & River (BRI)	N	River Only (RO)	N
1988	67.01	46.36 - 96.67	4.29	231	67.45	231	50.20	84
1989	31.41	24.51 - 40.18	3.44	252	32.27	252	54.19	84
1990	44.78	32.34 - 61.85	4.14	248	45.28	248	53.06	81
1991	16.83	12.28 - 21.60	4.66	238	16.56	238	21.44	83
1992	1.92	1.45 - 2.49	8.20	238	1.96	238	4.39	82
1993	9.78	7.23 - 13.13	5.68	240	9.74	240	11.85	84
1994	9.23	6.88 - 12.27	5.61	240	9.07	240	8.88	84
1995	1.56	1.15 - 2.05	9.25	248	1.52	248	2.37	92
1996	5.26	4.15 - 6.60	5.30	407	4.52	244	4.84	88
1997	11.50	9.11 - 14.45	4.20	421	8.63	256	19.68	100
1998	2.51	1.92 - 3.23	7.36	374	1.88	214	3.04	96
1999	4.72	3.63 - 6.07	6.07	402	3.98	238	6.61	100
2000	3.32	2.57 - 4.23	6.51	421	2.70	253	4.94	97
2001	3.09	2.45 - 3.85	6.06	432	2.83	264	3.69	100
2002	2.89	2.10 - 3.88	8.38	360	2.09	196	3.12	100
2003	2.85	2.25 - 3.56	6.32	420	2.58	256	2.32	100
2004	3.96	3.14 - 4.95	5.68	420	3.21	255	6.91	99
2005	12.12	9.80 - 14.94	3.78	420	8.91	256	16.58	100
2006	3.37	2.71 - 4.16	5.61	420	2.67	256	3.20	100
2007	9.17	7.38 - 11.35	4.18	420	7.79	256	12.75	100
2008	19.89	15.16 - 26.01	4.22	420	16.83	256	16.77	100
2009	6.08	4.96 - 7.40	4.39	420	4.74	256	9.05	100
2010	74.97	59.30 - 94.70	2.67	420	74.50	256	29.81	100
2011	5.29	4.22 - 6.57	5.05	420	4.33	256	6.72	100
2012	17.18	13.49 - 21.82	3.92	420	16.09	256	14.15	100
2013	12.38	10.14 - 15.08	3.54	420	11.05	256	9.2	100
Average	14.73							

Table 15. Striped Bass indices (RSI_{GM}; 1988–2013).

	Random Stratified Index (RSI)				Original Index	
	Geo.				River Only	
Year class	Mean	95% C.I.'s	C.V.	N	(RO)	N
1988	1.24	0.65 - 2.06	19.19	35	1.93	35
1989	1.65	1.12 - 2.32	11.51	37	1.59	37
1990	1.06	0.49 - 1.84	22.33	36	1.14	36
1991	1.09	0.31 - 2.33	31.00	36	1.02	36
1992	1.22	0.76 - 1.81	13.18	39	2.15	39
1993	2.52	1.09 - 4.94	19.32	41	3.30	41
1994	1.31	0.85 - 1.87	12.58	39	1.07	39
1995	0.63	0.34 - 0.99	20.19	61	1.22	39
1996	0.61	0.32 - 0.95	20.56	90	1.19	39
1997	0.55	0.25 - 0.93	24.75	90	0.41	39
1998	0.89	0.44 - 1.47	21.30	90	1.22	39
1999	0.21	0.00 - 0.47	51.55	84	0.26	39
2000	1.54	0.76 - 2.67	19.70	90	2.72	39
2001	0.53	0.27 - 0.85	21.84	90	1.94	39
2002	0.71	0.42 - 1.07	17.34	90	1.68	39
2003	0.63	0.24 - 1.13	27.59	90	1.01	39
2004	0.33	0.17 - 0.52	22.68	90	0.45	39
2005	0.59	0.30 - 0.95	21.79	90	0.53	39
2006	0.27	0.13 - 0.42	23.65	90	0.55	39
2007	0.37	0.21 - 0.55	20.10	90	0.74	39
2008	0.62	0.22 - 1.15	29.31	90	1.58	39
2009	0.48	0.28 - 0.70	17.93	90	1.06	39
2010	0.33	0.19 - 0.48	19.31	90	1.28	39
2011	0.44	0.10 - 0.89	37.16	90	0.32	39
2012	0.14	0.07 - 0.22	25.07	90	0.20	39
2013	1.33	0.94 - 1.79	10.74	90	2.09	39
Average	0.82					

Table 16. Summer Flounder indices (RSI_{GM}; 1988–2013).

	Random Stratified Index (RSI)				Original Index			
Year	Geo. Mean	95% C.I.'s	C.V.	N	Bay & River (BRI)	N	River Only (RO)	N
1988	0.54	0.35 - 0.75	14.99	143	0.53	143	0.54	36
1989	1.24	0.94 - 1.58	8.77	162	1.23	162	0.96	36
1990	2.54	2.06 - 3.09	5.73	162	2.54	162	2.61	36
1991	2.79	2.26 - 3.41	5.66	153	2.78	153	1.42	36
1992	0.92	0.70 - 1.17	9.25	153	0.91	153	0.49	36
1993	0.52	0.38 - 0.68	11.87	153	0.53	153	0.49	36
1994	2.54	2.01 - 3.15	6.39	153	2.50	153	1.08	36
1995	0.71	0.52 - 0.92	10.89	149	0.72	149	0.74	36
1996	0.81	0.62 - 1.02	9.32	224	0.86	153	0.62	36
1997	0.89	0.69 - 1.12	8.77	226	0.97	153	0.70	36
1998	0.73	0.55 - 0.93	9.92	226	0.78	153	0.17	36
1999	0.53	0.41 - 0.67	9.94	219	0.58	147	0.36	36
2000	0.57	0.43 - 0.73	10.81	227	0.62	154	0.52	36
2001	0.47	0.34 - 0.61	11.84	236	0.52	161	0.53	36
2002	0.77	0.54 - 1.04	12.21	179	0.80	107	0.43	36
2003	0.44	0.33 - 0.56	10.95	225	0.43	153	0.50	36
2004	1.30	1.03 - 1.60	7.50	225	1.40	153	1.17	36
2005	0.35	0.25 - 0.46	13.18	225	0.36	153	0.29	36
2006	0.80	0.60 - 1.02	10.03	203	0.87	139	0.59	32
2007	1.00	0.78 - 1.24	8.22	225	1.04	153	0.53	36
2008	1.35	1.10 - 1.63	6.68	225	1.49	153	1.09	36
2009	0.75	0.58 - 0.92	8.76	225	0.82	153	0.84	36
2010	0.55	0.41 - 0.69	10.61	225	0.57	153	0.65	36
2011	0.17	0.11 - 0.23	17.54	225	0.18	153	0.08	36
2012	2.03	1.69 - 2.40	5.29	212	2.23	140	0.53	36
2013	0.82	0.65 - 1.02	8.42	225	0.87	153	0.65	36
Average	1.01							

Table 17. Weakfish indices (RSI_{GM}; 1988–2013).

	Random Stratified Index (RSI)				Original Index			
Year	Geo. Mean	95% C.I.'s	C.V.	N	Bay & River (BRI)	N	River Only (RO)	N
1988	8.13	5.37 - 12.07	8.12	173	8.89	173	21.72	63
1989	11.74	8.18 - 16.88	6.44	189	12.22	189	21.27	63
1990	4.46	3.10 - 6.26	8.44	184	4.87	184	30.01	59
1991	3.16	2.32 - 4.21	7.92	179	3.56	179	15.32	62
1992	6.78	4.74 - 9.53	7.39	178	6.93	178	15.91	61
1993	5.81	4.06 - 8.17	7.76	180	6.12	180	15.42	63
1994	2.51	1.76 - 3.47	9.59	180	2.67	180	7.04	63
1995	5.95	4.26 - 8.18	7.20	186	6.07	186	11.00	69
1996	7.26	5.33 - 9.78	6.31	305	7.85	183	7.42	66
1997	6.81	5.26 - 8.74	5.38	316	7.15	192	14.82	75
1998	7.60	5.46 - 10.45	6.65	269	8.18	150	9.95	71
1999	6.78	5.01 - 9.06	6.28	303	7.38	180	16.25	75
2000	8.35	6.34 - 10.92	5.42	316	9.39	191	11.09	74
2001	5.09	3.74 - 6.82	6.93	327	5.14	200	11.52	75
2002	6.93	4.27 - 10.94	9.89	270	6.30	147	8.59	75
2003	9.23	6.72 - 12.54	6.04	315	9.34	192	5.42	75
2004	6.66	4.94 - 8.88	6.24	315	7.27	192	10.47	75
2005	5.69	4.26 - 7.50	6.31	315	5.93	192	7.10	75
2006	6.34	4.83 - 8.25	5.80	315	6.21	192	6.20	75
2007	5.35	3.99 - 7.08	6.51	315	5.30	192	14.37	75
2008	5.77	4.33 - 7.60	6.26	315	5.51	192	25.87	75
2009	6.18	4.75 - 7.96	5.63	315	6.25	192	11.44	75
2010	14.11	11.16 - 17.78	4.00	315	15.79	192	17.94	75
2011	5.23	3.86 - 6.99	6.78	315	5.71	192	7.67	75
2012	3.02	2.30 - 3.90	7.14	315	2.66	192	13.92	75
2013	9.41	7.30 - 12.07	4.85	315	9.79	192	14.92	75
Average	6.71							

Table 18. White Catfish juvenile indices (RSI_{GM}, 1988–2013).

	Rappahannock				York				James			
Year class	RSI	N	CV	95% C.I.	RSI	N	CV	95% C.I.	RSI	N	CV	95% C.I.
1988	0.01	16	100.00	0.00 - 0.03	0.12	20	25.19	0.06 - 0.19	0.10	16	53.10	0.00 - 0.22
1989	0.02	16	49.70	0.00 - 0.05	0.11	19	22.05	0.06 - 0.16	3.09	16	15.17	1.67 - 5.26
1990	0.01	16	100.00	0.00 - 0.04	0.09	20	28.16	0.04 - 0.14	0.59	16	10.45	0.45 - 0.76
1991	0.00	16		0	0.04	20	35.46	0.01 - 0.07	0.03	16	64.55	0.00 - 0.07
1992	0.00	16	100.00	0.00 - 0.01	0.06	20	29.09	0.02 - 0.10	0.70	16	9.59	0.54 - 0.88
1993	0.00	16	100.00	0.00 - 0.01	0.24	20	29.51	0.09 - 0.40	0.42	16	28.95	0.16 - 0.75
1994	0.00	16		0	0.21	20	5.77	0.19 - 0.24	0.04	16	66.82	0.00 - 0.09
1995	0.02	41	82.41	0.00 - 0.04	0.04	40	29.21	0.02 - 0.06	0.15	28	38.45	0.03 - 0.28
1996	0.01	40	76.61	0.00 - 0.01	0.09	40	13.88	0.06 - 0.11	0.24	40	30.98	0.09 - 0.42
1997	0.02	40	82.02	0.00 - 0.05	0.14	40	16.47	0.09 - 0.19	0.18	40	29.44	0.07 - 0.30
1998	0.00	40		0	0.05	40	22.69	0.03 - 0.07	0.02	40	55.01	0.00 - 0.04
1999	0.00	40		0	0.00	40	100.00	0.00 - 0.01	0.00	34		0
2000	0.00	40		0	0.01	40	54.94	0.00 - 0.02	0.04	40	69.29	0.00 - 0.11
2001	0.00	40		0	0.02	40	73.60	0.00 - 0.04	0.00	40		0
2002	0.00	40		0	0.00	40		0	0.00	40		0
2003	0.03	40	55.35	0.00 - 0.07	0.06	40	24.39	0.03 - 0.08	0.18	40	26.06	0.08 - 0.29
2004	0.00	40		0	0.02	40	41.31	0.00 - 0.03	0.10	40	37.93	0.02 - 0.18
2005	0.00	40		0	0.01	40	48.39	0.00 - 0.02	0.03	40	58.96	0.00 - 0.07
2006	0.00	40		0	0.02	40	36.03	0.01 - 0.04	0.06	40	42.25	0.01 - 0.12
2007	0.00	40		0	0.00	40		0	0.02	40	46.28	0.00 - 0.04
2008	0.00	40		0	0.00	40	67.42	0.00 - 0.01	0.03	40	90.55	0.00 - 0.08
2009	0.00	40	100.00	0.00 - 0.01	0.04	40	26.13	0.02 - 0.07	0.08	40	34.70	0.02 - 0.14
2010	0.00	40		0	0.00	40		0	0.00	40	100.00	0.00 - 0.01
2011	0.00	40		0	0.02	40	32.84	0.01 - 0.03	0.13	40	44.00	0.02 - 0.26
2012	0.00	40		0	0.00	40		0	0.01	40	100.00	0.00 - 0.02
2013	0.00	40		0	0.02	40	38.10	0.00 - 0.03	0.07	40	39.57	0.01 - 0.14
Average	0.00				0.05				0.24			

Table 19. White Catfish age 1+ indices (RSI_{GM}, 1988–2014).

	Rappahannock				York				James			
Year	RSI	N	CV	95% C.I.	RSI	N	CV	95% C.I.	RSI	N	CV	95% C.I.
1988	0.07	16	66.83	0.00 - 0.18	0.56	20	21.07	0.29 - 0.88	0.62	16	24.19	0.28 - 1.05
1989	0.11	16	27.53	0.05 - 0.17	0.24	20	21.13	0.13 - 0.36	1.10	16	13.65	0.71 - 1.57
1990	0.08	16	23.83	0.04 - 0.12	0.21	19	30.54	0.08 - 0.36	2.24	16	18.65	1.09 - 4.03
1991	0.77	16	4.68	0.68 - 0.87	0.19	20	20.61	0.11 - 0.27	1.12	16	22.77	0.51 - 1.99
1992	0.37	16	73.37	0.00 - 1.16	0.20	20	18.03	0.12 - 0.28	0.90	16	13.12	0.61 - 1.25
1993	0.52	16	6.86	0.43 - 0.61	0.11	20	21.86	0.06 - 0.16	2.13	16	7.15	1.66 - 2.68
1994	0.17	16	75.27	0.00 - 0.48	0.16	20	18.40	0.10 - 0.22	1.32	16	18.46	0.70 - 2.16
1995	0.11	16	27.27	0.05 - 0.17	0.25	20	12.12	0.18 - 0.31	1.02	16	14.87	0.64 - 1.49
1996	0.24	41	52.37	0.00 - 0.55	0.12	40	16.43	0.08 - 0.16	0.40	28	27.52	0.17 - 0.69
1997	0.15	40	27.52	0.07 - 0.25	0.19	40	13.43	0.13 - 0.24	0.50	40	15.48	0.32 - 0.70
1998	0.39	40	22.78	0.19 - 0.61	0.23	40	11.01	0.17 - 0.28	0.67	40	13.06	0.46 - 0.91
1999	0.21	40	15.76	0.14 - 0.28	0.15	40	16.00	0.10 - 0.20	0.59	40	23.28	0.28 - 0.97
2000	0.13	40	25.42	0.06 - 0.20	0.12	40	13.96	0.09 - 0.16	0.22	34	28.68	0.09 - 0.37
2001	0.06	40	68.56	0.00 - 0.14	0.07	40	21.46	0.04 - 0.10	0.14	40	32.12	0.05 - 0.23
2002	0.09	40	55.04	0.00 - 0.19	0.06	40	19.11	0.03 - 0.08	0.13	40	35.69	0.04 - 0.23
2003	0.13	40	76.56	0.00 - 0.37	0.07	40	22.51	0.04 - 0.10	0.12	40	31.04	0.04 - 0.20
2004	0.11	40	42.06	0.02 - 0.21	0.05	40	22.45	0.03 - 0.08	0.27	40	27.74	0.11 - 0.45
2005	0.06	40	42.11	0.01 - 0.12	0.06	40	33.81	0.02 - 0.10	0.14	40	32.81	0.05 - 0.24
2006	0.02	40	35.34	0.00 - 0.03	0.08	40	22.80	0.04 - 0.12	0.28	40	26.42	0.12 - 0.46
2007	0.03	40	33.60	0.01 - 0.05	0.07	40	20.60	0.04 - 0.10	0.22	40	22.33	0.11 - 0.33
2008	0.04	40	47.21	0.00 - 0.07	0.07	40	22.89	0.04 - 0.10	0.11	40	43.59	0.01 - 0.21
2009	0.04	40	63.91	0.00 - 0.09	0.05	40	20.36	0.03 - 0.07	0.09	40	35.03	0.03 - 0.17
2010	0.01	40	61.58	0.00 - 0.02	0.05	40	19.07	0.03 - 0.07	0.13	40	34.50	0.04 - 0.22
2011	0.01	40	46.32	0.00 - 0.02	0.02	40	46.13	0.00 - 0.04	0.09	40	48.16	0.00 - 0.18
2012	0.05	40	53.78	0.00 - 0.11	0.06	40	22.84	0.03 - 0.09	0.30	40	29.74	0.11 - 0.51
2013	0.03	40	55.15	0.00 - 0.06	0.06	40	21.26	0.03 - 0.09	0.17	40	31.01	0.06 - 0.28
2014	0.00	40	57.08	0.00 - 0.01	0.05	40	22.41	0.03 - 0.07	0.26	40	25.90	0.12 - 0.42
Average	0.15				0.13				0.57			

Table 20. White Perch juvenile indices (RSI_{GM}, 1988–2013).

	Rappahannock				York				James			
Year	RSI	N	CV	95% C.I.	RSI	N	CV	95% C.I.	RSI	N	CV	95% C.I.
1988	0.14	11	27.24	0.06 - 0.22	0.22	12	25.05	0.11 - 0.35	4.14	12	12.36	2.43 - 6.70
1989	0.94	12	15.16	0.59 - 1.38	0.44	15	22.85	0.22 - 0.69	3.99	10	16.62	1.93 - 7.52
1990	0.99	12	3.64	0.90 - 1.10	0.06	14	41.92	0.01 - 0.12	1.00	10	28.42	0.35 - 1.97
1991	1.28	11	6.52	1.05 - 1.54	0.13	15	16.73	0.08 - 0.18	1.00	10	56.13	0.00 - 3.34
1992	0.34	12	11.36	0.26 - 0.44	0.03	15	36.25	0.01 - 0.05	0.97	12	25.62	0.39 - 1.78
1993	0.74	14	40.57	0.11 - 1.73	0.20	15	18.51	0.12 - 0.29	8.67	12	22.74	2.44 - 26.14
1994	0.71	12	4.02	0.64 - 0.79	0.56	15	12.23	0.40 - 0.74	4.73	12	15.29	2.36 - 8.77
1995	0.75	24	22.88	0.36 - 1.27	0.06	25	30.75	0.02 - 0.10	0.93	12	25.60	0.38 - 1.70
1996	1.34	30	27.09	0.48 - 2.72	0.58	30	8.31	0.46 - 0.70	5.88	30	9.74	3.73 - 9.02
1997	0.82	30	20.61	0.42 - 1.32	0.23	30	10.58	0.18 - 0.28	3.64	30	9.51	2.46 - 5.21
1998	0.18	30	29.47	0.07 - 0.30	0.16	30	22.94	0.08 - 0.24	2.53	30	18.65	1.20 - 4.64
1999	0.34	30	29.18	0.13 - 0.60	0.01	30	73.10	0.00 - 0.02	0.28	24	29.71	0.11 - 0.49
2000	0.72	30	34.20	0.19 - 1.50	0.35	30	14.99	0.23 - 0.47	2.98	30	17.21	1.47 - 5.40
2001	0.28	30	36.59	0.07 - 0.54	0.18	30	25.24	0.08 - 0.28	0.94	30	26.55	0.36 - 1.76
2002	0.06	30	45.17	0.01 - 0.11	0.10	30	19.20	0.06 - 0.14	3.88	30	7.15	2.89 - 5.13
2003	2.24	30	28.04	0.68 - 5.27	0.40	30	11.56	0.30 - 0.51	4.06	30	10.41	2.61 - 6.09
2004	0.75	30	29.32	0.26 - 1.42	0.19	30	23.03	0.10 - 0.29	2.62	30	17.74	1.30 - 4.72
2005	1.06	30	29.98	0.34 - 2.19	0.23	30	17.01	0.14 - 0.31	4.04	30	7.64	2.94 - 5.45
2006	0.21	30	21.81	0.11 - 0.31	0.08	30	23.78	0.04 - 0.12	3.12	30	14.47	1.73 - 5.20
2007	0.81	30	31.27	0.25 - 1.63	0.03	30	40.75	0.00 - 0.05	1.20	30	23.33	0.52 - 2.19
2008	1.01	30	26.01	0.40 - 1.90	0.13	30	14.54	0.09 - 0.17	3.14	30	23.40	1.13 - 7.04
2009	0.70	30	32.18	0.21 - 1.40	0.05	30	29.63	0.02 - 0.09	3.58	30	12.20	2.16 - 5.63
2010	0.78	30	12.90	0.53 - 1.06	0.36	30	15.30	0.24 - 0.49	3.03	30	20.64	1.27 - 6.15
2011	1.49	30	25.17	0.57 - 2.95	0.25	30	15.40	0.16 - 0.33	3.72	30	13.82	2.07 - 6.25
2012	0.03	30	71.21	0.00 - 0.74	0.06	30	28.08	0.03 - 0.10	0.35	30	32.68	0.11 - 0.64
2013	0.26	30	26.40	0.12 - 0.42	0.23	30	14.53	0.16 - 0.30	4.21	30	14.86	2.19 - 7.50
Average	0.73				0.20				3.02			

Table 21. White Perch age 1+ indices (RSI_{GM}, 1988–2013).

	Rappahannock				York				James			
Year	RSI	N	CV	95% C.I.	RSI	N	CV	95% C.I.	RSI	N	CV	95% C.I.
1988	0.72	11	16.05	0.45 - 1.05	0.58	12	8.85	0.46 - 0.72	13.89	12	6.11	9.71 - 19.70
1989	1.00	12	11.10	0.72 - 1.34	0.70	15	6.97	0.58 - 0.82	6.00	10	7.42	4.25 - 8.34
1990	3.86	12	6.27	2.98 - 4.92	0.87	14	10.42	0.64 - 1.14	3.00	10	14.35	1.69 - 4.95
1991	2.96	11	8.63	2.13 - 4.03	0.47	15	15.89	0.30 - 0.67	5.94	10	4.47	4.83 - 7.25
1992	0.96	12	18.98	0.52 - 1.54	0.34	15	16.16	0.22 - 0.47	3.93	12	8.89	2.71 - 5.54
1993	0.92	14	46.79	0.04 - 2.52	0.49	15	7.95	0.40 - 0.58	3.12	12	11.16	2.00 - 4.65
1994	0.90	12	7.72	0.72 - 1.10	0.59	15	8.68	0.47 - 0.72	7.48	12	9.86	4.56 - 11.92
1995	2.14	24	26.31	0.72 - 4.73	0.55	25	11.58	0.40 - 0.71	2.27	12	13.38	1.38 - 3.48
1996	1.26	30	23.02	0.55 - 2.29	0.45	30	7.48	0.37 - 0.53	2.06	30	12.22	1.33 - 3.02
1997	2.15	30	17.30	1.12 - 3.69	0.44	30	5.27	0.38 - 0.49	3.50	30	13.36	2.01 - 5.73
1998	1.01	30	16.19	0.60 - 1.52	0.34	30	11.68	0.25 - 0.43	3.42	30	12.28	2.07 - 5.36
1999	1.13	30	16.81	0.65 - 1.74	0.29	30	8.62	0.24 - 0.35	3.14	24	14.54	1.74 - 5.25
2000	1.05	30	20.04	0.54 - 1.74	0.28	30	12.45	0.20 - 0.36	2.30	30	21.48	0.98 - 4.52
2001	0.71	30	16.40	0.43 - 1.03	0.31	30	12.57	0.22 - 0.40	1.51	30	22.84	0.65 - 2.83
2002	0.22	30	34.65	0.06 - 0.41	0.29	30	11.62	0.22 - 0.37	4.18	30	8.42	2.93 - 5.84
2003	2.19	30	20.29	0.99 - 4.10	0.37	30	10.06	0.29 - 0.46	3.60	30	12.50	2.14 - 5.74
2004	1.67	30	13.32	1.05 - 2.46	0.22	30	16.19	0.14 - 0.30	1.42	30	22.80	0.62 - 2.62
2005	1.12	30	21.87	0.53 - 1.95	0.29	30	10.29	0.22 - 0.36	2.44	30	9.04	1.75 - 3.30
2006	0.61	30	21.33	0.31 - 0.96	0.28	30	11.58	0.21 - 0.36	2.61	30	12.36	1.63 - 3.96
2007	1.33	30	18.84	0.70 - 2.21	0.24	30	10.03	0.19 - 0.29	1.59	30	14.73	0.96 - 2.43
2008	0.85	30	14.33	0.55 - 1.20	0.26	30	12.91	0.18 - 0.33	1.62	30	26.81	0.56 - 3.39
2009	0.87	30	21.23	0.44 - 1.45	0.24	30	14.33	0.16 - 0.32	2.71	30	12.40	1.68 - 4.14
2010	0.53	30	17.41	0.32 - 0.78	0.16	30	14.67	0.11 - 0.22	1.59	30	18.81	0.81 - 2.71
2011	1.73	30	14.87	1.02 - 2.67	0.30	30	11.02	0.23 - 0.38	3.08	30	11.81	1.93 - 4.68
2012	1.02	30	17.56	0.58 - 1.59	0.34	30	9.24	0.27 - 0.41	2.24	30	15.20	0.58 - 1.59
2013	1.10	30	16.78	0.64 - 1.70	0.34	30	11.32	0.25 - 0.43	3.25	30	11.15	2.08 - 4.87
Average	1.31				0.39				3.53			

FIGURES

Figure 1. The VIMS trawl survey random stratified design in the Chesapeake Bay. Transect lines indicate geographic regions as designated below.

Chesapeake Bay	B1	Bottom Bay
	B2	Lower Bay
	B3	Upper Bay
James River	J1	Bottom James
	J2	Lower James
	J3	Upper James
	J4	Top James
York River	Y1	Bottom York
	Y2	Lower York
	Y3	Upper York
	Y4	Top York (lower Pamunkey River)
Rappahannock River	R1	Bottom Rappahannock
	R2	Lower Rappahannock
	R3	Upper Rappahannock
	R4	Top Rappahannock
Mobjack Bay	MB	Routine monitoring established March 2010 and ending December 2012

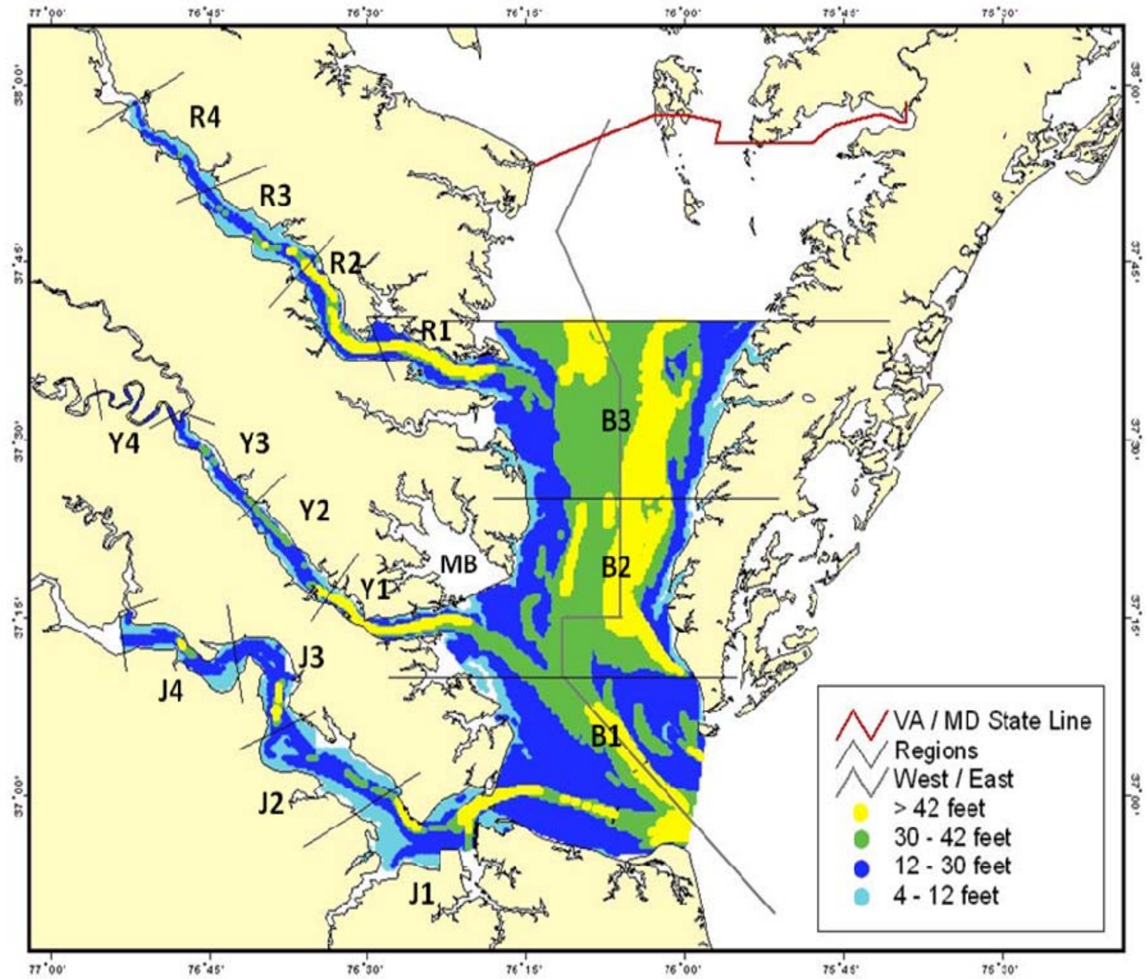


Figure 1 (continued)

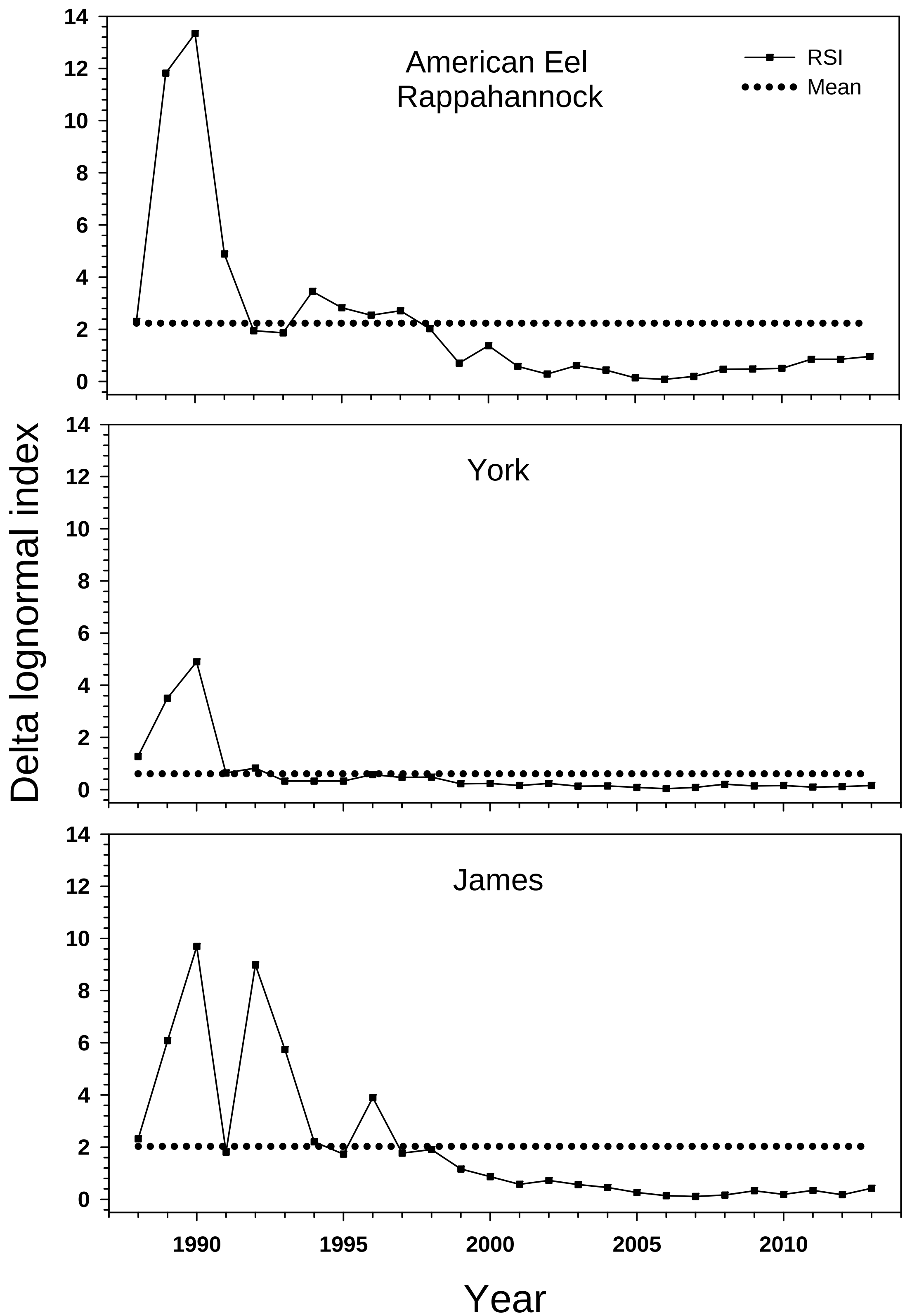


Figure 2. American Eel random stratified index (RSI_{Delta}) and time series averages (dotted line) based on the RSI_{Delta}'s from the Rappahannock, York, and James rivers.

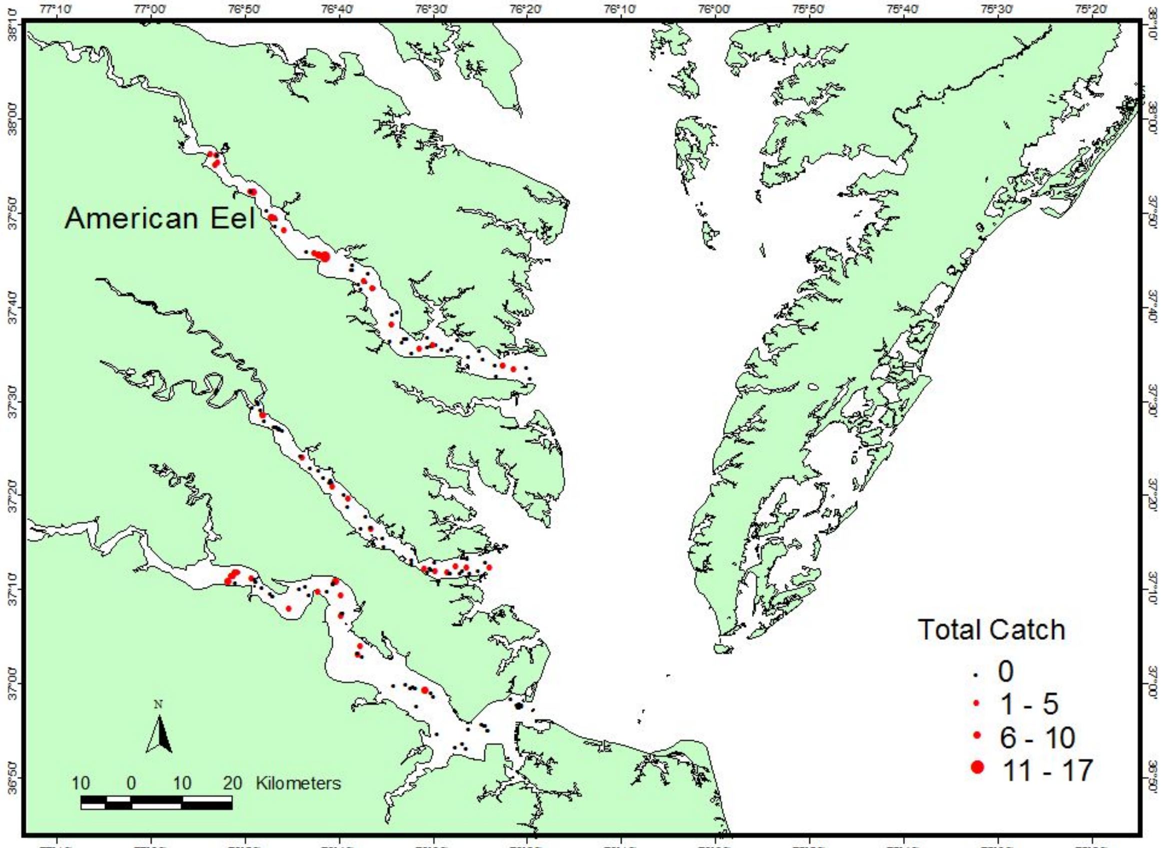
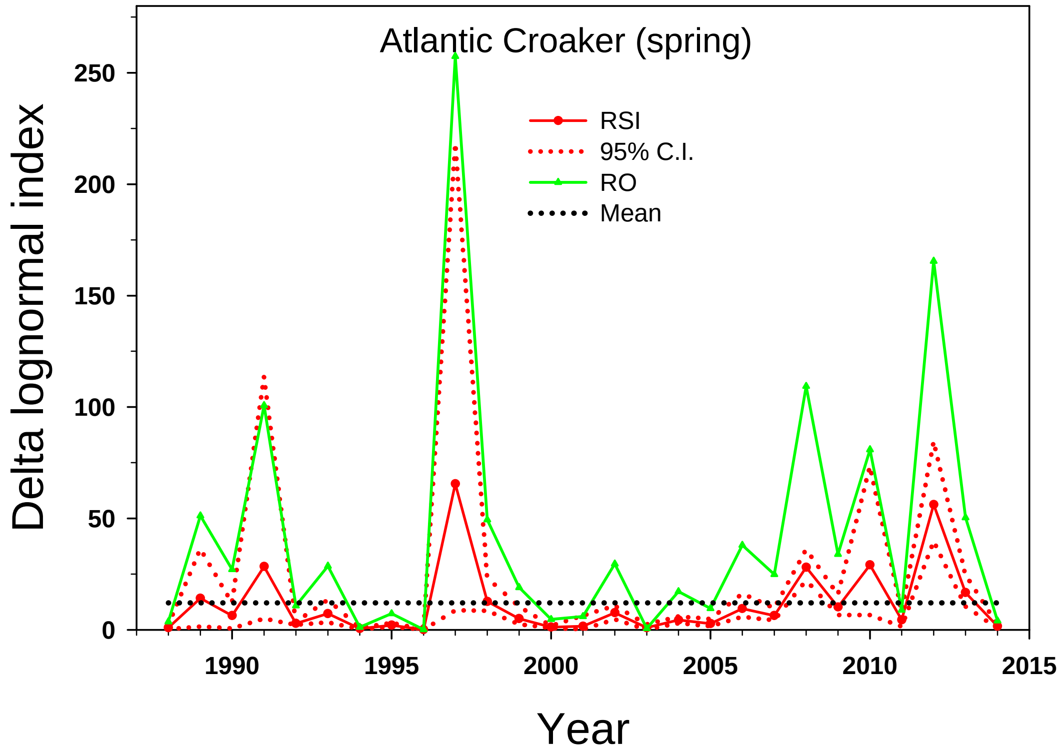


Figure 3. Distribution of index-sized American Eel from index strata and months.



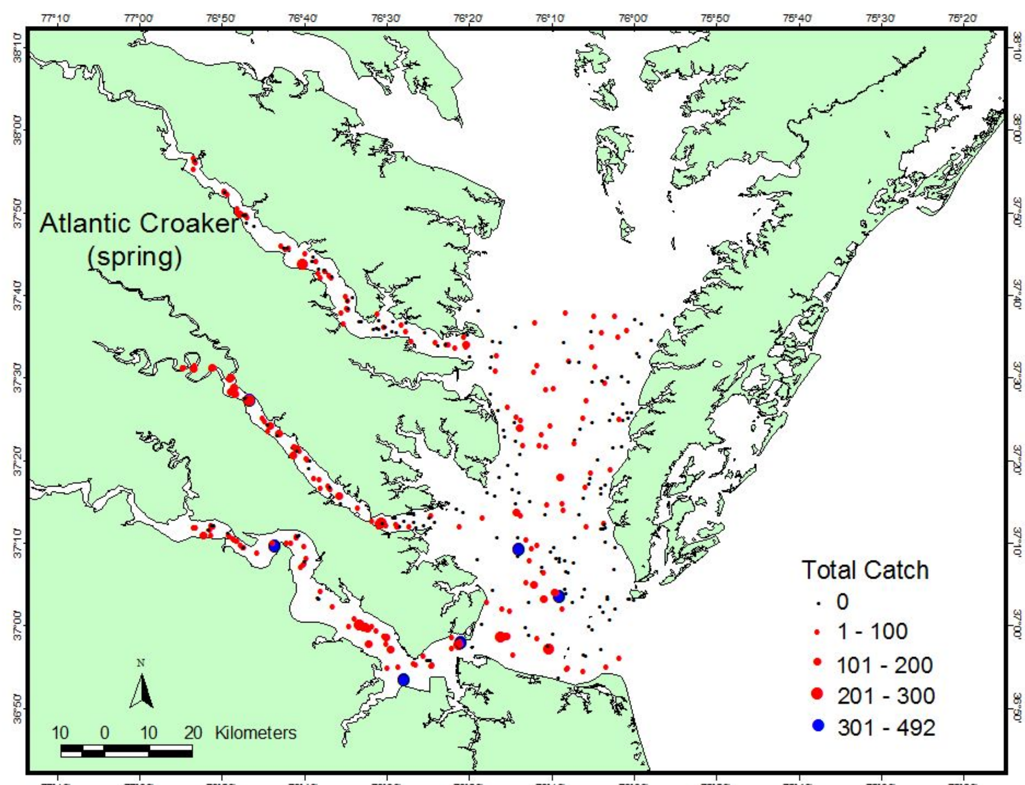


Figure 4. Spring juvenile Atlantic Croaker random stratified index (RSI_{Delta}, 95% C.I.), fixed transect index (Rivers only - RO), the time series average based on the RSI_{Delta} (dotted line, Top), and distribution of index-sized juvenile Atlantic Croaker from index strata and months (Bottom).

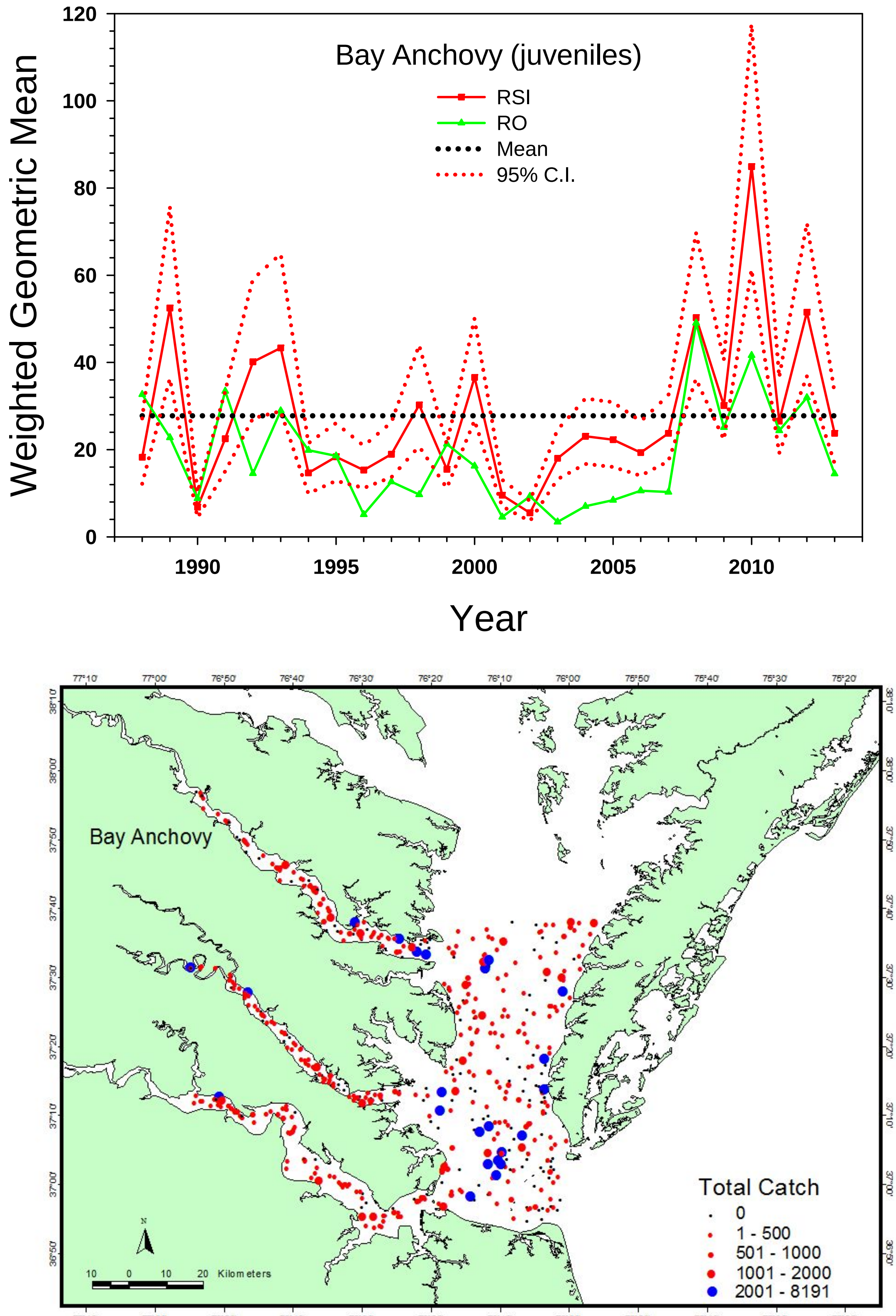
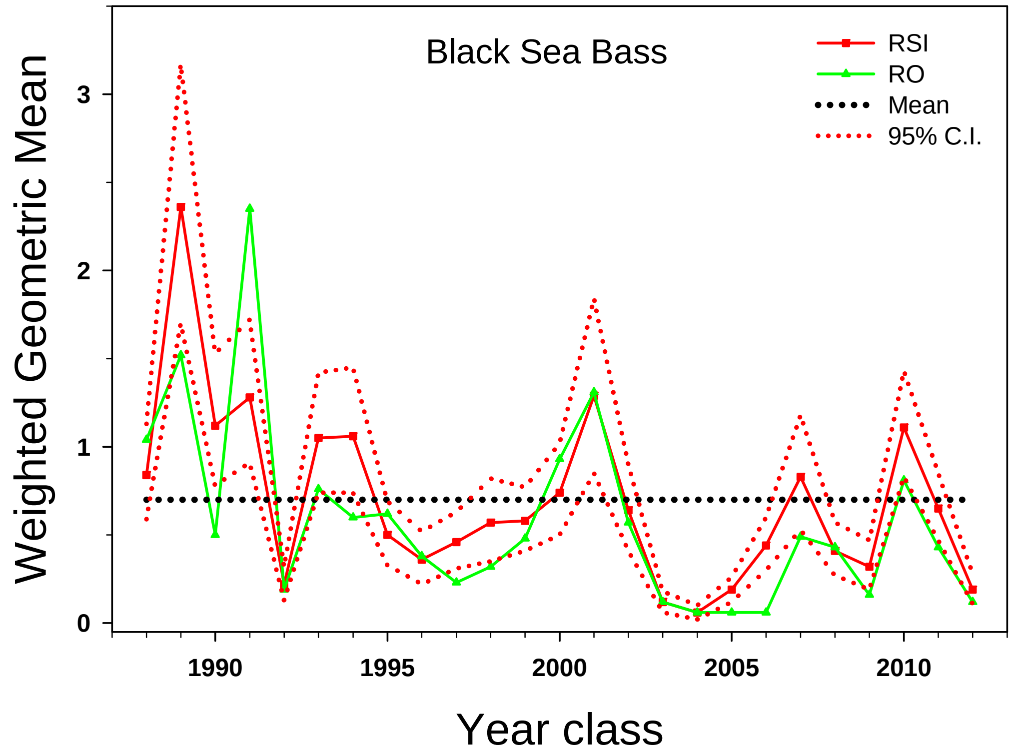


Figure 5. Juvenile Bay Anchovy random stratified index (RSI_{GM}, 95% C.I.), fixed transect index (Rivers only - RO), the time series average based on the RSI_{GM} (dotted line, Top), and distribution of Bay Anchovy from index strata and months (Bottom).



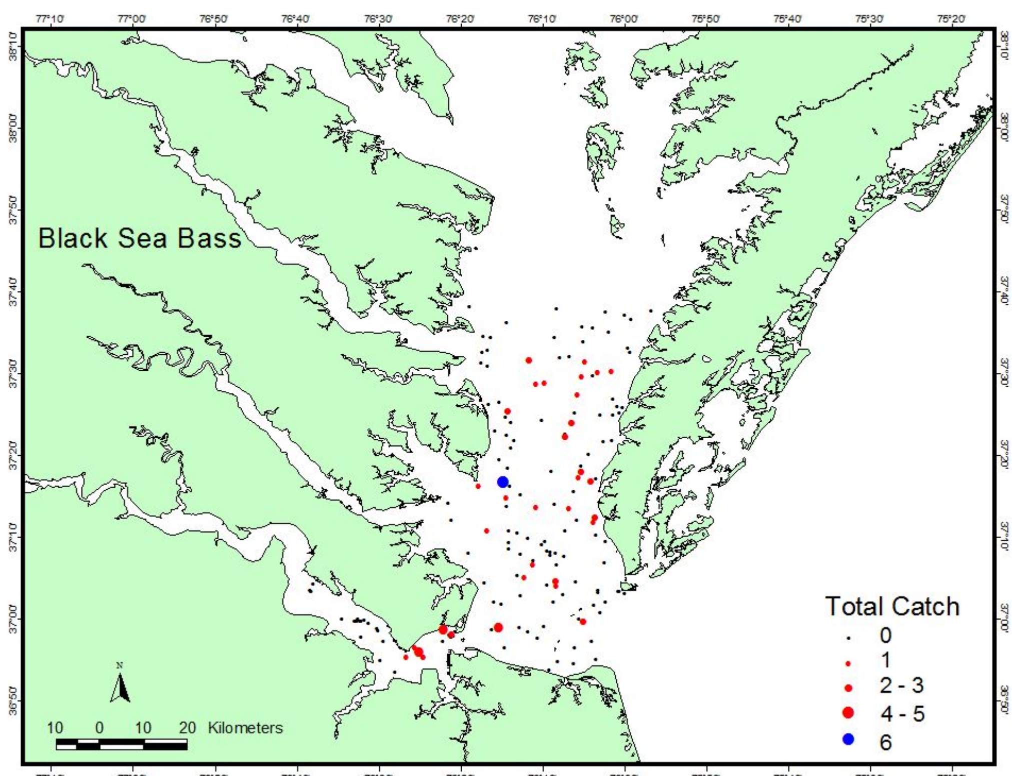


Figure 6. Black Sea Bass random stratified index (RSI_{GM}, 95% C.I.), fixed transect index (Rivers only - RO), the time series average based on the RSI_{GM} (dotted line, Top), and distribution of juvenile Black Sea Bass from index strata and months (Bottom).

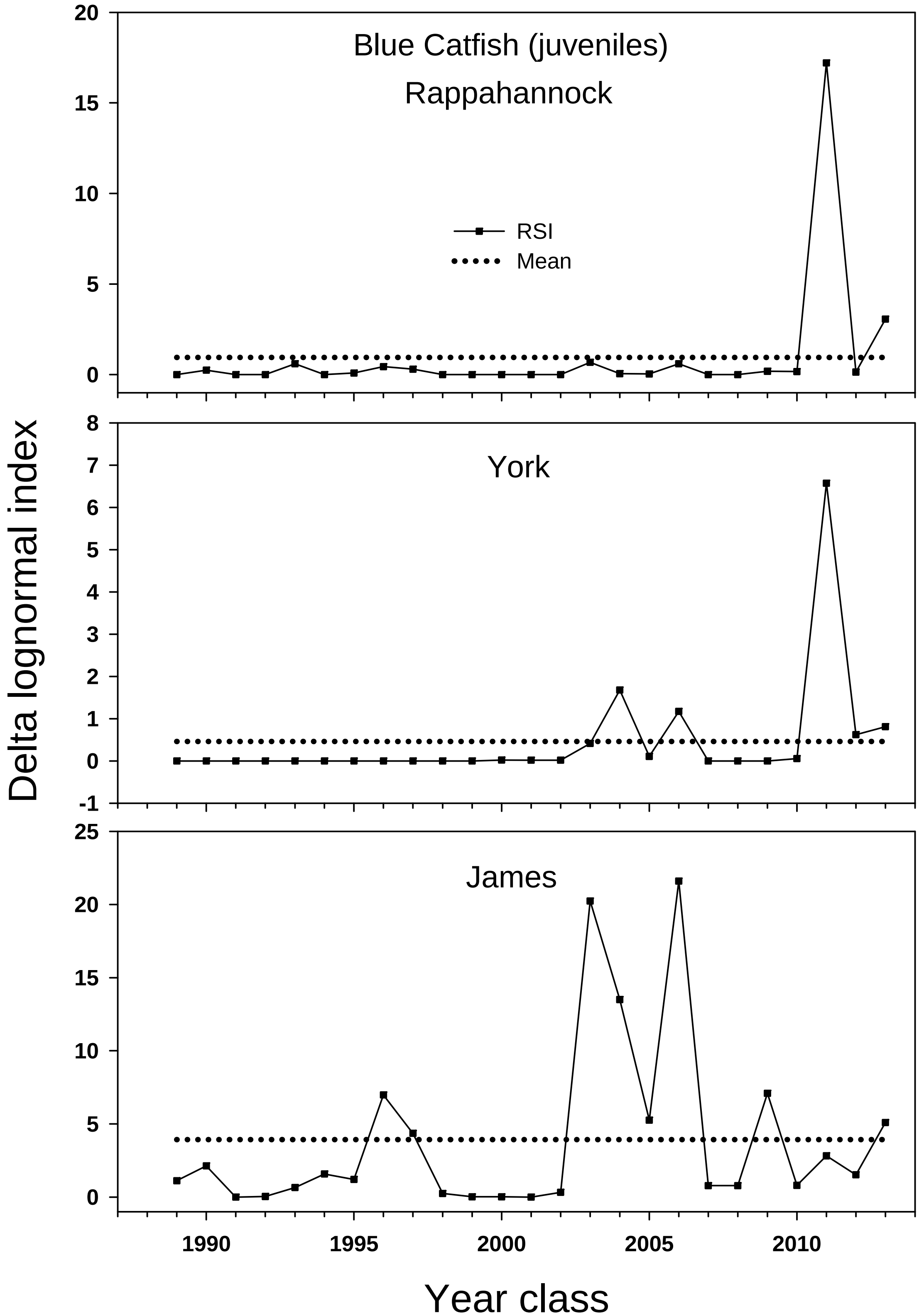


Figure 7. Juvenile Blue Catfish random stratified index (RSI_{Delta}) and time series averages (dotted line) based on the RSI_{Delta}'s from the Rappahannock, York, and James rivers. Note change in scale on y-axes.

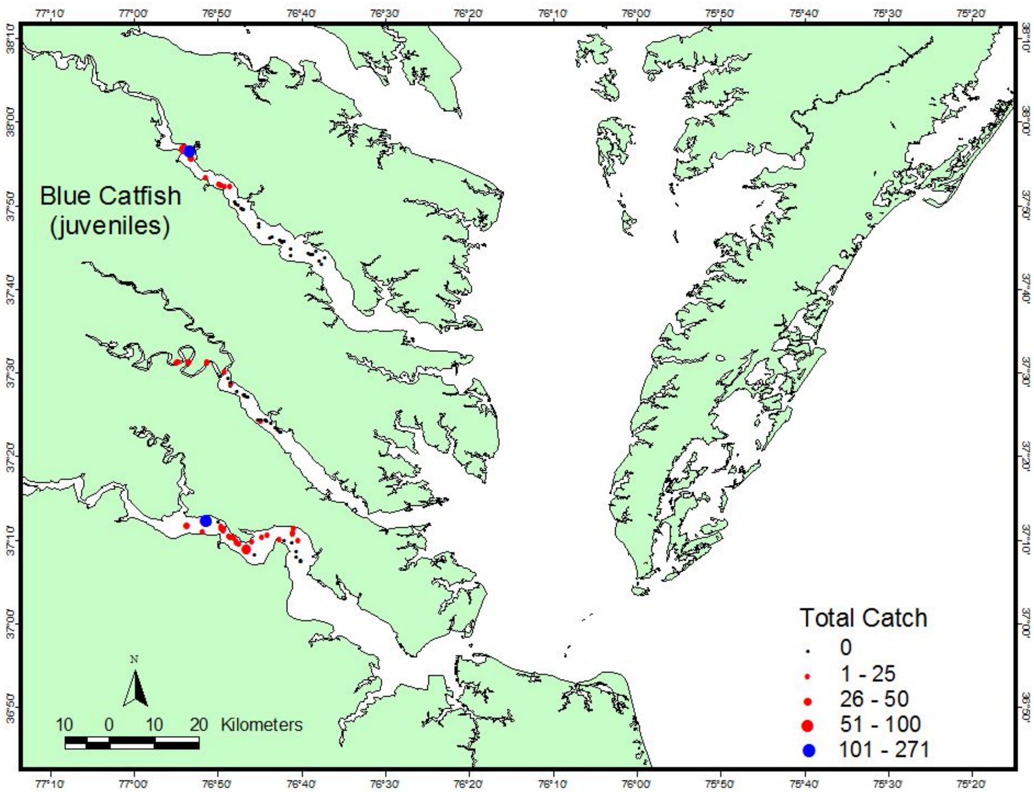


Figure 8. Distribution of index-sized juvenile Blue Catfish from index strata and months.

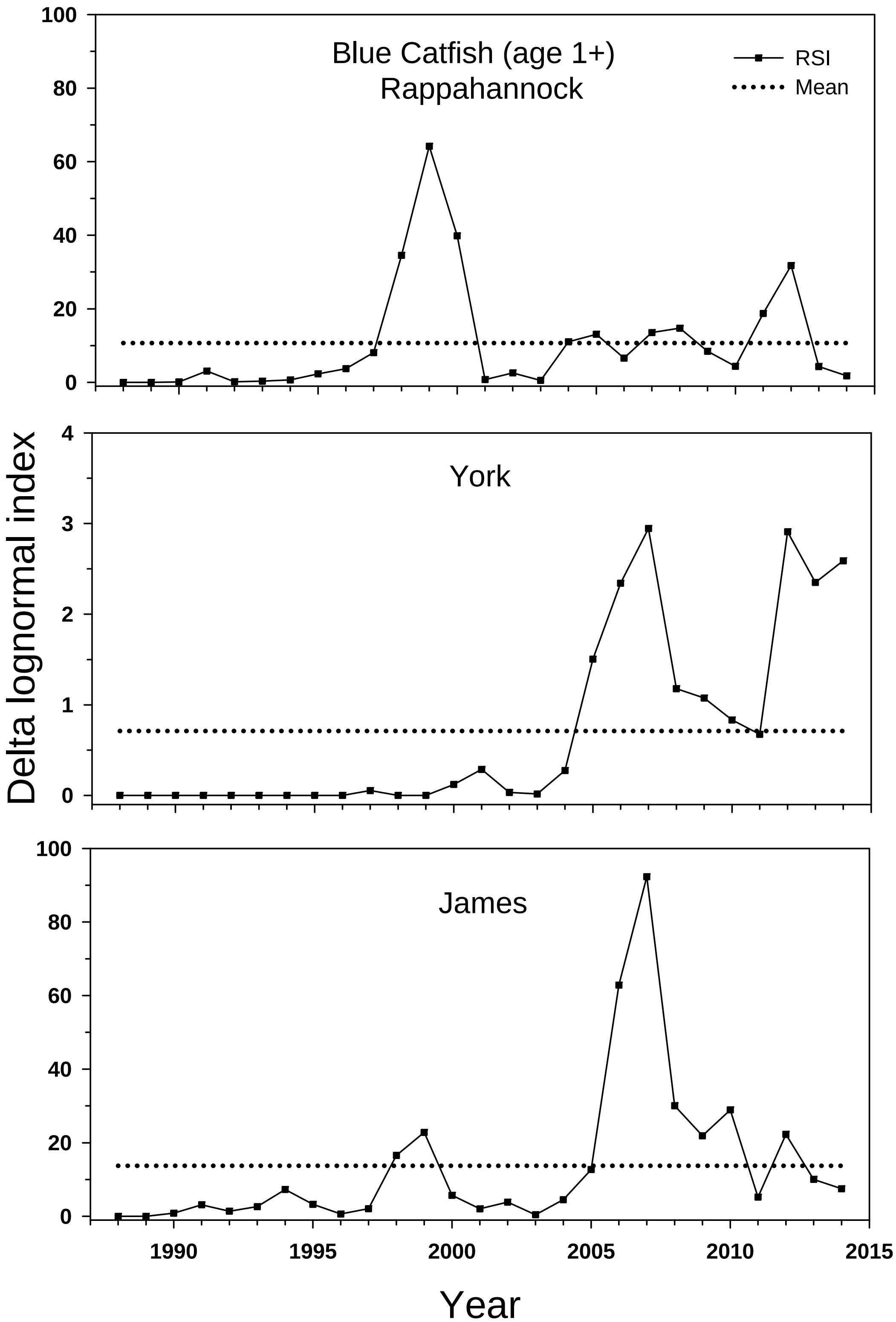


Figure 9. Age 1+ Blue Catfish random stratified index (RSI_{Delta}) and time series averages (dotted line) based on the RSI_{Delta}'s from the Rappahannock, York, and James rivers. Note change in scale on y-axes.

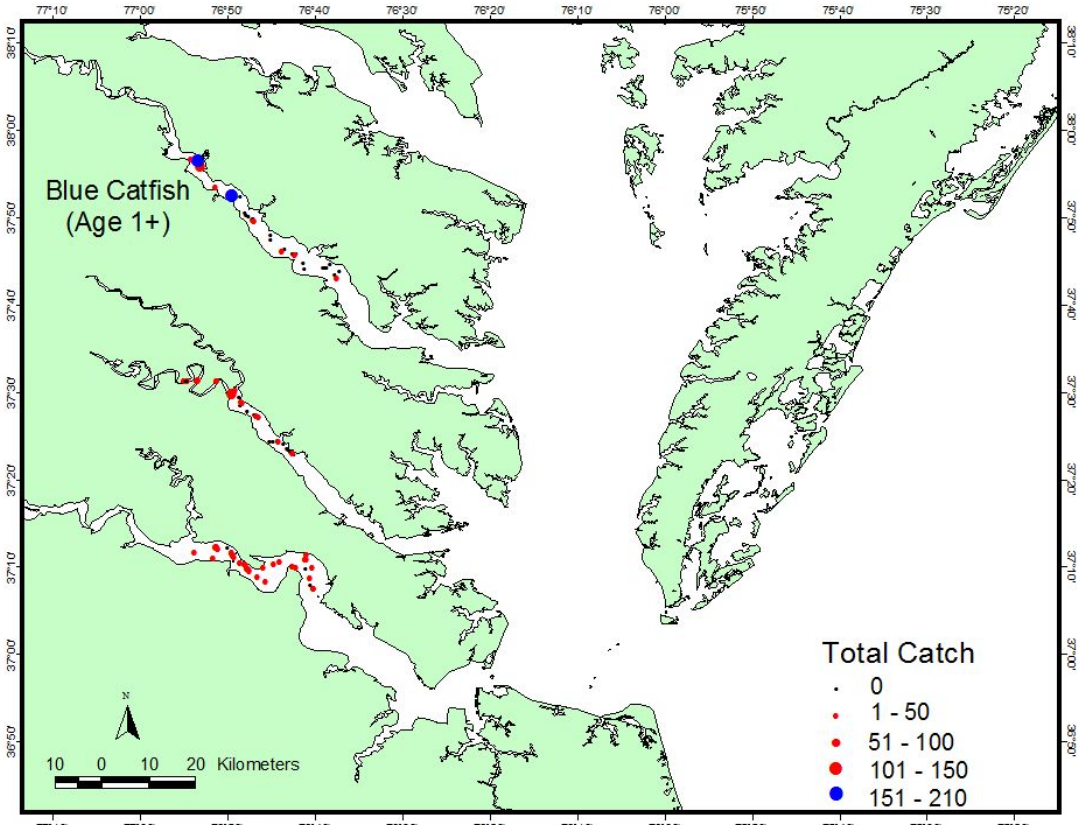


Figure 10. Distribution of Age 1+ Blue Catfish from index strata and months.

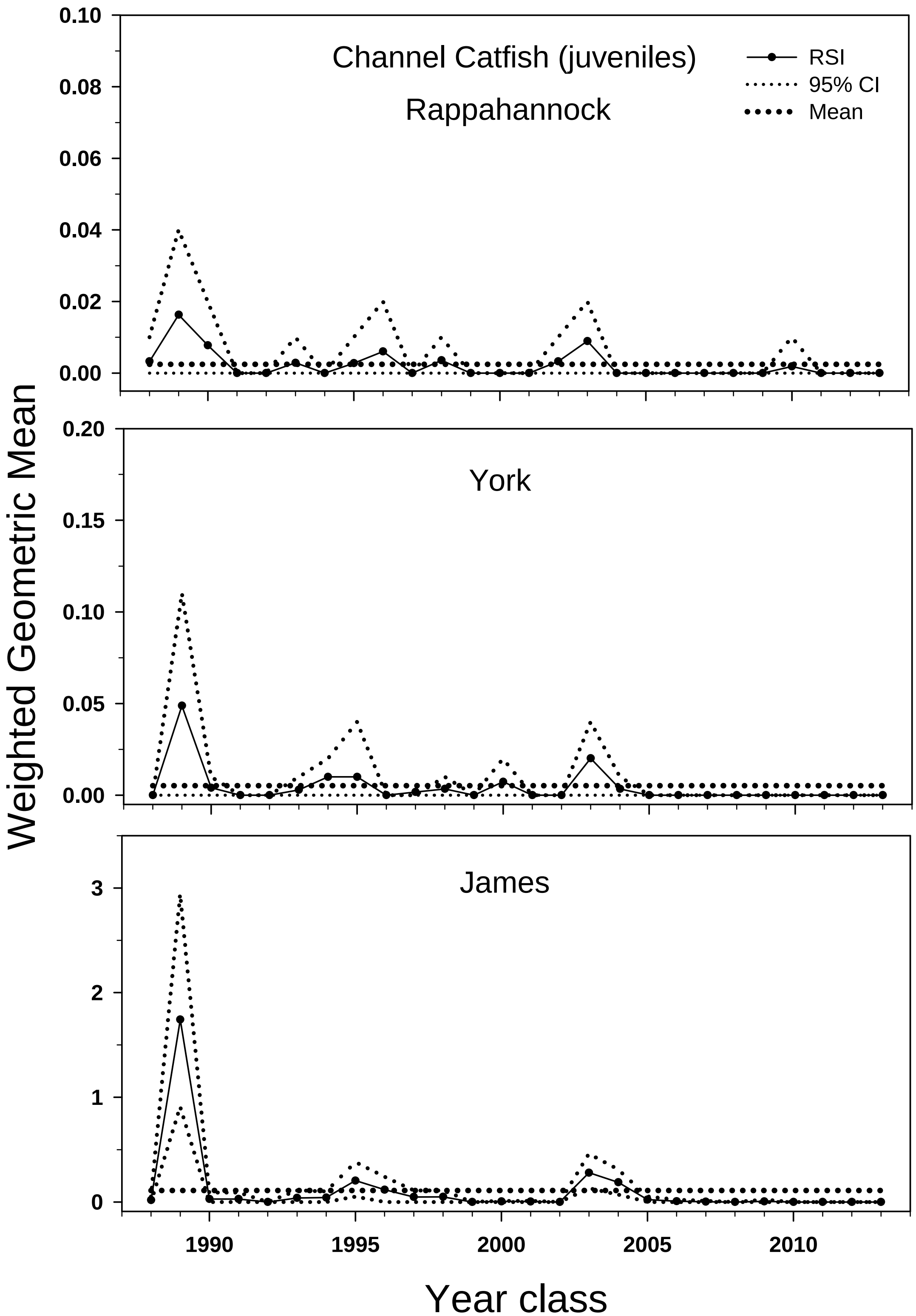


Figure 11. Juvenile Channel Catfish random stratified indices (RSI_{GM}, 95% C.I.) and time series averages (dotted line) based on the RSI_{GM}'s from the Rappahannock, York, and James rivers. Note change in scale on y-axes.

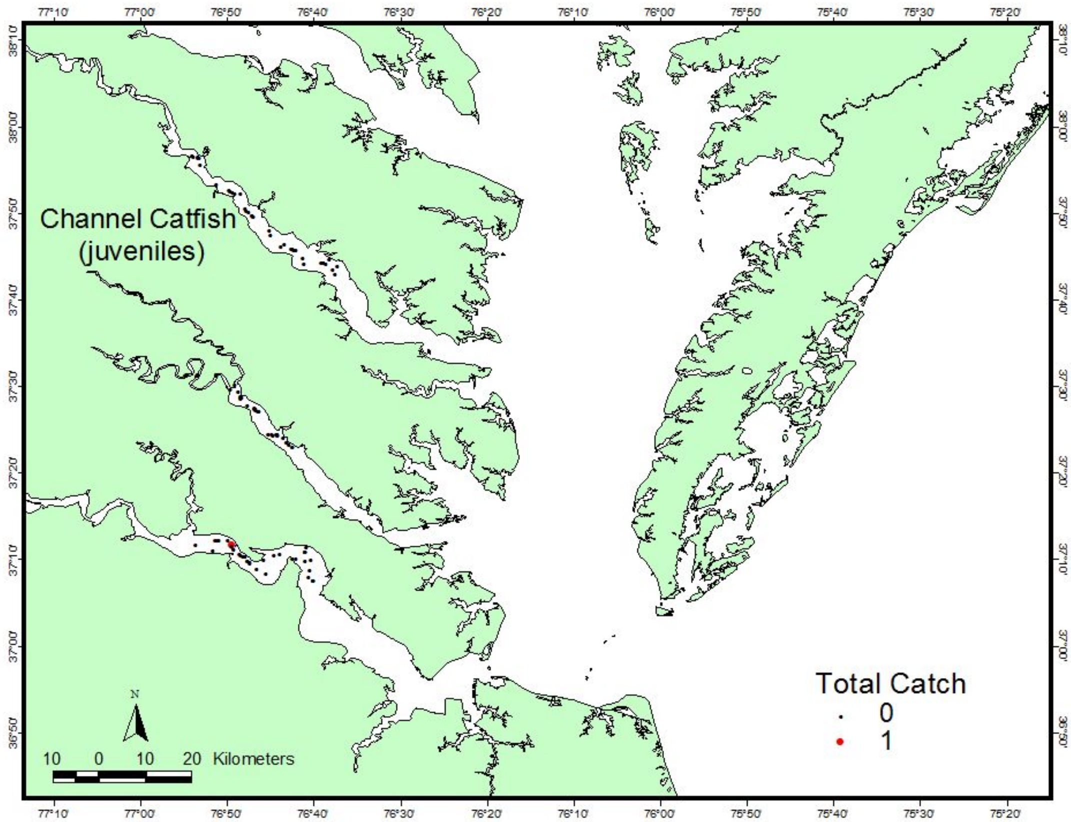


Figure 12. Distribution of juvenile Channel Catfish from index strata and months.

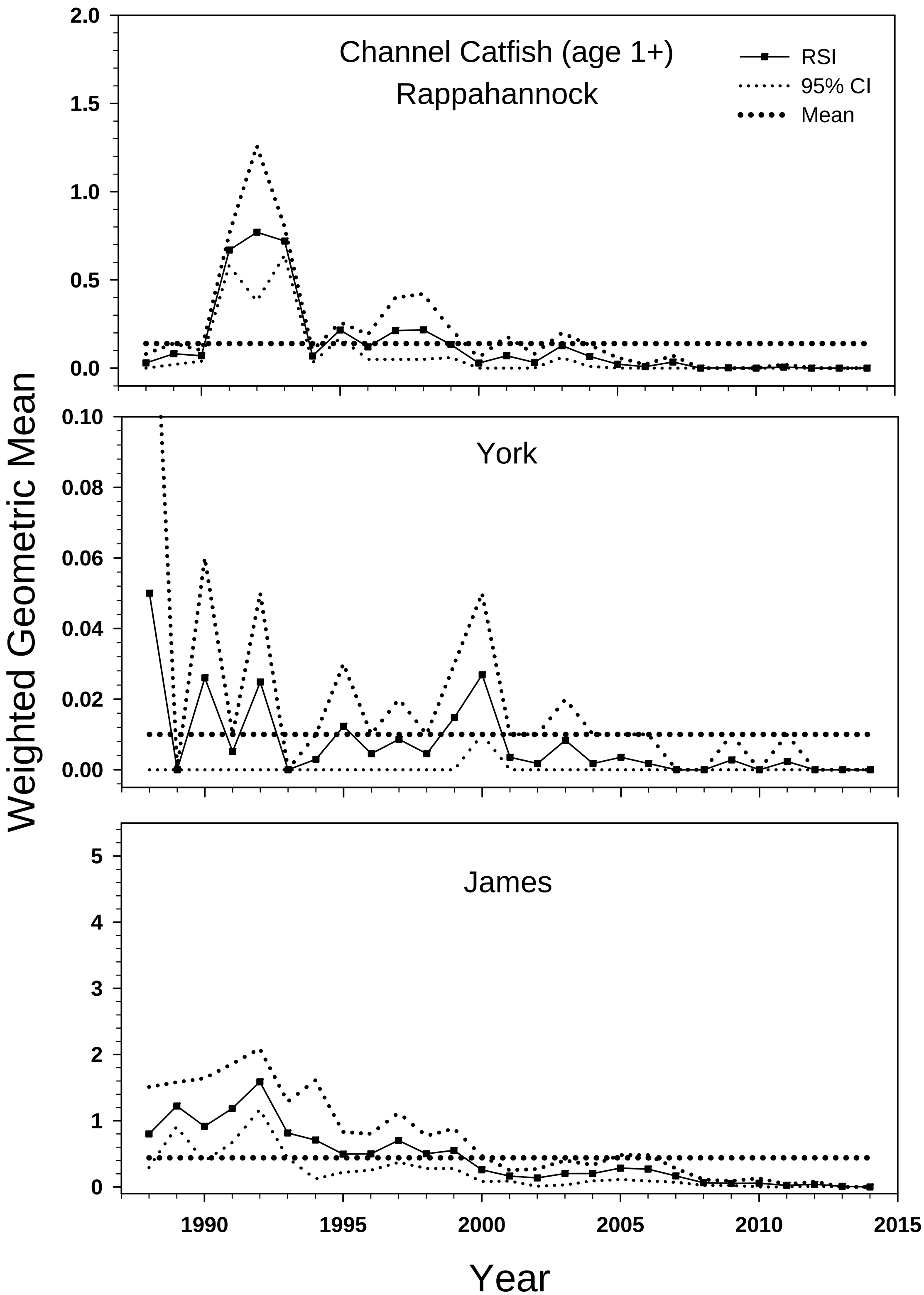


Figure 13. Age 1+ Channel Catfish random stratified indices (RSI_{GM}, 95% C.I.) and time series averages (dotted line) based on the RSI_{GM}'s from the Rappahannock, York, and James rivers. Note the change in scale for the y-axes.

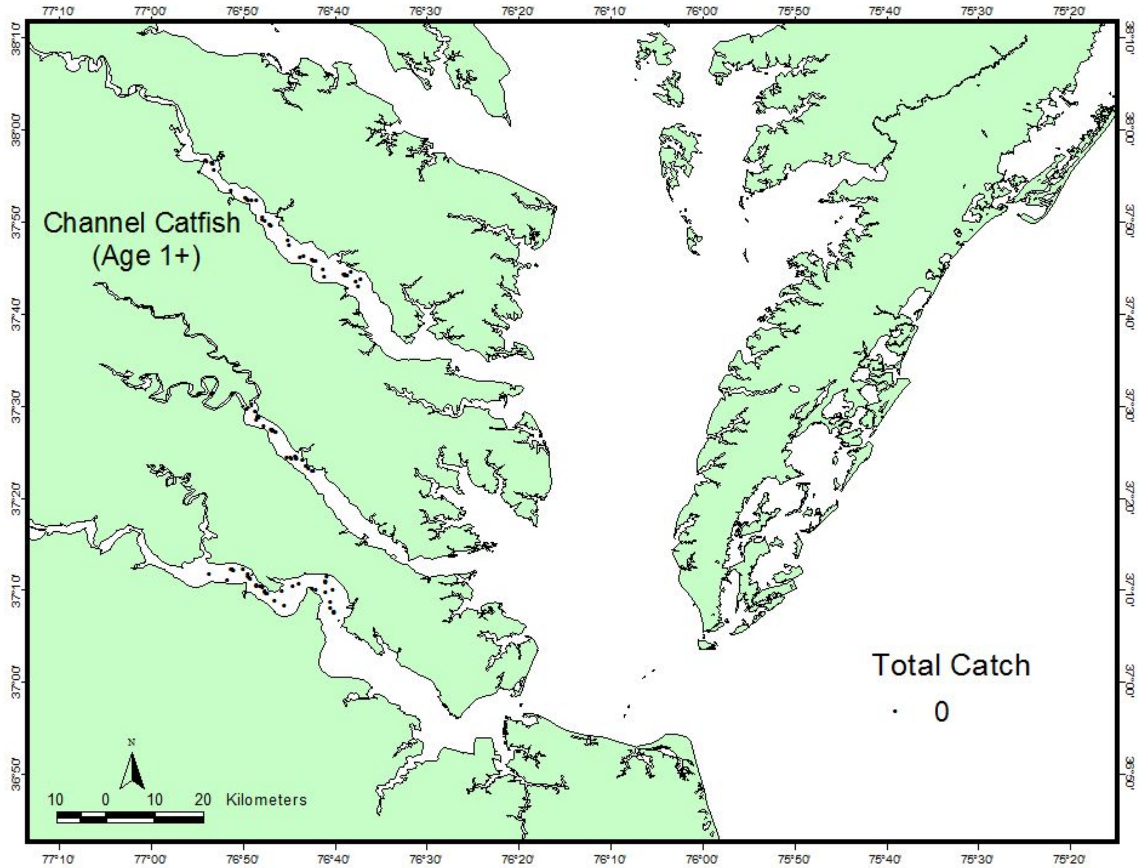


Figure 14. Distribution of Age 1+ Channel Catfish from index strata and months.

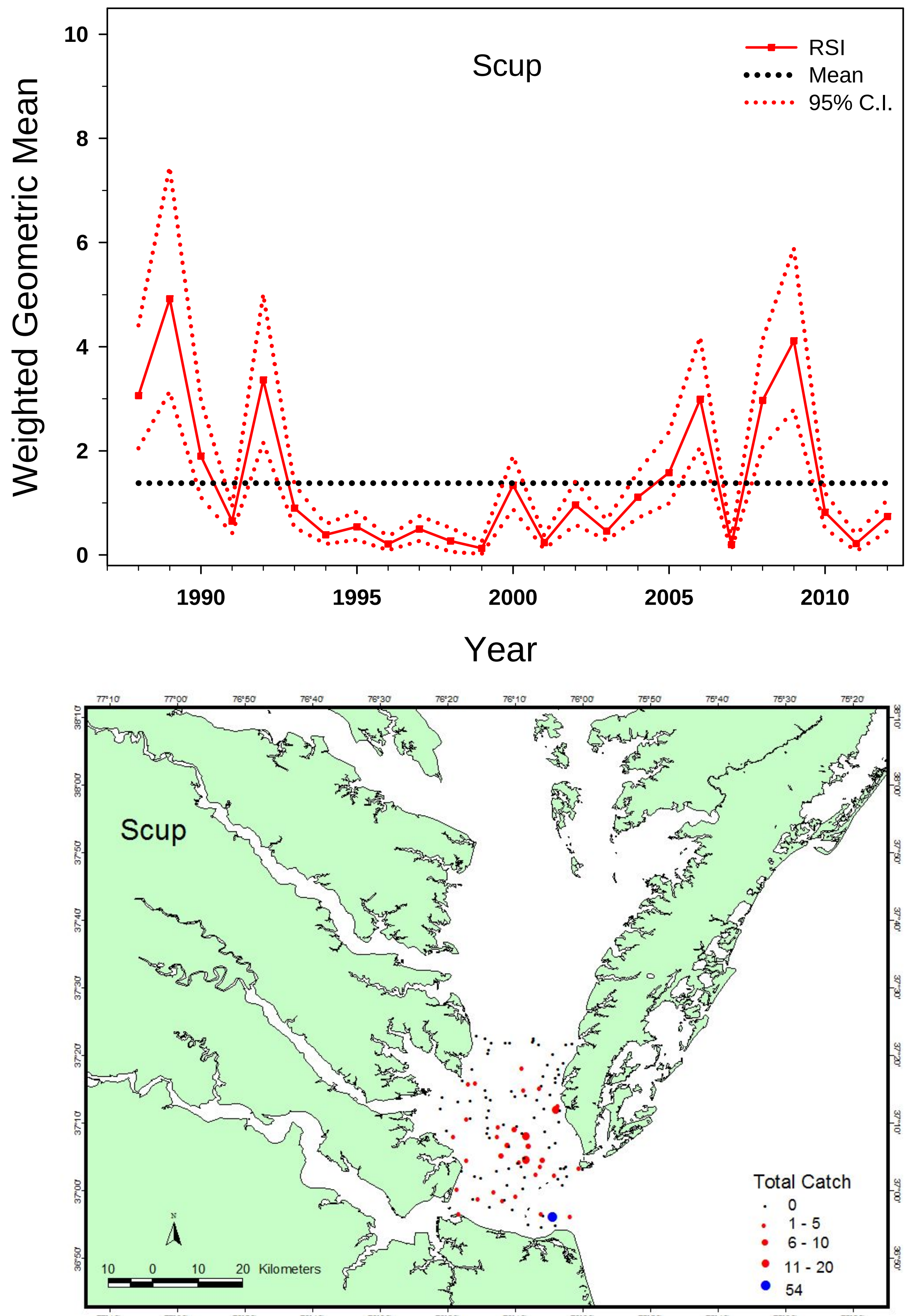
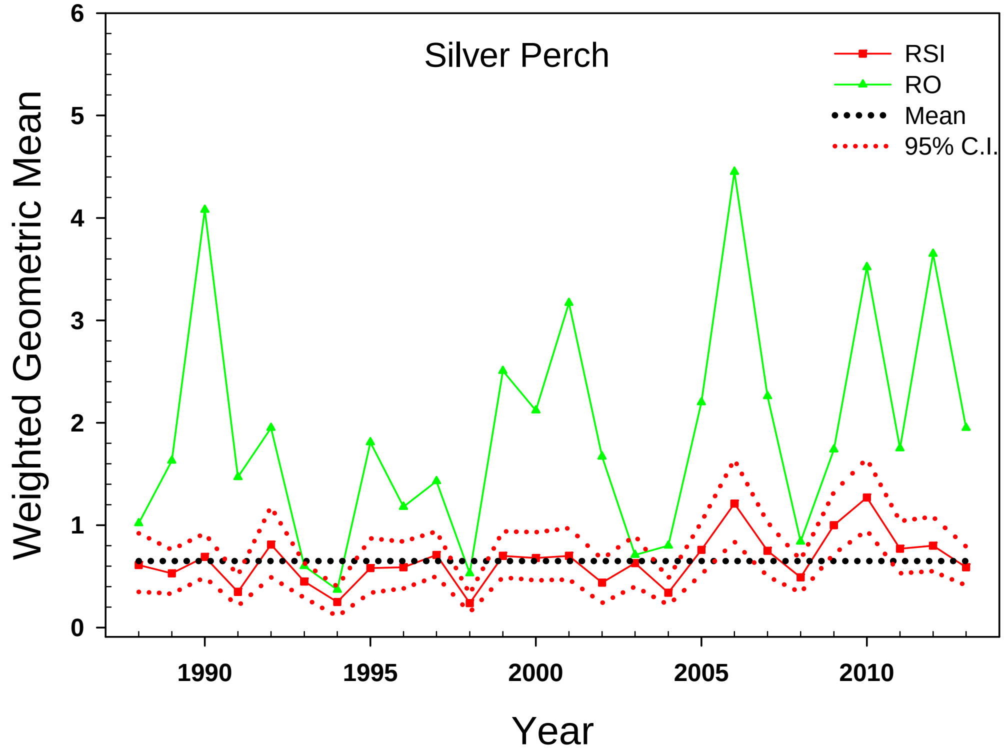


Figure 15. Juvenile Scup random stratified index (RSI_{GM}, 95% C.I.) and the time series average (dotted line, Top), and distribution of index-sized Scup from index strata and months (Bottom).



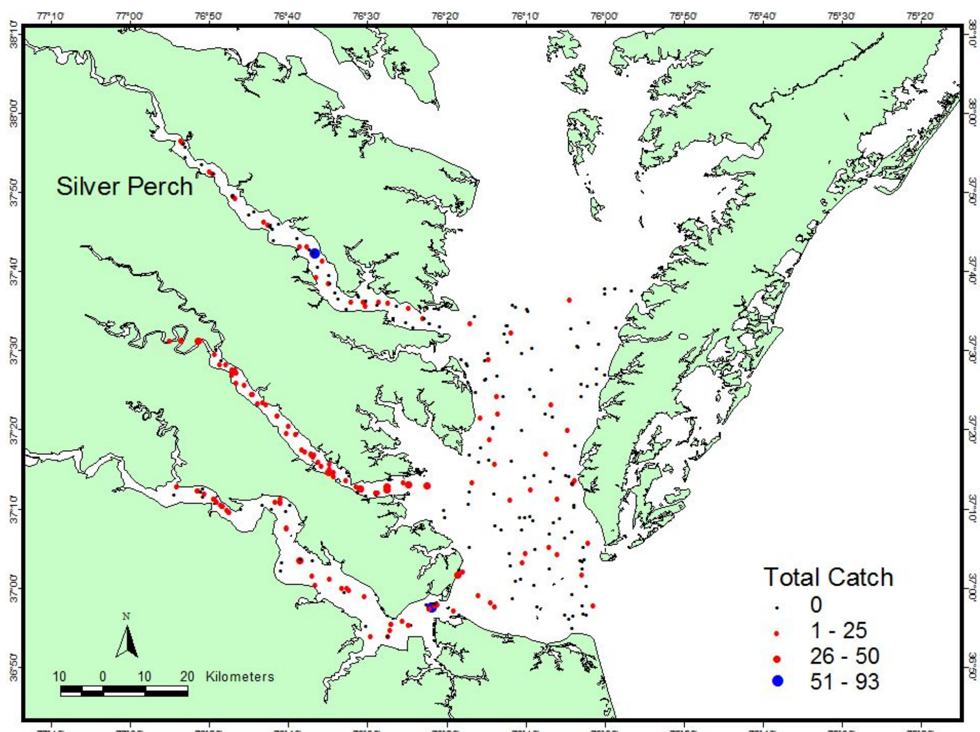


Figure 16. Juvenile Silver Perch random stratified (RSI_{GM}, 95% C.I.), fixed transect (Rivers only – RO), and the time series average (dotted line) based on the RSI_{GM} (Top), and distribution of juvenile Silver Perch from index strata and months (Bottom).

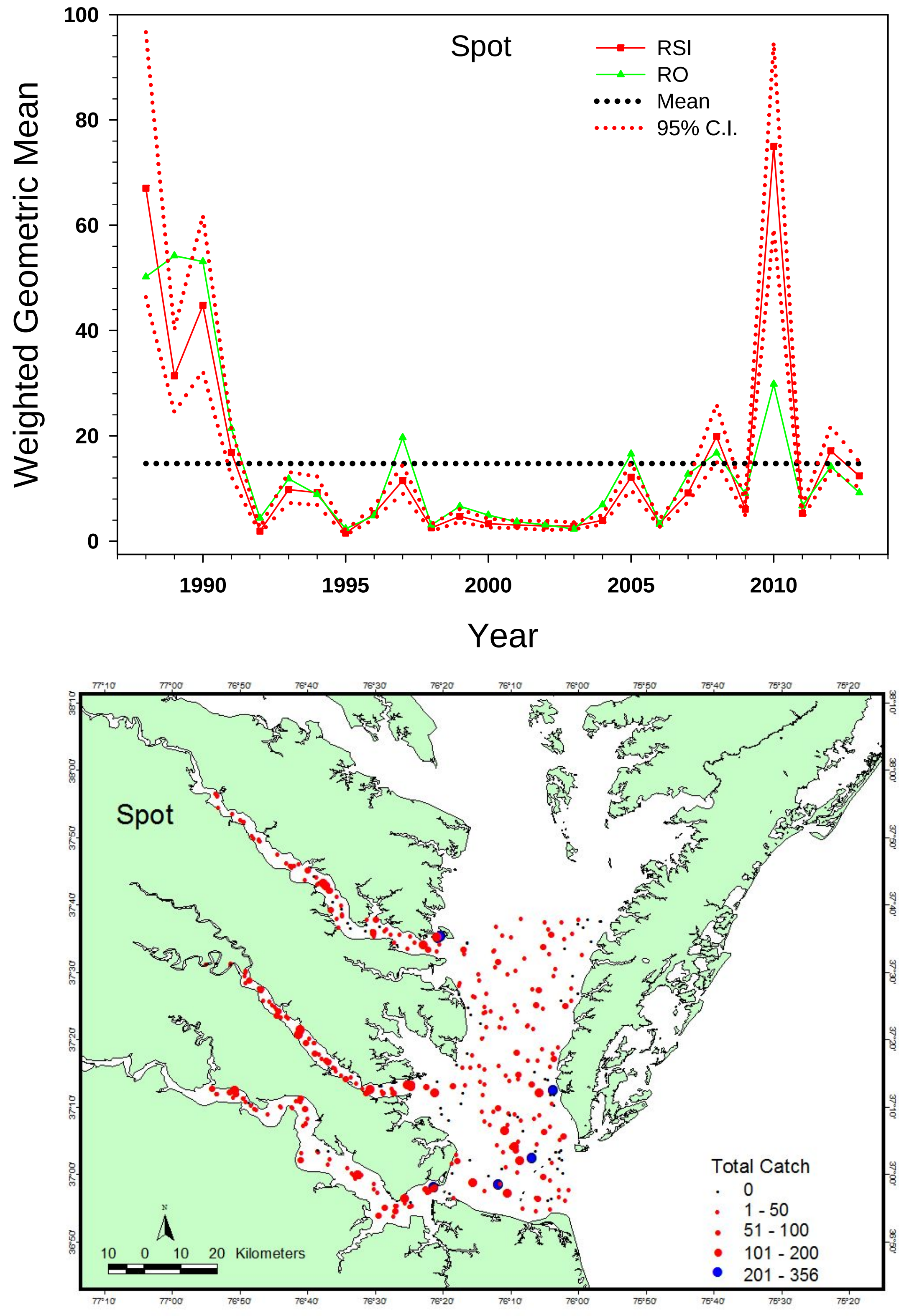


Figure 17. Juvenile Spot random stratified (RSI_{GM}, 95% C.I.), fixed transect (Rivers only – RO), and Bay and fixed river station (BRI) indices, the time series average (dotted line) based on the RSI_{GM} (Top), and distribution of juvenile Spot from index strata and months (Bottom).

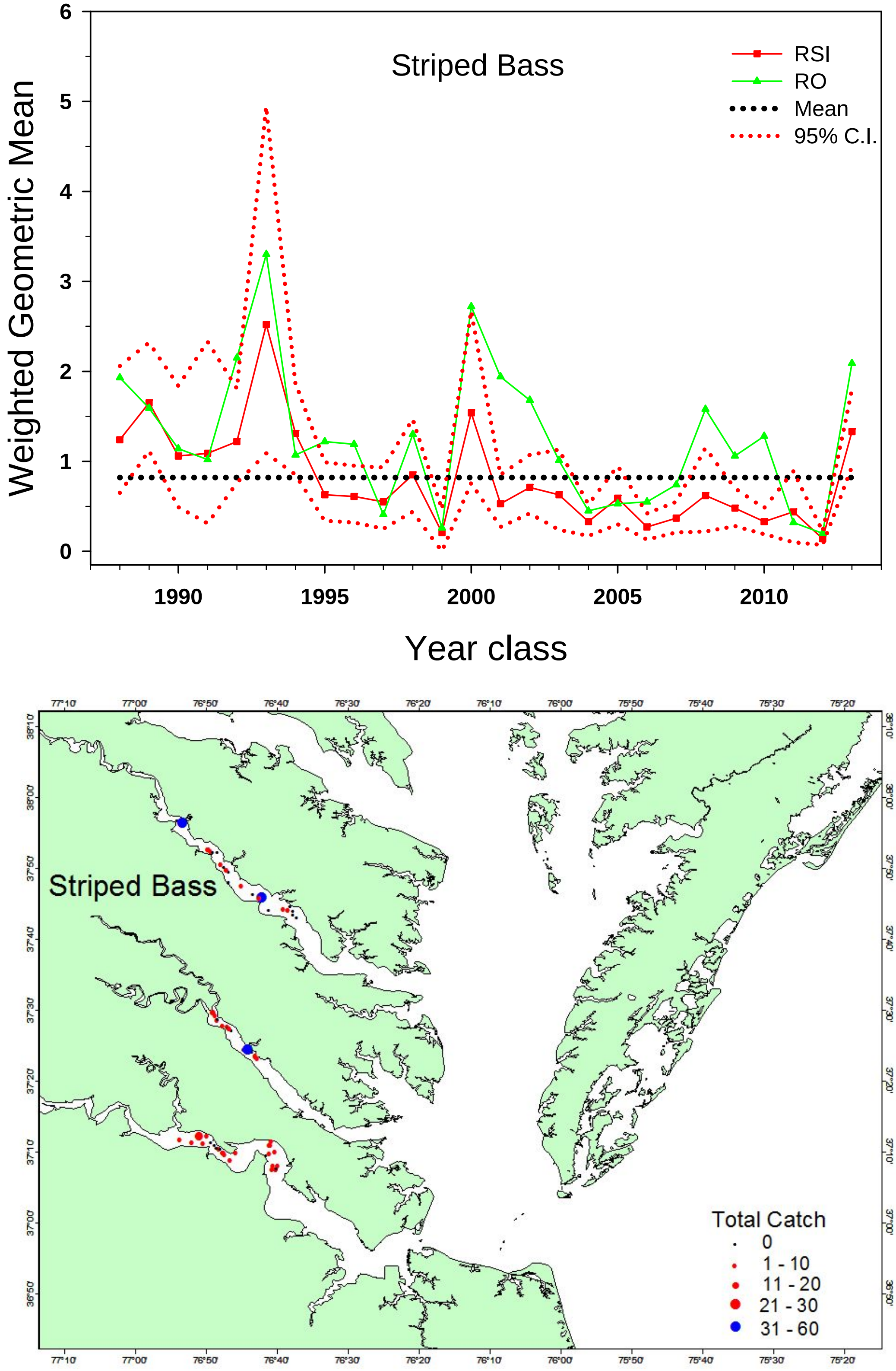
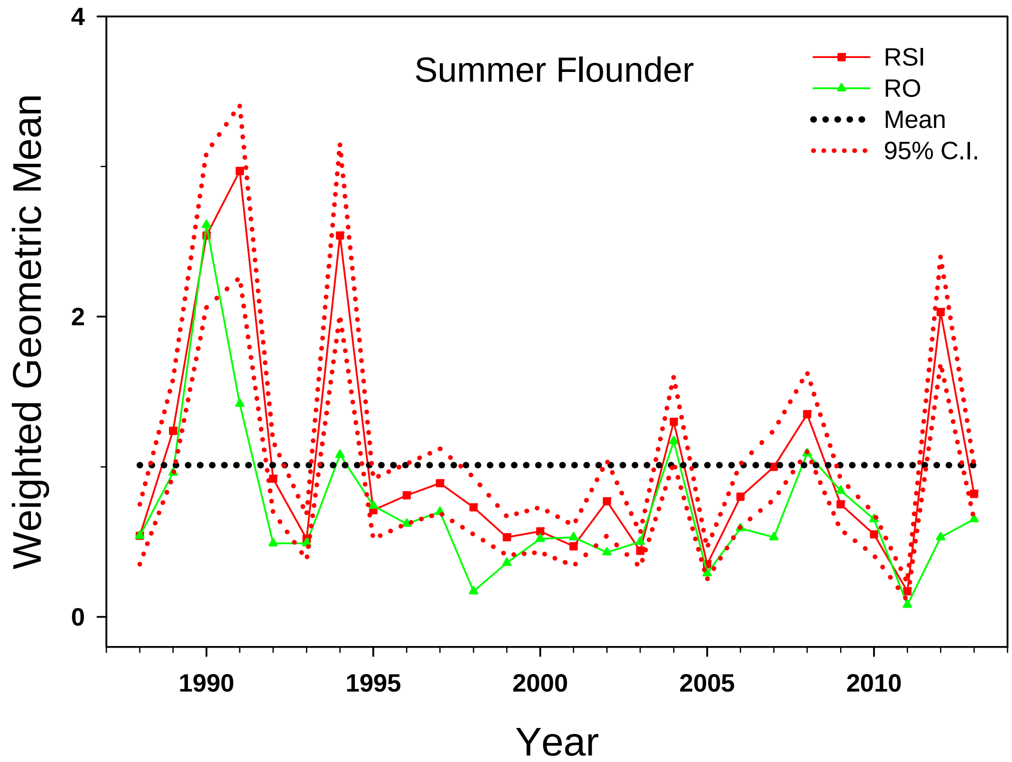


Figure 18. Juvenile Striped Bass random stratified index (RSI_{GM}, 95% C.I.), fixed transect index (Rivers only – RO), the time series average (dotted line) based on the RSI_{GM} (Top), and distribution of juvenile Striped Bass from index strata and months (Bottom).



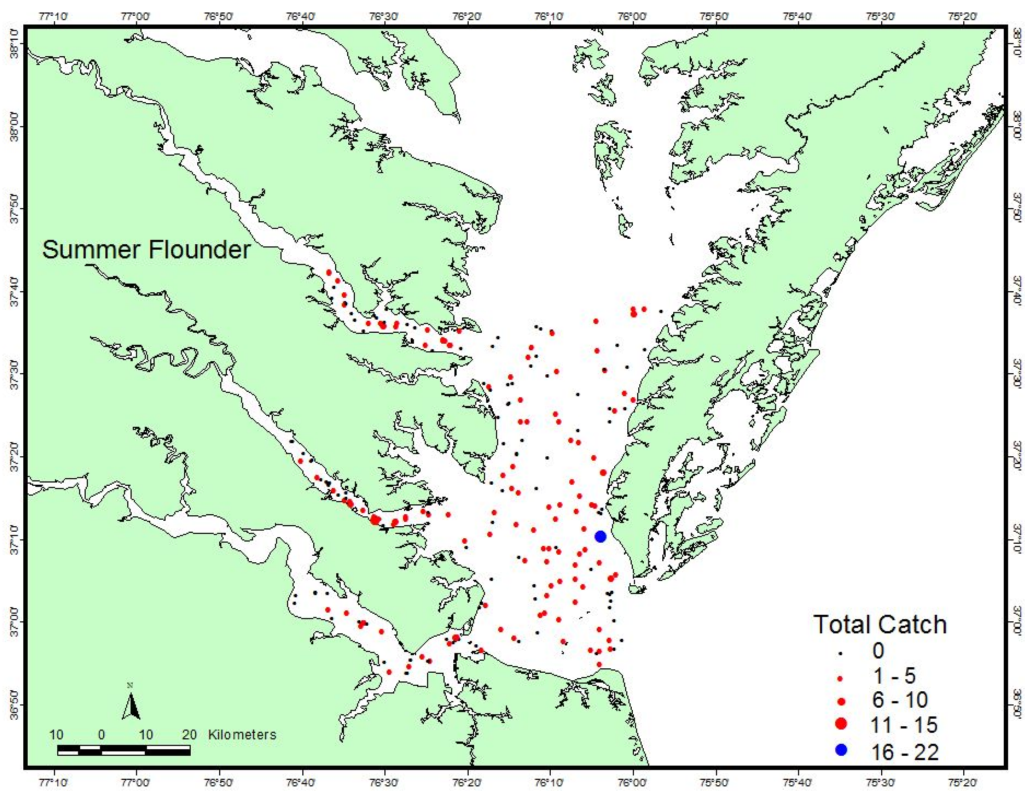


Figure 19. Juvenile Summer Flounder random stratified (RSI_{GM}, 95% C.I.), fixed transect (Rivers only – RO), and Bay and fixed river station (BRI) indices and the time series average (dotted line) based on the RSI_{GM} (Top), and distribution of juvenile Summer Flounder from index strata and months (Bottom).

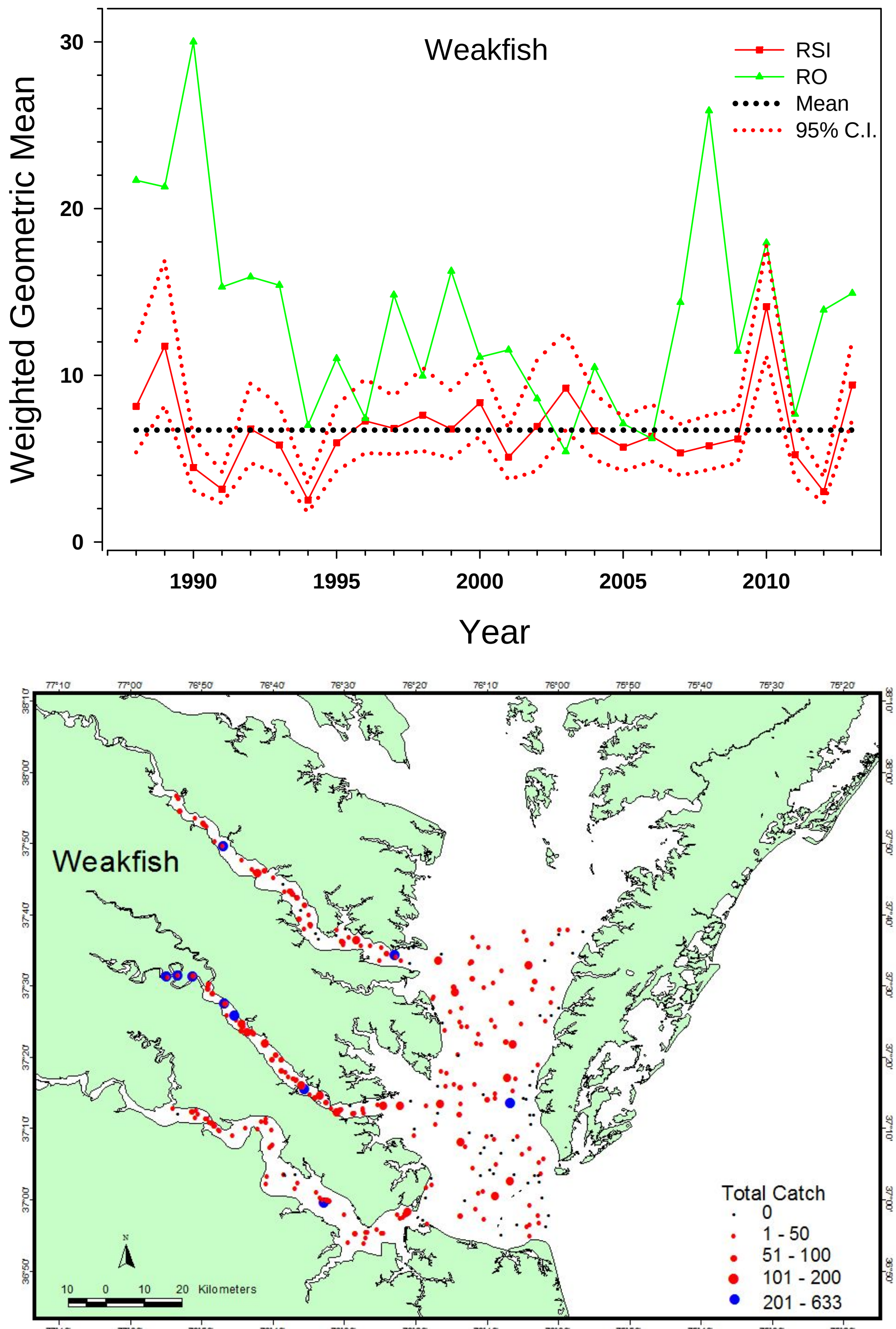


Figure 20. Juvenile Weakfish random stratified (RSI_{GM}, 95% C.I.), fixed transect (Rivers only – RO), and Bay and fixed river station (BRI) indices and the time series average (dotted line) based on the RSI_{GM} (Top), and distribution of juvenile Weakfish from index strata and months (Bottom).

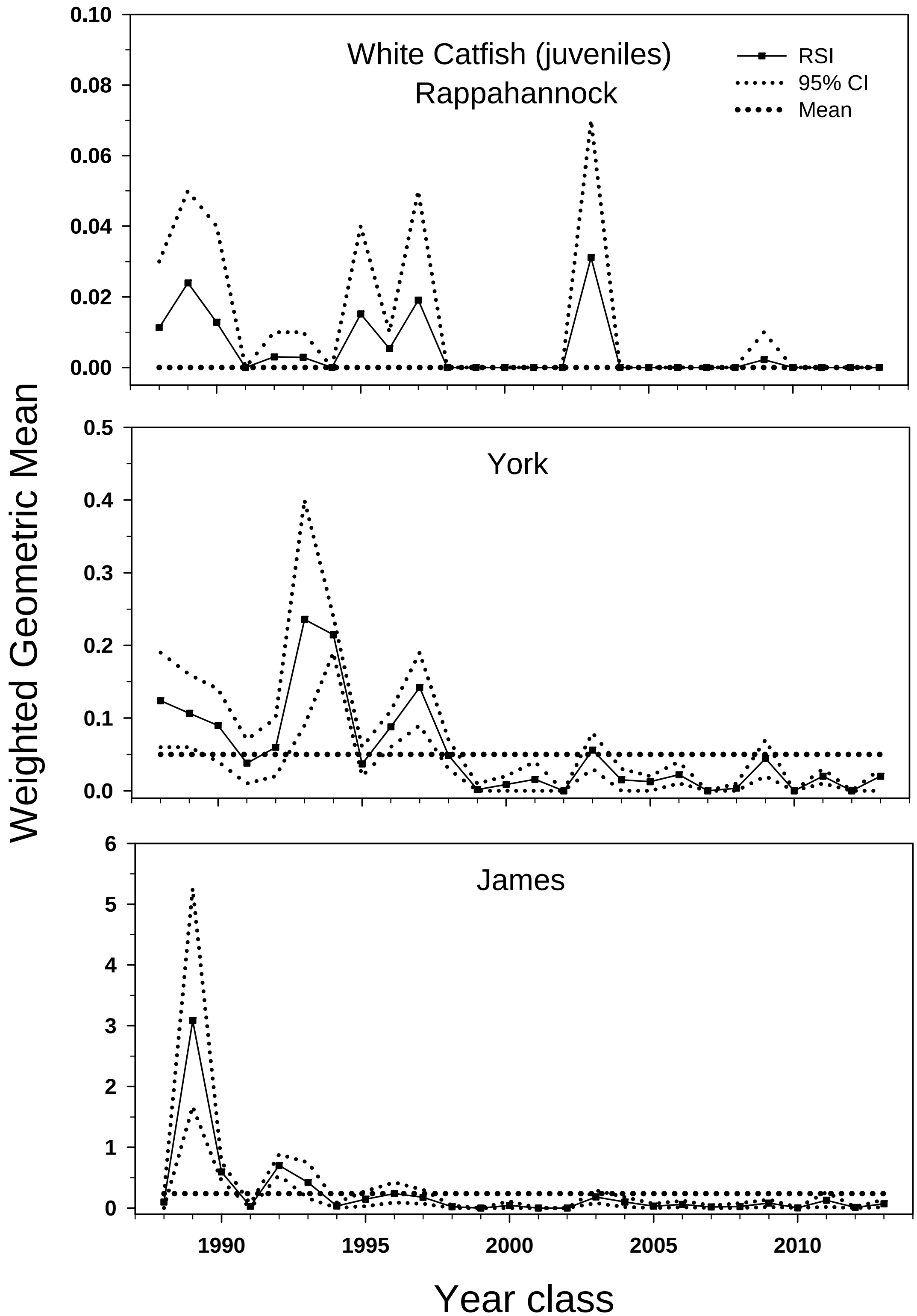


Figure 21. Juvenile White Catfish random stratified indices (RSI_{GM}, 95% C.I.) and times series averages (dotted line) based on RSI_{GM}'s from the Rappahannock, York, and James rivers. Note change in scale on y-axes.

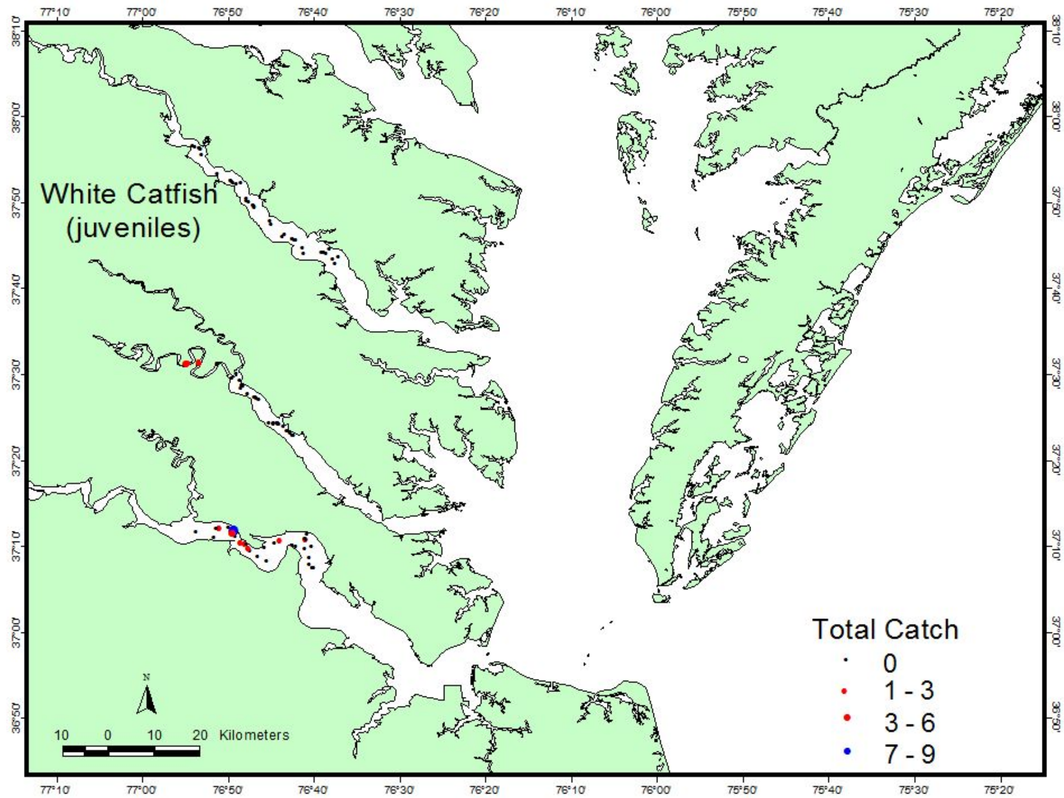


Figure 22. Distribution of juvenile White Catfish from index strata and months.

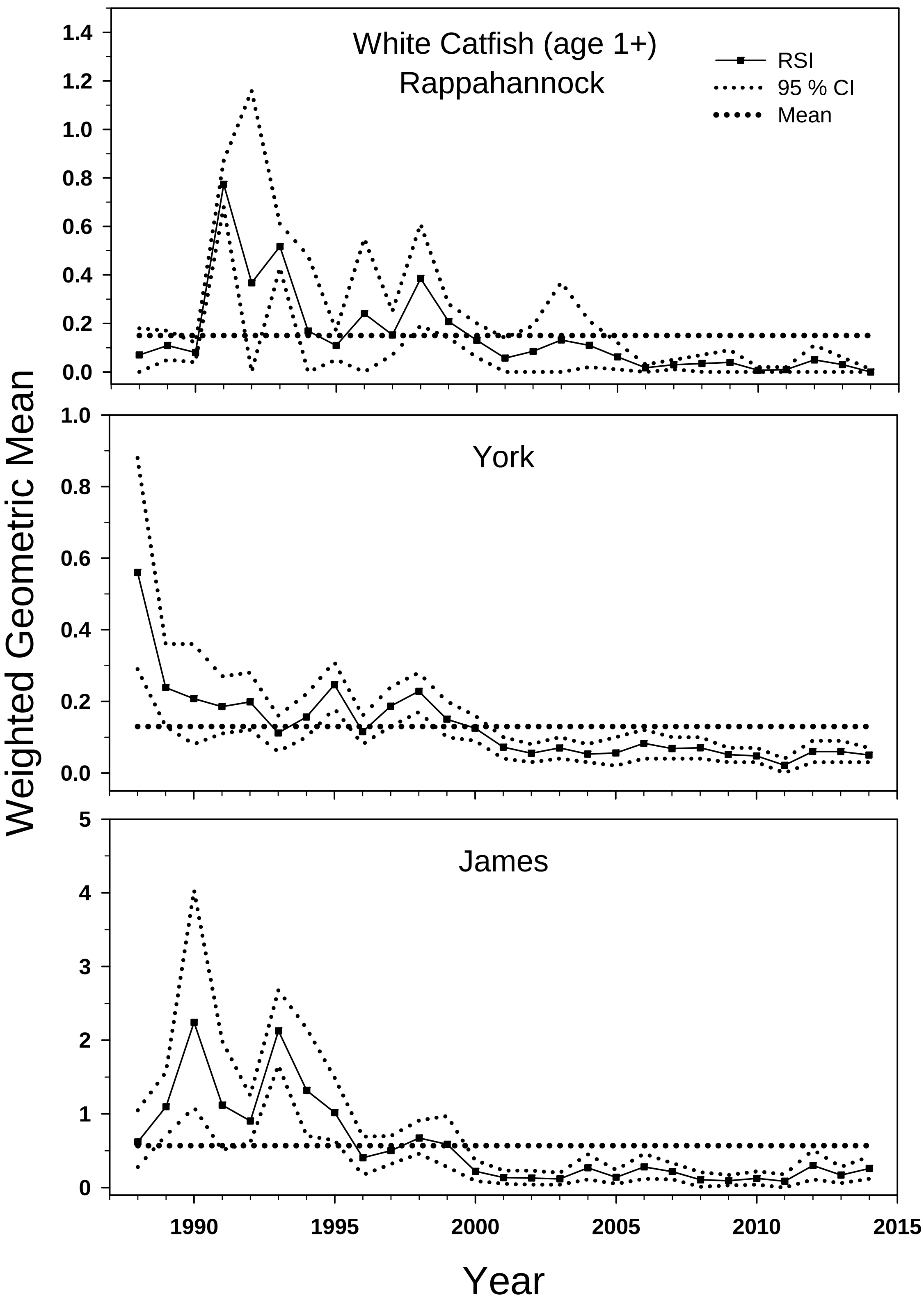


Figure 23. White Catfish age 1+ random stratified indices (RSI_{GM}, 95% C.I.) and time series averages (dotted line) based on RSI_{GM}'s from the Rappahannock, York, and James rivers. Note change in scale on y-axes.

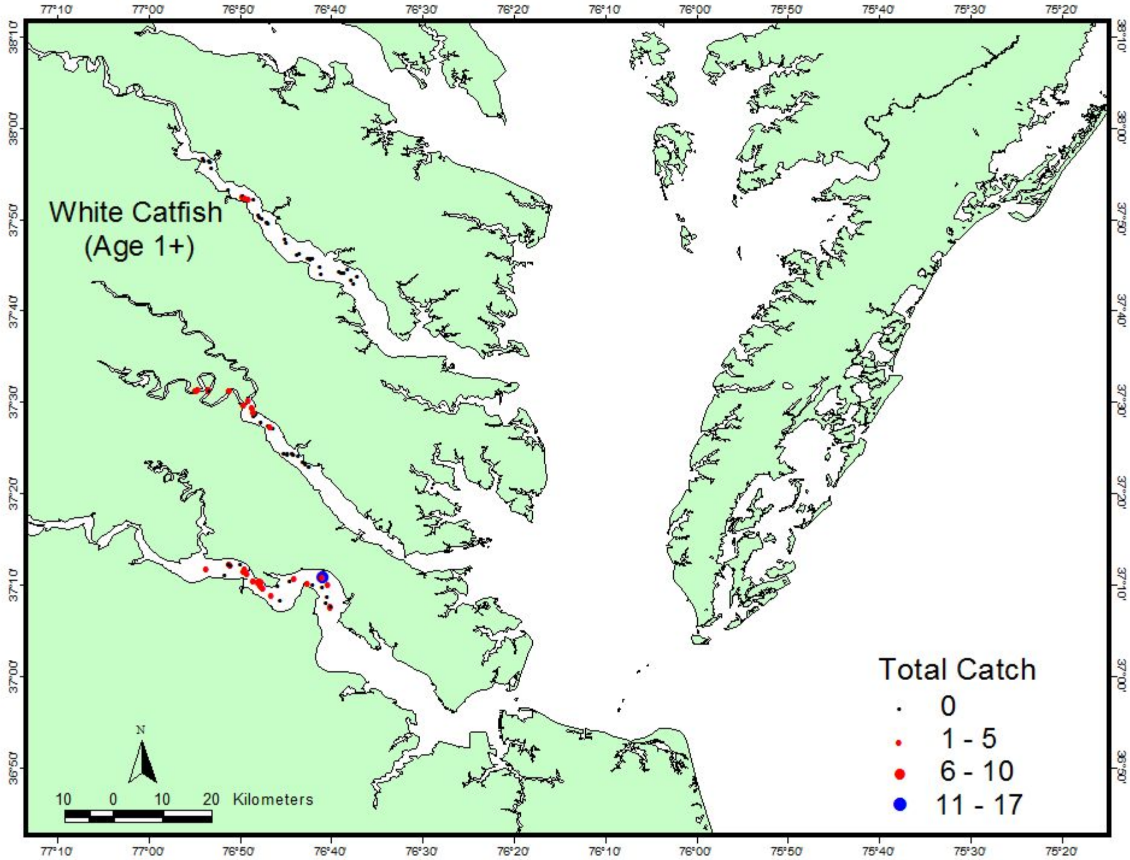


Figure 24. Distribution of White Catfish age 1+ from index strata and months.

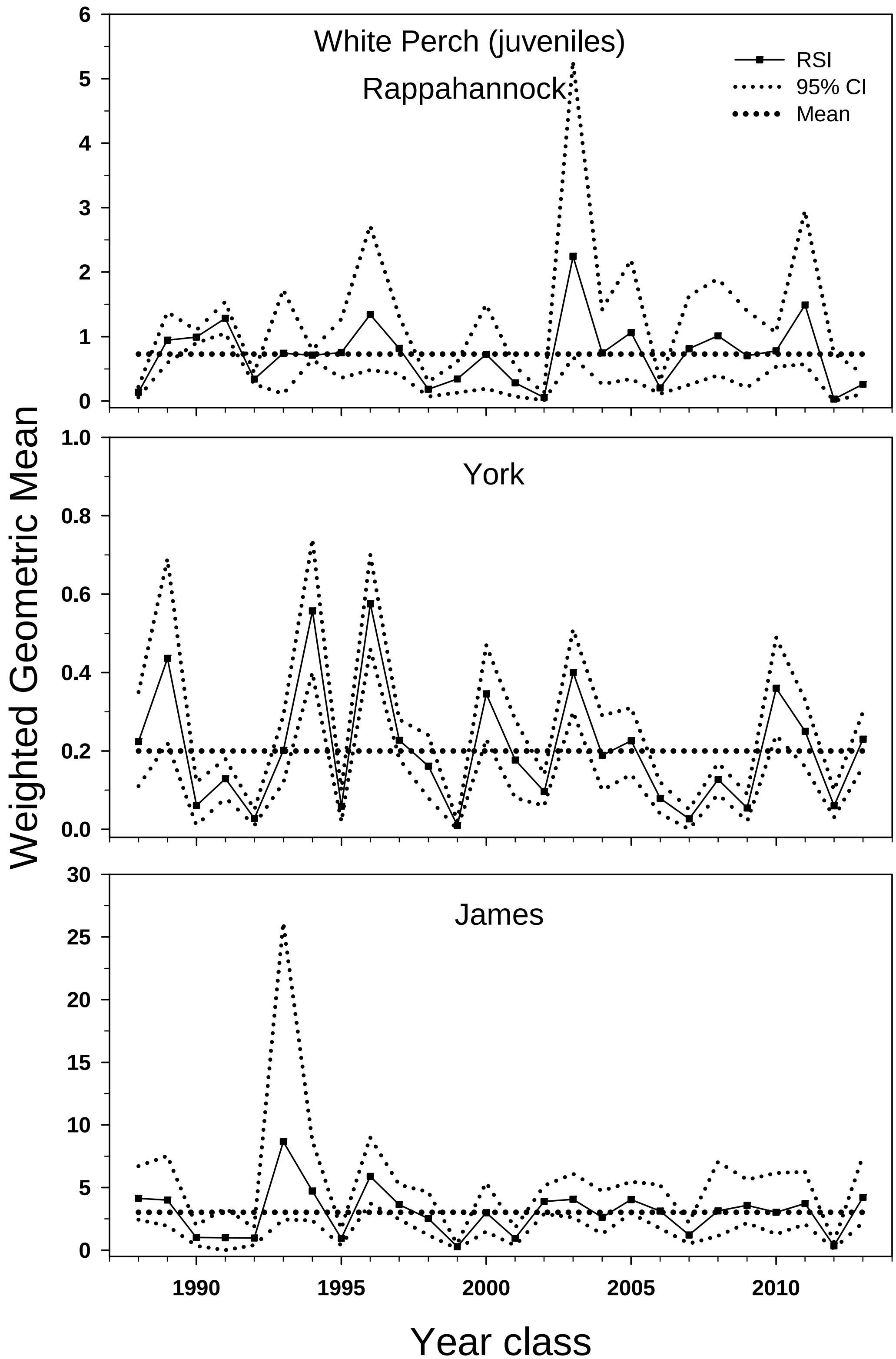


Figure 25. Juvenile White Perch random stratified indices (RSI_{GM}, 95% C.I.) and time series averages (dotted line) based on RSI_{GM}'s from the Rappahannock, York, and James rivers. Note change in scale on y-axes.

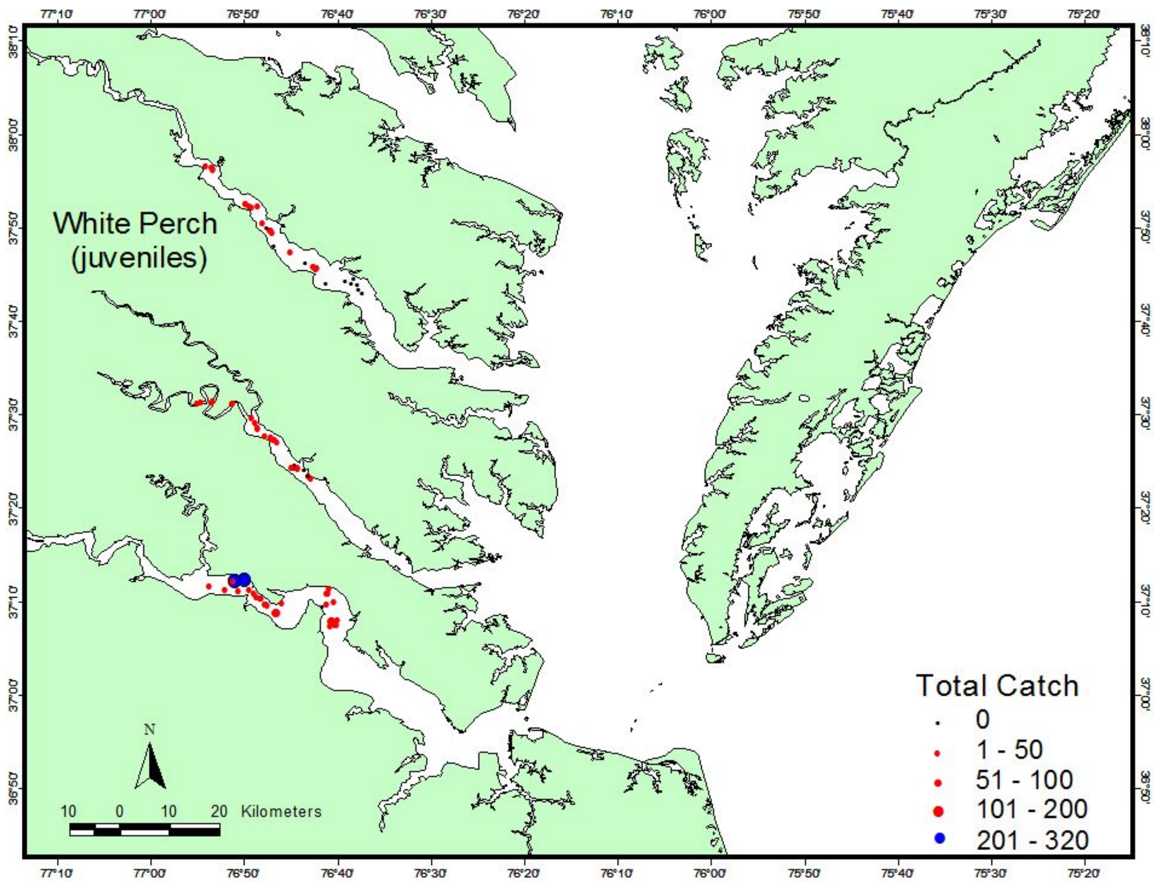


Figure 26. Distribution of juvenile White Perch from index strata and months.

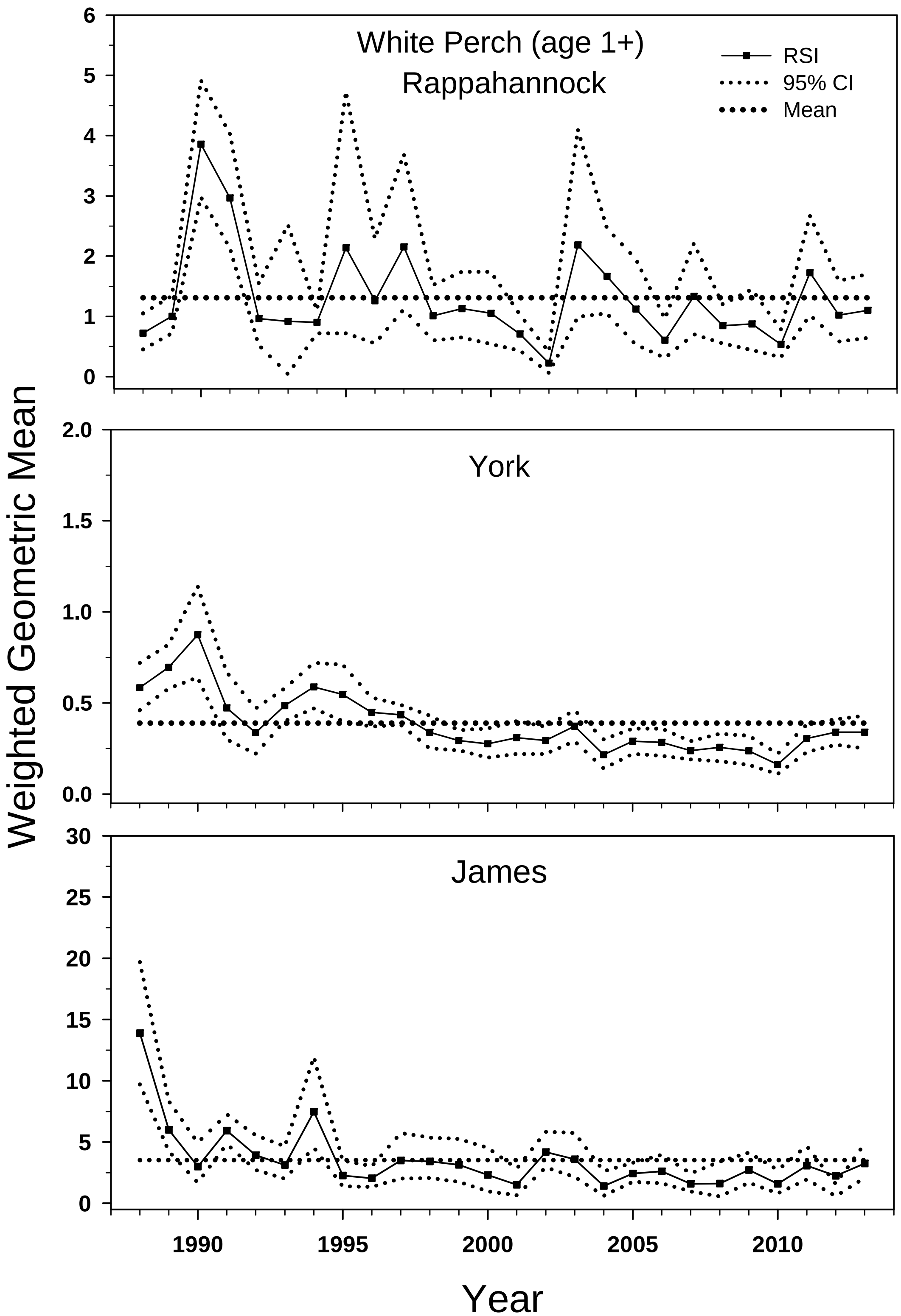


Figure 27. White Perch age 1+ random stratified indices (RSI_{GM}, 95% C.I.) and time series averages (dotted line) based on RSI_{GM}'s from the Rappahannock, York, and James rivers. Note change in scale on y-axes.

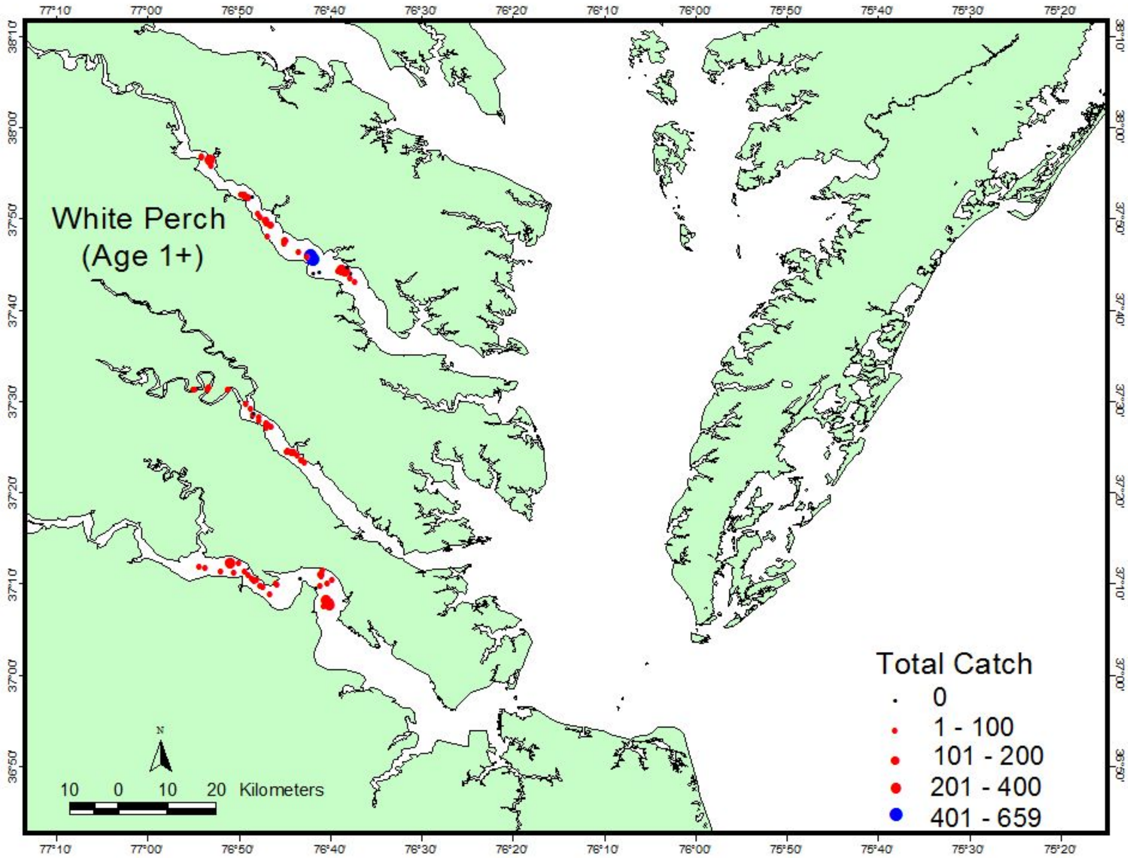
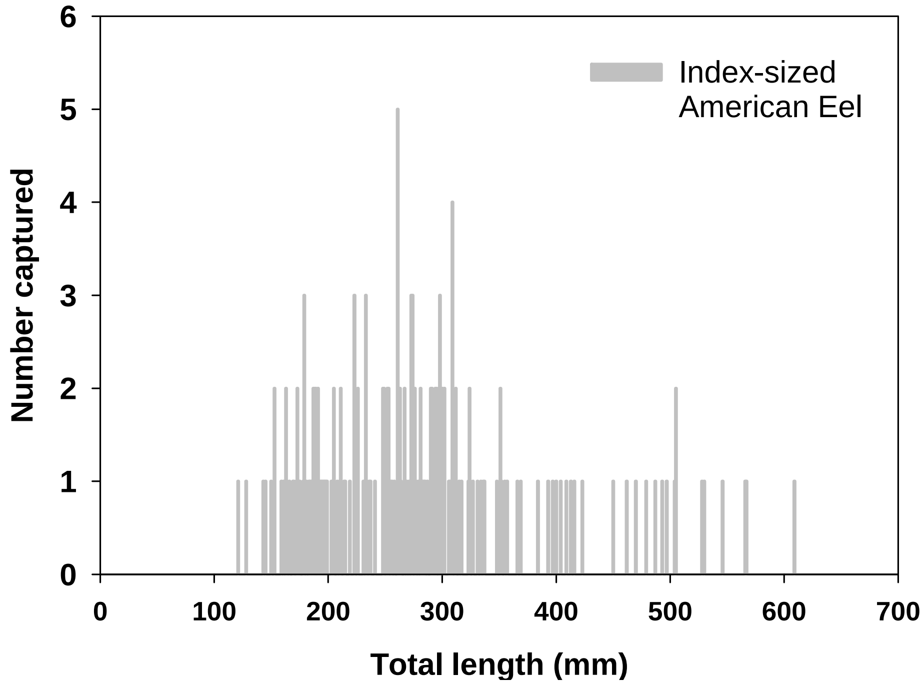


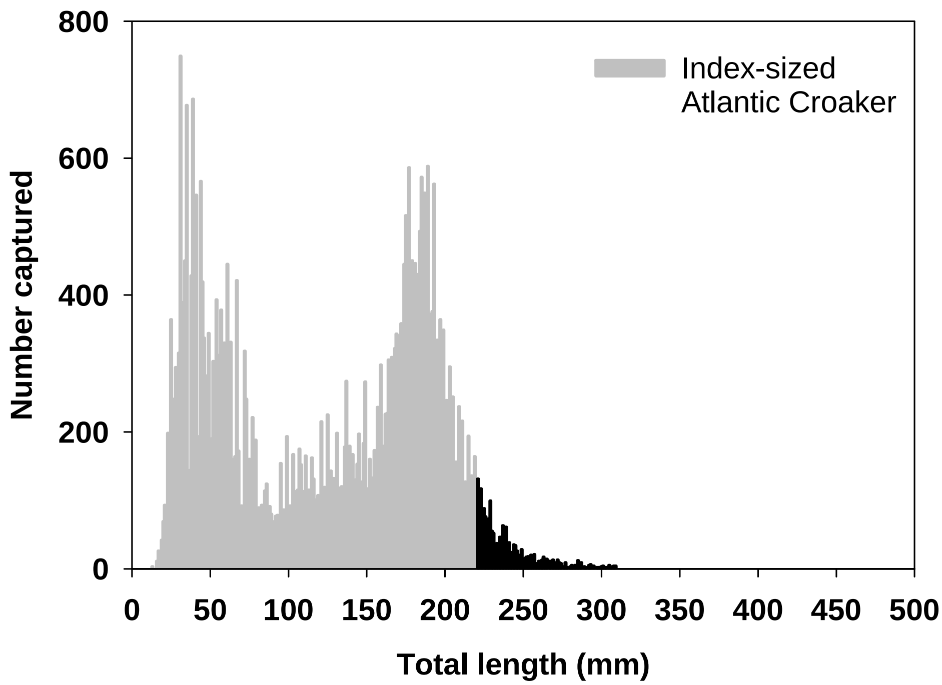
Figure 28. Distribution of White Perch age 1+ from index strata and months.

Appendix Table 1. Trawl survey advisory requests, data requests, and specimen requests from June 2013 to May 2014.

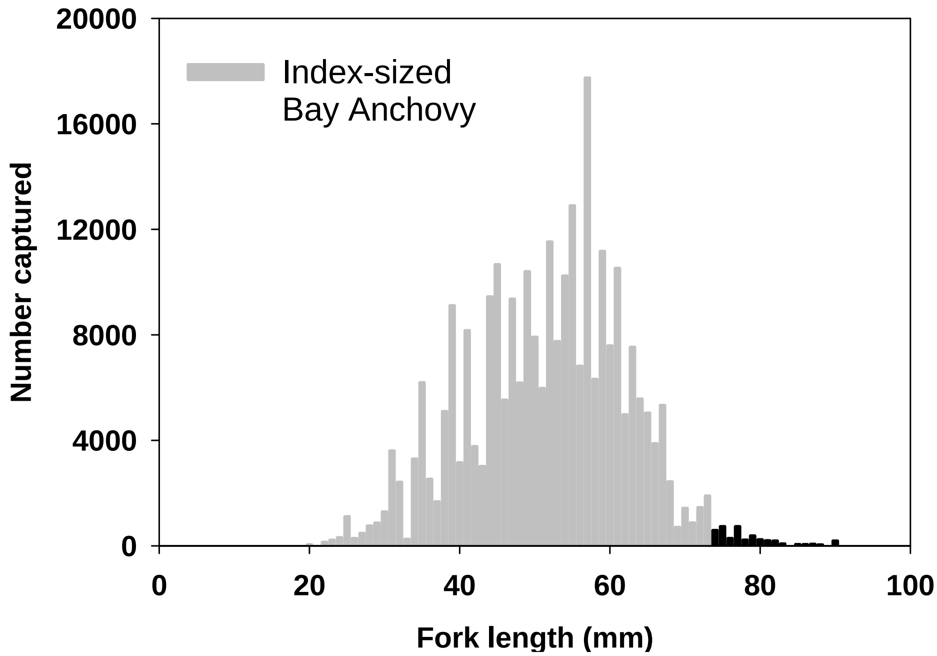
			2013							2014				
Name	Agency	Nature of request	J	J	A	S	O	N	D	J	F	M	A	M
Troy Tuckey	VIMS - Fisheries	White Perch juveniles	■	■	■	■	■	■	■	■	■	■	■	■
Ryan Schloesser	VIMS - Fisheries	Summer Flounder	■	■	■	■	■	■	■	■	■	■	■	
Ryan Schloesser	VIMS - Fisheries	Atlantic Croaker	■	■	■	■	■	■	■	■	■	■		
Ryan Schloesser	VIMS - Fisheries	Striped Bass	■		■	■	■	■	■	■	■	■	■	■
Dan Sennett	VIMS - Aquarium	Various spp.	■	■	■	■	■	■						
Joe Cimino	VMRC	Tautog	■	■	■	■	■	■	■	■	■	■	■	■
Rob Aguilar	SERC	Various spp.	■	■	■	■	■	■	■	■	■	■	■	■
Kristene Parsons	VIMS - Fisheries	All Butterfly Rays	■	■	■	■	■	■	■	■	■	■	■	■
Brian Watkins	VIMS - Fisheries	American Shad	■	■	■	■	■	■	■	■	■	■	■	■
Troy Tuckey	VIMS - Fisheries	American Eel		■	■	■	■	■	■	■	■	■	■	■
Pat McGrath	Governor's School	Longnose Gar	■	■	■	■								
Todd Mathes	GA - DNR	Northern Kingfish			■	■	■	■	■					
Laurie Sanderson	W&M	Gizzard Shad					■	■						
Alicia Norris	VIMS - Fisheries	Blue Catfish								■				
Aimee Comer	VIMS - Fisheries	Seaboard and Naked gobies									■	■	■	■
Susanna Musick	VIMS - Sea Grant	Various spp.											■	■
CJ Schlick	George Mason	River herring												■
Eric Hilton	VIMS - Fisheries	American Shad data	■											
Eric Hilton	VIMS - Fisheries	Blueback Herring data	■											
Eric Hilton	VIMS - Fisheries	Alewife data	■											
Joe Cimino	VMRC	Butterfish data	■											
Adam Kenyon	VMRC	American Eel collections	■											
Jeff Buckel	NCSU	Red Drum indices			■									
Eric Hilton	VIMS - Fisheries	Atlanttic Sturgeon			■									
Rich Bell	NOAA	Winter Flounder			■									
Rob Latour	ASMFC	Menhaden data					■							
Pat Lynch	NOAA - NMFS	Alosine indices							■					
Mathew Ogburn	SERC	Blue crab data										■		
Alexandra Fries	UMCES	Bay anchovy data											■	
Mark Terceiro	NOAA	Scup index											■	
Paul Harnik	Franklin and Marshall	Mercenaria											■	
Adam Kenyon	VMRC	Atlantic Croaker juvenile index												■

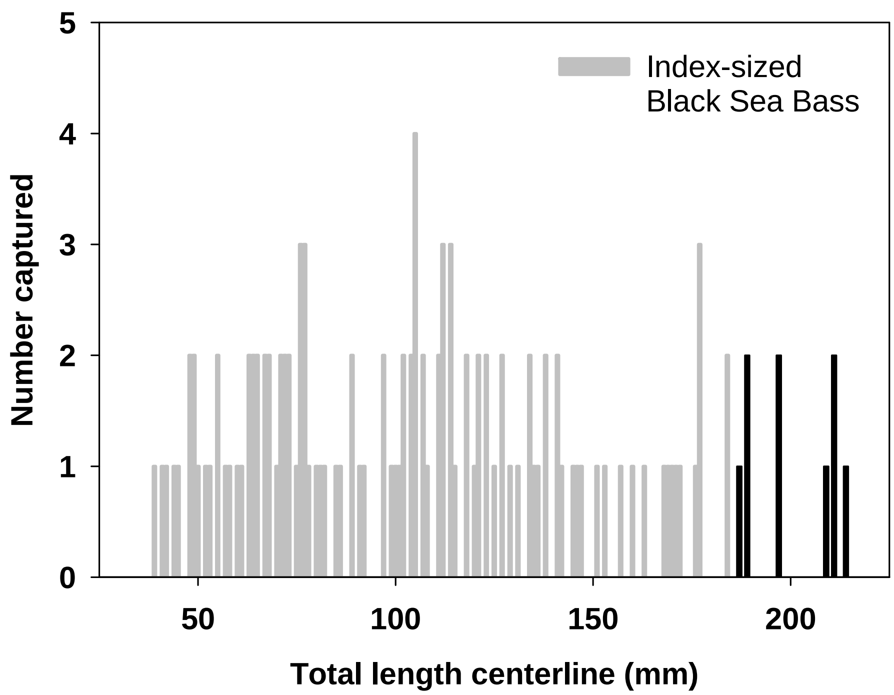
Appendix Figure 1. Length frequency distributions by species from June 2013 to May 2014. (Note that actual indices are calculated using a subset of months and strata. Therefore, not all index-sized fish are included in index calculations.)





Appendix Figure 1. (continued)





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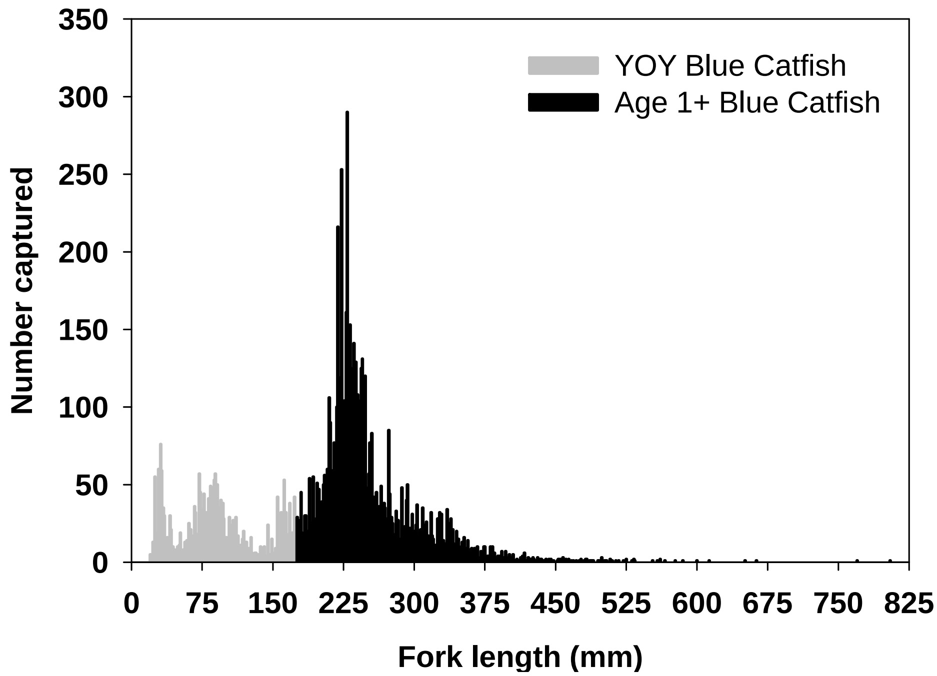

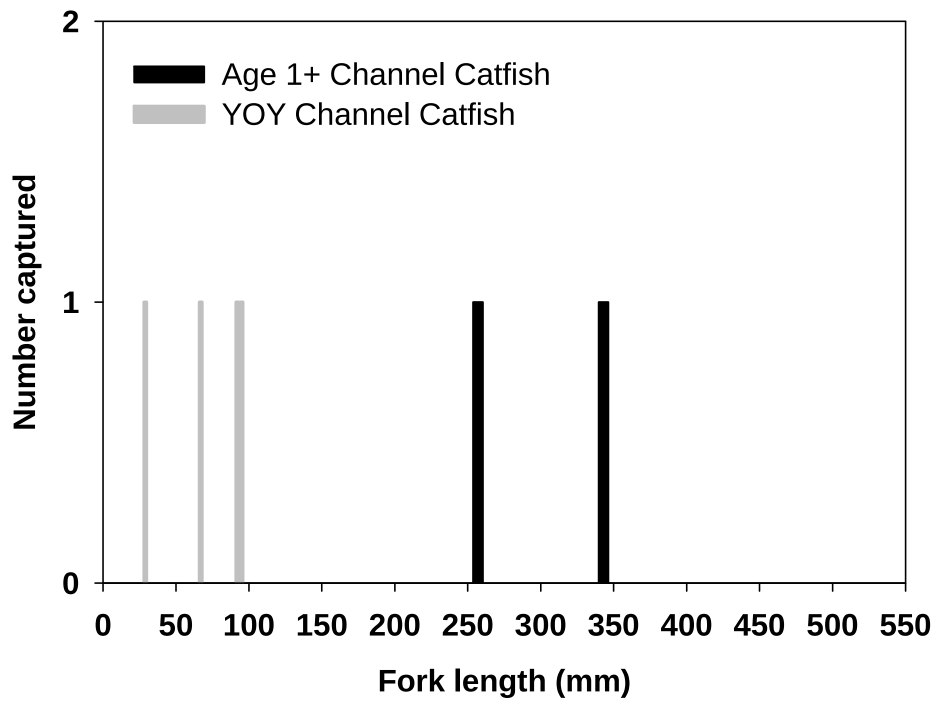

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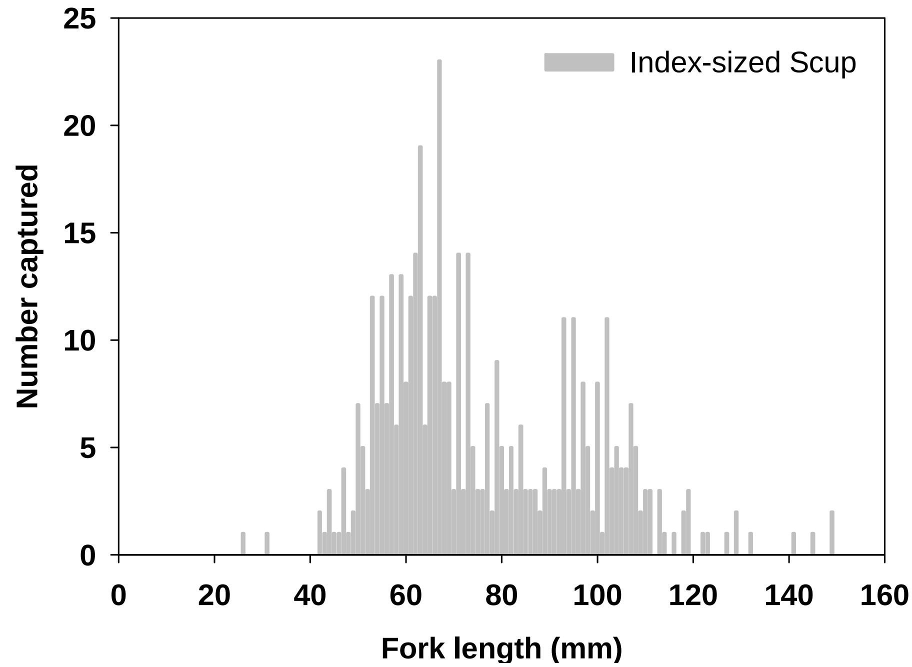

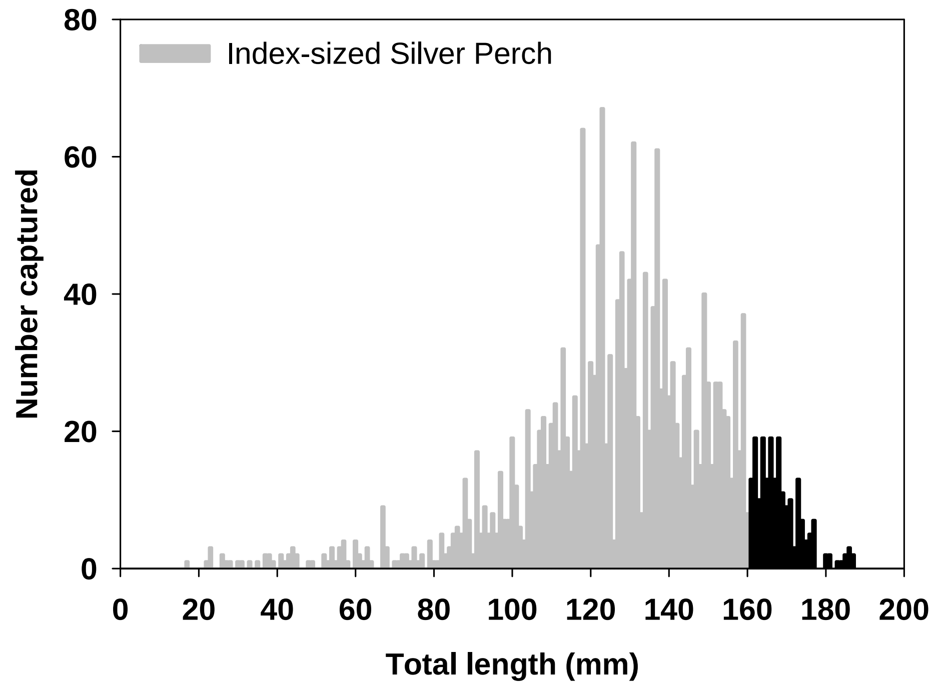

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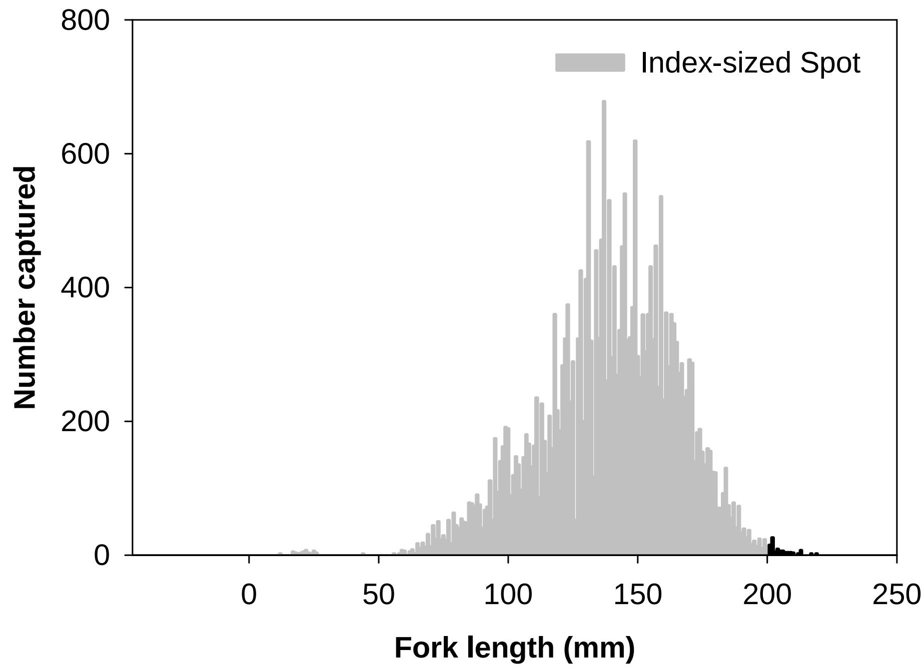

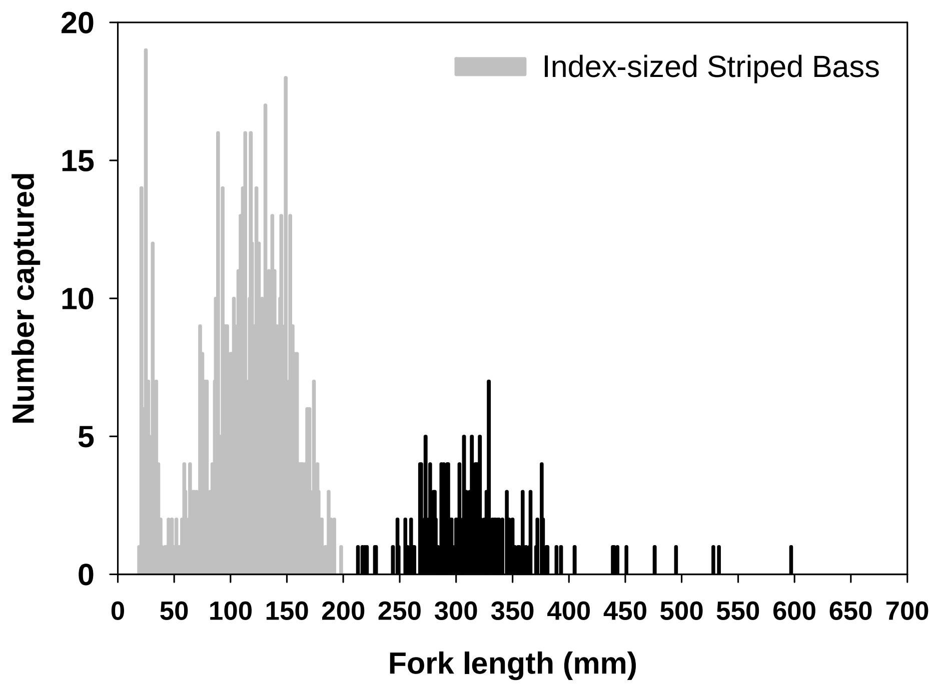

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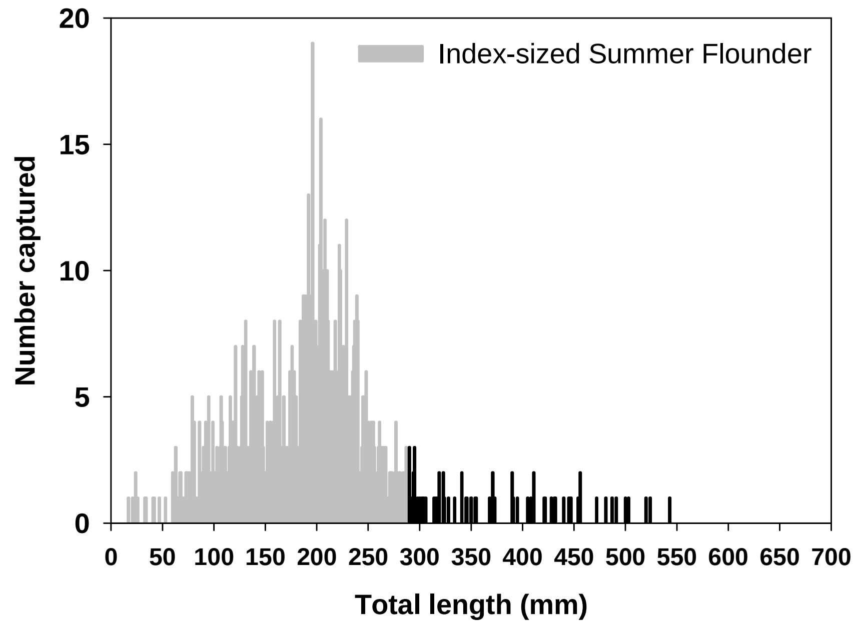

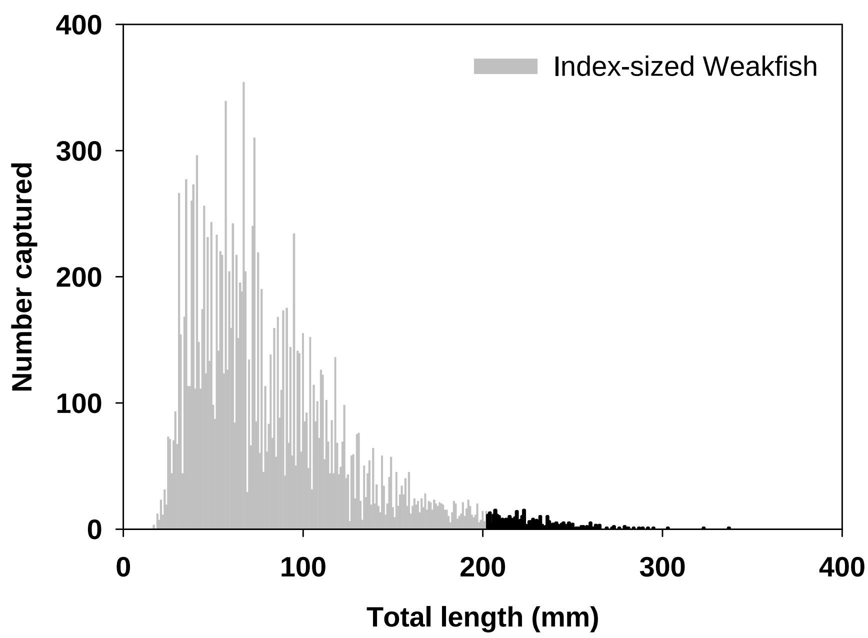

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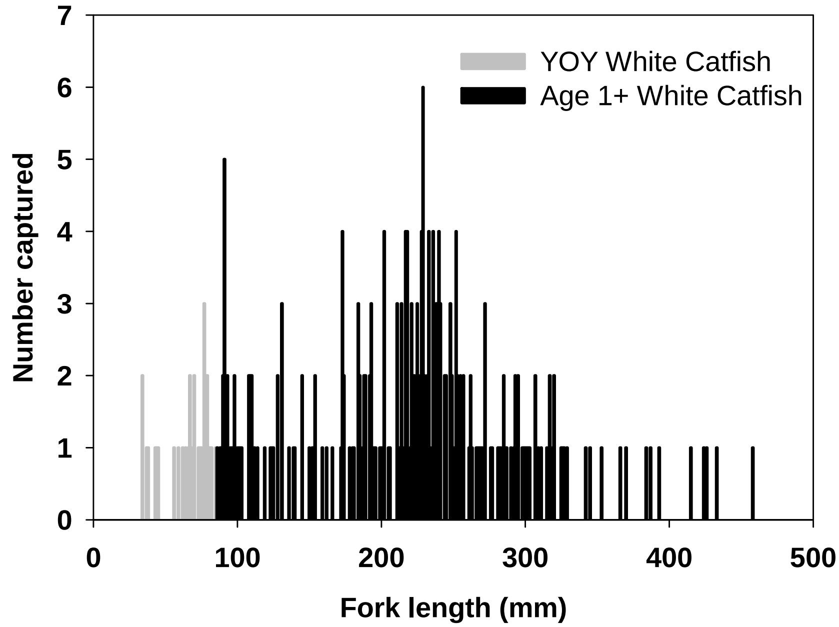

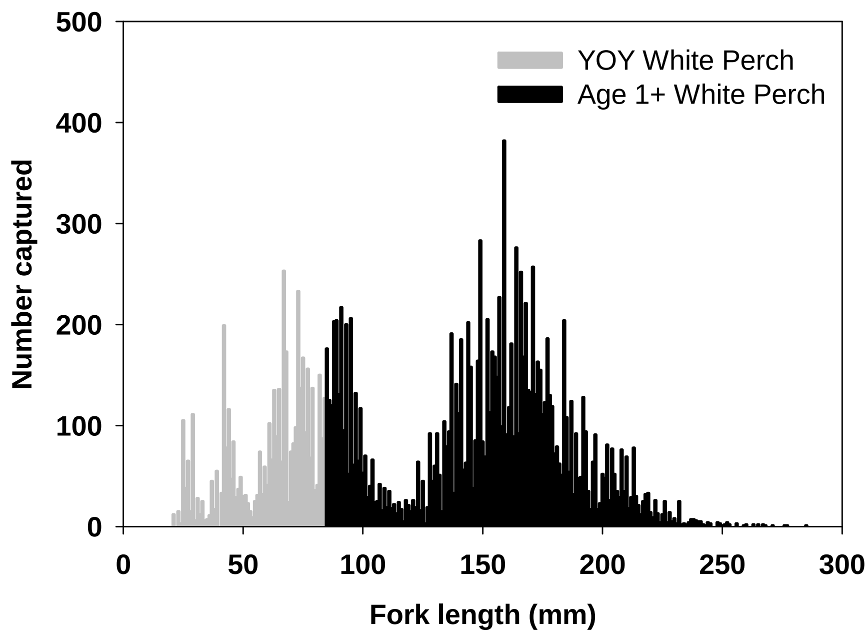

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