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

2011 ANNUAL REPORT

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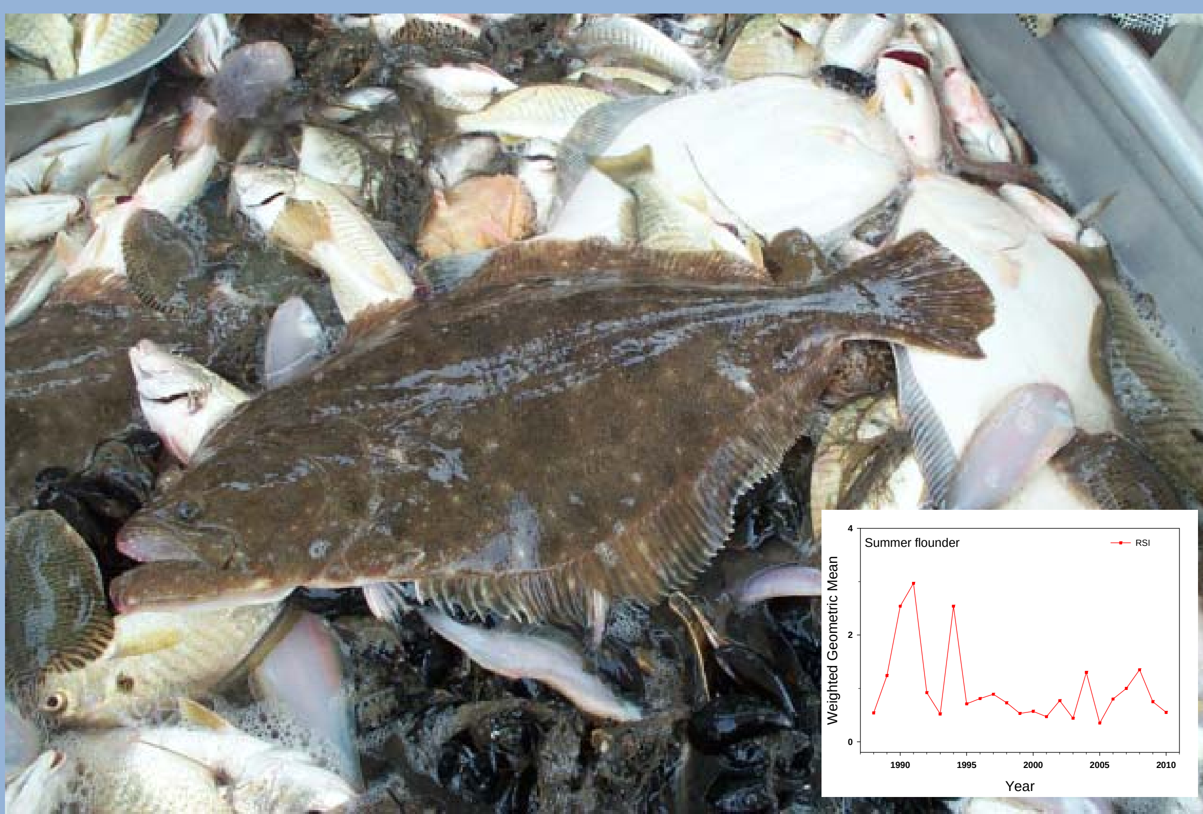

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DISCLAIMER

Some of the results contained in this report have recently been completed and may contain errors and/or need further refinement.

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EXECUTIVE SUMMARY

June 2010 – May 2011

The juvenile fish trawl survey conducted by the Virginia Institute of Marine Science (VIMS) is the oldest continuing monitoring program (56 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, and the American eel index was a vital component of the assessment that led to the 2006 ASMFC American Eel Management Plan.

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 different estimates of relative abundance were developed and reported for juvenile finfish 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. 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.

In 2010, abundance indices for American eel, blue catfish, channel catfish, white catfish, and white perch were calculated on a river-specific basis because these species tend to reside within each system and show river-specific differences in abundance. Abundance indices for YOY Atlantic croaker, bay anchovy, spot and weakfish showed above-average recruitment, and all but Atlantic croaker showed the highest recruitment levels ever observed in the time series (1988 – 2010, based on the RSI). Indices for black sea bass, scup, silver perch, striped bass, and summer flounder indicated below-average recruitment in 2010.

Routine sampling in Mobjack Bay, located on the western side of Chesapeake Bay and north of the York River entrance, was continued in 2010-11. Mobjack Bay sampling stations consist of a mix of seven fixed and ten random stratified stations each month that encompass the main portion of the bay and the four river systems that empty into it. Extensive seagrass beds occur in Mobjack Bay and likely serve as important nursery habitat for juvenile fishes. Results from Mobjack Bay sampling were analyzed separately to maintain consistency in spatial coverage discussed in our previous reports.

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 "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 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 Fisheries Statistics Survey shows that 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. 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).

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 most species (Geer and Austin, 1997).

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.

This report summarizes the activity of the VIMS Juvenile Finfish Trawl Survey from June 2010 through May 2011. 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

The field sampling protocol is described in detail in Lowery and Geer (2000). In brief, 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 also 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 (≥ 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 ≥ 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.

With the exception of the fixed river stations, 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 create separate depth 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 new 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.

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.

Since May 1998, habitat or substrate type sampled by the trawl has been recorded (Table 1). Fish distribution and abundance may be influenced by various substrates such as shell, sponge, hydroids, and sea squirts that may be used as shelter, spawning habitat or for feeding. Substrates are measured at each trawling site based on the quantity (volume in a standard container) observed in the net. Volumetric measurements of gelatinous zooplankton are also recorded for each trawl site because large catches of jellyfish and ctenophores may affect the catch (e.g., changes in gear saturation or efficiency).

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 changes). 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 scope 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 juvenile index calculation (Table 2). 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 usually 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 2). The extent of overlapping lengths and the proportion within that range attributable to each year class was 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, most of the data used to construct juvenile indices were drawn from months when no overlap was present.

After removing non young-of-year individuals, monthly stratum-specific abundances and occurrence rates are calculated for each target species. Numbers of individuals captured are 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/ EY_{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 in 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 (6 months for bay anchovies) that provided reasonable abundance data for each species were identified (Table 2).

Using these 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 for American eel 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 and blue catfish, an index is calculated assuming a delta lognormal distribution (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.

The following indices are produced for each species for 1988 to the present: 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 are being addressed). Multiple indices are presented in this report for completeness, but usually only the RSI will be described in detail.

Mobjack Bay

Routine sampling in Mobjack Bay, located on the western side of Chesapeake Bay and north of the York River entrance, continued from June 2010 to May 2011 (Figure 1). Seventeen stations were sampled each month (seven fixed stations and ten random stations) following the depth stratification scheme described previously for the trawl survey. Three fixed stations occur in the main portion of Mobjack Bay, one fixed station occurs in each river (Ware, East, Severn, and North rivers), and the ten depth-stratified random stations are selected from sites located throughout the bay and river system.

RESULTS

A summary of tows completed from 1988 through May 2011 (Table 3) provides a comprehensive synopsis of the sampling completed for this report. For the 2010-2011 project year (June through May), 1224 sites were sampled resulting in 774,324 fishes identified and enumerated from 102 different species (Table 4). Bay anchovy, spot, and hogchoker accounted for 85.2% of the catch by numbers. Ignoring bay anchovy and hogchoker, five species – spot, Atlantic croaker, weakfish, white perch, and spotted hake – represented 85.0% of the catch numerically (Table 4).

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, eels 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. American eel indices exhibited above-average recruitment in the Rappahannock River (mean RSI_{Delta} = 2.42) and the James River (mean RSI_{Delta} = 2.25) in the late 1980's and early 1990's and below-average recruitment thereafter (Table 5; Figure 2). In the York River, below-average recruitment (mean RSI_{Delta} = 0.67) 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 spring index is presented. The Atlantic croaker spring RSI_{GM} remained average to below-average from 1992 to 2006, and has been above average for the past three years (Table 6 and Figure 4, top; mean RSI_{GM} = 1.29).

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 ‰ (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 - 2002 (Table 7; Figure 5, top). The 2010 index (RSI_{GM} = 84.92) was the highest value ever observed in the time-series (mean RSI_{GM} = 26.95). As expected, bay anchovy are ubiquitous in trawl survey catches (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 2009 year class is based on catches from May to July 2010). 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 and 2007 (Table 8; Figure 6, top).

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 collected 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. The juvenile blue catfish RSI_{Delta} is highest in the James River with above-average recruitment (mean RSI_{Delta} =

4.03) in 1996, 1997, 2003 – 2006, and 2009 (Table 9; Figure 7). Above-average recruitment of juvenile blue catfish occurred periodically in the Rappahannock River since 1990, and has been observed in 2003, 2004, and 2006 the York River (Figure 7).

Abundance indices for age 1+ blue catfish have been stable around the long-term mean in the Rappahannock River since 2003 (mean RSI_{Delta} = 11.09; Table 10; Figure 9). Above-average abundance estimates for age 1+ blue catfish have been observed for five of the past six years in the James River (mean RSI_{Delta} = 15.51; Table 10; Figure 9). In the York River, abundance indices for age 1+ blue catfish have been above average since 2005 (mean RSI_{Delta} = 0.51; Table 10; Figure 9).

Blue catfish indices have increased since 1988 and the ecosystem effects of this introduced species are unknown. Age 1+ blue catfish reside in mesohaline portions of the Rappahannock, York and James rivers (Figure 10). Diets of small blue catfish are dominated by invertebrates (mostly amphipods, isopods and mud crabs), while larger blue catfish diets include invertebrates, 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.

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 juveniles (≤ 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, and in the past two years, one juvenile channel catfish was captured each year by the VIMS trawl survey (Table 11, Figures 11 and 12). The age 1+ channel catfish RSI_{GM} has exhibited below-average values in the Rappahannock and James rivers since 1999 (Table 12; Figures 13 and 14).

Similarly, RSI_{GM}'s for juvenile white catfish indicate average or above-average recruitment prior to 1998 in all three rivers (Table 19; Figures 21 and 22) and failed recruitment in all three rivers thereafter with a few exceptions (2003 and 2009). Abundance indices for age 1+ white catfish exhibited below-average abundance since 2000 in all three rivers (Table 20; 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, but older juveniles can be found in the Bay during their second summer. Early juvenile scup (25-40 mm FL) occasionally appear in survey catches in June. Older scup first appear in catches in May, and 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 0 and age 2+ scup are highly variable and low, index calculations using trawl survey catches are based on age 1 individuals only. Age-1 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 increased in recent years, with the exception of 2007, and the 2009 index was the second highest value observed since 1989 (mean RSI_{GM} = 1.49; Table 15; Figure 10, top).

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 16; Figure 11, top). The time series average RSI_{GM} index for silver perch is 0.64 with the 2010 RSI_{GM} = 1.27.

Spot (*Leiostomus xanthurus*) – Spot indices are calculated using all strata from July to October. Spot is often one of the most abundant recreational species captured by the survey, however compared with catches in the late 1980s and early 1990s, numbers have remained below average for much of the time series (Table 15; Figure 17, top). The RSI_{GM} index in 2010, however was the highest value ever observed (RSI_{GM} = 74.97) for the time series and well above average (mean RSI_{GM} = 15.14). Spot are widely distributed throughout the Bay and tributaries (Figure 17, bottom).

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 greater abundance, but then diminish in abundance 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 1993 and 2000 year classes but recruitment has declined in recent years (Table 16; Figure 18, top). Index values for the past 10 years have been below the time-series average (mean RSI_{GM} = 0.84).

Summer flounder (*Paralichthys dentatus*) – Summer flounder spawn on the continental shelf from September through January with the peak occurring in October and November (Murdy et al., 1997). 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 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, but recruitment appears to be consistent since 1995 (Table 17; Figure 19, top). The 2010 index was below average (mean RSI_{GM} = 1.00). During index months, juvenile summer flounder were captured throughout the Bay and lower portions of the rivers (Figure 19, bottom), though summer flounder can 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 (RSI_{GM}) is consistent and indicates steady recruitment since 1988 (mean RSI_{GM} = 6.81; Table 18; Figure 20, top) with an increase in recruitment in 2010 (RSI_{GM} = 14.11).

White perch (*Morone americana*) – Spawning of white perch occurs in the upper tributaries 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 (Figure 26).

Juvenile (age 0) white perch recruitment has been stable in each of the rivers with high and low periods of recruitment (Table 21; Figure 25). The three rivers show different time series averages with most juvenile white perch occurring in the James River (mean RSI_{GM} = 3.06) followed by the Rappahannock River (mean RSI_{GM} = 0.75) and the York River (mean RSI_{GM} = 0.21). Recruitment was below average in the James and Rappahannock rivers in 2010 and above average in the York River.

Abundance of age 1+ white perch has been average in the Rappahannock River (mean RSI_{GM} = 1.23) for most of the time series except for 2010 (RSI_{GM} = 0.49; Table 22; Figure 27). In the York River, abundance of age 1+ white perch has been average (mean RSI_{GM} = 0.43) since 1991 and below-average values have been observed since 1997 (Table 22; Figure 27). Abundance of age 1+ white perch has been average in the James River (mean RSI_{GM} = 3.95) with notable peaks in 1988, 1989, and 1994 (Table 22; Figure 27). White perch are collected throughout the upper rivers (Figure 28).

Mobjack Bay

Routine sampling in Mobjack Bay continued in 2010-2011 (June to May) and a total of 167,368 fishes were collected in 204 tows (Appendix Table 2). Fifty-seven species were captured in Mobjack Bay with the same top two species by number (i.e., bay anchovy and spot) caught by the full trawl survey. Most species that were captured in Mobjack Bay were also captured in the regular sampling with the exception of sheepshead minnow which were found only in Mobjack Bay. One economically important species, spotted seatrout (n = 26), was captured in great numbers in Mobjack Bay compared with the trawl survey (n = 6).

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 more protective harvest regulations in Virginia. Other indices utilized by management agencies include those for Atlantic croaker, spot, and weakfish. Though the 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) and the U.S. Fish and Wildlife Service American Eel Status Review. 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 (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 recent 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. However, additional work needs to be conducted to address potential effects of depth on the distribution and catch of these species before refined indices can be recommended and adopted (Woodward, 2009).

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 affects management options. It may be difficult to observe the effects of regulations aimed at improving recruitment 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 (Connelly, 2001; this report). 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). The 2010 index for spot was the highest value observed since 1988. Atlantic croaker recruitment indices show the greatest 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. Weakfish indices have remained low since the mid-1990s with the exception of 2010, and the decline may be attributed to both habitat degradation (loss of seagrass beds in coastal areas) and overfishing. Declines in summer flounder abundance have been observed and may be due to overfishing or year-class failure (Terceiro, 2006). 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). After closure of the fishery in the mid- to late-1980s due to overfishing, poor recruitment, and low stock abundance (Richards and Rago, 1999), the striped bass recruitment index peaked in 1987. Finally, white catfish and channel catfish indices, while variable, have decreased over the past 19 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.

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TABLES

Table 1. Annual comparisons of substrate (habitat) type from June 1998 – May 2011.

Substrate Description	1998 - 1999 % of Stations	1998 - 1999 Max. Qty.	1999 - 2000 % of Stations	1999 - 2000 Max. Qty.	2000 - 2001 % of Stations	2000 - 2001 Max. Qty.	2001 - 2002 % of Stations	2001 - 2002 Max. Qty.	2002 - 2003 % of Stations	2002 - 2003 Max. Qty.	2003 - 2004 % of Stations	2003 - 2004 Max. Qty.	2004 - 2005 % of Stations	2004 - 2005 Max. Qty.	2005 - 2006 % of Stations	2005 - 2006 Max. Qty.	2006 - 2007 % of Stations	2006 - 2007 Max. Qty.	2007 - 2008 % of Stations	2007 - 2008 Max. Qty.	2008 - 2009 % of Stations	2008 - 2009 Max. Qty.	2009 - 2010 % of Stations	2009 - 2010 Max. Qty.	2010 - 2011 % of Stations	2010 - 2011 Max. Qty.
Artificial	0.68	2.0	3.90	3.0	4.83	2.0	5.68	15.0	5.72	4.0	7.03	7.0	3.27	2.0	1.98	2.0	2.34	3.0	4.17	16.0	4.41	12.0	2.53	12.0	2.29	8.0
Dead man's fingers	7.21	5.0	9.54	4.0	7.42	5.0	8.89	6.0	12.16	16.0	10.29	1.0	3.76	0.5	5.04	24.0	8.30	2.0	9.97	3.0	21.40	23.0	23.28	24.0	18.63	6.0
Detritus	27.55	6.0	40.53	10.0	37.03	4.0	36.91	6.0	50.09	7.0	61.36	10.0	65.69	8.0	54.91	2.0	59.34	19.0	59.80	10.0	50.93	3.0	49.75	5.0	46.90	5.0
Hydroids	38.59	5.0	54.19	4.0	43.20	5.0	57.01	10.5	49.36	5.0	59.15	12.0	72.63	5.0	61.77	4.0	59.09	5.0	60.29	5.0	62.21	6.0	57.68	5.0	56.70	8.0
Sea Squirts (*Molgula* spp.)	20.35	5.0	29.55	12.0	22.54	14.0	27.86	18.0	15.34	5.0	21.08	9.0	25.57	8.0	19.98	14.0	34.03	7.0	30.88	12.0	29.22	24.0	27.45	4.0	24.59	18.0
Seaweeds	14.79	4.0	23.84	10.0	25.67	5.0	29.86	30.0	34.30	18.0	41.75	3.0	33.74	4.0	22.79	2.0	24.73	8.0	23.20	1.0	18.10	5.0	27.45	4.0	25.08	3.0
Shell (oyster, clam, or	18.84	3.0	26.73	4.0	22.00	5.0	29.06	8.0	32.12	4.0	25.98	3.0	21.08	4.0	23.12	12.0	21.29	2.0	21.98	8.0	21.60	4.0	20.02	3.0	18.63	10.0
Sponges	7.96	6.0	9.47	5.0	9.84	5.0	12.33	10.0	14.34	18.0	11.03	3.0	9.48	4.0	7.10	4.0	8.21	4.0	11.11	17.0	14.54	25.0	14.46	5.0	18.22	28.0
Submerged Aquatic	4.35	3.0	8.60	1.0	10.47	2.0	5.04	2.0	6.08	1.0	3.02	0.5	6.70	2.0	2.97	0.5	4.53	1.0	5.15	0.1	4.86	0.5	7.11	1.0	4.00	0.5
Worm Tubes	5.33	1.0	9.54	1.0	10.47	1.0	9.29	1.0	12.34	1.0	14.05	2.0	10.87	1.0	5.45	1.0	8.05	1.0	11.11	0.5	10.83	4.0	8.82	3.0	7.11	4.0
Mud [2]	7.36	---	6.50	---	7.60	---	6.73	---	10.89	---	8.99	---	14.30	---	14.37	---	6.62	---	6.86	---	7.22	---	5.23	---	8.33	---
Sand [2]	10.21	---	0.87	---	1.43	---	1.04	---	0.36	---	0.49	---	0.57	---	0.08	---	1.00	---	8.33	---	5.96	---	3.59	---	2.94	---
Unknown [3]	13.66	---	5.42	---	4.83	---	2.80	---	2.72	---	1.06	---	0.74	---	4.38	---	6.71	---	3.51	---	1.85	---	3.76	---	2.12	---
NUMBER OF TRAWLS:	1,332		1,384		1,118		1,249		1,102		1,224		1,224		1,211		1,193		1,224		1,224		1,224		1,224	

1. Percent (%) of Stations based on the number of occurrences of a habitat type divided by the total
2. Sand and Mud are used when verification can be confirmed by direct observation.
3. Unknown is used when none of the categories are found in the trawl.

Abundance is estimated relative to the capacity of a commercial tote (internal dimensions 25.7" x 16.6" x 10", approximately 72 liters).
Categories include: 0.5 = < 1/4 bin, 1 = 1/4 bin, 2 = 1/2 bin, 3 =3/4 bin, 4 = full bin, etc.

Table 2. Spatial, temporal, and length (mm) criteria used to calculate recruitment indices.

	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										86-300	86-300	86-300	96-300	36-300	66-300	74-300	81-300	86-300	85-300	86-300	86-300

Table 3. Sample collection history of the VIMS Trawl Survey, 1988 – May 2011. 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	*	1224	0	0	0	1224	300	924	1224	0	0
2011	453	66	105	66	105	111								123	110	0	110	110	*	453	0	0	0	504	125	328	453	0	0
TOT	26,074	1,458	2,090	1,502	2,165	2,469	2,377	2,371	2,299	2,422	2,422	2,343	2,156	9,771	4,813	52	5,067	5,936	435	23,692	2,277	105	2,556	23,569	7,511	18,563	26,027	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, 10-11; Pocomoke Sound (CP) -1973-81, 98-01; Great Wicomico R. (GW) - 1998-00. * Current Mobjack Bay sampling consists of 17 stations each month.

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 4. VIMS trawl survey pooled catch for June 2010 to May 2011 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	423,101	996	54.64	345.67	.	378,624	54	0.07	17	96
spot	130,775	790	16.89	106.84	53.25	114,881	113	0.13	21	229
hogchoker	105,651	753	13.64	86.32	.	36,194	84	0.17	21	196
Atlantic croaker	30,056	686	3.88	24.56	12.24	18,204	138	0.51	14	377
weakfish	22,636	616	2.92	18.49	9.22	20,066	106	0.38	19	376
white perch	17,994	275	2.32	14.7	7.33	7,987	114	0.56	23	286
spotted hake	7,279	285	0.94	5.95	2.96	7,260	122	0.47	38	267
blue catfish	5,771	190	0.75	4.71	2.35	1,791	252	1.17	31	602
silver perch	3,689	364	0.48	3.01	1.5	3,005	127	0.49	22	200
scup	2,953	108	0.38	2.41	1.2	2,918	98	0.47	42	179
northern searobin	2,505	218	0.32	2.05	1.02	2,416	83	0.57	28	186
blackcheek tonguefish	2,180	335	0.28	1.78	0.89	603	121	0.86	35	184
southern kingfish	2,088	280	0.27	1.71	0.85	1,676	129	1.18	27	338
alewife	1,984	118	0.26	1.62	0.81	1,982	96	0.67	34	272
blueback herring	1,882	135	0.24	1.54	0.77	1,766	69	0.54	31	223
Atlantic menhaden	1,581	236	0.2	1.29	0.64	1,311	105	1.42	27	294
striped anchovy	1,269	121	0.16	1.04	0.52	1,223	88	0.54	34	126
Atlantic silverside	1,266	134	0.16	1.03	0.52	1,266	83	0.39	46	117
kingfish spp	1,150	188	0.15	0.94	0.47	1,082	85	1.47	17	285
summer flounder	854	361	0.11	0.7	0.35	551	244	3.18	57	600
striped bass	777	143	0.1	0.63	0.32	671	108	3.55	15	625
harvestfish	701	135	0.09	0.57	0.29	677	66	1.17	16	169
smallmouth flounder	697	134	0.09	0.57	0.28	686	81	0.66	38	138
oyster toadfish	655	190	0.08	0.54	0.27	.	178	2.87	26	400
butterfish	590	114	0.08	0.48	0.24	343	96	1.62	19	207
gizzard shad	554	109	0.07	0.45	0.23	209	227	3.7	80	396
American shad	300	68	0.04	0.25	0.12	300	104	0.88	54	147
windowpane	299	95	0.04	0.24	0.12	286	120	2.01	44	240
black seabass	253	92	0.03	0.21	0.1	224	94	2.29	36	242
white catfish	217	88	0.03	0.18	0.09	9	237	5.66	76	434
Atlantic spadefish	211	74	0.03	0.17	0.09	.	87	2.29	22	199
northern pipefish	209	133	0.03	0.17	0.09	.	146	2.5	54	238
northern puffer	174	95	0.02	0.14	0.07	145	100	2.93	12	213
American eel	174	89	0.02	0.14	0.07	.	311	8.44	156	850
seaboard goby	160	70	0.02	0.13	0.07	.	39	0.58	23	60
red hake	147	16	0.02	0.12	0.06	.	159	2.35	85	227
banded drum	130	47	0.02	0.11	0.05	.	54	2.38	25	222
naked goby	120	53	0.02	0.1	0.05	.	41	0.8	21	59
clearnose skate	118	58	0.02	0.1	0.05	.	437	3.24	326	524
Atlantic thread herring	109	21	0.01	0.09	0.04	.	60	3.56	32	186
hickory shad	104	37	0.01	0.08	0.04	.	85	2.27	37	159
striped searobin	88	62	0.01	0.07	0.04	.	74	4.09	29	201
silver hake	88	10	0.01	0.07	0.04	.	131	2.27	65	179
threadfin shad	59	10	0.01	0.05	0.02	.	106	1.72	87	145
Atlantic moonfish	54	18	0.01	0.04	0.02	.	66	1.85	39	96
skilletfish	51	44	0.01	0.04	0.02	.	46	1.68	15	73
feather blenny	50	21	0.01	0.04	0.02	.	64	2.48	21	98
Atlantic herring	49	17	0.01	0.04	0.02	.	145	11.12	48	268
lined seahorse	38	25	0	0.03	0.02	.	82	3.65	36	137
inshore lizardfish	33	21	0	0.03	0.01	13	204	12.45	59	318
bluefish	31	21	0	0.03	0.01	.	184	7.56	124	275
Atlantic cutlassfish	29	16	0	0.02	0.01	.	480	32.5	82	695
striped mullet	29	8	0	0.02	0.01	.	181	5.83	121	242
sea lamprey	27	12	0	0.02	0.01	.	160	2.3	141	190
striped cusk-eel	27	6	0	0.02	0.01	.	164	3.76	123	222
spottail shiner	27	2	0	0.02	0.01	.	73	0.9	63	85
bluntnose stingray	25	17	0	0.02	0.01	.	422	29.71	191	795
spiny butterfly ray	25	13	0	0.02	0.01	.	544	19.46	429	940

Table 4 (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)
channel catfish	22	11	0	0.02	0.01	1	347	14.83	119	521
northern kingfish	20	10	0	0.02	0.01	9	153	12.07	73	269
green goby	18	12	0	0.01	0.01	.	45	1.58	31	53
Atlantic stingray	15	15	0	0.01	0.01	.	352	27.2	202	522
longnose gar	12	7	0	0.01	0	.	857	44.52	720	1210
eastern silvery minnow	11	3	0	0.01	0	.	95	2.86	79	112
pigfish	9	8	0	0.01	0	.	156	5.44	140	188
smooth butterfly ray	9	7	0	0.01	0	.	479	57.82	321	851
black drum	9	6	0	0.01	0	.	199	8.55	156	245
northern stargazer	8	7	0	0.01	0	.	82	25.77	15	200
spotted seatrout	6	6	0	0	0	.	217	21.54	123	263
smooth dogfish	6	5	0	0	0	.	524	60.36	364	718
spiny dogfish	6	5	0	0	0	.	771	10.44	745	805
rough scad	6	4	0	0	0	.	92	9.45	45	105
conger eel	5	5	0	0	0	.	429	90.54	188	740
striped burrfish	5	5	0	0	0	.	183	15.32	126	211
tautog	5	4	0	0	0	.	234	40.51	112	360
brown bullhead	5	4	0	0	0	.	178	28.81	112	286
silver seatrout	5	4	0	0	0	.	162	14.03	130	203
Spanish mackerel	4	3	0	0	0	.	176	65.42	79	369
cobia	3	3	0	0	0	.	356	238.07	108	832
common carp	3	3	0	0	0	.	541	34.9	475	594
sheepshead	3	3	0	0	0	.	405	117.93	170	540
tessellated darter	3	3	0	0	0	.	63	8.5	54	80
bullnose ray	3	3	0	0	0	.	373	94.17	277	561
yellow perch	3	2	0	0	0	.	109	3.21	104	115
inland silverside	3	2	0	0	0	.	56	7.51	43	69
red drum	2	2	0	0	0	.	56	17.5	38	73
mummichog	2	2	0	0	0	.	77	27	50	104
striped blenny	2	2	0	0	0	.	74	2	72	76
Atlantic angel shark	2	2	0	0	0	.	845	269.5	575	1114
crevalle jack	2	2	0	0	0	.	103	2	101	105
pumpkinseed	2	1	0	0	0	.	87	1	86	88
rough silverside	2	1	0	0	0	.	95	2	93	97
round herring	1	1	0	0	0	.	75	.	75	75
bluespotted cornetfish	1	1	0	0	0	.	139	.	139	139
banded killifish	1	1	0	0	0	.	45	.	45	45
striped killifish	1	1	0	0	0	.	118	.	118	118
threespine stickleback	1	1	0	0	0	.	57	.	57	57
bluegill	1	1	0	0	0	.	63	.	63	63
sandbar shark	1	1	0	0	0	.	510	.	510	510
roughtail stingray	1	1	0	0	0	.	630	.	630	630
spotfin butterflyfish	1	1	0	0	0	.	73	.	73	73
goosefish	1	1	0	0	0	.	118	.	118	118
All Species Combined	774,324									

Table 5. American eel indices (RSI_{Delta}, 1988–2010).

	Rappahannock			York			James		
Year	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
Average	2.42			0.67			2.25		

Table 6. Spring Atlantic croaker indices (RSI_{GM}; 1988–2010).

	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	0.36	0.21 - 0.44	16.05	234	0.38	234	2.22	84
1989	0.65	0.38 - 0.85	15.63	252	0.78	252	4.63	84
1990	0.48	0.23 - 0.67	20.56	252	0.52	252	2.98	85
1991	4.12	2.83 - 5.84	8.87	307	4.35	238	12.87	83
1992	1.17	0.77 - 1.67	13.17	309	1.34	240	10.26	84
1993	1.98	1.33 - 2.80	11.20	301	2.21	240	19.40	84
1994	0.86	0.56 - 1.22	14.33	300	0.95	240	2.98	84
1995	0.95	0.67 - 1.28	11.55	306	0.93	246	5.55	90
1996	0.19	0.11 - 0.28	19.63	405	0.16	242	0.36	88
1997	1.47	1.15 - 1.85	7.78	419	0.87	255	7.78	100
1998	1.19	0.95 - 1.47	7.51	374	0.48	214	6.21	96
1999	1.50	1.05 - 2.05	10.83	397	1.28	232	4.08	100
2000	0.60	0.42 - 0.80	12.68	413	0.44	245	1.39	97
2001	0.37	0.25 - 0.49	14.38	420	0.32	256	1.18	100
2002	1.59	1.07 - 2.22	11.59	361	1.11	197	4.80	100
2003	0.49	0.28 - 0.74	19.19	405	0.52	241	0.28	100
2004	0.96	0.73 - 1.22	9.34	420	0.7	255	4.42	99
2005	0.47	0.35 - 0.59	10.46	420	0.31	256	1.85	100
2006	1.27	1.00 - 1.59	7.90	420	0.77	256	3.92	100
2007	1.04	0.76 - 1.37	10.34	420	0.76	256	3.05	100
2008	4.10	3.04 - 5.45	7.16	420	2.84	256	18.62	100
2009	1.82	1.41 - 2.30	7.65	420	1.48	256	10.06	100
2010	2.12	1.52 - 2.86	9.34	420	1.83	256	3.44	100
Average	1.29							

Table 7. Bay anchovy indices (RSI_{GM}; 1988–2010).

	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	2.17 - 27.15	6.42	346	18.06	346	32.66	128
1989	52.47	6.27 - 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	5.05 - 33.43	6.04	491	22.83	350	33.41	125
1992	40.14	7.17 - 59.09	5.10	448	40.79	355	14.53	128
1993	43.31	8.80 - 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	2.84 - 26.07	5.66	540	18.52	362	18.57	138
1996	15.31	1.20 - 20.82	5.21	607	16.91	363	5.11	135
1997	18.96	3.63 - 26.23	5.19	625	17.33	378	12.64	150
1998	30.26	0.75 - 43.93	5.27	579	30.47	336	9.70	146
1999	15.47	1.20 - 21.22	5.35	606	14.38	360	21.26	150
2000	36.58	6.69 - 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	3.17 - 24.56	5.01	624	20.65	378	3.41	150
2004	23.06	6.71 - 31.70	4.82	624	21.45	377	7.02	149
2005	22.27	6.01 - 30.85	4.98	613	21.26	367	8.43	150
2006	19.31	4.00 - 26.50	5.03	592	16.99	360	10.59	142
2007	23.76	7.33 - 32.44	4.69	624	21.15	378	10.27	150
2008	50.29	6.21 - 69.68	4.07	624	43.11	378	49.06	150
2009	30.12	2.30 - 40.55	4.21	624	25.64	378	25.09	150
2010	84.92	.27 - 117.54	3.61	624	79.68	378	41.60	150
Average	26.95							

Table 8. Black sea bass indices (RSI_{GM}; 1988–2009).

	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	0.84	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
Average	0.70							

Table 9. Blue catfish juvenile indices (RSI_{Delta}; 1989–2010).

	Rappahannock			York			James		
YearClass	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
Average	0.15			0.16			4.03		

Table 10. Blue catfish age 1+ indices (RSI$_{Delta}$; 1990–2011).

	Rappahannock			York			James		
Year	Index	Prop. pos.	N	Index	Prop. pos.	N	Index	Prop. pos.	N
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
Average	11.09			0.51			15.51		

Table 11. Channel catfish juvenile indices (RSI_{GM}, 1988–2010).

	Rappahannock				York				James			
Year	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 - 0.11	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 - 0.11	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	79.70	0.00 - 0.03	0.20	28	36.13	0.05 - 0.38
1996	0.01	40	78.78	0.00 - 0.02	0.01	40	59.70	0.00 - 0.02	0.12	40	48.23	0.00 - 0.24
1997	0.00	40		0	0.00	40	100.00	0.00 - 0.11	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 - 0.11	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 - 0.11	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	30	100.00	0.00 - 0.01	0.00	30		0	0.00	30		0
Average	0.00				0.01				0.12			

Table 12. Channel catfish age 1+ indices (RSI_{GM}; 1988–2010).

	Rappahannock				York				James			
Year	RSI	N	CV	95% C.I.	RSI	N	CV	95% C.I.	RSI	N	CV	95% C.I.
1988	0.08	16	35.63	0.02 - 0.14	0.00	20		0	1.22	16	9.35	0.91 - 1.58
1989	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
1990	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
1991	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
1992	0.72	16	4.41	0.64 - 0.80	0.00	20		0	0.81	16	19.59	0.44 - 1.29
1993	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
1994	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
1995	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
1996	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
1997	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
1998	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
1999	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
2000	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
2001	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
2002	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
2003	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
2004	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
2005	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
2006	0.04	40	51.20	0.00 - 0.07	0.00	40		0	0.17	40	29.20	0.07 - 0.28
2007	0.00	40		0	0.00	40		0	0.06	40	32.35	0.02 - 0.11
2008	0.00	40	100.00	0	0.00	40	100.00	0.00 - 0.01	0.05	40	35.13	0.02 - 0.09
2009	0.00	40		0	0.00	40		0	0.06	40	57.37	0.00 - 0.13
2010	0.01	30	100.00	0.00 - 0.02	0.00	30	100.00	0.00 - 0.01	0.02	30	47.98	0.00 - 0.04
Average	0.16				0.01				0.50			

Table 13. Scup indices (RSI_{GM}; 1988–2009).

	Random Stratified Index (RSI)			
Year	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
Average	1.49			

Table 14. Silver perch indices (RSI_{GM}; 1988–2010).

	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	0.4	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
Average	0.64							

Table 15. Spot indices (RSI_{GM}; 1988–2010).

	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	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
Average	15.14							

Table 16. Striped bass indices (RSI_{GM}; 1988–2010).

	Random Stratified Index (RSI)				Original Index	
Year	Geo. Mean	95% C.I.'s	C.V.	N	River Only (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	0.26	39
Average	0.84					

Table 17. Summer flounder indices (RSI_{GM}; 1988–2010).

	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
Average	1.00							

Table 18. Weakfish indices (RSI_{GM}; 1988–2010).

	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	6.3	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	5.3	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
Average	6.81							

Table 19. White catfish juvenile indices (RSI_{GM}, 1988–2010).

	Rappahannock				York				James			
Year	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	30		0	0.00	30		0	0.00	30	100.00	0.00 - 0.01
Average	0.01				0.06				0.27			

Table 20. White catfish age 1+ indices (RSI_{GM}, 1988–2010).

Year	Rappahannock				York				James			
	RSI	N	CV	95% C.I.	RSI	N	CV	95% C.I.	RSI	N	CV	95% C.I.
1988	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
1989	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
1990	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
1991	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
1992	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
1993	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
1994	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
1995	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
1996	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
1997	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
1998	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
1999	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
2000	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
2001	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
2002	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
2003	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
2004	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
2005	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
2006	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
2007	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
2008	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
2009	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
2010	0.01	30	46.32	0.00 - 0.02	0.02	30	46.13	0.00 - 0.04	0.09	30	48.16	0.00 - 0.18
Average	0.17				0.12				0.61			

Table 21. White perch juvenile indices (RSI_{GM}, 1988–2010).

	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
Average	0.75				0.21				3.06			

Table 22. White perch age 1+ indices (RSI_{GM}, 1988–2010).

	Rappahannock				York				James			
Year	RSI	N	CV	95% C.I.	RSI	N	CV	95% C.I.	RSI	N	CV	95% C.I.
1988	0.67	11	19.81	0.36 - 1.04	0.63	12	10.08	0.48 - 0.80	15.88	12	7.72	9.91 - 25.13
1989	0.95	12	15.77	0.58 - 1.41	0.76	15	6.09	0.64 - 0.88	7.34	10	3.35	6.23 - 8.61
1990	3.94	12	8.62	2.75 - 5.51	0.97	14	11.40	0.68 - 1.29	3.22	10	13.25	1.88 - 5.18
1991	2.51	11	10.20	1.72 - 3.53	0.55	15	14.40	0.37 - 0.76	5.87	10	6.66	4.31 - 7.88
1992	1.13	12	20.93	0.55 - 1.92	0.39	15	16.81	0.24 - 0.55	4.51	12	7.42	3.28 - 6.09
1993	0.91	14	46.93	0.04 - 2.52	0.51	15	9.19	0.40 - 0.63	3.15	12	11.21	2.01 - 4.70
1994	0.87	12	12.34	0.60 - 1.18	0.60	15	10.62	0.45 - 0.77	8.80	12	9.61	5.32 - 14.19
1995	1.91	24	30.14	0.53 - 4.55	0.49	25	12.68	0.35 - 0.65	2.68	12	10.61	1.79 - 3.85
1996	0.93	30	31.02	0.28 - 1.90	0.47	30	7.50	0.39 - 0.56	1.83	30	15.41	1.06 - 2.91
1997	1.99	30	22.91	0.81 - 3.94	0.46	30	5.71	0.40 - 0.53	3.58	30	17.40	1.70 - 6.78
1998	1.03	30	15.79	0.62 - 1.53	0.41	30	9.94	0.32 - 0.52	4.09	30	16.09	2.01 - 7.58
1999	1.01	30	18.22	0.56 - 1.60	0.31	30	8.76	0.25 - 0.38	2.55	24	23.41	0.96 - 5.44
2000	0.99	30	28.13	0.35 - 1.94	0.30	30	14.85	0.20 - 0.40	2.91	30	25.31	0.96 - 6.81
2001	0.60	30	21.89	0.30 - 0.97	0.37	30	13.20	0.26 - 0.49	1.35	30	29.64	0.42 - 2.90
2002	0.08	30	41.44	0.01 - 0.15	0.37	30	10.37	0.28 - 0.46	4.19	30	8.89	2.87 - 5.95
2003	1.89	30	27.51	0.61 - 4.18	0.38	30	11.34	0.28 - 0.48	3.37	30	15.75	1.75 - 5.96
2004	1.61	30	16.23	0.91 - 2.56	0.25	30	17.47	0.16 - 0.35	1.66	30	26.45	0.58 - 3.45
2005	1.00	30	20.22	0.51 - 1.64	0.34	30	9.86	0.26 - 0.42	2.66	30	11.14	1.74 - 3.88
2006	0.57	30	21.15	0.30 - 0.91	0.35	30	8.37	0.28 - 0.42	2.61	30	12.36	1.63 - 3.96
2007	1.42	30	24.06	0.58 - 2.70	0.27	30	9.03	0.22 - 0.33	1.88	30	16.24	1.04 - 3.06
2008	0.90	30	18.93	0.49 - 1.43	0.30	30	13.01	0.21 - 0.39	1.87	30	32.09	0.46 - 4.64
2009	0.99	30	22.60	0.46 - 1.72	0.30	30	13.47	0.21 - 0.39	2.74	30	15.70	1.47 - 4.66
2010	0.49	30	19.51	0.28 - 0.74	0.21	30	11.97	0.15 - 0.26	2.22	30	17.67	1.13 - 3.86
Average	1.23				0.43				3.95			

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

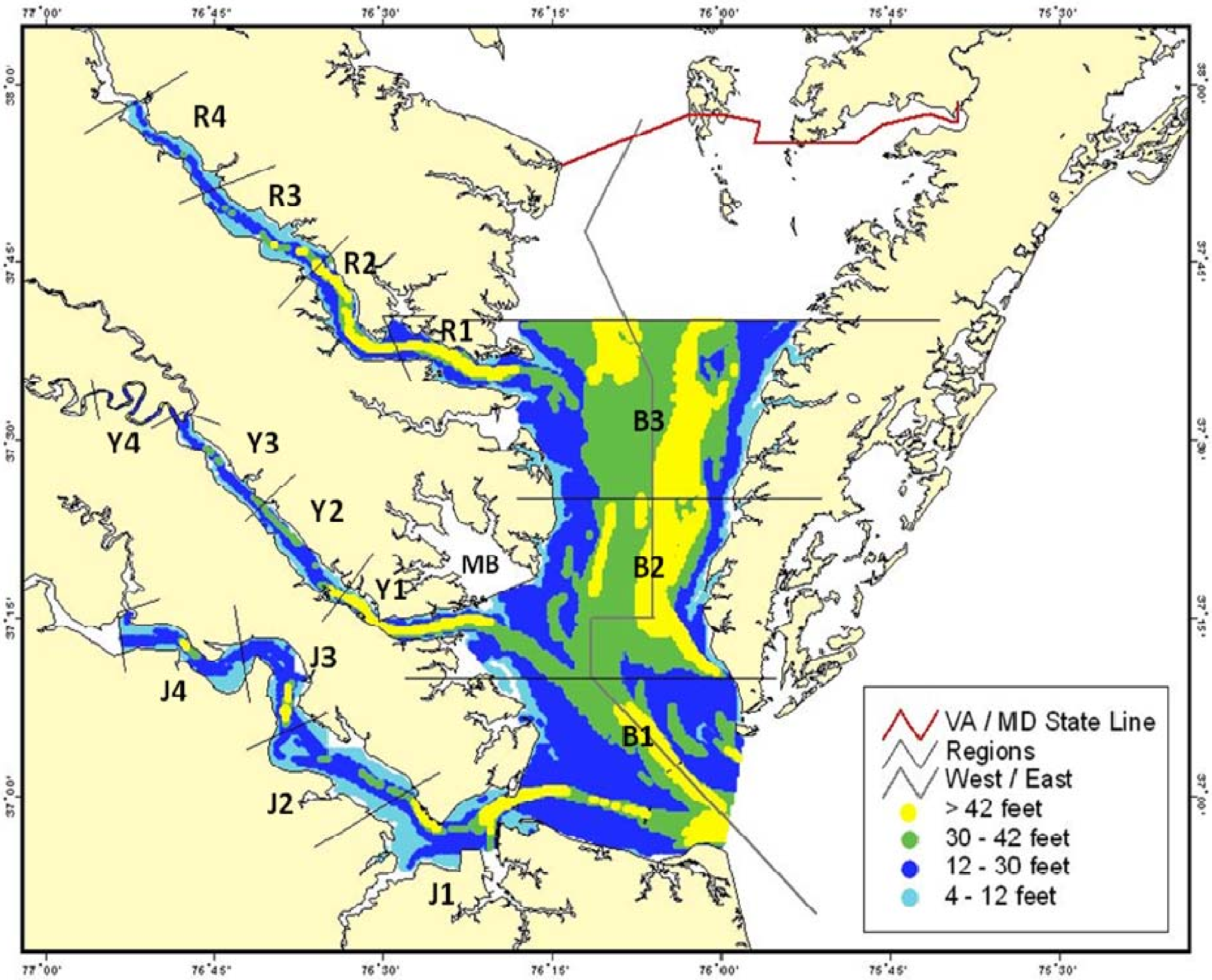


Figure 1 (continued)

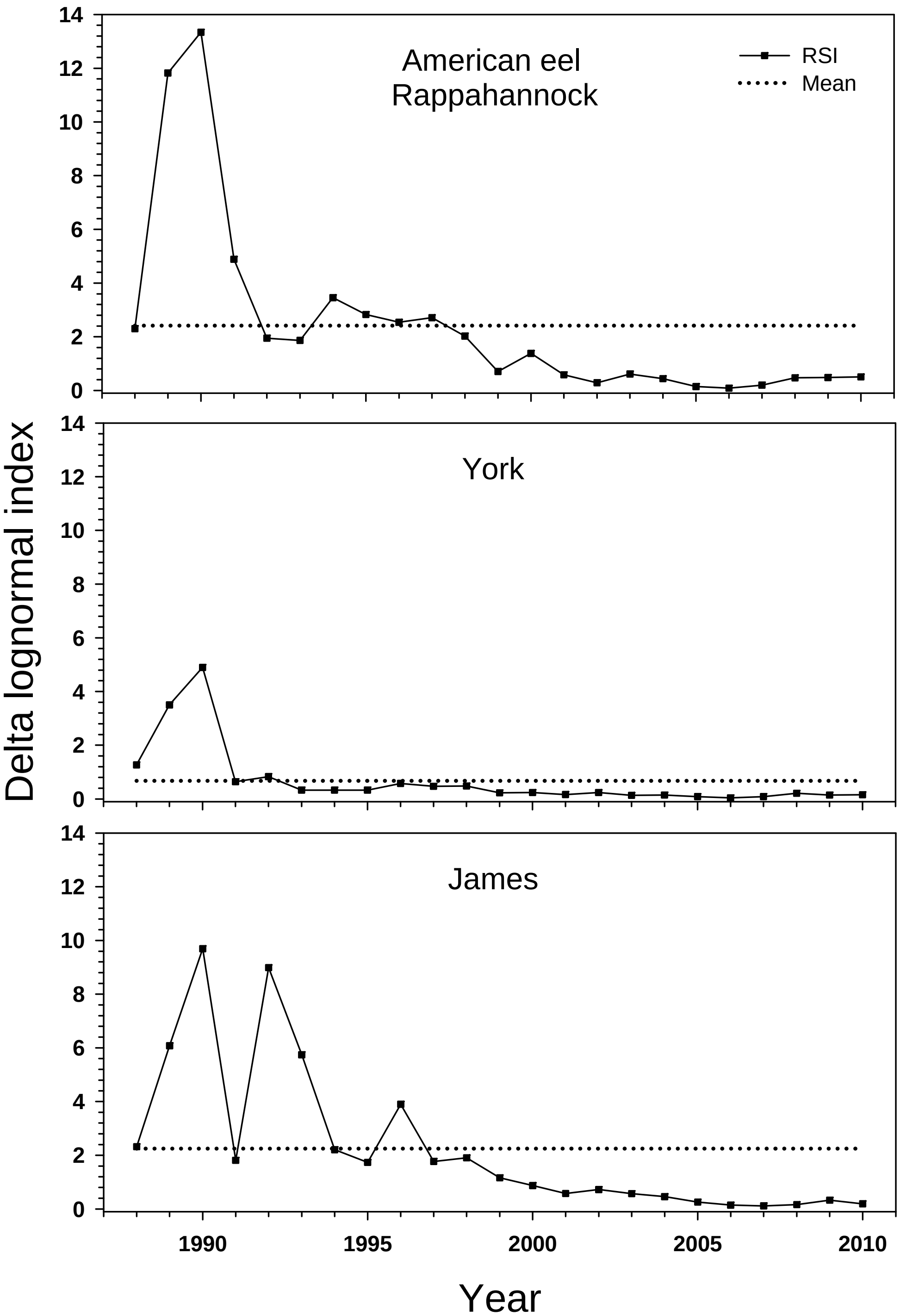


Figure 2. American eel random stratified index (RSI_{Delta}) and time series averages (dotted line) based on the RSI_{Delta}'s from the Rappahannock, York, and James rivers.

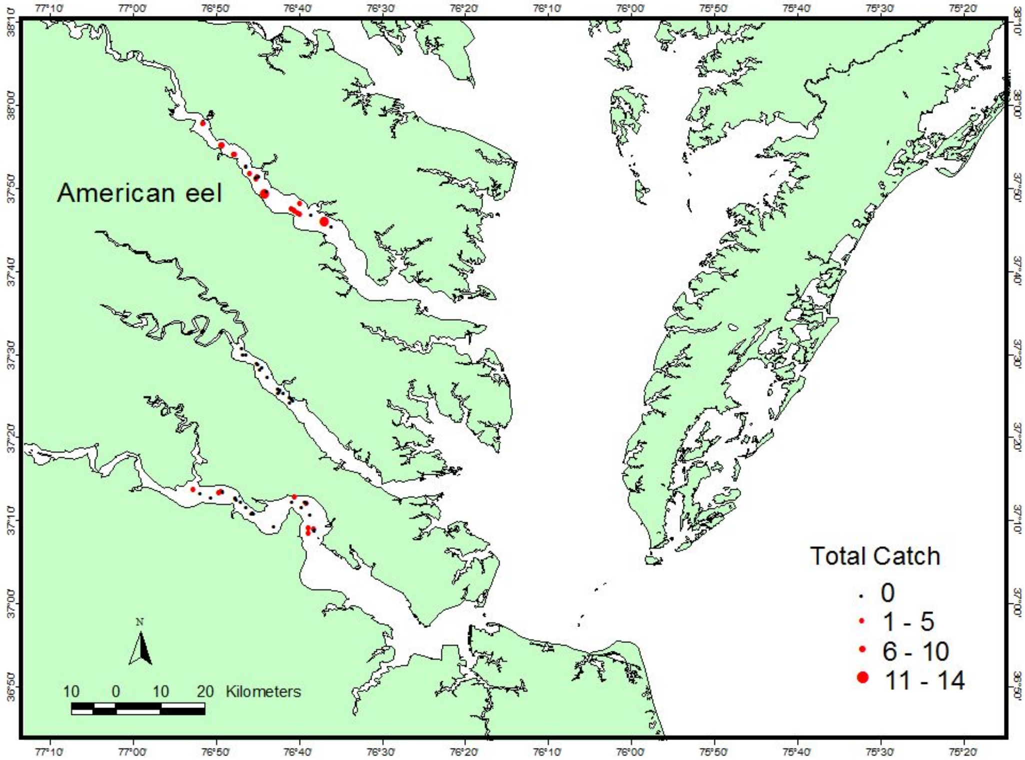
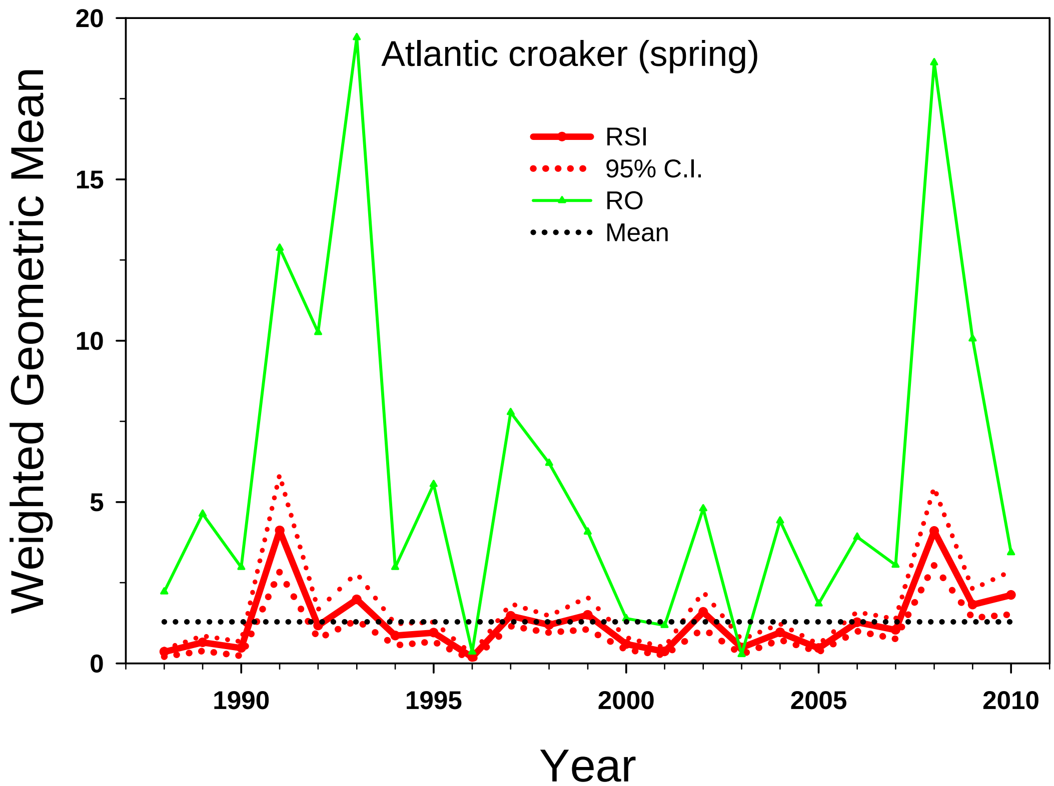


Figure 3. Distribution of index-sized American eel from index strata and months.



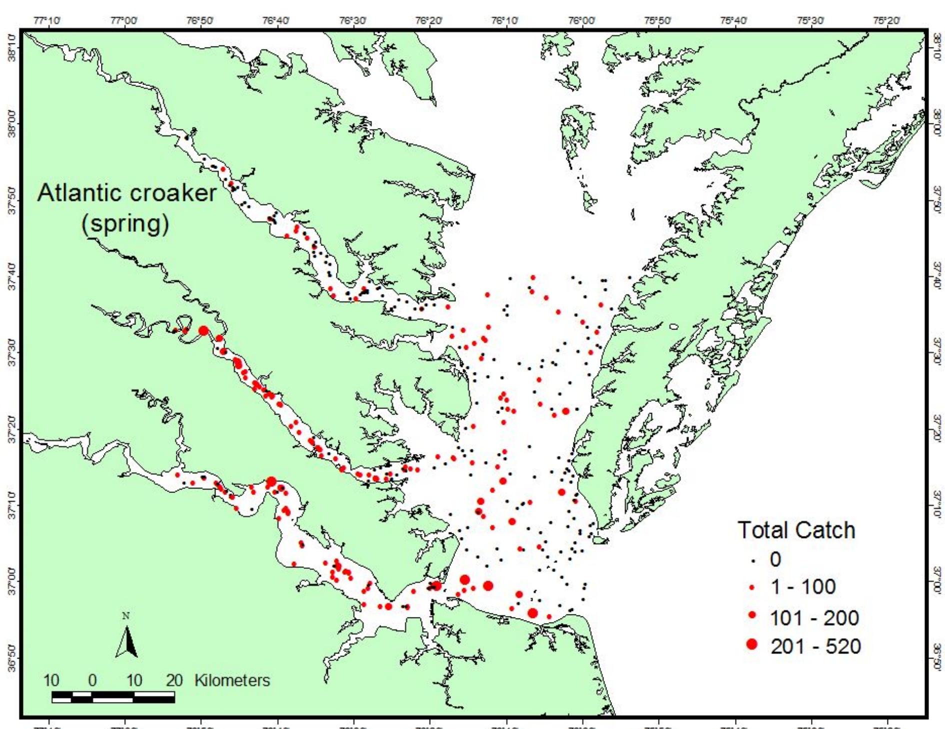


Figure 4. Spring juvenile Atlantic croaker random stratified (RSI_{GM}, 95% C.I.), fixed transect (Rivers only - RO) indices, the time series average based on the RSI_{GM} (dotted line, Top), and distribution of index-sized juvenile Atlantic croaker from index strata and months (Bottom).

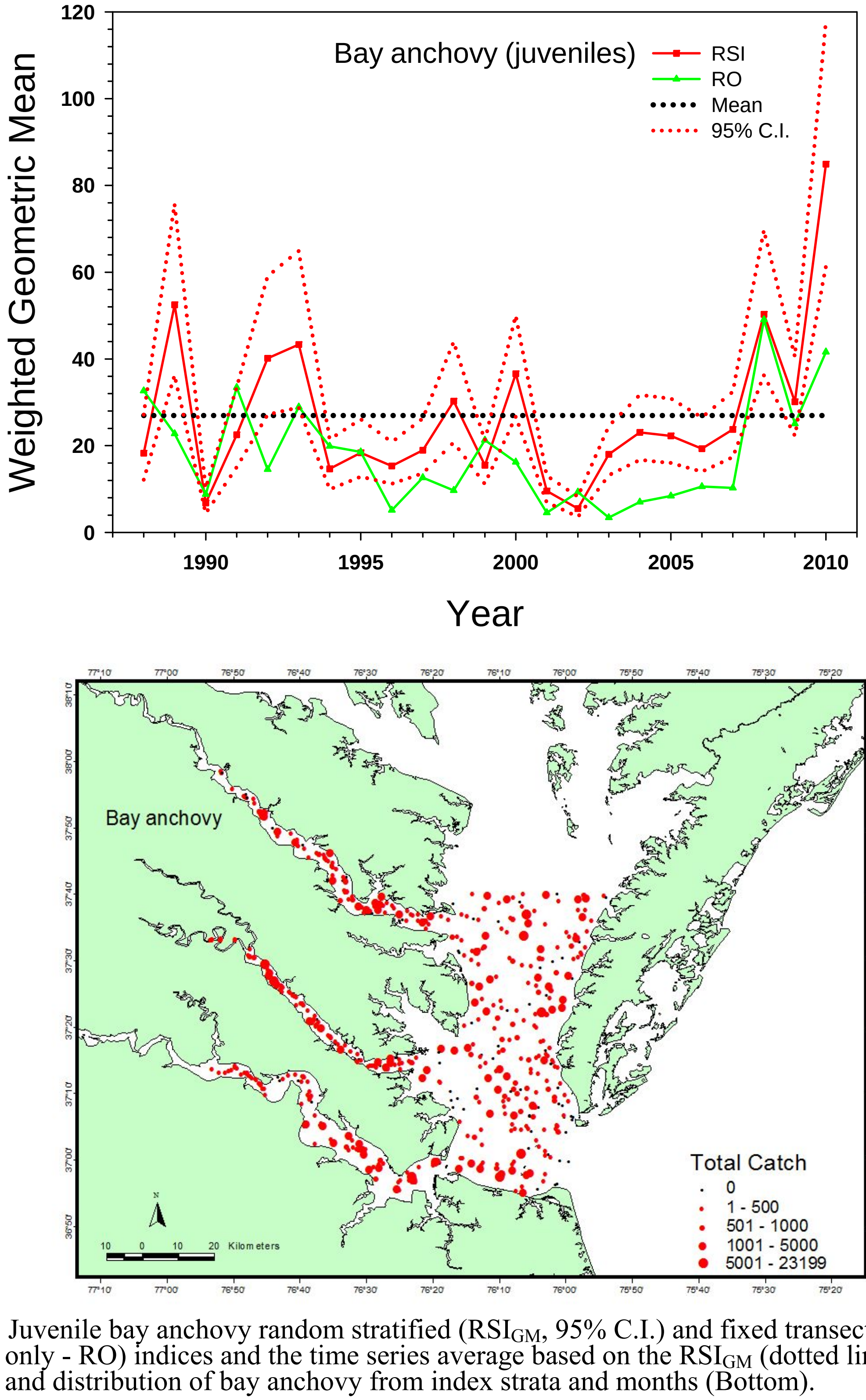
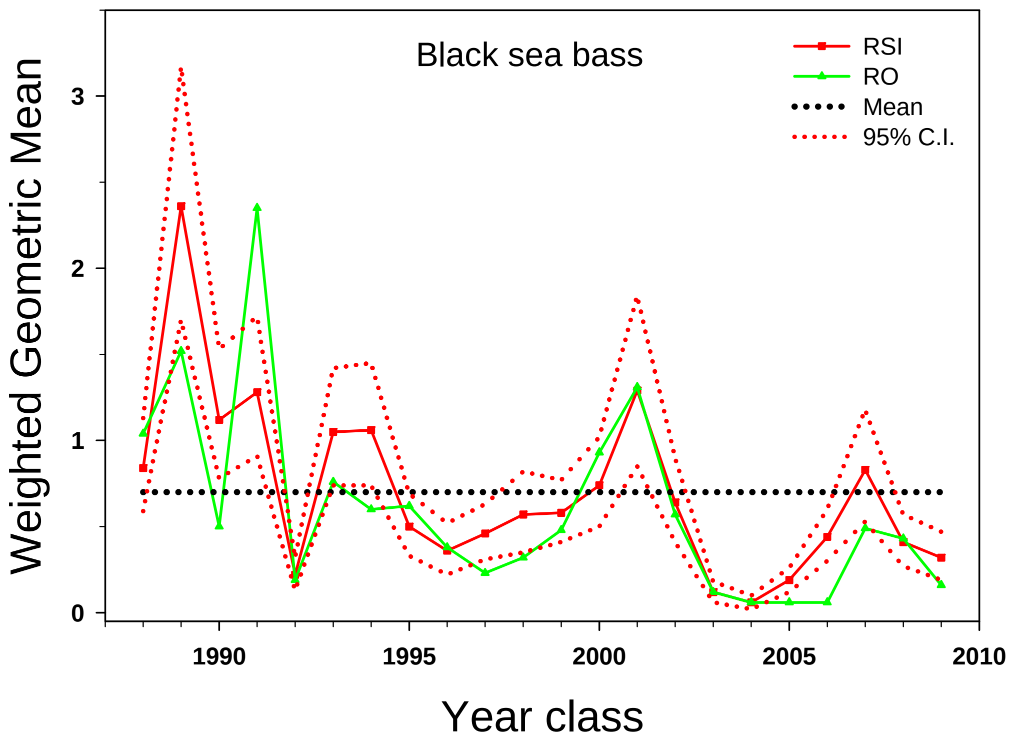


Figure 5. Juvenile bay anchovy random stratified (RSI_{GM}, 95% C.I.) and fixed transect (Rivers only - RO) indices and the time series average based on the RSI_{GM} (dotted line, Top), and distribution of bay anchovy from index strata and months (Bottom).



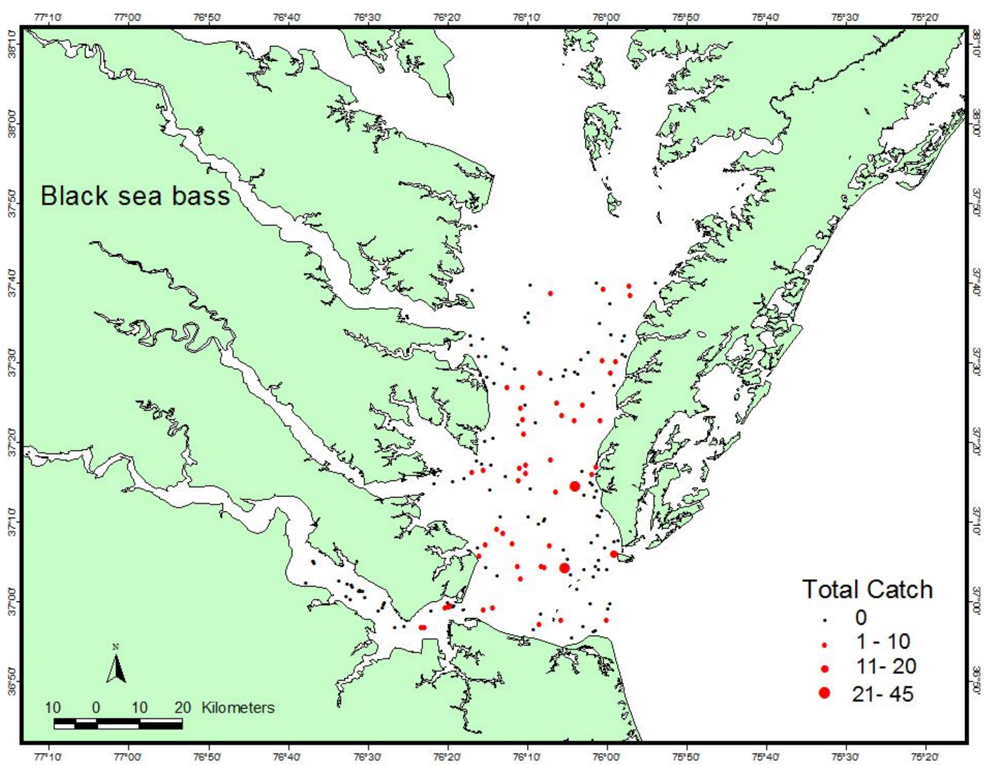


Figure 6. Black sea bass random stratified index (RSI_{GM}, 95% C.I.) and fixed transect (Rivers only - RO) the time series average based on the RSI_{GM} (dotted line, Top), and distribution of juvenile black sea bass from index strata and months (Bottom).

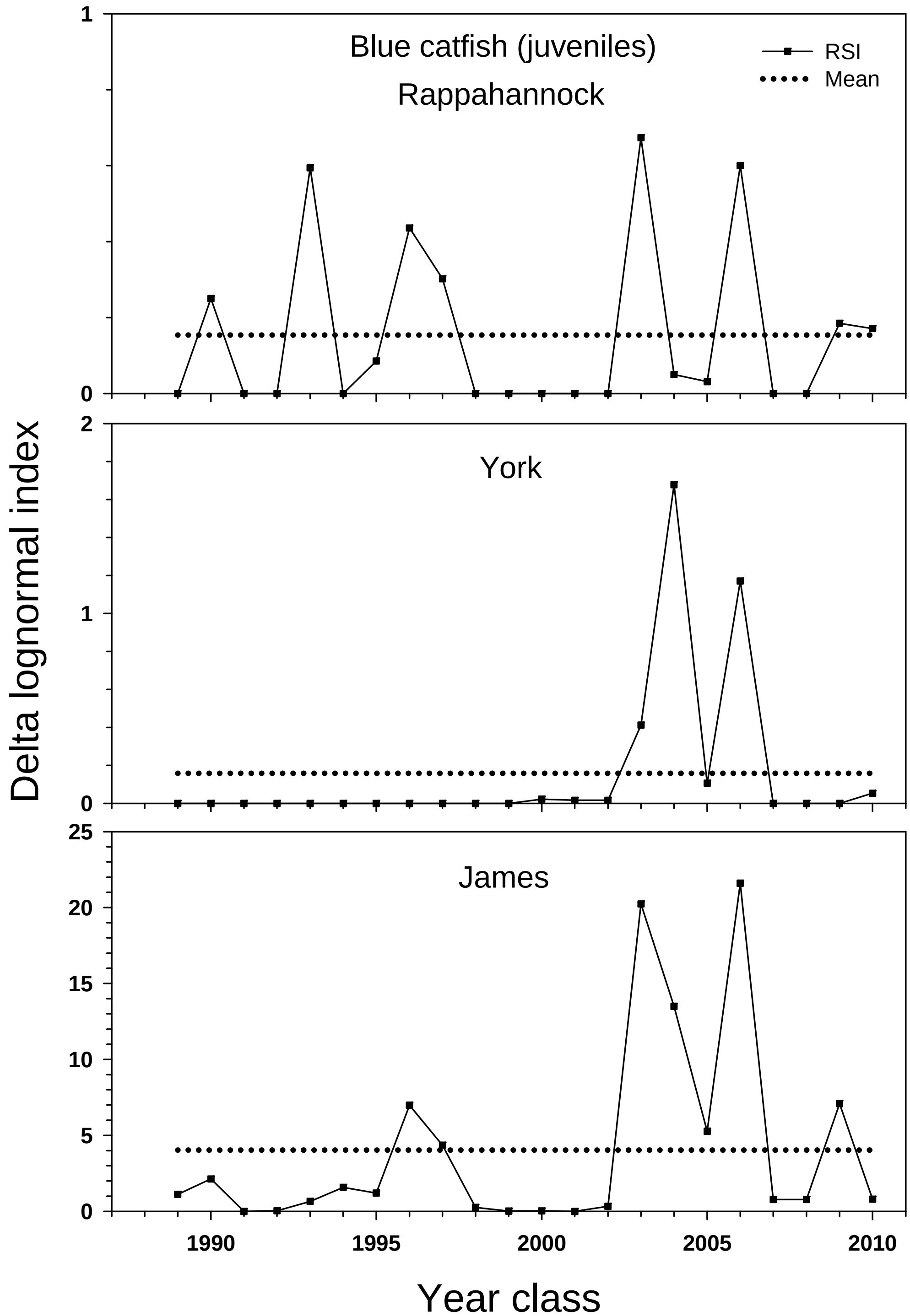


Figure 7. Juvenile blue catfish random stratified index (RSI_{Delta}) and time series averages (dotted line) based on the RSI_{Delta}'s from the Rappahannock, York, and James rivers. Note change in scale on y-axes.

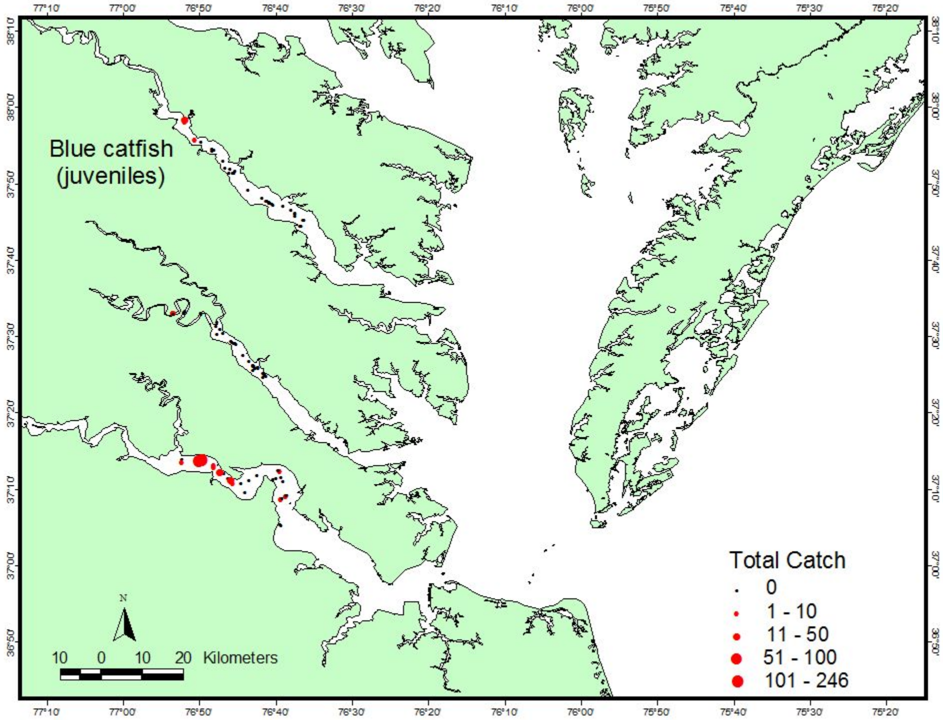


Figure 8. Distribution of index-sized juvenile blue catfish from index strata and months.

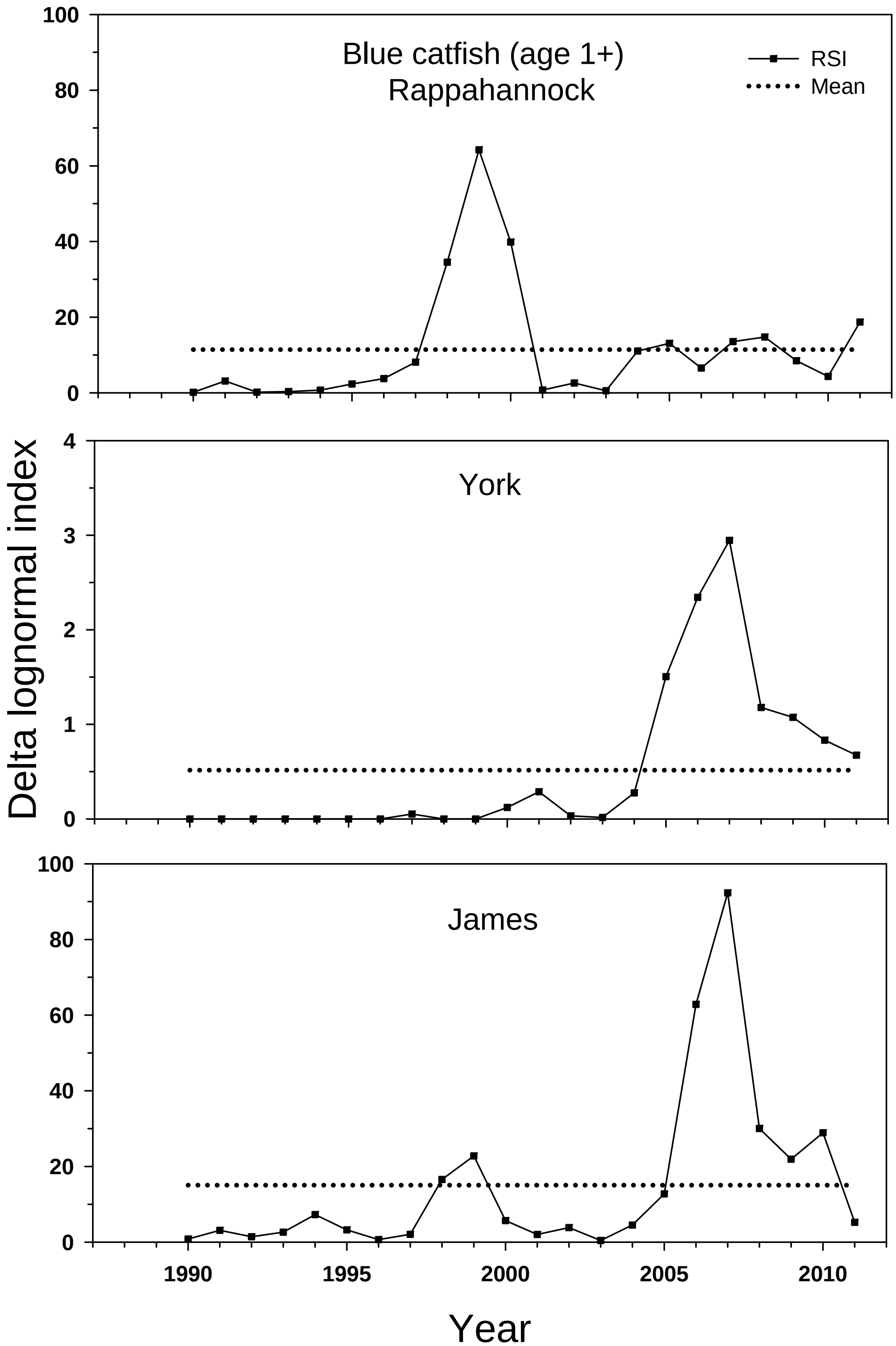


Figure 9. Age 1+ blue catfish random stratified index (RSI_{Delta}) and time series averages (dotted line) based on the RSI_{Delta}'s from the Rappahannock, York, and James rivers. Note change in scale on y-axes.

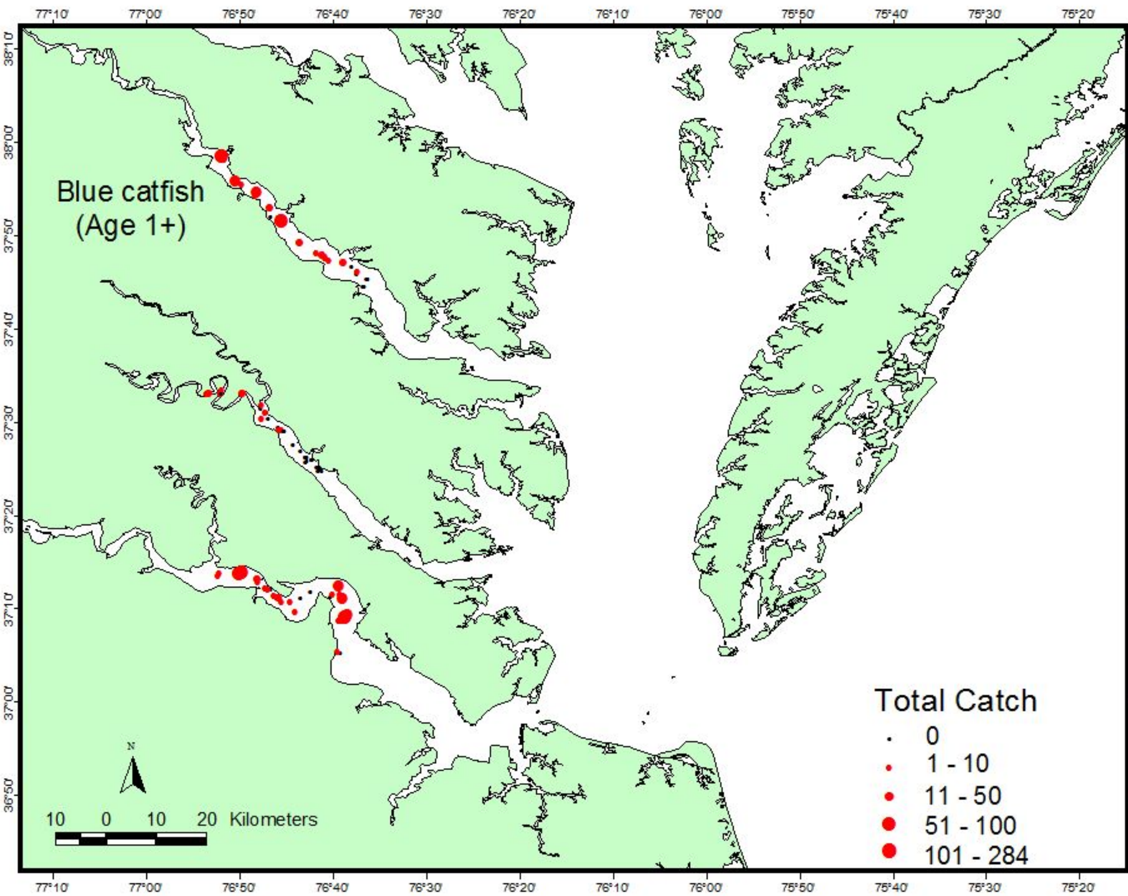


Figure 10. Distribution of Age 1+ blue catfish from index strata and months.

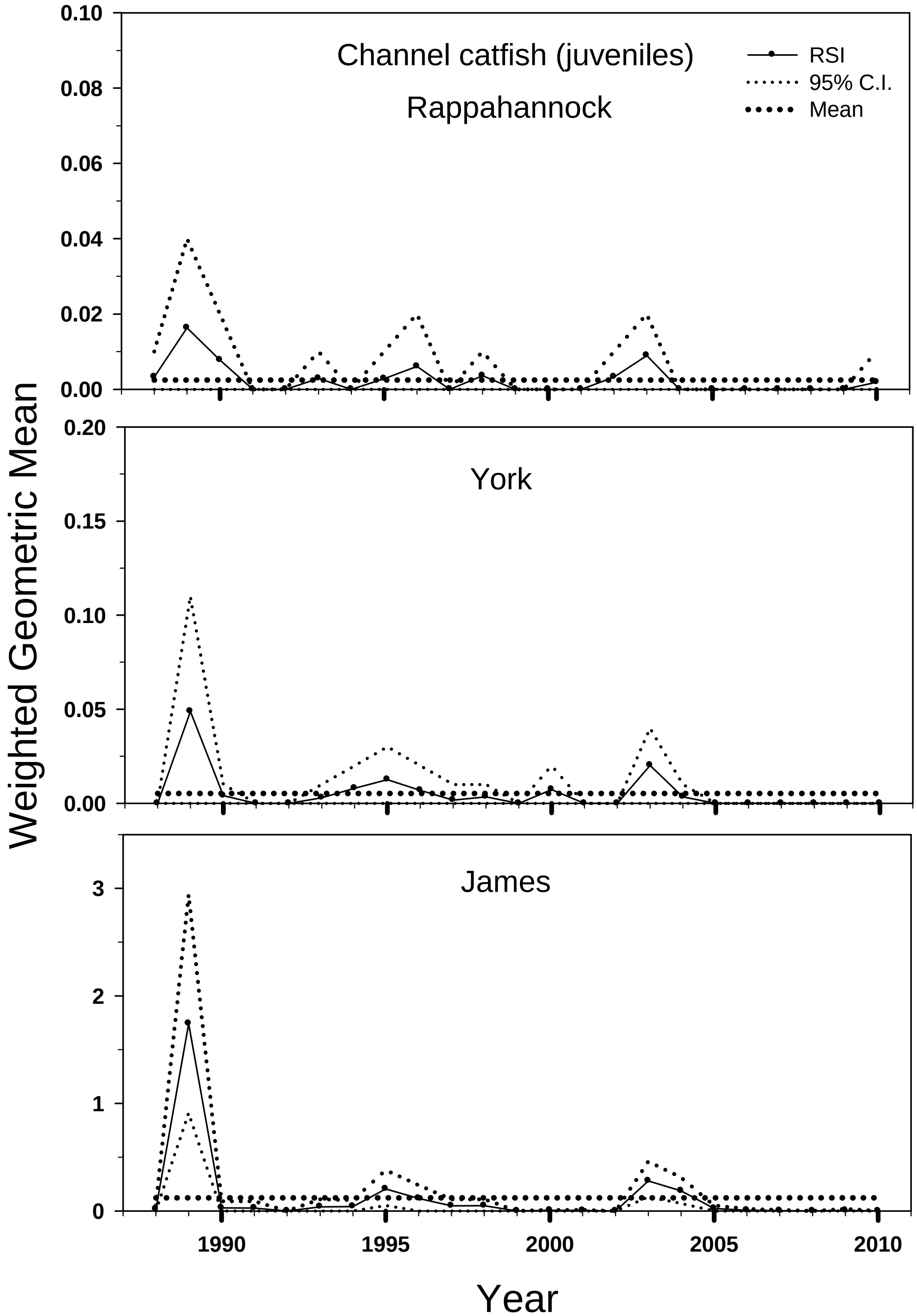


Figure 11. Juvenile channel catfish random stratified indices (RSI_{GM}, 95% C.I.) and time series averages (dotted line) based on the RSI_{GM}'s from the Rappahannock, York, and James rivers. Note change in scale on y-axes.

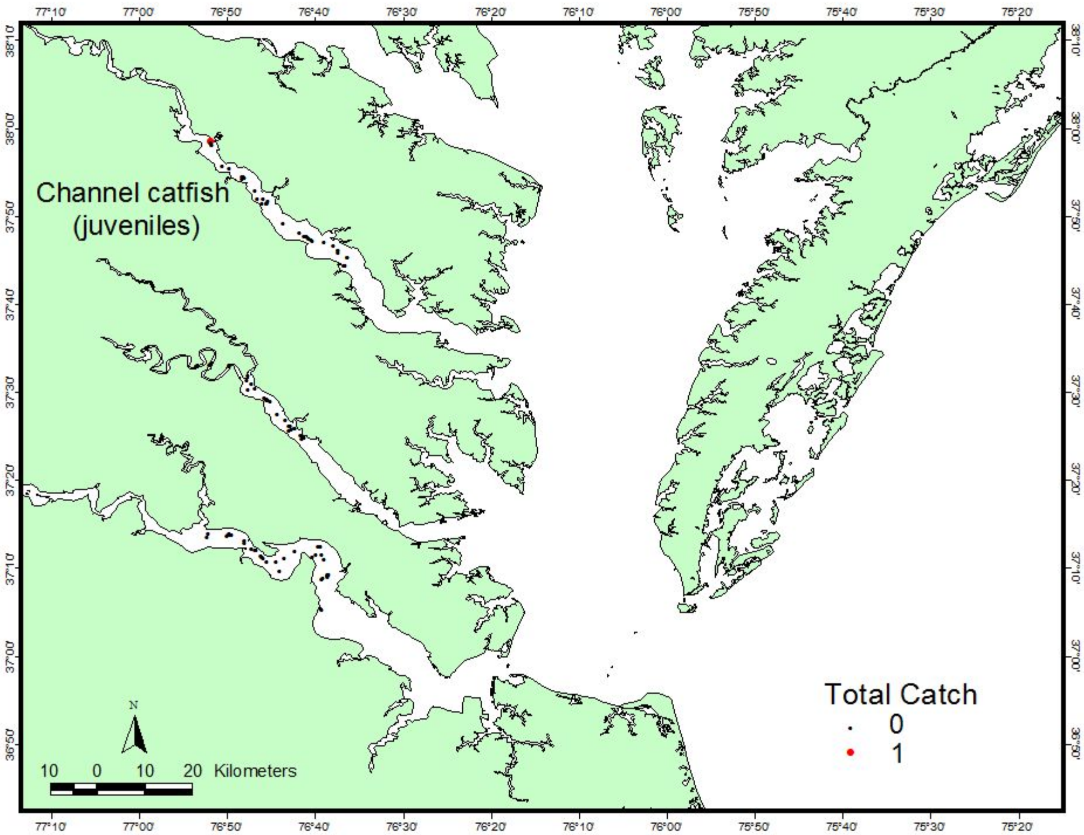


Figure 12. Distribution of juvenile channel catfish from index strata and months.

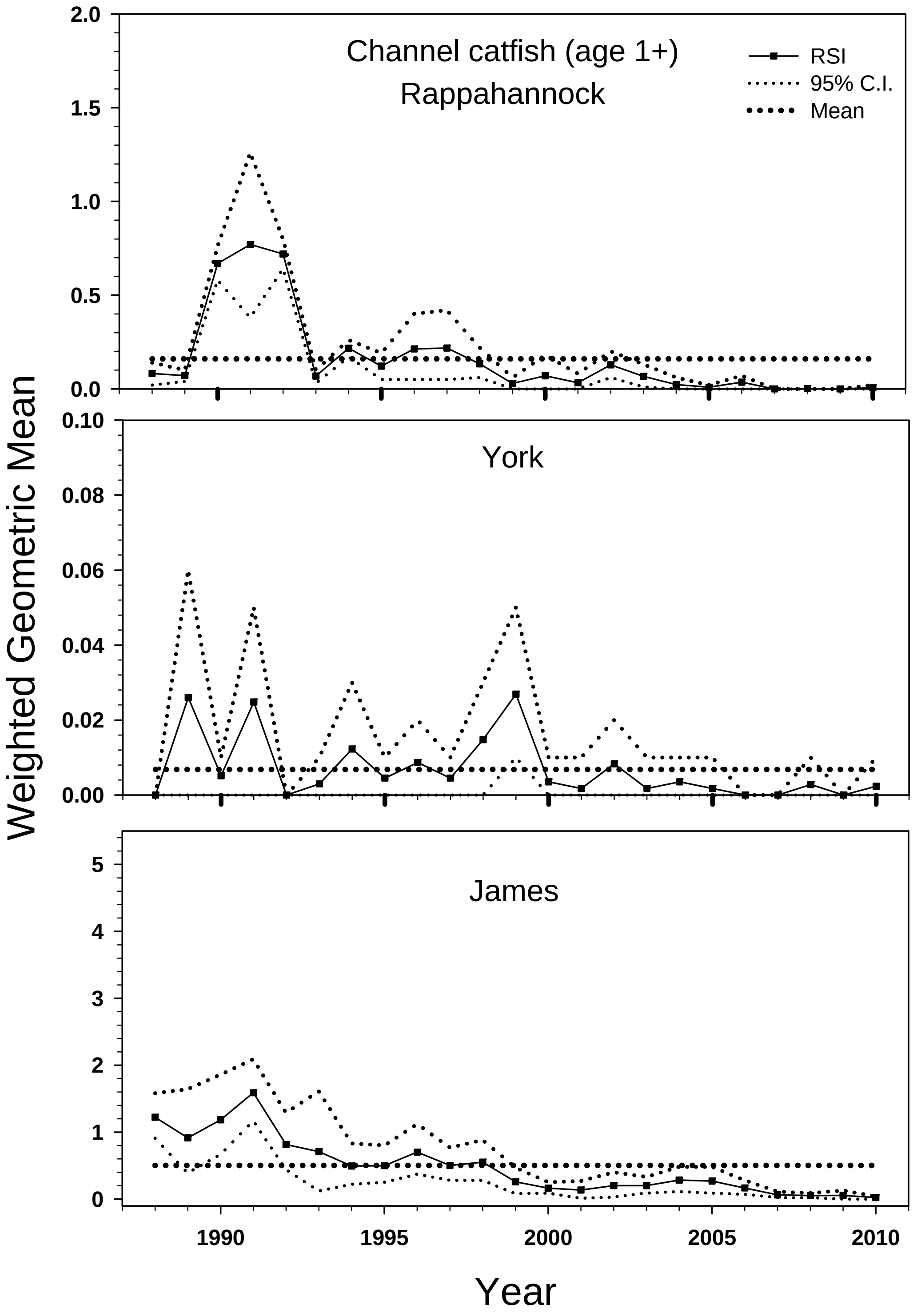


Figure 13. Age 1+ channel catfish random stratified indices (RSI_{GM}, 95% C.I.) and time series averages (dotted line) based on the RSI_{GM}'s from the Rappahannock, York, and James rivers. Note the change in scale for the y-axes.

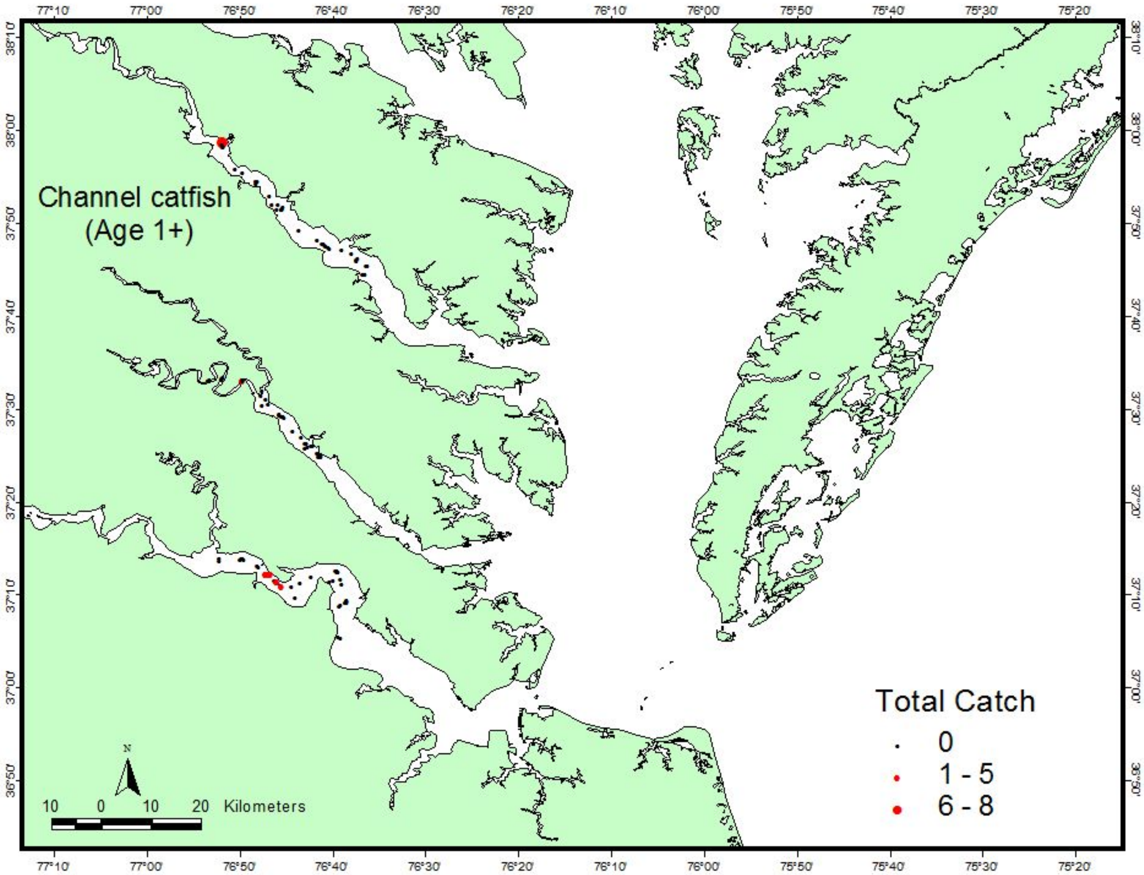


Figure 14. Distribution of Age 1+ channel catfish from index strata and months.

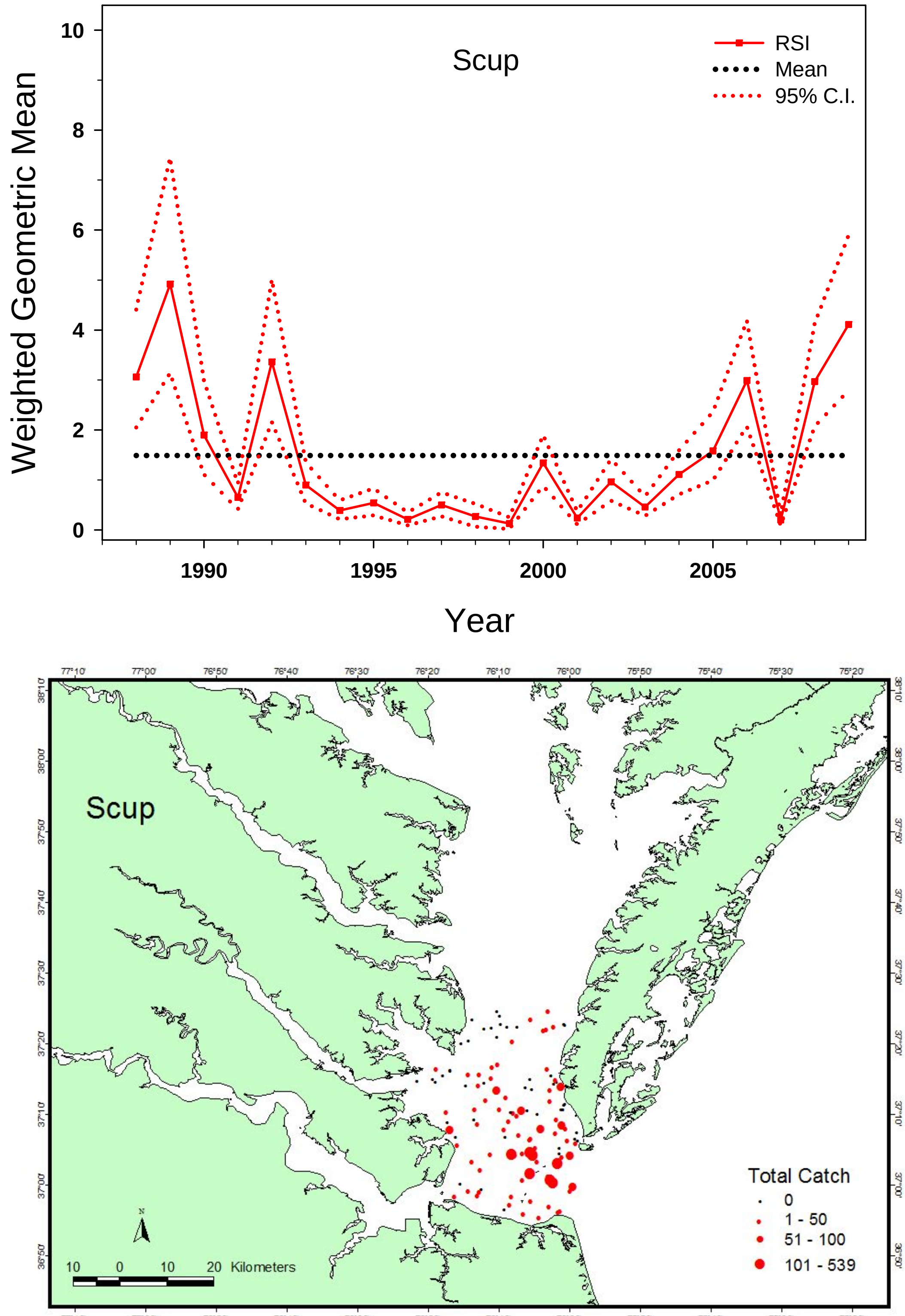
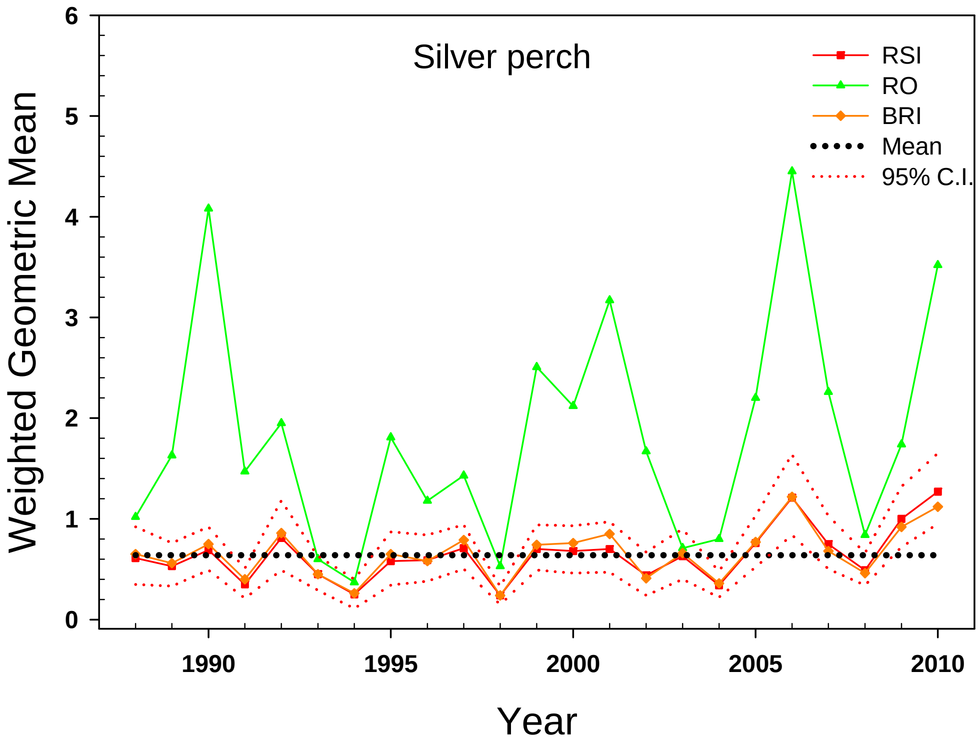


Figure 15. Age 1+ Scup random stratified index (RSI_{GM}, 95% C.I.) and the time series average (dotted line, Top), and distribution of index-sized scup from index strata and months (Bottom).



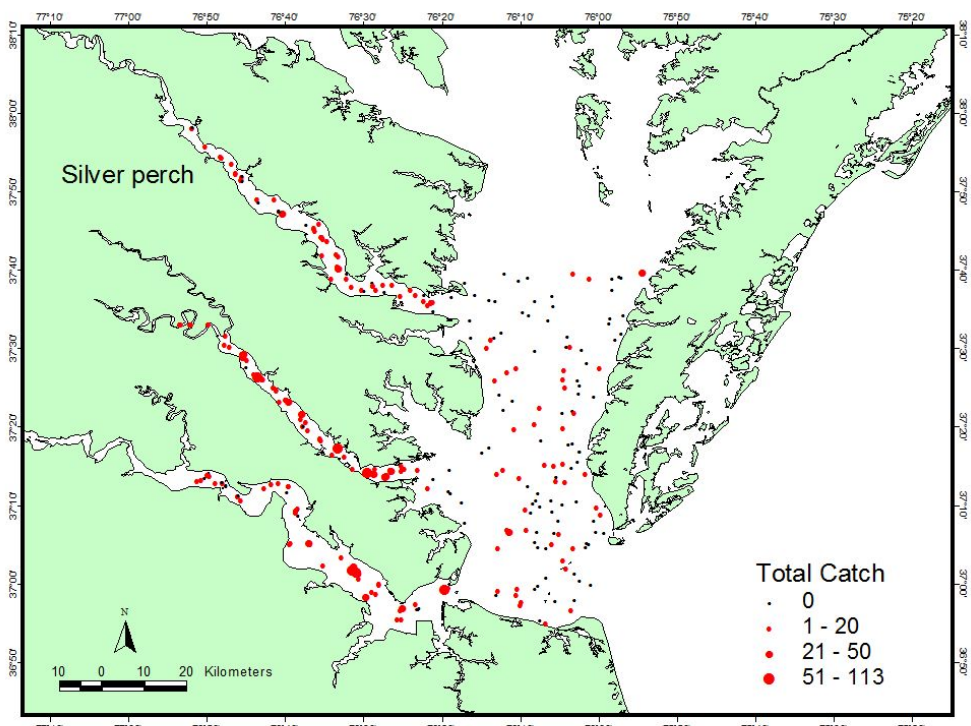


Figure 16. Juvenile silver perch random stratified (RSI_{GM}, 95% C.I.), fixed transect (Rivers only – RO), and Bay and fixed river station (BRI) indices and the time series average (dotted line) based on the RSI_{GM} (Top), and distribution of juvenile silver perch from index strata and months (Bottom).

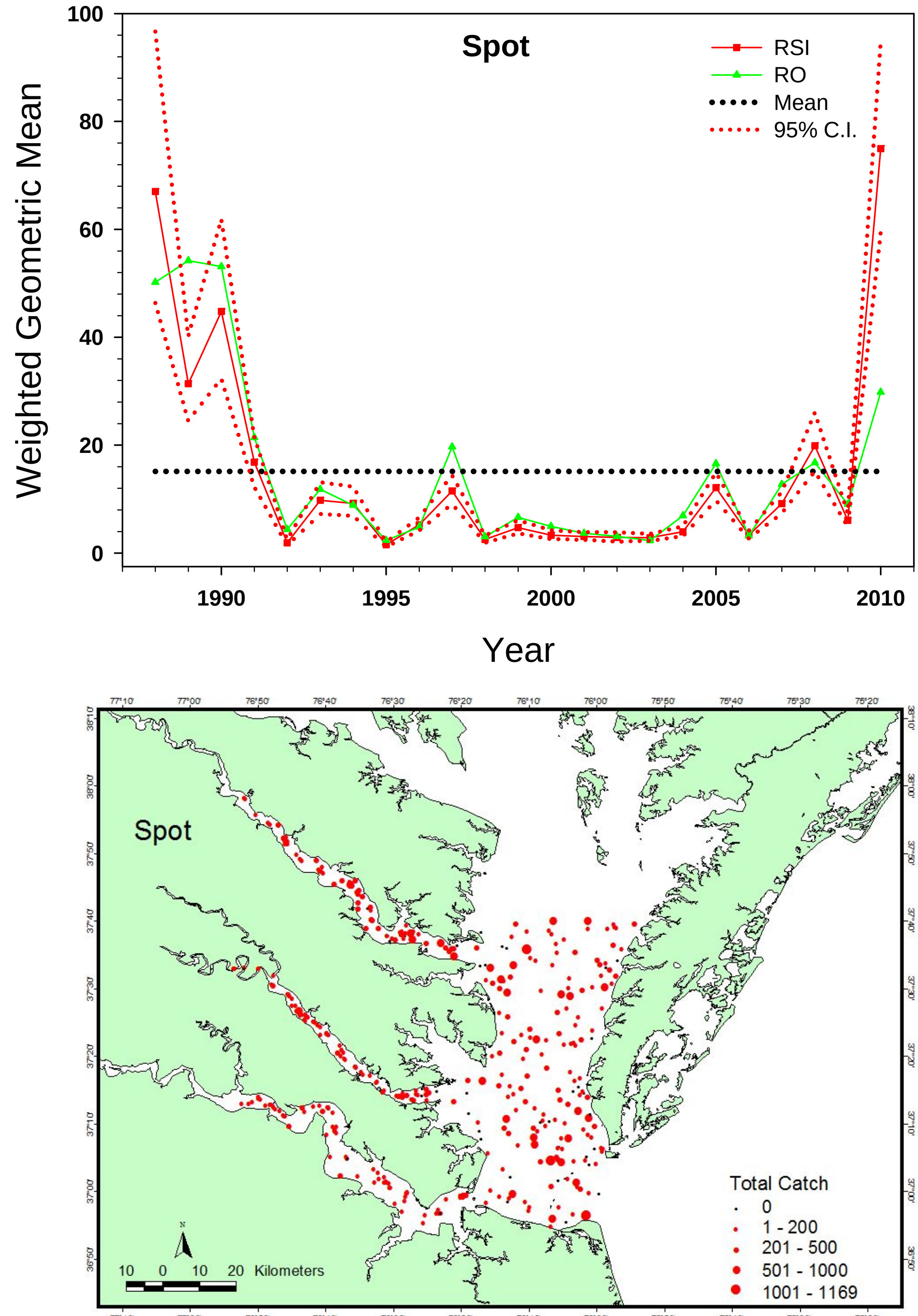


Figure 17. Juvenile spot random stratified (RSI_{GM}, 95% C.I.) fixed transect (Rivers only – RO), and Bay and fixed river station (BRI) indices and the time series average (dotted line) based on the RSI_{GM} (Top), and distribution of juvenile spot from index strata and months (Bottom).

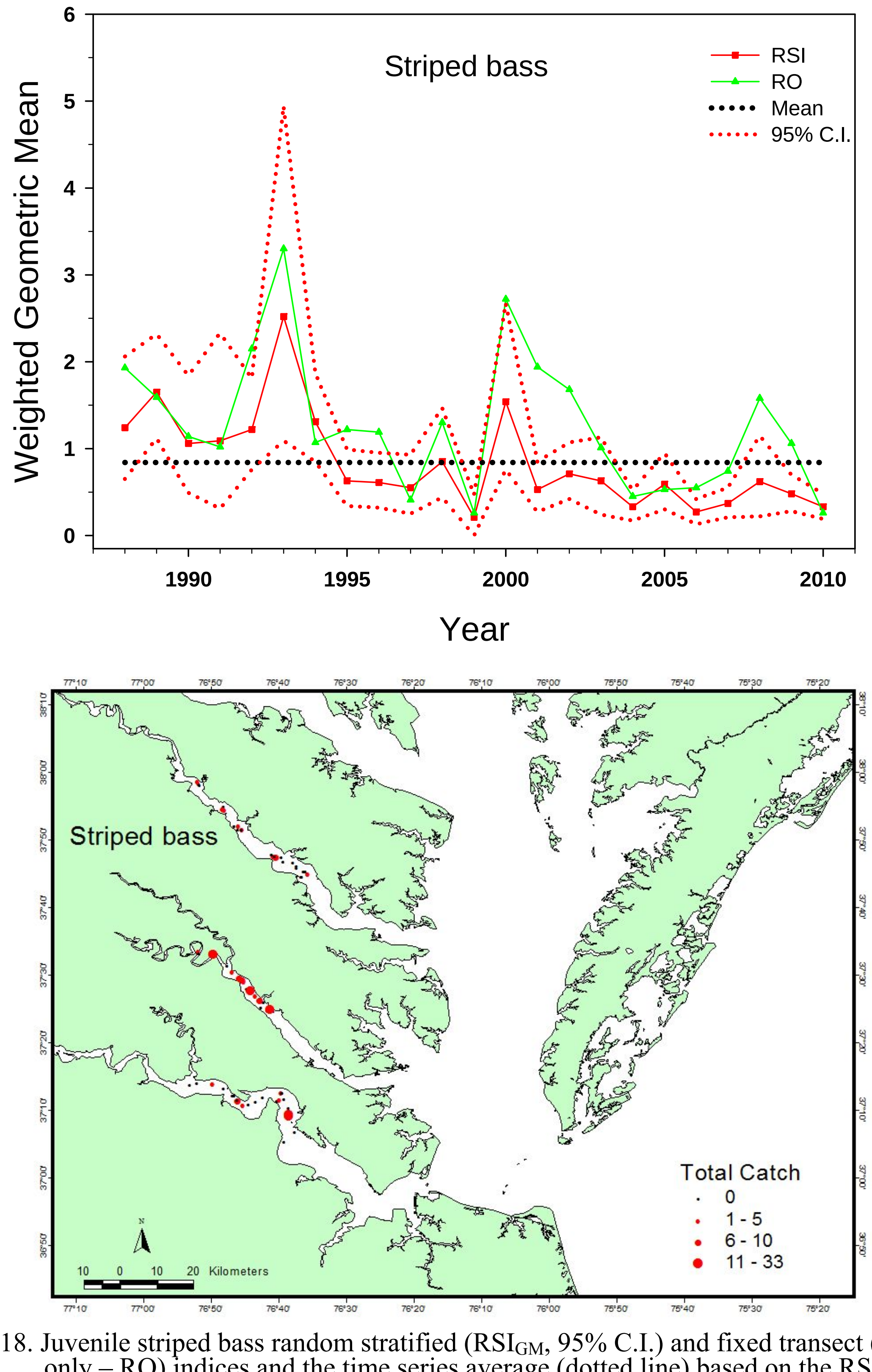
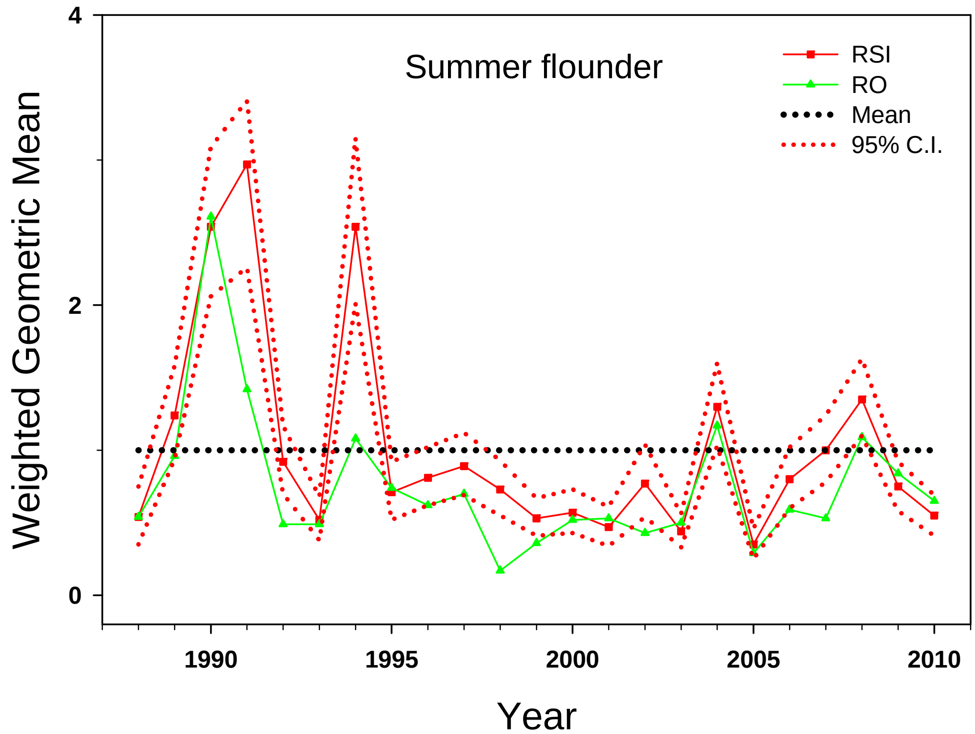


Figure 18. Juvenile striped bass random stratified (RSI_{GM}, 95% C.I.) and fixed transect (Rivers only – RO) indices and the time series average (dotted line) based on the RSI_{GM} (Top), and distribution of juvenile striped bass from index strata and months (Bottom).



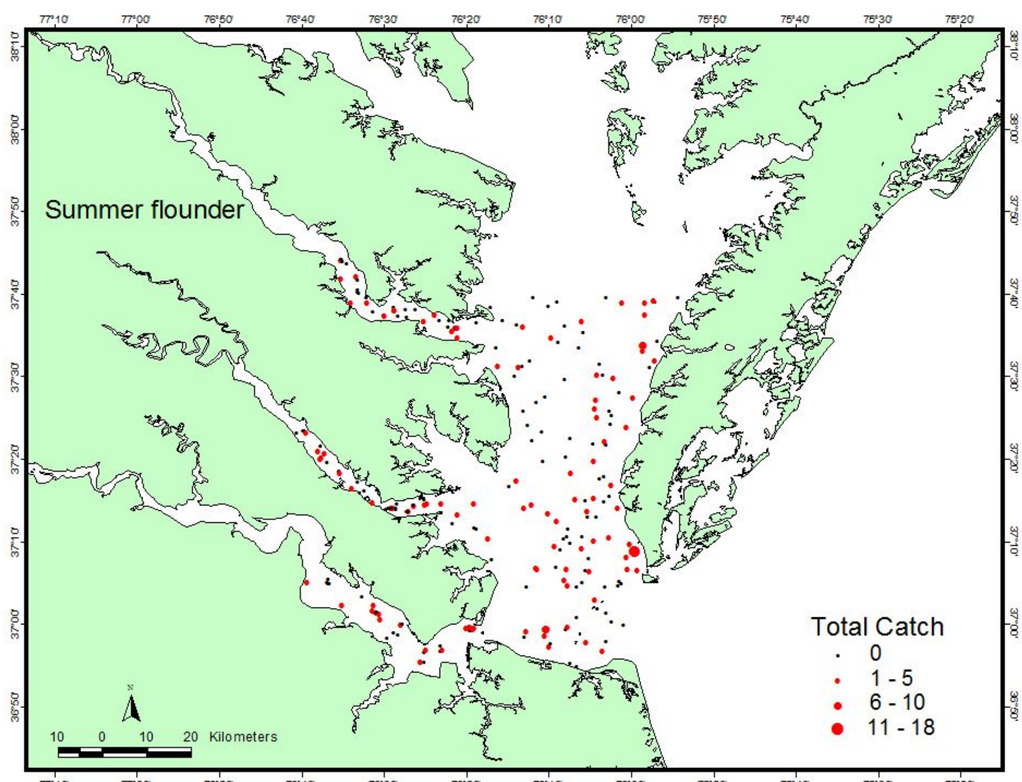


Figure 19. Juvenile summer flounder random stratified (RSI_{GM}, 95% C.I.), fixed transect (Rivers only – RO), and Bay and fixed river station (BRI) indices and the time series average (dotted line) based on the RSI_{GM} (Top), and distribution of juvenile summer flounder from index strata and months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

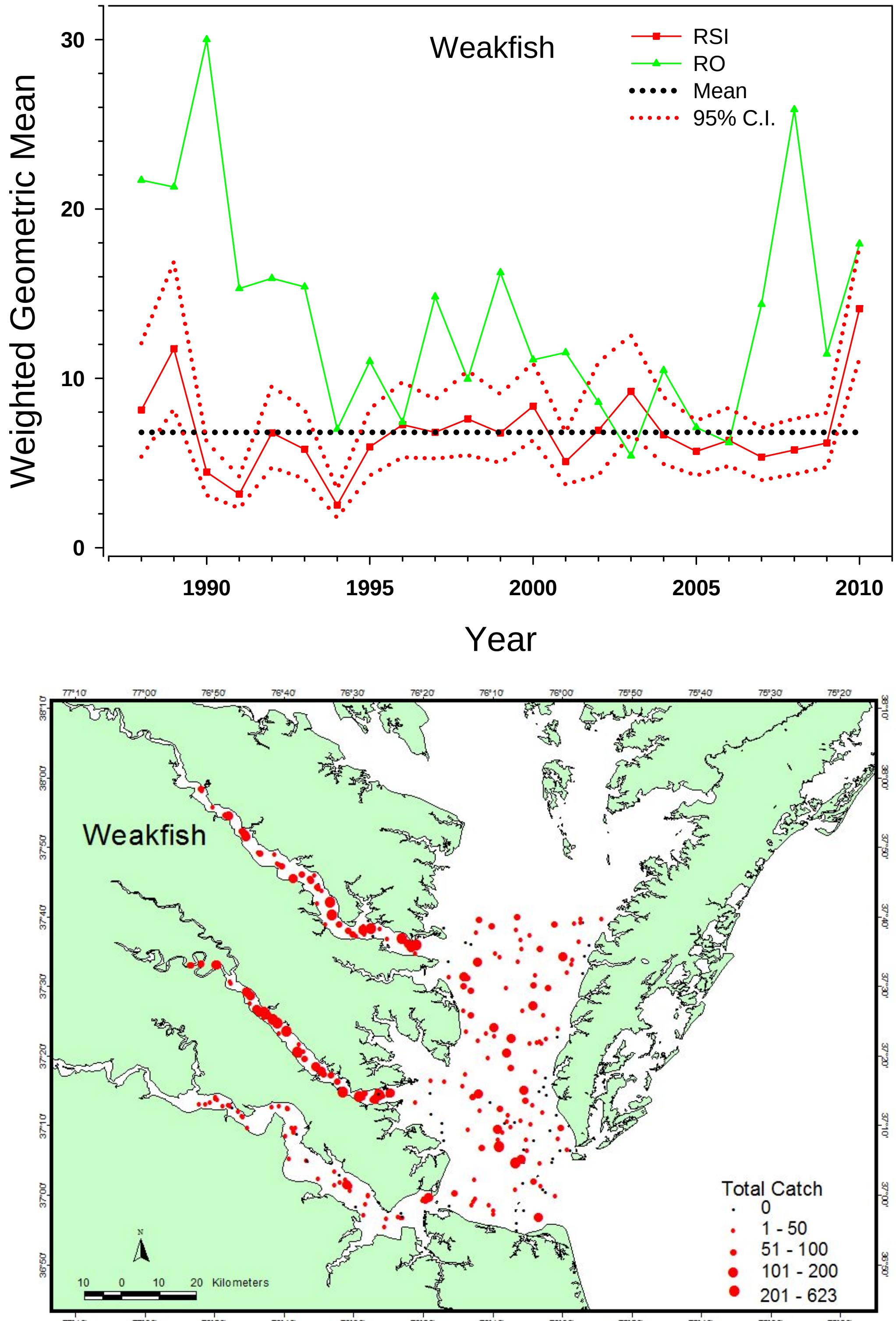


Figure 20. Juvenile weakfish random stratified (RSI_{GM}, 95% C.I.), fixed transect (Rivers only – RO), and Bay and fixed river station (BRI) indices and the time series average (dotted line) based on the RSI_{GM} (Top), and distribution of juvenile weakfish from index strata and months (Bottom).

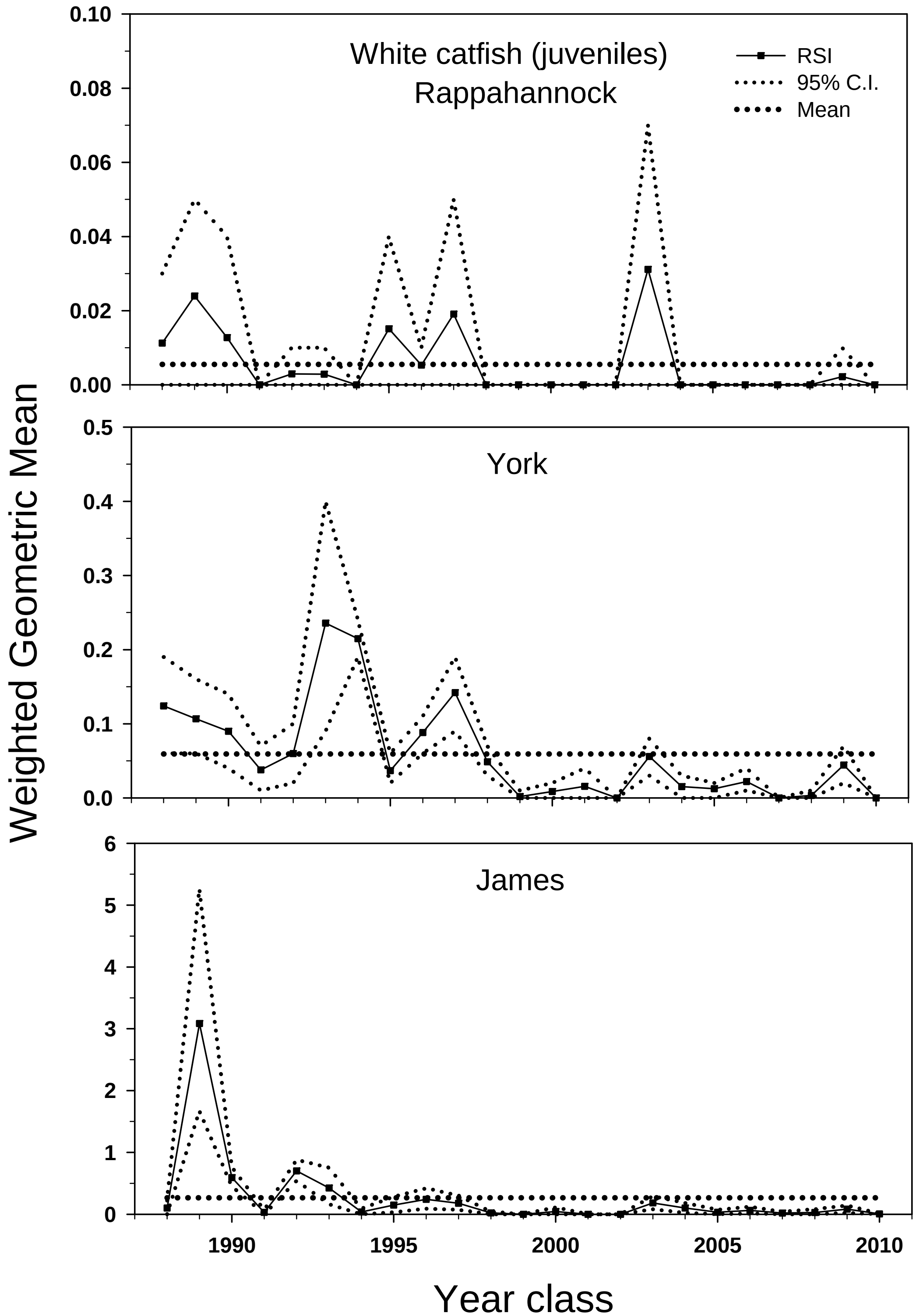


Figure 21. Juvenile white catfish random stratified indices (RSI_{GM}, 95% C.I.) and times series averages (dotted line) based on RSI_{GM}'s from the Rappahannock, York, and James rivers. Note change in scale on y-axes.

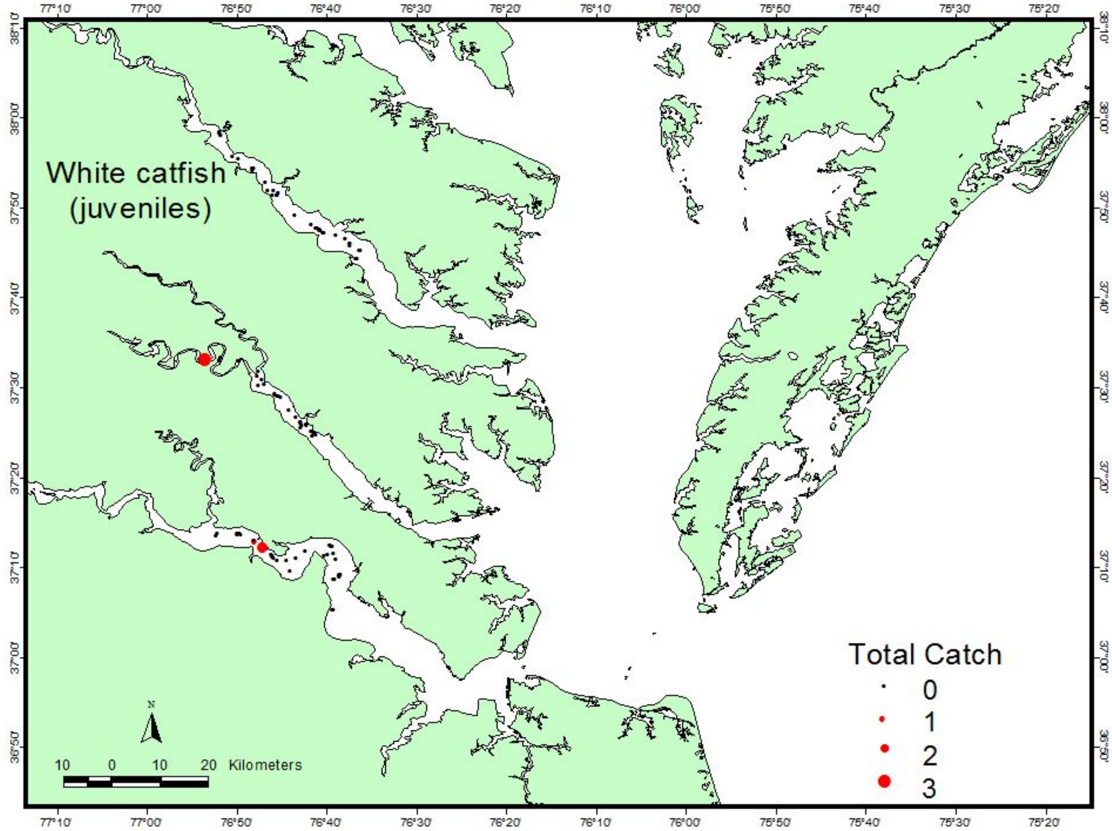


Figure 22. Distribution of juvenile white catfish from index strata and months.

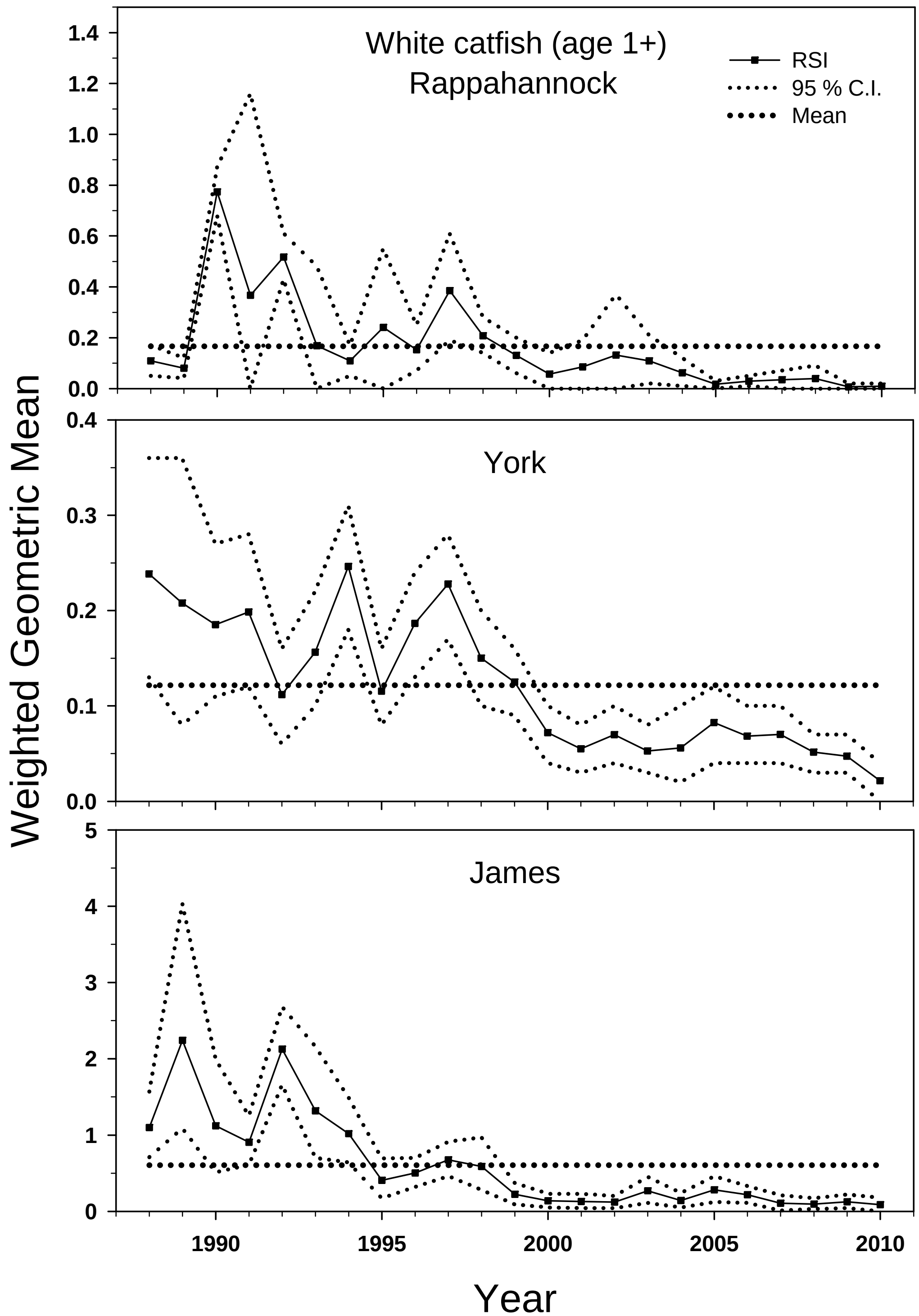


Figure 23. White catfish age 1+ random stratified indices (RSI_{GM}, 95% C.I.) and time series averages (dotted line) based on RSI_{GM}'s from the Rappahannock, York, and James rivers. Note change in scale on y-axes.

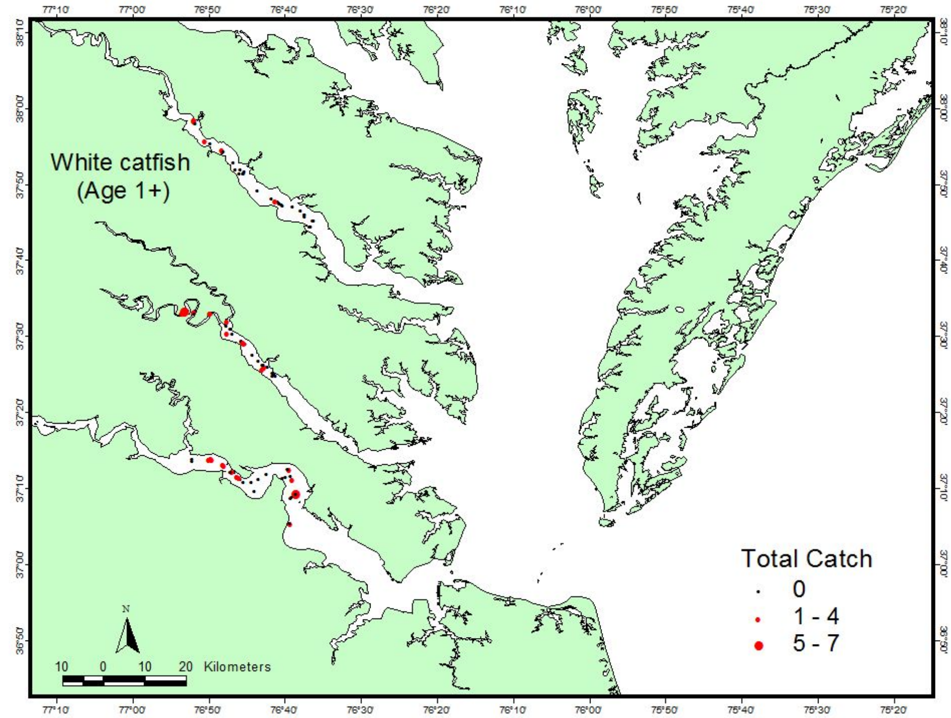


Figure 24. Distribution of white catfish age 1+ from index strata and months.

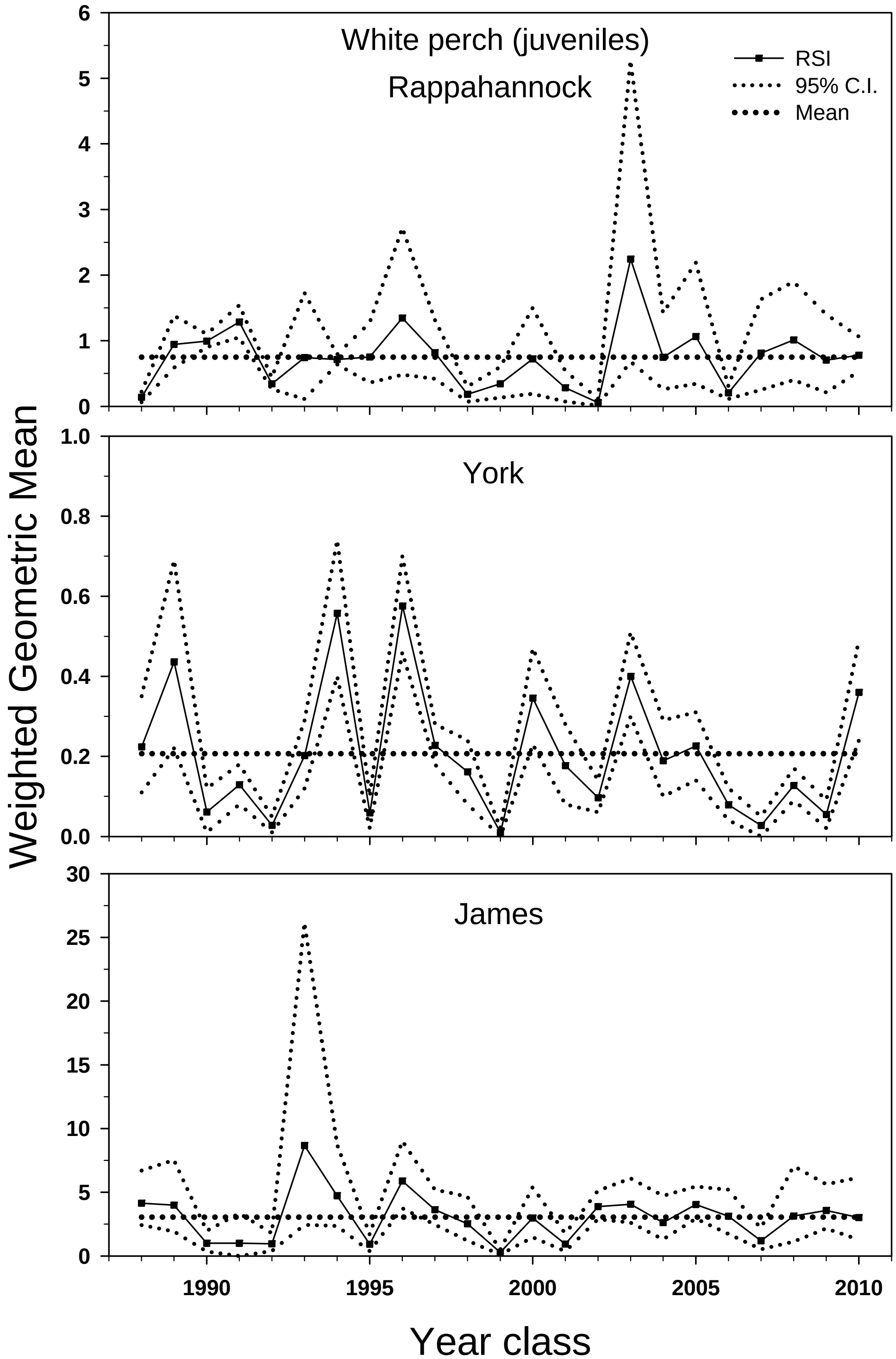


Figure 25. Juvenile white perch random stratified indices (RSI_{GM}, 95% C.I.) and time series averages (dotted line) based on RSI_{GM}'s from the Rappahannock, York and James rivers. Note change in scale on y-axes.

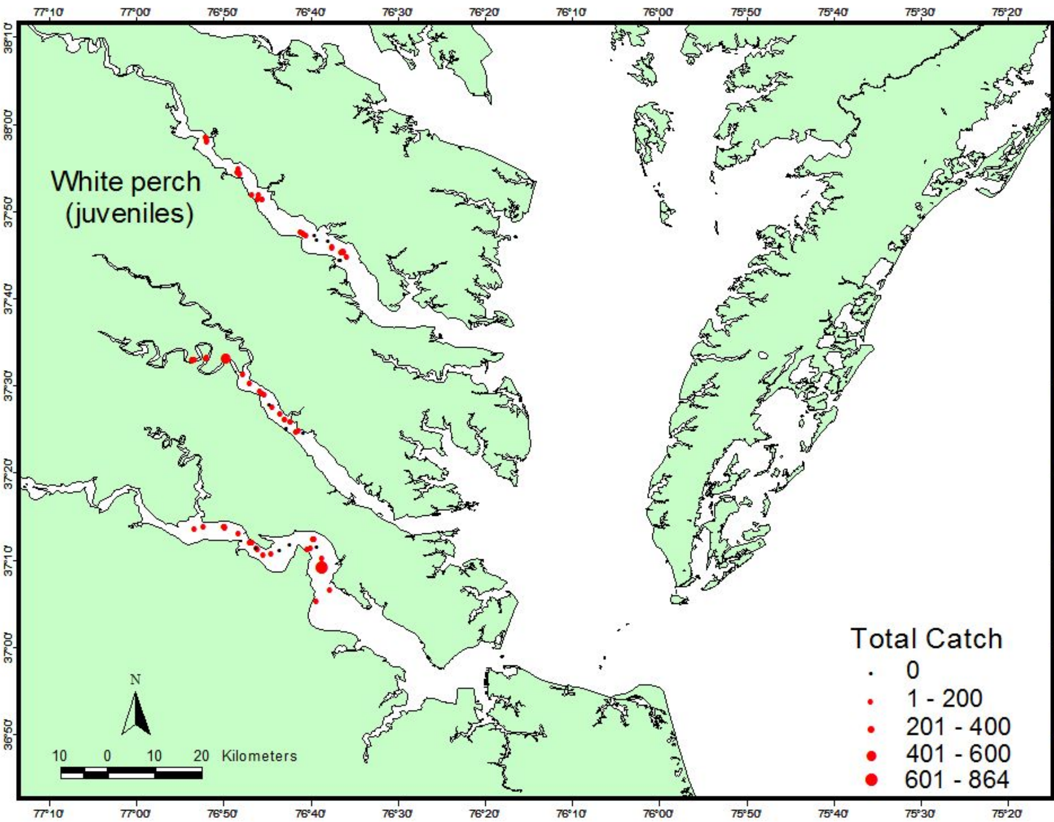


Figure 26. Distribution of juvenile white perch from index strata and months.

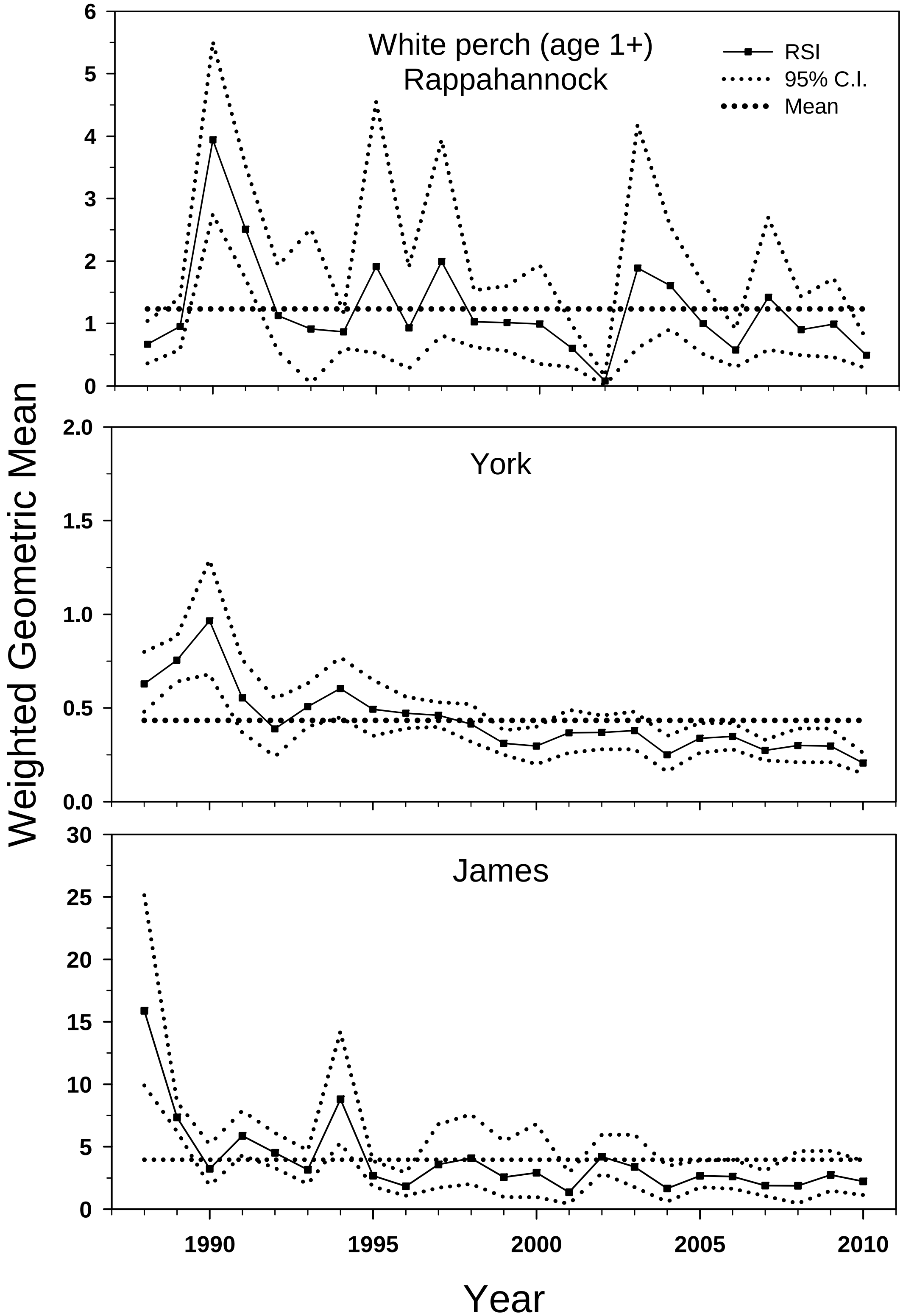


Figure 27. White perch age 1+ random stratified indices (RSI_{GM}, 95% C.I.) and time series averages (dotted line) based on RSI_{GM}'s from the Rappahannock, York, and James rivers. Note change in scale on y-axes.

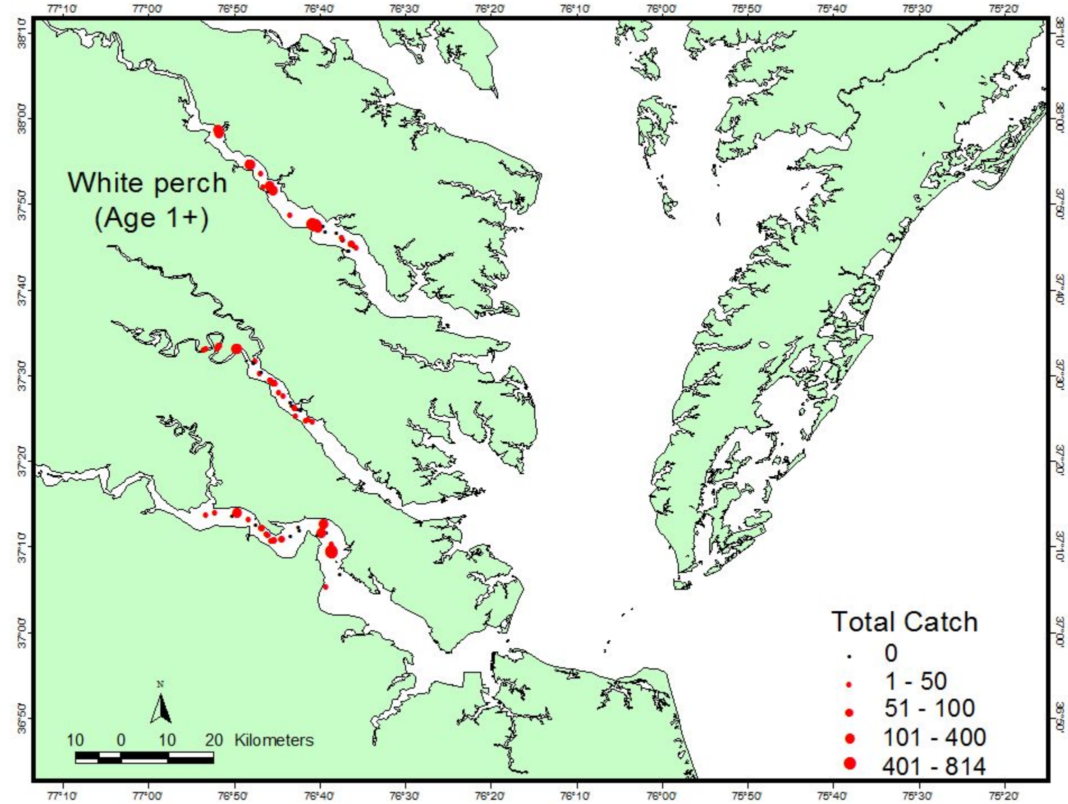


Figure 28. Distribution of white perch age 1+ from index strata and months.

Appendix Table 1. Trawl survey advisory requests, data requests, and specimen requests from June 2010 to May 2011.

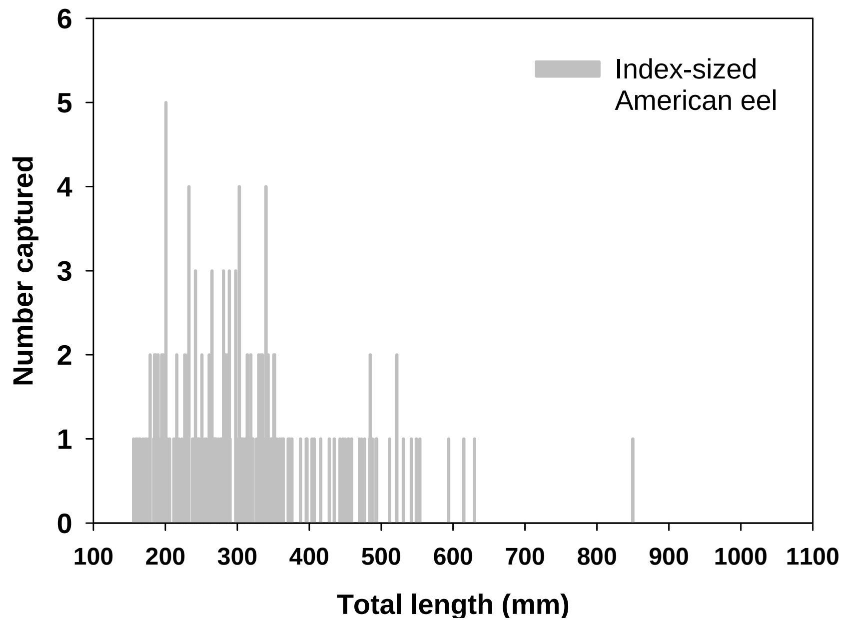
Contact	Agency	Nature of Request
Pat McGrath	VIMS	Gar specimens
Karin Limburg	SUNY	Alosine specimens
Edward McGinley	WVU	Bay anchovy specimens
Edward McGinley	WVU	Atlantic croaker specimens
Edward McGinley	WVU	Atlantic menhaden specimens
Joel Boehm	River Project	Dusky pipefish specimens
Joel Boehm	River Project	Northern pipefish specimens
Joel Boehm	River Project	Lined seahorse specimens
Paul Gerdes	VIMS	Naked goby specimens
Paul Gerdes	VIMS	Bay anchovy specimens
Paul Gerdes	VIMS	Striped anchovy specimens
Paul Gerdes	VIMS	Scup specimens
Alicia Nelson	VMRC	2009 Horseshoe Crab data
Sally Upton	VIMS	Fish specimens for education dept
Laura Lee	VMRC	Eel data
Jack Travelstead	VMRC	Blue catfish data summary
Mike Newman	VIMS	Fish for mercury study
Laura Lee	VMRC	Spot indices
Rob O'Reilly	VMRC	Atlantic Croaker Indices, fall and spring 2008
Eric Hilton	VIMS	Feather blenny specimens
Eric Hilton	VIMS	Striped blenny specimens
Eric Hilton	VIMS	Crested blenny specimens
Troy Tuckey	VIMS	White perch juveniles
Lyle Varnell	VIMS	Fish distribution data
Lyle Varnell	VIMS	James River water temperature data
VIMS Aquarium	VIMS	Live specimens for display and education
Tracey Sutton	VIMS	Spiny dogfish data
Chris Hager	VA Sea Grant	Atlantic sturgeon data
Tom Miller	CBL	Blue crab indices 1968-2009, age 0 spring/fall, age 1+, adult female

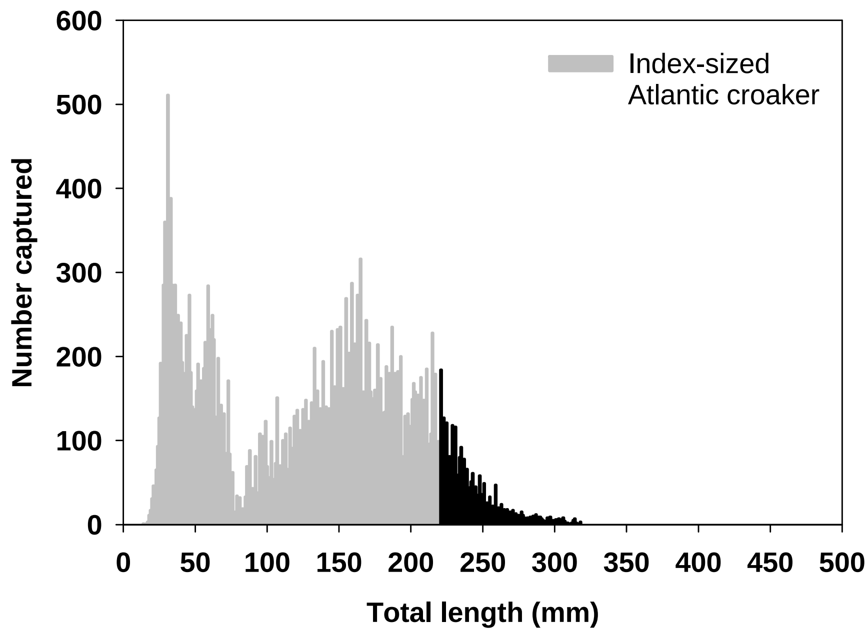
Appendix Table 2. Mobjack Bay pooled catch for June 2010 to May 2011 from 204 tows.

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	111,790	136	66.55	547.99	.	95,829	54	0.17	21	91
spot	44,711	121	26.62	219.17	79.99	41,578	102	0.34	24	229
Atlantic menhaden	2,521	37	1.5	12.36	4.51	2,508	49	1.57	27	231
weakfish	2,410	92	1.43	11.81	4.31	2,143	105	1.19	22	318
silver perch	2,043	80	1.22	10.01	3.65	1,938	114	0.58	21	178
Atlantic croaker	1,666	99	0.99	8.17	2.98	1,192	115	2.14	19	293
southern kingfish	354	42	0.21	1.74	0.63	327	115	1.9	38	301
hogchoker	301	73	0.18	1.48	.	9	103	0.89	34	159
harvestfish	298	46	0.18	1.46	0.53	296	63	1.53	17	168
Atlantic silverside	208	14	0.12	1.02	0.37	208	87	0.83	63	109
striped anchovy	193	45	0.11	0.95	0.35	193	83	1	55	113
kingfish spp	141	21	0.08	0.69	0.25	141	70	1.82	25	189
summer flounder	129	59	0.08	0.63	0.23	100	209	7.68	67	529
spotted hake	70	27	0.04	0.34	0.13	70	98	3.37	47	161
northern searobin	55	9	0.03	0.27	0.1	55	75	1.99	39	133
butterfish	49	21	0.03	0.24	0.09	35	128	4.08	28	171
naked goby	43	12	0.03	0.21	0.08	.	33	1.48	21	59
Atlantic spadefish	37	19	0.02	0.18	0.07	.	75	3.47	29	122
oyster toadfish	28	13	0.02	0.14	0.05	.	89	9.86	31	221
feather blenny	27	9	0.02	0.13	0.05	.	47	2.16	24	68
blackcheek tonguefish	26	18	0.02	0.13	0.05	24	80	5.55	43	141
northern pipefish	26	17	0.02	0.13	0.05	.	164	7.07	85	238
spotted seatrout	26	16	0.02	0.13	0.05	.	111	9.98	46	207
green goby	21	16	0.01	0.1	0.04	.	42	0.95	35	52
seaboard goby	21	8	0.01	0.1	0.04	.	39	2.64	27	87
northern puffer	20	17	0.01	0.1	0.04	8	137	9.46	33	196
bluefish	17	14	0.01	0.08	0.03	.	152	14.19	42	251
Atlantic thread herring	14	6	0.01	0.07	0.03	.	53	8.78	34	164
Atlantic herring	13	5	0.01	0.06	0.02	.	54	1.11	48	63
inshore lizardfish	12	8	0.01	0.06	0.02	4	202	18.29	97	286
striped blenny	12	5	0.01	0.06	0.02	.	61	2.34	41	73
scup	8	6	0	0.04	0.01	8	120	7.43	78	139
striped searobin	7	7	0	0.03	0.01	.	127	23.34	33	225
mummichog	7	3	0	0.03	0.01	.	62	5.99	40	92
American shad	6	5	0	0.03	0.01	6	119	9.78	76	139
Atlantic stingray	6	5	0	0.03	0.01	.	310	26.97	203	374
Atlantic moonfish	6	3	0	0.03	0.01	.	71	5.4	61	96
blueback herring	5	4	0	0.02	0.01	5	77	5.59	67	95
striped bass	5	2	0	0.02	0.01	5	161	5.38	141	173
skilletfish	4	4	0	0.02	0.01	.	42	7.56	21	53
sheepshead minnow	4	3	0	0.02	0.01	.	39	2.5	32	44
Atlantic cutlassfish	4	3	0	0.02	0.01	.	497	79.7	321	699
gizzard shad	3	3	0	0.01	0.01	0	322	2.08	318	325
pigfish	3	2	0	0.01	0.01	.	139	21.52	116	182
black seabass	2	2	0	0.01	0	2	133	12	121	145
hickory shad	2	2	0	0.01	0	.	127	7	120	134
American eel	2	2	0	0.01	0	.	313	249	64	562
windowpane	2	2	0	0.01	0	2	107	32	75	139
alewife	2	1	0	0.01	0	2	119	0.5	118	119
red drum	1	1	0	0	0	.	50	.	50	50
Spanish mackerel	1	1	0	0	0	.	63	.	63	63
sheepshead	1	1	0	0	0	.	560	.	560	560
lined seahorse	1	1	0	0	0	.	73	.	73	73
dusky pipefish	1	1	0	0	0	.	80	.	80	80
banded drum	1	1	0	0	0	.	26	.	26	26
spotfin butterflyfish	1	1	0	0	0	.	47	.	47	47
smallmouth flounder	1	1	0	0	0	1	66	.	66	66
All Species Combined	167,368									

Appendix Figure 1. Length frequency distributions by species from June 2010 to May 2011. Gray bars are index-sized fish. (Note that actual indices are calculated using a subset of months and strata. Therefore, not all index-sized fish are included.)





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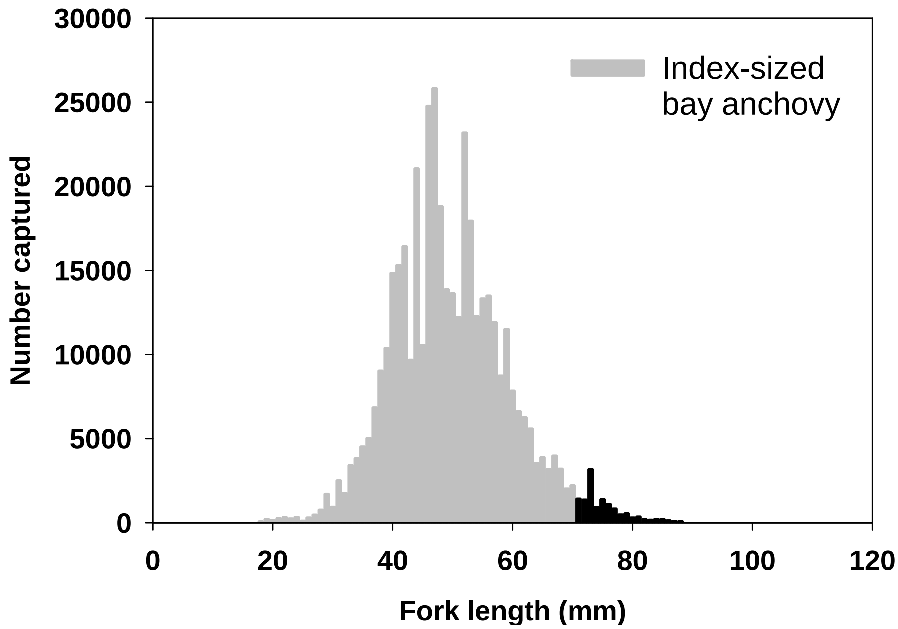

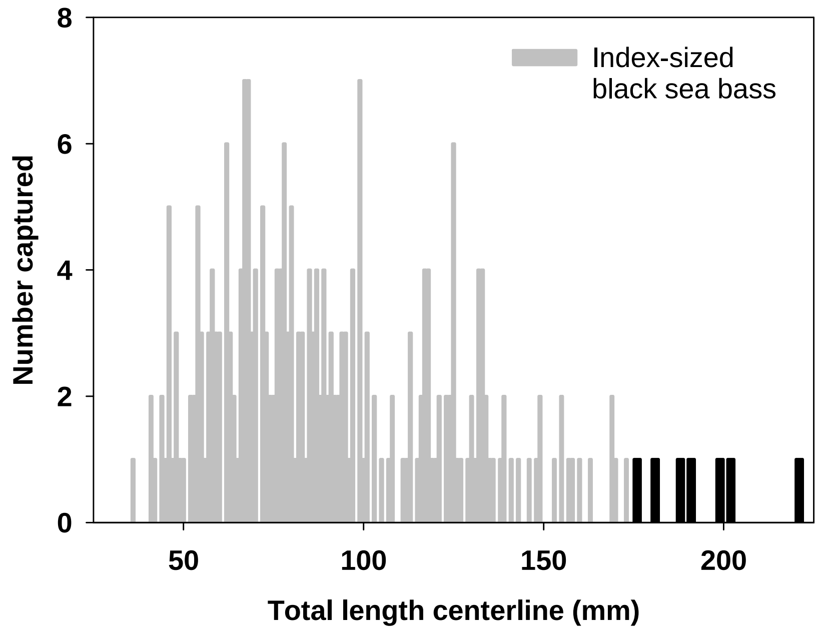

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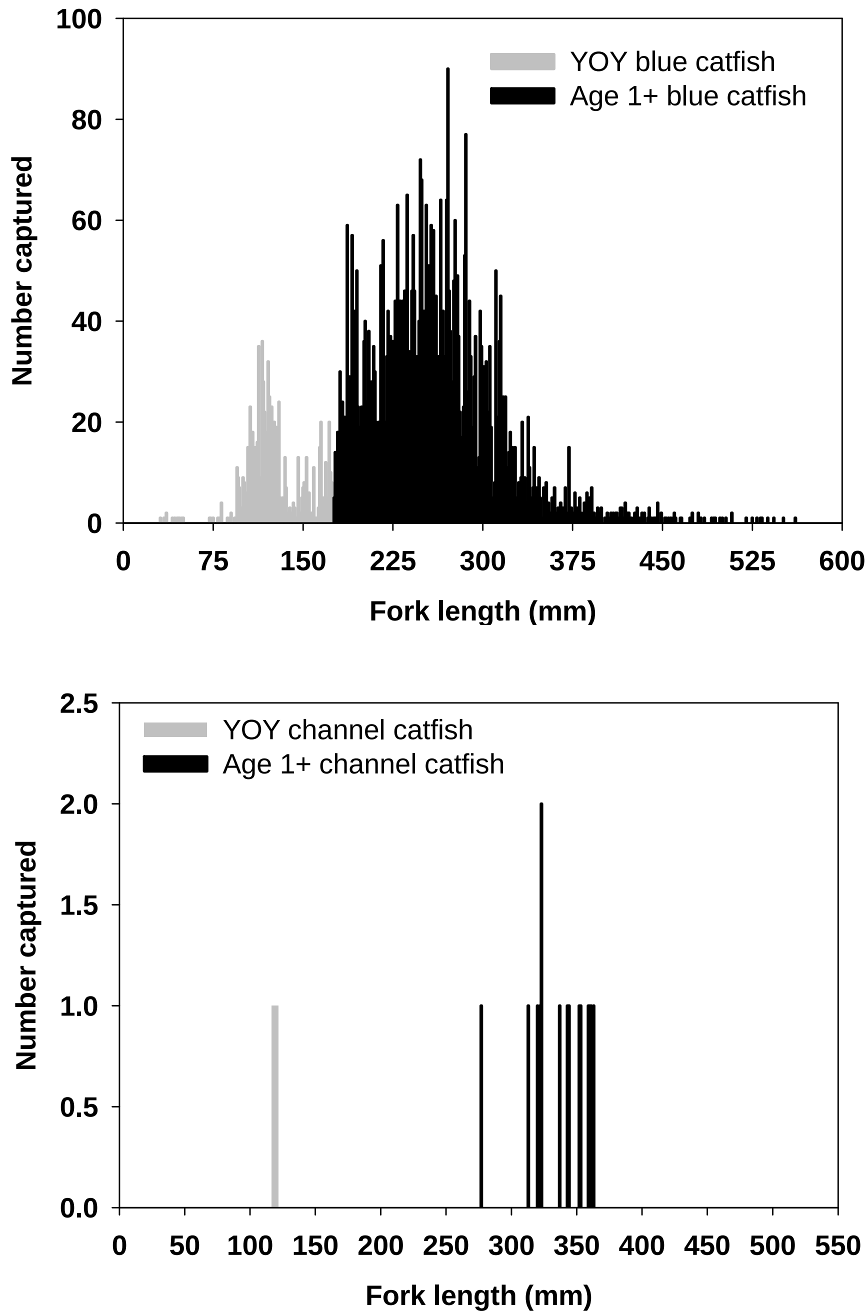

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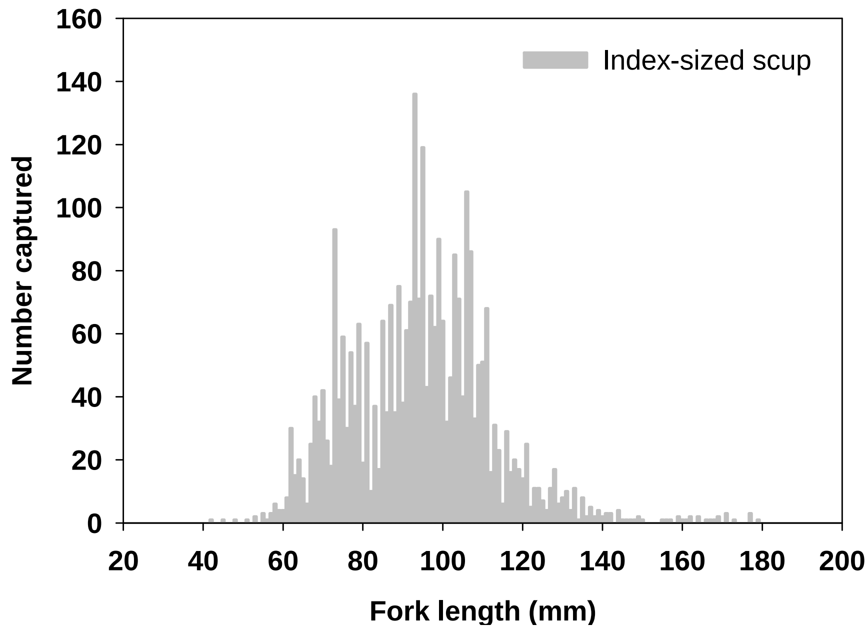

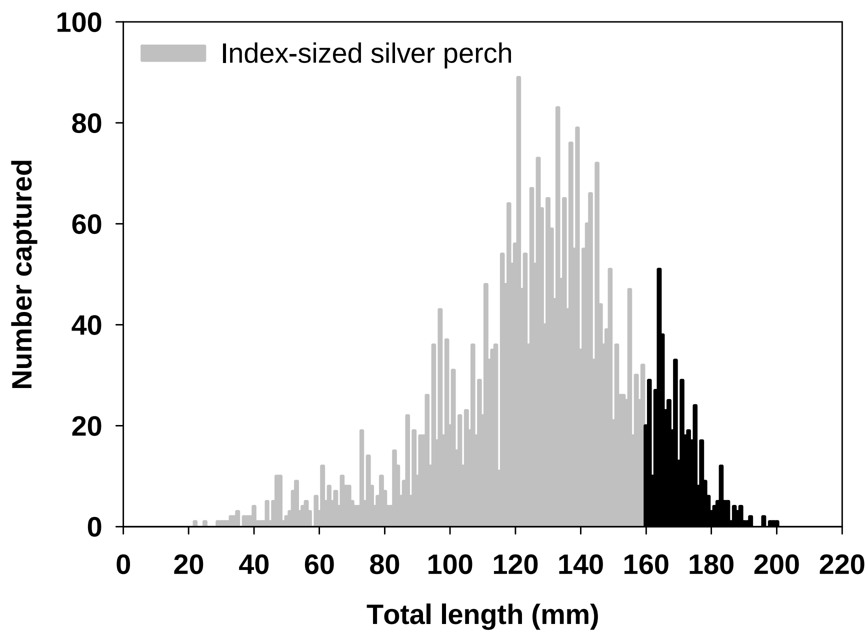

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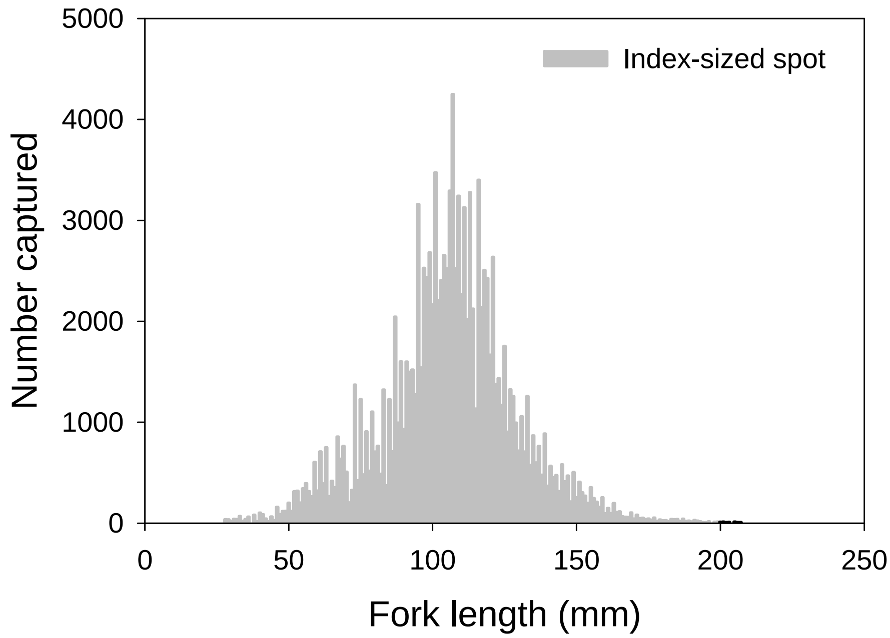

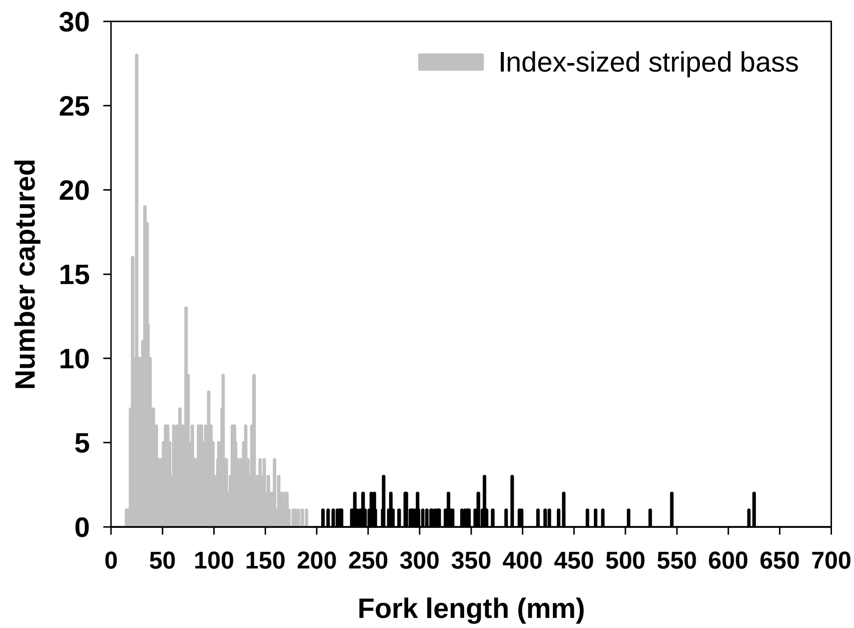

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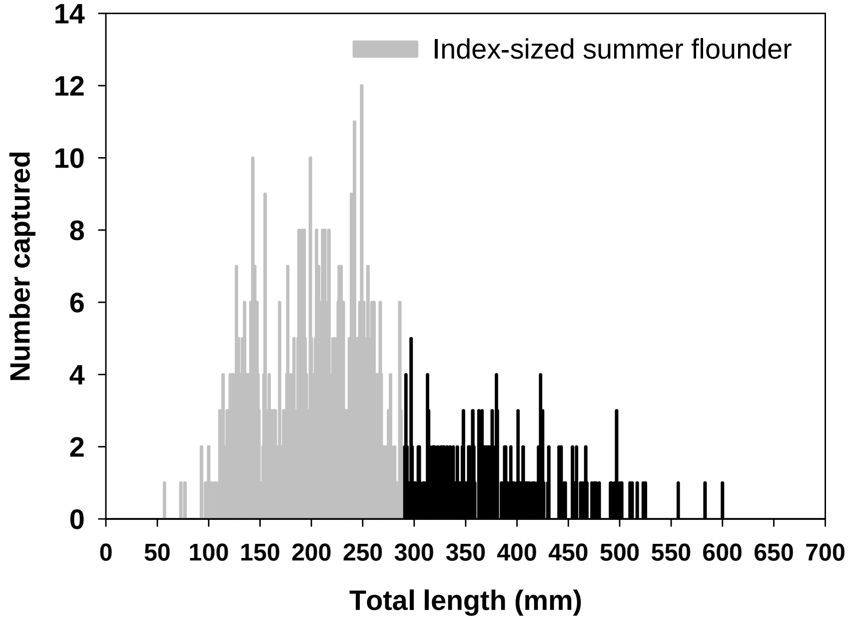

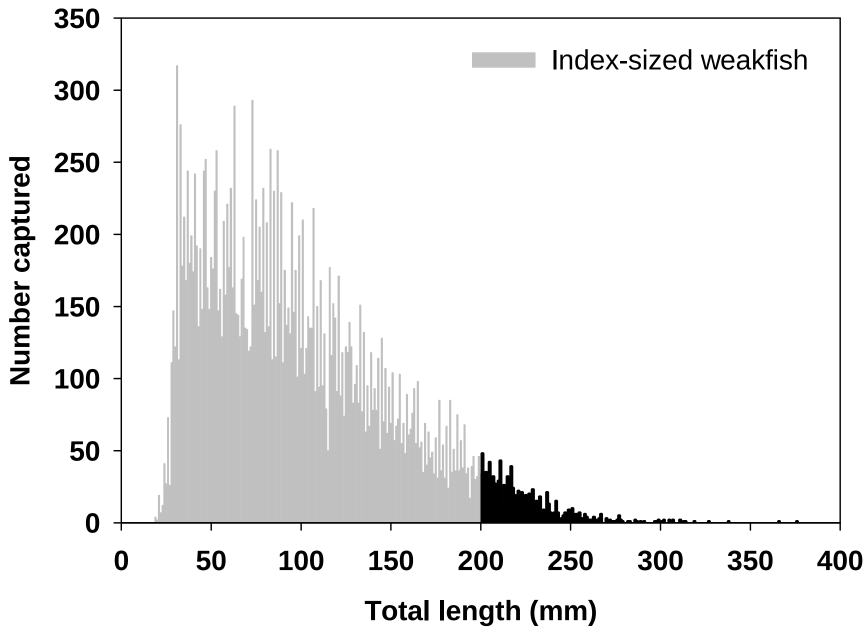

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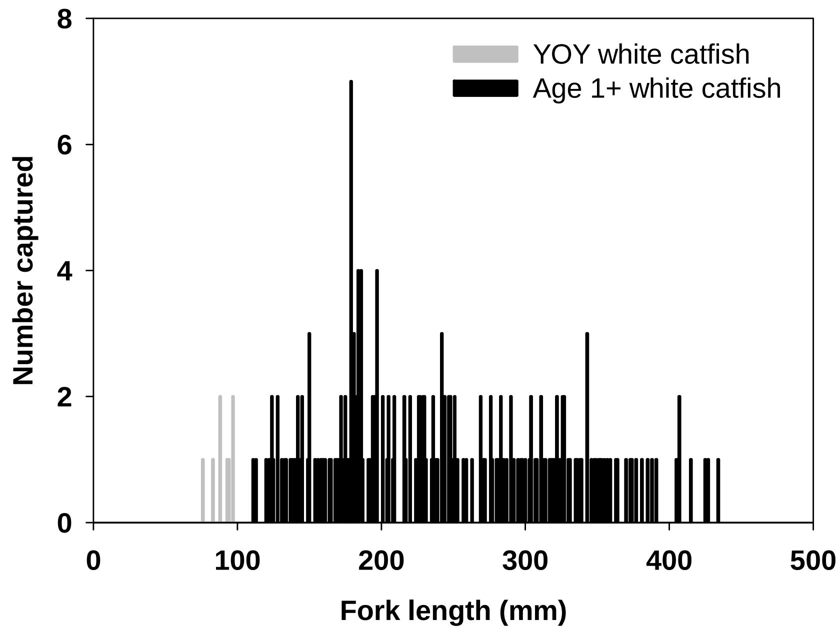

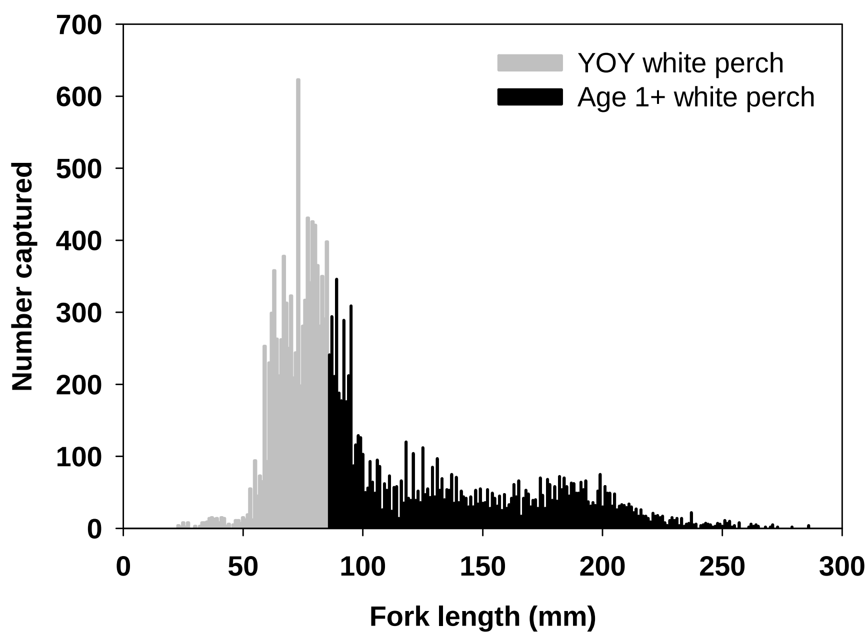

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