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Monitoring Relative Abundance of American Shad in Virginia Rivers 2009 Annual Report

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2009 Annual Report

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Summary

- A staked gill net was set and fished each week on the James, York and Rappahannock rivers in the spring of 2009. This was the twelfth year of monitoring in a stock assessment program for American shad that was initiated in spring 1998. Our approach was to establish a sentinel fishery, based on traditional methods used prior to the imposition of the current in-river moratorium in 1994. The primary objective is to establish a time series of catch rates that can be compared to historical data recorded in logbooks voluntarily submitted by commercial fishers when the staked gill net fishery was active. The monitoring provides information on the current status of shad stocks relative to conditions prior to the moratorium dating to 1980 in the James and Rappahannock rivers. In the case of the York River, monitoring allows assessment of current status relative to catch rates recorded in the 1980s and the 1950s.

- Sampling occurred for thirteen weeks on the James River (16 February to 5 May 2009), twelve weeks on the York River (25 February to 5 May 2009) and ten weeks on the Rappahannock River (10 March to 12 May 2009). After 27 April, post-spawning fish were mixed with pre-spawning fish in the catch on the York River. No post-spawning fish were observed on the James or Rappahannock River in 2009. Only pre-spawning fish were included in the calculation of catch indices for each river. A total of 633 pre-spawning female American shad (900.5 kg total weight) were captured. The 2009 total catch increased from the 2008 catch (431 pre-spawning females weighing 623.7 kg).

- Total numbers and weights of females in 2009 were similar on the York (n=165, 240.3 kg) and James (n=156, 218.7 kg) Rivers. The highest catch of females was on the Rappahannock River (n=312, 441.5 kg). Numbers of males captured were: James, 23; York, 39; Rappahannock River, 49. The total weight of males captured on all rivers was 132.97 kg. The total catch and weight of males was higher than it was in 2008 (n=71, 80.63 kg).

- Based on age estimates from scales, the 2004 (age 5) year class of female American shad was the most abundant on the James and Rappahannock Rivers, with peak age-specific seasonal catch rates exceeding 0.0136 kg/m and 0.0341 kg/m respectively. On the York River, the 2003 and 2004 (age 6 and 5) year classes were most abundant with similar seasonal catch rates of 0.0135 kg/m and 0.0144 kg/m. The 2003 (age 6) year class was also abundant on the James and Rappahannock Rivers with seasonal catch rates exceeding 0.0090 kg/m and 0.0202 kg/m respectively. Total instantaneous mortality rates of females calculated from age-specific catch rates were: York River, 0.95 (r^2=0.90); James River, 0.67 (r^2=.95); and Rappahannock River, 1.18 (r^2=0.97). Total instantaneous mortality rates of males calculated from age-specific catch rates were: York River, 0.72 (r^2=0.88); James River, 0.45 (r^2=0.49); and Rappahannock River, 0.81 (r^2=0.94).

- Otoliths of 90 American shad captured on the James River were scanned for hatchery marks. The proportion of the sample with hatchery marks on the James River was 8.8% (8 of 90 fish). In 2007 and 2008 the prevalence of fish with hatchery marks was 32.2% and 25.6%, respectively.

- The geometric mean catch (followed by standard deviation and number of seine hauls in parentheses) of juvenile American shad captured in daylight seine hauls in 2009 was: James River (inclusive of Chickahominy River), 0.05 (0.176, 30); Chickahominy River, 0.07 (0.219, 10); Rappahannock River, 0.13 (0.360, 34); York River (inclusive of Pamunkey and Mattaponi rivers), 0.01 (0.115, 92); Mattaponi River, 0.02 (0.160, 47); and Pamunkey River, 0 (0, 40).

- Twenty-four species of fishes (total of 14,573 specimens) were caught as by-catch in the staked gill net monitoring gear. On 28 April by-catch was not recorded on the Rappahannock River. The total number of striped bass captured was 3,024 (James River, n=1,224; York River, n=990; Rappahannock River, n=810). Live striped bass captured in the gear were counted and released. A random subsample of the dead striped bass was brought back to the laboratory for analysis. Sex, fork length, and total weight were recorded for each specimen. The proportions of dead striped bass on each river were: James River, 35.9%; York River, 34.1%; and the Rappahannock River, 44.3%.

- In monitoring years 2000-2005, mean age of females increased as a result of lower proportions of younger fish in the monitoring catch. In 2006, mean age of females decreased sharply, signaling an influx of younger fish on all three rivers. In 2007 and 2008, mean age increased again as this year class of young fish matured. In 2009, mean age of females decreased on the James and Rappahannock Rivers. This is due to the absence of older year classes and relatively high catches of the 2004 and 2005 year class. On the York River, mean age of females increased. This is primarily due to a weak 2005 year class.

- A seasonal catch index was calculated by estimating the area under the curve of daily catch versus day for the years 1998-2009 and for each year of the historical record of staked gill net catches on each river. On the York River, the seasonal catch index in 2009 (2.92) decreased from the 2008 value and is similar to the 2006 value (2.85), which is the lowest value recorded in the time series. During the eleven years of monitoring, the index has been variable with high values (>12) in 1998 and 2001 and lower values (<9) in other years. The geometric mean of the historical data during the 1980s on the York River is 3.22. The geometric mean of the current monitoring data is higher (6.20) but this mean is lower than the geometric mean of catch indexes from logbook records in the 1950s (17.44).

These older data were adjusted for differences in the efficiency of multifilament and monofilament nets using the results of comparison trials in 2002 and 2003.

- On the James River, the 2009 index (2.69) increased from the low value of 1.51, which was recorded in 2008. The geometric mean of the historical data during the 1980s on the James River is 6.40 while the geometric mean of the current monitoring data is lower (4.10). The stock continues to be dependent on hatchery inputs since recruitment of wild fish is negligible based on available data from juvenile abundance surveys.

- The catch index on the Rappahannock River in 2009 (5.36) increased from the 2008 value (3.12). The 2009 index is the highest value seen since 2004 (7.06). The 2004 index is the highest value in the time series since monitoring began in 1998. The geometric mean of the historical data during the 1980s on the Rappahannock River is 1.45. The geometric mean of the current monitoring data is higher (3.26).

Preface

Concern about the decline in landings of American shad (*Alosa sapidissima*) along the Atlantic coast prompted the development of an interstate fisheries management plan (FMP) under the auspices of the Atlantic States Marine Fisheries Management Program (ASMFC 1999). Legislation enables imposition of federal sanctions on fishing in those states that fail to comply with the FMP. To be in compliance, coastal states are required to implement and maintain fishery-dependent and fishery-independent monitoring programs as specified by the FMP. For Virginia, these requirements include spawning stock assessments, the collection of biological data on the spawning run (e.g., age-structure, sex ratio, and spawning history), estimation of total mortality, indices of juvenile abundance, biological characterization of permitted by-catch and evaluation of restoration programs by detection and enumeration of hatchery-released fish.

This annual report documents continued compliance with Federal law. Since 1998, scientists at the Virginia Institute of Marine Science have monitored the spawning run of American shad in the James, York and Rappahannock rivers. The information resulting from this program is reported annually to the ASMFC, has formed the basis for a significant number of technical papers published in the professional literature, formed the basis for a recent coast-wide stock assessment and peer review for American shad (ASMFC 2007a, 2007b) and is contributing substantially to our understanding of the status and conservation of this important species.

A number of individuals make significant contributions to the monitoring program and the preparation of this report. Commercial fishermen Tony Kellum, Raymond Kellum, Marc Brown and Jamie Sanders construct, set, and fish the sampling gear and offer helpful advice. They have participated in the sampling program since its beginning in 1998. Their contributions as authors of historic log books of commercial catches during the 1980s and as expert shad fishermen are essential elements of the monitoring program. We also extend our appreciation to several commercial fishers for their cooperation in our studies of by-catch of American Shad. In 2009, these individuals include: Kenneth Heath, Joseph Hinson, Demtri Hionis, George Trice, Robert Weagley, and Charles Williams. In 2009, the staff and students of the Virginia Institute of Marine Science who participated in the program were: B. Watkins, P. Crewe, A. Rhea, and R. Harris. Their dedication, consistent attention to detail and hard work in the field and in the laboratory are appreciated. B. Watkins determined ages of fish. B. Watkins and A. Rhea determined hatchery origins of fish. Fish products from the sentinel fishery are donated to the Food Bank of Newport News, Virginia. We offer thanks to the Hunters for the Hungry (Virginia Hunters Who Care) organization for their assistance.

Introduction

A moratorium on the taking of American shad (*Alosa sapidissima*) in the Chesapeake Bay and its tributaries was established by the Virginia Marine Resources Commission (VMRC) beginning 1 January 1994. The prohibition applied to both recreational and commercial fishers, and was imposed at a time when commercial catch rates of American shad in Virginia's rivers were experiencing declines. At the time, data from the commercial fishery were the best available for assessing the status of individual stocks. Catch-per-unit-effort (CPUE) data were compiled from logbooks that recorded landings by commercial fishermen using staked gill nets at various locations throughout the middle reaches of the James, York and Rappahannock rivers. The logbooks were voluntarily provided to the Virginia Institute of Marine Science (VIMS) during the period 1980-1992, and subsequently used in an assessment of the status of American shad stocks along the Atlantic coast by the Atlantic States Marine Fisheries Commission (ASMFC) (ASMFC 1999).

Immediately following the moratorium, there were no monitoring programs that provided direct assessment of stock recovery. The ban on in-river fishing in Virginia remained in effect, creating a dilemma for managers who needed reliable information in order to make a rational decision on when the in-river ban could be lifted safely. To address this deficiency, a method of scientific monitoring was proposed to estimate catch rates relative to those recorded before the prohibition of in-river fishing in 1994. This monitoring program began in 1998 and consisted of sampling techniques and locations that were consistent with, and directly comparable to, those that generated historical logbook data collected by VIMS during the period 1980-1992 in the York, James and Rappahannock rivers. The results of the twelfth year in the sampling program (2009) are reported in this document and compared to some results in previous years of monitoring. Detailed results of the first eleven years of sampling (1998-2008) are reported in previous annual reports (Olney and Hoenig 2000a, 2000b; Olney and Hoenig 2001a; Olney and Maki 2002; Olney 2003a, 2004, 2005; Olney and Delano 2006; Olney and Walter 2007; Olney and Watkins 2008, 2009). Copies of these reports are available upon request.

In addition to the objective of assessment of the status of stocks in Virginia's rivers, there are other significant information needs. First, extensive efforts are being made to rehabilitate shad stocks through release of hatchery-raised fish. Evaluating the success of these programs requires determination of the survival of the stocked fish to adulthood. Second, there is an extensive time series of observations on juvenile shad abundance from push net surveys in the York River and seine surveys in the James, York and Rappahannock rivers. These juvenile index data could have utility for predicting future spawning run sizes, detecting years of failed recruitment and confirming the health of the stocks.

These ongoing studies of American shad in Virginia waters are significant to recreational fisheries for at least three reasons.

- American shad fight well when angled using light tackle. Harvest of American shad by the recreational fishery in the James, York and Rappahannock rivers is

prohibited but recreational fishing is popular in Florida, North Carolina, Maryland and several other states where these bans do not exist. Anecdotal information suggests that there were historical recreational fisheries for American shad on the James, Mattaponi and Rappahannock rivers. Currently, many anglers catch and release American shad and legally harvest hickory shad (*Alosa mediocris*) on the James River near Richmond, the Mattaponi River above Walkerton, and the Rappahannock River near Fredericksburg. Recreational fishing also occurs on the Nottoway and Blackwater rivers near Franklin, Virginia; these rivers, however, do not drain into the Chesapeake Bay and the ban on harvest does not apply to these spawning stocks. Continued development of a recreational shad fishery in Virginia could constitute an important opportunity to expand or restore recreational fishing opportunities if the stocks are rehabilitated and managed carefully.

- American shad are important for trophic and ecological reasons. Spawning site selection by adults as well as the abundance and occurrence of juveniles are closely linked to water quality and the availability of good fish habitat. Young shads and river herrings (*Alosa* spp.) form an important prey group for striped bass and other recreationally important species in Chesapeake Bay. The decaying carcasses of post-spawning anadromous fishes are known to play an important role in nutrient and mineral recycling in riverine and estuarine systems. In recent years, there have been shifts in community structure in the major tributaries to the Chesapeake Bay with striped bass and gizzard shad numbers increasing greatly. Monitoring changes in abundance of key species is essential for understanding community dynamics.

- Monitoring the shad spawning run using historic gear also allows for a description of the by-catch associated with a commercial fishery for shad in Virginia's rivers. This is important for determining the impact of the commercial fishery for shad on other recreationally important species, especially striped bass, if the ban on commercial and recreational harvest was lifted.

Background

Herring and shad have supported recreational and commercial fisheries along the east coast of the United States and within the Chesapeake Bay since colonial times. They also play a vital ecological role. Juvenile *Alosa* are important prey for striped bass and other recreational species while they remain on their freshwater and upper estuarine nursery grounds. In the autumn they move to coastal waters where they are subjected to predation by many types of marine piscivores until they return to their native streams to spawn for the first time at ages 3 to 7 (Maki et al., 2001, Limburg et al. 2003).

Management and conservation of Virginia's stocks of American shad date to colonial times. Before Virginia was settled, Native Americans caught American shad in large quantities using a seine made of bushes (Walburg and Nichols 1967). Shad were so

plentiful that they could be speared with pointed sticks as they swam on the flats (VCF 1875). Remains of American shad and Atlantic sturgeon have been found in recent archaeological digs at Jamestown, the site of first English settlement (Bowen and Andrews 2000). Apparently, these species were important dietary components during the starving time in 1609. The early settlers used haul seines, and utilized shad as a major food supply (Walburg and Nichols 1967). By 1740, shad were less abundant, presumably due to fishing and obstructions that prevented them from reaching their spawning grounds. Concerned colonists passed laws requiring the removal of dams or the building of fish passages, and prohibiting hedges and other obstructions (VCF 1875). In 1771, the Virginia Assembly passed a law requiring that a gap for fish passage be built in dams adhering to specific dimensions, and that it be kept open from February 10 to the last day of May. However, due to the approaching conflict of the Revolutionary War, the law was never enforced (VCF 1875).

The shad fishery of Chesapeake Bay became important about 1869, and developed greatly in the ensuing years. Fishing gear used included haul seines, pound nets, and staked gill nets (Walburg and Nichols 1967). Catches reached a low in 1878, and the U.S. Fish Commission and Virginia Commission of Fisheries instituted an artificial hatching program in 1875. By 1879 the fishery began to improve, and the increase in catches led biologists to believe that the shad fishery was largely dependent upon artificial propagation. However, by the early 1900s the decline in shad harvests resumed despite improved hatching methods and increased numbers of fry released (Mansueti and Kolb 1953).

Stevenson (1899) provided important information on catch and effort in the American shad fishery in Virginia during the fishing season in 1896. Using an average weight per female of 1.7 kg, the following fishery statistics can be obtained from his report. On the lower James River, 60,750 females (approximate weight: 103,278 kg) were landed by staked gill nets totaling approximately 79,263 m in length. On the York River, 28,232 females (approximate weight: 49,994 kg) were landed by staked gill nets totaling approximately 5,874 m in length. The value of these roe shad in 1896 dollars was approximately $4,000. On the Rappahannock River, 104,118 females (approximate weight: 177,000 kg) were landed by staked gill nets totaling 24,694 m in length. The local value of these shad was approximately $8,000. Seasonal catch averages (total female weight/total length of net) depict higher seasonal catch rates on the York River (8.5 kg/m) and the Rappahannock River (7.2 kg/m) than on the James River (1.3 kg/m) in 1896. Stevenson (1899) also reported large catches of American shad on the Chickahominy and Appomattox rivers in 1896.

Nichols and Massmann (1963) estimated total catch, fishing rate, escapement and total biomass of American shad in the York River in 1959 and summarized landings during the period 1929-1959. Landings were low (~100,000 lbs annually) in the 1930s but rose abruptly in the years following World War II, reaching the highest levels (400,000-700,000 lbs annually) in the 1950s. During this latter period of higher annual landings, catch-per-unit-effort remained relatively constant. Of the major gears used in the fishery in 1959 (pound nets, haul seines, fyke nets, stake gill nets and drift gill nets),

gill nets (stake and drift combined) accounted for the greatest effort expended and the highest total catches. A tagging study conducted in 1959 produced the following estimates: overall fishing rate, 55.2%; estimated population biomass, 838,892 lbs; and estimated escapement, 375,768 lbs. Using catch and effort data, Nichols and Massmann (1963) estimated population biomass for the period 1953-1959 to range from 839,000-1,396,000 lbs. Sex composition of the catch was not reported. Using the average female weight of 3.2 lbs in 1959 and assuming that the sex ratio of the catch was 1:1, the estimated total number of females in the York River in 1953-1959 ranged from about 131,000-218,125.

Today, many American shad stocks along the eastern seaboard of the United States are in low abundance (Figure 1). Large catches no longer occur as they did at the turn of the century and in many areas, including Chesapeake Bay, harvest is banned or severely restricted. Commercial American shad landings in Virginia decreased from 11.5 million pounds in 1897 to less than a million pounds in 1982. Over-fishing, dam construction, pollution, and loss of natural spawning grounds are a few of the factors that may be related to this decline. Historically, the majority of American shad were captured within the rivers. Beginning in 1984, the largest proportion of American shad taken in Virginia's fishery was captured offshore. The overall impact of this shift in the fishery on egg production and annual recruitment of Virginia stocks is unknown. Genetic studies of the catch composition of Virginia and Maryland's coastal landings have suggested that the intercept fishery claimed a highly variable proportion of Virginia's riverine stocks (Brown and Epifanio 1994). American shad were pursued by recreational fishermen in Virginia in the past, but the extent and success of this activity is not easily assessed.

In spring 1994, the Virginia Department of Game and Inland Fisheries (VDGIF) and the US Fish and Wildlife Service (USFWS) began a hatchery-restocking effort in the James and Pamunkey rivers. Adult shad from the Pamunkey River are used as brood stock, eggs are stripped and fertilized in the field, and larvae are reared in the VDGIF hatchery at Stephensville, Virginia, and the USFWS hatchery at Harrison Lake, Virginia. Prior to release, the larvae are immersed in an oxytetracycline (OTC) solution that marks otoliths with a distinctive epifluorescent ring. The initial success of this ongoing program was documented by Olney et al. (2003) who reported that catch rates by monitoring gear increased in 2000-2002 as large numbers of mature hatchery fish returned to the James River.

In most years, prevalence of hatchery fish returning as adults to the York system is low (~2-4 % each year; Olney and Hoenig 2000a, 2000b, 2001a; Olney and Maki 2002, Olney 2003a, Olney 2004, Olney 2005). Annual monitoring of the abundance of juvenile *Alosa* spp. (American shad, hickory shad, blueback herring and alewife) was conducted on the Pamunkey River system during 1979-2002. After 1995, juveniles bearing the OTC mark were collected by VIMS and VDGIF. The data show that hatchery-released larval shad constituted 0.1-8 % of the total catch of juveniles on the Pamunkey River during the 4-y period (1995-1999). VDGIF personnel also began a new hatchery-release program on the upper Rappahannock River in 2003. The restoration program uses progeny of Potomac River brood stock. The goal of this program is to restore American shad to historical spawning areas that were previously blocked by Embrey Dam.

Prior to 1991, there were no restrictions on the American shad commercial fishery in Virginia rivers and the Chesapeake Bay. A limited season (4 February - 30 April) was established for 1991 by the Virginia Marine Resources Commission (VMRC), and kept in place in 1992. In 1993, a further limitation to the season was established (15 March - 15 April 1993). However, due to bad weather conditions, the season was extended through 30 April. A complete moratorium was established in 1994. At that time, the regulation stated:

> "On and after 1 January 1994 it shall be unlawful for any person to catch and retain possession of American shad from the Chesapeake Bay or its tidal tributaries." (VMRC Regulation 450-01-0069).

In 1997 and 1998, during a series of public hearings, commercial-fishing interests asked that the in-river ban on shad fishing be lifted. This proposal was opposed by the VMRC staff, scientists of the Virginia Institute of Marine Science, and representatives of various other public and private agencies. The Commission decided to leave the ban in place but also decried the lack of information necessary to assess the recovery of Virginia stocks of American shad. The current monitoring project began in the spring of 1998 in response to the VMRC's request for information.

In spring 2003, Virginia imposed a 40% reduction in effort on the ocean intercept (gillnet) fishery prosecuted on the coast. This reduction in effort was mandated by the ASMFC. According to Amendment 1 (ASMFC 1999), "[States] must begin phase-out reduction plans for the commercial ocean-intercept fishery for American shad over a five-year period. States must achieve at least a 40% reduction in effort in the first three years, beginning January 1, 2000." The Virginia offshore fishery was closed on 31 December 2004.

In spring 2006, the VMRC authorized a limited by-catch fishery for American shad in specific areas. This by-catch authorization was extended into the 2009 fishing season (see Appendix 1). Fishers with special permits were allowed to possess fish caught in anchored or staked gill nets in the by-catch area. The by-catch area in 2009 was defined as those tidal waters of (i) the James River, from the James River Bridge upstream to a line connecting Dancing Point and New Sunken Meadow Creek; (ii) the York River, from the George P. Coleman Bridge upstream to the Rt. 33 Eltham and Lord Delaware bridges at West Point; and (iii) the Rappahannock River, from the Norris Bridge upstream to the Rt. 360 Downing Bridge at Tappahannock. Limits were 10 American shad per boat per day and fishers were required to phone in a weekly report of the harvest. In addition, American shad by-catch could only be possessed if equal numbers of other species (such as striped bass) were also landed.

Current Information

Historic and current catch data can be accessed through the VMRC website (http://www.mrc.state.va.us). Annual monitoring of the abundance of juvenile *Alosa* spp. (American shad, hickory shad, blueback herring and alewife) was conducted on the York River system with a push net developed in the late 1970s (Kriete and Loesch, 1980) until 2002. The data record extends back to1979 but sampling was not conducted during 1987-1990. The push net survey was terminated in 2002 when it was determined that the survey results were highly correlated with those of the striped bass seine survey (Wilhite et al., 2003). Although fewer individual fish are collected each year in the seine survey as compared to the evening push net survey, the seine survey has larger geographic coverage (all three rivers in Virginia vs. the Mattaponi and Pamunkey Rivers only) and the data record is uninterrupted since 1979.

Since the American shad monitoring program at VIMS began in 1998, 23 papers on various aspects of the biology of American shad and the VIMS stock assessment program have appeared in peer-reviewed journals (Maki et al., 2001; Olney et al., 2001; Olney and Hoenig, 2001b; Maki et al., 2002; Bilkovic et al., 2002a, 2002b; Olney and McBride, 2003; Olney et al., 2003; Walter and Olney, 2003; Wilhite et al., 2003; Olney 2003b; Hoffman and Olney, 2005; McBride et al., 2005; Maki et al., 2006; Olney et al., 2006a, b; Hoffman et al. 2007; Hoffman et al. 2007a, b; Hoffman et al. 2008, Walther et al. 2008; Hoenig et al. 2008; Aunins and Olney 2009). Reprints of these papers are available on request.

VIMS' authors contributed to three peer-reviewed sections to the recent stock assessment for American shad (Olney 2007; Olney et al. 2007; Carpenter et al 2007). In addition, manuscripts based on two completed theses describing the spawning grounds of American shad in the James River (Aunins 2006) and seasonal fecundity of shad in the York River (Hyle 2004) are in preparation. Two additional studies formed the basis for a thesis and a dissertation that were supported in part by the monitoring program: a validation of age determination of American shad using otolith isotopes as natural tags (Upton 2008) and a study of the population dynamics of juvenile *Alosa* spp. in Virginia rivers (Tuckey 2009); manuscripts based on these theses are currently in review. Finally, our monitoring data have been used in a recent revision of the on-line Chesapeake Bay Report presented annually by the Chesapeake Bay Program of the Environmental Protection Agency (http://www.chesapeakebay.net).

Objectives

The primary objectives of the monitoring program have remained largely unchanged since 1998: (1) to establish time series of relative abundance indices of adult American shad during the spawning runs in the James, York and Rappahannock rivers; (2) to relate contemporary indices of abundance of American shad to historical logbook data collected during the period 1980-1992 and older data if available; (3) to assess the relative contribution of hatchery-reared and released cohorts of American shad to adult

stocks; (4) to relate recruitment indices (young-of-the-year index of abundance) of American shad to relative year-class strength and age-structure of spawning adults; and (5) to determine the amount of by-catch of other species in the staked gill nets.

In 2006 an additional objective (6) was added to monitor a new by-catch fishery for American shad established by the VMRC. The results of this monitoring in 2009 are appended as a report to the American shad and river herring technical committee as Appendix I.

Methods

The 2009 sampling methods for the monitoring program were the same as those in 1998-2008 (see Appendix I for additional methods used to monitor the by-catch fishery). In 1998, a sentinel fishery was developed that was as similar as possible to traditional shad fishing methods in the middle reaches of Virginia's rivers. When the in-river fishing moratorium was imposed in 1994, commercial fishermen who held permits for existing stands of staked gill nets (SGNs) were allowed to retain priority rights for the locations of those stands in the various rivers. VIMS has records of the historic fishing locations (Figures 2-4), and one of these locations on each river (the James, York and Rappahannock) was used to monitor catch rates by SGNs in 1998-2009. Three commercial fishermen were contracted to prepare and set SGN poles, hang nets, replace or repair poles or nets, and set nets for each sampling event during the monitoring period. Two of these commercial fishermen, Mr. Raymond Kellum (Bena, Virginia) and Mr. Marc Brown (Rescue, Virginia), were authors of the historical logbooks on the James and York rivers. However, authors of historic logbooks on the Rappahannock River were either retired or not available. Thus, we chose a commercial fisherman (Mr. Jamie Sanders, Warsaw, Virginia) who had previous experience in SGN fishing but who had not participated in the shad fishery on the Rappahannock River in the 1980s. Scientists accompanied commercial fishermen during each sampling trip and all catches were returned to the laboratory for analysis.

One SGN, 900 ft (approximately 274 m) in length, was set on the York and James rivers (Figures 5-6). One staked gill net, 912 ft (approximately 277 m) in length, was set on the Rappahannock River (Figure 7). Locations of the sets were as follows: lower James River near the James River Bridge at river mile 10 (36^0 50.0' N, 76^0 28.8' W); middle York River near Clay Bank at river mile 14 (37^0 20.8' N, 76^0 37.7' W); and middle Rappahannock River near the Rappahannock River bridge (at Tappahannock) at river mile 36 (37^0 55.9' N, 76^0 50.4' W). Historical catch-rate data on the York and James rivers were derived from nets constructed of 4 7/8" stretched-mesh monofilament netting, while historic data from the Rappahannock River were based on larger mesh sizes (nets constructed of 5" stretched-mesh). To insure that catch rates in the current monitoring program were comparable to logbook records, nets on the York and James rivers were constructed of 4 7/8" (12.4 cm) stretched-mesh monofilament netting, while nets on the Rappahannock River were constructed of 5" (12.7 cm) netting. Panel lengths were consistent with historical records (30 ft each on the James and York rivers; 48 ft each on

the Rappahannock River). Each week, nets were fished on two succeeding days (two 24-h sets) and then hung in a non-fishing position until the next sampling episode. Occasionally, weather prevented the regularly scheduled sampling on Sunday and Monday, and sampling was postponed, canceled or re-scheduled for other days. In 2009, sampling occurred for thirteen weeks on the James River (15 February to 5 May 2009); twelve weeks on the York River (24 February to 5 May 2009); and ten weeks on the Rappahannock River (9 March to 12 May 2009). Surface water temperature and salinity were recorded at each sampling event.

Individual American shad collected from the monitoring sites were measured and weighed on a Limnoterra FMB IV electronic fish measuring board interfaced with a Mettler PM 30000-K electronic balance. The board recorded measurements (fork length and total length) to the nearest mm, received weight input from the balance, and allowed manual input of additional data (such as field data and comments) or subsample designations (such as gonadal tissue and otoliths) into a data file for subsequent analysis. Catches of all other species were recorded and enumerated on log sheets by observers on each river and released. For striped bass (*Morone saxatilis*), separate records were kept of the number of live and dead fish in the nets and released (if alive) or returned to the laboratory (if dead). Random subsamples of dead striped bass from each river were analyzed for sex, fork length and total weight.

Sagittal otoliths were removed from samples of adult American shad, placed in numbered tissue culture trays, and stored for subsequent screening for hatchery marks. To scan for hatchery marks, otoliths were mounted on slides, then ground and polished by hand using wet laboratory-grade sandpaper. Otolith scanning was performed by B. Watkins (VIMS) in 2005-2009. Scanning in previous years was performed by D. Hopler (VDGIF), J. Goins (VIMS) and G. Holloman (VIMS).

Scales for age determination were removed from a mid-lateral area on the left side posterior to the pectoral-fin base of each fish. Scales were cleaned with a dilute bleach solution, mounted and pressed on acetate sheets, and read on a microfilm projector by one individual (B. Watkins, VIMS) using the methods of Cating (1953). Ages were determined by a different reader in 1998-2002 (K. Maki). To ensure consistency, B. Watkins has re-aged all scale samples collected during the monitoring program.

An ASMFC age-determination workshop using known-age fish from the Susquehanna River system was held at VIMS in August 2004 to test the validity of scale-age techniques (McBride et al., 2005). As a result of this analysis, the ASMFC stock assessment subcommittee chose to moderate its use of age data in the 2007 coastwide assessment but not abandon those data entirely (Olney 2007). One recommendation of the workshop was to validate age determination in all major stocks. Upton et al. (in review) used a unique stable isotope signature to track the 2002 cohort for three consecutive years (age-4, age-5, and age-6) in the York River. Neither scale-based methods nor whole otolith-based methods were found to be suitable for aging fish, with 50% and 62% of individuals incorrectly aged, respectively.

Catch data from each river were used to calculate a standardized catch index (the area under the curve of daily catch rate versus time of year). The catch index, the duration of the run in days, the maximum daily catch rate in each year and the mean catch rate in each year were compared to summaries of historical logbook data to provide a measure of the relative size of the current shad runs. In the historical data, catches are reported daily through the commercial season with occasional instances of skipped days due to inclement weather or damaged fishing gear. In the current monitoring data, catches on two successive days are separated by up to five days (usually Tuesday-Saturday) in each week of sampling. In some rare cases, catches are separated by more than five days. To compute the catch index, we estimated catches on skipped days using linear interpolation between adjacent days of sampling.

Results

Catches of American shad by staked gill nets in 2009

Fishing days, numbers of American shad captured, catch rates (males and females) and length frequencies are reported in Tables 1-8 and Figures 8-15. On 27 and 28 April 2009 post-spawning American shad were encountered on the York River. Post-spawning fish were identified macroscopically and microscopically depending on gonad condition. Since the historic fishery was a roe fishery and spent or partially-spent fish were not routinely captured or marketed in the historic fishery, post-spawning fish were removed from the monitoring sample.

A total of 744 American shad (111 males; 633 females) were captured. The total weight of the sample was 1033.50 kg (male, 132.97 kg; female, 900.53 kg). Catches in 2009 were lowest on the James River (179 total fish, 23 males and 156 females) and York River (204 total fish, 39 males and 165 females). Catches on the Rappahannock River (361 total fish, 49 males and 312 females) were highest.

On the York River, catches of females peaked on 24 March – 6 April when catch rates usually exceeded 0.04 fish/m or 0.06 kg/m. During that period on the York River, 39% (64 of 165) of all females were captured. Surface temperatures during this time ranged from 9.2^{o}C - 14.0^{o}C. The largest catch of pre-spawning female American shad on the York River (26 fish) occurred on 30 March when the surface temperature was 11.2^{o}C (Figure 16). On the James River, catches of females peaked between 16 March and 13 April. Catch rates during this time were sporadic with peaks reaching 0.09 fish/m or 0.13 kg/m and lows occurring at 0.02 fish/m or 0.02 kg/m. During that period on the James River, 78% (121 of 156) of all females were captured. Surface temperatures during this time ranged from 8.6^{o}C – 12.6^{o}C. The two largest catches of pre-spawning female American shad on the James River (25 fish each) occurred on 17 March and 6 April when surface temperatures were 8.1^{o}C and 13.9^{o}C respectively (Figure 16). Catches of females on the Rappahannock River peaked on 6 April – 21 April when catch rates exceeded 0.19 fish/m or 0.26 kg/m. During that period on the Rappahannock River, 72% (223 of 312) of all females was captured. Surface temperatures during this time ranged from 11.8^{o}C –

15.0°C. The largest catch of pre-spawning female American shad on the Rappahannock River (54 fish) occurred on 21 April when the surface temperature was 15.0°C (Figure 17). As in previous years of monitoring, numbers and catch rates of males were lower than catch rates of females throughout the period. Sex ratios (males:females) were: York River, 1:4.2; James River, 1:6.8; Rappahannock River, 1:6.4. It is important to note that the monitoring gear mimics an historical fishery that was selective for mature female fish.

The duration of the spawning run is defined as the number of days between the first and last observation of a catch rate that equals or exceeds 0.01 female kg/m. The 2009 spawning run duration was estimated to be 55 days on the James River (10 March – 5 May), 69 days on the York River (26 February – 5 May), and 50 days on the Rappahannock River (11 March – 28 April).

Biological characteristics of the American shad catch in 2009

Age, mean length (mm TL) and mean weight (g) of American shad in staked gill nets are summarized in Tables 9-10. Patterns of mean age are depicted in Figure 22 and 23. Mean total length at age of males and females from all rivers ranged from 389.0 – 520.0 mm TL and 456.6 – 569.0 mm TL, respectively. Mean weight at age of males and females from all rivers ranged from 0.57 – 1.7 kg and 1.19 – 2.05 kg, respectively.

Using scale-based ageing methods, we estimated that the 2005, 2004 and 2003 year classes (ages 4, 5 and 6) of female American shad were the most abundant on the James and Rappahannock Rivers (Table 11). The 2004, 2003 and 2002 year classes (ages 5, 6 and 7) were most abundant on the York River. On the James River, four age-classes of females were represented (2002-2005, ages 4-7) and with the sample dominated by age-5 fish (47.1% of the total that was aged). On the York River, six age-classes of females were represented (2000-2005, ages 4-8). The sample was equally represented by age-5 (39.1% of the total that was aged) and age-6 (39.7% of the total that was aged) fish. On the Rappahannock River, six age-classes of females were taken (2000-2005, ages 4-9) with the sample dominated by age-5 fish (47.9 % of the total that was aged).

The 2004 and 2003 year classes of males were the most abundant on the York, James, and Rappahannock Rivers, respectively (Table 12). These year classes (ages 5-6) of male American shad constituted 80.0 % (York River), 70.6 % (James River) and 76.2 % (Rappahannock River) of the aged sample. Mean age of females in each river have followed similar patterns until 2008 (Figure 22). In 2009, mean age of females decreased on the James and Rappahannock River and increased on the York River. This difference can be primarily attributed to a weak 2005 year-class on the York River. Mean age in 2009 was 5.4 y (James River), 5.2 y (Rappahannock River) and 5.7 y (York River).

Age-specific catch rates of American shad are reported in Tables 11-12. Total instantaneous mortality (Z) was estimated using simple linear regression analysis of the natural log of age-specific catch on the descending limb of the catch curve. Total instantaneous mortality rates of females were: York River, 0.95 (r^2=0.90); James River, 0.66 (r^2=0.95); and Rappahannock River, 1.19 (r^2=0.97). Total instantaneous mortality

rates of males calculated from age-specific catch rates were: York River, 0.72 (r^2=0.88); James River, 0.45 (r^2=0.49); Rappahannock River, 0.81 (r^2=0.94).

Spawning histories of American shad collected in 2009 are presented in Tables 13-14. On the York River, fish (both sexes combined) ranged in age from 4–9 years with 0 (virgin) to 4 spawning marks. On the James River, fish (both sexes combined) ranged in age from 4–8 years with 0-4 spawning marks. On the Rappahannock River, fish (both sexes combines) ranged in age from 4-9 years with 0-4 spawning marks. The following percentages of fish in each river had at least one prior spawn (termed "repeat spawners"): York River, 66.8 % (60 virgins in a sample of 181); James River, 63.1 % (58 virgins in a sample of 157); Rappahannock River 46.4 % (179 virgins in a sample of 334 fish).

Evaluation of hatchery origin of American shad in 2009

James River - Otoliths of 90 American shad captured in staked gill nets on the James River were processed for hatchery marks. The proportion of the 2009 sample with hatchery marks was 8.8% (8 of 90 fish). The biological attributes of these specimens are presented in Table 15. Prevalence of hatchery fish has been variable with a peak of 51.4% in 2003. From 2003 to 2006, prevalence declined to 10.3%. In 2007, the proportion of fish with hatchery tags once again rose to 32.2%. In 2008, prevalence was 25.6% and the 2009 value is the lowest value seen in 10 years of monitoring. In most years, fish with hatchery tags from rivers other than the James River were detected in the monitoring sample. These strays were not included in the estimates of hatchery prevalence and are as follows (year captured as an adult, number, river of release): 1999, n= 1, Patuxent River (Maryland); 2000, n= 7, Pamunkey River (Virginia) and Juniata River (Pennsylvania); 2001, n= 3, Pamunkey River, Juniata River, and the western branch of the Susquehanna River (Pennsylvania); 2002, n= 2, Pamunkey River, n= 2 unknown tag; 2005, n=3, tentatively Pamunkey River and Mattaponi River (Virginia); 2007, n=1, Pamunkey River; 2008, n=1, Undetermined; 2009, n=1, Chemung River (New York). In 2003, 2004, and 2006 there were no stray fish.

Most hatchery-reared adults taken in 2009 had OTC marks that indicated these specimens were released after 2002. These tags could not be easily differentiated microscopically, so we determined the year of release using scale-determined ages (Tables 13-16). Most of the fish in the sample were from the 2002, 2003 and 2004 year class. All of these fish had spawned at least once. Only one fish was from the 2005 year class indicating low survivability in that year. The absence of year 4 shad is a contributing factor in the low prevalence of hatchery fish in 2009.

York and Rappahannock Rivers - Otoliths of 50 American shad (24.2% of the total that were caught) from the York River were processed for hatchery marks. No fish with hatchery marks were detected from this subsample. In 2009, 80 American shad (22.2% of the total that were caught) from the Rappahannock river were scanned for the prevalence of hatchery marks. Three specimens (3.8%) with OTC marks were detected in this sample. Stocking of American shad in the Rappahannock River began in 2003.

Juvenile abundance of American shad

Tables 17 and 18 and Figures 18-21 report index values of juvenile abundance of American shad based on seine surveys (1979-2009) on the James and Chickahominy rivers, the Rappahannock River, the main stem of the York River, the Pamunkey River and the Mattaponi River. The geometric mean catch (followed by standard deviation and number of seine hauls in parentheses) of juvenile American shad captured in daylight seine hauls in 2009 was: James River, inclusive of Chickahominy River, 0.05 (0.176, 30); Chickahominy River, 0.07 (0.219, 10); Rappahannock River, 0.13 (0.360, 34); York River, inclusive of Pamunkey and Mattaponi Rivers, 0.01 (0.115, 92); Mattaponi River, 0.02 (0.160, 47); and Pamunkey River, 0 (0, 40). Calculations for all years were adjusted in 2009 to include fish greater than 72 mm, which had not been included in the indices in previous years.

The seine survey data on the James River (Table 17) shows an increase in abundance in recent years. In 2009, James River indices for all years were recalculated to include seine survey stations located in the Chickahominy River. Independent results from the Chickahominy River are also reported, although it is unknown whether fish captured in this river form a unique stock (i.e., distinct from that of the James River). Stocking of American shad took place on Chickahominy Lake in 2000 and on the Chickahominy River in 2004. Results from an independent survey below Bosher's Dam on the James River depict no measureable recruitment in most years (VDGIF, T. Gunter, pers. comm.). On the Rappahannock River, the highest JAI values (>0.5) were recorded in 1982, 1989, 2003 and 2004. The Rappahannock River time series depicts no measurable recruitment in 1980-1981, 1985, 1988, 1991-1992, 1995, and 2002.

Within the York River system, except for 2003, the juvenile index values based on the seine survey are consistently higher on the Mattaponi River than they are on the Pamunkey River and the York River (Table 18). In the time series, recruitment is highest (>7.0 on the Mattaponi River and >3.0 on the York River) in 1982, 1984-85, 1996 and 2003. Recruitment was low (<0.10) on both of these rivers in 2009; there was no measureable recruitment in the Pamunkey River in 1986-1989, 1992-1993, 1999, and 2007-2009.

By-catch of striped bass and other species in 2009

Daily numbers and seasonal totals of striped bass and other species captured in staked gill nets are reported in Tables 19-21. Twenty- four species of fishes were taken as by-catch in the staked gill net monitoring gear for a total of 14,573 specimens. The most commonly encountered by-catch species were: gizzard shad (*Dorosoma cepedianum*), striped bass (*Morone saxatilis*), menhaden (*Brevoortia tyrannus*) and blue catfish (*Ictalurus furcatus*).

The total number of striped bass captured was 3,024 (James River, n=1,224; York River, n=990; Rappahannock River, n=810). Live striped bass captured in the gear were counted and released. The proportions of dead striped bass on each river were: James River 35.9%; York River, 34.1%; and the Rappahannock River, 44.3%. A subsample of dead striped bass was collected on each river. Length of males and females ranged from 380 - 849 mm FL and 413 – 718 mm FL, respectively. Total weights of males and females ranged from 1.06 – 5.12 kg and 0.79 – 7.77 kg, respectively.

Seasonal catch indices, 1980-1992 and 1998-2009

A seasonal catch index was calculated by estimating the area under the curve of daily catch versus day for the years 1998-2009 and for each year of the historical record of staked net catches on each river (Tables 22-27 and Figures 24-27). Seasonal catch indices in 2009 were: York River, 2.92; Rappahannock River, 5.36; James River, 2.69.

Discussion

The staked gill net monitoring program continues to be useful for assessment of stocks of American shad in Virginia. It is the only direct method available to determine the size of the spawning runs relative to what was obtained in the decades prior to the moratorium. The program also provides information for evaluating the hatchery-based restoration program, validating the juvenile index of abundance and for determining the amount of by-catch that could be expected in a commercial fishery if the in-river fishing ban is lifted.

In 1998, states were required to develop and submit restoration targets for stocks under moratorium. Virginia presented preliminary targets to the Plan Review Team of the ASMFC Shad and River Herring Management Board with the proviso that these targets would be revised as appropriate historical data became available (see below). Criteria to achieve restoration targets were proposed as either: (1) a three-year period during which the catch index remains at or above the target level in the staked gill net monitoring of the spawning run; (2) a three-year period during which the average catch index is above the target level and the target level is exceeded in two of the years; or (3) a significant increasing trend over a five-year period with the target exceeded in the last two years.

Voluntary logbooks of catches from the York River exist in the archives of the Department of Fisheries Science (Table 24). These historical records from the 1950s form the basis for gear comparison trials conducted in 2002 and 2003 in the York River (Maki *et al*., 2006). Based on these comparisons, we have concluded that the multifilament nets of the type used in the 1950s have approximately half of the fishing power of monofilament nets used in the 1980s and the current monitoring. Thus, the older data have been adjusted upward (by a factor of 2.16) to make appropriate comparisons with current monitoring results.

Voluntary log books from the 1950s also exist for the James River. The most extensive data are those of Mr. J. C. Smith who fished staked gill nets on the upper James River in 1954-1957, just above the mouth of the Chickahominy River. Current monitoring on the James River is well below this location, complicating direct comparisons with Smith's log books. There are no historic records in department archives for the Rappahannock River.

Using the information presented above and additional analysis, the ASMFC stock assessment subcommittee developed benchmarks for restoration of Virginia's stock of American shad (ASMFC 2007a). These benchmarks were reviewed and accepted by the ASMFC American shad stock assessment peer review panel in 2007 (ASMFC 2007b).

For the York River, a restoration target of 17.44 (the geometric mean of the catch index values observed in 1953-1957) was accepted as an appropriate benchmark to assess the stocks since American shad abundance in the 1980s was insufficient to support the fishery. In the 1950s, shad abundance was higher (estimated at 131,000-218,000 total females annually using data from Nichols and Massmann 1962), and landings were relatively stable in the face of a high fishing rate (50%). Thus, restoring the York River shad stocks to a 1950s level could allow for a sustainable fishery operating at a lower level of exploitation.

For the James River, an interim target of 6.40 (the geometric mean of the catch index values observed in 1980-1993) is available. However, American shad abundance in the 1980s was insufficient to support the fishery. The James River stock is dependent on hatchery inputs and there is strong evidence of persistent recruitment failure of wild stocks.

For the Rappahannock River, an interim restoration target of 1.45 (the geometric mean of the catch index values observed in 1980-1993) is available.

On the York River, the seasonal catch index in 2009 was 2.92. This value is lower than the 2008 value of 3.28. During twelve years of monitoring, the index has been variable with high values (>12) in 1998 and 2001 and lower values (<9) in other years. The geometric mean of the historical data during the 1980s on the York River is 3.22. The geometric mean of the current monitoring data is higher (6.20), but this mean is lower than the benchmark based on 1950s data (17.44). In recent years of monitoring (2006 - 2009), mean age of females has increased as a result of lower proportions of younger fish in the monitoring catch (Figures 22-23). Catch indices have been trending downward in recent years and are close to all-time lows.

Our overall assessment of the York River stock is that it has recovered to a level that is close to its average abundance during the 1980s. However, as noted previously, the stock level was low during that period, and incapable of supporting an active fishery. Since 2004, the catch index has shown a significant decline and is cause for concern. Although there is a moratorium on American shad harvest in the Chesapeake Bay, there are fish taken in the York River each year from several sources. Since 2005 there has

been a limited by-catch fishery of American shad. Results from this permitted activity in 2009 are reported in Appendix I. The Mattaponi and Pamunkey tribal governments harvest American shad and do not report landings to the VMRC. There are also losses to capture of brood stock on the Pamunkey River by the VDGIF. The stock is currently well below the proposed 1950s target (Figure 27) when abundance of American shad was higher and harvest was apparently sustainable (Nichols and Massmann 1963). As a result, the stock requires continued protection.

On the James River, the 2009 index (2.69) increased from 2008 (1.51). This value is still well below the peak catch index observed in the 1980s (29.20). Index values in 2000-2005 were higher than those in 1998 and 1999 (2.57 and 2.99, respectively). In 2006, the index fell to a value of 1.74, but recovered in 2007 to 4.45. The lowest value in the eleven year time-series was recorded in 2008 (1.51). The geometric mean of the historical data during the 1980s on the James River is 6.40. The geometric mean of the current monitoring data is lower (4.10), and continues to decline. Hatchery cohorts are believed to be recruiting in high proportions to the population, mean age of females has increased in recent years of monitoring (2000-2005), and an increase in the proportion of younger year classes entering the monitoring gear was observed in 2006 and 2007 (Figure 23). In 2008, mean age of females once again increased as the proportion of age 4 fish decreased. This decline in age 4 fish, possibly indicates recruitment failure of the 2004 year class. In 2009 the proportion of age 4 fish once again increased as the 2005 year class returned to the system. Our overall assessment for the James River is that the stock continues to decline and remains at historically low levels. The stock requires continued protection and hatchery-based restoration. Due to budget constraints stocking efforts of American shad on the James River have been reduced in recent years. The current reduction in stocking effort is projected to continue.

On the Rappahannock River, the 2009 index (5.36) increased to the highest value seen since 2004 (7.06) and is above the 1998 – 2009 geometric mean (3.26). The 2003-2004 index values were higher than any previous year of monitoring and higher than all years of the historic data. The 1998-2009 geometric mean (3.26) is above the mean of the historical data (1.45) and the 2003-2004 index values were above the proposed target of 6. However, 2005-2009 values have continued to stay below the proposed target of 6. In recent years of monitoring (2006 - 2008), mean age of females has increased as a result of reduced catches of younger fish in the monitoring gear (Figure 23). In 2009 mean age of females decreased due to a higher proportion of age 4 fish. Abundance of juvenile fish in the Rappahannock River was very low in 1999-2001. No juveniles were captured in 2002. However, recruitment has increased in recent years and in 2009 mean age of females decreased due to an increase in younger year classes entering the monitoring gear. It should be noted that since the catch index for the Rappahannock River is low in the historical data relative to the York and James rivers, there is uncertainty about what an appropriate target level should be for this stock. There is little evidence of severe stock decline in the Rappahannock River, although such a decline was reported in the most recent stock assessment (ASMFC 1999). The present status of the Rappahannock River stock is stable with evidence of increasing abundance. VDGIF personnel began a new hatchery-release program on the upper Rappahannock River

recently (2003), which uses progeny of Potomac River brood stock. The goal of this program is to restore American shad to historical spawning areas that were previously blocked by Embrey Dam.

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Table 1. Summary of sampling dates, total number, and total weight of American shad captured in staked gill nets in the James, York, and Rappahannock Rivers, spring 2009.

Stock	Sampling dates in 2009	Total pre-spawn females	Total males	Total pre-spawn female weight (kg)	Total male weight (kg)	Total fish	Total weight (kg)
James River	2/16-5/5	156	23	218.74	28.63	179	247.38
York River	2/25-5/5	165	39	240.25	46.33	204	288.88
Rappahannock River	3/9-5/12	312	49	441.54	58.01	361	499.55
Totals		633	111	900.53	132.97	744	1035.81

Table 2. Total length, fork length, and total weight of post-spawning female American shad taken in a staked gill net in the York River, spring 2009. These individuals were removed from the monitoring data.

River	Date	Specimen number	Total length (mm)	Fork length (mm)	Total weight (g)
York River	4/27/2009	14185	483	427	1061.4
	4/28/2009	14218	498	442	1236.1

Table 3. Dates of capture, number, total weight, and catch rates of pre-spawn female American shad taken in staked gill net monitoring on the James River, spring 2009.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (g)	Catch rate (kg/m/day)
2/16/2009	47	1	0.004	1243.9	0.005
2/17/2009	48	0	0	0	0
2/23/2009	54	1	0.004	1304.1	0.005
2/24/2009	55	0	0	0	0
3/6/2009	65	1	0.004	1188.4	0.004
3/7/2009	66	0	0	0	0
3/10/2009	69	9	0.032	11556.3	0.041
3/11/2009	70	1	0.004	1739.0	0.006
3/16/2009	75	13	0.047	19520.0	0.071
3/17/2009	76	25	0.091	35670.9	0.130
3/23/2009	82	10	0.036	14077.6	0.051
3/24/2009	83	6	0.022	7794.4	0.028
3/30/2009	89	12	0.044	17128.9	0.062
3/31/2009	90	5	0.018	8648.0	0.032
4/6/2009	96	25	0.091	34146.1	0.125
4/7/2009	97	5	0.018	6121.0	0.022
4/13/2009	103	20	0.074	27755.4	0.103
4/14/2009	104	6	0.022	8655.9	0.032
4/20/2009	110	4	0.015	5536.3	0.020
4/21/2009	111	2	0.007	2769.7	0.010
4/27/2009	117	5	0.018	6807.6	0.025
4/28/2009	118	4	0.015	5314.4	0.020
5/4/2009	124	1	0.004	1766.8	0.006
5/5/2009	125	0	0	0	0
Totals		156		218744.7	

Table 4. Dates of capture, number, total weight, and catch rates of male American shad taken in staked gill net monitoring on the James River, spring 2009.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (g)	Catch rate (kg/m/day)
2/16/2009	47	0	0	0	0
2/17/2009	48	0	0	0	0
2/23/2009	54	0	0	0	0
2/24/2009	55	0	0	0	0
3/6/2009	65	0	0	0	0
3/7/2009	66	1	0.004	1260.6	0.005
3/10/2009	69	0	0	0	0
3/11/2009	70	1	0.004	963.6	0.004
3/16/2009	75	6	0.022	7500.3	0.027
3/17/2009	76	7	0.026	9872.0	0.036
3/23/2009	82	1	0.004	655.6	0.002
3/24/2009	83	2	0.007	2516.0	0.009
3/30/2009	89	4	0.015	5135.3	0.019
3/31/2009	90	0	0	0	0
4/6/2009	96	0	0	0	0
4/7/2009	97	0	0	0	0
4/13/2009	103	1	0.004	728.2	0.003
4/14/2009	104	0	0	0	0
4/20/2009	110	0	0	0	0
4/21/2009	111	0	0	0	0
4/27/2009	117	0	0	0	0
4/28/2009	118	0	0	0	0
5/4/2009	124	0	0	0	0
5/5/2009	125	0	0	0	0
Totals		23		28631.6	

Table 5. Dates of capture, number, total weight, and catch rates of pre-spawn female American shad taken in staked gill net monitoring on the York River, spring 2009.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (g)	Catch rate (kg/m/day)
2/25/2009	56	0	0	0	0
2/26/2009	57	4	0.015	5720.1	0.021
3/6/2009	65	2	0.007	2352.1	0.009
3/7/2009	66	3	0.010	4442.0	0.015
3/10/2009	69	5	0.018	8333.1	0.030
3/11/2009	70	10	0.036	14904.1	0.054
3/16/2009	75	16	0.059	21483.0	0.079
3/17/2009	76	17	0.062	25476.9	0.093
3/23/2009	82	4	0.015	5948.1	0.022
3/24/2009	83	14	0.051	21020.8	0.077
3/30/2009	89	26	0.094	36388.5	0.131
3/31/2009	90	12	0.044	16955.6	0.062
4/6/2009	96	12	0.045	17639.7	0.066
4/9/2009	99	9	0.034	13114.0	0.049
4/13/2009	103	14	0.051	20830.7	0.075
4/14/2009	104	3	0.011	3862.8	0.014
4/20/2009	110	0	0	0	0
4/21/2009	111	0	0	0	0
4/27/2009	117	5	0.018	7878.4	0.029
4/28/2009	118	5	0.018	7631.1	0.028
5/4/2009	124	2	0.007	3653.4	0.013
5/5/2009	125	2	0.007	2615.6	0.010
Totals		165		240250.0	

Table 6. Dates of capture, number, total weight, and catch rates of male American shad taken in staked gill net monitoring on the York River, spring 2009.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (g)	Catch rate (kg/m/day)
2/25/2009	56	0	0	0	0
2/26/2009	57	0	0	0	0
3/6/2009	65	1	0.004	1112.0	0.004
3/7/2009	66	2	0.007	2693.7	0.009
3/10/2009	69	5	0.018	6004.5	0.022
3/11/2009	70	0	0	0	0
3/16/2009	75	5	0.018	6303.1	0.023
3/17/2009	76	8	0.029	9700.7	0.035
3/23/2009	82	1	0.004	1154.0	0.004
3/24/2009	83	2	0.007	2484.1	0.009
3/30/2009	89	6	0.022	7332.9	0.027
3/31/2009	90	3	0.011	3418.3	0.012
4/6/2009	96	2	0.007	2583.4	0.010
4/9/2009	99	0	0	0	0
4/13/2009	103	1	0.004	1056.9	0.004
4/14/2009	104	0	0	0	0
4/20/2009	110	0	0	0	0
4/21/2009	111	0	0	0	0
4/27/2009	117	0	0	0	0
4/28/2009	118	1	0.004	871.3	0.003
5/4/2009	124	1	0.004	1051.1	0.004
5/5/2009	125	1	0.004	565.0	0.002
Totals		39		46331.0	

Table 7. Dates of capture, number, total weight, and catch rates of pre-spawn female American shad taken in staked gill net monitoring on the Rappahannock River, spring 2009.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (g)	Catch rate (kg/m/day)
3/10/2009	69	1	0.004	1290.8	0.005
3/11/2009	70	2	0.007	2794.7	0.010
3/16/2009	75	12	0.043	16625.2	0.060
3/17/2009	76	7	0.023	10394.5	0.035
3/23/2009	82	1	0.004	1597.9	0.006
3/24/2009	83	9	0.032	15061.3	0.054
3/30/2009	89	10	0.037	14899.3	0.055
3/31/2009	90	10	0.036	13699.8	0.049
4/6/2009	96	22	0.079	31148.4	0.112
4/9/2009	99	39	0.146	54334.9	0.204
4/13/2009	103	49	0.176	69213.2	0.249
4/14/2009	104	24	0.077	35356.3	0.113
4/20/2009	110	35	0.131	49128.0	0.184
4/21/2009	111	54	0.190	73327.7	0.259
4/27/2009	117	17	0.064	24913.0	0.093
4/28/2009	118	17	0.064	23559.9	0.085
5/4/2009	124	1	0.004	1592.5	0.006
5/5/2009	125	1	0.004	1262.5	0.005
5/11/2009	131	0	0	0	0
5/12/2009	132	1	0.004	1336.1	0.005
Totals		312		441536.0	

Table 8. Dates of capture, number, total weight, and catch rates of male American shad taken in staked gill net monitoring on the Rappahannock River, spring 2009.

Date	Day of year	Number	Catch rate (count/m/day)	Total weight (g)	Catch rate (kg/m/day)
3/10/2009	69	2	0.007	2466.6	0.009
3/11/2009	70	4	0.014	5521.8	0.020
3/16/2009	75	7	0.025	8303.4	0.030
3/17/2009	76	4	0.013	4199.7	0.014
3/23/2009	82	0	0	0	0
3/24/2009	83	2	0.007	5223.0	0.019
3/30/2009	89	2	0.007	2052.4	0.008
3/31/2009	90	7	0.025	7425.2	0.027
4/6/2009	96	4	0.014	5042.4	0.018
4/9/2009	99	4	0.015	4937.9	0.019
4/13/2009	103	6	0.022	7119.0	0.026
4/14/2009	104	2	0.006	2389.8	0.008
4/20/2009	110	1	0.004	1366.5	0.005
4/21/2009	111	3	0.011	3579.1	0.013
4/27/2009	117	1	0.004	1083.9	0.004
4/28/2009	118	0	0	0	0
5/4/2009	124	0	0	0	0
5/5/2009	125	0	0	0	0
5/11/2009	131	0	0	0	0
5/12/2009	132	0	0	0	0
Totals		49		58010.7	

Table 9. Mean total length and mean weight of pre-spawn female American shad captured in staked gill nets in the James, York, and Rappahannock Rivers, spring 2009. The abbreviation NA is "not aged". Age estimates are based on examination of scales following Cating (1953).

River	Year class	Number	Mean total length (mm)	Standard deviation	Mean weight (g)	Standard deviation
James River	2005	19	456.6	15.0	1189.5	125.2
	2004	66	480.8	22.5	1365.6	188.8
	2003	41	491.0	28.5	1458.1	273.3
	2002	14	507.8	25.0	1710.2	232.0
	NA	16	484.2	25.7	1393.2	194.9
York River	2005	9	462.6	17.0	1268.2	169.4
	2004	59	478.2	20.8	1377.2	197.5
	2003	60	488.5	18.1	1438.4	158.4
	2002	15	509.0	32.1	1684.9	302.7
	2001	7	529.4	15.0	1848.0	181.2
	2000	1	542.0		2048.1	
	NA	14	499.0	20.5	1501.6	266.3
Rappahannock River	2005	55	464.6	15.1	1235.3	114.4
	2004	140	478.3	17.6	1356.0	148.7
	2003	74	496.1	19.0	1516.4	217.8
	2002	17	526.8	25.1	1775.7	240.3
	2001	5	536.2	24.2	1991.8	257.2
	2000	1	569.0		1879.6	
	NA	20	491.5	24.9	1475.6	207.7

Table 10. Mean total length and mean weight of male American shad captured in staked gill nets in the James, York, and Rappahannock Rivers, spring 2009. The abbreviation NA is "not aged". Age estimates are based on examination of scales following Cating (1953).

River	Year class	Number	Mean total length (mm)	Standard deviation	Mean weight (g)	Standard deviation
James River	2005	2	389.0	12.7	691.9	51.3
	2004	8	462.9	17.8	1184.3	132.1
	2003	4	474.0	16.1	1311.3	76.9
	2002	1	494.0		1412.1	
	2001	2	505.5	33.2	1542.0	397.6
	NA	6	477.2	45.5	1338.7	352.3
York River	2005	1	413.0		565.0	
	2004	12	463.3	24.8	1160.3	166.3
	2003	12	465.5	17.7	1223.1	168.8
	2002	4	471.8	16.4	1218.9	108.8
	2001	1	520.0		1708.0	
	NA	9	465.8	21.7	1175.7	127.2
Rappahannock River	2005	6	443.3	15.1	1068.7	103.8
	2004	25	458.9	14.3	1131.6	117.8
	2003	7	472.4	21.3	1256.4	171.3
	2002	4	492.3	3.3	1410.2	39.4
	NA	7	470.0	26.1	1267.5	240.6

Table 11. Number, total weight, and seasonal catch rates by year class of pre-spawn female American shad captured in staked gill nets in the James, York, and Rappahannock Rivers, spring 2009. The abbreviation NA is "not aged". Age estimates are based on examination of scales following Cating (1953).

River	Year class	Number	Total weight (kg)	Total effort (days)	Seasonal catch rate (count/m/season)	Seasonal catch rate (kg/m/season)
James River	2005	19	22.6	24.2	0.0029	0.0034
	2004	66	90.1	24.2	0.0099	0.0136
	2003	41	59.8	24.2	0.0062	0.0090
	2002	14	23.9	24.2	0.0021	0.0036
	N/A	16	22.3	24.2	0.0024	0.0034
York River	2005	9	11.4	21.9	0.0015	0.0019
	2004	59	81.3	21.9	0.0098	0.0135
	2003	60	86.3	21.9	0.0100	0.0144
	2002	15	25.3	21.9	0.0025	0.0042
	2001	7	12.9	21.9	0.0012	0.0021
	2000	1	2.0	21.9	0.0002	0.0003
	N/A	14	21.0	21.9	0.0023	0.0035
Rappahannock River	2005	55	67.9	20.0	0.0099	0.0122
	2004	140	189.8	20.0	0.0252	0.0341
	2003	74	112.2	20.0	0.0133	0.0202
	2002	17	30.2	20.0	0.0031	0.0054
	2001	5	10.0	20.0	0.0009	0.0018
	2000	1	1.9	20.0	0.0002	0.0003
	N/A	20	29.5	20.0	0.0036	0.0053

Table 12. Number, total weight, and seasonal catch rates by year class of male American shad captured in staked gill nets in the James, York, and Rappahannock Rivers, spring 2009. The abbreviation NA is "not aged". Age estimates are based on examination of scales following Cating (1953).

River	Year class	Number	Total weight (kg)	Total effort (days)	Seasonal catch rate (count/m/season)	Seasonal catch rate (kg/m/season)
James River	2005	2	1.4	24.2	0.0003	0.0002
	2004	8	9.5	24.2	0.0012	0.0014
	2003	4	5.2	24.2	0.0006	0.0008
	2002	1	1.4	24.2	0.0002	0.0002
	2001	2	3.1	24.2	0.0003	0.0005
	N/A	6	8.0	24.2	0.0009	0.0012
York River	2005	1	0.6	21.9	0.0002	0.0001
	2004	12	13.9	21.9	0.0020	0.0023
	2003	12	14.7	21.9	0.0020	0.0024
	2002	4	4.9	21.9	0.0007	0.0008
	2001	1	1.7	21.9	0.0002	0.0003
	N/A	9	10.6	21.9	0.0015	0.0018
Rappahannock River	2005	6	6.4	20.0	0.0011	0.0012
	2004	25	28.3	20.0	0.0045	0.0051
	2003	7	8.8	20.0	0.0013	0.0016
	2002	4	5.6	20.0	0.0007	0.0010
	N/A	7	8.9	20.0	0.0013	0.0016

Table 13. Spawning histories of American shad (combined sexes) collected in spring, 2009 in the York and James Rivers. Table entries are total numbers of fish that were aged (York River, n = 204; James River, n = 157). Ages are based on scale analysis by one reader (B. Watkins). Numbers in bold are virgins in year class. For the James River, the number in parentheses is the number of aged fish out of the total that had hatchery marks on their otoliths (n = 6). The table truncates at age 7 since American shad are mature by that age (Maki et al. 2001).

Age at Maturity

York River Year Class	Age at Capture	3	4	5	6	7
2006	3	**0**	-	-	-	-
2005	4	3	**7**	-	-	-
2004	5	4	30	**37**	-	-
2003	6	4	15	39	**14**	-
2002	7	0	8	4	5	**2**
2001	8	0	2	5	1	0
2000	9	0	0	0	0	1

Age at Maturity

James River Year Class	Age at Capture	3	4	5	6	7
2006	3	**0**	-	-	-	-
2005	4	3	**18(1)**	-	-	-
2004	5	5(1)	41(1)	**28**	-	-
2003	6	0	10(1)	23	**12**	-
2002	7	0	7	4(1)	4(1)	**0**
2001	8	0	1	1	0	0

Table 14. Spawning histories of American shad (combined sexes) collected in spring, 2009 in the Rappahannock River. Table entries are total numbers of fish that were aged (n = 334). Ages are based on scale analysis by one reader (B. Watkins). Numbers in bold are virgins in year class. The table truncates at age 7 since American shad are mature by that age (Maki et al. 2001).

		Age at Maturity				
Rapp. River Year Class	Age at Capture	3	4	5	6	7
2006	3	**0**	-	-	-	-
2005	4	4	**57**	-	-	-
2004	5	16	47	**102**	-	-
2003	6	0	17	44	**20**	-
2002	7	0	7	8	6	**0**
2001	8	0	0	5	0	0
2000	9	0	0	1	0	0

Table 15. River of origin, age, number of spawns, fork length (FL), total length (TL), total weight (TW), and sex of American shad with hatchery marks (n= 8) taken in staked gill net monitoring on the James River in 2009. A total of 90 American shad were scanned for hatchery marks. Data are sorted by spawning history and age. Age estimates are based on scales following Cating (1953). Abbreviations are: NA, not aged.

Specimen Number	Sequence	River Origin	Age	Spawns	FL (mm)	TL (mm)	TW (g)	Sex
13555	3	James	7	2	457	510	1739.0	Female
13598	3	James	5	2	420	471	1279.3	Male
13650	3	James	NA	NA	400	447	1267.7	Male
13652	3	James	7	1	475	528	2025.5	Female
13693	3	James	6	2	423	471	1320.2	Female
13847	3	James	4	0	415	465	1338.8	Female
13849	3	James	NA	NA	458	510	1459.8	Female
13969	3	James	5	1	422	473	1255.2	Female

Table 16. Total numbers in nine year classes of hatchery-marked American shad taken in staked gill nets in the James River, 1998-2009. Ages are based on examination of scales. Hatchery production data courtesy of the Virginia Department of Game and Inland Fisheries (D. Fowler). Abbreviation: NA, not aged.

Hatchery Year Class	Hatchery Production (millions)	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Total	% Total
1992	0.05		1											1	0.1
1993	0.5	7	2	1										10	1.4
1994	1.6	7	3	9			1							20	2.7
1995	5.3			59	9	8	4	3						83	11.4
1996	5.8			53	62	43	10	4	1					173	23.7
1997	5.9			2	27	78	57	5	4		1			174	23.8
1998	10					13	52	17	13					95	13.0
1999	7.3						14	29	7					50	6.8
2000	8.9						1	5	9		1			16	2.2
2001	9.3								3	4	3			10	1.4
2002	8.4									4	20	7	2	33	4.5
2003	8.7										12	8	1	21	2.9
2004	6.6										2	3	2	7	1.0
2005	6.0												1	1	0.1
2006	7.0														
2007	6.5														
2008	6.2														
2009	3.8														
NA	--					12	3	5	3	1	9	2	2	37	5.1
Total	97.85	14	6	124	98	154	142	68	40	9	48	20	8	731	100.0

Table 17. Indexes of abundance of juvenile American shad collected in beach seine surveys (1980-2009) on the James, Chickahominy and Rappahannock rivers. The index is the geometric mean catch per haul. Abbreviations are: SD, standard deviation; N, number of seine hauls.

Year	James River	SD	N	Chickahominy River	SD	N	Rappahannock River	SD	N
1980	0		16	0		5	0		4
1981	0		16	0		4	0		4
1982	0		18	0		6	0.86	7.081	6
1983	0		12	0		4	0.32	0.549	4
1984	0.06	0.20	12	0		4	0.41	0.693	4
1985	0		24	0		8	0		8
1986	0.06	0.259	18	0		6	0.06	0.20	12
1987	0		24	0		8	0.17	0.345	16
1988	0		24	0		8	0		20
1989	0		24	0		8	0.56	0.932	25
1990	0		24	0		8	0.04	0.208	28
1991	0		30	0		10	0		31
1992	0		30	0		10	0		35
1993	0		30	0		10	0.25	0.526	31
1994	0		30	0		10	0.11	0.301	34
1995	0		30	0		10	0		33
1996	0		30	0		10	0.41	0.698	33
1997	0		30	0		10	0.30	0.61	35
1998	0.02	0.127	30	0		10	0.14	0.402	29
1999	0		30	0		10	0.02	0.117	35
2000	0		30	0		10	0.08	0.245	34
2001	0		30	0		10	0.34	0.434	35
2002	0		30	0		10	0		35
2003	0.12	0.335	30	0		10	0.59	0.659	28
2004	0.02	0.127	30	0		10	0.81	0.94	35
2005	0		30	0		10	0.27	0.656	33
2006	0.35	0.521	30	0.23	0.335	10	0.11	0.302	34
2007	0.12	0.389	30	0		10	0.40	0.504	34
2008	0.02	0.127	30	0		10	0.02	0.117	35
2009	0.05	0.176	30	0.07	0.219	10	0.13	0.36	34

Table 18. Indexes of abundance of juvenile American shad collected in beach seine surveys (1980-2009) on the Mattaponi, Pamunkey, and York rivers. The index is the geometric mean catch per haul. Abbreviations are: SD, standard deviation; N, number of seine hauls.

Year	Mattaponi River	SD	N	Pamunkey River	SD	N	York River	SD	N
1980	1.76	1.064	21	0.56	0.888	9	1.15	1.014	33
1981	0.37	0.594	16	0.33	0.588	16	0.35	0.582	32
1982	13.03	1.256	16	0.51	0.543	12	4.4	1.502	28
1983	2.82	0.961	16	0.63	0.775	12	1.65	0.97	28
1984	18.05	1.150	16	0.06	0.20	12	4.52	1.694	28
1985	7.53	1.349	32	0.98	1.031	24	3.56	1.415	56
1986	1.10	0.922	24	0		18	0.49	0.774	56
1987	0.33	0.609	24	0		18	0.17	0.477	42
1988	0.05	0.203	40	0		24	0.03	0.161	64
1989	0.71	0.846	40	0		32	0.32	0.666	76
1990	0.57	0.694	40	0.02	0.123	32	0.28	0.551	76
1991	0.33	0.609	50	0.02	0.111	39	0.17	0.467	94
1992	0		39	0		32	0		75
1993	0.31	0.626	50	0		39	0.15	0.474	94
1994	1.73	1.158	50	0.15	0.435	39	0.81	0.989	94
1995	0.28	0.586	50	0.03	0.174	40	0.15	0.451	95
1996	14.66	1.356	49	2.05	1.299	39	5.89	1.57	93
1997	2.25	1.112	50	0.48	0.782	40	1.19	1.038	95
1998	2.33	1.235	48	0.08	0.478	38	0.95	1.103	91
1999	0.26	0.584	47	0		38	0.13	0.441	88
2000	5.77	1.305	39	0.08	0.256	31	1.83	1.331	74
2001	0.58	0.697	49	0.15	0.357	40	0.35	0.577	94
2002	0.23	0.496	48	0.02	0.11	40	0.12	0.374	93
2003	8.57	1.317	50	13.11	1.057	39	9.04	1.295	94
2004	7.52	1.393	47	0.10	0.287	38	2.21	1.448	90
2005	1.66	1.353	50	0.05	0.203	40	0.70	1.092	95
2006	0.93	0.916	48	0.09	0.351	37	0.47	0.76	90
2007	0.30	0.509	47	0		36	0.15	0.393	88
2008	0.11	0.303	50	0		40	0.06	0.225	95
2009	0.02	0.160	47	0		40	0.01	0.115	92

Table 19. Daily numbers and seasonal totals of live or dead striped bass (SB) and other species captured by staked gill net in the James River, 2009.

Date	Live SB	Dead SB	Total SB	Other species	Total
2/16/2009	82	63	145	14	159
2/17/2009	157	28	185	20	205
2/23/2009	82	44	126	12	138
2/24/2009	62	15	77	5	82
3/6/2009	110	28	138	9	147
3/7/2009	32	4	36	58	94
3/10/2009	67	84	151	492	643
3/11/2009	99	86	185	273	458
3/16/2009	38	20	58	49	107
3/17/2009	16	12	28	65	93
3/23/2009	9	8	17	30	47
3/24/2009	10	6	16	18	34
3/30/2009	0	2	2	30	32
3/31/2009	7	2	9	16	25
4/6/2009	3	2	5	47	52
4/7/2009	2	3	5	39	44
4/13/2009	1	2	3	100	103
4/14/2009	2	1	3	57	60
4/20/2009	0	0	0	35	35
4/21/2009	0	0	0	40	40
4/27/2009	0	2	2	405	407
4/28/2009	1	4	5	174	179
5/4/2009	0	8	8	140	148
5/5/2009	4	16	20	143	163
Totals	784	440	1224	2271	3495

Table 20. Daily numbers and seasonal totals of live or dead striped bass (SB) and other species captured by staked gill net in the York River, 2009.

Date	Live SB	Dead SB	Total SB	Other species	Total
2/25/2009	167	55	222	653	875
2/26/2009	135	75	210	42	252
3/6/2009	146	55	201	38	239
3/7/2009	27	7	34	41	75
3/10/2009	33	22	55	54	109
3/11/2009	32	30	62	33	95
3/16/2009	18	16	34	83	117
3/17/2009	7	7	14	47	61
3/23/2009	47	16	63	47	110
3/24/2009	17	8	25	23	48
3/30/2009	1	3	4	87	91
3/31/2009	3	4	7	38	45
4/6/2009	1	3	4	115	119
4/9/2009	1	2	3	31	34
4/13/2009	0	1	1	50	51
4/14/2009	0	0	0	57	57
4/20/2009	0	0	0	53	53
4/21/2009	3	0	3	51	54
4/27/2009	1	1	2	143	145
4/28/2009	5	8	13	151	164
5/4/2009	3	11	14	183	197
5/5/2009	5	14	19	219	238
Totals	652	338	990	2239	3229

Table 21. Daily numbers and seasonal totals of live or dead striped bass (SB) and other species captured by staked gill net in the Rappahannock River, 2009. DNR are days that by-catch was not recorded.

Date	Live SB	Dead SB	Total SB	Other species	Total
3/10/2009	33	33	66	160	226
3/11/2009	90	40	130	289	419
3/16/2009	103	46	149	238	387
3/17/2009	112	104	216	361	577
3/23/2009	16	22	38	431	469
3/24/2009	44	33	77	514	591
3/30/2009	11	17	28	410	438
3/31/2009	18	17	35	316	351
4/6/2009	2	4	6	543	549
4/9/2009	14	20	34	664	698
4/13/2009	1	6	7	409	416
4/14/2009	2	1	3	556	559
4/20/2009	0	0	0	262	262
4/21/2009	0	2	2	379	381
4/27/2009	0	2	2	491	493
4/28/2009	DNR	DNR	DNR	DNR	DNR
5/4/2009	3	1	4	293	297
5/5/2009	2	0	2	339	341
5/11/2009	0	5	5	161	166
5/12/2009	0	6	6	223	229
Totals	451	359	810	7039	7849

Table 22. Summary of historical catch and effort data of American shad by staked gill nets in the Rappahannock River, Virginia. Historical data are taken from the voluntary logbooks of Mr. M. Delano, Urbanna, Virginia.

Year	Effort (10^3 m/yr)	Duration of run (days)	Highest catch rate (female kg/m/day)	Mean catch rate (female kg/m/day)	Area under the catch curve (SE)
1980	43.4	35	0.121	0.036	1.79
1981	112.1	57	0.032	0.011	1.89
1982	82.3	51	0.046	0.009	1.68
1983	106.7	59	0.093	0.031	0.59
1984	30.5	48	0.139	0.033	0.60
1985	77.2	60	0.136	0.029	1.83
1986	34.9	43	0.155	0.039	2.18
1987	23.3	37	0.090	0.023	0.97
1988	23.2	53	0.073	0.025	1.25
1989	16.2	44	0.856	0.123	6.19
1990	41.3	55	0.092	0.023	1.31
1991	25.9	54	0.129	0.022	1.13
1992	8.6	51	0.299	0.044	1.44
Geometric mean					**1.45**

Table 23. Summary of recent catch and effort data of American shad by staked gill nets in the Rappahannock River, Virginia.

Year	Effort (10^3 m/yr)	Duration of run (days)	Highest catch rate (female kg/m/day)	Mean catch rate (female kg/m/day)	Area under the catch curve
1998	3.8	----	0.053	0.020	1.46
1999	5.7	42	0.055	0.026	1.30
2000	6.6	73	0.141	0.042	1.75
2001	6.6	72	0.167	0.070	5.77
2002	5.4	57	0.110	0.028	3.08
2003	7.2	72	0.311	0.094	7.10
2004	5.2	65	0.232	0.107	7.06
2005	5.5	65	0.164	0.054	3.69
2006	6.7	75	0.088	0.037	3.01
2007	5.2	64	0.130	0.042	2.60
2008	6.1	64	0.175	0.045	3.12
2009	5.6	50	0.259	0.093	**5.36**
Geometric mean					**3.26**

Table 24. Historical catch and effort data of American shad captured by staked gill nets in the York River, Virginia. 1950s historical data are taken from the voluntary logbooks of Malvin Green, Aberdeen Creek,Virginia. The data were originally recorded as numbers of female shad per meter of net per day and were converted to weight (kg) of female shad per meter of net per day, assuming an average female weight of 1.45kg. Catch rates were multiplied by 2.16 to adjust for the lower fishing power of multifilament nets compared to current monofilament nets. 1980s historical data are taken from the voluntary logbooks of Mr. R. Kellum, Achilles, Virginia.

Year	Effort (10^3m/yr)	Duration of run (days)	Highest catch rate (female kg/m/day)	Mean catch rate (female kg/m/day)	Area under the catch curve
1953	36.0	56	0.549	0.443	14.88
1954	45.5	54	0.699	0.434	14.04
1955	40.1	55	0.310	0.270	8.70
1956	68.8	85	1.201	0.663	33.95
1957	56.2	65	0.955	0.667	26.14
Geometric mean					**17.44**
1980	79.4	44	0.556	0.268	10.15
1981	114.7	51	0.259	0.121	4.35
1982	86.4	44	0.326	0.101	5.31
1983	121.3	40	0.212	0.066	3.06
1984	171.4	48	0.548	0.139	8.21
1985	205.4	49	0.227	0.091	4.61
1986	185.2	38	0.145	0.055	2.17
1987	152.9	37	0.088	0.039	1.78
1988	126.2	40	0.134	0.028	1.34
1989	146.3	55	0.397	0.131	4.92
1990	106.9	38	0.951	0.037	1.31
1991	77.8	40	0.111	0.062	2.72
1992	60.8	41	0.079	0.041	1.60
Geometric mean					**3.22**

Table 25. Summary of recent catch and effort data of American shad by staked gill nets in the York River, Virginia.

Year	Effort (10^3m/yr)	Duration of run (days)	Highest catch rate (female kg/m/day)	Mean catch rate (female kg/m/day)	Area under the catch curve
1998	5.7	78	1.080	0.190	14.71
1999	6.3	65	0.209	0.075	5.42
2000	6.7	76	0.276	0.086	7.52
2001	6.3	79	0.627	0.163	12.97
2002	6.7	70	0.306	0.073	7.47
2003	6.0	70	0.390	0.111	8.98
2004	4.9	65	0.448	0.157	9.72
2005	5.5	73	0.135	0.063	4.64
2006	5.5	62	0.146	0.042	2.85
2007	5.8	70	0.243	0.069	5.04
2008	5.4	65	0.228	0.050	3.28
2009	6.0	69	0.131	0.042	**2.92**
Geometric mean					**6.20**

Table 26. Summary of historical catch and effort data of American shad by staked gill nets in the James River, Virginia. Historical data are taken from the voluntary logbooks of the Brown family, Rescue, Virginia.

Year	Effort (10^3m/yr)	Duration of run (days)	Highest catch rate (female kg/m/day)	Mean catch rate (female kg/m/day)	Area under the catch curve
1980	20.5	41	2.239	0.699	29.20
1981	67.7	41	0.547	0.130	5.20
1982	49.3	35	0.331	0.115	4.20
1983	94.0	57	1.274	0.297	16.50
1984	89.7	50	0.897	0.036	19.30
1985	91.3	45	0.295	0.103	4.90
1986	31.5	26	1.289	0.152	6.10
1987	30.1	30	0.352	0.085	2.70
1988	19.1	20	0.487	0.193	9.30
1989	31.5	30	0.331	0.176	6.40
1990	29.7	25	0.184	0.079	2.10
1991	28.3	40	0.138	0.062	1.90
1992	59.8	50	0.562	0.232	7.70
Geometric mean					**6.40**

Table 27. Summary of recent catch and effort data of American shad by staked gill nets in the James River, Virginia

Year	Effort (10^3m/yr)	Duration of run (days)	Highest catch rate (female kg/m/day)	Mean catch rate (female kg/m/day)	Area under the catch curve
1998	3.8	50	0.198	0.051	2.57
1999	6.0	66	0.183	0.042	2.99
2000	7.2	70	0.279	0.086	6.61
2001	6.8	78	0.285	0.064	5.01
2002	6.5	71	0.205	0.054	5.62
2003	6.6	79	0.284	0.112	9.34
2004	6.0	78	0.234	0.090	7.41
2005	5.3	72	0.357	0.099	7.16
2006	4.6	54	0.078	0.032	1.74
2007	5.5	58	0.159	0.068	4.45
2008	4.6	58	0.069	0.025	1.51
2009	6.6	55	0.130	0.035	**2.69**
Geometric mean					**4.10**

Figure 1. **Commercial landings of American shad along the Atlantic coast and in Virginia since 1950. Data source: National Marine Fisheries Service, Fisheries Statistics and Economics Division.**

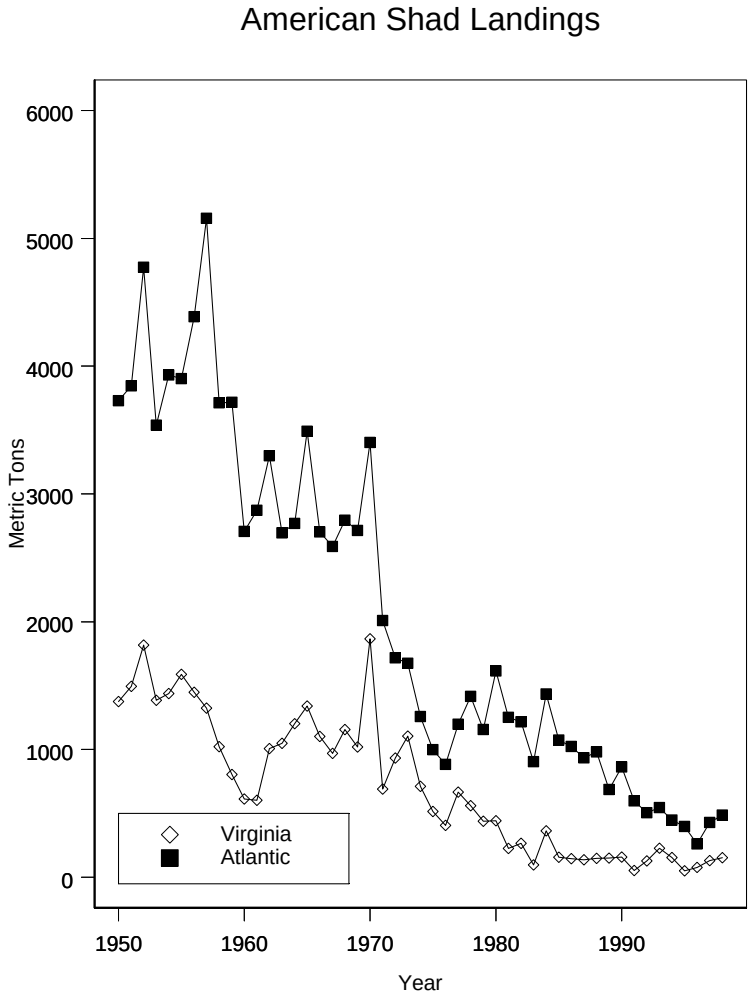


Figure 2. Number and location of staked gill nets on the James River in 1983.

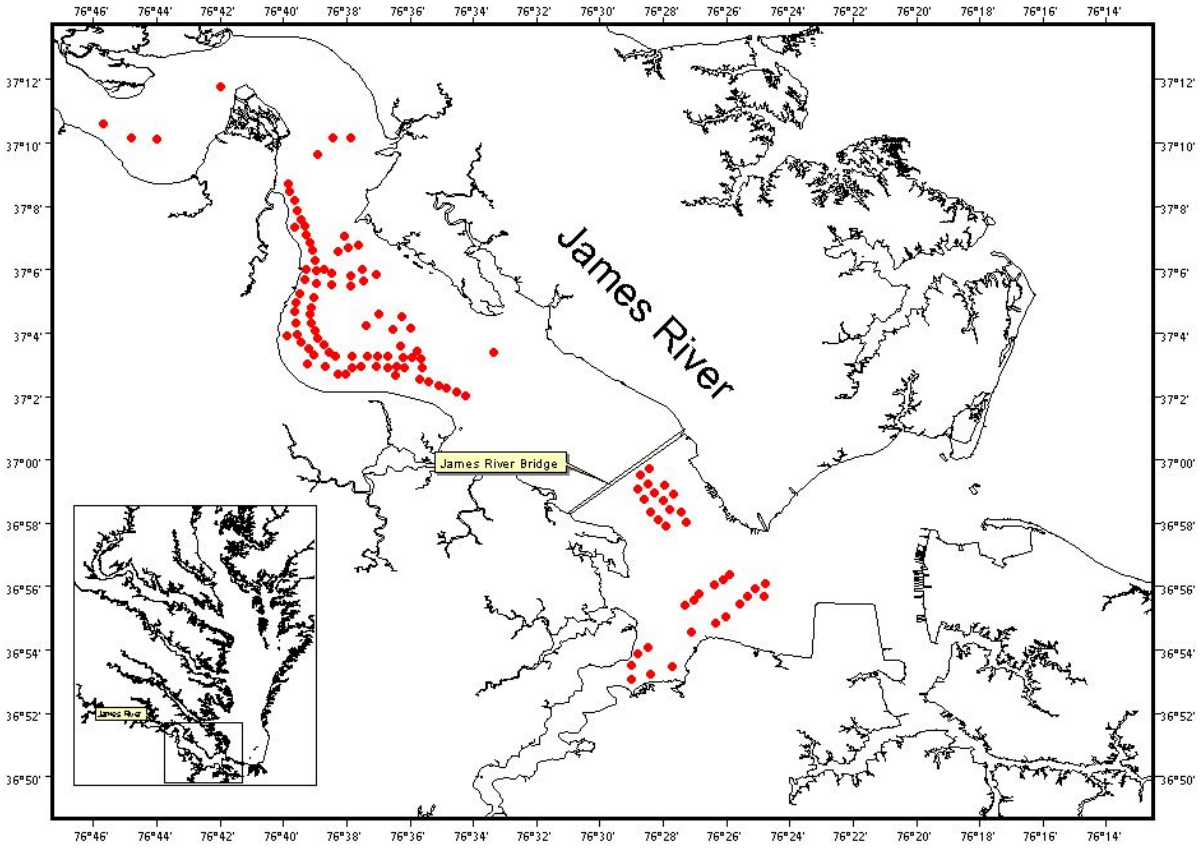


Figure 3. Number and location of staked gill nets on the York River in 1983.

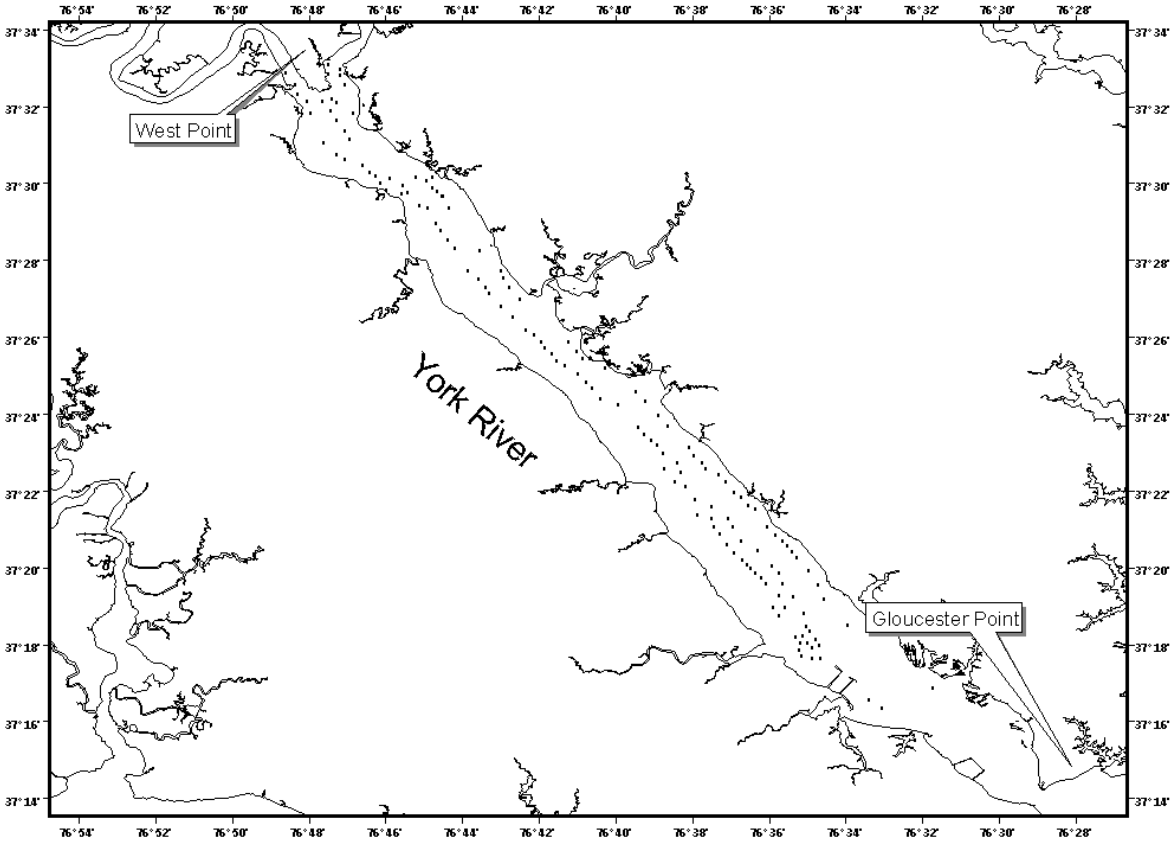


Figure 4. Number and location of staked gill nets on the Rappahannock River in 1983.

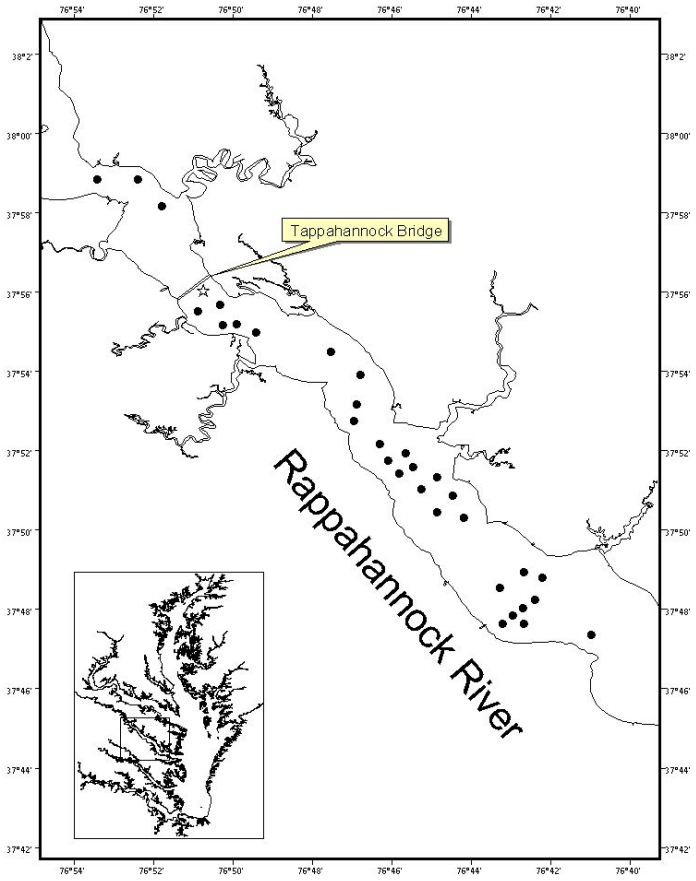


Figure 5. Location of the staked gill net fished by Mr. Marc Brown on the James River. The length of the net (274 m) is not to scale.

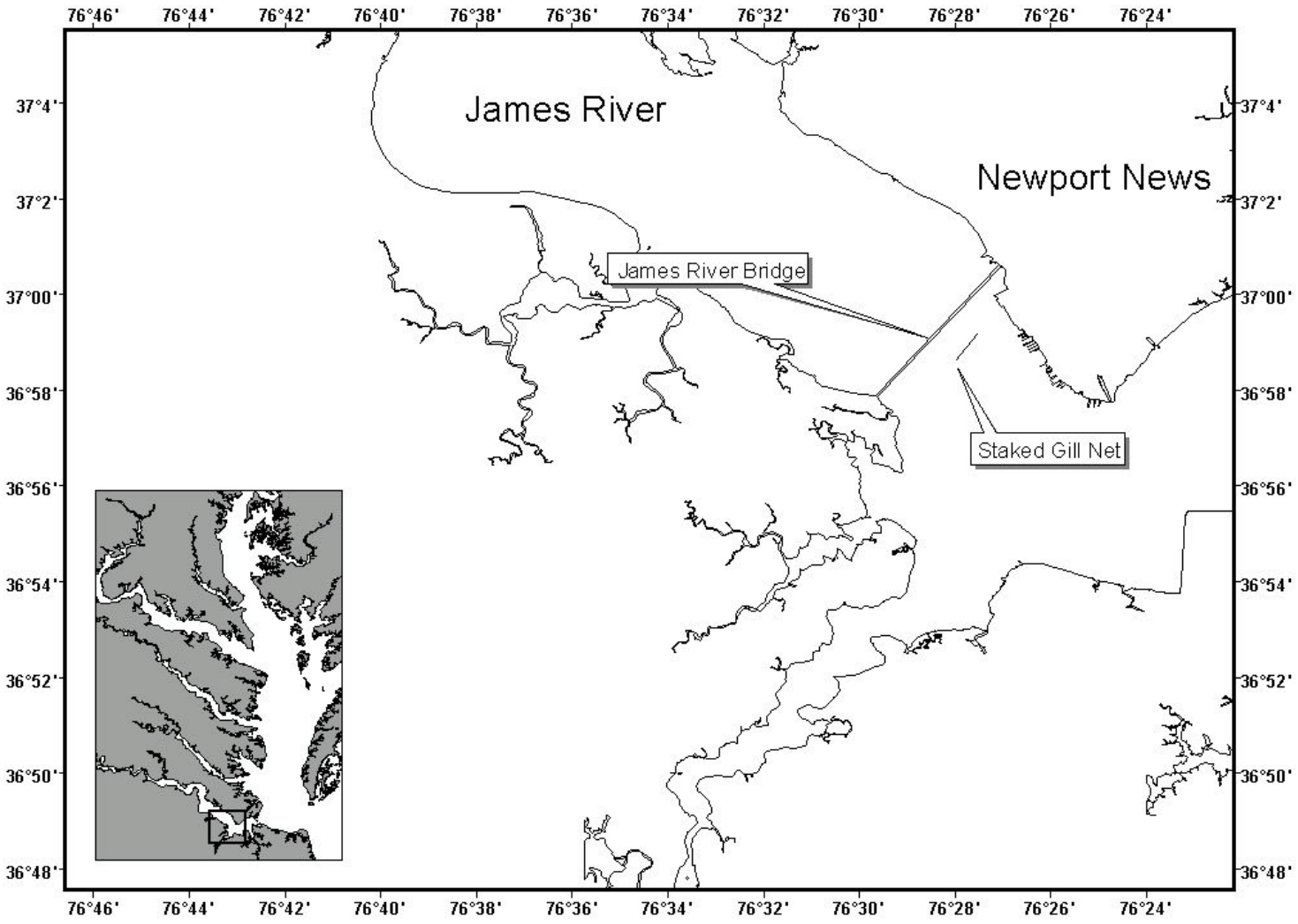


Figure 6. Location of the staked gill net fished by Mr. Raymond Kellum on the York River. The length of the net (274 m) is not to scale.

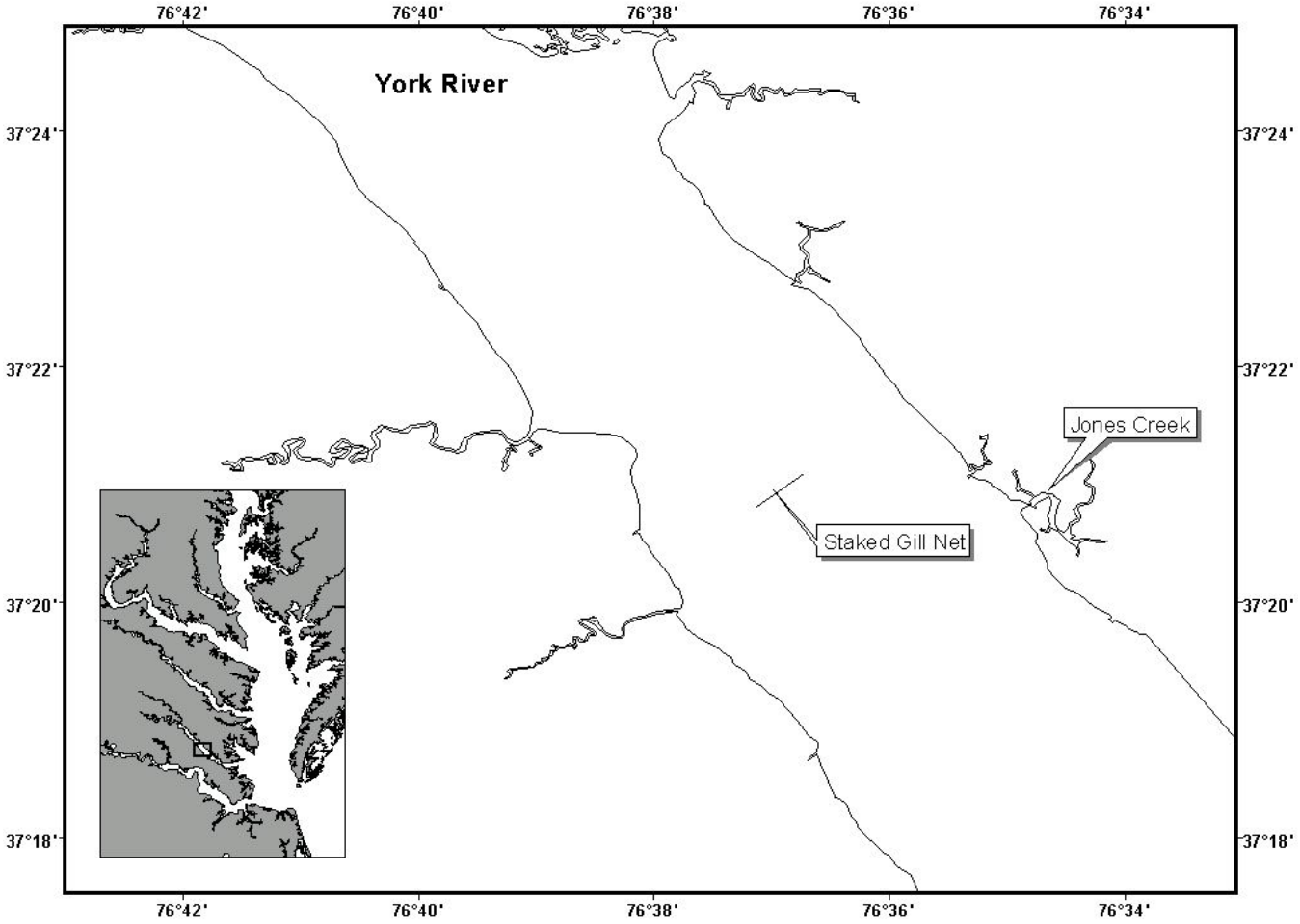


Figure 7. Location of the staked gill net fished by Mr. Jamie Sanders on the Rappahannock River. The length of the net (277 m) is not to scale.

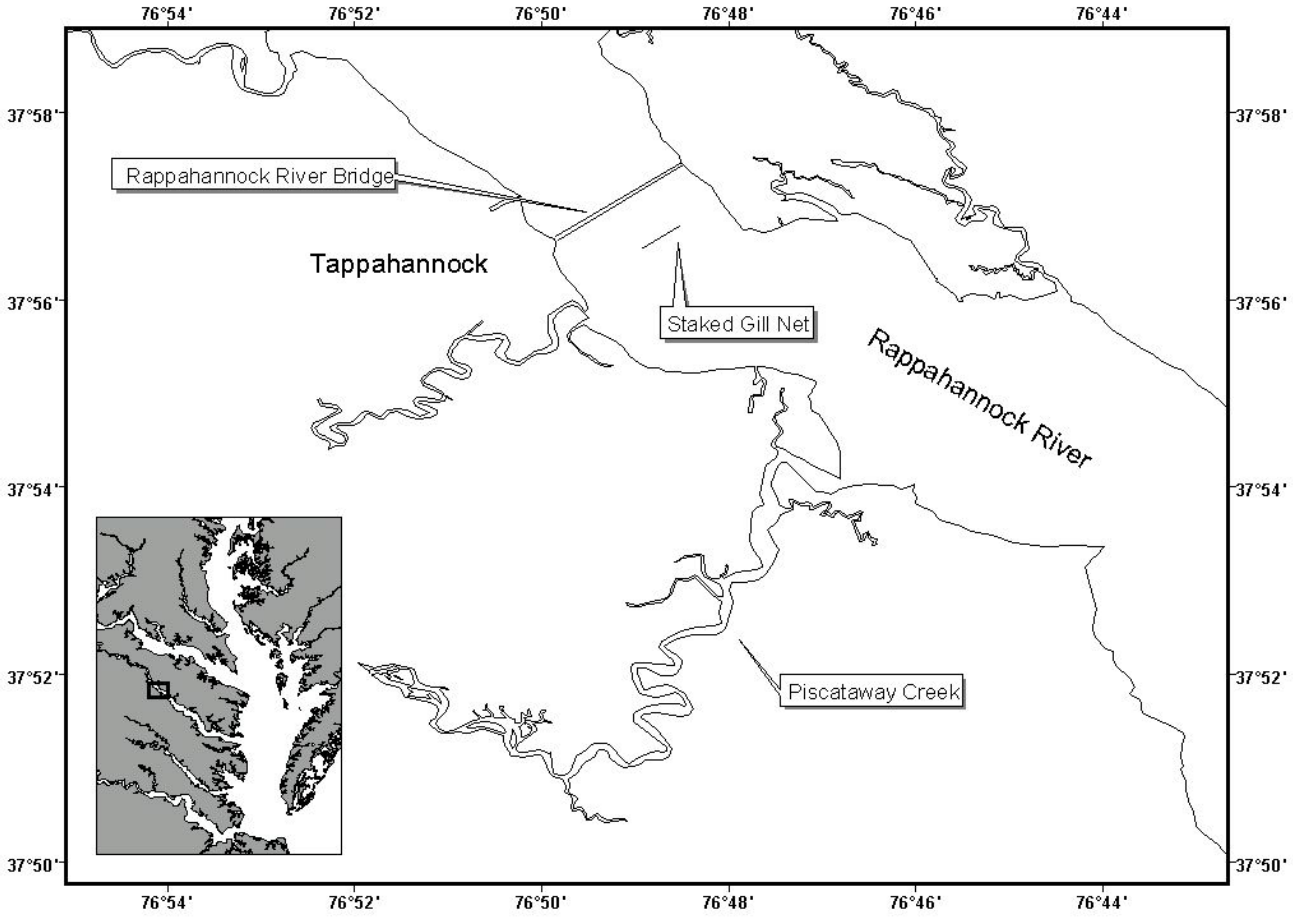


Figure 8. **Catch rates and total numbers of pre-spawn female American shad taken by staked gill nets in the James River, spring 2009.**

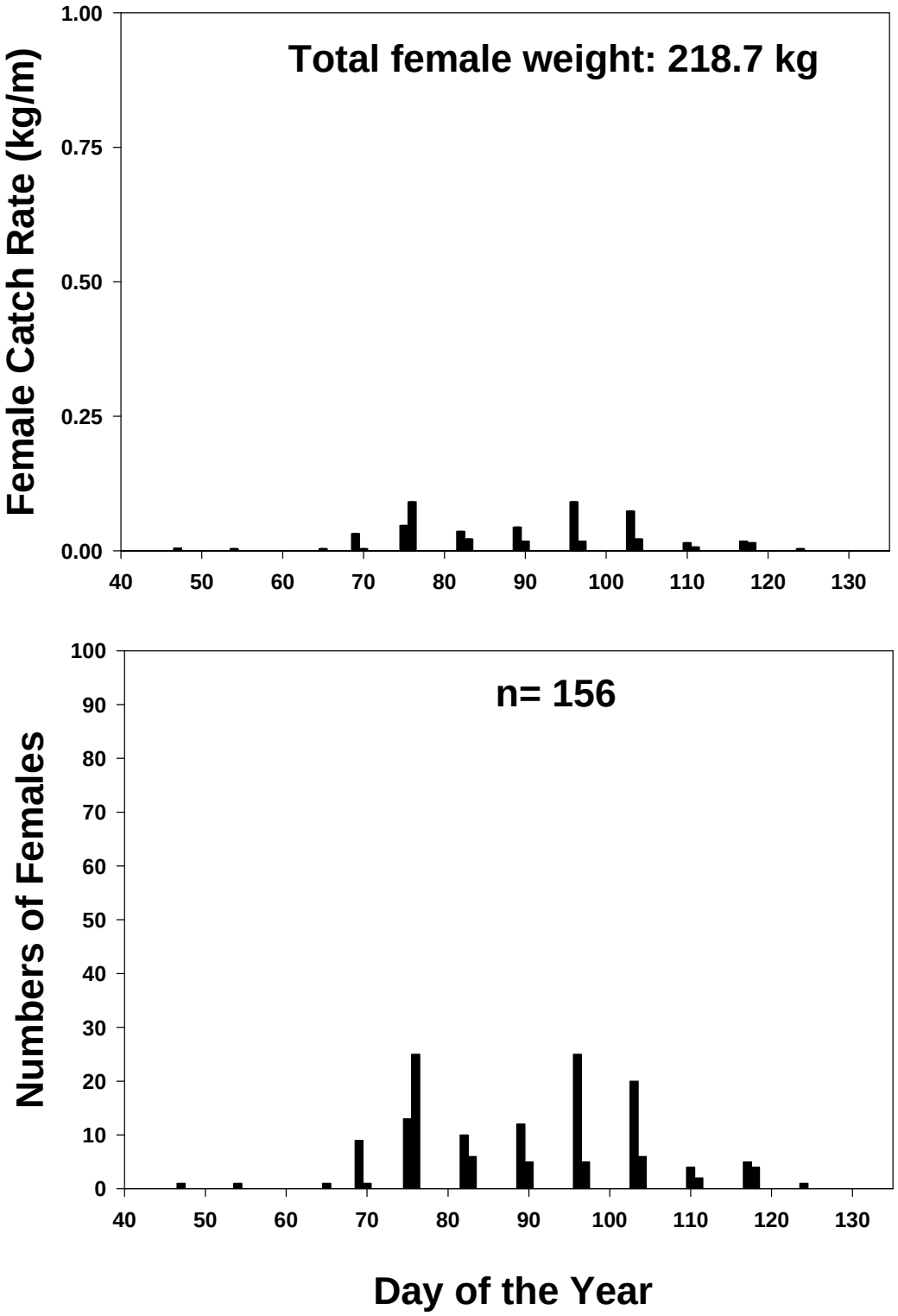


Figure 9. Catch rates and total numbers of pre-spawn female American shad taken by staked gill nets in the York River, spring 2009.

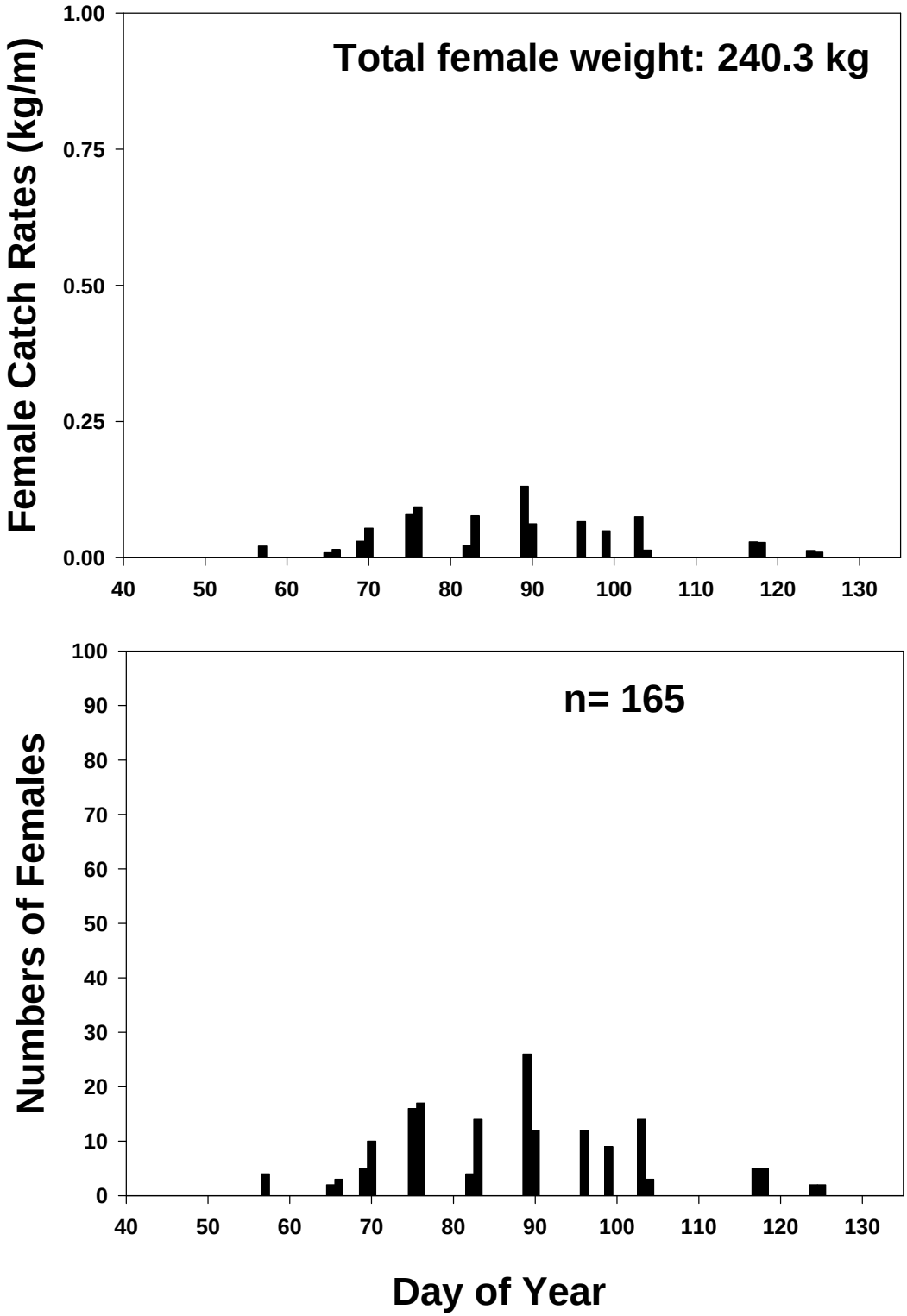


Figure 10. Catch rates and total numbers of pre-spawn female American shad taken by staked gill nets in the Rappahannock River, spring 2009.

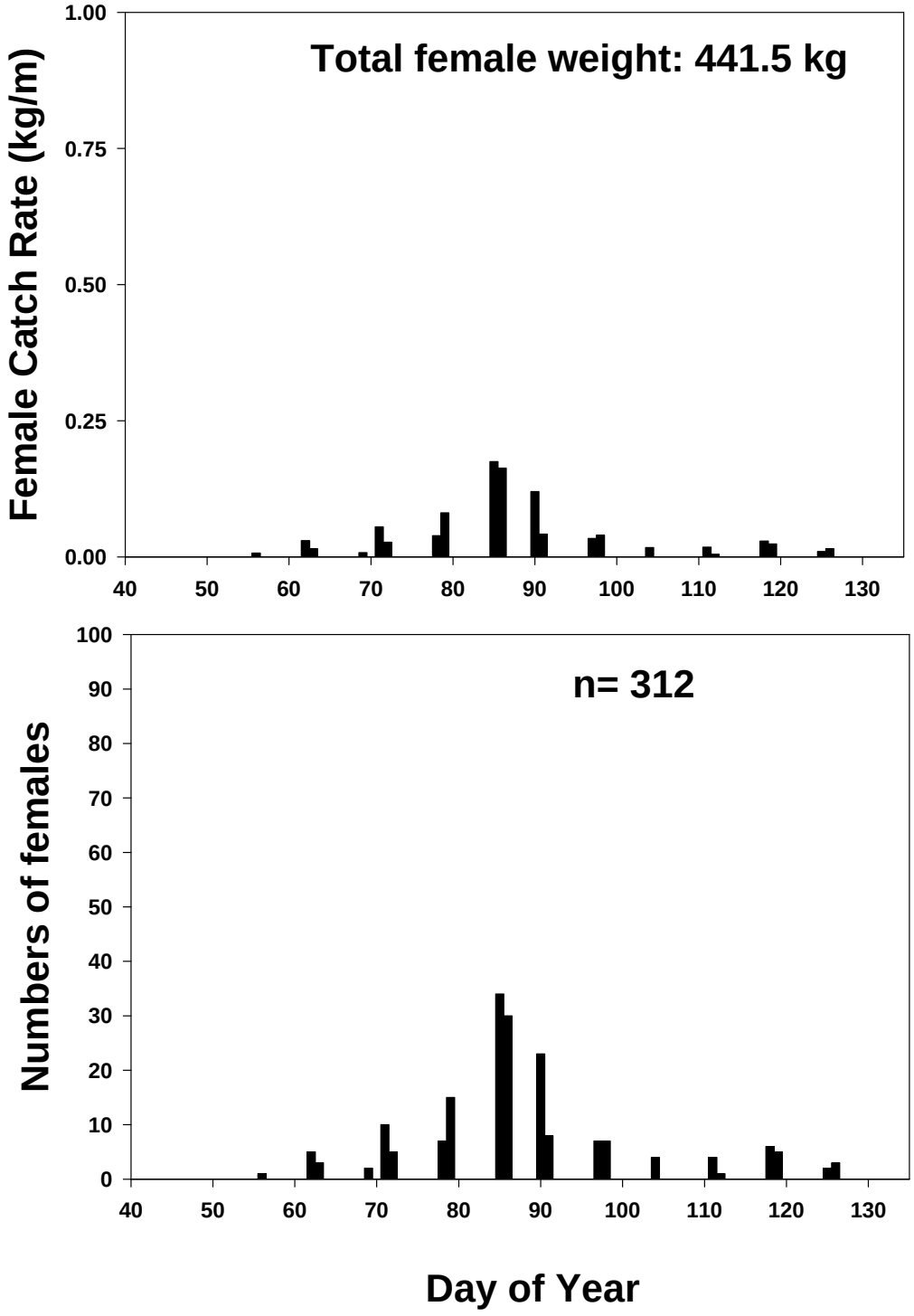


Figure 11. Catch rates and total numbers of male American shad taken by staked gill nets in the James River, spring 2009.

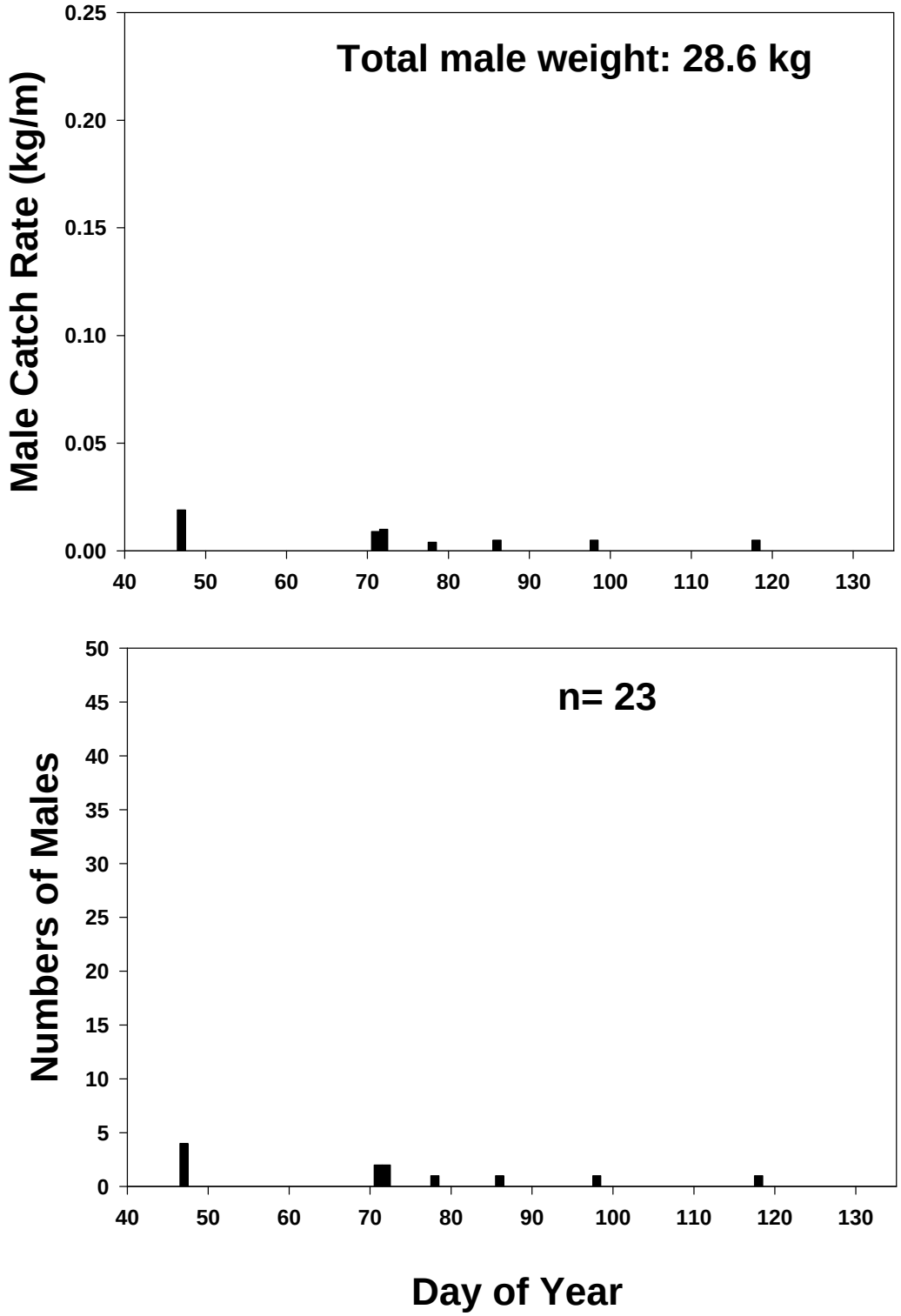


Figure 12. Catch rates and total numbers of male American shad taken by staked gill nets in the York River, spring 2009.

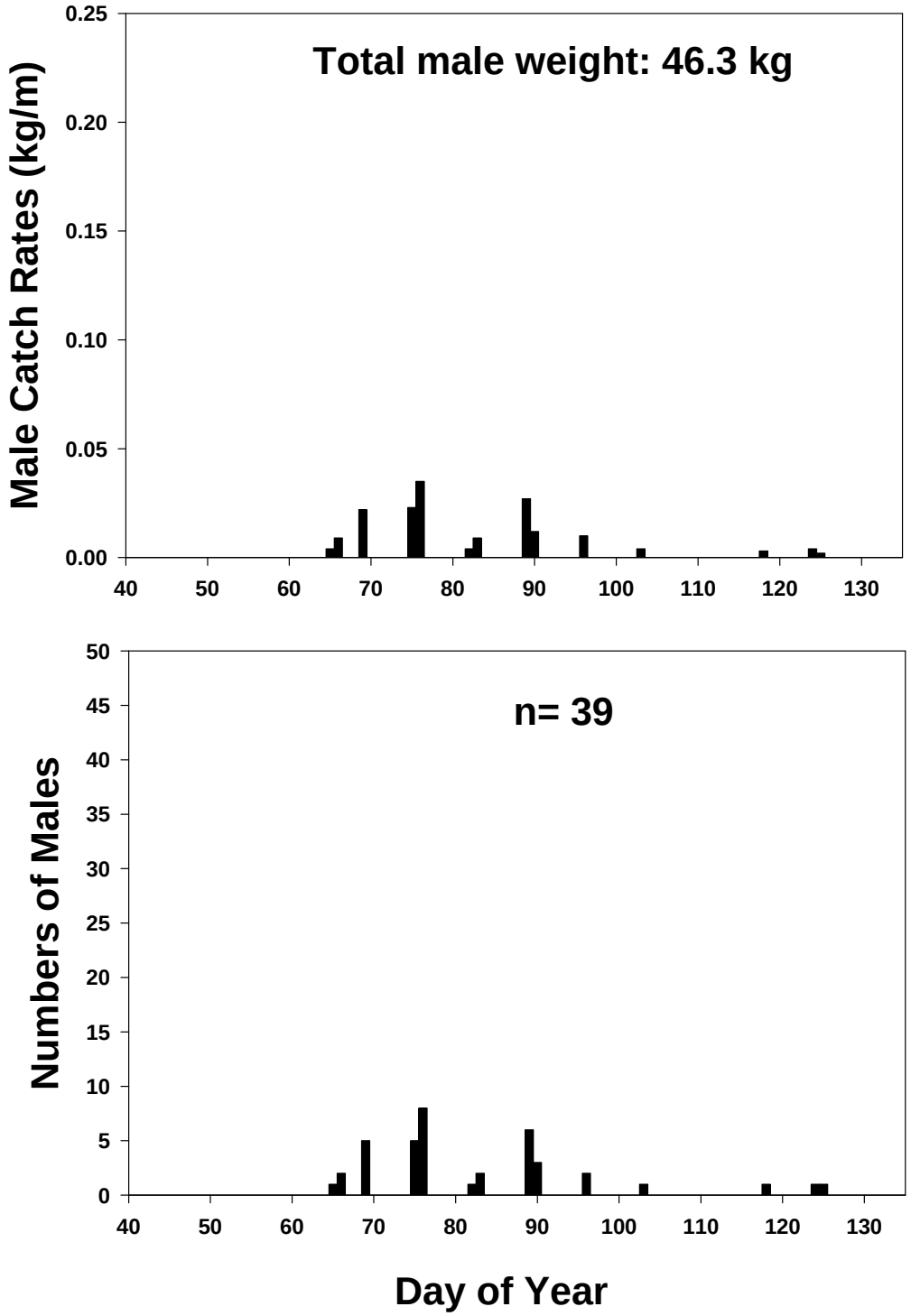


Figure 13. Catch rates and total numbers of male American shad taken by staked gill nets in the Rappahannock River, spring 2009.

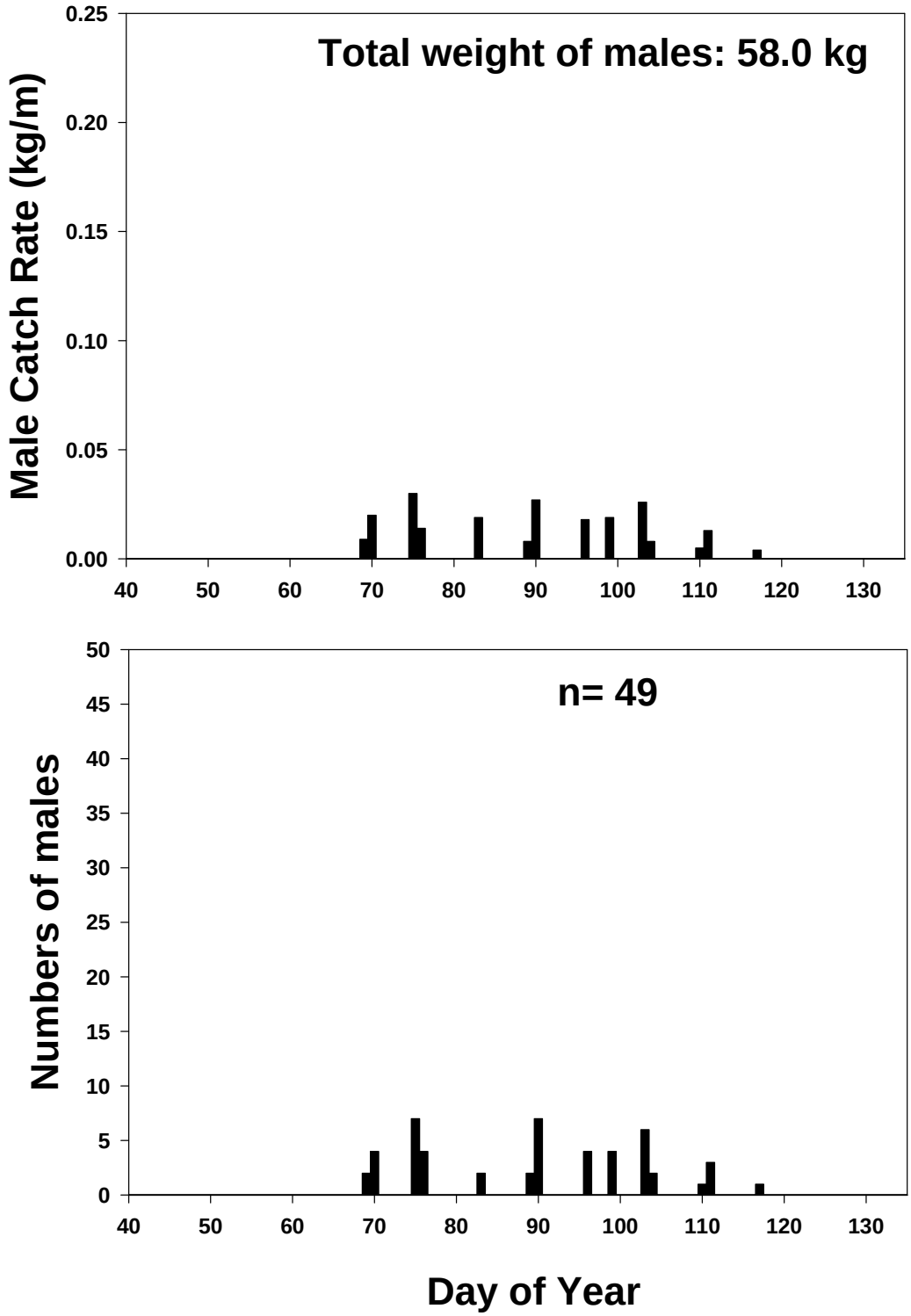
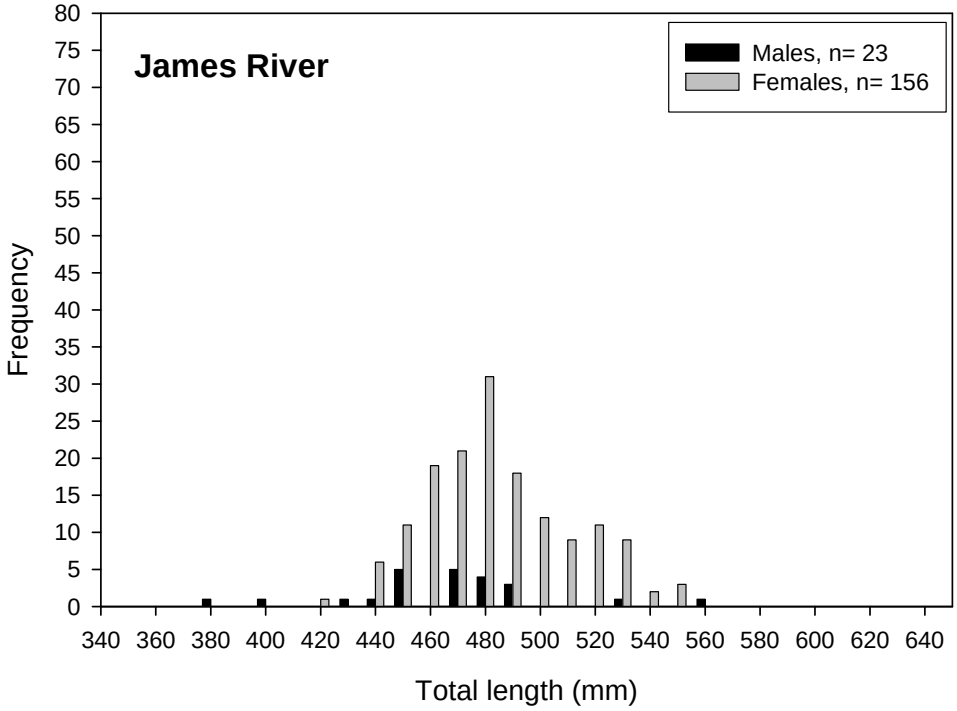


Figure 14. Total length (mm) frequency distributions for American shad captured in staked gill nets on the James and York rivers, spring 2009.



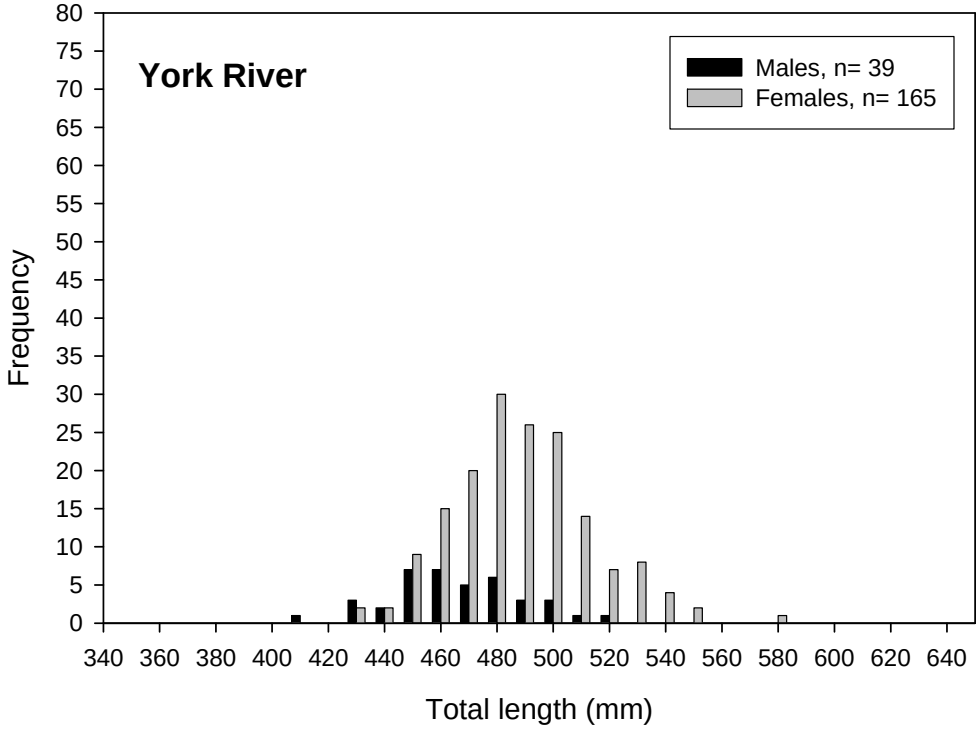


Figure 15. Total length (mm) frequency distributions for American shad captured in staked gill nets on the Rappahannock River, spring 2009.

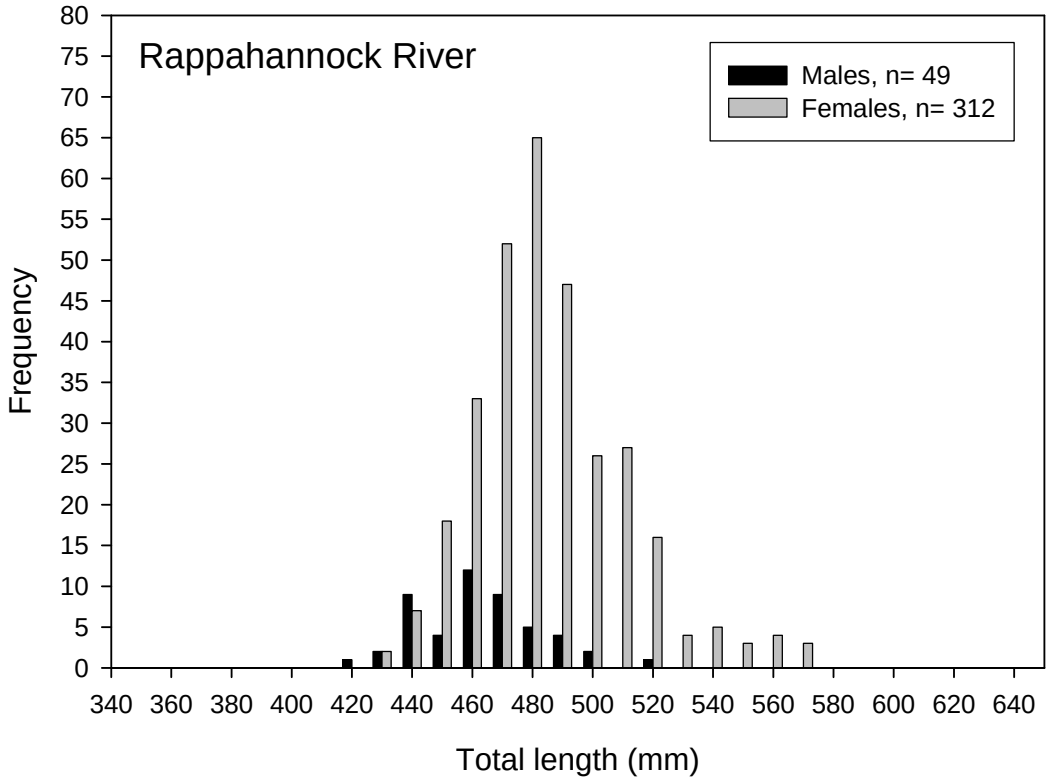
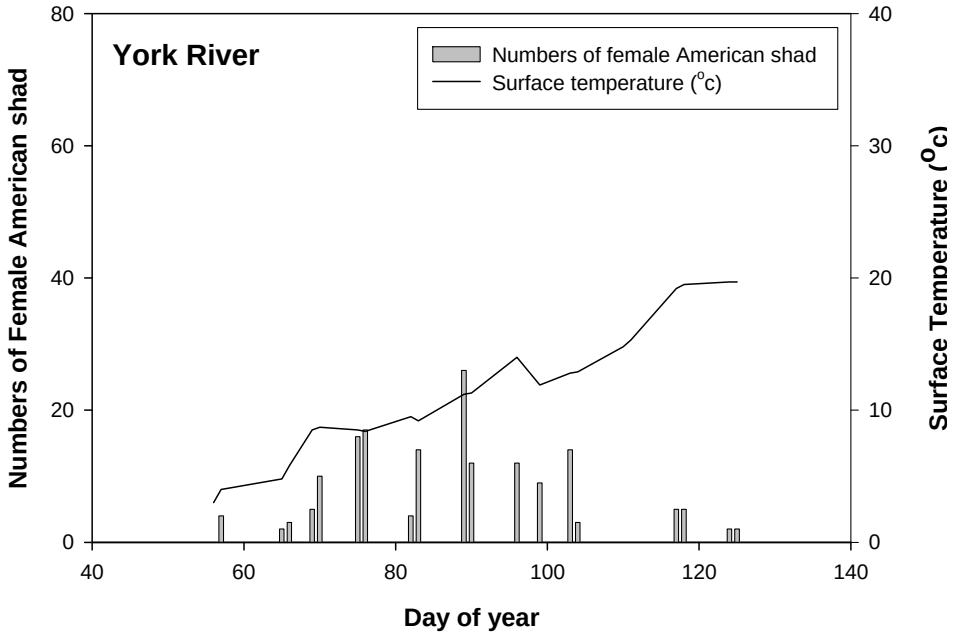


Figure 16. Total numbers of female American shad caught and surface temperature recorded at staked gill nets in the James and York Rivers, spring 2009.



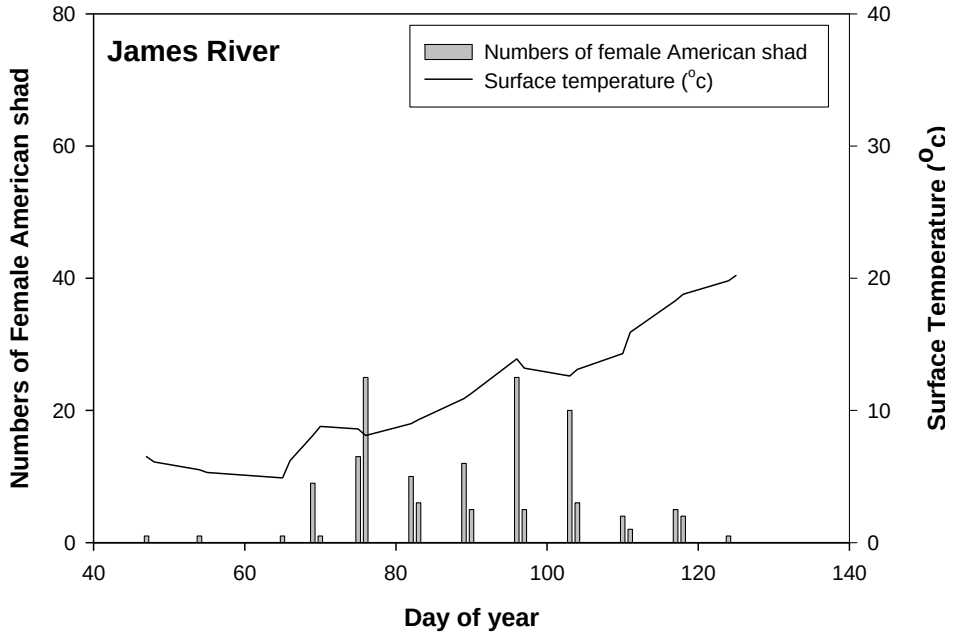


Figure 17. Total numbers of female American shad caught and surface temperature recorded at staked gill nets in the Rappahannock River, spring 2009.

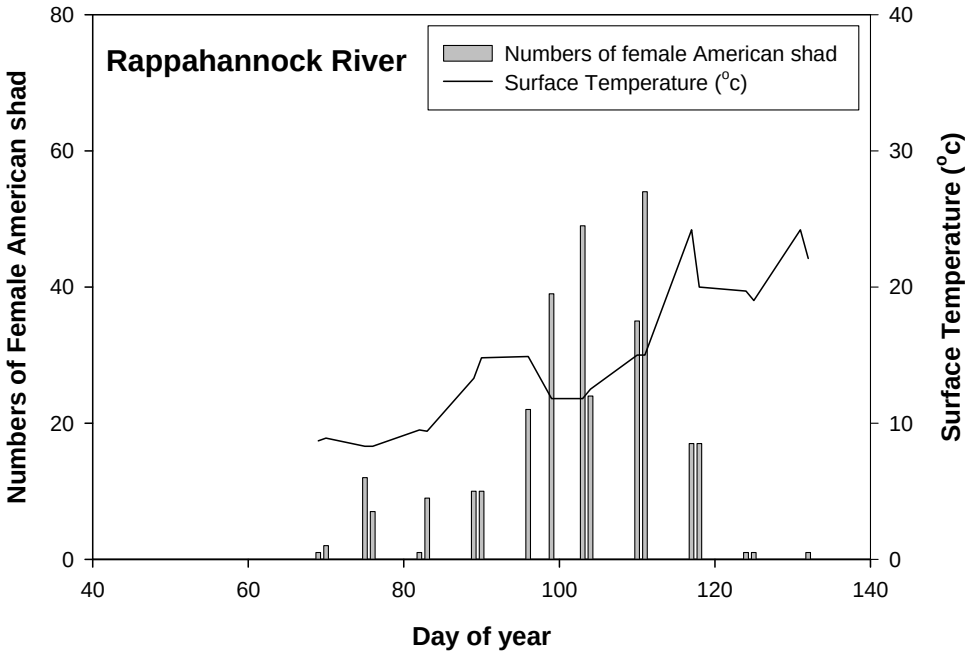


Figure 18. **The index of juvenile abundance of American shad in the York River system as estimated by daylight seine surveys, 1980-2009. The index is the geometric mean number of American shad juveniles per seine haul.**

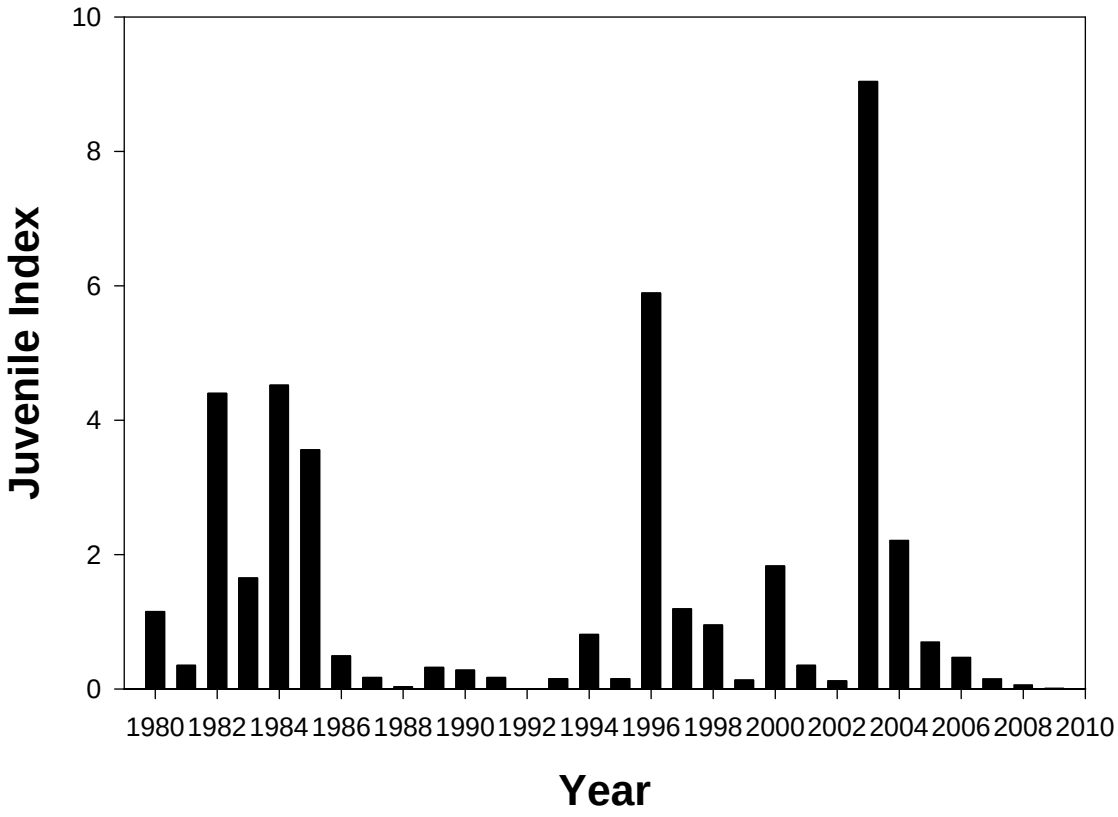


Figure 19. **The index of juvenile abundance of American shad in the Mattaponi and Pamunkey rivers as estimated by daylight seine surveys, 1980-2009. The index is the geometric mean number of American shad juveniles per seine haul.**

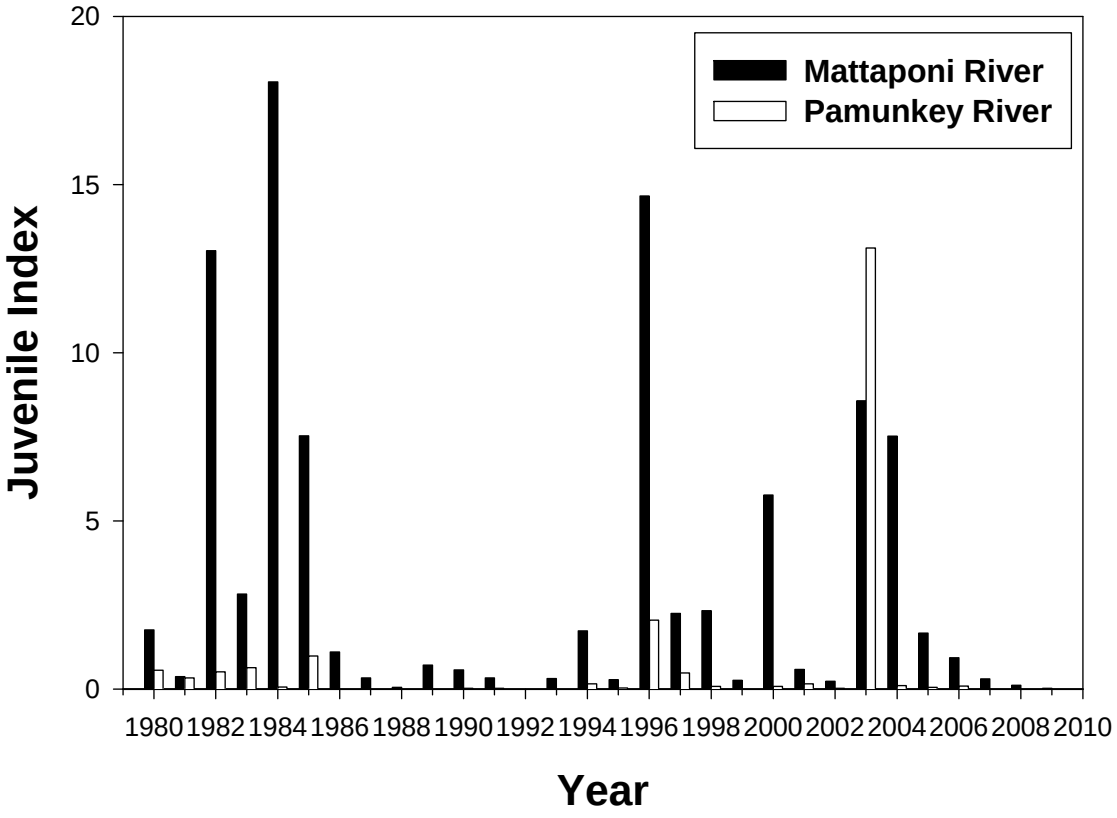


Figure 20. **The index of juvenile abundance of American shad in the Rappahannock River as estimated by daylight seine surveys, 1980-2009. The index is the geometric mean number of American shad juveniles per seine haul. The index in 1980 and 1981 was zero.**

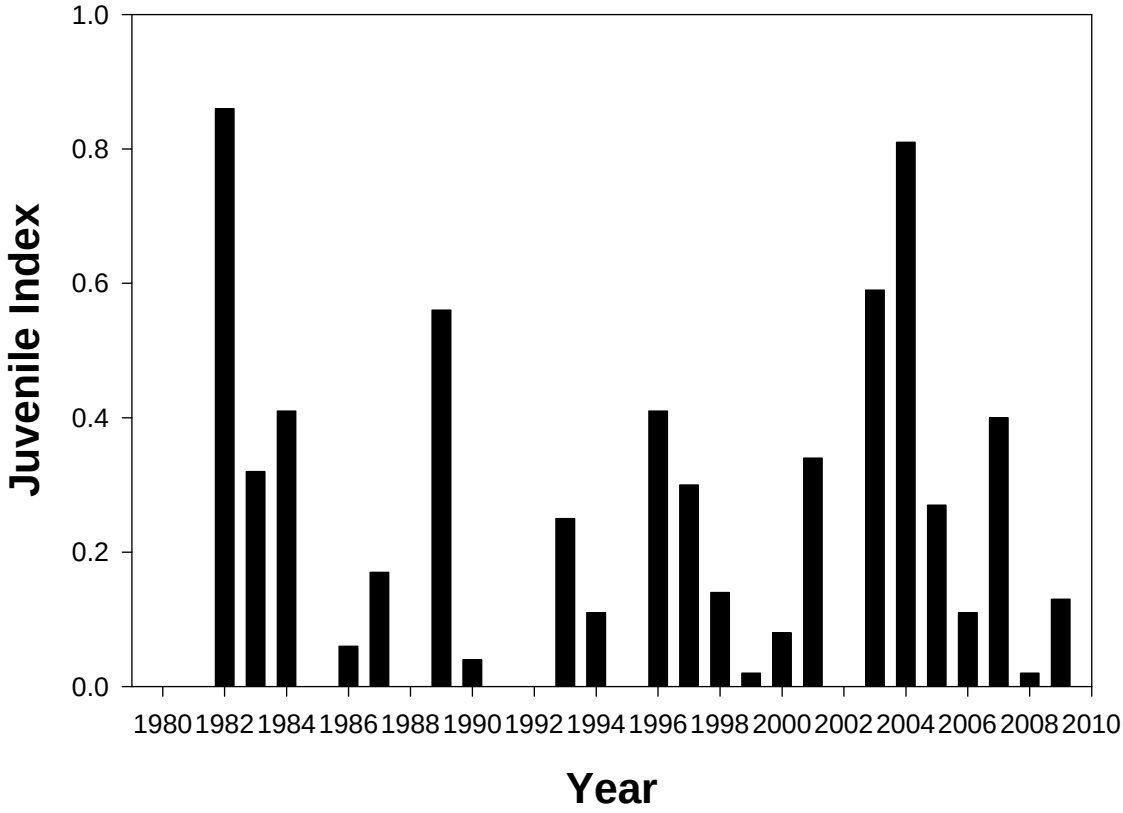


Figure 21. **The index of juvenile abundance of American shad in the James River as estimated by daylight seine surveys, 1980-2009. The index is the geometric mean number of American shad juveniles per seine haul.**

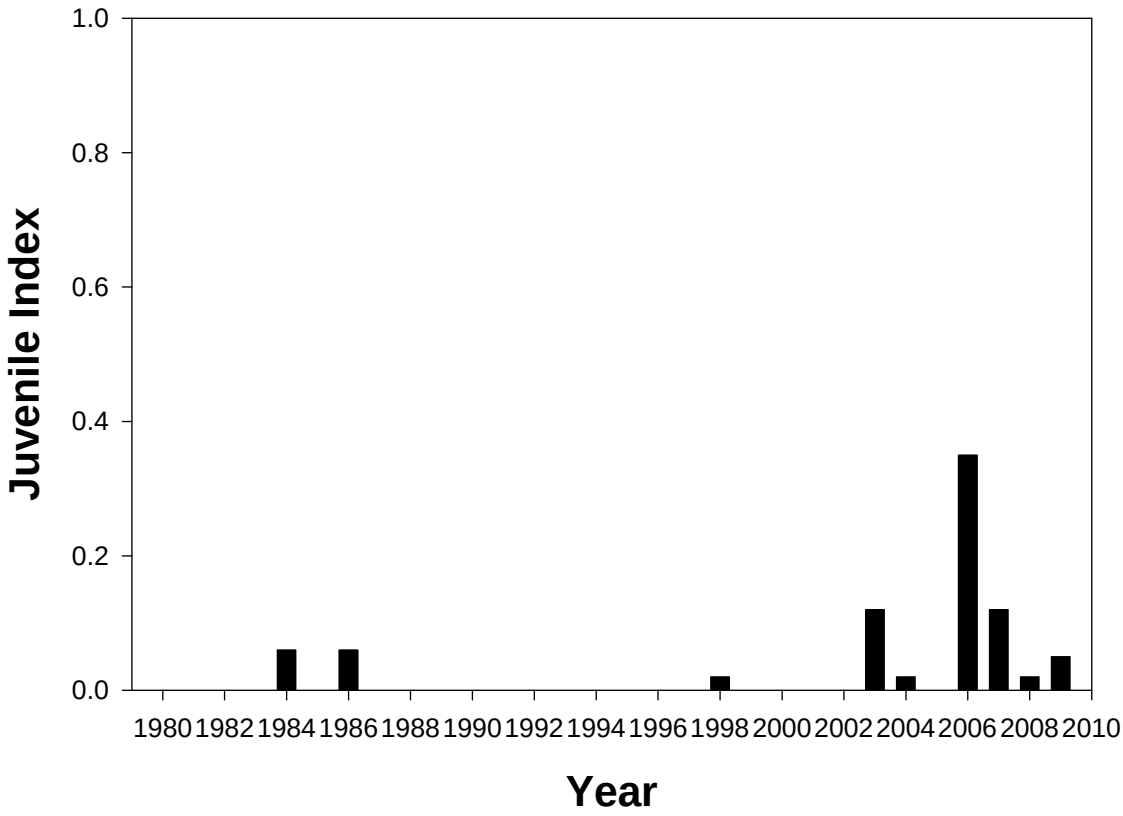


Figure 22. Mean age of females taken in staked gill nets in the James, York, and Rappahannock Rivers, 1998-2009.

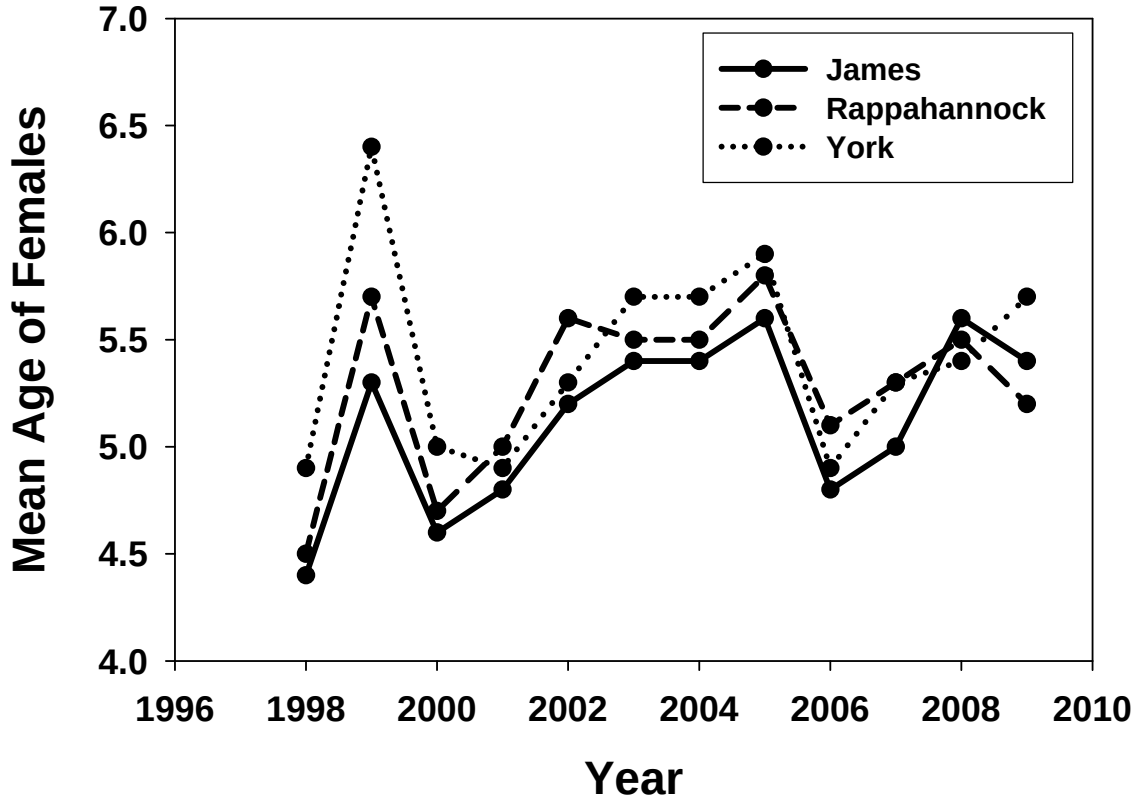


Figure 23. Mean age of females and the proportion of age-4 recruits in staked gill nets, 1998-2009.

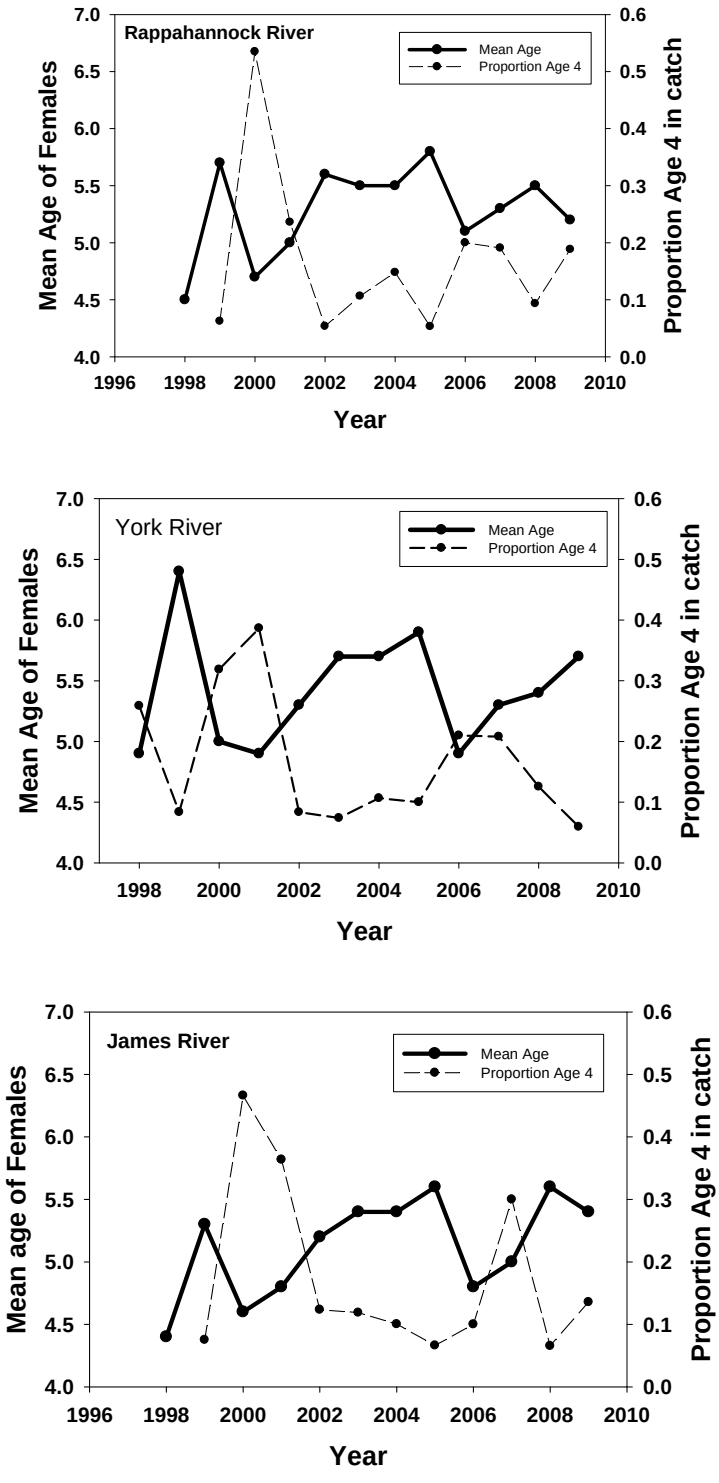


Figure 24. Recent (1998-2009) and historic values of the catch index of female American shad on the James River.

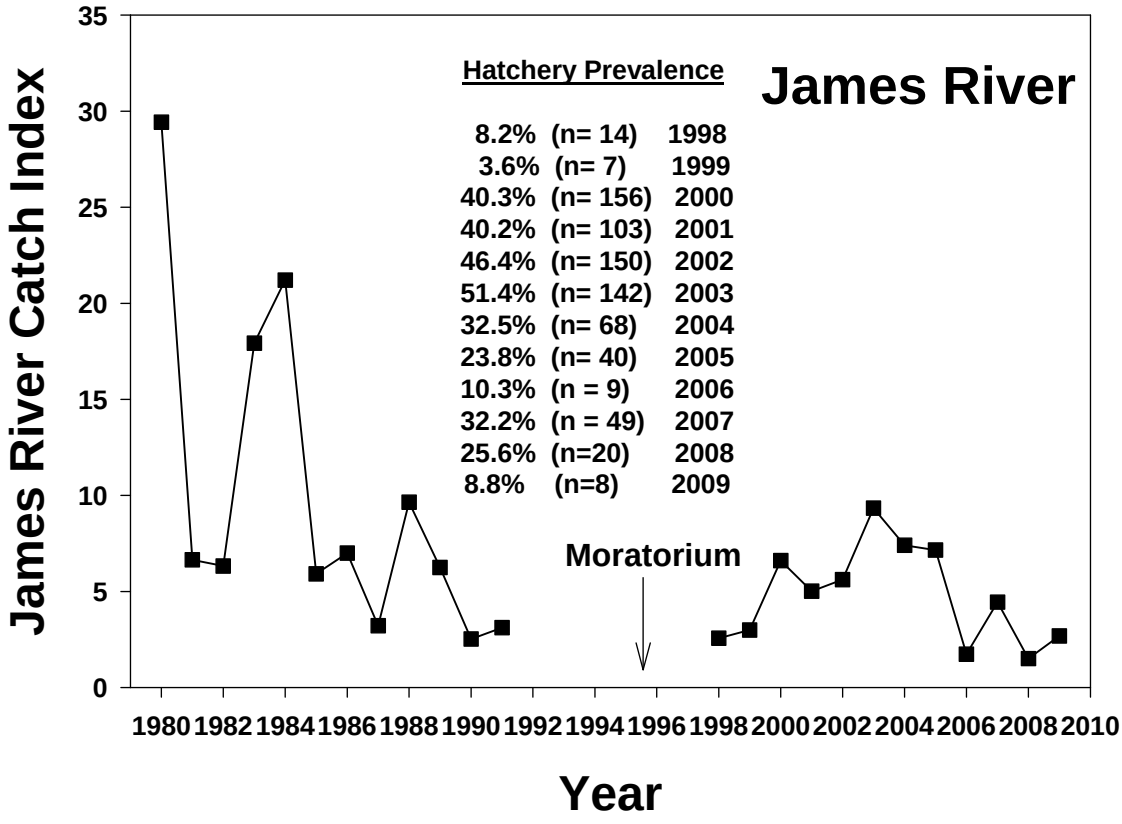


Figure 25. **Recent (1998-2009) and historic values of the catch index of female American shad on the York River.**

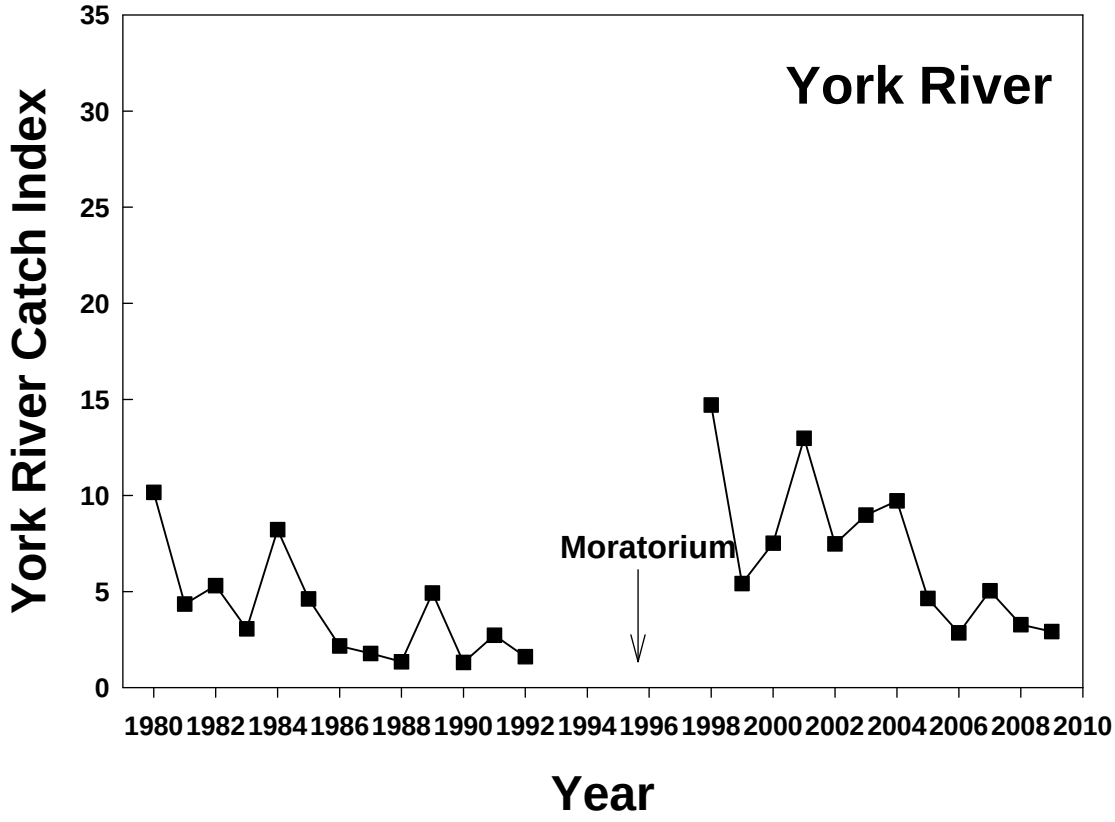


Figure 26. **Recent (1998-2009) and historic values of the catch index of female American shad on the Rappahannock River.**

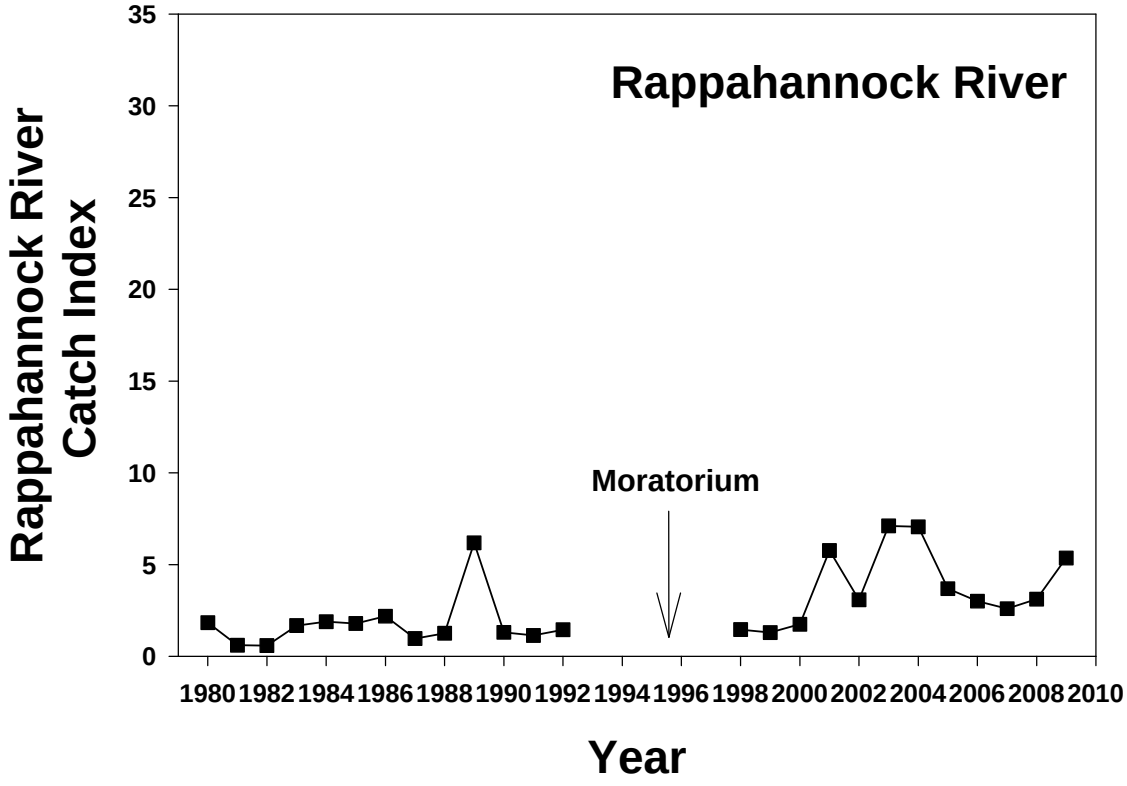
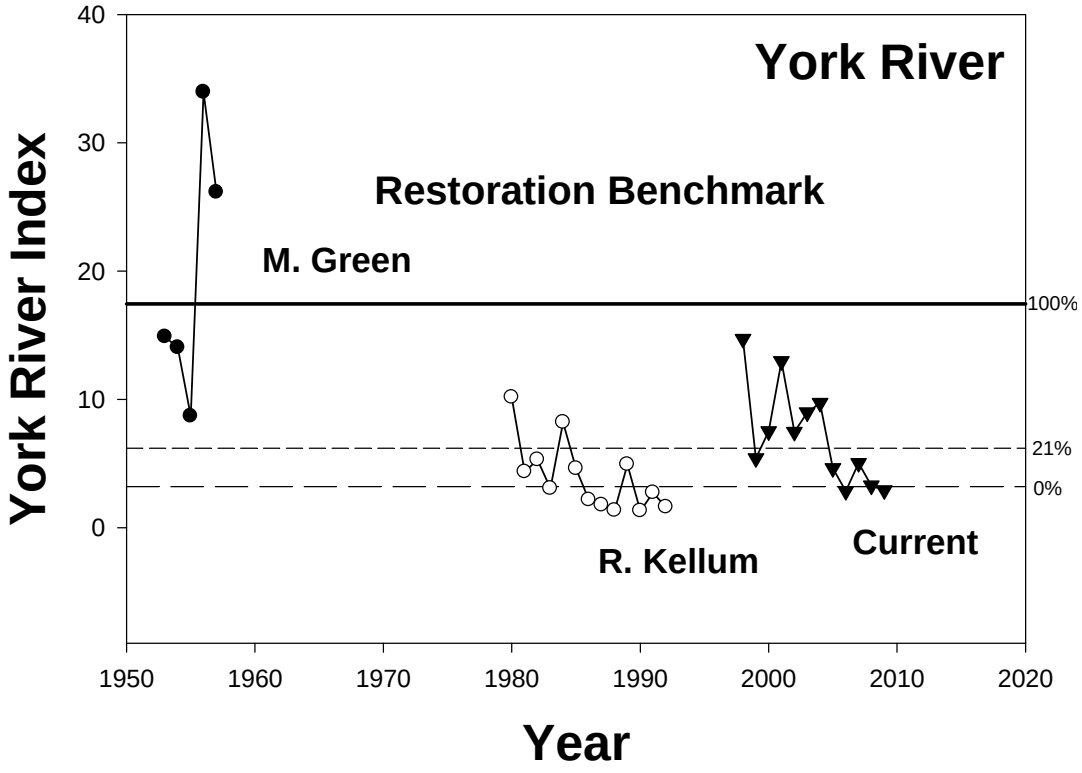


Figure 27. **Catch indices of historical logbook data from the 1950s (M. Greene), 1980s (R. Kellum), and current monitoring. The 1950s data have been adjusted by multiplying index values by 2.16 based on gear comparison trials. Horizontal lines are the geometric means of each data set (solid, 1950s; short dashes, current; long dashes, 1980s)**



Appendix I

Assessment of the 2009 Virginia by-catch of American shad
and the status of the Virginia stocks

Report to the Shad and River Herring Technical Committee of the Atlantic States Marine Fisheries Commission (ASMFC)

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Background

In spring 2009, scientists at the Virginia Institute of Marine Science (VIMS) interviewed permitted fishers who had agreed to participate in the ASMFC required monitoring program and obtained samples of their by-catch of American shad. Effort in the 2009 American shad by-catch fishery on the James and Rappahannock River continues to be low and was similar to the 2008 effort. On the York River effort in 2009 was slightly higher than in 2008 (Table 1).

This report is a companion to a separate report of the 2009 by-catch prepared by the Virginia Marine Resources Commission (VMRC) and submitted separately.

Biological Characterization of the 2009 Permitted Gill Net By-Catch in Virginia

A subsample of the 2009 by-catch of American shad (n=94 fish, 32.6% of the total number of fish reported to VMRC) was obtained from three cooperating gill netters and processed for length, weight, sex, maturity stage, age, and the presence of hatchery (OTC) marks (Table 2). The by-catch subsample contained 7 males and 87 females harvested in anchored gill nets. Fish were captured in the York River (n=92) and James River (n=2). The subsample ranged in size and age from 427-569 mm TL and 4-9 years (Table 2). Virgin and repeat spawners, 31% and 69% respectively, were both present in the subsample. Three hatchery-produced American shad were present in the by-catch subsample. Biological data on these fish are presented in Table 2.

By-Catch and Discards by Pound Nets in Virginia

In addition to the permitted by-catch samples of American shad taken in gill nets, VIMS scientists examined pound net samples from four pound net fishers operating at

locations in the upper and lower portions of Chesapeake Bay including the western and eastern shores (Figure 1). Pound net fishers had special permits to take American shad for scientific monitoring, but their catches were not permitted to be sold or retained as by-catch by the VMRC. Daily log books were also obtained from three of these cooperating fishers.

Samples of up to 87 American shad were collected from each pound net fisher at intervals of approximately every two weeks (Figure 2). Fish in these samples were taken randomly from the total catch on a given day or represented the entire catch from a single net. Some samples were taken more frequently when individual operations were catching American shad. A total of 464 American shad were processed for length, weight, sex, maturity stage, and age. Laboratory scans for hatchery marks are still in process. Biological information is recorded for each date of harvest in Tables 3-6. Year class composition from each pound net location is reported in Table 7. All locations had similar year class structures.

Numbers of males captured were lower than numbers of females (147 males; 317 females). Sex ratios (males:females) were: Great Wicomico, 1:1.3; Lynnhaven Inlet, 1:4.6; Rappahannock River, 1:1; Cape Charles, 1:1.8. Maturity stages were determined macroscopically for females in the laboratory. Spawning ratios (prespawning:postspawning) of females were: Great Wicomico, 1:0; Lynnhaven Inlet, 1:0; Rappahannock River, 1:0.33; Cape Charles, 1:2.7.

Our monitoring indicated that post-spawning fish exiting the Chesapeake Bay were taken by pound nets on the eastern shore near the Bay mouth.

A total of 5574 discarded American shad were recorded in commercial log book records of three pound net fishers in the spring of 2009 (Figures 3-5). We were unable to obtain log books from one other operator although we did purchase fish for biological characterization from those nets.

Results of the 2009 Fishery-Independent Monitoring Studies

The catch index values (the area of the curve of catch rate versus day of the year) of pre-spawning American shad in fishery-independent staked gill net monitoring is depicted in Figure 6.

On the Rappahannock River, the 2009 index was 5.36, the highest value seen since 2004.

In 2009 the catch index on the James River (2.72) increased from the 2008 value of 1.51. The 2008 index was the lowest value seen since monitoring began in 1998.

The 2009 York River index is 2.92. The trend of the York River monitoring data is a downward slope of catch index values through the 12-y time series.

Table 1. 2009 American shad by-catch permit and harvest data. Data provided by the Virginia Marine Resources Commission.

Water Body	Year	# Permit Holders	# Active Permits	Total Trips	# Shad Caught	# Shad Kept
James River	2009	8	1	6	2	0
	2008	6	2	3	3	3
	2007	16	7	58	119	52
	2006	32	*	27	24	23
York River	2009	11	6	97	302	288
	2008	10	6	85	89	89
	2007	15	8	104	199	199
	2006	31	*	198	233	228
Rappahannock River	2009	1	0	0	0	0
	2008	3	1	8	81	57
	2007	5	2	23	22	20
	2006	14	*	8	3	3

Table 2. Biological characteristics by sampling date for American shad permitted gill net by-catch samples processed at VIMS. Abbreviations: JA, James River; YK, York River; *, Unreadable.

River	DateFished	Fisherman	Sex	FL	TL	Weight (g)	Age	# Previous Spawns	OTC present
YK	3/4/2009	1	F	410	469	1222.3	5	1	N
YK	3/4/2009	1	F	415	462	1320.7	5	0	N
YK	3/4/2009	1	F	460	518	1764.3	6	2	N
YK	3/4/2009	1	F	473	532	2070.3	9	3	N
YK	3/10/2009	1	F	487	558	2122.7	8	3	N
YK	3/10/2009	1	F	505	569	1941.9	*	*	N
YK	3/11/2009	1	F	437	488	1423.5	6	2	N
YK	3/14/2009	1	F	435	496	1577.4	5	0	N
YK	3/14/2009	1	F	423	474	1368.3	6	1	N
YK	3/14/2009	1	F	467	527	1936.0	7	3	N
YK	3/17/2009	1	F	453	515	2030.0	*	*	N
YK	3/18/2009	1	F	405	454	1637.3	5	0	N
YK	3/18/2009	1	F	431	489	1936.7	6	2	N
YK	3/18/2009	1	F	422	473	1675.8	5	1	N
YK	3/19/2009	1	F	458	527	1739.3	5	1	N
YK	3/20/2009	1	F	491	557	2121.1	*	*	N
YK	3/20/2009	1	M	436	494	1379.7	*	*	N
YK	3/20/2009	1	F	445	508	1535.3	6	0	N
YK	3/20/2009	1	F	463	520	1623.4	6	1	N
JA	3/23/2009	2	F	448	498	1565.4	5	1	N
YK	3/23/2009	1	F	481	539	1906.8	8	2	N
YK	3/23/2009	1	F	438	496	1491.2	6	1	N
YK	3/23/2009	1	M	433	495	1395.0	4	0	N
YK	3/23/2009	1	F	500	567	2481.2	7	2	N
YK	3/24/2009	1	F	461	512	1734.5	7	3	N

YK	3/26/2009	1	F	437	489	1695.6	6	2	N
YK	3/26/2009	1	F	512	559	2304.9	*	*	N
YK	3/27/2009	1	F	461	518	1828.7	5	0	N
YK	3/27/2009	1	F	401	459	1287.9	5	1	N
YK	3/27/2009	1	F	427	477	1455.7	5	1	N
YK	3/30/2009	3	F	424	485	1341.4	6	1	N
YK	3/30/2009	3	F	399	455	1113.8	*	*	N
YK	3/30/2009	3	F	387	437	978.8	*	*	N
YK	3/30/2009	3	F	405	454	1134.6	6	2	N
YK	3/30/2009	3	F	451	503	1457.4	6	2	N
YK	3/30/2009	3	F	410	458	1159.8	5	1	N
YK	3/30/2009	3	F	419	465	1230.4	5	1	N
YK	3/30/2009	3	F	413	464	1109.8	5	1	N
YK	3/30/2009	3	F	406	460	1195.6	5	0	N
YK	3/30/2009	1	F	414	471	1327.5	5	1	N
YK	3/30/2009	1	F	457	522	1674.5	5	1	N
YK	3/30/2009	1	F	454	510	1687.1	8	3	N
YK	3/31/2009	1	F	504	565	2377.4	*	*	N
YK	3/31/2009	3	M	410	464	1178.3	5	0	N
YK	3/31/2009	3	F	419	474	1257.4	5	0	N
YK	3/31/2009	3	F	427	474	1237.8	6	1	N
YK	3/31/2009	3	F	405	460	1222.2	5	0	N
YK	4/1/2009	3	F	400	458	1141.8	5	1	N
YK	4/1/2009	3	F	440	494	1468.1	5	1	N
YK	4/1/2009	3	F	429	482	1245.0	5	0	N
YK	4/1/2009	3	F	450	508	1445.0	5	0	N
YK	4/1/2009	3	M	413	466	1207.0	6	2	N
YK	4/1/2009	3	F	419	476	1185.6	5	0	N
YK	4/1/2009	3	M	427	479	1286.2	*	*	N
YK	4/1/2009	3	M	412	464	1134.7	6	2	N

YK	4/1/2009	3	F	456	514	1778.3	5	0	N
YK	4/1/2009	3	F	448	508	1373.8	5	1	N
YK	4/1/2009	1	F	465	518	1771.1	*	*	N
YK	4/2/2009	1	F	457	512	1892.0	7	2	N
YK	4/2/2009	1	F	496	560	2146.1	8	3	N
YK	4/2/2009	1	F	440	498	1572.3	*	*	N
YK	4/2/2009	1	F	450	515	1734.1	7	2	N
YK	4/2/2009	1	F	444	498	1508.9	5	0	N
YK	4/2/2009	1	F	437	484	1428.4	6	2	N
YK	4/4/2009	1	F	436	494	1436.4	5	1	N
YK	4/4/2009	1	F	454	510	1644.3	6	3	N
YK	4/4/2009	1	F	456	518	1824.3	6	2	N
YK	4/5/2009	1	F	478	536	1877.5	*	*	N
YK	4/6/2009	3	F	419	469	1328.4	6	2	N
YK	4/6/2009	3	F	450	504	1501.1	6	1	N
YK	4/6/2009	3	F	379	429	1024.3	5	0	N
YK	4/6/2009	3	F	408	462	1304.1	5	0	N
YK	4/6/2009	3	F	455	506	1645.4	5	1	N
JA	4/6/2009	2	F	457	508	1888.0	7	3	Y
YK	4/7/2009	3	F	420	476	1218.6	*	*	N
YK	4/7/2009	3	F	395	452	1027.8	4	0	N
YK	4/7/2009	3	F	432	488	1466.6	6	1	N
YK	4/7/2009	3	F	465	526	1547.8	6	1	N
YK	4/7/2009	3	F	417	469	1239.9	4	0	N
YK	4/7/2009	3	F	424	479	1349.6	5	0	N
YK	4/7/2009	3	F	413	466	1236.6	4	0	N
YK	4/9/2009	3	F	408	461	1209.2	*	*	N
YK	4/9/2009	3	F	388	437	986.4	5	0	N
YK	4/9/2009	3	F	431	484	1411.8	6	1	N
YK	4/10/2009	3	M	401	450	1129.8	5	1	N

YK	4/10/2009	3	F	457	517	1583.5	6	1	N
YK	4/10/2009	3	F	423	464	1380.6	*	*	N
YK	4/13/2009	3	F	379	427	1031.9	*	*	N
YK	4/13/2009	3	F	415	461	1421.4	5	0	Y
YK	4/14/2009	3	F	420	469	1177.9	*	*	N
YK	4/17/2009	3	F	431	478	1252.6	5	1	N
YK	4/17/2009	3	F	422	468	1234.0	*	*	N
YK	4/17/2009	3	F	427	481	1350.2	*	*	N
YK	4/18/2009	3	F	420	464	1341.3	5	1	Y

Table 3. Biological data of American shad (n=100) collected from a pound net located at the mouth of the Great Wicomico River. Abbreviations: TW, total weight; Avg, Average; P. Spent, Partially Spent.

Date	Maturity Stage	# Females	TW (kg)	Avg Weight Per fish (g)	# Males	TW (kg)	Avg Weight Per fish (g)
3/26/09	Maturing				2	1.80	901.75
	Hydrated						
	P. Spent						
	Spent						
	Unstaged						
3/27/09	Maturing	8	12.19	1523.60	5	4.55	909.68
	Hydrated						
	P. Spent						
	Spent						
	Unstaged						
4/9/09	Maturing	20	25.61	1280.69	18	15.87	881.80
	Hydrated						
	P. Spent						
	Spent						
	Unstaged						
4/23/09	Maturing	18	23.96	1331.11	18	15.84	879.97
	Hydrated						
	P. Spent						
	Spent						
	Unstaged						
5/19/09	Maturing	9	10.68	1186.23	1	0.56	557.60
	Hydrated	1	0.93	931.60			
	P. Spent						
	Spent						
	Unstaged						
Total		56	73.37		44	38.62	

Table 4. Biological data of American shad (n=173) collected from a pound net located at the mouth of Lynnhaven Inlet. Abbreviations: TW, total weight; Avg, Average; P. Spent, Partially Spent.

Date	Maturity Stage	# Females	TW (kg)	Avg Weight Per fish (g)	# Males	TW (kg)	Avg Weight Per fish (g)
4/28/09	Maturing	35	43.98	1256.55	15	12.98	865.51
	Hydrated	2	3.39	1695.55			
	P. Spent						
	Spent	5	4.36	871.22			
	Unstaged						
5/4/09	Maturing	53	66.74	1259.19	7	6.18	883.56
	Hydrated	7	8.56	1222.31			
	P. Spent	1	0.74	737.50			
	Spent	1	0.82	819.00			
	Unstaged						
5/6/09	Maturing	38	46.89	1233.96	9	7.78	864.59
	Hydrated						
	P. Spent						
	Spent						
	Unstaged						
Total		142	175.48		31	26.94	

Table 5. Biological data of American shad (n=24) collected from a pound net located at the mouth of the Rappahannock River. Abbreviations: TW, total weight; Avg, Average; P. Spent, Partially Spent.

Date	Maturity Stage	# Females	TW (kg)	Avg Weight Per fish (g)	# Males	TW (kg)	Avg Weight Per fish (g)
4/30/09	Maturing	12	12.02	1001.50	12	9.04	753.48
	Hydrated						
	P. Spent						
	Spent						
	Unstaged						
Total		12	12.02		12	9.04	

Table 6. Biological data of American shad (n=167) collected from a pound net located in the vicinity of Cape Charles, VA. Abbreviations: TW, total weight; Avg, Average; P. Spent, Partially Spent.

Date	Maturity Stage	# Females	TW (kg)	Avg Weight Per fish (g)	# Males	TW (kg)	Avg Weight Per fish (g)
4/17/09	Maturing	17	22.97	1351.39	5	4.34	868.68
	Hydrated						
	P. Spent						
	Spent						
	Unstaged						
4/20/09	Maturing	5	6.38	1276.44	4	3.59	717.42
	Hydrated						
	P. Spent						
	Spent						
	Unstaged						
5/19/09	Maturing	3	2.64	878.43	8	4.51	564.09
	Hydrated						
	P. Spent	20	16.81	840.36			
	Spent	18	15.69	871.64			
	Unstaged						
5/29/09	Maturing	4	3.89	971.50	43	29.00	674.48
	Hydrated						
	P. Spent	27	22.42	830.34			
	Spent	13	10.55	811.21			
	Unstaged						
Total		107	101.35		60	41.44	

Table 7. Year class composition of fish taken in pound nets in 2009, indicated as percent of aged catch from four pound net locations in Chesapeake Bay.

	Year Class	Great Wicomico	Lynnhaven	Cape Charles	Rappahannock
Males	2006	15.0	11.5	2.6	0.0
	2005	45.0	50.0	43.6	50.0
	2004	20.0	27.0	25.6	40.0
	2003	15.0	11.5	23.0	10.0
	2002	5.0	0.0	2.6	0.0
	2001	0.0	0.0	2.6	0.0
	2000	0.0	0.0	0.0	0.0
Females	2006	0.0	8.2	1.3	9.0
	2005	12.0	15.5	13.9	18.2
	2004	50.0	50.9	55.7	36.4
	2003	30.0	20.0	15.2	36.4
	2002	6.0	5.5	8.9	0.0
	2001	2.0	0.0	3.8	0.0
	2000	0.0	0.0	1.3	0.0

Figure 1. Location of pound net operations with special American Shad by-catch permits.

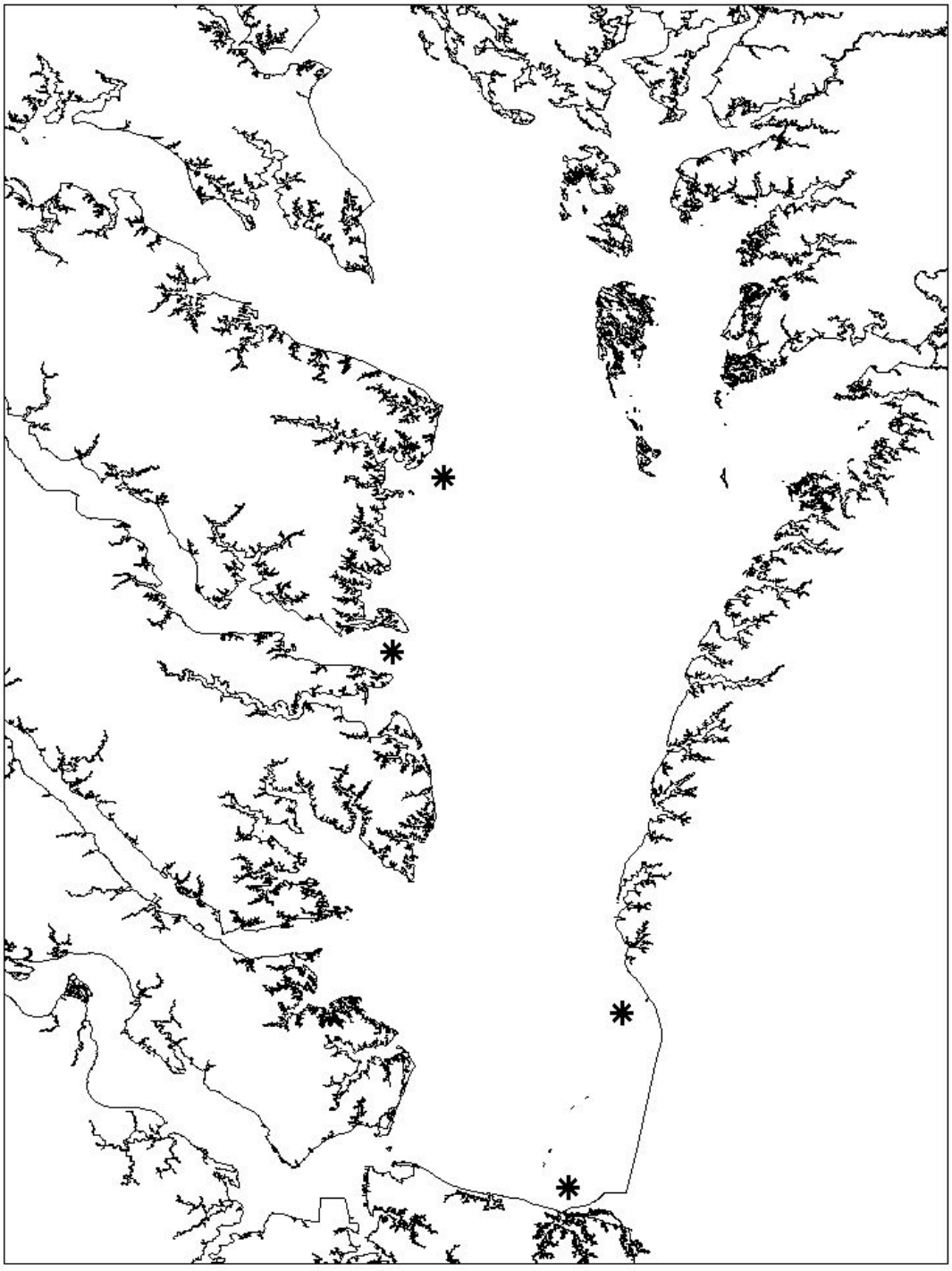

Figure 2. Number of American Shad processed by VIMS caught with special pound net by-catch permits. N is the number of samples obtained.

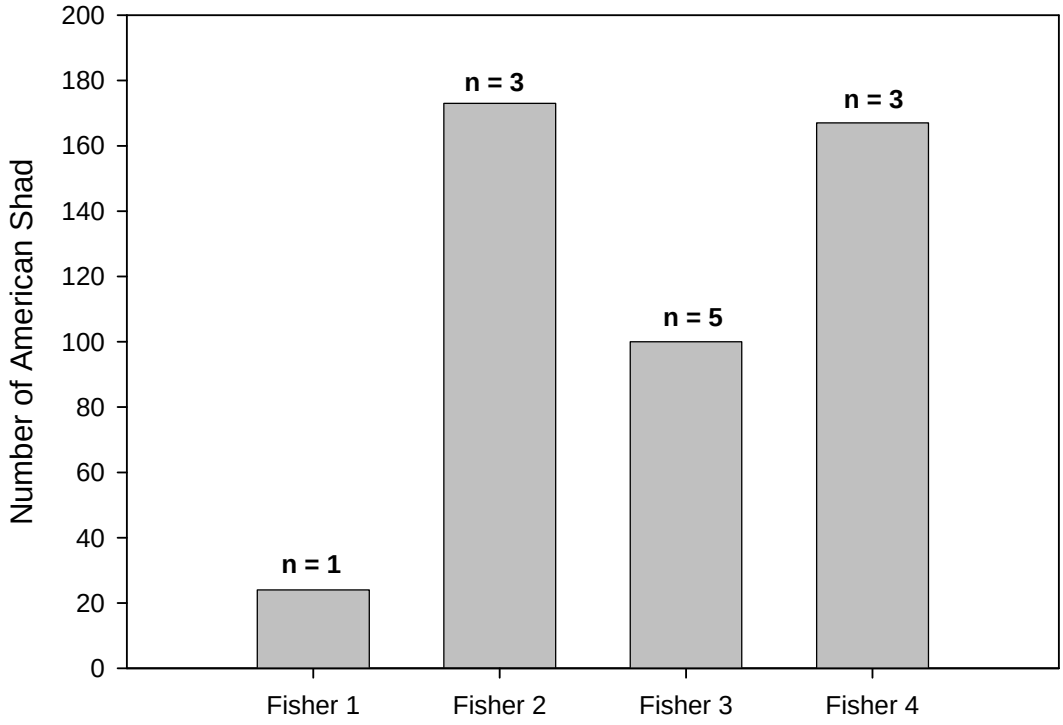

Figure 3. Catches (number of shad per trip) in pound nets located in the upper Virginia Chesapeake Bay near the Great Wicomico River. Data are taken from 2009 commercial fisher log books.

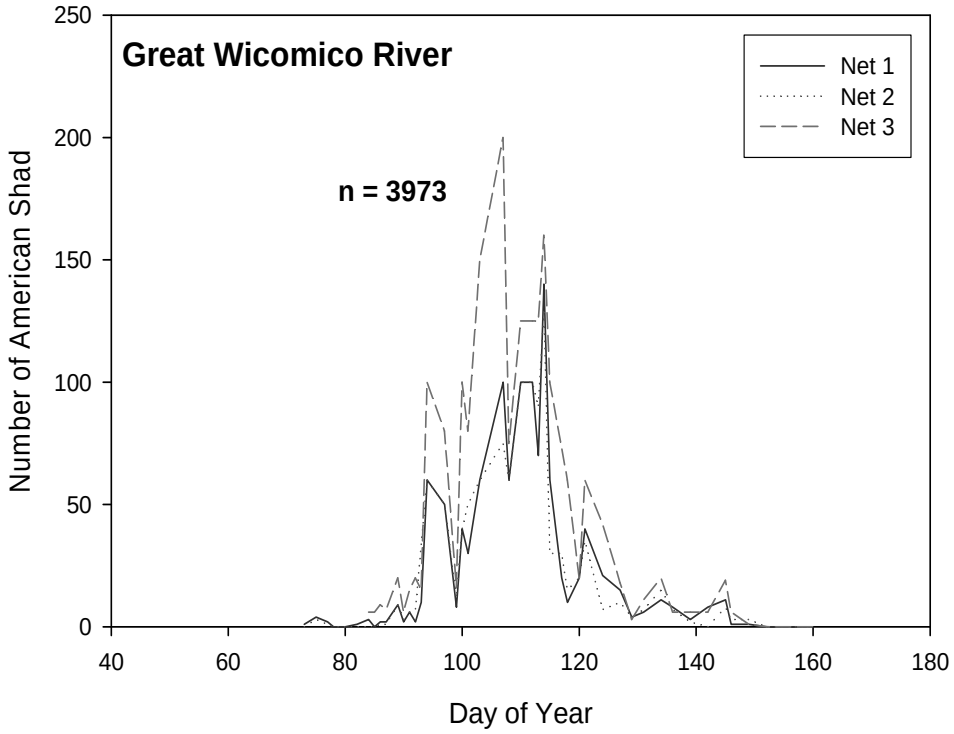

Figure 4. Catches (number of shad per trip) in pound nets located in the upper Virginia Chesapeake Bay near the Rappahannock River mouth. Data are taken from 2009 commercial fisher log books.

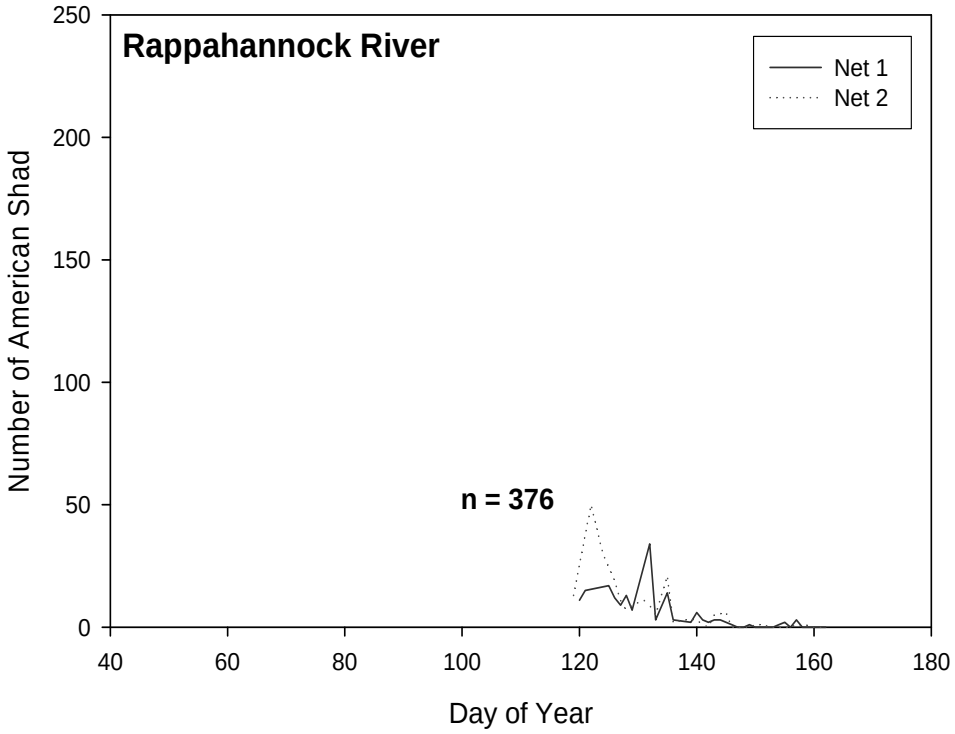

Figure 5. Catches (number of shad per trip) in pound nets located in the lower Virginia Chesapeake Bay near Cape Charles, VA. Data are taken from 2009 commercial fisher log books.

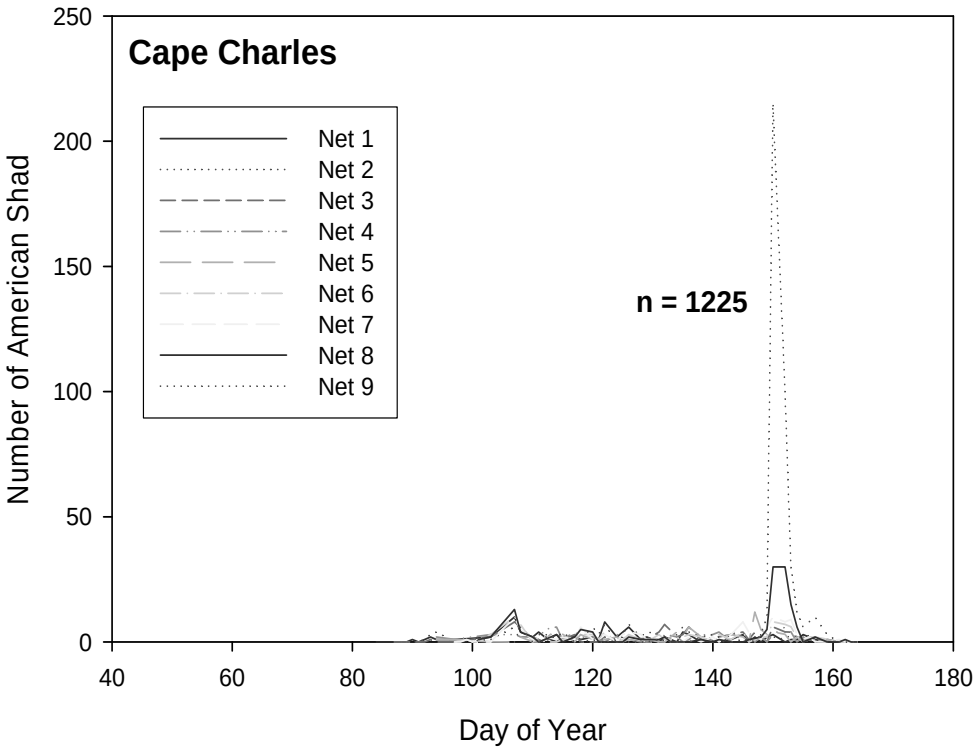

Figure 6. Time series of catch index from staked gill net monitoring in Virginia, 1998-2009.