ANNUAL PROGRESS REPORT

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

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ACKNOWLEDGEMENTS

We are deeply indebted to the many landowners on the tributaries of Chesapeake Bay that have graciously allowed us to conduct sampling on their property. We thank the Mariners Museum, Jamestown 4-H Camp, Powhatan Resorts, and the United States Army at Fort Eustis for their permission to sample. We would also like to thank the many students and staff who assisted in the field sampling and data compilation of this report.

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PREFACE

The Virginia Institute of Marine Science (VIMS) has conducted a juvenile striped bass seine survey from 1967 through 1973 and from 1980 through the present. The primary objective has been the monitoring of the relative annual recruitment success of juvenile striped bass in the spawning and nursery areas of Lower Chesapeake Bay. Initially (1967-1973), the survey was funded by the U.S. Fish and Wildlife Service and when reinstated in 1980 with funding from the National Marine Fisheries Service under the Emergency Striped Bass Study program. Commencing with the 1988 annual survey, support of the program has been jointly made through the Sportfish Restoration Program (Wallop-Breaux Act), administered through the U.S. Fish and Wildlife Service and the Virginia Marine Resources Commission. This report summarizes the results of the 2000 sampling period and compares these results with the previous work.

Specific objectives planned for the 2000 program were to:

1. Measure the relative abundance of the 2000 year class of striped bass from the James, York and Rappahannock river systems.

2. Quantify environmental conditions at the time of collection.

3. Examine relationships between juvenile striped bass abundance and measured or proxy environmental and biological data.
INTRODUCTION

The estimation of juvenile striped bass abundance in Virginia waters, funded by the U.S. Fish and Wildlife Service, is part of a coast-wide sampling program of striped bass recruitment conducted from New England to North Carolina under the coordination of the Atlantic States Marine Fisheries Commission (ASMFC). Virginia's efforts started in 1967 with funding from the Commercial Fisheries Development Act of 1965 (PL 88-309) and continued until 1973 when the program was terminated. It was re-instituted in 1980 with Emergency Striped Bass Study funds (PL 96-118, 16 U.S.C. 7678, the "Chafee Amendment"), and since 1989 has been funded by the Wallop-Breaux expansion of the Sportfish Restoration and Enhancement Act of 1988 (PL 100-448 known as the Dingle-Johnson Act).

The Atlantic Coast Striped Bass Interstate Fisheries Management Plan was developed by ASMFC, in 1981, then adopted by the Virginia Marine Resources Commission (VMRC) in March 1982 (Regulation 450-01-0034). Amendment IV to the plan requires "producing states" (e.g. Virginia, Maryland, Delaware and New York) to develop and support monitoring programs of recruitment levels. This became a mandate when Congress passed the Atlantic Striped Bass Conservation Act in 1984 (reauthorization 1991, PL102-130). To remain in compliance with the Act, each state must adhere to all provisions in the interstate FMP (ESBS 1993). Virginia has done this through December 2000.

Originally, the Virginia program used a 6' x 100' (2m x 30.5m) x 0.25" (6.4mm) mesh bag seine,
but after comparison tows with Maryland gear, 4' x 100' x 0.25" mesh (1.2m x 30.5m x 6.4mm) showed virtually no statistical differences in catch, Virginia adopted the "Maryland seine" (Colvocoresses 1984). The original purpose of the gear comparison study was to standardize methods thereby allowing a Bay-wide examination of recruitment success (Colvocoresses and Austin 1987). This was never realized however, for various differences in data handling (MD: arithmetic index, VA: geometric index) and state politics. A Bay-wide index using a weighted (by river spawning area) geometric mean was finally developed in 1993 (Austin, Colvocoresses and Mosca 1993).

**METHODS**

Field sampling was conducted during five approximately biweekly sampling periods from July through mid-September of 2000. During each sampling period the seine was hauled at eighteen historically sampled sites (index stations) and twenty-three auxiliary stations along the shores of the James, York and Rappahannock systems (Fig. 1). Addition of the auxiliary sites in 1989 was made to provide better geographic coverage and create larger within-river-system sample sizes so that trends in juvenile abundance can be meaningfully monitored on a system by system basis, particularly as the stock size increases and the nursery ground expands.

One seine haul was made at each auxiliary station, and two duplicate hauls made at each index station during each sampling round. Collections were made by deploying a 100' (30.5m) long, 4' (1.22m) deep, 1/4" (0.64cm) bar mesh minnow seine perpendicular to the shoreline (either until the net was fully extended or a depth of approximately four feet was encountered), pulling the offshore
end down-current and back to the shore. In the case of index stations, all fish taken during the first tow were removed from the net, measured, and held in water-filled buckets until after the second tow. All fish collected were identified and counted, and all striped bass and all individuals or a subsample of at least 25 individuals of other species measured to the nearest mm fork length (or total length if appropriate). Salinity, water temperature, pH and dissolved oxygen concentrations were measured after the first haul using a Hydrolab Reporter® water quality sampler. Sampling time, tidal stage and weather conditions were recorded at the time of each haul. When two hauls were made, an intervening period of 30 minutes was allowed between hauls and the first sample was processed during this interlude. All fishes captured, excepting those preserved for life history studies, were returned to the water at the conclusion of sampling.

In the present report, comparisons with prior years will be made on the basis of the 'primary nursery' standardized data set (Colvocoresses 1984), i.e. only the data collected from the months and area covered during all surveys will be included in the analyses. Data from the auxiliary stations will not be included since there is no direct basis for comparison. Since the frequency distribution of catch size of these collections is extremely skewed and approximates a negative binomial distribution (Colvocoresses 1984), a logarithmic transformation (ln(x+1)) was applied in order to normalize the data prior to analyses (Sokal and Rohlf 1981). Subsequently computed mean values were retransformed (i.e. the geometric mean) and scaled up arithmetically to allow comparison with Maryland data.

Mean catch rates are contrasted by comparing 95% confidence intervals. Reference to "significant" differences between means in this context will be restricted to cases of non-overlap by
these confidence intervals. Because the standard errors are calculated using the transformed (logarithmic) values, confidence intervals on the retransformed and adjusted scale are non-symmetrical.

RESULTS

Objective 1: Measure the relative abundance of the 2000 year class of juvenile striped bass from the James, York and Rappahannock river systems.

A total of 2741 young-of-the-year striped bass were collected from 180 seine hauls during the 2000 index station sampling and an additional 710 age 0 striped bass were collected in 100 hauls at the auxiliary sites (Table 1, Fig. 1). The adjusted overall mean catch per seine haul (CPUE) for the index stations was 16.18, the third highest index in Virginia (Table 2, Fig. 2). This value was more than twice the overall average index of 6.22 (significantly different) and was significantly higher than the 1999 value (2.8). Indices for each river system were higher than their overall average and each individual river was more than its respective overall average.

The 2000 catch in the James drainage was 26.64, significantly higher than the 1999 index (5.33) and the overall average (8.06)(Table 3, Fig. 3). The 2000 index for the James system is the second highest recorded. The main-stem James (23.56) catch rate was three times higher than its overall average (7.11). The Chickahominy catch rate (33.97) rose in 2000 and was also three times higher than its overall average (10.33). This increase reversed a two year trend of lower than average indices in the Chickahominy. The individual indices for both the James and Chickahominy were the
third highest recorded. Juvenile striped bass were caught throughout the James system during 2000 (Table 1, Fig. 4). Distribution and catches peaked in the mid-portion of the nursery area (C1 and J46) while consistent catches were made at nearly all of the sampling sites with the one exception being the most down-river auxiliary site (J12).

The 2000 index in the York drainage (11.88) was the third highest on record for the system and double the historical average (5.32)(Table 3, Fig. 3). The catch in the Pamunkey (23.11) and the Mattaponi (6.86) were also above their respective overall averages (Pamunkey (6.27), Mattaponi (4.69)). The Pamunkey index was more than three times its historical average (significantly higher) and was the highest index recorded for the river. The Mattaponi was slightly higher than its historical average and the difference was not significant.

All sites in the York River proper are auxiliary sites. Only Y28 produced striped bass during the 2000 sampling season and striped bass were caught there on all sampling visits. Catches on the Mattaponi River were made at all index sites during each sampling round except for round 5 at M47, the uppermost site. Catches were low at this site during all rounds. The three lower index sites (M33, M41, M44) produced most of the striped bass in the Mattaponi. M33 consistently produced good numbers of stripers except for round 5 while M41 had a large catch in round 1 with lower catches in later rounds. (Table 1; Fig. 5).

In the Pamunkey River, highest catches occurred at P45 and P50, the two upper index sites (Figure 6). While catches were made during each sampling visit to P42, they were generally small. P36, the downriver auxiliary site was more productive than P42 but the upriver auxiliary site (P55) produced
few striped bass. Sampling at P61 was missed during rounds 2 through 5 due to weather and associated tidal height related problems.

The 2000 index in the Rappahannock River was 13.32, double the value of and significantly higher than the historic average of 6.63 (Table 3). Highest catches were at the three uppermost index sites (R44, R50, R55) (Table 1, Fig. 7). Up-river auxiliary sites (R60 through R76) produced fish during most sampling visits though not in great numbers. The two lower index sites, R28 and R37, produced low numbers of stripers on most visits. R41, an auxiliary site within the index area had good catches of striped bass. The two lower auxiliary sites, R12 and R21, again produced no striped bass during any sampling visits.

In the Pamunkey and Rappahannock Rivers, catches at most sites appeared to be highest in the earlier rounds with catches diminishing as the sampling rounds (and summer) progressed. This follows the overall catch pattern (Table 4). This trend was not observed in the James and Mattaponi. In these rivers, a few sites had lower catches as the summer progressed but other sites either increased over the summer or fluctuated substantially from round to round. Presumably, these differences are attributable to the schooling behavior of striped bass and ingress/egress to the shallow water habitats that we sample.

Because the number and precise timing of sampling rounds has varied throughout the history of the sampling program, results by sampling period cannot be directly compared. However, temporal usage of the nursery area can be evaluated by comparing round by round results with historical monthly averages. Generally, catch rates are highest during July and early-August and taper off in
the later rounds of August and September and in 2000 this overall pattern was observed. (Table 4). In the York and Rappahannock, round 5 catches were considerably less than round 1 totals (York = 86%; Rapp. = 89%) while the James catches only decreased by 29% over the sampling season. We offer no explanation for the differences observed between systems except for the higher abundance (index) in the James. Sampling during 1999 captured too few fish to examine this trend although it was somewhat similar in the James and Rappahannock (Austin et al, 2000). The 1998 catches did not exhibit the dramatic catch reduction through the season as seen in 2000 (Austin et al, 1999).

A total of seventy young-of-the-year (y-o-y) and three post y-o-y striped bass were captured at the former Bluefish Seine Survey sites in the lower James River and Chesapeake Bay. One y-o-y was captured at Willougby Spit in the lower James River on June 20. One y-o-y was captured at Kiptopeke Beach and fifty y-o-y were captured at Bloxom on the same date. Fifteen y-o-y were captured at Bloxom in July and three were caught in August. Bloxom is located on the Bay side of the Eastern Shore in Pocomoke Sound. Fish captured at this site probably came from the Pocomoke River.

Objective 2: Quantify environmental conditions at the time of collection.

Collection information and pertinent environmental variables recorded at the time of each collection in 2000 are given in Tables 5 through 8. Generally, direct round by round comparisons of environmental and water quality parameters are difficult because of local site conditions and variations, so they must be examined on a broader basis.

Generally, salinities were lower in 2000 than in 1999 (Table 5)(Austin et al, 2000). Salinities at
down-river index sites were considerably lower than those recorded in 1999. The Palmer Drought Index (Palmer, 1964) and the Standard Precipitation Index (SPI) from the Southeast Regional Climate Center indicated that the spring of 2000 was near a normal moisture condition keeping salinities lower than the 1999 levels when moderate drought was experienced. The SPI for Virginia indicated normal or slightly wet conditions from mid-March through the end of May.

Overall, water temperatures were slightly lower in 2000 (Table 6) than in 1999 (Austin et al, 2000). The normal pattern of higher temperature in the early rounds and temperature slowly declining during the later rounds was observed in 2000. Water temperatures by round may have varied slightly from 1999 readings but there were no major weather anomalies that affected water temperatures during the 2000 sampling season. Water temperature readings in these estuaries are not only affected by the long term weather patterns of summer but significant variations from day to day and river to river can be caused by time of sampling (morning versus afternoon, etc) and local events such as thunderstorms. We sample the shallow shoreline areas and these are easily affected by such conditions.

Dissolved oxygen levels were generally within the norms expected during this sampling period (Table 7). No depressed readings that might affect catches were observed in 2000.

The pH levels during the 2000 sampling were near normal for most areas during 2000 (Table 8). Generally the James and Rappahannock systems have pH values that are slightly basic. The Pamunkey River is near neutral pH and the Mattaponi River has pH values that are slightly acidic.
All index sites were completed without interruption, however some hydrological data were not collected due to malfunctions of the water quality instrument.

Objective 3: Examine relationships between juvenile striped bass abundance and measured or proxy environmental and biological data.

Overall distribution of catch rates with respect to salinity in 2000 followed the normally observed pattern i.e. a definitive trend towards higher catches at lower salinities within the primary nursery area (Table 9). Figure 8 shows the relationship of juvenile striped bass catches with respect to historical salinity gradients within each river system. This figure shows the data from 1967 to 1999 and represents the long term trend while Figure 9 shows the salinity gradients for 2000. Overall, catches were highest in the areas of lowest salinities (0-4.9ppt) for both the long term and 2000.

Catch rates with respect to water temperature in 2000 clearly adhered to the pattern seen in most years, i.e. catch rates varied directly with water temperature at the time of collection (Table 10). Most fish are captured in the 25-30°C range which is the normal water temperature range during our sampling. As noted in previous reports, this relationship is considered to be largely the result of a coincident downward progression of both catch rates and temperature as the survey season progresses (at least after the second sampling round) rather than any causative effect of water temperature on juvenile distribution. The growth and subsequent gear escapement or movement of fish into deeper waters usually play a larger role in this trend. Generally, catches within the sampling season are not governed by water temperatures and the overall relationship between catch and water temperature within the sampling season is probably coincidental.
Data on pH, dissolved oxygen concentrations and secchi disc visibility depth readings have been recorded with the seine collections since the expansion of the sampling program in 1989. Dissolved oxygen concentrations generally exceeded 5mg/l outside of the York system, and have little or no effect on juvenile striped bass distributions. pH values during our sampling are generally near neutral to slightly basic outside of the Mattaponi River. Secchi disc readings are a relative measure of turbidity and can affect catches in two ways: when turbidity is extremely high fish are more vulnerable to our gear and when it is low (e.g. greater clarity) net avoidance becomes a potential problem. We saw no high turbidity episodes in 2000 and though secchi readings are not presented herein, the data are collected, stored, and are available upon request.

DISCUSSION AND CONCLUSIONS

The striped bass juvenile index recorded in the Virginia Chesapeake Bay nursery areas in 2000 was significantly higher than both the historical average (Table 2) and the 1999 index (Austin et al, 2000). It was the third highest index recorded since 1985 after stringent harvest regulations of the ASMFC Interstate Fisheries Management Plan were implemented in 1982. All rivers and river systems were above historical averages and all except the Mattaponi were significantly higher. The James system exerted the greatest positive influence on the overall index while the Mattaponi exerted the least.

The spring and summer of 2000 in the coastal plain of Virginia had near normal to slightly
elevated rainfall patterns that promoted a more normal distribution pattern of juvenile striped bass. Distribution of juvenile striped bass was generally within the confines of the index area except in the James River where the high abundance probably led to earlier and more extensive distribution patterns that contributed to higher catches outside the defined index area.

Juvenile striped bass captured at Bloxom probably moved into Pocomoke Sound from the Pocomoke River nursery area. Spatial dispersal of earlier spawned recruits responding to high recruitment levels in the nursery area probably expanded the normal nursery to include the Virginia portion of Pocomoke Sound.

The strong recruitment of juvenile striped bass in 2000 was likely a result of the normal to slightly elevated rainfall conditions that produced sufficient river flow during the spring of 2000, depressed temperatures, and an increasing spawning stock. Conditions resulting from these flow/temperature conditions were more conducive to successful recruitment in the Virginia portion of Chesapeake Bay than those experienced in 1999. Wood, (2000) found that weather conditions in March affect springtime temperatures and rainfall (thus river flow) and can affect the recruitment success of anadromous fishes. With the persistence of the winter Ohio Valley High climate pattern, cold and fresh conditions extend into March and as a result the suitable anadromous fish nursery areas are extended both spatially and temporally benefitting recruitment. When March is dominated by the Azores-Bermuda High, warm and dry conditions are present in spring which is not as conducive to anadromous fish recruitment success.
Striped bass recruitment success in the Virginia portion of Chesapeake Bay remains variable between years and between the different nursery areas within years. These fluctuations had been bracketing a much higher average until 1999 when weak recruitment occurred. However, with favorable survival and recruitment conditions, a strong recruitment of striped bass was seen in 2000. The strong yearclasses in 1998 and 2000 should adequately overcome any weakness in spawning stock that may have resulted from the 1999 recruitment. Continued monitoring of recruitment success will be an important factor in determining management strategies to protect the spawning stock of Chesapeake Bay striped bass.

The addition of auxiliary stations in 1989 has provided better areal coverage of the nursery areas. These additional areas of coverage have revealed that in years of high or low salinity there may be a shift in the traditional nursery areas up or down-river plus in years of high abundance the nursery area generally expands both up and down river. Figures 4-7 represent average catch per haul at all sites and past analyses have demonstrated that catches are consistently higher in the first haul of any given set of seine hauls. Since only one haul is made at the auxiliary sites, the figures tend to over-emphasize the relative contribution of the auxiliary sites. They are included only to demonstrate the spatial distribution of the yearclass. They are important in that they allow us to see a shift in distribution that could be affecting catches at the index sites. Reducing hauls at index sites to one per site and including some of the auxiliary sites in the index and deleting others may lead to a more precise estimate of relative year-class strength but it will undoubtedly elevate the recalculated indices.
LITERATURE CITED


Wood, R. J. 2000. Synoptic scale climatic forcing of multispecies recruitment patterns in Chesapeake Bay /by Robert J. Wood, Dissertation, College of William and Mary, School of Marine Science, Gloucester Point, VA.
Table 1. Catch of young-of-the-year striped bass per seine haul during the 2000 survey. Two hauls were made per sampling round at each of the historical index stations (bold).

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Table 2. Catch of young-of-the-year striped bass per seine haul in the primary nursery area summarized by year (adjusted mean = retransformed mean of $\ln (x+1) \ast 2.28$, the ratio of overall arithmetic and geometric means through 1984).

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>Mean $\ln (x+1)$</th>
<th>Std. Dev.</th>
<th>Adjust Mean</th>
<th>C.I. ($\pm 2 \ SE$)</th>
<th>N</th>
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<td>1967</td>
<td>209</td>
<td>1.07</td>
<td>0.977</td>
<td>4.40</td>
<td>2.82-6.45</td>
<td>53</td>
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<tr>
<td>1968</td>
<td>208</td>
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<td>2.35-4.94</td>
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<tr>
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<td>1.80-3.84</td>
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<tr>
<td>1970</td>
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<td>1.121</td>
<td>6.17</td>
<td>4.27-8.63</td>
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<td>1971</td>
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<td>0.857</td>
<td>2.61</td>
<td>1.76-3.64</td>
<td>81</td>
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<tr>
<td>1972</td>
<td>96</td>
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<td>1973</td>
<td>139</td>
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<td>87</td>
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<tr>
<td>1980</td>
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<td>0.900</td>
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<td>1.68-3.53</td>
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<tr>
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<td>0.967</td>
<td>2.71</td>
<td>1.85-3.74</td>
<td>106</td>
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<td>1983</td>
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<td>0.833</td>
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<tr>
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<td>0.859</td>
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<td>1.036</td>
<td>4.74</td>
<td>3.62-6.06</td>
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<td>1.127</td>
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<td>6.10-9.45</td>
<td>180</td>
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<td>1.096</td>
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<td>5.89-9.05</td>
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<td>0.951</td>
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<td>2.96-4.68</td>
<td>180</td>
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<tr>
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<td>1.247</td>
<td>7.32</td>
<td>5.69-9.28</td>
<td>180</td>
</tr>
<tr>
<td>1993</td>
<td>2323</td>
<td>2.19</td>
<td>0.975</td>
<td>18.12</td>
<td>15.4-21.3</td>
<td>180</td>
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<tr>
<td>1994</td>
<td>1510</td>
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<td>1.034</td>
<td>10.48</td>
<td>8.66-12.6</td>
<td>180</td>
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<tr>
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<td>926</td>
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<td>1.045</td>
<td>5.45</td>
<td>4.33-6.75</td>
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<tr>
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<td>1.227</td>
<td>23.00</td>
<td>18.8-28.1</td>
<td>180</td>
</tr>
<tr>
<td>1997</td>
<td>1484</td>
<td>1.63</td>
<td>1.097</td>
<td>9.35</td>
<td>7.59-11.4</td>
<td>180</td>
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<td>1998</td>
<td>2084</td>
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<td>1.139</td>
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<td>10.8-16.1</td>
<td>180</td>
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<tr>
<td>1999</td>
<td>442</td>
<td>0.80</td>
<td>0.862</td>
<td>2.80</td>
<td>2.19-3.50</td>
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<tr>
<td>2000</td>
<td>2741</td>
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<td>1.240</td>
<td>16.18</td>
<td>13.06-19.92</td>
<td>180</td>
</tr>
<tr>
<td>Overall</td>
<td>28571</td>
<td>1.35</td>
<td>1.171</td>
<td>6.54</td>
<td>6.21-6.88</td>
<td>3849</td>
</tr>
</tbody>
</table>
Table 3. Catch of young-of-the-year striped bass per seine haul in primary nursery area in 2000 summarized by drainage and river.

| Drainage River | 2000 | | All Years combined | |
|----------------|------|-------------------|-------------------|
|                | Total| Adjust. Mean      | C.I. (2 ± SE)     | N    | Total| Adjust. Mean | C.I. (±2 SE) | N    |
| James          | 1174 | 26.64             | 19.84-35.54       | 60   | 11032| 8.06          | 7.39-8.77     | 1278 |
| Chickahom.     | 377  | 33.97             | 23.70-48.29       | 20   | 4618 | 10.33         | 8.88-11.96    | 418  |
| York           | 783  | 11.88             | 8.37-16.55        | 70   | 8450 | 5.32          | 4.91-5.76     | 1452 |
| Pamunkey       | 546  | 23.11             | 14.34-36.51       | 30   | 4337 | 6.27          | 5.52-7.09     | 616  |
| Mattaponi      | 237  | 6.86              | 4.32-10.37        | 40   | 4113 | 4.69          | 4.23-5.19     | 836  |
| Rappahannock   | 784  | 13.32             | 8.25-20.84        | 50   | 9089 | 6.63          | 5.99-7.32     | 1119 |
| Overall        | 2741 | 16.18             | 13.06-19.92       | 180  | 28571| 6.54          | 6.21-6.88     | 3849 |
Table 4. Catch of young-of-the-year striped bass per seine haul in the primary nursery area in 2000 summarized by sampling period and month.

<table>
<thead>
<tr>
<th>Month</th>
<th>Total</th>
<th>Adjust. Mean</th>
<th>C.I. (± 2 SE)</th>
<th>N</th>
<th>Total</th>
<th>Adjust. Mean</th>
<th>C.I. (± 2 SE)</th>
<th>N</th>
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<td>All Years Combined</td>
<td>8085</td>
<td>9.24</td>
<td>8.31-10.25</td>
<td>818</td>
<td></td>
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<tr>
<td>July (1st)</td>
<td>921</td>
<td>28.26</td>
<td>17.23-45.51</td>
<td>36</td>
<td>8085</td>
<td>9.24</td>
<td>8.31-10.25</td>
<td>818</td>
</tr>
<tr>
<td>Aug. (2nd)</td>
<td>682</td>
<td>21.52</td>
<td>13.22-34.29</td>
<td>36</td>
<td>7214</td>
<td>7.43</td>
<td>6.65-8.29</td>
<td>829</td>
</tr>
<tr>
<td>Aug. (3rd)</td>
<td>451</td>
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<td>10.04-23.54</td>
<td>36</td>
<td>5149</td>
<td>5.86</td>
<td>5.25-6.52</td>
<td>821</td>
</tr>
<tr>
<td>Sept. (4th)</td>
<td>410</td>
<td>14.23</td>
<td>9.22-21.44</td>
<td>36</td>
<td>4776</td>
<td>6.05</td>
<td>5.35-6.82</td>
<td>685</td>
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<tr>
<td>Sept. (5th)</td>
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<td>4.61-12.25</td>
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<td>3142</td>
<td>5.48</td>
<td>4.80-6.23</td>
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Table 5. Salinity (parts per thousand) recorded at 2000 seine survey stations. York system includes Pamunkey and Mattaponi Rivers.

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<th>Station</th>
<th>J12</th>
<th>J22</th>
<th>J29</th>
<th>J36</th>
<th>J40</th>
<th>C1</th>
<th>C3</th>
<th>J46</th>
<th>J51</th>
<th>J56</th>
<th>J62</th>
<th>J68</th>
<th>J74</th>
<th>J78</th>
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</thead>
<tbody>
<tr>
<td>JAMES</td>
<td>Round 1</td>
<td>17.00</td>
<td>9.10</td>
<td>5.00</td>
<td>2.30</td>
<td>0.80</td>
<td>0.90</td>
<td>0.70</td>
<td>0.20</td>
<td>0.10</td>
<td>0.10</td>
<td>0.20</td>
<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
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<tr>
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<td>Round 2</td>
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<td>3.60</td>
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<td>0.70</td>
<td>0.70</td>
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<td>0.10</td>
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<tr>
<td></td>
<td>Round 3</td>
<td>17.00</td>
<td>8.80</td>
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<td>1.40</td>
<td>1.40</td>
<td>1.10</td>
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<td>0.10</td>
<td>0.10</td>
<td>0.10</td>
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<td>0.20</td>
<td>0.10</td>
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<td>9.60</td>
<td>7.10</td>
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<td>0.30</td>
<td>0.10</td>
<td>0.10</td>
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</tr>
<tr>
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<td>17.40</td>
<td>ns</td>
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<td>2.90</td>
<td>0.60</td>
<td>0.20</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>Round 4</td>
<td>16.80</td>
<td>ns</td>
<td>17.50</td>
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<th>R37</th>
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<th>R44</th>
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<th>R55</th>
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<td>0.00</td>
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<tr>
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<tr>
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<td>12.30</td>
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<td>2.90</td>
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</tbody>
</table>

* = bad data; ns = no sample taken
Table 6. Water temperature (°C) recorded at 2000 seine survey stations. York system includes Parnunkey and Mattaponi Rivers.

<table>
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<tr>
<th>Drainage</th>
<th>Station</th>
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<th>J22</th>
<th>J29</th>
<th>J36</th>
<th>J40</th>
<th>C1</th>
<th>C3</th>
<th>J46</th>
<th>J51</th>
<th>J56</th>
<th>J62</th>
<th>J68</th>
<th>J74</th>
<th>J78</th>
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ns = no sample taken
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<td>6.70</td>
<td>7.80</td>
<td>7.30</td>
<td>7.70</td>
<td>7.30</td>
<td>ns</td>
<td>7.30</td>
<td>ns</td>
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</tr>
<tr>
<td>4</td>
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<td></td>
<td>7.40</td>
<td>7.00</td>
<td>6.70</td>
<td>7.20</td>
<td>7.00</td>
<td>7.20</td>
<td>7.10</td>
<td>8.50</td>
<td>7.40</td>
<td>7.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>7.60</td>
<td>7.30</td>
<td>7.00</td>
<td>7.20</td>
<td>7.30</td>
<td>7.20</td>
<td>7.40</td>
<td>7.60</td>
<td>7.80</td>
<td>7.30</td>
<td>7.40</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

ns = no sample taken
Table 9. Catch of young-of-the-year striped bass per seine haul in the primary nursery area in 2000 summarized by salinity.

<table>
<thead>
<tr>
<th>Salinity (ppt.)</th>
<th>2000</th>
<th>All Years Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Adjust.</td>
</tr>
<tr>
<td>0-4.9</td>
<td>2686</td>
<td>18.71</td>
</tr>
<tr>
<td>5-9.9</td>
<td>55</td>
<td>6.32</td>
</tr>
<tr>
<td>10-14.9</td>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>15-19.9</td>
<td>2</td>
<td>0.13</td>
</tr>
<tr>
<td>Overall</td>
<td>2741</td>
<td>16.18</td>
</tr>
</tbody>
</table>
Table 10. Catch of young-of-the-year striped bass per seine haul in the primary nursery area in 2000 summarized by water temperature.

<table>
<thead>
<tr>
<th>Temp. (deg. C)</th>
<th>2000</th>
<th>All Years Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Adjust. Mean (± 2 SE)</td>
</tr>
<tr>
<td>15-19.9</td>
<td>91</td>
<td>6.19 2.73-12.04</td>
</tr>
<tr>
<td>20-24.9</td>
<td>2557</td>
<td>17.72 14.16-22.04</td>
</tr>
<tr>
<td>25-29.9</td>
<td>93</td>
<td>15.57 3.18-56.07</td>
</tr>
<tr>
<td>30-34.9</td>
<td>2741</td>
<td>16.18 13.06-19.92</td>
</tr>
<tr>
<td>Overall</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Figure 1. Juvenile striped bass seine survey stations. Numeric portion of station designations indicate river mile from the mouth.
Figure 2. Scaled average catch of young-of-the-year striped bass per seine haul in the primary nursery area (index stations) by year. Vertical bars are 95% confidence intervals as estimated by ±2 standard errors of the mean.
Figure 4. Average catch of young-of-the-year striped bass per seine haul by station in the James drainage.
Figure 5. Average catch of young-of-the-year striped bass per seine haul by station in the Mattaponi and York rivers.
Figure 6. Average catch of young-of-the-year striped bass per seine haul by station in the Pamunkey and York rivers.
Figure 7. Average catch of young-of-the-year striped bass per seine haul by station in the Rappahannock River.
Figure 8. Catch per unit effort of young-of-the-year striped bass with respect to salinity from 1967-1999.
Figure 9. Catch per unit effort of young-of-the-year striped bass with respect to salinity in 2000.