

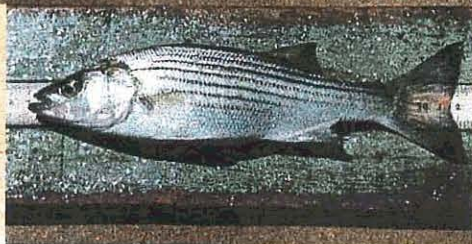
ANNUAL PROGRESS REPORT

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

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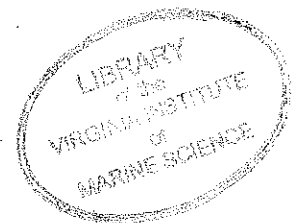
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PREFACE

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 2002 sampling period and compares these results with the previous work.

Specific objectives for the 2002 program were to:

1. Measure the relative abundance of the 2002 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 (PL88-309) 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. 767g, 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 VI (adopted in February, 2003) 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 2002.

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 2002. During each sampling period the seine was hauled at eighteen historically sampled sites (index stations) and twenty-two 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.

Duplicate hauls were made at each index station during each round and a single haul was made at each auxiliary station. Collections were made by deploying a 100' (30.5m) long, 4' (1.22m) deep, 1/4" (0.64cm) 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, then released unharmed. All fish collected were identified and counted, and all striped bass and all individuals or a sub-sample 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 are made on the basis of the 'primary nursery' standardized data set (Colvocoresses 1984), i.e. only the data collected from the months and areas 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 2002 year class of juvenile striped bass from the James, York and Rappahannock river systems.

A total of 813 young-of-the-year striped bass were collected from 180 seine hauls during the 2002 index station sampling and an additional 312 age 0 striped bass were collected in 103 hauls at the auxiliary sites (Table 1, Fig. 1). The adjusted overall mean catch per seine haul (CPUE) for the index stations was 3.98, the third lowest index in Virginia (Table 2, Fig. 2) since the implementation of stringent harvest regulations in 1985. This value was significantly less than the overall average index of 6.64 (non overlap of confidence intervals) and was significantly less than the 2001 value (14.17). The indices for the York and Rappahannock river systems were lower than their overall average while the James system (both the James proper and the Chickahominy) index surpassed its overall average.

The 2002 catch in the James drainage was 9.97, marginally higher than the overall average of 8.56 (Table 3, Fig. 3). Juvenile striped bass were widely distributed throughout the James system in 2002 and consistent catches were made at nearly all of the sampling sites. (Table 1, Fig. 4). Several sites produced only small catches but fish were captured on most visits. Only one site (J12, the most downriver site) failed to produce striped bass in 2002. In previous years, J22 frequently had

substantial catches of yoy striped bass and this year's low catch was probably attributable to elevated salinities at the site.

The main-stem James catch rate (8.67) was slightly higher than its overall average of 7.56. The Chickahominy catch rate (13.04) decreased over fifty percent in 2002 but remained higher than its overall average of 10.93 (Table 1; Fig. 4). J46 was the highest producing index site in the James River while J51 and J68 (auxiliary sites) had good catches producing a bimodal center of abundance. J56, the uppermost index site situated just upriver of J51 rarely produces large catches and 2002 was no exception. Catches within the defined nursery area appeared to increase with the distance upriver until reaching the mid to upper portion of that area. Mile 3 in the Chickahominy was an exception that produced small, consistent catches. C1 catches were more variable and ranged from a sizable catch in round one to a small catch in round five.

The second area of abundance was centered from J68 to J74 but since these are auxiliary sites and only one tow is made, the levels of abundance may be somewhat elevated. The upriver abundances are not unexpected given the severity of the regional drought experienced in 2001 and 2002. However, data from past years do show infrequent catches of substantial numbers of striped bass at some of the upriver auxiliary sites in the James.

The 2002 index in the York drainage (0.90) was the second lowest index recorded and was far below the historical average (5.15) (Table 3, Fig. 3). Only the 1999 yearclass produced a lower index (0.64). The index in the Pamunkey (0.11) and the Mattaponi (1.65) were both well below their respective overall averages (Pamunkey = 6.01, Mattaponi = 4.58). The Pamunkey index is the lowest

on record for that river. Only two yoy striped bass were captured in thirty hauls while the Mattaponi sites produced forty-three fish in forty hauls.

All sites in the mainstem York River are auxiliary sites. No striped bass were captured at these sites in 2002 (Table 1; Fig. 5). Catches on the Mattaponi River were highest at M41 and M44, index sites near the center of the defined index area. In the Pamunkey River, only two fish were captured at index sites; one at P42 and one at P45. Though small, catches were made at the uppermost auxiliary sites in both the Mattaponi and Pamunkey Rivers during round five. No striped bass had been captured at either site during rounds one through four and these catches could indicate a downriver movement of fish that had been displaced upriver of our sampling area by elevated salinities.

The 2002 index in the Rappahannock River was 4.96, twenty-seven percent less than the historic average of 6.79 (Table 3). Highest catches were at the two uppermost index sites (R50, R55) and R37, a downriver index site (Table 1, Fig. 7). Up-river auxiliary sites (R65 through R76) produced fish during most sampling visits though not in great numbers. This pattern was also seen in 2001 and may be a result of the continuing drought conditions. R37, a lower index site, produced low numbers of stripers on most visits except round one when a high catch was recorded. R10 and R21, downriver auxiliary sites, had no catches of striped bass.

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 as fish disperse to deeper water and grow large enough to effectively avoid capture. In 2002 this overall pattern was observed (Table 4). Total catches during the first three rounds remained relatively stable but there was a sixty percent drop between rounds three and four. This pattern is more the norm than 2001 when large drops in catch were recorded between rounds one and two.

One young-of-the-year striped bass was captured at the former Bluefish Seine Survey sites in the lower James River, Chesapeake Bay and seaside Eastern Shore. That fish was captured at Bloxom in July. Bloxom is located on the Bay side of the Eastern Shore in Pocomoke Sound and this fish probably came from a nearby nursery area.

This is in contrast to the 286 striped bass captured in 2001 and the disparity is likely a result of the difference in yearclass size. In years of high abundance, fish tend to disperse downriver/bay more readily, probably in response to increased competition for food and space in the upriver nursery areas.

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

Collection information and pertinent environmental variables recorded at the time of each collection in 2002 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 substantially higher in 2002 than in 2001 (Table 5) (Austin et al, 2002). Salinities at all index sites were higher than those recorded in 2001. The Palmer Drought Index (Palmer, 1965) and data from the National Climate Data Center indicated that the spring of 2002 was very dry with severe drought conditions present over most of the state. This drought began in the summer of 2001 and continued through the summer of 2002. Measurable salinity was recorded at every site on the York and James systems while the freshwater interface on the Rappahannock was displaced fifteen to twenty miles upriver from its normal location.

Overall, water temperatures were near normal in 2002 (Table 6). The normal pattern of higher temperature in the early rounds and temperature slowly declining during the later rounds was observed in 2002. Water temperatures by round may have varied slightly from 2001 readings but there were no major weather anomalies that affected water temperatures during the 2002 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 that are easily affected by such conditions and these effects on site specific striped bass abundances are not easily assessed.

Dissolved oxygen levels were generally within the norms expected during this sampling period (Table 7). Slightly depressed levels were recorded at the lowermost sites in the Mattaponi River in early rounds but catches at those times did not appear to be adversely affected (Table 1; Fig. 5)

The pH levels during the 2002 sampling were near normal for most areas during 2002 (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. In 2002, pH values in the Mattaponi were near neutral with several readings that were slightly acidic.

All index sites were completed without interruption although 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 2002 followed the normally observed pattern of higher catches at lower salinities within the primary nursery area (Table 9), however, due to severe drought conditions in 2002, areas of higher salinity intruded into the defined nursery areas. Even so, little upriver movement of yoy striped bass was observed. Highest catches were observed at our mid to upriver index sites though a few large catches were made at upriver auxiliary sites. These catches were not consistent over the entire sampling season. 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 2002 and represents the long-term trend while Figure 9 shows the salinity gradients for 2002. Figure 9 clearly shows that the defined salinity regimes were displaced upriver ten to fifteen miles and in some cases salinity was measurable within the entire defined nursery area. Overall, catches were highest in the areas of lowest salinities (0-4.9ppt) for both the long term and 2002 but the percentage of catch was substantially lower in 2002 (60% in 2002 vs 92% overall (Table 9). Percentage of catches in the 5-9.9ppt and 10-14.9ppt ranges was

higher in 2002.

Catch rates with respect to water temperature in 2002 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 and like dissolved oxygen appear to have little effect. *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 2002 and though secchi readings are not presented herein, the data are collected, stored, and are available upon request.

Data and indices for other species captured during the juvenile striped bass abundance survey can be accessed on the web at <http://www.fisheries.vims.edu/seinedata/>.

DISCUSSION AND CONCLUSIONS

The striped bass juvenile index recorded in the Virginia Chesapeake Bay nursery areas in 2002 was forty percent lower than the historical average (Table 2) and significantly (three times) lower than the 2001 index (Austin et al, 2002). It was the third lowest index recorded since 1985 after stringent harvest regulations of the ASMFC Interstate Fisheries Management Plan were implemented in 1982. Only the James and Chickahominy rivers were above historical averages while the York system index was the second lowest on record. The James system exerted the greatest positive influence on the overall index while the York system again exerted a strong negative effect similar to 1999.

The spring and summer of 2002 had little or no rainfall and severe drought continued throughout the entire Chesapeake Bay watershed through September. Salinities were elevated and the freshwater interface in each river was displaced miles upstream, in some cases completely upriver of the defined nursery area. Even though salinities were elevated at the index sites, catches of striped bass remained highest within our defined nursery area. Some upstream displacement may have occurred, evidenced by a few higher catches at the upriver auxiliary sites and with the exception of J22, there were no catches at the lower auxiliary sites.

The weak recruitment of juvenile striped bass in 2002 was likely a result of the severe drought that produced insufficient river flow during the spring spawning season. The environment resulting from these flow/temperature conditions was less conducive to successful recruitment in the Virginia portion of Chesapeake Bay. Wood, (2000) found that weather in March affects 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 benefiting 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.

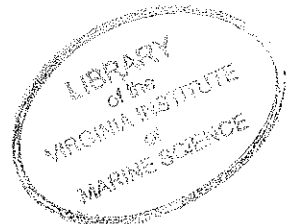
Striped bass recruitment success in the Virginia portion of Chesapeake Bay remains variable between years and between the different nursery areas within years. These fluctuations had been bracketing a much higher average with the exception of 1999 and 2002 when weak recruitment occurred. Conditions were not conducive for recruitment of young striped bass in 2002 and a relatively weak yearclass survived. However, the elevated salinity regimes in the defined nursery areas may have affected distribution and movement of juvenile striped bass and led to a slight underestimation of the yearclass strength.

The lack of recruitment in the York system in 2002 clearly had a dramatic effect on the weak overall recruitment in Virginia. The James index was above its historical average and the Rappahannock, while below its historical average cannot be considered a failure. The strong

yearclasses in 1998, 2000, and 2001 should adequately overcome any weak yearclasses that may have resulted from the low 1999 and 2002 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.

In both the 1999 and 2002 indices, the York system exerted a strong negative effect on the overall value as these were the two lowest indices recorded for that system. The Rappahannock while slightly below average, did not exert a great negative influence in either year. The James system mirrored the Rappahannock in 1999 but was a positive influence in 2002 offsetting some of the negative influence of the York.

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 river flow 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 may 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 (Rago et al, 1996).



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Table 1. Catch of young-of-the-year striped bass per seine haul during the 2002 survey. Two hauls were made per sampling round at each of the historical index stations (bold).

Drainage																
JAMES																
	Station Round	J12	J22	J29	J36	J42	C1	C3	J46	J51	J56	J62	J68	J74	J78	TOT.
	1	0	2	1/0	2/4	4	40/23	8/1	4/3	18	0/0	0	10	6	10	136
	2	0	4	4/2	5/3	ns	4/12	11/1	37/10	18	1/2	0	7	35	3	159
	3	0	0	6/5	18/12	10	21/12	4/1	31/68	7	1/3	6	16	2	6	229
	4	0	2	7/0	5/4	3	10/13	5/4	11/4	20	2/0	2	18	15	0	125
	5	0	3	10/1	7/9	6	2/1	7/1	11/9	12	0/1	1	26	0	0	107
																756
YORK																
	Station	Y15	Y21	Y28	P36	P42		P45	P50	P55						
	1	ns	0	0	0	1/0		0/0	0/0	0						1
	2	0	0	0	0	0/0		0/1	0/0	0						1
	3	0	0	0	0	0/0		0/0	0/0	0						0
	4	0	ns	0	0	0/0		0/0	0/0	0						0
	5	0	ns	0	0	0/0		0/0	0/0	3						3
	Station				M33	M37	M41	M44	M47	M52						
	1				6/1	1	6/0	3/1	2/1	0						21
	2				1/0	3	1/0	4/0	0/1	0						10
	3				0/0	0	2/2	0/1	0/1	0						6
	4				0/0	ns	0/2	2/2	1/0	ns						7
	5				1/0	0	0/1	1/0	0/0	1						4
																53
RAPPAHANNOCK																
	Station	R10	R21	R28	R37		R41	R44	R50	R55	R60	R65	R69	R76		
	1	0	ns	1/0	25/28		0	2/0	13/14	37/16	3	3	1	0		143
	2	0	0	0/0	6/5		0	6/6	13/3	36/13	2	2	1	7		100
	3	0	0	0/0	0/0		0	0/0	4/3	16/6	0	2	0	2		33
	4	0	0	0/0	3/0		0	0/0	4/0	6/0	0	2	1	1		17
	5	0	0	0/0	2/7		2	0/0	0/1	6/2	0	3	0	0		23
																316
																1125

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 $\ln(x+1)$ * 2.28, the ratio of overall arithmetic and geometric means through 1984).

Year	Total	Mean $\ln(x+1)$	Std. Dev.	Adjust Mean	C.I. (± 2 SE)	N
1967	209	1.07	0.977	4.40	2.82-6.45	53
1968	208	0.93	0.900	3.50	2.35-4.94	66
1969	207	0.78	0.890	2.71	1.80-3.84	77
1970	461	1.31	1.121	6.17	4.27-8.63	78
1971	178	0.76	0.857	2.61	1.76-3.64	81
1972	96	0.39	0.575	1.07	0.73-1.45	119
1973	139	0.53	0.790	1.59	0.98-2.32	87
1980	228	0.74	0.900	2.52	1.68-3.53	89
1981	165	0.52	0.691	1.57	1.10-2.09	116
1982	323	0.78	0.967	2.71	1.85-3.74	106
1983	296	0.91	0.833	3.40	2.53-4.42	102
1984	597	1.09	1.059	4.47	3.22-6.02	106
1985	322	0.72	0.859	2.41	1.78-3.14	142
1986	669	1.12	1.036	4.74	3.62-6.06	144
1987	2191	2.07	1.228	15.74	12.4-19.8	144
1988	1348	1.47	1.127	7.64	6.10-9.45	180
1989	1978	1.78	1.119	11.23	9.15-13.7	180
1990	1249	1.44	1.096	7.34	5.89-9.05	180
1991	667	0.97	0.951	3.76	2.96-4.68	180
1992	1769	1.44	1.247	7.32	5.69-9.28	180
1993	2323	2.19	0.975	18.12	15.4-21.3	180
1994	1510	1.72	1.034	10.48	8.66-12.6	180
1995	926	1.22	1.045	5.45	4.33-6.75	180
1996	3759	2.41	1.227	23.00	18.8-28.1	180
1997	1484	1.63	1.097	9.35	7.59-11.4	180
1998	2084	1.92	1.139	13.25	10.8-16.1	180
1999	442	0.80	0.862	2.80	2.19-3.50	180
2000	2741	2.09	1.240	16.18	13.06-19.92	180
2001	2624	1.98	1.271	14.17	11.33-17.60	180
2002	813	1.01	1.085	3.98	3.05-5.08	180
Overall	32008	1.36	1.181	6.64	6.33-6.98	4209

Table 3. Catch of young-of-the-year striped bass per seine haul in primary nursery area in 2002 summarized by drainage and river.

Drainage River	2002			All Years combined				
	Total Fish	Adjust. Mean	C.I. (2 ± SE)	N (sites)	Total Fish	Adjust. Mean	C.I. (± 2 SE)	N (sites)
James	484	9.97	7.15-13.63	60	12776	8.56	7.88-9.28	1398
James	303	8.67	5.59-12.95	40	7354	7.56	6.84-8.34	940
Chickahom.	181	13.04	7.79-21.01	20	5422	10.93	9.49-12.56	458
York	45	0.90	0.53-1.31	70	9099	5.15	4.76-5.56	1592
Pamunkey	2	0.11	-0.04-0.27	30	4709	6.01	5.30-6.78	676
Mattaponi	43	1.65	0.99-2.45	40	4390	4.58	4.14-5.04	916
Rappahannock	284	4.96	2.86-7.91	50	10133	6.79	6.16-7.47	1219
Overall	813	3.98	3.05-5.08	180	32008	6.64	6.33-6.98	4209

Table 4. Catch of young-of-the-year striped bass per seine haul in the primary nursery area in 2002 summarized by sampling period and month.

Month	<u>2002</u>				<u>All Years Combined</u>			
	Total Fish	Adjust. Mean	C.I. (± 2 SE)	N (sites)	Total Fish	Adjust. Mean	C.I. (± 2 SE)	N (sites)
July (1 st)	243	5.80	3.10-9.86	36	9643	9.75	8.79-10.79	890
July (2 nd)	188	5.32	3.02-8.63	36	7823	7.54	6.78-8.37	901
Aug. (3 rd)	217	4.33	2.11-7.68	36	5710	6.00	5.40-6.65	893
Aug. (4 th)	85	2.69	1.39-4.46	36	5202	6.02	5.35-6.74	757
Sept. (5 th)	80	2.48	1.27-4.11	36	3425	5.28	4.66-5.97	631

Table 5. Salinity (parts per thousand) recorded at 2002 seine survey stations. York system includes Pamunkey and Mattaponi Rivers.

Drainage		J12	J22	J29	J36	J42	C1	C3	J46	J51	J56	J62	J68	J74	J78
JAMES	Station Round														
	1	19.7	12.3	9.0	6.8	3.9	3.9	3.4	1.9	0.6	0.3	0.2	0.2	0.2	0.2
	2	19.0	12.1	10.4	8.2	ns	5.1	4.6	3.1	1.0	0.6	0.3	0.2	0.2	0.3
	3	23.0	15.0	10.7	7.9	5.6	6.2	5.8	3.4	1.8	1.0	0.5	0.3	0.3	0.3
	4	18.5	14.9	12.0	8.9	6.6	6.9	6.6	4.6	2.8	1.9	0.8	0.4	0.3	0.3
	5	16.4	14.4	12.7	9.8	6.7	7.6	7.3	4.9	2.9	1.6	0.7	0.3	0.2	0.2
YORK	Station	Y15	Y21	Y28	P36	P42		P45	P50	P55					
	1	ns	18.8	16.4	11.9	6.9		3.9	2.1	1.5					
	2	20.5	18.7	15.9	10.6	6.7		3.9	2.7	2.0					
	3	25.0	19.1	17.4	11.4	7.7		4.8	3.6	2.8					
	4	21.0	ns	18.0	13.0	8.8		6.0	4.4	3.5					
	5	21.1	ns	17.1	11.9	7.7		4.9	3.9	2.5					
	Station				M33	M37	M41	M44	M47	M52					
	1				11.2	7.7	5.3	2.0	1.3	0.3					
	2				10.8	8.9	5.7	2.7	1.6	0.5					
	3				11.9	8.8	6.5	3.4	1.9	0.9					
	4				13.4	ns	7.9	4.7	2.5	ns					
	5				12.9	11.2	8.1	4.9	3.3	1.8					
RAPPAHANNOCK	Station	R10	R21	R28	R37		R41	R44	R50	R55	R60	R65	R69	R76	
	1	17.5	ns	13.8	9.1		7.6	4.6	2.6	1.5	0.5	0.2	0.1	0.0	
	2	17.2	16.1	14.6	9.6		8.2	5.9	4.2	3.1	1.1	0.7	0.2	0.0	
	3	18.1	16.7	14.2	11.4		9.1	7.0	4.9	3.4	1.6	1.1	0.3	0.1	
	4	18.7	17.5	15.8	12.1		9.9	8.2	5.9	4.5	2.5	1.8	0.9	0.1	
	5	18.8	17.4	15.8	11.6		10.5	8.6	6.5	5.1	2.8	2.1	0.8	0.1	

ns = no sample taken

Table 6. Water temperature (°C) recorded at 2002 seine survey stations. York system includes Pamunkey and Mattaponi Rivers.

Drainage		J12	J22	J29	J36	J42	C1	C3	J46	J51	J56	J62	J68	J74	J78
JAMES	Station Round														
	1	32.1	32.7	28.8	24.9	28.3	27.3	27.3	28.3	28.5	28.1	30.1	30.8	33.3	30.8
	2	31.9	33.3	27.7	27.5	ns	27.1	27.4	27.6	29.2	28.4	29.8	30.8	32.5	30.7
	3	30.5	34.8	28.9	25.2	28.5	27.0	27.0	28.4	27.7	25.6	22.8	30.1	34.0	31.3
	4	25.5	24.6	29.2	27.7	28.0	28.7	8.9	29.0	28.2	27.8	28.6	30.9	33.3	31.0
	5	25.1	25.4	25.5	24.6	26.8	26.4	25.9	27.6	24.8	24.8	27.0	27.3	28.6	27.0
YORK	Station	Y15	Y21	Y28	P36	P42		P45	P50	P55					
	1	ns	26.7	25.8	26.8	26.9		27.3	27.0	29.3					
	2	30.4	28.5	28.2	28.3	28.8		28.8	28.9	31.0					
	3	29.3	27.0	26.8	27.9	28.4		28.3	28.3	30.4					
	4	24.9	ns	27.0	28.5	28.6		29.0	28.9	28.3					
	5	25.3	ns	22.5	24.6	25.4		25.6	25.4	26.8					
	Station				M33	M37	M41	M44	M47	M52					
	1				27.2	27.4	27.0	27.5	30.7	28.8					
	2				28.8	28.6	28.4	29.6	31.0	30.9					
	3				28.1	28.4	27.8	28.8	30.5	29.9					
	4				28.0	ns	28.0	27.5	27.6	ns					
	5				25.1	25.1	24.8	25.1	27.1	25.2					
RAPPAHANNOCK	Station	R10	R21	R28	R37		R41	R44	R50	R55	R60	R65	R69	R76	
	1	27.1	ns	26.1	24.7		26.5	25.2	29.3	29.8	28.9	29.2	30.2	31.5	
	2	26.9	26.3	25.7	26.1		27.5	26.3	29.1	29.8	29.2	29.8	30.2	31.2	
	3	27.5	27.0	25.7	25.3		25.1	25.7	28.9	28.9	28.5	27.1	29.6	30.1	
	4	30.0	30.1	29.6	27.7		28.1	28.3	29.2	29.7	29.7	30.2	30.3	30.7	
	5	25.2	25.3	25.9	25.0		25.0	25.8	25.0	25.3	24.9	24.5	25.8	26.3	

ns = no sample taken

Table 7. Dissolved oxygen (milligrams per liter) recorded at 2002 seine survey stations. York system includes Pamunkey and Mattaponi Rivers.

Drainage		J12	J22	J29	J36	J42	C1	C3	J46	J51	J56	J62	J68	J74	J78
JAMES	Station Round														
	1	9.5	8.3	7.7	5.4	6.8	6.0	5.2	5.3	5.8	6.7	8.8	5.5	5.3	5.8
	2	10.5	7.8	6.0	4.7	ns	5.4	4.9	5.1	5.8	6.0	10.1	6.0	5.6	5.9
	3	ns	ns	7.6	5.9	6.6	6.0	4.7	5.5	5.7	6.7	7.0	5.7	6.1	7.2
	4	4.0	4.6	6.2	5.0	5.9	4.9	5.0	5.2	5.6	6.0	7.4	5.6	6.8	7.6
	5	6.5	6.8	6.0	7.4	7.2	6.9	6.4	7.3	7.4	8.7	8.9	7.0	8.2	6.5
YORK	Station	Y15	Y21	Y28	P36	P42		P45	P50	P55					
	1	ns	6.4	4.7	3.1	3.9		5.1	4.7	7.1					
	2	7.8	6.9	5.6	4.5	4.7		5.3	5.4	6.7					
	3	ns	7.7	6.1	4.9	5.2		5.5	4.9	6.6					
	4	4.4	ns	4.1	4.5	4.6		4.8	4.6	6.0					
	5	5.8	ns	6.7	5.6	6.3		6.0	6.5	7.8					
	Station				M33	M37	M41	M44	M47	M52					
	1				2.9	3.9	4.9	5.0	7.0	5.3					
	2				3.8	3.6	4.2	4.8	5.5	5.4					
	3				4.1	4.4	4.9	4.7	5.4	5.8					
	4				3.9	ns	4.4	4.9	4.5	ns					
	5				4.9	5.3	5.7	6.1	6.8	7.1					
RAPPAHANNOCK	Station	R10	R21	R28	R37		R41	R44	R50	R55	R60	R65	R69	R76	
	1	7.6	ns	7.1	6.4		5.7	7.0	5.2	5.1	6.0	6.8	5.8	6.5	
	2	6.8	7.0	6.1	6.3		5.2	6.9	5.3	6.0	5.5	7.2	5.9	7.2	
	3	7.4	6.7	7.6	6.0		5.8	5.8	5.7	6.3	6.4	7.3	6.6	6.5	
	4	6.7	6.4	6.2	4.7		4.5	4.7	5.3	5.7	5.3	7.2	7.5	6.6	
	5	6.2	6.5	7.3	6.4		5.0	6.6	6.8	7.3	7.4	7.3	7.9	7.2	

ns = no sample taken

Table 8. pH recorded at 2002 seine survey stations. York system includes Pamunkey and Mattaponi Rivers.

Drainage															
JAMES		J12	J22	J29	J36	J42	C1	C3	J46	J51	J56	J62	J68	J74	J78
Station Round															
1		8.3	8.3	8.1	7.6	7.9	7.7	7.7	7.6	7.9	8.5	9.2	8.2	8.2	8.0
2		8.5	8.4	7.8	7.5	ns	7.6	7.5	7.6	7.9	8.0	9.2	8.0	8.2	8.1
3		ns	ns	8.0	7.6	8.1	7.7	7.6	7.8	7.9	8.5	8.5	8.2	8.5	8.5
4		7.6	7.8	7.8	7.7	ns	7.5	7.5	7.6	7.8	8.0	8.8	8.3	8.4	8.7
5		7.6	7.8	7.5	7.7	7.9	7.6	7.5	7.7	7.6	8.2	8.4	8.0	8.3	7.5
YORK		Station	Y15	Y21	Y28	P36	P42	P45	P50	P55					
1		ns	7.5	7.5	7.1	7.1		7.3	7.0	8.4					
2		8.2	7.7	7.6	7.3	7.3		7.3	7.3	7.2					
3		ns	8.0	7.8	7.4	7.4		7.4	7.3	7.6					
4		7.7	ns	7.5	7.5	7.5		7.4	7.3	7.5					
5		7.6	ns	7.5	7.3	7.3		7.3	7.3	7.6					
Station					M33	M37	M41	M44	M47	M52					
1					7.3	7.1	7.0	7.2	7.5	7.2					
2					7.1	7.1	7.0	7.2	7.2	6.9					
3					7.3	7.2	7.2	7.2	7.1	7.1					
4					7.4	ns	7.2	7.4	7.0	ns					
5					7.1	7.1	7.0	6.9	6.8	6.8					
RAPPAHANNOCK		Station	R10	R21	R28	R37	R41	R44	R50	R55	R60	R65	R69	R76	
1			8.2	ns	8.0	7.7	7.5	7.8	7.4	7.5	7.6	8.1	8.3	8.8	
2			8.2	8.0	7.8	7.6	7.4	7.7	7.3	7.4	7.4	8.1	7.8	8.4	
3			8.3	8.1	8.2	7.9	7.4	7.8	7.5	7.6	7.5	7.9	7.9	8.1	
4			8.2	8.1	8.1	7.7	7.3	7.5	7.5	7.5	7.4	8.0	8.1	8.2	
5			7.9	7.6	7.8	7.6	7.2	7.4	7.2	7.1	6.9	7.1	7.2	7.5	

ns = no sample taken

Table 9. Catch of young-of-the-year striped bass per seine haul in the primary nursery area in 2002 summarized by salinity.

Salinity (ppt.)	<u>2002</u>				<u>All Years Combined</u>			
	Total Fish	Adjust. Mean	C.I. (± 2 SE)	N (sites)	Total Fish	Adjust. Mean	C.I. (± 2 SE)	N (sites)
0-4.9	485	4.65	3.02-6.79	80	29435	7.65	7.26-8.06	3485
5-9.9	271	4.50	2.99-6.45	66	2325	3.97	3.42-4.57	516
10-14.9	57	2.30	1.10-3.91	30	246	1.59	1.19-2.02	179
15-19.9	0	0	0.0-0.0	4	2	0.11	-0.04-0.28	29
Overall	813	3.98	3.05-5.08	180	32008	6.64	6.33-6.98	4209

Table 10. Catch of young-of-the-year striped bass per seine haul in the primary nursery area in 2002 summarized by water temperature.

Temp. (deg. C)	<u>2002</u>				<u>All Years Combined</u>			
	Total Fish	Adjust. Mean	C.I. (± 2 SE)	N (sites)	Total Fish	Adjust. Mean	C.I. (± 2 SE)	N (sites)
15-19.9					79	2.85	1.40-4.86	30
20-24.9	77	8.04	2.47-20.14	10	2154	3.25	2.82-3.72	591
25-29.9	731	3.90	2.94-5.04	164	24411	7.58	7.16-8.02	2927
30-34.9	5	1.59	0.43-3.26	6	4974	7.85	6.87-8.95	562
Overall	813	3.98	3.05-5.08	180	32008	6.64	6.33-6.98	4209

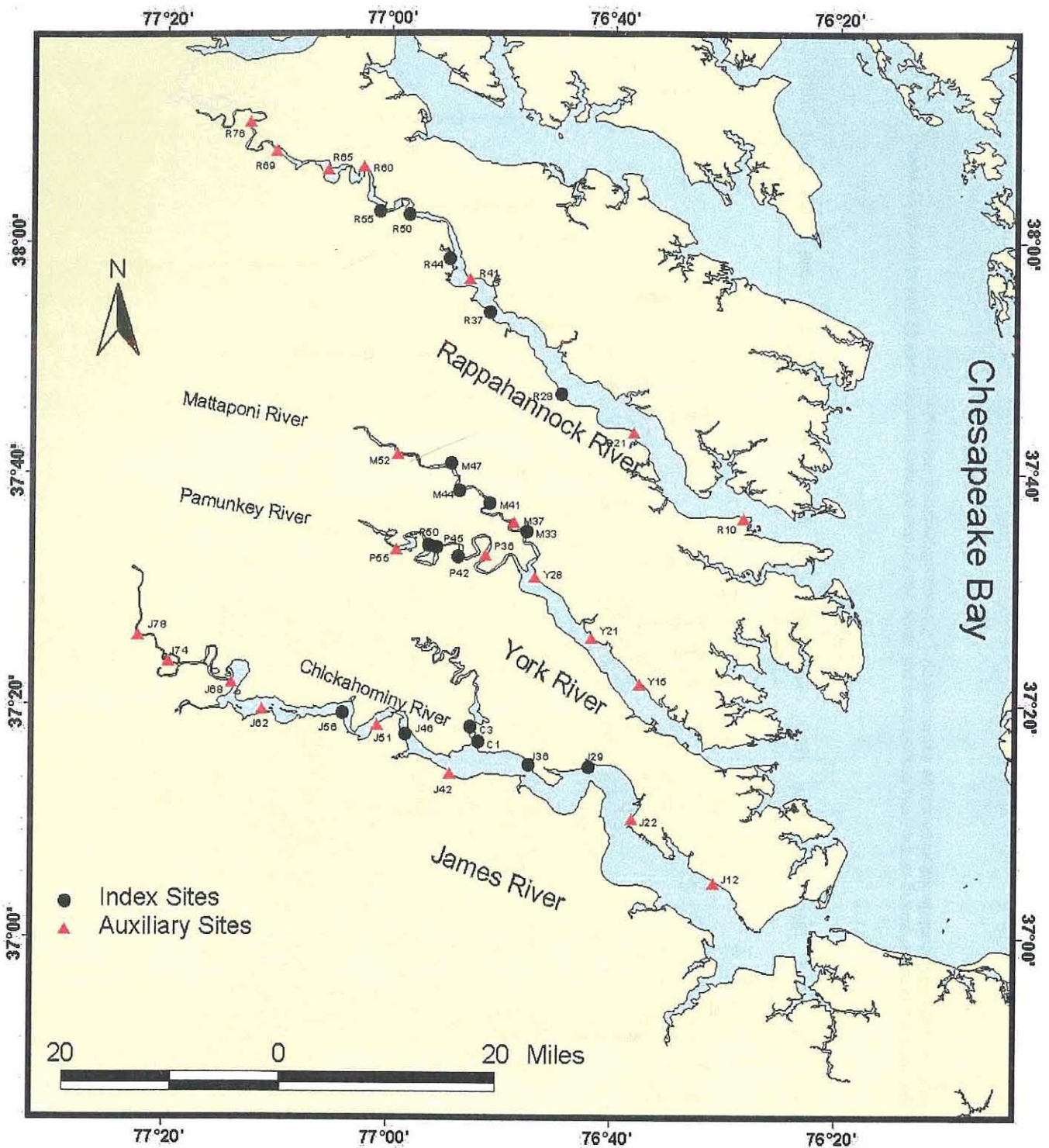


Figure 1. Juvenile striped bass survey stations. Numeric portion of station designations indicate river mile from the mouth.

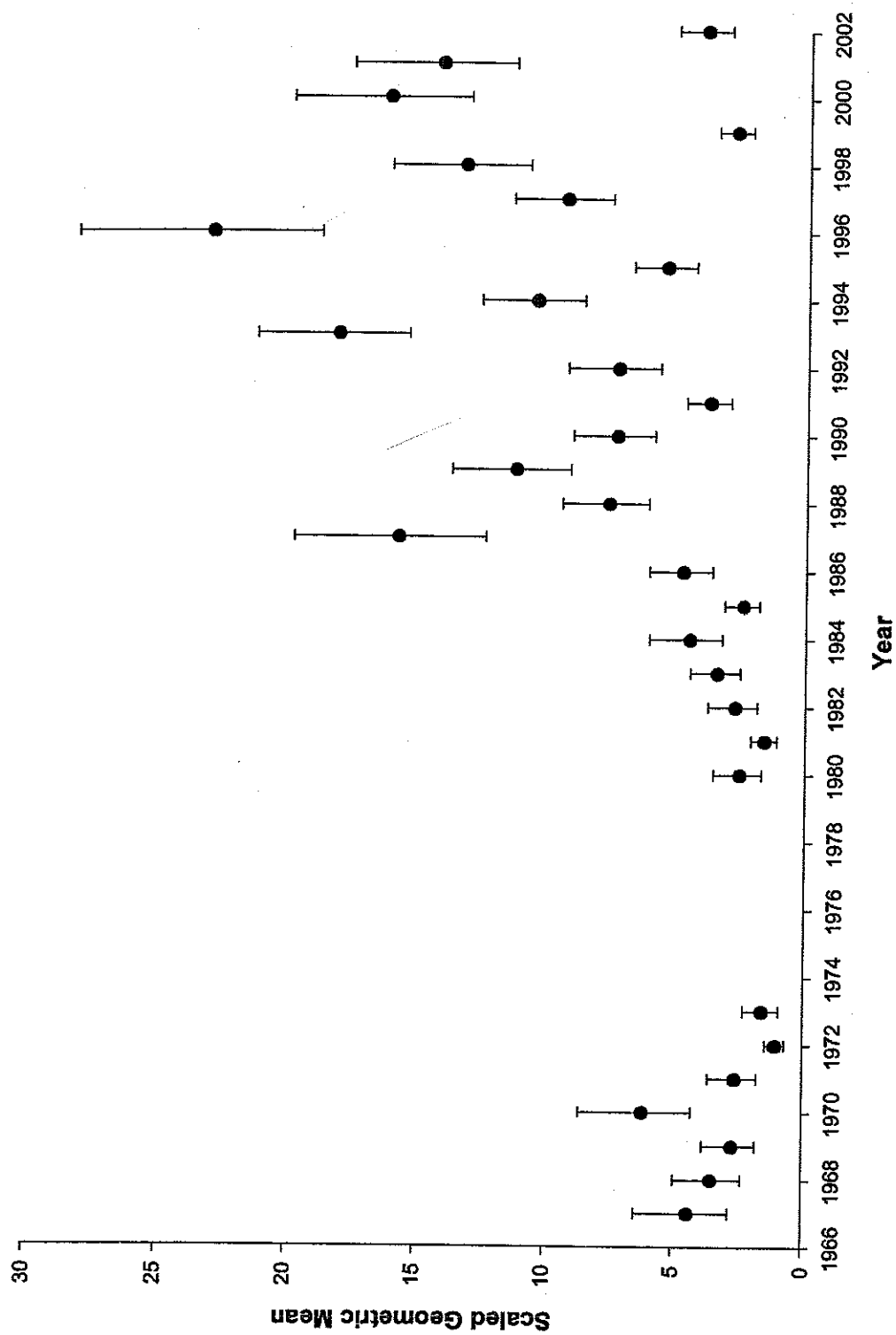


Figure 2. Scaled average catch of young-of-the-year striped bass per seine haul in the primary nursery area (index stations) by year. Vertical bars are 95% confidence intervals as estimated by ± 2 standard errors of the mean.

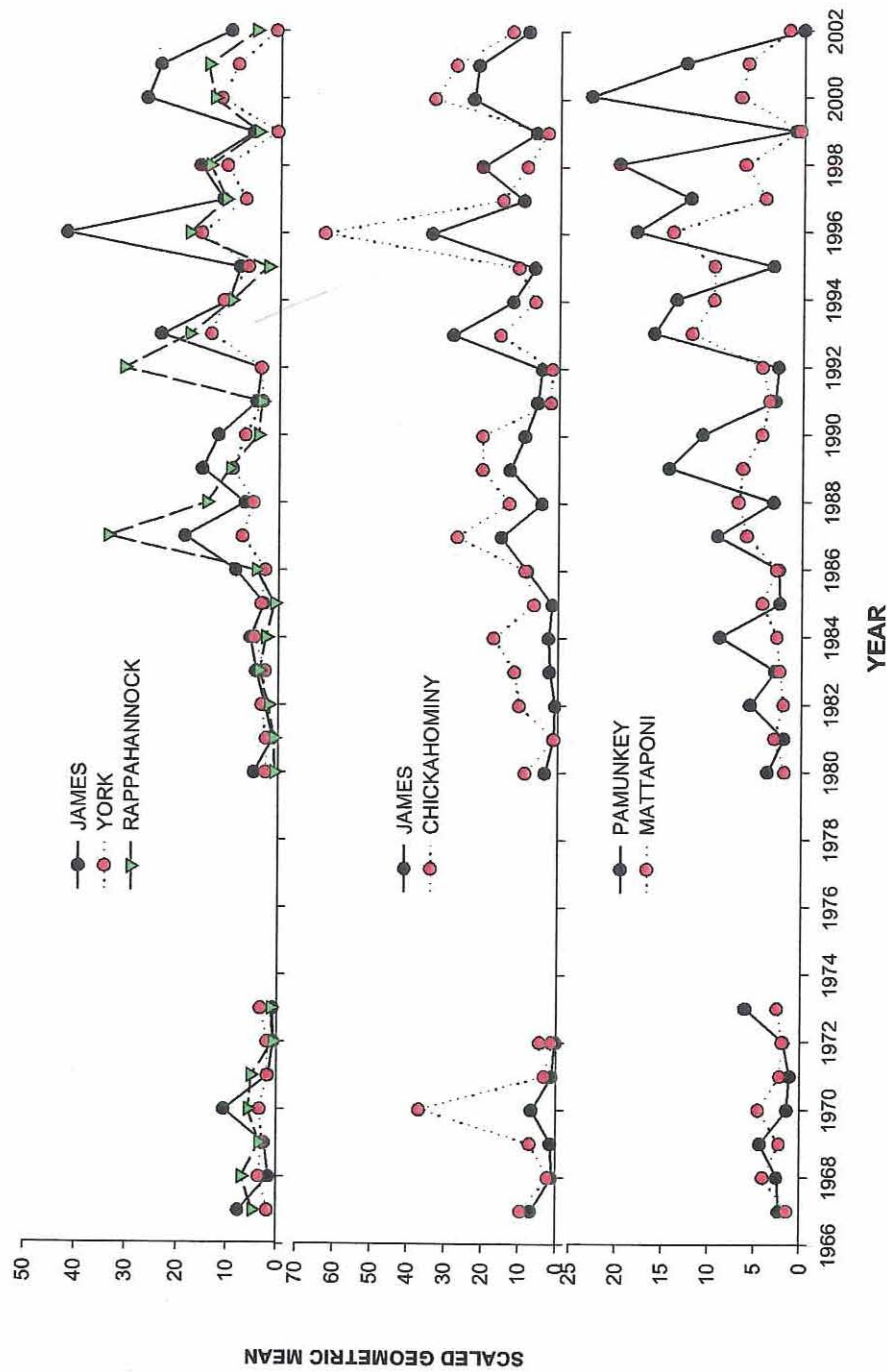


Figure 3. Adjusted average annual catch of young-of-the-year striped bass per seine haul in the primary nursery area by drainage and river.

2002 Seine Survey

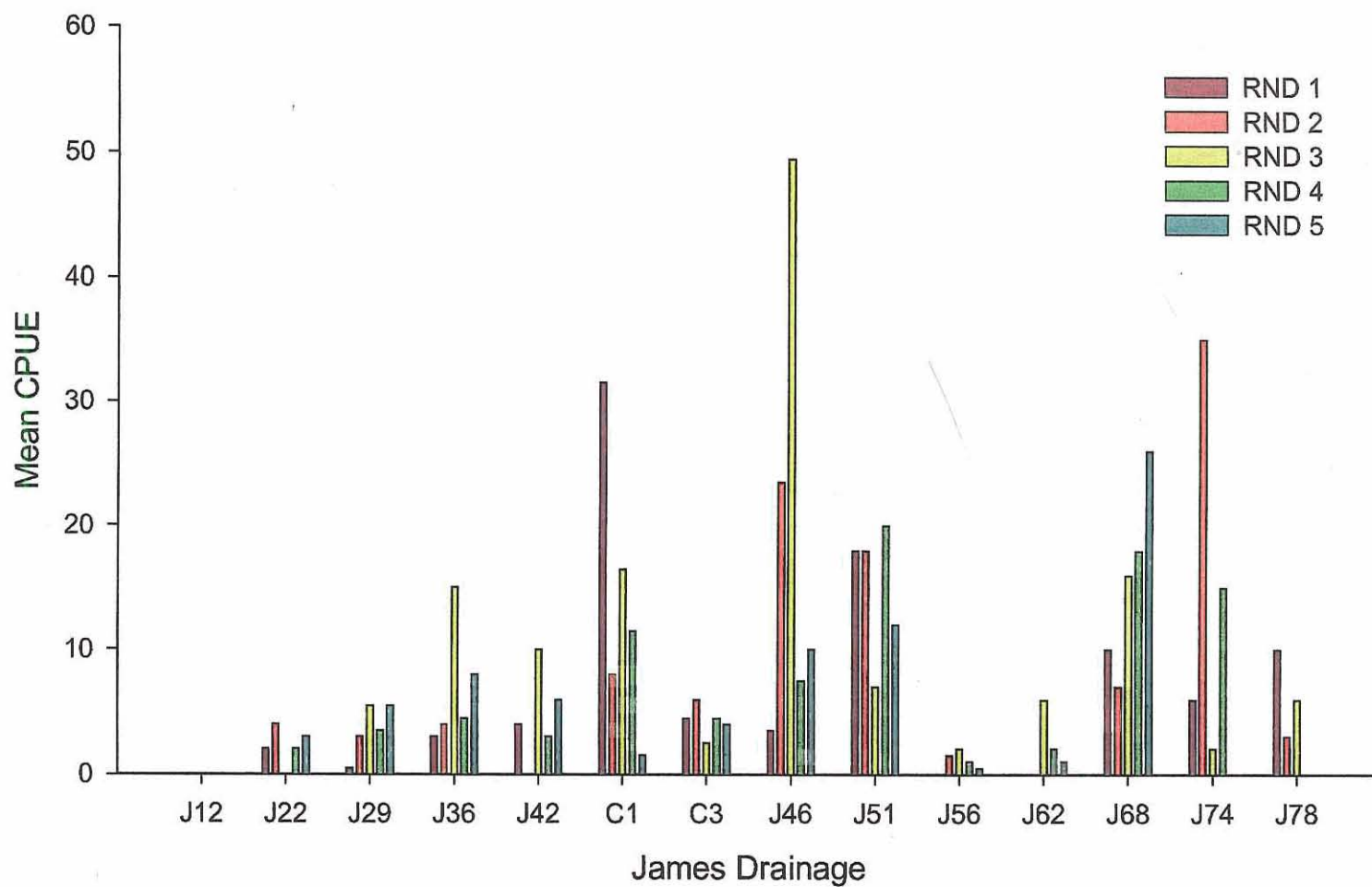


Figure 4. Average catch of young-of-the-year striped bass per seine haul in the James drainage.

2002 Seine Survey

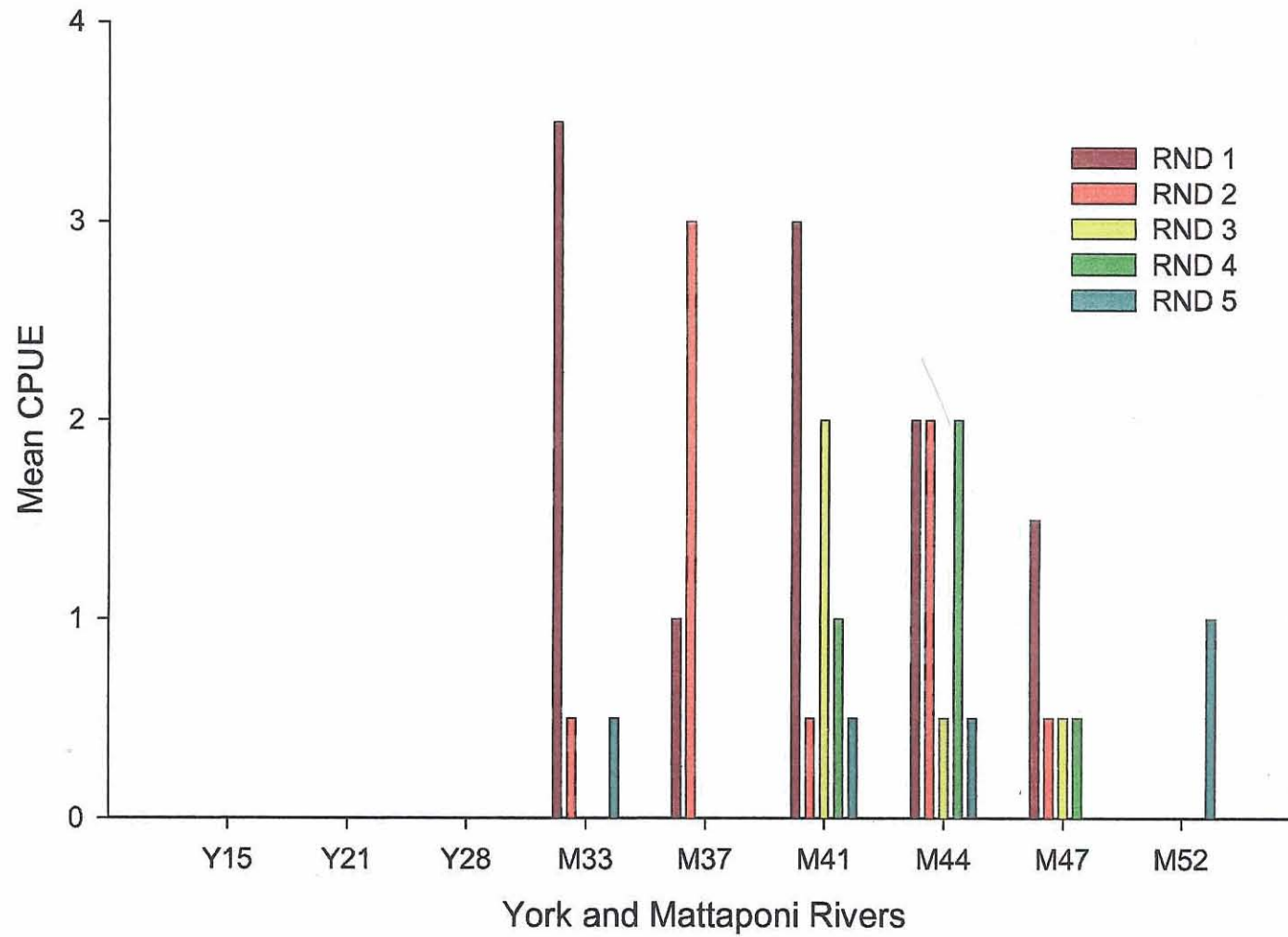


Figure 5. Average catch of young-of-the-year striped bass per seine haul by station in the Mattaponi and York Rivers.

2002 SEINE SURVEY

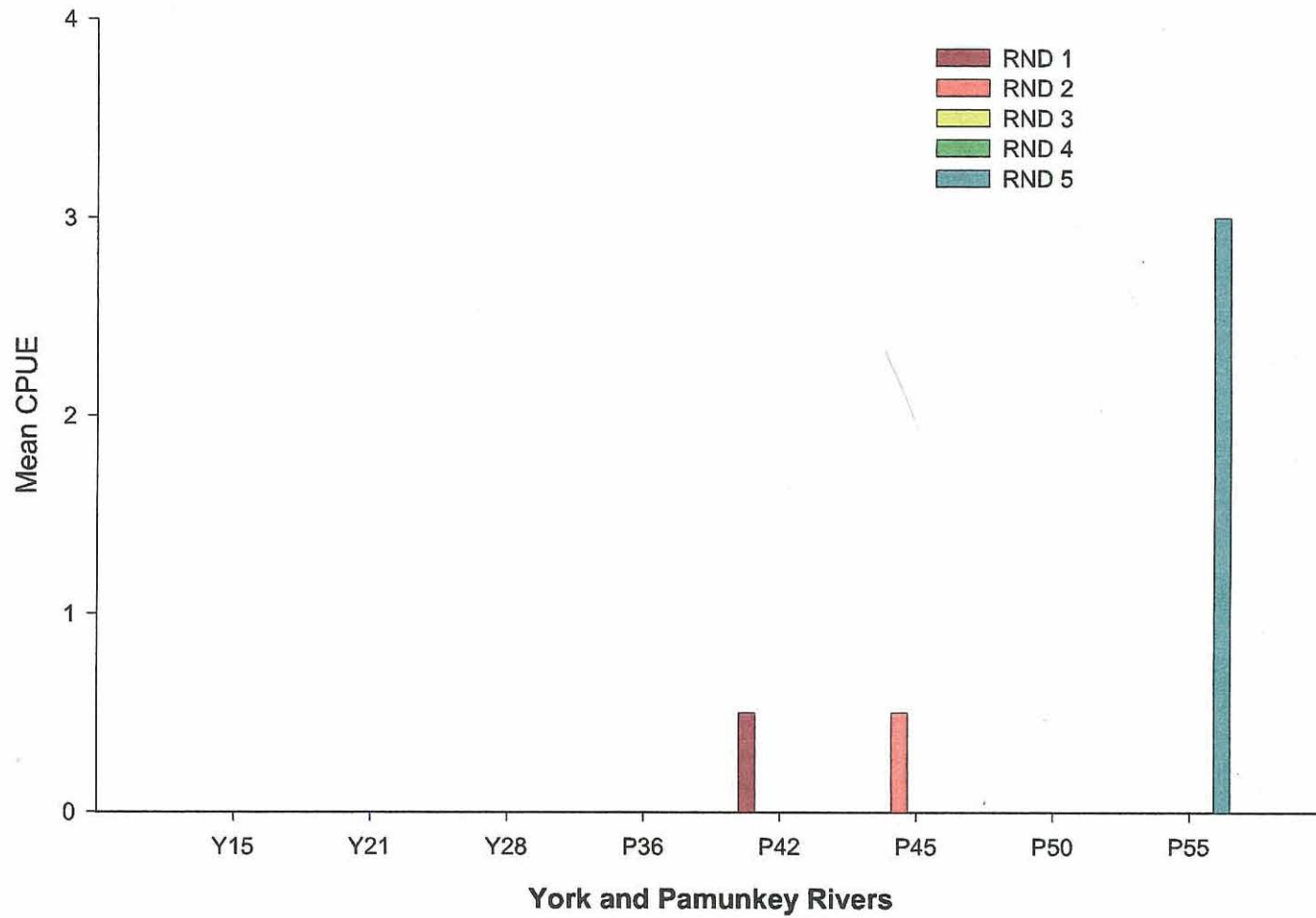


Figure 6. Average catch of young-of-the-year striped bass per seine haul by station in the Pamunkey and York rivers.

2002 Seine Survey

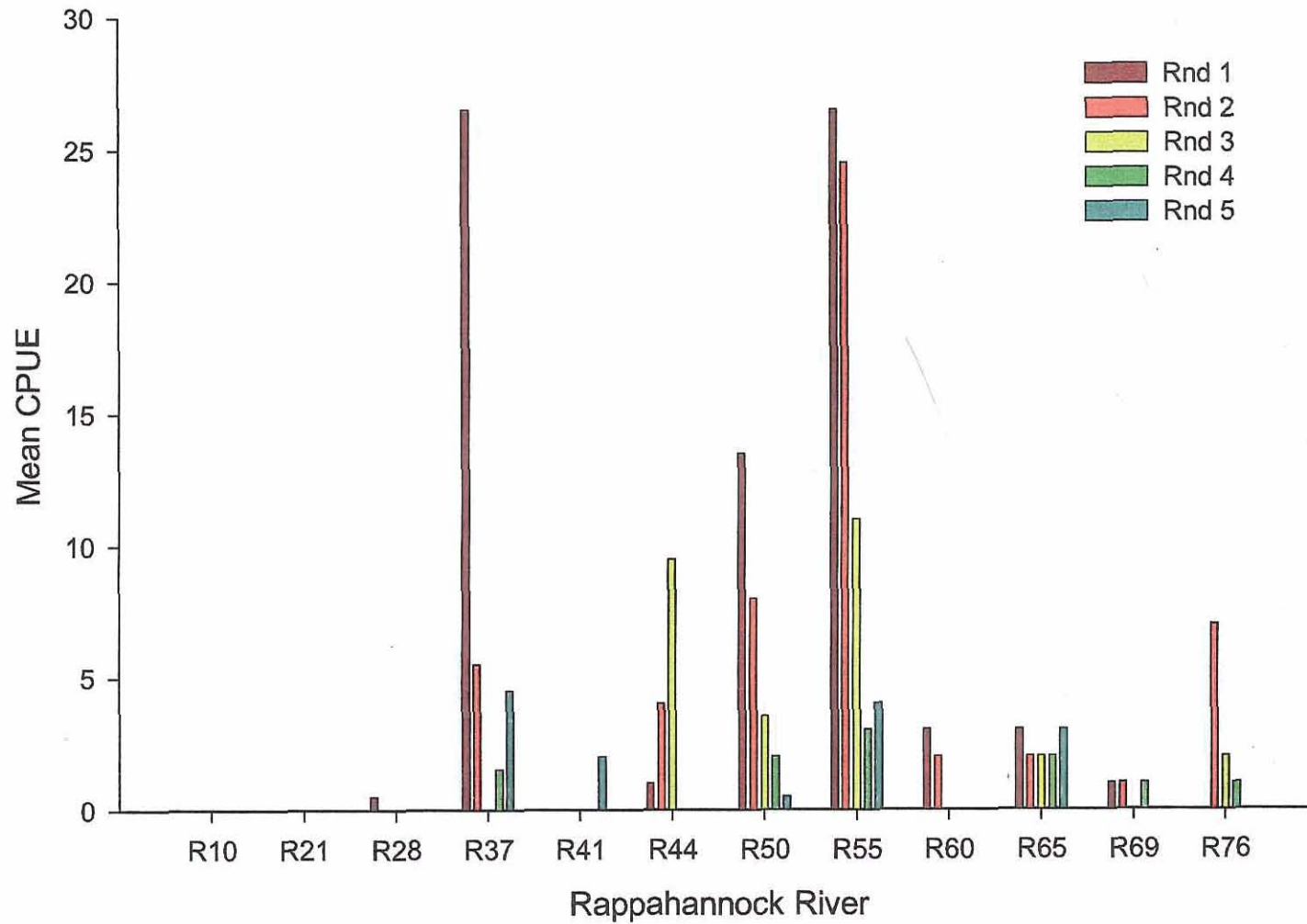


Figure 7. Average catch of young-of-the-year striped bass per seine haul by station in the Rappahannock River.

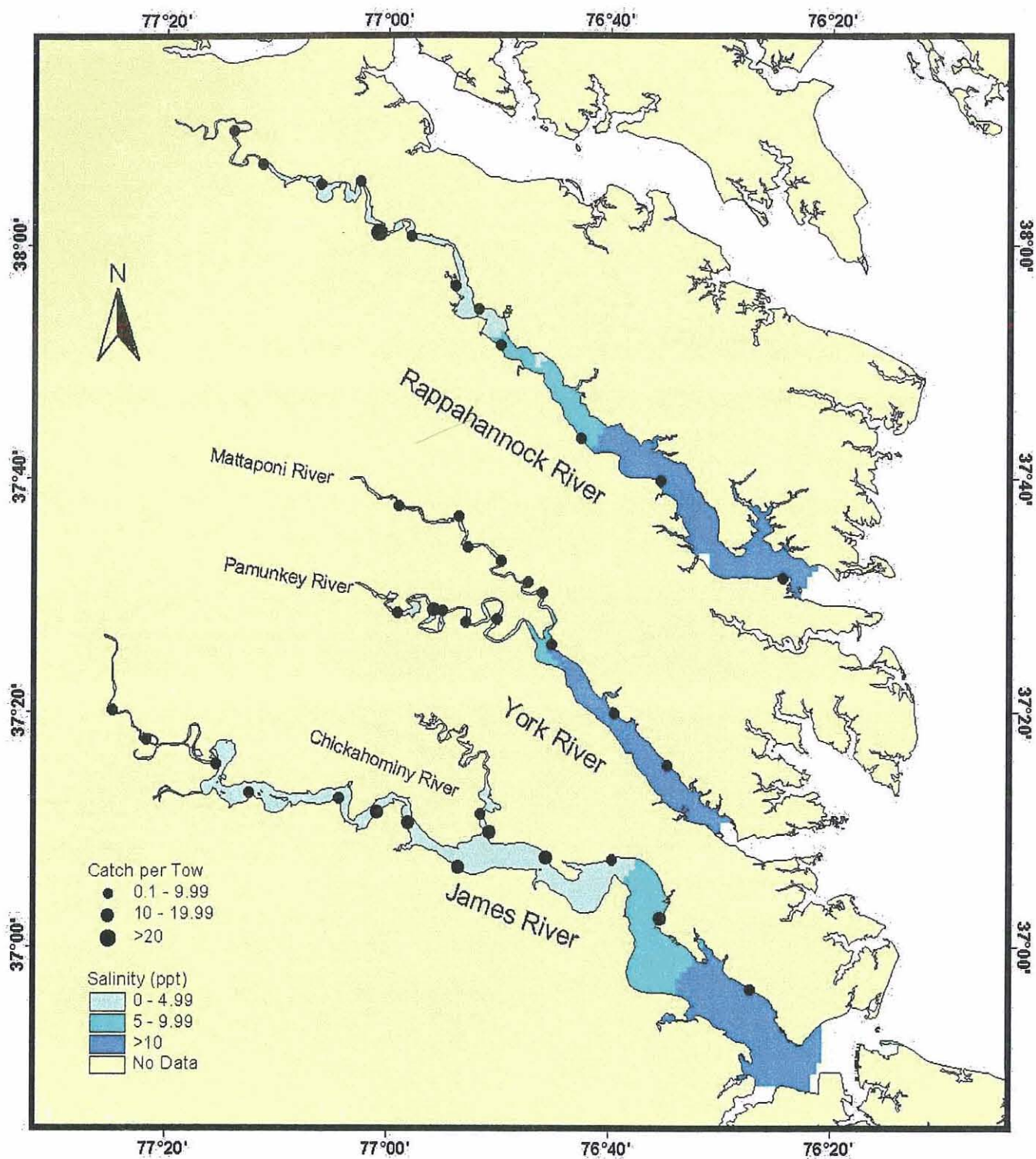


Figure 8. Catch per unit effort of young-of-the-year striped bass with respect to salinity from 1967-2002.

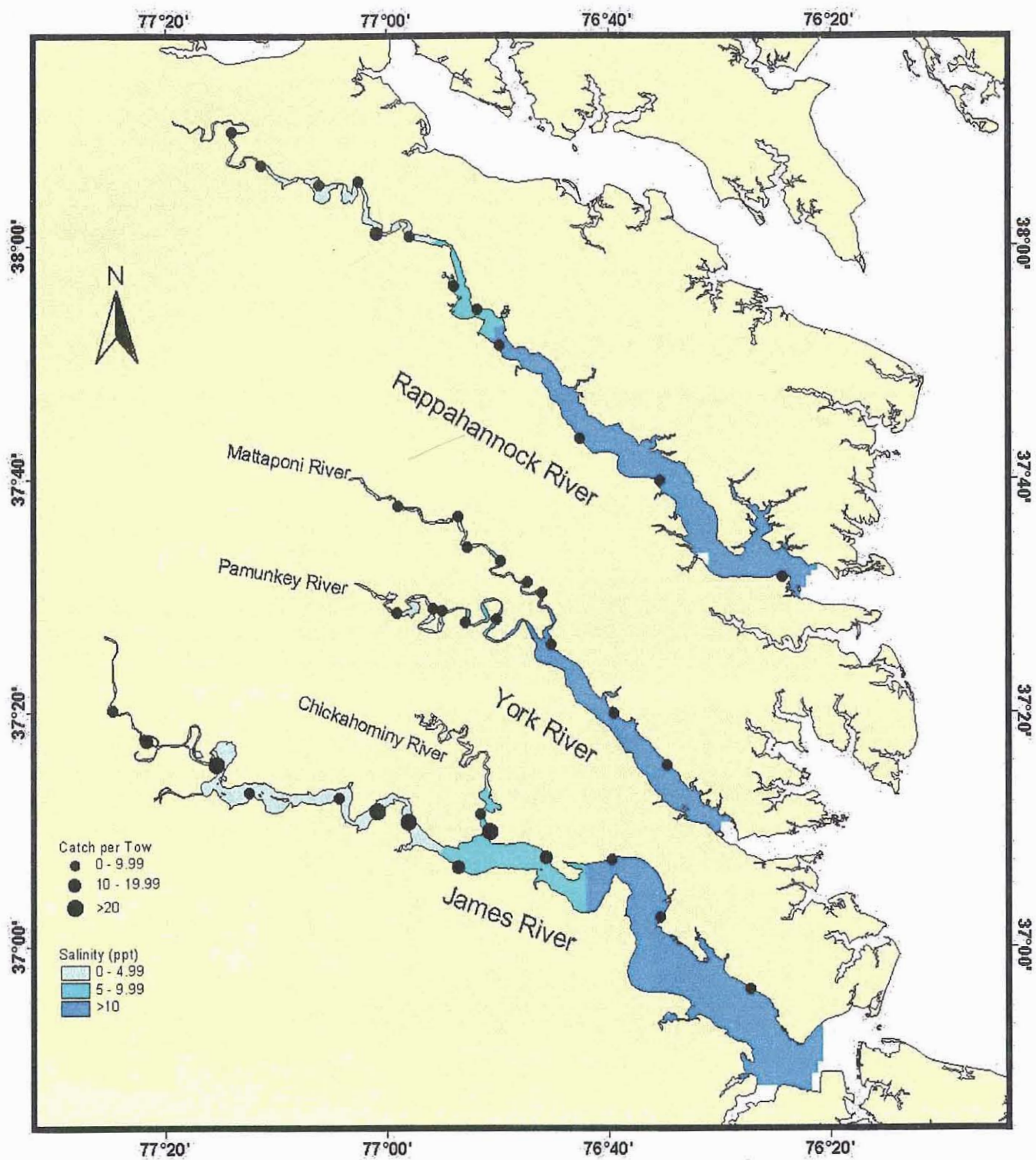


Figure 9. Catch per unit effort of young-of-the-year striped bass with respect to salinity in 2002.