ANNUAL PROGRESS REPORT

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

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by

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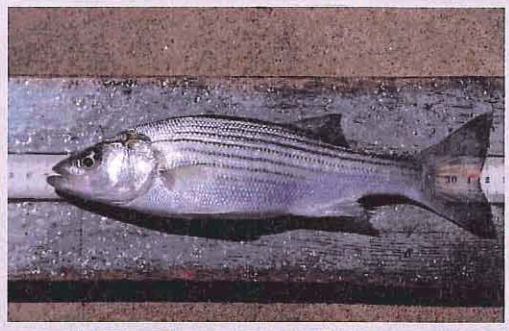

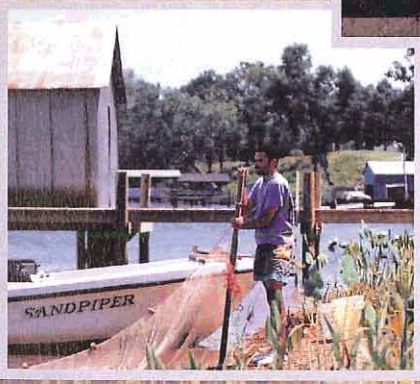

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PREFACE

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 to the 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 1997 sampling period and compares these results with the previous work.

Specific objectives planned for the 1997 program were to:

1. Measure the relative abundance of the 1997 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'a 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 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 adopted 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 1997.

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 studies 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 1997. During each sampling period beach seine hauls were conducted at eighteen historically sampled sites (index stations) and twenty-two auxiliary stations along the shores of the James, York and Rappahannock river systems (Fig. 1). Addition of the auxiliary sites was made to provide better geographic coverage and, once a sufficient time series of data is developed, create larger within-river-system sample sizes so that trends in juvenile abundance can be meaningfully monitored on a system by system basis.

One seine haul was made at each auxiliary station, and two replicate 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) and then leaving the onshore brail in a fixed position while pulling the offshore end downcurrent and back to the shore, resulting in the sweeping of a quarter circle quadrant. In the case of index stations, all fish taken during the first tow were removed from the net 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 instrument. 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 in the period between the two hauls. 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 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 (Sokal and Rohlf 1981) prior to analyses. Subsequently computed mean values

were retransformed (i.e. the geometric mean), but because the geometric means of such a strongly skewed distribution are much smaller than the arithmetic means, for comparative purposes (particularly with respect to the results of the Maryland survey, wherein arithmetic means are reported) the geometric means have been scaled up to the arithmetic means by multiplication by the ratio of the overall arithmetic to geometric means to give adjusted means as of the 1984 survey (2.28).

Mean catch rates are contrasted by comparing 95% confidence intervals as estimated by $\pm$ two standard errors (square root of the variance divided by n) of the mean. 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 1997 year class of juvenile striped bass from the James, York and Rappahannock river systems.

A total of 1484 young-of-the-year striped bass were collected from 180 seine hauls during the 1997 index station sampling, and an additional 357 age 0 striped bass were collected in 107 hauls at the auxiliary sites (Fig. 1, Table 1). The adjusted overall mean catch per seine haul (CPUE) for the index stations was 9.35 which was less than half the 1996 value of 23.0 and represented a significant decrease in the index from the 1996 value (Table 2,Fig. 2). This value was one and

one-half times the overall average index of 6.20 and was significant. Indices for each individual river, except the Mattaponi River, exceeded its respective historical average and each river drainage system exceeded its historical average.

The 1997 catch rate in the James drainage (11.48) was sixty-four percent higher than the historical average which was significantly higher (7.43)(Table 3, Fig. 3). Both the mainstem James (9.81) and the Chickahominy (15.52) were both approximately one and one-half times their respective historical average but confidence intervals overlapped and were therefore not significant. Juvenile striped bass were caught throughout the James system during 1997 (Table 3, Fig. 4) but were most abundant in the center of the index region. The greatest number of fish were captured at station J46 with the Chickahominy sites (C1and C3) the next two highest producing sites. An upriver auxiliary site, J62, adjacent to the index area, produced high catches in rounds one and two but produced very few fish thereafter.

The 1997 index in the York drainage (6.87) was slightly higher than the historical average (5.23)(Table 3, Fig. 3).The catch rate in the Pamunkey (12.3) was more than double its historical average (5.76) and was significant while the Mattaponi index (4.19) was fourteen percent lower than its historical average (4.87) and was not significant (Table 3, Fig. 3). Even though the Pamunkey index declined from the record 1996 value, it was the fifth highest on record. The Mattaponi index has historically remained at low levels and the 1997 value returned to those lower levels after a four year trend of indices that were significantly higher than the historical average.

Highest catches on the Mattaponi River occurred at M37, an auxiliary site within the index area

(Figure 5). However, consistent catches were made from M33, the most downriver index site, through M44, another index site. M47, the most upriver index site only produced striped bass in rounds 1 and 2.

In the Pamunkey River, highest catches were made at P50, the uppermost index site (Figure 6). This site consistently outproduced the other sites except for round 2 when P45 produced more fish. Consistent catches were made from P36 to P55, the former being an auxiliary site just downriver of the index area and the latter being just upriver of the index area. P61, the uppermost site, was not sampled during round 3 due to a coastal storm that caused the loss of available beach at that site.

The 1997 index in the Rappahannock River (11.00) was slightly less than double the historical average and was significant (6.23)(Table 3) but only two-thirds the value seen in 1996 (18.18)(Austin et al, 1997). Confidence intervals from the 1996 and 1997 values overlapped therefore 1997 was not judged to be a significant decline from 1996. Highest catches were at the three uppermost index sites (R44,R50,R55) but catches on either side of this area were greatly reduced (Fig. 7). Stations R12 and R21 were not sampled during round three due to severe thunderstorms at the time of sampling.

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 into early-August

and taper off in the later rounds of August and September. In 1997, there was a small increase in catch in round 4 which is a slight deviation from the norm (Table 4). However, the increase was not significant and was fueled by high catches at just a few sites.

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

Collection information and pertinent environmental variables recorded at the time of each collection in 1997 are given in Tables 5 through 7. 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 higher in 1997 than in 1996 (Table 5)(Austin et al, 1997). Salinities returned to a more "normal" summertime level with a warm, dry period in July and August. The Palmer Drought Index indicated that the spring/summer period of 1997 was slightly drier than normal (Palmer, 1964).

Water temperatures averaged slightly higher in 1997 (Table 6) than in 1996 (Austin et al, 1997), returning to the more normal pattern of higher temperature in the early rounds and temperature slowly declining during the later rounds.

Dissolved oxygen levels were generally within the norms experienced during this sampling period (Table 7). No depressed readings that affected catches were observed in 1997.

pH levels during the 1997 sampling were found to be consistently acidic. Upon further investigation, a faulty pH probe was discovered and all readings were assumed to be erroneous. Therefore, a table of pH values for 1997 are not included in this report.

All index sites were completed without interruption during all five sampling rounds, however some data were not collected due to malfunctions of the Hydrolab 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 1997 followed the normally observed pattern i.e. a definitive trend towards higher catches at lower salinities (Table 8). Overall mean catches were highest in the areas of lowest salinities (0-4.9ppt).

Catch rates with respect to water temperature in 1997 clearly adhered to the pattern seen in most years, i.e. catch rates varied directly with water temperature at the time of collection (Table 9). 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 into deeper waters usually play a larger role in this trend. Generally, catches within the

sampling season are not noticeably 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 should have little or no effect on juvenile striped bass distributions as they inhabit shallow water. pH values for 1997 were unavailable but pH values during our sampling are generally near neutral to slightly basic outside of the Mattaponi River. These values may be seen in Table 8 of the 1996 report (Austin et al, 1997). Secchi disc readings are a measure of turbidity at each site which can affect utilization of a particular area when turbitity is extreme or can increase net avoidance when turbidity is low. We saw no high turbidity episodes in 1997 and though secchi readings are not presented herein, the data are collected and stored to document such occurrences should they occur.

DISCUSSION AND CONCLUSIONS

The striped bass juvenile index recorded in the Virginia Chesapeake Bay nursery areas in 1997 was significantly higher (though not highly significant) than the historical average (Table 2), but was a significant decrease from the record 1996 index (Austin et al, 1997). No individual system unduly influenced the overall index as all system indices were slightly above its historical average. The Pamunkey River index was strong and carried the York system index. Although 1997 was not

a dominant yearclass by recent standards, it was a relatively strong yearclass and a definite continuation of the successful recruitment that has been observed since the mid-1980's. Even though it is below the 1996 record index it is still significantly above average and will contribute to the continuation of a sound, spawning stock.

The spring and summer of 1997 exhibited normal weather patterns, i.e. a mild spring with a hot, low rainfall mid-summer therby producing more normal meteorlogical and hydrological parameters. These parameters (e.g. salinities) and the juvenile striped bass densities encountered in 1997 contributed to distribution patterns that were centered in the index sites. Highest densities were in the mid-regions of the index areas declining both below and above the index areas. Only on the James system were consistent catches recorded from the lowest to the uppermost station.

The strong year classes of late are probably a product of a substantial increase in spawning stocks due to stringent harvest regulations in place since implementation of the ASMFC Interstate Fisheries Management Plan. Refinements to our sampling program have focused on the spatial and temporal usage of the nursery areas and probably served to give us a more precise estimate of yearclass strength.

Striped bass recruitment success in the Virginia portion of Chesapeake Bay remains variable between years and between the different nursery areas within years.However, these fluctuations

have been bracketing a much higher average over the past eleven years. This pattern is consistent with an increase in spawning stock size resulting from the stringent harvest regulations in place over the period since 1985.

The addition of auxiliary stations in 1989 has provided a better areal coverage of the nursery areas. These additional areas of coverage have revealed that in years of high or low salinities there may be a shift in the traditional nursery areas up or downriver ordue to dispersion of fish up and/or downriver. 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 overemphasize 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 may lead to a more precise estimate of relative year-class strength but it will undoubtedly elevate the recalculated indices. This change was recommended in 1992 at a juvenile abundance workshop at Kent Island, MD (Rago et al, 1995). Figure 8 presents a comparison of indices calculated using only one haul versus two. However, in order to achieve this, all past indices must be recalculated using this formula and suitable complementary auxiliary sampling sites were probably not sampled adequately to make those indices comparable. Further, any change must be approved by the stock assessment sub-committee of the Striped Bass Technical Committee of ASMFC.

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Table 1. Catch of young-of-the-year striped bass per seine haul during the 1997 survey. Two hauls were made per sampling round at each of the historical index stations (bold).

Drainage														
JAMES														
Station	J12	J22	**J29**	**J36**	**C1**	**C3**	**J46**	J51	**J56**	J62	J68	J74	J78	TOT.
Round														
1	6	1	5/7	5/15	32/7	28/16	14/45	1	1/1	53	7	8	7	245
2	0	3	6/0	7/4	55/4	31/9	13/27	2	2/2	26	2	5	11	209
3	9	5	5/7	9/2	24/5	13/9	5/4	5	1/1	0	5	0	8	117
4	2	0	3/5	5/5	10/1	2/1	27/32	1	11/3	2	0	0	3	113
5	2	7	2/1	3/0	1/10	0/0	2/7	6	1/0	0	2	2	8	54
														738
YORK														
Station	Y15	Y21	Y28	P36	**P42**		**P45**	**P50**	P55	P61				
Round														
1	0	0	0	4	9/2		2/3	24/4	11	0				59
2	0	0	2	8	9/8		60/8	5/51	6	0				157
3	0	0	0	1	1/4		8/6	46/21	7	ns				94
4	0	1	0	3	1/1		4/5	30/6	6	2				59
5	0	1	0	7	1/0		0/0	8/6	6	0				29
Station				**M33**	M37	**M41**	**M44**	**M47**	M52					
Round														
1				5/0	9	10/12	7/1	2/2	1					49
2				17/6	6	2/2	6/1	4/1	2					47
3				6/0	6	7/4	2/0	0/0	1					26
4				4/3	22	0/1	3/1	0/0	4					38
5				1/0	4	0/3	6/3	0/0	0					17
														575
RAPPAHANNOCK														
Station	R12	R21	**R28**	**R37**		R41	**R44**	**R50**	**R55**	R60	R65	R69	R76	
Round														
1	0	0	0/0	0/0		1	14/6	2/2	27/6	2	4	4	1	69
2	2	0	4/1	2/0		4	12/6	24/6	30/17	4	8	4	1	125
3	ns	ns	0/1	0/0		1	28/14	7/4	21/7	0	2	2	0	87
4	0	0	4/2	1/1		2	43/27	21/16	6/2	2	2	1	1	131
5	0	0	3/1	1/3		1	44/12	11/11	13/13	1	2	0	0	116
														528
														1841

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 the 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	77
1971	178	0.76	0.857	2.61	1.76-3.64	80
1972	96	0.39	0.575	1.07	0.73-1.45	117
1973	139	0.53	0.790	1.59	0.98-2.32	84
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
Overall	23302	1.31	1.156	6.20	5.87-6.55	3303
Unweighted Annual Mean				6.53		25

Table 3. Catch of young-of-the-year striped bass per seine haul in the primary nursery area in 1997 summarized by drainage and river.

Drainage River	1997 Total	1997 Mean ln(x+1)	1997 Std. Dev.	1997 Adjust. Mean	1997 C.I. (± 2 SE)	1997 N	All Years Combined Total	All Years Combined Mean ln(x+1)	All Years Combined Std. Dev.	All Years Combined Adjust. Mean	All Years Combined C.I. (± 2 SE)	All Years Combined N
James	553	1.80	1.043	11.48	8.23-15.73	60	8888	1.45	1.195	7.43	6.75-8.16	1091
James	295	1.67	0.942	9.81	6.70-14.01	40	4831	1.33	1.140	6.30	5.61-7.06	733
Chickahom.	258	2.06	1.204	15.52	8.11-28.22	20	4057	1.70	1.266	10.23	8.66-12.02	358
York	455	1.39	1.061	6.87	4.82-9.51	70	6892	1.19	1.035	5.23	4.81-5.69	1243
Pamunkey	333	1.86	1.137	12.30	7.34-19.80	30	3212	1.26	1.077	5.76	5.04-6.55	527
Mattaponi	122	1.04	0.859	4.17	2.64-6.19	40	3680	1.14	1.001	4.87	4.35-5.43	716
Rappahannock	476	1.76	1.169	11.00	7.26-16.21	50	7552	1.32	1.238	6.23	5.58-6.93	969
Overall	1484	1.63	1.097	9.35	7.59-11.41	180	23302	1.31	1.156	6.20	5.87-6.55	3303

Table 4. Catch of young-of-the-year striped bass per seine haul in the primary nursery area in 1997 summarized by sampling period and month.

Month	1997 Total	1997 Mean ln(x+1)	1997 Std. Dev.	1997 Adjust. Mean	1997 C.I. (± 2 SE)	1997 N	All Years Combined Total	All Years Combined Mean ln(x+1)	All Years Combined Std. Dev.	All Years Combined Adjust. Mean	All Years Combined C.I. (± 2 SE)	All Years Combined N
July (1st)	316	1.74	1.094	10.73	6.76-16.5	36	6701	1.59	1.190	8.91	7.96-9.96	710
(2nd)	442	2.03	1.072	15.11	9.88-22.6	36	5862	1.40	1.191	6.96	6.17-7.81	721
Aug. (3rd)	272	1.60	1.094	9.06	5.60-14.1	36	4096	1.22	1.089	5.42	4.81-6.07	713
(4th)	287	1.62	1.044	9.29	5.88-14.1	36	3922	1.26	1.146	5.78	5.05-6.59	578
Sept. (5th)	167	1.14	1.044	4.87	2.77-7.85	36	2518	1.20	1.098	5.32	4.57-6.14	451

Table 5. Salinity (parts per thousand) recorded at 1997 seine survey stations.

Drainage														
JAMES														
Station	J12	J22	J29	J36	C1	C3	J46	J51	J56	J62	J68	J74	J78	MEAN
Round														
1	17.4	6.1	2.9	1.2	0.5	0.4	0.2	0.2	0.2	0.3	0.2	0.3	0.3	2.3
2	13.9	5.9	4.4	1.7	0.8	0.7	0.3	0.3	0.3	0.3	0.3	0.3	0.3	2.3
3	14.6	6.8	4.1	1.5	0.6	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.4	2.3
4	17.2	8.6	5.2	2.2	1.3	1.1	0.4	0.3	0.3	0.4	0.3	0.3	0.3	2.9
5	18.8	11.4	7.6	5.0	2.2	1.9	0.8	0.4	0.4	0.4	0.4	0.4	0.4	3.9
														2.7
YORK														
Station	Y15	Y21	Y28	P36	P42		P45	P50	P55	P61				
Round														
1	18.6	13.0	8.8	2.7	0.7		0.3	0.2	0.2	0.2				3.3
2	15.9	12.5	11.9	5.0	1.5		0.6	0.3	0.2	0.2				3.8
3	15.9	13.3	11.3	4.2	1.1		0.5	0.3	0.3	ns				3.7
4	17.5	14.8	12.5	6.0	2.3		0.9	0.4	0.4	0.3				4.4
5	19.6	16.8	13.6	6.5	3.0		1.2	0.7	0.5	0.3				5.0
														4.0
Station				M33	M37	M41	M44	M47	M52					
Round														
1				2.6	1.2	0.4	0.2	0.2	0.2					
2				4.9	2.1	1.0	0.2	0.2	0.2					(included
3				2.7	0.9	0.4	0.2	0.2	0.2					above)
4				5.8	3.5	1.3	0.3	0.3	0.2					
5				6.1	3.8	1.5	0.5	0.4	0.3					
RAPPAHANNOCK														
Station	R12	R21	R28	R37		R41	R44	R50	R55	R60	R65	R69	R76	
Round														
1	12.7	11.7	9.5	3.7		1.5	0.8	0.1	0.0	0.0	0.0	0.0	0.0	3.3
2	13.1	12.1	10.4	5.2		2.5	1.1	0.2	0.2	0.2	0.2	0.2	0.2	3.8
3	ns	ns	9.4	5.2		2.5	1.1	0.3	0.2	ns	ns	ns	ns	3.1*
4	14.1	13.1	10.5	5.3		4.2	2.2	0.9	0.5	0.3	0.3	0.2	0.2	4.3
5	15.1	14.1	12.1	7.2		4.5	3.2	1.3	0.7	0.4	0.3	0.2	0.2	4.9
														3.9*

* - Missing values affected this average

Table 6. Water temperature (°C) recorded at 1997 seine survey stations.

Drainage														
JAMES														
Station	J12	J22	J29	J36	C1	C3	J46	J51	J56	J62	J68	J74	J78	MEAN
Round														
1	27.6	28.0	30.1	26.6	28.1	27.9	29.3	27.6	27.1	28.4	29.9	29.8	27.7	28.3
2	29.2	30.3	29.9	27.2	28.0	28.6	29.5	28.3	28.3	29.6	31.3	31.7	31.0	29.5
3	28.2	30.9	28.9	25.7	27.1	27.3	28.3	27.8	27.5	29.6	27.5	29.4	31.2	28.4
4	28.1	29.3	28.9	25.7	26.7	27.2	28.1	28.1	27.6	30.3	30.9	32.4	30.9	28.8
5	25.3	25.1	24.8	22.3	24.7	25.6	21.3	26.4	26.0	28.6	28.9	30.1	29.0	26.0
														28.2
YORK														
Station	Y15	Y21	Y28	P36	P42		P45	P50	P55	P61				
Round														
1	27.2	27.8	28.0	27.8	28.7		28.9	28.5	30.0	29.6				28.4
2	32.6	33.6	27.2	27.9	28.1		28.5	28.5	28.7	28.2				28.3
3	25.8	28.6	24.6	26.0	26.0		27.2	26.3	27.6	ns				26.8
4	26.2	26.9	25.4	26.9	27.6		27.9	27.5	28.7	28.1				27.0
5	27.1	24.6	21.6	24.4	24.8		25.2	24.6	24.7	24.1				24.8
														27.1
Station				M33	M37	M41	M44	M47	M52					
Round														
1				27.5	27.5	27.5	28.3	30.3	29.1					
2				26.9	26.7	26.9	27.1	27.0	26.6					(included
3				26.7	26.5	26.4	27.4	28.1	27.5					above)
4				26.5	26.4	26.0	26.5	27.1	27.5					
5				24.9	24.8	24.4	24.8	26.1	25.7					
RAPPAHANNOCK														
Station	R12	R21	R28	R37		R41	R44	R50	R55	R60	R65	R69	R76	
Round														
1	28.9	27.1	25.7	27.3		27.6	27.9	28.0	28.0	28.0	26.8	28.0	28.4	27.6
2	25.9	26.6	25.7	28.9		29.4	29.3	29.5	29.9	30.2	30.8	30.4	30.5	28.9
3	ns	ns	25.2	26.1		25.9	26.2	27.8	28.2	27.5	26.0	28.0	28.0	26.9
4	25.1	24.9	24.3	24.5		26.1	24.4	29.7	30.2	29.9	27.5	28.2	29.0	27.0
5	25.1	26.6	26.9	26.6		26.3	26.8	26.3	26.3	26.2	25.5	26.6	27.2	26.4
														27.4

Table 7. Dissolved oxygen (milligrams per liter) recorded at 1997 seine survey stations.

Drainage														
JAMES														
Station	J12	J22	J29	J36	C1	C3	J46	J51	J56	J62	J68	J74	J78	MEAN
Round														
1	8.2	8.1	8.1	7.0	7.3	5.8	7.9	6.2	6.9	6.0	5.9	6.0	7.3	7.0
2	6.8	9.3	7.3	7.4	8.6	5.4	7.7	5.8	6.2	5.4	6.2	6.6	5.5	6.8
3	8.1	9.0	7.9	6.1	8.4	7.0	5.7	6.1	7.0	8.4	7.3	8.1	6.4	7.3
4	8.1	8.6	7.0	7.0	6.3	5.6	5.4	6.2	7.4	8.1	5.8	6.9	6.7	6.9
5	7.7	6.9	5.2	7.2	9.6	7.6	9.3	5.9	7.3	8.2	6.8	7.3	7.9	7.5
														7.1
YORK														
Station	Y15	Y21	Y28	P36	P42		P45	P50	P55	P61				
Round														
1	8.1	7.6	6.8	6.2	7.3		6.9	5.3	5.6	6.4				6.6
2	ns	ns	4.9	6.3	5.6		6.3	5.2	5.5	5.5				5.1
3	6.3	6.4	5.7	4.9	5.8		5.6	4.8	5.1	ns				5.2
4	7.9	6.8	5.7	4.7	4.7		4.9	5.0	6.5	4.9				5.6
5	4.8	6.6	6.0	5.5	5.9		6.1	5.6	6.7	5.2				5.9
														5.7
Station				M33	M37	M41	M44	M47	M52					
Round														
1				6.7	5.6	5.1	6.4	7.5	7.2					
2				3.7	4.4	4.4	4.7	4.8	5.6					(included
3				4.2	4.2	4.4	4.7	4.4	5.6					above)
4				5.3	5.4	4.9	5.3	5.5	6.9					
5				6.1	5.6	6.0	5.9	6.1	5.7					
RAPPAHANNOCK														
Station	R12	R21	R28	R37		R41	R44	R50	R55	R60	R65	R69	R76	
Round														
1	7.7	7.6	7.8	6.4		6.8	7.7	ns	ns	ns	ns	ns	ns	7.3
2	4.7	5.2	8.3	8.1		7.0	8.2	5.8	6.6	6.0	9.2	5.8	4.7	6.6
3	ns	ns	7.0	6.6		5.8	7.8	6.8	7.5	ns	ns	ns	ns	6.9
4	5.5	7.0	6.7	6.9		6.1	7.6	6.6	7.9	6.5	7.5	7.0	6.9	6.9
5	5.7	6.0	7.3	6.4		6.2	7.0	7.1	7.6	6.6	7.1	7.9	7.8	6.9
														6.9

Table 8. Catch of young-of-the-year striped bass per seine haul in the primary nursery area in 1997 summarized by salinity.

	1997						All Years Combined					
Salinity (ppt.)	Total	Mean ln(x+1)	Std. Dev.	Adjust. Mean	C.I. (± 2 SE)	N	Total	Mean ln(x+1)	Std. Dev.	Adjust. Mean	C.I. (± 2 SE)	N
0-4.9	1438	1.78	1.099	11.26	9.05-13.91	152	21585	1.41	1.159	7.01	6.62-7.43	2815
5-9.9	31	0.70	0.623	2.29	1.23-3.68	22	1598	0.95	1.057	3.62	2.99-4.33	350
10-14.9	15	1.18	0.422	5.15	2.98-8.21	6	117	0.42	0.616	1.18	0.81-1.60	119
15-19.9							2	0.07	0.219	0.17	-0.06-0.43	19
Overall	1484	1.63	1.097	9.35	7.59-11.41	180	23302	1.31	1.156	6.20	5.87-6.55	3303

Table 9. Catch of young-of-the-year striped bass per seine haul in the primary nursery area in 1997 summarized by water temperature.

	1997						All Years Combined					
Temp. (deg. C)	Total	Mean ln(x+1)	Std. Dev.	Adjust. Mean	C.I. (± 2 SE)	N	Total	Mean ln(x+1)	Std. Dev.	Adjust. Mean	C.I. (± 2 SE)	N
15-19.9							79	0.81	0.908	2.85	1.40-4.86	30
20-24.9	132	1.29	0.999	5.98	3.22-10.15	24	1607	0.84	0.945	2.98	2.55-3.45	491
25-29.9	1328	1.69	1.123	10.05	7.99-12.53	150	16840	1.41	1.158	7.07	6.62-7.55	2190
30-34.9	24	1.52	0.469	8.13	4.82-12.99	6	4398	1.48	1.203	7.73	6.71-8.86	506
Overall	1484	1.63	1.097	9.35	7.59-11.41	180	23302	1.31	1.156	6.20	5.87-6.55	3303

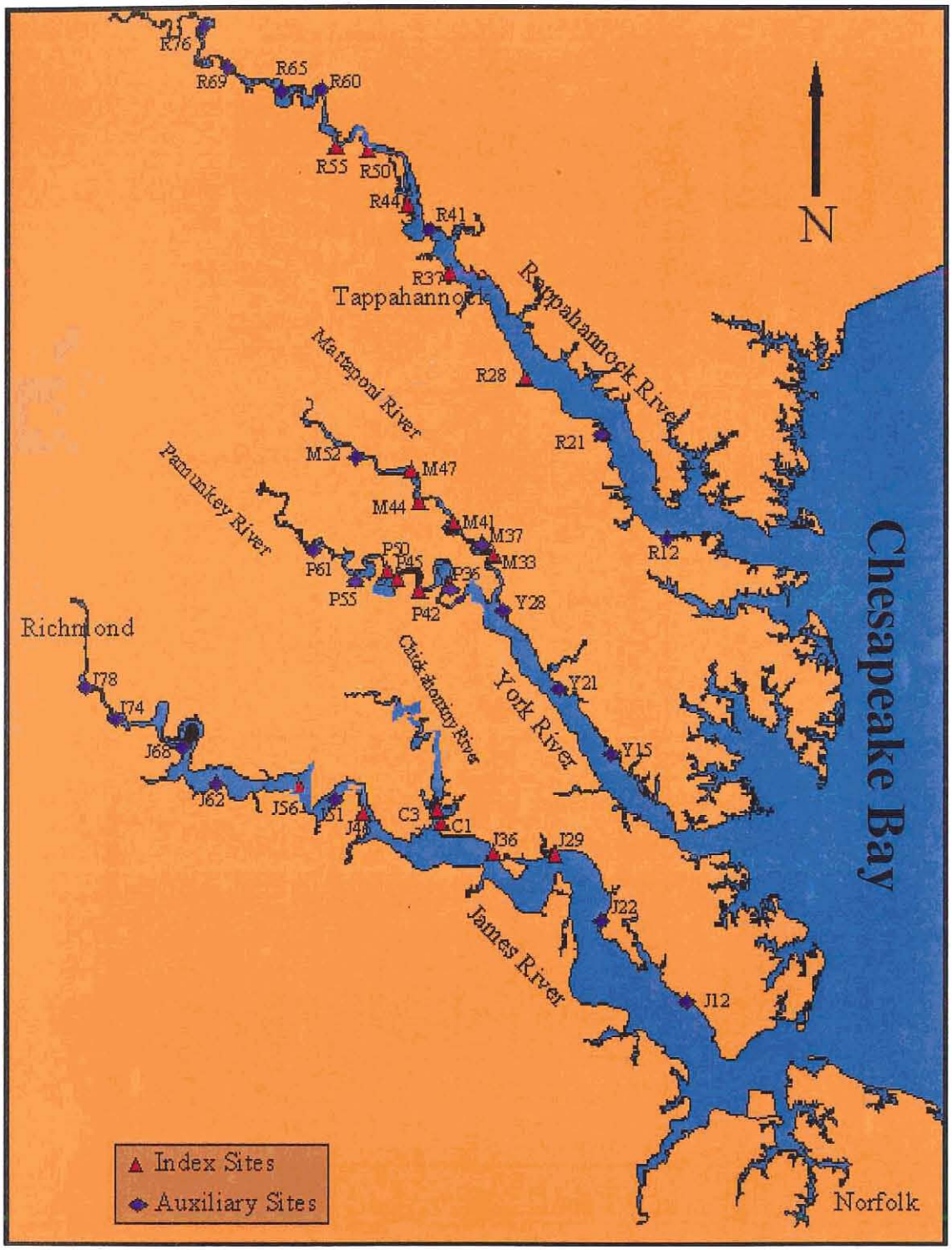

Figure 1. Juvenile striped bass seine survey stations. Numeric portion of station designations indicate river mile from the mouth.

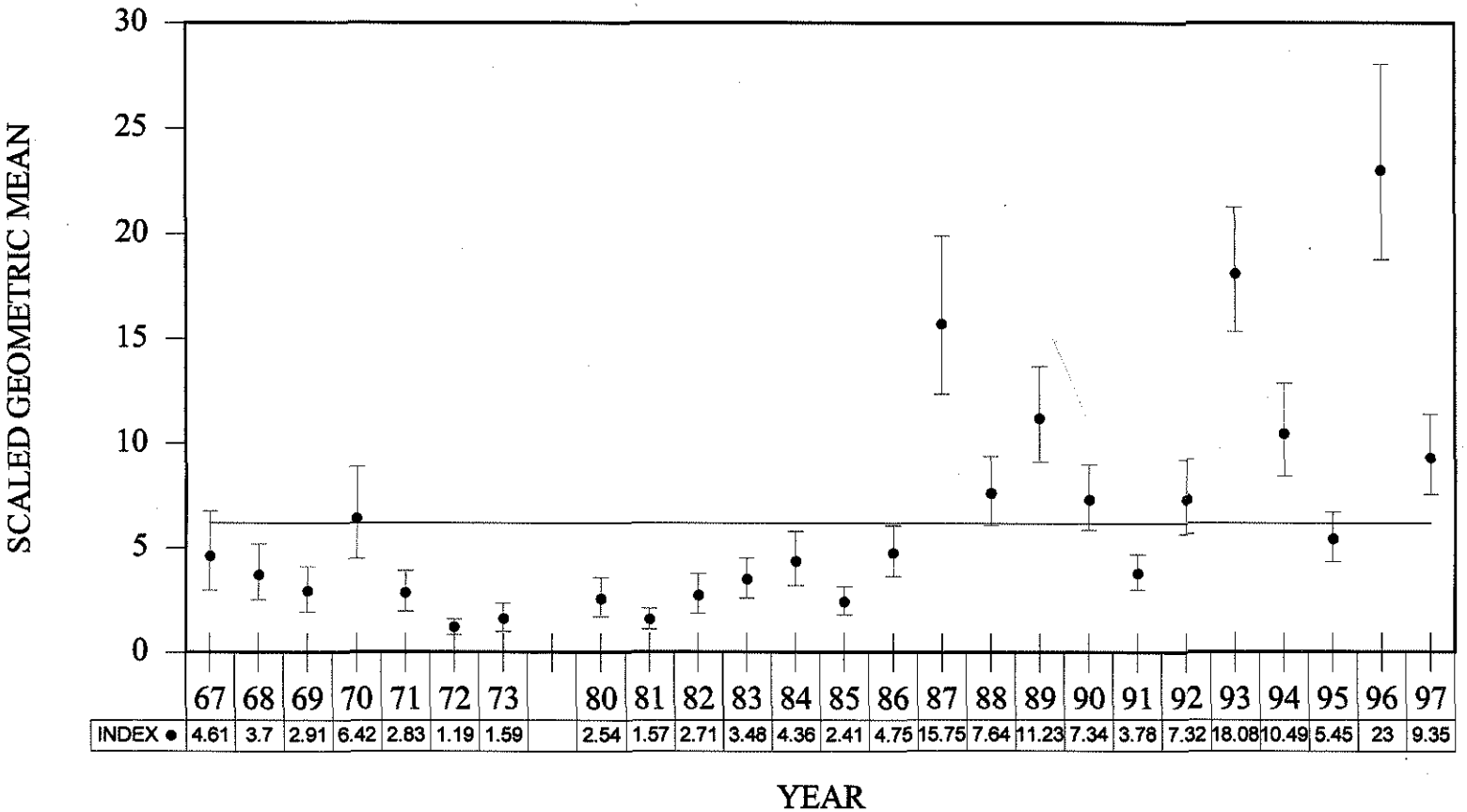

Figure 2. Scaled geometric mean of young-of-the-year striped bass per seine haul in the primary nursery area (index stations) by year.Vertical bars are 95% confidence intervals as estimated by ± 2 standard errors of the mean.

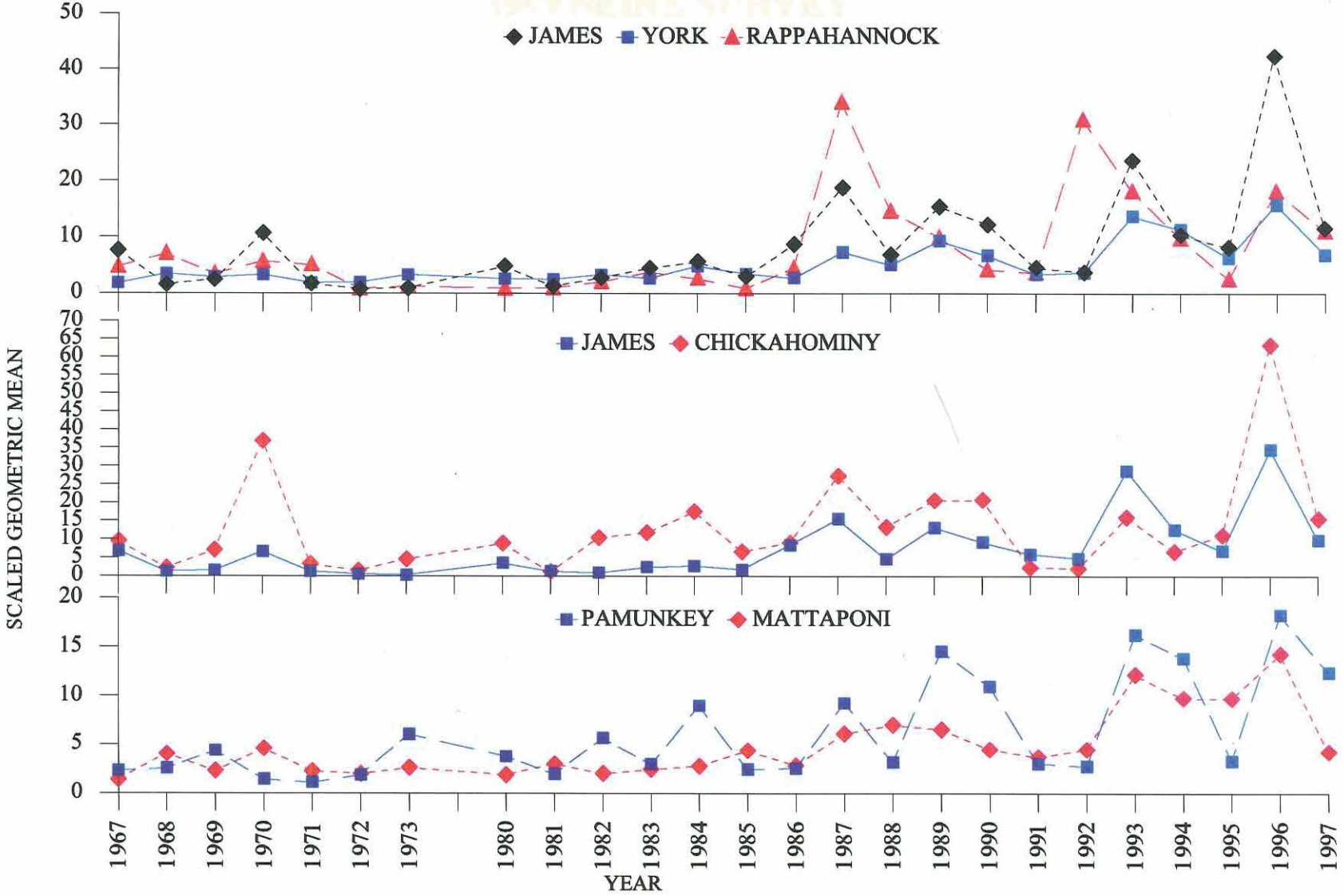

Figure 3. Scaled geometric mean of young-of-the-year striped bass per seine haul in the primary nursery area by drainage and river.

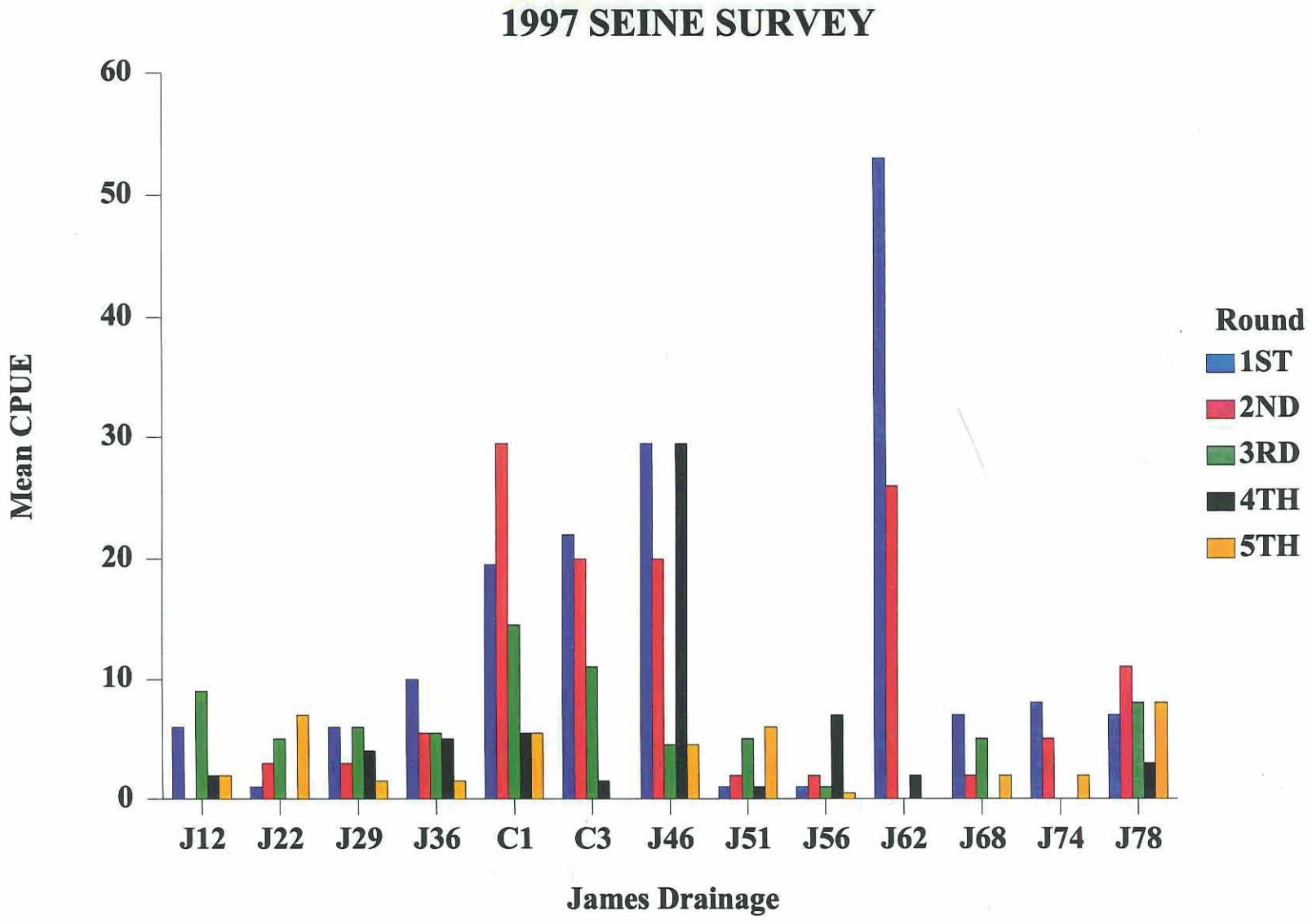

Figure 4. Average catch of young-of-the-year striped bass per seine haul by station in the James drainage.

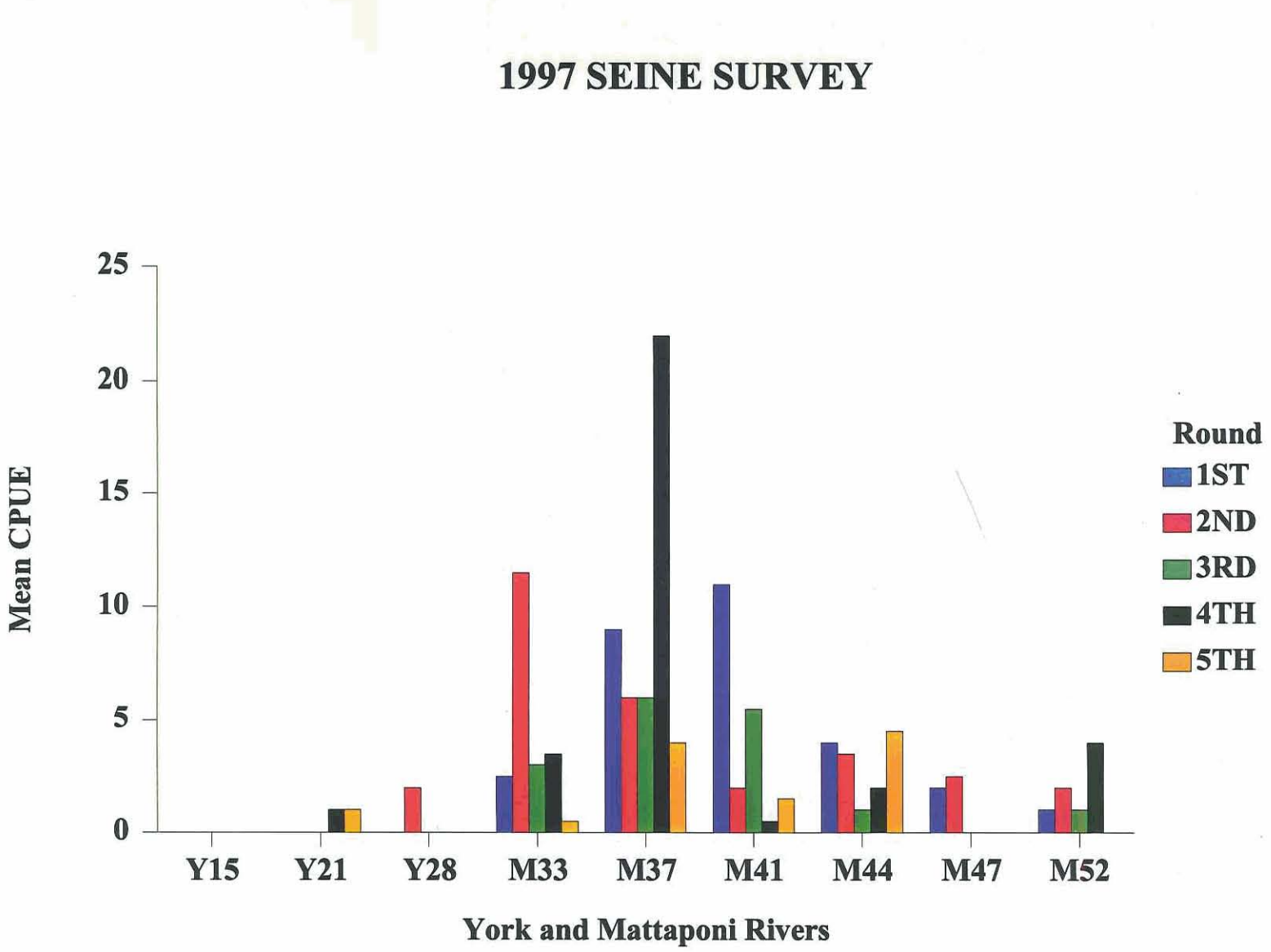

Figure 5. Average catch of young-of-the-year striped bass per seine haul by station in the Mattaponi and York rivers.

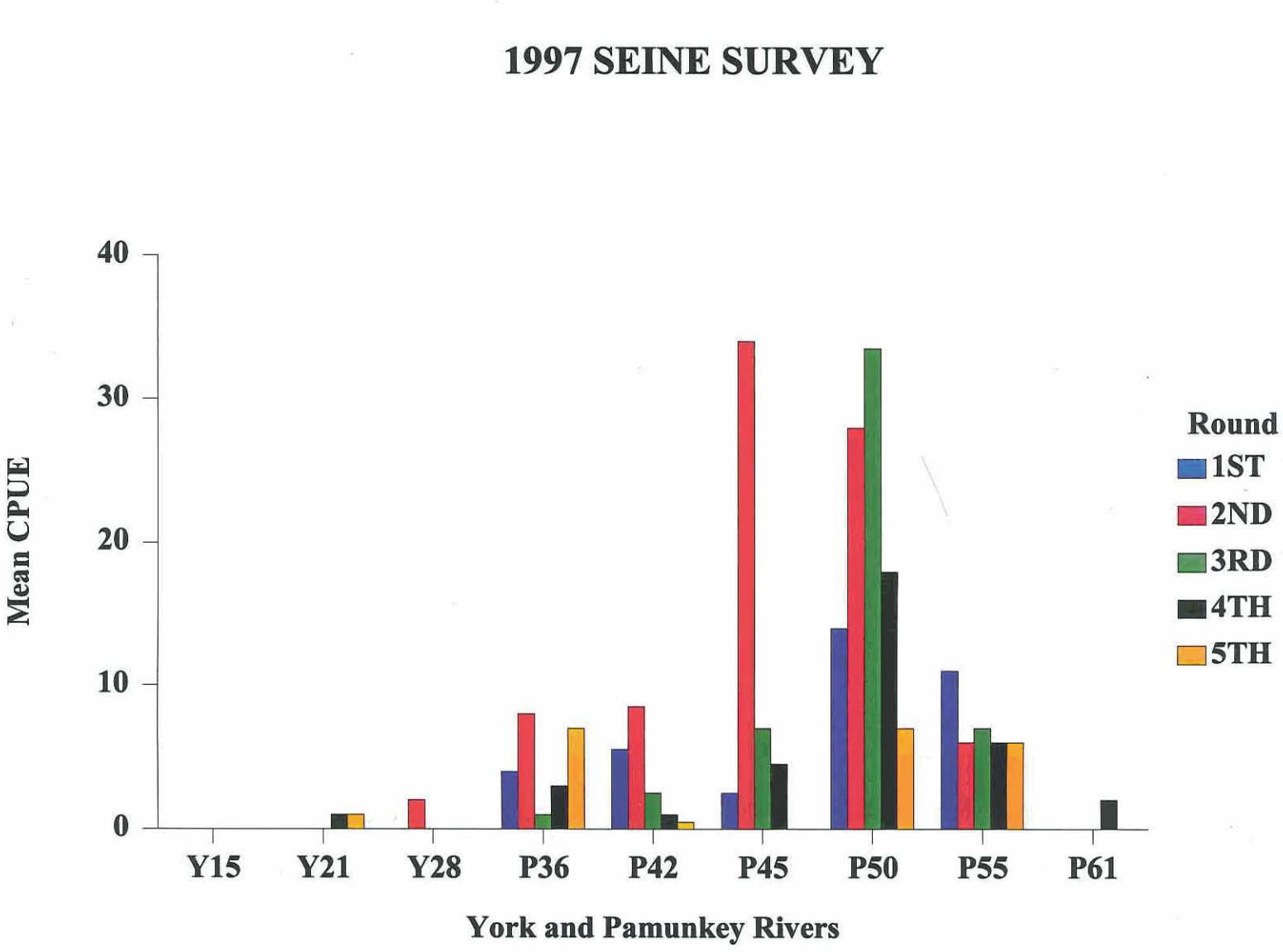

Figure 6. Average catch of young-of-the-year striped bass per seine haul by station in the Pamunkey and York rivers.

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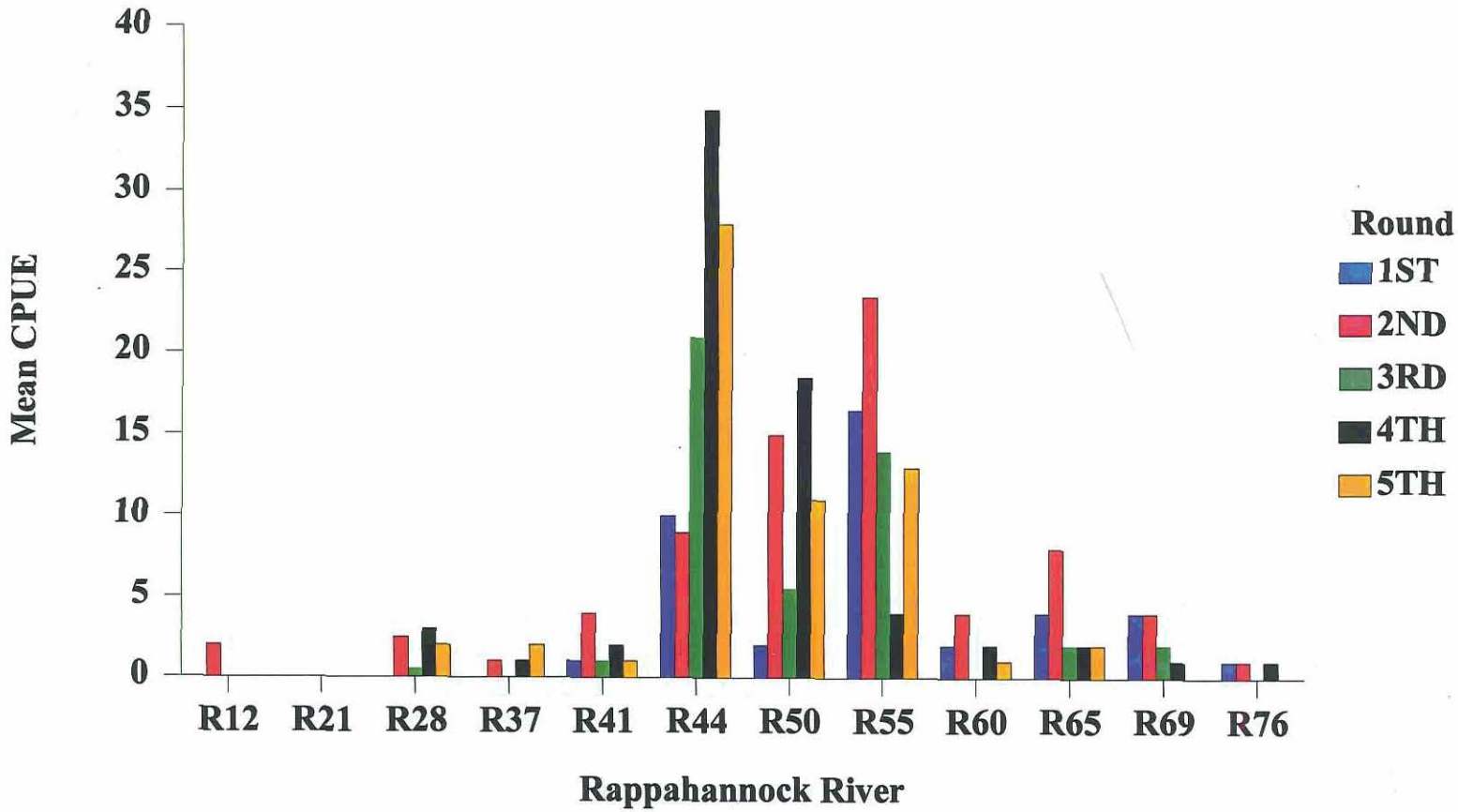
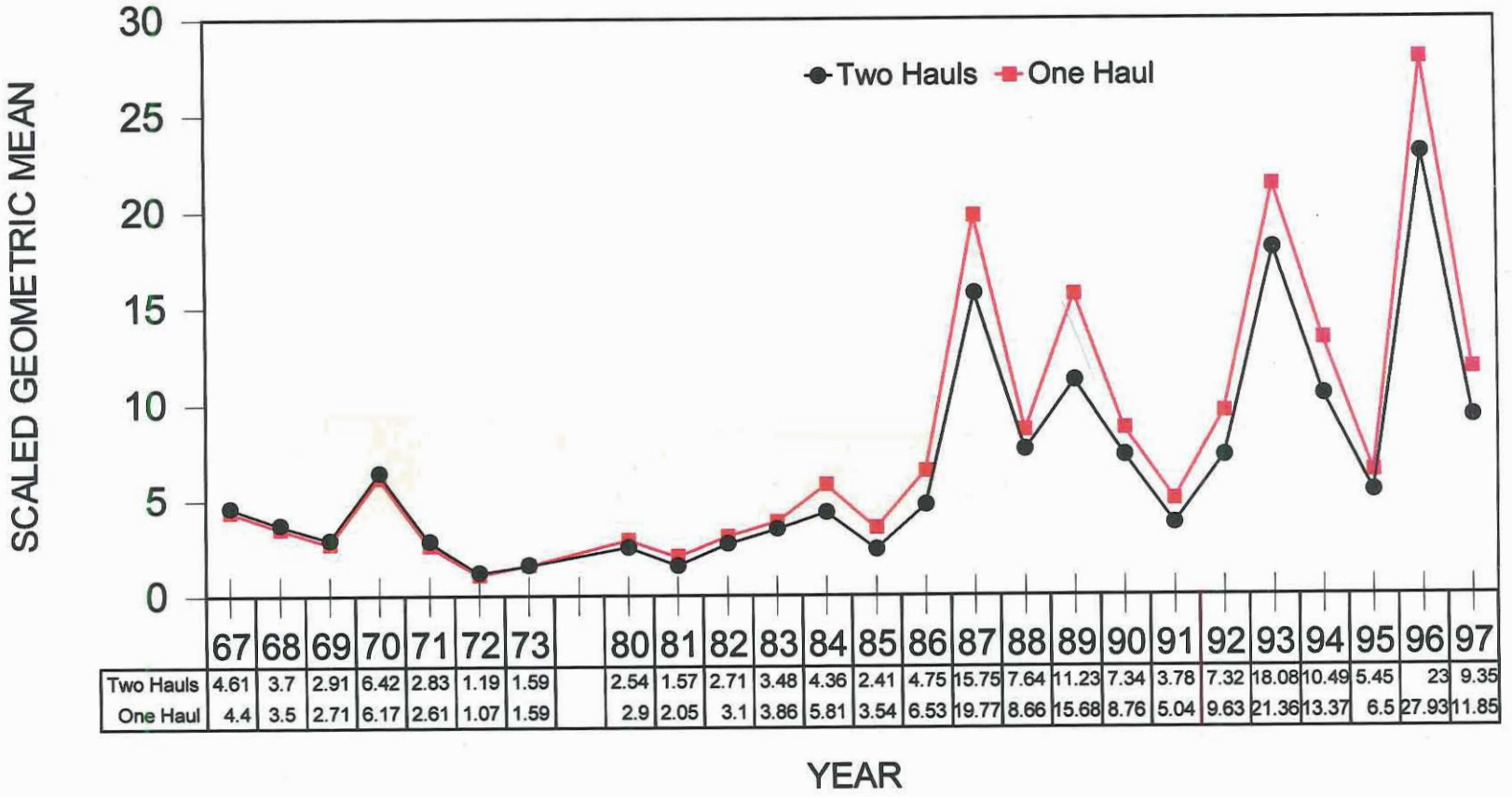


Figure 7. Average catch of young-of-the-year striped bass per seine haul by station in the Rappahannock River.



	67	68	69	70	71	72	73		80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97
Two Hauls	4.61	3.7	2.91	6.42	2.83	1.19	1.59		2.54	1.57	2.71	3.48	4.36	2.41	4.75	15.75	7.64	11.23	7.34	3.78	7.32	18.08	10.49	5.45	23	9.35
One Haul	4.4	3.5	2.71	6.17	2.61	1.07	1.59		2.9	2.05	3.1	3.86	5.81	3.54	6.53	19.77	8.66	15.68	8.76	5.04	9.63	21.36	13.37	6.5	27.93	11.85

Figure 8. Scaled geometric mean of the catch of young-of-the-year striped bass per seine haul in the primary nursery area (index stations) by year and by number of hauls.