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Feasibility of increasing striped bass populations by stocking of underutilized nursery grounds : annual progress report 1970-1971

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ANNUAL PROGRESS REPORT

ANADROMOUS FISH PROJECT

PROJECT TITLE: Feasibility of Increasing Striped Bass Populations by Stocking of Underutilized Nursery Grounds.

PROJECT NO: FA-Virginia - AFS-6-1

PROJECT PERIOD: July 1, 1970 - June 30, 1971

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FEASIBILITY OF INCREASING STRIPED BASS POPULATIONS BY STOCKING OF UNDERUTILIZED NURSERY GROUNDS

(FA-Virginia-AFS-6-1)

INTRODUCTION

Numerous estuaries in the lower Chesapeake Bay region and coastal Virginia possess physical, chemical and biological properties favorable to their use as nursery grounds for striped bass. Many of them, however, are not so utilized because of the absence of associated spawning grounds. This project was designed to investigate the feasibility of stocking such underutilized nursery grounds as a management device, while monitoring population parameters such as age composition, mortality rates and relative abundance of yearclasses.

Objectives of this research are 1) to monitor age composition, mortality rates and relative yearclass strength of striped bass stocks in lower Chesapeake Bay, 2) to select one or more tributaries having suitable nursery grounds for striped bass, but inadequate or unutilized spawning grounds, 3) to experimentally stock a tributary and assess survival and growth of the fish, 4) to refine and adapt existing techniques for rearing striped bass larvae, with an assessment of optimal size for stocking, 5) to experimentally stock additional tributaries, 6) to evaluate stocking in underutilized nursery grounds of Virginia as a management tool and to estimate expected benefits from its implementation.

This report summarizes progress within the above objectives for the first full year of the project, July 1, 1970 — June 30, 1971. Results reported under Objective 1 necessarily include, for meaningful comparison, certain findings obtained from a previous cooperative Anadromous Fish Act project (Grant, 1970); progress within Objectives 4-6 was not anticipated during this first year.

PROGRESS WITHIN OBJECTIVES

Objective 1 - Monitoring of Population Parameters

Age Composition

Non-selective catches

The age composition of resident striped bass populations is estimated from catches of commercial pound and fyke nets. These are considered to non-selectively trap striped bass, i.e. to catch various size-classes of fish in proportion to their relative abundance in the population.

Scale samples and fork lengths are obtained semi-monthly from 50 striped bass within each of the river systems (James, York and Rappahannock rivers), except when pound and fyke nets are not fishing. Such samples were unavailable in the James River during the first six months of 1971. Ages of individual fish are determined from plastic impressions of scale sculpture and entered on data processing cards. The age composition of non-selective catches during the year July 1970-June 1971 is given in Table 1.

Catches were, for the most part, dominated throughout the year by the 1969 yearclass, i.e. Age I striped bass. In past years, exception to the normal dominance of one-year-olds has occurred only where a notably strong yearclass, e.g. the 1966 yearclass (Grant and Joseph, 1969), has continued to dominate catches for two years. The 1967-1969 yearclasses were not exceptionally large ones.

The 1970 yearclass appeared strongly in 2nd quarter 1971 catches, especially in the York River where it numerically dominated sampled catches. This is unusual and is evidence of an exceptionally strong yearclass.

Table 1. Age composition of non-selective commercial striped bass catches in the James, York and Rappahannock rivers, for quarterly periods within July 1970-June 1971.

Quarterly Period	River System	Number of Fish in Yearclass											
		1970	1969	1968	1967	1966	1965	1964	1963	1962	1961	all older	Sample Total
July-Sept.	James	1	98	57	64	12	1	1	-	-	-	1	235
1970	York	-	223	48	2	-	-	-	-	-	-	-	273
	Rapp.	-	123	87	7	10	1	-	-	-	-	-	228
Oct-Dec.	James	-	33	8	6	-	-	-	-	-	-	-	47
1970	York	13	425	65	16	6	-	-	-	-	-	-	525
	Rapp.	8	200	86	4	1	-	1	-	-	-	-	300
Jan.-Mar.	James	(No sample)											0
1971	York	13	82	13	8	1	1	-	-	-	-	3	121
	Rapp.	3	127	64	16	14	1	4	-	-	1	-	230
Apr.-June	James	(No sample)											0
1971	York	145	131	9	12	7	-	2	1	-	-	1	308
	Rapp.	86	149	30	7	14	1	1	1	-	3	1	293
												Total striped bass aged	2560

Table 2 indicates further the strength of the 1970 yearclass. The 13.9% of the total York River sample contributed by the 1970 yearclass compares with a range of 0.3-4.6% contribution by incoming yearclasses during the three previous years. The 9.2% contribution of the 1970 yearclass in Rappahannock catches may be compared with a range of 0.9-2.9% for three previous years (see Grant, 1970). Comparable data are lacking from the James River.

Selective catches

The age composition of certain selective-gear catches is also being monitored. Such sampling is limited to a winter gill-net fishery for striped bass located in the Rappahannock River (Grant, Burrell, and Kriete, 1971) and the sport fishery in the York River.

Gill-net catches are sampled from a single landing on the Rappahannock River that is utilized by four cooperating fishermen. Scales and lengths are obtained from approximately 50 striped bass semi-monthly during the period December-April each winter. The age composition of these catches is given in Table 3. The employment of larger-mesh "shad nets" beginning in February, a seasonal practice, is evident from the age composition of catches. Continued catches of the strong 1966 yearclass were aided by limited use of a recommended 6 in.-mesh gill net, and this yearclass contributed significantly to total landings.

The 1970 yearclass of striped bass was not taken by this fishery, since its size range fell below the sizes of striped bass selected by gill nets. However, the 1970 yearclass should contribute substantially to catches early in the winter of 1971-72, when smaller-mesh "perch nets" are employed.

Table 2. Percent of total year's sample within yearclasses of striped bass caught in non-selective gear, July 1970-June 1971, in the James, York and Rappahannock rivers.

River System	Percent of Sample in Yearclass										All Older	Sample Size
	1970	1969	1968	1967	1966	1965	1964	1963	1962	1961		
James (July-Dec. only)	0.4	46.5	23.0	24.8	4.3	0.4	0.4	0	0	0	0.4	282
York	13.9	70.2	11.0	3.1	1.1	0.1	0.2	0.1	0	0	0.3	1227
Rappahannock	9.2	57.0	25.4	3.2	3.7	0.3	0.6	0.1	0	0.4	0.1	1051

Table 3. Age composition of winter gill-net catches of striped bass, sampled from the Rappahannock River, December 1970-April 1971.

	Number of Fish in Yearclass										
Month	1969	1968	1967	1966	1965	1964	1963	1962	1961	all older	Total
December	31	19	-	-	-	-	-	-	-	-	50
January	66	32	-	2	-	-	-	-	-	-	100
February	3	17	16	14	-	-	-	-	-	-	50
March	20	29	21	20	-	1	2	3	1	3	100
April	4	7	9	9	-	-	-	-	-	-	29
Seasonal Total	124	104	46	45	0	1	2	3	1	3	329
% of Total	37.7	31.6	14.0	13.7	-	0.3	0.6	0.9	0.3	0.9	

The sport fishery for striped bass in the York River extends, for the most part, from April through December. Most of our samples are obtained from the U.S. Navy's Cheatham Annex pier, where concentrations of striped bass result from attraction of bait to pier lights. A summary of the age composition of these catches is given in Table 4. These catches were dominated by the 1969 yearclass. Individuals of the 1970 yearclass first appeared in November 1970, and contributed 12.2% to the total catch for the period July 1970-June 1971. Contributions by incoming yearclasses to total York River sport catches in three previous years were only 2.4%, 1.6% and 3.9% for the 1967, 1968 and 1969 yearclasses, respectively.

Striped Bass Tagging-Winter 1970-1971

Tag returns are being used to estimate the proportion of the striped bass catch taken by each of the various fishing-gear types employed in Virginia and for estimates of mortality. Internal anchor tags (Dell, 1968) are applied each winter when local stocks are concentrated in river channels and subject to capture by bottom trawling. The dates, location, gear of capture, and numbers of striped bass tagged during the past year are listed in Table 5. The use of a 30' trawl in the Rappahannock River was finally abandoned in February, whereas considerable success resulted from its employment in the York River. Large numbers of 1969 yearclass fish were caught in the latter river, while trawl catches in the Rappahannock were completely dominated by the 1970 yearclass, most of which were less than 200 mm fork length, our lower limit for tagging. Successful tagging of striped bass in the Rappahannock River had to await the start of commercial pound net fishing in early March. The size and age of striped bass tagged in the York River is given in Table 6. Comparable data for the Rappahannock releases may be found in Table 7.

Table 4. Age composition of striped bass sport catches in the York River, July 1970-June 1971.

	Number of Fish in Yearclass				
Month	1970	1969	1968	1967	Total
July	-	15	6	2	23
August	-	41	10	1	52
September	-	87	7	-	94
October	-	119	8	1	128
November	8	81	11	1	101
December	23	59	6	-	88
.					
.					
.					
March	-	2	-	-	2
April	6	7	1	-	14
May	8	58	6	-	72
June	38	66	5	-	109
Total	83	535	60	5	683
% Total	12.2	78.3	8.8	0.7	

Table 5. Releases of tagged striped bass in Virginia rivers, winter 1970-71.

Date		Number of Fish Tagged	Fishing Gear Employed
17 Dec 1970-22 Jan 1971	York	1785	30' Trawl
12 Jan 1971-18 Feb 1971	Rappahannock	52	30' Trawl
9 Mar 1971-24 Apr 1971	Rappahannock	757	Pound Net
	Total	2594	

Table 6. Fork length and age distribution of striped bass tagged in the York River, winter 1970-1971.

Midpoint of 15 mm Size-class (fork length)	Yearclass 1970	1969	1968	1967	...	1963	Total
200	103	40					143
215	72	98					170
230	24	152					176
245	4	187	1				192
260	1	189					190
275		186	3				189
290		186	2				188
305		177	6				183
320		144	6				150
335		72	10				82
350		34	9				43
365		18	14				32
380		4	7				11
395		5	5				10
410			5	2			7
425			5	2			7
440			4	2			6
455							0
470				1			1
485			1	1			2
500			1				1
⋮							⋮
770						1	1
length unknown		1					1
TOTAL	204	1493	79	8	...	1	1785

Table 7. Fork length and age distribution of striped bass tagged in the Rappahannock River, winter 1971.

Midpoint of 15 mm Size-class (fork length)	Yearclass					
	1970	1969	1968	1967	1966	Total
200	82	6				88
215	83	9				92
230	20	18				38
245	15	36				51
260	3	52				55
275	1	56	2			59
290		55				55
305		49	3			52
320		45	7			52
335		57	18			75
350		30	15			45
365		13	12			25
380		4	22			26
395		2	20	1		23
410			14	1		15
425			9			9
440			9	4		13
455			3	6		9
470			1	2		3
485				5	2	7
500			1	5	5	11
515				1	2	3
530					1	1
545						0
560					1	1
.						
.						
.						
590				1		1
TOTAL	204	432	136	26	11	809

A total of 2594 striped bass were tagged, bringing the four-year total to 12,890 tagged fish released in Virginia rivers. Nearly 75% of those tagged this year were members of the 1969 yearclass.

Estimate of Proportional Catches by Gear-type

The proportion of total landings accounted for by each type of commercial fishing gear and by the sport catch is estimated from tag returns. Earlier results (Grant, 1970) showed significant differences between river systems and years. The data utilized for this estimate are limited to returns occurring within the river of release. Fish recaptured after migration to another body of water are excluded since our interest here is in a particular river system's fishery.

The same type of tag has now been used over three successive winter periods. Complete tag return data are available for two years; winter 1970-1971 tags have not yet been at large for a full year. Results are given in Table 8. Pound nets have consistently accounted for about one-half of total striped bass landings in the Rappahannock River; sport catches take between 10 and 20 percent of the catch. In the York River, pound nets are of minor importance. Most of the catch is accounted for by gill-nets and the sport catch, the latter predominating. Results for last winter's tagging, as yet incomplete, are biased by seasonal use of fishing gear.

Mortality Estimates from Tagging Data

Our earlier estimates of mortality rates (Grant 1969, 1970) were limited to use of the Jackson indirect method (Jackson, 1939), and to

Table 8. Share of returns (in percent) from the various types of fishing gear. Returns lacking information, those from striped bass that migrated out of the river of release, and those at large more than one year are excluded.

	Winter 1969			Winter 1970		Winter 1970-1971*	
	James	York	Rappahannock	York	Rappahannock	York	Rappahannock
Pound nets	1.8	10.1	45.2	6.7	45.7	-	80.4
Gill nets	10.9	36.7	9.5	21.4	33.3	79.7	13.4
Haul seines	65.5	6.3	26.2	4.5	6.8	5.8	0.6
Peeler traps	-	-	1.2	-	0.9	-	-
Fyke nets	3.6	1.3	-	1.1	-	3.5	-
Sport catch	18.2	45.6	17.9	66.3	13.2	11.0	5.6
Total returns	55	79	168	89	234	172	179

* Year at large not complete;
includes returns through June 30, 1971.

a crude estimate of annual fishing mortality. The Jackson method assumes constant recruitment, an assumption that is not met by striped bass populations, so was employed only as a rough interim estimate while awaiting the accumulation of two full years of comparable tag-and-recovery data. The winter 1969 tagging period is the starting point for our present estimates of total annual mortality (a). Calculations for those tag-and-recovery data that were adequate, follow Ricker (1958:128);

$$\hat{s}_1 = \frac{R_{12}M_2}{M_1(R_{22}+1)}$$

where $\hat{s}_1$, is the survival rate estimate during year 1, in this case the year from the 1969 marking period to the 1970 marking period (total annual mortality (a) = 1-s); M_1 and M_2 are the numbers of fish marked at the start of the first and second year, respectively; R_{12} is the number of recaptures of first-year marks in the second year, and R_{22} is the number of recaptures of second year marks in the second year. Available estimates are given in Table 9, along with estimates of variance:

$$V(\hat{s}_1) = \hat{s}_1^2 - \frac{M_2^2 R_{12}(R_{12}-1)}{M_1^2(R_{22}+1)(R_{22}+2)}$$

These estimates of survival are, essentially, for the calendar year 1969. The yearclasses 1966 and 1967 entered age groups III and II, respectively, in the spring of 1969, so were fully recruited to the local fisheries. However, the indicated mortality rates of 96-99% are much higher than expected. There is no accounting for tag loss in the method, however, and this could have been significant since the estimate depends heavily on second year returns of the first year tags. Another factor contributing to low estimates of survival could have been migration of these yearclasses to other areas from which tag recovery is less likely.

Table 9. Estimates of survival within yearclasses of striped bass from the York and Rappahannock rivers, based on 1969 and 1970 tag-and-recapture data and using Ricker's (1958) method.

Yearclass	River	Estimated Survival Rate ($\hat{S}_1$)	Variance ($V(\hat{S}_1)$)
1963	York	0.33333	*
1966	York	0.03475	0.00035
1966	Rappahannock	0.01720	*
1967	York	0.01928	0.00014
1967	Rappahannock	0.01090	0.00012

* no variance estimate since $R_{12} = 0$ or 1

Estimates of annual fishing mortality for the yearclasses 1966 and 1967 during the year 1969 were as follows (Grant, 1970):

	1966	1967
York River	0.165	0.152
Rappahannock River	0.362	0.188

This component of total annual mortality, although variable, does not offer any explanation for the 96-99% rate calculated above.

A second puzzling aspect of new estimates of mortality (Table 9) is the direction of change in rates with age of striped bass. Past results have shown that the older the striped bass, the more likely its capture in local fisheries; highest fishing mortality occurred among oldest fish. Data in Table 9, although limited, show the opposite effect, with the youngest yearclass estimated to have the lowest survival (or highest mortality).

Relative Abundance of Yearclasses

The relative strength of individual yearclasses of striped bass is being monitored continually. Estimates of relative abundance are obtained from three sources: 1) a minnow seine survey of young-of-the-year striped bass in the James, York and Rappahannock rivers conducted July-October of each year, 2) young fish trawl surveys of these rivers during winter months and 3) commercial sampling during the initial period of a yearclass' entry into the fishery.

Minnow Seine Surveys

Methods described in Grant (1970) have been continued and the results for July-October 1970 can now be added to those from 1967-1969. Indices of abundance are derived from total catch of striped bass per

total effort, where a unit of effort is one standard seine haul and catch is limited to young-of-the-year fish.

Indices for 1970 were 5.81 (James River), 2.17 (York River) and 5.07 (Rappahannock River). Except for the York River index, these are the highest values obtained in four years (Fig. 1) and indicate an exceptional 1970 yearclass hatch. The York River index of 2.17 was exceeded by the 1967 estimate from that river. The obvious strength of the 1970 yearclass is most interesting in that it matches a peak in the six-year cycle of Koo (1970).

Young Fish Trawl Surveys

Striped bass are most vulnerable to capture by trawl during winter months when cold waters force them into river channels. Catch-per-unit-effort data from trawl catches are used as a second estimate of the strength of in-coming yearclasses.

Data are now available for the five yearclasses 1966-1970 and are included in Fig. 2. Indices for the 1970 yearclass are 42.18 (James River), 221.75 (York River) and 446.80 (Rappahannock River). All are two to four times greater than the best previous years of record within river systems, including the 1966 yearclass which has been documented as a strong yearclass (Grant and Joseph, 1969).

Entry into Commercial Fishery

The final index of a yearclass' strength is obtained from its appearance in non-selective commercial catches during the summer of the calendar year following its hatch. Data are available for the summers 1967-1970, thus providing information on yearclasses 1966-1969. Results in this case are expressed as percentage of sampled catch (Fig. 3).

The 1969 yearclass contributed the following percentages to striped bass catches in the summer of 1970: James River-41.7%, York River-81.7%, and Rappahannock River-53.9%.

Correlation of the Three Indices

Evaluation of the three separate methods for estimating relative yearclass strength will require several years' data. Each index from each river provides a point estimate that may or may not be correlated with other point estimates. Calculated correlation coefficients for paired observations are given in Table 10. Only two of these are significant: 1) a correlation coefficient of 0.968($n=4$, $p<.05$) for minnow seine and winter trawl indices from the Rappahannock River, and 2) a coefficient of 0.803($n=12$, $p<.01$) for winter trawl and summer non-selective catches from the combined rivers.

Table 10. Correlation coefficients of all available paired indices in evaluating yearclass strength. Each index provides a point estimate for one yearclass in a given river.

Paired Indices		River System: James	York	Rappahannock	Total
Minnow seine --	r	0.936	0.175	0.968*	0.413
Winter trawl	(N)	(4)	(4)	(4)	(12)
Winter trawl --	r	0.427	0.535	0.824	0.803**
Summer non-sel.	(N)	(4)	(4)	(4)	(12)
Minnow seine --	r	0.163	-0.814	0.844	-0.201
Summer non-sel.	(N)	(3)	(3)	(3)	(9)

* $p < .05$

** $p < .01$

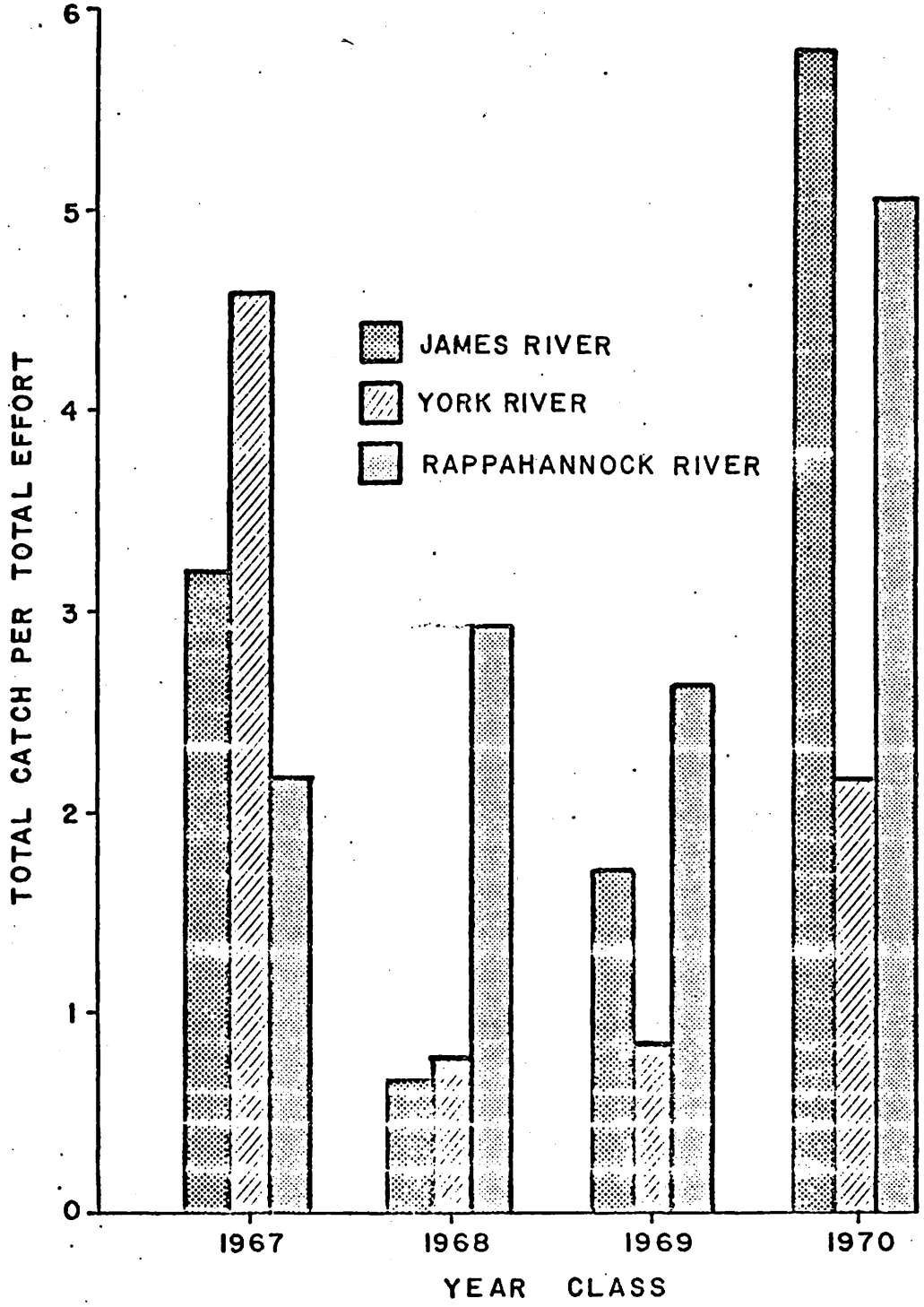

Fig. 1. Catch per minnow seine haul of 1967-1970 young-of-the-year striped bass in the James, York and Rappahannock rivers. Based on semi-monthly surveys, July-October.

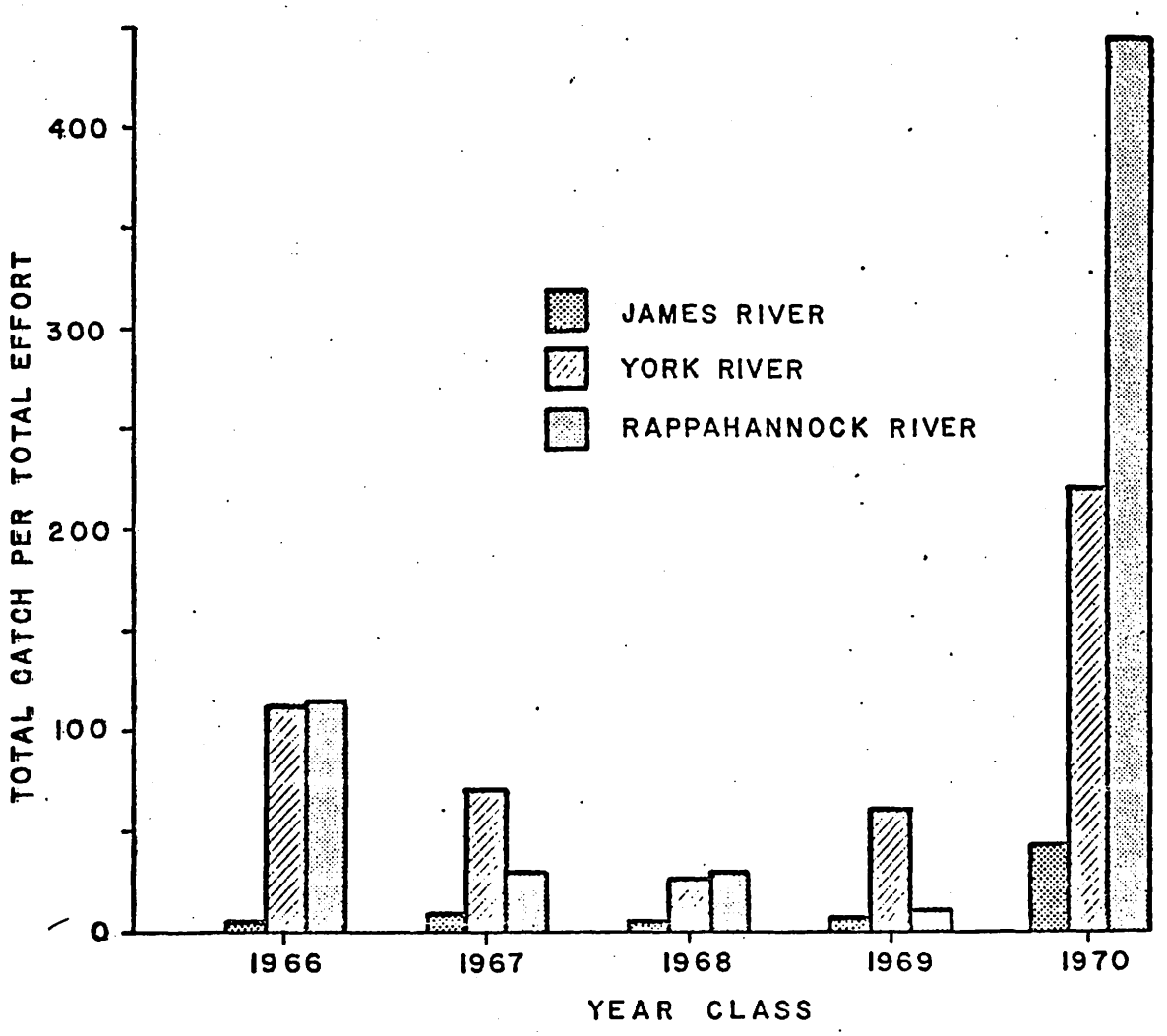

Fig. 2. Catch per trawl hour of five striped bass year-classes in the James, York and Rappahannock rivers. Based on 30-ft semi-balloon trawl catches during months (Jan-Mar) of calendar year following hatch.

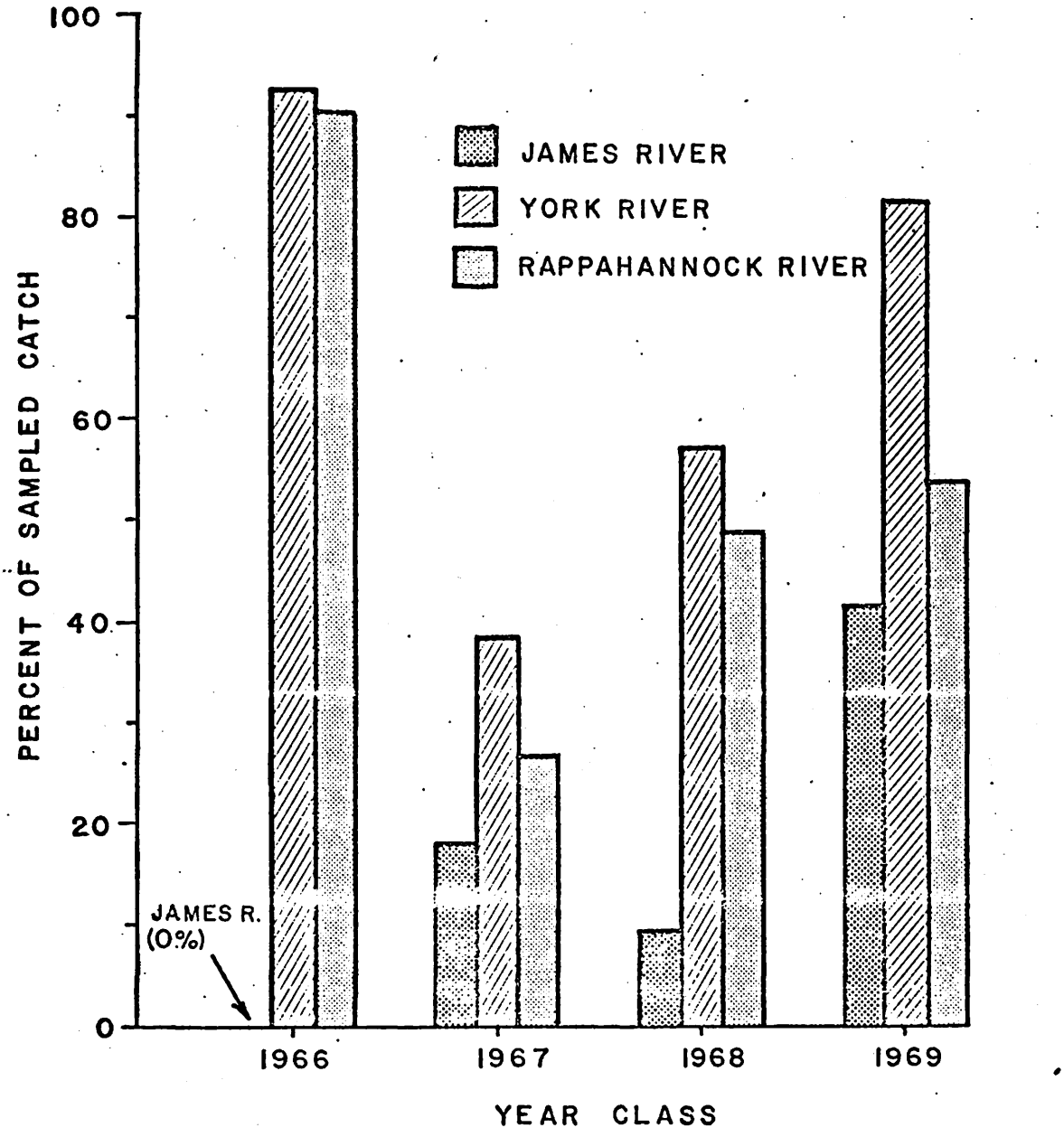

Fig. 3. Relative abundance of the 1966-1969 year-classes of striped bass in three Virginia rivers, expressed as percent of sampled non-selective catches during the summer months (July-September) of calendar year following hatch.

Objective 2 - Selection of Tributary to be Stocked.

Assessment of the Piankatank River and the Mobjack Bay system as possible stocking sites for striped bass was undertaken during the 1970-71 project year. Evaluation of each area was based upon three environmental aspects: hydrographic data, fish fauna, and availability of forage organisms other than fishes. Allocation of stations was a function of the length and relative size of a given area and the expected variation in parameters monitored (Figs. 4,5). During the spring additional sampling was conducted to determine the upper limit of saltwater intrusion, the presence or absence of migrating adult striped bass, and the presence or absence of striped bass eggs or larvae in the streams.

Estuarine systems may be arbitrarily classed according to their salinity regimes. A system ranging from 0 to 5 o/oo salinity is called oligohaline while a system ranging from 5 to 18 o/oo is termed mesohaline. Estuaries having 18-30 o/oo salinity are called polyhaline and those over 30 o/oo are termed marine. This classification aids observers in relating estuaries of similar salinity regimes though geographically separate.

The transition zone from freshwater to saltwater is of primary concern when considering the distribution of euryhaline and anadromous fishes. It was of particular concern to us as defining the lowest point at which striped bass could be stocked. Young fish would have to be stocked well above the transition zone to allow

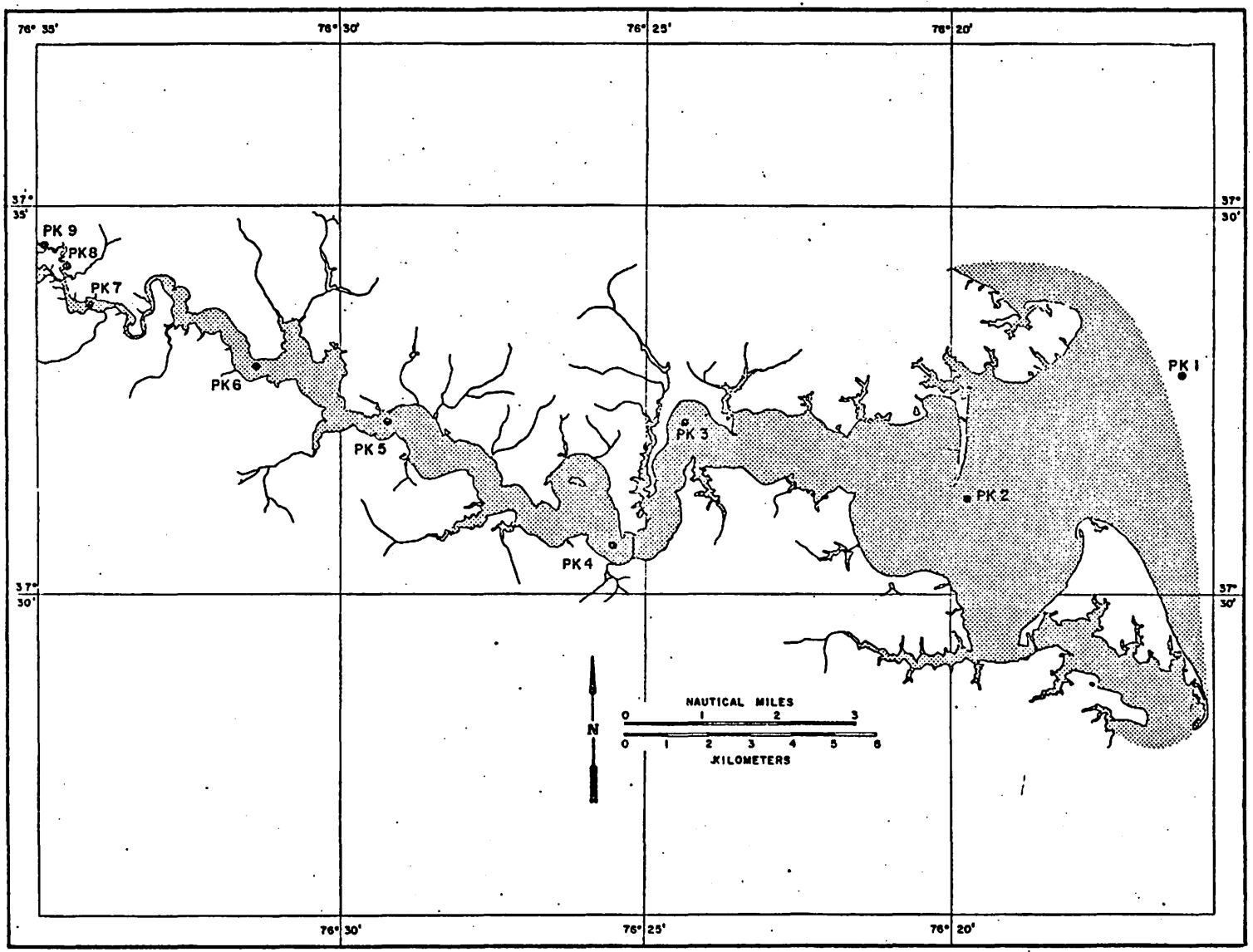

Fig. 4. Station locations within the Piankatank River, 1970-71.

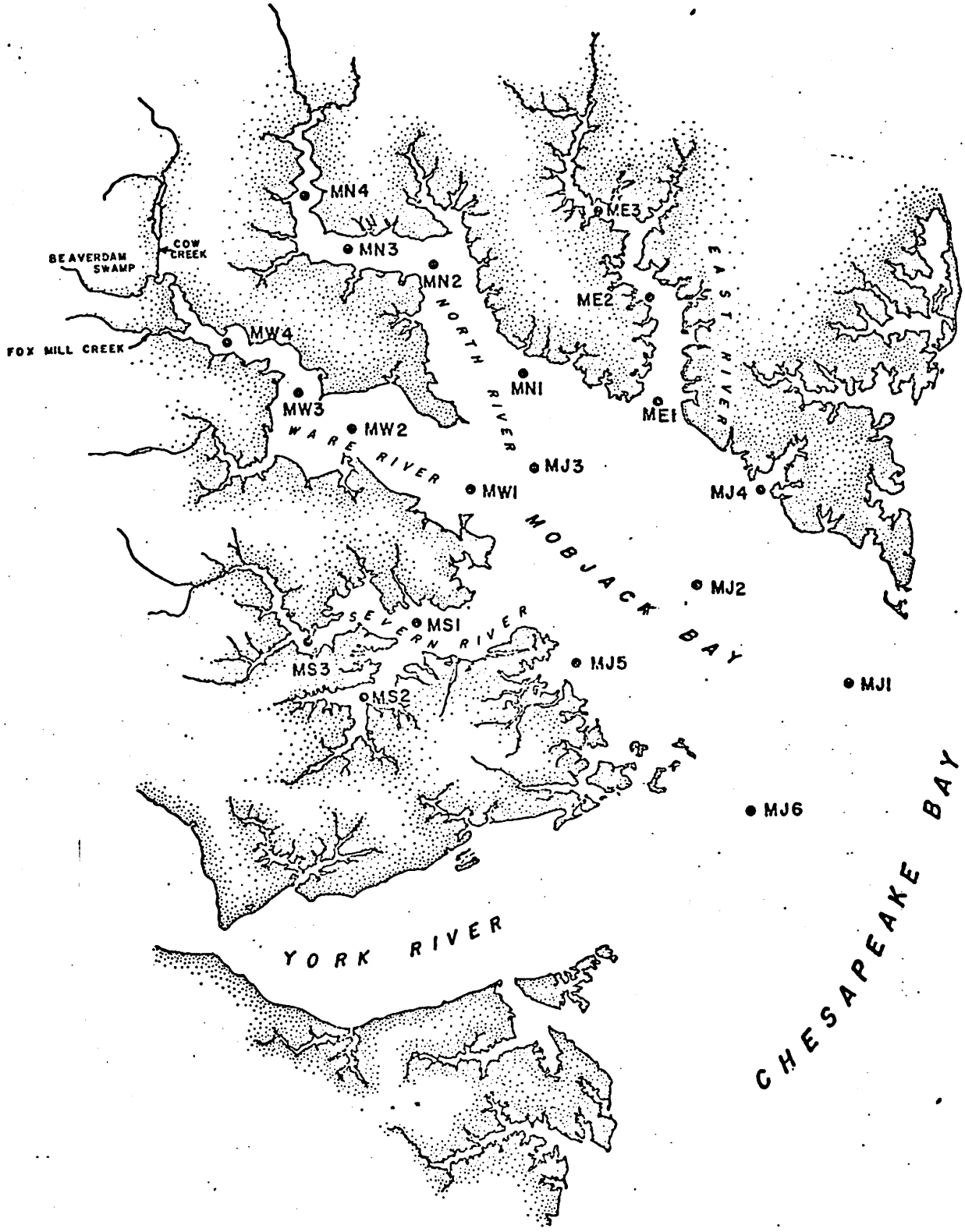

Fig. 5. Station locations within the Mobjack Bay system, 1970-71.

growth and development prior to movement into salt water as juveniles. For the purposes of this phase of the project the freshwater zone was defined as water having a salinity less than 1 o/oo.

Piankatank River

This river is situated between the Rappahannock River and Mobjack Bay on the western shore of Chesapeake Bay. It is characterized as a rather shallow estuary fed by swamp drainage. The primary tributary is Dragon Run which receives agricultural and timberland runoff. Flow varies depending primarily upon freshwater runoff. The waters are darkened by the tannins, etc. from the swamp.

Hydrographic Factors:

An estuary is a dynamic system characterized by fluctuating salinity, temperature, dissolved oxygen, and tidal flow. Monthly sampling was conducted from the project's 18' outboard and R. V. Pathfinder.

Stations within the Piankatank River fall into the oligo-meso-haline class. Salinities fluctuated between stations and seasonally at a given station (Table 11). Freshwater runoff is reflected in both the surface and bottom salinity and was most evident at PK-7 (Surface) range 13.2 to 0.14 o/oo and bottom range 13.37 to 0.09 o/oo). Ranges at stations lower in the river were of lesser magnitude but similar in monthly trend. Salinities above 5 o/oo extend to PK-7 from July through November; 5 o/oo occurred at PK-6 from January through May while the transition zone (1 o/oo or less) was between PK-6 and PK-7. Young striped bass would have to be stocked well above this point to allow growth before movement into saltwater as juveniles. Early exposure to saltwater is expected to cause excessive mortality, though juveniles and adults can make an abrupt shift from freshwater to saltwater (Talbot, 1966). Special stations (PK-8 and PK-9)

Table 11. Hydrographic data for Piankatank River stations July 1970 to May 1971.

		PK1					
		Salinity		D. O.		Temperature	
	Month	Surface	Bottom	Surface	Bottom	Surface	Bottom
1970	July	17.04	16.96	6.5	6.3	25.2	25.5
	August	-	-	-	-	-	-
	September	18.95	19.41	6.4	3.9	25.5	25.9
	October	-	-	-	-	-	-
	November	19.50	-	8.3	8.2	14.5	14.3
	December	-	-	-	-	-	-
1971	January	15.22	15.47	12.0	12.0	2.9	2.6
	February	-	-	-	-	-	-
	March	13.96	14.34	11.1	11.2	5.9	6.5
	April	-	-	-	-	-	-
	May	13.01	13.06	9.4	9.2	13.7	13.3
		PK2					
1970	July	16.14	17.06	6.3	3.1	26.1	25.9
	August	-	-	-	-	-	-
	September	18.33	18.79	7.3	4.4	26.8	26.2
	October	-	-	-	-	-	-
	November	19.23	19.42	8.4	8.3	14.6	14.1
	December	-	-	-	-	-	-
1971	January	15.68	16.66	11.5	11.3	2.9	2.6
	February	-	-	-	-	-	-
	March	14.18	14.47	11.4	11.5	6.5	6.7
	April	-	-	-	-	-	-
	May	12.89	13.04	9.1	8.8	14.7	-

Table 11. (continued).

PK3

	Month	Salinity Surface	Salinity Bottom	D. O. Surface	D. O. Bottom	Temperature Surface	Temperature Bottom
1970	July	14.97	16.90	7.3	0.8	26.8	26.1
	August	-	-	-	-	-	-
	September	17.65	18.35	6.8	4.4	27.1	26.6
	October	-	-	-	-	-	-
	November	18.70	18.83	8.1	8.4	15.1	15.0
	December	-	-	-	-	-	-
1971	January	15.88	16.58	11.5	10.9	3.2	3.8
	February	-	-	-	-	-	-
	March	12.98	14.14	11.2	10.9	7.8	7.5
	April	-	-	-	-	-	-
	May	11.82	12.72	8.7	8.5	15.9	15.0

PK4

1970	July	15.25	15.42	5.6	4.5	27.2	26.8
	August	-	-	-	-	-	-
	September	16.78	17.40	6.4	4.2	25.7	25.2
	October	-	-	-	-	-	-
	November	18.51	18.51	8.2	8.1	16.6	16.5
	December	-	-	-	-	-	-
1971	January	14.53	15.75	10.5	11.0	4.7	4.6
	February	-	-	-	-	-	-
	March	11.82	13.71	8.6	8.4	7.8	7.1
	April	-	-	-	-	-	-
	May	10.27	11.82	5.8	5.6	20.2	19.8

Table 11. (continued).

PK5

	Month	Salinity		D. O.		Temperature	
		Surface	Bottom	Surface	Bottom	Surface	Bottom
1970	July	13.03	13.93	5.1	5.1	28.4	27.6
	August	-	-	-	-	-	-
	September	15.07	15.03	6.7	7.5	25.6	25.0
	October	-	-	-	-	-	-
	November	17.25	17.49	8.4	9.2	16.4	16.5
	December	-	-	-	-	-	-
1971	January	10.40	14.54	10.7	10.4	5.2	4.9
	February	-	-	-	-	-	-
	March	9.74	10.97	10.9	10.9	8.4	8.0
	April	-	-	-	-	-	-
	May	6.72	9.37	7.6	7.0	20.8	21.0

PK6

1970	July	12.07	12.06	5.2	5.1	28.5	28.5
	August	-	-	-	-	-	-
	September	12.27	12.35	4.6	4.6	25.0	24.4
	October	-	-	-	-	-	-
	November	16.22	16.39	8.4	8.2	16.9	17.0
	December	-	-	-	-	-	-
1971	January	3.48	7.60	10.5	11.0	5.1	5.3
	February	-	-	-	-	-	-
	March	6.93	7.44	11.5	11.3	8.7	8.5
	April	-	-	-	-	-	-
	May	2.04	2.50	6.8	6.9	21.4	21.4

Table 11. (continued).

PK7

	Month	Salinity Surface	Salinity Bottom	D. O. Surface	D. O. Bottom	Temperature Surface	Temperature Bottom
1970	July	4.37	5.13	6.4	6.1	29.7	28.9
	August	-	-	-	-	-	-
	September	7.49	7.61	4.8	4.3	24.5	24.5
	October	-	-	-	-	-	-
	November	13.21	13.37	6.9	7.2	16.5	16.5
	December	-	-	-	-	-	-
1971	January	0.23	0.19	10.7	10.8	4.7	4.6
	February	-	-	-	-	-	-
	March	0.20	0.11	11.6	11.5	8.5	8.3
	April	-	-	-	-	-	-
	May	0.14	0.09	5.4	5.6	20.3	19.5
			PK8				
1971	May	0.08	0.06	5.6	5.9	18.5	20.4
			PK9				
1971	May	0.06	0.05	6.2	5.5	16.9	18.6

were sampled in May and found to be satisfactory in D.O. and salinity for young striped bass.

Temperatures at the surface and bottom at each station (Table 11). reflected no stratification. The trend of cooler water at the lower station and warmer water as one proceeds upstream reflects the lag effect with depth and surface area to spring warming and winter cooling. Surface water ranged from 29.7° C at PK-7 in July to 2.9° C at PK-1 in January. Bottom water temperature ranged from 28.9° C to 2.6°C at the same stations and dates. The maximum temperature range in the river for a given sampling period occurred in May (13.7°C to 20.3° C).

Dissolved oxygen values generally exceeded the 5 ppm suggested minimum for maintenance of warm water fish life (Doudoroff and Shumway, 1967) except the PK-3 bottom sample in July (Table 11). Samples were generally taken near the maxima period. Depressed D.O. values at PK-2 and PK-3 are probably due to a small pocket of salt water, suggested by surface and bottom salinities. Stratification of this type may result in a depression of D.O. within its mass since circulation is impeded by density differences between strata.

Fish Fauna

The fish fauna at each station was sampled every other month from July 1970 through May 1971. Stations PK-1 through PK-3 were sampled with an unlined 30 foot semiballoon trawl towed 7 1/2 minutes by the R/V Pathfinder. Stations PK-4 through PK-7 were sampled with a lined 16 foot semiballoon trawl pulled by the project's 18-ft outboard. Water depth and navigability of the upper reaches necessitated the switch to smaller gear and shallow draft vessel at stations PK-4 through PK-7. Total number of each species and fork lengths of up to 25 specimens per species were recorded for each station.

General seasonal variation for all stations pooled showed a peak numerical abundance of fishes in September (Table 12). Over winter (January and March) a decline occurred in the saltwater fauna with persistence of the resident species and occurrence of winter and early spring migrants such as winter flounder and alosids. A total of 3417 specimens including 41 species was taken during the year. Twenty-one species were obtained in the July trawls. By January the number of species taken had declined to 6. In May the species complement had climbed to 13. Thus the numeric and species abundance relect a seasonal pattern of species specific migrations (Table 13). The bay anchovy, Anchoa mitchilli, greatly exceeded the hogchoker, Trinectes maculatus, a resident species. Striped bass were taken in July (25 fish) and November (15 fish) at stations PK-3, 5, 6, and 7. Length frequencies place these fish in the 1970 year class (Table 14). Forage species for striped bass fluctuate with season. Winter forage appears to be scarce. Trawl surveys by project personnel have shown downstream movement of striped bass over winter.

Table 12. Species list and abundance for all trawl stations in the Piankatank River, 1970-71.

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Alosa aestivalis	5				17		22
Alosa pseudoharengus	4				14		18
Alosa sapidissima					1		1
Anchoa hepsetus		1					1
Anchoa mitchilli	54	866	34	1	158	5	1118
Anguilla rostrata						3	3
Apeltes quadracus					1		1
Bairdiella chrysura	26	343	215				584
Centropristis striatus	1						1
Chasmodes bosquianus			2				2
Cynoscion nebulosus			1				1
Cynoscion regalis	160	100	3				263
Etropus microstomus			1				1
Gobiesox strumosus			1			1	2
Gobiosoma bosci						2	2
Hippocampus hudsonius			1				1
Hypsoblennius hentzi			1				1
Ictalurus catus	1					1	2
Leiostomus xanthurus	9	26					35
Lepomis gibbosus				1		1	2
Lepomis macrochirus	1			1	2		4
Menidia menidia	146			3			149
Menticirrhus americanus		45	16				61
Menticirrhus saxatilus	1						1
Microgobius thalassinus						1	1
Micropogon undulatus		68	59				127
Morone americana	13	2				2	17
Morone saxatilus	25		15				40
Notropis hudsonius	24	2			2		28
Opsanus tau	4		2			2	8
Paralichthys dentatus		1	1			1	3
Peprilus alepidotus		5					5
Perca flavescens	1			2			3
Pomatomus saltatrix		1					1
Pseudopleuronectes americanus					2		2
Prionotus carolinus	7						7
Prionotus evolans	1						1
Scophthalmus aquosus	1						1
Sphoeroides maculatus	6	240				1	247
Trinectes maculatus	45	231	130	4	5	224	639
Urophycis regius						11	11
Total Fish	535	1931	482	12	202	255	3417
Number of Species	21	14	15	6	9	13	41

Table 13. Ranking of dominant species for all trawl stations in the Piankatank River, 1970-71.

	Most	Second	Third
July	C. regalis	M. menidia	A. mitchilli
September	A. mitchilli	B. chrysura	S. maculatus
November	B. chrysura	T. maculatus	M. undulatus
January	T. maculatus	M. menidia	P. flavescens
March	A. mitchilli	A. aestivalis	A. pseudoharengus
May	T. maculatus	U. regius	A. mitchilli
Year	A. mitchilli	T. maculatus	B. chrysura

Table 14. Length frequency of juvenile striped bass taken in the Piankatank River trawl survey 1970-71.

FL increment (mm)	July	November
45	4	
50	3	
55	10	
60	4	
65	3	
70	1	
	Σ 25	
110		3
115		4
120		2
125		1
130		1
135		
140		1
145		
150		2
155		
160		1
		Σ 15

Individual stations exhibited similar seasonal variation in species abundance (Appendix Table A1). The occurrence of freshwater forms at PK-7 suggests that the larval and early juvenile striped bass nursery area probably extends to that point in the river. PK-1 is dominated by seasonally migrant saltwater fishes such as weakfish, croaker, silver perch, and spotted hake (Appendix Table A2). Upstream, the saltwater migrants are gradually replaced by the resident fishes and seasonal forage species (silversides and bay anchovy). At PK-7 forage species and freshwater fishes, such as yellow perch and sunfishes, assume dominance.

Presence of adult striped bass on their spawning run was evaluated by gill net operations in March and April 1971. Stations occupied were 2-4 miles above the upper trawl station. Twenty-five yard sections of 5 inch and 3 1/4 inch stretch mesh nets were fished overnight on three occasions (March 25-26, April 23-24, and April 28-29). Nets were fished approximately 50 yards apart with the larger mesh downstream. A definitive answer was not obtained though a single mature female striped bass was caught in March. Other species taken were chain pickerel, white perch, alewife, hickory shad, carp, gizzard shad, longnosed gar, largemouth bass, golden shiner, white catfish, and bluegill sunfish.

Collections with a modified plankton net sled at PK-7 through PK-9 yielded no striped bass eggs or larvae. Due to the flow characteristics of the stream and heavy accumulation of organic detritus the distribution of eggs and larvae should be confined to a small area in proximity to the natural spawning ground.

Spawning in the Piankatank River is probable though collections during this contract year were inconclusive. The juveniles obtained in our trawling operations may have been Rappahannock River fish. Spawning success appears to have been great for 1970 and young may have become dispersed over a larger than normal area.

Mobjack Bay System

This estuarine system is located adjacent to and north of the York River, Virginia. The bay and its tributaries encompass a total surface area of 29,990 acres (46.7 sq. miles). The maximum depth within the system is 30 feet. Depths in the rivers range from 10-20 feet in the channels with broad flats to either bank. Depths in the bay proper are usually 18-24 feet. Mouths of the tributaries and the junction of major Severn River branches constitute the deepest points in the system. The drainage basin is predominantly swampy in tributary headwaters. Industrial development within the immediate area is non-existent. Agricultural crops, rural dwellings, and estates are predominant along the shoreline. Most property contiguous to the system is in large tracts though some subdivision housing is located on the Ware and Severn Rivers. At present pleasure boating is centered in the East River and is expected to develop in the Severn, Ware, and North Rivers.

Twenty sampling sites were allocated to the system: 6 in the bay, 3 in the Severn River, 4 in the Ware River, 4 in the North River, and 3 in the East River (Fig. 5). The surface areas within each tributary are: Severn, 3406 A.; Ware 4209 A.; North 4344 A.; and East 1753 A. Vessels used in the sampling program included the project's 18' outboard, W. K. Brooks, Investigator, and R/V Pathfinder.

Hydrographic Factors

Monthly determinations of salinity, temperature, and dissolved oxygen were made at each station from July 1970 through June 1971.

Salinities within the bay proper and all tributaries place the system in the mesohaline class (salinities from 5-18 o/oo). Within the bay station series (MJ-1 to 6) salinities were stable top to bottom and station to station (Table 15). Seasonal variation was slight with lowest values associated with freshwater runoff. Peak salinities (22.0-22.5 o/oo) occurred at the deep stations (MJ-1 to 3) in September and November. Annual variation at a given station was 5 o/oo. (Text continued on page 52).

Table 15. Hydrographic data for Mobjack Bay and its tributary rivers in 1970-71

	Month	Salinity		D.O.		Temperature	
		Surface	Bottom	Surface	Bottom	Surface	Bottom
				MJ1			
1970	July	19.54	21.69	6.9	2.9	26.8	25.6
	August		23.33		5.0		26.1
	September	22.38	22.53	6.4	5.4	26.7	26.1
	October						
	November	21.59	22.16	8.5	8.0	15.0	14.2
	December						
1971	January	18.54	19.49	12.2	11.2	3.5	3.8
	February		20.10		12.0		3.8
	March	17.66	20.41	11.2	9.7	5.6	5.9
	April		17.59		10.8		7.0
	May	17.66	20.36	7.6	6.1	15.5	14.4
	June		15.80		5.8		23.6
				MJ2			
1970	July	18.92	19.07	7.2	5.9	27.5	26.8
	August		20.37		6.5		26.7
	September	21.48	22.09	7.3	5.4	26.9	26.5
	October						
	November	21.98	22.14		8.3	14.4	14.8
	December						
1971	January	19.24	19.80	11.3	11.8	3.5	3.8
	February		19.98		9.8		2.2
	March	18.09	19.92	11.7	10.2	5.7	5.9
	April		17.78		11.2		7.5
	May	17.68	17.65	6.3	5.5	15.6	15.3
	June		16.20		5.9		24.4

Table 15. (continued).

MJ3

	Month	Salinity Surface	Salinity Bottom	D. O. Surface	D. O. Bottom	Temperature Surface	Temperature Bottom
1970	July	18.17	18.71	6.5	4.6	26.7	26.2
	August		19.36		5.5		27.1
	September	20.62	21.48	7.9	3.7	26.8	26.0
	October						
	November	22.07	22.24	8.2	7.8	13.9	12.9
	December						
1971	January	20.22	20.55	11.1	11.0	3.1	3.4
	February		18.88		7.6		3.5
	March	17.92	19.18	10.5	9.9	6.7	6.5
	April		18.53		10.9		8.0
	May	17.37	17.62	8.9	9.2	14.9	14.5
	June		16.10		7.7		25.2

MJ4

1970	July	18.45	18.59	6.5	6.1		
	August		19.70		7.0		27.0
	September	22.24	22.28	5.5	4.5	26.9	26.8
	October						
	November	21.75	21.88	8.2	8.1	15.5	15.4
	December						
1971	January	19.73	19.72	11.9	12.0	0.0	0.0
	February		19.21		8.2		5.6
	March	18.04	18.01	10.2	10.2	6.0	6.1
	April		17.56		10.0		12.0
	May	16.85	16.84	7.9	8.3	17.0	17.0
	June		16.50		6.4		25.4

Table 15. (continued).

MJ5

	Month	Salinity Surface	Salinity Bottom	D. O. Surface	D. O. Bottom	Temperature Surface	Temperature Bottom
1970	July	18.19	18.19	6.8	5.8		
	August		20.45		5.3		25.8
	September	22.47	22.59	7.3	7.8	27.3	27.3
	October						
	November	21.53	21.55	8.1	8.6	15.3	15.4
	December						
1971	January	19.41	19.48	12.1	12.2	1.0	1.0
	February		19.48		7.4		3.4
	March	17.90	17.95	10.7	10.9	4.0	3.0
	April		17.31		11.2		8.0
	May	15.94	15.94	7.9	8.3	19.0	19.5
	June		15.86		6.8		24.5

MJ6

1970	July	19.02	18.94	6.4	5.9		
	August		20.30		5.3		25.6
	September	22.84	22.89	6.6	6.5	26.8	27.1
	October						
	November	22.52	22.52	8.1	8.4	15.3	15.2
	December						
1971	January	18.32	18.23	12.2	11.5	2.0	2.0
	February		19.60		11.5		3.0
	March	16.82	16.77	10.6	10.0	6.0	5.5
	April		17.97		11.8		10.5
	May	17.04	17.98	9.0	7.4	17.0	17.0
	June		15.33		9.6		23.0

Table 15. (continued).

MS1

	Month	Salinity Surface	Salinity Bottom	D. O. Surface	D. O. Bottom	Temperature Surface	Temperature Bottom
1970	July	18.43	19.41	6.3	3.1	27.3	26.8
	August		19.41				26.6
	September	20.99	21.72	7.2	2.7	27.5	26.5
	October						
	November	22.27	22.27	8.2	7.9	14.4	14.3
	December						
1971	January	20.43	20.46	11.2		3.3	3.8
	February		18.71		11.2		4.4
	March	18.24	19.97	10.8	10.7	6.8	6.5
	April		17.21		10.9		10.0
	May	17.48	17.44	8.5	8.1	16.0	16.1
	June		16.33		6.9		24.4

MS2

1970	July	18.04	18.12	6.7	5.1		
	August		19.42		6.4		26.4
	September	21.11	21.34	6.0	4.0	26.8	26.9
	October						
	November	21.57	21.68	8.0	8.0	14.6	15.0
	December						
1971	January	20.25	20.20	11.7	11.9	0.0	0.0
	February		17.79		11.2		6.1
	March	17.47	17.56	10.1	9.1	6.5	5.3
	April		17.05		11.2		10.0
	May	16.87	16.90	7.8	7.5	18.0	18.0
	June		12.77		5.7		24.6

Table 15. (continued).

MS3

	Month	Salinity		D. O.		Temperature	
		Surface	Bottom	Surface	Bottom	Surface	Bottom
1970	July	17.21	18.15	7.1	3.5		
	August		19.70		6.9		26.7
	September	20.93	20.95	5.8	5.7	27.3	27.3
	October						
	November	21.49	21.58	8.0	8.0	14.9	15.0
	December						
1971	January	19.78	19.99	11.2	11.5	0.0	0.0
	February		18.51		11.3		5.1
	March	17.33	17.33	10.1	9.9	7.0	6.7
	April		16.98		10.2		10.5
	May	15.41	16.71	7.7	7.5	19.0	18.0
	June		16.22		6.5		25.3

Table 15. (continued).

MW1

	Month	Salinity Surface	Salinity Bottom	D. O. Surface	D. O. Bottom	Temperature Surface	Temperature Bottom
1970	July	17.76	17.73	7.7	7.8		
	August		19.23		6.7		27.2
	September	20.63	21.04	7.5	5.5	27.2	26.9
	October						
	November	21.78	21.93	8.1	8.1	14.9	14.9
	December						
1971	January	20.01	19.95	11.8	11.7	0.5	1.0
	February		18.92		11.3		4.4
	March	18.24	18.25	9.7	9.3	7.0	7.0
	April		17.39		10.0		10.0
	May	16.82	16.83	7.5	7.0	18.0	18.0
	June		16.15		7.3		24.7

MW2

1970	July	17.97	18.71	5.8	3.0	26.6	25.8
	August		19.03		6.5		27.3
	September	20.32	20.85	7.3	3.0	26.9	26.3
	October						
	November	22.07	22.02	8.3	8.4	14.1	14.1
	December						
1971	January	20.32	20.49	10.6	11.1	3.5	3.7
	February		19.05		11.0		4.7
	March	17.53	17.57		10.2	7.1	7.0
	April		17.20		9.9		11.0
	May	16.75	17.11	8.5	8.3	15.8	15.5
	June		16.06		4.8		24.5

Table 15. (continued).

MW3

	Month	Salinity Surface	Salinity Bottom	D. O. Surface	D. O. Bottom	Temperature Surface	Temperature Bottom
1970	July	16.28	17.74	6.8	4.6		
	August		18.56		7.0		27.5
	September	20.16	20.18	7.4	7.3	27.7	27.3
	October						
	November	20.98	21.00	8.4	8.0	15.0	15.4
	December						
1971	January	19.73	19.76	12.0	12.4	0.5	1.0
	February		17.58				5.4
	March	15.95	16.29	10.3	10.5	7.0	6.5
	April		16.56		10.3		12.0
	May	15.94	16.07	8.3	8.6	22.0	21.0
	June		15.59		3.8		25.2

MW4

1970	July	15.66	17.36	7.3	3.6		
	August		17.79		28.1		6.7
	September	19.50	19.49	6.9	6.8	28.3	28.3
	October						
	November	19.67	20.32	8.0	7.7	15.4	15.4
	December						
1971	January	19.19	19.21	12.2	12.0	0.5	0.5
	February		15.89		6.0		6.2
	March	11.21	14.75	10.8	10.1	6.5	6.0
	April		15.83		9.4		13.0
	May	15.19	15.32	7.8	8.1	22.5	22.0
	June		14.93		3.9		25.7

Table 15. (continued).

MN1

	Month	Salinity Surface	Salinity Bottom	D. O. Surface	D. O. Bottom	Temperature Surface	Temperature Bottom
1970	July	18.30	18.30	6.6	6.1	25.6	25.6
	August		19.21		5.6		26.5
	September	20.71	20.85	7.7	5.5	27.8	27.3
	October						
	November	21.59	22.10	8.7	8.3	14.8	14.7
	December						
1971	January	20.07	20.06	11.9	12.1	1.0	1.0
	February		19.07		7.3		3.9
	March	18.14	18.28	10.1	10.3	7.0	7.0
	April		17.50		11.2		8.5
	May	16.88	16.95	7.2	6.7	17.0	17.0
	June		16.24		4.7		24.0

MN2

1970	July	17.83	17.99	6.1		26.9	26.2
	August		19.06		5.9		27.8
	September	19.96	20.25	7.3	4.0	26.9	26.1
	October						
	November	22.16	22.17	8.1	8.7	13.9	13.9
	December						
1971	January	20.63	20.65	11.1	10.9	3.2	3.8
	February		18.97		7.9		3.8
	March	17.50	17.75	10.4	9.9	7.1	7.2
	April		17.19		11.1		8.0
	May	17.99	17.12	8.4	8.2	15.6	15.2
	June		16.23		4.1		23.6

Table 15. (continued).

MN3

	Month	Salinity Surface	Salinity Bottom	D. O. Surface	D. O. Bottom	Temperature Surface	Temperature Bottom
1970	July	17.69		6.8	5.7	27.1	26.6
	August		18.91		6.4		28.1
	September	19.87	19.93	8.7	5.1	28.3	27.6
	October						
	November	20.53	21.55	8.4	8.3	14.7	15.0
	December						
1971	January	19.95	19.92	12.0	11.9	0.5	0.5
	February		18.98		5.1		4.2
	March	16.54	17.44	9.6	9.9	7.0	7.0
	April		16.63		11.3		9.0
	May	16.76	16.80	8.1	8.2	21.5	
	June		15.87		3.4		24.2

MN4

1970	July	16.99	17.22	6.3	5.7	26.6	26.5
	August		18.72		7.3		27.9
	September	19.45	19.43	7.7	7.3	28.9	28.6
	October						
	November	18.29	21.03	7.5	7.8	15.4	15.2
	December						
1971	January	19.67	19.66	12.0	12.1	0.5	1.0
	February		17.08		8.6		5.7
	March	11.49	13.25	10.2	9.8	6.5	6.5
	April		15.73		10.8		11.5
	May	16.38	16.44	8.1	8.0	21.0	21.0
	June		14.99		5.6		25.4

Table 15. (continued).

ME1

	Month	Salinity Surface	Salinity Bottom	D. O. Surface	D. O. Bottom	Temperature Surface	Temperature Bottom
1970	July	18.22	18.37	6.4	5.7		
	August		19.81		4.8		26.7
	September	21.16	21.31	4.5	7.4	27.1	26.9
	October						
	November	21.72	22.11	8.4	8.3	14.9	14.8
	December						
1971	January	19.62	19.92	11.9	11.8	1.0	1.0
	February		19.26		8.8		3.5
	March	17.71	17.77	8.2	9.9	6.0	5.0
	April		18.61		11.1		8.0
	May	16.53	16.66		7.6	16.0	17.0
	June		16.03		6.9		26.2

ME2

1970	July	18.41	18.42	5.3	6.1		
	August		19.41		4.7		27.3
	September	20.87	20.93	4.6	6.8	27.6	27.4
	October						
	November	21.40	22.08	8.7	8.3	14.7	14.8
	December						
1971	January	19.78	19.71	12.0	12.2	1.0	1.0
	February		18.74		10.9		3.8
	March	16.74	17.45	9.1	9.9	7.0	6.0
	April		17.86		10.6		9.0
	May	16.51	16.61	7.4	6.5	18.0	18.0
	June		15.79		6.3		27.1

Table 15. (continued).

ME3

	Month	Salinity		D. O.		Temperature	
		Surface	Bottom	Surface	Bottom	Surface	Bottom
1970	July	18.09	18.11	6.2	6.1		
	August		19.16		5.5		27.9
	September	20.60	20.45	6.8	5.5	28.6	27.9
	October						
	November	20.70	20.69	8.4	7.9	15.0	15.0
	December						
1971	January	19.44	19.51	12.5	12.1	1.0	1.0
	February		17.83		6.5		4.6
	March	12.85	16.68	10.1	9.5	6.0	6.0
	April		17.31		10.8		9.0
	May	16.95	16.95	7.2	7.3	20.5	20.5
	June		15.0		6.8		26.6

Severn River salinities (Table 15) exhibited the same fluctuations and seasonal trend as shown in the bay stations. The slight decline in salinities between MS-1 and MS-2 and 3 reflects the very gradual salinity gradient characteristic of low flow, small drainage area streams. In these streams the transition zone is generally abrupt often exceeding 5 o/oo within 100 yards. Vertical stratification is minimal (less than 1 o/oo) throughout the river. Annual variation at a given station was 6 o/oo.

The Ware River stations span a distance of 5 miles from its mouth. Salinities mimic those of the Severn River and Mobjack Bay proper (Table 15). Salinity stratification occurred between surface and bottom (11.21 vs 14.75 o/oo in March at station MW-4. This was attributed to fresh water runoff. Maximum seasonal variation at a given station was 8 o/oo at MW-4.

Stations in the North River (Table 15) exhibited a vertical and horizonal pattern similar to the Ware River. MN-4 in November and March showed the greatest vertical salinity difference of 2.74 and 1.76 o/oo respectively. Seasonal variation at a given station was maximal at MN-4 (8 o/oo).

East River salinities were of the same vertical and horizonal pattern (Table 15). In March at ME-3 a maximal vertical difference of 3.63 o/oo was found. Seasonal variation at a given station was maximal for ME-3 (8 o/oo).

From the above description of the bay proper and individual rivers it is clear that a salinity gradient similar to that of the

major rivers does not exist. Instead salinity changes rapidly as one proceeds above the mud bars at the edges of marsh intrusion. Benthic infauna and ichthyofauna would be expected to be uniform throughout the area. Larval fish spawned in freshwater, i.e. striped bass and herring, would have to be capable of rapid acclimation when descending from the freshwater areas.

Thermal stratification did not occur within the bay and its tributaries during the study period (Table 15). Maximum difference between surface and bottom temperature was 1° C. Seasonal variation in temperature depended upon water depth. MJ-1, 2, and 3 (average depth 24 feet) had a 25° C annual variation in temperature while MJ4-6 (average depth 6 feet) had a 27° C variation. The tributary rivers resembled the shallow bay station variation. The deeper bay waters did not get as cold as shallow bay stations or the tributaries during winter and were slower in warming with the advent of spring.

Dissolved oxygen values less than 3 ppm were infrequent in the bay and tributaries. The surface waters were close to saturation values while bottom values fell to a minimum of 35 % saturation at MJ-1 in July. Weak salinity stratification was considered the cause of this low O_2 value. Diurnal variation in response to sunlight and organismal activity should be considered in evaluating probable maxima and minima within the system.

Local crabbers report late summer anerobiosis in the mouth of the Severn and North Rivers. Conditions responsible for this stratification are "dog days" weather conditions. Low freshwater

runoff, high temperatures, and moderate winds would interact allowing stratification in the deeper segments of the system. With stratification the respiratory activities of biota and decomposition of organic detritus within the area would depress D.O.

Sediment analysis

A Petersen grab at each station for sediment analysis was obtained during the February sampling cruise. Samples were returned to the laboratory and analyses performed to determine percent sand, silt, and clay. All tributary stations fell within the silty clay designation except MN1 which could arbitrarily be considered a bay station (Fig. 5 and 6). The bay stations proper (MJ-1 to 6) showed a progression from clayey silt to sand classes. Stations in the area of maximal tidal current or wave turbulance were higher in sand content. Results of these analyses shall be applied in the benthic infauna survey to describe the community structure of the Mobjack Bay system benthos.

Uniformity of hydrographic data within the Mobjack Bay system would indicate suitability of any of the tributaries for stocking striped bass.

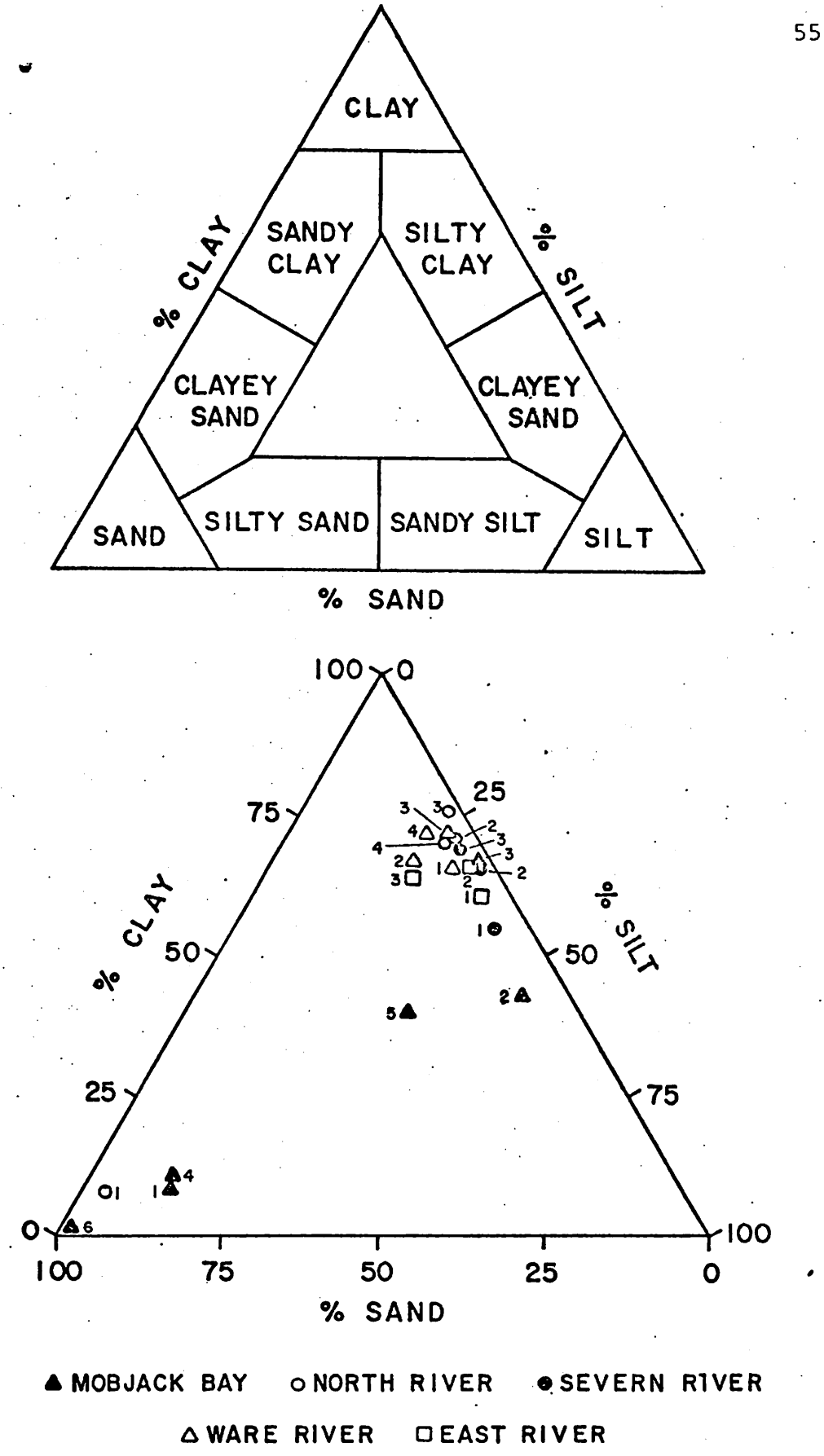

Fig. 6. Sediment particle size classification for stations within the Mobjack Bay System.

Fish Fauna

Fish fauna was sampled every other month from July 1970 through May 1971. Stations MJ-1 to 3, MS-1, MW-2, and MN-2 were sampled with a 30 foot unlined semiballoon trawl. The remaining stations were sampled with a lined 16 foot semiballoon trawl. R/V Pathfinder towed the 30 foot trawl. The W. K. Brooks and Investigator were used to tow the 16 foot trawl during the year. All trawls were of 7 1/2 minute duration. Fishes were identified and enumerated. Fork lengths of up to 25 fish per species were recorded for each station. Notes of bottom vegetation and invertebrates taken in the trawls were also recorded.

Collections at all twenty stations yielded a total of 4434 specimens comprising 40 species. Seasonality and abundance of individual species exhibited a general pattern similar to that of the Piankatank River collections. With the objective of stocking tributary selection in mind data were grouped in 5 units: bay stations and the four individual rivers.

Mobjack Bay:

Within the bay proper 1283 specimens comprising 31 species were obtained (Table 16). Areas trawled included mud and sandy bottoms with stations MJ-4 and 5 being over eel grass beds. The composite samples indicate movements of marine fishes such as silver perch, weakfish, spot, and croaker into the bay during spring and summer (Table 16). Forage fishes such as bay anchovy, silversides, and gobies were consistently available. Twelve to thirteen species were present from May through November. Winter conditions reduced

Table 16. Species list and abundance for all trawl stations in Mobjack Bay proper, 1970-71.

MJ 1-6 Pooled

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Alosa aestivalis					1		1
Anchoa mitchilli	70	153	7	1	15	25	271
Anchoa hepsetus		68					68
Anguilla rostrata					1		1
Apeltes quadracus				1			1
Bairdiella chrysura	231	187	1				419
Centropristis striatus						5	5
Chaetodipterus faber		2					2
Cynoscion regalis	109	116	2				227
Etropus microstomus						2	2
Gobiesox strumosus			1				1
Gobiosoma bosci		1		2		1	4
Hypsoblennius hentzi			1				1
Leiostomus xanthurus	14	7				31	52
Membras martinica			5				5
Menidia menidia			5	3	3	7	18
Menticirrhus americanus		11	7				18
Microgobius thalassinus						1	1
Micropogon undulatus		43	26				69
Monocanthus hispidus	1						1
Opsanus tau	1	1	1				3
Paralichthys dentatus	1	6				1	8
Peprilus triacanthus		2					2
Prionotus carolinus	4					11	15
Pseudopleuronectes americanus	1						1
Raja eglanteria			2				2
Sphoeroides maculatus	1					3	4
Syngnathus floridae				2			2
Syngnathus fuscus	1					7	8
Trinectes maculatus	28	14				4	46
Urophycis regius			1		1	23	25
Total Fish	462	611	59	9	21	121	1283
Number of Species	12	13	12	5	5	13	31

the number of species to five. Overwinter abundance (January and March) was greatly reduced. Abundance and species associations by station showed a similar trend toward uniformity within deeper stations and shallow stations over grassy areas (Table 17). The uniqueness of MJ6 arises from its bottom composition (sand) and its exposure to maximal tidal flow. Little growth of vegetation exists there while areas adjacent to the slough sampled possess dense beds of eel grass. Individual station data reflected the same migratory pattern of fishes related to season though to a less dramatic effect than when taken as an aggregate (Appendix Table A3).

Table 17. Ranking of dominant species for aggregate and individual trawl stations in Mobjack Bay, 1970-71.

MJ 1-6

	A	B	C
July	B. chrysura	C. regalis	A. mitchilli
September	B. chrysura	A. mitchilli	C. regalis
November	M. undulatus	A. mitchilli	M. americanus
January	M. menidia	G. bosci	S. floridae
March	A. mitchilli	M. menidia	U. regius
May	L. xanthurus	A. mitchilli	U. regius
Year	B. chrysura	A. mitchilli	C. regalis

MJ1

July	C. regalis	T. maculatus	L. xanthurus
September	C. regalis	A. mitchilli	P. dentatus
November	M. americanus	C. regalis	M. undulatus
January	M. menidia	G. bosci	-
March	M. menidia	A. mitchilli	U. regius
May	A. mitchilli	B. chrysura	U. regius
Year	C. regalis	A. mitchilli	T. maculatus

Table 17. (continued).

	A	B	C
MJ2			
July	C. regalis	T. maculatus	A. mitchilli
September	A. mitchilli	A. hepsetus	B. chrysura
November	M. undulatus	M. menidia	M. martinica
January	N O F I S H		
March	A. mitchilli	-	-
May	A. mitchilli	M. menidia	U. regius
Year	A. mitchilli	C. regalis	A. hepsetus
MJ3			
July	L. xanthurus	-	-
September	B. chrysura	A. mitchilli	C. regalis
November	M. undulatus	A. mitchilli	G. strumosus
January	N O F I S H		
March	A. aestivalis	-	-
May	U. regius	T. maculatus	A. mitchilli
Year	B. chrysura	A. mitchilli	C. regalis
MJ4			
July	B. chrysura	A. mitchilli	C. regalis
September	B. chrysura	M. americanus	L. xanthurus
November	A. mitchilli	M. undulatus	-
January	N O F I S H		
March	N O F I S H		
May	C. striata	L. xanthurus	S. fuscus
Year	B. chrysura	M. americanus	A. mitchilli

Table 17. (continued).

	A	B	C
	MJ5		
July	A. mitchilli	L. xanthurus	C. regalis
September	B. chrysura	A. mitchilli	-
November	N O F I S H		
January	A. quadracus	G. bosci	S. floridae
March	A. rostrata	-	-
May	L. xanthurus	A. mitchilli	P. carolinus
Year	A. mitchilli	L. xanthurus	B. chrysura
	MJ6		
July	A. mitchilli	-	-
September	T. maculatus	-	-
November	A. mitchilli	-	-
January	A. mitchilli	S. floridae	-
March	N O F I S H		
May	U. regius	P. carolinus	L. xanthurus
Year	U. regius	T. maculatus	P. carolinus

Severn River: A total of 689 specimens from 24 species was collected during the year (Table 18). Species complement for the river was consistent throughout the year though seasonality of select species was noted. Collections at individual stations were sporadic with greatest monthly fluctuation occuring at MS-1 (Appendix Table A4). Individual stations exhibited a decline in the species complement and total abundance over winter. Three young of year striped bass were obtained at station MS-2 (2 in September and 1 in November). The bifurcation of the river into two major segments (the NW and SW Branches) would constitute a drawback in assessment of stocking. Trawl collections from each branch indicated 1 1/2 times greater abundance of fishes and three additional species in the SW Branch. These extra species: Apeltes quadracus, Fundulus heteroclitus and F. diaphanus are likely forage species for juvenile and subadult striped bass.

Abundance ranking by station (Table 19) showed an ample supply of forage species with seasonal abundance of spot, silver perch, and weakfish. Considerable quantities of tunicates, crabs, amphipods, salt-and-pepper shrimp, and other invertebrates were found with the trawl catches.

Table 18. Species list and abundance for all trawl stations in the Severn River, 1970-71.

MS1-MS3 Pooled

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Alosa aestivalis					2		2
Alosa pseudoharengus					2		2
Anchoa mitchilli	18	237	27		2		284
Anchoa hepsetus		1					1
Anguilla rostrata						2	2
Apeltes quadracus						1	1
Bairdiella chrysura	43	131	2				176
Centropristis striatus						1	1
Chaetodipterus faber		1					1
Chasmodes bosquianus					1		1
Cynoscion regalis	11	21					32
Fundulus diaphanus				1			1
Fundulus majalis				1			1
Gobiosoma bosci		2		1	2	5	10
Hypsoblennius hentzi				1			1
Leiostomus xanthurus						41	41
Menidia menidia			4		72		76
Micropogon undulatus				7	1	3	11
Morone saxatilus		2	1				3
Opsanus tau	8	11				9	28
Peprilus alepidotus		1					1
Pseudopleuronectes americanus	1			1			2
Syngnathus floridae					1		1
Trinectes maculatus		4				6	10
Total Fish	81	411	34	12	83	68	689
Number of Species	5	10	4	6	6	8	24

Table 19. Ranking of dominant species for individual trawl stations and the aggregate collection in the Severn River, 1970-71.

MS 1-3

	Most	Second	Third
July	B. chrysura	A. mitchilli	C. regalis
September	A. mitchilli	B. chrysura	C. regalis
November	A. mitchilli	M. menidia	B. chrysura
January	M. undulatus	F. diaphanus	F. majalis
March	M. menidia	A. aestivalis	A. pseudoharengus
May	L. xanthurus	P. dentatus	T. maculatus
Year	A. mitchilli	B. chrysura	M. menidia

MS1

July	A. mitchilli	-	-
September	A. mitchilli	B. chrysura	C. regalis
November	M. menidia	-	-
January	N O F I S H		
March	M. menidia	A. aestivalis	A. pseudoharengus
May	C. striata	O. tau	T. maculatus
Year	A. mitchilli	M. menidia	B. chrysura

Table 19. (continued).

MS2

	Most	Second	Third
July	B. chrysura	C. regalis	O. tau
September	B. chrysura	A. mitchilli	C. regalis
November	A. mitchilli	M. saxatilus	-
January	M. thalassinus	F. diaphanus	F. majalis
March	G. bosci	A. mitchilli	-
May	O. tau	G. bosci	L. xanthurus
Year	B. chrysura	A. mitchilli	O. tau

MS3

July	B. chrysura	A. mitchilli	C. regalis
September	A. mitchilli	B. chrysura	C. regalis
November	B. chrysura	-	-
January	M. thalassinus	G. bosci	H. hentzi
March	M. thalassinus	S. floridae	-
May	L. xanthurus	G. bosci	O. tau
Year	B. chrysura	L. xanthurus	A. mitchilli

North River: From the trawl collections in the North River a total of 519 fish comprising 21 species were taken (Table 20). Abundance of Anchoa mitchilli in the July and September samples dominated the catch (281 specimens). Winter depression of total abundance and species presence was strongly associated with the seasonal migrants. Similar though less dramatic shifts in species abundance were shown for individual stations (Table 21 and Appendix Table A5). With the uniformity of hydrographic data little variation in the fishes from station to station was expected. Abundance of fishes declined in the upriver stations in a steady manner. The poor performance of the 30' trawl at MN2 is a mystery. The bottom configuration was smooth and sediments are silty-clays. Within the river little forage for juvenile striped bass appears to be available in the upper segment (MN3 and 4) though one striped bass was taken at MN-4 in September (95 mm FL).

Overnight gill net sets for migrating striped bass were made in the freshwater section in each branch of the river within 150 yards of route 14 crossings. At these locations large mesh (5") and small mesh (3 1/4") nets were stretched bank to bank and fished early the following morning. Fishes obtained by gill net were alewives, pumpkinseeds, sunfish, menhaden, and gizzard shad (Table 22).

In May samples for eggs and larvae of striped bass were taken in both branches of the river near route 14 crossings. A modified 1/2-meter net sled similar to that described for epibenthic sampling was used. No striped bass were obtained in the 5 minute samples.

Table 20 Species list and abundance for all trawl stations in the North River, 1970-71.

MN 1-4 Pooled

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli	148	133	10			4	295
Anguilla rostrata		3				2	5
Bairdiella chrysura	43	55	6				104
Chasmodes bosquianus		1	1				2
Cynoscion regalis		18	2				20
Gobiesox strumosus				1			1
Gobiosoma bosci		4	1		1	6	12
Leiostomus xanthurus	1	2					3
Lucania parva					2		2
Menticirrhus americanus		9					9
Microgobius thalassinus				13			13
Micropogon undulatus		9	2				11
Morone saxatilus		1					1
Opsanus tau	2	8				5	15
Paralichthys dentatus		1				2	3
Pseudopleuronectes americanus				2	1		3
Sphoeroides maculatus						1	1
Syngnathus floridae					2		2
Syngnathus fuscus			1		1	3	5
Trinectes maculatus		9					9
Urophycis regius						3	3
Total Fish	194	253	23	16	7	26	519
Number of Species	4	13	7	3	5	8	21

Table 21. Ranking of dominant species for individual trawl stations and the aggregate collection in the North River, 1970-71.

MN 1-4

	Most	Second	Third
July	A. mitchilli	B. chrysura	O. tau
September	A. mitchilli	B. chrysura	C. regalis
November	A. mitchilli	B. chrysura	C. regalis
January	M. thalassinus	P. americanus	G. strumosus
March	L. parva	S. floridae	G. bosci
May	G. bosci	O. tau	A. mitchilli
Year	A. mitchilli	B. chrysura	C. regalis

MN1

July	A. mitchilli	-	-
September	A. mitchilli	M. americanus	M. undulatus
November	A. mitchilli	M. undulatus	-
January	M. thalassinus	-	-
March	S. fuscus	-	-
May	S. fuscus	U. regius	P. dentatus
Year	A. mitchilli	M. americanus	M. undulatus

Table 21. (continued).

	Most	Second	Third
MN2			
July	N O F I S H		
September	B. chrysura	-	-
November	N O F I S H		
January	M. thalassinus	P. americanus	-
March	P. americanus	-	-
May	A. mitchilli	A. rostrata	S. maculatus
Year	B. chrysura	A. mitchilli	P. americanus
MN3			
July	B. chrysura	A. mitchilli	-
September	A. mitchilli	B. chrysura	C. regalis
November	A. mitchilli	B. chrysura	C. regalis
January	M. thalassinus	G. strumosus	P. americanus
March	N O F I S H		
May	G. bosci	-	-
Year	A. mitchilli	B. chrysura	C. regalis
MN4			
July	B. chrysura	A. mitchilli	O. tau
September	B. chrysura	C. regalis	O. tau
November	B. chrysura	C. bosquianus	G. bosci
January	M. thalassinus	-	-
March	L. parva	S. floridae	G. bosci
May	O. tau	G. bosci	A. mitchilli
Year	B. chrysura	A. mitchilli	O. tau

Table 22. Fishes obtained from the North River in gill net sets, March-April 1971.

East Branch

Species	Number	Date
Alosa pseudoharengus	2	29-30 March
	1	21-22 April
Brevoortia tyrannus	1	21-22 April
Dorosoma cepedianum	1	21-22 April

West Branch

Species	Number	Date
Alosa pseudoharengus*	1	19-20 April
Lepomis gibbosus	3	21-22 April

* One male observed in a private net near site sampled 29-30 March 1971.

Ware River: A total of 1160 specimens comprising 17 species were obtained at stations within the Ware River (Table 23). Peak abundance within the river occurred in September (958 specimens). Anchoa mitchilli was the dominant seasonal forage species with 975 specimens. Species abundance and composition declined overwinter though not as dramatically as in other tributaries (Table 24 and Appendix Table A6). Fluctuations between stations were due to Anchoa mitchilli occurrence. Species complement was rather constant between stations (range 7-10). Performance of the 30' trawl at MW-2 was more consistent than cited for MN-2. Forage species for juvenile striped bass occurred regularly throughout the sampling area. A single striped bass was obtained at MW-4 in the September trawl (188 mm FL).

Overnight gill net sets in the Ware River during March and April, 1971 were made to assess the spawning migration of adult striped bass into the tributary. No adult striped bass were obtained. The following fishes were taken alewife (5), brown bullhead (1), creek chubsucker (1), carp (2), and gizzard shad (1).

In May samples for eggs and larvae were taken in Fox Mill Creek and Beaver Dam Swamp using the 1/2 meter D-net sled. No fish eggs or larvae were obtained in Fox Mill Creek. Beaverdam Swamp yielded one centrarchid larva on May 6 and 5 darter larvae on May 26, 1971.

Table 23. Species list and abundance for all trawl stations in the Ware River 1970-71.

MW 1-4 Pooled

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli	39	834	96			6	975
Anchoa hepsetus		1					1
Bairdiella chrysura	13	89					102
Centropristis striatus						1	1
Cynoscion regalis	4	15					19
Gobiosoma bosci				2	1	5	8
Lucania parva					1		1
Menidia menidia			2				2
Microgobius thalassinus				3		6	9
Micropogon undulatus		9					9
Morone saxatilus	1						1
Opsanus tau	3	2	2	1		8	16
Peprilus triacanthus						1	1
Pseudopleuronectes americanus					1		1
Syngnathus fuscus	1		1				2
Trinectes maculatus		8			1		9
Urophycis regius						3	3
Total Fish	61	958	101	6	4	30	1160
Number of Species	6	7	4	3	4	7	17

Table 24. Ranking of dominant species for individual trawl stations and the aggregate collection in the Ware River, 1970-71.

	Most	Second	Third
	MW 1-4		
July	A. mitchilli	B. chrysura	C. regalis
September	A. mitchilli	B. chrysura	C. regalis
November	A. mitchilli	M. menidia	O. tau
January	M. thalassinus	G. bosci	O. tau
March	G. bosci	L. parva	P. americanus
May	O. tau	A. mitchilli	M. thalassinus
Year	A. mitchilli	B. chrysura	O. tau
	MW1		
July	A. mitchilli	-	-
September	A. mitchilli	C. regalis	M. undulatus
November	A. mitchilli	-	-
January	M. thalassinus	-	-
March	P. americanus	-	-
May	U. regius	C. striatus	M. thalassinus
Year	A. mitchilli	C. regalis	M. undulatus

Table 24. (continued).

	Most	Second	Third
	MW2		
July	C. regalis	A. mitchilli	B. chrysura
September	A. mitchilli	B. chrysura	C. regalis
November	M. menidia	-	-
January	G. bosci	-	-
March	N O F I S H		
May	A. mitchilli	U. regius	-
Year	A. mitchilli	B. chrysura	C. regalis
	MW3		
July	A. mitchilli	B. chrysura	-
September	A. mitchilli	B. chrysura	T. maculatus
November	A. mitchilli	S. fuscus	-
January	M. thalassinus	O. tau	-
March	G. bosci	L. parva	-
May	G. bosci	O. tau	-
Year	A. mitchilli	B. chrysura	G. bosci
	MW4		
July	A. mitchilli	B. chrysura	O. tau
September	A. mitchilli	O. tau	-
November	O. tau	-	-
January	G. bosci	M. thalassinus	-
March	T. maculatus	-	-
May	O. tau	M. thalassinus	G. bosci
Year	A. mitchilli	O. tau	B. chrysura

East River: From trawl stations in the East River 783 specimens comprising 22 species were obtained (Table 25). Peak species complement occurred in September while peak numeric occurrence was in July. Seasonality of species complement and individual species occurrence followed the same pattern as described earlier though extending from November through March, Table 26 and Appendix Table A7 . Again Anchoa mitchilli was the most abundant forage fish obtained in the trawl collections. Bairdiella chrysura was the dominant seasonal migrant with peak catches occurring at ME-1 and 2. The number of species found at each station was similar (range 11-15). Abundance of fishes station to station declined above the mouth. During the year striped bass were obtained at ME2 (2 fish in November) and ME3 (17 fish in July and 2 fish in September). Length frequencies placed these fish in the 1970 year class (Table 27).

Overnight gill net sets were made during March and April in the upper reaches of the East River to assess spawning migration of adult striped bass. No fish were obtained in March. April sets produced the following fishes:

Gizzard shad (2)
Menhaden (11)
Atlantic needlefish(1)
Weakfish (1)
White perch (1)
Blueback herring (1)
Silver perch (2)
Striped bass (2-251 and 252 mm FL)

Three 5 minute D-net samples in the freshwater reach of the river failed to produce striped bass eggs or larvae. Fundulus sp., a cyprinid, Microgobius thalassinus, mud minnow, eel, anchovy and two unidentified species were obtained.

Table 25. Species list and abundance for all trawl stations in the East River, 1970-71.

ME1-ME3 Pooled

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Alosa sapidissima			1				1
Anchoa mitchilli	18	85					103
Anguilla rostrata		1					1
Apeltes quadracus					1		1
Bairdiella chrysura	334	92	3				429
Chaetodipterus faber		1					1
Chasmodes bosquianus		2					2
Cynoscion regalis	22	26					48
Cyprinodon variegatus				1			1
Gobiosoma bosci		6	1	1	2	9	19
Leiostomus xanthurus		2				20	22
Lucania parva				1			1
Menidia menidia					1		1
Menticirrhus americanus	1						1
Microgobius thalassinus		8	11			8	27
Micropogon undulatus		3					3
Morone saxatilus	17	2	2				21
Opsanus tau	13	53				9	75
Syngnathus floridae				2	2		4
Syngnathus fuscus						3	3
Trinectes maculatus	4	11				3	18
Urophycis regius						1	1
Total Fish	409	292	7	16	6	53	783
Number of Species	7	13	4	5	4	7	22

Table 26. Ranking of dominant species for individual trawl stations and the aggregate collection in the East River, 1970-1971.

	Most	Second	Third
	ME 1-3		
July	B. chrysura	C. regalis	A. mitchilli
September	B. chrysura	A. mitchilli	O. tau
November	B. chrysura	M. saxatilus	G. bosci
January	M. thalassinus	S. floridae	C. variegatus
March	G. bosci	S. floridae	A. quadracus
May	L. xanthurus	G. bosci	O. tau
Year	B. chrysura	A. mitchilli	O. tau
	ME1		
July	B. chrysura	C. regalis	A. mitchilli
September	A. mitchilli	O. tau	B. chrysura
November	G. bosci	-	-
January	M. thalassinus	S. floridae	C. variegatus
March	A. mitchilli	G. bosci	A. quadracus
May	L. xanthurus	S. fuscus	M. thalassinus
Year	B. chrysura	A. mitchilli	O. tau

Table 26. (continued).

	Most	Second	Third
ME2			
July	B. chrysura	A. mitchilli	C. regalis
September	B. chrysura	O. tau	C. regalis
November	B. chrysura	M. saxatilus	A. sapidissima
January	M. thalassinus	G. bosci	-
March	N O F I S H		
May	M. thalassinus	G. bosci	T. maculatus
Year	B. chrysura	O. tau	C. regalis
ME3			
July	M. saxatilus	O. tau	A. mitchilli
September	B. chrysura	O. tau	C. regalis
November	N O F I S H		
January	M. thalassinus	-	-
March	M. menidia	S. floridae	-
May	G. bosci	O. tau	L. xanthurus
Year	O. tau	B. chrysura	M. saxatilus

Table 27. Length frequencies of striped bass taken by trawl in the East River.

Fork Length (mm)	Frequency by Month		
	July	Sept.	Nov.
50	2		
55	2		
60	6		
65	2		
70	3		
75	2		
	Σ 17		
120		1	
125			
130		1	
		Σ 2	
155			1
160			
165			1
			Σ 2

Forage Organism Availability

Epibenthic organisms were sampled in August and alternate months at each of the regular stations in the Mobjack Bay system. A modified meter net on sled runners with a D-shaped orifice was towed over the bottom for 5 minutes (Fig. 7). Sorting and enumeration of organisms is nearing completion. To date samples have shown an abundance of copepods, mysids, decapods, chaetognaths, coelenterates, amphipods, and fish eggs or larvae. From these groups individual species lists and reference collections are being compiled. The 1970-71 data shall be presented in detail when analysis is completed. We expect to monitor changes in the epibenthic community related to season, hydrographic factors, and stocking of striped bass.

Due to slight variation in temperature and salinity between stations organismal occurrence is expected to be a function of bottom type (sandy vs mud) with seasonal changes affecting all stations simultaneously.

Benthic infauna were collected with a Petersen dredge at each regular station in August and February. Samples were washed, screened through 1 mm mesh, preserved in 5% formalin, and returned to the laboratory. Laboratory processing includes sorting to group, identification and establishment of a reference collection, and enumeration. At this time samples have been sorted and species identification is underway. Polychaetes have been the most speciose group to date (Table 28). Other groups are presently being identified and enumerated. Analysis of the infauna data shall be presented in detail in a later progress report. Station similarity and seasonality of the infauna

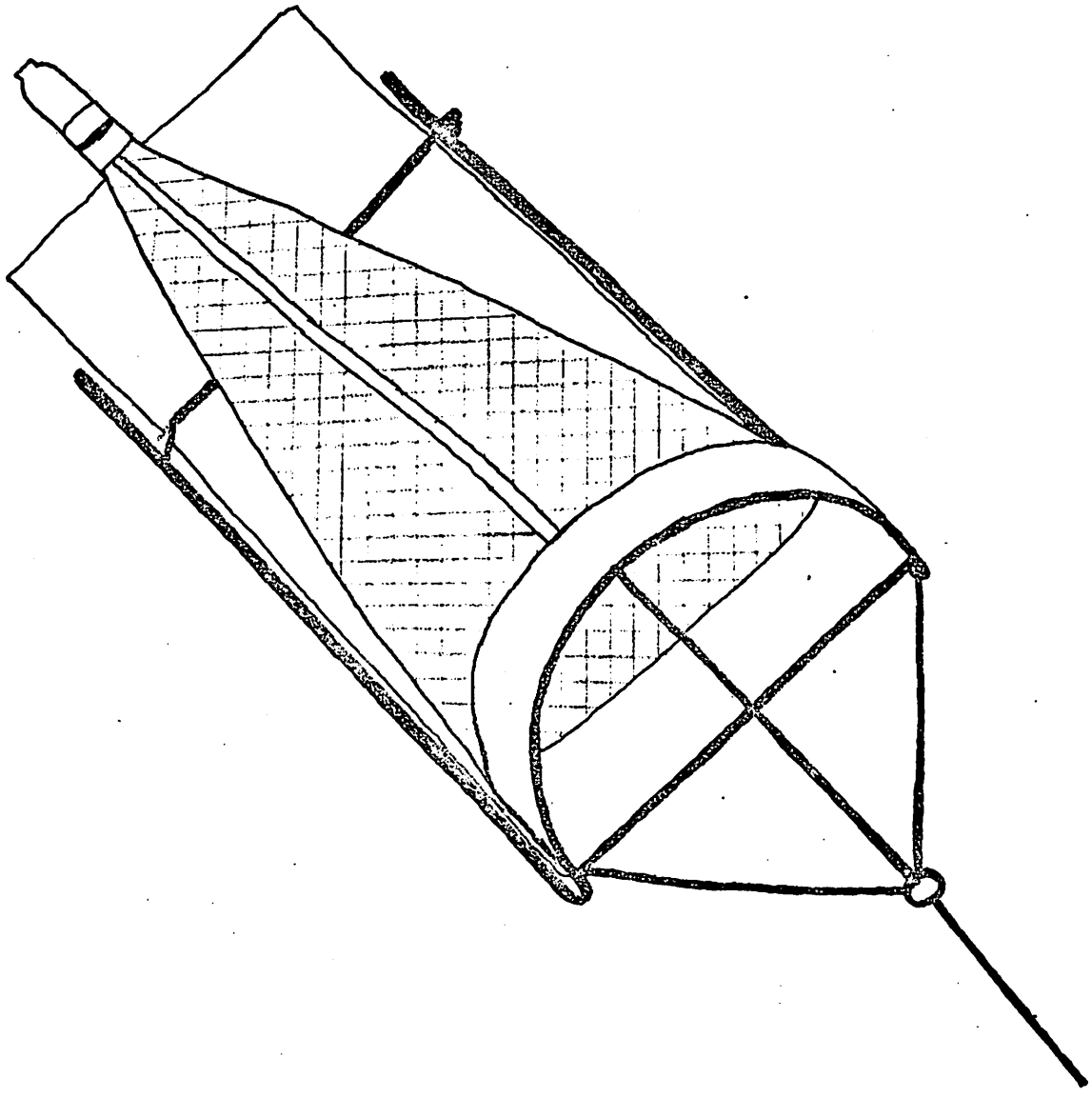

Figure 7 . D-Net sled apparatus used in epibenthic collections.

Table 28. List of 37 polychaete species from Mobjack stations, 1970-71.

Glycera americana
Glycera dibranchiata
Glycinde solitaria
Gyptis vittata
Lumbrineris tenuis
Nephyts picta
Nephyts incisa
Nereis succinea
Nereidae "A"
Eteone heteropoda
Phyllodocidae sp.
Paranaitis speciosa
Phyllodoce arenae
Sigambra tentaculata
Pectinaria gouldi
Sabellaria vulgaris
Melinna maculata
Heteromastus filiformis
Notomastus latericius
Capitella capitata
Capitellidae sp.
Spiochaetopterus oculatus
Cirriformia filigera
Maldanopsis elongata
Clymenella torquata
Clymenella sp.
Scoloplos robustus
Sabella microphthalma
Potamilla neglecta
Polydora ligni
Spiophanes bombyx
Paraprionospio pinnata
Pseudeurythoe paucibranchiata
Scale worm "A"
Scale worm "B"
Polynoidae sp.
Hydroides hexagona

Total: 37 Species

shall be presented and applied to trophic level descriptions of the Mobjack Bay system.

Tributary Selection

Based upon the occurrence of striped bass and likelihood of recruitment from the Rappahannock River population the Piankatank River system was eliminated as a stocking site for objective 3 of the project. Additional factors weighing against its use were the difficulty in post stock sampling within Dragon Run (head waters of the river) and considerable sportfishing activity.

Within the Mobjack Bay system little variation in the hydrographic factors and biotic composition between tributaries suggested that any tributary would be a suitable stocking area. However, monitoring growth of stocked fish vs natural population within similar waters eliminates the use of the East River for stocking. This river does afford an excellent comparative area due to its similarity to other Mobjack tributaries.

Configuration of the rivers and their tributaries would affect the evaluation of stocking success. The unit chosen should be as nearly singular as possible to eliminate intrariver variation which could mask growth differences. Upon this basis it was concluded that the Severn River would not be the best tributary for initial stocking. In addition, its proximity to the York River and expected shore dispersion of striped bass would make it a likely recipient of juvenile York River striped bass. Upstream access points are not available and freshwater inflow sites are small.

Both the Ware and North Rivers were considered equivalent streams for stocking. The North River was considered less optimal from two viewpoints. First due to its proximity to the East River and a supposedly natural striped bass population, contamination was considered likely. Secondly, from a logistic standpoint no access points are available to the project personnel within its upper reaches. Hence small boats would have difficulty reaching sampling stations. Thus the Ware River was selected for the initial stocking of striped bass in a latent nursery area. The Ware House Landing (public access ramp) situated approximately 1 1/2 miles above MW-4 provides ready access by small boat to the upper reaches of the estuary. Three small streams contribute to the Ware River at or near the primary access point: Beaverdam Swamp, Cow Creek, and Fox Mill Run. All three streams are accessible by highway in their upper reaches and by small boat in their lower and middle reaches. Striped bass could be stocked in each and thereby increase the probability of success. Calamity in one tributary would not destroy the total stock, insurance for continuity would be gained.

Objective 3 - Stocking of Selected Tributary

After selection of the Ware River as the prime stocking site, arrangements for receipt of striped bass were finalized with the Brookneal Fish Hatchery in Brookneal, Virginia.

One million striped bass sac-fry were transported in styrofoam boxes with an O_2 atmosphere from Brookneal to Gloucester Point, Virginia on June 4, 1971. The fry were three days old. Water at the hatchery was 18.4° C. and had a pH of 6.5. Brine shrimp had been placed in the holding tank 1 1/2 days after hatching.

Upon arrival at VIMS the water temperature in the boxes had risen to 22° C. Air temperature was deemed hazardous to their survival. A subsample of approximately 1500 fish was taken into the laboratory and placed in a 30 gallon aquarium for acclimation prior to salinity tolerance testing. The remaining fish were transported to the Ware River tributaries and stocked. Sites, water temperature, and number stocked are shown below:

Beaverdam Swamp	22.0° C	700,000
Cow Creek	24.5° C	100,000
Fox Mill Creek	22.5° C	200,000

A subsample of fry from one of the boxes stocked in Beaverdam Swamp was returned to the laboratory in the natural creek water. These fry were monitored daily for mortality to evaluate effects of stocking water on the fry. Samples of fry were taken periodically to provide a reference collection for comparisons to stream caught fish.

Mortality of striped bass fry held in aerated creek water was severe. The chronology of deaths is shown below:

June 5	980	June 15	856	June 28	19
June 8	210	June 21	34	July 2	3
June 10	105	June 23	2	4 Weeks	Σ= 22
June 12	76	3 Weeks	Σ= 992		
1st Week	Σ=1371				

Daily checks were made for mortality. All fish were dead on July 2, 1971. Response to the thermal abuse received in transit and due to stocking temperature differential is estimated at 43% (1 day mortality). The peak in mortality 11 days after stocking is believed to be a combination of natural and laboratory phenomena related to feeding habits and normal larval mortality on the one hand and inadequacy of holding facility on the other. Fry held for salinity tests experienced a similar first and 11 day mortality. Thus the abuses suffered in transit and the normal larval mortality are responsible for the 80+% mortality experienced. The effective stocking after initial mortality (1st day) was estimated 570,000 sac fry.

Weekly collections in the stocked tributaries were made with a modified 1/2 meter net on sled runners. Samples are presently being sorted for survivors. A more complete evaluation of the initial stocking attempt shall be presented in a subsequent progress report.

Analysis of growth relative to natural populations is contingent upon a successful stocking. Data gathered shall be applied to that end and presented in a later report.

Objective 4 - Techniques for Rearing and Stocking.

Development of techniques for holding and rearing striped bass are being evaluated. Our initial attempts to evaluate salinity tolerance of various sizes of young fish were unsuccessful with the June 4 sample from Brookneal Hatchery.

Arrangements are presently being formulated for receipt of fish earlier next spring to alleviate the thermal effect experienced during this project year.

We are hopeful that increased personnel allocation to this phase and earlier samples will enable us to fulfill our goals by next summer. Facilities are presently being outfitted to this end.

Objective 5 - Stocking of Additional Tributaries

Objective 6 - Evaluation of the Technique as a Management Tool

Progress within these phases is contingent upon the success achieved under objective 3. Pursuit of these objectives is scheduled for summer 1972 and spring 1973.

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Appendix Table A1. Species list and abundance for individual trawl stations in the Piankatank River, 1970-71.

PK1

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa hepsetus		1					1
Anchoa mitchilli	5	46	9		2	5	67
Bairdiella chrysura	16		63				79
Centropristis striatus	1						1
Cynoscion regalis	150	40	2				192
Etropus microstomus			1				1
Leiostomus xanthurus	2						2
Menidia menidia				3			3
Menticirrhus americanus		45	16				61
Menticirrhus saxatilus	1						1
Micropogon undulatus		50	9				59
Opsanus tau	1		1			2	4
Paralichthys dentatus		1	1			1	3
Peprilus alepidotus		2					2
Pomatomus saltatrix		1					1
Prionotus carolinus	7						7
Scophthalmus aquosus	1						1
Sphoeroides maculatus	5						5
Trinectes maculatus	11	10	6	1		2	30
Urophycis regius						7	7
Total Fish	200	196	108	4	2	17	527
Number of Species	11	9	9	2	1	5	20

Appendix Table A1. (continued).

PK2

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli		39			6		45
Bairdiella chrysura	10	339					349
Cynoscion regalis	10	44					54
Gobiesox strumosus			1			1	2
Gobiosoma bosci						1	1
Hippocampus hudsonius			1				1
Hypsoblennius hentzi			1				1
Leiostomus xanthurus	7	15					22
Micropogon undulatus		16	1				17
Opsanus tau	3						3
Peprilus alepidotus		2					2
Pseudopleuronectes americanus					2		2
Prionotus evolans	1						1
Sphoeroides maculatus	1	240				1	242
Trinectes maculatus	14	4					18
Urophycis regius						4	4
Total Fish	46	699	4	0	8	7	764
Number of Species	7	8	4	0	2	4	16

Appendix Table A1. (continued).

PK3

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Alosa aestivalis					17		17
Alosa pseudoharengus					14		14
Anchoa mitchilli		190			150		340
Anguilla rostrata						1	1
Apeltes quadracus					1		1
Bairdiella chrysura		3	152				155
Chasmodes bosquianus			2				2
Cynoscion nebulosus			1				1
Cynoscion regalis		16	1				17
Gobiosoma bosci						1	1
Leiostomus xanthurus		10					10
Microgobius thalassinus						1	1
Micropogon undulatus		1	47				48
Morone saxatilus			3				3
Trinectes maculatus	2	17	1		1	11	32
Total Fish	2	237	207	0	183	14	643
Number of Species	1	6	6	0	5	4	15

Appendix Table A1. (continued).

PK4

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anguilla rostrata						2	2
Micropogon undulatus		1					1
Opsanus tau			1				1
Peprilus alepidotus		1					1
Trinectes maculatus						33	33
Total Fish	0	2	1	0	0	35	38
Number of Species	0	2	1	0	0	2	5

Appendix Table A1. (continued).

PK5

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Alosa sapidissima					1		1
Anchoa mitchilli	4	68					72
Morone saxatilus			12				12
Trinectes maculatus	6	16	3			45	70
Total Fish	10	84	15	0	1	45	155
Number of Species	2	2	2	0	1	1	4

Appendix Table A1. (continued).

PK6

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Alosa aestivalis	5						5
Alosa pseudoharengus	2						2
Anchoa mitchilli	22	23		1			46
Bairdiella chrysura		1					1
Ictalurus catus						1	1
Leiostomus xanthurus		1					1
Menidia menidia	116						116
Micropogon undulatus		2					2
Morone americana						1	1
Morone saxatilus	3						3
Trinectes maculatus	1	184	108	3	4	133	433
Total Fish	149	209	110	4	4	135	611
Number of Species	6	4	2	2	1	3	11

Appendix Table A1. (continued).

PK7

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Alosa pseudoharengus	2						2
Anchoa mitchilli	23	500	25				548
Ictalurus catus	1						1
Lepomis gibbosus				1		1	2
Lepomis macrochirus	1			1	2		4
Menidia menidia	30						30
Morone americana	13	2				1	16
Morone saxatilus	22						22
Notropis hudsonius	24	2			2		28
Perca flavescens	1			2			3
Trinectes maculatus	11	12				21	44
Total Fish	128	504	37	4	4	23	700
Number of Species	10	3	2	3	2	3	11

Appendix Table A2. Ranking of dominant species for individual trawl stations in the Piankatank River, 1970-71.

Station		Dominant Species		
		Most	Second	Third
PK1	July	C. regalis	B. chrysura	T. maculatus
	September	M. undulatus	A. mitchilli	Ment. americanus
	November	B. chrysura	Ment. americanus	A. mitchilli
	January	M. menidia	T. maculatus	
	March	A. mitchilli		
	May	U. regius	A. mitchilli	Opsanus tau
	Year	C. regalis	B. chrysura	A. mitchilli
PK2	July	T. maculatus	B. chrysura	C. regalis
	September	B. chrysura	S. maculatus	C. regalis
	November	M. undulatus	H. hentzi	H. husdonius
	January			
	March	A. mitchilli	P. americanus	
	May	U. regius	S. maculatus	G. bosci
	Year	B. chrysura	S. maculatus	C. regalis
PK3	July	T. maculatus		
	September	A. mitchilli	T. maculatus	C. regalis
	November	B. chrysura	M. undulatus	m. saxatilus
	January			
	March	A. mitchilli	A. aestivalis	A. pseudoharengus
	May	T. maculatus	M. thalassinus	G. bosci
	Year	A. mitchilli	B. chrysura	M. undulatus

Appendix Table A2. (continued).

Station		Dominant Species Most	Second	Third
PK4	July, January, March - No Fish			
	September	M. undulatus	P. alepidotus	
	November	O. tau		
	May	T. maculatus	A. rostrata	
	Year	T. maculatus	A. rostrata	M. undulatus
PK5	July	T. maculatus	A. mitchilli	
	September	A. mitchilli	T. maculatus	
	November	M. saxatilus	T. maculatus	
	January			
	March	A. sapidissima		
	May	T. maculatus		
	Year	A. mitchilli	T. maculatus	M. saxatilus
PK6	July	M. menidia	A. mitchilli	A. aestivalis
	September	T. maculatus	A. mitchilli	B. chrysura
	November	T. maculatus	M. undulatus	
	January	T. maculatus	A. mitchilli	
	March	T. maculatus		
	May	T. maculatus	M. americana	I. catus
	Year	T. maculatus	M. menidia	A. mitchilli

Appendix Table A2. (continued).

		Dominant Species		
		Most	Second	Third
PK7	July	M. menidia	N. hudsonius	A. mitchilli
	September	A. mitchilli	M. americana	N. hudsonius
	November	A. mitchilli	T. maculatus	
	January	P. flavescens	L. macrochirus	L. gibbosus
	March	L. macrochirus	N. hudsonius	
	May	T. maculatus	M. americana	L. gibbosus
	Year	A. mitchilli	T. maculatus	M. menidia

Appendix Table A3. Species list and abundance for individual trawl stations in Mobjack Bay proper, 1970-71.

MJ1

Species	1970			1971			Total
	July	Sept.	Nov.	Jan.	March	May	
Anchoa mitchilli	2	5			2	9	18
Bairdiella chrysura	1					2	3
Cynoscion regalis	59	23	2				84
Gobiosoma bosci				1			1
Leiostomus xanthurus	6						6
Menidia menidia				3	3		6
Menticirrhus americanus		2	6				8
Micropogon undulatus		1	2				3
Paralichthys dentatus		3					3
Raja eglanteria			1				1
Trinectes maculatus	9						9
Urophycis regius			1		1	1	3
Total Fish	77	34	12	4	6	12	145
Number of Species	5	5	5	2	3	3	12

Appendix Table A3. (continued).

MJ2

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli	9	75			13	7	104
Anchoa hepsetus		68					68
Bairdiella chrysura		56	1				57
Cynoscion regalis	46	31					77
Hypsoblennius hentzi			1				1
Leiostomus xanthurus	1	2					3
Membras martinica			5				5
Menidia menidia			5			7	12
Menticirrhus americana		1	1				2
Micropogon undulatus		31	12				43
Opsanus tau	1		1				2
Paralichthys dentatus	1	1					2
Prionotus carolinus	4					1	5
Raja eglanteria			1				1
Sphoeroides maculatus						1	1
Trinectes maculatus	17	4					21
Urophycis regius						5	5
Total Fish	79	269	27	0	13	21	409
Number of Species	7	9	8	0	1	5	17

No Fish

Appendix Table A3. (continued).

MJ3

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Alosa aestivalis					1		1
Anchoa mitchilli		70	3			2	75
Bairdiella chrysura		97					97
Cynoscion regalis		62					62
Gobiesox strumosus			1				1
Leiostomus xanthurus	2	2					4
Micropogon undulatus		10	11				21
Peprilus triacanthus		2					2
Trinectes maculatus		3				3	6
Urophycis regius						8	8
Total Fish	2	246	15	0	1	13	277
Number of Species	1	7	3	0	1	3	10

No Fish

Appendix Table A3. (continued).

MJ4

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli	3	1	3				7
Bairdiella chrysura	230	27					257
Centropristis striatus						5	5
Chaetodipterus faber		2					2
Cynoscion regalis	1						1
Gobiosoma bosci		1				1	2
Leiostomus xanthurus		3				2	5
Menticirrhus americanus		8					8
Micropogon undulatus		1	1				2
Monocanthus hispidus	1			No Fish	No Fish		1
Opsanus tau		1					1
Paralichthys dentatus		2					2
Prionotus carolinus						1	1
Pseudopleuronectes americanus	1						1
Sphoeroides maculatus	1						1
Syngnathus fuscus	1					2	3
Total Fish	238	46	4	0	0	11	299
Number of Species	7	9	2	0	0	5	16

Appendix Table A3. (continued).

MJ5

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli	54	2				7	63
Anguilla rostrata					1		1
Apeltes quadracus				1			1
Bairdiella chrysura		9					9
Cynoscion regalis	3						3
Gobiosoma bosci				1			1
Leiostomus xanthurus	5					23	28
Microgobius thalassinus						1	1
Paralichthys dentatus						1	1
Prionotus carolinus						2	2
Sphoeroides maculatus						1	1
Syngnathus floridae				1			1
Syngnathus fuscus						2	2
Trinectes maculatus	2					1	3
Urophycis regius						1	1
			No Fish				
Total Fish	64	11	0	3	1	39	118
Number of Species	4	2	0	3	1	9	15

Appendix Table A3. (continued).

MJ6

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli	2		1	1			4
Etropus microstomus						2	2
Leiostomus xanthurus						6	6
Prionotus carolinus						7	7
Sphoeroides maculatus						1	1
Syngnathus floridae				1			1
Syngnathus fuscus						3	3
Trinectes maculatus		7					7
Urophycis regius						8	8
					No Fish		
Total Fish	2	7	1	2	0	27	39
Number of Species	1	1	1	2	0	6	9

Appendix Table A4 . Species list and abundance for individual trawl stations in the Severn River, 1970-71.

MS1

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Alosa aestivalis					2		2
Alosa pseudoharengus					2		2
Anchoa mitchilli	1	172			1		174
Anchoa hepsetus		1					1
Bairdiella chrysura		33					33
Centropristis striatus						1	1
Chaetodipterus faber		1					1
Chasmodes bosquianus					1		1
Cynoscion regalis		9					9
Menidia menidia			4		72		76
Opsanus tau		1				1	2
Trinectes maculatus						1	1
Total Fish	1	217	4	0	78	3	303
Number of Species	1	6	1	0	5	3	12

Appendix Table A4. (continued).

MS2

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli	6	40	27		1		74
Anguilla rostrata						1	1
Apeltes quadracus						1	1
Bairdiella chrysura	20	80					100
Cynoscion regalis	7	6					13
Fundulus diaphanus				1			1
Fundulus majalis				1			1
Gobiosoma bosci		2			2	2	6
Leiostomus xanthurus						2	2
Microgobius thalassinus				3		2	5
Morone saxatilus		2	1				3
Opsanus tau	7	6				5	18
Peprilus alepidotus		1					1
Pseudopleuronectes americanus	1						1
Trinectes maculatus		4				2	6
Total Fish	41	141	28	5	3	15	233
Number of Species	5	8	2	3	2	7	15

Appendix Table A4. (continued).

MS3

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli	11	25					36
Anguilla rostrata						1	1
Bairdiella chrysura	23	18	2				43
Cynoscion regalis	4	6					10
Gobiosoma bosci				1		3	4
Hypsoblennius hentzi				1			1
Leiostomus xanthurus						39	39
Microgobius thalassinus				4	1	1	6
Opsanus tau	1	4				3	8
Pseudopleuronectes americanus				1			1
Syngnathus floridae					1		1
Trinectes maculatus						3	3
Total Fish	39	53	2	7	2	50	153
Number of Species	4	4	1	4	2	6	12

Appendix Table A5. Species list and abundance for individual trawl stations in the North River, 1970-71.

MN1

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli	135	40	2				177
Bairdiella chrysura		4					4
Cynoscion regalis		6					6
Gobiosoma bosci						1	1
Menticirrhus americanus		8					8
Microgobius thalassinus				2			2
Micropogon undulatus		7	1				8
Opsanus tau		2					2
Paralichthys dentatus		1				2	3
Syngnathus fuscus					1	3	4
Trinectes maculatus		6					6
Urophycis regius						3	3
Total Fish	135	74	3	2	1	9	224
Number of Species	1	8	2	1	1	4	12

Appendix Table A5. (continued).

MN2

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli						3	3
Anguilla rostrata						1	1
Bairdiella chrysura		10					10
Microgobius thalassinus	No Fish		No Fish	1			1
Pseudopleuronectes americanus				1	1		2
Sphoeroides maculatus						1	1
Total Fish	0	10	0	2	1	5	18
Number of Species	0	1	0	2	1	3	6

Appendix Table A5. (continued).

MN3

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli	2	90	8				100
Bairdiella chrysura	11	17	5				33
Cynoscion regalis		7	2				9
Gobiesox strumosus				1			1
Gobiosoma bosci						1	1
Leiostomus xanthurus		2					2
Menticirrhus americanus		1					1
Microgobius thalassinus				8			8
Micropogon undulatus		2	1				3
Opsanus tau		1					1
Pseudopleuronectes americanus				1			1
Trinectes maculatus		3					3
Total Fish	13	123	16	10	0	1	163
Number of Species	2	8	4	3	0	1	12

Appendix Table A5. (continued).

MN4

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli	11	3				1	15
Anguilla rostrata		3				1	4
Bairdiella chrysura	32	24	1				57
Chasmodes bosquianus		1	1				2
Cynoscion regalis		5					5
Gobiosoma bosci		4	1		1	4	10
Leiostomus xanthurus	1						1
Lucania parva					2		2
Microgobius thalassinus				2			2
Morone saxatilus		1					1
Opsanus tau	2	5				5	12
Syngnathus floridae					2		2
Syngnathus fuscus			1				1
Total Fish	46	46	4	2	5	11	114
Number of Species	4	8	4	1	3	4	13

Appendix Table A6. Species list and abundance for individual trawl stations in the Ware River, 1970-71.

MW1

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli	1	425	89				515
Bairdiella chrysura		8					8
Centropristis striatus						1	1
Cynoscion regalis		14					14
Microgobius thalassinus				1		1	2
Micropogon undulatus		9					9
Peprilus triacanthus						1	1
Pseudopleuronectes americanus					1		1
Trinectes maculatus		7					7
Urophycis regius						2	2
Total Fish	1	463	89	1	1	5	560
Number of Species	1	5	1	1	1	4	10

Appendix Table A6. (continued).

MW2

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli	1	84				6	91
Anchoa hepsetus		1					1
Bairdiella chrysura	1	78					79
Cynoscion regalis	4	1					5
Gobiosoma bosci				1			1
Menidia menidia			2				2
Urophycis regius						1	1
					No Fish		
Total Fish	6	164	2	1	0	7	180
Number of Species	3	4	1	1	0	2	7

Appendix Table A6. (continued).

MW3

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli	7	300	7				314
Bairdiella chrysura	3	3					6
Gobiosoma bosci					1	1	2
Lucania parva					1		1
Microgobius thalassinus				1			1
Opsanus tau				1		1	2
Syngnathus fuscus			1				1
Trinectes maculatus		1					1
Total Fish	10	304	8	2	2	2	328
Number of Species	2	3	2	2	2	2	8

Appendix Table A6. (continued).

MW4

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli	30	25					55
Bairdiella chrysura	9						9
Gobiosoma bosci				1		4	5
Microgobius thalassinus				1		5	6
Opsanus tau	3	2	2			7	14
Syngnathus fuscus	1						1
Trinectes maculatus					1		1
Total Fish	44	27	2	2	1	16	92
Number of Species	5	2	1	2	1	3	8

Appendix Table A7. Species list and abundance for individual trawl stations in the East River, 1970-71.

ME1

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli	3	75			3		81
Anguilla rostrata		1					1
Bairdiella chrysura	154	30					184
Chasmodes bosquianus		2					2
Cynoscion regalis	14	9					23
Cyprinodon variegatus				1			1
Gobiosoma bosci		3	1		2		6
Leiostomus xanthurus		1				16	17
Lucania parva				1			1
Menticirrhus americanus	1						1
Microgobius thalassinus		7		2		1	15
Opsanus tau		31				1	32
Syngnathus floridae				2	1		3
Syngnathus fuscus						3	3
Total Fish	172	159	1	11	7	21	371
Number of Species	4	9	1	4	4	4	15

Appendix Table A7. (continued).

ME2

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Alosa sapidissima			1				1
Anchoa mitchilli	9						9
Bairdiella chrysura	178	41	3				222
Cynoscion regalis	7	6					13
Gobiosoma bosci		1		1		3	5
Microgobius thalassinus		1		3		6	10
Micropogon undulatus		2			No Fish		2
Morone saxatilus			2				2
Opsanus tau	5	7				2	14
Trinectes maculatus	1	4				3	8
Total Fish	200	62	6	4	0	15	287
Number of Species	5	7	3	2	0	5	11

Appendix Table A7. (continued).

ME3

Species	1970 July	1970 Sept.	1970 Nov.	1971 Jan.	1971 March	1971 May	Total
Anchoa mitchilli	6	10					16
Bairdiella chrysura	2	21					23
Chaetodipterus faber		1					1
Cynoscion regalis	1	11					12
Gobiosoma bosci		2				6	8
Leiostomus xanthurus		1				4	5
Menidia menidia					1		1
Microgobius thalassinus				1		1	2
Micropogon undulatus		1					1
Morone saxatilus	17	2					19
Opsanus tau	8	15				6	29
Syngnathus floridae					1		1
Trinectes maculatus	3	7					10
Total Fish	37	71	0	1	2	17	128
Number of Species	6	10	0	1	2	4	13

No Fish