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ABSTRACT

Otter trawl hauls for demersal fish were made between June 1955 and July 1957 in Long Island Sound at St. 1 on a sand and shell bottom at a depth of 9 m, and at St. 3A on a mud bottom at a depth of 17 m. The tows between July 17, 1956, and July 23, 1957 have been analysed quantitatively.

The standing crop of demersal fish was 0.60 g/m^2 at St. 1, 1.1 g/m^2 at St. 3A, and 0.76 g/m^2 for the two stations combined. The ten commonest species constituted 93% of the total standing crop; one species, *Pseudopleuronectes americanus*, accounted for 67%.

On each of 19 separate days two consecutive tows were made at St. 1, one in an easterly direction and one in a westerly direction over the same ground. The analysis of variance was applied to the total catch by number, the total number of species, and the total number of individuals within each species. Such large variations in total catch occurred within those taken in a westerly direction that no statistically significant differences in total catch or in total number of species occurred between the two groups of tows. However, the number of individuals of each species was statistically significantly different between each group of tows. Similar analyses of a group of 20 hauls from St. 1 and a group of 20 hauls from St. 3A taken on the same dates gave similar results. The varying number of individuals within each species masked any seasonal trends and locality differences which may have been present. In addition, an analysis using indices of diversity and heterogeneity, as outlined by Margalef (1958), showed that within each locality the fish communities were as heterogeneous as the combined community from both localities.

Throughout the year, a total of 37 different species was taken—36 of these at St. 1 and 25 at St. 3A. Analysis showed a seasonal pattern of abundance in which the total weight of the catch, but not the total number of individuals, varied proportionally with the quantity of *P. americanus* caught. In general, the abundance of fish, both adults and juveniles, was less in summer than at other times of year. An increase in abundance in the fall, mostly due to the influx of juveniles, was followed by a decrease early in the winter. In late winter an increase in abundance of sublittoral and diadromous species was accompanied by a decrease of adult *P. americanus.* An increase in the abundance of many species took place throughout the spring.

The species taken are divisible into two groups—residents and migrants. The chief residents are *P. americanus, Scophthalmus aquosus,* and *Merluccius bilinearis,* the most common migrant *Stenotomus chrysops.* More sublittoral residents, such as *Ammodytes americanus,* and juvenile migrants were taken from the sand-shell bottom of St. 1 than from the mud bottom at St. 3A. Pertinent information concerning the movements of several common species at Sts. 1 and 3A and elsewhere in the Sound is included.

Attempts to define the community structure, using MacArthur's (1957) hypothesis of non-overlapping niches, indicate the presence of a composite community, controlled primarily by the movements of *P. americanus* and other abundant species. Possibly the demersal fish population of L.I.S. will have to be arranged in "groups" other than taxonomic groups before homogeneous community structures can be determined.

INTRODUCTION

During the first few years of the Bingham Laboratory's study of Long Island Sound (hereafter L.I.S.), little emphasis was laid upon the demersal fish. This gap was partially filled when a fish sampling program was initiated in 1955. From data collected between June 1955 and July 1957, knowledge of the structure and role of the demersal fish population in the Sound has improved. A complete sampling of the fish population still has not been accomplished, so that we can only estimate the order of magnitude of the standing crop of these organisms in L.I.S. We can, however, gain some idea of the structure of the fish community, the changes which take place throughout the year, the food eaten, and something of the relationship of one species with another. This paper is the first of a series which reports the progress of this work, primarily on juvenile fish of the 0- to 2-year age groups.

The samples discussed here were collected at two stations in the Sound about two miles apart. The first group is from St. 1—a sand-shell bottom (sediment analysis by Sanders, 1956), 9 m deep, 1 mile SE of Charles Island; the second from St. 3A—a mud bottom, 17 m deep, 3 miles SSE of Charles Island.

MATERIALS AND METHODS

Eighty-four half-hour hauls were made at the two stations from June 1955 to July 1957, using various small-mesh trawls which varied from 10 to 20 feet in width at the mouth. Between July 17, 1956, and July 23, 1957, 41 tows at St. 1 and 25 at St. 3A were made nearly fortnightly with a single net which was a modified shrimp trawl built after a model described by Bullis (1951). This trawl had a 20′ mouth, one-inch mesh (stretched), with a $^1/_4$″ mesh liner for the cod end, and was rigged with $2^1/_2$′ boards. It was towed at two knots from the SHANG WHEELER with half an hour elapsing between the time when the net struck bottom and the start of the hauling-in process.

Generally two successive tows were taken at St. 1 in the morning: the first easterly toward New Haven Harbor; the second, when possible, westerly over the same area[1]. At St. 3A the tow was made in the afternoon, usually in a northeasterly direction; if time permitted the net was towed back again over the same ground toward the southeast. Occasionally fog or wind prevented the second tow at both stations from being made over exactly the same ground as the first. Without a recording fathometer the exact amount of departure from the path could not be ascertained, but further analysis showed that no significant differences arose due to this factor. Quantitative analysis of the population will be limited to those tows made from July 1956 through July 1957 by the methods described above.

Small adults and juveniles of all species that were caught were preserved at once. The fish were measured and weighed, and stomach contents were examined in the laboratory. Meristic counts, age analyses, etc., were made on species of particular interest. The larger fish were counted and measured on the boat, and occasionally scales were taken for age analysis; few stomachs of these fish were examined. A thorough study of the adult population would have required a larger boat capable of accommodating commercial-sized gear.

ACKNOWLEDGMENTS

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[1] On six occasions only one tow was made because of bad weather, lack of time, etc.

RESULTS

Relative Abundance and Standing Crop. A total of 3,949 individuals of 37 species, ranging in length from 19 to 470 mm, was taken from July 17, 1956, to July 23, 1957, in 65 tows from Sts. 1 and 3 A (Table I). The number of fish caught per day ranged from 44 to 660, and the number of species from 2 to 21. These fluctuations formed a vague pattern (see Fig. 1) which differed slightly at the two stations. On the whole the fluctuations in numbers were not due to fluctuations in the number of the most abundant species, *Pseudopleuronectes americanus.* Considering the data from both stations together, few fish were taken in summer, a fact which is difficult to explain. A tremendous increase in number of juveniles occurred in September–October, followed by a decrease in number and variety in early and midwinter; an increase in number of inshore and diadromous species occurred in February and March, many of which were taken rather steadily throughout early spring along with the warm-water species which gradually returned at this time. Number and variety decreased again in early summer.

TABLE I. COMPARISON OF THE ENVIRONMENTAL CHARACTERISTICS AND THE STANDING CROP OF DEMERSAL FISH AT STS. 1 AND 3A.

	Station 1	Station 3A	Stations 1 & 3A
Location	1 mi SE Charles Is.	3 mi SSE Charles Is.	–
Depth	9 m	17 m	–
Bottom type	sand-shell	mud	–
Total area covered by net (m^2)	265,000	136,000	401,000
No. of tows VII/56–VII/57	41	24†	65
No. of species	36	25	37
No. of specimens	2,343	1,606	3,949
No. of fish/m^2	0.009	0.012	0.010
Total weight (g)	160,000	144,000	305,000
Standing crop (g/m^2)	0.60	1.06	0.76
Size range (mm)	19–470	22–335	19–470
10 commonest species:			
no./m^2 in $^0/_0$	89.8	90.7	90.0
g/m^2 in $^0/_0$	86.0	97.0	93.0
P. americanus:			
standing crop g/m^2	0.40	0.72	0.50
$^0/_0$ of total standing crop	65.6	67.3	66.7
Standing crop of species taken throughout year	0.45*	0.91*	0.60

† Tow No. 118 excluded.
* St. 1: *S. aquosus, P. americanus*; St. 3A: *M. bilinearis, S. aquosus, P. americanus.*

In contrast to the above findings, the variation in weight of fish from both stations was somewhat proportional to the variation in total weight of *P. americanus*. The importance of the winter flounder in the total weight of the catch is emphasized when it is realized that this species averaged 67 °/₀ by weight of the total, but only 45 °/₀ by number. A gradual increase in weight of total

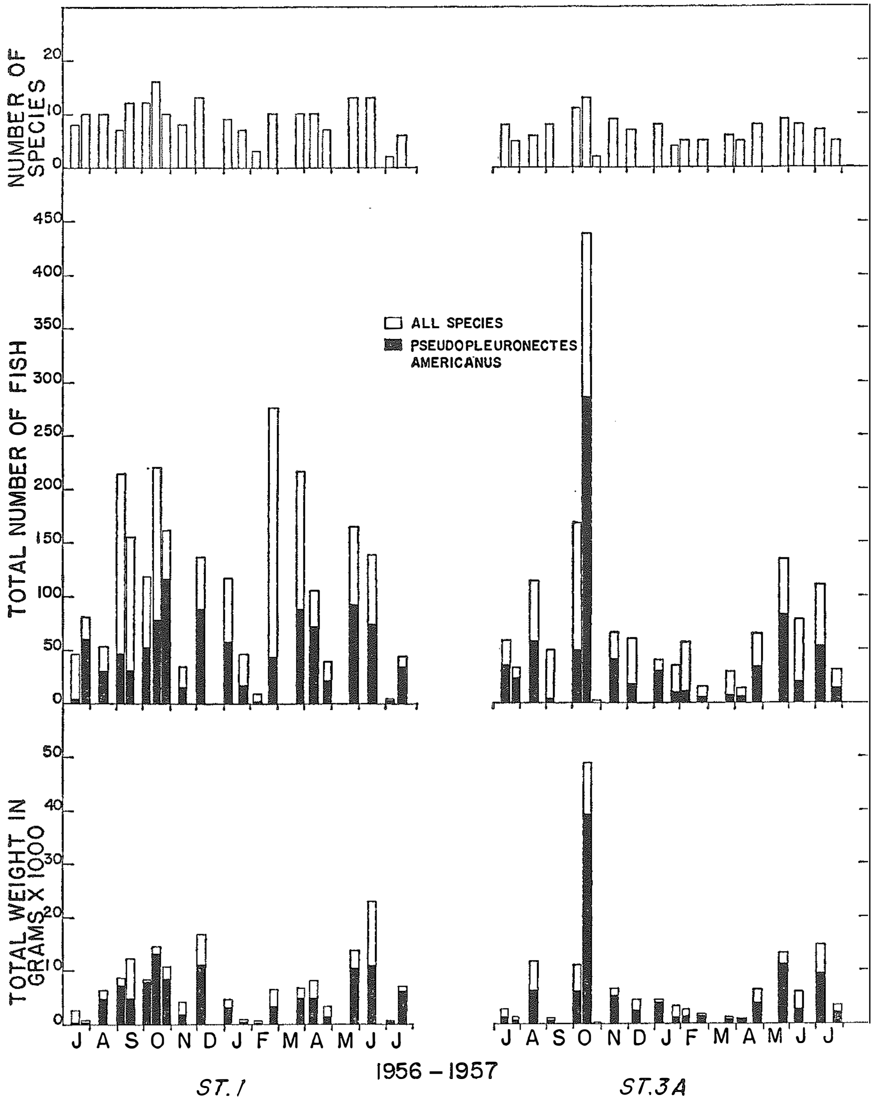

Figure 1. Catch by weight and number of all fish species and of the most abundant species, *Pseudopleuronectes americanus*, from Sts. 1 and 3A.

fish occurred throughout late summer and fall. Decrease in winter resulted from the absence of adult flounders, and their reappearance contributed to the gradual spring increase. The other large adult species which contributed most of the peaks of late fall and late spring were *Raja erinacea* and *Tautoga onitis*.

As Fig. 1 shows, the fluctuations in number and weight of fish at St. 1 were greater than at St. 3A. In spring and summer the difference between the stations was small, but in fall a greater number of smaller individuals was taken at St. 1. As we have already noted from the statistical analysis, the greatest difference was apparent during winter months. Fish at St. 1, moving in and out of the shallower sand-shell area at a fairly rapid rate, varied in number, variety, and size far more than at St. 3A.

The approximate total weight of all fish netted at both stations was at least 3.0×10^5 g, composed of fish ranging in weight from 0.04 to 1,250 g. This total is low because weight measurements were unobtainable for a small proportion of the fish[2]. From the boat's known speed of two knots, the fishing width of the net (approximately 11.3 feet)[3], and the length of time of the tow, it is possible to estimate that a tow covers 3,350 m^2. Since 65 tows were made at both stations, we arrive at an average figure for the standing crop of bottom fish in L.I.S. of at least 0.76 g/m^2; the ten commonest species constituted 93% of the total. At St. 1 the standing crop was at least 0.60 g/m^2; at St. 3A it was at least 1.1 g/m^2.

The average number of fish is $0.010/m^2$ and the 10 commonest species constituted 90% of the total. At St. 1 there was 0.009 fish/m^2, and at St. 3A, 0.012 fish/m^2 (or about one fish/100 m^2). Since the 10 commonest species constituted almost the same percentage by number at St. 1 as at St. 3A, although slightly smaller percentage by weight, the population at St. 1 obviously contained a larger proportion of the smaller fish.

The average total standing crop is about 11% of the standing crop of demersal fish in the English Channel, and less than 9% of the value for Block Island Sound. It is only 10% of that found by Clark (1959) for the Highlands Ground, 10 miles NE of Provincetown, Massachusetts in 56–62 fathoms. Possibly the catch of the 20-ft net used in L.I.S. should not be compared with that of a commercial-sized net (Bullis, personal communication, IV–6–55), but until figures from commercial operations in L.I.S. are available, the above must suffice.

Statistical Analysis of the Catch. The catches from both stations were statistically analysed. Not only does such an analysis permit greater facility in handling the data from both sets of hauls from St. 1, so long as they do not differ significantly, but also it allows comparisons between Sts. 1 and 3A.

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[2] Some weights were also figured on the basis of length-weight relationships.

[3] Figured on the basis of 56% of the total width of the mouth (Merriman and Warfel, 1948).

Tows at St. 1 made in an easterly direction and those which were made shortly afterwards in a westerly direction were grouped separately. These pairs of tows are compared by total catch and by the total number of each species taken on each date. The first set of hauls from St. 1 is compared in the same manner with the first set of hauls from St. 3A. The second set of hauls from St. 3A was too infrequent to warrant comparison with the first set of hauls from the same station.

Before treatment of the data by the analysis of variance, two adjustments were made. Since the standard deviation of the mean of the total catch of each group of hauls varied proportionately with the mean, and since there were zero values in most of the tests, a log $(X+1)$ transformation was necessary (Quenouille, 1950). In the analysis of the total number of species taken on each date at St. 1 and at St. 3A it was sufficient to use a simple log transformation because there were no zero values. After the transformation was applied to the catch data, whether listed by total catch of each species or by catch of all species on each date, the standard deviation varied much less with the mean. Even so, the distribution of the catch within each group of hauls was not completely normalized. Such normalization should be achieved before further use of the analysis of variance, but unfortunately this condition seldom is realized in this type of study (M. Bagenal, 1955).

COMPARISON OF 19 PAIRS OF SUCCESSIVE HAULS FROM ST. 1. The analysis of variance using the transformed data showed no significant differences between the total catch of the east and of the west hauls at St. 1, whether the data were treated by total catch per date or by total catch per species. This result allows future combination of the catches from both sets of hauls (Table III A, B).

Within the first group of hauls in an easterly direction, and within the second group made in a westerly direction, there were large variations in the catch of a given species from sample to sample regardless of date. In fact, the variations in catch of a given species were greater, as expected, than the variations between two successive samples of the same date. These large fluctuations within each group of hauls may be sufficient to create the large residual error which is noted when the total catch data for all samples are compared. As seen in Table IIIA (the test of the total catch) the residual mean square is almost as large as the mean square of the comparison between samples taken on any given date. Apparently the variations in the catch of each species concealed seasonal fluctuations in total catch of all species. In contrast, note the small residual error in the test concerning the variations in total number of species (Table IIIB).

The possible effects of tidal current direction and of wind on the catch from St. 1 were also examined. In the area of towing, the current varies between zero and two knots, depending on the stage of the tide. The results were not significantly modified, whether the net was towed with the current, or

TABLE II. Tows with a 20-Foot Trawl at Sts. 1 and 3 A in Long Island Sound, 1956–57.

Date	Tow	Hour	Dir. of Haul	Depth (feet)	Bottom sand-s shell-sh mud-m	Tide	Wind		Weather	No. Spp.		No. Indiv.	
							Dir.	Sp.*					
STATION I													
VII–17–56	50	0901–0931	E	30	s-sh	H-going	–	0	clear	2	8	3	47
”	51	0947–1017	W	35	s-sh	H-going	SW	1	cloudy	8		44	
VII–31–56	54	0850–0920	E	30	s-sh	L-going	NE	1	clear	10	10	78	82
”	55	0936–1006	W	35	–	L-going	NE	1	clear	3		4	
VIII–14–56	58	0900–0930	E	30	m, s-sh	L-going	W	1	cloudy	4	10	13	54
”	59	0943–1013	W	31	m, s-sh	L-going	W	2	cloudy	8		41	
IX–6–56	62	0907–0937	E	30	m, s-sh	H-coming	S	2	clear	4	7	–	214
”	63	1007–1037	W	30	–	H-coming	S	2	clear	7		–	
IX–18–56	65	0940–1010	E	30	s-sh	H-slack	NW	5	clear		12		155
X–2–56	67	0900–0930	E	30	–	H-slack	N	1	clear	11	12	88	123
”	68	0952–1022	W	30	–	H-going	N	1	clear	6		35	
X–16–56	70	0900–0930	E	30	s-sh	H-going	NW	0.5	hazy	14	16	177	222
”	71	0955–1025	W	30	s	H-going	NW	0.5	hazy	8		45	
X–30–56	73	0900–0930	E	>30	s-sh	H-going	NE	2	cloudy	10	10	106	112
”	74	1005–1025	W	>30	s-sh	H-going	NE	2	cloudy	3		6	
XI–14–56	77	0900–0930	E	>30	s-sh	H-going	SW	0.5	cloudy	1	8	–	34
”	78	1010–1040	W	>30	s-sh	M-going	SW	3	cloudy	8		34	
XII–4–56	81	0900–0930	E	35	s-sh	H-going	SW	2	clear	6	13	14	136
”	82	0945–1015	W	35	s-sh	H-going	SW	3	clear	11		122	
I–8–57	85	0910–0940	E	29	–	L-going	NW	1	clear	6	9	64	117
”	86	0957–1027	W	30	–	L-slack	NW	2	clear	6		53	
I–25–57	88	0905–0935	E	31	s-sh	H-going	E	1	cloudy	7	7	17	46
”	89	0955–1025	W	31	s-sh	H-going	E	1	cloudy	5		29	
II–5–57	91	0905–0935	E	30	s-sh	L-coming	NW	2	cloudy	4	4	12	14
”	92	0950–1020	W	30	s-sh	M-coming	NW	2	cloudy	1		2	
II–26–57	95	0913–0943	E	35	s-sh	H-slack	E	0.5	foggy	9	10	174	276
”	96	0955–1025	W	35	s-sh	H-going	–	0	foggy	6		102	
III–22–57	98	0902–0932	E	31	s-sh	M-coming	NW	1	clear	8	10	110	217
”	99	0950–1025	W	31	s-sh	M-coming	NW	1	clear	9		107	
IV–11–57	101	0940–1010	W	35	s-sh	H-going	SW	2	clear	10	10	57	105
”	102	1030–1100	E	35	s-sh	H-going	SW	2	clear	5		48	
IV–26–57	104	0905–0935	E	34	s-sh	H-going	–	0	cloudy	6	7	14	39
”	105	0945–1015	W	34	s-sh	H-going	–	0	cloudy	7		25	
V–27–57	108	0855–0935	E	35	s-sh	H-slack	SW	1	cloudy	9	13	69	165
”	109	0940–1010	W	35	s-sh	H-going	SW	1	cloudy	12		96	
VI–13–57	111	0905–0935	E	30	s-sh	L-coming	NE	2	clear	8	13	68	138
”	112	0955–1025	W	30	s-sh	L-coming	NE	1	clear	9		70	
VII–10–57	115	0907–0937	E	30	s-sh	H-coming	NW	3	clear	0	2	0	3
”	116	0950–1020	W	30	s-sh	H-slack	NW	3	clear	2		3	
VII–23–57	119	0912–0942	E	35	s-sh	H-going	–	0	cloudy	3	6	13	44
”	120	0957–1027	W	35	s-sh	H-going	–	0	cloudy	5		31	
Total	41												
STATION 3A													
VII–17–56	53	1518–1548	NE	55	m	M-coming	WNW	2	cloudy		8		59
VII–31–56	57	1455–1525	NE	50	–	H-coming	SW	2	clear		5		39
VIII–14–56	61	1445–1515	NE	55	m	M-coming	NW	4	cloudy		6		114
IX–6–56	64	1447–1517	NE	–	m	H-going	S	2	clear		8		50
X–2–56	69	1450–1520	NE	50	–	H-slack	S	1	clear		11		168
X–16–56	72	1420–1453	NE	50	m	L-slack	–	0	hazy		13		438
X–30–56	76	1515–1545	NE	50	m	L-going	E	2	clear		2		2
XI–14–56	80	1500–1530	NE	50	m	L-going	SW	2	clear		9		67
XII–4–56	84	1500–1530	NE	50	m	M-going	NW	>3	clear		7		61
I–8–57	87	1517–1547	NE	50	m	H-coming	NW	3	clear		8		40
I–25–57	90	1100–1130	NE	50	m	L-coming	E	2	cloudy		4		35
II–5–57	93	1405–1435	NE	>50	m	H-coming	–	0	cloudy	–	5	–	57
”	94	1450–1520	E	<50	s-m**	H-slack	SE	1	cloudy	–		–	
II–26–57	97	1410–1440	NE	50	–	L-going	E	–	foggy		5		15
III–22–57	100	1430–1500	–	50	s-m**	H-coming	SW	2	cloudy		6		29
IV–11–57	103A	1425–1500	NE	50	**	L-slack	SW	3	clear	5	5	6	14
”	103	1525–1555	SW	50	**	L-going	SW	3	clear	5		8	
IV–26–57	106	1050–1120	NE	–	m	M-going	SE	0.5	cloudy	7	7	29	65
”	107	1255–1325	SW	–	s	L-going	SE	0.5	fog	7		36	
V–27–57	110	1420–1450	NE	50	s-m	L-going	SW	3	cloudy		9		134
VI–13–57	113	1050–1120	NE	50	–	H-slack	NE	1	clear	–	8	–	78
”	114	1140–1210	SW	50	–	H-going	NE	1	clear	–		–	
VII–10–57	117	1337–1407	NE	50	m	M-going	NW	4	clear	7	7	110	144
”	118††	–	N	<50	s, m	L-going	NW	4	clear	6		34	
VII–23–57	121	1340–1410	NE	50	m	L-going	NW	1	cloudy		5		31

* Beaufort scale. ** Approximately 0.5 to 1 mile east of usual position. †† Between Sts. 1 and 3A.

TABLE III. RESULTS OF THE ANALYSIS OF VARIANCE ON 19 PAIRS OF SUCCESSIVE HAULS FROM ST. 1 and 20 PAIRS OF HAULS FROM Sts. 1 and 3A, BY TOTAL CATCH PER DATE, NUMBER OF EACH SPECIES, AND NUMBER OF SPECIES PER DATE.

Total catch per date

	A. 19 pairs of hauls from St. 1			C. 20 pairs of hauls from Sts. 1 and 3A		
	Deg. freed.	Mean square	Var. ratio	Deg. freed.	Mean square	Var. ratio
Among samples (dates)	18	0.4579	1.154	19	0.2766	0.645
Between sets of hauls	1	0.0362	0.091	1	0.1380	0.322
Residual error	18	0.3968	–	19	0.4291	–
Total	37	–	–	39	–	–
Coefficient of variation	45.1 %			39.3 %		

Total catch of each species

	B. 19 pairs of hauls from St. 1			D. 20 pairs of hauls from Sts. 1 and 3A		
Among samples (species)	35	0.7895	14.620	36	0.7808	2.83
Between sets of hauls	1	0.0362	3.593	1	0.3232	1.17
Residual error	35	0.0540	–	36	0.2759	–
Total	71	–	–	73	–	–
Coefficient of variation	55.7 %			53.3 %		

Total number of species per date

E. 20 pairs of hauls from Sts. 1 and 3A

	Deg. freed.	Mean square	Var. ratio
Among samples (dates)	19	0.1957	1.85
Between sets of hauls	1	0.0002	0.002
Residual error	19	0.1055	–
Total	39	–	–
Coefficient of variation	44.3 %		

against it. The effects of wind direction and force were not thoroughly tested, since the necessity for reasonably good weather for the operations precluded many tows in easterly winds or in really strong westerlies. The wind varied in strength from zero to force five during the time of towing, and ranged through all points of the compass, but there was no evidence that wind affected the catch.

COMPARISON OF 20 PAIRS OF HAULS FROM STS. 1 AND 3A. The analysis of variance applied to the data from Sts. 1 and 3A produced results similar to those from the successive hauls at St. 1 only. There were no significant differences between the two localities when the samples were treated by total catch, total number of each species, or by total number of species taken on each date (Table III C, D, E), but there was a significant difference in the number of a particular species taken in each sample within each group of hauls (Table III D). As in the test on the hauls from St. 1, the difference in number of each species in each tow seemed to mask any seasonal effects, and was large enough to produce the high residual error which is apparent when the data are treated by total catch (Table III C).

A comparison of the catches of winter and summer hauls showed that the number of species taken on a specific date was not significantly different at either station, but that a greater over-all variation between winter and summer existed at St. 3A. During the summer a few species sought the slightly deeper area of St. 3A, and more species were found there than at St. 1. In the winter the opposite condition was found. Many common sublittoral species seldom ventured farther than St. 1, thus producing a more varied and less stable population at this station in winter, while at this time only a few residents were found at St. 3A.

The coefficients of variation lie within the range of those of Barnes and Bagenal (1951) for catches from an inshore ground off Great Britain, even after being refigured according to Bagenal (1958). However, the hypothesis presented by Barnes and Bagenal, that the catch of one haul needs to be near one-third as much as or three times greater than the catch of another haul in order to differ significantly, may also apply to hauls from L.I.S.

Index of Heterogeneity for Sts. 1 and 3A. A crude comparison of the catch as an indication of the community structure at the two stations was based on Margalef's (1958) analysis, which utilized indices of diversity and heterogeneity. This is $d = S - 1 / \log_e N$, where S is the number of species and N is the number of individuals. The heterogeneity index is $H = {}^{d}\mathrm{St.}\ 1 + \mathrm{St.}\ 3A \,/\, {}^{d}\mathrm{St.}\ 1 + {}^{d}\mathrm{St.}\ 3A$. If the two communities are really distinct, this analysis might indicate a difference more accurately than does the analysis of variance, which is hindered by both a non-normal distribution and the large residual error. Therefore three tests were made. The catch data from consecutive dates at both St. 1 and St. 3A were pooled separately for each station, and then compared with the combined data from both stations for each date. This method should indicate whether the combined data from both stations were more heterogeneous than the pooled data from each station; if so, the two communities would differ from one another in some manner.

However, results of this analysis showed little difference in heterogeneity indices between Sts. 1 and 3A (Table IV). Variations between dates at each station were almost as much as variations between the two stations on the same date. Evidently the intermingling which takes place between these two areas is sufficiently widespread to prevent separation into two geographical communities by the use of this method.

TABLE IV. HETEROGENEITY INDICES OF POOLED DATA FROM ST. 1 AND FROM ST. 3A COMPARED WITH COMBINED DATA FROM BOTH STATIONS.

Date 1956–57	St. 1	St. 3A	Date 1956–57	Sts. 1 & 3A
VII–17, 31	0.68	0.62	VII–17	0.70
VII–31/VIII–14	0.71	0.51	VII–31	0.39
VIII–14/IX–6	0.68	0.54	VIII–14	0.93
IX–6/X–2	0.56	0.45	IX–6	0.70
X–2/X–16	0.56	0.77	X–2	0.69
X–16/X–30	0.60	0.64	X–16	0.70
X–30/XI–14	1.15*	0.56	X–30	0.57
XI–14/XII–4	1.00*	0.54	XI–14	1.17*
XII–4/I–8	0.58	0.69	XII–4	0.56
I–8/I–25	0.55	0.57	I–8	0.64
I–25/II–5	0.64	0.58	I–25	0.81
II–5/II–26	0.61	0.55	II–5	0.55
II–26/III–22	0.51	0.62	II–26	0.66
III–22/IV–11	0.57	0.46	III–22	0.53
IV–11/IV–26	0.57	0.56	IV–11	0.54
IV–26/V–27	0.60	0.51	IV–26	0.58
V–27/VI–13	0.51	0.43	V–27	0.51
VI–13/VII–10	1.00*	0.42	VI–13	0.66
VII–10/VII–23	1.00*	0.54	VII–10	1.02*
			VII–23	0.67

* The net at St. 1 was not fishing correctly.

Species Composition of the Catch, and Notes concerning Important Species. The demersal fish in our catch may be divided into the two categories of residents and migrants, and both groups may be further subdivided. Residents, which were taken in greater quantity than migrants, comprise (1) species which are found throughout the year and apparently move randomly or exhibit only slight offshore-onshore movements; (2) species found in some or most of the tows but which exhibit an offshore-onshore seasonal movement; (3) sublittoral species which also exhibit offshore-onshore movements. Migrants, which constituted 17% of the catch, include: (1) species which come from lower latitudes in the warm weather; (2) species which come from the east, chiefly in cold weather; (3) diadromous species which appear in fall and winter, primarily in the shallower zone (Table V).

Special mention should be made of *A. mitchilli*, which may be a resident with an offshore-onshore seasonal movement. Juveniles 20 to 35 mm in length occurred in the fall in enormous quantities at St. 1; they were not collected quantitatively because many escaped through the mesh of the net and fell onto the deck and into the water. Juveniles occurred in such small quantities at St. 3A that all were recorded. As a result, only the adults from St. 1, together with the few juveniles from St. 3A, were recorded. This accounts for the small quantity of this abundant species listed under St. 1 in Table V. Since adult anchovies may not be taken successfully with otter trawls, one would not expect many of them to appear in these catches.

Of the residents present throughout the year, *P. americanus* appeared in all but one tow, and was less abundant at St. 1 than at 3 A. Nevertheless, the range in size was greater at St. 1, and during the fall and winter months younger fish were taken there in greater numbers. The 0-year class was absent from St. 1 catches in summer[4], appeared in September, and increased in number throughout the winter to a peak in March. At St. 3 A only an occasional 0-year class fish appeared in fall. The 1-year class was present at both stations throughout the year. At St. 1 it was most abundant in the fall, fluctuated through the winter, and decreased in abundance during March, while at St. 3 A it decreased steadily during the winter from a high in the fall. An increase of this age group at 3 A in the spring, simultaneous with a decrease at St. 1, indicated a slight scattering offshore of the 0-year class, which by this time had renewed its growth and entered the 1-year class. The 2-year class was present at both stations primarily in fall and spring. Its midwinter decrease at St. 1 was precipitous and of short duration (January–February), whereas a steady decline in numbers took place at 3 A over a longer period (November–March). Older fish, as previously mentioned, decreased in abundance at both stations during the winter, but more gradually at St. 3 A. They probably migrated to spawning grounds, which are primarily in water shallower than that at St. 1.

Another resident, *S. aquosus*, was far less numerous than *P. americanus* or even less than some of the migratory species. Although less abundant at St. 1, the number fluctuated less than at St. 3 A. Specimens of all sizes were taken at both stations, in a more irregular pattern than the winter flounder exhibited. The younger fish of the 0-year class, with a wide range in length, as well as those of the 1-year class, appeared at both stations during the spring and in October; older fish were more abundant in the winter.

A third resident, *M. bilinearis* (only 0- to 2-year olds), appeared somewhat seasonally. This species was not present in midwinter or midsummer at St. 1, but was taken in all but one tow at 3 A, outnumbering *S. aquosus* there. During the spring 0-year class fish appeared at St. 3 A along with 1-year olds which had remained there throughout the winter, and both age groups gradually reappeared at St. 1. In summer a group of 2-year olds appeared at both stations, remained through the fall, and then were gone.

Three common residents, *Raja erinacea*, *Tautogolabrus adspersus*, and *Prionotus carolinus* appeared at both stations somewhat seasonally. At St. 1 none of these was caught in midwinter, and only *T. adspersus* and *P. carolinus* were taken in midsummer. At 3 A *R. erinacea* was present in winter, but the other two species were not taken then. In midsummer at St. 3A, only *T. adsper-*

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[4] Specimens as small as 12 mm were present in dredge samples from St. 1 in summer 1960.

TABLE V. Species from St. 1 and from St. 3A, taken by Trawl from July 17, 1956 to July 23, 1957.

	Station 1				Station 3A			
Species	Total No.	Total Wgt. (g)	Size Range (mm)	Date and number taken (both tows)	Total No.	Total Wgt. (g)	Size Range (mm)	Date and number taken (both tows)
Raja erinacea	35	+11,430	42.5–470	VII–17(2); X–2(1), 16(3), 30(3); XI–14(4); XII–4(7); I–8(1); III–22(2); IV–11(3), 26(2); V–27(1); VI–13(6).	12	–	96–+400	VII–17(1); X–16(6); I–8(1), 25(4).
Clupea harengus	7	4	33.9–232	I–25(1); II–26(1); III–22(5).	24	163	49–121	I–8(1); II–5(9); III–22(12); IV–11(2).
Alosa pseudoharengus	9	73	57.6–101	XII–4(6); III–22(3).	0	–	–	–
Alosa aestivalis	2	4	56.8, 60.1	II–26(1); III–22(1).	1	4	60	III–22(1).
Brevoortia tyrannus	29	116	16.2–305	XI–14(2); I–25(9); II–26(17); VI–13(1).	1	11	101	XII–4(1).
Anchoa mitchilli	4*	–	63–76*	IX–18(many); X–2(many +1), 16(many), 30(many +2), XI–14(many); XII–4(1).	23	–	Juvenile	IX–6(18); X–2(5).
Osmerus mordax	2	52	136.5, 147.8	I–8(1), 25(1).	1	51	168	II–26(1).
Conger oceanica	1	19	263	III–22(1).	0	–	–	–
Merluccius bilinearis	106	2,911	73.5–296	VII–17(17), 31(4); X–16(1), 30(5); XI–14(1); XII–4(8); II–26(17); III–22(10); IV–11(1); V–27(25); VI–13(17).	310	13,519	77–276	VII–17(5), 31(5); VIII–14(17); IX–6(3); X–2(57), 16(25); XI–14(2); XII–4(29); I–8(2), 25(3); II–5(33), 26(6); III–22(4); IV–11(3), 26(5); V–27(38); VI–13(35); VII–10(28), 23(10).
Pollachius virens	2	1	38.9, 47.4	IV–26(2).	0	–	–	–
Enchelyopus cimbrius	1	68	211	V–27(1).	18	1,031	146–250	VII–17(4), 31(2); VIII–14(4); X–16(2); XI–14(1); XII–4(3); II–26(1); VII–23(1).
Urophycis chuss	19	437	85.9–193.4	X–2(3), 16(4), 30(4); XI–14(1); XII–4(2); V–27(4); VI–13(1).	99	8,552	97–335	VII–17(5), 31(4); VIII–14(6); X–2(13), 16(43), 30(1); XI–14(11); XII–4(7); III–22(1); IV–26(1); V–27(2); VI–13(5).
Urophycis regius	15	335	56.1–195	VII–31(1); VIII–14(2); IX–18(1); IV–11(2); V–27(4); VI–13(5).	23	792	57–251	X–2(1), 16(1); I–8(1); IV–26(6); V–27(2); VI–13(4); VII–10(3), 23(5).
Apeltes quadracus	4	6	43–53	II–5(3), 26(1).	0	–	–	–
Syngnatus fuscus	9	9	88–160.6	IX–18(1); X–2(1), 16(3); XII–4(1); IV–11(3).	3	4	125–189	IV–26(3).
Menidia menidia	33	100	57.3–116.9	XII–4(1); I–8(28), 25(4).	3	12	67–100	I–8(1); II–5(1); IV–11(1).
Cynoscion regalis	0	–	–	–	48	107	22–83	IX–6(20); X–2(15), 16(13).
Stenotomus chrysops	316	1,967	28–146	VII–17(7), 31(1); VIII–14(7); IX–6(133), 18(50); X–2(47), 16(45), 30(8); XII–4(1); V–27(15); VI–13(1); VII–23(1).	24	1,029	63–154	IX–6(2); X–2(16), 16(4); V–27(2).
Centropristes striatus	25	17	19.1–43.8	IX–6(4), 18(14); X–2(1), 16(6).	0	–	–	–
Gobiosoma ginsburgi	1	4	27	X–16(1).	0	–	–	–

(Cont.)

(Cont.)

TABLE V. (Cont.)

STATION 1 (Cont.)

Species	Total No.	Total Wgt. (g)	Size Range (mm)	Date and number taken (both tows)
Tautogolabrus adspersus . . .	44	4,642	36.5–220	VII–17(4), 31(5); VIII–14(2); IX–18 (4); X–30(1); XII–4(2); IV–11(2), 26(1); V–27(4); VI–13(14); VII–10 (1), 23(4).
Tautoga onitis	16	+3,556	109–370	VII–17(2), 31(3); VIII–14(1); I–8(1), V–27(4); VI–13(5).
Ammodytes americanus	320	1,373	66–129	I–8(22), 25(20); II–5(7), 26(179); III–22(92).
Pholis gunnellus	3	13	59–118.1	II–26(1); IV–11(2).
Poronotus triacanthus	3	5	30–48.5	VIII–14(3).
Prionotus carolinus	143	1,104	21–230	VII–17(2), 31(1); VIII–14(5); IX–6 (15), 18(19); X–2(8), 16(66), 30(16); XI–14(5); V–27(5); VII–23(1).
Prionotus evolans	3	549	183.6–235	VIII–14(1); V–27(1); VI–13(1).
Myoxocephalus aeneus	20	606	72.2–134.9	I–8(1), 25(5); II–26(4); III–22(2); IV–11(8).
Myoxocephalus octodecimspinosus	4	705	230–275	XII–4(1); IV–11(2), 26(1).
Paralichthys oblongus	8	218	54.8–243	IX–18(2); X–2(1), 16(4); V–27(1).
Paralichthys dentatus	3	+1,500	209.5–356	X–16(1); VII–23(2).
Scophthalmus aquosus	132	15,296	36.2–287	VII–17(9), 31(2); VIII–14(2); IX–6 (12), 18(2); X–2(1), 16(2), 30(4); XI–14(6); XII–4(17); I–8(5); II–5(2), 26(12); III–22(13); IV–11(11), 26(9); V–27(8); VI–13(12); VII–23(3).
Etropus microstomus	12	76	39.5–99.8	VII–31(1); IX–6(1); X–2(1), 16(5), 30(3); XII–4(1).
Pseudopleuronectes americanus	965	105,232	48.6–340	VII–17(4), 31(62); VIII–14(30); IX–6(48), 18(31); X–2(53), 16(79), 30(66); XI–14(15); XII–4(88); I–8(57), 25(6); II–5(2), 26(43); III–22(88); IV–11 (71), 26(21); V–27(92); VI–13(74); VII–10(2), 23(33).
Trinectes maculatus	2	–	136	VII–31(2).
Sphaeroides maculatus	40	241	29.4–125	VIII–14(1); IX–6(1), 18(30); X–2(5), 16(2); VI–13(1).
Lophius americanus	2	+6,800	609	IX–18(1); I–8(1).

* Juveniles neither counted nor measured.

STATION 3A (Cont.)

Total No.	Total Wgt. (g)	Size Range (mm)	Date and number taken (both tows)
45	6,045	39–232	VII–17(1), 31(1); VIII–14(16); X–2(1), 16(3); XI–14(3); IV–26(7); V–27(1); VI–13(2); VII–10(10).
5	3,530	163–240	VII–17(1); IV–26(1); V–27(1); VII–10(2).
0	–	–	–
0	–	–	–
5	52	21–100	IX–6(1); X–2(3), 16(1).
23	59	65–102	X–16(16), 30(1); XI–14(3); XII–4(1); V–27(2).
1	339	235	VI–13(1).
0	–	–	–
1	65	178	XI–14(1).
19	795	36–255	IX–6(1); X–2(1), 16(14); XI–14(1); VI–13(2).
2	+1,100	306–356	VII–10(1), 23(1).
115	12,837	25–270	VII–17(6); VIII–14(13); IX–6(1); X–2(7), 16(23); XI–14 (4); XII–4(3); I–8(3), 25(18); II–5(3), 26(2); III–22(3); IV–11(2), 26(8); V–27(3); VI–13(9); VII–10(7).
0	–	–	–
796	97,444	36–275	VII–17(36), 31(24); VIII–14(58); IX–6(4); X–2(49), 16(287); XI–14(41); XII–4(17); I–8(30), 25(10); II–5(11), 26(5); III–22(8); IV–11(6), 26(34); V–27(83); VI–13(20); VII–10(59), 23(14).
0	–	–	–
0	–	–	–
1	–	195	I–8(1).

sus was found. All sizes of *T. adspersus* were collected at both stations. Small ones appeared in the early spring, and in fall these were more abundant at St. 1 than at 3A. *P. carolinus* of the 0-year class were taken primarily at St. 1 in the fall. A few individuals of older age groups were taken at both stations in spring and summer.

Urophycis chuss of the 0- to 2-year old categories may be residents; the adults are migratory. All sizes of this species were present at both stations in spring and fall but they were far more abundant at 3A than at St. 1. Small numbers of the 0-year class appeared in the fall at both stations. One- and 2-year olds were present at both stations in the spring, and the oldest fish appeared in the fall at St. 3A.

Ammodytes americanus, 0- to 1-year old, were found in large numbers in winter at St. 1. Of the other sublittoral species which were taken from St. 1 in the cold half of the year, only *Menidia menidia* and *Syngnathus fuscus* occasionally found their way into the deeper waters of St. 3A.

Twice as many migrants from the south were taken at St. 1 as at 3A. In the fall many more juvenile migrants than residents were caught, which is understandable when the size and concentration of their schools are considered. Most of these fish (*Cynoscion regalis*, *Poronotus triacanthus*, *Centropristes striatus*, for example) were 0- to 1-year old, and some (notably *Stenotomus chrysops*) may have hatched from eggs spawned in the Sound during the summer. Unlike the others, young *Urophycis regius*, provisionally assigned to this category until more is known of its life history, was captured more abundantly at both stations in spring than fall; the 0-year *U. regius* arrived in April, and older fish were present in October.

Migrants from the east were not abundant at either station and appeared primarily in winter. Of these, *Clupea harengus* and *Lophius americanus* were immature specimens whereas all *Myoxocephalus octodecimspinosus* were adult.

A few anadromous species were taken in winter, almost exclusively at St. 1; all were juveniles with the exception of *Osmerus mordax*. A few species may be somewhat pelagic (i. e., *Alosa* sp.), and an otter trawl may not be the most efficient means of catching them.

Community Structure. Attempts were made to define the structure of this demersal fish population, utilizing MacArthur's (1957) hypothesis of non-overlapping niches as a measure of community heterogeneity. According to this hypothesis[5], the divergence of the observed data from the calculated, when

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[5] MacArthur has compared the environment to a stick of unit length on which $n-1$ points are thrown at random. The stick is broken at these points, and the lengths of n segments are proportional to the abundance of n species, giving a situation wherein the expected abundance of rth rarest species among n species and m individuals is

$$m/n \sum_{i=1}^{r} \left[1/(n-i+1) \right] .$$

species are ranked from commonest at the left to rarest at the right, is a measure of the heterogeneity of the population. According to MacArthur a curve that is steeper than the predicted one (too many common species and too few rare ones) indicates a composite community. When a census is broken down, on the basis of factors which might produce heterogeneity, the curves are sometimes in better agreement. The results of such an analysis of the data from L.I.S. are shown in Fig. 2, which includes the two curves for the total data from all tows from both stations.

The divergences between the calculated and observed curves are equally large at each station. If MacArthur's assumption is correct, and the divergence indicates composite communities, this could arise from many factors. The most important to be considered in this situation are the behavioral characteristics of the fish, their food, and the type of gear used to sample the population.

The curve from St. 1 was not changed by sorting the catch according to season, nor by separating demersal from semi-demersal, nor residents from

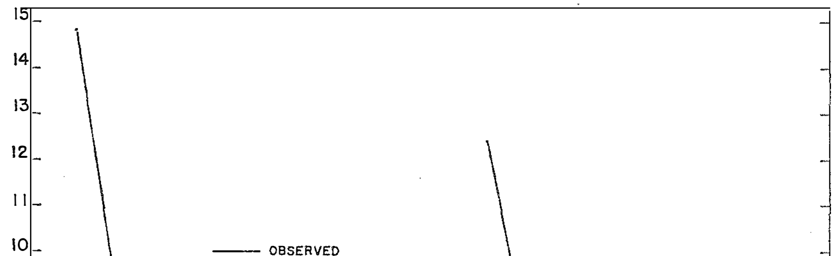

Figure 2. The observed abundance of fish species from Sts. 1 and 3A, ranked from commonest, on the left, to rarest, on the right, plotted for comparison with the expected abundance; based on MacArthur's (1957) first hypothesis of non-overlapping niches; see equation, ftn. 5.

migratory fish. Some change was noted, however, when each sample from each station was tested with and without *P. americanus*, which was not only the most abundant species, as has already been noted, but was distinctive in being the dominant polychaete consumer in the area (Richards, 1963; this issue). Because of its abundance, and its somewhat different feeding habits as compared with the crustacean feeders, this fish is temporarily treated as a separate entity in the population.

In four catches from each station the observed data differed little from the calculated. These catches were characterized by a smaller total catch, a small percentage of *P. americanus*, lack of marked abundance of any one species, and a low average number of individuals per species. They were made at each station during the absence of those species which exhibit the greatest fluctuations in abundance.

In the catches in which subtraction of *P. americanus* produced a change in the curves (nine of which have been recorded for St. 1 and eight for 3 A), the following characteristics were observed: (a) an unusually large number of species; (b) a high percentage of *P. americanus*; (c) no very abundant second species; and (d) sometimes a high average number of individuals per species because of the number of winter flounder. These catches occurred primarily in spring and fall when *P. americanus* was abundant in both areas.

Seven catches at each station belong to a group in which little change was produced by subtracting *P. americanus*. These showed a lower percentage of winter flounders, due to a high percentage of one or two other species. The tows were made at the time of influx of juvenile migrants in fall and of *A. americanus* and clupeoids in winter at St. 1; and when *M. bilinearis* was abundant at St. 3 A.

Catches from the same dates at the two stations frequently fell into different categories. Apparently an influx of a particularly abundant demersal or semidemersal species, or of many less common species, changed the situation at one station independently of the other. For instance, on February 26, 1957, at St. 3 A there were few species and no one was extraordinarily abundant, whereas at St. 1 *A. americanus* was so abundant that subtraction of *P. americanus* from the catch produced little change in the divergence of the curves. In the catch of June 13, 1957, there were so few species but so many *M. bilinearis* at St. 3 A that the divergence was large and *P. americanus* subtraction was without effect; on the same date St. 1 had many less abundant species and so many *P. americanus* that subtraction of this species significantly altered the curve. Composite communities, therefore, are produced from what may have been a homogeneous situation simply by the movement of a species. The commonest species (*M. bilinearis*, *S. chrysops*, *P. carolinus*, *A. americanus*, and *P. americanus*), when taken in abundance, either separately or together, may produce heterogeneity. Such complications were most evident during times of abundance of winter flounders, juvenile migrants, or sublittoral species.

Unlike bird populations, on which MacArthur's analysis was first employed, few L.I.S. fish display territorial behavior; instead the intermingling of species is very common. Under these conditions one possible mechanism for separation of species or schools of species is by feeding habits. Conceivably taxonomic grouping is not as good a measure of the community organization as grouping by feeding habits might be. Such a division awaits further analysis of the present data from the two areas in L.I.S.

Analyses made of catches taken with different kinds of gear in various areas include beach seine data from Morris Cove (Warfel and Merriman, 1944), trawl catches from Block Island Sound (Merriman and Warfel, 1948), and industrial trash fishery landings at Point Judith, Rhode Island (Edwards, 1958). All produced similar steep curves. Therefore it is doubtful that the type of net used in the present survey seriously influenced the curves shown in Fig. 2.

However, it is well to bear in mind two effects of net selectivity on the present analysis. Various modifications in a net can affect the catch, and an otter trawl is primarily designed to catch flatfish. Therefore we cannot be sure that the results of the analysis present a true picture of population heterogeneity; they may be, in effect, a result of sampling error. It is not possible at this time to estimate how much of the abundant catch of *P. americanus* is the result of gear selectivity. But, since *M. bilinearis* appears equally capable of producing heterogeneity when it is available in quantity, gear selectivity for winter flounder may be a minor consideration. Secondly, during a small proportion of the total drag-time, the net may pass through a dense school of juveniles, taking a disproportionate amount of one species. Under these circumstances the results will be confusing. Does gear selectivity only appear to change the community structure? Or are such aggregations large enough to produce heterogeneity in the population (due to the very lack of territoriality) so that the data give a true estimate of the situation? Further investigations of the demersal fish population along the lines mentioned above may help solve this dilemma.

DISCUSSION

The standing crop of demersal fish from L.I.S., as recorded from two stations, is less than that recorded for the English Channel and Block Island Sound (B.I.S.). Although L.I.S. has a larger standing crop of phytoplankton and a greater basic productivity than either of the other areas, these resources in terms of zooplankton and invertebrate fauna do not produce a population of large fish. The lack of efficient conversion has been discussed by Riley (1955). He felt that the high organic content of the mud which covers much of the bottom of the Sound, due to the inefficiency of the zooplankton feeders, fails to produce organisms which are successfully utilized for food by marketable fish. Although a greater standing crop of fish occurred on the mud bottom, only a small percentage of the total fish were adult specimens of marketable size.

The demersal fish population in L.I.S., based on the data from these two stations, consists of rather small specimens of many species, both residents and migrants, of which *P. americanus* is the most abundant. With the exception of *R. erinacea*, *T. onitis*, *S. aquosus*, and *P. americanus*, most of the specimens are either juveniles or species which never grow large. Even the largest specimens of these species are smaller than those to the eastward. It has been suggested that these species may be in the process of separating into different races (for *R. erinacea* in particular, see Merriman, *et al.*, 1953; and Richards, *et al.*, in press).

Competition among species or between fish and invertebrate epifauna may affect the growth rate and abundance of the fish. Competition for food between these two latter groups must await further studies of the feeding habits of the organisms concerned. Still another possibility might be competition for space on the desirable ground from the epifauna, particularly *Asterias forbesi*. This species is enormously abundant at times; and estimates (Burkenroad, 1945) for an area off Milford, Connecticut in less than 40 feet of water show 8.7 g/m^2 in average years to 157 g/m^2 in peak years – about 15 to 250 times the weight of fish from St. 1. When our hauls were made, a peak of abundance of starfish was rapidly approaching. Loosanoff (1958) estimated 16.3 starfish/m^2 for 1958 near Milford, which may be enough to affect the fish population. Whether these fluctuations in starfish numbers or biomass actually result in variations in fish abundance or growth rate remains to be investigated.

There may be additional physiological reasons for smaller fish inhabiting L.I.S. compared with B.I.S. and further east which are not yet understood. Experimental work is needed to determine whether the growth rates of these species are effected by changes in osmoregulation, metabolic rates, and thyroid activity due to environmental factors.

On the whole the demersal fish population of L.I.S. resembles that of other areas in southern New England. Elasmobranchs, gadids, cottids, and particularly pleuronectids are dominants, around which other species fluctuate in abundance. Comparison of data from Sts. 1 and 3A with older records from L.I.S. and B.I.S. (Bingham Oceanographic Laboratory, unpublished records; Merriman and Warfel, 1948) show interesting results. At Sts. 1 and 3A, *P. americanus* formed 45 % by number and 67 % of the weight of the catch. In 1943–46 *P. americanus* formed 41 % of the catch of L.I.S. by number and 42 % by number and 36 % of the B.I.S. catch by weight (see Table VI). The difference in abundance by weight is primarily due to the size of the other species in the catch. In B.I.S. large species (i. e., *Raja laevis*) were taken along with larger adults of the species which also appeared in L.I.S. Some of the smaller species from L.I.S. do not appear in B.I.S. Consequently the percentage by weight of *P. americanus* was less in the catch from B.I.S.

TABLE VI. COMPARISON OF PERCENTAGE OF TOTAL CATCH CONSISTING OF THE THREE MOST ABUNDANT SPECIES FROM B.I.S. AND L.I.S. IN 1943–46 AND FROM L.I.S. IN 1956–57.

	1943–1946				1956–1957					
	B.I.S.		L.I.S.		L.I.S.		L.I.S.: St. 1		L.I.S.: St. 3A	
Species	No.	Wgt.	No.	Wgt.	No.	Wgt.	No.	Wgt.	No.	Wgt.
P. americanus	42	36	41	–	45	66	41	65	50	70
S. aquosus	6	4	25	–	6	9	5	10	7	9
M. octodecimspinosus	21	13	–	–	–	–	–	–	–	–
R. erinacea	11	18	12	–	–	–	2	>8	–	–
M. bilinearis	–	–	–	–	11	5	–	–	19	9
S. chrysops	–	–	–	–	9	<2	14	2	–	–
A. americanus	–	–	–	–	–	–	13		–	–

Differences in the relative abundance of these species between these surveys are due to different sampling techniques, differences in the behavior of the fish, and possibly to real differences in abundance. For instance most nets used in 1943–46 would allow small fish, such as *A. americanus*, to escape, whereas the net used at Sts. 1 and 3A in 1956–57 did not. Some fish, such as *M. octodecimspinosus*, occur more frequently offshore and to the east; and some, such as *A. americanus*, occur more frequently in shallow water. The abundance of a few species appears to have changed. Juvenile *S. chrysops*, for instance, may have increased in L.I.S. in the last dozen years.

Within L.I.S. there are certain differences in the numbers of less abundant species depending upon the depth of water, type of bottom, seasons, etc., but the percentage of the commonest species, *P. americanus*, appears stable over a year's time on all types of bottom, whether sand-shell, mud, or eel grass.

The catches from Sts. 1 and 3A are essentially similar, yet two notable differences exist. The amount of fish taken at St. 1 is less, but the variety, consisting of species from more varied locales, is greater than that at St. 3A. The chief factors which account for the greater variety but smaller catch at St. 1 would appear to be temperature, distance from shore, bottom sediment, and quantity and quality of bottom fauna and zooplankton. Although bottom temperature differed little between the two places (Fig. 3), the one or two degrees of difference in winter and summer may have been sufficient to keep *R. erinacea*, *M. bilinearis*, and *U. chuss* in the deeper locality at these times. The distance between the two stations is only two miles, yet some of the sublittoral species seldom venture as far as St. 3A. As for bottom sediment as a factor, it should be noted that hard sand-shell areas, such as St. 1, support an epifauna dominated by crustaceans (Sanders, 1956), which are the chief food of the juvenile migrants and sublittoral species (Richards, 1963; this issue). St. 1 also has a large copepod population (Deevey, 1956) – the primary food of some species, such as *A. americanus*. But in spite of these differences in environmental factors between the stations, no statistical differences in the fish catch were noticed. The large fluctuations in abundance of nearly every fish species between samples concealed significant differences in the composition of the catch between localities.

All demersal fish were considered in the estimate of standing crop in these two areas of L.I.S. Perhaps the areas include two or more communities which should be estimated separately in the future, but no such estimates can be made until the reason for the superabundance of *P. americanus* is found. In some circumstances, intra-specific competition may limit the flounder abundance in different localities. At certain periods of the year inter-specific competition may be important. Such periods may include the fall when juvenile scup appear in large groups. The difficulty of a clear definition of the community is compounded by the temporary abundance of certain species, i. e., *A. americanus*, and our present inability to estimate the abundance of juvenile anchovies. The actual structure of the community is important when considering the population dynamics and biology of a single species, and also if in future, management of the Connecticut marine fishery becomes a necessity.

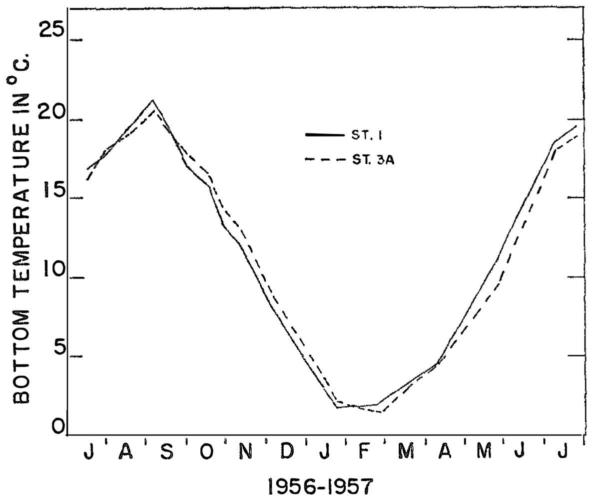

Figure 3. Comparison of the bottom water temperature, in °C, between Sts. 1 and 3A.

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Сара В. Ричардс

ДЕМЕРСАЛЬНОЕ НАСЕЛЕНИЕ РЫБ В ПРОЛИВЕ ЛОНГ ИСЛАНД. 1. СОСТАВ И ОТНОСИТЕЛЬНОЕ ОБИЛИЕ ВИДОВ В ДВУХ МЕСТАХ ПРОЛИВА. 1956-1957.

Краткий обзор

Демерсальныя рыбы были пойманы оттер-тралами между июнем 1955 и июлем 1957 года в проливе на станции 1 на глубине в 9 метров с дном из песка и раковин и на станции 3А на глубине в 17 метров с илистым дном. Уловы сделанные между 17 июля 1956 года и 23 июля 1957 года были квантитативно аналзироаны.

Биомасса демерсалъных рыб равнялась 0.60 г/м^2 на станции 1: 1.1 г/м^2 на станции 3А и 0.76 г/м^2 совместно для этих двух станций. Десять наиболее обычных видов составляли 93 $^0/_0$ всей виомассы, а из них *Pseudopleuronectes americanus* составлял 67 $^0/_0$.

В каждый из 19 отдельных дней два последоватлыных улова тралом были сделаны на станции 1, один в восточном направлении и другой в западном: оба на том же месте. Анализ вариантности был применен к общему улову по обшему числу особей, по числу видов и по числу особей каждаго вида. Такия болышия вариации были обнаружены в общем улове в сборах сделанных в обоих направлениях что статистически важных разниц ни в общем улове, ни в общем числе видов не было между обеими группами. Однако общее число особей каждаго вида представляло статистически важные отличия и между каждой группой уловов и в каждом улове. Подобный анализ группы двадцати сборов на станцие 1 и двадцати же сборов на станцие 3А сделанных в те же дни дали сходные результаты. Число особей колеблющееся в каждом виде маскировало возможность присутствия сезонных и местных различий. В добавок к этому анализ с применением индексов различия и гетерогении, сделанный в согласии с указаниями Маргалева 1958 показал что в каждой местности общества рыб были настолько же гетерогенны как и совместные обшества обеих местностей.

В течении года были пойманы 37 видов рыб, 36 на станцие 1 и 25 на станцие 3А. Анализом был обнаружен сезонный шаблон по которому ВЕС

общаго улова колебался пропорционально с числом пойманных особей *P. americanus*, но эта пропорциональность не простиралась на общее число пойманных рыб. В общем число как взрослых рыб так и молоди было меньше летом чем в другие времена года. После возрастания численности осенью, обязанное преимущественно появлению молоди, зимой наступало понижение. Поздней зимой возрастающее обилие сублиторальных и диадромных видов сопровождалось понижением числа взрослых *P. americanus*. Увеличние обилия многих видов продолжалось втечение всей весны.

Пойманные виды состояли из двух групп, резидентных рыб и мигрирующих. Главные резиденты: *P. americanus, Scophthalmus aquosus* И *Merluccius bilinearis*: а наиболее обычный мигрант *Stenotomus chrysops.* Больше сублиторальных резидентов вроде *Ammodytes americanus* и молоди мигрантов были пойманы на песчанораковинном дне станци 1, чем на илистом дне станции 3А. Даны сведения о перемещении нескольких обычных видов на обеих станциях и в других местах пролива.

Сделана попытка определения структуры сообщества с применением гипотезы Макартура о неперекрывающих нишах. Зто указало на существование слюжнаго сообщества обязанного преимущественно передвижениям *P. americanus* и других обычных видов. Возможно что придется разбить популяцию демерсальных рыб на несколько ,,групп,, отличных от таксономных групп, прежде чем структура гомогеннаго сообщества может быть определена.

The Demersal Fish Population of Long Island Sound
II. Food of the Juveniles from a Sand-shell Locality (Station 1)

By

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ABSTRACT

Identified food of 33 juvenile demersal fish species (19–235 mm) collected at St. 1 in Long Island Sound consisted of one hydroid, 38 polychaetes, 50 crustaceans, 11 mollusks, and 3 fish. The most important food items were a hydroid (unidentified), *Neanthes succinea*, *Ampharete acutifrons*, *Pseudodiaptomus coronatus*, *Temora longicornis*, *Acartia* spp., *Balanus balanoides* larvae, *Neomysis americana*, *Leptocheirus pinguis*, *Ampelisca* sp., *Caprella* spp., and *Crago septemspinosus*. More predators ate *N. americana* than any other prey, and with respect to both numbers and volume this form outranked all the other food items. Greater numbers of epifauna were consumed on the whole than infaunal invertebrates. The greatest food diversity occurred in spring and fall, which were also the seasons when the greatest variety of predators occurred.

Two omnivorous predators, *Stenotomus chrysops* and *Pseudopleuronectes americanus* (the dominant polychaete predator), ate over 50% of the identified prey species; four, *Urophycis regius, Centropristes striatus, Prionotus carolinus, Etropus microstomus,* ate over 15%; seven, *Merluccius bilinearis, Pollachius virens, Urophycis chuss, Cynoscion regalis, Tautogolabrus adspersus, Ammodytes americanus,* and *Sphaeroides maculatus,* ate over 10%; and all the rest ate less than 10%. On the whole, abundant predators consumed a greater variety of prey than the less abundant species. Obvious exceptions included abundant stenophagous predators such as *Scophthalmus aquosus.*

Freshly consumed food in full stomachs of a few predators was weighed. The amount of food varied between 1.1 and 9.4% of their body weight, and for all predators combined averaged 4.2%. Rough calculations of productivity of the *juvenile* demersal fish (approximately 0.15 g/m^2/yr) from St. 1 were less than 10%, and the efficiency of conversion of bottom fauna into juveniles was one-fifteenth of that of *all* demersal fish of the English Channel. The productivity of *P. americanus,* the most abundant predator at St. 1, averaging 2.8% of its body weight in food at one time, equalled roughly 0.05 g/m^2/yr.

Nearly all predators were consumers of similar-size herbivores and detritus-feeders and belonged in the same trophic level. Within this level emigration by many predators to other areas during the growing season and possible competition for the major prey on the sand-shell sediments partially explain the low fish productivity.

INTRODUCTION

The food of most adult demersal fish from southern New England is roughly known, and the fish have been categorized as bottom feeders, zooplankton feeders, piscivorous forms, etc. For a general picture of the feeding habits over a large area these categories may be sufficient. However, if the fish population of a small area, defined by certain characteristics, is to be described, a closer scrutiny of the feeding habits of the components of the population is necessary.

An analysis of the benthic fauna of St. 1 (1 mile SE of Charles Island, 9 m, sand-shell bottom) in Long Island Sound has been continued over a number of years. Sanders (1956) described the invertebrate fauna, and Richards (1963; this issue) the fish fauna. The feeding habits of these fish have also been of interest. This paper describes, within the limits of our sampling ability, the food of the juvenile demersal fish from St. 1.

Much incidental but invaluable information has been gathered during this study. Seasonal variations in prey availability, in the selection of food by different predators, the amount of food consumed over a short period of time, and the possibility of competition between predators or between age groups were all significant contributions to a study primarily concerned with population structure and productivity. In the New England area little of this type of information has been published concerning fish.

Feeding habits have been intermittently reported in life history studies, but only a few publications list the food of many coexisting fish from New England waters. Verrill (1871) was one of the first. His work concerned fish from

Great Egg Harbor, New Jersey, and from Grand Manan, New Brunswick, Canada. Linton (1901) summarized the food of many species from Woods Hole, Massachusetts during his studies on fish parasites. In 1943–46 Smith (1950) examined stomachs of many fish from B.I.S. in connection with a study of the benthic fauna, and analyzed the prey-predator interrelationship of eight common fish species.

To demonstrate such relationships in L.I.S., or to solve some of the questions raised concerning demersal fish community structure (Richards, 1963a; this issue), the food of each species must be known in some detail. Some species were taken at St. 1 in sufficient quantities to provide considerable information; others were not. Data concerning each species, rare or common, are included here for those who may be interested.

This paper is in two parts. The results list all prey, their seasonal changes in abundance, and availability. The list of predators includes a discussion of the principal prey, seasonal changes, the possibilities of competition, and some data on the amount of food consumed at one time. The Appendix (p. 94) lists the prey consumed by each predator.

MATERIALS AND METHODS

Fish were collected in 59 tows from St. 1 in Long Island Sound, between June 13, 1955, and July 23, 1957, with various small-mesh trawl nets. During the first year St. 1 was sampled irregularly with only one tow on each sampling date. During the second year a total of 41 samples was taken (between July 17, 1956, and July 23, 1957) approximately fortnightly with the same net (Richards, 1963a; this issue), and in most cases two successive tows were made. Since statistical analyses showed no significant differences between these pairs of successive tows, their catches were combined.

Of a total of 2,343 fish caught, the stomachs of 1,382 fish ranging in standard length from 19.1 to 235 mm were examined (Table I). Juveniles predominated, although some adults of small species were included (i. e., *Myoxocephalus aeneus*).

Only the content of the stomach was examined rather than that of the whole digestive tract since the food of the past few hours was of primary interest. The food was identified, counted and sometimes measured, but it was weighed only when the stomach was absolutely full of fresh material. Partially digested food or partially filled stomachs gave no indication of the total weight of food consumed. Volumetric determinations were also excluded because of uncertainty concerning the significance of the results. Counts alone were unsatisfactory, because they did not indicate the proper value of different size prey. Counts and size measurements together gave some indication of the relative importance of some invertebrates. However, in the future, counts and volume determinations should be combined.

TABLE I. NUMBERS OF SPECIES (SP.) AND INDIVIDUALS (I.) OF JUVENILE DEMERSAL FISH FROM ST. 1 WHOSE STOMACHS WERE EXAMINED (1955–57); THE PERCENTAGE OF PREY SPECIES EATEN BY EACH PREDATOR, AND THE PERCENTAGE OF EMPTY STOMACHS FROM EACH SAMPLE FIGURED ONLY FOR SAMPLES TAKEN DURING 1956–57.

Date	Sp.	I.	Prey spp. (%)	Empty stom. (%)	Date	Sp.	I.	Prey spp. (%)	Empty stom. (%)
VI–13–55	6	14	–	–	X–2–56	10	50	42.6	0
IX–21–55	6	57	–	–	X–16–56	14	108	54.6	5.6
X–10–55	7	17	–	–	X–30–56	8	45	30.5	4.4
X–27–55	5	6	–	–	XI–14–56	5	13	10.2	15.0
XII–7–55	3	48	–	–	XII–4–56	12	32	20.8	6.2
II–2–56	8	52	–	–	I–8–57	7	75	21.2	32.0
IV–2–56	4	15	–	–	I–25–57	7	45	16.7	26.7
IV–30–56	5	15	–	–	II–5–57	4	14	9.3	21.5
V–17–56	3	10	–	–	II–26–57	10	159	24.0	46.6
V–29–56	5	32	–	–	III–22–57	10	145	40.7	38.4
VI–20–56	2	4	–	–	IV–11–57	9	47	24.0	10.6
VII–3–56	2	5	–	–	IV–26–57	5	22	23.1	0
VII–17–56	6	29	23.1	17.0	V–27–57	8	75	50.9	2.6
VII–31–56	7	13	16.7	0	VI–13–57	7	36	27.8	11.1
VIII–14–56	10	25	31.5	0	VII–10–57	0	0	–	–
IX–6–56	7	46	26.8	0	VII–23–57	4	7	14.8	14.3
IX–18–56	10	70	29.6	2.8					

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RESULTS

Juvenile demersal fish ate 113 species identified from entire specimens or identifiable partial remains (Table II) ranging in length from 0.7 to 153 mm. By far the most common were the crustaceans, although hydroids, nemerteans, polychaetes, and mollusks were included. Many of these, notably the active crustaceans, were not sampled with Sanders' dredge at St. 1 in 1953–54 (Sanders, 1956). Although each identified prey is listed in Table II, it is discussed within its major group, i. e. polychaetes, crustaceans, etc. Only the most common prey are analyzed in detail. Sand and twigs are also listed.

TABLE II. STOMACH CONTENTS OF 33† SPECIES OF JUVENILE DEMERSAL FISH†† FROM ST. 1, L.I.S., INCLUDING TOTAL NUMBER AND PERCENTAGE** OF PREDATOR SPECIES AND INDIVIDUALS EATING EACH PREY SPECIES.

PREY	SPECIES		INDIV.	
	(N)	(°/o)	(N)	(°/o)
Sand	18	51	292	21
Diatoms and Dinoflagellates*	4	11	7	1
Algae*	3	9	4	+
Twig*	2	6	2	+
Sponge-unident.*	2	6	2	+
Hydroid	8	23	89	7
Eggs-invertebrate*	6	17	12	1
Eggs-fish*	2	6	2	+
Cerebratulus luridus	3	9	10	1
Nemerteans-unident.	3	9	136	10
Syllidae	1	3	1	+
Autolytus cornutus	1	3	1	+
Autolytus sp. β	2	6	2	+
Lepidonotus squamatus α	3	9	7	1
*Harmothoë imbricata**	1	3	2	+
*Sthenelais gracilis**	2	6	18	1
Phyllodoce fragilis	2	6	17	1
*Eumida sanguinea**	1	3	4	+
*Nereis pelagica**	3	9	12	1
*Nereis ciliata**	1	3	1	+
Nereidae	4	11	15	1
Neanthes succinea α	5	14	77	6
Nephthys incisa	4	11	26	2
*Nephthys ingens**	1	3	1	+
Nephthys caeca	2	6	6	+
Nephthys sp.	3	9	11	1
Arabella iricolor	2	6	5	+
*Eunicidae**▽	1	3	2	+
*Lumbrinereis tenuis**	1	3	2	+
Lumbrinereis sp.*	1	3	1	+
Glycera dibranchiata	2	6	11	1
*Glycera americana**	3	9	4	+
Glycera sp.	3	9	16	1
*Goniada gracilis**	1	3	2	+
Spionidae	1	3	2	+
*Megalona papillicornis**	1	3	1	+
Cirratulus grandis	2	6	4	+
Terebellidae	1	3	3	+
*Polycirrus eximus**	1	3	1	+
Ampharete acutifrons	3	9	119	9
Ampharete sp. δ	2	6	7	1
Melinna cristata	2	6	11	1
Cistenides gouldii	3	9	12	1
Capitella capitata	2	6	4	+
Capitellidae	2	6	13	1
Scoleciformidae	1	3	1	+
Travisia sp.*	1	3	1	+
*Clymenella torquata**	1	3	8	+
Maldane sp.	2	6	4	+
*Scalibregma inflatum**	1	3	1	+
Arenicola sp.*	1	3	1	+
Flabilligera affinis	2	6	11	1
*Amphicora fabricii**	2	6	13	1
*Eupomatus dianthus**	2	6	12	1
Polychaete-unident.	8	23	62	5
"Stuff"*△	6	17	52	4
Polychaete spines	2	6	2	+
*Clitellio arenarius**	2	6	13	1
Oligochaete-unident.	2	6	4	+
Worm-unident.	2	6	4	+
Sagitta sp.*	1	3	1	+
*Calanus finmarchicus**	1	3	4	+
Paracalanus sp.*	1	3	1	+
*Paracalanus crassirostris**	4	11	9	1
Pseudocalanus minutus	3	9	24	2
Centropages hamatus	2	6	4	+
Centropages sp.	3	9	31	2
Pseudodiaptomus coronatus	10	29	98	7
Temora longicornis	18	51	294	21
Eurytemora sp.*	1	3	1	+
Labidocera aestiva	9	26	59	4
Acartia clausi	4	11	12	1
Acartia tonsa	4	11	6	+
Acartia spp.	14	40	150	11
*Tortanus discaudatus**	1	3	12	1
*Alteutha depressa**	1	3	1	+
Copepod-unident.	7	20	12	1
Cyclopoid-unident.	1	3	1	+
*Halocypris brevirostris** ?	1	3	2	+
Ostracod-unident.	2	6	2	+
Balanus balanoides nauplii	3	9	40	3
Balanus balanoides cyprids	4	11	91	7
Neomysis americana	27	77	493	36
*Heteromysis formosa**	12	34	39	3

(Cont.)

TABLE II. (Cont.)

	Species		Indiv.			Species		Indiv.	
Prey	(N)	(%)	(N)	(%)	Prey	(N)	(%)	(N)	(%)
*Michtheimysis stenolepis**	2	6	4	+	*Palaemonetes vulgaris**	1	3	1	+
Mysid-unident.	1	3	1	4	*Sabinea sarsii**	1	3	1	+
Nebalia sp.*	1	3	1	+	Shrimp-unident.	1	3	1	+
Edotea montosa	1	3	1	+	*Upogebia affinis**	2	6	6	+
Edotea sp.θ	2	6	1	+	*Callianassa stimpsoni**	1	3	1	+
Cyathura polita	1	3	1	+	*Pagurus longicarpus*	3	9	3	+
Idothea sp.*	1	3	1	+	*Pagurus pollicaris**	1	3	4	+
Isopod larvae	1	3	1	+	*Pagurus* sp.	7	20	19	1
Ampelisca sp.	10	29	62	5	Panopeid crab	7	20	23	2
Stenothoë cypris	9	26	65	5	Crab-unident.	4	11	4	+
Stenothoë minuta	1	3	1	+	Crab larvae	1	3	1	+
Stenothoë sp.π	6	17	63	5	Decapod larvae	1	3	1	+
*Monoculodes edwardsi**	1	3	2	+	Crustacean remains	11	31	19	1
*Calliopius laeviusculus**	2	6	2	+	*Nymphon grossipes*	3	9	4	+
Orchomenella sp.*	1	3	1	+	*Nucula proxima*	1	3	1	+
*Photis reinhardi**	4	11	17	1	*Yoldia limatula*	1	3	1	+
Podoceropsis nitida	4	11	22	2	*Astarte undulata**	1	3	1	+
Leptocheirus pinguis	11	31	151	11	*Macoma tenta*	4	11	9	+
*Erichthonius brasiliensis**	5	14	16	1	*Ensis directus*	7	20	23	2
Unciola irrorata	4	11	11	1	*Mulinia* sp.	3	9	16	1
*Siphonoecetes smithianus**	6	17	22	2	Pelecypod-unident.	5	14	25	2
Corophium sp.	11	31	66	5	*Crepidula* sp.*	3	9	28	2
Aeginella longicornis	5	14	57	4	*Acmea* sp.*	2	6	6	+
*Caprella geometrica**	5	14	7	1	*Nassarius triviattatus*	2	6	2	+
Caprella linearis	9	26	101	7	*Mitrella lunata*	1	3	8	+
Caprellid	5	14	15	1	*Retusa caniculatum*	1	3	1	+
Amphipod-unident.	3	9	13	1	Gastropod-unident.	1	3	1	+
Amphipod coxal plates	2	6	17	1	*Anchoa mitchilli*	3	9	4	+
Amphipod sand tubes	3	9	3	+	*Merluccius bilinearis**	2	6	2	+
Crago septemspinosus	18	51	232	17	*Ammodytes americanus*	4	11	6	+

† *Enchelyopus cimbrius* and *Conger oceania* empty; *Myoxocephalus octodecimspinosus*, *Paralichthys dentatus*, and *Trinectes maculatus* not examined for stomach contents.

†† See Appendix for details of food of each predator species.

** All percentages rounded off to the nearest whole number; all percentages <1 indicated by a + sign.

* Not identified from the stomach contents of juveniles from St. 3A.

β Not including *A. cornutus.*

α See ftn. 1.

∇ Not including *Arabella iricolor.*

δ Not including *A. acutifrons.*

△ Amorphous mass of organic material found only in species eating polychaetes.

θ Not including *E. montosa.*

π Not including *S. cypris* and *minuta.*

PREY

Although half of the predators ate sand along with their food, it was common only in those which depended primarily on the infauna. Green food was rare; phytoplankton was eaten primarily by *C. harengus* and *A. mitchilli*, while small pieces of algae and twigs occasionally occurred in *U. regius*, *M. menidia*, *M. aeneus*, and *P. americanus*. Consumption of eggs, both invertebrate and fish, was also rare. The invertebrate eggs may have been introduced along with females, particularly copepods. Two sponges, both unidentified, were eaten by *E. microstomus* and *P. americanus*.

Hydroids, in the stomachs of eight predators, were consumed primarily by *S. chrysops* and *P. americanus*. Although a large hydroid mass occurred occasionally, hydroids were not utilized in proportion to their abundance on the bottom. Scarcely eaten at all in winter, they were principally consumed in spring and fall.

Nemerteans on the whole remained unidentified. Only *Cerebratulus luridus* was recognized. Tangled masses of these worms were found in 0-year class *S. chrysops*, and were consumed by *P. americanus* in the spring. Rarely did other species bother with these worms.

A wide variety of polychaetes was eaten by one third of the predators. Thirty-six polychaetes were identified at least as far as genus, and the total number of species may have been nearer 40. Eighteen of the species eaten were not taken from St. 1 by dredge, but were found near Charles Island. Seven species of polychaetes, which were taken by dredge, were not consumed by the fish.

Consumption of polychaetes (1.3–76 mm) occurred throughout the year, but on the whole the greatest numbers were registered at times of greatest abundance of *P. americanus*, which accounted for 79 % of all polychaetes eaten while *S. chrysops* and *E. microstomus* ate 15.4 and 1.0 % respectively. Polychaete diversity, greatest in spring and fall, showed a higher correlation with the variety of fish than with the number. Apparently dependence on a particular polychaete species was shown by few predators.

Two polychaetes were consumed somewhat more commonly than the others, *Neanthes succinea*[1] and *Ampharete acutifrons* (4.3–15.3 mm). Preyed upon by five species, 95 % of the former was taken by *P. americanus* and 3 % by *S. chrysops*, primarily in the spring, the season in which it was most commonly taken by Sanders' dredge. *A. acutifrons*, on the other hand, which Sanders found to be a year-round member of the fauna, was preyed upon at all seasons by three predators. *P. americanus* consumed 97 % – it formed an important segment of their diets, but others were not dependent on this species. Both *N. succinea* and *A. acutifrons* were relatively more abundant in the stomachs than in the dredge samples. Two explanations are possible. Either

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[1] Since this paper went to press it was discovered that well digested *Neanthes succinea* and *Lepidonotus squamatus* may have been confused. Some of those listed as the former may have been the latter.

the predators actively selected them from other infauna, or their abundance increased between 1953–54 and 1955–57.

Other common polychaetes intermittently noted in the stomachs were the Nereidae, Nephthyidae, and Glyceridae. All three families constituted a significant percentage of the invertebrate fauna at St. 1.

The food item listed as "stuff" occurred occasionally in six polychaete predators. The term refers to a white, semi-hard mass which showed no structure. Rarely a polychaete spine was contained in the mass. Since it occurred only in polychaete predators, principally in *S. chrysops* and *P. americanus*, and sometimes contained polychaete remains, it was considered to be a digested mass of these organisms.

Oligochaetes, probably all *Clitellio arenarius*, occurred only in *S. chrysops* and *P. americanus*, while the chaetognath, *Sagitta* sp., occurred once in *S. chrysops*. Neither of these was recorded from the dredge samples at St. 1.

Twelve identified species of copepods (0.8–3.0 mm) were consumed in a definite seasonal pattern by 20 predators (Fig. 1). The greatest number and variety were eaten in winter and spring during the time of abundance of *A. americanus* and juvenile clupeoids. Fewer were consumed in the fall during the abundance of juvenile migrators, and hardly any were eaten during the summer. Thus, the times when a variety and large number of predators were consuming the greatest number and variety of copepods were not always when the latter were most abundant in the plankton (Deevey, 1956). Occa-

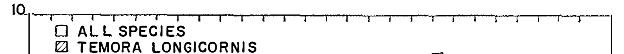

Figure 1. Number and variety of copepods consumed by juvenile demersal fish from St. 1.

sionally large numbers were consumed previous to the peak of abundance (*i.e.*, early January 1957) due to active selection by *A. americanus*.

A. americanus, the principal copepod predator, consumed 79°/o of the total, *S. chrysops* 7°/o, *B. tyrannus* nearly 5°/o, and 17 others less than 10°/o. Due to the seasonal nature of these predators, the copepods appeared less important to them than they really were. When the percentages eaten were based only upon those copepods consumed in the samples in which particular predators appeared, the importance of these prey to particular predators was emphasized. *A. americanus* ate 93°/o of the copepods eaten by all species only in the samples in which sand eels were present. On this basis *S. chrysops* ate 67°/o, *P. triacanthus* 34°/o, *B. tyrannus* 35°/o, *P. carolinus* 19°/o, and all the rest less than 6°/o. *C. harengus* was found to have eaten surprisingly little, less than 1°/o.

Fifty per cent of all copepod prey was *Temora longicornis*, 42°/o was *Acartia* spp., and 4°/o was *Pseudodiaptomus coronatus*. Eleven species constituted the other 4°/o. [Since some copepods were identified only to genus, i. e., *Acartia* and *Centropages*, the exact number of species is unknown. Both *A. clausi* and *A. tonsa* were identified but seldom counted separately and only one species of *Centropages* (*C. hamatus*) was identified, although *C. typicus* may have been present. Therefore *Acartia* spp. refers to one or both species, while *Centropages* sp. refers to other than *C. hamatus*.]

Consumption of *T. longicornis* (both nauplii and adults) by a large number and variety of predators occurred principally in the spring and fall (Fig. 1). Of the 18 predators, *A. americanus* alone consumed 86°/o, *B. tyrannus* 9°/o, and all others 5°/o. At times, pairs of predators consumed *T. longicornis* in equal amounts: in the fall *S. chrysops* and *P. carolinus*, in the winter *A. americanus* and *B. tyrannus*. All four predators were also consuming other prey.

Acartia spp. (both nauplii and adults) occurred in the stomachs of 15 predators, primarily in spring and fall (Fig. 1). *A. americanus* ate 87°/o of all that were eaten, *S. chrysops* 7°/o, and all others 6°/o.

The midwinter vertical distribution of both *T. longicornis* and *Acartia* spp. may be an important factor determining their availability. Possibly these copepods remained near the bottom during winter (thus accounting for their abundance in stomachs) at times of low numbers in the plankton tows. Increased availability near the bottom perhaps decreased competition among predators, thus allowing *M. menidia* and others to overwinter at St. 1 while *A. americanus* was abundant.

Pseudodiaptomus coronatus and *Labidocera aestiva* were each consumed by eight predators, primarily in the fall when they were most abundant in the plankton. *S. chrysops* ate 60°/o of the former, *P. carolinus* 23°/o, and the others 17°/o. *L. aestiva* was more evenly divided between predators than the other copepods; *A. americanus* consumed 37°/o, two adult specimens of *A. mitchilli* ate 30°/o, *S. chrysops* 15°/o, *A. pseudoharengus* 11°/o, and all others 7°/o. Some competition may have arisen between first-year *S. chrysops*, *P. carolinus*, and

A. mitchilli for these and other copepods, but the first appeared far less dependent on the copepods than either of the other two. Although *L. aestiva* was longer and heavier than other copepods, except for *Calanus finmarchicus* and *Tortanus discaudatus*, both of which were consumed in small quantity, it ranked only fourth in abundance by volume. The total consumed weight of *L. aestiva* was less than that of *T. longicornis*, *Acartia* spp. or *P. coronatus*.

The amount of predation upon other species of copepods was not in direct proportion to their relative abundance in the plankton. Thus, small quantities of *Paracalanus crassirostris* and *Pseudocalanus minutus*, two of the most abundant species in L.I.S., were consumed intermittently. Predators apparently preferred the larger copepods, even including juvenile *Clupea harengus*, which in B.I.S. preyed heavily on *P. minutus* (Sanders, 1952).

Ostracods and cumaceans were rarely eaten.

Free-swimming larvae of *Balanus balanoides*, which appeared in L.I.S. from January to May, were preyed upon by four species, primarily in February and March. Nauplii were eaten in early February, and cyprids (0.8–1.4 mm) were consumed from February through April. Eighty per cent of the nauplii and 33 °/₀ of the cyprids were consumed by 25 °/₀ of *A. americanus*, whereas 19 °/₀ of the nauplii and 61 °/₀ of the cyprids were eaten by 50 to 60 °/₀ of *B. tyrannus*. The amount of barnacles consumed by these two fish species was compared with the number of consumed *T. longicornis* which are similar in size. The volume of *T. longicornis* was nearly five times that of cyprids in *A. americanus*, but only one sixth of the volume of cyprids in *B. tyrannus*. Menhaden concentrated more on cyprids than any other predator from St. 1. Only two other fish species, *Apeltes quadracus* and *Alosa pseudoharengus*, ate barnacle nauplii, and only to a limited extent.

Mysids (1.3–20 mm), particularly *Neomysis americana*, were the most important prey of the juvenile demersal fish at St. 1. They were consumed in greater numbers by 77 °/₀ of the predators than any other prey except *T. longicornis* and *Acartia* spp., and the latter were of lesser significance because of their smaller size. These results corroborated evidence of the importance of mysids as demersal fish-food, a point already emphasized by Hopkins (1958).

N. americana (1.3–13.7) occurred in stomachs from all the samples except June 20 and July 3, 1956. The numbers fluctuated, but on the whole the greatest quantity was consumed in winter and the least in summer (Fig. 2). The amount eaten in any given sample generally depended upon the variety of predators present although certain inconsistencies were noted which probably were due to variations in the availability of mysids. Thus, on December 4, 1956, 2,000 *N. americana* occurred in the stomachs of *A. pseudoharengus*, *B. tyrannus*, *M. bilinearis*, and *S. aquosus*, whereas on January 8, 1957, 72 *N. americana* occurred, when some of the principal predators of mysids were absent or had empty stomachs. At this time there were no clupeiods or *M. bilinearis*, and *S. aquosus* was empty.

No predator ate an outstandingly high percentage of *N. americana.* Nine specimens of *A. pseudoharengus* ate a greater amount (19%) than any other predator. About 15% was accounted for by 72% of *S. aquosus* and 62% of *M. bilinearis*; while 6% of the total number was consumed by 82% of *B. tyrannus*, 46% of *M. menidia*, 21% of *A. americanus*, 53% of *P. carolinus*, 75% of *M. aeneus*, and 22% of *P. americanus.* Competition perhaps occurred in winter between *A. pseudoharengus*, *A. americanus*, *B. tyrannus*, *M. menidia*, and *S. aquosus*, which, with less varied diets, probably depended on mysids more than *P. carolinus*, *S. chrysops*, and *P. americanus.*

Due to the swarming behavior of *N. americana*, difficulty arises in estimating its abundance. It did not occur in the dredge samples, but Deevey (1956) mentions larvae as "rarely numerous" in the plankton tows for all months but August. *N. americana* appeared in small quantities in trawl hauls from February to May and in September. At present (1960–61) a new sampling program for epifauna is in progress. Although the dredge, rigged with a stramin net, captures *N. americana*, it is too early to estimate the abundance of these organisms.

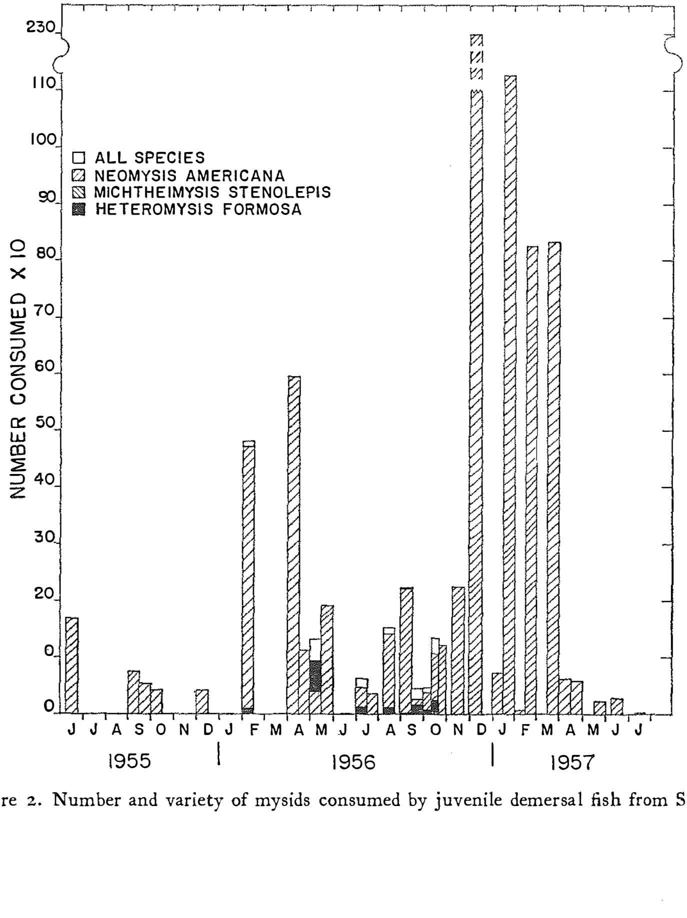

Figure 2. Number and variety of mysids consumed by juvenile demersal fish from St. 1.

One third of the fish species preyed on *Heteromysis formosa* in May and from July through October; however, it was eaten in far less quantity than *N. americana*. Two specimens of *Pollachius virens* accounted for 50%, while *C. striatus*, *S. chrysops*, and *P. carolinus* ate 34% of the total number. The rest occurred sporadically in a few fish.

Five *Michtheimysis stenolepis* were eaten by *C. striatus* and *S. chrysops* in October. Only these two predators ate all three species of mysids.

Three species of isopods, *Edotea montosa*, *Cyathura polita*, and *Idothea* sp., were eaten by five predators but only rarely. Only the former was found in the dredge samples.

Seventeen amphipods (1.0–15.6 mm), identified at least to genus, were eaten by 42% of the predators, chiefly *P. americanus*, *S. chrysops*, *P. carolinus*, *C. striatus*, *T. adspersus*, and *E. microstomus*. The greatest variety and number of amphipods were consumed during May and June and from August through October, corresponding to their seasons of abundance in the dredge samples. Of these, the *Stenothoë* group and the caprellid group, as well as three species, *Ampelisca* sp., *Leptocheirus pinguis*, and *Corophium* sp., were consumed in the greatest quantities. Comparisons of the relative abundance of these prey in the stomachs and in the dredge samples demonstrated differences due to their behavior. Tube-dwelling amphipods were more frequent in the dredge samples and less frequent in the stomachs than the non-tube dwellers. In the dredge samples the tube-dweller, *L. pinguis*, and the non-tube-dweller, *Unciola irrorata*, were the most common, while in the stomachs *L. pinguis* and the caprellids were most abundant. Changes in the relative availability of the amphipods may have occurred – certainly changes in annual relative abundance were noted in the food.

The caprellids (1.2–11.2 mm) as a group, consisting of *Aeginella longicornis*, *Caprella linearis*, *Caprella geometrica*, and Caprellid (some of which were not one of the others), were most commonly preyed upon from August through October; 10% by *C. striatus*, 37% by *S. chrysops*, 12% by *T. adspersus*, 26% by *P. americanus*, 10% by *S. maculatus*, and 5% by all the others. Three of these predators, *S. chrysops*, one-year-old *T. adspersus*, and *P. americanus* ate hydroids, thereby capturing many caprellids by accident. Zero-year class specimens of *T. adspersus*, *C. striatus*, and *P. carolinus*, on the other hand, ate little hydroid material. Apparently they hunted caprellids.

L. pinguis (1.1–15.6 mm), consumed by one third of the predators, was preyed upon by *P. americanus*, which ate 68% of all that were eaten, while *S. chrysops* ate 9%, *P. carolinus* 6%, *U. regius* 5%, *M. bilinearis* 4%, and all the rest 8%. Its occurrence by number in the diets was greater during the spring of 1957 than at any other time (Fig. 3), but its biomass was less important since most were young of the year. Perhaps a temporary fluctuation in abundance following a successful breeding season accounted for the greater proportion of *L. pinguis* in the stomachs than in the dredge samples.

The *Stenothoë* group (1.2–1.9 mm), non-tube-dwellers inhabiting the hydroid beds, consisted of *S. cypris*, one *S. minuta*, and a third unidentified species, *Stenothoë* sp., which was not either of the other two. They were consumed throughout the year, primarily from August through October, by 25% of the predators; *S. chrysops* fed on 41%, *C. striatus* 7%, *P. carolinus* 10%, *P. americanus* 40%, and all others 2%.

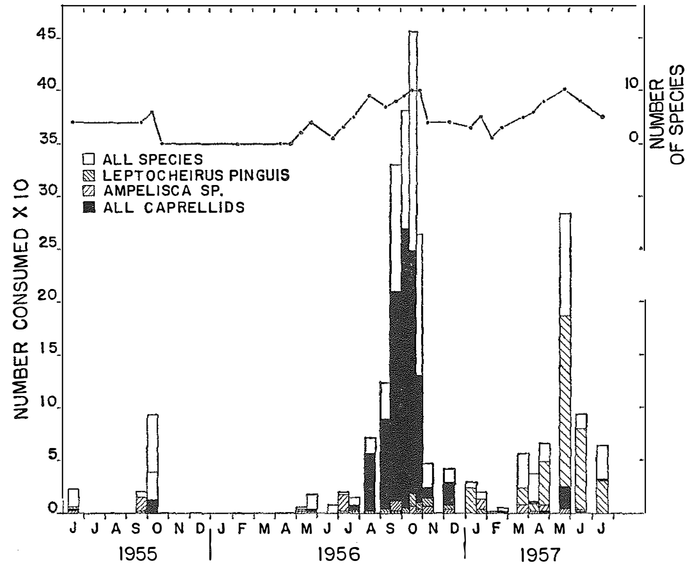

Figure 3. Number and variety of amphipods consumed by juvenile demersal fish from St. 1.

Ampelisca sp. (4.3–11.0 mm) (*Ampelisca* A of Sanders, 1956) and *Corophium* sp. (2.7–5.0 mm) were consumed in small quantities throughout the year by nearly 30% of the predators. The majority of both was consumed by *S. chrysops* and *P. americanus*. The former ate 29% of the *Ampelisca* and 18% of *Corophium*, and the latter ate 32% of the *Ampelisca* and 58% of the *Corophium*. Other predators fed on varying amounts; *M. bilinearis* 13% of *Ampelisca*, *C. regalis* 8% of *Ampelisca*, *C. striatus* 3% of *Ampelisca* and 5% of *Corophium* sp. and *P. carolinus* ate 12% of *Corophium* sp. The relative abundance of these prey compared to other amphipods was less in the stomachs than in the dredge samples.

Of the other amphipods, *Photis reinhardi*, *Podoceropsis nitida*, *Erichthonius brasiliensis*, and *Siphonocoetes smithianus*, all tube-dwellers, were fed on intermittently by 10 to 20% of the predators. Only *E. brasiliensis* occurred frequently in the dredge samples.

The total biomass of amphipods taken in the dredge was less than that of polychaetes, but they were preyed upon more heavily by a greater variety of fish than polychaetes. Their wandering habits and the choice of habitat produced a more available source of food than did the polychaetes. For instance, 97% of the specimens of *C. striatus*, 59% of *S. chrysops*, 58% of *E. microstomus* and 55% of *P. carolinus* ate amphipods, while only a few were consumers of polychaetes, and only intermittently. In contrast, 50% of *P. americanus* ate amphipods, but 72% ate polychaetes. Nevertheless, the volume or biomass of amphipods consumed by *P. americanus* was almost equal to the volume or biomass of polychaetes. Therefore the greater productivity of the short-lived two-generation organisms (Sanders, 1956), as compared with long-lived infauna, resulted in a greater contribution to the food supply of the demersal fish at St. 1 than would be evident simply on the basis of standing crop measurements.

Sand tubes, presumably those of amphipods and polychaetes, were occasionally eaten.

Three species of shrimps were consumed, of which *Crago septemspinosus*[2], the sand shrimp (5.1–37 mm), was the only one of any consequence. One *Palaemonetes vulgaris* was eaten by *B. tyrannus* in January, one *Sabinea sarsii* was eaten by *P. americanus* in March, in contrast to 883 *C. septemspinosus* which were consumed by 18 species throughout the whole year. The greatest variety of predators occurred in late summer and early fall, and in the spring. In winter there were fewer predators due perhaps to their migration into deeper water at this time.

The majority of individuals of seven species had eaten sand shrimp, but only four were principal predators; *M. bilinearis* consumed 24% in late winter, spring, and summer, *P. carolinus* ate 21% in summer and fall, *U. chuss* ate 18% in fall and spring, and *M. aeneus* ate 9% during the winter. Actually, *M. aeneus* and *M. bilinearis* were the principal winter predators, while *M. bilinearis*, *U. chuss*, *P. carolinus*, and *P. oblongus* were the principal summer and fall predators.

Consumption of the greatest number of shrimp occurred in July, October and May (Fig. 4) by about half of the total number of the fish which ate *N. americana*. Correlations between numbers consumed and abundance ascertained from plankton tows, dredge and trawl hauls were vague. Larvae occurred in the spring plankton (Deevey, 1956) and the greatest number of older specimens occurred in the dredge from August, December, and April, and in the trawl from January and February. The majority of those from the trawl in winter were ovigerous. Accurate analysis of sand shrimp abundance in any area depends upon knowledge of horizontal and vertical migrations, extent of

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[2] Since this paper went to press, Kent S. Price, Jr. has informed the author (personal communication, January 31, 1962) that L. B. Holthuis recently discovered that the proper name for this species is *Crangon septemspinosa*.

swarming, and general life history, all of which are dependent on the development of proper sampling gear. The sand shrimp was common enough in L.I.S. so that serious competition perhaps only arose when the principal predators, in this case *M. bilinearis*, *U. chuss*, and *P. carolinus*, occurred simultaneously, in late spring and in the fall.

The biomass of consumed sand shrimps was compared to that of *N. americana*. Rough calculations based upon preliminary weight-length relationships demonstrated that one shrimp of average size equalled the weight of five average mysids. Since one tenth as many shrimps was consumed as mysids, the biomass equalled about half that of mysids. Just the same, the sand shrimp was the second most important prey and must be emphasized along with the mysids.

Crabs, both anomurans and brachyurans in nearly equal numbers, were consumed in small quantities by a small number of predators. Of the anomurans,

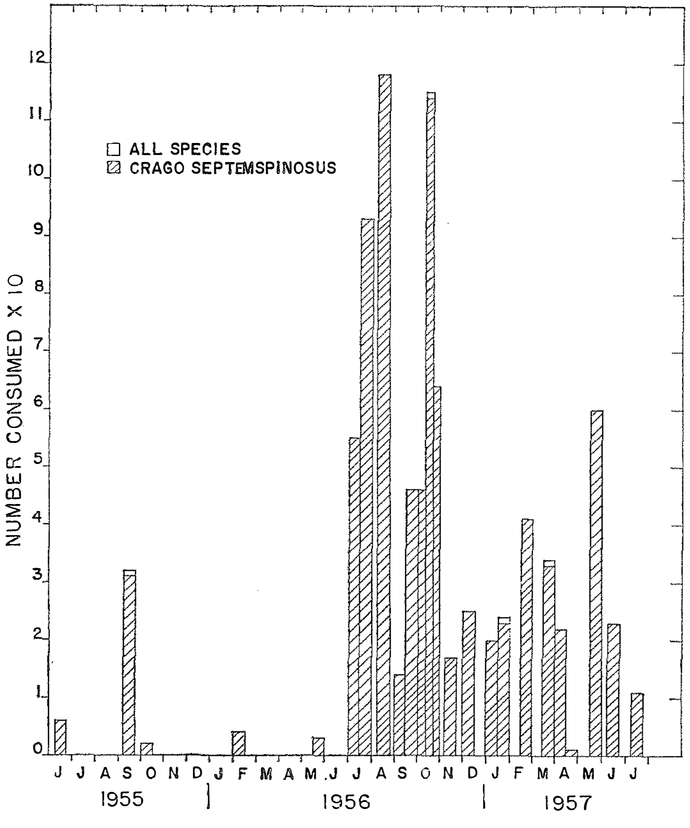

Figure 4. Number and variety of shrimps consumed by juvenile demersal fish from St. 1.

79% was *Pagurus* spp., listed in this manner to include both *P. longicarpus* and *P. pollicaris*, which were not always separable. Two other species of this group, *Upogebia affinis* and *Callianasa stimpsoni*, were eaten in far less abundance.

Pagurus spp. were consumed in September–October primarily by 20% of the predator species but by only 1% of the individuals. *E. microstomus* accounted for 36%, *C. striatus* and *P. carolinus* each ate 16%, *S. chrysops* and *P. americanus* each ate 13%, the rest 6%.

Of the brachyurans, by far the most common were the panopeids (2.9–5.0 mm). Due to an oversight, two species, *Neopanope texana sayi* and *Panopeus herbstii*, were not separated. They were consumed most abundantly in October and in June, although *N. t. sayi* appeared in the dredge samples most abundantly in winter. The principal predators, *T. adspersus* and *P. americanus*, ate 26% and 55% of these crabs respectively. In winter these two were the only predators, joined in spring by *M. aeneus*. In the fall others such as *P. carolinus*, *C. striatus*, and *E. microstomus* ate a few.

Nymphon grossipes, of a very small size, was eaten, though only rarely, by three species, *S. chrysops*, *T. onitis*, and *P. americanus*, in summer and fall.

Meager predation of mollusks, both pelecypods and gastropods, occurred in all seasons with the exception of winter. The greatest diversity was consumed and by the greatest variety of predators, in the fall and in May.

Clams were more popular than snails as food. There were eight predators of clams and only five of snails. Eleven per cent of *S. chrysops* ate 25% of the clams, 9% *P. americanus* ate 61%, and 68% of the *S. maculatus* ate 9%. Only 1% of *S. chrysops* ate 4% of the snails, 12% of *P. americanus* ate 76%, and 5% of *S. maculatus* ate 19%. Apparently *S. maculatus* depended more upon the mollusks than *S. chrysops* and *P. americanus*.

Ensis directus (12.1–44 mm) was consumed by seven predators more frequently than any other identifiable clam, particularly during summer and fall. *P. americanus* fed on 90%, *T. adspersus* ate 5%, the rest the other 5%. *Mulinia* sp. was consumed by three species at the same time, primarily by *S. chrysops* (75%), *P. americanus* (18%) and *S. maculatus* (9%). "Unidentified" clams were probably of the *Mulinia* group.

During fall and spring, 95% of *Crepidula* spp., which were common throughout the year in the dredge samples, occurred in *P. americanus*, and the rest occurred in *S. chrysops* and *E. microstomus*. Other species of snails were eaten by *P. americanus* and *S. maculatus*, but only infrequently.

Three species of fish (63–153 mm) were consumed by seven predators. The prey consisted of *A. mitchilli*, both fry and adults, age 1 *M. bilinearis*, and age 1 *A. americanus*. All three were eaten by *M. bilinearis* during seasons in which each was most available. Other predators, *U. regius*, *C. regalis*, *A. americanus*, included fish rarely in their diets during their first year, while *L. americanus*, probably one of the few almost entirely piscivorous forms in the area, was rarely caught.

SEASONAL CHANGES IN VARIETY AND AMOUNT OF FOOD

The less abundant predators, many of which appeared in the winter and summer, tended to have less varied diets, while most of the common predators which were abundant in the spring and the fall had more omnivorous diets (Table III). Thus, seasonal changes (based on 1956–57 only) observed in the variety of food for the entire population were dependent on the feeding habits of the predators as well as on the availability of the prey. During the spring and fall a large variety of food was noted. At these times two omnivorous predators, *S. chrysops* and *P. americanus*, each of which ate over 50% of the prey species, were present along with others such as *U. regius*, *P. carolinus*, *C. striatus*, and *E. microstomus*, which ate 15–20% of all the prey. In summer *S. chrysops* and *P. americanus* were less abundant, and less variety was noted in the food. During winter a marked decrease in variety occurred while *A. americanus*, *M. menidia*, and the clupeoids, all of which ate less than 15% of the prey, were present in large numbers. Correlations between variety of food and variety and numbers of fish showed that when there was a greater variety of predators present there was a more varied total diet. Variety of fishes was more important in this respect than total number.

Seasonal changes in the amount of food were based only on the percentages of empty stomachs, because counts of prey were not significant in this connection, due to their size variation. The highest percentage of empty stomachs occurred during late winter and early spring and showed no significant correlation with the total number of fish caught (Table I). Assuming that consumption of food per fish was no greater during winter than during the rest of the year, less total food was consumed in February–March than in the warmer seasons. Little growth occurred amongst the predators at this time. In the spring rapidly growing juveniles of three age-groups, and in the fall abundant first-year juveniles steadily consumed a large amount of food. The surprisingly high percentage of empty stomachs which occurred in June and early July remains unexplained.

FOOD OF EACH SPECIES (see Appendix)

Raja erinacea. Three juvenile skates with full stomachs had eaten *T. longicornis*, *N. americana*, *H. formosa* and *C. septemspinosus* in small numbers. One stomach was full of freshly eaten *C. septemspinosus* weighing 4% of the skate's body weight. Comprehensive accounts of the food of adult skates from B.I.S. are given in Smith (1950) and of juvenile and adults from both B.I.S. and L.I.S. by Richards, *et al.* (in press). Their data showed *R. erinacea* to be a carnivore all its life; at an early age it subsists on pelagic crustaceans; when older it depends on demersal fauna.

Clupea harengus. Seventy-eight per cent of 17 0-year class herring and one adult, taken in winter and early spring, consumed 14 species of planktonic

TABLE III. Number of Each Species Examined from St. 1†, Including the Number and Percentage** of Fish with Stomachs Empty, <0.5 Full, and >0.5 Full; Also the Number of All Identified Food Species Eaten by Each Predator Species. The Percentage of All Identified Food Species Based on 113 Identified Items.

	No. of stomachs examined								
Predator Species	Empty		<0.5 full		>0.5 full		Total	Food Spp.	
	(No.)	(%)	(No.)	(%)	(No.)	(%)	(No.)	(No.)	(%)**
Raja erinacea	0	0	0	0	3	100	3	4	4
Clupea harengus	4	22	4	22	10	56	18	10	9
Alosa pseudoharengus	0	0	0	0	9	100	9	6	5
Alosa aestivalis	0	0	1	50	1	50	2	4	4
Brevioortia tyrannus	2	7	4	14	22	79	28	10	9
Anchoa mitchilli	–	–	–	–	–	–	6	6	5
Osmerus mordax	–	–	–	–	2	100	2	4	4
Merluccius bilinearis	24	21	24	22	63	57	111	11	10
Pollachius virens	0	0	0	0	22	100	22	11	10
Urophycis chuss	0	0	0	0	20	95	21	11	10
Urophycis regius	0	0	1	6	16	94	17	18	16
Apeltes quadracus	0	0	1	25	3	75	4	6	5
*Gasterosteus aculeatus**	–	–	–	–	–	–	1	1	1
Syngnathus fuscus	3	23	7	54	3	23	13	9	8
Menidia menidia	21	39	17	31	16	30	54	9	8
Centropristes striatus	0	0	0	0	28	100	28	19	17
Cynoscion regalis	0	0	3	13	20	87	23	14	13
Stenotomus chrysops	2	1	11	7	153	92	167	55	49
Tautogolabrus adspersus	3	11	4	14	17	61	28††	16	14
Tautoga onitis	2	50	0	0	2	50	4	6	5
Pholis gunnellus	1	33	0	0	2	67	3	3	3
Ammodytes americanus	155	53	32	11	103	36	290	14	13
Poronotus triacanthus	2	14	5	36	7	50	14	5	4
Gobiosoma ginsburgi	0	0	0	0	1	100	1	3	3
Prionotus carolinus	6	6	4	4	93	90	103	25	22
*Prionotus evolans**	–	–	–	–	–	–	2	2	2
Myoxocephalus aeneus	3	11	4	14	21	75	28	9	8
Paralichthys oblongus	1	13	0	0	7	87	8	2	2
Scophthalmus aquosus	9	18	6	12	34	70	49	5	4
Etropus microstomus	0	0	2	17	10	83	12	18	16
Pseudopleuronectes americanus	17	6	54	19	216	75	287	73	65
Sphaeroides maculatus	3	14	8	36	11	50	22	14	13
Lophius americanus	0	0	0	0	1	100	1	2	2

† See Appendix for details of food of each predator species.

** All percentages rounded off to the nearest whole number.

* No data included in the Appendix for these predator species.

†† Only 24 fish listed in number of stomachs; stomach condition not noted for four fish.

prey, most of which were copepods and mysids. Common copepods (0.9–2.0 mm) formed the bulk of the diet, particularly *P. crassirostris*, *C. hamatus*, and *A. clausii*. *P. minutus*, a dominant form in B.I.S. (Deevey, 1952), was consumed in far greater quantity there (Sanders, 1952) than in L.I.S., where the copepod is less abundant. Diatoms and dinoflagellates listed in the Appendix perhaps had been eaten by the copepods which were eaten by the herrings. A three-year-old male (I–25–57) consumed 170 specimens of *N. americana* (7.5–11.2 mm). Herring of 40 to 70 mm which were taken from Morris Cove and inshore areas near West Haven, Connecticut in 1943, ate both *N. americana* and *H. formosa* along with copepods and *B. balanoides* cyprids. If present in large numbers, the herring might seriously affect the availability of mysids to other predators.

Alosa pseudoharengus. Nine first-year alewives from December and March contained crustacean food dominated in both weight and number by *N. americana*. Sixty-seven per cent, all from December, ate copepods (1.7–2.7 mm), the largest of which was *L. aestiva*, while 100 % ate mysids (2.2–9.4 mm). As a matter of fact this predator accounted for nearly 20 % of all *L. aestiva* and *N. americana* taken by all predators. Apparently as alewives grow the diet changes from only copepods to large copepods and mysids, then to mysids and fish (Hildebrand and Schroeder, 1928).

Alosa aestivalis. Two 0-year class glut herring from February and March ate small amounts of copepods. This predator and *C. harengus* accounted for all identified *C. hamatus* found in the stomachs.

Brevoortia tyrannus. Menhaden of the 0- and 1-year age group, taken in winter, were primarily crustacean feeders. *Balanus* nauplii and cyprids, *N. americana*, and the larger copepods constituted the bulk of their diet. No green food of any kind occurred. Only two menhaden from November had empty stomachs, the rest were better than one-half full. Those taken in January had consumed primarily *T. longicornis* and mysids. A single specimen of *P. vulgaris* was taken at this time. Those taken in February accounted for the majority of the cyprids and a large percentage of barnacle nauplii. No differences were noted in the diets of menhaden of different sizes. These results differed from those of Peck (1894), who examined the food of juvenile and adult menhaden from Buzzards Bay in the summer. His results indicated that menhaden were primarily herbivorous, with copepods as a supplementary diet. At this time it is impossible to decide if seasonal variation produced the different results.

Anchoa mitchilli. The stomachs of six adult anchovies from St. 1 contained crustaceans, principally copepods and mysids. *L. aestiva*, present in quantity in September–October in L.I.S., was eaten by all anchovies in greater numbers than by any other predator at that time, and was of a size (1.9–2.5 mm) similar to that of the mysids (1.5–3.5 mm), which were also consumed. The food of the postlarval and juvenile anchovies from the fall tows is discussed in detail by Booth (1959). His results showed that more green food remains were taken by the smaller anchovies than by the adults, but small copepods were the principal diet of the majority of all sizes. Juvenile anchovies are present in such enormous quantities in the fall that they may be a factor in the decrease in copepod numbers in the plankton at that time (Deevey, 1956). Frequent parasitism by *Distomum* sp. was noted.

Osmerus mordax. Two smelts, in January, consumed *N. americana* (5–6 mm) in greater numbers than any other prey. Specimens of *C. septemspinosus* (av. 17.4 mm) occurred in the smelt from I–25–57 and the presence of tube-dwelling amphipods indicated bottom feeding.

Conger oceanica. One specimen from III–22–57 was empty.

Merluccius bilinearis[3]. Whiting in the first three years of age consumed 12 prey species, primarily mysids and shrimps. *H. formosa* (20 mm) was taken only once, but *N. americana* (5.4–11.1 mm) and 25 % of all *C. septemspinosus* (5.1–32 mm) were consumed throughout the year by two-thirds of all the whiting. Amphipods (3–14.6 mm), the largest *L. pinguis*, were eaten in small quantities in spring and summer by approximately 12 % of the 1- and 2-year fish. An unidentified crab and *E. directus* (20.6 mm) were consumed only once. *A. mitchilli* (63, 73 mm), *A. americanus* (av. 85 mm), and *M. bilinearis* (153 mm) were eaten by the two- and three-year-olds at times when the prey were most available. Whiting was one of the few piscivorous predators from St. I and accounted for the majority of the fish prey.

During most of the year empty stomachs were infrequent, but from May through mid-July, at the time whiting showed evidence of bottom feeding, a high percentage of empty or nearly empty stomachs occurred. The highest percentage of full stomachs occurred in fall and early spring. Some whiting had eaten so much that the superfluity of mysids and shrimps was crammed into the gullet and gill cavity. The freshly eaten food of two of these fish was weighed. One two-year-old (182 mm, 44.2 g) held in its stomach and gullet 2.3 % of its body weight in the form of 78 *N. americana* (av. 7.8 mm) and eight *C. septemspinosus* (7.5–22.6 mm). The other fish, almost three years old (207 mm, 73.5 g), contained 9.4 % of its body weight in the form of two anchovies (63, 73 mm; 6, 9 g).

One- and two-year-old whiting (73–114 mm, 115–203 mm), usually caught together, showed no differences in their food. Both ate mysids and shrimps of equal size, both fed on the bottom in May, June, and July, and

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[3] See Jensen and Fritz (1960) which appeared since the completion of this manuscript.

both showed an increase in the percentage of empty stomachs at this time. However, by the third year, *N. americana* was no longer included in their diet. According to Smith (1950), older whiting from B.I.S. were primarily nekton predators, and did not compete with the invertebrate predators.

Pollachius virens. Twenty-two 0-year pollack, caught in middle and late spring, consumed 13 crustacean prey, principally copepods and mysids. Of the copepods, *C. finmarchicus* (3.0 mm), which is rare in L.I.S., and *T. discaudatus* (1.6–2.0 mm) were consumed in late May. A much more common form, *P. crassirostris* was eaten in greater abundance by pollack than by any other predator. Other common spring copepods were also consumed. Mysids (2.1–8.5 mm) were eaten by pollack (38–66 mm) more frequently than any other crustaceans. These included young *H. formosa* (2.1–3.1 mm) as well as *N. americana*, of which about 10% was larger than the largest copepods. Large fish of the 0-year class only (55–66 mm) consumed, in small quantity in late May and June, three amphipod species (3.7–6.8 mm) which inhabit hydroid beds.

Enchelyopus cimbrius. One 211-mm rockling from a haul on v-27-57 contained only sand.

Urophycis chuss. Only 0- and 1-year squirrel hakes were examined. Sand, a twig, and 10 species of prey were found: three polychaetes, three amphipods, two mysids, one shrimp, and one crab (the only specimen of *C. stimpsoni*). *C. septemspinosus* (3.4–23 mm) formed the basis of the squirrel hakes's diet, although only 17.6% of the total number of shrimp was consumed by this fish. In any one sample, however, 20 to 100% of the shrimp were consumed by this predator. In two samples (x-16-56, xi-14-56) in which less than 40% of the shrimp was eaten by hake, *M. bilinearis*, *P. oblongus*, and *P. carolinus* together consumed the greatest portion of this prey.

Consumption of only small proportions of mysids (1.5–10 mm) and amphipods (2.2–15.6 mm) was noted. The latter, primarily male *L. pinguis* (2.2–15.6 mm) and *Ampelisca* sp. (11.3 mm), as well as the presence of sand and a few polychaetes, provided evidence of bottom feeding in nearly every sample in which small hake were present. Although these organisms were never eaten in large quantity or to the exclusion of the shrimp, a slightly greater variety in the diet was noted from the fall collections than from those of the spring.

No stomachs were empty, but only one was full of sufficiently fresh material to be weighed. This specimen (188 mm, 74 g, v-27-57) ate 3.5% of its body weight in the form of shrimps which averaged 20.6 mm in length. Slightly smaller amphipods, shrimps, and mysids were consumed by specimens between 86 and 115 mm than by those over 120 mm.

Urophycis regius. Nineteen identified prey, ranging from hydroids to fish, were consumed by 17 spotted hakes. Amphipods, which usually inhabit hydroid beds (caprellids, *S. cypris*, etc.) were ingested in small amounts, along with *T. longicornis*, ostracods, both mysids, and a crab. Consumption of a few polychaetes and *M. tenta* occurred in May and June, while *A. americanus* was eaten in April. The most common prey of the spotted hakes was *L. pinguis* (small-14.2 mm) and *C. septemspinosus* (5.9–15.4 mm), most of the latter occurring in the fall. The most varied diet was shown by the smallest hakes (55–98 mm) during spring. Bottom feeding was evident by some, while others consumed pelagic organisms. Late in summer larger specimens (140–144 mm) ate only crustaceans, both benthic and pelagic, and in September the largest specimen (195 mm) preyed only on pelagic forms. No stomachs were empty. One 0-year class specimen (58.6 mm, 2.0 g) ate 3.9 % of its body weight in the form of *A. americanus* and five *N. americana*.

Apeltes quadracus. Five prey were consumed by four sticklebacks taken in February: three copepods, barnacle larvae, and *N. americana*. Apparently the sticklebacks ate whichever crustaceans were most common. There were no empty stomachs and one (47.5 mm, 1.3 g) ate at least 1.4 % of its body weight in the form of mysids and copepods.

Gasterosteus aculeatus. One three-spined stickleback (II-2-56) was half filled with small *N. americana*.

Syngnathus fuscus. The pipefish's diet, consisting of nine prey, principally crustaceans, varied more during fall than during spring. The 0-year class (85–120 mm) in fall ate five species of copepods, small *N. americana* (1.9–7.1 mm), small *S. cypris*, and one snail, *N. triviattatus*, whereas in spring the 1-year fish (120–178 mm) concentrated only on *N. americana*. Two copepods, *Eurytemora* sp. and *A. depressa*, were consumed only by pipefish.

Menidia menidia. During winter and spring nine prey, primarily small crustaceans, were consumed by 61 % of the silversides of the 1-year class (47–97 mm). In early winter the diet included four species of copepods, *P. coronatus*, *T. longicornis*, *L. aestiva*, and *Acartia* spp. (1.0–2.0 mm), a fish egg, and *N. americana* (4.4–13.8 mm); in midwinter only the mysid and a bit of algae were consumed. At no time did silversides account for a large percentage of any common prey. The high percentage of empty stomachs may have been due to the cold and to possible competition from other predators.

Centropristes striatus. Small sea bass of the 0-year class were taken only in September–October. Fin-ray counts were similar to those from Chesapeake Bay (Hildebrand and Schroeder, 1928) and areas to the east (Bigelow and Schroeder, 1953) indicating that these specimens were similar to those outside L.I.S. Since no sea bass eggs were recognized within L.I.S. (Wheatland, 1956;

Richards, 1959), immigrants presumably came from the east, but spent little time at St. 1. While they were in this vicinity, a varied diet of 20 prey, principally motile amphipods and small crabs, was consumed. These few sea bass accounted for 7% of all amphipods (1.2–6.3 mm) consumed by all predators, of which the motile forms, caprellids (1.2–6.1 mm), *Stenothoë* spp. (1.2–1.9 mm), and *E. brasiliensis* appeared to be the most important. Aside from these, sand, hydroids, a few copepods, three mysids (1.7–8.2 mm), shrimp (5.9–11.0 mm), and two crabs were consumed by all sizes of this year-class. Within each sample this predator consumed a rather high percentage of these prey, but due to the limited stay at St. 1, the numbers were a small percentage of the yearly consumption by all predators. However, 11% of the crabs, a prey infrequently utilized by the others, was eaten by sea bass.

Cynoscion regalis. Zero-year class weakfish, caught only once, chose a diet of various small crustaceans and an occasional anchovy. *C. septemspinosus* (up to 18 mm) was eaten most frequently. Three species of copepods were also consumed, as well as *Ampelisca* sp. (av. 4.1 mm) and *Nebalia* sp., the latter being the only cumacean in the list of prey. The presence of *A. mitchilli* fry indicated the preference of weakfish for a fish diet.

Stenotomus chrysops. Zero-year class scup, taken in large numbers in summer and fall, coincided with the one-year-olds only twice, both times in September. One-year-olds appeared in late spring and remained until fall, while 0-year class specimens appeared in fall only. Unfortunately the stomach contents of the larger scup preserved poorly, making comparison with the smaller group difficult. A large number of prey species was consumed by both ages, a far greater variety than by any species except for *P. americanus*. Scup concentrated on polychaetes, amphipods, other crustaceans, and mollusks. Copepods were more prevalent in the younger group, while mollusks were more common in the older group.

Fifteen per cent of all polychaetes was found in 40% of the scup. Of the 17 identified species (7.4–30 mm), the greatest diversity was consumed in the fall, although in any one sample scup sometimes ate a large percentage of a particular polychaete. These included burrowing, tube-dwelling, and non-burrowing forms. *Ampharete acutifrons* (7.4–8.5 mm), the favorite polychaete prey of *P. americanus*, was consumed intermittently by scup. Others were Nereidae, Nephthyidae, *P. fragilis*, *C. gouldii* ($<$ 19.9 mm), and *E. dianthus*.

A small percentage of the total copepods (0.8–2.7 mm) was consumed by scup less than 100 mm long. Of five species, *P. coronatus* (0.8–1.0 mm) was consumed most abundantly along with *L. aestiva* (2.2–2.7 mm). Both species were common in the plankton during the fall. *T. longicornis* and *Acartia* spp. were eaten in spring as well as in fall. Evidently scup ate whichever copepods were available.

Consumption of 15 species of amphipods by one third of the scup occurred primarily in the fall. One group of five species, the tube-dwellers, *P. reinhardi*, *P. nitida*, *L. pinguis*, *S. smithianus*, and *Corophium* sp. was consumed less abundantly than the motile groups, *Stenothoë* spp., and the caprellids. Of the former group, *Corophium* sp., eaten more than the other four species, usually was accompanied by *Stenothoë* spp. Twenty-eight per cent of all *Ampelisca* sp. was eaten in the fall; 41 °/₀ of all *Stenothoë* sp. (0.8–1.8 mm) and 38 °/₀ of all caprellids (1.0–6.3 mm) were eaten during spring-summer and fall. Some of these were no larger than small copepods and frequently were ingested at the same time as hydroids.

N. americana (1.8–7.9 mm) was often consumed by only small scup, while the other mysids, *C. septemspinosus*, and crabs were eaten by larger 0-year class specimens. Predation on mollusks was most common by one-year-olds longer than 70 mm in summer. Pelecypods, primarily *Mulinia* sp. and *M. tenta*, were eaten far more abundantly than the gastropods, *Crepidula* and *Acmea* sp.

The greatest diversity of food was not only positively correlated with the number of scup examined but also with the total number of all predators examined, rather than with either the size of the scup or the season of the year. On the other hand, the food diversity of *M. bilinearis*, an example of a predator of few prey species, showed correlation only with the number of whiting examined, and none with the total number of all fish examined. A comparison of these results indicated the possibility of intra-specific competition in both predators and of some inter-specific competition between scup and other members of the juvenile demersal fish population.

Ninety-two per cent of the stomachs was full or nearly full. None of the contents was weighed, but estimates from known weights of similar-size material show that small 0-year class scup ate approximately 2 to 4 °/₀ of their body weight at a time.

Parasitism by both *Ascaris* sp. (similar to Linton's, 1901, specimen from *P. dentatus*) and *Distomum* sp. was prevalent in the 0-year class. Approximately 20 °/₀ of the scup was infested with one or both of these organisms.

Tautogolabrus adspersus. Twenty-four cunners, zero to fourth year, caught in spring, summer and fall, ate 18 identifiable prey, of which crustaceans, primarily motile amphipods, were the most important. Small cunners exhibited less over-all evidence of bottom feeding than did the larger specimens. Occasional polychaetes did not form an important segment of the diet, and small numbers of copepods were consumed only by the 0-year class. Seven species of small amphipods (1.8–4.0 mm) were eaten by all age-groups far more frequently than any other prey. Occasional mysids (2–3 mm), shrimps (5.6–16.0 mm), crabs, and mollusks were primarily eaten by the older cunners. Ten per cent of the total caprellids was consumed by 11 cunners, while hydroids, in which the caprellids live, were eaten only by cunners from 94 to 138 mm.

Very small cunners were apparently able to select the amphipods from the hydroids, whereas the older cunners were not able to do so. The only specimen of *Orchomenella* sp. was eaten by a cunner 37 mm long. Empty stomachs occurred infrequently and at no particular season.

Tautoga onitis. Two blackfish, 0- and 1-year old, ate seven prey, of which decapods, amphipods, and *E. directus* were the most abundant. Two others were empty.

Pholis gunnellus. Only three rock gunnels were examined, and one was empty. Two specimens, from April, ate two polychaetes (*N. succinea* and *L. squamatus*) and *C. linearis*.

Ammodytes americanus. During winter and early spring, one- and two-year-old sand eels, occurring in large schools at St. 1, ate 10 species of prey, primarily pelagic crustaceans. Bottom feeding was shown by only 3 °/₀ of this predator. Seven species of copepods (1.0–1.8 mm) were consumed, of which *T. longicornis* (1.0–1.8 mm) and *Acartia* spp. (1.0–1.2 mm), which included both *A. clausii* and *A. tonsa*, were the most important. Sand eels consumed 85 °/₀ of *T. longicornis*, 88 °/₀ of *Acartia* spp., the majority of *Centropages* sp., and few *P. minutus*. Since *P. coronatus* and *L. aestiva* were rare in the plankton at this time, few were consumed.

During winter fewer *T. longicornis* and *Acartia* spp. occurred in plankton samples from St. 1 than during other times of year (Deevey, 1956), yet these copepods figured prominently in the sand eel's diet at this time. Some of their predators caught in otter trawls also contained sand grains and thus were feeding near the bottom. This suggests that these copepods also were concentrated near the bottom where they would not have been caught quantitatively by the plankton net, although *A. tonsa* is the only one of these three species that is definitely known to prefer bottom waters at this time of the year (Conover, 1956).

Sand eels ate 80 °/₀ of *B. balanoides* nauplii and 38 °/₀ of the cyprids (0.8–1.4 mm). Next to *B. tyrannus* they were the most important barnacle predators. The percentage (9 °/₀) of *N. americana* eaten by 21 °/₀ of the sand eels was small, when based upon the total number eaten by all predators all year round. In any given sample, however, in which sand eels were present, they ate over 30 °/₀ of the *N. americana* (4.4–13.7 mm) that were consumed by all species in the sample. By volume, compared with copepods, the mysid was of great importance. They were usually consumed along with copepods but not always simultaneously. Full stomachs were frequently stratified; the mysids were packed into one area and the copepods into another. Apparently sand eels passed through a swarm of mysids while feeding. Such obvious changes in diet were rare among the species from St. 1, and reflected the patchiness of the zooplankton and larger crustaceans. The reason for a predator leaving one source of food and passing on to another is not known, but similar behavior by *Oncorhynchus keta* and *O. gorbuscha* was noted by Allen and Aron (1958) from the western Pacific. One *E. cimbrius* egg and four sand eel larvae were consumed.

Seasonal changes in the diet were noted. During January quantities of *T. longicornis*, and *Acartia* spp., some *L. aestiva*, and *N. americana* were consumed by nearly all of the sand eels. In February some *Centropages* sp., *T. longicornis*, *Acartia* spp., and a few *N. americana* were consumed along with barnacle nauplii and cyprids. By March and April an increase in both numbers and variety of copepods, an increase in mysids, and a decrease in barnacles were noted. Diet changes were affected more by fluctuations in plankton constituents than by number of zooplankton predators. Food diversity was not correlated with an increase in either sand eels only or in total predators. However, the amount of food, as measured by the number of empty stomachs, appeared to diminish at the time isospondylous and sublittoral species invaded St. 1. In February few empty stomachs were noted, but throughout early spring the proportion of empty stomachs increased; whether this was due to competition or cold water temperature is at present unknown.

Eight sand eel stomachs and esophagi, full of freshly eaten material, were weighed (Table IV). On the average, they ate 3 to 4 % of their body weight. A full stomach of mysids weighed more than one full of copepods and cyprids. Since few sand eels ever contained well digested contents and all were taken before 10 A.M., they apparently ate soon after daylight. We know nothing of their feeding habits later in the day.

The food of one- and two-year-olds was similar to that listed by Covill (1959) for postlarvae. No differences were noted in the amount or variety of food between the older age groups. No internal parasites were noted.

Poronotus triacanthus. The stomach contents of most of the 0-year class butterfish were difficult to identify due to digestion. Available crustaceans formed the majority of prey, of which six were partially recognized. Of these, *Acartia* spp. were eaten by 65 % of the butterfish. One acanthocephalid parasite was noted.

Gobiosoma ginsburgi. One naked goby, 27.1 mm, was full of three species of prey, *C. luridus*, *Corophium* sp., and *H. formosa* (4.8 mm).

Prionotus carolinus. Zero-year class searobins, one of the more common species at St. 1, appeared in September through November and one- and two-year-old specimens were present from May through summer. They were omnivorous crustacean feeders interested primarily in mysids and shrimps. A few other organisms, such as *N. pelagica* and *A. mitchilli* larvae, were also consumed.

TABLE IV. Number, Weight, and Percentage of Body Weight of the Prey of Eight *A. americanus* from St. 1.

Date	Fish		Food wgt. (mg)	% of fish body wgt.	Stomach Contents by Species
	SL (mm)	wgt. (g)			
IV–2–56	91.5	2.3	84.4	3.7	39 *T. longicornis* 4 *Acartia* sp. 25 *Balanus balanoides* cyprids 3 copepods unident.
IV–2–56	94.9	2.7	236.9	8.7	174 *T. longicornis* 229 *Acartia* sp. 17 *N. americana*
IV–2–56	92.1	2.5	175.7	7.0	21 *T. longicornis* 5 *Acartia* sp. 9 *N. americana*
IV–2–56	95.9	2.6	164.4	6.3	433 *T. longicornis* 356 *Acartia* sp. 5 cyprids 1 *N. americana* 4 *A. americanus* larvae
IV–30–56	94.8	2.9	80.2	2.8	329 *T. longicornis* 18 *Acartia clausi* 1 cyprid
IV–30–56	96.3	3.2	93.7	2.9	275 *T. longicornis* 5 *Acartia* sp. 125 cyprids
IV–30–56	103.9	4.4	137.2	3.1	–
IV–30–56	106.1	4.8	124.4	2.6	358 *T. longicornis* 5 *Acartia* sp. 40 cyprids

Crustacean prey depended to some extent upon the size of the searobin. Those under 75 mm long ate five species of copepods (0.8–2.8 mm), of which *P. coronatus* and *T. longicornis* were most abundant, and nine species of amphipods (1.9–14.6 mm), both tube-dwellers and non-tube-dwellers; the older predators ate four kinds of amphipods. The small variety may be due to the lack of numbers of older specimens available for examination. *S. cypris*, *L. pinguis*, and various caprellids were the most important prey in both age groups. Searobins of all ages frequently contained sand. *N. americana* (1.9–7.8 mm) and a few *Pagurus* spp. (2.5 mm) were consumed by small specimens, while *C. septemspinosus* (5.0–19.6 mm) and only one crab appeared in older searobins.

Seasonal changes in the diets reflected the occurrence of different age groups. Predation of copepods and amphipods was greatest in fall when small specimens were common, whereas mysids and shrimp were consumed whenever searobins of all ages were available. Although wide food diversity was shown by single individuals, on the whole a significantly greater diversity was shown by the younger specimens. A small percentage of empty stomachs occurred, yet no searobin had a stomach full of fresh material.

Prionotus evolans. No 0-year class striped searobins were present at St. 1. Only two adults were caught and they had eaten *N. americana* and *C. septemspinosus* (8.1–17.4 mm).

Myoxocephalus aeneus. Second- and third-year brassy sculpins were caught during winter and spring, 75 % of which was female, and all but four were ripe. They consumed nine prey, primarily crustaceans. Although 12 % of the stomachs was empty at this time, a one-year-old ripe female (88 mm, 22 g) consumed 5.4 % of its body weight in the form of *L. pinguis*, two shrimp (av. 20 mm), and seven mysids. The food diversity was directly related to the number of sculpins examined. Seventy-five per cent ate *N. americana* (5.0–13.5 mm) while 61 % ate *C. septemspinosus* (13.3–37.0 mm). Two amphipods, *L. pinguis* and *P. reinhardi*, a crab, algae, *N. succinea*, and *A. americanus* larvae also occurred in their stomachs.

Paralichthys oblongus. Eight 0-year class fourspot flounders, caught in September–October, consumed two organisms, *N. americana* (3.2–7.4 mm) occasionally and *C. septemspinosus* (5.3–23.2 mm) more regularly.

Scophthalmus aquosus. Of all predators at St. 1, the windowpane had the most limited diet; the food diversity was in no way correlated with the number of windowpanes examined. Of the five species of prey consumed by zero- and one-year-olds, *N. americana* (2.9–12.5 mm) was the most important. Ninety per cent of all windowpanes which ate at all consumed 16 % of all mysids. In one-half of the samples which contained windowpanes they consumed *N. americana* exclusively. Even so, this predator constituted only 8 % of all fish preying on mysids; juvenile whiting and alewives ate more mysids than the windowpane. Smith (1950) felt that within B.I.S., where mysid predators were less abundant, competition was not a serious factor for the windowpane. In L.I.S., on the other hand, the many mysid predators, particularly in fall, winter, and early spring, perhaps created competition which caused the slower growth rate of windowpane, compared to that in B.I.S., mentioned by Moore (1947). A few *T. longicornis* were taken by a few small specimens, *C. septemspinosus* (8.2–11.5 mm) by 14 % of all windowpanes, and *H. formosa* and *E. directus* (44 mm) each occurred once. No seasonal changes were noted in the diet. Stomach contents of a one-year-old windowpane (132 mm, 48 g) were weighed. However, digestion had begun so that 68 mysids constituted only 1.1 % of the fish's weight.

Etropus microstomus. Records of occurrences of smallmouth flounders in southern New England waters are rare. In fact, little is known of their distribution or life history except that the range extends from Florida to Cape Cod. Parr (1931) claimed that in Delaware Bay it is most common in shallow water, but Shuster (1959) does not list this species. Two females, 69 and 77 mm, almost ripe, caught by oyster suction dredge, VI-30-52, south of Milford, Connecticut, raised the possibility that this species may mature in its second year and spawn in L.I.S.

Twelve smallmouth flounders, 0- and 1-year old (?), caught between July 31 and December 4, 1956, consumed 19 identifiable prey species, primarily polychaetes and crustaceans. No particular prey dominated, but amphipods and hermit crabs were eaten most frequently. One unidentified small sponge, a piece of hydroid, nemerteans, *Edotea* sp., a crab, *Crepidula* sp., and sand appeared in the stomachs. Four identified polychaetes (7.4–26.5 mm) contributed little to the total volume with the exception of the largest, *N. caeca*. Of the amphipods (3.1–8.8 mm), *Ampelisca* sp. was most frequently consumed although five other species occurred in nearly every fish. Small *N. americana* (1.6–6.6 mm) occurred more frequently than *C. septemspinosus* (2.4–14.3 mm). Pagurids (3.1–3.8 mm) were the most consistent prey; they were consumed more frequently by smallmouth flounders than by any other predator. No empty stomachs were noted, yet none was full enough to be weighed.

Pseudopleuronectes americanus. Winter flounders, of the first two years of age, taken in nearly every sample, were omnivorous. They ate a greater variety of food (73 identified prey) than any other demersal fish from St. 1. Hydroids, nemerteans, polychaetes, amphipods, decapods, and pelecypods provided most of the diet. Only scup demonstrated a comparable omnivorous diet.

Hydroids and nemerteans were not counted. The former were eaten by 21 % of the winter flounders, primarily in spring and fall. Nemerteans, of which *C. luridus* was the most common – the others remained unidentified, were eaten by 40% of the flounders.

Eighty per cent of all polychaetes was consumed by 72% of the winter flounders throughout the year. Among these, 33 species were wholly or partially identified, the most important of which were *N. succinea* (see ftn. 1) and *A. acutifrons*. Consumption of *N. succinea* (*c* 2 mm–+20 mm) by 24% of the flounders of all ages occurred primarily in winter and spring 1956–57. These fish accounted for 91 % of the predators of this polychaete. Consumption of *A. acutifrons* (3.6–15.3 mm), by 37% of the flounders of all ages, constituting 90% of all its predators, occurred throughout the year, but in greatest numbers in the fall. The majority of four other polychaetes, *S. gracilis* (in May only), *N. incisa* (all year), *Glycera* spp. (all year), *F. affinis* (fall and spring), and various nereids as a group, were consumed by less than 10% of the flounders. Some of the other polychaetes were more commonly consumed by scup, such as the capitellids, *A. fabricii*, and *E. dianthus*. Nevertheless, all polychaetes, whether free-swimmers, crawlers, or tube-dwellers, were vulnerable to the flounder.

Half of the winter flounders contained 41% of all amphipods consumed. Fourteen species were identified, of which *L. pinguis* (2.1–14.6 mm) was the most important. Although it was found in 28% of the flounders, the latter accounted for two-thirds of the total consumption of this species and constituted one-half of its total predators, primarily in the winter and spring. Other amphipods frequently eaten were *Ampelisca* sp. (4.3–11 mm-fall, winter, and spring), *Stenothoë* sp. (fall), *P. nitida* (1.6–5.4 mm), *S. smithianus* (3.1–7.1 mm), *Corophium* sp. (1.7–5.0 mm), and various caprellids (2.0–11.2 mm), the last four, in late spring and fall, along with hydroids. Although winter flounders ate nearly all amphipod prey listed from St. 1, the numbers and variety were less than the polychaetes.

Two isopods, two shrimps, a mysid, and four crabs were eaten. *N. americana* (2.7–11.5 mm) was found in 26% of the flounders, primarily first year specimens and only during winter and spring. Three of the four crab species (*Pagurus* spp., *U. affinis*, and a panopeid) were frequently consumed by all ages, but never in large numbers.

Consumption of ten mollusks, six pelecypods, and four gastropods occurred in all seasons except winter, primarily by the older group. Of the first, *E. directus* (12.1–31 mm) was eaten in the greatest quantity in summer, and of the gastropods, *Crepidula* sp. was consumed primarily in fall and spring. Others, such as *Mulinia* sp., *Acmea* sp., and *M. lunata* occurred intermittently.

In general, during winter the flounder concentrated on *N. succinea* and *A. acutifrons*, but it also consumed about one-half of the total variety of amphipods as well as a few *N. americana*. By spring a few mollusks and mysids were combined with many amphipods and polychaetes of large variety, but in summer, a greater number of mollusks was consumed along with fewer amphipods and polychaetes than in spring. During the fall, the number and variety of mollusks and amphipods, and the number of *A. acutifrons* increased, while the total variety of polychaetes decreased.

Seasonal changes in the type of prey consumed were due in part to the availability of the latter and also to the numbers and ages of the predators. Consumption of *N. succinea* and *A. acutifrons* occurred in greatest numbers among all ages at times of their greatest abundance as given by Sanders (1956). Small *L. pinguis* were preyed upon during their peak of abundance following the breeding season. Instances of availability effects, however, were not always so obvious. Reasons for other fluctuations in the diet, such as lack of mollusks during winter, were obscure.

Correlations between the food diversity and the total number of flounders were sometimes close. The greatest number of young flounders occurred in fall and spring, accompanied by an increase in numbers and variety of amphipods and polychaetes in spring and of mollusks and amphipods in the fall. In order to test the significance of the predator's age, the diversity of the food of each age-group in each season was compared. Table V shows that the food diversity of each age, highest in spring and fall, was not always proportional to the number of fish within each age grouping. Some other factors besides number was partially responsible for some of the diversity fluctuations.

TABLE V. SUMMARY OF THE SEASONAL FOOD DIVERSITY* OF FIRST THROUGH THIRD YEAR CLASSES OF *P. americanus* TAKEN AT ST. 1, 1956–57 ONLY. N = NUMBER OF FISH; D. I. = DIVERSITY INDEX.

	Year class							
	First		Second		Third		Total	
Season	N	D. I.	N	D. I.	N	D. I.	N	D. I.
Fall	8	4.16	31	5.66	3	2.51	42	5.73
Winter	31	3.53	24	3.93	2	0.78	57	4.14
Spring	84	6.38	13	5.34	1	1.55	98	7.20
Summer	13	3.71	5	3.60	1	0.87	19	5.72

* Diversity Index = $S - 1/\log_e N$, where S is the number of prey species, N the number of individual prey (Margalef, 1958).

Although differences were demonstrated in diets of each age group, there were sufficient similarities to raise the question of inter-age competition, particularly during the time of invasion of St. 1 by the 1-year class. To test this hypothesis, two methods of analysis were employed. The first was the simple diversity index mentioned above, which is based on the formula $d = S - 1/\log_e N$, where S equals the number of species and N equals the number of individuals (Margalef, 1958). Indices were computed for polychaetes, crustaceans, and mollusks and compared between each age-group in each season. Secondly, an index of "competitive independence" taken from Smith (1950) was computed for the same groups of prey and compared between each age-group in each season. The competitive independence score is based upon the percentage of a prey in the diet of each age-group multiplied by the percentage in the diet of all age groups. A complete discussion and derivation of the formula for this index appears in Smith (1950) and Richards (1963b; this issue). Suffice it to state here that the scores resulted in figures between zero and one; a high score indicated an ability of an age group to eat a particular species of prey with little interference from the other age groups. A low score indicated that only a small or a similar amount of a particular prey was consumed compared to the other age groups. The results of the two analyses are given in Fig. 5.

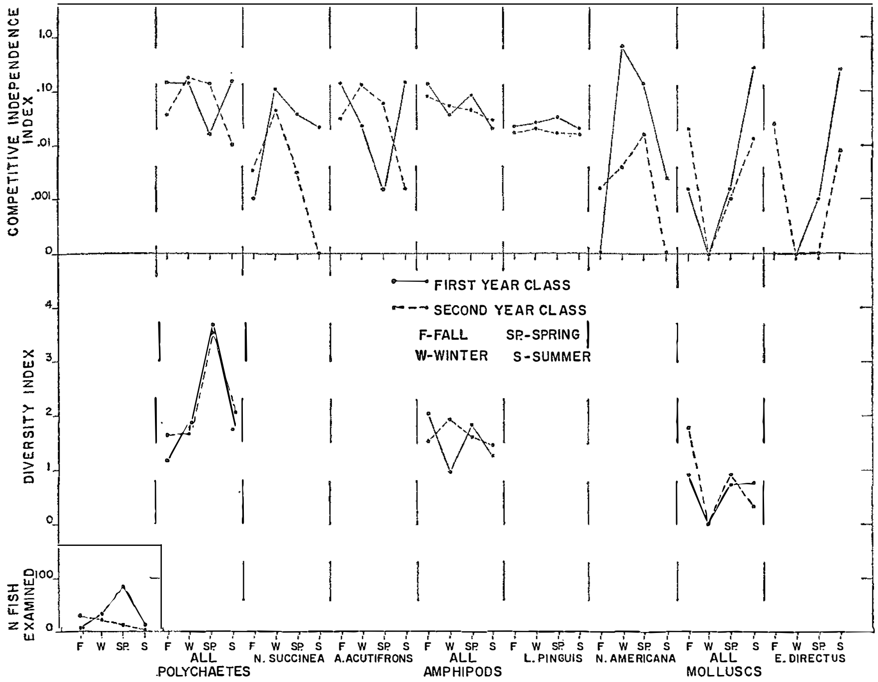

Figure 5. Seasonal changes in the diversity and competitive independence indices for polychaetes, crustaceans, and mollusks eaten by the first and second year *P. amerianus* from St. 1.

Within the polychaetes, the group containing the most species, parallel fluctuations in diversity occurred while the scores of competitive independence varied between ages of fish. The ability of the two-year-olds to consume polychaetes was greater than that of the 1-year class. The former fed more consistently on polychaetes as their diversity increased in the spring. This does not signify that competition forced a more diversified diet among the two year-olds; perhaps they were more interested in polychaetes than the 1-year fish. Comparison of the competitive independence scores in each age group for the two common polychaetes, *N. succinea* and *A. acutifrons*, showed seasonal variations in their ability to eat these prey. Both fed most successfully on *N. succinea* in winter but neither relied heavily on it. The 2-year class fed successfully on *A. acutifrons* in winter and spring, while the 1-year group consumed them primarily in the fall and spring.

Although over-all seasonal fluctuations in diversity of amphipods, eaten by both age groups of flounders, were small, differences between the age groups were obvious while the scores of competitive independence were almost equal. During the winter the 1-year class fed on a less diversified group of amphipods than did the 2-year class, but in spring and summer the two age groups showed less noticeable diversity differences. In fall the 1-year invaders ate a wider selection of amphipods than the older group, although during this season the latter ate a greater quantity of amphipods than during the rest of the year. Variations in the ability of the year classes to feed on the most popular amphipod, *L. pinguis*, were insignificant. Differences in the utilization of this prey perhaps were more marked between juveniles and adults than within the juvenile age groups.

N. americana, on the other hand, was consumed in winter and spring by the 1-year fish and seldom by the two-year-olds. The availability of *N. americana* to the youngest fish perhaps prevented their competition with the older flounders at this time. However, other predators were eating mysids in large numbers.

Between seasons, the consumption of mollusks varied widely, but comparison of different ages showed parallel fluctuations in diversity throughout the year along with parallel fluctuations in the competitive independence scores. As previously noted, no mollusks were consumed during the winter. In summer, two-year-olds fed on a variety, while one-year-olds concentrated on *E. directus*. By fall there was a noticeable increase in the amount of mollusks consumed by the two-year-olds. In fact, availability of mollusks may have contributed to the decreased interest shown by the two-year-olds in polychaetes at that time.

Some relationships between the diversity indices of a group of prey and the competitive independence scores of an individual prey species were noted. Thus, groups with the most seasonal variation in diversity usually showed greatest variation in competitive scores for a single species. The availability of a single species or even of a diverse group varied enough during the year to have a marked effect upon the ability of all the fish to feed on it. Thus, as the availability (as measured by diversity) of the polychaete and amphipod prey of the two-year-olds increased, the one-year-olds tended to feed less upon these organisms. Conclusive evidence of competition was not demonstrated, but from the data at hand, the 1- and 2-year age groups were not constantly competing. The possibility that all juveniles competed with the adults has yet to be investigated.

Little seasonal differences were noted in the sizes of the prey within the different year classes. Copopods occurred occasionally in fish under 50 mm, together with nemerteans. Small *N. succinea* and amphipods, such as *S. cypris*, occurred in small flounders. Consumption of both large and small specimens of a prey, such as *L. pinguis* in May, tended to be divided between year classes. The small specimens were more common in the smaller flounders, while the large specimens occurred more frequently in the larger fish. Above 60 mm, omnivorousness increased, perhaps accounting for some of the increased food diversity during the spring at the time of the resumption of growth by the 1-year fish.

Only three other species of fish were considered as possible serious competitors, namely *S. chrysops*, *P. carolinus*, and *E. microstomus*. At times of mutual abundance, particularly in the fall and in May, they preyed upon some of the same polychaetes and amphipods that the winter flounder fed upon. Further analyses of these interrelationships are planned.

Empty stomachs occurred only in winter and early spring. At this time the one-year-olds were the most abundant; thus the majority of empty stomachs was in this group. Only two fish had stomachs full enough to be weighed. One, 89.5 mm, 11.9 g, consumed 3.1 °/₀ of its body weight in the form of 45 *N. americana*, and the other, 103.2 mm, 21.4 g, consumed 2.3 °/₀ of its body weight in the form of 91 *N. americana*.

Flounders of all ages from St. 1 were parasitized. Anywhere from 50 to 100 °/₀ of them in a single sample contained an *Ascaris* sp., similar to that found in the gut of *S. chrysops*. A few were infested with *Distomum* sp., also similar to that of *A. mitchilli* and *S. chrysops*.

Sphaeroides maculatus. Two 1-year class and 20 0-year class puffers were examined from August through the middle of October. They ate a diet of polychaetes, crustaceans, and mollusks. An unidentified hydroid, three polychaete species (of which *A. iricolor*, 76 mm, was the largest prey consumed), five amphipods, and a hermit crab occurred occasionally. *C. linearis* (2.8–4.1 mm), consumed by 36 °/₀ of the puffers, was the most important crustacean. Pelecypods, primarily *Mulinia* sp., which was consumed by 60 °/₀ of the puffers, *E. directus*, and an occasional gastropod, such as *R. caniculatum*, constituted a greater proportion of the puffer's diet than that of any other predator. Only one-year-old scup consumed comparable amounts of molluskan material. Three stomachs were empty, many (36 °/₀) contained well digested contents, and none was full enough to be weighed.

Lophius americanus. One specimen, 195 mm, from January 8, 1957, had eaten one *M. bilinearis* (*c* 120 mm) and two large *C. septemspinosus*. This species is one of the few piscivorous demersal fish in L.I.S.

DISCUSSION

Station 1, characterized by a high percentage of sand, shell, and gravel, is occupied by a biomass of epifauna five times that of the infauna (Sanders, 1956). Due to its abundance, the epifauna was expected to dominate the diets of the demersal fish. That this was so is evident from the results. Few other correlations were discovered between the relative abundance of prey in the fish stomachs and in the dredge samples. There are several reasons why this is so; changes in abundance may have occurred between the time of the dredge samples (1953–54) and the time of the trawl hauls (1955–57), and more importantly the dredge was not adapted to catch the motile free-swimming crustaceans. Detailed comparisons between data from bottom dredge samples and demersal fish diets must await the information from the present epifauna sampling program. Fish selected certain prey, not only those which were not caught by Sander's dredge, such as *Neomysis americana* and the copepods, but also certain less common amphipods, hermit crabs, and polychaetes. They also fed in areas of muddier sediments in juxtaposition with the sand-shell zone, which contained bottom fauna not listed from St. 1.

Although polychaetes were constantly preyed upon by *P. americanus*, which constituted at least half of the juvenile fish, these prey were not as important a fish food at St. 1 as the crustaceans. The winter flounder was the only fish which ate two polychaetes, *Ampharete acutifrons* and *Neanthes succinea*, in numbers comparable to certain crustaceans. Consumption of other species occurred intermittently by a few predators. Different groups of prey, such as mollusks and hydroids, were even less important than polychaetes.

Crustaceans were the most important food. Of these, *Neomysis americana* was consumed more abundantly, as judged both by numbers and by weight, than any other prey and by the greatest variety and number of predators. Only *Crago septemspinosus*, consumed by a far lesser number and variety of fish, approximated the volume of *N. americana*. Other prey formed a significant portion of some diets by number, but not by volume, i. e., *Temora longicornis*, *Acartia* spp., and *Pseudodiaptomus coronatus*, while some were volumetrically more important, such as *Leptocheirus pinguis*, the caprellids, and other non-tube-dwelling amphipods.

In many cases fluctuations in variety of diet were directly related to the numbers of specimens of a predator examined. Examples of positive correlations were found primarily amongst the omnivorous species, such as *S. chrysops*, *M. aeneus*, *E. microstomus*, and *P. americanus*. Increase in the number of stomachs examined led naturally to an increase in the variety of the food of these species. Whether an increased abundance of omnivorous fish at St. 1 was directly related to their ability to select a greater variety of food and thereby lessen the effects of competition is unknown. At this time there is no way of accurately measuring the difference between the effect of numbers of stomachs examined and the predator's abundance since the numbers examined were not proportional to the abundance. In contrast, an example of a diet which did not fluctuate in variety with numbers of stomachs examined or with the predator's abundance at St. 1 was that of *Scophthalmus aquosus*. In this species the possibility of competition was not reflected in the variety of its diet. It may be reasonably assumed that competition between stenophagous predators might produce the absence of one or more of them, whereas competition between stenophagous predators might force one or more to seek a greater variety of food without decreasing their abundance.

The possibility of interspecific competition arising from the dependence of a variety of fish upon so few species of similar size can not be analyzed at present, thus only preliminary evidence of possible competition is presented. Such evidence is based primarily on size, seasonal presence of empty stomachs, and on subjective considerations. For example, the adult size of *S. aquosus* in L.I.S. is less than that of B.I.S. *S. aquosus*, primarily a mysid feeder in both areas, may have difficulty eating as much in L.I.S. where there are so many mysid predators, thus slowing its growth rate. An example of the second piece of evidence occurred in L.I.S. in late winter. Many predators, with similar diets, which invaded St. 1 simultaneously, had empty stomachs. Two factors could cause this result: competition or low water temperature. The latter could be of advantage to these fish. A decrease in appetite and an increase in prey availability due to the cold would allow *A. americanus*, *M. menidia*, and the clupeoids to coexist during the time of minimum feeding and growth rates. Thirdly, competition between the *C. septemspinosus* predators, *M. bilinearis*, *U. chuss*, and *P. carolinus*, as well as between the two omnivorous predators, *P. americanus* and *S. chrysops* in the fall, is a distinct possibility on the basis of the available evidence.

The similarity of the trophic level (see also Darnell, 1958; Larkin, 1956) shown by all species within the juvenile demersal fish population may also produce competition. At St. 1 all species belonged primarily to the third level of the food chain – consumers of herbivores and detritus-feeders. Three species, *M. bilinearis*, *C. regalis*, and *L. americanus*, showed tendencies toward the fourth level as they grew older. Few supplemented their diets by being herbivorous themselves. Even in the postlarval stage those which have been investigated were not entirely herbivorous (Covill, 1959; Booth, 1959; Richards, unpubl.), but they relied heavily on copepod nauplii. If the trophic level of each species be figured on the basis of weight or volume of food, the importance of the third stage is increased to the detriment of the second and fourth stages. A superabundance of herbivorous and detritus-feeding prey may be responsible for the ability of the demersal fish community to maintain so many juveniles in the same trophic level, but two effects may result. A large number of species in this trophic level may provide food for a number of second-stage pelagic carnivores, such as *Roccus saxatilis* and *Pomatomus saltatrix*, which are seasonally abundant in L.I.S. The effect of these predators on the demersal and sublittoral fish communities is unknown. Secondly, competition within the demersal fish population may result in a generally lowered fish productivity.

Fish productivity at St. 1 was figured on the basis of the weight of food eaten by a fish in a day in those species whose stomachs were full of freshly eaten material and were weighed, on efficiency of conversion figures based on Dawes' (1931) work on plaice, and on standing crop of fish at St. 1 (Richards, 1963a; this issue). Such figures are of necessity crude, and various factors affecting them can be divided into three categories: sampling error, fish behavior variations, and nutritional variations of the prey. It is assumed that the catch of the fishing gear accurately reflected the amount of fish in the area. Seasonal changes in the amount of food consumed were assumed to average out. Uncertainty existed as to the number of times a fish ate in a day. The assumption that the fish ate once is based on the fact that the percentage of body weight of food per day eaten by the flounder was similar to that found experimentally by Pearcy (1960) and that the range of variation of the percentage of food per day of all weighed stomachs was similar to that found experimentally by Krohkin (1957) for the sockeye salmon and the three-spined stickleback. If juveniles from St. 1 ate twice a day or more or less continuously (evidence for which is scarce) and all the figures in Table VI are doubled, the productivity estimates are still low. Despite the various possibilities of error it seemed desirable to estimate production and efficiency of trophic level conversion (see Table VI).

On the sand-shell bottom the approximate productivity of juvenile demersal fish which ate both infauna and epifauna was less than 10% of the productivity of all demersal fish in the English Channel, and the efficiency of conversion of bottom fauna into young fish was far less at St. 1 than in the Channel. No direct estimates of adult productivity were available. If we assume that the adults at St. 1 ate the same amount of food as the juveniles, then the yearly production was 50% while the trophic level conversion was 67% of those in the English Channel. Since adults may have eaten less, percentagewise, than the juveniles, these estimates for St. 1 are perhaps high.

The same methods, applied to *P. americanus* alone, showed a juvenile production of 0.06 $g/m^2/yr$. On the basis of the amount of food it consumed, the productivity of infauna appeared sufficient to support this species without additional epifauna in its diet. Trophic level conversion figures were based on the consumption of both epi- and infauna, so figures for both together as well as for infauna separately are included in Table VI. The efficiency of conversion for infauna alone was six times that of infauna and epifauna combined, due to the enormous standing crop of epifauna at St. 1. Based either way, however, the efficiencies appeared to be low. Thus the most abundant juvenile predator did not appear to make maximum use of its available food.

Since Riley's (1955) explanation for the fish productivity in L.I.S. applied to the Sound as a whole, with particular reference to the mud bottom, which constitutes the major portion of the bottom of L.I.S., a partial explanation for the low productivity on the sand-shell area is necessary. In the first place, data collected by a net, which is 20′ wide at the mouth, perhaps should not be compared with those from commercial operations. Secondly, production figures from St. 1 alone may be low, since many fish caught at St. 1 spend much of their growing season in other areas. Thirdly, possible competition from invertebrates and between some fish may result in slow growth rates and small resultant adult sizes, and fourthly, abundant zooplankton and small pelagic crustaceans may be available only to those abundant species which never grow

TABLE VI. PRODUCTIVITY OF JUVENILE DEMERSAL FISH FROM ST. 1 (WET WEIGHT), BASED ON THE PERCENTAGE OF BODY WEIGHT IN FOOD CONSUMED/DAY. INVERTEBRATE STANDING CROP FROM SANDERS (1956); FISH STANDING CROPS FROM RICHARDS (1963a; THIS ISSUE); EFFICIENCY FIGURES OF DAWES (1931) FOR THE PLAICE. EPIF. = EPIFAUNA; INF. = INFAUNA.

	Juv. of all spp. eatingepif. and inf.	Juv. *P. americanus* eating		Juv. & adult of all spp. eating epif. and inf.	Juv. and adult *P. americanus* eating	
		epif. and inf.	inf. only		epif. and inf.	inf. only
Av. $^0/_0$ of body weight in food/day	4.2	2.8	2.8	4.2	2.8	2.8
Av. stand. crop of demersal fish (g/m^2) .	.07	.03	.03	.6	.4	.4
Total wgt. of food/yr. (g/m^2)	1.0	0.4	0.4	8.8	1.1	1.1
Eff. of conversion						
Range	2.3–17.8	2.3–17.8	2.3–17.8	2.3–17.8	2.3–17.8	2.3–17.8
Av.	7.0	7.0	7.0	7.0	7.0	7.0
Product. of demersal fish						
Range ($g/m^2/yr.$) ..	.5–.06	.17–.02	.17–.02	3.7–.49	.48–.06	.48–.06
Av.	.15	.06	.06	1.3	.16	.16
Eng. Channel ($g/m^2/yr.$)				1.9		
Invert. Product. (g/m^2)						
Epif. and inf.	73	73	–	73	73	–
Inf. only	–	–	12	–	–	12
Troph. level conver. – $^0/_0$ of invert. product. conv. to fish product.						
L.I.S.	.2	.08	.5	2.0	0.2	1.3
Eng. Channel	–	–	–	3.0	–	–

to large size. Above all, the production of the major component of the demersal fish population at St. 1 is not in direct proportion to its relative abundance. *P. americanus* juvenile production occurred primarily in the shallow water and estuaries of L.I.S. (Pearcy, 1960), thus, the data from St. 1 underestimates the production and trophic conversion of L.I.S. waters as a whole.

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Сара В. Ричардс

ДЕМЕРСАЛЬНОЕ НАСЕЛЕНИЕ РЫБ В ПРОЛИВЕ ЛОНГ ИСЛАНД.

2. Пища молоди в местностях с песчано-раковинным дном. Станция 1

Краткий Обзор

Пища молоди тридцати трех видов демерсальных рыб, от 19 до 235 мм., со Станции 1 состояла из одного неопределеннаго вида гидроиднаго полипа,

тридцати восьми полихетов, пятидесяти ракообразных, одиннадцати моллюсков и трех рыб. Наиболее важными видами были: полип; *Neanthes succinea, Ampharete acutifrons, Pseudodiaptomus coronatus, Temora longicornis, Acartia spp.*, личинки *Balanus balanoides, Eomysis americana, Leptocheirus pinguis, Ampelisca sp., Caprella spp.* и *Crago septemspinosus.*

Большинство хищников ели больше *N. americana* чем каких бы то нн было иных видов добычи. В общем было сьедено большее количество епифауны чем бозпозвоночных собственной фауны. Пища была наиболее разнообразной весною и осенью, то-есть в те сезоны когда состав хищников тоже был наиболее разнообразен.

Два вида многоядных хищников, *Stenotomus chrysops* и *Pseudopleuronectes americanus*, главный потребитель полихетов, сьели больше 50 °/₀ определенных видов. Четыре вида рыб, *Urophysis regius, Centropristes striatus, Prionotus carolinus* и *Etropus microstomus* сьели больше 15 °/₀. Семь видов, *Merluccius bilinearis, Pollachius virens, Urophysis chuss, Cynoscion regalis, Tautogolabrus adspersus, Ammodytes americanus* и *Sphaeroides maculatus* съели свыше 10 °/₀, ха все остальные виды меьше 10 °/₀. В общем виды обильных хищников ели более разнообразную пищу чем виды менее обильных хищников. Явное исключение представляли такие стенофаги как *Scopthalmus aquosus.*

Пища толькочто сьеденная и наполнявшая желудок хищников была взвешена. Вес пищи колебался от 1.1 °/₀ до 9.4 °/₀ веса тела. В общем вес пищи хищников равнялся 4.2 °/₀ веса их тела. Подсчет продуктивности молоди демерсальных рыб Станции 1, приблизитезьно 0.15 g/m² вы́год, показал что она меньше 10 °/₀. а производительность превращения придонной фауны в молодь равняется только одной пятнадцатой подобнаго превращения в молодь всех демерсальных рыб Английскаго Пролива. Продуктивность *P. americanus*, наиболее обычнаго хищника Станции 1, вес пищи котораго в среднем равнялся 2.8 °/₀ веса его тела, приблизительно составляла 0.05 °/₀ в год.

Почти все хищники ели травоядных и детритоядных одной и тойже величины и принадлежали к тому же пищевому уровню. В пределах этого уровня эмиграция многих хищников в другие районы в сезон роста и возможное соревнование в ловле главной добычи на песчано- раковинных осадках отчасти обьясняют низкий уровень продуктивности рыб.

The Demersal Fish Population of Long Island Sound

III. Food of the Juveniles from a Mud Locality (Station 3A)

By

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TABLE OF CONTENTS

ABSTRACT

The most important identified food species of 20 juvenile fish species (21.6–217.1 mm) from St. 3A were *Nephthys incisa, Pseudodiaptomus coronatus, Labidocera aestiva, Neomysis americana, Leptocheirus pinguis,* and *Crago septemspinosus.* Crustaceans were consumed in greater quantity, both in number and volume, than any other group of prey. Of these, *N. americana* was eaten by the greatest number of predators, while *C. septemspinosus* was eaten in the greatest quantity by volume. Seasonal fluctuations occurred in the quality and diversity of the food. The most noticeable variation was the increased consumption of small crustaceans during the fall and winter. At these times there was an increase in the diversity of the predator species.

Comparison with data from St. 1 indicated (1) less variety of invertebrates were consumed in the mud locality than in the sand-shell locality; (2) infaunal organisms constituted a greater percentage of the total food at St. 3A than at St. 1; (3) a higher percentage of empty stomachs occurred at St. 3A, perhaps due to the smaller amount of available bottom illumination there than at St. 1.

Analyses of food selection showed that competition did not exist between three chosen resident species: *Merluccius bilinearis, Scophthalmus aquosus,* and *Pseudopleuronectes americanus.* Slight competition for *N. americana* and *C. septemspinosus* was noted at certain times of year between *M. bilinearis* and *S. aquosus* and the migratory crustacean feeders. *P. americanus* avoided competition by feeding on polychaetes and by being omnivorous. Small well defined feeding niches were seldom evident within the demersal fish population of Long Island Sound.

INTRODUCTION

Analyses of the food of juvenile demersal fish from a mud locality conclude the 1955–1957 study of the demersal fish population from Long Island Sound previously described (Richards, 1963a, b; this issue). The locality (St. 3A) discussed herein, which is three miles SSE of Charles Island near Milford, Connecticut, is 17 m deep, and has a mud substrate characterized by a high percentage of fine silt (0.049–0.105 mm) similar in texture and color to that found at St. 3, four miles S of St. 3A (Sanders, 1956). St. 1, the first locality from which the food habits of the demersal fish were studied (Richards, 1963b; this issue), is characterized by a high percentage of medium and coarse sand (0.25–1.0 mm) (Sanders, 1956) and broken shell. Furthermore, considerable differences exist in the fauna of the two areas; St. 3A is occupied by a less varied invertebrate fauna (Richards and Riley, unpubl.) and a slightly less varied fish fauna (Richards, 1963a; this issue) than is St. 1. It will be shown that the food of the juvenile fish from St. 3A is also less varied than the food from fish at St. 1. Secondly, a comparison of three methods of food study is included: the numbers method, volume method, and the occurrence method (terminology from Hynes, 1950). Due to size differences, the relative amounts of individual prey species varied according to the method employed. Yet the importance of the crustaceans as a group as food for the juvenile fish (Fig. 2) was brought out by all three methods. Thirdly, seasonal fluctuations in the quality of the food are discussed. Lastly, a method of analyzing food selection was employed. In this analysis three common resident predators, *Merluccius bilinearis*, *Scophthalmus aquosus*, and *Pseudopleuronectes americanus* were treated individually, and the remainder of the predator species were combined and treated as a single group. Problems of food selection and competition of these forms were examined in relation to eight selected prey.

MATERIALS AND METHODS

A total of 498 specimens (21.6–217.1 mm) of 20 species from 19 afternoon trawl hauls between July 17, 1956, and July 23, 1957 was examined; of these, 96 (or 19%) were empty (Table II). Thus, the results will be based on the stomach contents of 402 fish. Each species is listed in Table II along with the number of specimens with stomachs of varying degrees of fullness: empty, $<^1/_2$ full, $>^1/_2$ full. Also included in this table are the number of food species eaten by each fish predator species as well as the percentage of all identified food species eaten by all predators. The Appendix includes the food of each predator species as (1) the percentage (by number) of all predators eating each prey, and (2) the percentage of each prey eaten (by number) of all that prey eaten by all predators.

In most cases the data are arranged by seasons: June through August, September through November, December through February, March through May. These intervals are based on seasonal fluctuations in the fish population.

Food (Table I) from the stomach proper was identified, counted, and measured. It was weighed only when the stomach was absolutely full of fresh material. Volumes were determined by measuring the amount of water displaced in graduate cylinders or centrifuge tubes to the nearest 0.01 cc. The small size of many organisms precluded independent volume measurements, thus different species of crustaceans or of polychaetes were frequently combined. These combined volume determinations were particularly applicable to the stomach contents of the euryphagous species, such as *Stenotomus chrysops* and *P. americanus*.

A rough analysis of the relationships between three resident predators and eight chosen prey depended upon a comparison of the "indices of competitive independence" according to Smith's (1950) method described on p. 86.

RESULTS

Eighty food items, including "unidentified", ranging in size from 0.4–90 mm, were consumed by 402 juveniles. Of these, 56 were identified to species, 65 to genus, and 73 to family or group (Table I). There were three hydroids, two nemerteans, 28 polychaetes, and 31 crustaceans. Also there were 13 mollusks, and three fish, besides "animal remains" and sand. The total variety of food species was less than that of St. 1, where 113 identified items were eaten – 11 miscellaneous items, 38 polychaetes, 50 crustaceans, 11 mollusks, and three fish (Richards, 1963b; this issue). The smaller variety of food of fish from St. 3A partially resulted from the examination of fewer stomachs of certain species, notably *S. chrysops*, *P. carolinus*, and *P. americanus*, from St. 3A than from St. 1 (Fig. 1). In addition, the variety of available food in the mud areas is less than in the sand-shell localities (Sanders, 1956; Richards and Riley, unpubl.).

Sand and mud accompanied the food in the stomachs of 33% of the predator species, primarily *P. americanus*, but in only 5% of the individuals. Comparison with the data from St. 1, where 50% of the predators species

TABLE I. FOOD OF EIGHTEEN†† SPECIES OF JUVENILE DEMERSAL FISH† FROM ST. 3A, LONG ISLAND SOUND, INCLUDING THE NUMBER AND PERCENTAGE** OF TOTAL PREDATORS AND THE SIZE RANGE OF THE PREY.

	Predators				Prey Size
	Species		Indiv.		
Prey	(N)	(%)	(N)	(%)	(mm)
Sand	6	33	23	5	–
Hydroid-unident.	1	6	9	2	–
Hydroid medusa	1	6	1	+	–
Campanularidae	1	6	2	+	11.2
Nemertean-unident.	2	11	8	2	–
Cephalothrix linearis	1	6	1	+	8–9.6
Syllidae	1	6	1	+	–
Autolytus sp.	1	6	1	+	–
Lepidonotus squamatus	1	6	1	+	12
Phyllodoce fragilis	2	11	4	1	3–6
Eteone alba	1	6	2	+	7.2
Nephthys sp.	2	11	2	+	1–3
Nephthys caeca	1	6	1	+	–
Nephthys incisa	6	33	63	13	6–48
Nereis sp.	2	11	5	1	small
Arabella iricolor	2	11	8	2	9.6
Glycera dibranchiata	1	6	1	+	6.4
Cirratulus sp.	1	6	1	+	–
Cirratulus grandis	1	6	1	+	–
Terebellidae	1	6	6	1	small
Ampharetidae	1	6	1	+	4.9
Ampharete acutifrons	2	11	18	4	4.8–17.6
Melinna cristata	2	11	27	5	4–28.4
Cistenides gouldii	2	11	16	3	3–12.8
Capitellidae	1	6	3	+	4–5
Capitella capitata	1	6	8	2	–
Maldanidae	1	6	1	+	small
Maldane sarsi	1	6	1	+	–
Praxillella sp.*	1	6	1	+	–
Flabelligera affinis	1	6	2	+	5.6–10.4
*Potamilla neglecta**	2	11	5	1	–
Spionidae	1	6	1	+	–
*Paranaitis speciosa**	1	6	1	+	–
Polychaete-unident.	6	33	26	5	3–5
Worm-unident.	1	6	4	1	–
*Sarsiella zostericola**	3	17	10	2	1.0–1.5
*Cytheridea americana**	4	22	11	2	1.0–2.4
Pseudocalanus minutus	2	11	28	6	1.0–1.4
Centropages hamatus	1	6	2	+	> 1.0
Pseudodiaptomus coronatus	8	44	48	10	0.6–1.8
Temora longicornis	3	17	16	3	1.5
Labidocera aestiva	6	33	37	7	2.1–3.0

(Cont.)

TABLE I. (Cont.)

	Predators				Prey Size
	Species		Indiv.		
Prey	(N)	(%)	(N)	(%)	(mm)
Acartia spp.	1	6	2	+	–
Balanus balanoides	1	6	6	1	1.4
Neomysis americana	16	89	188	38	1.9–11
*Oxyurostylis smithi**	1	6	1	+	5.4
*Diastylis quadrispinosa**	1	6	2	+	2.0–3.1
Edotea montosa	7	43	30	6	1.8–8
Cyathura polita	1	6	1	+	–
Amphipoda-unident.	2	11	4	1	2.2
Ampelisca sp.	4	22	12	2	1.5–4.8
Stenothoë cypris	3	17	4	1	1.5–2.5
Stenothoë minuta	2	11	2	+	2.5
Podoceropsis nitida	2	11	9	2	4–8
Leptocheirus pinguis	9	50	72	14	1.5–14.1
Unciola irrorata	2	11	2	+	6.9
Corophium cylindricum	3	17	4	1	1.3–4.2
Caprella linearis	1	6	2	+	8
Aeginella longicornis	4	22	6	1	3.2–11.4
Crago septemspinosus	10	56	93	19	5.3–29
Pagurus longicarpus	2	11	2	+	3.0–4.5
Neopanope texana sayi	2	11	2	+	7.0–8.8
*Pinnixia sayana**	1	6	1	+	8.7
Squilla sp.*	1	6	3	+	–
Crustacean-unident.	4	22	4	1	–
Nymphon grossipes	2	11	5	1	1.9
Nucula proxima	3	17	9	2	0.9–5.6
Yoldia limatula	2	11	6	1	2.2–8.3
*Lyonsia hyalina**	1	6	2	+	5.6
*Cerastoderma pinnulatum**	2	11	5	1	2.7–4.0
*Gemma gemma**	1	6	4	1	1.0–3.8
Macoma tenta	2	11	4	1	4.4
Ensis directus	1	6	11	2	2.0–5.2
Mulinia lateralis	1	6	2	+	–
Nassarius triviattatus	1	6	1	+	1.1
Retusa caniculatum	1	6	3	+	0.4–2.8
Mitrella lunata	2	11	3	+	1.9
Loligo sp.	1	6	2	+	12–15
Mollusk-unident.	4	22	6	1	–
Anchoa mitchilli	2	11	4	1	15.2–78
Ammodytes americanus	2	11	5	1	larva–< 90
Fish-unident.	3	17	4	1	1.1–11.2
Animal Remains	3	17	4	1	–

†† Data lost for *Menidia menidia* and *Syngnathus fuscus.*

† See Appendix for details of food for each species.

** All percentages rounded off to nearest whole number; those less than one indicated by a + sign.

* Species not found in the stomachs of juveniles from St. 1.

TABLE II. Number of Each Species Examined from St. 3A†, Including the Number and Percentages** with Empty, <0.5 Full, >0.5 Full Stomachs, as Well as the Number of All Identified Food Species Eaten by Each Predator Species. The Percentage of All Food Species is Based on 65 Identified Items.

	Number of stomachs						Total	Ident.	Prey
Predator Species	empty		<0.5	full	>0.5	full	No.	(N)	spp.
	(N)	(%)	(N)	(%)	(N)	(%)			(%)
Raja erinacea	0	0	0	0	5	100	5	4	6
Clupea harengus	0	0	2	8	22	92	24	7	11
Alosa aestivalis	0	0	0	0	1	100	1	2	3
Brevoortia tyrannus	0	0	0	0	1	100	1	4	6
Anchoa mitchilli	0	0	0	0	18	100	18	5	8
Osmerus mordax	0	0	0	0	1	100	1	2	3
Merluccius bilinearis	55	33	36	22	74	45	165	17	26
Enchelyopus cimbrius	3	33	4	44	2	22	9	8	12
Urophycis chuss	5	19	6	22	16	59	27	12	18
Urophycis regius	0	0	1	6	15	94	16	8	12
*Menidia menidia**	1	33	–	–	–	–	3	–	–
*Syngnathus fuscus**	2	67	–	–	–	–	3	–	–
Cynoscion regalis	0	0	5	10	43	90	48	7	11
Stenotomus chrysops	0	0	1	7	13	93	14	26	40
Tautogolabrus adspersus	2	17	2	17	8	66	12	5	8
Poronotus triacanthus	4	80	0	0	1	20	5	1	1
Prionotus carolinus	0	0	0	0	23	100	23	10	15
Paralichthys oblongus	0	0	0	0	12	100	12	3	5
Scophthalmus aquosus	10	40	7	28	8	32	25	2	3
Pseudopleuronectes americanus	14	16	13	15	59	69	86	48	74

† See Appendix for details of food of predator species.
** All percentages rounded off to whole numbers.
* Data for these species lost.

contained sand with their food, indicated that fewer species ate directly off the bottom in the muddy area.

Prey. Hydroids, occurring almost exclusively in *P. americanus* stomachs, were probably eaten in areas bordering the sampled locality. Representatives of this group were seldom found by dredging at St. 3A (Richards and Riley, unpubl.). Nemerteans were occasionally consumed by *P. americanus*.

Of the 28 polychaetes (1–48 mm) consumed by 43% of the predator species (see Appendix), 13 were exclusively eaten by *P. americanus*, six by *S. chrysops*, and nine were found in small quantity in the stomachs of six predators. The most available polychaete, *Nephthys incisa* (6–48 mm), was the most important in the fish diets. Although it was eaten by all predators which ate polychaetes, 74% of the total was consumed by *P. americanus*. Certain other species appeared in the stomachs, such as *Melinna cristata*, *Cistenides*

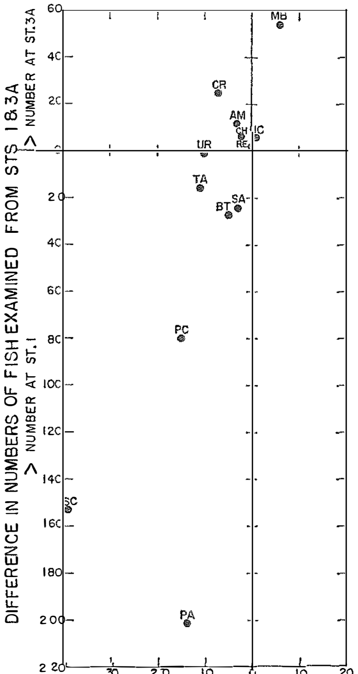

Figure 1. Comparison of the differences in numbers of fish species examined and the differences in numbers of identified food items consumed between Sts. 1 and 3A. Initials indicate the first letters of the genus and species name of the fish.

gouldii, *Ampharete acutifrons*, and *Lepidonotus squamatus*. The first two were important to *S. chrysops* and *P. americanus*. The others were consumed in far less quantity than at St. 1.

All predators ate a variety of crustaceans (0.6–29 mm) of which mysids, shrimps, isopods, amphipods, and copepods were of greatest importance. Of these, *Neomysis americana* (1.9–11 mm) interested the greatest variety of predators. It was consumed by 89% of the predator species and by 38% of the individuals (Table I). Chief among its predators were *M. bilinearis*, *C. regalis*, *P. carolinus*, and *S. aquosus* (see Appendix). Although the number of mysids consumed was less than the number of copepods, and the total volume consumed was less than the volume of *C. septemspinosus*, they still played an important role in the food of the juvenile fish. *C. septemspinosus*[1] (5.3–29 mm) was eaten

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[1] Since this paper went to press, Kent S. Price, Jr. has informed the author (personal communication, January 31, 1962) that L. B. Holthuis recently discovered that the proper name for this species is *Crangon septemspinosa*.

by more than half of the predator species, but by only 19% of the individuals, yet its total volume was approximately twice that of the mysid. The greatest percentage of shrimp was consumed by *M. bilinearis*, both *Urophycis* spp., and *P. oblongus* (Appendix). *Leptocheirus pinguis* (1.5–14.1 mm) was consumed by about 50% of the predator species and 14% of the individuals in approximately the same quantity by volume as *N. americana* but in less numbers. Chiefly responsible were *P. americanus* which ate 80% of the total consumed, and *S. chrysops* which ate 4%. Other crustaceans, particularly *Ampelisca* sp., and the isopod, *Edotea montosa*, were eaten in much smaller quantity than *L. pinguis* by a variety of predators. Copepods (0.6–3.0 mm) appeared in the stomachs in great numbers because of their small size. However, only two, *Pseudodiaptomus coronatus* and *Labidocera aestiva*, were eaten by a variety of predators, principally *R. erinacea*, *A. mitchilli*, *C. regalis*, *S. chrysops*, and *P. carolinus*, while two others, *Pseudocalanus minutus* and *Temora longicornis*, were eaten nearly exclusively by *C. harengus*.

Two other groups of prey, namely mollusks and fish, were represented in about the same quantity as at St. 1. The former group (0.4–8.3 mm) was found in small quantities in the stomachs of one-third of the predators. Of the 11 mollusk species (excluding for the moment, *Loligo* sp.), six were eaten exclusively by *P. americanus*. Only *Nucula proxima* (0.9–5.6 mm) and *Yoldia limatula* (2.2–8.3 mm), two of the most available species in the mud sediments (Sanders, 1956; Richards and Riley, unpubl.), appeared in the stomachs of other predators in significant amounts (Table I). Of the fish (1.1–< 90 mm), *Anchoa mitchilli* and *Ammodytes americanus* were the most important prey. *M. bilinearis* alone consumed 26% by number and 71% by volume of all fish prey. Other predators were *B. tyrannus*, *U. regius*, *C. regalis*, and *P. oblongus*, but fish prey were less important as to relative number than either polychaetes or crustaceans.

Comparison with previous data (Richards, 1963b; this issue) shows that the majority of juvenile demersal fish depends upon *N. americana* and *C. septemspinosus* regardless of the type of substrate; only *P. americanus* constantly consumed a significant amount of polychaetes. Of the other important prey, a slightly greater quantity of *N. incisa* and *L. pinguis* was consumed in the mud locality than on the sand-shell bottom. At St. 1, on the other hand, greater quantities of *A. acutifrons*, copepods, and crabs were eaten than at St. 3A, because of the availability of the prey at St. 1, and because of the presence there of certain copepod feeders such as *Ammodytes americanus*.

Three methods were used to compare the quantities of the five principal groups of prey that were consumed: percentage of all groups by number, percentage by volume, and percentage by the number of occurrences in the fish stomachs. These percentages are shown graphically in Fig. 2, in which the importance of the crustacean group is apparent, regardless of the method of measuring their quantity. The similarity between the percentage of occur-

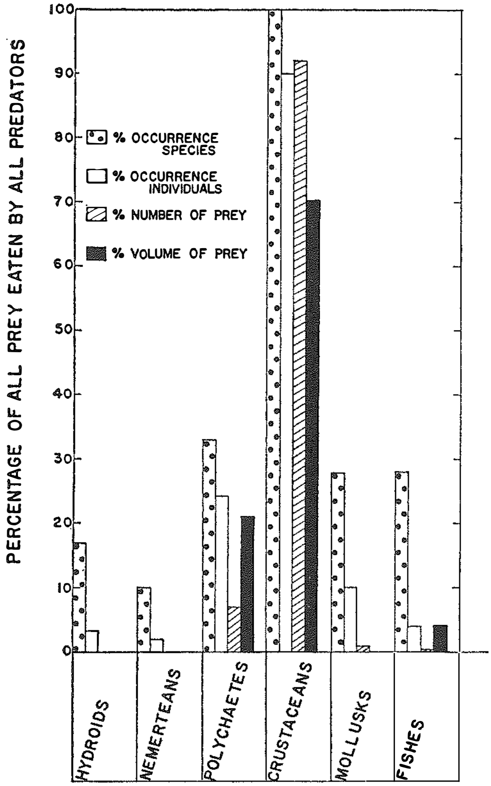

Figure 2. Comparison of the consumption of groups of prey according to three methods of measurement.

rence by predator species and by predator individuals was due to the universality of crustaceans as fish food in L.I.S. The difference between percentage quantity by number and by volume was due to the consumption of a greater number of species of small size rather than species of large size. Thus, the assessment of the relative quantity of crustaceans in the fish diet varied according to the criteria used. An indication of the relative amount of the second most important group of prey, polychaetes, also depended upon the method of evaluation. Volume measurements were underestimated because of digestion: more so, actually, than in the case of the crustaceans. *N. incisa*, for instance, occurred frequently as flaccid bits with very little volume. Nevertheless, due to the large size of this species, as well as of *M. cristata*, the total percentage of polychaetes by volume was greater than the percentage shown by number. Estimates of polychaete consumption by percentage of occurrence were higher than those obtained by either the volume or the number method. The percentage of occurrence by species was similar to that based on individuals, because so many individuals of one of the most abundant predators, *P. americanus*, ate polychaetes.

Based on all three methods, the estimated consumption of the other three groups was less than the consumption of polychaetes or crustaceans. In the first place, the quantity of fish consumed, estimated by volume, was much less than that for polychaetes or crustaceans. Secondly, the number and volume of hydroids, nemerteans, and mollusks were difficult to assess. Hydroids could not be counted, and nemerteans and mollusks occurred in too many broken fragments for counts or volume determinations. Only by the occurrence method could the importance of these groups be compared with the other groups. All three showed similar percentages of occurrence and appeared in far fewer stomachs than did either polychaetes or crustaceans.

Seasonal Fluctuations in Food and Feeding Habits. Two methods were utilized to estimate seasonal change in the food of the fish. First a general comparison based on all three methods of estimation of the quantity of each group of prey (Table III) indicated over-all changes in the quality of the food items as well as changes in the size of the prey. Secondly, a summary of the changes in quantity and diversity of prey is given. Five principal groups of food are listed in Table III, including the most important species, such as *N. incisa*, *A. acutifrons*, and *M. cristata*, because they constituted 41 °/₀ by number and 63°/₀ by volume of all polychaetes; copepods, mysids, shrimps, and *L. pinguis* constituted over 90°/₀ of all crustaceans. *N. proxima* was not necessarily the most commonly consumed mollusk, but it was the easiest to identify and measure due to its thick shell which resisted digestion. Two points should be remembered (1) the small number of hauls for each season allows only the most generalized statements about food fluctuations; and (2) the differences in estimates of consumption between summer 1956 and 1957 indicate the minimum range of variation which can be expected.

The data in Table III show that three groups of prey, polychaetes, crustaceans, and mollusks were consumed throughout the year, while others, *i. e.* hydroids, nemerteans, and fish were each neglected at one particular season. Further examination shows that two of the common polychaetes, *N. incisa* and *M. cristata*, and two of the common crustaceans, *N. americana* and *C. septemspinosus*, were eaten in all seasons, while other common items, such as copepods and *L. pinguis*, were neglected during one season or another.

During the summer all groups of prey were eaten; hydroids, nemerteans, polychaetes, and mollusks in greater quantities than at any other time during the year, crustaceans in slightly less quantity during 1956 than 1957, and fish only in 1957. The consumption of individual species of polychaetes varied; in 1956 *M. cristata* was the favorite, in 1957 *N. incisa* was eaten more abundantly, and *A. acutifrons* was neglected entirely. Of the crustaceans, copepods were never eaten in summer by the fish species examined, the consumption of

TABLE III. COMPARISON (IN PER CENT) OF SEASONAL CONSUMPTION OF GROUPS OF PREY ACCORDING TO THREE METHODS: NUMBER (N), VOLUME (V), AND OCCURRENCE (PREDATOR SPECIES–FSP; PREDATOR INDIVIDUALS–FI.)†

Prey	Summer 1956				Autumn				Winter				Spring				Summer 1957			
	N	V	Fsp	Fi	N	V	Fsp	Fi	N	V	Fsp	Fi	N	V	Fsp	Fi	N	V	Fsp	Fi
Hydroid	+	+	20	26	+	+	17	1	0	0	0	0	+	+	17	4	+	+	14	5
Nemerteans	+	+	20	5	+	+	8	2	0	0	0	0	+	+	8	3	+	+	14	3
Polychaetes*	60	17	60	63	5	1	25	16	2	31	25	24	9	22	42	26	7	35	71	33
Nephthys incisa	1	1	20	26	+	1	25	11	2	30	25	23	1	9	17	16	4	34	71	28
Ampharete acutifrons	+	?	20	5	+	+	17	6	0	0	0	0	+	+	8	7	0	0	0	0
Melinna cristata	21	?	20	60	+	?	17	9	+	+	8	3	+	+	8	2	1	+	14	3
Crustaceans	38	84	100	63	93	81	83	94	98	59	100	88	90	68	100	89	91	61	100	85
Copepods	0	0	0	0	31	3	42	33	51	5	42	26	44	2	33	17	0	0	0	0
Neomysis americana	22	9	60	21	48	29	67	72	45	33	83	65	31	23	83	37	7	3	29	10
Leptocheirus pinguis	0	0	0	0	9	9	42	14	+	1	25	8	10	26	58	37	71	38	57	5
Crago septemspinosus	8	65	40	42	3	41	50	28	+	20	42	30	2	16	33	19	8	19	43	40
Mollusks*	2	+	20	58	2	1	17	10	+	+	17	3	+	2	17	4	4	1	57	18
Nucula proxima	+	?	20	11	+	?	8	+	0	0	0	0	2	+	8	3	+	+	14	8
Fish	0	0	0	0	+	1	25	3	3	9	17	5	8	8	17	7	+	1	14	3
Total of all prey, all seasons	5	16	–	–	34	22	–	–	45	20	–	–	12	22	–	–	4	20	–	–
Total no. of hauls	2				5				5				4				3			
Total no. of predators eating:																				
species	5				10				10				12				7			
individuals	19				162				66				115				40			
% empty	35				11				33				7				39			
Divers. by number:																				
prey	6.05				8.40				3.64				7.00				3.78			
predator	1.36				2.16				2.63				2.32				1.63			

† All percentages rounded off to the nearest whole number; those less than one indicated by a + sign.
* Volumes in these groups tend to be underestimated.

C. septemspinosus remained stable, while the quantity of mysids and particularly *L. pinguis* varied. In fact, the lack of *L. pinguis* in 1956 largely accounted for the decline in the total quantity of crustaceans. *N. proxima* occurred in similar small amounts during both summers.

During the fall a change took place in the quality of the food. A decreased consumption of polychaetes accompanied an increased consumption of crustaceans. The increased quantity of crustaceans was perhaps due to an influx of pelagic crustacean feeders at this time. Note the differences between the percentage quantity by number and by volume which reflects the increase in copepod and mysid consumption by first-year migrants at the time of decreased consumption of the large crustaceans by such residents as *M. bilinearis*. The amount of mollusks, hydroids, and nemerteans eaten remained similar to that of summer, while the amount of fish increased, due to availability of enormous numbers of anchovy fry.

In winter, no hydroids or nemerteans were eaten. The only polychaete eaten in abundance was *N. incisa*, and only a few mollusks occurred in the stomachs – none of these from mid-January through February. In contrast, crustaceans were popular. Of these, copepods and mysids were more abundant in the stomachs than during the warm half of the year. The relative quantity of *C. septemspinosus* decreased a little, while the occurrence of *L. pinguis* decreased considerably. The consumption of fish, primarily the abundant or readily available *A. americanus* fry, increased a little.

Hydroids, nemerteans, and mollusks appeared again in the stomachs of a few fish during spring. Though polychaetes became slightly more abundant, with *N. incisa* still the most important, polychaete fluctuations were not correlated with the seasonal fluctuations in the relative number of their dominant predator, *P. americanus*. The consumption of crustaceans as a whole remained constant, but within the group, interest in copepods and mysids decreased. Rather there occurred an increased interest in *L. pinguis* which continued through the following summer. The amount of *C. septemspinosus* eaten through the spring remained about the same as during winter.

Seasonal fluctuations in total numbers of food organisms were large compared with variations in volumes. During the summer a small variety and number of predators fed on an unvaried diet of organisms of similar size. An increase in variety and number of prey of different sizes occurred in fall, thus altering the relative number of food items considerably while the relative volume remained about the same. The slight increase in volume between summer and fall was due to the development of a more accurate technique for volume determinations as well as to an increased number of fish available for examination. During winter such a large number of small crustaceans were eaten by the majority of predators that the total volume of food remained the same as during the fall. During spring there was an increase in numbers of *M. bilinearis* and *P. americanus*, neither of which were interested in copepods. For this reason the number of food items in the stomachs decreased.

Seasonal fluctuations in diversity of food and of predators according to the simple formula, $d = S - 1/\log_e N$, where S = the number of species, and N = the number of individuals, are listed in the last two lines of Table III. Predator diversity was low during summer, increased during fall, and remained rather constant throughout the rest of the year. Prey diversity, on the other hand, showed wider variations; it increased from summer to fall, decreased again in winter, increased in spring, and then decreased again in summer. Some qualitative interpretations of these changes are pertinent. Fish from two hauls in summer 1956 showed a greater diversification in diet than from summer 1957, due to variation in the food of *P. americanus*. The increased prey diversity during fall was a result of the influx of first-year migrant predators, while the prey diversity in winter, clearly due to the consumption of large numbers of a few species of copepods, was accompanied by an increase in the percentage of predators with empty stomachs. The spring increase in diversity of prey occurred at a time of no increase in the diversity of predators but of a decrease in numbers of fish feeding on copepods, and an increased consumption of benthic crustaceans. The summer decrease was synchronized with a decrease in diversity and number of predators, and with an increased percentage of fish with empty stomachs. The apparent correlation between a high percentage of fish with empty stomachs and low prey diversity was perhaps an effect of the small numbers of hauls examined. Nevertheless, it appeared both here and at St. 1, that fish eating rapidly or consistently (thus with a low percentage of empty stomachs) consumed a diversified diet.

The relative number of fish with empty stomachs from Sts. 1 and 3A is compared in Table IV. A greater percentage of empty fish occurred at St. 3A than at St. 1 in almost all seasons. In addition to the fact that the St. 3A hauls were taken at a different time of day than those at St. 1, there are two other reasonable explanations for this result. One, a greater variety of motile epifauna was available at St. 1 than at 3A (Sanders, 1956, Richards and Riley, unpubl.). Secondly, there is a greater amount of bottom illumination at the shallower St. 1 than at 3A (Table IV). Even during the winter, 1957, which included the time of the height of the plankton bloom, bottom illumination at St. 1 was thirty times that of St. 3A. Predators of pelagic crustaceans and benthic epifauna thus perhaps have a greater advantage in the St. 1 area than further offshore. Even *P. americanus* had a lower average percentage of empty stomachs at St. 1 (6%) than at St. 3A (16%). Conclusive results of the effect of seasonal changes in illumination on the feeding of fish in L.I.S. require sampling of similar type substrates at many depths during different hours of the day, as well as experimental work on the limits of the vision of the fish.

Food Selection and Competition. Three species of fish occurring in nearly every sample from St. 3A were selected for analysis: *M. bilinearis*, *S. aquosus*, and *P. americanus*. All other predators were grouped as one (referred to here-

TABLE IV. COMPARISON OF SEASONAL CHANGE IN BOTTOM ILLUMINATION WITH THE PERCENTAGE OF PREDATORS HAVING EMPTY STOMACHS, STS. 1 AND 3A, 1956–1957. THE EXTINCTION COEFFICIENT ($k = 1.7/S.D.$, OF POOLE AND ATKINS, 1929) MULTIPLIED BY DEPTH (z) WAS USED TO ESTIMATE THE PERCENTAGE OF SURFACE ILLUMINATION WHICH REACHED THE BOTTOM ACCORDING TO THE EQUATION, $I_z/I_0 = e^{-kz}$.

	St. 1 ($z = 9$ m)		St. 3 A ($z = 17$ m)	
Season	Bot. Illum.	% Empty	Bot. Illum.	% Empty
Summer	10.6	5.7	0.04	34.5
Fall	10.5	4.6	0.12	10.5
Winter.........	1.5	27.9	0.04	33.3
Spring.........	14.4	17.2*	0.87	7.3
Summer	6.1	12.2	0.21	38.5
Average	8.6	13.0	0.34	19.3

* Subtraction of a large school of *Ammodytes americanus* taken March 22, 1956 which had an extraordinarily high percentage of empty stomachs gives 2.7% as the total for the spring at St. 1.

after as OTHERS) regardless of species composition or seasonal distribution. Eight prey were chosen: *N. incisa*, *M. cristata*, all copepods, *N. americana*, *L. pinguis*, *C. septemspinosus*, *N. proxima*, and all fish. All other prey were also grouped as one (hereafter "others"). The method employed for the study of food selection establishes an arbitrary and relative index of the amount of a given prey eaten by a given predator in relation to the amount of that prey eaten by all other species of predators and the amount of other prey eaten by the predator in question (see Smith, 1950).

Thus in a particular sample or in a series of samples which we intend to combine into a single average value, we define the following:

P_1 = number (or volume) of prey of a given species found in the stomach contents of a given species of predator.
ΣP_1 = number or volume of the same species of prey found in all predators.
ΣR_1 = number or volume of all prey taken by the given predator under consideration.

Then the ratio $P_1/\Sigma P_1$ indicates the relative proportion of the total consumption of the given prey species which is allocated to the chosen predator species. The ratio $P_1/\Sigma R_1$ indicates the degree to which this predator feeds on the given species of prey to the exclusion of other prey. The index of competitive independence, C. I., combines the two ratios. Thus C. I. = $(P_1)^2/(\Sigma P_1 \Sigma R_1)$. The index so obtained ranges from zero to unity. An index of zero indicates that none of the given species of prey is eaten by the predator

TABLE V. SCORES OF COMPETITIVE INDEPENDENCE DETERMINED FOR THREE RESIDENT PREDATORS – *M. bilinearis, S. aquosus, P. americanus,* AND FOR OTHERS – AND FOR EIGHT PREY AND "others", FOR EACH SEASON AND FOR THE TOTAL YEAR, BY BOTH AVERAGE NUMBER AND AVERAGE VOLUME OF PREY/PREDATOR SPECIES. A + SIGN INDICATES A SCORE LESS THAN 0.001; A ? INDICATES THAT THE AMOUNT WAS NOT DETERMINED. SEE TEXT FOR EXPLANATION OF THE EQUATION FOR SCORES.

Prey Species	*M. bilin.*		*S. aquos.*		*P. amer.*		OTHERS	
	N	V	N	V	N	V	N	V
June–August								
Nephthys incisa	.000	.000	.000	.000	.015	.371	.000	.000
Melinna cristata	.000	.000	.000	.000	.321	?	.000	.000
Copepods (all)	.000	.000	.000	.000	.000	.000	.000	.000
Neomysis americana	.014	+	.932	.977	+	+	.000	.000
Leptocheirus pinguis	.000	.000	.000	.000	.000	.000	.000	.000
Crago septemspinosus	.495	.759	.000	.000	.000	.000	.146	.094
Nucula proxima	.000	.000	.000	.000	.004	?	.000	.000
Fish	.000	.000	.000	.000	.000	.000	.000	.000
"others"	.000	.000	.000	.000	.603	.097	.051	.588
September–November								
Nephthys incisa	.000	.000	.000	.000	.004	.056	.001	?
Melinna cristata	.000	.000	.000	.000	.025	?	.001	?
Copepods (all)	.001	+	.000	.000	.000	.000	.554	.051
Neomysis americana	.023	.018	.650	.557	+	+	.085	.069
Leptocheirus pinguis	+	+	.000	.000	.564	.283	.003	.001
Crago septemspinosus	.007	.265	+	+	.000	.000	.045	.373
Nucula proxima	.000	.000	.000	.000	.000	.000	.002	?
Fish	.050	.002	.000	.000	.000	.000	+	.110
"others"	.010	+	.000	.000	.032	.376	.043	.045
December–February								
Nephthys incisa	.000	.000	.000	.000	.184	.091	.009	.313
Melinna cristata	.000	.000	.000	.000	.113	.098	.000	.000
Copepods (all)	.000	.000	.000	.000	.000	.000	.539	.060
Neomysis americana	.023	.014	.064	.168	+	+	.394	.248
Leptocheirus pinguis	.007	.003	.000	.000	.008	+	+	.147
Crago septemspinosus	.015	.295	.000	.000	.000	.000	.005	.007
Nucula proxima	.000	.000	.000	.000	.000	.000	.000	.000
Fish	.003	.051	.000	.000	.000	.000	.003	.063
"others"	.000	.000	.000	.000	.001	.003	+	+
March–May								
Nephthys incisa	.000	.000	.000	.000	.125	.298	+	.010
Melinna cristata	.000	.000	.000	.000	.021	.014	.000	.000
Copepods (all)	+	+	.000	.000	.000	.000	.544	.024
Neomysis americana	.017	.001	.352	.385	.001	+	.142	.116
Leptocheirus pinguis	.023	.013	.000	.000	.265	.120	.031	.167
Crago septemspinosus	.015	.106	.000	.000	.000	.000	.019	.132
Nucula proxima	.000	.000	.000	.000	.021	.006	.000	.000
Fish	.027	.251	.000	.000	.000	.000	.009	.020
"others"	+	+	.000	.000	.021	.018	.112	.238

(Cont.)

TABLE V. (Cont.)

Prey Species	*M. bilin.*		*S. aquos.*		*P. amer.*		OTHERS	
	N	V	N	V	N	V	N	V
June–August								
Nephthys incisa	.023	.021	.000	.000	.001	+	.103	.402
Melinna cristata	.000	.000	.000	.000	.018	.060	.000	.000
Copepods (all)	.000	.000	.000	.000	.000	.000	.000	.000
Neomysis americana	.000	.000	.969	.991	.000	.000	+	+
Leptocheirus pinguis	+	+	.000	.000	.861	.258	.025	.274
Crago septemspinosus	.140	.414	.000	.000	.000	.000	.204	.045
Nucula proxima	.000	.000	.000	.000	.000	.000	+	+
Fish	.027	.084	.000	.000	.000	.000	.000	.000
"others"	.013	.001	.000	.000	.009	.064	.116	.032
Totals								
Nephthys incisa	+	.002	.000	.000	.014	.040	.006	.155
Melinna cristata	.000	.000	.000	.000	.104	.030	+	?
Copepods (all)	+	+	.000	.000	.000	.000	.536	.030
Neomysis americana	.019	.004	.346	.429	+	+	.222	.085
Leptocheirus pinguis	+	.001	.000	.000	.432	.157	.003	.097
Crago septemspinosus	.043	.405	+	+	.000	.000	.019	.119
Nucula proxima	.000	.000	.000	.000	.002	+	+	+
Fish	.007	.042	.000	.000	.000	.000	.002	.021
"others"	.001	+	.000	.000	.073	.051	.011	.111

in question. An index of unity is obtained under the extreme conditions where the given prey is the only food taken by the chosen predator and is not eaten by any other predator. Scores between unity and zero indicate feeding overlap resulting from three possible situations. In the first place, active interspecific competition may be present. In this analysis it is difficult to separate the effect of active competition from the effect of passive indifference to a prey or the lack of specific ability of a predator to catch a prey which is actively consumed by another predator. The actual degree of dependence of a predator on a given prey can be judged when the index is either fairly high or very low. Yet, this method measures the amount of interference from other predators a little more clearly than either the "frequency" or "dominance" methods of Nilsson (1955). However, its application requires the assumption of constant prey availability, a less important assumption for the application of Nilsson's techniques (1955, 1960).

Differences in scores, depending on whether numbers or volumes were used in the computation, are noted in Table V. Such differences were minimal in cases such as *S. aquosus*, which was almost entirely dependent on one species of prey. Differences were larger when prey of different sizes were commonly eaten. Since the method does not lead to a single clear-cut result, it seems desirable to list both sets of scores.

The total annual scores listed in the lower part of Table V indicate that there is little competition among the three resident species for any one prey. *M. bilinearis* ate 14 species but concentrated on *C. septemspinosus*, while *S. aquosus* was almost entirely limited to *N. americana*. *P. americanus* relied primarily on *N. incisa*, *M. cristata*, and *L. pinguis*, although the total list of prey included 49 species. Some competition existed between *S. aquosus* and OTHERS and between *M. bilinearis* and OTHERS, but no really serious competition arose between *P. americanus* and OTHERS with the possible exception of one of the group, *S. chrysops*. On the whole the OTHERS group relied upon *N. incisa*, copepods, *N. americana*, *L. pinguis*, and *C. septemspinosus* out of a total of 57 prey identified to species. These species varied in importance, depending on the constituents of the predator group, the season of the year, and the method of measuring prey quantity (Table V). Copepods were eaten only by OTHERS, and there was always some species present, in addition to *S. aquosus*, which fed on mysids. Those species in OTHERS which ate any significant amount of mysids were *B. tyrannus*, *A. mitchilli*, *U. chuss*, *U. regius*, *C. regalis*, and *P. carolinus*; none relied upon it heavily with the exception of the last one in the list. *C. septemspinosus*, the favorite food of *M. bilinearis*, was eaten by *U. chuss*, *U. regius*, *P. carolinus*, and *P. oblongus*. Only the last relied upon it heavily. The constant presence of juveniles of both this species and the whiting, as well as the sea robin and the windowpane, would perhaps result in serious food competition. Prey other than the favorite species were eaten only by *P. americanus* and OTHERS to any extent, the former because of the euryphagous nature of its diet, the latter due to the inclusion of predators of varying food habits within the group.

In addition to variations which resulted from the method of determining the quantity of prey consumed, there were other fluctuations in these scores. These are discussed below for each species in turn, along with simultaneous analyses of the effect of fluctuations in prey and predator diversities on the scores of each predator. The results are shown in Fig. 3.

In general, the scores of *M. bilinearis*, which remained at a rather low level throughout most of the year, increased during summer when the whiting concentrated on *C. septemspinosus*. At this time predator diversity was low. An increase in diversity was accompanied not only by a decrease in the whiting's total score, but also by an increase in the variety of its prey.

Precipitous seasonal changes in *S. aquosus* scores of competitive independence are noted involving one species, *N. americana*. Decreasing steadily from summer to winter, the scores increased through the spring to a high again the following summer. There was, of course, no connection between the scores and prey diversity due to the stenophagous nature of the windowpane's diet. Rather, these scores were inversely proportional to changes in predator diversity. Since such a variety and number of fish consume *N. americana* in L.I.S., the apparent seasonal fluctuations in *S. aquosus* scores for this prey may have

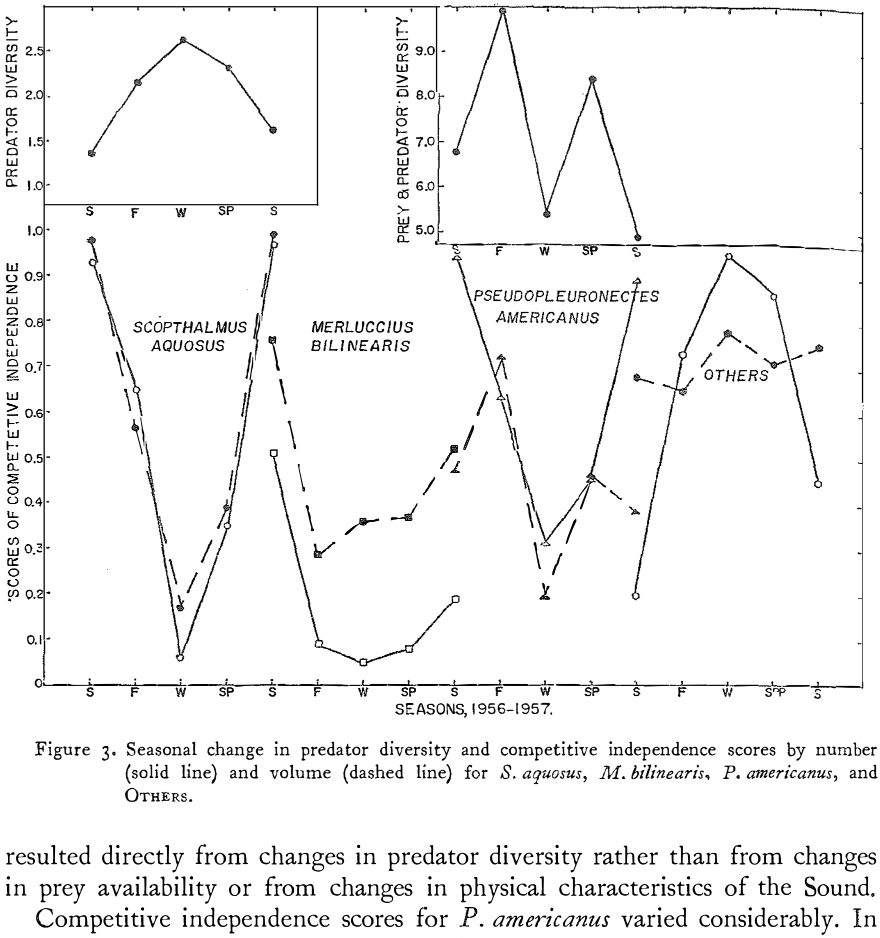

Figure 3. Seasonal change in predator diversity and competitive independence scores by number (solid line) and volume (dashed line) for *S. aquosus*, *M. bilinearis*, *P. americanus*, and Others.

resulted directly from changes in predator diversity rather than from changes in prey availability or from changes in physical characteristics of the Sound.

Competitive independence scores for *P. americanus* varied considerably. In the first place, those based on numbers of prey decreased during fall and winter and increased during spring as did the scores of the other two residents. On the other hand, the scores resulting from volume measurements increased during spring and fall but decreased during winter and during summer. Thus, fluctuations by volume were directly proportional to changes in prey and predator diversities combined, while fluctuations in scores for numbers of prey were proportional to changes in predator diversity only. These results may have been due to the expansion of the winter flounder's diet to include less commonly consumed prey at the time of fall abundance of migratory predators, and to include a greater diversity of polychaetes and a greater amount of *L. pinguis* in the spring.

The scores of the remaining predators, Others, fluctuated quite differently from those of the three chosen residents, due to a combination of a variety of predators and to definite seasonal trends in their feeding habits. By numbers the scores increased from summer to winter and decreased during the spring and thus were possibly proportional to changes in predator diversity. The correlation may be explained in part by the increased consumption of large numbers of mysids and copepods during the fall and winter. By volume, hardly any changes occurred in the scores.

Removal of the prey called "others" from the total of all prey effected the scores of some predators. Naturally, no change occurred in the scores of *S. aquosus*, which depended on one chosen prey. By the same token very little effect was noted in the *M. bilinearis* scores, because it depended on chosen shrimp, mysid, and fish. Subtraction of "others" drastically altered the flounder scores for summer and fall, the seasons in which the flounder created most of the prey diversity. Removal of "others" resulted in little changes in the scores of all other predators as a group, during fall and winter since copepods and mysids were primarily eaten. During spring and summer however, a difference was noted; other prey besides the chosen species were more heavily consumed by a small variety of predators at these times.

DISCUSSION

An accurate determination of the amount of food consumed by juvenile fish in L.I.S. depended on both counts and volume measurements of prey. Furthermore, the percentage of occurrence (relative number of species or individual predators consuming a prey) was necessary to measure the prey's horizontal spread through the fish population. The size of the prey combined with these measurements of quantity allowed comparison of the food of predators from the mud locality with those from the sand-shell locality.

The food of juvenile demersal fish at St. 3A was less varied than that from St. 1, due in part to fewer fish examined, but also to the more uniform nature of available prey associated with the mud bottom. Nevertheless, the principal food at both stations consisted of the crustaceans, *Neomysis americana* and *Crago septemspinosus*. The first of these probably provided the basic diet of more predator species than any other organism in L.I.S., while the second was eaten in greater volume than any other prey. The importance of copepods, *L. pinguis*, *A. acutifrons*, and *N. incisa* should not be overlooked at either station. The first two formed the basic diet of many species, while the two polychaetes were important to the most common predator from both localities, *P. americanus*.

The percentage of the total variety of identified prey which was consumed by the principal predators at Sts. 1 and 3A was compared (see Table I; also Richards, 1963b: table I, this issue). The majority of these predators consumed less than 20% of the total variety of prey in both areas, while two predators, *S. chrysops* and *P. americanus*, consumed 50% or more of the total variety. Many less common predators consumed less than 10% of the variety of prey. A few predators occurring in both areas consumed less variety at St. 3A than at St. 1, for example, *S. chrysops*. Fewer specimens were examined from St. 3A than from St. 1 (Fig. 1). Only two major predators, *M. bilinearis* and *U. chuss*, had a greater variety of food at St. 3A than at St. 1. This resulted in part from the larger total number examined from St. 3A, but perhaps primarily to greater fluctuations in availability of their favorite prey at the mud locality. It is clear, however, that only a few prey constituted the major portion of the diets of most predator species from both areas.

In general the nature of the diet of *P. americanus* was almost unique. Its dependence on polychaetes separated it from most others, which tended to be primarily crustacean feeders. Furthermore, its omnivorous tendencies allowed it to consume a variety of prey at any time. Although overlap existed between its food and that of other predators, extensive competition with the crustacean feeders was precluded by the flounder's omnivorous diet. The greater size of the feeding niche of *P. americanus*, in contrast to the other resident predators, is probably the reason for its greater relative abundance in L.I.S.

Immigration of migratory predator species, which occurred sporadically throughout the year, increased the chances of interspecific competition. However, two factors tended to keep such competition to a minimum for all species with the exception of *S. aquosus*; the superabundant and well distributed food resources and the lack of territorial behaviour of the predators. The mobility of both prey and predators in a temperate marine environment such as L.I.S. results in constant shifts in the amount of feeding overlap, thus preventing the formation of well defined small feeding niches such as are common on Pacific coral reefs (Hiatt and Strasburg, 1960).

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Сара В. Ричардс

ДЕМЕРСАЛЪНОЕ НАСЕЛЕНИЕ РЫБ В ПРОЛИВЕ ЛОНГ ИСЛАНД.

3. Пища молоди в илистой местности. Станция 3А.

Краткий Обзор

Наиболее важные определенные виды пищи двадцати видов молоди демерсальных рыб с глубины от 21.1 до 217.1 метров на Станции 3А были *Nepthys incisa Pseudodiaptomus coronatus*, *Labidocera aestiva*, *Neomysis americana*, *Leptocheirus pinguis* и *Crago septemspinosus*. Число и обьем сьеденных ракообразных были больше чем таковые других групп. Большинство хищников ели *N. americana*, а наибольший обьем занимали *C. septemspinosus*.

Сезонные колебания наблюдались и в качестве и в разнородности пищи. Наиболее заметной вариацией было увеличенное пожирание маленьких ракообразных осенью и зимой, когда и разнообразие видов хищников тоже возрастало.

Сравнение с данными Станции 1 показало: 1), что разнообразие беспозвоночных сьеденных в местности с илистым дном было меньше такового в местности с песчано-раковинным дном: 2), что больший процент пищи состоял из организмов принадлежащих местной Фауне на Станции 3А чем на Станции 1: и 3). что обьяснение этому заключбется, быть может, в более слабом освещении дна на Станции 3А чем на Станции 1.

Анализ выбора пищи показал, что не было соревнования между избранными для анализа тремя местными видами рыб, *Merluccius bilinearis, Scophthalmus aquosus* и *Pseudopleuronectes americanus*. В определенные времена года некоторое соревнование наблюдалось в пользу *N. americana* и *C. septemspinosus* по сравнению с *M. bilinearis* и *S. aquosus*, а мигрирующий потребитель ракообразных, *P. americanus*, избегал конкуренцию как питанием полихетами так и тем что он многояден. Небольшия, хорошо очерченныя пищевыя ниши в населениях демерсальных рыб Пролива встречалис только изредка.

APPENDIX

THE FOOD* OF EACH PREDATOR SPECIES FROM STS. 1 AND 3A: COLUMN A, THE PERCENTAGE** OF ALL PREDATOR SPECIES WHICH ATE EACH PREY SPECIES; COLUMN B, THE PERCENTAGE OF ALL PREY SPECIES EATEN BY ALL PREDATOR SPECIES.

	St. 1 A	St. 1 B	St. 3A A	St. 3A B
Raja erinacea	N† = 3 89–110 mm		N = 5 90–120 mm	
Sand	+	–	0	0
Pseudocalanus minutus	0	0	14	1
Pseudodiaptomus coronatus	0	0	10	33
Temora longicornis	+	+	0	0
Neomysis americana	+	+	0	0
Heteromysis formosa	1	3	0	0
Leptocheirus pinguis	0	0	1	+
Crago septemspinosus	+	+	4	2
Crustacean – unident.	0	0	25	33

	St. 1 A	St. 1 B	St. 3A A	St. 3A B
Clupea harengus	N = 18 33.9–51.1 mm, 23.2 cms		N = 24 46.0–122.1 mm	
Sand	+	–	0	0
Diatoms + dinoflagellates	57	73	0	0
Eggs – invertebrate	50	72	0	0
Paracalanus sp.	100	100	0	0
Paracalanus crassirostris	45	60	0	0
Pseudocalanus minutus	17	13	86	99
Centropages hamatus	75	30	100	100
Pseudodiaptomus coronatus	0	0	21	2
Temora longicornis	1	+	69	97
Acartia clausi	25	16	0	0
Acartia sp.	0	0	50	50
Copepods – unident.	17	28	0	0
Balanus balanoides	0	0	100	100
Neomysis americana	+	2	6	4
Crustacean – unident.	10	–	0	0

	St. 1 A	St. 1 B	St. 3A A	St. 3A B
Alosa pseudoharengus	N = 9 57.6–101 mm		N = 0	
Sand	+	–	0	0
Temora longicornis	1	+	0	0
Labidocera aestiva	8	11	0	0
Acartia tonsa	17	8	0	0
Acartia spp.	1	+	0	0
Balanus balanoides (cyprids)	1	+	0	0
Leptocheirus pinguis	3	+	0	0
Neomysis americana	2	18	0	0

	St. 1 A	St. 1 B	St. 3A A	St. 3A B
Alosa aestivalis	N = 2 56.8, 60.1 mm		N = 1 93.2 mm	
Eggs – invertebrate	8	+	0	0
Centropages hamatus	25	70	0	0
Pseudodiaptomus coronatus	0	0	2	+
Temora longicornis	1	+	0	0
Acartia spp.	+	+	0	0
Copepod – unident.	8	11	0	0
Neomysis americana	0	0	+	+

	St. 1 A	St. 1 B	St. 3A A	St. 3A B
Brevoortia tyrannus	N = 28 16.2–120.1 mm		N = 1 100 mm	
Centropages sp.	13	1	0	0
Paracalanus crassirostris	22	>2	0	0
Temora longicornis	7	9	0	0
Labidocera aestiva	2	+	3	1
Acartia spp.	+	+	25	2
Copepod* – unident.	8	4	0	0
Balanus balanoides (nauplii)	37	19	0	0
Balanus balanoides (cyprids)	19	61	0	0
Neomysis americana	5	6	+	6
Photis reinhardi	6	4	0	0
Palaemonetes vulgaris	100	100	0	0
Crustacean – unident.	5	–	0	0
Anchoa mitchilli	0	0	25	40

* broken *T. longicornis* and *P. crassirostris* combined.

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* Stomach contents of less than 1% indicated by a plus sign.

** All percentages rounded off to the nearest whole number.

† N = number examined.

	St. 1		St. 3A	
	A	B	A	B
Anchoa mitchilli	N = 6 64.0– 83.1 mm		N = 18 63.5– 78.4 mm	
Sand	0	0	4	–
Diatoms + Dinoflagellates	14	+	0	0
Centropages sp.	7	2	0	0
Pseudodiaptomus coronatus	2	6	33	57
Labidocera aestiva	7	34	94	77
Ostracods – unident.	25	63	0	0
Neomysis americana	1	1	7	4
Amphipod – unident.	0	0	25	–
Pagurus longicarpus	0	0	50	50
Osmerus mordax	N = 2 136.5, 147.8 mm		N = 1 166.7 mm	
Neomysis americana	+	1	+	1
Ampelisca sp.	2	8	0	0
Calliopius laeviusculus	50	67	0	0
Crago septemspinosus	+	1	1	1
Merluccius bilinearis	N = 111 72.5– 211 mm		N = 165 62.8– 216 mm	
Sand	+	–	0	0
Hydroid medusa – unident.	0	0	100	100
Nephthys incisa	0	0	5	2
Temora longicornis	0	0	13	+
Labidocera aestiva	0	0	3	16
Neomysis americana	14	15	29	15
Heteromysis formosa	3	1	0	0
Edotea montosa	0	0	7	1
Ampelisca sp.	10	13	8	21
Leptocheirus pinguis	9	4	8	+
Corophium cylindricum	0	0	25	11
Corophium sp.	2	1	0	0
Aeginella longicornis	0	0	17	4
Amphipod – unident.	14	13	0	0
Crago septemspinosus	24	25	47	33
Crab – unident.	25	25	0	0
Yoldia limatula	0	0	17	6
Macoma tenta	0	0	25	8
Ensis directus	4	1	0	0
Mitrella lunata	0	0	33	50
Loligo sp.	0	0	100	100
Anchoa mitchilli	25	40	75	60
Merluccius bilinearis	50	50	0	0
Ammodytes americanus	60	45	40	14
Fish – unident.	0	0	25	25
Animal remains	0	0	25	–

	St. 1		St. 3A	
	A	B	A	B
Pollachius virens	N = 22 23.1– 66.2 mm		N = 0	
Calanus finmarchicus	100	100	0	0
Paracalanus crassirostris	22	37	0	0
Pseudocalanus minutus	67	79	0	0
Pseudodiaptomus coronatus	1	+	0	0
Temora longicornis	3	+	0	0
Acartia clausi	17	1	0	0
Acartia spp.	3	1	0	0
Tortanus discaudatus	100	100	0	0
Neomysis americana	4	3	0	0
Heteromysis formosa	5	51	0	0
Stenothoë cypris	2	1	0	0
Siphonoecetes smithianus	5	3	0	0
Caprellid – unident.	7	1	0	0
Enchelyopus cimbrius	N = 0		N = 9 146.8– 217.1 mm	
Sand	0	0	4	–
Polychaete – unident.	0	0	8	+
Nephthys incisa	0	0	8	4
Cytheridea americana	0	0	9	7
Neomysis americana	0	0	+	+
Edotea montosa	0	0	3	+
Ampelisca sp.	0	0	8	16
Crago septemspinosus	0	0	1	1
Neopanope t. sayi	0	0	50	50
Mollusk – unident.	0	0	17	17
Urophycis chuss	N = 21 85.9– 203.8 mm		N = 27 70– 168.3 mm	
Sand	1	–	0	0
Twig	50	50	0	0
Nereidae – unident.	7	5	0	0
Nephthys incisa	0	0	13	14
Nephthys sp.	0	0	50	25
Glycera sp.	6	4	0	0
Polychaete – unident.	2	1	4	+
Sarsiella zostericola	0	0	10	6
Cytheridea americana	0	0	9	7
Neomysis americana	2	1	4	1
Heteromysis formosa	3	2	0	0
Edotea montosa	0	0	10	9
Ampelisca sp.	2	1	0	0
Leptocheirus pinguis	5	4	7	1

	St. 1		St.3A	
	A	B	A	B
Corophium sp.	3	2	0	0
Aeginella longicornis	0	0	33	21
Crago septemspinosus	9	18	13	8
Callianasa stimpsoni	100	100	0	0
Neopanope t. sayi	0	0	50	50
Pinnixia sayana	0	0	100	100
Crustacean – unident.	0	0	25	33
Cerastoderma pinnulatum	0	0	20	4
Urophycis regius	N = 17 56.1–195mm		N = 16 48.2–186.1 mm	
Sand	2	–	4	–
Hydroid – unident.	1	–	0	0
Nephthys incisa	4	2	5	1
Glycera americana	50	57	0	0
Polychaete – unident.	2	1	8	–
"Stuff"*	2	2	0	0
Pseudodiaptomus coronatus	0	0	2	+
Temora longicornis	1	+	19	3
Halocypris brevirostris?	100	100	0	0
Ostracod – unident.	100	100	0	0
Neomysis americana	1	+	3	+
Heteromysis formosa	5	5	0	0
Edotea montosa	100	100	0	0
Stenothoë cypris	3	2	0	0
Calliopius laeviusculus	50	33	0	0
Leptocheirus pinguis	5	5	8	1
Unciola irrorata	9	8	0	0
Corophium cylindricum	0	0	25	44
Corophium sp.	2	1	0	0
Caprella geometrica	14	4	0	0
Caprella linearis	3	+	0	0
Crago septemspinosus	3	8	6	4
Crab – unident.	25	25	0	0
Crustacean – unident.	5	–	0	0
Macoma tenta	11	5	0	0
Ammodytes americanus	17	9	60	86
Animal remains	0	0	25	–

* Amorphous mass of organic material found only in species which ate polychaetes.

Apeltes quadracus	N = 4 43–53 mm		N = 0	
Temora longicornis	1	+	0	0
Labidocera aestiva	5	1	0	0
Acartia spp.	+	+	0	0

	St. 1		St 3A.	
	A	B	A	B
Balanus balanoides (nauplii)	2	+	0	0
Balanus balanoides (cyprids)	1	1	0	0
Neomysis americana	+	+	0	0
Crustacean – unident.	6	–	0	0
Syngnathus fuscus	N = 13 88–177.6 mm		N = 3 data lost	
Eggs – invertebrate	8	26	–	–
Pseudodiaptomus coronatus	3	5	–	–
Temora longicornis	1	+	–	–
Eurytemora sp.	100	100	–	–
Acartia tonsa	17	8	–	–
Acartia sp.	+	+	–	–
Alteutha depressa	100	100	–	–
Neomysis americana	1	+	–	–
Stenothoë cypris	5	4	–	–
Nassarius triviattatus	50	50	–	–
Menidia menidia	N = 54 47–116.9 mm		N = 3 data lost	
Sand	2	–	–	–
Algae	25	–	–	–
Egg – fish	50	67	–	–
Pseudodiaptomus coronatus	2	+	–	–
Temora longicornis	3	+	–	–
Labidocera aestiva	2	+	–	–
Acartia spp.	6	2	–	–
Copepod – unident.	17	6	–	–
Cyclopoid	100	100	–	–
Neomysis americana	5	4	–	–
Heteromysis formosa	3	1	–	–
Cynoscion regalis	N = 23 40–99 mm		N = 48 37–82.5 mm	
Eggs – invertebrate	8	+	0	0
Pseudodiaptomus coronatus	4	2	2	+
Temora longicornis	2	+	0	0
Labidocera aestiva	5	1	27	71
Acartia spp.	0	0	20	20
Neomysis americana	+	+	14	12
Nebalia sp.?	100	100	0	0
Ampelisca sp.	6	8	0	0
Leptocheirus pinguis	1	+	3	+
Corophium sp.	2	1	+	+
Amphipod – unident.	7	7	0	0

	St. 1		St. 3A	
	A	B	A	B
Crago septemspinosus	7	4	5	2
Upogebia affinis	50	57	0	0
Pagurus sp.	4	8	0	0
Panopeus herbstii	4	3	0	0
Anchoa mitchilli	50	40	0	0
Fish – unident.	0	0	50	50
	N = 28		N = 0	
Centropristes striatus	19.1–49.5 mm			
Sand	3	–	0	0
Hydroid – unident.	1	–	0	0
Sternaspis acutata	100	100	0	0
Polychaete – unident.	2	1	0	0
Pseudodiaptomus coronatus	6	1	0	0
Temora longicornis	3	+	0	0
Acartia spp.	+	+	0	0
Neomysis americana	4	1	0	0
Heteromysis formosa	25	14	0	0
Michtheimysis stenolepis	25	40	0	0
Ampelisca sp.	6	3	0	0
Stenothoë cypris	8	3	0	0
Stenothoë sp.	16	9	0	0
Erichthonius brasiliensis	19	45	0	0
Corophium sp.	11	5	0	0
Aeginella longicornis	2	+	0	0
Caprella linearis	10	14	0	0
Caprellid – unident.	13	8	0	0
Crago septemspinosus	3	2	0	0
Pagurus sp.	26	21	0	0
Panopeid – unident.	9	5	0	0
Crab larvae	100	100	0	0
Crab – unident.	25	25	0	0
	N = 167		N = 14	
Stenotomus chrysops	20–146 mm		28.6–82.8 mm	
Sand	11	–	0	0
Twig	50	50	0	0
Eggs – invertebrate	17	+	0	0
Hydroid – unident.	21	–	0	0
Cerebratulus luridus	10	+	0	0
Nemerteans – unident.	14	–	37	–
Autolytus sp.	50	50	0	0
Lepidonotus squamatus	29	23	0	0
Sthenelais gracilis	11	4	0	0
Phyllodoce fragilis	76	94	100	100
Eteone alba	0	0	100	100
Nereis pelagica	17	13	0	0
Nereis sp.	0	0	40	33

	St. 1		St. 3A	
	A	B	A	B
Nereidae – unident.	20	14	0	0
Neanthes succinea	5	3	0	0
Nephthys incisa	19	15	6	4
Nephthys sp.	0	0	50	75
Nephthyidae – unident.	9	7	0	0
Lumbrinereis sp.	100	33	0	0
Glycera americana	25	14	0	0
Glycera dibranchiata	0	0	100	100
Glycera sp.	19	17	0	0
Arabella iricolor	0	0	25	4
Cirratulus grandis	25	17	0	0
Cirratulus sp.	0	0	100	100
Ampharete acutifrons	8	3	22	26
Ampharete sp.	14	9	0	0
Melinna cristata	64	59	15	36
Cistenides gouldii	67	73	25	10
Capitella capitata	25	40	0	0
Capitellidae – unident.	85	92	0	0
Maldane sp.	50	33	0	0
Maldanidae – unident.	0	0	100	100
Flabelligera affinis	0	0	20	17
Amphicora fabricii	38	47	0	0
Eupomatus dianthus	92	94	0	0
Paranaitis speciosa	0	0	100	100
Polychaete – unident.	24	24	27	94
"Stuff"*	61	64	0	0
Clitellio arenarius	8	1	0	0
Oligochaete – unident.	25	12	0	0
Worm – unident.	50	50	0	0
Sagitta sp.	100	100	0	0
Pseudodiaptomus coronatus	48	61	10	7
Temora longicornis	19	2	0	0
Labidocera aestiva	44	15	13	5
Acartia clausi	17	1	0	0
Acartia tonsa	50	76	0	0
Acartia spp.	21	7	0	0
Copepod – unident.	25	8	0	0
Sarsiella zostericola	0	0	30	41
Cytheridea americana	0	0	9	7
Neomysis americana	10	2	4	+
Heteromysis formosa	15	12	0	0
Michtheimysis stenolepis	75	60	0	0
Mysid – unident.	100	100	0	0
Edotea montosa	0	0	13	8
Ampelisca sp.	16	28	33	26
Stenothoë cypris	28	31	25	10
Stenothoë minuta	100	100	50	50
Stenothoë sp.	46	44	0	0
Photis reinhardi	12	1	0	0
Podoceropsis nitida	9	10	56	52

	St. 1		St.3A	
	A	B	A	B
Leptocheirus pinguis	14	9	6	4
Erichthonius brasiliensis	25	11	0	0
Unciola irrorata	18	15	0	0
Siphonocoetes smithianus	14	9	0	0
Corophium sp.	21	18	0	0
Aeginella longicornis	32	30	0	0
Caprella geometrica	14	4	0	0
Caprella linearis	42	45	0	0
Caprellid – unident.	20	21	0	0
Amphipod – unident.	36	33	0	0
Amphipod – sand tube	40	50	0	0
Crago septemspinosus	4	1	0	0
Pagurus longicarpus	33	33	0	0
Pagurus sp.	14	10	0	0
Panopeid	4	–	0	0
Crustacea – unident.	39	–	0	0
Nymphon grossipes	60	67	20	20
Nucula proxima	0	0	11	8
Macoma tenta	44	33	0	0
Ensis directus	4	1	0	0
Mulinia sp.	56	74	0	0
Pelecypod – unident.	28	34	0	0
Crepidula sp.	4	5	0	0
Acmea sp.	17	10	0	0
Mollusk – unident.	0	0	50	67
Animal remains	–	–	0	0

* Amorphous mass of organic material found only in species which ate polychaetes.

Tautogolabrus adspersus	N = 28 38.3–180 mm		N = 12 40–149.5 mm	
Sand	2	–	0	0
Hydroid – unident.	4	–	0	0
Neanthes succinea	1	1	0	0
Polychaete – unident.	3	1	0	0
Polychaete spines	50	–	0	0
Temora longicornis	+	+	0	0
Acartia spp.	+	+	0	0
Neomysis americana	1	+	3	1
Edotea montosa	0	0	3	+
Stenothoë cypris	2	1	0	0
Stenothoë sp.	5	2	0	0
Orchomenella sp.	100	100	0	0
Leptocheirus pinguis	1	1	3	+
Aeginella longicornis	7	8	17	64
Caprella geometrica	28	21	0	0
Caprella linearis	5	8	0	0
Caprellid – unident.	27	52	0	0

	St. 1		St.3A	
	A	B	A	B
Amphipod sand tube	16	20	0	0
Crago septemspinosus	3	1	0	0
Panopeid – unident.	13	26	0	0
Crustacean remains	5	–	0	0
Crustacean – unident.	0	0	25	33
Nucula proxima	0	0	33	–
Macoma tenta	11	5	0	0
Ensis directus	13	5	0	0
Pelecypod – unident.	4	3	0	0
Mollusk – unident.	100	100	17	8

Tautoga onitis	N = 4 48.8–176 mm		N = 0	
Sand	+	–	0	0
Hydroid – unident.	2	–	0	0
Siphonocoetes smithianus	3	5	0	0
Crago septemspinosus	+	2	0	0
Crab – unident.	25	25	0	0
Nymphon grossipes	20	17	0	0
Ensis directus	4	1	0	0
Pelecypod – unident.	4	3	0	0

Pholis gunnellus	N = 3 59–118.1 mm		N = 0	
Lepidonotus squamatus	14	8	0	0
Neanthes succinea	1	1	0	0
Caprella linearis	1	+	0	0
Amphipod coxal plates	–	–	0	0

Ammodytes americanus	N = 290 74.3–132.1 mm		N = 0	
Sand	3	–	0	0
Diatoms + Dinoflagellates	14	1	0	0
Eggs – invertebrate	8	+	0	0
Eggs – fish, *E. cimbrius*	50	33	0	0
Polychaete – unident.	2	1	0	0
Pseudocalanus minutus	17	8	0	0
Centropages sp.	81	97	0	0
Pseudodiaptomus coronatus	5	2	0	0
Temora longicornis	42	85	0	0
Labidocera aestiva	19	37	0	0
*Acartia clausi**	42	82	0	0
*Acartia tonsa**	17	8	0	0
Acartia spp.	55	88	0	0
Copepods – unident.	17	2	0	0
Balanus balanoides (nauplii)	60	81	0	0

	St. 1		St. 3A	
	A	B	A	B
Balanus balanoides (cyprids)	79	38	0	0
Neomysis americana	12	9	0	0
Crustacean – unident.	10	–	0	0
Ammodytes americanus larvae	17	36	0	0
Unidentified object	–	–	0	0

* Included as *Acartia* spp. more frequently than as separate species.

Poronotus triacanthus	N = 14		N = 5	
	30–74.8 mm		21.6–100 mm	
Spionidae – unident.	100	100	0	0
Acartia spp.	6	2	0	0
Copepod – unident.	8	1	0	0
Neomysis americana	+	+	0	0
Isopod larvae	100	100	0	0
Amphipod tube	20	33	0	0
Shrimp – unident.	100	100	0	0
Decapod larvae	100	100	0	0
Squilla sp. pseudozoea	0	0	100	100
Crustacean – unident.	5	–	0	0
Animal remains	–	–	0	0

Gobiosoma ginsburgi	N = 1		N = 0	
	27.1 mm			
Cerebratulus luridus	10	–	0	0
Heteromysis formosa	3	+	0	0
Corophium sp.	2	2	0	0

Prionotus carolinus	N = 103		N = 23	
	21–159.7 mm		25.2–98 mm	
	St. 1		St. 3A	
	A	B	A	B
Sand	14	–	0	0
Nereis pelagica	8	7	0	0
Nereidae – unident.	7	5	0	0
Polychaete spines	50	–	0	0
Polychaete – unident.	0	0	4	+
"Stuff"*	2	2	0	0
Paracalanus crassirostris	11	2	0	0
Pseudodiaptomus coronatus	25	23	18	15
Temora longicornis	12	1	0	0
Labidocera aestiva	8	1	14	7
Acartia spp.	2	+	0	0
Neomysis americana	11	6	11	24
Heteromysis formosa	29	10	0	0
Oxyurostylis smithi	0	0	100	100
Edotea montosa	0	0	3	+
Cyathura polita	100	100	0	0
Ampelisca sp.	5	2	0	0
Stenothoë cypris	20	25	25	10
Stenothoë sp.	10	3	0	0
Leptocheirus pinguis	7	6	21	3
Erichthonius brasiliensis	25	11	0	0
Unciola irrorata	9	8	50	50
Siphonocoetes smithianus	9	6	0	0
Corophium sp.	18	12	0	0
Aeginella longicornis	18	4	0	0
Caprella geometrica	28	18	0	0
Caprella linearis	22	6	0	0
Crago septemspinosus	25	21	9	5
Pagurus sp.	16	21	0	0
Panopeid – unident.	4	3	0	0
Crustacean-unident.	5	–	0	0
Anchoa mitchilli	25	20	0	0

* Amorphous mass of organic matter found only in species eating polychaetes.

Myoxocephalus aeneus	N = 28		N = 0	
	76.7–134.9 mm			
Sand	+	–	0	0
Algae – unident.	25	–	0	0
Neanthes succinea	1	+	0	0
Neomysis americana	4	7	0	0
Heteromysis formosa	5	2	0	0
Photis reinhardi	6	8	0	0
Leptocheirus pinguis	3	1	0	0
Crago septemspinosus	7	9	0	0
Panopeid – unident.	4	5	0	0
Ammodytes americanus	17	9	0	0

Paralichthys oblongus	N = 8		N = 12	
	54.8–122.6 mm		33–137.7 mm	
Neomysis americana	+	+	5	4
Crago septemspinosus	3	5	12	54
Fish – unident.	0	0	25	25

Scophthalmus aquosus	N = 49		N = 25	
	31–131.8 mm		27.9–130.1 mm	
Sand	+	–	0	0
Temora longicornis	1	+	0	0
Neomysis americana	8	16	8	24

	St. 1		St. 3A	
	A	B	A	B
Heteromysis formosa	1	+	0	0
Crago septemspinosus	3	1	1	+
Crustacean remains	6	–	0	0
Ensis directus	4	1	0	0
Etropus microstomus	N = 12 39.5–99.8 mm		N = 0	
Sand	1	–	0	0
Sponge – unident.	50	50	0	0
Hydroid – unident.	1	–	0	0
Nemerteans – unident.	+	–	0	0
Nephthys incisa	8	4	0	0
Nephthys caeca	17	11	0	0
Nephthyidae – unident.	9	7	0	0
Ampharete acutifrons	2	+	0	0
Flabelligera affinis	9	9	0	0
Polychaete – unident.	2	5	0	0
"Stuff"*	2	2	0	0
Neomysis americana	1	+	0	0
Edotea sp.	50	33	0	0
Ampelisca sp.	2	3	0	0
Podoceropsis nitida	9	10	0	0
Leptocheirus pinguis	1	+	0	0
Siphonocoetes smithianus	5	3	0	0
Corophium sp.	2	2	0	0
Caprella linearis	1	+	0	0
Caprellidae – unident.	7	2	0	0
Crago septemspinosus	2	1	0	0
Pagurus pollicaris	100	–	0	0
Pagurus sp.	26	33	0	0
Panopeid – unident.	4	3	0	0
Crepidula sp.	4	3	0	0

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	St. 1		St. 3A	
	A	B	A	B
Pseudopleuronectes americanus	N = 287 37–165 mm		N = 86 81–159.5 mm	
Sand	54	–	74	–
Diatoms + Dinoflagellates	14	+	0	0
Algae – unident.	50	+	0	0
Sponge – unident.	50	50	0	0
Eggs – invertebrate	+	+	0	0
Hydroid – unident.	67	–	100	100
Campanularidae	0	0	100	100
Cerebratulus luridus	80	99	0	0
Cephalothrix linearis	0	0	100	100
Nemerteans – unident.	85	–	62	–
Syllidae	100	100	100	100
Autolytus cornutus	100	100	0	0
Autolytus sp.	0	0	100	100
Lepidonotus squamatus	57	69	100	100
Harmothoë imbricata	100	100	0	0
Sthenelais gracilis	89	96	0	0
Phyllodoce fragilis	24	6	33	7
Eumida sanguinea	100	100	0	0
Nereis pelagica	75	80	0	0
Nereis ciliata	100	100	0	0
Nereis sp.	0	0	60	67
Nereidae – unident.	67	76	0	0
Neanthes succinea	91	94	0	0
Nephthys ingens	100	100	0	0
Nephthys incisa	69	81	64	74
Nephthys caeca	83	89	100	100
Nephthyidae – unident.	82	86	0	0
Arabella iricolor	80	83	75	96
Eunicidae – unident.	100	100	0	0
Lumbrinereis tenuis	100	100	0	0
Glycera americana	25	29	0	0
Glycera dibranchiata	91	88	0	0
Glycera sp.	75	78	0	0
Goniada gracilis	100	100	0	0
Megalona papillicornis	100	100	0	0
Cirratulus grandis	75	83	100	100
Terebellidae – unident.	100	100	100	100
Polycirrus eximus	100	100	0	0
Ampharete acutifrons	90	96	78	74
Ampharete sp.	86	91	0	0
Melinna cristata	36	41	85	97
Ampharetidae – unident.	0	0	100	100
Cistenides gouldii	25	20	75	90
Capitella capitata	75	60	100	100
Capitellidae – unident.	15	8	100	100
Scoleciform polychaete	100	100	0	0
Travisia sp.	100	100	0	0
Clymenella torquata	100	100	0	0
Maldane sarsi	0	0	100	100
Maldane sp.	50	67	0	0
Praxillella sp.	0	0	100	100
Scalibregma inflatum	100	100	0	0
Arenicola sp.	100	100	0	0
Flabelligera affinis	91	91	80	83
Amphicora fabricii	62	53	0	0
Potamilla neglecta	0	0	100	100
Spionidae – unident.	0	0	100	100
Eupomatus dianthus	9	6	0	0
Polychaete – unident.	65	66	54	5

	St. 1		St. 3A	
	A	B	A	B
"Stuff"*	33	32	0	0
Clitellio arenarius	92	99	0	0
Oligochaete – unident.	75	88	0	0
Worm – unident.	50	50	100	100
Pseudodiaptomus coronatus	3	+	0	0
Temora longicornis	1	+	0	0
Acartia spp.	+	+	0	0
Sarsiella zostericola	0	0	60	53
Cytheridea americana	0	0	73	79
Neomysis americana	3	8	3	+
Diastylis quadrispinosa	0	0	100	100
Edotea montosa	0	0	60	80
Edotea sp.	50	66	0	0
Idothea sp.	100	100	0	0
Cyathura polita	0	0	100	100
Ampelisca sp.	45	32	50	37
Stenothoë cypris	32	32	50	70
Stenothoë minuta	0	0	50	50
Stenothoë sp.	22	42	0	0
Monoculodes edwardsi	100	100	0	0
Photis reinhardi	76	75	0	0
Podoceropsis nitida	68	70	44	48
Leptocheirus pinguis	54	69	43	89
Erichthonius brasiliensis	25	32	0	0
Unciola irrorata	64	69	50	25
Siphonocoetes smithianus	64	77	0	0
Corophium cylindricum	0	0	50	44
Corophium sp.	35	58	0	0
Aeginella longicornis	82	58	33	11
Caprella geometrica	14	53	0	0
Caprella linearis	8	10	100	100
Caprellidae – unident.	27	16	0	0
Amphipod – unident.	50	80	0	0
Amphipod coxal plates	–	–	0	0
Crago septemspinosus	3	1	0	0
Sabinea sarsii	100	100	0	0
Upogebia affinis	50	43	0	0
Pagurus longicarpus	33	33	50	50
Pagurus sp.	16	12	0	0
Panopeid – unident.	57	55	0	0
Crustacean – unident.	5	–	0	0
Nymphon grossipes	20	17	80	80
Nucula proxima	0	0	56	92
Nucula sp.	100	100	0	0
Yoldia limatula	0	0	84	94
Yoldia sp.	100	100	0	0
Lyonsia hyalina	0	0	100	100
Astarte undulata	100	100	0	0
Macoma tenta	33	57	75	92
Mulinia lateralis	0	0	100	100
Mulinia sp.	31	18	0	0
Cerastoderma pinnulatum	0	0	80	96
Gemma gemma	0	0	100	100
Ensis directus	65	90	100	100
Pelecypod – unident.	20	14	0	0
Crepidula sp.	93	92	0	0
Acmea sp.	83	90	0	0
Nassarius trivittatus	50	50	100	100
Mitrella lunata	100	100	67	50
Retusa caniculatum	0	0	100	100
Gastropod – unident.	100	100	0	0
Animal Remains	0	0	50	67
Unidentified Object	–	–	0	0

* Amorphous mass of organic material found only in species eating polychaetes.

Sphaeroides maculatus	N = 22 29.4–89.5 mm		N = 0	
Sand	2	–	0	0
Hydroid – unident.	1	–	0	0
Arabella irocolor	20	17	0	0
Glycera dibranchiata	9	12	0	0
Cistenides gouldii	8	7	0	0
"Stuff"*	2	+	0	0
Ampelisca sp.	3	2	0	0
Stenothoë cypris	2	1	0	0
Stenothoë sp.	2	+	0	0
Erichthonius brasiliensis	6	3	0	0
Corophium sp.	2	1	0	0
Caprella linearis	8	16	0	0
Pagurus longicarpus	33	33	0	0
Pagurus sp.	5	4	0	0
Mulinia sp.	12	8	0	0
Ensis directus	4	1	0	0
Pelecypod – unident.	44	46	0	0
Retusa caniculatum	100	100	0	0
Unidentified Object	–	–	0	0

Lophius americanus	N = 1 195 mm		N = 0	
Crago septemspinosus	+	+	0	0
Merluccius bilinearis	50	50	0	0