CHAPTER 4

HIGHER LEVEL CONSUMER INTERACTIONS

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Introduction

The basic objectives within this subtask of the grant were to analyze the structural and functional ecology of fish communities in submerged aquatic vegetation (SAV) and to assess the importance of SAV to the production and maintenance of important commercial fish populations. Areas that were addressed include the relative benefit of SAV from trophic and refuge standpoints, the effects of large migratory predators (megapredators) which may frequent the SAV areas, biomass estimates of the components of the fish community, sources of production consumed by the fish populations, the importance of SAV to early life history stages of fishes, and the determination of time of immigration and residence for dominant fishes of SAV areas.

The structural and functional ecology of resident fish communities in eelgrass (Zostrea marina) beds has been studied in the Beaufort, North Carolina area (Adams, 1976 a, b, c). Species composition as well as feeding habits of the benthic fish community in the study site have been qualitatively described (Orth and Heck, 1980). The dominant resident species in the lower Chesapeake Bay eelgrass bed was spot (Leiostomus xanthurus), contrasting with the

North Carolina eelgrass fish community, where pinfish (*Lagodon rhomboides*) and pigfish (*Orthopristes chrysoptera*) were the dominant species (Adams, 1976a). Mid- and late-summer gill netting also revealed certain of the migratory predators (Orth and Heck, in press), including the sandbar shark (*Carcharhinus milberti* = *Carcharhinus plumbeus*) and bluefish (*Pomatomus saltatrix*). Preliminary feeding analysis by Orth and Heck suggested that these predators were feeding in the eelgrass area. In other parts of the lower Chesapeake Bay, the cownose ray (*Rhinoptera bonasus*) has been shown to feed and have dramatic effects in eelgrass beds (Orth, 1975).

Previous characterizations of Chesapeake Bay ichthyoplankton assemblages (Pearson, 1941; Dovel, 1971; Olney, 1971) have concentrated on midchannel portions of the estuary and have concentrated on midchannel portions of the estuary and have neglected the generally inaccessible nearshore, shallow environments. As a result, the extent to which Chesapeake Bay fish stocks utilize these nearshore zones as spawning and/or nursery sites in unknown. This lack of data takes on added significance as a result of the recent emphasis on the importance of shallow seagrass beds as refuge and feeding grounds for many species of marine and estuarine fishes (Reid, 1954; Adams, 1976 a, c).

Our approach to the structural and functional ecology of fish communities in SAV has been to combine a program of field sampling with laboratory study. Field sampling for one and a half years with six different types of fishing gear has defined the structure of the fish community's three main components: i) fish eggs, larvae, postlarvae, and pelagic juveniles; ii) resident fishes; and, iii) megapredators. The laboratory effort involved predator/prey experiments as well as determination of several physiological parameters for two dominant fishes in the eelgrass study area.

MATERIALS AND METHODS

Field Sampling

The field sampling was conducted at the Vaucluse Shores study site, north of the channel of Hungar's Creek (Figure 1). Sampling of relatively large areas was required for adequate estimations of fish densities; for this reason our sampling areas were not distinctly defined with respect to vegetation type. Sampling was divided to three areas, designated as representative of *Zostera marina, Ruppia maritima*, and an adjacent unvegetated area. The nominal *Zostera* area was located between the sandbar and land, along transect A. The nominal *Ruppia* area was located on and northeast of transect C. The unvegetated sampling area was on the sandbar west of transect markers B and A in depths appropriate for the particular sampling gear. As was apparent in vegetation maps of the bed, the nominal sampling areas for *Ruppia* and *Zostera* contained mixed stands as well as pure stands of the respective vegetation types (Figure 1). Differences noted between the two sampling areas may have therefore represented faunal changes due to isolation from deeper water rather than differences attributable to vegetation type.

Sampling gears generally broke down to those for 1) ichthyoplankton and zooplankton, 2) resident fishes, and 3) migratory predators. A variety of gears were tested for

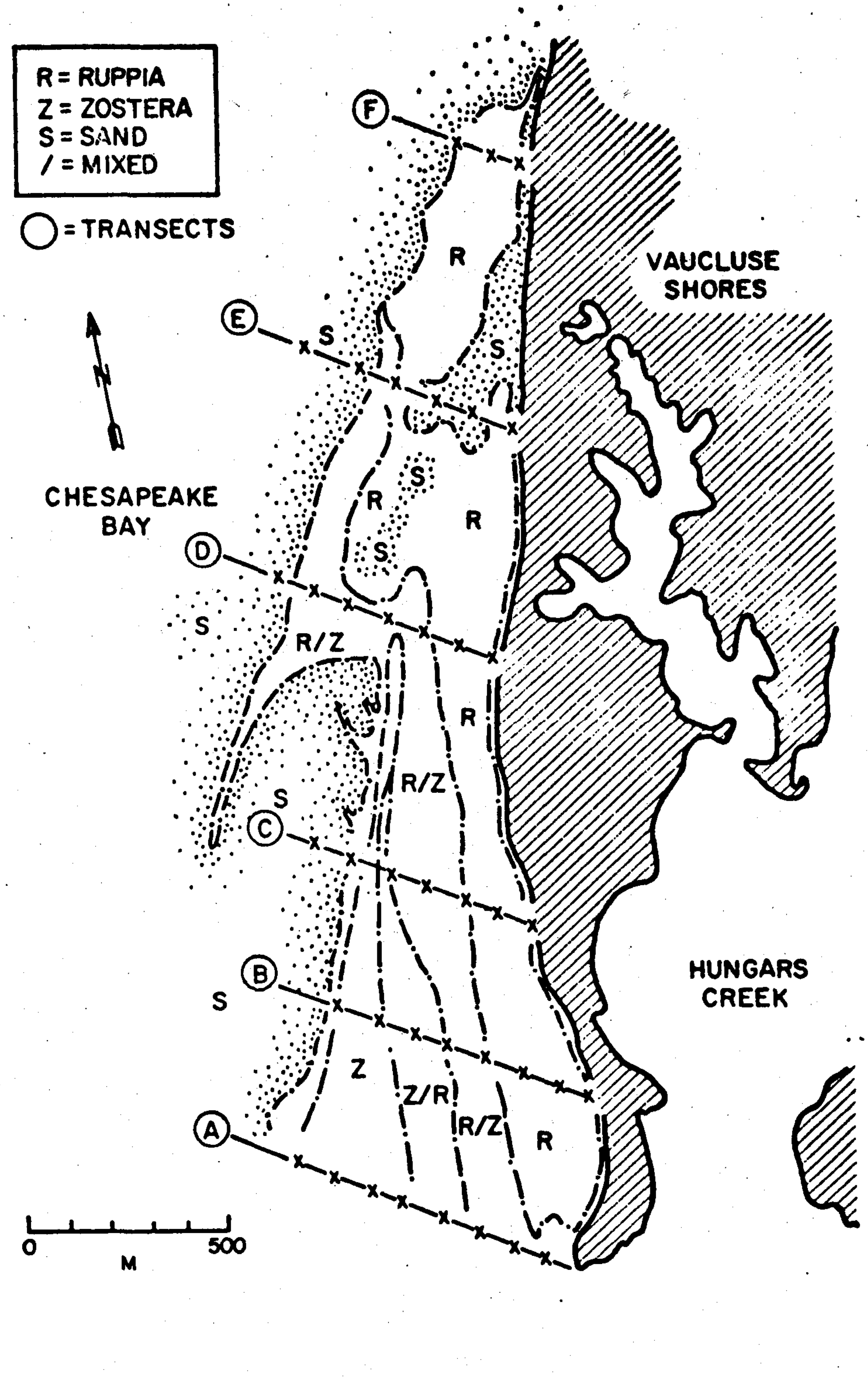

R = RUPPIA
Z = ZOSTERA
S = SAND
/ = MIXED
= TRANSECTS
N
CHESAPEAKE
BAY
VAUCLUSE
SHORES
HUNGARS
CREEK
F
E
D
C
B
A
R
S
R/Z
Z
Z/R
0
M
500

Figure 1

sampling these components of the fauna during the project. The field sampling schedule is presented in Table 1. Ichthyoplankton and zooplankton were a initially sampled with towed, bridled nets; these were abandoned due to excessive disturbance ahead of the net from the outboard motor which resulted in avoidance by fishes and samples with excessive silt, detritus, and dislodged vegetation. Resulting samples were often impossible to preserve and sort (especially zooplankton samples with large amounts of sand). Routine sampling for ichthyo- and zooplankton consisted of two replicate collections in each habitat (Zostera, Ruppia, and sand) utilizing a pushnet (Figure 2) constructed of ½" diameter galvanized pipe and deployed over the bow of a 19 foot outboard craft. The frame was equipped with a 1 meter ichthyoplankton net (500 um mesh) and two 18.5 cm zooplankton (202 um mesh); the ichthyoplankton net and one zooplankton net were fitted with calibrated General Oceanics flowmeters to assess the volumes of water filtered. Nets were fished at high tide for 2-3 minutes depending on abundance of plankton. The sampling duration and boat speed allowed the ichthyoplankton net to cover 74-175 m^2 of sea surface and filter from 68-117 m^3 of water. Routine monthly sampling was conducted at night; daylight samples were taken at high tide in selected months.

Table 1 . Field Sampling Program

Gear	1978		1979										1980						
	M	O	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J
Gillnet																			
7" mesh			X	X	X	X	X	X	X	X	X								
5" mesh			X	X	X	X	X	X	X	X	X								
3½" mesh															X	X	X	X	X
Haul Seine			X	X	X	X	X	X	X	X	X				DISCONTINUED				
Trawl									X	X	X				X	X	X	X	X
Zooplankton			X	X	X	X	X	X	X	X	X	X	X	X	X	X			
Ichthyoplankton			X	X	X	X	X	X	X	X	X	X	X	X					
Pushnet															X	X	X	X	X
<u>Food Analysis</u>																			
Residents	X	X																	
Migratory predators			X	X	X	X	X	X	X	X	X	X			X	X	X	X	X
Periodicity					X			X			X								

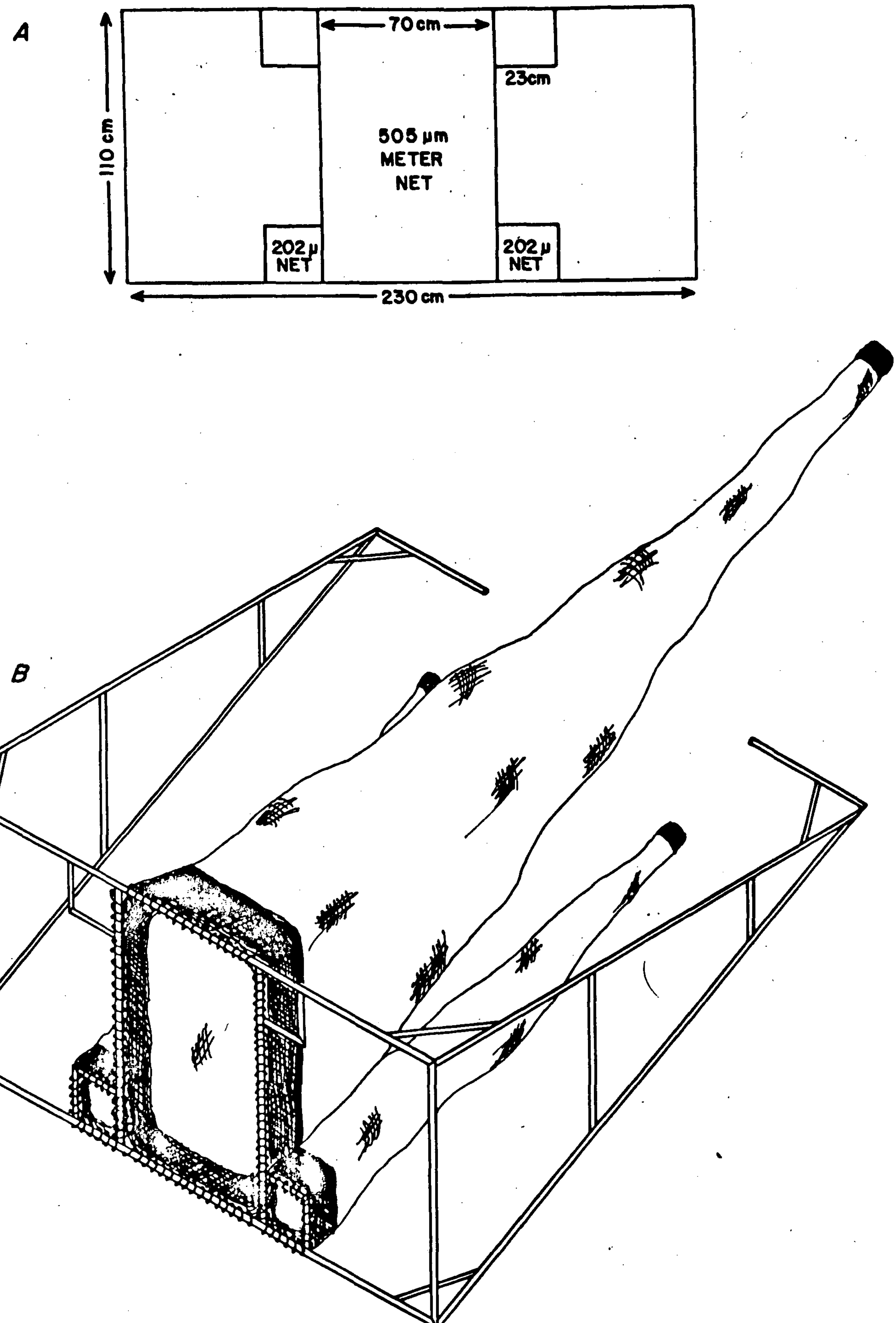


Figure 2

Each time the pushnet was deployed, one ichthyoplankton and two zooplankton samples resulted. One zooplankton sample was preserved in the 10% formalin for later taxonomic analysis and estimation of abundance; the other was washed with distilled water, frozen in the field on dry ice, lyophilized, weighed, and ashed in a muffle furnace (6 hours at 500°C) to determine organic biomass per unit volume. Ichthyoplankton samples were preserved in 5-10% buffered formalin. In the laboratory they were whole sorted for fish eggs, larvae, postlarvae, juvenile, and adult stages. Specimens were later identified to the lowest taxon possible, measured, and curated.

For sampling resident fishes, a portable dropnet similar to those described in Moseley and Copeland (1969) and Adams (1976a) was built; it covered an area of 9.3 m^2. Our initial experiences with this gear proved it to be unsatisfactory due to the small area covered, long deployment times, and instability in rough weather. We therefore abandoned the dropnet in favor of a 40 m long, 2.4 m deep seine (Figure 3) fished in the manner described for long haul seines by Kjelson and Johnson (1974). Briefly, the seine was deployed bag end first from the bow of an outboard craft travelling in reverse. The net was set in a circle and the long wing pulled past the bag end to decrease the circumference of the circle to approximately 7.3 m, after

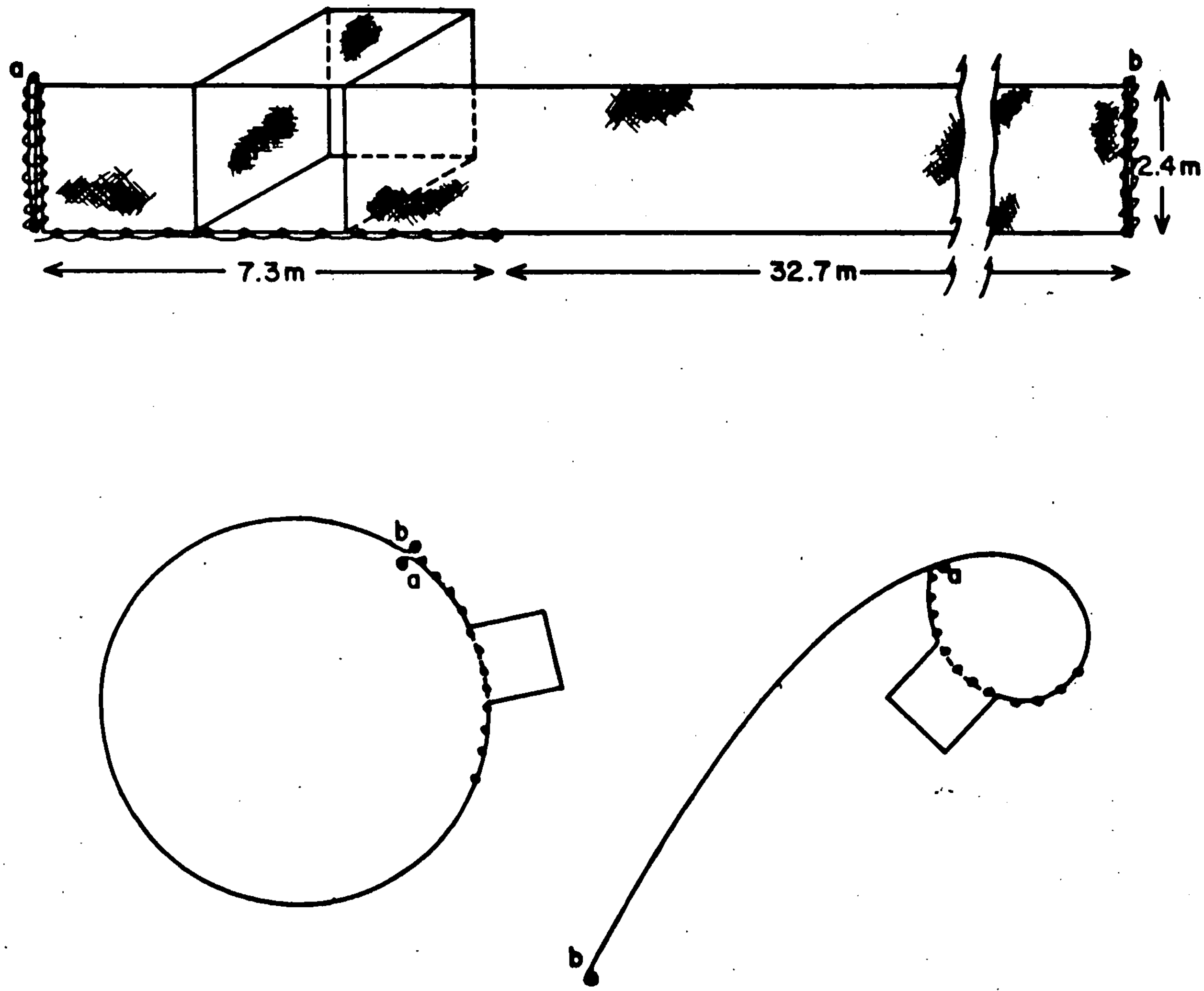


Figure 3

which the bottom of the net was closed off by tightening a purse line. The catch remained in the pursed section of net and was brought on board the boat for processing. When set in an ideal circle, this gear encompassed an area of 127 m^2. Duplicate or triplicate samples were taken monthly (from March through December, 1979) in each of the three habitats. Daylight samples were also taken in selected months for diel comparisons. Large specimens were identified, measured, and noted on the field sheets; the remainder of the catch was preserved in 10% buffered formalin for later identification in the laboratory.

In August 1979, a comparison of haul seine catch to Orth and Heck's otter trawl collections (in press) indicated that certain members of the benthic fish community were not being adequately sampled by the haul seine. Therefore an otter trawl was employed to supplement the routine haul seine sampling. Samples were collected with a 4.9 m otter trawl (1.9 cm mesh wings, .6 cm mesh liner, 15.2 m bridles) pulled behind the 19 foot outboard craft operated at 2000 RPM for two minutes. Area swept per trawl was calculated as the product of the distance across the opening of the trawl mouth and the average distance travelled during a trawl. The trawl opening was determined from measured horizontal net openings while the net was dragged over a shallow sand bottom. Distance travelled by the trawl was determined by suspending a calibrated General Oceanics flowmeter from the side of the boat during each trawl. Triplicate day and night samples were taken monthly from August through November 1979 and from March through July 1980.

From March to July 1980 resident fishes were sampled with a pushnet described by Kriete and Loesch (1980) and illustrated in Figure 4. This pushnet was constructed and operated in the same manner as the zooplankton pushnet. One flowmeter monitored volume strained by the modified 1.2 by 1.8 m Cobb Trawl net mounted on the pushnet frame. The body of the net was constructed of 1.9 cm stretch mesh while the cod end was made of 1.27 cm stretch mesh. Triplicate day and night samples were collected in each habitat.

Migratory predators were sampled in 1979 by deploying 30.5 meters each of 12.7 and 17.8 cm stretched mesh gill net perpendicular from shore in each of the three sampling habitats. These nets were fished every four hours over a 24 hour period. At each sampling time, the catch was removed, identified, measured, weighed, and the net was reset. Observations were made on relative fullness of stomach contents and selected stomachs were removed and preserved for analysis of contents. In November of 1979 a comparison of the catch of the 12.7 and 17.8 cm stretch

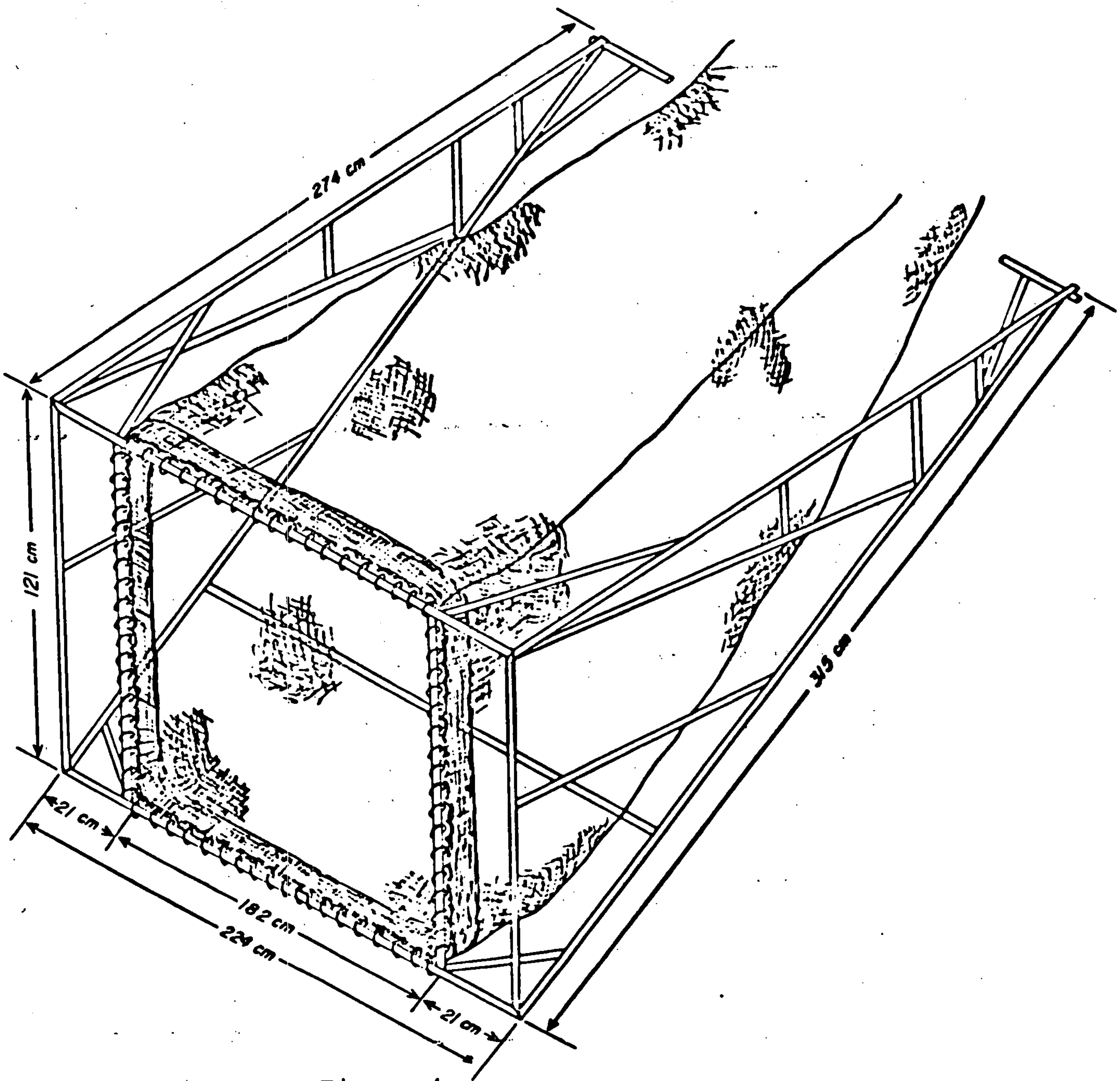


Figure 4

mesh gill nets indicated that the 12.7 cm mesh gill nets caught a larger diversity as well as a greater number of megapredators than the 17.8 cm mesh gill nets. Therefore, in 1980 the 12.7 stretch mesh gill nets were retained as megapredator sampling gear while the 17.8 cm stretch mesh gill nets were replaced by 8.8 cm stretch mesh gill nets. The sampling procedure remained the same for both years. As with other collection included date, time, habitat, tide stage, depth, water temperature, salinity, dissolved oxygen, and comments on weather.

To define residence time for Carcharhinus milberti in the study area, 10 sandbar sharks in June of 1980 and 50 sharks in August of 1980 were marked with Peterson disk tags supplied by NMFS (Narragansett Laboratory, RI). Sharks were examined for tags during routine sampling in July. Two weeks after the August shark tagging, gill nets were set overnight in each habitat to recapture marked sharks.

Laboratory Procedures

To determine the feeding behavior of the fishes and their impact upon the resident secondary producers, stomach contents and feeding periodicity studies were conducted. The resident fishes were collected by trawl during the times of day when feeding was actively occurring; stomach contents were removed for taxonomic analysis. For determination of feeding periodicity, trawling was conducted over 24 hour periods in May and August 1979. Stomachs from the larger, migratory predators were sampled during the monthly gill net collections.

The method of stomach collection depended upon the size of the fish. For resident fishes larger than 150 mm and for all migratory predators, stomachs were removed in the field and preserved in 10% buffered formalin immediately after capture. Tags were placed with the stomach describing fish length, species, and collection number to associate the stomach with further information available on the field data sheets. For resident fishes smaller than 150 mm, specimens were preserved whole in 20% buffered formalin; the body cavity was slit to facilitate penetration of the formalin. Contents were transferred to 40% isopropyl alcohol prior to analysis.

Analysis of stomach contents of piscivorous fishes was conducted by the Higher Level Consumer Interactions group; identification of stomach contents of fishes feeding on invertebrate secondary consumers was conducted by the Resident Consumer Interactions group. After contents were identified to the lowest toxon possible, individual food items were dried to constant weight at 56°C and weighed. An average individual weight for small prey items such as nematodes and harpacticoid copepods was obtained by pooling like food items from several fish stomachs, obtaining a pooled dry weight, and then dividing this weight by the number of individual prey that were weighed together.

Feeding periodicity was determined for spot (Leiostomus xanthurus), pipefish (Syngnathus fuscus), and silver perch (Bairdiella chrysoura). Collections were made by otter trawl over a 24 hour period. From each sampling period, total gut contents of up to six specimens were removed. The contents and the fish were then dried and weighed separately; the ratio of dry gut content weight to dry body weight yielded a measure of feeding periodicity and when combined with estimates of evacuation rate at the temperature of collection, allowed analysis of daily ration (Peters and Kjelson, 1975).

In July 1980, a series of storms disrupted the first attempt at routine sampling of migratory predators. All sandbar shark stomachs (full as well as empty) were processed from the resulting one and a half sets of gillnet collections.

July feeding periodicity and daily ration for *C. milberti* were then calculated using a model developed by Lane et al. (1979).

Length to dry weight relationships for *Leiostomus xanthurus*, *Brevoortia tyrannus*, *Bairdiella chrysoura*, *Syngnathus fuscus*, *Membras martinica*, *Menidia menidia*, and *Anchoa mitchilli* were determined from fresh as well as preserved specimens which were measured and then dried (at 56°C) to a constant weight.

Laboratory experiments were conducted to examine the effect of artificial *Zostera marina* on predator-prey relationships of migratory predators and resident fishes. The experimental setup (Figure 5) consisted of two circular wading pools, (3.66 m in diameter, 0.9 meters deep) with a volume of approximately 9500 liters each. A closed, recirculating system with a biological filter was utilized. The filter was comprised of a 0.24 m^3 of coarse sand, oyster shell, and gravel; circulation was provided by two 38 liter per minute pumps. Experimental fish, both predator and prey, were caught by a variety of methods, including (1) hook and line; (2) 16' otter trawl; and, (3) 50' beach seine. Predators were maintained as residents in the tanks; holding tanks provided a supply of both predator and prey fishes. Artificial eelgrass (3/16" wide green polypropylene ribbons, 0.6 density) mats were woven to observed field densities (dense - 1750 blades/m^2; average - 875 blades/m^2). Mats were placed in the center of the tank to mimic

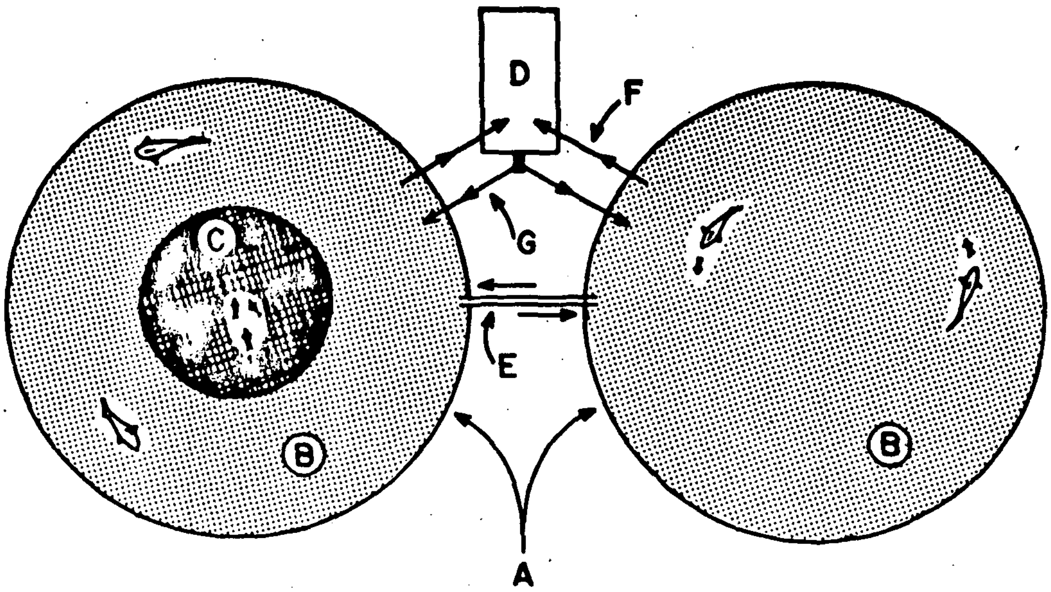


Figure 5

an eelgrass habitat; prey were released into the center of the tanks in both eelgrass densities and in base sand bottom controls.

Predator species; Paralichthys dentatus, and Cynoscion regalis were acclimated to experimental conditions for a minimum of 30 days. During this period predators were fed a variety of live prey fish. Prey species, Leiostomus xanthurus and Menidia menidia were acclimated for a minimum period of 14 days. Prey were fed Purina® trout chow.

Preliminary experiments were conducted to establish the sizes and numbers of both predators and prey. Predators were selected such that the confines of the model ecosystem did not severely inhibit their ability to pursue and capture prey. Prey were of a size small enough to be captured and consumed yet not so small as to be unattractive. Four predators and 12 prey of each species were used in each experimental replicate.

Each predator-prey combination was tested in triplicate against five substrate variations:

(1) 'N' - no artificial vegetation, bare sand substrate;

(2) 'A' - average density artificial grass, 1 m^2, 7% area covered;

(3) 'H' - high density artificial grass, 1 m^2, 7% area covered;

(4) 'IA' - increased area, 3 m^2, 1450 blades/ m^2, 22% area covered;

(5) 'IC' - increased complexity, 3-1 m^2 evenly spaced, 1450 blades/m^2, 22% area covered.

One hour observations were made at morning, midday and evening. Surviving prey were enumerated and behavioral characteristics of both predator and prey were noted at these times. All remaining prey were removed at the conclusion of each experiment. Predators were starved for a 24 hour period prior to initiating the next experiment.

Predator versus M. menidia were conducted for 12 hours from first to last daylight. Predator versus L. xanthurus experiments started at dawn and were conducted for a 24 hour period.

Temperature acclimation tanks were set up in the laboratory with optional flow-through or closed system capabilities. Typical acclimation temperatures were 12°, 17°, 22°, and 27°C. This allowed temperature related analysis of respiration rates of Bairdiella chrysoura, the silver perch, and analysis of evacuation rate for the pipefish Syngnathus fuscus. Respiration chambers (Figure 6) were constructed with flow-through characteristics to allow analysis of metabolic rate at different temperatures.

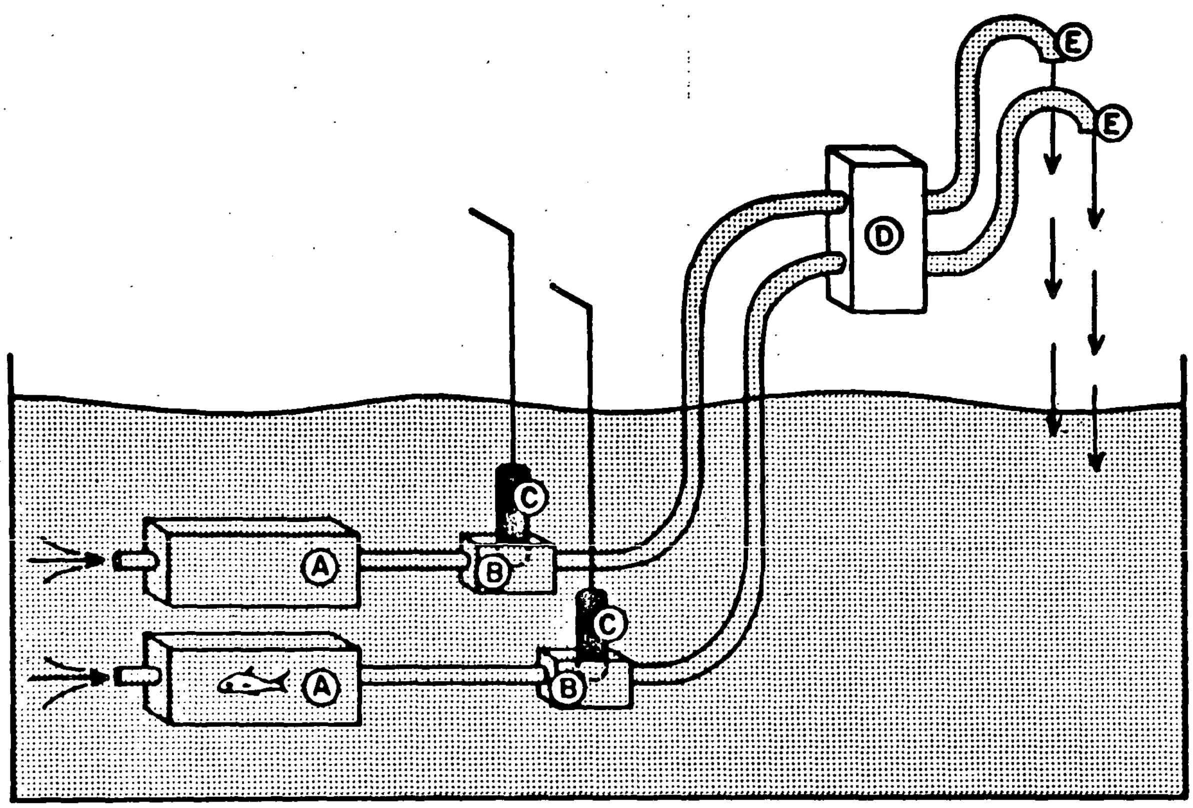


Figure 6

Results

Field Program

Migratory predators

Migratory predators sampled with gill nets were represented by 889 specimens of nineteen species in eleven families. Table 2 summarizes monthly gill net catch by year and mesh size. Catches represent the aggregate number of fish caught over a 24 hour period with gill nets fished every four hours. Menhaden (Brevoortia tyrannus) comprised 86% of the small catch in March over both years. In April and May, the total catch increased with movement of teleosts Pomatomus saltatrix, Cynoscion regalis, C. nebulosus, Paralichthys dentatus and the elasmobranchs Rhinoptera bonasus and Dasyatis sayi into the bay. In June the sandbar shark, Carcharhinus milberti dominated the catch and continued as the dominant species through September. Summer flounder (Paralichthys dentatus), spotted seatrout (Cynoscion nebulosus), and bluefish (Pomatomus saltatrix) inhabited the study area throughout the summer. By November, only menhaden, bluefish, and spotted seatrout were caught by the gill nets.

A comparison of April through July catch in 12.7 cm mesh gill net for 1979 and 1980 indicates that the major difference between the two years was the absence of bluefish in April 1979. The variability in the catch of bluefish is typical of patterns observed for most of migratory predators. One net fished overnight in the sand area 3 days prior to the April 1979 sampling caught 45 bluefish. Continuation of this sampling series was aborted by weather. Therefore, 1979 and 1980 migratory predator catches appear quite similar.

Table 2 also compares gill net catch by size of netting (8.8, 12.7, 17.8 cm stretch mesh). With the exception of Rhinoptera bonasus and Dasyatis sayi, in 1979 the 12.7 cm mesh gill nets was more effective than the 17.8 cm mesh nets for most species. The larger mesh nets were initially selected to catch sandbar shark; however, only 14% of the 1979 catch of this species was made in the 17.8 cm mesh nets. Therefore in 1980, the 17.8 mesh gill nets were replaced by 8.8 cm stretch mesh gill nets. In 1980, C. milberti, Dasyatis sayi, Pomatomus saltatrix and Rhinoptera bonasus were caught in greater numbers by 12.7 cm mesh nets than 8.8 cm mesh nets. The greatest differences in catch between these two net mesh sizes were seen in the catch of weakfish (C. regalis) and menhaden (B. tyrannus); 100% of the weakfish and 96% of the menhaden were caught by 8.8 cm mesh gill nets.

Tables 3 and 4 describe the migratory predator catch by year, habitat, and day or night. In 1979, more migratory predators were caught in the Zostera area (44%) than the sand (34%) or Ruppia area (27%). This tendency was not duplicated in 1980 where the greatest catch of migratory predators occurred in the sand area (37%) followed by the Ruppia (35%) and Zostera areas (28%).

Table 2. Comparison of migratory predator catch summarized by gear, month and year.

Month	Species	17.8 cm stretched mesh Number	17.8 cm stretched mesh Size Range (SL in mm)	12.7 cm stretched mesh Number	12.7 cm stretched mesh Size Range (SL in mm)	1979 Catch	12.7 cm stretched mesh Number	12.7 cm stretched mesh Size Range (SL in mm)	8.8 cm stretched mesh Number	8.8 cm stretched mesh Size Range (SL in mm)	1980 Catch	Total Catch
March	*Brevoortia tyrannus*	2	253-254	1	247	3			21	213-265	21	26
	Morone saxatilis								2	286-307	2	2
	Morone americana								2	204-205	2	2
April	*Pomatomus saltatrix*						17	498-732	5	310-710	22	22
	Paralichthys dentatus						1	255			1	1
	Morone saxatilis						1	381	1	290	2	2
	Alosa sapidissima						1	457			1	1
	Brevoortia tyrannus						1	239	139	250-352	140	140
	Cynoscion regalis								16	326-479	16	16
	Alosa mediocris								1	251	1	1
	Opisthonema oglinum								1	325	1	1
May	*Cynoscion nebulosus*			6	410-540	6	1	526			1	7
	Pomatomus saltatrix	5	340-465	9	210-740	14	11	275-532	16	296-535	27	41
	Rhinoptera bonasus	13	890-980*	5	850-910*	18	4	920-940*	2	878-950	6	24
	Cynoscion regalis			10	260-600	10			4	321-475	4	14
	Dasyatis sayi	5	490-600*	1	600*	6						6
	Sciaenops ocellata			1	765	1						1
	Tylosurus acus			1	1250	1						1
	Brevoortia tyrannus						1	167	2	260-268	3	3
	Paralichthys dentatus								1	185	1	1
	Alosa pseudoharengus								2	230-285	2	2
June	*Carcharhinus milberti*	1	600	33	500-820	34	39	501-716	5	515-680	44	78
	Pomatomus saltatrix	4	295-590	11	305-870	15	1	519	2	272-289	3	18
	Rhinoptera bonasus	4	850-860*	2	800-930*	6						6
	Dasyatis sayi	3	420-470*	2	540-660*	5	2	480-710*			2	7
	Cynoscion regalis			6	330-482	6			17	320-524	17	23
	Cynoscion nebulosus			1	400	1			1	411	1	2
	Paralichthys dentatus			1	220	1	1	292	1		2	3
	Brevoortia tyrannus	1	167			1			4	119-291	4	5
	Tylosurus acus								5	848-1000	5	5

Table 2. (Continued).

Month	Species	17.8 cm stretched mesh Number	17.8 cm stretched mesh Size Range (SL in mm)	12.7 cm stretched mesh Number	12.7 cm stretched mesh Size Range (SL in mm)	1979 Catch	12.7 cm stretched mesh Number	12.7 cm stretched mesh Size Range (SL in mm)	8.8 cm stretched mesh Number	8.8 cm stretched mesh Size Range (SL in mm)	1980 Catch	Total Catch
July	Carcharhinus milberti	9	570-780	49	500-990	58	63	486-644	61	440-710	124	182
	Cynoscion nebulosus			2	414-475	2	1	565	3	325-485	4	6
	Rhinoptera bonasus	1	885*	2	452-990*	3						3
	Cynoscion regalis	1	385			1			2	339-425	2	3
	Paralichthys dentatus						1	430	4	165-257	5	5
	Micropogonias undulatus						2	336-370	6	305-325	8	8
	Pomatomus saltatrix						5	295-376	5	280-415	10	10
	Brevoortia tyrannus						5	193-205	1	260	6	6
	Dasyatis sayi						1	700*			1	1
August	Carcharhinus milberti	5	600-730	44	420-880	49						49
	Pomatomus saltatrix	6	380-450	8	410-590	14		End of 1980 Sampling				14
	Rachycentron canadum			1	490	1						1
	Rhinoptera bonasus	1	755*	1	938*	2						2
	Paralichthys dentatus	1	280	5	260-290	6						6
	Cynoscion regalis	3	370-430	1	300	4						4
	Cynoscion nebulosus	1	448			1						1
September	Carcharhinus milberti	9	530-765	28	480-667	37						37
	Pomatomus saltatrix	5	303-514	6	254-502	11						11
	Cynoscion nebulosus			5	489-533	5						5
	Cynoscion regalis	4	318-425	3	267-540	7						7
	Paralichthys dentatus	1	400	6	279-324	7						7
	Sphoeroides maculatus			1	165	1						1
	Sciaenops ocellata			1	384	1						1
	Rhinoptera bonasus	1	946*			1						1
October	Paralichthys dentatus	2	304-308	4	252-294	6						6
	Cynoscion nebulosus			5	403-560	5						5
	Pomatomus saltatrix	4	333-390	7	320-504	11						11
November	Pomatomus saltatrix	13	333-460	8	340-412	21						21
	Cynoscion nebulosus			1	485	1						1
	Brevoortia tyrannus	1	165	14	152-222	15						15

* Disc Width

Table 2. (Continued).

Month	Species	17.8 cm stretched mesh Number	Size Range (SL in mm)	12.7 cm stretched mesh Number	Size Range (SL in mm)	1979 Catch	12.7 cm stretched mesh Number	Size Range (SL in mm)	8.8 cm stretched mesh Number	Size Range (SL in mm)	1980 Catch	Total Catch
TOTALS	Pomatomus saltatrix	37	295-590	49	210-870	86	34	275-732	28	272-710	62	148
	Carcharhinus milberti	24	530-780	154	430-990	178	102	430-716	66	440-710	168	346
	Cynoscion nebulosus	1	448	20	370-560	21	1	455-565	5	325-485	6	27
	Cynoscion regalis	8	318-430	20	260-600	28			39	320-524	39	67
	Paralichthys dentatus	4	304-400	16	220-324	20	3	255-430	6	165-257	9	29
	Rhinoptera bonasus	20	755-980*	10	452-990*	30	4	920-940*	2	878-950*	6	36
	Dasyatis sayi	8	420-600*	3	540-660*	11	3	480-710*			3	14
	Sphoeroides maculatus			1	165	1						1
	Rachycentron canadum			1	490	1						1
	Sciaenops ocellata			2	384-765	2						2
	Brevoortia tyrannus	4	165-254	15	152-247	19	7	167-239	167	225-325	174	193
	Alosa sapidissima						1	457			1	1
	Tylosurus acus			1	1250	1				848-1030	5	6
	Morone saxatilis						1	381	3	286-307	4	4
	Morone americana								2	204-205	2	2
	Alosa mediocris								1	251	1	1
	Opisthonema oglinum								1	325	1	1
	Alosa pseudoharengus								2	230-325	2	2
	Micropogonias undulatus						2	336-370	6	305-325	8	8
		106		292		398	158		333		491	889

* Disc Width

Table 3

Monthly Catch of Migratory Predator Species by Gillnets Within Habitat Types in Day and Night Sets.

		1979 Migratory Predators																											
		March			April			May			June			July			August			September			October			November			
		Z	R	S	Z	R	S	Z	R	S	Z	R	S	Z	R	S	Z	R	S	Z	R	S	Z	R	S	Z	R	S	Totals
Carcharhinus milberti	D										10	4	8	21	2	1	7	6	2	5	11	11							88
	N										6	5	1	23	8	3	12	15	7	5	1	4							90
Pomatomus saltatrix	D							2		3	3	2	3						10		7				1				31
	N							2	3	4	5	1	1				2		2	1	3		1		9			21	55
Cynoscion regalis	D							3			1									1	2								7
	N							4	2	1	2	3			1		3	1		3	1								21
Paralichthys dentatus	D																3				2	2	1	1					9
	N											1					3			1	2		3	1					11
Cynoscion nebulosus	D							3	1					1	1			1				1	1	1		1			10
	N							2			1									2	2		2	1					11
Tylosurus acus	D									1																			1
	N																												
Dasyatis sayi	D							1		2	2	1	1																7
	N							1	2		1																		4
Rhinoptera bonasus	D							1		11	4		2		1			1	1										21
	N								2	4					1	1					1								9
Sciaenops ocellata	D																												
	N								1												1								2
Rachycentron canadum	D																		1										1
	N																												
Brevoortia tyrannus	D																												
	N		3								1																	15	19
Sphoeroides maculatus	D																												
	N																			1									1
Totals			3					19	11	26	36	17	16	45	14	5	30	24	23	19	33	18	8	4	10	1		36	398

Table 4

Monthly Catch of Migratory Predator Species by Gillnets Within Habitat Types in Day and Night Sets.

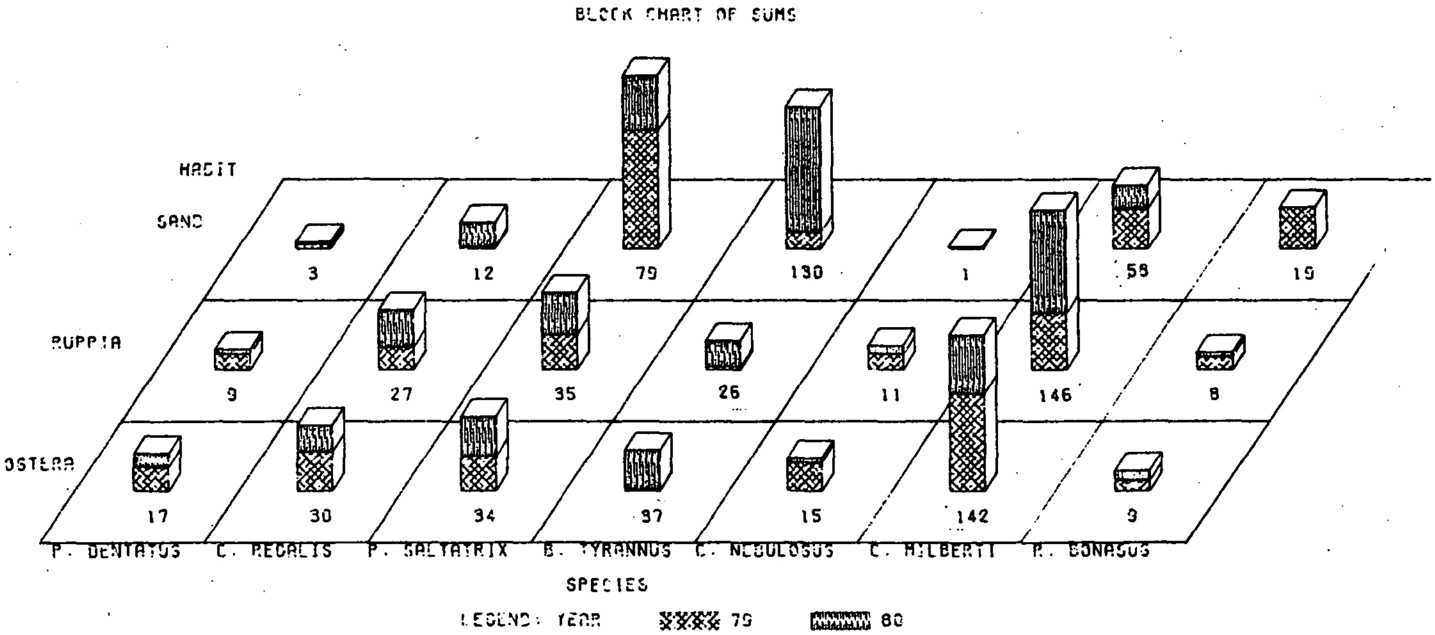
		1980 Migratory Predators															
		March			April			May			June			July			
		Z	R	S	Z	R	S	Z	R	S	Z	R	S	Z	R	S	Totals
<u>Carcharhinus</u> <u>milberti</u>	D										2	22		17	13	7	61
	N										18		2	16	59	12	107
<u>Pomatomus</u> <u>saltatrix</u>	D					1	18	2	6	3		1		3	1		35
	N				2		1	8	5	3		2		3	3		27
<u>Cynoscion</u> <u>regalis</u>	D						7										7
	N				6	2	1	1	2	1	4	12	1		1	1	32
<u>Paralichthys</u> <u>dentatus</u>	D													3	1		4
	N				1			1			1		1		1		5
<u>Cynoscion</u> <u>nebulosus</u>	D								1						2		3
	N										1			1	1		3
<u>Tylosurus</u> <u>acus</u>	D																
	N										1	4					5
<u>Dasyatis</u> <u>sayi</u>	D														1		1
	N											2					2
<u>Rhinoptera</u> <u>bonasus</u>	D							3									3
	N							1	2								3
<u>Morone</u> <u>saxatilis</u>	D		2				2										4
	N																
<u>Micropogonias</u> <u>undulatus</u>	D													1			1
	N													2	4	1	7
<u>Brevoortia</u> <u>tyrannus</u>	D	1	6	2	18	3	79										109
	N	3	3	6	11	1	28		3		3	1			6		65
<u>Morone</u> <u>americana</u>	D			1													1
	N			1													1
<u>Alosa</u> <u>mediocris</u>	D				1												1
	N																
<u>Alosa</u> <u>sappadissima</u>	D						1										1
	N																
<u>Opisthonema</u> <u>oglinum</u>	D						1										1
	N																
<u>Alosa</u> <u>pseudoharengus</u>	D																
	N							1		1							2
Totals		4	11	10	39	7	138	17	19	8	30	44	4	46	93	21	491

Figure 7 relates gill net catch of the seven dominant migratory species to habitat and year. Weakfish (C. regalis), spotted seatrout (C. nebulosus), sandbar shark (C. milberti), and summer flounder (P. dentatus) were more abundant in the vegetated areas while bluefish (P. saltatrix), cownose ray (R. bonasus), and menhaden (B. tyrannus) were more numerous in the sand area.

Nine species were captured more frequently at night than during the daylight period. For most species there were insufficient captures to provide an adequate estimate of diel temporal abundance patterns. Diel patterns of catch for three of the most abundant migratory predators are presented in Figure 8A and 8B. The sandbar shark, bluefish, and weakfish enter the study area after 10 a.m. The number of bluefish captured in the study area decreased around twilight while the sandbar shark and weakfish increased in number until midnight. These patterns may be related to feeding activity and will be discussed later under feeding analysis. Figure 9A and 9B indicate that C. regalis, P. saltatrix, and C. milberti were caught at a higher frequency during flooding tide stages than ebbing tide stages.

The sandbar shark tagging exercise produced two returns. A shark tagged in June was recaptured during July routine sampling. No tagged sharks were recaptured in the September gill net sets in the study area. A shark tagged in August was recaptured 38 days after release at the mouth of Onancock Creek, Va. (20 miles north of the study site). The low number of

ABUNDANCE OF DOMINANT MIGRATORY PREDATORS OF SAV STUDY AREA



TOTAL ABUNDANCE GIVEN WITHIN EACH BLOCK
HISTOGRAM OF C. MILBERTI AND B. TYRANNUS WERE SCALED TO ONE HALF ACTUAL ABUNDANCE

Figure 7

CATCH PER UNIT EFFORT OF C. REGALIS AND P. SALTATRIX VERSUS TIME

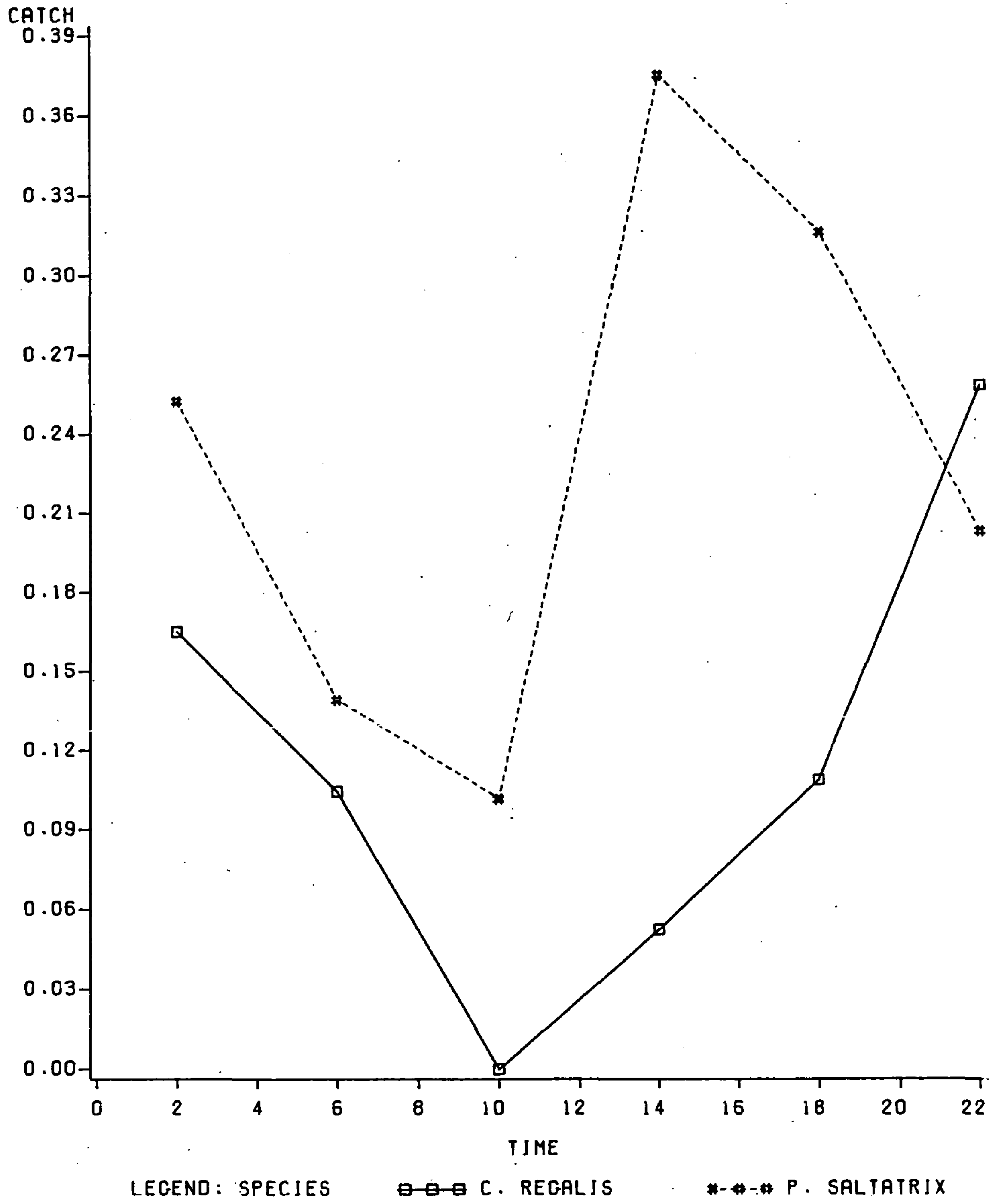


Figure 8A

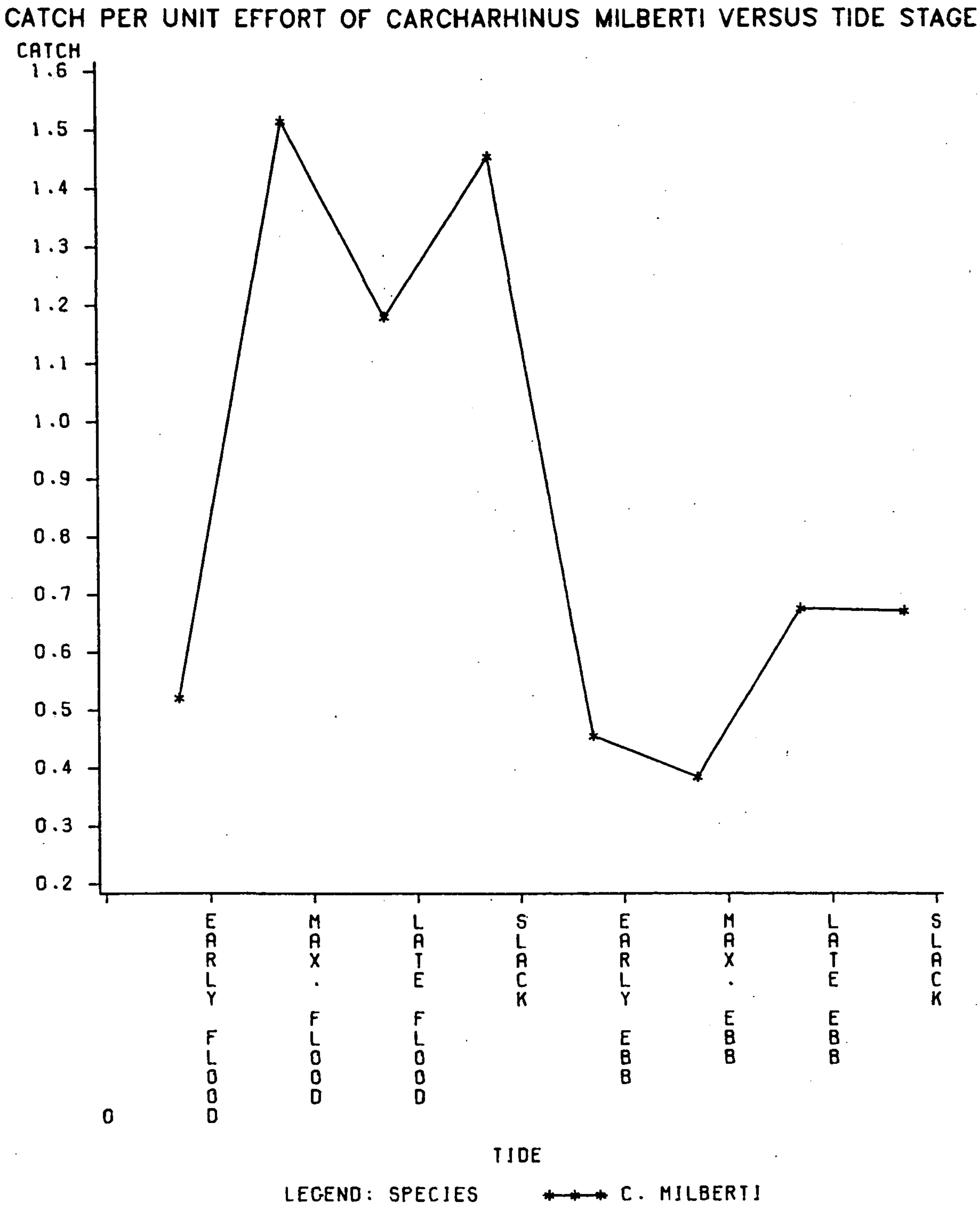

CATCH PER UNIT EFFORT OF CARCHARHINUS MILBERTI VERSUS TIDE STAGE
CATCH
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
EARLY FLOOD
MAX. FLOOD
LATE FLOOD
SLACK
EARLY EBB
MAX. EBB
LATE EBB
SLACK
TIDE
LEGEND: SPECIES
C. MILBERTI

Figure 8B

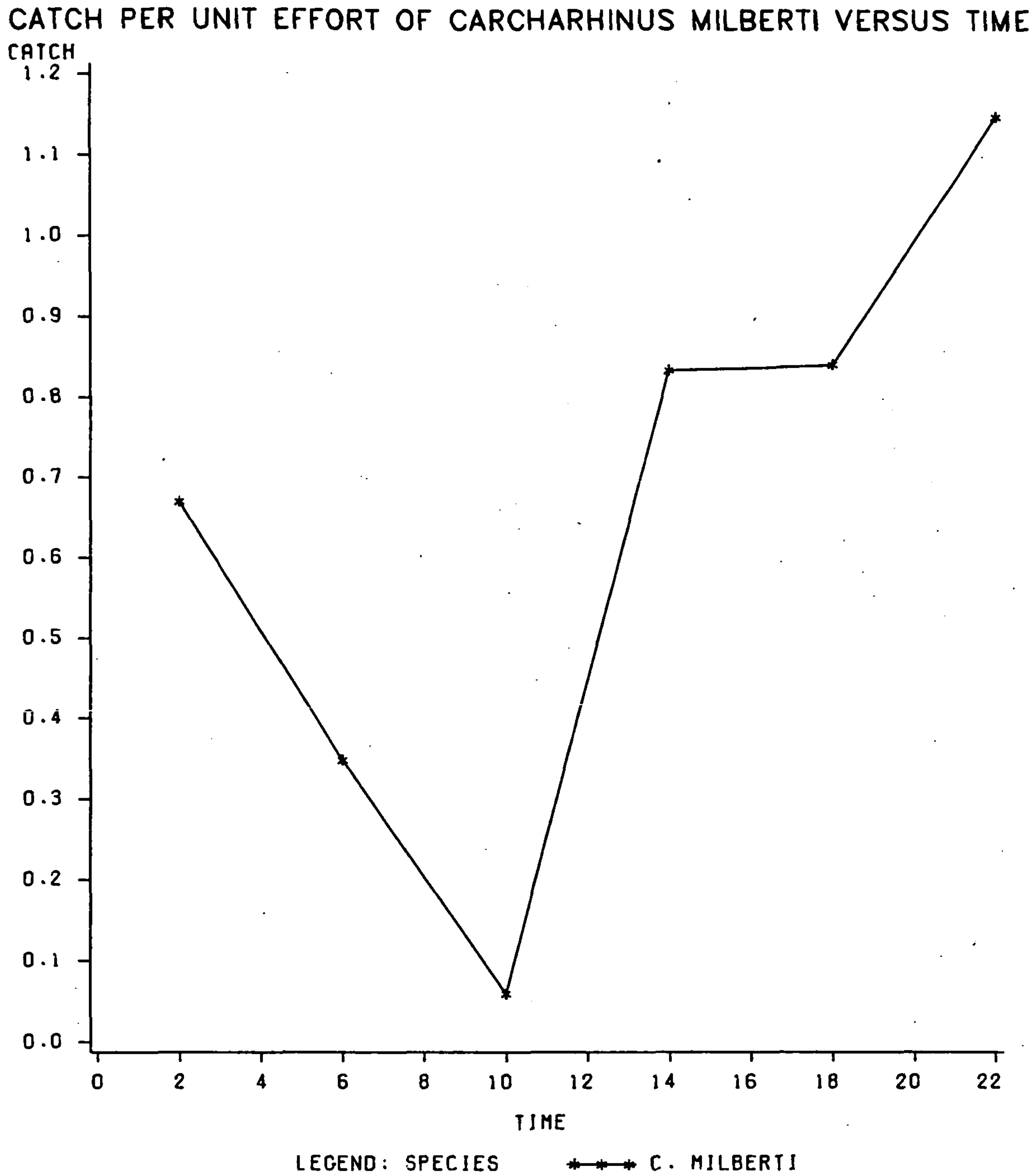

CATCH PER UNIT EFFORT OF CARCHARHINUS MILBERTI VERSUS TIME
CATCH
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
2
4
6
8
10
12
14
16
18
20
22
TIME
LEGEND: SPECIES
C. MILBERTI

Figure 9A

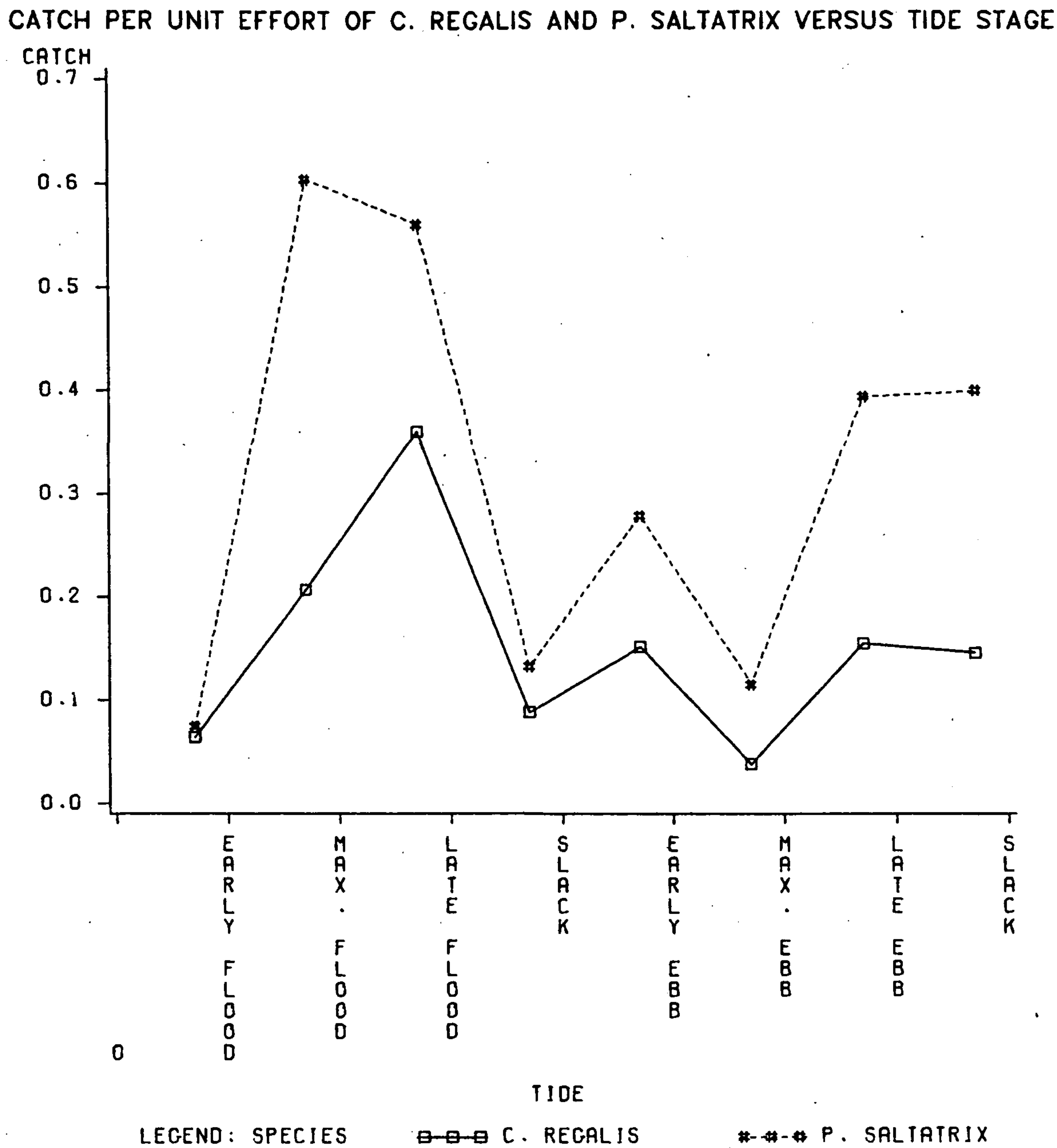

CATCH PER UNIT EFFORT OF C. REGALIS AND P. SALTATRIX VERSUS TIDE STAGE
CATCH
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
EARLY FLOOD
MAX. FLOOD
LATE FLOOD
SLACK
EARLY EBB
MAX. EBB
LATE EBB
SLACK
TIDE
LEGEND: SPECIES
C. REGALIS
P. SALTATRIX

Figure 9B

recaptures (2 out of 60) in the study area indicates that the sandbar shark is a highly mobile species and individual sharks may have a short residence time in the study area.

The two rays (_R_. _bonasus_ and _D_. _sayi_) and summer flounder (_P_. _dentatus_) were probably sampled poorly by gill nets since most captures occurred through entanglement rather than via "gilling" due to body shape. The needlefish, _Tylosurus_ _acus_, were observed to be very abundant at night but due to its long slender body was seldom caught in the gill nets.

Resident Fishes

Resident fishes were sampled with the haul seine from March through December, 1979. Haul seine collections include 178 night and 40 day sets. Eighty-seven hauls were made in *Zostera* habitat; 72 in *Ruppia* and 56 over sand bottom. Thirty-seven species from 23 families, representing 6,259 individuals were collected (Table 5).

Densities of resident species taken in the monthly night collections were presented in Table 6. Generally, numbers and diversity of species were greatest in the *Zostera* area followed by *Ruppia* and sand areas. The number of species captured and total fish density increased with temperature through October. Species diversity and population densities both declined rapidly with decreasing water temperatures in November and December.

Most species captured in the haul seine were taken sporadically; only *Anchoa mitchilli* was taken during every month (Table 6). This species was the numerical dominant in the sand area in March and May and in all habitats during June through November. The lowest densities ($0.26/m^2$) for this species were noted in December. *Membras martinica* was present in collections from April through November. However, this species was never abundant (densities ranged from $0.30-12.82/m^2$) in the collections. Pipefish (*Syngnathus fuscus*) were collected

Table 5. List of Resident Species captured by Haul Seine, 16' Otter Trawl and Pushnet

	Haul Seine	Otter Trawl	Pushnet
Anguilla rostrata	X	X	
Alosa aestivalis	X	X	
A. sapidissima	X		
Brevoortia tyrannus	X	X	X
Anchoa mitchilli	X	X	X
Opsanus tau	X	X	
Gobiesox strumosus	X	X	
Urophycis regius		X	
Hemiramphus brasilienis	X		X
Tylosurus acus			X
Strongylura marina	X		
Hyporhamphus unificiatus			X
Lucania parva	X	X	
Membras martinica	X	X	X
Menidia menidia	X	X	X
Apeltes quadracus	X	X	
Gasterosteus aculeatus	X		
Hippocampus erectus		X	
Syngnathus floridae		X	
S. fuscus	X	X	
S. louisianae		X	
Centropristis striata	X	X	
Orthopristis chrysoptera	X	X	
Bairdiella chrysoura	X	X	
Cynoscion nebulosus	X	X	
C. regalis	X	X	
Leiostomus xanthurus	X	X	X
Menticirrhus saxatilis		X	
Menticirrhus americanus	X		
Micropogonius undulatus		X	
Sciaenops ocellata	X	X	
Tautoga onitis		X	
Astroscopus guttatus	X	X	
Chasmodes bosquianus	X	X	
Hypsoblennius hentzi	X	X	
Gobiosoma bosci	X	X	
G. ginsburgi	X	X	
Peprilus alepidotus	X	X	
Prionotus evolans		X	
Paralichthys dentatus	X	X	
Scophthalmus aquosus	X	X	
Pseudopleuronectes americanus	X	X	
Trinectes maculatus	X	X	
Symphurus plagiusa		X	
Sphoeroides maculatus	X	X	
Chilomycterus schoepfi		X	

Table 6
Resident Fishes Collected by Haul Seine at Night in Zostera (Z), Ruppia (R) and Sand (S) habitats
#/100 m^2

Species	March			April			May			June			July		
	Z	R	S	Z	R	S	Z	R	S	Z	R	S	Z	R	S
Anguilla rostrata							1.97						0.58		
Alosa aestivalis				3.15	0.30	1.79									
A. sapidissima		0.31													
Brevoortia tyrannus					1.21	2.86	69.68	71.43	31.03		1.00	9.40	0.29	0.26	
Anchoa mitchilli	0.49	0.94	1.30	44.49	25.46	27.50	27.16	33.99	49.26	95.36	57.86	47.58	31.21	21.78	42.86
Opsanus tau															
Gobiesox strumosus															
Rissola marginata				0.79	1.21		1.58	0.49						0.26	0.28
Hemiramphus brasiliensis							0.78	0.49							
Strongylura marina															
Lucania parva							8.66	0.49			1.00				
Membras martinica				1.18	0.91	3.21	1.97	1.48	2.96	5.51	1.50	0.30	4.62	1.58	2.52
Menidia menidia	9.31	9.40	0.44	1.97	0.30	1.07									
Gasterosteus aculeatus	0.49														
Syngnathus fuscus							3.15	1.97		1.74	0.75		3.47	4.20	1.12
Centropristis striata								0.49							
Orthopristis chrysoptera															0.28
Bairdiella chrysoura															
Cynoscion nebulosus															
C. regalis															
Leiostomus xanthurus				259.8	148.8	71.07	37.40	5.42	10.84	5.80	8.48	3.03	1.73		4.48
Menticirrhus americanus															
Sciaenops ocellata															
Chasmodes bosquianus															
Hypsoblennius hentzi															
Gobiosoma bosci															
G. ginsburgi				0.39			0.39								
Paralichthys dentatus										0.29	0.25	0.30			
Scophthalmus aquosus	0.49														
Pseudopleuronectes americanus								0.49							
Trinectes maculatus										0.29					
Sphoeroides maculatus															

Table 6. (Continued).

Species	August Z	August R	August S	September Z	September R	September S	October Z	October R	October S	November Z	November R	November S	December Z	December R	December S
Anguilla rostrata		0.16													
Alosa aestivalis															
A. sapidissima															
Brevoortia tyrannus	0.23	0.49													
Anchoa mitchilli	51.04	36.36	14.47	8.38	3.62	14.64	81.09	38.30	22.05			11.53	0.26		
Opsanus tau				0.31			0.32	0.29							
Gobiesox strumosus				0.31	0.99		0.32	1.46							
Rissola marginata								0.29							
Hemiramphus brasiliensis															
Strongylura marina					0.33										
Lucania parva				1.55	1.64		8.01	0.88						1.58	
Membras martinica	3.22	1.46		1.24	1.64	4.05	12.82	3.22	5.74			0.50			
Menidia menidia		0.16					0.32						0.29	18.90	0.83
Gasterosteus aculeatus															
Syngnathus fuscus	3.45	1.95	0.22	5.59	12.17	0.31	6.73	5.56	0.60				0.26		
Centropristis striata															
Orthopristis chrysoptera															
Bairdiella chrysoura	1.84	0.97	0.22	3.73	1.97		0.64								
Cynoscion nebulosus	1.38		1.20												
C. regalis	1.14	0.49													
Leiostomus xanthurus	2.07		0.66	0.62											
Sciaenops ocellata														1.58	
Chasmodes bosquianus				0.62	0.33		1.28	0.29							
Hypsoblennius hentzi				0.93	1.32		0.32	0.58							
Gobiosoma bosci					1.64	0.31	4.17								
G. Ginsburgi															
Paralichthys dentatus															
Scophthalmus aquosus															
Pseudopleuronectes americanus															
Trinectes maculatus												0.25			
Sphoeroides maculatus	0.23		0.22												

from May through October, and once in December. Most pipefish were collected in the vegetated areas (see Table 5). Much lower densities were present over sand areas, particularly during July and August. Spot, *Leiostomus xanthurus*, recruited to Chesapeake Bay in April and at this time were clearly the numerically dominant species of fish in all habitats. Atlantic menhaden, *Brevoortia tyrannus*, was present from April through August and was the dominant species in vegetated areas during May (Table 6).

Length - dry weight relationships were determined for seven dominant species collected by haul seine (Table 7). These equations were used to determine biomass of field collected individuals of these species. Seasonal biomass (dry weight) measurements of seven dominant species are presented in Table 8. The dominant species in terms of biomass differed from the numerical dominant in certain months; with few exceptions, however, *Anchoa mitchilli* remained the dominant species. In March and December, *M. menidia* was dominant in all habitats; *L. xanthurus* was the dominant species only in May in the *Zostera* sampling area. Although spot was clearly the numerical dominant in April (Table 6), all specimens were newly recruited postlarvae (mean length 18.1 mm) which individually contribute little to the fish biomass. Other species collected in the haul seine and contributing significantly to the fish biomass at particular times were Atlantic menhaden in May and June, rough silverside in June and July; and silver perch in September. Menhaden and silver

Table 7 . Length - dry weight relationships for dominant fishes. Dry weight (w) is in g and length (l) is standard length in mm.

Species		n	Size Range (mm)	r^2
Leiostomus xanthurus	LOG (w) = 3.1858 LOG (l) - 5.8013	17	14- 23	0.87
Leiostomus xanthurus	LOG (w) = 3.2726 LOG (l) - 5.8751	32	>32	0.99
Brevoortia tyrannus	LOG (w) = 3.902 LOG (l) - 6.8819	21	25- 60	0.95
Bairdiella chrysoura	LOG (w) = 3.304 LOG (l) - 5.869	31	35-140	0.99
Syngnathus fuscus	LOG (w) = 3.7906 LOG (l) - 8.6256	29	90-200	0.92
Membras martinica	LOG (w) = 2.9569 LOG (l) - 5.5342	8	26-100	0.98
Menidia menidia	LOG (w) = 2.9582 LOG (l) - 5.5615	39	25-100	0.97
Anchoa mitchilli	LOG (w) = 3.5281 LOG (l) - 6.6570	16	38- 75	0.96

TABLE 8

Resident Fishes Collected by Haul Seine
Biomass (mg dry wt/m^2)

	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
*Brevoortia tyrannus										
Zostera			92.71		10.11	9.29				
Ruppia		0.49	91.65	7.62	6.09	38.16				
Sand		1.11	53.82	79.62						
*Anchoa mitchilli										
Zostera	0.79	178.16	46.74	180.93	80.32	133.86	2.99	180.48		0.15
Ruppia	3.92	87.44	50.60	100.27	48.08	95.72	4.60	76.75		
Sand	2.63	113.26	73.18	80.73	95.47	41.59	38.30	41.46	18.93	
Membras martinica										
Zostera		16.14	26.63	68.89	43.86	37.56	6.49	28.65		
Ruppia		12.13	15.47	13.82	19.21	15.11	9.82	6.56		
Sand		46.25	40.44	3.48	18.03		31.06	14.48	1.86	
Menidia Menidia										
Zostera	104.98	22.56						4.81		2.74
Ruppia	73.14	1.30				1.33				24.75
Sand	8.46	17.51								10.82
Syngnathus fuscus										
Zostera			11.62	8.19	4.71	3.09	4.84	4.78		0.08
Ruppia			6.46	0.60	6.69	4.47	11.25	7.47		
Sand					1.81	2.19	3.11	1.37		
Bairdiella chrysoura										
Zostera						1.90	127.07	4.81		
Ruppia						0.70	24.67			
Sand						2.19				
Leiostomus xanthurus										
Zostera		41.36	93.85	37.95	18.97	21.27	8.48			
Ruppia		25.49	12.16	31.61				2.92		
Sand		11.70	24.98	10.46	33.85	24.35				

perch are schooling species which undergo seasonal migrations. Therefore catches of these species were quite variable depending upon the presence of schools in the sampling area. Rough silversides were present in the study area for most of the year at relatively low densities and biomass.

Comparative day-night collections were made with the haul seine in June, September and December. Results are presented in Table 9. There were no clear trends in the data. Day collections in June yielded more species and individuals than were taken during night collections. Additionally biomass of those fishes collected during the day was greater than for night collections. In September both the number and biomass of species collected at night were greater than corresponding daytime collections. In December, night-time collections resulted in a greater catch in terms of all three parameters than daytime hauls.

Biomass of the dominant species for day and night collections from June, September and December is presented in Table 10. In June, Brevoortia tyrannus wasdominant in the Zostera area during the day; all specimens, however, were taken in a single collection and none were taken in the two other sets made in daylight in Zostera. By comparison this species was common at night only in the sand area, where it was taken in all three collections. It is possible that these juveniles school in daylight and disperse at night.

TABLE 10

Day-Night Comparison of Resident Fishes
Biomass (mg dry wt/m^2) from haul seine collections

	JUNE					
	Zostera		Ruppia		Sand	
	D	N	D	N	D	N
Brevoortia tyrannus	511.80	0	0	7.62	0	79.62
Anchoa mitchilli	3.42	180.93	12.08	100.27	0	88.47
Membras martinica	6.55	68.89	5.82	13.82	18.61	3.48
Menidia menidia	41.60	0	8.86	0	4.06	0
Syngnathus fuscus	16.39	8.19	0.99	0.60	0	0
Leiostomus xanthurus	5.02	37.95	10.92	31.61	0.43	10.46

	SEPTEMBER					
	Zostera		Ruppia		Sand	
	D	N	D	N	D	N
Brevoortia tyrannus	0	0	0	0	0	0
Anchoa mitchilli	41.26	2.99	0.12	4.60	0	38.30
Membras martinica	0	6.49	0.85	9.82	4.56	31.06
Menidia menidia	7.74	0	0	0	0	0
Syngnathus fuscus	9.74	4.84	0.45	11.25	0	0.11
Leiostomus xanthurus	3.42	8.48	0	0	0	0

	DECEMBER					
	Zostera		Ruppia		Sand	
	D	N	D	N	D	N
Brevoortia tyrannus	0	0	0	0	0	0
Anchoa mitchilli	0	0.15	0	0	0.65	0
Membras martinica	0	0	0	0	0	0
Menidia menidia	0	2.74	0	24.75	18.28	12.82
Syngnathus fuscus	0	0.08	0	0	0	0
Leiostomus xanthurus	0	0	0	0	0	0

With the exception of the September *Zostera* collections, *Anchoa mitchilli* was more abundant at night than during the day. *Membras martinica* exhibited the same trend in day-night abundance as did *A. mitchilli* (except for the night time sand collections).

For these two species it is unlikely that the day-night difference is an effect of enhanced avoidance during the daylight samples, since *Menidia menidia* is captured during the day. The increased abundance of *Syngnathus fuscus* during the day is probably due to increased activity during daylight hours and greater availability to the sampling gear. Lower daytime catches of *Leiostomus xanthurus* in vegetated areas, probably represents increased avoidance of the sampling gear. The ratios of night to day catch of spot are much greater in sand, however, suggesting that some movement from the vegetated areas may occur at night.

In September 1979, a comparison of the haul seine data from this study to trawl data of Orth and Heck (1980) indicated that benthic species, especially spot, were not adequately sampled by the haul seine. Therefore, sampling with a 16 foot otter trawl supplemented the routine haul seine collections. September day and October night samples in 1979 were representative of the relative gear selectivity of the haul seine and otter trawl for various species (Table 11). Planktivorous fishes such as *Anchoa mitchilli*, *Menidia menidia* and *Membras martinica* were more effectively captured with the haul seine than the otter trawl. Pipefish (*S. fuscus*) were also captured in greater numbers by the haul seine than the trawl. Density estimates for silver perch by both gears were the same in September but differed in October, which was probably due to increased haul seine avoidance as silver perch grew larger. Spot was avoiding the haul seine as demonstrated by the small haul seine catch and trawl density estimates in September and October. Similar trends were evident in comparisons of trawl and haul seine biomass estimates (Table 12).

Anchoa mitchilli, *Leiostomus xanthurus*, and *Syngnathus fuscus* were regularly captured by the otter trawl (Tables 13 and 14). *A. mitchilli* was taken during every month. This species was the numerical dominant in the sand area in March and April of 1980 and in the *Zostera* area in November 1979 and March 1980. Pipefish (*S. fuscus*) were collected from September 1979 through July 1980. Low densities of pipefish were seen over sand areas during October, March, June and July. As seen in the haul seine and trawl collections, spot recruited to the study area in April. Spot was the numerical dominant in all habitats from September to November 1979 and May through July 1980. Spot was more abundant in the *Zostera* and *Ruppia* areas than the sand area.

Table 11
Comparison of 1979 September Day and
October Night Haul Seine and Otter Trawl Catch
Density (#/100 m^2)

Species	September Day				October Night					
	Zostera		Ruppia		Zostera		Ruppia		Sand	
	Haul Seine	Trawl	Haul Seine	Trawl	Haul Seine	Trawl	Haul Seine	Trawl	Haul Seine	Trawl
Anguilla rostrata								.24		NO SAMPLES TAKEN
Anchoa mitchilli	96.87	1.17	.31	.16	81.09	.12	38.30	.12	22.05	
Opsanus tau		.05			.32	.12	.29	.36		
Gobiesox strumosus				.08	.32	.36	1.46	.60		
Urophycis regius										
Rissola marginata						.12	.29	.36		
Lucania parva	3.13		.31		8.01		.88			
Membras martinica					12.82		3.22	.12	5.74	
Menidia menidia	.85		.31	.08	.32					
Syngnathus louisianae		.05								
Syngnathus fuscus	15.38	.53	.31	.64	6.73	6.22	5.56	1.80	.60	
Centropristis striata				.08		.12		.72		
Orthopristis chrysoptera						.12				
Bairdiella chrysoura	8.83	9.78		3.03	.64	4.31		2.51		
Cynoscion nebulosus						.12				
C. regalis		.05								
Leiostomus xanthurus	.28	10.21		3.11		39.12	.29	94.02		
Tautoga onitis		.05								
Chasmodes bosquianus	1.99	.11		.08	1.28	.72	.29	.84		
Hypsoblennius hentzi	.28	1.28		.32	.32	4.66	.58	2.51		
Gobiosoma bosci	15.38				4.17	.12		.12		
Peprilus alepidotus				.08						
Paralichthys dentatus		.11		.08						
Trinectes maculatus		.11				.36				
Sphoeroides maculatus		.05								
Chilomycterus schoepfi		.05		.16						

Table 12
Comparison of 1979 Haul Seine and Trawl Collections
(mg dry wt/m^2)

Species	September-Day						October-Night					
	Haul Seine			Trawl			Haul Seine			Trawl		
	Z	R	S	Z	R	S	Z	R	S	Z	R	S
Anchoa mitchilli	41.26	.12		3.56	.41	N	180.48	76.75	41.5	.2	.32	N
Membras martinicia		.85	4.56			O	28.65	6.56	14.48		.46	O
Menidia menidia	7.74				1.04		4.81					
Syngnathus fuscus	9.74	.45		.50	1.02	S	4.78	7.47	1.37	11.3	3.57	S
Bairdiella chrysoura				111.50	33.58	A	4.81			39.9	20.62	A
Leiostomus xanthurus	3.42			160.85	53.92	M			2.92	658.16	1607.6	M
						P						P
						L						L
						E						E

Table 13
Resident Fishes Caught by Trawl 1979 by Month, Time of Day, and Habitat
Density/100 m^2

	September						October						November					
	Zostera		Ruppia		Sand		Zostera		Ruppia		Sand		Zostera		Ruppia		Sand	
Species	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N
Anguilla rostrata		N		N		N	0.6			.24		N						N
Anchoa mitchilli	1.17	O	.16	O		O	5.38	.12	1.02	.12	.90	O		2.03				O
Opsanus tau	.05							.12		.36								
Gobiesox strumosus		S	.08	S		S	.12	.36		.60		S						C
Rissola marginata		A		A		A		.12		.36		A						A
Lucania parva		M		M		M			.06			M						T
Membras martinicia		P		P		P				.12		P						C
Menidia menidia		L	.08	L		L	.06					L						H
Syngnathus louisianae	.05	E		E		E						E						
S. fuscus	.53		.64				2.33	6.22	2.33	1.80	.06		.36	.96	.72			
Centropristis striata	.11	T	.08	T		T	.06	.12				T						
Orthopristis chrysoptera		A		A		A	.12	.12		.72		A						
Bairdiella chrysoura	9.78	K	3.03	K		K	1.20	4.31	1.62	2.51		K			.96	.36		
Cynoscion nebulosus		E		E		E		.12				E						
C. regalis	.05	N		N		N						N						
Leiostomus xanthurus	10.21		3.11				10.53	39.12	4.31	94.02	1.08			2.03				
Sciaenops ocellata							.06											
Tautoga onitis	.05																	
Chasmodes bosquianus	.11		.08				.84	.72	.60	.84					.12			
Hypsoblennius hentzi	1.28		.32				.30	4.66	.42	2.51								
Gobiosoma bosci								.12	.06	.12								
Peprilus alepidotus			.08															
Paralichthys dentatus	.11		.08				.06				.06							
Trinectes maculatus	.11							.36						.12				
Sphoeroides maculatus	.05																	
Chilomycterus schoepfi	.05		.16															

Table 14
Resident Fishes Caught by Trawl by Month, Time of Day, and Habitat
Density/100 m^2

1980

	March						April						May					
	Zostera		Ruppia		Sand		Zostera		Ruppia		Sand		Zostera		Ruppia		Sand	
Species	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N
Anguilla rostrata								.12	.09	.48				.26	.55	.37		
Alosa aestivalis								.12										
Brevoortia tyrannus					1.04			.12			4.48	.48						
Anchoa mitchilli	.24	.08	.32		4.78	.16	.22	27.63	.09	1.68	1.70	20.21	3.34	.91	.82	2.94	2.55	3.59
Opsanus tau							.11	.12		.08				.39	.36			
Gobiesox strumosus										.08			.23			.13		
Urophycis regius					.08	.16	.11	.24		.08			.23	.26	.27	.24		.06
Rissola marginata								.48		.08		.24		.13		.49		.90
Menidia menidia							.11		.09		.18							
Apeltes quadracus			.16				.11		.54	.64				1.16	.09	.24		
Hippocampus erectus											.09							
Syngnathus floridae																		
S. fuscus				.16	.08		.44	2.39	.54	10.21			1.71	3.50	5.46	6.38		
Centropristis striata										.08					.09			
Orthopristis chrysoptera																		
Lagodon rhomboides																		
Bairdiella chrysoura																		
Leiostomus xanthurus							6.59	.12	8.96	1.12	.09	.24	8.61	35.61	34.50	19.74	4.78	18.66
Menticirrhus saxatilis											.09							
Micropogonius undulatus			.08															
Tautoga onitis												.12						
Astroscopus guttatus																		
Hypsoblennius hentzi										.16			.39	.26	.09			
Gobiosoma bosci															.09	.37		
G. ginsburgi										.08								
Peprilus alepidotus																.12		
Prionotus evolans								.24						.13	.09	.12	.16	.06
Paralichthys dentatus						.08							.23	2.20	.27	.49		.18
Scophthalmus aquosus						.32		.12				.48						
Pseudopleuronectes americanus																		
Trinectes maculatus																.13		

Table 14 continued
Resident Fishes Caught by Trawl 1980 by Month, Time of Day, and Habitat
Density/100 m^2

	1980											
	June						July					
	Zostera		Ruppia		Sand		Zostera		Ruppia		Sand	
Species	D	N	D	N	D	N	D	N	D	N	D	N
Anguilla rostrata	.08	.49	.32	.72						.24		
Anchoa mitchilli		.24	.08	4.54		.96		.12		.16		.48
Opsanus tau		.49	.16	.24				.12	.24	.40		
Gobiesox strumosus								.12		.16		
Rissola marginata		2.21						.12				.36
Menidia menidia	.08		.16									
Apeltes quadracus	.24	1.47	1.12	.96			.16	.36	.08	.40		
Syngnathus floridae										.40		
S. fuscus	5.54	19.97	3.59	13.64		.24	4.94	15.43	2.39	9.01	.08	.24
Centropristis striata				.48				.12		.48		
Orthopristis chrysoptera										.08		
Lagodon rhomboides			.08					.24	.32	.08		
Bairdiella chrysoura									.08	.08		
Leiostomus xanthurus	40.34	146.55	56.70	91.99	5.98	8.49	11.96	8.97	14.35	11.72		7.42
Astroscopus guttatus								.12				
Hypsoblennius hentzi	.16	1.96		.48			.32	.96				
Prionotus evolans		1.59										.12
Paralichthys dentatus	.41	5.02	1.52	2.63		.12	.96	.72	.72	1.75	.08	.72
Pseudopleuronectes americanus	.41	7.35	.32	4.31		.24	.56	2.03	.32	1.12	.08	
Trinectes maculatus		.24		.24				.12				
Symphurus plagiusa		4.78										
Sphoeroides maculatus								.12				

TABLE 15. Resident Fishes Collected by Trawl in 1979 Biomass (mg dry wt/m^2)

	September						October						November					
	Zostera		Ruppia		Sand		Zostera		Ruppia		Sand		Zostera		Ruppia		Sand	
	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N
Anchoa mitchilli	3.56	NO SAMPLE	.41	NO SAMPLE	NO SAMPLE	NO SAMPLE	15.68	.21	1.90	.32	.62	NO SAMPLE		6.94			NO CATCH	NO CATCH
Membras membras										.46								
Menidia menidia			1.04				.84											
Syngnathus fuscus	.51		1.02				3.26	11.32		3.57	.05		.29	1.09	.84			
Bairdiella chrysoura	111.50		33.58				15.77	39.92		20.62					9.42	3.41		
Leiostomus xanthurus	160.85		53.92				194.87	658.16	59.86	1607.59	45.26			48.54				

Table 16
Resident Fishes Collected by Trawl in 1980
(Biomass gm/100 m^2)

	March						April						May					
	Zostera		Ruppia		Sand		Zostera		Ruppia		Sand		Zostera		Ruppia		Sand	
	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N	D	N
Anchoa mitchilli	.20	.09	.94		9.6	.34	.97	71.05	.49	5.20	6.03	47.89	5.82	1.38	1.70	7.35	5.0	11.18
Brevoortia tyrannus					.40			10.8			2.60	15.18						
Menidia menidia							2.07		2.76		3.56							
Syngnathus fuscus				.21	.09		1.08	10.4	1.59	27.77			10.44	16.71	20.21	23.45		
Bairdiella chrysoura																		
Leiostomus xanthurus							5.29	.02	7.19	.15	.07	.04	15.26	25.60	31.18	30.84	5.74	54.43

	June						July					
	Zostera		Ruppia		Sand		Zostera		Ruppia		Sand	
	D	N	D	N	D	N	D	N	D	N	D	N
Anchoa mitchilli		.75	.24	10.72		1.92		.24		.40		1.16
Brevoortia tyrannus												
Menidia menidia	2.51		3.67									
Syngnathus fuscus	32.05	110.65	24.87	87.83		1.60	15.41	43.96	43.96	5.84	29.27	2.03
Bairdiella chrysoura										.212	.12	
Leiostomus xanthurus	265.67	684.15	254.76	359.36	21.05	44.42	145.92	117.29	146.73	195.85		70.41

Seasonal biomass (dry weight) measurements of seven dominant species are presented in Table 15 and 16. In terms of biomass, spot was the dominant species in all habitats. During September through November, the biomass of silver perch was larger than that of pipefish. April through July 1980, pipefish were the second most dominant species.

Comparative day-night otter trawl collections (Table 13 and 14), indicated that density estimates of silver perch and pipefish were typically higher at night than during the day. Except for April and July, spot was more abundant at night than during the day. Anchoa mitchilli was typically more abundant at night than during the day. As with the haul seine, the observed day/night differences in trawl catch may be due to gear avoidance. The large day densities of spot in April may be due to minimal gear avoidance by 15-25 mm spot.

From March to July 1980, resident pelagic species were sampled with a nekton push net instead of a haul seine. This gear has effectively sampled juvenile alosines (Kriete and Loesch, 1980) and was less labor intensive than the haul seine. The push net captured 1139 specimens representing seven species in six families of fishes (Tables 17 and 18). Catches were more diverse and numerically greater at night than during the day. Anchoa mitchilli was the only species captured every month. The push net caught more A. mitchilli at night than did the trawl (Table 19). Spot was poorly sampled by the push net. Although no direct gear comparison was made between the haul seine and the nekton push net; the haul seine was more consistent in capturing pelagic fishes in the SAV area than was the push net. Table 5 lists the species captured by the haul seine, trawl, and push net.

Table 17
Resident Fishes Collected by Nekton Push Net in 1980
(#/100 m^2)

Daytime

Species	March Z	March R	March S	April Z	April R	April S	May Z	May R	May S	June Z	June R	June S	July Z	July R	July S
Brevoortia tyrannus		6.0		3.2			4.0	1.2	.3			1.	no catch		
Anchoa mitchilli	.7			1.6	4.2		.1	1.6	3.5						
Leiostomus xanthurus							.1					1.8			
Membras martinicia								.1							

Nighttime

Species	March Z	March R	March S	April Z	April R	April S	May Z	May R	May S	June Z	June R	June S	July Z	July R	July S
Brevoortia tyrannus								10.4	.7		.2	.4			
Anchoa mitchilli			.2	No samples taken			7.0	20.6	11.2	12.2	36.9	.4	4.6	9.4	
Menidia menidia	.6	.7	.4								.5				
Membras martinica								.8		.8	1.7	.4	4.1	3.4	
Leiostomus xanthurus								1.9		.2					
Hyporhamphus unifaciatus								.1			.3	.2	.2		
Tylosaurus acus														.1	

Table 18
Resident Fishes Collected by Nekton Push Net in 1980
(mg dry wt/m^2)

Daytime

Species	March Z	March R	March S	April Z	April R	April S	May Z	May R	May S	June Z	June R	June S	July Z	July R	July S
Brevoortia tyrannus		2.3		2.4			5.5	1.0	.3				no catch		
Anchoa mitchilli	2.4			3.1	7.8		.04	3.3	5.0						
Leiostomus xanthurus							.2					6.0			
Membras martinicia								.4							

Nighttime

Species	March Z	March R	March S	April Z	April R	April S	May Z	May R	May S	June Z	June R	June S	July Z	July R	July S
Brevoortia tyrannus								11.5	2.2		1.0	1.5			
Anchoa mitchilli			.4	No samples taken			10.0	31.4	16.5	30.1	175.4	.7	12.7	25.3	
Menidia menidia	7.9	5.6	2.4								8.4				
Membras martinica								.9		8.4	14.3	4.9	3.7	33.5	
Leiostomus xanthurus								1.5		1.2					
Hyporhamphus unifaciatus								N/A			N/A	N/A	N/A		
Tylosaurus acus														N/A	

Table 19. Comparison of resident fishes captured by Nekton Push Net and Otter Trawl (#/100m²)

DAY COLLECTIONS

SPECIES	MARCH						APRIL						MAY					
	Push Net			Trawl			Push Net			Trawl			Push Net			Trawl		
	Z	R	S	Z	R	S	Z	R	S	Z	R	S	Z	R	S	Z	R	Z
Brevoortia tyrannus	.	6.0	.	.	.	1.4	3.2	.	.	.	.	4.48	4.00	1.20	.30	.	.	.
Anchoa mitchilli	.7	.	.	.24	.32	4.78	1.6	4.2	.	.22	.09	1.70	.10	1.60	3.50	3.34	.82	2.55
Menidia menidia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Membras martinica	.	.	.	.	.	.	.	.	.	.	.	.	.	.10	.	.	.	.
Leiostomus xanthurus	.	.	.	.	.	.	.	.	.	6.59	8.96	.09	.10	.	.	8.61	34.50	4.78
Hyprohamphus unifaciatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tylosurus acus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

NIGHT COLLECTIONS

SPECIES	MARCH						APRIL						MAY					
	Push Net			Trawl			Push Net			Trawl			Push Net			Trawl		
	Z	R	S	Z	R	S	Z	R	S	Z	R	S	Z	R	S	Z	R	S
Brevoortia tyrannus	.	.	.	.	.	.	No samples taken			.12	.	.48	.	10.4	.7	.	.	.
Anchoa mitchilli	.	.	.2	.08	.	.16	No samples taken			27.63	1.68	20.21	7.0	20.6	11.2	.91	2.94	3.6
Menidia menidia	.6	.7	.4	.	.	.	No samples taken			.	.	.	.	.	.	.	.	.
Membras martinica	.	.	.	.	.	.	No samples taken			.	.	.	.	.8	.	.	.	.
Leiostomus xanthurus	.	.	.	.	.	.	No samples taken			.12	1.12	.24	.	1.9	.	35.6	19.7	18.7
Hyporhamphus unifaciatus	.	.	.	.	.	.	No samples taken			.	.	.	.	.1	.	.	.	.
Tylosurus acus	.	.	.	.	.	.	No samples taken			.	.	.	.	.	.	.	.	.

Table 19 (Cont'd)

DAY COLLECTIONS

Species	JUNE Push Net Z	R	S	JUNE Trawl Z	R	S	JULY Push Net Z	R	S	JULY Trawl Z	R	S
Brevoortia tyrannus	.	.	.	.	.	.	No catch			.	.	.
Anchoa mitchilli	.	.	.	.	.08	.	No catch			.12	.16	.48
Menidia menidia	.	.	.	.08	.16	.	No catch			.	.	.
Membras martinica	.	.	.	.	.	.	No catch			.	.	.
Leiostomus xanthurus	.	.	1.8	40.3	56.70	5.98	No catch			11.96	14.35	11.72
Hyporhamphus unifaciatus	.	.	.	.	.	.	No catch			.	.	.
Tylosurus acus	.	.	.	.	.	.	No catch			.	.	.

NIGHT COLLECTIONS

Species	JUNE Push Net Z	R	S	JUNE Trawl Z	R	S	JULY Push Net Z	R	S	JULY Trawl Z	R	S
Brevoortia tyrannus	.	.2	.4	.	.	.	.	.	.	.	.	.
Anchoa mitchilli	12.4	36.9	.4	.24	4.54	.96	4.6	9.4	.	.12	.16	.48
Menidia menidia	.	.5	.	.	.	.	.	.	.	.	.	.
Membras martinica	.8	1.7	.4	.	.	.	4.1	3.4	.	.	.	.
Leiostomus xanthurus	.2	.	.	146.6	92.0	8.5	.	.	.	8.97	11.72	7.42
Hyporhamphus unifaciatus	.	.3	.2	.	.	.	.2	.	.	.	.	.
Tylosurus acus	.	.	.	.	.	.	.	.1	.	.	.	.

Zooplankton

Abundance, diversity, and diel availability of zooplankton components within the shallow water seagrass ecosystem and adjacent deep water unvegetated areas were analyzed and compared. A total of 118 species were identified from all habitats combined through the thirteen month study period (Table 20). The zooplankton assemblage consisted of obligate planktonic forms (holoplankton and meroplankton) and facultative planktonic forms (demersal plankton). Holoplankton was the numerically dominant component and included species of copepods (calanoids and cyclopoids), cladocerans, chaetognaths, rotifers, jellyfish and hydromdusae. The meroplankton component was made up of fish eggs and larvae, decapod larvae and larvae of gastropod, pelecypod, polychaete and barnacle species. Demersal plankters have been defined as organisms which are resident members of the bottom substrate community but emerge periodically to move into the water column, swimming freely (Hobson and Chess, 1976; Robertson and Howard, 1978). Amphipods, isopods, cumaceans, tanaids, leeches, adult polychaetes and mysids constituted the demersal component sampled in this study.

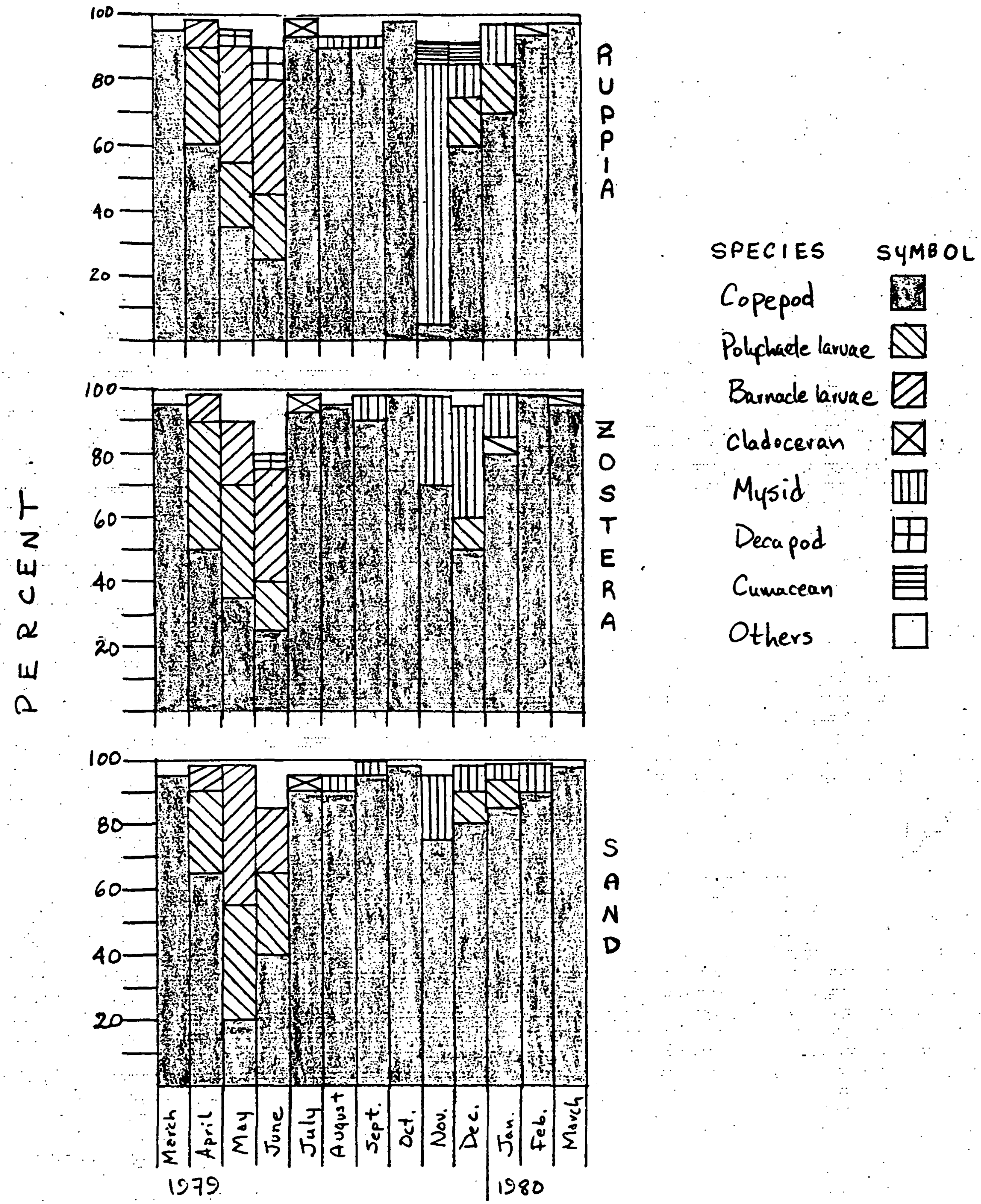
Temporal and spatial variations in zooplankton community structure were documented during the thirteen month program. Two distinct seasonal zooplankton communities were identified: a winter-spring assemblage peaking in March and a summer-fall assemblage peaking in July. In both cases holoplankters dominated the assemblage numerically, specifically calanoid copepods (Figure 10). During periods of peak abundance, calanoids accounted for 95% of the total zooplankton standing stock. Only during the transition periods (May-June; November-December) were copepods not the dominant taxon. At this time meroplanktonic forms such as larvae of polychaetes and barnacles constituted up to 45% of the total zooplankton community numerically. Temporal variations in abundance and distribution over a diel cycle were exhibited

TABLE 20. Number of species identified within individual taxa of the three zooplankton components.

ZOOPLANKTON COMPONENTS		
Obligate		Facultative
Holoplankton	Meroplankton	Demersal Plankton
Copepods n = 12	Decapod larvae n = 23	Amphipods n = 21
Cladoceran n = 12	Fish eggs and larvae n = 20	Cumaceans n = 6
Chaetognath n = 4	Pelecypod larvae n = 1	Isopods n = 4
Jellyfish n = 3	Gastropod larvae n = 1	Mysid n = 3
Hydromedusae n = 1	Polychaete larvae n = 1	Polychaete, adult n = 12
Rotifer n = 1	Barnacle larvae n = 1	Tanaid n = 1
		Leech n = 1
23	47	48

Total number of species 118

FIGURE 10. Dominant zooplankton taxa. Percent of total community.



for holoplankters and demersal plankters. In addition, interhabitat differences in abundance and distribution were observed for specific species of obligate and facultative zooplankters.

Holoplankton

Calanoid copepods were represented by the greatest number of species of all holoplankters and dominated this group numerically. The copepod population exhibited a seasonal succession pattern (Table 21). The winter-spring assemblage consisted of Acartia clausi, Acartia copepodites, Centropages hamatus, Eurytemora affinis, Oithona sp., Pseudocalanus minutus, Paracalanus crassirostris and Acartia tonsa. In 1979 Acartia clausi had replaced Acartia tonsa by March, a phenomenon well documented for Middle Atlantic estuaries (Jeffries, 1962; Jacobs 1978). Acartia clausi adults and Acartia copepodites constituted greater than 85% of the March 1979 copepod total. Acartia tonsa was present in low numbers, 4% or less of the total. In March 1980 a numerical pulse in copepod numbers was observed as expected, however the community structure differed considerably from that of 1979. Acartia clausi was not the dominant species nor had A. tonsa numbers decreased markedly to the levels observed in 1979. Acartia clausi represented less than 30% of the total and A. tonsa between 15-35%. In addition, Centropages hamatus and Pseudocalanus minutus increased in numbers well beyond the 1979 levels reaching 30% and 18% of the numerical total, respectively.

Species diversity was greater for the winter-spring community than the summer-fall copepod community. Acartia tonsa dominated the latter assemblage, accounting for 60-90% of the total, May through January 1980 reaching a peak abundance of 33,000/m^3 in July. Acartia copepodites, Pseudodiaptomus coronatus, and Labidocera aestiva were also present within this seasonal assemblage in relatively low numbers. The annual maximum

Table 21. Average density per cubic meter of dominant copepod species, all habitats combined.

	Acartia tonsa	Acartia clausi	Centropages hamatus	Pseudodiaptomus coronatus	Pseudocalanus minutus
1970					
March	532	7998	362	0	227
April	124	2059	141	0	143
May	275	0	0	6	0
June	551	0	0	23	0
July	27600	0	0	50	0
August	8813	10	0	1342	10
September	6272	0	0	1025	0
October	15108	0	0	8	0
November	84	0	1	0	0
December	194	5	0	0	0
January	1103	8	6	66	88
February	809	380	1961	107	1918
March	3809	3065	3203	105	946

density of copepods was observed in July coinciding with the Acartia tonsa peak.

Spatial variability in terms of abundance was evident for specific calanoid species between the three habitats. Eurytemora affinis, a winter species present in low density, occurred more often and in much higher relative numbers in Ruppia (585/m^3) compared to the sand habitat (158/m^3). In contrast Labidocera aestiva, a large summer-fall calanoid, was sampled more often and in greater numbers in the sand (328/m^3). Very low numbers were noted in the Ruppia area (20/m^3). Total copepod density was also much higher overall in the sand habitat from July to November.

Diel availability of calanoid copepods varied markedly between the three habitats. Similar abundance values of total copepods were observed at night in all three habitats for the May and August diel samples. In the sand, day and night densities were also similar. However daytime copepod abundances within areas of submerged aquatic vegetation were substantially lower (more than an order of magnitude) than night time densities or the sand day density. This held true in both diel comparisons and was consistent with trends in diel availability observed by Robertson and Howard (1978) in Australian eelgrass beds.

Of the other holoplanktonic taxa, cladocerans were second in numerical abundance. Their peak was of very short duration, numbers reaching 1850/m^3 during July, approximately 5% of the total zooplankton density. Podon polyphemoides accounted for 95% of the total cladocerans; Evadue tergestira was observed sporadically in low numbers.

Jellyfish abundance and species composition also exhibited a trend typical of the Chesapeake Bay (Jacobs, 1978). Chrysaora quinquecirrha dominated during the summer months while Cyanea capillata was present in low numbers during the winter season. Only one species of hydromedusae Nemopsis buchei was observed during the sampling period. This species was present in low numbers May through April, peaking in September, Ruppia ($41/m^3$) and Zostera ($61/m^3$). Numbers never exceeded $3/m^3$ in the sand area.

Chaetognaths were the second most diverse holoplankton group sampled, abundance and species structure varied seasonally. The summer fall population was comprised of Sagitta tenuis (95%), Sagitta enflata, and low numbers of S. hispida. Maximum densities reached $22/m^3$ in September for shallow water vegetated areas and $36/m^3$ in October for the sand. A winter species, Sagitta elegans, was present February and March reaching a peak of $15/m^3$.

Meroplankton

Decapod larvae were the most diverse group of all zooplankton taxa sampled. The number of species present in one sample was highest in the summer reaching a maximum during August.

The winter-spring decapod population (December through April) consisted almost entirely of larval Crangon septemspinosa. During March 1979 and 1980, this species was present in densities greater than $100/m^3$, resulting in the annual peak for total decapod larvae. Total larval decapod densities declined from June to August, however the number of species increased 5 fold by May and continued to increased to the August maximum. Very low abundance values ($10/m^3$) were observed September through January.

Spatial differences among habitats were noted for abundances of specific decapods. Paleomonetes larvae increased in numbers markedly by May ($28/m^3$) accounting for greater than 85% of the total within the Ruppia habitat. However the numbers in sand were much lower ($2/m^3$), 6% of the total decapod density. This trend continued resulting in higher total decapod abundances in Ruppia through August. Many other larval decapod species exhibited inter-habitat differences in distribution. In general, higher numbers of Paleomonetes spp., Neopanope texani sayi, and Pinnixa chaetopterana were observed in Ruppia. Likewise Crangon septemspinosa, Uca spp., Pagurus longicarpus and Callianassa spp. were observed in higher densities in the sand.

Fish eggs and larvae were the second most diverse group within the meroplankton compartment. Abundance values however were the lowest of the meroplankters. Community structure and distribution is described elsewhere in this report utilizing data from the 505 u mesh pushnet.

The remaining meroplankters were evaluated as broad taxonomic groups. Molluscan larvae, both gastropod and pelecypod, reached relatively high numbers ($1000/m^3$) sporadically during the summer fall period. However at no time did either group account for more than 10% of the total zooplankton community. Barnacle larvae, both naupliar and cypris stages, were important constituents of the zooplankton community April through June, reaching up to 35% of the total within SAV areas and 45% in the sand. During the day (May) barnacle larvae accounted for up to 65% of the numerical community total in SAV areas. This was an artifact of very low copepod abundances during the day; the absolute density of barnacle larvae did not exhibit a diel pattern.

Polychaete larvae also contributed in high numbers to the winter-spring assemblage. This group accounted for 20-35% of the total zooplankton density consistently in all three habitats, April through June. Maximum densities greater than $1500/m^3$ were observed in April.

Demersal Plankton

Of the major plankton components, demersal plankters (facultative) exhibited the most variation between habitats with respect to species richness and abundance. Generally, greater diversity and higher densities were observed within the Ruppia habitat compared to the sand. Diel availability also varied greatly, in that very few demersal plankters were captured during the day The observed trends were consistent with those of other studies (Alldredge and Kins, 1977; Robertson and Howard, 1978; Hobson and Chass, 1979).

Mysids were the numerically dominant taxa of the demersal component. Neomysis americana dominated the population throughout the study. This species exhibited patchy distribution between the three habitats and between replicates. High densities (500/m^3) were noted in August and September in sand but only in September for the SAV areas. Adult mysids far outnumbered juveniles at this time. A greater percentage of males were captured in the sand, also higher numbers of females with broods were observed in the sand habitat at this time. Neomysis americana remained in all three habitats in moderate numbers from October through January, peaking in February. However, juveniles outnumbered adult during this season.

Within the Ruppia habitat, amphipods and cumaceans constituted a maximum of 5% of the total zooplankton standing stock numerically. This was observed during the transition between the seasonal winter-spring and summer-fall communities when holoplankton numbers were low. At no time did a demersal category other than mysids reach 5% of the total in the Zostera and sand areas. Cumaceans exhibited seasonal shifts in community structure. Cyclaspis varicaus and Oryurostylis smithi dominated this group July-September, succeeded by O. smithi and Pseudoleptocuma minor during November through February. The summer peak in August reached 10/m^3 while the winter peak in December exceeded 19/m^3.

Amphipods were the most diverse group of demersal plankters sampled in this study. Monoculodes edwardsi, Gammarus mucronatus and Microprotopus raneyi were the most frequently occurring species year round and dominated March-June. Species number increased in May and remained at a high level through October. At times Ampelisca sp., Cymadusa compta and Corophium sp. were present in densities greater than $2/m^3$.

Adult polychaetes were observed in low numbers throughout the study. Nereis succinea, Eteone heteropoda, E. lactea, and Scoloplos sp. were the most commonly occurring species. Erichsonella attenuata and Idotea triloba dominated the isopod population reaching a peak in Ruppia of $12/m^3$ (August).

Demersal plankton greatly influence the food availability and feeding strategies of pelagic feeding fishes (Hammer and Zimmerman, 1979). Possible explanations for the diel vertical migration are reviewed in Robertson and Howard (1978) and Alldredge and King (1980).

A more comprehensive and comparative analysis of trends in abundance, composition and diel availability of all 3 zooplankton components will be presented in a thesis entitled "Structural and Functional Aspects of Zooplankton within Areas of Submerged Aquatic Vegetation in lower Chesapeake Bay" by Cathy Meyer. The thesis will be completed later this year and a copy will be submitted to EPA for their information and review at that time.

A zooplankton flux study was undertaken to determine the movement of zooplankton into and out of the bed relative to tidal cycles to analyze the input of zooplankton energy to the eelgrass ecosystem. Samples were collected and archived in April and August of 1980. Analysis was not conducted due to insufficient funding.

Ichthyoplankton Data and Hydrography

Pushnet sampling for ichthyoplankton and pelagic juvenile fishes resulted in 88 total collections (sand n=28; R. maritima n=29; Z. marina n=31) during the period 26 March 1979 - 7 March 1980 (Table 22). Sampling was conducted monthly through January 1980, however inclement weather in February 1980 delayed completion of the 12-month survey until early March 1980. Day-night comparison pushnet sampling was conducted on successive high tides during May and August 1979.

Volumetric and areal estimates of pushnet sampling effort (Table 22) revealed moderate monthly variability and almost equal effort between habitats. Statistics calculated for total effort per habitat per month are presented in Table 23.

Hydrographic measurements taken concurrently with pushnet collections revealed temporal variability typical of shallow, nearshore environments which are rapidly affected by short-term climatic changes (Table 22). Observed ranges of salinity, temperature and dissolved oxygen (14.1-21.5 $^{o}/oo$; 1.5-28.0°C; 6.6-12.6 mg/l, respectively) were similar to those recorded by Briggs and O'Conner (1971) and Orth and Heck (1980). Occasionally, temperature and salinity varied widely between successive sampling periods as evidenced by measurements recorded between 27 September and 1 November 1979 (Table 22). October

Table 22. Ichthyoplankton pushnet collection data summary, March 1979-1980. Abbreviations used are: S - sand, R - *Ruppia maritima*, Z - *Zostera marina*, N - number of collections, VF - water volume filtered, AC - surface area covered, DO - dissolved oxygen, T - surface temperature, SAL - surface salinity.

Date	Time (hrs)	Habitat	N	VF (m^3)	AC (m^3)	DO (mg/l)	T (°C)	SAL (°/oo)
26 Mar 79	1935	S	3	272.2	277.9	11.8	8.0	17.4
	2045	R	2	180.7	194.6	12.3	8.0	17.2
	2130	Z	2	194.4	198.5	12.6	8.0	17.7
26 Apr 79	2230	S	2	271.6	277.3	--	15.0	18.5
	2110	R	2	246.7	265.7	--	15.0	18.5
	2153	Z	2	269.1	274.8	--	15.0	18.5
1 May 79	0105	Z	1	136.0	138.9	--	18.6	17.5
31 May 79	0240	S	2	180.7	194.6	9.1	21.5	17.6
	0038	R	2	219.6	274.0	7.8	21.5	16.9
	0155	Z	2	152.9	164.7	8.7	21.5	17.0
	1520	S	2	217.4	234.2	10.2	21.5	17.6
	1400	R	2	212.9	293.6	8.3	21.5	16.6
	1440	Z	2	258.8	278.8	9.9	21.5	17.2
26 Jun 79	2135	S	2	258.6	278.2	7.1	20.8	19.0
	2235	R	2	221.5	328.4	6.6	20.6	20.0
	2347	Z	2	275.1	296.4	8.3	20.7	20.0
23-24 Jul 79	0020	S	2	164.0	176.7	--	28.0	15.2
	2230	R	2	192.8	240.6	9.4	27.0	15.8
	2320	Z	2	206.2	257.3	9.4	27.0	15.3
23 Aug 79	2013	S	2	270.1	283.2	--	--	--
	2058	R	2	221.9	232.6	10.8	28.0	--
	2154	Z	2	245.7	279.9	10.8	28.0	--
	1115	S	2	251.1	286.1	--	24.4	--
	0935	R	2	175.3	241.8	10.8	23.4	--
	1035	Z	2	193.8	241.9	10.8	24.1	--
27 Sept 79	0145	S	1	61.3	64.3	8.0	21.0	21.5
	0050	R	2	114.3	130.2	7.8	21.0	20.9
	2335	Z	2	210.7	220.9	8.7	21.0	20.8
25 Oct 79	0100	R	2	236.4	294.9	8.2	13.1	14.3
	0200	Z	2	232.2	264.7	8.7	13.1	14.1
1 Nov 79	2125	S	2	249.3	254.6	--	15.5	20.5
	2010	R	2	229.0	261.0	8.5	15.0	19.3
	2210	Z	2	260.1	280.2	8.4	15.5	19.2

Table 22 (continued)

Date	Time (hrs)	Habitat	N	VF (m^3)	AC (m^3)	DO (mg/l)	T (°C)	SAL (o/oo)
19 Nov 79	2210	S	2	262.4	267.9	11.1	12.0	16.8
	2130	R	1	97.6	111.2	12.0	12.5	16.4
	2030	Z	2	260.7	277.1	11.1	12.0	16.9
18 Dec 79	2108	S	2	314.9	321.5	--	4.0	--
	2017	R	2	245.7	338.8	--	4.0	--
	1934	Z	2	293.9	316.6	--	4.5	--
17 Jan 80	2143	S	1	77.5	164.1	--	5.5	--
	2056	R	2	140.7	151.4	--	5.5	--
	1956	Z	2	243.9	249.1	--	5.5	--
6 Mar 80	2355	S	2	295.7	302.0	11.8	1.5	19.0
	0105	R	2	159.4	220.0	11.4	2.0	18.7
	0145	Z	2	327.7	353.0	11.7	2.0	19.0
Totals		S	28	3230.0	3282.6			
		R	29	2894.5	3578.8			
		Z	31	3761.2	4092.8			

Table 23. Statistics describing monthly total volumetric and areal estimates of sampling effort, March 1979 - March 1980. Abbreviations are: N - number of observations, M - mean estimate, S - standard deviation around mean estimate, M - meters.

Habitat		N	Range	M	S
Sand	m^3	14	61.3 - 314.9	224.8	77.3
	m^2	14	64.3 - 321.5	241.6	69.3
Ruppia	m^3	15	97.6 - 245.7	192.9	47.2
	m^2	15	111.2 - 338.8	238.6	67.9
Zostera	m^3	16	136.0 - 327.7	235.1	50.5
	m^2	16	138.9 - 353.0	255.8	54.2

sampling was curtailed by inclement weather and temperature/salinity values were accordingly depressed because of decreased air temperatures and increased freshwater runoff. Five days later, surface temperatures had risen and salinity values had returned to pre-storm levels. Throughout the 12-month period, hydrographic values did not vary markedly between habitats during any given sampling period. As a result, hydrographic parameters were not considered important factors in comparisons of ichthyoplankton abundances between habitats.

General Composition and Seasonality

Pushnet collections yielded 24,354 fishes and 8,631 eggs representing 36 species and 20 families (Tables 24, 25 and 26). Fish eggs were present in collections during the 6-month period March - August 1979 (Table 25), but larval, postlarval or juvenile stages of fishes were present during all months sampled (Table 24). Mean abundance of fishes in all habitats gradually increased throughout the spring to a mid-summer peak, reflecting maximum densities of larval anchovies, of over 2000/100 m^3 in August 1979 (Table 27). After September, mean abundance dropped to low, mid-winter levels (18.8-43.7/100 m^3) with the exception of a small peak in December 1979 when several large collections of larval croakers, *Micropogonias undulatus* were taken. Fish egg abundances were greatest between May-August with peak spawning activity observed in July (Table 25).

Eggs of six species of fishes were identified in pushnet collections. In addition, eggs of unidentified species of the families Gobiidae and Sciaenidae as well as other unknown species were collected. Eggs of the windowpane flounder, *Scopthalmus aquosus*;

Table 24. Species, common name, life history stage and months of occurrence of fishes in pushnet collections, March 1979-March 1980.

SPECIES	COMMON NAME	STAGE	M	A	M	J	J	A	S	O	N	D	J	M
Anguilla rostrata	American eel	elver	X											
Alosa aestivalis	Blueback herring	juvenile	X	X								X		
Alosa pseudoharengus	Alewife	juvenile					X							
Brevoortia tyrannus	Atlantic menhaden	postlarva-juvenile	X	X	X	X					X	X	X	X
Anchoa mitchilli	Bay anchovy	egg-adult	X	X	X	X	X	X	X	X	X	X	X	X
Anchoa hepsetus	Striped anchoby	postlarva-juvenile					X	X						
Gobiesox strumosus	Skilletfish	larva			X									
Hyporhamphus sp.	Halfbeak	egg-juvenile			X	X	X	X						
Membras martinica	Rough silverside	egg-adult		X	X	X	X	X	X	X	X			
Menidia menidia	Atlantic silverside	adult	X	X		X						X	X	X
Atherinidae	silversides	larvae		X	X	X	X	X	X					
Gasterosteus aculeatus	Threespine stickleback	juvenile		X										
Hippocampus erectus	Lined seahorse	young					X							
Syngnataus fuscus	Northern pipefish	larva-adult			X	X	X	X	X	X	X			
Cynoscion regalis	Weakfish	larva-juvenile			X	X	X	X						
Sciaenops ocellatus	Red drum	larva						X						
Menticirrhus americanus	Southern kingfish	larva						X						
Leiostomus xanthurus	Spot	larva-juvenile		X	X		X							X
Micropogonias undulatus	Atlantic croaker	larva-postlarva						X	X		X	X	X	
Bairdiella chrysoura	Silver perch	larva-postlarva						X						
Sciaenidae	drums	egg			X	X	X	X						
Tautoga onitis	Tautog	egg		X										
Astroscopus guttatus	Stargazer	postlarva					X							
Hypsoblennius hentzi	Feather blenny	larva-postlarva			X	X	X	X		X				
Chasmodes bosquianus	Striped blenny	postlarva					X							
Ammodytes hexapterus	Sand lance	larva-postlarva												X
Gobiosoma ginsburgi	Seaboard goby	postlarva						X	X			X		
Gobiosoma bosci	Naked goby	postlarva								X				

Table 24. (continued)

SPECIES	COMMON NAME	STAGE	M	A	M	J	J	A	S	O	N	D	J	M
Gobiosoma sp.	gobies	egg-larva			X	X	X	X						
Microgobius thalassinus	Green goby	larva-postlarva				X	X	X						
Gobiidae	gobies	larva								X				
Peprilus paru	Harvestfish	larva						X						
Paralichthys dentatus	Summer flounder	postlarva	X	X							X	X	X	X
Scopthalmus aquosus	Windowpane	egg-larva	X	X	X									
Pseudopleuronectes americanus	Winter flounder	larva	X											
Trinectes maculatus	Hogchoker	egg-larva				X		X						
Symphurus plagiusa	Blackcheek tonguefish	larvae						X						
Sphoeroides maculatus	Northern puffer	larvae						X						
unknown	-	eggs		X	X									

Table 25. Monthly and cummulative totals of fish eggs collected by pushnet, March-August 1979.

SPECIES	M	A	M	J	J	A	TOTAL	% OF TOTAL
A. mitchilli			1247	383	3347	249	5226	60.55
M. martinica			6	2	15	12	35	0.41
Hy. unifasciatus				3			3	0.03
Sciaenidae			97	362	2580	44	3083	35.72
T. onitis		22					22	0.25
Gobiidae			2				2	0.02
S. aquosus	29	144					173	2.00
T. maculatus				3		9	12	0.14
unknown		75					75	0.87
Total	29	241	1352	753	5942	314	8631	99.99

Table 26. Ranked numerical abundance of fish species captured by pushnet, March 1979 - March 1980.

Species	Rank	Total	Percent Total
A. mitchilli	1	17475	71.76
Gobiosoma sp.	2	2177	8.94
B. tyrannus	3	1475	6.06
S. fuscus	4	968	3.97
M. undulatus	5	523	2.15
M. martinica	6	315	1.29
L. xanthurus	7	280	1.15
atherinid larvae	8	272	1.12
A. hexapterus	9	191	<1
C. regalis	10	146	<1
M. menidia	11	110	<1
A. hepsetus	12	66	<1
M. thalassinus	13	65	<1
S. aquosus	14	59	<1
P. dentatus	15	45	<1
H. hentzi	16	42	<1
Hyporamphus sp.	17	25	<1
A. rostrata	18	21	<1
M. americanus	19	20	<1
G. ginsburgi	20	17	<1
G. strumosus	21	16	<1
S. ocellata	22.5	11	<1
C. bosquianus	22.5	11	<1
B. chrysoura	24	9	<1
T. maculatus	25	7	<1
A. aestivalis	26	4	<1
G. aculeatus	27	2	<1
P. americanus	28	2	<1
A. pseudoharengus	32.5	1	<1
H. erectus	32.5	1	<1
G. bosci	32.5	1	<1
gobiidae	32.5	1	<1
P. paru	32.5	1	<1
S. plagiusa	32.5	1	<1
S. maculatus	32.5	1	<1
A. guttatus	32.5	1	<1
	Total	24,354	

Table 27. Monthly pushnet fish catch summary, March 1979-March 1980. Abbreviations are: N - total number of individuals captured, M - mean abundance (N/100m^3) as calculated by N divided by total water volume filtered, Range - maximum and minimum densities (N/100m^3) observed. Daylight sampling periods are excluded.

MONTH	ALL HABITATS			VEGETATED			SAND		RUPPIA		ZOSTERA	
	N	M	RANGE	N	M	RANGE	N	M	N	M	N	M
1979												
MAR	181	27.9	18.9-39.9	86	22.9	18.9-26.2	95	34.9	45	24.9	41	21.1
APR	668	84.8	27.0-156.6	585	113.4	27.0-156.6	83	30.6	278	112.7	307	114.1
MAY	1433	259.1	24.4-620.4	1387	372.3	86.9-620.4	46	25.5	1251	569.7	136	88.9
JUN	2483	328.8	100.3-786.6	955	192.3	100.3-377.5	1528	590.9	236	106.5	719	261.4
JUL	1047	185.9	68.2-379.0	707	177.2	68.2-228.4	340	207.3	263	136.4	444	215.3
AUG	15139	2052.2	264.3-3597.5	8302	1775.6	264.3-3597.5	6837	2531.0	1125	507.1	7177	2921.0
SEPT	1397	361.6	191.1-512.3	1090	335.4	191.9-5123	307	500.9	262	229.2	828	392.9
OCT	-	-	-	170	36.3	33.6-41.6	-	-	89	37.7	81	34.9
NOV(1)	229	31.0	0.8-69.9	221	45.2	11.7-69.9	8	3.2	149	65.1	72	27.7
NOV(19)	271	43.7	18.6-76.9	91	25.4	18.6-34.2	180	68.6	22	22.5	69	26.5
DEC	574	67.2	3.5-186.9	122	22.6	3.5-47.9	452	143.5	9	3.7	113	38.5
1980												
JAN	136	29.4	18.8-50.1	100	26.0	18.8-50.1	36	46.5	49	34.8	51	20.9
MAR	147	18.8	4.8-36.5	42	8.6	4.8-10.4	105	35.5	9	5.7	33	10.1

the bay anchovy, Anchoa mitchilli; and the drums, family Sciaenidae, dominated pushnet collections making up 98% of the total catch. Eggs of three species (Membras martinica; Hyporhamphus unifasciatus; Gobiidae) are demersal, being attached to vegetation by chorionic filaments (atheriniformes) or laid in open shell nest sites (Gobiidae). As a result, density estimates of these species were not considered quantitative.

Of the 36 species occurring as larvae, post-larvae, juveniles or adults in pushnet collections, eight species made up 96% of the total catch (Table 26). A single species, Anchoa mitchilli, the bay anchovy, completely dominated collections, making up over 70% of all fishes captured. The remaining seven species, in order of decreasing abundance were larval gobies (genus Gobiosoma); juvenile menhaden, Brevoortia tyrannus; larval, juvenile and adult northern pipefish, Syngnathus fuscus; larval and postlarval croakers, M. undulatus; juvenile and adult rough silversides, Membras martinica; postlarval spot, Leiostomus xanthurus, and unidentified atherinid larvae. Species names, common names, life history stages encountered, months of occurrence and numerical ranking of all species occurring in pushnet collections are presented in Tables 24 and 26.

Day-Night Comparison Data

Day vs. night pushnet catch comparison data are presented in Tables 28 and 29. During both May and August sampling periods, mean density estimates for all species in each habitat as well as total fishes captured in all habitats were greater in evening pushnet collections, in most cases by at least one order of magnitude

Table 28. Day versus night pushnet catch (numbers/100m^3) comparisons, May 1979. Pelagic egg abundance estimates are excluded. Abbreviations are: S-sand, R-*Ruppia maritima*, Z-*Zostera marina*, T-total fishes captured in all habitats divided by total water volume filtered.

SPECIES	DAY				NIGHT			
	S	R	Z	T	S	R	Z	T
B. tyrannus	0	0	0.8	0.3	2.8	489.5	52.9	200.8
A. mitchilli	0	0	6.2	2.3	16.6	62.4	41.9	41.8
S. fuscus	0	0.9	4.3	1.9	0.6	2.3	1.9	1.6
M. martinica	1.4	0.5	0.8	0.9	1.7	15.0	21.6	12.5
L. xanthurus					3.3	0	2.6	1.8
H. unifasciatus					0	0.5	0.7	0.4
C. regalis					0.6	0	0	0.2
S. aquosus	17.5	0	0	5.5				
H. hentzi	0	0.5	0	0.2				
G. strumosus	1.4	0	5.0	2.3				
Gobiosoma sp.	0.5	0	0.8	0.4				
ALL SPECIES	20.7	1.9	17.8	13.8	25.5	569.7	88.9	259.0

Table 29. Day versus night pushnet catch (numbers/100m^3) comparison, August 1979. Pelagic egg abundance estimates are excluded. Abbreviations are: S-sand, R-*Ruppia maritima*, Z-*Zostera marina*, T-total fishes captured in all habitats divided by total water volume filtered.

SPECIES	DAY				NIGHT			
	S	R	Z	T	S	R	Z	T
A. mitchilli	97.2	2.9	46.4	54.7	2378.8	283.0	2648.8	1838.3
atherinid larvae	2.8	3.9	1.0	2.6	1.5	46.9	14.3	19.4
S. fuscus	1.2	0.6	0.5	0.8	10.0	39.2	100.1	48.8
Gobiosoma sp.	0	0	0.5	0.2	65.9	74.8	150.2	96.7
M. americanus					4.1	0.5	0	1.6
P. paru					0	0.5	0	0.1
S. americanus					0.4	0	0	0.1
A. hepsetus					18.4	7.7	0	8.9
C. nebulosus					0.4	0.9	3.3	1.5
B. chrysoura					17.4	0	38.3	19.1
M. martinica					2.9	10.4	9.4	7.3
H. unifasciatus					0	0.9	0.4	0.4
M. undulatus					0.4	0	0	0.1
H. hentzi					0	0	0.4	0.1
S. plagiusa					0.4	0	0	0.1
G. ginsburgi					3.3	0	2.4	2.0
M. thalassinus					9.6	6.3	7.3	7.9
T. maculatus					0	0.5	2.4	0.9
ALL SPECIES	101.2	7.4	48.5	58.2	2513.1	474.1	2978.4	2055.2

(Tables 28 and 29). In May 1979, ten species of larval, juvenile and adult fishes were recorded with equal numbers of species (n=7) occurring in evening and daylight samples. Four species occurred in both evening and daylight collections but in all but one case, densities and mean sizes of these species were lowest during the day (Tables 30 and 31). Catches and size distributions of the northern pipefish, *S. fuscus*, appeared to be independent of time of collection (Table 30). Three species (*H. hentzi*, *G. strumosus*, *Gobiosoma* sp.), were only present in daylight collections as early larvae (3.4-6.6 mm NL). Postlarvae and juveniles of spot, halfbeaks and weakfish were only taken during evening hours in May.

In August 1979, 19 species of larval, juvenile and adult species occurred in day vs. night comparison collections, but only four species were taken in both day and night collections (Table 29). The remaining 15 species occurred exclusively in evening collections. Of the four species occurring in both night and day samples, bay anchovies dominated with density estimates of larvae in evening collections exceeding those in daylight collections by several orders of magnitude (Table 29). In addition, size frequency analysis of day vs. night caught larvae (Table 31) revealed extreme disparity in larval size distribution. Anchovies larger than 9.0 mm SL were not taken during daylight hours but were a significant component of the evening anchovy catch. In comparisons between the remaining three species (Table 31), size ranges did not differ markedly, but density estimates of silverside, goby and pipefish larvae were greater in evening collections.

Table 30. Length frequency distributions of four species of fishes occurring in daylight and evening pushnet collections, May 1979.

Size (mm)	*S. fuscus* D	*S. fuscus* N	*A. mitchilli* D	*A. mitchilli* N	*B. tyrannus* D	*B. tyrannus* N	*M. martinica* D	*M. martinica* N
2			3					
3			12					
4			1					
5							1	
6			1				2	
7								
8							1	
9	1	2					2	
10	7	2						
11	20	1						
12	16							
13	5							
14								
15								
16	1							
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29				1		1		
30						14		
Over 30	2	4		165	2	1097		69

Table 31. Length frequency distributions of four species of fishes occurring in daylight and evening pushnet collections, August 1979.

	A. mitchilli		atherinidae		*S. fuscus*		*Gobiosoma* sp.	
Size (mm)	D	N	D	N	D	N	D	N
								111
2	1	19		50				186
3	2	34	1	72				219
4	3	9	3	1				104
5	20	98	3				1	53
6	93	446	2	1		34		34
7	98	1615		2		139		22
8	11	2749		1	1	113		11
9	1	2246			1	17		
10		1895			1	17		
11		1146	1	1		6		
12		825				6		
13		589				5		
14		431				2		
15		344				3		
16		70	1			4		
17		96		1				
18		41		1				
19		46		1				
20		60						
21		32						
22		24				1		
23		23						
24		34						
25		18						
26		20						
27		10				1		
28		14						
29		9				1		
30		14						
Over 30		110				10		

Habitat Comparisons

Distribution and abundance data from pushnet collections were examined to determine the extent to which density estimates of fish eggs, larvae and juveniles differed between sand and vegetated habitats as well as between *Zostera* and *Ruppia* zones at Vaucluse Shores. Comparison of density data for pelagic eggs of the three species dominating pushnet collections is presented in Table 32. Mean densities and ranges for pelagic eggs of the windowpane flounder, *S. aquosus*, during March-April 1979 revealed no apparent distributional trends, although highest mean densities and peak discrete estimates were observed over vegetated habitats in each month. In general, *S. aquosus* egg abundances were low and may reflect a lack of spawning in nearshore habitats or the lower Chesapeake Bay proper (Olney 1978). Smith et al. (1975) consistently found mid- and inner-shelf concentrations of larval *S. aquosus* in 1965-1966 and no evidence of estuarine dependence for the species.

Mean densities and ranges of observed densities of pelagic eggs of *A. mitchilli* were consistently higher (by at least one order of magnitude) over sand bottom than over either vegetated zone. During peak spawning activity in July 1979, mean densities of *A. mitchilli* eggs exceeded 2000 eggs/100 m^3 over sand bottom habitat while concurrent estimates over *Zostera* or *Ruppia* habitats never exceeded 20 eggs/100 m^3.

Similar distribution and abundance patterns were observed for eggs of the various species of sciaenid fishes (Table 32). Overlapping identification characters and the probability that two or more sciaenid species spawn concurrently in the Bay prohibited separation of sciaenid eggs to species level (Olney, in press). As with eggs of *A. mitchilli*,

Table 32. Habitat comparison of pelagic fish egg totals (N), mean densities (M) reported as eggs/100 m^3 and range of density estimates (eggs/100 m^3), March-August 1979.

Species Month	Sand			Zostera			Ruppia		
	N	M	Range	N	M	Range	N	M	Range
S. aquosus									
Mar	11	4.0	2.2-5.1	3	1.5	1.0-2.1	15	8.3	7.5-9.1
Apr	47	17.3	13.6-21.2	57	21.2	16.1-26.5	17	13.5	13.5
A. mitchilli									
May	1009	253.5	48.9-597.4	215	52.2	0-231.0	23	5.3	0-10.9
Jun	338	130.7	109.9-157.3	45	16.4	12.6-20.4	0	0	--
Jul	3310	2018.3	211.3-3050.7	23	11.2	6.6-15.9	1	0.5	0-1.0
Aug	238	45.7	2.4-47.5	11	2.5	3.8-5.3	0	0	--
Sciaenidae									
May	53	13.3	0-52.9	19	4.6	0-19.1	25	5.8	0-14.3
Jun	328	126.8	94.4-152.9	33	12.0	9.1-15.1	1	0.5	0-1.7
Jul	1901	1159.2	769.8-1381.6	664	322.0	148.7-485.9	15	7.8	3.2-12.1
Aug	34	6.52	0-27.5	10	2.3	1.8-6.0	7	1.8	0-5.6

mean densities of sciaenid eggs were consistently highest over sand bottoms and, during periods of peak density, sciaenid egg mean abundance and peak observed density exceed those of vegetated zones by an order of magnitude. Sciaenids eggs, however, were taken in greater abundances over Zostera than were those of A. mitchilli in July 1979.

Eggs of the halfbeak (Hy. unifasciatus), the rough silverside (M. martinica) and gobies (Gobiidae) were taken in low densities but, with the exception of a single silverside egg collected over sand bottom in June, all eggs of these species (Table 25) occurred in collections over vegetated habitats. Eggs of these species are not pelagic (therefore not routinely collected by plankton net) but are demersal, being attached by filaments to submerged objects or laid in shell nests. In most cases, eggs of halfbeaks and silversides were found attached to floating Zostera blades or other vegetable material. Eggs of the hogchoker, Trinectes maculatus, were taken in very low abundances over sand habitat only. Eggs of this species are major summer components of lower Chesapeake Bay ichthyoplankton and ranked third in numerical abundance in Bay channel areas (Olney, in press).

Monthly mean densities of fishes (larvae, postlarvae, juveniles and adults) captured by pushnet in the evening over sand bottoms exceeded mean estimates of fishes in vegetated habitats (pooled Zostera and Ruppia catches) and density estimates of fishes in Ruppia zones during all but three sampling periods (Table 27). Sand collections were not made in October. Monthly mean densities over sand bottoms ranged from 3.2-2531.0 fishes/100 m^3, with peak abundances observed during the period June-September 1979.

Monthly mean densities of pushnet caught fishes over *Ruppia* beds ranged from 3.7-569.7 fishes/100 m^3 with peak densities recorded during the period April-September 1979. *Ruppia* catches exceeded densities observed over sand bottoms during spring and early summer months (April, May) when large catches of *B. tyrannus* were recorded over *Ruppia* and in early November. Densities observed in *Ruppia* beds exceeded mean *Zostera* pushnet densities of fish in May, October and November (19th) 1979 and January 1980. In general, however, densities of ichthyoplankton and pelagic juvenile fishes were lower in *Ruppia* zones than in the other two habitats.

Fish densities in *Zostera* zones peaked during the period June-September 1979 with highest mean density recorded in August (Table 27). Monthly mean densities ranged from 10.1-2921.0 fishes/ 100 m^3. Densities over *Zostera* beds exceeded those over sand bottom in April, May, July, August and November (1st) 1979, but mean density differences between these two habitats never exceeded 390 fish/100 m^3. Densities of pushnet catches over *Zostera* zones exceeded *Ruppia* estimates during all but five sampling periods. During the period of maximum abundance of fishes and maximum density of vegetation (April-September), catches over *Zostera* beds were only exceeded by those over *Ruppia* beds in May 1979 when large numbers of menhaden were taken.

A total of 23,875 fishes were captured in evening pushnet collections March 1979-March 1980. Of the total, 10,071 (42.2%) were taken over *Zostera* zones; 10,017 (41.9%) over sand bottom, and 3787 (15.9%) over *Ruppia* zones. Additional discussion of habitat comparison data for individual species will be presented in the following section.

Dominant Species

Anchoa mitchilli

Bay anchovies dominated pushnet collections, ranking first in numerical abundances and making up 71.8% (N=17,475) of all fishes captured. Table 33 summarizes monthly pushnet catch data, including daylight samples in May and August 1979. Peak monthly mean densities of A. mitchilli were recorded in all habitats in June-September 1979, a 4-month period including time of peak spawning (Table 32: Olney, in press) and during which larval and postlarval stages dominated collections. Bay anchovies were present in pushnet samples during all sampling periods and in all habitats during each sampling period with the exception of March 1979 Ruppia collections. Densities at positive stations ranged from 0.8-410.5 fish/100 m^3 over Ruppia beds; 0.7-3304.1 fish/100 m^3 over Zostera beds; and 0.8-2672.1 fish/100 m^3 over sand bottom habitat. In general, monthly mean densities of bay anchovies varied only slightly between habitats, with the exception of August 1979 data. During this period of peak abundance, larval anchovies were conspicuously less abundant over Ruppia beds at Vaucluse Shores. Numerically, pushnet catches over Ruppia contributed only 9.6% of the total anchovies taken during the 12-month period, March 1979 - March 1980. Densities of anchovies over sand and Zostera beds appeared to be habitat-independent.

Length frequency distribution of pushnet catches of Anchoa mitchilli are presented in Figures 11 - 22. Catches were dominated by juvenile and adult anchovies (fishes >30 mm SL) in March-May 1979 (Figures 11 - 13), and October-December 1979 (Figures 18 - 20). In

Table 33. Data summary of monthly catches of Anchoa mitchilli in pushnet collections, March 1979 - March 1980. Abbreviations are: N - number of specimens; M - monthly mean density (N/ 100 m^3).

Month	Sand			Zostera			Ruppia		
1979	N	M	Range	N	M	Range	N	M	Range
Mar	2	0.7	0-3.6	4	2.1	2.0-2.1	0	0	--
Apr	23	8.5	3.6-13.6	12	4.5	3.7-5.3	44	17.8	15.7-19.9
May	30	7.5	0-19.8	123	22.5	0-50.0	137	31.7	0-78.3
Jun	392	151.6	142.5-163.4	206	74.8	63.7-87.0	207	93.5	88.8-97.6
July	154	93.9	45.9-177.8	174	84.4	80.8-87.8	122	63.3	37.3-87.9
Aug	6647	1275.3	41.3-2672.1	6583	1497.8	37.1-3304.1	706	177.7	1.8-410.5
Sept	301	491.1	491.1	743	352.6	294.1-483.1	239	209.1	172.4-266.3
Oct		no samples		75	32.3	31.7-32.8	79	33.4	26.7-39.9
Nov (1)	7	2.8	0.8-4.9	69	26.5	10.3-44.5	131	57.2	49.8-64.6
Nov (19)	162	61.7	58.9-64.7	34	13.0	7.8-18.2	14	14.3	14.3
Dec	45	14.3	8.6-19.6	22	7.5	5.4-9.6	1	0.4	0-0.8
1980									
Jan	1	1.3	1.3	1	0.4	0-0.7	1	0.7	0-1.6
Mar	12	4.1	3.3-4.8	2	0.6	0-1.2	2	1.3	1.2-1.3
Total	7776			8048			1683		
Percent Total	44.4			45.9			9.6		

```
BAR CHART OF LOGN001
MIDPOINT
LENGTH                                                                  LOGN001
          ^
  2       ^                                                             0.000000
  3       ^                                                             0.000000
  4       ^                                                             0.000000
  5       ^                                                             0.000000
  6       ^                                                             0.000000
  7       ^                                                             0.000000
  8       ^                                                             0.000000
  9       ^                                                             0.000000
 10       ^                                                             0.000000
 11       ^                                                             0.000000
 12       ^                                                             0.000000
 13       ^                                                             0.000000
 14       ^                                                             0.000000
 15       ^                                                             0.000000
 16       ^                                                             0.000000
 17       ^                                                             0.000000
 18       ^                                                             0.000000
 19       ^                                                             0.000000
 20       ^                                                             0.000000
 21       ^                                                             0.000000
 22       ^                                                             0.000000
 23       ^                                                             0.000000
 24       ^                                                             0.000000
 25       ^                                                             0.000000
 26       ^                                                             0.000000
 27       ^                                                             0.000000
 28       ^                                                             0.000000
 29       ^                                                             0.000000
 30       ^                                                             0.000000
 31       ^                                                             0.000000
 32       ^                                                             0.000000
 33       ^                                                             0.000000
 34       ^                                                             0.000000
 35       ^                                                             0.000000
 36       ^◆◆◆◆                                                         0.301030
 37       ^                                                             0.000000
 38       ^◆◆◆◆                                                         0.301030
 39       ^                                                             0.000000
 40       ^                                                             0.000000
 41       ^                                                             0.000000
 42       ^                                                             0.000000
 43       ^                                                             0.000000
 44       ^◆◆◆◆                                                         0.301030
 45       ^                                                             0.000000
 46       ^                                                             0.000000
 47       ^                                                             0.000000
 48       ^                                                             0.000000
 49       ^◆◆◆◆                                                         0.301030
 50       ^                                                             0.000000
 51       ^                                                             0.000000
 52       ^                                                             0.000000
 53       ^◆◆◆◆◆◆                                                       0.477121
          ----+---+---+---+---+---+---+---+---+---+---+---+
             0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7  3  3.3 3.6
```

Figure 11. Length frequency distribution of pushnet catches of Anchoa mitchilli in all habitats during March 1979.

```
BAR CHART OF LOGNO02
MIDPOINT
LENGTH                                                              LOGNO02
         ^
   2     ^                                                          0.000000
   3     ^                                                          0.000000
   4     ^                                                          0.000000
   5     ^                                                          0.000000
   6     ^                                                          0.000000
   7     ^                                                          0.000000
   8     ^                                                          0.000000
   9     ^                                                          0.000000
  10     ^                                                          0.000000
  11     ^                                                          0.000000
  12     ^                                                          0.000000
  13     ^                                                          0.000000
  14     ^                                                          0.000000
  15     ^                                                          0.000000
  16     ^                                                          0.000000
  17     ^                                                          0.000000
  18     ^                                                          0.000000
  19     ^                                                          0.000000
  20     ^                                                          0.000000
  21     ^                                                          0.000000
  22     ^                                                          0.000000
  23     ^                                                          0.000000
  24     ^                                                          0.000000
  25     ^                                                          0.000000
  26     ^                                                          0.000000
  27     ^                                                          0.000000
  28     ^                                                          0.000000
  29     ^                                                          0.000000
  30     ^                                                          0.000000
  31     ^                                                          0.000000
  32     ^                                                          0.000000
  33     ^◆◆◆◆                                                      0.301030
  34     ^                                                          0.000000
  35     ^                                                          0.000000
  36     ^                                                          0.000000
  37     ^                                                          0.000000
  38     ^                                                          0.000000
  39     ^                                                          0.000000
  40     ^                                                          0.000000
  41     ^◆◆◆◆                                                      0.301030
  42     ^                                                          0.000000
  43     ^◆◆◆◆◆◆                                                    0.477121
  44     ^◆◆◆◆                                                      0.301030
  45     ^                                                          0.000000
  46     ^◆◆◆◆◆◆◆◆◆                                                 0.698970
  47     ^◆◆◆◆◆◆                                                    0.477121
  48     ^◆◆◆◆◆◆                                                    0.477121
  49     ^◆◆◆◆◆◆                                                    0.477121
  50     ^◆◆◆◆◆◆◆◆◆                                                 0.698970
  51     ^◆◆◆◆◆◆                                                    0.477121
  52     ^◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆                                           1.146128
  53     ^◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆                                1.949390
         ----+---+---+---+---+---+---+---+---+---+---+---+
            0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7  3  3.3 3.6
```

Figure 12. Length frequency distribution of pushnet catches of *Anchoa mitchilli* in all habitats during April 1979.

```
BAR CHART OF LOGNO03
MIDPOINT
LENGTH                                                                  LOGNO03
        ^
   2    ^◆◆◆◆◆◆◆◆                                                      0.602060
   3    ^◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆                                               1.113943
   4    ^◆◆◆◆                                                          0.301030
   5    ^                                                              0.000000
   6    ^◆◆◆◆                                                          0.301030
   7    ^                                                              0.000000
   8    ^                                                              0.000000
   9    ^                                                              0.000000
  10    ^                                                              0.000000
  11    ^                                                              0.000000
  12    ^                                                              0.000000
  13    ^                                                              0.000000
  14    ^                                                              0.000000
  15    ^                                                              0.000000
  16    ^                                                              0.000000
  17    ^                                                              0.000000
  18    ^                                                              0.000000
  19    ^                                                              0.000000
  20    ^                                                              0.000000
  21    ^                                                              0.000000
  22    ^                                                              0.000000
  23    ^                                                              0.000000
  24    ^                                                              0.000000
  25    ^                                                              0.000000
  26    ^                                                              0.000000
  27    ^                                                              0.000000
  28    ^                                                              0.000000
  29    ^◆◆◆◆                                                          0.301030
  30    ^                                                              0.000000
  31    ^◆◆◆◆◆◆                                                        0.477121
  32    ^◆◆◆◆                                                          0.301030
  33    ^◆◆◆◆                                                          0.301030
  34    ^◆◆◆◆◆◆◆◆◆                                                     0.698970
  35    ^◆◆◆◆◆◆◆◆◆◆◆◆                                                  0.903090
  36    ^◆◆◆◆◆◆◆◆◆◆◆◆                                                  0.903090
  37    ^◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆                                               1.113943
  38    ^◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆                                             1.278754
  39    ^◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆                                           1.414973
  40    ^◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆◆                                            1.342423
  41    ^◆◆◆◆◆◆◆◆◆◆◆◆◆                                                 1.000000
  42    ^◆◆◆◆◆◆◆◆◆◆◆◆◆◆                                                1.041393
  43    ^◆◆◆◆◆◆◆◆◆◆◆◆◆                                                 0.954243
  44    ^◆◆◆◆◆◆◆◆◆◆◆◆◆                                                 1.000000
  45    ^◆◆◆◆                                                          0.301030
  46    ^◆◆◆◆◆◆◆◆◆◆◆◆                                                  0.903090
  47    ^◆◆◆◆◆◆                                                        0.477121
  48    ^◆◆◆◆◆◆                                                        0.477121
  49    ^◆◆◆◆◆◆◆◆◆                                                     0.698970
  50    ^◆◆◆◆◆◆◆◆                                                      0.602060
  51    ^◆◆◆◆                                                          0.301030
  52    ^◆◆◆◆◆◆◆◆                                                      0.602060
  53    ^◆◆◆◆◆◆◆◆◆◆◆◆◆                                                 0.954243
        ----+----+----+----+----+----+----+----+----+----+----+----+
           0.3  0.6  0.9  1.2  1.5  1.8  2.1  2.4  2.7   3   3.3  3.6
```

Figure 13. Length frequency distribution of pushnet catches of *Anchoa mitchilli* in all habitats during May 1979.

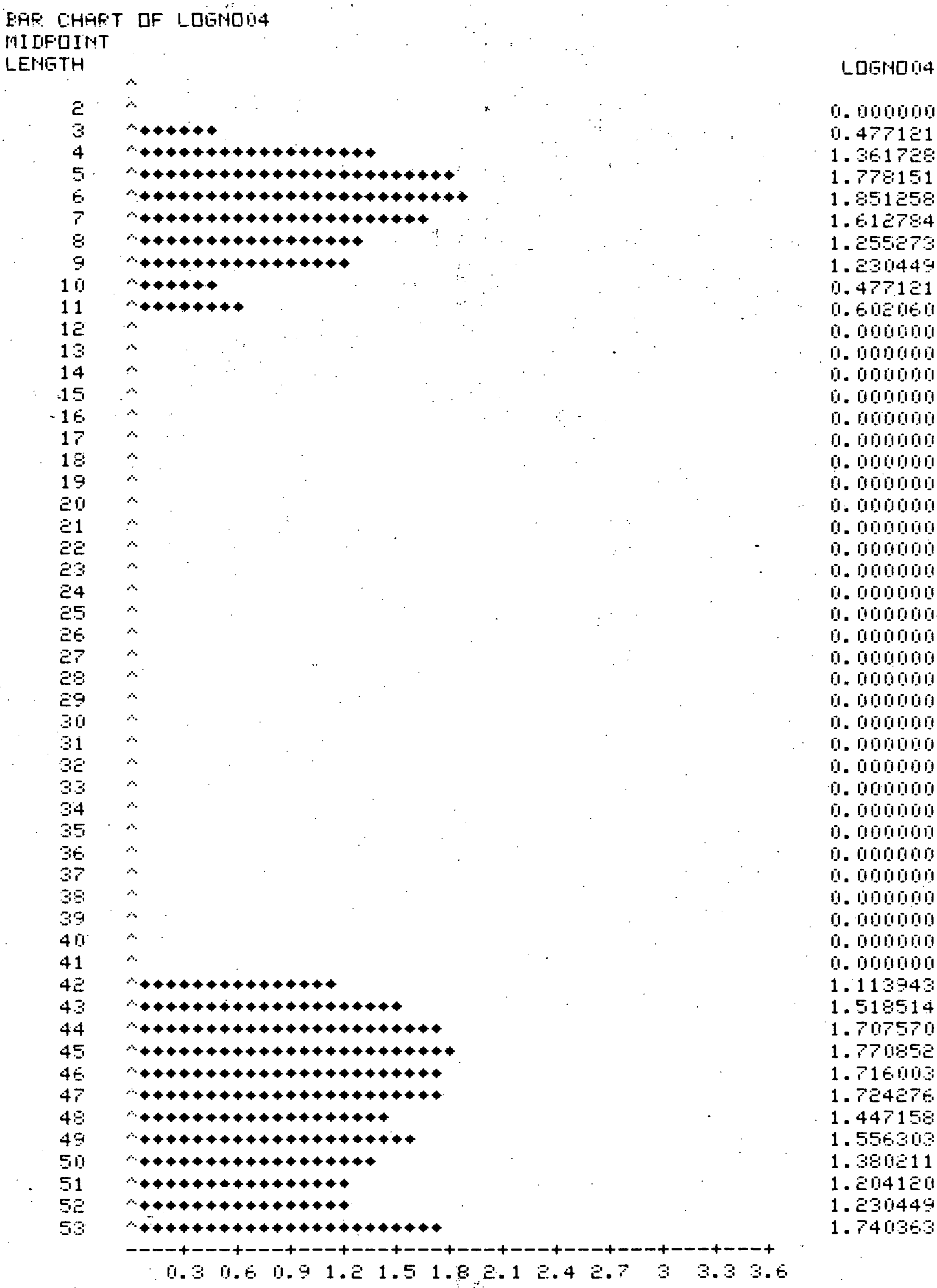


Figure 14. Length frequency distribution of pushnet catches of Anchoa mitchilli in all habitats during June 1979.

```
BAR CHART OF LOGNO05
MIDPOINT
LENGTH                                                                    LOGNO05
       ^
   2   ^♦♦♦♦♦♦♦♦                                                          0.602060
   3   ^♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦                                            1.672098
   4   ^♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦                                             1.579784
   5   ^♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦                                           1.732394
   6   ^♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦                                             1.579784
   7   ^♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦                                              1.531479
   8   ^♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦                                               1.397940
   9   ^♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦                                                   1.113943
  10   ^♦♦♦♦♦♦♦♦♦♦                                                        0.778151
  11   ^♦♦♦♦♦♦♦♦♦♦♦♦                                                      0.903090
  12   ^♦♦♦♦♦♦♦♦♦♦                                                        0.778151
  13   ^♦♦♦♦                                                              0.301030
  14   ^♦♦♦♦                                                              0.301030
  15   ^                                                                  0.000000
  16   ^                                                                  0.000000
  17   ^                                                                  0.000000
  18   ^                                                                  0.000000
  19   ^                                                                  0.000000
  20   ^                                                                  0.000000
  21   ^                                                                  0.000000
  22   ^                                                                  0.000000
  23   ^                                                                  0.000000
  24   ^                                                                  0.000000
  25   ^                                                                  0.000000
  26   ^♦♦♦♦                                                              0.301030
  27   ^                                                                  0.000000
  28   ^                                                                  0.000000
  29   ^♦♦♦♦                                                              0.301030
  30   ^                                                                  0.000000
  31   ^                                                                  0.000000
  32   ^                                                                  0.000000
  33   ^♦♦♦♦                                                              0.301030
  34   ^                                                                  0.000000
  35   ^♦♦♦♦                                                              0.301030
  36   ^♦♦♦♦                                                              0.301030
  37   ^                                                                  0.000000
  38   ^                                                                  0.000000
  39   ^                                                                  0.000000
  40   ^                                                                  0.000000
  41   ^♦♦♦♦                                                              0.301030
  42   ^♦♦♦♦                                                              0.301030
  43   ^                                                                  0.000000
  44   ^♦♦♦♦♦♦♦♦                                                          0.602060
  45   ^♦♦♦♦♦♦♦♦                                                          0.602060
  46   ^♦♦♦♦♦♦♦♦♦♦♦♦                                                      0.903090
  47   ^♦♦♦♦♦♦♦♦♦♦♦                                                       0.845098
  48   ^♦♦♦♦♦♦♦♦♦♦♦♦                                                      0.903090
  49   ^♦♦♦♦♦♦♦♦♦♦♦♦♦                                                     1.000000
  50   ^♦♦♦♦♦♦♦♦♦♦♦♦♦♦                                                    1.079181
  51   ^♦♦♦♦♦♦♦♦♦♦♦                                                       0.845098
  52   ^♦♦♦♦♦♦♦♦                                                          0.602060
  53   ^♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦♦                                                  1.204120
        ----+----+----+----+----+----+----+----+----+----+----+----+
           0.3  0.6  0.9  1.2  1.5  1.8  2.1  2.4  2.7   3   3.3  3.6
```

Figure 15. Length frequency distribution of pushnet catches of *Anchoa mitchilli* in all habitats during July 1979.

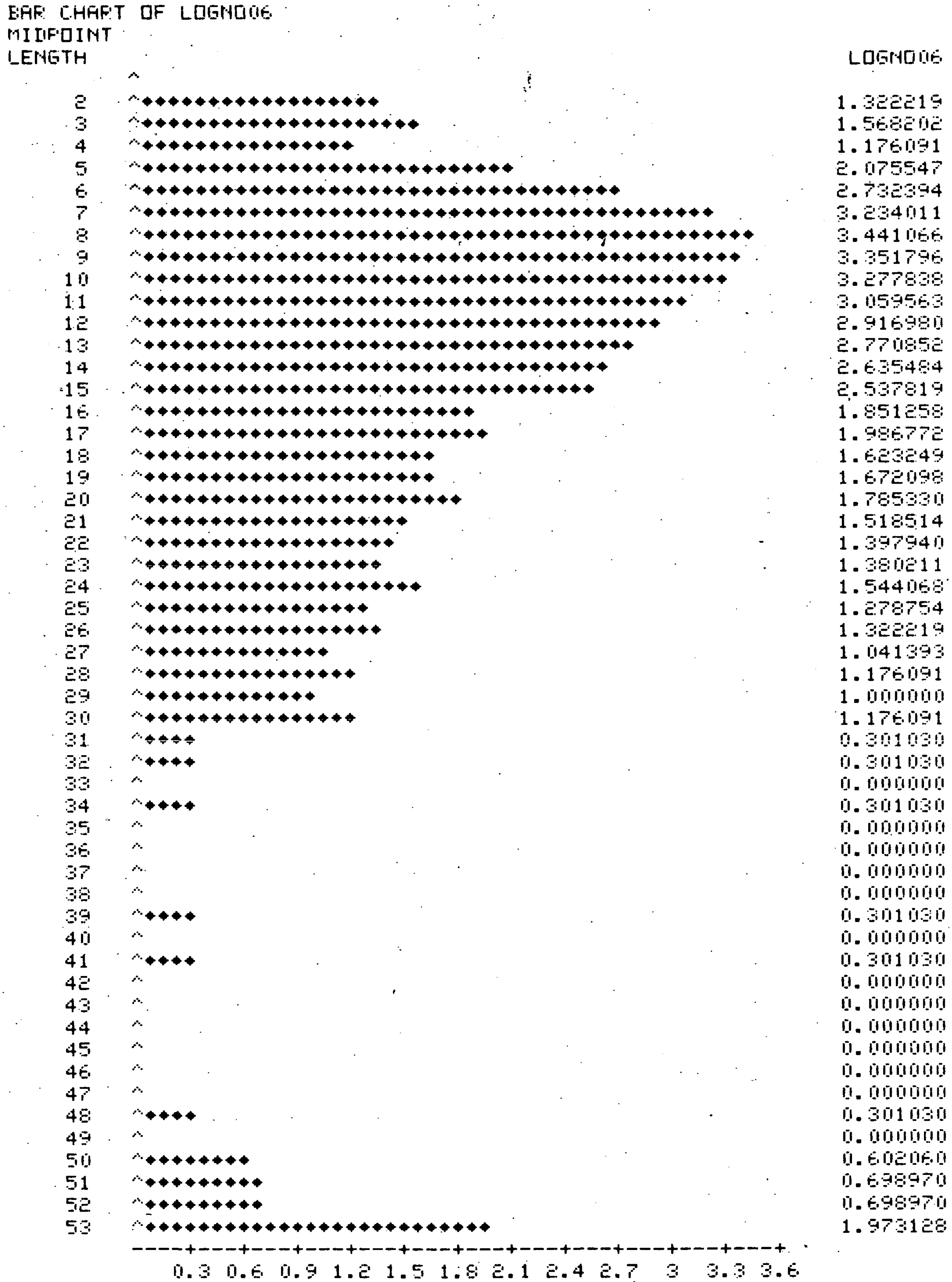


Figure 16. Length frequency distribution of pushnet catches of *Anchoa mitchilli* in all habitats during August 1979.

BAR CHART OF LOGN007

MIDPOINT LENGTH	LOGN007
2	0.000000
3	0.000000
4	0.000000
5	0.000000
6	0.000000
7	0.000000
8	0.000000
9	0.000000
10	0.301030
11	0.778151
12	1.255273
13	1.361728
14	1.672098
15	1.724276
16	1.991226
17	2.127105
18	2.158362
19	2.089905
20	2.285557
21	2.152288
22	2.004321
23	1.875061
24	1.342423
25	1.612784
26	1.255273
27	1.380211
28	0.477121
29	0.903090
30	0.954243
31	0.477121
32	0.602060
33	0.000000
34	0.000000
35	0.301030
36	0.000000
37	0.000000
38	0.000000
39	0.000000
40	0.301030
41	0.000000
42	0.000000
43	0.477121
44	0.000000
45	0.000000
46	0.000000
47	0.000000
48	0.301030
49	0.301030
50	0.000000
51	0.000000
52	0.477121
53	1.322219

0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7 3 3.3 3.6

Figure 17. Length frequency distribution of pushnet catches of *Anchoa mitchilli* in all habitats during September 1979.

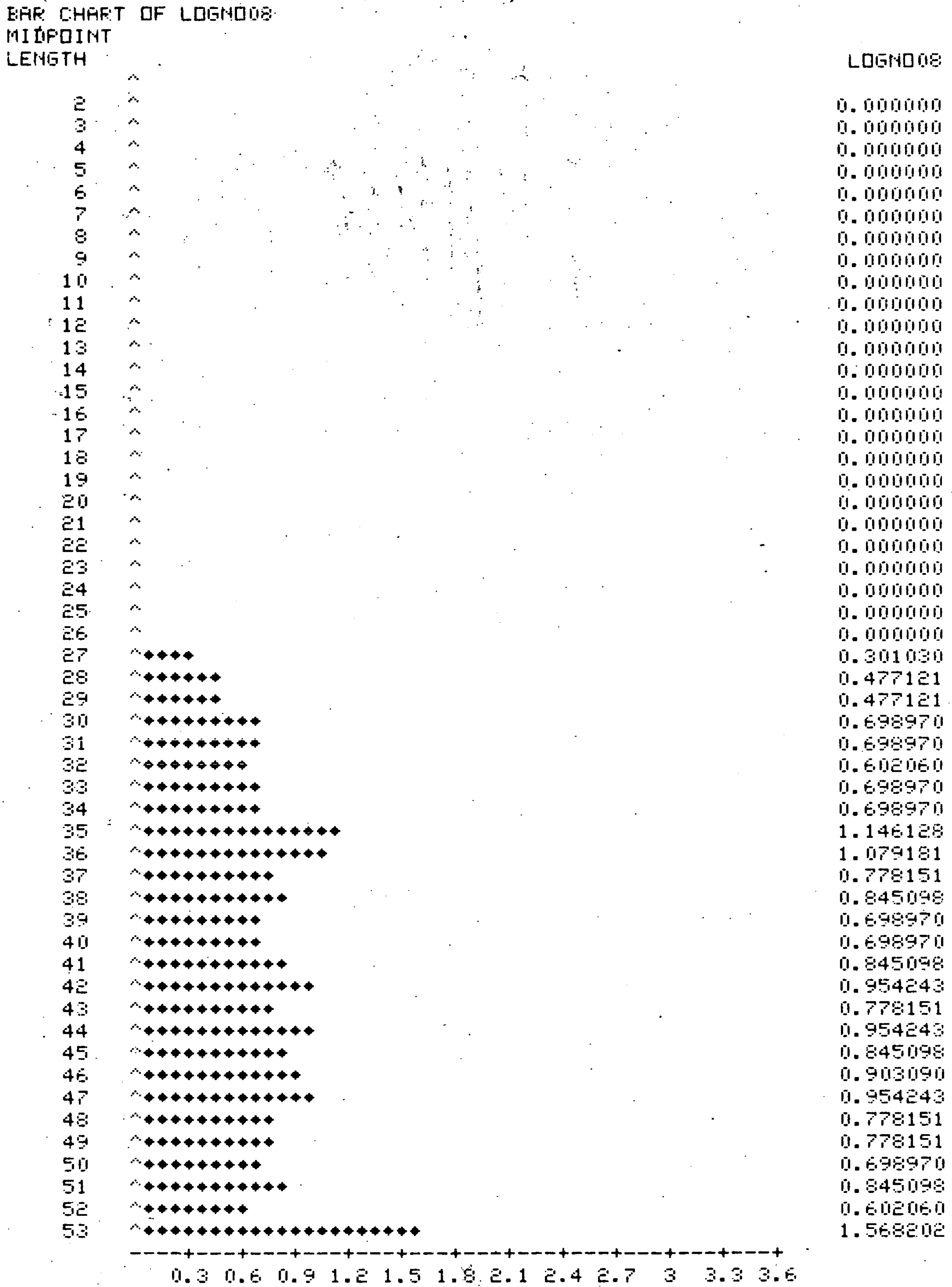


Figure 18. Length frequency distribution of pushnet catches of *Anchoa mitchilli* in all habitats during October 1979.

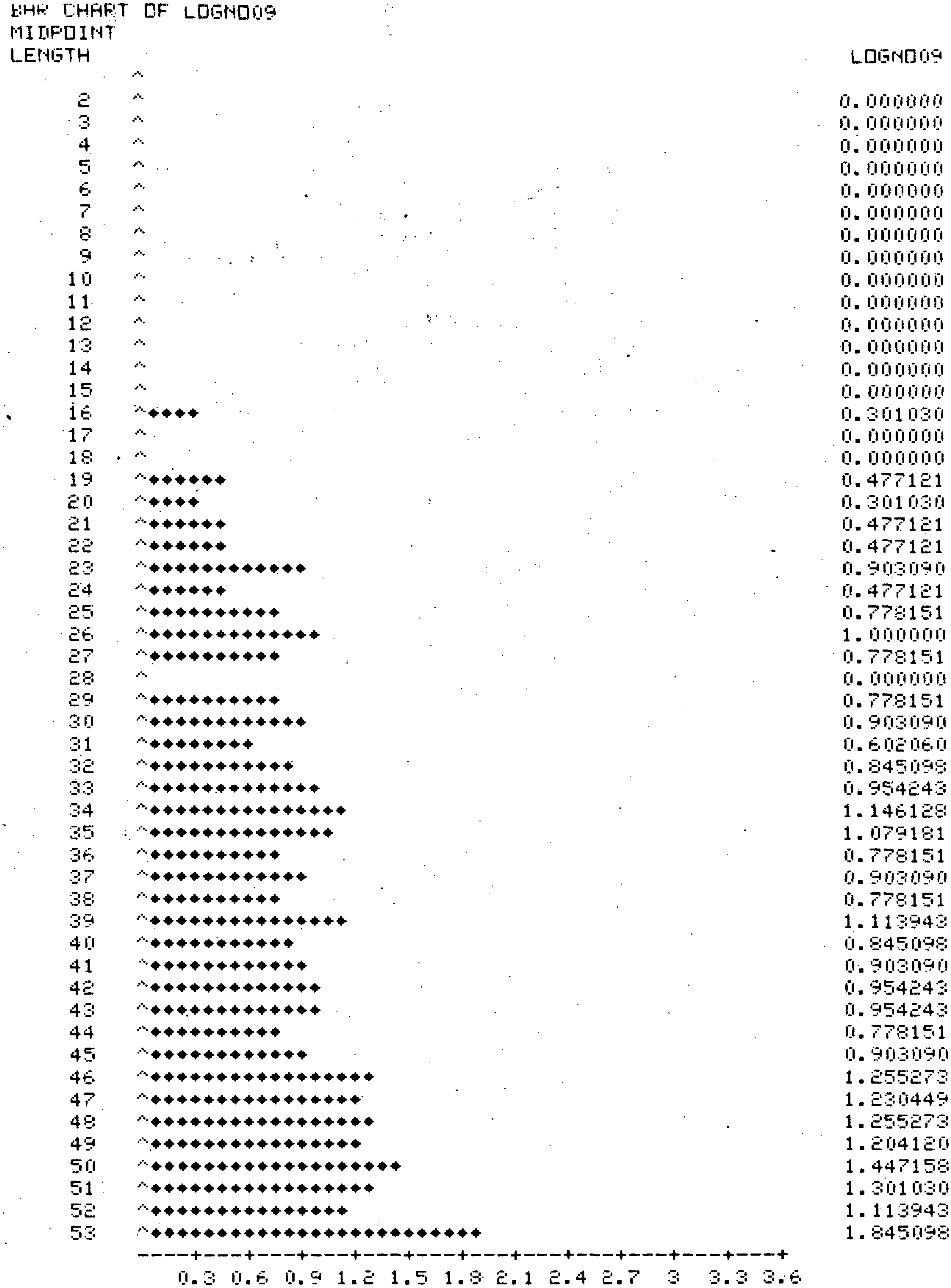


Figure 19. Length frequency distribution of pushnet catches of *Anchoa mitchilli* in all habitats during November 1979.

```
BAR CHART OF LOGNO10
MIDPOINT
LENGTH                                                              LOGNO10
          ^
    2     ^                                                         0.000000
    3     ^                                                         0.000000
    4     ^                                                         0.000000
    5     ^                                                         0.000000
    6     ^                                                         0.000000
    7     ^                                                         0.000000
    8     ^                                                         0.000000
    9     ^                                                         0.000000
   10     ^                                                         0.000000
   11     ^                                                         0.000000
   12     ^                                                         0.000000
   13     ^                                                         0.000000
   14     ^                                                         0.000000
   15     ^                                                         0.000000
   16     ^                                                         0.000000
   17     ^                                                         0.000000
   18     ^                                                         0.000000
   19     ^                                                         0.000000
   20     ^                                                         0.000000
   21     ^                                                         0.000000
   22     ^                                                         0.000000
   23     ^                                                         0.000000
   24     ^                                                         0.000000
   25     ^                                                         0.000000
   26     ^                                                         0.000000
   27     ^                                                         0.000000
   28     ^                                                         0.000000
   29     ^                                                         0.000000
   30     ^                                                         0.000000
   31     ^                                                         0.000000
   32     ^                                                         0.000000
   33     ^                                                         0.000000
   34     ^◆◆◆◆                                                     0.301030
   35     ^                                                         0.000000
   36     ^                                                         0.000000
   37     ^                                                         0.000000
   38     ^◆◆◆◆                                                     0.301030
   39     ^◆◆◆◆◆◆◆◆                                                 0.602060
   40     ^◆◆◆◆◆◆◆◆◆◆                                               0.778151
   41     ^◆◆◆◆                                                     0.301030
   42     ^◆◆◆◆◆◆                                                   0.477121
   43     ^◆◆◆◆◆◆◆◆◆                                                0.698970
   44     ^◆◆◆◆◆◆◆◆◆◆◆                                              0.845098
   45     ^◆◆◆◆◆◆◆◆◆◆                                               0.778151
   46     ^◆◆◆◆◆◆◆◆◆◆◆◆◆                                            0.954243
   47     ^◆◆◆◆◆◆◆◆◆                                                0.698970
   48     ^◆◆◆◆◆◆◆◆◆◆                                               0.778151
   49     ^◆◆◆◆◆◆                                                   0.477121
   50     ^◆◆◆◆◆◆                                                   0.477121
   51     ^◆◆◆◆◆◆                                                   0.477121
   52     ^◆◆◆◆◆◆◆◆◆                                                0.698970
   53     ^◆◆◆◆◆◆◆◆◆◆◆◆◆◆                                           1.079181
          ----+---+---+---+---+---+---+---+---+---+---+---+
             0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7  3  3.3 3.6
```

Figure 20. Length frequency distribution of pushnet catches of *Anchoa mitchilli* in all habitats during December 1979.

```
BAR CHART OF LOGNO11
MIDPOINT
LENGTH                                                              LOGNO11
         ^
    2    ^                                                         0.000000
    3    ^                                                         0.000000
    4    ^                                                         0.000000
    5    ^                                                         0.000000
    6    ^                                                         0.000000
    7    ^                                                         0.000000
    8    ^                                                         0.000000
    9    ^                                                         0.000000
   10    ^                                                         0.000000
   11    ^                                                         0.000000
   12    ^                                                         0.000000
   13    ^                                                         0.000000
   14    ^                                                         0.000000
   15    ^                                                         0.000000
   16    ^                                                         0.000000
   17    ^                                                         0.000000
   18    ^                                                         0.000000
   19    ^                                                         0.000000
   20    ^                                                         0.000000
   21    ^◆◆◆◆                                                     0.301030
   22    ^                                                         0.000000
   23    ^                                                         0.000000
   24    ^                                                         0.000000
   25    ^◆◆◆◆                                                     0.301030
   26    ^                                                         0.000000
   27    ^◆◆◆◆                                                     0.301030
   28    ^                                                         0.000000
   29    ^                                                         0.000000
   30    ^                                                         0.000000
   31    ^                                                         0.000000
   32    ^                                                         0.000000
   33    ^                                                         0.000000
   34    ^                                                         0.000000
   35    ^                                                         0.000000
   36    ^                                                         0.000000
   37    ^                                                         0.000000
   38    ^                                                         0.000000
   39    ^                                                         0.000000
   40    ^                                                         0.000000
   41    ^                                                         0.000000
   42    ^                                                         0.000000
   43    ^                                                         0.000000
   44    ^                                                         0.000000
   45    ^                                                         0.000000
   46    ^                                                         0.000000
   47    ^                                                         0.000000
   48    ^                                                         0.000000
   49    ^                                                         0.000000
   50    ^                                                         0.000000
   51    ^                                                         0.000000
   52    ^                                                         0.000000
   53    ^                                                         0.000000
         ----+---+---+---+---+---+---+---+---+---+---+---+
            0.3 0.6 0.9 1.2 1.5 1.8 2.1 2.4 2.7  3  3.3 3.6
```

Figure 21. Length frequency distribution of pushnet catches of *Anchoa mitchilli* in all habitats during January 1980.

```
BAR CHART OF LOGNO12
MIDPOINT
LENGTH                                                        LOGNO12
        ^
   2    ^                                                     0.000000
   3    ^                                                     0.000000
   4    ^                                                     0.000000
   5    ^                                                     0.000000
   6    ^                                                     0.000000
   7    ^                                                     0.000000
   8    ^                                                     0.000000
   9    ^                                                     0.000000
  10    ^                                                     0.000000
  11    ^                                                     0.000000
  12    ^                                                     0.000000
  13    ^                                                     0.000000
  14    ^                                                     0.000000
  15    ^                                                     0.000000
  16    ^                                                     0.000000
  17    ^                                                     0.000000
  18    ^                                                     0.000000
  19    ^                                                     0.000000
  20    ^                                                     0.000000
  21    ^◆◆◆◆                                                 0.301030
  22    ^                                                     0.000000
  23    ^                                                     0.000000
  24    ^                                                     0.000000
  25    ^                                                     0.000000
  26    ^◆◆◆◆                                                 0.301030
  27    ^◆◆◆◆                                                 0.301030
  28    ^◆◆◆◆◆◆                                               0.477121
  29    ^◆◆◆◆◆◆                                               0.477121
  30    ^◆◆◆◆◆◆                                               0.477121
  31    ^◆◆◆◆◆◆◆◆                                             0.602060
  32    ^                                                     0.000000
  33    ^◆◆◆◆                                                 0.301030
  34    ^                                                     0.000000
  35    ^                                                     0.000000
  36    ^◆◆◆◆◆◆◆◆                                             0.602060
  37    ^                                                     0.000000
  38    ^                                                     0.000000
  39    ^                                                     0.000000
  40    ^                                                     0.000000
  41    ^                                                     0.000000
  42    ^                                                     0.000000
  43    ^                                                     0.000000
  44    ^                                                     0.000000
  45    ^                                                     0.000000
  46    ^                                                     0.000000
  47    ^                                                     0.000000
  48    ^                                                     0.000000
  49    ^                                                     0.000000
  50    ^                                                     0.000000
  51    ^                                                     0.000000
  52    ^                                                     0.000000
  53    ^                                                     0.000000
        ----+----+----+----+----+----+----+----+----+----+----+----+
           0.3  0.6  0.9  1.2  1.5  1.8  2.1  2.4  2.7   3   3.3  3.6
```

Figure 22. Length frequency distribution of pushnet catches of *Anchoa mitchilli* in all habitats during March 1980.

January and early-March 1980, few juveniles and no adult anchovies were taken. Larval anchovies appeared in collections in May 1979 (Figure 13), corresponding to the time of first occurrence of pelagic eggs (Table 32) and ranged in size from 2-6 mm NL. Catches exhibited bimodal distributions in June and July 1979, (Figures 14 - 15), but by August 1979 (Figure 16) larval and postlarval anchovies (2 mm NL - 30 mm SL) completely dominated pushnet collections. By September 1979 (Figure 17) spawning had ceased and no early larval stages appeared in collections. Young anchovies ranged from 10-32 mm SL and this larval cohort dominated September catches. Postlarval and early juvenile stages (16-30 mm SL) remained in pushnet collections throughout the remainder of sampling (October 1979 - March 1980), apparently a period of minimal growth. This conclusion is supported by the presence of a few juvenile individuals of the 1978 year class in March and April 1979 collections.

August 1979 length frequency data (Figure 16) from sand and *Zostera* habitats was examined to determine if sand vs. *Zostera* size distributions were significantly different utilizing the Wilcoxon signed rank test, a non-parametric distribution-free test (Zar 1974). Sand vs. *Zostera* size distributions of larval *A. mitchilli* (2 mm NL - 30 mm SL) were not significantly different ($T=17.15>T_{0.05(2),29}$) during periods of peak abundance.

Gobiosoma sp.

Larval gobies (genus *Gobiosoma*) less than 8 mm SL ranked second in numerical abundance after anchovies and constituted 8.9% (n=2177) of the total pushnet fish catch (Table 34). Identification of gobies to

Table 34. Abundance of larval gobies (Gobiosoma sp.) during months of occurrence in pushnet collections, 1979. Abbreviations are N - number of specimens; M - monthly mean abundance (N/100 m^3).

Habitat	Months			
	May	June	July	August
Sand				
N	0	1071	8	218
M	0	414.2	4.9	41.8
Range	-	263.5-604.8	4.8-5.0	0-122.2
Ruppia				
N	0	8	10	161
M	0	3.6	5.2	40.5
Range	-	0-6.8	1.1-9.1	0-105.5
Zostera				
N	2	346	5	370
M	0.5	125.8	2.4	84.2
Range	0-1.5	51.1-206.5	0.9-3.9	0-198.5

species level is not possible in specimens under 9 mm SL (Olney, in press). Postlarvae of two species, G. bosci and G. ginsburgi, occurred in collections but G. ginsburgi predominated numerically (Table 26). Larval gobies appeared in pushnet collections during the period May-August 1979 (Table 34). Peak densities were recorded in June 1979 with a secondary peak in August. Goby densities at positive stations ranged from 4.8-604.8/100 m^3 in sand; 1.1-105.5/100 m^3 over Ruppia; and 0.9-206.5/100 m^3 over Zostera. Although the highest abundances occurred over sand in June, density patterns did not reveal identifiable distributional trends. The abrupt appearance and disappearance of larval gobies in collections and the polymodal nature of density data (May - low; June - high; July - low; August - high) suggested a highly pulsed spawning behavior.

Brevoortia tyrannus

Postlarval and juvenile menhaden ranked third in numerical abundance and constituted 6.1% (n=1475) of the total pushnet fish catch (Table 26). Menhaden were present during March-June 1979 and November 1979-March 1980 (Table 35). Size frequency analysis (Table 36) presented a bimodal distribution, which was interpreted as representing seperate recruitment populations. The first population, collected initially in 1979, appeared in collections as postlarvae 22-29 mm SL during March-April. May 1979 catches were predominated by transforming individuals (29-44 mm SL) and by June, all menhaden captured were juvenile fishes (Table 36). Curiously, a few specimens (n=7) captured in May 1979 represented a distinct size cohort (51-56 mm SL), apparently independent of the majority of the catch. No explanation for the presence of this size class was readily apparent.

Table 35. Abundance of menhaden, *B. tyrannus*, during months of occurrence in pushnet collections, March 1979 - March 1980. Abbreviations are N - total number of specimens; M - monthly mean density (N/100 m^3). Daylight samples excluded.

	Sand			Zostera			Ruppia		
	N	M	Range	N	M	Range	N	M	Range
1979									
Mar	16	5.9	2.4-10.2	9	4.6	2.9-6.4	9	4.9	4.3-5.7
Apr	3	1.1	0.7-1.5	11	4.1	3.8-4.4	112	45.4	37.1-53.4
May (1)		no samples		70	51.5	51.5		no samples	
May (31)	5	2.8	2.3-3.2	31	20.3	20.2-20.3	1075	489.5	462.6-521.3
Jun	42	16.2	9.6-21.6	1	0.4	0-0.8	2	0.9	0-1.9
Nov (19)	16	6.1	0.8-11.6	17	6.5	3.9-9.1	5	5.1	5.1
Dec	1	0.3	0-0.6	0	0	--	0	0	--
1980									
Jan	17	21.9	21.9	16	6.6	5.6-7.9	11	7.8	7.6-8.1
Mar	2	0.7	0.7-0.7	1	0.3	0-0.6	1	0.6	0-1.3
Total	102			156			1215		
Percent of Total	6.9			10.6			82.5		

Table 36. Length frequency distribution of young menhaden, Brevoortia tyrannus, in pushnet collections, March 1979-March 1980.

SIZE CLASS (mm)	MONTH M	A	M	J	J	A	S	O	N	D	J	M	ALL MONTHS
17													
18									1				1
19									1				1
20									4	1			5
21									4				4
22	4								9				13
23	2								7		1	1	11
24	6	3							2		1		12
25	11	25							2		6		44
26	6	42									5		53
27	1	64									12	2	79
28	1	37									13	1	52
29		10	1						1		5		17
30			14										14
31			122										122
32			221										221
33			266										266
34			144										144
35			117										117
36			85										85
37			29										29
38			46										46
39			14										14
40			25										25
41			6										6
42			7										7
43			1	4									5
44			7	1									8
45				4									4
46				3									3
47				4									4
48				5									5
49				5									5
50				2									2
51			2	2									4
52			2	3									5
above 53			2	3									5
M			1	9									10
N													
PT													

A second recruitment population appeared in late November 1979 and included postlarvae ranging in length from 18-29 mm SL. Collections in early November (1st) failed to detect the presence of postlarvae, thereby pinpointing in time the fall entry of recruits to the study area. Postlarvae were sparse in December 1979 and early-March 1980 samples, but January collections (23-29 mm SL postlarvae) confirmed the continued presence of menhaden in these nearshore habitats.

Density data (Table 35) revealed generally equal distribution of individuals among habitats. May 1979 abundances, however, were clearly greatest over *Ruppia* beds, but schooling behavior of this species at size ranges above 25 mm SL likely contributes to extremely patchy distribution. The disproportionate percentage of total catch over *Ruppia* is also related to this phenomenon, since 88% of all menhaden captured in *Ruppia* zones were taken in two pushnet collections in May 1979. Postlarval densities at positive stations ranged from 0.7-53.4 in all habitats in spring 1979 and 0.3-21.9 during the period 19 November 1979 - March 1980.

Syngnathus fuscus

Northern pipefish ranked fourth in numerical abundance (n=968) and represented 3.9% of the total pushnet catch (Table 26). Recently born pipefish are essentially adult-like when extruded from the male brood sac, do not exhibit a larval stage typical of other teleostean fishes, and, except for stages under 10 mm SL, are associated with a substrate (*Zostera* blades, floating vegetation) and thus not generally available to standard plankton gear.

Table 37. Abundance of northern pipefish, *Syngnathus fuscus*, during months of occurrence in pushnet collections, March 1979 - March 1980. Abbreviations are N - total number of specimens; M - monthly mean density (N/100 m^3). Daylight samples excluded.

	Sand			Zostera			Ruppia		
	N	M	Range	N	M	Range	N	M	Range
May	1	0.6	0-1.1	3	1.9	1.2-2.9	5	2.3	1.7-2.9
Jun	20	7.7	6.1-9.0	100	36.4	23.1-50.7	2	0.9	0.8-0.9
Jul	127	77.4	30.7-159.3	214	103.8	99.8-107.6	61	31.6	8.5-53.6
Aug	27	10.0	4.2-16.3	246	100.1	76.0-128.5	87	39.2	11.3-61.2
Sept	0	0	--	32	15.2	4.6-19.9	14	12.3	7.2-20.1
Oct		no samples		2	0.9	0.8-0.9	0	0	--
Nov (1)	1	0.4	0-0.8	2	0.8	0.7-0.8	0	0	--
Nov (19)	0	0	--	1	0.4	0-0.8	0	0	--
Total	176			600			169		
Percent of Total	18.6			63.5			17.8		

Young pipefish and adults were present in collections during May-November 1979. Pushnet catches peaked in June-August, during which time a higher percentage of the total catch (88.6-92.0%) was under 10 mm SL. Densities (Table 37) during periods of peak abundance ranged from 0.8-159.3 fish/100 m^3. As expected, densities were generally higher in pushnet collections over *Zostera* beds. Over 80% of the total pipefishes collected were taken in pushnet collections over vegetated habitats.

Micropogonias undulatus

Larvae and postlarvae of the croaker, *Micropogonias undulatus*, ranked fifth in numerical abundance and made up 2.2% (n=523) of all fishes taken in pushnet collections. Data on pelagic larvae and postlarvae of croakers in the Chesapeake Bay are sparse and, with the exception of a small collection of *M. undulatus* larvae (n=111) at the bay mouth by Pearson (1941), no additional larval or postlarval records exist (Olney 1978, Chao and Musick 1977). Croakers were taken in pushnet collections during the period August 1979-January 1980. Abundance data (Table 38) revealed peak densities from the latter part of November 1979 through January 1980 with the highest recorded mean density (122.3 postlarvae/100 m^3) over sand bottom in December 1979. During the period of peak abundance, density estimates at positive stations ranged from 0.8-170.4 postlarvae/100 m^3. Postlarvae were generally evenly distributed in all three habitats, although December 1979 catches over sand were exceptionally high. Larval croakers (less than 10 mm SL) were only taken over sand in late summer (August, September) and only over vegetated habitats in January 1980.

Table 38. Abundance of young croakers, Micropogonias undulatus, during monthes of occurrence in pushnet collections, March 1979 - March 1980. Abbreviations are: N - total specimens collected; M - monthly mean density (N/100 m). Daylight collections excluded.

	Sand			Zostera			Ruppia		
	N	M	Range	N	M	Range	N	M	Range
1979									
Aug	1	0.4	0-0.7	0	0	--	0	0	--
Sept	1	1.6	1.6	0	0	--	0	0	---
Oct	0	0	--	0	0	--	0	0	--
Nov (1)	0	0	--	1	0.4	0-0.7	1	0.4	0-0.9
Nov (19)	2	0.8	0.8-0.8	16	6.1	6.1-6.2	3	3.1	3.1
Dec	385	122.3	77.7-170.4	26	8.9	6.1-11.6	0	0	--
Jan	15	19.4	19.4	34	13.9	12.6-15.9	36	25.6	15.2-38.8
Total	404			77			40		
Percent of Total	77.5			14.8			7.7		

Length frequency data (Table 39) indicated that croakers greater than 18 mm SL were unavailable to surface pushnet collections. During the period of peak abundance, postlarvae ranged from 10-17 mm SL with only a few (n=4) larvae less than 10 mm SL taken. The presence of small specimens in both late summer and early 1980 indicate a protracted period of recruitment into the Bay from offshore spawning grounds.

Membras martinica

Juvenile and adult rough silversides, Membras martinica, ranged in size from 16-87 mm SL, ranked sixth in numerical abundance and constituted 1.3% (n=315) of the total fishes collected by pushnet (Table 26). Rough silversides were captured by pushnet during the eight month period April-November 1979. Densities at positive stations ranged from 0.8-34.8 fish/100 m^3 and peak mean densities were observed between May and June 1979 with a secondary peak in September 1979 (Table 40). Rough silversides were more available to pushnet capture over vegetated habitats than sand bottoms. Over 93% of all M. martinica collected occurred in Zostera and Ruppia collections. In addition, mean densities of silversides over Zostera or Ruppia beds always exceeded density estimates over sand during any given sampling period. Peak densities over vegetation coincided with peak abundances of M. martinica egg collections and summer peaks in abundance of atherinid larvae (Tables 25 and 43).

Table 39. Length frequency distribution of young croaker, *Micropogonias undulatus*, in pushnet collections, March 1979-March 1980.

SIZE CLASS (mm)	MONTH M	A	M	J	J	A	S	O	N	D	J	M	ALL MONTHS
(mm)						1							
5						1							1
6													
7											1		1
8											1		1
9							1				2		3
10									1	9	10		20
11									3	17	21		41
12									3	63	24		90
13									4	100	15		119
14									3	100	5		108
15									1	39	1		41
16										45	3		48
17										14			14
18													
19													
20													

Table 40. Abundance of rough silversides, Membras martinica, during months of occurrence in pushnet collections, March 1979 - March 1980. Abbreviations are N - number of specimens; M - monthly mean abundance (N/100 m^3). Daylight collections are excluded.

	Sand			Zostera			Ruppia		
	N	M	Range	N	M	Range	N	M	Range
1979									
April	3	1.1	0-2.3	8	2.9	2.9-3.0	2	0.8	0.8-0.8
May (1)	no samples			32	23.5	23.5	no samples		
May (31)	3	1.7	0-3.2	33	21.6	10.7-34.8	33	15.0	12.6-17.8
Jun	0	0	--	47	17.1	13.3-21.2	13	5.9	5.1-6.8
Jul	5	3.1	0-4.8	9	4.4	2.8-5.9	16	8.3	7.1-9.6
Aug	8	2.9	2.1-3.9	23	9.4	5.3-12.8	23	10.4	6.2-13.7
Sept	5	4.9	4.9	33	15.7	13.1-21.5	8	7.0	2.2-10.1
Oct	no samples			2	0.9	0-1.6	4	1.7	1.6-1.7
Nov (1)	0	0		0	0	--	17	7.4	5.2-9.6
Total	22			187			116		
Percent of Total	6.8			57.5			35.7		

Leiostomus xanthurus

Postlarval and juvenile spot ranked seventh (n=280) in numerical abundance and constituted 1.2% of the total fishes captured by pushnet (Table 26). Length frequency data (Table 41) indicated an extremely abbreviated period of recruitment into the grass beds (March-April) and high growth rates during spring months. Postlarval spot appeared in April 1979 in a size range of 13-24 mm SL. By May 1979, spot were far less available to pushnet collection and ranged from 30-41 mm SL. Only a few juveniles (n=4) over 50 mm SL were taken after May. April 1979 densities ranged from 12.9-49.4 fish/100 m^3 with generally equal distribution of young fish among the three habitats. Although over 78% of all spot taken occurred over vegetated bottoms, a single, large collection taken on 1 May 1979 (Table 42) in *Zostera* with no concurrent samples in the other habitats biased these totals.

Atherinid Larvae

Larval silversides of undetermined identity ranked eighth in numerical abundance and constituted 1.1% (n=272) of all fishes taken by pushnet (Table 26). Silversides under 18 mm SL could not be identified with certainty (Olney, 1978), however, with the exception of April 1979 collections (Table 43), silverside larvae taken in June-August 1979 co-occurred with eggs and adults of *M. martinica*. Eggs or adult *M. menidia* were not taken during this period suggesting that the majority of unidentified atherinid larvae in pushnet collections may be referable to only one species, *M. martinica*.

Atherinid larvae peaked in abundance in July and August 1979. Densities at positive stations ranged from 0.8-78.9 larvae/100 m^3 and

Table 41. Length frequency distrubution of young spot, <u>Leiostomus xanthurus</u>, in pushnet collections, March 1979-March 1980.

SIZE CLASS (mm)	MONTH M	A	M	J	J	A	S	O	N	D	J	M	ALL MONTHS
12		4										1	5
13		4										1	5
14		11											11
15		27											27
16		48											48
17		63											63
18		50											50
19		34											34
20		14											14
21		2											2
22		3											3
23		1											1
24		1											1
25													
26													
27													
28													
29													
30			2										2
31			2										2
32			2										2
33		1	1										2
34													
35			1										1
36			1										1
37													
38													
39													
40													
41			1										1
42													
43													
44													
45													
46													
47													
48													
49													
Over 50				6									4

Table 42. Abundance of spot, *Leiostomus xanthurus*, during months of occurrence in pushnet collections, March 1979 - March 1980. Abbreviations are N - number of specimens; M - monthly mean abundance (N/100 m^3).

	Sand			Zostera			Ruppia		
	N	M	Range	N	M	Range	N	M	Range
1979									
Apr	53	19.5	12.9-25.8	65	23.4	16.1-31.0	102	41.4	33.0-49.4
May (1)	no samples			47	34.6	34.6	no samples		
May (31)	6	3.3	2.3-4.2	4	2.6	0-4.8	0	0	--
Jul	0	0	--	2	0.9	0-1.9	4	2.1	2.0-2.1
1980									
Mar	0	0	--	1	0.3	0-0.6	0	0	--
Total	59			117			106		
Percent of Total	20.9			41.5			37.6		

Table 43. Abundance of atherinid larvae during months of occurrence in pushnet collections, March 1979 - March 1980. Abbreviations are N - number of specimens; M - monthly mean abundance (N/100 m^3). Daylight samples are excluded.

	Sand			Zostera			Ruppia		
	N	M	Range	N	M	Range	N	M	Range
1979									
Apr	0	0	--	1	0.4	0-0.8	14	5.7	2.4-9.1
Jun	0	0	--	11	4.0	0-8.3	0	0	--
Jul	23	14.0	11.5-18.5	27	13.1	8.5-17.9	31	16.1	6.4-25.3
Aug	4	1.5	0.8-2.1	35	14.3	10.5-18.6	104	46.9	6.2-78.9
Total	27			74			149		
Percent of Total	10.8			29.6			59.6		

mean density estimates ranged from 1.5-46.9 larvae/100 m^3 during these months. Over 88% of all larvae were taken over vegetated habitats although July 1979 densities over sand bottom exceeded Zostera estimates.

Notes on Additional Species

Postlarval striped anchovies, A. hepsetus, ranging in size from 13 to 41 mm SL (n=66), appeared in pushnet collections during July and August 1979. Greatest densities were recorded in August 1979. Abundance estimates (fish/100 m^3) in all habitats during peak density were: sand - 24.9, 33.9; Ruppia - 7.2, 8.0; and Zostera - 2.7, 12.8. Postlarval striped anchovies were conspicuously absent from previous collections in the lower Chesapeake Bay (Pearson 1941; Massman et al. 1961, 1962; Olney, in press). Massman et al. (1961, 1962) provided the only reports of postlarvae north of Cape Hatteras, North Carolina; one 19 mm SL specimen taken in the Atlantic Ocean off the Bay entrance and one 23 mm SL postlarva in the Pamunkey River, Va. The present collections confirm Hildebrand and Cable's (1930) suspicion that larvae of this species occur in areas which have received low sampling intensity, such as estuarine shallows and grassy areas.

Juvenile and adult Atlantic silversides (n=110), Menidia menidia were collected in March, April and June 1979 and during the period December 1979 - March 1980. Monthly mean density fish/100 m^3 during months of occurrence were: March 1979, 0.5; April 1979, 0.1; June 1979, 0.5; December 1979, 10.4; January 1980, 0.4; and March 1980, 1.4. Atlantic silversides were considerably less abundant than rough silversides, M. martinica, (Table 40) and collections indicated strong temporal discontinuity between these two atherinid species. In addition, eggs of M. menidia were conspicuously absent from collections, whereas M. martinica eggs were relatively common, especially considering their demersal nature.

Eggs (n=3) early larvae (n=19) and juveniles (n=6) of the halfbeak, Hyporhamphus sp., were taken in pushnet collections during the period May - August 1979. Late larval stages of Hyporhamphus sp. are reported from the Chesapeake Bay region (Hardy and Johnson 1974), however eggs and early larvae are undescribed and the importance of submerged aquatic vegetation as a spawning habitat for this species has not been investigated. Eggs and larvae were taken over vegetated habitats in June, July and August but did not occur in pushnet samples over sand bottom during this period. Peak larval density (11.1 larvae/ 100 m^3) was observed in Ruppia beds in July 1979.

In addition to M. undulatus and L. xanthurus, four sciaenid species were represented as larvae in pushnet collections. These were the weakfish, Cynoscion regalis, (n=146); southern kingfish Menticirrhus americanus, (n=20); red drum, Sciaenops ocellata (n=11); and the silver perch, Bairdiella chrysoura, (n=9). Monthly pushnet density data for these species are presented in Tables 44 and 45.

C. regalis larvae were taken by pushnet during the period May - August 1979, with peak densities in August 1979 (Table 44). Larval weakfish are important components of lower Chesapeake Bay summer ichthyoplankton (Pearson 1941, Olney 1978) ranking second in numerical abundance after anchovies. The infrequent occurrence of C. regalis larvae in nearshore habitats is indicative of the minimal importance of SAV as a spawning habitat for this species.

Table 44. Monthly mean density and size ranges of *Cynoscion regalis* captured by pushnet in evening collections, March 1979 - March 1980.

	May	Jun	Jul	Aug
Total Specimens	1	3	1	141
Size Range (mm)	3.8 NL	3.1 NL-5.3 SL	4.3 NL	2.0 NL-51.0 SL
Zostera (N/100 m^3)	0	0	0	38.3
Ruppia (N/100 m^3)	0	0	0	0
Sand (N/100 m^3)	0.6	1.2	0.6	17.4

Table 45. Monthly mean density and size ranges of *Sciaenops ocellata* *Menticirrhus americanus* and *Bairdiella chrysoura* in evening pushnet collections in August 1979.

	S. ocellata	*M. americanus*	*B. chrysoura*
Total Specimens	11	20	9
Size Range (mm)	2.0 NL-5.2 SL	3.8 NL-9.2 SL	2.0 NL-5.1 SL
Zostera (N/100 m^3)	3.3	3.3	1.2
Ruppia (N/100 m^3)	0.9	0.5	2.7
Sand (N/100 m^3)	0.4	4.1	0

Larvae of M. americanus, S. ocellata and B. chrysoura were taken in August 1979 in low abundance (Table 45). The presence of larval red drum over grass beds is consistent with previous studies (Powles and Stender 1978 and references therein) but these specimens represent the first record of spawning activity for the species in Chesapeake Bay. The absence of large numbers of silver perch larvae is surprising considering the importance of this species in previous studies of SAV ichthyofauna (Orth and Heck, 1980). Apparently, B. chrysoura (as well as all sciaenid species) only utilize SAV as a nursery and refuge but not as a spawning habitat. M. americanus larvae were infrequent in pushnet collections as they were in previous lower Bay ichthyoplankton surveys (Pearson 1941, Olney 1978).

Occurrence of larvae and postlarvae of the sand lance, Ammodytes hexapterus, was consistent with previous collections in the lower Chesapeake Bay (Pearson 1941, Norcross et al. 1961, Olney 1978, Grant and Olney 1979). A. hexapterus larvae (n=191) were captured by pushnet in March 1979, 1980. Monthly mean density (N/100 m^3) in each habitat during each year were: Sand - 19.8 (1979), 24.7 (1980); Ruppia - 12.2 (1979), 1.9 (1980); Zostera - 8.7 (1979), 5.2 (1980). Larvae ranged from 9.0 mm NL to 27 mm SL.

Seasonal assemblages

Numerically dominant species during each month of pushnet sampling are listed in Table 46. Patterns of dominance are related to water temperature in Table 47 and then listed in seasonal patterns of occurrence.

Table 46. Numerically dominant species of ichthyoplankton, listed in order of abundance, taken by pushnet in evening collections, March 1979 - March 1980. Eggs are excluded.

	Sand	Ruppia	Zostera
1980			
Mar	A. hexapterus B. tyrannus A. rostrata	A. hexapterus B. tyrannus A. rostrata	A. hexapterus B. tyrannus P. dentatus
Apr	L. xanthurus A. mitchilli	B. tyrannus L. xanthurus A. mitchilli	L. xanthurus B. tyrannus A. mitchilli
May	A. mitchilli L. xanthurus B. tyrannus	B. tyrannus A. mitchilli M. martinica	A. mitchilli M. martinica B. tyrannus
Jun	Gobiosoma sp. A. mitchilli B. tyrannus	A. mitchilli M. martinica Gobiosoma sp.	Gobiosoma sp. A. mitchilli S. fuscus
Jul	A. mitchilli S. fuscus atherinidae	A. mitchilli S. fuscus atherinidae	A. mitchilli S. fuscus atherinidae
Aug	A. mitchilli Gobiosoma sp. A. hepsetus	A. mitchilli Gobiosoma sp. S. fuscus	A. mitchilli Gobiosoma sp. S. fuscus
Sept	A. mitchilli M. martinica	A. mitchilli S. fuscus M. martinica	A. mitchilli M. martinica S. fuscus
Oct	no samples	A. mitchilli H. hentzi M. martinica	A. mitchilli
Nov (1)	A. mitchilli	A. mitchilli M. martinica	A. mitchilli S. fuscus
Nov (19)	A. mitchilli B. tyrannus M. undulatus	A. mitchilli B. tyrannus M. undulatus	A. mitchilli B. tyrannus M. undulatus
Dec	M. undulatus A. mitchilli M. menidia	M. menidia	M. menidia M. undulatus A. mitchilli

Table 46 (continued)

	Sand	*Ruppia*	*Zostera*
1980			
Jan	*M. undulatus* *B. tyrannus*	*M. undulatus* *B. tyrannus*	*M. undulatus* *B. tyrannus*
Mar	*A. hexapterus* *P. dentatus* *A. mitchilli*	*A. hexapterus*	*A. hexapterus* *M. menidia* *P. dentatus*

Table 47. Summary of seasonal ichthyoplankton assemblages in nearshore habitats in Chesapeake Bay. Species life history stages (E - egg, L - larva, P - postlarva, J - juvenile, A - adult), surface temperature range and months of collection are reported from pushnet collections, March 1979 - March 1980.

Surface Temperature Range (°C)	Season (months)	Characteristic Species	(life history stage)
1-12	Winter (November - March)	A. hexapterus	(L, P)
		B. tyrannus	(P)
		P. dentatus	(P)
		A. rostrata	(elver)
		M. undulatus	(L, P)
		A. mitchilli	(J, A)
		M. menidia	(J, A)
15-22	Spring (April - May)	L. xanthurus	(P, J)
		B. tyrannus	(P, J)
		M. martinica	(J, A)
		A. mitchilli	(J, A)
		S. aquosus	(L)
		atherinidae	(L)
		S. fuscus	(A)
20-28	Summer (June - August)	A. mitchilli	(E, L, J, A)
		Gobiosoma sp.	(L)
		A. hepsetus	(P)
		S. fuscus	(L)
		Sciaenidae	(E, L, J)
		M. martinica	(E, J, A)
		atherinidae	(L)
		M. thalassinus	(L)
		Hyporamphus sp.	(E, L)
		H. hentzi	(L)
13-21	Fall (September - October)	A. mitchilli	(P, J, A)
		M. martinica	(J, A)
		S. fuscus	(J, A)
		H. hentzi	(P, J)

Winter Assemblage - Winter pushnet collections (November - March) were characterized by the occurrence of postlarvae of five species of offshore spawners: A. hexapterus, B. tyrannus, P. dentatus, A. rostrata and M. undulatus. Larval and postlarval stages of these fishes (elvers in the case of American eel) enter the Chesapeake Bay when surface water temperatures range from 1-12°C. Patterns of immigration into the Bay are unknown, but the presence of these stages in nearshore habitats along the eastern Bay margin likely relates to Bay salinity patterns. The eastern Bay margin is characterized by high salinity salt wedge intrusion. Postlarvae are believed to utilize the non-tidal, upriver vector of this intrusion as a mechanism in estuarine dependence. The absence of dense Zostera or Ruppia beds during this period precludes utilization by these species of SAV habitat. In addition to immigrant postlarvae resident populations of A. mitchilli and M. martinica occupy the nearshore waters during winter periods.

Spring assemblage - With increasing surface temperatures (15-22°C), pushnet collections revealed the continued presence of B. tyrannus postlarvae and juveniles; the introduction of postlarval and juvenile spot, L. xanthurus to the SAV system; the continued presence of resident populations of juvenile and adult anchovies and rough silversides and the spawning activity of atherinids and windowpane flounder, S. aquosus. Atherinid spawning, and the presence of adult S. fuscus and young spot in collections was interpreted to relate to initiation of SAV growth.

Summer Assemblage - The summer ichthyoplankton assemblage was dominated by egg and larval stages of resident lower Chesapeake Bay spawners including anchovies, gobies, pipefish, sciaenids (*C. regalis*, *M. americanus*, *S. ocellata*, and *B. chrysoura*), atherinids, blennies and halfbeaks. In addition, some immigration of offshore (or coastal) spawned larvae was observed, namely postlarval *A. hepsetus*. Summer pushnet collections revealed peaks in density and diversity of nearshore ichthyoplankton populations but habitat comparison data (see earlier section) confirmed that these peaks were independent of the presence of dense SAV beds. However, the high numerical rank abundance of goby and pipefish larvae was clearly a function of water depth and the presence of vegetation. This conclusion is based on the relative importance of the species in ichthyoplankton surveys of deeper waters in the Bay (Pearson 1941, Olney 1978).

Fall Assemblage - Late postlarval, juvenile and adults of four species, all resident lower Bay fishes were present in fall (September, October) pushnet collections. During this period, density and diversity of catch was low and little evidences of SAV dependence was observed.

Laboratory analysis

Food Habits

Non empty stomachs from 669 resident fishes and 348 migratory predators were collected, sorted, contents identified (Table 48). Gravimetric and numerical analyses were then undertaken to define the relative importance of prey items. Spot, silver perch, and pipefish stomachs were examined for ontogenetic shifts in food preference and monthly changes in prey selectivity.

Three different indices were computed to define the relative "importance" of prey items to each species of fish. Percent frequency of occurrence was calculated by recording the number of stomachs containing one or more individuals of each food category and then expressing this number as a percentage of all non empty stomachs from a single species of fish. Percent number was determined by counting the number of individuals in a food category and the total is expressed as a percentage of the total individuals in all food categories. Percent dry weight was calculated by summation of the dry weights of individuals in a food category and expressing the results as a percentage of the dry weight of the total individuals in all food categories. Three indices were utilized since no one food index properly describes the relative importance of prey items to the predators. Frequency of occurrence demonstrates the regularity at which an item is fed upon, but gives no indication of quantity or number of food items eaten. Percent number gives an indication of the amount of effort exerted in selecting and capturing different organisms. However percent number overemphasizes the importance of small prey; is difficult to use because of mastication of the food before it reaches the stomach; and is not suitable for dealing nondiscrete food items such as macroalgae and detritus. Percent

Table 48

Feeding Analysis of SAV Fishes

Resident Species	Number	Length Range
Centropristis striata	4	72-158
Micropogonius undulatus	1	305
Clupea harengus	1	132
Morone americana	1	204
Pseudopleuronectes americanus	8	47-100
Orthopristis chrysoptera	19	29-107
Scophthalmus aquosus	2	221-246
Urophycis regius	10	49-113
Prionotus evolans	6	35-105
Leiostomus xanthurus	56	20-50
" "	103	60-100
" "	36	110-150
Bairdiella chrysoura	51	20-50
" "	118	60-100
" "	38	100-150
Syngnathus fuscus	93	60-100
" "	103	110-150
" "	19	160-180

Migratory Species	Number	Length Range
Paralichthys dentatus	24	131-140
Cynoscion regalis	26	320-580
Pomatomus saltatrix	63	122-870
Morone saxatilis	2	286-307
Sciaenops ocellata	2	384-765
Rachycentron canadum	1	490
Cynoscion nebulosus	20	400-595
Carcharhinus milberti	199	435-852
Dasyatis sayi	2	700-710
Tylosurus acus	7	970-1140
Strongylura marina	2	380-403

weight demonstrates the bulk of food items and is related to caloric content. This index tends to overestimate the contribution of items with heavy exoskeletons such as molluscs and crabs.

Figure 23 and 24, illustrate, and Table 49 and 50 describe the food habits of resident fishes captured in the SAV study area. Prey categories were composed of members of the benthic, epibenthic and planktonic communities in the Zostera and Ruppia areas. The dominant prey items (by all three food indices) of the resident fishes were the mysid shrimp (Neomysis americana), the sand shrimp (Crangon septemspinosa), and calanoid copepods. Isopods, amphipods, and polychaetes were very important for certain species of fishes but were not eaten regularly by all resident fishes. Spot (L. xanthurus), croaker (M. undulatus) and hogchoker (T. maculatus) demonstrated benthic feeding behavior by the abundance of harpacticoid copepods, nematodes, bivalves, polychaetes, and detritus found in their stomachs. Epibenthic feeding in black seabass (C. striata), pipefish (S. fuscus), pigfish (O. chrysoptera) and white perch (M. americana) occurred as shown by the presence of amphipods and shrimps in their stomachs. B. chrysoura and C. harengus were plankton feeders that consumed calanoid copepods, mysids, and occasionally larger shrimps.

The food habits of the three dominant resident species (L. xanthurus, B. chrysoura and S. fuscus) were analyzed for monthly changes in prey selectivity and ontogenetic shifts in food preference. Frequency of occurrence (Table 51) indicated that plant detritus, nematodes, polychaetes, ostracods, harpacticoid and calanoid copepods were frequently consumed by all sizes of spot. By percent number (Figure 25) all sizes of spot consumed a large number of harpacticoid copepods and nematodes while the largest spot consumed primarily N. americana. Figure 26 indicates that

PERCENT NUMBER OF PREY ITEMS FOUND IN THE STOMACHS OF RESIDENT SPECIES

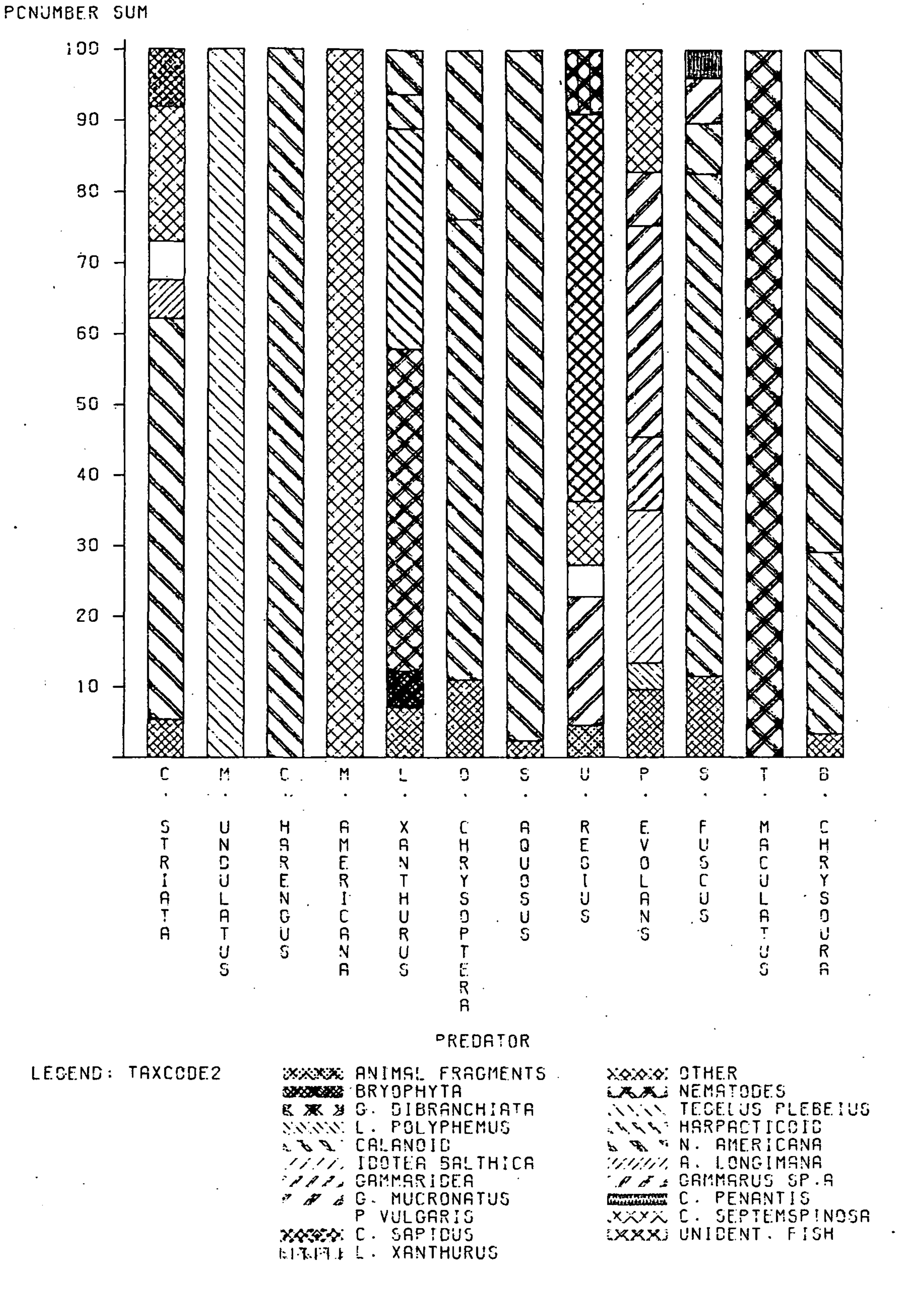


Figure 23

PERCENT WEIGHT OF PREY ITEMS FOUND IN THE STOMACHS OF RESIDENT SPECIES

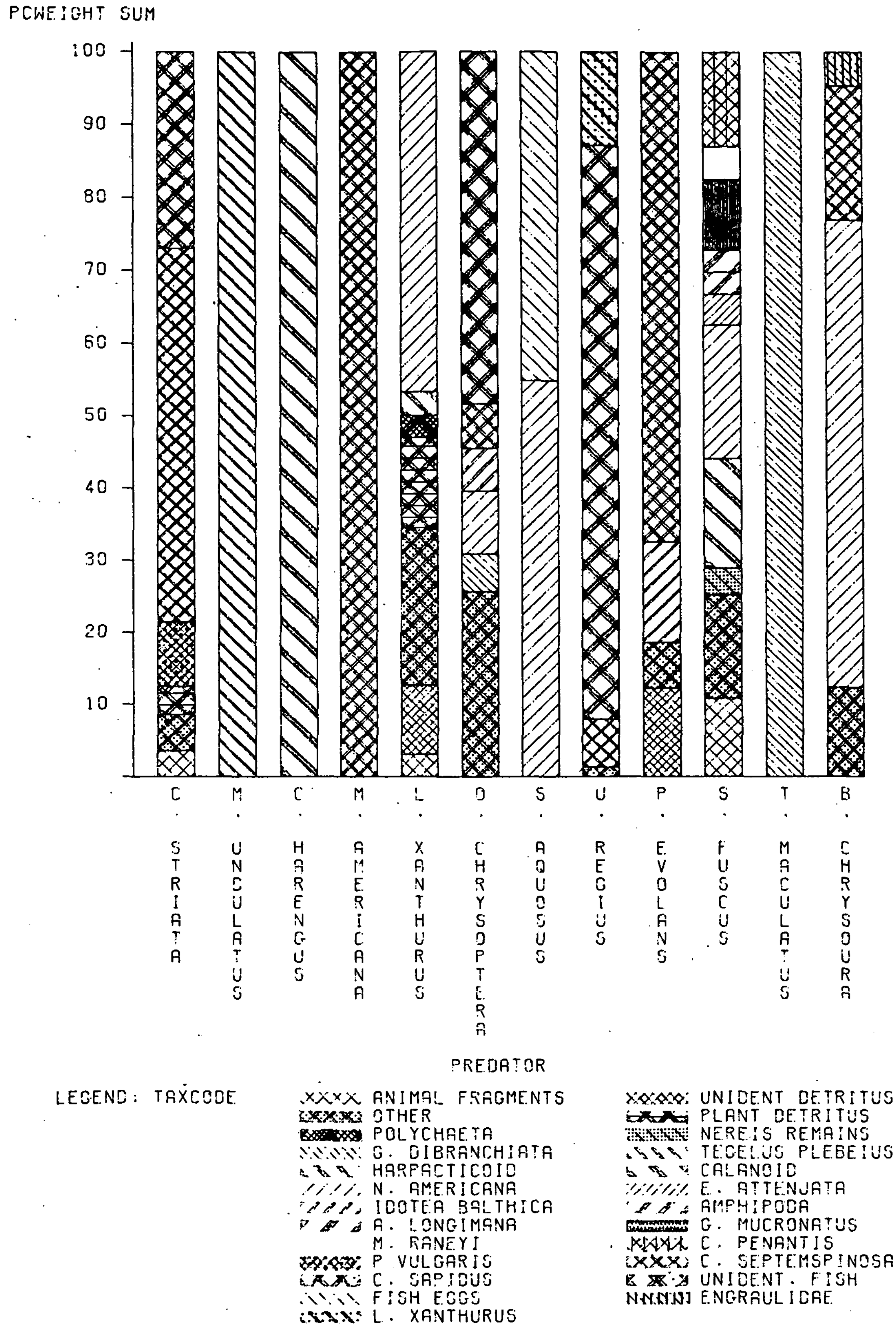


Figure 24

Table 49

Resident Fishes of SAV Study Area

	Syngnathus fuscus (214)			Leiostomus xanthurus (170)			Bairdiella chrysoura(161)			Orthopristis chrysoptera (19)		
	% Wt	% Occ	% N	% Wt	% Occ	% N	% Wt	% Occ	% N	% Wt	% Occ	% N
Animal Fragments	10.8	46.9	1.2	3.0	26.5	0.2	0.2	2.4	trace	1.8	26.3	0.3
Unid. Detritus	.1	2.8	.1	9.6	27.6	0.2	1.1	13.0	0.2	2.2	15.8	0.2
Bryophyta				.5	14.7	5.3						
Algae				trace	1.8	trace						
Plant Detritus	2.4	2.8	.1	12.5	24.7	0.2	.1	2.4	trace	1.1	21.1	0.3
Zostera marina	.1	.5	trace	trace	.6	trace	.2	0.5	trace			
Ruppia maritima							trace	0.5	trace			
Foraminifera	.1	2.3	.2	.1	4.1	0.1						
Hydrozoans	trace	0.5	trace	1.7	5.9	trace				0.3	5.3	0.1
Stylochus ellipticus				trace	.5	trace						
Trematoda				trace	.5	trace						
Nemertea				.2	.5	trace						
Nematodes				1.7	52.5	45.6				trace	5.3	0.1
Polychaeta	.7	1.4	trace	3.1	20.4	.3	.9	.5	trace			
Phyilodocidae				.1	1.0	trace						
Eteone heterodpoda				1.2	16.8	.8						
Phyllodoce arena							.9	.5	trace			
Syllidae				trace	5.1	0.1						
Nereis remains	3.8	.7	.1	.1	2.0	trace				0.7	10.5	0.1
Nereis succinea	.1	0.9	trace	.8	4.6	trace						
Glycera dibranchiata				.2	2.6	trace				5.3	5.3	0.1
Glycera solitaria				.5	6.1	0.1						
Capitellidae				.5	3.0	.1						
Heteromastus filiformis				trace	1.1	trace						
Maldanidae				1.3	1.1	trace						
Clymenella torquata				2.1	.5	trace						
Spinodiae				.2	2.6	.1						
Polydora longni				.9	7.1	0.1						
Polydora pinnata				trace	.5	trace						
Orbinidae				trace	1.5	trace						
Tharys setigera				trace	.5	trace						

Table 49 (Continued)

	Syngnathus fuscus (214)			*Leiostomus xanthurus* (170)			*Bairdiella chrysoura* (161)			*Orthopristis chrysoptera* (19)		
	% Wt	% Occ	% N	% Wt	% Occ	% N	% Wt	% Occ	% N	% Wt	% Occ	% N
Mollusca				trace	1.1	trace				.3	5.3	.1
Gastropoda				0.2	6.1	0.1				.6	5.3	.1
Crepidula convexa	trace	.5	trace	.4	3.1	trace						
Nudibranchia				trace	.5	trace						
Hamindae solitaria				trace	.5	trace						
Retusa canaliculata												
Doridella obscura				trace	.5	trace				0.9	5.3	.1
Pelecypoda				.2	6.6	0.1						
Anadora transversa				trace	1.1	trace						
Gemma gemma				0.5	1.1	0.1						
Crustacea				trace	1.1	trace	0.1	2.9	trace			
Ostracoda	.4	9.3	0.7	0.8	25.6	2.7				trace	10.5	0.1
Copepoda				trace	1.0	0.1				0.5	10.5	0.2
Harpacticoid	.1	2.3	.7	3.2	51.5	31.1						
Calanoid	15.1	39.5	71.1	.6	23.5	4.8	1.1	26.6	25.7	2.8	47.4	65.2
Cennipedia				.1	1.1	trace						
Balanus improvisus	.1	1.9	.1	1.4	8.6	.2						
Neomysis americana	18.4	25.6	7.0	46.7	37.2	6.6	64.6	77.8	70.9	8.7	42.1	23.8
Mysidopsis bigelowi	trace	.5	trace	.3	2.1	0.1	0.2	3.9	0.1			
Cumacea				trace	3.6	trace						
Cyclaspis varians				trace	0.5	trace	0.3	1.4	0.1			
Oxyurostylis smithi				trace	5.1	0.1	trace	.5	trace			
Isopoda				trace	.5	trace				trace	5.3	0.1
Chirodotea caeca							0.1	0.5	trace			
Erichsonella attenuata	4.3	12.6	1.3				0.3	6.7	0.1	1.6	15.8	0.4
Idotea balthica	2.4	15.8	0.8				0.9	5.3	.2	5.9	42.1	1.1
Edotea triloba	trace	3.7	0.1	trace	0.5	trace	0.1	1.0	trace			
Paracerceis caudata	trace	0.9	trace									
Amphipoda	3.0	14.4	1.7	.1	10.7	0.2	.7	9.7	0.2	1.9	21.0	0.4
Ampeliscidae							0.1	1.0	trace			
Ampelisca abdita				.1	3.1	trace	0.2	3.9	0.2	trace	5.3	0.1
Ampelisca radorum				trace	0.5	trace						
Ampithoidae	.7	1.4	trace	trace	.5	trace	trace	1.4	trace			
Ampithoe							trace	.5	trace			
Ampithoe longimana	3.0	15.3	1.6	0.2	1.5	trace	0.2	3.9	.1	1.4	21.1	0.5

Table 49 (continued)

Food Items	*Syngnathus fuscus* (214)			*Leiostomus xanthurus* (170)			*Bairdiella chrysoura* (161)			*Orthopristis chrysoptera* (19)		
	% Wt	% Occ	% N	% Wt	% Occ	% N	% Wt	% Occ	% N	% Wt	% Occ	% N
Ampithoe valida							0.1	2.4	trace			
Cymadusa compta	1.4	.8	0.1	trace	1.0	trace	0.1	3.9	.1	2.7	36.8	1.0
Batea catharinensis				trace	1.0	trace	trace	.5	trace			
Corphiidae	.1	0.9	trace							trace	5.3	0.1
Cerapus tubularis	trace	0.5	trace	0.1	1.5	trace	0.1	2.9	trace			
Corophium				trace	.5	trace	.8	4.3	0.1			
Corophium acherusicum	.1	.5	trace				0.1	1.4	trace			
Corophium simile										0.9	5.3	0.1
Corophium tuberculatum	1.0	.9	trace				0.1	.5	trace			
Erichthonius brasiliensis				trace	0.5	trace	0.1	1.0	trace	trace	5.3	0.1
Gammaridae	1.8	12.1	1.6	trace	1.0	trace	trace	1.0	trace	trace	5.3	0.1
Gammarus sp. A										0.8	10.5	0.2
Gammarus palustris	1.1	1.9	.1									
Gammarus mucronatus	10.0	16.7	6.3	.5	8.2	.1	.3	8.7	.3	1.3	31.6	.5
Microprotopus raneyi	4.6	9.3	.4	1.0	13.3	0.5	1.2	15.9	.3	1.2	26.3	0.5
Microprotopus edwardsi				trace	0.5	trace	trace	.5	trace			
Caprellidae	trace	2.3	.1	trace	2.0	trace						
Caprella penantis	12.9	31.1	4.0	0.2	4.6	.1	1.1	17.4	0.4	2.0	31.6	.9
Caprella equilibra	trace	.5	trace									
Paracaprella tenuis	.6	7.4	0.4	trace	4.1	.1	trace	.5	trace	0.3	15.8	0.5
Decopoda							0.2	.5	trace			
Lucifer faxoni							trace	.5	trace			
Crangon septemspinosa	.1	.5	trace	2.5	2.6	trace	18.3	24.8	0.6	6.1	36.8	2.8
Callinectes sapidus				0.1	.5	trace	trace	.5	trace			
Pinnixa chaetopterana							trace	1.0	trace			
Pinnixa sayana				0.2	.5	trace				trace	5.3	0.1
Insecta	1.0	.5	trace									
Polydesmida	.1	.5	trace									
Unid. Fish				trace	1.0	trace	1.0	1.9	trace	48.4	10.5	0.1
Fish Eggs				trace	.5	trace						
Engraulidae							4.7	.5	trace			
Anchoa mitchilli							0.5	1.4	trace			

Table 50

Occasional Fishes of SAV Study Area

Food Item	Urophycis regius (10) % Wt	% Occ	% N	Pseudopleuronectes americanus (8) % Wt	% Occ	% N	Prionotus evolans (6) % Wt	% Occ	% N	Centropristis striata (4) % Wt.	% Occ	% N	Scophthalmus aquosus (2) % Wt	% Occ	% N
Animal Fragments	0.0008	10	4.5455							3.6191	25	2.7027			
Unid. Detritus							12.2735	16.6667	0.7463						
Plant Detritus							0.0039	16.6667	0.7463	3.8564	25	2.7027			
Polychaeta				6.0487	25.0	1.0417									
Nereis remains				5.8514	25.0	1.0417									
Glycera dibranchiata															
Gastropoda				2.3011	12.5	1.0417									
Crepidula convexa				2.6298	12.5	0.5208									
Pelecypoda							0.1059	16.6667	0.7463						
Mya arenaria															
Limulus polyphemus							0.2000	16.6667	3.7313						
Calanoid															
Neomysis americanus										2.7588	50	56.7568	54.8167	100	97.561
Mysidopsis bigelowi				19.3294	25.0	90.6250	0.7843	16.6667	0.7463						
Erichsonella attenuata							1.2156	16.6667	0.7463						
Idotea balthica							13.9754	83.3333	21.6418						
Edotea triloba				2.3669	12.5	0.5208									
Amphidpoda							0.1372	33.3333	2.9851						
Ampithoe longimana										2.2249	25	5.4054			
Cymadusa compta							0.6274	16.6667	0.7463						
Gammaridea							0.0039	16.6667	10.4478						
Gammarus sp. A							0.7215	50.0000	29.8507						
Gammarus macronatus	0.7688	20	18.1818	3.0901	12.5	0.5208	2.1489	66.6667	7.427						
Microprotopus raneyi				3.9448	25.0	1.0417									
Caprella penantis							0.0078	33.3333	1.4925						
Decapoda															
Paleomonetes vulgaris	0.5952	10	4.5455							8.9588	50	5.4054			
Crangon septemspinosa	6.6889	10	9.0909	54.4379	25.0	3.6458	67.4496	83.3333	17.1642	51.5574	75	18.9189			
Callinectes sapidus										27.0246	25	8.1081			
Unid. Fish	79.2073	100	54.5455				0.3451	16.6667	0.7463	51.5574					
Fish Eggs													45.1833	50	2.439
Brevoortia tyrannus															
Anchoa mitchilli															
Atherinidae															
Leiostomus xanthurus	12.8388	10	9.0909												

Table 51

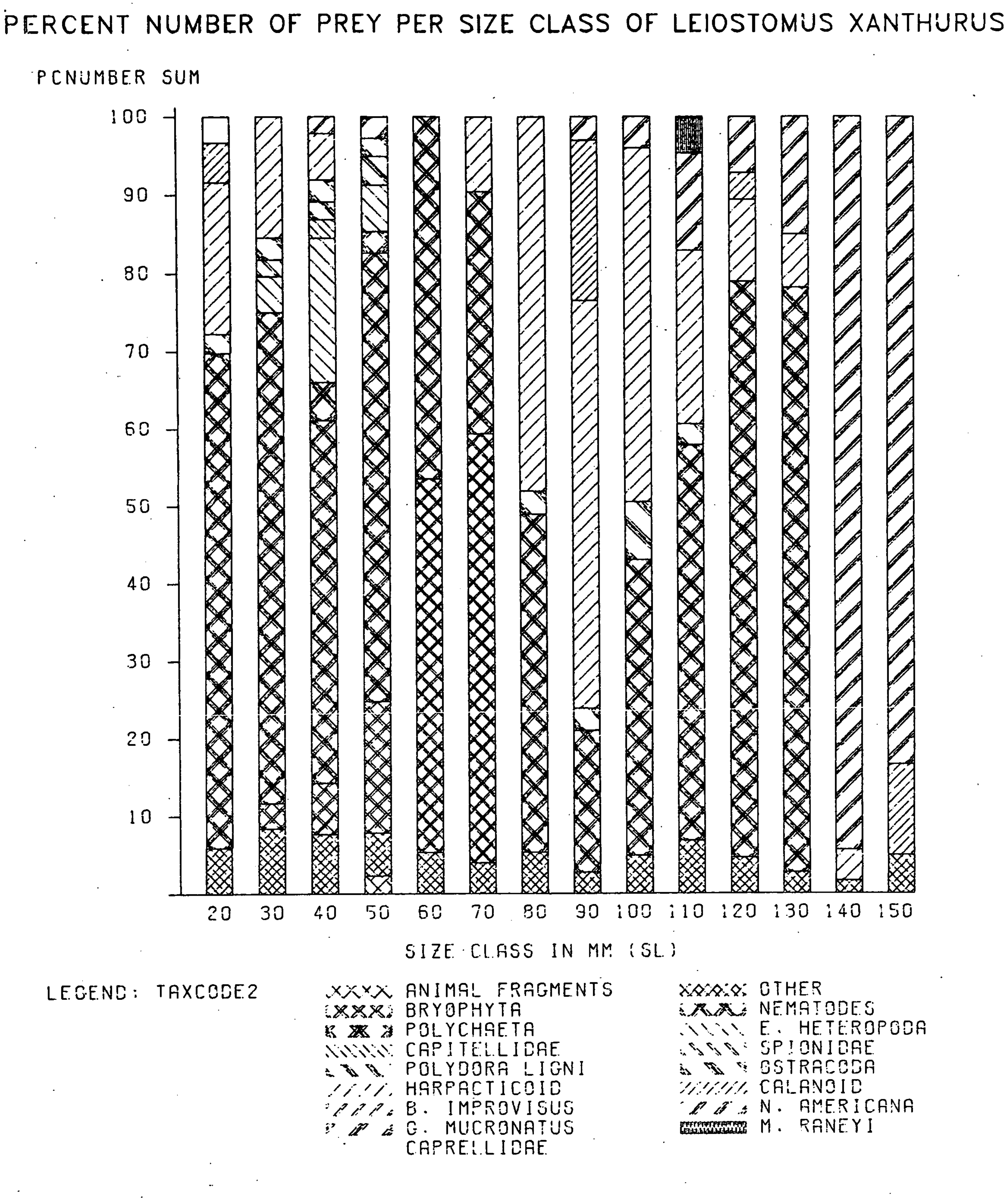
FREQUENCY OF OCCURRENCE FOR DOMINANT PREY ITEMS FOUND IN THE STOMACHS OF LEIOSTOMUS XANTHURUS

L20=20MM LENGTH (SL)

TAXCODE	L20	L30	L40	L50	L60	L70	L80	L90	L100	L110	L120	L130	L140	L150
ANIMAL FRAGMENTS	.	23.5	50.0	55.6	72.7	58.8	14.3	.	.	.	.	14.3	33.3	.
UNIDENT DETRITUS	.	.	.	.	.	.	53.6	30.8	38.1	41.7	41.7	71.4	.	.
BRYOPHYTA	.	17.6	15.4	33.3	54.5	41.2	.	.	.	.	.	.	.	.
PLANT DETRITUS	50.0	47.1	15.4	11.1	.	.	17.9	38.5	23.8	33.3	75.0	71.4	66.7	50.0
FORMANIFERA	.	.	.	.	.	.	10.7	.	.	.	16.7	.	.	.
HYDROZOANS	.	.	.	.	.	17.6	21.4	.	.	.	.	.	.	.
TREMATODA	.	.	.	.	.	.	.	.	.	.	.	.	.	50.0
NEMATODES	50.0	70.6	57.7	66.7	63.6	29.4	57.1	46.2	52.4	66.7	50.0	42.9	.	.
POLYCHAETA	25.0	35.3	23.1	33.3	.	11.8	21.4	23.1	.	25.0	25.0	42.9	.	.
E. HETEROPODA	50.0	58.8	46.2	44.4	.	.	.	.	.	.	.	.	.	.
SYLLIDAE	.	.	.	.	.	.	.	.	.	16.7	.	14.3	.	.
NEREIS SUCCINEA	.	.	.	11.1	.	.	.	.	.	.	.	.	.	.
G. DIBRANCHIATA	.	.	.	11.1	.	.	.	.	.	.	.	.	.	.
G. SOLITARIA	.	.	.	.	.	.	.	.	.	16.7	41.7	28.6	.	.
CAPITELLIDAE	.	11.8	11.5	11.1	.	.	.	.	.	.	.	.	.	.
H. FILIFORMIS	.	.	.	.	.	.	.	.	.	.	.	28.6	.	.
SPIONIDAE	.	.	11.5	.	.	.	.	.	.	.	.	.	.	.
POLYDORA LIGNI	.	23.5	15.4	44.4	.	.	.	.	.	.	.	.	.	.
P. PINNATA	.	.	.	.	.	.	.	.	.	.	.	14.3	.	.
ORBINIDAE	.	.	.	.	.	.	.	.	.	.	25.0	.	.	.
GASTROPODA	.	.	.	.	.	.	.	.	14.3	16.7	16.7	14.3	.	50.0
C. CONVEXA	.	.	.	.	.	.	14.3	.	.	.	.	.	.	.
PELECYPODA	.	11.8	.	11.1	.	.	.	.	.	.	.	.	.	.
OSTRACODA	25.0	47.1	19.2	44.4	.	.	35.7	34.6	28.6	41.7	50.0	28.6	.	.
HARPACTICOID	50.0	58.8	19.2	.	.	.	67.9	84.6	76.2	66.7	91.7	71.4	66.7	.
CALANOID	25.0	.	.	.	.	.	28.6	42.3	38.1	25.0	66.7	42.9	66.7	100
B. IMPROVISUS	.	23.5	19.2	11.1	36.4	11.8	.	.	.	.	.	.	.	.
N. AMERICANA	.	.	.	.	18.2	.	35.7	57.7	71.4	75.0	91.7	71.4	100	100
M. BIGELOWI	.	.	.	.	.	.	.	.	.	.	.	14.3	33.3	.

Table 51. (continued)

TAXCODE	L20	L30	L40	L50	L60	L70	L80	L90	L100	L110	L120	L130	L140	L150
CUMACEA	.	.	.	.	.	.	10.7	.	.	.	.	.	.	.
O. SMITHI	.	.	.	.	.	.	.	15.4	.	.	16.7	.	.	.
AMPHIPODA	.	.	.	.	.	.	14.3	26.9	.	16.7	16.7	.	.	.
AMPELISCA ABDITA	.	.	.	11.1	18.2	.	.	.	.	.	.	.	.	.
A. LONGIMANA	.	.	.	.	.	.	.	.	.	.	.	14.3	.	.
GAMMARIDEA	25.0	.	.	.	.	.	.	.	.	.	.	.	.	.
G. MUCRONATUS	25.0	.	15.4	55.6	.	.	.	.	.	.	.	14.3	.	.
M. RANEYI	.	.	.	.	.	.	17.9	23.1	23.8	41.7	25.0	28.6	.	.
CAPRELLIDAE	25.0	.	.	.	.	.	.	.	.	.	.	.	.	.
C. PENANTIS	.	.	11.5	.	.	.	.	.	.	.	.	.	.	.
P. TENUIS	.	.	.	.	.	.	.	11.5	.	.	.	.	.	.



PERCENT NUMBER OF PREY PER SIZE CLASS OF LEIOSTOMUS XANTHURUS
PCNUMBER SUM
100
90
80
70
60
50
40
30
20
10
20 30 40 50 60 70 80 90 100 110 120 130 140 150
SIZE CLASS IN MM (SL)
LEGEND: TAXCODE2
ANIMAL FRAGMENTS
BRYOPHYTA
POLYCHAETA
CAPITELLIDAE
POLYDORA LIGNI
HARPACTICOID
B. IMPROVISUS
G. MUCRONATUS
CAPRELLIDAE
OTHER
NEMATODES
E. HETEROPODA
SPIONIDAE
OSTRACODA
CALANOID
N. AMERICANA
M. RANEYI

Figure 25

PERCENT WEIGHT OF PREY PER SIZE CLASS OF LEIOSTOMUS XANTHURUS

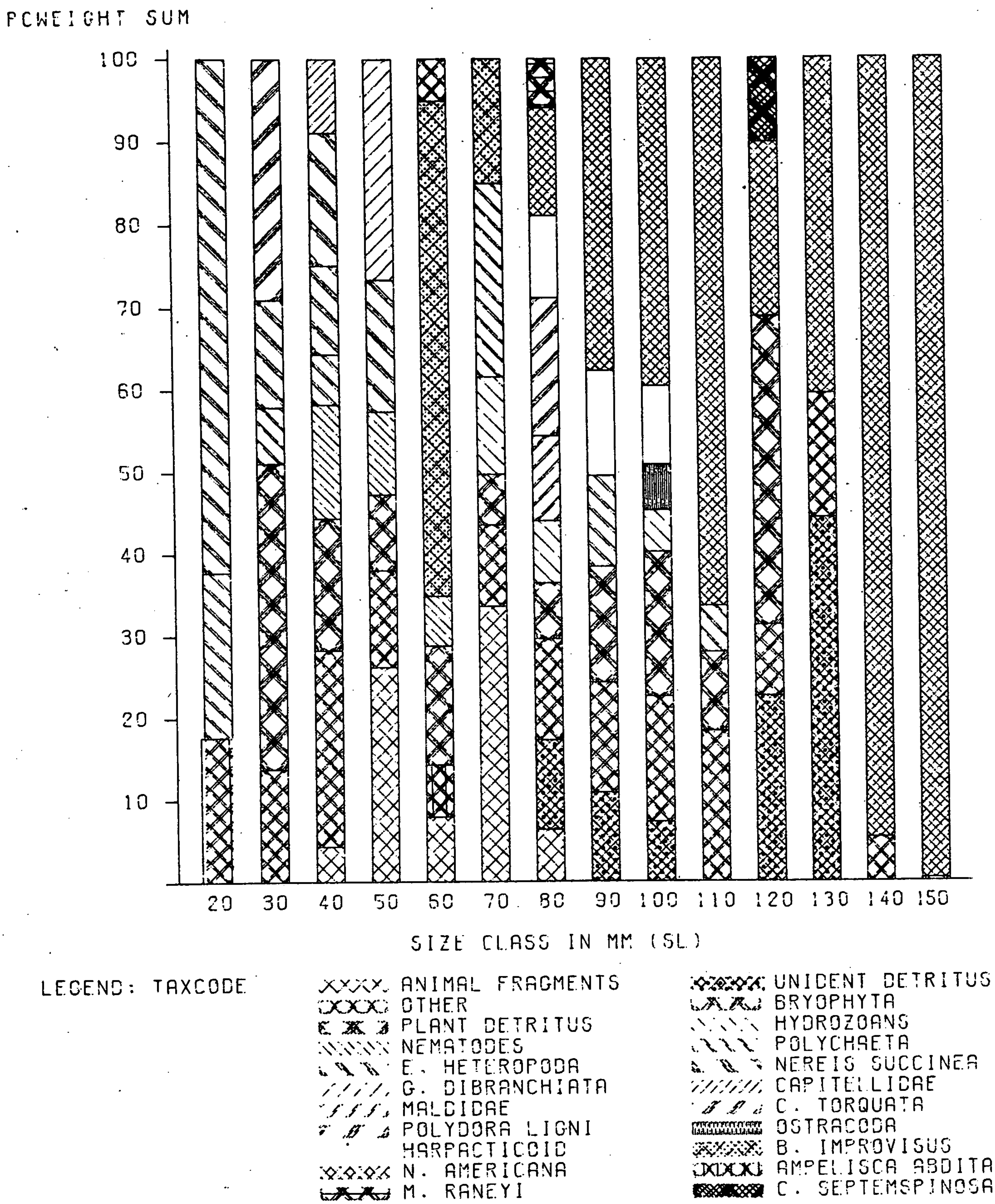


Figure 26

by percent weight, as spot increased in size, the amount of unidentified material in their stomachs increased. Frequency of occurrence (Table 51) suggests that polychaetes are frequently eaten by most sizes of spot. Percent number and percent weight may not adequately define the importance of polychaetes to spot. Mastication of polychaetes creates difficulty in counting and polychaetes digest quickly so that their true weight is often underestimated. As early juvenile spot enter the SAV bed in April (Figures 27 and 28, Table 52) planktonic feeding on calanoid copepods quickly switched in May to epibenthic and benthic feeding on amphipods, isopods, harpacticoid copepods, and polychaetes. August and September spot stomachs contained a large portion of animal fragments in their stomachs (Figure 28) and Table 24) and indicate a large difference in prey selectivity between October of 1978 and 1979. Unlike October 1979, in October 1978 swarms of Neomysis americana covered the study area. In 1979, spot switched to preying on mysid shrimps in November instead of October.

Percent number, percent weight and frequency of occurrence (Figure 29 and 30, Table 53) indicate a large reduction in consumption of calanoid copepods as silver perch grows from 20mm to 70mm. Silver perch also increase consumption of Neomysis americana from 30mm to 150mm. Crangon septemspinosa was also a dominant prey item by weight for 50mm to 110mm B. chrysoura. Monthly changes in percent number (Figure 31) and frequency of occurrence (Table 54) of prey items consumed by silver perch indicate a gradual shift from a predominantly calanoid copepod consumer (August to October to a diet of mysid shrimp by November. However, percent weight (Figure 32) indicates that C. septemspinosa is also a dominant food item from August

MONTHLY CHANGE IN THE PCNUMBER OF PREY ITEMS FOUND IN THE STOMACHS OF LEIOSTOMUS XANTHURUS

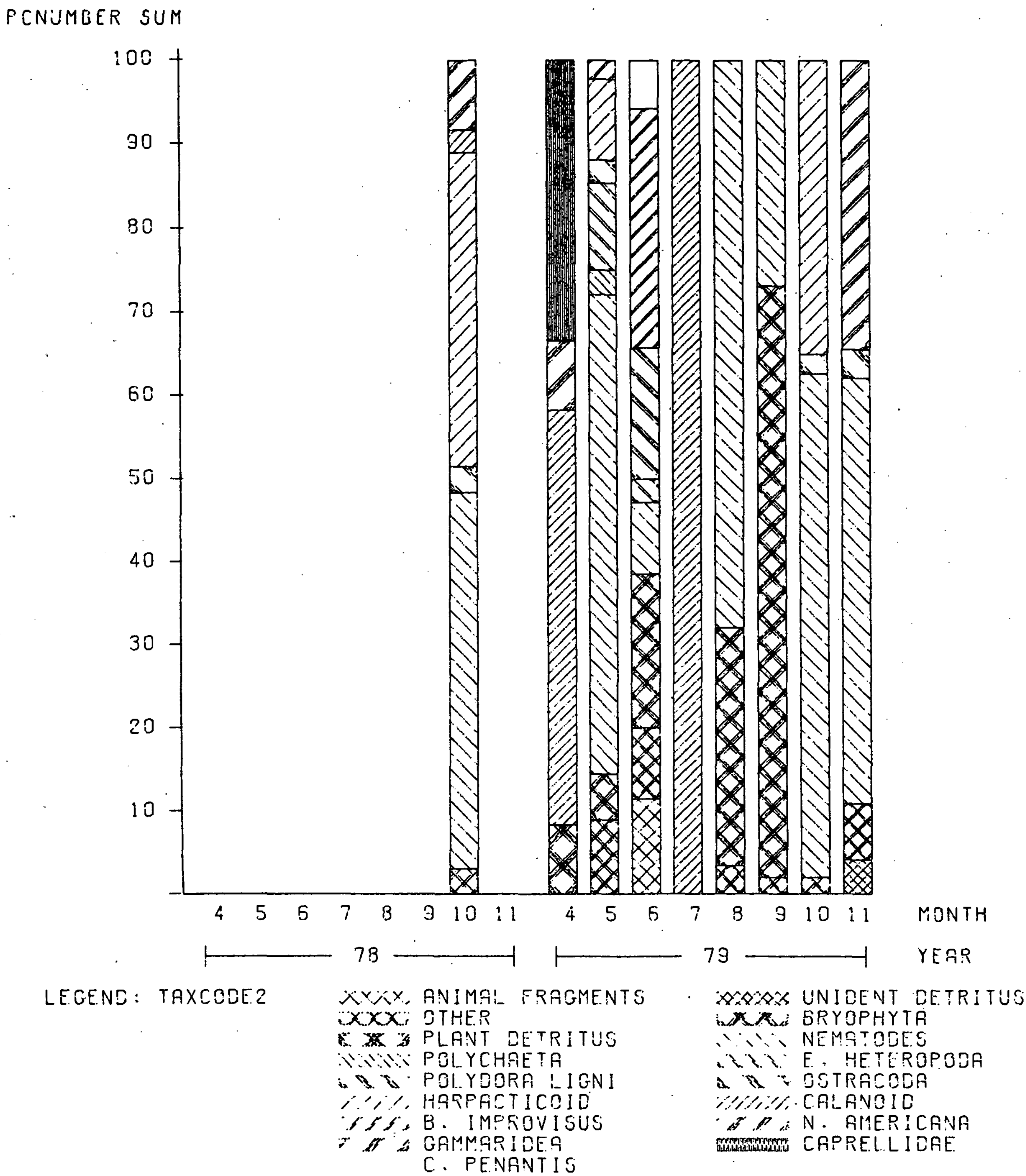


Figure 27

MONTHLY CHANGES IN THE PCWEIGHT OF PREY ITEMS FOUND IN THE STOMACHS OF LEIOSTOMUS XANTHURUS

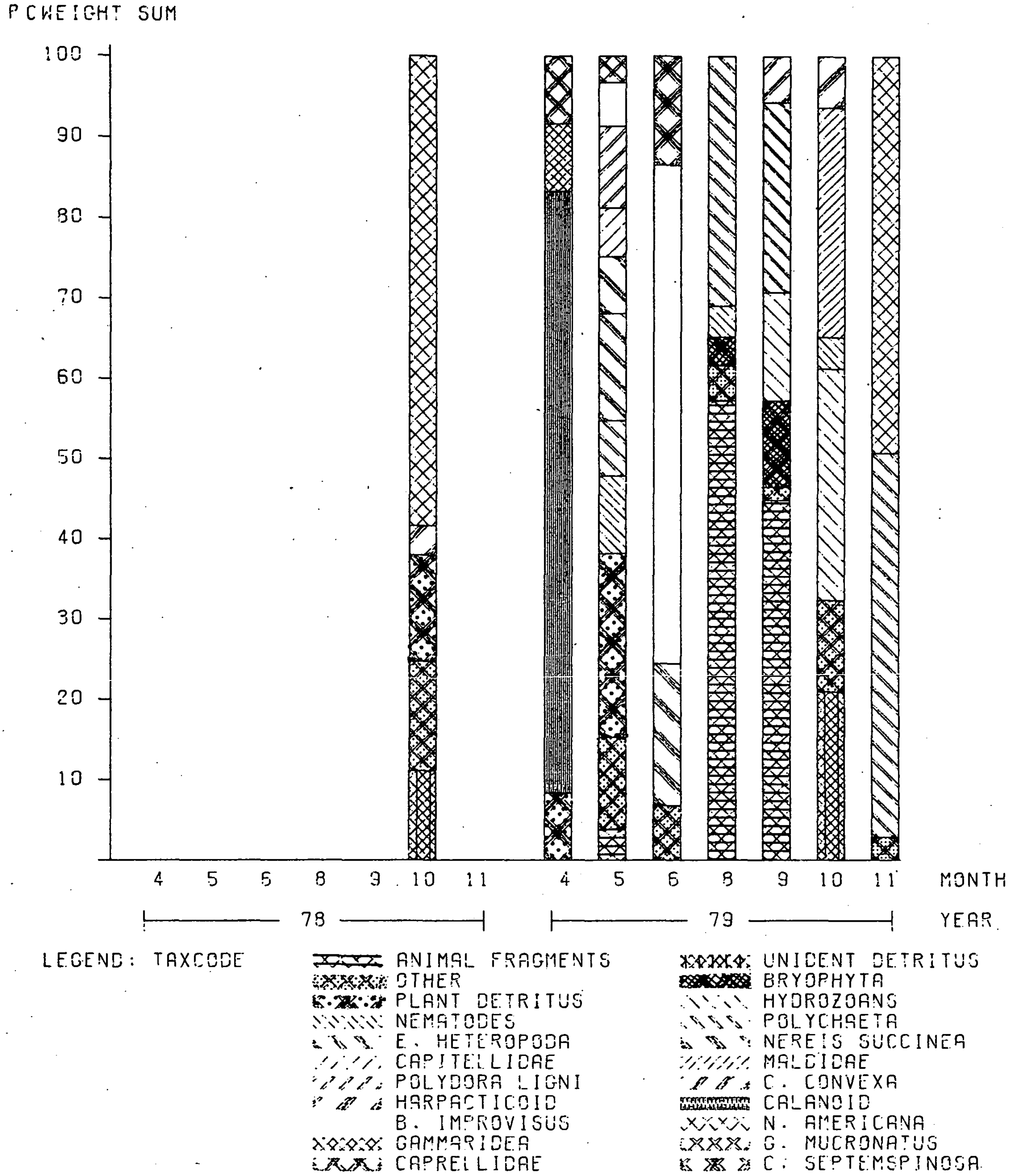


Figure 28

Table 52

FREQUENCY OF OCCURRENCE OF DOMINANT PREY ITEMS FOUND IN THE STOMACHS OF LEIOSTOMUS XANTHURUS

TAXCODE	JULY78	OCT78	APRIL79	MAY79	JUNE79	JULY79	AUG79	SEPT79	OCT79	NOV79
ANIMAL FRAGMENTS	.	.	.	38.8	61.5	.	87.5	69.2	.	.
UNIDENT DETRITUS	.	42.7	.	.	.	.	.	.	43.8	41.7
BRYOPHYTA	.	.	.	18.4	23.1	.	62.5	61.5	.	.
PLANT DETRITUS	.	50.0	50.0	28.6	.	.	.	.	.	.
HYDROZOANS	.	.	.	.	.	.	.	15.4	43.8	.
NEMATODES	.	59.8	.	71.4	15.4	.	87.5	30.8	31.3	.
POLYCHAETA	.	19.5	.	32.7	.	.	50.0	.	.	16.7
E. HETEROPODA	.	.	.	55.1	15.4	.	.	.	.	.
SYLLIDAE	.	12.2	.	.	.	.	.	.	.	.
NEREIS SUCCINEA	.	.	.	.	.	.	12.5	.	.	.
G. DIBRANCHIATA	.	.	.	10.2	.	.	.	.	.	.
G. SOLITARIA	.	14.6	.	.	.	.	.	.	.	.
CAPITELLIDAE	.	.	.	12.2	.	.	.	.	.	.
POLYDORA LIGNI	.	.	.	22.4	23.1	.	.	.	.	.
GASTROPODA	.	14.6	.	.	.	.	.	.	.	.
C. CONVEXA	.	.	.	.	.	.	.	.	18.8	.
PELECYPODA	.	.	.	10.2	.	.	12.5	.	.	.
OSTRACODA	.	42.7	.	38.8	.	.	.	.	12.5	.
HARPACTICOID	.	96.3	.	34.7	.	.	.	.	31.3	.
CALANOID	.	53.7	50.0	.	.	100	.	.	.	.
B. IMPROVISUS	.	.	.	24.5	30.8	.	.	.	.	.
N. AMERICANA	.	75.6	.	.	.	.	37.5	.	.	58.3
AMPHIPODA	.	17.1	.	.	.	.	12.5	.	.	16.7
AMPELISCA ABDITA	.	.	.	.	.	.	12.5	.	.	.
GAMMARIDEA	.	.	50.0	.	.	.	.	.	.	.
G. MUCRONATUS	.	.	.	24.5	.	.	.	.	.	.
M. RANEYI	.	31.7	.	.	.	.	.	.	.	.
CAPRELLIDAE	.	.	50.0	.	.	.	.	.	.	.
C. PENANTIS	.	.	.	.	23.1	.	.	.	.	.


PERCENT NUMBER OF PREY PER SIZE CLASS OF BAIRDIELLA CHRYSOURA
PCNUMBER SUM
100
90
80
70
60
50
40
30
20
10
20 30 40 50 60 70 80 90 100 110 120 130 140 150
SIZE CLASS IN MM (SL)
LEGEND: TAXCODE2
OTHER
N. AMERICANA
G. MUCRONATUS
C. PENANTIS
CALANOID
IDOTEA BALTHICA
M. RANEYI
C. SEPTEMSPINOSA

Figure 29

PERCENT WEIGHT OF PREY PER SIZE CLASS OF BAIRDIELLA CHRYSOUR/

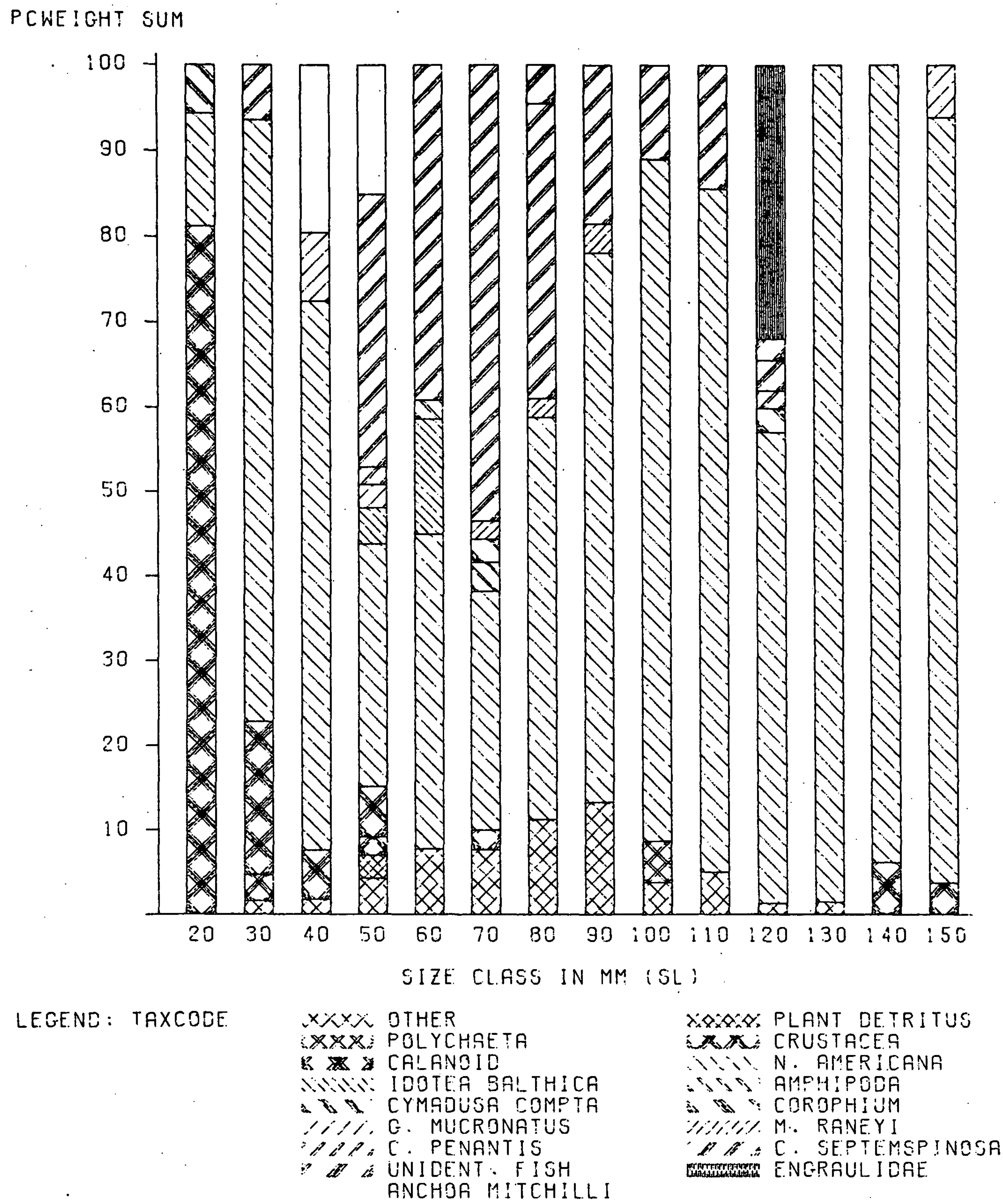


Figure 30

Table 53

FREQUENCY OF OCCURRENCE FOR DOMINANT PREY ITEMS FOUND IN THE STOMACHS OF BAIRDIELLA CHRYSOURA

----------------------------------[L20=20MM LENGTH (SL)]------------------------------------

TAXCODE	L20	L30	L40	L50	L60	L70	L80	L90	L100	L110	L120	L130	L140	L150
UNIDENT DETRITUS	.	.	.	.	.	19.0	22.7	23.3	13.0	26.3	16.7	.	.	.
PLANT DETRITUS	.	.	11.1	.	.	.	.	.	.	.	.	.	.	.
CRUSTACEA	.	.	.	11.1	.	.	.	.	.	.	.	.	.	.
CALANOID	100	54.5	27.8	27.8	22.7	33.3	31.8	20.0	.	21.1	.	25.0	100	100
N. AMERICANA	50.0	54.5	61.1	55.6	68.2	71.4	77.3	93.3	95.7	94.7	83.3	100	100	100
M. BIGELOWI	.	.	.	.	.	.	.	.	13.0	.	.	.	.	.
E. ATTENUATA	.	.	.	16.7	.	.	13.6	.	.	.	.	25.0	.	.
IDOTEA BALTHICA	.	.	.	11.1	22.7	.	.	.	.	.	.	.	.	.
AMPHIPODA	.	.	16.7	11.1	13.6	.	13.6	13.3	.	10.5	.	.	.	.
AMPITHOIDAE	.	.	.	.	.	.	.	.	.	.	.	.	50.0	.
A. LONGIMANA	.	.	.	.	.	.	13.6	.	.	.	.	.	.	.
CYMADUSA COMPTA	25.0	.	11.1	.	.	.	.	.	.	.	.	.	.	.
COROPHIUM	.	.	.	.	.	14.3	.	.	.	.	.	.	.	.
G. MUCRONATUS	.	.	22.2	11.1	22.7	.	.	.	.	.	.	.	.	100
M. RANEYI	.	.	11.1	.	.	23.8	50.0	20.0	13.0	15.8	.	.	.	.
C. PENANTIS	.	.	11.1	16.7	13.6	19.0	31.8	33.3	13.0	10.5	16.7	.	.	.
C. SEPTEMSPINOSA	.	.	.	22.2	36.4	38.1	40.9	23.3	26.1	36.8	.	.	.	.
UNIDENT. FISH	.	.	.	.	.	.	.	.	.	.	16.7	.	.	.
ANCHOA MITCHILLI	.	.	11.1	.	.	.	.	.	.	.	.	.	.	.

MONTHLY CHANGES IN THE PERCENT NUMBER OF PREY ITEMS FOUND IN THE STOMACHS OF BAIRDIELLA CHRYSOUR

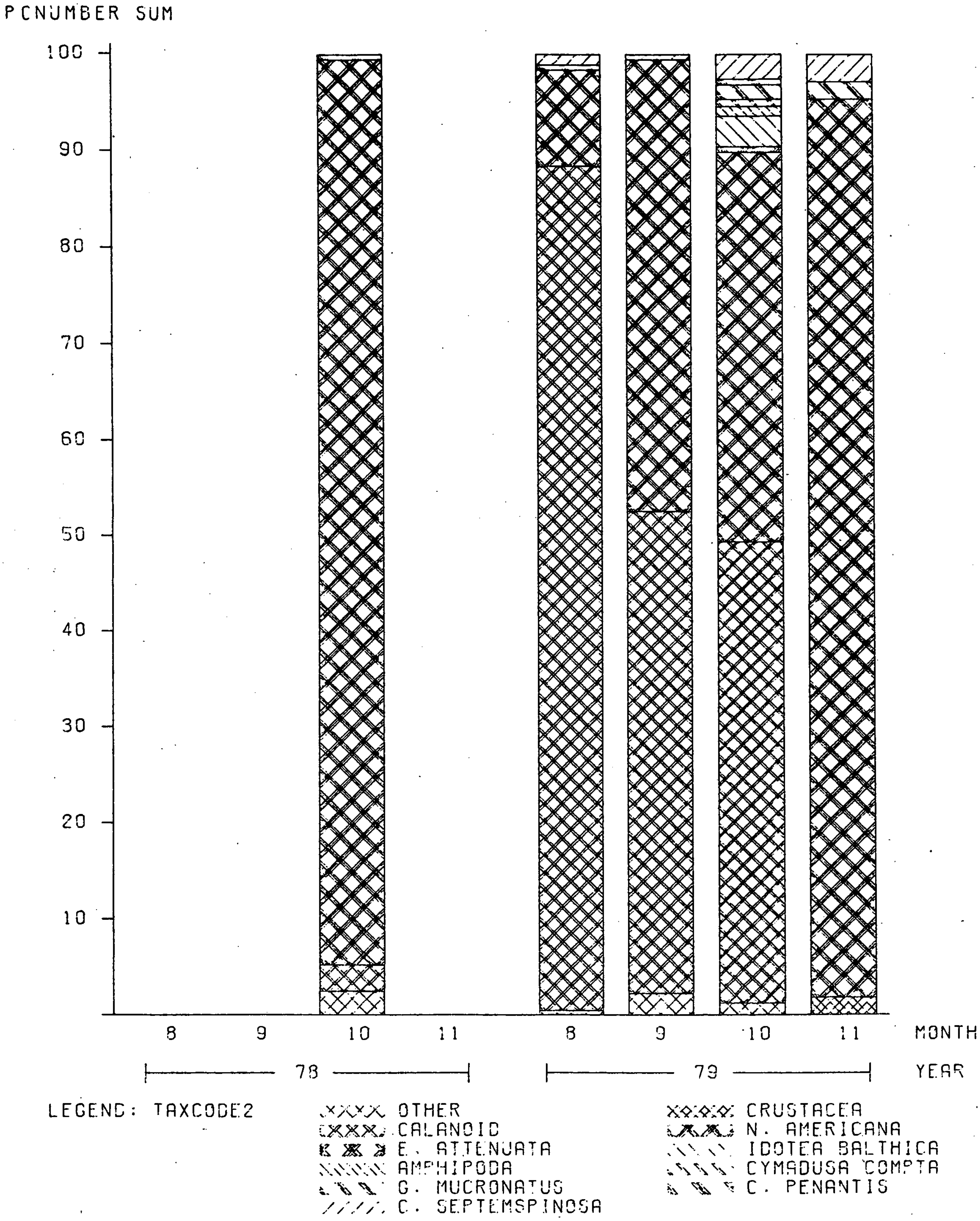


Figure 31

MONTHLY CHANGES IN THE PCWEIGHT OF PREY ITEMS FOUND IN THE STOMACHS OF BAIRDIELLA CHRYSOURA

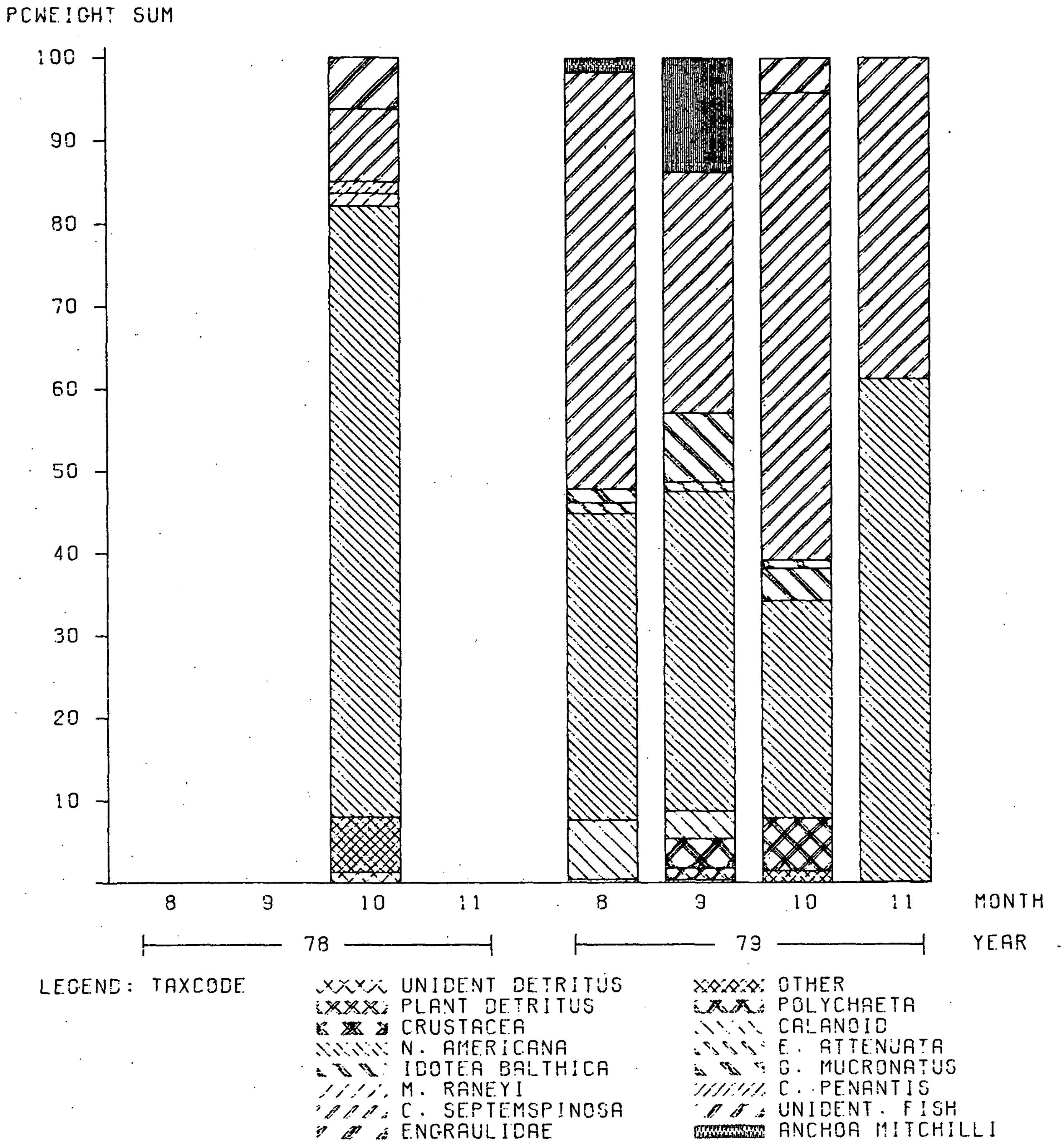


Figure 32

Table 54

FREQUENCY OF OCCURRENCE OF DOMINANT PREY ITEMS FOUND IN THE STOMACHS OF BAIRDIELLA CHRYSOURA

TAXCODE	JULY78	OCT78	APRIL79	MAY79	JUNE79	JULY79	AUG79	SEPT79	OCT79	NOV79
UNIDENT DETRITUS	.	23.5	.	.	.	.	.	.	.	.
PLANT DETRITUS	.	.	.	.	.	.	.	.	17.4	.
CRUSTACEA	.	.	.	.	.	.	.	.	.	18.2
CALANOID	.	28.7	.	.	.	.	44.4	19.4	17.4	.
N. AMERICANA	.	95.7	.	.	.	.	55.6	67.7	26.1	81.8
E. ATTENUATA	.	.	.	.	.	.	.	.	17.4	.
IDOTEA BALTHICA	.	.	.	.	.	.	.	.	34.8	.
AMPHIPODA	.	11.3	.	.	.	.	.	.	17.4	.
CYMADUSA COMPTA	.	.	.	.	.	.	.	.	17.4	.
G. MUCRONATUS	.	.	.	.	.	.	14.8	.	34.8	18.2
M. RANEYI	.	25.2	.	.	.	.	.	.	.	.
C. PENANTIS	.	26.1	.	.	.	.	.	.	21.7	.
C. SEPTEMSPINOSA	.	23.5	.	.	.	.	14.8	16.1	52.2	27.3

to November. Percent number (Figure 31) points out that as with spot, B. chrysoura food habits during October 1978 were more like November 1979 than October 1979.

Syngnathus fuscus feed upon a wide variety of amphipods as well as calanoid copepods, mysids, and polychaetes. Percent number (Figure 33) and frequency of occurrence (Table 55) indicate that calanoid copepods were the dominant prey item selected by 60-160mm pipefish. Figure 34 illustrates that although calanoid copepods were important prey items, Neomysis americana and several species of amphipods were more important in terms of weight to this size range of pipefish. All three food indices indicate that 120-180mm pipefish have a diverse diet dominated by Caprella penantis and Gammarus mucronatus.

Pipefish food habits were analyzed from July 1978 to November 1979 (Figures 35 and 36, Table 56). Calanoid copepods were the most consistently consumed prey (Figure 22 and Table 28). All food indices showed large variations in preferred species of amphipods. The variations may be due to changes in available prey sizes as well as prey density. Pipefish prey items of July and October of 1978 and 1979 were very different. Unlike October 1978, in October 1979 N. americana was not an important food item. N. americana was an important prey item in November 1979.

The migratory predators fed primarily on fishes, blue crab, and sand shrimp (Figures 37 and 38, Tables 57 and 58). Summer flounder (P. dentatus) under 200mm SL preyed almost exclusively on mysids and Crangon septemspinosa. Larger specimens preyed almost primarily on fishes which included Leiostomus xanthurus and Syngnathus fuscus. Spotted seatrout (Cynoscion nebulosus) and weakfish (C. regalis) demonstrated similar feeding habits. Diets were comprised primarily of fishes (including Brevoortia tyrannus, L. xanthurus, Anchoa mitchilli, and Mugil cephalus) and several invertebrates (Crangon

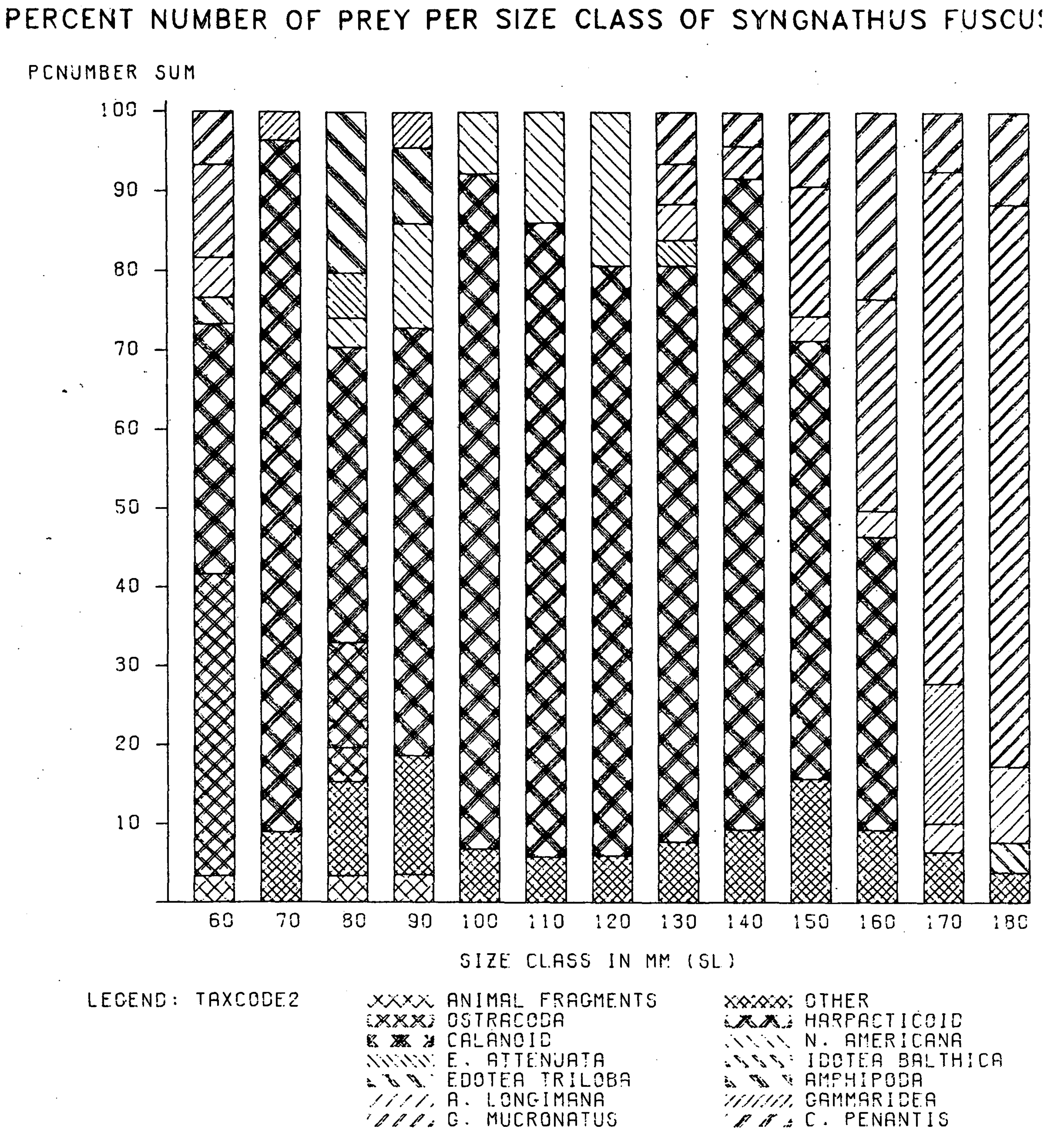

PERCENT NUMBER OF PREY PER SIZE CLASS OF SYNGNATHUS FUSCU
PCNUMBER SUM
100
90
80
70
60
50
40
30
20
10
60
70
80
90
100
110
120
130
140
150
160
170
180
SIZE CLASS IN MM (SL)
LEGEND: TAXCODE2
ANIMAL FRAGMENTS
OTHER
OSTRACODA
HARPACTICOID
CALANOID
N. AMERICANA
E. ATTENUATA
IDOTEA BALTHICA
EDOTEA TRILOBA
AMPHIPODA
A. LONGIMANA
GAMMARIDEA
G. MUCRONATUS
C. PENANTIS

Figure 33

Table 55

FREQUENCY OF OCCURRENCE FOR DOMINANT PREY ITEMS FOUND IN THE STOMACHS OF SYNGNATHUS FUSCUS

-----------------------------------[L20=20MM LENGTH (SL)]-----------------------------------

TAXCODE	L60	L70	L80	L90	L100	L110	L120	L130	L140	L150	L160	L170	L180
ANIMAL FRAGMENTS	66.7	35.7	58.8	57.7	39.4	37.5	30.4	53.3	37.5	64.7	45.5	100	75.0
UNIDENT DETRITUS	.	.	.	.	.	12.5	.	.	.	.	.	.	.
PLANT DETRITUS	.	.	.	.	.	.	.	.	12.5	.	18.2	.	.
FORMANIFERA	.	.	23.5	.	.	.	.	.	.	.	.	.	.
NEREIS REMAINS	.	.	.	.	.	.	.	13.3	.	.	.	.	.
OSTRACODA	33.3	.	11.8	.	.	.	.	13.3	12.5	17.6	.	50.0	.
HARPACTICOID	.	.	17.6	.	.	.	.	.	.	.	.	.	.
CALANOID	66.7	78.6	52.9	46.2	48.5	54.2	39.1	26.7	20.8	17.6	.	.	.
B. IMPROVISUS	.	.	.	.	.	.	.	.	.	11.8	.	25.0	.
N. AMERICANA	.	14.3	.	30.8	33.3	54.2	47.8	13.3	16.7	17.6	.	.	.
E. ATTENUATA	.	.	29.4	15.4	.	.	13.0	13.3	16.7	11.8	.	.	.
IDOTEA BALTHICA	.	.	17.6	15.4	.	16.7	.	26.7	20.8	11.8	18.2	25.0	75.0
EDOTEA TRILOBA	66.7	.	11.8	.	.	.	.	.	.	.	.	.	.
AMPHIPODA	.	28.6	58.8	30.8	.	.	.	.	.	11.8	18.2	.	.
A. LONGIMANA	33.3	.	11.8	.	.	.	21.7	26.7	29.2	23.5	27.3	50.0	75.0
GAMMARIDEA	.	14.3	11.8	15.4	.	.	.	26.7	25.0	.	.	50.0	.
G. PALUSTRIS	.	.	.	.	.	.	.	.	.	.	18.2	.	.
G. MUCRONATUS	33.3	.	.	11.5	.	.	13.0	13.3	25.0	41.2	27.3	100	100
M. RANEYI	.	.	.	11.5	.	.	17.4	.	12.5	23.5	.	25.0	.
C. PENANTIS	33.3	.	11.8	11.5	18.2	16.7	21.7	60.0	50.0	64.7	81.8	50.0	75.0
P. TENUIS	.	.	23.5	11.5	.	.	.	.	.	11.8	.	.	25.0

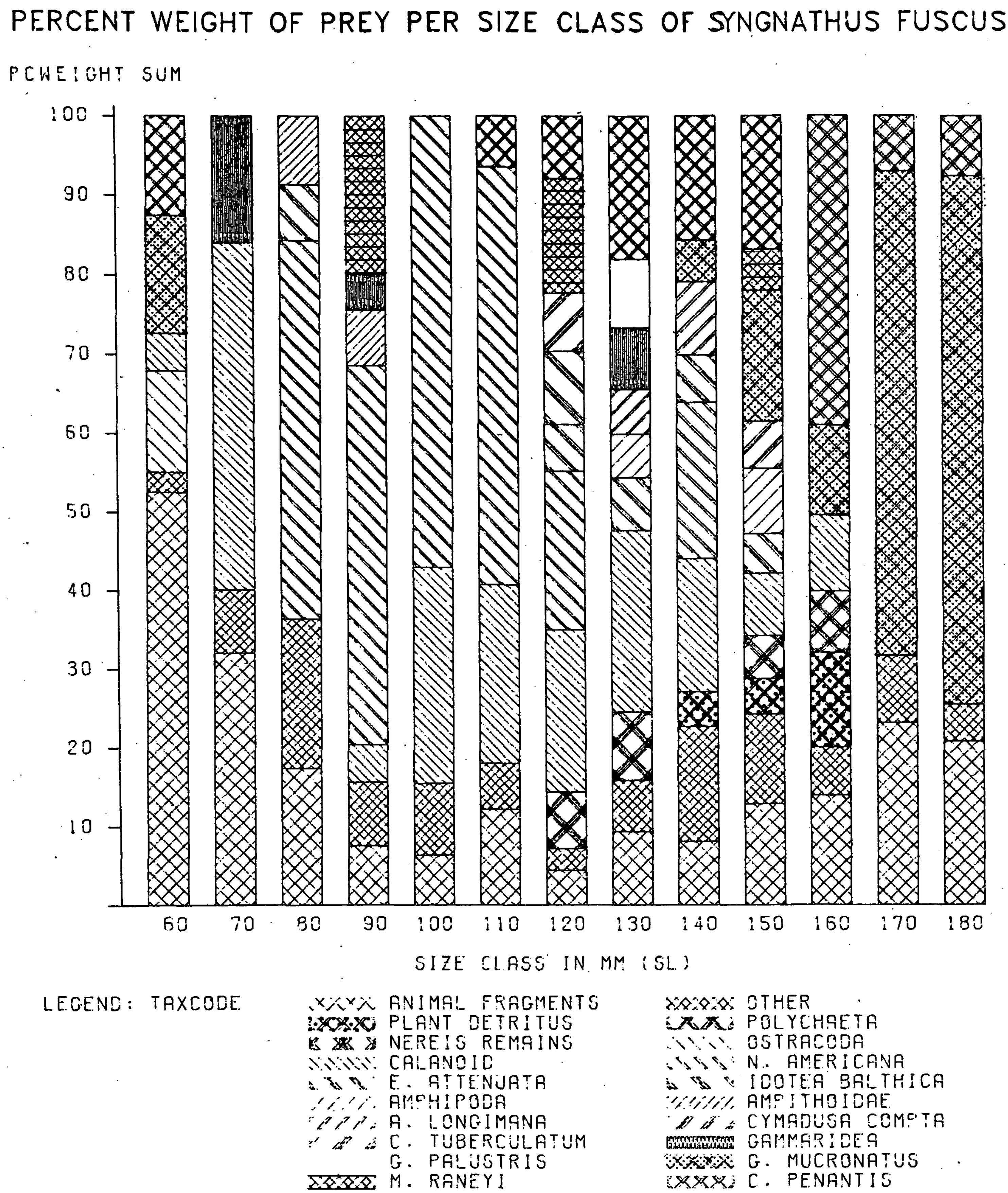

PERCENT WEIGHT OF PREY PER SIZE CLASS OF SYNGNATHUS FUSCUS
PCWEIGHT SUM
100
90
80
70
60
50
40
30
20
10
60
70
80
90
100
110
120
130
140
150
160
170
180
SIZE CLASS IN MM (SL)
LEGEND: TAXCODE
ANIMAL FRAGMENTS
PLANT DETRITUS
NEREIS REMAINS
CALANOID
E. ATTENUATA
AMPHIPODA
A. LONGIMANA
C. TUBERCULATUM
G. PALUSTRIS
M. RANEYI
OTHER
POLYCHAETA
OSTRACODA
N. AMERICANA
IDOTEA BALTHICA
AMPITHOIDAE
CYMADUSA COMPTA
GAMMARIDEA
G. MUCRONATUS
C. PENANTIS

Figure 34

MONTHLY CHANGES IN THE PCNUMBER OF PREY ITEMS FOUND IN THE STOMACHS OF SYNGNATHUS FUSCU:

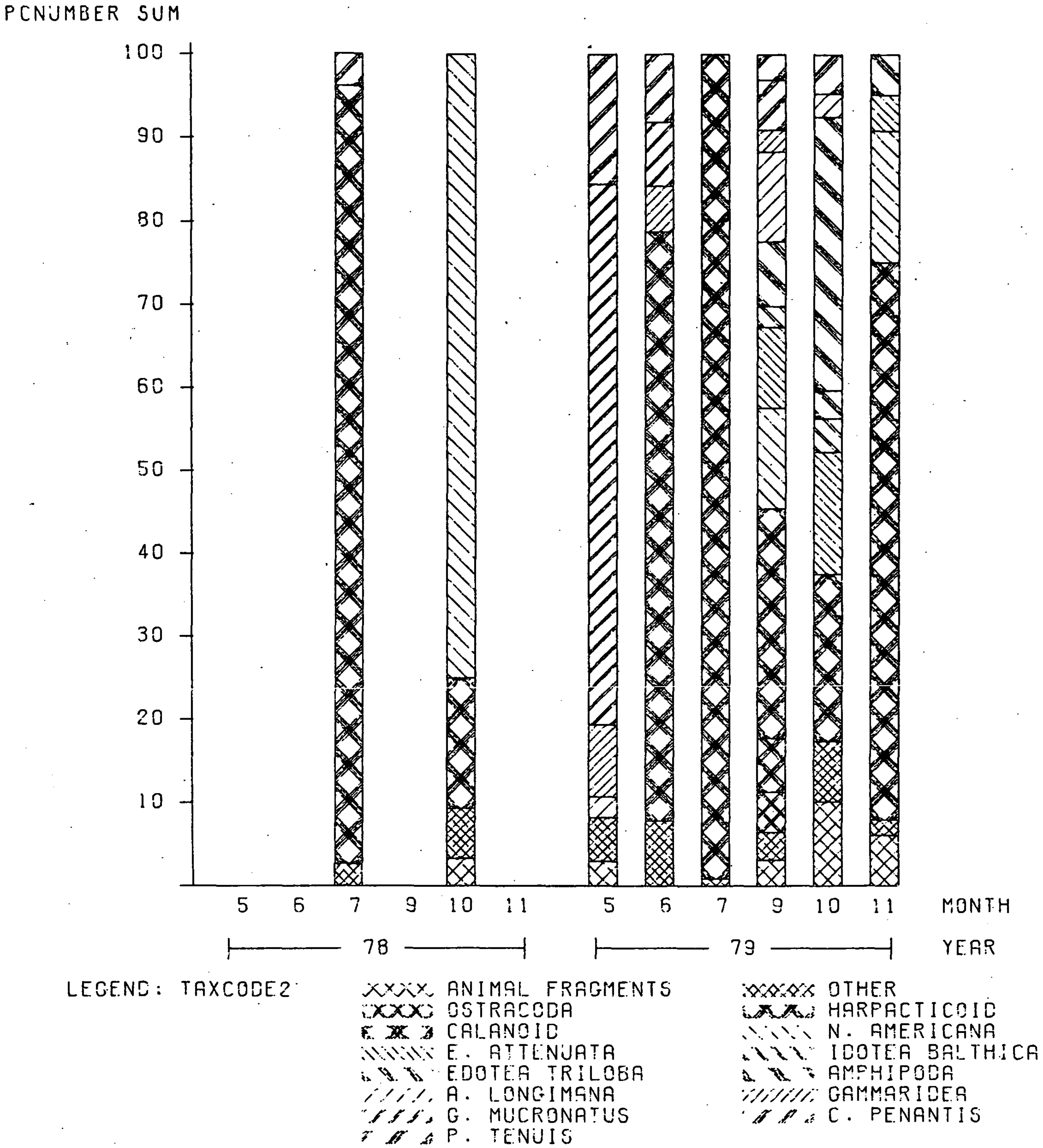


Figure 35

MONTHLY CHANGES IN THE PCWEIGHT OF PREY ITEMS FOUND IN THE STOMACHS OF SYNGNATHUS FUSCUS

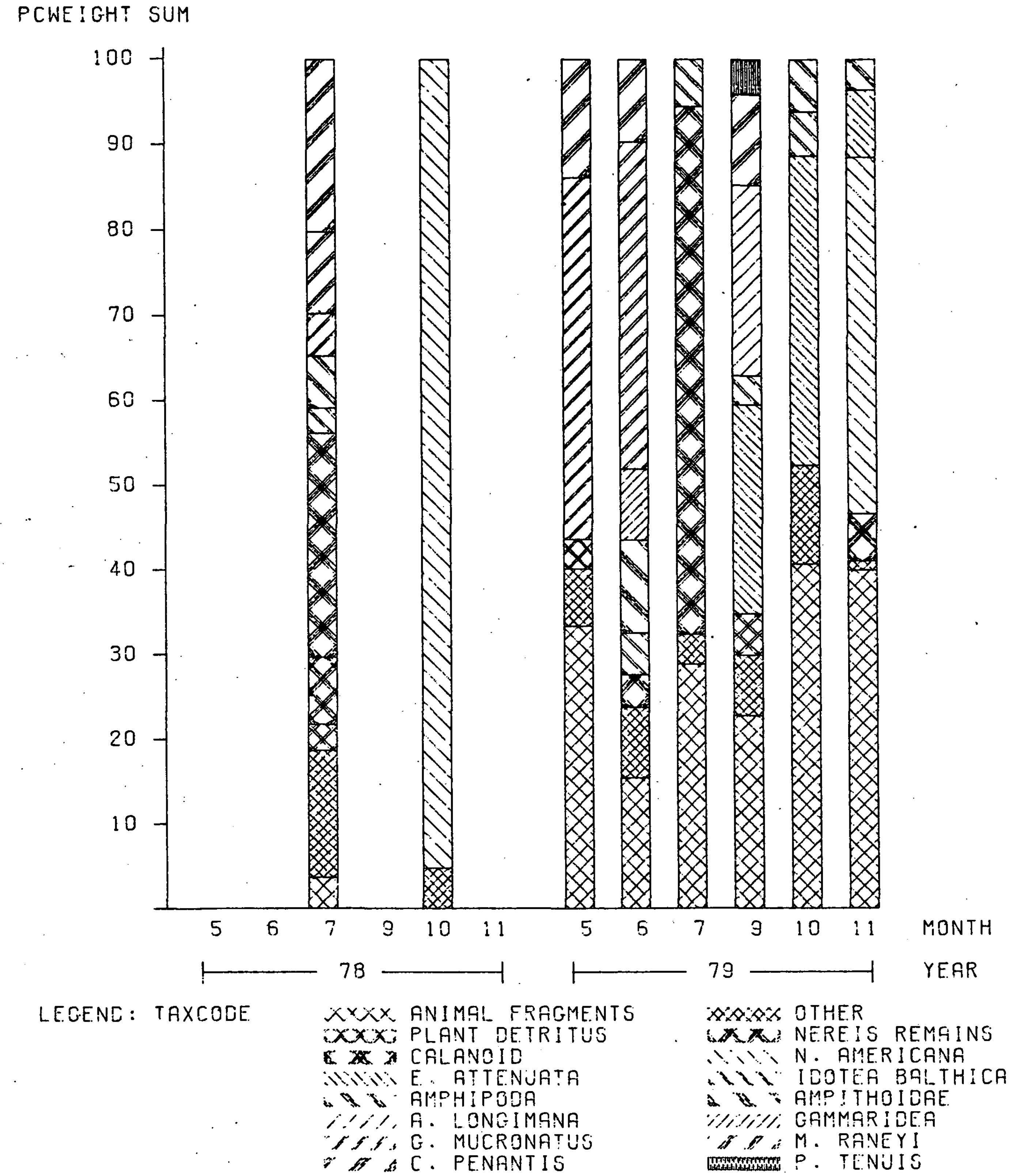


Figure 36

Table 56

FREQUENCY OF OCCURRENCE OF DOMINANT PREY ITEMS FOUND IN THE STOMACHS OF SYNGNATHUS FUSCUS

TAXCODE	JULY78	OCT78	APRIL79	MAY79	JUNE79	JULY79	AUG79	SEPT79	OCT79	NOV79
ANIMAL FRAGMENTS	.	25.0	.	95.5	48.0	14.3	.	73.0	78.9	50.0
FORMANIFERA	.	.	.	.	.	.	.	.	10.5	.
NEREIS REMAINS	15.4	.	.	.	.	.	.	.	.	.
OSTRACODA	.	.	.	31.8	.	.	.	21.6	10.5	.
HARPACTICOID	.	.	.	.	.	.	.	10.8	.	.
CALANOID	57.7	28.8	.	.	52.0	92.9	.	37.8	42.1	25.0
B. IMPROVISUS	.	.	.	18.2	.	.	.	.	.	.
N. AMERICANA	.	82.7	.	.	.	.	.	.	.	50.0
E. ATTENUATA	.	.	.	.	.	.	.	37.8	47.4	.
IDOTEA BALTHICA	11.5	.	.	.	36.0	14.3	.	32.4	26.3	.
EDOTEA TRILOBA	.	.	.	.	.	.	.	.	15.8	.
P. CAUDATA	.	.	.	.	.	.	.	.	10.5	.
AMPHIPODA	23.1	.	.	.	.	.	.	21.6	52.6	30.0
A. LONGIMANA	.	.	.	27.3	16.0	.	.	40.5	10.5	.
GAMMARIDEA	11.5	.	.	31.8	36.0	.	.	18.9	.	.
G. PALUSTRIS	15.4	.	.	.	.	.	.	.	.	.
G. MUCRONATUS	11.5	.	.	90.9	44.0	.	.	.	.	.
M. RANEYI	30.8	.	.	13.6	.	.	.	.	.	.
C. PENANTIS	50.0	.	.	86.4	56.0	.	.	45.9	.	.
P. TENUIS	.	.	.	.	.	.	.	24.3	21.1	.

PERCENT NUMBER OF PREY ITEMS FOUND IN THE STOMACHS OF MEGAPREDATORS

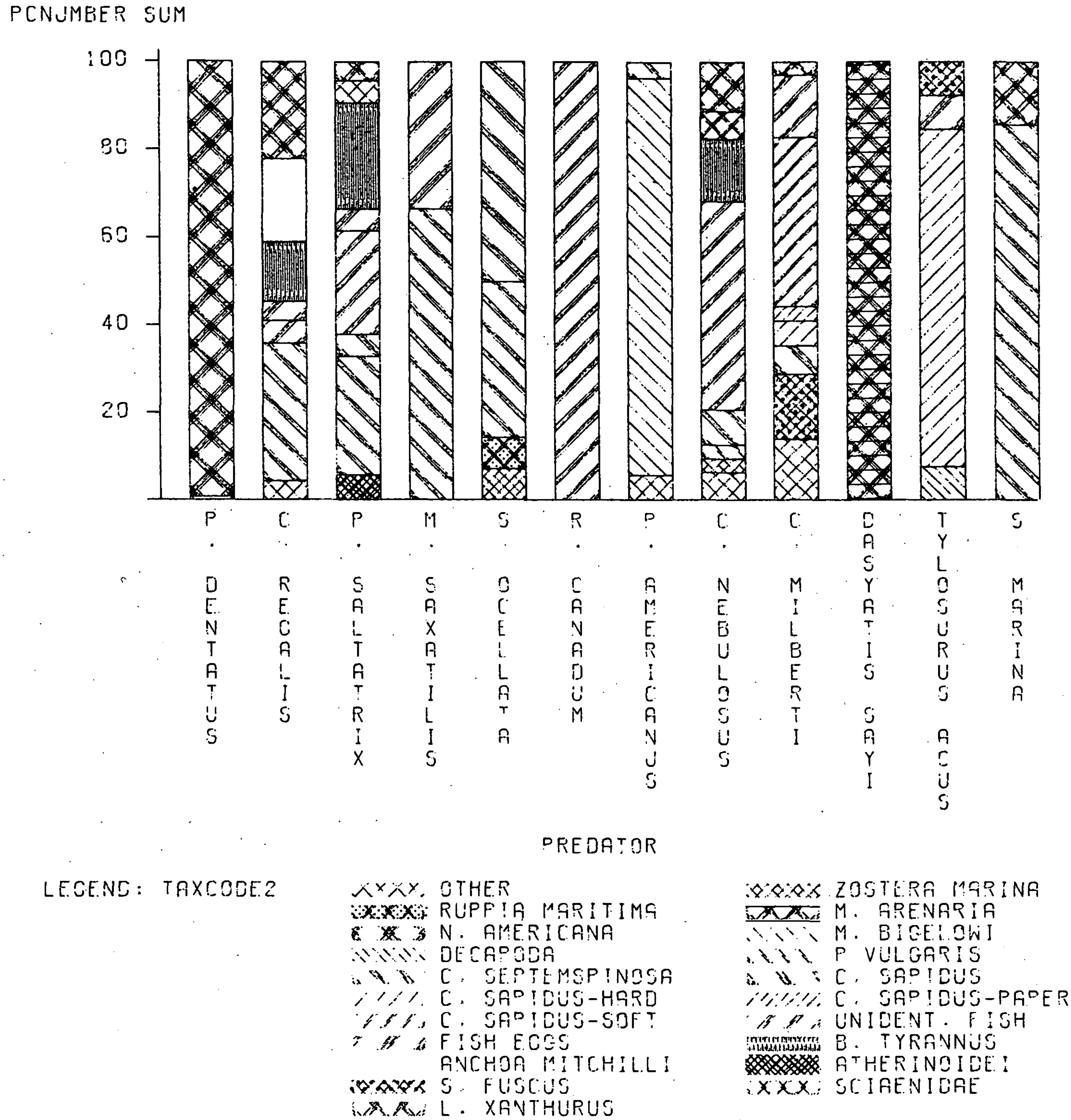


Figure 37

PERCENT WEIGHT OF PREY ITEMS FOUND IN THE STOMACHS OF MEGAPREDATORS

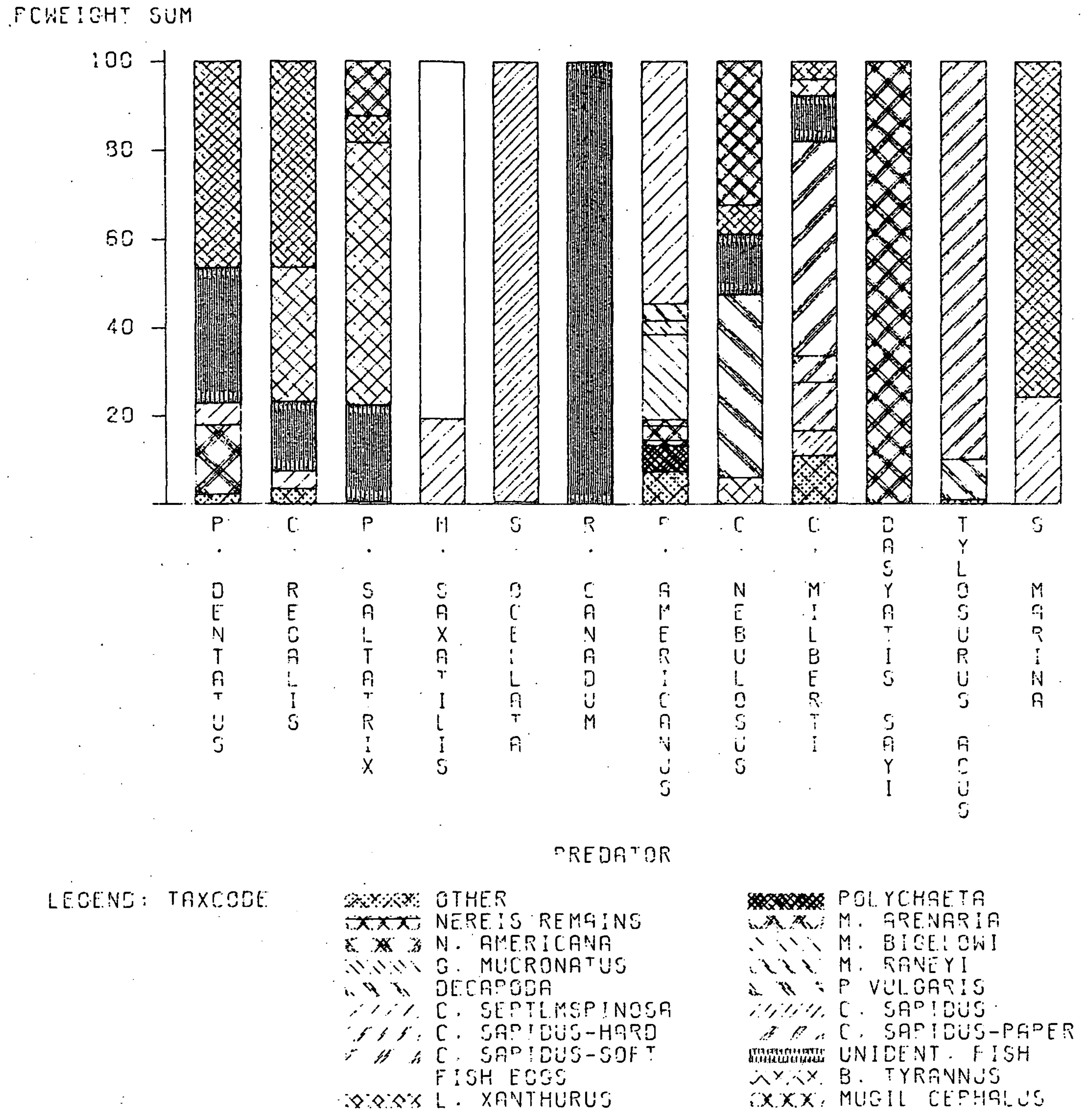


Figure 38

Table 57
Dominant Megapredators

Food Item	*Carcharhinus milberti* (199) % Wt	% Occ	% N	*Pomatomus saltatrix* (63) % Wt	% Occ	% N	*Cynoscion regalis* (26) % Wt	% Occ	% N	*Paralichthys dentatus* (24) % Wt	% Occ	% N	*Cynoscion nebulosus* (20) % Wt	% Occ	% N
Plant detritus				trace	3.2	1.4									
Zostera marina	1.4	32.2	14.7							0.8	16.7	0.1	0.2	10	3.2
Ruppia maritima	trace	5.0	2.3							trace	4.2	trace			
Invertebrates															
Gastropoda	0.5	1.5	0.7												
Crepidula convexa	trace	0.5	0.2												
Nassarius obsoletus	0.1	0.5	0.2												
Retusa canaliculata										trace	4.2	trace			
Pelecypoda	trace	0.5	0.2												
Squilla empusa	0.2	0.5	0.2												
Neomysis americana										15.7	58.3	99.2			
Isopoda													trace	5	1.6
Amphidpoda										trace	4.2	trace			
Decapoda	0.1	2.0	0.9	trace	1.6	0.7	trace	3.8	0.9	trace	4.2	trace			
Paleomonetes vulgaris	trace	0.5	0.2										41.5	10	3.2
Crangon septemspinosa	0.1	2.5	1.0	0.1	4.8	27.1	3.9	30.8	31.6	5.0	41.7	0.5	trace	10	7.9
Callinectes sapidus	5.6	9.5	6.5	0.1	1.6	5.0	0.6	11.5	2.6						
C. sapidus - hard	11.0	9.5	5.6	0.1	1.6	0.7									
C. sapidus - paper	6.0	5.5	3.3												
C. sapidus - soft	43.3	56.8	38.6										0.3	5	1.6
Ovalipes ocellatus	0.1	0.5	0.5												
Libinia dubia	0.8	2.0	0.9												
Fishes															
Anguilla rostrata	0.3	1.0	0.5												
Brevoortia tyrannus	3.6	2.5	1.2	59.3	41.3	24.3	30.3	23.1	13.7				2.3	5	14.3
Engraulidae				trace	1.6	0.7									
Anchoa mitchilli	0.1	1.0	0.7				1.4	26.9	18.8						
Opsanus tau	0.2	0.5	0.2												
Rissola marginata	0.2	1.0	0.5												
Fundulus majalis	1.5	0.5	0.2												
Atherinidae	0.1	1.0	0.5	0.1	3.2	5.0	0.3	3.8	0.8						
Syngnathus fuscus	0.2	1.5	0.7							1.0	4.2	trace			
Sciaenidae															
Cynoscion regalis	2.4	0.5	0.2												
Leiostomus xanthurus	4.0	6.4	3.0	5.9	6.3	4.3	46.3	19.2	22.2	46.4	16.7	0.1	6.8	25	11.1
Mugil cephalus				12.3	4.8	2.1							32.1	5	1.6
Blenniidae															
Hypsoblennius hentzi	0.1	0.5	0.2												
Trinectes maculatus	2.3	2.0													
Paralichthys dentatus													1.4	5	1.6
Unid. Fish	10.3	28.1	14.0	21.9	34.9	23.6	16.0	19.2	5.1	30.6	4.2	trace	13.6	65	47.6
Animal fragments	trace	0.5	0.2												

Table 58

Occasional Megapredators

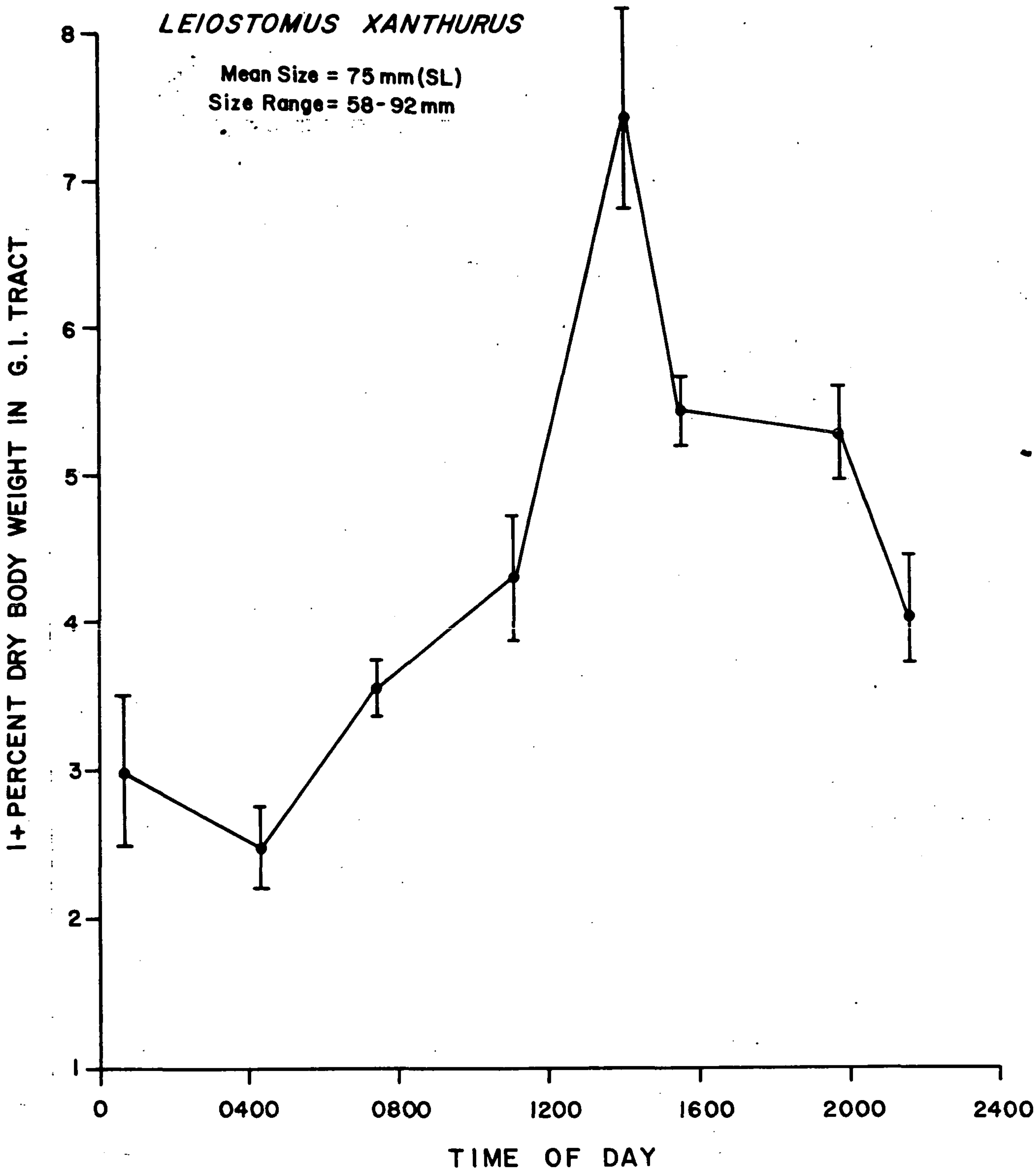
Food Item	*Tylosurus acus* (7)			*Strongylura marina* (2)			*Dasyatis sayi* (2)			*Morone saxatilis* (2)			*Sciaenops ocellata* (2)			*Rachycentron canadum* (1)		
	% Wt	% Occ	% N	% Wt	% Occ	% N	% Wt	% Occ	% N	% Wt	% Occ	% N	% Wt	% Occ	% N	% Wt	% Occ	% N
Zostera marina													0.1	50	7.1			
Ruppia maritima													trace	50	7.1			
Mya arenaria							100	100	100									
Decapoda	9.1	14.3	7.7															
Crangon septemspinosa				24.3	50	85.7				19.3	100	66.7	0.4	100	35.7			
Callinectes sapidus																		
C. sapidus - hard	89.8	71.4	76.9										99.5	100	50.0			
Fishes																		
Syngnathus fuscus	0.3	14.3	7.7															
Leiostomus xanthurus				75.7	50	14.3												
Unid. Fish																100	100	100
Fish Eggs										80.7	100	33.3						

septemspinosa, Palaemonetes vulgaris, and Callinectes sapidus). The dominant migratory predator after May was the sandbar shark (Carcharhinus milberti) for which the dominant food item was clearly soft shell blue crab. A wide variety of fishes were also consumed. Pomatomus saltatrix, fed almost exclusively on fish. The dominant prey species was Brevoortia tyrannus (59.3% by weight). The portion of the stomachs of C. milberti, P. dentatus, C. nebulosus, and P. saltatrix contained fragments of Zostera marina or Ruppia maritima. This indicates that these species were feeding in the SAV bed.

Feeding periodicity and daily ration

Feeding periodicity was determined for spot, silver perch, and pipefish. The geometric means (± one standard error) of the percent dry body weight found in the gastrointestional tracts of six fish captured every three to four hours over a twenty-four hour period were plotted against time (Figure 26, 27 and 28). Spot and pipefish fed during daylight hours indicating that they are sight feeders. Silver perch is predominantly a nocturnal feeder. It's dominant food items (Neomysis americana and Crangon septemspinosa) were most abundant in the SAV area after sunset.

The daily ration of spot and pipefish were estimated by the evacuation method of Peters and Kjelson (1975). The ingestion rate may be determined from stomach or gastrointestinal evacuation rate, because the average ingestion rate must equal the rate at which material leaves, whether by assimilation or expulsion (Bajkov, 1935). Evacuation rates for pipefish fed a single meal of juvenile amphipods were obtained in the laboratory at 17°, 22°, and 27°. Regression analysis on the data yielded rate constants which were used to calculate instantaneous evacuation rates. The feeding periodicity (figures 39, 40, and 41) determined the quantities of food



LEIOSTOMUS XANTHURUS
Mean Size = 75 mm (SL)
Size Range = 58-92 mm
1+PERCENT DRY BODY WEIGHT IN G.I. TRACT
1
2
3
4
5
6
7
8
0
0400
0800
1200
1600
2000
2400
TIME OF DAY

Figure 39

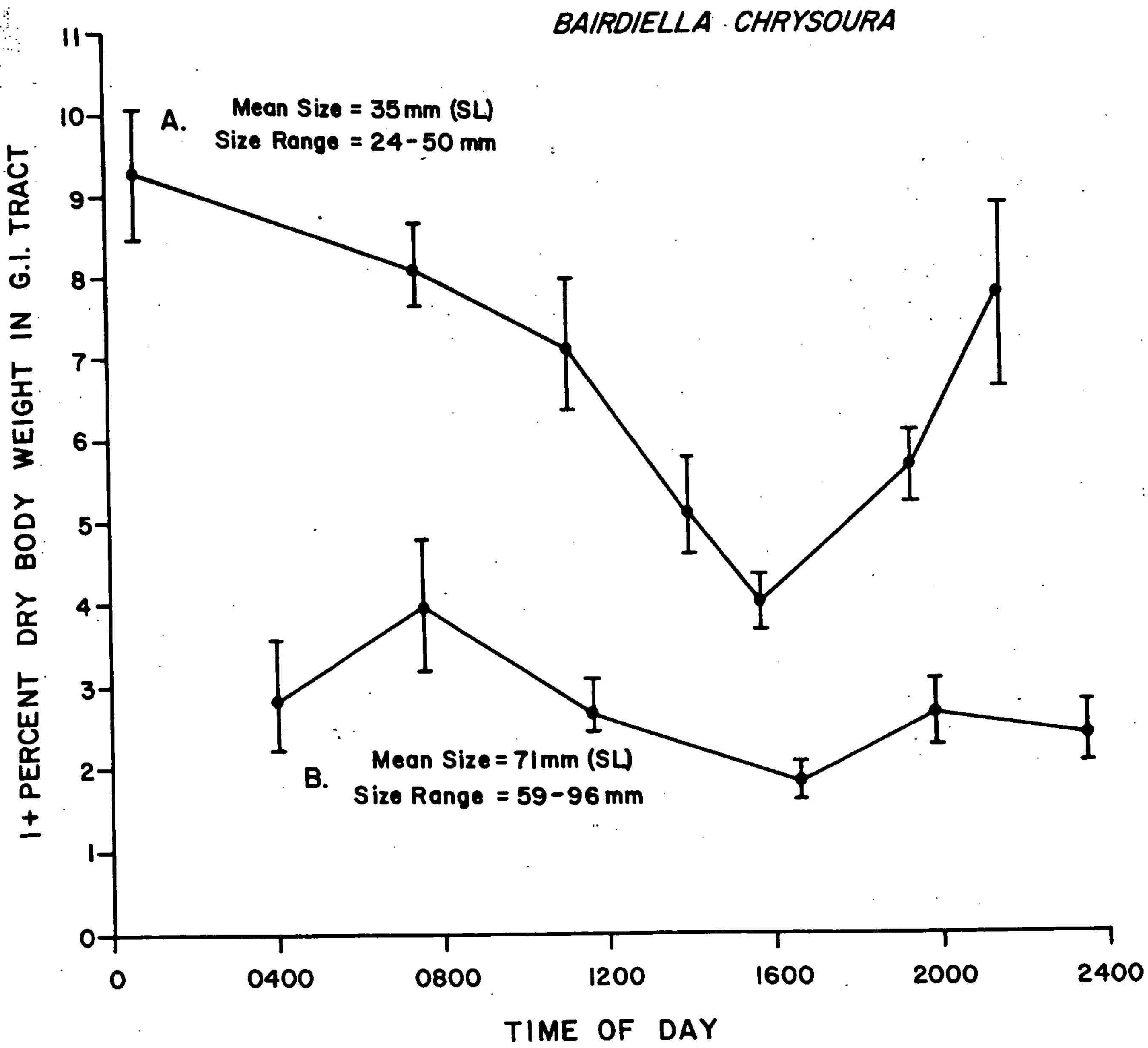

BAIRDIELLA CHRYSOURA
A. Mean Size = 35 mm (SL)
Size Range = 24-50 mm
B. Mean Size = 71 mm (SL)
Size Range = 59-96 mm
1+PERCENT DRY BODY WEIGHT IN G.I. TRACT
TIME OF DAY
0
1
2
3
4
5
6
7
8
9
10
11
0400
0800
1200
1600
2000
2400

Figure 40

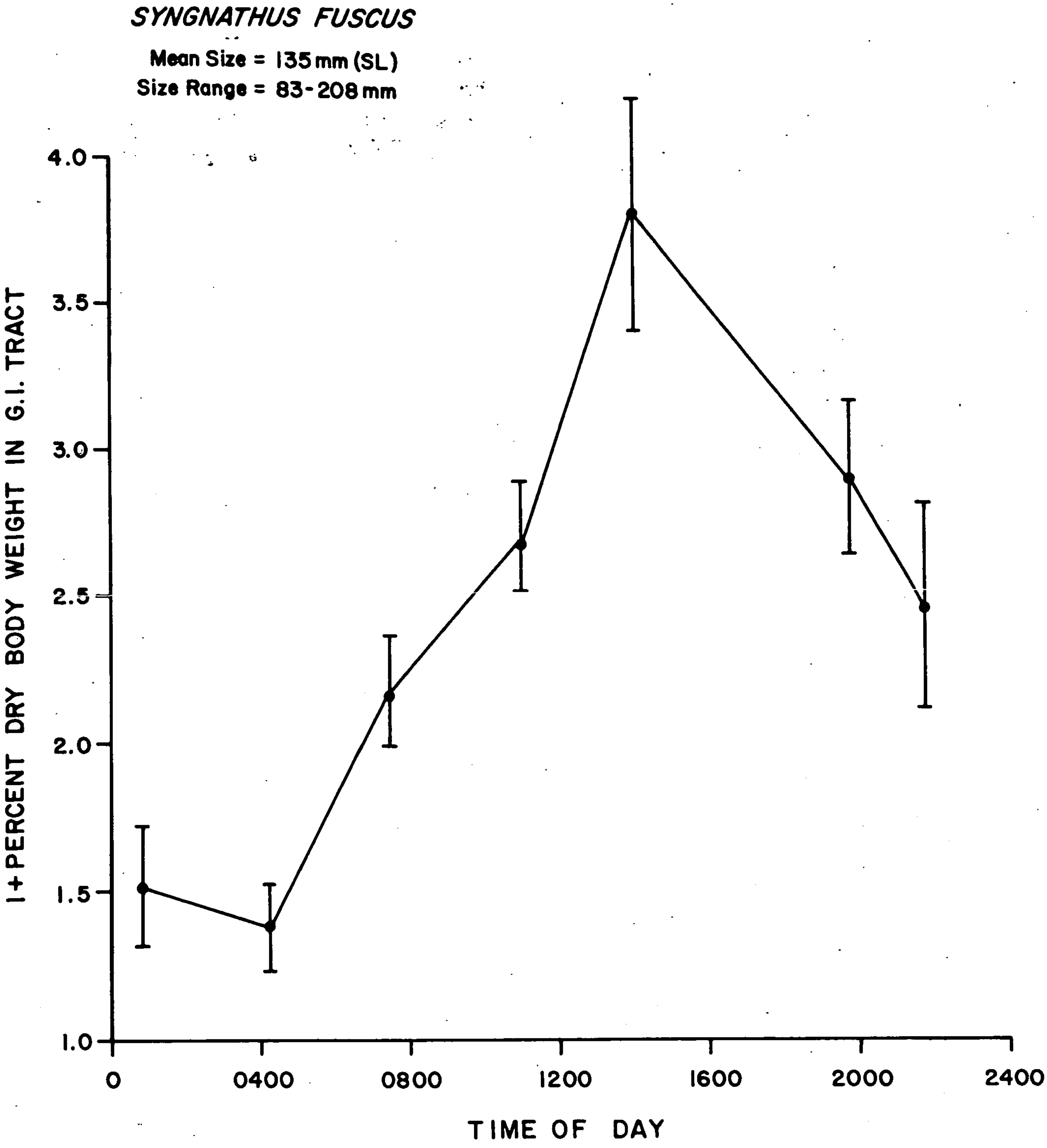

SYNGNATHUS FUSCUS
Mean Size = 135 mm (SL)
Size Range = 83-208 mm
1+PERCENT DRY BODY WEIGHT IN G.I. TRACT
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0
0400
0800
1200
1600
2000
2400
TIME OF DAY

Figure 41

present in the guts of selected species at 4 hour intervals throughout a 24 hour cycle. Instantaneous evacuation rates were calculated for each of the 4 hour intervals by the following equation

$$\frac{dC}{dt} = 2.303BC \qquad \text{where}$$

B = evacuation rate constant and

C = content of gastrointestinal tract + 1.

Summing the evacuation during each of these periods produced an estimate of total evacuation of daily ration. The evacuation rate constant (B) for pipefish at 22° was .032. The daily ration for pipefish was 4.4% dry body weight per day at 22°C. A graduate student at VIMS is utilizing this information to construct a model that will describe the effects of pipefish predation on the epifauna of the SAV bed. The evacuation rate of juvenile spot at 22°C has been reported to be .033 (Peters et al, 1974). Using this information and figure 26 our estimate of daily ration for juvenile spot at 22°C was 7.7% dry body weight per day. We are still in the process of determining evacuation rates for silver perch.

Feeding periodicity for P. saltatrix and C. regalis are illustrated in figures 42, 43A, and 43B. These figures are composites of one and a half years of gill net data. Weakfish (C. regalis) appeared to utilize the SAV bed from dusk to dawn (figure 42). The dashed line indicates that during this time they were feeding. Maximum feeding occurred around dawn. Bluefish exhibited different feeding patterns in the sand area and SAV bed (figure 43A and 43B). On the sand bar, bluefish were typically schooling and eating menhaden. Bluefish were captured during mid-day and their stomachs were also fullest at this time. In the SAV bed bluefish were captured alone or in small groups. They were twilight feeders with the main feeding peak at dawn.

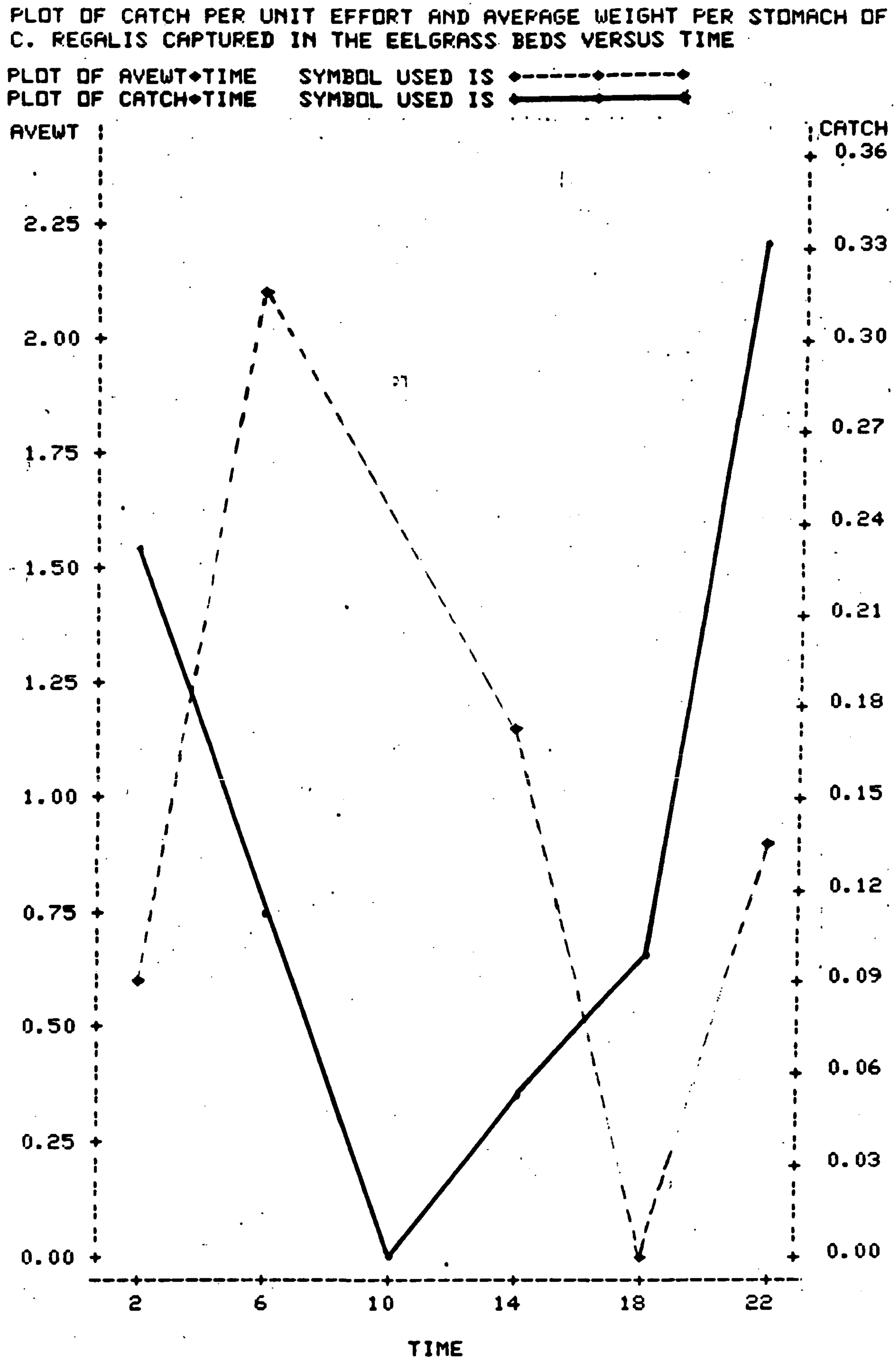

PLOT OF CATCH PER UNIT EFFORT AND AVERAGE WEIGHT PER STOMACH OF
C. REGALIS CAPTURED IN THE EELGRASS BEDS VERSUS TIME
PLOT OF AVEWT*TIME SYMBOL USED IS
PLOT OF CATCH*TIME SYMBOL USED IS
AVEWT
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
CATCH
0.36
0.33
0.30
0.27
0.24
0.21
0.18
0.15
0.12
0.09
0.06
0.03
0.00
2
6
10
14
18
22
TIME

Figure 42

PLOT OF CATCH PER EFFORT AND AVERAGE WEIGHT PER STOMACH OF P. SALTATRI
CAPTURED IN THE EELGRASS BED

PLOT OF AVEWT*TIME SYMBOL USED IS ◆———◆———◆
PLOT OF CATCH*TIME SYMBOL USED IS ◆------◆------◆

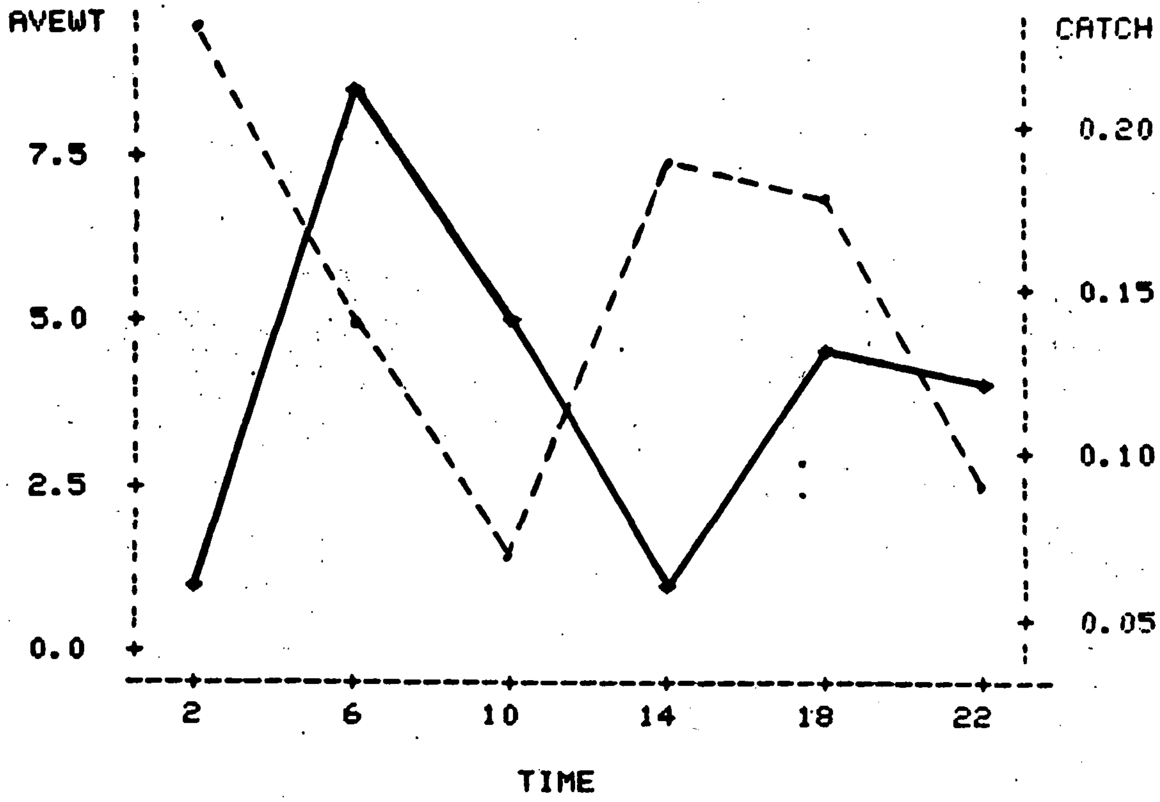


Figure 43A

PLOT OF CATCH PER EFFORT AND AVERAGE WT. PER STOMACH OF P. SALTATRIX
IN THE SAND AREA

PLOT OF AVEWT*TIME SYMBOL USED IS ◆———◆———◆
PLOT OF CATCH*TIME SYMBOL USED IS ◆------◆------◆

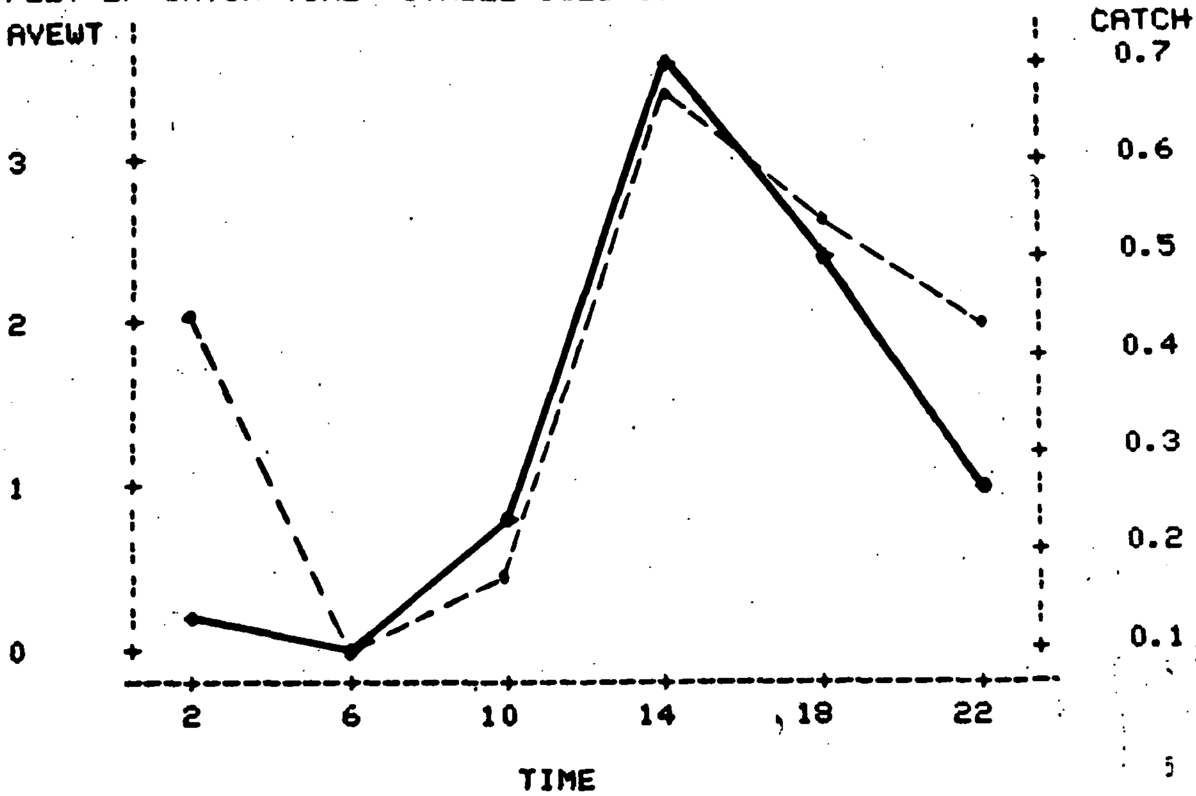


Figure 43B

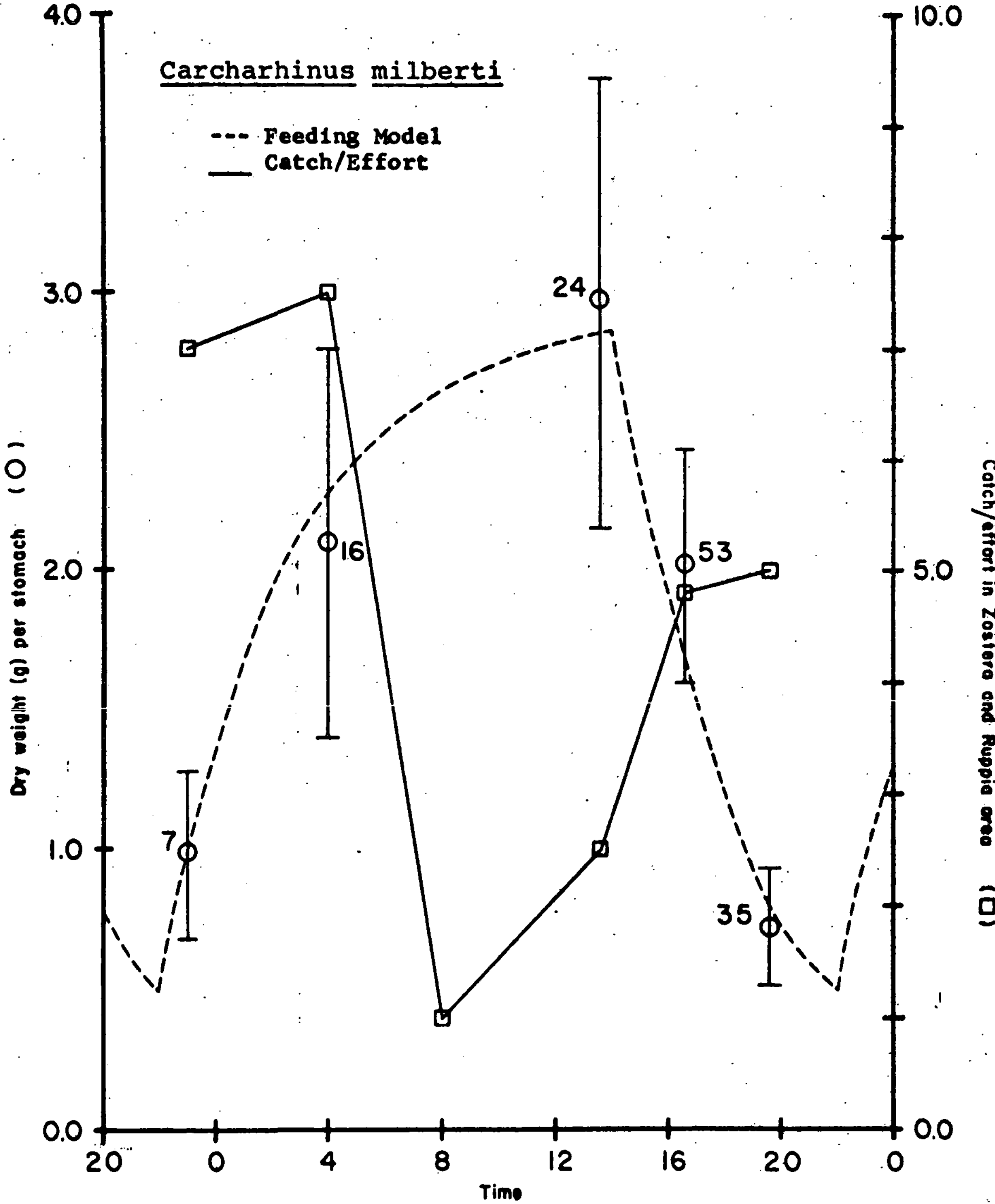
Feeding periodicity and catch per gill net pull for the sand bar shark in July of 1980 is shown in figure 44. The solid line (catch/effort) indicates that the main increase of sharks in the SAV bed occurred from dusk to 4 am. The dashed line in the figure is a feeding model described by Lane et al., (1979). The model indicates that feeding started at 10 pm and continued until 1 pm the following day. As the ingestion rate started to plateau around 8 am catch per effort of sand bar shark dropped quickly. It therefore appears that sand bar sharks enter the SAV beds to feed and leave the area as they become satiated. The feeding model estimated daily ration for a typical 1800 g (wet wt.) shark in July 1980 at a water temperature of 27° as 10.5 grams dry weight per day

Predator-prey experiments

Laboratory experiments were conducted to determine the effect of artificial *Zostera marina* on predator-prey relationships of migratory predators and resident fishes. The migratory predators were the weakfish (*C. regalis*) and summer flounder (*P. dentatus*). The two resident prey species chosen for the experiments were spot (*L. xanthurus*) and the Atlantic silverside (*Menidia menidia*). Salinity varied between 16 and 20% while water temperature was maintained at 22$\pm$ 2°C over the duration of the experiments.

Figure 45 illustrates the number of prey consumed in each of the three replicates of five vegetative substrate treatments. The average number of prey consumed over each of these treatments is shown in Table 59. Flounder consumed all 12 silversides in each replicate of the bare sand, average density vegetation, and high density vegetation experiments. In the increased complexity treatment, flounder consumed an average of 11 silversides.

Figure 44. Feeding periodicity of Carcharhinus milbert. Circles are arithmetic mean ($\pm$ one standard error) of dry weight of stomach contents of C. milberti. The number beside each mean is the number stomachs represented by the mean.


Carcharhinus milberti
--- Feeding Model
Catch/Effort
Dry weight (g) per stomach (O)
Catch/effort in Zostera and Ruppia area (□)
Time
4.0
3.0
2.0
1.0
0.0
10.0
5.0
0.0
20
0
4
8
12
16
20
0
7
16
24
53
35

EXPERIMENTAL RESULTS

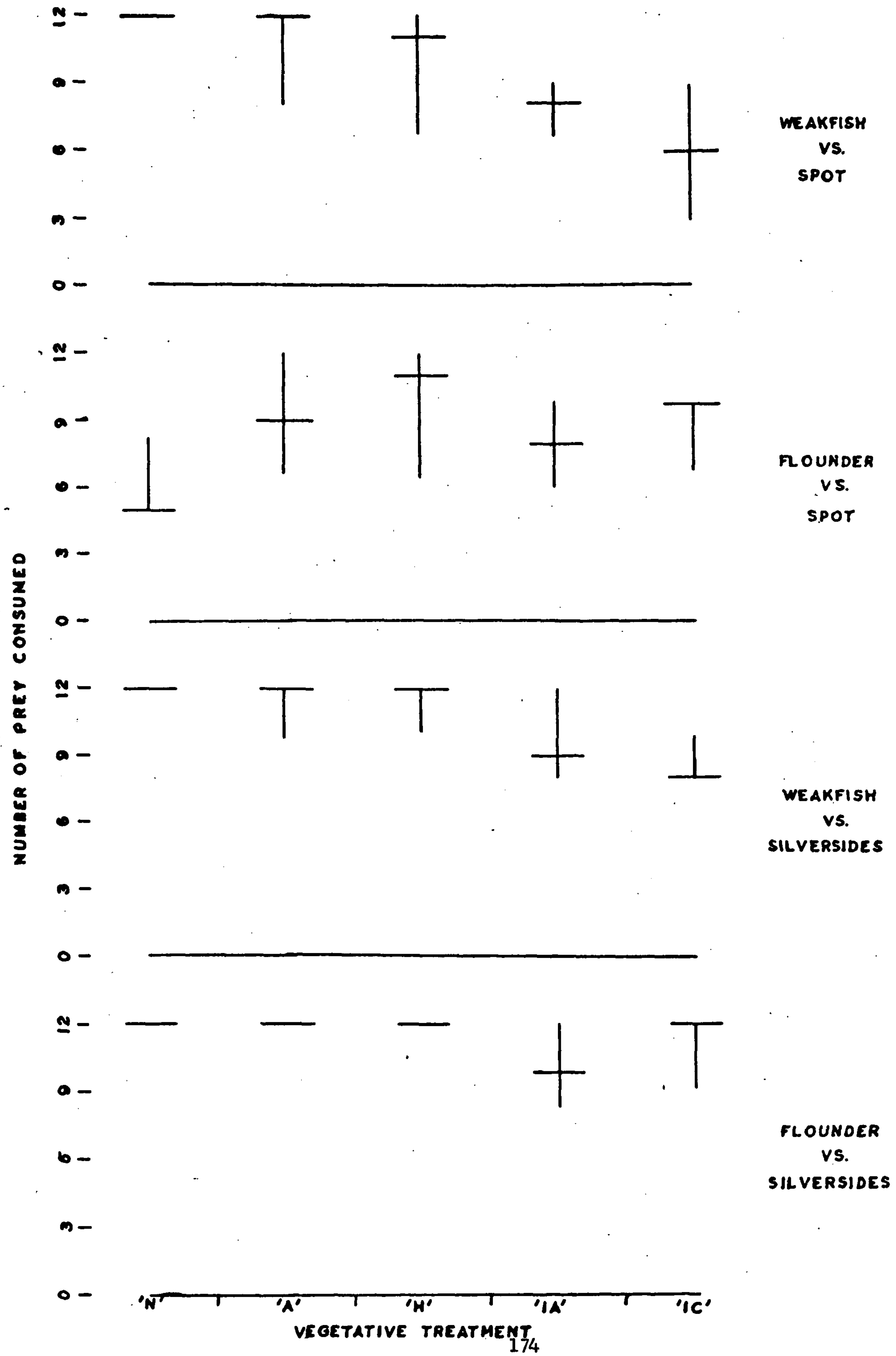


Table 59

Average Number Prey Consumed

Prey	Predator	N	A	H	IA	IC
		Treatment				
Menidia menidia	*Cynoscion regalis*	12	11.3	11.3	9 7	8.7
	Paralichthys dentatus	12	12	12	10	11
Leiostomus xanthurus	*Cynoscion regalis*	12	10.7	10	8	6
	Paralichthys dentatus	6	9.3	10	8	9

Numbers represent average for 3 replicates

N = no artificial grass
A = average density, 1 m^2, 875 blades/m^2, 7.5% area covered
H = high density, 1 m^2, 1750 blades/m^2, 7.5% area covered
IA = increased area, 3 m^2, 1450 blades/m^2, 22% area covered
IC = increased complexity, 3-1 m^2 evenly spaced, 1450 blades/m^2, 22% area covered

The lowest average (10) captured over the three replicates occurred in the increased area treatment. Weakfish consumed all silversides in all three replicates of the bare sand substrate experiments. In both the average and high density experiments weakfish consumed all prey in two replicates and ten in the other. Eight, nine and twelve silversides were consumed over the increased area vegetated substrate. At least two M. mendia survived in each replicate of the increased complexity treatment. This vegetative arrangement also yielded the lowest average number of prey consumed, 8.66.

An average of six spot were consumed by summer flounder in the non-vegetated treatment. This was the lowest average of spot consumed for any treatment. The average number of spot consumed for average density and high density vegetation increased area and increased complexity treatments were 9.3, 10, 8, and 9. Weakfish consumed all spot in each replicate of the non-vegetated treatment. In both IA and IC no replicate exceeded 9 prey consumed; the average number of spot consumed were 8 and 6, respectively. The average number of spot consumed was 10.6 for the average density treatment and 10 for the high density treatment, both of which contained at least one replicate in which all 12 prey were consumed.

Figure 46 shows the general trend in percentage of prey survival versus percentage vegetative cover. Weakfish captured progressively fewer prey, of both species, as the amount (% area) of artificial grass increased. The trend is most pronounced in the weakfish vs. spot experiments where the percentage of prey surviving rises from zero for non-vegetated to 15 for 7% covered to 40 for 22% covered. A similar, but less pronounced trend is evident with flounder vs. silversides. Here, percentage prey survival rises from zero at both 0 and 7% vegetative cover to 12% survival at the 22% area covered treatment. For the flounder vs. spot experiments the trend is reversed. A greater percentage of prey survived in the non-vegetated than at either of the vegetated treatments.

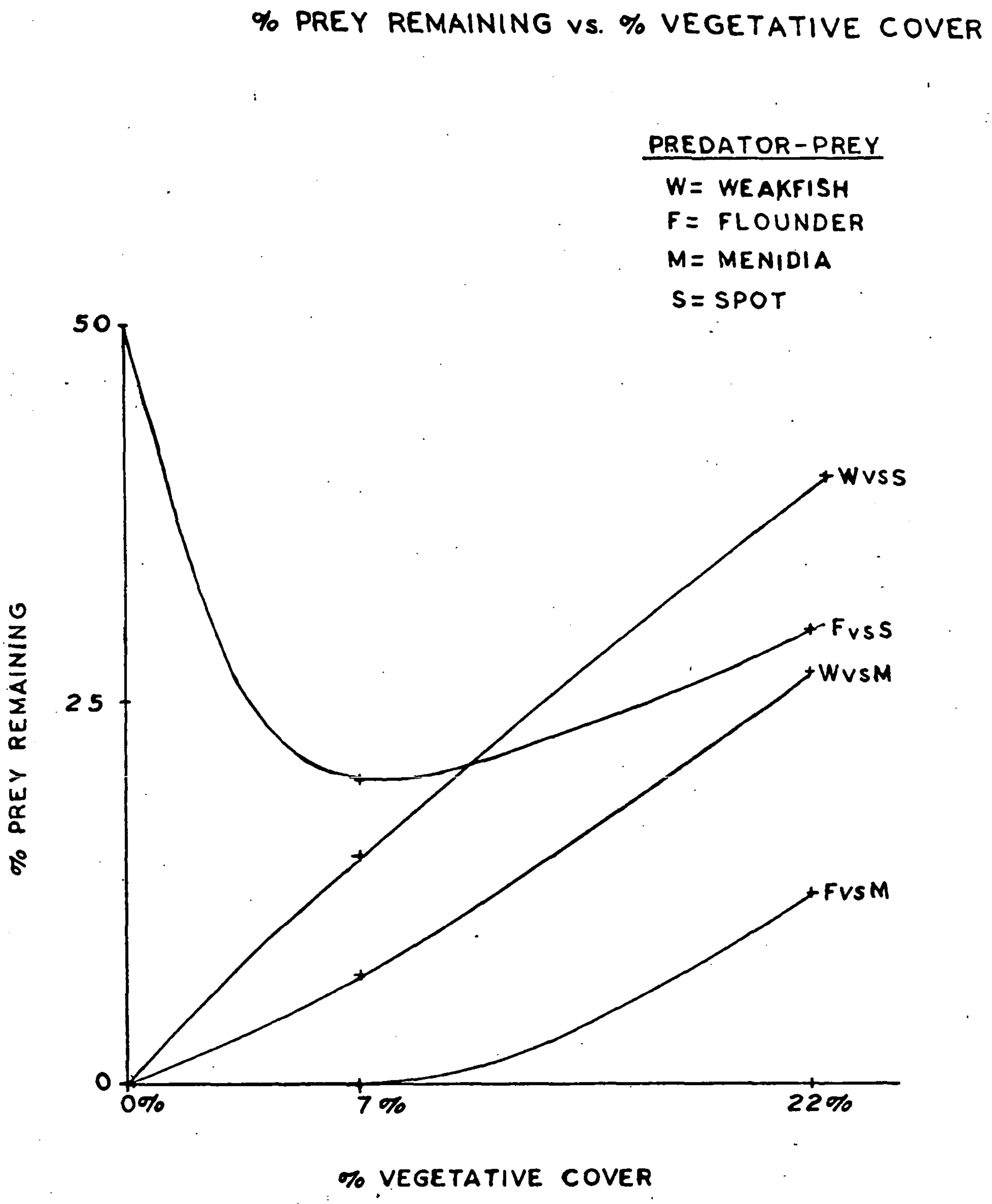

% PREY REMAINING vs. % VEGETATIVE COVER
PREDATOR-PREY
W= WEAKFISH
F= FLOUNDER
M= MENIDIA
S= SPOT
50
25
0
% PREY REMAINING
WvsS
FvsS
WvsM
FvsM
0%
7%
22%
% VEGETATIVE COVER

Figure 46

The median test, a nonparametric procedure was employed for statistical examination of data. The null hypothesis (H_0) states there is no difference, among the treatments, in the median number of prey consumed. Table 60 summarizes the results of the median test for the four predator-prey combinations. Test results indicate H_0 is rejected (p=0.95) for the weakfish vs. spot experiments. Statistical analysis can not, legitimately, be employed to isolate differences between specific treatments (Conover, 1971). However, visual inspection of illustrated data (figure 31) revealed most apparent differences occur between the non-vegetated and increased area treatments and the non-vegetated and increased complexity treatments. No significant differences, at alpha =0.05 or alpha - 0.10, occur among treatments for the other predator-prey combinations. The calculated value, 7.49, for the weakfish vs. silverside experiments falls just below the alpha =0.10 critical value of 7.779. Again, visually, most apparent differences here occur between the non-vegetated and the increased complexity treatments. These experiments were part of a VIMS graduate student's Masters Thesis entitled "Fish predator-prey interactions in areas of submerged aquatic vegetation."

Respiration measurements

Figure 47 illustrates the routine respiration of the silver perch, Bairdiella chrysoura. The routine respiration of 300 silver perch were measured in flow through respiration chambers. These measurements are part of a VIMS graduate student's dissertation thesis on the bioenergetics of Bairdiella chrysoura.

Table 60

Predator - Prey Experiments

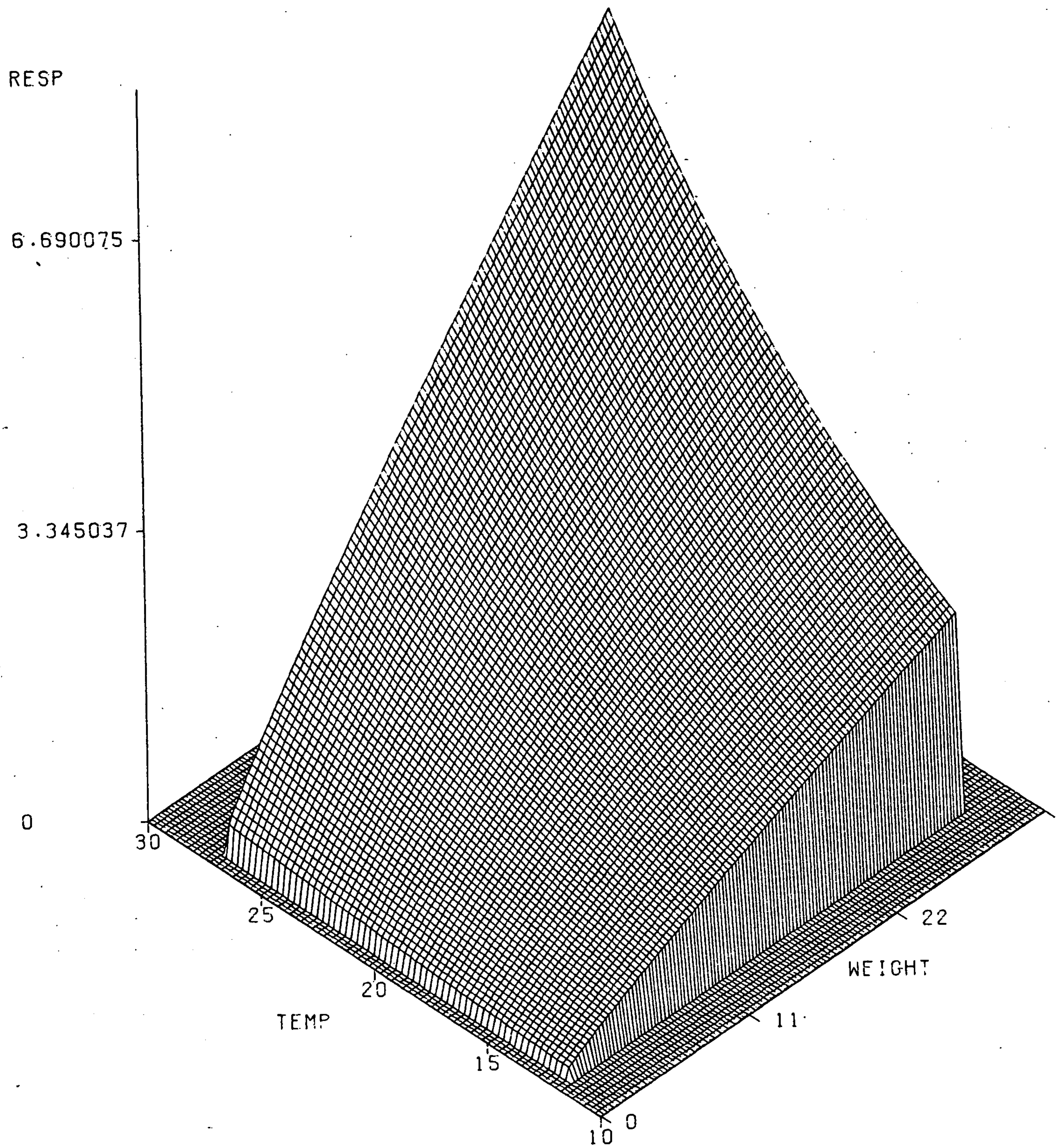
Median Test Results

Predators vs. Prey	Calculated Statistic	Critical value at σ 9.48 σ = 0.05	7.78 σ = 0.10
Paralichthys dentatus vs. *Menidia menidia*	6.64	NS	NS
Cynoscion regalis vs. *Menidia menidia*	7.49	NS	NS
Paralichthys dentatus vs. *Leiostomus xanthurus*	4.24	NS	NS
Cynoscion regalis vs. *Leiostomus xanthurus*	10.27	*	*

* indicates median number of prey consumed differed significantly among regetative treatments

NS - not significant

ROUTINE RESPIRATION OF BAIRDIELLA CHRYSOURA



LOG(RESPIRATION)=(TEMPERATURE*.03130)+(LOG(WEIGHT)*.85337)-1.2802
COEFFICIENT OF DETERMINATION=.92 SIGNIFICANCE LEVEL=.001
TEMP=TEMPERATURE (C), RESP=RESPIRATION MG O2/G/HR,WEIGHT=WET WEIGHT (G)

Figure 47

DISCUSSION

The trends in distribution and abundance of migratory predators and resident fishes recorded in the present study generally show agreement with other studies in shallow-water habitats in the lower Chesapeake Bay (Orth and Heck, 1980). Migratory predators occurred sporadically with the exception of the sand bar shark, C. milberti, which was consistently abundant from June through October. Although gill nets are selective (Hamley, 1975), the catch in this study appeared to give an estimate of relative abundance of most species with the probable exception of the rays Rhinoptera bonasus and Dasyatis sayi, and the summer flounder, Paralichthys dentatus. Of the three gill net mesh sizes employed to capture migratory predators, 12.7 cm and 8.8 cm stretched mesh gill nets were most effective. However, 17.8 cm mesh gill nets entangled rays to a greater extent than did the other two mesh size gill nets. Although the nets foul visibly with jellyfish, large ctenophores, and drifting aquatic vegetation due to current flow, the catch is not markedly greater at night when visual detection would be less effective. This may be due to the low water clarity during most months. Fifty-two to fifty-seven percent of the bluefish, sandbar shark, and spotted sea trout catch were captured at night. Seventy-seven percent of the weakfish captured were taken at night. This contrasts with Pristas and Trent (1977), who found 93% of the most abundant species taken at night in gill nets.

Availability of most species arises from populations moving through the area or coming from adjacent deep water areas. Temporal analysis indicates that C. milberti, P. saltatrix, and C. regalis start to move into the shallow areas in the afternoon. _C. milberti_ and _C. regalis_ were most abundant around midnight while _P. saltatrix_ left the area after twilight. These megapredators were also captured in greater numbers on flooding tide stages than ebbing tide stages. Sandbar shark, spotted sea trout, and weakfish were captured primarily in the vegetated areas while bluefish were captured in the sand area. Feeding periodicity indicated that bluefish, weakfish and sandbar sharks entered the vegetated area with very little material in their stomachs and left the eelgrass bed after feeding. Weakfish were twilight feeders with maximum feeding occurring at dawn. Two other sea trouts (_C. nebulosus_ and _C. arenarius_) have been found to possess a tapetum lucidum or reflective layer in their eyes which increases dim-light vision (Arnott et al, 1970). This adaptation would give _C. regalis_ a great advantage when feeding at twilight periods. Sandbar sharks fed from midnight to midmorning. Bluefish exhibited two feeding strategies; twilight feeding in the vegetated area and mid-morning to late afternoon feeding in the sand area. In the vegetated area bluefish were found in small groups but on the sandbar bluefish were in larger schools typically preying on menhaden. Bluefish are predators that use vision as a primary sense in feeding (Olla et al, 1970). It has been demonstrated that cone movements of the retina of young bluefish (which are related to light-dark adaptation) may be under internal control (Olla and Marchioni, 1968). Through internal control, the retina might be predisposed to the coming of light or dark. This preconditioning would effectively lessen the time for the eyes of the bluefish to adapt to the change in light and represent a significant adaptation for a predator which is highly active during morning twilight (Olla, 1972). Since bluefish and weakfish hunt by sight one would also expect feeding from mid morning to late afternoon when light intensities permit the highest visual acuity. However, schooling by prey that would enhance a confusion effect on the predator should be most effective under bright light. This may explain why schooling fishes appear relatively safe from predators during most of the day (Hobson 1968). Observations of tropical reefs have indicated that small fishes (especially schooling fishes) are most vulnearble at twilight periods (Hobson, 1979). As light diminished at twilight, the schools fall into disarray. The eye adaptations of bluefish and weakfish allow prey capture to reach maximum efficiency during this time of day as seen in bluefish and weakfish feeding periodicity data. The highly streamlined and deeply forked tail-fins of bluefish indicate that they are built for high speed chase and capture of prey. They are known to charge schools of menhaden, killing many more than can possibly be eaten (Hildebrand and Schroeder, 1928). This type of feeding by bluefish has been witnessed in the sand area at the Vaucluse Shore site. The bluefish may be disrupting the school of menhaden by chasing it from deep water on the abrupt shallow sand bar surrounding the eelgrass bed. If disruption of the school occurs one would expect that individual menhaden could be captured with maximum efficiency when light intensity is highest typically from midmorning to late afternoon. This may explain why there were two feeding strategies exhibited by bluefish in the SAV study area.

The occurrence of plant detritus and Zostera and/or Ruppia fragments in the stomachs of C. milberti, P. saltatrix, P. dentatus, and C. nebulosus indicated that these migratory predators were feeding in the SAV bed. Spot was heavily preyed upon by C. regalis and P. dentatus. A daily ration of 10.5g (dry wt.) per day was calculated for the sandbar shark in July 1980 when the average water temperature was 27°C. The diet of the sandbar shark was 66% blue crab of which 43.3% was soft shell crab; 6% was paper shell crab; and 16.7% was hard shell crab. These crab molt stages were distinct in the shark stomachs because the shells of hard shell crabs were compressed and shattered but remained thick in the stomachs. Through even late stages of digestion, hard shell blue crabs were discernable from the soft and very thin shells of recently molted blue crabs. Premolting blue crabs are by weight 67% water while postmolt blue crabs are 86% water (Lewis and Haefner, 1976). The resident fishes averaged 79% water by weight. If one converts the daily ration of C. milberti to wet weight it becomes 3.3% body weight per day. This figure may be low due to regurgitation while the sharks were in the gill nets.

The impact of predation by sandbar shark on blue crabs is significant. In July 1980, the relative abundance estimate for the sandbar shark in the SAV bed was 105. Density estimates in July 1979 (Orth, this manuscript) for blue crab indicated that the bed contained 9394g dry wt of blue crab. This implies that every day, 7.7% of the blue crab biomass of the SAV bed is consumed by sandbar sharks. Orth has stated that his density estimates are probably not accurate for crabs larger than 60 mm. The sharks ate crabs that ranged from 35mm to 115 mm and averaged 60 mm carapace width. One must also realize that gill nets did not capture every shark in the SAV bed. The daily ration calculated for the sandbar shark is not unreasonable when compared to daily rations of large piscivorous teleosts (Gerking, 1978). The sharks leave the SAV area with full stomachs and enter the bed with their stomachs empty. Since C. milberti were found to be very mobile in tagging experiments, sand bar sharks which feed and pass through the study area may be a significant loss of energy from the SAV system.

Resident fishes were sampled with a haul seine, otter trawl, and push net. The nekton push net was the least successful in capturing resident fishes. Kriete and Loesch (1980) utilized this gear in the channels of major tributaries of the Chesapeake Bay. It appears that in shallow areas, this gear is not suitable for sampling pelagic fishes. The differences between haul seine and trawl collections indicate the selectivity of each gear. The haul seine stressed the importance of pelagic species (B. tyrannus, A. mitchilli, M. menidia, and M. martinica) with the numerical dominant being A. mitchilli. The numerical dominants of the trawl survey were spot (L. xanthurus), silver perch (B. chrysoura), and pipefish (S. fuscus). The 16 foot otter trawl was towed behind an outboard vessel which fishes effectively only one meter off the bottom; thus both avoidance and fishing of the net below the depth of occurrence of pelagic species suggests that their relative abundance was underestimated. Gear comparisons by simultaneous haul seine and trawl collections indicated that juvenile spot and silver perch effectively avoided the haul seine. To accurately sample both benthic and pelagic fishes in shallow SAV areas, a multiple gear approach is necessary.

Adams (1976a) showed dominance of pinfish (Lagodon rhomboides) and pigfish (Orthopristes chrysoptera) in North Carolina eelgrass beds. In the present study, these species were seen in very low numbers in the 1980 trawl catch. Spot and silver perch were recruited to Adams (1976a) eelgrass bed approximately 2 months earlier than they entered the Vaucluse Shore study area. With the exception of A. mitchilli Adams (1976a) drop net density estimates (per species) in North Carolina eelgrass beds were higher than either the haul seine or trawl density estimates in the study area.

Within the assemblage of resident fishes, two subgroups are apparent. The first is comprised of the pelagic and/or schooling group ("pelagic residents") including B. tyrannus, A. mitchilli, M. martinica, and M. menidia.

Adams (1976a) did not consider these species as true residents of the bed. Although the same is probably true in the present study for all four of the above species, they are considered with the residents in terms of ecological impact upon the ecosystem due to their relatively high biomass in the vegetated areas. In the night collections these species were taken in all three habitats without clear trends in abundance. Comparing day and night haul seine collections the abundance of B. tyrannus showed no trend. M. martinica and A. mitchilli were typically taken in low abundance during the day and high abundance during the night. The other atherinid, M. menidia, however, showed an opposite pattern. No M. menidia were captured at night except in March and April when Membras densities were low. In the day collections Menidia was common. Trawl collections indicated that A. mitchilli was more abundant at night than during the day.

The second group of resident fishes ("true residents") was dominated by spot (L. xanthurus), pipefish (S. fuscus), and silver perch (B. chrysoura). Members of this component of the resident fish group were captured most frequently in the vegetated areas. Day-night sampling by haul seine and trawl suggested that spot and silver perch are more a abundant at night. Haul seine collections indicated that pipefish were abundant during the day while trawl samples suggest that pipefish are more abundant at night. Orth and Heck (1980) observed increased catch of spot in all habitats at night as observed in the present study. It remains to be determined, however, whether the increases at night are due to increased daytime avoidance or to actual movements to the bed from other areas.

In general the biomass reported in the present study for the seven major species falls within the range of total fish·biomass for *Zostera marina* beds in New England by Nixon and Oviatt (1972) but is less than that reported in studies to the south (North Carolina, Adams 1976 a; Texas, Hoese and Jones 1963).

Feeding periodicity collections determined that spot and pipefish feed during daylight hours indicating that they are sight feeders. However, Peters and Kjelson (1975) reported that juvenile spot fed continuously. Silver perch is predominantly a nocturnal feeder. Adams (1976) also found that silver perch fed during the night. Like the weakfish, silver perch also has an unusual tapetum lucidum (a reflecting layer) in it's eyes which increases dim-light vision (Arnott et al, 1970). The daily ration at 22° C for spot and pipefish were 7.7% and 4.4% body weight per day, respectively. Peters and Kjelson (1975) estimated a daily ration at 29° C for spot as 10.1% body weight per day.

Feeding relationships of fishes within the Vaucluse Shores study site are generally similar to those of dominant species observed in other studies in vegetated habitats (Carr and Adams 1973; Adams 1976c). The lack of the dominant species from North Carolina (*Lagodon rhomboides* and *Orthopristis chrysoptera*), however, may alter the feeding behavior of *L. xanthurus* through availability of other food sources. Although plant material and detritus occur frequently gravimetric data suggests that they are less important in the diet than in North Carolina *Zostera* beds (Adams 1976c). Spot are initially planktivorous, after which they switch to predominantly benthic feeding (Kjelson et al, 1974; Sheridan 1978). In the present study, spot collected in April were planktivorous, but this shift in feeding strategy is not clearly seen in the feeding analysis of different sizes of spot. This may be due to the small number of 15-25 mm spot analyzed in April. Cathy Meyer is conducting a more indepth study of feeding of early juvenile spot and her results will be sent to EPA later this year. Spot exhibited benthic feeding on ostracods, harpacticoid copepods and, nematods as well as planktonic feeding on mysids. The importance of mysids in the diet are likely evidence of high availability, since _L. xanthurus_ has a subterminal mouth primarily adapted to feeding on infauna and benthic organisms (Chao and Musick 1976). _Bairdiella chrysoura_ immigrates to the vegetated areas in Aguust. This species has a terminal mouth and is adapted for pelagic feeding, although some epibenthic feeding takes place. Most feeding studies of this species (summarized in Chao and Musick, 1976) show fish, mysids, and decapod shrimp to be the predominant dietary items. Adams (1976c), by contrast, observed no mysids in the diet of this species in North Carolina eelgrass beds. A clear ontogenic switch from consumption of calanoid copepods by 20 mm to 70 mm silver perch to consumption of predominantly mysids by 30 mm to 150 mm _B. chrysoura_ was noted. Pipefish (S. fuscus) was the major epifaunal predator of the SAV bed. However, as observed by Adams (1976c), planktonic food items such as calanoid copepods and mysids were as important as epifaunal components in the pipefish diet.

Predator-prey experiments indicated a general trend of reduced predator success with increasing artificial eelgrass density. The three dominant resident fishes appear to rely more upon planktonic and benthic food sources than prey specific to the SAV bed. The planktonic food items were typically as abundant or more abundant in the adjacent sand area. (Unfortunately no meiofaunal comparisons between habitats were analyzed to compare densities of spot's benthic prey items). It therefore appears that the major attraction of the SAV bed to the resident fishes (at least pipefish and silver perch) is the protection from major predators offered by the bed.

Summary

A major objective of the SAV research component relating to higher level consumer interactions was the qualitative and quantitative definition of the community of resident and migratory biota utilizing the SAV area. To accomplish this objective a drop net, nekton pushnet, otter trawl, haul seine, ichthyoplankton and zooplankton pushnet, and three different mesh size gill nets were tested to determine the most efficient sampling gears to monitor shallow water nekton, zooplankton and ichthyoplankton communities. The ichthyoplankton and zooplankton pushnet was an effective method to collect zooplankton and ichthyoplankton in the SAV area. The sampling of resident fishes required an enclosing gear such as a haul seine to capture pelagic species as well as an otter trawl for benthic species that escaped under the haul seine as it was lifted by the eelgrass in the pursing operation. Megapredators were sampled effectively with 3½" and 5½" stretch mesh gill nets. A thorough description of seasonal changes in SAV nekton, zooplankton, and ichthyoplankton communities was compiled through monthly field sampling over a one and a half year period. Comparison sampling between the SAV bed and adjacent "open" bottom areas indicated that the resident SAV fish community was more diverse and superior in number and biomass to the "open" bottom fish community. Day-night sampling found more resident and migratory fishes in the SAV bed at

night than during the day. However, this night-time increase may be due as much to gear avoidance as actual nightly movements of fishes onto the eelgrass bed. These numerical and biomass estimates for zooplankton, ichthyoplankton, resident fishes, and megapredators also provide an essential data base for the Wetzel SAV model (this manuscript).

The other major goals of the higher consumer interactions group were to define the trophic importance and refuge function of SAV to migratory consumers. The trophic importance of SAV to migratory consumers was addressed by stomach analysis, feeding periodicity studies, and calculation of daily ration for the dominant resident fishes and megapredators. Stomach analysis defined the components of the SAV that were preyed upon by these fishes. Prey preference varied seasonally as well as with predator size. Consumption of only SAV origin food was not found and resident fishes relied heavily upon planktonic food sources. Feeding periodicity studies indicated that megapredators were entering the bed during twilight and night-time periods and then leaving with full stomachs during the day. Estimates of daily ration for spot, pipefish and the sandbar shark were calculated to later model the effects of these predators upon the SAV invertebrate community. The daily ration calculated for the sandbar shark indicates that intense predation by this species may have severely impacted the density of the blue crab population in the SAV bed. Our analysis also suggests Orth's (this manuscript) blue crab biomass and secondary production estimates for the study area are underestimations.

The refuge function of different densities of eelgrass was experimentally tested in large swimming pools. Megapredators (*C. regalis* and *P. dentatus*) became less efficient at capturing prey (*M. menidia* and *L. xanthurus*) with increasing eelgrass density. Since resident fishes (except pipefish) did not rely heavily upon SAV origin food sources, the primary advantage of SAV to resident fishes appears to be refuge rather than of trophic importance.

Several questions posed in the initial proposal could not be answered due to cancellation under adverse weather conditions of one third of our planned sampling trips and discontinuation of funding:estimation of secondary production, mortality rates and residence time of the resident fishes in the SAV bed. Due to escapement from the haul seine, reliable secondary production estimates could not be determined for spot and silver perch. Residence time was investigated for the sandbar shark through a tagging program. Through, a Virginia Commonwealth University mini-grant, Brooks and Weinstein are currently sampling the study area (with multiple gears) to determine secondary production of resident fishes in the SAV bed. Two intensive marking programs for spot and silver perch will define their residence times and mortality rates in the SAV area.

One of the most significant and nagging management questions not addressed by this study is relative habitat value for commercial and recreationally important resources. The importance of SAV beds cannot be assessed without concurrent or parallel studies of marshes, mudflat areas and other nursery zones.

The primary objectives of the comparison program should be: 1. To define community structure and secondary production for individual species within each habitat; 2. Relative benefits of each habitat to fishes from a trophic and refuge stand point; 3. Via an intensive marking program, determination of the period of residency for selected species and definition of microhabitat partitioning. Do the dominant species of each habitat view a marsh, tidal creek, mudflat or eelgrass bed as separate habitats or is there a free exchange between them?

Weinstein and Brooks efforts address a portion of the intra-habitat objectives through comparison sampling and tagging studies at the Vaucluse Shores site and a tidal creek area less than .2 km from the SAV bed. Initial spring sampling indicated that the density of early juvenile spot in the tidal creek area was at least four times higher than the spot density found in the SAV bed. Tidal creek spot were also larger than SAV bed spot which indicates a higher residency time for spot in the tidal creek than on the eelgrass bed. Without comparison studies between primary shallow water nursery habitats, the relative value of SAV to "resident" and migratory species cannot be determined.

LITERATURE CITED

Adams, S. M. 1976a. The ecology of eelgrass, Zostera marina (L.), fish communities. I. Structural analysis. J. exp. mar. Biol. Ecol. 22:269-291.

Adams, S. M. 1976b. The ecology of eelgrass, Zostera marina (L.), fish communities. II. Functional analysis. J. exp. mar. Biol. Ecol. 22:293-311.

Adams, S. M. 1976c. Feeding ecology of eelgrass fish communities. Trans. Amer. Fish. Soc. 105:514-519.

Alldredge, A. L. and J. M. King. 1974. Distribution, abundance, and substrate preference of demersal reef zooplankton at Lizard Island Lagoon, Great Barrier Reef. Mar. Biol. 41:317-333.

Alldredge, A. L. and J. M. King. 1980. Effects of moonlight on the vertical migration patterns of demersal zooplankton. J. exp. mar. Biol. Ecol. 44:133-156.

Arnott, H. J., N. J. Maciolek, J. A. C. Nicol. 1970. Retinal tapetum lucidum: a novel reflecting system in the eye of teleosts. Science 169:478-480.

Briggs, P. T., and J. S. O'Connor. 1971. Comparison of shore-zone fishes over naturally vegetated and sand-filled bottoms in Great South Bay. N. Y. Fish Game J. 18:15-41.

Carr, W. E. S., and C. A. Adams. 1972. Food habits of juvenile marine fishes: Evidence of the cleaning habit in the leather jacket Oligoplites saurus, and the spottail pinfish Diplodus holbrooki.

Carr, W. E. S., and C. A. Adams. 1973. Food habits of juvenile marine fishes occupying seagrass beds in the estuarine zone near Crystal River, Florida. Trans. Am. Fish. Soc. 102:511-540.

Chao, L. N., and J. A. Musick. 197 . Life history, feeding habits, and functional morphology of juvenile sciaenid fishes in the York River estuary, Virginia, Fish. Bull. U. S. 75:657-702.

Dovel, W. 1971. Fish eggs and larvae of the upper Chesapeake Bay. Nat. Res. Inst., Univ. of Md. Contrib. #460, 71 pp.

Emery, A. R. 1968. Preliminary observations on coral reef plankton. Limn. Oceanog. 13(2):293-303.

Fenwick, G. 1978. Plankton swarms and their predators at the Snares Islands. N. Z. Journal Mar. Freshwater Res. 12:223-224.

Grant, G. C. and J. E. Olney. 1979. Lower bay zooplankton monitoring survey: an introduction to the program and results of the initial survey of March 1978. VIMS SSR No. 93, 92pp.

Hardy, J. D. and R. K. Johnson. 1974. Descriptions of halfbeak larval and juveniles from Chesapeake Bay (Pisces: Hemiramphidae). Ches. Sci. 15(4):241-246.

Hamley, J. M. 1975. Review of gill net selectivity. J. Fish. Res. Bd. Can. 32(11):1943-1969.

Hammer, R. M. and R. C. Zimmerman. 1979. Species of demersal zooplankton inhabiting a kelp forest ecosystem off Santa Catalina Island, California. Bull. Southern California Acad. Sci. 78:199-206.

Hamner, W. H., and J. H. Carleton. 1979. Copepod swarms: attributes and role in coral reef ecosystems. Limnol. Oceanogr. 24:1-14.

Hildebrand, S. F. and W. C. Schroeder. 1927. Fishes of the Chesapeake Bay. Bull. U. S. Bur. Fish. 43:1-366.

Hildebrand, S. F. and L. E. Cable. 1930. Development and life history of fourteen teleostean fishes at Beaufort, N. C. U. S. Bus. Fish. Bull. 46:383-488.

Hobson, E. S. 1968. Predatory behavior of some shore fishes in the Gulf of California. U. S. Fish. Wildl. Serv. Res. Rep. 73, 92pp.

Hobson, E. S. 1979. Interactions between piscivorous fishes and their prey. In: International Symposium on predator-prey systems in fish communities and their role in fisheries management. (ed. Clepper, H.) Sports Fishing Institute, Wash. D. C.

Hobson, E. S. and J. R. Chess. 1976. Trophic interactions among fishes and zooplankters nearshore at Santa Catalina Island, California. Fishery Bull. 74:567-598.

Hobson, E. S. and J. R. Chess. 1979. Zooplankton that emerge from the lagoon floor at night at Kure and Midway Atolls, Hawaii. Fishery Bull 77:275-280.

Hoese, H. D., and R. S. Jones. 1963. Seasonality of larger animals in a Texas grass community. Publs. Inst. mar. Sci. Univ. of Texas 9:37-46.

Jacobs, F. 1978. Zooplankton distribution, biomass, biochemical composition, and seasonal community structure in lower Chesapeake Bay. Ph.D. Dissertation, University of Virginia. Charlottesville, Va. 105 pp.

Jeffries, H. P. 1962. Succession of two Acartia species. Estuaries Limnol. Oceanogr. 7:354-364.

Kjelson, M. A., D. S. Peters, G. W. Thayer, and G. N. Johnson. 1974. The general feeding ecology of postlarval fishes in the Newport River Estuary. Fish. Bull. 73:137-144.

Kjelson, M. A. and G. N. Johnson. 1974. Description and evaluation of a long haul seine for sampling fish populations in offshore estuarine habitats. Proc. 28th Ann. Conf. S. E. Assoc. Game Fish Comm. pp. 171-175.

Kriete, W. and J. G. Loesch. 1980. Design and relative efficiency of a bow-mounted pushnet for sampling juvenile pelagic fishes. Trans. Am. Fish. Soc. 109:649-652.

Lane, E. D., M.C.S. Kingsley, and D.E. Thornton. 1979. Daily feeding and food conversion efficiency of the diamond turbot:an analysis based on field data. Trans. Am. Fish. Soc. 108:530-535.

Lewis, E. G. and P. A. Haefner. 1976. Oxygen consumption of the blue crab Callinectes sapidus, from proecdysis to postecdysis. Comp. Biochem. Physiol. 54A:55-60.

Massmans, W. H., J. J. Norcross, and E. B. Joseph. 1961. Fishes and fish larval collected from Atlantic plankton cruises of R/V Pathfinder, December 1959 - December 1960. Virginia Fish. Lab. SSR No. 26, 15 pp.

Massmann, W. H., J. J. Norcross and E. B. Joseph. 1962. Fishes and fish larval collected from Atlantic plankton cruises of R/V Pathfinder, March 1961 - March 1962. VIMS SSR No. 33, 20 pp.

Moseley, F. N. and B. J. Copeland, 1969. A portable drop-net for representative sampling of nekton. Contr. Mar. Sci. Tex. 14:37-45.

Nixon, S. W. and C. A. Oviatt. 1972. Preliminary measurements of mid-summer metabolism in beds of eelgrass, Zostera marina. Ecology. 53: 150-153.

Norcross, J. J., W. H. Massmann, and E. B. Joseph. 1961. Investigations of inner continental shelf waters of the lower Chesapeake Bay. Part III. Sand lance larval, Arnmodytes americanus. Ches. Sci. 2(1-2):49-60

Olla, B. L. and W. W. Marchioni. 1968. Rhythmic movements of cones in the retina of bluefish, Pomatomus saltatrix, held in complete darkness. Biol. Bul. 135:143.

Olla, B. L., H. M. Katz and A. L. Studholme. 1970. Prey capture and feeding motivation in the bluefish, Pomatomus saltatrix. Copeia. 14:360-362.

Olla, B. L. and A. L. Studholme. 1972. Behavior of marine animals. Volume 2:Vertebrates. p. 303-325. (ed. Winn, H. E. and B. L. Olla). Plenum Press, New York.

Olney, J. E. 1978. Planktonic fish eggs and larvae of the lower Chesapeake Bay. MS Thesis, College of William and Mary, Williamsburg, Va. 123 pp.

Olney, J. E. In Press. Eggs and early larvae of the bay anchovy, Anchoa mitchilli, and the weakfish, Cynoscion regalis, in lower Chesapeake Bay with notes on associated ichthyoplankton. Estuaries 6(1).

Orth, R. J. 1975. Destruction of eelgrass, Zostera marina, by the cownose ray, Rhinoptera bonasus, in the Chesapeake Bay. Ches. Sci. 16:206-208.

Orth, R. J. and K. L. Heck, Jr. 1980. Structural components of eelgrass (Zostera marina) meadows in the lower Chesapeake Bay:fishes. Estuaries. 3:278-288.

Pearson, J. C. 1941. The young of some marine fishes taken in lower Chesapeake Bay, Virginia, with special reference to the grey sea trout, Cynoscion regalis (Bloch). USFWS Fish. Bull. 50:79-102.

Popova, O. A. 1978. The role of predaceous fish in ecosystems. Ecology of freshwater fish production. p. 215-249 (ed. Gerking, S. D.). Blackwell Scientific Publications, Oxford.

Peters, D. S. and M. A. Kjelson. 1975. Consumption and utilization of food by various postlarval and juvenile fishes of North Carolina estuaries. Estuarine Research. Vol. 1:447-472. Academic Press Inc., New York.

Peters, D. S., Kjelson, M. A. and M. T. Boyd. 1974. The effect of temperature on digestion rate in the pinfish Lagoda rhomboides, spot Leiostomus xanthurus, and silverside Menidia menidia. Proc. 26th Ann. Conf. Southeastern Assoc. Game Fish Comm. p. 637-643.

Pristas, P. J. and L. Trent. 1977. Comparisons of catches of fishes in gill nets in relation to webbing material, time of day, and water depth in St. Andrew Bay, Florida. Fish. Bull. 75:103-108.

Ried, G. K., Jr. 1954. An ecological study of the Gulf of Mexico fishes, in the vicinity of Cedar Key, Florida. Bull. Mar. Sci. Gulf. Caribb. 4:1-94.

Robertson, A. I. and R. K. Howard. 1978. Diel trophic interactions between vertically-migrating zooplankton and their fish predations in an eelgrass community. Mar. Biol. 48:207-213.

Sheridan, P. F. 1978. Trophic relationships of dominant fishes in the Apalachicola Bay system (Florida). Ph.D. Thesis, Florida State Univ. 232 pp.

Smith, W. G., J. D. Sibunka, and A. Wells. 1975. Seasonal distributions of larval flatfishes (Pleuronectiformes) on the continental shelf between Cape Cod and Cape Lookout, 1965-1966. U. S. Dept. Commerce, NOAA Tech. Rep. NMFS SSRF-691, 68p.

Thayer, G. W., M. A. Kjelson, D. E. Hoss, W. F. Hettler, Jr., and M. W. LaCroix. 1974. Influence of postlarval fishes on the distribution of zooplankton in the Newport River estuary. Ches. Sci. 15:9-16.

Zar, J. H. 1974. Biostatistical Analysis. Prentice Hall, Inc., Englewood Cliffs, New Jersey. 620 pp.