Ingestion and selection of suprabenthic crustaceans by small-sized fishes in a lower saltmarsh system

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● *Abstract*: This study was performed in the lower saltmarsh system of the Arrozal, in the Cananéia lagoon estuarine region (25°02'S - 47°56'W), Brazil. Suprabenthic fauna was surveyed with a small sledge and fishes were captured with casting and set nets to analyse: crustacean fauna as food for local fish species; difference in the diet at different times of the year; if there is diet overlap between species and the feeding behaviour of the species analysed. The fauna of Arrozal is poor in species, dominated mainly by *Metamysidopsis elongata atlantica, Acartia lilljeborgi, Atylus minikoi*, decapod larvae, and reveals a strong seasonal variation. The fishes were all carnivorous with suprabenthic crustacean as their main food resource. Seasonal changes in food supply are also reflected in the diet. Of the 12 fish species collected six were opportunistic feeders whereas six others were selective feeders. Food overlap value of 0.08 for all of the fish community indicates an almost completely distinct food niches. The increased overlapping of summer food between *Cathorops spixii* and species of Group II and between *Oligoplites* sp and species of Group I seems to have two different explanations: 1) the diminishing of food supply for species feeding on benthic originated suprabenthic crustaceans and 2) overabundance of planktonic forms of suprabenthos as well as a period of high feeding activity of fishes with such diet.

● *Resumo:* O presente estudo foi realizado no infralitoral contíguo à marisma, na Ponta do Arrozal, região estuarina lagunar de Cananéia (25°02'S - 47°56'W), Brasil. A fauna suprabêntica foi amostrada com uma pequena draga e os peixes capturados com tarrafa e rede de espera, com a finalidade de analisar: a composição de espécies dos crustáceos suprabênticos como itens alimentares dos peixes; diferenças na dieta em diferentes épocas do ano; se ocorre sobreposição alimentar entre as espécies e o comportamento alimentar das espécies de peixe analisadas. A fauna suprabêntica do Arrozal é pobre em espécies, dominada principalmente por *Metamysidopsis elongata atlantica, Acartia lilljeborgi, Atylus minikoi* e larvas de decapoda, e revela uma forte variação temporal. Os peixes são todos carnívoros e têm crustáceos suprabênticos como sua principal fonte alimentar. Variação temporal no suprimento alimentar se reflete na dieta. Das 12 espécies de peixes coletadas, 6 são oportunistas e 6 seletivas, em relação à captura do alimento. O valor da sobreposição alimentar de 0,08 para toda a comunidade de peixes indica nichos alimentares completamente distintos. O aumento de sobreposição alimentar no verão entre *Cathoropsis spixii* e espécies do Grupo II e *Oligoplites* sp e espécies do Grupo I parece ter duas explicações diferentes: 1) a diminuição do fornecimento alimentar para as espécies que se alimentaram de crustáceos suprabênticos com origem bêntica e 2) superabundância de formas planctônicas do suprabentos, assim como um período de alta atividade alimentar para peixes com esta dieta.

● *Descriptors:* Suprabenthic crustaceans, Fish food, Niche overlap, Southeastern Brazil.

● *Descritores:* Crustáceos suprabênticos, Alimento de peixes, Sobreposição alimentar, Sudeste do Brasil.

Introduction

In estuaries, density and biomass of permanent suprabenthos, the same as hyperbenthos (Sibert, 1981;

Mees & Hamerlynck, 1992 and Mees *et al.*, 1993), are much higher than in neighboring coastal areas (Mees & Hamerlynck, *op. cit.*). The importance of suprabenthic small crustaceans in the diets of estuarine fishes is well established and has been the subject of several investigations (Chao & Musick, 1977; Sibert, *op. cit.*).

According to Sibert (1981), suprabenthic populations are composed of surface dwelling benthic and planktonic species presenting upward and downward movements respectively. Components of both origins are found in the diet of small fish inhabiting the infralittoral adjacent to the lower marsh at Arrozal, Cananéia lagoon estuarine region, and suprabenthic crustaceans comprises more than 70% of the diet of all fishes considered (Wakabara et al., 1993).

The feeding ecology of small sized fish has increasingly become the subject of investigation (Zander, 1979; Evans, 1984; Pihl, 1985; Thorman & Wiederholm, 1983 and 1986). These studies proved the importance of the food supply, competition with related species, availability of the prey organisms and the influence of the predatory activity as influencing food choice. Nevertheless, much of the prey selectivity has not yet been explained.

Our primary objectives were to describe suprabenthic crustacean food resources utilized by fish species, to determine whether differences or overlap in diet occurred between species and at different times of the year, and to evaluate whether the diet composition is influenced by the presence and abundance of the prey items only or whether in addition, it is affected by a selective behaviour.

Material and methods

This study was conducted in Cananéia lagoon estuarine region (25°02'S-47°56'W) São Paulo (Fig. 1). The material was collected monthly from August, 1981 to July, 1982 at the infralittoral of Arrozal, 1-3 m depth, where plants of *Spartina alterniflora* (Loiseleur), appear in a low density. The suprabenthic crustacean fauna was surveyed with a small sledge. The sampling gear consisted of a steel framework weighting about 5.5 kg and a nylon bag with 0.5 mm stretch mesh fixed from the inside. Fifteen-minutes' tows were made at each 15 m long transect, perpendicularly to the water line. Six transects were sampled monthly corresponding to approximately 360 m². Fishes were captured using a 16 m casting net (height 3 m and 3 cm stretch mesh) thrown in the water from a boat (5 times in each month sampled). A 15 m set net (1.30 m height and 2 cm stretch mesh) was placed in the water for 30 minutes. All fishes were collected at a diurnal high tide and presented low vacuity index besides a good amount of fresh items in the stomachs.

Macrofauna samples were washed through a sieve of 0.5 mm mesh size and preserved in 70% ethanol. The fauna was sorted under a binocular microscope and the crustaceans were identified to species, when possible, and counted. We collected 15 groups of crustaceans but only 8 in sufficient numbers for quantitative analyses.

Fishes were preserved in ice boxes and taken to the laboratory, where they were identified, weighted and measured. Stomachs were cut longitudinally under a stereoscopic microscope and crustacean food items were identified to species level, whenever possible, counted and their volume directly measured. In certain occasions the volume of some items was immeasurable. Empty stomachs were recorded for calculation of the vacuity index and then discarded.

For the analyses and presentation of data, monthly samples were grouped as follows: spring (October - December); summer (January - March); autumn (April - June) and winter (July - September).

For quantitative analyses only fish and crustacean species with at least two specimens in average per sample were considered, according to Jackson (1972). The overall similarity of diets based on volume of each prey item from the different species of fish were measured with the Morisita index (Sokal and Sneath, 1973). Groupings were determined by WPGA (Weighted Pair Group Average) and were arbitrarily associated at similarity coefficients exceeding 0.60 (Davis, 1973).

Feeding preferences (FP) were calculated by the linear index of food selection (Strauss, 1979), when the number of sampled fishes exceded 10 individuals:

$$Li = ri - pi$$

where ri is the relative abundance of a species in the stomach and pi is the relative abundance of a species in the natural habitat samples. It ranges from -1 to +1 with positive values indicating preference and negative values indicating avoidance or inaccessibility. The expected value of the index for random feeding is zero. Electivity values were tested by a two-sided Wilcoxon's signed rank test (Kohler & Ney, 1982).

Diet overlap was measured using the Schoener index (Schoener, 1970). It ranges from 0 (no overlap) to 1 (complete overlap). Overlap in this index is generally considered to be biologically significant when the value exceeds 0.60 (Zaret & Rand, 1971; Mathur, 1977).

Stomach contents were analyzed for each fish species or group of species using the indexes:

1. Numerical abundance (N) - the number of each crustacean prey item in all non empty stomachs.

2. Percentage of the total number (F%) - the percentage that each food category contributed to the total number of crustacean food items in all stomachs.

3. Percentage of total volume (V%) - the percentage that each food category contributed to the total volume of crustacean food items in all stomachs.

4. Vacuity index (V.I.) - (number of empty stomachs/ total number of stomachs) x 100.

5. Species richness (S.R.) - number of items ingested by a certain fish or group of fishes.
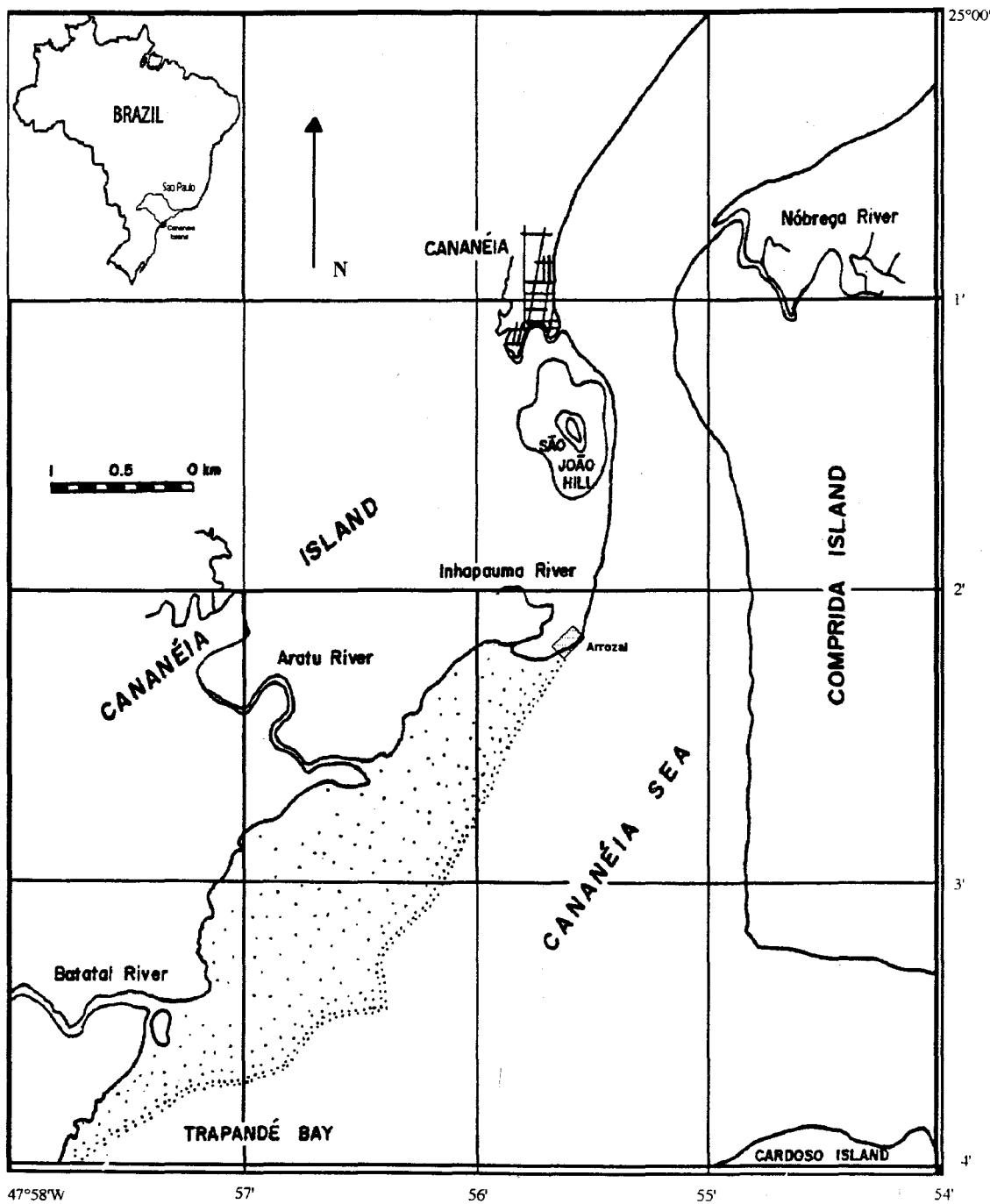

Fig. 1. Location of sampling site (Arrozal) in Cananéia lagoon estuarine region, São Paulo State, southeastern Brazil.

Results

Regarding the suprabenthic fauna, a total of 8 crustacean groups were considered among 15 sampled groups for quantitative analyses (Table 1). Crustacean fauna of the suprabenthos at Arrozal ranged in number from 447 specimens in summer to 22,567 in spring. Mysidacea, Copepoda and Amphipoda were the groups with higher species number and abundance among the local suprabenthos. Fluctuations in number of individuals of some species revealed replacement of dominant species and seasonal succession in the area. *Metamysidopsis*

elongata atlantica was preponderant in spring and autumn, *Acartia lilljeborgi* and decapod larvae in summer, *Atylus minikoi* and *M. elongata atlantica* in winter.

From the total of 30 collected fish species only 12 could be analyzed numerically. These species are: *Stellifer stellifer*, *Micropogonias furnieri*, *Oligoplites* sp, *Cathorops spixii*, *Isopisthus parvipinnis*, *Harengula jaguana*, *Eucinostomus* sp, *Symphurus jenynsii*, *Opisthonema oglinum*, *Anchoviella brevirostris*, *Haemulon* sp, *Sphoeroides pachygaster*. Number of specimens, number of empty stomachs, total length and weight of fishes considered are in Table 2.

Table 1. Suprabenthic crustacean species sampled during the four seasons of the period (1981-1982) - numerical abundance (N), percentage of the total number (F%)

SPECIES	SPRING		SUMMER		AUTUMN		WINTER	
	N	F%	N	F%	N	F%	N	F%
OSTRACODA								
Cyprideis salebrosa hartmanni	45	0.199	21	4.698	2	0.186	154	4.419
COPEPODA								
Acartia lilljeborgi	5	0.022	279	62.416	49	4.567	15	0.430
Eucalanus pileatus	-	-	1	0.224	2	0.186	53	1.521
Labidocera fluviatilis	1	0.004	3	0.671	24	2.237	130	3.730
Temora stylifera	7	0.031	20	4.474	2	0.186	34	0.976
DECAPODA (larvae)	16	0.071	51	11.409	78	7.269	21	0.603
PENAEIDAE								
Penaeus brasiliensis	118	0.523	13	2.908	6	0.559	-	-
MYSIDACEA								
Metamysidopsis elongata atlantica	22352	99.047	17	3.803	824	76.794	975	27.977
Mysidopsis coelhoi	2	0.009	28	6.264	4	0.373	8	0.230
Mysidopsis tortonesi	15	0.066	4	0.895	7	0.652	4	0.115
TANAIDACEA								
Kalliapseudes schubarti	-	-	5	1.119	71	6.617	76	2.181
ISOPODA								
Munna cananeia	-	-	-	-	-	-	47	1.349
AMPHIPODA								
Ampithoe ramondi	2	0.009	-	-	-	-	320	9.182
Atylus minikoi	3	0.013	-	-	-	-	1484	42.582
Corophium acherusicum	-	-	-	-	-	-	123	3.529
Grandidierella bonnieroides	1	0.004	5	1.119	4	0.373	41	1.176
TOTAL	22567	100.00	447	100.00	1073	100.00	3485	100.00

Table 2. Number of specimens (N), number of empty stomachs (E), length and weight of twelve fish species

Species	N	E	Total length (cm)	Weight (g)
Anchoviella brevirostris	29	0	6.2 - 11.0	3.0 - 11.0
Cathorops spixii	64	5	10.0 - 19.8	12.0 - 39.5
Eucinostomus sp.	31	7	8.0 - 13.0	5.0 - 25.0
Haemulon sp.	26	10	9.0 - 12.0	9.0 - 23.0
Harengula jaguana	54	7	10.0 - 12.0	10.0 - 20.0
Isopisthus parvipinnis	62	30	10.9 - 17.2	11.0 - 48.0
Micropogonias furnieri	117	13	7.0 - 17.0	4.5 - 51.0
Oligoplites sp.	84	26	6.7 - 14.0	3.0 - 21.0
Opisthonema oglinum	30	0	9.8 - 12.9	10.0 - 25.0
Symphurus jenynsii	30	4	8.5 - 18.0	3.0 - 49.0
Sphoeroides pachygaster	21	4	7.8 - 27.0	8.0 - 238.0
Stellifer stellifer	155	74	9.5 - 17.0	10.0 - 30.0

A cluster analysis was run on trophic data for all 12 fish species (Fig. 2), dividing them into 2 groups with 3 species each. *A. brevirostris, H. jaguana* and *O. oglinum* occurred as one group denominated Group I , *M. furnieri, S. jenynsii* and *S. stellifer* occurred as another group denominated Group II. The other species were not grouped.

Species of Group I were not persistent throughout the four seasons (Fig. 3). They decrease in number from spring to summer. In autumn they were absent, presenting maximum number in winter. Their diet comprises 13 species of Copepoda, 5 of Amphipoda and 4 of Mysidacea, besides Ostracoda, Luciferidae, Callianassidae, Decapoda larvae and Tanaidacea (Table 3). *Temora stylifera, Labidocera fluviatilis* and *M. elongata atlantica* were the most ingested items in spring, *A. lilljeborgi* and decapod larvae in summer, decapod larvae and *L. fluviatilis* in winter. The most rejected or inaccessible items for this group being *M. elongata atlantica* and *A. minikoi*.
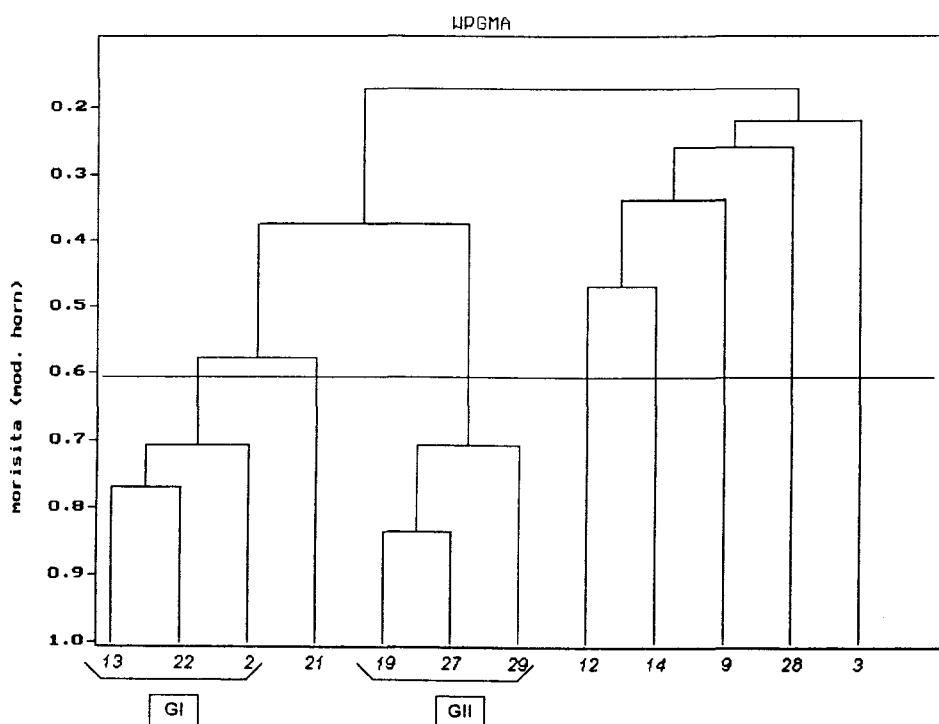
Fig. 2. Cluster analysis based on similarity of food items in the stomach of twelve fish species (Group I: 2 - *Anchoviella brevirostris,* 13 - *Harengula jaguana,* 22 - *Opistonema oglinum;* Group II: 19 - *Micropogonias furnieri,* 27 - *Symphurus jenynsii,* 29 - *Stellifer stellifer* and not grouped species; 3 - *Cathorops spixii,* 9 - *Eucinostomus* sp, 12 - *Haemulon* sp, 14 - *Isopisthus parvipinnis,* 21 - *Oligoplites* sp, 28 - *Sphoeroides pachygaster).*
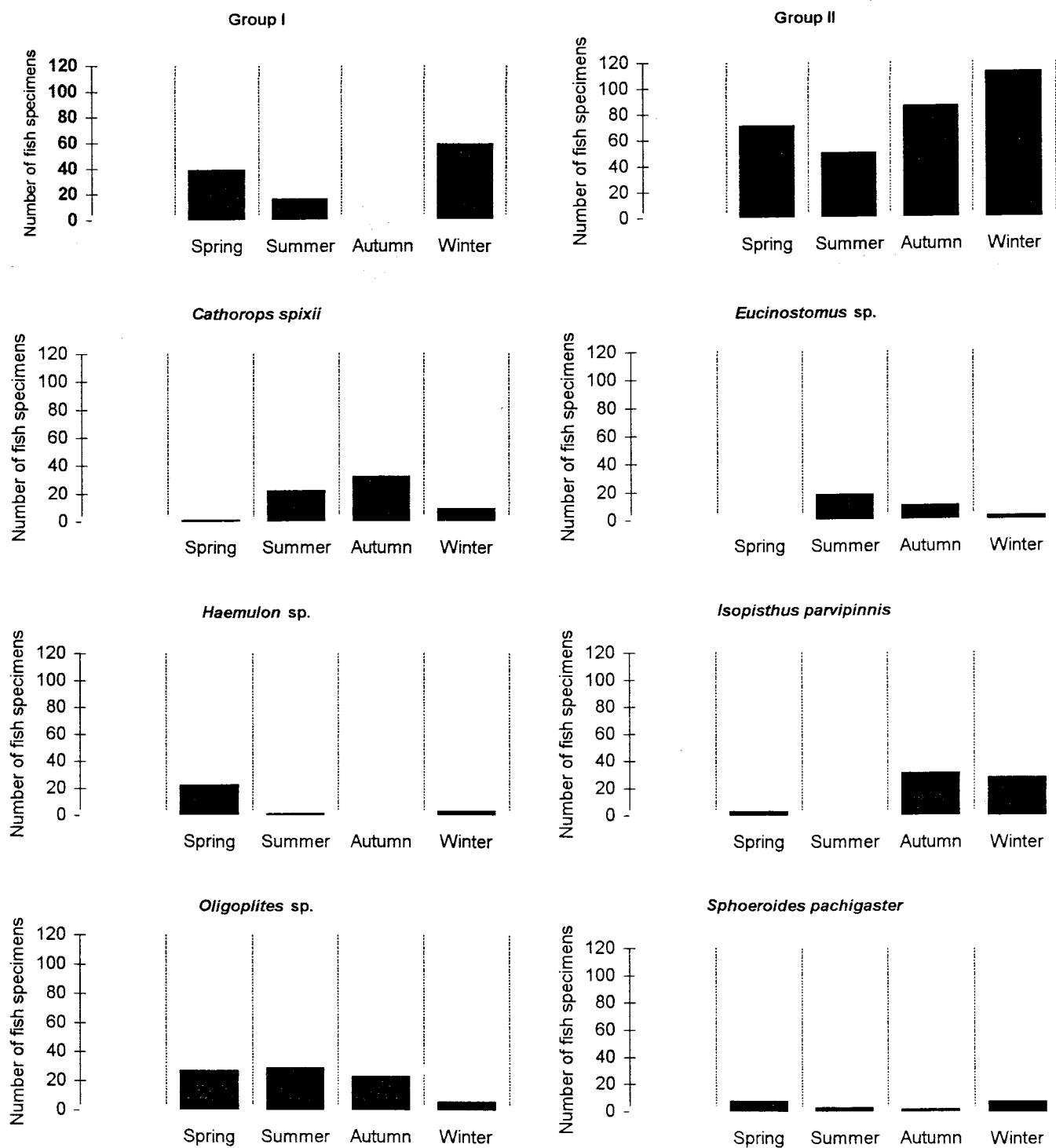
Fig. 3. Abundance of fish species during the period 1981 - 1982

GI: *Anchoviella brevirostris* + *Harengula jaguana* + *Opistonema oglinum*

GII: *Micropogonias fumieri* + *Symphurus jenynsii* + *Stellifer stellifer*

Table 3. Crustaceans found in stomachs of Group I - *Anchoviella brevisrostris* (N = 29), *Opistonema oglinum* (N = 30) and *Harengula jaguana* (N = 54) - numerical abundance (N), vacuity index (V.I.), species richness (S.R.), feeding preference (FP), percentage of the total number (F%) and percentage of total volume (V%)

Prey item	Spring V.I. = 7.69 S.R. = 16				Summer V.I. = 25.00 S.R. = 8				Winter V.C. = 0 S.R. = 18			
	F%	V%	FP	N	F%	V%	FP	N	F%	V%	FP	N
OSTRACODA												
Loxoconcha sp.	-	-	-	-	-	-	-	-	23.22	10.28	0.23	317
COPEPODA												
Acartia lilljeborgi	2.28	0.99	0.00	43	81.72	49.58	0.20	304	17.58	7.54	0.17	240
Centropages velificatus	0.05	0.00	0.00	1	-	-	-	-	0.07	0.00	0.00	1
Corycaeus giesbrechti	-	-	-	-	-	-	-	-	0.07	0.00	0.00	1
Ctenocalanus vanus s. l.	0.11	0.00	0.00	2	-	-	-	-	-	-	-	-
Cyclopinidae (not identified)	-	-	-	-	-	-	-	-	0.15	0.00	0.00	2
Eucalanus pileatus	0.43	0.00	0.00	8	1.07	0.84	0.01	4	4.18	1.92	0.03	57
Euterpina acutifrons	-	-	-	-	0.81	0.00	0.00	3	1.98	0.82	0.01	27
Harpacticoida (not identified)	-	-	-	-	0.27	0.00	0.00	1	1.54	1.41	0.01	21
Labidocera fluviatillis	14.03	13.15	0.14	264	7.26	4.20	0.07	27	38.90	16.46	0.35	531
Paracalanus crassirostris	-	-	-	-	-	-	-	-	0.15	0.00	0.00	2
Pseudodiaptomus acutus	5.31	2.26	0.05	100	5.37	3.36	0.05	20	2.56	1.09	0.02	35
Siphonostomatoida (not identified)	0.05	0.00	0.00	1	-	-	-	-	-	-	-	-
Temora stylifera	60.36	38.33	0.60	1136	0.81	0.00	-0.04	3	5.27	2.19	0.04	72
DECAPODA (larvae)	0.53	-	-	10	2.69	42.02	-0.09	10	3.44	58.29	0.02	47
LUCIFERIDAE												
Lucifer faxoni	0.05	-	-	1	-	-	-	-	-	-	-	-
THALASSINIDEA												
Callianassidae (not identified)	0.32	-	-	6	-	-	-	-	-	-	-	-
MYSIDACEA												
Bowmaniella brasiliensis	0.05	-	-	1	-	-	-	-	-	-	-	-
Metamysidopsis elongata atlantica	11.90	42.43	-0.88	224	-	-	-	-	-	-	-0.27	-
Mysidopsis coelhoi	0.05	0.00	0.00	1	-	-	-	-	0.07	0.00	0.00	1
Mysidopsis tortonesi	4.04	2.83	0.04	76	-	-	-	-	-	-	-	-
TANAIDACEA												
Kalliapseudes schubarti	-	-	-	-	-	-	-	-	0.59	0.00	-0.02	8
AMPHIPODA												
Caprella equilibra	0.43	0.00	0.00	8	-	-	-	-	-	-	-	-
Atylus minikoi	-	-	-	-	-	-	-	-	-	-	-0.42	-
Corophium acherusicum	-	-	-	-	-	-	-	-	0.07	0.00	-0.03	1
Parhyale hawaiensis	-	-	-	-	-	-	-	-	0.07	0.00	0.00	1
Tiron sp.	-	-	-	-	-	-	-	-	0.07	0.00	0.00	1

Fishes of Group II were persistent throughout the year and numerically dominant in all seasons. They decreased in number from spring toward summer, increased in autumn and in winter they presented the highest value (Fig. 3). The food spectrum of this group is made up by 34 taxonomic items being Amphipoda, Caridea, Copepoda and Mysidacea with 9, 5, 4 and 3 species respectively the richest

food groups in species (Table 4). Mysids were the most ingested items in spring, *Alpheus armillatus* in summer, *M. elongata atlantica* and *A. armillatus* in autumn and *Munna cananeia* and *Kalliapseudes schubarti* in winter. The most rejected or inaccessible items for this groups being *M. elongata atlantica*, *A. lilljeborgi* and *A. minikoi*.

Table 4. Crustaceans found in stomachs of Group II - *Stellifer stellifer* (N = 155), *Micropogonias furnieri* (N = 117) and *Symphurus jenynsii* (N = 30) - numerical abundance (N), vacuity index (V.I.), species richness (S.R.), feeding preference (FP), percentage of the total number (F%) and percentage of total volume (V%)

Prey item	Spring				Summer				Autumn				Winter			
	V.I. = 12.68 S.R. = 8				V.I. = 12.00 S.R. = 6				V.I. = 45.98 S.R. = 12				V.I. = 34.61 S.R. = 24			
	F%	V%	FP	N	F%	V%	FP	N	F%	V%	FP	N	F%	V%	FP	N
COPEPODA																
Acartia lilljeborgi	-	-	-	-	-	-	-0.62	-	0.76	-	-0.04	15	0.14	-	0.00	1
Calanopia americana	-	-	-	-	-	-	-	-	-	-	-	-	0.14	-	0.00	1
Pseudodiaptomus acutus	-	-	-	-	-	-	-	-	0.10	-	0.00	2	-	-	-	-
Temora stylifera	-	-	-	-	-	-	-	-	-	-	-	-	0.43	-	-0.01	3
EUPHAUSIACEA																
Euphausiacea (not identified)	0.02	-	0.00	1	-	-	-	-	-	-	-	-	-	-	-	-
DECAPODA (larvae)	-	-	-	-	-	-	-	-	-	-	-	-	0.14	-	-0.01	1
PENAEIDAE																
Penaeus sp.	-	-	-	-	-	-	-	-	0.05	-	0.00	1	-	-	-	-
Trachypenaeus constrictus	-	-	-	-	-	-	-	-	-	-	-	-	0.29	-	0.00	2
SERGESTIDAE																
Acetes americanus americanus	-	-	-	-	-	-	-	-	0.15	-	0.00	3	-	-	-	-
CARIDEA																
Alpheus armillatus	0.05	-	0.00	2	57.14	85.25	0.57	12	1.06	50.21	0.01	21	0.43	-	0.00	3
Alpheus chacei	-	-	-	-	-	-	-	-	-	-	-	-	0.14	-	0.00	1
Leander paulensis	-	-	-	-	-	-	-	-	0.05	-	0.00	1	0.14	-	0.00	1
Ogyrides alphaerostris	-	-	-	-	14.29	2.46	0.14	3	-	-	-	-	0.58	-	0.00	4
Processa sp.	0.02	-	0.00	1	-	-	-	-	-	-	-	-	-	-	-	-
THALASSINIDEA																
Upogebia sp.	-	-	-	-	-	-	-	-	-	-	-	-	0.14	-	0.00	1
Callianassidae (not identified)	-	-	-	-	-	-	-	-	0.15	-	0.00	3	0.14	-	0.00	1
BRACHYURA																
Brachyura (not identified)	-	-	-	-	14.29	1.64	0.14	3	-	-	-	-	-	-	-	-
Pilumnus sp.	-	-	-	-	4.76	1.64	0.00	1	0.05	-	0.00	1	-	-	-	-
MYSIDACEA																
Bowmaniella brasiliensis	-	-	-	-	-	-	-	-	-	-	-	-	0.29	-	0.00	2
Metamysidopsis elongata atlantica	54.86	79.38	-0.55	2296	4.76	5.74	0.01	1	95.97	49.62	0.20	1904	3.03	42.98	-0.24	21
Mysidopsis coelhoi	44.83	20.63	0.44	1876	-	-	-	-	0.05	-	0.00	1	-	-	-	-
CUMACEA																
Cumacea (not identified)	-	-	-	-	-	-	-	-	-	-	-	-	0.29	-	0.00	2
TANAIDACEA																
Kalliapseudes schubarti	0.10	-	0.00	4	-	-	-	-	1.56	0.17	-0.05	31	35.79	39.28	0.33	248
ISOPODA																
Munna cananeia	-	-	-	-	-	-	-	-	-	-	-	-	37.66	5.55	0.36	261
Tholozodium rhombofrontalis	-	-	-	-	-	-	-	-	-	-	-	-	0.14	-	0.00	1
AMPHIPODA																
Ampelisca sp.	-	-	-	-	-	-	-	-	-	-	-	-	0.14	-	0.00	1
Ampithoe ramondi	-	-	-	-	-	-	-	-	-	-	-	-	1.44	0.05	-0.08	10
Aoridae (not identified)	-	-	-	-	-	-	-	-	-	-	-	-	0.14	-	0.00	1
Atylus minikoi	-	-	-	-	4.76	-	0.04	1	-	-	-	-	6.06	1.99	-0.36	42
Cerapus sp.	-	-	-	-	-	-	-	-	-	-	-	-	1.59	-	0.01	11
Corophium acherusicum	0.02	-	0.00	1	-	-	-	-	-	-	-	-	10.53	10.17	0.07	73
Grandidierella bonnieroides	-	-	-	-	-	-	-	-	-	-	-	-	0.14	-	0.00	1
Parhyale hawaiensis	0.10	-	0.00	4	-	-	-	-	0.05	-	0.00	1	-	-	-	-
Amphipoda (not identified)	-	-	-	-	-	3.28	-	-	-	-	-	-	-	-	-	-

C. spixii presented peak numbers during summer and autumn (Fig. 3). The number of items in the stomach contents varied from 4, in summer to 14 in autumn (Table 5). The species feeds mainly on *A. armillatus* in summer; Harpacticoidea in autumn; *A. armillatus* and *M. cananeia* in winter. The species showed avoidance to *A. lilljeborgi* and decapod larvae.

Eucinostomus sp was not collected in spring (Fig. 3). In winter it ate no crustacean items. The species had a very narrow food spectrum, with one item in autumn and 2 in summer and the main food item was *K. schubarti* in the two seasons (Table 6). The species showed avoidance to *A. lilljeborgi* and *M. elongata atlantica*.

Table 5. Crustaceans found in stomachs of *Cathorops spixii* (N = 64) - numerical abundance (N), vacuity index (V.I.), species richness (S.R.), feeding preference (FP), percentage of the total number (F%) and percentage of total volume (V%)

Prey item	Summer V.I. = 4.55 S.R. = 4				Autumn V.I. = 9.37 S.R. = 14				Winter V.I. = 11.12 S.R. = 7			
	F%	V%	FP	N	F%	V%	FP	N	F%	V%	FP	N
COPEPODA												
Acartia lilljeborgi	=	=	-0.61	-	0.14	-	-0.04	5	-	-	-	-
Cyclopinidae (not identified)	-	-	-	-	1.52	-	0.01	54	-	-	-	-
Halicyclops crassicornis	-	=	-	-	0.23	-	-	8	-	-	-	-
Harpacticoida (not identified)	=	=	-	-	91.49	98.00	0.91	3251	-	-	-	-
Oncaea curta	=	=	-	-	0.06	-	-	2	-	-	-	-
Paracalanus crassirostris	=	=	-	-	0.14	-	-	5	-	-	-	-
Pseudodiaptomus acutus	-	=	-	-	0.03	-	-	1	-	-	-	-
Temora stylifera	-	=	-	-	0.03	-	-	1	-	-	-	-
EUPHAUSIACEA												
Euphausiacea (not identified)	-	=	-	-	0.17	-	-	6	-	-	-	-
DECAPODA (larvae)	-	=	-0.11	-	-	-	-	-	-	-	-	-
PENAEIDAE												
Penaeus sp. (post-larvae)	8.33	=	0.06	1	0.11	-	-	4	-	-	-	-
Trachypenaeus constrictus	8.33	-	0.08	1	-	-	-	-	-	-	-	-
CARIDEA												
Alpheus armillatus	75.00	100.00	0.75	9	-	-	-	-	3.57	49.67	0.04	1
Ogyrides alphaerostris	-	-	=	-	0.03	-	-	1	-	-	-	-
THALASSINIDEA												
Callianassidae (not identified)	-	-	-	-	-	-	-	-	3.57	-	0.04	1
MYSIDACEA												
TANAIDACEA												
Kalliapseudes schubarti	-	-	-	-	2.53	-	-0.04	90	17.86	8.28	-	5
ISOPODA												
Munna cananeia	-	-	-	-	3.54	2.00	0.03	126	7.14	41.39	-0.05	2
AMPHIPODA												
Ampithoe ramondi	-	-	-	-	-	-	-	-	3.57	-	0.00	1
Atylus minikoi	-	-	-	-	-	-	-	-	57.14	0.66	0.30	16
Corophium acherusicum	8.33	-	0.08	1	-	-	-	-	7.14	-	0.06	2
Monoculodes nyei	-	-	-	-	0.03	-	-	1	-	-	-	-
Not Consumed												
Metamysidopsis elongata atlantica	-	-	-	-	-	-	-	-	-	-	-0.27	-

Table 6. Crustaceans found in stomachs of *Eucinostomus* sp (N = 31) - numerical abundance (N), vacuity index (V.I.), species richness (S.R.), feeding preference (FP), percentage of the total number (F%) and percentage of total volume (V%)

Prey item	Summer V. I. = 22.23 S. R. = 2				Autumn V. I. = 30.50 S. R. = 1			
	F%	V%	FP	N	F%	V%	FP	N
COPEPODA								
PENAEIDAE								
Penaeus sp.	11.11	86.96	0.08	1	-	-	-	-
MYSIDACEA								
TANAIDACEA								
Kalliapseudes schubarti	88.88	13.04	0.87	8	100.00	100.00	0.94	97
Not Consumed								
Acartia lilljeborgi	-	-	-0.61	-	-	-	-	-
Metamysidopsis elongata atlantica	-	-	-0.03	-	-	-	-0.75	-

Haemulon sp was not present in autumn and had its higher abundance in spring (Fig. 3). The species fed largely on *Mysidopsis coelhoi* in spring, *K. schubarti* and *A. armillatus* in winter (Table 7). The species showed avoidance to *M. elongata* atlantica in spring.

I. parvipinnis was not collected in summer and had its higher abundance in autumn and winter (Fig. 3). The species ate Euphausiacea, *Mysidopsis tortonesi* and *A. americanus americanus* in autumn; *K. schubarti* and *A. minikoi* in winter (Table 8). The species showed avoidance to *M. elongata atlantica* in autumn and winter; and to *A. minikoi* in winter. It has a narrow food spectrum as only 2 to 5 types of items were present in the stomach at any time period.

Table 7. Crustaceans found in stomachs of *Haemulon* sp (N = 26) - numerical abundance (N), vacuity index (V.I.), species richness (S.R.), feeding preference (FP), percentage of the total number (F%) and percentage of total volume (V%)

Prey item	Spring V. I. = 45.46 S. R. = 3				Winter V. I. = 0 S. R. = 4			
	F%	V%	FP	N	F%	V%	FP	N
COPEPODA								
Cyprideis salebrosa hartmanni	3.19	-	0.03	3	-	-	-	-
DECAPODA (larvae)	-	-	-	-	2.44	-	0.01	1
SERGESTIDAE								
Acetes americanus americanus	-	-	-	-	-	-	-	-
CARIDEA								
Alpheus armillatus	-	-	-	-	7.32	60.00	0.07	3
Ogyrides alphaerostris	7.45	67.31	0.07	7	-	-	-	-
MYSIDACEA								
Mysidopsis coelhoi	89.36	32.69	0.89	84	-	-	-	-
TANAIDACEA								
Kalliapseudes schubarti	-	-	-	-	85.36	40.00	0.02	35
AMPHIPODA								
Corophium acherusicum	-	-	-	-	4.88	-	0.03	2
Not Consumed								
Acartia lilljeborgi	-	-	-	-	-	-	-	-
Metamysidopsis elongata atlantica	-	-	-0.99	-	-	-	-	-

Table 8. Crustaceans found in stomachs of *Isopisthus parvipinis* (N = 62) - numerical abundance (N), vacuity index (V.I.), species richness (S.R.), feeding preference (FP), percentage of the total number (F%) and percentage of total volume (V%)

Prey item	Autumn				Winter			
	V. I. = 19.36 S. R. = 5				V. I. = 85.72 S. R. = 2			
	F%	V%	FP	N	F%	V%	FP	N
EUPHAUSIACEA								
Euphausiacea (not identified)	50.00	-	0.50	7	-	-	-	-
SERGESTIDAE								
Acetes americanus americanus	14.29	-	0.14	2	-	-	-	-
CARIDEA								
Alpheus armillatus	7.14	-	0.07	1	-	-	-	-
THALASSINIDEA								
Callianassidae (not identified)	7.14	-	0.07	1	-	-	-	-
MYSIDACEA								
Mysidopsis tortonesi	21.43	-	0.21	3	-	-	-	-
TANAIDACEA								
Kalliapseudes schubarti	-	-	-	-	83.33	-	0.81	5
AMPHIPODA								
Atylus minikoi	-	-	-	-	16.66	-	-0.21	1
Not consumed								
Metamysidopsis elongata atlantica	-	-0.75			-	-	-0.27	-

Oligoplites sp was collected throughout the year and in larger numbers during spring and summer (Fig. 3). In spring it ate basically two species of mysids, in summer, the species ingested mainly *A. americanus americanus*, decapod larvae and *Lucifer faxoni* (Table 9). In autumn it fed basically on *M. elongata atlantica* and *T. stylifera*, and in winter, *M. elongata atlantica* and *L. fluviatilis*. The number of items in the stomach contents of this species varied from 10 in spring to 2 in autumn. The species showed avoidance to *M. elongata atlantica, A. minikoi* and *A. lilljeborgi*.

S. pachygaster was present throughout the year but it didn't eat crustaceans in summer and presented higher abundance during winter and spring (Fig. 3). The species

Table 9. Crustaceans found in stomachs of *Oligoplites* sp (N = 84) - numerical abundance (N), vacuity index (V.I.), species richness (S.R.), feeding preference (FP), percentage of the total number (F%) and percentage of total volume (V%)

Prey item	Spring				Summer				Autumn				Winter			
	V. I. = 14.82 S. R. = 10				V. I. = 27.59 S.R. = 8				V. I. = 56.52 S. R. = 2				V. I. = 16.67 S. R. = 5			
	F%	V%	FP	N	F%	V%	FP	N	F%	V%	FP	N	F%	V%	FP	N
COPEPODA																
Acartia lilljeborgi	7.30	1.96	0.07	186	0.63	-	-0.61	5	-	-	-	-	16.90	2.50	0.17	12
Centropages velificatus	0.35	-	0.00	9	-	-	-	-	-	-	-	-	-	-	-	-
Eucalanus pileatus	0.04	-	0.00	1	0.13	-	0.00	1	-	-	-	-	5.63	0.63	0.05	4
Labidocera fluviatillis	0.04	-	0.00	1	0.25	-	0.00	2	-	-	-	-	69.01	9.38	0.67	49
Pseudodiaptomus acutus	0.20	-	0.00	5	-	-	-	-	-	-	-	-	1.41	-	0.01	1
Temora stylifera	-	-	-	-	0.13	-	-0.04	1	28.06	1.61	0.28	39	-	-	-	-
DECAPODA (larvae)	0.16	-	0.00	4	63.79	8.31	0.52	502	-	-	-	-	-	-	-	-
PENAEIDAE																
Penaeus sp. (post-larvae)	0.16	-	0.00	4	-	-	-	-	-	-	-	-	-	-	-	-
SERGESTIDAE																
Acetes americanus americanus	2.90	-	0.02	74	8.89	83.80	0.08	70	-	-	-	-	-	-	-	-
LUCIFERIDAE																
Lucifer faxoni	-	-	-	-	11.18	5.54	0.11	88	-	-	-	-	-	-	-	-
MYSIDACEA																
Metamysidopsis elongata atlantica	34.22	65.36	-0.65	872	14.99	2.35	0.11	118	71.94	98.39	-0.03	100	7.04	87.50	-0.20	5
Mysidopsis coelhoi	54.63	32.68	0.49	1392	-	-	-	-	-	-	-	-	-	-	-	-
Not Consumed																
Atylus minikoi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-0.42	-

ate, in spring, *Callinectes* sp and *Sphaeromopsis mourei* (Table 10). In autumn, it ingested *Callinectes* sp and *K. schubarti*. During winter, it utilized mainly *Parhyale hawaiensis, Ampithoe ramondi* and *K. schubarti*. The species showed avoidance to *M. elongata atlantica* in spring, autumn and winter and *A. minikoi* in winter.

To investigate resource partitioning between fish species, food niche overlap was calculated each season from spring to winter, when possible (Table 11). Mean food niche overlap between pairs of fish or group of fish was estimated to be 0.08. The seasonal food overlap values to determine the interspecific differences in utilization of food

Table 10. Crustaceans found in stomachs of *Sphoeroides pachygaster* (N=21) - numerical abundance (N), vacuity index (V.I.), species richness (S.R.), feeding preference (FP), percentage of the total number (F%) and percentage of total volume (V%)

Prey item	Spring V.I. = 50.00 S.R. = 2				Autumn V.I. = 0 S.R. = 2				Winter V.I. = 0 S.R. = 6			
	F%	V%	FP	N	F%	V%	FP	N	F%	V%	FP	N
BRACHYURA												
Callinectes sp.	50.00	67.53	0.50	1	50.00	98.04	0.50	1	-	-	-	-
MYSIDACEA												
TANAIDACEA												
Kalliapseudes schubarti	-	-	-	-	50.00	1.96	0.44	1	13.04	3.60	0.11	3
ISOPODA												
Sphaeromopsis mourei	50.00	32.47	0.50	1	-	-	-	-	-	-	-	-
AMPHIPODA												
Ampithoe ramondi	-	-	-	-	-	-	-	-	17.39	2.16	0.08	4
Atylus minikoi	-	-	-	-	-	-	-	-	8.70	1.44	-0.34	2
Hyale sp.	-	-	-	-	-	-	-	-	4.35	-	0.00	1
Platorchestia sp.	-	-	-	-	-	-	-	-	4.35	-	0.00	1
Parhyale hawaiensis	-	-	-	-	-	-	-	-	52.17	92.81	0.52	12
Not Consumed												
Metamysidopsis elongata atlantica	-	-	-0.99	-	-	-	-0.75	-	-	-	-0.27	-

Table 11. Food - niche overlap (α) between all pairs of species for each season during the period August/1981 to July/1982

Species/Group	Spring	Summer	Autumn	Winter	ᾱ
Group I/Group II	0.43	0.00	-	0.00	0.140
Group I/*Cathorops spixii*	0.00	0.00	-	0.00	0.000
Group I/*Eucinostomus* sp.	-	0.00	-	0.00	0.000
Group I/*Haemulon* sp.	0.00	0.00	-	0.00	0.000
Group I/*Isopisthus parvipinnis*	0.00	-	-	0.00	0.000
Group I/*Oligoplites* sp.	0.44	0.89	-	0.13	0.490
Group I/*Sphoeroides pachygaster*	0.00	-	-	0.00	0.000
Group II/*Cathorops spixii*	0.00	0.85	0.00	0.15	0.250
Group II/*Eucinostomus* sp.	-	0.00	0.01	-	0.005
Group II/*Haemulon* sp.	0.20	0.00	-	0.47	0.330
Group II/*Isopisthus parvipinnis*	-	0.00	0.00	0.40	0.130
Group II/*Oligoplites* sp.	0.05	-	0.50	0.00	0.180
Group II/*Sphoeroides pachygaster*	0.00	-	0.01	0.06	0.020
Cathorops spixii/*Eucinostomus* sp.	-	0.00	0.00	-	0.000
Cathorops spixii/*Haemulon* sp.	0.00	0.00	-	0.58	0.520
Cathorops spixii/*Isopisthus parvipinnis*	-	0.00	0.00	0.08	0.026
Cathorops spixii/*Oligoplites* sp.	0.00	0.00	0.00	0.00	0.000
Cathorops spixii/*Sphoeroides pachygaster*	-	0.00	0.00	0.05	0.016
Eucinostomus sp./*Haemulon* sp.	-	0.00	-	-	0.000
Eucinostomus sp./*Isopisthus parvipinnis*	-	-	0.00	-	0.000
Eucinostomus sp./*Oligoplites* sp.	-	0.00	0.00	-	0.000
Eucinostomus sp./*Sphoeroides pachygaster*	-	-	0.02	-	0.020
Haemulon sp./*Isopisthus parvipinnis*	0.00	-	-	0.40	0.200
Haemulon sp./*Oligoplites* sp.	0.32	0.00	-	0.00	0.106
Haemulon sp./*Sphoeroides pachygaster*	-	0.00	-	0.04	0.020
Isopisthus parvipinnis/*Oligoplites* sp.	0.00	-	0.00	0.00	0.000
Isopisthus parvipinnis/*Sphoeroides pachygaster*	0.00	-	0.00	0.04	0.013
Oligoplites sp./*Sphoeroides pachygaster*	0.00	-	0.00	0.00	0.000
mean overlap for fish community	0.08	0.15	0.03	0.11	0.080

resource resulted that the overlap occurred at two situations in summer between *C. spixii* and each species of Group II and between *Oligoplites* sp and species of Group I. Data of annual food niche overlap between pair of species within Groups I and II are presented on Table 12.

Table 12. Annual food niche overlap (α) between pairs of species within groups

Group	Species	α	$\bar{\alpha}$
I	Anchoviella brevirostris x Opisthonema oglinum	0.68	0.67
	Anchoviella brevirostris x Harengula jaguana	0.66	
II	Micropogonias furnieri x Stellifer stellifer	0.88	0.87
	Micropogonias furnieri x Symphurus jenynsii	0.82	
	Symphurus jeninsii x Stellifer stellifer	0.91	

Discussion

It was considered in our previous work (Wakabara *et al.*, 1993) that the majority of the twelve fish species analysed have their main food source on groups as mysids, copepods, epifaunal crustaceans as amphipods and isopods, infaunal tanaids besides decapod larvae and sergestids, comprising more than 70% of the diet. Indeed, such organisms could be considered as making part of the suprabenthos (sensu Dauvin *et al.*, 1994). So, here we will treat them as suprabenthic species and that is why only crustaceans items were thoroughly investigated in this paper.

In Arrozal, Cananéia lagoon estuarine region, as in other saltmarsh or seagrass systems, crustacean members of suprabenthos were the major source of available food for small sized fish (Burchmore *et al.*, 1984; Wakabara *et al.*, 1993). Even for continental shelf fishes, in their first year, these small mobile benthic crustaceans are the most important food resource (Sorbe, 1981).

The suprabenthic community of a shallow coastal area has a marked seasonal pattern. This is mainly due to the sequential appearance, high abundance and disappearance of temporary suprabenthic species (Mees & Hamerlynck, 1992). Even in brackish water parts of estuary where most temporary and migratory suprabenthic species are not able to penetrate, the suprabenthic community, although poor in species, has extremely high densities of mysids and strong temporal variations in abundance of species (Mees *et al.*, 1993). In accordance to the latter, Cananéia suprabenthic community at Arrozal shows a low species diversity, mainly

dominated by *M. elongata atlantica*, *A. lilljeborgi*, *A. minikoi* and decapod larvae and presents strong seasonal variations.

The 12 species of fish analyzed in this study are all carnivorous and have the suprabenthic crustaceans as a primary food resource. From this total, 4 species (*A. brevirostris*, *O. oglinum*, *H. jaguana* and *Oligoplites* sp) utilized mainly suprabenthic crustaceans with planktonic origin such as copepods and decapod larvae, besides mysids, while the remaining 8 species (*S. stellifer*, *M. furnieri*, *S. jenynsii*, *C. spixii*, *Eucinostomus* sp, *Haemulon* sp, *I. parvipinnis* and *S. pachygaster*) ate suprabenthic crustaceans with benthic origin such as *M. cananeia*, *K. schubarti*, mysids, *A. armillatus* and *A. minikoi*. As some planktonic originated items were present only in stomach contents of fishes, it is concluded that the sampler used in this study was not efficient for the sampling of planktonic copepods, probably due to inadequate mesh size of the bag.

Seasonal variation in total abundance is a common feature in dynamic ecosystems such as estuaries. The local fish assemblage showed seasonal fluctuation. The 12 fish species appeared in higher abundance in different seasons corresponding probably to different recruitment periods into the system. According to Subrahmanyan and Coultas (1980) the staggered seasonal occurrence of species may be in concordance with the local availability of food resources. In the present study the overall number of fish, due mainly to fishes from Groups I and II, increased in the spring and winter with the rising of the suprabenthic crustacean numbers, due mainly to the tremendous rise of *M. elongata atlantica* numbers comprising 99% of the total fauna. This fact justified the almost uniform negative feeding preference values for *M. elongata atlantica* exhibited by most of the fish species considered, since they should have to consume strictly this mysids to provide feeding preference positive values.

The seasonal changes of the food supply is clearly reflected in the observed seasonal variations in the diet of fishes from Group I and II. In relation to feeding preference, species from Groups I and II (*A. brevirostris*, *O. oglinum*, *H. jaguana*, *S. stellifer*, *M. furnieri* and *S. jenynsii*) were considered opportunistic feeders, since the relative abundance of the more important crustacean food resource in the environment was similar to their relative abundance in stomachs. The other six species, not grouped, were considered selective feeders, since they ingested the crustaceans in proportionally greater numbers than occurred in the environment. These concepts of opportunistic and selective feeders are based on ideas discussed in Sagar and Eldon (1983) and Jacksic (1989).

The low value, 0.08 of the mean total overlap for all the fish community, indicates that each fish predator or group of fishes have an almost completely distinct food niche, avoiding in this manner food competition.

The same cannot be said for the species within Group I and Group II. Group I species (*A. brevirostris, H. jaguana* and *O. oglinum*) had a significant mean food overlap (0.67) revealing that they use similar food items. Species of Group II (*M. furnieri, S. jenynsii* and *S. stellifer*) had also a high mean food overlap (0.87). When cohabiting species are similar in food preference and habitat, the question arises as to whether they are in competition defined as the demand of more than one organism for the same resource. According to Mathur (1977) two species exploring a similar niche may coexist without competition if the food resource is temporarily superabundant. This may be true for the fish species in Cananéia estuary.

The significant overlap found in summer seems to have 2 different explanations; between species with benthic originated suprabenthic food resource, the increased food overlap may be due to the diminishing food supply in summer as Thorman (1982) found in estuarine region. He interpreted this raised overlap as increasing competition for food in summer. This would be the case of *C. spixii* and species of Group II. In relation to the summer overlap between *Oligoplites* sp and species of Group I, species with a planktonic originated suprabenthic food resource, it may indicate superabundance of food resource as this is the time of density peaks of planktonic forms such as some copepods, sergestids and decapod larvae highly ingested by these fish species.

Acknowledgements

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