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Demersal fish community on the inner shelf of Ubatuba, southeastern Brazil

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• ***Abstract:*** Fluctuations in the distribution and abundance of demersal fishes collected by otter trawl on the continental shelf of Ubatuba were examined over a two-year sampling period, in an area up to 50 m depth. A total of 111 species were collected. Seasonal and annual fluctuations in species abundance were related to differences in the distribution of Coastal Water and South Atlantic Central Water masses. The demersal fish fauna in the area was divided into three ecologically distinct communities: Tropical Sciaenid, Subtropical Sciaenid, and Gerreid-Haemulid. The most important one is the Tropical Sciaenid Community, characterized by *Ctenosciaena gracilicirrhus, Paralonchurus brasiliensis,* and *Cynoscion jamaicensis.*

• ***Resumo:*** A distribuição e a abundância de peixes demersais na plataforma continental de Ubatuba, até 50 m de profundidade, foram examinadas durante dois anos. Foram coletadas 111 espécies. As flutuações sazonais de abundância estiveram relacionadas com a dinâmica das massas d'água. Três comunidades ocupam a área: Sciaenidae Tropical, Sciaenidae Subtropical e Gerreidae-Haemulidae, sendo a primeira a mais importante, dominada por *Ctenosciaena gracilicirrhus, Paralonchurus brasiliensis* e *Cynoscion jamaicensis.*

• ***Descriptors***: Sciaenidae, Demersal fish, Community, Southwestern Atlantic.

• ***Descritores***: Sciaenidae, Peixes demersais, Comunidades.

Introduction

Tropical ecosystems are highly complex and poorly studied. Data on the ecology of tropical fishes are scarce and mainly limited to studies of commercially important species. Before 1985 there were few reports describing demersal fish communities from waters off Ubatuba, southeastern Brazil. A list of species was published by Nonato *et al.* (1983), Cunningham (1983) studied the ichthyofauna composition and its variations in some bays and islands of the area, and Braga & Goitein (1984) described the biology of the common species off Anchieta Island. Since then Rocha (1990), Rossi-Wongtschowski & Paes (1993) and Natali Neto (1994) have been studying different aspects of the demersal fish community, mainly related to composition, abundance, and diversity of species, as part of a broad interdisciplinary research program.

Little is known of the dynamics and organization of the Ubatuba ecosystem. This lack of information provided the impetus for a project developed in that area from 1985 to 1988, with the purpose of understanding its structure and function (Pires-Vanin & Matsuura, 1993; Pires-Vanin *et al.*, 1993). As the trend for management of living resources moves from single-species to multispecies assemblages, it becomes increasingly important to encompass ecosystems as management units. As a contribution to that goal, this study describes seasonal variation in abundance and species composition of the demersal fish community on the inner shelf of Ubatuba.

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Study area

The area under study is located off the southeastern coast of Brazil (Fig. 1). Three water masses converge in the region: Coastal Water (CW) (T>20°C, S<36), South Atlantic Central Water (SACW) (T<18°C, S>36) and Tropical Water (TW) (T>20°C, S>36). During summer cold water (SACW) is often found in the inner portion of the continental shelf (20-100 m), while warm water (CW) is found in a narrow band nearshore. It results in a vertical stratification over the inner shelf, with a strong thermocline at mid-depths. In the winter period when SACW is restricted to outer shelf, horizontal and vertical thermal gradients are reduced and almost no stratification is observed in the inner shelf (Castro Filho *et al.*, 1987).

During autumn and winter, a cooling of the surface water and an intensification of vertical mixing processes, due to higher frequency of strong winds, cause an inversion of the circulation which destroys the seasonal thermocline observed in summer (Castro Filho *et al.*, *op. cit.*). As a result, the water temperature in the bottom layer is higher in winter than in summer. The region can be divided into two domains based on its physical dynamics: interior and exterior. The interior domain is controlled by the wind, while the exterior, although influenced by the wind, is under the direct influence of the Brazil Current. The interior domain is limited by the coastline and the 40 to 50 m isobaths, and its width is about 50 km. The exterior domain extends from these isobaths to the continental shelf break.

Sand and silt sediments predominate in the area. The southern inner shelf is more sheltered, by São Sebastião island, and strongly influenced by the continent. Closer to the shoreline, mud of continental origin and organic matter are deposited on the bottom. In contrast, coarser particles settle on the northern inner shelf and in offshore areas. Temperature-Salinity diagrams and the distribution of sediment grain sizes in the area were shown in Pires (1992).

The demersal ichthyofauna of the southern Brazilian shelf, transitional between tropical and temperate zones, is part of the Argentinean marine zoogeographic province, which extends between 22° and 42°S (Figueiredo, 1981). Species with tropical and temperate water affinities of both northern and southern hemisphere and a series of endemic species overlap here.

Material and methods

Sampling was carried out on a seasonal basis, during a two-year period, from October 1985 to July 1987. Hauls were made at nine fixed stations, at depths of 15 m (stations 3, 6 and 9), 30 m (2, 5 and 8) and 50 m (1, 4 and 7) (Fig. 1). Fish were collected with an otter trawl, of 6 m mouth opening, 40 mm stretch mesh in the body and sleeve, and 25 mm bar mesh at the codend; each door was 1.0 m long, 0.5 m wide, and weighed 40 kg. One-hour tows were made during daylight hours at a speed of 2 kn, resulting in a swept area of 22,236 m^2. Bottom water samples were collected 0.5 m above the bottom with Nansen bottles at each station prior to trawling. Water temperature, salinity and dissolved oxygen were determined.

In the laboratory specimens were sorted, identified, counted, weighed (nearest 0.1 g) and measured (total length). The state of maturity was determined when possible.

Although the objective was to capture demersal species, a variety of pelagic species occurred as well. Because the gear was not designed to capture pelagic species effectively, they were excluded from the analysis to avoid bias.

The species which accounted for 90% of the catch in weight and number were considered dominants. These species were then ranked by importance, which was calculated by multiplying the frequencies in number, in weight and of occurrence.

The dominant species were grouped into assemblages. Canonical Correspondence Analysis (CCA) was performed using the program CANOCO (version 3.1) (ter Braak, 1990) to examine the relation between species, stations, and environmental variables. Only species present at more than 10% of the stations in every year were used for analysis. Weight data were log-transformed [ln (x + 1)] prior to analysis. Within the CCA procedure, forward selection of the environmental variables and Monte Carlo permutation tests were used to test the significance of each environmental variable. The variables were further evaluated by examining intra-set correlations (correlations between species axes and environmental variables). Data on depth, temperature, salinity, dissolved oxygen, organic matter, calcium carbonate, sand and clay content were tested.

Results

Seasonal isotherms are shown in Figure 2. Variations in salinity and dissolved oxygen were taken into consideration for classifying water masses. Salinity values showed a small variation (34.96 to 35.93 ppt) and oxygen was frequently over 70 % of saturation.

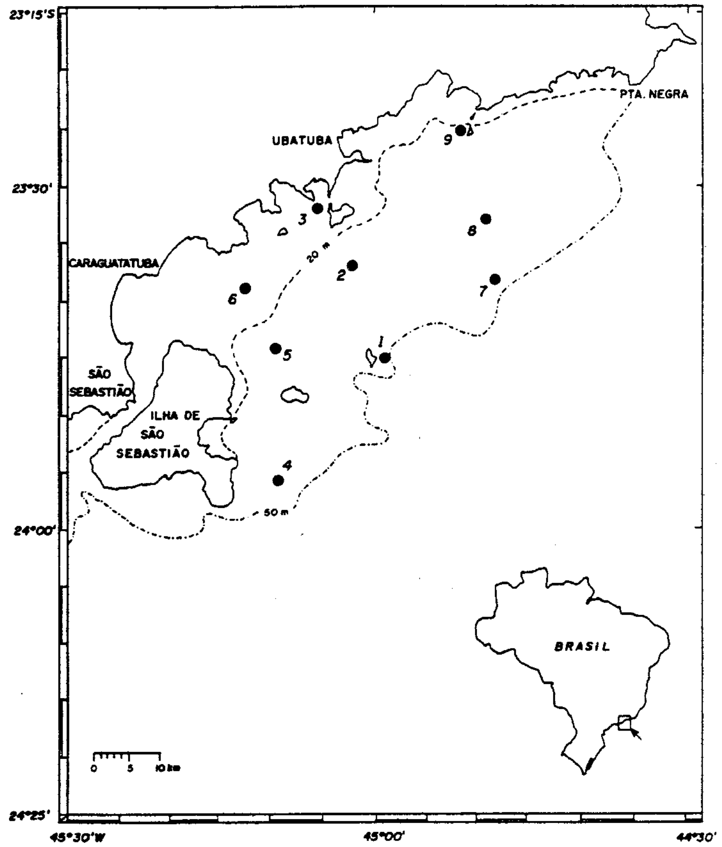

Fig. 1. Study area in the south-eastern Brazilian shelf showing sampling stations (1 to 9).

A total of 43 families comprising 111 demersal fish species was collected during the two-year sampling period (Table 1). Sciaenidae was the most abundant family both in number of species (18) and individuals (62.6 %). The number of species and the abundance in number of individuals and weight by season are in Table 2. A great fall in abundance was observed on second sampled year, especially in autumn and winter. Twenty and twenty six species accounted for 90 % of the total number and weight, respectively. After ranking, twenty-two species were abundant both in number and weight, which were considered as dominant (Table 3).

Both abundance and number of species were greatest in autumn. In both years the number of individuals increased from spring to autumn and declined in winter. Since samples were not replicated, differences could not be tested. Although in the first sampled year the weight in summer and autumn was very similar, the number of individuals in autumn was almost twice the observed in summer (Table 2, Figs 3, 4). A few different species were found in autumn but they were not abundant. Most of the abundant species were present both in summer and autumn. So this difference could indicate a great entrance of juveniles in autumn. In fact, the length analysis showed a greater proportion of small individuals at this season. The same was observed in the second year, but in a smaller magnitude.

Species distribution

The distribution of the dominant species in relation to the environmental factors was examined. It is important to emphasize that these species have a wide geographical distribution, and only a small part of their population occupies the studied area.

Most of the dominant species were present throughout the year, with seasonal fluctuations in abundance (Figs 3, 4). *Ctenosciaena gracilicirrhus* and *Paralonchurus brasiliensis* were the most abundant species in the area. The former was widely distributed and occurred at temperatures between 18 and 22°C. The latter was mainly associated with shallow waters, although it occurred up to 50 m, at temperatures of 22 to 25°C (Fig. 5). *Cynoscion jamaicensis* was also distributed throughout the area, associated with the Coastal Water, and in sites with sandy-clay substrata. A more restricted distribution was detected during the second year.

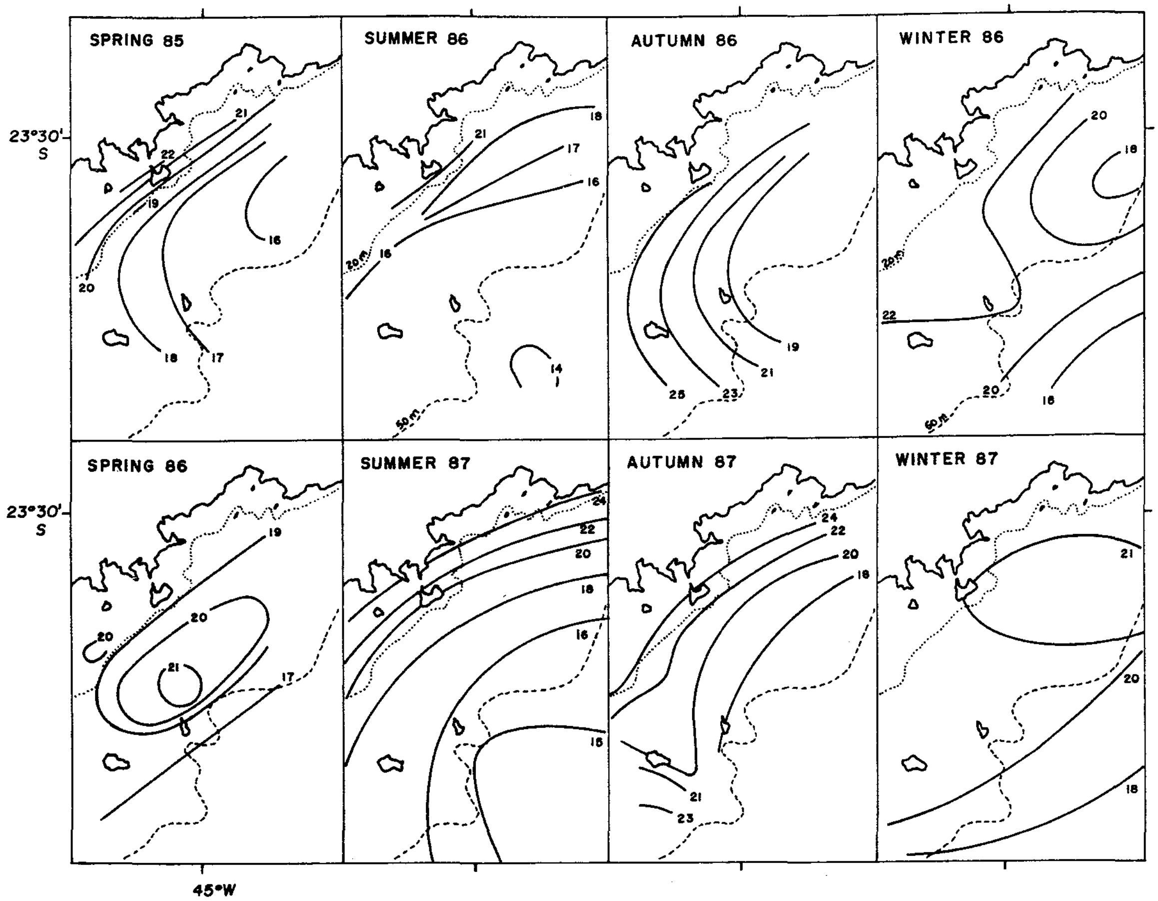

Fig. 2. Horizontal distribution of bottom temperature (°C) in spring, summer, autumn and winter during 1985-87 period.

There was a remarkable decrease in the abundance of dominant species throughout the second sampled year (Table 1). However, since total catch was smaller in the second year, relative abundance did not show the magnitude of this decline (Table 3). Only a few species, such as *Raja agassizii, Dules auriga, Psammobatis glansdissimilis, Pagrus pagrus*, and *Squatina guggenheim*, showed an increase of abundance from one year to another.

Prionotus punctatus was the only species collected at all stations, in all seasons (Fig. 5), although its abundance changed greatly (Figs 3, 4). It occurred in sites with sand and sandy-mud sediments and at temperatures between 17 and 26°C, mainly above 20°C. *Porichthys porosissimus* was also widely distributed (Fig. 5) and was one of the few eurybathic species in the area, found on both inner and outer shelf up to 100 m depth (Natali Neto, 1994).

In contrast to *Cynoscion jamaicensis*, *Cynoscion guatucupa* was more frequent and abundant around 50 m depth (Fig. 5) during summertime. It occurred at temperatures from 15 to 18°C, following the coastward movement of the SACW.

Raja agassizii was the third most abundant species in weight and also the most widely distributed of the skates present in the area. It occurred up to 50 m depth (Fig. 6), in sandy sediments and at temperatures from 18 to 23°C.

Other Sciaenidae species associated with warmer waters were *Micropogonias furnieri*, *Menticirrhus americanus*, and *Isopisthus parvipinnis*. The latter was more restricted to shallower stations. These species were most abundant in autumn and winter, occurring at temperatures from 16 to 26°C, particularly between 22 and 24°C.

Dules auriga, *Etropus longimanus*, and *Paralichthys patagonicus* were often found at stations 1, 2, 7, and 8 (Figs 5, 6), but were not restricted to them. They were more abundant in spring and summer, with influence of the colder SACW waters. They occurred at temperatures between 15 and 18°C, over sand bottoms, with slightly different distributions. While the former was the most important species on the outer shelf, the second occurred mainly between 30 and 70 m depth, though it may be found as deep as 100 m (Natali Neto, 1994). The latter was a permanent species on the inner shelf, rarely found at stations deeper than 50 m (Natali Neto, *op. cit.*).

Table 1. Species composition, code and number of individuals on 1985-1986 and 1986-1987 periods and both.

species	code	1985-86	1986-87	both	species	code	985-86	986-87	both	species	code	1985-86	1986-87	both
Anisotremus virginicus		1	3	4	*Gymnura altavela*		1	1	2	*Prionotus punctatus*	Ppu	1761	1059	2820
Ariosoma opisthophthalma		1	0	1	*Haemulon aurolineatum*	Ha	23	7	30	*Psammobatis glansdissimilis*	Pg	316	423	739
Bagre bagre		1	0	1	*Haemulon steindachneri*	Hs	4	4	8	*Raja agassizii*	Ra	254	332	586
Balistes capriscus	Bc	7	8	15	*Hippocampus reidi*		1	1	2	*Raja castelnaui*	Rca	35	33	68
Boridia grossidens		0	1	1	*Isopisthus parvipinnis*	Ip	667	873	1540	*Raja cyclophora*	Rcy	86	153	239
Bothus ocellatus		1	1	2	*Lagocephalus laevigatus*	Ll	21	61	82	*Raneya fluminensis*	Rf	107	28	135
Bothus robinsi		6	0	6	*Larimus breviceps*	Lb	143	104	247	*Rhinobatos horkelii*	Rh	33	28	61
Cathorops spixii		7	9	16	*Lophius gastrophysus*	Lg	46	50	96	*Rhinobatos percellens*		5	3	8
Chaetodipterus faber		0	3	3	*Macrodon ancylodon*	Man	38	35	73	*Rhizoprionodon lalandei*		0	1	1
Chilomycterus spinosus	Cs	114	44	158	*Menticirrhus americanus*	Mam	262	581	843	*Rhizoprionodon porosus*		0	1	1
Citharichthys macrops		5	1	6	*Menticirrhus littoralis*		0	2	2	*Sciadeichthys luniscutis*		2	2	4
Conodon nobilis	Cn	19	1	20	*Merluccius hubbsi*	Mh	91	108	199	*Scorpaena isthimensis*		19	22	41
Conger orbignyanus	Co	16	3	19	*Micropogonias furnieri*	Mf	746	368	1114	*Sphoeroides dorsalis*		2	1	3
Ctenosciaena gracilicirrhus	Cgr	5583	2940	8523	*Mullus argentinae*	Mar	80	129	209	*Sphoeroides sp*		0	2	2
Cyclopsetta chittendeni		2	5	7	*Mustelus canis*		7	4	11	*Sphoeroides testudineus*		0	3	3
Cynoscion guatucupa	Cgu	1419	1311	2730	*Mustelus schimitii*	Ms	51	65	116	*Sphoeroides tyleri*		5	7	12
Cynoscion jamaicensis	Cja	4912	1392	6304	*Myliobatis freminvillei*		1	2	3	*Squatina guggenheim*	Sg	29	40	69
Cynoscion virescens		1	0	1	*Narcine brasiliensis*	Nb	12	4	16	*Squalus cubensis*	Sc	24	14	38
Dactilopterus volitans	Dv	299	58	357	*Nebris microps*		0	3	3	*Stellifer brasiliensis*	Sb	241	191	432
Dasyatis guttata		0	1	1	*Netuma barba*		7	15	22	*Stellifer rastrifer*		29	0	29
Dasyatis say		3	3	6	*Notarius grandicassis*		2	0	2	*Stellifer sp*		4	0	4
Diapterus rhombeus		3	0	3	*Odontoscion dentex*		7	0	7	*Stephanolepis hispidus*	Sh	118	467	585
Diplectrum formosum	Df	11	12	23	*Ogcocephalus vespertilio*	Ov	33	21	54	*Syacium papillosum*	Sp	74	31	105
Diplectrum radiale	Dr	31	23	54	*Ophichthus gomesii*		3	1	4	*Syacium sp*		15	0	15
Diplodus argenteus		1	3	4	*Ophidion holbrooki*		6	0	6	*Symphurus diomedianus*		1	0	1
Dules auriga	Da	571	732	1303	*Orthopristis ruber*	Or	524	163	687	*Symphurus jenynsi*	Sj	33	16	49
Epinephelus morio		0	1	1	*Pagrus pagrus*	Ppg	162	559	721	*Symphurus plagusia*	Spl	200	120	320
Epinephelus niveatus		2	4	6	*Paralichthys patagonicus*	Ppa	219	184	403	*Symphurus trewavasae*		2	11	13
Etropus crossotus	Ec	126	147	273	*Paralichthys triocellatus*		40	1	41	*Synodus foetens*	Sf	15	25	40
Etropus longimanus	El	1273	952	2225	*Paralonchurus brasiliensis*	Pab	4826	2717	7543	*Trachinocephalus myopis*		1	3	4
Eucinostomus argenteus	Ea	1009	260	1269	*Peprilus paru*		20	68	88	*Trinectes microphthalmus*		0	1	1
Fistularia petimba		21	34	55	*Percophis brasiliensis*	Pb	21	21	42	*Umbrina canosai*	Uc	549	333	882
Fistularia tabacaria		1	0	1	*Phrynelox scaber*		0	1	1	*Umbrina coroides*		6	10	16
Genidens genidens		8	1	9	*Pomadasys corvinaeformis*	Pc	44	7	51	*Upeneus parvus*	Up	111	126	237
Gymnachirus nudus	Gn	25	8	33	*Porichthys porosissimus*	Ppo	1942	375	2317	*Urophycis brasiliensis*	Ub	87	34	121
Gymnothorax conspersus		2	0	2	*Priacanthus arenatus*	Pa	6	4	10	*Verecundum rasile*	Vr	35	85	120
Gymnothorax ocellatus	Go	13	4	17	*Prionotus nudigula*	Pnu	216	147	363	*Zapteryx brevirostris*	Zb	91	108	199
										annual total		30056	18364	48420

Table 2. Seasonal number of species (S), number of individuals (N) and weight (W) in kg on 1985-86 and 1986-87 periods.

	S	N	W
1985-86			
Spring	66	3692	215
Summer	55	6023	410
Autumn	75	11258	408
Winter	63	9083	330
1986-87			
Spring	68	2883	174
Summer	60	6009	361
Autumn	71	6075	272
Winter	66	3397	122

Umbrina canosai inhabited the 40-70 m range and was also associated with the SACW. However, it was common only in summer. It occurred exclusively at stations around 50 m (Fig. 6) with temperatures from 16 to 18°C.

Orthopristis ruber and *Eucinostomus argenteus* presented a similar distribution pattern, strongly associated with station 2, and to a lesser extent, stations 8 and 9 (Figs 5, 6). They occurred over sandy-gravel sediments, up to 35-40 m depth, and were mainly associated with warm waters (18 to 25°C). They were less common in summer.

Raja cyclophora, *Psammobatis glansdissimilis*, *Squatina guggenheim*, and *Raja castelnaui* did not occur at shallow stations (20 m) and were most abundant near 50 m depth (Fig. 6). They occurred over sand and sandy-mud substrates, at temperatures from 15 to 24°C, particularly below 20°C. All of them were rarely found in winter in either year and were apparently influenced by the SACW, but distribution of *R. castelnaui* was more strongly related to depth. In contrast to these other skates, *Zapteryx brevirostris* was most abundant at shallow stations, around 35 m (Fig. 6). It was present at temperatures between 16 and 26°C, especially around 18-20°C, and almost exclusively over sandy bottom.

Pagrus pagrus was common at stations 2 and 8 (Fig. 5), where temperatures ranged from 16 to 21°C. Its association with gravel bottom and greater abundance in summer and autumn made its distribution relatively distinct from that of other species in the sample area.

Although young and adults were found in the area throughout the year, a seasonal distribution was observed for some of the species. Adults from *Menticirrhus americanus* predominated in winter, in contrast to *Cynoscion guatucupa*, *Orthopristis ruber*, and *Umbrina canosai* adults, that occurred mainly in summer. For all species, but *Dules auriga* and *Paralichthys patagonicus*, catches were dominated by young, which increased slightly on the second year. *Micropogonias furnieri*, *Pagrus pagrus*, and *Squatina guggenheim* catches were composed almost exclusively of young.

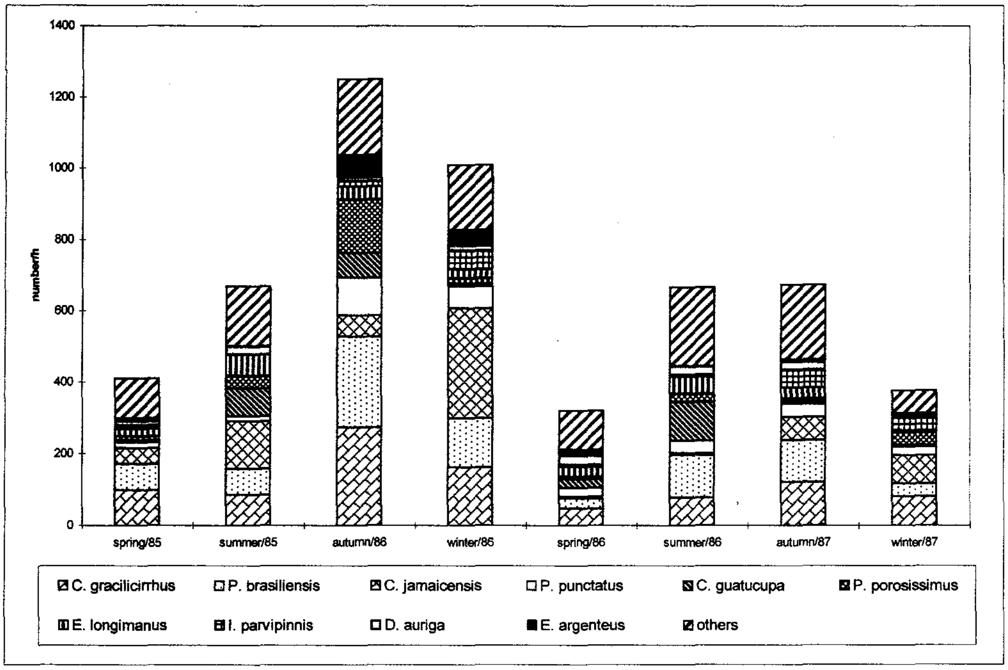

Fig. 3. Seasonal variation in number of individuals by hour for the most abundant species during 1985-87 period.

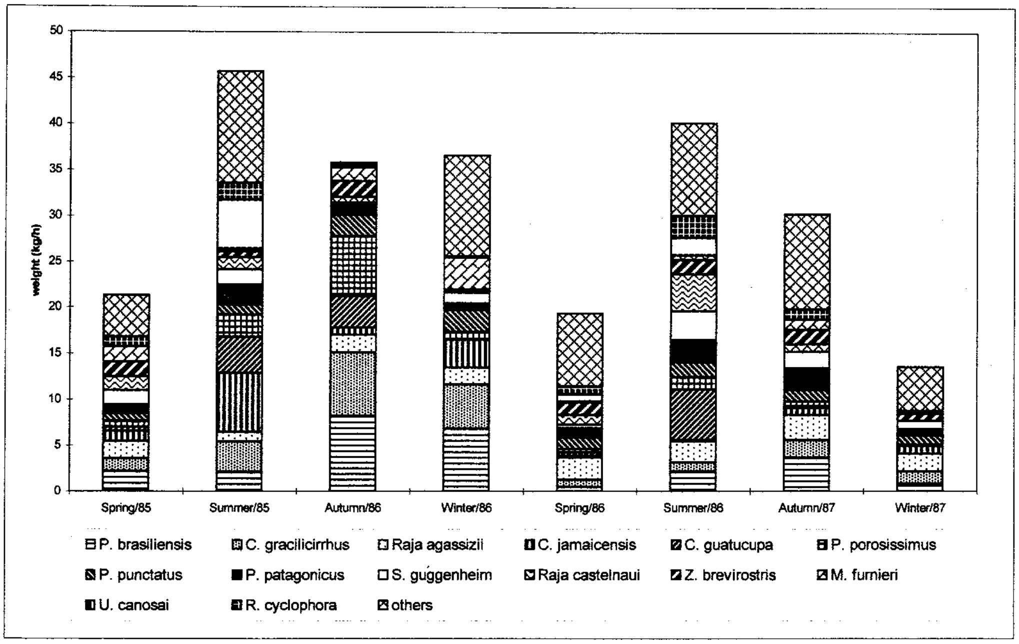

Fig. 4. Seasonal variation of weight (kg/h) for the most abundant species during 1985-86 period.

Table 3. Dominant species total and relative number, weight (kg) and occurrence for 1985-86, 1986-87 periods and both.

	% NUMBER			% WEIGHT			% OCCURRENCE		
	1985-86	1986-87	both	1985-86	1986-87	both	1985-86	1986-87	both
Ctenosciaena gracilicirrhus	18.58	16.01	17.60	10.99	4.91	8.50	83	78	80
Paralonchurus brasiliensis	16.06	14.80	15.58	12.93	6.76	10.40	72	33	53
Cynoscion jamaicensis	16.34	7.58	13.02	7.61	1.90	5.28	86	56	69
Prionotus punctatus	5.86	5.77	5.82	4.43	4.96	4.64	94	100	97
Porichthys porosissimus	6.46	2.04	4.79	6.96	2.23	5.02	89	78	83
Cynoscion guatucupa	4.72	7.14	5.64	5.34	5.95	5.59	42	44	43
Raja agassizii	0.85	1.81	1.21	4.47	9.12	6.38	78	75	76
Micropogonias furnieri	2.48	2.00	2.30	4.70	1.82	3.52	72	44	58
Menticirrhus americanus	0.87	3.16	1.74	2.12	3.58	2.72	72	50	61
Dules auriga	1.90	3.99	2.69	1.42	2.92	2.04	50	53	51
Paralichthys patagonicus	0.73	1.00	0.83	3.41	6.29	4.59	78	69	74
Etropus longimanus	4.24	5.18	4.60	0.69	0.73	0.70	72	72	72
Eucinostomus argenteus	3.36	1.42	2.62	1.79	0.97	1.46	61	39	50
Orthopristis ruber	1.74	0.89	1.42	3.09	2.20	2.72	58	42	50
Psammobatis glansdissimilis	1.05	2.30	1.53	1.74	3.47	2.45	47	47	47
Umbrina canosai	1.83	1.81	1.82	3.79	2.68	3.33	19	14	17
Isopisthus parvipinnis	2.22	4.75	3.18	0.48	0.99	0.69	42	31	36
Raja cyclophora	0.29	0.83	0.49	2.23	4.36	3.11	42	36	39
Zapteryx brevirosotris	0.30	0.59	0.41	2.80	5.08	3.73	36	42	39
Pagrus pagrus	0.54	3.04	1.49	0.22	1.44	0.59	33	33	33
Squatina guggenheim	0.10	0.22	0.14	3.00	5.95	4.21	33	31	32
Raja castelnaui	0.12	0.18	0.14	2.36	5.75	3.75	33	22	28
absolute total	30056	18364	48420	1340	928	2268	36	36	72

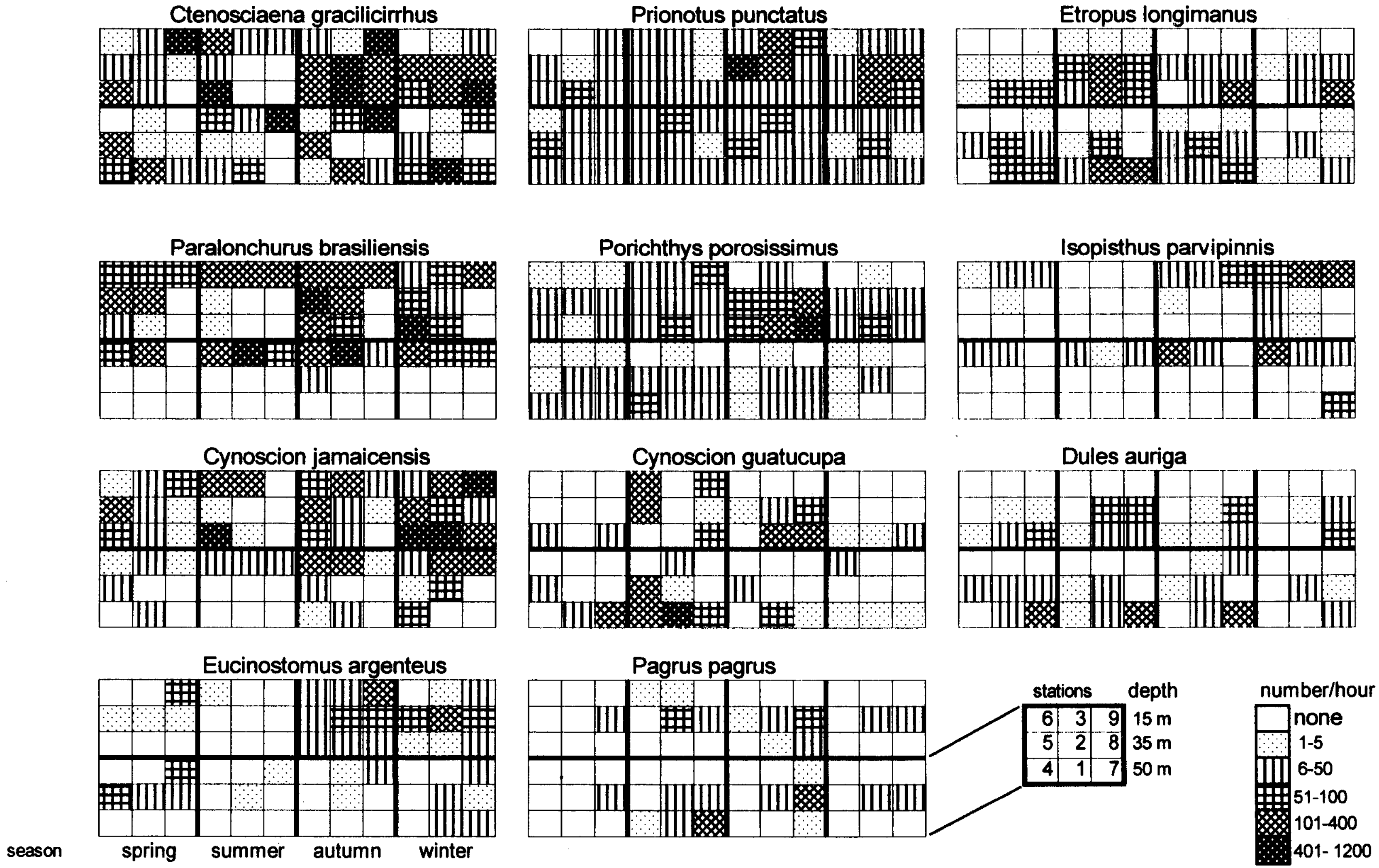

Fig. 5. Abundance levels in number of individuals per hour, in 1985-86 and 1986-87 periods. Blocks present abundance at stations 1 to 9, seasonally. For each species, upper half represents first sampling year, lower half represents second year.

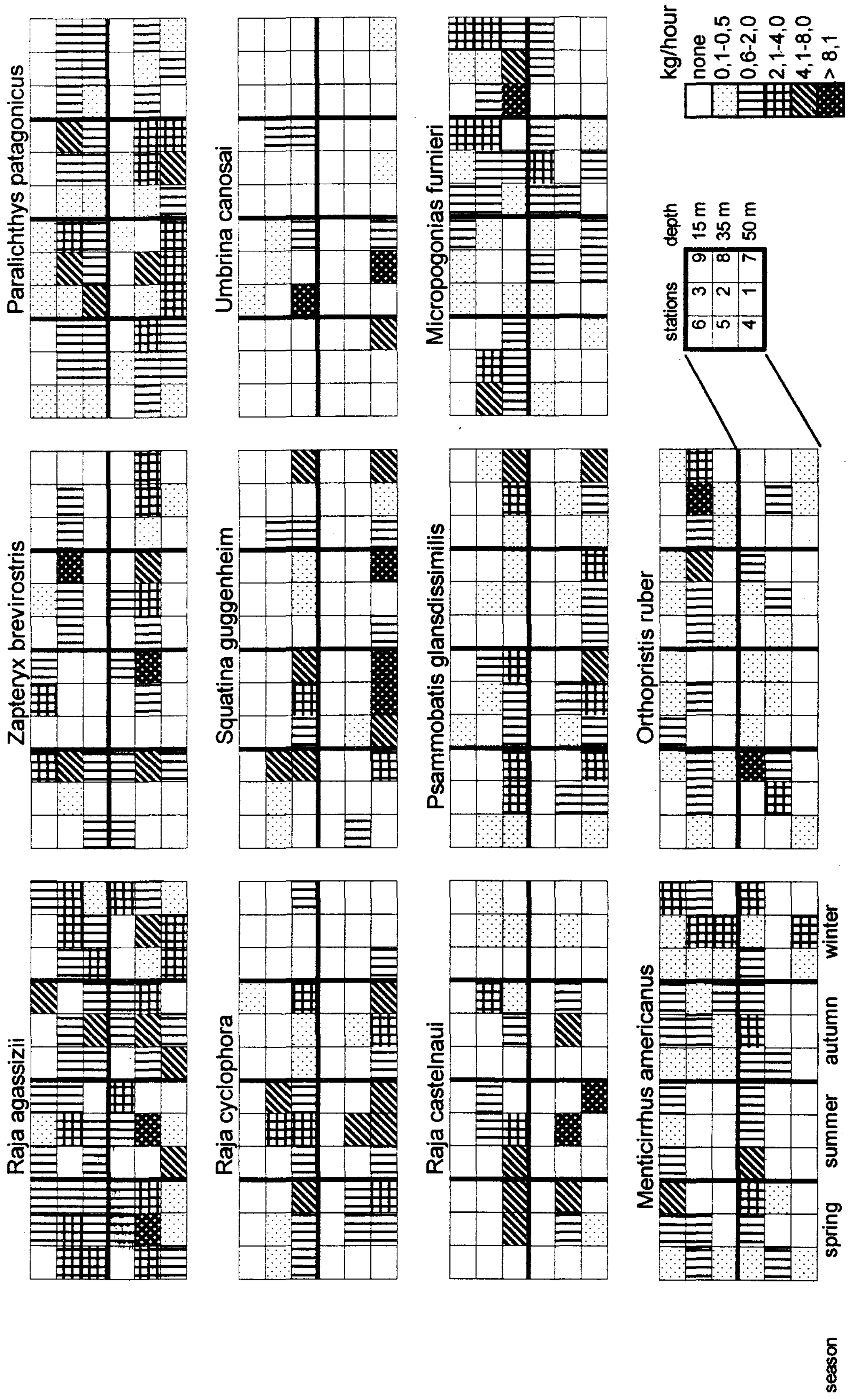

Fig. 6. Abundance species levels in weight (kg/h) in 1985-86 and 1986-87 periods. Blocks present abundance at stations 1 to 9, seasonally. For each species, upper half represents first sampling year and lower half represents second year.

The species distribution indicated the existence of different assemblages in the area, which were clarified with a CANOCO analysis.

Communities

CCA provides an ordination of species and sites, constrained by environmental variables (Figs 7 and 8). In both years, Axis I was correlated to temperature and depth, while Axis II was related to salinity and organic matter in 1985-86 period, and to bottom sediment types, in the following year. In the first year, Axes I and II accounted for 21.5 and 6.1 % of the variation, respectively and in the second year they accounted for 19.2 and 8.1 %. Axes III and IV accounted for less than 5 % each one and were not considered here (Tab. 4). Axis I represents a gradient from shallower and warmer stations (on the positive side of the axis) to deeper and colder ones (on the negative) (Figs 7a, 8a). Axis II runs from sand and sandy-clay localities on the negative side of the axis to sandy-shell, rich organic stations on the positive side. The species scores along Axes I and II show their association with the localities and the environmental gradients (Figs 7b, 8b). Results of the ordination analyses, relating abundance of the dominant species to the environmental factors, identified three distinct assemblages of species in the area. Since communities composition was similar to that observed elsewhere by Longhurst & Pauly (1987), their community classification was adopted here.

Sciaenids were the most widely distributed family down to 50 m depth, with three species *Ctenosciaena gracilicirrhus*, *Paralonchurus brasiliensis*, and *Cynoscion jamaicensis* contributing almost 50 % of the number and more than 20 % in weight of the total catches (Tab. 3). These species, together with other sciaenids associated with warm waters and sand and sandy-mud sediments, constituted the Tropical Scianid Community. This group accounted for > 60 % of the numbers and 40 % of the biomass in the total catch. Species belonging to other families, such as *Prionotus punctatus, Zapteryx brevirostris*, and *Raja agassizii*, overlapped in distribution with the Tropical Scianid group, but were less affected by water masses.

Species such as *Eucinostomus argenteus* and *Orthopristis ruber* were associated with Coastal Water, but had a more restricted distribution, occurring at shallow and sandy-shell bottom stations, in the northern portion of the area. Many Haemulidae and Serranidae species also associated with this kind of substratum, but were not classified among the most important species because of their low abundance. These species constituted the Gerreid-Haemulid Community and correspond to the Lutjanid Community of Longhurst & Pauly (1987). They represented 6 % by number and weight of the total catch. In the ordination space, the Tropical Sciaenid and Gerreid-Haemulid communities were associated with the positive side of Axis I, but were split by Axis II.

Table 4. Correlation matrix relating species axis to environmental variables (Interset correlations) and eigenvalues (%).

	Axis I	Axis II	Axis III	Axis IV
1985-1986				
Depth	-0.81	0.288	-0.284	-0.016
Temperature	0.781	0.197	-0.257	0.254
Salinity	0.001	0.598	-0.168	-0.458
Organic matter	0.2	-0.357	-0.694	0.169
eigenvalues	21.5	6.1	3.5	1.3
1986-1987				
Depth	-0.75	-0.123	0.089	0.195
Temperature	0.579	0.232	0.202	-0.173
CaCO3	-0.244	0.414	-0.013	0.615
Sand	-0.416	0.47	-0.255	-0.405
argila	0.181	-0.369	0.56	0.19
eigenvalues	19.2	8.1	3.3	2.6

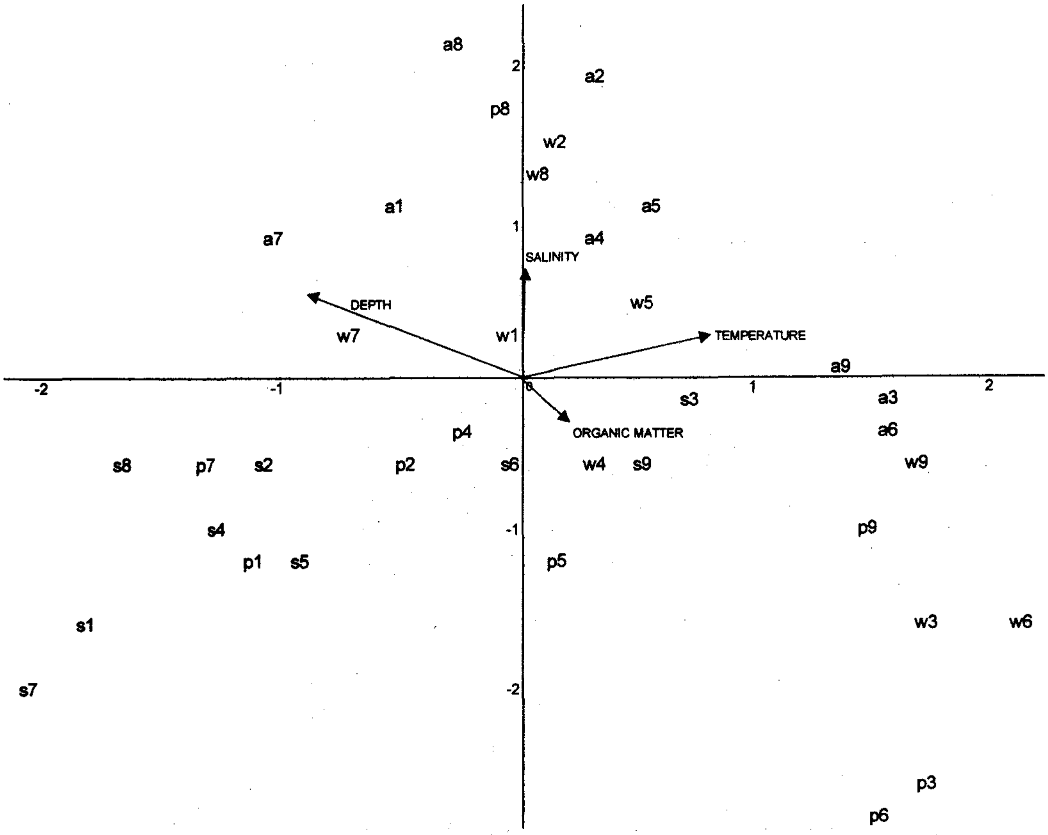

Fig. 7a. Ordination plot of environmental variables and stations (1 to 9) for 1985-86 seasons.
Spring (p) Summer (s) Autumn (a) Winter (w)

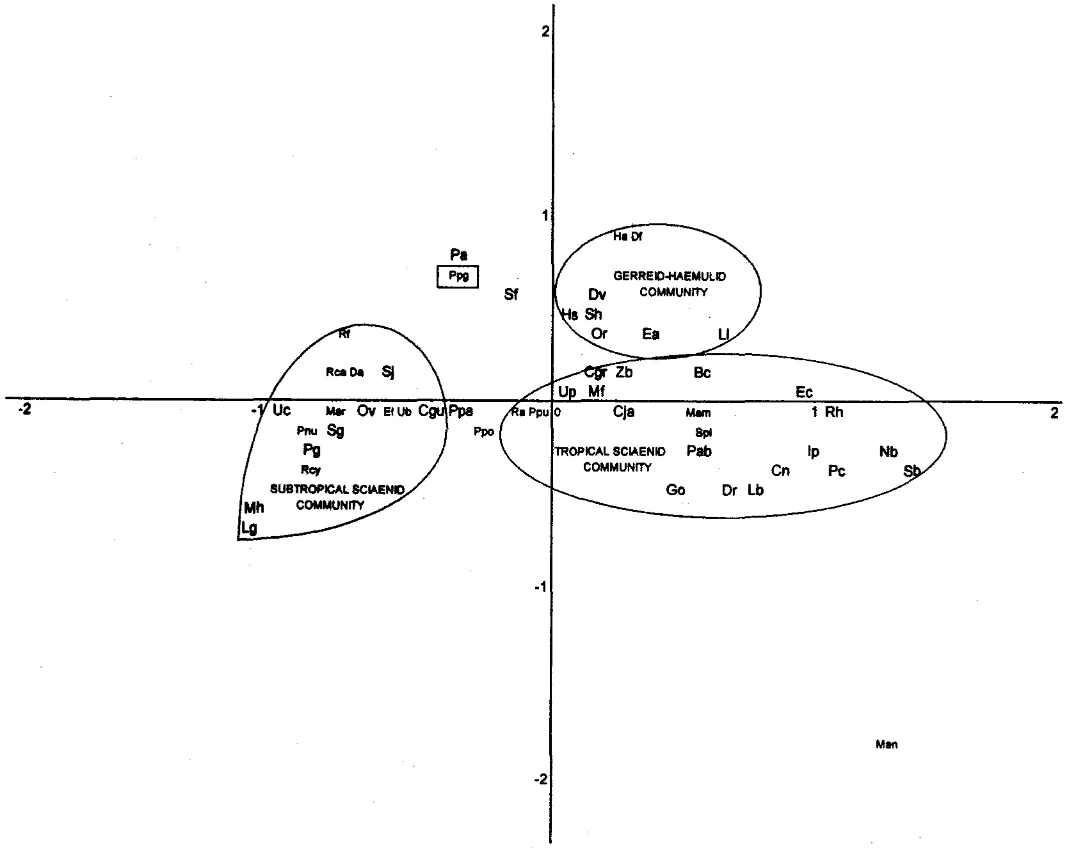

Fig. 7b. Species scores on Axis I and II, during 1985-86. Species codes are found in Table 1.

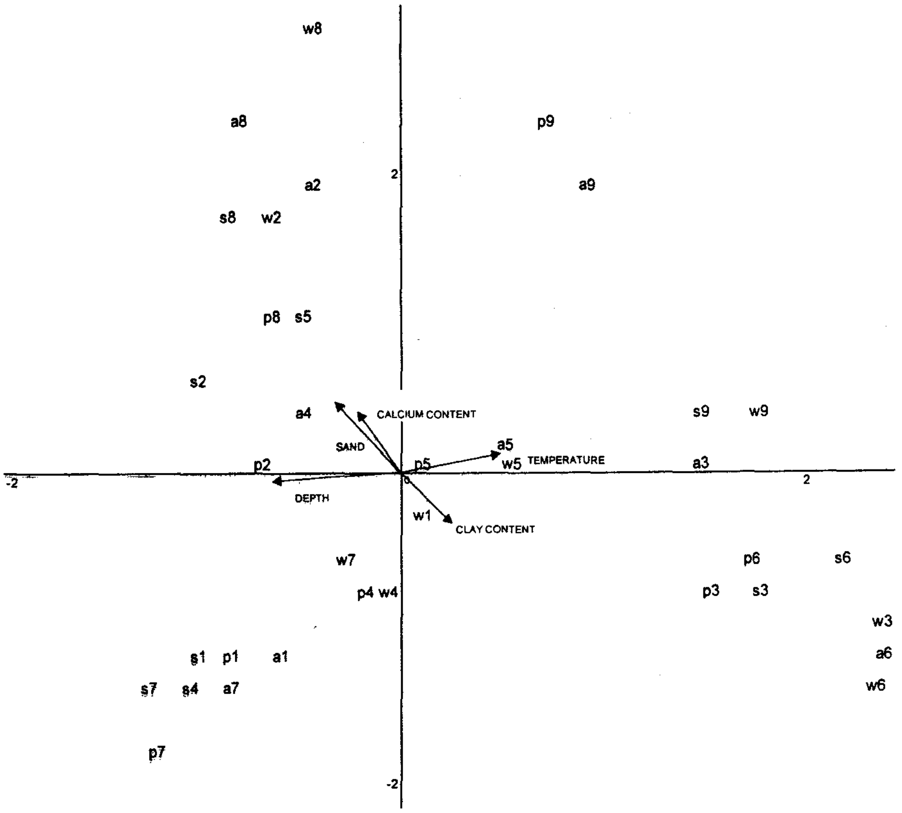

Fig 8a. Ordination plot of environmental variables and station (1 to 9), for 1985-87 seasons.
Spring (p) Summer (s) Autumn (a) Winter (w)

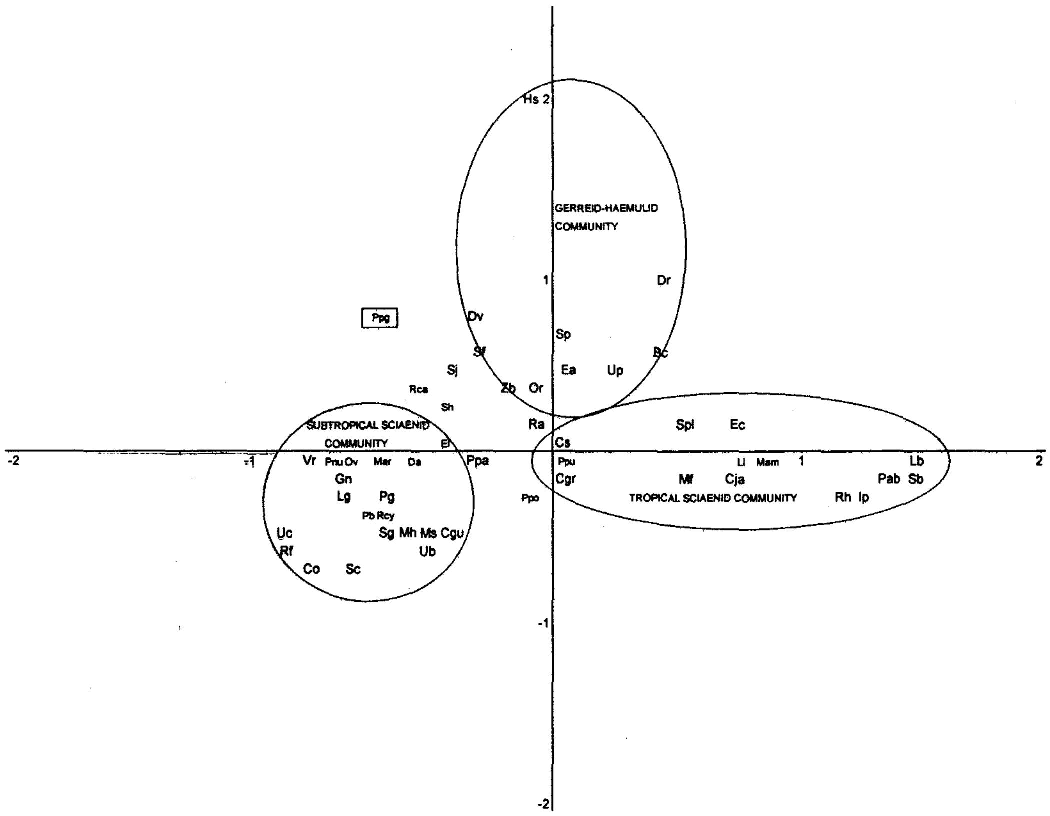

Fig. 8b. Species scores on Axis I and II, during 1986-87 period. Species codes are found in Table 1.

At depths around 50 m, the sciaenids *Cynoscion guatucupa* and *Umbrina canosai*, together with *Dules auriga, Merluccius hubbsi, Raja cyclophora, Etropus longimanus*, and *Prionotus nudigula*, among others, were closely associated with SACW. They comprised the Subtropical Sciaenid Community and accounted for 15 % of number and weight of the demersal icthyofauna in the area.

Temperature together with depth and substratum were the main environmental factors structuring the major assemblages. However, some species such as *Squatina guggenheim, Raja castelnaui, Paralichthys patagonicus*, and *Porichthys porosissimus* were distributed according to depth rather than by water mass movements. In addition to three main assemblages, the *Pagrus pagrus* distribution was distinct from all others. Its position in the multivariate space was clearly isolated from any other assemblages (Figs 7b, 8b), and may indicate the existence of a unique life history strategy for this species.

Discussion

Many authors consider dominant species those which together contribute > 90 % of the total number of individuals (Dahlberg & Odum, 1970; Horn, 1980), while others also consider frequency of occurrence (Richards & Castagna, 1970; Colvocoresses & Musick, 1984) or biomass (Mahon & Balon, 1977) to be important. According to Yánez-Arancibia (1986), in tropical regions, the definition of a species as dominant has to consider at least three ecological factors: abundance in number and weight, and frequency of occurrence. Therefore, all of these variables were considered here.

The Ubatuba ecosystem is an important habitat for young fish. Most of the species use the area for growing and maturing but not spawning. Only three of the species collected in this study (*M. americanus, P. patagonicus*, and *P. glansdissimilis*) reproduce in the area (Vazzoller *et al*, 1989 a, b*; Louro, 1995).

Sea temperature is the major factor in the division of marine faunas (Lowe-McConnell, 1987). The tropical fauna lies between the 20°C isotherms for surface water temperatures at the coolest time of year, flanked on either side by subtropical faunas living where the water temperature does not fall bellow 16-18°C. Marine fish faunas are also greatly affected by depth, current systems, salinity, oxygenation, availability of food, and many other factors (Lowe-McConnell, *op. cit.*). Considering the ecological attributes of tropical fish communities and their responses to environmental conditions, Lowe-McConnell (*op. cit.*) points out that seasonality, even in tropical waters, is a major factor affecting many aspects of the community. Longhurst & Pauly (1987) also consider seasonality an important factor in tropical oceans.

Ichthyofauna has been divided into zones based on depth and substratum type. On the Continental Shelf of Guyana, Lowe-McConnell (1962) reported zones of "brown, golden, silver and red fish". Longhurst (1965) and Maurin (1968) emphasized the importance of the thermocline as a biological barrier, and suggested a strong association between the presence and abundance of tropical species and the existence of waters with bottom temperatures around 20°C. Longhurst (*op. cit.*) proposed a division of demersal fish into Sciaenid, Sparid and Deep Communities, and eurybathic species. The main assemblages of fishes recognized by computer analyses off West Africa are also found in the western Atlantic and appear again in the Indo-Pacific (Lowe-McConnell, 1987). In a recent publication Longhurst & Pauly (1987) confirmed the occurrence of four communities in tropical regions: Tropical Sciaenid, Subtropical Sciaenid, Lutjanid, and Sparid. Nevertheless, no references to these communities were found in the southern Brazilian waters.

The area included in the present study is clearly a transition zone, with elements of tropical and temperate faunas. The tropical species grouped in the Tropical Sciaenid Community dominate. Previous studies have noted the coexistence of *Ctenosciaena gracilicirrhus, Paralonchurus brasiliensis*, and *Cynoscion jamaicensis* (Vazzoler, 1975; Benvegnu-Lé, 1978; Cunningham, 1983; Braga & Goitein, 1984), as well as their importance along the southeastern Brazilian coast to latitude 32°S (Costa, 1977; Cunningham, 1978; Facchini, 1995). In Santos Bight (24°S), at depths up to 20 m, Ribeiro Neto (1989) also observed the dominance of sciaenids, with 20 species reaching more than 30 % in number and weight, although the dominant species was *Stellifer rastrifer*. Between 22° and 29°S, in the zone up to 50 m depth, Facchini (1995) reported the same sciaenid species found on the Ubatuba inner shelf as dominants. Among these species, only *Cynoscion guatucupa, Umbrina canosai, Micropogonias furnieri*, and *Ctenosciaena gracilicirrhus* were important beyond 50 m.

(*) Vazzoler, A. E. A. de M.; Santoro-Mazagão, E. C. & Lizama, M. de los A. P. 1989a. Função reprodutiva dos Sciaenidae em ecossistema tropical costeiro do estado de São Paulo. In: SIMPÓSIO SOBRE OCEANOGRAFIA, I. São Paulo, 1989. Resumos. São Paulo, IOUSP. p 76.

Vazzoler, A. E. A. de M.; Silveira, M. M. C.; Lizama, M. de los A. P. & Santoro-Mazagão, E. C. 1989b. Função reprodutiva dos Pleuronectiformes em ecossistema tropical costeiro do estado de São Paulo. In: SIMPÓSIO SOBRE OCEANOGRAFIA, I. São Paulo, 1989. Resumos. São Paulo, IOUSP. p 72.

The Subtropical Sciaenid Community gains importance on the external domain (Natali Neto, 1994), and southward, where SACW is closer to the coast and lower water temperatures are found. Between 29° and 33°S, Vazzoler (1975) referred to *Cynoscion guatucupa* and *Umbrina canosai* as the most abundant sciaenids, while Benvegnu-Lé (1978) reported the occurrence of these species at greater average depths and lower temperatures than that for Tropical Sciaenid species.

At Cabo Frio (23°S, 42°W), where the penetration of the SACW promotes an upwelling during spring and summer, Fagundes Netto and Gaelzer (1991) noted the presence of *Dules auriga*, *Etropus longimanus*, and *Prionotus nudigula* throughout the year, associated with depths around 45 and 60 m and temperatures from 14 to 22°C. In that area *Etropus longimanus* was the most abundant species in number of individuals, while *Cynoscion guatucupa* and *Umbrina canosai* were less abundant. The authors also reported the occurrence of *Ctenosciaena gracilicirrhus*, *Cynoscion jamaicensis*, *Micropogonias furnieri*, and *Prionotus punctatus*, during autumn and winter periods, when warmer waters predominated. Their results suggest that the ichthyofaunal elements from 45-60 m move to 30-45 m, during the upwelling period. Similar dynamics was observed on the Ubatuba's shelf, although to a lesser degree.

Figueiredo (1981) identified the south western Atlantic as a marine zoogeographic province based on a series of endemic species he found there. The endemic species, such as *Cynoscion guatucupa*, *Umbrina canosai*, and *Prionotus nudigula*, were observed in colder and deeper waters than their tropical counterparts (*Cynoscion jamaicensis*, *Ctenosciaena gracilicirrhus*, and *Prionotus punctatus*, respectively). While these tropical species occurred throughout the year, the endemic species reached the Ubatuba inner shelf mainly in summer, with the inward movement of SACW.

The Lutjanid Community is dominant in the Antilles and Caribbean (Longhurst & Pauly, 1987). Similar of species were also found in the Gulf of Mexico (Yáñez-Arancibia *et al.*, 1985). Comparing eastern and western Atlantic Communities, Lowe-McConnell (1987) considers that the Lutjanid Community assumes much greater importance in the Caribbean than off West Africa, since there are much larger areas of hard bottom in the western Atlantic. Species from this family have great importance for fisheries along the northeastern coast of Brazil (Fonteles Filho, 1969; Paiva *et al.*, 1971), but their occurrence decreases southward. At Cabo Frio, Fagundes Netto and Gaelzer (1991) noted the association of *Orthopristis ruber* and *Eucinostomus argenteus* in the catches, but did not record any Lutjanidae species. Cunningham (1983) found Gerreidae and Pomadasyidae to be among the most important families in bays near Ubatuba. The three Gerreidae and five Pomadasyidae species present accounted for more than 11 % of the individuals, while Lutjanidae was unimportant.

At Santos Bight, Ribeiro Neto (1989) reported five Gerreidae and seven Pomadasyidae species as relatively abundant, whereas only one species of Lutjanidae rarely occurred. Between 22° and 29°S, Facchini (1995) also emphasized the importance of Haemulidae (5 % of individuals) in the catches, and to a smaller degree, of Gerreidae, Diodontidae, Tetraodontidae, and Serranidae; Lutjanidae were rare. These results show that the Lutjanid Community is replaced by Gerreidae and Haemulidae species, as one moves south.

The Sparid Community, observed in other areas (Longhurst & Pauly, 1987), could not be characterized as an assemblage on the Ubatuba inner shelf. Nevertheless, *Pagrus pagrus* was among the 10 most abundant species of the outer shelf, and reached almost 5 % in number and 2 % in weight of the total catches from 50 m to 100 m (Natali Neto, 1994). The *Pagrus pagrus* is associated with hard bottom (Manooch III & Hassler, 1978), which is a rare habitat in the study area. However, this species is increasing in importance in the fishery along the Brazilian south coast (Silva, 1996).

Although changes in species composition and relative abundance occurred at different levels, three communities were always present in the Ubatuba area. Facchini's (1995) recent study showed their presence to 29°S.

Bianchi (1991) suggested that when the depth range is wide enough to include areas where different water layers impinge on the shelf slope, the greatest changes in species composition are depth related. However, within each water layer, other factors such as temperature and sediment type become relevant. Pires (1992) studied the benthic megafauna in continental shelf waters of Ubatuba and reported depth and water mass dynamics as main factors in the division of species assemblages. On the inner shelf, depth and water masses were also important in the determination of the fish communities.

Understanding the relationships between physical factors of the environment and changes in species composition is important. In a long-term study of groundfish assemblages, Gomes *et al.* (1995) considered that, when the entire community is subjected to prolonged adverse conditions, the sequence of species reactions should be roughly correlated with species abundance on the shelf, with the most widespread and abundant species reacting later. Thus, changes in the distribution patterns of less abundant species could anticipate changes at community level. Gomes *et al.* (*op. cit.*) found it difficult to account for the observed decline of many species (especially noncommercial ones) with arguments that revolve strictly around exploitation and decimation by fisheries. They suggested that changing environmental conditions were at least an important contributing factor underlying the observed trends in community composition and abundance.

Overholtz & Tyler (1985) point out the importance of investigating the long-term temporal scale of community dynamics, so that ecologists and managers can function in terms of ecological time. Since this study was conducted for only a two-year period, community trends could not be determined. However, it identifies changing environmental conditions that have to be taken into consideration for future management purposes.

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References

Benvegnu-Lé, G. de Q. 1978. Distribuição dos peixes teleósteos marinhos demersais na plataforma continental do Rio Grande do Sul. Tese de doutorado. Universidade de São Paulo, Instituto de Biociências. 94p.

Bianchi, G. 1991. Demersal assemblages of the continental shelf and slope edge between the Gulf of Tehuantepec (Mexico) and the Gulf of Papagayo (Costa Rica). Mar. Ecol. Prog. Ser., 73(2-3):121-140.

Braga, F. M. S. & Goitein, R. 1984. Lista prévia das espécies de peixes demersais na região da Ilha Anchieta (Lat. 23°33'S – Long. 45°05'W), Ubatuba, litoral norte do Estado de São Paulo, Brasil. Naturalia, S Paulo, 9:61-72.

Castro-Filho, B. M. de; Miranda, L. B. de & Miyao, S. Y. 1987. Condições hidrográficas na plataforma continental ao largo de Ubatuba: variações sazonais e em média escala. Bolm Inst. oceanogr., S Paulo, 35(2):135-151.

Colvocoresses, J. A. & Musick, J. A. 1984. Species associations and community composition of middle Atlantic bight continental shelf demersal fishes. Fish. Bull., U.S., 82(2):295-313.

Costa, C. C. C. 1977. Aspectos do ciclo de vida e bionomia de *Ctenosciaena gracilicirrhus* (Metzelaar, 1919) da plataforma continental do Rio Grande do Sul, Brasil. Dissertação de mestrado. Universidade de São Paulo, Instituto Oceanográfico. 63p.

Cunningham, P. T. M. 1978. Bionomia e ciclo de vida de *Ctenosciaena gracilicirrhus* (Metzelaar, 1919) na plataforma continental brasileira entre as latitudes de 22°10'S e 30°S. Dissertação de mestrado. Universidade de São Paulo, Instituto Oceanográfico. 106p.

Cunningham, P. T. M. 1983. Estudo comparativo da ictiofauna da costa oeste e Enseada das Palmas da Ilha Anchieta, Enseada do Flamengo e Enseada da Fortaleza (Lat 23°29'S - 23°33'S, Long 45°03'W - 45°09'W), Ubatuba, Estado de São Paulo - Brasil. Tese de doutorado. Universidade de São Paulo, Instituto Oceanográfico. 133p.

Dahlberg, M. D. & Odum, E. P. 1970. Annual cycles of species ocurrence, abundance and diversity in Georgia estuarine fish populations. Am. Midl. Naturalist, 83(2): 382-392.

Facchini, B. H. 1995. Ecologia de associações de peixes teleósteos demersais da plataforma continental sudeste do Brasil, de Cabo de São Tomé a Torres (22°04'-29°21'S). Tese de doutorado. Universidade de São Paulo, Instituto Oceanográfico. 228p.

Fagundes Netto, E. B. & Gaelzer, L. R. 1991. Associações de peixes bentônicos e demersais na região de Cabo Frio, RJ, Brasil. Nerítica, Curitiba, 6(1-2):139-156.

Figueiredo, J. L. de 1981. Estudo das distribuições endêmicas de peixes da Província Zoogeográfica Marinha Argentina. Tese de doutorado. Universidade de São Paulo, Instituto de Biociências. 121p.

Fonteles Filho, A. A. 1969. Estudo preliminar sobre a pesca do pargo, *Lutjanus purpureus* Poey, no nordeste brasileiro. Arq. Ciênc. Mar, Fortaleza, 9(1):83-88.

Gomes, M. C.; Haedrich, R. L. & Villagarcia, M. G. 1995. Spatial and temporal changes in the groundfish assemblages on the north-east Newfoundland/Labrador shelf, north-west Atlantic, 1978-1991. Fish. Oceanogr., 4(2):85-101.

Horn, M. H. 1980. Diel and seasonal variation in abundance and diversity of shallow-water fish populations in Morrow Bay, California. Fish. Bull., U. S., 78(3):759-770.

Longhurst, A. R. 1965. A survey of the fish resources of the eastern Gulf of Guinea. J. Cons. int. perm. Explor. Mer, 29(3):302-334.

Longhurst, A. R. & Pauly, D. 1987. Ecology of tropical oceans. San Diego, Academic Press. 407p.

Louro, M. P. 1995. Estratégias e táticas reprodutivas de elasmobrânquios no ecossistema de Ubatuba, SP, Brasil. Dissertação de mestrado. Universidade de São Paulo, Instituto Oceanográfico. 2v.

Lowe-McConnell, R. H. 1962. The fishes of the British Guiana Continental Shelf, Atlantic coast of South America, with notes on their natural history. Zool. J. Linn. Soc., 44(301):669-700.

Lowe-McConnell, R. H. 1987. Ecological studies in tropical fish communities. Cambridge, Cambridge University Press. 382p.

Mahon, R. & Balon, E. K. 1977. Ecological fish production in Long Pond, a lakeshore lagoon on Long Point, Lake Erie. Environ. Biol. Fishes, 2(3):261-284.

Manooch III, C. S. & Hassler, W. W. 1978. Synopsis of biological data on the red porgy, *Pagrus pagrus* (Linnaeus). NOAA Tech. Rep. NMFS Circ., 412:1-19.

Maurin, C. 1968. Écologie ichthyologique des fonds chalutables Atlantiques (de la Baie Ibéro-Marocaine a la Mauritanie) et de la Méditerranée occidentale. Revue Trav. Inst. Pêches marit., 32:1-147.

Natali Neto, J. F. 1994. Ictiofauna do ecossistema tropical marinho de Ubatuba (23°36' - 24°22'S; 44°33'S - 45°08'W), SP - Brasil, entre 50 e 100 m de profundidade: composição, distribuição, abundância e diversidade. Dissertação de mestrado. Universidade de São Paulo, Instituto Oceanográfico. 2v.

Nonato, E. F.; Amaral, A. C. Z. & Figueiredo, J. L. 1983. Contribuição ao conhecimento da fauna de peixes do litoral norte do Estado de São Paulo. Bolm Inst. oceanogr., S Paulo, 32(2): 143-152.

Overholtz, W. J. & Tyler, A. V. 1985. Long-term responses of the demersal fish assemblages of Georges bank. Fish. Bull., U. S., 83(4): 507-520.

Paiva, M. P.; Bezerra, R. C. F. & Fonteles Filho, A. A. 1971. Tentativa de avaliação dos recursos pesqueiros do nordeste brasileiro. Arq. Ciênc. Mar, Fortaleza, 11(1):1-43.

Pires, A. M. S. 1992. Structure and dynamics of benthic megafauna on the continental shelf offshore of Ubatuba, southeastern Brazil. Mar. Ecol. Prog. Ser., 86(1):63-76.

Pires-Vanin, A. M. S. & Matsuura, Y. 1993. Estrutura e função do ecossistema de plataforma continental da região de Ubatuba, estado de São Paulo: uma introdução. Publção esp. Inst. oceanogr., S Paulo, (10):1-8.

Pires-Vanin, A. M. S.; Rossi-Wongtschowski, C. L. D. B.; Aidar, E.; Mesquita, H. S. L.; Soares, L. S. H.; Katsuragawa, M. & Matsuura, Y. 1993. Estrutura e função do ecossistema de plataforma continental da região de Ubatuba, Estado de São Paulo: síntese dos resultados. Publção esp. Inst. oceanogr., S Paulo, (10):217-231.

Ribeiro Neto, F. B. 1989. Estudo da comunidade de peixes da Baía de Santos, SP. Dissertação de mestrado, Universidade de São Paulo, Instituto Oceanográfico. 196p.

Richards, C. E. & Castagna, M. 1970. Marine fishes of Virginia's eastern shore (inlet and marsh, seaside waters). Chesapeake Sci., 11(4):235-248.

Rocha, G. R. A. 1990. Distribuição, abundância e diversidade da ictiofauna na região de Ubatuba, SP (23°20'S-24°00'S; 44°30'W-45°30'W), Brasil. Dissertação de mestrado. Universidade de São Paulo, Instituto Oceanográfico. 2v.

Rossi-Wongtschowski, C. L. D. B. & Paes, E. T. 1993. Padrões espaciais e temporais da comunidade de peixes demersais do litoral norte do estado de São Paulo - Ubatuba, Brasil. Publção esp. Inst. oceanogr., S Paulo, (10):169-188.

Silva, A. O. A. da 1996. Idade, crescimento, mortalidade e aspectos reprodutivos do pargo, *Pagrus pagrus* (Teleostei: Sparidae), na costa do Estado de São Paulo e adjacências. Dissertação de mestrado. Universidade de São Paulo, Instituto Oceanográfico. 116p.

ter Braak, C. J. F. 1990. CANOCO - a FORTAN program for canonical community ordination by (partial) (detrended) (canonical) correspondence analysis and redundance analysis (version 3.10). Wageningen, ITI-TNO.

Vazzoler, G. 1975. Distribuição da fauna de peixes demersais e ecologia dos Sciaenidae da plataforma continental brasileira, entre as latitudes 29°21'S (Tôrres) e 33°41'S (Chuí). Bolm Inst. oceanogr., S Paulo, 24:85-169.

Yánez-Arancibia, A.; Sánchez-Gil, P.; Villa-Lobos-Zapata, G. J. & Rodriguez-Capetillo, R. 1985. Distribución y abundancia de las especies dominantes en las poblaciones de peces de la plataforma continental mexicana del Golfo de México. In: Yáñez-Arancibia, A. ed. Recursos pesqueros potenciales de México: la pesca acompañante del camarón. México, U.N.A.M., 1985. p. 315-397.

Yánez-Arancibia, A. 1986. Ecologia de la zona costera: análisis de siete tópicos. México, A. G. T. Editor. 189p.

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