STRUCTURE OF THE FISH ASSEMBLAGE IN THE SURF ZONE OF THE BEACH AT PONTAL DO SUL, PARANÁ

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INTRODUCTION

In general, few studies have investigated the role of the beaches in the life cycle of fishes (Modde, 1980; Lasiak, 1983). Those who did report from 26 to 71 species in assemblages dominated by few species and by juveniles (Romer, 1990; Yang & Senta, 1993; Lamberth *et al.*, 1994; Clark *et al.*, 1994). Since the surf zones harbor specimens in both larval and juvenile stages, some authors have concluded that beaches constitute important nursery areas for many fish species (Anderson *et al.*, 1977; Ruple, 1984; Yang & Senta, 1993).

The highest densities of fishes usually occur during the hottest months, and decline with a diminution in temperature (Ruple, 1984; Senta & Kinoshita, 1985; Ross *et al.*, 1987; Gibson *et al.*, 1993). This is usually attributed to environmental factors such as wind, wave height and water temperature (Lasiak, 1984; Gaspar, 1987; Ross et al., 1987; Clark *et al.*, 1996). Most fish remain in the surf zone for a short period of time (Lasiak, 1983; Gibson *et al.*, 1993),with few species remaining all year around (Brown & McLachlan, 1990).

Few studies have been performed on the fish communities of Brazilian beaches. Those that do exist have shown an assemblage composed of up to 79 species, mainly in the juvenile stage and with a numerical dominance of a few species (Cunha, 1981, Paiva-Filho *et al.*, 1987; Monteiro-Neto *et al.*, 1990; Monteiro-Neto, 1990; Graça Lopes *et al.*, 1993; Saul & Cunningham, 1995). This study therefore reports on the fish

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assemblage of the surf zone at Pontal do Sul and on its temporal structure, a reflective sandy beach situated in the south corner of Paranaguá Bay (25°16'34"S, 48°17'42"W), southern Brazil (Fig 1).

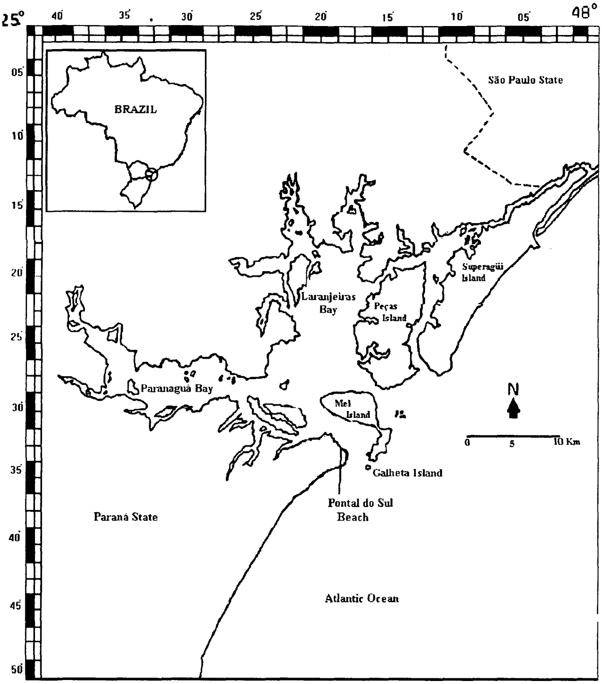

Fig. 1
The stuary of Paranagua, showing the location of the sampling site.

MATERIAL AND METHODS

The samples were obtained in the surf zone at Pontal do Sul with a beach seine (mesh size of 1 mm, 18 m in length and 2 m in height), between May 1993 and April 1994. Collections were done twice a month during the high and low tides (daytime and nightime) of the new moon and full moon in the same area. Eight monthly tows were made in the same direction as the current, at a depth which never surpassed 1.70 m along a 100 m strip paralel to the beach. Data of salinity, surface water temperature, wave height and frequency, air temperature, direction and velocity of the wind and rainfall were collected at the same time. Morphodynamic state of the surf zone was distinguished on the basis of the surf-scaling (ε) (Guza & Inman, 1975) and omega (Ω) (Dean, 1973) parameters.

To determine patterns of monthly and seasonal variation in assemblage composition and abundance, monthly total number of species, specimens and weight were compared. Species richness was estimated through Margalef's index, species diversity with Shanon-Wiener index of diversity and evenness with Pielou's evenness index (Pielou, 1969; Ludwig & Reynolds, 1988). The seasons were defined in the following way: September to November = spring; December to February =summer; March to May = autumn; June to August = winter.

Inverse Cluster Analysis was used to identify species assemblages, the 17 most abundant species were grouped in terms of their monthly abundance (analyses on log (x+1) transformed data). The temporal structure of the assemblage was established using Normal Cluster Analysis, with species as the attributes. The similarity between the attributes was calculated with the Bray-Curtis similarity coefficient and the assemblage method by the simple mean of its similarity values (UPGMA) (Romesburg, 1984; Ludwig & Reynolds, 1988). As there are not always discreet entities in nature, the MDS ("Non Metric Multidimensional Scaling") ordination technique, which, as the other ordination techniques,is based on the existence of a continuity in nature was also used. The ordination axes represent biological or environmental gradients through which the species or months were distributed (Gauch, 1982).

The evaluation of the influence of environmental factors on the temporal variation of assemblage structure was made through analytical interpretation of the dimensions, using multiple regression analysis to regress the environmental variables on the coordinates of the different dimensions (Snedecor & Cochran, 1980).

RESULTS

Seasonal Variation of Environmental Parameters

Monthly average values of surface water and air temperature showed seasonal pattern, with the smallest values between June and September and a progressive increase between spring and summer, followed by a reduction throughout autumn (Table I). Salinity of the surface water did not show any seasonality, with significant differences between months of the same season, primarily during winter and spring. Mean precipitatios were higher in spring and summer than in winter and fall, with the exception of September. North and northwest winds predominated from the end of autumn until the end of winter whereas in the spring south and southeast winds dominated. Wind direction varied the most in the summer months, with winds from SE, E and N. In general, wind velocity was more intensive in the spring, summer and in the first two months of autumn, and least intense between May and the end of winter. Wave period varied more in summer and winter, and least in the spring.

The monthly means for wave height were greater in winter and spring, and smaller in summer and autumn. In the morphodynamical state of the beach environment, the values of the omega parameter (Ω) varied between 0.02 and 0.05, characterizing the beach as reflective in all the studied period.

Seasonal Variation in Abundance and Composition of the ictiofauna

A total of 14,516 fishes, for the majority in the juvenile and larval stages, were captured, comprising, 32 families, 51 genera and 70 species (Tablle 2). The most abundant species were *Eucinostomus argenteus* (28.7%), *Harengula clupeola* (19.3%), *Anchoa tricolor* (10.4%), *Oligoplites saurus* (6.9%), *Anchoa parva* (4.7%) and *Sardinella brasiliensis* (4.7%), which represented 74.7 % of the total capture, while the 64 remaining species contributed only 25.3% of the total. The total weight of the capture was 22067.6 gr, of which 78.9 % (17414.2 gr) was made up by only four species: *Harengula clupeola* (37.7%), *Oligoplites saurus* (27.1%), *Anchoa tricolor* (7.3%) and *Hyporhamphus unifasciatus* (6.8 %).

No seasonal tendency was observed in the capture biomass (Fig. 2a). More fishes were captured during summer, constituting 54.18 % of the annual capture. Of this, 79,87% of the fish were captured in December and January (39,85% and 40,02%, respectively) (Fig 2b). The number of species showed a seasonal pattern during most of the sampled period, with a gradual diminution through winter and spring, reaching a minimum of 12 species in November (Fig 2c). There was marked increase in the first month of summer, a tendency which continued throughout this season, culminating in February with the greatest number of species.

Table 1 - Physical environmental variables recorded at the surf zone of Pontal do Sul Beach, between May, 1993 and April, 1994. (S = salinity, T wat = water temperature, T air = air temperature, Dir wind = wind direction, Vel wind = wind velocity, P = wave period, Hb = wave height, Ω = omega, ε = surf-scaling parameter).

Month	Physical variables								Morphodinamics	
	S (‰)	T wat (°C)	T air (°C)	Rainfall (mm)	Dir wind	Vel wind (m/s)	P (s)	Hb (cm)	Ω	ε
May	30,7	22,2	21,52	103,8	NW	1,87	9	30	0,02	4,14
June	29,9	16,45	18,75	64,8	NW	1,85	11,5	42,5	0,03	3,59
July	34,8	20,2	17,87	65,1	N	2,29	8,2	40	0,04	6,64
August	32,1	18,4	17,03	10,4	N	1,92	6,6	32	0,04	8,20
September	31,2	18,9	18,3	320,3	SW	2,85	8,25	50	0,05	8,20
October	28,6	22,2	21,62	49,5	S	2,72	8,6	42	0,04	6,34
November	33,7	23,9	24,81	0	SE	3,49	8,6	40	0,03	6,04
December	31,4	26,4	25,55	161,5	E	4,05	8,6	30	0,03	4,53
January	31,4	25,2	24,98	249,1	SE	3,46	12	25	0,02	1,94
February	27,1	27	26,91	352,4	N	2,27	9,6	28,8	0,02	3,49
March	27,7	26,4	25,38	302,3	SE	2,9	11,2	30	0,02	2,67
April	30,1	24,35	23,03	300,6	SW	2,38	9,2	30	0,02	3,96

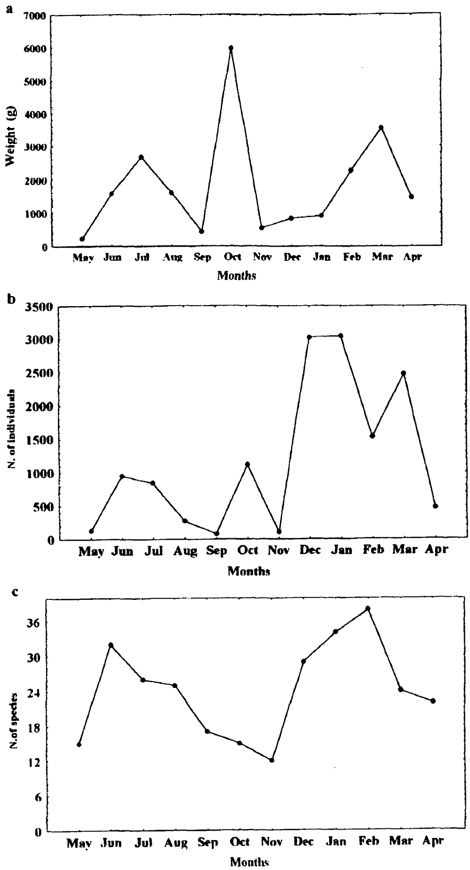

Fig. 2
Monthly variations in the total weight (a), total number of individuals (b) and total number of species (c) in the surf zone fish at Pontal do Sul beach, between May 1993 and April 1994.

Community structure indices did not indicate seasonal changes in the assemblage. The ichthyofauna diversity, expressed by the Shannon-Wiener index of diversity, peaked in June, September and April, although these months did not have the greatest number of species (Fig 3a). The greater diversity in these months could be explained by greater evenness on the distribution of number of individuals per species. The lower diversities were in the months of October and January, the latter with a considerable number of species but with low evenness. (Fig.3b). Species richness peaked in February, June and August (Fig 3c), this latter result being mainly due to the relatively high proportions of individuals to species. Species richness bottoned in October and November.

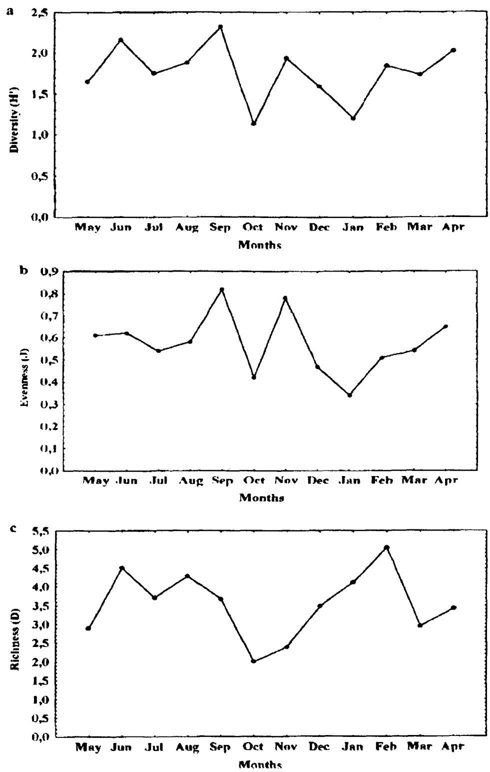

Fig. 3
Monthly variations in the indexes of diversity of Shanon-Wiever (H') (a), evenness of Pielou (J) (b) and richness of Margalef (D) (c) in the surf zone fish at Pontal do Sul beach, between May 1993 and April 1994.

The faunistic similarities between months (combined samples) were analyzed through Cluster analyses and non-metric MDS on log (x+1) transformed data. The resulting dendrogram separates the 12 months of collection into two major groups which connect at the 50% similarity level (Fig 4a). The first group included the months of December, January, February and March, (which showed a similarity of 63%) corresponds to a high density period of juveniles, a great number of species, relatively low values in diversity and lower evenness. This group was split into two secondary groups, one comprised of the months of December and January, united on the similarity level at 79%, showing the greatest number of individuals, a great number of species, low diversity and small evenness levels. The second group, formed by the months of February and March, was united on the similarity level at 70%, and when in comparison with the previous group, showed a lesser number of individuals and species, higher

Table 2 - General data on fish capture with a beach seine net at the beach of Pontal do Sul between May, 1993 and April, 1994. (PF = post flexion larvae, J = Adult).

Taxon	Nº de individuals	Proportion of capture %	Stage	Taxon	Nº de individuals	Proportion of capture %	Stage
Narcinidae *Narcine brasiliensis*	1	0,01	A	Carangidae *Trachinotus goodei*	3	0,02	J
Elopidae *Elops saurus*	21	0,15	PF	Carangidae *Uraspis secunda*	1	0,01	J
Albulidae *Albula vulpes*	20	0,14	PF	Lobotidae *Lobotes surinamensis*	1	0,01	J
Engraulidae *Anchoa filifera*	1	0,01	A	Gerreidae *Diapterus rhombeus*	2	0,01	A
Engraulidae *Anchoa lyolepis*	286	2,04	J-A	Gerreidae *Eucinostomus argenteus*	4016	28,71	PF-J-A
Engraulidae *Anchoa parva*	660	4,72	PF-J-A	Gerreidae *Eucinostomus gula*	254	1,82	PF-J-A
Engraulidae *Anchoa tricolor*	1449	10,36	PF-J-A	Gerreidae *Eucinostomus melanopterus*	4	0,03	A
Engraulidae *Cetengraulis edentulus*	35	0,25	J-A	Gerreidae *Eucinostomus spp.*	627	4,47	PF
Clupeidae *Brevoortia spp.*	1	0,01	PF	Haemulidae *Conodon nobilis*	18	0,13	J
Clupeidae *Harengula clupeola*	2697	19,28	J-A	Haemulidae *Haemulon steindachneri*	6	0,04	J-A
Clupeidae *Harengula jaguana*	29	0,21	PF	Haemulidae *Pomadasys corvinaeformis*	67	0,48	J-A
Clupeidae *Opisthonema oglinum*	50	0,36	PF-J-A	Sparidae *Archosargus rhomboidalis*	1	0,01	A
Clupeidae *Pellona harroweri*	1	0,01	A	Sciaenidae *Bairdiella ronchus*	8	0,06	PF-J
Clupeidae *Sardinella brasiliensis*	657	4,70	PF-J	Sciaenidae *Cynoscion leiarchus*	4	0,03	PF-J-A
Argentinidae *Glossanodon pygmaeus*	3	0,02	PF	Sciaenidae *Menticirrhus americanus*	277	1,98	PF-J
Synodontidae *Synodus foetens*	2	0,01	J	Sciaenidae *Menticirrhus littoralis*	36	0,26	PF-J-A
Gobiesocidae *Gobiesox strumosus*	1	0,01	J	Sciaenidae *Menticirrhus spp.*	208	1,49	PF
Atherinidae *Adenops dissimilis*	72	0,51	PF-J-A	Sciaenidae *Micropogonias furnieri*	369	2,64	PF
Atherinidae *Odontesthes bonariensis*	7	0,05	J-A	Sciaenidae *Umbrina canosai*	2	0,01	J
Atherinidae *Atherinella brasiliensis*	197	1,41	J-A	Sciaenidae *Umbrina coroides*	168	1,20	PF-J-A
Exocoetidae *Hemiramphus brasiliensis*	1	0,01	J	Centropomidae *Centropomus parallelus*	1	0,01	A
Exocoetidae *Hyporhamphus unifasciatus*	158	1,13	PF-J-A	Ephippididae *Chaetodipterus faber*	8	0,06	J
Belonidae *Strongylura marina*	6	0,04	J-A	Pomatomidae *Pomatomus saltatrix*	33	0,24	J-A
Belonidae *Strongylura timucu*	9	0,06	J-A	Uranoscopidae *Astroscopus sexspinosus*	2	0,01	J
Belonidae *Strongylura spp.*	2	0,01	PF	Uranoscopidae *Astroscopus ygraecum*	2	0,01	J
Syngnathidae *Syngnathus elucens*	1	0,01	J	Polynemidae *Polydactylus oligodon*	1	0,01	PF
Syngnathidae *Syngnathus folletti*	15	0,11	J	Polynemidae *Polydactylus virginicus*	1	0,01	PF-J
Syngnathidae *Syngnathus spp.*	1	0,01	J	Scombridae *Scomberomorus brasiliensis*	2	0,01	J
Syngnathidae *Syngnathus rousseau*	1	0,01	J	Mugilidae *Mugil curema*	23	0,16	PF-J-A
Fistulariidae *Fistularia petimba*	3	0,02	J	Mugilidae *Mugil gaimardianus*	202	1,44	PF-J-A
Fistulariidae *Fistularia tabacaria*	1	0,01	J	Mugilidae *Mugil incilis*	1	0,01	J
Fistulariidae *Fistularia spp.*	1	0,01	J	Mugilidae *Mugil spp.*	46	0,33	PF-J
Serranidae *Epinephelus nigritus*	1	0,01	J	Triglidae *Prionotus punctatus*	14	0,10	J-A
Carangidae *Caranx latus*	4	0,03	J	Tetraodontidae *Lagocephalus laevigatus*	1	0,01	J
Carangidae *Chloroscombrus chrysurus*	4	0,06	J-A	Pleuronectidae *Oncopterus darwini*	2	0,01	J
Carangidae *Oligoplites saliens*	4	0,02	J	Paralichthyidae *Citharichthys arenaceus*	1	0,01	J
Carangidae *Oligoplites saurus*	9674	6,91	PF-J-A	Paralichthyidae *Citharichthys spilopterus*	3	0,02	J
Carangidae *Trachinotus carolinus*	146	1,04	PF-J-A	Paralichthyidae *Etropus crossotus*	23	0,16	J

diversity and evenness. The second major group, comprised April, June, July, August, September, October and November, and showed a similarity of 53%. It represented a period of low captures, fewer species, greater diversity and greater evenness. Within this group, 2 smaller groups had a greater affinity: first, the months of June and July, showing similarity at 75%, comprised of samples with an intermediate number of individuals and species captured, high diversity and comparatively higher evenness values; secondly, the samples from April and August, with similarity at 65%, and fewer individuals and species captured in comparison with the previous group, but similar with regards to diversity and evenness (Fig.4a).

The separation of the clustered samples in the monthly MDS analysis corresponds to the pattern generated by the Cluster analysis. In the above-mentioned similarity levels, the months are grouped together in the plotting of the first two dimensions (stress = 0.0994), which reflects a good relationship between the similarities and final distances (Fig.4b).

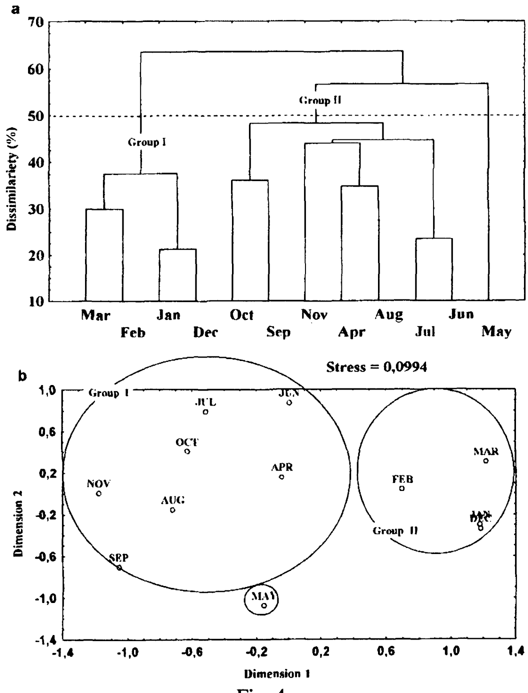

Fig. 4

Dendrogram and MDS ordination plot of density data from 17 most abundant taxa, from monthly seine net hauls made in the surf zone atf Pontal do Sul beach, between May 1993 and April 1994. Groups of months delineated at the 50 % level in the dendrogram are circled in the ordination plot. Stress for the MDS ordination= 0,0994.

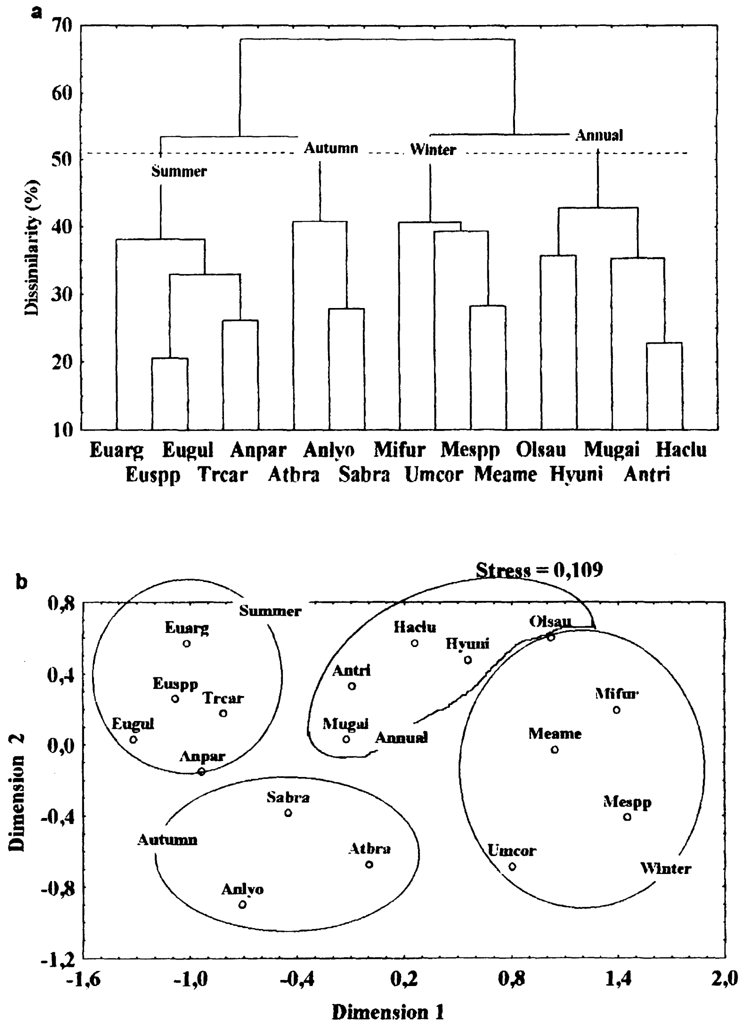

Fig. 5

Dendrogram and MDS ordination plot showing similarities between species based on their occurrence in the 12 sampling months. Group of species delineated at the 55% level in the dendrogram are circled in the ordination plot. Stress for the MDS ordination= 0,109. (Euarg = *Eucinostomus argenteus*, Euspp = *Eucinostomus spp*, Eugul = *Eucinostomus gula*, Trcar = *Trachinotus carolinus*, Anpar = *Anchoa parva*, Atbra = *Atherinella brasiliensis*, Anlyo = *Anchoa lyolepis*, Sabra = *Sardinella brasiliensis*, Mifur = *Micropogonias furnieri*, Umcor = *Umbrina coroides*, Mespp = *Menticirrhus spp.*, Meame = *Menticirrhus americanus*, Olsau = *Oligoplites saurus*, Hyuni = *Hyporhamphus unifasciatus*, Mugai = *Mugil gaimardianus*, Antri = *Anchoa tricolor*, Haclu = *Harengula clupeola*).

The group comprised of the months of December, January, February and March was characterized by higher mean temperatures of both air and water, and lower mean values of wave height and period in comparison with the other group comprised of the months of April, June, July, August, September, October and November. Water temperature, air temperature, wave height and period explained a significant proportion of the variance of the assemblage structure (multiple regression of environmental parameters on sample groups, Table 3). On the other hand, the parameters of rainfall, salinity, and wind intensity, explain little of monthly variation in abundance in the considered species (Table 3).

A pattern of seasonality was apparent in the numerically dominant species. The cluster analysis revealed four main groups united on a similarity level at 55% (Fig 5a). The first seasonal group (summer) grouped in the 62% similarity level, was comprised of greater abundance in the summer of larvae in the post-flexion stage of *Eucinostomus argenteus, Eucinostomus spp.* and *Eucinostomus gula*, and of juveniles of *Trachinotus carolinus* and *Anchoa parva.* A second group (autumn) had a similarity level of 60%, and was comprised mainly of juveniles of *Sardinella brasiliensis, Anchoa lyolepsis* and *Atherinella brasiliensis*. The third seasonal group (winter) grouped at the 60% level on the dendrogram, and represented basically post-flexion stage larvae of *Menticirrhus americanus*, *Micropogonia*s *furnieri*, *Umbrina coroides* and *Menticirrhus spp*. Lastly, an annual group was comprised for the most part by juveniles of *Harengula clupeola*, *Anchoa tricolor*, *Mugil gaimardianus*, *Hyporhamphus unifasciatus* and *Oligoplites saurus*, all of which in the four annual seasons, especially *Harengula clupeola* and *Anchoa tricolor*, species with the closest similarity within the group (Fig.5a). The assemblages evident at the 55 % level of the dendrogram are clearly visible with the MDS ordination method . The stress of a two-dimensional configuration of MDS was moderately high (0.109), which indicates difficulty in showing the relationship between the 17 species in two dimensions. In the plotting of the two dimensions, the winter group appears on the right, with the groups of autumn and annual in the middle position and the summer group to the left of the ordination plot (Fig. 5b).

A multiple regression analysis indicated the relative importance of environmental variables in the occurrence of fish. Of these factors, air temperature, surface water tempertaure, wave height and period all explained a significant proportion of the variance of the 17 selected taxa . The fishes in the summer group, are associated with higher air and water temperatures, and lesser height and period of waves. Intermediate conditions, which are closer to the summer mean values, were observed only in autumn, whereas there were no significant differences between winter and spring, which could explain in part the presence of an autumn group and the absence of a spring one (Table 4).

Table 3 - Results of multiple regression analysis of environmental parameters on sample groups (* = significant $p < 0,05$ NS = non-significant, R^2 = coeficient of multiple determination).

Environmental parameter	R^2	
Rainfall	0,292	NS
Salinity	0,175	NS
Water temperature	0,884	*
Air temperature	0,869	*
Wave height	0,762	*
Wave period	0,764	*
Wind velocity	0,12	NS

DISCUSSION

The ichthyofauna associated with the beaches, despite the high species diversity, is characterized by the domination of a few species which occur principally in assemblages, also a characteristic of estuarine regions (Kennish, 1990; Brown & McLachlan, 1990). The dominance of a few species and the large number of rare species collected in the beach at Pontal do Sul are characteristics of systems with a very dynamic surf zone, due to the constant changes of physical factors (Moyle & Cech, 1988). In this study we observed a numerical dominance of the species *Eucinostomus argenteus*, *Harengula clupeola*, *Anchoa tricolor*, *Oligoplites saurus*, *Anchoa parva and Sardinella brasiliensis*, which accounted for 74.7% of the total catch. The predominance of a few species in the catch has been reported for beaches of the Brazilian coast (Paiva Filho & Toscano, 1987; Paiva Filho *et al.*, 1987; Cunha, 1981; Monteiro-Neto *et al.*, 1990; Graça Lopes *et al.*, 1993), as well as for many samplings performed on the American east coast and in the Gulf of Mexico (Naughton & Saloman, 1978; Modde & Ross, 1981).

An important component of the structure of a beach fish community is the length of time that the fish remain in the area. Generally speaking, the presence of a small number of resident species which regularly frequent the surf zone has been verified, which does not mean that the same group of individuals are constantly present in the area throughout. A large part of the individuals in this community is comprised of migrant species which, sporadically or seasonally, pass through the area (Brown & McLachlan, 1990). In this study, as in others performed on the beach of Pontal do Sul (Cunha, 1981; Hofstaetter, personal communication), it was evident that the ichthyofauna in the surf zone is formed for the most part of individuals which pass through the area and remain in this habitat only for a short period of time. Of the 70 taxa present, only the species *Harengula clupeola*, *Opisthonema oglinum*, *Anchoa tricolor*, *Hyporhamphus unifasciatus*, *Pomatomus saltatrix*, *Oligoplites saurus*, *Pomadasys cor-*

vinaeformis, *Menticirrhus americanus* and *Mugil gaimardianus* could be classified as resident throughout the year, which means that of the 61 remaining species, approximately 45 occur in a sporadic manner and 16 are seasonal residents.

Table 4 - Results of multiple regression analysis of environmental parameters on species groups (* = significant $p < 0,05$ NS = non-significant, R^2 = coeficient of multiple determination).

Environmental parameter	R^2	
Rainfall	0,289	NS
Salinity	0,154	NS
Water temperature	0,899	*
Air temperature	0,885	*
Wave height	0,882	*
Wave period	0,858	*
Wind velocity	0,324	NS

Despite the fact that the beach is situated at the entrance of the estuary, the studied beach is, in reference to ichthyofauna, intimately associated with the adjacent sea. With the exception of estuarine taxa such as Gerreidae, Centropomidae, Mugilidae, Syngnathidae families and of the larvae of *Gobionellus spp.*, *Microgobius spp.* and *Batygobius soporator*, probably present in the area during the ebb tide, and those of *Atherinella brasiliensis* which were present in the area during the lowest salinities, the great majority of the individuals captured were initial stages in the life cycles of marine species. These are dependent on the estuary, and were using the surf zone, before relocating to nursery areas in the interior of the estuary.

There was a greater similarity between the species composition of the beach at Pontal do Sul with those of the Brazilian coast more to the North (Paiva Filho *et al.*, 1987; Graça Lopes *et al.*, 1993; Saul & Cunningham, 1995), than between Pontal do Sul and the beaches of Rio Grande do Sul (Cunha, 1981; Monteiro-Neto, 1990; Pereira, 1994). This diminution in the similarity in direction to higher latitudes, which has also been reported for the beaches of the Gulf of Mexico (Modde & Ross, 1981; Ross *et al.*, 1987) and the Eastern American coast (Tagatz & Dudley, 1961; Anderson *et al.*, 1977, Delancey, 1984), is due to a larger contribution of tropical and subtropical taxa in the formation of fish assemblages in the lower latitudes. The fish assemblage observed in this study was comprised of species that, for the most part, are originally from tropical and subtropical regions, with few species present from colder waters, such as *Adenops dissimilis*, *Odontesthes bonariensis*, *Syngnathus folletti*, *Umbrina canosai* and *Oncopterus darwini*, these agrees with the statements of Corrêa (1987, 1994) who observed that the fauna of the Paraná littoral is transitory and very similar to that of warm-water tropical regions, especially the Caribbean.

The studies on surf zone fishassemblages show seasonal changes in abundance and diversity, and primarily reflect recruitment patterns determined by the seasonality of reproductive activity and coastal circulation (Monteiro-Neto, 1990). On the beach of Cassino, Cunha (1981) observed the greatest diversity in the summer, followed by autumn and spring. Monteiro-Neto (1990), studying the fishes on the same beach, observed similar densities from spring until autumn, with a lesser diversity in winter. Higher diversities in summer and lower ones in winter are common on the American southern and eastern coasts (Tagatz & Dudley, 1961; Springer & McErlean, 1962; McFarland, 1963; Ross *et al.*, 1987). In Pontal do Sul, although the larger diversity tended to occur also in summer, a smaller diversity was observed in spring, while in winter the diversity was also large.

Large numbers of fish in summer and autumn and small numbers in winter and spring have also been reported in beach collections done in the Bay of Santos (Paiva Filho & Toscano, 1987) and on the coast of Rio Grande do Sul (Cunha, 1981; Monteiro-Neto, 1990). Generally speaking, despite regional differences in periods of maximum abundance, the small numbers were always present in the winter (Tagatz & Dudley, 1961; McFarland, 1963; Modde & Ross, 1981; Clark *et al.*, 1996 b). This is different from Pontal where on average the abundance was smaller in the spring. A larger weight biomass during the hotter periods of the year, which is generally associated with a greater capture of individuals, was observed in the surf zone of different beaches (McFarland, 1963; Cunha, 1981; Ross *et al.*,1987). No such relationship between biomass and temperature was observed along a beach of the Bay of Santos (Giannini & Paiva Filho,1990), which has a relatively constant biomass throughout the year. The absence of seasonality in the weight of the captures also occurred in this study.

In the studied area, no seasonality was observed in the community structure indices. The sampled assemblage was characterized by a smaller number of species (spring and autumn) and by large captures of few species (summer and winter). In an area near this study, Saul & Cunningham (1995) also observed the smallest mean values of diversity and evenness in summer. Cunha (1981) whoever, observed along the beach at Cassino a larger diversity index in summer and smaller in spring, which was confirmed for that beach by Monteiro-Neto (1990). Community structure indices were also non-seasonal in the beaches investigated by Lasiak (1984 a) and Clark *et al.*, (1996 b). However, the maximum and minimum diversity and evenness periods did not coincide with those of the beach at Pontal do Sul.

The cluster of months defined by normal Cluster analysis does not follow a pattern of seasonality and reflects differences in the qualitative and quantitative occurrence of the more important taxa, correlated with the environmental variables of temperature and of waves height and period. On the other hand, in an area further to the south where the seasons of the year are more defined, Monteiro-Neto (1990) detected four seasonal groups similar in specific composition and which were characterized by seasonal changes in temperature and salinity parameters. The seasonality of the selected species clusters showed not only seasonal patterns of distribution and abundance, but also some ecological affinities among the species. The summer group was comprised of larvae of *Eucinostomus argenteus* and *Eucinostomus gula* and of juveniles of *Trachinotus carolinus* and *Anchoa tricolor*, the first three being the three most often captured species. This group could be characterized as juveniles of spring-summer, who hatched not far from recruitment areas, with the larger recruitment in the surf zone in summer. The autumn group, formed by juveniles of *Sardinella brasiliensis*, *Anchoa lyolepis* and *Atherinella brasiliensis*, is composed of three species spawning in spring and summer, in regions a little father from the study area, on the adjacent continental shelf in the case of clupeiforms and in the estuary in the case of Atherinidae their recruitment is in the surf zone in summer and autumn, principally at the beginning of autumn. The winter group is comprised of larvae of *Menticirrhus americanus*, *Micropogonias furnieri* and of juveniles of *Umbrina coroides*, who also hatch in spring and summer in coastal areas and whose recruitment in the surf zone is in winter. The annual group formed by the species *Harengula clupeola*, *Anchoa tricolor*, *Mugil gaimardianus*, *Hyporhamphus unifasciatus* and *Oligoplites saurus*, all of which are species more commonly found in estuarine waters, probably spawns throughout the year and showed a relatively continuous recruitment in the surf zone.

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ABSTRACT

The assemblage structure of the ichthyofauna in the surf zone of the Beach of Pontal do Sul was studied between May 1993 and April 1994 through bi-monthly collections in high and low syzygy tides. The fish community was characterized by a high diversity with numerical dominance of the species *Eucinostomus argentus*, *Harengula clupeola*, *Anchoa tricolor*, *Oligoplites saurus*, *Anchoa parva* and *Sardinella brasiliensis* which represented 74,7 % of the total capture. The majority of the species were marine species and remained in this habitat for a brief period, and only 10 species could be classified as annual residents. No seasonality was observed in the community structure indices in the area. The sampled assemblage was characterized by a high species evenness in periods with a lesser number of species (spring and fall) and by large captures of a few species in periods with greater diversity (summer and winter). The group of months did not follow a pattern of seasonality and reflected differences in qualitative and quantitative occurrences of the more important species, correlated with water temperature and the waves period and height. The seasonality of the groups of selected species showed probable ecological affinities between species.

Key-words: Ichthyofauna, surf zone, seasonal variation, Brazil.

RESUMO

A estrutura populacional da ictiofauna da zona de arrebentação da praia de Pontal do Sul, PR foi estudada entre maio de 1993 e abril de 1994, através de coletas quinzenais, na preamar e baixa-mar de sizígia, durante ciclos completos de 24 horas. A comunidade local foi caracterizada por uma alta diversidade, porém com o domínio numérico das espécies *Eucinostomus argentus, Harengula clupeola, Anchoa tricolor, Oligoplites saurus, Anchoa parva* e *Sardinella brasiliensis* responsáveis por 74,7 % da captura total. A maioria dos taxa são marinhos e permanecem neste habitat por um curto período de tempo, sendo que somente 10 espécies podem ser classificadas como residentes anuais. Nenhuma sazonalidade foi observada nos índices de estrutura da comunidade. A população amostrada se caracterizou por uma maior uniformidade das ocorrências em períodos com menor número de espécies (primavera e outuno) e por grandes capturas de poucas espécies nos períodos com maior diversidade (verão e inverno). Os agrupamentos de meses não seguiram um padrão de sazonalidade e refletiram diferenças na ocorrência qualitativa e quantitativa dos taxa mais importantes, correlacionadas com a temperatura da água e o período e altura das ondas. A sazonalidade dos agrupamentos das espécies selecionadas revela não somente padrões sazonais de distribuição e ocorrência, mas também algumas prováveis afinidades ecológicas entre as espécies.

Palavras-chave: Ictiofauna, zona de arrebentação, variação sazonal, Brasil.

REFERENCES

ANDERSON, W. D., DIAS, J. J. K., DIAS, R. K., CUPKA, D. M. & CHAMBERLAIN, N. A., 1977. The macrofauna of the surf zone of Folly Beach, South Carolina. NOAA Tech. Rep., NMFS SSRF - 704.

ANG, C. & SENTA, T. 1993. The surf ichthyofauna of the Penghu Islands, Taiwan. *Bull. Fac. Fish.*, 73: 7-14.

BROWN, A. C. & McLACHLAN, A., 1990. *Ecology of sandy shores.* Elsevier, 328 p.

CASTELLO, J.P., YAMAGUTI, N., CORRÊA, M. F. M. & LEDO, B. S., 1994. *Diagnóstico ambiental oceânico e costeiro das regiões sul e sudeste do Brasil.* Petrobras, 472 pp.

CLARK, B.M., BENNETT, B. A. & LAMBERTH, S. J., 1994 . A comparison of the ichthyofauna of two estuaries and their adjacent surf zones, with an assessment of the effects of beach seining on the nursery function of estuaries for fish. *S. Afr. Mar. Sci.*, 14: 121 - 131.

CLARK, B.M., BENNETT, B. A. & LAMBERTH, S. J., 1996 . Temporal variations in surf zone fish assemblages from False Bay, South Africa. *Mar. Ecol. prog. Ser.*, 131: 35 - 47.

CUNHA, L. P. R., 1981. *Variação sazonal da distribuição, abundância e diversidade dos peixes na zona de arrebentação da praia do Cassino, RS, Brasil.* Dissertação de Mestrado, Universidade Federal do Rio de Janeiro, Rio de Janeiro, 44p.

CORRÊA, M. F. M., 1987. *Ictiofauna da Baía de Paranaguá e adjacências (litoral do estado do Paraná - Brasil). Levantamento e produtividade.* Dissertação de Mestrado, Universidade Federal do Paraná, 406 p.

______., 1994. Paraná. In: Castello, J. P., Yamaguti, N., Corrêa, M. F. M. & Ledo, B. S. *Diagnóstico ambiental oceânico e costeiro das regiões sul e sudeste do Brasil.* Petrobrás, 472 p.

DEAN, R.F. 1973. Heuristic models of sand transport in the surf zone. *Proc. Ist. Austr. Conf. Cstl. Engin.* 208-214.

DELANCEY, L. B., 1984. *An ecological study of the surf zone at Folly Beach, South Carolina.* Dissertação de Mestrado, College of Charlestone, South Carolina, 131 p.

GASPAR, A. G., 1987. Estructura de la comunidad de peces en playas arenosas de la Bahia de Charagato, Isla de Cubagua, Venezuela. *Bol. Inst. Oceanog. Univ. Oriente*, 26 (1/2): 53 - 66.

GAUCH JR., H. G., 1982. *Multivariate analysis in community ecology.* Cambridge University Press, 298 p.

GIANNINI, R. & PAIVA FILHO, A. M., 1990. Os Sciaenidae (Teleostei - Perciformes) da Baía de Santos (SP), Brasil. *Bolm. Inst. Oceanogr.*, São Paulo, 38(1): 69 - 86.

GIBSON, R. N.; ANSELL, A. D. & ROBB, L., 1993. Seasonal and annual variations in abundance and species composition of fish and macrocrustacean communities on a Scottish sandy beach. *Mar. Ecol. Prog. Ser.*, 98: 89 - 105.

GRAÇA LOPES, R.; SEVERINO RODRIGUES, E.; PUZZI, A.; PITA, J. B; COELHO, J. A. P. & FREITAS, M. L., 1993. Levantamento ictiofaunístico em um ponto fixo na Baía de Santos, Estado de São Paulo, Brasil. *B. Inst. Pesca*, 20: 7 - 20.

GUZA, R.I. & INMAN, D.L. 1975. Edge waves and beach and cusps. *J. Geol. Res.* 80 (21): 2997-3013.

KENNISH, M.J. 1990. *Ecology of estuaries.* CRC Press, Boston, 391 p.

LASIAK, T. A., 1983. The impact of surf zone fish communities on faunal assemblages associated with sand. In: McLachlan, A. & Erasmus, T. (eds.). *Sandy beaches as ecosystems.* The Hague, Junk, P., 501 - 506.

LASIAK, T. A. 1984 . Structural aspects of the surf zone fish assemblage at King's Beach, Algoa Bay, South Africa: Short - term fluctuations. *Est. Coast. Shelf Sci.*, 18 : 347 - 360.

LAMBERTH, S. J., BENNETT, B. A. & CLARK, B. M., 1994. Catch composition of the commercial beach seine fishery in False Bay, South Africa. *S. Afr. J. Mar. Sci.*, 14 : 69 - 78.

LUDWIG, J. A. & REYNOLDS, J. F., 1988. *Statistical ecology.* John Wiley & Sons, 337 p.

MCFARLAND, W. N., 1963. Seasonal changes in the number and the biomass of fishes from the surf at Mustang Island, Texas. *Pub. Ins. Mar. Sci.*, 9: 91 - 105.

MODDE, T., 1980. Growth and residency of juvenile fishes within a surf zone habitat in the Gulf of Mexico. *Gulf. Res. Rep.*, 6: 377 - 385.

MODDE, T. & ROSS, S. T., 1981. Seasonality of fishes occuping a surf zone habitat in the northern Gulf of Mexico. *Fish. Bull.*, 78 (4): 911 - 922.

MONTEIRO-NETO, C., 1990. *Comparative community structure of surf zone fishes in the Chesapeake Bight and Southern Brazil.* Tese de Doutorado, Faculty of the School of Marine Science, The college of William and Mary, 150 p.

MONTEIRO-NETO, C. , BLACHER, C., LAURENT, A. A. S., SNIZEK, F. N., CANOZZI, M. B. & TABAJARA, L. L. C. DE A., 1990. Estrutura da comunidade de peixes em águas rasas na região de Laguna, Santa Catarina, Brasil. *Atlântica*, 12 (2): 53 - 69.

MOYLE, P. B. & CECH, J. J., 1988. *Fishes: an introduction to ichthyology.* 2. ed. New Jersey. Prentice Hall, 559 p.

NAUGHTON, S. P. & SALOMAN, C., 1978. Fishes of nearshore zone of St. Andrew Bay, Florida, and adjacent coast. *Northeast Gulf.* Sci., 2: 43 -55.

PAIVA FILHO, A. M. & TOSCANO, A. P., 1987. Estudo comparativo e variação sazonal da ictiofauna na zona entre-marés do Mar Casado - Guarujá e Mar Pequeno - São Vicente, SP. *Bolm. Inst. Oceanogr.*, São Paulo, 35 (2): 153 - 165.

PAIVA FILHO, A. M. ; GIANNINI, R.; RIBEIRO NETO, F. B. & SCHMIEGELOW, J. M.M., 1987. Ictiofauna do complexo Baía Estuário de Santos e São Vicente, Sp. Brasil. *Relat. Int. Inst. Ocenogr. Univ. S. Paulo.*, 17: 1 - 10.

PALACIO, F. J., 1982. Revision zoogeografica marina del sur del Brasil. *Bolm. Inst. Oceanogr.*, 31 (1): 69 - 92.

PEREIRA, L. E., 1994. Variação diurna e sazonal dos peixes demersais na barra do estuário da Lagoa dos Patos, RS. *Atlântica*, 16: 5 - 21.

PIELOU, E. C., 1969. *An introduction to mathematical ecology.* Wiley, New York

REID, G. K. JR. 1955. A summer study of the biology and ecology of East Bay, Texas. Part II. The fish fauna of East Bay, the Gulf beach, and summary. *Tex. J. Sci.*, 7: 430-453.

ROMER, G. S., 1990. Surf zone fish community and species response to a wave energy gradient. *J. Fish. Biol.*, 36(3): 279 - 287.

ROMESBURG, H. C., 1984. *Cluster analysis for researches.* Lifetime Learning Publications, Belmont.

ROSS, S. T.; MCMICHAEL, R. H. & RUPLE, D. L., 1987. Seasonal and diel variation in the standing crop of fishes and macroinvertebrates from a Gulf of mexico surf zone. *Est. Coast. Shelf Sci.*, 25: 391 - 412.

RUPLE, D., 1984. Occurence of larval fishes in the surf zone of a nothern Gulf of Mexico barrier Island. *Est. Coast. Shelf Sci.*, 18: 191 - 208.

SAUL, A. C. & CUNNINGHAM, P. T. M., 1995. Comunidade ictiofaunística da Ilha do Bom Abrigo, Cananéia, São Paulo, Brasil. 2 - Lanço. *Arq. Biol. Tecnol.*, 38(4): 1053 - 1069.

SENTA, T. & KINOSHITA, I., 1985. Larval and juvenile fishes occurring in surf zones of western Japan. *Trans. Amer. Fish. Soc.*, 114: 609 - 618.

SNEDECOR, Q. W. & COCHRAN, W. G., 1980. *Statistical methods.* The Iowa State University Press, 507 p.

SOKAL, R. R. & ROHLF, F. J., 1981. *Biometry.* W. H. Freeman and Company, 859 p.

SPRINGER, V. G. & WOODBURN, K.D. 1960. An ecological study of the fishes of the Tampa Bay area. Fl. St. Board Conserv. *Mar. Lab. Prof. Pap. Ser.*, 1: 104 pp.

SPRINGER, V. G. & MCERLEAN, A. J., 1962. Seasonality of fishes on a south Florida shore. *Bull. Mar. Sci. Gulf Car.*, 12 (1): 39 - 60.

TAGATZ, M.E. & DUDLEY, D.L. 1961. Seasonal occurrence of marine fishes in four shores habitats near Beaufort, N.C. 1957-1960. *Spe. Sci. Rep. Fis.*, 390: 1-19.

YANG, C. & SENTA, T. 1993. The surf ichthyofauna of the Penghu Islands. Taiwan. *Bull. Fac. Fish.*, 73: 7-14.