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Benthic macrofauna of sandy intertidal zone at Santos estuarine system, São Paulo, Brazil

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• *Abstract:* Species composition, faunal density, species diversity and zonation patterns of benthic macrofauna, as well as its relation to sediment characteristics were examined and compared in three sandy beaches on the polyhaline area at Santos estuarine system in the State of São Paulo. Samples were collected quarterly during one year (July/1977 - May/1978). Low, mean and high intertidal levels were sampled. Polychaetes dominated the fauna, both in terms of numbers of species and numbers of individuals. The community structure of Ponta da Praia beach was characterized by high density, low diversity (H') and evenness (J'), due to the dominance of the spionid *Scolelepis squamata*. At Vicente de Carvalho the fauna was characterized by the dominance of the polychaetes *Laeonereis acuta* and *Capitella capitata* and presented low density, high diversity and evenness. At Bertioga Channel, intermediate values were observed and the fauna was dominated by *Scololepis squamata* and *Laeonereis acuta*. The sediment texture was responsible for those figures, although some differences in diversity may be explained by differences in wave energy. The low number of crustaceans and molluscs suggests the effect of the estuarine pollution upon the fauna. The zonation pattern of both species distribution and community structure differed at the studied sites; it was not correlated with sediment characteristics which were relatively uniform down shore; however, the lowest diversity was observed at the high level in all sites.

• *Descriptors:* Zoobenthos, Intertidal environment, Community composition, Species diversity, Estuaries, Santos, SP.

• *Descritores:* Zoobentos, Zona entremarés, Composição da comunidade, Diversidade das espécies, Estuários, Santos, SP.

Introduction

The Santos estuarine system is considered a highly polluted environment due to the presence of a harbor, a considerable urban development and the presence of an industrial centre which utilizes the fluvial complex as output (Tommasi, 1979). The biological communities as well as the effect of pollution on them were investigated by several authors (CETESB, 1978; Gianesella-Galvão, 1978; Tommasi, 1979; Monteiro, 1980; Sousa, 1983; Eston, 1985).

The present research has been conducted in order to study the benthic macrofauna of intertidal sandy zones in the polyhaline area of Santos estuarine system. Last years there was a steady interest in studing the macrobenthos of Brazilian sandy beaches quantitatively (Gianuca, 1987; Amaral *et al.*, 1990); however, community structure received little attention (Monteiro, 1980; Varoli, 1988).

The purpose of this study was to examine species composition, faunal density, species diversity and zonation patterns, related to sediment characteristics and to compare in three sandy beaches.

Study area

Santos estuarine system is situated on the coast of the State of São Paulo (23°56'S - 46°20'W). The climate is wet

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and tropical, presenting a mean annual temperature of 22°C (Santos, 1965). Tides are semidiurnal and the mean tidal range is 0.77 m (Brasil, DHN, 1977).

Three sites were chosen in the polyhaline area of the system (Fig. 1), salinities ranging from 19 to 34‰ (Corbisier, 1981). Water temperature ranged from 21.0 to 29.5°C over the study period.

Site 1, Ponta da Praia Beach, at the entrance of Santos Channel is a sand depositional zone, 50 m wide deeply situated at the Santos Bay. Site 2, Vicente de Carvalho Beach is situated in the interior of the Santos Channel, very close to the port area, unliable to wave action and approximately 40 m wide. These two beaches are gently sloped (1:33). Site 3, approximately 40 m, with a slope of 1:25, is situated on the northern margin of the Bertioga Channel, at its eastern entrance, on one side of the channel. Following McLachlan's definition of beaches (1980) in terms of exposure to wave action, the three beaches were considered very sheltered. For the purposes of this study, they were distinguished as semi-sheltered (site 1), sheltered (site 3) and very sheltered (site 2), according to increasing sheltering conditions.

Material and methods

At each study site, one transect was established and three intertidal levels were chosen on each transect. They were located near 0.0 water level (low), mean and high tide levels, the last one near 1.0 water level, and the other one at the mean distance between the other two. These levels were located with reference to permanent landmarks in relation to 0.0 water level. The samples were collected at 3-monthly intervals during one year: July 28 - August 2 (winter), October 29 - 30 (spring) 1977, January 31 - February 1 (summer) and May 5 (fall) 1978. During ebb-tide, ten replicate sediment samples were randomly collected within an area of 1 m^2, at every level, using a PVC core, 10 cm diameter x 10 cm deep, giving a total sampling area of 0.08 m^2. This number of cores was determined as representative in a previous collection (Corbisier, 1981). All samples were gently washed on a 0.5 mm mesh sieve so as to remove excess sediment, and preserved in 70% ethanol. In the laboratory, macrofaunal organisms were sorted under stereomicroscope, identified to the lowest possible taxon and then counted.

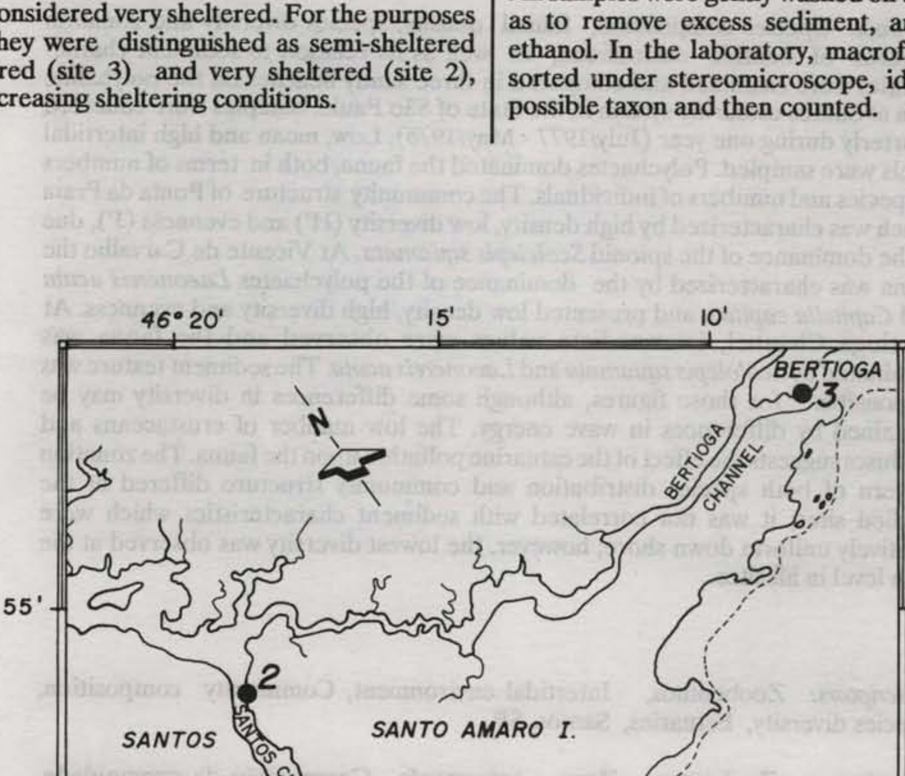

Fig. 1. Study sites along the Santos estuarine system: 1 - Ponta da Praia, 2 - Vicente de Carvalho and 3 - Bertioga Channel beaches.

One core (the same size as described above) was taken from each level in order to estimate grain size distribution and organic matter content. Sediment was analysed by sieving and pipetting classic methods (Suguio, 1973). To estimate the total percentage of organic matter, an aliquot was taken out of each sample before washing, dried at 70°C, and afterwards combusted in a muffle furnace at 550°C for 2 h.

Community structure was evaluated by comparing number of individuals per 0.08 m^2 (N), and species numbers (S), Shannon index of species diversity (H', $\log_2$) and Pielou's index of evenness (J') per sample (Pielou, 1969). As suggested by Dauer & Simon (1975) numbers of individuals per site were estimated by calculating the average number of individuals per 0.08 m^2 from the three levels to reduce error due to patchiness distribution of organisms. The differences among sites were examined by Kruskal-Wallis rank test K (2 - tailed probabilities) (Zar, 1974) and "*a posteriori*" multiple comparison test of Dunn (Gibbons, 1976). Correlations were examined using Spearman rank coeficient r_s.

Results

Sediment

The sediment was characterized as very fine sand (Mz between 3 and 4 ø) at all sites (Table 1). At sites 1 and 3, the sand was well to very well sorted, while at site 2 it was predominantly moderately sorted, with a higher δ than the other two sites (Tables 1 and 7). Statistical analysis of the sorting coefficient of the sediments has not shown zonal trends high to down shore at any of the beaches (Table 7).

In sediments with higher silt-clay content (site 2), organic content was also high (Tables 1 and 7). A positive correlation was found between these two parameters (r_s = 0.72, r_{scrit} = 0.35). There were no significant differences in the distribution of these two factors among tidal levels at any of the study sites, except for silt-clay at site 2, which was generally lower at high level (Figs 2 and 3, Table 7).

Macrofauna

Species composition and numerical dominance

A total number of 24 species of benthic macroinvertebrates was identified in the samples (Tables 2 to 5). Polychaetes dominated the fauna, both in terms of species (14 species) and number of individuals (92.2 to 98.5% of total fauna). They were followed by bivalves with seven species and from 0.3 to 7.6% of total number of individuals.

At site 1, the spionid *Scolelepis squamata* accounted for 86.7 to 98.4% of all macrofauna and was present throughout the year. This species was considerably abundant at the high intertidal level (Tables 2 to 5). Agregates of tubes of *Diopatra* cf *cuprea* were always observed at this beach; however its presence was not quantified because its distribution was deeper in the sediment than the depth of the samples. The bivalve *Donax gemmula* was the one significantly represented. This species was more numerous at low and middle levels, depending on the water level. This species was absent from samples during the fall (Table 5).

At site 2, the numerical dominant species were the nereid *Laeonereis acuta* (38.8 - 75.4% of total) and the capitelid *Capitella capitata* (12.7 - 35.6%) mainly at the high intertidal level (tab. 2 to 5). The pilargid *Sigambra bassi* was substantially found (2.5 to 13.6% in total fauna). The glycerid *Glycinde multidens*, the bivalves *Anomalocardia brasiliana* and *Tagelus divisus* were commonly observed in low numbers. The decapod *Callinectes* sp was the only crustacean that occurred in more than one sample.

At site 3, the spionid *Scolelepis squamata* was the dominant species (82.5 - 95.3%), except during the fall. The second more abundant species was *Laeonereis acuta* (3.1 - 13.1%) from winter to summer. *Capitella capitata* was not found in winter samples (Table 2) but, during the fall, this species represented 57.8% of total fauna, while *S. squamata*, 31.3%. Polychaetes were usually more abundant at high and middle intertidal levels; but during the fall, a beach profile modification was observed and polychaetes occurred only at middle and low levels (Table 5).

Community structure

Differences in overall faunal density were observed among the three study sites as well as along the length of each transect (Table 6). The highest densities (249 to 724 inds.0.08m^{-2}) occurred at site 1, while the lowest were observed at site 2 (35 to 141 inds.0.08m^{-2}) (Tables 6-7). The general standard of total faunal density was a rise in number of individuals from low to high levels, except during the fall, at site 3 (Tables 6-7).

A pattern of species numbers along each transect on the beaches was not observed, but a significant difference among the sites was observed, site 1 presenting a lower number of species than site 3 (Tables 6-7).

Species diversity (H') and evenness (J') varied considerably from season to season at a given site and level (Table 6). Overall diversity and evenness were generally higher in site 2 and lower in site 1 (Table 7). The zonation pattern of species diversity and evenness was not similar in the three sites. At site 1, the highest values of diversity and evenness were observed at the middle level, whereas these values were usually lower at the high level, although the J' values were not significantly different (Tables 6-7). At site 2, the lowest values were found at the high level (Table 7). This was also true for site 3, except during the fall, when the highest species diversity and evenness were found at the middle level, showing insignificant diferences among levels in H' and J' (Tables 6-7).

Discussion and conclusions

Comparison among sites

The sites were marked by polychaetes dominance probably on account of the sheltered characteristic of the sites. This was observed by both Knott *et al.* (1983) and Croker (1977), in the U.S. Atlantic coast in contrast with the dominance of peracarid crustaceans in larger exposed sandy beaches. Dexter (1983) found the same in beaches of New South Wales, Australia.

Table 1. Results of the sedimentological analysis. M_z = mean grain size (ø), δ = standard deviation. L - low, M - middle, and H - high intertidal levels. W - winter, Sp - spring, Su - summer, F - fall

Level	Period	M_z	δ	Silt-clay (%)	Organic content (%)
Site 1					
L	W	3.35	0.37	3.31	1.41
M	W	3.34	0.36	3.24	1.50
H	W	3.34	0.36	3.57	1.52
L	Sp	3.30	0.39	2.33	0.74
M	Sp	3.30	0.35	2.52	0.86
H	Sp	3.33	0.34	2.19	0.63
L	Su	3.27	0.35	2.00	0.79
M	Su	3.14	0.39	1.89	0.70
H	Su	3.27	0.38	3.08	1.26
L	F	3.33	0.36	2.72	0.99
M	F	3.23	0.41	2.35	1.36
H	F	3.28	0.40	2.68	1.32
Site 2					
L	W	3.38	0.40	4.91	1.30
M	W	3.48	0.48	7.68	1.74
H	W	2.94	1.07	3.78	0.99
L	Sp	3.39	0.75	10.62	1.50
M	Sp	3.31	0.49	3.84	1.15
H	Sp	3.18	0.63	2.78	1.63
L	Su	3.31	0.87	5.98	2.21
M	Su	3.39	1.06	13.11	3.30
H	Su	3.16	0.84	2.21	0.69
L	F	-		-	-
M	F	3.34	0.74	6.78	1.08
H	F	3.08	0.93	2.50	1.55
Site 3					
L	W	3.19	0.41	2.55	0.69
M	W	3.19	0.34	2.62	0.64
H	W	3.18	0.38	2.81	0.76
L	Sp	3.09	0.42	2.34	0.98
M	Sp	3.16	0.32	2.18	0.69
H	Sp	3.15	0.43	2.57	0.74
L	Su	3.11	0.35	2.12	0.50
M	Su	3.32	0.47	2.29	0.64
H	Su	3.12	0.35	3.32	0.40
L	F	3.10	0.46	2.72	0.61
M	F	3.03	0.41	2.52	0.68
H	F	3.09	0.33	2.08	0.36

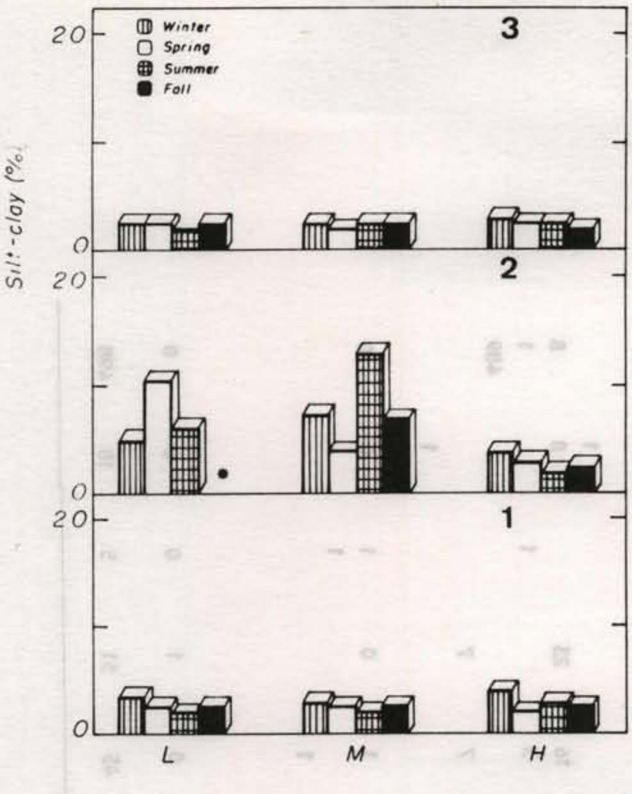

Fig. 2. Silt-clay fraction variation at each level of the three study sites. L - low, M - middle, and H - high intertidal levels. * = sample not collected due to high water level.

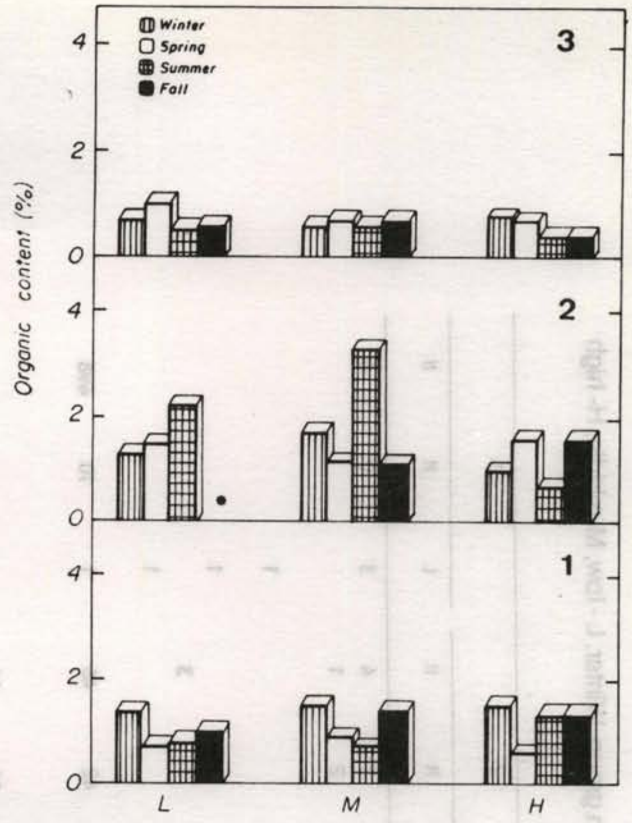

Fig. 3. Organic matter content of sediment variation at each level of the three study sites. L - low, M - middle, and H - high intertidal levels. * = sample not collected due to high water level.

In South Brazilian sandy beaches, which are exposed to strong wave action, great numbers of bivalves and crustaceans characterize the intertidal zone (Gianuca, 1983, 1987; Loyola e Silva *et al.,* 1984, 1985). In contrast, in the northern coast of São Paulo State sandy beaches not so exposed to wave action present greater polychaetes numbers aside from crustaceans and molluscs (Amaral *et al.*, 1990).

Sediment at sites 1 and 3 was structurally simple (in Gray's concept, 1974), constituted by very fine and well sorted sand, with low silt-clay and organic matter contents. These factors seem to be responsible for the numerical dominance of the spionid *Scolelepis squamata* and, consequently, for the low diversity and evenness of the sites. This result is in accordance with Retière (1967) and Wolff (1973) who correlated the distribution of *S. squamata* with well sorted sands. On the northern coast of São Paulo State, *S. squamata* also occurs preferentially in fine sediments (Amaral, 1979; Amaral *et al.,* 1990).

At site 2, the sediment was structurally more complex, constituted by very fine sand with higher percentage of coarse sand as well as silt-clay and organic matter. At this site, diversity and evenness were greater than at the other sites moreover a lower faunal density. These results were in accordance with Gray's hypothesis (1974) that intertidal variations of diversity be influenced by structural sediment complexity. As Read *et al.* (1978) have suggested, high values of diversity and species number are positively correlated to silt-clay content in predominantly sandy beaches.

The texture of the sediment was the studied factor responsible for the differences observed in species composition and dominance among the studied sites, as well as in community structure . On the other hand, the small difference observed between diversity index of sites 1 and 3 seemed to reflect a difference in wave exposure of the sites. Site 1 is moderately exposed to wave action and, as a result, diversity is lower. The degree of wave exposure has an effect on aspects of community structure. Croker (1977) found that species richness, evenness and diversity were all considerably higher on a semi-protected intertidal beach than at a moderately exposed site in U.S. Atlantic coast. Knott *et al.* (1983) observed the same in the studied beaches after an increase of sheltering owing to a jetty construction, although sediment features did not change. Dexter (1983), studying sandy beaches in New South Wales, Australia, also found that more species occurred with an increasing protection from wave exposure.

At site 3, the observed change in faunal dominance during the fall might be explained by an accumulation of sand, primarily observed at high level. The polychaete *Capitella capitata* is known as an opportunistic species in situation of fine sediment deposition (Eagle & Rees, 1973).

Table 2. Total number of individuals per 0.08 m^2. (*) total numbers in group. Winter. L - low, M-middle, H- high intertidal levels

Organisms	1			2			3		
	L	M	H	L	M	H	L	M	H
Mollusca: Bivalvia(*)	4	3	0	0	2	4	3	0	0
Anomalocardia brasiliana					2	1			
Donax gemmula	4	2							
Anatina anatina							1		
Lucinidae							1		
Mesodesma mactroides						3			
Tagelus divisus		1					1		
Annelida: Polychaeta (*)	2	5	917	7	42	46	1	10	498
Armandia agilis		2							
Capitellides jonesi	2		4						
Capitella capitata				2	16	16			
Dispio uncinata		3							
Dorvillea rudolphi				1					
Glycinde multidens				2				1	
Laeonereis acuta				1	16	23		8	8
Loandalia americana				1	3		1		1
Scolelepis squamata			913						489
Sigambra bassi					7	7			
Phyllodocidae								1	
Arthropoda: Crustacea (*)	0	1	0	1	1	0	1	0	0
Clibanarius vittatus							1		
Callinectes sp (juv.)					1				
Sesarma (Holometopus) cinereum				1					
Kalliapseudes sp		1							
Phoronida (*)	0	0	0	0	0	1	0	0	0
Total/Level	6	9	917	8	45	51	5	10	498

Table 3. Total number of individuals per 0.08 m^2. (*) total numbers in group. Spring. L-low, M-middle, and H- high intertidal levels

Organisms	1			2			3		
	L	M	H	L	M	H	L	M	H
Nematoda (*)	0	0	0	0	0	0	0	0	1
Nemertina (*)	0	0	0	0	1	0	0	0	2
Mollusca: Bivalvia(*)	23	3	0	1	2	9	0	0	0
Anomalocardia brasiliana						2			
Diplodonta sp (juv.)					1	6			
Donax gemmula	23	3							
Lucinidae				1					
Tagelus divisus					1	1			
Annelida: Polychaeta (*)	0	208	513	10	113	286	2	7	350
Capitella capitata				2	8	83			12
Glycinde multidens			1	3	4	1			2
Hemipodus sp									1
Heteromastus filiformis					2	1			
Laeonereis acuta				2	75	168			56
Loandalia americana				1			1		
Nephtys caeca				2	2	2			
Neanthes succinea					1				
Scolelepis squamata		207	512				1	7	278
Sigambra bassi					20	31			1
Arthropoda: Crustacea (*)	0	0	0	0	1	0	0	0	0
Callinectes sp (juv.)					1				
Total/Level	23	211	513	11	117	295	2	7	353

Table 4. Total number of individuals per 0.08 m^2. (*) total numbers in group. Summer. L-low,', M-middle, and H-high intertidal levels

Organisms	1			2			3		
	L	M	H	L	M	H	L	M	H
Nemertina (*)	0	0	0	0	0	0	1	0	1
Mollusca: Bivalvia(*)	84	182	14	0	0	0	4	0	1
Anomalocardia brasiliana							1		
Diplodonta sp (juv.)									1
Donax gemmula	84	182	14						
Tagelus divisus				1			1		
Tellina versicolor							2		
Annelida: Polychaeta (*)	2	365	1526	3	10	104	18	75	1351
Capitellides jonesi		3	2						
Capitella capitata						15	1	20	18
Dispio uncinata		1							
Goniada sp		1					4		
Glycinde multidens	1			1	8		7	3	
Heteromastus filiformis								1	
Laeonereis acuta				1	1	87	1	42	171
Loandalia americana							2		
Nephtys caeca					1				
Neanthes succinea								5	5
Scolelepis squamata	1	360	1524				3	4	1157
Sigambra bassi				1		2			
Total/Level	86	547	1540	4	10	104	23	75	1353

Table 5. Total number of individuals per 0.08 m^2. (*) total numbers in group. Fall. L-low, M-middle, and H- high intertidal levels

Organisms	1			2			3		
	L	M	H	L	M	H	L	M	H
Mollusca: Bivalvia(*)	1	0	0		2	1	0	0	0
Anomalocardia brasiliana	1					1			
Chione cancellata	1								
Tagelus divisus					1				
Tellina versicolor					1				
Annelida: Polychaeta (*)	0	0	0		0	0	0	0	9
Acanthrodrillidae									9
Annelida: Polychaeta (*)	2	2	1047		61	214	134	516	0
Capitellides jonesi	1		2						
Capitella capitata					39	60	119	257	
Dispio uncinata	1	1							
Goniadidae (juv.)							3	1	
Glycinde multidens							1	1	
Heteromastus filiformis					6			1	
Laeonereis acuta					12	120	10	49	
Neanthes succinea						1			
Scolelepis squamata		1	1045					204	
Sigambra bassi					4	33	1	2	
Arthropoda: Crustacea (*)	11	0	0		0	0	0	1	0
Callinectes sp (juv.)								1	
Atylus minikoi	11								
Total/Level	15	2	1047		63	215	134	517	9

Table 6. Number of species (S), number of individuals per 0.08 m², species diversity H' in bits, and evenness J' for each level and site during four sampling periods. W- winter, Sp- spring, Su- summer and F - fall. L- low, M- middle, and H- high intertidal levels

Level		Site 1				Site 2				Site 3			
		No. spp	No. inds. 0.08 m⁻²	H'	J'	No. spp	No. inds. 0.08 m⁻²	H'	J'	No. spp	No. inds. 0.08 m⁻²	H'	J'
W	L	2	6	0.92	0.92	6	8	2.50	0.97	5	5	2.32	1.00
Sp		1	23	0.00	0.00	6	11	2.48	0.96	2	2	1.00	1.00
Su		3	86	0.18	0.12	4	4	2.00	1.00	10	23	2.94	0.89
F		5	15	1.37	0.59	-	-	-	-	5	134	0.66	0.28
W	M	5	9	2.20	0.95	6	45	2.06	0.80	3	10	0.92	0.58
Sp		3	211	0.15	0.08	11	117	1.83	0.53	1	7	0.00	0.00
Su		5	547	1.00	0.43	3	10	0.92	0.58	6	75	1.73	0.67
F		2	2	1.00	1.00	6	63	1.65	0.64	9	517	1.47	0.46
W	H	2	917	0.04	0.04	6	51	1.90	0.73	3	498	0.14	0.09
Sp		2	513	0.02	0.02	9	295	1.64	0.52	7	353	1.02	0.36
Su		3	1540	0.09	0.06	3	104	0.73	0.46	6	1353	0.70	0.27
F		2	1047	0.02	0.02	5	215	1.47	0.63	1	9	0.00	0.00
Site Total			Mean				Mean				Mean		
W		7	311	0.19	0.07	11	35	2.29	0.66	10	171	0.36	0.11
Sp		4	249	0.25	0.12	14	141	1.84	0.48	8	121	1.02	0.34
Su		6	724	0.59	0.23	6	40	1.22	0.47	13	484	0.99	0.27
F		6	355	1.52	0.06	8*	139*	1.66*	0.55*	9	220	1.53	0.48

* considering two levels (M and H only)

Table 7. Results of A) Kruskal-Wallis rank test and B) *"a posteriori"* multiple comparison test of Dunn. (*) indicates the test is significan at $\alpha = 0.05$. L - low, M - middle, and H - high intertidal levels.

A

	Among Sites	Among levels		
		Site 1	Site 2	Site 3
δ	19.85*	0.27	1.75	0.26
Silt-clay	12.21*	1.08	7.05*	0.11
Org. cont.	18.24*	0.27	1.29	0.13
No.inds.0.08 m^{-2}	7.04*	6.73*	6.42*	3.11
No.spp	5.74*	5.38	2.27	0.60
H'	6.27*	6.04*	7.69*	2.63
J'	15.47*	5.11	6.41*	5.32

B

δ	1 3<2			
Silt-clay	1 3<2		M>L>H	
Org. cont.	3<1 2			
No.inds.0.08 m^{-2}	1 3>2	L M<H	L<M<H	
No. spp	1 2 3			
H'	1<3<2	M>L>H	L M>H	
J'	1 3 2		L>M H	

Owing to a lack of previous quantitative work in the studied area, a quantitative evaluation of the effects of pollution upon the intertidal associations could not be conducted. Nevertheless, the extremely low numbers of crustaceans and bivalves collected during the investigations suggest this effect. This was also suggested by Tommasi (1979) in relation to the infralitoral bivalves of Santos Channel. In the estuarine-lagoonal system of Iguape-Cananéia, considered as unpolluted, Varoli (1988) observed that polychaetes were numerically dominant in the studied sand flats, whereas peracarid crustaceans were the second group in abundance. A possible explanation might be the constant presence of hydrocarbonates in the Santos estuarine system (CETESB, *apud* Tommasi, 1979) which might affect some of those organisms in their planktonic stages. In the polluted Tees estuary, England, the most dramatic reduction in the macrofauna had been in the bivalves, possibly due to the effect of pollution on their larval recruitment (Gray, 1976). The species that had disappeared were primarily those with long lived planktotrophic larvae. The reduction in crustaceans and bivalves numbers in relation to organic enrichment and pollution was also reported by Pearson & Rosenberg (1978) who analysed results of several studies.

Diversity index of the three sites varied from 0.19 to 2.29 bits.ind.$^{-1}$ (Table 6). This range in species diversity H' is the same as that reported for tropical, temperate and boreal sandy beaches exposed to strong wave action (respectively, Dexter, 1972, 1974, 1979, 1983 and Croker, 1977). This fact suggests that macrofaunal associations in the study sites were subjected to a high environmental stress.

Intertidal zonation

In the studied beaches, sediment composition from high to low intertidal zone was relatively uniform. Therefore, the pattern of species distribution among different levels was not correlated with sediment characteristics. Salinity of interstitial water, water content of sediment and time of air exposure can be responsible for species distribution (Newell, 1979), as well as biological interactions such as predation or competition (McLachlan, 1983). Although these factors were not evaluated in this study, great abundance of *Laeonereis acuta* and *Scolelepis squamata* at high shore might be related to low salinity of interstitial water. The abundance of these species was related to salinity of interstitial water lower than 10‰ in Ubatuba beaches on the northern coast of the State of São Paulo (Amaral, 1979).

As regards the donacid *Donax gemmula* in site 1, it was observed that its distribution varied in relation to tidal level, a typical migratory behaviour of the genus (Domaneschi & Lopes, 1988).

The present results has not suggested a clear faunal zonation, which is in accordance to McLachlan (1983) who stated that a real zonation pattern in sandy beaches has never been proved, although some species show preference for a certain level at the beach.

Differences in density, diversity (H') and evenness (J') were observed among tidal levels in the studied beaches. At site 1, the faunal density increased from low to high shore, while diversity and evenness were great at the middle shore. This results from the overlap of population distribution of the donacid *D. gemmula* and the spionid *S. squamata*. At sites 2 and 3, species diversity and evenness were greater at low level whereas density was greater at high shore.

The lowest diversity and evenness were generally found at high level. Increasing in community structure towards low shore is usually related to intertidal stress gradient (Johnson, 1970; Gray, 1974; Holland & Dean, 1977; Dexter, 1983; Knott *et al.*, 1983; McLachlan, 1983), the greater diversity at the low level being related to lesser physical stress.

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Resumo

Neste trabalho foi estudada a macrofauna bentônica da zona entremarés arenosa da área polihalina do sistema estuarino de Santos. A composição em espécies, densidade e diversidade e o padrão de zonação da fauna foram analisados e comparados, bem como sua relação com as características do sedimento em três praias arenosas. As amostras foram coletadas trimestralmente durante o período de um ano (julho/1977 - maio/1978). Em cada local, foram amostrados os níveis inferior, médio e superior da zona entremarés.

Os poliquetos constituíram o grupo faunístico dominante, seja em termos de número de espécies como de indivíduos. Na Ponta da Praia, a estrutura da comunidade foi caracterizada por alta densidade faunística e baixos índices de diversidade (H') e equabilidade (J') devido à dominância numérica do poliqueto *Scolelepis squamata*. Na Praia de Vicente de Carvalho, a fauna caracterizou-se pela dominância dos poliquetos *Laeonereis acuta* e *Capitella capitata* e por baixa densidade e alta diversidade e equabilidade. Na praia do Canal da Bertioga, esses valores foram intermediários e as espécies numericamente dominantes foram *Scolelepis squamata* e *Laeonereis acuta*. A textura do sedimento foi o principal fator analisado responsável por essas diferenças observadas entre as praias, embora diferenças na diversidade possam também estar relacionadas ao grau de proteção à ação de ondas.

O reduzido número de crustáceos e moluscos coletados durante o período do estudo sugerem o efeito da poluição do sistema sobre essa fauna.

Nas praias, o padrão de distribuição das espécies e estrutura das comunidades entre os diferentes níveis não foi semelhante nos locais estudados, como também não foi relacionado às características do sedimento, relativamente uniformes; contudo, foi observado que a diversidade foi menor no nível superior de todos os locais.

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