# Ecology and distribution of Peracarida (Crustacea) in the continental shelf of São Sebastião (SP), with emphasis on the amphipod community.

Santos[1], K. C. and Pires-Vanin[1], A. M. S.

[1]Instituto Oceanográfico, Universidade de São PauloPraça do Oceanográfico, 191 – Cidade Universitária 05508-900 São Paulo, SP, Brasil

## Abstract

Abundance, biomass, diversity and species composition of benthic peracarid communities were investigated in the São Sebastião shelf, São Paulo State northern coast. The summer collection was obtained from 21 stations in a depth gradient between 10 and 74 m in February 1994 and yelded a total of 111 species of Peracarida. Amphipoda was the most diverse group completing 58 species. Peracaridan data show that abundance and density of all orders increase with depth, and a rich area both in number of species and specimens was found east to the São Sebastião Island (SSI). Multivariate analyses indicate significant site-related trends in amphipod assemblages and life style guilds, some of which are related to geomorphological characteristics (bathymetry, topography, and substratum), and others to hydrodynamics. Amphipod community data show that the deep stations are dominated by *Liljeborgia quinquedentata* and the shallow sites by *Ampelisca paria*. A frontal or intermediary zone was identified between both areas, dominated by *Pseudharpinia dentata*, especially in the site southeast to the SSI. The guild data points out that deep stations and mid-depth stations, north and south to frontal zone, dominated by burrowers and epifaunal tubicoles, were distinct from stations with shallow bottoms, where infaunal tubicoles dominated. The importance of the proportion of silt and clay and organic nitrogen content to maintain the amphipod communities is discussed.

**Key words:** Community ecology; Peracarida distribution; continental shelf; São Sebastião shelf; macrobenthic communities

## Introduction

In the inner continental shelf the island influence is high. Many vital processes for the benthos, such as primary productivity, sedimentation and resuspension, are governed by forces constantly in change. The structure and function of benthic and pelagic communities off Ubatuba were intensively studied (Pires-Vanin, 1993 a), and a trophic model of the ecosystem functioning was presented by Rocha *et al.* (1998; 2000). However, no ecosystem-based studies were carried out to the south of Ubatuba region, in particular São Sebastião continental shelf. This region is peculiar by the presence of many islands near the coast.

The continental shelf off São Sebastião receives a strong influence both from the adjacent continent and from some islands, mainly São Sebastião and Búzios. The proximity of the São Sebastião Island from the continent originates a narrow and deep channel, which influences the local hydrodynamism and sedimentation (Furtado *et al*, 1998). The characteristics of the channel, besides the seasonal intrusion of an offshore water mass, the South Atlantic Central Water – SACW, have a profound effect on the composition and distribution of the benthic fauna. In order to study the consequences of the variation of the governing physical and biological processes on the southeastern Brazilian coastal shelf system, a broad interdisciplinary research project was performed in recent years at the Oceanographic Institute of the University of São Paulo (Pires-Vanin *et al*, 1997).

Some aspects of the benthic fauna were studied in the São Sebastião shelf, such as species composition and distribution, community structure and polychaete trophic structure, but mainly in the São Sebastião Channel (Pires-Vanin *et al.*, 1997; Muniz and Pires, 1999, 2000; Flynn *et al.*, 1999).

Quantitative studies focusing on soft bottom Peracarida communities are scanty (Santos and Pires-Vanin, 1999; Pires-Vanin, *in press*), and the present paper is the first on the ecology and distribution of the group on the adjacent continental shelf area, excluding the channel.

Peracarida plays an important ecological role in benthic marine systems presenting all the trophic habits and many life styles. They are significant components of the soft bottom macrofauna (Brandt, 1993, 1995; Pires-Vanin, 1993 b; Gambi and Bussoti, 1999). Amphipoda is by far the dominant group among the peracarids on continental shelves throughout the world (Weisshappel and Svavarsson, 1998; Grove and Probert, 1999). They are used for communities studies due to their high density and diversity (Wakabara, 1972; Brandt, 1995; Weisshappel and Svavarsson, 1998). Besides, Amphipoda is important as food for many invertebrates and demersal fishes (Wakabara *et al.*, 1982; Lucato, 1997).

The Amphipoda was been studied on the Brazilian coast since 1940, in particular their taxonomy (Wakabara *et al.*, 1988, 1991; Serejo, 1995, 1997, 1998, 1999). Ecological accounts were presented by Valerio-Berardo *et al.* (2000) for the Ubatuba continental shelf communities and by Gallerani (1997) for the Campos Basin communities, Rio de Janeiro northern shelf.

The present paper investigates the effect of the environmental factors on the composition and spatial distribution of the peracarid crustaceans from the continental shelf off São Sebastião. The analysis of the structure and dynamics of the community was based on the Amphipoda species, taking into account biological community indicators such as density, diversity, biomass, dominance and frequency of occurrence of the species.

## Material and Methods

The macrofauna was sampled at 21 sites located between 15 and 74 m depth over the continental shelf off São Sebastião (20°30' to 24°15'S and 45°00' to 45°45'W) (Fig. 1), by the RV "Prof. W. Besnard" of the University of São Paulo, during the summer of 1994.

The benthic fauna was collected with a 0.1 $m^2$ vanVeen grab. The samples were taken in duplicate from 21 stations placed on five transects, perpendicular to the coast, from 10 to 74 depth. A total of 42 grab and 21 trawl samples were obtained. The samples were washed on board through

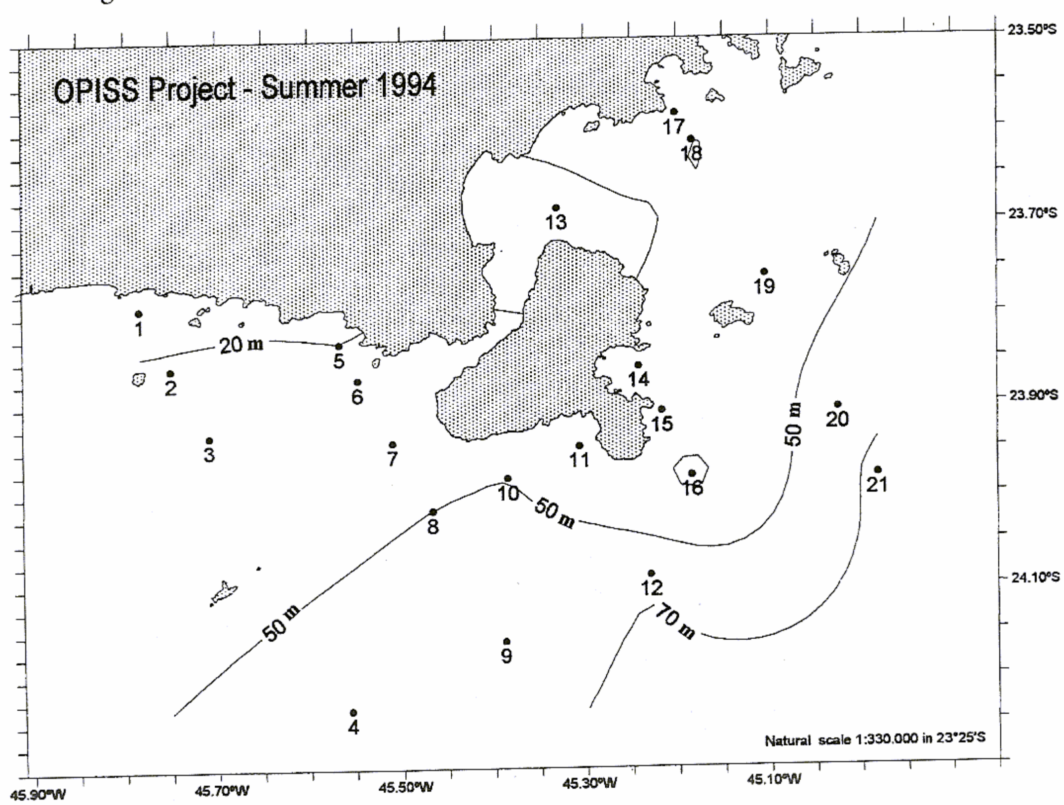


Figure 1: Study area showing the localization of the sampling stations.

a 0.5mm mesh and the sediment preserved in 70% alcohol. After elutriation (Santos *et al.*, 1997), the fauna was sorted and identified under stereomicroscope. The peracarids were identified to the species level for most of the material. At each location, the specimens of the same taxonomic group (order) were weighed (wet weight) after blotted dried for one minute (Pires-Vanin, 1993 b). Density data were expressed in numbers of individuals/ 0.1 $m^2$. Shannon-Wiener's (H') index for diversity and Pielou's index for evenness (J') were employed only for the Amphipoda species data. For calculation of H' the logarithm base 2 was employed and the results are expressed in bits.

## Data analysis

### 1. Environmental data

Bottom temperature, salinity and water oxygen concentration were measured at each station. The salinity was measured with an inductive salinometer and the values are expressed in practical salinity unities. Oxygen was calculated according to the Winkler method (Strickland and Parsons, 1968). Grain size was determined according to Suguio (1973). Folk and Ward parameters (Folk and Ward, 1957) and Sheppard triangular diagram (Sheppard, 1954) were obtained for granulometric classification. Sixteen factors were considered for multivariate analyses: depth, bottom temperature, salinity, dissolved oxygen, percentage of gravel, coarse sand, medium sand, fine sand, very fine sand, silt, clay, calcium carbonate, organic carbon (C), organic nitrogen (N), C/N ratio and mean diameter of the grains.

The present work considers the two concepts of division of the shelf, the biological and the hydrodynamic. The biological division was proposed by Pires (1992) based on the distribution of the benthic megafauna in the area offshore of Ubatuba: inner domain, ranging from coast to nearly 50 m depth and outer domain, from 50 to 100 m isobath. The hydrodynamic concept (Castro and Miranda, 1998) divides the shelf area according to the presence of the water masses on the bottom. So, inner shelf is under the domain of the warm and low saline Coastal Water and medium shelf is the area where the 18°C isotherm reaches the bottom, and the cold and high saline South Atlantic Central Water predominates. A frontal zone, characterized by the mixing of the water masses, lays between both areas. The width of these bands varies temporally according to the water masses dynamics. In the present work the inner domain includes inner shelf plus frontal zone and the outer domain includes the medium shelf.

### 2. Biological data

The abundance and biomass of Peracarida as a whole and of the main Amphipoda families, were analyzed in two different ways: 1) fixing depth intervals and 2) considering the longitudinal orientation. In the first case, four bathymetric bands parallel to the coast were fixed (A to D) according to the limits: A = 12 to 20 m; B = 21 to 40 m; C = 41 to 50 and D = 51 to 74 m depth. In the second case, five bands perpendicular to the coast were established, I to V, from west to east in relation to the São Sebastião Island (SSI).

The community structure was studied using the Amphipoda data. A total of 58 species was obtained. The initial data matrix was reduced after calculation of the specific value index (SVI) proposed in Osse (1995). The resulting matrix was 42 species x 21 stations. Cluster Analysis (Q-mode and R-mode), Multiple Discriminant Analysis and Canonical Correspondence Analysis (CCA) were then employed to identify and interpret the spatial changes showed by the fauna.

To investigate the occupation of the area by the Amphipoda species, according to the role they play in the bottom system, the matrix was reorganized after grouping the species within the following life style categories: tubicolous from the epifauna, tubicolous from the infauna, free epifauna, burrowers and inquilines (Barnard, 1956; Biernbaum, 1979; Bousfield, 1973). Q-mode Cluster Analysis was performed to bring together locations in function of the different behavior of the species.

The FITOPAC program (G. Sheppard, UNICAMP) was used to perform the cluster analyses, grouping stations and species based on the similarities of faunal composition using the Weighted

Pair-Group Method (WPGMA) and the Morisita-Horn's similarity coefficient. The STATIGRAPHICS® and STATISTICA® computer packages were used for the multi- dimensional analysis and the CANOCO program (Ter Braak, 1988; 1990) for ordination.

## Results

### The physical environment

Table 1 presents the environmental data obtained for the area. Higher temperature and lower salinity water were found near the coast, indicating the presence of the Coastal Water up to 18 m depth. The cold and dense South Atlantic Central Water occurred offshore, deeper than 50 m. Therefore, during the period of study, the inner shelf extended from the coast down to 18 m depth, the medium shelf was deeper than 50 m, and the frontal zone lay from about 19 to nearly 49 m depth. The bottom sediment was composed mainly by sand with a conspicuous area of silt and clay to the southeast of the São Sebastião Island. The contents of organic carbon and nitrogen were low, but tended to be slightly higher in fine grained sediments.

**Table 1:** Environmental data from the summer cruise - 1994. GR: gravel; CS: coarse sand; MS: median sand; FS: fine sand; VFS: very fine sand; OC: organic carbon: ON: organic nitrogen.

| Station | Depth (m) | Latitude (S) | Longitude (W) | Temp. (°C) | Salin. (UPS) | O2 (ml/l) | % GR | % CS | % MS | % FS | % VFS | Mean diameter | % Clay | % Silt | % CaCo3 | % OC | % NC | C/N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15 | 45°47.0' | 23°47.5' | 27.3 | 33.62 | 3.28 | 0 | 0 | 0.22 | 5.09 | 93.59 | 3.42 | 0.04 | 1.07 | 4.5 | 0.24 | 0.02 | 14.4 |
| 2 | 22 | 45°45.0' | 23°51.5' | 26.79 | 34.28 | 3.09 | 0 | 0.59 | 2.13 | 8.08 | 76.57 | 3.33 | 1.84 | 10.69 | 9.23 | 0.67 | 0.05 | 14.9 |
| 3 | 30 | 45°42.5' | 23°56.0' | 26.43 | 35.43 | 3.32 | 0 | 0.15 | 0.75 | 26.46 | 68.31 | 3.15 | 0.04 | 4.33 | 6.8 | 0.29 | 0.03 | 11.8 |
| 4 | 60 | 45°33.3' | 24°14.1' | 16.66 | 35.58 | 3.47 | 0 | 0 | 0.56 | 16.99 | 73.12 | 3.3 | 3.75 | 5.59 | 11.1 | 0.51 | 0.04 | 11.5 |
| 5 | 20 | 45°34.0' | 23°49.9' | 26.94 | 34.34 | 3.24 | 0 | 0 | 0.11 | 1.05 | 86.7 | 3.61 | 0.04 | 12.13 | 8 | 0.21 | 0.02 | 8.9 |
| 6 | 25 | 45°32.8' | 23°52.3' | 26.64 | 35.03 | 3.89 | 0 | 0 | 0.1 | 0.83 | 92.83 | 3.49 | 0 | 6.23 | 3.77 | 0.22 | 0.03 | 8.3 |
| 7 | 41 | 45°30.6' | 23°56.5' | 26.3 | 35.03 | 3.69 | 0 | 0.83 | 2.08 | 25.7 | 61.99 | 3.15 | 2.09 | 7.22 | 20.1 | 0.41 | 0.04 | 11 |
| 8 | 50 | 45°28.0' | 24°01.0' | 18.5 | 35.73 | 3.42 | 0 | 0.15 | 0.4 | 2.44 | 83.62 | 3.5 | 7.29 | 6.05 | 8.6 | 0.49 | 0.06 | 8.4 |
| 9 | 60 | 45°23.3' | 23°09.6' | 16.83 | 35.65 | 3.05 | 0 | 0 | 0.46 | 16.44 | 76.6 | 3.21 | 0.04 | 6.49 | 6.53 | 0.26 | 0.03 | 7.8 |
| 10 | 50 | 45°23.1' | 23°58.9' | 17.39 | 35.67 | 2.9 | 0 | 2.48 | 3.26 | 7.46 | 32.23 | 5.26 | 22.6 | 31.65 | 19.67 | 0.93 | 0.07 | 13.3 |
| 11 | 34 | 45°18.4' | 23°56.8' | 26.2 | 35.05 | 3.63 | 0 | 1.04 | 2.48 | 8.4 | 69.41 | 3.61 | 6.21 | 12.42 | 13.4 | 1.26 | 0.08 | 15.3 |
| 12 | 69 | 45°13.8' | 24°05.3' | 16.51 | 35.66 | 2.96 | 0.1 | 1.76 | 2.67 | 58.8 | 21.58 | 2.95 | 5.03 | 9.51 | 33.73 | 0.35 | 0.04 | 9.4 |
| 13 | 13 | 45°19.8' | 23°41.1' | 27.59 | 33.69 | 3.23 | 9.66 | 21.35 | 27.51 | 18.77 | 7.99 | 0.99 | 0.02 | 0.15 | 36.47 | 0.17 | 0.03 | 6.2 |
| 14 | 24 | 45°14.5' | 23°51.5' | 16.51 | 35.09 | 3.39 | 0 | 0 | 0 | 0 | 8.17 | 6.08 | 18.37 | 73.46 | 21.9 | 0.94 | 0.08 | 12.5 |
| 15 | 39 | 45°13.0' | 23°54.5' | 21.79 | 35.7 | 2.85 | 0 | 0 | 0 | 0 | 5.44 | 6.7 | 26 | 68.56 | 26.7 | 2.17 | 0.11 | 19.7 |
| 16 | 53 | 45°12.1' | 23°35.0' | 16.83 | 35.73 | 2.77 | 0 | 0.21 | 0.3 | 1.44 | 25.89 | 5.83 | 21.22 | 50.93 | 20.07 | 1.78 | 0.13 | 13.2 |
| 17 | 12 | 45°11.1' | 23°58.8' | 28.43 | 33.61 | 3.68 | 0 | 0 | 0.26 | 0.97 | 28.72 | 4.21 | 0.04 | 70.02 | 19.4 | 0.27 | 0.03 | 10.9 |
| 18 | 18 | 45°11.0' | 23°36.8' | 21.21 | 35.03 | 2.71 | 0 | 3.15 | 3.51 | 4.49 | 48.16 | 4.24 | 6.74 | 33.69 | 19.57 | 0.32 | 0.03 | 12.6 |
| 19 | 37 | 45°06.3' | 23°45.5' | 23.44 | 35.43 | 4.12 | 0 | 0 | 0.11 | 0.93 | 84.37 | 3.62 | 1.86 | 12.73 | 10.47 | 0.39 | 0.03 | 11.8 |
| 20 | 62 | 45°01.5' | 23°54.4' | 16.81 | 35.96 | 3 | 0 | 0.26 | 0.85 | 9.97 | 54.81 | 4.42 | 8.52 | 25.55 | 16.57 | 1.23 | 0.08 | 15.6 |
| 21 | 74 | 44°58.9' | 23°58.8' | 16.67 | 35.81 | 3.5 | 0 | 0.1 | 0.78 | 18.45 | 71.28 | 3.15 | 0.05 | 9.39 | 31.53 | 0.3 | 0.04 | 7.8 |

### Composition of the fauna

Nearly 2,000 individuals of Peracarida were obtained with the vanVeen grab. Amphipoda was the most numerous order having 1,128 individuals and 58 morphospecies, 34 of which identified to species level. It was followed by, Tanaidacea (298 individuals, 14 species), Isopoda (228 individuals, 22 species) and Cumacea (217 individuals, 16 species) (Table 2).

### Distribution of density and biomass with depth

As a general trend among the Peracarida, an increase in density with depth was observed (Fig. 2). It was continuous for the Isopoda and the Cumacea, but started on band C for Amphipoda (41 m depth) and was discontinuous for Tanaidacea. In the latter, density increased from the coast to 40m depth, decreased in band C and increased again conspicuously in band D. Here, the increase in density is striking and represents nearly twice the number of all bands summed.

The biomass of Peracarida increased also with depth. High medium values were located in band D and C (0.136 and 0.118g/0.1 m$^2$, respectively). In the other places biomass was nearly half of these values. Amphipods tend to present high biomass in deeper sites and Isopods tend to present high numbers in shallower sites, from the coast to about 50 m depth (Fig.3).

Table 2: List of Peracarida species from the São Sebatião shelf / Summer - 1994.

| | AMPHIPODA | G | D |
|---|---|---|---|
| *Ampelisca brevisimulata* | JL Barnard, 1954 | 12 | 0 |
| *Ampelisca cristata* | Holmes, 1908 | 12 | 5 |
| *Ampelisca cristoides* | JL Barnard, 1954 | 4 | 0 |
| *Ampelisca indentata* | JL Barnard, 1954 | 11 | 52 |
| *Ampelisca panamensis* | JL Barnard, 1954 | 8 | 1 |
| *Ampelisca paria* | Barnard & Agard, 19 | 145 | 1 |
| *Ampelisca pugetica* | Stimpson, 1864 | 52 | 7 |
| *Ampelisca* sp | | 1 | 27 |
| Ampeliscidae | | 0 | 14 |
| *Ampelisciphotis podophthalma* | (JL Barnard, 1958) | 76 | 68 |
| *Amphilocus neapolitanus* | Della Valle, 1871 | 2 | 1 |
| *Atylus* sp | | 6 | 1 |
| *Birubius* sp | | 16 | 0 |
| *Byblis* sp1 | | 7 | 0 |
| *Byblis* sp2 | | 4 | 0 |
| *Byblis* sp3 | | 8 | 2 |
| *Caprella equilibra* | Say, 1818 | 1 | 2 |
| *Ceradocus* sp | | 1 | 0 |
| *Cerapus tubularis* | Say, 1817 | 2 | 2 |
| *Cheiriphotis megacheles* | (Giles, 1885) | 7 | 102 |
| *Cheiriphotis williamsoni* (?) | Salman & Jabbar, 19 | 1 | 9 |
| *Cheiriphotis* sp | | 0 | 284 |
| *Dulichiella appendiculata* | | 0 | 15 |
| *Ericthonius brasiliensis* | (Dana, 1853) | 2 | 49 |
| *Ericthonius punctatus* | (Bate, 1857) | 9 | 176 |
| *Ericthonius* sp | | 3 | 73 |
| *Eudevenopus gracilipes* | (Schellenberg, 1931) | 3 | 0 |
| *Gammaropsis togoensis* | (Schellenberg, 1925) | 14 | 21 |
| *Harpinia* sp | | 4 | 0 |
| *Harpiniopsis galerus* | JL Barnard, 1960 | 16 | 2 |
| *Heterophoxus videns* | KH Barnard, 1930 | 65 | 6 |
| Ischyroceridae | | 0 | 62 |
| *Ischyrocerus* sp | | 3 | 1 |
| *Jassa* sp | | 0 | 3 |
| *Laetmatophilus* sp | | 0 | 20 |
| *Liljeborgia quinquedentata* | Schellenberg, 1931 | 113 | 14 |
| Lysianassidae | | 0 | 1 |
| *Listriella titinga* | Wakabara et al, 1988 | 1 | 1 |
| *Lysianassa* sp | | 4 | 3 |
| *Maera hirondellei* | Chevreux, 1900 | 1 | 24 |
| *Maera grossimana* | (Montagu, 1808) | 10 | 0 |
| *Maera* sp | | 2 | 15 |
| *Metaphoxus frequens* (?) | JL Barnard, 1960 | 1 | 4 |
| *Microphoxus cornutus* | (Schellenberg, 1931) | 53 | 0 |
| *Netamelita (microtelsonica) sp* | | 10 | 0 |
| Oediceratidae sp1 | | 0 | 8 |
| Oediceratidae sp2 | | 0 | 8 |

| | AMPHIPODA | G | D |
|---|---|---|---|
| *Orchomene* sp | | 1 | 0 |
| *Paracaprella digitimanus* | Quitete, 1971 | 7 | 4 |
| *Paracentromedon* sp | | 3 | 0 |
| *Parajassa angularis* | Shoemaker, 1942 | 21 | 108 |
| *Parametopella ninis* | JL Barnard, 1962 | 8 | 15 |
| *Photis brevipes* | Shoemaker, 1942 | 7 | 332 |
| *Photis longicaudata* | (Bate & Westwood, 186 | 13 | 466 |
| *Photis macromanus* | McKinney et al, 1978 | 5 | 146 |
| *Photis* sp | | 12 | 63 |
| *Phoxocephalopsis zimmeri* | Schellenberg, 1931 | 7 | 0 |
| *Podocerus brasiliensis* | (Dana, 1853) | 0 | 1 |
| *Podocerus* sp | | 2 | 83 |
| *Pontharpinia pinguis* | Stebbing, 1897 | 0 | 3 |
| *Prachynella* sp | | 1 | 0 |
| *Pseudharpinia dentata* | Schellenberg, 1931 | 112 | 31 |
| *Pseudomegamphopus barnardi* | Myers, 1968 | 68 | 19 |
| *Ptisica marina* | Slaber, 1769 | 0 | 1 |
| *Puelche orensanzi* | Barnard & Clark, 1982 | 11 | 0 |
| Stenothoidae | | 0 | 3 |
| *Synchellidium* sp | | 3 | 0 |
| *Tiburounella viscana* | (JL Barnard, 1964) | 11 | 0 |
| *Tiron tropakis* | JL Barnard, 1972 | 50 | 115 |
| *Urothoe falcata* | Schellenberg, 1931 | 96 | 6 |
| **Total Amphipoda** | | 1128 | 2480 |
| | **TANAIDACEA** | | |
| *Apseudes* sp1 | | 13 | 4 |
| Apseudidae | | 8 | 0 |
| Agathotanaidae | | 12 | 20 |
| Anarthuridae | | 28 | 22 |
| *Calozodion bacescui* | Gutu, 1996 | 31 | 189 |
| *Kalliapseudes (M.) viridis brasiliens* | Bacescu, 1986 | 50 | 17 |
| *Leptochelia dubia* | (Kroyer, 1842) | 24 | 77 |
| *Leptochelia* sp1 | | 3 | 26 |
| *Leptochelia* sp2 | | 5 | 6 |
| *Paratanaidae* sp1 | | 35 | 105 |
| *Paratanaidae* sp2 | | 0 | 65 |
| *Psammokalliapseudes granulosus* | Silva-Brum, 1973 | 11 | 0 |
| *Psammokalliapseudes* sp | | 4 | 0 |
| *Saltipedis paulensis* | (Silva-Brum, 1971) | 70 | 0 |
| *Sinelobus stanfordi* | (Richardson, 1901) | 4 | 56 |
| **Total Tanaidacea** | | 298 | 587 |
| | **CUMACEA** | | |
| *Anchistylis* sp | | 120 | 91 |
| *Campylaspis tumulifera* | Jones, 1984 | 3 | 1 |
| *Campylaspis* sp1 | | 1 | 0 |
| *Campylaspis* sp2 | | 2 | 0 |
| *Campylaspis* sp3 | | 1 | 0 |

| | CUMACEA | G | D |
|---|---|---|---|
| *Cyclaspis micans* | Roccatagliata, 1985 | 2 | 0 |
| *Cyclaspis reticulata* | Roccatagliata, 1985 | 1 | 0 |
| *Cyclaspis variabilis* | Roccatagliata, 1985 | 11 | 10 |
| *Cyclaspis* sp | | 1 | 0 |
| *Cumella argentinae* | (Jones, 1984) | 6 | 9 |
| *Diastylis planifrons* | (Calman, 1912) | 107 | 18 |
| *Diastylis* sp | | 25 | 77 |
| Diastylidae | | 3 | 5 |
| *Eudorella* sp | | 36 | 1 |
| *Leucon* sp | | 21 | 13 |
| Leuconidae n.id. | | 4 | 1 |
| **Total Cumacea** | | 217 | 134 |
| | **ISOPODA** | | |
| *Ancynus brasiliensis* | Castro, 1959 | 1 | 0 |
| Anthuridae sp 1 | | 33 | 7 |
| Anthuridae sp 2 | | 0 | 3 |
| Arcturidae sp1 | | 2 | 0 |
| Arcturidae sp2 | | 1 | 4 |
| Arcturidae sp3 | | 6 | 16 |
| Arcturidae sp4 | | 18 | 65 |
| Asellota sp1 | | 4 | 0 |
| Asellota tipo 3 | | 0 | 2 |
| Asellota tipo 4 | | 2 | 1 |
| Asellota tipo 5 | | 0 | 5 |
| *Bathygnathia magnifica* | Moreira, 1977 | 1 | 0 |
| *Cristaserolis laevis* | (Richardson, 1911) | 1 | 44 |
| *Cristaserolis similis* | (Moreira, 1974) | 0 | 1 |
| Cymodoce sp | | 1 | 1 |
| *Cymothoa liannae* | Sartor & Pires, 198 | 0 | 3 |
| *Gnathia ubatuba* | Pires, 1966 | 12 | 439 |
| Hyssuridae | | 71 | 4 |
| *Macrochiridotea liliannae* | Moreira, 1973 | 8 | 0 |
| *Malacanthura caribbica* | Paul & Menzies, 19 | 26 | 11 |
| Munnidae | | 2 | 1 |
| *Natatolana* sp | | 11 | 0 |
| *Neoserolis uaperta* | (Moreira, 1971) | 0 | 3 |
| Paranthuridae | | 6 | 0 |
| *Politolana eximia* | (Hansen, 1890) | 5 | 4 |
| *Politolana* sp2 (em estudo) | | 11 | 2 |
| *Serolis* sp | | 0 | 1 |
| *Sphaeroma walkeri* | Stebbing, 1905 | 1 | 2 |
| *Synidotea* sp | | 0 | 6 |
| *Thysanoserolis completa* | (Moreira, 1971) | 6 | 38 |
| **Total Isopoda** | | 228 | 663 |
| Total Peracarida (G) | | 1871 | |
| Total Peracarida (D) | | 3864 | |
| Total Peracarida (G+D) | | 5735 | |

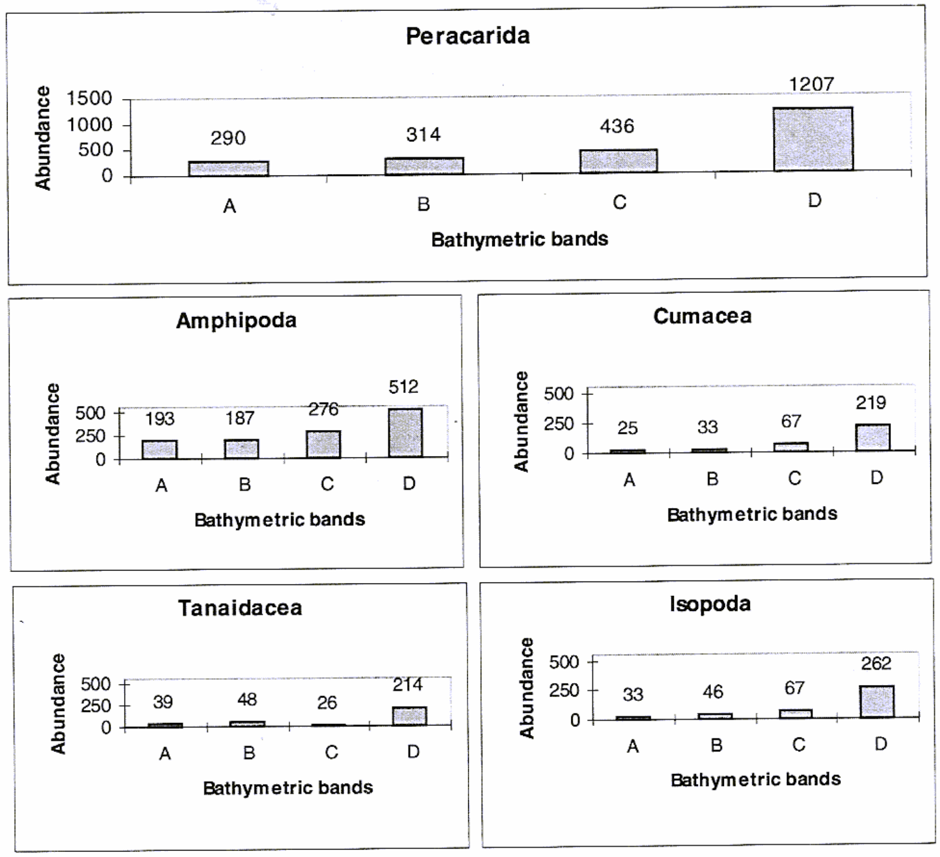


**Figure 2:** Abundance of the whole Peracarida and of each order of Peracarida found at the four bathymetric bands, from the shallow (A) to the deep (D). A= 12-20m; B=21-40m; C= 41-50m; D= 51-75m.

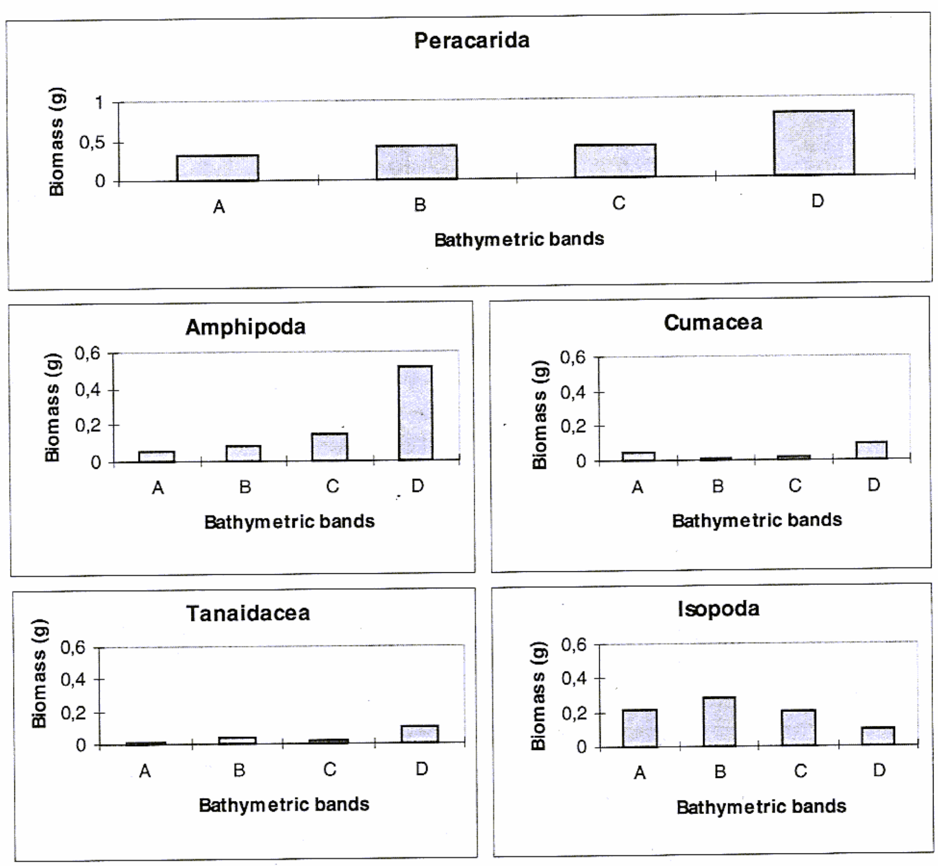


**Figure 3:** Biomass of the whole Peracarida and of each order of Peracarida found at the four bathymetric bands, from the shallow (A) to the deep (D). A= 12-20m; B=21-40m; C= 41-50m; D= 51-75m.

Among the families of Amphipoda, the Ampeliscidae dominated between 12 and 20 m depth (band A, 60%), whereas the Phoxocephalidae dominated band C (41 to 50 m, 53%) and the Corophiidae and the Urothoidae, band D (31 and 20%, respectively) (Fig.4).

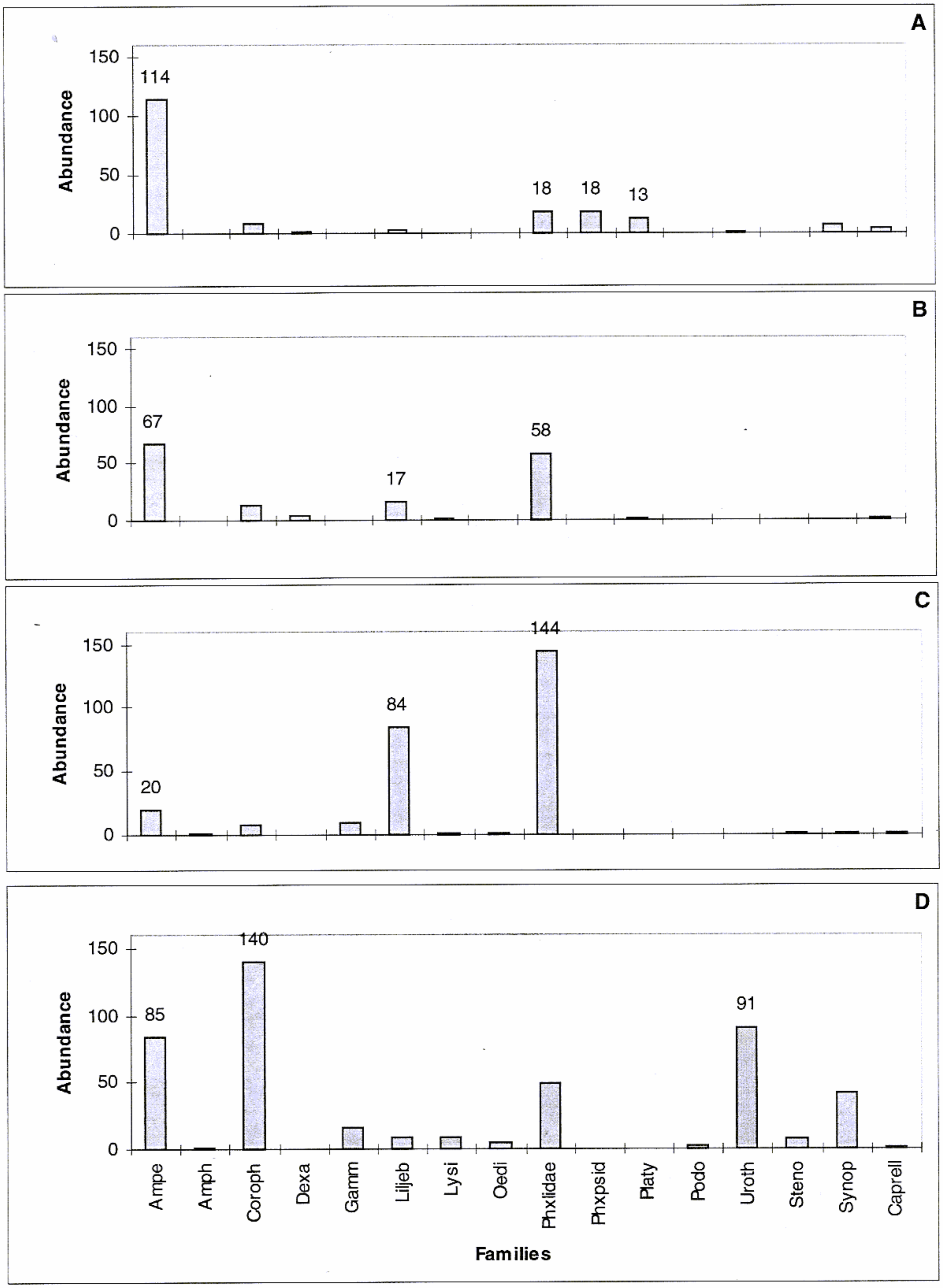


Figure 4: Abundance of the families of Amphipoda at the four bathymetric bands. A=2-20m; B=21-40m; C= 41-50m; D= 51-75m.

## Distribution of density and biomass with longitude (west to east)

The greatest abundance of Peracarida (617ind/0.1m²) was obtained in transect V, located in the eastern part of the area, followed by transect II in the southwest part. The lowest value (192) was found in transect IV, to the north of São Sebastião Island (Fig. 5). This tendency was followed by

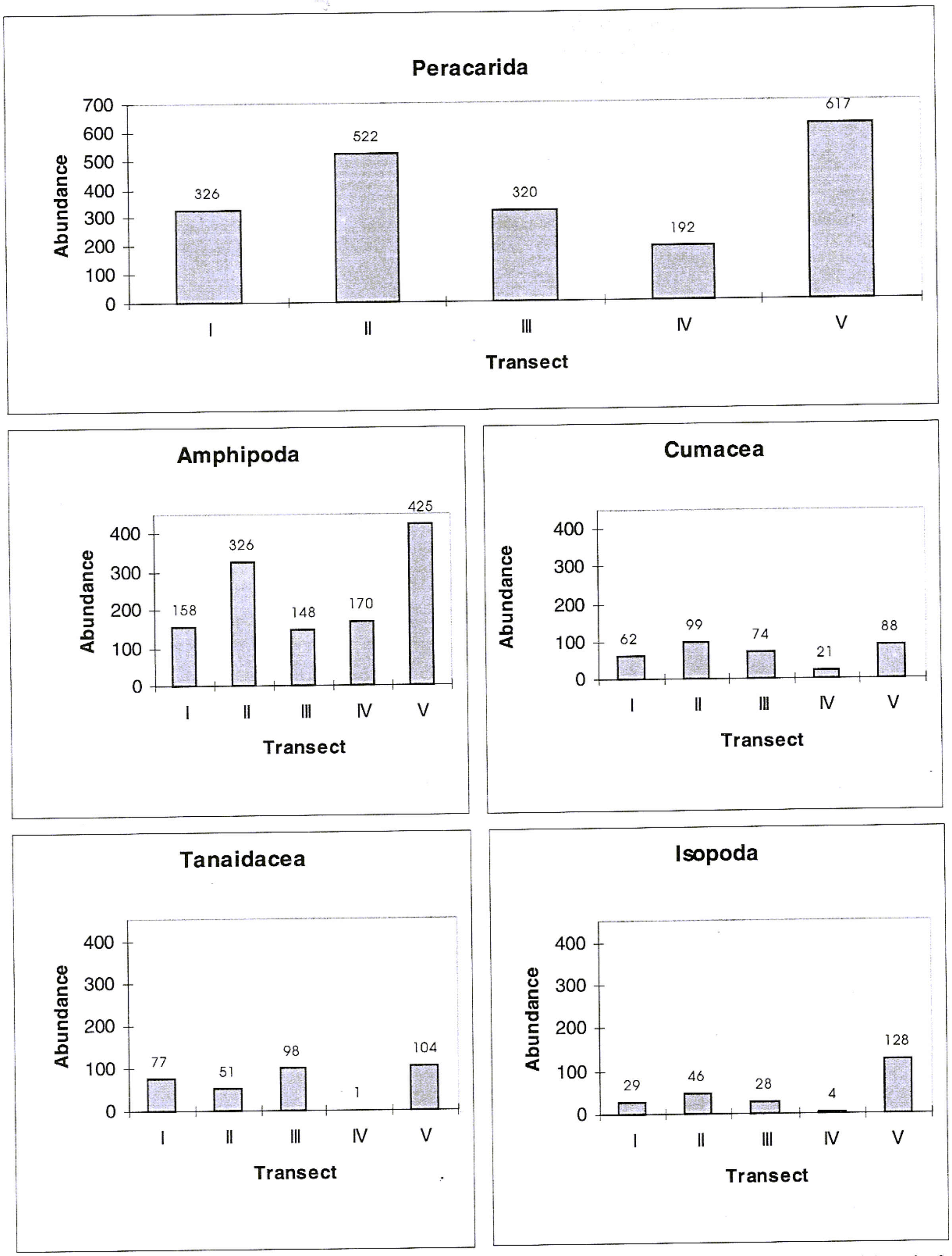


Figure 5: Abundance of the whole Peracarida and each order of Peracarida found at each transect from west (I) to east (V) to the São Sebastião Island.

Isopoda and Tanaidacea, whereas Amphipoda presented the lowest value in transect III and Cumacea the highest in transect II.

High values of biomass were found in transects II, III and V (0.135, 0.102 and 0.094g/0,1m$^2$, respectively). Lowest value was found in the westernmost transect (0.045g/0.1 m$^2$) (Fig.6).

Regarding the Amphipoda, two or three families dominated in all areas except in the transect IV. Ampeliscidae and Phoxocephalidae were more abundant in the western part (transects I and II), Corophiidae and Liljeborgidae in the middle of the area (III) and Corophiidae and Ampeliscidae in the eastern side (transect V). In transect IV, the Phoxocephalidae widely dominated (55%).

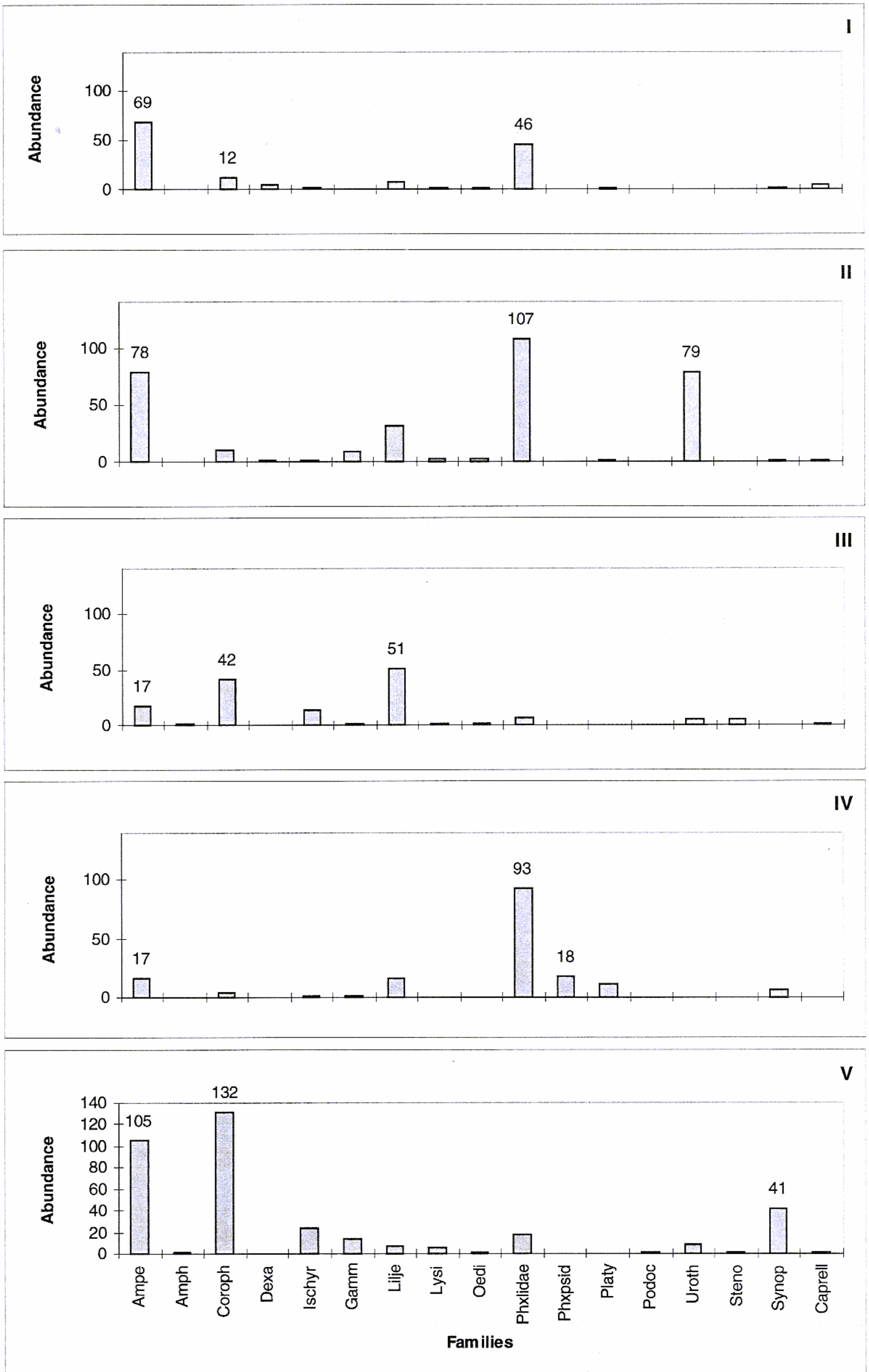


**Figure 6:** Biomass of the whole Peracarida and of each order of Peracarida found at the five transects from west (I) to the São Sebastião

## Biological variables of the Amphipoda communities

Density. The most abundant species of Amphipoda were *Ampelisca paria, Liljeborgia quinquedentata, Pseudharpinia dentata* and *Urothoe falcata*. The values of density for all species are showed in Table 3. *A. paria* was more numerous in shallow places, *L. quinquedentata* between 40-50 m depth, whereas *P. dentata* and *U. falcata* in depths down to 50 m.

**Table 3:** Density of Amphipoda species (n° ind./0.1m2) at each station from the São Sebatião shelf.

| Depth (m) | 15 | 22 | 30 | 60 | 20 | 25 | 41 | 50 | 60 | 50 | 34 | 69 | 13 | 24 | 39 | 53 | 12 | 18 | 37 | 62 | 74 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stations | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | |
| AMPHIPODA | | | | | | | | | | | | | | | | | | | | | | Total |
| *Ampelisca brevisimulata* | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 12 |
| *Ampelisca cristata* | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 6 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 12 |
| *Ampelisca cristoides* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| *Ampelisca indentata* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 11 |
| *Ampelisca sp3* | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 8 |
| *Ampelisca paria* | 30 | 10 | 0 | 0 | 22 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 0 | 39 | 14 | 1 | 0 | 0 | 145 |
| *Ampelisca pugetica* | 0 | 0 | 3 | 15 | 0 | 0 | 4 | 4 | 1 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 9 | 52 |
| *Ampelisca* sp | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ampelisciphotis podophthalma* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 11 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 55 | 76 |
| *Amphilocus neapolitanus* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| *Atylus* sp | 1 | 3 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| *Birubius* sp | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 16 |
| *Byblis* sp1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| *Byblis* sp2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| *Byblis* sp3 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 8 |
| *Caprella equilibra* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Ceradocus* sp | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Cerapus tubularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 2 |
| *Cheiriphotis megacheles* | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 7 |
| *Cheiriphotis sp* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| *Ericthonius brasiliensis* | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| *Ericthonius punctatus* | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 9 |
| *Ericthonius* sp | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| *Eudevenopus gracilipes* | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| *Gammaropsis togoensis* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 14 |
| *Harpinia* sp | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| *Harpiniopsis galerus* | 0 | 0 | 1 | 0 | 0 | 0 | 3 | 6 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 16 |
| *Heterophoxus videns* | 0 | 0 | 6 | 7 | 0 | 0 | 7 | 16 | 20 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 4 | 1 | 0 | 65 |
| *Ischyrocerus* sp | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| *Liljeborgia quinquedentata* | 1 | 2 | 4 | 1 | 1 | 1 | 9 | 14 | 7 | 50 | 0 | 1 | 0 | 2 | 2 | 11 | 0 | 1 | 5 | 1 | 0 | 113 |
| *Listriella titinga* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Lysianassa* sp | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 |
| *Maera sp* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 |
| *Maera hirondellei* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Maera grossimana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 10 |
| *Maera* sp | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| *Metaphoxus sp* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| *Microphoxus cornutus* | 10 | 14 | 0 | 0 | 4 | 13 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 3 | 0 | 0 | 0 | 1 | 6 | 0 | 0 | 53 |
| *Netamelita sp* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 10 |
| *Orchomene* sp | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Paracaprella digitimanus* | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 7 |
| *Paracentromedon sp* | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| *Ruffojassa angularis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 | 21 |
| *Parametopella ninis* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 8 |
| *Photis brevipes* | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 7 |
| *Photis longicaudata* | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 3 | 13 |
| *Photis macromanus* | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| *Photis* sp | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 12 |
| *Phoxocephalopsis sp* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| *Podocerus* sp | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| *Prachynella* sp | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| *Pseudharpinia dentata* | 0 | 0 | 0 | 0 | 0 | 1 | 9 | 12 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 86 | 0 | 1 | 0 | 0 | 0 | 112 |
| *Pseudomegamphopus barnardi* | 2 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 12 | 42 | 3 | 68 |
| *Puelche orensanzi* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 |
| *Synchellidium* sp | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| *Tiburounella viscana* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 |
| *Tiron tropakis* | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 41 | 50 |
| *Urothoe falcata* | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 81 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 7 | 96 |
| Total | 50 | 31 | 28 | 40 | 28 | 42 | 41 | 64 | 143 | 68 | 4 | 71 | 42 | 16 | 6 | 98 | 43 | 23 | 50 | 48 | 195 | 1131 |

Diversity. Species richness (S) ranged between 3 and 28, and deeper bottoms with very fine sand presented more species (Table 4). Diversity (H′) was very variable, ranging between 0.59 (station 16) to 4.37 (station 12). Most of the stations lay between 1.5 and 3.0 bits. It was observed a tendency for high diversity values in stations deeper than 50 m, excepting the muddy stations 16 (53m) and 20 (62m) with H' values of 0.59 and 0.82 respectively. The values of evenness varied between 0.32 and 0.96 , with the lowest values concentrating in the deep southwest places near the São Sebastião Island (Table 4).

**Table 4:** Diversity (H'), Eveness (J') and Species Richness (S) of Amphipoda at each sampling station

| Station | Depht (m) | Diversity (H') | Eveness (J') | Richness (S) |
|---|---|---|---|---|
| 1 | 15 | 1.79 | 0.64 | 7 |
| 2 | 22 | 1.94 | 0.75 | 6 |
| 3 | 30 | 3.44 | 0.9 | 14 |
| 4 | 60 | 2.91 | 0.78 | 13 |
| 5 | 20 | 1.02 | 0.51 | 4 |
| 6 | 25 | 2.18 | 0.65 | 10 |
| 7 | 41 | 3.14 | 0.91 | 11 |
| 8 | 50 | 2.75 | 0.83 | 10 |
| 9 | 60 | 2.36 | 0.58 | 17 |
| 10 | 50 | 1.55 | 0.47 | 10 |
| 11 | 34 | 1.5 | 0.95 | 3 |
| 12 | 69 | 4.37 | 0.95 | 24 |
| 13 | 13 | 1.99 | 0.77 | 6 |
| 14 | 24 | 2.08 | 0.8 | 6 |
| 15 | 39 | 1.92 | 0.96 | 4 |
| 16 | 53 | 0.59 | 0.37 | 3 |
| 17 | 12 | 0.54 | 0.34 | 3 |
| 18 | 18 | 2.21 | 0.66 | 10 |
| 19 | 37 | 2.8 | 0.88 | 9 |
| 20 | 62 | 0.82 | 0.32 | 6 |
| 21 | 74 | 3.59 | 0.75 | 28 |

## Amphipod communities

Q-mode cluster analysis showed two main groups. Group 1 with sites deeper than 30 m, on the frontal zone and medium shelf, and groups of density and diversity and the presence of *L. quinquedentata*. Two sub-groups could be recognized, the first (1.1) situated on the southern and northern limits of the area, containing the deepest stations, and the second (1.2) placed to southwest and southeast of São Sebastião Island, between the 30 and 50 m isobaths. Group 1.1. had bottoms of very fine sand mixed with some silt and clay where *U. falcata, Ampelisciphotis podophthalma* and *Pseudomegamphopus barnardi* dominated. Group 1.2 assembled sites with fine grained bottoms and high C/N ratio with high number of *P. dentata*. Group 2, formed by the coastal sites between 13 and 25 m depth, presented low species richness and diversity and the presence of *Ampelisca paria*. Stations 13 and 11 were not grouped with any other station. The first due to a quite different bottom, composed mainly by gravel and coarse sand, and the latter due to a very low number of amphipods (4 individuals only).

The R-mode dendrogram indicated the presence of four groups of species in the area (A to D) (Fig. 8). The names and codes of the species are in Table 5. Group A and B comprised species which occurred at the deepest stations from the southeast (group A, stations 21 and 12) and from the southwest (group B, station 9). Group C assembled species with wide bathymetric range, whereas group D clustered the shallower water species.

The multiple discriminant analysis employed for the two main groups from the Q-mode cluster analysis revealed that two functions were sufficient to separate the groups (Table 6). The functions account for 100% of the variance of the data, and the descriptor selected was depth ($P<0.05$).The first function corresponded to 78.6% of the total variance. Depth and mean diameter of the grains were positively correlated with axis I, and organic nitrogen and carbonates were negatively correlated. This function separated the shallow sites of group 2 from the deeper sites of group 1. The function 2 splitted group 1 in two sub-groups. Group 1.1, with sites deeper than 60 m and group 1.2, with

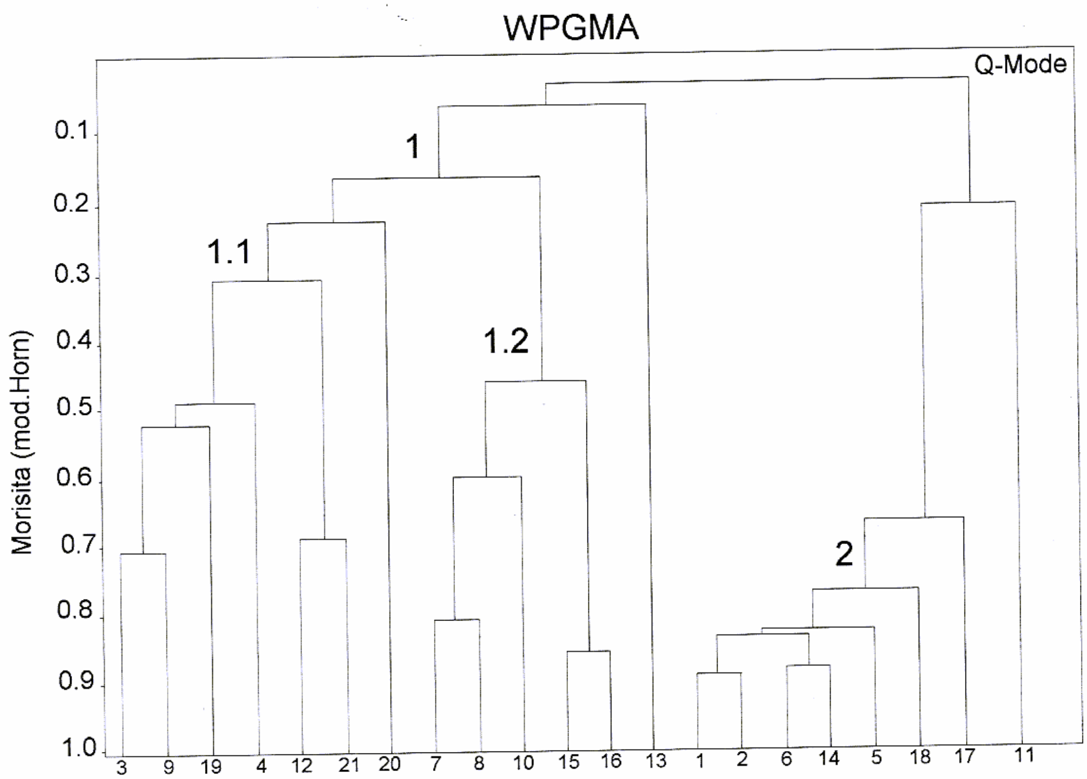


**Figure 7:** Dendrogram from Q-mode cluster analysis with the amphipod species from the São Sebastião shelf, during summer 1994.

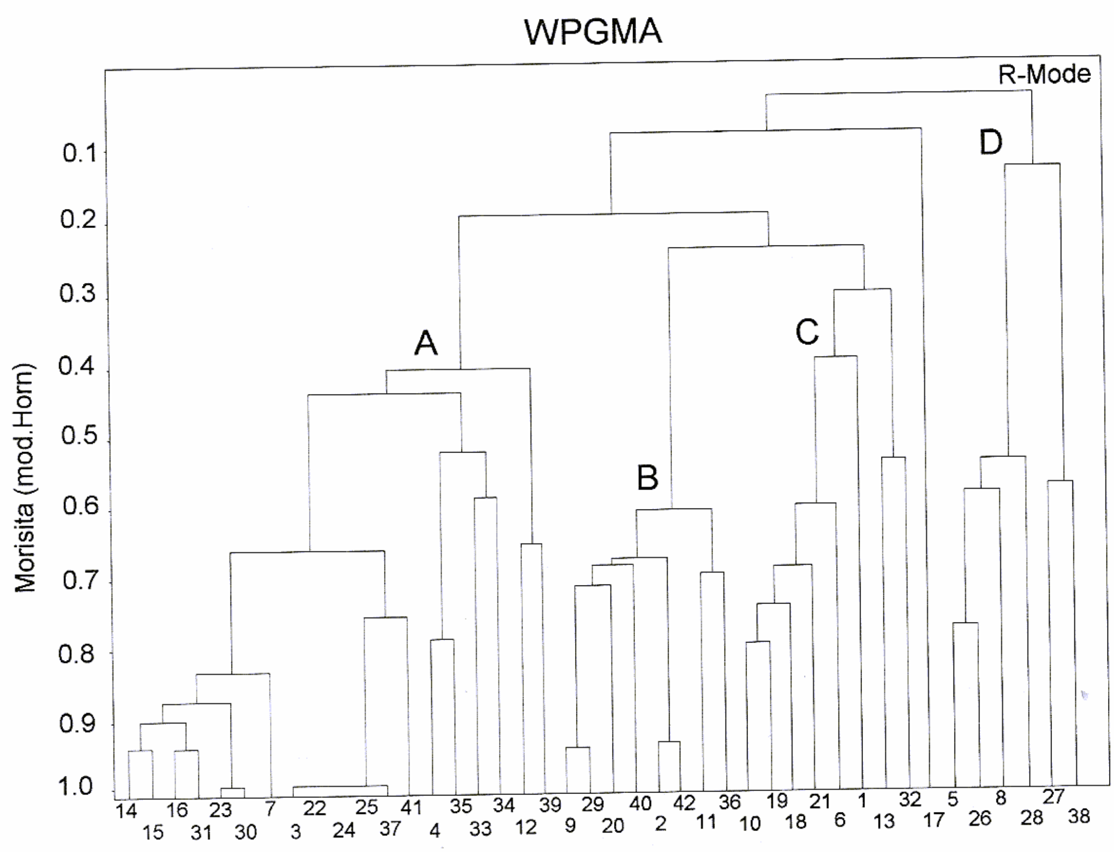


**Figure 8:** Dendrogram from R-mode cluster analysis with the amphipod species from the São Sebastião shelf, during summer 1994. The species code is in Table 4.

Table 5: Amphipoda species used in the R-mode cluster analysis, with their respective code.

| *Groups* | *Code* | *Species* |
|---|---|---|
| A1 | 14 | *Ericthonius brasiliensis* |
| A1 | 15 | *Ericthonius punctatus* |
| A1 | 16 | *Ericthonius* sp |
| A1 | 31 | *Parajassa angularis* |
| A1 | 23 | *Lysianassa* sp |
| A1 | 30 | *Paracentromedon* sp |
| A1 | 7 | *Ampelisciphotis podophthalma* |
| A2 | 3 | *Ampelisca indentata* |
| A2 | 22 | *Liljeborgia quinquedentata* |
| A2 | 24 | *Maera hirondelei* |
| A2 | 25 | *Maera grossimana* |
| A2 | 37 | *Podocerus* sp |
| A2 | 41 | *Tiron tropakis* |
| A3 | 4 | *Ampelisca sp3* |
| A3 | 35 | *Photis macromanus* |
| A3 | 33 | *Photis brevipes* |
| A3 | 34 | *Photis longicaudata* |
| A3 | 12 | *Byblis* sp2 |
| A3 | 39 | *Pseudomegamphopus barnardi* |
| B1 | 9 | *Birubius* sp |
| B1 | 29 | *Paracaprella digitimanus* |
| B1 | 20 | *Heterophoxus videns* |
| B1 | 40 | *Synchellidium* sp |
| B1 | 2 | *Ampelisca cristata* |
| B1 | 42 | *Urothoe falcata* |
| B2 | 11 | *Byblis* sp1 |
| B2 | 36 | *Photis* sp |
| C1 | 10 | *Byblis* sp3 |
| C1 | 19 | *Harpiniopsis galerus* |
| C1 | 18 | *Harpinia* sp |
| C1 | 21 | *Ischyrocerus* sp |
| C1 | 6 | *Ampelisca pugetica* |
| C1 | 1 | *Ampelisca brevisimulata* |
| C2 | 13 | *Cheiriphotis megacheles* |
| C2 | 32 | *Parametopella ninis* |
| | 17 | *Gammaropsis togoensis* |
| D1 | 5 | *Ampelisca paria* |
| D1 | 26 | *Maera* sp |
| D1 | 8 | *Atylus* sp |
| D1 | 28 | *Netamelita sp* |
| D2 | 27 | *Microphoxus cornutus* |
| D2 | 38 | *Pseudharpinia dentata* |

sites of intermediate depths, between 40 and 53 m. These results confirmed the interpretation of the division of the area based on the species distribution.

Four environmental variables were selected with the forward selection procedure and were employed in the Canonical Correspondence Analysis (CCA). They were significant at $p \leq 0.05$. The variables selected were: depth, gravel, biodetritic carbonate and organic nitrogen. They account for 42% of the total variance on the species data. Two axes were significant to interpret the species distribution, axis I explaining 23% and axis II, 19% of the variation. Axis I separated sites and species from deep, cold water bottoms, with calcareous fragments from sites and species from medium and shallow depths. Axis I distinguished the cluster group of station 1.1 from groups 1.2 and 2 (Fig. 9). Station 13 was placed in group 1.1, despite its small depth, by having a bottom with high quantity of biodetritic carbonate and gravel. Axis II individualized the group of stations of medium depths (group 1.2) from those from shallow water (group 2). The high nitrogen content linked to finer grained sediments of group 1.2 was the main factor responsible for this result. Species and sites in the middle of the diagram indicate no relation with the variables analyzed.

## Strategies of mobility within the Amphipoda

Q-mode cluster results showed that, considering the three groups of stations found in the area, the burrowers predominated in group 1 and the infaunal tubicolous in group 2. In group 1.1, from the deepest sites, the more numerous species were *U. falcata* (38%) and *Tiron tropakis* (19%) (burrowers) followed by the epifaunal tubicolous *A. podophthalma* (37%). In group 1.2, from medium depths, the burrower *P. dentata* dominated (58%) followed by the inquiline *L. quinquedentata* (36%). The shallow water group 2 was characterized by the dominance of the infaunal tubicolous *A. paria* (48%). Figure 10 shows the distribution of the Amphipoda life styles in the study area.

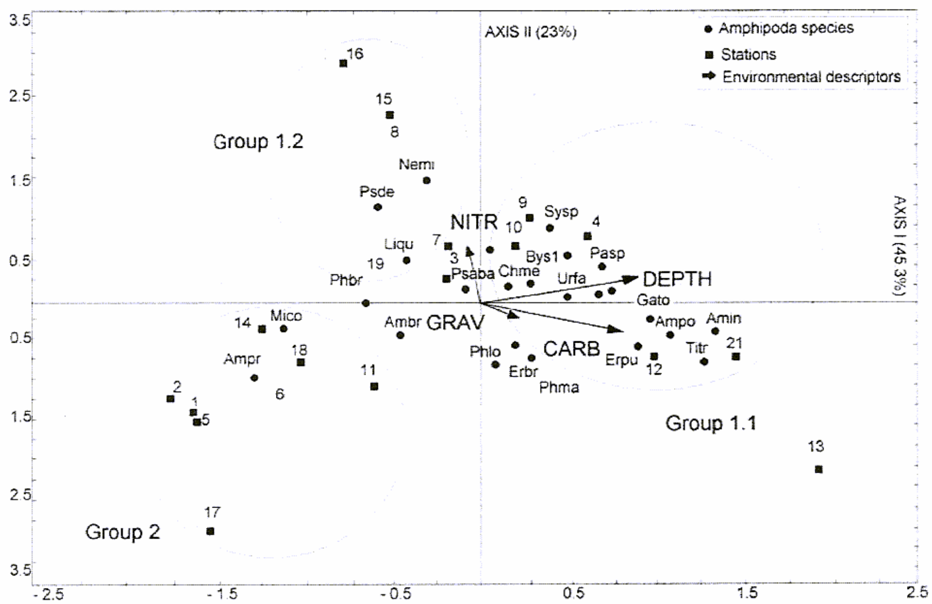


**Figure 9:** Ordination diagram of the Amphipod species, stations and environmental variables on the two first axis of the CCA. Arrows show magnitudes and distribution of environmental variables.

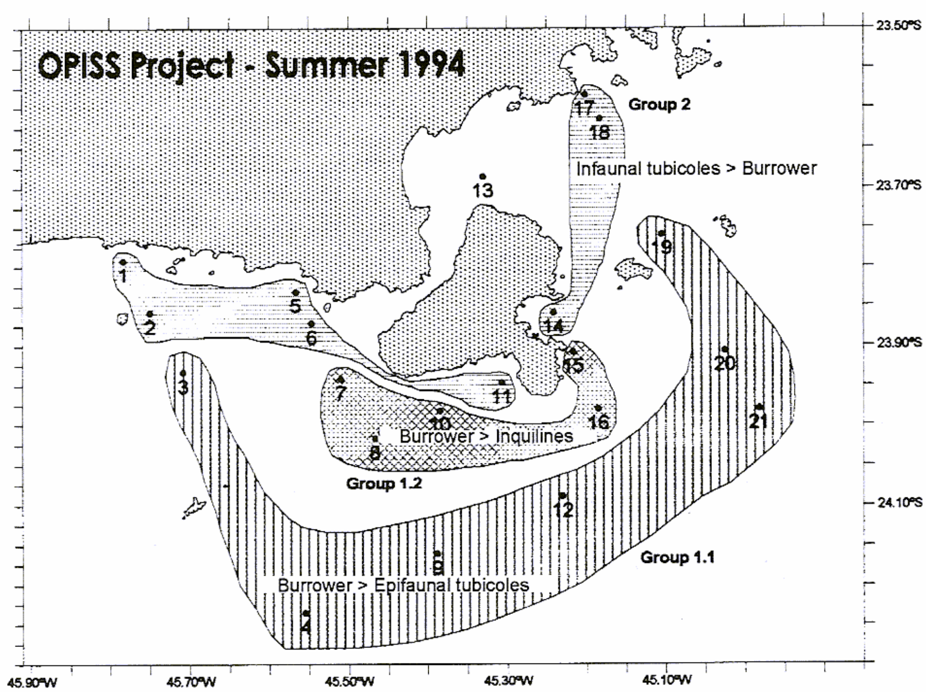


**Figure 10:** Distribution of the Amphipoda life styles in the study area based on the Q mode cluster analysis.

# Discussion

The present results stressed the importance of depth, sediment type and composition and temperature in structuring the amphipod communities from the São Sebastião shelf. The first two factors are directly dependent of both hydrologic regime and topography, whereas temperature is a consequence of the water masses interaction.

The water masses dynamics and the presence of the São Sebastião Island are the main physical characteristics of the study area. The gradient of temperature and salinity observed was directly related to the summer intrusion of the South Atlantic Central Water (SACW) toward the coast. Studies on benthic communities of the Ubatuba shelf showed the ecological importance of the SACW for the macro- and megafaunas of the Brazilian waters. This water mass promotes seasonal variability in species distribution (Paiva, 1993; Valerio-Berardo *et al.*, 2000), causes the intrusion of cold water species in shallow depths (Pires-Vanin, 1993 b; Santos and Pires-Vanin, 1999), and modifies the equilibrium of key-species on the inner shelf (Pires, 1992).

In the present work the influence of SACW could be analysed only in the spatial context. The presence of the SACW contributed to divide the shelf in three main areas, based on the distribution of the Amphipoda species. Each area presented different communities associated mainly to depth, water masses and sediment type. In spite of macrobenthic communities are generally related to sediment type and depth (Gray, 1974; Fresi *et al.*, 1983; Snelgrove and Butman, 1994), the pattern found in the São Sebastião shelf is dependent also of the SACW intrusion. The water masses dynamics is closely related to depth because it promotes a sharp thermal change on the bottom, which exposes the fauna to quite different temperatures. However, the water masses act not only on the thermal control of the species biological processes, but also contributes to enhance the food supply content for the benthos (Pires-Vanin *et al.*, 1993). Therefore, it helps to maintain the species both in a thermal-depth and food-depth gradients.

The canonical correspondence analysis pointed out the importance of sediment in structuring the amphipod community. Except by the east-southeasten shelf area, the majority of the bottom is composed by fine sand, which is positively correlated with biomass and diversity. The distribution of sediments in the shelf shows that the São Sebastião Island forms an important barrier to the impact of waves and currents from the open sea, changing the pattern of deposition of sediments over the bottom (Furtado, 1995). Consequently, finer grained sediments occur on the east-southeastern shelf, except in the vicinities of the north mouth of the São Sebastião Channel, where hydrodynamics is high. The presence of burrower and tubicoles amphipods, as *P. dentata* and *P. barnardi*, together with high values of organic carbon and nitrogen found in the eastern area, confirm the observed pattern of sedimentation. In general, amphipods were neither abundant nor diverse in the muddy sediments close to the island, places where high values of dominance occurred. These facts seem to indicate that this eastern area could function as a filter for the majority of the Amphipoda species present in the study shelf.

The close relation obtained between sand, density and diversity point out the importance of bottom type for the amphipods distribution. The very fine sand combined with fine sand allows the existence of more intersticial space per area of sediment, improving the quantity of potential niches to the species. As showed by many authors, the adequate mixture of grains is a very important factor for the occurrence and maintenance of marine macrofaunal species throughout the world (Chevrier *et al.*,1991; Brandt and Piepenburg, 1994; Santos and Pires-Vanin, 1999).

The increase in amphipod community diversity with depth observed in the São Sebastião shelf was also showed on the whole northern shelf of the São Paulo State (Pires-Vanin, ed., 1993; Valerio-Berardo *et al.*, 2000). The causes to explain this phenomenon are related to the increase in environmental stability with depth (Sanders, 1958; Klopfer, 1959) and or to an increase in food supply (Grebmeier *et al.*, 1988; Brandt, 1996). In study area, the latter seems to be a very important one, since primary productivity increases nearly 10 times under the influence of the SACW (Aidar *et al.*, 1993) and the benthic deposit feeders increase in number also during the summer (Rocha *et al,* 1998), period when the SACW exerts more influence. The rise in diversity observed was more related to the species richness component than to eveness, as pointed out by Boesch (1972) and verified by Valerio-Berardo *et al.*, (2000).

The study of life style is important for analysing the organism-sediment relationships (Posey, 1987). Species or group of species with different types of mobility can influence the community structure changing the characteristic of the sediments and favouring or not the establishment of new organisms. At inner shelf, mainly in the shallower areas, the infaunal tubicole *A. paria* dominated over the burrower species. After Posey (1987), an exclusion between these two strategies of mobility may eccurr since dense aggregations of tubes stabilizes the substrate making more difficult the burrowing activity. The inverse situation occurred also in the study area, since in the shallow northern coarse bottoms burrowers highly dominated.

Considering the rest of the area, in the frontal zone and medium shelf burrowers were highly numerous, except in the area close and to the south of the São Sebastião Island, where they were almost as numerous as inquilines. According to Posey (1987) the burrower species did not overlap the inquilines or free epifauna allowing co-existence. As pointed out by Bousfield (1982) species of both life styles can inhabit the same area since inquilines are more linked to the host than to the substrate. The predominant inquiline species in the São Sebastião shelf, *L. quinquedentata,* is commensal in tubes of crustaceans and polychaetes, and the high abundance of this Liljeborgidae hardly suggests an association with the maldanid *Clymenella,* polychaete abundantly found in these depths, specially in the southeastern places (unpubl. data).

Valerio-Berardo *et al.* (2000) observed an annual variation in dominance between burrowers and tubicoles at the neighbor shelf of Ubatuba, but our data agree with their summer's data which point out the dominance of the infaunal tubicoles, mainly of *A. paria*, upon the burrowers at inner shelf.

The patterns of spatial distribution of life in coastal area can only be achieved through temporal studies, due the high dynamyc conditions of this system. However, in the present paper the peracarid distribution should be assessed as an important bulk of new information which will contribute to a better understanding of the benthic communities from shallow waters.

## Acknowledgements.

The authors are grateful to the Centro de Biologia Marinha of the University of São Paulo (CEBIMAR) for logistic support, and to CAPES for the scholarship to one of us (KCS). This is part of a research project supported by Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) (Project 92/3449-0).

## References

Aidar, E.; Gaeta, S. A.; Gianesella-Galvão, S. M. F.; Kutner, M. B. B. and Teixeira, C. 1993. Ecossistema costeiro tropical: nutrientes dissolvidos, fitoplancton e clorofila-a, e suas relações com as condições oceanográficas na região de Ubatuba. Publicação especial do Instituto Oceanográfico (10): 9-43.

Barnard, J. L. 1956. Two rare Amphipods from California with notes on the genus *Atylus*. Bulletin of the Southern California Academy of Sciences, 55: 35-43, pls. 12-14.

Biernbaum, C. K. 1979. Influence of sedimentary factors on the distribution of benthic amphipods of Fishers Island Sound, Connecticut. Journal of Experimental Marine Biology and Ecology, 38: 201-223.

Boesch, D. F. 1972. Species diversity of marine macrobenthos in the Virginia area. Chesapeake Science, 13(3): 206-211.

Bousfield, E. L. 1973. Shallow-water gammaridean Amphipoda of New England. vii-xii + 312 pp., 13 figs, 69 pls. Ithaca and London: Cornell University Press.

Bousfield, E. L. 1982. Amphipoda. S.P. Synopsis and classification of living organisms. vol. 2. Parker (ed.). Mc Graw-Hill, New York, 1232 p.

Brandt, A. 1993. Composition, abundance, and diversity of peracarid crustaceans on a transect of the Kolbeinsey Ridge, north of Iceland. Polar Biology, 13: 565-576.

Brandt, A. 1995. Peracarid fauna (Crustacea, Malacostraca) of Northeast Water Polynya off Greenland: documenting close benthic-pelagic coupling in the Westwind Trough. Marine Ecology Progress Series, 121: 39-51.

Brandt, A. 1996. Peracarid crustaceans (Malacostraca) from a "time-series-station" the Westind Trough of New Polynya (Geenland): a benthic response to productivity? Crustaceana, 69: 958-1004.

Brandt, A. and Piepenburg, D. 1994. Peracarid crustacean assemblages of the Kolbeinsey Ridge, north of Iceland. Polar Biology, 14: 97-105.

Castro, B. M. and Miranda, L. B. 1998. Physical Oceanography of the western Atlantic Continental Shelf located between 4°N and 34°S. In: Robinson and Brink (eds). The Sea. Vol.11. Wiley & Sons ,Oxford: 209-251.

Chevrier, A.; Brunel, P and Wildish, D. J. 1991. Structure of a suprabenthic shelf community of gammaridean Amphipoda in the Bay of Fundy compared with similar sub-communities in the Gulf of St. Lawrence. Hydrobiologia, 223: 81-104.

Flynn, M. N.; Berardo, M. T. V.; Wakabara, Y. and Miyagi, V. K. 1999. Preliminary study of the spatial distribution of the benthic macrofauna of São Sebastião Channel, Southeastern Brazil. Oceanides, 14(2): 97-111.

Folk, R. L. and Ward, W. C. 1957. Brazos River bar: a study of the significance of Grain size parameters. Journal of Sediment Petrology, 27(1): 3-27.

Fresi, E.; Gambi, M. C.; Focardi, S.; Bargali, R.; Baldi, F. and Falciai, L. 1983. Benthic community and sediment types: a structural analysis. Marine Ecology (P.S.Z.N.I.), 4(2): 101-121.

Furtado, V. V. 1995. Sedimentação Quaternária no Canal de São Sebastião. Publicação especial do Instituto Oceanográfico, São Paulo, 11: 27-35.

Furtado, V. V.; Bonetti Filho, J.; Rodrigues, M. and Barcelos, R. L. 1998. Aspectos da sedimentação no Canal de São Sebastião. Relatório técnico do Instituto Oceanográfico, 10(43): 15-31.

Gallerani, G. 1997. Análise Qualitativa dos Amphipoda da Bacia de Campos, RJ, Brasil. MS Dissertation. University of São Paulo, 143p.

Gambi, M. C. and Bussotti, S. 1999. Composition, abundance and stratification of soft-bottom macrobenthos from selected areas of the Ross Sea shelf (Antarctica). Polar Biology, 21: 347-354.

Gray, J. S. 1974. Animal-sediment relationships. Oceanography and Marine Biology Annual Review, 12: 223-261.

Grebmeier, J. M.; Mc Roy, C. P. and Feder, H. M. 1988. Pelagic-benthic coupling on the shelf of the Northern Bering and Chukchi Seas. Marine Ecology Progress Series, 48: 57-67.

Grove, S. L. and Probert, P. K. 1999. Sediment macrobenthos of upper Otago Harbour, New Zealand. New Zealand Journal of marine and freshwater research, 33(3): 469-480.

Klopfer, P. H. 1959. Environmental determinants of faunal diversity. American Naturalist, 93: 337-343.

Lucato, S. H. B. 1997. Trofodinâmica dos peixes pleuronectiformes do Canal de São Sebastião, São Paulo, Brasil. Master Science Dissertation. University of São Paulo, 110p.

Muniz, P. and Pires, A. M. S. 1999. Trophic structure of polychaetes in two bays of the São Sebastião Channel (southeastern Brazil). Marine Biology, 134(3): 517-528

Muniz, P. and Pires, A. M. S. 2000. Polychaete associations in a subtropical environment (São Sebastião, Brazil): a structural analysis. P.S.Z.N. Marine Ecology, 21(2): 145-160.

Osse, A. C. 1995. Aspectos da estrutura Espaço-temporal de uma comunidade intermareal de costão rochoso da Ponta da Fortaleza - Ubatuba - SP. Master Science Dissertation. University of São Paulo, 140p.

Paiva, P. C. 1993. Anelídeos poliquetas da plataforma continental norte do Estado de São Paulo: I – Padrões de densidade e diversidade específica. Boletim do nstituto Oceanográfico, S Paulo, 41(1/2): 69-80.

Pires, A. M. S. 1992. Structure and dynamics of benthic megafauna on the continental shelf offshore of Ubatuba, southeastern Brazil. Marine Ecology Progress Series, 86: 63-76.

Pires-Vanin, A. M. S. (Ed.) 1993a. Estrutura e função do ecossistema de plataforma continental do Atlântico Sul brasileiro. Publicação especial do Instituto Oceanográfico, S Paulo, 10: 1- 245.

Pires-Vanin, A. M. S. 1993b. A macrofauna bêntica da plataforma continental ao largo de Ubatuba, São Paulo, Brasil. Publicação especial do Instituto Oceanográfico, S Paulo, 10: 137-158.

Pires-Vanin, A. M. S. (*in press*). Isopods assemblages on the continental shelf and upper slope from the Southeastern Atlantic. Isopod systematics and evolution. Crustacean Issues, vol.13.

Pires-Vanin, A. M. S.; Rossi-Wongtschowski, C. L. D. B.; Aidar, E.; Mesquita, H. S. L.; Soares, L. S. H.; Katsuragawa, M. and Matsuura, Y. 1993. Estrutura e função do Ecossistema de plataforma continental do Atlântico sul brasileiro: síntese dos resultados. Publicação especial do Instituto Oceanográfico, S Paulo, 10: 217-231.

Pires-Vanin, A. M. S.; Corbisier, T. N.; Arasaki, E. and Moellmann, A. M. 1997. Composição e distribuição espaço-temporal da fauna bêntica no Canal de São Sebastião. Relatório técnico do Instituto Oceanográfico, (41): 29-46.

Posey, M. H. 1987. Influence of relative mobilities on the composition of benthic communities. Marine Ecology Progress Series, 39: 99-104.

Rocha, G. R. A.; Gasalla, M. A.; Jarre-Teichmann, A.; Rossi-Wongtschowski, C. L. D. B.; Soares, L. S. H.; Pires-Vanin, A. M. S.; Muto, E. Y.; Cergole, M. C.; Aidar, E.; Mesquita, H. S. L.; Gianesella-Galvão, S. M. F. and Veja-Perez, L. A. 1998. A quantitative model of trophic interactions in the Ubatuba shelf system (Southeastern Brazil), in Summer (1985). Naga, Filipinas (ICLARM): 25-32.

Rocha, G. R. A. ; Rossi-Wongtschowski, C. L. D. B.; Pires-Vanin, A. M. S. and Soares, L. S. H. 2000. Estudo do ecossisterma de plataforma continental de Ubatuba (SP): I. Estimativa de Biomassa, consumo e produção dos grupos tróficos. Anais do V Simpósio de Ecossistemas Brasileiros: Conservação. Anais da Academia Brasileira de Ciências(ACIESP), 109(2): 45-52.

Sanders, H. L. 1958. Benthic Studies in Buzzards Bay - I. Animal-sediment relationships. Limnology and Oceanography, 3: 245-258.

Santos, M. F. L.; Pires, A. M. S. and Muniz, P. 1997. A simple and efficient device for sorting large marine benthic samples. Revista Brasileira de Oceanografia 44(1): 57-60.

Santos, M. F. L. and Pires-Vanin, A. M. S. 1999. The Cumacea community of the southeastern Brazilian continental shelf: structure and dynamics. Scientia Marina, 63(1): 15-25.

Serejo, C. S. 1995. *Podocerus fissipes* n.sp., a new species of sponge-dwelling amphipod (Amphipoda, Podoceridae) from the Brazilian Coast. Nauplius, 3: 49-57.

Serejo, C. S. 1997. *Hemiaegina costai* Quitete, 1972, a synonym of *Hemiaegina minuta* Mayer, 1890 (Amphipoda, Caprellidae). Crustaceana, 70(5): 630-632.

Serejo, C. S. 1998. The genus *Leucothoe* (Crustacea, Amphipoda, Leucothoidae) on the Brazilian coast. Beaufortia, 48 (6): 105-135.

Serejo, C. S. 1999. Taxonomy and distribution of the family Hyalidae (Amphipoda, Talitroidea) on the Brazilian coast. Proceedings of the International Crustacean Congress, 4. Amsterdam: 591-616.

Sheppard, F. P. 1954. Nomenclature basead on sand-silt-clay ratios. Journal of sedimentary petrology, 24(3): 151-158.

Snelgrove, P. V. R. and Butman, C. A. 1994. Animal-sediment relationships revisited: cause versus effect. Oceanography and marine biology annual review, 32: 111-177.

Strickland, J. D. H. and Parsons, T. R. 1968. A pratical handbook of sea water analysis. Bulletin. Fisheries Research Board of Canada, 167: 1-311 .

Suguio, K. 1973. Introdução à sedimentologia. Edgard Blücher/EDUSP, São Paulo, 317 p.

ter Braak, C. J. F. 1988. CANOCO: a fortran program for canonical community ordination by partial, detrended, canonical, correspondence analisys, principal components analisys and redundancy analisys. Version 2.1. Technical report, LWA-88-02. 95 p.

ter Braak, C. J. F. 1990. Update notes: CANOCO Version 3.10. Agricultural Mathematics Group, Wageningen, The Netherlands.

Valério-Berardo, M. T.; Flynn, M. N. and Wakabara, Y.2000. Structure and dynamics of a shelf Amphipod taxocenosis in Southeastern Brazil. Bulletin of Marine Science 66(1): 59-72.

Wakabara, Y. 1972. Espécies da família Gammaridea (Crustacea, Amphipoda entre as Latitudes 03° 23'S e 38° 05'S do Atlântico Ocidental. Doctoral Thesis. University of São Paulo, 87 p.

Wakabara, Y.; Kawakami, E. and Tararam, A. S. 1982. Amphipod as one of the main food components of three Pleuronectiforms from the continental shelf of South Brazil and North Uruguay. Marine Biology, 68: 67-70.

Wakabara, Y.; Tararam, A. S.; Valério-Berardo, M. T. and Leite, F. P. P. 1988. Liljeborgiidae (Amphipoda-Gammaridea) from the southern coast of Brazil. Relatorio interno do Instituto Oceanográfico, 23: 1-10.

Wakabara, Y.; Tararam, A. S.; Valério-Berardo, M. T.; Duleba, W. and Leite, F. P. P. 1991.Gammaridean and Caprellidean fauna from Brazil. Hydrobiologia, 223: 69-77.

Weisshappel, J. B. F. and Svavarsson, J. 1998. Benthic amphipods (Crustacea: Malacostraca) in Iceland waters: diversity in relation to faunal patterns from shallow to intermediate deep Artic and North Atlantic Oceans. Marine Biology, 131: 133-143.

Received: 15th / 12 / 2000
Approved: 15th / 12 / 2001