

## ORIGINAL PAPER

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## Benthic megafauna of the nearshore zone of Martel Inlet (King George Island, South Shetland Islands, Antarctica): depth zonation and underwater observations

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**Abstract** The benthic megafauna from the soft bottoms of the shallow coastal zone of Martel Inlet (Admiralty Bay, King George Island, South Shetland Islands, Antarctica) was studied during three austral summers (1989/1990, 1990/1991 and 1994/1995) in relation to the bathymetric features. Surveying and sampling, based on specimen counting and underwater observations, were undertaken by scuba-diving at depths down to 25 m. The depth zonation appears to be influenced by the nature of the substrate and especially by the action of the ice. The multiple action of ice flows prevents the occurrence of sessile forms in the shallower areas, where a low-diversity community, dominated by motile animals, was found. In the area around 18 m in depth, the action of icebergs generated faunistic and sedimentary patches of impacted and non-impacted areas. The more stable conditions prevailing below depths of 20–25 m allowed the establishment of a more diversified epifauna, including many sessile forms. The interannual differences observed in the densities of the mobile isopod *Serolis polita* may be associated with the summer period when the sampling was undertaken.

### Introduction

Nearshore benthic environments have been a subject of particular interest in Antarctica. Unlike the deeper zone, this area is liable to great variability in physical parameters and mechanical damage (Gutt, in press), mainly due to the dominant action of ice (Dayton et al. 1969, 1970; Peck and Bullough 1993; Sahade et al. 1998). This occurs in four main forms: the ice-foot, ice scour, anchor ice and fast ice, each of which influences benthos in very different temporal and spatial ways, depending on a number of factors such as depth, substratum profile and latitude (Barnes 1999). The benthic communities of the South Shetlands appear to have distinctive features as compared to those of continental Antarctica, mainly regarding the composition of the shallow-water communities (Arnaud et al. 1998).

Previous studies on the benthic ecology of Admiralty Bay have been summarised by Jazdzewski and Sicinski (1993) and Jazdzewski (1998). These authors emphasised the importance of this area as providing a good example of the principles formulated to date concerning the qualitative and quantitative diversity of Antarctic zoobenthos, and regarded the different habitats found in Admiralty Bay as consequences of the differing hydrological conditions and, particularly, of the sedimentation characteristics. Despite the great number of studies on Antarctic benthic ecology, little knowledge has so far been recorded as to the structure and distribution of the Antarctic benthic megafauna from soft bottoms of shallow waters (Kirkwood and Burton 1988; Wägele and Brito 1990; Rauschert 1991; Arntz et al. 1994; Sakurai et al. 1996; Sahade et al. 1998).

Sampling by scuba-diving in the nearshore vicinities of the Brazilian Antarctic Station “Comandante Ferraz” was introduced in 1988, during the VI Brazilian Antarctic Expedition, as part of a joint project of the Instituto Oceanográfico, University of São Paulo, Brazil and the University of Oldenburg, Germany (Wägele and Brito 1990; Nonato et al. 1992).

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Our results show the bathymetric distribution of the benthic megafauna of the nearshore zone off the Brazilian Antarctic Station and provide an evaluation of the influence of ice on this distribution.

## Materials and methods

### Study area

King George Island is the largest island (1300 km<sup>2</sup>) of the South Shetland Archipelago (Fig. 1). Admiralty Bay, its largest embayment, covers an area of 122 km<sup>2</sup> and has a volume of 24.24 km<sup>3</sup> distributed among its three inlets (Ezcurra, Martel and Mackellar Inlets) and the main part of the bay. The bay's shoreline extends for 83.4 km, of which ice-free shores account for 44.5 km (Rakusa-Suszczewski 1995).

The coastline of Admiralty Bay is varied with sandy, gravelly, stony and rocky beaches, and most of its length is protected from wave action by the presence of glaciers or pack ice in winter. The eastern and northern shores of the bay are partly formed by glaciers (Arnaud et al. 1986).

The configuration of the bottom shows great topographical diversity (Pruszek 1980). Coarse sediments, prevailing at the shore, can occur down to a depth of about 50 m; as depth increases the sediments become mixed with muddy sand and the deeper parts of the bottom are covered by a fine mud and only single drop-stones can be found (Jazdzewski et al. 1986; Nonato et al. 1992; Brito 1993). Macroalgal beds fringe Admiralty Bay down to depths of 70–90 m (Zieliński 1981), and macroalgal debris covers more than 30% of its bottom. Martel Inlet is characterised by stony beaches and its central part, where it can reach 270 m in depth, is covered by a muddy substratum (Rakusa-Suszczewski et al. 1993).

Salinity and temperature are relatively stable throughout the bay. In the austral summer they range from 32.9 to 34.2 and

–0.2 °C to 3.4 °C, respectively, at the surface and between 33.8 and 33.4 and –0.4 °C and 0.9 °C, respectively, at the bottom (Jazdzewski et al. 1986). The freezing of water in the bay may take place from May to August. Freezing is associated with frosty and windless weather and an absence of waves. Prior to November, the ice is disrupted and disappears as a result of intensive waves from the sea and strong north winds. The weather is calm again by late December (Bodungen 1986).

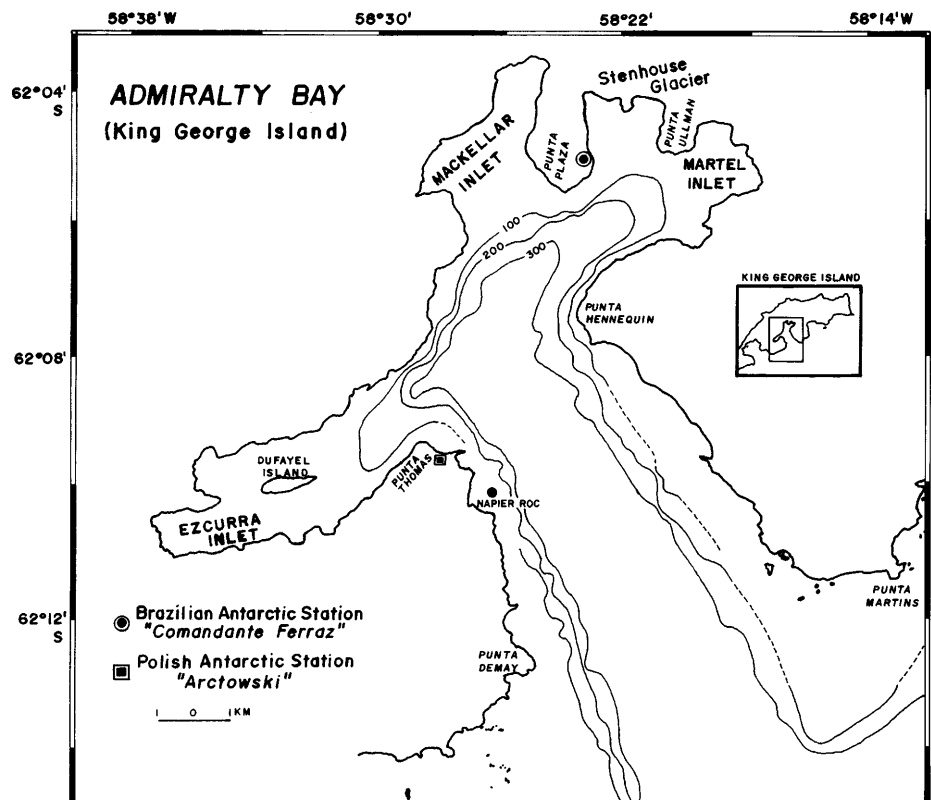
The Brazilian Antarctic Station "Comandante Ferraz" is located in Martel Inlet (Fig. 1). The bottom topography off the station shows a steep slope down to 30 m, and multiple deep scours and troughs produced by the ice action were observed at a depth of around 18 m. At a distance of 100 m from the coast, a depth of 25 m is attained (Nonato et al. 1992).

### Sampling

Surveying and sampling by means of scuba-diving took place during three summers: end of December 1989, beginning of February 1991 and end of December 1994. Three divers worked along a transect running from the coastline down to a depth of 25 m. Sampling was carried out at fixed depths (6, 11, 18 and 25 m), according to the environmental variability (Wägele and Brito 1990). In 1989, an additional sampling site was located at 15 m depth. Sediment samples were collected with cylindrical corers (10 cm diameter). Grain-size analysis was undertaken according to Suguio (1973).

The depth zonation of the benthic megafauna was assessed in two ways: (1) qualitative data, based on underwater observations, and (2) quantitative data by individual counting employing a quadrat method, using a square metal frame (1 m<sup>2</sup>), subdivided into four quadrants. The frame was randomly placed at each of the sampling depths. The fauna density was counted per frame and its average value was calculated per depth. The number of frames varied per summer: in 1989, six frames per depth, in 1991, four frames and in 1994, ten frames were counted. The quantitative information was complemented with further visual observation of the sea-bed, which

Fig. 1 Martel Inlet, Admiralty Bay, King George Island, South Shetland Islands



was found to be biotically heterogeneous, especially between depths of 18 and 25 m. Sporadic samples of some species were taken for identification. The specimens were identified by species, except for Nudibranchia, Porifera, Ascidiacea and Actiniaria. The quantitative results presented hereafter refer only to the larger epifaunal organisms, observed and counted while diving, and to the infaunal bivalve *Laternula elliptica*, whose siphons it was possible to observe. Despite the observation of a great number of amphipods, they were not included in the quantitative analysis because of their small size.

#### Data analysis

Mean densities and number of taxa were estimated at each depth and for each year. For each replicate, species diversity ( $H'$ ) on a  $\log_{10}$  basis (Shannon and Weaver 1949) and evenness ( $J'$ ) (Pielou 1975) were calculated.

Spatial and temporal variation of megafauna were evaluated by a two-way Analysis of Variance (ANOVA) with the factors year and depth. The following community descriptors were used: density of taxonomic groups, total density, number of taxa, diversity and evenness. Before analysis, data were transformed ( $\log \times + 1$ ) as the best transformation for ANOVA assumptions according to Taylor's power law (Green 1979). For the study of the variation of all species, a Multivariate Analysis of Variance (MANOVA) with the same factors (year and depth) was also applied. Pillai's statistic was used for hypothesis testing, given its robustness and power when the homoscedasticity assumption is violated (Johnson and Field 1993). Since the chosen model of ANOVA and MANOVA was the balanced one, only four randomly sorted replicates per year and depth were considered.

To present the relation of species and sampling stations (replicates pooled by depths for each year), a Detrended Correspondence Analysis (DCA) was applied, ranking samples and species scores by their reciprocal weighted average (Ludwig and Reynolds 1988); i.e. species are awarded scores according to a sample gradient and sample scores are calculated as a weighted average of species scores, and the procedure is repeated (interactions) until there is no change in either score. This method allows species and sampling stations to be plotted on one and the same graph and hence gives the interpretation of their relationship. Species that occurred only once were excluded from this analysis.

## Results

### Underwater observations and sedimentological data

In the intertidal zone and adjacent areas, down to a depth of 4 m, the surface sediment was predominantly

composed of different-sized boulders and gravels overlaying a sandy substratum. Macroalgal debris, especially of the genera *Desmarestia*, *Himantothallus* and *Leptosomia*, was often found in abundance on the shore, where it was deposited by tide and storm waves. Epifauna was virtually absent in the upper littoral, down to a 5-m depth, apart from the patellid gastropod *Nacella concinna*, which was most abundant at 3 m depth. Living between the pebbles in the infralittoral zone was a whole variety of amphipod species, such as *Gondogeneia antarctica*, *Paramoera walkeri*, *Bovallia gigantea* and *Cheirimedon femoratus*, amongst others.

Below 4 m depth, the coarse sediment found in the very shallow water gave way to a typically sandy sediment, whose composition could be made up of 96% sand (Table 1). A markedly high density of the isopod *Serolis polita* could be seen on sandy substrata, at a depth of 11 m in the summer of 1991, when 364 of them were counted in 1 frame of 1 m<sup>2</sup>. These isopods were often observed in pre-copula. *N. concinna* was occasionally found at this depth, as well as a few specimens of nudibranchs. Proceeding downwards, the first specimens of the bivalve *L. elliptica* could be observed. The existence of a diatom mat on the surface sediment and flocculant ooze deposited on the water-sediment interface hindered an adequate survey of the surface macrofauna. The polychaete *Barrukia cristata*, for instance, exhibited an almost perfect disguise, having the body covered by scales with protuberances like sand grains and hirsute setae, the animal thus being confounded with the sediment.

The area between 15 and 18 m depth was characterised by a peculiar topography, consisting of depressions and crests of up to 2 m in height, with 1–2 m between successive crests. These special features of the sea bottom, referred to as ice scours, are created by the underside of icebergs. These formations caused remarkable differences in the sediment texture, which could be observed in some sampling sites, where a variation of 29–73% of the sand content was found in consecutive summers (Table 1). The crests and upper sides of the scours were inhabited by *L. elliptica* and occasionally by ascidians. In the depressions, a motile fauna

**Table 1** Granulometric analysis of the sediment

Year	Depth (m)	Granules (%)	Sand (%)	Silt (%)	Clay (%)	Classification of Folk and Ward (1957)
1989	6	2.7	94.2	3.1	0.0	Fine sand
	11	4.7	80.6	9.4	5.2	Fine sand
	18	13.1	29.2	25.1	32.5	Medium silt
	25	15.7	34.7	23.3	26.3	Very fine sand
1991	6	0.5	96.4	3.1	0.0	Fine sand
	11	1.6	40.6	26.3	31.6	Medium silt
	18	2.6	73.2	13.7	10.5	Very fine sand
	25	4.7	22.4	34.9	38.1	Fine silt
1994	6	0.4	87.6	8.5	3.4	Very fine sand
	11	1.5	73.0	13.6	11.9	Very fine sand
	18	1.9	31.9	27.9	38.3	Fine silt
	25	6.1	23.2	40.4	30.3	Medium silt

predominated, constituted mainly by the sea-urchin *Sterechinus neumayeri*, the nemertean *Parborlasia corrugatus* and the gastropod *Neobuccinum eatoni*, which were often seen associated with algal debris. Some scours presented damaged shells of *L. elliptica* on the walls.

At 25 m depth, a smooth featureless bottom of muddy sediment was found (Table 1). The dominant forms at 18 m depth, such as *Parborlasia corrugatus*, *Neobuccinum eatoni* and *L. elliptica* were also present, although in lower densities. Sessile forms such as sponges, ascidians and some anemones and motile forms, such as the isopod *Glyptonotus antarcticus*, the ophiuroid *Ophionotus victoriae* and some asteroids, especially *Odontaster validus*, with occasional occurrence at shallower depths, attained their highest density at 25 m depth.

The depth profile of the shallow coastal area off the Brazilian Antarctic Station "Comandante Ferraz", with the topographic variation and the bathymetric distribution of the megafaunal taxa, is shown in Fig. 2.

#### Quantitative data

A total of 4406 specimens belonging to 12 taxa were counted in 89 surveyed quadrats. The density of each species along the transect is shown in Table 2 and a

depth zonation is observed with interannual differences (Fig. 3). Higher values of density were recorded in 1991, at depths of 6 and 11 m, owing to the high number of *Serolis polita*. At 18 and 25 m depth the values of density were quite similar in the different summers.

The number of taxa was very low and showed a slight increase with depth, except in 1989 (Fig. 4). In 1989, the mean values of  $H'$  and  $J'$  were higher at 11 and 15 m depth and showed the lowest value at 18 m depth. A great dominance of *L. elliptica* at this depth was responsible for this value. The low mean values obtained at 6 and 11 m depth in 1991 were due to the dominance of *Serolis polita*. In 1994, both indices had an increase with depth.

#### Depth and interannual variation

ANOVA results show clearly that, as expected, the variation of density, number of taxa and diversity between different depths is very high. Besides this, an interannual variation was also high for diversity and

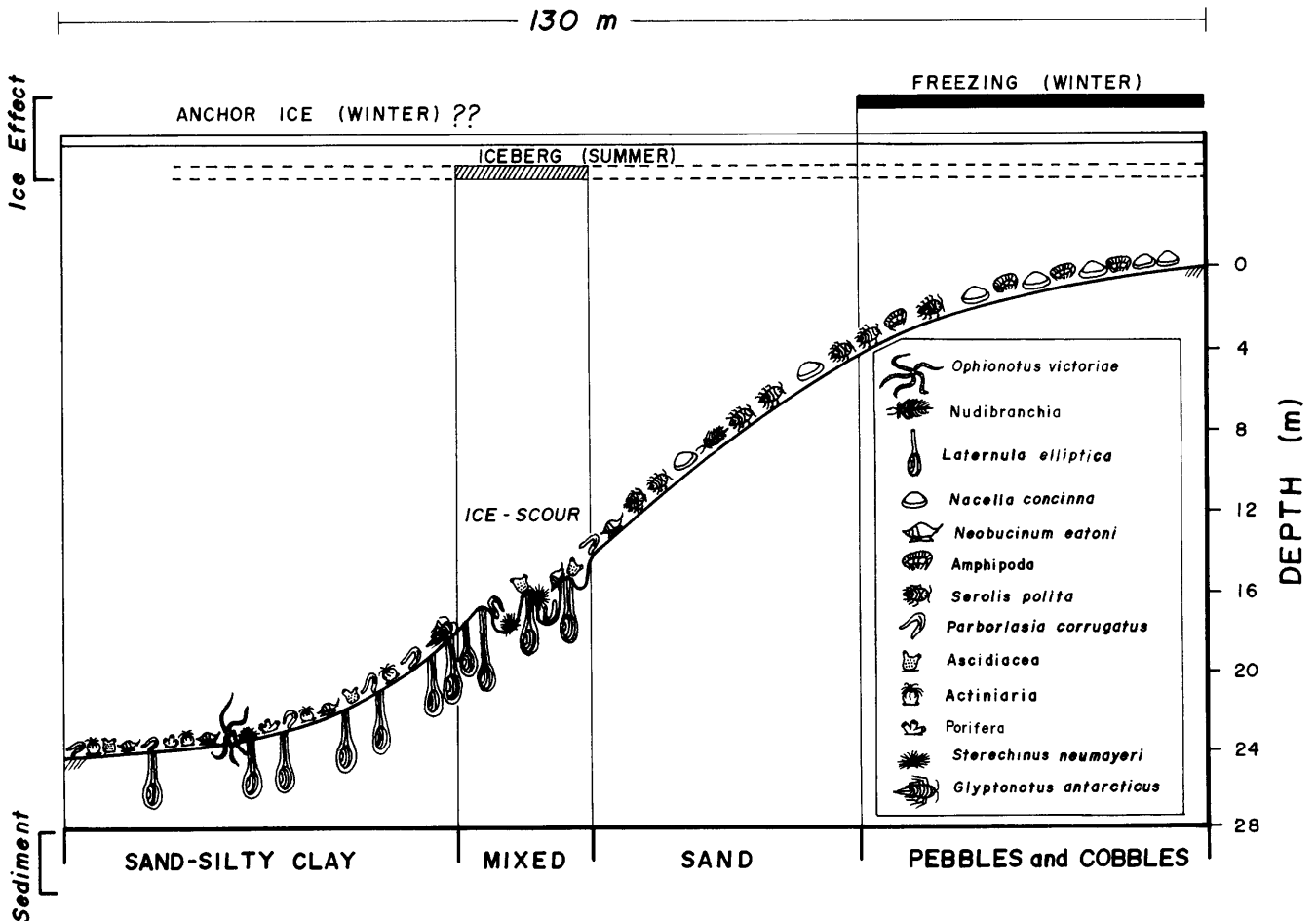


Fig. 2 Depth profile of the shallow coastal area off the Brazilian Antarctic Station "Comandante Ferraz", showing the topographic variation and the bathymetric distribution of the megafaunal taxa

**Table 2** Means ( $\pm$  standard deviations) of density (individuals  $\cdot$  m<sup>-2</sup>) of the benthic megafauna

Depth (m)	11			15			18			25		
	1989	1991	1994	1989	1991	1994	1989	1991	1994	1989	1991	1994
<i>Nacella concinna</i> (Gastropoda)	0.5 $\pm$ 0.5	1.8 $\pm$ 2.1	2.1 $\pm$ 3.4	2.1 $\pm$ 2.2	2.0 $\pm$ 2.3	0.6 $\pm$ 1.1	0.2 $\pm$ 0.4	0	0	0	0	0
<i>Serolis polita</i> (Isopoda)	4.8 $\pm$ 4.3	103.6 $\pm$ 58.3	29.3 $\pm$ 29.5	16.3 $\pm$ 16.4	274.3 $\pm$ 251.8	49.4 $\pm$ 26.1	0	0	27.8 $\pm$ 9.3	15.4 $\pm$ 16.6	0	1.1 $\pm$ 2.5
Nudibranchia	0	0	0	0	1.8 $\pm$ 0.4	0	0	0	0	0	0	0
<i>Sterechinus neumayeri</i> (Echinoidea)	0	0	0	0.1 $\pm$ 0.3	0	0.1 $\pm$ 0.3	10.0 $\pm$ 12.2	0	0	0	0	0
<i>Parborlasia corrugatus</i> (Nemertini)	0	0	0	0.4 $\pm$ 1.0	0	1.5 $\pm$ 3.1	0.7 $\pm$ 0.9	0.8 $\pm$ 1.9	1.3 $\pm$ 2.2	0.7 $\pm$ 0.8	0.3 $\pm$ 0.5	0.8 $\pm$ 1.3
<i>Laternula elliptica</i> (Bivalvia)	0	0	0	11.3 $\pm$ 11.4	1.0 $\pm$ 0.4	4.4 $\pm$ 6.0	13.7 $\pm$ 12.8	65.5 $\pm$ 20.3	24.3 $\pm$ 15.3	23.3 $\pm$ 23.2	30.5 $\pm$ 15.6	7.5 $\pm$ 7.6
<i>Neobuccinum eatoni</i> (Gastropoda)	0	0	0	0	0	0	0.5 $\pm$ 0.8	0.8 $\pm$ 1.2	0.3 $\pm$ 0.4	0.5 $\pm$ 0.5	0.2 $\pm$ 0.4	2.3 $\pm$ 1.8
Asciacea	0	0	0	0	0	0	1.5 $\pm$ 2.6	0	0	0	0	2.3 $\pm$ 1.9
Actiniaria	0	0	0	0	0	0	0.5 $\pm$ 0.8	0.3 $\pm$ 0.5	0	0.4 $\pm$ 0.5	3.0 $\pm$ 3.6	2.1 $\pm$ 3.9
Porifera	0	0	0	0	0	0	0	0	0	0	0.2 $\pm$ 0.4	0.3 $\pm$ 0.4
<i>Glyptonotus antarcticus</i> (Isopoda)	0	0	0	0	0	0	0	0	0	0	0	0.1 $\pm$ 0.3
<i>Ophionotus victoriae</i> (Ophiuroidea)	0	0	0	0	0	0	0	0	0	0	0	0.1 $\pm$ 0.3
Total	5.3 $\pm$ 4.5	105.4 $\pm$ 64.4	31.4 $\pm$ 28.8	30.1 $\pm$ 22.9	279.0 $\pm$ 100.7	56.0 $\pm$ 30.0	27.0 $\pm$ 19.5	69.2 $\pm$ 18.2	53.5 $\pm$ 29.6	40.3 $\pm$ 22.1	34.2 $\pm$ 15.3	15.5 $\pm$ 9.3
												15.5 $\pm$ 11.9

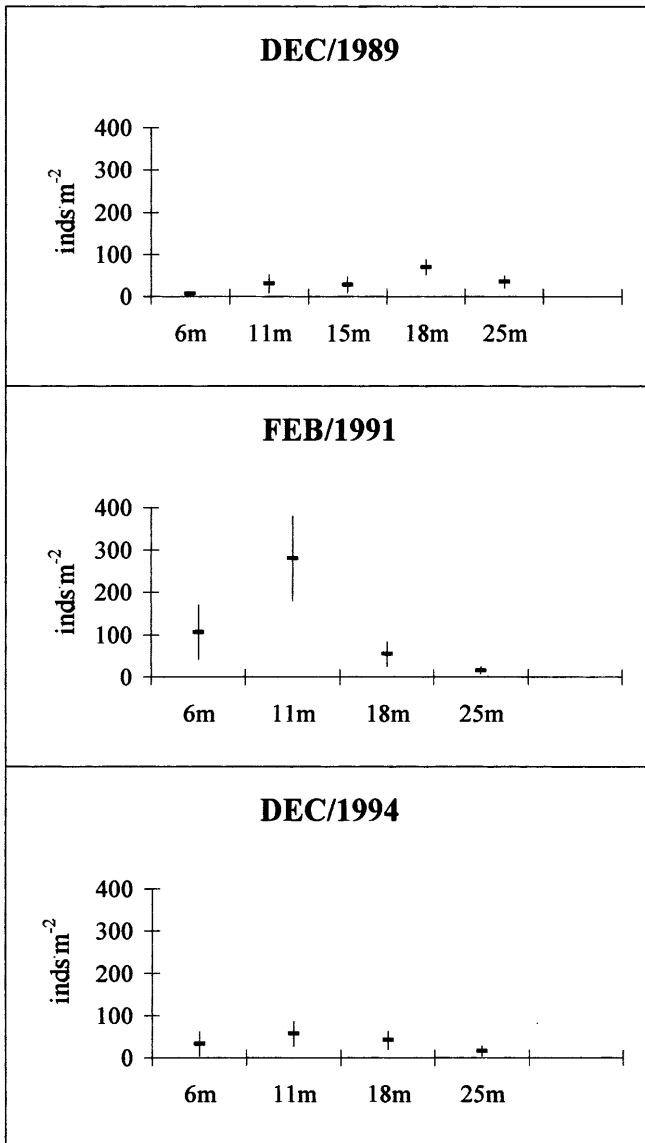


Fig. 3 Mean densities (individuals  $m^{-2}$ ) of the total benthic megafauna at each depth

mainly for total density (Table 3). Evenness was the community parameter that showed the lowest variation, mainly between years, although the interaction factor (year  $\times$  depth) was significant, indicating a variation with depth in different years.

The results of the MANOVA for the dominant species showed the same pattern observed for density, with variation in both factors and a strong interaction factor, indicating that the depth range of species changed in different years. *Serolis polita*, for instance, common in shallower depths (6 and 11 m) in 1991 and 1994 was less abundant in 1989 and presented a wider distribution with a secondary abundance peak at 18 m. *L. elliptica*, conversely, was much more abundant in 1989 and more restricted to depths below 18 m.

In the DCA ordination, the first main axis ranked the pooled replicates by depth range, with the exception of

the 1989/25 m depth that was gathered to 18 m depth in 1991 and 1994 (Fig. 5). Conversely, 1989/15 m and 1989/18 m depths are ranked close to the 25 m depth in 1991 and 1994, indicating that the 15 and 18 m depths are not totally different from 25 m depth, characterised by finer sediments and a gentle slope as compared to the shallower stations. A shift of benthic dominance occurred in this area, with the presence of less motile forms like *L. elliptica* and sessile ones (sponges, anemones and ascidians).

The second axis of the DCA was much less variable, but showed differences between years. This indicated some temporal variation, which is likely to occur when one considers that the surveys were made at different periods of the austral summer.

## Discussion

The depth zonation of the benthic megafauna in the study area appears to be influenced by two main factors: the nature of the substratum and, particularly, by the effect of the ice (Fig. 2). This effect can be in the form of the frozen sea surface (fast ice) and the formation of anchor ice in winter, and by floating ice grounding and scraping on substratum (ice scour) in summer (Barnes 1999).

Despite the suitable substratum, the multiple action of the ice prevents the occurrence of sessile forms, such as sponges, ascidians and anemones, in the shallower areas of the bay that are subject to freezing during winter. These conditions enable the maintenance of a low-diversity community dominated by the herbivorous *Nacella concinna*, many amphipods and the isopod *Serolis polita*, which are capable of escaping to deeper zones during winter, a well-known pattern for the Antarctic nearshore areas (Dayton et al. 1970; Arntz et al. 1994; Gutt et al. 1996; Sakurai et al. 1996). The return of species to an impacted site and the recovery of communities are controlled by several factors. The earliest species to return to sites are those that are mobile, such as amphipods and isopods (Peck et al. 1999). At 11 m depth, the finer sediments permitted the establishment of the first specimens of *L. elliptica*.

Off the Brazilian Station, ice scours were observed only in a narrow band of 8- to 10-m width in water depths between 15 and 18 m. The bed gradient is the steepest in this region and may be an important factor for the local distribution of ice scours in the area. This feature was restricted to this limited site, since adjacent areas (200 m apart) showed a gentle slope and no scours were observed. The presence of damaged fauna in some scours and an established sessile fauna in others, as well as the recovery of the original superficial substrata on the walls of the disturbed area, suggest the occurrence of different scour events. Locomotion, dispersal by water currents and larval recolonisation are the major mechanisms (identified by Peck et al. 1999) acting on the

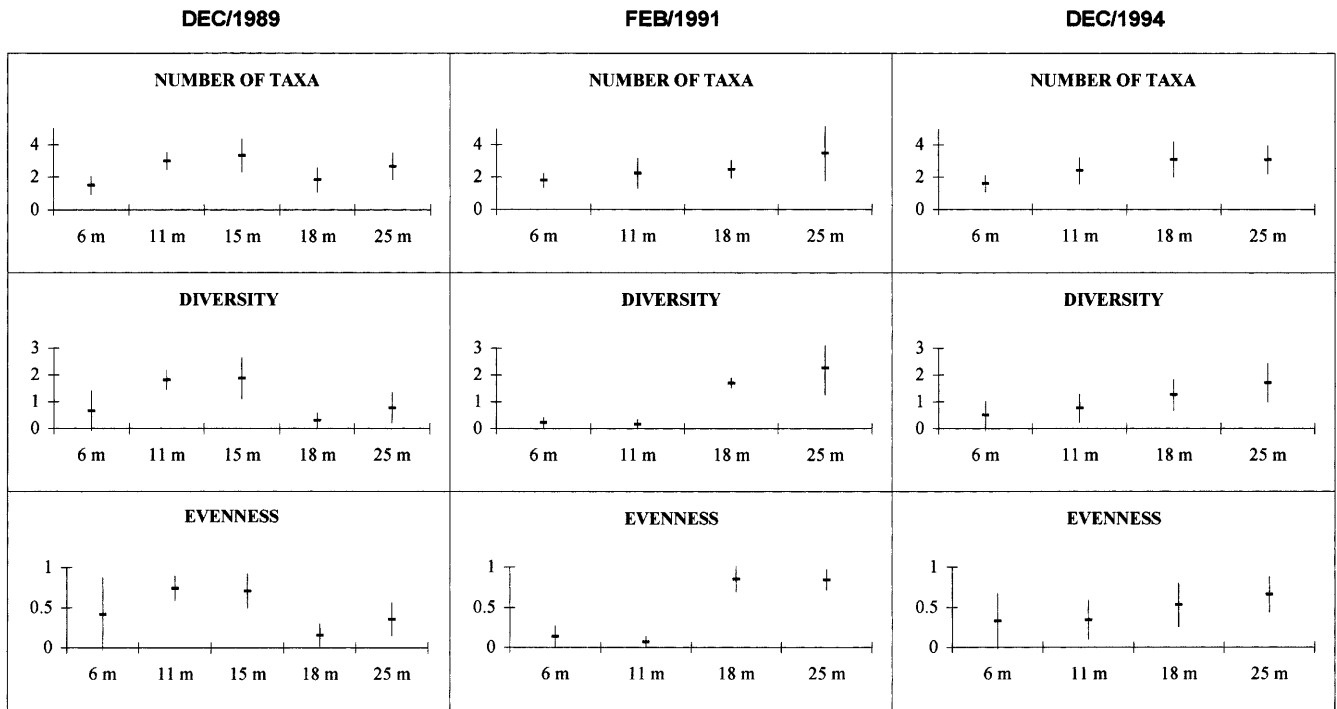


Fig. 4 Mean values of number of taxa, diversity ( $H'$ ) and evenness ( $J'$ ) at each depth

Table 3 Results of the ANOVA and MANOVA analyses

	Year	Depth	Interaction (Year × Depth)
ANOVA			
Density	$P = 0.002$	$P < 0.001$	$P < 0.001$
Number of taxa	$P = 0.197$	$P < 0.001$	$P = 0.061$
Diversity ( $H'$ )	$P = 0.077$	$P < 0.001$	$P < 0.001$
Evenness ( $J'$ )	$P = 0.572$	$P = 0.150$	$P = 0.002$
MANOVA			
Species	$P < 0.001$	$P < 0.001$	$P = 0.007$

recolonisation of iceberg-impacted sites on shallow soft sediments. They act on different timescales.

In Martel Inlet, winds usually blow from northern or southeastern directions because of the passage of low-pressure systems. This generally prevents icebergs from the Bransfield Strait from being carried towards the coast off the Brazilian Station. The largest icebergs that occasionally enter Admiralty Bay run aground in the main channel and are unable to penetrate further inside the inlet. Icebergs originating from the Stenhouse Glacier (Fig. 1) are more likely to impinge on the area in front of the station. A single iceberg with a height of 5 m would be able to cause, under the action of strong winds and tides, all the irregularities observed. The turning over of an iceberg after partial melting could also have a significant impact on the sea-bed, possibly causing deeper circular scarring rather than abrasions parallel to the coast.

The spatial distribution of *L. elliptica* is a good indication of the stability of the benthic community

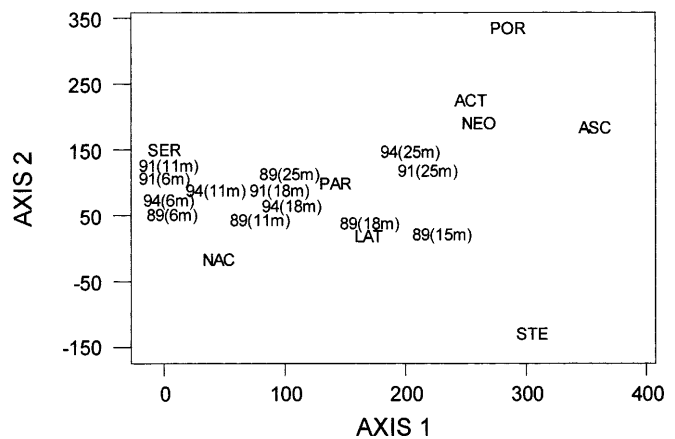


Fig. 5 DCA (Detrended Correspondence Analysis) plot of the samples and species rank (*SER Serolis polita*, *NAC Nacella concinna*, *PAR Parborlasia corrugatus*, *LAT Laternula elliptica*, *ACT Actiniaria*, *NEO Neobuccinum eatoni*, *POR Porifera*, *STE Sterechninus neumayeri*, *ASC Ascidiacea*)

(Wägele and Brito 1990), owing to its slow growth and long life-cycle. The occurrence of specimens of *L. elliptica* on the tops of the ice-scour zone indicates that the action of icebergs at this depth band is rare, allowing the maintenance of faunistic and sedimentary patches between impacted areas and older stable areas. In some areas of strong disturbance, only empty shells of *L. elliptica*, *Yoldia eightsi* and *Nacella concinna* were present.

Observations made on either side of the transect at 18 m depth showed regions free of ice scours, where the densities of *L. elliptica* were much higher than at 25 m depth. The patchy distribution in the zone of ice scouring, with *L. elliptica* and some ascidians on the

crests of the scours and some motile forms such as *Sterechinus neumayeri*, *Parborlasia corrugatus* and *Neobuccinum eatoni* found in the depressions of the scoured areas, prevents the evaluation of the real population density of these forms using remote sampling. Better results are obtained with direct sampling or visualisation techniques.

In general terms, the more stable condition prevailing below 20–25 m depth allowed the establishment of a more diversified epifauna, including many sessile forms. In spite of this, the fauna was still very poor if compared with other areas (Sahade et al. 1998). Jazdzewski and Sicinski (1993) considered that the 30-m isobath is an important zoocenological boundary in the central part of Admiralty Bay, where a mass occurrence of Bryozoa and Ascidiacea begins and, together with brittle stars, these groups contribute to the great zoobenthos biomass. Between 25 and 45 m depth, in the same line as the transect, a community consisting mainly of *L. elliptica* and *Ophionotus victoriae* was observed by remote VT. Below 30 m depth, high densities of ascidians and sponges were found, and octocorals of the order Pennatulacea were observed for the first time (Brito et al. 1997). Although a richer and more diverse community was observed at 25 m depth in 1991 and 1994, it seems that greater stability relating to the ice effect had not yet been attained. Anchor-ice formation was never observed during our sampling, since it was done in summer, but it is possible, as commented on by Sahade et al. (1998), that this phenomenon may be responsible for the comparatively low diversity and faunistic patches recorded at this depth. We believe that off the Brazilian Antarctic Station, only below 30 m depth was a more stable area found, with a substantial change in the structure, composition and diversity of the benthic megafauna. This consideration is supported by the remote VT observations and by the lower limit of anchor-ice formation (33 m depth) established by Dayton et al. (1969) in McMurdo Sound. Unfortunately, it was not possible to dive below 30 m depth.

The conspicuous depth-related increase in diversity and density for the meio- (Skowronski et al. 1998) and macrofauna (Bromberg et al., in press) in the same transect was not observed for the megafauna. In the same way, differences in the community observed at 18 m depth and attributed to ice scours were not so clear for the megafauna. Although we did not have values of megafaunal biomass, it seems, by underwater observations, that an increase with depth occurs in this transect.

The differences observed in the densities of *Serolis polita* between the three austral summers may be associated with the period of the summer when the sampling was undertaken. In 1989, sampling was carried out at the beginning of the summer (December), possibly prior to the migration of these organisms to the shallower areas. At the end of the summer in 1991 the densities were higher, in accordance with the observations of Wägele and Brito (1990), whose sampling in 1988 was also done in February. For *L. elliptica*, sponges,

ascidians and anemones, the differences in densities might be associated with patchy distribution determined by disturbed and undisturbed areas. The only epibenthic study conducted in four summer seasons in Fildes Bay (King George Island) made no comments on differences due to the sampling period (Sakurai et al. 1996). Otherwise, differences in anchor-ice formation to depths of 30 m at McMurdo Sound were referred to as possible examples of large-scale physical processes exerting profound biological effects over long time periods, possibly decades (Dayton 1989).

Although direct sampling is more appropriate than remote sampling, its results should be analysed with care. The agility of forms such as *Serolis polita* could result in underestimates of the density value, because it swims away after placement of the quadrat on the bed. Difficulties in placement of the quadrat in areas of local bed irregularities such as ice scours may lead to misrepresentation of the populations in these areas. In this case, visual observations, even if semi-quantitative, provide much more reliable information. This is also true for the meio- and macrobenthic studies conducted at the same transect, since it was possible to sample differentially scoured and non-scoured areas (Skowronski et al. 1998; Bromberg et al., in press). At 25 m depth, because of the patchy distribution, a more reliable estimate of the population density could have been obtained by counting a higher number of quadrats, but this was impractical owing to the limited diving time available for this activity.

The differences in benthic communities existing between the area studied and other Antarctic regions are shown to be dependent on zonation. The species encountered in the area studied are largely the same as those observed on similar substrata at other sites in the region (Kirkwood and Burton 1988; Rauschert 1991; Sakurai et al. 1996; Sahade et al. 1998), indicating homogeneity in the benthic fauna of the Antarctic Peninsula.

Some clear faunal differences between the zoobenthos of Admiralty Bay and the zoobenthos studied in other areas may be due to the comparatively sheltered situation of Admiralty Bay as a whole (Jazdzewski and Sicinski 1993). In the same way, differences obtained between the Polish benthic studies and our study may be due to the fact that the sampling transect of Polish scientists was situated in a non-sheltered region of Admiralty Bay and, in comparison with Martel Inlet, was less influenced by the sedimentation of suspended matter introduced by inflowing water from melting glaciers (Jazdzewski and Sicinski 1993).

The sampling and underwater observations of the Antarctic benthic fauna from shallow waters over a whole summer period and the possibility of following iceberg impacts, as was done by Conlan et al. (1998) and Peck et al. (1999), could contribute to a better understanding of the influence of ice on the movement of this fauna along the coast and its temporal variation in Martel Inlet. The tendency to present a great number of motile individuals in shallower areas at the end of the



austral summer appears to be an Antarctic pattern, and was also observed for the macrofauna (Bromberg 1999; Bromberg et al., in press) in the same transect.

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