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Macrobenthos–sediment relationships in a sandy bottom community off Mar del Plata, Argentina

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The aim of this study is to characterize the different macrozoobenthos communities in Mar del Plata waters (south-western Atlantic) on the basis of their abundance and habitat, and to determine how sediment characteristics, like the grain-size composition, affect macrobenthic community structure. Multivariate techniques indicated that benthic communities and sediments in the surveyed area were included into the following five well-defined groups: (1) a medium sand assemblage dominated by the bivalve Crassinella marplatensis *and* Diplodonta patagonica*, the echinoderm* Encope emarginata*, the tanaidacean* Bacescapseudes *sp. and the polychaete* Armandia loboi*; (2) a medium to very fine sand assemblage dominated by ostracods, the tanaidacean* Bacescapseudes *sp., amphipods and polychaetes of the family Nephtyidae; (3) a fine to very fine sand assemblage dominated by the tanaidacean* Bacescapseudes *sp.; (4) a silt and fine sand assemblage dominated by polychaetes particularly* Scolelepis *sp. and individuals of the family Nephtyidae; and (5) a fine sand assemblage dominated by amphipods and the tanaidacean* Bacescapseudes *sp. These results revealed the patchy distribution of macrobenthic assemblages as a result of sediment characteristics and serve as baseline information for this area strongly subjected to trawling perturbations.*

Keywords: macrobenthos, grain size composition, patchy distribution, south-western Atlantic

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INTRODUCTION

The understanding of the distribution of organisms in their habitat is a relevant issue in ecology. Macrobenthos in marine sediments is a key component of soft-bottom food webs including crustaceans and fish, and plays an important role in system dynamic processes such as nutrient cycling, dispersion and burial. The distribution and abundance of the macrobenthos communities are controlled by a series of environmental factors such as habitat characteristics (Peeters *et al.*, 2004), sediment quality (Chapman *et al.*, 1997), grain-size composition (Mannino & Montagna, 1997) and some ecological interaction factors such as competition and predation (Wilson, 1990). In studies conducted in the northern seas, many authors have shown that macrobenthic community distribution is correlated with the type of sediments (Sanders, 1958; Hensley, 1996; Warwick & Davies, 1997), while others suggested that it is controlled by physical factors at the sediment–water interface (Snelgrove & Butman, 1994) or by seasonal events (Holme & Wilson, 1985).

There have been only few studies dealing with soft-bottom macrozoobenthic communities in the South Atlantic Ocean, mainly focusing on the negative impact of coastal sewage discharge (Elías, 1992; López Gappa *et al.*, 1993; Elías *et al.*, 2003). In this regard, Elías *et al.* (2001) reported that organic enrichment decreased the relative abundance of macroinfauna in the shallowest subtidal zone and areas around the outfall.

The aim of this study is to determine the assemblage structure of macrozoobenthos communities off Mar del Plata (south-western Atlantic), to characterize them in terms of abundance and habitat, and to evaluate sediment characteristics influencing their structure. In order to assess the role of external factors in community structure, the community structure was related to sediment characteristics like the grain-size composition. On the basis that the studied area is subject to intensive fishing pressure and is heavily influenced by fishery activities such as dredging and oil pollution, this work aimed to provide data for further evaluation of changes in the macrobenthos community structure as a consequence of trawling.

MATERIALS AND METHODS

Study area

The study was conducted over the inner shelf next to the open coast off the port of Mar del Plata City (38°00′S 57°31′W), near the Corrientes Cape. The area, with a biomass ranging from 192 to 638 g 100 m^{-2}, is a prawn-shrimp fishing ground for *Artemesia longinaris* Bate, 1888 and *Pleoticus*

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muelleri (Bate, 1888) (Scelzo *et al.*, 2002). The sampling was made at 15–18 m depth, over an area of approximately 0.12 km² (Figure 1). During the year, salinity varies between 33.5 and 33.8 psu and temperature between 8 and 21°C (Guerrero & Piola, 1997).

Sampling of sediment and benthos

Samples for biological and sediment analyses were collected from June 2003 to January 2004. Fifty-five sampling stations were selected within the studied area. At each station, samples were taken with a Van Veen bottom grab with a sampling surface of 0.026 m².

On board, the sediment was stored in plastic bags and preserved in a 5% formalin–seawater solution. In the laboratory, grab samples were passed through a series of stacked sieves (smallest sieve: 500 μm mesh size). The residues retained in the sieves were stained with rose Bengal to distinguish macrofauna, which was separated and preserved in 70% ethanol. Benthic fauna was recognized using a stereomicroscope and invertebrates were identified to the lowest taxonomic level possible.

Sediment samples were analysed for grain-size distribution. The coarser samples were dry-sieved through a nested series of sieves and the material retained was weighed. The rest of the samples were analysed using a diffraction particle size distribution analyser (CILAS 1180 Liquid). Six particle size-classes were used: silt (<62 μm); very fine sand (62–120 μm); fine sand (120–250 μm); medium sand (250–500 μm); coarse sand (500–1000 μm) and very coarse sand (>1000 μm). Granulometric fractions were determined according to Perillo *et al.* (1985).

Statistical analyses

The PRIMER (Plymouth Routines in Multivariate Ecological Research) software package (Clarke & Warwick, 1994) was used for data analysis. Different assemblages were described based on the community structure. Hierarchical clustering with group-average linking was applied to abiotic and biotic data. The Bray–Curtis similarity index was used for species abundance and Euclidean distance for sediment characteristics. An *a priori* ANOSIM test was performed to examine if significant differences exist between months. These analyses were followed by a non-metric multidimensional scaling (MDS). The organisms which most contributed to the differences observed among groups were determined by the SIMPER (similarity percentages) procedure. The Shannon–Wiener diversity index (H) was calculated as: $H = -\sum pi \times (\log_e pi)$, where pi is the proportion of abundance ith species from total benthos abundance (A). Differences among groups were tested with analysis of variance (ANOVA) followed by the Tukey test. Normality was tested with the Kolmogorov–Smirnov test and homoscedasticity with the Levene test. Comparisons were considered significantly different at a level of $P < 0.05$. The two similarity matrices were compared with the Spearman's rank-correlation coefficient (ρ) using the RELATE routine; values close to zero indicate

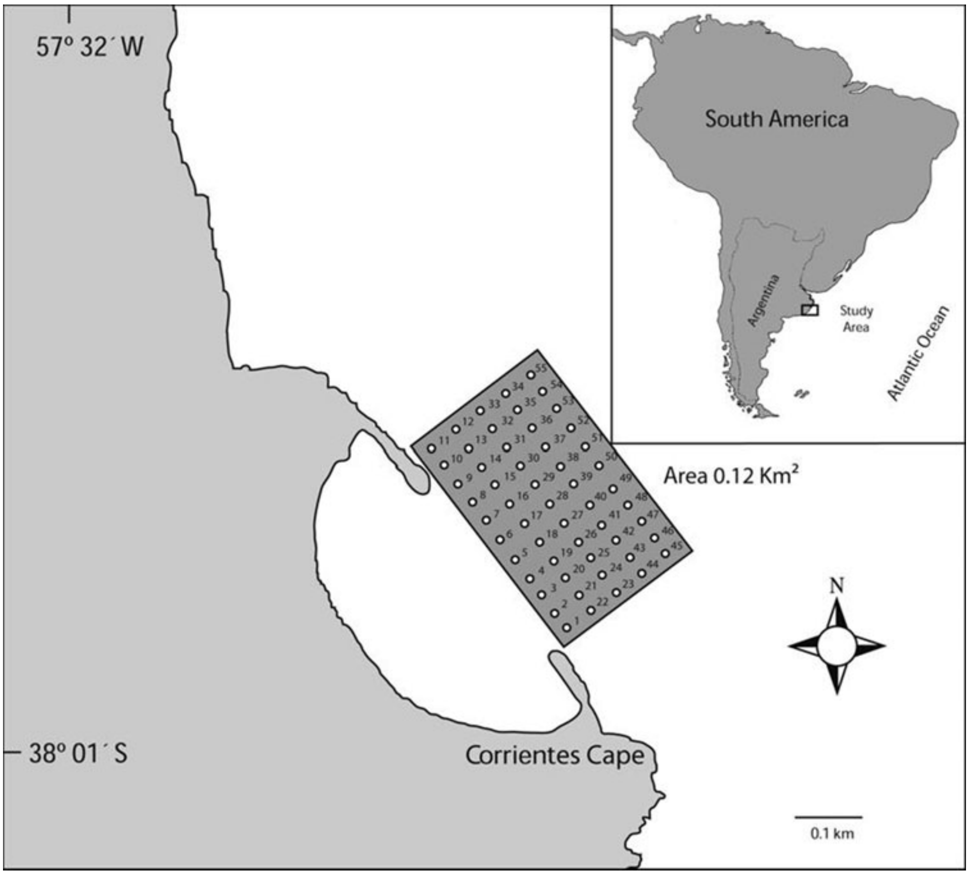

Fig. 1. Map of Mar del Plata City showing the location of the sampling area.

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Table 1. List of species within each group and their total abundance (individuals m^{-2}).

Species		Group I	Group II	Group III	Group IV	Group V
Bacescapseudes sp.	T	486	1602	24297	312	1602
Amphipods	A	156	1172	1797	156	6523
Anchistylis notus	C	39	0	0	0	0
Leptocuma kinbergii	C	39	0	273	0	78
Makrokylindrus bacescui	C	0	78	0	0	39
Claudicuma sp.	C	0	78	1172	59	157
Cyclaspis sp.	C	0	0	352	0	195
Ancinus sp.	I	117	0	0	20	0
Leptoserolis sheppardae	I	0	0	0	0	352
Ostracods	O	0	8945	1602	78	1406
Bivalve unidentified	B	39	703	117	39	156
Crassinela marplatensis	B	1641	273	0	20	78
Diplodonta patagonica	B	547	330	195	0	195
Solen tehuelchus	B	0	0	0	20	156
Tellina gibber	B	78	156	117	0	78
Corbula patagonica	B	0	0	0	78	0
Mytilidae	B	117	0	0	0	0
Gastropod unidentified	G	0	39	0	0	0
Olivella puelcha	G	39	0	0	0	0
Nephtyidae unidentified	P	78	625	117	176	312
Nephtys sp.	P	39	39	39	0	0
Aglaophamus uruguayi	P	0	39	0	0	0
Magelonidae unidentified	P	78	0	0	0	0
Scolelepis sp.	P	0	156	78	410	195
Lacydoniidae unidentified	P	0	0	0	20	0
Goniadidae unidentified	P	0	0	0	0	39
Sphaerodoridae unidentified	P	0	39	39	0	39
Phyllodocidae unidentified	P	78	0	39	0	0
Orbiniidae unidentified	P	0	39	0	0	117
Haploscoloplos sp.	P	0	0	0	0	78
Scalibregmidae unidentified	P	0	117	0	0	0
Scalibregma sp.	P	39	39	195	0	0
Syllidae unidentified	P	117	0	0	0	0
Spionidae unidentified	P	39	0	78	0	78
Prionospio sp.	P	39	273	117	0	0
Ophelina sp	P	0	39	0	0	0
Armandia loboi	P	195	0	0	0	156
Paraonidae unidentified	P	78	39	78	0	0
Cirratulus sp.	P	0	117	0	20	0
Onuphis sp.	P	0	0	0	0	234
Encope emarginata	E	508	0	0	0	0
Total abundance		4586	14937	30702	1408	12263

T, tanaidaceans; A, amphipods; C, cumaceans; I, isopoda; B, bivalve; G, gastropoda; tanaidaceans; A, amphipods; C, cumaceans; I, isopoda; B, bivalve; G, gastropoda; P, polychaete; E, echinoderm; P, polychaete; E, echinoderm.

lack of relationship. The BIO-ENV procedure was used to match biotic patterns with environmental variables, in this case particle size composition.

RESULTS

Characteristics of macrobenthic assemblages

Forty-one species/taxa comprising 1745 individuals were collected from the 55 sampling stations. The number of species (S) in a single sample varied between 3 and 11 species/taxa. Amphipods and polychaetes were the most common taxa, both were found in 81% of the samples, followed by tanaidaceans (71%), bivalves (54%), cumaceans (47%) and ostracods (44%). Other taxa (i.e. isopods, gastropods and echinoderms) occurred in less than 12% of the samples. Total abundance in each sample varied between 156 and 6758 ind. m^2. Tanaidaceans, followed by bivalves and amphipods, were the most abundant taxa (Table 1). An *a priori* ANOSIM test revealed that the community composition was not significantly different between months ($r = 0.0292$, $P < 0.1$).

Five well-differentiated groups were identified by the cluster analysis (Figure 2). The SIMPER revealed differences in macrobenthos composition and abundance among sampling sites (Table 2). Group I was dominated by bivalves (with *Crassinella marplatensis* Castellanos, 1970 being the most abundant, followed by *Diplodonta patagonica* d'Orbigny, 1842), the echinoderm *Encope emarginata* (Leske, 1778), the tanaidacean *Bacescapseudes* sp. Guto, 1981 and polychaetes (particularly *Armandia loboi* Elías & Bremec, 2003). Group II was characterized by the presence of ostracods, *Bacescapseudes* sp., amphipods and polychaetes (mainly unidentified individuals belonging to the family

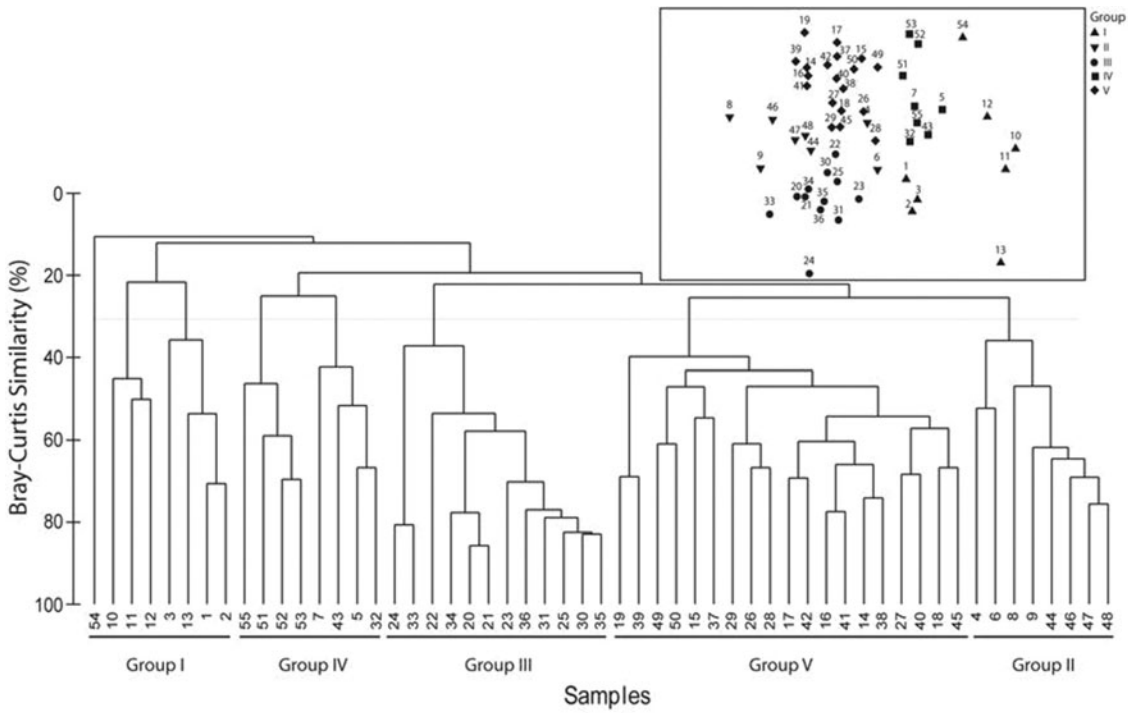

Fig. 2. Bray–Curtis similarity index for macrobenthic abundance, and the corresponding two-dimensional MDS (multi-dimensional scaling) ordination (stress = 0.21).

Nephtyidae and, to a lesser extent, to the family Spionidae). Group III was characterized by *Bacescapseudes* sp.; this group showed the highest abundance values. Group IV was characterized by polychaetes, particularly *Scolelepis* sp. Blainville, 1828 and individuals of the family Nephtyidae and *Bacescapseudes* sp.; this group had low abundance. Finally, group V was dominated by amphipods and *Bacescapseudes* sp. The MDS analysis discriminated the same five groups obtained by the cluster analysis (Figure 2).

Analysis of variance showed that there were significant differences in diversity ($P < 0.05$) (Figure 3). The *post-hoc* Tukey's test showed difference between group III and the other groups and the same result was obtained for group IV.

Table 2. SIMPER analysis of macrobenthic community.

	Average abundance	Average similarity	Similarity/SD	Per cent (%)
Group I. Average similarity: 26.38				
Crassinela marplatensis	5.25	12.45	0.98	47.19
Diplodonta patagonica	1.63	4.53	0.60	17.17
Encope emarginata	1.25	3.36	0.58	12.72
Bacescapseudes sp.	1.75	2.02	0.45	7.68
Group II. Average similarity: 48.92				
Ostracoda	28.63	33.79	2.97	69.07
Bacescapseudes sp.	5.13	4.68	1.01	9.57
Amphipods	3.75	4.52	1.28	9.25
Nephtyidae unidentified	2.00	1.29	0.71	2.65
Group III. Average similarity: 56.47				
Bacescapseudes sp.	51.83	47.31	2.94	83.78
Amphipods	3.83	3.20	0.99	5.67
Ostracods	2.42	2.95	1.16	5.22
Group IV. Average similarity: 36.44				
Scolelepis sp.	2.00	13.13	0.88	36.03
Bacescapseudes sp.	1.00	7.48	1.36	20.53
Nephtyidae unidentified	2.63	7.21	0.62	19.78
Group V. Average similarity: 47.85				
Amphipods	8.79	35.49	3.35	74.17
Bacescapseudes sp.	2.16	4.56	0.62	9.53
Ostracods	1.89	2.95	0.46	6.17

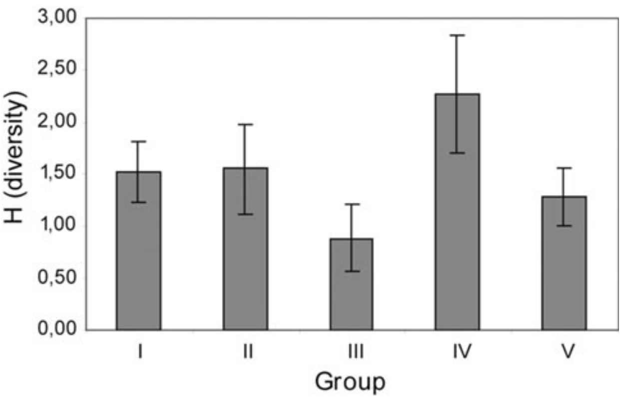

Fig. 3. Mean ± standard deviation of Shannon–Wiener diversity index.

Characteristics of sediments

An *a priori* ANOSIM test revealed that the sediment compositions were not significantly different between months ($r = 0.0883$, $P < 0.1$). The results of the cluster analysis and MDS ordination based on the percentage particle-size distribution at each of the stations sampled are shown in Figure 4. In these analyses, five groups were identified featuring the following assemblages: group A, medium sand (250–500 μm); group B, medium to very fine sand (62–500 μm); group C, fine to very fine sand (62–250 μm); group D, silt (<62 μm); and group E, fine sand (120–250 μm).

Relationship between particle size and macrofauna composition

The correlation coefficient between sediment composition and the structure of the benthic community was high ($\rho = 0.497$; $P < 0.01$), thus suggesting that the occurrence of some species was related to particular sediment types. The relationship between macrofauna composition and sediment composition is summarized in Table 3 by representing the combination of environmental variables which yield the best matches of macrofauna and sediment similarity matrices, as measured by weighted Spearman rank-correlation. The correlations between individual faunal groups and particle size composition were high.

In group I macrobenthic community is associated with medium sand sediments. The group II community is associated mainly with medium to very fine sand. The group III community is characterized by fine to very fine sand; it showed the highest abundance and lowest Shannon–Wiener diversity index. The group IV community is associated with silt and fine sands and showed the lowest values of abundance and number of species and the highest value of diversity index. The group V community is characterized by fine sand.

DISCUSSION

The objective of this study has been to establish a relationship between macrobenthic community composition and grain-

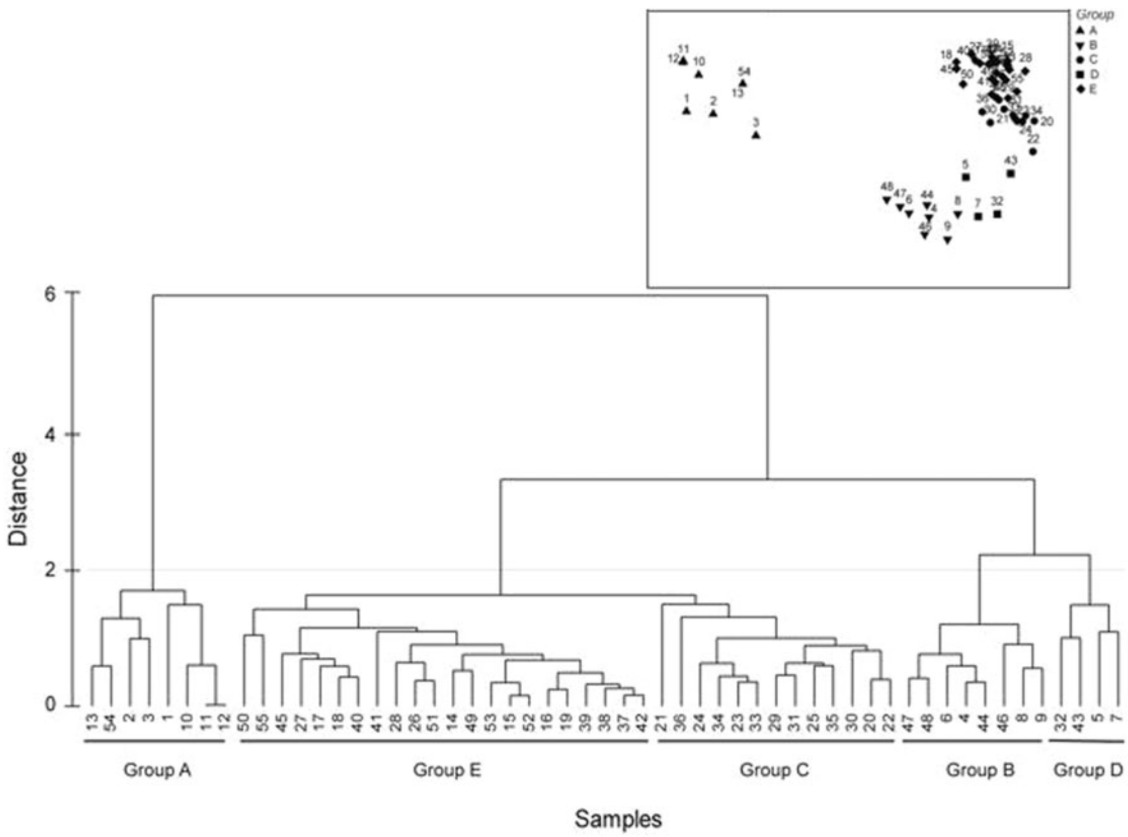

Fig. 4. Euclidean distance for sediment composition, and the corresponding two-dimensional MDS (multi-dimensional scaling) ordination for sediment composition (stress = 0.13).

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Table 3. Combination of environmental variables giving the largest weighted Spearman rank-correlation between macrobenthic faunal groups and sediment composition (particle size-classes and per cent composition).

Faunal group	Variables	Optimum variable combination	Spearman's correlation coefficient (ρ_w)
I	Particle size-class	1000, 500, 250	0.867
	Per cent composition	% medium sand	0.765
II	Particle size-class	500, 250, 120, 62	0.745
	Per cent composition	% fine	0.791
III	Particle size-class	250, 120,62	0.691
	Per cent composition	% very fine	0. 843
IV	Particle size-class	250, 120,62, <62	0.491
	Per cent composition	% silt	0.400
V	Particle size-class	250, 120	0.702
	Per cent composition	% fine sand	0.531

size composition in sandy bottoms off Mar del Plata City. The close relationship between macrobenthic communities and sediment composition has been shown in numerous studies (e.g. Sanders, 1958; Wilson, 1990; Nanami *et al.*, 2005), although other studies suggest little correspondence between sediment composition and benthic communities (Seiderer & Newell, 1999; Newell *et al.*, 2001). In some South American systems, the granulometric type proved to be the main abiotic variable determining the spatial distribution of polychaete assemblages (Elías & Bremec, 1994; Capitoli *et al.*, 2004; Bremec & Giberto, 2006).

The present study reveals that the study area was not homogeneous in terms of macrobenthic community composition and grain-size composition, and that they were related to each other. Despite the fact that similarity was lower for benthic communities than for sediments, they fell into the same well-defined groups. Comparison of the similarity matrices for benthic communities and sediments yields a value of 0.5 for the Spearman's rank-correlation (RELATE routine). The correlation between individual faunal groups and particle-size composition yields values of >0.4 for the weighted Spearman's rank-correlation (BIO-ENV routine). Those values suggest that different environmental conditions, in this case distinct grain-size composition, may contribute in controlling macrobenthic communities.

Five macrobenthic assemblages, separable largely on the basis of sediment characteristics, were recognized within the studied area. The bivalves *Crassinella marplatensis* and *Diplodonta patagonica* were the dominant species in group I, featuring sandy sediment. This result is consistent with the distribution pattern of benthic organisms proposed by Sanders (1958), with filter-feeders dominating in coarse sediments. In contrast, mud substrates were dominated by deposit-feeders, represented in group IV by the polychaete *Scolelepis* sp., which fed on deposited particles (Pardo & Amaral, 2004). This spatial separation of suspension-feeders and deposit-feeders may result from different causes. Rhoads & Young (1970) reported a tendency for suspension feeders to dominate in sandy substrates. According to Nanami *et al.* (2005), the high current activity in this type of sediment avoids accumulation of detritus on the bottom, thereby providing suspension-feeders with more potential food in comparison to weaker currents. In the case of deposit-feeders, Sanders (1958) stated that the large surface area of silty bottoms contributes to the binding of organic matter to bottom sediments, leading to an increased availability of nutrients. On the other hand, larvae of suspension- and sediment-feeders may tend to settle on different substrate types. This behaviour was proposed by Rhoads & Young (1970), who found that suspension-feeders are unable to successfully colonize silt bottoms which had been intensively reworked by deposit-feeders. Further studies are needed to determine the influence of granulometry on macrobenthic larvae.

The results presented above reveal differences in the structure of macrobenthic assemblages in relation to sediment characteristics at a micro-environmental scale and this agrees with studies in the subtidal area of Argentinean waters where several authors have shown spatial heterogeneity of bottoms in relatively larger scales than those we studied (Olivier *et al.*, 1968; Bremec & Roux, 1997). This pattern is consistent with models for patchy communities where habitat partitioning accounts for the patchy distribution of populations. This information improves the understanding of ecosystems in areas subjected to fishing disturbance as is the case for Mar del Plata. On the other hand, since changes in macroinvertebrate community structure are considered sensitive tools for detecting alterations in aquatic ecosystems (Pinel-Alloul *et al.*, 1996), in this study, we provided important data to assess the effects of the trawl on macrobenthic communities.

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