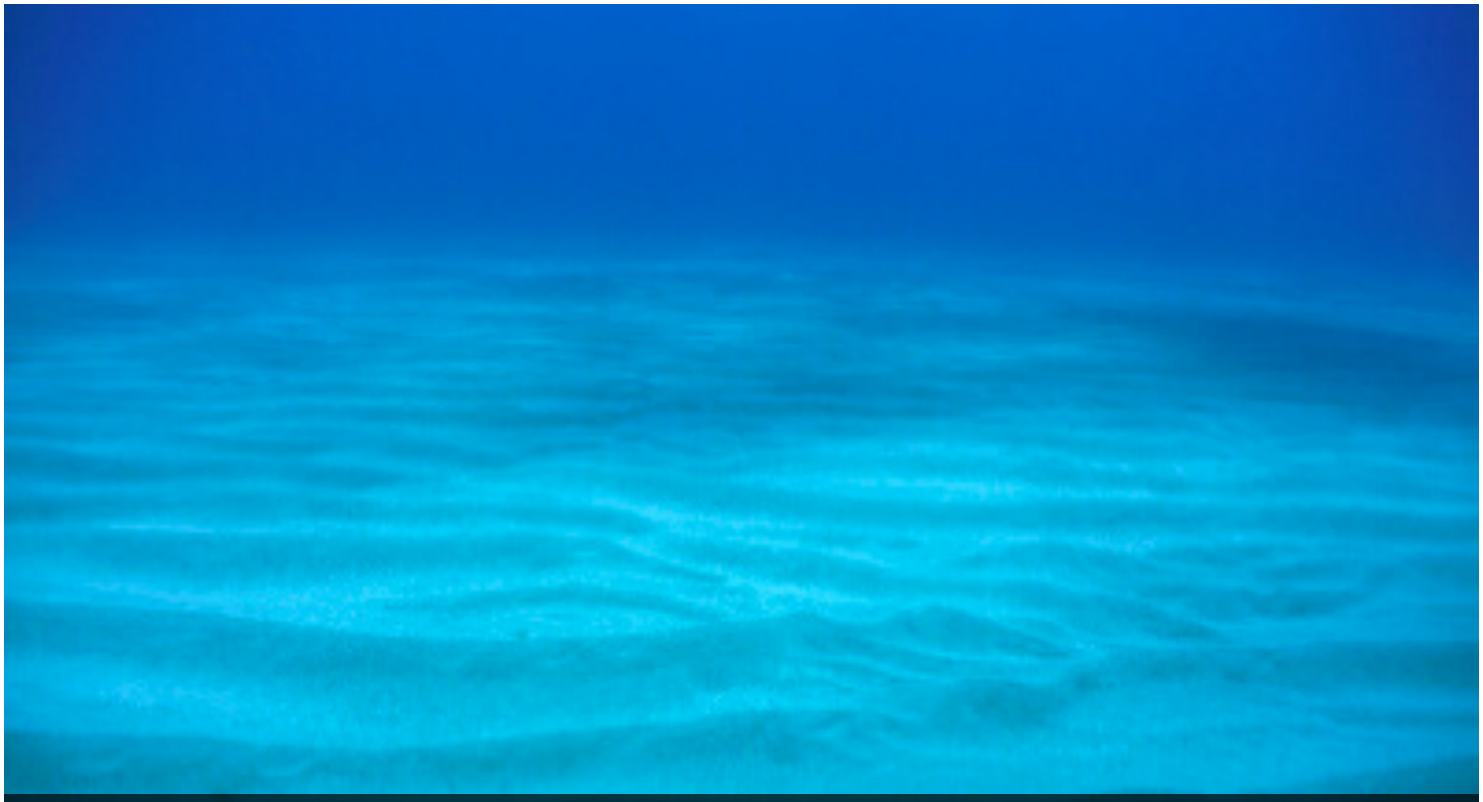

Soft-Bottom Macroinvertebrates

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Abstract

Nine sampling points, from 8 to 14 m depths, were selected along a latitudinal gradient from Portbou (northern Catalan coast) to Barcelona (central coast), encompassing the section of the coast most affected by the storm. Effects of the impact of this event were assessed on soft-bottom benthic communities, in terms of macroinvertebrates composition and sediment characteristics. The sampling was performed in June-July 2009 and compare to same sampling missions performed in 2002 and 2007. Results showed sligth changes in terms of granulometry and organic content that could be related to the impact of storm, but no effect was observed on macroinvertebrates soft-bottom communities. Differences observed in the faunistic composition seemed to be related more to the interanual variability than to the impact of the severe storm.

Image: Sandy bottom in the Costa Brava, by Susana Pinedo

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Effects of the 2008 eastern extreme storm on the sublittoral soft-bottom macroinvertebrates communities along the NW Mediterranean Catalan coast

By

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Resumen

Se muestrearon 9 zonas, entre 8 y 14 metros de profundidad, seleccionadas a lo largo de un gradiente latitudinal desde Portbou (Norte Costa Brava) a Barcelona (Costa Central) que incluyen el sector de la costa catalana más afectado por la tormenta. Los efectos de este evento sobre las comunidades de fondos blandos fueron estimados en términos de composición faunística de las comunidades bentónicas y de características del sedimento. El muestreo se realizó en Junio-Julio de 2009 y se comparó con los resultados de los años 2002 y 2007. Los resultados muestran ligeras variaciones de granulometria y de contenido orgánico que pueden ser atribuidas al impacto del temporal, pero no se observaron efectos en las comunidades de macroinvertebrados de fondos blandos. Las diferencias observadas a nivel de composición faunística parecen estar más relacionadas con la variabilidad anual que con el impacto del fuerte temporal.

Abstract

Nine sampling points, from 8 to 14 m depths, were selected along a latitudinal gradient from Portbou (northern Catalan coast) to Barcelona (central coast), encompassing the section of the coast most affected by the storm. Effects of the impact of this event were assessed on soft-bottom benthic communities, in terms of macroinvertebrates composition and sediment characteristics. The sampling was performed in June-July 2009 and compare to same sampling missions performed in 2002 and 2007. Results showed sligth changes in terms of granulometry and organic content that could be related to the impact of storm, but no effect was observed on macroinvertebrates soft-bottom communities. Differences observed in the faunistic composition seemed to be related more to the interanual variability than to the impact of the severe storm.

Introduction

Pérès & Picard (1964) and Pérès (1967) described different soft-bottom communities in the northwestern Mediterranean Sea taking into account the dominant species of macroinvertebrates. For the Catalan coast the community associated with sublittoral soft-bottom communities between 2 and 25 m depth was named "well calibrated fine-sand sediment community with *Spisula subtrucata*".

Several studies have been carried out on this community, which is considered as a reference for determining the degree of disturbance of the sediments or changes in time and space (Sardá, 1986; Pinedo, 1998; Cardell et al., 1999).

The macrobenthos is a key component of coastal ecosystems as it plays a vital role in detritus decomposition, nutrient cycling and energy flow to higher trophic levels (Masero et al., 1999; Carvalho et al., 2007). Moreover, the marine benthic macrofauna has often been regarded as an indicator of environmental changes due to its long-life spans, sensitive stages, and reduced motility (Pearson & Rosenberg, 1978; Glémarec & Hily, 1981; Bellan, 1984). Changes in the composition of the macrobenthos are thus indicative of changes in environmental conditions, which can be of anthropogenic and/or natural origin (Glémarec, 1979; Gray, 1979; 1981; Pinedo, 1998; Salen-Picard et al., 2003; Elliot & Quintino, 2007). More recently, this faunal component has been frequently used in environmental quality assessment of coastal systems (Borja et al., 2003; Salas et al., 2006; Teixeira et al., 2010) in relation to disturbances induced by human activities; however, little is known about the response of these communities to changes in environmental parameters induced by strong and unpredictable meteorological events (Grémare et al., 2003).

The severe winter storm that occurred on 26 December 2008, with waves reaching a maximum height of 9 m, provided the possibility of studying the effects of this natural event on the soft-bottom communities along the Catalan coasts. One of the difficulties in correlating changes in macrofauna to changes in environmental parameters is the rarity of long time series that monitor the composition of the benthic fauna. On the NW Mediterranean Catalan coast, the macrofaunal composition in soft-bottom sediments was recorded in 2002 and 2007 within a broad monitoring program aimed at assessing the seawater quality in coastal areas [European Water Framework Directive (WFD, 2000/60/EC)]. This allowed the results obtained before the storm (sampling in 2002 and 2007) to be compared with those obtained after the storm (2009).

The aim of the present study was to assess the impact of the easterly storm on soft-bottom communities in terms of macroinvertebrate composition and sediment properties (granulometry and organic matter content).

Materials and Methods

Study site

The study was carried out from Portbou (northern Catalan coast) to Barcelona (central coast) (Figure 1), encompassing the section of the coast most affected by the storm. Nine sampling points were selected along this latitudinal gradient. The soft bottoms were always characterised by the so-called benthic assemblage "NW Mediterranean well calibrated fine sand community" (Pérès & Picard,

1964). The sampling was performed in 2009 (after the storm). Given that large seasonal variations have been reported for this community, the sampling was conducted during June-July to coincide with the sampling periods in 2002 and 2007, performed as part of a broad monitoring program aimed at assessing the quality of coastal waters (European Water Framework Directive [2000/60/EC]).

that measured particle size distribution with a laser diffraction system. The sediment category was characterised by the mean grain size and the percentage of the fine fraction (<63 μm).

The organic matter content in the sediment was measured by combustion. A portion of sediment from each sample was first placed in

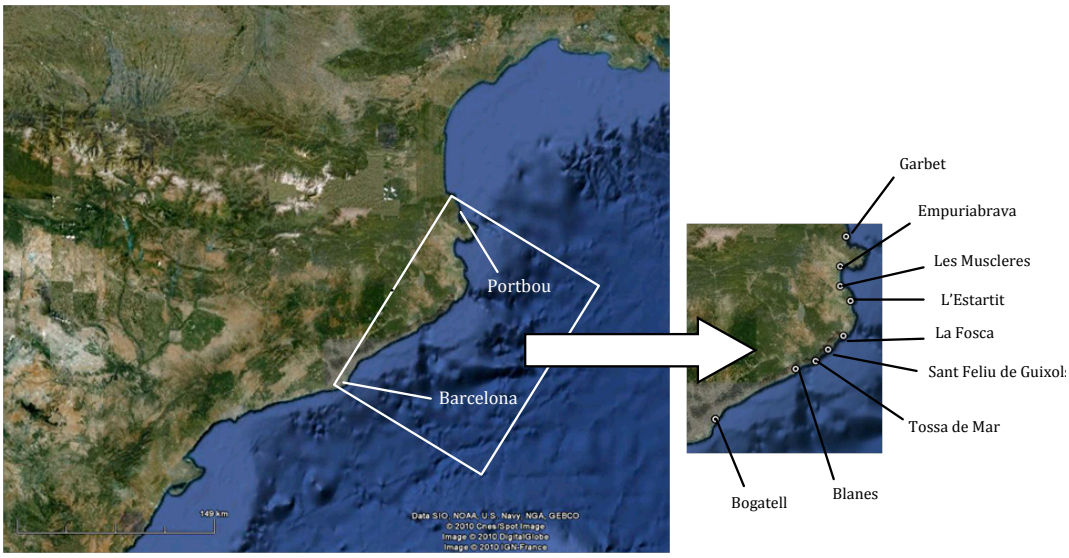

Figure 1. Map of the studied area and position of the nine locations sampled along the Catalan coast in 2009.

Field and laboratory works

Two replicate samples were taken at each sampling point (between 8 and 14 m) with a van Veen grab of 600 cm^2. Sample sites similarly exposed to predominant waves during the storm (east orientation), were more or less equidistantly scattered to ensure that they were representative of the different geomorphologies of the more impacted area. Two sub-samples for sedimentological analysis were processed with a MASTERSIZER 2000

an oven at 80°C for 24h and then burned at 450°C for 5h. The organic content was then calculated as the difference between the dry weight and the weight after combustion.

Data treatment

In order to assess the possible changes due to the storm in soft benthic communities, a Detrended Correspondence Analysis (DCA; Canoco ©) was carried out including the samples from 2002, 2007 and 2009 and all species. The same

Table 1. Results of sediment properties before (2002 and 2007) and after (2009) the storm.

Station	Locality	Mean grain size (µm)			Percentage of silt-clay (%<63µm)			Organic matter (%)		
		2002	2007	2009	2002	2007	2009	2002	2007	2009
1	Garbet	182	216	231	3.9	0.0	0.0	1.3	2.0	2.5
6	Empuriabrava	123	150	142	12.9	3.9	2.4	0.9	1.0	1.6
8	Les Muscleres	165	162	171	2.4	0.0	0.0	0.6	0.8	1.5
10	L'Estartit	179	195	236	13.4	0.0	0.0	1.5	1.0	1.5
13	La Fosca	182	255	341	0.6	0.0	0.0	0.9	1.0	1.7
16	Sant Feliu de Guíxols	212	209	180	2.0	0.3	0.1	0.8	0.6	1.4
18	Tossa de Mar	149	184	183	2.8	0.0	0.4	0.7	0.6	1.0
20A	Blanes	-	182	189	-	0.5	0.0	-	0.9	1.2
B1	Bogatell	130	141	155	9.9	6.4	4.5	1.4	1.2	1.7

analysis was repeated with molluscs, annelids, and the rest of the fauna (nematodes, echinoderms, nemertins, etc.) separately in order to assess if different taxa had different response patterns to the storm.

Results and Discussion

The sedimentary characteristics (granulometry and organic matter content in sediments; Table 1) of the 9 stations sampled in this study show slight changes that could be related to the storm. In terms of mean grain size, a slight increase was observed between 2007 and 2009 at Garbet, L'Estartit and La Fosca. In these stations fine particles are removed from the sediment when high hydrodinamism occurs thus mean sediment size increases. However, for the percentage of silt-clay (fraction< 63 µm) changes were larger between 2002 and 2007 than between 2007 and 2009, when variations were unremarkable. In fact, in 2007 there was a decrease compared with data from 2002, which was especially important at the stations of Empuriabrava and L'Estartit. This pattern observed between 2002 and 2007 could be attributed to the natural variability, or to less severe common storms. Moreover, no changes were registered in 2009 compared to 2007. A general increase in the organic matter content of about 0.5% was observed at all the stations in the last survey (2009). This increase could be related to the presence of the macrophytes debris accumulated on the bottom, after being pulled up during the storm.

The study of the community composition did not reveal any clear effect of the storm. The total species richness and abundance is shown in Table 2. However, there was a general decline in both parameters at almost all sampling stations from 2007 to 2009. In terms of abundance, a slight decrease in the number of individuals was observed in 2009 at all sites except for the location situated off the coast of Barcelona (Bogatell), where an increase in abundance values between 2007 and 2009 was observed

Table 2. Abundance and richness of sampling stations before (2002 and 2007) and after (2009) the storm.

Station	Locality	Abundance (individuals/600 cm²)				Richness (species number/600 cm²)		
		2002	2007	2009		2002	2007	2009
1	Garbet	426	825	189		50	61	48
6	Empuriabrava	194	148	123		46	35	41
8	Les Muscleres	236	256	227		45	51	36
10	L'Estartit	425	379	337		46	50	39
13	La Fosca	271	364	166		48	47	37
16	Sant Feliu de Guíxols	324	628	283		52	68	59
18	Tossa de Mar	723	750	342		45	54	56
20A	Blanes	-	532	316		-	62	56
B1	Bogatell	386	259	358		41	53	60

and reached the values recorded in 2002. This station would have been the least affected by the storm, which was much less intense here than at the more northern stations. These results indicate that the effects of the storm were probably lower in this area, and the variability observed during the study period was due to natural variability. However, important changes in abundance values were observed in Garbet, Sant Feliu de Guíxols and Tossa de Mar, where abundance decreased between 2007 and 2009. The same pattern was observed for richness values in Garbet, Les Muscleres, L'Estartit and La Fosca. No changes were observed in the number of species at the other sites. The correspondence analysis (DCA) showed differences in the macrofaunal composition between different years and sampling stations (Figure 2). The first and second axis accounted for 10.2% and 6.3% of the total variance respectively. The general pattern shows a clear separation of years along the first axis, on which 2002 is situated on the left, 2009 in the centre and 2007 on the right (Figure 2). The differences observed between 2002 and 2009 were quite similar to those observed between 2007 and 2009; and between 2002 and 2009; thus, the dissimilarities in composition and abundance among years could not be related to the possible effects of the storm. These changes could be attributed to the natural annual variability, mainly due to different recruitment rates. In fact, the community composition of samples from 2002 was more similar to that of the samples of 2009 than those of 2007. Unlike 2002 and 2009, the year 2007 was unusual in the recruitment of bivalve molluscs, and the abundance of some species reached the highest values in this year.

The results of three separate DCA analyses for annelids, molluscs and the rest of the fauna (peracarids, echinoderms, nematodes and nemertinids) can be seen in Figures 3–5. The variance explained by the firstº and second axes was 22.0% and 8.5%, respectively for molluscs; 14.9% and 7.5% respectively for annelids; and

14.5% and 9.6% respectively for the rest of the taxonomic groups. Maximum interannual variation was observed for molluscs (Figure 4); thus, as mentioned above, the number of recruits among years varied most in this group, while for the annelids (mostly polychaetes) and other groups, the stations from the different years were not as unbounded along the first factor.

Conclusions

These results support the idea that the differences observed in the soft-bottom community composition at 8-14 m in the Catalan coast after the storm are comparable to those observed between the forward years. Therefore, our study provides evidence that the storm event did not affect the soft-bottom benthic communities in this area, more than other least severe common storms. As the exposure of sites to predominant waves (east) was similar we consider that this factor did not affect the results. We can conclude that the differences observed during the study period were due to the natural variability

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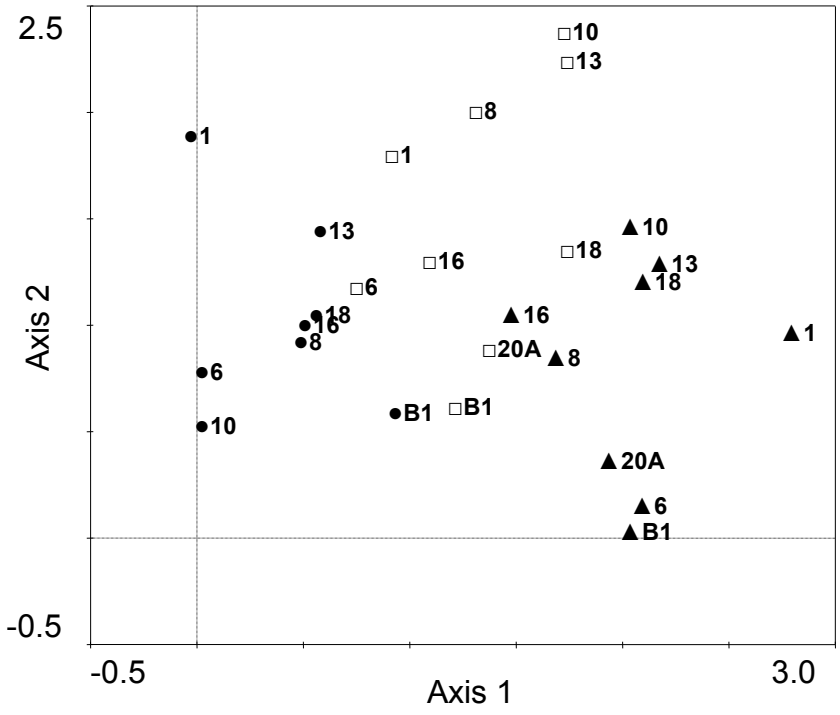

Figure 2. Sampling sites of the fine sand community of the Catalan coast in the factorial space defined by the first two main axes (DCA). Ordination based on macrofaunal composition. The three years are represented by different symbols (●2002; ▲2007; □ 2009).

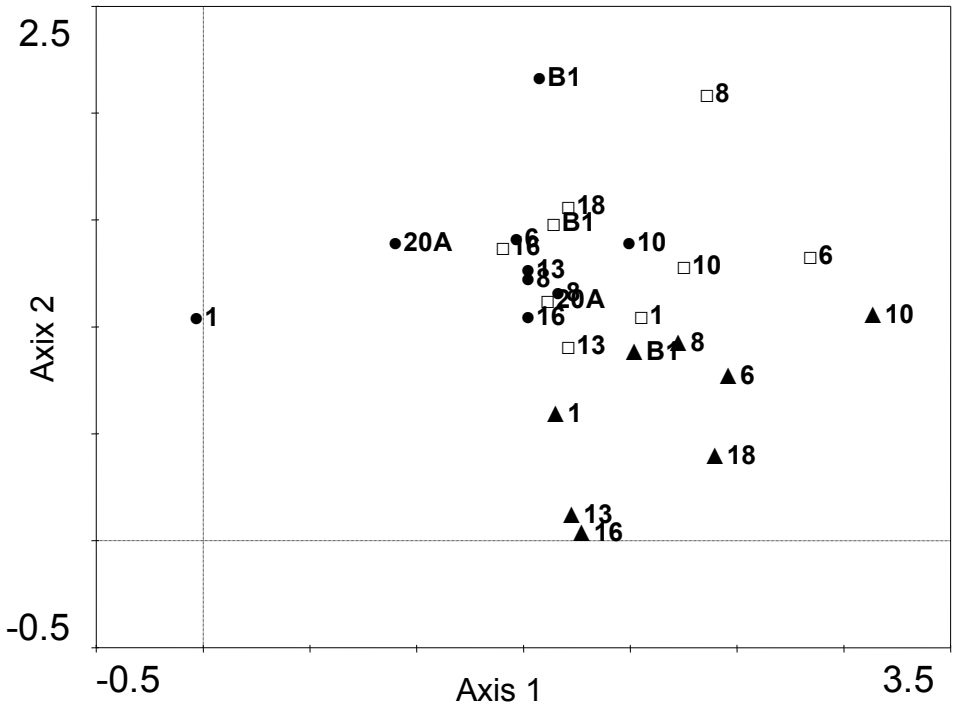

Figure 3. Sampling sites of the fine sand community of the Catalan coast in the factorial space defined by the first two main axes (DCA). Ordination of the group of annelids. The three years are represented by different symbols (●2002; ▲2007; □ 2009).

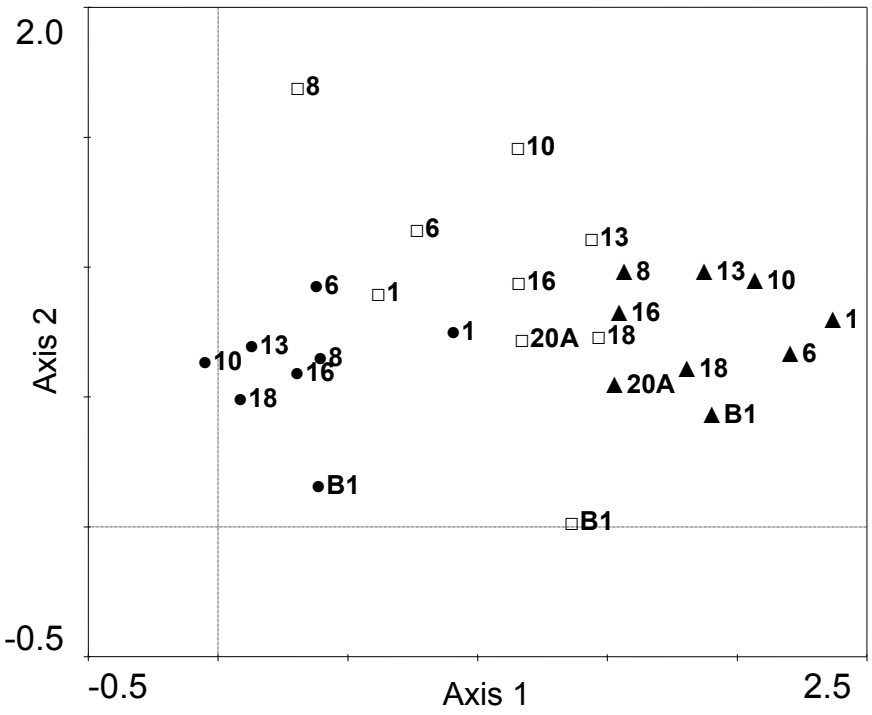

Figure 4. Sampling sites of the fine sand community of the Catalan coast in the factorial space defined by the first two main axes (DCA). Ordination of the group of molluscs. The three years are represented by different symbols (●2002; ▲2007; □ 2009).

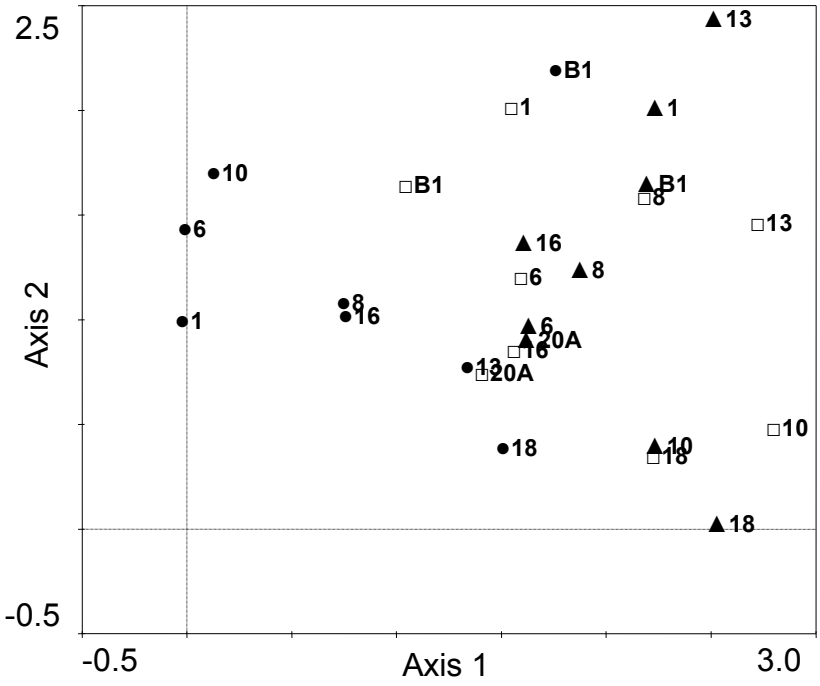

Figure 5. Sampling sites of the fine sand community of the Catalan coast in the factorial space defined by the first two main axes (DCA). Ordination of the rest of the groups (peracarids, echinoderms, nematodes, nemertinids...). The three years are represented by different symbols (●2002; ▲2007; □ 2009).