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Subtidal macrobenthic structure in the lower Lima estuary, NW of Iberian Peninsula

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Seasonal variation of the subtidal macrobenthic community in the lower Lima estuary was investigated at twelve sites. Univariate and multivariate analyses were used to establish patterns in species distribution, abundance, and biomass; and to determine the influence of site and season on the subtidal macrobenthic community. A total of 101 macrobenthic taxa were identified and values of diversity were generally low indicating a high degree of dominance of few species. Average abundance and biomass per site ranged from 46.7 to 8060 ind. m^{-2} and 0.56 to 28.96 g AFDW m^{-2}, respectively. *Abra alba* was most abundant and had the highest biomass. Multivariate analysis revealed four distinct groups. Each group was represented by a specific species composition and characterised by different environmental conditions, in particular, the sediment characteristics and salinity. Abundance/biomass comparison (ABC) indicated that the lower part of the estuary is under environmental stress and is dominated by opportunistic species. The subtidal macrobenthic community of the lower Lima estuary differed between sites but not between seasons of the year.

Introduction

Estuaries are generally recognized as distinct areas of biological and environmental importance (Day *et al.* 1989, Costanza *et al.* 1993, Moreira 1997, Maes *et al.* 1998, Ysebaert *et al.* 2000, Attrill & Rundle 2002). At the same time, large cities are common near estuaries which, as a result, are used as receptors of all types of contaminants (Gray 1997, McLusky 1999, Warwick 2001). Estuarine ecosystems are regularly subjected to several impacts, such as the discharge of nutrients and other substances derived from domestic, industrial and agricultural areas, commercial and recreational fishing, upland runoff, harbour and dredging activities, and hydrological modifications (Newell *et al.* 1998, Warwick *et al.* 2002, Ysebaert *et al.* 2002).

The Lima estuary, located in the NW of Iberian Peninsula, was studied during autumn of 2001 and winter, spring and summer of 2002 to monitor the estuarine macrobenthic community. This is fundamental for understanding the spatial and temporal macrobenthic distribution within this estuarine area and for allowing future predictions about potential environmental changes due

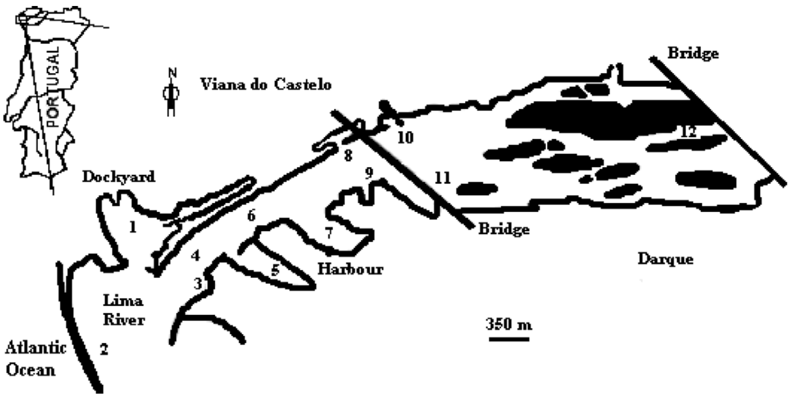

Fig. 1. Map of the Lima estuary showing location of the 12 sites.

to human impact. In fact, macrobenthic organisms are useful indicators of estuarine environmental condition because they respond to many kinds of natural and/or human-induced changes (Turner *et al*. 1995, Underwood & Chapman 1996, Constable 1999, Ritter & Montagna 1999, Ysebaert *et al*. 2003).

The aims of this study were to analyse spatial and seasonal variability of the macrobenthic community present in the lower Lima estuary, to identify possible key species, and to determine any possible impacts caused by dredging. While these objectives are specific to the macrobenthic community present in this estuary, the results can be generalized and compared with data from other estuarine ecosystems and enhance our understanding of the environmental processes involved in the spatial and temporal estuarine macrobenthic distribution.

Material and methods

Study area

The Lima estuary is partially mixed, however, during periods of high floods (predominantly in winter months) it tends to evolve towards a salt wedge estuary (Alves 1996, Sousa 2003). In recent years, this mesotidal estuarine area has become an important Portuguese harbour, serving commercial navigation and fishing activities. This estuary has been subjected to different sources of disturbance due to the constant dredging of a navigation channel within its first 3 km, as well as the input of agricultural run off and urban and industrial sewage. All these activities have modified the physical nature of the lower part of the estuary with consequential alterations in bathymetry and have also been responsible for eutrophication (Alves 1996, Sousa 2003). Some intertidal habitats such as marshes present on the various islands and on the north bank still remain in undisturbed ecological conditions.

Sampling and laboratory analysis

Samples were collected between autumn 2001 and summer of 2002 in the subtidal area of the lower Lima estuary (Fig. 1), at high tide. Nine replicates per site were collected with a Van Veen grab (area of 500 cm^2 and the maximum capacity of 5000 cm^3).

During the fieldwork, the following abiotic water parameters were recorded: temperature, salinity, dissolved oxygen and pH. The measurements were carried out *in situ*, close to the bottom, with a multiparametrical sea gauge YSI 6820. Particle size and organic matter content of the sediment at every site were also measured. Sediment granulometry was assessed by first drying the samples at 60 °C for 72 hours. Next we proceeded with a dimensional analysis by sifting with Ro-Tap agitation, using columns of sieves corresponding to integer values of the Wentworth scale. The frequency of each class was expressed as the percentage of the total weight. The quantity of the organic matter in the sediment was determined after combustion

(24 hours at 550 °C) in a muffle furnace. Values were expressed as percentages relative to the weight loss on ignition of each sample analysed.

Biological material was sifted through a sieve with a mesh size of 1 mm and animals were separated, sorted and fixed in 4% seawater formalin. The organisms were enumerated and identified to the lowest possible taxon (usually to the species level). The faunal biomass was calculated using the Ash Free Dry Weight Method (AFDW; Kramer *et al*. 1994).

Data analysis

To compare the similarity between sites (data of nine samples pooled for each site) in terms of species composition (abundance and biomass), univariate and multivariate analyses were carried out using the PRIMER package (Clarke & Warwick 2001). Individual species abundance and biomass were converted to abundance and biomass per m^2. Univariate measures included abundance, biomass, number of species, Shannon-Wiener diversity (H') and Pielou's evenness (J') indices. Cluster analysis (with comparisons made at the 30% Bray-Curtis similarity level) based on the 4th root transformed abundance data was used to analyse the pattern of distribution of benthic assemblages.

In order to establish correlations between biological parameters and abiotic characteristics, indices of abiotic and biotic similarity were compared using PCA (Principle Components Analysis) and BIOENV (using the Spearman coefficient) (Clarke & Ainsworth 1993).

Significance tests for differences between sites and seasons were performed using a two-way crossed ANOSIM2 (Clarke & Green 1988). These non-parametric tests compare ranked similarities between and within groups selected *a priori*. The similarities percentages procedures (SIMPER) was used to assess the species contributing most to similarities within groups defined by cluster analysis (Clarke 1993). Finally, the ABC method (abundance/biomass comparisons) was used in order to determine environmental stress (Warwick 1986, Clarke & Warwick 2001).

Results

Environmental analysis

The highest temperature, 19.6 °C, was registered at site 5, in the summer and the lowest, 11.7 °C, at site 10 in the winter (Table 1). Seasonal salinity values decreased upstream and from the center of the channel to the margins. In most cases, channel salinities were higher reflecting a strong oceanic influence. The highest value, 34.2 psu, was measured at site 2 in the summer, and the lowest, 23.4 psu, at site 5 in the spring. The pH values ranged between 7.1 (site 3 in the autumn) and 8.2 (site 12 in the summer) and dissolved oxygen values varied between 2.8 mg l^{-1} (site 7 in the winter) and 7.7 mg l^{-1} (site 10 in the autumn) (Table 1). There was extreme variation in the sediment cumulative curves throughout the 12 sites (Table 1 presents only the estimation of the silt + clay fraction). In general, the grain size of the sediment increased from the mouth of the estuary towards the upper sites. Areas with fine sediments occurred principally in the mouth of the estuary (sites 1, 2, 4 and 6) and in estuarine bays, sheltered from the influence of hydrodynamic factors (sites 5, 7 and 11). Areas with coarse sediments were found upstream (sites 8, 9, 10 and 12) and at site 3. Organic matter ranged between 0.8% at site 8 and 12.6% at site 5, both in winter (Table 1). A clear correlation ($r = 0.96$, $P < 0.001$) between the quantity of silt and clay and the quantity of organic matter was found.

Biological analysis

Our biological data set consisted of 27 862 individuals from 101 macrobenthic species belonging to the following taxa: Mollusca (40), Annelida (31), Arthropoda (17), Echinodermata (5), Nemertea (4), Cnidaria (2) and Spinculida (2) (the total abundance and biomass matrices can be obtained on request from the corresponding author).

Abundance per site (Table 2) ranged from 46.7 ind. m^{-2} at site 1 in winter to 8060 ind. m^{-2} at site 2 in summer with an annual average of 1219 ind. m^{-2}. Mollusca (64.9%) and

Table 1. Temperature (T, °C), salinity (S, psu), pH and dissolved oxygen (DO, mg l^{-1}) of water column and organic matter (OM,%) and silt + clay (S+C,%) of sediment at the 12 sites.

	Autumn						Winter						Spring						Summer					
	T	S	pH	DO	S+C	OM	T	S	pH	DO	S+C	OM	T	S	pH	DO	S+C	OM	T	S	pH	DO	S+C	OM
S1	13.7	34.1	7.4	4.7	38.1	10.8	12.4	34.0	7.5	5.6	55.1	10.3	14.3	33.0	7.6	5.6	28.9	10.3	18.8	34.0	7.9	6.0	45.8	11.5
S2	13.6	34.1	7.3	5.2	31.7	10.9	12.5	34.0	7.5	5.5	28.1	9.2	14.1	33.0	7.6	6.4	33.5	8.9	18.9	34.2	7.9	6.5	40.2	11.4
S3	13.8	34.0	7.1	5.4	1.5	1.7	12.5	33.5	7.5	5.0	0.8	1.4	14.2	31.8	7.6	6.1	1.3	2.1	18.9	34.0	7.8	7.2	4.8	2.5
S4	13.7	34.0	7.9	5.6	13.7	8.4	12.5	34.0	7.5	5.0	13.2	6.4	14.0	31.0	7.5	6.2	32.9	10.8	18.6	34.1	7.7	6.5	26.1	11.5
S5	13.7	33.6	7.6	4.8	52.3	10.2	12.3	32.2	7.3	4.9	48.5	12.6	14.2	23.4	7.7	5.1	35.0	12.0	19.6	29.7	7.9	6.8	40.6	10.9
S6	13.6	34.0	7.9	5.8	21.4	9.8	12.5	34.0	7.4	4.7	23.6	8.9	14.0	31.1	7.5	6.1	19.4	7.5	18.7	33.7	7.8	7.1	24.4	8.8
S7	13.9	33.8	7.7	5.6	54.3	11.4	12.2	33.8	7.5	2.8	28.9	9.2	14.5	33.8	7.7	5.6	45.6	11.2	18.4	32.6	8.1	6.0	44.2	11.7
S8	13.7	33.3	7.2	6.6	1.3	1.1	12.3	34.0	7.5	6.1	0.4	0.8	14.6	29.8	7.8	6.3	0.3	0.9	18.8	32.0	7.9	6.7	0.2	1.0
S9	13.6	33.5	7.2	6.6	5.9	2.4	12.1	34.0	7.5	6,4	2.8	1.5	14.6	28.1	7.7	6.9	2.4	1.4	18.6	32.3	8.1	6.3	2.5	1.8
S10	13.7	32.7	7.8	7.7	0.2	0.9	11.7	33.4	7.5	5.8	0.2	0.9	14.7	29.6	7.6	6.2	4.3	1.7	18.6	32.6	8.1	6.6	5.6	2.4
S11	13.8	32.6	7.6	5.4	38.3	7.5	12.4	33.0	7.5	5.6	17.6	4.6	14.8	29.0	7.9	6.1	37.6	9.4	17.5	33.0	7.5	5.9	37.5	7.6
S12	13.9	27.1	7.7	7.2	1.5	1.9	12.5	29.0	7.6	7.5	4.8	1.8	14.2	27.0	7.9	7.5	0.9	1.9	18.8	30.0	8.2	7.5	2.3	2.1

Table 2. Number of species (*N*), abundance (*A*, ind. m^{-2}), biomass (*B*, g AFDW m^{-2}), equitability (*J´*) and Shannon & Wiener index (*H´*) at the 12 sites.

	Autumn					Winter					Spring					Summer				
	N	*A*	*B*	*J´*	*H´*	*N*	*A*	*B*	*J´*	*H´*	*N*	*A*	*B*	*J´*	*H´*	*N*	*A*	*B*	*J´*	*H´*
S1	6	82.2	2.537	0.91	1.64	6	46.7	0.563	0.80	1.43	10	402.2	2.777	0.52	1.21	14	188.9	1.477	0.63	1.66
S2	30	2033.3	14.267	0.40	1.38	11	737.8	2.717	0.50	1.20	27	3812.0	9.903	0.22	0.73	29	8060.0	25.813	0.25	0.83
S3	22	282.2	2.240	0.72	2.22	16	333.3	1.540	0.64	1.77	10	280.0	2.170	0.47	1.09	17	708.9	1.663	0.50	1.41
S4	21	1006.7	7.130	0.46	1.41	17	1020.0	12.213	0.51	1.45	23	1126.2	9.247	0.42	1.32	29	6611.1	27.430	0.16	0.53
S5	14	244.4	2.113	0.66	1.74	9	611.1	1.620	0.31	0.68	18	1751.1	1.017	0.43	1.23	15	1415.6	1.723	0.43	1.15
S6	26	3815.6	14.600	0.25	0.82	11	1013.3	7.757	0.55	1.31	14	2517.2	19.303	0.13	0.35	23	4208.9	28.957	0.24	0.74
S7	16	144.4	0.823	0.76	2.12	6	177.8	0.717	0.69	1.23	6	308.9	0.690	0.26	0.47	7	160.0	0.560	0.66	1.28
S8	19	100.0	2.760	0.80	2.37	14	95.6	1.170	0.84	2.23	12	182.2	0.930	0.60	1.48	20	173.3	7.127	0.84	2.51
S9	21	1393.3	10.130	0.57	1.75	9	444.4	1.073	0.60	1.32	11	631.1	4.570	0.58	1.39	13	542.2	3.067	0.65	1.66
S10	15	137.8	0.907	0.46	1.24	12	111.1	0.717	0.77	1.91	17	142.2	12.923	0.74	2.10	20	153.3	1.060	0.93	2.80
S11	14	971.1	1.993	0.24	0.64	13	1448.9	1.430	0.28	0.72	19	1242.2	1.480	0.26	0.77	18	988.9	1.653	0.32	0.91
S12	6	1780.0	3.803	0.12	0.22	7	1117.8	3.183	0.24	0.47	7	1253.8	1.320	0.28	0.54	8	2522.2	6.037	0.25	0.53

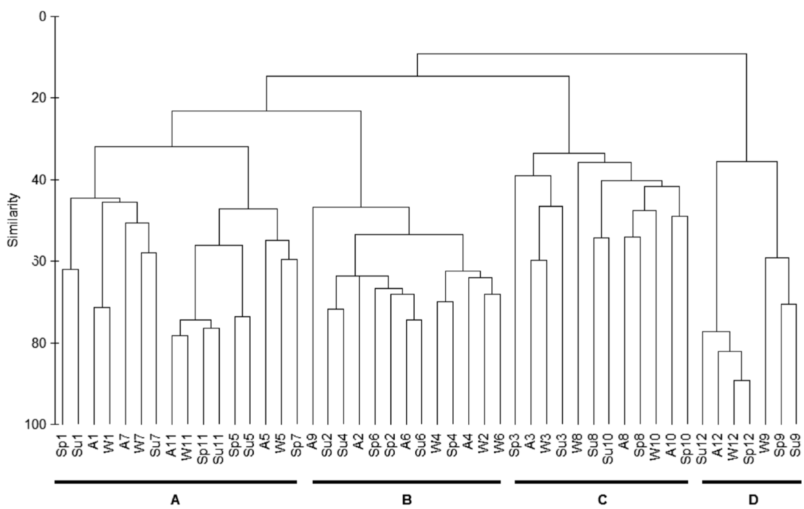

Fig. 2. A dendogram of the 12 sites studied in the Lima estuary, grouped by seasons: A = Autumn, W = Winter, Sp = Spring, Su = Summer.

Annelidea (32.9%) dominated the abundances gathered (notably, *Abra alba* dominated with 52.6% of the total specimens gathered). Crustacea (1.2%), Echinodermata (0.2%) and other faunal groups (0.8%) were poorly represented. *Capitella capitata* (11.7%) and *Hediste diversicolor* (10.6%) were the second and third most abundant species, respectively.

Species richness (Table 2) also varied in time and space. The maximum number of 30 species was registered at site 2 (autumn) and the minimum of 6 species at sites 1 (autumn and winter), 7 (winter and spring) and 12 (autumn). The Shannon-Wiener index (H') (Table 2) had low values. The maximum value was obtained for site 10 in summer ($H' = 2.80$), and the minimum for site 12 in autumn ($H' = 0.22$). As for the Pielou's evenness index (J') (Table 2) we verified significant time/space oscillations. The maximum value ($J' = 0.93$) was calculated for site 10 in summer, and the minimum ($J' = 0.12$) for site 12 in autumn.

Biomass (Table 2) ranged from 0.56 g AFDW m^{-2} at site 7 to 28.96 g AFDW m^{-2} at site 6, both values in summer, with an annual average of 5.64 g AFDW m^{-2}. Mollusca (63.5%) and Annelidea (20.4%) had the highest values. *Abra alba* was the species that with 35.7% clearly dominated in the total biomass, followed by *Hinia reticulata* and *Nephtys hombergi* with 12.8% and 7.0%, respectively.

Cluster analysis (Fig. 2) based on the abundance matrix showed a biological community with four distinct groups (*see* Discussion for a detailed description of these groups). The same procedure applied to the biomass data generated similar results (data not shown). These four faunal groups are well separated in the cluster analysis (Fig. 2) and the species responsible for spatial sample grouping (cut-off = 90%) (SIMPER) are given in Table 3. The ANOSIM2 tests based on the abundance or biomass similarities resulted in significant differences between the sites ($r = 0.695$ and $r = 0.761$ for abundance and biomass, respectively; $P < 0.001$), but not between the seasons of the year ($r = 0.032$,

Table 3. Average similarities for the groups defined by cluster analysis. Only species which altogether contribute with more than 90% of total similarity were included.

Species	Group A	B	C	D
Nephtys hombergi	27.32	11.01	–	–
Abra alba	12.73	73.61	8.07	–
Solen marginatus	–	–	1.16	–
Nephtys cirrosa	–	–	61.17	–
Hinia reticulata	–	6.44	3.45	–
Hediste diversicolor	–	–	–	58.10
Capitella capitata	52.60	–	–	–
Euclymene lumbricoides	–	–	2.32	–
Spisula solida	–	–	1.84	–
Scrobicularia plana	–	–	–	28.34
Cerastoderma edule	–	–	1.02	6.67
Tellina tenuis	–	–	11.63	–

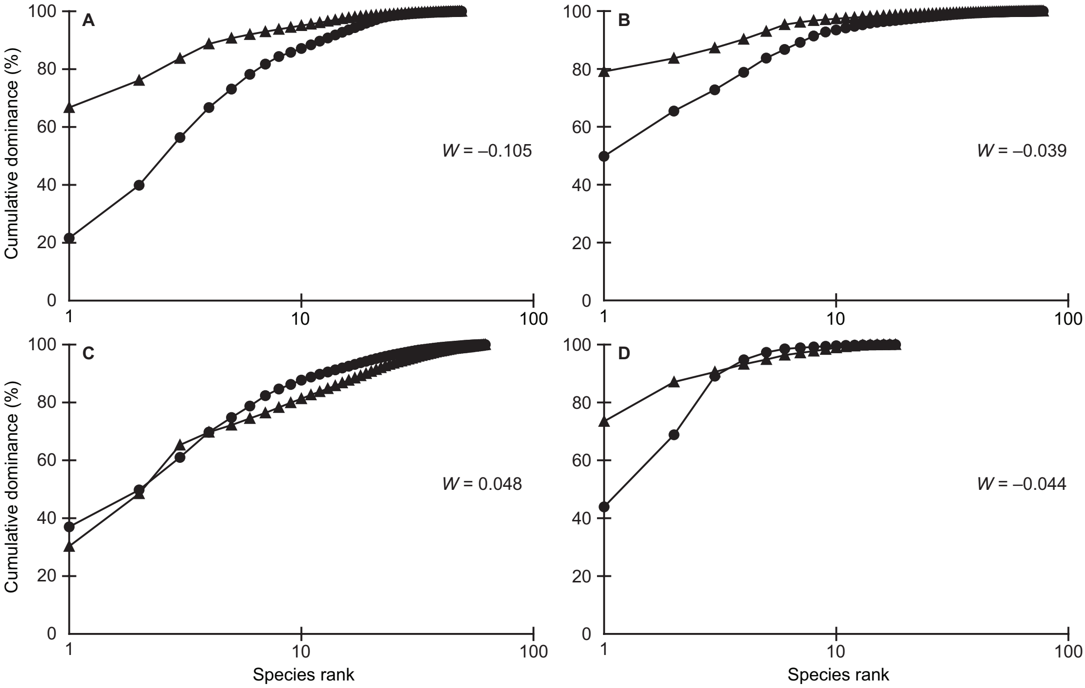

Fig. 3. ABC curves (triangles represent abundance and circles biomass) for each group identified by cluster analysis (*see* Fig. 2).

$P < 0.255$ for abundance and $r = 0.015$, $P < 0.337$ for biomass).

The ABC curves analyses (Fig. 3) conducted on the different groups identified by cluster analysis, indicates a negative *W* value for Groups A, B and D, showing a high degree of disturbance since the cumulative abundance curve was above the biomass curve over its entire range. Only Group C have a positive *W* value but the two curves were closely coincident.

The PCA analysis (Fig. 4) revealed a clear spatial pattern. From the projection against the two axes of variability, the sites appear distributed along a physical and chemical gradients, with the sites with finer sediments along one of the edges and the sites with coarser sediments located at the other edge. The results of the BIOENV analysis (Table 4) indicated that the best correlations occurred with variables related to the sediment characteristics and salinity.

Discussion

Seasonal pattern

The lower Lima estuary macrobenthic community was shown to be reasonably stable over

Table 4. Summary of results from BIOENV analysis — combination of variables (*k*) giving the highest correlation (using the Spearman rank correlation) between biotic and environmental matrices.

$k = 1$	0.529 Very fine sand	0.521 Organic matter	0.512 Silt + Clay
$k = 2$	0.562 Organic matter and Fine sand	0.549 Salinity and Very fine sand	0.548 Very fine sand and Fine sand
$k = 3$	0.575 Dissolved oxygen, Organic matter and Fine sand	0.572 Salinity, Organic matter and Fine sand	0.564 Temperature, Organic matter and Fine sand

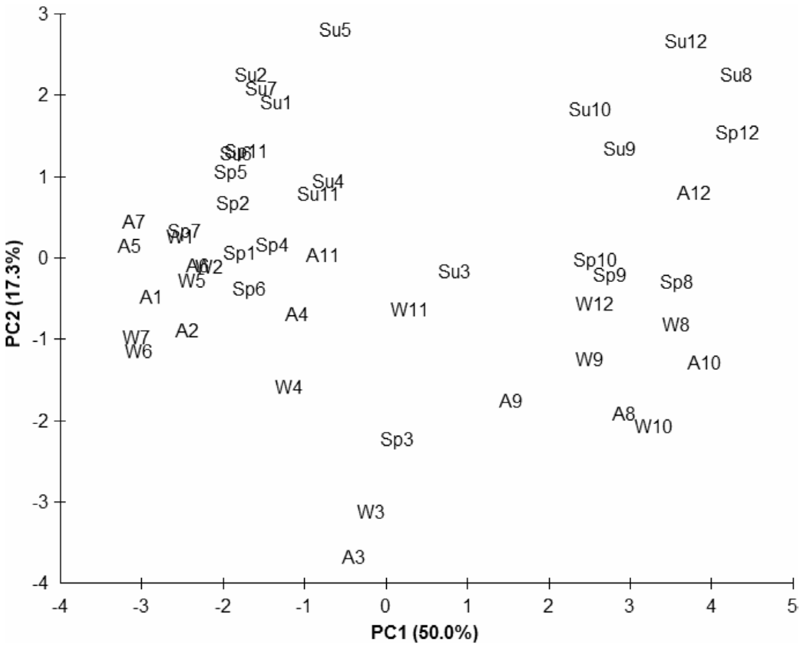

Fig. 4. Analysis of water column and sediment environmental factors from PCA of factors × site matrices, grouped by seasons: A = Autumn, W = Winter, Sp = Spring, Su = Summer. The percentage of variability explained by the principal axes is given.

the sampling period. However, the community structure had seasonal oscillations in abundance, biomass, and diversity (with low values of abundance, biomass, and diversity in winter and higher during the rest of the year). These fluctuations could be related to recruitment, which in this estuary normally happens in spring/early summer, and to seasonal movements of species from the adjacent marine area. Despite these seasonal fluctuations the community maintained some stability with the dominant populations always present. Such seasonal stability, resulting from a pattern of species abundance and distribution had been identified in several estuarine ecosystems (Gaston *et al*. 1988, Kennish 1990, Marques *et al*. 1993).

Spatial pattern

There were structural macrobenthic differences at the spatial scale that correlated with abiotic factors, principally, the type of sediment and salinity. These abiotic factors are fundamental environmental parameters influencing the small-scale spatial macrobenthic distribution in estuarine ecosystems (Warwick *et al*. 1991, Yates *et al*. 1993, Meire *et al*. 1994, Mannino & Montagna 1997, Ysebaert *et al*. 1998, 2002) and same was true for the Lima estuary. Factors such as biomass and productivity of microphytobenthos, productivity of the phytoplankton, nutrient levels, metal concentrations, and biotic interactions such as predation and competition were not measured in this study but may also affect the spatial and temporal distribution of estuarine macrobenthos (Wilson 1991, Herman *et al*. 1999).

As revealed by the multivariate analysis, there were four distinct benthic groups in the lower Lima estuary. Group A (sites 1, 5, 7 and 11, during the whole yearly cycle): fine deposits rich in organic matter, shallow depth, and was subjected to environmental stress. These sites were subjected to high levels of several metallic elements, harbour activity, high nutrient concentrations, sand washing and inert extractions, and were dominated by the opportunistic species *C. capitata*. Group B (sites 2, 4, 6 whole year, and site 9 only in autumn): fine sediment deposits rich in organic matter, where dredging was regular in order to allowed navigation. This assemblage presented high macrobenthos abundances, biomass, and number of species and was dominated by *A. alba*. Additionally, this estuarine area was colonized by species with marine characteristics (e.g. *Pectinaria koreni*, *Melinna palmata*, *Hinia reticulata*, *Glycera convuluta*, *Liocarcinus arcuatus*, *Liocarcinus holsatus*, *Diogenes pugilator*, *Amphipholis squamata*, *Amphiura filiformis*, amongst others), as long as they were not subjected to stress provoked by abiotic factors, specifically, lower salinity. This group has high ecological importance in this estuarine ecosystem constituting potentially important food resources for higher trophic levels. Group C sites (3, 8 and 10 whole year) were located in the navigation channel area, with sandy sediments and were dominated by some species originating from the adjacent marine areas (e.g. *Nephtys cirrosa* and *Tellina tenuis*). The abundance and biomass of this group were low, which is typical of mobile sands deposits with low organic matter (Van Hoey *et al*. 2004). Group D sites (9 and 12 whole year except site 9 in autumn) were located in shallow areas with coarse sediments and were dominated by *H. diversicolor*. In these shallow upper areas, the salinity oscillations were the greatest therefore true estuarine species (e.g. *H. diversicolor*, *Cyathura carinata*, *Carcinus maenas* and *Hydrobia ulvae*) as defined by Remane (1969) (cited in Michaelis *et al*. [1992]) colonized this area.

Environmental disturbance

The benthic community present in the lower part of the estuary was dominated by one or a few opportunistic species that occurred at high densities but did not have high biomass. The single exception — coincident abundance and biomass curves — occured at Group C sites. This analyse provide strong evidence that the community present in the lower Lima estuary remain in early succession, and indicate stress or disturbance (Warwick 1986, Gaston *et al*. 1998). In these types of polluted or stressed environments, the most sensitive species become rare or disappear, and are replaced by a opportunistic species (Dauer 1993). Continuous disturbance of the Lima estuary sediments by dredging, navigation, and organic and heavy metal contamination maintains the present community in a state of continuous change. Therefore, opportunistic species with high abundances but low biomass are more successfull than other species (Newell *et al*. 1998). Among all the species the one that contributed most to the high abundances was *A. alba*. This species is able to colonize areas known to be subject to environmental stress, particularly at points of sewage discharge (Dauvin *et al*. 1993, Skei *et al*. 1996, Austen *et al*. 1998). In areas with fine sediments rich in organic matter, where discharges of nutrients and other substances occurs (the case of Group A sites) and therefore more prone to eutrophication, we observed high abundances of *C. capitata*.

In this study a well-developed but unstable community was found in the dredged area. The higher abundances, biomass and number of species were registered at sites 2, 4 and 6 (Group B) where the dredging ocurred. Several studies reported a complete disappearance of the benthic fauna as a result of dredging (Quigley & Hall 1999). However, the small volume dredged in this estuary could permit the presence of intact areas which can facilitate the maintenance of the community structure. If dredging does not provoke considerable hydrological changes, the resulting sediment matrix will be similar to the original and repopulation can result from migration of adults, reproduction and recruitment of the larva from undisturbed areas (Hall 1994, Lu & Wu 2000, Bolam & Fernandes 2002). This repopulation can be initiated by opportunistic and transitional species typically found in environmental stressed habitats, such as estuaries (Newell *et al*. 1998, Bolam & Rees 2003).

Similarity with other European estuaries

Comparing our results with those from other European estuarine and coastal ecosystems we conclude that the Lima estuary was colonized in its mouth and in the navigation channel by typical marine species associated with the *Abra alba* community (colonizing finer deposits rich in organic matter) and the *Nephtys cirrosa* community (colonizing sandier deposits with low organic matter). These two communities are very common and widely distributed in the European coastal areas (Dauvin 1998, 2000, Dauvin *et al*. 2004, Van Hoey *et al*. 2004, 2005 and references therein). In addition to these communities, we also found an opportunistic group dominated by

C. capitata which colonized the most disturbed areas and in the upper sites we found taxa usually associated with brackish conditions, dominated by *H. diversicolor*. The species present in these two areas are also very common in several Portuguese and European subtidal estuarine ecosystems (Marques *et al*. 1993, Ysebaert *et al*. 2003, Carvalho *et al*. 2005, Chainho *et al*. 2006).

Conclusion

The macrobenthic community of the lower Lima estuary comprised four distinct macrobenthic groups that correlated with the sediment characteristics and salinity. The species *A. alba*, *H. diversicolor*, *H. reticulata* and *N. hombergi*, with great abundances and biomass, possibly play a key role in the Lima estuary and serve as an important food source for the higher trophic levels. Future studies are required to identify the potential human impacts caused by dredging and harbour activities, nutrient enrichment and dissemination of heavy metals in the Lima estuary macrobenthic community and may use this study as baseline information.

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