Macrobenthic community structure in relation to sediment composition at the Iberian Margin

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Abstract

Samples were taken for meio-, meso- (not yet sorted) and macrofauna and for sediment analyses along two transects at the Iberian Margin in June/July 1997. The first transect was from the coast off La Coruña to the abyssal plain at water depth ranging from 175 to 4909 m and the second transect from the Galicia Bank perpendicular to the coast. Macrofauna densities were high at the shelf and decreased with increasing water depths. Macrofauna densities were relatively low at 1522 m at the La Coruña transect and on top of the Galicia Bank at 764 m. At these stations median grain-size and the % of $CaCO_3$ were very high and the % of organic C and total N within the sediment low. Relatively high numbers of filter-feeding taxa were found at these stations, suggesting high flow velocities. At mid slope depths (1000-2000 m) most macrofauna was concentrated in the upper 1 cm of the sediment (~59%), whereas at the shelf more fauna was found in deeper sediment layers. Macrofauna biomass was lower at the shelf and upper part of the slope at the Iberian Margin than at the Goban Spur, whereas density and biomass were more or less similar at the lower part (>2000 m). At the lower part, however, the % of organic carbon and nitrogen were higher at the Iberian Margin than was found at the Goban Spur, whereas the median grain-size was similar. A larger fraction of the organic matter arriving at these depths thus seems to be buried within the sediment at the Iberian Margin compared to the Goban Spur, whereas a similar amount seems to be used by the macrofauna.

Introduction

Benthic infauna play an important direct and indirect role in determining the fate of organic material arriving at the sediment-water interface. The fauna physically transports particles through the benthic boundary layer. Organic material is stored temporarily as biomass and by feeding and excretion the burial and regeneration rates of carbon in the sediment are altered (Grehan *et al*. 1994). Bioturbation due to moving animals substantially modifies the physical, chemical and biological properties of sediments (Boudreau 1994, Soetaert *et al.* 1996). The majority (usually 80% or more by numbers in macrofaunal taxa) of animals captured in deep-sea cores are deposit-feeders (Jumars & Gallagher 1982). Bulk feeding by deposit-feeders in an environment of low rates of sedimentation results in intense reworking of the sediment and has considerable importance when trying to understand geochemical cycles and interpreting the geological record represented by the sediment (Gage & Tyler 1991).

Structural characteristics of benthic communities can give important indirect but time integrated information about the quantity and quality of organic material arriving at the sea floor and the burial of organic material in the sediments. The relationship between expected vertical distributions of macrofauna and organic food supply has been discussed by Jumars *et al*. (1990). If the majority of usuable food for deposit feeders arrives as pulses of labile matter, a selectively advantageous feeding strategy is to sequester as much as possible of this material as soon as it is available. Most heterotrophs are concentrated near the sediment surface and one possible strategy of sequestering may therefore be to bury the catch deep below the sediment-water interface.

In order to fulfil our tasks as stated in the Technical Annex within Work Package III of OMEX-II the macrobenthic community structure (density, biomass, taxonomic composition and size) was studied in relation to the sediment composition along two bathymetric transects at the Iberian Margin. Differences and similarities of the macrobenthic community and the sediment composition at this steep slope with upwelling are discussed in comparision to the smooth, non-upwelling slope of the Goban Spur.

Material and methods

Samples were taken along two transects with the RV Pelagia at the Iberian Margin from 23 June to 14 July 1997, one transect from the coast off La Coruña to the abyssal plain at water depth ranging from 175 to 4909 m and a second transect from the Galicia Bank perpendicular to the coast. Fig. 1 shows the depth profiles of the two transects. Exact sampling dates, positions and water depths are given in Table 1.

At these stations macrofauna samples were taken with the circular boxcorer of the Netherlands Institute of Sea Research (NIOZ). Because of logistic reasons different numbers of boxes of different sizes were taken at different stations. Boxcores with a diameter of 30 cm (mainly used at the shallow stations) and 50 cm were used (Table I). For this reason only mean densities and biomass per m² are given. Boxcore-samples were sliced in sediment layers of 0-1, 1-3, 3-5, 5-10 and 10-15 cm and sieved on a 0.5 mm-sieve. Samples were stored in 4 % formaldehyde, stained and sorted under a stereo microscope. Macrofauna was sorted to major taxonomic groups (phyla, order, class). Biomass was estimated in wet weight per major taxon after drying the animals a few seconds on absorbent paper. Because of the small size of most individuals no attempt was made to puncture shells of bivalves to drain them of water. Weighing was done with 0.1 mg accuracy.

Small subcores of 10 cm diameter were taken out of boxcore samples for mesofauna. These samples were treated as the macrofauna samples, but sieved on a 0.3 mm-sieve instead of 0.5 mm. This was done to be able to compare with some deep-sea researchers, who use 0.3-mm sieves for macrofauna. These samples are not yet sorted.

Meiofauna was sampled with a multicorer. Two small cores per station were sliced in 0-5, 5-10, 10-15, 15-20, 20-30, 30-40, 40-50 and 50-100 mm layers and stored in 4 % formaldehyde. Meiofauna samples are not yet sorted.

Multicorer samples were also taken for sediment analysis. Samples were sliced in layers of 5 mm (0-20 mm) and 10 mm to a depth of 150 mm for sediment analysis. Particle size of the sediments was estimated using a Malvern Particle Sizer 3600 EC. $CaCO_3$ was determined by gas volumetry (Scheibler method). Porosity was calculated out of the % moisture in the sediment. For C/N analysis samples were immediately frozen at -25 °C on board. The total nitrogen and the organic carbon content of the sediments were analysed with a Carlo Erba type NA-1500 elemental analyzer according to Nieuwenhuize *et al*. (1994). Carbon was partitioned in inorganic and organic fractions by acidification with 25% HCl in situ within silver sample cups.

Besides the stations mentioned for macrofauna, multicorer samples (meiofauna and sediment composition) are also available for station C14 (43°46.8´N, 8°54.0´W) at the La Coruña transect at a water depth of 734 m.

Results

Macrofauna

Macrofauna densities were high near the coast (~5000-6000 n/m²) at both transects and much lower farther offshore (Fig. 2a). At the La Coruña-transect an extreme low density (~400 n/m²) was found at station C36 at 1522 m. At this station density was nearly three times lower than at the deeper station C41 at 2200 m, and also lower than at the abyssal plain station. At this station C36 densities were low for all taxonomic groups (Fig. 3). Relative to its depth macrofauna density at the Galicia Bank station (764 m) were also very low (Fig. 2a). At this station relatively high numbers of Echinodermata (Fig. 2b) were found, which were mainly ophiuroids (brittlestars) (Fig. 3a). Polychaeta was the most abundant taxon at all stations (Fig. 2d), although its relative abundance varied from more than 70% at the shelf stations to only ~37% at station G85 at 1784 m and ~44% at station C41 at 2200 m (Fig. 2b).

At station C41 Crustacea were relatively abundant (~29%, Fig. 2b), especially isopods were found at high numbers (Fig. 3b). At the other ~2000 m stations G56 (2372 m) and G30 (2626 m) crustaceans were also relatively abundant (~25% and 22%, resp.). Although abundant, isopods did not dominate the crustacean fauna at these stations, at station G56 ostracods were very abundant. The highest numbers of crustaceans were found at the shelf stations, mainly amphipods and cumaceans (Fig. 3b). At the low density station C36 and the Galicia Bank station G100 the only crustaceans that were found, were amphipods and tanaids (Fig. 2b). At the Galicia Bank station G85 (1794 m) and the abyssal plain station C59 Mollusca were relatively abundant (~28% and 23%, resp.). At all stations bivalves were the most abundant molluscs (Fig. 3c). At the Galicia Bank station G100 (764 m) relatively high numbers of filter-feeding taxa (Porifera, Tunicata, Hydrozoa) were found (Fig. 3f). Filter-feeding taxa were also relatively abundant at the low density station C36 at 1522 m. Deposit-feeding Sipuncula, on the other hand, were relatively abundant at station G85 (1794 m), G56 (2372 m), C41 (2200 m) and the abyssal plain station C59. Although Nematoda are generally reckoned to be meiofauna, some nematodes were also found in the macrofaunal size fraction at all stations. They are given in Fig. 3e, but not included in total macrofauna density.

Fig. 4 shows the relative abundance of total macrofauna within the different sediment layers. High numbers were found in the upper 1 cm of the sediment at all stations. Especially at the mid-slope stations C36 (1522 m) and G85 (1794 m) was the fauna mainly concentrated in this upper layer (~59%, Fig. 4b). Whereas, at the shallowest station G0 (154 m) only 25% of the fauna was found in the upper 1 cm. Only a very few animals were found deeper than 5 cm in the sediment, at most stations less than 12%. Only at the two shelf stations relatively higher numbers of macrofauna were found deeper than 5 cm in the sediment (18-23%), which were more than 1000 individuals per m².

Macrofauna overall biomass was higher at the Galicia Bank transect than at the La Coruña transect (Fig. 5). The highest biomass was found at the shallowest station G0 at 154 m (23.4 g/m²), mainly due to the polychaetes. Excluding one extremely large polychaete of 2.63 g, mean biomass at this station was 10.7 g/m². At the deepest Galicia Bank station G30 (2626 m) also a high biomass was found, which was mainly due to one large pourtalesid echinoid of 1.24 g. However, even without this large echinoid, biomass was still relatively high (3.7 g/m²) for this depth (Fig. 5b). The lowest biomass at the Galicia Bank transect was found at station G56 at 2372 m (2.24 g/m²), and no large individuals were found here. At about the same depth at the La Coruña transect (C41 at 2200 m) biomass was nearly two times higher (4.4 g/m²). It was even higher when one large polychaete of 0.38 g was excluded (3.29 g/m²). The shelf and mid-slope stations at the La Coruña transect had relatively low biomass. Especially station C36 at 1522 m had low biomass (2.18 g/m²), excluding two large ophiuroids even lower than the abyssal plain station (Fig. 5b).

Mean individual weight without some extreme large individuals increased with increasing water depth at the La Coruña transect (Fig. 5c). At the Galicia Bank transect mean individual weight was also low at the shelf, but the lowest mean individual weight was found at station G56 at 2372 m. The highest mean individual weight was found on top the Galicia Bank at 764 m. The overall pattern along the Galicia Bank transect was also an increase, but not with increasing water depth but with increasing distance from the shore (Fig. 5c).

Sediment composition

Fig. 6 shows the sediment composition of the upper 1 cm of the sediment against water depth along both transects. Median grain-size was high at the shelf and low at all stations deeper than 1700 m (Fig. 6a). Very high median grain-size was found at station C36 at 1522 m and also on the Galicia Bank at 764 m. Porosity increased with increasing water depth (Fig. 6b). The percentage of calciumcarbonate ($CaCO_3$) increased along both transects, thus increasing with increasing distance from the shore. Along the La Coruña transect this also means an increase with increasing water depth, although the highest value was found at station C36 at 1522 m (~65%). Along the Galicia Bank transect it means an increase towards the Bank, with the highest values (nearly 90%) found on top of the Bank at 764 m. The percentage of organic carbon, on the other hand, is lowest on the Galicia Bank and increased towards the coast (Fig. 6d). At the La Coruña transect the percentage organic carbon is low at the shelf, but even lower at station C36 at 1522 m. At the nearby station C41 at 2200 m it is very high (~0.9%), whereas at the abyssal station C59 (4909 m) it is lower again, although still relatively high (~0.65%). A similar pattern was found for the percentage of total nitrogen within the sediment (Fig. 6e), although the differences between bank and coast were not so large as in organic carbon. The C/N ratio was highest near the coast (~10,5) and decreased with increasing distance from the shore (Fig. 6f). At the stations with high % of $CaCO_3$ the C/N ratio was very low.

Discussion

The macrofauna density was high at the shelf and decreased with increasing water depth and distance from the shore. Macrofauna densities at the shelf were more or less similar and also similar to the density found at the shelf station A of the Goban Spur transect from August 1995 (Fig. 7a). At the lower part of the slope (>2000 m) densities were also more or less similar. Very low densities were found at the La Coruña station C36 at 1522 m and at the Galicia Bank station at 764 m (Fig. 7a). At these stations median grain-size was very high, as were the % of $CaCO_3$.. The % of organic carbon, on the other hand, were very low at these stations. At both stations relatively high numbers of filter-feeding taxa were found, suggesting high flow velocities (Flach et al., in press). At station C36 also 59% of the fauna was found in the upper 1 cm, whereas at G100 only 43% was found in the upper 1 cm. At the Galicia Bank transect most fauna was concentrated in the upper 1 cm at station G85 at 1794 m (Fig. 4). At the Goban Spur transect most fauna was concentrated in the upper 1 cm (~70% in August 1995) at the stations B and II (1034 m and 1425 m) (Flach & Heip, 1996). The vertical distribution of the macrofauna thus seems to be depth related, with most fauna concentrated in the upper 1 cm at mid-slope depths (1000-2000 m). This could mean that at these depths food would arrive as pulses of labile matter (Jumars *et al.,* 1990).

Macrofauna biomass (without some extreme large individuals) shows an overall pattern of decrease with increasing water depth (Fig.7b). The shelf station C0 near La Coruña had a very low biomass compared to the shelf stations at the Galicia Bank and the Goban Spur transects. Extreme low biomass was found at station C36 at 1522 m and station G100 on the Galicia Bank had also a low biomass for its depth. The low biomass at these two stations was due to low densities (as discussed above) and not to small size of the animals (Fig. 5c), whereas at the shelf station C0 animals were very small. At the Galicia Bank mean individual weight was high, as were the mean individual weights at the deep La Coruña stations. Both transects show a similar pattern of relatively fewer individuals of larger size with increasing distance from the coast.

No direct relationship with the % of organic carbon or nitrogen with either density, biomass or size could be observed. These percentages increased with increasing distance from the coast at the La Coruña transect, whereas they decreased towards the Galicia Bank. Both percentages, however, did show a negative correlation with median grain-size. At the lower part of the slope (>2000 m) biomass and mean individual weight were more or less similar to the values found at the Goban Spur at similar depths. At these depths, however, the % of organic carbon and nitrogen were about two times higher at the La Coruña transect and also higher at station G30 at 2626 m than was found at the Goban Spur (Fig. 6), whereas the median grain-size was similar. A larger fraction of the organic matter arriving at these depths thus seems to be buried within the sediment at the Iberian Margin compared to the Goban Spur, whereas a similar amount seems to be used by the macrofauna.

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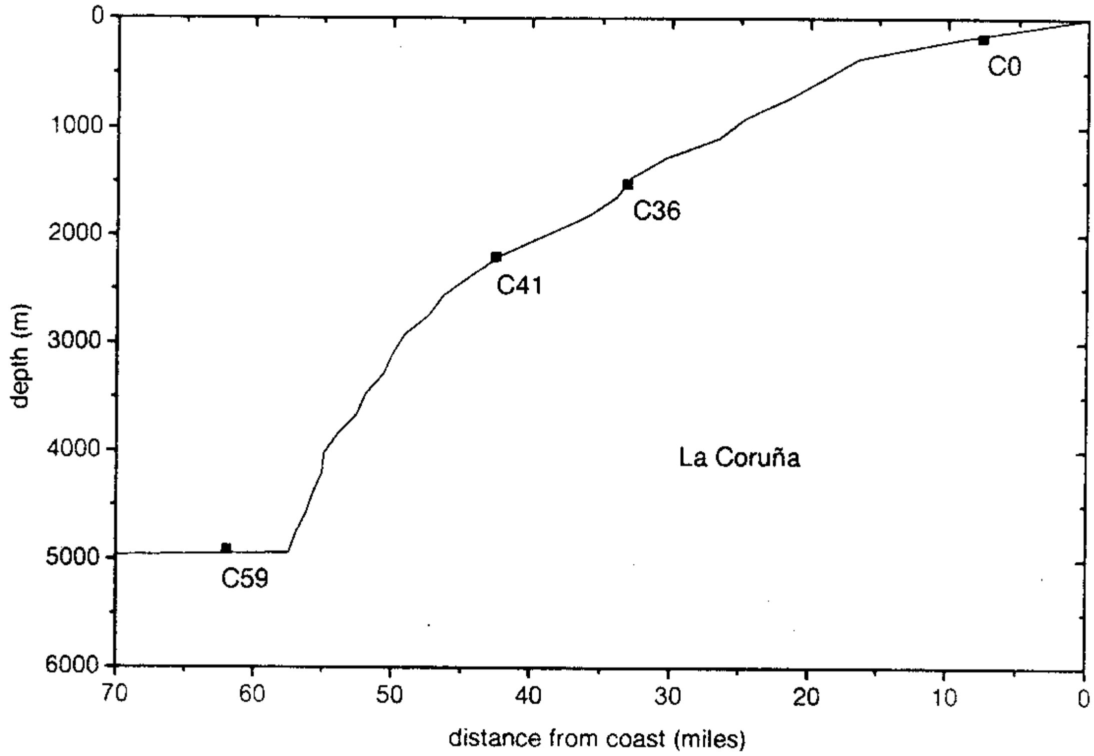
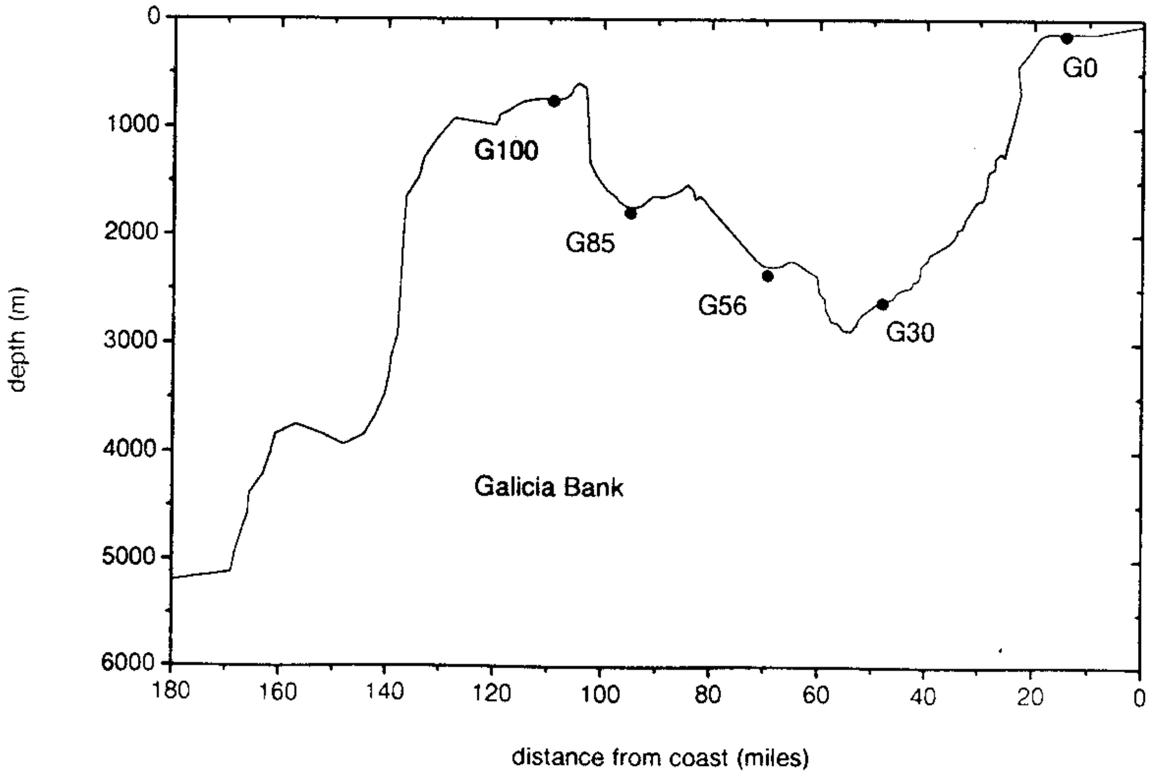
Table 1. Stations sampled for macrofauna at the Iberian Margin.

Station	Sampling date	Depth (m)	Position N	Position W	n boxcore	size boxcore
C0	28/06/97	175	43°40.9´	8°37.2´	4	Ø 30cm
C36	01/07/98	1522	43°40.9´	9°26.8´	2	Ø 50cm
C41	02/07/98	2200	43°45.4´	9°32.8´	2	Ø 50cm
C59	04/07/98	4909	44°00.6´	9°54.1´	2	Ø 50cm
G0	12/07/98	153	42°39.8´	9°28.2´	4	Ø 30cm
G30	11/07/98	2625	42°40.0´	10°10.0´	3	Ø 30cm
G56	09/07/98	2373	42°39.9´	10°44.0´	2	Ø 50cm
G85	08/07/98	1794	42°40.1´	11°22.1´	1	Ø 50cm
G100	07/07/98	764	42°44.9´	11°44.2´	4	Ø 30cm

Fig. 1. Depth profiles of the two transects sampled for macrofauna at the Iberian Margin.





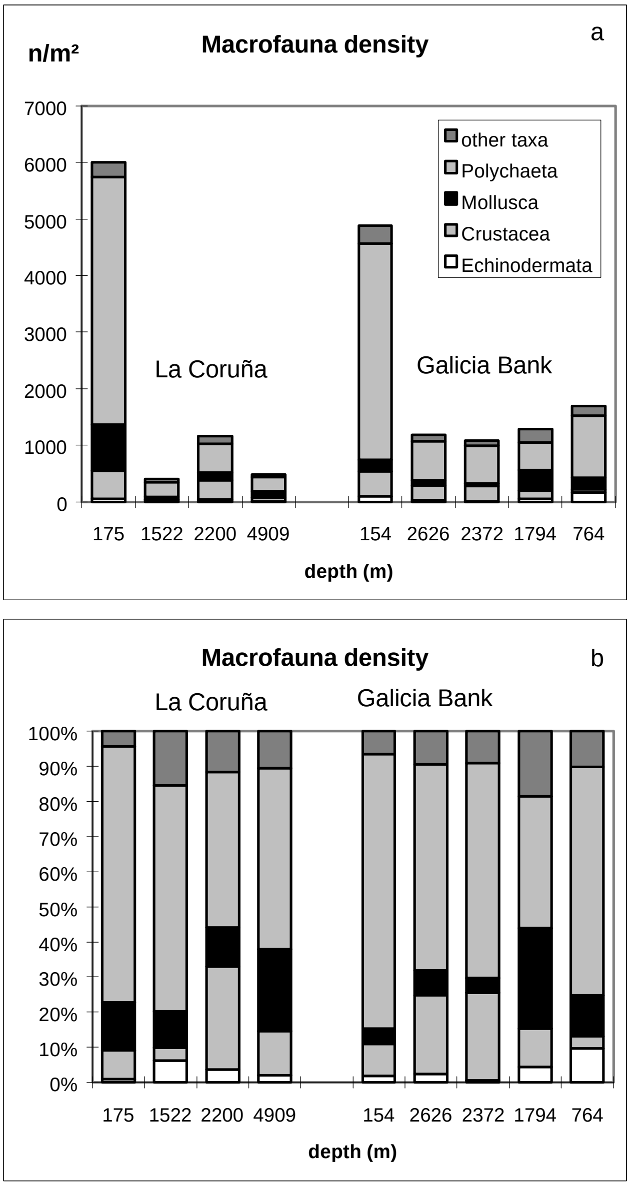


Fig. 2. Mean macrofauna densities (n/m²) (a) and relative abundance (b) of the major taxonomic groups along the two transects at the Iberian Margin.

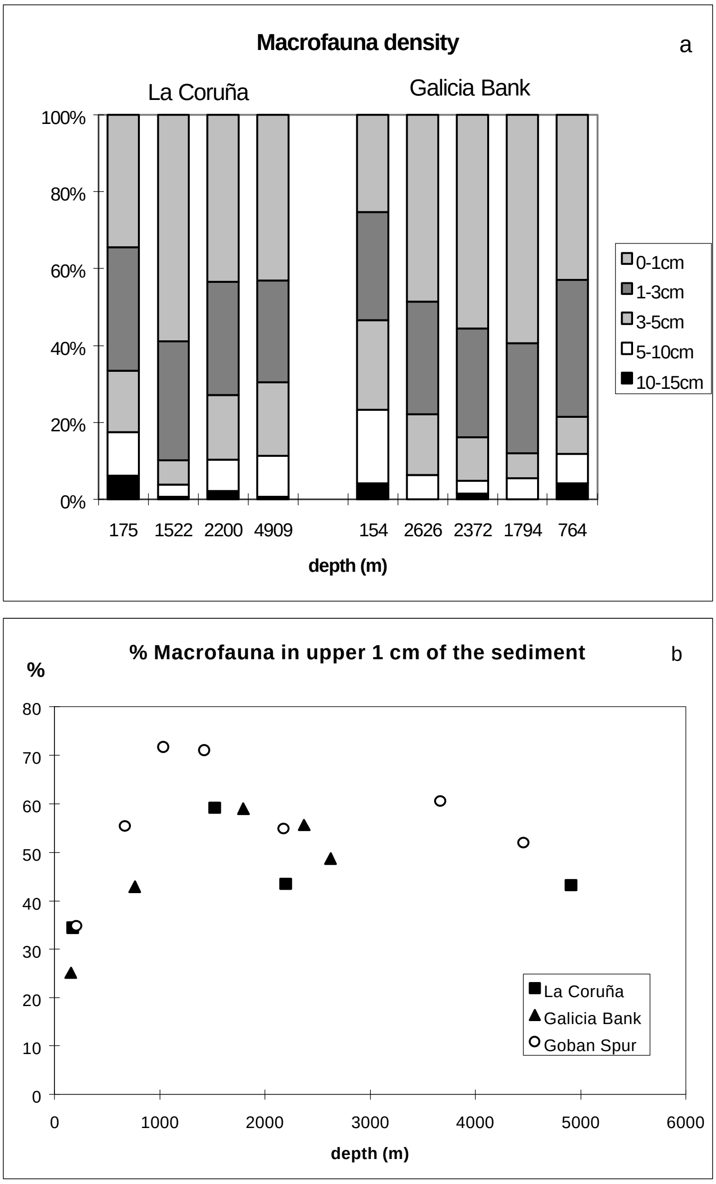


Fig. 4. Relative abundance of the macrofauna within different layers of the sediment along the two transects at the Iberian Margin (a) and the relative abundance in the upper 1 cm of the sediment along the depth gradient at the Iberian Margin in June/July 1997 and at the Goban Spur in August 1995 (b).

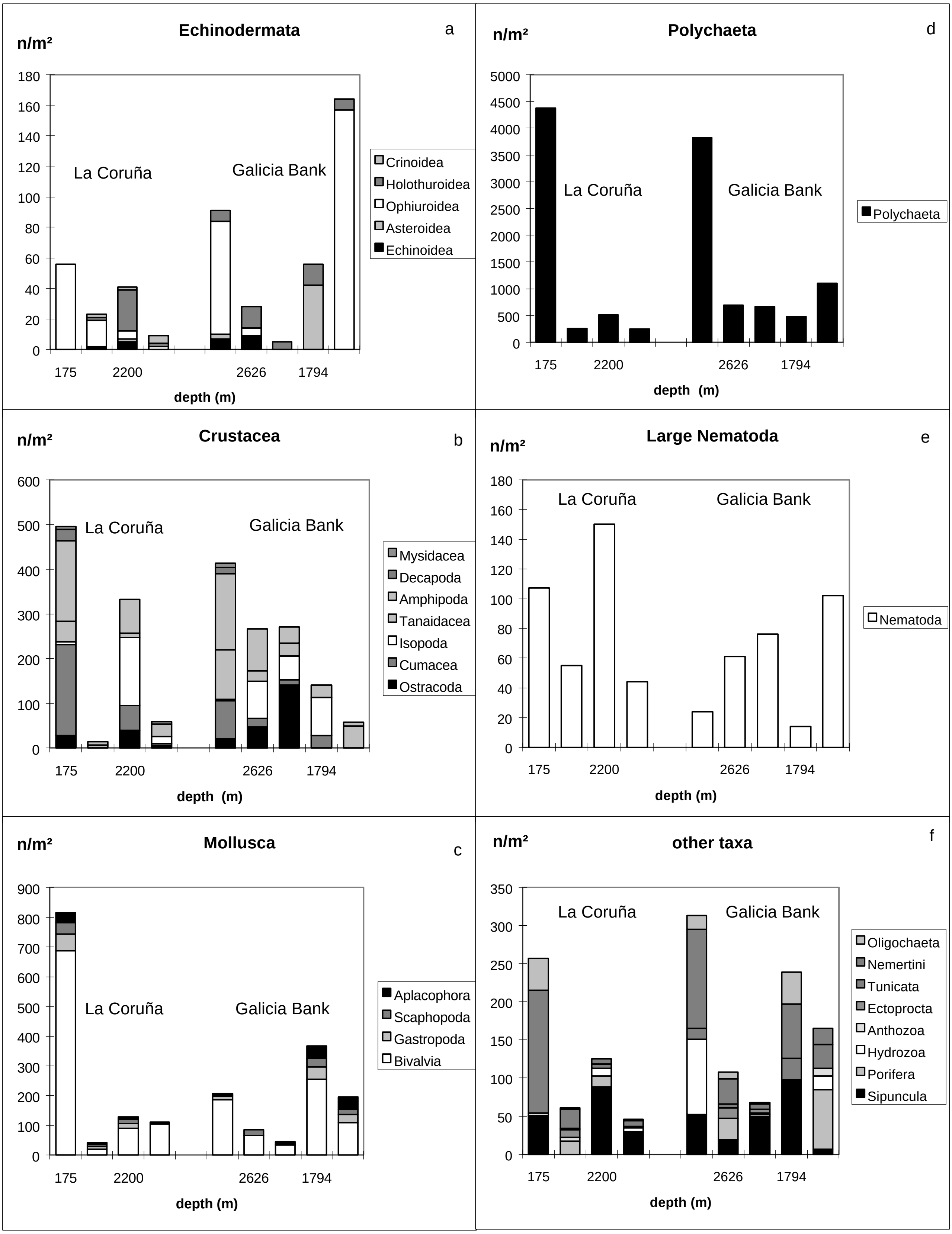


Fig. 3. Mean macrofauna densities (n/m²) of the taxonomic groups along the two transects at the Iberian Margin.

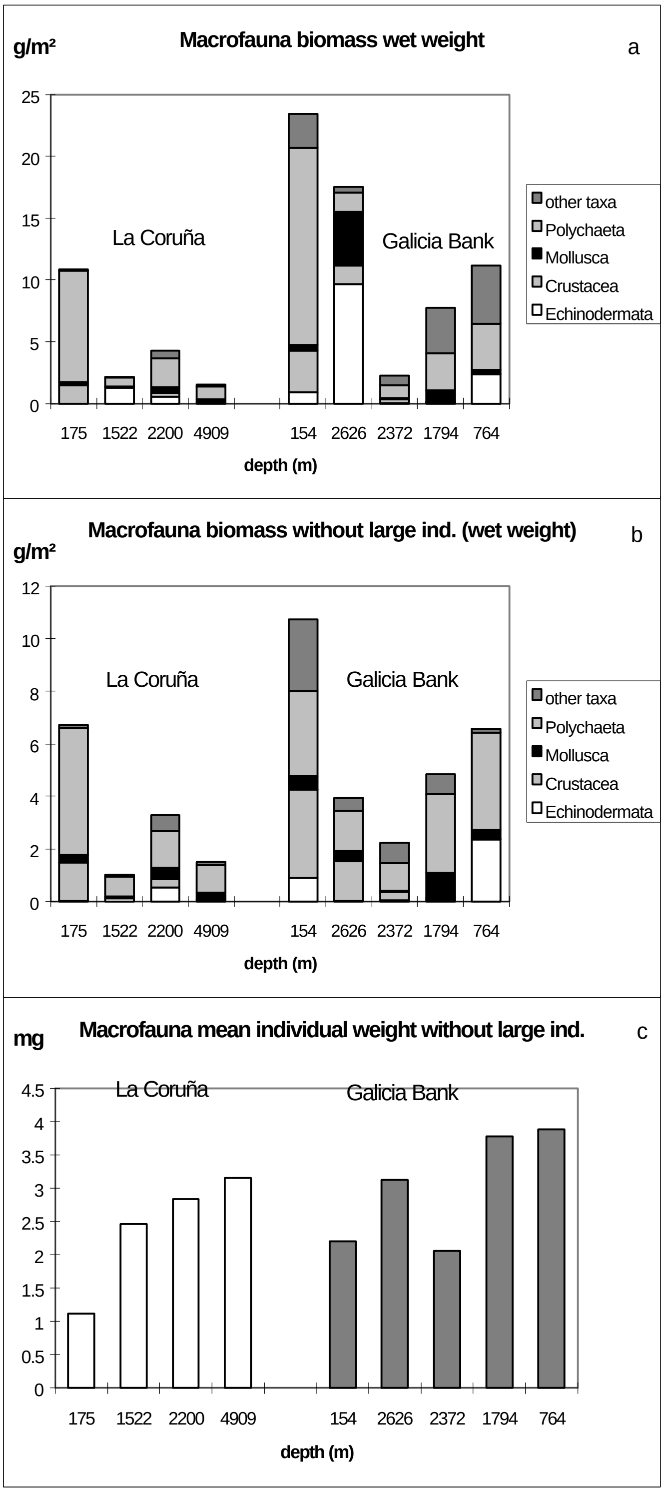


Fig. 5. Mean macrofauna biomass in g wet weight per m² and mean individual weight along the two transects at the Iberian Margin.

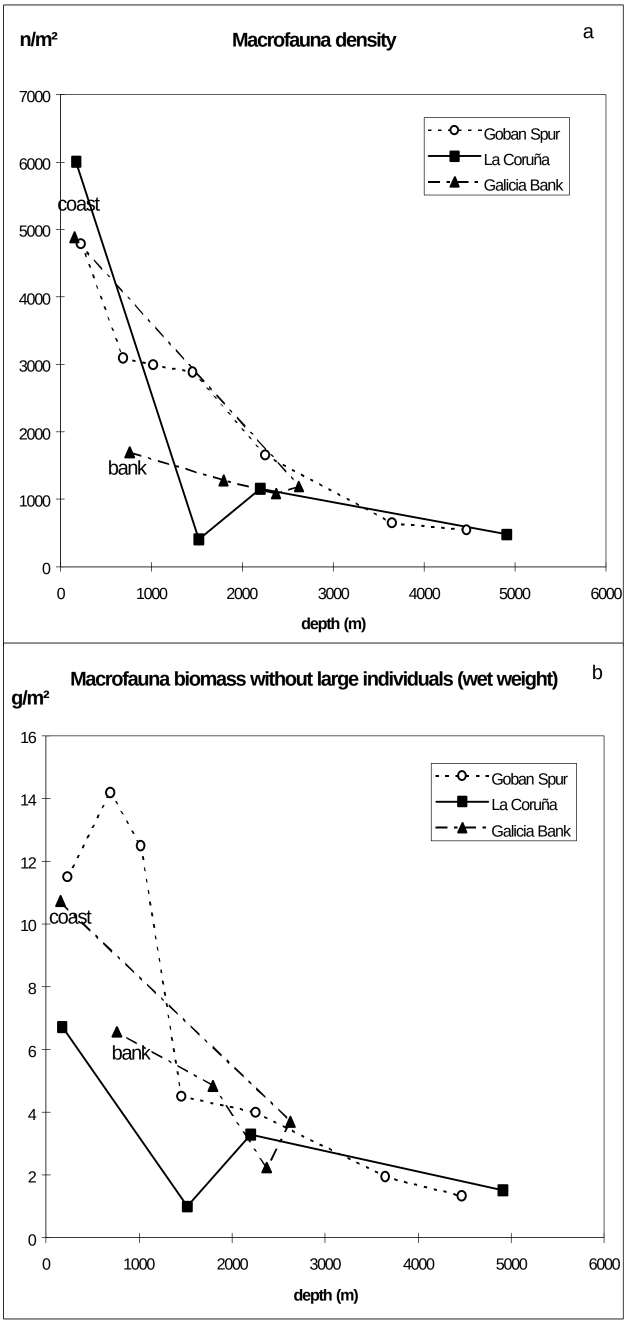


Fig. 7. Mean macrofauna densities (n/m²) (a) and mean macrofauna biomass in g wet weight per m² (b) along the depth gradient at the two transects at the Iberian Margin compared to the results of the Goban Spur transect of August 1995.

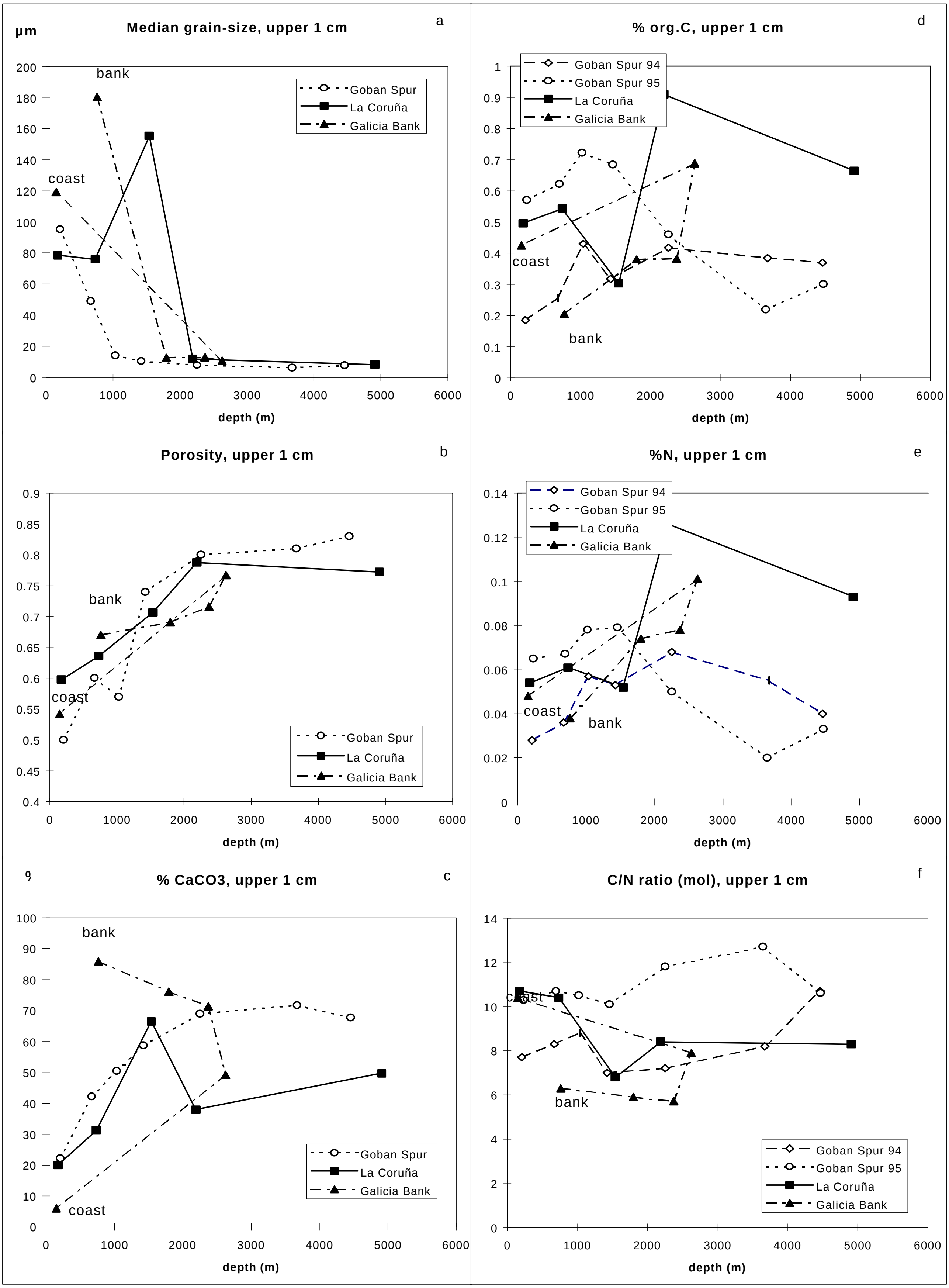


Fig. 6. Sediment composition of the upper 1 cm of the sediment along the depth gradient at the two transects at the Iberian Margin compared to the results of the Goban Spur transect of May/June 1994 and August 1995.