Benthic community structure in relation to sediment composition at the Iberian Margin.

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Introduction

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, size, vertical distribution and carbon requirement) and meiofauna (density, biomass) were studied in relation to the sediment composition at the Iberian Margin. Two transects were sampled, one from the coast off La Coruña and one from the Galicia Bank perpendicular to the coast. These two transects were situated in two somewhat different regions. Upwelling more frequently occurs at the northern transect, near La Coruña, whereas the western transect, besides coastal upwelling, is influenced by outflow of organic matter rich waters from the Rias Bajas (López-Jamar *et al.*, 1992).

Material and methods

Samples were taken for macro-, meso- and meiofauna 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 (stations C0 to C59) and the second transect from the Galicia Bank perpendicular to the coast (stations G100 to G0). In June 1998 five stations were sampled at a depth range from 770 to 4950 m of which two (G100 at ~770 m and C59 at ~4910 m) were at positions close to those sampled in 1997 (Fig. 1). Station C125 was very difficult to sample with the box-corer, we do not have good box-core (thus macrofauna) samples from this station. So, although I will give data for this station they have to be considered as not reliable. Exact sampling dates, positions and water depths are given in Table 1. Besides the stations mentioned for macrofauna, multi-corer samples (meiofauna and sediment composition) are also available for station C14 (43°46.8´N, 8°54.0´W) on the La Coruña transect at a water depth of 734 m.

At these stations macrofauna samples were taken with the circular box-corer of the Netherlands Institute of Sea Research (NIOZ). Because of logistic reasons different numbers of boxes of different sizes were taken at different stations. Box-cores 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 m^2 are given. Box-core 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. Biomass values were converted into organic C-content per major taxon using the conversion factors given by Rowe (1983).

The respiration of the macrofaunal community was estimated after Mahaut *et al.* (1995) in two steps: *via* individual respiration

$$R = 0.0074 \times W^{-0.24}$$

in which R= individual respiration rate (d^{-1}), and W= mean individual weight (mg org.C),
to community respiration = B x R (mg org.C. m^{-2} d^{-1}), in which B= biomass (mg org.C. m^{-2})

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

Station	Sampling date	Depth (m)	Position N	Position W	n box-core	size box-core
C0	28/06/97	175	43°40.9´	8°37.2´	4	Ø 30 cm
C36	01/07/97	1522	43°40.9´	9°26.8´	2	Ø 50 cm
C41	02/07/97	2200	43°45.4´	9°32.8´	2	Ø 50 cm
C59	04/07/97	4909	44°00.6´	9°54.1´	2	Ø 50 cm
G0	12/07/97	153	42°39.8´	9°28.2´	4	Ø 30 cm
G30	11/07/97	2625	42°40.0´	10°10.0´	3	Ø 30 cm
G56	09/07/97	2373	42°39.9´	10°44.0´	2	Ø 50 cm
G85	08/07/97	1794	42°40.1´	11°22.1´	1	Ø 50 cm
G100	07/07/97	764	42°44.9´	11°44.2´	4	Ø 30 cm
C125	30/05/98	4951	44°10.0’	11°09.9’	1	Ø 50 cm
C59	01/06/98	4915	44°.00.0’	09.°54.0’	2	Ø 50 cm
CG	04/06/98	3800	43°.11.5’	10.°37.0’	2	Ø 50 cm
G100	06/06/98	772	42°44.8’	11°.44.7’	2	Ø 50 cm
G25	07/06/98	2270	42°.38.2’	10°.02.5’	2	Ø 50 cm

Respiration of large individuals was estimated separately and afterwards added to respiration of the macrofaunal community. The estimation by Mahaut *et al.* (1995) was for deep sea conditions with temperatures between 2 and 4°C. Because temperatures at the shelf and upper slope stations were higher (Duineveld and Lavaleye, 1997; Lavaleye and Duineveld 1998), corrections for temperature were made using Krogh's "normal curve" (Winberg, 1971).

Small sub-cores of 10-cm diameter were taken out of box-core samples for mesofauna in 1997. These samples were treated as the macrofauna samples, but sieved on a 0.3 mm-sieve instead of 0.5 mm on board. This was done to be able to compare with some deep-sea researchers, who use 0.3-mm sieves for macrofauna. In the laboratory these samples were sieved over 1-, 0.5- and 0.3-mm sieves to estimate the abundance and biomass in the different sieve-fractions.

Meiofauna was sampled with a multi-corer. Two small cores of 10 cm^2 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. Meiofaunal organisms were extracted from the sediment by centrifugation with Ludox (Heip *et al.*, 1985). Macrofauna was excluded by means of a 1-mm sieve. All animals retained on a 32-µm sieve were counted, and nematodes were picked out *at random* from each site and mounted in glycerine slides. Nematode length (excluding filiform tails, if present) and maximal width were measured using an image analyser (Quantimet 500+). Nematode wet weight biomass was calculated from volume calculated with Andrassy’s formula (Andrassy, 1956) assuming a density of 1.13. Nematode wet weight was converted to organic carbon using the conversion factor (12.4%) given by Jensen (1984). Meiofauna biomass is thus restricted to nematode biomass, but because nematodes were the most abundant meiofaunal taxon (~90%, Vanaverbeke *et al.*, 1997) it gives a good estimate of meiofauna biomass.

Multi-corer 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 analyser 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.

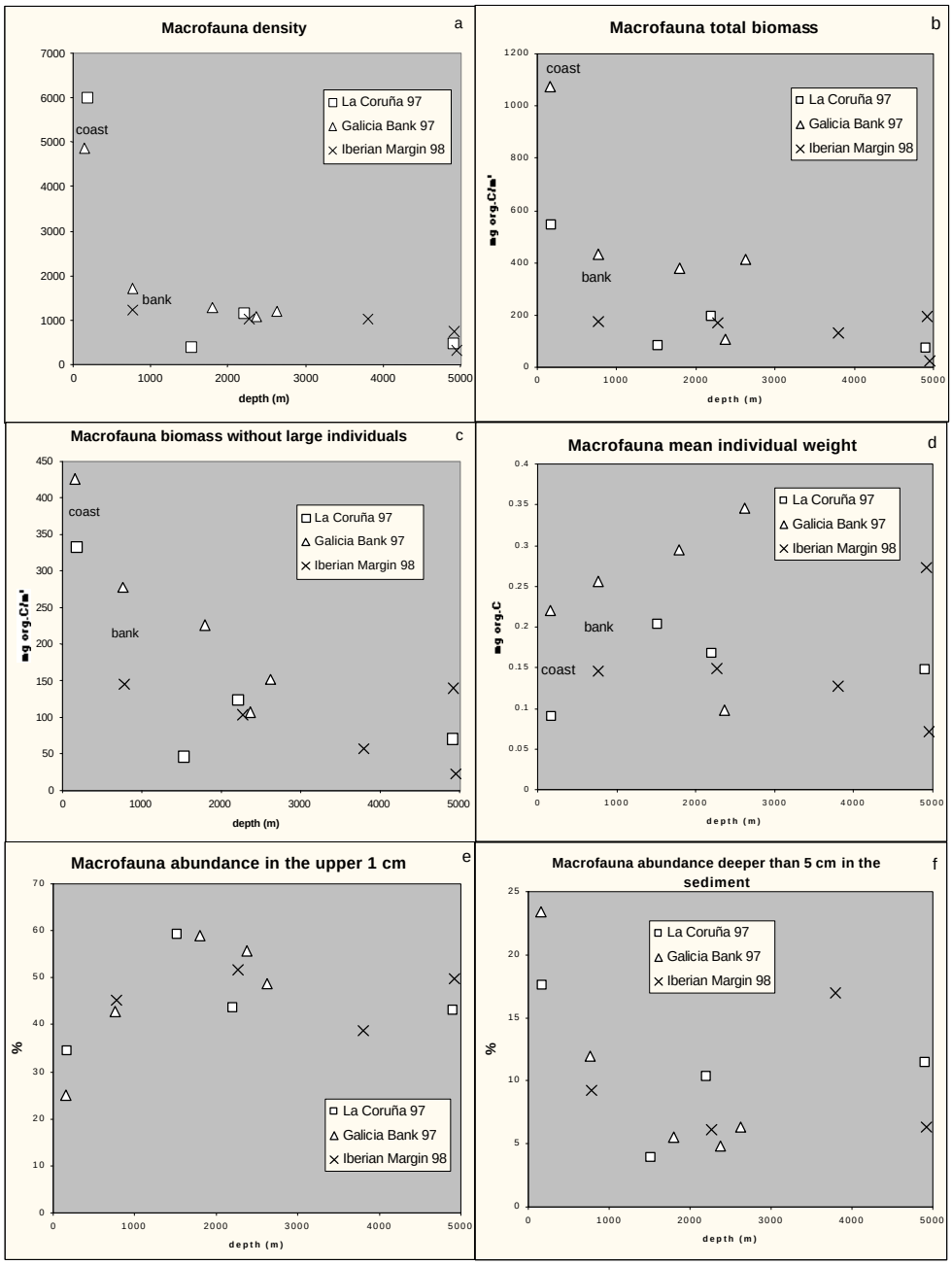


Fig. 1. Mean Macrofauna at the Iberian Margin.

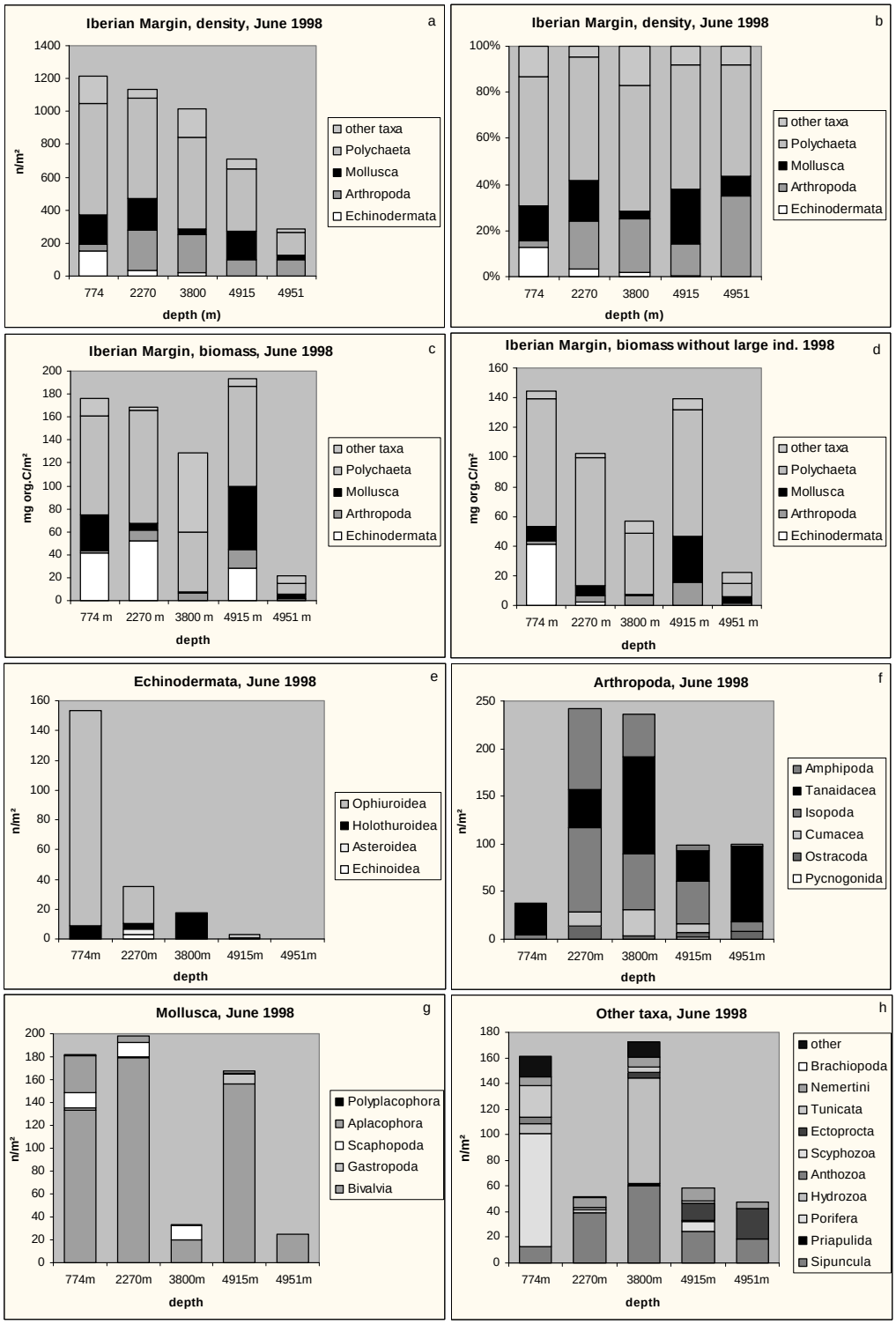


Fig. 2. Taxonomic composition of total macrofauna and the major taxonomic groups.

Results

Macrofauna

Macrofauna densities decreased with increasing water depth (Fig. 2a). Macrofauna densities were relatively low for its depth on the Galicia Bank (~770 m) and at station C36 (1522 m). No significant differences in density were found between the samplings of 1997 and 1998 at stations at about similar depths. Biomass, however, was lower in 1998 on the Galicia Bank, but higher at the deep La Coruña station C59 both with and without large individuals (Fig. 2b,c). This was due to on average smaller individuals found on the Bank in 1998, and larger ones at C59 (Fig. 2d). On average individuals were larger at the Galicia Bank transect than on the La Coruña transect and they were also small at station CG in the through (saddle) at 3800 m between the two transects. The low values at the abyssal plain station C125 should be considered with care, as no real good samples were available. It is therefore not attempted to get a vertical distribution pattern of this station. The results of the other stations showed a peak in relative abundance in the upper 1 cm of the sediment at mid-slope depths (1000-2500 m, Fig. 2e), whereas on the shelf (especially G0) and at the between transects station CG more fauna was found deeper than 5 cm in the sediment (Fig. 2f). The observed patterns were similar on both transects and in both years.

Detailed information about the macrobenthic community structure at the two transects sampled in 1997 is given in the 1st Annual Report of OMEX II-II (Flach *et al.*, 1998). Here we present the results of the five stations sampled in June 1998. Although not situated along one transect and the shallowest stations situated far offshore on the Galicia Bank, still an overall pattern of decrease in macrofauna densities with increasing water depth was found (Fig. 3a). This decrease was mainly caused by a decrease in polychaete density, which was the most abundant taxon at all stations (Fig. 3a,b). The relative abundance of the major taxa also followed the generally observed pattern of decrease in relative abundance of the echinoderms and increase of the crustaceans with depth (Fig. 3b). Total biomass, however, was highest at the deep La Coruña station C59 (Fig. 3c). Even when some extreme large individuals were excluded biomass at this deep station remained high (Fig. 3d), whereas the other four stations again showed the pattern of decrease with increasing water depth. This high biomass at station C59 is caused by high mean individual weight in all major macrobenthic taxa, except the group of small miscellaneous taxa (Fig. 4). Within the echinoderms this high value was caused by one large ophiuroid, but within all other groups all individuals were relatively large. At station G25 also one large ophiuroid was found besides several smaller ones, whereas the high biomass and mean individual weight of the group of other taxa at station CG was caused by one large sipunculid.

High numbers of ophiuroids were found on top of the Galicia Bank and also relatively high numbers on the other Galicia Bank transect station G25. At this station G25 also asteroids were found, which were not found at any other station. At the in between station CG (3800 m) the only echinoderms found were holothurians (Fig. 3e). Very low numbers of crustaceans were found on top of the Galicia Bank, only some tanaids and a very few isopods (Fig. 3f). High numbers of crustaceans were found on the other Galicia Bank transect station G25 and at the in between station CG, mainly amphipods, isopods and especially at CG also tanaids. High numbers of tanaids were also found on the abyssal plain station C125 (Fig. 3f). Molluscs were abundant at the two Galicia Bank transect stations and the deep La Coruña station C59, which were mainly bivalves. On the Galicia Bank also relatively high numbers of *Aplacophora* were found (Fig. 3g). Low numbers of bivalves were found at station CG, whereas the numbers of scaphopods were similar to those found at the two shallower stations. At station CG high numbers of other taxa were found, mainly sipunculids and *Hydrozoa* (Fig. 3h). On top of the Galicia Bank also high numbers of other taxa were found, but here it were mainly sponges (*Porifera*) and tunicates. Remarkable were the high numbers of *Ectoprocta* (*Bryozoa*) at the two deepest stations (Fig. 3h).

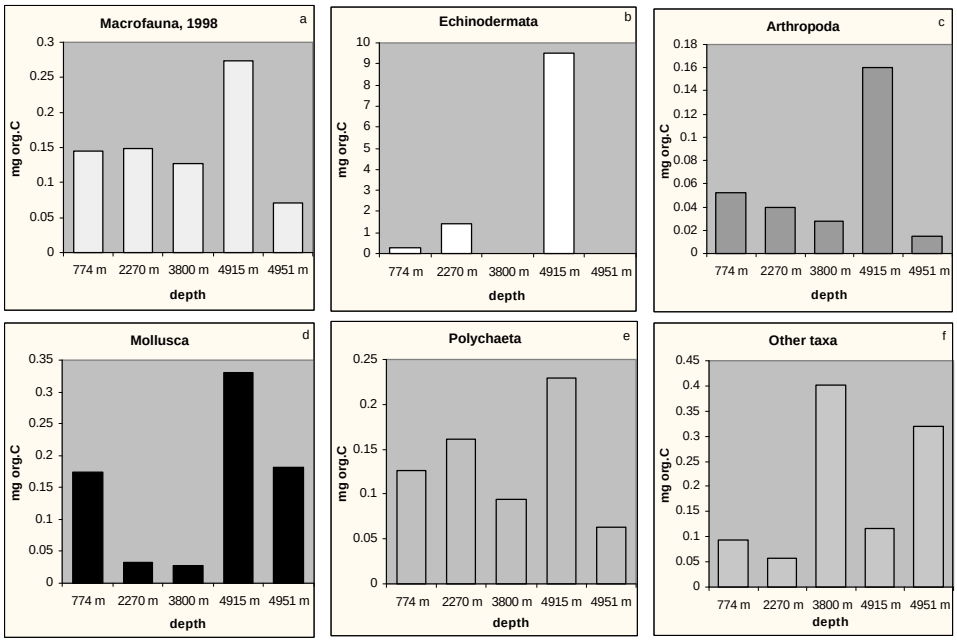


Fig. 3. Mean individual weight of total macrofauna and major taxa.

Mesofauna (sieve-experiment)

The relative abundance of macrofaunal taxa in the sieve-fraction between 0.3 and 0.5 mm (mesofauna) decreased with increasing water depth from ~60% on the shelf to ~25% at 4900 m (Fig. 5a). At the two mid-slope stations C36 and G85 (1500-1800 m) the percentage of macrofaunal taxa within this fraction was also low (20-25%). At these stations meiofaunal taxa (mainly nematodes) thus dominate this fraction. On average about 40% of total macrofauna density was found in the sieve-fraction between 0.3 - 0.5 mm, another 40% in the fraction between 0.5 -1 mm and 20% in the 1-mm sieve (Fig. 6a). No significant differences in these fractions along the depth gradient were found, although a slight decrease in the percentage in the fraction between 0.3 - 0.5 mm with water depth was found (Fig. 5b). The macrofaunal biomass in the fraction between 0.3 - 0.5 mm was very low, between 2 and 20% (Fig. 6b), at nearly all stations biomass was highest in the fraction >1 mm. Meiofauna biomass and density, on the other hand, were very low in the fraction >1 mm (Fig. 6c,d). The highest percentage of meiofaunal taxa were found in the fraction between 0.3 - 0.5 mm (~80%), and also in biomass this fraction was highest at most stations (Fig.6c,d).

Although no significant trends along the depth gradient were found, the use of the different sieve-sizes did make a difference in the relative community structure and vertical distribution (Fig. 5c,d). The use of a 0.5-mm sieve for the macrofauna gave an underestimation of the relative abundance of the molluscs and an overestimation of the echinoderms and the group of other taxa within total macrofauna (Fig. 5c). The use of a 0.5-mm sieve for the vertical distribution of the macrofauna taxa in the sediment gave an underestimation of the relative abundance in the upper 1 cm and an overestimation in the fraction deeper than 5 cm (Fig. 5d).

Respiration rate and total respiration of the macrofauna was calculated from the box-core samples for the fraction >0.5 mm and of the mesofauna from the small samples in the fraction between 0.3 - 0.5 mm. The respiration rate decreased with increasing water depth and was higher for the mesofauna (Fig. 7a). The total respiration for the mesofauna, however, was much lower than for the macrofauna (Fig. 7b). The relative importance of the mesofauna in total macrofaunal taxa respiration varied between 3 and 10% and again no significant trend with depth could be observed. Total respiration decreased from ~6.4 gC m^{-2} y^{-1} at station G0 (154 m) to ~0.5 gC m^{-2} y^{-1} at station C59 (4910 m).

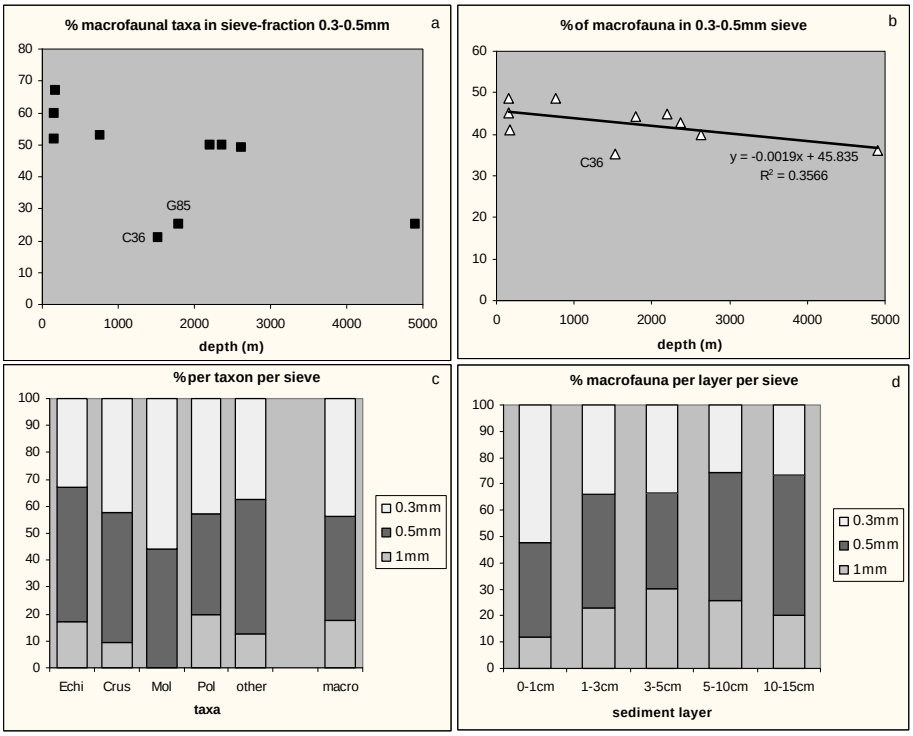


Fig.4. Relative macrofauna densities in different sieve fractions.

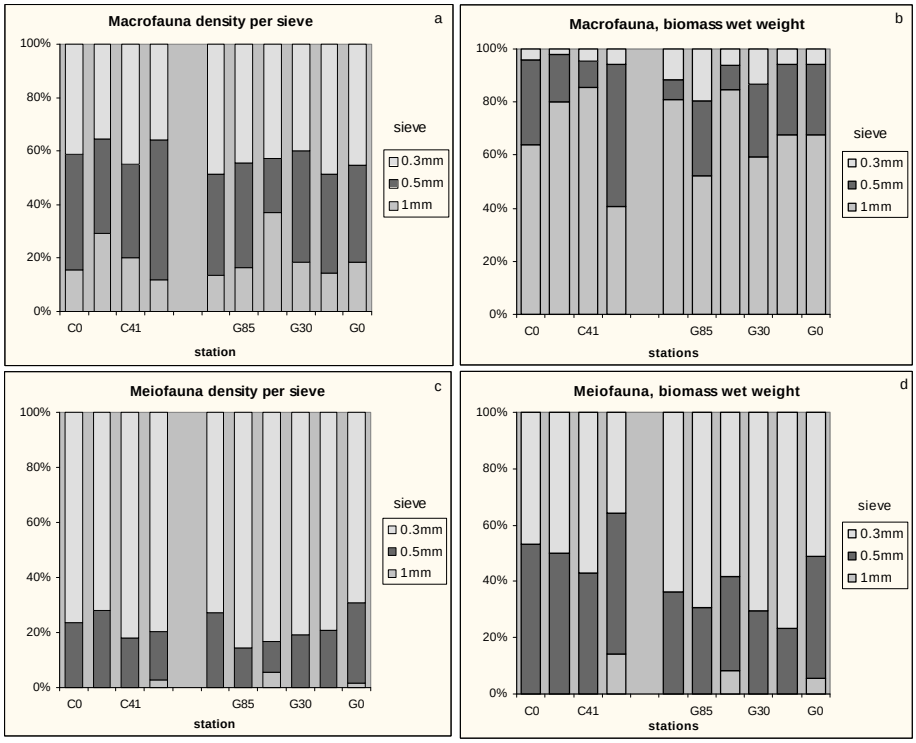


Fig. 5. Relative fractions on sieves of different mesh sizes.

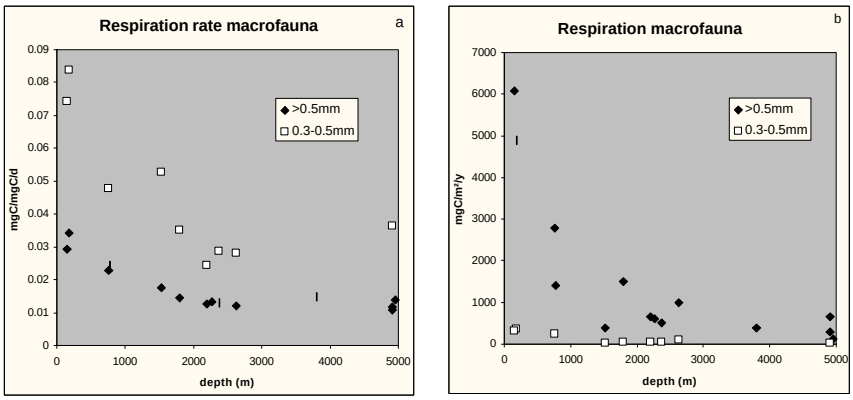
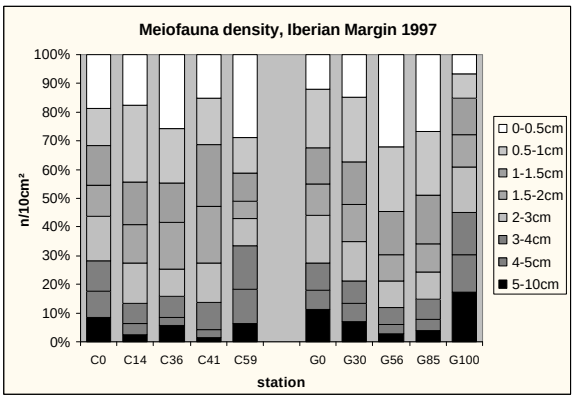


Fig. 6. Respiration rate and total respiration of macrofauna in different sieve fractions.

Meiofauna

Meiofauna densities on the shelf were very high, especially off La Coruña (Fig. 7a). Also the two deep stations on the La Coruña transect had high meiofauna densities, whereas it was low at station C36 at ~1500 m. Meiofauna densities on the Galicia Bank transect decreased with increasing distance from the shore and were thus low on the Galicia Bank. The relative amount of nematodes within the meiofauna showed an overall pattern of increase with increasing water depth (Fig. 7b). The relative amount of nematodes on the Galicia Bank transect was ~90%. On the shelf off La Coruña, however, the % nematodes was only ~70%, at this station high numbers of turbellarians were found. Also at station C36 the % nematodes within the meiofauna was relatively low (~80%). This could have had some effect on the meiofauna biomass as meiofauna biomass is considered to be about equal to nematode biomass. *Nematoda* biomass, however, is still very high at station Co and although lower at C36, it was not lower than the Galicia Bank station G85 at about similar depth (Fig. 7c). This was caused by a relative high mean individual weight of the nematodes at these La Coruña stations (Fig. 7d). Mean individual weight showed an overall pattern of decrease with increasing water depth on both transects. The vertical distribution of meiofauna densities within the sediment showed that on the shelf ~30% of the meiofauna was found in the upper 1 cm on the sediment and ~50% at upper- and mid-slope depths (Fig. 8). On top of the Galicia Bank, however, only ~20% of the meiofauna was found in the upper 1 cm. At this station G100 ~60% of the meiofauna was found deeper than 2 cm in the sediment. On both shelf stations and at the deepest station C59 (4909 m) more than 40% of the meiofauna was found deeper than 2 cm in the sediment, whereas at most slope stations it was less than 30%.

Fig. 8. The relative vertical distribution of meiofauna densities within the sediment.



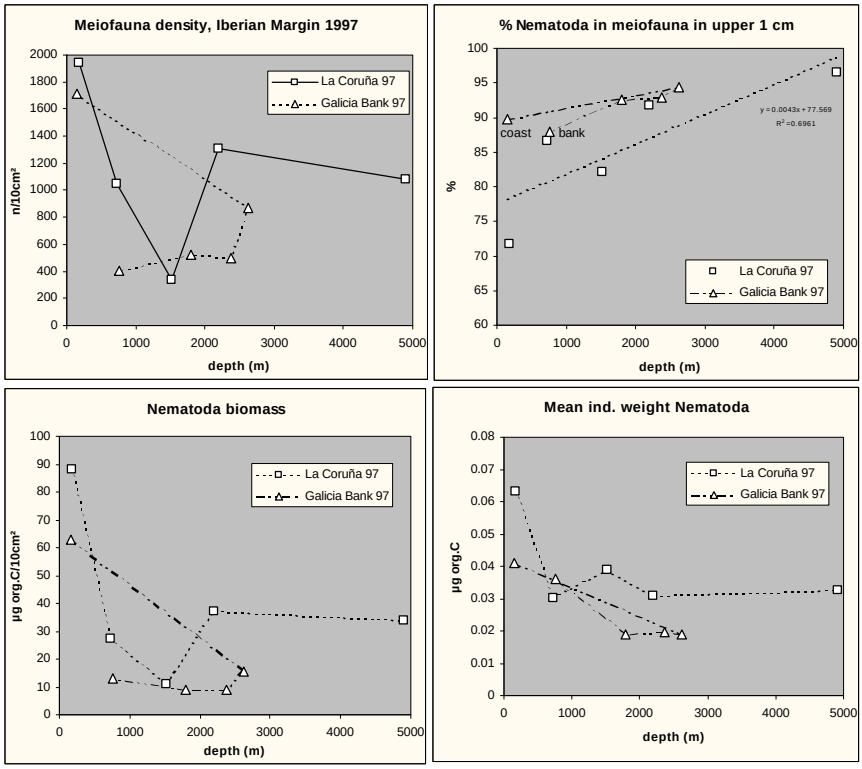


Fig. 7.Total meiofauna densities, the relative amount of nematodes within the meiofauna and nematode biomass and individual weight.

Sediment composition

Median grain-size was relatively low on the shelf off La Coruña (~80 µm) and increased to ~150 µm at ~1500 m, after which it decreased again to ~12 µm at ~2200 m and ~8 µm at 4900 m (Fig. 9a). This pattern was found in all sediment layers to a depth of 15 cm (vertical profiles of all sediment analyses are available by the authors). Median grain-size was very high on top of the Galicia Bank (Fig. 9a). The vertical profiles at this station differed between the two years, in 1997 the upper 1.5 cm had lower grain-sizes than the deeper layers, whereas in 1998 the upper 2 cm had higher grain-sizes, in the deeper than 2 cm layers similar values of ~250 µm were found in both years. The coastal station of the Galicia Bank transect had higher grain-size values than off La Coruña, whereas the deep stations had similar values (Fig. 9a). The $\%CaCO_3$ increased from the coast towards the Galicia Bank, whereas at the La Coruña transect it showed a peak at ~1500 m (Fig. 9b). This coincided with low values in the %org.C and total N at these depths (Fig. 9c,e). High %org.C and N were found at the deep La Coruña stations, especially station C41 at ~2200 m. The vertical profiles showed a slight decrease with sediment depth at nearly all stations, resulting in about the same pattern within different sediment layers along the water depth gradient (Fig. 9c-f). The C/N ratio showed an overall pattern of decrease with increasing distance from the shore (Fig. 9g, h), although low values were found at station C36 at ~1500 m.

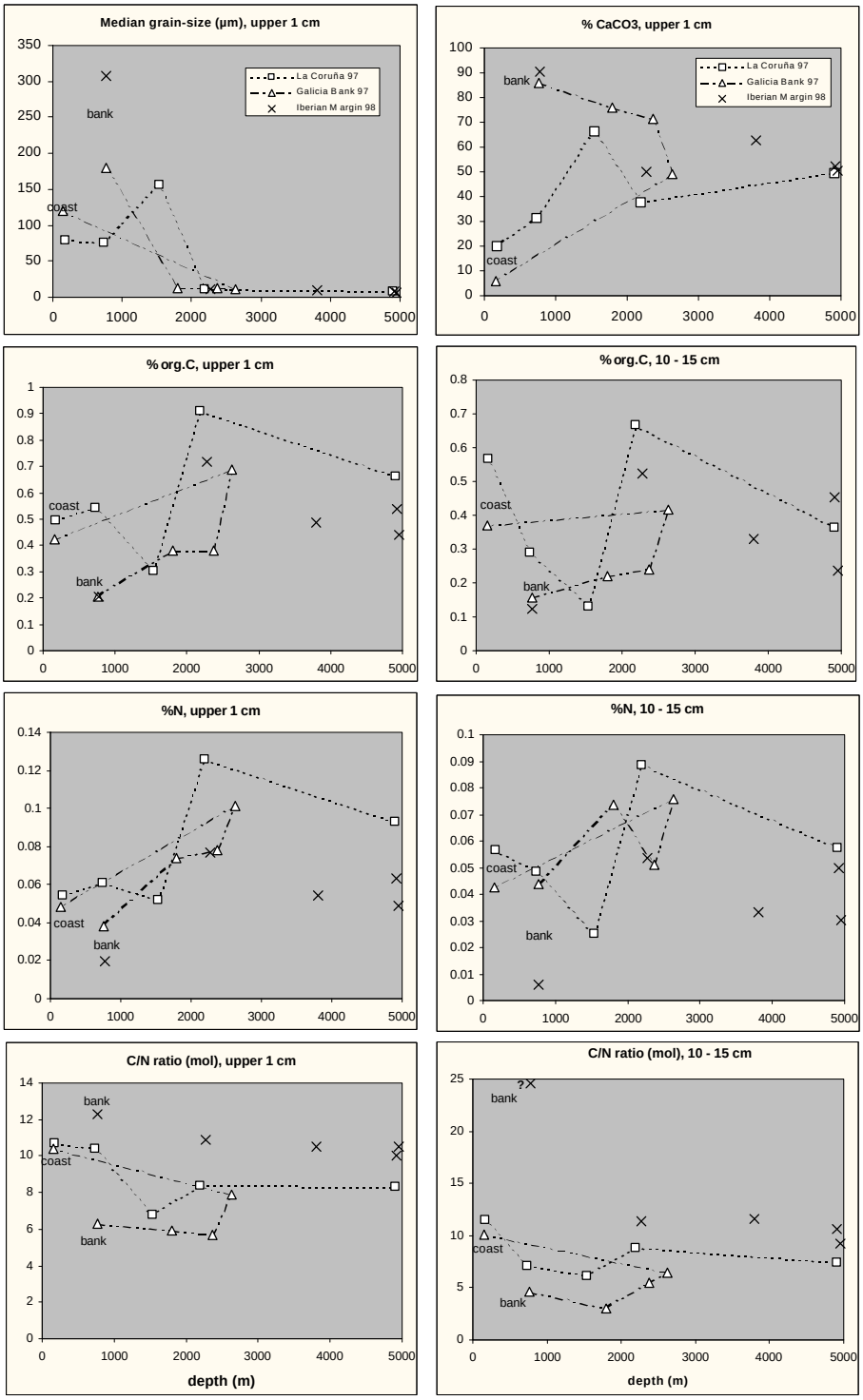


Fig. 9. The sediment composition of the upper 1 cm and the % org. C and N in the 10 - 15 cm layer.

Conclusions

Although besides upwelling outflow of organic rich water should enrich the Galicia Bank transect, neither the % of organic C and total N in the sediment nor the faunal densities were higher at the shelf site of this transect than near La Coruña. Macrofauna biomass, however, was about two times higher at the shelf site of Galicia Bank transect than near La Coruña, due to higher mean individual weight of the animals. Nematodes, however, were larger on the shelf near La Coruña, resulting in a higher meiofauna biomass although the relative amount of nematodes within the meiofauna was much lower than at the shelf site of Galicia Bank transect.

The relatively low meiofauna densities and macrofauna densities and biomass at 1522 m at the La Coruña transect and on top of the Galicia Bank at 764 m coincided with low % of organic C and total N within the sediment. At these stations relatively high numbers of filter-feeding macrofauna taxa were found, indicating either high flow velocities and/or extreme poor feeding conditions within or on the sediment.

At the deeper (>2000 m) stations, however, the higher % of organic C and N on the La Coruña transect were not reflected in the macrofauna densities, but clearly reflected in the meiofauna densities. A larger fraction of the organic matter arriving at these depths thus seems to be used by the meiofauna and buried within the sediment, whereas a similar amount seems to be used by the macrofauna.

Carbon requirements, estimated by macrofaunal respiration, decreased with increasing water depths from ~6.4 gC m^{-2} y^{-1} at the shelf site of Galicia Bank transect to ~0.5 gC m^{-2} y^{-1} at the deepest station on the La Coruña transect. The relative importance of the mesofauna (0.3-0.5 mm mesh-sieve) in carbon requirements was very low (3-10%), although ~40% of macrofauna densities could be found within this sieve fraction.

References

Andrassy I., 1956. The determination of volume and weight of nematodes. Acta Zool. (Hungarian Academy of Science), 2 (1-3): 1-15.

Duineveld G.C.A. and M.S.S. Lavaleye, 1997. Benthic Biology of the Iberian Upwelling Margin. Cruise Report, R.V. *Pelagia*, 23 June-14 July.

Flach E., C. Heip and A. Sandee, 1998. Macrobenthic community structure in relation to sediment composition at the Iberian Margin. OMEX II-II, 1st Annual Report.

Heip C., M. Vincx and G. Vranken, 1985. The ecology of marine nematodes. Oceanogr. Mar. Biol. Ann. Rev., 23: 399-489.

Jensen P., 1984. Measuring carbon content in nematodes. Helgol. Meeresunters., 38: 83-86.

Lavaleye, M.S.S. and G.C.A. Duineveld, 1998. Shipboard report of the OMEX-98 Biology expedition to NW Spain with the R.V. *Pelagia*, 25 May-12 June.

López-Jamar E., R.M. Cal, G. González, R.B. Hanson, J. Rey, G. Santiago and K. Tenore, 1992. Upwelling and outwelling effects on the benthic regime of the continental shelf off Galicia, NW Spain. J. Mar. Res. 50:465-488.

Mahaut M.L., M. Sibuet and Y. Shirayama, 1995. Weight-dependent respiration rates in deep-sea organisms. Deep-Sea Res. I, 42(9): 1575-1582.

Nieuwenhuize J., Y.E.M. Maas and J.J. Middelburg, 1994. Rapid analysis of organic carbon and nitrogen in particulate materials. Marine Chemistry 45: 217-224.

Rowe G.T., 1983. Biomass and production of deep-sea macrobenthos. In: G.T. Rowe (ed.). Deep-sea Biology. The Sea, Vol. 8, John Wiley and Sons, New York: 97-121.

Vanaverbeke J., Soetaert, K., Heip C. and Vanreusel, A., 1997. The meiobenthos along the continental slope of the Goban Spur (NE Atlantic). J. Sea Res., 38: 93-108.

Winberg G.G., 1971. Methods for estimation of production of aquatic animals. Academic Press, London and New York.