Megabenthos, benthic respiration and phytopigments off NW Spain.

M.S.S. Lavaleye, G.C.A. Duineveld and E.M. Berghuis

Netherlands Institute for Sea Research
P.O. Box 59, Texel, The Netherlands

1. INTRODUCTION

Export of shelf-derived organic matter (OM) near continental margins may add to the vertical rain of OM from local production over the slope. In such cases the continental rise and slope may act as (temporary) deposit centers of organic carbon and consequently become a site with augmented benthic mineralisation (*e.g.*, O_2 respiration) and benthic biomass as was found to be the case on the US Atlantic and Pacific margins (Rowe *et al*, 1994, Jahnke *et al*, 1990). In general benthic communities underneath upwelling systems seem to be even more active in terms of respiration and richer in biomass than at comparable sites without upwelling (Jahnke and Shimmield, 1995; Sibuet *et al*. ,1993). The latter even holds for areas where adverse oxygen minima exist (Bett, 1995; Gage *et al.*, 1995).

In the OMEX II-II program we attempt to relate the structure and metabolism of the benthic community along the NW Iberian margin to vertical and horizontal particle fluxes fueled by upwelling and shelf export. With respect to the community structure we focus on large long -living organisms as these better integrate the seasonal and erratic variations of the food supply. The metabolic activity of the whole sediment community is measured *in situ* with a benthic lander. These measurements are supplemented with shipboard measurements of diffusive (porewater oxygen profiles) and total fluxes in decompressed sediment cores.

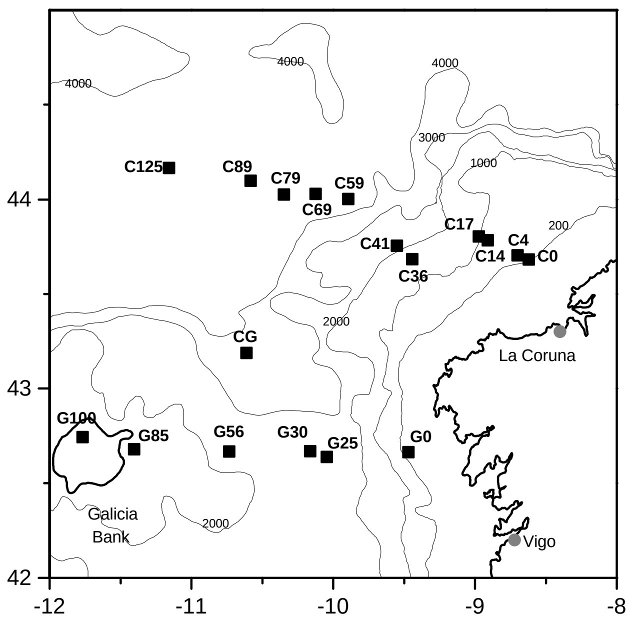


Fig. 1. Map of the area NW of Spain with the station sampled during three successive cruises with the RV *Pelagia* in 1997 and 1998.The upper transect is called the Coruña transect (C), while the lower is called the Galicia transect (G).

2. STUDY SITES AND METHODS

2.1. Positions of sampling stations

During the first cruise in June-July 1997 we took samples along two transects (see Fig. 1) *i.e.*, one transect crossing the slope off La Coruna and ending on the abyssal plain (4900 m) and another at 42^o 40'N ending at the Galicia Bank. The maximum depth of the second transect was 3000 m. This latter transect comprised the OMEX station (G25, Fig. 1) where long-term moorings (2200 m) were to be deployed. A second cruise was made in May-June 1998. Research was focused on the OMEX station (G25), the interesting abyssal station C59, and the deepwater coral stations C17 and G100. To find further evidence for the relatively high input of organic material at the abyssal station C59 two other stations were sampled. Station C125 to compare a true abyssal station with one near the slope, and station CG in the channel towards the abyssal plain between the slope and Galicia Bank to check if this was a transport route of material (Fig.1).
A third cruise was made in September 1998 to get new data from the main OMEX station (G25), sample an abyssal transect (C59-C89) to measure the extension of the relatively rich zone here, and pay short visits to station CG and G100.

Table 1. Depth and geographical positions of all stations visited during three cruises with the RV *Pelagia*. The numbers under the heading Cruise denote during which cruise the stations were sampled. 1 = Cruise 108, 23 June -14 July 1997, 2 = Cruise 118, 25 May - 12 June 1998, and 3 = Cruise 123, 2 Sept. - 18 Sept. 1998.

STATION	CRUISE	DEPTH	Position
C0	1	180	43°40.96 N 08°37.25 W
C4	1	250	43°42.25 N 08°41.97 W
C14	1	750	43°47.03 N 08°54.62 W
C17	1,2	1030	43°48.31 N 08°58.39 W
C36	1	1540	43°41.10 N 09°26.50 W
C41	1	2200	43°45.37 N 09°33.00 W
C59	1,2,3	4910	44°00.67 N 09°54.01 W
C69	3	4904	43°59.94 N 10°05.73 W
C79	3	4920	44°01.58 N 10°20.86 W
C89	3	4926	44°05.91 N 10°34.96 W
C125	2	4951	44°10.07 N 11°09.49 W
CG	2,3	3796	43°11.46 N 10°36.02 W
G0	1	150	42°39.81 N 09°28.19 W
G25	2,3	2278	42°38.09 N 10°02.84 W
G30	1	2630	42°40.16 N 10°09.80 W
G56	1	2380	42°40.00 N 10°43.98 W
G85	1	1800	42°40.74 N 11°24.21 W
G100	1,2,3	760	42°44.93 N 11°44.17 W

2.2. Methods

On each transect a seismic survey was made with a 3.5 Kc echosounder to locate suitable sampling locations. Once a potential track was selected, a short acoustic survey was made followed by a tow with the video-Agassiz trawl. The trawl is 3.5 m wide with a net having a 1-cm mesh-size. Two odometers are mounted on the trawl to measure the track length. A door in the trawl opening keeps pelagic animals out during lowering and hauling. The beam of the trawl carries a programmable video camera, which provides a view just in front of the trawl. The trawl was successfully operated at the 12 stations that were visited. The animals caught in the net were identified, counted, and weighed. Selected species were dissected on board for the analysis of the RNA:DNA ratio (condition index) of their somatic tissue. At each trawling station, we made a CTD profile of the water column and simultaneously collected samples from the near-bottom water. Sediment samples were also collected with box- or multi-corer for the following analysis: macro- and meiofauna (NIOO, Yerseke), and

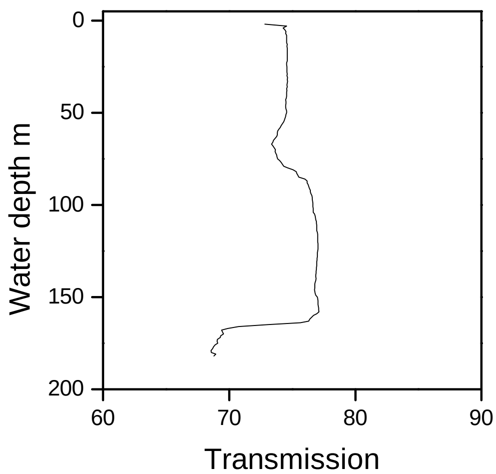
phytopigments. Individual phytopigments (chlorophylls and carotenoids) in the near-bottom water and the surface sediment were analysed in the laboratory by means of HPLC (Wright *et al*, 1991). The results of the pigment analysis will be used to describe quality and origin of the phytodetritus.
Finally, we made a series of SCOC measurements in shipboard incubated and decompressed cores of 30 cm diameter under *in situ* temperatures (Duineveld *et al*., 1997). During the last two cruises these studies were continued with *in situ* measurements of sediment community respiration (SCOC) using a new benthic lander system that compensates the loss of the former BOLAS lander.

3. RESULTS

3.1. *Pelagia* cruise *PE108*, 23 June - 14 July 1997
Briefly, we found a large difference in biomass and species composition of megafauna along the Coruna transect. The most conspicuous features were the high density of filter-feeders on the shelf break and upper slope. The trawl samples showed a clear succession of species with increasing water depth with around 750 - 1000 m depth patches of the colonial deep water coral *Lophelia*. The dominance of filter-feeding megafauna on the slope points to a food source consisting of suspended particles. This conclusion is supported by the video images which showed a distinct bottom nepheloid layer at the shelf break (see CTD profile, Fig. 2) which disappeared at the upper slope, and extensive ripple fields at the upper slope. The ripple marks are indicative of high currents and hence little deposition of organic matter. Deposit feeders - mainly echinoderms - were mainly important at the deeper stations. This pattern was mirrored by the distribution of labile chlorophyllous pigments, *i.e.*, highest concentrations at the deepest stations and lowest levels at the upper slope.

Fig. 2 Nepheloid layer at the shelfbreak off La Coruña (st. C0)

The OMEX or Galicia-transect along 42°40’N did not allow any sampling between depths of 200 and



2000 m because of the steep profile. Below 2000 m water depth the sediment surface was smooth and compact. The megafauna is dominated by various species of holothurians but is otherwise poor in terms of biomass. The Galicia Bank (*ca.* 800 m) appears to be covered by isolated patches of *Lophelia* amidst of large mega-ripples consisting of pelagic sediment. The chlorophyll levels in the shelf sediment of the OMEX transect were similar to those at the Coruna transect. Levels in the lower slope sediments (> 2000 m) were widely different *i.e.*, much lower, than along the Coruna transect.
Sediment respiration was measured on board in decompressed cores (Table 2). The values are comparable to those measured at the OMEX-I transect over the Goban Spur (Duineveld *et al*, 1997). Outstanding is the high value at the deepest station C59 (4900 m), which is three times as high as normal for an NE Atlantic abyssal station (see Lohse *et al*., 1998). The fact that this station is situated just at the foot of the steep slope is a probable explanation for the high value.

3.2. *Pelagia* cruise *PE118*, 25 May - 12 June 1998

Fig. 1 shows the geographic position of the sampling stations. The emphasis during this cruise was put on *in situ* measurements of sediment community oxygen consumption (SCOC).We made such measurements on two abyssal stations situated on the Coruna transect (C59, C125) as well as on the OMEX station (G25). At all stations during this cruise (Tab. 1) we additionally took sediment samples for pigments and made a CTD cast. The reason for sampling at C125 was our previous finding of high pigment concentrations at C59 and the question if and how far the enrichment extended from the coast. We furthermore sampled station CG situated in the opening of the channel between the Galicia Bank in the west and the margin to the east. This site at 3800 m water depth could potentially be one where material transported northward is deposited. Finally we re-visited the Galicia Bank for further investigation of the deep water coral *Lophelia*.

Unfortunately, the SCOC measurements were hampered by the loss of the oxygen optrodes in the ALBEX chambers which left us with the estimates from the BOLAS chamber. SCOC rates at G25 (2200 m) were almost twice as high as those at C59 (4900 m), 0.49 vs 0.26 mmol m^{-2} d^{-1}. This difference between the *in situ* measurements is in line with the fact that the maximum oxygen penetration depth that we found in decompressed cores at C59 was twice that of G25. At the end of the *PE118* cruise we moored the ALBEX lander at the OMEX stations for the duration of 3 months. During this period (June-September) vertical fluxes (PPS3 trap) were measured (still to be analysed) and one SCOC measurement was made at 1 July. This yielded almost the same rate as the one from beginning of June.

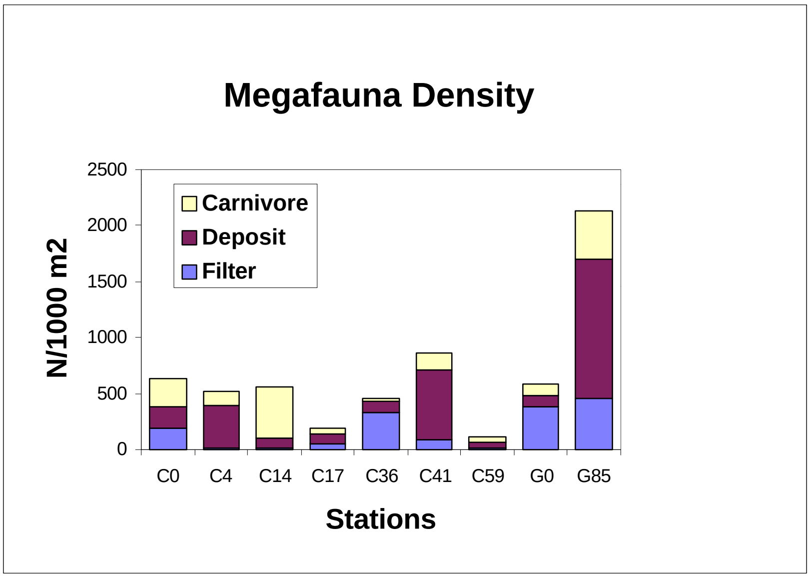
The distribution of phytopigments showed the reverse pattern *i.e.*, the flux and concentration of chlorophyll-a at the sediment surface of C59 was respectively 25 and 100 times higher than at station G25 (Fig. 4). Pigment concentrations at the other stations that we sampled (C125, CG, G100) were of the same order of magnitude as those at G25. This pattern suggest that in May 1998 a strong pulse of phytodetritus is delivered to the sediment just underneath the slope off la Coruna while everywhere else hardly any fresh phytodetritus is found. The pulse, however, did not lead to an enhancement of the sediment respiration.

The video trawl made at station C125 (4950 m) did not differ much from that at C59. This is contrary to our expectations. As C125 is situated much further from the slope we did not expect to see lots of traces of large animals at the bottom. Large sea-cucumbers, sea-anemones (*Actinauge*), starfishes and Ophiuroidea were among the large animals in the catch. During an acoustic search for traces of *Lophelia* at the slope off La Coruna, we found some promising echoes at the seafloor of st. C17. However, when checking these out with the video we only found isolated patches of the deep water coral. At the Galicia Bank we tried to substantiate our supposition that *Lophelia*, which we found living in discrete patches on the sandy plateau (G100), has a more dense distribution at the summit of the seamount. The video transect over very top only revealed bare rock instead of large coral reefs. However, the transition between the summit and sandy plateau was covered by extensive and exceptionally dense fields of crinoids (featherstars) suggesting that food is not short but mainly supplied in suspended form. The video trawl at station G25 confirmed our earlier impression that the area here is poor in megafauna. Two species of gorgonians (*Acanella* and a large whip-like species) are the most promint animals. The bottom is smooth and has few traces of animal activity.

3.3. *Pelagia* cruise *PE123*, 2 -18 September 1998

During this cruise we made *in situ* SCOC measurements at the OMEX station (G25) and at the abyssal station C59 off la Coruna. The respiration rate at C59 was markedly higher than in May *i.e.*, 0.75 *vs.* 0.26 mmol m^{-2} d^{-1} respectively. At the OMEX station we found an average rate of 0.61 mmol m^{-2} d^{-1} which is only slightly higher than in May. Just as in the previous cruises chlorophyll *a* levels in the sediment at C59 were higher than at G25 and CG but not quite so much as in May. We found highest chlorophyll-a concentrations of this cruise at C69 -10 nm west of C59 - while another station, C79, had levels which were intermediate between C59 and C69. Apparently the enrichment of the abyssal plain extended at least 20 nm from the foot of the slope.

The results of the video trawls at G25 and C69 did not radically alter our previous impression of these stations based on data procured during the second cruise. An addition to the megafauna at G25 were the fishes of the families Macrouridae, Synaphobranchidae and Alepocephalidae



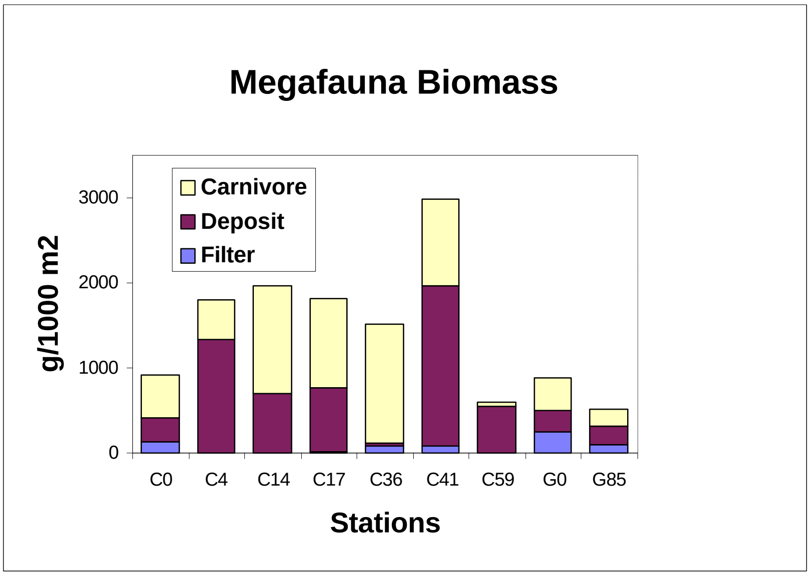


Fig. 3. Density and biomass (wet weight) of the megabenthos at the stations sampled during the 1997 expedition. Some stations have not yet been analysed.

4. CONCLUSIONS

<u>Megafauna and bottom features</u>

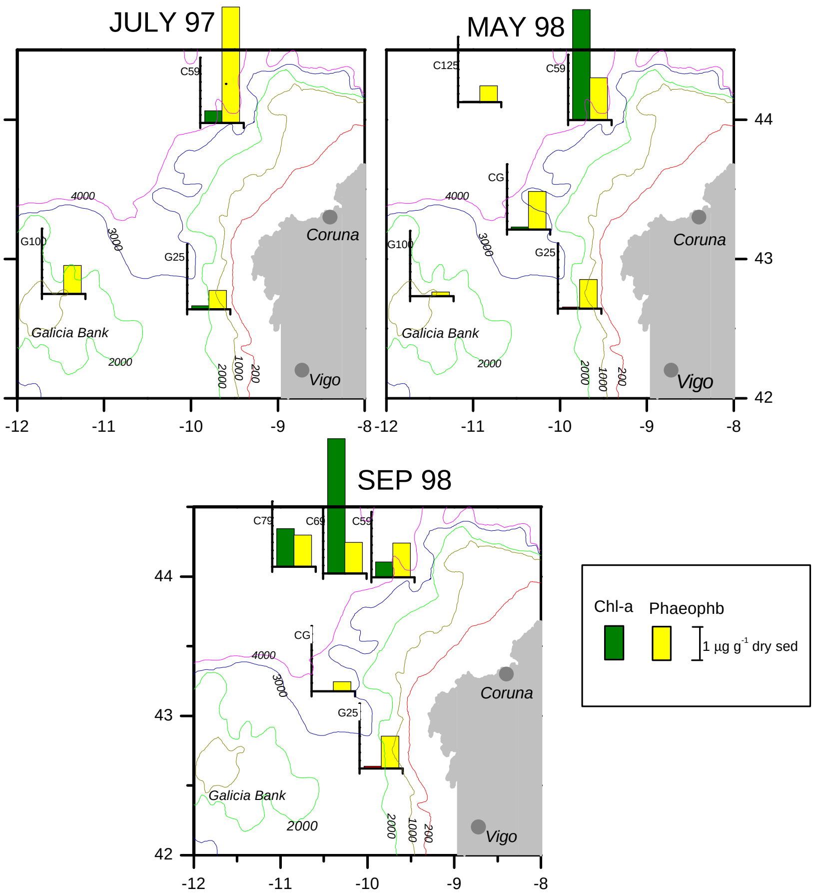
Densities and biomass of megabenthos (Fig. 3) on the Iberian margin have the same order of magnitude as on the Celtic continental margin (see OMEX-I project; Duineveld *et al.*, 1997). Differences between the two areas concern biomass at the abyssal station off La Coruna and at the Galicia transect which seem distinctly lower that at corresponding depths in OMEX-I. This conclusion is partly based on video images from the Galicia transect stations as not all samples have been analysed.

On the Iberian margin, filter feeders form a conspicuous feature at most stations, except for the abyssal station. This often does not show up in density figures. In terms of biomass, these filter feeders always play a minor role. At the Coruna transect there is no decrease of megafauna biomass with depth. The high biomass – sea urchins - and video images of the bottom at C41 suggest that this station might be particularly enriched. At the Galicia transect we did not find a similarly rich station. Megaripples and smaller current ripples at the stations C14-C36 and at G100 suggest high bottom currents at these stations. Thickets of the cold water corals (*Lophelia* and *Madrepora*) were found at station C36 and G100.

Phytopigments

The most striking findings were the high phytopigment concentrations in the sediment at the near-slope abyssal stations on the Coruna transect. (Fig. 4). Especially in spring (May 1998) and in the late summer (September 1998) the freshness of these phytopigments (high chlorophyll-a concentrations) point to a rapid sinking rate. We conclude that this corresponds with our findings near the Goban Spur where the abyssal stations receive autonomous pulses from offshore algal blooms (Duineveld *et al.*, 1997), and where food supplies to the slope and the near-slope abyssal stations seem uncoupled. The relatively low phytopigment concentrations at the shallower stations and at all stations of the Galicia-transect point to either a lower sinking rate, smaller blooms or a higher degradations (*e.g.*, by zooplankton) in the water column. Based on phytopigment concentrations in the sediment no marked depo-centre on the slope could be found.

Fig. 4. Phytopigment in the upper millimeter of the sediment at selected stations sampled during the three *Pelagia* cruises.



SCOC

SCOC values derived from shipboard incubations and porewater profiles made on deck at the same stations are quite close, and mostly approach the global averages from corresponding water depth

(Fig. 5). Only the Galicia Bank (800 m) and station C36 (1500 m) show a much lower SCOC value. This is in accordance with the coarse grain size and high bottom currents at these two stations which might cause winnowing of the sediment. The occurrence of high current speeds we conclude from the abundant mega-ripples at both stations. The *in situ* SCOC measurements at selected stations by the lander are lower than the deck measurements, and strengthen the conclusion that the OMEX station (G25) is not a very rich station with respect to mineralisation by the benthic community. The *in situ* SCOC values (Fig. 5) at the abyssal station C59 (4900 m), however, were remarkably high in September 1998, and even higher than at the much shallower station G25 (2200 m). From this observation, together with the data on the phytopigment concentrations in the sediment, it is concluded that C59 is outstanding relative to the other stations, especially in view of its great depth.

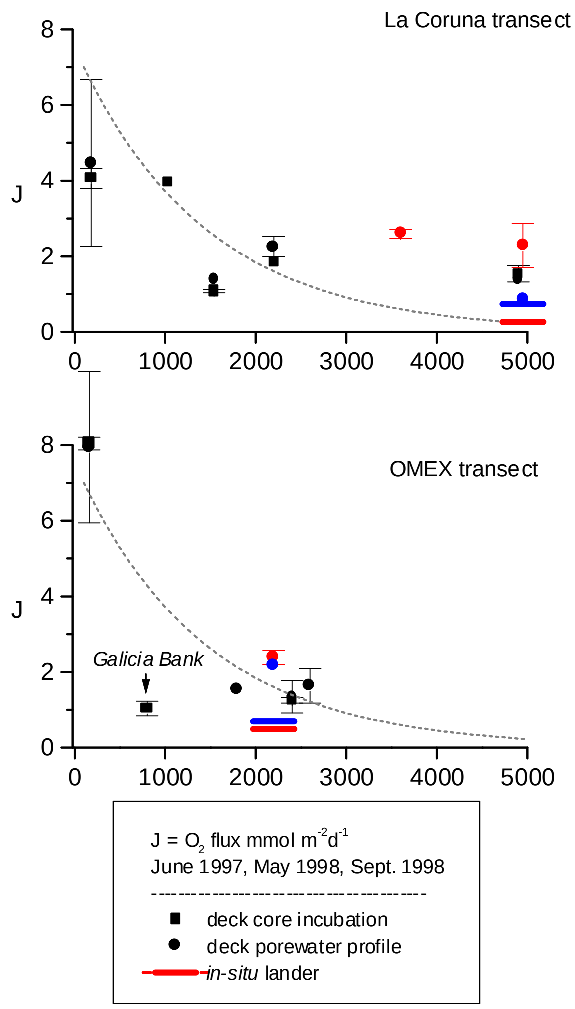


Fig. 5. SCOC measurements by means of deck incubations and oxygen-profiles or *in situ* by a lander at the Coruña and the OMEX transect. The dotted line represents the global average SCOC values for different depths (from Middelburg *et al.*, 1997).

5. REFERENCES

Bett, B. (1995). A million spider crabs can't be wrong! *Deep-Sea Newsletter*, **23**, p28.

Duineveld G., M. Lavaleye, P. de Wilde, E.M. Berghuis, P.A.W.J de Wilde, J. van der Weele, A.Kok, S.D. Batten and J.W. de Leeuw (1997). Patterns of benthic fauna and benthic respiration on the Celtic continental margin in relation to the distribution of phytodetritus. *Int. Revue ges. Hydrobiol.* **82**, 395-424.

Gage, J.D., A.J. Patience, P.A. Lamont, D.J. Smallman and L. Levin (1995). Deep-sea benthic dynamics- Arabian Sea studies on RRS Discovery 4 October-9 November 1994. The Scottish Association for Marine Science, Annual Report 1994-1995, 21-22.

Heip C., E. Falch, G. Duineveld, G. Graf, M. Lavaleye, O. Pfannkuche, K. Soetaert, T. Soltwedel, H. Stigter, L. Thomsen, J. vanaverbeke and P. de Wilde, *in press*. Benthic pelagic coupling: The role of the benthic biota in the exchange processes through the benthic boundary layer of the Goban Spur area.

Jahnke R.A., C.E. Reimers and D.B. Craven (1990). Intensification of recycling of organic matter at the sea floor near oceanic margins. *Nature*, **348**, 50-53.

Jahnke R.A., G.B. Shimmield (1995). Particle flux and its conversion to the sediment record: coastal upwelling systems. In: Upwelling in the Ocean. Modern Processes and ancient records. C.P. Summerhayes, K.-C. Emeis, M.V. Angel, R.L. Smith, and B. Zeitschel (Eds.). *Dahlem Workshop Reports, Environmental Sciences Research Report* **ES 18**: 83-102.

Lampitt R.S., D.S.M. Billet and A.L. Rice (1986). Biomass of the invertebrate megabenthos from 500 to 4100 m in the northeast Atlantic Ocean. *Marine Biology*, **93**, 69-81.

Lohse , L , W. Helder, E. Epping and W. Balzer (1998). Benthic carbon mineralization along a shelf-slope transect in the NE Atlantic (Goban Spur). *Progress in Oceanography (in press)*

Middelburg, J.J., K. Soetaert, P.M.J. Herman (1997). Empirical relationships for use in global diagenetic models.*Deep-Sea Research* **44**: 327-344.

OMEX-I, Final report, 1997. CD-ROM. prepared by the British Oceanographic Data Centre,

Rowe G.T., G.S. Boland, W.C. Phoel, R.F. Anderson and P.E. Biscaye (1994). Deep-sea floor respiration as an indication of lateral input of biogenic detritus from continental margins. *Deep-Sea Research II*, **41**, 657-668.

Sibuet, M., C.E. Lambert, F. Chesselet and L. Laubier (1989). Density of major size groups of benthic fauna and trophic input in deep basins of the Atlantic Ocean. *Journal of Marine Research*, **47**, 851-867.

Sibuet, M., Ph. Albert, S. Charmasson, J. Deming, A. Dinet, J. Galeron, L. Guidi-Guilvard, M.-L. Mahaut, and cruise-particpants (1993). The benthic ecosystem in the three EUMELI sites in the northeast tropical Atlantic: general perspectives and initial results on biological abundance and activities. *Ann. Inst. Océanogr*., Paris, **69**, 22-33.

Thurston, M.H., B.J. Bett, A.L. Rice and P.B. Jackson (1994). Variations in the invertebrate abyssal megafauna in the North Atlantic Ocean. *Deep-Sea Research*, **41**, 1321-1348.

Wright, S.W., S.W. Jeffrey, R.F.C. Mantoura, C.A. Llewellyn, T. Bjørnland, D. Repeta and N. Welschmeyer (1991). Improved HPLC method for the analysis of chlorophylls and carotenoids from marine phytoplankton. - *Marine Ecology Progress Series* **77**: 183-196.