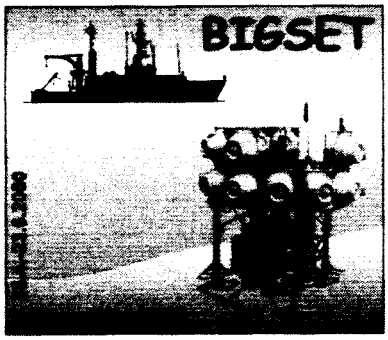
FS POSEIDON
FAHRTBERICHT POS 260
CRUISE REPORT POS 260

BIGSET

BIOGEOCHEMICAL TRANSPORT OF MATTER AND ENERGY IN THE DEEP SEA

LEIXOES/OPORTO (PORTUGAL) - GALWAY (IRELAND) - CORK (IRELAND)
APRIL 26 - JUNE 23, 2000



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GEOMAR
Forschungszentrum
für marine Geowissenschaften
Wischhofstr. 1-3
D - 24148 Kiel
Tel. (0431) 600-2555, 600-2505

Editor of this issue: Olaf Pfannkuche and Christine Utecht

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GEOMAR
Research Center
for Marine Geosciences
Wischhofstr. 1-3
D - 24148 Kiel
Tel. (49) 431 / 600-2555, 600-2505

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1. Introduction

The 260th expedition of RV POSEIDON started on 26 April 2000 in Oporto/Leixoes (Portugal) and ended on 23. June 2000 in Cork (Ireland). Research was carried out at the time series Station BENGAL in 49°50´N. 16°35´W at water depth of 4850m on the Porcupine Abyssal Plain in the NE-Atlantic. The expedition was exclusively dedicated to the research programme „Biogeochemical Transports of Matter and Energy in the Deep Sea" (BIGSET).

BIGSET is a collaborative programme of two research institutes and five university institutions (co-ordination GEOMAR, Kiel) within the national research focus „Deep Sea Research" sponsored by the Bundesministerium für Bildung und Forschung (Table 1). BIGSET is concerned with the biogeochemical processes in the ecosystem of the deep sea. Main objective is the fate of sedimenting organic matter. Investigations concentrate to the abyssopelagic and benthic realm with the benthic boundary layer (BBL) as a focal point. The BBL is operationally defined as a zone extending from about 500 m above the sea floor to about one metre into the sediment, containing the nepheloid layer, the bottom contact water and the bioturbated sediment horizons. The activity of various groups of organisms inhabiting the BBL from the bacteria to the megabenthos and the nekton acts as a generator of the chemical fluxes and partly also for the physical mixing processes. The quantification of biochemical and geochemical fluxes (esp. carbon compounds, opal) within the BBL, the identification of the role of different ecological groups and their interactions are key questions. The results will enlarge our knowledge of deep ocean fluxes and of the early diagenesis of pelagic sediments, thus also being important for a better interpretation of the geological record.

In its first phase (1996-1999) BIGSET concentrated on the analysis of the effects of naturally pulsed deposition of particulate matter on the biology, biochemistry and geochemistry of deep sea sediments. Studies were performed during different seasons in the monsoon system of the Arabian Sea (PFANNKUCHE & LOCHTE 2000) and in the NE-Atlantic.

Both areas receive pulsed phytodetrital depositions on the seafloor after surface phytoplankton blooms. Such pulses can cover the ocean floor with a layer of detritus („fluff"). The impact of such events on the biology of organisms and the cycling of organic matter has been demonstrated to a certain extent. However, we are still uncertain about the chronology and amplitude of benthic reactions, since conventional expeditions only yielded a „snapshot" of a certain stage of the benthic reaction and failed to reveal the chronology of benthic reactions.

Expedition POSEIDON 260 was laid out to perform a series of *in situ* experiments simulating the deposition of phytodetritus on the sea floor in lander integrated benthic chambers and to follow benthic reaction.

Three landers each carrying three benthic chambers were deployed on the Porcupine Abyssal Plain (4850m) for different time intervals. Phytodetritus (mixture of diatoms and chitin in a concentration of a natural pulse) was injected into the chambers and the benthic reaction was studied by various methods.

Another lander (benthic observation system) was moored for the whole period of investigation (65 days) to observe natural sedimentation pulses. The lander carried a sediment trap, two ADCP's and a stereo camera system. One mile apart from this lander a mooring with two sediment traps was deployed (traps in 50mab and 500mab).

Table 1: The BIGSET Partnership: The collaborative programme is co-ordinated at GEOMAR and is comprised of the following subprojects (SP).

Co-ordination BIGSET (O. Pfannkuche, GEOMAR Kiel)	
SP-1	Fluxes of matter through the benthic community (GEOMAR Kiel)
SP-2	Benthic resuspension, bioturbation and irrigation (University Rostock)
SP-3	Microbial and benthic community remineralisation rates in the deep sea. (Max-Planck Institute for Marine Microbiology, Bremen)
SP-4	The preservation potential of primary climatic and environmental signals in the deep sea (University Hamburg)
SP-5	Near bottom particle flux, habitat demands and early diagenetic processes in the benthic deep sea foraminiferal community (University Tübingen)
SP-6	Interactions between the seasonality in benthic turn over rates and the distribution of trace elements in deep-sea sediments (University Bremen)
SP-7	Reactions and fluxes in surface sediments: Geochemical measurements and modelling of the biogeochemical system (GEOMAR Kiel)
SP-8	Biogenic, lithogenic, aeolic and hydrothermal signals of trace elements in deep sea sediments (University Oldenburg)

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2. Objectives

Background

The export of primary produced organic material is an episodical process that is mirrored in a pulsed deposition of particles on the deep-sea floor (BILLETT et al 1983, LAMPITT 1985, THIEL et al 1989). Individual elevated sedimentation events that can be clearly differentiated from the background signal of the general particle flux to the sea floor are usually limited to a few days. The effects of such sedimentation pulses on the benthos could be observed in different deep-sea areas (GRAF 1989, GOODAY & TURLEY 1990, BALDWIN et al. 1998, PFANNKUCHE 1993, PFANNKUCHE et al 1999, SMITH et al. 1998). The results pointed out that episodical variations of POM deposition are mirrored in a reduced and temporally postponed reaction of benthic organisms (MARTIN & BENDER 1988, PFANNKUCHE et al 1999, SOETAERT et al. 1996). The reaction amplitudes and the delay of the benthic reaction depend basically on the amount and reactivity of the deposited material. Some investigations indicate that deposited material on the seafloor can be very reactive and can also release an immediate biological reaction (SAYLES et al 1994, RABOUILLE et al. 1998, HAMMOND et al. 1996).
The knowledge of these reactions to the deposition of POM on the seafloor is of major significance for the modelling of early diagenetic processes in deep sea sediments. The deposition of POM influences level and interval of the remineralisation processes as well as the distribution and composition of the benthic community.
The fate of freshly sedimentated phytodetritus directly after its deposition on the seafloor still remains unclear in many respects. This is especially valid for the reaction of different organism groups to the increased input of nutrient rich organic substance as well as for the mixing rates and deposition in the sediment column and bottom water. Geochemical deposition pathways can be changed by bioturbation in deeper sediment layers caused by a fast distribution of reactive POM (ALLER 1990, SUN et al 1993).
We know from single investigations of different deep-sea areas that distinct organism groups react in a different manner on POM deposition. While some groups such as bacteria and protozoa colonise and decompose fresh phytodetritus rather fast (GOODAY 1988, LOCHTE & TURLEY 1988, GOODAY & LAMBSHEAD 1989, LINKE 1992, BOETIUS & LOCHTE 1994, 1996), such a reaction could not be established for metazoan meiofauna, e.g. nematoda (GOODAY et al. 1996). However radio-isotopic labelled phytodetritus was assimilated by meiofauna organisms in shallow waters in a differentiated reaction. Organisms dwelling in deeper sediment layers ingested a higher proportion of already more degraded POM than organisms at the sediment surface (RUDNICK 1989). Macrofauna organisms in shallow water showed increased assimilation rates when offered fresh phytodetritus (KRISTENSEN et al. 1992, BLAIR et al 1996). It is hypothesised that in case of a sedimentation pulse of fresh detritus a competitive situation between bacteria, protozoa and macrofauna could arise.
The fast burial of detritus by the activity of makrobenthos could be proofed on the basis of radionukleids maxima (SMITH et al. 1986, WHEATCROFT & MARTIN

1996, LEVIN et al. 1997) and chlorophyll a (GRAF 1989) in deeper sediment horizons of abyssal sediments. This size class of the benthic community obviously plays a major role in the structuring of sediments and in the distribution of POM in the sediment column. Therefore the composition of macrofauna is decisive for the regulation of benthic turnover processes even when the deposition of organic material is mainly carried out by micro-organisms (PFANNKUCHE 1993). Suspension and surface deposit feeders can absorb large amounts of detritus and bury it in the sediment by defecation (BETT et al. 1993). Whereas the food utilisation of infaunal deposit feeders depends on the bioturbation intensity meaning the burial of organic material into the sediment.
Field investigations on the effects of natural sedimentation pulses on deep-sea benthos are particularly hampered by a variety of factors. Expeditions are fitted into multiyear national ship schedules which can consider seasonality of forcing factors only to a certain extend and can not be adjusted to interannual variations of such factors. Therefore benthic investigations on time limited conventional expeditions of typically 4 weeks only cover a certain stage of the benthic reaction and typically fail to reveal the chronology of the reactions from the arrival of a sedimentation pulse at the sea bed to the fully ranged diversified biological and geochemical response. Previous BIGSET expeditions to the Arabian Sea and the NE-Atlantic therefore yielded only spotlights of the processes of pelago/benthic coupling. However a combination of the field data with a modelling approach (LUFF et al. 2000) demonstrated a dynamic and surprisingly fast benthic response towards POM-deposition. The chronology of the response and the amplitudes of reactions and fluxes remained largely unknown.
A single *in situ* experiment carried out in 1998 at the BENGAL station lasting for nine days offered first trend-setting results for the design of the experiments of POSEIDON 260. A mixture of algae and chitin particles injected into two experimental chambers of the GEOMAR lander increased the activity of the enzyme chitobiase significantly compared to an unlabelled control chamber.

Research objectives

To answer the most important open questions for the understanding of control mechanisms of biological and geochemical reactions triggered by short and medium-term changes of the input of organic material we therefore carried out a series of investigations.

The following subjects were of first importance:
- *in situ* experiments to study the decomposition of organic material in the BBL (main theme);
- high-resolution determination of C_{org} input into the BNGS with regard to the transport and reaction processes in the near bottom water column;
- the role of DOC in the benthic cycle.

Focal point of our investigation was the realisation of enrichment experiments with phytodetritus in mesocosms (benthic chambers) to address the following subjects:

- The fate of deposited organic material at the seafloor and in the bottom nepheloid layer.
- The influence of POM deposition on benthic carbon remineralisation rates.
- Investigation of the degradation pathways through different benthic groups (bacteria, meiofauna, macrofauna).
- Effect of POM sedimentation on sediment pore water nutrients.
- Development of an early diagenetic model considering different organism groups.

The BENGAL station in the NE-Atlantic was destined as investigation area since a large data set from the BIGSET and the MAST-III project BENGAL already exists from this location (Fig.1) and it is also easy to reach from a landbase in Ireland for short-term cruise legs.

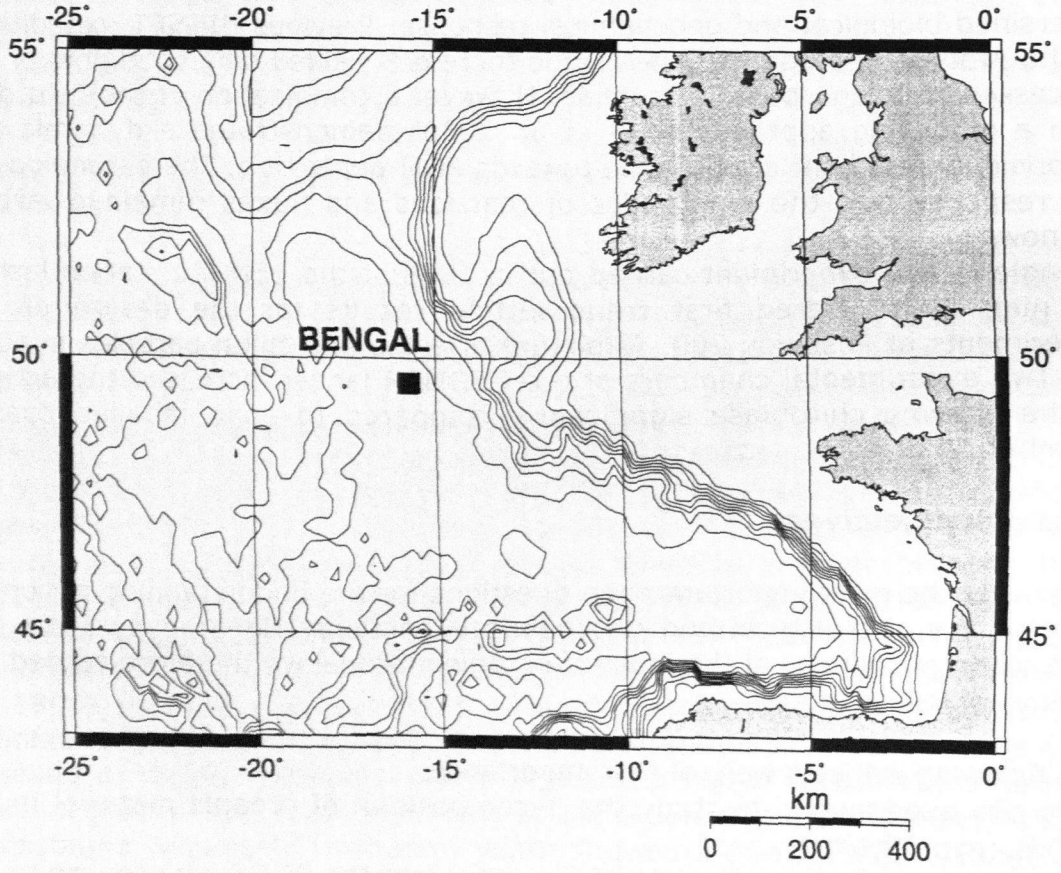

Figure 1: Geographical position of BENGAL in the Western European Basin

Technological realisation

Our developments of advanced landers with benthic chambers in the frame of BIGSET and the EU projects ALIPOR and BENGAL offered the possibility to induce and follow the changes of biological and geochemical turnover processes in *in situ* experiments.
This *in situ* experiment campaign is an internationally unique and ambitioned project for which realisation a reliable, fully-developed lander system is required.
The existing GEOMAR modular lander system that was modified and improved in the course of BIGSET and which was deployed successfully during five expeditions fulfilled these requirements and warranted for the success of this project.
Four lander systems were available for the expedition. Foundation is a three-legged basis-lander with floats, two acoustic releases, VHF and ARGOS transmitters, a flash light, and a universal (all-purpose) platform (Fig.2). This basic system can be equipped for different purposes which were for the expedition:

Benthic chamber lander:

Corresponding to landers FFR-I, -II, -III the basis-lander is equipped with three to four benthic chambers (Fig.3). A chamber of 20 x 20 cm is guided by a stainless-steel frame which is incorporated into the lander's central instrument platform (Fig.4). It is built of Delrin and represents an autonomous module with its own control unit and power supply with rechargeable NiCd-battery packs (6 V, 10 Ah). The chamber is driven into the sediment by a motor (motor 1). After implementation of the chamber a top lid supporting a stirrer and a POM injection module seals the chamber. At the end of each incubation a shutter is closed by a 2nd motor in order to retrieve the sediment. Once the shutter is closed the chamber is slowly driven out of the sediment by the 1st motor. All maintenance-free drive units are standard DC motors in stainless steel pressure housings that guarantee stable low power consumption. The shaft is sealed by a specially developed double O-ring construction. The chambers have been successfully (›60times) used on benthic lander system in water depths down to 4900m.
The Water sampler/ injector is a device to take time sequenced water samples from or inject liquid tracèrs into the benthic chambers. Both functions are implemented in one carrier frame of about 45cm x 30cm x 15cm which is mainly built of Delrin and PVC. A deep-sea motor is coupled with a cam shaft and releases a series of eight 50ml glass syringes. The force needed to pull the syringe plungers is delivered by a strong rubber band. A control unit controls the release functions. The module works totally autonomous with power supply rechargeable NiCd-battery packs (7.2 - 12 V, 10 Ah).

Benthic observation lander

Corresponding to lander FFB-IV the base-lander carries tools for the following measurement and observations (Fig.5):

- two high-resolution ADCPs for current measurements (down-looking 0-2mab, up-looking 2-100mab);
- stereo-camera to take a shot of the sea floor in 1h intervals to document phytodetritus depositions and benthic activity patterns;
- sediment trap with cups rotated in seven days intervals to follow natural sedimentation patterns.

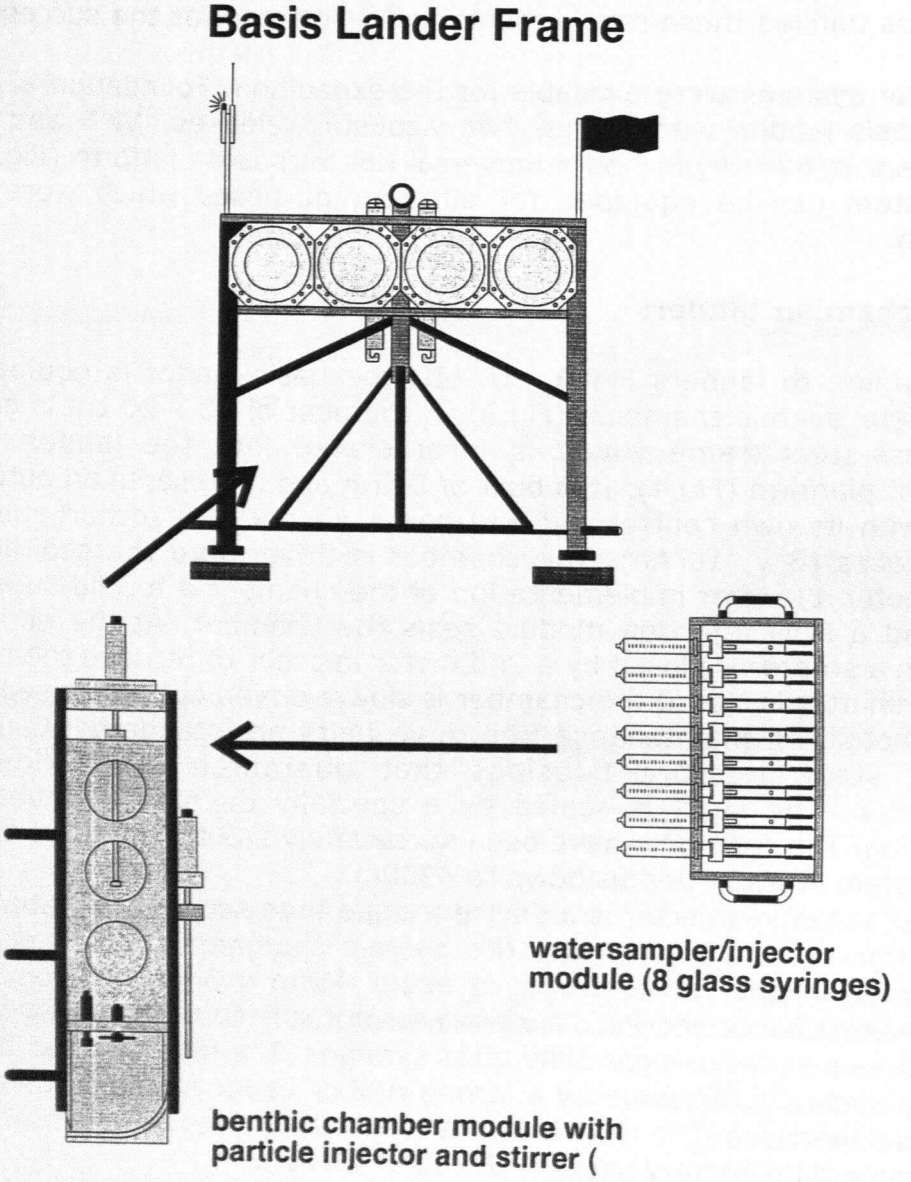

Figure 2: GEOMAR base-lander and units for the *in situ* experiments (type benthic chamber lander).

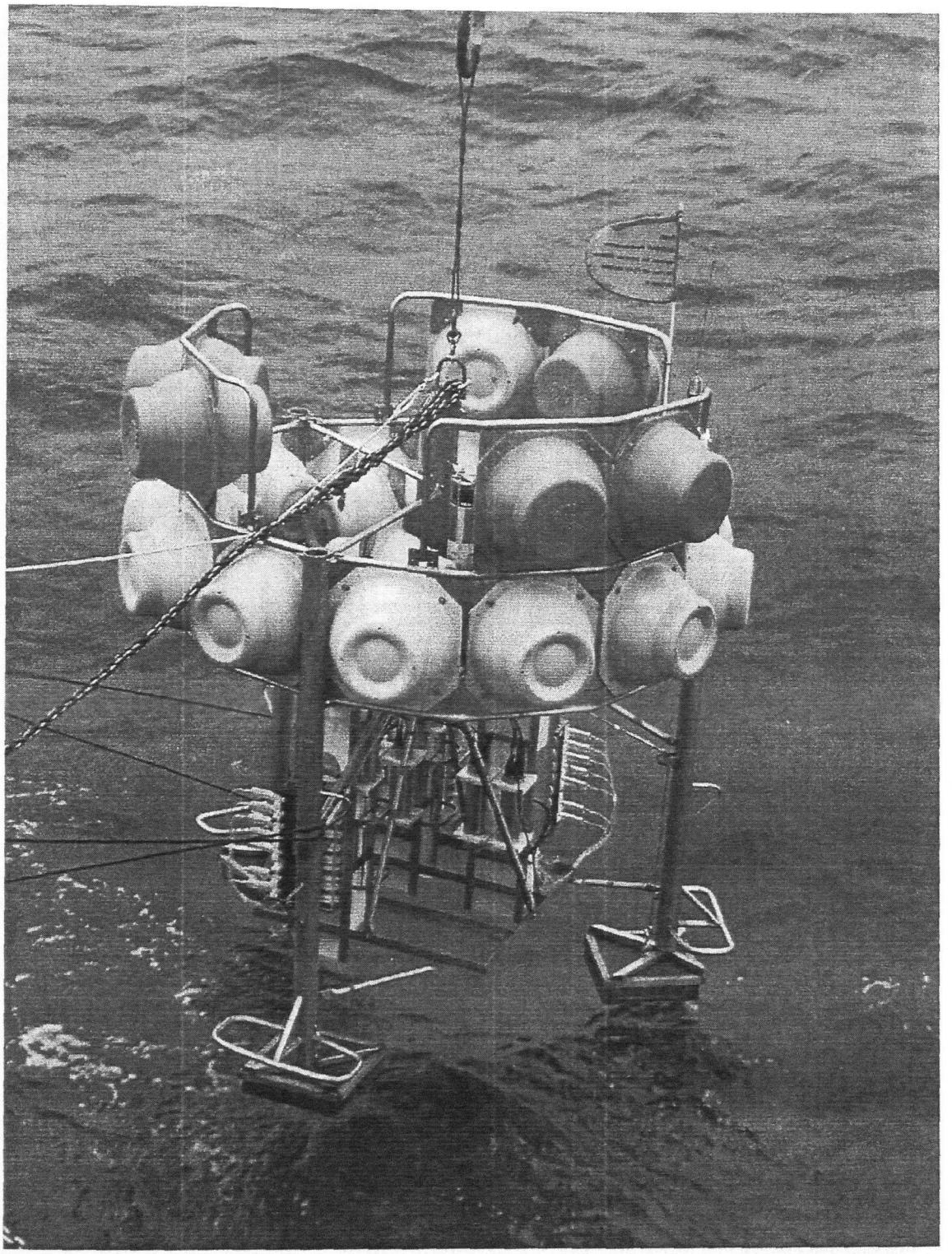

Figure 3: Benthic chamber lander (FFR-I, -II, -III) during deployment (leg 2 POSEIDON 260)

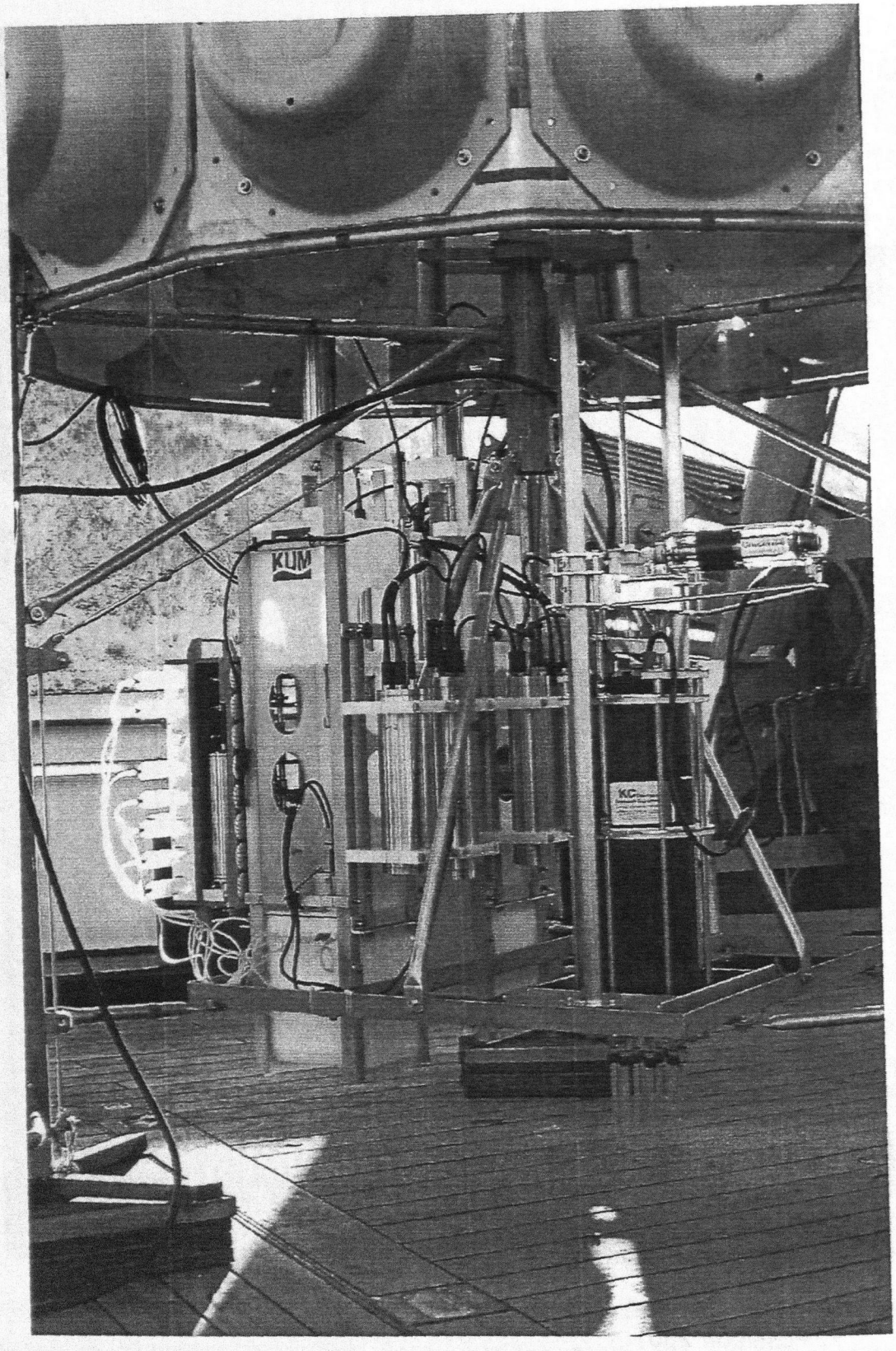

Figure 4: Instrument platform housing two benthic chambers + syringe water sampler module and a micro-electrode profiler.

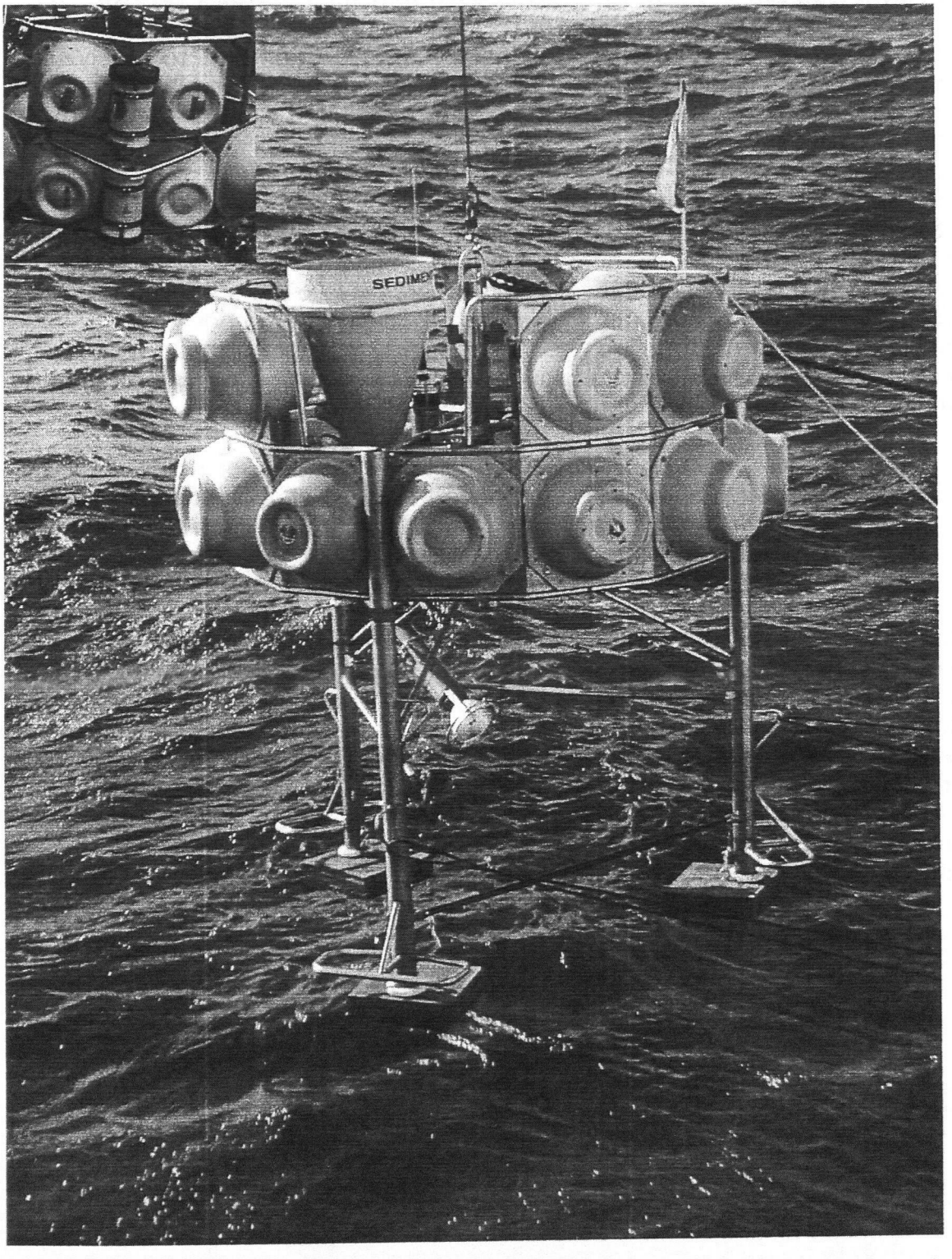

Figure 5: Benthic observation lander (FFB-IV) during deployment (leg 2 POSEIDON 260) carrying a sediment trap, a stereo-camera (flash visible) and 2 ADCPs (detail photo from opposite side).

In situ food pulse experiment series with benthic chamber lander

Prime objective of the cruise was to conduct *in situ* experiments to resolve the amplitude, timing and mechanisms of biological and geochemical response reactions after enrichment with particulate organic matter under the following aspects:

- to assess the response time and reaction amplitudes of the deep-sea benthos to deposition events of organic matter,
- to ensue the fate of degradable organic matter within the different groups of the deep-sea benthos (bacteria, protozoa, meio- and makrofauna),
- to determine biologically mediated transport rates of solutes and particles (bioirrigation and bioturbation) following organic matter deposition,
- to analyse POM enrichment on sediment pore water chemistry,
- to provide a sound data basis for the development of an early diagenetic model with consideration of the various groups of organisms.

The experiments were conducted with three benthic chamber landers (FFR-I, FFR-II, FFR-III). Each lander was equipped with three benthic chambers (area of the chamber: 400 cm^2) allowing the incubation of an enclosed sediment volume and the overlying water body (Figs. 3, 4). To simulate a food pulse a new module was developed which allows the injection of particulates and solutes under *in situ* conditions. Each chamber was further equipped with a water sampling device, taking samples from the overlying water body inside the chamber at pre-defined time intervals. By means of these water samples which were stored in glass syringes (volume: 50ml) until recovery oxygen and nutrient concentrations during the time course of the incubation were measured. The incubated sediment within the benthic chambers was sampled for shipboard analysis of biological and biogeochemical parameters.
Response time of the deep-sea benthos to the food pulse was evaluated by employing the landers for three different time periods (short-term: ~2.5d; medium-term: ~8d; long-term: ~20d). The deployments are listed in Table 2.

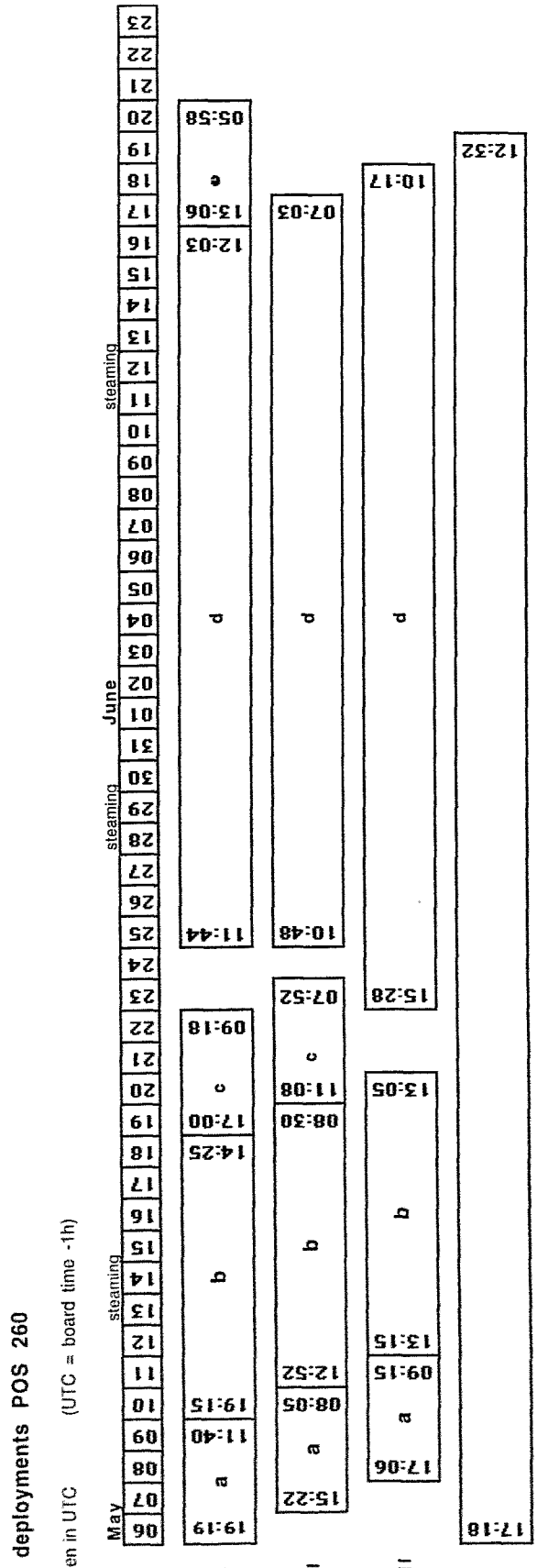

Table 2: Schedule of lander deployments (FFR and FFB) during cruise POS260. The time given at the beginning of each deployment represent the time when the lander programme was started, the time at the end represents the time when the lander was released from the sea floor. All times are given in UTC.

Thirty min after the penetration of a benthic chamber into the sediment a mixture of 200 mg dry weight of freeze dried Thalassiosira rotula and 200 mg chitin was injected into the food enriched chambers (Tab. 3). The result corresponds with a food pulse of ca. 1 g algalC x m^{-2} which copmpares to a major deposition event of phytodetritus after a spring bloom observed in this part of the NE Atlantic (THIEL et al, 1989). Prior to the deployment algae and chitin was kept in filtered seawater for several hours in the dark. T. rotula was additionally labelled with $^{13}C/^{15}N$ to follow the organic matter transfer between the different benthic organisms and geochemical reactions. As tracers for bioirrigation and bioturbation 4.1 g sodium bromide and glass beads of two different size classes (30 and 60 µm) were used.
In several chambers no mixture of T. rotula and chitin was added to enable control measurements (Table 3). Control measurements were conducted within each short-term, medium-term and long-term deployments of the landers. The experiment series was terminated with the deployment of a short-term lander to detect possible natural variation. Additional sediment samples were obtained using a multiple corer (MUC) and a mini multiple corer (mMUC). These samples were used for the determination of the natural background variability.

Short-term lander

	FFR-Ia			FFR-IIa			FFR-IIIa		
	K1	K2	K3	K1	K2	K3	K1	K2	K3
algae									
chitin									
glass beads									
bromide									
membrane status	hole	broken	hole	not broken	partly broken	not broken	broken, algae distributed regularly	broken, algae distributed irregularly	broken, algae distributed regularly
overlying water body volume (l)	4.8	3.2	4.8	4.4	4.4	4.8	4.6	4.8	4.8

	FFR-Ic			FFR-IIc			FFR-Ie		
	K1	K2	K3	K1	K2	K3	K1	K2	K3
algae									
chitin									
glass beads									
bromide									
membrane status	no sediment	broken algae distributed regularly	broken	not broken	broken	not broken			
overlying water body volume (l)		3.6	3.6	4.8	4.6	4.2	4	4	4

Medium-term lander

	FFR-Ib			FFR-IIb			FFR-IIIb		
	K1	K2	K3	K1	K2	K3	K1	K2	K3
algae									
chitin									
glass beads									
bromide									
membrane status	broken	no sediment	not broken	no sediment		broken	broken	broken	broken
overlying water body volume (l)	5.4		5.2		4.8	5.2	4.4	4.4	4.8

Long-term lander

	FFR-Id			FFR-IId			FFR-IIId		
	K1	K2	K3	K1	K2	K3	K1	K2	K3
algae									
chitin									
glass beads	30µm		30µm	30µm	30µm	30µm			
bromide									
membrane status	broken	broken	broken	broken	no sediment	broken	not broken	broken	broken
overlying water body volume (l)	3.8	3.8	3.8	5		4.8	4.8	5.6	4.8

Table 3: List of substances in the enrichment experiments. Injection was successfully completed when the membrane of the injection module broke completely. The volume of overlying water body in each chamber is given.

During POS260 thirteen landers (including FFB) were successfully deployed in total. Entire bottom time of all landers was about 144d, which is approximately three fold the ships time of the cruise.

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3. Participants and participating institutes

	LEG 1	LEG 2	LEG 3	LEG 4	LEG 5
	Date / duration	25.4.-3.5.2000	3.5.-15.5.2000	15.5.-29.5.2000	29.5.-13.6.2000	13.6.-23.6.2000
	Ports	Porto- Galway	Galway-Galway	Galway-Galway	Galway-Galway	Galway-Cork
1.	Chief scientist	[1] Pfannkuche, Olaf	[1] Pfannkuche, Olaf	[3] Witte, Ursula	[6] Springer, Barbara	[1] Pfannkuche, Olaf
2.		[2] Kähler, Anja	[3] Aberle, Nicole	[3] Aberle, Nicole	[6] Bödeker, Christian	[3] Boetius, Antje
3.		[4] Lahajnar, Niko	[2] Cremer, Axel	[3] Boetius, Antje	[5] Bühring, Solveig	[2] Cremer, Axel
4.		[4] Schroll, Gunnar	[1] Gröger, Björn	[2] Cremer, Axel	[5] Christiansen, Bernd	[1] Gröger, Björn
5.			[7] Heinz, Petra	[1] Grandel, Sibylle	[1] Häckel, Matthias	[1] Häckel, Matthias
6.			[2] Kähler, Anja	[1] Gröger, Björn	[6] Ihnken, Sven	[7] Heinz, Petra
7.			[6] Pielenz, Holger	[7] Heinz, Petra	[6] Kleine, Jörn	[2] Kähler, Anja
8.			[1] Queisser, Wolfgang	[1] Häckel, Matthias	[6] Lakowski, Jörn	[4] Lahajnar, Niko
9.			[1] Sand, Meike	[2] Kähler, Anja	[6] Pielenz, Holger	[1] Queisser, Wolfgang
10.			[4] Schroll, Gunnar	[1] Queisser, Wolfgang	[6] Plathner, Nicola	[1] Sommer. Stefan
11.			[1] Sommer, Stefan	[1] Sand, Meike	[4] Schroll, Gunnar	[4] Warncken, Carolin
12.			[6] Springer, Barbara	[3] Wenzhöfer, Frank	[6] Turnewitsch, Robert	[3] Wenzhöfer, Frank

Institutes:

[1] GEOMAR Forschungszentrum für marine Geowissenschaften der Christian-Albrechts-Universität zu Kiel, Wischhofstr. 1-3, 24148 Kiel
[2] BIOLAB Forschungsinstitut, Kieler Str. 51, 24594 Hohenwestedt
[3] Max-Planck-Institut für Mikrobiologie, Celsiusstraße 1, 28359 Bremen
[4] Universität Hamburg, Institut für Biogeochemie und Meereschemie, Bundesstraße 55, 20146 Hamburg
[5] Universität Hamburg, Institut für Hydrobiologie und Fischereiwissenschaft, Zeiseweg 9, 22765 Hamburg
[6] Universität Rostock, Fachbereich Biologie, Lehrstuhl Meeresbiologie, Freiligrathstr. 7/8, 18055 Rostock
[7] Universität Tübingen, Institut für Geologie und Paläontologie, Sigwartstraße 10, 72076 Tübingen

4. Narrative

Leg 1

O. Pfannkuche

The scientific party of four persons boarded FS POSEIDON in the Port of Leixoes (Oporto) in the afternoon of April 25. The 26.04. started with the unloading of a container with scientific equipment and its sea safe storage onboard. POSEIDON left Leixoes at 21.00h and headed north to the so called BENGAL site. This area has been intensively studied by the British Institutions IOS and SOC under the name PAP-site. It has also been the study area of the MAST III Project BENGAL (High-resolution temporal and spatial study of the **BEN**thic biology and **G**eochemistry of a north-eastern **A**tlantic abyssal **L**ocality) from which the name of our study area was adapted.
The BENGAL area at 49°N, 16°40´W was reached at 15.00h on April 29. Station work started with a Rosette water sampler cast. In the course of April 30 two release transponder were successfully tested in deep water, while a multiple corer haul failed due to strong movements of the ship during the sampling, which caused a premature release of the core catchers. In the afternoon the Hamburg group successfully deployed a mooring with two sediment traps. In the early morning of May 1 another multiple corer haul failed. Afterwards the ship left the BENGAL area and headed to Galway. FS POSEIDON was moored in Galway Harbour at 5.13h on the 03.05. thus finishing leg one.

Leg 2

O. Pfannkuche

During our stay at Galway 9 scientists boarded FS POSEIDON in the late afternoon of the 03.05. In the course of the 04.05 new equipment was loaded including four landers which have been previously assembled and prepared by an advance group of four technicians at the Marine Technical Development Services Ltd. in Galway. FS POSEIDON left Galway Harbour with high tide at 05.00h on the 05. 05 and headed back to the BENGAL site. BENGAL was reached again at 17.30h on 06.05. Station work started with the deployment of the long-term observation lander (FFB) which will be moored for ~60 days in about 1nmile distance from the sediment trap array moored on leg 1. The system houses two ADCP's (down- and up-looking), a stereo camera, which takes shots of the sea floor in a two hour sequence and a sediment trap (Kiel Type) with 7 cups changed in 7 days intervals. Afterwards the first of three benthic chamber landers (FFR-Ia) was deployed to measure sediment oxygen uptake rates.
The morning of 07.05. was spent with two multiple corer hauls with only limited success, since only 3 respectively 2 sediment cores could be retrieved from a batch of eight cores. Another multiple corer in the afternoon failed completely due to the rigid movements of the ship during bottom contact. In

the late afternoon the second lander (FFR-IIa) was deployed to carry out the first short-term POC- enrichment experiment (3days). Station work ended with a successful CTD/Rosette cast. Water samples were taken 10m above the seabed.
During the morning of the 08. 05. two multiple corer hauls were driven which both failed completely again due to the heavy rolling of the ship. The station was followed by a deployment of the bottom water sampler (BWS). Next came the first cast of the bottom water sampler (BWS). In the afternoon the third FFR (FFR-III) was deployed for three days. The day was finished with an Apstein plankton net haul (20µm mesh size) sampling the water layer 0-50m.
The morning of the 09.05. was dedicated again to sediment sampling. Instead of the ordinary multiple corer we used a smaller device with four core tubes, the Mini-corer (mMUC). The gear proved to be very successful even under frequent strong rolling of the ship movements thus we gained two sets of well preserved sediment cores. In the afternoon FFR-Ia was retrieved. Station work ended with a successful CTD/Rosette cast.
The morning of the 10.05. started again with mMUC sampling followed by the retrieval of FFR-IIa. The BWS was deployed during the afternoon and the day was finished with the re-deployment of FFR-Ib. The system was moored for 8 days to be retrieved on leg 3.
During the 11.05 the following stations were performed: mMUC sediment coring, retrieval of FFR-IIIa, test of the particle camera mounted to the BWS, re-deployment of FFR-IIb (for 8 days) and CTD/Ro sampling.
The last working day of leg two (12.05) begun with a mMUC haul which was followed by another bottom water sampler (BWS) cast. Station works finished with the mooring of FFR-IIIb (8 days). At 16.00h FS POSEIDON left the BENGAL site and started its transit to Galway.
During the night we encountered a gale with wind speeds from 8-10 BFT blowing from southern direction. The gale ceased and weather conditions improved during the 13.05. After a smooth passage during the 14.05 we reached Galway in the afternoon thus finishing leg two.

Leg 3

U. Witte

During our second stay at Galway 5 scientists were exchanged, the new group boarding FS POSEIDON in the late afternoon of the 15.05. In the course of the 15.05. and 16.05. part of the scientific equipment was exchanged and new equipment loaded including a profiling lander (PROFILUR, MPI Bremen) and a combined profiling/ multiple coring unit (SISSI, GEOMAR). POSEIDON left Galway Harbour with high tide at 15.00h on the 16. 05 and headed back to the BENGAL site. Due to strong winds we proceeded rather slowly and BENGAL was reached again at 13.30h on 18.05. Station work started with a successful mini multiple corer haul and continued with the retrieval of a benthic chamber lander (FFR-Ib) that hat been moored for 8.5 days. Station work on the 18.05 was finished with another successful multiple corer haul.

The morning of the 19.05 was spent with one successful multiple corer haul and the retrieval (FFR-IIb) of the second medium-term benthic chamber lander. In the afternoon, the profiling unit SISSI was deployed. The coring unit worked successfully, but unfortunately the motor of the *in situ* profiling unit was completely destroyed by water entering the pressure housing. In the late afternoon, the benthic chamber lander (FFR-Ic) was again deployed for another short-term experiment of 2,5 days duration.
After another successful mini multiple corer haul early in the morning of 20.05., the third benthic chamber lander deployed to perform medium-term enrichment experiments was retrieved (FFR-IIIb). First results indicated that the benthic deep-sea community is able to respond quickly to the input of fresh algal material: the activity of several specific enzymes, FDA and the benthic oxygen consumption were elevated in comparison to controls. In the afternoon, another mMUC proved the reliability of this gear and again the station work ended with the deployment of an additional short-term benthic chamber lander experiment (FFR-IIc).
The 21.05. was dedicated exclusively to sediment sampling by mMUC, all three deployments were successful.
During the 22.05., more sediment samples were taken and the chamber lander FFR-I was deployed for another short-term incubation of 2,5 days duration. In the afternoon, the profiling lander PROFILUR was deployed in order to take *in situ* measurements of O_2, pH and CO_2 porewater concentrations.
PROFILUR was successfully retrieved first thing in the morning of the 23.5. despite an unintended premature release of the system which fortunately occurred after completion of the data aquisition. During the course of the day, 1 more lander, FFR-IIc was retrieved and with FFR-IIId the first long-term experiment was deployed for a duration of approx. 3 weeks. In addition, phytoplankton samples were taken via Apstein net.
The most of 24.5. was again dedicated to sediment sampling by three mMUC hauls. In the evening, PROFILUR was deployed for a second overnight profiling deployment.
The last working day of leg three (25.05.) began with a mMUC haul which was followed by the successful retrieval of PROFILUR. During midday, the chamber landers FFR-I-d and II-d were deployed for their long-term missions. Station works finished with these moorings and at 14.30h FS POSEIDON left the BENGAL site and started its transit to Galway.
After a smooth passage we reached Galway in the afternoon of the 27.05. thus finishing leg three.

Leg 4

B. Springer

Eleven scientists were exchanged at Galway in the afternoon of May 29. The activities on board started with the unloading of a container with scientific equipment and its sea safe storage. POSEIDON left Galway with the next high tide the following day at 14.00h and headed again to the BENGAL site.
The BENGAL site was reached at 49°N, 16°37´W at 15.00h on June 01. Station work started with a mMUC cast. Since the first haul failed it was successfully repeated (4 cores). In the late evening and in the night two CTD rosette hauls followed. The second indicating a permanent loss of transmission during the cast probably due to leakage in the sensor.
June 02 started with two multiple corers who failed completely due to the rigid movements of the ship during bottom contact. So we abandoned that device and continued with a CTD/Ro cast followed by a swimming test of the amphipod trap mooring on wire. Shortly after the test the trap was deployed for about 18 hours. The device consists of four trap modules of cylindrical shapes with fish baits in plastic bag in order to catch amphipods avoiding feeding on the baits. The sinking of the mooring was followed acoustically up to 3000m depths. A multiple corer and three CTD cast followed the station.
The next morning (June 03) started with the recovery of the amphipod trap followed by two multiple corer which both were successful. Next on this station was a bottom water sampler (BWS), a device that collects water from 0.8 meters above bottom and simultaneously measures current velocity, transmission and has an integrated CTD. The following CTD/Ro was finished before deployment since a rig broke during craning of the gear. Since the CTD cast could not be continued so we steamed to the next station (seamount, slope east) and continued with another bottom water sampler (BWS) without particle camera and another multiple corer cast.
June 04 started with the towing of deep observation system. This is a kind of photo-sled. Photographs are taken from 3 meters above bottom every time a bottom weight hits the ground. This mission was followed by two CTD/Ro casts - both had problems with the electronics so we had to change the fuses several times during the cast. The failure was caused by a leakage in the transmissiometer so we omitted the use of the transmissiometer for the rest of the cruise. Afterwards station work was continued with a multiple corer.
The next day (June 05) began with another deployment of the amphipod trap in the vicinity of the seamount followed by two CTD/Ro casts. Directly before the deployment of next gear, the bottom water sampler (BWS) the conducting wire exploded on deck due to water inversion into the rubber part of the terminal end. After repair of the wire the ship headed to the northern slope of the seamount and we continued station work with another multiple corer. In the night during the next CTD/Ro cast (at 295 meters wire length) we had to change a few more fuses for the CTD deck unit and detected another leakage in the recently repaired conducting wire. We had to cut 240 meters of the wire and to repair it again. After this we continued with two CTD/Ro casts.

In the morning of June 06 we recovered the amphipod trap followed by a multiple corer. The sediment at the slopes is more compressed which caused the damage of a multiple corer leg that had to be replaced. The following two CTD casts passed without problems. In the night we continued with another towing of the deep observation system. This time the photographs were taken automatically in time intervals of 10 seconds.
The next station, the western slope of the seamount, was reached at 04.00h (June 07). We started station work with a CTD/Ro cast followed by a multiple corer cast with the oxygen profiler, which failed due to drifting of the ship. The wind increased and we tried another multiple corer (mMUC) which also failed. Last device was a CTD/Ro before we had to stop station work due to heavy weather conditions. No more station work was possible that day.
On Thursday 8th we tried to continue station work on the western slope with a CTD/Ro. Samples were taken 100, 250, 500 and 1000 meters above bottom. After the CTD/Ro we moored another amphipod trap near the top of the seamount. Although the weather condition slowly became better forecasts were not very promising. We finished this station with another CTD and a multiple corer. The first multiple corer did not reach the bottom so we repeated it and equipped it with additional weight to gain deeper cores. In the late night we headed to the top of the seamount and continued with two CTD/Ro.
The next morning (Friday 9th) started with an OPI-MUC (multiple corer mounted on the oxygen profiler), which failed and twisted the wire causing another break for repair. We continued with the recovery of the amphipod trap and another CTD/Ro cast. Next was a mMUC with floats on the wire to avoid damage of the wire. In the evening the deep observation system (DOS) was deployed at the top of the seamount drifting in northward direction. The station on top of the seamount was finished with another multiple corer and a CTD/Ro.
In the night of the 10th of June we headed towards the southern slope of the seamount to employ two CTD/Ro casts. Afterwards the ship moved to the plain again and finished station work with a successful multiple corer haul. During retrieval of the MUC the wire was rinsed with fresh water.
Afterwards the ship left the BENGAL area and headed to Galway. POSEIDON docked in Galway Harbour June 12 in the afternoons thus finishing leg 4.

Leg 5

O. Pfannkuche

POSEIDON left the Port of Galway with high tide in the afternoon 14. 06. After a smooth passage we reached the BENGAL site in the afternoon of 16.06. Station work started with the retrieval of the first chamber lander (FFR-Id) out of a series of three landers moored during leg 3. This lander was immediately refitted for another deployment after recovery.
In the course of 17.06. the second chamber lander (FFR-IId) was successfully salvaged. Sediment samples were taken with the mMUC. In the early evening the lander retrieved the day before was deployed again for a 48h mission (FFR-Ic).

Station work started on Sunday 18.06. with sediment sampling employing the mMUC. This was followed by the successful salvage of the third chamber lander deployed during leg III (FFR-IIIa) and the mooring of the MPI-lander (Profilur).
On 19.06 we retrieved two systems which had already been anchored during leg I respectively early leg II: the sediment trap mooring followed by long-term observation lander (FFB). Both systems had worked well. All cups of the sediment traps had rotated as pre-programmed. The filling of the cups from the 6-day period immediately before retrieval indicated a strong sedimentation pulse of phytoplankton debris. Station work proceeded with sediment sampling (mMUC) and the retrieval of the MPI- lander.
The benthic chamber lander moored on 17.06. (FFR-Ie) was salvaged in the morning of the 20.06. During the ascent of the system we took a series of plankton samples with the Apstein net. After securing the lander on the deck station works of leg V ended at mid day. The ship took course to Cork, which was reached in the morning of the 22.06. In the course of the day the scientific equipment was unloaded and stored into containers at Tivoli Pier. At mid day the 23.06. POSEIDON steamed further upstream into the City Harbour of Cork. The scientific party left the ship thus finishing cruise POSEIDON No. 260.

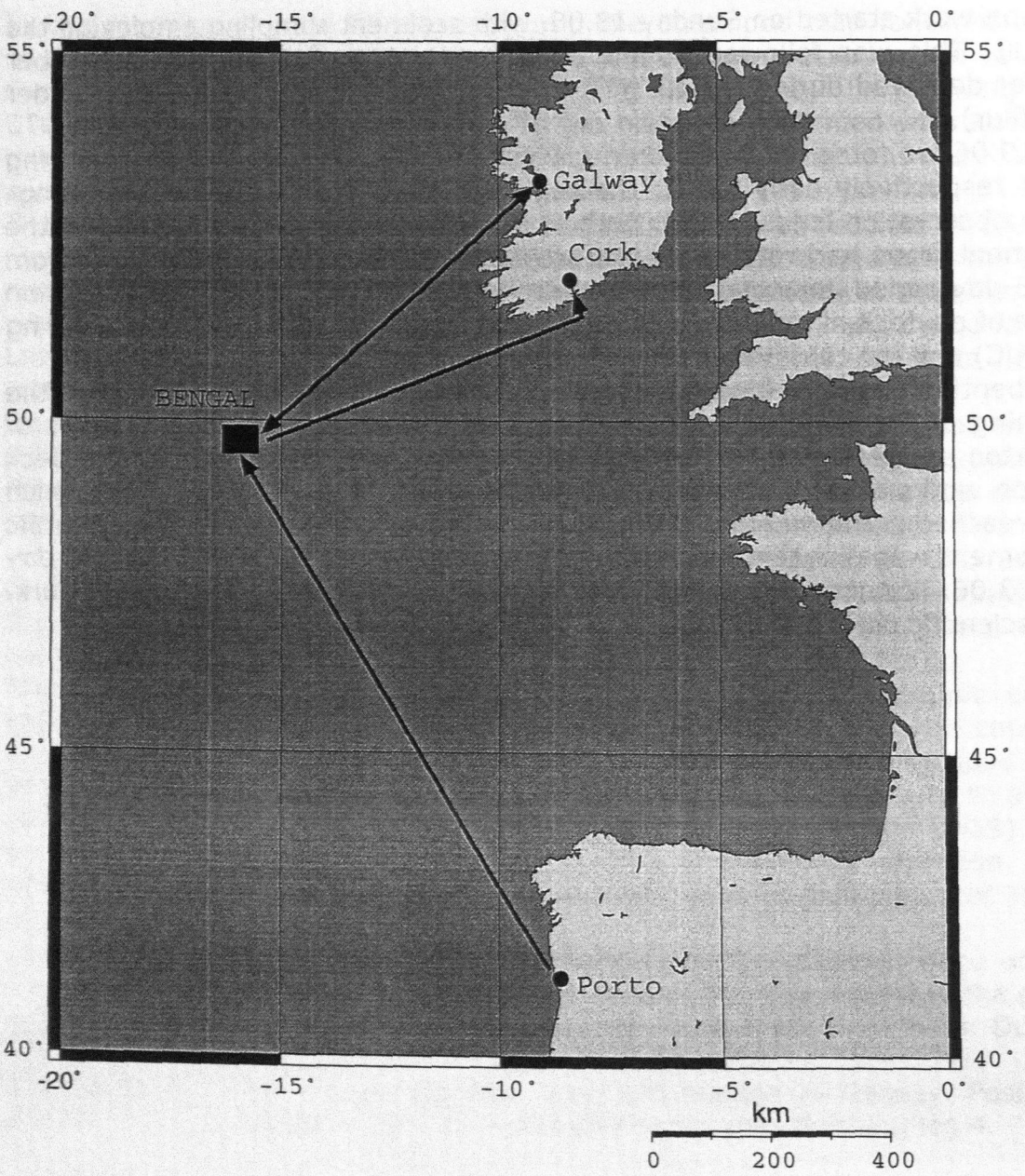

Figure 6: Cruise tracks and sampling station POSEIDON Expedition No. 260.

5. Results

5.1 Benthic response to a simulated pulsed sedimentation event of organic matter under in situ conditions

O. Pfannkuche, S. Sommer, A. Kähler, M. Sand

Introduction

Export of primary produced organic matter is an episodic process, which can be reflected by a pulsed deposition of particulate material on the deep-sea floor. The duration of these individual deposition events is typically limited to only a few days. Effects of the pulsed deposition of organic matter on the deep-sea benthos were described for several regions and indicate that benthic organisms show an attenuate reaction after a certain lag phase. The amplitude and longetivity of the lag phase are primarily dependent on the amount and reactivity of the deposited organic material. The sedimentation of organic matter induces changes in the dynamic of remineralisation processes as well as in the composition and distribution of the benthic community.
However, the fate of degradable organic material following a sedimentation event is still not clarified. This is primarily true for different groups of benthic organisms (bacteria, protozoa, meiofauna and macrofauna) as well as for biologically mediated mixing and degradation processes. Different groups of deep-sea organisms respond in variable ways and at different time scales to the deposition of organic matter. A rapid colonisation and degradation of fresh organic material was found for bacteria and foraminifera, whereas for other protozoans or nematodes (metazoan meiofauna) such a rapid response was not detected.

Major aim of the investigations during cruise POS260 was to resolve timing, amplitude and mechanisms of response reactions of the small-sized benthic biota (SSBB; bacteria, fungi, protozoa and meiofauna) to a simulated pulse of organic matter in benthic chambers.
Major questions were:
- How fast does the deep-sea benthos and biologically mediated transport rates respond to the pulsed deposition of organic matter ?
- What are the amplitudes, turnover and timing of these response reactions ?
- A determination of major pathways of organic carbon and nitrogen transfer between the different groups of organisms by the use of $^{13}C/^{15}N$ labeled algal material as tracer.

Methods

High-quality surface sediment samples were obtained from benthic chamber landers, which allowed the incubation of an enclosed sediment volume and overlying water body under *in situ* conditions for different incubation periods (Table 2). For enrichment experiments a mixture of $^{13}C/^{15}N$ labelled algal material (*Thalassiosira rotula*, reared at GEOMAR) and chitin as well as tracers for the determination of bioirrigation and bioturbation were injected into

benthic chambers in contrast to untreated chambers serving as control samples (Table 2). Additional sediment samples describing the natural background processes were obtained by using a multiple corer (MUC) mMUC.
Replicate subsamples were taken with piston corers which were sectioned vertically at 0.5 cm intervals down to 3 cm followed by samples from the sediment horizons 3-4 and 4-5 cm. Addtionally, from selected chamber sediments, slurries of the sediment horizons 0-2, 2-5 and 5-10 cm were made from which 5 replicate samples for each parameter were taken.
Chloroplastic pigment equivalents (CPE) were determined. They are operationally defined as the sum of chlorophyll a (chl.a) and pheopigments and serve as input parameter of phytodetrital matter. Both chl.a and pheopigment concentrations were separately determined with a TURNER fluorometer as described by PFANNKUCHE et al. (1999).
Potential activity of hydrolytic enzymes was measured with fluorescein-di-acetate (FDA) as substrate after a modified method of MEYER-REIL and KÖSTER (1992) as described by PFANNKUCHE et al. (1999).
Total adenylates (TAN) which represent the sum of the concentrations of ATP, ADP and AMP were used as a measure of the biomass of the SSBB. TAN mainly reflect the amount of plasma within the cells and therefore are closely related to biovolume (KARL 1993). Concentrations of TAN were determined using the luminiscence of Firefly following the method described by PFANNKUCHE et al (1999).
The concentration of total phospholipids (PL) in sediments also serve as an estimate of the total SSBB biomass and reflects mainly the amount of cell membranes. PL were determined as described in BOETIUS and LOCHTE (2000) after a modified method of FINDLAY et al. (1989).
Bioirrigation (BI) and bioturbation (BT) will be detected by the use of sodium bromide (4.1 g) and glass beads of the size classes 30 and 60 µm as tracers.
To study the incorporation of ^{13}C of the labelled algal material into the bacterial cell walls, lipids were extracted from the sediment, fractionated, and the fatty acids of the phospholipid fraction were investigated with a GC-C-IRMS in cooperation with Dr. W.R. Abraham, Gesellschaft für Biotechnologische Forschung, Braunschweig.

Table 4: List of parameters which were determined from benthic chambers, MUC- and mMUC-sediment samples (MF: meiofauna, CPE: chloroplastic pigment equivalents, TAN: total adenylates, FDA: potential activity of hydrolytic enzymes, PL: phospholipids, GL: total lipids, BI: bioirrigation, and BT: bioturbation). Those parameter indexed with ***s*** were determined from sediment slurries. Duration of incubation is given below each lander. Chambers enriched with organic material and chitin are marked with grey shadings.

lander	chamber	parameter										
FFR-Ia	1	MF	CPE		TAN		FDA		PL	GL		
2.5d	2	MF	CPE		TAN		FDA		PL	GL	BI	BT
	3	MF	CPE		TAN		FDA		PL	GL		
FFR-IIa	1	MF	CPE		TAN		FDA		PL	GL		
2.5d	2	MF	CPE		TAN		FDA		PL	GL		
	3	MF	CPE		TAN		FDA		PL	GL	BI	BT
FFR-Ic	1											
2.5d	2	MF	CPE		TAN		FDA		PL	GL	BI	BT
	3	MF	CPE	CPEs	TAN		FDA		PL	GL	BI	BT
FFR-IIc	1											
2.5d	2	MF			TAN	TANs		FDAs			BI	BT
	3	MF		CPEs	TAN	TANs		FDAs				
FFR-Ib	1	MF		CPEs		TANs		FDAs				BT
8d	2											
	3	MF	CPE	CPEs	TAN	TANs	FDA	FDAs	PL	GL		
FFR-IIb	1											
8d	2	MF	CPE	CPEs	TAN	TANs	FDA	FDAs	PL	GL		
	3			CPEs		TANs		FDAs			BI	BT
FFR-IIIb	1	MF	CPE		TAN		FDA		PL	GL		BT
8d	2		CPE	CPEs	TAN		FDA		PL	GL	BI	BT
	3	MF	CPE	CPEs	TAN		FDA		PL	GL		BT
FFR-Id	1	MF		CPEs		TANs		FDAs			BI	BT
20d	2	MF	CPE	CPEs	TAN		FDA		PL	GL	BI	BT
	3	MF	CPE		TAN		FDA		PL	GL	BI	BT
FFR-IId	1	MF		CPEs		TANs		FDAs			BI	BT
20d	2											
	3	MF	CPE		TAN		FDA		PL	GL	BI	BT
FFR-IIId	1		CPE	CPEs	TAN	TANs	FDA	FDAs	PL	GL		
20d	2	MF									BI	BT
	3		CPE	CPEs	TAN				PL	GL	BI	BT

Corer	parameter					
MC5		CPE	TAN	FDA	PL	GL
mMUC1		CPE	TAN	FDA	PL	GL
mMUC2	MF					
mMUC3	MF					
mMUC4	MF					
mMUC5		CPE	TAN	FDA	PL	GL
mMUC7	MF					
mMUC8	MF					
mMUC9	MF					
mMUC11		CPE	TAN	FDA	PL	GL
mMUC12	MF					
mMUC15		CPE	TAN	FDA	PL	GL
mMUC18		CPE	TAN	FDA	PL	GL
mMUC38		CPE	TAN	FDA	PL	GL

Preliminary results

During the cruise a total of 13 benthic chamber lander were successfully employed and both control and amended chamber sediments were obtained from the different incubation periods. The newly developed module for the injection of particulates and tracers inside the chambers worked reliable under *in situ* conditions. In some cases when the lander was retrieved a regular distribution of the injected algal material on the sediment surface was observed.
The benthos clearly reacts on the simulated pulsed deposition of organic matter. This becomes particularly evident in sediment slurries which overcome the problems of small scale variability within the chamber. But also piston corer subsamples rendering vertical profiles of CPE confirm successful injection of algae and chitin. After only 2.5 days elevated concentrations of chl.a were detected also in deeper sediment layers, indicating enhanced transport of fresh phytodetritus, Figure 7.

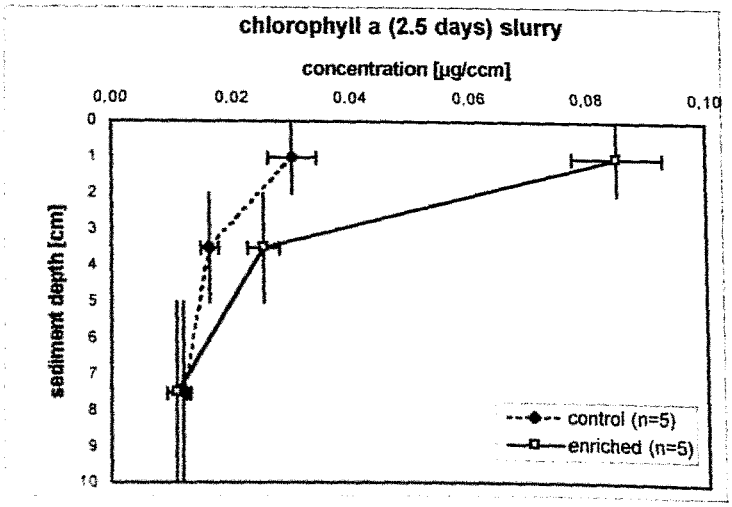

Figure 7: Vertical profiles of chlorophyll a from a control and enriched chamber after a 2.5 days incubation period. Depth interval and 95% confidence interval is indicated.

The biomass parameters PL and TAN as well as FDA turnover were distinctively elevated in the upper 0-5 cm sediment layers after a 20 days incubation period. The group of bacteria also showed a clear response to the addition of labeled organic matter as indicated by increased $\delta^{13}C$ values of fatty acids which were used as bacterial biomarker (C15:0i and C17:0i; WHITE 1983, CANUEL et al. 1995, BOSCHKER et al. 1999) after a 20 days incubation in comparison to the 2.5 days incubation, Figure 8.

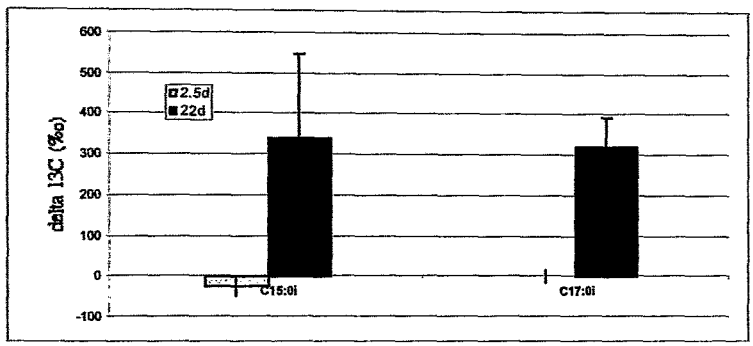

Figure 8: δ ^{13}C values of two different bacterial biomarkers (C15:0i; C17:0i) after a 2.5 and 20 days incubation period. The 95% confidence interval is indicated.

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5.2 *Sediment community oxygen consumption and the role of bacteria and macrofauna for degradation and entrainment into the sediment*

F. Wenzhöfer, N. Aberle, U. Witte

1. Remineralisation rates of organic carbon at the deep-sea floor

In well-oxygenated marine sediments the sediment community oxygen consumption is generally considered to be an adequate measure of the total benthic mineralization of organic carbon. Oxygen is either consumed directly in the heterotrophic degradation of organic matter by micro-organisms and animals, or consumed by the often microbially mediated reoxidation of upward diffusing, reduced solutes. Diffusive (DOU) and total (TOU) oxygen uptake rates were obtained by the use of a profiling lander (MPI) as well as a chamber lander.
In the benthic chambers, oxygen consumption was determined by winkler titration of syringe water samples. In addition, the chambers of one lander were equipped with oxygen microsensors (optodes) in order to continuously monitor the oxygen concentration in the chamber water. Both the profiling lander as well as the optode-equipped chamber lander. were deployed several times during the measurement campaign (Table 5).

Table 5: Deployment list of the MPI profiling lander and the GEOMAR chamber lander (FFR-I) with oxygen optodes.

	deployments leg 2	deployments leg 4
MPI - Profiler		
- microelectrodes	2	1
- deep-pentrating optodes	-	1
GEOMAR chamber lander FFR-I with oxygen optodes	1 (8 days)	2 (21 and 8 days)

The pre-programmed free falling lander is designed to measure *in situ* profiles of various species with a depth resolution of 25 to 200 µm. At this cruise the profiling lander was equipped with two different measuring modules: one system for electro-chemical measurements and one for opto-chemical measurements. The electrochemical microsensors are typically able to penetrate the sediment to a depth of max. 10 cm. The profiles are used to determine the diffusive boundary layer (DBL) and to calculate the DOU. The oxygen penetration depth could hardly be measured with oxygen electrodes. Therefore a second profiling system for determination of the oxygen penetration depth was added. With the deep-penetrating optodes oxygen penetration down to a sediment depth of 55 cm can be measured. At BENGAL

oxygen penetration depth was > 15 cm confirming that DOU and TOU are appropriate measures of benthic carbon remineralisation.

GEOMAR – Benthic chamber lander

To investigate the reaction of the total benthic oxygen consumption in response to a settling algal bloom, *in situ* pulse chase experiments were carried out using benthic chamber landers. In all deployments sediment community oxygen consumption (SCOC) was determined by winkler titration of syringe water samples. An overview of the respective deployments and chambers sampled is given in Table 6. In addition, one GEOMAR lander (FFR-I) was equipped with oxygen optodes. In each of the three chambers two oxygen optodes were mounted in the lid to follow the depletion of oxygen in the incubated overlying water. Additionally one chamber was equipped with a chamber profiling unit. In pre-programmed time intervals oxygen profiles were measured to investigate the change in the DOU during the incubation.

Table 6: Sampling for determination of SCOC by winkler titration

Experiment type	lander/chamber no. **control**	lander/chamber no. **enriched**
short-term 2.5 days	IIc-1 IIc-3 IIa-1 IIa-3	Ic-2 Ic-3 IIc-2 IIIa-3
medium-term 7.5 days	IIIb-1	Ib-1 Ib-3 IIb-1 IIb-3 IIIb-1 IIIb-3
Long term 23 days		Id-1 IIId-3

Preliminary results

Oxygen dynamics were measured with oxygen microelectrodes and optodes (Fig. 1). Both methods exhibited a similar decrease in the oxygen concentration, while the anoxic horizon was only reached by optodes. The penetration depth of oxygen, which controls the depth distribution of many redox reactions in deeper sediment layers, was 15 cm (Figure 9). Diffusive oxygen uptake rates (DOU), calculated from the linear gradient in the DBL of the oxygen profiles measured with microelectrodes ranged between 0.59 and 0.62 mmol m^{-2} d^{-1} and showed no significant difference between the deployments (Table 7).

Table 7: Diffusive oxygen uptake rates (DOU) calculated from electrode oxygen microprofiles

	Diffusive oxygen uptake [mmol m^{-2} d^{-1}]
leg 2	
23. May	0.59 (± 0.02)
25. May	0.62 (± 0.15)
leg 4	
18. June	0.59 (± 0.26)

Comparison of winkler titration of water samples with the optode measurements revealed a very good agreement of both methods indicating that the oxygen consumption in the syringes after sampling is negligible (Figure 10).

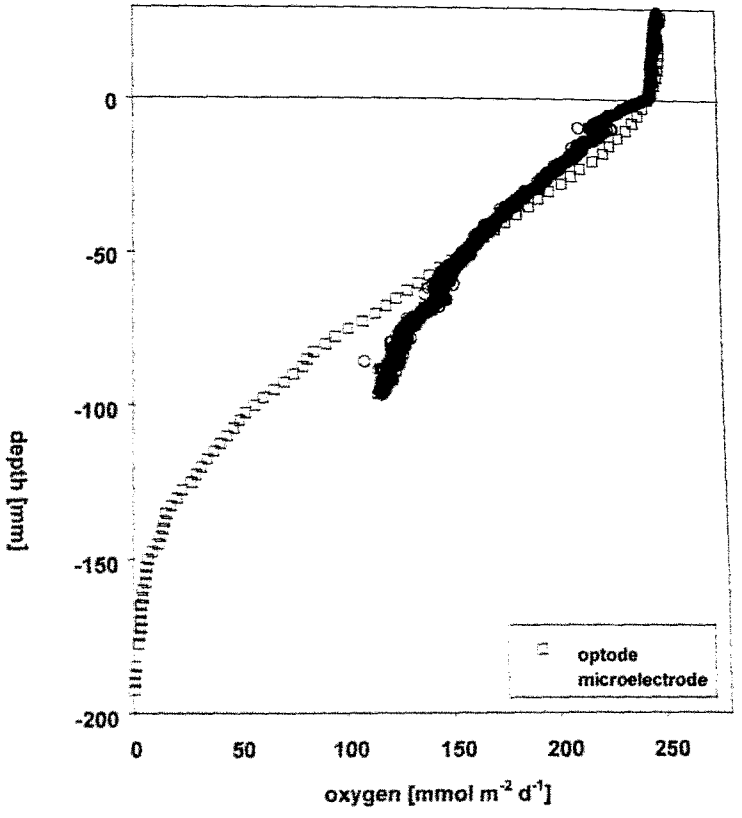

Fig. 9: Oxygen profiles measured with oxygen optodes and microelectrodes

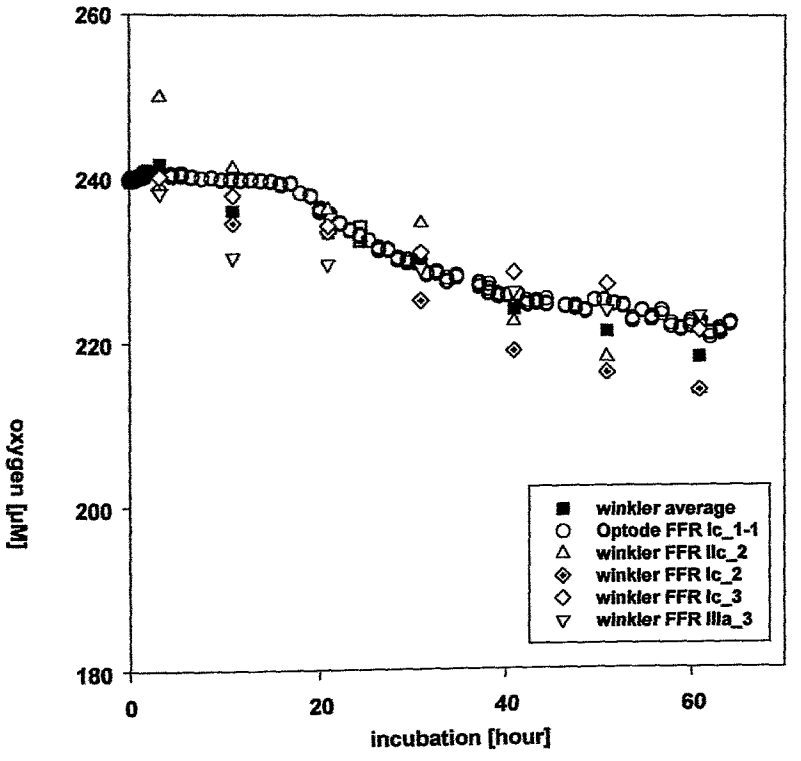

Figure 10: Comparison of optode measurements and winkler titration of syringe water samples

The enrichment experiments demonstrated a very fast benthic response to a sedimentation event in terms of sediment community oxygen consumption that did not decline within the duration of our long-term experiments.

2. Incorporation and transport of organic carbon by macrofaunal organisms

In order to investigate the role of macrofaunal organisms for the degradation and entrainment of phytodetritus into the sediment, tracer experiments were carried out using $^{13}C/^{15}N$- labelled diatoms *Thalassiosira rotula*. The algae were inserted into benthic chambers to examine patterns of macrofaunal consumption of fresh phytodetritus under *in-situ* conditions.
Macrofauna samples were collected from the short-, medium- and long-term experiments. The sediment was divided into five horizontal layers (0-1, 1-2, 2-3, 3-5, 5-10 cm), sieved through a 250µm mesh and preserved by freezing (-20°C). Meiofauna samples were taken from the same sediment volume and an overview of the deployments and chambers sampled for macrofauna is given in

Table 4. Macrofauna from background sediments was additionally sampled from mMUC samples and processed in the same way as mentioned above.
The samples were analysed for community composition, biomass and vertical distribution within the sediment column. In addition, the $^{13}C/^{15}N$ isotopic signatures of individual macrofaunal organisms will be determined in order to elucidate the influence of taxa, body size and feeding mode on the incorporation rate of fresh phytodetritus. Measurements of isotope ratios on macrofaunal specimen are still in progress.

Preliminary results

In the laboratory, all specimen were sorted and identified to higher taxa (phylum, class, order or family) in order to obtain an estimate of the taxonomic composition of the macrofaunal community at the BENGAL study site. The macrofaunal abundance was evaluated and afterwards each specimen was freeze-dried and weighed on a microbalance in order to obtain biomass data.
Mean abundance, mean biomass and the taxonomic composition of the macrofaunal community on the BENGAL-Site are shown in Fig. 11-13.

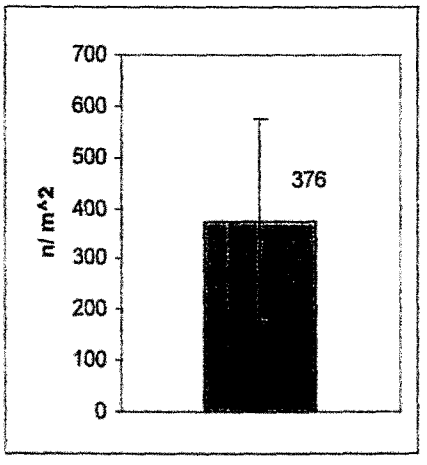

Figure 11:
Mean macrofauna abundance

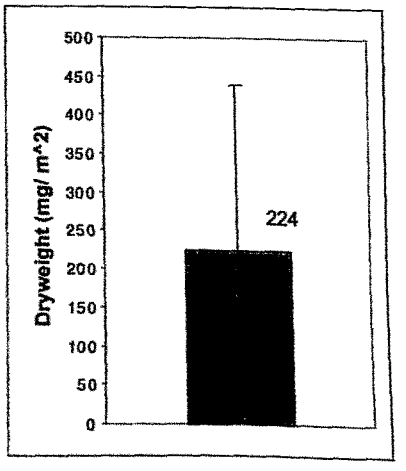

Figure 12:
Mean macrofauna biomass

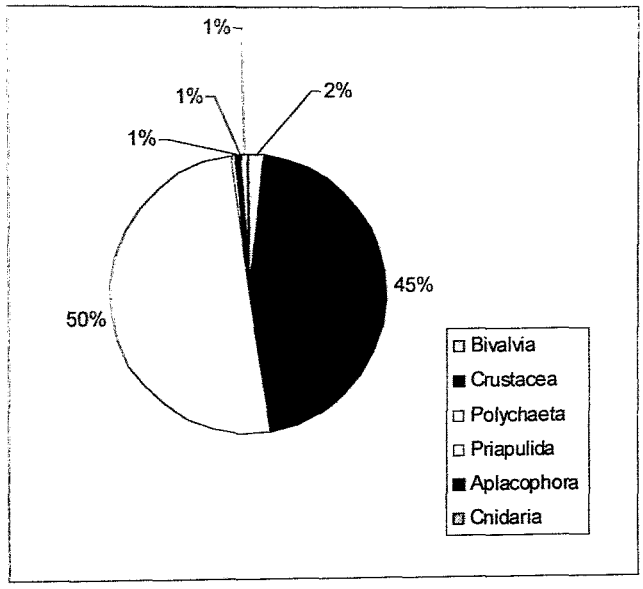

Figure 13: Taxonomic composition

The taxonomic composition given in Figure 13 shows the predominance of the taxa Polychaeta and Crustacea, a composition typical for an abyssal community.
The mean macrofauna abundance (Figure 11) and biomass (Figure 12) were as high as usually observed at comparable depths.
As mentioned above, the measurements of $^{13}C/^{15}N$ isotopic signatures from macrofauna specimen are have not been completed yet. However, first results revealed a high tracer uptake by all macrofauna organisms and a rapid diatom ingestion primarily by polychaetes.

5.3 Microbial degradation of chitin in deep-sea sediments

A. Boetius

Introduction

In deep-sea sediments, bacteria are the primary agents of the early diagenesis of organic matter (OM). To use macromolecular organic substances as source of energy and nutrients, bacteria produce extracellular hydrolytic enzymes. The products of the enzymatic degradation of OM can be taken up by the bacteria and are either incorporated into the biomass or respired and remineralized. In general, the highest bacterial activity is measured at sediment surface where fresh detritus is deposited. Most deep-sea sediments receive only low amounts of sedimenting OM which is efficiently degraded under oxic conditions. Recent investigations have shown that the autochtonous deep-sea bacteria are well adapted to the low temperature and to the high pressure prevailing in the deep sea. A substantial fraction of the bacterial populations were found to be psychro- and barophiles. Thus, it is assumed that accurate rate measurements of bacterial turnover of OM can only be performed under *in situ* temperature and pressure. However, in absolute numbers, little is known on the effect of pressure on rate measurements of bacterial hydrolysis, production and respiration in different sediment horizons. Thus, the aim of this study was to carry out an *in situ* experiment focussing on the microbial response to an enrichment with organic matter. For comparison, a parallel laboratory experiment was carried out with sediments obtained from the same station with a multiple corer. These sediments were repressurized and incubated at *in situ* pressure and temperature on board of the ship. Both sediment samples received the same amount of substrate and were incubated for the same time intervals.

This investigation was mainly concerned with the microbial turnover of chitin in deep-sea sediments. Chitin is the most abundant polysaccharide in the marine environment. It occurs in crustacean shells, in the peritrophic membrane of fecal pellets as well as in the cell wall of algae and protozoa. Despite its quantitative importance in the particle flux to the seafloor, chitin does not accumulate in marine sediments. Chitin is resistant to most chemical and physical agents, however, it is quickly dissolved by chitinolytic enzymes (GOODAY, 1990). Not many animals are able to digest chitin and probably most of them harbour chitinolytic microorganisms in their guts (DEMING and BAROSS, 1993). Thus, it is likely that most of the chitin reaching the seafloor is utilized by bacteria. Enrichment experiments with deep-sea sediments have shown that the natural microbial assemblages may produce high amounts of chitinolytic enzymes within days when chitin becomes available as a substrate. The bacteria may then utilize this C+N source with relatively high growth efficiencies. The addition of different amounts of chitin induced chitobiase to different levels relative to the availability of this substrate (BOETIUS and LOCHTE, 1996). Hence, chitin is an important substrate for bacteria in deep-sea sediments and even high amounts as introduced by large food falls can be quickly remineralized.

The main questions of the experiments were:

1. How fast do the benthic bacteria respond to the input of chitin *in situ* ?
2. What is the succession and amplitude of microbial reactions?
3. How do the turnover rates compare between the *in situ* and the laboratory experiments?
4. Can the turnover of chitin be attributed to a specific group of bacteria?

Methods

Samples for the determination of extracellular enzyme activities (EEA), bacterial numbers (BN), bacterial production (BP), respiration, hexosamine uptake and fluorescence *in situ* hybridization (FISH) were obtained from triplicate lander deployments of different time intervals (~2, ~8 and ~20 days) (Table 8). Samples were taken from the sediment horizons 0-2 cm, 2-5 cm and 5-10 cm sediment depth. The hydrolytic activity of chitobiase was measured on board using a fluorescence-labelled MUF-substrate (BOETIUS and LOCHTE 1994). Bacterial production was estimated by measuring the incorporation of ^{3}H-labelled thymidine into into DNA (Kemp 1994). To determine bacterial respiration potentials, ^{14}C labelled Synechococcus material was added to the sediment and the subsequent release of $^{14}CO_2$ was measured (LOCHTE 1992). Some samples were additionally incubated with ^{14}C-N-acetylglucosamine. For the determination of bacterial numbers, samples were fixed and are counted by epifluorescence microscopy in the home laboratory (MEYER-REIL 1986). Furthermore, samples were taken for fluorescence *in situ* hybridization of different phylogenetic groups of bacteria (SNAIDR et al. 1997).

Table 8: benthic chamber lander samples obtained for the analysis of microbial chitin turnover

lag	station	lander	time interval (d)	control chamber	enrichment chamber
260-3	95	Ic	2.7	-	K2
260-3	97	IIc	2.7	K3	K2
260-2	81	Ib	7.8	K3	K1
260-2	84	IIb	7.8	K2	K3
260-2	88	IIIb	7.8	K2	K3
260-3	112	Id	20.1	K2	K1
260-3	111	IId	20.1	-	K1
260-3	106	IIId	20.1	K1	K3

Additionally, batches of sediment (0-2, 2-5, 5-10 cm) obtained with a multiple corer were amended with the same amount of chitin and algal material and incubated in parallel to the lander incubations, at *in situ* pressure (480 bar) and temperature (4°C). Furthermore, microbial biomass, respiration and

production were measured in replicate multiple corer samples during leg POS260-3 to obtain information about the background situation at the station BENGAL (stations 96-2, 99-3, 107-2).

Preliminary Results

The microbial enzymatic activities in sediments of station BENGAL in May 2000 (POS260-3) were low compared to the activities in the summer and autumn situation in earlier years (Figure 14). A strong microbial response to the addition of particulate organic substances such as algal detritus and chitin flocs was measured in the *in situ* enrichment experiments with the benthic chamber landers. A significant increase in microbial chitobiase activity was recorded after 8 days (Figure 15). Within 20 days, the chitobiase activity increased 16-fold in the enriched lander chambers compared to the unenriched incubations. In the parallel laboratory incubations, chitobiase activity increased only 5-fold. Hence, the populations in the undisturbed sediments were more efficient in producing chitobiase. The de- and repressurization during and after recovery of the samples obviously had a negative effect on the microbial activity in the laboratory incubations. However, no difference in the response time was observed between lander and laboratory experiment. The measurements of other microbial parameters such as biomass, production and respiration are currently in progress.

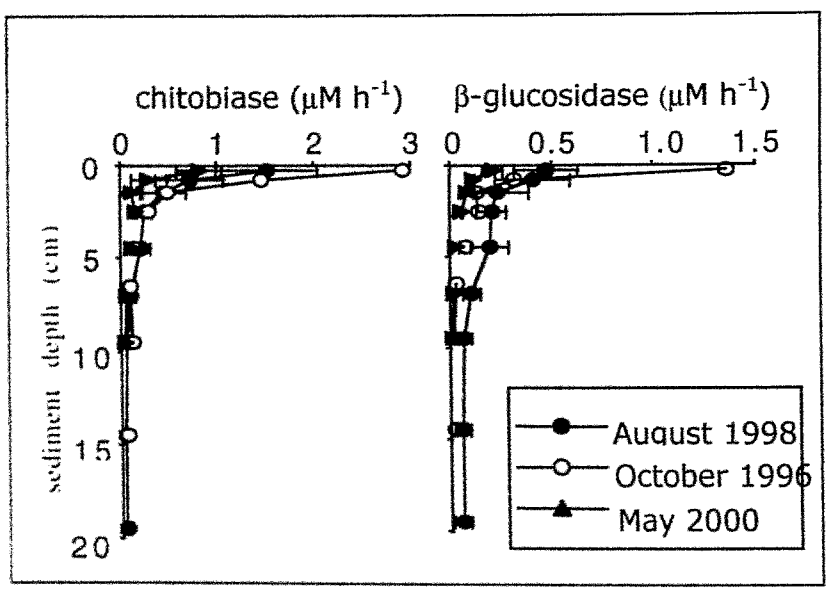

Figure 14: Background extracellular enzyme activity at station BENGAL

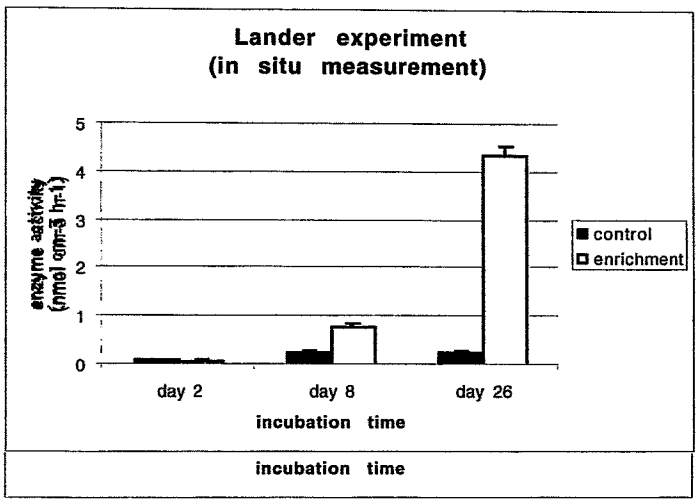

Figure 15: Changes in chitobiase activity due to chitin input. Chitin particles were added *in situ* (lander experiment) or to a sediment slurry (laboratory experiment) and the change in chitobiase activity was recorded over time.

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5.4 Benthic foraminifera

P. Heinz

Research programme

Organic carbon flux is one of the main environmental factors that control benthic foraminiferal distribution patterns. Seasonal or intermittent fluxes of organic carbon, caused by phytoplankton blooms or anthropogenic nutrient inputs, regulate species composition, vertical distribution in the sediment, population dynamics, and reproduction cycles of benthic foraminifera. In oligotroph areas as BENGAL, some opportunistic species (like *Alabaminella weddellenis, Epistominella exigua and Tinogullmia* sp.) react very quickly to phytodetritus blooms arriving on the sediment surface. They rapidly colonize freshly deposited phytodetrital aggregates and respond with a high increase in abundance due to reproduction (GOODAY 1988, GOODAY 1993, GOODAY & TURLEY 1990, GOODAY & LAMBSHEAD 1989, SMART & GOODAY 1997). The biomass of benthic foraminifera has been reported to correlate well with the organic carbon flux (ALTENBACH & Sarntheim 1989, ALTENBACH et al. 1999). Shipboard experimental addition of organic material resulted in an increase of biomass and in a higher number of vacuoles (ALTENBACH 1992, LINKE et al. 1995). After some days, food was converted into biomass. The biomass of benthic foraminifera in deep-sea sediments is thus controlled by the primary production in the oceanic surface layer. The foraminiferal metabolism is adapted to this environment and reacts very rapidly on arriving food material. Hence, benthic foraminifera are important remineralizers of organic matter and represent an important link in the bentho-pelagic coupling.
Objectives of this cruise were to analyse the influence of an experimental *in situ* food pulse (labelled algae) to the activity of the benthic foraminifera with regard to microhabitat changes, species response, response times and amplitudes, and the comparison of the trophical regimes.

Station works and preliminary results

Sediments of the different lander experiments were collected to analyse the reaction of benthic foraminifera to the added food pulse of labelled algae. The different in-situ incubation times enable to investigate the time-depending response. Isotope analyses (C^{13}/N^{15}) of the biomass give a measure for the enrichment of stable isotopes and therefore for the algae uptake. TEM-fixations of foraminiferal cytoplasma were carried out to investigate food particles. To recognize changing faunal compositions, abundances, and shifting vertical distribution patterns during the in-situ-experiments, samples for faunal analysis were taken. Additionally, these faunal data will be compared to former investigations in the BENGAL area from previous BIGSET expeditions.

A list of samples taken from the different multicorer and the in-situ-lander experiments is given in Table 9. For isotopic investigations, sediments were cut in 0.5-cm-slices for the first two centimetres and in 1.0cm slices for the

centimetres 3-5. Sediment samples were sieved over a 30µm mesh screen with seawater and were immediately frozen after sieving. The samples were transported frozen to our lab in Tübingen for further investigations. For TEM-fixation, some residence sediment from the upper 2cm was sieved over a 30 µm-screen and was washed with filtered seawater. Subsequently, the living foraminifera were picked under the stereo microscope, fixed and stained. For faunal analysis, sediment was sliced in half centimetre intervals for the top two centimetres and thereafter in one centimetre slices. The slices of the upper 10 cm were stained with a solution of ethanol and Rose BENGAL for distinguishing between living and dead specimens.

Table 9: List of sediment samples taken from the different multiple corers and the lander experiments for isotopic and faunal analysis of benthic foraminifera and TEM-Fixations.

Label	Latitude	Longitude	Elevation	Samples		
				core /chamber I	core /chamber II	core /chamber III
POS260-2_mMUC-02	48°50.02'N	16°36.89'W	-4805	fauna analysis	isotope analysis	
POS260-2_mMUC-04	48°50.28'N	16°36.84'W	-4805	fauna analysis	isotope analysis	
POS260-3_mMUC-08	48°49.94'N	16°37.08'W	-4805	fauna analysis	isotope analysis	
POS260-3_mMUC-10	48°49.96'N	16°37.02'W	-4802	fauna analysis		
POS260-3_mMUC-12	48°49.98'N	16°36.95'W	-4806	isotope analysis, TEM		
POS260-3_mMUC-17	48°49.97'N	16°36.90'W	-4802	fauna analysis	fauna analysis	isotope analysis
POS260-5_mMUC-37	48°49.89'N	16°16.96'W	-4838	fauna analysis	isotope analysis	fauna analysis
POS260-2_FFR-Ia	48°49.93'N	16°34.92'W	-4805	isotope analysis	fauna analysis	isotope analysis
POS260-2_FFR-IIa	48°49.94'N	16°34.49'W	-4810	isotope analysis	isotope analysis	fauna analysis
POS260-2_FFR-IIIa	48°50.56'N	16°35.00'W	-4807	isotope analysis	fauna analysis	isotope analysis
POS260-3_FFR-Ib	48°49.89'N	16°34.89'W	-4820	isotope analysis,TEM		
POS260-3_FFR-IIb	48°49.92'N	16°34.64'W	-4820	fauna analysis	isotope analysis	
POS260-3_FFR-IIIb	48°51.01'N	16°35.02'W	-4820	fauna analysis, TEM		
POS260-3_FFR-Ic	48°50'N	16°35'W	-4820		TEM	fauna analysis,TEM
POS260-3_FFR-IIc	48°49.90'N	16°34.41'W	-4820	fauna analysis		
POS260-5_FFR-Id	48°50'N	16°35'W	-4850	isotope analysis	isotope analysis	isotope analysis
POS260-5_FFR-IId	48°49.98'N	16°34.50'W	-4850	isotope analysis	isotope analysis,TEM	
POS260-5_FFR-IIId	48°50.9'N	16°35'W	-4820	fauna analysis		fauna analysis

Preliminary results and conclusions

Preliminary data from the TEM prepared individuals and the first specimens collected for isotopic measurements showed the following species composition: the dominant species in the sediment is the calcareous species *Epistominella pusilla*, followed by an agglutinated species that is identified presently as *Haplophragmoides* sp. Other important species are *Epistominella exigua*, *Cribrostomoides* sp., *Adercotryma glomerata*, *Glomospira charoides* and *Hippocrepina indivisa*. A comparison of the percentage of these dominant species to other species of the samples and to the faunal analysis from a former cruise (M42-2, July 1998) is given in Table 10. The species compositions between the two cruises are in a rather good agreement. *Epistominella pusilla* and *E. exigua* are opportunistic epifaunal species, that should response very fast to the arriving labelled algae and ingest it.

Table 10: Relative abundance (%) of dominant species in a comparison between the samples of cruise POSEIDON 260-2 (May 00), and M42-2 (July 98).

	M42-2 MC1	Pos 260-2 Mini-MC2	FFRIIa K1-	FFRIIIa K1+
Allogromida	0.00	0.43	0.00	0.32
Millioida	0.57	0.86	0.35	0.96
Epistominella pusilla	36.40	24.07	45.57	41.40
Epistominella exigua	5.19	6.30	6.73	10.19
other calcareous species	22.39	11.75	4.37	5.73
Haplophragmoides sp.	22.42	14.04	14.99	14.97
Hippocrepina indivisa	0.14	5.44	0.35	0.96
Cribrostomoides sp.	0.00	9.17	4.13	0.00
Cribrostomoides subglobosum	0.00	0.14	0.00	0.00
Glomospira charoides	0.00	5.30	1.06	1.91
Adercotryma glomerata	0.21	0.14	7.67	3.82
other agglutinated species	12.54	22.35	14.76	19.75

A direct comparison between the abundances of living foraminifera in July 1998 and May 2000 is difficult, because counted numbers of this cruise come from not stained specimens, and the faunal analysis from the fixed and stained samples are presently under investigation. But for a first comparison, data are arranged in Figs. 16 and 17. Abundances of May 2000 are obciouly underestimated at this point of progress, because individuals with colourless or very reduced cytoplasma and very small individuals may be overlooked. This may be the explanation for the large differences in the numbers of foraminifera between the two cruises, but also between the multiple corer and the lander sediments during the POSEIDON cruise. A final comparison of foraminiferal abundances can only be made using the results of the stained samples that are in preparation.

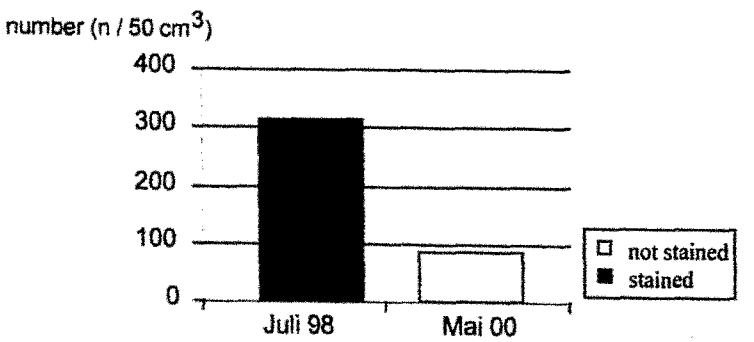

Figure 16: Comparison of the abundances of found living benthic foraminifera, isolated from unstained sediment (cruise POSEIDON 260-2, May 00: Mini-MC2) and from Rose-BENGAL stained sediment (cruise M42-2, July 98, MC1).

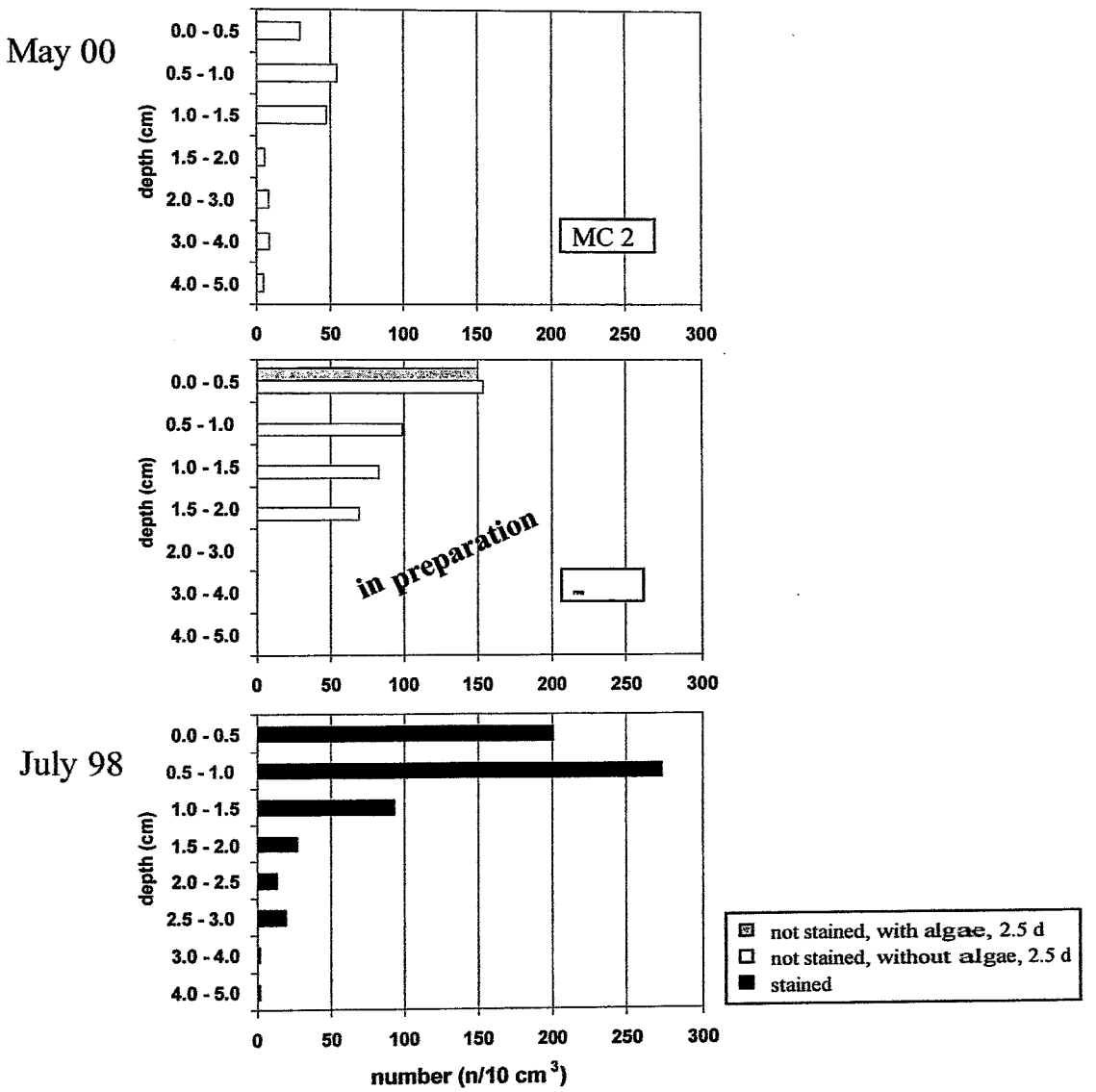

Figure 17: Comparison of the vertical distribution of living benthic foraminifera, isolated from unstained sediment (cruise POSEIDON 260-2, May 00: mMUC2, FFR-IIIa (chamber I), FFR-IIa (chamber I)), and from Rose-BENGAL stained sediment (cruise M42-2, July 98, MC-01).

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5.5 Geochemistry of the sediment - pore water system

M. Haeckel and S. Grandel

Research programme

Aim of the geochemical programme was to investigate mainly chemical parameters influencing decomposition and dissolution of biogenic compounds in the sediment. I.e. modelling the process mechanisms, and determining regional budgets of remineralization rates using a geographical information system (GIS).
During the cruise a comprehensive geochemical data-set has been collected including solid phase and the pore water samples of sediments that have been recovered by benthic chambers as well as by multiple corers. The latter were deployed to characterise the natural geochemical background situation.
Early diagenesis is mainly driven by the degradation of organic matter that has been deposited on the sea floor. The microbial community which mediates these decomposition reactions utilizes different available electron acceptors in order of decreasing free energy production per mole organic carbon oxidized. Hence, the following redox zones can be sequentially observed in marine sediments: oxygen respiration and nitrification, denitrification, manganese(IV) reduction, iron(III) reduction, sulfate reduction, and finally methanogenesis. In deep-sea sediments about ninety percent of the organic carbon decomposes via the oxic pathway and therefore it is especially important to investigate the oxygen consumption in order to model the geochemical environment and the benthic ecosystem of the deep sea.
The collected sediment and water samples were analysed onboard for NO_3^-, NH_4^+, PO_4^{3-}, SiO_4^{4-}, alkalinity and pH, while further measurements of C_{org}, Mn^{2+}, Fe^{2+}, SO_4^{2-}, Ca^{2+}, Cl^-, Br^- and porosity are carried out in shore-based laboratories. An oxygen profiling instrument (OPI) was deployed to gain *in situ* concentration-depth profiles of oxygen and pH. Additionally, sediment samples for laboratory experiments on the adsorbed fraction of ammonium were taken. These results will improve the thermodynamic handling of adsorption-desorption processes within a numerical early diagenetic model.

Station works and preliminary results

Surface sediment samples (the upper 10-20 cm) were retrieved from the benthic chambers as well as from several multiple corer deployments. The sediment was extruded out of the plastic tubes and cut into 0.5-2 cm slices. Subsequently, pore water was extracted using a low pressure-squeezer (argon, 1-5 bar), while squeezing the samples were filtered through a 0.2 µm polycarbonate Nuclepore filter. Pore water samples were collected in two recipient vessels, an acidified (20 µl 30% HCl suprapur) for analysis of metal cations and a non-acidified for nutrients. A small portion of each wet sediment slice was collected for the analyses of organic carbon content, porosity and ex situ pH. Unfortunately, all of the above procedures had to be conducted at

room temperature (about 15-20 °C) as no cold room was available aboard of RV POSEIDON. Hence, temperature induced artifacts cannot be excluded.
The oxygen content and pH in the pore water of the surface sediments was determined by an *in situ*-profiling instrument (OPI), mounted into a lander system. Profiling was executed by means of oxygen and pH microelectrodes (ARCHER et al., 1989; REVSBECH and JØRGENSEN, 1986) permitting a step-resolution of 0.1-0.2 mm. In case of the oxygen sensors a two-point calibration was performed by determining the O_2-concentration in the bottom water by Winkler titration (GRASSHOFF et al., 1999) and the zero current in an anoxic sodium dithionite solution at *in situ* temperature. Whereas the pH glass electrodes were calibrated using three buffer solutions (Ampy, TRIS, BIS) at pH-values of about 7.3, 8.8 and 9.5, respectively (DICKSON, 1993). In situ oxygen measurements are necessary to determine reliable benthic O_2-utilization rates, as ex situ data are considered to be afflicted with 6x decompression artefacts while retrieving the gear from greater depths (GLUD et al., 1999; GLUD et al., 1994). Similarly, ex situ pH measurements are artificially altered by calcite precipitation, which is also induced by decompression, i.e. the interstitial water becomes more acidic.
Analyses for the nutrients NO_3^-, NH_4^+, PO_4^{3-}, SiO_4^{4-} were completed on board using a spectrophotometer. The respective chemical analytics follow standard procedures (GRASSHOFF et al., 1999), i.e. nitrate was detected as sulphanile-α-naphthylamide, ammonium as indophenol blue and phosphate and silicate as molybdene blue. The total alkalinity of the pore water was determined by titration with 0.001N HCl against the Tashiro indicator (a mixture of methyl red and methylene blue). IAPSO sea water standard was used for calibrating the method.
A list of the measured properties is presented in Table 11 including a short description of the analytical method and its analytical precision.

Table 11: Analytical methods for determining pore water parameters.

Parameter	Method	Error (Detection limit)
O_2	microelectrode	2 µmol/l (1 µmol/l)
NO_3^-	photometer	5% (1 µmol/l)
NH_4^+	photometer	5% (2 µmol/l)
PO_4^{3-}	photometer	1 µmol/l (2 µmol/l)
SiO_4^{4-}	photometer	5 µmol/l (1 µmol/l)
pH	glass electrode	0.05
alkalinity	titration	0.05 meq/l

Other parameters, such as of C_{org}, Mn^{2+}, Fe^{2+}, SO_4^{2-}, Ca^{2+}, Cl^-, Br^- and porosity, are determined after the cruise at shore-based laboratories. Therefore, the solid phase (squeeze cakes and wet sediment) as well as the pore water samples (acidified and non-acidified) were stored frozen with dry

ice (about -30 °C). The samples for the adsorption experiments of ammonium were suspended in 20 ml 2N KCl solution, i.e. the first step in the extraction procedure (LAIMA, 1992; ROSENFELD, 1979), and also stored frozen at -30 °C.

Preliminary results and Conclusions

The pore water data (Figure 18) at the BENGAL site reflect the expected natural background situation with respect to early diagenesis: the degradation of organic matter currently proceeds through oxygen respiration and denitrification within the upper 30 cm of the sediment, whereas the following diagenetic stages, manganese, iron and sulfate reduction, are not reached (not shown).

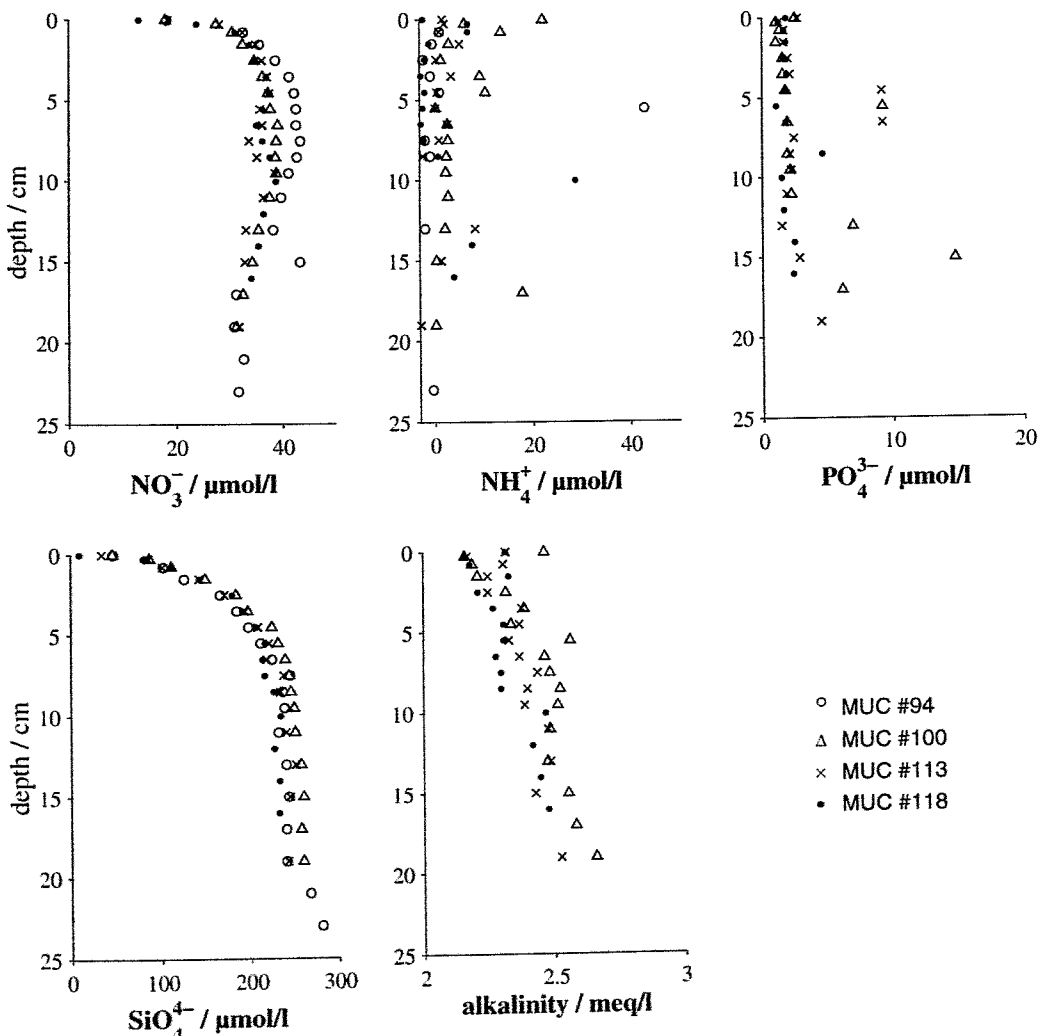

Figure 18: Nutrient and alkalinity pore water distributions at the BENGAL site (North Atlantic).

Starting from a mean bottom water concentration of about 240 µmol/l, O_2 penetrates about 10 to 15 cm into the sediment (data not shown). Thus, the

nitrate profile shows a subsurface increase with a maximum of nearly 40 µmol/l at 8-10 cm sediment depth. Further downcore the nitrate concentration slowly starts to decrease again. Ammonium and phosphate, as products of the organic matter degradation, stay at a low concentration level near the detection limit throughout the sediment core, whereas alkalinity increases generally about 0.5 meq/l to greater depths. Following Emerson et al. (1980), organic matter degradation through oxygen respiration and denitrification alone would only contribute to a potential alkalinity increase of 0.1-0.2 meq/l at greater depths. However, the observed alkalinity production can easily be explained by an additional proceeding calcite dissolution and precipitation, as the BENGAL site is located deeper than the carbonate compensation depth (CCD).
Silicate concentrations increase asymptotically from 45 µmol/l in the bottom water to 250 µmol/l within the uppermost ten centimetres of the sediment. These are typical silicate distributions for pore waters in the North Atlantic with relatively low biogenic silica contents in the sediment itself (3-4 wt%, RICKERT, 2000).
The 20-days *in situ* lander experiments show a significant increase in the rates of organic matter degradation after 240 hours, i.e. the nitrate concentration in the overlying water decreases, while ammonium, phosphate and alkalinity concentrations increase. The effect of the nutrition impulse on the benthic microbial community is even reflected in the pore water profiles derived from subcores taken from the benthic chambers: nitrate shows a subsurface minimum and hence, ammonium a subsurface maximum. The shorter termed lander experiments of 2.5 and 7.5 days do not show any significant changes in the nutrient concentrations both in the bottom water and in the sediment.
These data will enable us to improve the existing state of early diagenetic modelling because for the first time an extensive data-set including a time series exists. By means of these data, a better description of how organic matter degradation starts and proceeds after a distinct detritus impulse is possible. This kind of knowledge is of major importance for modelling and predicting the impacts of natural and anthropogenic impacts in the deep sea like waste disposal or deep-sea mining, for instance.

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5.6 Sinking and suspended particles in the low bottom water column and the sediment

N. Lahajnar and G. Schroll

Research programme

The objective of sub-project 4 was to collect sinking and suspended particles and samples of sediment and pore water. The project aims to measure the particle flux in the deep sea, to compare the biogeochemical composition of sinking particles with suspended particles and sediments as well as to examine early diagenesis of organic matter with the help of detailed analyses of labile organic compounds in sediments and pore waters. The carbon and nitrogen isotopic composition of sinking particles will be compared with those of the sediments. The alterations of the primary isotopic signals reaching the seafloor will be interpreted in combination with the data on labile organic substances in sediments and porewaters.
At station BENGAL a sediment trap mooring system (e.g. HONJO and DOHERTY, 1988) was deployed for 7 weeks. This mooring consisted of two Mark 7 sediment traps ("BENGAL-Shallow" and "BENGAL-Deep"). Each trap was programmed for a weekly sampling interval (7x7 days). In addition to the mooring a trap (Kiel type) installed on a benthic observation lander ("BENGAL-lander") was deployed at the same location for six weeks (6x7 days).
Sediment and pore water samples were taken from multiple corer from three stations at BENGAL. Furthermore, a seamount near BENGAL was sampled at five different spots. At every station (BENGAL and seamount site) water samples for DOC-measurement were taken from various depths.
In co-operation with other sub-projects several experiments with isotopically labelled algal material (^{13}C and ^{15}N) were carried out at the sediment-water interface during POS260. Sediment samples with their corresponding bottom water were taken from benthic chambers, which had been incubated for ~2.5, ~8, and ~20 days, respectively.

Station works and methods

The mooring system information is shown in Table 12 and Figure 19, the deployment schedule is directly taken from the timer boards (Table 13).

Table 12: Mooring system and deployment information for sediment traps during POS260

Region	BENGAL		BENGAL (Sub-project 2)
Mooring name	BENGAL-Shallow	BENGAL-Deep	BENGAL-lander (FFB-01)
Mooring position	48°49.588' N 16°30.108' W		48°49.89' N 16°31.80' W
Deployment	30.04.2000, 15:45-16:55 UTC		06.05.2000, 18:18 UTC
Deployment station	65#1		67#1
Recovery	19.06.2000, 06:00-08:25 UTC		19.06.2000, 12:32 UTC
Recovery station	161		163
Water depth (m)	4802		4808
Trap depth (m)	4233	4767	4806
Distance to seafloor (m)	569	40	2
Sampling start	01.05.2000, 01:00 UTC		08.05.2000, 01:00 UTC
Sampling end	19.06.2000, 01:00 UTC		19.06.2000, 01:00 UTC
Sampling duration (d)	7 x 7		6x7

Mooring-I.D.: BENGAL

Deployment Date: 30.04.2000
Start: 15:45 UTC

Release: Enable 2C, Release 2B
Radio Frequency: 156.425 MHz, Channel 68
Anchor Drop: 48°49.588' N 16°30.108' W 16:52:00 UTC
Buoyancy speed: 50.75 m/s (calculated during recovery)

Recovery Date: 19.06.2000
Start: 06:00 UTC

Mooring Diagram m.a.b.	Mooring Diagram m.b.s.	Mooring Description	Deployment Time out UTC	Recovery on Deck UTC
597 m	4205 m	3 Ball Radio Float + Flasher 2 m Chain	15:48	07:48
594 m	4208 m	G-6600-3 Triple Float	15:50	07:49
593 m	4209 m	G-6600-3 Triple Float 20 m Nylon Rope 2 m Chain	15:50	07:49
569 m	4233 m	Mark 7 Sediment Trap BENGAL-Shallow 2 m Chain 500 m Wire Rope	15:54 16:06	07:54 08:09
64 m	4738 m	G-6600-3 Triple Float 2 m Chain	16:14	08:10
40 m	4762 m	Mark 7 Sediment Trap BENGAL-Deep 2 m Chain 5 m Chain	16:23	08:15
35 m	4767 m	G-6600-3 Triplefloat	16:35	08:21
28 m	4774 m	Benthos Release 3 m Chain 20 m Nylon Rope 2 m Chain	15:44	08:21
0 m	4802 m	Anchor (2 Railroad Wheels)	0 m	4802 m

Figure 19: Sediment trap system moored during POS260

Table 13: Deployment schedule for BENGAL-Shallow and BENGAL-Deep

Deployment schedule BENGAL-Shallow	Deployment schedule BENGAL-Deep
McLane Research Laboratories, USA MK7G-21 ITC Sediment Trap Operation Program V2.02 ********** * MAIN MENU * ********** TRAP V2.02 POSEIDON 260 BENGAL-Shallow S/N 1376 04/29/00 21:56:20 ----------VERIFICATION---------- Event 01 of 08 = 05/01/00 01:00:00[1] Event 02 of 08 = 05/08/00 01:00:00 Event 03 of 08 = 05/15/00 01:00:00 Event 04 of 08 = 05/22/00 01:00:00 Event 05 of 08 = 05/29/00 01:00:00 Event 06 of 08 = 06/05/00 01:00:00 Event 07 of 08 = 06/12/00 01:00:00 Event 08 of 08 = 06/19/00 01:00:00	McLane Research Laboratories, USA MK7G-21 ITC Sediment Trap Operation Program V2.02 ********** * MAIN MENU * ********** TRAP V2.02 POSEIDON 260 BENGAL-Deep S/N 1380 04/29/00 21:38:55 ----------VERIFICATION---------- Event 01 of 08 = 05/01/00 01:00:00 Event 02 of 08 = 05/08/00 01:00:00 Event 03 of 08 = 05/15/00 01:00:00 Event 04 of 08 = 05/22/00 01:00:00 Event 05 of 08 = 05/29/00 01:00:00 Event 06 of 08 = 06/05/00 01:00:00 Event 07 of 08 = 06/12/00 01:00:00 Event 08 of 08 = 06/19/00 01:00:00

[1] Time in UTC

Sediment trap sample processing and description

The recovered samples were kept cool at 4°C until processing, which was carried out within 12 hours after retrieval.
For the analyses of dissolved organic compounds the supernatant in the sediment trap cups was filtered through glass microfibre filters (GF/F, 0.7 µm, pre-combusted at 450°C) as well as through 0.2 µm cellulose acetate filters. The filtrate was filled into 10 ml glass ampoules (pre-combusted at 550°C), sealed under nitrogen atmosphere and stored frozen at -20°C. For further analyses 100 ml of the supernatant were filled into pre-cleaned PE-bottles and stored frozen at -20°C.
After initial macroscopic description of the samples they were split using a rotary splitter (Table 14). The sub-samples were filtered on pre-weighed polycarbonate filters and dried (50°C) for further biogeochemical analyses.

Table 14: Splitting protocol for sediment trap samples applied during POS260

Samples	Shallow-1	Shallow-2	Shallow-3	Shallow-4	Shallow-5	Shallow-6	Shallow-7	Deep-1	Deep-2	Deep-3	Deep-4	Deep-5	Deep-6	Deep-7	lander-2	lander-3	lander-4	lander-5	lander-6	lander-7
Filtered onto polycarbonate filter and dried at 50°C	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
Filled into PE-bottles and stored at -20°C	83/256	83/256	83/256	83/256	83/256	83/256	83/256	3/256	3/256	3/256	11 52 56	67/256	19/256	83/256	66/256	83/256	35/256	83/256	83/256	83/256
Filtered onto GF/F-filter (0.7µm) and dried at 20°C (SP-2, POC)	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16
Filtered onto GF/F-filter (0.7µm), sealed in Al-foil and stored at -20°C (SP-2, Chl-a)	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16	1/16
Filtered onto 142mm PC-filter (0.4µm) and dried at 20°C (SP-2, ^{234}Th)	3/64	3/64	3/64	3/64	3/64	3/64	3/64	3/64	3/64	3/64	3/64	3/64	3/64	3/64	3/64	3/64	3/64	3/64	3/64	3/64
Filtered onto cellulose-nitrate filter (0.45 µm) and dried at 20°C (SP-5, REM).	1/256	1/256	1/256	1/256	1/256	1/256	1/256	1/256	1/256	1/256	1/256	1/256	1/256	1/256	1/256	1/256	1/256	1/256	1/256	1/256

Sediment and porewater sampling

Sediment and pore water samples from several cores were taken by a "regular" multiple corer (MC) and by a small multiple corer (mMUC), respectively, at station BENGAL as well as from a seamount near BENGAL (Table 15). For both multiple corers liners of 10 cm in diameter were used.
Sediment samples were split into sub-samples by applying the following splitting intervals:
0-0,5; 0,5-1; 1-1,5; 1,5-2; 2-2,5; 2,5-3; 3-4; 4-5; 6,5-7,5; 9-10; 14-15; 19-20; 24-25; 29-30 cm.
Bottom water was obtained from multiple corer supernatant. The samples were centrifuged at a temperature of 2°C at 2000 rpm for 20 minutes. Subsequently, the bottom water was filtered through glass microfibre filters (GF/F, 0.7 µm, pre-combusted at 450°C) or through cellulose acetate filters (0.2 µm).
Similarly, pore water for the analysis of dissolved organic compounds was centrifuged from the sediment subsamples at 2°C at 2000 rpm for 20 minutes. After centrifugation the supernatant pore water was removed with syringes and filtered through glass microfibre filters (GF/F, 0,7 µm, pre-combusted at 450°C) or through cellulose acetate filters (0,2 µm).
Both bottom water and pore water samples were filled into 10 ml glass ampoules (pre-combusted at 550°C). The ampoules were sealed under nitrogen and deep frozen (-20°C).
At each station blanks (double deionized water) were taken and treated similarly to the sampling procedure (centrifuged, filtered, and stored in ampoules).

Table 15: Overview of sediment samples taken during POS260

Date	Station Number.	Position	Number Multicorer	Water Depth [m]	Core length [cm]	Sediment untreated	Water samples [0.7 µm]	Water samples [0.2 µm]
07.05.00	BENGAL 69#1	48°50.08' N 16°37.00' W	MC-04	4806	33	yes	no	yes
02.06.00	BENGAL 118	48°49.98' N 16°35.99' W	mMUC-23	4803	20	yes	yes	yes
03.06.00	BENGAL 121#1	48°49.77' N 16°40.82' W	mMUC-24	4798	20	yes	yes	yes
05.06.00	Slope-East 127	49°04.06' N 16°33.46' W	mMUC-27	4557	20	yes	yes	yes
06.06.00	Slope-North 134	49°07.38' N 16°35.66' W	mMUC-29	4358	20	yes	yes	yes
08.06.00	Slope-West 143#2	49°08.64' N 16°40.13' W	mMUC-32	4468	20	yes	yes	yes
09.06.00	Summit 150	49°07.03' N 16°38.35' W	mMUC-34	3850	20	yes	yes	yes
10.06.00	Slope-South 153	49°05.79' N 16°43.02' W	mMUC-35	4750	20	yes	yes	yes
17.06.00	BENGAL 156	48°49.35' N 16°36.86' N	mMUC-36	4711	25	yes	yes	yes

Chamber lander samples

Several benthic chamber landers (WITTE and PFANNKUCHE, 2000) were deployed and recovered at station BENGAL (Table 16). The detailed lander program is described Tables 2 and 3.
The sediment and water samples were treated similarly to the multiple corer sediment samples.

Tab. 16: Benthic chamber sediment samples taken during POS260

lander-No./ Chamber- No.	Position / Station No.	Sampling Start / End	Water Depth [m]	Samp. Interval [cm]	Sediment samples	No. Ampoules [0.7 µm]	No. Ampoules [0.2 µm]
FFR-I c K2 (marked)*	48°50.00' N 16°35.00' W BENGAL 95#1	19.05.00, 21:00 22.05.00, 07:00	4820	chamber water	-	-	4
				0-2	1	-	4
				2-5	1	-	6
				5-10	1	-	6
FFR-I c K3 (marked)	48°50.00' N 16°35.00' W BENGAL 95#1	19.05.00, 21:00 22.05.00, 07:00	4820	chamber water	-	-	4
				0-2	-	-	-
				2-5	-	-	-
				5-10	-	-	-
FFR-I d K1 (marked)	48°50.00' N 16°35.00' W BENGAL 112	25.05.00, 15:44 14.06.00, 11:34	4820	chamber water	-	2	14
				0-2	1	1	4
				2-5	1	1	5
				5-10	1	1	6
FFR-I d K2 (control)**	48°50.00' N 16°35.00' W BENGAL 112	25.05.00, 15:44 14.06.00, 11:34	4820	chamber water	-	2	8
				0-2	1	1	2
				2-5	1	1	2
				5-10	1	1	3
FFR-II b K2 (control)	48°49.92' N 16°34.64' W BENGAL 84#1	11.05.00, 16:52 19.05.00, 05:22	4803	chamber water	-	-	2
				0-2	1	-	2
				2-5	1	-	2
				5-10	1	-	2
FFR-II b K3 (marked)	48°49.92' N 16°34.64' W BENGAL 84#1	11.05.00, 16:52 19.05.00, 05:22	4803	chamber water	-	-	2
				0-2	1	-	4
				2-5	1	-	2
				5-10	1	-	3
FFR-II c K2 (marked)	48°49.90' N 16°34.41' W BENGAL 97#1	20.05.00, 15:08 23.05.00, 01:38	4820	chamber water	-	-	5
				0-2	1	-	5
				2-5	1	-	5
				5-10	1	-	6
FFR-II c K3 (control)	48°49.90' N 16°34.41' W BENGAL 97#1	20.05.00, 15:08 23.05.00, 01:38	4820	chamber water	-	-	2
				0-2	1	-	2
				2-5	1	-	2
				5-10	1	-	2
FFR-II d K1 (marked)	48°49.98' N 16°34.50' W BENGAL 111	25.05.00, 14:48 14.06.00, 11:18	4820	chamber water	-	2	14
				0-2	1	1	2
				2-5	1	1	2
				5-10	1	1	3
FFR-II d K3 (marked)	48°49.98' N 16°34.50' W BENGAL 111	25.05.00, 14:48 14.06.00, 11:18	4820	chamber water	-	2	14
				0-2	-	-	-
				2-5	-	-	-
				5-10	-	-	-
FFR-III b K2 (control)	48°51.01' N 16°35.02' W BENGAL 88#1	12.05.00, 17:15 20.05.00, 05:45	4820	chamber water	-	-	2
				0-2	1	-	2
				2-5	1	-	2
				5-10	1	-	2
FFR-III b K3 (marked)	48°51.01' N 16°35.02' W BENGAL 88#1	12.05.00, 17:15 20.05.00, 05:45	4820	chamber water	-	-	4
				0-2	1	-	3
				2-5	1	-	5
				5-10	1	-	4
FFR-III d K1 (control)	48°50.09' N 16°35.00' W BENGAL 106	23.05.00, 19:28 12.06.00, 15:48	4820	chamberwater	-	2	18
				0-1	1	-	1
				1-2	1	-	1
				2-3	1	-	1
				3-4	1	-	1
				4-5	1	-	1
				5-6	1	-	1
				6-7	1	-	1
				7-8	1	-	1
				8-9	1	-	1
FFR-III d K3 (marked)	48°50.09' N 16°35.00' W BENGAL 106	23.05.00, 19:28 12.06.00, 15:48	4820	chamberwater	-	2	18
				0-1	1	1	1
				1-2	1	-	1
				2-3	1	-	1
				3-4	1	-	1
				4-5	1	-	1
				5-6	1	-	1
				6-7	1	-	1
				7-8	1	-	1
				8-9	1	-	1

* marked = isotopically labelled algae material added onto the sediment
** control = sediment samples without adding algae material

First results of particle flux studies during POS260

The sediment trap samples were examined macroscopically immediately after recovery (Table 17 a-c). Subsequently most of the samples were analysed under a binocular. The samples did not contain significant amounts of sinking particles > 1 mm, except for a few pteropod shells. The composition of every sample was dominated by phytodetritus, which indicated that the sediment traps had collected sinking particles from the beginning of a plankton bloom. Such a spring bloom occurs frequently in the NE-Atlantic (e.g. HONJO and MANGANINI, 1993; NEWTON ET AL., 1994).

Table 17a: Macroscopic sample description for BENGAL-Shallow

BENGAL-Shallow	Shallow-01	Shallow-02	Shallow-03	Shallow-04	Shallow-05	Shallow-06	Shallow-07
Date of sample description	19.06.00	19.06.00	19.06.00	19.06.00	19.06.00	19.06.00	19.06.00
Supernatant volume (%)	99	98	97	96	95	84	28
Supernatant volume (ml)	247	245	243	240	238	210	70
Supernatant colour	clear	clear	clear	clear	clear	clear	clear
Subsample	4 pteropods	-	-	-	-	-	1 pteropod
Particle volume (%)	1	2	3	4	5	16	72
Particle volume (ml)	3	5	7	10	12	40	180
Particle colour	green-brown	green-brown	green-brown	green-brown	green-brown	green-brown	green-brown
Large amorphous aggregates	T	T	T	T	T	T	T
Small amorphous aggreagtes	M	M	M	M	M	M	M
Coarse-grained material	T	T	T	T	T	T	T
Fine-grained material	m	m	m	m	m	m	m
Fecal pellets >1 mm	-	-	-	-	-	-	-
Fecal pellets <1 mm	T	T	T	T	T	T	T
Gastropods	T	-	-	-	-	-	T
Foraminifera	T	T	T	T	T	T	T
Remarks	Samples almost exclusively consist of phytodetritus. Hardly any material >1 mm						

Amount: M = major (50-100%), m = minor (10-50%), T = trace (<10%)

Table 17b: Macroscopic sample description for BENGAL-Deep

BENGAL-Deep	Deep-01	Deep-02	Deep-03	Deep-04	Deep-05	Deep-06	Deep-07
Date of sample description	19.06.00	19.06.00	19.06.00	19.06.00	19.06.00	19.06.00	19.06.00
Supernatant volume (%)	99	98	97	96	96	92	60
Supernatant volume (ml)	247	245	243	240	240	230	150
Supernatant colour	clear	clear	clear	clear	clear	clear	clear
Subsample	1 pteropod	-	1 pteropod	-	-	-	1 pteropod
Particle volume (%)	1	2	3	4	4	8	40
Particle volume (ml)	3	5	7	10	10	20	100
Particle colour	green-brown	green-brown	green-brown	green-brown	green-brown	green-brown	green-brown
Large amorphous aggregates	-	-	T	T	T	T	T
Small amorphous aggreagtes	M	M	M	M	M	M	M
Coarse-grained material	T	T	T	T	T	T	T
Fine-grained material	m	m	m	m	m	m	m
Fecal pellets >1 mm	-	-	-	-	-	-	-
Fecal pellets <1 mm	T	T	T	T	T	T	T
Gastropods	T	-	T	-	-	-	T
Foraminifera	T	T	T	T	T	T	T
Remarks	Samples almost exclusively consist of phytodetritus. Hardly any material >1 mm						

Amount: M = major (50-100%), m = minor (10-50%), T = trace (<10%)

Table 17c: Macroscopic sample description for BENGAL-lander

BENGAL-lander (SP-2)	lander-02	lander-03	lander-04	lander-05	lander-06	lander-07
Date of sample description	19.06.00	19.06.00	19.06.00	19.06.00	19.06.00	19.06.00
Supernatant volume (%)	99	99	98	98	96	81
Supernatant volume (ml)	415	415	413	412	405	340
Supernatant colour	clear	clear	clear	clear	clear	clear
Subsample	2 pteropods		-	-	-	-
Particle volume (%)	1	1	2	2	4	19
Particle volume (ml)	5	5	7	8	15	80
Particle colour	yellow-brown	yellow-brown	yellow-brown	yellow-brown	yellow-brown	yellow-brown
Large amorphous aggregates	-	-	-	-	(T)	T
Small amorphous aggreagtes	m	m	m	m	m	m
Coarse-grained material	-	-	T	-	-	T
Fine-grained material	M	M	M	M	M	M
Fecal pellets >1 mm	-	-	-	-	-	-
Fecal pellets <1 mm	T	T	T	T	T	T
Gastropods	T	-	-	-	-	-
Foraminifera	T	T	T	T	T	T
Remarks	Samples almost exclusively consist of phytodetritus. Hardly any material >1 mm. Samples generally less mucifaginous than BENGAL-Shallow and BENGAL-Deep					

Amount: M = major (50-100%), m = minor (10-50%), T = trace (<10%)

The weights of the dried material from the filters were used to calculate total fluxes of sinking particles (Figure 20). Total fluxes increase significantly from the beginning towards the end of the deployments. Highest fluxes were measured during the last interval (Shallow: 261.8 mg m^{-2} d^{-1}; Deep: 199.6 mg m^{-2} d^{-1}; lander: 259.8 mg m^{-2} d^{-1}). Assuming an average sinking speed of 80 to 100 md^{-1} (ALLDREDGE and SILVER, 1988; ASPER, 1987), the formation of the spring bloom in the year 2000 would have started between late March and early April.

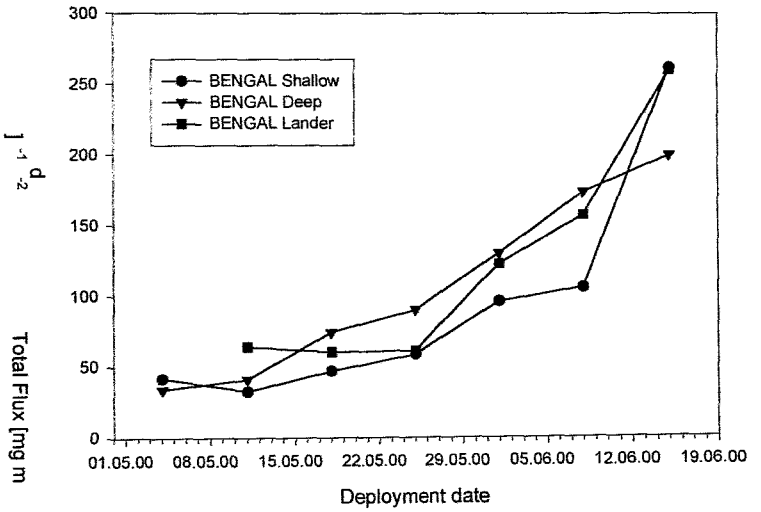

Figure 20: Total fluxes of sinking particles at station BENGAL measured by sediment traps during POS260.

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5.7 Cycling of particulate matter in the bottom-near water column.

B. Springer, R. Turnewitsch, H. Pielenz, B. Christiansen, S. Bühring, N. Plathner, C. Bödeker, S. Ihnken, J. Kleine, J. Lakowski, G. Schroll

Research Programme

The principal aims are to quantify particle-associated transport processes in the near-bottom water column and in the upper layers of the sediment and to investigate how they are coupled. The processes in this zone form an essential 'intermezzo' between processes in the upper water column and processes below the bioturbated zone of the sediment as they are important for diagenetical changes of settling and settled particles before being buried (RUTGERS VAN DER LOEFF and BOUDREAU, 1997).
Profiles of potential temperature, transmission and/or particulate and dissolved ^{234}Th obtained on earlier cruises during the first phase of the BIGSET project indicated a subdivision of the near-bottom water column into a benthic mixed layer (BML) with contact to the bottom and a thickness of 10 – 70 m mixed on a time scale of <100 days and a layer above the BML reaching up to the upper boundary of the BNL (ca. 1000 mab). The latter is slowly mixed and still shows a ^{234}Th/^{238}U disequilibrium up to 1000 mab. The excess ^{234}Th content in the sediment is not able to balance this disequilibrium which points to a ^{234}Th sink. In his PhD thesis R. Turnewitsch calculated residence times of ^{234}Th within the two layers of different mixing intensities (TURNEWITSCH and SPRINGER, subm.). In the BIGSET–II phase we will upgrade the model and try to calculate and couple fluxes of ^{234}Th to fluxes of SPM and carbon. Another goal is to separate primary flux from resuspension flux in the BNL by deploying 3 sediment traps within and above the BML (2, 40 and 569 metres above bottom) in co-operation with subprojects (compare chapter 5.6.).
During previous studies we focussed on the BNL of the abyssal plain at the central stations of the BENGAL and BIOTRANS sites. In recent years there is evidence from other studies (e.g. LUECK and MUDGE, 1997; POLZIN et al., 1997; LEDWELL, 2000) that deep circulation and mixing intensities are linked to underlying bathymetry. In this campaign we also focus upon topographically influenced BNLs and sampled the bottom-near water column and the sediment around and over a small seamount northeast of the BENGAL central station (elevation ca. 900 m above the plain).
On the Porcupine Abyssal Plain, epibenthic megafauna is a major constituent of the benthic boundary layer biocoenosis. It comprises a wide variety of different taxa, but holothurians are the most important faunal group in terms of abundance and biomass. However, the investigations on the epibenthic megafauna of the Porcupine Abyssal Plain so far focussed only on the flat plain of the so-called 'BENGAL trawling area' at a water depth of ca 4800 m, whereas the surrounding hills had not been sampled yet. Our main aim was to find out if the faunal composition and abundance on the abyssal hills is different from that of the plains as found for other seamounts (e.g. de FORGES et al., 2000; HAURY et al., 2000).

Station work

1. Investigations of the Bottom Nepheloid Layer (BNL) at the BENGAL site

The water column of the BNL at the central station was sampled with high spatial and temporal resolution. A typical profile consists of 13 sampling points, normally 0.3, 0.8, 4, 9, 25, 40, 55, 100, 250, 500, 1000, 1500 and 2500 metres above bottom (mab). During leg 2 these profiles were sampled twice and once during leg 4 three weeks later.
5 - 10 liters of water samples from the bottom water sampler (BWS, sampling at 0.3 and 0.8 mab) and from the CTD-rosette (sampling points, see above) were taken for determination of suspended particulate material (SPM) according to the method of Lenz (1971), of particulate organic carbon (POC) and particulate nitrogen (PN) on the same filter (for methods see VERADO et al 1997). 5 - 10 litres were filtered for determination of chlorophyll a and phaeopigments with the HPLC method. For bacterial abundance and volume determination 100 ml-samples of water preserved with buffered formalin were taken. They will be stained with DAPI and analysed with an epifluorescence microscope in co-operation with subproject 3. Subsamples were also taken for the determination of dissolved organic carbon (DOC) that will be analysed in co-operation with subproject 4. Some samples were taken for REM analysis of particles on filters in co-operation with subproject 5.
While sampling near-bottom water with the BWS the programmed particle camera (a camcorder with a close up lens in a pressure housing, described in THOMSEN et al., 1996) mounted on the BWS filmed aggregates (about 30 minutes during bottom time each deployment). The videotapes of the particle camera will also be analysed with an image analysis system for amount, size classes and velocity of aggregates.
For bottom near current measurements, transmission and bottom near CTD data a Falmouth Scientific CTD with acoustic current meter and transmissometer (part of the BWS) was used. The current meter gives information about all three velocity components and also about the tilt of the device. Further information on currents on a longer time scale will be gained from ADCP measurements on the long-term observation lander system.
The sediment traps were deployed for 49 days (the trap on top of the long-term observation lander-trap for 42 days) near the BENGAL central station (for details see chapter 5.6). In addition to SPM, POC, PN and pigments (methods, see above) particulate ^{234}Th was also measured in samples from the trap moorings. The methods for the measurement of dissolved and particulate ^{234}Th are published in detail by RUTGERS VAN DER LOEFF and MOORE (1999) with some modifications (see TURNEWITSCH and SPRINGER, subm.).
All analyses are still in progress. From the CTD data we calculated a BML thickness of 20 – 70 metres.

2. Investigations at a small seamount

During leg 4 investigations focussed on a small seamount ("Mount Ben Billett") which lies northeast of the BENGAL central station and peaks about 900 m above the plains. The dimensions are ~ 10 nautical miles in length and ~ 5 nautical miles in width.
For determination of influence of this single topographic structure on particle characteristics in the BNL we sampled five stations, four located in each orientation on the mid slope of the hill and one station on the summit. Sampling heights were the more or less same than for the central station (0.3, 0.8, 4, 9, 25, 40, 55, 100, 250, 500, 1000, 1500 and 2500 mab) as well as the determined parameters (SPM, POC, DOC, PN, pigments, REM images, dissolved and particulate ^{234}Th, salinity, temperature, transmission and current velocity during bottom time of the BWS). At all seamount-stations sediment samples were taken with a multiple corer for ^{234}Th measurements.
The analyses are still in progress. From the first view of the sediments one can see that the sediments of the seamount are different from the plain – they are coarser with layers of different colours. The shape of the BML (derived from profiles of potential temperature and transmission) seems more complex at all hill stations in comparison to the central abyssal plain station.
In addition one goal of this study was to find out if the faunal composition and abundance on the abyssal hills is different from that of the plains. This was undertaken in collaboration with B. Christiansen and S. Bühring. A Deep-Sea Observation System (DOS) which consists of a frame carrying a Benthos Standard Camera, a flash and an altimeter to monitor bottom distance was employed to take photo-transects along the slopes. The camera has a capacity of 800 frames and was loaded with Kodak Ektachrome 100 film. The DOS was lowered above the top of the hill until 3 mab, then the ship drifted to the north-east with a speed of ca 1 knot. Wire was paid out to keep a bottom distance of ca 3 m when the DOS moved downwards the slope. Due to the swell the actual bottom distance ranged between 0.5 and 6 m.
During the first haul (DOS 10), the camera was equipped with a bottom contact switch which was supposed to trigger the camera at a bottom distance of three metres. Because the switch did not work properly, no frames were obtained from this haul. Two more hauls (DOS 11 and DOS 12) were conducted with automatic triggering of the camera, the interval set to 6 sec. These hauls were successful and delivered a total of 800 frames each.
Additional amphipod traps were deployed both in the plain and on top of the hill. Scavenging amphipods were captured for lipid analysis and to study their vertical distribution in order to gain information of their life strategies and feeding behaviour. They were caught with a free-fall trap system. The traps were fastened to the system at 0 m, 1 m, 8 m and 30 mab and were baited with fish heads and tails. The fish was wrapped in gauze netting to prevent the animals from feeding on the bait. A total of 3 trap system deployments were conducted. Stations 117 and 133 located at the BENGAL central station on the deep-sea plain and station 141 on the summit of a seamount (see station list). The bottom time of each deployment was between 20 and 29 hours. In all 3 deployments amphipods were caught at all depth layers.

The bottom traps of station 117 and 133 contained large amounts of small amphipods, most of them Paralicella tenuipes, Paralicella caperesca and Orchomene spec. Some small individuals and juveniles of Eurythenes gryllus were also abundant in the 0 and 1 mab traps. In the upper traps only Eurythenes gryllus was caught. At the seamount station no specimen of the genus Paralicella was found.
After recovery, the samples were immediately transferred into a refrigerator, until intact specimens were sorted under a stereomicroscope. They were put into glass vials and stored at -80 °C for further analysis in the laboratory.

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6. List of stations

Label	Campaign	Area	Station No.	Date	Time (UTC)	Gear	Latitude	Longitude	Elevation	Wire Length	Remarks
POS260-1_CTD-01	POS-260	BENGAL	63#1	29.04.2000	14:35	CTD	48°49.48'N	16°41.46'W	-4801	3500	
POS260-1_MUC-01	POS-260	BENGAL	63#2	29.04.2000		MUC			-4805		bad weather conditions
POS260-1_SF-01	POS-260	BENGAL	64#1	30.04.2000	05:00	SF	48°49.36'N	16°41.27'W	-4804	2370	
POS260-1_SF-02	POS-260	BENGAL	64#2	30.04.2000	07:45	SF	48°48.63'N	16°39.62'W	-4802	2370	
POS260-1_MUC-02	POS-260	BENGAL	64#3	30.04.2000	10:25	MUC	48°49.86'N	16°41.97'W	-4803	4835	
POS260-1_SF-03	POS-260	BENGAL	65#1	30.04.2000	16:52	SF	48°49.59'N	16°30.11'W	-4802		
POS260-1_MUC-03	POS-260	BENGAL	66#1	01.05.2000	06:21	MUC	48°50.38'N	16°42.15'W	-4803	4842	no bottom contact
POS260-2_FFB-01	POS-260	BENGAL	67#1	06.05.2000	18:18	FFB	48°49.89'N	16°31.80'W	-4808		deployment
POS260-2_FFR-Ia	POS-260	BENGAL	68#1	06.05.2000	19:19	FFR	48°49.93'N	16°34.92'W	-4808		deployment
POS260-2_MUC-04	POS-260	BENGAL	69#1	07.05.2000	05:10	MUC	48°50.08'N	16°37.00'W	-4806	4912	
POS260-2_MUC-05	POS-260	BENGAL	69#2	07.05.2000	09:00	MUC	48°50.08'N	16°37.00'W	-4806	4912	
POS260-2_MUC-06	POS-260	BENGAL	69#3	07.05.2000	12:25	MUC	48°50.08'N	16°37.00'W	-4809	4912	empty
POS260-2_FFR-IIa	POS-260	BENGAL	70#1	07.05.2000	15:22	FFR	48°49.94'N	16°34.49'W	-4810		deployment
POS260-2_CTD-02	POS-260	BENGAL	71#1	07.05.2000	18:56	CTD	48°50.07'N	16°36.05'W	-4810	4829	
POS260-2_MUC-07	POS-260	BENGAL	72#1	08.05.2000	05:06	MUC	48°50.13'N	16°36.96'W	-4810	4875	
POS260-2_MUC-08	POS-260	BENGAL	72#2	08.05.2000	09:29	MUC	48°50.04'N	16°36.76'W	-4810	4876	
POS260-2_BWS-01	POS-260	BENGAL	73#1	08.05.2000	14:34	BWS	48°49.32'N	16°35.08'W	-4805	4921	
POS260-2_FFR-IIIa	POS-260	BENGAL	74#1	08.05.2000	17:06	FFR	48°50.97'N	16°34.96'W	-4805		
POS260-2_APN-01	POS-260	BENGAL	74#2	08.05.2000	18:50	APN	48°49.92'N	16°35.10'W	-4850	50	
POS260-2_mMUC-01	POS-260	BENGAL	75#1	09.05.2000	05:11	mMUC	48°49.97'N	16°36.84'W	-4806	4880	
POS260-2_mMUC-02	POS-260	BENGAL	75#2	09.05.2000	08:19	mMUC	48°50.02'N	16°36.89'W	-4805	4881	
POS260-2_FFR-Ia	POS-260	BENGAL	76#1	09.05.2000	11:40	FFR	48°49.93'N	16°34.92'W	-4805		recovery
POS260-2_CTD-03	POS-260	BENGAL	77#1	09.05.2000	15:05	CTD	48°49.99'N	16°35.98'W	-4804	4866	
POS260-2_mMUC-03	POS-260	BENGAL	78#1	10.05.2000	05:05	mMUC	48°50.17'N	16°36.09'W	-4805	4882	
POS260-2_FFR-IIa	POS-260	BENGAL	79#1	10.05.2000	08:05	FFR	48°49.94'N	16°34.49'W	-4810		recovery
POS260-2_BWS-02	POS-260	BENGAL	80#1	10.05.2000	12:00	BWS	48°49.45'N	16°35.81'W	-4804	4921	
POS260-2_mMUC-test	POS-260	BENGAL	80#2	10.05.2000	14:57	mMUC	48°47.95'N	16°33.88'W	-4804	4700	Test Brenner
POS260-2_FFR-Ib	POS-260	BENGAL	81#1	10.05.2000	19:15	FFR	48°49.89'N	16°34.89'W	-4805		deployment
POS260-2_mMUC-04	POS-260	BENGAL	82#1	11.05.2000	07:15	mMUC	48°50.28'N	16°36.84'W	-4805	4882	
POS260-2_FFR-IIIa	POS-260	BENGAL	83#1	11.05.2000	09:15	FFR	48°50.56'N	16°35.00'W	-4807		recovery
POS260-2_BWS-03	POS-260	BENGAL	83#2	11.05.2000	11:05	BWS	48°50.30'N	16°34.57'W	-4803		
POS260-2_FFR-IIb	POS-260	BENGAL	84#1	11.05.2000	12:52	FFR	48°49.92'N	16°34.64'W	-4803		
POS260-2_CTD-04	POS-260	BENGAL	85	11.05.2000	14:51	CTD	48°49.99'N	16°98.92'W	-4804		
POS260-2_mMUC-05	POS-260	BENGAL	86#1	12.05.2000	05:09	mMUC	48°50.03'N	16°37.24'W			
POS260-2_BWS-04	POS-260	BENGAL	87#1	12.05.2000	10:30	BWS	48°49.22'N	16°36.70'W	-4802	4920	
POS260-2_FFR-IIIb	POS-260	BENGAL	88#1	12.05.2000	13:15	FFR	48°51.01'N	16°35.02'W	-4820		deployment

Label	Campaign	Area	Station No.	Date	Time (UTC)	Gear	Latitude	Longitude	Elevation	Wire Length	Remarks
POS260-3_mMUC-06	POS-260	BENGAL	89#1	18.05.2000	12:52	mMUC	48°50.36'N	16°37.16'W	-4802	4881	
POS260-3_FFR-Ib	POS-260	BENGAL	90#1	18.05.2000	14:25	FFR	48°49.89'N	16°34.89'W	-4820		recovery
POS260-3_mMUC-07	POS-260	BENGAL	91#1	18.05.2000	17:40	mMUC	48°50.30'N	16°37.99'W	-4804	4840	
POS260-3_mMUC-08	POS-260	BENGAL	92#1	19.05.2000	05:06	mMUC	48°49.94'N	16°37.08'W	-4805	4881	
POS260-3_FFR-IIb	POS-260	BENGAL	93#1	19.05.2000	08:30	FFR	48°49.92'N	16°34.64'W	-4820		recovery
POS260-3_OPI-01	POS-260	BENGAL	94#1	19.05.2000	12:27	SISSI	48°50'N	16°36'W	-4820	4930	oder SISSI ? MUC
POS260-3_FFR-Ic	POS-260	BENGAL	95#1	19.05.2000	17:00	FFR	48°50'N	16°35'W	-4820		deployment
POS260-3_mMUC-09	POS-260	BENGAL	96#1	20.05.2000	05:01	mMUC	48°49.92'N	16°37.21'W		4880	
POS260-3_mMUC-10	POS-260	BENGAL	96#2	20.05.2000	08:07	mMUC	48°49.96'N	16°37.02'W	-4802	4880	
POS260-3_FFR-IIc	POS-260	BENGAL	97#1	20.05.2000	11:08	FFR	48°49.90'N	16°34.41'W	-4820		deployment
POS260-3_FFR-IIIb	POS-260	BENGAL	98#1	20.05.2000	13:05	FFR	48°51.01'N	16°35.02'W			recovery
POS260-3_mMUC-11	POS-260	BENGAL	99#1	21.05.2000	07:12	mMUC	48°49.94'N	16°36.96'W	-4804	4880	
POS260-3_mMUC-12	POS-260	BENGAL	99#2	21.05.2000	11:29	mMUC	48°49.98'N	16°36.95'W	-4806	4881	
POS260-3_mMUC-13	POS-260	BENGAL	99#3	21.05.2000	14:27	mMUC	48°49.99'N	16°37.02'W	-4801	4880	
POS260-3_mMUC-14	POS-260	BENGAL	100#1	22.05.2000	05:59	mMUC	48°49.98'N	16°36.99'W		4880	
POS260-3_FFR-Ic	POS-260	BENGAL	101	22.05.2000	09:18	FFR	48°50'N	16°35'W	-4820		recovery
POS260-3_MPI-PRO-01	POS-260	BENGAL	102	22.05.2000	16:20	MPI-PRO	48°51.1'N	16°35.0'W	-4820		deployment
POS260-3_MPI-PRO-01	POS-260	BENGAL	103	23.05.2000	?	MPI-PRO	48°51.1'N	16°35.0'W	-4820		recovery
POS260-3_FFR-IIc	POS-260	BENGAL	104#1	22.05.2000	07:52	FFR	48°49.90'N	16°34.41'W	-4820		recovery
POS260-3_APN-02	POS-260	BENGAL	105#1	23.05.2000	09:45	APN	48°51'N	16°35'W	-4805	50	
POS260-3_FFR-IIId	POS-260	BENGAL	106	23.05.2000	15:28	FFR	48°50.9'N	16°35'W	-4820		deployment
POS260-3_mMUC-15	POS-260	BENGAL	107#1	24.05.2000	05:03	mMUC	48°49.76'N	16°37.34'W		4880	
POS260-3_mMUC-16	POS-260	BENGAL	107#2	24.05.2000	08:11	mMUC	48°49.89'N	16°36.96'W	-4803	4881	
POS260-3_mMUC-17	POS-260	BENGAL	107#3	24.05.2000	11:15	mMUC	48°49.97'N	16°36.90'W	-4802	4880	
POS260-3_MPI-PRO-02	POS-260	BENGAL	108	24.05.2000	16:15	MPI-PRO	48°50.0'N	16°34.5'W			deployment
POS260-3_mMUC-18	POS-260	BENGAL	109#1	25.05.2000	05:00	mMUC	48°30.00'N	16°36.99'W	-4801	4880	
POS260-3_MPI-PRO-02	POS-260	BENGAL	110	25.05.2000	08:00	MPI-PRO	48°50.0'N	16°34.5'W	-4820		recovery
POS260-3_FFR-IId	POS-260	BENGAL	111	25.05.2000	10:48	FFR	48°49.98'N	16°34.5'W	-4850		deployment
POS260-3_FFR-Id	POS-260	BENGAL	112	25.05.2000	11:44	FFR	48°50'N	16°35'W	-4820		deployment
POS260-4_mMUC-19	POS-260	BENGAL	113#1	01.06.2000	15:26	mMUC	48°49.87'N	16°37.90'W	-4801	4880	
POS260-4_mMUC-20	POS-260	BENGAL	113#2	01.06.2000	19:03	mMUC	48°49.67'N	16°37.66'W	-4804	4901	
POS260-4_CTD-05	POS-260	BENGAL	114#1	01.06.2000	21:37	CTD	48°49.58'N	16°35.94'W	-4803	4837	
POS260-4_CTD-06	POS-260	BENGAL	114#2	02.06.2000	01:20	CTD	48°50.06'N	16°35.40'W	-4803	4872	
POS260-4_mMUC-21	POS-260	BENGAL	115#1	02.06.2000	04:50	mMUC	48°50.06'N	16°36.92'W	-4805	4900	
POS260-4_mMUC-22	POS-260	BENGAL	115#2	02.06.2000	07:42	mMUC	48°49.73'N	16°36.46'W	-4802	4900	
POS260-4_CTD-07	POS-260	BENGAL	116	02.06.2000	11:30	CTD	48°49.83'N	16°39.97'W	-4799	5033	
POS260-4_RK-test	POS-260	BENGAL	117#1	02.06.2000	15:10	RK	48°50'N	16°38'W	-4801		Test
POS260-4_RK-01	POS-260	BENGAL	117#2	02.06.2000	15:31	RK	48°50.74'N	16°38.00'W	-4801		deployment
POS260-4_mMUC-23	POS-260	BENGAL	118	02.06.2000	17:38	mMUC	48°49.98'N	16°35.99'W	-4803	4901	
POS260-4_CTD-08	POS-260	BENGAL	119#1	02.06.2000	20:59	CTD	48°49.98'N	16°39.53'W	-4800	4839	
POS260-4_CTD-09	POS-260	BENGAL	119#2	03.06.2000	00:26	CTD	48°49.93'N	16°39.42'W	-4799	4869	
POS260-4_CTD-10	POS-260	BENGAL	119#3	03.06.2000	04:00	CTD	48°49.87'N	16°40.16'W	-4799	4842	
POS260-4_RK-01	POS-260	BENGAL	120	03.06.2000	09:30	RK	48°50.74'N	16°38.00'W	-4801		recovery
POS260-4_mMUC-24	POS-260	BENGAL	121#1	03.06.2000	10:11	mMUC	48°49.77'N	16°40.82'W	-4798	4900	
POS260-4_mMUC-25	POS-260	BENGAL	121#2	03.06.2000	12:59	mMUC	48°49.96'N	16°40.95'W	-4798	4900	
POS260-4_BWS-05	POS-260	BENGAL	122#1	03.06.2000	17:37	BWS	48°50.00'N	16°39.98'W	-4801	4890	
POS260-4_CTD-11	POS-260	BENGAL	122#2	03.06.2000	20:50	CTD	48°49.98'N	16°39.97'W	-4799	4831	

Label	Campaign	Area	Station No.	Date	Time (UTC)	Gear	Latitude	Longitude	Elevation	Wire Length	Remarks
POS260-4_BWS-06	POS-260	BENGAL	123	04.06.2000	03:00	BWS	49°43.64'N	16°33.54'W	-4437	4620	slope-East
POS260-4_mMUC-26	POS-260	BENGAL	124	04.06.2000	06:51	mMUC	49°04.07'N	16°33.51'W	-4560	4640	slope-East
POS260-4_DOS-01	POS-260	BENGAL	125	04.06.2000	12:07	DOS	49°07.01'N	16°37.84'W	-3899		slope-East
POS260-4_CTD-12	POS-260	BENGAL	126#1	04.06.2000	19:00	CTD	49°04.20'N	16°33.68'W	-4479	4600	slope-East
POS260-4_CTD-13	POS-260	BENGAL	126#2	04.06.2000	22.35	CTD	49°04.39'N	16°33.69'W	-4436	4586	slope-East
POS260-4_mMUC-27	POS-260	BENGAL	127	05.06.2000	01:59	mMUC	49°04.06'N	16°33.46'W	-4557	4640	slope-East
POS260-4_RK-02	POS-260	BENGAL	128	05.06.2000	15:23	RK	49°05.00'N	16°31.00'W	-4805		slope-East-plain / deplo
POS260-4_CTD-14	POS-260	BENGAL	129#1	05.06.2000	08:15	CTD	49°04.37'N	16°33.56'W	-4491		slope-East
POS260-4_CTD-15	POS-260	BENGAL	129#2	05.06.2000	11:28	CTD	49°04.42'N	16°33.56'W	-4430	4586	slope-East
POS260-4_BWS-07	POS-260	BENGAL	130	05.06.2000	17:40	BWS	49°07.80'N	16°35.99'W		4576	slope-North
POS260-4_mMUC-28	POS-260	BENGAL	131	05.06.2000	21:42	mMUC	49°07.38'N	16°35.79'W		4600	slope-North
POS260-4_CTD-16	POS-260	BENGAL	132#1	06.06.2000	04:48	CTD	49°07.80'N	16°36.02'W		4555	slope-North
POS260-4_CTD-17	POS-260	BENGAL	132#2	06.06.2000	07:42	CTD	49°07.80'N	16°36.02'W		4546	slope-North
POS260-4_RK-02	POS-260	BENGAL	133	06.06.2000	11:50	RK	49°05.00'N	16°31.00'W	-4807		slope-East/recovery
POS260-4_mMUC-29	POS-260	BENGAL	134	06.06.2000	13:53	mMUC	49°07.38'N	16°35.66'W	-4358	4600	slope-North
POS260-4_CTD-18	POS-260	BENGAL	135#1	06.06.2000	16:52	CTD	49°07.84'N	16°35.99'W	-4339	4585	slope-North
POS260-4_CTD-19	POS-260	BENGAL	135#2	06.06.2000	19:54	CTD	49°08.00'N	16°36.02'W	-4374	4558	
POS260-4_DOS-02	POS-260	BENGAL	136	06.06.2000	23:10	DOS	49°07.19'N	16°38.07'W	-4000		
POS260-4_CTD-20	POS-260	BENGAL	137	07.06.2000	05:39	CTD	49°08.86'N	16°39.83'W		4386	slope-West
POS260-4_OPI-02	POS-260	BENGAL	138#1	07.06.2000	09:34	OPI	49°08.53'N	16°39.63'W	-4333	4440	slope-West
POS260-4_mMUC-30	POS-260	BENGAL	138#2	07.06.2000	12:40	mMUC	49°08.82'N	16°40.94'W		4550	slope-West
POS260-4_CTD-21	POS-260	BENGAL	139#1	07.06.2000	17:15	CTD	49°08.00'N	16°38.48'W		4350	slope-West
POS260-4_CTD-22	POS-260	BENGAL	140	08.06.2000	09:00	CTD	49°09.01'N	16°39.40'W	-4426	4431	slope-West
POS260-4_RK-03	POS-260	BENGAL	141	08.06.2000	11:24	RK	49°05.08'N	16°43.00'W	-4100		summit / deployment
POS260-4_CTD-23	POS-260	BENGAL	142	08.06.2000	13:50	CTD	49°08.83'N	16°39.82'W	-4357	4379	slope-West
POS260-4_mMUC-31	POS-260	BENGAL	143#1	08.06.2000	16:51	nMUC	49°08.59'N	16°40.16'W	-4397	4500	slope-West
POS260-4_mMUC-32	POS-260	BENGAL	143#2	08.06.2000	19:42	nMUC	49°08.64'N	16°40.13'W	-4468	4701	
POS260-4_CTD-24	POS-260	BENGAL	144#1	08.06.2000	22:39	CTD	49°07.00'N	16°37.90'W		3960	summit
POS260-4_CTD-25	POS-260	BENGAL	144#2	09.06.2000	00:25	CTD	49°06.99'N	16°38'02'W	-3955	3909	summit
POS260-4_OPI-03	POS-260	BENGAL	145	09.06.2000	05:04	OPI	49°07.00'N	16°38.51'W	-3999	4100	summit
POS260-4_RK-03	POS-260	BENGAL	146	09.06.2000	09:13	RK	49°05.08'N	16°43.00'W	-4100		summit / recovery
POS260-4_CTD-26	POS-260	BENGAL	147	09.06.2000	11:00	CTD	49°07.06'N	16°37.69'W		3940	summit
POS260-4_mMUC-33	POS-260	BENGAL	148	09.06.2000	14:25	nMUC	49°06.92'N	16°38.33'W	-3850	4050	summit
POS260-4_DOS-03	POS-260	BENGAL	149	09.06.2000	17:14	DOS	49°06.95'N	16°37.01'W		3898	summit
POS260-4_mMUC-34	POS-260	BENGAL	150	09.06.2000	23:09	nMUC	49°07.03'N	16°38.35'W		4100	summit
POS260-4_CTD-27	POS-260	BENGAL	151	10.06.2000	02:00	CTD	49°06.95'N	16°37.95'W		4060	summit
POS260-4_CTD-28	POS-260	BENGAL	152#1	10.06.2000	05:37	CTD	49°05.43'N	16°36.99'W		4783	slope-South
POS260-4_CTD-29	POS-260	BENGAL	152#2	10.06.2000	07:22	CTD	49°05.45'N	16°36.93'W		4783	slope-South
POS260-4_mMUC-35	POS-260	BENGAL	153	10.06.2000	12:00	nMUC	49°05.79'N	16°43.02'W	-4750	4900	slope-South-plain
POS260-5_FFR-Id	POS-260	BENGAL	154	16.06.2000	12:03	FFR	48°50'N	16°35'W	-4850		recovery
POS260-5_FFR-IId	POS-260	BENGAL	155	17.06.2000	07:03	FFR	48°49.98'N	16°34.50'W	-4850		recovery
POS260-4_mMUC-36	POS-260	BENGAL	156	17.06.2000	11:23	nMUC	48°49.35'N	16°36.86'W	-4711	4880	

Label	Campaign	Area	Station No.	Date	Time (UTC)	Gear	Latitude	Longitude	Elevation	Wire Length	Remarks
POS260-5_FFR-1e	POS-260	BENGAL	157	17.06.2000	13:18	FFR	48°49.97'N	16°35.03'W		4850	
POS260-5_mMUC-37	POS-260	BENGAL	158	18.06.2000	08:23	nMUC	48°49.89'N	16°16.96'W	-4838	4881	deployment
POS260-5_FFR-IIId	POS-260	BENGAL	159	18.06.2000	10:17	FFR	48°50.9'N	16°35'W		4850	
POS260-5_MPI-PRO-03	POS-260	BENGAL	160	18.06.2000	14:10	MPI-PRO	48°50.0'N	16°34.5'W	-4820		recovery
POS260-5_SF-03	POS-260	BENGAL	161	19.06.2000	06:00	SF	48°50'N	16°32'W	-4850		deployment
POS260-5_mMUC-38	POS-260	BENGAL	162	19.06.2000	10:33	nMUC	48°50'N	16°37'W	-4838	4881	recovery
POS260-5_FFB	POS-260	BENGAL	163	19.06.2000	12:32		48°49.89'N	16°31.80'W			recovery
POS260-5_MPI-PRO-03	POS-260	BENGAL	164	19.06.2000	14:25	MPI-PRO	48°50'N	16°34'W			recovery
POS260-3_APN-03	POS-260	BENGAL	165#1	20.06.2000		APN	48°50'N	16°35'W	-4806		
POS260-5_FFR-1e	POS-260	BENGAL	165#2	20.06.2000	06:00	FFR	48°49.97'N	16°35.03'W			recovery

Abbreviations:

BWS	Bottom Water Sampler
mMUC	mini Multiple Corer
FFR	Benthic Chamber Lander
FFB	Deep-Sea Observation System
CTD	CTD system with rosette
RK	Reusenkette
APN	Apstein Net
MPI-PRO	Profiler Max-Planck-Institute
SF	Sediment Trap
OPI	Oxygen Profiler