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REPORT AND PRELIMINARY RESULTS OF METEOR-CRUISE M 42/4, Las Palmas - Las Palmas - Viena do Casstelo; 26.09.1998 - 26.10.1998

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1. Research objectives

During RV METEOR cruise M42/4, research was carried out in connection with the following projects:

- CANIGO ("Canary Islands Azores Gibraltar Observations")
- DOMEST ("Data transfer in the ocean and measurement technology for high resolution records of material transport in the deep sea")
- ESTOC ("European Station for Time-Series in the Ocean, Canary Islands")

Due to logistical reasons the cruise M42/4 was subdivided into two parts (M42/4a and M42/4b), one covering the ESTOC monthly sampling program, mooring-work and deep-sea research device testing (Fig. 1) and the other one concentrated on sedimentology work (Fig. 2).

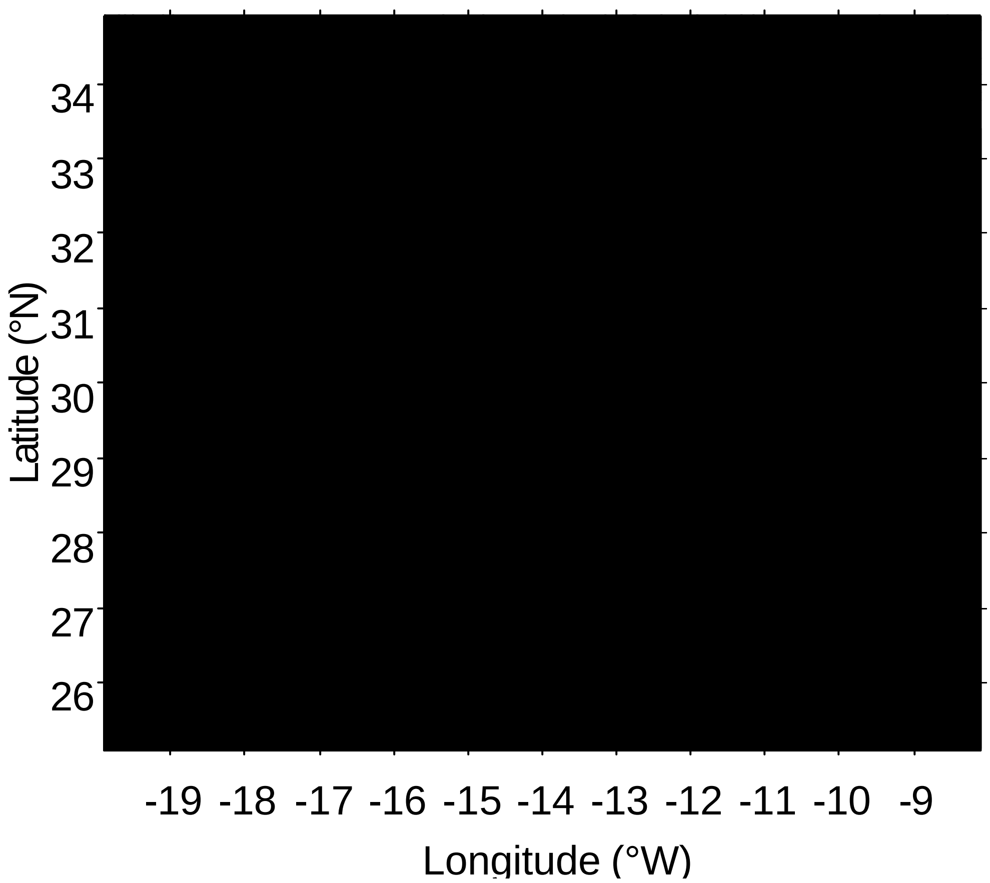

Fig. 1: Main working positions during RV METEOR cruise M42/4a (La Palma (LP) sediment trap mooring, DOMEST subsurface mooring and ESTOC sediment trap mooring)

Most of the research conducted during METEOR-cruise 42/4 was related to the EU-project CANIGO. CANIGO is a multidisciplinary programme within MAST III (Marine Science and Technology), consisting of 4 subprojects. The aim of Subproject 3 within

CANIGO ("Particle Flux and Paleoceanography in the Eastern Boundary Current System") is to quantitatively determine the influence of coastal upwelling and Saharan dust on the magnitude and composition of particle flux in the Canary region, and to investigate how this influence changed through the last glacial and interglacial period. Subproject 3 of CANIGO is organized in two main work packages. The main objective of the first work package "Flux of dissolved and particulate matter in the water column" is to quantify particle flux and to determine its composition on seasonal and interannual time scales along a zonal transect at 29°N to be able to discern autochtonous export production from the eolian input and deep and shallow sources of advected particulate matter. The first part (M42/4a) of the leg M42/4 was concentrated on that topic with mooring work (exchange of two sediment trap/current meter moorings north of La Palma and north of Gran Canaria) and the second part contributed to the work package with water column sampling using multinet and surface water membrane-punping system.

The main objective of the second work package "Flux variability through the last glacial-interglacial cycle" is to study the variability of accumulation rates of environmentally sensitive parameters and atmospheric dust through the last glacial-interglacial cycle across an upwelling margin. This work package will use the data from the water column in an actualistic approach to decifer the particle flux history back 250,000 years. Sedimentological work (surface sediments and cores) in the framework of this work package was done on the second part of M42/4 (M42/4b).

Another goal of this cruise was the testing of deep-sea research device in the framework of the BMBF project DOMEST. Testing includes acoustic data-transmission into the deep ocean, as well as the connection to a satellite communication network. New devices were tested for their functioning on board and in the deep ocean (all during M42/4a). The aim of the project DOMEST is the development of a moored sensor network in the deep sea. The advanced sensors will provide high-resolution data on particle fluxes and element concentrations in the open ocean and can be accessed from land via satellite and acoustic transmission. Communication under water will be performed through a bidirectional acoustic high-speed telemetry. Above water, a low-earth-orbit (leo) satellite network will establish the data transport between the moored system and a land-based ground station. The system will be deployed at 4000 m water depth over a maximum duration of one year. With DOMEST, a remotely controlled measurement of element and particle transport in the deep sea will be possible. Importantly, remote control includes access on a variety of data without recovering sensors from the deep ocean. These possibilities allow an advanced sampling and probing of parameters depending on various environmental parameters, such as satellite derived ocean color or particle input during dust storms. Such an "interactive" measurement of relevant parameters will enhance the understanding of transport processes from the surface to the deep ocean and allow a more detailed reconstruction of paleoclimatic changes.

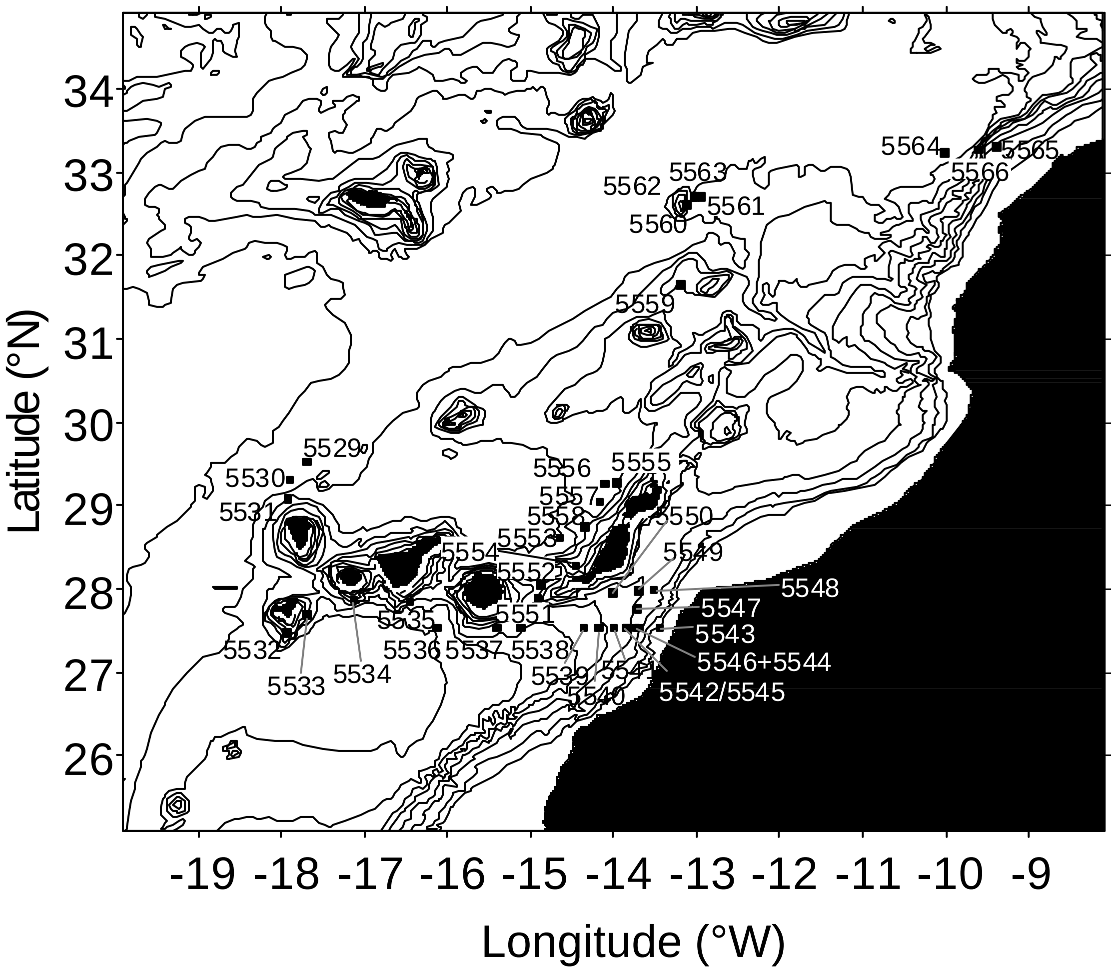

Fig.2: Station map M42/4b with positions of sediment cores and multinet hauls in the Canary Islands region and the Agadir Canyon region. The GeoB station numbers are indicated.

The third project ESTOC was one of the main foci of Leg M42/4a. This European, Spanish-German time-series station is located 100 km north of Gran Canaria and sampling is carried out monthly. During M42/4a the sampling for months September 1998 and October 1998 were covered. The main purpose of ESTOC is to build a long-term oceanographic data base so that seasonal and long-term variability of hydrographic and biogeochemical parameters may be discerned. ESTOC is also used as an important reference station for CANIGO.

2. Participants

For logistic reasons, the leg M 42/4 was divided in two parts with the following participants and institutions (Tabs.1, 2):

Part 42/4a: Las Palmas-Las Palmas, 26.09.1998 - 06.10.1998
Part 42/4b: Las Palams-Viena do Castelo, 08.10.1998 - 26.10.1998

Tab. 1: Participants of METEOR cruise no. 42/4

Leg M 42/4a

Name	Subject	Institution
Wefer, Gerold, Prof. Dr. (Chief Scientist)	DOMEST/CANIGO	GeoB
Bassek, Dieter , Technician	Meteorology	DWD
Buhlmann, Klaus, Dr.	Meteorology	DWD
Deeken, Aloys, Technician	Marine Chemistry/CANIGO	UBMCh
Drünert, Frank, Dipl.-Ing.	Satellite comunication	OHB
Goday, Juana,. M.Sc.	Marine Chemisty/ESTOC	ICCM
Gonzàlez-Davila, Melchor, Dr.	Marine Chemistry/ESTOC	ULPGC
Günther, Lutz, Dipl.-Ing.	Satellite comunication	OHB
Hayn, Christina, Technician	Particle Flux (ESTOC/CANIGO)	GeoB
Irmisch, Andreas, Dr.	DOMEST	BEO
Kotte, Norbert, Dipl.-Ing.	Marine Geology/DOMEST	GeoB
Koy, Uwe, Technician	Oceanography/ESTOC	IFMK
Kretschmar, Frank, Dr.	Satellite comunication	OHB
Langer, Jens, Student	Particle Flux (ESTOC/CANIGO)	GeoB
Makaoui, Ahmed, Dipl.-Chem.	Observer Morocco	
Maroto, Lleire, M.Sc.	Marine Chemistry/ESTOC	ICCM
Meinecke, Gerrit, Dr.	Marine Geology/DOMEST	GeoB
Metzler, Wolfgang, Dipl. Ing.	Marine Geology/DOMEST	GeoB
Neuer, Susanne, Dr.	Particle Flux (ESTOC/CANIGO)	GeoB
Nowald, Nicolas, Student	Marine Geology/DOMEST	GeoB
Ratmeyer, Volker, Dr.	Marine Geology/DOMEST	GeoB
Rosiak, Uwe, Technician	Marine Geology/DOMEST	GeoB
Schroeter, Marcel, Dipl.-Biol.	Particle Flux (ESTOC/CANIGO)	ICCM/GeoB
Segl, Monika, Dr.	Particle Flux (ESTOC/CANIGO)	GeoB

von Oppen, Caroline, Dipl.-Chem.	Marine Chemistry/CANIGO	UBMCh
Waldmann, Christoph , Dr.	Marine Geology/DOMEST	GeoB

Leg M 42/4b

Name	Subject	Institution
Segl, Monika, Dr. (Chief Scientist)	Marine Geology	GeoB
Bassek, Dieter , Technician	Meteorology	DWD
Buhlmann, Klaus, Dr.	Meteorology	DWD
Dehning, Klaus, Technician	Marine Geology	GeoB
Diekamp, Volker, Technician	Marine Geology	GeoB
Eberwein, Astrid, Student	Marine Geology	GeoB
Franke, Phillip, Student	Marine Geology	GeoB
Freudenthal, Tim, Dipl.-Geol.	Marine Geology	GeoB
Geisen, Markus, Dipl.-Geol.	Micropaleontology	ETHZ
Hayn, Christina, Technician	Marine Geology	GeoB
Henderiks, Jorijntje, M.Sc.	Micropaleontology	ETHZ
Jeronimo, David, Student	Micropaleontology	IGM
Makaoui, Ahmed, Dipl.-Chem.	Observer Morocco	
Meggers, Helge, Dr.	Marine Geology	GeoB
Moreno, Ana, M.Sc.	Sedimentology	UB
Nave, Silvia, M.Sc.	Micropaleontology	IGM
Sprengel, Claudia, Dipl.-Geol.	Sedimentology	GeoB
Targarona, Jordi, Dr.	Sedimentology	UB
Thiele, Julia, Student	Marine Geology	GeoB
Thierstein, Hans, Prof. Dr.	Micropalaeontology	ETHZ

Tab. 2: Participating Institutions

BEO	Projektträger Biologie, Energie, Umwelt des BMBF Außenstelle Rostock/Warnemünde Seestr. 15 D-18119 Rostock Germany
DWD	Deutscher Wetterdienst Geschäftsfeld Seeschiffahrt Bernhard-Nocht-Straße 76 D-20359 Hamburg Germany
ETHZ	Geologisches Institut ETH Zentrum Sonneggstr. 5 CH-8092 Zürich Switzerland
GeoB	Fachbereich 5 - Geowissenschaften Universität Bremen Klagenfurterstr. D-28359 Bremen Germany
IGM	Instituto Geológico e Mineiro Rua das Academia das Ciências 19-2° POR-1200 Lisbon Portugal
IFMK	Institut für Meereskunde Universität Kiel Düsternbrooker Weg 20 D-24105 Kiel Germany
ICCM	Instituto Canario de Ciencias Marinas Dirección General de Universidades e Investigación Consejeria de Educacion E-35200 Telde Canary Islands, Spain

OHB	Raumfahrt + Umwelttechnik OHB-System-GmbH Universitätsallee 27-29 D-28359 Bremen Germany
UB	Universidad de Barcelona Instituto de Ciencias del Mar CSIC Paseo Joan de Borbo s/n E-08039 Barcelona Spain
UBMCh	Fachbereich 2 - Biologie/Chemie Meereschemie Universität Bremen Leobener Straße D-28359 Bremen Germany
ULPGC	Universidad de Las Palmas de G. Canaria Edificio de Ciencias Básicas Campus Universitario Tafira E-35017 Las Palmas de Gran Canaria Canary-Islands, Spain

3. Research program

During METEOR cruise M42/4, work was carried out for the EU programme CANIGO, the German project DOMEST and the Spanish-German time-series programme ESTOC. The main purpose of the cruise was the investigation of biogeochemical processes and fluxes on different spatial and temporal scales in relation to water mass circulation. Due to its unique location, the Canary Islands region occupies a key position with respect to the biogeochemical cycles in the region and is a prime location to study environmental parameters sensitive to climate change.

In CANIGO, researchers from 51 European institutions study the regional hydrography and water mass structure in the northern Canary Islands, Azores and Gibraltar regions, as well as particle flux and paleoceanography north of the Canary Islands and along the Moroccan shelf. The purpose is to obtain an integrated view of oceanographic processes in this region both in the present and of the past.

Within the two workpackages of CANIGO the following was done:

1. Studying the particle flux by recovering and deploying two sediment trap moorings (ESTOC and LP ("La Palma-mooring")) on a zonal transect from the shelf to the

outer oligotrophic region of the Canary archipelago. The particulate material collected will be analysed to determine total flux, particulate flux, particulate organic carbon, particulate nitrogen, biogenic opal, carbonate and carbon isotopes of organic matter, and lithogenic material. The trapped material will further be investigated for species composition of the planktonic organisms (pteropods, foraminifera, radiolaria, coccolithophorids, and diatoms), together with the chemical and isotopic compositions of these organisms and the composition of the organic and terrigenous material.

2. Determining the standing stock of planktic foraminifera in the water column. The abundance and composition of planktic foraminifera will be determined on samples taken from the water by multiple opening-closing net hauls from 5 depths intervals.

3. Sampling the surface waters to determine the chlorophyll content, the content and the species composition of the coccolithophorides and the alkenones.

4. Studying the amplitudes and rates of longterm environmental variability exemplified by the flux variability of environmental tracers and atmospheric dust through the last glacial-interglacial cycle along a transect from the high-productivity coastal zone to the oligotrophic central gyre region by taking sediment cores. Helpful tools in taking sediment cores are the PARASOUND echosounder and the swath bathymetry system HYDROSWEEP. Both acoustic board systems are used on site as a proven tool to find suitable locations of sampling sites. Suitable locations are sampled with conventional wireline coring techniques (multicorer and/or boxcorer, gravity corer and/or piston corer).

The aim of DOMEST, a R&D project between the University of Bremen and the Communication and Technology Company OHB Teledata, Bremen is the development of a moored sensor network in the deep sea. The advanced sensors (autonomous Digital Camera System, Multi Pump System, enhanced Sediment Trap, etc.) will provide high-resolution data on particle fluxes and element concentrations in the open ocean. All sensors can be accessed from land via bi-directional satellite and acoustic transmission. Communication underwater will be performed through a bi-directional acoustic high-speed telemetry. Above water, a low-earth-orbit satellite network based on ORBComm and SAFIR satellites will establish the data transport between the moored system and a land based ground station. The system will be deployed at 3600 m water depth over a maximum duration of one year. With DOMEST, remotely controlled measurements of element and particle transport in the deep sea will be possible.

Within the framework of the deep-sea device testing programme DOMEST the following work was carried out:

1. Deployment of the SBU mooring with top buoy, controlling of the anchor-weight position of SBU.

2. Test of satellite telemetry via OrbComm / SAFIR -satellite. Controlling of the GPS-data. Programming and interface tests between the UW and satellite communication. Test of UW communication via the top buoy as a master unit.

3. Recording of the acoustic characteristic of RV METEOR to assess the ship-noise influence on the UW-communication. Test of UW-communication on shipswire down to 3500 m water-depth.

4. Deployment of MSU with UW-Plattform (SSP, 200 - 500 m water-depth with the Multi Sensor Device (3000 m water depth) and Dummy-unit for the Deep Ocean Bottom Station (DOBS, 3500 m water depth). Controlling of the anchor-weight position of MSU and position in the water column via SSP.

5. Acoustic tests of UW-communication from ship (possible from rubber dinghy). Tests with 10 stations in a distance from 0 to 3 nm from the MSU position. Communication with acoustic modems in SSP, MSD, DOBS and SBU.

6. Test of the total communication including the satellite.

ESTOC (located 60 nm north of Las Palmas at 29°10 N, 15°30 W) was initiated in 1994 as a joint Spanish -German initiative which is funded in Germany by the ministry for research and development (BMBF). The station is sampled monthly, supplemented by current meter and sediment trap moorings at the site. As often as possible, the monthly sampling stations are covered by German vessels in conjunction with regional cruises that aim at the validation of time-series observations for the larger region.

1. The sampling included nutrients, oxygen, gelbstoff, chlorophyll, aluminium and components of the CO_2-system, as well as pCO_2 measurements on the way.

2. Rate measurements were carried out with respect to primary production (dilution and oxygen incubations) and short-term particle flux using different free-floating particle trap arrays.

3. The particle trap mooring CI close to ESTOC was exchanged.

4. Narrative of the Cruise

4.1 Leg M 42/4a (G. Wefer)

During the first part of the cruise, the primary focus was on mooring work and measurements in the water column, as well as tests of wireless acoustic data transfer into the deep sea and its link to a satellite-supported communication network.

The METEOR left the harbor of Las Palmas on schedule Saturday, 26 September 1998 at 6:00 p.m. The cruise to the ESTOC station about 60 sea miles north of Gran Canaria provided a chance for XBT deployment and one CTD test station (Fig. 1). The station work was begun at midnight with two CTD rosette units. In the morning of 27 September course was set for the sediment-trap mooring station north of La Palma, and it was reached that evening (Fig. 1). With the approaching night, tests of the acoustic modems were carried out, and a CTD rosette and multinet were deployed. On the morning of 28 September, the current meter and sediment-trap mooring was retrieved. All the instruments were brought on board in good condition. In the afternoon, another mooring of similar construction was deployed at the same position.

On 28 September 1998 the METEOR departed the mooring position north of La Palma to begin working at the ESTOC station, and deployed two floating sediment traps. In addition, at this same station on 28-29 September, CTD/rosette casts were carried out, pumps were deployed at various water depths, and tests were conducted with the acoustic modems and with the deep-sea profiler. The ESTOC mooring, equipped with three sediment traps, two pumps, and a camera system, was successfully retrieved on the afternoon of 1 October. At this station, the CTD/rosette and pumps were also deployed, and the deep-sea profiler was tested. Maintenance work was performed on the mooring during the night, and in the morning of 2 October it was redeployed. CTD casts were run near the floating traps, as well as pumps at various depths. These were also accompanied by further tests of the acoustic modems.

On Saturday, 3 October 1998, the DOMEST surface mooring, with a length of about 4 km, was deployed approximately 20 sea miles west of the ESTOC position in a water depth of about 3600 m (Fig. 1). This position was chosen because it lies outside the normal lanes of ship traffic between Gran Canaria and Tenerife. Twenty glass spheres were used as floats initially, then later replaced by the three-meter wide surface buoy. A three-km long underwater series was deployed about 0.6 miles away from the buoy of the surface mooring on 4 October. During the night of 4 October, after several tests of the moored acoustic modem, the METEOR returned to the ESTOC station to run a shallow CTD and to deploy pumps.

In the morning of 5 October 1998, the subsurface mooring was retrieved again and in the afternoon a short weighted mooring was deployed. Because of a hardware error in the buoy discovered during communication tests between the buoy and satellite, the buoy had to be held alongside for two hours while the defective part was exchanged. The METEOR had to be held precisely on position during this time to prevent tension on the mooring line. Subsequent data transfer testing indicated that the problem had been repaired, and that a bi-directional communication link between Bremen and the deep-sea mooring was operational. Final testing was carried out near the buoy mooring and the particle camera was sent to a depth of 3500 m. On the morning of 6 October the METEOR arrived again at the ESTOC station to run a deep CTD and to retrieve the two floating traps.

On 6 October 1998 at 6:00 p.m. the METEOR docked at Las Palmas, ending leg M42/4a.

4.2 Leg M42/4b (M. Segl)

The second part of the cruise was concentrated on geological work and sampling of the water column in the framework of the EU-project CANIGO (Fig. 2).

METEOR departed Las Palmas on Thursday, 8 October, 1996 at 10:00 a.m., beginning the second part of leg 42/4. On board were 9 colleagues from the Geoscience Department of Bremen University, 3 from the Eidgenössische Technische Hochschule in Zürich, 2 from Instituto Geologico e Mineiro in Lisbon, 2 from Instituto de Ciencias del Mar in Barcelona, and 2 from the Sea Weather Office in Hamburg. On the way to the first working area north of La Palma, PARASOUND and HYDROSWEEP systems were switched on and were used on a 24 hours schedule a day during the entire cruise to record continous high resolution bathymetric and sediment echosounding profiles as a tool to find suitable positions for sediment sampling.

The first profile north of La Palma as the oligotrophic reference-profile was reached about 1.5 days later. After surveys with PARASOUND and HYDROSWEEP, sediments were sampled at 3 stations with multicorer, boxcorer and gravity corer in water depths between 3200 and 4200 m.

After finishing the scientific program on that profile on 10 October, METEOR steamed west of the Canary Islands southwards to continue on a 27°N-transect with 15 stations from the oligotrophic area at Hierro to the eutrophic domain off Cape Jubi. This profile was sampled with multicorer/boxcorer and gravity corer as well as with the multinet/CTD. In addition, at three stations nearby the Moroccan coast a piston corer was used. The objective of sampling the transect perpendicular to the coast was to obtain sediment material to reconstruct the history of coastal upwelling and Saharan dust supply during the last glacial/interglacial cycles and to reconstruct the interaction and the influence of filaments and island-generated features (anticyclonic and cyclonic eddies) on the particle flux. Initial results indicate that the 2 to 13 m long cores in water depths between 1000 and 3500 m were collected with little disturbance of the recovered material. Core desciptions and initial stratigraphic analyses showed continous sedimentation in most cores with a lot of vulcanic material in the western part of the profile and increasing sedimentation rates towards the coast from values between 1 and 2 cm/1000 years to more 10 cm/1000 years nearby the Moroccan coast.

After 5 days the sampling program on the 27°N transect was completed on 15 October and a smaller E-W profile with 4 stations south of Fuerteventura was sampled to complete the work which was done the during METEOR Leg M37/1.

In the evening of October 16, 1998 we started another profile west of Fuerteventura/Lanzarote (8 stations in water depths from 1500 to 3500 m) to obtain sediment material and water samples from a mesotrophic area to compare the results to these which were achieved east of the islands in the upwelling position. On that profile the station GeoB 5555-5 was sampled and celebrated.

After finishing these profile the DOMEST mooring which was deployed on the first part of M42/4 was sighted at noon of 19 October to check if the top buoy had not been affected by the bad weather condition experienced on the first week of Leg M42/4b.

The next geological profile was sampled in the area of two seamounts south and north of the Agadir canyon. On 5 stations in water depths ranging from 2900 to 4000 m sediments were recovered with multicorer/boxcorer and gravity corer.

In the evening of 21 October, METEOR took course northeast to the last profile of this cruise at 33°N/10°W nearby the Moroccan coast and sediments were sampled along a transect with 3 stations (800 to 4000 m water depth). In addition, planktic foraminifera were sampled using three times a multiple closing net from different water depths on that profile. This profile was finished in the early morning of 23 October.

During the whole cruise surface waters were sampled on the way at various stations using the shipboard membrane pumping system for chlorophyll and calcareous nannoplankton.

After completion of the work, METEOR continued to Viena do Castelo, Portugal, arriving on 25 October, ending the fourth leg of cruise 42.

5. Preliminary Results

5.1 Oceanography and Particle flux in the ESTOC region and La Palma during M42/4a

5.1.1 Hydrography and collection of water samples

(S. Neuer, U. Koy, M. Segl)

Temperature (T) and salinity (S) during M42/4a were determined using a Neil Brown CTD (NB4, IfM Kiel) which operated together with a General Oceanics rosette with 21x10 l Niskin bottles. In addition, a SeaBird CTD (SBE 19, GeoB) was deployed, during stations 594 (ESTOC) and 583 simultaneously with the NB4 CTD. In addition, 6 XBT (Expandable Bathythermograph) each were thrown on the way from Las Palmas to ESTOC and on the way back from ESTOC to Las Palmas to monitor temperature profiles along the way (see list of stations for details). This is part of the monthly sampling routine of the ESTOC programme.

The salinity and temperature profiles at ESTOC (Fig. 3) show a mixed layer depth of about 40 m and a fluorescence maximum at about 120 m depth at the basis of the seasonal thermocline. Oxygen peaks just above the fluorescence maximum. A weak salinity maximum at around 1000-1200 m depth is due to Mediterranean outflow water (MOW) which is also shown in the TS diagram (Fig. 4). In the TS the almost linear TS relationship of the North Atlantic deep water (NADW) below 1200 m depth can be recognized. The North Atlantic central water (NACW, between ca 100 and 700 m depth) has a linear portion that is absent in the surface probably due to mixing processes.

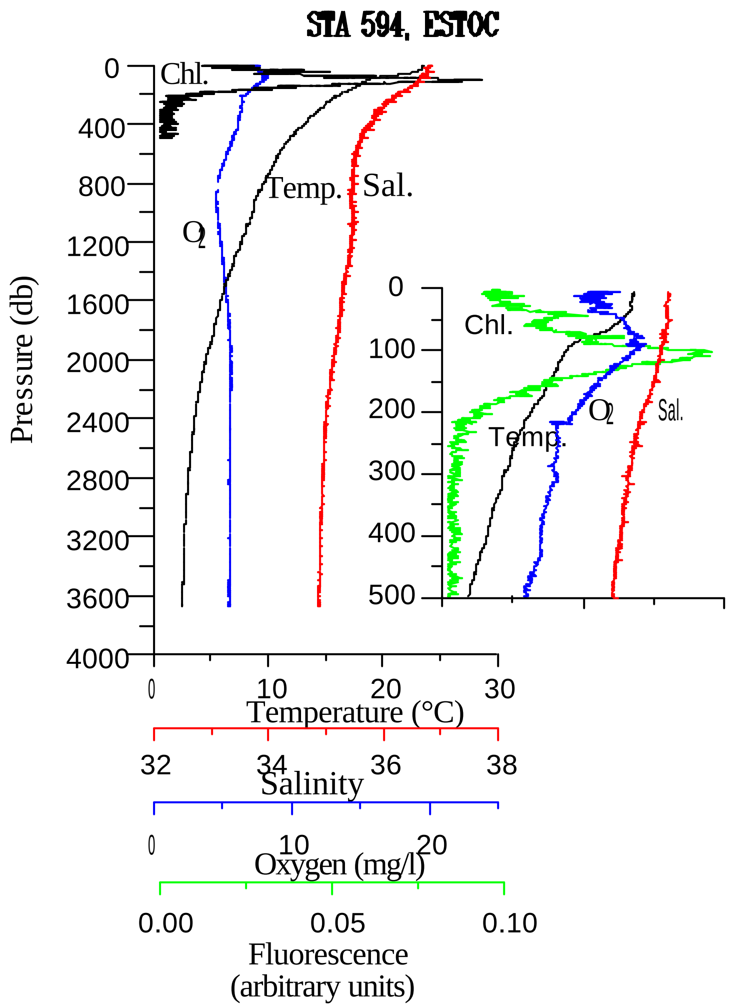

Fig. 3: Salinity, temperature, oxygen and fluorescence profiles at Station 594 (ESTOC). Insert shows profile to 500 m depth. Data taken from SBE 19

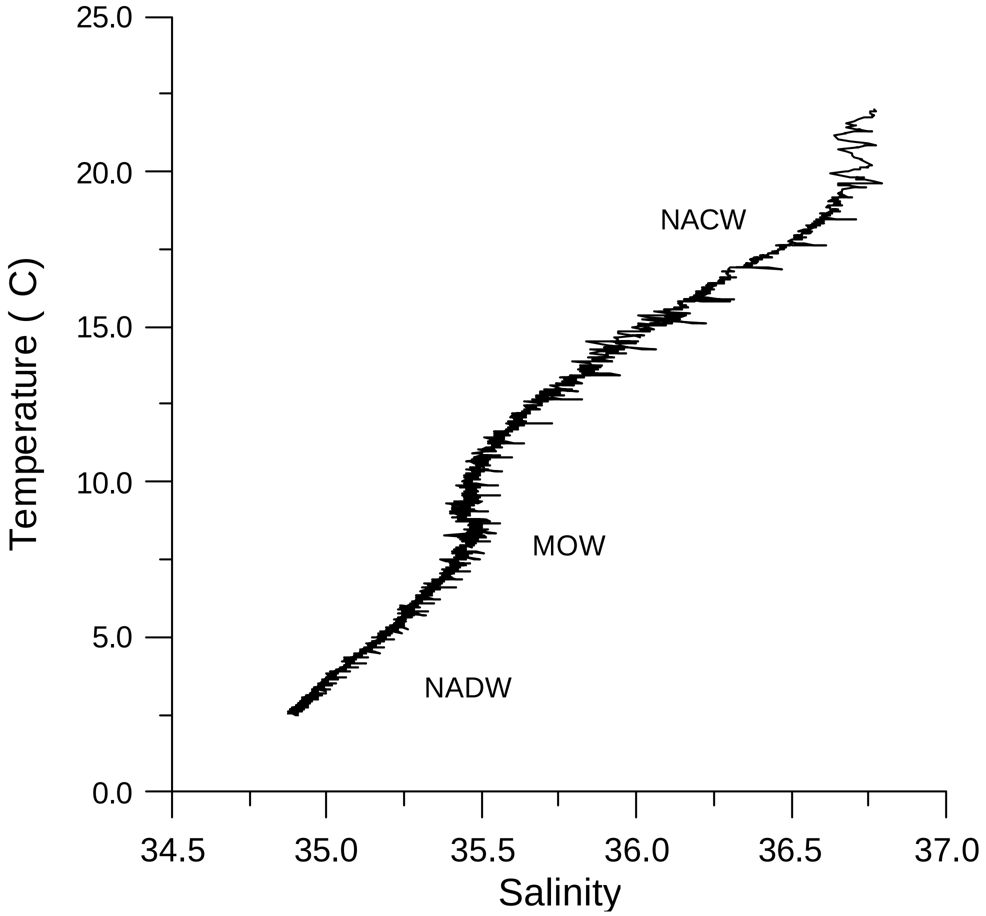

Fig. 4: TS diagramm for STA 594. Data taken from SBE 19. For abbreviations see text

5.1.2. Nutrients, oxygen, gelbstoff, salinity and dissolved aluminum

(J. Godoy, L. Maroto)

Samples for nutrients (nitrite, nitrate, phosphate, silicate) were collected in prewashed plastic bottles and frozen immediately until analysis onshore with a Skalar Scan Plus continuous flow autoanalyser. Samples for oxygen were taken in 125 ml glas bottles, fixed and titrated after precipitation (at least 6 hours after sampling) using a Metrohm 682 titroprocessor with dosimat 662 oxygen auto-titrator analyser. All analyses followed the WOCE operations manual, WHP Office Report No. 68/91. Salinity and gelbstoff, an indicator of dissolved organic matter, were sampled in dark bottles and kept refrigerated until analysis at the ICCM laboratory with a spectrofluorometer Shimadzu RF-5301PC at an excitation wavelenght of 341 nm. Salinity will be analysed using a Autosal salinometer 8400 A.

Samples for aluminum were taken at ESTOC only and manipulated while wearing plastic gloves to avoid metal contamination. Water was stored at 250 ml polyethylene bottles and immediately frozen until analysis at the land-based laboratory. Every container had been cleaned previously using conventional procedures in trace metal assays. The HPACSV (High Performance Adsorptive Cathodic Stripping Voltammetry) method will be used to measure dissolved aluminum in sea-water (J. Hernández-Brito, ULPGC).

5.1.3 Suspended particulate matter

(C. von Oppen, A. Deeken)

Particle-water interaction is supposed to play a key role in controlling trace element concentrations in the water column. We can distinguish between a particulate fraction of fast sinking particles being responsible for the transport of trace metals to the sediment, and the bulk of small particles providing a large surface area and being suspended in the water column. However, little is known by now about the nature of adsorption/ desorption processes of trace elements, but it is supposed that mainly the suspended matter is involved. Profiles of high vertical, spatial and temporal resolution for trace metals associated with suspended particles are necessary to improve our understanding of the processes involved.

During cruise M42/4a we attempted to

- complete our dataset of suspended matter for the ESTOC-station
- recover two multipump systems from mooring CI 9
- deploy two new multipump systems with mooring CI 10
- do performance checks on our *in situ* pumps
- making tests regarding quality control of our data

For the ESTOC station we collected suspended particulate material over the entire water column with main emphasis on the surface and Mediterranean water layer. With this new profile we could also improve the seasonal resolution of our dataset. Samples for quality control were taken, and will be analysed and evaluated in our home lab.

Recovering our two multipump systems in CI 9 revealed that only the upper pump at 3300 m water depth equipped with polycarbonate membranes (47 mm, ∅ 0,4 µm), micro quartz fibre filters and an *in-situ* preconcentration system had worked properly over the period from April 98 to October 98. Unfortunately, the second multipump system deployed at 3550 m failed due to a technical problem of the pump.

The deployment of two new multipump systems in the following mooring CI 10 was successful. Deployment depth and type of the multipump systems was chosen to be the same as in the preceding mooring.

5.1.4 Plankton biomass

(S. Neuer, J. Godoy, C. Hayn)

The phytoplankton community was quantified in the upper 200 m at the monthly ESTOC sampling at ESTOC, at La Palma and at the beginning and end of the trap deployments. Samples were taken for chlorophyll (2x200 ml), taxonomically characteristic pigments (analysed with High Pressure Liquid Chromatography, HPLC, 2 l) and POC (Particulate Organic Carbon, 2 l). All of the water samples were filtered on GF/F filters. While chlorophyll a was analysed onboard ship as an acetone extract using a Turner AU 10 fluorometer, POC and HPLC samples were kept frozen until analysis onshore.

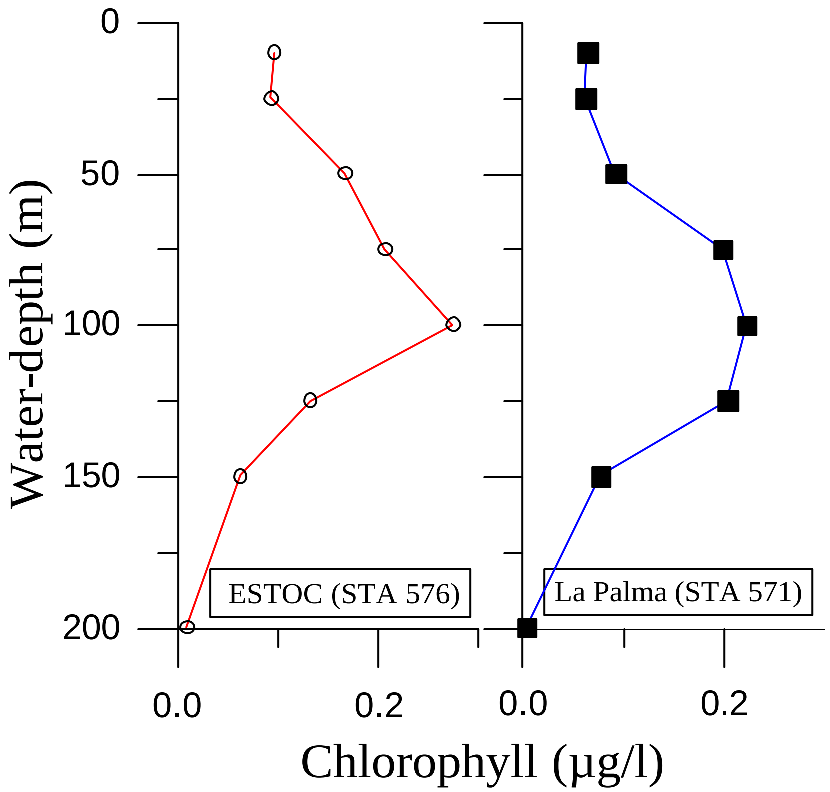

Fig. 5: Chlorophyll profiles at ESTOC and La Palma

In addition, samples for stable nitrogen isotopes were taken (5 l) to be analysed by T. Freudenthal, GeoB. Stable nitrogen isotopes allow valuable insights into the production and degradation history of organic particles. Low values of the stable nitrogen isotope ratio[1] and high concentrations of organic nitrogen and carbon are the expected of material generated in

[1] measured as $d^{15}N = \frac{(^{15}N/^{14}N)_{sample} - (^{15}N/^{14}N)_{air}}{(^{15}N/^{14}N)_{air}} \times 1000$ [‰]

an upwelling system. Higher $\delta^{15}N$ values, on the other hand, are typical of organic matter produced in oligotrophic systems. In addition, degradation of organic matter causes an enrichment of ^{15}N.

Chlorophyll profiles taken during the cruise at ESTOC show the development of a deep chlorophyll maximum in 100 m depth (Fig. 5). In comparison, the chlorophyll concentration at La Palma (Station 571) was slightly lower in the surface but the chlorophyll maximum was located also in 100 m depth albeit extending over a larger depth interval as at ESTOC. This may b e due to a deeper euphotic zone at this more oligotrophic station

5.1.5 Phytoplankton production rates

(S. Neuer, J. Godoy, M. Schroeter, C. Hayn)

Phytoplankton primary production was determined by dilution experiments and by the change of oxygen during incubation. Also, total and new production rates were determined by incubation experiments with added $^{15}NO_3$, $^{15}NH_4$ and $H^{13}CO_3$.

Dilution experiments were incubated for 24 h with water from 25, 50 m and 75 m in an on-deck incubator during 24 h, always starting at dawn or at night. Light-levels at depths were simulated with neutral density screens, and the incubator was cooled with flowing surface sea-water. Different dilutions of natural sea-water were incubated in 1 l poly-carbonate bottles. Phytoplankton growth and microzooplankton grazing rates can be determined from the change of chlorophyll in the different dilutions by linear regression of the apparent growth rate in each dilution on dilution factor.

O_2 - incubations were carried out under the same conditions, with the change of oxygen (for methods see 5.1.2.) determined in light and dark bottles of 250 ml volume. Incubation in the on-deck incubator lasted either 12 h (between dawn and dusk) or 24 h over a diel cycle. The change of oxygen in the dark bottles is due to respiration by the whole plankton community. The change in the light bottles reflects the production of oxygen by photosynthesis minus the loss due to respiration, and represents the net photosynthetic rate of the phytoplankton community. Gross photosynthesis can be determined by adding the loss of oxygen (calculated as hourly rate) due to respiration as determined from the dark bottles.

For the ^{15}N-experiments, discrete water samples were collected before dawn from nine optical depths (116, 93, 83, 53, 39, 21 and 8m), corresponding to 0.1, 0.5, 1, 6, 13, 34, 52, 66 and 100% of surface irradiance, respectively, to achieve a high resolution of the euphotic zone. Samples were incubated in bottles covered with neutral density filters of the corresponding light intensity on board (*simulated in-situ* incubation). Stable isotopes ($^{15}NO_3$, $^{15}NH_4$ and $H^{13}CO_3$) were added in trace concentrations in order to maintain the natural nutrient abundance. After about 12h, the experiments were stopped by filtering the samples onto precombusted GF/F filters. The incorporated isotopes and the particulare nitrogen and carbon contents (PON and POC) will be determined by mass spectrometry and elemental analyses in the laboratory. To normalize the primary production rates to biomass, samples for chlorophyll a and other phytoplankton pigments were taken for fluorometric and liquid chromatograhic analyses.

5.1.6 Carbon dioxide in sea-water

(M. González-Dávila)

In response to increased interest in global climate change and greenhouse warming, measurements of the marine carbon system (i.e. total CO_2, TCO_2, titration total alkalinity TA, pH and pCO_2) have been included in several global research programs such as the World Ocean Circulation Experiments (WOCE) and the Joint Global Ocean Flux Study (JGOFS). These programs include time series stations primarily designed to examine temporal variability and the mechanism controlling this variability. The Canary Islands Time series (ESTOC) is visited each month and the surrounding area approximately twice a year. Time series station data provide excellent opportunities to study the temporal variability of the carbon system at a single location over several years, while cruises around the ESTOC station will provide information about spatial variability of the carbon species in the area.

The main objective on this cruise was to study the spatio-temporal variability of the parameters which define the carbonate system in the water column. The parameters to be determined are pH and total alkalinity. Underway continuous pCO_2 were carried out in the ESTOC location and vicinity, together with air pCO_2 value (each hour). In addition, water samples for pH and titration alkalinity collected from surface to bottom were analysed on board within four hour of collection with a two-thermostatized (25ºC ± 0.1) 200 ml titration cells with ROSS glass pH electrode and Orion double junction Ag, AgCl reference electrodes. The reliability of the titration systems was tested by determining the TA of Certified Reference Material for Oceanic CO_2 measurements (batch 35) provided by Dr. Dickson, Scripps Institution of Oceanography, San Diego. The results of these measurements indicate that high-precision measurements of TA (±1.2 µmol kg^{-1}) can be obtained. Photometric pH was determined by a stopped-flow system designed by this group by using a m-cresol purple sea-water solution as dye for the pH determination following the DOE (1994) SOP 6 for the analysis of the carbonate system variables of oceanic sea-water samples. Reproducibility better than 0.003 pH units has been obtained.

Regarding pCO_2 values in surface waters, we observed that the pCO_2 was always above the atmospheric value (difference of 30 µatm, with diurnal variations of 3-4 µatm due to heat flux) showing that during the end of September and beginning of October the region around ESTOC was acting as a source of CO_2.

5.1.7 Particle flux measurements with drifting particle traps

(S. Neuer, U. Koy, J. Langer)

In addition to moored sediment traps, drifting trap experiments were carried out to determine particulate carbon flux that originates directly from the euphotic zone. These rates are then interpreted in the context of measurements of the standing stock and production rates of the plankton community in the euphotic zone.

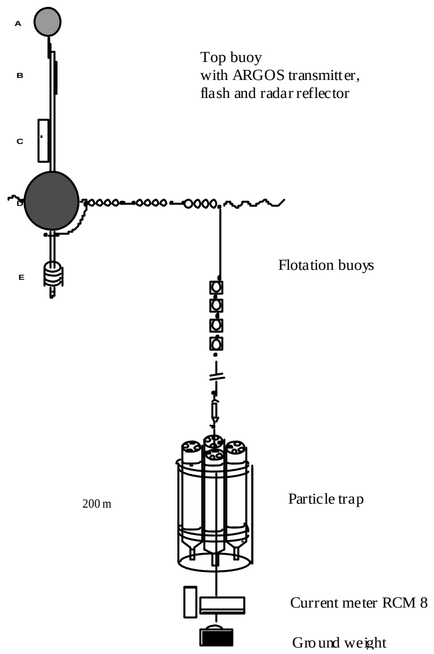

Fig. 6: Drifter I carrying one trap at 200 m depth

To study particle flux below the euphotic zone, three surface-tethered particle interceptor arrays were deployed north-east of the ESTOC station, one carrying one trap at 200 m (Trap I, Fig. 6), the other one three traps at 200, 300 and 500m depth (Trap III, Fig. 7). The third drifting trap array had an Aquatec trap attached instead of the cylinder traps (Aquatec, Fig. 8). The traps were attached to a surface buoy carrying an ARGOS transmitter and a Radar reflector. The main buoyancy was located at about 30 m depth to avoid the wind-induced EKMAN layer.

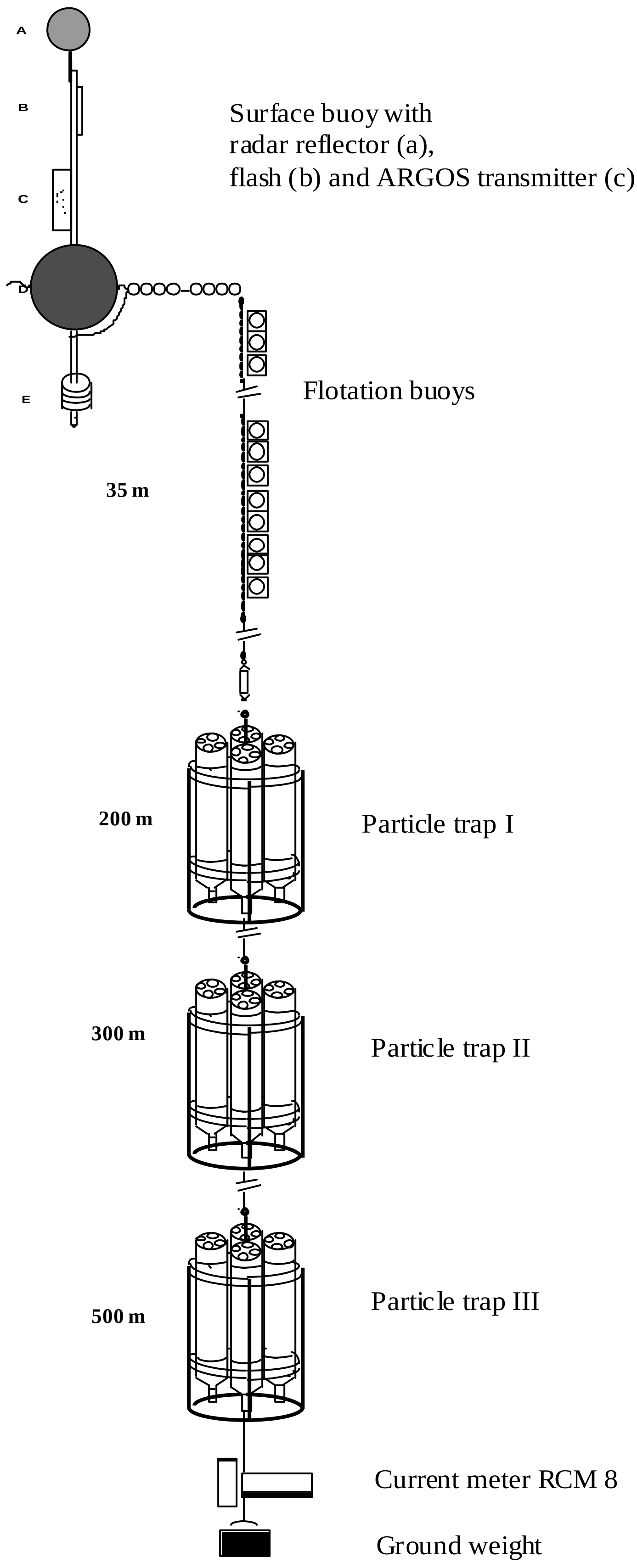

Fig. 7: Drifter III carrying traps 200, 300 and 500 m depth

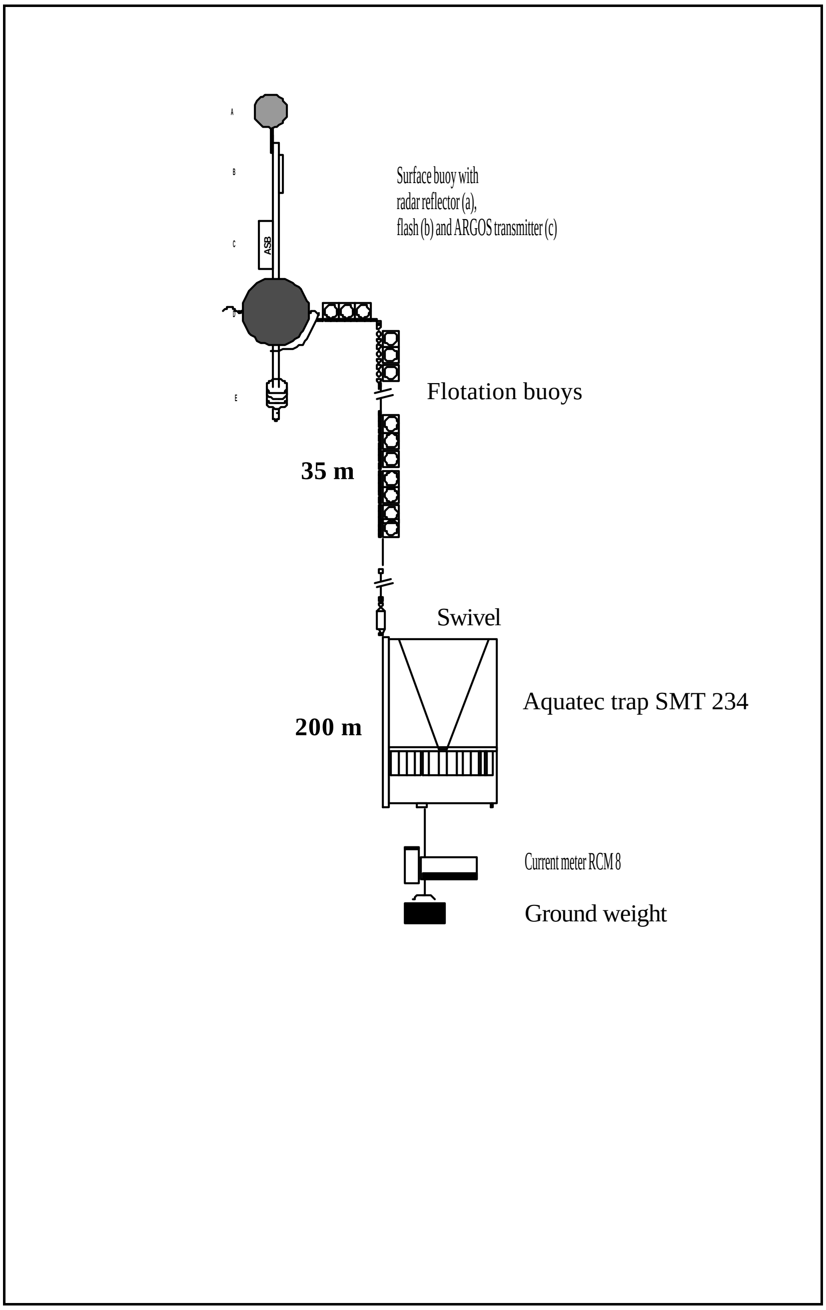

Fig. 8: Drifter Aquatec, with an Aquatec 234 trap at 200 m depth

Drifter I was deployed three times (I-1, I-2, I-3), drifter III was deployed twice (III-1, III-2) and Aquatec was deployed once (Tab. 3). During all deployment periods, the traps drifted south (Fig. 9 a, b) with a slight declination towards east. The drifting speeds were in the range expected from the mean water mass movement (Tab. 3), and were slowest during the second deployment period. In general, the drifters with only one trap had a tendency to drift faster than the 500 m drifters. This may be explained by the fact that longer drifters integrate over water masses moving with slower speed than the short drifters.

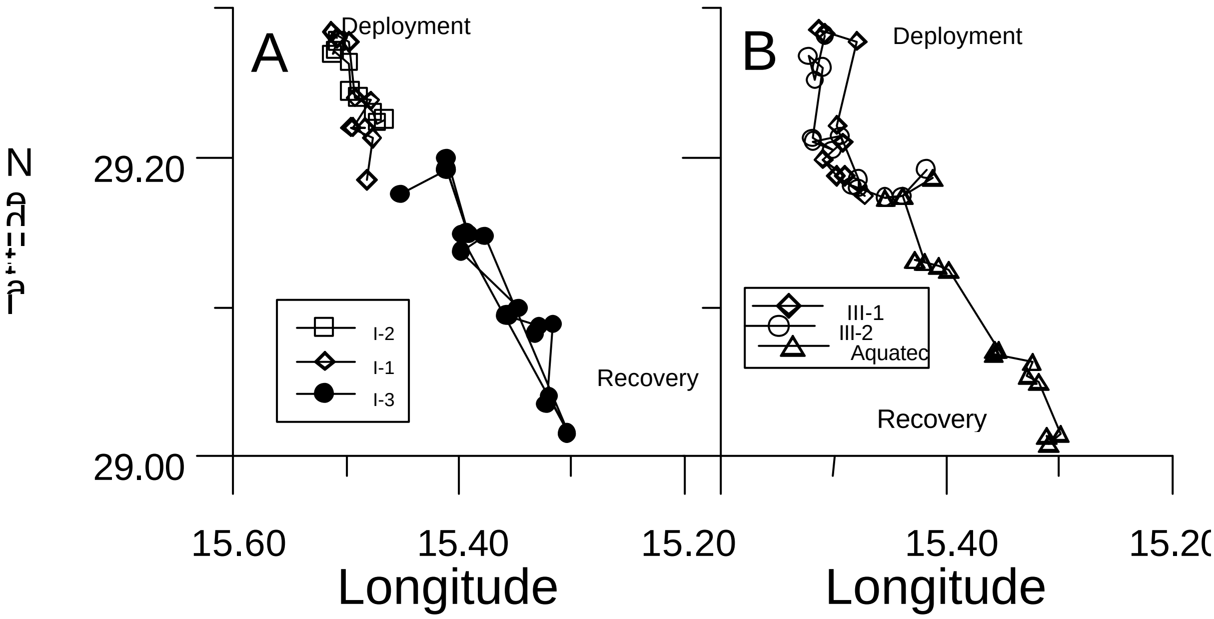

Fig. 9: Drift course of drifters deployed during M42/4a. A. Drifters I-1, I-2 and I-3. B. Drifter III-1, III-2 and Aquatec

Tab. 3: Distance and drifting speed of the different drifters deployed during M42/4a. For drift course see Fig. 9

Drifter	Deploymnet period	Hours Deployed	Distance km	Speed cm/s
I-1	29.9.-1.10	48	18.19	10.5
III-1	29.9.-1.10	48	12.50	7.3
I-2	1.10.-3.10	54	12.44	6.4
III-2	1.10.-3.10	57	13.18	6.5
I-3	3.10.-6.10.	64	22.90	9.9
Aquatec	3.10.-6.10.	62	18.75	8.5

5.1.8 Particle flux measurements with moored particle traps

(S. Neuer, V. Ratmeyer, M. Segl)

Particle flux measurements at the ESTOC (European Station for Time-series in the Ocean, Canary Islands) carried out since fall of 1991 show seasonal and short-term variability due to varying productivity and hydrographic conditions. This long-.term particle flux record also indicates that a large portion of deep particle flux originates laterally. In CANIGO, additional sediment traps were placed north of La Palma (mooring LP) and between the eastern Canary islands and the Moroccan shelf (moorings EBC 2 and 3). Including the ESTOC position, these three main trap locations cover the productivity gradient from the shelf region to the oligotrophic gyre.

On this cruise, the moorings LP2 and CI9 at ESTOC were exchanged. The LP 2 sediment trap mooring was recovered on Sept. 27, 1998. It carried two traps, an INFLUX current meter from AWI, Bremerhaven and 3 current meters from the IfM Kiel. All instruments functioned properly with the exception of the upper trap in 700 m depth which only turned to cup 12 (out of 20). Fouling of the flotation spheres and upper lines indicated that the upper portion of the mooring had come close to the surface, probably due to stretching of the polypropylen rope. This over-length due to stretching under pull was corrected in the subsequent deployment of the mooring on Sept. 28, 1998 (LP 3, see Fig. 10). LP 3 does not carry an INFLUX current meter but has an additional trap in the1000 m depth level. LP 3 will be exchanged in May 1999 on RV METEOR cruise M 45/1.

On Oct. 1, the ESTOC sediment trap mooring CI9 was recovered. It carried three traps, an INFLUX current meter, an Aanderaa current meter, a particle camera and 2 particle pumps (Marine Chemistry department, Univ. of Bremen). The upper two traps did not function during the deployment. The mooring was re-deployed on Oct. 2 (CI 10, see Fig. 11) without the camera and the INFLUX current meter. CI 10 will be exchanged in May 1999 on RV METEOR cruise M 45/1.

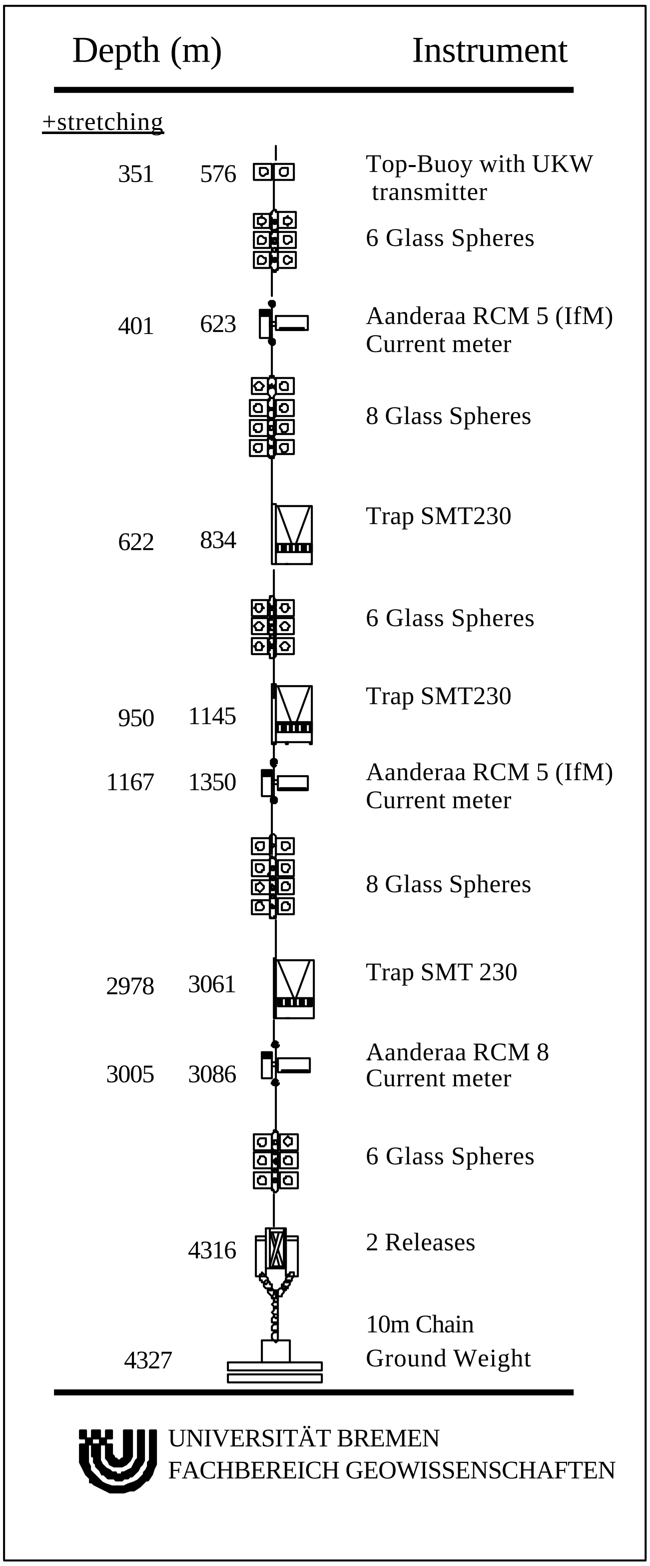

Fig. 10: Sediment trap mooring LP 3 deployed north of La Palma

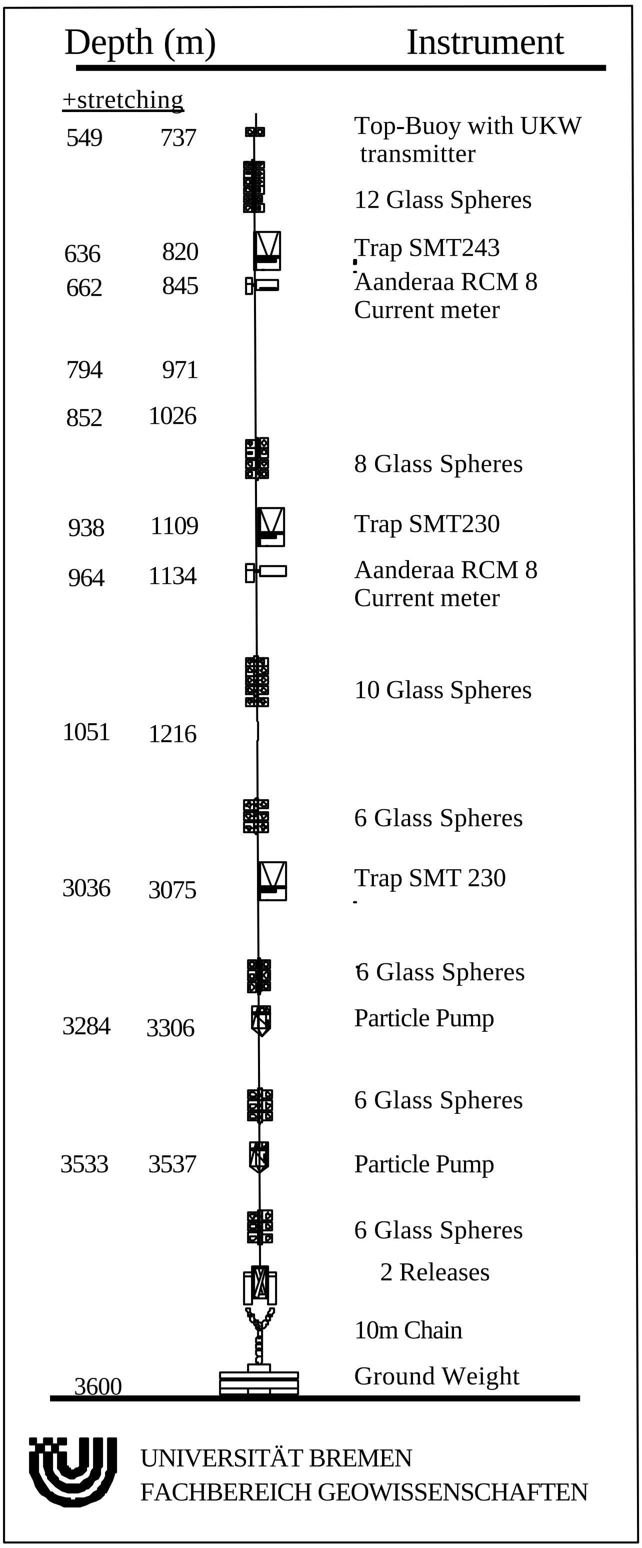

Fig. 11: Sediment trap mooring CI 10 deployed at ESTOC

5.1.9 Particle camera system

(V. Ratmeyer, W. Metzler)

A high-resolution photographic camera system was used to measure the vertical particle concentration, size distribution and aggregate composition in the water column (Ratmeyer and Wefer, 1996). It was designed and improved in consideration of similar systems used by Honjo et al. (1984), Asper (1987) and Lampitt (1985). This method provides *in situ* information on the origin and abundance of particles and aggregates (marine snow). In addition to the use of sediment traps, particle flux can be measured even in areas or depths with high lateral transport.

The aim of deployment to different depths down to 3600 m during M42-4 was to observe the deep-sea particle population and possible lateral advection of particle clouds from the continental shelf towards the open ocean.

For measuring particle size and sinking speed, a Sony VX1000E video camera was electronically modified and fitted to the controller of the ParCa system. Instrument testing was successfully performed aboard RV METEOR.

Quantitative analysis of concentration, shape and size of particles will be performed using a PC-based image analysis system. This was not possible during the cruise and will therefore be done in Bremen.

5.2 First field tests of a newly developed deep sea YOYO-Profiler

(C. Waldmann, N. Kotte, W. Metzler)

Introduction

Within the framework of the BMBF funded project DOMEST a deep sea YOYO profiler is to be developed. The goal of this system is to take continuous CTD-measurements over a depth range of 500 m above the ocean bottom. The system is designed to withstand a maximum pressure of 400 bar and is supposed to take one profile each day within one year. The advantage of such an instrument carrier compared to a sensor string is that it utilises one set of sensors and does not suffer from unknown offsets and drifts between different sensors.

The basic function of the instrument is based on a development of a shallow water profiler sponsored by the University of Bremen carried out at the University of Copenhagen. The system is propelled by buoyancy change and is guided by a taut mooring line. The further development of a deep sea version calls for a redesign of the whole mechanical construction. It is necessary to minimise the overall weight and volume as much as possible so the energy expenditure can be used as kinetic energy of the system and will not get lost to overcome the density difference between different water masses. Therefore we are going to test the applicability of new pressure housing materials as for example ceramics.

Purpose

The first field tests were done to get acquainted with the performance of the system as an instrument carrier. The most important parameters of the system that has to be determined are:

- Time interval for one complete depth cycle
- Power consumption
- Maximum profiling speed
- Performance of the hydraulic system under high pressure

The focus of the tests lies accordingly in the propulsion unit with the hydraulic system and the according sensors. The tests were meant to show the viability of the chosen concept.

Test course

The first tests were done to balance the system in seawater. From the balancing process in our lab we were able to predict the necessary additional mass within 200 g at an overall weight of 180 kg. The mass change due to the increased density of seawater is about 5 kg.

The present weight is much higher compared to what we can achieve. Our goal is to achieve less than 100 kg weight in air.

We made a total number of eight deployments where the last three delivered the expected data. During these last deployments we increased the operating depth from 50 m to 900 m. The depth interval covered by the profiler was between 50 and 100 m.

Results

The balancing of the profiler from board the ship in the surface region is quite a tedious process due to the wave induced motion. After we made some changes in the mechanical construction on board the ship we had to balance the system again. We were able to reach the operating region of our buoyancy system but the final adjustment could only be done after the first successful profiling cycle. The results of the last test is shown in Fig. 12.

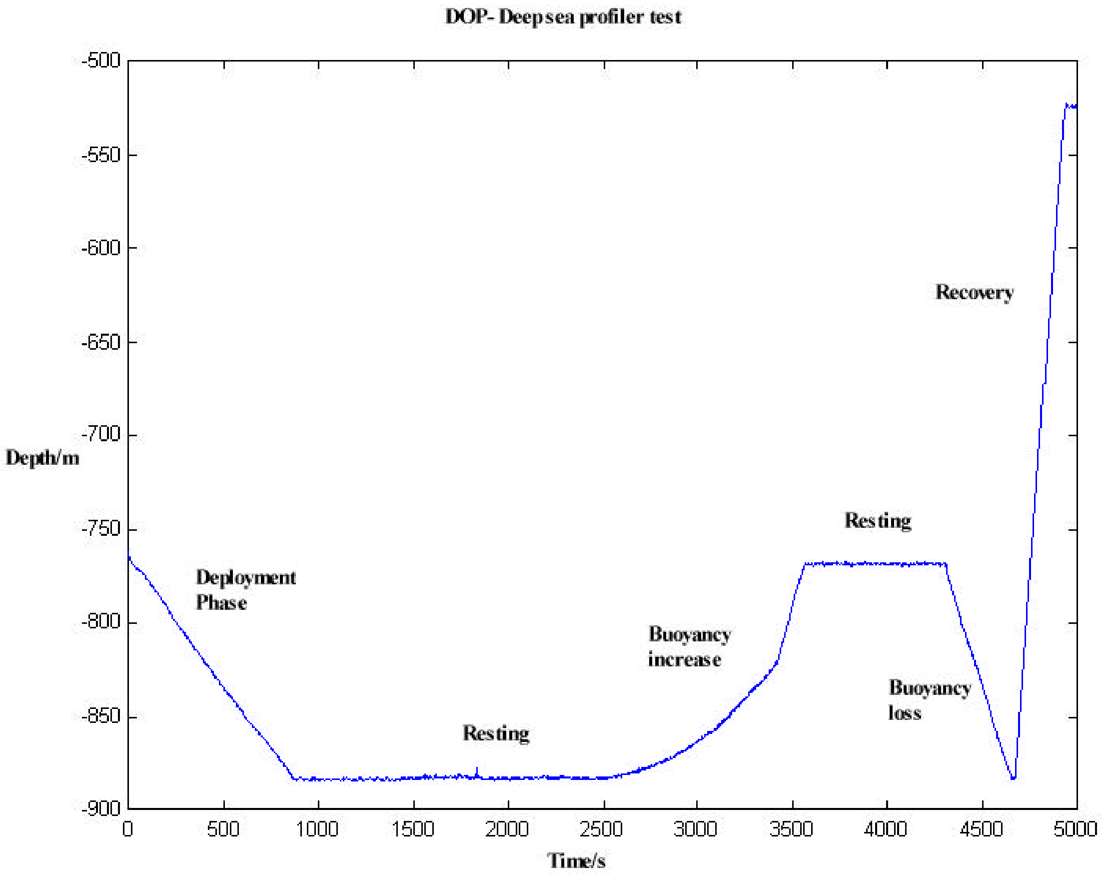

Fig. 12: Pressure plot of the profiler test at the final test depth

After a predetermined resting phase the hydraulic pump started to increase the buoyancy by pressing out the oil. After a slow start the profiler reached its final speed of about 14 cm/s. As the oil has pressed back by high pressure the final speed for the down cast was reached much faster. The speed numbers agreed very well with the calculated values.

During one of the tests the internal oil reservoir of the hydraulic was completely pumped out. That was due to a problem in the internal volume measurement. These problems have to be addressed in the future development. We are planning to publish our results on one of the next technically oriented conferences.

Conclusion

The first field tests of the profiler are proving that the principal outline is a viable concept. For the next step in the development we have to make the following improvements:

- The overall weight of the profiler in air has to be reduced to less than 100 kg
- The measurement of the volume change has to be more accurate
- The profilers need to have an mechanically initiated emergency pressure release. In comparison to other deep sea instruments there is an increased risk of recovering a pressurised system

The use of ceramic material for the pressure housing combined with titanium end caps looks very promising. We are planning to do some more tests of this housing in our high pressure facility at the University of Bremen.

5.3 Data Transmission in the Ocean "DOMEST"

(G. Meinecke, V. Ratmeyer, F. Drünert, L. Günther, K. Kretzschmar)

Introduction

The aim of the R&D project DOMEST between the University of Bremen (FRG) and the Communication and Technology Company OHB Teledata, Bremen (FRG) is the development of a moored sensor network in the deep sea. The advanced sensors (autonomous Digital Camera System, Multi Pump System, enhanced Sediment Trap, etc.) will provide high-resolution data on particle fluxes and element concentrations in the open ocean over a maximum duration of one year. All sensors can be accessed from land via bi-directional satellite link and acoustic transmission under water. With DOMEST, a remotely controlled measurement of element and particle transport in the deep sea will be possible. Communication under water will be performed through a bi-directional acoustic high-speed telemetry. Above water, a low-earth-orbit satellite network based on OrbComm satellites will establish the data transport between the moored oceanbased system and a landbased ground station in Italy. The interface at the sea surface should be the DOMEST surface buoy unit (SBU). For this reason, a separate mooring had to be deployed at 3.600 m water depth during this cruise. With the installed mooring in place, we had to perform the coupled underwater acoustic and satellite tests.

Field tests of the acoustic modem

Prior to the deployment of the SBU-mooring, the first steps were the extensive testing of the underwater acoustic modems, because one modem had to be installed onboard the surface buoy. The aim of the tests during this cruise were to resolve the performance of the underwater acoustic telemetry system. Transmission range in distance and angle and transmission speed, all in relation to ship noise, had to be checked. The acoustic modems were tested in several ways, separate and also in combination with the microcontroller BC1.

Acoustic Modems used for these tests are:			(working depth)
•	**DU**	Deck Unit	surface / onboard RV METEOR
•	**SBU**	Buoy Unit	surface
•	**SSP**	Subsurface Platform	500 m
•	**MSD**	Multi-Sensor Device MODEM	2.500 m
•	**DOBS**	Deep Ocean Bottom Station MODEM	3.500 m

Test of the SSP, MSD and DOBS modems at the ships wire

The modems were attached into a mooring frame with power supply by a deep sea battery (Fig.13). All modems has been lowered down to their "original working depth" (500m, 2.500m and 3.500 m water depth). The modems were set into the TEST MODE and all transmission speeds and modulation types up to 2.400 bit/sec were tested with great success. During these tests, build in messages inside the modems were transmitted from each modem to the deck unit on request. Transmission data and the "ship noise" itself has been recorded to a DAT Tape.

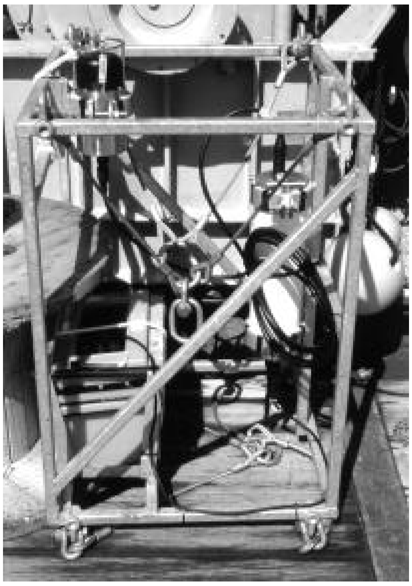

Fig. 13: Acoustic modem with separate Transducer and Deep Sea battery, attached into mooring frame

Test of the deep SSP, MSD and DOBS modems and BC1 at the ships wire

These tests were complementary tests to former test series. In addition, the microcontroller BC1 were attached to all modems. The microcontroller performs all transmission-overhead, means handshaking, controlling of 4 additional COM-ports, watch-dog abilities and also data buffering. All modems has been lowered down to their "*original working depth*" (500m, 2.500 and 3.500 m water depth). Now, the modems were controlled via their attached mircrocontroller BC1. Instead of sending the build in messages inside the modems on request, now an underwater acoustic network were build up. Via a terminal software, running on a laptop computer onboard RV METEOR, commands were send to the modems. Depending on the command, the modem stores new messages inside or pass them through to a dedicated modem. Afterwards, the requested modem transmits the data to the sender. In general, each modem is a underwater "client" and can be *master* or *slave*. During these tests, some errors occurred. One modem seemed to be "*different*" and liked to "*hang up*". In general, the "*time out*" times had to be modified to the transmission pathways. No problems were detected for the longest pathway, from surface modem SBU to the bottom station modem DOBS (3500 m), but often from DOBS (3.500m) to MSD (3.000m) - only 500 m above. Otherwise, the MSD modem was connected directly from the surface SBU modem, although the transducer was looking bottomwards. But despite these problems, the underwater acoustics were successfully tested up to 2.400 baud transmission speed.

Surface Buoy Unit

After the principle modem tests, the surface buoy unit had to be prepared for deployment. The surface buoy unit is a separate mooring of 4.000 m length (Fig. 14). The mooring line is built of 17 mm Polypropylene rope increments and the upper 500 m is built of 12 mm steel cable. The surface buoy of 2.4 m diameter and 1.5 t weight is attached to the steel cable with 30 m of chain. At the end of the chain, the buoy unit transducer is connected to a steel-triangle. The buoy itself and also the steel cable is decoupled by an swivel against the mooring line. The surface buoy is equipped with three transmission units:

1. SATEL short range UKW packet radio,
2. OrbComm bi-directional satellite transceiver,
3. ORCA underwater acoustic modem, with separate transducer 30 m below the buoy.

In addition, a radar reflector, a flasher and a small weather station were installed on this buoy. The power is supplied by two 12 Volts (115 Ah) lead acid batteries, which will be charged from solar panels (Fig. 15).

The surface buoy unit (SBU) has been successfully deployed with 2.7 tons anchor weight at 29°10.7´N and 15°55.4´W in 3.600m waterdepth. During first communication tests via the SATEL communication line to the buoy, some failures were detected. Due to this, the buoy itself had to be picked up again without disconnecting the mooring chain. The onboard electronic was fixed with a new EEPROM and the buoy was placed again.

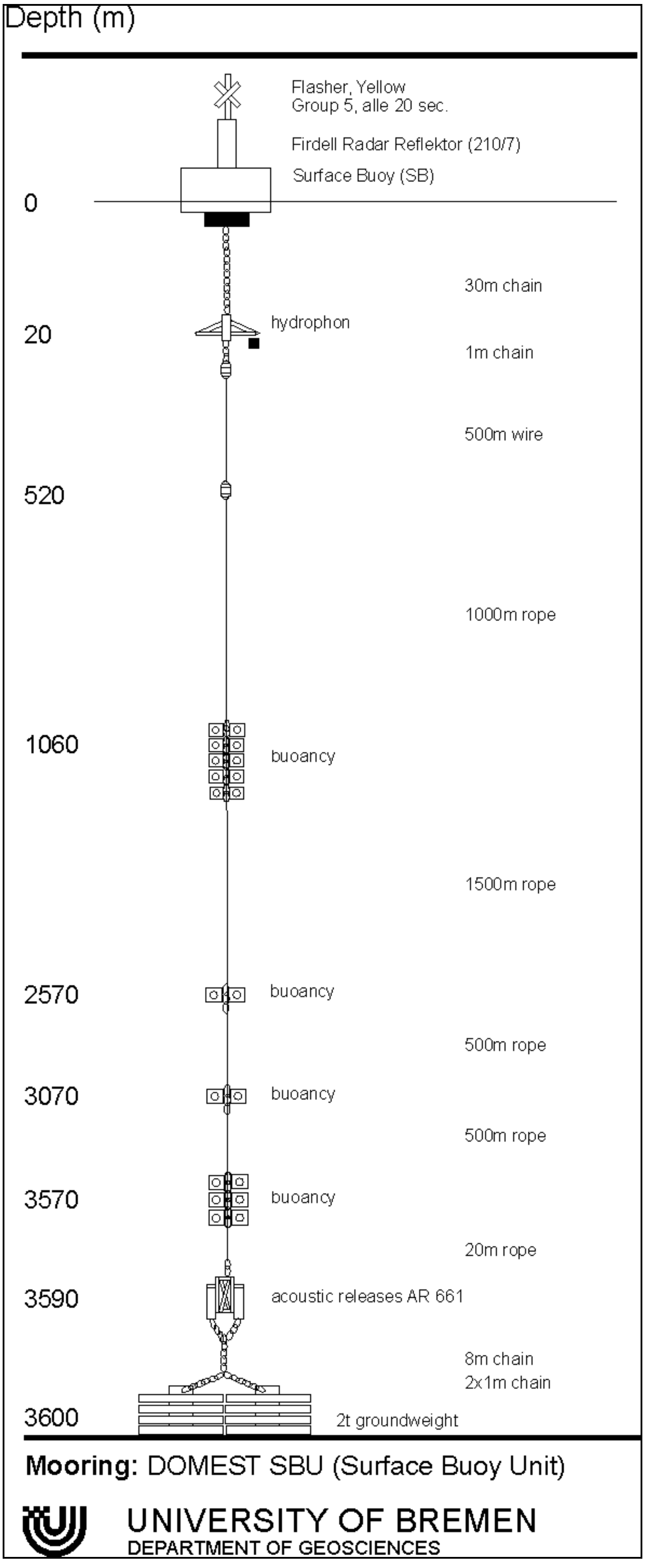

Fig. 14: Drawing of the SBU Mooring

Surface Buoy Unit (SBU)

Subsystem: Surface Buoy (SB)

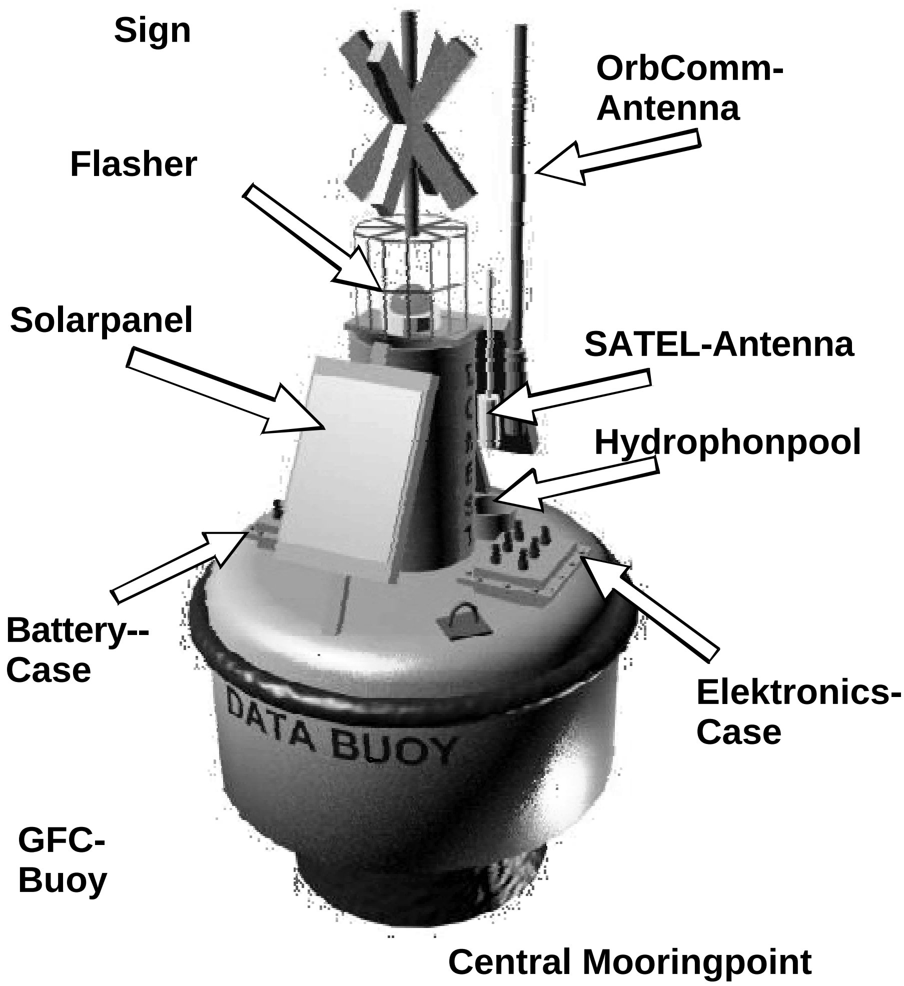

Fig. 15: Drawing of the surface buoy

Moored sensor unit MSU

After deployment of the SBU mooring, we needed to deploy the Moored Sensor Unit (MSU) for short time as close as possible to the SBU mooring, to proceed with the combined modem tests. For this reason, the MSU mooring, equipped with three modems (incl. mircocontrollers) Subsurface Platform (SSP, 500m), Multi Sensor Device (MSD, 2.000m) and Deep Ocean Bottom Station (DOBS, 3.500m), was prepared for deployment.

After the successful deployment, the MSU mooring was located at only 0.6 nm distance to the SBU mooring. During pile up of the MSU mooring, the final communication tests were prepared.

Test of complete Transmission link

The final test consisted of two pathways - the underwater link and the satellite link. Two moorings were in place - the MSU mooring (equipped with three modems) - and the SBU mooring (equipped with one modem, OrbComm Communicator and SATEL packet radio) (Fig. 16). Now, the moored acoustic network had to perform tests at request from the surface buoy modem. This surface buoy modem itself was remotely controlled via the attached SATEL short distance packet radio from the Control terminal onboard METEOR. In this configuration, we had the ability to send a command via SATEL from METEOR to the surface buoy unit i.e.: "*SBU ask the DOBS for stored test message*". After transmitting this to the SBU, the surface buoy unit modem transmits this request into the deep ocean - to the DOBS modem. Short time after this - the DOBS answered: "*I am still living*". A total of 277 tests were done in this configuration up to 2.400 baud and with different clients. As before, failures occurs due to the so called "*different modem*". But in principle the underwater acoustic network was running good.

A lot more problems occurred with the satellite link, installed onboard the surface buoy. Only one command was send from METEOR via SATEL to the surface buoy unit OrbComm communicator with a successful request for: "*Sending a satellite message from the SBU to BREMEN*". This message was confirmed from OHB in Bremen via FAX to METEOR. After this, no other request was successful. The reason for this failure is twofold:

1. a software problem with an installed "*power down*" modus onboard the surface buoy unit
2. and an incorrect "*name-setting*" at the OrbComm Ground Centre in Italy.

For this reason, return messages were routed incorrectly. Prior testing with a similar OrbComm Communicator onboard RV METEOR (with different "*name setting*" and no "*power down*" modus had worked perfectly and several "e-mails" were transmitted between METEOR and BREMEN without failures.

After these tests, the MSU mooring was recovered and replaced by a shorter version of only 300 m length. The mooring was lowered down by the ships wire "*under weight*", means with payload of 1 tons anchor weight. This test mooring consists only of the SSP-platform with installed DOBS-modem to test the reliability of the deep sea battery and the transmission between SBU mooring and this DOBS mooring.

Results

The overall results of the DOMEST tests in relation to acoustic data transmission were perfect. Despite the "*quite normal*" technical problems, in all cases it has been possible to build up a underwater acoustic communication. In most cases in the range of 1.200 to 2.400 baud transmission speed. The direct link with the greatest distance (3.600m) was very reliable. Some strange observations, like connecting the modems via bottom reflection or the problems with the short pathways from DOBS to MSD modems have to be investigated until the next cruise.

Regarding the satellite link, no general problems were detected. The OrbComm Ground Centre in Italy and also the global OrbComm Satellite System itself are still in the "*growing up*" stage. Nevertheless, the transmission tests from RV METEOR and also ongoing transmission tests in Bremen were showing, that the OrbComm Satellite System is a versatile Satellite System for "*bi-directional communication*", with respect to really small and low power consuming electronic transceiver components.

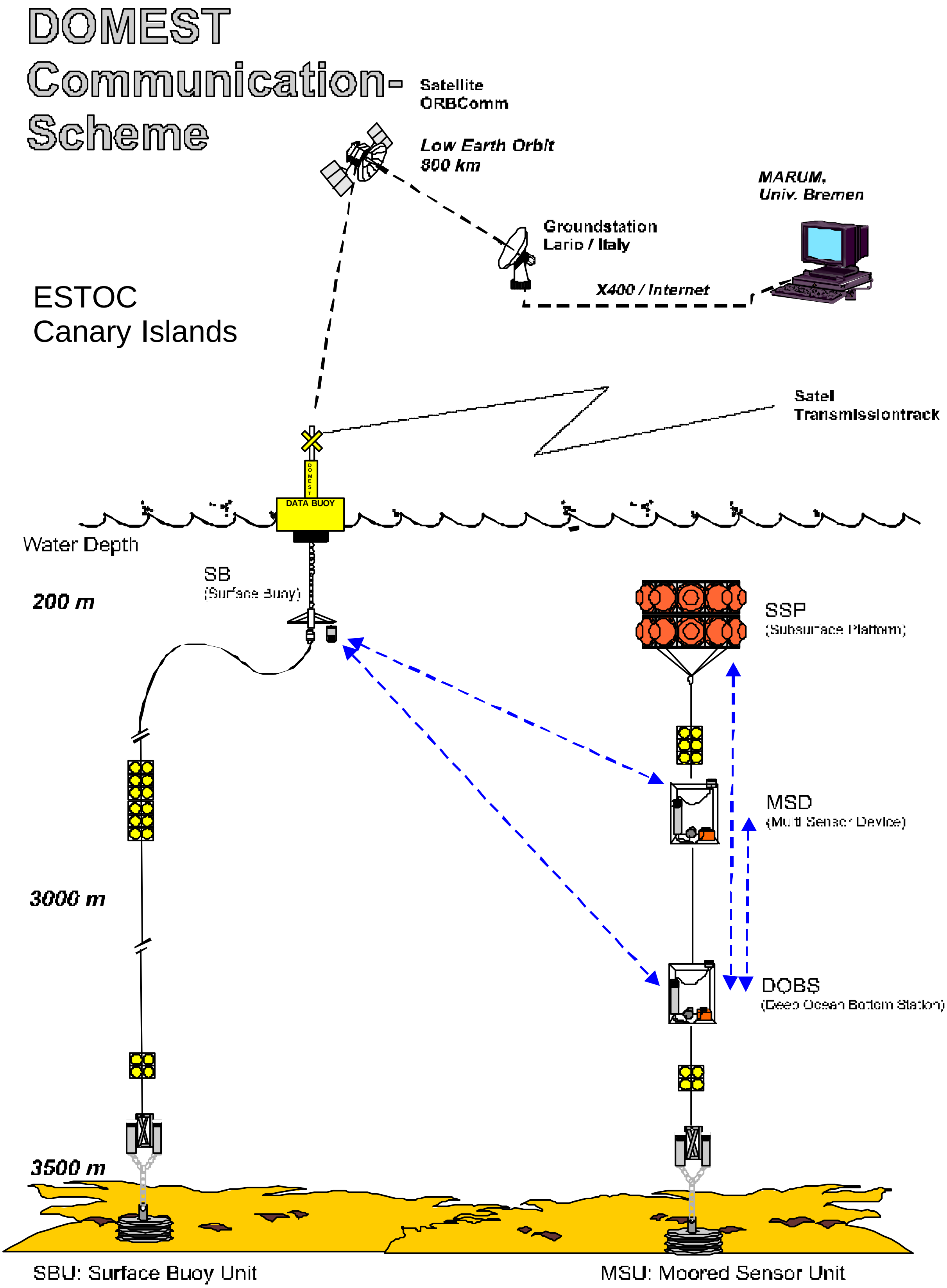

Fig. 16: Drawing of the deployed moorings and the Communication setup

5.4 Sedimentology and plankton studies during M42/4b

5.4.1 CTD-O_2-Chlorophyll probe

(T. Freudenthal, A. Makaoui, M. Segl)

The CTD-profiler SEABIRD SBE 19 was used for water column investigations. It was equipped with an oxygen sensor and a SEATECH fluorometer. For interpretation, the downcast raw data were recovered on board.

During M42/4b the CTD-profiler was attached 30 m above the multicorer. A total of 27 profiles were taken. At station 5532-2 recovery of the raw data failed, at stations 5533-1, 5534-2 and 5556-3 low battery charges caused problems during the measurements.

Fig. 17 shows two CTD-profiles characteristic for the southern (GeoB 5538) and for the northern (GeoB 5561) part of the investigation area. At GeoB 5538 fluorescence as an indicator for chlorophyll had a maximum just below the thermocline at about 30 m.

Oxygen decreased below the thermocline to values of about 3.5 mg/l at 750 m. The water of this depth could be identified as Antarctic Intermediate Water (AAIW) in a TS-diagram (Fig. 18). Below 750 m oxygen increased to about 5.3 mg/l in the North Atlantic Deep Water (NADW). Temperature showed below the thermocline a continuos decrease, which was strongest in the North Atlantic Central Water (NACW) between the thermocline and the center of AAIW. Salinity decreased as well between thermocline and 750 m and showed only little variations below 750 m. Besides of a deeper thermocline and an adjacent fluorescence maximum below 60m, GeoB 5561 showed different features related to the water masses: Instead of AAIW, Mediterranean Outflow Water (MOW) was identified between 700 and 1500 m showing a salinity maximum, comparably warmer temperatures and a broader but less intense oxygen minimum with oxygen concentrations of 4.8 mg/l.

Correlation of temperature with salinity on a transect from the north to the south (Fig.18) showed a decrease of the influence of MOW towards the south. At station GeoB 5551 which was located already south of the sill built up by the Canary Islands, no influence of MOW was detectable. Instead, AAIW was present shown by its comparable low salinity. It seems that the Canary Islands act as a barrier for the southward transport of MOW.

The oxygen profiles of the 27.5° N transect showed a striking similarity (Fig. 19). The oxygen minimum at 750 m revealed comparable intensities at all 7 stations compared between 15°24.1W (GeoB 5537) and 13°44.2W (GeoB 5546). We conclude that oxygen concentrations of 3.5mg/l are characteristic for the "old" AAIW, reflecting the progressive consumption of oxygen as oxidant for organic matter degradation during its transport from the south. A second oxygen minimum at about 250 m depth was observed only at the near coast stations GeoB 5542 and GeoB 5546. This minimum is assumed to be a local signal reflecting remineralization of organic matter at this depth in the near coast high productivity region. Near coast waters from this depth should be enriched in nutrients due to the mineralization processes, which is important with regard to the chemistry of upwelled waters in this region.

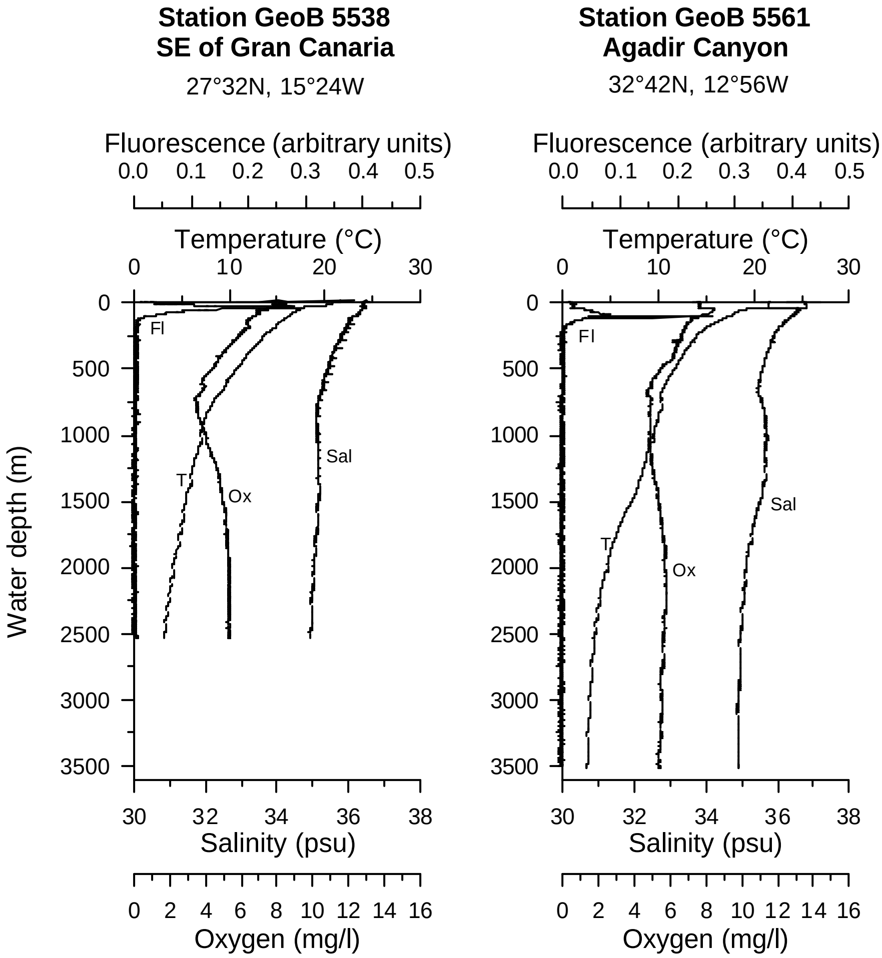

Fig.17: CTD-, oxygen and fluorescence values at site GeoB 5538 and GeoB 5561

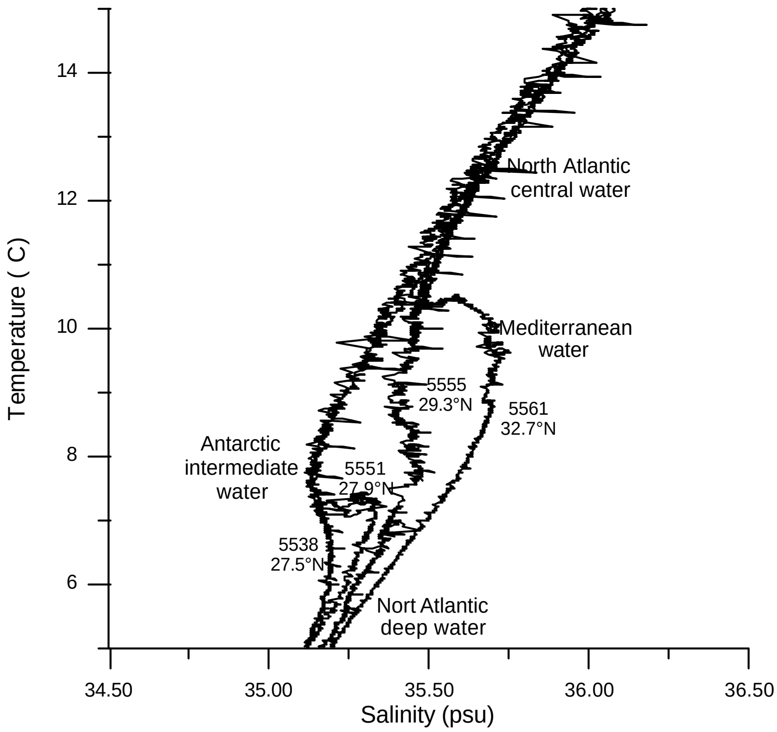

Fig. 18: TS-diagramm showing four stations along a NS transect

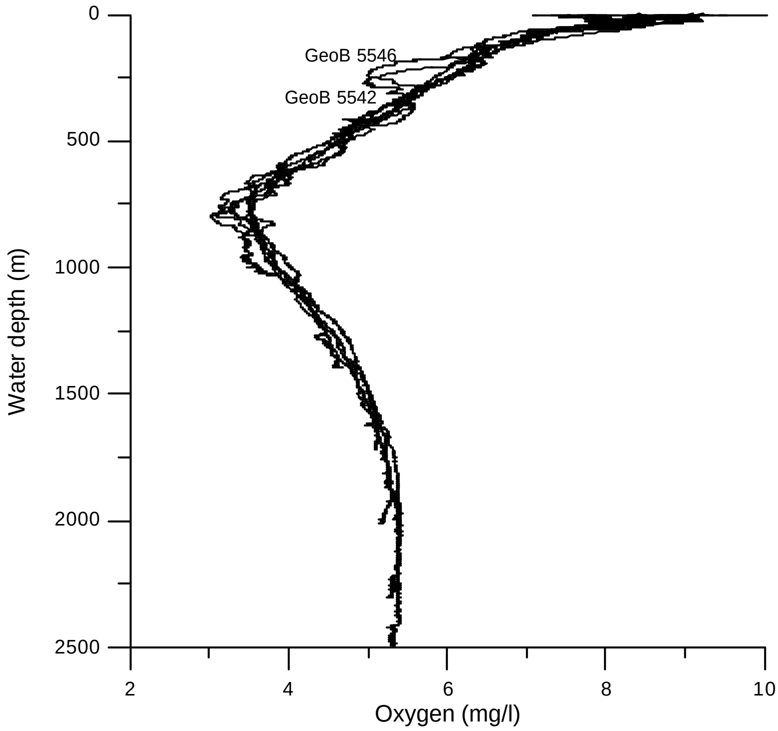

Fig. 19: Oxygen profiles along the 27.5N transect. Stations GeoB 5537, GeoB 5538, GeoB 5539, GeoB 5540, GeoB 5541, GeoB 5542 and GeoB 5546 are plotted. Only the near coast stations GeoB 5542 and GeoB 5546 are indicated since they show a second oxygen minimum at 250 m, which distinguish them from the other profiles. This minimum is interpreted as a local near coastal feature, reflecting the remineralization of organic matter in the high productivity upwelling area

5.4.2 Water sampling for Chlorophyll measurements

(T. Freudenthal, C. Hayn, H. Meggers)

Surface water for the determination of chlorophyll-a concentrations was collected from the ships sea water pump (inlet in about 3.5 m water depth). Nearly 100 water samples of 0.5 l were taken in duplicate (Fig.20, Tab.4). Due to short running times of the pump, the first 17 samples have to be taken with caution. For a comparison, at two stations a bucket (HWS) was used for water sampling. In order to control the closing depth of Niskin bottles of the multi-net, 200 ml of water was sampled from these bottles in duplicate. The water was filtered onto GF/F glass fibre filters. Chlorophyll of the filters was extracted during at least 24 h with 10 ml of 90% Aceton. Concentrations were measured on board using a Turner 10-AU-Fluorometer. Chlorophyll concentrations of water pump and HWS samples showed good correspondence.

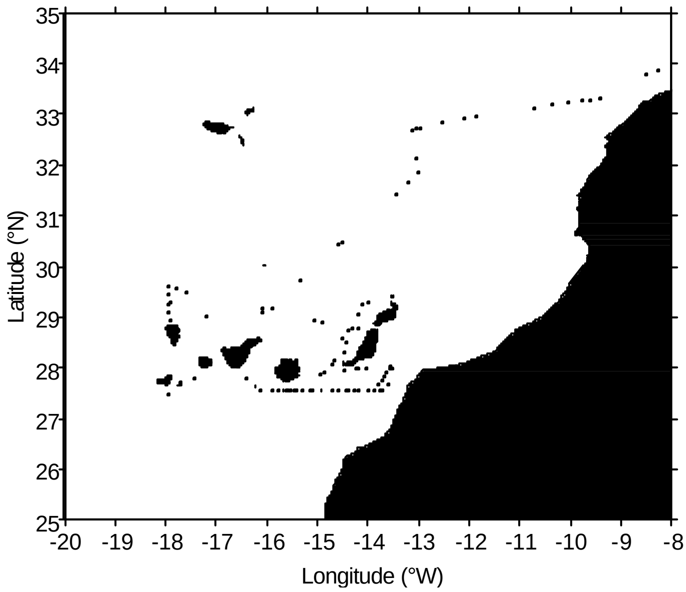

Fig. 20: Map of sampling sites for determination of surface water chlorophyll a concentrations

Chlorophyll concentrations of surface waters increased towards the colder waters of the Moroccan coast south of the Canary Islands (Fig.21). If surface water temperature in this region is regarded as an indicator of the mixing of cold, nutrient rich upwelled water and warm, oligotrophic surface water, it is obvious, that not only mixing is responsible for changes in chlorophyll concentrations. In addition to this it is speculate that the assimilation of upwelled nutrients result in a decrease of nutrients and chlorophyll concentrations. At water temperatures of about 20.5°C nearly all of the upwelled nutrients seem to be exhausted (Fig.22). Chlorophyll concentrations below 0.15 µg/l typical for surface waters above 20.5°C obviously represent values characterizing regenerated production. Comparison of surface water chlorophyll content, surface water temperature and fluorescence profiles reveals an interesting feature along the 27.5°N transect. The general trend of an increase of depth of the deep chlorophyll/fluorescence maximum with distance to coast is interrupted at stations GeoB 5537 and GeoB 5538. These two stations show chlorophyll maxima, which are shallower and higher in magnitude compared to surrounding stations. Surface chlorophyll concentrations do not vary but temperature showed a slight decrease in the vicinity of these two stations. The existence of a cold eddy derived from the Cape Yubi upwelling filament could explain these observations, assuming that nutrients are already depleted in the surface waters.

Tab. 4: Table of sampling sites and results of surface water chlorophyll measurements (P: ship sea water pump; HWS: bucket)

Number	Date	Time	Latitude	Longitude	Sampling	Chla	Std. deviation
1	8.10.	17:52	29,16	-16,05	P	0,12	0,014
2	8.10.	20:55	29,07	-16,07	P	0,10	0,015
3	8.10.	23:10	29,01	-17,17	P	0,10	0,019
4	9.10.	02:31	28,92	-17,88	P	0,12	0,011
5	9.10.	05:28	29,24	-17,92	P	0,13	0,026
6	9.10.	07:25	29,44	-17,94	P	0,06	0,015
7	9.10.	08:55	29,60	-17,94	P	0,09	0,013
8	9.10.	11:01	29,56	-17,76	P	0,09	0,003
9	9.10.	12:55	29,46	-17,59	P	0,10	0,003
10	9.10.	21:55	29,29	-17,91	P	0,11	0,002
11	10.10.	06:09	29,07	-17,92	P	0,11	0,036
12	10.10.	13:53	29,07	-17,92	P	0,14	0,008
13	11.10.	07:40	27,47	-17,93	P	0,11	0,002
14	11.10.	13:17	27,64	-17,72	P	0,12	0,002
15	11.10.	14:00	27,68	-17,69	HWS	0,15	0,006
16	11.10.	14:45	27,68	-17,69	P	0,14	0,039
17	11.10.	20:18	27,79	-17,41	P	0,10	0,003
18	12.10.	13:27	27,77	-16,37	P	0,15	0,004
19	12.10.	14:42	27,61	-16,21	P	0,11	0,003
20	12.10.	15:36	27,54	-16,13	P	0,12	0,004
21	12.10.	22:45	27,53	-15,86	P	0,12	0,001
22	12.10.	23:30	27,53	-15,74	P	0,10	0,004
23	13.10.	00:01	27,53	-15,65	P	0,10	0,001
24	13.10.	00:33	27,54	-15,57	P	0,15	0,004
25	13.10.	01:02	27,53	-15,51	P	0,13	0,005
26	13.10.	01:33	27,54	-15,43	P	0,10	0,001
27	13.10.	06:08	27,53	-15,40	P	0,12	0,002
28	13.10.	07:22	27,53	-15,29	P	0,13	0,003
29	13.10.	08:27	27,53	-15,11	P	0,12	0,003
30	13.10.	09:15	27,53	-15,09	P	0,12	0,002
31	13.10.	14,45	27,53	-14,90	P	0,12	0,002

32	13.10.	15:50	27,54	-14,69	P	0,12	0,001
33	13.10.	16:26	27,53	-14,57	P	0,13	0,001
34	13.10.	17:17	27,53	-14,40	P	0,13	0,002
gap in numeration							
40	13.10.	17:42	27,53	-14,35	P	0,10	0,005
41	13.10.	22:12	27,54	-14,26	P	0,10	0,002
42	13.10.	23:00	27,54	-14,15	P	0,11	0,002
43	13.10.	23:28	27,53	-14,17	P	0,10	0,001
44	14.10.	11:20	27,54	-13,99	P	0,11	0,001
45	14.10.	13:16	27,54	-13,84	P	0,39	0,017
46	14.10.	17:56	27,53	-13,75	P	0,73	0,033
47	14.10.	18:32	27,54	-13,70	P	1,03	0,042
48	14.10.	20:36	27,53	-13,61	P	over	
49	14.10.	22:09	27,65	-13,59	P	1,17	0,007
50	15.10.	00:38	27,98	-13,52	P	0,58	0,150
51	15.10.	01:42	28,00	-13,54	P	0,43	0,011
52	15.10.	02:37	27,90	-13,61	P	0,29	0,009
53	15.10.	03:21	27,82	-13,66	P	0,35	0,007
54	15.10.	04:49	27,66	-13,77	P	0,42	0,007
55	15.10.	09:41	27,53	-13,73	P	0,58	0,003
56	15.10.	13:29	27,76	-13,71	P	0,29	0,005
57	15.10.	19:01	27,99	-13,52	P	0,39	0,009
58	16.10.	07:13	27,98	-14,01	P	0,11	0,002
59	16.10.	10:23	27,96	-14,19	P	0,13	0,005
60	16.10.	12:04	27,93	-14,44	P	0,14	0,000
61	16.10.	14:44	27,91	-14,84	P	0,14	0,002
62	16.10.	19:05	27,87	-14,91	P	0,13	0,003
63	16.10.	22:23	28,87	-14,87	P	0,11	0,001
64	17.10.	00:08	28,05	-14,69	P	0,12	0,004
65	17.10.	07:50	28,14	-14,64	P	0,12	0,006
66	17.10.	13:47	28,57	-14,49	P	0,11	0,003
67	17.10.	14:51	28,27	-14,46	P	0,12	0,001
68	17.10.	16:33	28,47	-14,42	P	0,10	0,004
69	17.10.	18:43	28,76	-14,29	P	0,11	0,004
70	17.10.	19:28	28,76	-14,18	P	0,10	0,005
71	17.10.	23:05	29,04	-14,16	P	0,11	0,003
72	18.10.		29,27	-13,95	HWS	0,16	0,008
72	18.10.		29,27	-13,95	HWS	0,15	0,002
72	18.10.	07:35	29,27	-13,95	P	0,14	0,003
73	18.10.	12:41	29,26	-14,11	P	0,12	0,011
74	18.10.	19:29	29,04	-14,16	P	0,11	0,004
75	18.10.	23:23	28,74	-14,35	P	0,11	0,001
76	19.10.	07:51	28,92	-15,02	P	0,09	0,002
77	19.10.	12:34	29,17	-15,87	P	0,14	0,016
78	19.10.	17:20	29,72	-15,31	P	0,09	0,001
79	19.10.	11:01	30,41	-14,57	P	0,12	0,003
80	19.10.	23:34	30,47	-14,49	P	0,11	0,001
81	20.10.	08:18	31,42	-13,44	P	0,08	0,001

82	20.10.	10:11	31,63	-13,20	P	0,11	0,005
83	20.10.	17:48	31,83	-12,97	P	0,09	0,021
84	20.10.	19:42	32,10	-13,01	P	0,15	0,001
85	21.10.	00:32	32,66	-13,12	P	0,08	0,002
86	21.10.	10:01	32,70	-12,93	P	0,07	0,002
87	21.10.	16:03	32,70	-13,04	P	0,07	0,002
88	21.10.	20:46	32,80	-12,51	P	0,06	0,002
89	21.10.	22,57	32,89	-12,07	P	0,07	0,001
90	22.10.	00:11	32,93	-11,83	P	0,07	0,001
91	22.10.	05:41	33,11	-10,71	P	0,07	0,002
92	22.10.	07:31	33,17	-10,33	P	0,08	0,008
93	22.10.	11:28	33,22	-10,01	P	0,07	0,001
94	22.10.	17:23	33,25	-9,74	P	0,07	0,002
95	22.10.	19:33	33,29	-9,40	P	0,06	0,002
96	22.10.	21:59	33,29	-9,39	P	0,07	0,001
97	23.10.	01:30	33,27	-9,60	P	0,04	0,003
98	23.10.	11:22	33,76	-8,49	P	0,08	0,003
99	23.10.	12:41	33,85	-8,25	P	0,07	0,007
100	23.10.	14:53	34,02	-7,94	P	0,06	0,010

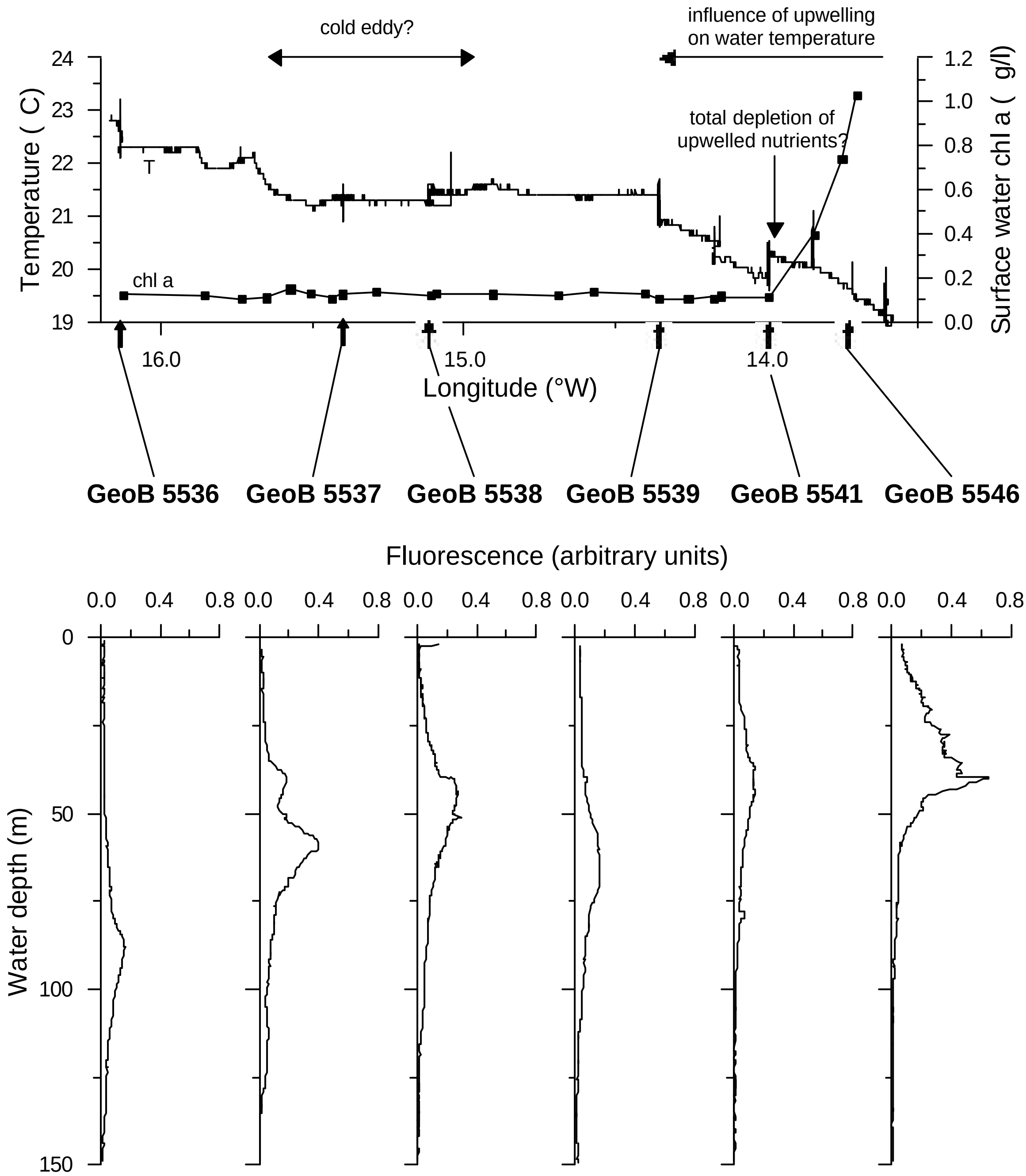

Fig. 21: Surface water temperature, chlorophyll concentrations and fluorescence profiles (CTD profiles) on selected stations of the 27.5°N transect. The near coast influence of cold and nutrient rich upwelled water is clearly visible. Higher fluorescence values in the deep chlorophyll maximum and slightly decreased temperatures may be indicative for a cold eddy

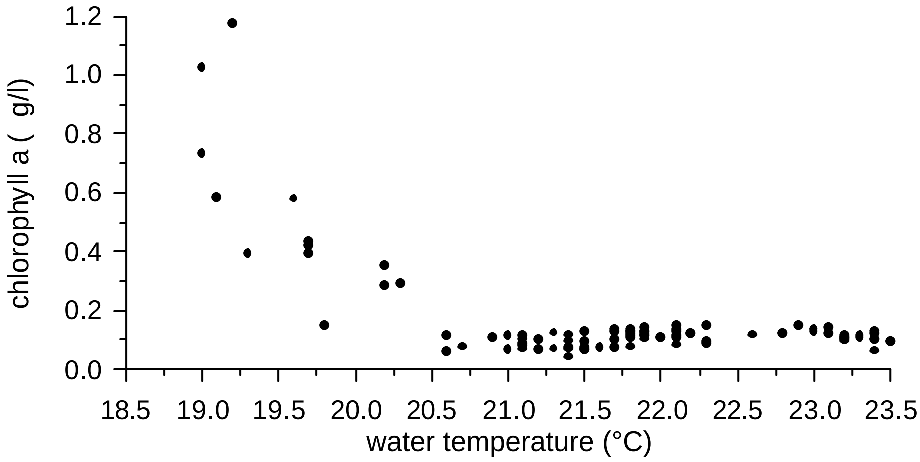

Fig. 22: Chlorophyll a concentrations in surface waters (all measurements) in dependence of the water temperature. Highest concentrations and lowest temperatures were measured near the Moroccan coast, indicating coastal upwelling

5.4.3 Plankton sampling using a multiple closing net

(H. Meggers, T. Freudenthal, C. Sprengel)

Plankton was sampled with a multiple closing net (Fa. HYDROBIOS) with 0.25 m^2 opening and 64 micrometer mesh size. It was used for vertical hawls at 24 sites (2 on M42/4a and 22 on M42/4b). The multinet stations comprised one hawl with depth intervals from 500-300 m, 300-200 m, 200-100 m, 100-50 m and 50-0 m water depth, except for station GeoB 5544-1 as the upwelling references station off Cape Yubi in 300 m water-depth with depth intervals from 200-100 m, 100-50 m, 50-25 m, 25-10 m and 10-0 m. All samples will be used for studies of the planktic foraminifera assemblage and the pteropods distribution.

The samples were carefully rinsed with fildered seawater into KAUTEX bottles, fixed with mercury chloride for the inhibition of bacterial activity, and stored at 4°C. On station, 2 l Niskin bottels were used to obtain water samples from the different water depths for analyses of carbon and oxygen stable isotopes and for chlorophyll measurements (compare with 5.4.2). Two macroscopically conspicuous samples have been taken on the 27°30`N transect nearby the coast (GeoB 5543-1 and GeoB 5544-1) showing highest numbers of phytoplankton. This samples coincided with the highest measured chlorophyll values >1.2 µg/l (see 5.4.2).

5.4.4 Plankton sampling for alkenones and coccolithophorides

5.4.4.1 Coccolithophore assemblage studies

(C. Sprengel, M. Geisen)

Coccolithophores are a diverse group of marine phytoplankton belonging to the algal class Prymnesiophyceae. Their cell surfaces are covered by minute external calcite scales (coccoliths) which form an important part of fine-grained deep-sea sediments and, therefore, are extensively used in paleontologic and paleoceanographic studies. The basic understanding of modern ecological affinities of the species is essential for palecological studies using coccolith assemblages in marine sediments. Their distribution in sediments is relatively well known, but information about their abundance, ecology and physiology in surface waters is still rare.

A total of 100 surface water samples have been taken from the ships membrane pump system at a water depth of approximately 5 m at 50 sites along the cruise track. At each site two samples of usually 2 l were taken for future coccolithophore analysis with the scanning electron microscope (SEM) and the light microscope (LM) (Tab. 5, series A and B). Additionally, at 5 stations water samples have been taken from NISKIN water bottles of the multiple closing plankton net at 500 m, 300 m, 200 m, 100 m, and 50 m water depth (Tab. 5). The water was filtered immediately through cellulose nitrate filters (25 mm diameter, 0.45 µm pore size) using a vacuum pump. During filtration, filters were rinsed carefully with buffered water (pH 8-9) to prevent crystallisation of salt. Afterwards, the filters were dried at 45°C for at least 12 hours and then kept permanently dry with silica gel in transparent film to protect them from humidity.

First filter analysis on board using an Olympus light microscope revealed generally low cell densities along the transect south of the Canary Islands with slightly higher values at the near shore sites. Identified coccospheres were mostly the ubiquitous species *Emiliania huxleyi*, *Gephyrocapsa* spp., *Syracosphaera pulchra*, and *Helicosphaera carteri*. Further filter analysis will be carried out at the University of Bremen (SEM) and the National History Museum, London (LM).

Tab.5: Station list of the coccolithophrides samples for SEM and LM analyses taken during M42/4b

A=SEM
B=LM

Sample no.	Date (1998)	Time (UTC)	Sampling depth (m)	Water filtered (l)	Latitude (°N)	Longitude (°W)	Water depth (m)	SST (¡C)	Salinity (ppt)	Comments
1A	08.10.	21:03	5	2	29.049	-16.730	3689	23.46	36.88	survey
1B			5	2						
2A	09.10.	07:15	5	2	29.450	-17.934	4155	23.51	36.89	survey
2B			5	2						
3A	09.10.	11:12	5	2	29.565	-17.762	4182	23.62	36.92	survey
3B			5	2						
4A	09.10.	13:56	5	2	29.507	-17.704	4165	23.55	36.88	site 5529
4B			5	2						
5A	10.10.	07:23	5	2	29.106	-17.934	3291	23.35	36.74	site 5531
5B			5	2						
6A	10.10.	18:03	5	2	28.591	-18.048	n/a	23.18	36.79	
6B			5	2						
7A	10.10.	22:30	5	2	27.960	-17.762	2985	22.75	36.76	
7B			5	2						
8A	11.10.	07:40	5	2	27.445	-17.934	3149	23.34	36.69	site 5532
8B			5	2						
9A	11.10.	11:40	5	2	27.502	-17.876	3224	23.17	36.6	
9B			5	2						
10A	11.10.	13:11	5	2	27.617	-17.762	3230	23.14	36.69	
10B			5	2						
11A	11.10.	14:00	5	2	27.674	-17.704	3252	23.12	36.62	membrane
11B			0.5	2						surface
12A	11.10.	21:45	5	2	27.846	-17.189	2563	23.47	36.76	survey
12B			5	2						
13A	12.10.	07:40	5	2	27.846	-16.387	2669	22.09	36.59	near site
13B			5	2						
14/1	12.10.	12:50	50	0.94	27.903	-16.444	2731	22.15	36.59	site 5535-3
14/2			100	0.90						
14/3			200	0.85						
14/4			300	0.88						
14/5			500	1						
15A	12.10.	15:36	5	2	27.559	-16.157	3448	23.35	36.76	site 5536-1
15B			5	2						
15/1			50	1.22						
15/2			100	1.17						
15/3			200	1.04						
15/4			300	0.91						
15/5			500	0.86						
16A	13.10.	06:25	5	2	27.559	-15.413	2361	21.96	36.47	site 5537
16B			5	2						
17A	13.10.	09:29	5	2	27.559	-15.126	2541	21.43	36.46	site 5538

A=SEM B=LM										
17B			5	2						
18A	13.10.	14:25	5	2	27.559	-14.897	2564	22.43	36.4	survey
18B			5	2						
19A	13.10.	16:08	5	2	27.559	-14.610	2433	22.23	36.41	survey
19B			5	2						
20A	13.10.	17:42	5	2	27.559	-14.381	2203	21.91	36.44	site 5539-1
20B			5	2						
21A	13.10.	22:40	5	2	27.559	-14.209	2066	21.26	36.37	survey
21B			5	2						
22A	13.10.	23:28	5	2	27.559	-14.152	2037	21.25	36.36	site 5540
22B			5	2						
23A	14.10.	13:16	5	2	27.559	-13.866	1425	19.42	36.41	site 5541
23B			5	2						
24A	14.10.	18:32	5	2	27.559	-13.694	913	19.14	36.36	site 5542
24B			5	2						
25A	14.10.	20:36	5	0.79	27.559	-13.636	342	18.22	35.22	site 5543
25B			5	1						
26/1	14.10.	21:00	200	0.60	27.559	-13.636	348	18.22	36.34	site 5544-1
26/2			100	0.57						
26/3			50	0.50						
26/4			25	0.80						
26/5			10	0.70						
27A	15.10.	01:02	5	2	28.018	-13.522	1190	19.86	36.24	survey
27B			5	1.90						
28A	15.10.	07:40	5	2	27.559	-13.866	1430	19.44	36.4	site 5545
28B			5	1.73						
29A	15.10.	09:20	5	1.66	27.559	-13.751	1071	19.34	36.37	site 5546-1
29B			5	1.59						
29/1			50	1.1						
29/2			100	1.1						
29/3			200	0.96						
29/4			300	1						
29/5			500	0.49						
30A	15.10.	13:29	5	2	27.731	-13.694	1309	20.52	36.33	site 5547-1
30B			5	2						
30/1			50	0.92						
30/2			100	1						
30/3			200	0.94						
30/4			300	0.50						
30/5			500	0.50						
31A	16.10.	04:17	5	2	27.960	-13.980	1728	20.87	36.46	survey
31B			5	2						
32A	16.10.	11:46	5	2	27.903	-14.381	1631	21.88	36.52	survey
32B			5	2						
33A	16.10.	14:44	5	2	27.903	-14.840	808	22.06	36.51	survey
33B			5	2						

A=SEM B=LM										
34A	17.10.	00:08	5	2	28.132	-14.668	1142	21.94	36.48	survey
34B			5	2						
35A	17.10.	07:50	5	2	28.591	-14.668	3402	22.3	36.68	site
35B			5	2						
36A	17.10.	19:28	5	2	28.762	-14.209	1961	21.61	36.61	survey
36B			5	2						
37A	17.10.	23:05	5	2	29.049	-14.152	2941	21.94	36.61	survey
37B			5	2						
38A	18.10.	09:45	5	2	29.278	-13.980	2838	21.92	36.6	site 5555
38B			5	2						
39A	19.10.	07:51	5	2	28.934	-15.011	3577	22.49	36.7	survey
39B			5	2						
40A	19.10.	12:34	5	2	29.164	-15.928	3634	23.19	36.91	DOMEST
40B			5	2						
41A	19.10.	18:38	5	2	29.908	-15.126	3410	22.51	36.75	survey
41B			5	2						
42A	19.10.	23:34	5	2	30.481	-14.496	2935	22.23	36.69	survey
42B			5	2						
43A	20.10.	08:18	5	2	31.398	-13.465	3146	22.22	36.82	survey
43B			5	2						
44A	20.10.	19:42	5	2	32.086	-13.006	3571	20.02	36.48	survey
44B			5	2						
45A	21.10.	09:50	5	2	32.716	-12.949	3499	21.75	36.73	site 5561
45B			5	2						
46A	22.10.	00:11	5	2	32.945	-11.860	3818	21.52	36.66	survey
46B			5	2						
47A	22.10.	06:20	5	2	33.117	-10.600	4327	21.76	36.73	survey
47B			5	2						
48A	22.10.	17:23	5	2	33.232	-9.740	n/a	21.56	36.62	survey
48B			5	2						
49A	23.10.	12:04	5	2	33.805	-8.365	215	20.93	36.52	survey
49B			5	2						
50A	23.10.	16:30	5	2	34.148	-8.136	1288	21.44	36.51	survey
50B			5	2						

5.4.4.2 Alkenones

(M. Geisen, C. Sprengel)

Coccolithophores, marine unicellular algae of the class Prymnesiophyceae, form a major part of the phytoplankton in present oceans. Coccolithophore species are able to synthesize long-chain (C_{37}, C_{38}, C_{39}) carbon compounds, so-called alkenones, which consist primarily of di- and triunsaturated methyl and ethyl ketones. Laboratory experiments showed that the degree of unsaturation in the ketone series biosynthesized depends on growth temperature. The calibration curve of the long-chain ketone series vs. growth temperature (U^k_{37} index; Brassell et al., 1986) depends on the investigated area and accurately predicts unsaturation patterns in natural particulate materials collected from oceanic waters of known temperature. On the other hand, U^k_{37} has proven to be a useful proxy for past sea surface temperature in low to mid latitudes:

$T(°C) = (U^k_{37} - 0{,}039)/0{,}034$ (Prahl and Wakeham, 1987)

Along with plankton samples, 17 water samples of usually 50 l were taken from the ships membrane pump system at a water depth of approximately 5 m (Tab. 6). Immediately afterwards the water was filtered through a precombusted glass fibre filter (47 mm in diameter) via membrane or water jet pump and stored at -20°C in the deep-freeze room. To enhance working speed, the filters were changed after filtering approximately 13 l. Future work will include extraction, separation, and gas chromatography - mass spectrometry (GC-MS) analyses of the alkenones (Nederlands Institut for Onderzoek der Zee) and plankton assemblage studies (University Bremen and Natural History Museum, London).

Tab. 6: Station list of alkenone samples taken during M42/4b

Sample no.	Date (1998)	Time (UTC)	Water filtered (l)	No. of filters	Latitude (°N)	Longitude (°W)	Water depth (m)	SST (°C)	Salinity (ppt)	Comments
01	09.10.	13:56	50	2	29.51	-17.70	4165	23.55	36.88	site 5529
02	10.10.	07:32	50	2	29.11	-17.93	3291	23.35	36.74	site 5529
03	10.10.	18:39	50	3	28.48	-17.99	2833	23.29	36.78	W La Palma
04	11.10.	08:43	50	2	27.44	-17.93	3175	23.37	36.68	site 5532, filter perforated
05	11.10.	13:11	50	3	27.67	-17.70	3252	23.12	36.62	filter touched
06	11.10.	21:45	50	3	27.85	-17.19	2563	23.47	36.76	survey
07	12.10.	07:40	50	3	27.85	-16.39	2669	22.09	36.59	near site 5535
08	12.10.	15:36	50	3	27.56	-16.16	3448	23.35	36.76	site 5536
09	13.10.	06:25	50	3	27.56	-15.41	2361	21.96	36.47	site 5537
10	13.10.	17:42	50	2	27.56	-14.38	2203	21.91	36.44	site 5539
11	14.10.	13:16	50	5	27.56	-13.87	1425	19.42	36.41	site 3541
12	14.10.	20:36	15	5	27.56	-13.64	342	18.22	35.22	site 3543
13	19.10.	18:38	50	2	29.91	-15.13	3410	22.51	36.75	survey
14	20.10.	19:42	41	3	32.09	-13.01	3571	20.02	36.48	survey
15	22.10.	00:11	50	3	32.95	-11.86	3818	21.52	36.66	survey

16	22.10.	06:20	50	2	33.12	-10.60	4327	21.76	36.73	survey
17	22.10.	17:23	50	2	33.23	-9.74	n/a	21.56	36.62	survey

5.4.5 Underway geophysics

(H. Meggers, M. Segl and Shipboard PARASOUND Watchers)

During METEOR Leg M 42/4b the shipboard acoustical systems HYDROSWEEP and PARASOUND were used on a 24 hour schedule to record continous high resolution bathymetric and sediment echosounding profiles. In addition, the registration and recording system HYDROMAP ONLINE allowed an increased online control of the swath-data quality by permitting the display of several different survey datasets at time in a windowed screen layout. Unfortunately rough sea bottom topography and bad weather conditions caused problems to the system.

The underway geophysical programme of Leg M42/4b along several profiles in the Canary Islands/ Agadir Canyon region serves the EU project CANIGO. Along the profiles the recorded data provided valuable information for finding suitable coring stations from different environments of the oligotrophic open ocean sites and the near-shore eutrophic positions.

5.4.5.1 Methods

PARASOUND

The PARASOUND system surveys the uppermost sedimentary layers of the seafloor. Due to the high signal frequency of 4 kHz, the short signal lenght of two sinoid pulses, and the narrow beam angle of 4.5°, a very high vertical resolution is achieved. Sedimentary layers along the ship track on a scale of less than one meter can be resolved. The PARASOUND data provided information about the physical state of the sea bottom as well as about sediment structures up to a depth of 50 m below sea floor. The penetration of the PARASOUND signal depends on the density of the uppermost sediment layers and the impedance contrasts between these layers and at the sea floor. Thus, the penetration was used as a first hint for the quality of a potential coring location. The digitization and storage of the echosounding seismograms were conducted by usage of the software package ParaDigMa (Spieß, 1993). This system converts the analog to digital data and stores them on 9-track tapes in a SEG-Y like format, making data available for further post-processing. The pre-processed data are plotted online with a HP colour printer and some plots of the cruise are presented here. These plots provided a first impression of variations in sea floor morphology, sediment coverage and sediment patterns along the ship track. In addition, navigation data are printed and stored to disk simultanously. Besides the usage of the PARASOUND as a tool for localization of promising core sites, it is possible to image and describe the dominating sedimentation processes and to interpret the structual context of the longer sediment cores.

HYDROSWEEP

The general purpose of the HYDROSWEEP is to survey topographic features of the seafloor. A sector of 90° is covered by a fan of 59 pre-formed beams. Thus, a stripe with the width of twice the water depth is mapped perpendicular to the ship track. Data are stored on magnetic tapes in a sensor independent format. Since a workstation is directly installed beside the ParaDigMa PC, the PARASOUND operator is able to check the topographic map and cross- and ahead profiles on the HYDROSWEEP screen. This optimized the PARASOUND control, because in combination with the sediment echosounder HYDROSWEEP is proved to be a very efficient aid for the selection of suitable coring stations. The precise knowledge of the local bathymetry is essential to select suitable sites, to select the coring device, and to evaluate the impact of morphology, slope angles and sediment instabilities on the continuity of sedimentation. Also, the detailed 3D information of the seafloor topography represents an important contribution to the interpretation of the 2D PARASOUND cross-sections. Since rough sea bottom topography and bad weather conditions caused problems with the system, the data processing of the multibeam sounder often resulted in gaps.

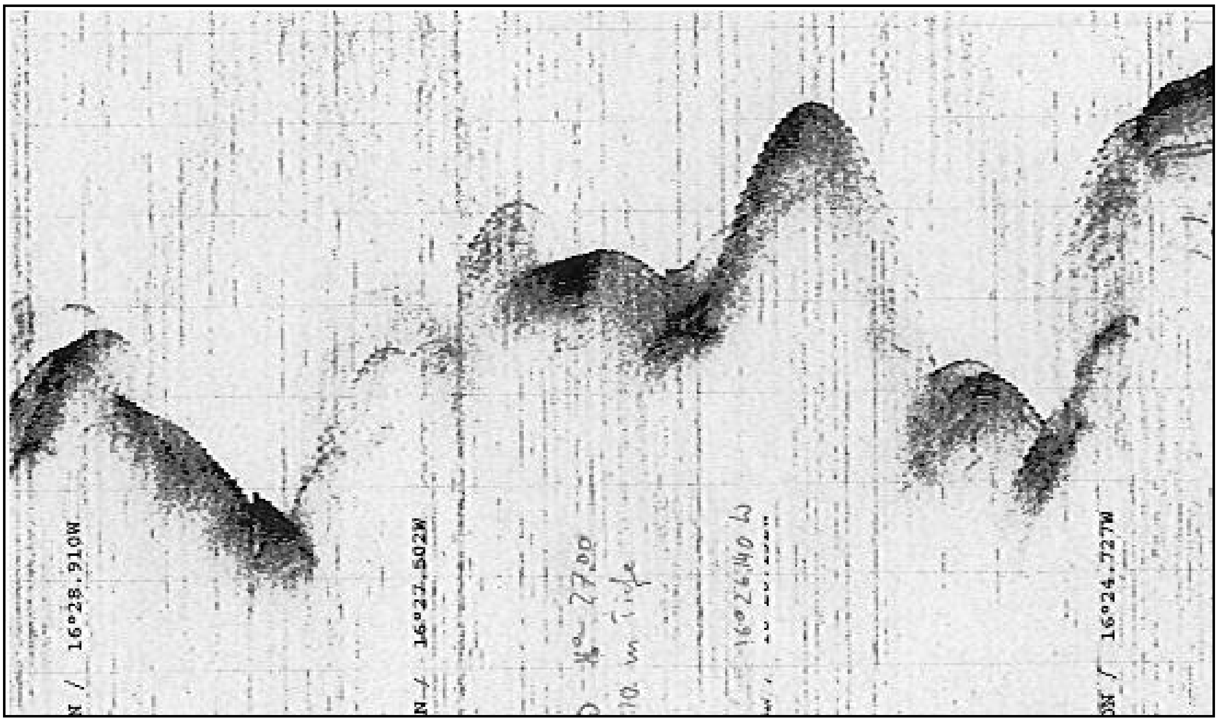

Fig. 23: Digital PARASOUND seismogram section recorded on a profil between 27°50,6; 16°28,9W snd 27°50,5N; 16°251,2W (oligotrophic site)

5.4.5.2 First shipboard results

During cruise METEOR M42/4b, different profiles of sediment cores were taken in the research field of Subproject 3 of CANIGO. These coring locations were exclusively found by the aid of the PARASOUND and HYDROSWEEP systems (old data from former cruises and/or new M42/4b data). The quality of PARASOUND data for sediment sampling will be illustrated with 2 examples from a zonal profile along 27°30`N, where the sampling locations GeoB 5532 to GeoB 5546 are situated (Fig. 23 and 24). This cores GeoB 5532 nearby Hierro and GeoB 5546 off Cape Jubi reflect the typical features in the geophysical characteristic of the sediments south of the Canary Islands.

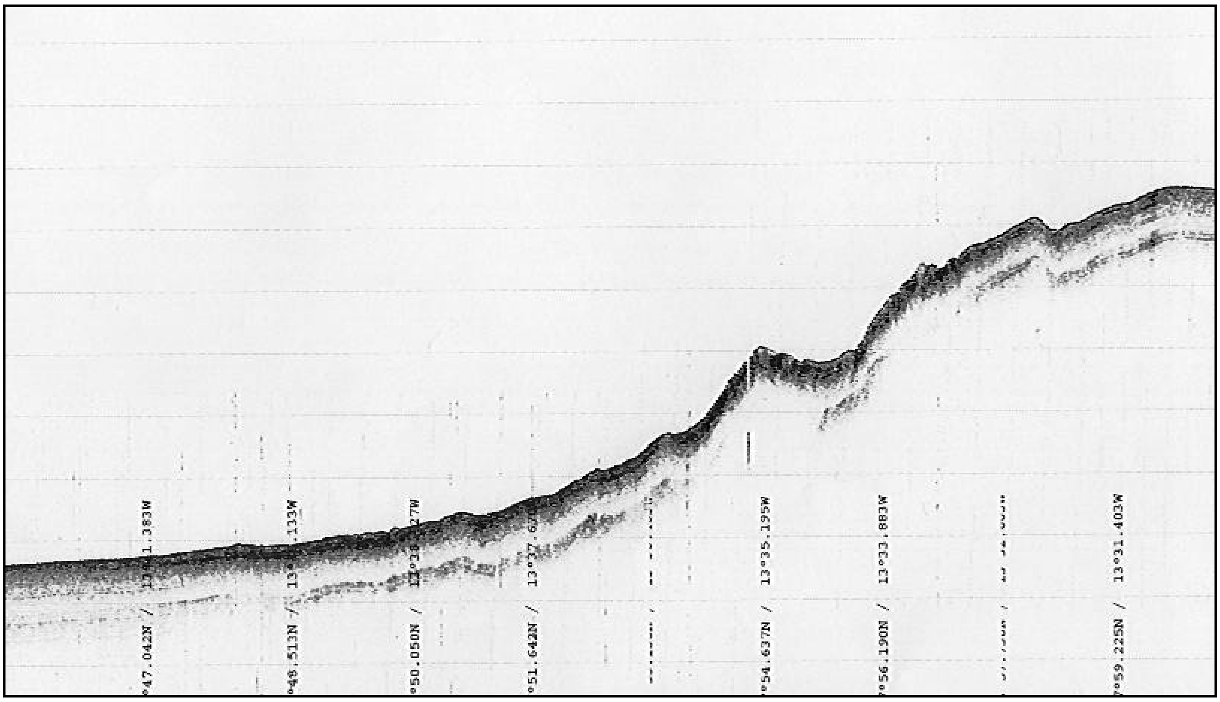

Fig. 24: Digital PARASOUND seismogram section recorded on a profil between 27°47,0; 13°41,4W and 27°59,5N; 13°31,2W (mesotrophic site)

The 27°30` profile strikes perpendicular to the coast and is located between 27°28,3N; 17°55,9W and 27°32,2N; 13°44,2W. The water depths were between 3450 m and 1070 m. The signal penetration was only 20 m in the off-shore site (Fig. 23), and about 40 m closer to the coast where the upwelling and the filaments are located (Fig. 24). From the western part of the profile at Hierro towards the coast, the influence of vulcanic material is strongly decreasing. In the upwelling region as well as in the cold-eddy domain SW of Gran Canaria there was a mostly regular layering with distinct reflectors to be observed. Therefore it is assumed that undisturbed deposited sediments were present there, while the western part is not only influenced by vulcanic ash, but also by turbidites. Since the cores off Cape Yubi consited mostly of homogenous foraminifera bearing nannofossil mud the core recovery as well as the signal penetration of the PARASOUND was high. In contrast to this the Hierro and La Gomera sites are much more heterogenous with a lot of vulcanic- and bioklastic components and core recovery and PARASOUND signal penetrtation were low (compare with 5.4.6).

5.4.6 Sediment Sampling

(K. Dehning, V. Diekamp, A. Eberwein, P. Franke, T. Freudenthal, C. Hayn, J. Henderiks, D. Jeronimo, A. Makaoui, H. Meggers, A. Moreno, S. Nave, M. Segl, C. Sprengel, J. Targarona, J. Thiele, H. Thierstein)

Sediments were recovered at 36 stations on a profile north of La Palma, on two profiles perpendicular to the NW African margin between 27^{o} and 28 ^{o}N, on a meridional profile west of Lanzarote/Fuerteventura and on two profiles north of the Agadir Canyon. Surface sediments were generally recovered with a multicorer, however, a box corer was used as an alternative only one time when the multicorer recovery was poor, on the La Palma profile (Tab. 7). A gravity corer with different pipe lengths and a weight of 1.5 tons on top was used at 32 stations to be able to recover deeper sediment sequences (Tab. 8 and Fig. 2). Piston coring was also succesfully done at three stations (GeoB 5541-4, GeoB 5545-1 and GeoB 5546-2). Both coring systems were utilized at station GeoB 5541. A core of 1106 cm was recovered by the gravity corer and a 1252 cm long core was recovered by the piston corer. The apparently higher sediment core recovery from the piston corer still has to be confirmed in a comparative study of the piston core and the shorter gravity core. Such a study will allow the identification of possible sediment disturbances by the respective coring techniques. Preliminary results of two cores taken during M37/1 (GeoB 4228-2 (gravity corer) and GeoB 4228-3 (piston corer)) indicate that the 2 m better recovery of the piston corer (1188 cm to 968 cm) equate with a 2 m longer time series (compare with Wefer et al., 1997).

5.4.6.1 Sediment surface sampling with multicorer and boxcorer

Multicorer

The main tool for the recovery of undisturbed sediment surfaces and the overlying bottom water was the multicorer equipped with 8 tubes of 10 cm and 4 smaller tubes of 5 cm in diameter. The multicorer was used at 32 stations. In some cases the system failed due to the underlying sediments, but mostly the core recovery was good, typically 10 to 12 tubes were filled, and cores of very good quality reaching 35 cm of sediment were recovered from station GeoB 5529 to station GeoB 5566.

At each multicorer station, the overlying bottom water of one of the large tubes was sampled for stable isotope measurements at Bremen. Mostly 4 of the large tubes and 1 of the smaller tubes were usually sampled in 1 cm slices for analysis of C_{org}, benthic and planktic foraminifera, coccoliths and diatoms. The C_{org} samples were frozen immediately after collection at -27°C. Benthic foraminifera samples were stained with a solution of 1g of rose bengal in 1 l ethanol. A second set of non-stained samples was also collected for planktic foraminiferal and coccolithophorides analysis. All the foraminifera, coccolithophoride and diatom samples were kept at 4° C. One large core was frozen for later AMS C-14 dating on planktic foraminifera and fine fraction (<38 µm). Mostly one large and/or one small core were frozen as archive material.

Tab. 7. Multicorer sampling, METEOR cruise 42/4b

A. Large tubes

GeoB No.	Depth (m)	Recovery (cm)	Corg.	Archives	PF/ Coc.	Cocc.	Diatoms	Benthic Forams	C14	Dinofl./ Sed.
5529-1	4166	9	1	1	-	-	-	2	-	-
5530-3	3982	0	-	-	-	-	-	-	-	-
5531-1	3301	0	-	-	-	-	-	-	-	-
5532-2	3150	16	1	1	-	-	-	2	1	-
5533-1	3251	16	1	1	-	-	1	2	1	surf.
5534-2	2832	15	1	1	1	-	1	2	1	-
5535-1	2690	35	1	1	1	-	1	2	1	1
5536-3	3456	24	1	1	1	-	1	2	1	surf.
5537-2	2362	22	1	1	-	-	1	2	1	-
5538-2	2537	13	1	1	1	-	1	2	1	surf.
5539-2	2201	15	1	1	-	-	-	2	1	surf.
5540-3	2035	15	1	1	-	-	-	2	1	-
5541-2	1748	21	1	1	-	-	1	2	1	surf.
5542-3	1431	17	1	1	-	-	1	2	1	surf.
5546-3	1071	18	1	1	-	surf.	1	2	1	surf.
5547-2	1310	18	1	1	-	surf.-	1	2	1	surf.
5548-	1162	16	1	1	-	-	1	2	1	-

3										
5549-2	1454	24	1	1	-	surf.	1	2	1	surf.
5550-3	1738	20	1	1	-	0-5cm	1	2	1	surf.
5551-2	1885	32	1	1	-	surf.-	1	2	1	surf.
5553-2	3397	13	1	1	-	surf.	1	2	1	surf.
5555-2	2837	29	1	1	-	0-5cm	1	2	1	surf.
5556-3	3170	29	1	1	-	0-5cm	1	2	1	surf.
5557-2	2949	4	1	-	1	-	-	-	-	-
5558-2	2471	32	1	1	-	surf. + 0-5cm	1	2	-	surf.
5559-1	3178	no surf. (8)	-	-	-	-	-	-	-	3
5560-2	3944	14	1	1	-	0-5cm	1	2	1	1
5561-1	3500	12	1	1	-	surf. + 0-5cm	-	2	1	surf.
5564-2	3967	20	1	1	-	surf.	1	2	1	surf.
5565-3	791	18	1	1	-	-	1	2	1	surf. 1
5566-2	2785	15	1	1	-	0-5cm	1	2	1	1

Tab. 7 continued - Multicorer sampling, METEOR cruise 42/4b

A. Small tubes Large tubes

GeoB No.	Depth (m)	Recovery (cm)	Corg.	Archives	PF/ Coc.	Cocc.	Diatoms	Benthic Forams	C14	Dinofl./ Sed.
5529-1	4166	9	-	-	2	-	1	-	-	1
5530-3	3982	0	-	-	-	-	-	-	-	-
5531-1	3301	0	-	-	-	-	-	-	-	-
5532-2	3150	16	-	1	1	-	-	-	-	surf.
5533-1	3251	16	-	1	1	-	-	-	-	-
5534-2	2832	15	-	1	-	-	-	-	-	surf.
5535-1	2690	35	-	1	-	-	-	-	-	-
5536-3	3456	24	-	1	-	-	-	-	-	-
5537-2	2362	22	-	1	1	-	-	-	-	-
5538-2	2537	13	-	1	-	-	-	-	-	-
5539-2	2201	15	-	1	1	-	1	-	-	-
5540-3	2035	15	-	1	1	-	1	-	-	-
5541-2	1748	21	-	1	1	-	-	-	-	-
5542-3	1431	17	-	1	1	-	-	-	-	-
5546-3	1071	18	-	1	1	2 surf.	-	-	-	-
5547-2	1310	18	-	1	1	2x 0-5cm	-	-	-	-
5548-3	1162	16	-	1	1	-	-	-	-	-
5549-2	1454	24	-	1	1	2x 0-5cm	-	-	-	-
5550-3	1738	20	-	1	1	-	-	-	-	-
5551-2	1885	32	-	1	1	2x 0-5cm	-	-	-	-

5553-2	3397	13	-	1	1	0.5cm	-	-	-	-
5555-2	2837	29	-	1	1	2 surf.	-	-	-	-
5556-3	3170	29	-	1	1	surf.	-	-	-	-
5557-2	2949	4	-	-	-	-	-	-	-	-
5558-2	2471	32	-	1	1	-	-	-	1	-
5559-1	3178	8	1	-	1	-	-	-	-	1
5560-2	3944	14	-	1	1	-	-	-	-	surf.
5561-1	3500	12	-	1	1	-	2	-	-	-
5564-2	3967	20	-	1	1	2x 0-5cm	-	-	-	-
5565-3	791	18	-	1	1	surf. + 0-5cm	-	-	-	-
5566-2	2785	15	-	1	1	surf.	-	-	-	surf.

When available, surface samples were also sampled for dinoflagellate and sedimentological studies by the members of the Barcelona group on board. From the Agadir Canyon region, samples were usually taken for the dinoflagellate and the sedimentological analyses (compare with Tab. 8).

Boxcorer

The boxcorer was used as an alternative only at one station (GeoB 5531-3) on the profile north of La Palma with a recovery of 36 cm. The boxcorer used permits the recovery of 50 x 50 x 50 cm of surface sediments. When on board, the overlying waters was removed from the box, sediment temperature was taken from 6 cm depth and the surface sediments described and photographed. The surface sediment was then sampled as follows.

2 cores (d=12 cm) as archive
1 core (d=12 cm) for organic carbon analyses
1 core (d=12 cm) for analysis of diatoms
1 core (d=12 cm) for sedimentological studies/Barcelona (in the Agadir Canyon)
200 cm^2 for foraminiferal analysis (stained with rose bengal)
200 cm^2 for organic carbon analysis (frozen at -27^{o}C)

The front cover of the boxcorer was removed, the sediment cleaned, described and photographed. Three series of syringe samples were then taken at 3 cm intervals, for analyses of foraminifera, coccoliths, diatoms, dinoflagellates, stable isotopes and physical properties.

5.4.6.2 Sediment sampling with gravity cores and piston cores

37 gravity- and piston cores, in a total of 220 m of sediments were recovered from 34 stations with recoveries which vary between 0.68 m and 12.56 m. Gravity coring was unsuccessful at stations GeoB 5530-1 and GeoB 5552-1, piston coring at station GeoB 5542-2.

24 cores were opened, described and sampled on board (Tab. 8, Figs. 25-47). After splitting, the archive section was described following the ODP nomenclature and sediment color was determined by comparison with the MUNSEL soil color charts. A color scanner was used to record the color of the fresh sediments at the 5 cm sampling interval (see spectrophotometry section). All core sections were photographed together with a color reference card.

On the working half of the split cores, four series of known volume samples, A, B, C and D were taken with 10 cm^3 syringes every 5 cm, starting at 3 cm below the top of the core. Series A will be analyzed for organic geochemistry and physical properties. Series B will be used for foraminiferal and stable isotope analyses, Series C will be used for coccoliths analysis and Series D for diatom analysis. On some cores a syringe series was taken also for sedimentology/dinoflagellate analyses. Tab. 8 summarizes the gravity core sampling.

Tab. 8 Gravity core sampling, METEOR cruise 42/4b

GeoB No.	Wate depth (m)	Recover (cm)	A-Corg	B-Serie Isotope Forams	C-Serie Coccolit	D-Serie Diatom	Sedi-mentology	Smearslid
5529-2	4163	188	38	38	38	18	-	8
5530-2	3982	148	30	30	-	-	-	-
5531-2	3288	500	100	100	100	100	-	21
5532-1	3142	254	51	51	-	-	-	15
5533-3	3245	259	52	52	-	-	-	9
5534-1	2825	231	46	46	-	-	-	-
5536-2	3455	880	176	176	88	176	-	17
5538-1	2543	1080	216	216	-	216	-	22
5541-4	1747	1252	250	250	63	-	-	23
5545-1	1431	1256	251	251	-	-	-	25
5546-2	1072	850	170	170	-	-	-	17
5547-1	1310	1050	210	210	-	210	-	22
5548-2	1161	739	148	148	-	148	-	17
5550-2	1739	1056	211	211	-	-	-	21
5551-3	1885	1014	203	203	-	-	-	32
5555-5	2848	234	47	47	47	47	-	6
5556-2	3169	521	104	104	-	-	-	17
5558-4	2472	976	195	195	-	195	-	8
5559-2	3177	585	117	117	-	117	117	18
5560-1	3944	469	94	94	24	-	94	6
5561-2	3501	434	87	87	44	-	87	7
5562-1	2895	85	17	17	9	-	17	-
5564-3	3968	710	142	142	-	-	142	18
5565-2	791	487	97	97	97	97	97	7

5.4.6.3 First shipboard results

Spectrophotometry

All opened gravity cores, except for GeoB 5529-2, GeoB 5530-2, GeoB 5534-1, and GeoB 5536-1, were submitted to light reflectance measurements at 31 wavelength channels in the range of visible light (400-700 nm). This method was used to quantify the colour of the sediment, and subsequently used as a tool to correlate different cores taken in similar depositional areas.

A Minolta CM-2002 hand-held spectrophotometer was used. The readings were taken immediately after splitting the core. The archive halves of the cores were scraped with a knife to expose a fresh, unsmeared surface for the measurements. This was then covered with a transparent plastic film to protect the camera. Measurements were taken every 5 cm, at the corresponding sampling positions of the work half. Before measurements were taken, the spectrophotometer was calibrated using a white calibration standard, covered with the same plastic film. All data were first stored in the instrument and then transferred to a personal computer.

Reflectance profiles at three wavelengths (400, 550, 700 nm) are shown next to the core diagrams. These should serve as a good overview of the sediment colour, since they cover most of the spectrum measured. Additionally, lightness (L*) and hue (H) profiles are given, which have shown to correlate well with carbonate content and terrigeneous material input, respectively.

Smear slide Analysis

An initial analysis of the components present in the sediments retrieved from the opened and described cores was investigated by means of smearslide analyses. The number of samples taken from each core varied depending on the homogeneity of the sediment and the occurrence of features of specific interest. However, the position of many samples was determined by changes in colour. Smearslides were prepared with Norland Optical Adhesive as a mounting medium, and dried under UV light for a minimum of 10 minutes. Slides were studied at 400X magnification on a Olympus BH-2 petrological microscope along random transects. Percent estimations were done using Rothwell's reproduction of Folk's series of comparative percentage diagrams as a guide (Rothwell, 1989). Sediment classification followed the ODP terminology (Dean et al., 1985). Downcore distribution of the major sediment components are presented in graphs next to the core description diagrams (Figs. 26-47).

Sites North of La Palma

3 gravity cores (GeoB 5529-2, GeoB 5530-2, and GeoB 5531-2) were taken north of the island of La Palma, which were all opened and described on board. These cores recovered 200, 68 and 510 cm of sediment, respectively. They are characterised by bioturbated, brown foram-bearing nannofossil mud with distinct intervals of coarse black volcanic sands. These intercalations have turbidite features such as cross-bedding, fining upwards and erosional contacts at their base.

Sites South of Canary Islands

2 gravity cores (GeoB 5532-1 and GeoB 5533-3) were taken on the southern slope of the island of Hierro. Sediment recovery was 248 and 259 cm, respectively. In the first core, brownish grey nannofossil muds are intercalated by up to 6 small turbidites of coarse volcanic and bioklastic sands. Additionally, a 65 cm-interval of volcanic muds and clays with volcanic clasts was present. The second core is characterised by several 2-5 cm thick volcanic sand layers and two distinct turbidites of coarse volcanic and bioklastic sands, within the sequence of grey foraminfera bearing nannofossil mud.

Gravity core GeoB 5534-1 was taken south of La Gomera, and we recovered 231 cm of sediment. Below the top 30 cm of brown foram bearing nannofossil mud, an interval of a muddy sand with abundant shell fragments and pteropods, wood remains and high water content was found, as well as several thin (1-4 cm) volcanic sand layers.

Cape Yubi Area

Two E-W transects of gravity cores were taken across the channel south of the Canary Islands, in the proximity of Cape Yubi (Morocco). 8 out of 12 gravity and piston cores from this area were opened on board (GeoB 5536-2, GeoB 5538-1, GeoB 5541-4, GeoB 5545-1, GeoB 5546-2, GeoB 5547-3, GeoB 5548-2, and GeoB 5550-2). Sediment recovery ranged from 755 to 1256 cm. The sediment characteristics are very similar for all cores described, and consisted mostly of overall homogeneous, foram bearing nannofossil mud and clayey mud. The most distinct feature for all cores was the olive green sediment colour below the brown top sediment.

Distinct horizontal burrow patterns, porcellaneous benthic foraminifera (milliolidae) , gastropods and H_2S smells were observed. "Cycles" of darker and lighter olive coloured sediment could be well recognised in cores GeoB 5541-4, GeoB 5545-2, GeoB 5546-2, GeoB 5547-3, GeoB 5548-2 and GeoB 5550-2. These patterns are reflected in the colourscan profiles, and were used to correlate between the different cores. Based on these correlations, we suggest that cores GeoB 5541-4 and GeoB 5546-2 have the highest relative sedimentation rates of this group.

In core GeoB 5536-2, the top of the *Gephyrocapsa* dominance interval (450-650 ka) was reached at 800 cm downcore, indicating a mean sedimentation rate of 1.5-2 cm/ka.

West of Fuerteventura and Lanzarote

In a transect going North between Gran Canaria and Fuerteventura, 6 gravity cores were recovered, and 4 opened (GeoB 5551-3, GeoB 5555-5, GeoB 5556-2, and GeoB 5558-4) west of the islands Fuerteventura and Lanzarote. All cores primarily consist of brownish grey foram bearing nannofossil mud, with occasionally distinct burrows. Additionally, core GeoB 5556-2 contains two sequences of mm- to cm-thick layered black volcanic sands and olive green muddy clays. Core GeoB 5558-4 contained sandy mud with a large variety in colours and intercalations of 5 cm thick volcanic ash layers.

Agadir Canyon Area

North-east from the Canary Islands, in the Agadir Canyon area the last 7 gravity cores of this CANIGO cruise were taken. 6 cores were opened and described on board (GeoB 5559-2, GeoB 5560-1, GeoB 5561-2, GeoB 5562-1, GeoB 5564-3, and GeoB 5565-2). Their sediment recovery ranges from 84 to 710 cm. The main lithology in these cores was (foram bearing) nannofossil mud and clay, with an exception in cores GeoB5564-3 and GeoB 5565-2, with prominent intervals of sandy, bioklastic foram sands were found.

In this area, the base of cores (or core catcher) consisted of a very light coloured, “sticky”, homogeneous nannofossil ooze, through smearslide analysis determined to be dominated by the coccoliths of *Gephyrocapsa* . This dominance interval was found in cores GeoB 5560-1 (at 390 cm), GeoB 5561-2 (at 410 cm) and GeoB 5562-1 (at 61 cm downcore). This implies mean sedimentation rates in these cores were well below 1 cm/ka.

Figs. 25-47 (core descriptions and legend; see separate zip-file)

5.4.6.4 Preliminary planktic foraminifera stratigraphy

(H. Meggers, P. Franke, J. Thiele)

Planktic foraminifera are often used to monitor past changes in the oceanic environment, particularly changes in temperature and salinity (Bé, 1977, Deuser & Ross, 1989, Ottens, 1991). Based on such results a preliminary shipboard planktic foraminiferal biostratigraphy analysis was attempted for 7 selected gravity cores (GeoB 5529, 5531, 5538, 5541, 5545, 5546 and 5556). The well-known Late Quaternary biostratigraphic zonation scheme based on the occurence of the *Globorotalia menardii* group in warmer isotopic stages 1, 5 and 7 (Ericson & Wollin, 1968) is not useful in these latitudes since this species group has its main distribution between 30°S and 20°N. Nevertheless, two stratigraphic key-species were used in a coarse fraction analyses: *Globigerinoides ruber* (white-variety) which shows clear maxima in northern and southern subtropical waters and is therefore used here as a warm water or interglacial indicator, and *Neogloboquadrina incompta* (or *Neogloboquadrina pachyderma* dextral) which is known to be abundant in subpolar water masses and is used here as a glacial indicator (Bé, 1977, Hemleben et al, 1989). This method derived from unpublished results on core material taken during the first CANIGO cruise in the Canary Island region (Leg M37/1) indicating clear maxima of *G. ruber* in isotopic substages 1.1, 5.5 and 7.3 correlated with minima in *N. incompta* percentages. The abundances of other key-species (e.g. *Globigerinoides sacculifer* or some rare specimen of *Globorotalia menardii* on the warm water-adapted side and *Turborotalita quinqueloba* as an other cold-water adapted species) confirm these results.

Samples were taken according to colour changes within the cores in a resolution of 10 to 50 cm. 5 cm^3 of sample material was sieved over a 125 µm mesh sieve, the coarse fraction was dried in an oven at 60° C and filled into glas tubes. Within 105 samples planktic foraminifera species and various other particles have been identified within the coarse fraction with a light microscope.

Cores GeoB 5529 and GeoB 5531 were taken in the oligotrophic area north of La Palma. The estimated sedimentation rate of 1-3 cm/1000 years is comparable to results calculated from an other oligotrophic core GeoB 4242 (unpublished data, M37/1). Since these cores are affected by turbidites, this calculation has strong uncertainities.

The cores GeoB 5538 to GeoB 5546 were recovered on a zonal transect along 27°30`N towards the African coast. Sedimentation rates increased from 3-4 cm/1000 years in the island-generated cyclonic eddy domain southwest of Gran Canaria towards values >10 cm /1000 years in the upwelling area off Cape Yubi. The maximum value of >11 cm/1000 years was estimated in the core GeoB 5546 located closest to shore (Fig. 48).

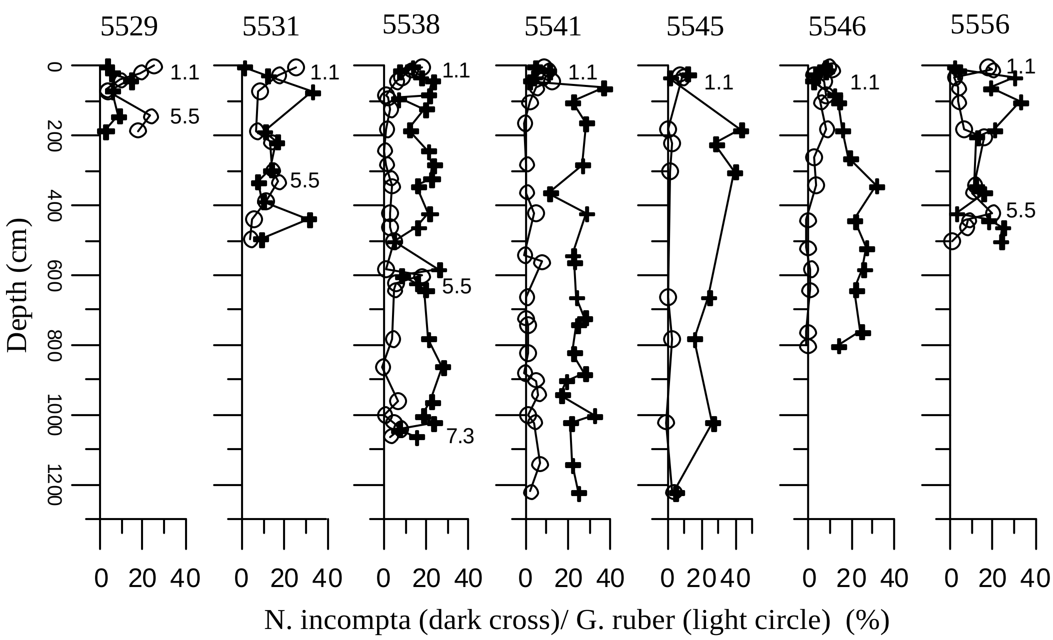

Fig. 48: The relative abundances of *Neogloboquadrina incompta* (dark cross) and *G. ruber* (white variety) (light circle) in cores GeoB 5529, 5531, 5538, 5541, 5545, 5546 and 5556. Isotopic substages 1.1, 5.5 and 7.3 are indicated

West of Fuerteventura/Lanzarote the core GeoB 5556 showed a sedimentation rate of 3-4 cm/1000 years indicating that this core was not strongly affected by upwelling processes or filament production (Fig. 48). The sedimentation rate was much smaller than that east of the islands (with values up to 10 cm/1000 years) indicating that at the western side of the islands long lasting upwelling did not occur during the past 130,000 years (compare with unpublished data, M37/1).

6. Ship's Meteorological Station

(K. Buhlmann, D. Bassek)

Weather and wind conditions during the cruise M42/4 of RV METEOR from Las Palmas to Viana do Castelo (26 September to 25 October 1998)

Normally the Atlantic subtropical high situated near the Azores and the Canary Islands lying in the zone of the trade winds, but in the third decade of September and in the beginning of October, however, the high was shifted southwards and reached from the Great Meteor bank to the Canary Islands and sometimes to Morocco. The reason for this deviation was the track of several tropical cyclones which took the short way from the tropics to the Azores and from there a course eastnortheast to the bay of Biscay and western Europe. As a result of this atmospheric circulation the trade winds were mostly weak or did not exist anywhere.

On 26 September when the first leg of the cruise M42/4 began RV METEOR sailed to the ESTOC-station, where a light trade wind with bft 3, occasionally 4 from eastnortheast was blowing for three days. On 30 September the wind increased to bft 5 from the northnortheast due to some pressurefall over northwestern Africa. Then in the next four days on the La Palma-station the wind was light and variable and sometimes calm. The first leg ended in Las Palmas on 6 October by northeasterly winds bft 4. During this cruise the sky was mostly fair and sometimes cloudy. The visibility was good and sand and dust from the Sahara was not observed.

When RV METEOR left Las Palmas on 8 October to the second part of the cruise the general circulation has changend. A large high with nearly 1040 hPa in its centre had developed in the sea-area northeast of Azores which caused strong trade winds with bft 6 and 7 from northeast. On 10th of october when RV METEOR sailed from the working area north of La Palma on the western side of the isle La Palma southwards an interesting phenomenom could be observed. By approaching the northern edge of the island in the afternoon the wind increased from bft 6 to gale force bft 8. Then one hour later the wind decreased rather quickly to bft 2 and turned to southwesterly directions accompanied by pressurefall nearly 4 hPa and dissipating clouds. The reason: In the leeside of the island a small low had developed which was caused by the 2400 m high mountains of the island. When RV METEOR had crossed this lee depression and reached the southern edge of La Palma winds increased again within a quarter of an hour to bft 8 with gusts up to bft 11 and continued in this gale force until the next morning, but got weaker during the day.

In the next days when RV METEOR was working in the southern and eastern parts of the Canary Islands the subtropical high was still dominating, but got weaker. So the wind amounted most of the time to bft 4 from northeast. On 17 of October a new high developed north of Madeira and the wind increased bft 5 to 6 for a time, but decreased bft 4 again, when we worked near the coast of Morocco. On 23 October in the evening RV METEOR took course northwards to Viana do Castelo by northeasterly winds bft 4 which turned southwesterly when we arrived the port of destination on 25 of October.

7. Station Lists

see PANGAEA data bank

8. References

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