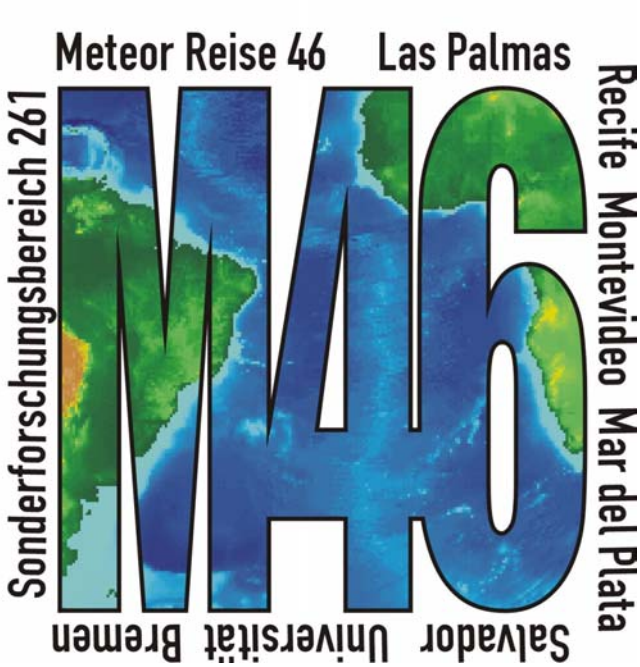
METEOR-Berichte 01-1

Geo Bremen South Atlantic 1999/2000

Part 1

Cruise No. 46, Leg 1

6 November – 29 November 1999, Las Palmas – Recife



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1.1 Participants M 46/1

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1.2 Research Program

In addition of transferring the ship to the South Atlantic as the main operational area of M 46, the emphasis during this first leg was put on the recovery/redeployment of moorings containing time-series sediment traps, on the sampling of dissolved and particulate trace elements, on the deployment of a special camera system, on the sampling of calcareous organisms, etc. The transit time between the stations was used for underway sampling of both chlorophyll a and dissolved iron pumped to the ships labs from the surface ocean and of aerosols sampled at one of the ship´s highest levels.

The Marine Chemistry programme aimed at a better understanding of the trace element cycling in the ocean. For this purpose the exchange processes between dissolved and particulate trace elements were studied. Uptake of dissolved trace elements onto particulate matter and subsequent sinking mechanisms (scavenging) exert major control on the chemical composition of seawater. The atmosphere, via dust deposition, provides significant inputs of both dissolved and particulate trace elements to the ocean. Many of the trace elements studied here with iron being a prominent example are essential for marine life. Thus, samples were collected for the analysis of trace elements in sinking particles (sediment traps) as well as in SPM (in-situ pumps) and the dissolved phase (GoFlo water samplers). Investigations were focussed on the upper 1200 m of the water column, as particle formation and remineralization processes take place mainly in this depth interval. At the mooring locations, however, the whole water column down to the sea floor was sampled. In addition, a few rain samples, aerosol particulates and surficial sediments were collected.

The Marine Geology program of the cruise is the extension of investigations of pelagic sediments in the tropical-subtropical Atlantic within the scope of the special research project SFB 261. During this cruise, surface sediment recovery was carried out with a multicorer. Sediment sampling took place preferentially at the sediment trap sites in the western Equatorial Atlantic (equatorial upwelling), in the oligotrophic Brazil basin and off West Africa close to the coastal upwelling. Sedimentological, micropaleontological, chemical and isotopic characteristics were determined at these sites. Marine plankton was sampled with the ships' membrane pump (three times a day); chlorophyll a concentrations in the surface waters are used to infer the seasonal and regional variability of biomass.

Seasonal particle sedimentation is monitored since several years in the western equatorial Atlantic and in the coastal upwelling area off NW Africa. For this purpose, three moorings with time-series sediment traps were installed on a SW-NE-transect through the Brasil basin during the METEOR cruise 41/4; another mooring was deployed off Cape Blanc (CB). All these arrays had to be recovered and were to be redeployed during this cruise. The objective is to obtain long-term information about productivity and export flux in the equatorial and coastal upwelling areas and to compare it with directly determined parameters. The particles collected will be investigated for species composition of planktonic organisms and their stable isotope composition ($\delta^{18}O$, $\delta^{13}C$), the trace element composition as well as for the composition of organic matter and terrigenous components.

Vertical particle concentration, size and distribution patterns in the water column were observed with an in-situ camera system (ParCa). The system utilizes a 70 mm photographic camera equipped with highly collimating strobelights. Images are digitized and analyzed for particle size and shape, in order to retrieve data on the vertical distribution of suspended and

sinking particulate matter in the subtropical and equatorial Atlantic Ocean. Profiles were taken especially in the equatorial upwelling regime. One aim was to quantify the amounts of SPM at different water depths, another aim is to correlate particle distibutions with CTD-derived density discontiuities in the water column.

To improve the quality and quantity of information gathered within the special research project 261 (SFB 261) on dinoflagellates during previous METEOR cruises, the regional distribution of cyst and test forming calcareous dinoflagellates had to be further analysed in surface waters and sediments during the cruise. The main aim of the METEOR cruise M 46 with respect to these organisms was to determine their major ecological, oceanographic and/or geological controlling factors (e.g. temperature, salinity, irradiance, nutrient supply, hydrodynamic variations, transport, preservation, reworking, etc.) and to determine their position in the water column. At a later stage these distributions can be used as models for palaeoecological interpretations in Quaternary sequences.

The Micropaleontology program aimed at the distribution patterns of dinoflagellate associations. Samples from the surface waters were collected several times a day by means of the ship's membrane pump during the whole cruise; from these samples, living individuals were isolated on board for culturing experiments; for further investigation, some of the samples were fixed and stored at 4°C. Furthermore, on every station water samples from different depths of the water column were taken from the rosette water sampler with focus on the depths of highest algae abundance. One core from the multicorer was taken at each station to investigate the associations of calcareous and organic walled dinoflagellate cysts in the sediments, which can be used as a proxy for glacial and interglacial climate fluctuations.

The main goal of the present research regarding coccolithophores was to determine their occurrence and distribution being directly dependent on the hydrography of the water masses. Since their fossil remains are important indicators for the reconstruction of provious ecological conditions, the ecological conditions for the composition and distribution of coccolithophore communities in the central Atlantic were investigated. The sampling program therefore comprised water samples for investigations of the coccolithophore communities in the uppermost 200 m and - during transit times - additional surface water plankton samples being obtained from the ship`s sea water pumping system.

The only biological programme during the cruise was performed by the Marine Microbiology group. For studies of the microbial colonisation of sinking particles in the water column (e.g. „marine snow"), samples from different depths (0-250 m) were collected with a Niskin water sampler. The samples were filtered to enrich particles and to isolate pure strains of attached heterotrophic bacteria. In addition, samples for the fluorescence in situ hybridisation were taken to investigate the existing groups of bacteria in the water column and on the particles. The samples are treated with the epifluorescence dye DAPI in order to count the bacterial cells of the free water column as well as the attached bacteria. The differentiation between live and dead is impossible with DAPI, so samples are treated also with Live/Dead-BacLight, a combination of two fluorescence dyes.

1.3 Narrative of the Cruise

The cruise M 46 leg1 of the Research Vessel METEOR began on November 6, 1999, at 8:30 a.m. when leaving the harbour of Las Palmas, Gran Canaria, in due time. Only 6 hours later the METEOR reached at its first station during this leg: the socalled ESTOC station, which is located 61 nm north of Gran Canaria. The station is used as a quasi-permanent time-series station by (mainly) Spanish and German scientists to identify the interannual variability of different biogeochemical processes. In the afternoon of this first day the mooring (CI 12) containing time-series sediment traps and several current meters, was re-deployed at exactly 29°11.9 N, 015°27.0 W. A similar set of devices had been recovered during the last cruise of RV METEOR a few days before. At 17:43 p.m. (in good time before sun set) the top buoy of the mooring vanished, meaning that the whole moored system was on its way to the sea floor (3609 m water depth). Afterwards, RV METEOR could start its 500 miles trip to the next station. This station at 22°15.0N, 020°30.0W (like all other following stations of this cruise) was located in the open sea, well outside the Exclusive Economic Zone of any country.

The cruise from Las Palmas to Recife was the first of the 4 legs of cruise M46 between Nov. 6, 1999, and March 13, 2000, which were organized by geologists from the University of Bremen to study oceanographic and geologic processes in the South Atlantic. The research during the first leg aimed at a comparison between the productive area off Northwest Africa and the oligotrophic open Southwest Atlantic off Brasil. Concomitantly, the (sub-)tropical sea areas off Africa experience a much higher dust deposition to the ocean surface as compared with regions off Brasil.

On Monday, Nov. 8 at 10:30 the second station (#626) of cruise M46/1 was reached where only the GoFlo rosette sampler and the profiling Particle-Camera were deployed. In the evening of the same day the sampling activities were started already at the next station which is of major significance due to its long-term mooring which is used to study the interannual variability of environmental properties. In the morning hours of Nov. 9 the mooring CB-9 was recovered and CB-10 was re-deployed within only 2 hours of the afternoon. The final position of this mooring is 21°17.20 N, 020°43.14 W at a water depth of 4125 m. Additional station work with 19 deployments of sampling devices, including the Niskin rosette sampler, the multi-net, the profiler for light attenuation, the GoFlo rosette sampler, the in-situ pumps and the multi-corer, lasted for another 22 hours. At the next station for the first time the multicorer was operated in addition to the devices used for water column sampling.

With blue sky and more than 24°C during the transit to #629 the METEOR started the work at the former mooring station CV (11°40 N, 021°00 W) at 21:00 of Nov. 12. Although the speed of the shafts revolutions had to be reduced due to the high water temperature, the sailing speed of the RV METEOR was still 12 knots. Since the beginning of the cruise the evaluation of satellite images showed a strong inter-tropical convergence zone (ITCZ) between 12°N and 7°N. Thus, during the following days heavy storms and intensive precipitation events often occurred. Since programs for the sampling of those precipitation events by using research vessels cannot be planned in advance, the opportunity was used to study the deposition of nutrients and trace elements to the surface ocean under the ITCZ. A prominent feature of these events was the short duration and the extreme rainfall of up to 74 mm in one hour. From more than 29.2°C for both the water and the air temperature at station 629, the air temperature decreased by 6 degrees during the transit to station #630 at 08°00 N, 021°45 W. The sampling program at this station

comprised deployments of the self-contained CTD, the particle camera, the GoFlo-rosette and the in-situ pumps. A similarly short program was also performed at the next station (04°00 N). When leaving the position a whirlwind was observed on Nov. 16. All the way south of 10°N it was tried to identify suitable positions for sediment coring in order to supplement the already existing suite of surface sediments in the equatorial region. A few miles south of #631 the multi-corer was deployed, the recovered tubes, however, were empty.

The three following stations(#633, #634, #635) were closely spaced (2° N, 0° N, 2° S) to investigate with all available water column sampling devices the equatorial upwelling in the vicinity of the mooring WA 15, which was recovered and re-deployed as WA 16 at 00°03.3 N, 23°28.2 W. The number of rain events dropped drastically in this region and the vessel was affected by SE trades with maximum speeds of 6 Bft. When passing the equator and entering the brasilian SISTRAM region, a short message was transferred to the Brasilian authorities. At prevailing fresh SE trades bringing air temperatures of about 26°C the sampling program at station #635 was finished on Nov. 21 at 04:27. In spite of the complicated bottom morphology at the following station (03°54 N, 25°35 W), the multi-corer came back from 5575 m to the surface with several tubes filled with sediments.

After 258 nm transit the station #637 was reached on Nov. 23 at 15:20. The sampling program lasted the whole night as usual, so that the mooring WA 14 could be recovered in only 3 hours soon after sun rise; in the afternoon of the same day the mooring was re-deployed as WA 17 in the northern Brasil Basin at 07°27.2 S, 028°12.8 W. The last sampling station of this cruise (#638) being located in the central Brasil Basin was occupied in the afternoon of Nov. 25. After deployments of in-situ pumps and the GoFlo-rosette which took the whole night due to the water depth of 5470 m, the mooring WAB 2 was recovered in the early morning hours and was re-deployed in the afternoon as 4800 m long WAB 3 from 12:47 to 15:14 (11°36.0 S, 028°31.7 W). Additional deployments of the pumps, the rosette sampler, the multi-corer with attached camera system lasted until Nov. 27 at 19:20 when the transit to Recife was commenced. The RV METEOR entered the 200 nm EEZ of Brasil on Nov. 28 at 14:00 and reached its destination port Recife in due time (08:36) where the cruise M 46/1 ended.

Summary: during M 46/1 altogether 13 stations (#625 to #638) were occupied and a total of 108 deployments of various instruments and devices was performed. In addition, four moorings were recovered and 5 moorings were deployed.The continuous recording systems HYDROSWEEP and PARASOUND were used at the stations, the two continuous pumps of the ship delivered surface water for which the Thermosalinograph recorded the properties.

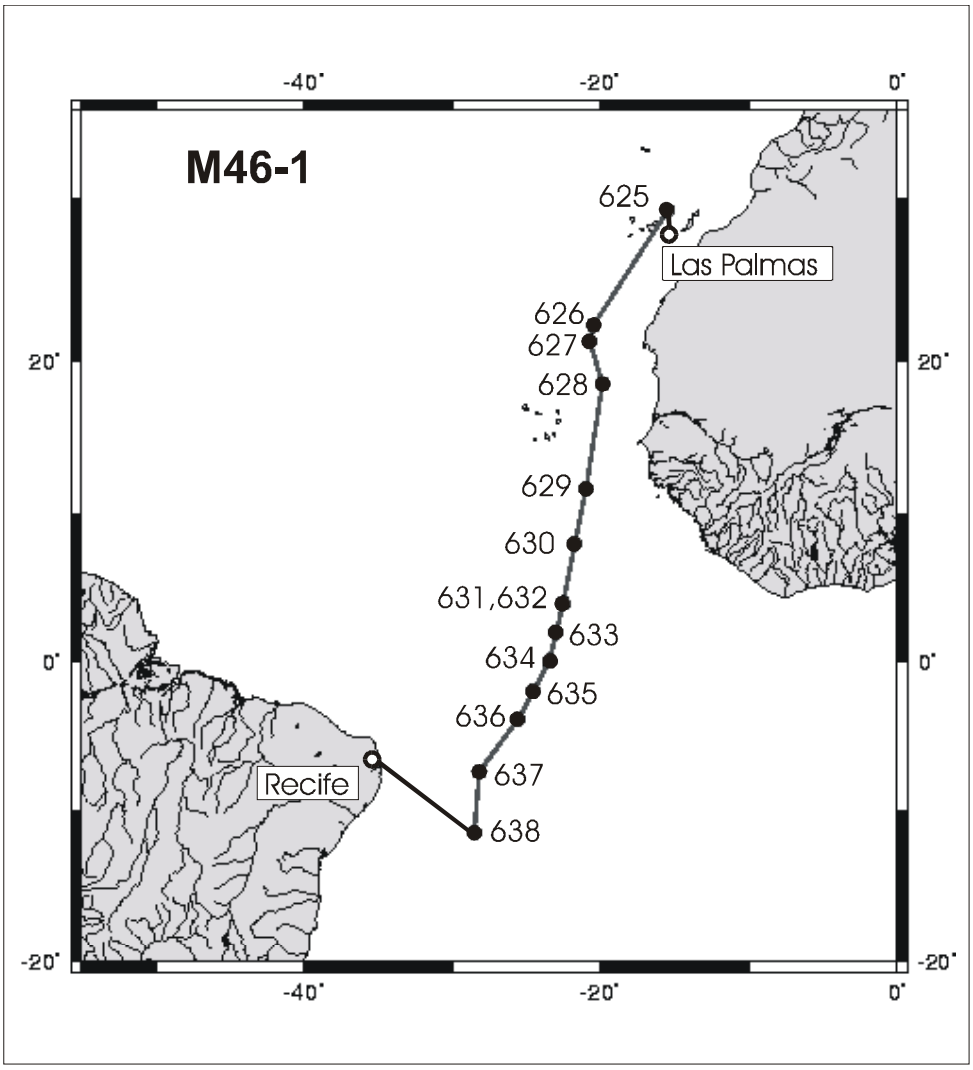

Fig. 1.1: Cruise track of METEOR cruise M 46/1 and locations of the stations.

1.4 Preliminary Results

1.4.1 CTD-O_2-Chlorophyll-Fluorescence/Turbitity Probe

(V. Ratmeyer, G. Fischer)

Sampling

CTD-profiles were taken either with a self-contained SBE 19 profiler equipped with a conductivity-temperature-depth probe plus oxygen sensor and a CHELSEA-fluorometer (SBE 19, No. 613A) or with a SEATECH transmissometer (SBE 19, No. 2069). All sensors from the SBE 2069 instrument were calibrated prior to the cruise by the manufacturer. The CTD was deployed 50 m above the bottom reaching multicorer, 20 to 50 m above the GoFlo-sampler and water sampler (KWS), or 10 m above the ParCa II video system. Profiles with the CTD were taken between 250 m and about 5600 m water depth (Table 1.1). The raw data were recovered on board and downcast standard plots were immediately produced for further particle sampling and information about the stratification of the water column, the oxygen minimum, and the occurrence of major water masses at the sampling sites. The oxygen sensor from the SBE 19

with the serial No. 613A revealed values which were too high and slightly drifting towards higher values in the deeper water column (>3000 m).

Preliminary Results

Some typical profiles are shown and described below (Figs. 1.2-1.4). Typical water masses recognized besides the surface waters and central water masses of the Subtropical Gyres were the AAIW, the NADW and the AABW. Off Cape Blanc, a chlorophyll fluorescence peak was found in about 80 m water depths within the seasonal thermocline. A deep oxygen minimum was observed in about 800 m depths in the AAIW (Fig. 1.2). Further south at site Cape Verde, a strong and shallow thermocline was developed and the main oxygen minimum was located in about 500 m water depth. Surface and subsurface water salinities were strongly reduced by more than one per mil in waters in the area of the Sierra Leone Rise between 4° and 8°N due to heavy rainfalls within the ITCZ (Fig. 1.3). Therefore, maximum salinity values were obtained between 50 and 80 m water depths where the chlorophyll fluorescence maximum was also found. Distinct oxygen minima (down to 2 ml l^{-1}) between 100 and 500 m water depths were obtained at the equator and further south to 4°S. In the Brazil Basin at 2° S to 11°S, we found the AABW below 4000-4300 m water depths. Partly, the turbidity sensor showed an increase in suspended particles in this water mass. South of 4°S, the chlorophyll fluorescence peaks (around 0.2-0.3 mg m^{-3}) were found below 100 m water depths in or at the top of the thermocline (Fig. 1.4).

Table 1.1: Stations at which CTD-profiles were obtained.

Station No. GeoB	water depths (m)	attached to....	equipped with.....
6102-3	4175	ParCa	transmissometer
6103-19	4118	ParCa	fluorometer
6104-3	3198	MUC	fluorometer
6105-4	4946	GoFlo	fluorometer
6107-2	4103	KWS	fluorometer
6107-4	4079	ParCa	transmissometer
6109-2	4335	ParCa	transmissometer
6109-3	4317	GoFlo	fluorometer
6110-7	3594	GoFlo	fluorometer
6110-8	3820	ParCa	transmissometer
6111-1	4936	GoFlo	fluorometer
6111-3	4910	ParCa	transmissometer
6112-1	5575	MUC	fluorometer
6112-4	5519	ParCa	transmissometer
6112-10	5520	GoFlo	fluorometer
6113-2	5559	GoFlo	fluorometer
6114-2	5455	GoFlo	fluorometer
6114-14	5478	MUC	transmissometer

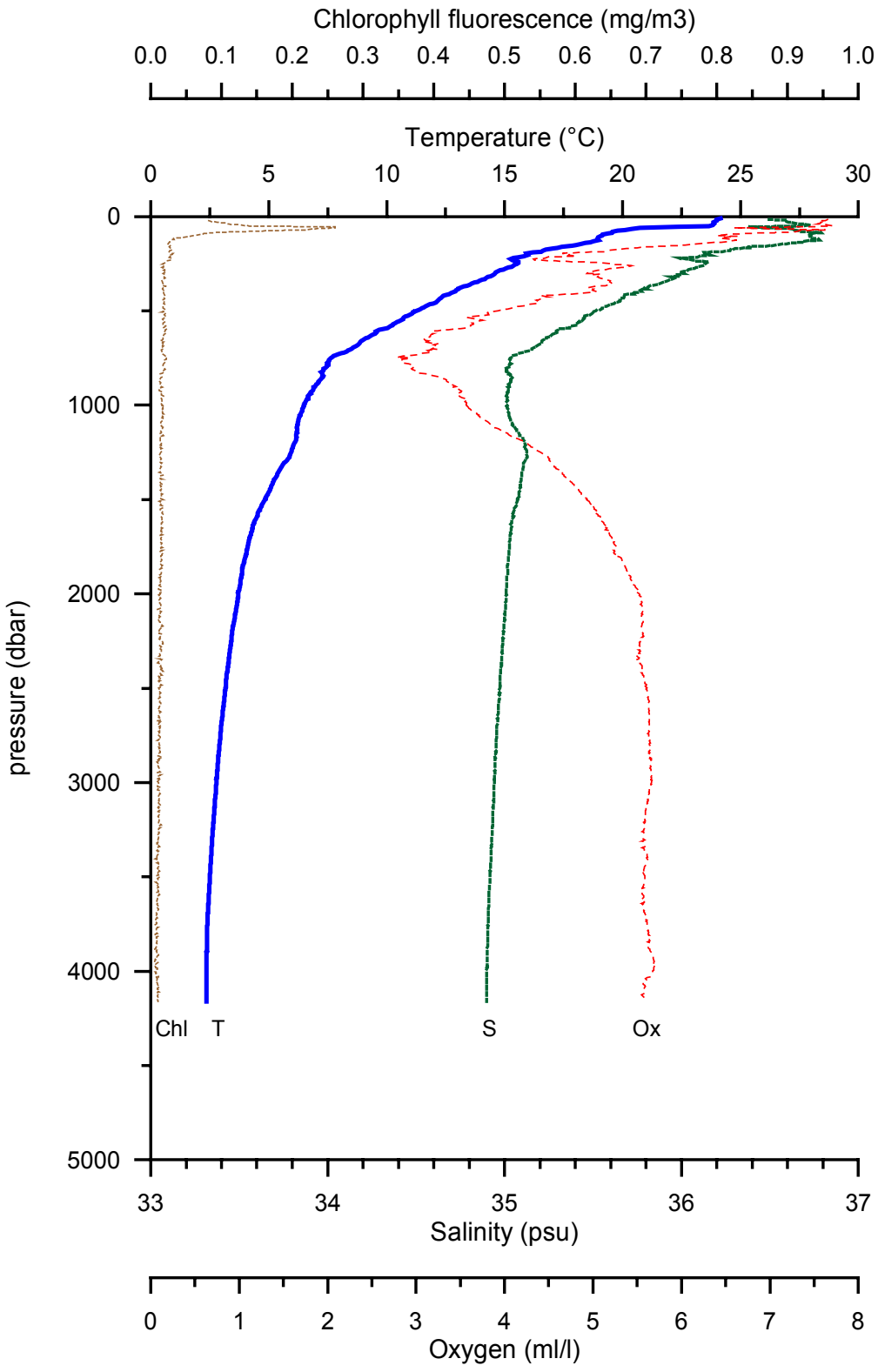

Fig. 1.2: CTD-O_2-chlorophyll fluorescence profile from site Cape Blanc (GeoB 6103-2).

Station GeoB 6107-2, Sierra Leone Rise

Position: ca. 4°N, 22°W

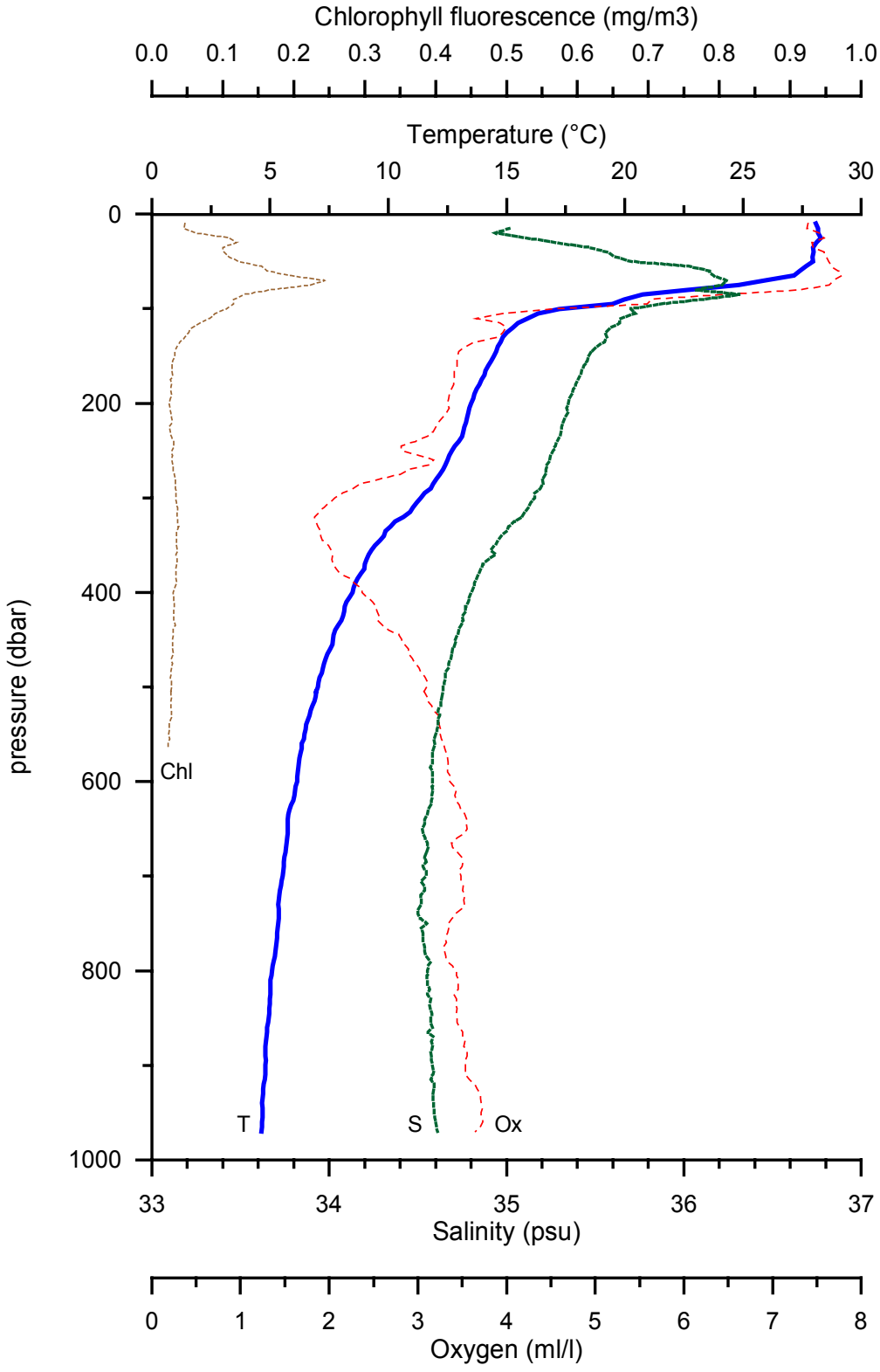

Fig. 1.3: CTD-O_2-chlorophyll fluorescence profile from the Sierra Leone Rise (GeoB 6107-2).

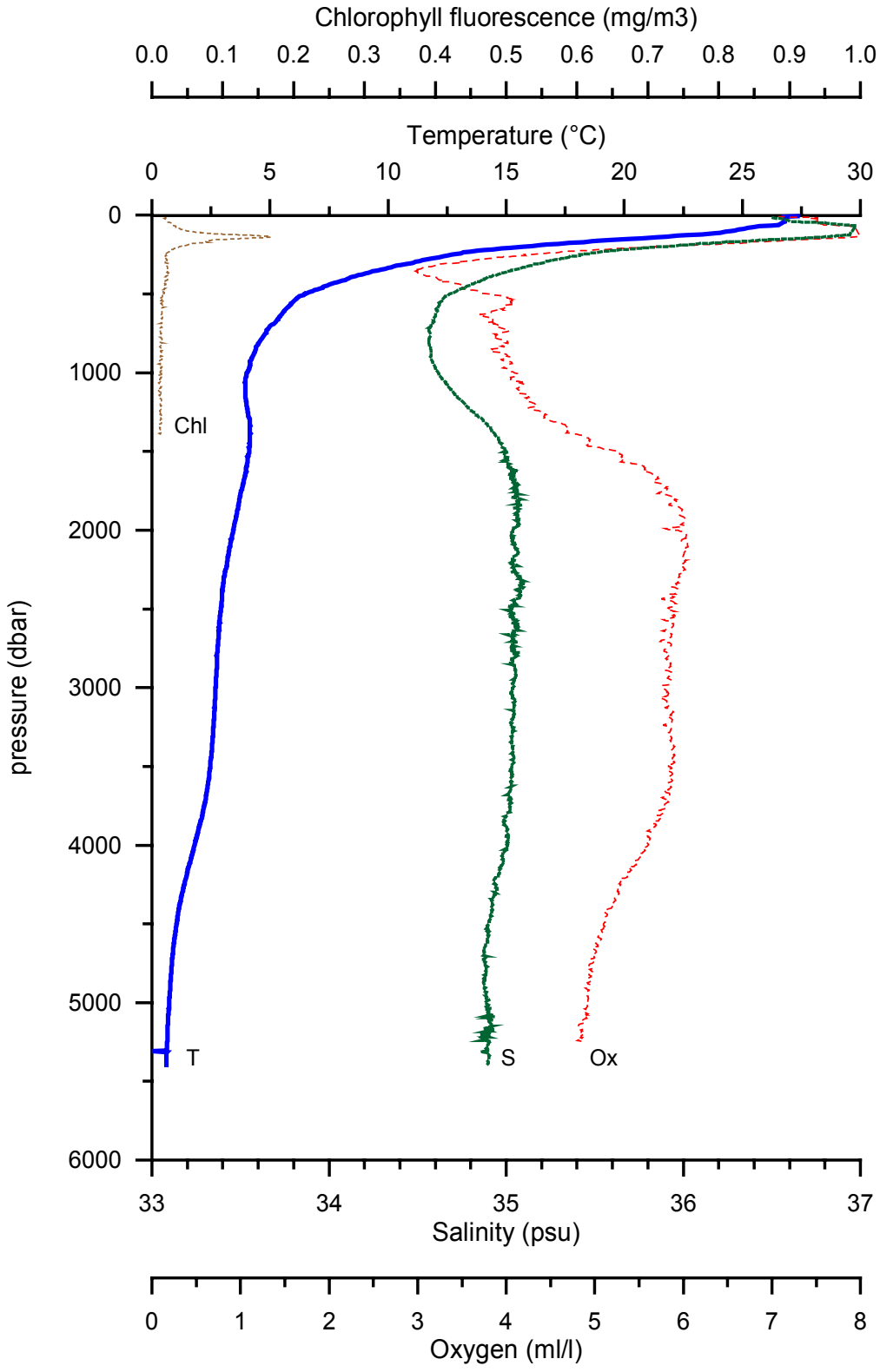

Fig. 1.4: CTD-O_2-chlorophyll fluorescence profile from site WAB (GeoB 6114-2).

1.4.2 Marine Chemistry

1.4.2.1 Dissolved Trace Metals and Hydrographic Parameters

(M. Gutsch, B. Brodherr, A. Deeken)

Particle-water interaction is a key process in the biogeochemical cycling of chemical elements in the ocean. Uptake onto particulate matter and subsequent sinking mechanisms (scavenging) exert the major control on the chemical composition of seawater. These processes keep the concentrations of many elements in seawater at very low levels. The particulate matter itself consists of (i) suspended particulate matter (SPM) which is supposed to consist of almost non-sinkable biogenic and terrestrial detritus with a large surface area and (ii) the relatively fast sinking particles found in particle traps, which are responsible for the vertical transport to the sediments. The comparison of the trace element composition and the distributions in these three different phases (dissolved, SPM and trap material) are expected to provide important clues on transport and sorption mechanisms as well as on the general geochemical behavior of these elements in the ocean. Many of the trace elements studied here, especially iron, are essential for marine life. The trace elements under investigation cover a broad range of chemical properties, thus enabling the study of biogeochemical processes in greater detail.

At the stations off Cape Blanc (CB), off Cabo Verde and at the Sierra Leone Rise, at four stations across the Western Equatorial Atlantic (4°N, 2°N, equator, 2°S), rosette samplers with GoFlo-bottles were used to study the vertical distribution of trace elements in the upper and partly also in the entire water column. To minimize contamination, GoFlo-bottles with pressure valves were employed, enabling the bottles to remain closed while passing through the surface layer; at a depth of 10-15 m these bottles open again before they are closed at depth. All manipulations after subsampling were performed under clean benches in a clean air lab container onboard. A total of 170 water samples were collected for nutrients, oxygen and trace element analysis (Table 1.2). The nutrients silicate, phosphate and nitrate were analyzed onboard according to standard photometric procedures. Immediately after collection, the oxygen content was determined by conventional Winkler titration.

After the water samples for trace elements were filtered through a polycarbonate filter (0.4 µm pore size) into a plastic container, they were acidified with subboiled HNO_3 for storage. The trace elements (primarily Cd, Co, Cr, Cu, Mn, Ni and Pb) will be analyzed onshore by employing graphite furnance atomic absorption spectrometry (GF-AAS) after separation from the sea water matrix and preconcentration by employing either conventional solvent extraction or by a procedure using complexing resins. Total dissolved aluminium was directly determined onboard employing a fluorometric method. In addition to the trace elements sampled with GoFlo-bottles, surface samples were taken every 30 nm for iron determinations in the home lab by using a chemiluminescence method.

Table 1.2: Station numbers and depths [m], for which trace elements samples (GoFlo-rosette) were obtained

#626	#627	#628	#630	#633	#635	#636	#638
5	9	9	12	4	11	7	10
15	19	11	25	10	21	10	30
25	29	24	49	20	50	20	50
75	49	27	51	50	70	50	70
100	79	50	84	70	90	70	90
125	79	85	86	90	126	90	125
150	89	87	125	125	175	125	200
200	99	125	199	175	250	175	300
300	125	199	201	250	400	250	399
400	150	201		400	700	400	600
500	201	400		1000	1000	549	800
	300				1499	699	1000
	400				1999	1000	1250
	500				2499		1500
	700	#629	#631	#634	2999	#637	1999
	702	7	5	5	3500	5	2450
	1000	11	10	10	3999	10	3000
	1250	20	20	21	4001	21	3499
	1500	50	50	51	4399	50	4400
	2000	70	70	71		70	4700
	2700	90	90	91		90	5100
	3720	125	125	125		126	5350
	3919	175	175	175		246	
	4020	400	250	250		400	
	4078	700	400	254		699	
	4107	1001	700	400		1000	
	4122		1000	700			
				1000			

1.4.2.2 In-situ Filtration of Suspended Particles

(A. Deeken, Ch. Grimmer)

As outlined above, the major key for the understanding of the the biogeochemical cycling of the chemical elements in the ocean is studying the particle-water interaction processes. The objective during this cruise was to increase our knowledge about the distribution of suspended trace elements and to investigate how it is related to particle sedimentation in high and low productivity regimes.

At the same stations where time-series sediment traps are deployed or have been operated before and at several stations in between, suspended particulate material (SPM) was filtered using in-situ pumps at different depths. The filtered suspended particulate material is supposed to consist of slowly sinking biogenic and terrestrial detritus exhibiting a large surface area for sorptive processes. Due to the low concentration of SPM large volumes of sea water have to be filtered, when trace elements are to be analyzed in the SPM. Between 20 L and 300 L sea water from depths down to 1000 m (at three stations down to the bottom) were filtered through acid cleaned polycarbonate filters (142 mm; 0.4 µm pore size) using in-situ pumps. To reduce contamination, a metal-free and non-greased KEVLAR wire was used and all handling of the filters was performed under a clean bench in the clean-air lab container. The pump deployments

yielded a total of 131 filters for trace elements (Table 1.3). In the home lab the filters with the retained particles will be subjected to a total dissolution procedure with nitric and hydrofluoric acid and analyzed for selected trace elements by ICP-MS.

Since very little is known about the relation between mineral (dust) and organic particles in the ocean, at most stations samples of suspended organic materials were also taken by filtering large volumes of seawater over pre-combusted GFF glassfiber filters. The determination of suspended trace elements gives results about the Al, Fe, Ti concentration from which the total amount of dust particles may be inferred. The concomitant analysis of organic and dust particles will be used for modelling studies on the significance of aggregation/disaggregation processes for the distribution of both refractory elements and organic carbon in the water column. In addition, it is intended to investigate the origin of the organic material by analyzing selected compound classes and by determining the ^{14}C age of the organic material on a few filters. For these purposes a total of 93 filters was obtained (Table 1.3). Filters which were lowered to depth but do not contain particles due to malfunction of the pump electronics will be used as procedural blanks for our method.

Table 1.3: Positions and sampling depths of the filters for trace elements and organic materials, respectively, which were obtained by in-situ filtration.

Station No.	Latitude	Longitude W	Water depth [m]	Sample depth [m]	Sample Volume [L]	Station No.	Filter size [mm]	Sample depth [m]	[Sample Volume [L]
				Trace elements			**Organic materials**		
627-10	21° 16.3 N	20° 41.9	4117	10	19.7	627-13	47	10	14.0
627-10	21° 16.3 N	20° 41.9	4117	30	11.2	627-13	47	30	24.0
627-10	21° 16.3 N	20° 41.9	4117	50	131.1	627-10	47	71	21.0
627-10	21° 16.3 N	20° 41.9	4117	70	19.2	627-10	47	126	56.0
627-10	21° 16.3 N	20° 41.9	4117	90	93.2	627-01	47	4111	0.0
627-10	21° 16.3 N	20° 41.9	4117	125	170.8	627-01	47	4123	72.0
627-13	21° 15.7 N	20° 42.6	4116	175	202.4				
627-13	21° 15.7 N	20° 42.6	4116	300	194.5				
627-13	21° 15.7 N	20° 42.6	4116	500	253.5				
627-13	21° 15.7 N	20° 42.6	4116	1000	204.4				
627-13	21° 15.7 N	20° 42.6	4116	2000	172.6				
627-13	21° 15.7 N	20° 42.6	4116	3200	177.4				
627-01	21° 17.0 N	20°42.9	4126	3726	253.5				
627-01	21° 17.0 N	20°42.9	4126	3926	347.5				
627-01	21° 17.0 N	20°42.9	4126	4026	312.3				
627-01	21° 17.0 N	20°42.9	4126	4076	217.4				
627-01	21° 17.0 N	20°42.9	4126	4099	189.0				
627-01	21° 17.0 N	20°42.9	4126	4114	213.7				
628-01	18° 34.0 N	19° 55.0	3199	10	111.6	628-01	47	12	19.0
628-01	18° 34.0 N	19° 55.0	3199	25	59.7	628-01	47	27	27.0
628-01	18° 34.0 N	19° 55.0	3199	50	141.2				
628-01	18° 34.0 N	19° 55.0	3199	100	287.3				
628-01	18° 34.0 N	19° 55.0	3199	200	269.6				
628-01	18° 34.0 N	19° 55.0	3199	400	281.9				
629-11	11° 40.4 N	20° 59.4	4945	10	16.1	629-01	142	10	442.0
629-11	11° 40.4 N	20° 59.4	4945	20	14.0	629-01	142	30	264.0
629-11	11° 40.4 N	20° 59.4	4945	50	116.3	629-01	142	50	557.5
629-11	11° 40.4 N	20° 59.4	4945	70	150.3	629-01	142	90	646.3
629-11	11° 40.4 N	20° 59.4	4945	90	75.0	629-01	142	150	60.2
629-11	11° 40.4 N	20° 59.4	4945	125	165.4	629-01	142	250	661.2
629-11	11° 40.4 N	20° 59.4	4945	250	0.0	629-01	142	500	531.3
629-11	11° 40.4 N	20° 59.4	4945	400	123.0	629-01	142	1000	560.7

Table 1.3: (continued) Positions and sampling depths of the filters for trace elements and organic materials, respectively, which were obtained by in-situ filtration.

Station No.	Latitude	Longitude W	Water depth [m]	Sample depth [m]	Sample Volume [L]	Station No.	Filter size [mm]	Sample depth [m]	[Sample Volume [L]
				Trace elements			**Organic materials**		
630-03	08° 00.9 N	21° 45.0	4188	10	31.2	630-03	47	12	15.0
630-03	08° 00.9 N	21° 45.0	4188	25	20.3	630-03	47	27	63.0
630-03	08° 00.9 N	21° 45.0	4188	50	17.2				
630-03	08° 00.9 N	21° 45.0	4188	100	177.9				
630-03	08° 00.9 N	21° 45.0	4188	200	187.0				
630-03	08° 00.9 N	21° 45.0	4188	400	189.3				
631-01	03° 59.8 N	22° 32.9	4099	10	115.0	631-05	142	10	266.0
631-01	03° 59.8 N	22° 32.9	4099	20	217.0	631-05	142	30	341.0
631-01	03° 59.8 N	22° 32.9	4099	50	122.1	631-05	142	50	280.0
631-01	03° 59.8 N	22° 32.9	4099	70	153.6	631-05	142	90	555.8
631-01	03° 59.8 N	22° 32.9	4099	90	169.9	631-05	142	150	497.0
631-01	03° 59.8 N	22° 32.9	4099	125	278.7	631-05	142	250	457.9
631-01	03° 59.8 N	22° 32.9	4099	250	296.7	631-05	142	500	489.3
631-01	03° 59.8 N	22° 32.9	4099	400	280.0	631-05	142	1000	456.8
633-01	01°59.9 N	23°00.2	4316	10	206.0				
633-01	01°59.9 N	23°00.2	4316	20	61.0				
633-04	01°59.9 N	22°59.1	4305	45	196.0				
633-04	01°59.9 N	22°59.1	4305	46	141.4				
633-04	01°59.9 N	22°59.1	4305	55	25.1				
633-04	01°59.9 N	22°59.1	4305	56	81.3				
633-01	01°59.9 N	23°00.2	4316	70	28.3				
633-01	01°59.9 N	23°00.2	4316	90	65.9				
633-01	01°59.9 N	23°00.2	4316	125	136.2				
633-01	01°59.9 N	23°00.2	4316	250	184.9				
633-01	01°59.9 N	23°00.2	4316	400	180.0				
633-04	01°59.9 N	22°59.1	4305	700	0.0				
633-04	01°59.9 N	22°59.1	4305	701	373.9				
633-04	01°59.9 N	22°59.1	4305	710	127.6				
633-04	01°59.9 N	22°59.1	4305	711	418.6				
633-01	01°59.9 N	23°00.2	4316	1000	194.2				
633-10	01°59.9 N	22°59.8	4320	1500	0.0				
633-10	01°59.9 N	22°59.8	4320	2500	129.0				
633-10	01°59.9 N	22°59.8	4320	3500	157.9				
633-10	01°59.9 N	22°59.8	4320	3900	160.3				
633-10	01°59.9 N	22°59.8	4320	4120	144.1				
633-10	01°59.9 N	22°59.8	4320	4220	146.0				
633-10	01°59.9 N	22°59.8	4320	4270	59.8				
633-10	01°59.9 N	22°59.8	4320	4295	156.8				
634-06	00°03.0 N	23°26.5	3692	10	86.0	634-09	142	10	342.0
634-06	00°03.0 N	23°26.5	3692	20	144.0	634-09	142	30	0.0
634-06	00°03.0 N	23°26.5	3692	50	18.7	634-09	142	50	282.2
634-06	00°03.0 N	23°26.5	3692	70	55.6	634-09	142	90	413.4
634-06	00°03.0 N	23°26.5	3692	90	138.9	634-09	142	150	421.1
634-06	00°03.0 N	23°26.5	3692	125	186.1	634-09	142	250	452.3
634-06	00°03.0 N	23°26.5	3692	250	195.0	634-09	142	500	500.4
634-06	00°03.0 N	23°26.5	3692	400	199.6	634-09	142	1000	442.5
635-02	01°59.5 S	24°33.6	4908	10	97.0	635-04	142	10	267.0
635-02	01°59.5 S	24°33.6	4908	20	197.0	635-04	142	20	327.0
635-02	01°59.5 S	24°33.6	4908	50	8.1	635-04	142	50	301.7
635-02	01°59.5 S	24°33.6	4908	70	30.7	635-04	142	70	138.4
635-02	01°59.5 S	24°33.6	4908	90	0.2	635-04	142	90	125.3
635-02	01°59.5 S	24°33.6	4908	125	211.1	635-04	142	125	442.9
635-02	01°59.5 S	24°33.6	4908	250	275.2	635-04	142	250	480.5
635-02	01°59.5 S	24°33.6	4908	400	270.4	635-04	142	400	460.6
635-07	02° 00.8 S	24°33.4	4938	700	187.8	635-07	142	700	281.0

Table 1.3: (continued) Positions and sampling depths of the filters for trace elements and organic materials, respectively, which were obtained by in-situ filtration.

Station No.	Latitude	Longitude W	Water depth [m]	Sample depth [m]	Sample Volume [L]	Station No.	Filter size [mm]	Sample depth [m]	[Sample Volume [L]
				Trace elements			**Organic materials**		
635-07	02° 00.8 S	24°33.4	4938	1000	0.6	635-07	142	1000	0.0
635-07	02° 00.8 S	24°33.4	4938	1500	218.9	635-07	142	1500	325.9
635-07	02° 00.8 S	24°33.4	4938	2000	334.4	635-07	142	2000	0.0
635-06	02° 00.8 S	24°33.4	4940	2500	67.5	635-06	142	2500	0.0
635-06	02° 00.8 S	24°33.4	4940	3000	215.2	635-06	142	3000	265.0
635-06	02° 00.8 S	24°33.4	4940	4000	207.3	635-06	142	4000	384.1
635-06	02° 00.8 S	24°33.4	4940	4600	205.1	635-06	142	4600	0.9
636-03	03°59.8 S	25°40.2	5518	10	12.0	636-05	142	10	12.0
636-03	03°59.8 S	25°40.2	5518	20	70.0	636-05	142	20	257.0
636-03	03°59.8 S	25°40.2	5518	50	24.9	636-05	142	50	224.1
636-03	03°59.8 S	25°40.2	5518	70	22.9	636-05	142	70	91.1
636-03	03°59.8 S	25°40.2	5518	90	30.4	636-05	142	90	113.8
636-03	03°59.8 S	25°40.2	5518	125	87.8	636-05	142	125	438.9
636-11	03°59.9 S	25° 38.9	5520	175	89.0	636-11	142	175	384.1
636-03	03°59.8 S	25°40.2	5518	250	192.2	636-05	142	250	375.2
636-11	03°59.9 S	25° 38.9	5520	400	169.9	636-11	142	400	455.4
636-11	03°59.9 S	25° 38.9	5520	700	182.8	636-11	142	700	347.2
636-11	03°59.9 S	25° 38.9	5520	1000	156.4				
637-01	07°24.4 S	28°11.6	5558	10	83.0	637-03	142	10	11.7
637-01	07°24.4 S	28°11.6	5558	20	26.7	637-06	142	10	11.7
637-01	07°24.4 S	28°11.6	5558	50	25.1	637-03	142	20	254.0
637-01	07°24.4 S	28°11.6	5558	70	16.2	637-03	142	50	249.5
637-01	07°24.4 S	28°11.6	5558	90	22.8	637-03	142	70	85.7
637-01	07°24.4 S	28°11.6	5558	125	50.3	637-03	142	90	96.9
637-06	07°24.7 S	28°10.8	5557	250	108.0	637-03	142	125	531.4
637-06	07°24.7 S	28°10.8	5557	398	266.5	637-03	142	250	353.9
637-06	07°24.7 S	28°10.8	5557	698	153.2	637-06	142	400	454.2
						637-06	142	700	432.7
						637-06	142	1000	253.5
638-15	11° 33.7 S	28° 30.7	5453	10	112.0	638-12	142	10	203.0
638-16	11° 33.7 S	28° 30.7	5454	30	63.0	638-15	142	30	9.1
638-16	11° 33.7 S	28° 30.7	5454	50	14.7	638-15	142	50	125.0
638-16	11° 33.7 S	28° 30.7	5454	90	32.2	638-16	142	70	119.0
638-16	11° 33.7 S	28° 30.7	5454	125	66.3	638-15	142	90	227.5
638-16	11° 33.7 S	28° 30.7	5454	250	190.9	638-15	142	125	97.4
638-15	11° 33.7 S	28° 30.7	5453	300	180.8	638-16	142	175	8.3
638-16	11° 33.7 S	28° 30.7	5454	400	181.3	638-15	142	250	207.0
638-12	11° 33.9 S	28° 30.8	5479	1000	198.4	638-15	142	400	242.5
638-12	11° 33.9 S	28° 30.8	5479	2000	130.1	638-12	142	700	328.3
638-09	11° 34.2 S	28° 30.7	5477	3000	1.0	638-12	142	1002	369.6
638-12	11° 33.9 S	28° 30.8	5479	3000	182.9	638-12	142	2002	182.9
638-09	11° 34.2 S	28° 30.7	5477	3900	115.7	638-09	142	2250	1.0
638-09	11° 34.2 S	28° 30.7	5477	4700	159.5	638-09	142	3002	371.6
638-01	11° 31.5 S	28° 31.0	5485	5115	332.0	638-09	142	3902	215.5
638-01	11° 31.5 S	28° 31.0	5485	5415	35.2	638-09	142	4702	296.5
638-01	11° 31.5 S	28° 31.0	5485	5465	218.5	638-01	142	4715	0.0
						638-01	142	5117	0.0
						638-09	142	5130	211.5
						638-01	142	5315	1.1
						638-01	142	5417	311.3
						638-01	142	5467	0.9

1.4.2.3 Aerosol and Rain Sampling

(W. Balzer, M. Gutsch)

Aerosol sampling was performed during parts of the cruise as a starting point for the study of the composition of suspended mineral particles in the ocean. Samples were obtained by filtering air from an inlet, which was positioned above the ship´s bridge, over acid-cleaned Nuclepore filters. Air was pumped at a rate of approximately 0.8 m³/h through the filter and the actual volume was recorded by a flowmeter. As a protection against short term rain events the filterholder was covered by a large plastic beaker. Potential contamination of the samples from fly ash of the ship´s smoke-stack was avoided by careful inspection of the relative wind direction. In general, during station work aerosol sampling was discontinued. Due to adverse winds and stronger precipitation (especially in the ITCZ) only a limited number of suitable intervals for aerosol sampling existed (c.f. Table 1.4). The filters will be subjected to a total dissolution procedure and analyzed for selected trace elements by ICP-MS.

During the transit through the ITCZ a number of precipitation events occurred which strongly varied in intensity between 0.1 and 10 mm precipitation per 10 minute interval. The sampling was performed at the level above the ship´s bridge by means of an acid-cleaned large funnel whose orifice was protected during non-sampling periods. When a rain event started, the cover was removed from the funnel and an acid-cleaned PE-bottle was screwed to the bottom of the funnel. Since the history of the rain events at the time of the sample start and their areal extent were unknown, a balance delineating the significance of the rain ingredients for the properties of the respective surface ocean cannot be constructed. Therefore, only a few characteristics of a few rain samples as determined by shipboard analysis are detailed here. The pH of the samples ranged from 4.2 to 5.1. Nutrient analysis revealed rather high nitrate concentrations in most samples of 11-37 µM but generally low phosphate (< 1µM) and low silicate values (< 1µM). Aluminum was determined by fluorimetry to check whether the low pH of the rain may dissolve a substantial portion of the abundant eolian dust particles associated with the rain. Indeed, three samples had Al concentration of 57-98 nM. One rain sample which may represent the first part of a longer rain event was 10 times higher in Al and NO_3^- , respectively, compared to the ranges given before, and was slightly above 1 µM for both phosphate and silicate.

Table 1.4: Durations and positions of the aerosol sampling intervals

Filter	Start			End			Filt. Vol.
	UTC	Lat	Long	UTC	Lat	Long	[m³]
X68	07.11.11:20	24°13N	17°38 W	08.11.12:35	22°16 N	20°30 W	22.047
X67	10.11.19:30	20°17 N	20°12 W	11.11.07:20	18°34 N	19°55 W	11.363
X143	11.11.11:30	18°34 N	19°55 W	12.11.11:15	13°37 N	20°42 W	20.94
X142	12.11.11:25	13°35 N	20°42 W	12.11.19:35	11°58 N	20°57 W	7.365
X109	13.11.22:42	10°56 N	21°06W	18.11.09:55	00°15 N	23°25 W	7.989
X106	18.11.10:05	00°15 N	23°25	19.11.13:10	00°20 S	23°35 W	18.902
X105	19.11.13:25	00°23.5S	23°39.6W	21.11.09:40	02°37 S	24°54 W	37.485
X52	21.11.09:48	02°42 S	24°57 W	22.11.20:00	04°12 S	25°48 W	28.255
X131	22.11.20:15	04°14 S	25°50 W	24.11.15:50	07°27 S	28°13 W	35.744
X130	24.11.17:05	07°27 S	28°14 W	26.11.14:00	11°36S	28°33 W	29.332
X74	26.11.15:00	11°36S	28°33 W	27.11.22:00	11°24 S	28°48 W	25.795
X73	27.11.22:10	11°24 S	28°48 W	28.11.23:20	09°43 S	31°48 W	23.158

1.4.3 Plankton Samples

1.4.3.1 Chlorophyll-a Measurements

(H. Buschhoff, G. Fischer)

For the determination of chlorophyll-a concentrations in the surface waters, seawater from the shipboard installed seawater pump ('Membranpumpe') was sampled at three times daily when sailing in international waters (Table 1.5). Two portions of 0.5 l seawater each were filtered onto a glass microfibre filter (Whatman, GF/F, 25 mm diameter). The samples were frozen at dark and will be analyzed by means of photometry at the laboratory in Bremen. The chlorophyll-a data should give information on seasonal and regional variability in biomass distribution. The results will be compared with satellite-derived chlorophyll concentration maps and may serve as calibration of these data.

Table 1.5: Sampling locations for chlorophyll-a measurements.

No.	Date	Time	location		Water-depth	Salinity	Water-temp.	Sample volume	Station
		UTC			(m)	(‰)	(°C)	(l)	
1 + 2	.07.11.99	19:20	18°25,3´W	24°49,8´N	2838	36,9	24,3	1	
3 + 4	08.11.99	08:29	20°14,5W	22°34,6N	4038	36,6	24,6	1	
5 + 6	08.11.99	12:24	20°29,9´W	22°15,6´N	4174	36,6	24,6	1	GeoB 6102
7 + 8	08.11.99	18:40	20°34,0´W	21°57,2´N	4179	36,6	24,7	1	
9 +10	09.11.99	07:51	20°42,5´W	21°14,6´N	4114	36,5	23,8	1	GeoB 6103
11+12	09.11.99	12:31	20°42,4´W	21°15,2´N	4118	36,5	24,0	1	GeoB 6103
13+14	09.11.99	19:00	20°43,3´W	21°16,3´N	4116	36,6	24,5	1	GeoB 6103
15+16	10.11.99	07:46	20°44,7´W	21°16,2´N	4134	36,6	24,1	1	
17+18	10.11.99	11:31	20°42,6´W	21°15,7´N	4117	36,6	24,1	1	
19+20	10.11.99	18:25	20°29,5´W	20°31,2´N	3809	36,2	25,1	1	
21+22	11.11.99	07:46	19°55,0´W	18°34,0´N	3199	35,8	27,0	1	GeoB 6104
23+24	13.11.99	07:43	21°00,1´W	11°40,6´N	4946	35,0	29,0	1	GeoB 6105
25+26	13.11.99	19:35	21°01,1´W	11°32,8´N	4961	35,3	29,1	1	
27+28	14.11.99	09:30	21°45,2´W	09°09,1´N	4131	35,1	28,8	1	
29+30	14.11.99	16:41	21°44,9´W	08°00,0´N	4101	34,7	28,5	1	GeoB 6106
31+32	15.11.99.	08:39	22°31.3´W	05°48,5´N	3874	34,5	28,7	1	
33+34	15.11.99	13:21	22°20,6´W	05°0,6´N	3925	34,8	2839	1	
35+36	15.11.99	20:31	22°33,0´W	03°60,0´N	4099	34,8	29,0	1	GeoB 6107
37+38	16.11.99	08:49	22°32,4´W	04°00,6´N	4069	34,9	28,8	1	GeoB 6107
39+40	16.11.99	21:21	22°57,3´W	02°29,6`N	3995	35,1	28,9	1	
41+42	17.11.99	08:57	22°59,1´W	01°59,9´N	4305	35,3	28,4	1	
43+44	18.11.99	09:31	23°21,6´W	00°28,3´N	3552	35,7	28,2	1	
45+46	18.11.99	20:48	23°26,4´W	00°03,2´N	3686	35,8	27,8	1	GeoB 6110
47+48	19.11.99	15:32	23°51,5´W	00°42,4´S	4163	35,9	27,2	1	
49+50	19.11.99	21:51	24°27,8´W	01°48,8´S	3462	36,1	27,0	1	
51+52	20.11.99	15:39	24°34,0´W	02°00,5´S	4966	36,0	27,0	1	GeoB 6111
53+54	21.1.199	09:54	24°5735´W	02°42,8´S	5059	36,0	26,8	1	
55+56	21.11.99	15:36	25°29,2´W	03°40,4´S	5571	36,0	27,2	1	
57+58	22.11.99	09:12	25°39,6´W	04°00,7´S	5518	36,0	27,0	1	GeoB 6112
59+60	23.11.99	09:59	27°27,2´W	06°24,7´S	5614	36,1	27,2	1	
61+62	23.11.99	15:52	28°09,2´W	07°21,2´S	5560	36,1	27,4	1	
63+64	24.11.99	10:10	28°13,2´W	07°27,3´S	5549	36,1	27,2	1	GeoB 6113
65+66	24.11.99	20:40	28°16,6´W	07°54,3´S	5503	36,1	27,3	1	
67+68	25.11.99	10:02	28°26,1´W	10°15,5´S	6240	36,3	27,3	1	
69+70	25.11.99	15:54	28°31,2´W	11°24,3´S	5472	36,3	27,4	1	
71+72	26.11.99	11°29	27°35,4´W	11°35,7´S	5479	36,2	27,3	1	GeoB 6114

1.4.3.2 Plankton and Water Sampling using a Multiple Closing Net

(H. Buschhoff, G. Fischer)

Plankton was sampled with a multiple closing net (Fa. HYDROBIOS) with 0.25 m2 opening and 64 µm mesh size. It was used for vertical hawls at 4 sites (see: 1.6 Station List). Each multinet station comprised two hawls with:

a. depth intervals from 500-300, 300-200, 200-100, 100-50 and 50-0 m.

b. depth intervals from 250-100, 100-75, 75-50, 50-25 and 25-0 m.

Hawl 1 will be used for studies on planktonic foraminifera, hawl 2 for geochemical and isotopic analyses. The samples containing mostly zooplankton and some phytoplankton were carefully rinsed with seawater into KAUTEX bottles, fixed with mercury chloride for the reduction of bacterial degradation, and stored at 4°C. At all stations, 1.5 l NISKIN-bottles were used during the first and the third hawl to obtain water samples from the different water depths for analyses of carbon and oxygen stable isotopes and phytoplankton investigations. To obtain a better depth resolution and to extend the regional distribution, we also collected water for stable isotope analysis from other devices such as the multicorer and two water samplers (KWS, GoFlo; Table 1.6).

Table 1.6: Sites where water samples for $\delta^{13}C$ and $\delta^{18}O$ analyses were taken. Water samples taken from several devices (MN=multinet, MUC=multicorer, KWS=water sampler, GoFlo=clean water sampler).

Station GeoB	depth (m)	$\delta^{13}C$	$\delta^{18}O$	Position Latitude Longitude	Device
6103-2	4127	x x	x	21°17,0´N 20°43,0´W	MUC
6103-4	10	x x	x	21°15,2`N 20°42,4´W	KWS
	20	x x	x		
	150	x x	x		
6103-12	500	x	x	21°16,2´N 20°42,0´W	MN
	300	x	x		
	200	x	x		
	100	x	x		
	50	x	x		
	25	x	x		
6104-3	3199	x x	x	18°34,0´N 19°55,0´W	MUC
6105-5	4946	x x	x	11°40,6´N 21°00,0´W	MUC
6109-9	4401	x x	x	02°10,1´N 22°59,4´W	MUC
6110-12	10	x x	x	00°04,0´N 23°24,0´W	KWS
	20	x x	x		
	50	x x	x		
	75	x x	x		
	150	x x	x		
	250	x x	x		
6110-13	500	x x	x	00°04,2´N 23°23,4´W	GoFlo
6112-1	5531	x x	x	03°53,8´N 25°35,5´W	MUC
6112-7	10	x x	x	04°00,0´N 25°39,5´W	KWS
	20	x x	x		
	50	x x	x		
	75	x x	x		
	150	x x	x		
	250	x x	x		
6113-4	500	x x	x	07°24,6´S 28°11,1´W	MN
	300	x x	x		
	200	x x	x		
	100	x x	X		
	50	x x	X		

Table 1.6: (continued) Sites where water samples for $\delta^{13}C$ and $\delta^{18}O$ analyses were taken. Water samples taken from several devices (MN=multinet, MUC=multicorer, KWS=water sampler, GoFlo=clean water sampler).

Station GeoB	depth (m)	$\delta^{13}C$	$\delta^{18}O$	Position Latitude Longitude	Device
6113-8	10	x x	X	07°27,7´S 28°14,1´W	KWS
	20	x x	X		
	150	x x	X		
6114-4	10	x x	X		KWS
	20	x x	X		
	150	x x	X		

1.4.3.3 Dinoflagellate Investigations

(A. Freesemann, C. Höll, A. Meyer)

Dinoflagellates are unicellular, biflagellated organisms forming a major part of the phytoplankton. They live in all aquatic environments and can be found from tropical to arctic regions. This extremely variable group of organisms can either live planktic, benthic, parasitic or symbiotic and feed autotrophic, mixotrophic and/or heterotrophic. In general, the free-living (motile) dinoflagellates live in the upper water column were either enough light for photosynthesis or, in case of heterotrophic feeding strategy, enough food in form of other phytoplankton or organic debris is available. The majority of dinoflagellates lives marine-planktic with highest diversity in tropical regions.

During their life cycle, dinoflagellates undergo certain stages: a motile vegetative thecate stage and a cyst stage. Dinoflagellates in the motile vegetative thecate stage usually consist of cellulose, the only exception being the calcareous-walled vegetative coccoid Thoracosphaera heimii. The fossilisable cysts can be either organic- or calcareous-walled.

Motile dinoflagellates react sensitive to their environment, therefore it can be assumed that changes in the environmental conditions lead to changes in the dinoflagellate assemblage and cyst association. A number of studies have shown that dinoflagellate cysts are a useful tool in reconstructing palaeoenvironments. However, the knowledge about calcareous cyst forming dinoflagellates is still quite limited. For a better understanding of the palaoecological signals of this group it is necessary to investigate the recent geographic and vertical distribution of these organisms in comparison to the prevailing environmental parameters such as salinity, temperature, light, nutrient supply, stratification / mixing etc.. Furthermore, culturing experiments are very useful to obtain information about the ecological preferences of the calcareous dinoflagellates. For these purposes water- and sediment samples were taken during the cruise.

Surface water samples

Surface water samples from a depth of approximately 5 m were collected between the stations three times a day (7:00 - 10:00; 12:00 - 15:00; 17:00 - 20:00 board time) using the ships membrane pump (Table 1.7). A measured amount of water passed a 100 µm- and a 5 µm-filter and was concentrated down to 150 ml using a 5 µm polycarbonate filter and a vacuum pump system. These samples were qualitatively analysed with a light microscope and briefly described regarding their plankton content with emphasis on the calcareous cysts of the dinoflagellates and the calcareous shell of Thoracosphaera heimii. Some of the living cysts were isolated and placed

in sterile polytrene Cell WellsTM containing 0,2 µm-filtered sea water and different types of culturing media (f/2 35%, K 35% and a 1:1 mixture of these with sea water) for future culturing experiments carried out at the University of Bremen. On board the Cell Wells™ were kept under light conditions of the local day / night cycle and a temperature of ca. 20°C. After the isolation step the water samples together with the filters were fixed using about 10 ml formaldehyde (37%) and stored in the dark at 4°C.

Water column studies

At seven stations water samples from seven various water depths were acquired (Table 1.8) using a rosette (Multi Water Sampler MWS, cat. nr. 436918A). Six of the 10 L NISKIN-bottles were closed at each water depth, so the rosette had to be used three times at each station. Ca. fifty litres of each water depth were passed over a 100 µm mesh sieve (DIN 4188) and filtered using a vacuum pump in order to concentrate the samples to a volume of 150 ml per each water depth. These samples then were treated in the same way as the surface water samples taken with the membrane pump.

Of the remaining ten litres of each water depth four litres were taken for pigment analyses. These samples were concentrated on glass microfibre filters and afterwards stored in the dark at -20°C. For nitrate analyses ca. 55 ml water of each depth were taken and stored at -20°C.

Light measurements

Photosynthetic organisms require different light regimes depending on their particular photosynthetic pigments. Thus, the comparison of the depth distribution of autotrophic dinoflagellates and the corresponding underwater irradiance properties might elucidate patterns of preferred depths and migration. The MER-2040 Profiling Spectroradiometer (Biospherical Instruments) allows monitoring of apparent optical properties during vertical profiles from the ship. In addition to a PAR broad-band (400-700 nm) sensor, 14 down- and 14 upwelling monochromatic sensors (narrow bandwidths) measure the spectral irradiance. At seven stations light profiles were recorded to a water depth of 100 m (Table 1.9). All profiles were driven at a winch speed of 0.5 m/sec. Later on, the data will be related to surface irradiance measurements. The real depth data, given by a pressure transducer, will also be calculated later.

Surface sediment samples

At five stations sediment samples were taken of the multicorer (Table 1.10). The surface sediments (fluffy material of the upper cm of the core) together with some of the bottom water were stored in petri dishes. The remaining core was cut into slices of 1 cm and also stored in petri dishes at 4°C. The aim of further investigations is to analyse the dinoflagellate cyst content, its changes in time and to compare it with environmental factors in order to gain information about environmental and climatic changes.

Preliminary results

Motile thecate dinoflagellates were found in almost all water samples.

In the surface water samples provided by the membran pump calcareous dinoflagellate cysts and shells of *Thoracosphaera heimii* were found in low amounts south of 23°N. *Orthopithonella granifera* was observed between 23°N and 20°N. Cysts of *Sphaerodinella albatrosiana* and *S.*

tuberosa occurred from 5°N to further southwards. Organic-walled cysts (*Impagidinium* spp.) were rarely observed in the samples.

In the water samples aquired with the rosette from seven various depths calcareous dinoflagellates were found in most of the samples. At station GeoB 6103 (Cape Blanc) only two calcareous dinoflagellate species were observed (*O. granifera*, *T. heimii*). In this profile *O. granifera* shows a depth-related occurrence with highest abundance at 75 m water depth, high abundance at 50 m and 100 m, and low abundance at the other water depths. At station GeoB 6105 (Cape Verde) *O. granifera*, *T. heimii, S. tuberosa* and *Calciodinellum pacificum* were observed in low amounts with no relation to certain water depths. The same species and additionally *S. albatrosiana* were detected at station GeoB 6109 (WA 2°N) above 120 m, and at station GeoB 6110 (WA 0°) in all investigated water depths. At stations GeoB 6112 (WA 4°S) and GeoB 6113 (WA 7°30'S) all latter named species, with exception of *O. granifera*, were observed.

From first sight on board, no clear water depth related occurrence of the single calcareous dinoflagellate species was observed, with exception of O. granifera at station GeoB 6103. The last named species was not recorded south of the equator.

Table 1.7: Surface water samples for dinoflagellate analyses. Sampling with 5µm vacuum pump filtration.

Sample No.	Time of sampling start and end UTC	Latitude Start and end of sampling	Longitude Start and end of sampling	Air temp. (°C)	Water temp. (°C)	Salinity (‰)	Volume of filtered water (m^3)
11/7/a	7:15	26°51.45´N	17°00.75´W	22.7	23.4	36.8	0.071
	9:50	26°26.14´N	17°17.85´W	23.1	23.9	36.9	
11/7/b	12:13	26°02.04´N	17°34.07´W	23.2	24.1	36.9	0.217
	14:53	25°33.78´N	17°52.80´W	23.6	24.5	36.09	
11/7/c	17:12	25°09.23´N	18°09.23´W	23.3	24.4	36.9	0.016
	19:53	24°42.47´N	18°31.31´W	23.3	24.2	36.9	
11/8/a	7:05	22°48.12´N	20°03.54´W	23.5	24.5	36.7	0.033
	9:50	22°20.97´N	20°25.38´W	23.4	24.6	36.6	
11/8/c	17:37	22°10.25´N	20°31.16´W	24.5	24.7	36.6	0.027
	19:57	21°41.30´N	20°37.58´W	23.4	24.3	36.7	
11/10/c	17:14	20°45.59´N	20°33.65´W	23.5	24.1	36.3	0.004
	no data	20°12.15´N	20°23.73´W	23.2	25.8	35.9	
11/11/b	12:13	18°08.86´N	19°59.05´W	25.0	27.1	35.7	0.1
	14:50	17°36.19´N	20°04.18´W	25.3	27.5	36.0	
11/11/c	17:00	17°11.86´N	20°08.18´W	25.8	27.6	36.0	0.021
	19:50	16°37.56´N	20.13.50´W	25.5	27.2	36.0	
11/12/a	7:04	14°23.24´N	20°34.63´W	26.1	27.9	35.3	0.244
	9:59	13°48.68´N	20°40.11´W	26.9	28.6	34.7	
11/14/a	8:04	09°17.20´N	21°35.25´W	27.2	28.7	35.2	0.117
	10:20	08°59.25´N	21°45.20´W	26.5	28.9	35	
11/15/a	8:05	05°55.17´N	22°10.07´W	26.9	28.4	34.2	0.465
	10:51	05°22.45´N	22°16.62´W	27.2	28.8	34.6	
11/15/b	13:06	05°03.45´N	22°19.88´W	27.5	28.9	34.8	0.086
	15:51	04°34.76´N	22°26.75´W	25.4	29.0	34.8	
11/15/c	18:10	04°12.65´N	22°30.52´W	25.9	29.1	34.9	0.057
	19:26	03°59.86´N	22°32.88´W	26.3	29.0	34.7	
11/16/b	13:07	03°56.42´N	22°33.77´W	26.7	28.8	34.9	0.321
	16:31	03°18.00´N	22°42.51´W	27.7	28.9	35.1	

Table 1.7: (continued) Surface water samples for dinoflagellate analyses. Sampling with 5µm vacuum pump filtration.

Sample No.	Time of sampling start and end UTC	Latitude Start and end of sampling	Longitude Start and end of sampling	Air temp. (°C)	Water temp. (°C)	Salinity (°/oo)	Volume of filtered water (m^3)
11/16/c	18:24	03°02.56´N	22°54.66´W	26.6	29.3	35.1	0.535
	20:00	02°28.46´N	22°57.42´W	26.9	28.8	35.2	
11/18/a	8:03	00°43.27´N	23°17.98´W	26.5	28.4	35.5	0.070
	11:00	00°05.17´N	23°27.11´W	26.3	27.4	35.8	
11/19/b	13:08	00°18.58´S	23°36.22´W	26.3	27.5	35.8	0.008
	15:58	00°50.70´S	23°56.34´W	no data	no data	no data	
11/19/c	18:06	01°09.19´S	24°06.36´W	26.5	27.0	36.1	0.094
	21:02	01°40.09´S	24°23.18´W	25.6	27.0	36.1	
11/21/b	13:00	03°13.88´S	25°14,48´W	26.1	27.0	36.0	0.154
	16:00	03°46.35´S	25°32.53´W	26.6	27.2	36.0	
11/22/c	19:08	04°03.73´S	25°41.98´W	26.6	27.1	36.0	0.134
	21:04	04°21.68´S	25°55.83´W	26.2	27.1	36.1	
11/23/a	08:07	06°06.71´S	27°13.83´W	25.8	27.1	36.1	0.145
	10:53	06°33.43´S	27°33.69´W	26.2	27.2	36.1	
11/23/b	13:15	06°55.88´S	27°50.33´W	26.4	27.3	36.1	0.201
	15:51	07°21.05´S	28°09.16´W	26.8	27.4	36.1	
11/25/a	08:02	09°54.95´S	28°24.62´W	25.5	27.3	36.2	0.010
	10:54	10°25.36´S	28°26.86´W	25.5	27.3	36.3	
11/25/b	13:03	10°51.64´S	28°28.79´N	25.9	27.2	36.3	0.016
	16:01	11°25.55´S	28°31.24´W	26.1	27.2	36.3	

Table 1.8: Water samples for analyses of dinoflagellates, pigments and nitrate from 10 l NISKIN bottles at about 10, 20, 50, 75, 100, 120, 150 m water depth taken during cruise M 46/1. Filtration with 5µm poly-carbonate filters.

Sample No.	Time Start End UTC	Water depth (m)	Volume of filtered water (l)	Salinity (°/oo)	Water temperature (°C)	Latitude	Longitude
Station 6103-4/5/6	12:22	4118				21°15.20´N	20°42.41´W
10 m	14:00		50	36.4	no data		
20 m			50	36.4	no data		
50 m			50	36.3	no data		
75 m			46	36.2	21.8		
100 m			50	36.2	21.0		
120 m			49	36.2	19.9		
150 m			48	35.5	19.8		
Station 6105-7/8/9	14:03	4946,6				11°40.33´N	20°59.7´W
10 m	15:34		37	35.1	28.9		
20 m			49.2	35.4	28.0		
50 m			50	35.5	20.5		
75 m			50	35.3	17.4		
100 m			49.8	35.2	16.7		
120 m			49.9	35.1	15.9		
150 m			50	35.1	16.0		

Table 1.8: (continued) Water samples for analyses of dinoflagellates, pigments and nitrate from 10 l NISKIN bottles at about 10, 20, 50, 75, 100, 120, 150 m water depth taken during cruise M 46/1. Filtration with 5µm poly-carbonate filters.

Sample No.	Time Start End UTC	Water depth (m)	Volume of filtered water (l)	Salinity (‰)	Water temperature (°C)	Latitude	Longitude
Station 6109-5/6/7	11:39	4311				1°59,72´N	22°39,37´W
10 m	13:00		46	35.2	27.9		
20 m			50	35.5	27.9		
50 m			45	35.6	27.7		
75 m			51.5	36.1	25.0		
100 m			46.5	35.5	18.5		
120 m			50	35.3	17.4		
150 m			50	35.0	17.3		
Station 6110-3/4/12	15:45	3730				00°06,04´N	23°27.62´W
10 m	16:45		49.5	35.6	27.8		
20 m			50	35.6	27.9		
50 m			50	36.0	25.9		
75 m			50.5	36.2	24.6		
100 m			50	35.9	20.1		
120 m			50	35.5	18.5		
150 m			50	35.1	17.6		
Station 6112-7/8/9	12:30	5518				04°0.015´S	25°39.43´W
10 m	14:00		48	36.2	27.0		
20 m			50	36.0	27.0		
50 m			51	36.1	27.1		
75 m			50	36.0	26.1		
100 m			50	35.9	21.8		
120 m			49.5	35.7	19.5		
150 m			50	34.9	17.3		
Station 6113-8/9/10	11:13	5547				07°27.72´S	28°14.04´W
10 m	13:00		48.5	36.2	26.8		
20 m			51	36.2	26.9		
50 m			50	36.2	26.4		
75 m			49.9	36.3	26.6		
100 m			49.9	36.0	25.0		
120 m			49.8	36.3	23.6		
150 m			50	36.1	21.1		
Station 6114-4/5/6	11:39	5466				11°36.09´S	28°35.46´W
10 m			49.9	36.5	27.0		
20 m			50	36.4	27.0		
50 m			50.5	36.6	26.8		
75 m			50.1	36.8	25.2		
100 m			50	36.8	24.8		
120 m			49.9	36.7	23.6		
150 m			50	36.3	22.1		

Table 1.9: Light measurements in combination with dinoflagellate analyses using a MER-2040 Profiling Spectroradiometer.

Station No.	Latitude	Longitude	Water depth (m)	Time UTC
6103-16	21°15.7´N	20°42.5´W	4117	10:40
6105-6	11°40.3´N	20°59.7W	4946	13:43
6109-8	02°00.3´N	22°59.3´W	4314	12:17
6110-3	00°06.1´N	23°27.8´W	3733	15:09
6112-6	04°00.1´S	25°39.06´W	5519	12:10
6113-11	07°27.3´S	28°13.5´W	5547	13:00
6114-7	11°36.0´S	28°35.35´W	5466	13:10

Table 1.10: Sediment samples for dinoflagellate analyses. Sampling was done using the Multicorer.

Station No.	Date	Time UTC	Latitude	Longitude	Water depth (m)	Core length (cm)
6103-2	09.11.99	05:47	21°17.0´N	20°43.0´W	4120	35
6104-3	11.11.99	07:56	18°34.0´N	19°55.0´W	3198	25
6109-9	17.11.99	14:50	02°10.1´N	22°59.4´W	4409	4
6112-1	21.11.99	18:05	03°53.8´S	25°36.5´W	5541	33 cm

1.4.3.4 Coccolithophore Communities

(K.-H. Baumann)

Coccolithophores, which are autotrophic, marine algae (Prymnesiophyceae), form a major component of the oceanic microplankton and are one of the main open ocean primary producers. Their cell surfaces are covered by minute external calcite scales with a complex ornamentation. These coccoliths constitute the single most important component of deep-sea sediments and provide floral, and biomarker signals for interpreting global change in the geological record. Therefore, they are extensively used in paleoecological and paleoceanographical studies (e.g., McIntyre and Bé, 1967; Winter and Siesser, 1994).

Knowledge of their living occurrences as well as their distribution in surface sediments is a prerequisite for palaoecological and palaeoceanographical studies using coccoliths as proxies in Quaternary sediments. However, the environmental parameters that control their distribution are still poorly understood. In addition, there have been only few studies that have provided information on the distribution and occurrence of coccolithophores in surface waters of the equatorial Atlantic (McIntyre and Bé, 1967; Baumann et al., 1999).

Therefore, an investigation of the living coccolithophore communities in the South Atlantic was carried out in the uppermost water column. At 12 stations water samples were taken from NISKIN-bottles of the rosette generally from 6-10 water depths between 5 and 250m (see Table 1.11). In addition, 56 surface water samples were taken from the vessel's membrane pump system at about 5 m water depth along the ship's transect (Table 1.12). Of these, 15 samples were filtered for alkenone analysis. Samples were taken about every latitude, and collection time usually was at dawn, noon, twilight and in the night.

Generally, the up to 2l of water were filtered through cellulose nitrate filters (25 mm diameter, 0,45 µm pore size) by means of a vacuum pump immediately onboard. Without

washing, rinsing or chemical conservation the filters were dried at 40°C for at least 24 h and then kept permanently dry with silica gel in transparent film to protect them from humidity. The filtered material will be used for studies on the distribution and composition of the coccolithophore communities using Scanning Electron Microscope (SEM). Species composition and abundance will be determined by identification and counting on measured filter transects. For alkenone analysis 30-90l of water were filtered through glass microfibre filters (Whatmann GF/F, 25mm diameter). The samples were immediately frozen and will later be analysed by capillary gas chromatography.

Table 1.11: Surface water sampling for coccolithophore analysis (Rosette samples).

GeoB No.	Sample No.	Equipment	Location Latitude	Location Longitude	Water Depth (m)	Sampling Depth (m)	Water Temp. (∞)	Sali-nity (psu)	Filter Vol. (L)	Remarks
Cape Blanc										
6102-2	I-1	ROS12	22°15.5'N	20°30.0'W	4174	5	24.3	36.45	1.5	--
	I-2					25	24.15	36.55	1.5	
	I-3					75	18.94	36.53	1.5	!Niskin 50m open!
	I-4					100	18.74	36.58	2.0	
	I-5					150	16.71	36.17	2.0	
	I-6					200	15.55	35.95	2.0	
6103-3	II-1	ROS18	21°15.2'N	20°42.4'W	4118	5	24.0	36.6	1.0	--
	II-2					20	23.99	36.60	1.0	
	II-3					50	23.67	36.65	1.5	
	II-4					75	19.81	36.66	1.5	
	II-5					100	19.13	36.73	2.0	?problems with filter?
	II-6					150	18.01	36.53	2.0	?problems with filter?
	II-7					200	15.95	36.14	2.0	
	II-8					250	15.51	36.14	2.0	
6103-15	II-10	ROS12	21°15.6'N	20°42.5'W	4118	125	18.99	36.78	2.0	additional samples
	II-11					175	16.73	36.28	2.0	
6104-2	III-1	ROS12	18°34.0'N	19°55.0'W	3199	10	26.56	35.8	1.5	--
	III-2					25	26.60	35.87	1.5	
	III-3					50	19.81	36.43	2.0	
	III-4					85	16.93	36.15	2.0	
	III-5					125	14.73	35.62	2.0	
	III-6					200	13.12	35.51	2.0	
Cape Verde										
6105-4	IV-1	ROS12	11°40.5'N	21°00.1'W	4947	7	28.7	35.2	2.0	--
6105-7	IV-2	ROS18				20	28.59	35.35	1.5	
	IV-3					50	17.34	35.90	2.0	
	IV-4					75	15.36	35.59	2.0	
	IV-5					100	14.57	35.50	2.0	
6105-4	IV-6	ROS12				125	13.81	35.41	2.0	
6105-7	IV-7	ROS18				150	13.33	35.36	2.0	
	IV-8					200	12.65	35.30	2.0	
	IV-9					250	11.87	35.21	2.0	
Sierra Leone Rise										
6106-1	V-1	ROS12	08°00.0'N	21°44.9'W	4185	5	28.05	34.75	1.5	--
	V-2					25	27.57	35.48	1.5	
	V-3					50	20.24	35.91	1.5	
	V-4					85	15.52	35.49	2.0	

Table 1.11: (continued) Surface water sampling for coccolithophore analysis (Rosette samples).

GeoB No.	Sample No.	Equipment	Location Latitude	Location Longitude	Water Depth (m)	Sampling Depth (m)	Water Temp. (∞)	Sali-nity (psu)	Filter Vol. (L)	Remarks
Sierra Leone Rise										
6107-2	VI-1	MP	04°00.5'N	22°32.8'W	4101	5	28.39	34.75	1.5	--
	VI-2	ROS18	03°57.8'N	22°33.0'W	4104	20	28.30	35.03	1.5	
	VI-3					50	27.47	35.96	1.5	
	VI-4					75	21.76	36.07	1.5	
	VI-5					100	16.18	35.60	1.5	
6107-3	VI-6	ROS12				125	14.89	35.39	1.5	
6107-2	VI-7	ROS18				150	14.41	35.33	1.5	
	VI-8					200	13.39	35.20	2.0	
Equatorial Atlantic										
6109-3	VII-1	ROS12	01°59.8'N	22°59.5'W	4318	4	27.75	35.26	1.5	--
	VII-2					20	27.70	35.59	1.5	
	VII-3					50	27.66	35.75	1.5	
	VII-4	ROS18				75	26.93	36.24	1.5	
	VII-5					100	16.59	35.78	2.0	
	VII-6	ROS12				125	14.72	35.56	2.0	
	VII-7					175	13.56	35.39	2.0	
	VII-8					250	12.00	35.17	2.0	
6110-12	VIII-0	ROS18	00°04.0'N	23°24.0'W	3832	10	27.42	35.65	1.5	--
	VIII-1					20	27.42	35.65	1.5	
	VIII-2					50	25.15	36.06	1.5	
	VIII-3					75	20.58	36.27	2.0	
	VIII-4					100	17.03	35.79	2.0	
6110-7	VIII-5	ROS12	00°03.2'N	23°26.4'W	3816	125	14.91	35.45	1.5	
6110-12	VIII-6	ROS18				150	13.80	35.28	2.0	
6110-13	VIII-7	ROS12				175	13.56	35.23	1.75	Niskin bottle nearly empty
6110-12	VIII-8	ROS18				200	13.51	35.22	2.0	
	VIII-9					250	11.15	34.97	2.0	
6111	IX-1	MP	02°00.0'S	24°33.1'W	4860	5	26.5	35.91	2.0	--
6111-1	IX-2	ROS12	01°59.9'S	24°34.1'W	4930	20	26.50	35.91	1.5	
	IX-3					50	26.40	35.93	1.5	
	IX-4					70	23.74	35.99	1.5	
	IX-5					90	15.87	35.69	1.5	
	IX-6					125	13.99	35.30	2.0	
	IX-7					175	13.38	35.20	2.0	
Northern Brazil Basin										
6112	X-1	MP	04°00.0'S	25°39.7'W	5521	5	26.65	36.04	2.0	= MP #46!
6112-7	X-2	ROS18	04°00.1'S	25°39.4'W	5518	10	26.67	36.08	2.0	
	X-3					20	26.69	36.09	2.0	
	X-4					50	26.59	36.04	2.0	
	X-5					75	26.57	36.02	1.75	
	X-6					100	23.99	35.94	1.5	
6112-2	X-7	ROS12				125	15.61	35.61	2.0	Niskin bottle rested over night
6112-7	X-8	ROS18				150	13.72	35.37	2.0	
6112-10	X-9	ROS12				175	12.77	35.23	1.75	
6112-7	X-10	ROS18				200	12.56	35.20	2.0	
6112-2	X-11	ROS12				250	11.72	35.09	2.0	
6113-8	XI-1	ROS18	07°27.7'S	28°14.1'W	5547	20	26.83	36.25	1.75	(MP#50 = 5m)
	XI-2					50	26.81	36.40	1.75	
	XI-3					75	26.80	36.63	2.0	
	XI-4					100	24.75	36.69	1.5	
6113-2	XI-5	ROS12	07°24.4'S	28°11.6'W	5559	125	21.88	37.02	1.75	
6113-8	XI-6	ROS18				150	18.14	36.69	2.0	
6113-2	XI-7	ROS12				175	14.27	36.09	2.0	
6113-8	XI-8	ROS18				200	11.98	35.59	2.0	
	XI-9					250	10.18	35.14	2.0	

Table 1.11: (continued) Surface water sampling for coccolithophore analysis (Rosette samples).

GeoB No.	Sample No.	Equipment	Location Latitude	Location Longitude	Water Depth (m)	Sampling Depth (m)	Water Temp. (∞)	Sali-nity (psu)	Filter Vol. (L)	Remarks
Brazil Basin										
6114-4	XII-1	ROS18	11°36.1'S	28°35.5'W	5467	10	26.79	36.16	1.5	
	XII-2					20	26.82	36.54	1.75	
	XII-3					50	26.66	36.81	2.0	
	XII-4					75	25.42	37.01	2.0	
	XII-5					100	24.50	37.11	2.0	
	XII-6					120	23.30	37.00	2.0	
	XII-7					150	20.22	36.59	2.0	
	XII-8					200	15.73	35.86	2.0	
	XII-9					250	12.72	35.41	2.0	

Table 1.12: Surface water sampling (membrane pump) for coccolithophore analysis.

Sample No.	Date 1999	Time (UTC)	Location Latitude	Location Longitude	Water Depth (m)	Sample Depth (m)	Water Temp. (°C)	Sali-nity (psu)	Filter Vol. (L)	GeoB No/ Remarks
Canary Islands to Cape Blanc										
1	07.11.	07:45	26°40.0'N	17°06,7'W	3637	5	23.8	36.9	2	--
2		12:15	26°01.5'N	17°34.3'W	3490	5	24.2	36.9	2	--
2a		12:15	26°01.5'N	17°34.3'W	3490	5	24.2	36.9	1	Subsample
3		14:40	25°35.0'N	17°53.1'W	3208	5	24.4	37.0	2	--
4		14:40	25°35.0'N	17°53.1'W	3208	5	24.4	37.0	30	Alkenonsample
5		18:50	24°54.2'N	18°21.8'W	2863	5	24.4	36.9	1.5	--
6		23:15	24°08.4'N	18°58.4'W	2999	5	24.3	36.9	1	--
7	08.11.	07:55	22°40.3'N	20°09.7'W	3990	5	24.5	36.65	1.5	--
8a		08:35	22°31.8'N	20°16.7'W	4054	5	24.5	36.6	1	--
8b		08:35	22°31.8'N	20°16.7'W	4054	5	24.5	36.6	1.5	Subsample
9		08:35	22°31.8'N	20°16.7'W	4054	5	24.5	36.6	2x30	Alkenonsample
10		19:30	21°47.0'N	20°36.3'W	4167	5	24.6	36.6	1	--
11		22:10	21°17.0'N	20°42.9'W	4126	5	24.4	36.6	1.5	GeoB 6103
12		22:10	21°17.0'N	20°42.9'W	4126	5	24.4	36.6	2x20	Alkenonsample GeoB 6103
Cape Blanc										
14	10.11.	18:50	20°25,0'N	20°27.5'W	3761	5	25.2	36.1	1.5	--
15		23:20	19°33.0'N	20°12.1'W	3416	5	25.7	36.1	1.5	--
16	11.11.	08:10	18°34.0'N	19°55.0'W	3200	5	27.0	35.8	1.5	GeoB 6104
17		08:10	18°34.0'N	19°55.0'W	3200	5	27.0	35.8	2x30	Alkenonsample GeoB 6104
18		12:30	17°58.0'N	20°00.6'W	3195	5	27.3	35.8	1.5	--
Way to Cape Verde										
19		17:30	17°05.0'N	20°09.1'W	3385	5	27.8	35.8	2	--
20		20:05	16°32.9'N	20°14.3'W	3526	5	27.2	36.0	2x25	Alkenonsample (!!KP!!)
21a		22:30	16°05.0'N	20°18.6'W	3955	5	27.1	36.0	1.3	--
21b		22:30	16°05.0'N	20°18.6'W	3955	5	27.1	36.0	0.7	--
22	12.11.	08:05	14°09.5'N	20°36.8'W	4299	5	28.3	34.9	1.5	--
23		14:00	13°00.0'N	20°47.6'W	4625	5	28.8	35.18	1.5	--
24		14:00	13°00.0'N	20°47.6'W	4625	5	28.8	35.18	2x30	Alkenonsample
25		22:30	12°07.0'N	20°55.8'W	4847	5	29.0	35.3	1.5	--
26	13.11.	13:30	11°40.3'N	20°59.6'W	4947	5	29.1	35.2	2x25	Alkenonsample GeoB 6105

Table 1.12: (continued) Surface water sampling (membrane pump) for coccolithophore analysis.

Sample No.	Date 1999	Time (UTC)	Location Latitude	Longitude	Water Depth (m)	Sample Depth (m)	Water Temp. (°C)	Sali-nity (psu)	Filter Vol. (L)	GeoB No/ Remarks
Way to Equator										
27		23:50	10°41.7'N	21°11.9'W	5094	5	28.7	35.5	1.5	--
28	14.11.	07:00	09°17.7'N	21°34.0'W	4316	5	28.7	35.2	1.5	--
29		12:05	08°23.0'N	21°45.2'W	4417	5	28.3	34.5	1.5	--
30		18:10	08°00.0'N	21°45.0'W	4185	5	28.5	34.5	3x20	Alkenonsample GeoB 6106
31		23:50	07°17.0'N	21°53.7'W	3443	5	28.5	35.0	1.5	--
32	15.11.	08:22	05°40.0'N	22°13.0'W	3818	5	28.8	34.64	1.5	--
33		13:20	05°00.0'N	22°20.5'W	3925	5	28.9	34.81	1	--
34		18:00	04°01.0'N	22°32.9'W	4011	5	28.9	34.85	3x20	Alkenonsample GeoB 6107
35	16.11.	09:00	03°22.5'N	22°41.4'W	3985	5	29.1	35.07	2	--
36		21:00	02°33.5'N	22°56.9'W	3995	5	28.2	35.1	1.5	--
Equatorial Atlantic										
37	17.11.	13:00	02°08.0'N	22°59.5'W	4374	5	28.15	35.26	3x20	Alkenonsample GeoB 6109
38	18.11.	09:10	00°32.0'N	23°20.7'W	3539	5	28.3	35.7	1	--
39		15:13	00°06.1'N	23°27.8'W	3732	5	28.0	35.75	1.5	GeoB 6110
40		15:13	00°06.1'N	23°27.8'W	3732	5	28.0	35.75	4x20	Alkenonsample GeoB 6110
41	19.11	15:45	00°44.5'N	23°52.8'W	4169	5	27.1	36.0	1.5	--
42		19:41	01°26.0'N	24°15.5'W	4855	5	27.0	36.1	2	--
43	20.11.	09:01	02°00.0'N	24°33.1'W	4860	5	26.9	36.03	3x30	Alkenonsample GeoB 6111
44	21.11.	09:49	02°42.0'N	24°57.0'W	5065	5	26.8	36.0	1.5	--
45		14:43	03°31,3'N	25°24.2'W	5614	5	27.2	36.0	2	--
46	22.11.	09:07	04°00.0'S	25°39.7'W	5521	5	27.0	36.04	2	GeoB 6112
47		09:07	04°00.0'S	25°39.7'W	5521	5	27.0	36.04	4x20	Alkenonsample GeoB 6112
South Equatorial Atlantic										
48		23:11	04°56.9'S	26°22.2'W	?6090	5	27.1	36.06	1.5	--
49	23.11.	09:47	06°22.5'S	27° 25.6'W	5613	5	27.2	36.1	1.5	--
50		20:47	07°24.5'S	28°11.1'W	5559	5	27.3	36.11	1.5	GeoB 6113
51		20:47	07°24.5'S	28°11.1'W	5559	5	27.3	36.11	2x30	Alkenonsample GeoB 6113
52	24.11.	01:44	08°49.7'S	28°19.9'W	5530	5	27.3	36.2	1.75	--
53		10:29	10°24.0'S	28°26.8'W	5545	5	27.3	36.3	2	--
54	25.11.	13:10	11°00.0'S	28°29.4'W	5458	5	27.3	36.3	2	--
55	26.11.	13:20	11°35.0'S	28°32.8'W	5467	5	27.4	36.24	3x30	Alkenonsample GeoB 6114
56	27.11.	11:33	11°34.2'S	28°30.7'W	5485	5	27.2	36.2	2	GeoB 6114

1.4.4 Microbial Colonization of Organic Particles

(A. Heuchert)

Rapidly sinking particles in the water column, so-called „marine snow„ consist of dissolved and colloidal organic matter which aggregates (phytoplankton, fecal pellets and detritus). Bacteria and protozoa seem to play an important role in the decomposition of „marine snow„ which takes place mainly in the mesopelagic zone (Lochte, 1991; Lochte, 1993; Austin, 1988).

The aggregates have higher concentrations of nutrients and microbial activities in comparison to the surrounding water (Shanks and Trent, 1979; Caron et al., 1982). The particle associated bacteria have some morphological and metabolical properties different from the free-living bacteria (Iriberri and Herndl, 1995). On aggregates are more rod-like and normally bigger bacteria than in the surrounding water (Caron et al., 1982; Alldredge et al., 1986). In addition,

also phylogenetic differences exist. Associated heterotrophic bacteria could be classified as Cytophaga, Planctomyces and γ-Proteobacteria, whereas most of the free-living bacteria could be classified as α-Proteobacteria and some as γ-Proteobacteria (DeLong et al., 1993; Rath et al., 1998).

During this cruise, samples from different water depths (50, 100, 150, 200 m) were taken with a Niskin watersampler adjacent from the same stations sampled during the cruise M 38/1 (for a detailed list see Table 1.13). To investigate the amount of organic and inorganic carbon, 20 l of seawater were taken at eight different stations. The samples were filtrated through GF/F Whatman filters and rinsed with dest. H_2O. The filters were stored in small boxes and dried at 40°C over night. The filters are intended to be examined at the laboratory at Hamburg University.

From each water depth one liter seawater was taken to investigate the different bacterial groups on the aggregates and in the water column by fluorescence in situ hybridisation (FISH). The fluorescently labeled rRNA-targeted oligonucleotide-probes allow an identification of bacterial cells in their natural habitat without changing the appearance of the organisms (e.g. size, morphology). 800 ml of the seawater samples from each water depth were filtrated through 10 µm Isopore filters, and two 100 ml-samples were filtrated through 0.2 µm Isopore filters each. The bacteria on the filter were fixed with 3.7 % formaldehyde for 30 min. After that, they were rinsed with dest. H_2O and stored in petridishes at -18°C.

One ml seawater of each water depth was taken to distinguish between active and inactive (dead) bacteria. The samples of two stations were treated with 3 µl Live/Dead BacLight, a combination of two fluorescence dyes. One of the components labels all bacteria in a population, the other one penetrates only bacteria with damaged membranes. Bacteria with intact cell membranes stain fluorescent green, whereas bacteria with damaged membranes stain fluorescent red. After incubation at room temperature in the dark for 15 min, the samples were stored in a sterile Eppendorf-cap at -18°C. The samples of the other stations were stored in sterile caps at -18°C without staining. The counting of the bacteria will be done at the laboratory at Bremen University.

The water above the sediment recovered with the multicorer (five stations) was also taken for counting bacteria. These samples were transferred directly to sterile vessels and stored at -18°C.

Table 1.13: Water samples for microbial investigations from 10 l NISKIN-bottles at about 50, 100, 150, 200 m water depth.

Sample No.[a)]	Station No.	Date	Time UTC	Latitude N/S	Longitude E/W	Water depth (m)
KWS 1	6103-4	9.11.	12.24	21°15.2′N	20°42.2′W	50
KWS 2	6103-4	9.11.	12.24	21°15.2′N	20°42.2′W	100
KWS 3	6103-4	9.11.	12.24	21°15.2′N	20°42.2′W	150
KWS 4	6103-4	9.11.	12.24	21°15.2′N	20°42.2′W	200
KWS 5	6105-7	13.11.	14.16	11°40.3′N	20°59.7′W	50
KWS 6	6105-7	13.11.	14.16	11°40.3′N	20°59.7′W	100
KWS 7	6105-7	13.11.	14.16	11°40.3′N	20°59.7′W	150
KWS 8	6105-7	13.11.	14.16	11°40.3′N	20°59.7′W	200
KWS 9	6107-2	15.11.	22.15	3°59.7′N	22°33.0′W	50
KWS 10	6107-2	15.11.	22.15	3°59.7′N	22°33.0′W	100
KWS 11	6107-2	15.11.	22.15	3°59.7′N	22°33.0′W	150

Table 1.13: (continued) Water samples for microbial investigations from 10 l NISKIN-bottles at about 50, 100, 150, 200 m water depth.

Sample No.[a)]	Station No.	Date	Time UTC	Latitude N/S	Longitude E/W	Water depth (m)
KWS 12	6107-2	15.11.	22.15	3°59.7´N	22°33.0´W	200
KWS 13	6109-5	17.11.	11.39	1°59.7´N	22°59.4´W	50
KWS 14	6109-5	17.11.	11.39	1°59.7´N	22°59.4´W	100
KWS 15	6109-5	17.11.	11.39	1°59.7´N	22°59.4´W	150
KWS 16	6109-5	17.11.	11.39	1°59.7´N	22°59.4´W	200
KWS 17	6110-12	19.11.	9.38	0°04.0´N	23°24.0´W	50
KWS 18	6110-12	19.11.	9.38	0°04.0´N	23°24.0´W	100
KWS 19	6110-12	19.11.	9.38	0°04.0´N	23°24.0´W	150
KWS 20	6110-12	19.11.	9.38	0°04.0´N	23°24.0´W	200
KWS 21	6112-7	22.11.	12.40	4°00,1´S	25°39,5´W	50
KWS 22	6112-7	22.11.	12.40	4°00,1´S	25°39,5´W	100
KWS 23	6112-7	22.11.	12.40	4°00,1´S	25°39,5´W	150
KWS 24	6112-7	22.11.	12.40	4°00,1´S	25°39,5´W	200
KWS 25	6113-8	24.11.	11.20	7°27,7´S	28°14,0´W	50
KWS 26	6113-8	24.11.	11.20	7°27,7´S	28°14,0´W	100
KWS 27	6113-8	24.11.	11.20	7°27,7´S	28°14,0´W	150
KWS 28	6113-8	24.11.	11.20	7°27,7´S	28°14,0´W	200
KWS 29	6114-4	26.11.	11.39	11°36,1´S	28°35,47´W	50
KWS 30	6114-4	26.11.	11.39	11°36,1´S	28°35,47´W	100
KWS 31	6114-4	26.11.	11.39	11°36,1´S	28°35,47´W	150
KWS 32	6114-4	26.11.	11.39	11°36,1´S	28°35,47´W	200
MUC 1	6103-2	9.11.	5.47	21°17.0´N	20°43.0´W	4124
MUC 2	6104-3	11.11.	7.56	18°34.0´N	19°55.0´W	3199
MUC 3	6105-5	13.11.	11.15	11°40.2´N	20°59.9´W	4947
MUC 4	6109-9	17.11.	14.50	2°10.1´N	22°59.4´W	4401
MUC 5	6112-1	21.11.	19.56	3°53,8´S	25°35,5´W	5541

a) abbreviations: KWS, NISKIN-bottle water sampler; MUC, Multicorer

1.4.5 In-situ Particle Camera System (ParCa)

(V. Ratmeyer)

For measuring the vertical particle concentration, size distribution and aggregate composition through different water depth a high-resolution fotographic camera system was used (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, and during single profiles over short timescales.

During M46-1, the system was deployed on 11 profiles to water depths between 680 and 5600 m (Table 1.14). The aim was to measure the variability and quantitative abundance of deep-sea particles and to detect possible lateral advection of particle clouds from the continental shelf towards the open ocean or near-bottom resuspension at the different stations.

For best optical resolution we used a 70 mm deep-sea camera (model PHOTOSEA 70) with max. 45.7 m film capacity. A collimated DSPL SEASTROBE 2000 strobe light was installed as light source. The illuminating beam was collimated by a remote flash head with a parabolic reflector and a linear 20 Ws flash lamp, mounted at the steel frame at the focal distance of the camera's optical path. Camera and light source were installed in orthogonal position, thus avoiding backscatter of water molecules and highly hydrated particles and providing an evenly collimated quantitative volume of illuminated water. Power source is a 24V/38Ah rechargeable lead battery designed for the use to full ocean depth. Maximum operation depth is 6000 m for the complete system. The system is fixed inside a steel frame with the dimension 200 x 120 x 120 cm, made of 48 mm hot galvanized steel pipe. The complete system weight is approximately 300 kg in air.

The camera was triggered by a computer on deck of the ship through the ship's coax wire. Communication with the ship is performed by a micro-computer inside the ParCa system, allowing different exposure programs to be run during profiling and moored deployment. Pictures were exposed while lowering the system with a speed of 0.3 m/sec at 10 to 15 m intervals. The flash duration of < 1/2.000 second was short enough to get sharp pictures of particles down to a size of 80 µm using KODAK Tri X Pan Film. For calibration and instrument testing, a set of frames with different light and exposure setups was performed within a saltwater tank during the cruise aboard FS 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. Data obtained with the image analysis will be interpreted in comparison to the transmissometer and CTD profiles obtained during this cruise.

Table 1.14: Deployment of the ParCa Camera System

GeoB-Station	Profile depth	Interval	System
6102-1	2200 m	10 m	ParCa I
6103-7	test	-	ParCa I + FS-CTD
6103-8	130 m	10 m	ParCa I
6103-18	500 m	10 m	ParCa I
6105	4980 m	15 m	ParCa I + FS-CTD
6106-2	test	-	ParCa I
6107-4	680 m	10 m	ParCa I + FS-CTD
6109-2	4335 m	15 m	ParCa I + FS-CTD
6110-8	3920 m	10 m	ParCa I + FS-CTD
6111-3	4800 m	15 m	ParCa I + FS-CTD
6112-4	5575 m	15 m	ParCa I + FS-CTD

During 11 profiles a total of 320 m of B/W film was used.

1.4.6 Particle Collection with Sediment Traps

(G. Ruhland, V. Ratmeyer und G. Fischer)

The data for deployments and recoveries of the moorings are listed in Table 1.15 together with the sampling data of the traps. One mooring, which was recovered during METEOR cruise M45/5, was redeployed north of the Canary Islands. Subsequently, an array was recovered off Cape Blanc and three moorings were recovered in the western equatorial South Atlantic. All recovered arrays were redeployed at their original positions.

On November, 6th, the mooring CI-12 was deployed at the ESTOC site located north of Gran Canaria. This array was recovered on an earlier METEOR cruise M 45/5. CI-12 was equipped with three particle traps in 846 m, 1170 m, and 3096 m and a current meter in 869 m water depth. Additionally, two *in situ* pumps in 3324 m and 3550 m water depth were moored. On November, 9th, the mooring CB-9 was recovered successfully at a site located in the filamental upwelling zone off Cape Blanc. The array was deployed during the METEOR cruise M 41/4 in June, 1998. It was equipped with two particle traps in 746 m and 3580 m water depth. A current meter was 25 m below the upper trap. Both traps were programmed for the same time intervals of 18 days per cup except of the first (7 days) and last (12 days) cup. The current meter recorded in 120 min intervals. At the same day, the mooring CB-10 was deployed at the same position with a similar equipment (Table 1.15).

The mooring WA-15 was recovered on November, 18th. This mooring was located in the western equatorial upwelling area. The deep trap had worked perfectly while the upper trap had stopped at sample cup #1 due to a technical malfunction. The traps were programmed for a 27.5 day interval except of the first (21 days) and the last (25 days) cup. A similar mooring was deployed as WA-16 at the same location (Table 1.15). On November, 24th, the recovery of the mooring WA-14 was done which was located in the lower productive subtropical gyre in the northern part of the Brazil Basin. This mooring was equipped with two particle traps in 822 m und 4705 m water depth and a current meter in 845 m. The traps were programmed for a 27.5 day cycle except of the first (30.5 days) and the last (28.5 days) cup. Both traps and the current meter had worked perfectly. This mooring was redeployed at the same position (Table 1.15). The last mooring WAB2, located in the oligotrophic Brazil Basin was recovered on November, 26th. This array had two particle traps in 710 m and 4421 m and a current meter in 733 m water depth. The traps were programmed for a 27.5 day cycle except of the last cup (30.5 days). The upper trap had worked well although it was not at the final cup position. The lower trap had stopped on the 5th sampling cup due to an electronic failure. The current meter recorded for the entire deployment period. On the same day, a similar mooring was deployed at the same location (Table 1.15).

Table 1.15: Mooring data for recoveries and redeployments.

Mooring	Position	Water Depth (m)	Interval	Instr.	Depth (m)	Intervals (no x days)
Mooring recoveries during M46/1:						
CAPE BLANC REGION						
CB9	21°15.2'N		11.06.98	S/MT 234	746	1x7.5,18x27.5,1x11.5
	20°42.4'W		07.11.99	S/MT 234	3580	1x7.5,18x27.5,1x11.5
				RCM8	770	
BRAZIL BASIN / WESTERN EQUATORIAL ATLANTIC						
WAB2	11°34.8'S	5460	22.05.98	S/MT 234	710	19x27.5,1x30.5
	28°31.9'W		26.11.99	S/MT 230	4421	19x27.5,1x30.5
				RCM8	734	
WA14	07°27.6'S	5525	24.05.98	S/MT 234	822	1x25.5,18x27.5,1x28.5
	28°14.0'W		24.11.99	S/MT 234	4705	1x25.5,18x27.5,1x28.5
				RCM8	845	
WA15	00°02.6'N	3720	28.05.98	S/MT 234	697	1x21.5, 18x27.5,1x24.5
	23°27.5'W		20.11.99	S/MT 230	3180	1x21.5, 18x27.5,1x24.5
				RCM8	721	

Table 1.15: (continued) Mooring data for recoveries and redeployments.

Mooring	Position	Water Depth (m)	Interval	Instr.	Depth (m)	Intervals (no x days)
Mooring deployments during M46/1:						
CANARY ISLANDS						
CI-12	29°11,90'N	3609	6.11.99	S/MT 234	846	20x10
	15°27,00'W			S/MT 234	1147	20x10
				S/MT 234	3550	20x10
				RCM 8	869	
				RCM 8	1170	
				WTS 6-25-47EC		3324
				WTS 6-25-142FH		3550
CANARY ISLANDS REGION						
CB-10	21°17.20'N	4125	9.11.99	S/MT 234	803	19x18, 1x15
	20°43.14'W			S/MT 234	3586	19x18, 1x15
				RCM8	826	
BRAZIL BASIN / WESTERN EQUATORIAL ATLANTIC						
WA-16	00°03.30'N	3727	18.11.99	S/MT 234	904	20x25
	23°28.20'W			S/MT 234	3187	20x25
				RCM 8	928	
WA-17	07°27,20'S	5550	24.11.99	S/MT 234	935	1x19, 19x25
	28°12.80'W			S/MT 230	4713	1x19, 19x25
				RCM 8	958	
WAB-3	11°36.00'S	5413	26.11.99	S/MT 234	866	1x17, 19x25
	28°31.70'W			S/MT 234	4373	1x17, 19x25
				RCM 8	889	

Instruments used:
S/MT 230 = Particle trap S/MT 230 Aquatec Meerestechnik, Kiel
S/MT 234 = Particle trap S/MT 234 Aquatec Meerestechnik, Kiel
S/MT 105 = Inclinometer S/MT 105 Aquatec Meerestechnik, Kiel
RCM 8 = Current meter Aanderaa, RCM 8
WTS 6-25 = in situ pumps

Preliminary Results

The lower trap at Cape Blanc site CB9 showed two main maxima of particle flux in summer 1998 and spring 1999 (Fig. 1.5). Secondary maxima were found in summer and fall 1999. The background level of particle fluxes is rather high as expected from earlier records. In the Equatorial Atlantic at 23.5°W (site WA15) the upper trap collected only one sample, the lower one collected continuously from May 1998 to November 1999 (Fig. 1.6). Seasonality and absolute flux values in the lower trap level were about half compared to site CB9. Maxima were obtained in summer 1998 and spring and late summer in 1999. Further south at 7°S (site WA14) the absolute values as well as the seasonal pattern (Fig. 1.7) show some similarity to the fluxes obtained at site WA15 (Equator). At site WAB2, fluxes were unexpectedly high showing a maximum in fall 1998 and winter 1999 (Fig. 1.8).

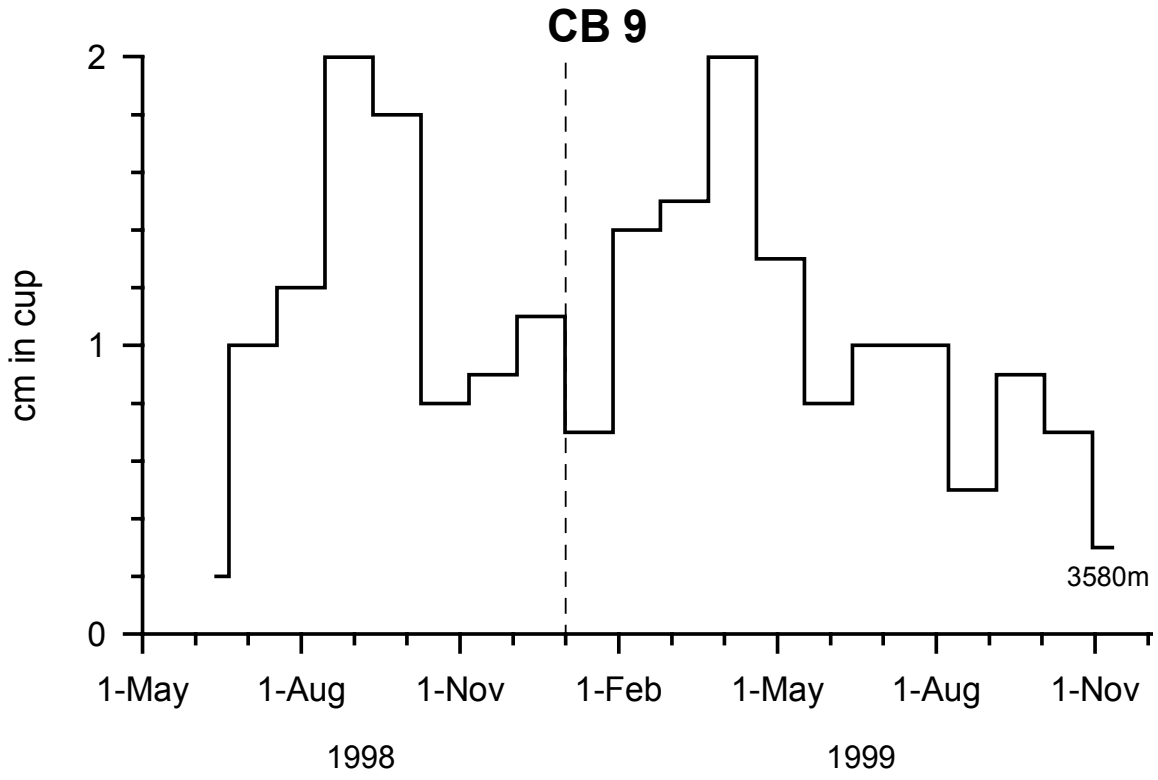

Fig. 1.5: Flux estimates at mooring site CB 9.

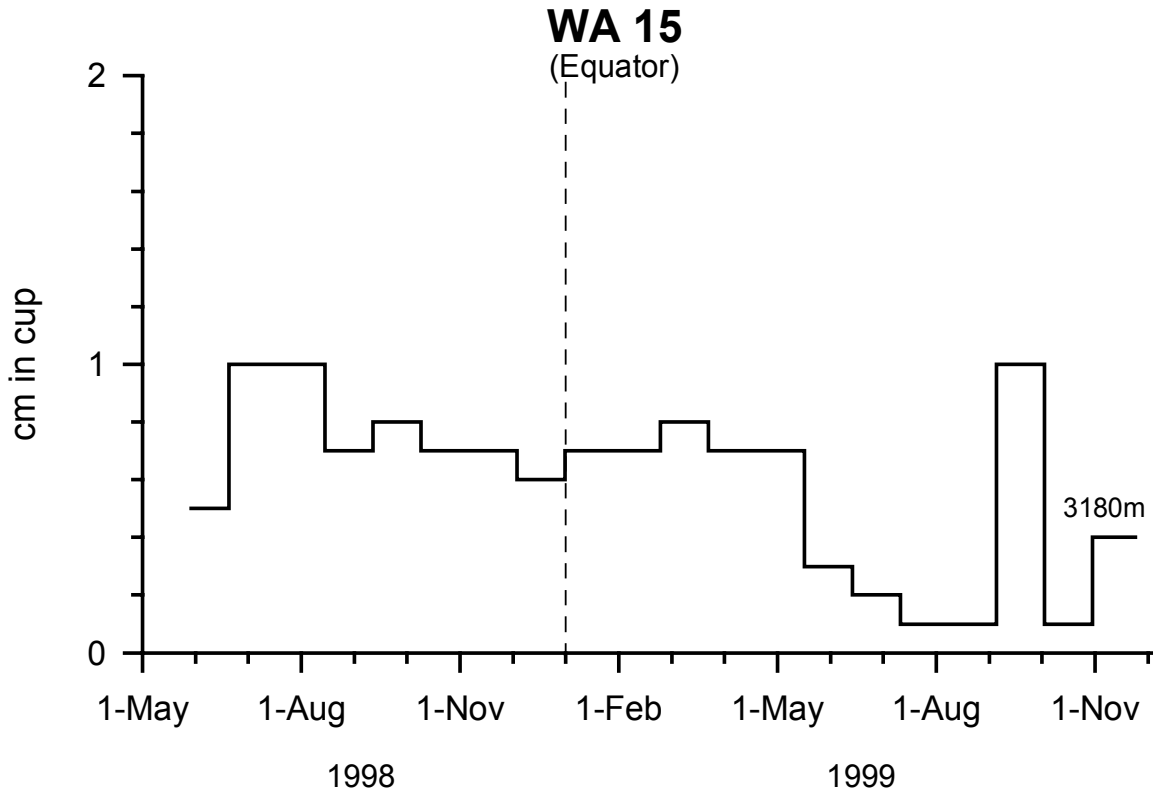

Fig. 1.6: Flux estimates at mooring site WA15, equatorial Atlantic (0°).

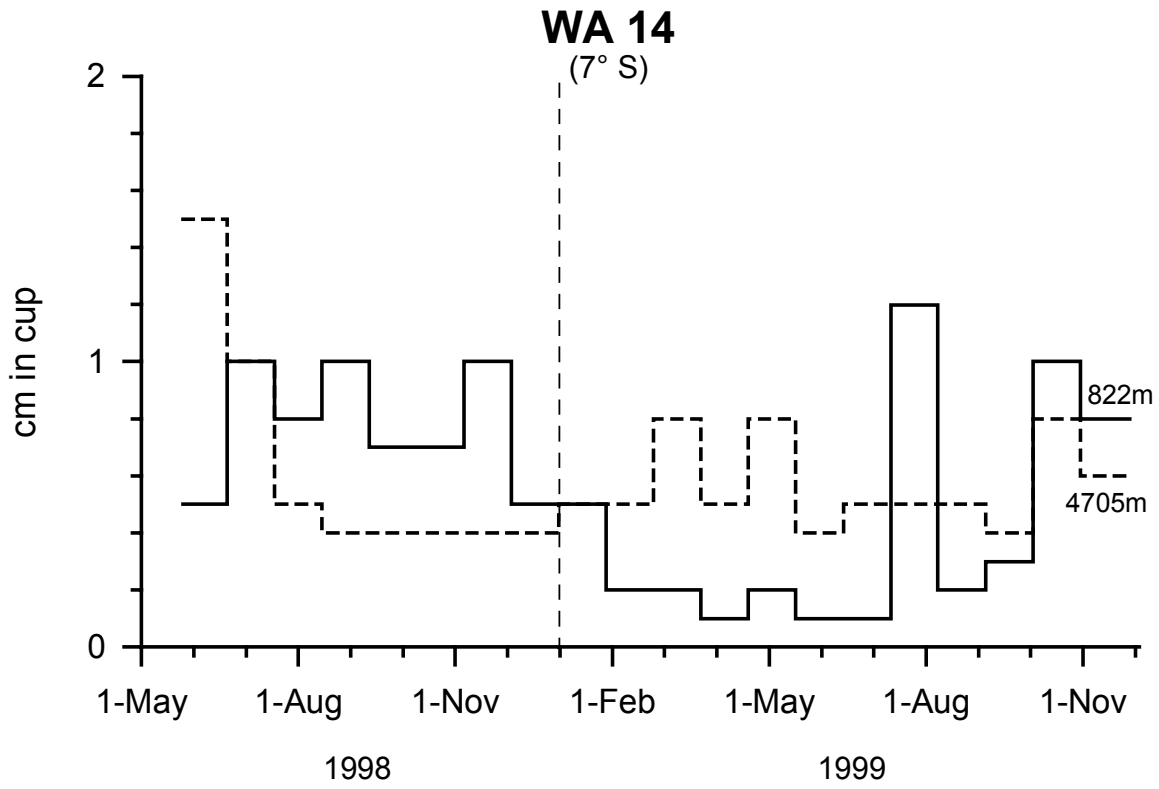

Fig. 1.7: Flux estimates at mooring site WA14, equatorial Atlantic (7°S).

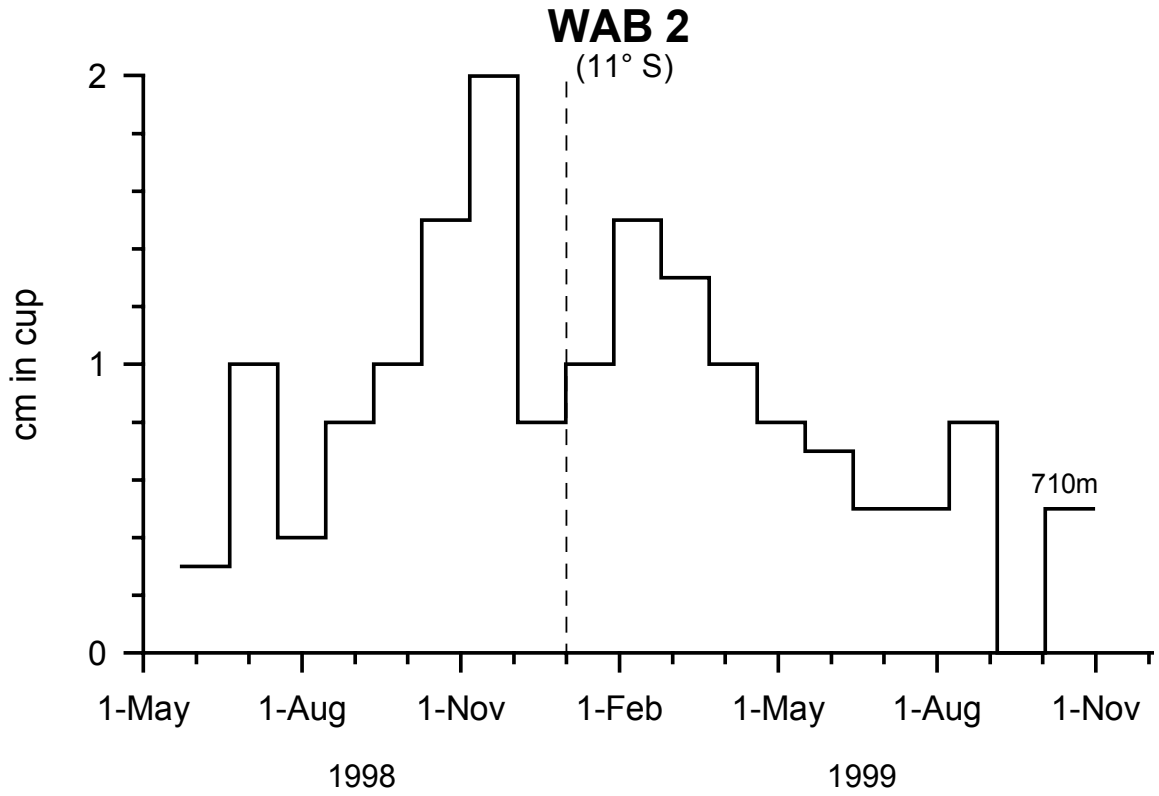

Fig. 1.8: Flux estimates at mooring site WAB2, equatorial Atlantic (11°S).

1.4.7 Sediment Sampling - Marine Geology

(G.Fischer, H. Buschhoff)

To complement the data collected by the moored sediment traps, multicorer sediment and bottom water samples were taken at the mooring stations. Undisturbed seafloor surfaces and cores of the upper few centimeters of the sediment as well as bottom water samples provide important additional information to understand the sedimentary environment at the mooring sites. The data obtained through coring combined with the analysis of the trapped sediment helps budgeting the flux through the water column. During this cruise, the multicorer (small version) was used 7 times for collections sediments from 3198m to 5541m water depths (Table 1.16). Problems arose in very soft sediments (deep-sea clay) where the small version of the multicorer did not release. At the last site, a video camera system was installed on the multicorer. We therefore were able to watch how the multicorer was penetrating the surface sediment (deep-sea clay in 5450m water depth)..

1.4.7.1 Multicorer Samples

(G.Fischer, H. Buschhoff)

For the sampling of complete and undisturbed sediment surfaces and the overlying bottom water, a multicorer (MUC) equipped with eigth large (10 cm diameter) and four small (6 cm diameter) tubes was used. Penetration depths range from 4 cm to 35 cm in the Brazil Basin (Table 1.16).

Sampling
Sediment from the MUC tubes was sampled as follows (if 8 large and 4 small tubes were available):

- 1 large tube cut into slices of 1 cm thickness was frozen for organic carbon (TOC) measurements, bottom water samples were taken for stable isotope analysis (2 x 50 ml for $\delta^{13}C$, poisoned with mecury chloride, 1 x 50 ml for $\delta^{18}O$; water sample bottles were sealed with hot wax and stored at 4°C).
- 2 large tubes were cut into slices of 1 cm, filled into KAUTEX plastic bottles and fixed with a solution of rose begal in ethanol (1g/l) and stored at 4°C for the study of foraminifera.
- 1 large tube was cut into 1 cm slices and stored at 4°C for investigation of dinoflagellate communities (top 1 cm bottom water included).
- 1 large tube was cut into slices of 1 cm thickness and frozen for the study of coccolithophorid communities.
- 1 large tube was used for trace metal analysis. The bottom water was sampled, the top 2 cm of the sediment were cut into 0.5 cm slices, the sediment between 2 and 10 cm core depth was cut into slices of 1 cm thickness, the rest of the core was sampled in 2 cm slices. The outer part of the sediment was scraped off to avoid contamination by contact with the tubes. Sediment samples were frozen, water samples were analyzed for nutrients and oxygen in the shipboard labs.
- The surface of 1 small tube was taken for radiolaria and diatom investigations, the rest of the sediment was taken for the sampling of planktonic foraminifera.
- 3 small tubes were frozen as archive cores.

Table 1.16: Multicorer sampling during M46-1.

GeoB	Water depth (m)	Core length (m)	Core recov. Large/ small tubes	Organic Geo-chemistry	Foramini-fera	Dino-flagell.	Cocco-lithoph.	Trace metals	Archive frozen	Bottom water C-Isot. O.Isot.	Radiol./ Diatoms from surface
6103-2	4120	35	8/4	1/0	2/0	1/0	1/0	1/0	0/4	x	0/2
6104-3	3198	25	7/0	7/0	2/0	1/0	1/0	1/0	1/0	x	1/0
6105-5	4946	25	0/4	0/1	0/2	0/0	0/0	0/1	0/0	x	0/1
6108-1	4118	0	all tubes empty								
6109-9	4401	4-11	3/4	1/0	1/1	0/1	0/1	0/1	1/0	x	0/1
6112-1	5541	35	0/4	0/1	0/0	0/1	0/0	0/1	0/1	x	0/0
6114-14	5478 (HS)	0	all tubes emty	0/0	0/0	0/0	0/0	0/0	0/0	-	0/0

1.4.8 Profiling Hydroacoustic Systems (HYDROSWEEP and PARASOUND)

(G. Fischer)

During METEOR Cruise M 46/1 the shipboard hydroacoustic systems HYDROSWEEP and PARASOUND were operated close to the mooring sites as well as at some additional sites where marine chemistry studies were performed. The two systems are valuable tools to examine seafloor topography and sedimentary characteristics. Information on these parameters is essential for successful coring and helps interpreting the core material. The HYDROSWEEP system which provides bathymetric data worked reliably well. PARASOUND in combination with the software packaga PARADIGMA provides information about the internal structure of the sedimentary cover of the ocean floor. The echosounding data from the coring locations were printed out as online plots but not stored on CD roms or tapes.

1.5 Ship's Meteorological Station

When METEOR sailed from Las Palmas, on November 6, 1999, the general synopsis over the Eastern Atlantic was dominated by a wedge of high pressure extending from a large high over the European Continent southwestwards and a trough of low pressure west of 20° W. The cold front connected to this low was swinging eastwards slowly during the next days but did not cause any significant weather in the ship's operation area. So METEOR found light to moderate northeasterly winds on the way south.

On November 11 the ITCZ was located between 10°N and 5°N with it's main activity concentrated in it's western part. The next day activity was shifting towards the African coast and during the night from November 12 to 13 the ship met with some rain showers.

During the following days the intensity of the ITCZ weakened again so just a few more light showers were met from November 13 to 16 at latitudes between 5°N and 2°N.

METEOR passed the Equator on the 19th of November and found southeasterly winds at the northern edge of the subtropic high which was located considerable far north. The situation during the next days remained stable with fair weather and moderate southeasterly trade winds.

A wedge of the subtropic high extended towards the Brazilian coast and was intensifying during the last week of November. Under this influence light to moderate southeasterly to easterly winds occured in the ship's operation area. This situation remained until METEOR ended the cruise on November 29 at the Port of Recife.

1.6 Station List M 46/1

GeoB No.	Ship´s No.	Date 1999	Device	Time Seafloor/ max.wire -length (UTC)	Latitude	Longitude	Water depth [m]	Samples/ core recovery	Remarks
Canary Islands									
6101-1	**625**	06.11.	CI 12	14:45	29°13,5N	15°28,4W	3611		start deployment of mooring CI 12
Cape Blanc									
6102-1	**626**	08.11	GoFlo	11:00	22°15,6N	20°29,8W	4174	12x12L	down to 1000m, cleaning of bottles
6102-2			GoFlo	11:54	22°15,6N	20°29,9W	4174	12x12L	down to 500m: 5, 15, 26, 75, 100, 126, 150, 200, 300, 400, 500m
6102-3			ParCa	14:49	22°15,6N	20°29,9W	4188	4175m	with CTD 613a
6103-1	**627**	09.11.	ISP	00:38	21°17,0N	20°43,0W	4123	8 pumps	depths: 3726, 3926, 4026, 4076, 4099, 4101, 4116, 4118m
6103-2			MUC	05:47	21°17,0N	20°43,0W	4120	35 cm	8 large/4 small tubes filled
6103-3			CB9	08:40	21°15,6N	20°42,3W	4123	2 traps, each 20 samples	
6103-4			KWS1	12:24	21°15,2N	20°42,2W	4119	18 x 10Ll	depths: 10, 20, 50, 75, 100, 120, 150, 200, 250m
6103-5			KWS2	13:15	21°15,2N	20°42,2W	4118	18 x 10L	depths: 75, 100, 120, 150m
6103-6			KWS3	13:39	21°15,2N	20°42,2W	4118	18 x 10L	depths: 10, 20, 50, 75m
6103-7			CB 10	13:56	21°17,2N	20°43,1W	4125		deployment of mooring CB 10
6103-8			GoFlo	18:49	21°16,3N	20°42,3W	4116	12 x 12L	depths: 1000, 1250, 1500, 2000, 2700, 3320, 3720, 3920, 4020, 4070, 4095, 4110m
6103-9			ParCa	20 :52	21°16,2N	20°42,5W	4117		test: lower down to 100m
6103-10			ISP	21:50	21°16,3N	20°42,0W	4115	8 pumps	depths: 10, 30, 50, 70, 71, 90, 125, 126m
6103-11			ParCa	23 :23	21°16,3N	20°42,1W	4116		test: lower down to 100m
6103-12		10.11.	MN1	00:19	21°16,2N	20°42,2W	4116	5 cups	Forams, water isotopes; depths: 500, 300, 200, 100, 50m
6103-13			MN2	01:15	21°16,2N	20°42,0W	4117	5 cups	organic matter; depths: 250, 100, 75, 50, 25m
6103-14			ISP	03:55	21°15,8N	20°42,6W	4117	8 pumps	10, 30, 175, 300, 500, 1000, 2000, 3200m

Station List METEOR cruise M 46/1 (continued).

GeoB No.	Ship´s No.	Date 1999	Device	Time Seafloor/ max.wire -length (UTC)	Latitude	Longitude	Water depth [m]	Samples/ core recovery	Remarks
Cape Blanc									
6103-15			GoFlo	09:00	21°15,6N	20°42,5W	4116	12x12L	depths : 30, 50, 70, 90, 125, 150, 201, 300, 400, 500, 700m
6103-16			MER	10 :40	21°15,7N	20°42,5N	4117	-	down to 100m
6103-17			GoFlo	12:55	21°15,6N	20°42,5W	4118	12x12L	depths: 10, 20, 80, 100, 700m
6103-18			ParCa	13:26	21°15,6N	20°42,5W	4118		down to 500m
6103-19			ParCa	14:23	21°15,6N	20°42,5W	4118		down to 300m, with CTD 2069
6104-1	**628**	11.11.	ISP	05:11	18°34,0N	19°55,0W	3199	8 pumps	depths: 10, 12, 25, 27, 50, 100, 200, 400m
6104-2			GoFlo	07:29	18°34,0N	19°55,0W	3193	12 x12L	depths: 10, 25, 50, 85, 125, 200, 400m
6104-3			MUC	07:56	18°34,0N	19°55,0W	3198	25 cm	with CTD 2069, 7 large / 0 small tubes filled
Cape Verde									
6105-1	**629**	12.11.	ISP	22:05	11°40,6N	21°00,1W	4947	8 pumps	depths: 10, 30, 50, 90, 150, 250, 500, 1000m
6105-2		13.11	GoFlo	02:15	11°40,5N	21°00,0W	4964	12 x 12L	depths: 5, 10, 20, 50m
6105-3			ParCa	05:25	11°40,7N	20°59,2W	4945		down to 4950m; pictures every 10 (upper 500m) and 15m (rest of water column)
6105-4			GoFlo	08:30	11°40,6N	21°00,0W	4946	12 x 12L	with CTD 2069; depths: 70, 90, 125, 175, 400, 700, 1000m
6105-5			MUC	11:15	11°40,2´N	20°59,9´W	4946	25cm	0 large / 4 small tubes filled
6105-6			MER	13:43	11°40,3N	20°59,7W	4946		
6105-7			KWS1	14:16	11°40,3N	20°59,7W	4946	18 x 10L	depths: 10, 20, 50, 75, 100, 120, 150, 200, 250m
6105-8			KWS2	15:00	11°40,3N	20°59,7W	4946	18 x 10L	depths: 75, 100, 120, 150m
6105-9			KWS3	15:27	11°40,3N	20°59,8W	4946	18 x 10L	depths: 10, 20, 50, 75m
6105-10			GoFlo	16:01	11°39,9N	20°59,5W	4946	12 x 12L	depths: 5, 10, 20, 30, 40, 50m
6105-11			ISP	17:13	11°40,4N	20°59,4W	4946	8 pumps	depths: 10, 20, 50, 70, 90, 125, 250, 400m
Sierra Leone Rise									
6106-1	**630**	14.11.	GoFlo	16:37	08°00,0N	21°45,0W	4101	12 x12L	depths: 10, 25, 50, 85, 125, 200, 400m
6106-2			ParCa	17:02	08°00,0N	21°45,0W	4101		tests: 3 times
6106-3			ISP	18:41	08°00,8N	21°45,0W	4191	6 pumps	depths: 10, 25, 50, 100, 200, 400m
6106-4			CTD 613a	20:45	08°01,0N	21°45,1W	4191		down to 500m
6107-1	**631**	15.11.	ISP	20:10	03°59,8N	22°32,9W	4099	8 pumps	10, 20, 50, 70, 90, 125, 250, 400m
6107-2			KWS	22:15	03°59,7N	22°33,0W	4103	18 x 10L	with CTD (2069) to 520m; depths: 20, 50, 75, 100, 150, 200m
6107-3			GoFlo	23:36	04°00,3N	22°32,7W	4107	12 x12L	depths: 5, 10, 20, 50, 70, 90, 125, 175, 250, 700, 1000m
6107-4		16.11.	ParCa	03:07	04°00,3N	22°32,8W	4079		with CTD (613), pictures every 10m
6107-5			ISP	05:50	04°00,6N	22°32,5W	4056	8 pumps	depths: 10, 30, 50, 90, 150, 250, 500, 1000m
6108-1	**632**		MUC	10 :10	03°57,9N	22°33,1W	4118	0 cm	all tubes empty

Station List METEOR cruise M 46/1 (continued).

GeoB No.	Ship´s No.	Date 1999	Device	Time Seafloor/ max.wire -length (UTC)	Latitude	Longitude	Water depth [m]	Samples/ core recovery	Remarks
Equatorial Atlantic (2°N)									
6109-1	**633**	17.11.	ISP	00:15	02°00,0´N	23°00,0´W	4323	8 pumps	depths: 10,20,70,90,125,250,400,1000m
6109-2			ParCa	02:53	02°00,0´N	23°00,1´W	4335		with CTD 613a
6109-3			GoFlo	07:23	01°59,8´N	22°59,5´W	4317	12 x 12L	with CTD 2069; depths: 5, 10, 20, 50, 70, 90, 125, 175, 250, 400, 700m
6109-4			ISP	08 :46	01°59,9´N	22°59,1´W	4305	5 pumps	25, 55, 700, 710; filter comparison
6109-5			KWS 1	11:39	01°59,7´N	22°59,4´W	4312	18x 10L	depths : 250, 200, 150, 120, 100, 75, 50, 20, 10m
6109-6			KWS 2	12:25	01°59,7´N	22°59,4´W	4314	18 x 10L	depths: 150, 120, 100, 75m
6109-7			KWS 3	12:51	01°59,3´N	22°59,3´W	4313	18 x 10L	depths: 10, 20, 50, 75m
6109-8			MER	12:17	02°00,3´N	22°59,3´W	4314		down to 100m
6109-9			MUC	14:50	02°10,1´N	22°59,4´W	4409	4-11cm	3 large / 4 small tubes filled
6109-10			ISP	19:20	01°59,9´N	22°59,8´W	4320	8 pumps	depths: 1500, 2500, 3500, 3900, 4120, 4220, 4270, 4295m
Equatorial Atlantic (0°)									
6110-1	**634**	18.11.	WA 15	11:55	00°02,9´N	23°27,6´W	3700	2 traps:1/20 samples	upper: 1 sample; lower trap: at #20 during recovery
6110-2			MER	15 :09	00°06,1´N	23°27,8´W	3733		down to 100m
6110-3			KWS 2	15:46	00°06,0´N	23°27,5W	3730	18 x 10L	depths: 150,120,100,75m
6110-4			KWS 3	16:22	00°06,0´N	23°27,3´W	3730	18 x 10L	depths: 75,50,20,10m
6110-5			WA 16	16:43	00°03,3´N	23°28,2´W	3718		deployment of array
6110-6			ISP	19:40	00°02,8´N	23°26,7´W	3703	8 pumps	depths:10, 20, 50, 70, 90, 125, 250, 400m
6110-7			GoFlo	21:52	00°03,2´N	23°25,5´W	3594	12 x 12L	depths :5, 10, 20, 50, 70, 90, 125, 175, 250m with CTD
6110-8			ParCa	23:16	00°03,3´N	23°25,2´W	3820		with CTD 613 a
6110-9		19.11.	ISP	03:32	00°03,7´N	23°26,0´W	3619	8 pumps	depths: 10, 30, 50. 90, 150, 250, 500, 1000m
6110-10			MN 1	08:00	00°03,8´N	23°24,5´W	3834	5 cups	no samples for isotopes in seawater depths: 500, 300, 200, 100, 50m
6110-11			MN 2	09:00	00°03,9´N	23°24,4´W	3834	5 cups	depths: 250, 100, 75, 50, 25m
6110-12			KWS 2	09:38	00°04,0´N	23°24,0´W	3826	18 x 10L	depths: 250, 200, 150, 120, 100, 75, 50, 20, 10m
6110-13			GoFlo	10:15	00°04,2´N	23°23,4´W	3654	12 x 12L	depths: 5, 10, 175, 250, 300, 500m sampling for water isotopes
Equatorial Atlantioc (2°S)									
6111-1	**635**	19.11.	GoFlo	23:42	02°00,0S	24°34,1W	4936	12 x 12L	with CTD 2069; depths: 5, 10, 20, 50, 70, 90, 125, 175, 250, 400, 700, 1000m
6111-2		20.11.	ISP	01:00	01°59,9S	24°33,6W	4909	8 pumps	depths: 10, 20, 50, 70, 90, 125, 250, 400m
6111-3			ParCa	06:05	01°59,9S	24°33,7W	4910		with CTD 613a ; to 150m : picture every 5m to 500m: every 10m to 4800m: every 15m
6111-4			ISP	08 :35	02°00,0S	24°33,1W	4911	8 pumps	depths: 10, 20, 50, 70, 90, 125, 250, 400m

Station List METEOR cruise M 46/1 (continued).

GeoB No.	Ship´s No.	Date 1999	Device	Time Seafloor/ max.wire -length (UTC)	Latitude	Longitude	Water depth [m]	Samples/ core recovery	Remarks
6111-5			GoFlo	14:33	02°00,0S	24°34,0W	4985	12 x 12L	depths: 5, 1250, 1500, 2000, 2500, 3000, 3500, 4000 (2x), 4400, 4700m (2x)
6111-6			ISP	19:05	02°00,8S	24°33,4W	4940	8 pumps	depths: 2500, 3000, 4000, 4600m
6111-7		21.11.	ISP	01:41	02°00,8S	24°33,4W	4940	8 pumps	depths: 700, 1000, 1500, 2000m
N' Brazil Basin									
6112-1	**636**	21.11.	MUC	19:56	03°53,8S	25°35,5W	5575		with CTD 2069; 0 large, 4 small tubes filled
6112-2			GoFlo	23:30	04°00,1S	25°40,0W	5517	12 x 12L	10, 20, 50, 70, 90, 125, 175, 250, 700, 1000m
6112-3		22.11.	ISP	03 :35	03°59,9S	25°40,0W	5517	7 pumps	10, 20, 50, 70, 90, 125, 250m
6112-4			ParCa	05:52	03°59,8S	25°40,2W	5519		with CTD 613a ; to 150m : picture every 5m to 5520: picture every 15m
6112-5			ISP	08 :25	04°00,1S	25°39,6W	5519	7 pumps	depths: 10, 20, 50, 70, 90, 125, 250m
6112-6			MER	12:10	04°00,1S	25°39,6W	5519		to 100m
6112-7			KWS1	12:40	04°00,1S	25°39,5W	5519	18 x 10L	depths : 250, 200, 150, 120, 100, 75, 50, 20, 10m
6112-8			KWS2	13:22	03°59,8S	25°39,5W	5518	18 x 10L	depths: 150, 120, 100, 75m
6112-9			KWS3	13:43	03°59,8S	25°39,5W	5524	18 x 10L	depths: 10, 20, 50, 75m
6112-10			GoFlo	14:35	03°59,8S	25°39,3W	5520	12 x 12L	with CTD 2069; depths: 5, 70, 90, 400, 550m
6112-11			ISP	15 :49	03°59,9S	25°38,9W	5520	8 pumps	depths: 175, 400, 700, 1000m
6113-1	**637**	23.11.	ISP	17:00	07°24,4S	28°11,6W	5557	6 pumps	depths: 10, 20, 50, 70, 90, 125m
6113-2			GoFlo	19:03	07°24,4S	28°11,6W	5559	12 x 12L	with CTD 2069; depths: 5, 01, 20, 50, 70, 90, 125, 175, 250, 400, 700, 1000m
6113-3			ISP	20:06	07°24,5S	28°11,1W	5559	7 pumps	depths: 10, 20, 50, 70, 90, 125, 250m
6113-4			MN1	23:32	07°24,6S	28°11,1W	5558	5 cups	depths: 500, 300, 100, 50, 25m; water isotopes
6113-5		24.11.	MN2	00:27	07°24,6S	28°11,1W	5557	5 cups	depths: 250, 100, 75, 50, 25m
6113-6			ISP	01:40	07°24,6S	28°10,8W	5557		depths: 10, 250, 400, 700, 1000m
6113-7			WA14	08:02	07°27,4S	28°14,6W	5400	2 x 20 samples	start: recovery of mooring array
6113-8			KWS1	11 :20	07°27,7S	28°14,0W	5547	18 x 10L	depths : 250, 200, 150, 120, 100, 75, 50, 20, 10m
6113-9			KWS2	12 :02	07°27,4S	28°14,0W	5546	18 x 10L	depths: 150, 120, 100, 75m
6113-10			KWS3	12 :22	07°27,4S	28°13,9W	5546	18 x 10L	depths: 10, 20, 50, 75m
6113-11			MER	13 :00	07°27,3S	28°13,5W	5547		down to 100m
6113-12			WA17	14:00	07°27,2S	28°12,8W	5550		deployment of mooring array WA17
Brazil Basin									
6114-1	**638**	25.11.	ISP	19:33	11°31,0S	28°31,0W	5484	8 pumps	depths: 5463, 5413, 5313, 5113, 4713m
6114-2		26.11.	GoFlo	03:49	11°30,9S	28°31,0W	5455	12 x 12L	with CTD 2069, depths : 1250, 1500, 2000, 2500, 3000, 3500, 3900, 4200, 4400, 4700, 5100, 5350m
6114-3			WAB2	07:58	11°35,7S	28°32,4W	5407		start: recovery of mooring array WAB2

Station List METEOR cruise M 46/1 (continued).

GeoB No.	Ship´s No.	Date 1999	Device	Time Seafloor/ max.wire -length (UTC)	Latitude	Longitude	Water depth [m]	Samples/ core recovery	Remarks
6114-4			KWS1	11:48	11°36,1S	28°35,5W	5493	18 x 10L	depths : 250, 200, 150, 120, 100, 75, 50, 20, 10m
6114-5			KWS2	12:27	11°36,0S	28°35,5W	5494	18 x 10L	depths: 150, 120, 100, 75m
6114-6			KWS3	12:48	11°36,0S	28°35,5W	5494	18 x 10L	depths: 10, 20, 50, 75m
6114-7			MER	13:25	11°36,0S	28°35,3W	5494		down to 1000m
6114-8			WAB3	13:47	11°36,0S	28°31,7W	5413		deployment of mooring array
6114-9			ISP	19:50	11°34,2S	28°30,7W	5481	8 pumps	depths :
6114-10		27.11.	MN1	01 :07	11°34,0S	28°30,9W	5477	5 cups	depths : 500, 300, 200, 100, 50m sampling for water isotopes
6114-11			MN2	02 :12	11°33,9S	28°30,9W	5477	5 cups	depths: 250, 100, 75, 50, 25m
6114-12			ISP	03 :49	11°33,9S	28°30,9W	5467	5 pumps	depths : 10, 700, 1000, 2000, 3000m
6114-13			GoFlo	08 :06	11°34,0S	28°30,9W	5476	12 x 12L	depths: 10, 30, 50, 90, 125, 200, 300, 400, 600, 800, 1000m
6114-14			MUC	12:57	11°34,2W	28°30,7W	5478	0 cm	not released, 0/0; with video camera
6114-15			ISP	15:58	11°33,7W	28°30,7W	5454	8 pumps	depths: 10, 30, 50, 90, 125, 250, 400, 700m
6114-16			ISP	18 :25	11°33,6S	28°30,7W	5454	8 pumps	depths: 30, 50, 70, 90, 125, 175, 250, 400m

MER	MER-2040 Profiling Spectroradiometer
MUC	Multiple Corer with 8 large and 4 small tubes
ParCa	Profiling Particle Camera
KWS	Multiple Water Sampler
MN	Multinet with 5 Niskin bottles
ISP	In-situ Pumps
GoFlo	Rosette with 12 GoFlo-bottles

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