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REPORT AND PRELIMINARY RESULTS OF POSEIDON CRUISE 310
LAS PALMAS (SPAIN) - LAS PALMAS (SPAIN)

April 12th -April 26th, 2004

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2. Research Objectives

The upwelling area off NW-Africa is one of the most important upwelling systems of the global ocean, influenced by high amounts of Sahara dust which is transporting nutrients into the ocean. Both factors are of fundamental importance for the particle production in the ocean, influencing the processes of the biological carbon pump system. Hence, they are controlling factors of the global atmospheric CO_2-budget. Despite the main driving-force for climatic variability is located in the North-Atlantic, the upwelling area off NW-Africa is suitable to reconstruct the past climatic variability, via observation of present in-situ enviromental datasets. During R/V POSEIDON cruise 310 it was planned to work on two main research areas, Canary Islands and Cape Blanc.

2.1 Canary Island Area

ESTOC (European Station for Time series in the Ocean, Canary Islands)

One goal of R/V POSEIDON cruise 310 will be the work at ESTOC site, which is located 60 nm north of Gran Canaria (29°10`N, 15°30`W) in the eastern boundary flow of the subtropical North Atlantic gyre. Standard parameters of hydrography, nutrients, oxygen, chlorophyll a and DIC have been determined monthly since 1994. In addition, long-term particle flux has been determined with moored traps since 1991 and seasonal with free-drifting traps. The ESTOC time-series station is co-operated by the ICCM (Instituto Canario de Ciencias Marinas) and the GeoB (Department of Geosciences, University Bremen). The main purpose of the station is to build up a long-term oceanographic data base in order to discern seasonal from long-term variability of hydrographic and biochemical parameters in this environmentally sensitiv region.

DOLAN (Operational Data Transmission in the Ocean and Lateral Acoustic Network in the Deep-Sea)

The second main topic of R/V POSEIDON cruise 310 will be the work at DOLAN site. The station is located 25 nm west of ESTOC site and comprises technological devices for transmission of scientific data sets by means of acoustic communication in the water column via satellite into the internet and research institutes. Attached to the mooring array is a sediment trap, which allows, in co-operation with ESTOC mooring site, a comparison of particle fluxes in between a short distance.

DOBS (Deep Ocean Bottom Station)

This mooring array is linked to the DOLAN surface buoy mooring (SBU) as an additional acoustic client and will be maintained during this cruise.

ANIMATE (Atlantic Network of Interdisciplinary Moorings and Time series for Europe)

A further task in this research area will concentrate on the ANIMATE EU project, which is closely linked to the ESTOC and DOLAN project. In the ANIMATE project, moorings were deployed on key sites in the northern Atlantic (ESTOC, Canary Islands; PAP, Porcupine Abyssal Plain; CIS, Central Irminger Sea) in order to gain data of CO_2, nutrients and fluorescence, which will be transmitted directly via satellites to the participating scientific institutes. A significant element in ANIMATE is the technology for the transmission of datasets from deep-sea, still in use in the DOLAN project. Till year 2003, ESTOC was used as reference site for the subtropical NE-Atlantic within the ANIMATE project. Since spring 2003, a mooring array (ANIMATE Canary Island, ACI), consisting of several scientific sensors (MicroCats, currentmeter, ADCP) was moored 25 nm northwest of ESTOC.

2.2 Cape Blanc Area

CB and CBi (Cape Blanc Mooring / Cape Blanc Interior Mooring)

In the Cape Blanc area it is planned to work on two mooring sites. The Cape Blanc mooring (CB) is located about 200 nm west of Cape Blanc (Mauretania) in the border area of the Cape Blanc filament. This mesotrophic study site is in operation since 1988. The additional eutrophic study site Cape Blanc Interior mooring (CBi) is located around 80 nm further to the east in the coastal upwelling of Mauretania. Both moorings, CB and CBi, are influenced by the NE trade winds, being part of the North Atlantic climate system. They are characterized by enhanced supply of terrigenous material, mainly dust particles. The spatial and temporal distribution of productivity and biomass, and the supply of dust particles to the ocean will be monitored by satellite imagery (SeaWIFS) and shall be compared to the patterns of deep ocean particles fluxes.

3. Narrative of the Cruise

R/V POSEIDON left the port of Las Palmas on April 12th with heading to DOLAN position. During the morning of April 13th station work at DOLAN site started with two CTD/Rosette casts down to 3629 m water depth, and was continued by the successful recovery of the DOLAN surface buoy (SBU). In the afternoon the DOLAN Multi Sensor Device (MSD) was recovered. Afterwards, R/V POSEIDON left the DOLAN position with heading to Cape Blanc area. Underway 8 XBT´s were launched.

In the morning of April 16th R/V POSEIDON reached the Cape Blanc site, and CB-14 mooring was recovered. Station work was continued with operation of two CTD/Rosette casts down to 4160 m and ended with the successful deployment of CB-15 mooring at 6:00 pm of the same day. On April 17th the R/V POSEIDON moved to the interior Cape Blanc position (CBi) and the CBi-1 mooring was recovered and redeployed as CBi-2. Two CTD/Rosette cast down to 2351 m were run in-between. Afterwards, R/V POSEIDON steamed back to the Canary Island area.

During the transit 13 XBT´s were launched. In the beginning of April 20th the scientific task started with a CTD/Rosette cast down to 3598 m, close to the DOLAN site. in addition, one NOAA drifter was deployed. The DOBS mooring array was successfully recovered on April 21st. Afterwards, as the first step of the DOLAN deployment, a dummy buoyancy package and the anchor for the DOLAN SBU mooring were deployed. The station work ended with a calibration cast of MicroCats and fluorometer, using the Rosette frame. The next day the dummy package was recovered again and replaced with the DOLAN surface data buoy. In the afternoon R/V POSEIDON reached the ANIMATE position and the work began with the recovery of ACI-3 mooring, finished at 7:00 am. As preparation work for the new ANIMATE mooring the station work started with a CTD/MicroCats calibration cast down to 1000 m on April 23rd. After that, ACI-4 mooring was deployed and R/V POSEIDON steamed with heading to ESTOC position.

During the next day the CI-16 mooring was successfully recovered. Finally, the station work was finished with a CTD/Rosette cast down to 3595 m. On April 25th the ESTOC mooring was redeployed as CI-17 and the scientific work scheduled for R/V POSEIDON cruise 310 was finished at noon. The R/V POSEIDON steamed back to the Canaries and arrived at Las Palmas harbour late in the evening, and all station work could be completed as planned.

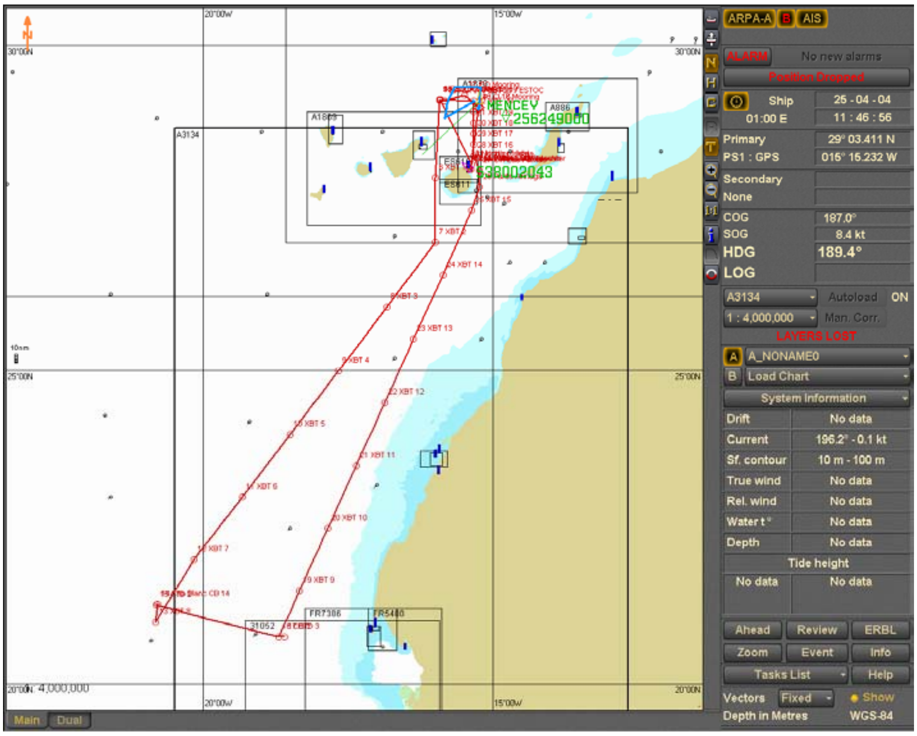


Figure 1: Cruise track and main stations during R/V POSEIDON cruise 310.

4. Scientific Report

4.1 Particle Sampling with Sediment Traps

The particulate material collected will be analysed to determine total flux, particulate flux, particulate organic carbon, particulate nitrogen, biogenic opal, carbonate and stable isotopes of organic matter, and lithogenic material. The trapped material also will be investigated for species composition of the planktonic organisms (pteropods, foraminifera, coccolithophorides and diatoms). The objective of these studies is to identify signals of seasonal variations in those components, which play an important role in the sediment formation process. The results of these investigations will form a basis for the reconstruction of paleo-current and paleoproduction systems of the Canary Island region.

All data of recovery and deployment of the mooring arrays are listed in Tab.1, together with sampling data of sediment traps.

4.1.1 Cape Blanc Moorings (CB-14 / CB-15 and CBi-1 / CBi-2)

Figure 2: Recovery of the lower sediment trap from mooring CB-14.

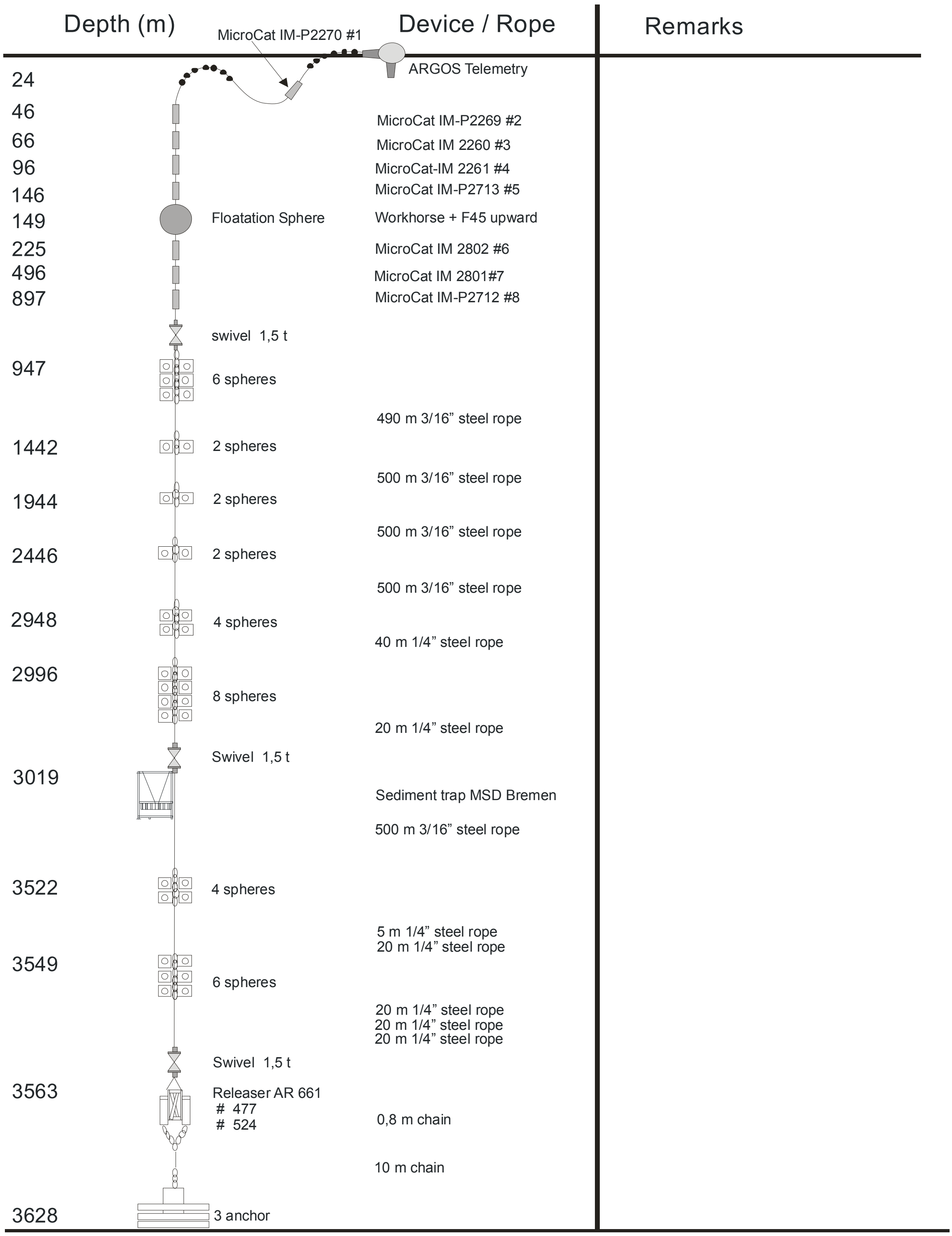
On April 16th, we successfully recovered CB-14, which at least was deployed by R/V METEOR during cruise M53/1c in April 2003. The mooring was located 200 nm of Cape Blanc in 2700 m water depth. CB-14 was equipped with two sediment traps and one currentmeter. The upper trap provided a complete sample set of 20 cups. The lower trap stopped at cup 2, which seems to be a technical problem. The mooring array was redeployed as CB-15 with the same configuration on the same day. It is planned to recover this mooring in summer 2005 with R/V METEOR.

The additional mooring CBi-1, was recovered on April 17th and redeployed on the same day as CBi-2. Both traps provided complete sample sets of 20 cups. The CBi-2 mooring array should be recovered in summer 2005 with R/V METEOR.

4.1.2 ANIMATE Canary Island Mooring (ACI-3 / ACI-4)

On April 22nd we started to recover ACI-3 mooring, located at 29°09,60`N and 15°50,05`W in 3627 m water depth. This study site was at least deployed in fall 2003 during the R/V POSEIDON cruise 305. Attached to the ACI-3 array were one sediment trap and one currentmeter (other devices described in chapter 4.2). The sediment trap provided not the whole sample set of 12 cups. But considering that there was no mechanical problem, which stopped rotation at cup 4, it seems to be a technical malfunction. The array was redeployed as ACI-4 with a similar configuration on the same day. The SN trap (SOC, Southampton Oceanographic Centre) was exchanged by the Multi Sensor Device (MSD) trap, the currentmeter was not redelpoyed. It is planned to recover this mooring in spring 2005 with R/V POSEIDON.

Figure 3: Deployment of the MSD trap, fitted into the ACI-4 mooring array.



Mooring: ACI-4 (ANIMATE Canary Islands)
Cruise: POS 310
Area: N’ Canary Islands
Waterdepth: 3625 m
Date: 23.04.2004

Position: 29°09,50’N 015°50,10’W

Codes			
	# 477	I/R	- 5847
		Rel	- 5848
	# 524	I/R	- 8A67
		Rel	- 8A68

Figure 4: Drawing of the ANIMATE mooring array ACI-4.

4.1.3 Canary Island Mooring (CI-16 / CI-17)

On April 24th the mooring CI-16 was recovered and redeployed as CI-17. This study site is located 60 nm north of Gran Canaria in about 3600 m water depth. It was at least deployed during the R/V POSEIDON cruise 296 in April 2003. The CI-16 mooring consisted of two sediment traps, the lower trap delivered the whole sample set of 20 cups whereas the upper trap only turned to cup 3. The reason therefore seems to be a fish, which blocked the sample device.

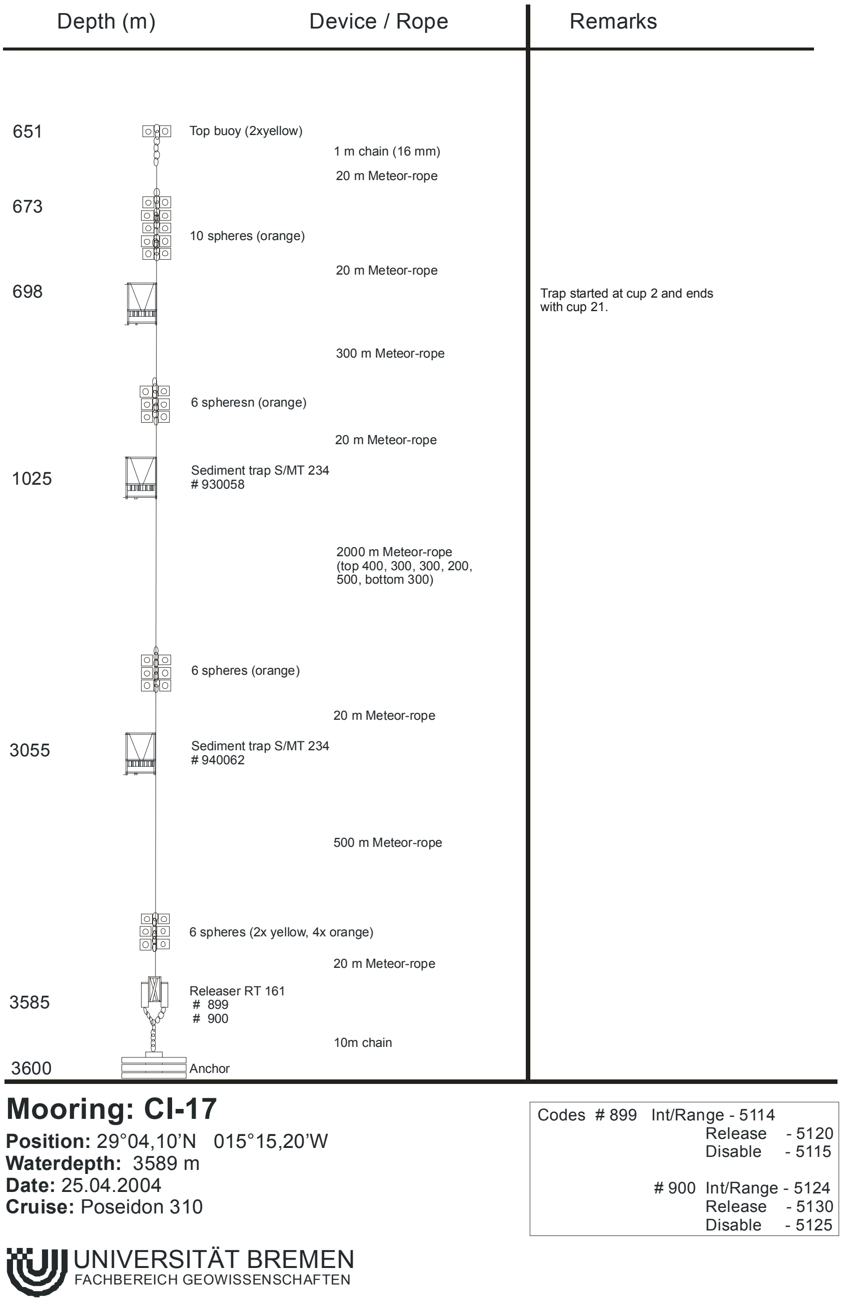


Figure 5: Design of the redeployed ESTOC mooring CI-17.

The mooring was redeployed as CI-17. The equipment was enhanced by one more sediment trap. The next recovery is planned for the R/V POSEIDON cruise in spring 2005.

4.1.4 DOLAN Mooring (MSD)

On April 13th the recovery of the DOLAN MSD, in the course of recovering the DOLAN surface buoy (SBU), started. The array was positioned at 29°10,40`N and 15°55,30`W in 3630 m water depth. This site was at least maintained during the cruise POS 305 in fall 2003. It contains one sediment trap among other devices (described in chapter 4.2). The MSD trap consists of two separate sample devices, which both deliver the whole sample set of 20 cups. This trap was attached to the ACI-4 mooring on April 23rd. It is planned to recover the DOLAN MSD array with R/V POSEIDON in spring 2005.

Table 1: Mooring data for recoveries and redeployments during R/V POSEIDON cruise 310.

Mooring	Position	Water depth	Interval	Instr.	Device	Intervals depth
	(m)	(no x days)		(m)		
Mooring recoveries						
Cape Blanc						
CB-14	21°16,80'N	4131	23.04.02-	SMT 234	1228	20 x 19
	20°46,70'W		08.05.03	SMT 234	3606	20 x 19
		1250		RCM 8		
Cape Blanc						
CBi-1	20°45.00'N	2714	05.06.03-	SMT 243	1296	1x 10.5,
	18°42.00'W		05.04.04	SMT 243	1876	19 x 15.5
ANIMATE						
ACI-3	29°09,60`N	3628	16.11.03-	SN 532	2996	5 x 21,
	15°50,05`W		20.06.04	(SOC)		8 x 14
		3019		RCM 8		
DOLAN						
MSD-2	29°10,40`N	3630	15.06.03-	MSD	3050	40 x 7.25
	15°55,30`W		30.03.04			
ESTOC						
CI-16	29°04,25`N	3600	12.04.03-	SMT 234	1025	20 x 18
	15°15,08`W		06.04.04	SMT 230	3055	20 x 18
Mooring deployments						
Cape Blanc						
CB-15	21°17.20'N	4162	31.05.03-	SMT 243	1246	20 x 15.5
	20°47.63'W		05.04.04	SMT 243	3624	20 x 15.5
				RCM 8	1269	
Cape Blanc						
CBi-2	20°45.00'N	2714	05.06.03-	SMT 243	1296	1 x 10.5,
	18°42.00'W		05.04.04	SMT 243	1876	19 x 15.5
		1320		RCM8		
DOLAN						
MSD-3	29°10,40`N	3630	26.04.04	MSD	3019	40 x 7.5
	15°55,30`W		19.02.05			
ESTOC						
CI-17	29°04,25`N	3600	26.04.04	SMT 234	1025	20 x 15
	15°15,08`W		19.02.05	SMT 230	3055	

Instruments used:
SMT 243 = Titan particle sediment trap SMT 243 KUM, Kiel
SMT 230 = Particle sediment trap SMT 243 KUM, Kiel
MSD = Particle sediment trap KUM, Kiel
SN 532 = McLane (SOC)
RCM 8 = Aanderaa current meter, RCM 8

4.2 Equipment Development and Tests

4.2.1 DOLAN moorings - SBU, - MSD and DOBS

During R/V POSEIDON cruise 310 the DOLAN mooring was recovered for maintenance reasons and for integration of additional components into the Surface Buoy Unit (SBU). The MSD and DOBS moorings, containing additional sensors and acoustic client units were also recovered. The SBU operates since 1997 and was formerly part of the DOMEST project. The unit serves for the development of satellite based telemetry technologies including data transmission into and from the deep ocean via acoustic modems. The data link is based on a sensor network moored in the Canary Island area.

Figure 6: SBU and SAMI sensor with heavy bio fouling.

On April 13th the DOLAN mooring array was recovered, which is located at 29°10,40`N and 15°55,30`W at a water depth of 3630 m. The last routine maintenance has been carried out during cruise POS 305 in fall 2003. Fig. 6 is showing the heavy bio fouling of all components from sea surface down to 20 m, including the surface buoy itself as well as the SAMI sensor. During this cruise the telemetry was extended by an additional microcontroller. This specific PC is controlling various sensors attached by serial cable links, in the following called Animate2 telemetry. The Animate2 telemetry consists of a *Tiny Tiger Module E* RTC microcontroller which has 5 serial interfaces to collect and transmit sensor data. The software reads data from the following sensors:

- Vaisala Ultrasonic Wind Sensor WS 425
- PNI Corporation TCM2 electronic compass
- Hydroscat-2 Spectral Backscattering Sensor (Fluorometer)
- NAS-3x In-situ Nutrient Analyzer

The collected sensor data are send via an Orbcomm satellite link using a Panasonic Subscriber Communicator.

On Board Assembly and Integration of the Animate2 Telemetry

The microcontroller software was adapted to read out the output of the fluorometer and the nutrient sensor and to filter the output for relevant data. After reading out a complete measurement cycle the data are passed to the Panasonic communicator, which transmits the data set via an Orbcomm satellite link. The functionality of filtering and passing the data to the Panasonic communicator was validated via the logging output of the microcontroller. Due to poor Orbcomm availability during the ship's presence at the sampling site it was not possible to validate the transmission of the fluorometer and nutrient data via the Orbcomm link.

The integration of the wind sensor and the compass was made during the Animate2 development in Bremen. The microcontroller reads the following values from the sensors:

- Wind speed
- Wind direction
- Buoy orientation

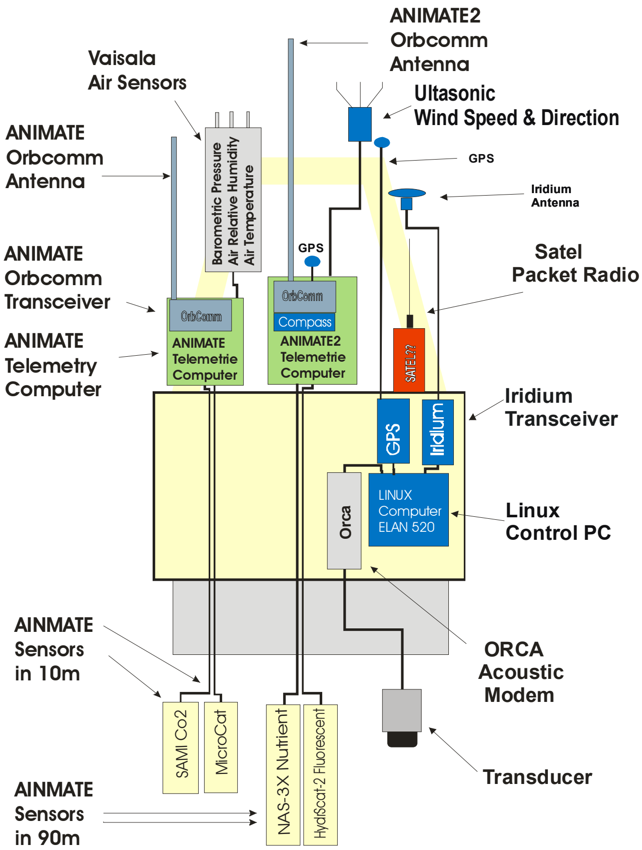


Figure 7: New configuration of the Dolan Buoy.

The resulting sensor data values are averaged over 600 single values and send via the Orbcomm link. On April 21st the first emails that were sent by the Animate2 telemetry during the on board testing phase, arrived at the Dolan account at the university Bremen. Unfortunately, the fluorometer could not be started prior to deployment due to problems with the assembly of the external battery pack.

The nutrient sensor could be started. However, the telemetry link did not deliver any data after the deployment of the mooring. A possible reason could be that the voltage level of the serial interface of the sensor does not suffice to transmit the data via the serial cable.

The acoustic server component of the SBU was replaced by a Linux PC connected to an Iridium satellite link. A new acoustic client implemented on a Tiny Tiger microcontroller was deployed within the DOLAN mooring. The acoustic communication link uses Orca acoustic modems. The bottom unit measures its supply power via an AD converter interface and transmits the values to the surface unit in 24 hour intervals. In addition, a data echo function was implemented. The surface unit sends the actual date and time once every 24 hours and waits for the bottom unit to return the data. The data received by the surface unit are transmitted via the Iridium link.

The bottom unit and the software of the surface unit were tested in Bremen during the development phase. The communication link was operating continuously during a 60 hours test sending data in 2 hour intervals. Prior to deployment the system was tested successfully on board after integration of all original hardware components. However, since the deployment the server did not receive any data from the acoustic client.

The closely linked DOBS mooring array was recovered on April 21st. Due to a lack of anchor weight this site was not redeployed again. Instead, the attached devices will be integrated in the DOLAN mooring array.

Figure 8: Redeployment of the DOLAN-SBU (Fig. 9).

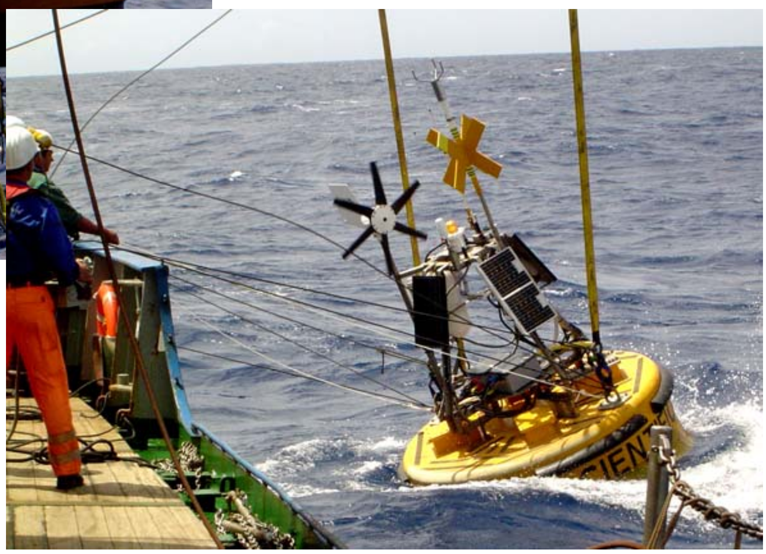


Figure 9

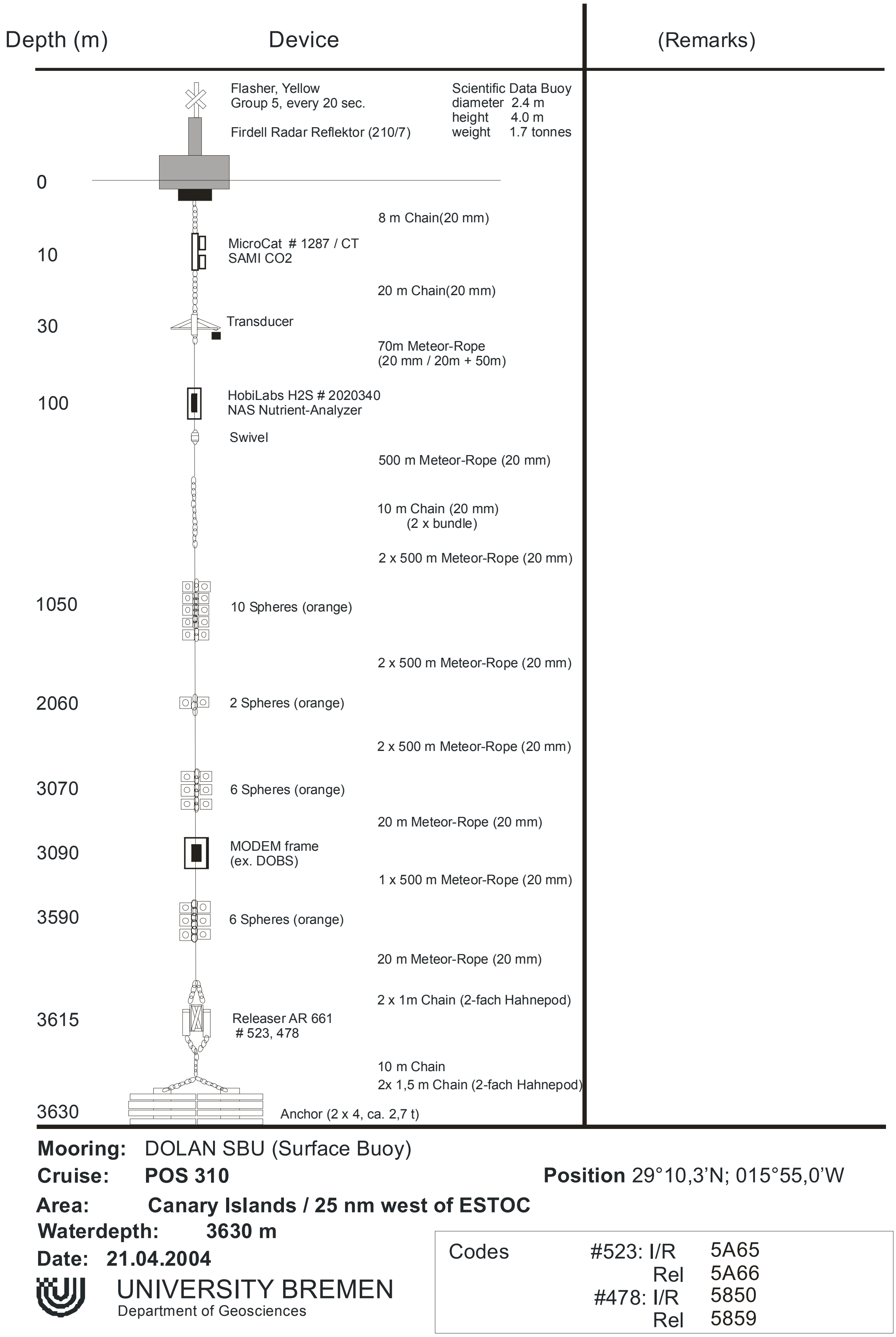


Figure 10: Drawing of the DOLAN SBU mooring.

4.2.2 ANIMATE

The recovery of the ACI-3 mooring started on April 22nd. The ANIMATE array at least was deployed during POSEIDON cruise 305. The moored array included the ARGOS telemetry buoy, 8 MicroCats, a floatation sphere with an ADCP, one sediment trap and one currentmeter. The ARGOS telemetry were more or less completely cut, probably by a ships propeller. The telemetry glass sphere was floating away since the first attempts of recovery. After releasing of the remaining mooring array, it was possible to pick up the deeper parts of the mooring. The recovery was difficult, due to turned steel ropes. The search for the telemetry buoy was continued on April 23rd.

Figure 11: Recovery of the MicroCats, which were turned into the wire rope and buoyancy spheres.

Figure 12: Redeployment of the floatation sphere (ADCP).

Figure 13: Deployment of the MicroCats.

The position of the MicroCats chanced from 4 over/under the floatation sphere to 5 over and 3 under the sphere. Till now there is no data transfer from the 3 MicroCats below the sphere.

4.2.3 SAMI (CO_2 sensor)

The SAMI-CO_2 is a renewable reagent fibre optic sensor for measuring the partial pressure of carbon dioxide in water. It is capable of measuring the partial pressure of carbon dioxide over

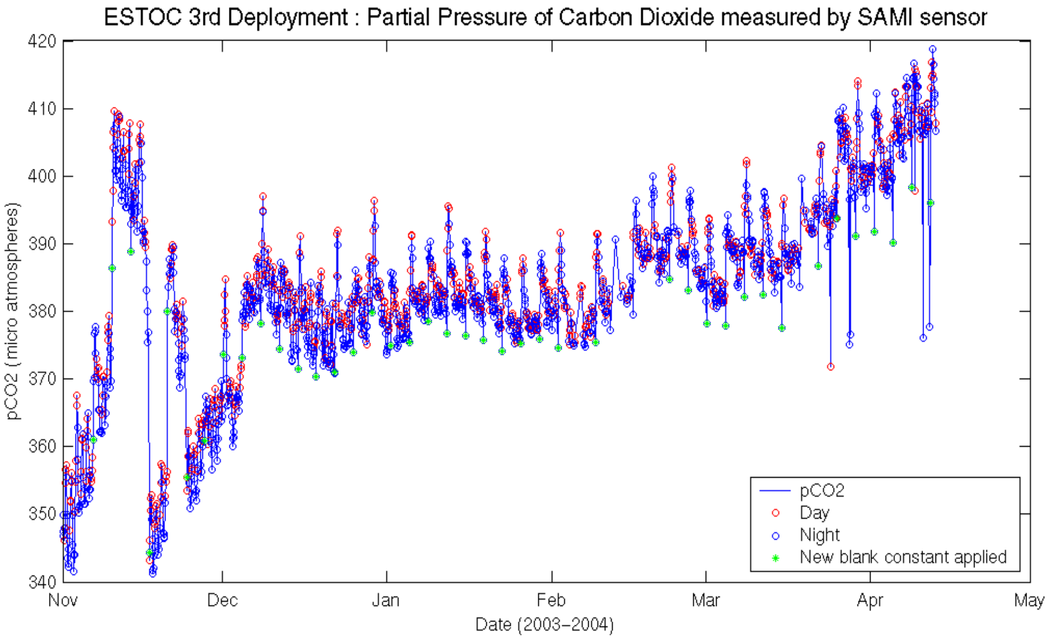


Figure 15: Sami-CO_2 Data.

a range of approximately 200-600 µatm with a precision of ~ 1 µatm, unattended for up to one year. Its PVC housing is rated to withstand pressures up to 100 m. The sensor had been deployed for the third time within the DOLAN array at a depth of 10 m, recording data in two hour intervals. The data is continuously read out by the Animate telemetry and transmitted via an Orbcomm satellite link. The recorded data of the SAMI-CO_2 sensor were read out after recovery and the sensor was sent back to the manufacturer for maintenance. On April 22nd a new SAMI-CO_2 was deployed at a depth of 10 m within the DOLAN array.

4.2.4 Fluorometer

The HydroScat-2 is a fully autonomous in-situ optical backscattering sensor that measures the backscattering coefficient at two wavelengths and fluorescence at one wavelength. Measurements are made once per hour providing an accurate description of the particles in the water column and the chlorophyll concentration. The sensor had been deployed for the three times within the MSD array at a depth of 100 m recording data in 60 min intervals. The recorded data of the Fluorometer were read out after recovery. The Fluorometer was calibrated on April 21st . Due to problems with the assembly of the external battery pack the fluorometer could not be started prior to deployment.

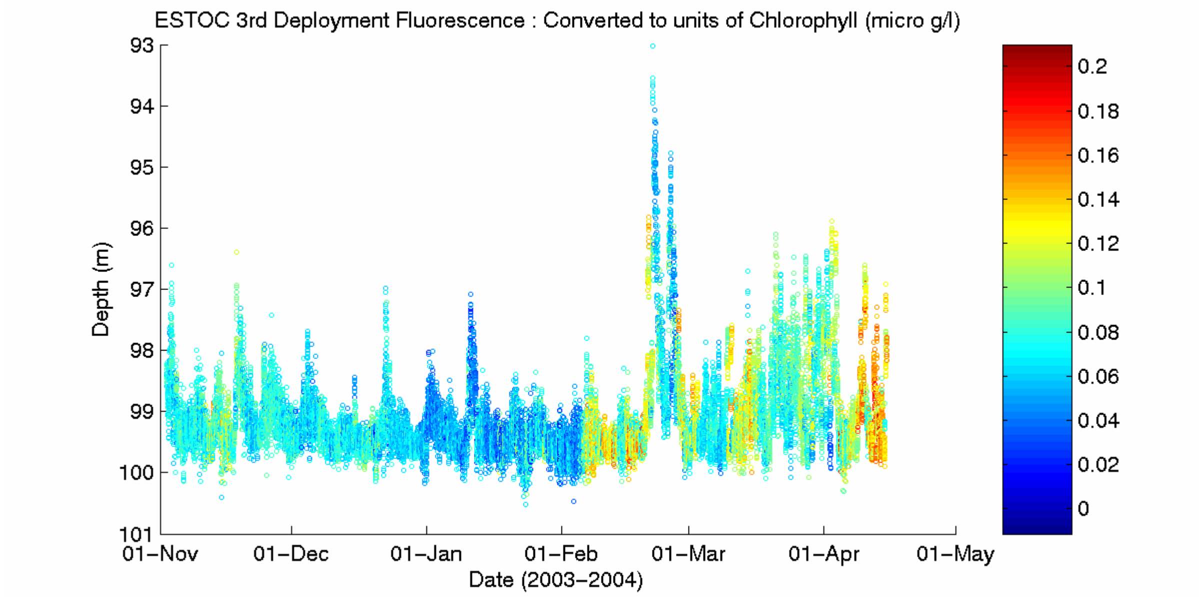


Figure 16: Data from the fluorometer.

4.2.5 Nutrient Analyser

The NAS-2E is an in-situ nutrient analyzer for high-frequency time-series determination of nutrient concentrations in marine and fresh waters. Four versions are available for the measurement of nitrate (and/or nitrite), phosphate, silicate and now ammonia. The NAS-2E is typically deployed unattended for periods up to 60 days, although much longer deployments have been achieved. The device may be used near surface, in buoy and riverine applications, or be deployed at depths to 250 m in taut-line mooring scenarios. On the ANIMATE moorings only Nitrate will be measured in the first instance. The Nutrient Analyzer was deployed on April 22nd.

4.2.6 MicroCats

The MicroCats are high accuracy temperature and conductivity sensors which record and internally store these two variables at high data rate (e.g. every 10 min) for up to one year. Within the ACI array the microcats are deployed in sets of single sensors, moored at specific depths to follow mixed-layered evolution and processes. The data are recorded in the internal memory of the microcats and transmitted to the ARGOS telemetry via an inductive link. The ARGOS telemetry sends the data online via satellite link.

During the cruise all MicroCats have been read out and calibrated prior to redeployment. The Microcats of the ACI array have been rearranged according their mooring depths and an inductive swivel has been added to the mooring cable, without interrupting the inductive link.

4.3 Marine chemistry

Along R/V POSEIDON cruise 310 for the first time a nitrate sensor with the capability to transmit measured data in near real time was placed. At the same time it was necessary to do the biogeochemical monthly samplings at the ESTOC station, in order to compare the insitu and long term data. Calibration casts with CTD/Rosette were also made to accomplish the requirements of the ANIMATE sensors being recovered/ deployed.

Taking advantage of the ship transit from DOLAN mooring site to Cape Blanc mooring sites in order to exchange them, a XBT line was made repeating some of the stations that were done during the R/V METEOR cruise M53/1c. Further on, 2 CTD/Rosette stations, collecting physical and biogeochemical data, were made in the Cape Blanc transect where the moorings were exchanged.

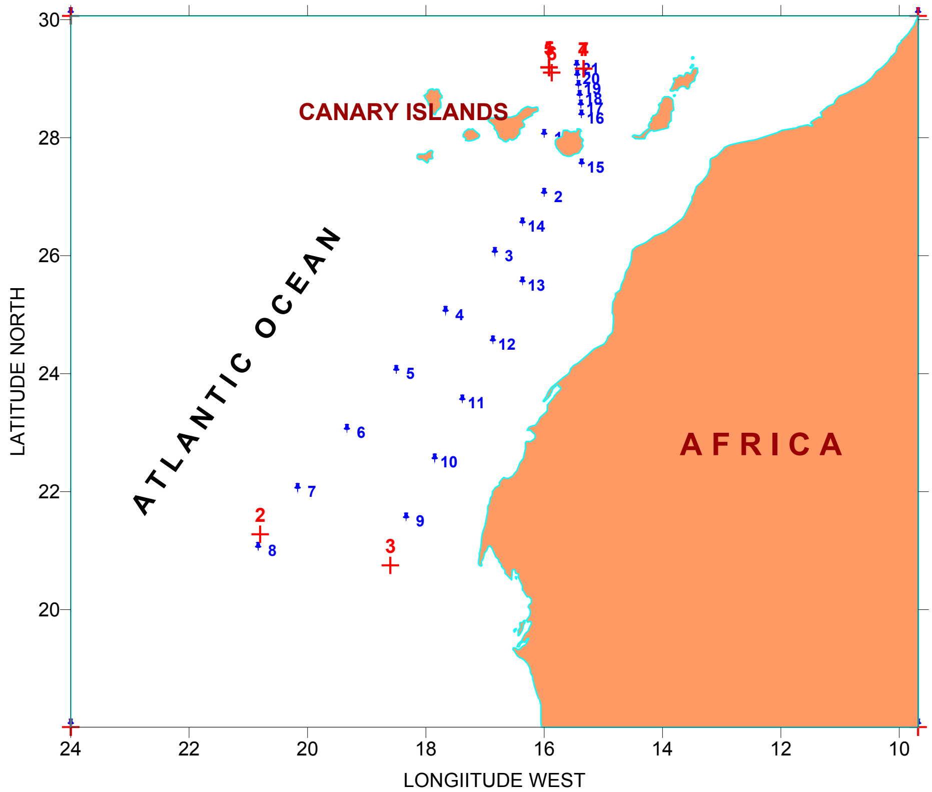


Figure 17: Position of the CTD stations (crosses) and XBT launches (pins) made by ICCM along R/V Poseidon cruise 310.

At the beginning of the cruise the DOLAN/ANIMATE moorings had to be recovered, hence a Rosette/CTD cast down to 200 m was made. In the transect from the DOLAN position to Cape Blanc 8 XBT's (eXpendable BatiThermograph) were deployed, one every degree starting at latitude 21°N (Tab. 4, P310CBD1-D8). During the transit from Cape Blanc back to ESTOC, 7 XBT's were deployed in the line from Cape Blanc to the Gran Canaria-Fuerteventura channel (Tab. 4, P310CD09-D15). Then, the customary XBT transect (6 launching points) from Las Palmas to the ESTOC station was made (Tab. 5, ESTOC-D1/D6).

A total of 13 sampling Rosette-CTD casts (Tab. 3) were made and a CTD/Rosette *Seabird Plus* unit with 12 bottles was used: one test station already mentioned (#1), two in a Cape Blanc transect where two Bremen moorings (CB, CBi) had to be exchanged (#2 and #3) down to 2000 m and twice the customary monthly sampling at the ESTOC station, down to 3500 m were also made (#4 and #7). Two other stations were made for the purpose of the sensors calibration - one at DOLAN site due to restriction of the Nutrient analyser only down to 500 m due to restrictions of the device (#5), and one at ESTOC mooring for the MicroCats (1000 m, #6).

The NAS nutrient sensor was prepared for deployment below the DOLAN buoy and it was done prior to its deployment.

Table 3: List of stations sampled along the R/V POSEIDON cruise 310, Las Palmas-DOLAN-Cape Blanc ANIMATE-DOLAN-Las Palmas (0=oxygen, A= alkalinity, P=pH, N=nutrients, S=salinity, C=chlorophyll “a”, INCID.= incidences).

date time	st. #, cast #	water depth m	Lat. N	Long. W	sample depth m	PARAMETERS O	A	P	N	S	C	INCID.
13.04 06:34	1,001	3629	29°11.25’	15°55.00’		Test cast by DOLAN mooring, also used for fluorometer calibration before recovery						
					200					√	√	
					150						√	
					125						√	
					110						√	
					100						√	
					90						√	
					75							Not closed
					60							Not closed
					55		√				√	
					35		√				√	
					25							Not closed
					10		√				√	
16.04 11:34	2,001	4160	21°16.65’	20°48.65’	2000	√	√		√	√		
					1800	√	√		√	√		
					1500	√	√		√	√		
					1300	√	√		√	√		
					1200	√	√		√	√		
					1100	√	√		√	√		
					1000							Not closed
					900	√	√		√	√		
					800	√	√		√	√		
					700	√	√		√	√		
					600	√	√		√	√		
					400(A)	√	√		√	√		
16.04 12:40	2,002	4161	21°16.62	20°48.51	400(B)	√	√		√	√		
					300	√	√		√	√		
					150	√	√		√	√	√	
					125	√	√		√	√	√	
					100	√	√		√	√	√	
					90	√	√		√	√	√	
					80	√	√		√	√	√	
					75	√	√		√	√	√	
					50	√	√		√	√	√	
					25	√	√		√	√	√	
					10	√	√		√	√	√	
17:04 11:28	3,001	2360	20°45.00’	18°36.00’	2000	√	√		√	√		
					1800	√	√		√	√		
					1500	√	√		√	√		
					1300	√	√		√	√		
					1200	√	√		√	√		
					1100	√	√		√	√		

Table 3: continued

date time	st. #, cast #	water depth m	Lat. N	Long. W	sample depth m	PARAMETERS							
						O	A	P	N	S	C	INCID.	
17:04 11:28	3,001	2360	20°45.00’	18°36.00’	1000	√	√		√	√			
					900	√	√		√	√			
					800	√	√		√	√			
					700	√	√		√	√			
					600	√	√		√	√			
					400(A)	√	√		√	√			
17:04 12:27	3 002	2349	20°45.00’	18°36.00’	400(B)	√	√		√	√			
					300	√	√		√	√			
					200	√	√		√	√	√		
					150	√	√		√	√	√		
					125	√	√		√	√	√		
					100	√	√		√	√	√		
					90							Not closed	
					75	√	√		√	√	√		
					50	√	√		√	√	√		
					30	√	√		√	√	√		
					25	√	√		√	√	√		
					10	√	√		√	√	√		
20.04 14:28	4,001	3603	29°10.22’	15°20.07’	3500	√	√	√	√	√			
	ESTOC 04/04				3000	√	√	√	√	√			
					2800	√	√	√	√	√			
					2500	√	√	√	√	√			
					2000	√	√	√	√	√			
					1800	√	√	√	√	√			
					1500	√	√	√	√	√			
					1300	√	√	√	√	√			
					1200	√	√	√	√	√			
					1100	√	√	√	√	√			
					1000	√	√	√	√	√			
					800 (A)	√	√	√	√	√			
20.04 15:55	4,002	3598	29°10.03’	15°20.01	800 (B)	√	√	√	√	√			
	ESTOC04/04				600	√	√	√	√	√			
					400	√	√	√	√	√			
					300	√	√	√	√	√			
					200	√	√	√	√	√	√		
					150	√	√	√	√	√	√		
					125	√	√	√	√	√	√		
					75	√	√	√	√	√	√		
					50	√	√	√	√	√	√		
					25	√	√	√	√	√	√		
					10	√	√	√	√	√	√		
21.04 18:59	5,001	3630	29°10.32’	15°55.63’	500 (A)				√			√	N U
ANIMATE pre-deployment calibration chemicalpack					500 (B)				√			√	T
					150		√		√			√	R
					125		√		√			√	I
					100		√		√			√	E
					90		√		√			√	N
					80		√		√			√	T
					70		√		√			√	S
					55		√		√			√	
					40		√		√			√	S
					25		√		√			√	O
					10	√	√	√	√	√	√	√	C
23.01 14:43	6,001	3625	29°06.00’	15°52.35’	Cast for microcat calibration, not Niskin bottles								
25.04 12:32	7,001	3597	29°10.01’	15°20.01’	3500	√		√	√	√			
	ESTOC 04/04 BIS				3000	√		√	√	√			
					2800	√		√	√	√			
					2500	√		√	√	√			
					2000	√		√	√	√			
					1800	√		√	√	√			
					1500	√		√	√	√			
					1300	√		√	√	√			
					1200	√		√	√	√			
					1100	√		√	√	√			

Table 3: continued

date time	st. #, cast #	water depth m	Lat. N	Long. W	sample depth m	O	A	P	N	S	C	INCID.
25.04 12:32	7,001	3597	29°10.01’	15°20.01’	1000	√		√	√	√		
					800 (A)	√		√	√	√		
25.04 13:55	7,002	3597	29°10.08’	15°19.93’	800 (B)	√		√	√	√		
	ESTOC 04/04 BIS				600	√		√	√	√		
					400	√		√	√	√		
					300	√		√	√	√		
					200	√		√	√	√	√	
					150	√		√	√	√	√	
					125	√		√	√	√	√	
					75	√		√	√	√	√	
					50	√		√	√	√	√	
					25	√		√	√	√	√	
					10	√		√	√	√	√	

Physical (CTD, salinity) and biochemical (oxygen, alkalinity, pH, nutrients, chlorophyll) parameters were measured in order to characterize the water masses present in the study area (Tab. 3). Some of the parameters (oxygen, chlorophyll filtration) were analysed on board after sampling, and others were taken frozen to the ICCM (nutrients and filters from chlorophyll, fixed sample for alkalinity/pH).

Table 4: List of XBT that were launched from the channel between Tenerife and Grand Canary Islands to Cape Blanc (D1-D8) and return (D9-D15).

XBT sta #	date	Latitude	Longitude
P310CBD1	14.04.2004	28°00,00'N	16°00.00'W
P310CBD2	14.04.2004	27°00,00'N	16°00.00'W
P310CBD3	14.04.2004	26°00,00'N	16°50.00'W
P310CBD4	14.04.2004	25°00,00'N	17°40.00'W
P310CBD5	15.04.2004	24°00,00'N	18°30.00'W
P310CBD6	15.04.2004	23°00,00'N	19°20.00'W
P310CBD7	15.04.2004	22°00,00'N	20°10.00'W
P310CBD8	16.04.2004	21°00,00'N	20°50.00'W
P310CBD9	17.04.2004	21°30,00'N	18°20.00'W
P310CD10	18.04.2004	22°30,00'N	17°51.00'W
P310CD11	18.04.2004	23°30,00'N	17°23.00'W
P310CD12	18.04.2004	24°30,00'N	16°52.00'W
P310CD13	19.04.2004	25°30,00'N	16°22.00'W
P310CD14	19.04.2004	26°30,00'N	16°22.00'W
P310CD15	20.04.2004	27°30,00'N	15°22.00'W

Table 5: List of XBT that were launched between Las Palmas and ESTOC.

XBT sta #	date	Latitude	Longitude
ESTOC-D6	20.04.2004	28°20,00'N	15°30.00'W
ESTOC-D5	20.04.2004	28°30,00'N	15°30,00'W
ESTOC-D4	20.04.2004	28°40.00'N	15°30,00'W
ESTOC-D3	20.04.2004	28°50.00'N	15°30,00'W
ESTOC-D2	20.04.2004	29°00.00'N	15°30,00'W
ESTOC-D1	20.04.2004	29°10,00'N	15°30,00'W

4.3.1 Water Sampling and Analysis

Samples were collected immediately after the Niskin bottles were on board from each depth. The sampling sequence was as follows:

Oxygen

Oxygen was taken in glass bottles of about 125 ml of volume which were previously cleaned and washed with HCl acid and was fixed at once; then it was kept for at least six hours according to WOCE regulations and finally it was analysed at the laboratory on board the ship. The samples were analysed using the method described in the WOCE Operations Manual, WHP Office Report No. 68/91; the final titration point was detected using a Metrohm 665 Dosimat Oxygen Auto-Titrator Analyser.

Nutrients

Nutrients were taken in polypropylene bottles which were previously cleaned and washed with HCl acid and were completely dry. Samples were immediately frozen at -20°C, analysing them as soon as possible after arrival at the laboratory. Freezing the samples is a common practice; it does not or only in a non-significant way affects the nitrate+nitrite and the phosphate values (by a slight decrease) and is not noticeable in the silicate values (Kremling and Wenck, 1986; McDonald and McLunghlin, 1982).

Salinity samples were taken in dark glass bottles which were previously cleaned and washed with HCl acid. Then, they were kept in boxes to protect them from light till analysis on land.

The nutrients determination was performed with a segmented continuous-flow autoanalyser, a Skalar® San Plus System (ICCM).

Nitrate and Nitrite

The automated procedure for the determination of nitrate and nitrite is based on the cadmium reduction method; the sample is passed through a column containing granulated copper-cadmium to reduce the nitrate to nitrite (Wood et al.,1967), using ammonium chloride as pH controller and complexer of the cadmium cations formed (Strickland and Parsons, 1972). The optimal column preparation conditions are described by several authors (Nydahl, 1976; Garside, 1993).

Phosphate

Orthophosphate concentration is understood as the concentration of reactive phosphate (Riley and Skirpow, 1975) and according to Koroleff (1983a) is a synonym of “dissolved inorganic phosphate”. The automated procedure for the determination of phosphate is based on the following reaction: ammonium molybdate and potassium antimony tartrate react in an acidic medium with diluted solution of phosphate to form an antimony-phospho-molybdate complex. This complex is reduced to an intensely blue-coloured complex, ascorbic acid. The complex is measured at 880 nm. The basic methodology for this anion determination is given by Murphy and Riley (1962); the used methodology is the one adapted by Strickland and Parsons (1972).

Silicate

The determination of the soluble silicon compounds in natural waters is based on the formation of the yellow coloured silicomolybdic acid; the sample is acidified and mixed with an ammonium molybdate solution forming molybdosilicic acid. This acid is reduced with ascorbic acid to a blue dye, which is measured at 810 nm. Oxalic acid is added to avoid phosphate interference. The used method is described in Koroleff (1983b).

Phytoplankton pigments

Pigments were measured using fluorimetric analysis, following the methodology described by Welschmeyer (1994). The determination was achieved using a fluorometer TURNER 10-AU-000.

Salinity

Samples were measured with a salinometer, model Autosal 8400a, whose measurement range was between 0.005-42 (psu), with an accuracy of ±0.003, according to the manufacturer. It was calibrated following the manufacturer´s information and standarizing it with IAPSO Standard Seawater. Salinity values were calculated as practical salinity according to Unesco (1978, 1984).

Chlorophyll

Chlorophyll samples of one liter of water were taken. The chlorophyll samples were filtered immediately and the filters were frozen subsequently at -20°C. Their analyses takes place at the ICCM laboratory in land.

Carbonate system measurements, in this case pH (at ESTOC only) and alkalinity: samples were taken in glass bottles and were fixed immediately on board. Finally, they were also analysed on board along the cruise. Additionally, fugacity of carbon dioxide in the air and in the seawater was determined using a flow system continuously along the ship track.

Carbonate system measurements

The pH_t in total scale (mol $(kg\text{-}SW)^{-1}$) was measured following the spectrophotometric technique of Clayton and Byrne (1993) using the m-cresol purple indicator (DOE, 1994). 0.0047 pH units were added to the pH experimental values in order to take into consideration the recommendations by Lee et al. (2000). A system similar to that described by Bellerby et al. (1995) was developed in our lab. The pH_t measurements were carried out using a Hewlett Packard Diode Array spectrophotometer in a 25°C-thermostated 1-cm flow-cell using a Peltier system. A stopped-flow protocol was used to analyse seawater previously thermostated to 25°C for a blank determination at 730, 578 and 434 nm. The flow was restarted, and the indicator injection valve switched on to inject 10 µl dye through a mixing coil (2 m). Three photometric measurements were carried out for each injection in order to remove all dye effect on the seawater pH_t measurement. Repeatedly, seawater measurements of the different Certified Reference Materials (CRM provided by Dr. Dickson, Scripps Institution of Oceanography) samples gave a standard deviation of ± 0.0015 (n = 54).

The total alkalinity of seawater (A_T) was determined by titration with HCl to the carbonic acid end point using two similar potentiometric systems, as described in more detail by Mintrop et al. (2000). In order to yield an ionic strength similar to open ocean seawater, the HCl solution (25 l, 0.25 M) was made from concentrated analytical grade HCl (Merck®, Darmstadt, Germany) in 0.45 M NaCl. The acid was standardised by titrating weighed amounts of Na_2CO_3 dissolved in 0.7 M NaCl solutions. The total alkalinity of seawater was evaluated from the proton balance at the alkalinity equivalence point, $pH_{equiv} = 4.5$, according to the exact definition of total alkalinity (Dickson, 1981). The performance of the titration systems was monitored by titrating different samples of certified reference material (CRM, batch 42) with known inorganic carbon and A_T values. The agreement between our data and CRM values was within ±1.5 μmol kg^{-1}. Total inorganic carbon (C_T) is computed from experimental values of pH_t and total alkalinity, using the carbonic acid dissociation constants of Mehrbach after Dickson and Millero (1987). This set of constants presented the best agreement between $C_T(pH, A_T)$ calculations and certified C_T values for CRM, batch 42, with a C_T residual of ± 3 μmol kg^{-1}, n=54 (Millero, 1995, Lee et al., 1997).

Fugacity of carbon dioxide (fCO_2) in the air and in surface seawater was determined using a flow system similar to the unit designed by Wanninkhof and Thoning (1993) and developed by Frank J. Millero´s group at the University of Miami. The equilibrator used is based on the design by R.F. Weiss and described by Butler et al (1988). The concentration of CO_2 in the air and in the equilibrated air sample was measured with a differential, non-dispersive, infrared gas analyser supplied by LI-COR (LI-6262 CO_2/H_2O Analyser). The sample was measured wet and the signal corrected for water vapour using the water channel of the LI-COR detector. The instrument was operated in the absolute mode and gathered CO_2 concentrations directly from the instrument. The LI-COR instrument analyses the concentration of CO_2 every six seconds, then averaged these values over a 5-min interval, and recorded them. Atmospheric air was pumped at the bow of the ship and measured every hour. The system was calibrated by measuring two different standard gases with mixing ratios of 348.55 and 520.83 ppm CO_2 in the air. These calibrated standards were provided by the National Oceanographic and Atmospheric Administration and they are traceable to the World Meteorology Organisation scale. Our system has demonstrated a precision of less than 1 μatm and is accurate, relative to standard gases, to 2 μatm. Fugacity of CO_2 in the seawater is calculated from the measured xCO_2 (mol fraction of CO_2 gas corrected to dry air and to the pressure of 1 atm).

All samples were taken using the procedures established in the WOCE Operations Manual, WHP Office Report WHPO 91-1/WOCE Report No.68/91.

4.3.2 Preliminary Results

Figure 18a shows the temperature distribution according to the data obtained from the XBT's launched starting at 28°N of latitude and 16°W of longitude, corresponding to a site located in the channel between Tenerife and Gran Canaria Islands (see Fig. 18b). Figure 18b shows the same for the 7 XBT's launched from Cape Blanc towards Gran Canaria Islands. As expected, temperature increases at the surface layer (0-200 m) as going from north to south reaching 21.2°C at 0.68 m in the southern most latitude. At the level of central waters the values remain quite stable whereas at intermediate and deeper waters it shows an increase when moving southwards. Lower temperatures for XBT's number 11 and 12 at deep waters in Fig. 18b is an artefact due to the fact that the XBT's failed at a certain depth during launching.

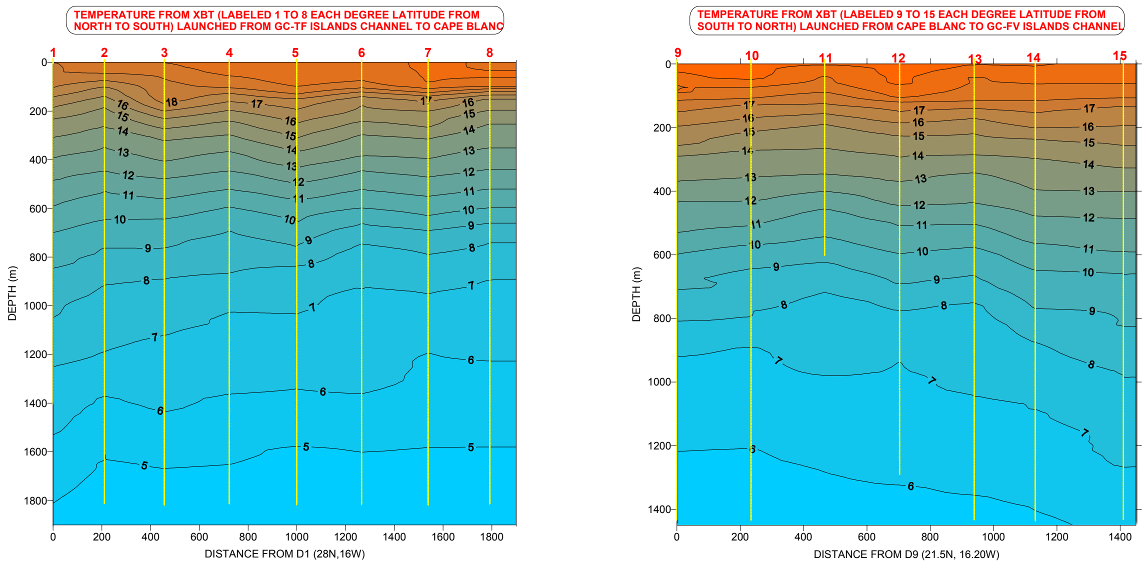


Figure 18a / b: Temperature distribution from XBT's deployed during R/V POSEIDON cruise 310: a) between the TF-GC Islands and Cape Blanc. b) between Cape Blanc and the GC-FV Islands.

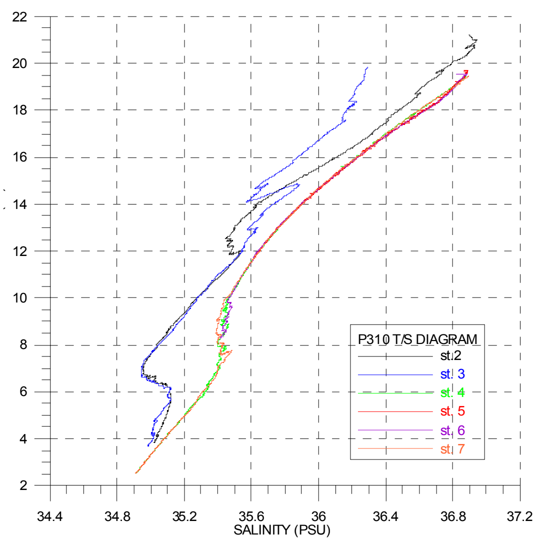


Figure 19: T/S preliminary results from CTD/Rosette stations made along R/V POSEIDON cruise 310.

The T/S diagrams for the CTD stations (Fig. 19) show a strong differentiation between the stations made in the north (at ESTOC and surroundings) and those made at the Cape Blanc transect. At the north, the salinity is greater whereas temperature values are similar to the southern ones, except at the surface. However, the more or less presence of Mediterranean and Antarctic Waters at intermediate depths at northern stations is not seen at Cape Blanc stations, where the intermediate depths at northern stations is not seen at Cape Blanc stations, where the Mediterranean waters do not reach the site.

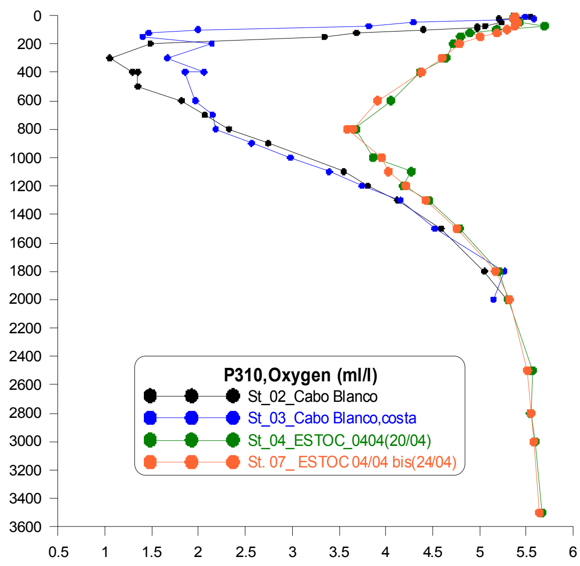


Figure 20: oxygen preliminary results from CTD/rosette stations made along R/V POSEIDON cruise 310.

The Antarctic Intermediate Water, fresher and colder water, arrives to Cape Blanc from the south as shown by the salinity minimum at 7°C for stations #2 and #3. At the same time at depths corresponding to central waters, a differential behaviour is encountered at temperatures between 12 and 15°C, due to the influence of South Atlantic Central Water (SACW) at different intensities in the Cape Blanc transect. Further, the station nearest to the coast (#3) could also be influenced by the upwelling events occurring randomly in this area of the African coast. The oxygen graph has the same trend as the T/S diagrams, a strong separation between northern stations and the Cape Blanc ones.

At the north, ESTOC shows the usual oxygen profile, decreasing from surface (around 6 ml/l) to its minimum at around 3.6 ml/l at 800 m water depth, and increasing gradually with depth to reach at the bottom approximately same values as the surface ones (around 5.7ml/l). However in the south, similar values to the north are found at the surface but there is a strong primary production in the upper layer that induces oxygen consumption. This fact produces a sharp gradient of oxygen depletion from the surface to the minimum of 0.89 ml/l at about 300 m depth, increasing again towards the bottom to reach the same values as in the north.

4.4 Stable Nitrogen and Carbon Isotopes of Marine Particles

4.4.1 Introduction

The origin of organic matter may be characterized by its chemical composition. Especially the stable nitrogen isotopes allow valuable insights into the production and degradation history of organic particles. Low values of the stable nitrogen isotope ratio $\delta^{15}N$ and high concentration of organic nitrogen and carbon are expected of material generated in an upwelling system. Higher $\delta^{15}N$ values, on the other hand, are typical of organic matter produced in oligotrophic systems. In addition, degradation of organic matter causes an enrichment of $\delta^{15}N$. In this study, the stable nitrogen isotope ratio as well as the carbon isotope ratio of particulate (mainly suspended) material will be determined and compared to the organic chemistry of fast sinking material sampled by particle traps. To get a better compendium of the isotopic composition of the different water masses influencing the particle trap sample isotope compositions, sea surface samples were also taken for nitrogen and carbon isotope measurements.

4.4.2 Methods

Sea surface samples

During the R/V POSEIDON cruise 310 32 water samples were taken via the surface water pumping system, taking water five meters below the ship for analysis of $\delta^{15}N$ and $\delta^{13}C$ of particulate material.

For the Rosette samples as well as the sea surface samples, 5 l of seawater from each depth and site were filtrated onto precombusted GGF-filters. The filters were dried at 60°C for further analysis on shore. $\delta^{15}N$ and $\delta^{13}C$ will be measured using a Finigan mass spectrometer. For the analysis the filters will be divided into halves, one for decalcified and one for non decalcified series of measurements. All sampling sites are shown in Tab. 4.

Table 4: Surface water sampling sites with oceanographic data.

sample number	date 2004	time (UTC)	Longitude (W)	Latitude (E)	waterdepth (m)	volume (l)	temperature (°C)	salinity (PSU)
1	12.04.	09:57	29°10,49	15°54,59		3	22,55	36,53
2	13.04	20:48	28°44,56	15°56,87		3	23,29	36,59
3	14.04	03:10	27°40,741	16°00,065	2992,5	3	22,73	36,592
4	14.04	06:48	27°03,251	15°59,918	3441,5	3	22,422	36,594
5	14.04	11:06	26°27,318	16°27,236	3550,5	3	22,276	36,579
6	14.04	15:23	25°50,717	16°57,559	343,0	3	22,234	36,561
7	14.04	18:51	25°21,906	17°21,585	3154,5	3	22,293	36,557
8	14.04	23:39	24°44,011	17°53,197	2779,5	3	22,441	36,546
9	15.04	07:11	23°45,492	18°41,998	3056,5	3	22,51	36,552
10	15.04	11:08	23°14,012	19°08,286	3464,5	3	22,568	35,55
11	15.04	14:56	22°44,284	19°32,923	3703,5	4	22,269	36,548
12	15.04	18:56	22°13,154	19°59,008	3979,5	4	22,873	36,532
13	15.04	22:23	21°46,958	20°18,640	4081,5	3	23,275	36,526
14	16.04	07:28	20°44.371	18°42.029	4157,0	3	23,275	36,544
15	16.04	15:24	21°19,004	20°47,802	4168,5	4	24,322	36,53
16	16.04	19:51	21°13,277	20°31,188	4070,5	4	25,335	36,51
17	17.04	07:28	20°44,371	18°42,029	2718,5	4	23,770	36,593
18	17.04							
19	17.04	19:58	21°14,743	18°27,948	2544,5	1,7	23,678	36,604
20	18.04	06:47	22°35,410	17°48,508	2030,5	2	22,527	36,605
21	18.04	12:58	23°21,519	17°26,504	1406,5	3	22,515	36,566
22	18.04	16:49	23°49,383	17°13,025	1181,5	2,7	22,537	36,558
23	18.04	23:08	24°34,432	16°49,827	1563,5	3	22,494	36,552
24	19.04	06:50	25°29,603	16°22,506	1636,5	3	22,461	36,551
25	19.04	10:21	25°53,777	16°10,350	2258,5	3	22,423	36,553
26	19.04	14:49	26°27,216	15°53,536	3306,5	3	22,262	36,563
27	19.04	19:03	26°59,938	15°37,083	3286,5	3	22,16	36,56
28	19.04	22:17	27°23,570	15°25,154	2902,5	3	22,121	36,555
29	20.04	07:41	28°40,262	15°20,008	3584,5	3	21,789	36,561
30	20.04	19:40	29°10,783	15°42,808	3626,5	4	21,908	36,544
31	21.04	06:53	29°10,127	15°55,162	3628,0	4	21,931	36,552
32	23.04	07:10	29°14,872	15°29,671	3612,5	3	22,623	36,587

5. List of Stations

Station-No.	date 2004	Discription and Devices	LAT [deg-min]		LONG [deg-min]		WD [m]	Samples	Remarks
49-1	13.04.	CTD/Rosette	29-10,4	N	015-54,8	W	3629		Sensor problems
49-2	13.04.	CTD/Rosette	29-10,4	N	015-54,8	W	3629	2 x 12 bottles	
50	13.04.	DOLAN-SBU recovery	29-10,1	N	015-54,8	W	3629		extrem bio fouling
51	13.04.	DOLAN MSD recovery	29-09,9	N	015-55,2	W	3816		recovery
52	14.04.	XBT #1	28-00,0	N	016-00,0	W	972		
53		XBT #2	26-59,9	N	016-00,0	W			
54		XBT #3	25,59,9	N	016-50,0	W	3479		
55		XBT #4	25-00,0	N	017-40,0	W	2983		
56	15.04.	XBT #5	24-00,0	N	018-29,9	W	2841		
57		XBT #6	23-00,0	N	019-19,9	W	3526		
58		XBT #7	22-00,0	N	020-10,0	W	4035		
59	16.04.	XBT #8	21-00,0	N	020-50,0	W	4108		
60	16.04.	CB-14 recovery	21-16,5	N	020-47,6	W	4152		
61	16.04.	CTD/Rosette	21-16,2	N	020-48,8	W	4160	12 bottles	
62	16.04.	CTD/Rosette	21-16,7	N	020-48,5	W	4159	12 bottles	
63	16.04.	CB-15 redeployment	21-19,7	N	020-47,8	W	4252		
64	17.04.	CBi-1 recovery	20-44,5	N	018-42,1	W	2707		
65	17.04.	CTD/Rosette	20-44,8	N	018-36,0	W	2358	12 bottles	
66	17.04.	CTD/Rosette	20-44,3	N	018-35,8	W	2350	12 bottles	
67	17.04.	CBi-2 redeployment	20-47,3	N	018-42,0	W	n. a.		
68	17.04.	XBT #9	21-30,0	N	018-20,6	W	2405		
69	18.04.	XBT #10	22-30,0	N	017-50,1	W	2318		
70		XBT #11	23-30,0	N	017-22,9	W	1199		
71		XBT #12	24-30,0	N	016-52,0	W	1396		
72	19.04.	XBT #13	25-30,0	N	016-22,3	W	1625		
73		XBT #14	26-30,0	N	015-51,9	W	3309		
74	20.04.	XBT #15	27-30,0	N	015-21,9	W	2607		
75		XBT #16	28-20,0	N	015-20,0	W	3148		
76		XBT #17	28-30,0	N	015-20,0	W	3445		
77		XBT #18	28-40,0	N	015-20,0	W	3578		
78		XBT #19	28-50,0	N	015-20,0	W	3590		
79		XBT #20	29-00,0	N	015-20,0	W	3594		
80		XBT #21	29-10,0	N	015-20,0	W	3596		
81	20.04.	CTD/Rosette	29-10,0	N	015-20,0	W	3596	12 bottles	
82		CTD/Rosette	29-10,0	N	015-20,0	W	3597	12 bottles	
83		Drifter deployed	29-09,9	N	015-20,6	W	3598		
84	21.04.	DOBS recovery	29-10,1	N	015-55,4	W	3628		
85	21.04.	DOLAN-SUB redeployment	29-08,9	N	015-55,9	W	3629		
86	21.04.	MicroCats / SAMI	29-10,8	N	015-55,6	W	3629		Calibration cast
87	22.04.	DOLAN-MSD redeployment	29-11,5	N	015-54,8	W	3628		
88	22.04.	ACI-3 recovery	29-09,2	N	015-50,0	W	3627		
89	23.04.	Hydrophone	29-14,8	N	015-29,6	W	3704		

Station-No.	date 2004	Discription and Devices	LAT [deg-min]		LONG [deg-min]		WD [m]	Samples	Remarks
90	23.04.	MC-calibration cast	29-05,9	N	015-52,3	W	3623		technical problems
91	23.04.	MC-calibration cast	29-05,5	N	015-53,0	W	3624		
92	23.04.	ACI-4 redeployment	29-08,1	N	015-51,8	W	3625		
93	24.04.	CI-16 recovery	29-04,0	N	015-15,3	W	3590		
94	24.04.	CTD/Rosette	29-09,9	N	015-19,9	W	3692	12 bottles	
95	24.04.	CTD/Rosette	29-09,8	N	015-19,5	W	3596	12 bottles	
96	25.04.	CI-17 redeployment	29-02,4	N	015-14,7	W	3589		

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