METEOR-Berichte 11-3

Circulation and Oxygen Distribution in the Tropical Atlantic

Cruise M80, Leg 1

October 26 to November 23, 2009
Mindelo (Cape Verde) to Mindelo (Cape Verde)

Peter Brandt, Darlene Brownell, Marcus Dengler, Sven-Helge Didwischus, Sandra Fehsenfeld, Sebastian Fessler, Jürgen Fischer, Andreas Funk, Tobias Großkopf, Johannes Hahn, Hannah Halm, Verena Hormann, Uwe Koy, Gerd Krahmann, Andreas Krupke, Vito Melo, Mario Müller, Gerd Niehus, Uwe Papenburg, Andreas Pinck, Anke Schneider, Tobias Steinhoff, Tim Stöven, Thorsten Truscheit, Nuno Viera, Holger von Neuhoff, Thibaut Wagener, Kathrin Wuttig, Rainer Zantopp

Editorial Assistance:

Senatskommission für Ozeanographie der Deutschen Forschungsgemeinschaft
MARUM – Zentrum für Marine Umweltwissenschaften der Universität Bremen

Leitstelle Deutsche Forschungsschiffe
Institut für Meereskunde der Universität Hamburg

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Table of Content (R/V METEOR 80/1)

1. Summary

METEOR cruise 80/1 was a contribution to the SFB 754 "Climate-Biogeochemistry Interactions in the Tropical Ocean". Shipboard, glider and moored observations are used to study the temporal and spatial variability of physical and biogeochemical parameters within the oxygen minimum zone (OMZ) of the tropical North Atlantic. As part of the BMBF "Nordatlantik" project, it further focuses on the equatorial current system including the Equatorial Undercurrent (EUC) and intermediate currents below. During the cruise, hydrographic station observations were performed using a CTD/O_2 rosette, including water sampling for salinity, oxygen, nutrients and other biogeochemical tracers. Underway current measurements were successfully carried out with the 75 kHz ADCP borrowed from R/V POSEIDON during the first part of the cruise, and R/V METEOR's 38 kHz ADCP during the second part. During M80/1, an intensive mooring program was carried out with 8 mooring recoveries and 8 mooring deployments. Right at the beginning of the cruise, a multidisciplinary mooring near the Cape Verde Islands was recovered and redeployed. Within the framework of SFB 754, two moorings with CTD/O_2 profilers were recovered and redeployed with other instrumentation in the center and at the southern rim of the OMZ of the tropical North Atlantic. The equatorial mooring array as part of BMBF "North Atlantic" project consists of 5 current meter moorings along 23°W between 2°S and 2°N. It is aimed at quantifying the variability of the thermocline water supply toward the equatorial cold tongue which develops east of 10°W during boreal summer. Several glider missions were performed during the cruise. One glider was recovered that was deployed two months earlier. Another glider was deployed for two short term missions, near the equator for about 8 days and near 8°N for one day. This glider was equipped with a new microstructure probe in addition to standard sensors, i.e. CTD/O_2, chlorophyll and turbidity.

Zusammenfassung

Die METEOR-Reise 80/1 ist ein Beitrag zum SFB 754 „Klima-Biogeochemische Wechselwirkungen im tropischen Ozean“. Mit Hilfe von Schiffsbeobachtungen sowie Messungen von Gleitern und Verankerungen soll die zeitliche und räumliche Variabilität verschiedener physikalischer und biogeochemischer Parameter in der Sauerstoffminimumzone (OMZ) des tropischen Nordatlantiks untersucht werden. Ein weiterer Schwerpunkt der Forschungsfahrt, der Teil des BMBF Projekts „Nordatlantik“ ist, befasst sich mit der Variabilität des äquatorialen Strömungssystems. Während hydrographischer Stationsarbeiten mit der CTD-Rosette wurden Wasserproben zur Analyse des Salz- und Sauerstoffgehalts sowie von Nährstoffen und anderen biogeochemischen Spurenstoffen genommen. Strömungsmessungen wurden während des ersten Teils der Reise mit dem von FS POSEIDON geliehenen 75 kHz ADCP durchgeführt und während des zweiten Teils mit dem 38 kHz ADCP vom FS METEOR. Mit 8 Verankerungsaufnahmen und 8 Auslegungen beinhaltete M80/1 ein sehr intensives Verankerungsprogramm. Gleich zu Beginn von M80/1 konnte die multidisziplinäre Verankerung nördlich der Kapverden erfolgreich geborgen und wieder ausgelegt werden. Im Zentrum und am südlichen Rand der OMZ wurden im Rahmen des SFB 754 Verankerungen ausgetauscht. Dabei wurden zwei verankerte, profilierende CTD-Sonden durch jeweils mehrere CTD/Sauerstoffsensoren und ein ADCP ersetzt. Das äquatoriale Array entlang von 23° W zwischen 2° S und 2° N besteht aus 5 Strömungsmesserverankerungen. Diese Verankerungen

dienen hauptsächlich der Erfassung des ostwärtigen Transports im Bereich der Thermokline zur Versorgung des äquatorialen Auftriebs in der Kaltwasserzunge des Ostatlantiks. Verschiedene Gleitermissionen wurden während M80/1 durchgeführt. Darunter ist die Aufnahme eines Gleiters der 2 Monate vorher von den Kapverden nach Süden geschickt wurde. Zwei weitere kurze Missionen mit einem Gleiter, der zusätzlich mit einer Mikrostruktursonde ausgerüstet war, lieferten hervorragende Daten zur Bestimmung der diapyknischen Vermischung am Äquator sowie bei 8°N in der OMZ.

2. Participants

	Name.	Discipline	Institution
1	Brandt, Peter, Prof. Dr.	Chief Scientist	IFM-GEOMAR
2	Brownell, Darlene	Tracer (CFC-12, SF6, SF5)	BIO
3	Dengler, Marcus, Dr.	Microstructure	IFM-GEOMAR
4	Didwischus, Sven-Helge	CTD, moorings	IFM-GEOMAR
5	Fehsenfeld, Sandra	Incubation, genetics	IFM-GEOMAR
6	Fessler, Sebastian	DIC/alkalinity	IFM-GEOMAR
7	Fischer, Jürgen, Dr.	Moorings	IFM-GEOMAR
8	Funk, Andreas, Dr.	ADCP/ Microstructure	IFM-GEOMAR
9	Großkopf, Tobias	Incubation, particle analysis	IFM-GEOMAR
10	Hahn, Johannes	CTD, optodes	IFM-GEOMAR
11	Halm, Hannah	Incubations	MPI-Bremen
12	Hormann, Verena, Dr.	Salinometer/CTD	IFM-GEOMAR
13	Koy, Uwe	Microstructure	IFM-GEOMAR
14	Krahmann, Gerd, Dr.	Glider, CTD, LADCP	IFM-GEOMAR
15	Krupke, Andreas	Incubations	MPI-Bremen
16	Melo, Vito	CTD, Chlorophyll	INDP
17	Müller, Mario	Moorings / computer	IFM-GEOMAR
18	Niehus, Gerd	Moorings / technology	IFM-GEOMAR
19	Papenburg, Uwe	Moorings / technology	IFM-GEOMAR
20	Pinck, Andreas	Glider, CTD, optodes	IFM-GEOMAR
21	Schneider, Anke	Tracer (CFC-12, SF6, SF5)	IFM-GEOMAR
22	Steinhoff, Tobias	DIC/alkalinity, O_2	IFM-GEOMAR
23	Stöven, Tim	O_2, nutrients, DIC	IFM-GEOMAR
24	Viera, Nuno	CTD/ADCP	INDP
25	von Neuhoff, Holger	Media	Freelance
26	Wagener, Thibaut, Dr.	Trace metals, GoFlo	IFM-GEOMAR
27	Wuttig, Kathrin	Trace metals, GoFlo	IFM-GEOMAR
28	Zantopp, Rainer	CTD/Moorings	IFM-GEOMAR
29	Truscheit, Thorsten	Meteorological technology	DWD

IFM-GEOMAR Leibniz-Institut für Meereswissenschaften an der Universität Kiel, Düsternbrooker Weg 20, 24105 Kiel - Germany, e-mail: pbrandt@ifm-geomar.de

BIO Bedford Institute of Oceanography, Ocean Science, Katherine Ellis Laboratory, Workstation 4-12, 1 Challenger Drive, Dartmouth, Nova Scotia, B2Y 4A2, Canada, e-mail: BrownellD@mar.dfo-mpo.gc.ca

DWD Deutscher Wetterdienst, Geschäftsfeld Seeschiffahrt, Bernhard-Nocht-Str. 76, 20359 Hamburg - Germany, e-mail: edmund.knuth@dwd.de

INDP Instituto de Desenvolvimento das Pescas, Cova de Inglesa, P.B. 132 Mindelo, S. Vicente - Cape Verde, e-mail: pericles.silva@tenatso.com

MPI-Bremen Max-Planck-Institut für Marine Mikrobiologie, Celsiusstrasse 1, 28359 Bremen - Germany, e-mail: glavik@mpi-bremen.de

3. Research Program

Research cruise M80/1 focused on two aspects of tropical Atlantic climate variability: 1) changes in the oxygen minimum zone (OMZ) of the tropical North Atlantic, and 2) the equatorial current system in the central Atlantic. Specific topics addressed during the research cruise were:

- Oxygen supply toward the North Atlantic OMZ;
- Oxygen variability on daily to interannual time scales;
- Distributions of key nutrients, pelagic community responses to redox-induced changes in nutrient stoichiometry;
- Transport variability of the Equatorial Undercurrent (EUC) and intermediate currents below;
- Role of advection and vertical mixing for the heat budget of the equatorial mixed layer, particularly within the equatorial cold tongue.

Changes in the North Atlantic OMZ were studied using observational data acquired during previous research cruises, particularly METEOR cruise 68/2 and L'ATALANTE cruise IFM-GEOMAR-4. By comparing recent shipboard data with historical hydrographic data, Stramma et al. (2008) were able to show a continuous reduction of the oxygen content in the OMZ. Brandt et al. (2010) analyzed ventilation pathways toward the OMZ and suggested a weakening of zonal current bands possibly contributing to the ongoing oxygen depletion. During M80/1, the further evolution of the OMZ was documented. Hydrographic and current data were successfully acquired along the 23°W section cutting through the OMZ. The complete dataset taken during M80/1, including microstructure data as well as data from gliders and moorings, allows to address oxygen and current variability in the OMZ on daily to interannual time scales and particularly quantifying different ventilation mechanisms. Problems with moored profilers, mainly due to interference with longline fishing gear that was discovered during IFM-GEOMAR-4 as well, resulted in measured time series much shorter than the deployment time. For the next mooring deployment period, we changed the mooring design. Instead of moored profilers we deployed several single point CTD and oxygen sensors together with ADCPs. During hydrographic station work along the 23°W line, water samples were taken for the analysis of salinity, oxygen, key nutrients, inorganic carbon parameters, trace metals, phosphorus, tracers (CFC-12, SF6, SF5CF3) and CDOM. Additional water samples were taken for dedicated incubation experiments to study nitrogen fixation and for simultaneous DNA/RNA analysis. Aerosol sampling for the analysis of Saharan dust input was conducted during the cruise.

The equatorial current meter mooring array was completely recovered and redeployed. Data from previous mooring deployments at the same location were used to analyse the mean circulation, seasonal cycle and year-to-year variability (Hormann and Brandt, 2009), Tropical Instability Waves (von Schuckmann et al., 2008) and shallow stacked jets at the equator (Brandt et al., 2008). The available time series of equatorial currents, now spanning a period of more than 6 years, shows surprisingly large variability at intermediate depths on time scales of 4-5 years that seems to play an important role in the ventilation of the equatorial Atlantic. First analysis of moored current data indicates that reliable EUC transport estimates can be obtained. Besides traditional microstructure measurements with a loosely-tethered probe, we used for the first time a glider equipped with a microstructure probe. Microstructure and mooring data will further constrain uncertainties in the heat budget of the equatorial mixed layer.

In addition to the main goals listed above, the research cruise was also used to recover and redeploy a multidisciplinary mooring near the Cape Verde Islands, which includes a large number of physical and biogeochemical sensors. Between 5°N and 5°S deep CTD/LADCP stations were performed in support of a cooperative effort of WHOI and IFM-GEOMAR aimed at studying deep equatorial currents (deep jets) and their impact on water mass transformation within the North Atlantic Deep Water range.

4. Narrative of the Cruise

R/V METEOR departed from Mindelo on October 26, 2009 at 10:00 and headed north between the Cape Verdean islands of São Vicente and Santo Antão (Fig.1.1). North of São Vicente, the Tenatso mooring (**KPO_1028)** was recovered on the day of departure from Mindelo as the first activity of the cruise – just 6h after leaving port. The upper 400m of the mooring were heavily entangled in monofilament fishing lines. However, all instruments were in place with only two Microcats damaged. Biofouling of the upper part of the mooring again was an issue.

During the following night, two CTD/O_2 stations were carried out to be used for water sampling of N_20, dissolved inorganic carbon (DIC), alkalinity, nutrients, oxygen, chlorophyll and other chemical and biological parameters. The two CTD/O_2 stations were also needed for calibration of different moored instruments to be deployed during the next day. Additionally, we had a GoFlo station with water sampling for the determination of trace metals (Fe, Mn, and Cu) and phosphate content as well as an extended microstructure profiling. During the CTD/O_2 and GoFlo stations we tried to read data from a pressure - inverted echo sounder (PIES) that had been deployed in March 2008. Although we were able to establish communication with the instrument and infer the correct depth recording of the instrument, we failed in transferring the recorded dataset.

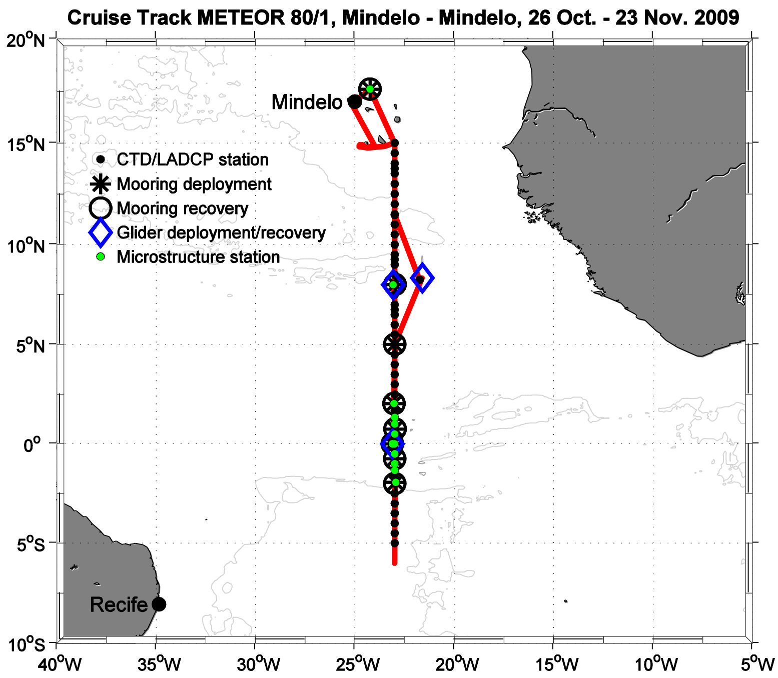

Fig. 4.1: Cruise track of R/V METEOR cruise M80/1.

October 27 began with a mooring deployment (**KPO_1041**) simulation (to be used at each of the deployments). Again, this mooring was very ambitious as the top element was planned for just 20 m below the surface. Topography was known in great detail and we dropped the anchor at the tentative position, allowing for 10% backfall of the anchor. The descent of the top element was well observed (as was possible during each of the deployments). Immediately afterwards we deployed an Inverted Echo Sounder (PIES) at the mooring site und waited for another half hour. We then began a survey along the deployment track of the mooring to make sure that the mooring top remained underwater; no problems were encountered, and the mooring was declared successfully deployed.

After these first two very intensive working days, R/V METEOR headed southeast to reach the 23°W meridian at about 15°N. The 23°W section is an important repeat section for hydrographic and current observations (Brandt et al., 2010). Current observations from aboard R/V METEOR were carried out using a 75-kHz shipboard ADCP. This instrument normally belongs to R/V POSEIDON and was used here because of a failure of R/V METEOR's 75 kHz ADCP a few legs before our cruise. Along the 23°W section, few CTD/O_2 stations followed for instrument calibration and releaser tests. At 8°15'N we started water sampling for incubations aimed at studying nitrogen fixation. Due to the large amount of water needed for the incubations and accompanying water sample analysis, we performed a 600m- CTD/O_2 cast exclusively dedicated to the incubation work every other day of the cruise.

Two months earlier, a glider (**ifm03**) had been deployed south of São Vicente. This glider was able to reach 8°N following a 1300km long path through the Cape Verdian islands and along the 23°W section, recording a full suite of hydrographic data before its batteries ran low. After a few days of surface drift, the glider was recovered at 8°15'N, 21°45'W. This was the most extended mission of an IFM-GEOMAR glider up to now.

Our cruise proceeded along the 23°W section, primarily doing mooring work with few CTD/O_2, GoFlo and Microstructure stations in between. In the morning of October 31, we recovered the mooring at 5°N (**KPO_1026**). This mooring contained a moored profiler (MMP) and it was suspected that fishing lines would be found in the top part of the mooring. To our surprise, the MMP was parked at his upper stop and was overgrown with algae. At the lower stop we then found lots of fishing equipment wrapped around the instrument group below the profiling range. Later we found that the profiler worked for only 4 months and then stopped with the batteries drained. In the afternoon, following a CTD/O_2 station at the mooring position, we redeployed the SFB-mooring at 5°N (**KPO_1047**); instead of a moored profiler (as in the recovered mooring) we now used discrete measurements of CTD/O_2 about 100m apart. The oxygen loggers used here were developed at IFM-GEOMAR.

The current meter mooring at 2°N (**KPO_1025**) was recovered in the afternoon of November 1^{st}, and redeployed (**KPO_1046**) during the following morning. On November 3, we recovered (**KPO_1024**) and redeployed (**KPO_1045**) the current meter mooring at 0° 45'N. During the next day we reached the equator, where we started our work with microstructure measurements. These measurements were continued in between mooring work, CTD/O_2 and GoFlo stations to obtain a complete daily cycle of equatorial turbulence. The equatorial mooring (**KPO_1023**) was recovered during the morning of November 4. During the next day, we had a visit with R/V POLARSTERN on the high seas. We organized a transfer between the two ships allowing scientists and crew members to discuss results and get a tour of the respective other ship, machinery and instrumentation. After the visit, we continued with the deployment of the equatorial mooring (**KPO_1044**). At the equator we deployed our second glider (**ifm02**) in use. For the first time, such a glider was equipped with a MicroRider microstructure probe. It was sent out for an 8 day mission to be recovered on our way back to Mindelo. Problems (leak detect) with our third glider (**ifm08**) did not allow to send the glider for a planned northward transect from the equator towards the Cape Verdean islands.

On our way toward 6°S, we recovered only one other mooring (**KPO_1022**) at 0°45'S. On our way back, on November 11, the mooring at 2°S was then recovered (**KPO_1021**) and also redeployed (**KPO_1042**) on the same day. The mooring at 0°45'S (**KPO_1043**) was redeployed the next day. The only significant failure within the equatorial mooring array was the upward looking NB-ADCP which stopped working due to a loose connector. It contained no data. Overall, the instrument performance was exceptionally good. All the deployments went very smoothly into the water. This was particularly important for all moorings equipped with moored profilers (in cooperation with J. Toole, WHOI) for the measurement of deep circulation and hydrography between 1000 and 3500 m depth. Thus the mooring work here can be considered a very successful operation.

Between 5°N and 5°S we took deep CTD/O_2 profiles down to 4500m (or the bottom if shallower). At the beginning of the deep CTD/O_2 stations there were few problems with noisy oxygen and later also with conductivity data. After exchanging sensors, the CTD/O_2 probe itself was identified as the source of data noise and was replaced with the second instrument aboard. Few CTD/O_2 casts had to be repeated on the way back. Attached to the CTD/O_2 rosette, we used two 300 kHz WorkHorse ADCPs, which were chosen out of a set of 4 instruments as the best performing combination. Throughout the cruise, they delivered very good velocity data even at larger depth.

Back at the equator, the glider (**ifm02**)/MicroRider package was recovered after an 8 day mission. The MicroRider recorded 256 microstructure profiles (up and downcasts) from the surface to 350m. The 4GB flashcard was full after 6.5 days. A first look at the data showed high quality turbulence data. This was an extremely successful mission demonstrating the value of such a single glider mission with the MicroRider. In comparison, during about 36h of ship time, we were only able to take 106 microstructure profiles by the loosely tethered microstructure probe connected to the winch at the ship's aft deck.

On the way back from 5°N to 15°N, we changed the shipboard ADCP inside the moon pool. For this section, we used the 38-kHz ADCP which has an increased range compared to the 75-kHz instrument. Due to this change we were able to also cover the lower part of the OMZ with continuous velocity measurements.

During two days of mooring recovery (**KPO_1027**) and redeployment (**KPO_1048**), on November 17 and 18, we used the time for another one day mission of the glider/MicroRider package. Again, a full set of microstructure profiles was collected, this time between the surface and 700 m. The recovered mooring was the second SFB754 mooring with an MMP as the main instrument. The MMP sitting at the lower end was also entangled with fishing line, and it must have been caught soon after deployment, with only 3 profiles (2 days) recorded. In conclusion, MMP's in the upper 1000 m are subject to heavy interference by fishing lines and should not be used in this region.

The 23°W section was continued with water sampling for incubations, CTD/O_2 and GoFlo casts until we reached 15°N. Throughout the entire cruise, we collected 80 CTD/O_2 profiles, including 4 6h-yoyo stations for the observation of short term variability in the OMZ, 16 GoFlo casts, and one station with the in-situ pump for collecting microorganisms. The scientific work of R/V METEOR cruise M80/1 ended with the ADCP section along the glider transect running between the Cape Verdean islands of Fogo and Santiago towards their nominal deployment position south of São Vicente. From there, the ship headed toward Mindelo where the cruise ended on November 23, 9:00.

5 Preliminary Results

5.1 CTD and Oxygen Measurements: Technical Aspects

(Gerd Krahmann, Verena Hormann)

During the cruise two Seabird SBE 9 plus systems, the IFM-GEOMAR, Kiel SBE-4 S/N 752 and the IFM-GEOMAR, Kiel SBE-2 S/N 612 were used. The software used was the Seabird Seasave V7.18d program. For the final calibrated data sets, the data from the primary set of sensors (SBE-4: temperature s/n 4547, conductivity s/n 2452, oxygen: see below; SBE-2: temperature s/n 4833, conductivity s/n 3379, oxygen s/n 1312) were used.

Until profile 13, there were persistent problems with the closing of bottles which could be solved by swapping the deck units. Due to worsening problems with the primary oxygen sensor s/n 985, it was swapped between profiles 23 and 24. The primary oxygen sensor s/n 992 broke on upcast in profiles 27 to 29 between about 2000 and 1000m and was swapped with the original secondary one s/n 145 (swapped between profiles 26 and 27 because of a generally wavy noise signal) after profile 29. Profile 30 showed still bad oxygen data from the primary sensor and we swapped the CTD-system between profiles 30 and 31. Although the secondary oxygen sensor s/n 145 was noisy in profile 31 (and swapped after profile 48), the rest was much improved.

During the cruise, a total of 80 CTD-profiles were performed. These were usually taken to the bottom between 5°S and 5°N and to 1300m depth northward of 5°N.

A comparison between the primary and secondary (SBE-4: s/n 4831, SBE-2: s/n 4051) temperature sensors resulted in a median difference of 0.0003°C, with a median rms of 0.007°C, for the whole cruise.

The salinity samples were analyzed with a Guildline Autosal salinometer (mostly Kiel AS8). The conductivity calibration was performed using a linear fit with respect to pressure, temperature, and conductivity itself. Using 66% of the 104/160 samples for calibration of SBE-4/SBE-2, an rms difference of 0.00015/ 0.00018 S m^{-1} corresponding to a salinity of 0.0015/0.0019 was obtained for the upcast. We chose the downcast as final dataset for several reasons: 1) Sensor hysteresis starts from a well defined point, 2) the incoming flow is not perturbed by turbulence generated by the CTD-rosette, and 3) long stops during the upcast profiles lead to unsteady profiles over depth. For the downcast conductivity, we obtained an rms difference of 0.00019/0.00029 S m^{-1} corresponding to a salinity of 0.0019/0.0028. A comparison of up- and downcast profiles shows that the intrinsic time and space variability are much larger than the uncertainties involved in the calibration processes.

For the oxygen calibration, the oxygen content of the water samples was determined by Winkler’s titration method. The downcast was calibrated using 66% of the 380/595 samples for SBE-4/SBE-2 and led to an rms difference of 1.28/1.48 µmol kg^{-1} using a linear correction for pressure, temperature, and oxygen itself.

The fluorometer was also calibrated versus water samples using a linear fit with respect only to chlorophyll.

5.2 Current Observations: Technical Aspects

5.2.1 Vessel Mounted ADCPs

(Andreas Funk)

Ocean current velocities were observed with RDI Ocean Surveyor (OS) ADCPs during the whole cruise. R/V METEOR's 75 kHz OS, which is permanently mounted in the ship's hull, was broken and could not be fixed before R/V METEOR's next visit in the dock. For this reason, the 75 kHz OS from RV Poseidon was lowered into the mid-ship well. RV Poseidon's processing computer, board unit and connecting cable were also used. The instrument was started in broadband mode immediately after leaving the port in Mindelo October 26th at 9:19 UTC. The mean range of the instrument was about 600m. It delivered very good data. However, the simultaneous use of the ship’s Doppler log (DoLog) results in an almost complete data loss of the shipboard ADCP. Additionally, the use of the ship’s thruster regularly used during station work significantly reduces velocity data quality. On November 14th at 6:59 UTC the instrument was stopped.

The latest RDI VmDas software v1.46 has been installed on the Poseidon processing PC. The setup of the instrument was as follows:

The first NMEA string came from CNAV-GPS and its GPGGA string was used as primary position input. The second NMEA string came from the ADU-II (Ashtec) and was used for heading information only. The third NMEA string came from the fibre optics gyro compass (FOG) and was used as a backup only. 50 bins of 8m length each were recorded.

For the track from 2°N northward, R/V METEOR's 38 kHz OS was installed in the well. It was started November 14th at 10:20 UTC in broadband mode. Its range was approximately 1000m. It was not affected by interference with the DoLog, but was heavily influenced by the thruster. The section was continued until its end point at 15°N when the 75 kHz instrument was re-installed for the next leg. The setup of navigational input was the same as for the 75 kHz instrument. The latest RDI VmDas software V1.46 was installed onto R/V METEOR's processing PC. We did not manage to set the speed of the serial interface between the board unit and the recording PC to a speed higher than 9600 baud. However, the instrument worked well with this speed.

During the entire cruise, the ADU-II heading data had 252 breakdowns of typically 60 s duration and 2 longer ones lasting 1-2 hours.

5.2.2 Lowered ADCPs

(Gerd Krahmann)

During the cruise two 300 kHz RDI Workhorse ADCPs were attached to the CTD rosette at all CTD stations. With these two instruments, full CTD depth current profiles were obtained. In total four different ADCP systems were used. For all stations, the down-looking ADCP was serial number 6468. System 680 was used for the first two stations but we found that its range was substantially lower than that of the down-looker. We swapped it with system 11461 which had a range comparable to the down-looker. During station 13, this system developed a broken beam and was replaced with system 11436 which worked with good results until the end of the cruise. In spite of the difficult working area for LADCPs with few scatterers below 1000 m, the system collected trustworthy profiles on all 80 stations.

After bad experiences during the last cruises using our old LADCP setup, new battery housing and new cables between computer and ADCPs had been developed at IFM-GEOMAR. This setup performed very well and we were able to download data from both instruments at the same time without any problems.

5.3 Zonal Currents and Oxygen

(Verena Hormann, Andreas Funk, Gerd Krahmann)

Fig. 5.3.1a shows a composition of zonal velocity data from 38 kHz vessel mounted ADCP 10-minute-averages and LADCP data along 23°W. The most prominent feature is the eastward Equatorial Undercurrent (EUC), with its core at 60 to 80 m depth; underneath, the westward Equatorial Intermediate Current (EIC) is clearly visible. Near the southern edge of the section, the South Equatorial Undercurrent (SEUC) is centered at about 4.25°S. The Southern and Northern Intermediate Countercurrents (SICC and NICC) at around 2.5°S and N are observed below about 300 m. In the surface layer, two branches of the westward South Equatorial Current (SEC) are found on either side of the EUC and the North Equatorial Countercurrent (NECC) can be observed at about 6°N. There is also a clear expression of the North Equatorial Undercurrent (NEUC) between 4° and 6°N and the eastward structure at around 8°N can be interpreted as the northern branch of the NECC. In general, eastward current bands are associated with elevated oxygen content (cf. Fig. 5.3.1a and b). Lowest oxygen concentrations, with values below 60 µmol kg^{-1} and a minimum of 39.3 µmol kg^{-1}, are observed between 300 and 600 m as well as northward of 9°N in the oxygen minimum zone of the eastern tropical North Atlantic (Fig. 5.3.1.b).

The deep equatorial zonal velocity section (Fig. 5.3.2a) shows a remarkable structure of alternating jets between about 1°S and 1°N. There are also clear indications for the so-called tall jets south- and northward of 1°S and N, respectively. In the lower North Atlantic Deep Water (lNADW) layer between the isopycnals σ_4=45.83 and 45.9 kg m^{-3}, eastward flow is found between 1-3°S as part of the tall jets and the corresponding oxygen distribution shows here values of more than 250 µmol kg^{-1} (Fig. 5.3.2b). Similar high oxygen concentrations are also found at around 2000 m depth, i.e. in the upper NADW (uNADW) layer. In general, salinity changes are rather small throughout the whole NADW layer (σ_1=32.15 – σ_4=45.9 kg m^{-3}) but a weak maximum is observed in the uNADW layer (Fig. 5.3.2c). The salinity minimum associated with the Antarctic Intermediate Water (AAIW, S<34.6) is found between 500 and 1000 m, most pronounced southward of 1°S.

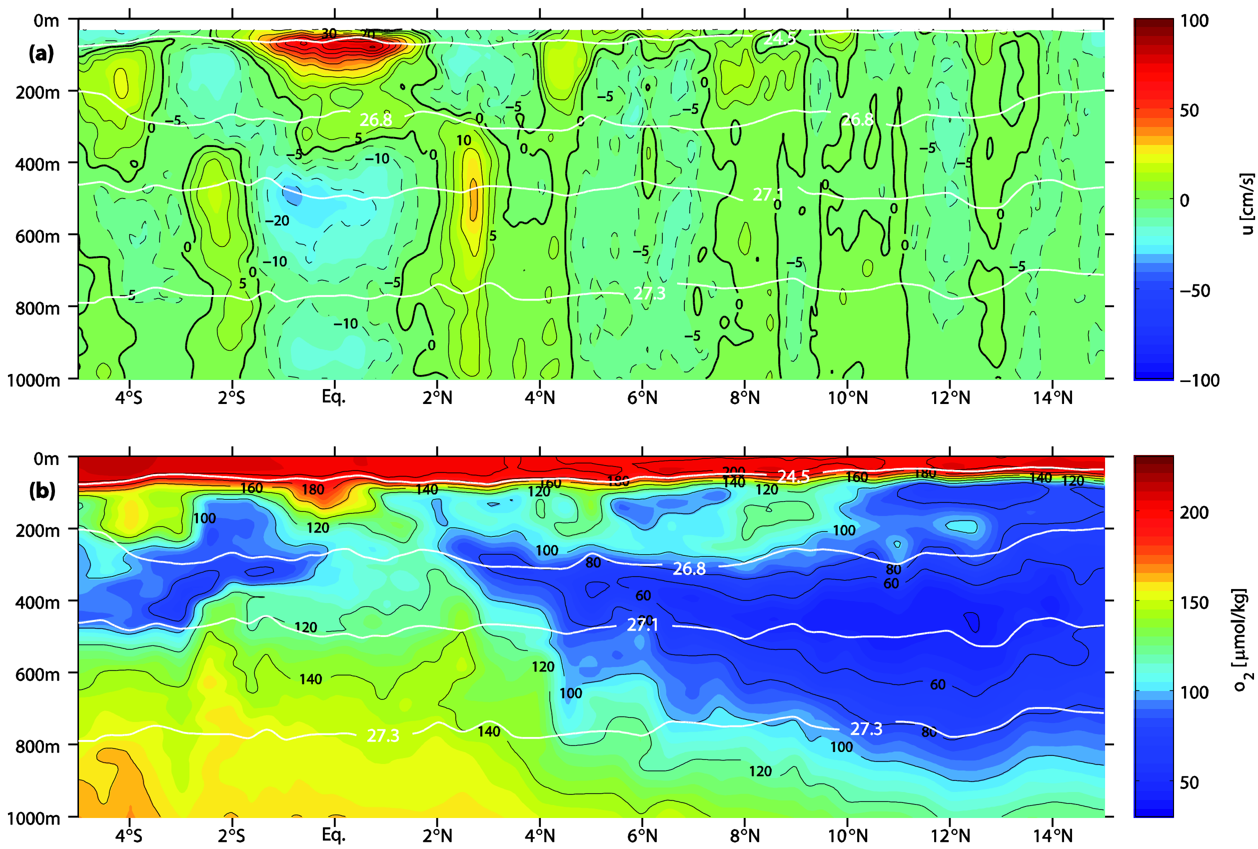

Fig. 5.3.1: Zonal velocity (a), and oxygen content (b) along 23°W; white contours show potential density surfaces.

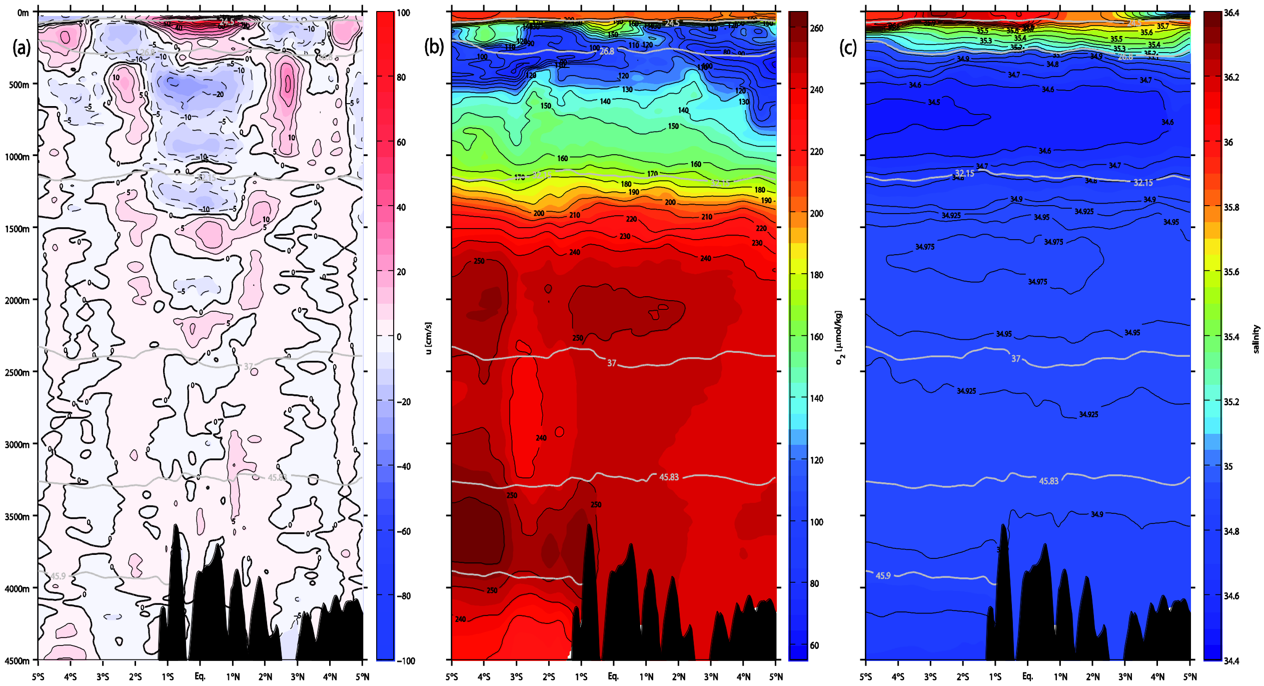

Fig. 5.3.2: Zonal velocity (a), oxygen content (b), and salinity (c) at 23°W between 5°S and 5°N; gray contours show potential density surfaces.

5.4 Mooring Operations

(Jürgen Fischer, Rainer Zantopp, Uwe Papenburg, Gerd Niehus)

The mooring activities of R/V METEOR 80/1 served two major scientific programs, the BMBF-funded ‘North Atlantic’ project with a focus on the shallow to intermediate deep equatorial circulation, and the SFB 754 which focuses on OMZ’s in the eastern tropical Atlantic. Furthermore, an array of MMPs was added to the deep part of the moorings in the equatorial band to study equatorial deep jets – this was done in collaboration with J. Toole, Woods Hole Oceanographic Institution. Altogether 8 full ocean depth moorings were recovered after being in the water for about 20 months, and 8 moorings were deployed.

For recoveries we always used the same procedure, namely to contact the acoustic releases from a horizontal distance of 0.3 to 0.4 nm – all moorings had double releases for increased safety; depth sounders and the bow thruster of the ship were (and had to be) switched off during the release procedure. Most of the releases worked flawlessly, but at depths greater 4000 m we were not able to communicate with some of the releases. However, release commands were generally accepted and only one of the releases in the 2°S mooring did not work at all. Regarding corrosion, we experienced only very little corrosion on mooring hardware and instruments (only ADCP s/n 270 showed strong corrosion at the transducer head and cannot be used for any further deployments). Mooring watchdogs were a mixed success: While the SMM type watchdogs and the in-house-built unit worked well, some of the older units did not work at all when surfacing. Another problem occurred in conjunction with fishing lines; the TENATSO mooring north of Cape Verde, and the SFB754 profiler mooring at 5°N were entangled in fishing lines. While the fixed instruments were not really affected (one instrument was mechanically damaged), the profiler performed properly only 4 out of 20 months and had the batteries completely drained – it is questionable whether this failure was caused by the fishing line or something else. The profiler at 8°N recorded only 3 profiles and was also heavily entangled with longline fishing gear.

The general deployment procedure was to steam at slow speed (1.5 kn through water), thereby paying the wire out over the stern of the ship. Instruments and floatation were safely lifted into the water by using R/V METEOR's A-frame. This was especially important for the 5 delicate MMPs for the equatorial deep jet study (Fig. 5.4.1).

For most of the locations this procedure worked fine, but for the 3 near-equatorial moorings we also took into account that the EUC pulls part of the mooring wire in an eastward direction. Therefore, we adjusted the direction of the deployment according to the strength of the EUC which we obtained on site from the shipboard Ocean Surveyor. Also of great help was the Dynamic Positioning System (DP) of R/V METEOR, allowing us to alter the ship's heading while proceeding along a constant predetermined track.

Fig. 5.4.1: Left: One of the WHOI MMPs mounted on the mooring wire – ready to be deployed. The upper stopper prevents slippage of the profiler - there exists a movie documenting the whole procedure; Right: The profiler on its way to the water. (Photos H. v. Neuhoff)

With respect to the fishing line problems, we switched from continuous measurements (previous deployment) to discrete measurements at about 100 m vertical resolution over the top kilometer of the water column. For this purpose we used newly developed combination mounts for Microcat CTD's and O_2-Loggers in a protective cage that we used here for the first time.

Following each of the mooring deployments, we were able to see the top element disappearing from the surface about 20 minutes after anchor drop. For two of the moorings (TENATSO and the equatorial mooring) we waited for about an hour to be sure that the top was not re-surfacing. However, later inspection of the retrieved top of the equatorial mooring showed that it might take significantly longer for the mooring to point straight up – on the order of 3 hours.

A special mooring component was a detachable instrumentation package on the equatorial mooring, containing a near surface, downward looking ADCP, plus a new instrument, a DVS (Doppler Volume Sampler), which was provided to us by Teledyne Inc. for testing purposes.

During the previous deployment of this mooring component we found that the small top element altered the mooring behavior significantly. Now, with the evidence from two pressure-recording MTD's we saw only little vertical excursion, but the ADCP compass exhibited up to 30° direction variations at relatively short time scales.

Instrument performance and pre-deployment preparation

Summarizing the instrument performance from the recovered moorings and comparing the outcome with the previous deployment period, we found that with the exception of the MMP performance all categories held their level or increased even a bit. An exceptional 100% data return was obtained from Microcats and the Argonaut current meters (Fig. 5.4.2).

Most important was that we retrieved all 8 moorings and we only lost 2 MTD's torn off by fishing lines.

Another issue was biofouling in those moorings extending very close to the surface. Almost all of the near-surface instruments were heavily overgrown with mussels and algae.

As part of the pre- and post-deployment procedures, we calibrated a total of 61 Microcats, 33 O_2-Loggers and 11 MTD's.

The MMPs had already been serviced in port in Mindelo prior to the cruise. For this purpose, Scott Worrilow of WHOI flew in to prepare both the WHOI MMP's and our own instrument. During this process, the latest version of the MMP firmware was installed for comparable performance of all 5 MMP's.

O2-loggers suffered from excessive power consumption. This problem occurred on some of the retrieved loggers, but not to all of them. All O2-loggers, also those from the gliders, were calibrated prior to and after the deployment period by attaching and lowering them together with the CTD. No stops were required for that procedure. The newly deployed units had both hardware and software improvements built in to avoid excess power consumption.

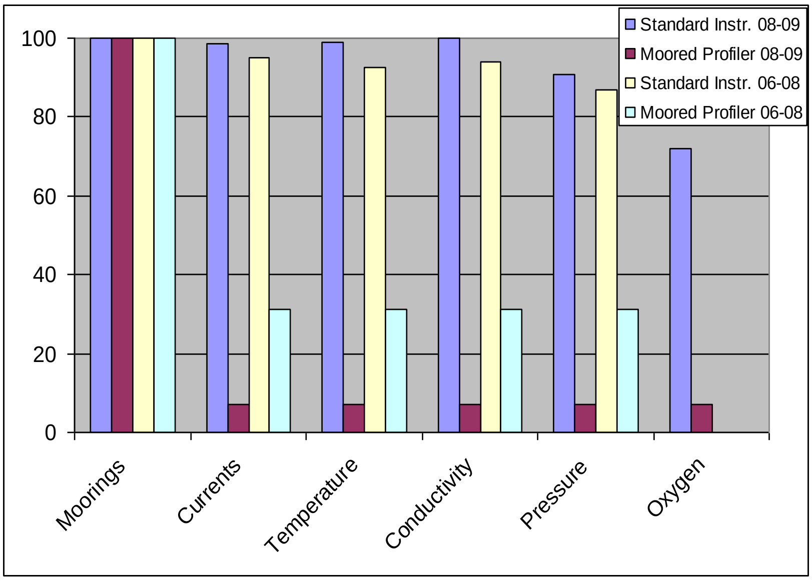

Fig. 5.4.2: Summary the instrument performance (in %) from this and previous mooring deployment period. Note the improved performance for all parameters and instrument types.

Equatorial flow

The equatorial flow field was measured by upward looking ADCP's in each of the 5 moorings; long ranging ADCP's in the near equatorial field cover the top 600 m; farther north and south we had ADCP's with shorter range (around 350 m); the northern one at 2°N failed. At the equator we had a second ADCP (French PIRATA 150 KHz ADCP), and it is the flow field at the equator that is shown here in conjunction with earlier measurements at that site (Fig. 5.4.3).

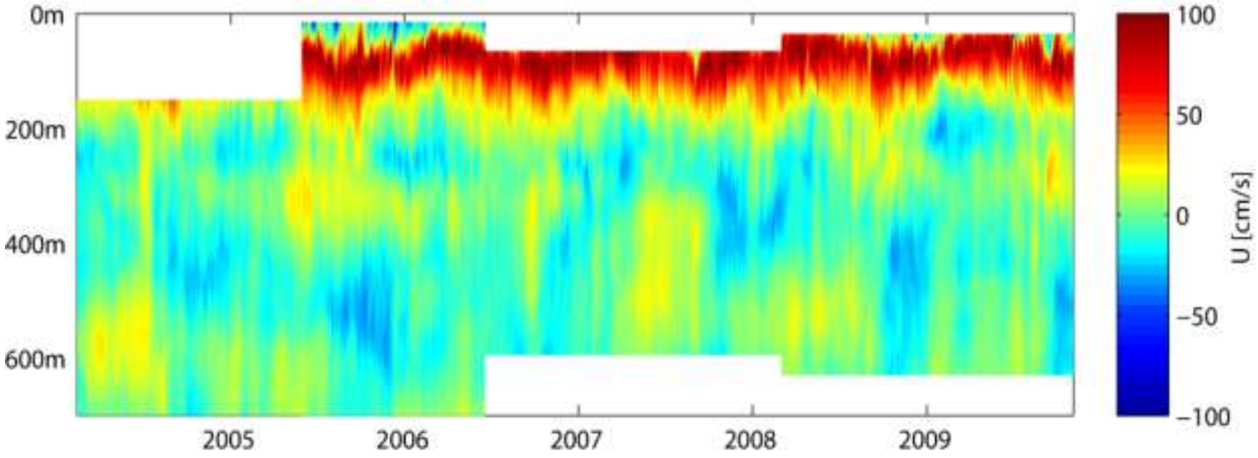

Fig. 5.4.3: Zonal flow at the equator from 2004 until November 2009 measured by ADCP's. The period from March 2008 to November 2009 is from 2 up-looking ADCP's covering the range from 650m to 50m depth (data published Brandt et al. 2011).

5.5 Glider Recovery/Deployment

(Gerd Krahmann, Andreas Pinck, Mario Müller)

Three autonomous glider systems manufactured by Teledyne/Webb Research were used during the cruise. With the intention of covering a section along 23°W from the Cape Verde Islands to the equator, one system (**ifm03**) was launched near Mindelo on August 20, 2009. After spending a few days near the deployment location to ensure that everything was functioning properly, it was sent southeast on August 23 towards the northern end of the section at 14°N 23°W. The glider reached this position on September 10. It then turned south and traveled until October 14, when at 8°11'N, 23°10'W its batteries reached a level that forced us to stop measurements and wait for recovery. We reached the glider, which by then had been drifting for about two weeks, on October 29 and recovered it near 8°13'N, 21°47'W.

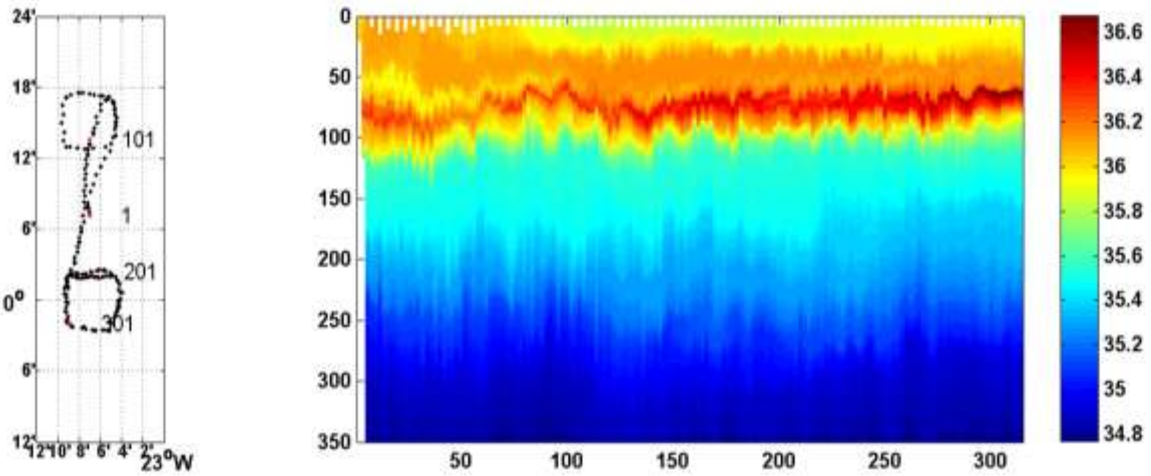

Fig. 5.5.1: Track steered by and salinity distribution observed by glider IFM02 during its first deployment with the MicroRider.

During the whole deployment the sensors of the glider, a Seabird CTD system, an Aanderaa oxygen measuring Optode, and a Wetlabs Fluorometer, worked without problems. The glider made some 280 dives down to 980 m depth. The number of dives translates into an average distance between profiles of about 4km. The CTD sensors will be calibrated against climatology as well as observations from R/V METEOR, while the oxygen sensor has been attached to a logger for comparison with the main CTD system during a calibration cast.

As on an earlier cruise on R/V L'ATALANTE we intended to deploy another glider, system **ifm08** prepared at INDP in Mindelo/Cape Verde, near the equator to fill the section on 23ºW. We attempted the deployment three times. Every single time the glider aborted its mission at 150m depth after detecting a leak. After the first two attempts the glider was closely inspected and we found two possible sources for the leak. Both were fixed on board. The third leak abort did however show that we had not been successful in detecting the location of the leak. As this system is brand new, we intend to return it to the manufacturer for repair under warranty.

The third glider used on this cruise was system **ifm02** (Deepy) which in summer 2009 had been modified to carry a microstructure probe in separate pressure housing. This glider was similarly prepared at INDP before the cruise. The glider was deployed near the equator on November 4. It was commanded to steer a 4nm by 4nm square and dive down to 500 m. Initially the square was centered 15nm north the equator so that the glider did not hinder mooring operations by R/V METEOR (see Figure 5.5.1). After we had left this area, the waypoints were shifted to be centered on the location of one of our moorings on the equator. Deepy with the attached MicroRider was recovered 9 days later. By then the glider had covered the square track 3 times and performed some 150 dives. We found that one of its pressure sensors was badly calibrated and the maximum dive depth had reached only 350 m.

This same system was again deployed for some 26 hours at 8ºN, 23ºW and collected data on 10 dives down to 700 m.

All glider operations in the water were done with the help of a zodiac inflatable. For the freewave radio system the antenna was installed above the atmospheric lab with a 6 m long cable running into the atmospheric lab where it was connected to a Webb dockserver laptop. As previously on M77/3, this setup only allowed us to obtain good connections at distances up to a maximum of 1nm. This differs very much from the experience on R/V L'ATALANTE where we had good connection at distances up to 3nm.

5.6 Autonomous and shipboard microstructure measurements

(Marcus Dengler, Andreas Funk, Uwe Koy)

The focus of the microstructure measurement program was to quantify diapycnal fluxes of heat, oxygen and trace gases in the upper equatorial Atlantic and the oxygen minimum zone, and to identify the dominant mixing processes responsible for these fluxes. It combined the research objectives of three projects: the Junior Research Group (DFG Emmy Noether-Nachwuchsgruppe) "Microstructure" focussing on quantifying the impact of upper ocean diapycnal mixing processes on the variability of sea surface temperature, subproject A3 of Sonderforschungsbereich 576 aimed at quantifying diapycnal fluxes of oxygen in the oxygen minimum zone, and Theme 3.4 of the BMBF-Verbundvorhaben SOPRAN which focuses on diapycnal fluxes and subsequent out-gassing of trace gas N_2O.

Sampling and technical aspects

The measurement program consisted of autonomous microstructure sampling by a glider which was equipped with a MicroRider microstructure instrument package, and of shipboard microstructure profiling using an MSS system (Sea & Sun Technology). The cruise marked the beginning of a new epoch in microstructure sampling as autonomous glider-based microstructure measurements were performed for the first time in open waters. The MicroRider, attached to the top of the Glider (Fig. 1.8), was recently developed by Rockland Scientific (Victoria, Canada) and the combined system had previously been tested only during short test dives in shallow seas. This system has the advantage of performing microstructure measurements for periods of up to 3 weeks without requiring additional ship time except for glider deployment and recovery.

The MicroRider was equipped with two shear sensors (airfoil), two fast thermistors (FP07) and a micro-conductivity sensor (SeaBird). Additionally, a pressure sensor and accelerometers which record pitch, roll and hive of the system were attached. The microstructure data are recorded at a rate of 512 Hz. The MicroRider does not have a separate power supply but draws it power from the glider. Via this connection, the glider controls the sampling period of the MicroRider. Data, however, are recorded internally by the MicroRider and are not transferred via the glider's Iridum satellite connection.

Fig. 5.6.1: Microstructure instrument package MicroRider mounted on top of a Slocum Glider

During the cruise, the Glider-MicroRider system was deployed for two missions: An eight day mission at the equator where it surveyed a box at 23°W, and a 26 hour mission at 8°N, 23°W. During the first mission, the MicroRider collected a microstructure shear and temperature profile between the surface and 350m depth about every 35 minutes, totalling 256 profiles. After 6.5 days, the memory card of the MicroRider was full and no further microstructure data was recorded. During the second mission, the glider sampled the water column from the surface to 700m depth, and the MicroRider collected a profile about every hour. On both missions, the MicroRider data was recorded during up and downcasts of the glider. Due to uneven ballasting of the glider, vertical velocities during upcast profiles (about 0.22 ms^{-1}) were larger than during downcast profiles (about 0.17 ms^{-1}). The microstructure conductivity sensor failed during both mission, presumably due to a malfunctioning of one of the sensor tips.

In addition to the measurements by the MicroRider, ship-based microstructure measurements were performed. The tethered microstructure profiling system (Sea & Sun Technology) used during the cruise consisted of a profiler (serial numbers 26 and 32), a winch and a data interface. The profilers were equipped with two or four shear sensors, a fast-response temperature sensor, an acceleration sensor, two tilt sensors and conductivity, temperature, depth sensors that sample at a lower frequency (24 Hz). In addition, a compass was installed in one profiler. The loosely-tethered profiler was optimized to sink at a rate of 0.55 ms^{-1}. In total, 106 profiles were collected which translates into a total profiling period of 1.5 days. A large number of those profiles were collected simultaneously to Glider-MicroRider measurements to assess the level of agreement between both microstructure platforms.

Preliminary results

First results of the comparison of turbulent dissipation rates determined from the MicroRider and the glider system were very encouraging. The vertical structures of simultaneously recorded profiles from the equator were strongly correlated and dissipation rate estimates showed a high degree of consistency. Both data sets indicated elevated patches of mixing occurring in the upper and lower shear zone of the equatorial undercurrent and within the mixed layer due to night time convection. However, a band of low mixing just below the mixed layer was observed in the equatorial data that inhibits a strong diapycnal flux of heat out of the mixed layer. During previous measurement programs and particularly in summer, dissipation rates in this depth interval reached values above $1x10^{-6}$ Wkg^{-1} and average diapycnal heat flux were as large as 60 to 90 Wm^{-2}. The low dissipation rates below the mixed layer are due to strong stratification in this depth interval that prevent Kelvin-Helmholz Instabilities to occur although the vertical shear of zonal velocity is strongly elevated within the EUC.

5.7 Chemical Measurements

5.7.1 Oxygen, nutrients and inorganic carbon analyses

(Tobias Steinhoff, Tim Stöven, Sebastian Fessler)

We investigated discrete samples of nutrients (phosphate, silicate, nitrate and nitrite), dissolved oxygen and inorganic carbon parameters, i.e. dissolved inorganic carbon (DIC) and total alkalinity (TA).

Sampling procedures

Oxygen samples were drawn into 100 mL wide neck bottles with a short drawing tube extending from the niskin bottle to the bottom of the sample bottle. The bottles were filled carefully to avoid any air bubbles coming into the sample and they were allowed to overflow two to three times the bottle volume. Then 1 mL MgCl2 and 1 mL KI/KOH solution were added from two dispensers with small tubes reaching to the bottle bottom. The glass stoppers were used to displace the upper 25 mL water and also to close the bottle. The bottle was shaken carefully for at least one minute. After fixation of the oxygen, the precipitate was allowed to settle for minimum of half an hour, before starting the Winkler titration.

Nutrient samples were drawn directly from the Niskin bottle into 60 mL NALGENE PP bottles. The bottles were rinsed twice and then filled. The samples were frozen within 30 minutes after sampling at -20°C for later analysis at IFM-GEOMAR.

Samples for DIC/TA were drawn into 500 mL DURAN glass bottles with glass stopper. A drawing tube was used to fill the bottles from bottom. The bottles were rinsed with about 50 mL of sample, then filled up from the bottom and allowed to overflow by at least 250 mL of water. A head space of about 1% was achieved by clamping and removing the tubing. After closing the bottles, the stoppers were held down firmly with a rubber band. Most samples were analyzed within 24 hours of being collected. At 5 stations the samples were poisoned by adding 100 µL of saturated mercury chloride solution. These samples will be analyzed at IFM-GEOMAR.

Analyses

Oxygen samples were analyzed by Winkler titration (Grasshoff, 1999). 1016 samples were taken at 59 stations. 218 duplicate samples were taken to determine the precision of the analyses which was 0.34 µmol/kg.

908 nutrient samples were taken at 46 stations. They will be analyzed at IFM-GEOMAR with a Continuous-Flow-Autoanalyzer-(CFA) System developed and built at IFM-GEOMAR according to Grashoff et al. (1999). To determine the precision of measurements 79 duplicate samples were taken, spread over all stations.

DIC and TA were determined from 619 samples at 35 stations. The DIC analyses were made by a coulometric titration method using the SOMMA (single operator multi-parameter metabolic analyzer) system (Johnson et al., 1993). SOMMA collects and dispenses an accurately known volume of seawater to a stripping chamber, acidifies it, sparges the CO_2 from the solution, dries the gas, and delivers it to a coulometer cell that determines the amount of CO_2. The instrument is calibrated with known amounts of CO_2. Certified reference material (CRM) and duplicate measurements (66) are used to determine accuracy and precision of the measurements.

Alkalinity is determined by titration of seawater with a strong acid, following the electric motoric force with a proton sensitive electrode. The titration curve shows two inflection points, characterizing the protonation of carbonate and bicarbonate, respectively. The acid consumption up to the second point is equal to the titration alkalinity. Alkalinity was determined by a semi-automatic analysator, the VINDTA instrument (Versatile Instrument for the Determination of Titration Alkalinity). The sea water titration was done in an open cell by twenty eight 150 mL additions of hydrochloric acid (0.1 molar) to 100 mL sample. The analysis was performed at 25°C, which was maintained by a water bath. The titration was potentiometrically followed by a pH-sensitive OrionTM Ross-electrode (model8101) a MetrohmTM Ag-/AgCl-reference electrode (model 6.0729.100). The difference in pH potential was measured by a pH-meter which sent the data to the computer for the recording and calculation of total alkalinity.

The standardization was done identical to the DIC samples, running CRM (see above) and duplicate (66) samples.

5.7.2 Tracer measurements

(Anke Schneider, Darlene Brownell)

The tracers CFC-12, SF6 and SF5CF3 were measured directly on board using a purge and trap system, followed by a gas chromatograph and an electron capture detector. The water was sampled in glass ampoules, heated to ~35°C for 20 minutes and transferred into the purge chamber by vacuum. The sample was purged for ten minutes with a purge flow of ~100 ml/min. This gave a purge efficiency of higher than 99%. Trapping was done at -60°C and desorption at 160°C. Due to problems with the system during the first two weeks, samples from 8 stations were flame sealed for later analysis.

Observed tracer fields showed a rapid decrease of SF6 with depth. CFC-12 has a maximum at 150 m depth and another relative maximum at 1500 m depth. The tracer SF5CF3 was released in April 2008 at roughly 8°N and 23°W. On the 23°W section during this cruise we found tracer in all stations north of 3°N at depths between 200 m and 400 m.

5.7.3 Trace metal analysis

(Thibaut Wagener, Kathrin Wuttig)

The work is related to the projects: SFB 754 – B5, DAPOP, Marie Curie IEF, Grant contract N°: PIEF-GA-2009-236694. The concentrations and speciation of different trace metals (i.e. Fe, Mn, Cu) are investigated in the water column on discrete samples collected during M80-1. Collection of aerosols is also performed along the cruise, to investigate the atmospheric fluxes of trace metals. Additionally, parameters related to biogeochemical processes involved in trace metal cycles are measured.

Seawater sampling

Seawater sampling for the study of trace metals was performed using 4 Teflon coated PVC General Oceanics (Miami, Florida, USA) GO-FLO (8 L) bottles. The bottles were deployed on the Kevlar line of R/V METEOR (W3-winch). For each location sampled along the cruise transect, two casts were performed: one shallow cast down to 100 meters depth and one deep cast down to 400 meters. Bottles were immediately transferred into the IFM-GEOMAR clean container (HEPA filtered air environment) after recovery, in order to avoid the contamination of the seawater samples. Seawater was filtered with a small overpressure (0.2 bar) of nitrogen on Sartobran (Sartorius, Germany) membranes (0.2 µm) directly connected to the bottles. For the direct measurement of the short-lived species Fe(II) and H_2O_2, contamination problems are less relevant than for other trace metals and samples for these parameters have therefore also been sampled on some CTD in addition to the GO-FLO casts.

Aerosol sampling

Along the cruise transect, aerosol samples for the study of trace metal deposition were collected using a sampler developed of the *Laboratoire d'Océanographie de Villefranche sur Mer* (CNRS-FRANCE) alowing a confident cumulative sampling for the study of trace elements (Wagener et al., 2008a). The sampler was located on the highest deck of R/V METEOR. Pumps and control devices were located in the "Luftchemielabor". Nine aerosol samples were collected during the cruise.

Parameters measured and methods

In seawater

a) Dissolved manganese (dMn) was measured on filtered and acidified (pH 1.7) seawater samples collected from the GO-FLO bottles. dMn was measured by flow injection analysis and spectrophotometric detection after reaction with Leucomalachite green (LMG) following the method developed by Aguilar-Islas et al. (2006).

b) Dissolved iron (dFe) was measured on filtered and acidified seawater (< pH 2) collected from the GO-FLO bottles. dFe was measured by flow injection analysis with chemiluminescence detection after preconcentration on 8-hydroxyquinoleine column following the original method of Obata et al., (1993).

c) Iron (II) and peroxide were measured on unfiltered seawater samples from GO-FLO bottles and CTD. Fe(II) and H_2O_2 were measured simultaneously by flow injection analysis with chemiluminescence detection following the protocol developed by Croot and Laan (2002).

d) Organic speciation of copper was measured on filtered seawater collected from the GO-FLO bottles. Cu speciation was measured by ligand competition with salicylaldoxime and voltammetry following the method developed by Campos and Van den Berg (1994).

e) Dissolved Inorganic Phosphorus (DIP) at nanomolar concentration was measured on filtered seawater collected from the GO-FLO bottles by spectrophotometry on a long path cell following the method developed by Zhang and Shi (2002).

f) CDOM (Colored Dissolved Organic Matter) was measured on filtered seawater immediately after collection from the GO-FLO bottles on a long-path cell following the method of Bricaud et al. (1981).

g) Dust dissolution experiments were performed on surface seawater samples (20 m) following the protocol described in Wagener et al. (2008b). Dissolution of iron and phosphorus was estimated after 72 hours of contact between dust particles and seawater. A dust end-member largely used in other similar experiments was used (e.g. Bonnet and Guieu, 2004)

h) Analysis of dissolved (<0.2µm) trace metals (cadmium, cobalt, copper, iron, nickel, lead and zinc) was performed on acidified filtered seawater samples, which were taken from the GO-FLO bottles, at IFM GEOMAR by GF-AAS after simultaneous dithiocarbamate-freon extraction following the protocol described in Grashoff et al. (2002).

On aerosols

i) Aerosol trace metal concentrations were determined at the *Laboratoire Interuniversitaire des Sciences Atmosphériques* (LISA-CNRS, France) using X-Ray fluorescence following the method described by Losno et al. (1987). Furthermore electron microscope observations were performed at LISA-CNRS in order to obtain a physical description of the particles collected.

j) Soluble iron and phosphorus from aerosol particles was estimated in seawater and Milli-Q water following the "aerosol leaching" protocol described by Buck et al. (2006). Iron and phosphorus were determined following the method described before.

Samples collected are still under analysis or data treatment. However, preliminary examination of the analysis results demonstrate that the sampling performed has been successful. None of the samples analyzed appears to be contaminated.

5. 8. Incubation experiments

5.8.1 Nitrogen fixation and assimilation of inorganic nitrogen compounds

(Hannah Halm, Andreas Krupke)

Vast areas of open ocean waters are often limited in the availability of nutrients and elements which are crucial for microbial growth and activity. In those oligotrophic regions, particularly biologically fixed nitrogen is assumed to be the limiting factor for primary productivity. Fixed nitrogen occurs as inorganic nitrogen compounds like ammonium (NH_4^+), nitrate (NO_3^-) and nitrite (NO_2^-) and organic N like for example amino acids. Different microorganisms are capable of assimilating different organic and inorganic nitrogen compounds. Organisms with the ability of fixing atmospheric nitrogen, so-called diazotrophs, have an advantage over others because they do not depend on available fixed nitrogen and therefore are supposed to be abundant in oligotrophic parts of the oceans.

During R/V METEOR Cruise 80/1, we were interested in heterotrophic nitrogen fixation and assimilation of inorganic nitrogen compounds. In particular we were interested in the uptake of nutrients at the single cell level. Concurrently, we aimed at exploring the natural bacterial community and to identify known and unknown species that were performing the targeted metabolic processes.

At 12 CTD stations [CTD 4,6,11,19,25,33,37,42,47,56,63,77] we collected seawater mainly from the upper 600 m, and at 5 CTD stations [CTD 15,27,34,48,62] the whole water column was sampled to the bottom. Additionally, we collected water samples from 5 and 10 m depth at CTD station number 73. We performed incubation experiments with isotopically labeled ^{15}N and ^{13}C-compounds, and collected simultaneously water samples for nutrients, DNA/RNA, DIC (Dissolved Inorganic Carbon), and ammonium analysis. Ammonium was measured directly on board, while the other samples were stored for analysis in a shore-based laboratory. Furthermore we filtered 30 ml of seawater from several depths (45 mm diameter, 0.2 µm pore size) for CARD-FISH (Catalyzed Reporter Deposition-Fluorescence *in situ* Hybridization) analysis. This method is a molecular tool that enables us to quantify and identify microorganisms which are present in those waters.

For the incubation experiments we incubated a series of 250 ml seawater in inoculation bottles by injecting a combination of ^{15}N-labeled nitrogen ($^{15}N_2$, $^{15}NH_4^+$, $^{15}NO_3^-$, $^{15}NO_2^-$) and ^{13}C-labeled carbon compounds ($H^{13}CO_3^-$ and ^{13}C-Glucose). Triplicates were done per depth and label combination. Surface water samples were incubated in incubators on deck, water samples from the chlorophyll maximum were incubated in a cool room with 11°C and under 10% of the surface light conditions and 12:12 h day:night cycle. After 24 hours the experiment was stopped by filtering on 25 mm GF/F filters and immediately frozen at -20°C for transport to Bremen. These samples will be analyzed by IRMS (Isotope Ratio Mass Spectrometry) and provide information on the existence and range of N-assimilation and heterotrophic nitrogen fixation. Additionally, we collected subsamples from certain incubations for nano-SIMS (nano Secondary Ion Mass Spectrometry) analysis in order to identify nitrogen fixing microorganisms and to measure nitrogen fixation and assimilation rates on single cell level.

5.8.2 Nitrogen fixation and community structure

(Tobias Großkopf, Sandra Fehsenfeld)

Nitrogen fixation

The tropical North Atlantic Ocean is an area with a high N* anomaly in the water masses below the photic zone. It is believed that newly produced biomass from nitrogen fixing organisms is exported and remineralised in these layers. To assess the amount of surface and deep water nitrogen fixation, the bacteria involved and the gross community primary productivity, as well as the enumeration of picophytoplancton and bacterioplancton, different methods were applied during the cruise to give a complete resolution of the nitrogen fixing community and its biogeochemical impact.

Experiments

In total 12 nitrogen fixation profiles (0m, 20m, chlorophyll maximum, 400m) were taken in parallel with the MPI group. Additionally, 8 glucose profiles, that consist in a glucose enriched incubation with $^{15}N_2$ and ^{13}C-glucose labels from every of the 22 CTD bottles, and 33 DNA/RNA profiles from 0-800 meters depth were sampled. At 8°N 4 in-situ pumps were deployed at 440m, 130m, 60m and 20m that filtered around 500-600 liters of water each on a 47mm 0.2 µm pore size filter. The analysis of these filters in the lab will give insights into the community structure at genetic level.

Samples

The samples were taken from the CTD or with a bucket from the surface and consist of 864 flow cytometry samples for total and phytoplankton cell number determination, 413 GF/F filters for community chlorophyll a content measurements, 576 DNA/RNA samples for occurrence and genetic diversity of diazotrophs (nitrogen fixing bacteria), 48 POC filters, 575 ^{15}N+^{13}C incubations to measure primary productivity of carbon and nitrogen and 96 nanosims (**nano**-scale secondary **i**on **m**ass **s**pectrometry) filters that allow primary productivity measurements on the single cell level.

5.9 Thermosalinograph Measurements

(Gerd Krahmann, Verena Hormann)

Sea surface salinity (SSS) was measured by a Thermosalinograph. The Thermosalinograph worked well for the whole cruise. No water samples for salinity calibration were taken from the sea water intake. The calibration was instead based on the calibrated CTD data. A comparison done on M77/3 had shown that the CTD data was sufficient for the calibration.

Sea surface temperature (SST) was observed by two lower quality thermometers of the German meteorological service. These were calibrated similarly to the SSS by comparison with the calibrated CTD measurements near the surface.

6 Ship's Meteorological Measurements

(Thorsten Truscheit)

Weather conditions during M80/1: In the morning of November 26th, R/V METEOR left the port of Mindelo/Cape Verde Islands for leg 80/1. The scheduled working plan took R/V METEOR to a position 60 nm northeast of Mindelo at first. The synoptic situation in these days looked as follows:

A wedge (1015 hPa) of a high pressure system over southeastern Canada extended into the sea area west of the Cape Verde Islands and remained mostly unchanged over the next few days. The Intertropical Convergence Zone (ITCZ) extended from Guinea westward to Venezuela. A tropical wave developed within the ITCZ and was located directly over the Cape Verde Islands, influencing the weather conditions with only partly cloudy skies.

Following the mooring work northeast of Mindelo, the ship initially headed south-southeast, and then south. The weather conditions over the next few days were stable, with just a moderate northeasterly trade wind and a swell of 2 meters or less.

On October 30th, R/V METEOR crossed the northern part of the ITCZ and a small area of the equatorial westwind zone. Here the wind briefly decreased to 2 Bft.

However, in the southern part of the ITCZ the conditions changed significantly. Heavy rain showers, accompanied by gusts of up to 8 Bft were observed temporarily. Finally, the ship crossed the ITCZ on November 1st and reached the area of the southeast trade winds with 4 to 5 Bft. The next two weeks showed stable conditions with partly cloudy skies and moderate trade winds.

The only light rain showers were observed on November 5th at the conclusion of an at-sea meeting between RV/ METEOR and R/V Polarstern. On November 13th, R/V METEOR reached again the equator on its northerly course, but weather conditions did not change significantly until the ship reached the southern part of the ITCZ on November 15th. On November 16th and 17th, the ship repeatedly encountered strong rain showers, accompanied by gusts up to 8 Bft. These shower patterns ended when R/V METEOR left the ITCZ in the afternoon of November 19th. Afterwards, R/V METEOR was under the influence of northeasterly trade winds at 4 Bft. For the last two days of the cruise, the conditions were stable, with predominant trade winds of 5 to 6, and gusts up to 7 Beaufort, a swell of 1.5 to 2 meters and a cloudless sky. In the morning of Monday November 23rd, R/V METEOR arrived at the port of Mindelo in the Cape Verde Islands.

7 Station Lists M80/1

Tab. 7.1: Station List M80/1

Station Ship/Science	Latitude	Longitude	Time	Work
1070/ KPO_1028	17°36.40' N	24°14.98' W	26.10. 15:30-19:40	**Mooring** released, on deck
1071/1	17°36.04'N	24°14.61'W	26.10. 20:40-21:10	**GoFlo** water sampling (100m)
1072/1	17°36.01'N	24°14.63'W	26.10. 21:20-00:40	**CTD/LADCP** station (to bottom), additional stops for microcat calibration
				During GoFlo and CTD station PIES communication (correct depth recording but no data transfer possible)
1073/-			26.10. 00:50-02:00	**Microstructure**
1074/2			27.10. 02:20-3:50	**CTD/LADCP** station (~1000m)
1075/-			27.10. 04:00-07:10	**Microstructure**
1076/2			27.10. 07:30-08:30	**GoFlo** water sampling (400m)
1077/ KPO_1041	17°36.40' N	24°14.98' W	27.10. 08:40-16:00	Drift test, **mooring** deployment, anchor slipped, submerse of top-element observed
1078/-			27.10. 16:10	PIES deployment
			27.10. 16:10-16:30	Check that **mooring** stays under water
1079/3	11°30'N	23°W	29.10. 05:10-06:30	**CTD/LADCP** station (1000m), water sampling for salinometer substandard, calibration of microcats, optodes, releaser test
1080/4	11°30'N	23°W	29.10. 08:00-08:40	CTD/LADCP station (600m), water sampling for **Incubations**
1081/3	8°15'N	21°45'W	30.10. 05:00-05:20	**GoFlo** water sampling (100m)
1082/5	8°15'N	21°45'W	30.10. 05:30-06:30	**CTD/LADCP** station (800m), calibration of microcats, optodes
1083/4	8°15'N	21°45'W	31.10. 06:50-07:50	**GoFlo** water sampling (400m)
1084/ ifm03	8°20.22'N	21°37.37'W	30.10. 08:00-09:30	**Glider** recovery
1085/6	5°03'N	23°00.0'W	31.10. 06:50-07:40	CTD/LADCP station (600m), water sampling for **Incubations**
1086/ KPO_1026	5°00.9'N	23°00.0'W	31.10. 08:00-10:50	**Mooring** released, on deck
1087/7	5°00.9'N	23°00'W	31.10. 11:10-12:00	**CTD/LADCP** station (1000m)
1088/ KPO_1047	5°00.90'N	23°00.00'W	31.10. 12:10-18:00	Drift test, **mooring** deployment, anchor slipped, submerse of top-element observed
1089/KPO_1025	2°02.5'N	23°02.0' W	1.11. 11:40-15:30	**Mooring** released, on deck
1090/5	2°02.5'N	23°02.0' W	1.11. 15:50-16:10	**GoFlo** water sampling (100m)
1091/8	2°02.5'N	23°02.0' W	1.11. 16:30-19:40	**CTD/LADCP** station (to bottom)
1092/6	2°02.5'N	23°02.0' W	1.11. 19:40-20:30	**GoFlo** water sampling (400m)
1093/-	2°02.5'N	23°02.0' W	1.11.20:30-21-10	**Microstructure**
1094/9	1°40'N	23°00' W	1.11. 23:40-2:40	**CTD/LADCP** station (to bottom)
1095/10	2°02.5'N	23°02.0'W	2.11. 05:00-05:20	CTD/LADCP station (600m), water sampling for **Incubations**
1096/11	2°02.5'N	23°02.0'W	2.11. 05:40-06:20	**CTD/LADCP** station (600m), instrument calibration
1097/ KPO_1046	2°02.43'N	23°01.93'W	2.11. 06:30-13:40	**Mooring** deployment, anchor slipped, submerse of top-element observed
1098/12	1°20'N	23°00'W	2.11.17:40-21:00	**CTD/LADCP** station (to bottom)
1099/-	1°20'N	23°00'W	2.11.21:10-22-00	**Microstructure**
1100/13	1°00'N	23°00'W	3.11.00:10-02:50	**CTD/LADCP** station (to bottom)
1101/-	1°00'N	23°00'W	3.11.03:00-05-50	**Microstructure**
1102/KPO_1024	0°45.2'N	22°59.3' W	3.11. 07:20-09:40	**Mooring** released, on deck
1103/14	0°45.2'N	22°59.3' W	3.11.10:20-13:20	**CTD/LADCP** station (to bottom)

Station Ship/Science	**Latitude**	**Longitude**	**Time**	**Work**
1104/ KPO_1045	0°45.13‘N	22°59.30‘ W	3.11. 14:40-18:50	**Mooring** deployment, anchor slipped, submerse of top-element observed
1105/15	0°30’N	23°00’W	3.11.20:30-23:10	**CTD/LADCP** station (to bottom)
1106/-	0°30’N	23°00’W	3.11.23:10-00:00	**Microstructure**
1107/16	0°15’N	23°00’W	4.11.01:40-04:30	**CTD/LADCP** station (to bottom)
1108/-	0°00’N	23°06.8’W	4.11.06:20-07:10	**Microstructure**
1109/KPO_1023	0°00’N	23°06.8’W	4.11. 07:30-09:40	**Mooring** released, on deck
1110/-	0°00’N	23°06.8’W	4.11.10:00-11:00	**Microstructure**
1111/17	0°00’N	23°06.8’W	4.11.11:20-12:30	**CTD/LADCP** station (to 1000), instrument calibration without bottles
1112/-	0°00’N	23°06.8’W	4.11.13:20-14:40	**Microstructure**
1113/ifm02	0°07’N	23°06.8’W	4.11.15:00-18:30	**Glider** deployment
1114/-	0°00’N	23°00’W	4.11.19:50-20:50	**Microstructure**
1115/7	0°00’N	23°00’W	4.11.21:20-21:40	**GoFlo** water sampling (100m)
1116/-	0°00’N	23°00’W	4.11.21:50-22:40	**Microstructure**
			22:40-01:00	**CTD cable termination**
1117/-	0°00’N	23°00’W	5.11.00:20-01:00	**Microstructure**
1118/18	0°00’N	23°00’W	5.11. 01:10-04:00	**CTD/LADCP** station (to bottom)
1119/-	0°00’N	23°00’W	5.11.04:20-05:10	**Microstructure**
1120/8	0°00’N	23°00’W	5.11. 05:30-06:30	**GoFlo** water sampling (400m)
1121/19	0°00’N	23°00’W	5.11. 06:40-07:20	CTD/LADCP station (600m), water sampling for **Incubations**
1122/-	0°00’N	23°00’W	5.11.07:30-09:20	**Microstructure**
			5.11. 10:00-13:00	**R/V POLARSTERN** visit
1123/ KPO_1044	0°00.17‘N	23°06.84‘ W	5.11. 13:00-19:00	Drift test, **mooring** deployment, anchor slipped, submerse of top-element observed
1124/-	0°00.2‘N	23°06.8‘ W	5.11.19:10-20:10	**Microstructure**
1125/20	0°15’S	23°00’W	5.11. 22:10-01:10	**CTD/LADCP** station (to bottom)
1126/21	0°30’S	23°00’W	6.11. 2:50-06:00	**CTD/LADCP** station (to bottom)
1127/-	0°30‘S	23°00‘ W	6.11.6:00-7:20	**Microstructure**
1128/ifm08	0°30‘S	23°00‘ W	6.11.7:40-10:00	**Glider** deployment/recovery (leak detect)
1129/ KPO_1022	0°44.94’S	22°59.70’W	6.11.11:50-13:50	**Mooring** recovery
1130/ifm08	0°45‘S	23°00‘ W	6.11.14:20-15:50	**Glider** deployment/recovery (leak detect)
1131/22	0°45’S	23°00’W	6.11. 16:40-19:10	**CTD/LADCP** station (to bottom)
1132/23	1°00’S	23°00’W	6.11. 21:10-00:00	**CTD/LADCP** station (to bottom)
1133/-	1°00‘S	23°00‘ W	7.11.0:10-1:10	**Microstructure**
1134/24	1°20’S	23°00’W	7.11. 03:10-06:10	**CTD/LADCP** station (to bottom)
1135/-	1°20‘S	23°00‘ W	7.11.6:20-7:10	**Microstructure**
1136/25	1°20’S	23°00’W	7.11. 07:30-08:10	CTD/LADCP station (600m), water sampling for **Incubations**
1137/26	1°40’S	23°00’W	7.11. 10:20-13:20	**CTD/LADCP** station (to bottom)
1138/-	2°00‘S	23°00‘ W	7.11.15:30-16:20	**Microstructure**
1139/9	2°00’S	23°00’W	7.11. 16:30-17:00	**GoFlo** water sampling (100m)
1140/27	2°00’S	23°00’W	7.11. 17:10-20:20	**CTD/LADCP** station (to bottom)
1141/10	2°00’S	23°00’W	7.11. 20:30-21:20	**GoFlo** water sampling (400m)
1142/28	2°30’S	23°00’W	8.11. 00:30-04:00	**CTD/LADCP** station (to bottom)
1143/29	3°00’S	23°00’W	8.11. 06:50-10:00	**CTD/LADCP** station (to bottom)
1144/30	3°30’S	23°00’W	8.11. 13:10-16:20	**CTD/LADCP** station (to bottom)
1145/31	4°00’S	23°00’W	8.11. 19:20-22:40	**CTD/LADCP** station (to bottom)
1146/32	4°30’S	23°00’W	9.11. 01:40-04:50	**CTD/LADCP** station (to bottom)
1147/33	4°30’S	23°00’W	9.11. 05:50-06:20	CTD/LADCP station (600m), water sampling for **Incubations**
1148/11	5°00’S	23°00’W	9.11. 09:30-09:50	**GoFlo** water sampling (100m)
1149/34	5°00’S	23°00’W	9.11. 10:00-12:50	**CTD/LADCP** station (to bottom)
1150/12	5°00’S	23°00’W	9.11. 13:00-13:50	**GoFlo** water sampling (400m)
	6°00’S	23°00’W		**ADCP section**

Station Ship/Science	**Latitude**	**Longitude**	**Time**	**Work**
1151/35	3°30'S	23°00'W	10.11. 12:50-17:20	**CTD/LADCP** station (to bottom)
1152/36	2°00'S	23°00'W	11.11. 01:40-04:50	**CTD/LADCP** station (to bottom)
1153/-	2°00'S	23°00' W	11.11.04:50-06:10	**Microstructure**
1154/37	2°00'S	23°00'W	11.11. 06:20-06:50	CTD/LADCP station (600m), water sampling for **Incubations**
1155/ KPO_1021	1°56.4'S	22°57.0'W	11.11.08:20-11:00	**Mooring** recovery
1156/ KPO_1042	2°00.04'S	22°59.98'W	11.11.13:10-17:50	**Mooring** deployment, anchor slipped, submerse of top-element observed
1157/38	1°00'S	23°00'W	11.11. 23:30-02:20	**CTD/LADCP** station (to bottom)
1158/39	0°45'S	23°00'W	12.11. 03:50-06:20	**CTD/LADCP** station (to bottom)
1159/ KPO_1043	0°44.95'S	22°59.74'W	12.11. 06:30-11:50	**Mooring** deployment, anchor slipped, submerse of top-element observed
1160/40	0°30'S	23°00'W	12.11. 13:10-17:00	**CTD/LADCP** station (to bottom)
1161/-	0°00'S	23°00' W	12.11. 20:00-22:20	**Microstructure**
1162/41	0°00'S	23°00'W	12.11. 22:50-01:30	**CTD/LADCP** station (to bottom)
1163/-	0°00'S	23°00' W	13.11. 01:40-04:20	**Microstructure**
1164/42	0°00'S	23°00'W	13.11. 04:50-05:20	CTD/LADCP station (600m), water sampling for **Incubations**
1165/-	0°00'S	23°00' W	13.11. 05:30-06:30	**Microstructure**
1166/ KPO_1044a	0°00.2'N	23°06.8'W	13.11. 07:30-08:00	**Mooring** recovery (only top element)
1167/ifm02	0°00'N	23°04.5'W	13.11. 08:00-08:40	**Glider recovery**
1168/-	0°00'N	23°04.5' W	13.11. 09:00-10:10	**Microstructure**
1169/43	2°00'N	23°00'W	14.11. 00:00-07:00	**Yoyo-CTD/LADCP station** (280-520m)
1170/ifm08	2°00'N	23°00'W	14.11. 07:30-09:00	**Glider deployment/recovery** (leak detect)
1171/44	2°00'N	23°00'W	14.11. 09:20-12:20	**CTD/LADCP** station (to bottom)
1172/45	2°30'N	23°00'W	14.11. 15:30-18:40	**CTD/LADCP** station (to bottom)
1173/46	3°00'N	23°00'W	14.11. 23:50-04:30	**CTD/LADCP** station (to bottom)
1174/47	3°30'N	23°00'W	15.11. 07:40-08:10	CTD/LADCP station (600m), water sampling for **Incubations**
1175/48	3°30'N	23°00'W	15.11. 09:00-12:30	**CTD/LADCP** station (to bottom)
1176/49	4°00'N	23°00'W	15.11. 15:20-18:40	**CTD/LADCP** station (to bottom)
1177/50	4°30'N	23°00'W	15.11. 21:40-01:00	**CTD/LADCP** station (to bottom)
1178/13	5°00'N	22°58'W	16.11. 03:40-04:10	**GoFlo** water sampling (100m)
1179/51	5°00'N	22°58'W	16.11. 04:20-07:30	**CTD/LADCP** station (to bottom)
1180/14	5°00'N	22°58'W	16.11. 07:40-08:50	**GoFlo** water sampling (600m)
1181/52	5°00'N	22°58'W	16.11. 09:00-15:10	**Yoyo-CTD/LADCP station** (180-520m)
1182/53	5°30'N	23°00'W	16.11. 18:00-18:50	**CTD/LADCP** station (to 1300m)
1183/54	6°00'N	23°00'W	16.11. 21:40-22:50	**CTD/LADCP** station (to 1300m)
1184/55	6°30'N	23°00'W	17.11. 01:50-02:40	**CTD/LADCP** station (to 1300m)
1185/56	6°45'N	23°00'W	17.11. 04:20-04:50	CTD/LADCP station (600m), water sampling for **Incubations**
1186/57	7°00'N	23°00'W	17.11. 06:30-07:20	**CTD/LADCP** station (to 1300m)
1187/58	7°30'N	23°00'W	17.11. 10:30-11:30	**CTD/LADCP** station (to 1300m)
1188/ifm02	7°58'N	23°05'W	17.11. 14:20-16:30	**Glider** deployment
1189/ KPO_1027	8°01'N	22°59'W	17.11. 17:40-20:30	**Mooring** recovery
1190/59	8°01'N	22°59'W	17.11. 21:00-22:00	**CTD/LADCP** station (to 1300m)
1191/-	8°01'N	22°59'W	17.11. 22:20-23:50	**Microstructure**
1192/60	8°01'N	22°59'W	17.11. 00:20-06:10	**Yoyo-CTD/LADCP station** (180-520m)
1193/-	8°01'N	22°59'W	18.11. 06:20-07:40	**Microstructure**
1194/ KPO_1048	8°01'N	22°59'W	18.11. 08:00-14:10	**Mooring** deployment
1195/-	8°01'N	23°04.5'W	18.11. 15:10-16:40	**Microstructure**
1196/ifm02	8°00'N	23°05'W	18.11. 17:10-17:50	**Glider** recovery
1197/61	8°00'N	23°05'W	18.11. 18:20-18:50	**CTD/LADCP** station (to 500m)
1198/-	8°00'N	23°05'W	18.11. 19:10-22:40	**In-situ Pump** station
1199/62	8°30'N	23°00'W	19.11. 01:50-02:50	**CTD/LADCP** station (to 1300m)
1200/63	9°00'N	23°00'W	19.11. 05:40-06:20	CTD/LADCP station (600m), water sampling for **Incubations**

Station Ship/Science	**Latitude**	**Longitude**	**Time**	**Work**
1201/64	9°00'N	23°00'W	19.11. 07:00-08:00	**CTD/LADCP** station (to 1300m)
1202/65	9°15'N	23°00'W	19.11. 09:30-11:00	**CTD/LADCP** station (to 1300m)
1203/66	9°30'N	23°00'W	19.11. 12:40-13:40	**CTD/LADCP** station (to 1300m)
1204/67	10°00'N	23°00'W	19.11. 16:30-17:30	**CTD/LADCP** station (to 1300m)
1205/68	10°30'N	23°00'W	19.11. 20:40-21:40	**CTD/LADCP** station (to 1300m)
1206/15	11°00'N	23°00'W	20.11. 00:50-01:10	**GoFlo** water sampling (100m)
1207/69	11°00'N	23°00'W	20.11. 01:20-02:20	**CTD/LADCP** station (to 1300m)
1208/16	11°00'N	23°00'W	20.11. 02:30-03:10	**GoFlo** water sampling (400m)
1209/70	11°28'N	23°00'W	20.11. 06:10-12:20	**Yoyo-CTD/LADCP station** (280-520m)
1210/71	11°28'N	23°00'W	20.11. 12:20-13:40	**CTD/LADCP** station (to 1300m)
1211/72	12°00'N	23°00'W	20.11. 17:50-18:40	**CTD/LADCP** station (to 1300m)
1212/73	12°00'N	23°00'W	20.11. 19:10-20:10	**CTD/LADCP** station (to 1300m)
1213/74	12°30'N	23°00'W	20.11. 23:20-00:20	**CTD/LADCP** station (to 1300m)
1214/75	13°00'N	23°00'W	21.11. 03:30-04:30	**CTD/LADCP** station (to 1300m)
1215/76	13°30'N	23°00'W	21.11. 07:50-08:40	**CTD/LADCP** station (to 1300m)
1216/77	13°45'N	23°00'W	21.11. 10:20-11:00	CTD/LADCP station (600m), water sampling for **Incubations**
1217/78	14°00'N	23°00'W	21.11. 12:50-13:50	**CTD/LADCP** station (to 1300m)
1218/79	14°30'N	23°00'W	21.11. 17:00-18:00	**CTD/LADCP** station (to 1300m)
1219/80	15°00'N	23°00'W	21.11. 21:20-22:20	**CTD/LADCP** station (to 1300m)
	14°53'N	24°00'W		**ADCP section**

Tab. 7.2: CTD Stations

CTD	Date	Time	Latitude	Longitude	Depth	max P	Btls	Samples						
1	2009/10/26	21:37	17 35.97N	24 14.61W	NaN	3640	8	1	2	3				7
2	2009/10/27	02:19	17 36.03N	24 14.62W	3591	1009	8	1	2	3		5b		7
3	2009/10/29	05:03	11 29.98N	22 59.98W	5109	1011	10	1	2	3	4			7
4	2009/10/29	07:53	11 29.98N	23 00.01W	5109	606	22					5a	6	7
5	2009/10/30	05:23	8 14.96N	21 44.98W	4393	807	19		2	3a				7
6	2009/10/31	06:44	5 03.01N	22 59.98W	4211	607	22					5a	6	7
7	2009/10/31	11:08	5 01.03N	22 59.08W	4201	1008	22	1	2	3	4	5c		7
8	2009/11/01	16:30	2 02.50N	23 02.01W	4364	4318	22	1	2	3				7
9	2009/11/01	23:38	1 39.91N	23 00.04W	4122	4151	0							
10	2009/11/02	04:57	2 02.51N	23 01.98W	4365	399	0					5a		
11	2009/11/02	05:34	2 02.51N	23 01.99W	4359	608	22						6	7
12	2009/11/02	17:35	1 20.01N	23 00.01W	4717	4728	21	1	2	3	4	5b		7
13	2009/11/03	00:12	1 00.16N	23 00.06W	3207	3199	0	1	2	3	4			7
14	2009/11/03	10:14	0 45.22N	22 59.49W	4309	4310	22		2	3	4	5b		7
15	2009/11/03	20:28	0 30.01N	23 00.01W	3743	3771	22	1	2	3	4	5c	6	7
16	2009/11/04	01:43	0 15.01N	23 00.01W	3869	3906	22		2	3	4	5b		7
17	2009/11/04	11:17	0 00.63N	23 05.53W	3914	1010	0							
18	2009/11/05	01:11	0 00.54S	22 59.79W	3956	3995	22	1	2	3				7
19	2009/11/05	06:40	0 00.00S	22 59.59W	3955	606	22					5a	6	7
20	2009/11/05	22:04	0 14.92S	23 00.07W	4163	4192	22	1	2	3a	4	5b		7
21	2009/11/06	02:50	0 29.97S	22 59.98W	4622	4573	22		2	3	4	5b		7
22	2009/11/06	16:37	0 43.99S	22 58.81W	3729	3703	22	1	2	3a		5b		7
23	2009/11/06	21:06	0 59.89S	23 00.04W	4141	4188	22		2	3	4	5b		7
24	2009/11/07	03:13	1 19.93S	23 00.00W	4846	4573	22	1	2	3a				7
25	2009/11/07	07:30	1 19.96S	23 00.01W	4856	607	22					5a	6	7
26	2009/11/07	10:19	1 40.03S	23 00.01W	4935	4578	22	1	2	3				7
27	2009/11/07	17:06	1 59.98S	23 00.01W	5236	4572	22	1	2	3	4	5c	6	7
28	2009/11/08	00:32	2 29.94S	23 00.15W	5765	4573	22	1	2	3a		5b		7
29	2009/11/08	06:54	3 00.01S	22 59.98W	5487	4573	22	1	2	3	4	5b		7
30	2009/11/08	13:07	3 29.98S	23 00.01W	5482	4571	22	1	2	3		5b		7
31	2009/11/08	19:20	4 00.01S	23 00.03W	5874	4574	22		2	3a	4	5b		7
32	2009/11/09	01:39	4 29.98S	23 00.04W	5171	4572	22		2	3				7
33	2009/11/09	05:45	4 29.98S	23 00.01W	5170	604	22					5a	6	7
34	2009/11/09	09:59	4 59.98S	23 00.06W	5202	4565	22	1	2	3		5c	6	7
35	2009/11/10	12:47	3 29.89S	23 00.19W	5488	5497	22	1	2					7
36	2009/11/11	01:36	1 59.96S	23 00.00W	5234	4572	22		2	3a	4			7
37	2009/11/11	06:16	2 00.72S	22 59.26W	5177	605	22					5a	6	7
38	2009/11/11	23:27	0 59.98S	23 00.00W	4143	4144	22		2	3a	4			7
39	2009/11/12	03:53	0 44.98S	23 00.04W	3668	3672	22		2	3a	4			7
40	2009/11/12	13:13	0 29.98S	23 00.01W	4622	4573	22	1	2	3a	4			7
41	2009/11/12	22:45	0 00.01S	23 00.01W	3956	3989	22	1	2	3	4			7
42	2009/11/13	04:45	0 00.01S	23 00.01W	3957	605	22					5a	6	7
43	2009/11/13	23:59	1 59.92N	23 00.03W	4328	526	0							
44	2009/11/14	09:22	2 00.16N	23 00.46W	4335	4341	22	1	2	3a		5c		7
45	2009/11/14	15:28	2 30.07N	23 00.22W	4774	4575	22		2	3	4	5b		7
46	2009/11/14	23:52	3 00.00N	22 59.98W	4643	4571	22	1	2	3		5b		7
47	2009/11/15	07:39	3 30.01N	23 00.00W	4381	605	22				4	5a	6	7
48	2009/11/15	08:50	3 30.01N	23 00.00W	4382	4390	22		2	3			6	7
49	2009/11/15	15:21	4 00.01N	23 00.03W	4145	4213	22	1	2	3	4	5b		7
50	2009/11/15	21:40	4 30.06N	23 00.00W	4116	4142	22		2	3		5b		7
51	2009/11/16	04:20	5 00.01N	22 57.99W	4190	4215	22	1	2	3		5b		7
52	2009/11/16	09:02	5 00.01N	22 57.99W	4190	531	22							7
53	2009/11/16	17:52	5 30.07N	22 59.98W	4228	1313	22		2			5b		7
54	2009/11/16	21:41	6 00.03N	22 59.92W	4091	1310	22	1	2	3	4	5b		7
55	2009/11/17	01:46	6 29.97N	22 59.95W	3514	1311	22		2			5b		7
56	2009/11/17	04:16	6 44.98N	22 59.98W	3564	605	22					5a	6	7
57	2009/11/17	06:24	7 00.00N	22 59.98W	2989	1312	22	1	2	3	4	5c		7
58	2009/11/17	10:34	7 29.83N	23 00.09W	4381	1311	22		2			5b		7
59	2009/11/17	21:00	8 01.00N	22 58.99W	4472	1309	22	1	2	3	4	5b		7
60	2009/11/18	00:16	8 00.83N	22 59.20W	4467	529	0							

CTD	Date	Time	Latitude	Longitude	Depth	max P	Btls	Samples						
61	2009/11/18	17:59	7 59.88N	23 05.07W	4408	504	22	1	2		4			7
62	2009/11/19	01:47	8 29.98N	22 59.98W	4776	1312	22		2			5b	6	7
63	2009/11/19	05:43	8 59.95N	22 59.98W	4884	606	22					5a	6	7
64	2009/11/19	06:58	8 59.98N	23 00.01W	4890	1311	22	1	2	3	4			7
65	2009/11/19	09:32	9 15.01N	22 59.89W	4952	1312	0							
66	2009/11/19	12:36	9 30.01N	22 59.94W	4634	1313	22		2			5b		7
67	2009/11/19	16:34	10 00.03N	23 00.01W	5056	1312	22	1	2	3	4	5b		7
68	2009/11/19	20:36	10 29.95N	22 59.98W	5181	1312	22		2			5c		7
69	2009/11/20	01:22	11 00.04N	23 00.16W	5146	1313	22	1	2	3		5b		7
70	2009/11/20	06:05	11 27.97N	23 00.01W	5109	528	0							
71	2009/11/20	12:33	11 28.05N	23 00.03W	5110	1313	22		2			5b		7
72	2009/11/20	17:44	11 59.98N	23 00.01W	5039	1008	17					5b		7
73	2009/11/20	19:08	11 59.98N	23 00.01W	5040	1313	22	1	2	3	4		6	7
74	2009/11/20	23:14	12 29.92N	22 59.95W	4915	1311	22		2			5b		7
75	2009/11/21	03:27	12 59.95N	22 59.95W	4735	1312	22	1	2	3		5b		7
76	2009/11/21	07:44	13 29.94N	23 00.00W	4531	1313	22		2					7
77	2009/11/21	10:24	13 44.91N	23 00.01W	4429	605	22					5a	6	7
78	2009/11/21	12:45	13 59.92N	23 00.04W	4319	1312	22	1	2	3		5b		7
79	2009/11/21	17:01	14 29.98N	23 00.04W	4085	1312	22		2			5c		7
80	2009/11/21	21:21	14 59.94N	23 00.07W	2703	1309	22		2			5b		7

Sample codes :

1 = tracer (SF6, F12, SF5CF3) 2 = dissolved oxygen	4 = trace metals	6 = incubation (assimilation, fixation), DNA, nutrients, FISH-Filter
3/3a = CO2 and nutrients/ only nutrients	5a/5b/5c = incubation (fixation) / DNA / glucose	7 = salinity

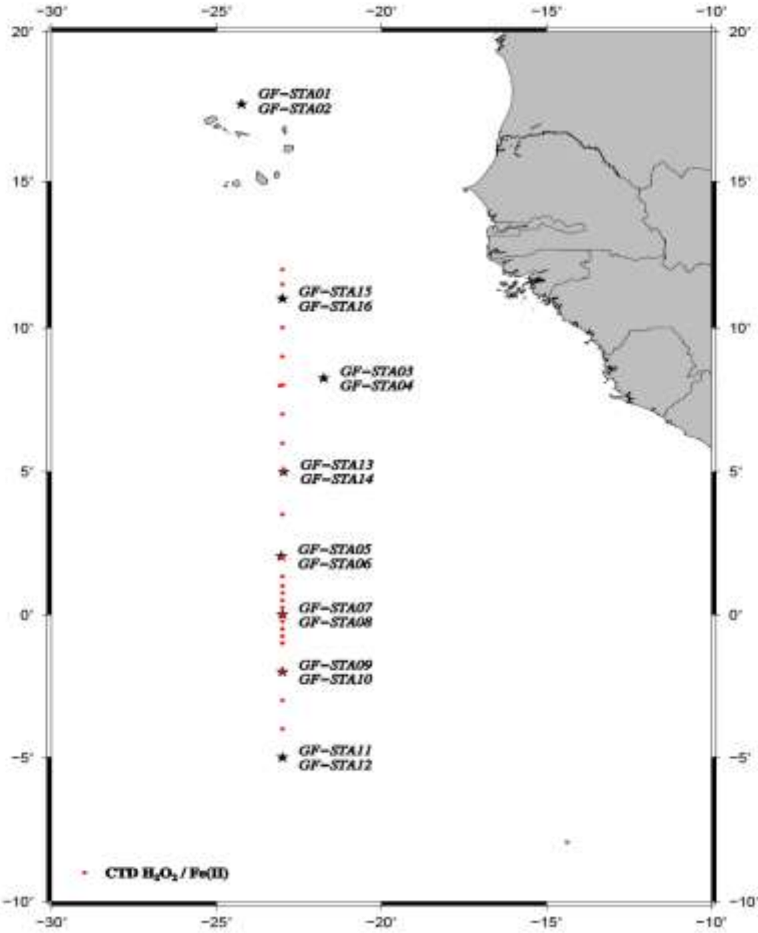

Fig. 7.1: Map of sampled GO-FLO stations (black stars) and sampled CTD casts for measurements of Fe(II) and H_2O_2 (red dots).

Tab. 7.3: GO-FLO stations during M80-1

Station	Label	Depths sampled
1071	GO-FLO 01	20, 40, 55, 80
1076	GO-FLO 02	100, 150, 250, 350
1081	GO-FLO 03	20, 40, 40, 80
1083	GO-FLO 04	100, 200, 300
1090	GO-FLO 05	20, 40, 40, 80
1092	GO-FLO 06	100, 200, 300, 400
1115	GO-FLO 07	20, 40, 40, 80
1120	GO-FLO 08	100, 150, 200, 400
1139	GO-FLO 09	20, 40, 40, 80
1141	GO-FLO 10	100, 200, 300, 400
1148	GO-FLO 11	20, 40, 40, 80
1150	GO-FLO 12	100, 200, 300, 400
1178	GO-FLO 13	20, 40, 40, 80
1180	GO-FLO 14	100, 200, 300, 400, 600
1206	GO-FLO 15	20, 40, 40, 80
1208	GO-FLO 16	100, 200, 300, 400

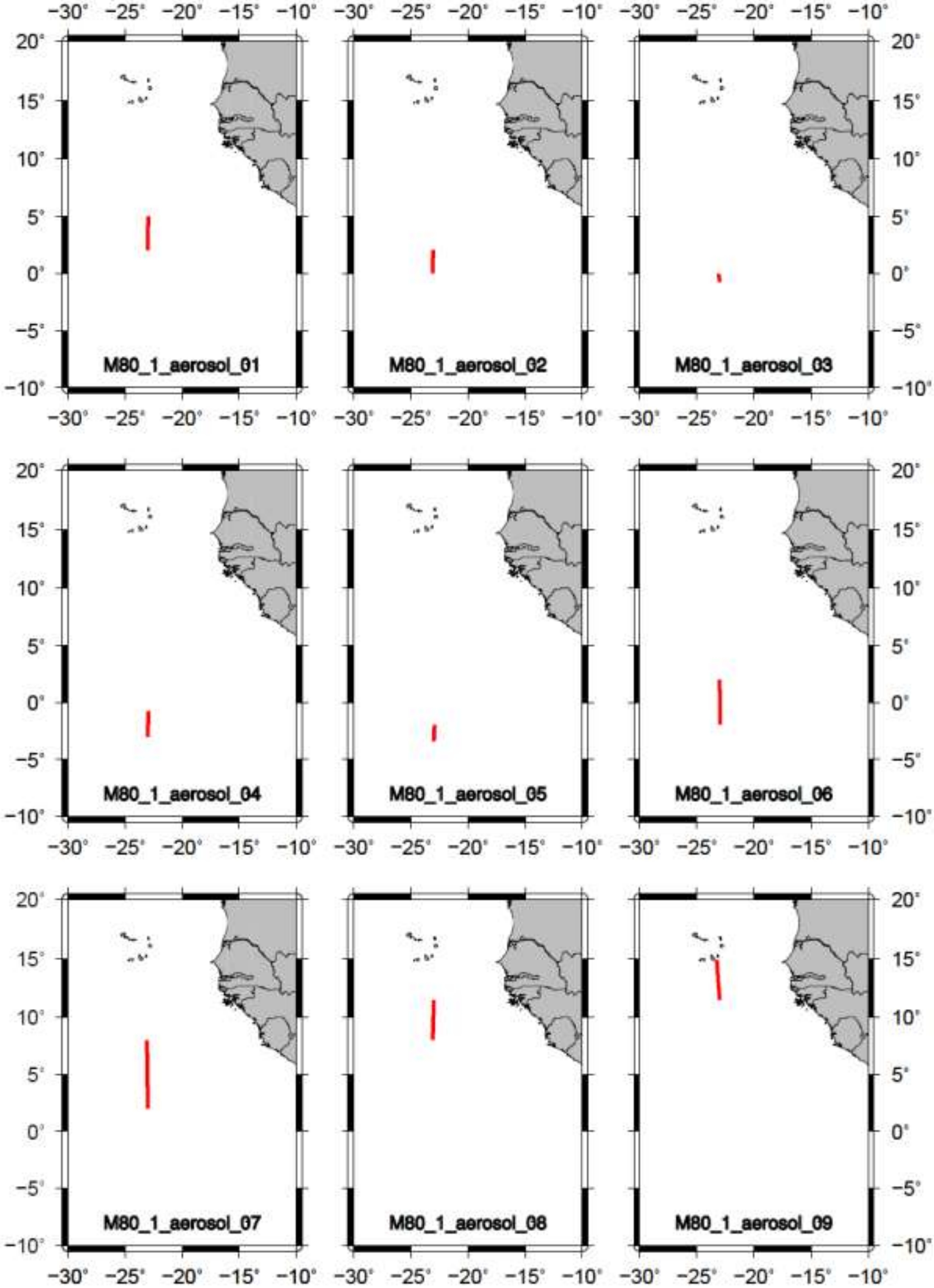

Fig. 7.2: Location of aerosol sample collection during M80/1. Each aerosol sample corresponds to the cumulative amount of air filtered during periods of "good sampling conditions" (wind coming from the bow of the vessel) during the portion of the cruise transect.

Table 7.4: Aerosol samples collected during M80/1

Sample	*Starting date and hour*	Ending date and hour	Sampling duration
M80_1_aerosol_1	*31.10.09 14:30*	02.11.09 08:00	1803 minutes
M80_1_aerosol_2	*02.11.09 08:30*	04.11.09 12:00	2327 minutes
M80_1_aerosol_3	*04.11.09 12:20*	06.11.09 14:15	1815 minutes
M80_1_aerosol_4	*06.11.09 14:30*	08.11.09 12:15	1935 minutes
M80_1_aerosol_5	*08.11.09 12:30*	11.11.09 10:15	1871 minutes
M80_1_aerosol_6	*11.11.09 10:40*	14.11.09 11:45	2097 minutes
M80_1_aerosol_7	*14.11.09 11:55*	17.11.09 17:05	2101 minutes
M80_1_aerosol_8	*17.11.09 17:25*	20.11.09 13:30	1233 minutes
M80_1_aerosol_9	*20.11.09 13:45*	22.11.09 09:45	1745 minutes

Table 7.5: CTD stations from which samples were collected for incubations, DNA/RNA, CARD-FISH, Nano-SIMS, Nutrients and DIC measurements.

	CTD15		CTD27		CTD34		CTD 48		CTD 62	
Depth	**15NH4 + 13C-Gluc.**	**nS***	**15NH4 + 13C-Gluc.**	**nS***	**15NH4 + 13C-Gluc.**	**nS***	**15NH4 + 13C-Gluc.**	**nS***	**15NH4 + 13C-Gluc.**	**nS***
5m	X	X	X	X	X	X	X	X	X	X
10m	X		X		X		X		X	
20m	X		X		X				X	
40m			X	X	X				X	
42,5m	X	X								
57m									X	X
60m	X				X	X	X			
80m	X	X	X		X		X	X	X	
100m	X	X	X		X	X	X		X	
150m			X		X					
200m	X		X	X	X		X	X	X	X
250m			X		X					
300m			X		X		X		X	
400m	X	X	X		X		X		X	
600m	X	X	X		X	X	X		X	
800m	X		X		X		X		X	
1000m	X	X	X	X	X	X	X	X	X	X
1300m									X	
1500m	X									
2000m	X	X	X		X		X			
2500m	X									
3000m	X	X	X		X		X			
3500m	X									
3700m			X		X					
bottom	X	X	X	X	X	X	X			

*nS= nano-SIMS

Tab. 7.5: Continued

CTD	Depth	15NH4+ 13C-DIC	15NO2 + 13C-DIC	15NO3 + 13C-DIC	15N2 + 13C-Gluc.	15NH4 + 13C-Gluc.	picoeuk.	nutrients	NH4	DNA/RNA	CARD-FISH	nano-SIMS
4	0m	X	X		X			X	X	X	X	X
	37m	X	X					X	X	X	X	X
6	0m	X						X	X	X	X	X
	70m	X		X	X			X	X	X	X	X
	150m			X				X	X		X	X
	400m		X+Gluc.	X+Gluc.		X		X	X		X	X
10	0m	X			X			X	X	X	X	X
	76m	X	X					X	X	X	X	X
	150m		X+Gluc.	X+Gluc.				X	X		X	X
	200m		X+Gluc.	X+Gluc.				X	X		X	X
19	0m	X						X	X	X	X	X
	57m		X		X			X	X	X	X	X
	200m		X		X			X	X		X	
25	0m	X			X	X	X	X	X	X	X	X
	68m		X		X	X	X	X	X	X	X	X
	200m		X+Gluc.	X+Gluc.	X			X	X		X	X
	400m		X+Gluc.	X+Gluc.	X			X	X		X	X
33	0m	X			X		X	X	X	X	X	X
	68m		X		X		X	X	X	X	X	X
	400m			X+Gluc.	X			X	X		X	X
37	0m	X			X		X	X	X	X	X	X
	65m		X	X	X		X	X	X	X	X	X
	200m		X+Gluc.	X+Gluc.	X			X	X		X	X
42	0m	X			X		X	X	X	X	X	X
	55m		X	X	X		X	X	X	X	X	X
	400m			X+Gluc.	X+Gluc.			X	X		X	X
47	0m				X		X	X	X	X	X	X
	63m		X		X		X	X	X	X	X	X
	200m				X+Gluc.			X	X		X	X
56	0m	X			X		X	X	X	X	X	X
	64m		X	X	X		X	X	X	X	X	X
	400m		X+Gluc.		X			X	X		X	X
63	0m	X			X		X	X	X	X	X	X
	59m		X		X		X	X	X	X	X	X
	400m		X+Gluc.	X+Gluc.				X	X		X	X
73	5m				X			X	X		X	X
	10m				X			X	X		X	X
77	0m				X+Gluc.	X+Gluc.	X	X	X		X	X
	20m							X	X		X	
	42m	X	X		X		X	X	X		X	X
	50m							X	X		X	
	100m							X	X		X	
	150m							X	X		X	
	200m							X	X		X	
	400m		X+Gluc.	X+Gluc.	X			X	X		X	
	600m							X	X		X	X

x = sample | no sample (shaded) | X+Gluc.= + 13C Glucose

Tab. 7.6: Calibration coefficients for Microcats and MTD Logger

CTD No.	S/N	Temperature Bias	Temperature Slope	Temperature RMS	Conductivity Bias	Conductivity Slope	Conductivity RMS	Pressure Bias	Pressure Slope	Pressure RMS
1	2245	0.004911	0.998937	0.012	-.023994	1.000162	0.011			
1	2247	0.004947	0.999078	0.011	-0.055289	1.001080	0.012			
1	2248	0.003766	0.998999	0.012	-0.000530	0.999448	0.011			
2	3196	0.008469	0.998214	0.013	0.034991	0.998588	0.009			
4	53	-0.003237	0.999920	0.007	-0.021154	1.000142	0.011			
4	1269	0.000111	0.999252	0.011	-0.170789	1.004694	0.026			
4	1284	0.000637	0.999300	0.011	-0.172329	1.005047	0.024			
4	1286	-0.000276	0.999322	0.010	-0.170304	1.004671	0.024			
4	2250	0.002997	0.998878	0.012	0.013979	0.997658	0.014			
4	3144	0.002068	0.999017	0.011	-0.000707	0.999503	0.013			
5	1320	0.000663	0.999191	0.013	-0.034962	1.001357	0.025			
5	2249	0.001262	0.999005	0.015	0.025490	0.998195	0.013			
5	2251	0.000946	0.999071	0.015	0.026441	0.998598	0.014			
20	1723	0.008747	0.997897	0.021	-0.014345	0.999530	0.020			
20	2262	0.008516	0.997957	0.021	-0.005466	0.999579	0.020	1.605862	1.001700	0.295
20	2488	0.007380	0.998181	0.022	-0.007331	1.000148	0.020	1.588798	1.000768	0.541
20	3411	0.008690	0.998016	0.022	-0.029081	0.999708	0.024	1.316540	1.002815	0.385
20	3415	0.008521	0.997876	0.020	-0.051253	1.000956	0.027	1.441111	1.002220	0.498
20	3755	0.009967	0.997919	0.021	-0.025978	0.999450	0.022	1.283954	0.998873	0.365
24	2718	-0.006062	1.000384	0.025	-0.047725	1.000955	0.030	-0.235581	1.002688	0.413
24	1550	-0.004278	0.999749	0.025	-0.030215	1.000341	0.027			
24	1682	-0.005485	0.999813	0.024	-0.026442	1.000165	0.026			
24	2468	-0.002495	0.999897	0.022	-0.014239	1.000012	0.026			
24	2472	-0.003592	1.000136	0.025	-0.012015	0.999527	0.029			
24	2618	-0.006761	1.000462	0.025	-0.029201	1.000327	0.029			
25	1162	0.000821	0.999275	0.013	-0.040287	1.000003	0.010			
25	1268	-0.001834	0.999504	0.013	-0.254478	1.007531	0.033			
25	2279	0.000388	0.999255	0.014	-0.003304	1.000010	0.011			
25	2617	0.002528	0.999230	0.014	0.000494	0.999600	0.011			

CTD No.	S/N	Temperature Bias	Temperature Slope	Temperature RMS	Conductivity Bias	Conductivity Slope	Conductivity RMS	Pressure Bias	Pressure Slope	Pressure RMS
29	**2254**	**-0.001425**	**0.999531**	**0.010**	**-0.047930**	**1.001028**	**0.016**			
29	2257	-0.001622	0.999565	0.010	-0.050548	1.000494	0.014			
29	2933	-0.002023	0.999559	0.009	-0.092354	1.002212	0.020			
29	24	0.088106	0.999515	0.019	MiniTD			3.267423	0.997745	0.654
29	26	-0.090633	1.000866	0.014	MiniTD			15.098628	1.009004	3.477
30	2252	-0.001873	0.999286	0.020	-0.042792	1.000477	0.019			
30	2255	-0.000544	0.999318	0.020	-0.053731	1.000985	0.019			
30	3752	-0.000441	0.999493	0.014	-0.090715	1.000949	0.019	2.315372	1.001572	0.346
30	3753	0.001113	0.999524	0.015	-0.073271	1.000087	0.016	2.607432	1.001131	0.349
30	3757	-0.000749	0.999561	0.015	-0.086916	1.001883	0.018	-0.413203	1.003270	0.498

CTD No.	S/N	Temperature Bias	Temperature Slope	Temperature RMS	Conductivity Bias	Conductivity Slope	Conductivity RMS	Pressure Bias	Pressure Slope	Pressure RMS
35	3754	0.006626	0.998641	0.015	0.008818	0.998980	0.012	0.765704	1.000394	0.520
35	52	0.001956	0.999758	0.013	-0.062161	1.001668	0.011			
35	55	-0.001090	0.999883	0.013	-0.047535	1.001431	0.010			
35	278	-0.003546	1.000110	0.017	-0.244667	1.007412	0.026			
35	381	0.006351	0.999807	0.012	-0.337975	1.010176	0.030			
35	780	0.001791	0.999836	0.011	-0.350030	1.013055	0.035			
35	921	-0.000040	0.999924	0.010	-0.257379	1.007588	0.019			
35	2256	0.008486	0.998265	0.017	0.041119	0.998298	0.015			
40	922	-0.006065	1.000383	0.008	-0.174512	1.005103	0.027			
40	925	-0.006815	1.000520	0.008	-0.194128	1.006081	0.028			
40	936	-0.003843	1.000050	0.007	-0.160516	1.004714	0.025			
40	1281	-0.005014	1.000396	0.009	-0.250646	1.007043	0.021			
40	1282	-0.006009	1.000509	0.009	-0.171192	1.005412	0.026			
40	1583	-0.001413	1.000219	0.009	0.007603	0.999202	0.009			
40	1599	-0.001351	0.999701	0.007	0.007569	0.999685	0.007			

Tab. 7.7: Mooring Recoveries

Mooring Deployment Equatorial Atlantic 23W 2S					**Notes:**	**KPO_1021**
Vessel:	Atalante					
Deployed:	3-Mar	2008		14:09		
Vessel:	METEOR					
Recovered:	11-Nov	2009		7:30		
Latitude:	1	56.701	S			
Longitude:	22	56.653	W			
Water depth:	4840	Mag Var:		-16.9		
ID	**Depth**	**Instr. type**		**s/n**		
		Argos		7373		
KPO_1021_01	298	ADCP NB up		270	clean, full record	
KPO_1021_02	298	MiniTD		67	clean, full record	
KPO_1021_03	395	Argonaut		304	clean, full record	
KPO_1021_04	549	RCM-8		10504	clean, full record	
KPO_1021_05	694	RCM-8		94	zero rotor count for 3 months	
KPO_1021_06	848	Argonaut		179	clean, full record	
KPO_1021_07	1003	RCM-8		10500	rotor count drops out after Apr 09	
	4232	Release	RT661 / 31		Spargel response: none	
	4232	Release	AR661 / 121		Spargel response: none **(ex)**	

Mooring Deployment Equatorial Atlantic 23W 0:45S					**Notes:**	**KPO_1022**
Vessel:	Atalante					
Deployed:	4-Mar	2008		18:43		
Vessel:	METEOR					
Recovered:	6-Nov	2009		11:42		
Latitude:	0	44.940	S			
Longitude:	22	59.700	W			
Water depth:	3670	Mag Var:		-16.3		
ID	**Depth**	**Instr. type**		**s/n**		
		Argos		12620		
KPO_1022_01	62	MiniTD		68	clean, full record	
KPO_1022_02	96	Microcat		1269	clean, full record	
KPO_1022_03	144	Microcat		2250	clean, full record	
KPO_1022_04	295	MiniTD		46	clean, full record	
KPO_1022_05	553	ADCP LR up		3173	clean, full record	
KPO_1022_06	698	RCM-8		9933	clean, full record	
KPO_1022_07	853	Argonaut		329	clean, full record	
KPO_1022_08	997	RCM-8		9833	clean, full record	
	3117	Release	RT661 / 173		Spargel response: 3407	
	3117	Release	RT661 / 174		Spargel response: none **(ex)**	

Mooring Deployment Equatorial Atlantic 23W 0:00N					**Notes:**	**KPO_1023**
Vessel:	Atalante					
Deployed:	1-Mar	2008		19:43		
Vessel:	METEOR					
Recovered:	4-Nov	2009		7:27		
Latitude:	0	0.000	N			
Longitude:	23	6.800	W			
Water depth:	3935	Mag Var:		-16.0		
ID	**Depth**	**Instr. type**		**s/n**		
		Argos		108		
KPO_1023_01	~~40~~	~~ADCP 1200 up~~		~~7279~~		
KPO_1023_02	198	MiniTD		58	clean, full record	
KPO_1023_03	198	ADCP up		8237	clean, full record	
KPO_1023_04	203	Microcat		1284	clean, full record, many read errors	
KPO_1023_05	305	Microcat		1286	clean, full record, many read errors	
KPO_1023_06	306	O2 Logger		939	only 16 days of data	
KPO_1023_07	500	Microcat		1320	clean, full record, many read errors	
KPO_1023_08	501	O2 Logger		942	only 16 days of data	
KPO_1023_09	703	ADCP LR up		1181	clean, full record	
KPO_1023_10	848	Argonaut		144	clean, full record	
KPO_1023_11	1003	RCM-8		6122	Heavy berth line wrapped around instrument	
	3322	Release	RT661 / 107		Spargel response: 3316, 3315, 3314	
	3322	Release	AR861 / 435		Spargel response: 3349, 3349, 3156 **(ex)**	

Mooring Deployment Equatorial Atlantic 23W 0:45N					**Notes:**	**KPO_1024**
Vessel:	Atalante					
Deployed:	6-Mar	2008		10:35		
Vessel:	METEOR					
Recovered:	3-Nov	2009		7:00		
Latitude:	0	45.170	N			
Longitude:	22	59.280	W			
Water depth:	4320	Mag Var:		-15.7		
ID	**Depth**	**Instr. type**		**s/n**		
		Argos		11458		
KPO_1024_01	64	MiniTD		57	clean, full record	
KPO_1024_02	97	Microcat		2249	clean, full record	
KPO_1024_03	143	Microcat		2251	clean, full record	
KPO_1024_04	300	MiniTD		31	no data, dead battery	
KPO_1024_05	555	ADCP LR up		2290	clean, full record	
KPO_1024_06	700	RCM-8		10658	clean, full record	
KPO_1024_07	855	Argonaut		151	clean, full record	
KPO_1024_08	1009	RCM-8		9311	many zero rotor counts	
	3642	Release	AR861 / 271		Spargel response: 3689, 3687, 3685 **(ex)**	
	3642	Release	AR661 / 122		Spargel response: 3664, 3663, 3613, 3548	

Mooring Deployment Equatorial Atlantic 23W 2N					**Notes:**	**KPO_1025**
Vessel:	Atalante					
Deployed:	28-Feb	2008		20:55	corrected date!!!	
Vessel:	METEOR					
Recovered:	1-Nov	2009		12:12		
Latitude:	2	2.500	N			
Longitude:	23	2.000	W			
Water depth:	4363	Mag Var:		-15.2		
ID	**Depth**	**Instr. type**		**s/n**		
		Argos		5481		
KPO_1025_01	297	ADCP up		623	no data, loose connector	
KPO_1025_02	297	MiniTD		70	clean, full record	
KPO_1025_03	300	O2 Logger		944	clean, full record	
KPO_1025_04	301	Microcat		3144	clean, full record	
KPO_1025_05	394	Argonaut		294	clean, full record	
KPO_1025_06	495	O2 Logger		945	clean, full record	
KPO_1025_07	496	Microcat		53	clean, full record	
KPO_1025_08	549	RCM-8		12004	clean, full record	
KPO_1025_09	693	RCM-8		8365	clean, full record	
KPO_1025_10	848	Argonaut		299	clean, full record	
KPO_1025_11	1003	RCM-8		10659	clean, full record	
	3832	Release	AR861 / 95		Spargel response: 3919, 3921	
	3832	Release	RT661 / 41		Spargel response: 3897, 3899, 4022, 4015 **(ex)**	

Mooring Deployment Equatorial Atlantic 23W 5N					**Notes:**	**KPO_1026**
Vessel:	Atalante					
Deployed:	27-Feb	2008		18:30		Mooring got hit by longlines
Vessel:	METEOR					in July 2008, broke profiler
Recovered:	31-Oct	2009		8:03		
Latitude:	5	0.900	N			
Longitude:	23	0.000	W			
Water depth:	4216	Mag Var:		-14.0		
ID	**Depth**	**Instr. type**		**s/n**		
		Argos		2267		
KPO_1026_01	76	MiniTD		71	clean, full record	
KPO_1026_02	77	O2 Logger		941	clean, full record	
KPO_1026_03	80	Microcat		2247	clean, full record	
KPO_1026_04	594	M-CTD MMP		12201-1	only 3 months of data	
KPO_1026_05	1022	RCM-8		9345	full record, speed drop-out Apr - mid Jun 2009	
KPO_1026_06	1023	Microcat		3196	clean, full record	
	3513	Release	AR861 / 107		Spargel response: 3530	
	3513	Release	AR661 / 350		Spargel response: 3498, 3504, 3479 **(ex)**	

Mooring Deployment Equatorial Atlantic 23W 8N					**Notes:** **KPO_1027**
Vessel:	Atalante				
Deployed:	26-Feb	2008		10:49	
Vessel:	METEOR				
Recovered:	17-Nov	2009		17:37	
Latitude:	8	1.000	N		
Longitude:	22	59.000	W		
Water depth:	4484	Mag Var:		-13.0	
ID	**Depth**	**Instr. type**		**s/n**	
		Argos		2255	
KPO_1027_01	81	MiniTD		59	Instrument lost, no data
KPO_1027_02	85	Microcat		2245	clean, full record
KPO_1027_03	599	M-CTD MMP		12255-1	only 3 profiles recorded, fishing line!!!
KPO_1027_04	1027	RCM-8		9727	clean, full record
KPO_1027_05	1028	Microcat		2248	clean, full record
	3922	Release	AR661 / 351		Spargel response: 4046, 4039, 4041 **(ex)**
	3922	Release	AR661 / 659		Spargel response: 4057, 4053

Mooring Deployment Cape Verde V440-02				**Notes:**	**KPO_1028**
Vessel:	Atalante				
Deployed:	14-Mar	2008	10:58		
Vessel:	METEOR				
Recovered:	26-Oct	2009	15:32		
Latitude:	17	36.400 N			
Longitude:	24	14.980 W			
Water depth:	3598	Mag Var:	-11.2		

ID	**Depth**	**Instr. type**	**s/n**	**Remarks**
		~~Argos WD~~	~~5511~~	Wire cut after top float resurfaced on 14-Mar-08
KPO_1028_01	~~42~~	~~Microcat /p~~	~~2488~~	
KPO_1028_02	~~42~~	~~Fluorometer~~	~~268~~	
KPO_1028_03	57	Microcat	1268	clean, full record
KPO_1028_04	77	Microcat	1723	clean, full record
KPO_1028_05	79	O2 NIOZ	A7	
KPO_1028_06	100	Microcat	1599	clean, full record
KPO_1028_07	103	ADCP WH up	1522	clean, full record
KPO_1028_08	127	RCM-11	325	clean, full record
KPO_1028_09	127	O2 Logger	349	
KPO_1028_10	128	Microcat	1162	clean, full record
KPO_1028_11	201	Microcat	1682	clean, full record
KPO_1028_12	300	Microcat /p	3411	clean, full record
KPO_1028_13	301	RBR	10385	clean, full record
KPO_1028_14	401	O2 NIOZ	A4	
KPO_1028_15	403	Microcat	2279	clean, full record
KPO_1028_16	602	RCM-8	9322	clean, full record
KPO_1028_17	603	Microcat	2262	clean, full record
KPO_1028_18	852	Microcat	2478	clean, full record
KPO_1028_19	1103	Microcat	1550	clean, full record
KPO_1028_20	1295	Sediment Trap	900000	
KPO_1028_21	1329	RCM-8	10815	clean, full record
KPO_1028_22	1403	Microcat /p	3755	clean, full record
KPO_1028_23	1702	Microcat /p	2718	clean, full record
KPO_1028_24	1703	Mini-TD	42	clean, full record
KPO_1028_25	2028	Microcat /p	3415	clean, full record
KPO_1028_26	2029	Mini-TD	26	clean, full record
KPO_1028_27	2528	Microcat	2617	clean, full record
KPO_1028_28	2529	Mini-TD	24	clean, full record
KPO_1028_29	3001	Microcat	2618	clean, full record
KPO_1028_30	3002	Mini-TD	36	clean, full record
KPO_1028_31	3468	Sediment Trap	11804-1	
KPO_1028_32	3503	RCM-8	10074	clean, full record - low speeds
KPO_1028_33	3504	Microcat	2472	clean, full record
KPO_1028_34	3505	Mini-TD	34	clean, full record, 2 dbar jump in April 2009
	3565	Release	AR861 / 270	Spargel response: none
	3565	Release	RT661 / 28	Spargel response: 3614, 3616, 3593

Tab. 7.7: Mooring Deployments

Mooring Deployment Cape Verde V440-03						**Notes:**	**KPO_1041**
Vessel:	METEOR						
Deployed:	27-Oct	2009		15:31			
Vessel:							
Recovered:							
Latitude:	17	36.400	N				
Longitude:	24	14.980	W				
Water depth:	3603	Mag Var:		-10.6			
ID	**Depth**	**Instr. type**		**s/n**	**Startup**		**Remarks**
KPO_1041_01	21	Microcat		922			
KPO_1041_02	30	Microcat		925			
KPO_1041_03	40	Microcat		381			
KPO_1041_04	54	O2 Logger		206			
KPO_1041_05	54	Microcat		1316			
KPO_1041_06	69	Microcat /p		3414			
KPO_1041_07	89	Microcat		1317			
KPO_1041_08	119	ADCP WH up		2140			
	119	Watchdog		12618			
KPO_1041_09	181	SAMI		36			
KPO_1041_10	182	O2 Logger		219			
KPO_1041_11	182	Microcat		1288			
KPO_1041_12	299	Microcat /p		2271			
KPO_1041_13	399	Microcat		940			
KPO_1041_14	598	RCM-8		11441			
KPO_1041_15	600	Microcat /p		2488			
KPO_1041_16	850	Microcat		1322			
KPO_1041_17	1075	Microcat		952			
KPO_1041_18	1300	Sediment Trap		910004			
KPO_1041_19	1330	RCM-8		11621			
KPO_1041_20	1500	Microcat /p		3754			
KPO_1041_21	1751	Microcat		938			
KPO_1041_22	1752	Mini-TD		39			
KPO_1041_23	2000	Microcat		942			
KPO_1041_24	2001	Mini-TD		23			
KPO_1041_25	2700	Microcat		941			
KPO_1041_26	2701	Mini-TD		47			
KPO_1041_27	3449	Sediment Trap		910014			
KPO_1041_28	3483	RCM-8		9831			
KPO_1041_29	3485	Microcat /p		2717		pressure sensor defective	
	3568	Release		190	Code:		
	3568	Release		633	Code:		

Mooring Deployment Equatorial Atlantic 23W 2S						**Notes:**	**KPO_1042**
Vessel:	METEOR						
Deployed:	11-Nov	2009		17:29			
Vessel:							
Recovered:							
Latitude:	2	0.035	S				
Longitude:	22	59.975	W				
Water depth:	5220	Mag Var:		-17.0			
ID	**Depth**	**Instr. type**		**s/n**	**Startup**		
		Argos		7373			
KPO_1021_01	293	ADCP NB up		267			
KPO_1021_02	293	MiniTD		63			
KPO_1021_03	389	Argonaut		182			
KPO_1021_04	543	RCM-8		10501			
KPO_1021_05	698	RCM-8		10664			
KPO_1021_06	854	Argonaut		329			
KPO_1021_07	1485	M-CTD MMP		11617			
	4122	Release		52	Code:		
	4122	Release		221	Code:		

Mooring Deployment Equatorial Atlantic 23W 0:45S						**Notes:**	**KPO_1043**
Vessel:	METEOR						
Deployed:	12-Nov	2009		11:33			
Vessel:							
Recovered:							
Latitude:	0	44.954	S				
Longitude:	22	59.743	W				
Water depth:	3685	Mag Var:		-15.9			
ID	**Depth**	**Instr. type**		**s/n**	**Startup**		
		Argos		5361			
KPO_1022_01	545	ADCP LR up		12538			
KPO_1022_02	690	RCM-8		9818	**x**		
KPO_1022_03	845	Argonaut		299	**x**		
KPO_1022_04	1496	M-CTD MMP		106			
	3548	Release		821	Code:		
	3548	Release		110	Code:		

Mooring Deployment Equatorial Atlantic 23W 0:00N					**Notes:**	**KPO_1044**
Vessel:	METEOR					
Deployed:	5-Nov	2009	18:44		Top part retrieved on 13-Nov-09	
Vessel:						
Recovered:						
Latitude:	0	0.200	N			
Longitude:	23	6.800	W			
Water depth:	3935	Mag Var:	-16.1			
ID	**Depth**	**Instr. type**	**s/n**	**Startup**		
		Argos	7372			
KPO_1044_01	~~15~~	~~ADCP 1200 dn~~	~~7279~~	-	clean, full record	
KPO_1044_02	~~15~~	~~MiniTD~~	~~57~~	-	clean, full record	
KPO_1044_03	~~15~~	~~MiniTD~~	~~70~~	-	clean, full record	
KPO_1044_04	~~25~~	~~RDI DVS~~	~~11028~~	-	clean, full record	
KPO_1044_05	213	ADCP up	8237			
KPO_1044_06	213	MiniTD	61			
KPO_1044_07	218	ADCP LR dn	2627			
KPO_1044_08	300	O2 Logger	135			
KPO_1044_09	300	Microcat	52			
KPO_1044_10	506	O2 Logger	1143			
KPO_1044_11	506	Microcat	958			
KPO_1044_12	759	RCM-8	10810			
KPO_1044_13	843	Argonaut	188			
KPO_1044_14	928	RCM-8	10075			
KPO_1044_15	1489	M-CTD MMP	114			
	3614	Release	271	Code:		
	3614	Release	122	Code:		

Mooring Deployment Equatorial Atlantic 23W 0:45N					**Notes:**	**KPO_1045**
Vessel:	METEOR					
Deployed:	3-Nov	2009	18:29			
Vessel:						
Recovered:						
Latitude:	0	45.129	N			
Longitude:	22	59.301	W			
Water depth:	4310	Mag Var:	-16.1			
ID	**Depth**	**Instr. type**	**s/n**	**Startup**		
		Argos	5367			
KPO_1045_01	553	ADCP LR up	57			
KPO_1045_02	698	RCM-8	10077			
KPO_1045_03	844	Argonaut	183			
KPO_1045_04	1485	M-CTD MMP	110			
	4012	Release	861 # 107	Code:		
	4012	Release	661 # 350	Code:		

Mooring Deployment Equatorial Atlantic 23W 2N					**Notes:**	**KPO_1046**
Vessel:	METEOR					
Deployed:	2-Nov	2009	12:42			
Vessel:						
Recovered:						
Latitude:	2	2.430 N				
Longitude:	23	1.930 W				
Water depth:	4373	Mag Var:	-15.0			
ID	**Depth**	**Instr. type**	**s/n**	**Startup**		
		Argos	5481			
KPO_1046_01	296	MiniTD	52			
KPO_1046_02	296	ADCP NB up	589			
KPO_1046_03	300	O2 Logger	1140			
KPO_1046_04	300	Microcat	6863			
KPO_1046_05	394	Argonaut	145			
KPO_1046_06	496	O2 Logger	1141			
KPO_1046_07	496	Microcat	1318			
KPO_1046_08	549	RCM-8	10550			
KPO_1046_09	704	RCM-8	2317			
KPO_1046_10	860	Argonaut	184			
KPO_1046_11	1481	M-CTD MMP	116			
	4062	Release	235	Code:		
	4062	Release	54	Code:		

Mooring Deployment Equatorial Atlantic 23W 5N					**Notes:**	**KPO_1047**
Vessel:	METEOR					
Deployed:	31-Oct	2009				
Vessel:						
Recovered:						
Latitude:	5	0.900 N				
Longitude:	23	0.000 W				
Water depth:	4210	Mag Var:	-14.1			
ID	**Depth**	**Instr. type**	**s/n**	**Startup**		
		Argos	2267			
KPO_1047_01	97	MiniTD	29			
KPO_1047_02	99	O2 Logger	1138			
KPO_1047_03	99	Microcat	6859			
KPO_1047_04	200	O2 Logger	1160			
KPO_1047_05	200	Microcat	1323			
KPO_1047_06	296	O2 Logger	1136			
KPO_1047_07	296	Microcat	6860			
KPO_1047_08	398	O2 Logger	1071			
KPO_1047_09	396	Microcat	936			
KPO_1047_10	500	O2 Logger	1142			
KPO_1047_11	500	Microcat	6861			
KPO_1047_12	595	O2 Logger	1144			
KPO_1047_13	595	Microcat	1321			
KPO_1047_14	697	O2 Logger	1132			
KPO_1047_15	697	Microcat	6862			
KPO_1047_16	799	ADCP LR up	2395			
KPO_1047_17	801	O2 Logger	1070			
KPO_1047_18	801	Microcat	946			
	4210	Release	460	Code:		
	4210	Release	270	Code:		

Mooring Deployment Equatorial Atlantic 23W 8N						**Notes:**	**KPO_1048**
Vessel:	METEOR						
Deployed:	18-Nov	2009		13:47			
Vessel:							
Recovered:							
Latitude:	8	1.065	N				
Longitude:	22	58.990	W				
Water depth:	4485	Mag Var:		-12.2			
ID	**Depth**	**Instr. type**		**s/n**	**Startup**		
		Argos		2255			
KPO_1048_01	101	MiniTD		64			
KPO_1048_02	102	O2 Logger		145			
KPO_1048_03	102	Microcat		6856			
KPO_1048_04	204	O2 Logger		144			
KPO_1048_05	204	Microcat		6854			
KPO_1048_06	299	O2 Logger		1135			
KPO_1048_07	299	Microcat		6855			
KPO_1048_08	401	O2 Logger		1074			
KPO_1048_09	401	Microcat		3196			
KPO_1048_10	503	O2 Logger		1037			
KPO_1048_11	503	Microcat		6858			
KPO_1048_12	599	O2 Logger		1134			
KPO_1048_13	599	Microcat		1682			
KPO_1048_14	701	O2 Logger		1133			
KPO_1048_15	701	Microcat		6857			
KPO_1048_16	803	ADCP LR up		12530			
KPO_1048_17	805	O2 Logger		1139			
KPO_1048_18	805	Microcat		2247			
	3387	Release		95	Code:		
	3387	Release		121	Code:		

8 Data and Sample Storage and Availability

All data were collected within the Sonderforschungsbereich (SFB) 754 and the BMBF project "Nordatlantik". At GEOMAR Kiel a joint Data Management Team is active, providing data services to the SFB 754, the BMBF project "Nordatlantik", the Excellence Cluster "Future Ocean" as well as other projects of GEOMAR. Through a web based portal data are managed, archived, and shared. All data collected during the cruise will be delivered to the data portal. Three years after the cruise the Data Management Team will verify quality control by the principle investigators and submit all data to the information system PANGAEA.

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