METEOR-Berichte

Oxygen Supply Tracer Release Experiment (OSTRE)

Cruise No. M97

May 25 – June 28, 2013
Mindelo (Cape Verde) – Fortaleza (Brazil)

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1 Summary

The cruise M97 to the Tropical Eastern North Atlantic was a contribution to the DFG Sonderforschungsbereich (SFB) 754, Climate - Biogeochemistry Interactions in the Tropical Ocean. The cruise was the first cruise to map the deliberately released tracer that was injected to the area in December of 2012 as the "Oxygen Supply Tracer Release Experiment (OSTRE)". The results from these measurements will constrain the diapycnal and lateral mixing rates in the region with the aim of quantifying and better understanding the supply of oxygen to the oxygen minimum zone (OMZ) of the Tropical Atlantic. Toward this goal we measured the tracer content of the water column at 171 CTD stations, focused on the area close to the density at which the tracer was released (σ_Θ=27.03). The sampling was focused along a grid pattern with the borders 8 to 12°N and 23 to 19°W where we found tracer at about 2/3 of the stations. This allowed for a detailed mapping of the tracer within the area, both in the vertical as in the horizontal. The sampling at the CTD staions also included oxygen measurements that provided observations on temporal variability and inventory of the oxygen concentration within the OMZ. A zooplankton sampling program aimed to elucidate the role of zooplankton in biogeochemical cycles, in particular their role for the transport of organic and inorganic matter from the surface layer to OMZ depths via diurnal vertical migrations. Zooplankton was sampled with different nets and also measured by a Underwater Vision Profiler at all stations. Additionally experiments aiming at quantifying the nitrogen fixation were carried out during the cruise.

During the first day of the cruise a deep CTD profile was conducted at the Cape Verde Ocean Observatory (CVOO), where also a mooring was deployed .Continuous surface water measurements of pCO_2 was conducted throughout the entire cruise.

Zusammenfassung

Die Reise M97 in den tropischen Ostatlantik war eine Fahrt zu Untersuchungen im Rahmen des DFG Sonderforschungsbereich (SFB) 754 „Climate-biogeochemistry interactions in the tropical ocean". Die Reise war die erste Fahrt um die Verteilung eines im Dezember 2012 in dieser Region im Rahmen des Experiment "Oxygen Supply Tracer Release Experiment (OSTRE)" ausgebrachten Tracers zu kartieren. Die Ergebnisse werden helfen die diapyknischen und lateralen Mischungsraten besser zu quantifizieren und ein besseres Verständnis der Zufuhr von Sauerstoff in die Sauerstoffminimumzonen (OMZ) des tropischen Atlantiks zu erlangen. Um diese Ziele zu erreichen wurde der Tracerinhalt der Wassersäule auf 171 CTD Stationen gemessen, wobei der Focus auf dem Tiefenbereich nahe der Dichte auf der der Tracer ausgebracht wurde (σ_Θ=27.03) lag. Die Messungen wurden auf einem Gitter mit den Begrenzungen bei 8°N und 12°N sowie 23°W und 19°W durchgeführt wobei der Tracer auf 2/3 der Stationen gefunden wurde. Dies ergab die Möglichkeit einer detaillierten Kartierung der vertikalen wie aus der horizontalen Verteilung des Tracers in dem Gebiet. Die Messungen auf den CTD Stationen schlossen Sauerstoffmessungen ein, die Informationen zur zeitlichen Variabilität und dem Inventar der Sauerstoffkonzentration lieferten. Ein Zooplankton Messprogramm hatte zum Ziel die Rolle des Zooplanktons in biogeochemischen Zyklen einzuengen, speziell in Bezug auf ihre Rolle für den Transport von organischem und inorganischem Material von der Meeresoberfläche zur OMZ-Schicht durch tägliche Vertikalwanderungen. Zooplankton wurde mit unterschiedlichen Netzen gefangen sowie mit einem optischen Gerät (Underwater Vision Profiler) auf allen Stationen gemessen. Zusätzliche Experimente zur Quantifizierung der Stickstofffixierung wurden während der Fahrt durchgeführt. Am ersten Tag der Reise wurde ein tiefes CTD an der Zeitserienstation Kapverden Ozeanobservatorium (CVOO) durchgeführt und anschließend eine Verankerung ausgelegt. Entlang der gesamten Fahrtroute wurde kontinuierlich der Partialdruck von CO_2 (pCO_2) bestimmt.

2 Participants

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Zenk, Cordula	mooring	GEOMAR
Torres Vega, Maria	mooring	Develogic
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3 Research Program

The cruise M97 to the Tropical Eastern North Atlantic was a contribution to the DFG Sonderforschungsbereich (SFB) 754, Climate - Biogeochemistry Interactions in the Tropical Ocean. The main goals of this cruise were to:

1) Quantify and better understand the supply of oxygen to the oxygen minimum zone (OMZ) of the Tropical Atlantic with a particular focus on the role of sub-mesoscale processes for lateral and vertical oxygen fluxes and thus a critical aspect of the ventilation of this region.

2) Provide the oxygen distribution of Tropical Eastern North Atlantic OMZ with high temporal and spatial resolution and to identify sub-tropical-tropical circulation pathways that provide oxygen to the eastern tropical oxygen minimum zones; to observe temporal variability in the supply of oxygen to the OMZ, and in the inventory of oxygen in the OMZ.

3) Study the zooplankton-mediated carbon, oxygen and nitrogen flux and heterotrophic responses to low oxygen. Abundance, biomass and diversity of the zooplankton community will be studied in relation to water mass characteristics.

<u>Scientific background</u>

Oxygen minimum zones (OMZ) in the depth range 100 to 900 m in the Atlantic and Pacific oceans cover the eastern tropical boundary regions. The lowest oxygen values are reached at 300-500 m depth and while the oxygen minimum values in the eastern Pacific become suboxic, the OMZ of the eastern Atlantic is better oxygenated with minimum oxygen values slightly less than 40 µmol kg^{-1} in the North Atlantic. The ventilation of the ocean interior is not homogeneous and may occur via more than one pathway. In particular, the ventilation processes of the so called ‘shadow zones’ which host the OMZs and which are shielded from direct subduction pathways have not been fully established. Theory and models on supply routes of oxygen to the OMZ have made great progress over the last decades and observations in the area has increased.

Hydrographic analysis of the eastern tropical North Atlantic reveals that oxygen-rich water supplied by the zonal eastward flowing tropical current bands is one possible oxygen supply route into the North Atlantic OMZ. A second pathway is based on the very steep vertical oxygen gradient in the upper part of the OMZ combined with some amount of diapycnal mixing that supplies about 1/3 of the oxygen to the OMZ, as determined from results from a previous TRE in the area (Banyte et al., 2012, Fischer et al., 2013). A third pathway of oxygen supply is due to horizontal stirring by mesoscale eddies within the Cape Verde frontal zone to the north of the Guinea Dome upwelling regime. Recent work suggests that latitudinal alternating zonal jets in the depth range of the OMZ contribute to the ventilation of the OMZ (Brandt et al., 2010). Large uncertainties in the current generation of ocean circulation models highlights the need for observationally sound measures of time integrated mixing rates and lateral exchanges. Comparisons of different ocean circulation models have shown a large sensitivity of the mean circulation, stratification and water mass properties on the particular choice of subgridscale vertical (often diapycnal) mixing and lateral viscosity. Tracer release experiments have been shown to provide excellent integral measurements from which to directly deduce the time averaged diapycnal diffusion and lateral dispersion rates.

The simulation of biogeochemical cycles in global climate models requires accounting for subgridscale processes, e.g. small-scale turbulence and mesoscale eddies. However, simulated parameters in global simulations are shown to be sensitive to the chosen parameterizations for diapycnal and isopycnal mixing. During recent years, parameterizations for isopycnal mixing in global climate models, on the one hand, were obtained from high-resolution ocean models resolving the mesoscale eddy field. On the other hand, observational estimates of isopycnal diffusivities in the subsurface ocean were obtained by using different techniques, among them are subsurface floats, artificial tracer releases, or detailed observation of hydrography and natural tracers.

Oxygen minimum zones (OMZs) are large volumes of hypoxic or suboxic water in intermediate depths of 200 to about 1000 m in tropic regions. For some metazoan organisms the OMZ is an inhospitable region whereas other organisms constantly live therein or perform diel vertical migrations (DVMs) into and out of this area. DVMs of zooplankton are an important factor in the transfer of organic matter from surface to deeper water layers and thereby in the establishment of OMZs. Food is consumed in upper layers and excreted as faecal pellets as well as respired at deeper layers. Although zooplankton is a major factor of the biological pump, only very scarce data on its abundance, distribution and biomass is available for the Tropical Eastern North Atlantic. The extent of the OMZ in this region increased during the last 50 years and is predicted to increase further (Stramma et al 2008). However, the effects of the OMZ on the whole ecosystem structure are not well understood. Of particular interest is the effect of the OMZ and its development on the zooplankton community, its species composition and biomass. Feedback mechanisms between zooplankton composition and abundance and the strength of the biological pump are to be expected.

Science during M97

During the M97 cruise the main objective was to map out an artificial tracer (CF_3SF_5) that was injected in the area (~11°N, 21°W) in December of 2012 (cruise MSM23). The objectives were particularly aimed at mapping the horizontal dispersion of the tracer. Therefore the cruise covered a grid of stations with in “control volume” see Figure 1. By measuring the decay of tracer within the control volume over time, estimates of isopycnal mixing can be obtained. In all we conducted tracer measurements on 171 CTD station, and found the tracer at 113 of those stations. The horizontal and vertical distribution of the tracer was well mapped out during the cruise. Complementary measurements with a microstructure sonde were carried out to more than 800 meters depth, i.e. deeper than we normally have done in the past in this region.

The choice of tracer to inject into the ocean was dictated by a few requirements that we carefully considered. 1) The tracer has to be harmless to marine life; this is certainly the case for the very inert gas CF_3SF_5. 2) The tracer has to be stable in the marine environment; indeed, CF_3SF_5 is very stable and remains in the water column. 3) There should be low or no background concentration of the tracer; this is also true for CF_3SF_5. Several previous tracer release experiments were performed with SF_6 as a tracer, but on a tracer community meeting in 2006 it was agreed to dis-continue the use of SF_6 in order to preserve the use SF_6 as a transient tracer; the tracer CF_3SF_5 had been tested in the field prior to this discussion, and was found to be an ideal tracer (Ho et al., 2008).

During the cruise we carried out 14 MOCNESS and 18 MultiNet casts in order to study the vertical flux of biogeochemical parameters by zooplankton and nekton. Experiments were carried out in the climate controlled lab to determine fluxes. For positions were net sampling were conducted we also sampled for a range of biogeochemical variables in the water column. In addition, a total of 13 incubation experiments for quantification of nitrogen fixation were carried out during the cruise.

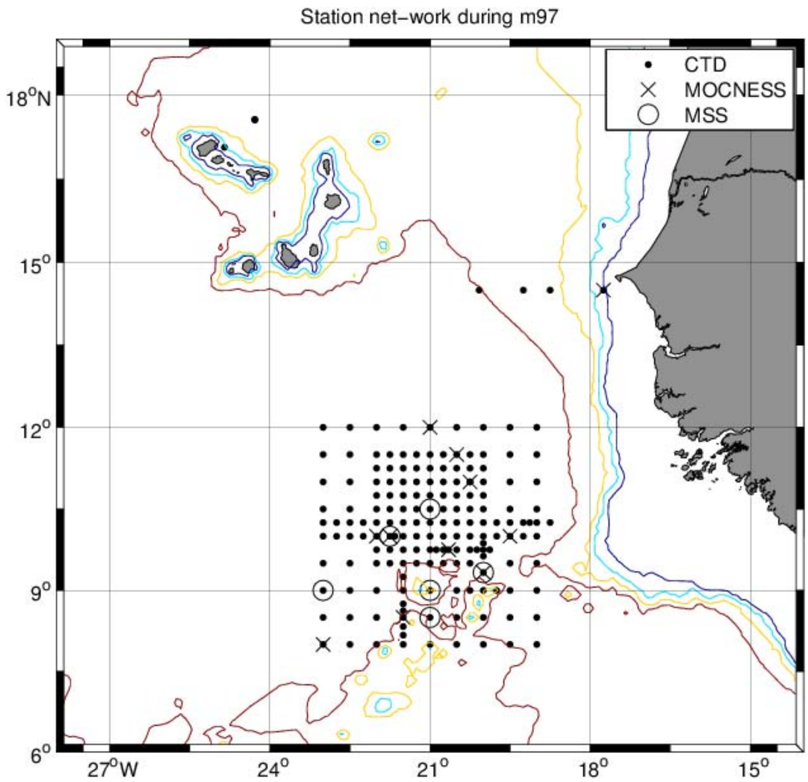


Fig. 3.1 Map of CTD stations (dots), MOCNESS stations (crosses) and microstructure stations (circles) carried out during M97.

All the goal of the METEOR 97 cruise could be realized; 1) we conducted an intense CTD station net in a grid, with additional tracer-CTD stations in areas of high tracer concentrations, 2) we carried out extensive zoo-plankton sampling (MOCNESS and MultiNet) and conducted experiments on-board, 3) we conducted deep MSS profiles in the area, 4) we carried out a large number of incubations for nitrogen-fixation, 5) we deployed a glider, 6) we finalized the section along 14°30' N that was started during M96, 7) We deployed a mooring at the CVOO site, and repaired an existing surface element on another mooring on the CVOO site. We did, however, loose some valuable time by having to go back to Dakar for an observer from Senegal half-way through the cruise. The scientific work on the METEOR could be conducted without any problems that we could not solve.

4 Narrative of the Cruise

The science party arrives to the METEOR in the morning of May 25, 2013; some of the scientists have already been busy during the previous two days with unloading containers and setting up some sensitive experiments. In the afternoon of May 25, a team of 4 persons from ZDF also arrives. The METEOR leaves the dock in Mindelo at 19:00 of May 25. A test CTD is performed at the 2000 meter depth contour shortly after leaving port. METEOR arrives to the Cape Verde Ocean Observatory (CVOO) in the late night and a MultiNet (in the dark) was performed, followed by a deep CTD station where a large range of parameters were sampled. In the early morning of May 26 work to deploy a new mooring begin at 08:00. At noon the mooring is deployed – this time with the weight first due to a sensitive piece of equipment in the top part of the mooring. After a couple of hour communication tests with the mooring, METEOR moves back to the CVOO station for a day-time MultiNet cast. The next action was replacement of the swivel on the "old" mooring about 3 nm northeast of the CVOO station. The surface element with data communication now seems to work. The day at the CVOO station ends with a few additional hours of communication tests with the "new" which also seems to work as it should. As the last action of the METEOR we conduct an additional test-CTD and MSS profiling at the CVOO site.

METEOR docks again in Mindelo at 07:00 on May 27 for exchange of scientific personnel and unloading of a few scientific items. Within 2 hours METEOR depart again for the open ocean.

METEOR steams towards the last station that was carried out along 14°30' during the M96 cruise, where we plan to start with the station-work. However, our permission to carry out science in Senegal was revoked and we changed course towards the area where we expect to find the tracer, i.e. a box with the sides 12°N, 19°W, 8°N, 23°W. We start the search for the tracer on a section along 12°N.Already on the second station (at 21°W) we find the tracer at the roughly the density where we injected it. This is really good news for the tracer group since this is the firs confirmation that the tracer injection at MSM23 was successful. At 21°W we also carried out the first MOCNESS cast together with a MultiNet cast and sampling for initiation of the first N_2 fixation incubations.

During May 30 to June 4 we carry out a CTD stations every 4 hours, roughly. We find the tracer at most, but not all, stations. Particularly high concentrations are found in the western edge of our sample box. We carried out one multiple mulitnet/MOCNESS sampling in the dark and one in during day-time. Sampling for N_2 fixation takes place every second morning before sunrise. On the NE corner of the release position we carried out a deep CTD to the bottom and found low concentration of the tracer on the two deepest depths.

We deployed a glider at 10°30'N, 19°30'W on June 5that will do sections along the coast of Senegal and Mauretania for the AWA project. We continue with tracer CTD work along 19°30' W and 19°00' W. In the morning of June 7 we steam back to a position in the vicinity of where the glider was deployed; it was too heavily ballasted and could not reach the surface in the low salinity warm water (i.e. low density). The glider had dropped its "emergency weight" and was drifting on the surface. The glider could be recovered just after breakfast. We then steam towards Dakar in order to pick an observer from Senegal that we need to complete work within the EEZ of Senegal. During the transit, the CTD group mounts the uCTD on starboard side aft.

We arrive to Dakar in the morning of June 8 and wait on the roads for our observer to arrive. After about an hour, the observer arrives with a several persons from various authorities in Dakar. We can soon leave Dakar and start with the science again. The underway instruments (TSG, ADCP, pCO2) are turned on at the 12nm border of Senegal, and we make the first underway CTD cast. Since none of those on-board have any experience with this instrument, it is somewhat nervous, particularly since it is only 260 meters depth so that we have to be careful not to set the sonde in the sand. We then conduct a MOCNESS cast starting at the 1000 m isobaths. The cast reveals similar species composition as over the Namibian shelf, but different compared to above the OMZ. Genetic analytic will show if it is really the same species, or just the same morphology. We continue with uCTD and deep CTD casts along 14°30'N and by evening on the 9th we have completed the section that was started during M96 on the other side of the Atlantic, but could not be completed during M96 due to logistical reasons.

We resume work in the tracer box in the late morning of the 10th, this time doing the stations in EEZ of Senegal that we could not do before. On June 12 we conduct one more night/day station, i.e. we conduct multiple MultiNet and MOCNESS sampling on the same position; once during daylight hours, and one during night-time. In the afternoon of the 13th we deploy the glider again. This time it is ballasted somewhat lighter. The position is 10°00'N, 20°'00'W and it all seems to work fine this time around. During the night of the 14th we extend a section along 10°15' towards the east to find the end of the tracer patch along this latitude. A new decision scheme was developed that allowed for fast decision from the tracer lab once the results of the first tracer measurements were known; if more than 100 fM tracer found – stop for one extra station in between the regular stations. Along the 9°45'N section we do find a few stations that qualified, so we stopped and made extra stations. On one station with particularly high concentrations we even made a complete survey 7.5 nm from the original station in all four directions.

We continued with the fine resolved grid for tracer CTDs. In the evening of the 17th we made a rendezvous with the glider; it still had a rubber cap on the oxygen sensor. We continue to perform tracer stations and one MOCNESS migration study in the evening of the 19th. The Meteor is during this time moving in the ITCZ with weak winds and an occasional squall in the afternoon. During this time we do a few microstructure stations as well; multiple technical issues have prevented most of this work before during the cruise. By doing casts to deeper than 800 m we are on the technical limit of the current equipment.

Meteor is south of the ITCZ by June 21 and had to steam against the south east trade wind, and current, to reach the southeastern most position at 8°N 19°W. We finalized the 8°00'N section with some extra stations along 21°30'W. Last CTD is conducted in the morning of the 23rd, CTD#184. On this position we also conduct a MOCNESS/MultiNet day/night station, with a final MSS cast.

June 23 to 28 is steaming time towards Fortaleza in Brazil. Already on the 24th we turn off the underway measurements as we are entering Brazilian EEZ where we do not have permission to conduct scientific work. Since Fortaleza is south of the equator, we make sure that no participants are carrying the "northern hemisphere bug" to the southern hemisphere. We have enough time to pack instruments and equipment in the containers during the transit. In the morning of the 28th, the METEOR arrives to the port of Fortaleza.

5 Preliminary Results

In the following a detailed account of the types of observations, the methods and instrument used as well as some of the early results are given.

5.1 CTD/Rosette and Hydrographic Samples

(L. Stramma, R. Link)

During M97 a total of 184 CTD-profiles were conducted. At the beginning a test station was made shortly after leaving Mindelo reaching deep water and then the Cape Verde Ocean Observatory (CVOO) site was sampled at roughly 17° 36' N, 24° and 18' W, see station table. At the CVOO a CTD cast to the bottom and a second cast with a realer test to 700 m were carried out. The stations in the tracer survey region stating with CTD number 4 were mostly carried out to 700 m and 1200 m depth. On some stations samples were taken for biological sampling in addition to the tracer sampling. On these stations also larger volume of water was needed for N_2-fixation measurements so that a shallow 100 m CTD cast was sampled in addition to the 1200 m deep biological CTD profile. On 8 June the 14°30'N section across the Atlantic was completed with 5 deep CTD-stations (CTD's 77-79, 81-82) within the EEZ of Senegal. This section was sampled during the previous cruise, M96, from the western border, except for the Senegal 200 miles zone.

Additional to the normal setup of the CTD system an underwater vision profiler (UVP) and a new constructed Integrating Water Sampler (IWS) were attached to the CTD system (Table 5.1). Data acquisition was done using Seabird Seasave software version 7.22.1. The CTD was mounted on the GO1 rosette frame with a 24 bottle rosette sampling system with 10 L bottles. In varying configurations 21 to 23 bottles were attached to the rosette. On most profiles a configuration with 23 bottles was used, with the IWS on the free bottle space 24. For the 5 deep CTD station on the 14.5°N section a lowered ADCP was attached to the CTD system and only 21 bottles could be used on the rosette.

Most of the time the CTD system was working fine without problems and without showing any significant spikes in the results. On the first CTD-profile the data flow stopped during up-cast due to a broken fuse. CTD-profile 78 returned without any of the bottles closed. Inspection showed that the releaser carousel was flooded and a new releaser carousel was built in, which then worked reliable. The winch worked well most of the time, only in the last week of measurements on some stations stops had to be made during the up-cast due to wire problems. Unfortunately some of these stops had been at depth were the integrated water sampler was running. This device has to run continuously with constant speed of the wire for reliable results, hence the water collected by the integrated water sampler could not be used for those stations.

The GEOMAR Guildline Autosal salinometer #7 was used for CTD conductivity cell calibration (operated by L. Stramma). The Guildline Autosal salinometer #4 was available as backup, but had not been used for measurements. Calibration during operation was done in two ways: IAPSO Standard Seawater (P154, K15=0.99990) was measured at the beginning of the salinometer use. In addition, a so called “substandard” (essentially a large volume of water with constant but unknown salinity), obtained from deep bottles from the CTD profile 3 was used to track the stability of the system. The substandard showed in the mean an increase 2 to 4 ten-thousandths in salinity during the measurements. However the substandard itself increase by about 1 to 2 thousandths in salinity between measurement days, hence the slight increase during measurements might be related to the general increase of the substandard and was not corrected as being small and in the range of measurement accuracy.

Device	**Model number**	**Serial number**
CTD deck unit	SBE 11 plus	SN 11P34783-0674
CTD underwater unit	SBE 9 plus (**SBE03**)	SN 09P25213-0615
Pressure Sensor	Digiquarz	SN 75760
Pump, primary	SBE 5T	SN 4503
Pump, second	SBE 5T	SN 3021
Temperature, primary	SBE 3	SN 5020
Temperature, second	SBE 3	SN 4823
Conductivity, primary	SBE 4	SN 2452
Conductivity, second	SBE 4	SN 3381
Oxygen, primary	SBE 43	SN 0215
Oxygen, second	SBE 43	SN 1739
Fluorescence	Dr. Haardt	SN 1739
Altimeter	Benthos/Teledyne	SN 41840
UVP		
IWS		

Table 5.1: Sensors used for the CTD SBE 03.

A preliminary conductivity calibration of the downcast data was performed using a linear fit with respect to conductivity, temperature, and pressure. For the 184 profiles the calibration was: C_corrected = C_observed -0.0023468-4.6642e-08*P-9.965e-05*T+0.00082885*C). Using 67% of the 256 samples for calibration a r.m.s. of 0.00009 S/m, corresponding to a salinity of 0.0020 PSU, was found for the downcast. The CTD oxygen sensor calibration was performed similarly to the conductivity calibration. The resulting calibration correction for the secondary oxygen sensor for profiles 1 to 184 was: o_corrected = o_observed (μmol/kg) +0.96976+0.0023733*P-0.025645*T+0.041973*O. Using 67% of the 978 samples for calibration a r.m.s. of 0.68 μmol kg^{-1} were determined as uncertainty of the calibration.

We chose the downcast as final dataset as: 1) Sensor hysteresis starts from a well-defined point, and 2) the incoming flow is not perturbed by turbulence generated by the CTD-rosette. The final calibration will be carried out at GEOMAR after the cruise.

5.1.1 Preliminary Hydrographic Results

(L. Stramma, T. Fischer)

An important task during the CTD measurements was to determine the pressure of the target density σ_θ=27.03 kg m^{-3}, at which the tracer was released in December 2012. According to the target density determined during the downcast of the CTD, 11 to 13 bottles were fired in 10 dbar steps around the target density for tracer sampling. The Figure 5.1 (left panel) shows the pressure distribution of the isopycnal σ_θ=27.03 kg m^{-3} in June 2013. The shallowest target pressure values are located at 11°30'N west of 20°W just north of the tracer release site (10°30'N to 10°46'N and 20°45'W to 21°W). The region south of the Cape Verde Islands is the location of the cyclonic Guinea Dome and the shallowest pressure at the isopycnals at 11°30'N indicates that the center of the Guinea Dome is located here.

The oxygen distribution on isopycnal σ_θ=27.03 kg m^{-3} (Figure 5.1 right panel) shows the lowest oxygen values below 40 µmol kg^{-1} near the core of the tracer release site. Record low oxygen concentrations below 40 µmol kg^{-1} were described for this region the first time from observations in fall 2008 (Stramma et al. 2009) related to a deoxygenation of the last years. The tracer was intended to be injected in the core of the low oxygen layer and a map with the lowest oxygen values shows a similar distribution as on the tracer target density, hence the tracer was injected in the core of the low oxygen layer.

The salinity distribution on the section along 19°W (Figure 5.2 left panel) shows the northward progression of the low saline Antarctic Intermediate Water (AAIW) at depth layers below 600 m depth. South of 9°30'N low salinity water is located in the upper 20 m of the ocean. This is fresher water from the tropical Atlantic with reduced salinity from precipitation in the Intertropical Convergence Zone (ITCZ). The isopycnals included in the salinity distribution show an uplift near 9°N between 200 dbar and 500 dbar related to lower salinity, reaching higher up then in the neighboring regions. The uplift of isopycnals indicates cyclonic circulation, however the sea surface hight anomaly (SSHA) satellite data for early June 2013 showed a positive SSHA in this region indicating anticyclonic flow. However, near the surface the isopycnals show a downward excursion, hence the anticyclonic feature seems to be limited to the near surface layer.

The ADCP section along 19°W confirms the reversing flow direction (see chapter on ADCP measurements). The zonal velocity component in the mean surface layer south of ~9.5°N shows eastward flow as expected from the SSHA and westward flow north of ~9.5°N in accordance with the SSHA. Only south of 9°N a small layer of about 20-30 m thickness shows westward flow caused by the fresh water lens seen in the salinity distribution, while the strong eastward flow at 30 – 300 m dominates and is responsible for the positive SSHA. Below 200 m the eastward flow south of 9°N and the westward flow between 9°N and 9°30'N is the cyclonic circulation expected from the density field. Hence the SSHA signal is related to the flow field in the upper ocean layer, while the strong cyclonic feature below the surface layer is not reflected in the SSHA field.

The oxygen distribution on the 19°W section (Figure 5.2 right panel) similar to the salinity section shows the uplift of water and subsurface isopycnals at 9°N in the meridional oxygen distribution as low oxygen water rises up. Between 9°N and 10°N the core of the oxygen minimum layer is visible just below 400 dbar with a layer of dissolved oxygen of less than 40 μmol kg^{-1}.

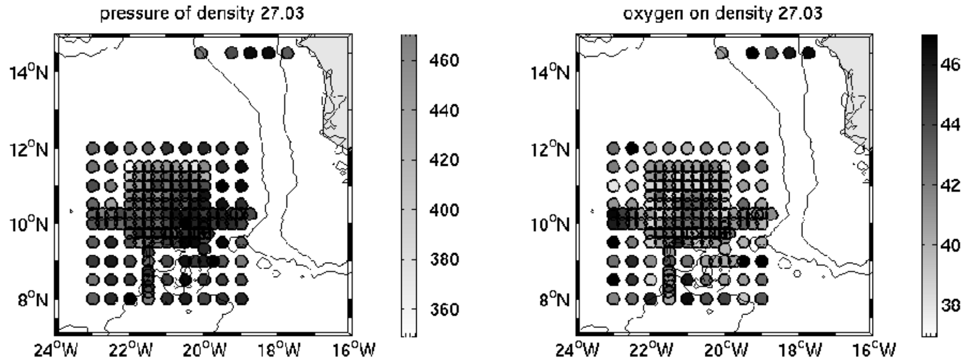


Figure 5.1: Pressure in dbar of the tracer target density of σ_θ=27.03 kg/m^3 (left panel) and oxygen in μmol/kg on the same density layer (right panel).

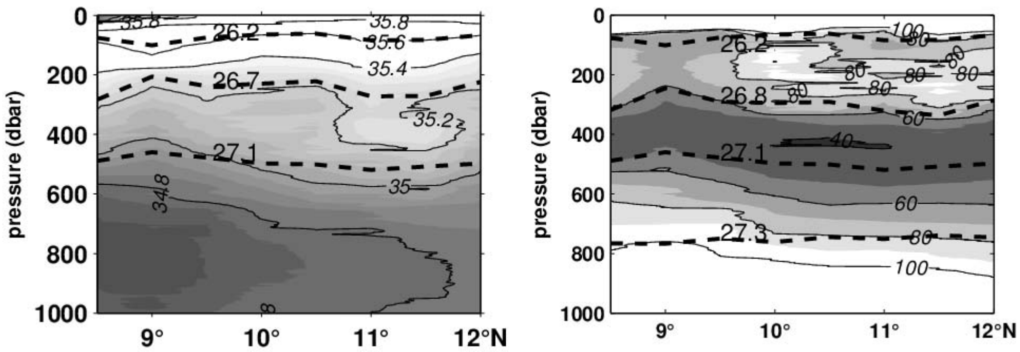


Fig. 5.2 Salinity (left panel) and oxygen in μmol kg^{-1} (right panel) from CTD measurements along 19°W on June 6 and 7, 2013 between 8°30’N and 12°N. Some selected isopycnals are shown as dashed black lines.

5.1.2 Underway CTD

(F. Schütte)

From the 8^{th} to the 10^{th} of June 2013 an underway-CTD (uCTD) system was operated on the METEOR. During these two days 22 profiles were collected on latitude 14° 30’N between the coast of Senegal and approximately 19° 30’W. The data complete an Atlantic basin wide section that was initiated during M96 and the part within the EEZ of Senegal was finalized during M97. The uCTD measurements will be used to investigate the mixed layer in the upper part of the water column. The measurements were performed from the starboard stern while METEOR was moving at speed of about 9kn. During the 22 profiles the casts reach an averaged depth of 400m (maximum depth was 476m). In order to have a fairly constant horizontal resolution (~ 4.5nm) a profile was performed every 30 minutes.

Probe #68 was used for all 22 profiles; this probe was equipped with temperature, conductivity and pressure sensors from SeaBird, and records data with a frequency of 16 Hz.

In the tropical sun on deck the probe is heating up very fast. To avoid erroneous measurements in the first meters of the profile the probe was cooled down with freshwater before each cast. The first two profiles on the shelf of Senegal were spooled with the maximal water depth on the tail of the uCTD; the other 20 profiles were spooled with 550m line on the tail. The duration of recording during the dive (cast) was 200 seconds, which led to 3800 recordings per cast at an averaged vertical resolution of ~ 0.2 db.

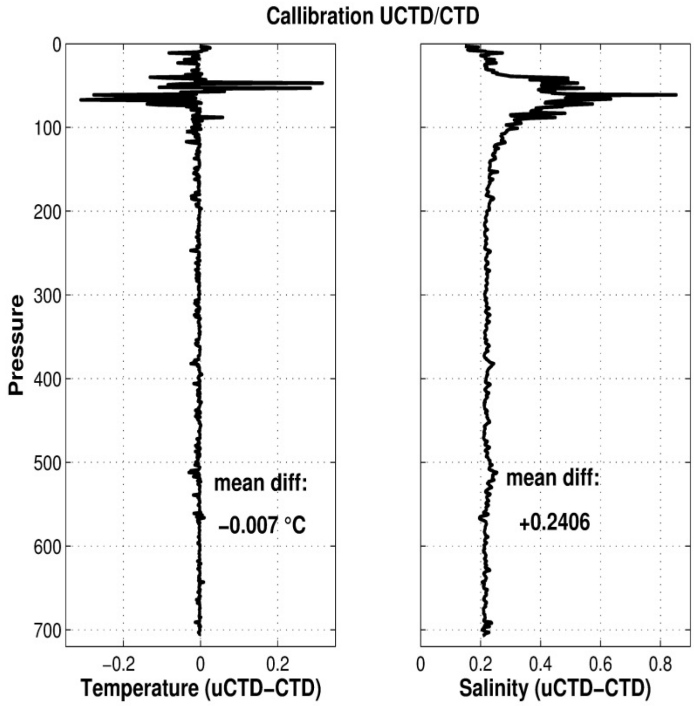


Fig. 5.3 Difference between temperature and salinity measurements for uCTD and SBE911CTD vs. depth.

Two winches were available, one used several times in the past (W1) and a nearly new one (W2). From cruise M96 it was known that W1 has some problems with its bearings; therefore we used W2. However, after 15 profiles technical problems with W2 appeared as well. It was harder to freely spool out the line during the cast from profile to profile; multiple cleaning with fresh water doesn't decrease the problems. After 22 profiles we interrupted the measurements because it was no longer possible to reach depths beyond 200m. An initial diagnose showed that W2 also had problems with its bearings. A preliminary calibration was applied by mounting the probe on a 700m SBE911 CTD cast (CTD number 167). The comparison resulted in a temperature offset of -0.007°C and a salinity offset of +0.24 in comparison to the SBE911 CTD, Figure 5.3. A preliminary temperature section along 14°30'N as recorded from the uCTD is shown in Figure 5.4.

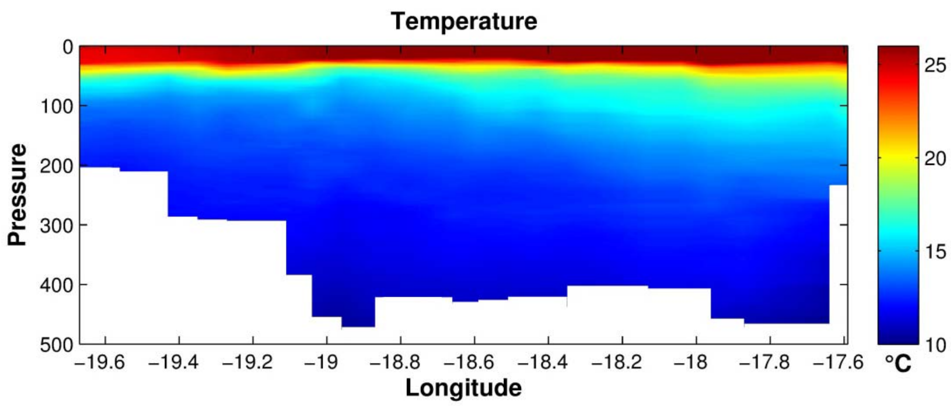


Fig. 5.4 Temperature section along 14°30'N from the uCTD.

5.2 Current Measurements

(T. Fischer)

Two vessel mounted Acoustic Doppler Current Profilers (ADCP) continuously recorded vertical profiles of current velocities: a 75kHz RDI Ocean Surveyor (OS75) mounted in the ship's hull, and a 38kHz RDI Ocean Surveyor (OS38) placed in the moon pool. The OS38 was aligned to zero degrees in order to reduce interference with the OS75 that is aligned to a fix 45 degrees. Each of the two instruments was run in the more precise but less robust broadband mode. The two configurations were: OS75) 100 bins of 8m, pinging at 35 per minute, range 550m; OS38) 80 bins of 16m, pinging at 25 per minute, range 1000m. During the entire cruise the SEAPATH navigation data was of high quality. Acoustic interference from other shipboard acoustic devices was avoided by switching these off whenever possible, particularly the Doppler Log and the multibeam echosounder. One exception was the 12kHz echosounder EM122 which continuously delivered high quality bathymetry without detectable interference. A remaining strong source of noise which affected or even destroyed the OS75 data was the bow thruster during stations.

Additionally, lowered-ADCP (lADCP) profiles were performed during the CTDs to the bottom on the 14°30' N section off Senegal. The CTD-System was equipped with a lADCP setup based on two 300kHz RDI Workhorse ADCPs (uplooking ADCP #11461, downlooking ADCP #6468, battery pack #003). The lADCP data was collected during 5 CTDs (CTD077 to 080 and 082) on June 8 and 9 to depths of 1650, 2600, 3200, 3600, and 4000m, respectively. Processing will be performed after the cruise.

A section showing the velocity structure in the upper 600 meters of the water column along 19°W is shown in Figure 5.5; where a mode eddy can be detected. Similarly, enhanced internal wave activity is evident in a section along 9°N in the vicinity of the Sierra Leone Seamount Range, Figure 5.6.

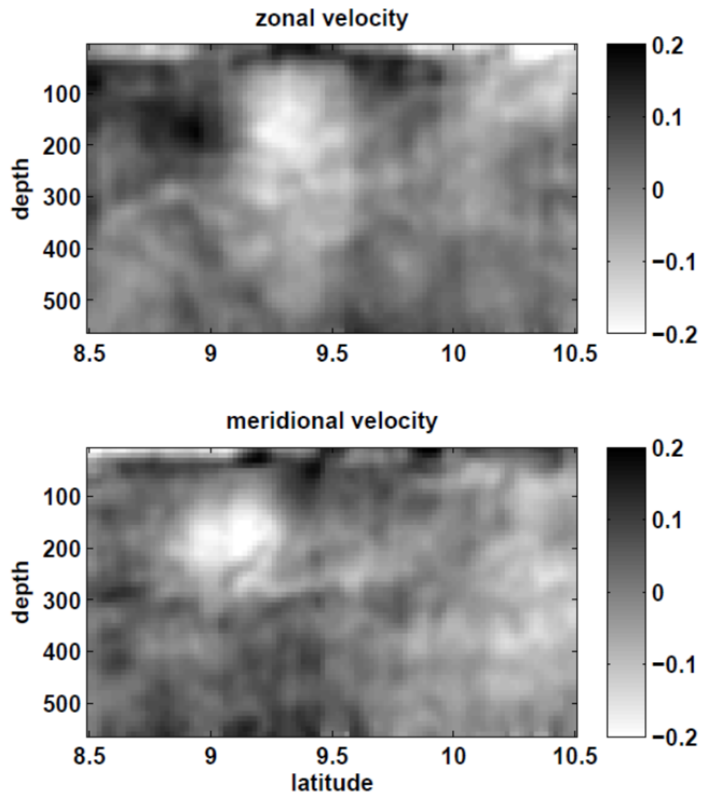


Fig. 5.5 Section along 19°W, showing a velocity structure that seems to be a cyclonic eddy in 100m to 200m depth and an anticyclonic eddy in the uppermost 50m.

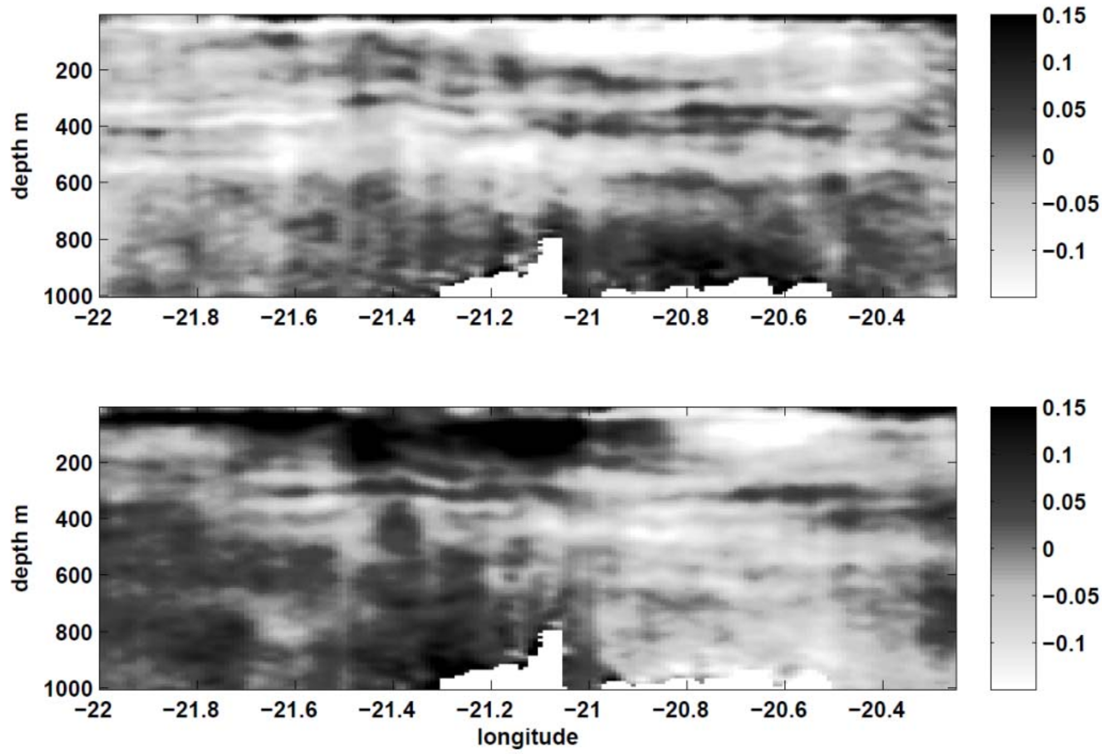


Fig. 5.6 Velocity section along 9°N, data from 38kHz and 75kHz ADCP merged. Enhanced internal wave activity is apparent in the vicinity of Sierra Leone seamount range.

5.3 Shipboard Microstructure Measurements
(T. Fischer)

A MSS90-D microstructure profiler (#032) of Sea and Sun Technology was used to infer turbulent dissipation rate and diapycnal diffusivity, particularly aiming at quantifying the diapycnal flux of oxygen below and above the core of the OMZ. The loosely tethered profiler was equipped with 3 airfoil shear sensors and a fast thermistor, as well as with pressure, conductivity, temperature and turbidity sensors. Profiler sink velocity was adjusted to 0.5 m/s. In total, 21 profiles to maximum 900m depth were recorded at 8 ship stations, generally 3 microstructure profiles following a CTD cast.

In the beginning of the cruise, problems with the data transfer from the microstructure probe to the deck unit had to be overcome. These problems seem to be a combination of a long cable length needed for the deep profiles, drifts in the electronics, and poor shielding of the cable, microstructure probe and deck unit against electromagnetic noise radiated from the ship. The working setup consisted of 1100m cable and deck unit #36 equipped with reduced termination resistor (from 112 Ohms to 56 Ohms). In the upper 100 meters of the profiles, some data transfer errors occurred nonetheless, but did not generally degrade the data quality. Particularly near the Sierra Leone Rise seamount ridge we observed intensified turbulence (one example profile in figure 3), presumably caused by internal tides.

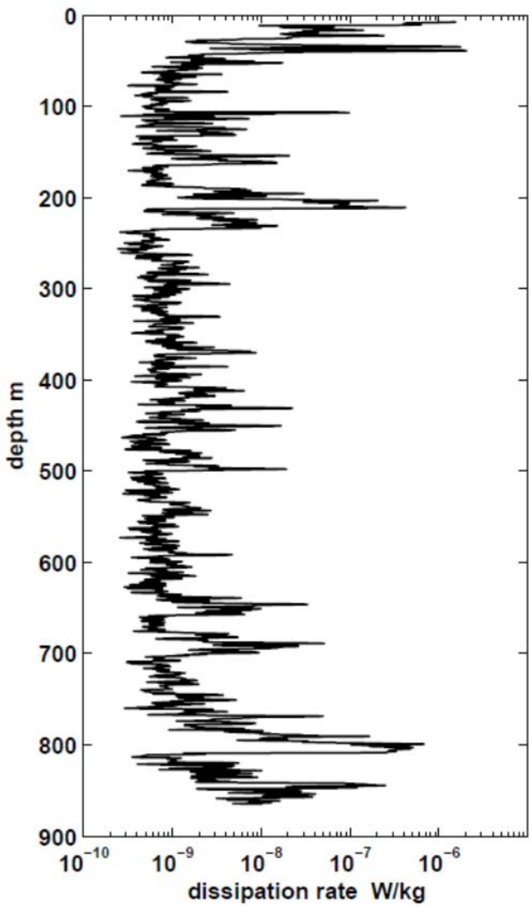


Fig. 5.7 Profile of turbulent dissipation rate from the vicinity of Sierra Leone Rise seamount range (9°N 21°W). Enhanced mixing activity is apparent through the entire depth range captured.

5.3 Underway Measurements (TSG)
(J. Maas)

Underway temperature and salinity measurements were made with a SEABIRD Thermosalinograph SBE21 (see METEOR Handbuch) installed in the ship's port well about 5 m below sea surface. For calibration purposes we took salinity samples during the first days of the cruise. Furthermore, the Thermosalinograph (TSG) data were compared to conductivity-temperature-depth (CTD) profiles at stations.

During M97 (May 27 to June 27), CTD measurements were performed in tropical regions, thus an elevated range of sea surface temperature (SST) ranging from 23.78 °C off the Cape Verde coast to 29.45 °C in equatorial regions and typical sea surface salinity (SSS) characteristics ranging from 34.34 to 36.31 were encountered (Figure 5.8). Clearly visible is the decline of SSS at 8°N - 9 °N from 18th June onwards due to fresh water input of increased precipitation in the Intertropical Convergence Zone (ITCZ).

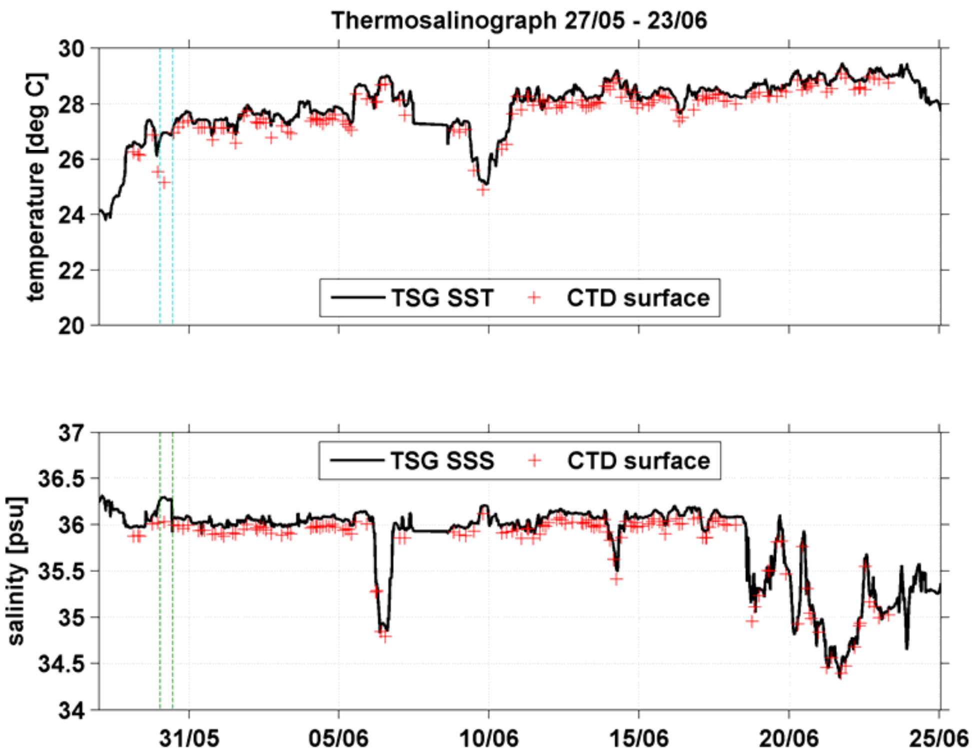


Fig. 5.8 Sea Surface Temperature (top) and Sea Surface Salinity (bottom). SSTs and SSSs from the ships Thermosalinograph (TSG) were compared to surface measurements of the CTD preliminary profiles (average of the upper 4 db). TSG-measurements are denoted by solid lines, CTD-measurements by red crosses. Vertical dashed lines indicate times of erroneous TSG measurements on 30/05/13 between 1 am to 11 am excluded from calibration.

Generally good agreement was found between the CTD reference measurements and the TSG data shown in Figure 5.8. Solid lines indicate measurements from the ship's Themosalinograph, red crosses denote preliminary-calibrated CTD-data that was averaged over the upper 4 db of the profiles. Therefore the variance from the mean offset from TSG-data to CTD-data is small; 0.0191 for SST variance and 0.0011 for SSS variance (Table 5.1). Comparison of these two quantities shows that TSG-salinity is on average higher relative to CTD-measurements by 0.094871±0.0326. TSG-temperature also tends to be higher than CTD-surface temperatures by 0.31467±0.1383 °C (Fig. 5.9). Note that on 30/05/13 from 1 am to 11 am the TSG measurements didn't work properly (see note in the DSHIP-Data) and thus are not considered in the calculations for the calibration coefficients.

Table 5.2: Offsets and variance of the difference between TSG and CTD surface temperature and salinity.

	SST	SSS
Mean Offset	0.31467	0.094871
Variance	0.019124	0.0010642

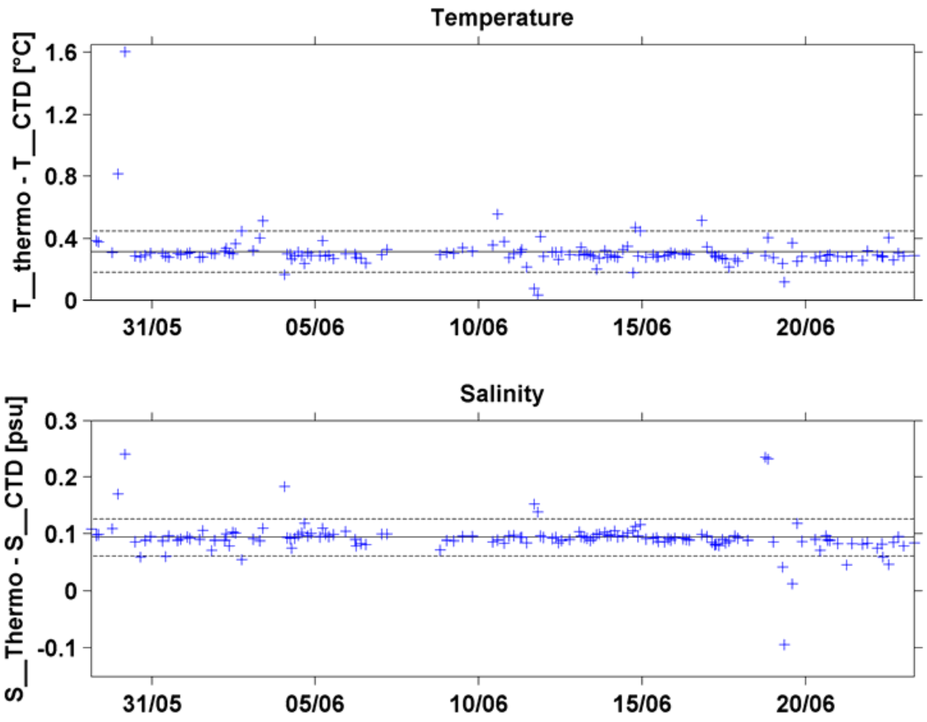


Fig. 5.9 Difference between thermosalinograph and CTD measurements; the solid line shows the average difference and the dashed line the standard deviation.

5.5 Underway Measurements of Trace Gases

(R. Brünjes. Not on-board: B. Fiedler, T. Steinhoff and A. Körtzinger).

Underway measurements of surface water pCO_2 were performed using a commercially available GO-pCO_2 measuring system (General Oceanics, Miami, FL). The instrument is described in detail in Pierrot (2009). Underway measurements of surface water oxygen (O_2), total gas pressure (GTD) and salinity were also carried out in a flow-through box. The following instruments were implemented: Aanderaa Oxygen Optode, Pro Oceanus Gas tension device and an Aanderaa Conductivity Sensor.

A submersible pump and a temperature sensor (SBE38, Seabird, USA) were installed in the ship's moonpool. The pump supplied a continuous flow of surface water to the underway instruments (GO-System, through-flow box and bypass). A calibration of the IR-sensor was performed approximately every three hours by using two different standard gases containing ambient air with different partial pressures of CO_2 (347.9 and 450.2 ppm). The standard gases were calibrated against NOAA primary standards. After every control measurement, atmospheric pCO_2 was measured for several minutes. Air was pumped through a piping from the top of the ship. All temperature sensors were calibrated against international standards.

In addition discrete samples for dissolved inorganic carbon (DIC) and total alkalinity (TA) were taken from the bypass and subsequently poisoned with $HgCl_2$ following the recommendations of Dickson et al. (2007). The discrete samples will be analyzed in the laboratory at the GEOMAR in Kiel.

Due to leakage problems at the pCO_2 system, the CO_2 data before June 16 need to be carefully re-checked post-cruise and therefore they are not shown here. All shown data are preliminary and un-calibrated. Figure 5.10 shows underway data of pCO_2, SST and O_2. The SST shows the expected pattern with warmer water at the south around 29°C and colder water in the northern part of the cruise track. Increased temperatures were observed near the West African coast close to Cape Blanc. Also shown in Figure 5.10 is the oxygen anomaly (i.e. O_2(measured) – O_2(solubility)). The O_2 data are slightly supersaturated during most parts of the cruise track; in the south small spots with stronger super-saturation are observed. CO_2 generally shows super-saturation due to the warm temperatures, but along 9°N also under-saturation (with respect to the atmosphere) was observed.

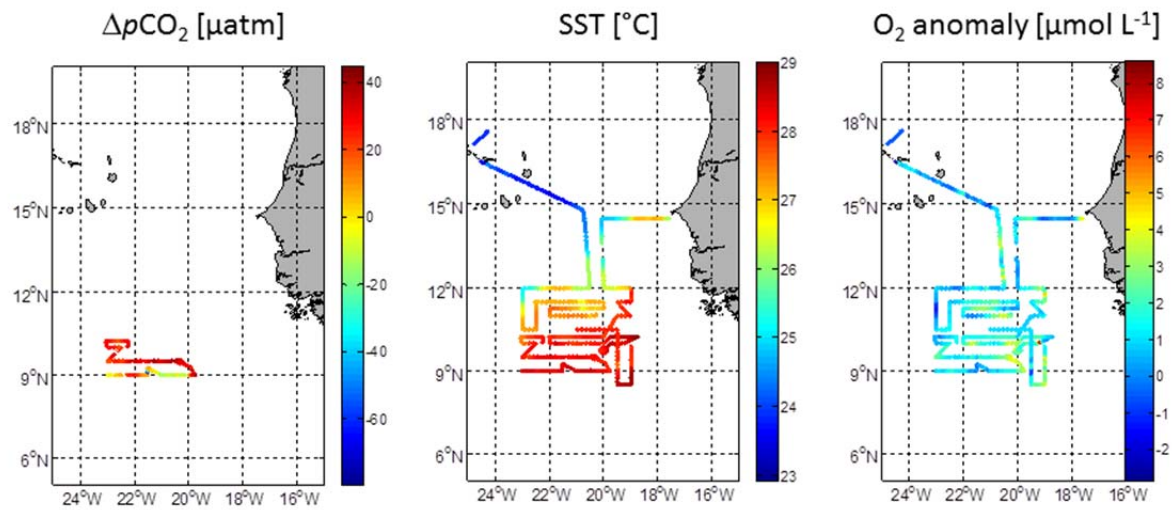


Fig. 5.10 Preliminary underway data of ΔpCO_2 (seawater pCO_2 – atmospheric pCO_2), SST and Oxygen anomaly (O_2 measured – O_2 solubility).

5.6 Determination of Dissolved Oxygen
(M. Lohmann)

Samples for oxygen determination were taken at distinct depths from 65 tracer-CTDs and from 7 bio-CTDs (all together 1020 samples) for calibration of the oxygen sensor of the CTD. The concentration values were reported in µmol kg^{-1}. Oxygen was measured following the Winkler titration method. Samples for dissolved oxygen were taken immediately after the tracers.

<u>Titration</u>

The reagents used during the cruise were:

Manganous chloride (600 g/l)
Sodium iodide (600 g/l) / sodium hydroxie (320 g/l)
Sulfuric acid (50%)
Thiosulfate (0.02 mol/l)
Zink iodate starch solution (Merck)
Standard solutions: potassium hydrogen diiodate (0,325 g/l, homemade) and
potassium iodate (CSK Standard Solution, 0.01N, provided by Wako (Japan))

Titrations were done within the sampling calibrated flasks using a Piston Burette TITRONIC universal from Schott instruments. Dosing accuracy reported by the company is 0.15%, referred to the nominal volume, indicated as a measurement uncertainty with a confidence level of 95%. The NaI/NaOH and $MnCl_2$ solutions were dispensed with a high precision bottle-top dispenser 0.4-2.0 ml (Ceramus classic, Hirschmann). The iodate standard was dispensed with a Piston Burette TITRONIC universal from Schott instruments. The precision of the measurements (1σ) of the oxygen concentration determined from the titration is 0.3 µmol L^{-1} based on 147 replicate measurements. The standard solution for the titration was found to be accurate to better than 0.02 µmol L^{-1} based on comparison of the homemade standard with the independent reference materials from WAKO inc. (USA).

<u>Reagent blank and standardization of thiosulfate</u>

The titration procedure for each measurement is the following:

1) Start up and rinsing the system to withdraw any bubbles in the dosing tubes
2) 5 times thiosulfate standardizations
3) Real samples
4) The reagent blank was measured at the beginning, mid and end of the cruise.

<u>Note</u>: On the first sampling stations a small air bubble appeared in a few samples after storing them for about one hour, most probably due to temperature differences. This problem could be solved by sealing the bottle necks of the warmer surface samples with MilliQ water.

5.7 Glider

(F. Schütte)

During M97 one autonomous glider system (ifm05) manufactured by Teledyne Webb Research was deployed. The glider was part of the project “Ecosystem **A**pproach to the management of fisheries and the marine environment in **W**est **A**frican waters” (AWA) to investigate the water mass distribution due to mesoscale variability in the upwelling region off Mauretania and Senegal. It is planned that the glider system ifm05 should be in the water for more than two months after its deployment in mid-June from the METEOR, and is expected to be recovered near the Cape Verde Islands.

The glider was equipped a set of build-in sensors; a CTD, an Aanderaa optode to measure dissolved oxygen and a Wetlabs combined CHL-a fluorescence and turbidity sensor. The glider was equipped with enough battery power to operate for about three months. On 05/06/2013 the glider system ifm05 was deployed on 10° 30’N and 19° 30’W at 14:00 UTC. After several test dives in the area, there was a problem with its ballasting of the glider; the glider was too heavy for the ambient water density and had problems surfacing correctly. One day after the deployment it was not able to surface and aborted the dive with help of a controlled release of its security weight. The glider was recovered on 07/06/2013 at 8:40 UTC on position 10° 23’W and 19° 37’W. Back on deck of the RV Meteor a new security weight was installed and 130 grams of led were removed from the glider. It was deployed again on 13/06/2013 at 17 UTC on position 10° 00’N 20° 00’W. In the following days some problems with its pressure sensor and with the oxygen measurements were discovered. Luckily the cruise track of the RV Meteor lay close to the actual glider position at 9°33’N 20°17’W, and on 17/06/2013 at 18:50 UTC we were able to have a rendezvous with at the glider after 4 days in the water. We checked if the wings were installed correctly, checked the optode and recalibrated the pressure sensor, and we removed some bio-fouling that had developed. After this service the glider delivered good data. All deployment, service and recovery operations were done with inflatable boats.

5.8 Measurements of CFC-12 and CF_3SF_5

(B. Bogner, M. Köllner, T. Tanhua)

During the cruise, two GAS CHROMATOGRAPH / PURGE-AND-TRAP (GC/PT) systems were used for the measurements of the transient tracers CFC-12 and the deliberatly released tracer CF_3SF_5. The systems are modified versions of the set-up normally used for the analysis of CFCs (Bullister and Weiss, 1988). The first 18 stations the instrument “PT3” was used for measuring SF_5 and CFC-12, later both instruments were used. At the CVOO – Station one profile was flame-sealed in ~350ml ampoules for measurement onshore at GEOMAR.

The traps for both systems were 100 cm of 1/16” tubing packed with 70cm Heysep D. PT3 was setup with a 1/8” main column packed with 180cm Heysep D and a 50cm Molsieve 5A tailend; PT3s column temperature was at 90°C. PT4 used a 1/8” packed main column consisting of 180 cm Carbograph 1AC (60-80 mesh) and a 50 cm Molsieve 5A tailend; operated at 60°C. For both systems, the pre-column was packed with 50 cm Porasil C and

50cm Molsieve 5A in a 1/8" stainless steel column. The tracers were trapped at -60 to -68°C and desorbed at 130°C. Detection was performed on an Electron Capture Detector (ECD). This set-up allowed efficient analysis of CF_3SF_5 and CFC-12 on both systems (CFC-12 elutes slightly after, but well separated from CF_3SF_5).

Normal samples were collected in 250 ml ground glass syringes from the Niskin bottles. For most stations an integrated sample was used additionally. This device collected water in two 250ml syringes in situ within a range of 100 – 120m around the target density. The syringe was controlled by a motor that drew samples at a fixed speed; set-point was 200 seconds of sampling time and the winch operated at 0.5 to 0.6 m/s. This device did not work on all stations, mostly due to uneven load on the syringes. For most samples, an aliquot of about 20 ml was injected into the analytical systems. For PT4, a second purge tower was used alternatively for the integrated samples, and an aliquot of about 200 ml was injected into the system through a selection valve.

Standardization was performed by injecting small volumes of gaseous standard containing CF_3SF_5 and CFC-12. This working standard was prepared by the company Dueste-Steiniger (Germany). The CFC-12 concentration in the standard has been calibrated vs. a reference standard obtained from R.F Weiss group at SIO, and the CFC-12 data are reported on the SIO98 scale. Another calibration of the working standard will take place in the lab after the cruise. Calibration curves were measured every few days to characterize the non-linearity of the system, depending on work load and system performance. Point calibrations were always performed between stations to determine the short term drift in the detector. Replicate measurements were only taken on a few stations due to high work load. The determined values for precision and accuracy are listed in Table 5.3.

Compound	**System PT3 precision**	**System PT4 precision**	**Intersystem precision**
CF_3SF_5	2.43 %	1.11 %	5.36 %
CFC-12	0.98 %	0.59 %	4.11 %

Table 5.3: Preliminary precision of tracer measurements determined from replicate measurements. A final calibration will likely reduce the intersystem variation.

	System PT3	**System PT4**
Total measurements	2005	1733
Measured samples	1347	1065
Standard curves	6	7
Point calibrations	366	315
CF_3SF_5 double measurements	52	31
All double measurements	130	65

Table 5.4: Number of tracer and standard measurements for both systems. Total measurements including test runs, measured samples including "integrated samples", all double measurements including measurements from the surface layer with no CF_3SF5.

On a total of 168 stations discrete samples were taken and on 88 stations integrated samples were taken in addition. More details about the number of measurements are listed in Table 5.4.

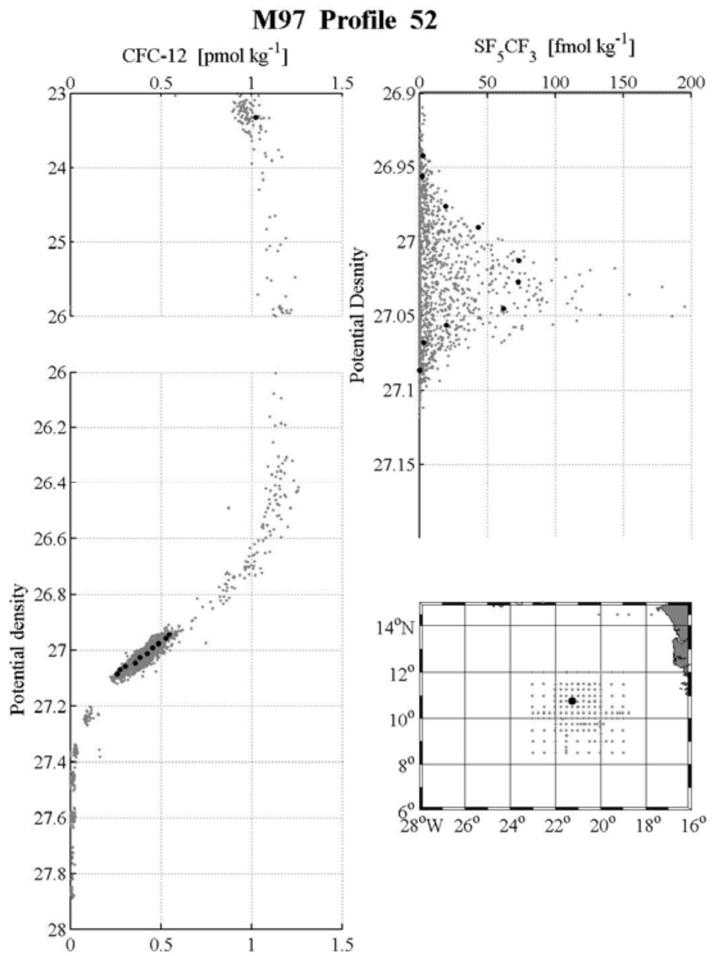


Fig. 5.11 Tracer profile against potential density anomaly for CFC-12 in pmol kg^{-1} on the left and for CF_3SF_5 on the right side for CTD-Station 52. All measured values of the cruise are plotted in gray in the background. The black dots indicate the measurements at the specific station. The black dot in the map under the CF_3SF_5 profile indicates the location of the station.

All CFC-12 and CF_3SF_5 measurements are shown in Figure 5.11, plotted vs. density. Concentrations up to 200 fmol kg^{-1} CF_3SF_5 per sample were found during the cruise. The maximum CF_3SF_5 concentration was mostly found in a range of about 10m from the target density of 27.03 kg/m³, on which the tracer was released 6 month earlier. A few profiles showed a distribution with two maxima.

The width of the vertical distribution of the CF_3SF_5 differs between the stations. To find out how much tracer would be in the water column at each location, a tracer column integral was calculated. Therefore an integral over all tracer depth was build. The result shows a lateral tracer distribution around the injection area at 10°30’N 21°W. Our preliminary results (Figure 5.12) show that the injected tracer streaks did not spread in a singular patch. Four CTD stations were done at the release position. In two of them no CF_3SF_5 could be detected, in the other two the concentrations were very low. It seems that Eddies transported tracer additionally to the spreading due to diffusive processes.

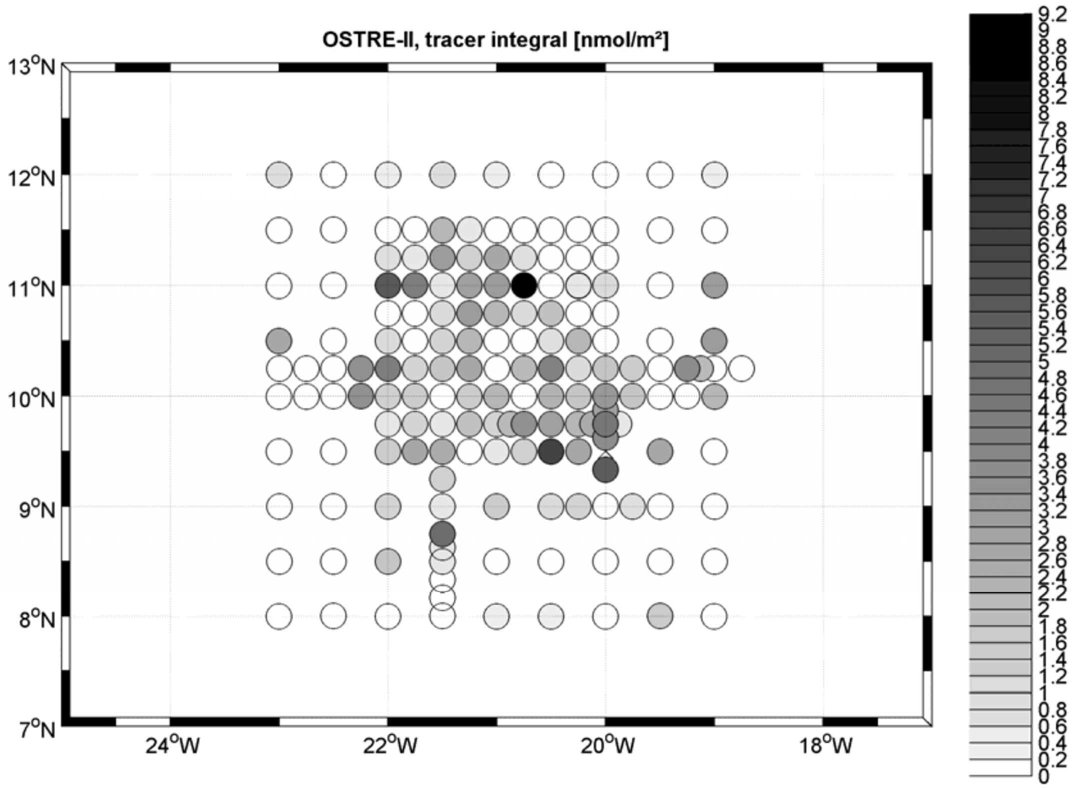


Fig. 5.12 Tracer column integral of CF_3SF_5 in nmol m^{-2}. White dots are stations where no tracer was found.

Figures 5.13 and 5.14 shows the (preliminary) vertical distribution of CF_3SF_5 in fmol kg^{-1} along two sections. Figure 5.13 shows the section along 10°15'N between 18° 45'W and 23° W and Figure 5.14 shows the section along 21° 30'W between 8°N and 12°N. Both sections show that the tracer has spread in separated small patches with local maxima of more than 90 fmol kg^{-1}. The tracer concentration reduces to zero or nearly zero in a range of 50 m around the depth of the highest concentration while the lateral reduction cannot easily be quantified from the preliminary data.

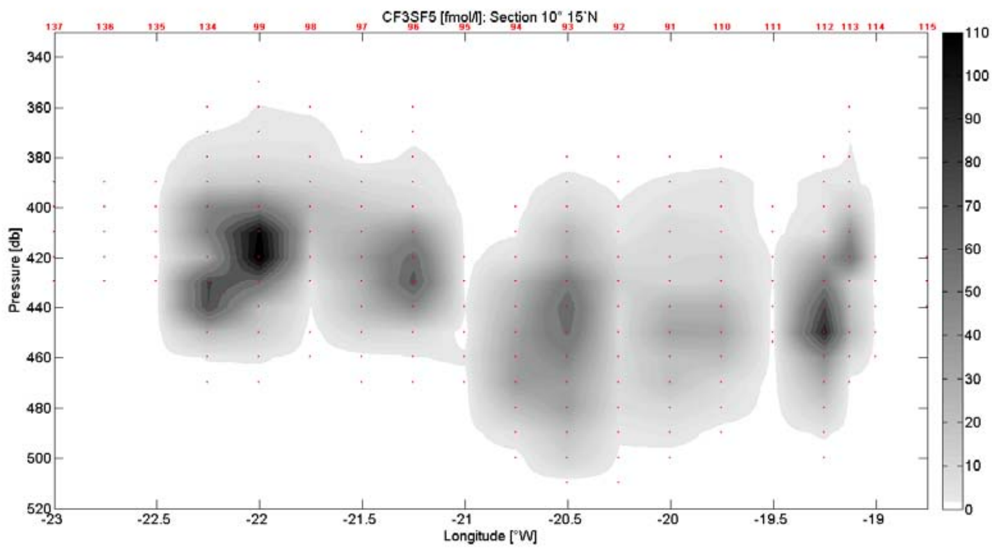


Fig. 5.13 Section of CF_3SF_5 in fmol kg^{-1} found in the different depth levels along 10° 15' N. The dots indicate the position of measurements.

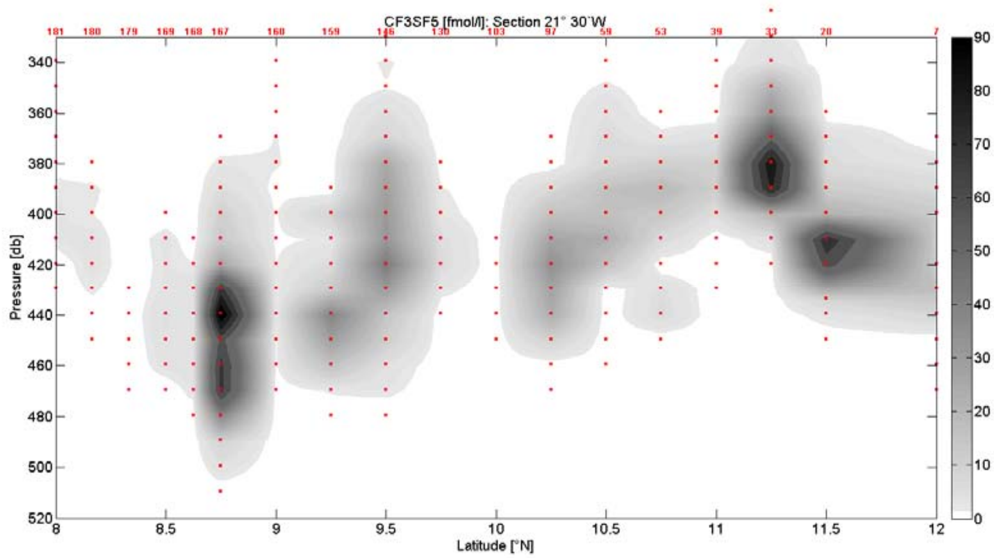


Fig. 5.14 Section of CF_3SF_5 in $fmolkg^{-1}$ found in the different depth levels along 21° 30' W The dots indicate the position of measurements.

5.9 Zooplankton and Nekton

(R. Kiko, H. Hauss, F. Buchholz, H. Ossenbrügger, U. Piatkowski)

The main goal of the zooplankton and nekton work on the cruise was to determine the vertical distribution of organisms as well as the migrant biomass and the mutual relationship between the hydrographic environment and the pelagic community. In particular, their impact on the oxygen consumption and nutrient recirculation was studied by coupling *in situ* observations with laboratory experiments.

UVP

During all CTD-casts, an Underwater Vision Profiler 5 (UVP 5) - kindly provided by Prof. Lars Stemmann, Laboratoire d'Océanographie de Villefranche (LOV), France - was mounted on the CTD-rosette. The instrument consists of one downward facing HD camera in a 6000dbar pressure-proof case and two red LED lights that illuminate a 0.93L-water volume. During the downcast, the UVP takes 3-11 pictures of the illuminated field per second, of which particles larger than 60µm are immediately enumerated and sized. Furthermore, images of particles with a size > 500 µm are saved as a separate "Vignettes" - small cut-outs of the original picture – which allow for later, computer assisted identification and grouping into different particle, phyto- and zooplankton classes. Since the UVP was integrated in the CTD rosette, fine-scale vertical distribution of particles and major planktonic groups can be related to environmental data. In total 184 UVP profiles were collected during the cruise.

MultiNet

A Hydrobios Multinet Midi with an aperture of 0.25 m^2 and 5 nets (mesh size 200 µm) was deployed at 18 stations for vertically stratified hauls (sampling depths: 1000-600 m, 600-300 m, 300-200 m, 200-100 m, 100-0 m). Samples were fixed in 4% formaldehyde in seawater solution. They will be scanned and analyzed using automated imaging software allowing taxonomical classification and biomass estimation.

MOCNESS

The cruise gave the opportunity to deploy a "krill-net", i.e. a MOCNESS (Multi Opening and Closing Net with Environmental Sensing System), optimized for catch of fast swimming macro-zooplankton which avoid smaller nets, with 9 nets (1 m² mouth) of large mesh-size (2mm) equipped with soft cod ends for careful catch.

In the frame of the cruise objectives, Euphausiids are of special interest as large swarms consume considerable amounts of plankton in the surface layers at night and transport the biomass down into the OMZ during the day where the processing of excretion products and decomposition add to oxygen depletion. Furthermore, different species of krill with different vertical migration ranges initiate the "ladder of migration", thereby transporting biomass further down, until the deep sea.

Fourteen MOCNESS hauls were performed in depth-discrete steps, i.e. single nets opened and closed at pre-determined depths from 1000 to 0 m at night and day to differentiate vertical positioning of target species. Krill was counted in the net samples, and residence depths noted. Individuals were isolated and maintained in ambient cooled water until species, size and sex were determined in all specimens. Additionally, in two species molt rate, sexual development stage, visual lipid stages and mid-gut gland color were scored to assess their adaptive capacity. Samples were shock-frozen for later determination of stable isotopes and biochemical composition. In the area, 18 krill species were found, which make up 21% of the known worldwide species repertoire (n=86). Species complexes indicated different water masses. While the 75 kHz-ADCP registered, parallel net catches revealed a characteristic backscatter band corresponding to krill rising and descending during dusk and dawn. Vertical migration timing, ranges and swimming speeds can be deduced now from the shipboard ADCP-data set. A comparison to data of krill from the Northern Benguela is envisaged within the running BMBF-Project GENUS, Geochemistry and Ecology of the Namibian Upwelling System.

Speciation

Another major objective of our group was the collection of pelagic snails (pteropods and heteropods), cephalopods and fish that were sampled with various nets. We took all pelagic snails, cephalopods and some fish out of the MOCNESS and CALCOFI samples in order to identify species, to collect tissue samples for genetic barcoding, and for further studies in the home laboratory. In total we collected 41 different species of pelagic snails (535 specimens), and 22 cephalopod species (95 specimens). Additionally, all species of pelagic snails and cephalopods were photographed after capture for compiling color plate tables.

Physiological measurements

Physiological measurements with the euphausiid species *Thysanopoda tricuspidata* and *Euphausia gibboides* were carried out. Their respiration and excretion (NH_4^+, PO_4^{3+}, urea) were measured during incubations at different oxygen and carbon dioxide partial pressures and three different temperatures (11°, 18° and 23°C), resembling at-surface and at-depth conditions.

Watercolumn biogeochemistry

Watercolumn biogeochemistry samples were collected at 13 stations, accompanying zooplankton work or N_2 fixation experiments. Samples comprised nutrients, POC/PON, POP, Chl-a and d15N of DIN with standard depths being 850, 450, 250, 150, 100, 80, 60, 40, 20 and 10m (plus additional depths at CVOO).

In addition, filter samples were collected to measure the activity of the electron-transport system (ETS), which gives an estimate of the potential respiration rate and will be linked to the particle abundance and distribution from the UVP5 dataset.

5.10 N_2 Fixation Experiments

(A. Singh and P. Stange)

Research Objectives:

- To estimate N_2 fixation and primary production during summer in the eastern-tropical part of the North Atlantic Ocean. Experiments were performed using a newly developed method.
- To examine the contribution of smaller (<10 µm) diazotrophs to N_2 fixation in this region. This was tested by doing incubation experiments in the filtrate (filtered through 10 µm pore size polycarbonate) water.
- To examine the role of Saharan dust inputs on N_2 fixation in the study region.
- To understand diel variation in N_2 fixation and carbon uptake.
- To estimate release of dissolve organic nitrogen (DON) and ammonium (NH_4^+) release during incubation experiments.

Experimental approaches:

Stable isotopes of nitrogen (^{15}N) and carbon (^{13}C) were used in incubation experiments to study the above objectives. Along the cruise track of M97, a total of thirteen N_2 fixation and carbon uptake incubation experiments were performed (Figure 5.15). Water samples were collected from 4 different depths, corresponding to 100, 50, 25, 13% light levels, to cover the entire euphotic zone. Samples were collected using Niskin bottles attached to a CTD rosette sampler. Individual samples were taken, in triplicates, in 4.5 L polycarbonate Nalgene bottles. This was followed by addition of $^{15}N_2$ dissolved gas and $NaH^{13}CO_3$ (99 atom %) tracers to individual samples. Samples were then incubated on the deck after attaching light filters to the incubators to simulate the light levels for the corresponding depths. Sea water was continuously circulated during the incubation to maintain the temperature. Samples were incubated for 24 hrs. All samples were filtered subsequently through pre-combusted (4 hrs at 400°C) 25 mm diameter and 0.7µm pore size Whatman GF/F filter, dried in oven at 50°C overnight and preserved for mass-spectrometric analysis at the on shore laboratory.

Time-series incubations (TS-1 & 2) at two sampling locations (Figure 3.15) were also performed along with above mentioned regular experiments. Incubations for such experiments were stopped after 1, 4, 8, 14 and 24 hrs through filtration. Further, size fractionation experiments (SF-1 & 2) were conducted at two locations in the filtrate water filtered through 10 µm pore size polycarbonate filter.

Samples were collected for nutrient (NO_3^-, NH_4^+, PO_4^{3-}, SiO_4) measurements in 15 ml tubes from each depth and preserved at -20 °C. Samples for chlorophyll were filtered through 0.7 µm pore size Whatman GF/F filter and filters were preserved at -80 °C for further analysis. Flow cytometry samples were collected in 5 ml Nalgene tubes to estimate cell abundance. 300-400 ml tracer added surface water incubated in separate bottles was filtered for nanoSIMS analysis.

Expected Results:

Recent studies have highlighted the problems (e.g., under equilibration of $^{15}N_2$ gas tracer) associated with the earlier method of estimating N_2 fixation (Großkopf et al., 2012). A new methodology, which was recommended by Mohr et al. (2010) and adopted in present expedition, would provide precise estimates of N_2 fixation and better understanding of nutrient cycling. NanoSIMS analysis will provide an insight into the fate of fixed nitrogen. DON and NH_4^+ in incubated filtrate would also provide additional information on the fate of newly fixed N_2. Moreover, this region has been overlooked by biogeochemists because it receives ample amount of nutrients through upwelling. Therefore, chances of N_2 fixation, as per old paradigm, are less. However, excess PO_4^{3-} in this region through upwelling might play a role in enhancing N_2 fixation. N_2 fixation results comparing with the CTD and nutrient data would answer such questions.

Presently there is no consensus among marine biogeochemists on duration of conducting the incubations. Time series study conducted at two stations will help to understand the effect of incubation time on estimated rates. Size fractionation experiments conducted at the other couple of stations will provide an estimate of contribution of smaller diazotrophs such as *Crocosphaera*.

The N_2 fixation and carbon uptake rates will be correlated to environmental parameters, e.g., temperature, light, ambient nutrients and aerosol optical depth (for dust deposition). The results obtained from this expedition may be further incorporated in biogeochemical models to understand global biogeochemical cycle.

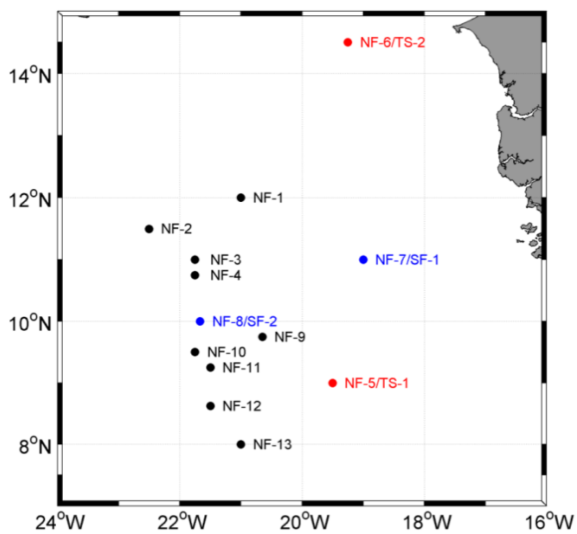


Fig. 5.15 Map showing sampling location for carbon uptake and N_2 fixation (NF1-13) along with two time-series (TS1-2, red circles) and size fractionated (SF1-2, blue circles) on M-97.

5.11 Aerosol Optical Depth (AOD) Measurements
(R. Redler)

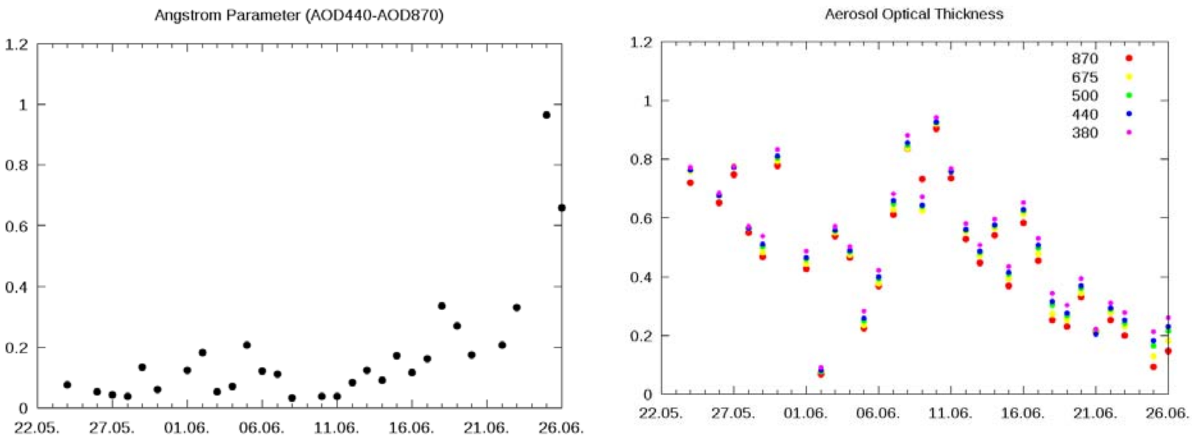
In collaboration with the National Aeronautics and Space Administration Goddard Space Flight Center (NASA-GSFC), MICROTOPS II® handheld Sun photometer measurements are conducted worldwide on an opportunity basis on (research) vessels as part of the Maritime Aerosol Network (MAN), which has been developed as a component of the Aerosol Robotic Network (AERONET). Details about the AERONET-MAN program are described in detail by Smirnov et al. (2009) and are not repeated here. These ship-based measurements complement the continental aerosol monitoring at AERONET sites e.g. for evaluations of satellite retrievals or model simulations over oceans. During cloud-free conditions at daytimes, direct solar attenuation samples with MICROTOPS II® instruments provide – in a vertically integrated sense – data about the atmospheric aerosol amount (the aerosol optical depth – AOD), the aerosol size (via the Ångström Parameter, derived from the AOD) and atmospheric water vapor. For further details about the MICROTOPS II® instrument the reader is referred to the publication by Knobelspiesse et al. (2004) and the references cited therein.

The atmosphere takes up dust over the Sahara desert. With the Northeast trade wind system the dust particles are advected westward into the region over the North Atlantic roughly between 30°N and 5°N. Compared to the average optical depth in dust free regions over the ocean of about 0.07 (Smirnov et al., 2002) the advection of Sahara dust results in notably high values of the optical depth of values up to 1 or even higher.

During M97 each day data have been collected in the “tracer box” as well as on the Atlantic cross-section from the southwestern tip of the “tracer box” at 8°N, 23°W across the Equator to Fortaleza (3°47’S, 38°36’W) using the MICROTOPS II® #16827. As far as cloud conditions permitted (the sun disk must not be covered by any type of clouds) measurements were carried out roughly every 15 minutes. Typically, each measurement interval consisted of 10 consecutive scans lasting about two minutes in total. On a couple of days the ship got under the influence of the Inter-Tropical Convergence Zone (ITCZ), and resulting cloud conditions did not allow for any measurements. South of 5°N outside the Sahara dust region in addition to #16827 a second instrument (#16826) was used to allow for a direct inter-comparison between the two instruments and to determine the impact of environment conditions on the instrument’s filter in #16827 under dust conditions.

During the cruise each day the measured MICROTOPS II® data – accompanied by a brief report about weather (and cloud) conditions – were transferred via internet to the NASA-GSFC for further processing. Raw (Level 1.0) data and screened data with cloud and pointing errors having been removed (Level 1.5) are already available to the public at http://aeronet.gsfc.nasa.gov/new_web/cruises_new/Meteor_13_2.html.

For the first 28 days of the cruise FS Meteor has been operating under the Sahara dust and only left the dust belt when crossing 5°N on the transit to Fortaleza on June 22nd. Daily averaged Level 1.5 properties for the aerosol optical depth (AOD), the aerosol Ångström parameter (AnP), and the column water vapor are presented in Figure 5.16. On the May 31st clouds diluted the measurements during the whole day on June 9th a pollution of the instrument window caused a strong bias of the measurements in the 870 nm band. The data will be corrected for these errors when the final (postfield) calibration will be applied. As expected the AOD declines from values between 0.4 and 0.9 north of the ITCZ to values of 0.2 near or in the ITCZ (from June 18th to 25th) and decreases further south of the ITCZ (values not shown in the plot). The very low values of the Ångström parameter in the tracer box are either caused by dust with different particles sizes or dust with a mixture of clouds. The higher values of 1 south of the ITCZ indicate a mixture of aerosols.



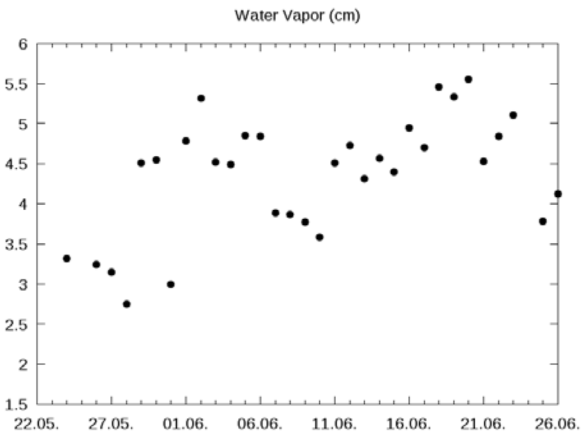


Fig. 5.16 Daily mean along cruise track: Level 1.5 values of Ångström parameter (top left), aerosol optical depth (top right) and water vapor (lower left).

5.12 Cape Verde Ocean Observatory (CVOO) Station Service during M97

(T. Steinhoff[1], G. Niehus[1], A. Pinck[1], M. Vega[2], C. Zenk[1]. Not on-board; J. Karstensen[1] and A. Körtzinger[1])
[1]GEOMAR, Kiel, Germany; [2]Develogic, Hamburg, Germany

The main objectives of the scientific work at the CVOO station were:

- Extend existing time series data with a full-depth CTD Hydrocast including water sampling for various parameters
- Deploying a new test-bed mooring at CVOO which includes a novel moored underwater winch and a profiling device
- Servicing the satellite-based telemetry unit at the surface of the existing CVOO main mooring

The field work conducted during the cruise can be subdivided into 3 work packages according to the above named objectives. This field work was out successfully carried out during the first 36 hours of the M97 expedition.

a) Full-depth CTD hydrocast at CVOO

Hydrocast station work at CVOO has led to a suite of high quality samples throughout the entire water column. These samplings are most important for the CVOO time series for three reasons: First, local facilities don't allow regular full-depth hydrocast samplings within the entire water column at CVOO. Second, highly accurate and precise measurements on Meteor act as a benchmark for local CVOO sample analysis work and, third, potential gaps in time-series data can be minimized. Results of this hydrocast station will be integrated into the CVOO dataset soon after post-cruise analysis has been performed.

We performed a full-depth CTD hydrocast at the CVOO station in order to extend existing time-series data. Next to high-resolution CTD sensor data we collected discrete water samples for the following parameters: SF_6, dissolved oxygen (DO), inorganic carbon parameters such as DIC (dissolved organic carbon) and TA (total alkalinity), nutrients (nitrate, nitrite, phosphate and silicate), particulate organic carbon (POC) and particulate organic nitrogen (PON), chlorophyll-a (Chl-a), total organic carbon (TOC) and total nitrogen (TN). Samples for DO were analysed immediately after sampling on board; all other samples will be analyzed onshore either at the INDP in Mindelo (Cape Verde) or at GEOMAR in Kiel (Germany).

b) Mooring deployment at CVOO

An oceanographic mooring system was successfully deployed during the cruise at a water depth of 3600 m. This testbed mooring is equipped with a novel underwater winch system which is mounted as the uppermost part of the mooring at a water depth of 140 m. The underwater winch system consists of the winch unit (incl. an upward looking acoustic modem for ship-based telecommunication) and above a buoyant profiling unit attached to the winch. The latter acts as a sensor carrier for a suite of sensors for the measurement of various biogeochemical parameters: CTD (Seabird SBE 52MP), pCO_2 (CONTROS HydroC), O_2 (Seabird SBE 63), and chl-a & turbidity (Wetlabs ECO FLNTURT). This unit is supposed to be winched up and down based on an almost daily basis, thereby conducting highly resolved measurements of the parameters listed above. A small telemetry buoy above the profilers enables the system to broadcast profile data to shore. Prior to deployment various on-deck tests with the system were performed and after deployment a number of further in-water tests were performed with the system. All important system components worked properly but some problems occurred with the satellite telemetry unit. Communications between ship, winch and profiler were found to work reliable. After successful functional tests an autonomous test profile was conducted by the winch system which has delivered first in situ sensor data recorded by the profiling unit (Fig. 5.18). Sensor data are in good shape and represent the actual water mass properties which are typical for the upper water column at CVOO. The system was then programmed to perform a profile every 38 h for the next 12 months. The mooring was deployed at 17° 36.27' N , 24° 18.82' W. However, due to communication error with the mooring, the releaser mounted below the winch was activated and the top element of the mooring was recovered on June 25, 2013. The lower part of the mooring is still on position, although there are currently no active sensors on the mooring.

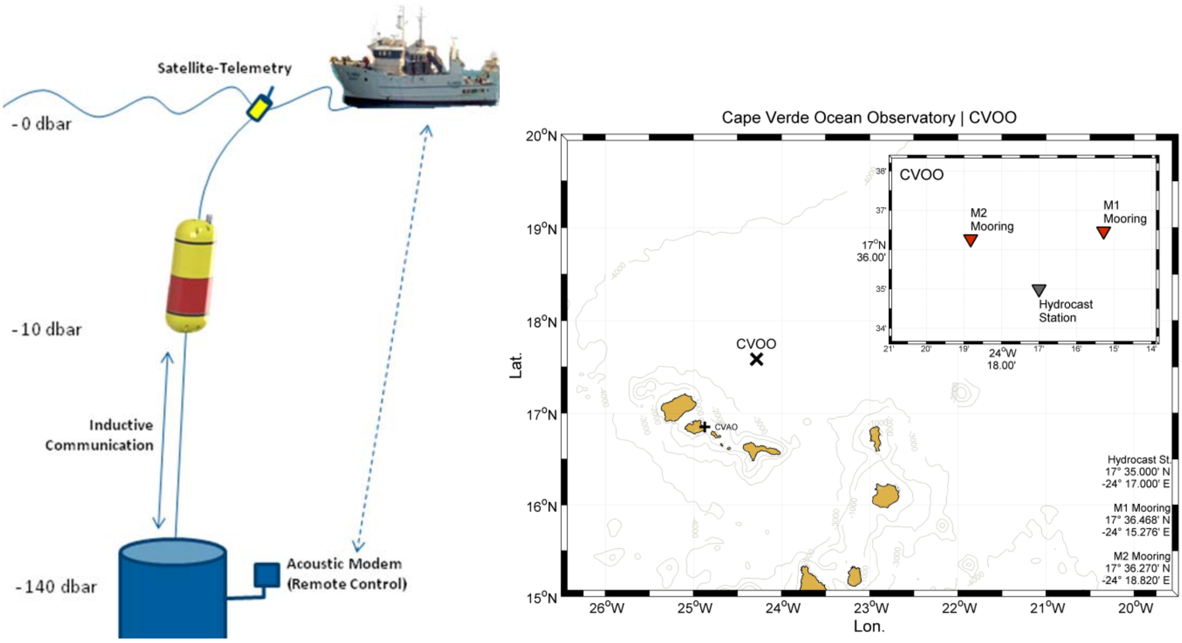


Fig. 5.17 Left: Scheme of the deployed winch system at the uppermost part of the new test-bed mooring at CVOO. Right: Most recent locations of stations/moorings at CVOO (M1=main mooring, M2=testbed mooring).

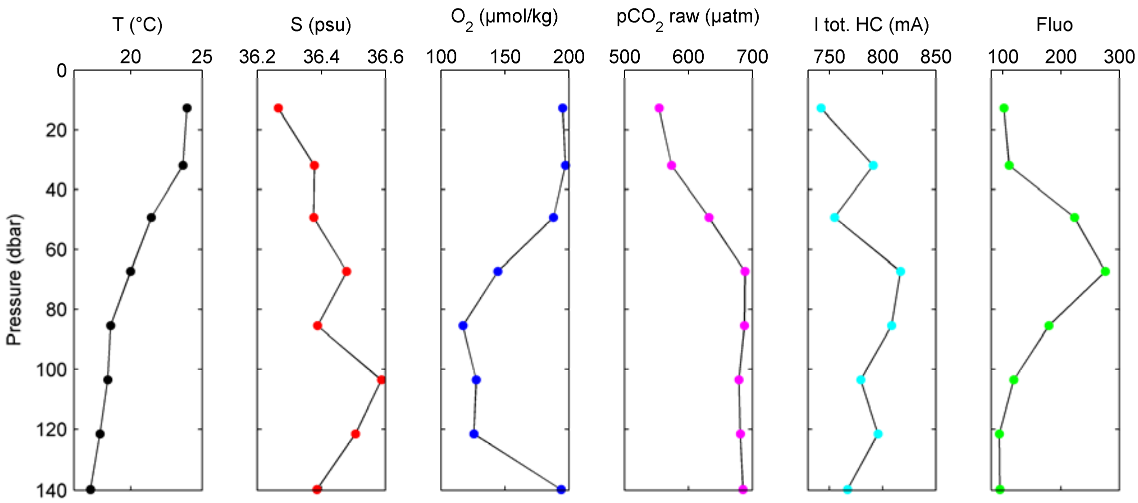


Fig. 5.18 Raw sensor data recorded by the profiling unit of the new underwater winch system. Measurements were conducted during a test profile shortly after deployment with RV Meteor.

c) *CVOO mooring service*

The latest deployment of the CVOO main mooring was conducted during the Maria S. Merian MSM-22 expedition in fall 2012. This setup was additionally equipped with a satellite-telemetry system which is based on a small buoy at the surface. Due to unknown reason the satellite link was interrupted a few months after its deployment. This Meteor expedition was used to recover the surface-buoy followed by immediate on-deck repair and re-deployment. The temporary recovery of the main mooring's surface telemetry buoy (M1; Figure 5.17, right panel) revealed that the satellite telemetry was interrupted by a broken cable. Quick repair of this cable on deck of Meteor was done. After the buoy was released back into the water, data from the buoy were successfully received (i.e. O_2, salinity, temperature and pressure in the upper 50 m of the water column).

6. Ship's Meteorological Station

(M. Stelzner)

When METEOR left Mindelo on May 25, the research area remained under the influence of a ridge on the southern flank of an extensive high to the northwest of the Azores. The wind was strong with 6 to 7 Bft from north to northeast. The northeasterly swell was up to 2m bringing up the significant wave height to 2.5 m.

On the 27th of May the transit to the planned working area commenced. This was accompanied by strong northeast winds 6 to 7 Bft, weakening on the way down to the south to 4 Bft. The significant wave height from 2.5 m decreased to 1.5 m. The sky was partly cloudy with a moderate visibility. In the early hours of the 29th METEOR reached the working area at 12°N and 20°30'W and the research commenced. The wind blew with 3 to 4 Bft from north to northeast. The swell came from the north with a significant wave height of 1 to 1.5 m. The visibility was still moderate. The sky was mostly cloudy at first with a partly clearing during the day. The air temperature was 25°C, the water temperature hovered around 27°C. From the 30th to the 06th the weather was persistent due to an extensive high to the west of the Azores extending a ridge into the working area of the METEOR.

On the 7th the transit to Dakar began. The weather pattern hardly changed, but the visibility deteriorated as Meteor approached the mainland. On the 8th METEOR reached the port of Dakar. The visibility decreased to 10km with the sky only showing cumulus and cirrus clouds. Outside the harbor a southwest wind with 4 Bft was experienced with a swell from the northwest resulting in a significant wave height of 1.5m. Later on the day clouds increased with an overcast sky to follow during the evening. The wind shifted to west to northwest with the temperature falling to 24 degrees. This weather pattern accompanied the meteor on their journey along the section at 14°30'N.

On the 10th METEOR headed back south into the main working area; the temperature increased to 26°C, the northeasterly winds decreased to 3 Bft with the northerly swell abating a little to about 1m. From the 11th Meteor cruised in a low pressure gradient of the ITCZ. Until the 17th this resulted in north to northwesterly winds of 2 to 3 Bft, a northerly swell with a significant wave height of 1m, air temperatures around 27° C and water temperatures of 28°C. The sky was mostly cloudy.

From the 18th the working area of METEOR was within the ITCZ. This resulted in large towering clouds bringing at times heavy showers lasting into the 21th. The wind with strength from 2 to 3 Bft was variable. Occasionally Meteor experienced showery gusts with a northerly swell keeping the significant wave height on 1m. Showers were in the vicinity, at times they moved across METEOR.

From the 22th METEOR cruised along the southern border of the ITCZ and crossed it further on the way south. Until the 25th the sky was cloudy to mostly cloudy. The east to southeast wind blew with 4 to 5 Bft, the swell came from various directions with a significant wave height of up to 1.5m.

From the 26th METEOR was south of the ITCZ and crossing the equator around 10:30 UTC. The weather was fine; the wind blew with 4 to 5 Bft from the southeast with a weak swell. The slightly stronger wind sea brought the significant wave height up to 1.5 m. Until the 28th there was no significant change in the weather situation.

7. Station list

Station METEOR	CTD	Date	Time	Latitude	Longitude	max. p [db]	Comment/measurements
M97/1087-1	001	25.05.13	22:02	17° 04.17'N	24°51.16'W	1006	CTD test station
M97/1088-1		26.05.13	04:16	17° 33.99' N	24° 17.09'W		MSN
M97/1089-1	002	26.05.13	05:16	17° 34.00'N	24° 17.00'W	3640	CVOO deep cast
M97/1090-1		26.05.13	08:00	17° 33.92'N	24° 17.06'W		Mooring deployment begins
M97/1091-1		26.05.13	15:55	17° 33.95' N	24° 16.99' W		MSN
M97/1092-1		26.05.13	17:36	17° 36.25' N	24° 15.34' W		MOR information
M97/1093-1		26.05.13	19:16	17° 36.07' N	24° 18.98' W		Hydrophone into water
M97/1094-1	003	27.05.13	00:00	17° 33.90' N	24° 17.02' W	709	Test of sampler
M97/1095-1		27.05.13	00:46	17° 33.98' N	24° 16.98' W		MSS (did not work)
M97/1096-1	004	29.05.13	03:27	11° 59.98' N	20° 29.97' W	1201	Tracer 1200 m cast
M97/1097-1	005	29.05.13	07:10	11° 59.98' N	21° 00.00' W	101	N_2fix 100 m cast
M97/1098-1		29.05.13	07:42	11° 59.98' N	21° 00.00' W		MSN
M97/1099-1	006	29.05.13	08:40	11° 60.00' N	21° 00.00' W	1200	Bio 1200 m cast
M97/1100-1		29.05.13	09:47	11° 59.99' N	21° 00.21' W		Mocness
M97/1101-1	007	29.05.13	15:11	12° 00.00' N	21° 29.99' W	1213	Tracer 1200 m cast
M97/1102-1	008	29.05.13	18:48	11° 59.96' N	22° 00.04' W	1223	Tracer 1200 m cast
M97/1103-1	009	29.05.13	22:59	11° 59.95' N	22° 30.06' W	1202	Tracer 1200 m cast
M97/1104-1		30.05.13	02:47	11° 60.00' N	23° 00.00' W		MSN
M97/1105-1		30.05.13	03:47	11° 60.00' N	23° 00.00' W		Bio CTD Sensor problem
M97/1106-1	010	30.05.13	04:17	11° 60.00' N	23° 00.00' W	1202	Bio 1200 m cast
M97/1107-1	011	30.05.13	07:58	11° 29.97' N	23° 00.04' W	1202	Tracer 1200 m cast
M97/1108-1	012	30.05.13	11:40	10° 59.88' N	23° 00.08' W	1200	Tracer 1200 m cast
M97/1109-1		30.05.13	12:06	10° 59.91' N	23° 00.18' W		Secchi disc
M97/1110-1		30.05.13	12:39	10° 59.92' N	23° 00.16' W		Secchi disc
M97/1111-1	013	30.05.13	15:35	10° 29.99' N	23° 00.03' W	1213	Tracer 1200 m cast
M97/1112-1	014	30.05.13	19:16	10° 30.00' N	22° 30.00' W	1211	Tracer 1200 m cast
M97/1113-1	015	30.05.13	23:11	11° 00.06' N	22° 30.08' W	1201	Tracer 1200 m cast
M97/1114-1	016	31.05.13	03:00	11° 30.03' N	22° 30.02' W	100	N_2fix 100 m cast
M97/1115-1		31.05.13	03:23	11° 30.03' N	22° 30.02' W		W2 net Calcofi
M97/1116-1	017	31.05.13	04:06	11° 30.05' N	22° 30.09' W	1207	Bio 1200 m cast
M97/1117-1	018	31.05.13	07:46	11° 30.00' N	21° 60.00' W	1202	Tracer 1200 m cast
M97/1118-1	019	31.05.13	10:06	11° 30.10' N	21° 44.98' W	721	Tracer 700 m cast
M97/1119-1	020	31.05.13	12:16	11° 29.96' N	21° 29.95' W	1212	Tracer 1200 m cast
M97/1120-1	021	31.05.13	14:37	11° 30.05' N	21° 14.97' W	706	Tracer 700 m cast
M97/1121-1	022	31.05.13	16:38	11° 30.01' N	20° 59.93' W	1203	Tracer 1200 m cast
M97/1122-1	023	31.05.13	18:56	11° 30.02' N	20° 44.98' W	702	Tracer 700 m cast
M97/1123-1	024	31.05.13	21:02	11° 29.98' N	20° 30.00' W	1199	Bio 1200 m cast
M97/1124-1		31.05.13	22:10	11° 29.91' N	20° 29.92' W		Mocness
M97/1125-1	025	01.06.13	01:56	11° 30.07' N	20° 15.01' W	704	Tracer 700 m cast
M97/1126-1	026	01.06.13	04:04	11° 29.97' N	20° 00.01' W	1202	Tracer 1200 m cast
M97/1127-1	027	01.06.13	06:28	11° 14.97' N	19° 59.98' W	1202	Tracer 1200 m cast
M97/1128-1	028	01.06.13	08:52	11° 14.95' N	20° 14.99' W	700	Tracer 700 m cast
M97/1129-1	029	01.06.13	11:02	11° 14.97' N	20° 30.00' W	1202	Tracer 1200 m cast
M97/1130-1	030	01.06.13	13:20	11° 14.97' N	20° 44.99' W	706	Tracer 700 m cast
M97/1131-1	031	01.06.13	15:25	11° 14.97' N	20° 59.98' W	1212	Tracer 1200 m cast
M97/1132-1	032	01.06.13	17:51	11° 14.99' N	21° 15.02' W	705	Tracer 700 m cast
M97/1133-1	033	01.06.13	20:02	11° 15.01' N	21° 30.03' W	1209	Tracer 1200 m cast
M97/1134-1	034	01.06.13	22:15	11° 15.06' N	21° 45.10' W	701	Tracer 700 m cast

Station METEOR	CTD	Date	Time	Latitude	Longitude	max. p [db]	Comment/measurements
M97/1135-1	035	02.06.13	00:22	11° 15.03' N	21° 59.98' W	1201	Tracer 1200 m cast
M97/1136-1	036	02.06.13	02:56	11° 00.03' N	22° 00.04' W	1200	Tracer 1200 m cast
M97/1137-1	037	02.06.13	05:26	11° 00.01' N	21° 44.99' W	102	N_2fix 100 m cast
M97/1138-1		02.06.13	05:50	11° 00.01' N	21° 44.99' W		W2 net Calcofi
M97/1139-1	038	02.06.13	06:32	11° 00.01' N	21° 44.99' W	1202	Bio 1200 m cast
M97/1140-1	039	02.06.13	08:58	10° 59.99' N	21° 30.02' W	1201	Tracer 1200 m cast
M97/1141-1	040	02.06.13	11:23	11° 00.08' N	21° 15.08' W	700	Tracer 700 m cast
M97/1142-1	041	02.06.13	13:28	11° 00.05' N	20° 59.97' W	1212	Tracer 1200 m cast
M97/1143-1	042	02.06.13	15:48	11° 00.05' N	20° 44.96' W	706	Tracer 700 m cast
M97/1144-1	043	02.06.13	17:52	10° 59.96' N	20° 29.99' W	1202	Tracer 1200 m cast
M97/1145-1	044	02.06.13	20:08	11° 00.00' N	20° 15.02' W	1202	Bio 1200 m cast
M97/1146-1		02.06.13	21:14	11° 00.00' N	20° 15.02' W		MSN
M97/1147-1		02.06.13	22:16	11° 00.20' N	20° 15.05' W		Mocness
M97/1148-1	045	03.06.13	02:16	11° 00.01' N	19° 60.00' W	1200	Tracer 1200 m cast
M97/1149-1	046	03.06.13	04:40	10° 44.99' N	19° 59.98' W	1201	Tracer 1200 m cast
M97/1150-1	047	03.06.13	07:04	10° 44.96' N	20° 15.00' W	702	Tracer 700 m cast
M97/1151-1	048	03.06.13	09:24	10° 59.93' N	20° 14.98' W	1204	Bio 1200 m cast
M97/1152-1		03.06.13	10:28	10° 59.93' N	20° 14.98' W		MSN
M97/1153-1		03.06.13	11:24	11° 00.04' N	20° 14.99' W		Mocness
M97/1154-1	049	03.06.13	16:07	10° 44.98' N	20° 30.00' W	1210	Tracer 1200 m cast
M97/1155-1	050	03.06.13	18:28	10° 44.98' N	20° 45.00' W	5108	5043 m deep cast, release pos.
M97/1156-1	051	03.06.13	22:59	10° 44.97' N	21° 00.03' W	1202	Tracer 1200 m cast
M97/1157-1	052	04.06.13	01:18	10° 45.02' N	21° 15.04' W	701	Tracer 700 m cast
M97/1158-1	053	04.06.13	03:16	10° 45.01' N	21° 30.00' W	1201	Tracer 1200 m cast
M97/1159-1	054	04.06.13	05:32	10° 44.98' N	21° 45.05' W	99	N_2fix 100 m cast
M97/1160-1		04.06.13	05:52	10° 45.01' N	21° 45.02' W		W2 net Calcofi
M97/1161-1	055	04.06.13	06:29	10° 45.01' N	21° 45.02' W	1202	Bio 1200 m cast
M97/1162-1	056	04.06.13	08:48	10° 45.00' N	22° 00.04' W	1201	Tracer 1200 m cast
M97/1163-1	057	04.06.13	11:20	10° 29.97' N	22° 00.05' W	1250	Tracer 1200 m cast
M97/1164-1	058	04.06.13	14:01	10° 29.99' N	21° 45.05' W	706	Tracer 700 m cast
M97/1165-1	059	04.06.13	16:10	10° 30.03' N	21° 29.99' W	1213	Tracer 1200 m cast
M97/1166-1	060	04.06.13	18:34	10° 30.00' N	21° 15.05' W	708	Tracer 700 m cast
M97/1167-1	061	04.06.13	20:44	10° 30.02' N	21° 00.01' W	5230	5162 m deep cast
M97/1168-1		05.06.13	00:01	10° 30.05' N	21° 00.06' W		MSS
M97/1169-1	062	05.06.13	03:20	10° 30.04' N	20° 45.01' W	707	Tracer 700 m cast
M97/1170-1	063	05.06.13	05:26	10° 30.03' N	20° 30.01' W	1202	Tracer 1200 m cast
M97/1171-1	064	05.06.13	07:42	10° 30.00' N	20° 15.00' W	702	Tracer 700 m cast
M97/1172-1	065	05.06.13	09:00	10° 30.00' N	20° 00.35' W	1201	Tracer 1200 m cast
M97/1173-1	066	05.06.13	13:28	10° 30.01' N	19° 29.98' W	1211	Tracer 1200 m cast
M97/1174-1		05.06.13	14:22	10° 30.01' N	19° 29.97' W		Glider deployment
M97/1175-1		05.06.13	17:45	10° 08.54' N	19° 30.18' W		Mocness
M97/1176-1	067	05.06.13	22:17	09° 59.95' N	19° 29.99' W	1201	Bio 1200 m cast
M97/1177-1	068	06.06.13	01:50	09° 29.99' N	19° 29.98' W	1201	Tracer 1200 m cast
M97/1178-1	069	06.06.13	05:22	08° 59.98' N	19° 29.95' W	51	N_2fix 49 m cast
M97/1179-1		06.06.13	05:24	08° 59.99' N	19° 29.95' W		Hand net
M97/1180-1	070	06.06.13	06:00	08° 60.00' N	19° 30.00' W	1201	Tracer 1200 m cast
M97/1181-1	071	06.06.13	09:35	08° 29.92' N	19° 29.97' W	1203	Tracer 1200 m cast
M97/1182-1	072	06.06.13	13:10	08° 29.97' N	18° 59.98' W	1212	Tracer 1200 m cast
M97/1183-1	073	06.06.13	17:06	08° 59.97' N	18° 59.95' W	1202	Tracer 1200 m cast
M97/1184-1	074	06.06.13	21:00	09° 30.02' N	19° 00.01' W	1202	Tracer 1200 m cast
M97/1185-1	075	07.06.13	00:46	09° 59.97' N	18° 59.99' W	1212	Tracer 1200 m cast

Station METEOR	CTD	Date	Time	Latitude	Longitude	max. p [db]	Comment/measurements
M97/1186-1	076	07.06.13	04:31	10° 29.98' N	19° 00.02' W	1203	Tracer 1200 m cast
M97/1187-1		07.06.13	08:40	10° 23.50' N	19° 36.52' W		Glider recovery
M97/1188-1		08.06.13	14:44	14° 29.95' N	17° 35.96' W		uCTD
M97/1189-1		08.06.13	15:03	14° 29.96' N	17° 38.86' W		uCTD
M97/1190-1		08.06.13	15:29	14° 29.98' N	17° 41.68' W		Mocness
M97/1191-1		08.06.13	18:05	14° 29.92' N	17° 44.96' W		MSN
M97/1192-1	077	08.06.13	19:30	14° 29.99' N	17° 45.00' W	1657	1649 m deep cast
M97/1193-1		08.06.13	21:36	14° 30.00' N	17° 52.67' W		uCTD
M97/1194-1		08.06.13	22:16	14° 30.00' N	17° 58.53' W		uCTD
M97/1195-1		08.06.13	22:44	14° 30.00' N	18° 02.50' W		uCTD
M97/1196-1		08.06.13	23:23	14° 30.00' N	18° 08.18' W		uCTD
M97/1197-1	078	09.06.13	00:23	14° 30.00' N	18° 14.87' W	2612	2599 m deep cast
M97/1198-1		09.06.13	02:20	14° 30.00' N	18° 16.95' W		uCTD
M97/1199-1		09.06.13	02:49	14° 29.92' N	18° 21.42' W		uCTD
M97/1200-1		09.06.13	03:19	14° 30.00' N	18° 25.98' W		uCTD
M97/1201-1		09.06.13	03:50	14° 30.00' N	18° 30.63' W		uCTD
M97/1202-1		09.06.13	04:23	14° 30.00' N	18° 35.64' W		uCTD
M97/1203-1		09.06.13	04:50	14° 30.00' N	18° 39.72' W		uCTD
M97/1204-1	079	09.06.13	05:32	14° 30.06' N	18° 44.95' W	3245	3216 m deep cast
M97/1205-1		09.06.13	07:52	14° 30.00' N	18° 47.20' W		uCTD
M97/1206-1		09.06.13	08:25	14° 30.00' N	18° 52.33' W		uCTD
M97/1207-1		09.06.13	09:04	14° 30.00' N	18° 58.33' W		uCTD
M97/1208-1		09.06.13	09:34	14° 30.00' N	19° 02.84' W		uCTD
M97/1209-1		09.06.13	10:04	14° 30.00' N	19° 07.33' W		uCTD
M97/1210-1	080	09.06.13	11:02	14° 30.00' N	19° 14.99' W	101	N_2fix 100 m cast
M97/1211-1		09.06.13	11:26	14° 30.00' N	19° 15.00' W		MSN
M97/1212-1	081	09.06.13	12:02	14° 30.00' N	19° 15.00' W	3648	3613 m deep cast
M97/1213-1		09.06.13	13:33	14° 30.00' N	19° 15.00' W		Plankton net
M97/1214-1		09.06.13	14:26	14° 30.13' N	19° 16.48' W		uCTD
M97/1215-1		09.06.13	14:58	14° 30.00' N	19° 21.47' W		uCTD
M97/1216-1		09.06.13	15:27	14° 30.00' N	19° 26.08' W		uCTD
M97/1217-1		09.06.13	16:16	14° 30.00' N	19° 33.87' W		uCTD
M97/1218-1		09.06.13	16:57	14° 30.00' N	19° 40.38' W		uCTD
M97/1219-1	082	09.06.13	19:14	14° 29.98' N	20° 05.00' W	4081	4038 m deep cast
M97/1220-1	083	10.06.13	10:20	11° 59.96' N	19° 59.97' W	1202	Tracer 1200 m cast
M97/1221-1	084	10.06.13	13:55	12° 00.01' N	19° 29.99' W	1211	Tracer 1200 m cast
M97/1222-1		10.06.13	17:30	11° 59.99' N	18° 59.97' W		MSN
M97/1223-1	085	10.06.13	18:28	11° 59.99' N	18° 59.97' W	1201	Bio 1200 m cast
M97/1224-1	086	10.06.13	22:05	11° 29.94' N	18° 59.98' W	1202	Tracer 1200 m cast
M97/1225-1	087	11.06.13	01:48	11° 30.00' N	19° 30.01' W	1202	Tracer 1200 m cast
M97/1226-1	088	11.06.13	06:40	10° 59.99' N	18° 59.98' W	100	N_2fix 100 m cast
M97/1227-1		11.06.13	06:46	10° 59.99' N	18° 59.98' W		Hand net
M97/1228-1		11.06.13	07:02	10° 59.99' N	18° 59.98' W		MSN
M97/1229-1	089	11.06.13	07:32	10° 59.99' N	18° 59.98' W	1203	Bio 1200 m cast
M97/1230-1	090	11.06.13	11:07	11° 00.07' N	19° 29.97' W	1200	Tracer 1200 m cast
M97/1231-1		11.06.13	11:22	11° 00.08' N	19° 29.98' W		Hand net
M97/1232-1		11.06.13	11:32	11° 00.08' N	19° 29.98' W		Hand net
M97/1233-1	091	11.06.13	16:47	10° 15.00' N	19° 59.97' W	1201	Tracer 1200 m cast
M97/1234-1	092	11.06.13	19:10	10° 15.02' N	20° 15.01' W	708	Tracer 700 m cast
M97/1235-1	093	11.06.13	21:18	10° 14.99' N	20° 29.98' W	1210	Tracer 1200 m cast
M97/1236-1	094	11.06.13	23:36	10° 15.06' N	20° 44.96' W	702	Tracer 700 m cast

Station METEOR	CTD	Date	Time	Latitude	Longitude	max. p [db]	Comment/measurements
M97/1237-1		11.06.13	23:39	10° 15.07’ N	20° 44.97’ W		Hand net
M97/1238-1		11.06.13	23:55	10° 15.07’ N	20° 44.97’ W		Hand net
M97/1239-1	095	12.06.13	01:43	10° 15.01’ N	20° 59.99’ W	1201	Tracer 1200 m cast
M97/1240-1	096	12.06.13	04:02	10° 15.01’ N	21° 14.99’ W	700	Tracer 700 m cast
M97/1241-1	097	12.06.13	06:06	10° 15.01’ N	21° 30.03’ W	1201	Tracer 1200 m cast
M97/1242-1	098	12.06.13	08:28	10° 14.97’ N	21° 45.00’ W	713	Tracer 700 m cast
M97/1243-1	099	12.06.13	10:30	10° 15.01’ N	22° 00.02’ W	1201	Tracer 1200 m cast
M97/1244-1	100	12.06.13	12:56	09° 59.99’ N	22° 00.02’ W	1211	Tracer 1200 m cast
M97/1245-1		12.06.13	14:49	09° 60.00’ N	21° 51.09’ W		Mocness
M97/1246-1		12.06.13	17:44	10° 00.01’ N	21° 44.99’ W	1202	MSN
M97/1247-1	101	12.06.13	18:40	10° 00.01’ N	21° 44.99’ W		Bio 1200 m cast
M97/1248-1		12.06.13	19:52	09° 59.95’ N	21° 44.98’ W		MSS
M97/1249-1		12.06.13	22:09	09° 59.53’ N	21° 44.67’ W		MSN
M97/1250-1		12.06.13	23:07	09° 59.78’ N	21° 44.62’ W		Mocness
M97/1251-1	102	13.06.13	01:50	09° 59.85’ N	21° 39.81’ W	101	N_2fix 100 m cast
M97/1252-1	103	13.06.13	03:13	09° 59.99’ N	21° 30.01’ W	1202	Tracer 1200 m cast
M97/1253-1	104	13.06.13	05:36	09° 59.98’ N	21° 15.01’ W	701	Tracer 700 m cast
M97/1254-1	105	13.06.13	07:38	09° 59.96’ N	21° 00.01’ W	1202	Bio 1200 m cast
M97/1255-1	106	13.06.13	09:56	10° 00.06’ N	20° 44.99’ W	704	Tracer 700 m cast
M97/1256-1	107	13.06.13	12:04	10° 00.02’ N	20° 30.03’ W	1201	Tracer 1200 m cast
M97/1257-1	108	13.06.13	14:26	09° 59.98’ N	20° 15.00’ W	709	Tracer 700 m cast
M97/1258-1	109	13.06.13	16:28	10° 00.00’ N	19° 59.99’ W	1201	Tracer 1200 m cast
M97/1259-1		13.06.13	17:22	10° 00.00’ N	19° 59.99’ W		Glider deployment
M97/1260-1	110	13.06.13	20:32	10° 14.98’ N	19° 45.02’ W	701	Tracer 700 m cast
M97/1261-1	111	13.06.13	22:41	10° 15.03’ N	19° 29.99’ W	701	Tracer 700 m cast
M97/1262-1	112	14.06.13	00:49	10° 14.97’ N	19° 15.01’ W	701	Tracer 700 m cast
M97/1263-1	113	14.06.13	02:24	10° 15.06’ N	19° 07.52’ W	701	Tracer 700 m cast
M97/1264-1	114	14.06.13	03:50	10° 15.04’ N	19° 00.02’ W	700	Tracer 700 m cast
M97/1265-1	115	14.06.13	05:52	10° 15.00’ N	18° 45.01’ W	701	Tracer 700 m cast
M97/1266-1	116	14.06.13	09:49	10° 00.03’ N	19° 15.04’ W	701	Tracer 700 m cast
M97/1267-1	117	14.06.13	13:02	10° 00.00’ N	19° 44.99’ W	712	Tracer 700 m cast
M97/1268-1		14.06.13	13:12	10° 00.00’ N	19° 44.98’ W		Plankton net
M97/1269-1	118	14.06.13	15:35	09° 45.01’ N	19° 60.00’ W	1212	Tracer 1200 m cast
M97/1270-1	119	14.06.13	17:24	09° 44.98’ N	20° 07.06’ W	706	Tracer 700 m cast
M97/1271-1		14.06.13	17:26	09° 44.98’ N	20° 07.06’ W		Hand net
M97/1272-1	120	14.06.13	19:04	09° 52.48’ N	20° 00.01’ W	701	Tracer 700 m cast
M97/1273-1	121	14.06.13	20:48	09° 44.99’ N	19° 52.52’ W	703	Tracer 700 m cast
M97/1274-1	122	14.06.13	22:37	09° 37.52’ N	20° 00.07’ W	701	Tracer 700 m cast
M97/1275-1	123	15.06.13	00:50	09° 44.99’ N	20° 15.05’ W	700	Tracer 700 m cast
M97/1276-1	124	15.06.13	02:50	09° 45.01’ N	20° 30.00’ W	1201	Tracer 1200 m cast
M97/1277-1	125	15.06.13	04:34	09° 44.98’ N	20° 39.04’ W	101	N_2fix 100 m cast
M97/1278-1		15.06.13	05:00	09° 44.96’ N	20° 39.25’ W		Mocness
M97/1279-1	126	15.06.13	07:58	09° 44.98’ N	20° 44.92’ W	1201	Bio 1200 m cast
M97/1280-1		15.06.13	08:53	09° 44.98’ N	20° 45.00’ W		MSN
M97/1281-1	127	15.06.13	10:35	09° 45.01’ N	20° 52.52’ W	701	Tracer 700 m cast
M97/1282-1	128	15.06.13	12:01	09° 45.02’ N	21° 00.01’ W	1201	Tracer 1200 m cast
M97/1283-1	129	15.06.13	14:25	09° 45.04’ N	21° 14.99’ W	706	Tracer 700 m cast
M97/1284-1	130	15.06.13	16:29	09° 45.03’ N	21° 30.02’ W	1212	Tracer 1200 m cast
M97/1285-1	131	15.06.13	18:56	09° 45.05’ N	21° 44.97’ W	701	Tracer 700 m cast
M97/1286-1	132	15.06.13	20:59	09° 45.00’ N	21° 59.98’ W	1200	Tracer 1200 m cast
M97/1287-1		15.06.13	21:01	09° 45.00’ N	21° 59.98’ W		Hand net

Station METEOR	CTD	Date	Time	Latitude	Longitude	max. p [db]	Comment/measurements
M97/1288-1		15.06.13	21:26	09° 45.00’ N	21° 59.98’ W		Hand net
M97/1289-1	133	15.06.13	23:52	10° 00.04’ N	22° 15.03’ W	700	Tracer 700 m cast
M97/1290-1	134	16.06.13	02:02	10° 14.98’ N	22° 15.00’ W	701	Tracer 700 m cast
M97/1291-1	135	16.06.13	04:03	10° 15.05’ N	22° 30.00’ W	701	Tracer 700 m cast
M97/1292-1	136	16.06.13	06:06	10° 14.99’ N	22° 44.99’ W	703	Tracer 700 m cast
M97/1293-1	137	16.06.13	08:12	10° 15.00’ N	22° 60.00’ W	703	Tracer 700 m cast
M97/1294-1	138	16.06.13	10:36	09° 59.96’ N	23° 00.05’ W	1202	Tracer 1200 m cast
M97/1295-1	139	16.06.13	13:02	09° 60.00’ N	22° 45.01’ W	704	Tracer 700 m cast
M97/1296-1	140	16.06.13	15:07	10° 00.03’ N	22° 30.03’ W	1212	Tracer 1200 m cast
M97/1297-1	141	16.06.13	19:44	09° 30.00’ N	22° 60.00’ W	1203	Tracer 1200 m cast
M97/1298-1	142	16.06.13	23:26	09° 30.00’ N	22° 29.98’ W	1202	Tracer 1200 m cast
M97/1299-1	143	17.06.13	02:57	09° 30.04’ N	22° 00.01’ W	1202	Tracer 1200 m cast
M97/1300-1	144	17.06.13	05:18	09° 30.00’ N	21° 45.00’ W	101	N_2fix 100 m cast
M97/1301-1		17.06.13	05:36	09° 30.00’ N	21° 45.00’ W		Calcofi
M97/1302-1	145	17.06.13	06:02	09° 30.00’ N	21° 45.00’ W	1202	Bio 1200 m cast
M97/1303-1	146	17.06.13	08:22	09° 29.99’ N	21° 30.01’ W	1201	Tracer 1200 m cast
M97/1304-1	147	17.06.13	10:49	09° 29.99’ N	21° 15.04’ W	701	Tracer 700 m cast
M97/1305-1	148	17.06.13	13:05	09° 30.00’ N	21° 00.12’ W	1211	Tracer 1200 m cast
M97/1306-1	149	17.06.13	15:35	09° 30.01’ N	20° 45.02’ W	706	Tracer 700 m cast
M97/1307-1		17.06.13	18:53	09° 32.81’ N	20° 16.75’ W		Glider service
M97/1308-1	150	17.06.13	20:02	09° 30.00’ N	20° 15.01’ W	702	Tracer 700 m cast
M97/1309-1	151	17.06.13	22:14	09° 30.01’ N	20° 30.05’ W	1204	Tracer 1200 m cast
M97/1310-1		18.06.13	01:28	09° 21.99’ N	20° 05.97’ W		Mocness
M97/1311-1		18.06.13	04:19	09° 20.07’ N	19° 59.97’ W		MSN
M97/1312-1	152	18.06.13	05:18	09° 20.07’ N	19° 59.97’ W	1204	Bio 1200 m cast
M97/1313-1		18.06.13	06:32	09° 20.07’ N	19° 59.94’ W		MSS
M97/1314-1		18.06.13	08:18	09° 19.79’ N	19° 59.97’ W		MSN
M97/1315-1		18.06.13	09:16	09° 19.73’ N	19° 59.93’ W		Mocness
M97/1316-1	153	18.06.13	13:51	09° 00.06’ N	19° 44.97’ W	706	Tracer 700 m cast
M97/1317-1	154	18.06.13	15:55	09° 00.11’ N	19° 59.96’ W	1212	Tracer 1200 m cast
M97/1318-1	155	18.06.13	18:16	09° 00.00’ N	20° 14.99’ W	704	Tracer 700 m cast
M97/1319-1	156	18.06.13	20:26	09° 00.02’ N	20° 29.99’ W	1203	Tracer 1200 m cast
M97/1320-1	157	19.06.13	00:08	09° 00.03’ N	21° 00.00’ W	2006	Tracer 2000 m cast
M97/1321-1		19.06.13	01:35	09° 00.09’ N	21° 00.02’ W		MSS
M97/1322-1	158	19.06.13	07:06	09° 14.99’ N	21° 29.99’ W	101	N_2fix 100 m cast
M97/1323-1		19.06.13	07:26	09° 15.00’ N	21° 29.98’ W		MSN
M97/1324-1	159	19.06.13	08:22	09° 15.00’ N	21° 30.00’ W	853	Bio 700 m cast
M97/1325-1	160	19.06.13	10:34	09° 00.01’ N	21° 30.03’ W	1201	Tracer 1200 m cast
M97/1326-1	161	19.06.13	14:06	09° 00.01’ N	21° 59.98’ W	1212	Tracer 1200 m cast
M97/1327-1		19.06.13	14:17	09° 00.01’ N	21° 59.98’ W		Plankton net
M97/1328-1	162	19.06.13	17:46	09° 00.02’ N	22° 29.96’ W	1203	Tracer 1200 m cast
M97/1329-1	163	19.06.13	21:23	08° 60.00’ N	22° 59.94’ W	1203	Tracer 1200 m cast
M97/1330-1		19.06.13	22:29	08° 59.88’ N	22° 59.93’ W		MSS
M97/1331-1	164	20.06.13	03:36	08° 29.99’ N	22° 59.98’ W	1201	Tracer 1200 m cast
M97/1332-1	165	20.06.13	07:02	08° 29.99’ N	22° 30.00’ W	1203	Tracer 1200 m cast
M97/1333-1	166	20.06.13	10:34	08° 30.00’ N	21° 59.97’ W	1206	Tracer 1200 m cast
M97/1334-1	167	20.06.13	14:37	08° 44.97’ N	21° 30.04’ W	707	Tracer 700 m cast
M97/1335-1		20.06.13	14:43	08° 45.00’ N	21° 30.02’ W		Plankton net
M97/1336-1	168	20.06.13	16:08	08° 37.50’ N	21° 30.03’ W	701	Tracer 700 m cast
M97/1337-1	169	20.06.13	17:38	08° 29.97’ N	21° 30.06’ W	1203	Bio 1200 m cast
M97/1338-1		20.06.13	18:40	08° 30.00’ N	21° 29.95’ W		Mocness

Station METEOR	CTD	Date	Time	Latitude	Longitude	max. p [db]	Comment/measurements
M97/1339-1	170	20.06.13	23:37	08° 30.02' N	21° 00.09' W	1201	Tracer 1200 m cast
M97/1340-1		21.06.13	00:47	08° 30.02' N	21° 00.07' W		MSS
M97/1341-1	171	21.06.13	06:06	08° 30.01' N	20° 30.03' W	1203	Tracer 1200 m cast
M97/1342-1	172	21.06.13	09:57	08° 30.02' N	20° 00.02' W	1206	Tracer 1200 m cast
M97/1343-1	173	21.06.13	17:34	08° 00.02' N	19° 00.03' W	1202	Tracer 1200 m cast
M97/1344-1		21.06.13	17:38	08° 00.02' N	19° 00.03' W		Hand net
M97/1345-1	174	21.06.13	21:16	08° 00.04' N	19° 29.99' W	1203	Tracer 1200 m cast
M97/1346-1	175	22.06.13	00:50	08° 00.02' N	20° 00.03' W	1201	Tracer 1200 m cast
M97/1347-1	176	22.06.13	04:18	08° 00.02' N	20° 29.99' W	1203	Tracer 1200 m cast
M97/1348-1	177	22.06.13	07:52	08° 00.01' N	21° 00.02' W	100	N_2fix 100 m cast
M97/1349-1		22.06.13	08:18	08° 00.01' N	21° 00.02' W		Calcofi
M97/1350-1	178	22.06.13	08:40	08° 00.01' N	21° 00.02' W	1205	Bio 1200 m cast
M97/1351-1	179	22.06.13	12:52	08° 20.00' N	21° 29.99' W	707	Tracer 700 m cast
M97/1352-1	180	22.06.13	14:34	08° 10.05' N	21° 29.98' W	708	Tracer 700 m cast
M97/1353-1	181	22.06.13	16:16	08° 00.05' N	21° 29.99' W	1213	Tracer 1200 m cast
M97/1354-1	182	22.06.13	20:00	07° 59.99' N	21° 59.98' W	1202	Tracer 1200 m cast
M97/1355-1	183	22.06.13	23:57	08° 00.07' N	22° 30.02' W	1201	Tracer 1200 m cast
M97/1356-1		23.06.13	02:35	08° 00.02' N	22° 45.89' W		Mocness
M97/1357-1		23.06.13	05:12	07° 55.40' N	22° 47.40' W		MSN
M97/1358-1	184	23.06.13	07:30	08° 00.00' N	23° 00.02' W	1201	Tracer 1200 m cast
M97/1359-1		23.06.13	08:32	07° 59.91' N	23° 00.03' W		MSS
M97/1360-1		23.06.13	10:43	07° 57.92' N	23° 00.04' W		MSN
M97/1361-1		23.06.13	11:40	07° 57.72' N	23° 00.04' W		Mocness

Table over station work on M97; at CTD-bio stations samples for the following parameters were taken: POC/PON, POP, Chl-a, nutrients, $\delta^{15}N$, ETS for later analysis in Kiel, see section 5 for details.

8 Data and Sample Storage and Availability

In Kiel a joint Data-management-Team is active, which stores the data from various projects and cruises in a web-based multi-user-system. Data gathered during M97 will be stored at the Kiel data portal, and are initially proprietary for the PIs of the cruise. The data will be submitted to PANGAEA within 3 years, i.e. by June 2016. Preliminary CTD data were submitted to CORIOLIS during the cruise.

Preliminary, off-the-ship data from all activities within the EEZ from Senegal was handed over to the observer at the end of the cruise. No samples for storage or archiving were taken during the M97 cruise.

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