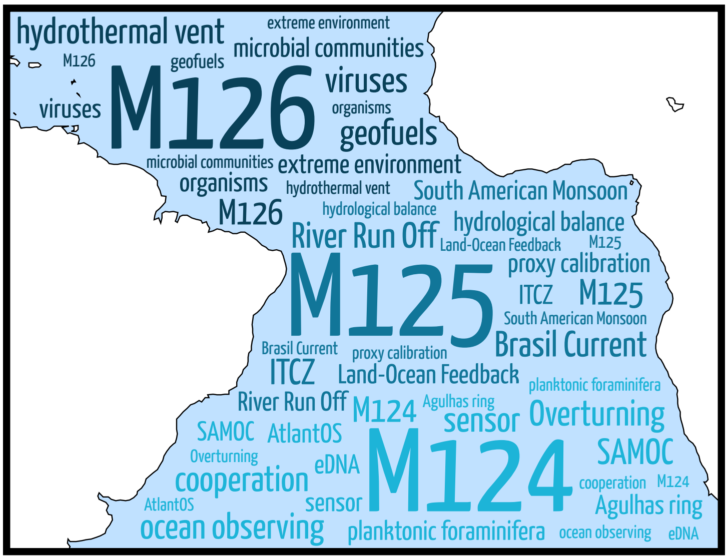
METEOR-Berichte

Oceanic & atmospheric variability in the South Atlantic

Cruise No. M124

29. February – 18. March 2016

Cape Town (Republic South Africa) – Rio de Janeiro (Brazil)



J. Karstensen, S. Speich, R. Morard, K. Bumke, J. Clarke, M. Giorgetta, Y. Fu, E. Köhn, A. Pinck, E. Manzini, B. Lübben, A. Baumeister, R. Reuter, A. Scherhag, T. de Groot, E. Louropoulou, F. Geißler, A. Raetke

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MARUM – Zentrumfür Marine Umweltwissenschaften der Universität Bremen

2016

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1 Summary

The FS METEOR expedition M124 was the first of the two SACross2016 expeditions (second cruise: M133, CS: Martin Visbeck, GEOMAR). Measurements were carried out in the lower atmosphere / upper water column in the so far sparsely-sampled South Atlantic. In particular, the M124 program aimed at studies on differences in the vertical structure of the water column within and outside of mesoscale eddies using underway systems (uCTD, XBT, ADCP, TSG, biogeochemistry). Data were collected with the rosette system was used to determine the contrasts in the distribution of biogeochemical (nutrients, oxygen), biological (foraminifers), physical (T/S, currents) parameters in eddies and surrounding water. Areosol measurments and turbulent fluxes were measured at the air/sea interface in the atmosphere boundary layer quasi continuously. A CTD profile was recorded in the Vema channel to determine the hydrographic characteristics of the Antarctic Bottom Water. Sensor technology tests for measuring pCO_2 and incubation experiments for nitrogen fixation rate estimates were also carried out.

The expedition was used as a "MyScience cruise" for training purposes. There were 9 students from 7 countries on board (South Africa / USA, Brazil, Uruguay, Argentina, Togo, Germany) who were trained in modern ocean observing techniques, but also working out own scientific projects.

Zusammenfassung

Die FS METEOR Reise M124 war die erste der beiden SACross2016 Reisen (zweite Reise: M133, FL: Martin Visbeck, GEOMAR). Auf M124 wurden Messungen in der untere Atmosphäre/oberen Wassersäule im bisher wenig beprobten Südatlantik durchgeführt. Insbesondere zielte das Programm der M124 auf Untersuchungen zu Unterschieden in der Vertikalstruktur des Ozeans innerhalb und außerhalb mesoskaliger Wirbel mit Unterwegsmessungen ab (unter Verwendung von: uCTD, ADCP, XBT, TSG, Biogeochemie). Die Datenaufnahme mit der Rosette geschah um die Kontraste in der Verteilung von biogeochemischen (Nährstoffe, Sauerstoff), biologischen (Foraminiferen), physikalischen (T/S, Strömungen) Parametern von Wirbeln zum Umgebungswasser zu ermitteln. Messungen von Aerosolen und Messungen von turbulente Flüsse über die Ozean/Atmosphäre Grenzschicht wurden quasi permanent durchgeführt. Im Vema-Kanal wurde ein CTD Profil aufgenommen um dort die hydrographische Charakteristik des Antarktischen Bodenwassers zu ermitteln. Sensortest zur Messung des CO_2 Partialdruck und Inkubationsexperimente zur Stickstofffixierung wurden ebenfalls durchgeführt.

Die Expedition wurde für Ausbildungszwecke als eine „MyScience cruise“ genutzt. Es waren 9 Studenten aus 7 Ländern an Bord (Südafrika/USA, Brasilien, Uruguay, Argentinien, Togo, Deutschland) die in moderne Messverfahren eingewiesen wurden und eigene wissenschaftliche Projekte erarbeiteten.

2 Participants

	Name	Task	Institution
1	Dr. Johannes Karstensen	Chiefscientist	GEOMAR
2	Dr. Sabrina Speich	Salinometer/"My science cruise"	ENS
3	Yao Fu	Underway data/CTD	GEOMAR
4	Dipl.-Ing. Andreas Pinck	Technician/CTD	GEOMAR
5	Eike Köhn	ADCP/CTD	ENS
6	Dr. Jennifer Clarke	Towed Pump/Sensor	GEOMAR
7	Dr. Karl Bumke	Disdrometer, turbulence	GEOMAR
8	Dr. Marco Giorgetta	Photometer	MPI-M
9	Dr. Elisa Manzini	Photometer	MPI-M
10	Dr. Raphaël Morard	Multinet/Foraminifera	MARUM
11	Birgit Lübben	Multinet/Foraminifera	MARUM
12	Adrian Baumeister	Multinet/Foraminifera	MARUM
13	Runa Reuter	Multinet/Foraminifera	MARUM
14	Anne Scherhag	Pesticides/other chemicals	MPI-C/MU
15	Tim de Groot	Towed Pump/Titration	GEOMAR
16	Evangelia Louropoulou	Towed Pump/Nutrients	GEOMAR
17	Felix Geißler	Towed Pump/Carbon	GEOMAR
18	Anahí Amaru Brun	Student „My Science cruise"	Exzellenzcluster
19	Aziayibor Kodjo Mawouéna	Student „My Science cruise"	Exzellenzcluster
20	Lais Fernanda de Palma Lopez	Student „My Science cruise"	Exzellenzcluster
21	Mareike Koerner	Student „My Science cruise"	Exzellenzcluster
22	Javier Rabellino	Student „My Science cruise"	Exzellenzcluster
23	Livia M.B. Sancho	Student „My Science cruise"	Exzellenzcluster
24	Kevin Mikus Schmidt	Student „My Science cruise"	Exzellenzcluster
25	Christina Schmidt	Student „My Science cruise"	Exzellenzcluster
26	Veronica van der Schyff	Student „My Science cruise"	Exzellenzcluster
27	Andreas Raetke	Meteorology technican	DWD

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ENS: École normale supérieure; 45, rue d'Ulm, Paris /France

MARUM: MARUM/Universität Bremen, Leobener Str., 28359 Bremen / Germany

MPI-M: Max Planck Institute for Meteorology,Bundesstraße 53, 20146 Hamburg / Germany

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Exzellenzcluster: Exzellenzcluster "Ozean der Zukunft", Christian-Albrechts-Platz 4, Kiel / Germany

MU: Masaryk University, RC Toxic Compounds in the Environment, Kamenice 3, Brno / Czech Rep.

3 Research Program

The M124 expedition aimed to collect data to:

- Investigate the physical/biogeochemical/biological (Foraminifera) characteristics of mesoscale eddies (including Agulhas Rings)
- Determine turbulent heat fluxes and estimating the surface radiation balance, also considering the aerosol load of the atmosphere
- Measure the surface water carbonate system parameters (pCO_2) using newly developed sensors
- Estimate the nitrogen fixation rates from incubation experiments
- Contribute to the long term temperature time series in the Vema Channel
- Provide temperature and salinity observations in real-time to the GTS
- Teach modern ocean observing techniques to students in the framework of a "MyScience cruise"

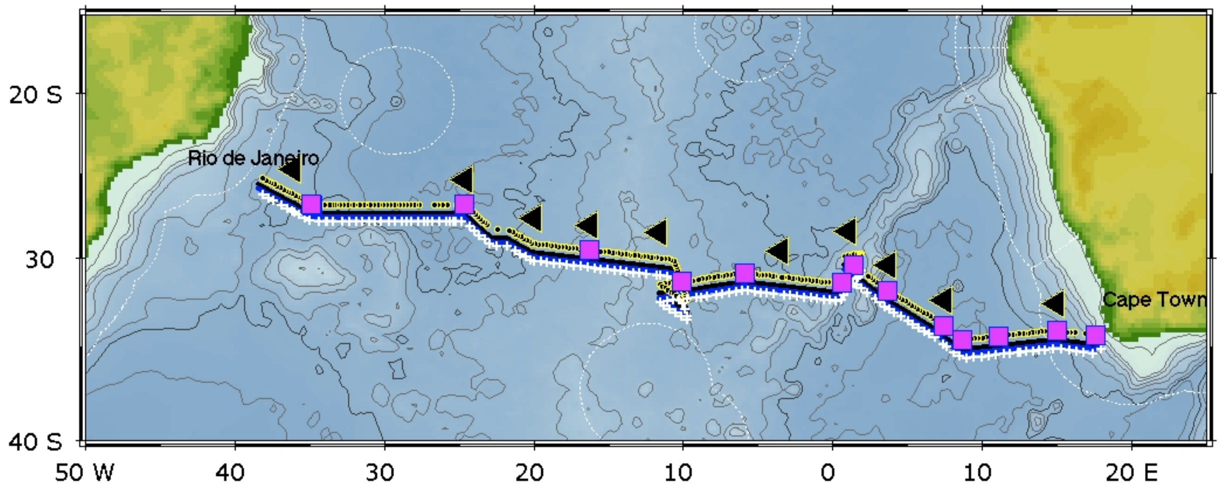


Fig. 3.1 Track chart of R/V METEOR Cruise M124 projected on a bathymetry from Smith and Sandwell (1997). Yellow dots: uCTD Statio (0-450m), magenta square CTD-rosette (0-2000m), black triangle: Multinet/CTD (0-700m), black line: ADCP recordings, white crosses: XBT launches (0-700m). The symbols for the instrument groups have been shifted by 1° in latitude for clarity.

4 Narrative of the Cruise

(Johannes Karstensen)

Shortly after R/V METEOR arrived in Cape Town on the 27. February 2016 groups from MARUM, GEOMAR, MPI-M, MPI-C started to unload and install equipment for the upcoming M124 expedition. In parallel students from the M124 "MyScience cruise" project arrived in Cape Town. All science crew embarked the ship on the 28.02. One student (Stefano Crivellari) was not allowed to arrive in RZA because of him not having a yellow fever vaccination. A first meeting of the science crew took place in the late afternoon. After a dog squad examined the ship (starting at about 06:00LT) for blind passengers R/V METEOR left Cape Town at about 10:00 on the 29.02. A swell from the south slowly move the ship up and down and, accompanied by many sea-life – dolphins, humpback-whales and seals, the first hours reserved for an engine test, passed away quickly. A safety information and "familiarization with the ship" was done during that period.

After returning back close to port, to disembark a technician for the engine test, we finally headed for the first XBT – launched at 18:10, at about 200 m water depths. During M124 we do an XBT program in collaboration with NOAA who maintain a high-resolution XBT line at around 30°S (AX18) since about 2002 with 4 crossing a year using container ships. During M124 we will do a standard crossing, launching an XBT every 2 hours measuring temperature to 700 m depth – however, we will stop the program at the 200nm zone of Brazil. One aim of the program is to compare the XBT recording with measurements achieved with an underway CTD system (uCTD). The uCTD is operated more frequent (every hour) but covering only the upper 450 m. Other underway systems (ADCP, echo sounding) have been started after passing the 12 nm zone. A first CTD/rosette sampling was done at the SAMOC CPIES station. Full sampling of biogeochemical variables and dO18 (Zabel, University Bremen, and Martinez, GEOMAR, Kiel) was done. The group from Eric Achterberg (GEOMAR) Tim de Groot, Eva Louropoulou, did a first test with the towed fish that supplies water via a trace metal clean pump for underway sampling. The underway biogeochemistry measurements were started, including sensors for phosphate analysis and pCO2 that are under development. R/V METEORological observations of turbulent fluxes in the marine boundary layer were started (Karl Bumke, GEOMAR) as well as the air sampling for pollutants observations (Gerhard Lammel/Anne Scherhag, Uni Mainz). A first multinet/CTD cast was performed by the team of Rapahel Morard (MARUM, University Bremen). The foraminifers' abundance was analysed under the microscope. After the picking, two students used the remnant of the catches to analyse it for the occurrence of microplastic (Veronica van de Schyff) and zooplankton (Lais Fernanda de Palma). Kevin Schmidt (student from Cape Town University) did the first presentation in the daily science meeting. The watch system was set up: each of the three watch teams had an experienced watch leader and 3 students. The routine daily work was CTD, uCTD, and XBT profiling as well as watching ADCP, and topography logging. The first night passed by with regular

XBT, uCTD work. Some irregularities occurred with the uCTD as one probe did not record on some casts and also did record corrupt data – the probe was replaced.

The daily "Kapitänsbesprechung" at 08:30 started on the 01. March. A safety drill was set at 10:20. We analysed, with support from the home-bases in Kiel and Brest, the recent sea-level anomaly and absolute dynamic topography maps in order to locate mesoscale eddies along the proposed track. A first uCTD/XBT section through one cyclonic eddy was done. The ADCPs (75kHz, 38kHz) worked very well. In the science meeting Sabrina Speich presented an introduction to the South Atlantic.

During the night, some problems with knots and turns in the uCTD rope appeared and the robe was exchanged by a new one, as it was suspected that salt crystals lead to sticking the robe and hamper the free spooling. The new robe worked well during the following operations. The satellite data based eddy tracking revealed us some change in the position of a cyclone and we delayed the CTD and the CTD/MSN on the 02.03. to 23:00, in order to measure close to the centre of the eddy. Along the cruise we always tried to align the CTDs with the best-estimated location of the centre of eddies. The students science themes were further discussed and a presentation on optical instruments was given (Lais Fernanda de Palma Lopez).

A routine work was developing and typically we did a Multinet/CTD (700m) at 08:30 in the morning at the current position. The rest of the day was then used to count the foraminifers under the microscope. Candidate eddies were identified along the track and centre's determined were a deep (2000m) CTD cast was done and sometimes another Multinet/CTD. We also tried to align the weather observations with the eddy sampling. Student presentations of instrumentation (Christina Schmidt 03.03., Livia Sancho 04.03.) where given during the seminars and two presentations on physical oceanography fundamentals and ocean eddies were given (J. Karstensen).

A very intense (in absolute dynamic topography) anticyclone was approached and a CTD was done it is centre on the 06. March, followed by an X-shaped track to survey the "3-d" velocity structure and hydrography (uCTD, XBT). The ship speed was lowered to 6kn to reach greater depth with the uCTD but also to exchange ballast water for the ship. At the seminars of the following days, four presentations were given by students (Kodjo Mamouena, Mareike Körner, Anahi Brun, Veronica van der Schyff). A science theme review was done and plans were made for the poster presentations planned for the reception in Rio de Janeiro on the 19. March 2016. The watch groups were getting more and more adapted to the shift work and handling the instrumentation. On the 12th March at around 07:00 LT the dGPS signal was stopped because of some contractual issues and the signal appeared again on the 13th March 15:00.

One of the uCTD winches failed and a replacement system (University Hamburg) was used instead. Repair of the winch system failed because a certain set of bearings was not available. Two Agulhas Rings (Anticyclones) were sampled, one again with an X-shaped survey pattern. We approached the Vema Channel Extension region and on the 15th March we did two full depth CTDs, primarily to survey the Antarctic

Bottom Water properties and which showed the increase in temperature observed now since more than a decade.

Brazilian authorities complicated the ships logistical preparations for the arrival in Rio. In particular relevant for the scientific crew was the information from the federal police that three students (from USA, Togo, and China) were not allowed to enter Brazil. All three had visas for Brazil and issued by the individual countries embassies, but local authorities in Rio refused to accept the visas and requested work-visas instead. The issue was resolved on the 19th March early morning.

The scientific program ended at 00:00 on the 17th March 2016, shortly before entering the EEZ of Brazil, and all measurements were stopped. The posters for the reception were finalized. The R/V METEOR moored in Rio de Janeiro at 09:00. Unfortunately the container to be used for shipping back our equipment was not delivered to the ship. We move the equipment to the lower deck of R/V METEOR to organize shipping from the next port (Fortsaleza). The reception on the 19th, invited by the German Ambassador Mr. Brengelmann, the Consul Mr. Klein, and the Captain of RV METEOR Michael Schneider, took place in the early afternoon.

5 Preliminary Results

5.1 CTD measurements and calibration

(Yao Fu, Sabrina Speich, Johannes Karstensen)

During M124 in total 14 profiles of pressure (p), temperature (T), conductivity (c) and oxygen (O) were recorded. 2 of these profiles reached 20 m above the bottom at Vema Chanel Exit, the remaining profiles ranged to 2000 m or shallower. We used a Seabird Electronics (SBE) 9plus system, attached to the water sampler carousel, and the latest Seabird Seasave software. The SBE underwater unit had two sensor sets (table 5.1: p #979, T1 #5678, c1 #3732, O1 #1818, T2 #5600, c2 #3717. The Oxygen sensor #2415 malfunctioned for the first two profiles. Therefore, it was replaced with a new sensor #1818 since the 3rd profile; it worked normally for the rest of profiles. The two temperature and conductivity sensor sets worked properly during the entire cruise. The secondary sensor set was chosen for the final data processing report, for being slightly less noisy. Conductivity was calibrated using a linear relation in p, T and c. This relation was obtained by fitting the according CTD salinity to 94 water samples, which were analysed with a Guildline Autosal salinometer. Rms salinity misfit was 0.0021 after removal of 33% of bottle values. Oxygen was calibrated using a relation linear in T and O, and quadratic in p. Winkler titration of 117 bottle samples led to a relation with an rms misfit of 0.86 µmol/kg if the first 2 profiles are excluded (33% of bottle values removed). Further sensors were attached to the carousel and recorded, but not calibrated: a fluorescence sensor and a Photosynthetically Active Radiation (PAR) sensor (Biospherical). The latter could only be employed during casts less than 2000m deep. The altimeter showed reliable signal for profile 13 and 14, which stopped 20 m above the sea floor.

CTD-conductivity calibration

The GEOMAR Guildline Autosalsalinometer #7 (Model 8400 B, operated by S. Speich) was used for calibration of the primary and secondary conductivity sensor. Calibration of the salinometer was done in reference to the IAPSO Standard Seawater (P157, k15=0.99985). In addition, one sub-standard (25 litres of seawater of unknown but constant salinity) was used to trace the stability of the salinometer. A drift could not be detected from the substandard measurements during the analysis period (see Fig. 5.1.).

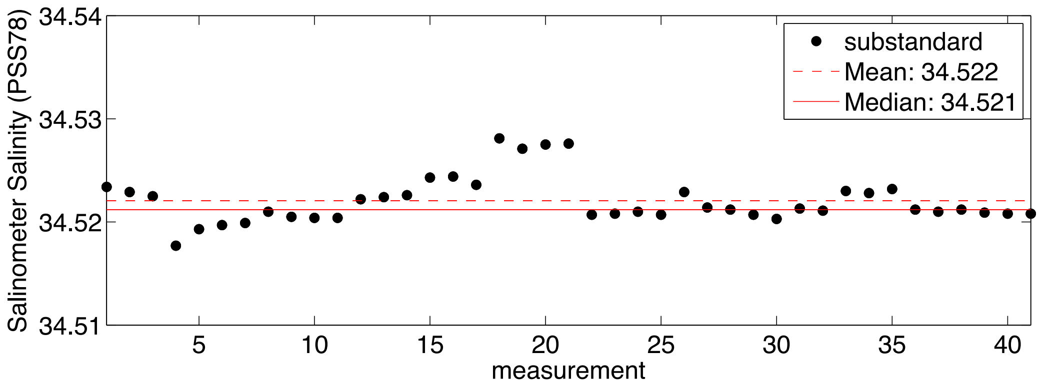


Fig. 5.1 Evolution of the substandard measurements in relation to sample number.

To account for possible outliers in the salinometer data, 33% of the largest differences between CTD and bottle samples were discharged and not considered for calibration. The projection from the bottle stop of the up- to the downcast was done by searching for similar potential temperatures within 30dbar pressure internal around similar pressure horizons between up- and downcast. For the critical loop edit velocity 0.01 m/s were used. The conductivity calibration of the downcast data was performed using a 1st order linear fit with respect to temperature, pressure and conductivity (Table 5.1).

Tab. 5.1 Serial numbers (S/N) and end-of-cruise conductivity and oxygen misfit root-mean-square (last two rows) after calibration with the bottle samples (as of 31. March 2016, see data archive for access to the latest data version).

Used for stations	1 and 2	3 to 14
Pressure S/N	979	979
Temperature S/N	5600	5600
Conductivity S/N	3717	3717
Oxygen S/N	2415 (defect)	1818
Cond. misfit (in salinity units)	0.002	0.002
Oxygen misfit	- defect	0.86 μmol kg^{-1}

First results

The CTD sampling was concentrated on sampling interior / centre of mesoscale eddies. From daily maps of sea level anomaly (SLA) as well as absolute dynamic topography (ADT) (both obtained from AVISO) the position of eddies close to our cruise track where determined. According to the maximum/minimum in SLA the eddy centre position was estimated and the CTD casts performed. The Mulitnet cast was in most cases performed at 08:00 am Local ship time eventually being shifted to align the sampling with an eddy centre survey. With this technique 13 eddies were survey (Figure 5.1).

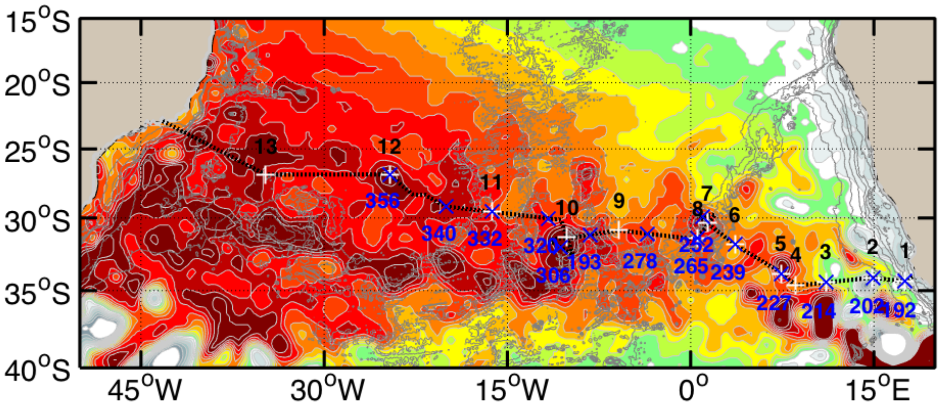


Fig. 5.2 M124 cruise track with numbers indicating the eddy surveys as derived from SLA/ADT satellite data. ADT contours from 10. March 2016 are shown as background (red high; greenish low). The numbers indicate RV METOR (blue) and consecutive CTD (black) stations numbering.

As can be seen below, in section 5.3 (Underway profiling – uCTD and XBT observations), the water mass structure along the track is very complex because we crossed different types of mesoscale eddies (cyclonic, anticyclonic, anticyclonic modewater). Therefore the water mass structure cannot be reconstructed based on the 14 CTD profiles we recorded. In fact, because we sampled preferentially in the eddies, a section created out of the CTD profiles would make the impression the hydrography along the track is much more "Indian Ocean" like, as this is the water mass characteristic found in the eddies. Instead we interpreted the T/S characteristics (Figure 5.3). In absolute numbers the largest hydrographic variability is seen in the upper 500 m (above 11°C; compare with Figure 5.6 and Figure 5.7) and in the Antarctic Intermediate Water (salinity minimum) range. Given that the profiles are taken in coherent eddies, this indicate the impact of the trapping of water masses in these oceanic features but other processes contribute as well. Interesting is the deep reaching anomalies in one eddy close to the western boundary that impacted even the North Atlantic Deep water range (2.5°C and above). The Vema Channel observations confirmed the long term warming.

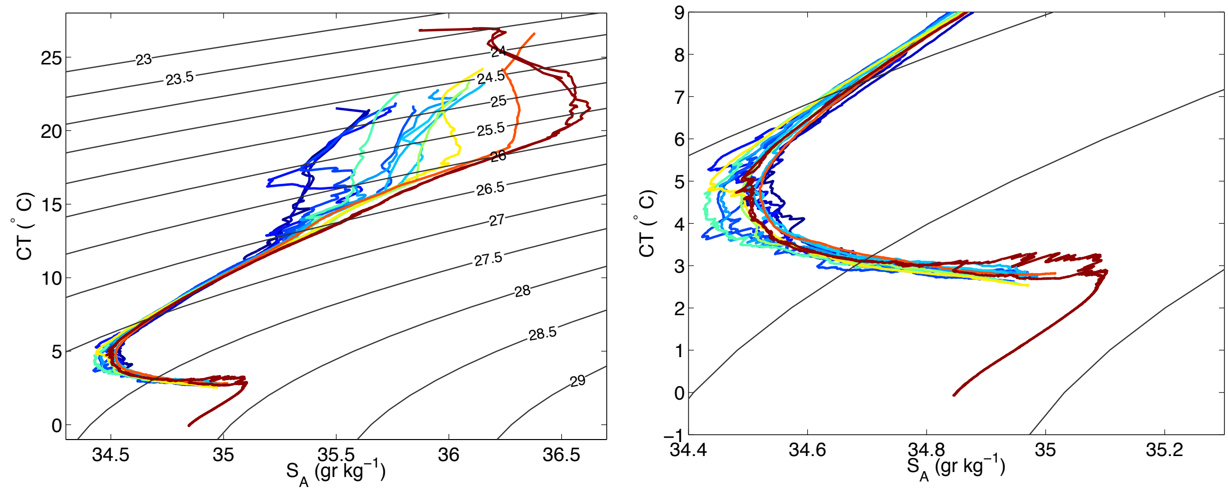


Fig. 5.3 Conservative Temperature/Absolute Salinity diagram of the CTD data: (left) full data set; (right) only intermediate (salinity Minimum) and deep water masses. The colour indicates qualitatively the longitude (east blue and west red) the profile was taken.

5.2 Oxygen Titration

(Jennifer Clarke, Felix Geißler)

Sampling Procedure

For the determination of the oxygen concentration in seawater (Winkler method), with the aim to calibrate the CTD, all depths were sampled in duplicates with ~ 100 mL wide necked glass bottles (matched pair of flask and stopper) from each CTD Niskin bottle in accordance to the Langdon (2010) and Dickson (1994). Immediately after sampling, the seawater samples were spiked from the bottom first with 1 mL NaI/NaOH, then with 1 mL $MnCl_2$. To ensure an entire oxygen fixation the flask was stoppered and shook vigorously for at least 20 seconds. All samples were kept in the dark for ca. 4 hours, shook again and sealed by adding water to the neck of the flask. After further ca. 4 hours in the dark the samples were titrated, based on a visual determination of the equivalence point based on colour changes.

Titration

All Winkler titrations, including the determination of the factor of the used sodium thiosulfate solution as well as the titration for the determination of the seawater oxygen concentration, were done according to the procedure set forth by Frank Malien (GEOMAR).

Determination of the thiosulfate factor

The determination of the factor of the sodium thiosulfate solution (~0.02 M) was done every day or for any freshly prepared sodium thiosulfate solutions. The average of five determinations was used to calculate the factor f and the real concentration c_{real} for the used sodium thiosulfate solution according to the following equations.

$$f = \frac{5}{V} \quad , \quad c_{\mathrm{real}} = \frac{0.1}{V} \text{ mol L}^{-1}$$

Where V is the average of the used sodium thiosulfate volumes of the five titrations in mL. Figure 5.4 shows the determined factor for each CTD cast.

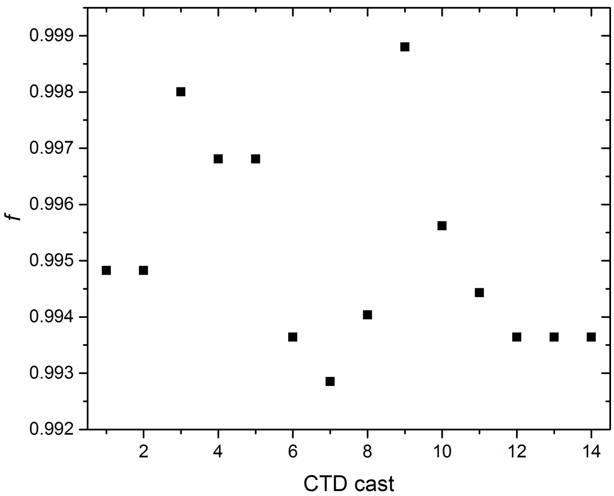


Fig. 5.4 Determined factor of ~0.02 M sodium thiosulfate for every CTD cast. Between cast #8 and #9 a new sodium thiosulfate working solution was prepared.

Determination of the seawater oxygen concentration

The used volume of sodium thiosulfate at the equivalence point, where the blue mixture turned into transparent was noted for the calculation of the oxygen concentration $c(O_2)$ in µmol·L^{-1} in accordance to the following equation:

$$c(\mathrm{O}_2) = \frac{a \cdot f \cdot 5000}{b - 2},$$

with the used volume a in mL as average of the sampled duplicates, the factor f of the sodium thiosulfate solution and the volume of the used glass bottle b in mL, which was find in a specific table for each pair of stopper and flask.

During the titration and sampling procedure several problems occurred, which affected the calculated oxygen concentration. During the spiking of the samples the tubing of the NaI/NaOH dispenser popped off and fell into the sample. If this happened the spiking was proceeded without NaI/NaOH tubing. The titrated volume of the flasks including the tubing was always higher than the corresponding duplicate and was not taken into account for the calculation of the oxygen concentration. Another issue during the titration were air bubbles in the titration capillary which falsified the value of the used sodium thiosulfate solution. In this case the respective titrated sample was not taken into account for the determination of the oxygen concentration as well as over-titrated samples, where the zinc iodide starch solution was added to late (after reaching the equivalence point).

As a first check the seawater oxygen concentration for two depth at 5 m and 2000 m with the corresponding standard deviations was plotted (Figure 5.5). During the cruise M124 the surface oxygen concentration is decreased while the oxygen concentration at 2000 m is increased with steaming westwards.

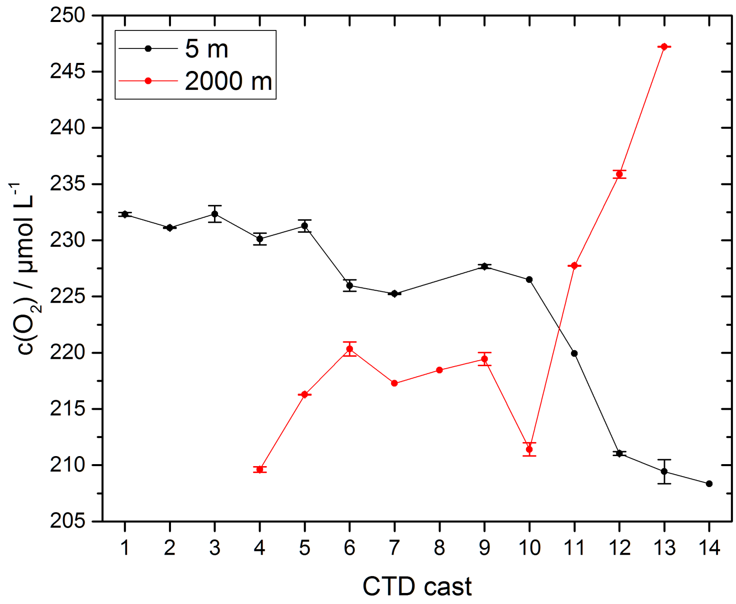


Fig. 5.5 Calculated seawater oxygen concentration for 5 m and 2000 m based on the Winkler titration method.

5.3 Underway profiling – uCTD and XBT observations

(Y. Fu, J. Karstensen, S. Speich)

During M124 cruise, underway CTD (uCTD) data were collected from 29 February to 17 March. The uCTD system was used to measure the temperature and salinity in the upper 450 m throughout most of the section. The primary interest is to investigate the T-S structures and variability within the cyclonic and anti-cyclonic eddies along the cruise track. In total, 288 profiles with an averaged spacing of 23 km and averaged depth of 480 m (maximum 800 m) were recorded at roughly 1-hour temporal resolution (Figure 5.6). The measurement was conducted while the ship was steaming at an averaged speed of 11 kn across the southern Atlantic Ocean.

The uCTD consists of a probe, a tail and a winch. One temperature, conductivity and pressure sensor from SeaBird are installed inside the probe. The sensors records data at a frequency of 16 Hz. For most of the profiles, 500 m of rope were spooled on the tail, and the recording time during the dive was manually controlled at about 120 seconds, which led to 1920 recordings per downcast and an averaged vertical resolution of ~ 0.25 db.

During the survey, 3 uCTD probes (SN #70200155 #70200195 and #70200238) and 2 winches (W1 and W2) were used. The probe #155 was only used for the first three profiles, because its conductivity sensor was broken, and the salinity data for these three profiles are not usable. Since the 4th profile, probe #195 and #238 were deployed alternatingly. Loose spooling of the rope on the tail was a problem during the operations, which often led to rope knots on the recovery of the probe due to the large tension on the rope. At one point, both of the winches were not functioning, due to a broken piece close to the motor, so that the rope could not be paid out freely from the winch when the probe dived. One of the winches (W2) was fixed by our engineer, and it remained functioning till the end. To counteract a lagged response of temperature sensor relative to the conductivity sensor and the impact of vertical diving speed, a preliminary calibration was applied to the salinity data. The calibration model we used is:

$$lag = \frac{1}{16} \times [1.7 - \frac{1.8}{w}],$$

where, *w* is the diving speed of the probe. This lag relation is fitted from all the uCTD data recorded during previous surveys. Other calibration models will be applied later (Fu et al., 2017).

On the 4th March we did a first lab test with the RapidCast system, provided for field-testing by Teledyne Oceansciences. The company was interested in conducting a test of the recently developed system during M124 regarding general performance but also in comparison with uCTD and XBT systems. The RapidCast is a winch system like the uCTD but with a lot more control on motor heating and robe tension. On the 7th March the system was tested with a probe and in water with the ship moving with 10kn. Due to a wrong setting in the interface a too long robe was spooled out and the system was overloaded when attempting to rewind the robe. The wire had to be rewinded by hand. After communication with Teledyne Oceansciences it was decided that the RapidCast could not be used further during M124.

XBT observations

Less high resolved but measuring to deeper depth then the uCTD, in total 161 Deep-Blue T7 Expandable Bathythermograph (XBT) temperature profiles were collected during the cruise. The probes were launched with MK21 (S/N 246) owned by the RV METEOR and the data was recorded with the software WinMK21 v3.02. Unfortunately the NMEA data input failed and position data was missing in the raw files. At a later stage this information was added in the processed files. In comparison to the uCTD, the XBT reach about 300 m deeper, to about 750 m depth.

First results

The XBT (Figure 5.6) and uCTD (Figure 5.7) provide a very detailed picture of individual eddies surveyed during the cruise (see Figure 5.2 for an overview). The temperature and salinity sections show the upper layer structure of these eddies in greater detail. Three anticyclonic Modewater eddies where surveyed (denoted A2, A3, A4) and A2 and A3 also showed a clear low stability mode (N^2) centred at 200 m depth (Figure 5.7, lower). For A4 some indication for low N^2 exist but problems with the uCTD occurred at that time. The XBT data however shows a thermostat. See also the section on ADCP data (section 5.4) for the velocity structure of the eddies.

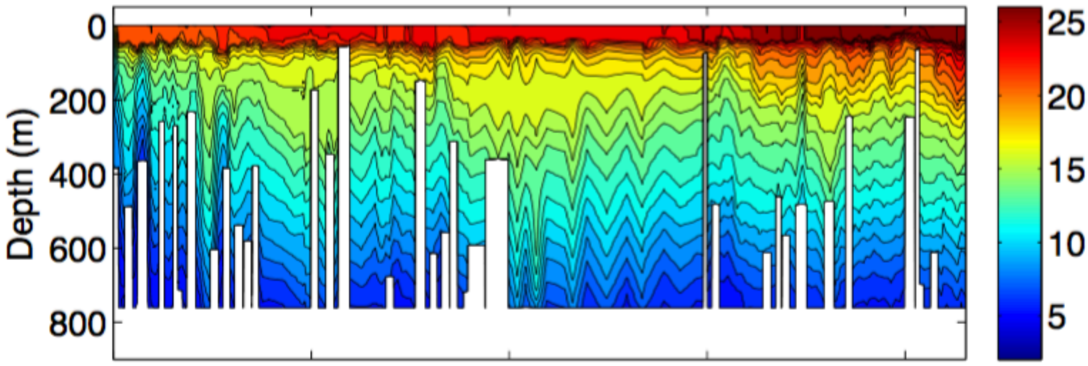


Fig. 5.6 Temperature section from XBT profiles (Africa on left, EEZ Brazil on right).

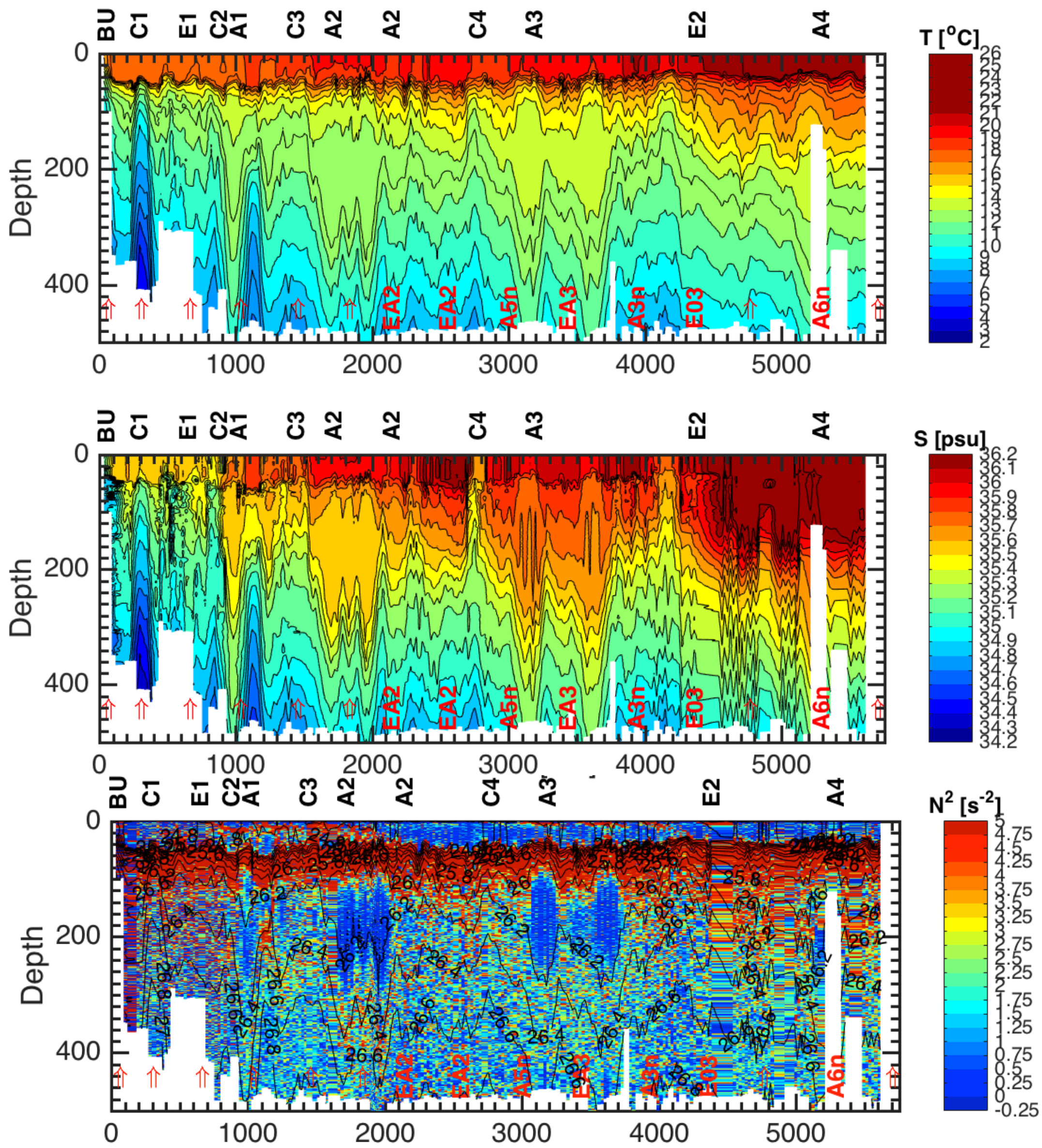


Fig. 5.7 uCTD temperature (upper), salinity (middle), and buoyancy frequency (N^2) (lower) during M124. Africa on left, EEZ Brazil on right. Abbreviations: BU Benguela upwelling; C Cylon; A Anticyclone; E Waypoints.

5.4 Underway Shipboard ADCP (Acoustic Doppler Current Profiler)

(Eike Koehn, Johannes Karstensen)

Underway current measurements were carried out using the Ocean Surveyor (OS) ADCP system of R/V METEOR. It comprises two transducers pinging at different frequencies: The 75 kHz transducer (SN: 2175) is built into the ship's hull at the bow, whereas the 38 kHz transducer (SN: 1214) is installed in the moon pool in the centre of the ship. Both transducers are located approximately 5.5 m below the sea surface. To avoid interferences between the instruments the 75 kHz transducer is mounted at a 45° degree angle, while the 38 kHz transducer has approximately 0° alignment.

The OS38 was set up to measure in the Narrowband (NB) mode with a vertical bin size of 32 m. The instrument's range gradually decreased throughout the cruise from approx. 1200 m to a maximum of 1500 m. The OS75 was originally set up to measure in the Broadband (BB) mode with a vertical bin size of 8 m. With this set up a range of 600 m was reached. However, during parts of the cruise the data quality dropped around 300 m, so that a change to NB mode for the OS75 was conducted (see ADCP-log below). As a result, the range slightly increased to 700-800 m, while the noise level increased. The attempt to go back to BB mode at a later point was aborted after a short time, as the data quality remained poor around the 300 m depth level.

To set up the ADCP and for data acquisition the vmDAS software was used. Navigational data was continuously obtained from the NMEA system. From March 13, 09:00 UTC to March 14, 17:00 UTC the DGPS signal was lost (only GPS data was available), so that the error of positioning increases, affecting the data quality. However, the effect seems to be only minor.

Tab. 5.2 ADCP-Log. List of events during M124 related to ADCP measurements.

Day	Time (UTC)	Event
February 29	16:00	Initialization of ADCP measurements after leaving South African Waters
March 2	05:44	OS38: does not work upon regular check, restarting the data collection
March 10	15:56	OS75: change from BB to NB
March 12	16:02	OS75: change back from NB to BB
March 13	09:00	DGPS signal lost
March 13	14:20	OS75: change from BB to NB
March 14	17:00	DGPS signal back
March 17	02:00	End of measurements upon reaching Brazilian EEZ

During steaming, none of the other active acoustic systems lie in the same frequency range as the ADCP systems. However, the old Doppler Log (DOLOG) system, required for the deployment of the Multinet (Foraminifera), uses 79 kHz and interferes with the OS75. Data quality on Multinet (and CTD) stations dropped significantly. After leaving South African waters on February 29 the measurements were initialized. Upon entering the Brazilian EEZ on the night from March 16 to March 17, the logging was stopped. A summary of events is found in table 5.2.

First results

The ADCP section is dominated by strong variability in the currents that rise from the eddy surveys (see also Figure 5.2; Section 5.1 and Figure 5.8). In particular the anticyclonic Modewater eddies are characterized by a baroclinic velocity structure with a subsurface velocity maximum of more than 0.5 m s^{-1} at about 100 to 200 m depth. The vertical "layering" in the velocity structure, as seen in the two left panels in Figure 5.9, is visually enhanced by subtracting a vertical box car filtered field (120 m filter length; right panel) from the original time series. It shows a connection between the mixed layer base and the centre of the region deep (about 400 to 600 m) below the eddy indicating the downward propagation of near-inertial internal waves (e.g. Lee and Niiler, 1998; Karstensen et al. 2016).

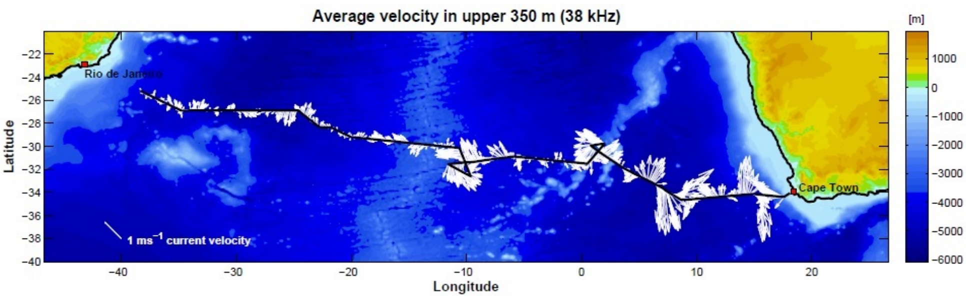


Fig. 5.8 Average current velocities in upper 350 m from 38 kHz ADCP along the M124 cruise track.

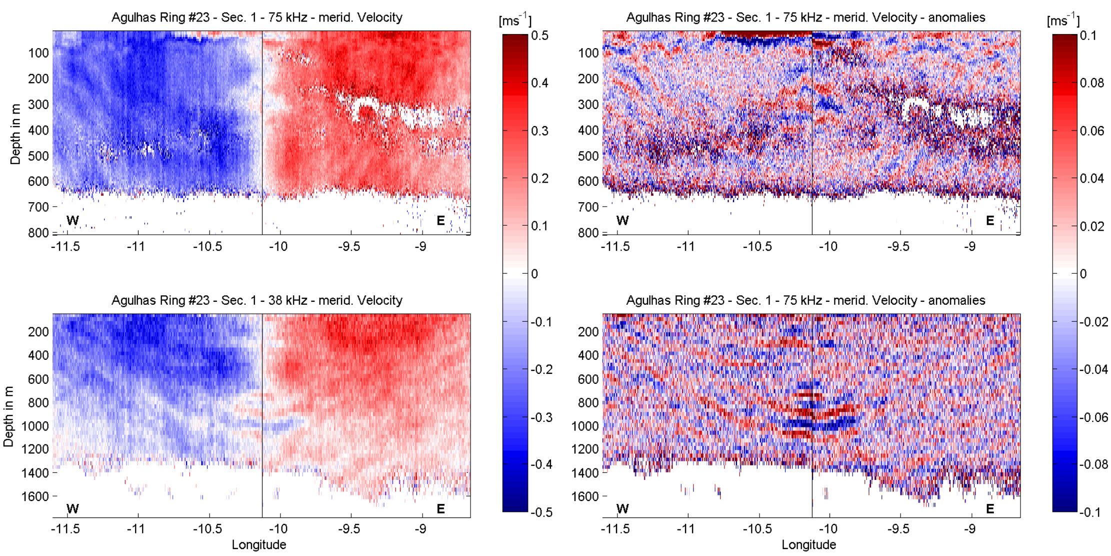


Fig. 5.9 Meridional velocity and anomaly field for first (East-West) section through Agulhas Ring #23 (A3 in Figure 5.2) 75kHz (upper panels) and 38 kHz (lower panel). The anomalies (two left panels) are calculated with respect to a vertically box car average (15 and 7 bins for 75 and 38 kHz respectively) of the velocity field.

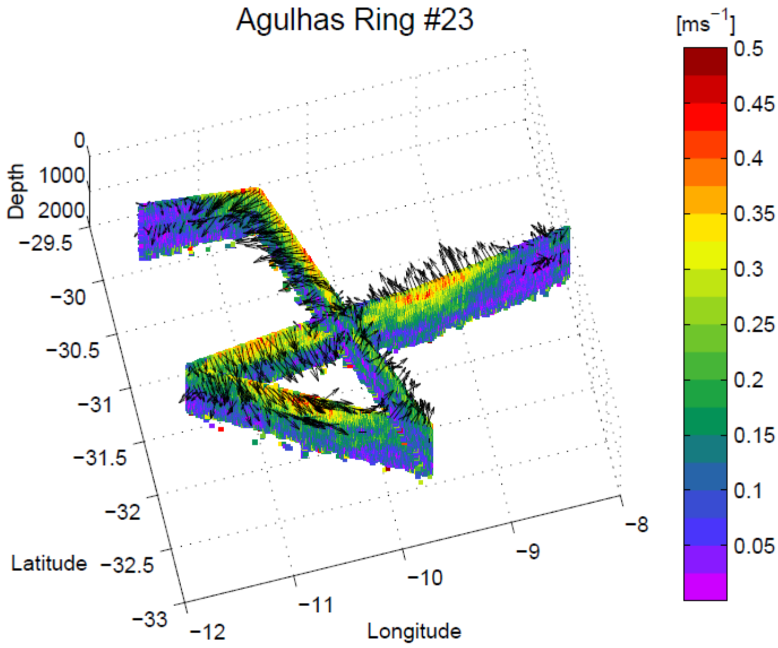


Fig. 5.10 Velocity section from 38 kHz ADCP through the Agulhas Ring #23 (A3 in Figure 5.2). The contour colour indicate the velocity magnitude, the arrows the direction.

A pseudo 3-d plot of the Agulhas Ring A3 (Figure 5.10) nicely reveals the anticyclonic (southern hemisphere) rotation of the eddy. The eddy rotation is deep reaching and below the depth range resolved by the 38kHz ADCP, which is at about 1300 to 1500 m.

5.5 Air and Water Sampling for Analysis of Persistent Organic Pollutants

(Anne Scherhag)

Persistent organic pollutants (POPs), mostly originated from atmospheric long-range transport, should be analyzed in surface water samples using an "active" passive sampler system. The system permanently pumps surface seawater along silicon rubber sheets. In parallel the POPs are sampled in air, based on parallel air sampling with a Digital high volume sampler DH-77. Both instruments were installed on the R/V METEOR as described below. All sample analysis will be performed after shipment of the samples to the lab (University of Mainz).

Passive Sampling of POPs dissolved in seawater

For seawater sampling during R/V METEOR expedition M124, an "active" passive sampler system was installed in the wet lab under deck. Surface seawater was permanently pumped from an under-keel seawater jet to the laboratories. Starting on 29th February at 17:00 UTC, two seawater taps (membrane pump) were used at the same time, using a T-split to connect them, to constantly fill a 200L stainless steel barrel (see Figure 5.11). One tap can provide approximately 1 L/min, so ~2L/min was used as constant flow. The sampling started after flushing the barrel for 2h with the seawater. For the outflow, a large diameter hosepipe was used to ensure an appropriate level of seawater in the barrel. The barrel was fixed to the wall with several ropes. In the barrel, a submersible pump was used to produce a water jet along a sampler to enrich hydrophobic compounds. Each sampler consists of four Altesil silicon rubber sheets (each with dimensions 7 cm x 28 cm and 0.5 cm thickness). Two temperature loggers were used during sampling to retrieve the actual temperature in the barrel. The samplers were meant to accumulate hydrophobic compounds from the dissolved phase during their exposure to seawater. In addition, they were spiked with performance reference compounds (PRCs) for partial release during exposure to determine the water flow. The water sampling period was 3.5 days for each sampling stretch (last sampling stretch only 2.5 days), covering the distance from Cape Town to Rio de Janeiro with 5 samples. In total four field blanks were used when handling the samples.

Fig. 5.11 Stainless steel barrel for passive sampling of organic pollutants dissolved in seawater

A clean workspace was prepared with aluminium foil every time before changing the filters. After the sampling, the silicon rubber sheets were cleaned with seawater and dried with lint-free paper tissues. All samples and field blanks were stored at -20°C. Before shipping, the device was cleaned with freshwater and dried with lint-free paper tissues.

No problems occurred during the sampling periods. The samplers were continuously exposed to the surface seawater during the whole trip. When the ballast water of the ship was released on 4th March, the sampling was not stopped, since the ship was still moving during this time and the surface seawater was retrieved from the front of the ship. Therefore, no interference with the sampling should have occurred.

High volume sampling in air

For air sampling, a high volume sampler DH-77 (Digitel, Volketswil, Switzerland) was used with a PM_{10} sampling head (Figure 5.12). The device was fixed in the front part of the ship, directly under the bridge (3^{rd} superstructure deck, 12.8 m above the water) i.e., during normal motion, freely advectable and protected from the chimney. Air filters were changed daily around sunrise, so the sample period was 24h (or 2x12h if water samplers were changed in the evening to ensure comparable results between air and water sampling). For sampling, each 2 PUF plugs (in total 12 cm depth) and 1 QMA filter (Whatman) were used. A clean workspace was prepared with aluminium foil every time before changing the filters. When changing the filters, everything was prepared in an under-deck laboratory and transported to the device using aluminium foil as protection from contamination. The samples and field blanks were stored at -20°C.

Fig. 5.12 Digital High Volume Sampler (view from bridge)

Normally, the PUF plugs changed their colour from white to light yellow during exposure, whereas the QMA filters remain white. On several dates, a grey colour was observed on the QMA filters. The changes on one date can, at least partially, be explained with changes in air composition. More aerosols were observed as well as a higher humidity. The other colour changes still have to be evaluated. On several days, the chimney was blowing in the direction of the sampler but mostly with no effect on the colour of the filters. The air of the chimney was detected on a higher level above the bridge, so a possible contamination cannot be excluded and should be considered for data interpretation, but is not proven. In addition, on one day, a smoker was observed two decks below the device (1^{st} superstructure deck) and which should be considered, too.

5.6 Multiple Plankton Sampler Cast

(R. Morard, A. Baumeister, R. Reuter, B. Lübben, MARUM)

The main Planktonic foraminifera were collected for genetic and habitat characterization using a Multiple Plankton Sampler (MPS, HydroBios, Kiel) with 50x50 cm opening, 100 µm mesh size and 5 cod-ends, which allowed sampling 5 different depths per haul. A total of 17 stations have been sampled for a total of 54 MPS casts (Table 5.3). Two different MPS casts were performed during the cruise, a shallow cast with depth intervals 100–80 m, 80–60 m, 60–40 m, 40–20 m, 20–0 m and a deep cast with depth intervals 700–500 m, 500–300 m, 300–200 m, 200–100 m, 100–0 m. This sampling scheme provides a nine-level resolution of the water column with spare bulk sample for the 100–0 m level. At 11 stations 2 shallow and one deep casts were performed and at 5 stations the entire sampling scheme was replicated. It was done in order to constitute a parallel sampling for counting and metagenomic analysis (see below). The full replication was done at fewer stations because of time limitation. At station 192 only 1 shallow MPS cast was done to test the equipment.

Tab. 5.3 Station List where the MPS have been deployed. The number of samples recovered and each station is provided.

Station Ship Number	**Latitude**	**Longi-tude**	**Date**	**Deep Cast**	**Shallow Cast**	**Filtered Samples**	**Live specimen**	**Empty shell**	**Total**
192	33.27	-34.39	29/02/2016	0	1	0	395	57	452
202	56.47	-34.13	01/03/2016	1	2	6	306	43	349
214	5.18	-34.45	02/03/2016	1	2	6	338	137	475
227	23.22	-33.88	03/03/2016	1	2	6	245	48	293
239	37.54	-31.88	04/03/2016	1	2	6	501	195	696
252	0.78	-29.92	05/03/2016	1	2	6	146	89	235
265	34.86	-31.41	06/03/2016	1	2	6	274	55	329
278	34.31	-31.10	07/03/2016	1	2	6	586	107	693
193	13.30	-31.17	08/03/2016	1	2	6	1291	131	1422
306	40.06	-32.05	09/03/2016	1	2	6	867	152	1019
320	39.52	-30.03	10/03/2016	2	2	11	1082	277	1359
332	16.76	-29.56	11/03/2016	2	2	11	1332	376	1708
344	3.15	-29.18	12/03/2016	2	2	11	1472	238	1710
356	37.64	-26.87	13/03/2016	2	2	11	926	194	1120
370	41.42	-26.88	14/03/2016	1	2	6	1957	245	2202
382	53.18	-26.89	15/03/2016	1	2	6	1001	120	1121
394	7.01	-26.25	16/03/2016	2	2	11	436	172	608
			Total:	**21**	**33**	**121**	**13155**	**2636**	**15791**

For all deployments, the MPS was slacked with all the nets closed to avoid contamination. The slacking was done at a speed of 0.5 $m.s^{-1}$ and stopped when the rope length equalled the lowest depth plus 10 to 20 meters to account the angle of the rope. The MPS was hoist at a speed of 0.5 $m.s^{-1}$ and the successive closing/opening depth level were automatically triggered by an in-house software running under MATLAB 2011b based on the absolute depth determined by the pressure sensor of the MPS. Rough sea was encountered at station 265 and the hoist speed was reduced at 0.3 $m.s^{-1}$ to reduce the tension on the nets. The triggering was activated 2.5 meters before the MPS reached a given depth-level to account for the time needed for the net to open/close. For 2 MPS deployment at stations 202 and 302, the opening and closing of the nets was done manually because of connectivity problems between the software and the controlling unit of the MPS. After each hauls, the nets were carefully rinsed using seawater (Figure 5.13). The collected plankton was recovered in the cod-ends and brought to the lab and empty cod-ends were mounted on the MPS for the next cast. The sampling process was thus repeated until the station work plan was completed. At the end of each station the MPS was carefully rinsed with soft-water and the nets were inspected to ensure that they have not been damaged during the deployment.

In addition to the MPS sensor necessary read the pressure and activate the opening/closing of the nets, a CTD was mounted on the MPS to measure physical and chemical characteristics of the water column (Temperature, Salinity, Oxygen, Chlorophyll-a, PH) during the cast. The CTD was set on a recording mode to make measurement every second. The CTD was switched on before starting the operation and was running during the whole station. The data were downloaded to a notebook at the end of the operation.

The recovered plankton samples were transferred from the cod-end to glass cups. The cod-ends were carefully rinsed with filtered seawater several times to ensure that all planktonic particles were recovered. After having recovered each sample, the cod ends were rinsed thoroughly under freshwater and cleaned into an ultrasonic bath to remove the finest planktonic particles that may clog the mesh.

Sample Processing

From the 15 samples for each station, 6 have been filtered for metagenomic analysis (0-20, 20-40, 40-60, 60-80, 80-100 and 0-100m) and 9 were processed for single-cell genetic analysis and ecological inferences (0-20, 20-40, 40-60, 60-80, 80-100, 100-200, 200-300, 300-500 and 500-700m).

Filtration for metagenomics analyses

Filtration was carried out using 3 funnels of 500mL mounted in series and connected to a pump and a vacuum bottle (Figure 5.13). Before each collection, every part of the filtration system in contact with the sample were washed using 96% ethanol and freshwater to eliminate potential contaminants. After cleaning, a filtration membrane of 47mm and 20µm mesh size were placed on the gasket using sterile tweezers and the funnel was screwed on top of it. The samples were then poured from the glass cups into the funnels and the glass cups were then rinsed several times using filtered sea water to ensure than no particles remained into it. After the three first samples were ready, the pump was switched on and the samples filtrated through the membrane. After the entire sampled passed through the membrane, the pump was switched off and the filters folded and disposed into sampling bags and frozen at -80°C. After the first set of samples was processed, the filtration system was cleaned and the rest of the sample processed following the same procedure. The entire process took less than 2 hours for all the sampled material after collection. 121 samples in total have been filtered during the cruise.

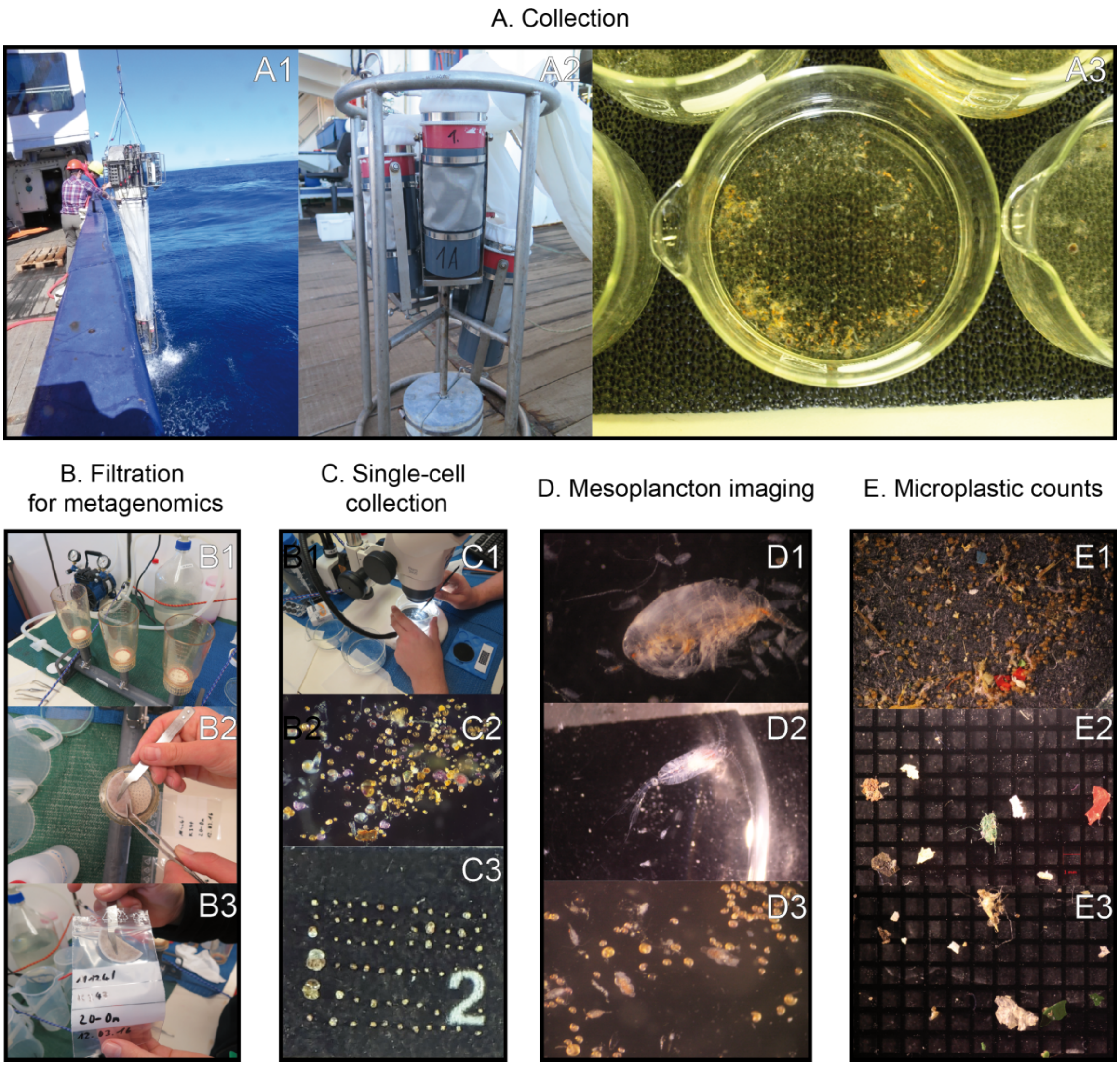
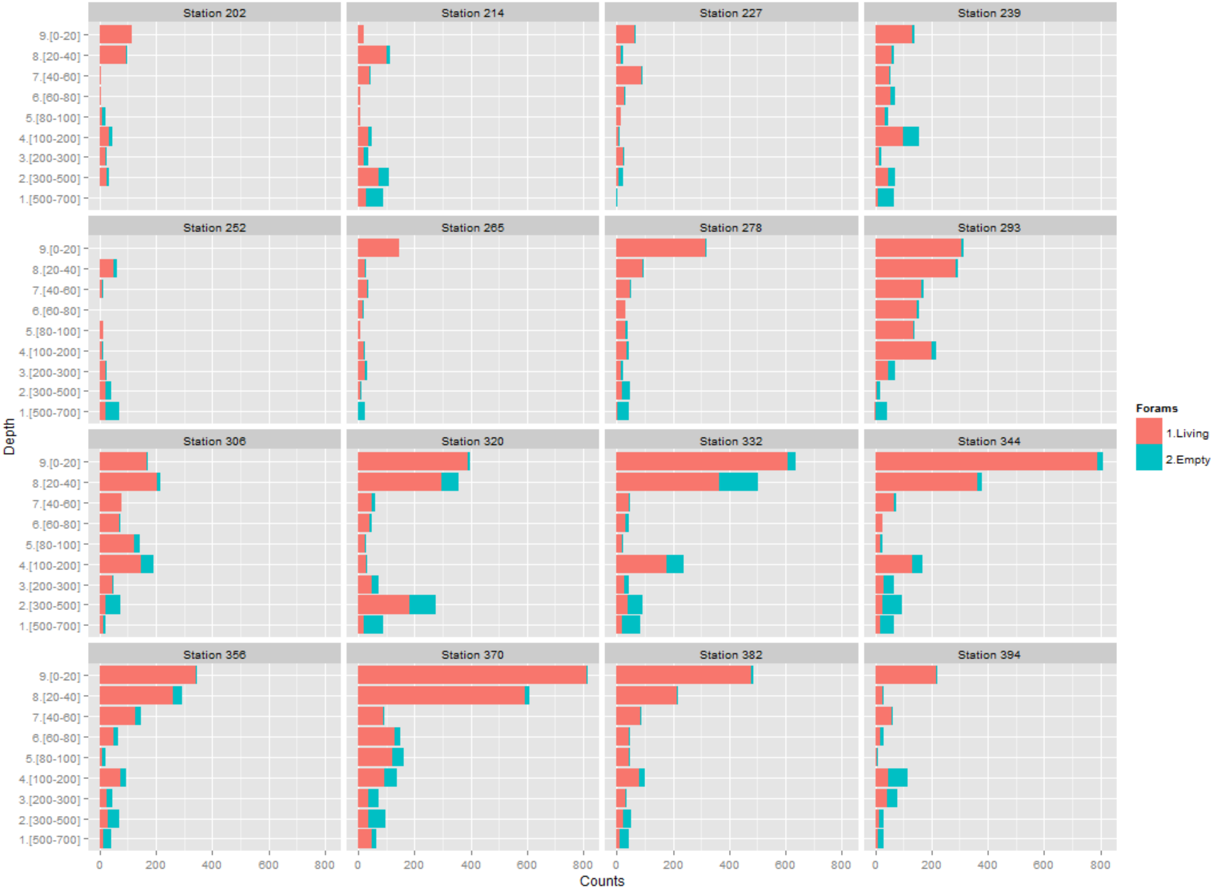


Fig. 5.13 Worklflow for plankton collection and processing during the cruise M124. (A1) Rising of the net after the bas, (A2) Cod-ends, (A3) Glass cup containing plankton sample, (B1) Filtration apparatus, (B2) Folding of the filter membrane after filtration, (B3) archiving of the processed sample, (C1) Picking of planktonic foraminifera under Stereo microscope, (C2) concentrated plankton sample, (C3) planktonic foraminifera sorted onto micropaleontological slide, (D1-D3) mesoplankton imaging, (E1) filtered sample for microplastic sampling (E2-E3) microplastic particles.

Single cell collection

The samples dedicated for census counted were swirled to concentrate the planktonic foraminifera in the middle of the dish and separate them from the major part of the zooplankton and organic particles. The planktonic foraminifera were pipetted out on a filter and transferred onto micro paleontological slides with a brush. All small patches of planktonic matter were also checked to pick exhaustively all foraminifera. Planktonic foraminifera were separated using clean brushes and needles under stereo microscopes to avoid cross-contamination between individuals on the cardboard slides. When each cardboard was fully covered with foraminifera the total number of picked individuals was reported separating the shell bearing cytoplasm and those completely empty (Table 5.3). The cardboard slides were air-dried during at least one hour and stored at –80°C. For all stations, except for the station 192 which has been carried out in the evening, all the samples have been processed during one working



day (Figure 5.14). The samples of the station 192 have been partially processed and the plankton residues have been placed into sampling bag and frozen. 15,791 single planktonic foraminifera have been collected during the cruise

Fig. 5.14 Summary of the collection of single cell planktonic foraminifera during M124 cruise for the station where the samples have been entirely processed (All except station 192). Each graph represent the living and dead specimens recovered for the 9 depth sampled.

5.7 Investigation of Fe biogeochemistry and utilization by marine diazotrophs

(Evangelia Louropoulou, Tim de Groot)

Marine diazotrophs are responsible for the conversion of the atmospheric N_2 to biologically accessible forms of nitrogen. A key issue for them is the need for iron, which is present at very low concentrations in open ocean surface waters. Iron is contained in nitrogenase complexes that catalyse the reduction of N_2 to fixed (reduced) nitrogen as well as in photosynthetic proteins in PSI, PSII and cytochrome b6f. The objective of this study was to assess the activity, abundance as well as the diversity of marine nitrogen fixers in the area of the Subtropical South Atlantic Ocean in relation to iron and nutrient availability. The South Atlantic Ocean is relatively under-sampled compared to other oceanic regions and limited field data exist that link diazotroph diversity and nitrogen fixation activity with iron. Another aspect of this study is the investigation of key iron proteins and the genes encoding them in order to identify differences in their expression patterns according to Fe availability.

Methods - Cruise Experiments

During the research cruise M124 we performed sampling of seawater from the CTD rosette equipped with Niskin Bottles and underway almost every four hours using the Towed FISH seawater sampler (Figure 5.15). The overall data set will provide a spatial (both horizontal and vertical) distribution of the key biogeochemical parameters and information on the activity and abundance of diazotrophs throughout the Subtropical South Atlantic Ocean. The sampling stations are presented in Tables 5.4 and 5.5. In total 13 CTD and 65 FISH stations were sampled during the research cruise.

The samples were treated immediately after their collection for the determination of heme b contents of the marine particulate matter, trace metals (both dissolved and particulate), nutrients, particulate organic nitrogen and carbon and chlorophyll a. Additionally, on-deck incubations were carried out in order to determine the nitrogen fixation rates and primary productivity in the South Atlantic Ocean following the method proposed by Groszkopf et al. (2012). The 11 stations for which incubations were carried out are presented in Table 5.6. Finally, seawater samples were also filtered for DNA and RNA analysis, in order to investigate the genes encoding key Fe-proteins and their expression patterns (e.g. nifH, PSaC, PsbA and cytochrome b6f).

It should be noted that no data were produced during the research cruise and analysis of all the samples obtained will be carried out upon return in the laboratory.

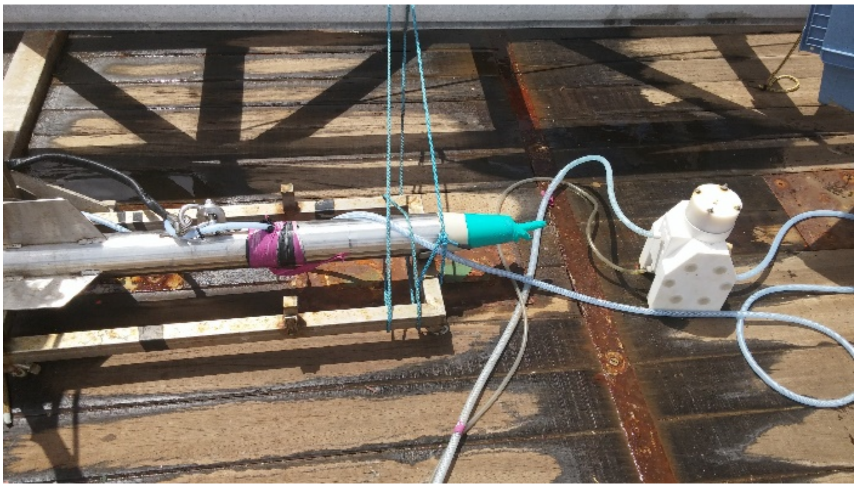


Fig. 5.15 Towed FISH for seawater sampling

Sample Treatment

Heme b

A volume of 2L of seawater was collected either from the CTD rosette or the FISH. The sample was then vacuum filtered in 25mm MF300 GF/Fs, placed in eppendorfs and stored in -80°C freezer on board prior analysis (Gledhill et al., 2013).

Chlorophyll a

A volume of 500 mL of seawater was collected either from the CTD rosette or the FISH. The sample was then vacuum filtered in 25mm MF300 GF/Fs, placed in eppendorfs and stored in -80°C freezer on board prior analysis. Analytical technique that will be used is fluorescence (Welschmeyer, 1994).

POC/N

A volume of 500 mL of seawater was collected either from the CTD rosette or the FISH. The sample was then vacuum filtered in pre-ashed (at 450°C for 5h) 25mm MF300 GF/Fs. The filters were placed in petri dishes and left to dry in the oven at 40°C overnight (Poulton et al., 2006).

Trace metals

A volume of 125 mL of seawater was collected from the trace-metal-free Towed FISH under a laminar flow hood for the determination of total trace metal content. Another 125 ml were collected using a pre-installed filter inside the laminar flow hood for the determination of dissolved trace metals. Samples were stored in room temperature without acidification.

Nutrients

A volume of 20 mL of seawater was collected either from the CTD rosette or the FISH. The sample was syringe filtered through 0.45um cellulose acetate filters. Samples were stored in -20 oC freezer.

DNA-RNA

Seawater was collected either from the CTD rosette or the FISH. A volume of 0.5 to 2L of seawater was vacuum filtered through 0.2 um PES filters, 47mm diameter depending on the biomass of each sample. The time of filtration was under 20 minutes and the pressure of the vacuum pump did not exceed the 200 mbars (Loescher et al., 2014). For RNA, ¾ of the filter were moistened with RNA-later and placed in eppendorfs whereas the rest ¼ of the filter was saved in a second eppendorf for DNA analysis. Both were Flash-frozen with Liquid Nitrogen and stored in -80°C prior analysis (Loescher et al., 2014).

Nitrogen Fixation Rates

In order to quantify nitrogen fixation rates by marine cyanobacteria in seawater samples, the technique was divided in two stages. First, the enriched in N-15 seawater was prepared. Seawater was collected from 5 m depth from the Towed FISH sampler and filtered using the pre-installed filter inside the laminar flow hood. The sample was degased after continuous recirculation through a membrane flow through system using both a peristaltic and a vacuum pump. After 2 hours of circulation, the sample was collected bubble free into a Tedlar bag and N2-15 gas was added using a syringe to the Tedlar bag. The gas was dissolved and the bag was kept in the 4°C refrigerator.

The incubations were carried out after sampling seawater from towed FISH; 4,5L in Naglege Bottles in triplicates. 100ml of the prepared N2-15 seawater and 1 ml from C13-HCO3- solution were injected to each incubation bottle. The bottles were placed in an incubator (on the deck) with ambient surface seawater flow-through and left there for 24h. After 24h, each bottle was filtered and handled for POC/N analysis as described in the section 1.3 and for DNA-RNA analysis as described in the section 1.6 (Mohr et al., 2010; Groszkopf et al., 2012).

Tab. 5.4 Station List Seawater Sampling Stations from the CTD rosette

STATION	LATITUDE	LONGITUTE	DATE	TIME UTC	DEPTHS (m)	PARAMETERS
CTD 1	34°23.303'S	17°33.387'E	29/2/2016	19:15	15; 45; 75; 150; 100; 320	Heme, chl, POC/N, DNA, RNA, nutrients
CTD 2	34°07.963'S	14°57.492'E	1/3/2016	11:15	5; 15; 45; 75; 150; 300	Heme, chl, POC/N, DNA, RNA, nutrients
CTD 3	34°27.241'S	11°05.176'E	2/3/2016	9:30	5; 15; 45; 75; 150; 300	Heme, chl, POC/N, DNA, RNA, nutrients
CTD 4	34°37.497'S	08°37.509'E	2/3/2016	23:20	20; 45; 75; 130; 300	Heme, chl, POC/N, DNA, RNA, nutrients
CTD 5	33°52.691'S	07°22.462'E	3/3/2016	7:30	20; 45; 75; 150; 300	Heme, chl, POC/N, DNA, RNA, nutrients
CTD 6	31°52.504'S	03°37.542'E	4/3/2016	9:30	20; 45; 75; 105; 150; 300	Heme, chl, POC/N, DNA, RNA, nutrients
CTD 7	30°22.510'S	01°22.554'E	5/3/2016	0:45	5; 20; 45; 80; 120; 300	Heme, chl, POC/N, DNA, RNA, nutrients, incubation water
CTD 8	31°24.323'S	00°34.984'E	6/3/2016	10:45	20;45;75;100; 150; 300	Heme, chl, POC/N, nutrients
CTD 9	30°52.64'S	05°53.36'W	7/3/2016	22:00	20; 45; 90; 130; 300	Heme, chl, POC/N, DNA, RNA, nutrients
CTD 10	31°22.487'S	10°07.497'W	8/3/2016	20:00	20; 45; 90; 150; 320	Heme, chl, POC/N, DNA, RNA, nutrients
CTD 11	29°33.002'S	16°17.341'W	11/3/2016	10:00	20; 45; 75; 105; 300	Heme, chl, POC/N, DNA, RNA, nutrients
CTD 12	26°52.449'S	24°37.637'W	13/3/2016	13:00	20; 45; 75; 120; 300	Heme, chl, POC/N, DNA, RNA, nutrients
CTD 13	26°53.152'S	34°06.044'W	15/3/2016	17:00	20; 45; 75; 100; 300	Heme, chl, POC/N, DNA, RNA, nutrients

Tab. 5.5 Station List Seawater Sampling stations underways – Towed fish

STATION	LATITUDE	LONGITUTE	DATE	TIME UTC	Parameter
F1	34°30.421'S	10°29.003'E	2/3/2016	14:49	n fixation water
F2	34°34.229'S	09°45.066'E	2/3/2016	18:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F3	34°36.992'S	08°54.870'E	2/3/2016	22:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F4	34°31.825'S	08°27.971'E	3/3/2016	1:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F5	34°05.59'S	08°44.24'E	3/3/2016	5:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F6	33°36.848'S	07°02.340'E	3/3/2016	9:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients, incubation water
F7	33°22.594'S	06°35.210'E	3/3/2016	13:00	n fixation water
F8	33°14.038'S	06°18.237'E	3/3/2016	17:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F9	32°49.108'S	05°28.822'E	3/3/2016	21:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F10	32°25.641'S	04°42.504'E	4/3/2016	1:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F11	32°02.157'S	03°56.359'E	4/3/2016	5:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F12	31°27.866'S	03°00.206'E	4/3/2016	13:36	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F13	30°32.500'S	01°19.465'E	5/3/2016	0:57	Heme, chl, POC/N, DNA, RNA, tm, nutrients + n fixation water
F14	31°09.149'S	00°49.981'E	6/3/2016	6:05	Heme, chl, POC/N, DNA, RNA, tm, nutrients, incubation water
F15	31°29.127'S	00°21.033'E	6/3/2016	14:05	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F16	31°24.166'S	00°29.741'E	6/3/2016	18:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F17	31°19.252'S	01°19.924'W	6/3/2016	22:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F18	31°14.410'S	02°09.403'W	7/3/2016	2:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F19	31°00.367'S	04°32.517'W	7/3/2016	14:25	Heme, chl, POC/N, DNA, RNA, tm, nutrients, incubation water
F20	30°55.234'S	05°24.735'W	7/3/2016	18:15	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F21	30°59.380'S	06°47.469'W	8/3/2016	2:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F22	31°06.146'S	07°41.555'W	8/3/2016	6:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F23	31°10.467'S	08°14 'W	8/3/2016	10:10	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F24	31°18.675'S	09°08.775'W	8/3/2016	14:30	Heme, chl, POC/N, DNA, RNA, tm, nutrients, incubation water
F25	31°22.282'S	09°51.047'W	8/3/2016	18:08	Heme, chl, POC/N, DNA, RNA, tm, nutrients

STATION	LATITUDE	LONGITUTE	DATE	TIME UTC	Parameter
F26	31°26.483'S	11°13.310'W	9/3/2016	1:45	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F27	32°04.183'S	10°37.293'W	9/3/2016	10:10	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F28	32°34.167'S	09°30.751'W	9/3/2016	14:45	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F29	32°62.122'S	09°51.655'W	9/3/2016	18:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F30	31°18.765'S	10°08.996'W	9/3/2016	22:08	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F31	30°35.837'S	10°26.032'W	10/3/2016	2:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F32	30°04.016'S	11°16.767'W	10/3/2016	7:30	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F33	29°58.002'S	12°16.687'W	10/3/2016	14:54	Heme, chl, POC/N, DNA, RNA, tm, nutrients, incubation water
F34	29°52.642'S	13°10.068'W	10/3/2016	19:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F35	29°47.225'S	14°03.886'W	10/3/2016	23:15	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F36	29°42.228'S	14°53.538'W	11/3/2016	3:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F37	29°37.034'S	15°45.140'W	11/3/2016	7:01	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F38	29°32.106'S	16°34.119'W	11/3/2016	15:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients, incubation water
F39	29°26.366'S	17°30.905'W	11/3/2016	19:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F40	29°21.408'S	18°20.110'W	11/3/2016	23:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F41	29°16.242'S	19°11.137'W	12/3/2016	3:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F42	29°00.020'S	20°24.641'W	12/3/2016	11:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F43	28°41.222'S	21°04.483'W	12/3/2016	15:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients, incubation water
F44	28°20.294'S	21°48.671'W	12/3/2016	19:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F45	28°07.403'S	23°02.335'W	13/3/2016	1:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F46	27°12.515'S	24°13.199'W	13/3/2016	8:15	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F47	26°52.520'S	24°54.797'W	13/3/2016	16:30	Heme, chl, POC/N, DNA, RNA, tm, nutrients, incubation water
F48	26°52.568'S	25°36.300'W	13/3/2016	20:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F49	26°52.626'S	26°28.071'W	14/3/2016	0:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F50	26°52.691'S	27°23.397'W	14/3/2016	4:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F51	26°52.748'S	28°13.605'W	14/3/2016	8:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F52	26°52.671'S	28°44.645'W	14/3/2016	12:15	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F53	26°52.842'S	29°34.790'W	14/3/2016	16:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients, incubation water
F54	26°52.960'S	30°22.011'W	14/3/2016	21:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F55	26°52.951'S	31°09.971'W	15/3/2016	0:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F56	26°53.004'S	31°59.156'W	15/3/2016	4:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F57	26°53.068'S	32°52.918'W	15/3/2016	8:15	Heme, chl, POC/N, DNA, RNA, tm, nutrients, incubation water
F58	26°53.066'S	33°19.649'W	15/3/2016	12:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F59	26°53.152'S	34°06.044'W	15/3/2016	17:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F60	26°44.079'S	35°06.607'W	16/3/2016	4:15	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F61	26°25.010'S	35°46.402'W	16/3/2016	8:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F62	26°14.699'S	36°08.436'W	16/3/2016	13:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients, incubation water
F63	25°55.703'S	36°47.528'W	16/3/2016	16:30	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F64	25°37.322'S	37°25.366'W	16/3/2016	20:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients
F65	25°17.070'S	38°07.207'W	17/3/2016	0:00	Heme, chl, POC/N, DNA, RNA, tm, nutrients

5.8 Biogeochemcial measurements

(Jennifer Clarke, Felix Geissler, GEOMAR)

Underway sampling

Almost every 4 hours samples for dissolved inorganic carbon/total alkalinity (DIC/TA) and nutrient analysis were directly tapped from the underway seawater supply (membrane pump) in the laboratory. At CTD stations, where the vessel was not moving, no underway samples were collected.

DIC/TA samples were collected in 250 mL small necked glass bottles following best practices in accordance to the standard operating procedure provided by Dickson et al. (2007). The stopper displaces the water. 2.5 mL of seawater were removed to adjust the headspace and the sample was poisoned with 50 µL saturated mercuric chloride solution. Finally, the bottles were sealed with a greased stopper (Apiezon L grease) and secured with tape around the bottle and stopper to hold the lid in position. All samples were stored in the dark.

To collect nutrient samples a 60 mL plastic syringe equipped with a 0.45 µm acetate filter on the tip was rinsed at least two times with underway seawater as well as the nutrient plastic vial with a volume of ca. 25 mL with filtered seawater. After filling the vial, the lid was screwed on and the samples were kept frozen at -20°C.

Tab. 5.7 Overview table on sampling. Sampler: JC Jennifer Clarke, FG: Felix Geissler

Bottle Number	Date Time	Sampler	Notes	Lat (S)	Lon (E)	Nuts
UW1	01.03.2016 10:00 (GMT)	JC		34.07	14.56	N
UW2	01.03.2016 14:05 (GMT)	JC		34.08	14.37	N
UW3	01.03.2016 18:05 (GMT)	FG		34.13	13.48	Y
UW4	02.03.2016 22:05 (GMT)	FG		34.17	13.02	Y
UW5	02.03.2016 02:00 (GMT)	JC		34.21	21.14	Y
UW6	02.03.2016 06:00 (GMT)	JC		34.25	11.23	Y
UW7	02.03.2016 10:30 (GMT)	JC		34.27	11.05	Y
UW8	02.03.2016 14:05 (GMT)	FG		34.3	10.24	Y
UW9	02.03.2016 18:00 (GMT)	FG		34.35	9.33	Y
UW10	02.03.2016 22:00 (GMT)	FG		34.37	8.42	Y
UW11	03.03.2016 02:00 (GMT)	FG		34.25	8.17	Y
UW12	03.03.2016 06:00(GMT)	JC		33.59	7.34	Y
UW13	03.03.2016 10:00 (GMT)	FG		33.53	7.23	Y
UW14	03.03.2016 14:10 (GMT)	JC		33.29	6.49	Y
UW15	03.03.2016 18:05 (GMT)	FG		33.08	6.06	Y
UW16	03.03.2016 22:00 (GMT)	FG		32.44	5.2	Y
UW17	04.03.2016 02:00 (GMT)	JC		32.2	4.32	Y
UW18	04.03.2016 06:00 (GMT)	JC		31.57	3.47	Y
UW19	04.03.2016 10:00 (GMT)	JC		31.52	3.37	Y
UW20	04.03.2016 14:00 (GMT)	FG		31.25	2.57	Y
UW21	04.03.2016 18:00 (GMT)	FG		31.09	2.32	Y
UW22	04.03.2016 22:00 (GMT)	JC		30.4	1.49	Y
UW23	04.03.2016 01:00 (GMT)	FG	ON STATION	30.22	1.22	N
UW24	05.03.2016 06:00 (GMT)	FG		29.56	0.49	Y
UW25	05.03.2016 10:00 (GMT)	FG		29.52	1.09	Y
UW26	05.03.2016 14:00 (GMT)	JC		29.45	4.58	Y
UW27	05.03.2016 18:00 (GMT)	FG		30.01	1.45	Y
UW28	05.03.2016 22:00 (GMT)	TdG		30.14	1.35	Y
UW29	06.03.2016 02:00 (GMT)	TdG		30.4	1.12	Y
UW30	06.03.2016 06:00 (GMT)	JC	Moved from E to W after here!!	31.07	0.49	Y
UW31	06.03.2016 18:10 (GMT)	FG		31.24	-0.29	Y
UW32	06.03.2016 22:00 (GMT)	FG		31.19	-1.17	Y
UW33	07.03.2016 02:00 (GMT)	FG		31.14	-2.09	Y
UW34	07.03.2016 06:00 (GMT)	JC		31.09	-3.01	Y
UW35	07.03.2016 10:00 (GMT)	JC		31.06	-3.34	Y
UW36	07.03.2016 14:05 (GMT)	JC		31	-4.27	Y
UW37	07.03.2016 18:15 (GMT)	FG		30.55	-5.23	Y
UW38	08.03.2016 02:00 (GMT)	FG		30.59	-6.45	Y

UW39	08.03.2016 06:00 (GMT)	JC		31.06	-7.4	Y
UW40	08.03.2016 10:00 (GMT)	JC		31.1	-8.13	Y
UW41	08.03.2016 15:00 (GMT)	FG	SW off @ 1400	31.19	-9.11	Y
UW42	08.03.2016 18:05 (GMT)	FG		31.22	-9.49	Y
UW43	08.03.2016 22:00 (GMT)	FG		31.24	-10.2	Y
UW44	09.03.2016 02:00 (GMT)	FG		31.29	-11.16	Y
UW45	09.03.2016 06:00 (GMT)	JC		31.47	-11.08	Y
UW46	09.03.2016 10:45 (GMT)	JC	Late leaving multinet	32.07	-10.3	Y
UW47	09.03.2016 14:20 (GMT)	Jc	Meeting too interesting	32.3	-9.47	Y
UW48	09.03.2016 18:00 (GMT)	FG		32.02	-9.51	Y
UW49	09.03.2016 22:00 (GMT)	FG		31.19	-10.08	Y
UW50	10.03.2016 02:00 (GMT)	FG		30.35	-10.26	Y
UW51	10.03.2016 06:00(GMT)	JC		30.06	-10.52	Y
UW52	10.03.2016 10:05 (GMT)	JC	ON STATION	30.01	-11.39	Y
UW53	10.03.2016 14:00 (GMT)	JC		29.59	-12.03	Y
UW54	10.03.2016 18:45 (GMT)	FG		29.53	-13.05	Y
UW55	10.03.2016 22:05 (GMT)	FG		29.48	-13.48	Y
UW56	11.03.2016 02:00 (GMT)	FG		29.43	-14.38	Y
UW57	11.03.2016 06:00 (GMT)	JC		29.38	-15.3	Y
UW58	11.03.2016 14:29 (GMT)	JC	Previously on station.	29.32	-16.26	Y
UW59	11.03.2016 18:00 (GMT)	FG		29.28	-17.14	Y
UW60	11.03.2016 22:00 (GMT)	FG		29.22	-18.07	Y
UW61	12.03.2016 02:00 (GMT)	FG		29.17	-18.58	Y
UW62	12.03.2016 06:05 (GMT)	JC		29.12	-19.51	Y
UW63	12.03.2016 13:51 (GMT)	JC	Previously on station	28.46		Y
UW64	12.03.2016 18:00 (GMT)	FG		28.24	-21.37	Y
UW65	12.03.2016 22:00 (GMT)	FG		28.21	-22.27	Y
UW66	13.03.2016 02:00 (GMT)	FG		28.00	-23.11	Y
UW67	13.03.2016 06:00 (GMT)	JC		27.31	-23.49	Y
UW68	13.03.2016 10:00 (GMT)	JC		27	-24.27	Y
UW69	13.03.2016 14:15 (GMT)	JC		26.52	24.46	Y
UW70	13.03.2016 19:10 (GMT)	FG		26.52	-25.24	Y
UW71	13.03.2016 22:00 (GMT)	FG		26.52	-26.02	Y
UW72	14.03.2016 02:00 (GMT)	FG		26.52	-26.55	Y
UW73	14.03.2016 06:00 (GMT)	JC		26.52	-27.47	Y
UW74	14.03.2016 10:00 (GMT)	JC		26.52	-28.34	Y
UW75	14.03.2016 14:00 (GMT)	JC		26.52	-29.05	Y
UW76	14.03.2016 18:00 (GMT)	FG		26.52	-29.57	Y
UW77	14.03.2016 22:10 (GMT)	FG		26.53	-30.46	Y
UW78	15.03.2016 02:00 (GMT)	FG		26.53	-31.35	Y
UW79	15.03.2016 06:00 (GMT)	JC		26.53	-32.22	Y
UW80	15.03.2016 10:00 (GMT)	JC		26.53	-33.12	Y
UW81	15.03.2016 14:00 (GMT)	FG		26.53	-33.38	Y
UW82	15.03.2016 18:00 (GMT)	FG		26.53	-34.31	Y
UW83	16.03.2016 06:00 (GMT)	FG		26.35	-35.24	Y
UW84	16.03.2016 10:00 (GMT)	JC		26.17	-36.02	Y
UW85	16.03.2016 14:15 (GMT)	JC		26.07	-36.21	Y
UW86	16.03.2016 18:00 (GMT)	FG		25.48	-37.03	Y

CTD rosette sampling

Besides underway sampling there was sampling of the bottle samples for the CTD casts performed (table 5.8).

Sampling order

For every chosen depth at each CTD cast samples for the following parameters were collected in the given order following best practices according to Dickson et al. (2007):

- O_2 in 250 mL glass bottles for Winkler titrations to determine the seawater oxygen concentration on-board (always sampled in duplicates)
- $\delta^{18}O$ in ca. 2.5 mL glass vials with a screw-on lid equipped with a septum
- $\delta^{13}C$ in 15 mL brown glass bottles with a screw-on lid

- DIC/TA in 250 mL small necked glass bottles with ground glass stopper (each 10th sample was collected as duplicate or replicate (in a 500 mL glass bottle), respectively)
- Nutrients in ca. 25 mL transparent plastic vials with a screw-on lid

Treatment after sampling and storage

O_2 samples were immediately spiked on the deck with NaI/NaOH and $MnCl_2$ solution after sampling, shaken vigorously and kept in the dark until titration. $\delta^{18}O$ sample vials were sealed neatly with Parafilm and stored in the dark. $\delta^{13}C$ sample vials were reopened in the lab to poison the samples with 15 µL saturated mercuric chloride solution. Afterwards they were sealed with hot wax. DIC/TA samples were reopened in the lab to remove 2.5 mL seawater for adjusting the headspace and spiked with 50 µL saturated mercuric chloride solution. The bottles were sealed with a greased stopper (Apiezon L grease) and secured with tape around the bottle and stopper to hold the lid in position. All samples were stored in the dark. Nutrients sample vials were stored at -20°C.

Tab. 5.8 Overview of parameter samples taken from Niskin bottles for CTD cast 1 to 14. (D) indicates duplicates, (R) replicates.

cast #	O2	δ18O/ δ13C	DIC/TA	Nutrients
1	1/6/9/11/16/22			1/6/22
2	1/3/4/6/7/9/10/12/21		1/3/4/6/7/9(D)/10/12/21	1/3/4
3	1/3/5/8/10/12/14/16/18/21		1/3/5/8/10(R)/12/14/16/18/21	1/3/5/8/10
4	1/3/5/6/8/12/14/15/16/20		1/3/5/6/8(D)/12/14/15/16/20	1/3/5/6/14/15/20
5	2/3/5/7/9/12/15/18/24		2/3/5/7/9(D)/12/15/18/ 24	2/3/5/7/24
6	1/3/6/9/11//14/18/23		1/3/6/9/11//14(D)/18/23	1/3/6/9/23
7	1/4/5/7/8/9/11/15/17/20	1/4/5/9/11/15/17/20	1/4/5/9/11/15/17/20(R)	1/4/5/9
8	1/6/7/9/14/16/23			1/6/7/9
9	1/4/6/8/13/16/17/21		1/4/6(D)/8/13/16/17/21	1/4/6/16/21
10	1/5/7/8/10/11/15/18/19/23		1/5/7/8/10(R)/11/15/18/19/23	1/5/7/8/10/23
11	1/3/5/7/9/11/13/21		1/3/5/7/9(D)/11/13/21	1/3/5/7/21
12	1/4/6/8/12/23			1/4/6/23
13	1/7/9/10/11/12/14/16/19/23		1(R)/7/9/10/11/12/14/16/19/23	1/7/9/11/12/ 23
14	1/7/11/12/14/16/18/20		-	-

Biogeochemcial Underway Sensor deployment

The carbonate system is a key component of the chemical perspective of oceanography as it plays an important role in the oceans' capacity to take up atmospheric CO_2. The circulation in the south Atlantic and the potential carbon transport is poorly constrained for this region. To further constrain this, high resolution sensors were deployed on the pumped underway seawater supply, with further discrete water samples collected from CTD deployments. This was also an opportunity to test two experimental sensors, a microfluidic phosphate sensor and a pCO_2 both developed at the National Oceanography Centre Southampton.

Instrumentation

For all underway sampling the tubes from the tap were cleaned weekly and kept wrapped in aluminium foil to prevent biological contamination. The sensors were regularly calibrated and were only offline for maintenance (fixing valves and running CRMS) and when the seawater pump was turned off.

Fig. 5.16 Sensors in the lab – In the foreground the phosphate sensor, while in the background the DIC analyser. The optode sampling tube can be seen on the tap wrapped in black material (to limit ambient light).

DIC Sensor

An Apollo SciTech ASC3 DIC analyser was deployed as an underway analyser. The analyser converts all the DIC into CO2 gas by acidifying seawater with 10% (v/v) phosphoric acid in a closed cell. The CO2 gas is then carried with N2 gas (99.9%) to the Li-COR infrared spectrometer. The flow rate of the nitrogen gas was maintained at 300 ml min-1.

The sample volume was 0.75 ml and a full calibration was undertaken twice daily. The calibration consisted of flushing the instrument with air (2 x 1.5ml), before being flushed with the Certified Reference Material provided by Professor A. Dickson from Scripps Oceanographic Institute (Batch 151). 5 volumes (0.25, 0.5, 0.75, 1, and 1.5 ml) were then run with the Certified Reference Material and the average over 5 runs used for in calibration. Every 30 underway samples, the CRM was analysed 7 times (0.75 ml) to allow correction due to the natural drift of the LICOR analyser.

The CRM was changed twice daily, and kept in the glass bottle with a special lid and sample tube that once the CRM was opened remained on the bottle until changed. The sample tube was always sampling from the bottom of the bottle.

The DIC sensor data was density corrected using the temperature and salinity information from the shipboard underway thermosalinograph.

Drift in the underway water measurements was corrected using the ratio of the measured CRM DIC (µmol kg-1) to the certified value for the particular CRM.

Cf = Certified CRM DIC value/ measured concentration

Data was finally quality controlled, and data which were clearly influenced by the switching between the underway supply and the CRM removed.

pCO_2 sensor

The sensor is based on an immobilised pH indicator entrapped in a polymer membrane alongside a fluorescent reference compound and a buffer molecule. The indicator fluorescence altered according to the pCO_2 of the seawater. The fluorescence intensity was recorded throughout the cruise and analysed based on time-domain dual-luminophore referencing (Liebsch, Klimant et al. 2000, Liebsch, Klimant et al. 2001, Stahl, Glud et al. 2006, Schroeder, Neurauter et al. 2007) using a PMT (Hamamatsu). The sensing spot was purchased from PreSens GmbH and attached to a fibre optic cable using Kwik-Sil glue and soaked in seawater for a day prior to use. The sensor spot was placed in a thick dark hose and measured continuously for one minute intervals with the water at a flow rate at 200 ml / min. This was then integrated to provide one measurement every two minutes.

DIC/TA CRM's were measured daily to allow drift correction using the same method as for the DIC data.

Phosphate sensor

The microfluidic phosphate sensor is based on the molybdenum blue methodology and is a prototype sensor being developed by Maxime Grand at the National Oceanography Centre. The reagents were made up in DI water and a calibration run with high (0.52 µmol kg^{-1}) and low (0.26 µmol kg^{-1}) phosphate standards weekly. The first half of the cruise used the high standard when recording the underway measurements and a 300s mixing time for the reagents, while in the second half of the cruise where the phosphate was anticipated to be lower, the lower standard was used with a 600s mixing time.

Results and troubleshooting

DIC

The DIC sensor suffered initially from problems emptying the measurement cell. This was fixed, and a further problem detected of a valve inconsistently open and closing. This caused the increased seawater vapour to occasionally enter the gas tubing to the LiCOR. To prevent the water vapour reaching the LiCOR and distorting the measurement, the drying agent Magnesium Perchlorate was refreshed twice daily (as opposed to once every 2-3 days) and the gas tubing all dried using the ships pressurised air supply with every measurement of certified reference material.

The data (Figure 5.17) will be further verified with the underway DIC/TA samples collected every 4 hours measured after the cruise at GEOMAR.

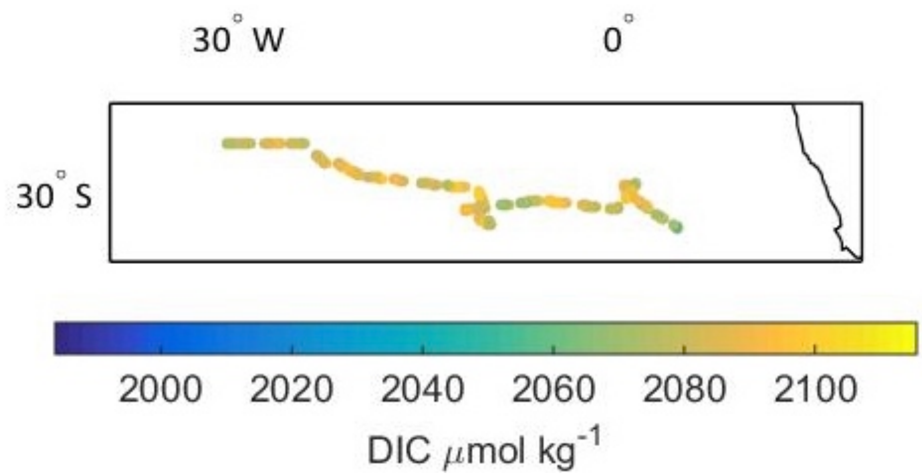


Fig. 5.17 DIC measured across the cruise, corrected with the correction factor (Figure 5.18) and density corrected.

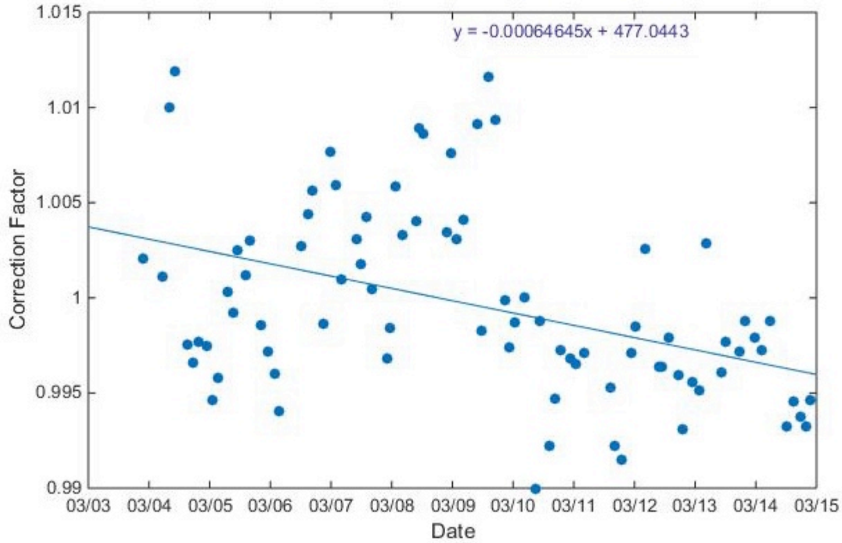


Fig. 5.18 The correction factor drift over the course of the cruise.

Phosphate

The phosphate sensor worked well for the first week. However after heavy swell one of the reagent bloodbags became dislodged and fell off. It was reattached but the sensor calibrations were inconsistent. Reagents were made up several times and correspondence with the developer yielded no solution. The sensor will be returned to the NOC for further analysis. The initial results will be verified and validated using the underway nutrient samples to be analysed at GEOMAR at a later date.

pCO_2 Optode

The pCO_2 optode software crashed twice during the cruise, though the sensor was only offline for ca. 20 minutes each time. The data will be corrected using the temperature and salinity data and the calibration curve from Clarke (2015) at a later date. This will be further validated using the discrete DIC/TA samples, with CO_2 calculated using CO2SYS.

5.9 Freshwater and energy budget at the air sea interface

(Karl Bumke)

To a large extent the ocean's surface salinity variations are caused by the geographically varying freshwater fluxes, which are generated by the difference between precipitation and evaporation at the ocean's surface. However, even to date, the uncertainties of net freshwater flux into the oceans are difficult to assess. This is mainly caused by the relative paucity of evaporation observations and a lack of in-situ precipitation measurements. Ocean currents are also driven directly by the flux of momentum and, in part, by the exchange of energy due to radiation fluxes. As for turbulent momentum and heat fluxes, there is still a shortage of available radiation flux measurements over the ocean.

Measurements

For the broadband radiation measurements an upward looking *Kipp&Zonen* pyrgeometer and a pyranometer were used on this cruise. A turbulence measurement system serves to estimate the turbulent flux of momentum and turbulent heat fluxes, which enables us together with radiation flux measurements to derive the energy budget at the air sea interface. Our measurements were completed by an optical disdrometer to perform precipitation measurements, which gives in conjunction with the turbulent flux of latent heat the fresh water flux between ocean and atmosphere. All instruments were mounted on the platform top of the air chemistry laboratory.

Preliminary results

Precipitation measurements on ships are generally difficult to operate. Uncertainties should be mainly caused by flow distortion and thus, depend on the instrument's location. The R/V METEOR cruise gave us the opportunity to mount an additional optical disdrometer on board, beside the existing one and a ship rain gauge. A first comparison of analysed raw data is given in Figure 5.19. It shows that the agreement between all precipitation measurements is in general good although not perfect. While the analysis of the turbulence measurements will take some time, a first estimate of turbulent fluxes was done by applying a bulk flux scheme (Fairall, 2011). These fluxes are shown in Figure 5.19 (right) together with short and long wave radiation fluxes. The total energy budget is given by the black line, the thick black line gives the mean value of the budget for the first week of the cruise. Comparing precipitation and latent heat flux shows that the ocean becomes saltier as it is expected for this area.

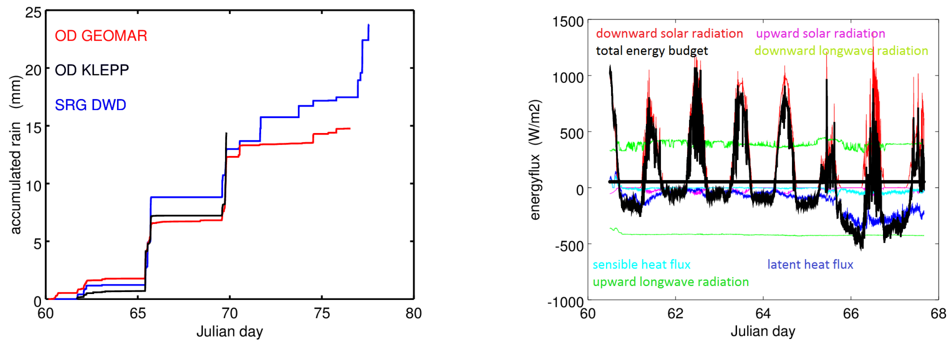


Fig. 5.19 Accumulated rain as measured by 2 optical disdrometers and a ship rain gauge. Energy fluxes and total energy budget. The thick black line gives the overall mean.

5.10 Sun-Photometric Aerosol Measurements

(M. Giorgetta, E.Manzini)

The R/V METEOR cruise M124 from Cape Town to Rio de Janeiro was used to make sun-photometric aerosol measurements in the South Atlantic in order to extend the database of the Maritime Aerosol Network (Smirnov et al., 2009) that is operated at the Goddard Space Flight Center (GSFC) of the NASA. Surface based direct measurements of aerosol optical depths are important for the calibration of the indirect radiometric aerosol measurements by satellites over ocean areas. The Maritime Aerosol Network has gathered sun-photometric aerosol measurements from research cruises in all ocean basins and all seasons since 2004. Aerosol measurements in the South Atlantic, however, are still rare. The M124 cruise increased the number of surface based aerosol measurements in this region substantially. This report describes the Microtops II sun photometer (Figure 5.20) used for the measurements, the quality assurance applied on R/V METEOR and at GSFC/NASA, the measurements taken, and shows results in terms of aerosol optical depths varying over a day and along the ship track

The Microtops II sun photometer

The Microtops II is a hand-held multi-band sun photometer that measures sun light at five wavelengths, which for our device are at 380, 440, 675, 870 and 936 nm, across the visible into the infrared of the solar spectrum. The optics has a narrow viewing angle of only 2.5° so that the sensors see the light from the sun disk alone, if the device is pointed directly at the sun.The sun photometer is used to measure the intensity I_k of the sun beam at these five wavelengths. I_k depends on the extraterrestrial intensity $I_{0,k}$ and the extinction of the beam on its way through the atmosphere to the sun photometer. Extinction is due to either absorption by gases or scattering due to molecules – so called Rayleigh scattering – or aerosol or clouds or rain. For our instrument the wavelengths are chosen to work well for the detection of aerosol particles, provided no clouds are in the way.

Fig. 5.20 Handheld sunphotometer

The aerosol scattering of the solar beam depends on the number of particles along the beam and their optical properties. Small particles are more efficient in scattering short wavelengths than long wavelengths, while larger particles can also scatter longer wavelengths efficiently. (And cloud droplets, which are large compared to aerosol particles, scatter all wavelengths or colours of the sun light equally, which is why clouds are white). Comparing the loss of intensity at different wave lengths therefore gives indication of the size of the scattering particles.

The extinction of the beam through the atmosphere obviously depends on the amount of air passed by the beam and therefore on the viewing angle of the instrument with respect to the zenith. The lower the sun, the longer the path of the sun beam through the atmosphere, the higher the atmospheric mass along the beam's path and the higher the chance for scattering. If the sun is directly above the observer, the zenith angle is 0 and the beam crosses one atmosphere. If the beam is at 48° below the zenith, then the beam crosses 1.5 times the atmospheric. At 80° the beam passes 6 times the atmospheric mass.

Altogether, if the zenith angle is known and the surface pressure, the atmospheric mass factor along the path of the beam can be computed by the sun photometer, and it can convert the measured intensities I_k to equivalent intensities for one atmospheric mass, as if the sun was in the zenith. From this the "aerosol optical thickness", which is the measure for the extinction of the beam at a given wavelength on the assumed vertical path can be estimated for each of the five wavelengths.

The accuracy of these results is practically dominated by two factors: First of all, if the sun photometer is not pointed exactly in the direction of the sun, then the sensors see only a part of the sun disk and hence the extra-terrestrial intensity $I_{0,k}$ is smaller than assumed. As the sun photometer has no direct information on the pointing quality it makes internally several measurements – 20 in our device – within about 10 seconds and keeps only that with the highest intensity, which is assumed to point directly at the sun. On a moving platform, as on R/V

METEOR, the observer cannot always point correctly at the sun, and hence some measurements receive less sun light and the sun photometer interprets this as a higher aerosol optical thickness instead of a lower extra-terrestrial intensity $I_{0,k}$. This sun pointing error is discussed in Porter et al. (2001) and Knobelspiesse et al. (2003), where also a post-processing algorithm is proposed to filter out the measurements possibly affected by the sun-pointing error.

The second factor limiting the accuracy is thin cirrus, which is hard to detect by the observer. If measurements are taken in the presence of thin cirrus, then the extinction will be increased, which again causes an overestimation of the aerosol optical thickness by the sun photometer.

The Microtops II sun photometer delivers the following parameters:

- Signal strength at 380, 440, 675, 870 and 936 nm
- Ratio of signal strengths: 380nm/440nm, 440nm/675nm, 675nm/870nm and 870nm/936nm.
- Aerosol optical depth at 380, 440, 675, 870 and 936 nm
- Water vapor column amount

With each measurements the following metadata are saved:

- Date and time
- Longitude and latitude
- height and pressure
- Solar zenith angle and corresponding atmospheric mass
- Temperature

From these parameters the following aerosol characteristics can be derived:

- The Angstrom exponent, characteristic for the size and nature of the aerosols
- The fine mode fraction and aerosol optical depth
- The coarse mode fraction and aerosol optical depth

Quality assurance

The sun photometer measurements are screened in three steps:

Level 1.0: On board screening for false measurements, which are triggered unintentionally. Such data are deleted. The remaining data were submitted to Dr. Alexander Smirnov at GSFC/NASA for further screening.

Level 1.5: At GSFC/NASA, to remove outlier data. If the sun photometer is not pointed accurately towards the sun, or a measurement is affected by clouds drifting into the optical path, then the intensities are reduced substantially, and concequently cannot be used. Outliers are removed by an algorithms that compares single measurements to a series mean and the series standard deviation. This data reduction is done separately for each frequency → Level 1.5

Level 2.0: At GSFC/NASA, to remove suspicious data possibly influenced by cirrus and to apply the final correction from the instrument calibration.

Measurements

Measurements were taken every during day light hours when the sun was not obscured by clouds. When possible series of 10 to 15 measurements were taken in intervals of 10 to 15 minutes. Measurements within a series vary mostly due to the sun pointing error, while measurements across all series resolve the variations along the ship track. No measurements were possible on March 01, 05, 16 and 17 due to cloudy conditions and on March 18 when the vessel was in the exclusive economic zone (EEZ) of Brazil, where no measurements could be taken. Table 5.9 shows the number of measurements and series taken during the M124 cruise. In total 3396 measurements were taken, resulting in 241 level 2.0 series.

Tab. 5.9 Number of measurements for all days of the cruise and resulting number of measurement series after Level 1.5 and Level 2.0 screening.

Date	Number of measurements Lev 1.0	Number of series Lev 1.5	Number of series Lev 2.0	Number of days Lev 2.0	Comment
28.2.2016	17	2	2	1	
29.2.2016	187	15	15	1	
1.3.2016	0	0	0	0	Cloudy
2.3.2016	146	10	10	1	
3.3.2016	313	22	22	1	
4.3.2016	514	42	42	1	
5.3.2016	0	0	0	0	Cloudy
6.3.2016	179	15	15	1	
7.3.2016	70	7	7	1	
8.3.2016	562	41	41	1	
9.3.2016	138	8	8	1	
10.3.2016	84	5	5	1	
11.3.2016	574	35	35	1	
12.3.2016	390	29	29	1	
13.3.2016	95	13	0	0	Discarded in level 2 screening
14.3.2016	12	1	1	1	
15.3.2016	115	9	9	1	
16.3.2016	0	0	0	0	Cloudy
17.3.2016	0	0	0	0	Cloudy, EEZ of Brazil
18.3.2016	0	0	0	0	EEZ of Brazil
Total	3396	254	241	14	

Results

The photometric aerosol measurements can be evaluated at the level of single measurement series or of daily means and at five frequencies. Figure 5.21 shows the measurements for March 8, when measurements could be taken through the whole day. The measurements show a diurnal variation related to the changing zenith angle, which is most pronounced in the 380 nm channel. Measurements 120 to 400 with zenith angles smaller than 42° are however relatively stable and suitable to characterize the aerosol optical depth in the area.

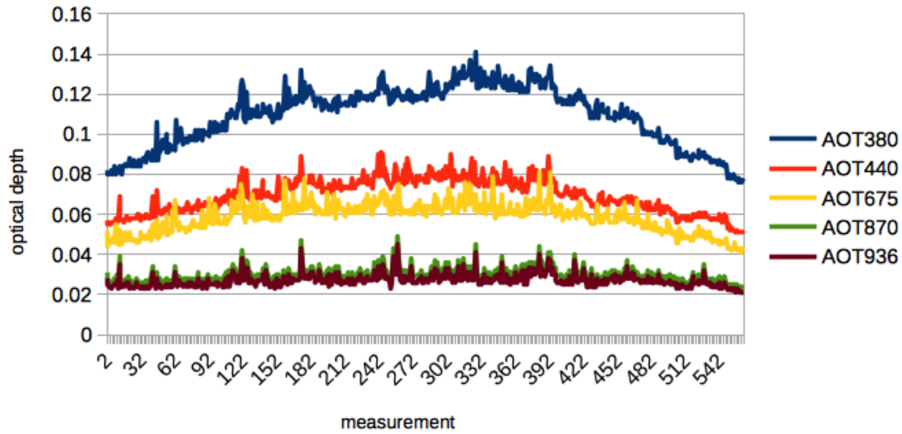


Fig. 5.21 Aerosol optical depth at five wavelengths (380, 440, 675, 870 and 936 nm) as measured aboard R/V METEOR in the South Atlantic on March 8 2016. The first measurement started at a zenith angle of 66° at 31.2°S/8.2°W. At local noon the minimum zenith angle reached 26.7° at 31.3°S/8.8°W. The last measurement was taken at a zenith angle of 73° at 31.4°S/9.7°W.

In the following maps produced at GSFC/NASA are shown for the daily mean aerosol optical depth at 500 nm wave length along th etrack of M124 (Figure 5.22) and for all cruises (Figure 5.23) including those of M124. As seen from the all-cruises map, the M124 cruise is one of a few that sampled aerosol optical depths along a zonal transect in the southern Atlantic. Weather conditions allowed measurements on 13 days.

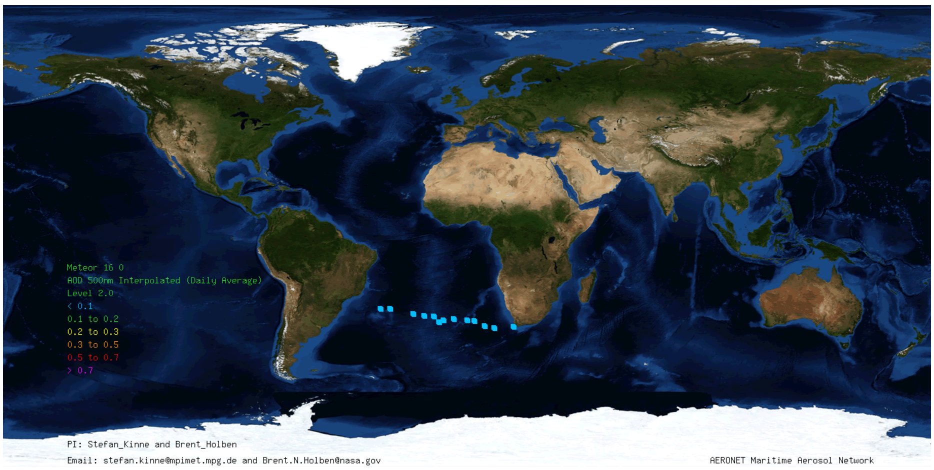


Fig. 5.22 Aerosol optical depth at 500 nm, as daily means along the ship track of M124 (from the Level 2 dataset in http://aeronet.gsfc.nasa.gov/new_web/DATA/Meteor_16_0.zip.)

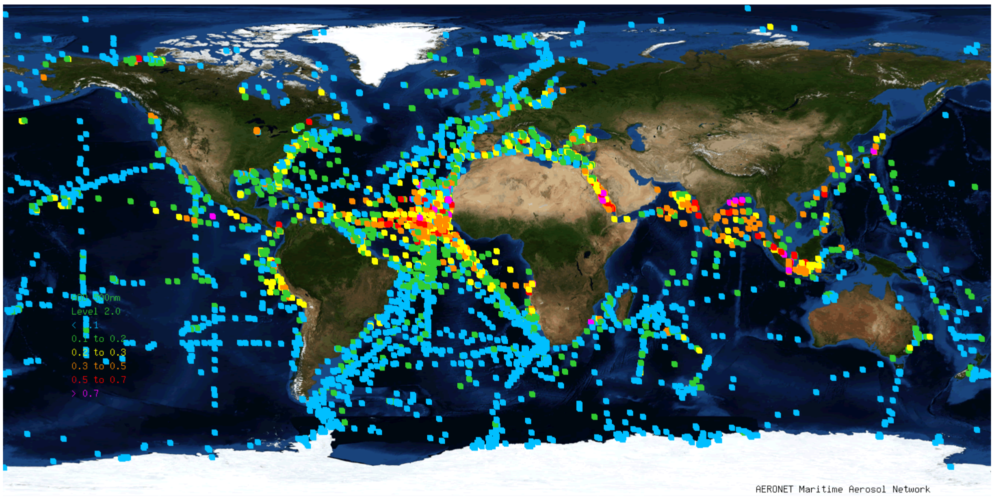


Fig. 5.23 Level 2 aerosol optical depth at 500 nm, as daily means along the ship tracks of all cruises (http://aeronet.gsfc.nasa.gov/new_web/MAPS/all_cruises_aod_lev20.gif).

The new measurements show low aerosol optical depth < 0.1 as expected for this region from other measurements. This is accounted to the facts that:

- the region is remote from land based aerosol sources, and
- the region is mostly under high pressure influence with descending dry air masses and weak surface winds, thus reducing the aerosol optical depth aloft and weakening local sources of sea salt aerosols.

Summary

The M124 cruise of the research vessel R/V METEOR, from Cape Town to Rio de Janeiro was used to make sun photometer measurements of the aerosol layer in the South Atlantic, from February 28 to March 15. In total 3396 measurements were taken, resulting in 241 valid series after level 2 screening. These data entered the database of the Maritime Aerosol Network, in order to enlarge the data coverage in the poorly sampled South Atlantic.

5.11 MyScience cruise

(Sabrina Speich, J. Karstensen)

The cruise had a strong educational and capacity building component that was embedded in the Excellence Cluster Semester Topic 2016 (PI's: J. Karstensen, GEOMAR; W. Hasselbring, CAU Kiel) "Ocean Observation: From sensor to knowledge". Ocean Observations are one of the cornerstones for understanding, assessing and predicting ocean change – the *MyScience-Cruise* provided the unique opportunity of a practical training on ocean observations and ocean research in the South Atlantic for 9 students from 8 nations (Table 5.10; Figure 5.23). Students from PhD to bachelor level attended.

During the cruise an "expert training" on a variety of observing instrumentation as well as lectures were provided. The three CTD/uCTD/XBT shifts were covered with one expert (Yao Fu, Andreas Pinck, Eike Köhn, all GEOMAR) and three MyScience cruise students each. At the beginning of the cruise the "experts" primarily trained the students but quickly the experts took the observers positions over and the students were fully operating the shifts.

Tab. 5.10 List of MyScience cruise students

First name	Name	Nationality	University enrolled	Area
Aziayibor	Kodjo Mawouéna	Togo	University of Abomey Calavi (Benin)	Physical Oceanography
Laís Fernanda	de Palma Lopes	Brazil	Universidade Federal do Rio Grande	Biological Oceanography
Mareike	Koerner	Germany	Christian-Albrechts University Kiel	Physics of the Earth System
Javier	Rabellimo	Uruguay	Universidad de la Republica	Biological Oceanography
Kevin	Schmidt	US	University of Cape Town	Applied Marine Science/Environmental Sciences
Veronica	van der Schyff	RSA	North-West University, Pretoria	Biology / Contamination heavy metal
Lívia	Sancho	Brazil	Universidade Federal do Rio de Janeiro	Physical Oceanography
Anahí Amaru	Brun	Argentina	University of Buenos Aires	Physical Oceanography/Biology
Christina	Schmidt	Germany	Christian-Albrechts University Kiel	Physics of the Earth System

Instruments

Each student was selected to be a "mentor" for a certain sensor (Table 5.11) – he/she prepared a presentation of the sensors functioning, usage of data, and preparing a one-pager for all students to use before and during the cruise. The presentations were given at the beginning of the cruise. The instrument description also included data calibration and data quality control procedures. During the cruise all students worked with the instruments somehow.

Tab. 5.11 List of MyScience cruise students instruments

Instrument	Student
XBT, uCTD	Livia Sancho
CTD system	Christina Schmidt
ADCP	Kevin Schmidt
Thermosalinograph	Veronica van der Schyff
Multinet	Javier Rabellino
Optode (pCO2/oxygen)	Anahi Brun
Salinometer	Kodjo Aziayibor
Sea level (anomaly) from space	Mareike Körner
Ocean optical sensors (Fluoresence)	Lais Lopes

Science themes

The students actively participate in the research conducted during M124. They had the chance to propose and worked on science themes related to physical oceanography, marine meteorology, biogeochemistry, plankton ecology, and paleoceanography (Table 5.12). The students prepared poster presentations about their results from the cruise and which are available at:

http://portal.geomar.de/web/mysciencecruise/science-themes.

Tab. 5.12 List of MyScience cruise students science themes

Title of science theme	Expert	Student
The South Atlantic water masses	S. Speich	Livia Sancho
Vema Channel: warming of the ocean abyssal waters	J. Karstensen	Christina Schmidt
Ekman transport in the South Atlantic	Yao Fu	Javier Rabellino
Agulhas Rings: Physics	S. Speich	Mareike Körner
Agulhas Rings: Biology	S. Speich	Lais Lopez
Planktonic foraminifera & water masses of the South Atlantic	R. Morard	Aniha A. Brun
Plastic in the Ocean	S. Speich	Veronica van der Schyff
Heat, freshwater and momentum flux	K. Bumke	Kodjo Aziayibor
Distribution of aerosols in the South Atlantic Ocean	M. Giorgetta	Kevin Schmidt

Outreach activities

Daily reports by the students about life at sea and their experiences have been published at: *http://www.oceanblogs.org/mysciencecruise/*

The students worked out a specific science theme during the cruise and the work was presented during a reception at the end of the cruise in Rio de Janeiro organized by the German Embassy.

6 Ship's Meteorological Station

(Andreas Raeke, DWD)

On 29th of February 2016 at about 10:15 local time, R/V METEOR left the harbour of Cape Town for research trip M124. At first R/V METEOR cruising area was located between the subtropical high over the southern central Atlantic and a trough along the South African coast line. On the open sea southerly winds of 5 to 6 Bft, at times 7 Bft were experienced. The sea was about 4m with a swell of 3m.

From 01th of March on the way to the west the swell decreased to 2m. Along the eastern fringe of the high southwesterly winds with strength 4 were measured. The air temperature was hovering around 22°C. Until the 03th of March low clouds produced local showers. On the 5th a trough line from a low close to Antarctica crossed the working area. The associated swell of about 3 m reached R/V METEOR in the evening. As R/V METEOR was on the northeastern fringe of the high the wind shifted to the southeast and increased to 6 Bft. From the 7th R/V METEOR reached the core of the high with the result of a decreasing pressure gradient. At first southeasterly winds of about 4 Bft and a sea of 2 m were experienced while later the horse latitudes showed their existence with only light winds. Within almost 12 hours of sunshine and only a swell of 1m perfect working conditions prevailed. From the 9th R/V METEOR altered the course to the southeast. From noon a low pressure with some rain crossed the working area. However the wind was still weak from the south. Below an Inversion of 1000 m some local isolated showers persisted well into the 10th. The wind shifted to the east and freshened only in the vicinity of showers. From the 10th until the 12th the southwesterly swell was overlapped by a secondary swell from the northeast of about 1m. From the 11th a low to the east of the Brazilian coast moved to the southeast. Along the western fringe of the high the pressure gradient increased with the result of temporarily freshening winds of about 5 Bft. The sea including the swell reached 1.5 to 2m. With only a few passing clouds and an air temperature of about 25 °C good working conditions persisted. From the 14th more humid air invaded into the lower levels with the result of a lifting of the inversion layer up to 2000m. The cruising area was now on the western edge of the South Atlantic high pressure zone.

On the 15th a weak trough to the southwest of the working area crossed. Local showers were experienced. The southeasterly winds increased to about 5 Bft with the sea showing 2 to 3m. During the next following days until the final destination Rio de Janeiro humid air brought wide spread showers and sheet lightning. However sea and wind decreased. The sea showed 1 to 1.5 m with wind dropping to 3 to 4 Bft while approaching to Brasilia.

On the18th of March 2016, R/V METEOR reached the port of Rio de Janeiro.

7 Station list

Gear coding

CTD/RO: Conductivity/Temperature/Pressure sonde with rosette sampler
uCTD: Underway CTD
MSN: Multinet
XBT: Expandable Bathythermograph
FISH: in-situ pump

Station	Date	Time UTC	Position Latitude	Position Longitude	Depth [m]	Gear	Gear station #
M124/189-1	29/02/16	16:50	34° 08.26' S	017° 58.32' E	234.4	XBT	XBT #1
M124/190-1	29/02/16	17:08	34° 09.67' S	017° 54.83' E	261.4	XBT	XBT #2
M124/191-1	29/02/16	17:29	34° 12.30' S	017° 51.47' E	290.7	uCTD	uCTD #1
M124/191-1	29/02/16	17:44	34° 14.01' S	017° 48.85' E	325.3	uCTD	uCTD #2
M124/192-1	29/02/16	19:25	34° 23.30' S	017° 33.27' E	1220.7	MSN	MSN #192
M124/192-2	29/02/16	20:30	34° 23.30' S	017° 32.99' E	1235.8	CTD/RO	CTD #1
M124/193-1	29/02/16	21:10	34° 23.26' S	017° 32.62' E	1248.9	FISCH	FISCH
M124/194-1	29/02/16	22:10	34° 22.39' S	017° 24.01' E	2036.6	XBT	XBT #3
M124/195-1	29/02/16	22:59	34° 21.20' S	017° 11.93' E	2851.7	uCTD	uCTD #3
M124/195-1	01/03/16	00:13	34° 19.46' S	016° 54.14' E	2838.6	uCTD	uCTD #4
M124/196-1	01/03/16	00:49	34° 18.62' S	016° 45.63' E	0	XBT	XBT #4
M124/195-1	01/03/16	01:16	34° 18.00' S	016° 39.25' E	0	uCTD	uCTD #5
M124/195-1	01/03/16	01:51	34° 17.19' S	016° 31.04' E	0	uCTD	uCTD #6
M124/197-1	01/03/16	02:42	34° 16.02' S	016° 19.16' E	3756	XBT	XBT #5
M124/198-1	01/03/16	03:12	34° 15.35' S	016° 12.31' E	3886	uCTD	uCTD #7
M124/198-1	01/03/16	04:22	34° 13.79' S	015° 56.46' E	4035.6	uCTD	uCTD #8
M124/199-1	01/03/16	04:45	34° 13.29' S	015° 51.40' E	4071.4	XBT	XBT #6
M124/200-1	01/03/16	05:23	34° 12.49' S	015° 43.23' E	4115.6	uCTD	uCTD #9
M124/200-1	01/03/16	06:32	34° 11.04' S	015° 28.41' E	4217.9	uCTD	uCTD #10
M124/201-1	01/03/16	07:07	34° 10.33' S	015° 21.27' E	4264.4	XBT	XBT #7
M124/200-1	01/03/16	07:37	34° 09.72' S	015° 15.04' E	4289.1	uCTD	uCTD #11
M124/200-1	01/03/16	08:46	34° 08.28' S	015° 00.38' E	4333.9	uCTD	uCTD #12
M124/193-1	01/03/16	09:10	34° 07.95' S	014° 57.04' E	4340.7	FISCH	FISCH
M124/202-1	01/03/16	09:52	34° 07.94' S	014° 56.47' E	4343.2	MSN	MSN #202
M124/202-2	01/03/16	10:21	34° 08.00' S	014° 56.50' E	4342.4	MSN	MSN #202
M124/202-3	01/03/16	10:38	34° 08.10' S	014° 56.54' E	4342.4	MSN	MSN #202
M124/202-4	01/03/16	11:41	34° 08.28' S	014° 56.64' E	4344.2	CTD/RO	CTD #2
M124/193-1	01/03/16	12:26	34° 08.32' S	014° 56.65' E	4345.4	FISCH	FISCH
M124/203-1	01/03/16	13:26	34° 08.21' S	014° 45.41' E	4387	XBT	XBT #8
M124/204-1	01/03/16	14:07	34° 08.84' S	014° 37.07' E	4423.6	uCTD	uCTD #13
M124/204-1	01/03/16	15:11	34° 09.95' S	014° 24.24' E	4476.6	uCTD	uCTD #14
M124/205-1	01/03/16	16:07	34° 10.92' S	014° 13.08' E	4484.1	XBT	XBT #9
M124/206-1	01/03/16	16:22	34° 11.18' S	014° 10.10' E	4485.5	uCTD	uCTD #15
M124/206-1	01/03/16	17:10	34° 12.02' S	014° 00.53' E	4483.6	uCTD	uCTD #16
M124/207-1	01/03/16	18:12	34° 13.10' S	013° 48.11' E	4483.6	XBT	XBT #10
M124/206-1	01/03/16	18:35	34° 13.51' S	013° 43.37' E	4497.5	uCTD	uCTD #17
M124/206-1	01/03/16	19:35	34° 14.60' S	013° 30.86' E	4529.8	uCTD	uCTD #18
M124/208-1	01/03/16	20:24	34° 15.21' S	013° 23.91' E	4539.4	XBT	XBT #11
M124/206-1	01/03/16	20:46	34° 15.61' S	013° 19.34' E	4561.4	uCTD	uCTD #19

Station	Date	Time UTC	Position Latitude	Position Longitude	Depth [m]	Gear	Gear station #
M124/206-1	01/03/16	21:42	34° 16.63' S	013° 07.53' E	4621	uCTD	uCTD #20
M124/209-1	01/03/16	22:27	34° 17.45' S	012° 58.15' E	4646.6	XBT	XBT #12
M124/206-1	01/03/16	22:48	34° 17.83' S	012° 53.84' E	4665.8	uCTD	uCTD #21
M124/206-1	01/03/16	23:45	34° 18.86' S	012° 41.98' E	4702.8	uCTD	uCTD #22
M124/210-1	02/03/16	00:23	34° 19.54' S	012° 34.22' E	4717.7	XBT	XBT #13
M124/206-1	02/03/16	00:55	34° 20.12' S	012° 27.56' E	4743.1	uCTD	uCTD #23
M124/211-1	02/03/16	01:21	34° 20.58' S	012° 22.18' E	4760.2	XBT	XBT #14
M124/206-1	02/03/16	02:07	34° 21.42' S	012° 12.54' E	4784.6	uCTD	uCTD #24
M124/206-1	02/03/16	03:14	34° 22.65' S	011° 58.43' E	4819.1	uCTD	uCTD #25
M124/212-1	02/03/16	03:42	34° 23.17' S	011° 52.40' E	4846.8	XBT	XBT #15
M124/206-1	02/03/16	04:19	34° 23.87' S	011° 44.38' E	4863.2	uCTD	uCTD #26
M124/206-1	02/03/16	05:10	34° 24.83' S	011° 33.33' E	4900.4	uCTD	uCTD #27
M124/213-1	02/03/16	05:37	34° 25.33' S	011° 27.60' E	4933.7	XBT	XBT #16
M124/206-1	02/03/16	06:20	34° 26.12' S	011° 18.49' E	4948.5	uCTD	uCTD #28
M124/214-1	02/03/16	08:16	34° 27.24' S	011° 05.18' E	4962.7	MSN	MSN #214
M124/214-2	02/03/16	08:53	34° 27.24' S	011° 05.18' E	4964.4	MSN	MSN #214
M124/214-3	02/03/16	09:09	34° 27.24' S	011° 05.18' E	4964.4	MSN	MSN #214
M124/193-1	02/03/16	09:28	34° 27.24' S	011° 05.18' E	4954.1	FISCH	FISCH
M124/214-4	02/03/16	10:17	34° 27.24' S	011° 05.18' E	4964.9	CTD/RO	CTD #3
M124/193-1	02/03/16	11:05	34° 27.24' S	011° 05.15' E	4949.1	FISCH	FISCH
M124/215-1	02/03/16	11:50	34° 28.05' S	010° 56.38' E	4963.5	XBT	XBT #17
M124/216-1	02/03/16	12:01	34° 28.26' S	010° 53.88' E	5008.1	XBT	XBT #18
M124/217-1	02/03/16	12:27	34° 28.78' S	010° 47.89' E	4990.1	uCTD	uCTD #29
M124/217-1	02/03/16	12:43	34° 29.10' S	010° 44.20' E	5012	uCTD	uCTD #30
M124/217-1	02/03/16	13:45	34° 30.33' S	010° 30.09' E	5010.9	uCTD	uCTD #31
M124/218-1	02/03/16	14:06	34° 30.74' S	010° 25.41' E	5019	XBT	XBT #19
M124/217-1	02/03/16	15:51	34° 32.76' S	010° 02.19' E	5017.1	uCTD	uCTD #32
M124/219-1	02/03/16	16:14	34° 33.19' S	009° 57.13' E	5027.1	XBT	XBT #20
M124/217-1	02/03/16	17:00	34° 34.08' S	009° 46.97' E	5066.6	uCTD	uCTD #33
M124/217-1	02/03/16	18:08	34° 35.35' S	009° 32.24' E	5076.5	uCTD	uCTD #34
M124/220-1	02/03/16	18:28	34° 35.72' S	009° 28.00' E	5069.4	XBT	XBT #21
M124/217-1	02/03/16	19:11	34° 36.53' S	009° 18.73' E	5037	uCTD	uCTD #35
M124/217-1	02/03/16	20:26	34° 37.25' S	009° 02.53' E	5025.2	uCTD	uCTD #36
M124/221-1	02/03/16	20:58	34° 37.01' S	008° 55.48' E	5046.5	XBT	XBT #22
M124/217-1	02/03/16	21:38	34° 36.80' S	008° 46.70' E	5037.3	uCTD	uCTD #37
M124/222-1	02/03/16	23:18	34° 37.50' S	008° 37.51' E	5062	CTD/RO	CTD #4
M124/223-1	03/03/16	00:51	34° 32.73' S	008° 29.52' E	5095.2	XBT	XBT #23
M124/224-1	03/03/16	01:32	34° 28.14' S	008° 21.85' E	5132.8	uCTD	uCTD #38
M124/224-1	03/03/16	02:39	34° 20.69' S	008° 09.41' E	5137	uCTD	uCTD #39
M124/225-1	03/03/16	03:02	34° 18.19' S	008° 05.24' E	4746.2	XBT	XBT #24
M124/224-1	03/03/16	04:03	34° 11.67' S	007° 54.36' E	5211.6	uCTD	uCTD #40
M124/224-1	03/03/16	05:03	34° 05.26' S	007° 43.70' E	5198.6	uCTD	uCTD #41
M124/226-1	03/03/16	05:41	34° 01.19' S	007° 36.93' E	4199.7	XBT	XBT #25
M124/224-1	03/03/16	06:10	33° 58.08' S	007° 31.77' E	5227	uCTD	uCTD #42
M124/227-1	03/03/16	08:01	33° 52.84' S	007° 22.76' E	5198	CTD/RO	CTD #5
M124/227-2	03/03/16	09:29	33° 53.34' S	007° 23.20' E	5190.7	MSN	MSN #227

Station	Date	Time UTC	Position Latitude	Position Longitude	Depth [m]	Gear	Gear station #
M124/227-3	03/03/16	10:07	33° 53.25' S	007° 23.17' E	5188.5	MSN	MSN #227
M124/227-4	03/03/16	10:24	33° 53.32' S	007° 23.19' E	5192	MSN	MSN #227
M124/228-1	03/03/16	10:45	33° 52.59' S	007° 22.48' E	5205.3	XBT	XBT #26
M124/229-1	03/03/16	11:30	33° 47.20' S	007° 15.68' E	5175.1	uCTD	uCTD #43
M124/229-1	03/03/16	12:31	33° 40.02' S	007° 06.44' E	5235.7	uCTD	uCTD #44
M124/229-1	03/03/16	13:35	33° 33.00' S	006° 56.02' E	5084.6	uCTD	uCTD #45
M124/230-1	03/03/16	13:59	33° 30.85' S	006° 51.72' E	5170.5	XBT	XBT #27
M124/229-1	03/03/16	14:40	33° 27.13' S	006° 44.32' E	5225.2	uCTD	uCTD #46
M124/229-1	03/03/16	15:46	33° 21.03' S	006° 32.16' E	5173.6	uCTD	uCTD #47
M124/193-1	03/03/16	16:00	33° 19.73' S	006° 29.57' E	5140.5	FISCH	FISCH
M124/231-1	03/03/16	16:10	33° 18.80' S	006° 27.73' E	5161	XBT	XBT #28
M124/229-1	03/03/16	17:00	33° 14.09' S	006° 18.37' E	5068	uCTD	uCTD #48
M124/193-1	03/03/16	17:03	33° 13.80' S	006° 17.80' E	5084.1	FISCH	FISCH
M124/232-1	03/03/16	17:55	33° 08.80' S	006° 07.86' E	5215.7	XBT	XBT #29
M124/229-1	03/03/16	18:07	33° 07.64' S	006° 05.56' E	5104.1	uCTD	uCTD #49
M124/229-1	03/03/16	19:14	33° 01.09' S	005° 52.58' E	5083.7	uCTD	uCTD #50
M124/233-1	03/03/16	19:45	32° 58.07' S	005° 46.58' E	5185.7	XBT	XBT #30
M124/229-1	03/03/16	20:17	32° 54.89' S	005° 40.29' E	5234	uCTD	uCTD #51
M124/229-1	03/03/16	21:10	32° 49.52' S	005° 29.67' E	5192.6	uCTD	uCTD #52
M124/234-1	03/03/16	21:40	32° 46.50' S	005° 23.68' E	5056.3	XBT	XBT #31
M124/229-1	03/03/16	22:18	32° 42.94' S	005° 16.66' E	5017.9	uCTD	uCTD #53
M124/229-1	03/03/16	23:18	32° 36.83' S	005° 04.60' E	5140.3	uCTD	uCTD #54
M124/235-1	03/03/16	23:49	32° 33.68' S	004° 58.39' E	5021	XBT	XBT #32
M124/229-1	04/03/16	00:23	32° 30.27' S	004° 51.66' E	4918.5	uCTD	uCTD #55
M124/229-1	04/03/16	01:23	32° 24.30' S	004° 39.90' E	4957.3	uCTD	uCTD #56
M124/236-1	04/03/16	01:52	32° 21.44' S	004° 34.27' E	5124.7	XBT	XBT #33
M124/229-1	04/03/16	02:26	32° 18.09' S	004° 27.69' E	4787	uCTD	uCTD #57
M124/229-1	04/03/16	03:23	32° 12.41' S	004° 16.52' E	4918.5	uCTD	uCTD #58
M124/237-1	04/03/16	04:02	32° 08.48' S	004° 08.82' E	4787.1	XBT	XBT #34
M124/229-1	04/03/16	04:22	32° 06.48' S	004° 04.89' E	4777.4	uCTD	uCTD #59
M124/229-1	04/03/16	05:18	32° 00.91' S	003° 53.96' E	4690.1	uCTD	uCTD #60
M124/238-1	04/03/16	05:56	31° 57.17' S	003° 46.64' E	4707.6	XBT	XBT #35
M124/229-1	04/03/16	06:09	31° 55.90' S	003° 44.16' E	4714.3	uCTD	uCTD #61
M124/239-1	04/03/16	07:15	31° 52.50' S	003° 37.54' E	4679.9	MSN	MSN #239
M124/239-2	04/03/16	07:52	31° 52.50' S	003° 37.54' E	4679.3	MSN	MSN #239
M124/239-3	04/03/16	08:08	31° 52.50' S	003° 37.54' E	4681.2	MSN	MSN #239
M124/239-4	04/03/16	09:10	31° 52.51' S	003° 37.54' E	4681.1	CTD/RO	CTD #6
M124/240-1	04/03/16	10:43	31° 48.09' S	003° 30.84' E	4799.6	XBT	XBT #36
M124/241-1	04/03/16	11:37	31° 41.85' S	003° 21.41' E	4979.9	uCTD	uCTD #62
M124/242-1	04/03/16	11:55	31° 39.78' S	003° 18.29' E	4975.7	CTD-RCST	CTD-RCST
M124/242-1	04/03/16	12:48	31° 33.59' S	003° 08.95' E	4992.4	CTD-RCST	CTD-RCST
M124/243-1	04/03/16	12:50	31° 33.35' S	003° 08.59' E	4992.7	XBT	XBT #37
M124/242-1	04/03/16	12:56	31° 32.64' S	003° 07.51' E	4996.5	CTD-RCST	CTD-RCST
M124/242-1	04/03/16	13:11	31° 30.86' S	003° 04.84' E	4926.4	CTD-RCST	CTD-RCST
M124/241-1	04/03/16	13:11	31° 30.86' S	003° 04.84' E	4926.4	uCTD	uCTD #63
M124/242-1	04/03/16	13:30	31° 28.61' S	003° 01.46' E	4269.1	CTD-RCST	CTD-RCST

Station	Date	Time UTC	Position Latitude	Position Longitude	Depth [m]	Gear	Gear station #
M124/242-1	04/03/16	14:15	31° 25.09' S	002° 56.18' E	2530	CTD-RCST	CTD-RCST
M124/242-1	04/03/16	15:35	31° 25.62' S	002° 55.51' E	2561.4	CTD-RCST	CTD-RCST
M124/241-1	04/03/16	15:43	31° 25.41' S	002° 55.02' E	2730	uCTD	uCTD #64
M124/244-1	04/03/16	16:05	31° 22.20' S	002° 51.76' E	2764.7	XBT	XBT #38
M124/241-1	04/03/16	16:48	31° 17.12' S	002° 44.17' E	1480.9	uCTD	uCTD #65
M124/241-1	04/03/16	17:53	31° 09.52' S	002° 32.76' E	2268.2	uCTD	uCTD #66
M124/241-1	04/03/16	18:42	31° 03.87' S	002° 24.28' E	3999.4	uCTD	uCTD #67
M124/245-1	04/03/16	19:09	31° 00.72' S	002° 19.57' E	3898.9	XBT	XBT #39
M124/241-1	04/03/16	19:56	30° 55.24' S	002° 11.36' E	3815.1	uCTD	uCTD #68
M124/241-1	04/03/16	20:58	30° 48.00' S	002° 00.53' E	4280.5	uCTD	uCTD #69
M124/246-1	04/03/16	21:21	30° 45.36' S	001° 56.59' E	4312.6	XBT	XBT #40
M124/241-1	04/03/16	21:59	30° 41.06' S	001° 50.17' E	4296.7	uCTD	uCTD #70
M124/241-1	04/03/16	22:55	30° 34.75' S	001° 40.75' E	4201.4	uCTD	uCTD #71
M124/247-1	04/03/16	23:26	30° 31.25' S	001° 35.53' E	4188.7	XBT	XBT #41
M124/241-1	05/03/16	00:10	30° 26.26' S	001° 28.10' E	3883	uCTD	uCTD #72
M124/248-1	05/03/16	01:36	30° 22.51' S	001° 22.55' E	3163.7	CTD/RO	CTD #7
M124/193-1	05/03/16	02:31	30° 22.51' S	001° 22.55' E	3162.9	FISCH	FISCH
M124/249-1	05/03/16	03:21	30° 16.93' S	001° 15.33' E	1986.8	uCTD	uCTD #73
M124/250-1	05/03/16	03:54	30° 12.65' S	001° 09.83' E	2888.4	XBT	XBT #42
M124/250-1	05/03/16	03:56	30° 12.39' S	001° 09.50' E	2896.4	XBT	XBT #43
M124/249-1	05/03/16	04:20	30° 09.28' S	001° 05.50' E	2990.2	uCTD	uCTD #74
M124/249-1	05/03/16	05:34	29° 59.62' S	000° 53.11' E	2614.7	uCTD	uCTD #75
M124/251-1	05/03/16	06:08	29° 55.24' S	000° 47.53' E	2946	XBT	XBT #44
M124/249-1	05/03/16	06:21	29° 54.76' S	000° 48.71' E	2924	uCTD	uCTD #76
M124/252-1	05/03/16	08:08	29° 54.98' S	001° 00.78' E	3154.4	MSN	MSN #252
M124/252-2	05/03/16	08:46	29° 54.97' S	001° 00.78' E	3153.2	MSN	MSN #252
M124/252-3	05/03/16	09:03	29° 54.94' S	001° 00.75' E	3153.5	MSN	MSN #252
M124/253-1	05/03/16	09:27	29° 54.13' S	001° 02.98' E	3385.1	uCTD	uCTD #77
M124/254-1	05/03/16	09:56	29° 52.34' S	001° 08.90' E	3598.8	XBT	XBT #45
M124/253-1	05/03/16	10:28	29° 50.88' S	001° 15.57' E	3645.4	uCTD	uCTD #78
M124/253-1	05/03/16	11:28	29° 49.28' S	001° 27.99' E	3685.8	uCTD	uCTD #79
M124/255-1	05/03/16	11:54	29° 48.56' S	001° 33.41' E	3685.7	XBT	XBT #46
M124/253-1	05/03/16	12:22	29° 47.78' S	001° 39.22' E	3686	uCTD	uCTD #80
M124/253-1	05/03/16	13:24	29° 46.03' S	001° 52.30' E	3630.1	uCTD	uCTD #81
M124/256-1	05/03/16	13:47	29° 45.36' S	001° 57.27' E	3578.1	XBT	XBT #47
M124/253-1	05/03/16	14:35	29° 49.90' S	001° 55.83' E	3619.4	uCTD	uCTD #82
M124/193-1	05/03/16	14:55	29° 50.97' S	001° 54.90' E	3609	FISCH	FISCH
M124/253-1	05/03/16	15:34	29° 53.45' S	001° 52.81' E	3621.8	uCTD	uCTD #83
M124/257-1	05/03/16	16:14	29° 56.02' S	001° 50.63' E	3654.7	XBT	XBT #48
M124/253-1	05/03/16	16:27	29° 56.67' S	001° 50.07' E	3654.6	uCTD	uCTD #84
M124/253-1	05/03/16	17:28	29° 59.89' S	001° 47.33' E	3567	uCTD	uCTD #85
M124/258-1	05/03/16	18:12	30° 02.59' S	001° 45.04' E	3555.2	XBT	XBT #49
M124/253-1	05/03/16	18:27	30° 03.54' S	001° 44.22' E	3550.9	uCTD	uCTD #86
M124/253-1	05/03/16	19:28	30° 06.86' S	001° 41.40' E	3477	uCTD	uCTD #87
M124/259-1	05/03/16	20:07	30° 08.31' S	001° 40.17' E	3014.6	XBT	XBT #50
M124/253-1	05/03/16	20:38	30° 10.00' S	001° 38.72' E	2732.2	uCTD	uCTD #88

Station	Date	Time UTC	Position Latitude	Position Longitude	Depth [m]	Gear	Gear station #
M124/253-1	05/03/16	21:47	30° 13.43' S	001° 35.78' E	2736.9	uCTD	uCTD #89
M124/260-1	05/03/16	22:06	30° 14.39' S	001° 34.97' E	2716.9	XBT	XBT #51
M124/253-1	05/03/16	22:50	30° 16.61' S	001° 33.08' E	2801.9	uCTD	uCTD #90
M124/253-1	05/03/16	23:50	30° 24.13' S	001° 26.65' E	3616.3	uCTD	uCTD #91
M124/261-1	06/03/16	00:17	30° 27.52' S	001° 23.76' E	3578.9	XBT	XBT #52
M124/253-1	06/03/16	00:55	30° 32.14' S	001° 19.96' E	3023.2	uCTD	uCTD #92
M124/253-1	06/03/16	01:57	30° 39.60' S	001° 13.41' E	3448.4	uCTD	uCTD #93
M124/262-1	06/03/16	02:12	30° 41.37' S	001° 11.89' E	3530.6	XBT	XBT #53
M124/253-1	06/03/16	03:14	30° 48.70' S	001° 05.60' E	4419.6	uCTD	uCTD #94
M124/253-1	06/03/16	04:07	30° 55.11' S	001° 00.09' E	4411.3	uCTD	uCTD #95
M124/263-1	06/03/16	04:24	30° 57.19' S	000° 58.30' E	4414.5	XBT	XBT #54
M124/263-1	06/03/16	04:27	30° 57.57' S	000° 57.97' E	4418.4	XBT	XBT #55
M124/253-1	06/03/16	05:04	31° 01.89' S	000° 54.26' E	4413.6	uCTD	uCTD #96
M124/253-1	06/03/16	06:03	31° 08.43' S	000° 48.62' E	4401.3	uCTD	uCTD #97
M124/264-1	06/03/16	06:21	31° 10.54' S	000° 46.80' E	4433.2	XBT	XBT #56
M124/253-1	06/03/16	07:06	31° 15.78' S	000° 42.29' E	4428.6	uCTD	uCTD #98
M124/265-1	06/03/16	09:01	31° 24.53' S	000° 34.86' E	4491.9	MSN	MSN #265
M124/265-2	06/03/16	09:43	31° 24.22' S	000° 35.08' E	4493.2	MSN	MSN #265
M124/265-3	06/03/16	10:13	31° 23.94' S	000° 35.28' E	4490.2	MSN	MSN #265
M124/266-1	06/03/16	11:25	31° 23.33' S	000° 35.60' E	4492.2	CTD/RO	CTD #8
M124/267-1	06/03/16	12:44	31° 25.24' S	000° 34.11' E	4492.5	XBT	XBT #57
M124/268-1	06/03/16	12:53	31° 26.31' S	000° 33.19' E	4494.9	uCTD	uCTD #99
M124/268-1	06/03/16	13:56	31° 29.33' S	000° 23.13' E	4485.4	uCTD	uCTD #100
M124/269-1	06/03/16	14:42	31° 28.37' S	000° 13.30' E	4364.1	XBT	XBT #58
M124/268-1	06/03/16	15:00	31° 27.99' S	000° 09.41' E	4415.4	uCTD	uCTD #101
M124/268-1	06/03/16	16:00	31° 26.75' S	000° 03.30' W	4439.5	uCTD	uCTD #102
M124/270-1	06/03/16	16:42	31° 25.90' S	000° 11.99' W	4362.3	XBT	XBT #59
M124/268-1	06/03/16	17:07	31° 25.39' S	000° 17.14' W	3802.1	uCTD	uCTD #103
M124/268-1	06/03/16	18:08	31° 24.18' S	000° 29.56' W	3257	uCTD	uCTD #104
M124/271-1	06/03/16	18:38	31° 23.58' S	000° 35.70' W	2877.4	XBT	XBT #60
M124/268-1	06/03/16	19:07	31° 23.00' S	000° 41.64' W	2800	uCTD	uCTD #105
M124/268-1	06/03/16	20:17	31° 21.59' S	000° 55.97' W	3446.4	uCTD	uCTD #106
M124/272-1	06/03/16	20:50	31° 20.93' S	001° 02.73' W	4041	XBT	XBT #61
M124/268-1	06/03/16	21:22	31° 20.28' S	001° 09.37' W	3406.7	uCTD	uCTD #107
M124/268-1	06/03/16	22:28	31° 18.93' S	001° 23.18' W	4701.6	uCTD	uCTD #108
M124/273-1	06/03/16	22:47	31° 18.53' S	001° 27.25' W	4746.8	XBT	XBT #62
M124/268-1	06/03/16	23:24	31° 17.75' S	001° 35.25' W	4750	uCTD	uCTD #109
M124/268-1	07/03/16	00:27	31° 16.41' S	001° 48.90' W	4620.2	uCTD	uCTD #110
M124/274-1	07/03/16	00:49	31° 15.92' S	001° 53.66' W	4595	XBT	XBT #63
M124/268-1	07/03/16	01:32	31° 15.03' S	002° 03.00' W	4313.2	uCTD	uCTD #111
M124/268-1	07/03/16	02:33	31° 13.72' S	002° 16.34' W	4428.1	uCTD	uCTD #112
M124/275-1	07/03/16	02:58	31° 13.18' S	002° 21.88' W	3297.8	XBT	XBT #64
M124/268-1	07/03/16	03:33	31° 12.42' S	002° 29.62' W	2899.3	uCTD	uCTD #113
M124/268-1	07/03/16	04:36	31° 11.06' S	002° 43.52' W	4306	uCTD	uCTD #114
M124/276-1	07/03/16	05:10	31° 10.31' S	002° 51.15' W	4165.3	XBT	XBT #65
M124/268-1	07/03/16	05:35	31° 09.76' S	002° 56.76' W	4617.5	uCTD	uCTD #115

Station	Date	Time UTC	Position Latitude	Position Longitude	Depth [m]	Gear	Gear station #
M124/268-1	07/03/16	06:42	31° 08.26' S	003° 12.03' W	4169.2	uCTD	uCTD #116
M124/277-1	07/03/16	07:00	31° 07.86' S	003° 16.16' W	4130.1	XBT	XBT #66
M124/268-1	07/03/16	07:29	31° 07.21' S	003° 22.80' W	4191.8	uCTD	uCTD #117
M124/278-1	07/03/16	08:54	31° 06.28' S	003° 34.30' W	4145	MSN	MSN #278
M124/278-2	07/03/16	09:30	31° 06.28' S	003° 34.31' W	4141.5	MSN	MSN #278
M124/278-3	07/03/16	09:45	31° 06.28' S	003° 34.31' W	4142.1	MSN	MSN #278
M124/279-1	07/03/16	11:08	31° 04.62' S	003° 49.15' W	4244.9	uCTD	uCTD #118
M124/280-1	07/03/16	11:33	31° 04.08' S	003° 54.62' W	4540.7	XBT	XBT #67
M124/279-1	07/03/16	12:05	31° 03.39' S	004° 01.68' W	4351.7	uCTD	uCTD #119
M124/279-1	07/03/16	13:14	31° 01.88' S	004° 17.05' W	4316.2	uCTD	uCTD #120
M124/281-1	07/03/16	13:41	31° 01.23' S	004° 22.93' W	4228.9	XBT	XBT #68
M124/279-1	07/03/16	14:11	31° 00.66' S	004° 29.52' W	4188.2	uCTD	uCTD #121
M124/279-1	07/03/16	15:12	30° 59.32' S	004° 43.09' W	4312.9	uCTD	uCTD #122
M124/282-1	07/03/16	15:37	30° 58.78' S	004° 48.66' W	4282	XBT	XBT #69
M124/279-1	07/03/16	16:10	30° 58.83' S	004° 55.97' W	4459.1	uCTD	uCTD #123
M124/279-1	07/03/16	16:55	30° 57.07' S	005° 06.03' W	4471.8	uCTD	uCTD #124
M124/283-1	07/03/16	17:15	30° 56.64' S	005° 10.45' W	4450.1	XBT	XBT #70
M124/279-1	07/03/16	18:07	30° 55.51' S	005° 21.87' W	4231.5	uCTD	uCTD #125
M124/279-1	07/03/16	19:05	30° 54.27' S	005° 34.55' W	4436.3	uCTD	uCTD #126
M124/284-1	07/03/16	19:25	30° 53.83' S	005° 38.93' W	4265.2	XBT	XBT #71
M124/285-1	07/03/16	21:15	30° 52.50' S	005° 52.50' W	4160.7	CTD/RO	CTD #9
M124/286-1	07/03/16	22:48	30° 53.55' S	006° 00.91' W	4052.9	XBT	XBT #72
M124/287-1	07/03/16	23:02	30° 53.96' S	006° 04.12' W	4385.4	uCTD	uCTD #127
M124/287-1	08/03/16	00:05	30° 55.79' S	006° 18.77' W	4139.5	uCTD	uCTD #128
M124/288-1	08/03/16	00:32	30° 56.61' S	006° 25.11' W	4064.6	XBT	XBT #73
M124/287-1	08/03/16	01:11	30° 57.74' S	006° 34.33' W	4090.7	uCTD	uCTD #129
M124/287-1	08/03/16	02:17	30° 59.66' S	006° 49.63' W	4188.3	uCTD	uCTD #130
M124/289-1	08/03/16	02:42	31° 00.39' S	006° 55.49' W	4473.8	XBT	XBT #74
M124/287-1	08/03/16	03:18	31° 01.43' S	007° 03.81' W	4383.5	uCTD	uCTD #131
M124/287-1	08/03/16	04:17	31° 03.15' S	007° 17.52' W	4435.6	uCTD	uCTD #132
M124/290-1	08/03/16	04:37	31° 03.72' S	007° 22.11' W	4366.3	XBT	XBT #75
M124/287-1	08/03/16	05:13	31° 04.76' S	007° 30.41' W	4413.1	uCTD	uCTD #133
M124/287-1	08/03/16	06:09	31° 06.38' S	007° 43.35' W	4399.3	uCTD	uCTD #134
M124/291-1	08/03/16	06:28	31° 06.93' S	007° 47.75' W	4413.8	XBT	XBT #76
M124/287-1	08/03/16	07:07	31° 08.05' S	007° 56.72' W	4417.6	uCTD	uCTD #135
M124/292-1	08/03/16	08:55	31° 10.33' S	008° 13.30' W	4422.2	MSN	MSN #193
M124/292-2	08/03/16	09:32	31° 10.33' S	008° 13.29' W	4422.2	MSN	MSN #193
M124/292-3	08/03/16	09:48	31° 10.33' S	008° 13.29' W	4422.5	MSN	MSN #193
M124/293-1	08/03/16	10:36	31° 11.05' S	008° 20.75' W	4342.4	XBT	XBT #77
M124/294-1	08/03/16	11:11	31° 12.08' S	008° 28.49' W	4335.3	uCTD	uCTD #136
M124/294-1	08/03/16	12:16	31° 14.76' S	008° 42.68' W	4367.3	uCTD	uCTD #137
M124/295-1	08/03/16	12:40	31° 15.52' S	008° 48.01' W	4353.3	XBT	XBT #78
M124/294-1	08/03/16	13:22	31° 17.16' S	008° 57.32' W	4327.5	uCTD	uCTD #138
M124/296-1	08/03/16	14:43	31° 18.32' S	009° 06.86' W	4239.3	XBT	XBT #79
M124/294-1	08/03/16	15:13	31° 19.32' S	009° 13.62' W	4088.7	uCTD	uCTD #139
M124/294-1	08/03/16	15:42	31° 20.20' S	009° 20.18' W	3805.6	uCTD	uCTD #140

Station	Date	Time UTC	Position Latitude	Position Longitude	Depth [m]	Gear	Gear station #
M124/294-1	08/03/16	16:53	31° 22.09' S	009° 36.06' W	3697.9	uCTD	uCTD #141
M124/297-1	08/03/16	17:41	31° 22.20' S	009° 44.69' W	3521.6	XBT	XBT #80
M124/294-1	08/03/16	18:17	31° 22.30' S	009° 52.92' W	3650.6	uCTD	uCTD #142
M124/298-1	08/03/16	20:09	31° 22.49' S	010° 07.50' W	3555.3	CTD/RO	CTD #10
M124/299-1	08/03/16	21:25	31° 23.54' S	010° 13.82' W	3642.6	XBT	XBT #81
M124/300-1	08/03/16	21:40	31° 24.09' S	010° 17.10' W	3478.8	uCTD	uCTD #143
M124/300-1	08/03/16	22:40	31° 25.37' S	010° 30.42' W	3676.9	uCTD	uCTD #144
M124/301-1	08/03/16	23:17	31° 25.92' S	010° 38.80' W	3376.4	XBT	XBT #82
M124/300-1	08/03/16	23:31	31° 26.17' S	010° 41.99' W	3335.1	uCTD	uCTD #145
M124/300-1	09/03/16	00:40	31° 27.83' S	010° 57.72' W	3505.4	uCTD	uCTD #146
M124/302-1	09/03/16	01:11	31° 28.59' S	011° 04.87' W	3449.4	XBT	XBT #83
M124/300-1	09/03/16	01:44	31° 29.40' S	011° 12.45' W	3276.3	uCTD	uCTD #147
M124/300-1	09/03/16	02:45	31° 30.86' S	011° 26.27' W	3235.1	uCTD	uCTD #148
M124/303-1	09/03/16	03:06	31° 31.38' S	011° 31.10' W	3186.1	XBT	XBT #84
M124/300-1	09/03/16	03:45	31° 33.79' S	011° 33.68' W	3206.8	uCTD	uCTD #149
M124/300-1	09/03/16	04:55	31° 41.04' S	011° 20.26' W	3570.9	uCTD	uCTD #150
M124/304-1	09/03/16	05:15	31° 43.10' S	011° 16.47' W	3657.2	XBT	XBT #85
M124/300-1	09/03/16	05:50	31° 46.73' S	011° 09.73' W	3724.9	uCTD	uCTD #151
M124/300-1	09/03/16	06:54	31° 53.43' S	010° 57.30' W	3613.7	uCTD	uCTD #152
M124/305-1	09/03/16	07:13	31° 55.43' S	010° 53.59' W	3527.3	XBT	XBT #86
M124/300-1	09/03/16	07:50	31° 59.35' S	010° 46.33' W	3658.5	uCTD	uCTD #153
M124/306-1	09/03/16	08:57	32° 02.87' S	010° 40.05' W	3675.7	MSN	MSN #306
M124/306-2	09/03/16	09:32	32° 02.91' S	010° 39.73' W	3694.8	MSN	MSN #306
M124/306-3	09/03/16	09:47	32° 02.93' S	010° 39.64' W	3704.2	MSN	MSN #306
M124/307-1	09/03/16	10:18	32° 04.72' S	010° 36.33' W	3699	uCTD	uCTD #154
M124/308-1	09/03/16	10:36	32° 06.69' S	010° 32.68' W	3733.9	XBT	XBT #87
M124/307-1	09/03/16	11:19	32° 11.40' S	010° 23.92' W	3873.5	uCTD	uCTD #155
M124/307-1	09/03/16	12:26	32° 19.01' S	010° 09.71' W	4119.5	uCTD	uCTD #156
M124/309-1	09/03/16	12:49	32° 21.36' S	010° 05.34' W	3882.1	XBT	XBT #88
M124/307-1	09/03/16	13:30	32° 25.66' S	009° 57.32' W	2966.5	uCTD	uCTD #157
M124/310-1	09/03/16	14:42	32° 33.38' S	009° 42.90' W	3945.4	XBT	XBT #89
M124/307-1	09/03/16	15:18	32° 32.85' S	009° 39.27' W	3935.3	uCTD	uCTD #158
M124/307-1	09/03/16	16:04	32° 25.28' S	009° 42.33' W	3672	uCTD	uCTD #159
M124/311-1	09/03/16	16:37	32° 19.20' S	009° 44.78' W	3971	XBT	XBT #90
M124/307-1	09/03/16	17:05	32° 13.75' S	009° 46.97' W	4058	uCTD	uCTD #160
M124/307-1	09/03/16	18:10	32° 01.75' S	009° 51.79' W	3771	uCTD	uCTD #161
M124/312-1	09/03/16	18:39	31° 56.72' S	009° 53.81' W	3859.8	XBT	XBT #91
M124/307-1	09/03/16	19:07	31° 51.28' S	009° 55.99' W	3821.3	uCTD	uCTD #162
M124/307-1	09/03/16	20:15	31° 38.45' S	010° 01.13' W	3973.1	uCTD	uCTD #163
M124/313-1	09/03/16	20:37	31° 34.88' S	010° 02.55' W	4012.3	XBT	XBT #92
M124/307-1	09/03/16	21:13	31° 27.82' S	010° 05.38' W	3579.7	uCTD	uCTD #164
M124/307-1	09/03/16	22:12	31° 17.29' S	010° 09.57' W	3607	uCTD	uCTD #165
M124/314-1	09/03/16	22:34	31° 13.93' S	010° 10.91' W	3008.1	XBT	XBT #93
M124/307-1	09/03/16	23:08	31° 07.24' S	010° 13.58' W	3817.8	uCTD	uCTD #166
M124/307-1	10/03/16	00:04	30° 57.01' S	010° 17.64' W	3693.2	uCTD	uCTD #167
M124/315-1	10/03/16	00:30	30° 52.63' S	010° 19.38' W	3581.3	XBT	XBT #94

Station	Date	Time UTC	Position Latitude	Position Longitude	Depth [m]	Gear	Gear station #
M124/307-1	10/03/16	01:13	30° 44.12' S	010° 22.74' W	3533.8	uCTD	uCTD #168
M124/307-1	10/03/16	02:09	30° 33.68' S	010° 26.88' W	3733.5	uCTD	uCTD #169
M124/316-1	10/03/16	02:47	30° 28.86' S	010° 28.78' W	3659.9	XBT	XBT #95
M124/307-1	10/03/16	03:12	30° 23.96' S	010° 30.71' W	3576.6	uCTD	uCTD #170
M124/307-1	10/03/16	04:15	30° 12.29' S	010° 35.31' W	3623.7	uCTD	uCTD #171
M124/317-1	10/03/16	04:51	30° 07.75' S	010° 39.53' W	3768.9	XBT	XBT #96
M124/307-1	10/03/16	05:22	30° 07.00' S	010° 47.01' W	3708.3	uCTD	uCTD #172
M124/307-1	10/03/16	06:18	30° 05.75' S	010° 59.46' W	3704.5	uCTD	uCTD #173
M124/318-1	10/03/16	06:35	30° 05.41' S	011° 02.82' W	3556.5	XBT	XBT #97
M124/307-1	10/03/16	07:05	30° 04.69' S	011° 10.00' W	3533.5	uCTD	uCTD #174
M124/307-1	10/03/16	08:21	30° 03.03' S	011° 26.54' W	3427.1	uCTD	uCTD #175
M124/319-1	10/03/16	08:39	30° 02.68' S	011° 30.02' W	3485.4	XBT	XBT #98
M124/320-1	10/03/16	09:54	30° 01.61' S	011° 39.52' W	3489.8	MSN	MSN #320
M124/320-2	10/03/16	10:30	30° 01.61' S	011° 39.52' W	3489.4	MSN	MSN #320
M124/320-3	10/03/16	11:07	30° 01.61' S	011° 39.52' W	3489.6	MSN	MSN #320
M124/320-4	10/03/16	11:46	30° 01.61' S	011° 39.52' W	3489.6	MSN	MSN #320
M124/321-1	10/03/16	12:22	30° 01.29' S	011° 43.92' W	3522.5	uCTD	uCTD #176
M124/322-1	10/03/16	12:42	30° 00.92' S	011° 47.61' W	3514.7	XBT	XBT #99
M124/321-1	10/03/16	13:28	29° 59.84' S	011° 58.36' W	3618.8	uCTD	uCTD #177
M124/321-1	10/03/16	14:26	29° 58.59' S	012° 10.81' W	3473.4	uCTD	uCTD #178
M124/321-1	10/03/16	15:23	29° 57.41' S	012° 22.57' W	3252.4	uCTD	uCTD #179
M124/323-1	10/03/16	15:42	29° 57.06' S	012° 25.98' W	3274.1	XBT	XBT #100
M124/321-1	10/03/16	16:30	29° 55.98' S	012° 36.78' W	3285.7	uCTD	uCTD #180
M124/321-1	10/03/16	17:30	29° 54.66' S	012° 49.98' W	3096.8	uCTD	uCTD #181
M124/324-1	10/03/16	17:50	29° 54.28' S	012° 53.70' W	3433.6	XBT	XBT #101
M124/324-1	10/03/16	17:53	29° 54.23' S	012° 54.25' W	3437.4	XBT	XBT #102
M124/321-1	10/03/16	18:29	29° 53.45' S	013° 02.00' W	2944.2	uCTD	uCTD #182
M124/321-1	10/03/16	19:31	29° 52.08' S	013° 15.61' W	3052	uCTD	uCTD #183
M124/325-1	10/03/16	19:49	29° 51.73' S	013° 19.07' W	2693.2	XBT	XBT #103
M124/321-1	10/03/16	20:40	29° 50.55' S	013° 30.86' W	2651.7	uCTD	uCTD #184
M124/321-1	10/03/16	21:37	29° 49.35' S	013° 42.76' W	2195.3	uCTD	uCTD #185
M124/326-1	10/03/16	21:56	29° 49.00' S	013° 46.21' W	3168.2	XBT	XBT #104
M124/321-1	10/03/16	22:31	29° 48.22' S	013° 54.00' W	3551.5	uCTD	uCTD #186
M124/321-1	10/03/16	23:28	29° 47.01' S	014° 06.03' W	2945.1	uCTD	uCTD #187
M124/327-1	10/03/16	23:46	29° 46.67' S	014° 09.41' W	3001.6	XBT	XBT #105
M124/321-1	11/03/16	00:22	29° 45.80' S	014° 18.08' W	3015.2	uCTD	uCTD #188
M124/321-1	11/03/16	01:27	29° 44.36' S	014° 32.40' W	2949.9	uCTD	uCTD #189
M124/328-1	11/03/16	01:51	29° 43.93' S	014° 36.68' W	2888.7	XBT	XBT #106
M124/321-1	11/03/16	02:25	29° 43.16' S	014° 44.24' W	2814.3	uCTD	uCTD #190
M124/321-1	11/03/16	03:25	29° 41.84' S	014° 57.42' W	3230.7	uCTD	uCTD #191
M124/329-1	11/03/16	03:46	29° 41.43' S	015° 01.43' W	3011.1	XBT	XBT #107
M124/321-1	11/03/16	04:42	29° 40.14' S	015° 14.29' W	3106.5	uCTD	uCTD #192
M124/321-1	11/03/16	04:50	29° 39.98' S	015° 15.83' W	3303.4	uCTD	uCTD #193
M124/330-1	11/03/16	05:50	29° 38.62' S	015° 29.37' W	3795.5	XBT	XBT #108
M124/321-1	11/03/16	06:04	29° 38.30' S	015° 32.52' W	3479	uCTD	uCTD #194
M124/321-1	11/03/16	06:49	29° 37.29' S	015° 42.57' W	4057.7	uCTD	uCTD #195

Station	Date	Time UTC	Position Latitude	Position Longitude	Depth [m]	Gear	Gear station #
M124/321-1	11/03/16	07:17	29° 36.72' S	015° 48.29' W	3823	uCTD	uCTD #196
M124/331-1	11/03/16	07:49	29° 36.01' S	015° 55.29' W	3585.6	XBT	XBT #109
M124/321-1	11/03/16	08:09	29° 35.53' S	016° 00.04' W	3863.4	uCTD	uCTD #197
M124/332-1	11/03/16	09:56	29° 33.89' S	016° 16.76' W	3806.2	MSN	MSN #332
M124/332-2	11/03/16	10:30	29° 33.74' S	016° 16.86' W	3821.3	MSN	MSN #332
M124/332-3	11/03/16	11:07	29° 33.53' S	016° 16.99' W	3867.1	MSN	MSN #332
M124/332-4	11/03/16	11:42	29° 33.32' S	016° 17.14' W	3929.9	MSN	MSN #332
M124/332-5	11/03/16	12:54	29° 32.98' S	016° 17.36' W	4046.5	CTD/RO	CTD #11
M124/333-1	11/03/16	14:19	29° 32.91' S	016° 24.43' W	4170.6	XBT	XBT #110
M124/334-1	11/03/16	14:39	29° 32.76' S	016° 29.14' W	4142.2	uCTD	uCTD #198
M124/334-1	11/03/16	15:42	29° 31.14' S	016° 43.53' W	4104.5	uCTD	uCTD #199
M124/335-1	11/03/16	16:11	29° 30.50' S	016° 49.89' W	3862.4	XBT	XBT #111
M124/334-1	11/03/16	16:37	29° 29.89' S	016° 56.02' W	3943.2	uCTD	uCTD #200
M124/334-1	11/03/16	17:43	29° 28.41' S	017° 10.67' W	3473.9	uCTD	uCTD #201
M124/336-1	11/03/16	18:22	29° 27.54' S	017° 19.23' W	3527.8	XBT	XBT #112
M124/334-1	11/03/16	18:41	29° 27.10' S	017° 23.62' W	3615.6	uCTD	uCTD #202
M124/334-1	11/03/16	19:44	29° 25.73' S	017° 37.51' W	3853.9	uCTD	uCTD #203
M124/337-1	11/03/16	20:22	29° 24.92' S	017° 45.71' W	4034.2	XBT	XBT #113
M124/334-1	11/03/16	20:45	29° 24.34' S	017° 50.97' W	4064.9	uCTD	uCTD #204
M124/334-1	11/03/16	21:43	29° 23.05' S	018° 03.77' W	4075.4	uCTD	uCTD #205
M124/338-1	11/03/16	22:44	29° 21.72' S	018° 16.87' W	4067.1	XBT	XBT #114
M124/334-1	11/03/16	22:50	29° 21.59' S	018° 18.18' W	3999.7	uCTD	uCTD #206
M124/334-1	12/03/16	00:02	29° 20.02' S	018° 33.75' W	4106.6	uCTD	uCTD #207
M124/339-1	12/03/16	00:21	29° 19.69' S	018° 36.98' W	4182.1	XBT	XBT #115
M124/334-1	12/03/16	01:02	29° 18.75' S	018° 46.31' W	4379.4	uCTD	uCTD #208
M124/334-1	12/03/16	02:12	29° 17.25' S	019° 01.08' W	4392.9	uCTD	uCTD #209
M124/340-1	12/03/16	02:30	29° 16.93' S	019° 04.27' W	4287.6	XBT	XBT #116
M124/334-1	12/03/16	03:03	29° 16.18' S	019° 11.73' W	4430.2	uCTD	uCTD #210
M124/334-1	12/03/16	04:09	29° 14.71' S	019° 26.24' W	4671.7	uCTD	uCTD #211
M124/341-1	12/03/16	04:30	29° 14.32' S	019° 30.09' W	4626.8	XBT	XBT #117
M124/334-1	12/03/16	05:11	29° 13.36' S	019° 39.63' W	4213.3	uCTD	uCTD #212
M124/334-1	12/03/16	06:09	29° 12.03' S	019° 52.71' W	4263.5	uCTD	uCTD #213
M124/342-1	12/03/16	06:33	29° 11.53' S	019° 57.72' W	4311.2	XBT	XBT #118
M124/343-1	12/03/16	07:26	29° 10.80' S	020° 03.18' W	4151.7	MSN	MSN #NA
M124/343-2	12/03/16	07:59	29° 10.80' S	020° 03.18' W	4149.5	MSN	MSN #NA
M124/343-3	12/03/16	08:32	29° 10.79' S	020° 03.18' W	4151.7	MSN	MSN #NA
M124/343-4	12/03/16	09:06	29° 10.80' S	020° 03.18' W	4149.3	MSN	MSN #NA
M124/344-1	12/03/16	09:32	29° 10.36' S	020° 05.47' W	3950.9	uCTD	uCTD #214
M124/345-1	12/03/16	09:58	29° 08.20' S	020° 09.95' W	4382.1	XBT	XBT #119
M124/345-1	12/03/16	10:02	29° 07.71' S	020° 10.71' W	4435.4	XBT	XBT #120
M124/344-1	12/03/16	10:36	29° 03.63' S	020° 17.02' W	4485.5	uCTD	uCTD #215
M124/344-1	12/03/16	11:30	28° 58.86' S	020° 27.33' W	4720.2	uCTD	uCTD #216
M124/346-1	12/03/16	11:47	28° 57.62' S	020° 30.07' W	4531.1	XBT	XBT #121
M124/344-1	12/03/16	12:23	28° 54.43' S	020° 37.67' W	4538.8	uCTD	uCTD #217
M124/344-1	12/03/16	13:36	28° 47.91' S	020° 51.26' W	4458.3	uCTD	uCTD #218
M124/347-1	12/03/16	13:58	28° 46.08' S	020° 54.88' W	4483.9	XBT	XBT #122

Station	Date	Time UTC	Position Latitude	Position Longitude	Depth [m]	Gear	Gear station #
M124/344-1	12/03/16	14:30	28° 42.85' S	021° 01.26' W	4304.8	uCTD	uCTD #219
M124/344-1	12/03/16	15:30	28° 37.41' S	021° 12.02' W	4474.9	uCTD	uCTD #220
M124/348-1	12/03/16	15:52	28° 35.66' S	021° 15.47' W	4464.1	XBT	XBT #123
M124/344-1	12/03/16	16:33	28° 31.63' S	021° 23.43' W	4556.7	uCTD	uCTD #221
M124/349-1	12/03/16	17:51	28° 25.64' S	021° 35.24' W	4479.4	XBT	XBT #124
M124/344-1	12/03/16	18:02	28° 24.62' S	021° 37.25' W	4581.9	uCTD	uCTD #222
M124/344-1	12/03/16	21:39	28° 21.21' S	022° 24.05' W	4629.1	uCTD	uCTD #223
M124/350-1	12/03/16	22:04	28° 21.25' S	022° 28.40' W	4760.3	XBT	XBT #125
M124/344-1	12/03/16	22:47	28° 20.47' S	022° 37.78' W	4602.3	uCTD	uCTD #224
M124/344-1	12/03/16	23:57	28° 15.74' S	022° 51.06' W	5116.8	uCTD	uCTD #225
M124/351-1	13/03/16	00:23	28° 12.86' S	022° 54.85' W	4772.6	XBT	XBT #126
M124/344-1	13/03/16	01:18	28° 05.80' S	023° 04.48' W	4792.1	uCTD	uCTD #226
M124/344-1	13/03/16	02:18	27° 58.65' S	023° 14.22' W	5029.7	uCTD	uCTD #227
M124/352-1	13/03/16	02:38	27° 56.54' S	023° 17.07' W	5289.1	XBT	XBT #127
M124/344-1	13/03/16	03:18	27° 51.16' S	023° 24.13' W	4809.1	uCTD	uCTD #228
M124/344-1	13/03/16	04:23	27° 43.18' S	023° 34.50' W	4658.9	uCTD	uCTD #229
M124/353-1	13/03/16	04:47	27° 40.49' S	023° 37.91' W	4523.2	XBT	XBT #128
M124/344-1	13/03/16	05:21	27° 35.91' S	023° 43.67' W	4701	uCTD	uCTD #230
M124/344-1	13/03/16	06:26	27° 27.74' S	023° 54.01' W	4986.3	uCTD	uCTD #231
M124/354-1	13/03/16	06:44	27° 25.71' S	023° 56.57' W	5155.2	XBT	XBT #129
M124/344-1	13/03/16	07:14	27° 21.70' S	024° 01.60' W	5100	uCTD	uCTD #232
M124/344-1	13/03/16	08:19	27° 13.32' S	024° 12.15' W	4757.1	uCTD	uCTD #233
M124/355-1	13/03/16	08:39	27° 11.05' S	024° 15.05' W	4541	XBT	XBT #130
M124/344-1	13/03/16	09:19	27° 05.63' S	024° 21.79' W	4765.1	uCTD	uCTD #234
M124/356-1	13/03/16	11:30	26° 52.45' S	024° 37.64' W	5577.4	MSN	MSN #356
M124/356-2	13/03/16	12:02	26° 52.45' S	024° 37.64' W	5577.5	MSN	MSN #356
M124/356-3	13/03/16	12:36	26° 52.45' S	024° 37.64' W	5571	MSN	MSN #356
M124/356-4	13/03/16	13:09	26° 52.45' S	024° 37.64' W	5575.1	MSN	MSN #356
M124/356-5	13/03/16	14:26	26° 52.45' S	024° 37.64' W	5570.5	CTD/RO	CTD #12
M124/357-1	13/03/16	16:17	26° 52.51' S	024° 47.22' W	5541.1	XBT	XBT #131
M124/358-1	13/03/16	16:36	26° 52.52' S	024° 51.56' W	5584.2	uCTD	uCTD #235
M124/358-1	13/03/16	17:46	26° 52.54' S	025° 06.77' W	5591.7	uCTD	uCTD #236
M124/359-1	13/03/16	18:15	26° 52.54' S	025° 12.79' W	5519.8	XBT	XBT #132
M124/360-1	13/03/16	18:57	26° 52.55' S	025° 22.32' W	5364.8	XBT	XBT #133
M124/361-1	13/03/16	20:00	26° 52.56' S	025° 36.50' W	5581.6	XBT	XBT #134
M124/358-1	13/03/16	20:23	26° 52.58' S	025° 41.64' W	5631.4	uCTD	uCTD #237
M124/358-1	13/03/16	20:45	26° 52.58' S	025° 45.98' W	5536.8	uCTD	uCTD #238
M124/362-1	13/03/16	21:08	26° 52.58' S	025° 50.80' W	5566	XBT	XBT #135
M124/358-1	13/03/16	22:00	26° 52.60' S	026° 02.65' W	5562.9	uCTD	uCTD #239
M124/363-1	13/03/16	23:14	26° 52.62' S	026° 18.74' W	5523.1	XBT	XBT #136
M124/363-1	13/03/16	23:19	26° 52.62' S	026° 19.88' W	5384.7	XBT	XBT #137
M124/358-1	13/03/16	23:25	26° 52.62' S	026° 21.05' W	5474.2	uCTD	uCTD #240
M124/358-1	14/03/16	00:41	26° 52.64' S	026° 37.64' W	5661.4	uCTD	uCTD #241
M124/364-1	14/03/16	01:14	26° 52.65' S	026° 44.25' W	5702.4	XBT	XBT #138
M124/365-1	14/03/16	02:36	26° 52.67' S	027° 03.01' W	5713.5	XBT	XBT #139
M124/366-1	14/03/16	03:37	26° 52.68' S	027° 16.53' W	5343.3	XBT	XBT #140

Station	Date	Time UTC	Position Latitude	Position Longitude	Depth [m]	Gear	Gear station #
M124/358-1	14/03/16	05:00	26° 52.70' S	027° 35.23' W	5657.6	uCTD	uCTD #242
M124/367-1	14/03/16	05:43	26° 52.71' S	027° 44.22' W	5694.4	XBT	XBT #141
M124/358-1	14/03/16	06:11	26° 52.72' S	027° 50.26' W	5400.9	uCTD	uCTD #243
M124/358-1	14/03/16	07:10	26° 52.74' S	028° 03.00' W	5458	uCTD	uCTD #244
M124/368-1	14/03/16	07:46	26° 52.74' S	028° 10.54' W	5123.4	XBT	XBT #142
M124/358-1	14/03/16	08:14	26° 52.75' S	028° 16.71' W	5313.7	uCTD	uCTD #245
M124/358-1	14/03/16	09:21	26° 52.77' S	028° 28.74' W	5272.3	uCTD	uCTD #246
M124/369-1	14/03/16	09:34	26° 52.77' S	028° 31.07' W	5351.1	XBT	XBT #143
M124/370-1	14/03/16	10:56	26° 52.57' S	028° 41.42' W	4676.1	MSN	MSN #370
M124/370-2	14/03/16	11:32	26° 52.57' S	028° 41.42' W	4678.7	MSN	MSN #370
M124/370-3	14/03/16	11:45	26° 52.57' S	028° 41.42' W	4676.2	MSN	MSN #370
M124/371-1	14/03/16	12:15	26° 52.67' S	028° 44.60' W	5157.6	uCTD	uCTD #247
M124/372-1	14/03/16	12:35	26° 52.79' S	028° 48.24' W	5352.1	XBT	XBT #144
M124/371-1	14/03/16	13:08	26° 52.79' S	028° 55.79' W	5345.2	uCTD	uCTD #248
M124/371-1	14/03/16	14:14	26° 52.81' S	029° 09.64' W	5338.8	uCTD	uCTD #249
M124/373-1	14/03/16	14:37	26° 52.82' S	029° 13.98' W	5331.2	XBT	XBT #145
M124/371-1	14/03/16	15:14	26° 52.83' S	029° 22.54' W	5289.4	uCTD	uCTD #250
M124/371-1	14/03/16	16:18	26° 52.84' S	029° 34.66' W	5292	uCTD	uCTD #251
M124/374-1	14/03/16	16:51	26° 52.85' S	029° 41.54' W	5289	XBT	XBT #146
M124/371-1	14/03/16	17:22	26° 52.86' S	029° 48.81' W	5278.5	uCTD	uCTD #252
M124/371-1	14/03/16	18:31	26° 52.88' S	030° 03.78' W	5271.3	uCTD	uCTD #253
M124/375-1	14/03/16	19:06	26° 52.88' S	030° 11.11' W	5240.4	XBT	XBT #147
M124/371-1	14/03/16	19:34	26° 52.89' S	030° 17.49' W	4943.1	uCTD	uCTD #254
M124/371-1	14/03/16	20:43	26° 53.06' S	030° 28.63' W	4954.3	uCTD	uCTD #255
M124/376-1	14/03/16	21:17	26° 52.91' S	030° 35.65' W	5090.2	XBT	XBT #148
M124/371-1	14/03/16	21:45	26° 52.92' S	030° 42.00' W	4921.3	uCTD	uCTD #256
M124/371-1	14/03/16	22:43	26° 52.93' S	030° 54.45' W	4859	uCTD	uCTD #257
M124/377-1	14/03/16	23:10	26° 52.94' S	030° 59.28' W	4900.1	XBT	XBT #149
M124/371-1	15/03/16	00:02	26° 52.95' S	031° 11.07' W	4925.2	uCTD	uCTD #258
M124/371-1	15/03/16	01:06	26° 52.97' S	031° 24.67' W	4817.1	uCTD	uCTD #259
M124/378-1	15/03/16	01:24	26° 52.97' S	031° 27.76' W	4802.2	XBT	XBT #150
M124/371-1	15/03/16	02:12	26° 52.98' S	031° 38.29' W	4672.1	uCTD	uCTD #260
M124/379-1	15/03/16	03:22	26° 53.00' S	031° 52.80' W	4769.6	XBT	XBT #151
M124/371-1	15/03/16	03:40	26° 53.01' S	031° 56.62' W	4714.5	uCTD	uCTD #261
M124/371-1	15/03/16	04:30	26° 53.02' S	032° 06.35' W	4701	uCTD	uCTD #262
M124/371-1	15/03/16	05:27	26° 53.03' S	032° 17.55' W	4717.9	uCTD	uCTD #263
M124/380-1	15/03/16	05:45	26° 53.03' S	032° 20.52' W	4733.1	XBT	XBT #152
M124/371-1	15/03/16	06:29	26° 53.04' S	032° 29.86' W	4680.4	uCTD	uCTD #264
M124/371-1	15/03/16	07:26	26° 53.05' S	032° 41.22' W	4601.5	uCTD	uCTD #265
M124/381-1	15/03/16	07:48	26° 53.06' S	032° 45.28' W	4586.5	XBT	XBT #153
M124/371-1	15/03/16	08:31	26° 53.07' S	032° 54.68' W	4524.8	uCTD	uCTD #266
M124/371-1	15/03/16	09:40	26° 53.09' S	033° 08.97' W	4403.2	uCTD	uCTD #267
M124/382-1	15/03/16	10:56	26° 53.20' S	033° 17.12' W	4117.2	MSN	MSN #382
M124/382-2	15/03/16	11:31	26° 53.20' S	033° 17.11' W	4117.1	MSN	MSN #382
M124/382-3	15/03/16	11:47	26° 53.21' S	033° 17.10' W	4117.7	MSN	MSN #382
M124/383-1	15/03/16	12:11	26° 53.06' S	033° 18.87' W	4092.3	uCTD	uCTD #268

Station	Date	Time UTC	Position Latitude	Position Longitude	Depth [m]	Gear	Gear station #
M124/384-1	15/03/16	13:00	26° 53.11' S	033° 25.40' W	4041.9	XBT	XBT #154
M124/383-1	15/03/16	13:12	26° 53.11' S	033° 28.10' W	4016.8	uCTD	uCTD #269
M124/383-1	15/03/16	14:11	26° 53.12' S	033° 40.58' W	3991.9	uCTD	uCTD #270
M124/385-1	15/03/16	14:52	26° 53.13' S	033° 49.37' W	3889.6	XBT	XBT #155
M124/385-1	15/03/16	14:57	26° 53.14' S	033° 50.58' W	3852.1	XBT	XBT #156
M124/385-1	15/03/16	15:10	26° 53.14' S	033° 53.71' W	3811.2	XBT	XBT #157
M124/383-1	15/03/16	15:35	26° 53.15' S	033° 59.23' W	3761.2	uCTD	uCTD #271
M124/383-1	15/03/16	17:00	26° 53.17' S	034° 18.20' W	4104.9	uCTD	uCTD #272
M124/386-1	15/03/16	17:20	26° 53.17' S	034° 22.20' W	4290.9	XBT	XBT #158
M124/383-1	15/03/16	17:57	26° 53.18' S	034° 31.07' W	4490.2	uCTD	uCTD #273
M124/387-1	15/03/16	20:45	26° 53.19' S	034° 47.56' W	4781.6	CTD/RO	CTD #13
M124/388-1	16/03/16	00:51	26° 50.08' S	034° 53.98' W	4682.7	CTD/RO	CTD #14
M124/389-1	16/03/16	03:05	26° 48.23' S	034° 57.93' W	4685	XBT	XBT #159
M124/390-1	16/03/16	03:22	26° 46.69' S	035° 01.15' W	4615.1	uCTD	uCTD #274
M124/391-1	16/03/16	05:11	26° 39.69' S	035° 15.77' W	4527.4	XBT	XBT #160
M124/390-1	16/03/16	05:35	26° 37.41' S	035° 20.51' W	4503.6	uCTD	uCTD #275
M124/390-1	16/03/16	06:41	26° 31.53' S	035° 32.78' W	4432.4	uCTD	uCTD #276
M124/392-1	16/03/16	07:22	26° 28.08' S	035° 39.97' W	4413.4	XBT	XBT #161
M124/390-1	16/03/16	07:44	26° 26.02' S	035° 44.28' W	4414	uCTD	uCTD #277
M124/390-1	16/03/16	08:45	26° 20.71' S	035° 55.33' W	4352.7	uCTD	uCTD #278
M124/393-1	16/03/16	09:32	26° 19.72' S	035° 57.39' W	4329.6	XBT	XBT #162
M124/394-1	16/03/16	10:54	26° 15.32' S	036° 07.01' W	4304.2	MSN	MSN #394
M124/394-2	16/03/16	11:29	26° 15.32' S	036° 07.01' W	4304.6	MSN	MSN #394
M124/394-3	16/03/16	12:04	26° 15.32' S	036° 07.01' W	4315.2	MSN	MSN #394
M124/394-4	16/03/16	12:36	26° 15.32' S	036° 07.01' W	4316	MSN	MSN #394
M124/395-1	16/03/16	12:57	26° 15.07' S	036° 07.68' W	4305.4	XBT	XBT #163
M124/396-1	16/03/16	13:02	26° 14.69' S	036° 08.43' W	4311.6	uCTD	uCTD #279
M124/396-1	16/03/16	14:16	26° 07.87' S	036° 22.02' W	4251.2	uCTD	uCTD #280
M124/397-1	16/03/16	14:59	26° 04.09' S	036° 29.88' W	4273.7	XBT	XBT #164
M124/396-1	16/03/16	15:00	26° 03.99' S	036° 30.08' W	4265.4	uCTD	uCTD #281
M124/396-1	16/03/16	16:07	25° 58.02' S	036° 42.48' W	4239.3	uCTD	uCTD #282
M124/398-1	16/03/16	16:49	25° 54.41' S	036° 49.96' W	4207.6	XBT	XBT #165
M124/396-1	16/03/16	17:24	25° 51.21' S	036° 56.60' W	4250.2	uCTD	uCTD #283
M124/396-1	16/03/16	18:28	25° 45.67' S	037° 08.08' W	4250.5	uCTD	uCTD #284
M124/396-1	16/03/16	19:28	25° 40.14' S	037° 19.54' W	4256.1	uCTD	uCTD #285
M124/399-1	16/03/16	19:52	25° 38.26' S	037° 23.42' W	4225.6	XBT	XBT #166
M124/396-1	16/03/16	20:33	25° 34.42' S	037° 31.37' W	4217.2	uCTD	uCTD #286
M124/396-1	16/03/16	21:28	25° 29.77' S	037° 40.97' W	4155.4	uCTD	uCTD #287
M124/400-1	16/03/16	21:46	25° 28.40' S	037° 43.82' W	4136.6	XBT	XBT #167
M124/396-1	16/03/16	22:28	25° 24.63' S	037° 51.60' W	4062.5	uCTD	uCTD #288
M124/396-1	16/03/16	23:39	25° 18.51' S	038° 04.24' W	3974.1	uCTD	uCTD #289
M124/401-1	17/03/16	00:13	25° 16.63' S	038° 08.11' W	3965.1	XBT	XBT #168
M124/402-1	17/03/16	00:52	25° 13.40' S	038° 14.76' W	3946	uCTD	uCTD #290
M124/193-1	17/03/16	01:41	25° 09.79' S	038° 22.20' W	3951.4	FISCH	FISCH
M124/402-2	17/03/16	01:51	25° 08.88' S	038° 24.08' W	3943.1	uCTD	uCTD #291

8 Data and Sample Storage and Availability

The Kiel Data Management Team (KDMT) provides an information and data archival system where metadata of the onboard DSHIP-System is collected and publicly available. This Ocean Science Information System (OSIS-Kiel) is accessible for all project participants and can be used to share and edit field information and to provide scientific data, as they become available. The central system OSIS is providing information on granted ship time with information on the scientific program and the general details down to the availability of data files from already concluded cruises. The transparency on the research activities is regarded as an invitation to external scientists to start communication on collaboration on behalf of the newly available data.

The KDMT will take care as data curators to fulfil the here proposed data publication of the data in a World Data Center (e.g. PANGAEA) which will then provide long-term archival and access to the data. The data publication process will be based on the available files in OSIS and is therefore transparent to all reviewers and scientists. This cooperation with a WDC will make the data globally searchable, and links to the data owners will provide points of contact to project-external scientists.

Availability of metadata in OSIS-Kiel (portal.geomar.de/osis): 2 weeks after the cruise. Availability of data in OSIS-Kiel (portal.geomar.de/osis): 6 months after the cruise.

Availability of data in WDC/PANGAEA (www.pangaea.de): maximum 3 years after the cruise.

During the cruise data was send in near real time to the European data centre Coriolis as well as to the NOAA data centre.

Type	*Contact*	*Present affiliation*	*Comment*
CTD/O2 data	Johannes Karstensen jkarstensen@geomar.de	GEOMAR	PANGAEA Dataset #863015
TSG data	Johannes Karstensen jkarstensen@geomar.de	GEOMAR	PANGAEA Dataset #863017
ADCP data	Johannes Karstensen jkarstensen@geomar.de	GEOMAR	OSIS-Kiel
lADCP data	Johannes Karstensen jkarstensen@geomar.de	GEOMAR	OSIS-Kiel
uCTD/XBT data	Johannes Karstensen jkarstensen@geomar.de	GEOMAR	OSIS-Kiel
sun photometer data	Stefan Kinne stefan.kinne@mpimet.mpg.de	MPI- Hamburg	aeronet.gsfc.nasa.gov/new_web/DATA/Meteor_16_0.zip
DIC/TALK samples from surface pump	Eric Achternberg Jennifer Clarke jclarke@geomar.de	GEOMAR	OSIS-Kiel
trace metals, nutrients, PON, carbon, chlorophyll a	Eric Achternberg Jennifer Clarke jclarke@geomar.de	GEOMAR	OSIS-Kiel
delta 18 O	Matthias Zabel mzabel@uni-bremen.de	University Bremen	
Foraminifera data	Michel Kucera Raphael Morard rmorard@marum.de	University Bremen	AG Kucera internal database
Multinet CTD / Fluoresence data	Michel Kucera Raphael Morard rmorard@marum.de	University Bremen	AG Kucera internal database
Persistent organic pollutants	Gerhard Lammel g.lammel@mpic.de	MPI Chemistry, Mainz, Masaryk University, Research Centre for Toxic Compounds in the Environment, Brno, Czech Republic	
Surface flux data	Karl Bumke kbumke@geomar.de	GEOMAR	OSIS-Kiel

9 Acknowledgements

We thank captain Michael Schneider, his officers and crew of R/V METEOR for their support of our measurement program and for creating a very friendly and professional work atmosphere on board. The ship time of R/V METEOR was provided by the German Science Foundation (DFG) within the core program METEOR/MERIAN. Financial support for the different projects carried out during the cruise was provided though the H2020 AtlantOS, The Excellence Cluster "Future Ocean" via the Semestertopic "Ocean Observation: From Sensor to Knowledge". MyScience cruise was sponsored by *The Excellence Cluster "Future Ocean",* by POGO.

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