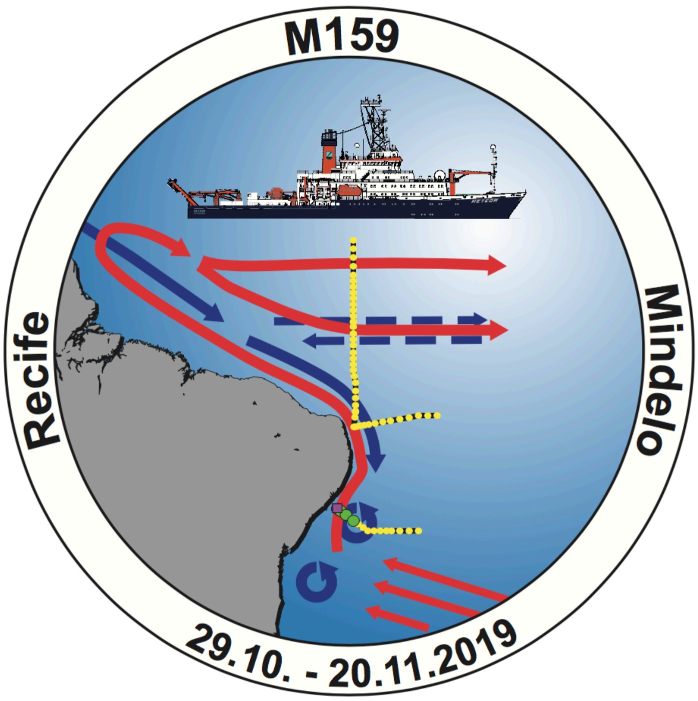
METEOR-Berichte

Circulation off Brazil

Cruise No. M159

October 29 – November 20, 2019
Recife (Brazil) – Mindelo (Cape Verde)



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1 Cruise Summary

1.1 Summary

The R/V METEOR expedition M159 "Circulation off Brazil" with its interdisciplinary work program was concerned with documenting the variability of the western boundary current systems off Brazil. The deep measurements along 11°S focused on the Atlantic Meridional Overturning Circulation (AMOC). Off the coast of Brazil the research looked at the transport variability of the North Brazil Undercurrent (NBUC) – as a part of the AMOC and subtropical cells (STC) – on intra seasonal to decadal time scales. The section along 35°W provided additional information on water mass property changes and the connection to equatorial signals.

The main work of M159 was the exchange of long-term moored ocean observatories and station work. The station work consisted mainly of a combination of CTD and Lowered ADCP system. In addition, the shipboard ADCP systems provided continuous velocity information and the thermosalinograph provided near surface water mass information.

The expedition is a contribution to the BMBF collaborative research program RACE – North Atlantic Synthesis, the GEOMAR research program OCEANS, and the BMBF collaborative research program REEBUS.

1.2 Zusammenfassung

Die R/V METEOR Forschungsfahrt M 159 „Zirkulation vor Brasilien" konzentrierte sich mit interdisziplinären Arbeiten auf die Dokumentation von Veränderungen des Stromsystems vor Brasilien. Die tiefen Messungen bei 11°S fokussieren auf die Variabilität der meridionalen Umwälzbewegung im Atlantik (AMOC). Vor der Küste Brasiliens stehen Untersuchungen von Transportschwankungen des Nordbrasilianischen Unterstroms (NBUC) - als Teil der AMOC und der Subtropischen Zellen (STCs) – auf intrasaisonalen bis dekadischen Zeitskalen im Vordergrund. Die Beprobung eines meridionalen Schnittes entlang von 35°W lieferte zusätzliche Informationen im Hinblick auf Wassermassenänderungen und Signalausbreitungen entlang des Äquators.

Die Hauptarbeiten während M159 waren der Tausch von Langzeitverankerungen und Stationsarbeiten. Für die Stationsarbeiten wurde hauptsächlich die Kombination aus CTD und Lowered ADCP genutzt. Zusätzlich wurden unterwegs mit den bordeigenen Schiffs-ADCPs Strömungen und mit dem Thermosalinographen Wassermasseneigenschaften gemessen.

Die Arbeiten tragen zu den Zielen des BMBF Verbundprojekt RACE – Nordatlantik Synthese, dem GEOMAR Forschungsprogramm OCEANS und das BMBF Verbundprojekt REEBUS bei.

2 Participants

2.1 Principal Investigators

Name	Institution
Visbeck, Martin, Prof. Dr.	GEOMAR

2.2 Scientific Party

No.	Name	Discipline	Institution
1	Visbeck, Martin, Prof. Dr.	PO, Chief Scientist	GEOMAR
2	Lopes Brum, André	PO, oxygen	FURG
3	Carbajal, Juan Cruz	PO, CTD	CENPAT
4	Dada, Olusegun	PO, CTD	FUTA
5	Galetti, Julia	PO, CTD	UFPE
6	Gonzalez Avalos, Everardo	PO, CTD processing, UVP	GEOMAR
7	Handmann, Patricia, Dr.	PO, Mooring processing, CTD	GEOMAR
8	Herrford, Josefine	PO, MicroCats, CTD	GEOMAR
9	Hundsdörfer, Marie	PO, MicroCats, CTD	GEOMAR
10	Jahr, Christin	PO, CTD	GEOMAR
11	Krahmann, Gerd, Dr.	PO, LADCP, CTD processing	GEOMAR
12	Leimann, Ilmar	PO, SADCP	GEOMAR
13	Link, Rudi	PO, CTD technician	GEOMAR
14	Michaelis, Patrick	PO, CTD processing, UVP	GEOMAR
15	Niebaum, Nils	PO, Salinometer, CTD	GEOMAR
16	Papenburg, Uwe	PO, Mooring technician	GEOMAR
17	Sarmiento Trujillo, Luisa F.	PO, CTD	CAU
18	Schmidt, Christina	PO, Mooring processing, CTD, oxygen	GEOMAR
19	Stelzner, Martin	Meteorology	DWD
20	Stramma, Lothar, Dr.	PO, Salinometer, CTD	GEOMAR
21	Trahms, Carola	PO, CTD	GEOMAR
22	Witt, René	PO, LADCP, Mooring technician	GEOMAR
23	De Souza Silva, Ana Emilia	Observer	Brazil Navy
24	Pais Ribeiro Da Cunha, Maria Marina	BO, Microbial growth experiments	UA

PO: Physical Oceanography, BO: Biological Oceanography

2.3 Participating Institutions

GEOMAR (16) GEOMAR Helmholtz-Zentrum für Ozeanforschung Kiel, Germany
DWD (1) Deutscher Wetterdienst, Germany
CAU (1) Christian-Albrechts Universität Kiel, Germany
FUTA (1) Federal University of Technology, Akure, Nigeria
CENPAT (1) Centro Nacional Patagónico, Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Buenos Aires, Argentina
UFPE (1) Federal University of Pernambuco, Recife, Brazil
FURG (1) Universidade Federal do Rio Grande, Rio Grande, Brazil
UA (1) Universidade de Aveiro, Aveiro, Portugal
Brazilian Navy

3 Research Program

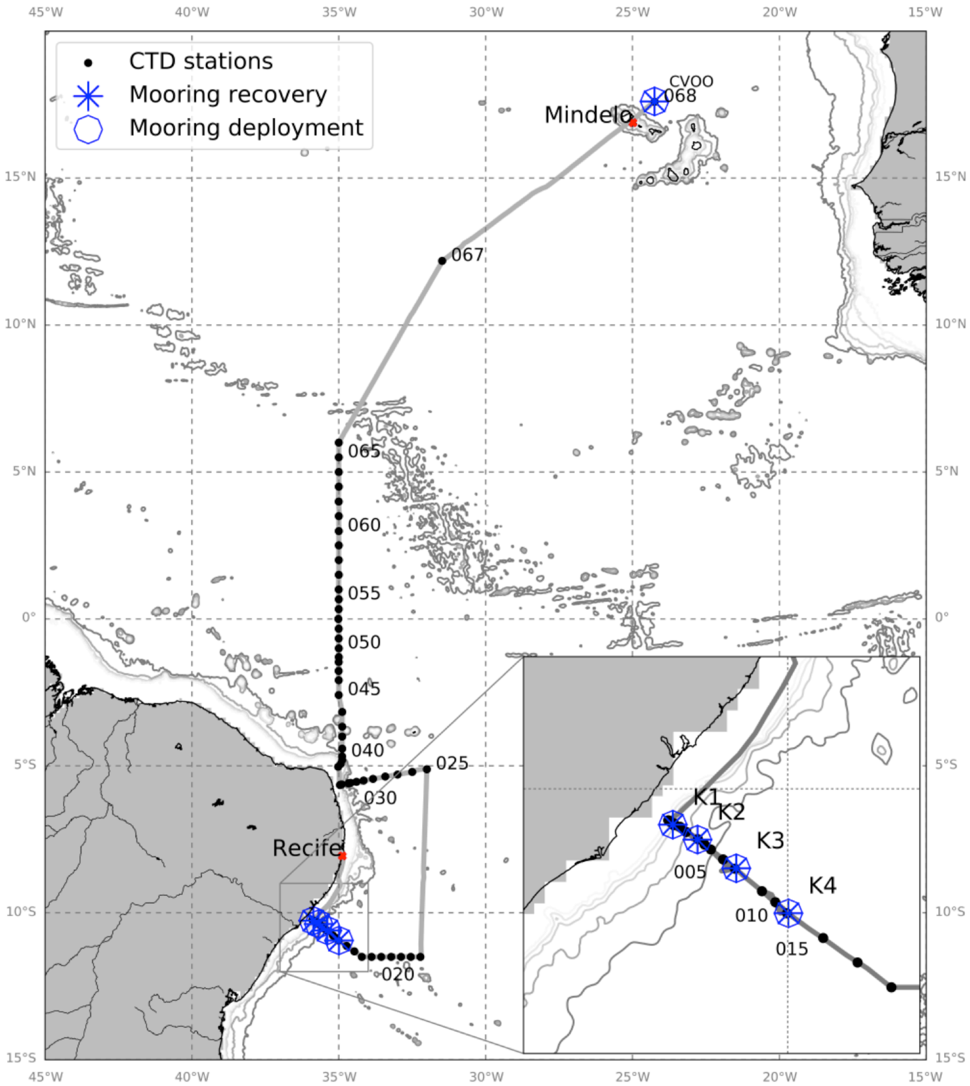

Fig. 3.1. Bathymetric map with cruise track of R/V METEOR cruise M159 (grey solid line) including locations of CTD/UVP/LADCP/AZFP stations, mooring recoveries and redeployments.

3.1 Description of the Work Area

The research program of M159 (Fig. 3.1) covered three main research areas that are 1) the coastal area off Brazil, 2) the equatorial Atlantic via the 35°W section and 3) the area north of the Cap Verde Islands concerning the CVOO mooring. Focus areas were the 11°S section off Brazil and the meridional section along 35°W between ~5°S and 6°N. The work off Brazil covered the western boundary current system, which plays an essential role in the meridional overturning circulation. The meridional section along 35°W covers the zonal branches of the equatorial current bands.

3.2 Aims of the Cruise

M159 was focusing on the maintenance and data recovery of the mooring array at 11°S. The mooring observatory at 11°S is providing vital data for the analysis of the variability of the NBUC and the western boundary currents (DWBC). The NBUC reacts very sensitive to fluctuations of the AMOC and the subtropical cell (STC) and therefor forms a key region for the Atlantic circulation. The data collected during the cruise is part of a long-term mooring observatory of velocity, temperature and salinity time series off the Brazilian coast 11°S and hydrographic time series along 11°S and 5°S. The collected data, in combination with data collected at 11°S at the Angolan Coast, will be used to determine the transport of the NBUC, DWBC and the AMOC – in combination with previously collected data intra-seasonal to decadal variability of these time series will be analyzed.

In addition, the section between 5°S and 6°N was sampled for the first time since 16 years and will be used to analyze changes in water mass properties and water mass pathways across the equator in order to get insights into the signal propagation across the hemispheres as well as along the equator in combination with the 23°W section which was covered during another cruise.

The study area north of the Cape Verde Islands at the CVOO mooring is aiming for a better understanding of the role of mesoscale eddies for the lateral transport of biogeochemical properties and their coupling to the carbon pump. By recovering and redeploying the CVOO mooring hydrographic data as well as biogeochemical and velocity data were recovered in order to analyze long term variability at this location.

3.3 Agenda of the Cruise

The measurement program of M159 included the 5 mooring recoveries, 4 along the 11°S section and one north of the Cape Verde Islands (CVOO), and 5 deployments at similar positions. The moorings along the Brazil shelf break along 11°S are all equipped with upward looking ADCPs monitoring velocities close to the surface and Aquadopps and current meters to survey the deeper velocities. Additionally, CTD sensors (MicroCats) are mounted on each of the moorings to collect hydrographic data and possible changes in the water column. The 11°S moorings are located to capture the features of the boundary current system since their first deployment on M98 (M106, M119, M130, M145).

After the mooring work at 11°S and the parallel hydrographic section work, the hydrographic and velocity sections along 5° and 35°W were conducted. Along all sections the station work included profiles with the CTD and LADCP system to observe temperature, salinity, O_2 , pressure and currents. Water samples were taken to calibrate the conductivity and oxygen sensors.

The CVOO mooring north of the Cape Verde Islands is a multi-disciplinary mooring featuring current and hydrographic measurements as well as sediment and particle traps in order to investigate biogeochemical parameters. CVOO was first deployed in 2006 and was recovered and deployed for the 9th time since on M159.

Continuous underway measurements were carried out through the Thermosalinograph (temperature, salinity at sea surface) and the vessel mounted two ADCP systems 75 kHz/ 38kHz (currents in the upper 1000m).

4 Narrative of the Cruise

R/V METEOR cruise M159 from Recife, Brazil to Mindelo, Cape Verde started on Tuesday October 29, 2019 at 10:00 local time and sailed south to reach the starting point of the 11°S CTD and section and the recovery and redeployment of the moored observatory. On the way a shallow test CTD with a bottom depth of 57 m was conducted on the 29th. In the Morning of the October 30 near the first mooring locations we tried to acoustically retrieve data from two PIES moorings. However, despite significant efforts to reduce the noise of R/V METEOR we could not establish contact to either of the two PIES. During the following four days we performed CTD casts mostly during the night and recovered and redeployed all four tall mooring that are part of the 10°S moored observatory. All mooring operations ran smoothly and 97% of the instruments provided high quality time series over the 18 months since deployment. Some of the nightly CTD stations were used for the calibration of moored instrumentation. The last CTD/O_2 station of the 11°S transect, #24, was completed on November 4th, at 15:00 UTC. On November 4th at 2:21 UTC we exited the Brazilian EEZ at 11° 28.71' S, 32° 48.20'W and reentered the Brazilian EEZ on the November 4 at 17:34 UTC at 10° 34.24' S, 32° 11.10' W.

From November 5 to 7 we conducted 12 CTD stations along the 5°S section between 5° 7.0' S and 32° 0' W and 5° 39.0' S and 34° 57.6' W. The stations varied between 30 nm offshore to less than 10 nm near the shelf break.

The meridional section along 35°W began on November 7 and lasted until November 13th, starting on the Brazilian shelf break at 5° 02' S and 35° W with 30 full ocean depth CTD stations until the northernmost station at 6° 0' N and 35° W. On November 7 R/V METEOR left the Brazilian EEZ at 0°43.31' S, 35° 0' N at 6:39 UTC. R/V METEOR reached the equator on Sunday, November 10 around lunchtime. On the equator, the PIRATA buoy was visually inspected and seemed to be missing several parts of the sensor set of an ATLAS mooring at the surface.

After finalizing the 35° W section in the night of November 13, R/V METEOR headed northeast towards the Cape Verde Islands. During this transit one 6000 m deep CTD station was included in order to re-spool the CTD wire, which had developed spooling errors during the last weeks.

On the evening of November 17 R/V METEOR passed between the Cape Verde Islands of Santo Antão and São Vicente after entering the Cape Verde EEZ on the 16th of November at 20:30 UTC at 14° 36.58' N, 28° 10.85' W. During this passage a scientist from Portugal came on board in order to support the science crew with the recovery and deployment of the Cape Verde Ocean Observatory mooring (CVOO) at 17° 36.55' N, 24° 14.85' W, which was done on the 18th and 19th of November.

R/V METEOR reached the port of Mindelo, Cape Verde on November 20, 2019.

5 Preliminary Results

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

5.1 Hydrographic observations

5.1.1 CTD system, oxygen measurements, and calibration

(Patricia Handmann, Rudolph Link, Lothar Stramma)

5.1.1.1 CTD-Rosette system

During M159, 68 profiles of pressure (P), temperature (T), conductivity (C) and oxygen (O) were recorded. All of these CTD/O_2 profiles ranged to the bottom or near the bottom. We used a Seabird Electronics (SBE) 9plus system, attached to the water sampler carousel, and recent Seabird Seasave software. The SBE underwater unit had, in addition to its own pressure sensor, two parallel sensor sets for T, C, and O. Additionally a Wetlabs Turbidity/Chl a Fluorescence sensor (SN #2294), a Wetlabs CDOM sensor (SN #2377), a CTD mounted lowered acoustic Doppler current profiler (lADCP), a photosynthetic active radiation sensor (PAR, SN #70714), an underwater vision profiler (UVP), an acoustic zooplankton and fish profiler (AZFP) and an UV spectral sensor for the measurement of nitrate (OPUS) were mounted on the CTD frame.
A Valeport altimeter system (SN #42299) was used during the cruise for bottom distance detection of the CTD. A GEOMAR developed globe-shaped acoustic protector allowed the altimeter to function reliably during the cruise while it had suffered from interference from the lADCP system in previous cruises.
Due to strongly changing bottom topography at CTD station 5 the carousel touched the ground without consequences for the mounted instruments.
The CTD system itself performed without major problems throughout the whole cruise.

From the first profile up until profile number 24 the serial numbers of the primary sensors ($_1$) and secondary sensors ($_2$) were # 2463 (T_1), # 2120(T_2), # 2443 (C_1), #3959 (C_2), #1149(P), #1312 (O_1) and #1739 (O_2). Occasional spikes were present in particular at depths below 2000 m for the secondary oxygen sensor. After CTD station 24 the secondary oxygen sensor was exchanged with sensor # 2600 (O_2). The intermittent spikes, however, did not vanish. A thorough cleaning of involved plugs was performed after CTD station 66. Due to prolonged times of the pump starting at 10m at the start of the stations the electric cable of the pump was exchanged after station 56, though the problem was later found to be caused by air bubbles in the measuring system.

5.1.1.2.1 CTD-conductivity calibration

The calibration of the conductivity and oxygen sensors was conducted following the recommendations in the GO-SHIP manual (https://www.go-ship.org). For the calibration of the conductivity sensors 225 measurements with a precision salinometer were used (see subsection 5.1.2). The conductivity calibration using linear correction terms in P, T, and C resulted in a root mean square (rms) salinity misfit of 0.002 for the both conductivity sensors after removal of the most deviating 33% of samples. For the final data the primary string of sensors was selected because of the continuous use of the same oxygen sensor.

5.1.1.3 Oxygen calibration

The calibration of the conductivity and oxygen sensors was conducted following the recommendations in the GO-SHIP manual (https://www.go-ship.org). For the calibration of the oxygen sensors 258 measurements of the dissolved oxygen content using Winkler titration were used (see subsection 5.1.3). The oxygen calibration using linear correction terms in T and O, quadratic correction terms in P as well as the product of P and O resulted in a rms oxygen misfit of 0.9 μmol/kg for the two oxygen sensors that were longer in use (#1312 O_1, #2600 O_2). For the oxygen sensor that was initially used as secondary sensor (#1379 O_2) not enough valid titration samples were measured to perform a reliable calibration.

5.1.2 Conductivity measurements

(Lothar Stramma)

In order to calibrate the salinity derived from the conductivity sensors of the CTD system, the salinity of water samples was measured using the GEOMAR OPTIMARE Precision Salinometer (OPS 20). The OPS measures conductivity and converse it to salinity and the derived salinity is used to define good or bad measurements. Two Optimare Salinometers (OPS 10 and OPS 20) were available on the previous cruise M158. Due to problems with the salinometers on M158 the prebath of one salinometer was exchanged with the prebath of the other salinometer to have salinometer OPS 20 working well, while the other salinometer was returned to Kiel after M158.

Water samples from the CTD-rosette were taken with the established Flensburger bottles. In addition, water samples were taken from the ship-intake of the R/V METEOR TS recorder (thermosalinograph) in Flensburger bottles and measured with the salinometer. Before measuring the conductivity of the water samples with the OPS, the bottled water samples had to be degassed to remove gas micro-bubbles, which would deteriorate the OPS instrument performance. Degassing was done after adjusting the bottles to the lab temperature for about 10 hours, then warming the sample bottles in a water bath at a temperature of about 40°C. After approximately 30 minutes the Flensburger bottles were opened for 1 to 2 seconds. Then the sample bottles were brought to the salinity lab where their conductivity could be measured after cooling down for at least 10 hours to the lab temperature.

At the first few days samples often did not reach a stable value of salinity within 0.0003 in three consecutive measurements, which is the criteria of the Optimare Salinometer to accept the measurement as successful and store the result. Reasons speculated on for unstable measurements were not enough time to adjust to the lab temperature and also the not so clean water near the coast of Brazil. After cleaning the cell with TritonX-100 the measurements improved. For further improvement the boxes were degassed 2 times and the waiting time to adjust to the lab temperature was increased to at least 1 day, leading to more stable measurements.

At the beginning of each measurement day an IAPSO standard sea water (batch: P162) with a respective salinity of 34.993 was measured, which calibrated the Salinometer. Right after the standardization a substandard was measured. After several measurements of CTD-bottle samples a substandard bottle was measured to check for possible drifts. Substandard water was taken from deep CTD casts from at least three CTD-rosette bottles closed at the same depth and filled in a large 25-liter container. After adjustment to the lab temperature this water was then filled in a box of 24 Flensburger bottles and degassed similar to the measurement bottles.

The conductivity of 225 water samples taken at 54 of the 68 CTD stations as well as 36 water samples taken at the thermosalinograph water intake was measured using the GEOMAR OPTIMARE Precision Salinometer (OPS) 20.

5.1.3. Oxygen Winkler measurements

(Christina Schmidt, Andre Brum)

Water samples for the Winkler titrations of dissolved oxygen were drawn from the Niskin bottles before other samples to limit any distortion by outgassing of the water. Oxygen samples were taken at 62 out of 66 CTD casts. The sample bottles (calibrated 100 mL WOCE bottles) were flushed at least three times by overflow to ensure air-bubble free samples. Oxygen fixation was carried out directly after sampling and the samples were stored in the dark prior to measurement.
Titrations were performed within the WOCE bottles using a 20 mL Piston Burette TITRONIC universal from Schott Instruments. The iodate standard was added with a 50 mL Piston Burette TITRONIC universal from Schott Instruments. 1 mL of the fixation solutions (NaI/NaOH and MnCl2) were dispensed with a high precision bottle-top dispenser (0.4-2.0 mL, Ceramus classic, Hirschmann). The mean of the standard deviation of the oxygen concentration measurements determined by Winkler titration was 1.32 µmol/L based on 40 replicate measurements with 2 or 3 replicants each. But when we removed 4 outliers the standard deviation was 0.69 µmol/L. Standard measurements for the determination of the thiosulfate factor were carried out on a daily basis.

We used the solutions prepared during the previous cruise M158 except for the standard that was empty. The value from the standardization was too high, so that we also made new manganese chlorid, alkaline sodium iodide and a sodium thiosulfate due to a potential drift especially in the last solution. A comparison against wako standard still showed too high values of 5.17 ml. Therefore, we made another Sodium Thiosulfate, to determine which of the solution was not correct. The standardization revealed a value of 4.84 ml for the thiosulfate factor whereas the standardization with wako standard gave a thiosulfate factor of 5.047 ml. Hence, we did a new standard solution.
Results from the oxygen titration before the 3.11.2019 are not reliable, but we are confident about our oxygen titration starting at 3.11.2019 when the standardization resulted in a thiosulfate factor of 5.004 ml and the determination of the reagent blank was 0.01 ml/L. A standardization with wako standard on the 5.11.2019 gave a thiosulfate factor of 5.036 ml.

5.1.4 Thermosalinograph, wind, meteorology

(Juan Cruz Carbajal, Christina Schmidt)

The SBE21 Thermosalinograph (TSG) is designed for shipboard determination of sea surface (pumped-water) conductivity (C) and temperature (T). The real-time sample interval of both TSG was set to 10 s during cruise M159. The intakes are in the ship's hull at ~ 5 m on both portside (TSG-1 Bb, #3313) and starboard side (TSG-2 Stb, #3394). In addition to the TSG, two external temperature sensors (SBE38, Bb #0747, Stb #0749) are located just after the intakes.
The performance of the C and T sensors from the TSG was successful. The mean difference for C and T between both TSG were (0.02±0.03) mS/cm and (0.01±0.02) °C, respectively. The TSG measurements were 0.2 °C warmer than the SBE38 for both TSG due to the internal plumbing system. The derived salinity differed by (0.01±0.01) psu between both TSG.
To determine the accuracy of the TSG salinity measurements, 24 water samples were collected from the intake (one for both TSG) and measured with the OPTIMARE Precision Salinometer

OPS20 onboard. The mean difference for salinity between TSG and water samples was (0.001±0.005) psu and (-0.007±0.004) psu for the portside and the starboard side, respectively.

5.2 Current observations

5.2.1 Vessel mounted ADCP

(Ilmar Leiman, Gerd Krahmann)

Underway-current measurements of the upper ocean were performed continuously throughout the entire cruise track using two VMADCPs: a 75kHz RDI Ocean Surveyor (OS75) mounted in the ship’s hull, and a 38 kHz RDI Ocean Surveyor (OS38) placed in the moon pool. Both Ocean Surveyor instruments worked well throughout the cruise. The OS38 was aligned to zero degrees (relative to the ship's centerline) in order to reduce interference with the OS75, which was aligned to 45 degrees.

Both instruments ran in narrowband mode. The OS75 instrument was configured with 100 bins of 8 m, pinging 23 times per minute, with a range of 600 m to 700 m. The OS38 used 55 bins of 32 m, pinging 18 times per minute, with a range between 1000 m and 1500 m. During the entire cruise, the SEAPATH navigation data was of high quality. No interference with the 12 kHz echosounder EM122 that delivered high quality bathymetry data was detected.

Post processing of the data was carried out separately for each instrument. The applied mean misalignment angles and amplitude factors with the associated standard deviation are summarized in Table 5.1.

Table 5.1. *Vessel mounted ADCP calibration*

OS	Mode	Misalignment angle ± standard deviation	Amplitude factor ± standard deviation
75	NB	0.007586°± 0.66103°	1.0002± 0.0095
38	NB	-0.1036° ± 0.6331°	1.0050± 0.0094

5.2.2 Lowered ADCP

(Gerd Krahmann, Marie Hundsdörfer, Rene Witt)

During the entire cruise the CTD/Rosette system was equipped with a lowered ADCP setup based on two Teledyne RDI ADCPs. The setup consisted of an upward and downward looking 300-kHz workhorse ADCP. These two instruments were mounted inside the CTD rosette with especially manufactured frames protecting the instruments and allowing zero obstruction of the acoustic beams. The LADCP system delivered consistently good data throughout the whole cruise. Initially the same instruments as on cruise M158 (#20508 downlooking, #11436 uplooking) were used and delivered good data. After CTD profile #15 the downlooking instrument #20508 had developed a broken beam. It remained in use until profile #21 after which it was exchanged for instrument #24497. Despite the broken beam #20508 still delivered good velocity data (one of the four beams is redundant for the velocity measurements).

A new GEOMAR-developed energy supply system that draws energy for the ADCPs from the CTD system worked well throughout the cruise.

For the data and command transmission between the ADCPs and a Windows PC, we used a new GEOMAR-developed system based on XBee wireless modules. Sending commands to the

ADCPs worked well, with the exception of CTD profile #16 when the ADCPs could not be started. However, data transfer from the ADCPs to the PC was at times difficult. The likely reason was interference with the ship's WIFI system which uses the same 2.4 GHz band. The XBee modules were reprogrammed to use channels away from channel 11, which was used by the WIFI router in the Geo-Lab. After that the reduction of the transmit power of the WIFI router to 10% improved the data transmission but was still not optimal. Back at GEOMAR we intend to modify the antenna setup for our XBee system or acquire an XBee system working on a different frequency band. During cruise M158 the two ADCPs had worked in un-synchronized mode, which results in some 5% unusable data. During the longer transit between CTD stations #24 and #25 we managed to reprogram the XBee modules so that starting with CTD profile #25 the two ADCPs worked in synchronized mode.

During the cruise we used a GEOMAR-developed software (ladcp_tool, v1.9b), which controlled the start, stop, download, and erase of the profiles of the two LADCP systems. During cruise M158 the software had been adapted to the new wireless data transmission system. On M159 the software was further optimized.

Data processing took place during the cruise using the GEOMAR LADCP processing software V11.0beta, which includes both shear and inversion methods to derive an absolute velocity profile. As additional data are necessary for the processing, the corresponding pre-processed CTD files were used containing pressure, temperature and salinity profiles as well as time and navigation data. Final processing of the LADCP profiles will be done back at GEOMAR once the finally processed CTD and vessel-mounted ADCP data are available.

Overall the LADCP system delivered good deep-ocean velocity profiles when processed in conjunction with the observations of the vessel-mounted ADCP (VMADCP) and when coming close enough to the seafloor to obtain TRDI bottom track data. Nevertheless, the generally adverse conditions for LADCP in the open tropical South Atlantic Ocean (too few scattered) lead to some profiles with elevated uncertainties in particular along the 5°S and 11°S transects.

Table 5.2. *LADCP instruments in use*

ADCP SN / Profile No.	20508 (DOWN)	24497 (DOWN	11436 (UP)
1 - 21	X		X
22-65		X	X

5.3 Sections at 11°S and 5°S

(Patricia Handmann)

The CTD station work conducted during M159 adds another snap-shot to the already existing sections between 2000-2004 and 2013- ongoing at 5°S and 11°S. The salinity and the oxygen distribution at the 11°S and 5°S sections are depicted in Figures 5.1 and 5.2 respectively for each section. Compared to Hummels et al. (2015) and Schott et al. (2005) a similar water mass structure was found and is set up the following way: at the top the surface waters reaching until $\sigma_\theta = 24.5$ kg m^3 ; then the upper thermocline waters, which supply the Equatorial Undercurrent (EUC) until σ_θ=26.8 kg m^3 ; the lower boundary of the upper AMOC limb is defined here at σ_1=32.15 kg m^3; then the upper, middle, and lower NADW layers that are divided by the isopycnals σ_2 =37.00 kg m^3 and σ_4=45.83 kg m^3; The NADW and AABW are separated by the

σ_4=45.83 kg m^3 isopycnal. The upper-layer water masses are marked in both, 11°S and 5°S (Figure 5.1 and 5.2), with a salinity maximum of the Subtropical Underwater (STUW) near 100 m depth decreasing northward from 11°S to 5°S. Below until ~400 m depth the fresher South

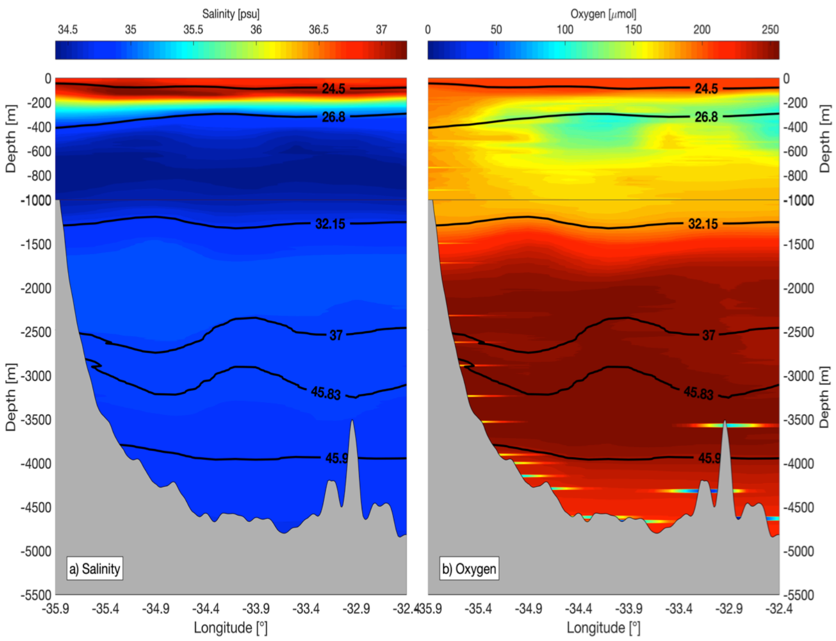

Figure *5.1 a) CTD Salinity and b) Oxygen section at 11°S. σ-Isopycnals are marked as black lines (σ_θ=24.5, 26.8* kg m^3, *σ_1=32.15* kg m^3, *σ_2=37* kg m^3, *σ_4=45.83,45.90* kg m^3*).*

Atlantic Central Water (SACW) is found and followed below by the relatively low salinity of the Antarctic Intermediate water (AAIW) to a depth of ~800m. The NADW, apart from being defined by the isopycnals mentioned below, also exhibits higher oxygen and salinity than the surrounding AAIW (above) and AABW (below).

The LADCP profiles at 11°S, exhibit the typical structure of the currents featuring the northward

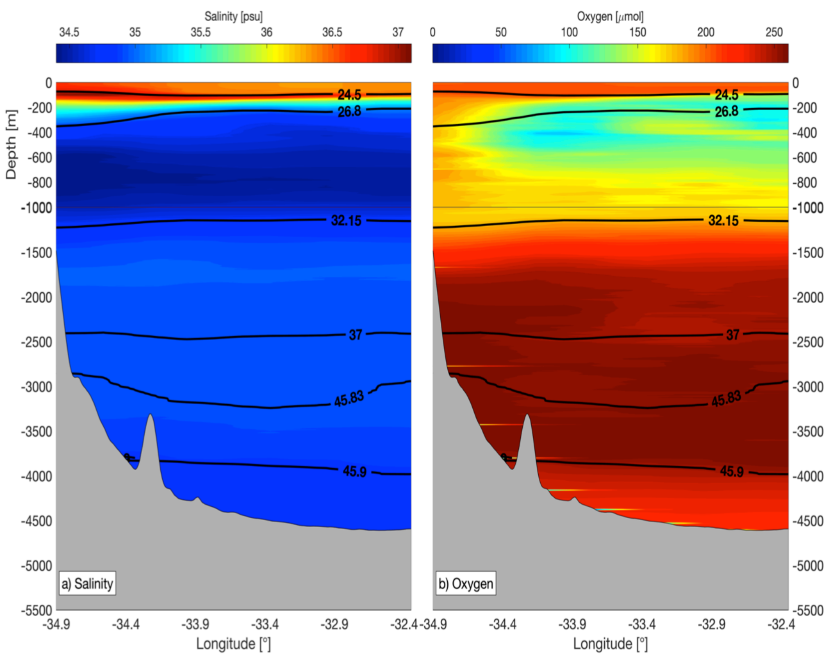

Figure *5.2 a) CTD Salinity and b) Oxygen section at 5°S. σ-Isopycnals are marked as black lines (σ_θ=24.5, 26.8* kg m^3, *σ_1=32.15* kg m^3, *σ_2=37* kg m^3, *σ_4=45.83,45.90* kg m^3*).*

North Brazil Under Current (NBUC) and the southward Deep Western Boundary Current

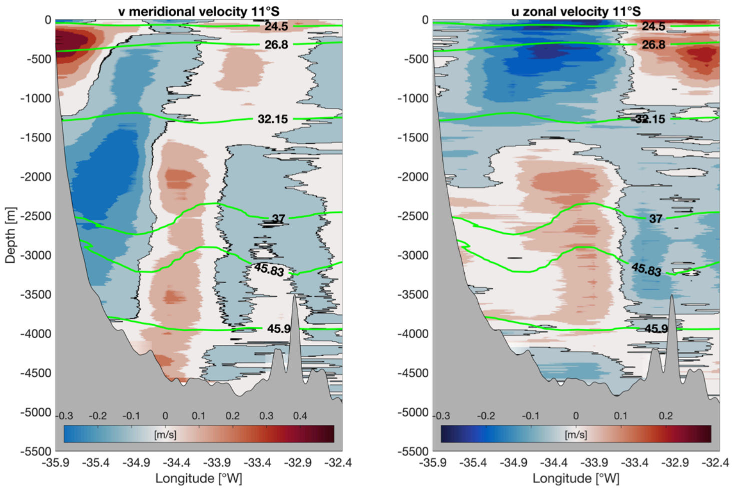

Figure *5.3 a) LADCP section of meridional and zonal velocity at 11°S. The velocities were rotated to be perpendicular/ parallel to the coastline (36° rotation (Schott et al. 2005)). σ - Isopycnals are marked as green lines (*σ_θ *=24.5, 26.8* kg m^3, σ_1*=32.15* kg m^3, σ_2 *=37* kg m^3, σ_4 *=45.83,45.90* kg m^3*).*

(DWBC) (Figure 5.3). From the meridional velocities in combination with the isopycnals one would expect a deep eddy at the 11°S section at the time of the cruise, but this will be investigated in further analysis of the mooring array data. The transport values were computed as a first estimate between 35.9°W and 34.5°W. The NBUC transport was defined to consist of all northward transport above σ_1 = 32.15 kg m^3. The DWBC transport was estimated for water densities higher than σ_1 = 32.15 kg m^3 and lower than σ_4 = 45.9 kg m^3. The preliminary transports derived from the LADCP data of the NBUC (13.32 Sv) and the DWBC (33.93 Sv) fit within the range of transport values published by Hummels et al. 2015.

5.4 Mooring operations

(Christina Schmidt, Uwe Papenburg, Rene Witt, Christin Jahr, Gerd Krahmann, PI: Rebecca Hummels)

***Table 5.3**. Mooring operations during M159*

M159 Mooring Recoveries					
Mooring	**New ID**	**Latitude**	**Longitude**	**Deployment Date**	**Recovery Date**
K1	KPO 1195	10° 16.00’S	35° 51.70’W	07-Mar-2018	30-Oct-2019
K2	KPO 1196	10° 22.80’S	35° 40.80’W	07-Mar-2018	30-Oct-2019
K3	KPO 1197	10° 36.50’S	35° 23.60’W	05-Mar-2018	31-Oct-2019
K4	KPO 1198	10° 56.40’S	34° 59.60’W	05-Mar-2018	01-Nov-2019
CVOO-09	KPO 1202	17°36.39’N	24°14.98’W	14-Feb-2018	18-Nov-2019
M159 Mooring Deployments					
Mooring	**New ID**	**Latitude**	**Longitude**	**Deployment Date**	**Recovery Date**
K1	KPO 1211	10° 15.99’S	35° 51.64’W	30-Oct-2019	

K2	KPO 1212	10° 22.79'S	35° 40.71'W	31-Oct-2019	
K3	KPO 1213	10° 36.49'S	35° 23.34'W	01-Nov-2019	
K4	KPO 1214	10° 56.47'S	34° 59.41'W	02-Nov-2019	
CVOO-10	KPO 1216	17°36.55'N	24°14.85'W	19-Nov-2019	

5.4.1 Instrument performance

(Josefine Herrford, Patricia Handmann, Marie Hundsdörfer)

The moored instruments recovered during M159 (Table 5.3) worked successful with an acquisition of 95% clean data averaged over all sensor types. Table 5.4 shows the instrument performance for each mooring and sensor type (T temperature; C conductivity; P pressure; U, V zonal, meridional velocity; O_2 oxygen; other – other variables) calculated as the percentage of maximum obtainable data. For the calculation of the instrument performance, every instrument was weighted homogeneously taking the following instrument types into account: MicroCat (T, C, P), Aquadopp (T, P, U, V), O_2 logger (T, O_2), ADCP (U, V), RCM (T, U, V), Argonaut (T, U, V) and other (other instruments with miscellaneous sensors as well as sediment or plankton traps).

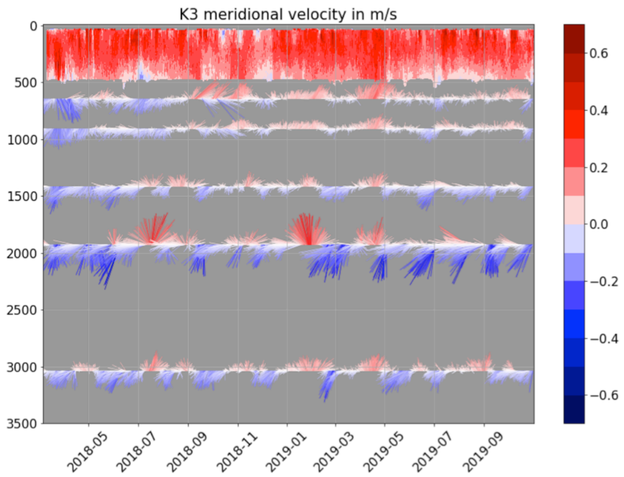

Figure *5.4 K3 meridional velocities from the ADCP (500m) and 6 Aquadopps (650m, 899m, 1400m, 1900m, 2380m, 3000m). (plot by Nils Niebaum)*

Along 11°S, all current meters and MicroCats performed excellent with 100% data acquisition at K1, K2 and K3 (Figure 5.4). Only at K4, one Aquadopp (T,U,V) at 2381m stopped working on the 17/5/2018. One MicroCat (#2248) mounted on the Cape Verde Ocean Observatory (CVOO) mooring on 89m depth failed completely due to water intrusion to the hull. Additionally, the O_2 loggers on 119m all stopped working before the recovery of the mooring (#1138 on 10^{th} November 2019, DO-0617-001 on 31^{st} March 2018 and DO-0617-002 on 05^{th} April 2020). Those deficiencies reduced the overall instrument performance for temperature (96,5%), conductivity (94,0%), pressure (100,0%), oxygen sensors (53.4%) and current meters (96.4%) and other instruments (98.9%).

A summarized description over the performance of all instrument types is given in the following. Details are shown in the mooring tables further down.

MicroCats: 25 out of 32 recovered MicroCats performed with a complete and clean data record. Three MicroCats (#1718, #2716 and #3411) from KPO 1202 showed multiple singularities (single bad data points) in the conductivity cell during two periods in November 2018 and in October to November 2019. One MicroCat (#2248) from KPO 1202 (CVOO) completely failed due to water intrusion. Three MicroCats (#2269, #3755, # 3413) where limited to deployment shallower than 3500m, which should be considered when calibrating (see 5.4.2).

Oxygen sensors: 2 Optodes from manufacturer AADI Aanderaa Data Instruments (subsequently named: O_2 logger) were installed in the recovered mooring KPO 1202. Optode # 383 on 42m was running stable and produced a complete and clean record for the whole deployment period. Optode #1138 on 119m started to collect unstable time series on 8th November 2019, still patchy data exists until the recovery of the mooring. The two Contros-O_2 Sensors only worked 45 days (#001) or 50 days (#002). Apparently, the consumption during pause time was too high; hence, the instrument ran out of battery very early during the deployment period.

Table 5.4. *Instrument performance by sensor type and mooring*

sensor type / mooring	**T (%)**	**C (%)**	**P (%)**	**U,V (%)**	**O_2 (%)**	**other (%)**
KPO_1202_CVOO	94.3	91.4	100.0	100.0	53.4	98.9
KPO_1195_K1	100.0	100.0	100.0	100.0		
KPO_1196_K2	100.0	100.0	100.0	100.0		
KPO_1197_K3	100.0	100.0	100.0	100.0		
KPO_1198_K4	91.2	87.5	100.0	85.4		
all moorings	96.5	94.0	100.0	96.4	53.4	98.9

Single point current meters: 18 of 19 current meter instruments (15 Aquadopps, 1 Argonaut, 1 RCM-11, 1 RCM-8) performed well and provided a complete and clean record. One Argonaut (#185) stopped working after two months on May 17th 2018.

ADCPs: 5 out of 5 ADCPs performed well and provided a complete and clean record over the entire moored periods.

PIES: The two PIES (pressure inverted echo sounder), deployed in 2017, were not answering after acoustic telemetry was tried three times on the early morning of October 30th 2019.

Other instruments (from KPO 1202): All the 10 plankton samplers were recovered successfully and all had complete samples. The Fluorometer was recording until the 9th January 2019.

5.4.2 Calibration of moored instruments

(Patricia Handmann)

CTD-O_2 cast calibrations were performed for all MicroCats either as pre- or post-deployment calibrations (CTD casts 001, 008, 012, 015, 024, 027) by attaching the instruments to the CTD frame. Aquadopps were attached to the CTD frame as well during casts 010, 013 and 027 in order to test the performance of the pressure and temperature sensor.

During each up-cast, 5-8 calibration stops were done over the whole profile range (depths chosen at low gradient-regimes for the respective parameters). Each stop had duration of at least 5 min (MicroCats), respectively, in order to ensure equilibrium at the calibration points. For MicroCats, calibration stops at around thermocline depth (upper few hundred meters of the water column) were prolonged to at least 6-10 min. However, in test cases we found that 5 to 10-minute-long calibration stops were not long enough (and had to be discarded afterwards) to particularly equilibrate the conductivity sensor of the MicroCats when reaching warmer water coming from the colder water below, which is likely the result of the thermal mass effect. As an alternative, we partly conducted calibration stops of at least 5 min length at about 10 m depth before starting the regular downcast profile right at the beginning of the CTD cast. This approach reduced the average equilibration time of the MicroCat conductivity sensors. Three MicroCats were mounted on too deep calibration casts. MicroCat #3413, #3755 and #2269 contain pressure sensors limited to 3500m, hence all calibration stops below ~3500m had to be discarded. Although limited to 3500m the pressure values showed a linear offset and the effect seemed to be reversible. The calibration for these three instruments was then conducted with data from the shallower calibration stops. The 5-8-minute calibration stops were far too short for the temperature logger of the Aquadopps to reach equilibrium with the surroundings. The temperature sensor is flush-mounted on the Aquadopp so it measures rather the temperature of the hull than of the surrounding waters. Hence, the Aquadopps were calibrated only for pressure. In a small test, the speed of the temperature sensor of the Aquadopp was tested being posed for hours in the fridge and then in the warm instrument-testing tank. Here, a MicroCat was used for comparison. We found adapting time ranges to 95% of the surrounding temperature of ~11 min. To reach the surrounding temperature the Aquadopp temperature sensor needs nearly an hour (~ 55 min).

5.5 Biochemical measurements

5.5.1 Underwater Vision Profiler

(Patrick Michaelis, Everardo González, PI: Rainer Kiko)

The Underwater Vision Profiler 5 (UVP5; serial number 10) was mounted on the CTD rosette and operated from CTD cast number 17 until 68 with exception of cast numbers 33, 34, 35, 56 and 67. The UVP is used to create vertical profiles of the size-spectrum of macroscopic particles and the occurrence of phyto- and zooplankton. Centerpiece of the UVP is a downward-facing HD camera pointed at a 0.88 litre water volume illuminated from two sides by red LED lights. The system is pressure-proof up to 6000 dbar and takes 20 pictures of the illuminated volume each second. Instead of saving the entire picture, only vignettes, cut-outs of the original images covering only the objects, for objects larger than 500 µm are stored. These vignettes can be classified into different species of plankton and types of particles using computer algorithms. Additionally, the UVP stores information like size and number on all objects it sees in an image, even if no vignette is created. This data can be analyzed in conjunction with measurements from other sensors on the CTD as the data is collected simultaneously.

5.5.2 Acoustic Zooplankton and Fish Profiler

(Carola Trahms, Rudolph Link, PI: Rainer Kiko)

Starting with the CTD cast at station 6, an ASL Acoustic Zooplankton and Fish Profiler (AZFP), serial number 55091, board version 132, was operated on the CTD rosette. The instrument consists of four echo-sonars that are facing to the side away from the CTD rosette. It is pinging with 1 Hz at four frequencies: 38 kHz, 125 kHz, 200 kHz and 455 kHz. There was no data collected at stations 10, 35, 36, 55. At stations 54 and 56, the data collection was incomplete.

5.5.3 OPUS Nutrient Sensor

(Rudolf Link, Gerd Krahmann, PI:Rainer Kiko)

The OPUS, manufactured by Trios, is a miniature UV spectrometer for in situ measurements of nitrate. On M159 an OPUS was attached to GEOMAR's CTD/ Rosette unit in a horizontal mounting position allowing for the free flow of seawater by the sampling path. The OPUS was powered by a GEOMAR-developed controller unit which itself received power from a CTD auxiliary port. The GEOMAR-developed controller unit allows for the magnet-aided switching on and off of the OPUS without using often-problematic underwater connectors. The controller has a LED, pressure protected by a transparent plastic dome, which shows the current status of the sensor (off, booting, sampling, shutting down). The strong sunlight in tropical regions posed a problem as the flashing LED was not detectable to the unaided eye. A black tube was cut that, when put over the dome, isolated the LED from daylight and made it visible. In addition to booting and shutting down the controller also sets the clock of the OPUS at a predefined rate (on M159 every 11^{th} sample).

Starting from CTD profile 8 the OPUS was regularly turned on before CTD casts and shutdown thereafter. In about weekly intervals the OPUS was connected to a PC to download the data. Only then the correct operation of the OPUS can be confirmed. By comparing the time stamps of the moments when the CTD/OPUS entered and left the water we also found that starting with CTD profile 25 the clock of the controller had an offset of about 45 minutes. Starting with profile 52 the controller was using a date of 10/00/01. This nonsensical date was not accepted by the OPUS which subsequently set its clock to 00:00:00 1970/1/1 and used this time stamp for all measurements thereafter. In addition, we found that the 3-second sampling rate triggered by the controller was apparently sometimes too fast for the OPUS. Because of that the OPUS missed some trigger signals and as a result sampled at irregular intervals. It might thus not be possible to recover timestamps for the measurements starting with CTD profile 52.

During the cruise we started to work on a Matlab software toolbox to calculate NO_3 concentrations from the raw spectra of the OPUS records. This software toolbox is a modification of an existing toolbox for the SUNA sensor, a comparable UV spectrometer manufactured by a different company. By the end of the cruise we were able to calculate NO_3 concentrations but since no concurrent nitrate measurements from water samples were made on M159 we were not able to confirm the calculations.

5.6 Hydrosweep, topography

(Ana Silva, PI: Colin Devey)

With the aid of the Kongsberg EM 122 Multibeam Echo Sounder bathymetric bands whose central position coincide with the route of the ship were collected. The study area is located between parallels 12°N and 12°S and meridians 31°W and 36°W. The bathymetric range is approximately 3700 km long, with a lateral coverage of up to 18km and depths of 43 to 5380 m.

The cruise route crossed the Mid-Atlantic Ridge and its submerged mountain range finding depths between 1700 and 4800 meters, with the 1700m ridge apex at 7° 3.00’ N 34° 26.00’ W. It should also be noted that the ridge is cut by transverse faults that determine abyssal pits and, that the depth of 4800 m is found at coordinates 7° 35.00’ N 34° 05.00’ W.

6 Ship´s Meteorological Station

(Martin Stelzner)

At the beginning of this cruise, a high ridge extended over an area from the ship to the mainland due to a subtropical high at 30° S 035°W. The wind blew with 3 to 4 Bft from southeast; the wind sea was at 1.5 m and a swell from east was noticed with a period of 9 s.
After a few hours of travelling southwards, R/V METEOR reached the research area in the evening. Over the next 6 days, the weather remained more or less the same. Several moorings were recovered and released again. Followed by a CTD transect along 11 ° 30’ S. The only change brought a second swell from southeast with 1.5 m on the 31st of October 2019.
On the 4th of November 2019, the research work at 11° 30’ S was finished. At the same time, a swell field from southeast reached R/V METEOR and could be observed over the 2-day crossing to 5° S 32° W. Due to this swell field, the southeast swell gradually increased to 2.5 m. Together with a weak wind sea the significant wave height was 3 m. On the arrival at the new research area on the 7th of November 2019, the significant wave height slowly reduced to 2 m. The wind changed its direction to southeast and increased to 5 Bft, over the two following days further to 6 Bft.
On the 9th of November 2019, the wind was still blowing with 5 to 6 Bft from southeast. The swell approached now only from southeast with a height of approx. 1.5 m. Following the crossing of the equator on the 10th of November 2019, R/V METEOR gradually left the influence of the South Atlantic subtropical high and approached the ITCZ at the same time. The first rain showers were observed on the day. The southeast wind decreased to 4 Bft. The swell was unchanged with 1.5 m coming from southeast. Two days later, on the 12th of November 2019, a second swell component from northeast appeared for the first time. More and more rain showers were observed around R/V METEOR. Already before noontime the first heavy rain shower reached R/V METEOR. Later in the evening, there was more light rain. During the following night and the next day, all together 6 strong rain showers occurred over the ship. In the night to the 14th of November 2019, the weather finally calmed down. As a result, it rained during these two and a half days for 21 hours and 60.9 l/m^2 of precipitation were measured.
After completing the research work, a 4-day transit to Cape Verde followed. Meanwhile there was only one swell component present from northeast with 1.5 m height. The initially light wind from variable directions increased to 3 to 4 Bft and came in the end from northeast.
The continued cruise with course northeast brought R/V METEOR gradually towards the south – later southeast flank of an extensive high-pressure area with its centre over the Azores. The wind increased to 4 to 5 Bft and the significant wave height reached 2 to 2.5 m. R/V METEOR reached the last research area of this voyage, just north of Sao Vicente, in the morning of the 18th November 2019.
The wind continued to increase to 5 to 6 Bft. The height of the wind sea was now 1 m. In connection with a swell field from north caused this a significant wave height of 2.5 to 3 m. This

less than optimal weather condition for the recovery and deployment of a mooring did not change until the arrival at port Mindelo / Sao Vicente, Cape Verde, in the morning of November 20th 2019.

7 Station Lists M159

7.1 CTD Station list

On CTD stations permanent measurements of salinity, fluorescence, temperature and oxygen took place. When additional bottle samples of O_2 or salinity at CTD stations were taken it is explicitly marked in the "measurements" column as O_2 and S.

Station No		Date	Gear	Time	Latitude	Longitude	Water Depth	Measurements*
M159	CTD	2019		[UTC]	[°]	[°]	[m]	
1-1	Test	29.10	CTD	19:36-19:47	09° 02.065' S	034° 56.332' W	57	
2-1		30.10	Mooring PIES	03:37-05:06	10° 13.494' S	035° 52.626' W	227	failed download
3-1		30.10	Mooring PIES	05:35-06:15	10° 13.912' S	035° 51.780' W	227	failed download
4-1	1	30.10	CTD	06:57-08:25	10° 15.566' S	035° 51.642' W	748	LADCP, O_2, S
5-1	2	30.10	CTD	09:06-09:18	10° 14.240' S	035° 54.252' W	83	LADCP, O_2
6-1	3	30.10	CTD	09:48-10:06	10° 14.636' S	035° 53.633' W	226	LADCP, O_2
7-1	4	30.10	CTD	10:35-11:02	10° 15.336' S	035° 52.614' W	520	LADCP, O_2, S
8-1		30.10	Mooring – KPO 1195 recovery	11:48-12:56	10° 16.065' S	035° 51.735' W	793	Argos, MCP, LR-ADCP, MC, Aquadopp
9-1		30.10	Mooring – KPO 1196 recovery	14:30-16:50	10° 22.448' S	035° 40.508' W	2306	Argos, MCP, LR-ADCP, MC, Aquadopp
10-1		30.10	Mooring – KPO 1211 deployment	19:30-20:36	10° 15.993' S	035° 51.638' W	922	Argos, MCP, LR-ADCP, MC, Aquadopp
11-1	5	30.10	CTD	21:04-21:50	10° 16.460' S	035° 51.794' W	940	LADCP, S
12-1	6	30.10	CTD	22:28-23:34	10° 17.162' S	035° 48.917' W	1506	LADCP, AZFP, O2, S
13-1	7	31.10	CTD	00:43-01:53	10° 19.508' S	035° 46.144' W	1716	LADCP, OPUS, AZFP, O_2, S
14-1	8	31.10	CTD	02:59-05:08	10° 22.823' S	035° 40.817' W	2322	LADCP, OPUS, AZFP
15-1	9	31.10	CTD	06:06-07:47	10° 25.189' S	035° 37.777' W	2620	LADCP, OPUS, AZFP, O_2, S
16-1		31.10	Mooring - KPO 1212 deployment	11:25-13:40	10° 22.786' S	035° 40.706' W	2136	Argos, MCP, LR-ADCP, MC, Aquadopp
17-1		31.10	Mooring – KPO 1197 recovery	15:00-18:54	10° 36.440' S	035° 23.840' W	3500	Argos, MCP, LR-ADCP, MC, Aquadopp
18-1	10	31.10	CTD	19:14-22:08	10° 36.167' S	035° 23.967' W	3513	LADCP, OPUS, O2, S
19-1	11	31.10	CTD	23:12-01:10	10° 32.002' S	035° 29.307' W	3211	LADCP, OPUS, AZFP, O_2, S
20-1	12	01.11	CTD	02:32-04:56	10° 27.461' S	035° 34.931' W	2873	LADCP, OPUS, AZFP
21-1		01.11	Mooring – KPO 1213 deployment	10:08-13:15	10° 46.49' S	035° 23.341' W	3280	Argos, MCP, LR-ADCP, MC, Aquadopp
22-1		01.11	Mooring – KPO 1198 recovery	16:00-19:40	10° 56.614' S	035° 00.209' W	4113	Argos, MCP, LR-ADCP, MC, Aquadopp, RCM11, RCM8, Argonaut
23-1	13	01.11	CTD	20:13-23:06	10° 56.420' S	035° 00.362' W	4119	LADCP, OPUS, AZFP, O2, S
24-1	14	02.11	CTD	00:45-03:12	10° 46.388' S	035° 11.675' W	3880	LADCP, OPUS, AZFP, S

25-1	15	02.11	CTD	04:43-07:41	10° 51.375' S	035° 05.605' W	3968	OPUS, AZFP, O_2, S
26-1		02.11	Mooring – KPO 1214 deployment	10:19-13:48	10° 56.466' S	034° 59.414' W	4052	Argos, MCP, LR-ADCP, MC, Aquadopp
27-1	16	02.11	CTD	15:52-18:34	11° 07.629' S	034° 43.929' W	4271	LADCP, OPUS, AZFP, O_2, S
28-1	17	02.11	CTD	20:43-00:20	11° 18.774' S	034° 28.299' W	4641	LADCP, UVP, OPUS, AZFP, O_2, S
29-1	18	03.11	CTD	02:24-05:16	11° 30.003' S	034° 12.980' W	4583	LADCP, UVP, OPUS, AZFP, O_2
30-1	19	03.11	CTD	07:23-10:26	11° 29.992' S	033° 52.999' W	5847	LADCP, UVP, OPUS, AZFP, O_2 , S
31-1	20	03.11	CTD	13:12-16:17	11° 30.027' S	033° 33.270' W	4975	LADCP, UVP, OPUS, AZFP, O_2 , S
32-1	21	03.11	CTD	18:40-21:21	11° 30.022' S	033° 12.982' W	5641	LADCP, UVP, OPUS, AZFP, O_2, S
33-1	22	03.11	CTD	23:25-01:41	11° 30.042' S	032° 52.981' W	3641	LADCP, UVP, OPUS, AZFP, O_2, S
34-1	23	04.11	CTD	03:49-06:42	11° 30.006' S	032° 32.957' W	4607	LADCP, UVP, OPUS, AZFP, O_2, S
35-1	24	04.11	CTD	08:48-12:29	11° 30.103' S	032° 13.134' W	4952	LADCP, UVP, OPUS, AZFP, O_2, S
36-1	25	05.11	CTD	22:23-01:01	05° 07.009' S	032° 00.073' W	4614	LADCP, UVP, OPUS, AZFP, O_2, S
37-1	26	06.11	CTD	04:34-07:31	05° 12.373' S	032° 30.109' W	4607	LADCP, UVP, OPUS, AZFP, O_2, S
38-1	27	06.11	CTD	10:24-13:56	05° 17.705' S	033° 00.029' W	4561	LADCP, UVP, OPUS, AZFP, O_2, S
39-1	28	06.11	CTD	16:41-19:30	05° 21.714' S	033° 25.085' W	4486	LADCP, UVP, OPUS, AZFP, O_2, S
40-1	29	06.11	CTD	21:54-00:31	05° 26.585' S	033° 50.101' W	4325	LADCP, UVP, OPUS, AZFP, O_2, S
41-1	30	07.11	CTD	02:33-05:22	05° 30.161' S	034° 10.060' W	4122	LADCP, UVP, OPUS, AZFP, O_2, S
42-1	31	07.11	CTD	06:52-09:21	05° 32.670' S	034° 24.027' W	3767	LADCP, UVP, OPUS, AZFP, O_2, S
43-1	32	07.11	CTD	10:39-12:51	05° 34.738' S	034° 36.070' W	3384	LADCP, UVP, OPUS, AZFP, O_2 S
44-1	33	07.11	CTD	14:07-15:58	05° 36.552' S	034° 46.049' W	2639	LADCP, OPUS, AZFP, O_2, S
45-1	34	07.11	CTD	17:06-18:33	05° 37.967' S	034° 54.032' W	1463	LADCP, OPUS, AZFP, O_2, S
46-1	35	07.11	CTD	19:13-19:49	05° 38.210' S	034° 55.931' W	1440	LADCP, OPUS, O_2
47-1	36	07.11	CTD	20:27-20:49	05° 38.993' S	034° 57.620' W	403	LADCP, OPUS, UVP, O_2
48-1	37	08.11	CTD	00:00-00:28	05° 01.891' S	035° 01.120' W	463	LADCP, OPUS, UVP, AZFP, O_2
49-1	38	08.11	CTD	01:31-02:10	04° 55.025' S	034° 55.132' W	830	LADCP, OPUS, UVP, AZFP, O_2
50-1	39	08.11	CTD	03:06-03:55	04° 47.955' S	034° 53.007' W	1020	LADCP, OPUS, UVP, AZFP, O_2
51-1	40	08.11	CTD	04:56-06:39	04° 40.059' S	034° 53.098' W	28	LADCP, UVP, OPUS, AZFP, O_2, S
52-1	41	08.11	CTD	08:09-10:19	04° 24.974' S	034° 53.029' W	3362	LADCP, UVP, OPUS, AZFP, O_2, S
53-1	42	08.11	CTD	12:41-15:00	03° 59.943' S	034° 53.073' W	3564	LADCP, UVP, OPUS, AZFP, O_2 S
54-1	43	08.11	CTD	17:08-19:14	03° 39.991' S	034° 53.069' W	3459	LADCP, UVP, OPUS, AZFP, O_2, S
55-1	44	08.11	CTD	22:03-00:14	03° 09.943' S	034° 52.961' W	3821	LADCP, UVP, OPUS, AZFP, O_2, S
56-1	45	09.11	CTD	03:43-06:10	02° 35.002' S	035° 00.030' W	3963	LADCP, UVP, OPUS, AZFP, O_2, S
57-1	46	09.11	CTD	09:04-11:35	02° 04.952' S	035° 00.038' W	4051	LADCP, UVP, OPUS, AZFP, O_2, S

58-1	47	09.11	CTD	13:39-16:08	01° 45.017' S	035° 00.049' W	4110	LADCP, UVP, OPUS, AZFP, O_2, S
59-1	48	09.11	CTD	17:58-20:38	01° 27.937' S	035° 00.041' W	4321	LADCP, UVP, OPUS, AZFP, O_2, S
60-1	49	09.11	CTD	22:00-00:31	01° 18.006' S	034° 59.976' W	4362	LADCP, UVP, OPUS, AZFP, O_2, S
61-1	50	10.11	CTD	02:24-05:02	00° 59.976' S	035° 00.031' W	4399	LADCP, UVP, OPUS, AZFP, O_2, S
62-1	51	10.11	CTD	07:03-09:43	00° 39.968' S	035° 00.085' W	4471	LADCP, UVP, OPUS, AZFP, O_2, S
63-1	52	10.11	CTD	15:32-18:28	00° 00.058' S	035° 00.861' W	4548	LADCP, UVP, OPUS, AZFP, O_2, S
64-1	53	10.11	CTD	22:37-01:29	00° 20.011' S	035° 00.043' W	4515	LADCP, UVP, OPUS, AZFP, O_2, S
65-1	54	11.11	CTD	05:15-08:00	00° 20.023' N	035° 00.088' W	4547	LADCP, UVP, OPUS, AZFP, O_2, S
66-1	55	11.11	CTD	09:58-13:58	00° 40.110' N	035° 00.024' W	4557	LADCP, UVP, OPUS, O_2, S
67-1	56	11.11	CTD	15:34-17:50	01° 00.008' N	035° 00.107' W	3583	LADCP, OPUS, AZFP, O_2, S
68-1	57	11.11	CTD	20:33-23:18	01° 30.067' N	035° 00.031' W	4049	LADCP, UVP, OPUS, AZFP, O_2 S
69-1	58	12.11	CTD	02:06-05:20	02° 00.087' N	034° 59.951' W	4183	LADCP, UVP, OPUS, AZFP, O_2, S
70-1	59	12.11	CTD	08:02-10:22	02° 30.184' N	034° 59.942' W	3559	LADCP, UVP, OPUS, AZFP, O_2, S
71-1	60	12.11	CTD	13:10-15:46	03° 00.118' N	034° 59.904' W	3819	LADCP, UVP, OPUS, AZFP, O_2, S
72-1	61	12.11	CTD	18:29-21:14	03° 29.894' N	034° 59.846' W	3962	LADCP, UVP, OPUS, AZFP, O_2 S
73-1	62	13.11	CTD	00:05-02:14	04° 00.130' N	034° 59.743' W	3481	LADCP, UVP, OPUS, AZFP, O_2, S
74-1	63	13.11	CTD	05:32-07:46	04° 29.966' N	034° 59.837' W	3879	LADCP, UVP, OPUS, AZFP, O_2, S
75-1	64	13.11	CTD	10:49-13:14	05° 00.072' N	035° 00.011' W	3739	LADCP, UVP, OPUS, AZFP, O_2, S
76-1	65	13.11	CTD	16:22-18:52	05° 30.035' N	034° 59.963' W	3946	LADCP, UVP, OPUS, AZFP, O_2
77-1	66	13.11	CTD	21:48-00:26	06° 00.042' N	034° 59.962' W	4237	LADCP, UVP, OPUS, AZFP, O_2
78-1	67	15.11	CTD	17:05-21:20	12° 11.200' N	031° 27.546' W	6113	OPUS
79-1		18.11	Mooring – KPO 1202 recovery	07:51-12:32	17° 36.094' N	024° 15.325' W	3585	Iridium Float, MCP, MC, ADCP, Aquadopp, O_2-Logger, VR2W, Argos, XEOS-XMA, Opt. Logger, Contros- O_2, SAMI, Plankton Sampler, Sediment Trap
80-1	68	18.11	CTD	16:29-18:47	17° 36.029' N	024° 14.871' W	3598	OPUS, UVP
81-1		19.11	Mooring – KPO 1216 deployment	09:39-17:05	17° 36.548' N	024° 14.847' W	3596	MCP, MC, ADCP, Aquadopp, O2-Logger, VR2W, XEOS XMA, Opt. Logger, Argos, SAMI, Plankton Sampler, Sediment Trap, ABeck Vane, Ellipse, Fluorometer

Depth information given is the maximum water depth at each station.

7.2 List of mooring deployments and recoveries

7.2.1 Mooring Recoveries

Mooring Recovery NBUC 11°S Array mooring K1					**Notes:** **KPO_1195**
Vessel:	Meteor	M145			
Deployed:	07-Mar	2018	11:07		
Vessel:	Meteor	M159			
Recovered:	30-Oct	2019	12:56		
Latitude:		10°	16.00’	S	
Longitude:		35°	51.70’	W	
Water depth:		900	Mag Var:	-22.8	
ID	**Designed Depth**	**Instr. Type**	**s/n**	**Start-up**	**Remarks**
KPO_1195_01	500	Argos	5506	**ready**	-
KPO_1195_02	500	ADCP LR up /p	12538	x	Complete and clean record
KPO_1195_03	505.8	MicroCat /p	10609	x	Complete and clean record
KPO_1195_04	648.6	MicroCat	2247	x	Complete and clean record
KPO_1195_05	649.1	Aquadopp down /p	P26209-18	x	Complete and clean record
KPO_1195_06	874.8	MicroCat	8947	x	Complete record, 7 days of bad data in April 2018, apart from that clean record
KPO_1195_07	886.6	Release AR661	220	Code:	Enable: 9151 / Release: 9152
KPO_1195_08	886.6	Release AR861	1771	Code:	Enable: OAEF / Release: 0A55

Mooring Recovery NBUC 11°S Array mooring K2					**Notes:** **KPO_1196**
Vessel:	Meteor	M145			
Deployed:	07-Mar	2018	15:25		
Vessel:	Meteor	M159			
Recovered:	30-Oct	2019	16:50		
Latitude:		10°	22.80’	S	
Longitude:		35°	40.80’	W	
Water depth:		2320	Mag Var:	-22.8	
ID	**Designed Depth**	**Instr. Type**	**s/n**	**Start-up**	**Remarks**
KPO_1196_01	500	Argos	7379	**ready**	-
KPO_1196_02	500	ADCP LR up /p	17590	x	Complete and clean record
KPO_1196_03	506	MicroCat /p	3416	x	Complete and clean record
KPO_1196_04	650	MicroCat	1721	x	Complete and clean record
KPO_1196_05	650	Aquadopp down /p	P26209-02	x	Complete and clean record
KPO_1196_06	899	Aquadopp down /p	P26209-20	x	Complete and clean record
KPO_1196_07	1200	MicroCat	2250	x	Complete and clean record
KPO_1196_08	1400	Aquadopp down /p	P26209-27	x	Complete and clean record
KPO_1196_09	1500	MicroCat	2249	x	Complete record, no clear linear T-C-relation (rms=0.0034 for T and C)
KPO_1196_10	1899	MicroCat	2472	x	Complete and clean record
KPO_1196_11	1900	Aquadopp down /p	P26209-28	x	Complete and clean record
KPO_1196_12	2293	MicroCat	2246	x	Complete and clean record
KPO_1196_13	2305	Release AR861	1772	Code:	Enable: OAFO / Release: 0A55
KPO_1196_14	2305	Release RT661	110	Code:	Enable: E972 / Release: E974

Mooring Recovery NBUC 11°S Array mooring K3					**Notes:**	**KPO_1197**
Vessel:	Meteor	M145				
Deployed:	05-Mar	2018	20:52			
Vessel:	Meteor	M159				
Recovered:	31-Oct	2019	18:54			
Latitude:		10°	36.50'	S		
Longitude:		35°	23.60'	W		
Water depth:		3520	Mag Var:	-22.9		

ID	Designed Depth	Instr. Type	s/n	Start-up	Remarks
KPO_1197_01	500	Argos	5467	**ready**	-
KPO_1197_02	500	ADCP LR up /p	1181	**x**	Complete and clean record
KPO_1197_03	506	MicroCat /p	3413	**x**	Complete and clean record, during 1 hour on April 4th (3:55-4:50) conductivity data discarded
KPO_1197_04	650	MicroCat	2933	**x**	Complete and clean record
KPO_1197_05	650	Aquadopp down /p	P24543-01	**x**	Complete and clean record
KPO_1197_06	899	Aquadopp down /p	P26209-16	**x**	Complete and clean record
KPO_1197_07	1400	Aquadopp down /p	P26209-19	**x**	Complete and clean record
KPO_1197_08	1900	MicroCat	3144	**x**	Complete and clean record
KPO_1197_09	1900	Aquadopp down /p	P26209-21	**x**	Complete and clean record
KPO_1197_10	2380	Aquadopp down/p	P26209-33	**x**	Complete and clean record
KPO_1197_11	2801	MicroCat	2251	**x**	Complete and clean record
KPO_1197_12	3000	Aquadopp down /p	P26209-34	**x**	Complete and clean record
KPO_1197_13	3399	MicroCat	2245	**x**	Complete and clean record
KPO_1197_14	3506	Release AR661	839	Code:	Enable: 4AD5 / Release: 4AD6
KPO_1197_15	3506	Release RT661	31	Code:	Enable: 5037 / Release: 5039

Mooring Recovery NBUC 11°S Array mooring offshore K4					**Notes:**	**KPO_1198**
Vessel:	Meteor	M145				
Deployed:	05-Mar	2018	13:04			
Vessel:	Meteor	M159				
Recovered:	01-Nov	2019	19:39			
Latitude:		10°	56.40'	S		
Longitude:		34°	59.60'	W		
Water depth:		4110	Mag Var:	-23.0		

ID	Designed Depth	Instr. Type	s/n	Start-up	Remarks
KPO_1198_01	500	Argos	7372	**ready**	-
KPO_1198_02	500	ADCP LR up /p	2330	**x**	Complete and clean record
KPO_1198_03	506	MicroCat /p	3755	**x**	Complete and clean record, no data recorded on 09/09/2018 6:39 – 10/09/2018 19:29 and on 03/01/2019 9:18 -04/01/2019 22:08. Bad data on 23/01/2019 6:18-6:29
KPO_1198_04	650	MicroCat	2269	**x**	Complete and clean record
KPO_1198_05	650	Aquadopp down /p	P26209-17	**x**	Complete and clean record
KPO_1198_06	880	RCM11	441	**x**	Complete and clean record
KPO_1198_07	1381	MicroCat	P26209-24	**x**	Complete and clean record
KPO_1198_08	1901	MicroCat	1268	**x**	Complete and clean record
KPO_1198_09	1902	Aquadopp down /p	P27523	**x**	Complete and clean record
KPO_1198_10	2381	Argonaut	185	**x**	Stopped working 17.05.2018
KPO_1198_11	2882	RCM8	12004	**x**	Complete and clean record

KPO_1198_12	3402	MicroCat	381	x	Complete and clean record
KPO_1198_13	4087	MicroCat	10705	x	Complete and clean record
KPO_1198_14	4098	Release AR861	110	Code:	Enable: 0498 / Release: 0455
KPO_1198_15	4098	Release RT661	174	Code:	Enable: 9337 / Release: 9339

Mooring Recovery Cape Verde CVOO-09				**Notes:**	**KPO_1202**
Vessel:	Meteor	M145			
Deployed:	14-Feb	2018	15:18		
Vessel:	Meteor				
Recovered:	18-Nov	2019	12:32		
Latitude:		17°	36.40’	N	
Longitude:		24°	14.98’	W	
Water depth:		3604	Mag Var:	-9.6	
ID	**Designed Depth**	**Instr. Type**	**s/n**	**Start-up**	**Remarks**
KPO_1202_01	-241	Develogic Iridium Float		**ready**	
KPO_1202_02	-222	MicroCat-IM	1718	x	Complete record, conductivity cell unstable during several periods
KPO_1202_03	-208	MicroCat-IM /p	2716	x	Complete record, conductivity cell unstable during several periods
KPO_1202_04	42	MicroCat-IM /p	3411	x	Complete record, conductivity cell unstable during several periods
KPO_1202_05	42	O2 Logger (ind. Opt.)	383	x	Complete and clean record
KPO_1202_06	42	VR2W	112332	**ready**	
KPO_1202_07	44	Mini-TD /p	77	x	Complete and clean record
KPO_1202_08	44	XEOS-XMA / Argos	567 / 2268	**ready**	
KPO_1202_09	69	Fluorometer	2856	x	Record until 09.01.2019
KPO_1202_10	69	MicroCat	1550	x	Complete and clean record
KPO_1202_11	89	MicroCat	2248	x	No data, water intrusion to hull
KPO_1202_12	119	MicroCat /p	6857	x	Complete and clean record
KPO_1202_13	119	O2 Logger	1138	x	Complete and clean record until 10.11.2019
KPO_1202_14	119	HydroFlash O2 optode	DO-0617-001	x	Clean data until 31.03.2018
KPO_1202_15	119	HydroFlash O2 optode	DO-0617-002	x	Clean data until 05.04.2018
KPO_1202_16	121	SAMI-2	C0048	**ready**	
KPO_1202_17	131	Plankton sampler		**ready**	
KPO_1202_18	131	Plankton sampler		**ready**	
KPO_1202_19	160	MicroCat	1282	x	Complete and clean record
KPO_1202_20	200	MicroCat-IM /p	2271	x	Complete and clean record
KPO_1202_21	301	ADCP QM 150 up /p	14911	x	Complete and clean record
KPO_1202_22	393	Plankton sampler		**ready**	
KPO_1202_23	393	Plankton sampler		**ready**	
KPO_1202_24	403	MicroCat /p	10713	x	Complete and clean record
KPO_1202_25	612	Aquadopp down /p	P26209-1	x	Complete and clean record
KPO_1202_26	737	Plankton sampler		**ready**	
KPO_1202_27	737	Plankton sampler		**ready**	
KPO_1202_28	747	MicroCat-IM	2256	x	Complete and clean record
KPO_1202_29	1098	MicroCat /p	10632	x	Complete and clean record
KPO_1202_30	1299	Sediment Trap	910026	**ready**	
KPO_1202_31	1351	Aquadopp down /p	P26209-13	x	Complete and clean record
KPO_1202_32	1490	Plankton sampler		**ready**	

KPO_1202_33	1490	Plankton sampler		**ready**	
KPO_1202_34	1500	MicroCat-IM	2255	**x**	Complete and clean record
KPO_1202_35	3000	Aquadopp down /p	P26209-36	**x**	Complete and clean record
KPO_1202_36	3579	Plankton sampler		**ready**	
KPO_1202_37	3579	MicroCat /p	10698	**x**	Complete and clean record
KPO_1202_38	3579	Plankton sampler		**ready**	
KPO_1202_39		Release AR661	633	Code:	Enable: 3A91 / Release: 3A92
KPO_1202_40		Release AR861	1647	Code:	Enable: 0A8C / Release: 0A55

7.2.2 Mooring Deployments

Mooring Deployment NBUC 11°S Array mooring K1				**Notes:**	**KPO_1211**
Vessel:	Meteor	M159			
Deployed:	30-Oct	2019	20:37		
Vessel:					
Recovered:					
Latitude:		10°	15.993’ S		
Longitude:		35°	51.638’ W		
Water depth:		900	Mag Var:	-22.8	
ID	**Designed Depth**	**Instr. Type**	**s/n**	**Start-up**	**Remarks**
KPO_1195_01	296	Argos	983	**ready**	
KPO_1195_02	296	MicroCat/p	10697	**x**	
KPO_1195_03	502.6	ADCP LR up /p	2395	**x**	
KPO_1195_04	504.2	MicroCat /p	10699	**x**	
KPO_1195_05	649.8	MicroCat	8945	**x**	
KPO_1195_06	650.3	Aquadopp down/p	40893-1-236	**x**	
KPO_1195_07	874.5	MicroCat	8946	**x**	
KPO_1195_08	886.3	Release RT661	28	Code:	Enable: 5022 / Release: 5024
KPO_1195_09	886.3	Release AR861	107	Code:	Enable: 0495 / Release: 0455

Mooring Deployment NBUC 11°S Array mooring K2				**Notes:**	**KPO_1112**
Vessel:	Meteor	M159			
Deployed:	31-Oct	2019	13:31		
Vessel:					
Recovered:					
Latitude:		10°	22.79’ S		
Longitude:		35°	40.71’ W		
Water depth:		2320	Mag Var:	-22.8	
ID	**Designed Depth**	**Instr. Type**	**s/n**	**Start-up**	**Remarks**
KPO_1196_01	500	Argos	7373	**ready**	
KPO_1196_02	500	ADCP LR up/p	2290	**x**	
KPO_1196_03	500	MicroCat /p	10706	**x**	
KPO_1196_04	650	MicroCat	6860	**x**	
KPO_1196_05	650	Aquadopp down/p	260	**x**	
KPO_1196_06	900	Aquadopp down/p	P26209-6	**x**	
KPO_1196_07	1200	MicroCat	10692	**x**	

KPO_1196_08	1400	Aquadopp down /p	261	x	
KPO_1196_09	1500	MicroCat	10690	x	
KPO_1196_10	1901	MicroCat	1583	x	
KPO_1196_11	1901	Aquadopp down /p	P26209-3	x	
KPO_1196_12	2294	MicroCat	1682	x	
KPO_1196_13	2306	Release AR861	1649	Code:	Enable: 0A8E / Release: 0A55
KPO_1196_14	2306	Release RT661	441	Code:	Enable: 8A03 / Release: 8A04

Mooring Deployment NBUC 11°S Array mooring K3				**Notes:**	**KPO_1113**
Vessel:	Meteor	M159			
Deployed:	01-Nov	2019	12:30		
Vessel:					
Recovered:					
Latitude:		10°	36.49 S		
Longitude:		35°	23.34' W		
Water depth:		3521	Mag Var:	-22.9	
ID	**Designed Depth**	**Instr. Type**	**s/n**	**Start-up**	**Remarks**
KPO_1197_01	500	Argos	5467	**ready**	
KPO_1197_02	500	ADCP LR up /p	2627	x	
KPO_1197_03	500	MicroCat /p	10636	x	
KPO_1197_04	650	MicroCat	2472	x	
KPO_1197_05	650	Aquadopp down/p	P25460-2	x	
KPO_1197_06	899	Aquadopp down /p	P26209-29	x	
KPO_1197_07	1400	Aquadopp down /p	P26209-20	x	
KPO_1197_08	1900	MicroCat	2617	x	
KPO_1197_09	1900	Aquadopp down /p	P26209-28	x	
KPO_1197_10	2399	Aquadopp down/p	P26209-18	x	
KPO_1197_11	2800	MicroCat	2485	x	
KPO_1197_12	3003	Aquadopp down /p	P26209-27	x	
KPO_1197_13	3402	MicroCat	2246	x	
KPO_1197_14	3508	Release AR661	221	Code:	Enable: 9153 / Release: 9154
KPO_1197_15	3508	Release AR661	838	Code:	Enable: 4AD3 / Release: 4AD4

Mooring Deployment NBUC 11°S Array mooring offshore K4				**Notes:**	**KPO_1114**
Vessel:	Meteor	M159			
Deployed:	02-Nov	2019	13:25		
Vessel:					
Recovered:					
Latitude:		10°	56.47' S		
Longitude:		34°	59.41' W		
Water depth:		4111	Mag Var:	-22.9	
ID	**Designed Depth**	**Instr. Type**	**s/n**	**Start-up**	**Remarks**
KPO_1198_01	500	Argos	7372	**ready**	
KPO_1198_02	500	ADCP LR up /p	19398	x	
KPO_1198_03	500	MicroCat /p	10609	x	
KPO_1198_04	650	MicroCat	2934	x	

KPO_1198_05	650	Aquadopp down /p	P24543-1	**x**	
KPO_1198_06	880	Aquadopp down/p	P26209-16	**x**	
KPO_1198_07	1382	MicroCat	P26209-21	**x**	
KPO_1198_08	1901	MicroCat	10656	**x**	
KPO_1198_09	1902	Aquadopp down /p	P26209-2	**x**	
KPO_1198_10	2381	Aquadopp down/p	P26209-33	**x**	
KPO_1198_11	2882	Aquadopp down/p	P26209-19	**x**	
KPO_1198_12	3403	MicroCat	10639	**x**	
KPO_1198_13	4086	MicroCat/p	6863	**x**	
KPO_1198_14	4097	Release AR661	220	**Code:**	Enable: 9151 / Release: 9152
KPO_1198_15	4097	Release AR661	839	**Code:**	Enable: 4AD5 / Release: 4AD6

Mooring Deployment Cape Verde CVOO-10				**Notes:**	**KPO_1202**
Vessel:	Meteor	M159			
Deployed:	19-Nov	2019	17:05		
Vessel:	Meteor				
Recovered:					
Latitude:		17°	36.55’	N	
Longitude:		24°	14.84’	W	
Water depth:		3604	Mag Var:	-22.9	

ID	**Designed Depth**	**Instr. Type**	**s/n**	**Start-up**	**Remarks**
KPO_1202_01	-236	XEOS XMA	184082	**ready**	
KPO_1202_02	-225	MicroCat	381	**x**	
KPO_1202_03	-210	MicroCat/p	1268	**x**	
KPO_1202_04	46	MicroCat-IM /p	3754	**x**	
KPO_1202_05	46	O2 Logger (ind. Opt.)	385	**x**	
KPO_1202_06	46	VR2W	124996	**x**	
KPO_1202_07	48	Mini-TP	60	**x**	
KPO_1202_08	48	SMM2000/ Argos	11460 / 11460	**ready**	
KPO_1202_09	70	Fluorometer	034858R	**x**	
KPO_1202_10	70	MicroCat	10653	**x**	
KPO_1202_11	90	MicroCat	1722	**x**	
KPO_1202_12	121	MicroCat /p / Opt.Logger	10659/219	**x**	
KPO_1202_13	121	SAMI	C0067	**x**	
KPO_1202_14	123	ABeck Vane	1	**x**	
KPO_1202_15	133	Plankton sampler	?	**x**	
KPO_1202_16	133	Plankton sampler	?	**ready**	
KPO_1202_17	162	MicroCat	2801	**ready**	
KPO_1202_18	202	MicroCat-IM/p	10651	**ready**	
KPO_1202_19	303	ADCP	21816	**x**	
KPO_1202_20	303	Ellipse	J06721-002	**x**	
KPO_1202_21	401	Plankton sampler	?	**x**	
KPO_1202_22	401	Plankton sampler	?	**ready**	
KPO_1202_23	411	MicroCat/p	10638	**ready**	
KPO_1202_24	620	Aquadopp down /p	P26209-34	**x**	
KPO_1202_25	746	Plankton sampler		**x**	

KPO_1202_26	746	Plankton sampler		**ready**	
KPO_1202_27	756	MicroCat-IM/p	2269	**ready**	
KPO_1202_28	1106	MicroCat/p	10681	**x**	
KPO_1202_29	1206	ABeck Vane	2	**x**	
KPO_1202_30	1308	Sediment Trap	930017	**ready**	
KPO_1202_31	1499	Plankton sampler		**x**	
KPO_1202_32	1499	Plankton sampler		**ready**	
KPO_1202_33	1509	MicroCat-IM	3755	**ready**	
KPO_1202_34	3009	Aquadopp down /p	P27523	**x**	
KPO_1202_35	3414	ABeck Vane	3	**x**	
KPO_1202_36	3579	Plankton sampler		**ready**	
KPO_1202_37	3579	MicroCat /p	10658	**x**	
KPO_1202_38	3579	Plankton sampler		**ready**	
KPO_1202_39	3590	Release RT661	110	Code:	Enable: E972 / Release: E974
KPO_1202_40	3590	Release AR861	1771	Code:	Enable: 0AEF / Release: 0A55

*IM stands for inductive

8 Capacity building and training in partnership with POGO

As part of its mandate, in conjunction with partnered major oceanographic institutions across the world, to provide a medium for training of young researchers from developing countries and those with economies in transition on the global ocean observing system; the Partnership for Observation of the Global Ocean (POGO) sponsored, in collaboration with GEOMAR, two training fellows from Nigeria and Argentina to be part of the M159 cruise aboard the R/V METEOR under its Nippon Foundation-Partnership for Observation of the Global Ocean (NF-POGO) Shipboard Training Fellowship program. The program provides hands-on, sea-going experience to young scientists from developing countries, and the opportunity to be involved in an internationally renowned scientific program.

During the first three days of the first week of the training, general orientations were given to the trainees on safety and the general operation onboard. Then, the two fellows were trained on the principle of physical oceanography comprising daily lectures and seminar presentations. Also, during the first week, the trainees were assigned to the mooring section to understudy, first, on how the first recovery of deep-sea mooring equipment such MicroCat, Aquadopp and ADCP were done, and second, on the deployment of the same equipment. This first phase of the training lasted until the middle of the second week when all recovery and deployment were done.

In the next phase of the training that spanned till the end of the cruise, the trainees were made to understudy how to deploy and recover combined CTD and Lowered ADCP with many sensors and process the data. In addition, they were taught on how to process data generated by the ship-mounted ADCP, echo sounders and thermosalinograph.

The trainees thank the funders of the training fellowship, the Nippon Foundation-Partnership for Observation of the Global Ocean (NF-POGO), GEOMAR and the German government for the exposure and experience they gained during the program.

9 Data and Sample Storage and Availability

In Kiel, a joint data management team is set up to store the data from various projects and cruises in a web-based multi-user-system. Data gathered during M159 are stored at the Kiel data portal, and remain proprietary for the PIs of the cruise. Each station is logged as an event file https://portal.geomar.de/metadata/leg/show/348941. All data will be submitted to PANGAEA within 3 years after the cruise, i.e. by November 2022. Preliminary CTD data were submitted to CORIOLIS during the cruise for real time oceanographic analysis and Argo calibration. Contact persons for the different datasets are listed in Table 9.1.

Tab. 9.1: Overview of contact persons for the different data sets.

Data Type	Contact Person	Current Affiliation	Email
CTD, VMADCP, LADCP, Thermosalinograph, O_2	Gerd Krahmann	GEOMAR	gkrahmann@geomar.de
Mooring data	Rebecca Hummels	GEOMAR	rhummels@geomar.de
Multibeam echosounder	Colin Devey	GEOMAR	cdevey@geomar.de
Underwater Vision Profiler	Rainer Kiko	GEOMAR	rkiko@geomar.de
AZFP	Rainer Kiko	GEOMAR	rkiko@geomar.de

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11 Appendix – List of Abbreviations

ADCP	Acoustic Doppler Current Profiler
AMOC	Atlantic Meridional Overturning Circulation
Atlas	Autonomous Temperature Line Acquisition System mooring
AZFP	Acoustic Zooplankton and Fish Profiler
BMBF	Federal Ministry of Education and Research
CDOM	Colored dissolved organic matter
CTD	Conductivity-temperature-depth (system)
CVOO	Cape Verde Ocean Observatory
DFG	German Science Foundation
DWBC	Deep Western Boundary Current
IAPSO	International Association for the Physical Sciences of the Oceans
ITCZ	Intertropical Convergence Zone
LADCP	Lowered ADCP
NBUC	North Brazil Undercurrent

OPS	OPTIMARE Precision Salinometer
OPUS	spectral sensors for online measurement of nitrogen and carbon compounds
OS38	38kHz RDI Ocean Surveyor
OS75	75kHz RDI Ocean Surveyor
PAR	Photosynthetically active radiation
PIES	Pressure inverted echo sounder
PIRATA	Pilot Research moored Array in the Tropical Atlantic / Prediction and Research Moored Array in the Tropical Atlantic
RACE	BMBF Research Project: Regional Atlantic Circulation and Global Change
REEBUS	Federal Ministry of Education and Research supports three joint multi-institutional projects: Role of Eddies in the Carbon Pump of Eastern Boundary Upwelling Systems
rms	Root mean square
SBE	Seabird Electronics
SSS	Sea surface salinity
SST	Sea surface temperature
STC	Subtropical cell
SUNA	Submersible Ultraviolet Nitrate Analyzer
TSG	Thermosalinograph
TRDI	Teledyne RD Instruments
UVP	Underwater vision profiler
VMADCP	Vessel-mounted Acoustic Doppler Current Profiler

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