ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG

696
2016

Berichte
zur Polar- und Meeresforschung

Reports on Polar and Marine Research

The Expedition PS88 of the Research Vessel POLARSTERN to the Atlantic Ocean in 2014

Edited by

Rainer Knust and Frank Niessen

with contributions of the participants

HELMHOLTZ
GEMEINSCHAFT

Die Berichte zur Polar- und Meeresforschung werden vom Alfred-Wegener-Institut, Helmholtz-Zentrum für Polar- und Meeresforschung (AWI) in Bremerhaven, Deutschland, in Fortsetzung der vormaligen Berichte zur Polarforschung herausgegeben. Sie erscheinen in unregelmäßiger Abfolge.

Die Berichte zur Polar- und Meeresforschung enthalten Darstellungen und Ergebnisse der vom AWI selbst oder mit seiner Unterstützung durchgeführten Forschungsarbeiten in den Polargebieten und in den Meeren.

Die Publikationen umfassen Expeditionsberichte der vom AWI betriebenen Schiffe, Flugzeuge und Stationen, Forschungsergebnisse (inkl. Dissertationen) des Instituts und des Archivs für deutsche Polarforschung, sowie Abstracts und Proceedings von nationalen und internationalen Tagungen und Workshops des AWI.

Die Beiträge geben nicht notwendigerweise die Auffassung des AWI wider.

The Reports on Polar and Marine Research are issued by the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI) in Bremerhaven, Germany, succeeding the former Reports on Polar Research. They are published at irregular intervals.

The Reports on Polar and Marine Research contain presentations and results of research activities in polar regions and in the seas either carried out by the AWI or with its support.

Publications comprise expedition reports of the ships, aircrafts, and stations operated by the AWI, research results (incl. dissertations) of the Institute and the Archiv für deutsche Polarforschung, as well as abstracts and proceedings of national and international conferences and workshops of the AWI.

The papers contained in the Reports do not necessarily reflect the opinion of the AWI.

Herausgeber
Dr. Horst Bornemann

Redaktionelle Bearbeitung und Layout
Birgit Reimann

Editor
Dr. Horst Bornemann

Editorial editing and layout
Birgit Reimann

Alfred-Wegener-Institut
Helmholtz-Zentrum für Polar- und Meeresforschung
Am Handeshafen 12
27570 Bremerhaven
Germany

www.awi.de
www.reports.awi.de

Alfred-Wegener-Institut
Helmholtz-Zentrum für Polar- und Meeresforschung
Am Handeshafen 12
27570 Bremerhaven
Germany

www.awi.de
www.reports.awi.de

Titel: Polarstern vor Anker vor Ascension Island (Foto: S. Hanisch/AWI).

Cover: Polarstern at anchor in front of Ascension Island (Photo: S. Hanisch/AWI).

The Expedition PS88 of the Research Vessel POLARSTERN to the Atlantic Ocean in 2014

Edited by

Rainer Knust and Frank Niessen

with contributions of the participants

Please cite or link this publication using the identifiers

hdl:10013/epic.46934 or http://hdl.handle.net/10013/epic.46934 and

doi:10.2312/BzPM_0696_2016 or http://doi.org/10.2312/BzPM_0696

ISSN 1866-3192

PS88

25 October 2014 – 28 November 2014

Bremerhaven - Las Palmas - Cape Town

Chief scientists
Rainer Knust
Frank Niessen

Coordinator
Rainer Knust

Contents

1. ZUSAMMENFASSUNG UND FAHRTVERLAUF

Rainer Knust, Frank Niessen AWI

Polarstern verließ Bremerhaven wie geplant am 25.10.2014. Auf dem ersten Abschnitt von Bremerhaven nach Las Palmas wurde ein intensives Trainingsprogramm zu hydroakustischen Messverfahren durchgeführt. Insgesamt nahmen 20 Master-Studenten und Doktoranden aus den internationalen Studiengängen der Universität Bremen und des Helmholtz - Graduiertenkollegs POLMAR teil, die von 5 Ausbildern der Universität Bremen und des Alfred-Wegener-Instituts Helmholtz-Zentrum für Polar- und Meeresforschung angeleitet wurden. Schwerpunkt der Ausbildung war der Einsatz der hydroakustischen Systeme Multibeam echosounder Atlas Hydrosweep DS3 und Sediment echosounder Atlas Parasound P70. Der Kurs ist Teil des Programms "Master of Sciences Marine Geosciences” an der Universität Bremen und des "postgraduate training" POLMAR. Neben dem studentischen Ausbildungsprogramm wurden eine Messkampagne zur Ermittlung von Wolken-, Aerosol- und Wasserparametern, sowie ein Programm zur Messung von kosmischen Strahlen begonnen, die beide bis Kapstadt vorgeführt wurden. Der erste Abschnitt der 88. Expedition endete am 02.11.2014 in Las Palmas auf Gran Canaria (Abb. 1.1).

Nach dem Austausch des wissenschaftlichen Personals verließ *Polarstern* Las Palmas noch am selben Tag zur Expedition PS88.2. An Bord befanden sich 16 Wissenschaftlerinnen und Wissenschaftler sowie Techniker der Ozeanographie, Meteorologie und Astrophysik sowie ein Meteorologe und Wettertechniker in der Bordwetterwarte. Während PS88.2 wurden Arbeiten an insgesamt 50 Stationen durchgeführt (s. http://doi.pangaea.de/10.1594/PANGAEA.840636). Der Fahrtverlauf führte zunächst zu den Kapverdischen Inseln, weiter in den zentralen äquatorialen Atlantik, dann über die Inseln Ascension und St. Helena zum Walfischrücken und von dort nach Kapstadt (Abb. 1.2). Die Ozeanographie als größte Gruppe an Bord umfasste 10 Mitarbeiter. Daneben waren einige Wissenschaftler und Logistiker zu Zwecken von Gerätetests und -kalibrationen für die Folgeexpeditionen an Bord. Die Hauptfragestellungen bzw. Aufgaben der drei wissenschaftlichen Disziplinen waren:

- wie verhalten sich (i) die Verbindung zwischen den Veränderungen in der Hydrographie (Sauerstoff, Temperatur, Salzgehalt) und Strömungsgeschwindigkeit mit besonderem Fokus auf die Sauerstoff-Minimum-Zone des östlichen, tropischen Nordatlantiks, (ii) die Veränderung der polwärts gerichteten küstennahen Wassermassenverlagerung innerhalb des Angola-Doms und, (iii) die Strukturen im Auftriebsgebiet vor Mauretanien auf mittleren Skalen?
- atmosphärische Parameter (Aerosole, optische Parameter, Wasserdampf und Wolken) in den marinen Tropen zu vermessen,
- Instrumente zu kalibrieren und den Einfluss von galaktischer kosmischer Strahlung, insbesondere Myonen und Neutronen an der Erdoberfläche in nicht-polaren Gebieten zu beobachten.

Das Messprogramm der Atmosphären- und Kosmogenen Teilchenphysik sowie en-route Messungen der Ozeanographie (ADCP, Thermosalinograph, Bestimmung chemischer Parameter, EK-60) waren entlang des gesamten Fahrtabschnitts aktiv. Das Hauptarbeitsgebiet der Ozeanographie und somit auch der Expedition stellte ein Schnitt entlang von 23°W von 14° N bis 2° S dar. Auf dem Weg dorthin wurde bereits mit Gerätetests begonnen. Insbesondere für die neu-installierte Synchronisationseinheit von der Fa. Kongsberg (K-Sync) für die *Polarstern*-Lote EK-60, Parasound und Hydrosweep waren die Lotbedingungen und Untergrundverhältnisse im Kanarenbecken bis zum Anstieg des Kapverden-Plateaus gut geeignet, um die Datenqualität und Funktion einer kombinierten Signalauslösung zu testen. Erste Ergebnisse zeigen, dass die kombinierte Triggerung einwandfrei funktioniert und sich - trotz der sich zwangsweise ergebenden Einschränkungen in der lateralen Auflösung der einzelnen Lote - durchaus brauchbare Ergebnisse erzielen lassen. Vor den Kapverdischen Inseln wurde auch zu Zwecken von Sensorkalibration eine CTD gefahren und ein "Glider" ausgebracht. Letzterer musste aber nach einem ersten Tauchversuch wieder geborgen werden, da die Heckflosse abgebrochen war. Fünfzig Seemeilen nördlich der Kapverden wurden an der Mooring KPO 1128, die zum Cape Verde Ocean Observatory gehört, durch die Ozeanographen vom Geomar ein defekter Datenlogger und -sender ausgewechselt.

Entlang von 23°W wurden dann insgesamt 38 CTD-Rosetten gefahren, davon 19 bis 1.300 m und alle weiteren bis zum Grund. Die Messungen wurden durch CTD-gestützte und schiffseigene ADCP-Messungen ergänzt. Das EK-60 war mit voller Auflösung im Einsatz. Daneben wurden 7 Tiefendrifter ("Floats") für das internationale ARGOS-Programm ausgesetzt, 3 davon entlang 23° W. Erste Ergebnisse des CTD-Schnitts zeigen deutliche Muster in den zonalen und meridionalen Strömungen sowohl in den obersten 1.000 m als auch bis zum Boden sowie einen sehr geringen Sauerstoffgehalt in der "Oxygen Minimum Zone" gegenüber den Vorjahren.

Am 10.11.14 wurde das CTD-Programm für 8 Stunden unterbrochen, um das Posidonia-System mit der neuen Antenne zu kalibrieren. Hierzu wurde ein Unterseeberg etwas westlich von 23° W ausgenutzt, an dessen Flanke die optimale Wassertiefe von 2.300 m für den Test vorlag. Der Transponder, der mittels eigens dafür ausgebrachter Verankerung nahe dem Boden fixiert wurde, konnte nach der Kalibrierung wieder geborgen werden. Der Unterseeberg wurde entlang des Fahrkurses im Rahmen der Testmessungen der K-Sync-Unit mit Hilfe des Hydrosweep-Fächerecholots bathymetrisch vermessen. Das Ergebnis ist, dass trotz der Einschränkungen in der Auflösung die flachste Stelle erfasst wurde und mit einer Tiefe von ca. 800 m unter dem Meeresspiegel deutlich flacher ist als in den bisherigen Datensätzen (1.480 m, GEBCO) angegeben.

Aufgrund der erforderlichen Vorbereitungszeit sowie relativ starken Winden (oft 4Bft, teilweise bis 6 Bft in den Passatwindzonen sowie im Bereich der ITKZ) konnte das geplante Training zur Kalibrierung des EK-60 entgegen der Planung nicht entlang vom 23°-Schnitts durchgeführt werden. Da die beiden Vulkaninseln Ascension und St. Helena annähernd genau auf der kürzesten Route vom 23°-Schnitt zum Walfischrücken liegen, wurde die geschützten Leeseiten beider Inseln am 17. bzw. 19.11. angelaufen, um unter ruhigen Bedingungen (vor Anker bei Ascension und driftend vor St. Helena) die EK-60-Kalibrierung zu trainieren und durchzuführen. Während das Training sehr erfolgreich verlief, waren die Kalibrationsbedingungen aufgrund von ungünstiger Wassertiefe und -temperatur sowie Fischreichtums nur bedingt brauchbar. Wissenschaftler und Besatzungsmitglieder konnten der Insel Ascension am 17.11. einen kurzen Besuch abstatten.

Auf der Weiterfahrt zum Walfischrücken wurden zwei weitere "Floats" ausgesetzt und bei 20° 59' S, 6° E eine Verankerung aus dem südlichen Angola Becken, direkt nördlich des Walfischrückens erfolgreich geborgen. Die Einzelverankerung AWI 247-3 war am 22.11.2012 ausgebracht worden und war mit einem passiven akustischen Rekorder (SonoVault) sowie mit einer CTD bestückt. Der Rekorder befand sich in einer Tiefe von etwa 900 m im Kern des SOFAR Kanals, wo Erkennungen in einer Größenordnung von mehr als 200 km erwartet werden. Der sogenannte SOFAR Kanal ist ein schall-leitender Bereich, der sich in etwa 1000 m Tiefe im subtropischen Ozean befindet. Die Verankerung war ausgebracht worden, um vermutete Aufzuchtgebiete von Bartenwalen mit einem passiven akustischen System zu überwachen und zu untersuchen.

Südlich vom Walfisch-Rücken wurden zwei weitere Floats ausgebracht und die K-Sync-Unit von Kongsberg noch einmal ausgiebig mit allen Loten getestet, da die Untergrundbedingungen im Übergangsbereich vom afrikanischen Schelf zur Namibia-Tiefsee-Ebene besonders gut für zur Überprüfung der Datenqualität des Parasound-Sedimentechographen bei externer Triggerung geeignet ist. Auch hier zeigte sich, dass bei der bisher nicht möglichen kombinierten Impulsauslösung aller Lote der *Polarstern* wissenschaftlich brauchbare Ergebnisse erzielt werden können.

Sämtliche Forschungsarbeiten konnten gemäß Planungszielsetzung ausgeführt werden. Aufgrund der ungewöhnlich ruhigen Wetterbedingen (Wind und Seegang) vor Angola und Namibia, der Wettervorhersage für Kapstadt (Chance auf Starkwinde) der guten Kraftstoffbilanz der Reise sowie einer neuerdings umfangreicheren Einklarierungsprozedur lief *Polarstern* bereits am 28.11.2014 um 16:30 Uhr in Kapstadt ein, um eine optimale logistische Abwicklung zwischen den Abschnitten PS88.2 und PS89 zu gewährleisten.

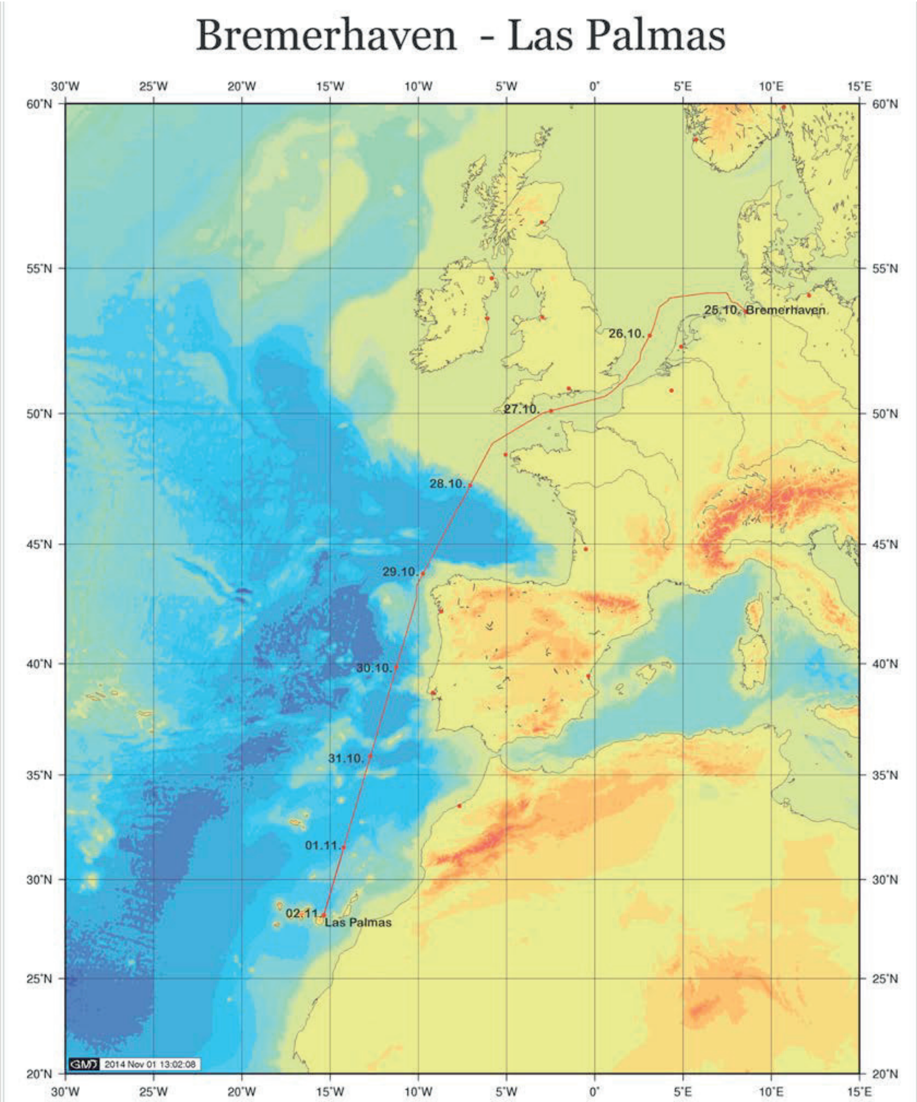

Abb. 1.1: Kursplot der Polarstern-Expedition PS88.1 (25.10.2014 – 02.11.2014)

Fig. 1.1: Course plot of Polarstern expedition PS88.1 (25.10.2014 – 02.11.2014)

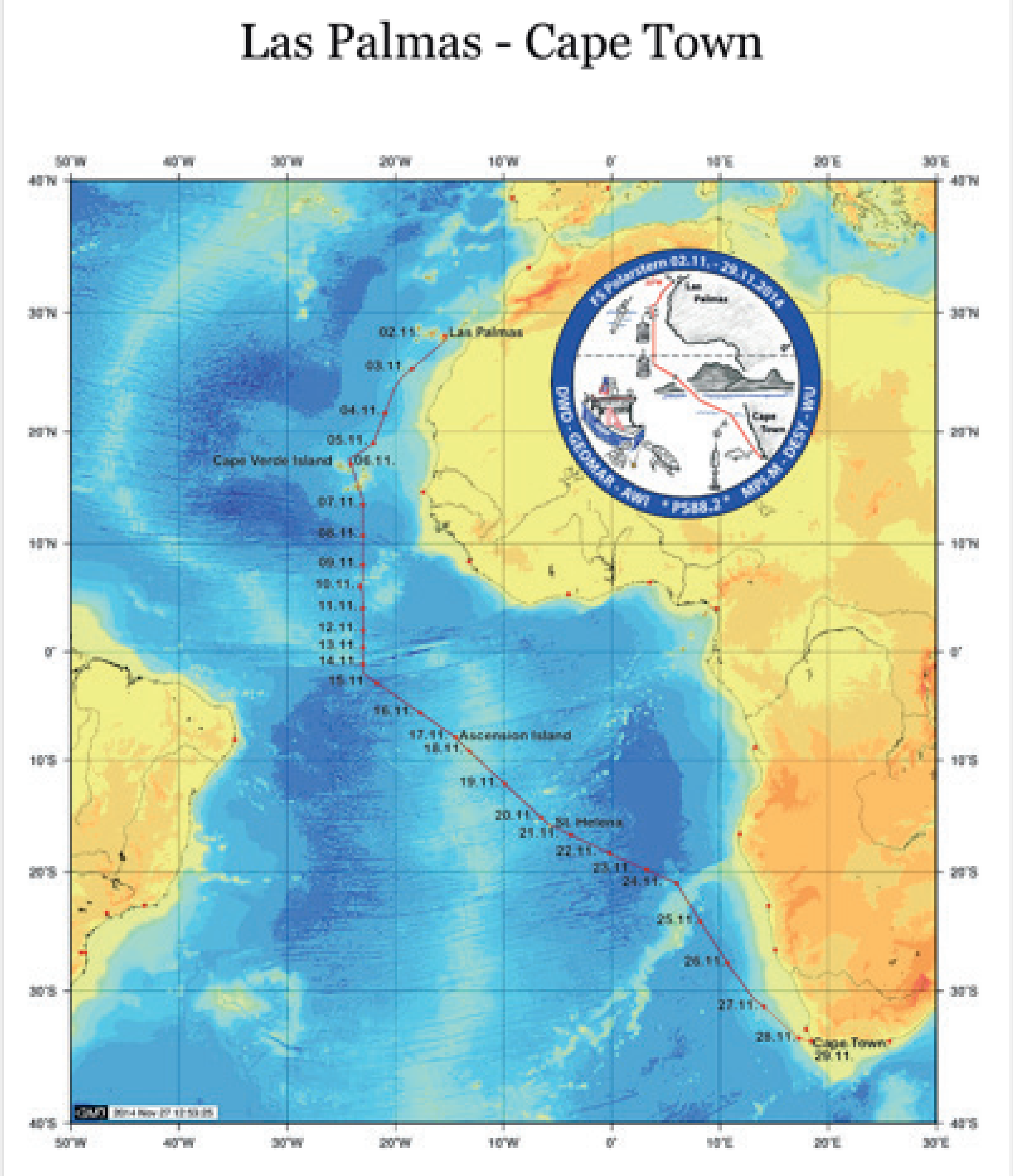

Abb. 1.2: Kursplot der Polarstern-Expedition PS88.2 (02.11.2014 – 29.11.2014)

Fig. 1.2: Course plot of Polarstern expedition PS88.2 (02.11.2014 – 29.11.2014)

ITINERARY AND SUMMARY

Polarstern left Bremerhaven on October 25, 2014 as scheduled. During the first leg from Bremerhaven to Las Palmas an intense training in hydro acoustic measuring methods was carried out. In total 20 master and doctoral students participated – all students from the international courses at the University of Bremen and from the Helmholtz post graduate programme POLMAR. They were guided and instructed by 5 scientists from the Alfred Wegener Institute Helmholtz Centre for Polar an Marine research and the University of Bremen. Main focus of the course was the operation of the hydro acoustic systems Multibeam echo sounder Atlas Hydrosweep DS3 and Sediment echo sounder Atlas Parasound P70. The course is part of the “Master of Science Marine Geosciences” at the University of Bremen and of the “post graduate training” POLMAR. Besides the education programme a measuring campaign for the detection of cloud, aerosol and water parameter was conducted as well as a measuring progamme for cosmic radiation. Both programmes were continued until Cape Town. The first leg of PS 88 ended on November 2, 2014 in Las Palmas on Gran Canaria (Fig. 1.1).

After a change of the scientific crew *Polarstern* left Las Palmas on the same day for the expedition PS88.2

Sixteen scientists and technicians of different disciplines namely oceanography, meteorology and physical astronomy, as well as one meteorologist and one technician of the ship's weather station were on board. During PS88.2 work was carried out on 50 stations. A station list may be found in the Appendix to this report (see also: http://doi.pangaea.de/10.1594/PANGAEA.840636). At first the ships track led to the Cape Verde Archipelago, further on to the central equatorial Atlantic area and then via the islands Ascension und St. Helena to the Walvis Ridge and from there to Cape Town (Fig. 1.2). The largest group on board of oceanographers had 10 members. In addition, 3 scientists and one engineer participated for testing and calibrating equipment to be used on forthcoming expeditions. Together with the weather station 6 institutions from 2 countries were involved. The major goals of the three scientific disciplines were:

- to investigate (i) the connection between hydrographic (oxygen, temperature and salinity) and velocity (current) variability in the eastern tropical North Atlantic Oxygen Minimum Zone region along 23°W, (ii) the variability of the poleward-directed, near-coastal flow of water inshore of the Angola Dome, and, (iii) the mesoscale structures in the upwelling region off Mauritania,
- to survey atmospheric properties in maritime tropical environments (aerosol optical properties, water vapor and clouds),
- to calibrate instruments and monitor the impacts of galactic cosmic ray induced muons and neutrons on the Earth’s surface outside of polar regions.

The survey of atmospheric and cosmogonic properties as well as the on-route data acquisition of the oceanography (ADCP, thermosalinograph, determination of chemical properties, EK-60 echsounding) was active along the entire ship track. The main working area of the oceanography (and thus of the expedition) was a CTD section along 23° W from 14° N to 2° S. On the way to this area equipment tests were performed. In particular, the newly installed synchronization unit

(Kongsberg K-Sync) was tested for combined trigger modes of the *Polarstern* hydroacoustic units EK-60, Parasound and Hydrosweep. In Canary Basin up to the rise of the Cape Verde Plateau the underground conditions were suitable to check proper data acquisition and quality. First results show that the combined triggering works without malfunctions and can produce data of reasonable quality despite the given fact that the lateral resolutions of the individual sounding systems are reduced. Close to the Cape Verde Islands a first CTD cast was performed to calibrate some instruments and a glider is deployed. For the glider a problem was discovered after a first test dive. A fin broke off and the instrument had to be recovered and was brought back to the ship. 50 nm north of the Cape Verde archipelago mooring KPO 1128, part of the Cape Verde Ocean Observatory, was reached where the Geomar oceanographers changed a faulty data logger and transmitter.

Along 23°W in total 38 CTD rosettes were run, 19 of which to a depth of 1,300 m and all others down to close to the sea floor. CTD data were completed by hull mounted and/or CTD-mounted ADCP data acquisition as well as EK-60 soundings of full possible resolution. In addition, 7 floats were deployed within the framework of the international ARGOS-Program, 3 of which along 23° W. First results about the situation along 23° W exhibited distinct pattern in zonal and meridional currents in the top 1,000 m of and/or in the entire water column. Also, a distinct oxygen minimum was measured compared to data from previous years.

On November 10, the CTD programme was interrupted for about 8 hours in order to calibrate the Posidonia system with new antennas. We used a flank of a seamount slightly west of 23°W to find the optimum water depth of 2,300 m needed for the calibration. A deployed mooring holding the transponder close to the sea floor during the calibration procedure was recovered at the end. In addition, the bathymetry of the seamount was mapped along the track using the swath echosounder Hydrosweep as part of the testing program of the new K-Sync-Unit. As a result, the shallowest depth at the top of the mount was recorded at about 800 m below sea level, which is significantly less than indicated in previous data sets (1,480 m, GEBCO).

Differently from the previously planning the training and calibration of the EK-60 echosounder was not possible along 23°W. This was the result of time needed for preparation and relatively strong winds (often 4 Bft up to 6 Bft on some days) within the ITCZ and further south. This work was then postponed until the ship reached the protected lee sides of the volcanic islands of Ascension (anchorage) and St. Helena (drifting), both of which are more or less exactly situated along the shortest route from the end of the 23°W section to Walvis Ridge. While the training was successful the calibration results were only partly useful due to shallow water conditions and high abundance of fish. On November 17 crew and scientists made use of an opportunity for a short visit of Ascension Island.

On the way between the islands and Walvis Ridge two more floats were deployed. As one major mission of the cruise, at 20° 59' S, 6° E, a mooring was recovered from the southern end of the Angola Basin, directly north of the Walvis Ridge.

The single oceanographic Mooring, AWI 247-3, which was deployed on 22.11.2012, hosted a passive acoustic recorder (SonoVault) and a recording CTD shall be recovered by the GEOMAR Team (see chapter 3). The recorder was deployed at a depth of about 900 m, the core of the SOFAR channel, where detections ranges are expected to exceed the order of 200 km. The so-called SOFAR channel is a sound-duct which is located at about 1,000 m depth in the subtropical ocean. The mooring had been deployed in order to monitor and explore suspected breeding areas of blue, fin and sei whales.

South of the Walvis Ridge two more floats were deployed. Also the K-Sync-Unit was tested again with all connected *Polarstern* echosounders. The area in the transition from the West African Shelf to the Namibia Abyssal Plain is known for variable sedimentary environments and thus particularly suitable for testing the data quality of the sediment echosounder Parasound under external trigger mode. Again, it can be demonstrated that the new device allows simultaneous recording in combined trigger mode, which, in case of Parasound and EK-60, exhibits resolution suitable for scientific use.

All work at sea was carried out as planned. Due to unusual calm weather conditions (wind and sea) off the coasts of Angola and Namibia, the forecasted chance of strong winds in Cape Town a few days ahead, the efficient fuel consumption, and because of a newly more time-consuming immigration procedure after port call in South Africa, *Polarstern* reached Cape Town already on November 28 at about 4:30 pm. This allowed an optimized logistic port procedure between the legs PS88.2 and PS89.

2. WEATHER CONDITIONS DURING PS88

Max Miller, Juliane Hempelt DWD

On Saturday, 25 October 2014, at 13:20 pm *RV Polarstern* left Bremerhaven for the campaign PS88 (ANT-XXX/1). South-westerly winds at Bft 4, cloudy skies and 13° C were registered while a weak ridge crossed the German Bight.

At the same time a storm arrived southwest of Iceland and moved on northeast which we came across at its southeast side while sailing the North Sea. During the night to Sunday (26 Oct.) south-westerly winds increased constantly to Bft 7 and caused a wind sea around 2.5 m. On Sunday these conditions continued, only in the evening winds abated a little. After crossing the Strait of Dover during the night to Monday we moved away from the storm. Winds veered south and abated continuously to Bft 4 until Tuesday (28 Oct.) at a swell around 2 m.

A new low moved from Newfoundland to an area south of Iceland and became stationary. It built a trough towards the Azores. This trough moved east only slowly. Therefore we observed southerly winds at Bft 4 to 5 until Thursday evening (30 Oct.). On Friday the trough crossed our area and light to moderate winds veered northwest to north. At the same time a high moved from west towards the Azores. We sailed at its east side until our arrival at Las Palmas. Tail winds from north to northeast increased to Bft 6 to 7.

On Saturday (8 Nov.) we reached the inner tropical convergence zone (ITCZ) at 11°N and moderate winds veered east. Several times we observed heavy showers and thunderstorms with typical gusts and temporary temperature drop (Fig. 2.1).

During the night to Thursday (13 Nov.) we entered the southeast trade wind zone close to the Equator at a prevailing wind force 5 to 6. Some showers still occurred, but not as strong as in the ITCZ.

On Monday (17 Nov.) morning we arrived at Ascension Island and stayed within the lee of the island until evening. Swell and winds were dampened clearly.

During the continuation of the journey towards St. Helena south-easterly winds hardly reached Bft 6 and abated Bft 4 while approaching the island on Thursday (20 Nov.).

Over central South Atlantic the subtropical high did hardly move. During the last part of our way to Cape Town we sailed at its east side. From Tuesday (25 Nov.) on winds veered south at Bft 4 to 5 and swell didn't exceed 2 m.

On Friday afternoon, 28 November 2014, *RV Polarstern* reached Cape Town at moderate south-easterly winds.

For further statistics see attached files (Fig. 2.1 – Fig. 2.4).

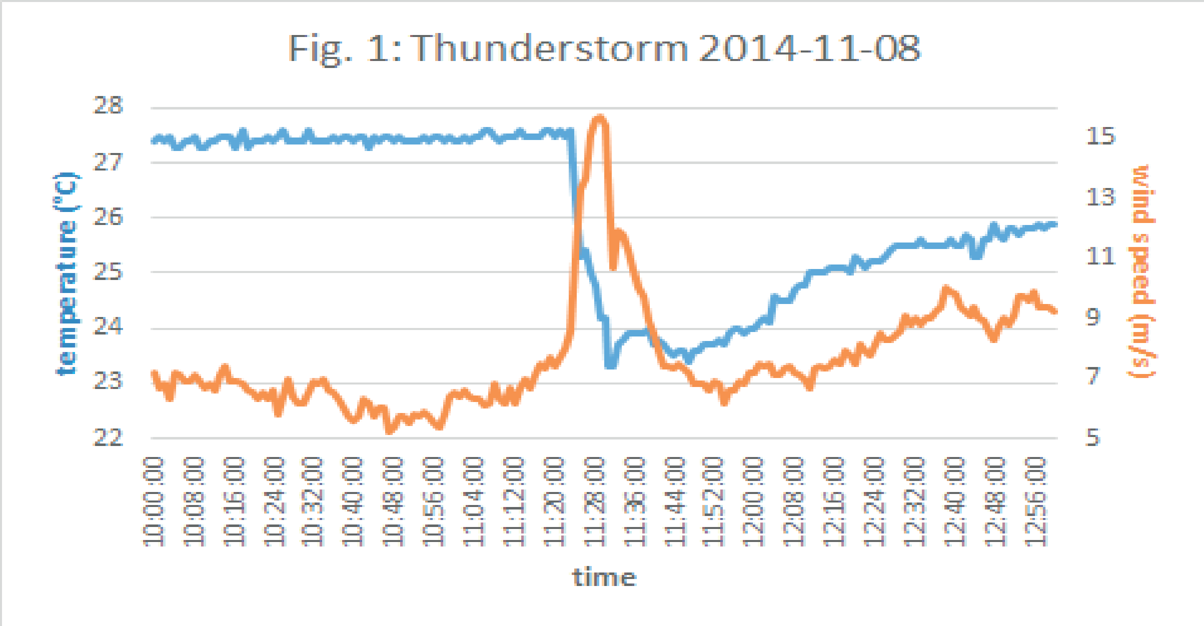

Fig 2.1: Thunderstorm 2014-11-08

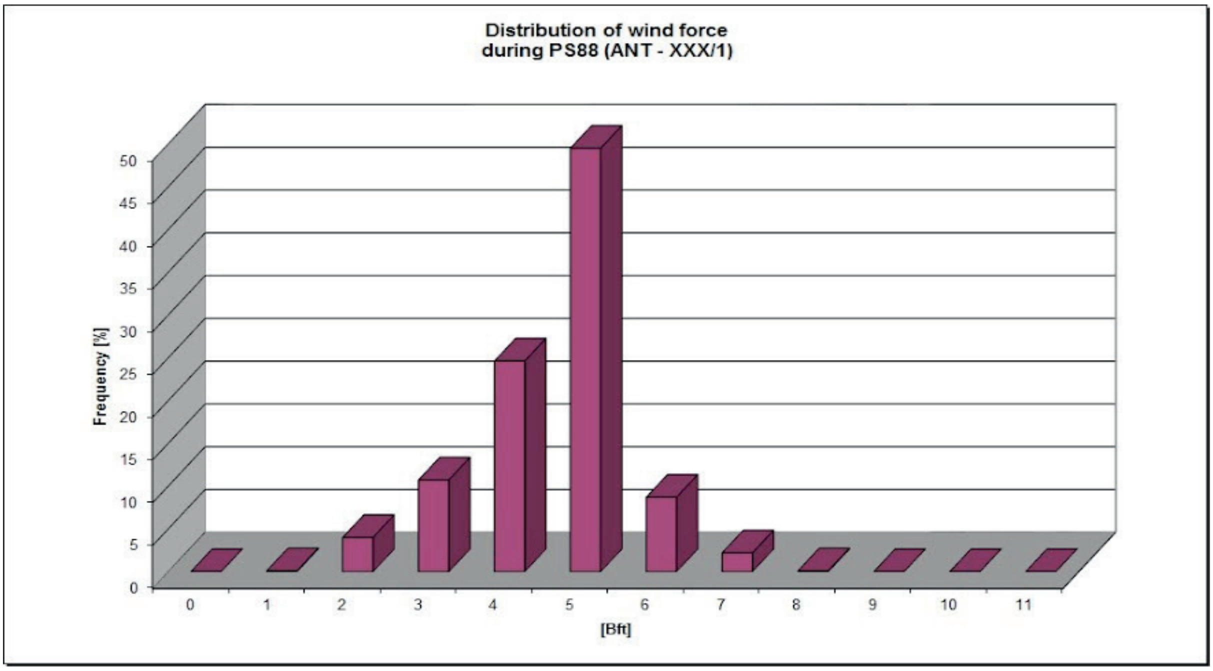

Fig. 2.2: Distribution of wind force during PS88

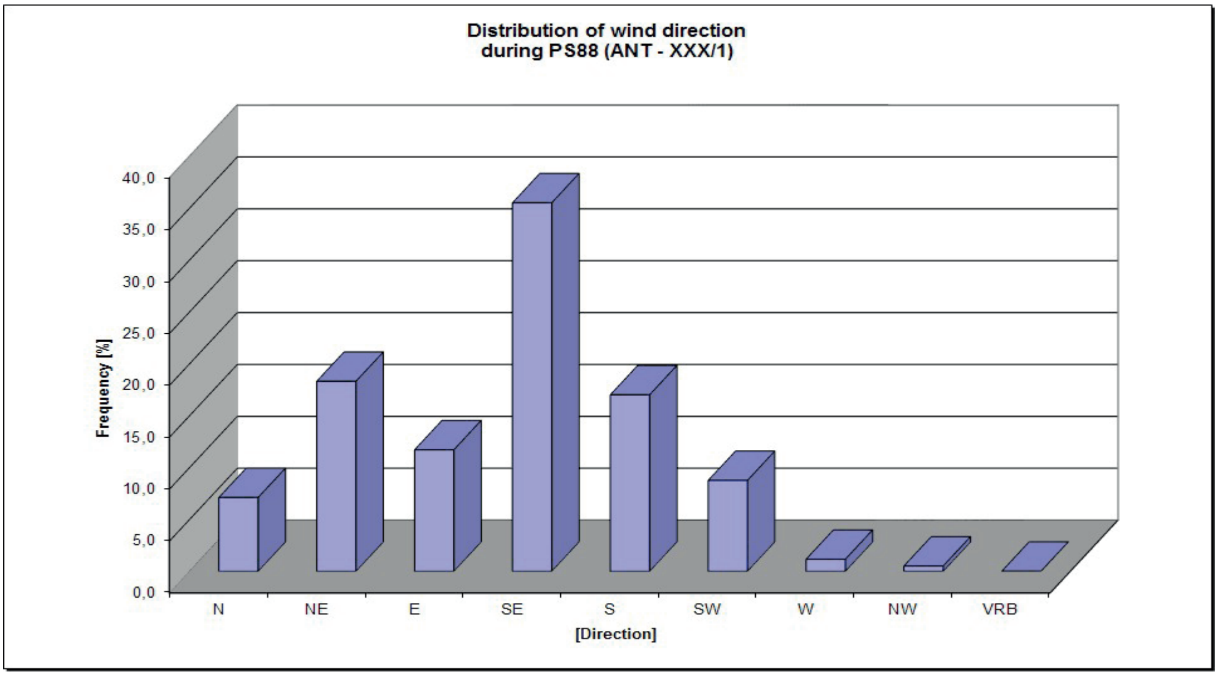

Fig. 2.3: Distribution of wind direction during PS88

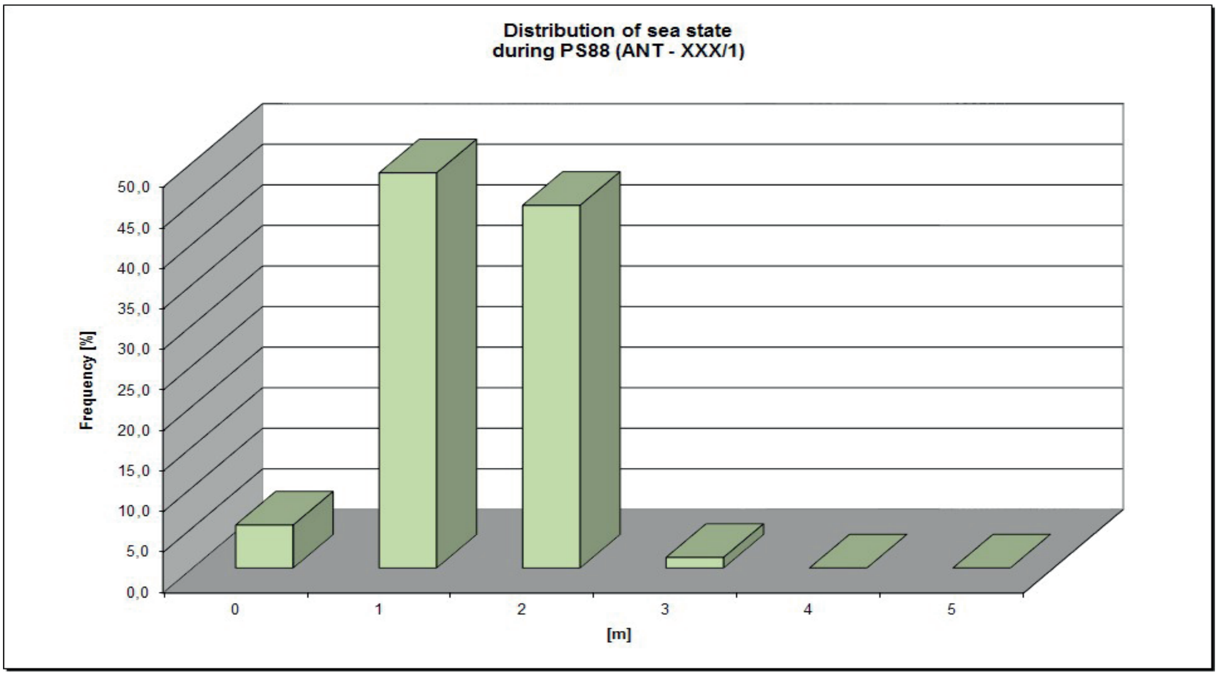

Fig. 2.4: Distribution of sea state during PS88

3. ECHOSOUNDING TRAINING CRUISE POLMAR-TRAIN

Claudia Hanfland, Boris Dorschel, Catalina Gebhardt, Johann Philipp Klages, Gerhard Kuhn — AWI

Objectives

POLMAR-TRAIN is a student training course that was jointly run by the AWI-based Helmholtz Graduate School for Polar and Marine Research (POLMAR) and the University of Bremen. The purpose was to provide master and PhD students from geosciences with a hands-on training in operating the hull-mounted echosounding systems of RV *Polarstern* (multibeam echosounder Atlas Hydrosweep DS3 and sediment echosounder Atlas Parasound P70). Parallel to the practical training, the aim was to promote peer-learning by combining master and PhD students in this course.

The course is part of the programme "Master of Sciences Marine Geosciences" at the University of Bremen as well as of the postgraduate training POLMAR is offering. Both programmes involve ship-based field-work for students and doctoral candidates. The training was carried out by five lecturers affiliated with both the University of Bremen and the Alfred Wegener Institute.

Work at sea

10 master students from the University of Bremen and 10 doctoral candidates from AWI and of ETH Zürich participated in the training. Watches were organised in a way that one master and one PhD student (Postdoc) were jointly responsible for one system. This approach aimed at learning amongst peers and proved to be successful. Master students benefited from the research experience of the postgraduates, could discuss possible topics for their master thesis and clarify their motivation for the next career step including the option of taking up doctoral studies.

The course started with a theoretical introduction into the physics of echosounding, followed by a general introduction into the operating systems. Afterwards, students started going on watches (4 hours on night shifts, 2 hours during day shifts). Both systems were operated continuously between Bremerhaven and Las Palmas. Participants were trained in data evaluation and interpretation with published and on-route collected examples. One main target was to study the spatial and temporal morphological variability of the huge sea-floor sand dunes in the English Channel.

In groups of four, participants discussed published case studies in order to apply and deepen their knowledge (Yermak Plateau, Arctic, and Amundsen Sea, Southern Ocean) and learned to combine sediment core and multibeam-bathymetric data with Parasound profiles.

During the cruise, the participants also learned to plan a bathymetric survey from acquisition to final map products. The workflow included the data acquisition with the Atlas Hydrosweep software packages Atlas Hydromap Control (AHC) and Atlas Parastore. Furthermore, the students learned how to process the data with the software packages CARIS HIPS and SIPS®

and to visualise the data with the software package QPS Fledermaus®. Post-processed data were imported in a geographical information system (GIS) for (planning) map generation. Several students used the opportunity to apply newly learned techniques to their own data and projects.

All participants gave a 15 min presentation on their Bachelor, Master or PhD project, which provided more examples on the application of echosounding and fostered further discussions.

Preliminary results

One research target was to study the spatial and temporal morphological variability of the huge sea-floor sand dunes in the English Channel. Therefore, data were collected during this cruise for comparison to former and upcoming cruises. Up to now it is unknown if the dunes change their morphology on a tidal or seasonal base. Daily, monthly or annual migration-rates shall be calculated once we will have collected enough observations on identical course lines.

The concept of combining undergraduates and postgraduates in this training proved to be a successful approach. Next to guidance and discussion with the team of lecturers, peer-learning was an important factor for the success of this training concept.

The combination of theoretical background, practical work on the hydroacoustic systems, discussion of published data and student presentations was the right combination for a thorough and comprehensive training in echosounding techniques.

Course preparation prior to the cruise was done by the graduate school POLMAR. Participants, lecturers and ship logistics department had one contact point to turn to which greatly improved maintaining the planning phase, coordination on board and the subsequent evaluation phase.

Data management

Hydroacoustic data (multibeam and sediment echosounder) collected during the expedition will be stored in the PANGAEA data repository at the AWI. Furthermore, the data will be provided to mapping projects and included in regional data compilations such as the General Bathymetric Chart of the Ocean (GEBCO).

4. MEASUREMENT OF GALACTIC COSMIC RAY INDUCED MUONS AND NEUTRONS

Achim Stoessl DESY

Objectives

Galactic cosmic rays are high-energy charged particles, mainly protons, doubly ionized helium, and other fully ionized nuclei originating in the galaxy and bombarding the Earth from all directions. They are a direct sample of material from far beyond the solar system. Measurements by various particle detectors have shown that the intensity varies on different time scales, caused by the Sun's activity and geomagnetic variation. The role of Interplanetary Coronal Mass Ejections (ICMEs) in causing Forbush decreases, and Corotating Interaction Regions causing recurrent decreases in the GCR intensity observed at Earth, has been well established since the last twenty years. However, these interplanetary disturbances cause space weather effects, which warrant a more detailed study. Most of the research on GCR intensity variations is based on the analysis of ground-based neutron monitors and muon telescopes. Their measurements depend on the geomagnetic position, and the processes in the Earth's atmosphere. Beside the modulation of cosmic rays in the heliosphere there are two possible lines of defense: while the atmosphere shields life against cosmic radiation uniformly, the Earth magnetosphere acts as a rigidity filter. Before the primary particles can enter the atmosphere they are subject to the deviations in the magnetic field in the vicinity of the Earth, and as a consequence the intensity of charged particles on top of the atmosphere is reduced with respect to interplanetary space. To estimate this shielding effect of the magnetic field it is helpful to characterize particles by their magnetic rigidity rather than their energy as the impact of the Lorentz force on a charged particle is related to the former quantity. Particles reaching the top of the atmosphere will undergo interaction with the atmospheric constituents, leading to ionization and secondary particle production to form a cascade of secondary particles. Neutron monitors are able to record these secondary cosmic rays, mainly the neutrons, with energies about a decade higher than detected by most spacecraft. Muon telescopes are able to measure the rate of the surviving muon component of the secondary cosmic rays at ground level and complement the neutron monitor measurements and provide a source of calibration data for the neutron monitors.

Work at sea

Surveillance and monitoring of the two detectors and checks of data integrity. Regular hardware maintenance tasks were performed, and the data acquisition software for the muon detector was upgraded during runtime. The detectors were calibrated and optimization for remote monitoring tasks of the system were implemented. First preliminary analysis of the recorded data was performed.

Preliminary results

The recorded muon and neutron data indicate that the detectors were operating as expected, the systems were running continuously with only planned maintenance downtime of several hours during the cruise. Especially the setup of the muon detector has proven to yield reliable data during tropical weather conditions, were previous setups were experiencing problems.

A first preliminary analysis of the muon data indicates sensitivity to the magnetic cosmic ray cutoff in the equatorial region, where a drop in the rate of recorded muons was observed. The observation of this effect allows verifying the operation of the setup in the desired parameter range. However, the data needs further cleaning and processing, which will be done on shore.

The plot shows the hourly mean of the measured muon rate. Without further treatment, already a slight dip in the curve is visible at the dates where *Polarstern* travelled in the equatorial region.

The effect is likely caused by the screening of cosmic rays due to the Earth's magnetic field.

Data management

The data will be publicly available via the DESY webpage shortly after the cruise.

5. SURVEY ON CLOUDS, AEROSOL AND WATER VAPOR

Tobias Becker MPI-M

Objectives

Transit-voyages with the RV *Polarstern* from Europe into the Southern Hemisphere (and vice versa) allow the survey of atmospheric properties in maritime, tropical environments. In the current expedition PS88 (ANT-XXX-1) we set out to gather new data on (column) aerosol optical properties, water vapor and clouds along the route from Bremerhaven, Germany, to Cape Town, South Africa. These measurements offer ocean reference data, which e.g., is needed for satellite remote sensing from space.

The equipment (Fig. 5.1) consists of an infrared (IR) cloud camera, with the objective to continuously measure emission height temperatures and thus derive cloud base height and cloud cover, and a handheld MICROTOPS-II sunphotometer (in combination with a GPS unit), with the objective to measure aerosol optical depth (AOD), aerosol size and water vapor.

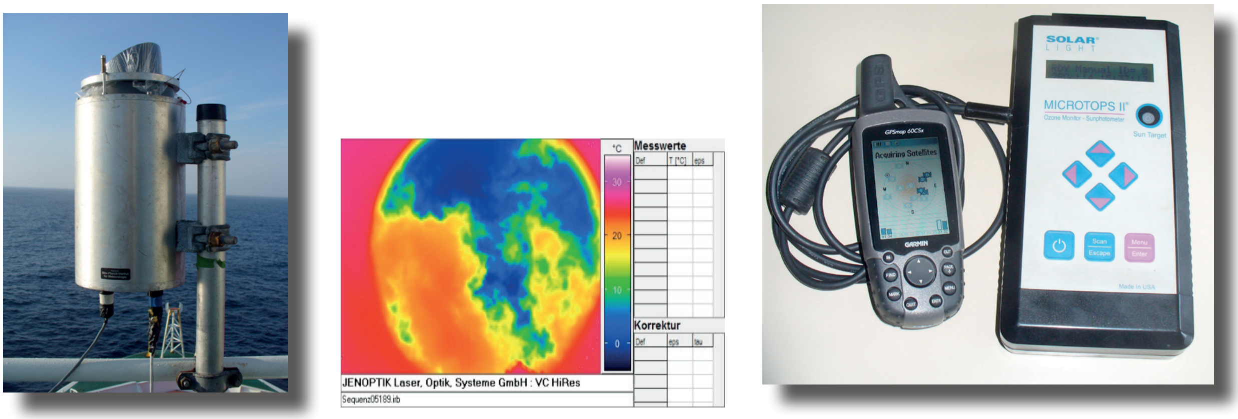

Fig. 5.1: IR (or thermal) cloud camera with a cloud (warmer temperatures) image example for the cloud survey and the MICROTOPS sunphotometer (with a GPS) for the aerosol and water vapor survey.

Work at sea

Both instruments, the IR cloud camera and the MICROTOPS-II sunphotometer, were operated as underway measurement systems, so no additional waypoints or stops of *Polarstern* were necessary to gather the data.

IR cloud camera

The infrared cloud camera is a commercial product, VarioCAM®, manufactured by Jenoptic, ESW, GmbH and the data acquisition software is provided by InfraTec, GmbH, Dresden. The cloud camera records automatically in a freeze frame mode, taking pictures every 10 seconds. It was mounted on the upper deck, attached to the middle of the front railing, to assure unobstructed views of the sky. The measurements were interrupted during those hours of the day with solar zenith angles smaller than 50° (roughly 9:00 to 16:00 local time), to avoid the sensitive optics to be exposed to direct sun light. A protective foil on top of the optics prevents water damage and signal contamination.

The sensitive area of the camera consists of a micro bolometer focal plane array with 384 x 288 pixels. This leads to a field of view of 30 x 23° or a visible area of about 1,000 m x 800 m at 1 km height. The spectral range covered is 7.5 to 14 µm. The IR camera surveys (1) the overhead cloud structure as a function of time (e.g. daily cycles), (2) the cloud structure movement (by capturing images in 10 seconds intervals) and (3) the approximate cloud altitude via the (detected cloud-base) temperature. Data were downloaded daily on a hard-drive and converted from an instrument internal format into (jpeg) images and (ascii) data-files.

MICROTOPS-II Sunphotometer

The MICROTOPS-II® is a calibrated unit of NASA-GSFC and is lent to the MPI-M as part of AERONET's MAN effort (Smirnov et al. 2009). For each sample (of many measurements), the instrument's solar spectral sensors are pointed for a few seconds directly into the sunlight at assured cloud-free conditions. From the sensed atmospheric solar sub-spectral attenuation (as the incoming radiation at the top of the atmosphere [defined by time and latitude] is reduced by solar atmospheric scattering and absorption processes), the atmospheric column load for aerosol and water vapor (from scan at 936 nm) is derived. Since the aerosol attenuation is determined at different wavelengths also information on the characteristic aerosol size is offered, indirectly also pointing to the dominant aerosol type. The MICROTOPS measurements are labor-intensive. Not only a correct pointing into the sun is required (in 15 to 30 min blocks of 10 consecutive samples), but also any contamination by clouds needs to be avoided. This is particular important and difficult in events of hardly visible cirrus clouds. Data was downloaded daily onto a laptop and sent via e-mail to Dr. Smirnov at NASA-GSFC (Alexander.Smirnov-1@nasa.gov), who provided immediate feedback on data quality and who uploads the processed data.

Preliminary results

Fig. 5.2a illustrates that the IR temperature distribution in the tropics has four peaks. The peaks at -15°C and -4°C can be attributed to clear skies with different water vapor concentrations, and the peak at 17°C can be attributed to low clouds, mostly located in 900 hPa at the inversion which separates the marine boundary layer from the free troposphere. The peak at 5°C is more difficult to interpret because the incoming infrared radiation at the surface in conditions with high cirrus clouds is similar to that in clear sky conditions with high atmospheric water vapor concentrations. Hence, finding a good threshold value to separate high clouds from clear skies is not an easy task. For the moment, a cloud threshold value of 7.5°C is used. For a further analysis, meteorological ship data as well as the Microtops-II water vapor measurements can help.

Fig. 5.2b shows that, during this expedition, cloud cover was on average lowest in the afternoon. This finding is independent of the selected cloud threshold value. The reason is that stratocumulus often evolved at the inversion above the marine boundary layer (which is very common in high pressure systems over cold SSTs). In the afternoon, solar heating of the cloud tops often initiated convection and caused a dissipation of the stratocumulus layer. In May 2014, Cedrick Ansorge found a different diurnal cycle in the tropical Atlantic at a Meteor cruise, with a minimum cloud cover just after sunset. At that expedition, cumulus clouds from shallow convection were most important for cloud cover.

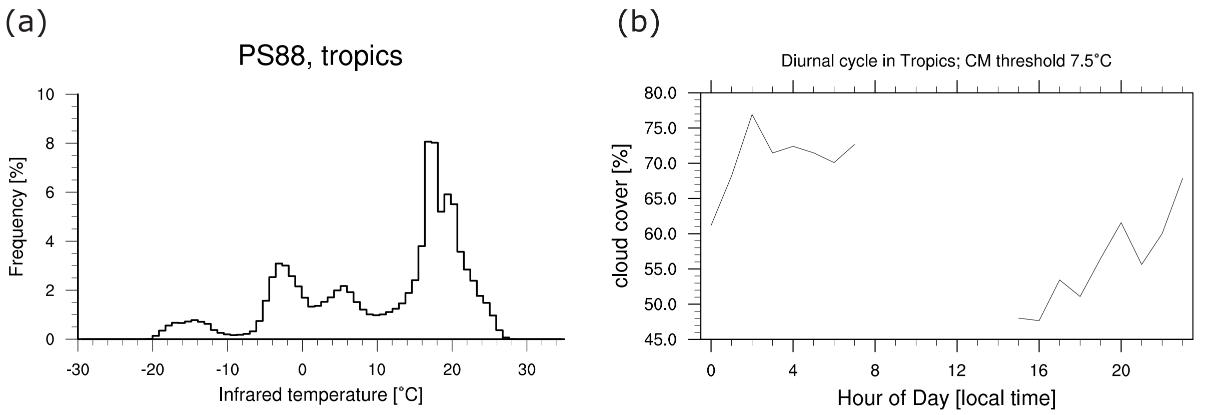

Fig. 5.2 (a): Distribution of measured infrared temperatures in the tropics and (b) diurnal cycle of cloud cover, with a cloud mask threshold value of 7.5°C.

Fig. 5.3a shows that the highest AODs (0.3 to 0.4) were observed when crossing the area west of Northafrica. A small Angstrom coefficient (Fig. 5.3b) confirms the presence of Saharan dust. During the rest of the transit, mostly the maritime background (sea salt particles) was observed, with AOD between 0.1 and 0.2, or even below 0.1 (especially in the Southern Hemisphere).

The column-integrated water vapor load was in the Northern Hemisphere mostly between 2 and 3 cm before rapidly increasing to 5 cm at the ITCZ, which was located roughly at 7°N. South of the ITCZ, the column-integrated water vapor decreased more slowly.

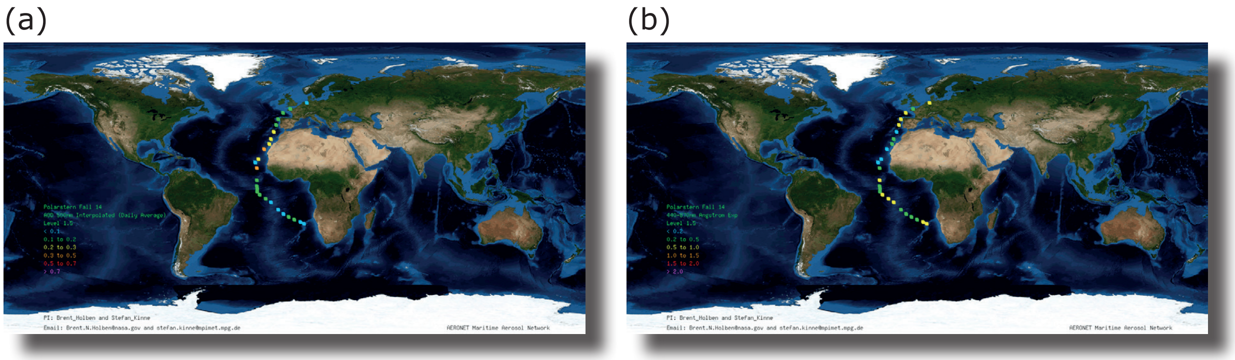

Fig. 5.3. Track of Polarstern with daily averages of (a) 500 nm aerosol optical depth and (b) 440-870 nm Angstrom coefficient.

Data management

The data for the cloud-camera are collected and archived immediately after the cruise at the Max-Planck Institute for Meteorology (Hamburg). These data can also be copied to a data-server related to the cruise. Output is offered both as images and as digital data, which can be quite voluminous (on the order of 500 GB).

The data of the MICROTOPS-II are sent to a NASA (-GSFC) archive where the (preliminary) aerosol and water-vapor measurements become visible and accessible via the web with days. After a past-voyage re-calibration of the MICROTOPS at NASA, a higher quality data version of the cruise data will be offered in addition.

References

Smirnov, A et al. (2009) Maritime Aerosol Network as a component of Aerosol Robotic Network, J. Geophys. Res. 114:D06204, doi:10.1029/2008JD011257.

6. OCEANOGRAPHY

Johannes Hahn, Anna-Lena Deppenmeier,Yao Fu, Tobias Hahn, Jaard-Okke Hauschild, Boris Kisjeloff, Thilo Klenz, Robert Kopte, Mario Müller, Franz Philip Tuchen

GEOMAR

not on board: H. Bittig, A. Körtzinger, C. Frank, T. Steinhoff

Objectives

The work carried out during this expedition is part of the collaborative research center SFB754 ("Climate-Biogeochemistry Interactions in the Tropical Ocean"), the BMBF joint projects SACUS and RACE as well as the trilateral (Germany, France, NW Africa) project AWA.

Focus in the framework of the SFB754 was the study of the oxygen minimum zone (OMZ) of the eastern tropical North Atlantic (ETNA). This OMZ is located between 5°N and 20°N off North West Africa at a depth of 300 m - 700 m, where it exhibits minimum oxygen concentrations of about 40 µmol/kg. It is of central interest to study the oxygen supply to the ETNA OMZ via different ventilation pathways: (i) eastward currents transport oxygen-rich water from the well-ventilated western boundary; (ii) vertical and (iii) lateral mixing contribute to an effective oxygen transport across the boundaries (upper and lower as well as northern and southern boundary) toward the core of the OMZ. In general, measurements, carried out since the 1960s, show a negative oxygen trend in the ETNA OMZ. In addition, repeated ship sections and moored observations, carried out along 23°W since 2008 within the framework of the SFB754, suggest that large-scale oxygen variability in the OMZ also occurs on seasonal to interannual time scales.

The general topic of the projects SACUS, RACE and AWA is the tropical Atlantic climate variability, which is strongly related to the variability of sea surface temperature (SST) in the eastern tropical Atlantic. It has been shown that this SST variability impacts rainfall variability in the tropical Atlantic region and particularly influences the strength and the onset of the West African monsoon thereby affecting droughts and epidemics in West Africa.

The primary goals of the expedition PS88.2 were to:

- investigate the connection between hydrographic (oxygen, temperature and salinity) variability and velocity variability in the ETNA OMZ region along 23°W (SFB754),
- improve the understanding of the oxygen budget of the ETNA OMZ (SFB754),
- investigate the variability of the equatorial current system (at 23°W) with respect to the western boundary current variability (at 11°S) as well as the variability of the poleward, near-coastal flow of water inshore of the Angola Dome (RACE, SACUS), and
- investigate the hydrographic distribution with respect to mesoscale structures in the upwelling region off Mauritania (AWA).

The main focus during the expedition was to carry out hydrographic (CTD) and velocity observations (ADCP) along 23°W from 14°N to 2°S. A further objective was to measure the distribution and abundance of particles, zooplankton and phytoplankton in the water column using an 'Underwater Vision Profiler 5' (UVP5), which was attached to the CTD rosette. The UVP data is used to derive a particle-based oxygen consumption rate, which provides an important contribution to the oxygen budget of the OMZ. Continuous underway measurements were carried out to observe temperature, salinity (thermosalinograph) and chemical parameters (underway-system: oxygen and total gas tension) of the sea surface as well as velocity (shipbased ADCP, 150 kHz) of the upper water column. Additional tests of oxygen sensors with long-term stability (by attaching them to the CTD rosette) were carried out to characterize their performance. A salinometer performance test was done with water samples taken from CTD casts.

In the framework of AWA, it was the goal to deploy an autonomous glider in the upwelling region of the eastern tropical North Atlantic (off Mauritania) to perform hydrographic measurements in the region between Cape Verde and Senegal in the following 3 months. In comparison to the two previous glider missions, which were carried out during the season of strong coastal upwelling (boreal spring), the currently planned glider deployment was aimed at observing the hydrography during the season with weak coastal upwelling (boreal autumn).

Between the glider deployment and the 23°W section, a CTD cast as well as mooring service (replacement of the top element) at the CVOO (Cape Verde Ocean Observatory) site north of Cape Verde were planned.

During the cruise, 6 floats from BSH (PI Birgit Klein) and one float from GEOMAR (PI Henry Bittig) were planned to be deployed.

Work at sea

CTD system, measurements and calibration

During PS88.2 40 profiles of pressure (p), temperature (T), conductivity (c) and oxygen (O) were recorded. 21 of these CTD-O_2 profiles ranged to the bottom, the remaining profiles ranged to 1,300 m. A Seabird Electronics (SBE) 911plus system was used, attached to the water sampler carousel, and the latest Seabird Seasave software. The SBE underwater unit was equipped with one Digiquartz pressure sensor (p #0287) and double sensor packages of temperature, conductivity, and oxygen (T1 #2929, c1 #3585, O1 #1834, T2 #4127, c2 #3290, O2-1 #0985, O2-2 #1306). After profile 2 the second oxygen sensor O2-1 was found to be faulty and replaced by O2-2. Consequently for profiles 1 and 2 the primary sensor set was chosen for report, as well as for profile 12, when the pump of the second sensor set got blocked during the downcast at approx. 1,180 m depth. For all remaining profiles the second sensor set was preferred for being slightly less noisy.

Conductivity was calibrated for the downcast using a linear relation in p, T and c. This relation was obtained by fitting the according CTD salinity to 198 (188) water samples for c1 (c2), which were analyzed using the standard measurement procedure with a Guildline Autosal salinometer. Rms conductivity misfit was 0.000089 S/m (0.000089 S/m) for sensor c1 (c2) after removal of 33 % of bottle values, resulting in Rms salinity misfits of 0.0010179 PSU (0.0010184 PSU) for s1 (s2), respectively.

The oxygen calibration for the downcast was similarly done using a linear relation in p, T and O. Removing the worst 33 % of a total of 296 (279) bottle samples derived from Winkler titration led to a relation with an Rms misfit of 0.86245 µmol/kg (0.57775 µmol/kg) for sensors O-1 (O2-2). Both a fluorescence and a turbidity sensor from Wetlabs were attached to the carousel and recorded, but not calibrated.

An altimeter, which did not interfere with the LADCP system, was supposed to detect the CTD's distance to the bottom, but failed for all the profiles. Attempts to repair the connection cable between the altimeter and the CTD did not solve the problem. Whether the altimeter itself nor the power cable was the reason for the malfunctioning needs to be investigated in the lab.

Winkler oxygen measurements

Observing and understanding the concentration of dissolved oxygen in the ocean is one of the key objectives of the SFB754. While the CTD system is capable to measure dissolved oxygen in the ocean at high vertical resolution, the sensors need to be carefully calibrated. Thus, high quality reference observations are essential.

Oxygen measurements

A total amount of 426 discrete water samples were taken from selected depths of 40 CTD casts for oxygen measurements by Winkler titration. Samples were taken with 100 ml WOCE bottles with well-defined volumes (calibrated flasks) in order to calibrate the SBE43 oxygen sensors attached to the CTD. It was ensured that the sample bottles were flushed with at least 3 times its volume and the samples were free of air-bubbles. At each CTD cast, at least one duplicate from one of the Niskin bottles was taken in order to quantify sampling and titration uncertainties. Additional 58 water samples were analyzed from the underway system to calibrate and verify the underway oxygen sensors.

Oxygen was determined by Winkler titration within a maximum of 13 hours after sampling following standard protocols (Langdon, 2010). The concentration values were reported in $\mu mol \cdot L^{-1}$. The precision of the Winkler-titrated oxygen measurements (1σ) was 0.23 $\mu mol \cdot L^{-1}$ based on 90 duplicates, and 0.24 $\mu mol \cdot L^{-1}$ for the underway samples based on 29 duplicates, respectively.

Measurement setup

The following reagents were used during this cruise:

- sulfuric acid (50%)
- zinc iodide starch solution (500 mL, Merck KGaA)
- stock solution: sodium thiosulfate pentahydrate (49,5 $g \cdot L^{-1}$); stock solution was diluted by a factor of 10 to create the working solution (0.02 $mol \cdot L^{-1}$)
- fixation solution: manganese(II)chloride (600 $g \cdot L^{-1}$), sodium iodide (600 $g \cdot L^{-1}$) and sodium hydroxide (320 $g \cdot L^{-1}$)
- standard solution: potassium hydrogen diiodate (0,325 $g \cdot L^{-1}$, homemade)

Titrations were performed within the WOCE bottles using a 20 mL Piston Burette (Nr. 00693123) TITRONIC universal from SI Analytics GmbH. Dosing accuracy reported by the company is 0.15 %, referred to the nominal volume, indicated as a measurement uncertainty with a confidence level of 95 %. The iodate standard was added with a 50 mL Piston Burette (Nr. 00693160) TITRONIC universal SI Analytics GmbH. 1 mL of the fixation solutions (NaI/NaOH and $MnCl_2$) were dispensed with a high precision bottle-top dispenser (0.4-2.0 mL, Ceramus classic, Hirschmann).

Titration procedure

The titration procedure for each measurement was the following:

- Switch on Piston Burettes and clear the system (dosing tubes) from air bubbles
- Determine factor of the thiosulfate working solution by titrating the homemade standard between 3 to 4 times on a daily basis
- Measure the actual Winkler samples
- Analyze the reagent blank at the beginning and the end of the research cruise

Note: 22 invalid oxygen samples due to possible sampling, storing (air bubbles) or measuring failures were recorded. Results derived from those measurements were not considered in the data evaluation. Furthermore, 16 oxygen samples from optode measurements within the Niskin bottles were taken. With respect to the amount of duplicates, 296 independent valid oxygen data points were used for the calibration of the CTD system.

Current observations: vessel mounted ADCP

Continuous shipboard velocity measurements of the upper ocean were carried out with a 150kHz Acoustic Doppler Current Profiler mounted in the ship's hull (vmADCP). It was mounted at an angle of 45° about 10 m towards the bow of the ship. It was programmed to ping as fast as possible, resulting in individual pings separated by about 2.3 sec, recording 100 bins at a vertical resolution of 4 m per bin. Post-processing of the data revealed a faulty first bin that should be excluded from the final product.

The vmADCP measured almost continuously throughout the cruise. On 5-Nov-2014, 07:00 UTC – 12:00 UTC, there was strong interference with some other unidentified ship's acoustics that degraded the ADCP data almost completely. Henceforth, this period was excluded from data processing to not affect the heading misalignment correction. The processing system was inactive due to a software failure from 09-Nov-2014, 00:00 UTC – 09-Nov-2014, 12:00 UTC. It was possible to recover most of the data by manually merging the raw velocities with the navigational data, except for the first hour of the system failure. On 12-Nov-2014, 14:20 UTC – 12-Nov-2014, 21:30 UTC, the vmADCP had a system outage and no data was recorded at all, i.e. no data exists for the latitude range between 2°N and 1°20'N along 23°W. During the calibration of the Posidonia system on 10-Nov-2014, the ADCP was switched off from 07:40 UTC – 14:40 UTC in order to not interfere with the sensitive calibrations. Same was done for the EK60 calibrations from 17-Nov-2014, 20:30 UTC – 18-Nov-2014, 01:15 UTC off Ascension and from 20-Nov-2014, 16:50 UTC – 21-Nov-2014, 00:20 UTC off St. Helena. The calibrations did not lead to any spatial gap of the vmADCP data set as they were carried out on-station. For the remaining time, good quality data could be acquired from 20 m to a depth of 250 m to 300 m, depending on ship speed, sea state and backscatter in the water column.

A water track calibration of the instrument using an averaging interval of 60 seconds resulted in a heading misalignment of 0.9111° with a standard deviation of 0.53353° and an amplitude factor of 1.0168 with a standard deviation of 0.035721.

In order to investigate the effect of the VmDas motion control software setting on the data output, motion control was turned off from 21-Nov-2014, 16:30 UTC - 22-Nov-2014, 11:30 UTC.

Current observations: Lowered-ADCP

During all CTD stations the CTD-System was equipped with a lowered-ADCP (LADCP) setup based on two 300 kHz Teledyne RDI ADCPs. These two ADCPs were mounted within the CTD-Rosette with particular manufactured frames protecting the instruments while not interfering with the acoustic beams. A battery pack was mounted between the down-looking master instrument (SN #11461) and the up-looking slave instrument (SN #839); both LADCPs used the battery pack for power supply as well as for the connection point for the data interface cable. Both the down-looking and up-looking instrument had 25 bins of 10 m bin-length and a ping rate of 1 second throughout each CTD/LADCP profile.

The LADCP system had a relatively stable performance, except for CTD cast no. 39. Already since cast 38, we had some difficulties in communication and data download through the communication cable after the CTD/LADCP package was recovered on board, but this was resolved by cleaning and reconnecting the cable plugs for several times. However, during preparation for cast 39, the LADCP deck unit was not able to communicate with the down-looking instrument through the cable and battery pack. The only way to proceed the cast with an operating LADCP was to separately communicate with the two LADCP instruments by direct connection to each LADCP with a computer via ADCP cable. This allowed us to start the two instruments with the same configuration as for the previous profiles. After this cast, the deck unit was able to communicate with both LADCPs through the cable and battery pack again and eventually, there were no problems with data download. LADCP communication before and after the following (and last) CTD cast 40 was without any problems.

Data processing took place during the cruise with the GEOMAR LADCP processing software V10.16, which includes both shear and inversion methods to derive an absolute velocity profile (Fischer and Visbeck 1993, Visbeck 2002). As an additional data set, necessary for the processing of each LADCP cast, the corresponding pre-processed CTD data (P, T, S and time) was used. The navigational data was taken from MINS scientific navigation platform with a relative accuracy of 0.1 m. The shipboard ADCP data (vmADCP) was used as a shallow depth velocity constrain of the LADCP processing. During the whole cruise, 40 LADCP profiles were measured with 19 shallow (1,300 m) and 21 deep (~ bottom) profiles. Overall both RDI instruments performed well and resulted in good deep ocean velocity profiles.

Glider operation

(J. Hahn, M. Mueller)

In the beginning of the cruise (05-Nov-2014), an autonomous glider from GEOMAR (ifm14) manufactured by Teledyne Webb Research should be deployed, which finally failed due to a broken fin during the deployment. The glider was equipped with the following sensors: a SEABIRD CTD, an Aanderaa optode to measure dissolved oxygen, a Wetlabs combined CHL-a fluorescence and turbidity sensor.

The deployment was operated from a Zodiak rubber boat. After a first successful 10 m dive, the rope of the safety buoy was removed from the rear end of the glider as a wave pushed the glider back and the fin slightly touched the outboard of the boat. Recent glider deployments showed that the glider fin is stable enough to stand such forces, but however, this time the fin broke. From a first subjective and qualitative analysis, we assume that the glider fin was already damaged prior to the deployment, since fine cracks were visible at the interior side of the broken piece of the fin. However, further analysis needs to be done in the lab to investigate the causes of this material defect and to minimize risks for future glider deployments.

Mooring service at CVOO

(J. Hahn, M. Müller, F.P. Tuchen)

On 06-Nov-2014 the top element of the Cape Verde Ocean Observatory (CVOO) mooring, located at 17°36.354’N, 24°14.976’W, was picked up from board RV *Polarstern* for service issues. Some time after the mooring deployment in April 2014, operated during RV *Meteor* cruise M106, the floating telemetry unit at the surface stopped transmitting data via satellite. This device is designed for transmission of online data obtained from near-surface observations with moored instruments (currently three microcats and one optode) to GEOMAR, Kiel. It allows us to immediately identify and react to low oxygen events and to possibly use the Cape Verdean RV *Islandia* for additional shipboard measurements with a CTD rosette water sampler. Having recovered the telemetry unit, an early and detailed investigation of its malfunctioning in the lab will help to improve its performance for upcoming mooring missions.

The very top element of the mooring, consisting of the telemetry unit and one inductive microcat along with 30 m mooring wire, was replaced onboard by a XEOS-Iridium watchdog, which sends its position via iridium satellite connection, as well as a new inductive microcat (see Table 6.1 for details). After replacement the inductive connection at the inductive swivel was cut by installing two dummy plugs. Overall, the mooring service could be completed successfully within one and a half hour.

For data recovery reasons, the telemetry unit was not opened to further investigate its malfunctioning onboard which is to be done in the lab. However, a first physical inspection didn't give any hints for water ingress.

PS88.2 Mooring Service					
Mooring	**New ID**	**Latitude**	**Longitude**	**Deployment Date**	**Service Date**
V440-06	KPO_1128	17N 36.35	24W 14.97	20-Apr-14	06-Nov-14

Tab. 6.1: Mooring operations KPO_1128

Mooring Service Cape Verde V440-06					**Notes:** KPO_1128
Vessel:	Meteor	M106			
Deployed:	20-Apr	2014			
Vessel:	Polarstern	PS88b			
Serviced:	06-Nov	2014			
Latitude:		17	36,354	N	
Longitude:		24	14,976	W	
Water depth:		3570	Mag Var:	-10,0	
ID	**Depth**	**Instr. Type**	**s/n**	**Start-up**	**Remarks**
	-233	~~Devilogics Sat-Trans~~	~~PE001~~	**ready**	Replaced with Xeos – Iridium Watchdog IMEI: 300034013902340 (double Benthos)
KPO_1095_01	-221	~~Microcat-IM~~	~~10696~~	**x**	Replaced with Microcat-IM #6862
KPO_1095_02	-206	Microcat-IM /p	2712	**x**	
KPO_1095_03	43	Microcat-IM	961	**x**	
KPO_1095_04	43	O2 Logger (ind. Opt.)	385	**x**	
	50	XEOS Argos Beacon	5481	**x**	
KPO_1095_05	50	Mini-TD	67	**ready**	
KPO_1095_06	71	Microcat	952	**x**	
KPO_1095_07	71	Fluorometer	2856	**x**	
KPO_1095_08	91	Microcat	1583	**x**	
KPO_1095_09	120	Microcat	1268	**x**	
KPO_1095_10	120	O2 Logger	937	**x**	
KPO_1095_11	121	SAMI-2	67	**x**	
KPO_1095_12	161	Microcat	1269	**x**	
KPO_1095_13	201	Microcat	1285	**x**	
KPO_1095_14	301	ADCP QM 150 up	14910	**x**	
KPO_1095_15	403	Microcat-IM	3415	**x**	
KPO_1095_16	599	Acoustic Recorder	---	**ready**	
KPO_1095_17	616	Aquadop up	26209-36	**x**	
KPO_1095_18	755	Microcat	10709	**x**	
KPO_1095_19	1106	Microcat-IM /p	2488	**x**	
KPO_1095_20	1304	Sediment Trap	910015	**ready**	bottle 9 & 16 missing
KPO_1095_21	1316	Aquadop down	26209-34	**x**	
KPO_1095_22	1500	Microcat-IM /p	3752	**x**	
KPO_1095_23	3014	Aquadop down	26209-13	**x**	
KPO_1095_24	3548	Microcat-IM /p	10660	**x**	
	3604	Release AR861	1256	Code:	0855
	3604	Release AR861	1772	Code:	0A55

Zooplankton Ecology with an Underwater Vision Profiler (UVP)

(J. Hahn)

On behalf of R. Kiko (GEOMAR), a UVP 5 (serial number 10) was operated on the CTD rosette during all 40 CTD casts. The instrument worked properly during 39 of the 40 casts. Only during CTD cast 008 at 12°N (ship station 010-1) the recording failed without any apparent reason. In the beginning of every CTD cast, the starting procedure for the UVP 5 was as follows: 1) lower CTD down to 10m, 2) stop at least for 1 min at 10 m to boot camera, 3) lower CTD down to 22 m to start camera, 4) CTD back to surface and start profile. The UVP 5 consists of one down-facing HD camera in a 6,000 dbar pressure-proof case and two red LED lights which illuminate a 0.88 L-water volume. During the downcast, the UVP 5 takes 3-11 pictures of the illuminated field per second. For each picture, the number and size of particles are counted and stored for later data analysis. Furthermore, images of particles with a size > 500 µm are saved as a separate “Vignettes” - small cut-outs of the original picture – which allow for later, computer-assisted identification of these particles and their grouping into different particle, phyto- and zooplankton classes. Since the UVP 5 was integrated in the CTD rosette and interfaced with the CTD sensors, fine-scale vertical distribution of particles and major planktonic groups can be related to environmental data.

Chemical Underway Measurements of O_2 and GTD

(T.Hahn; not onboard: C. Frank (CONTROS), T. Steinhoff, A. Körtzinger)

Underway (UW) measurements of surface water oxygen (O_2), total gas tension (GTD), temperature and salinity were carried out in a flow-through box. A high performance centrifugal pump (Klaus-pump, KLAUS-UNION Gmbh & Co. KG, Bochum, Germany), which is permanently installed on RV *Polarstern*, supplied a continuous flow of seawater from 10 m below the sea surface to the underway instruments in the through-flow box as well as a bypass for discrete water sampling. The following sensors were implemented: Oxygen optodes (model 3830 and 4330, SN# 529 and 1082, Aanderaa Data Instruments AS, Bergen, Norway; model HydroFlash O2, SN# DO-1014-001, DO-1014-003, DO-1014-004 and DO-1014-005, CONTROS GmbH, Kiel, Germany), GTD Pro gas tension device (SN# 22-019-06, Pro Oceanus Inc., Bridgewater, Canada) and conductivity sensor (model 4319, SN# 772, Aanderaa Data Instruments AS, Bergen, Norway). Temperature was obtained from the optodes. The oxygen optodes are to be multi-point calibrated directly after the cruise at GEOMAR. 58 discrete oxygen and 26 salinity samples were taken from the bypass to validate and partly calibrate these UW measurements. Both types of samples were measured onboard using Winkler titration and the standard measurement procedure with a Guildline Autosal salinometer, respectively (salinity data from the sample bottles 1311, 1484, 460, 371 and 629 need to be considered carefully due to a possible measuring problem). The UW measurements in the flow-through box were started on Nov 3 at 9:26 am and stopped on Nov 27 2014 at 04:04 pm (both UTC). All oxygen optodes as mentioned above were once calibrated onboard at two different temperatures each at 0% saturation level (Na2SO3) on Nov 16. The exact period of times for the measurements of the CONTROS optodes are given in Table 6.2.

Tab. 6.2: Measurement times (UTC) of CONTROS optodes in flow-through box

SN#	Start	End	Reason for stopping
DO-1014-001	Nov 4th, 7:05 pm	Nov 16th, 9:24 pm	0% calibration
	Nov 16th, 10:42 pm	Nov 27th, 4:04 pm	end of UW measurements
DO-1014-003	Nov 6th, 9:51 pm	Nov 16th, 9:24 pm	0% calibration
	Nov 16th, 10:42 pm	Nov 27th, 4:04 pm	end of UW measurements
DO-1014-004	Nov 16th, 11:11 pm	Nov 17th, 0:29 am	data logging failure
	Nov 17th, 10:59 am	Nov 27th, 4:04 pm	end of UW measurements
DO-1014-005	Nov 16th, 11:11 pm	Nov 17th, 0:29 am	data logging failure
	Nov 17th, 10:59 am	Nov 27th, 4:04 pm	end of UW measurements

Instrument Performance Test of Optimare Salinometer
(J. Hahn, B. Kisjeloff)

An Optimare salinometer (Optimare, Bremerhaven) was tested in the ship lab with regard to its performance, since recent operations at sea have shown that this model type is characterized by critical systematic measurement insufficiencies for water samples taken from the deep ocean. As reported by the manufacturer, a continuous drift in determined salinity for consecutive measurements of the same sample bottle is observed for this kind of samples. Following the manufacturer's recommendation, this can be avoided by degassing the water samples before conducting the actual measurement.

In order to check, understand and finally tackle these instrument characteristics, 42 water samples from the deep ocean (5,000 m) were taken in bottles with swing-stopper (24) as well as in bottles recommended by the customer (18) during the cruise. The degassing of the water samples was done as follows. 37 of the sample bottles were heated in water baths at different temperatures (15 bottles with swing-stopper and 18 customer's bottles at 40°C; 4 bottles with swing-stopper at 30°C). 5 bottles were not heated at all. After temperature equilibration (about 1 hour), the heated bottles were opened and immediately closed again to ensure pressure equilibration and degassing of the sample (not done for the 5 non-heated bottles). After cooling down the samples to lab temperature over night, the water samples were analyzed with the Optimare salinometer. When the samples had been heated to 40°C, no measurement drift (maximum difference between all measurements of a single sample was better than 0.001 PSU) was observable. Samples that were heated just to 30°C or that were not heated at all, showed a (negative) drift of the measured salinity where the maximum difference between all measurements of a single sample was more than 0.001 PSU with the highest drift for samples that were not heated at all).

Additionally, a comparison of water sample duplicates, analyzed in parallel with a Guildline Autosal salinometer, showed a salinity difference of better than 0.001 PSU for samples that were heated to 40°C. Measurement uncertainties were independent of the two bottle types, but the handling of the bottles with swing-stopper was easier compared to the customer's bottles.

Instrument Performance Test of CONTROS Optodes
(T.Hahn; not onboard: C. Frank (CONTROS), H. Bittig, PI: A. Körtzinger)

Besides the underway performance test of CONTROS optodes, optical oxygen measurements with new oxygen optodes (model: HydroFlash O2, SN# DO-1014-004, DO-1014-005 and DO-1014-006, CONTROS GmbH, Kiel, Germany) were carried out on 26 CTD casts in order to characterize their performance. The CTD profiles between casts 10 and 32 were used to determine the response signal during the up- and downcast of the CTD. Therefore, the optodes were attached on the near-bottom of the CTD-Rosette as close as possible to the inlet of the SBE43 CTD system for comparison.

To determine the optode behavior under changing pressure but constant oxygen, temperature and salinity conditions, the optodes were attached inside a Niskin bottle to the upper spring. Niskin bottle 1 was used for DO-1014-004 during CTD cast 34 to 42, and Niskin bottle 2 for DO-1014-005, respectively. As a first order assumption, salinity and oxygen are constant after closure of the Niskin bottle and changes of temperature are assumed to be small and slow. Thus, deep ocean conditions >3,000 dbar serve as a first order pressure calibration with no concurrent changes in other parameters.

Table 6.3 provides exact details of application for each optode during both experiments.

All data during each CTD cast were logged internally every 3 s with the optode using the power supply of a manufacturer customized battery module. The oxygen optodes were calibrated onboard at two different temperatures each at 0 % saturation levels (Na_2SO_3). Furthermore, CTD cast 10 served as an optode calibration cast with several stops at different oxygen concentration levels. All optodes are to be multi-point calibrated directly after the cruise at GEOMAR.

Tab 6.3: Details about attachments of CONTROS optodes on CTD-Casts and dates of their 0% calibration

SN#	Performance on CTD-Cast, profile #	In-situ Pressure Test, profile #	0% Calibration #1, cold/warm	0% Calibration #2, cold/warm
DO-1014-004	10, 17-19, 21-24, 26-32	34-40 (Niskin bottle 1)	Nov 8th 2:19pm/11:19am	Nov 16th 9:50pm/10:34pm
DO-1014-005	10, 17-32	34-40 (Niskin bottle 2)	Nov 8th 2:19pm/11:19am	Nov 16th 9:56pm/10:11pm
DO-1014-006	10, 17-24, 26-27	-	Nov 8th 2:19pm/11:19am	-

Calibration of AADI Optodes
(J. Hahn, B. Kisjeloff)

Overall, five Aanderaa (Aanderaa Data Instruments AS, Bergen, Norway) optodes were calibrated during the cruise. Among these were one glider optode from GEOMAR glider ifm14 and four optodes destined and equipped for deployment during the next service of the PIRATA moorings at 4°N, 23°W and 11.5°N, 23°W coordinated by NOAA.

CTD-O_2 cast calibrations were performed for the 4 PIRATA mooring optodes (s/n: 0839, 1141, 1142, 1160 / CTD cast 010) as pre-deployment calibrations. The calibration of the glider optode (s/n: 0271) during CTD cast 001 failed, because the attached optode logger stopped recording during the cast due to too low battery. During the calibration cast, 7 calibration stops were done with a duration of at least 2.5 min in order to ensure equilibrium at each calibration point.

Additionally, onboard lab calibrations were conducted for all optodes in water-filled beakers of 0% and 100% O_2-saturated water at two different temperatures (~5°C and ~22°C) following the Aanderaa optode manual.

Thermosalinograph Measurements
(J. Hauschildt)

Sea surface salinity (SSS) and sea surface temperature (SST) were measured with two separate thermosalinograph (TSG) units continuously throughout the cruise. The TSGs onboard RV *Polarstern* are installed in the ship's bow (TSB) and in the keel (TSK), respectively. Each unit contains a conductivity cell (SBE 21) and two temperature sensors (SBE 38, internal/external with respect to conductivity cell). The TSK sensor worked well throughout the cruise, whereas the TSB sensor showed some discontinuities, the largest one caused by a clotting of the pipes that required shutdown and cleaning. The offset between both systems was small (0.0026 PSU) until 14-Nov-2014 (corresponding to north of 0.5°S), while it was one order of magnitude larger (0.0199 PSU) afterwards (corresponding to the part of the cruise track south of 0.5°S). Apart from upper discontinuities, the offset remained constant most of the time and the two sensors were generally in good agreement. The temperature and salinity data were calibrated against 5 dbar CTD data obtained from 40 CTD casts throughout the cruise, resulting in uncertainties of 0.007°C/0.003 PSU and 0.008°C/0.001 PSU for TSB and TSK, respectively.

Additionally, water samples from TSB and TSK were taken during the cruise from 13-Nov-2014 – 24-Nov-2014 (duplicates from 13-Nov-2014 – 19-Nov-2014) once a day in order to directly determine the salinity with a Guildline Autosal salinometer. The RMS misfits obtained using the 12 independent samples were 0.0198 PSU and 0.0017 PSU for TSB and TSK, respectively. The larger misfit for the TSB sensor is the result of the partly corrupt conductivity cell as described above. Additional water samples from TSB and TSK were taken every second day from the ship's crew.

Float Deployments

(T.Hahn, J.Hahn not onboard: H.Bittig,A. Körtzinger)

A total amount of 7 battery-powered autonomous floats (1 NAVIS and 6 ARVOR) have been deployed throughout this research cruise. The NAVIS float was equipped with a SEABIRD SBE41CP CTD sensor as well as two oxygen sensors (SBE63 and Aanderaa 4330). The ARVOR floats were equipped with a SEABIRD SBE41CP CTD sensor. The typical deployment method was performed as follows: After the individual pre-deployment check, each float was prepared for its deployment by applying a customized releasing mechanism via attaching two cords and a timber slat. At a ship speed of about 2 kn and a deployment height of about 3 m, the float was then hand-lowered from the afterdeck onto the sea surface before making use of the releasing mechanism. The subsequent measuring procedure differs from each individual float. The exact details for each float deployment are given in Table 6.4.

Tab. 6.4: Details of all float deployments during PS88.2 (ANT-XXX/1.2)

Float SN# (Model)	Station# (CTD profile)	Time (UTC) of deployment in 2014	Lon, Lat of deployment	Person in Charge
0271 (NAVIS)	012-2 (CTD profile 010)	Nov 08, 10:01	11° 00.277' N, 23° 01.897' W	Tobias Hahn
OIN 14D ARL 09 (ARVOR)	028-2 (CTD profile 024)	Nov 11, 14:06	03° 59.900' N, 23° 01.950' W	Johannes Hahn
OIN 14D ARL 10 (ARVOR)	036-2 (CTD profile 032)	Nov 13, 10:15	00° 39.700' N, 23° 00.000' W	
OIN 14D ARL 11 (ARVOR)	046-1 (no CTD profile)	Nov 19, 11:03	12° 03.810' S, 10° 00.380' W	
OIN 14D ARL 12 (ARVOR)	048-1 (no CTD profile)	Nov 22, 13:57	18° 29.940' S, 00° 04.030' W	
OIN 14D ARL 13 (ARVOR)	050-1 (no CTD profile)	Nov 25, 10:15	23° 59.960' S, 07° 59.960' E	
OIN 14D ARL 14 (ARVOR)	051-1 (no CTD profile)	Nov 27, 10:15	30° 42.750' S, 13° 13.240' E	

Preliminary results

Hydrography and currents along 23°W
(R. Kopte, Y. Fu, T. Klenz)

Fig. 6.1 shows the upper 1,000 m section of oxygen content along 23°W from 2°S to 14°N. Within the core of the OMZ at 10°N-12°N an oxygen concentration below 40 µmol/kg was found (38 µmol/kg was the absolute minimum value obtained from Winkler titration during PS88.2), which is clearly lower than the minimum in the oxygen mean field obtained from ship sections carried out between 1999 and 2012 as presented in Brandt et al. (2014). A broad equatorial oxygen maximum was observed in the upper 200 m. Further north, well-defined oxygen maxima and minima were found at 100 m - 200 m at 5°N/8°N and 7°N/10°N, respectively.

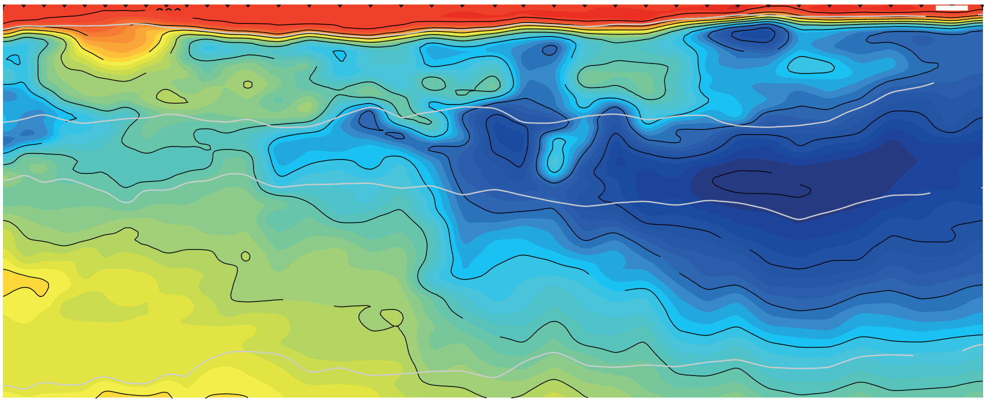

Fig. 6.1: Oxygen concentration [in µmol/kg] along 23°W in the upper 1,000m as obtained during PS88.2. Light grey lines mark lines of potential density [in kg/m3-1,000]

The 23°W section of zonal and meridional velocity between 14°N and 2°S as obtained from vmADCP is shown in Fig. 6.2. The most prominent feature is the core of the Equatorial Undercurrent, which is obvious as a zonal velocity maximum at the equator at a depth of approximately 90 m. The near-surface westward nSEC (northern band of the South Equatorial Current) at 1°N as well as the eastward NECC and nNECC (North Equatorial Countercurrent and its northern band) at 5°N and about 8°N-9°N are identified reaching up to 20 cm/s. The meridional velocity section shows a southward velocity approximately in the upper 90 m between 2°S and 5°N.

The vmADCP data along 23°W between 14°N-2°S was merged with data from the lowered-ADCP to a depth of 1, 000 m, as the range of the vmADCP was restricted to the upper 250-300 m of the water column. The 1,000 m section of zonal and meridional velocity along 23°W is shown in Fig. 6.3. Near-surface currents are as described above. In addition, we found strong westward velocity at about 500 m at the equator associated with the position of the EIC (Equatorial Intermediate Current). This current is meridionally flanked by the NICC/SICC (North/South Intermediate Countercurrent).

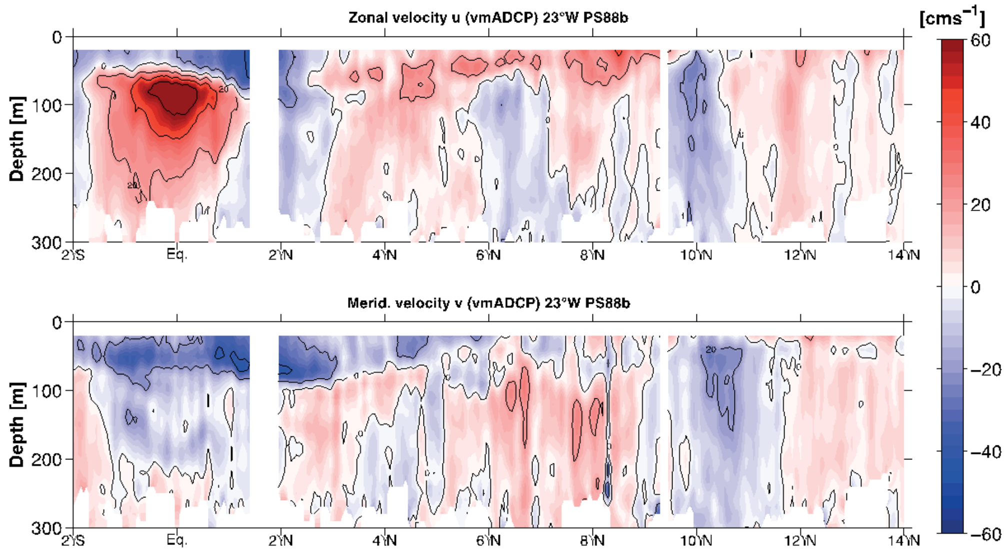

Fig. 6.2: 23°W section of zonal and meridional velocity between 14°N to 2°S as obtained from vmADCP. Data was interpolated on a 1/20° grid and smoothed using a 2D Gaussian mean. Positive zonal/meridional velocity defines eastward/northward direction.

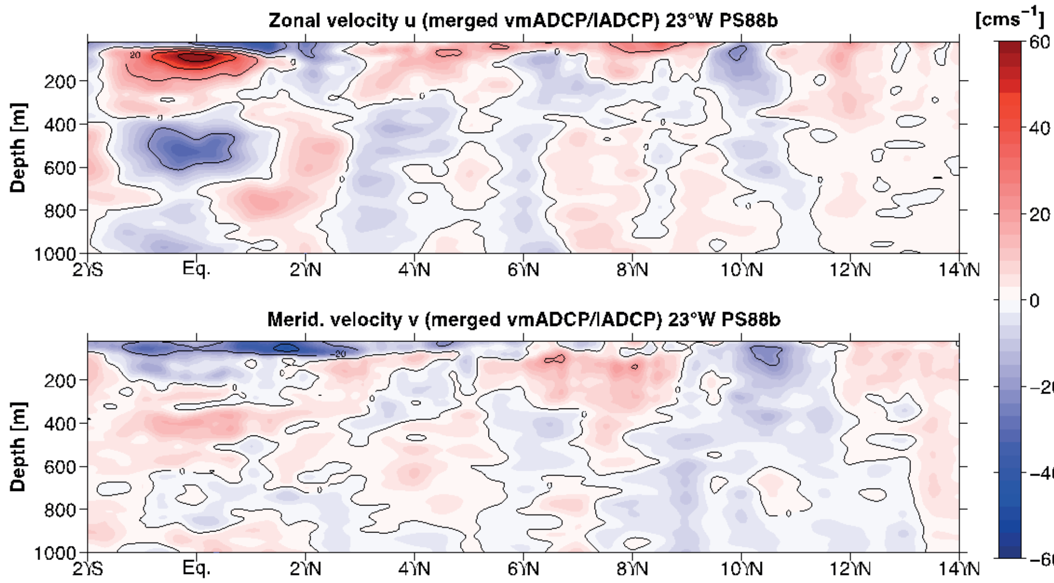

Fig. 6.3: Same section as in fig. 6.2, but VmADCP data was merged with lowered-ADCP data to achieve a 23°W section down to 1,000 m depth.

The latter two currents show structures reaching down to the deep ocean as obvious in the deep zonal velocity section (Fig. 6.4). In general, the current field in the deep ocean between 2°N and 2°S is rather eastward directed superimposed by vertically alternating zonal currents associated with Equatorial Deep Jets. A westward directed current was observed at 3°N-4°N below about 300 m over almost the whole water column.

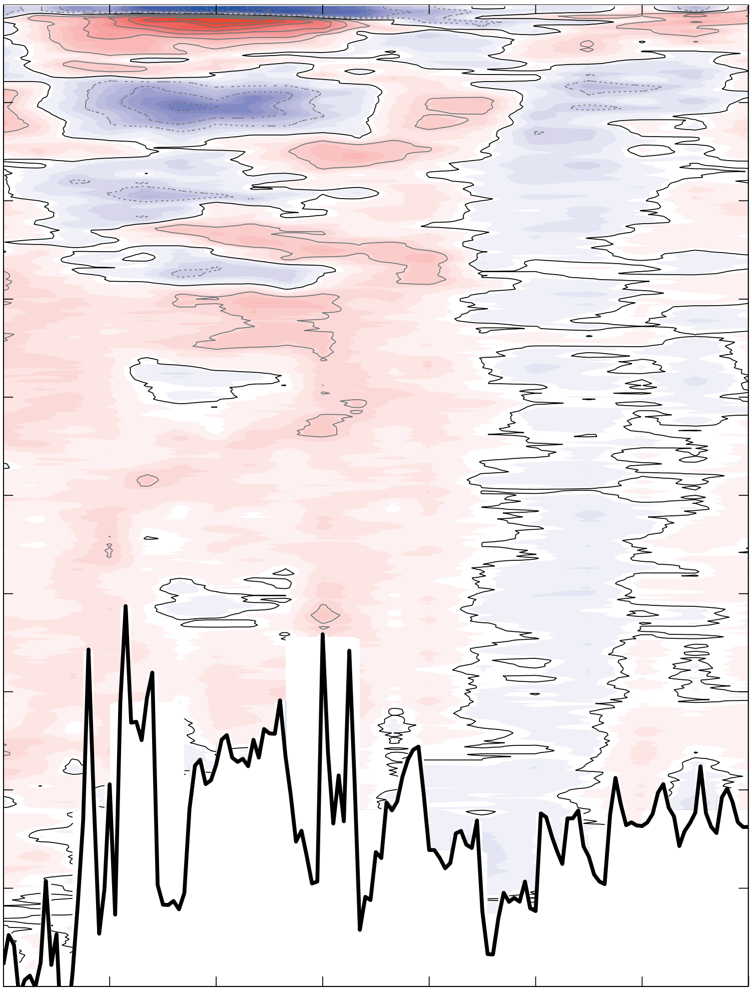

Fig. 6.4. Deep zonal velocity section along 23°W between 2°S and 5°N. Contour lines mark intervals 10 cm/s. Ocean bottom is indicated as thick black line.

Comparison of bathymetric data sets and echo sounder depths
(A.-L.Deppenmeier)

During the deep CTD casts carried out along 23°W, record has been kept of the different depth products available at the casts' positions, each of them shown in Table 6.5. Details are explained underneath.

Tab. 6.5: Estimated bottom depths from different bathymetries data sets, echo sounder measurements as well as CTD/LADCP measurements done during PS88.2 (ANT-XXX/1.2).

Latitude	Station / profile number	EK-60 (18 kHz) depth [m]	LADCD + CTD depth [m]	Δ(EK-60 – (LADCP+CTD)) [m]	GEBCO depth [m]	ETOPO1 [m]
5°N *	026-1/22	4216	4220	-4	4033	4262
4.5°N	027-1/23	4113	4112	-1	4000	4150
4°N	028-1/24	4204	4200	-4	4095	4089
3.5°N	029-1/25	4371	4382	-1	4068	4237
3°N	030-1/26	4627	4638	-11	4445	4551
2.5°N	031-1/27	4688	4725	-37	4404	4184
2°N	032-1/28	4323	4327	-4	4117	4251
1.67°N	033-1/29	4111	4117	-6	4208	4279
1.33°N	034-1/30	4701	4714	-13	4719	4035
1.0°N	035-1/31	3224	3234	-10	3998	3888
0.67°N	036-1/32	3897	3904	-10	4012	3579
0.33°N	037-1/33	3914	3913	+1	3740	3838
0.00°N *	038-1/34	3947	3947	+0	3582	3954
0.33°S	039-1/35	4596	4612	-16	4533	4538
0.67°S	040-1/36	3565	3563	+2	3244	3700
1.0°S	041-1/37	4098	4111	-13	4450	4619
1.33°S	042-1/38	4819	4844	-25	5067	5023
1.67°S	043-1/39	4899	4915	-16	4653	4849
2.0°S	044-1/40	5194	5216	-22	4939	4656

* Note the stations where the position deviates from 23°00'W by 2' (to west) as to not interfere with the moorings located at these latitudes.

The 18 kHz echo sounder of the onboard EK-60 was used to derive the bottom depth throughout the cruise using an average sound velocity of 1,500 m/s. The GEBCO (**Ge**neral **B**athymetric **C**hart of the **O**ceans) bathymetric set is the product of a combined scientific effort from hydrographers and geoscientists who aim to provide a complete set of bathymetric data for the global oceans (http://www.gebco.net/data_and_products/gridded_bathymetry_data/, downloaded in October 2014); it makes use of acoustic and satellite measurements. Similarly, ETOPO1 is a one arc-minute bathymetric product that consists of several global and regional measurements using sea-surface satellite altimetry and ocean soundings (http://www.ngdc.noaa.gov/mgg/global/relief/, downloaded in October 2014). The CTD has a build-in pressure sensor, which has been used to obtain the CTD depth. At the maximum CTD depth, the off-ground distance of the CTD was determined from analysis of LADCP data after the cast. Summing up both (CTD+LADCP depth) resulted in the best estimate of the total bottom depth. The obtained values from CTD+LADCP and 18 kHz EK-60 agree fairly well as can be seen from the table above. Overall, the GEBCO depth product underestimates the actual depth except in two cases where it (in one case drastically) overestimates it when compared to direct measurements (CTD+LADCP) and EK-60 depth. The ETOPO1 product delivers a more reliable data set for almost all of the deep CTD positions. The general conclusion is that the 18 kHz EK-60 echo sounder depths are reliable values useful for determining potential cast depths on-site, while bathymetric data sets allow only for fairly accurate planning beforehand. These results are also illustrated in Fig. 6.5.

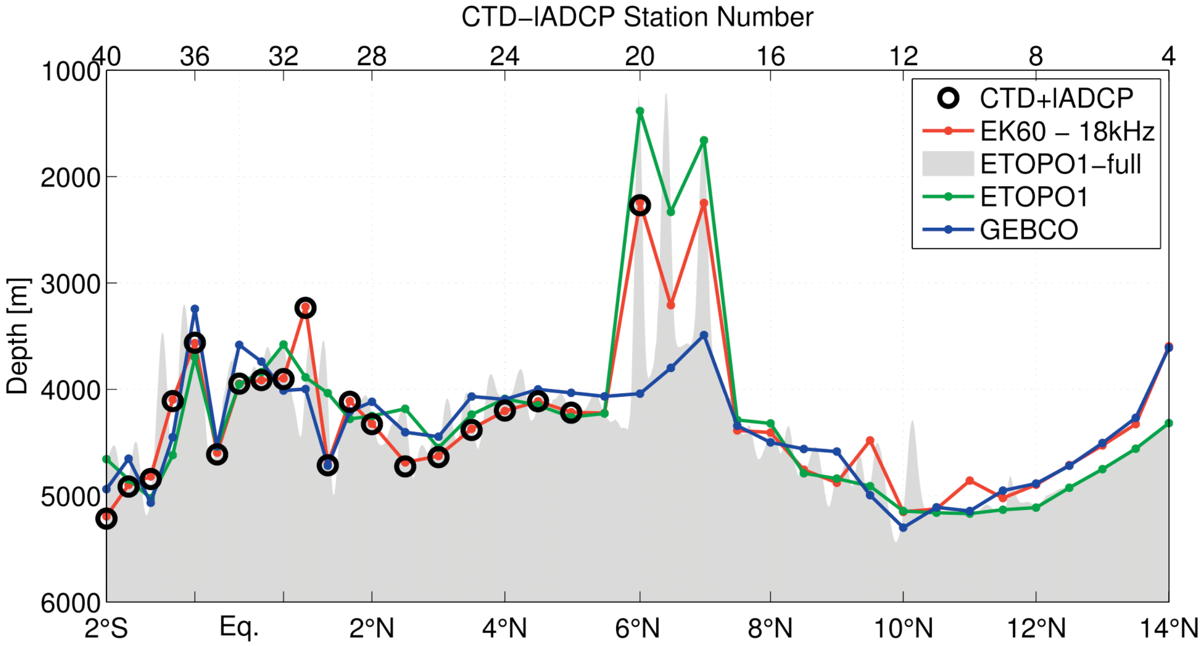

Fig. 6.5: Different bathymetric products over the section in comparison

Chemical Underway Measurements
(T.Hahn)

Fig. 6.6 shows preliminary underway data of temperature, oxygen concentration (both Aanderaa optode, un-calibrated O_2 data) and total gas tension from the flow-through box. Primarily, the general performance of the CONTROS optodes is of interest. The temperature (not actual SST due to possible warming during pump way from inlet into flow-through box) shows the expected pattern with warmer water between 27°C and 29°C from 12° N to the equator and colder water in the northern and southern part of the ITCZ. Cold water temperatures in the South Atlantic Ocean along the cruise track can be associated with the upwelling regime off the coast of Namibia and Angola. The surface water O_2 concentration is to first order a function of temperature rather than a function of the total gas tension.

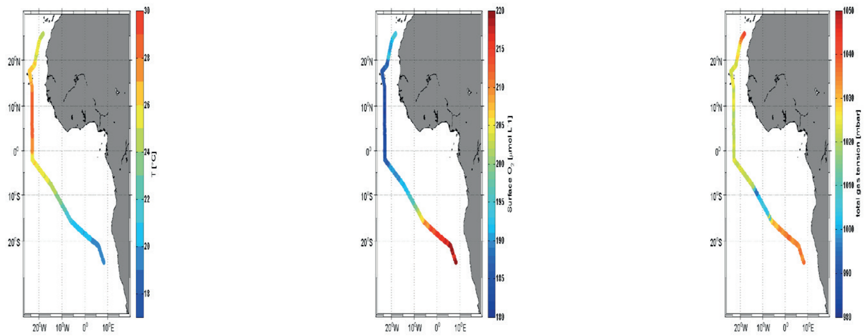

Fig. 6.6: Preliminary underway data of optode temperature, oxygen concentration (un-calibrated) and total gas tension; Note: the data only refers to measurements in the flow-through box.

Instrument Performance Test of CONTROS Optodes
(T. Hahn)

Fig. 6.7 shows a preliminary and un-calibrated example of a data set for temperature, optode raw phase signal dphi and un-calibrated partial pressure of oxygen (pO_2) of CONTROS oxygen optode DO-1014-005. The data was obtained during CTD – profile 34 in Niskin bottle 2 which was closed at the bottom for the subsequent *in-situ* pressure test. The temperature within Niskin bottle 2 is not constant throughout the entire up-cast and affects the optode's raw phase signal as it is a function of temperature. A pressure hysteresis of the optode oxygen sensor could not be observed as both dphi and un-calibrated pO_2 are to first order anticorrelated to the temperature anomaly during the up-cast. A detailed insight can be given after calibration of the optode and the analysis of the complete data set.

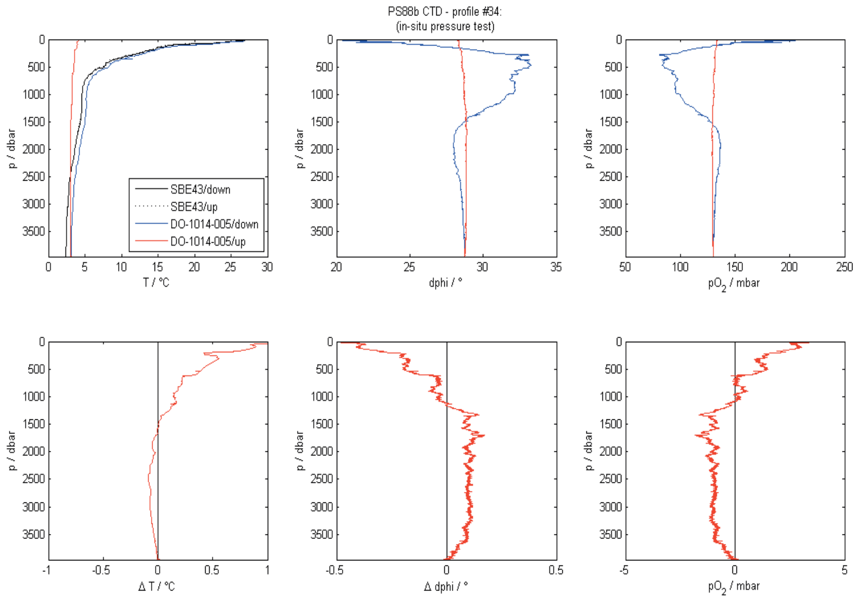

Fig. 6.7: Preliminary profiles of temperature, optode raw phase signal dphi and un-calibrated partial pressure of oxygen (upper panels) as well as corresponding anomalies with respect to the parameter value at the maximum profile depth (lower panels) of CONTROS oxygen optode DO-1014-005; data was obtained during CTD – profile 34 in Niskin bottle 2 which was closed at the bottom for the subsequent in-situ pressure test.

Thermosalinograph Measurements
(J. Hauschildt)

Fig. 6.8 shows measurements of SSS and SST with the thermosalinograph. The transition from colder, more saline water (24°C, 27 PSU) of the subtropical gyres to warm, less saline water (28°C, 34.5 psu) around the equator can be seen. The transition exhibits a strong gradient south of the salinity minimum, while the gradient is weaker north of it. The low salinity, high variability in SSS/SST and large salinity difference between the TSB and TSK sensors from 3°N to 13°N (blue shading) show freshwater input due to high precipitation below the Intertropical Convergence Zone (ITCZ).

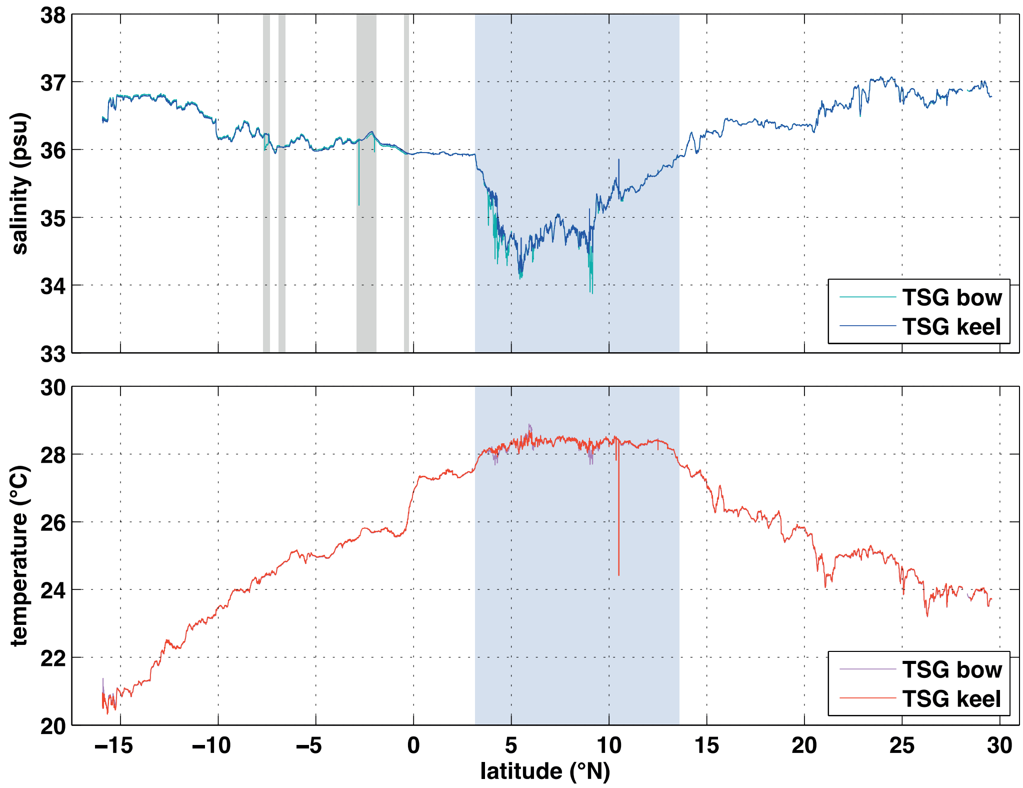

Fig. 6.8: Salinity (upper panel) and temperature (lower panel) as function of latitude obtained from 2 individual thermosalinograph (TSG bow, TSG keel) measurements throughout the cruise. ITCZ is marked by blue shading. Gray shadings mark regimes where the conductivity (salinity) sensor of TSG bow was corrupt.

Data management

The Kiel Data Management Team (KDMT) provides an information and data archival system where metadata of the onboard DSHIP-System is collected and made 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 provides 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 serve as data curators to fulfil the proposed 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 world data center 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 a WDC/PANGAEA (www.pangaea.de): 3 years after the cruise.

References

Brandt P, Banyte D, Dengler M, Didwischus SH, Fischer T, Greatbatch RJ, Hahn J, Kanzow T, Karstensen J, Körtzinger A, Krahmann G, Schmidtko S, Stramma L, Tanhua T, Visbeck M (2014) On the role of circulation and mixing in the ventilation of oxygen minimum zones with a focus on the eastern tropical North Atlantic. BGD, 11:1–68.

Fischer J, Visbeck M (1993) Deep Velocity Profiling with Self-contained ADCPs. Journal of Atmospheric and Oceanic Technology, 10:764-773.

Langdon C (2010) Determination of Dissolved Oxygen in Seawater by Winkler Titration Using the Amperometric Technique, edited by M Hood IOCCP report.

Visbeck M (2002) Deep Velocity Profiling Using Lowered Acoustic Doppler Current Profilers: Bottom Track and Inverse Solutions. Journal of Atmospheric and Oceanic Technology, 19:794-807.

7. BRIEFING AND TRAINING ON USE OF THE RECENTLY DEVELOPED EK60 CALIBRATION SYSTEM

Sören Krägefsky[1], WernerDimmler[2] , Thomas Feiertag[2]

[1]AWI
[2]RFL

Objectives

Active hydroacoustic measurements allow for surveying the distribution of organisms in the size range of small macrozooplankton to large nekton with a very high temporal and spatial resolution. This cannot be achieved with any other survey method. In fishery science, hydroacoustic surveys are defined as the standard stock assessment tool for purpose of fisheries management, including krill stock assessment and management in the Antarctic Ocean. On board RV *Polarstern*, a Simrad EK60 scientific multifrequency echosounder with frequencies of 18, 38, 70, 120, 200 kHz is used for these survey tasks.

The backscatter characteristics of different marine organisms is a function of their shape, size and material properties and sound frequency, causing characteristic species or group specific differences in backscattering properties at different frequencies. These differences are used for species (or organism group) discrimination and identification. In order to be able to compare measurements at the different frequencies for species identification and to derive reliable stock estimates, a proper calibration of the echosounder is needed. The Simrad EK60 calibration is performed by measuring the backscattering strength (target strength) of spheres with known target strength. For a reliable calibration, a sufficient number of measurements covering the full area of the sound beam is required. Due to the shape and dimensions of RV *Polarstern*, such calibration is a demanding and time-consuming task. A system for supporting calibration of the Simrad EK60 was developed, allowing for a relatively fast and semi-automatic calibration of the Simrad EK60 or similar echo sounders while facilitating the calibration process. The calibration unit consists of a deck unit and electronically controlled underwater winches. Due to the synchronized software-controlled operation of these winches, it is possible to exactly control the position of the calibration sphere in the sound beam of the echo sounder under the ship's hull.

Deployment of the underwater winches is by means of electrical winches positioned on deck, one at port and two at starboard side in a triangle configuration. The cable of the deck-winch is also used for power supply, data communication and control of the underwater winch. The underwater winch system is encased in a torpedo shaped housing serving as weight and winch protection. It also minimizes the drag and guarantees the free movement of the line connecting the underwater winch with the calibration sphere. Optical markers on this line serve as position markers allowing for measuring the length of the line heaved or veered out.

After different sea trials and subsequent improvements, the calibration system has reached a post-developmental state, allowing for its regular use. It significantly simplifies and fastens the calibration of the multifrequency echosounder. However, operation and calibration demands operational skills and thus trained operators and ideally a ship's crew familiar with the calibration procedure. Aim of the activities during the cruise was briefing and training enabling potential users and electronics engineers of RV *Polarstern* to use the calibration system and on the same time improve the efficiency of the calibration process.

Work at sea

After installation of the deck-winches, electronic deck units and preparation of the underwater winches, calibration exercises were carried out at two locations on 17.11.2014 and 20.11.2014 for about 9 and 7 hours, respectively. The first training was carried out in an anchored mode in front of the island Ascension at water depths of about 50 m. The low current velocity, found at the anchor place near Ascension, ensured little movement of the underwater winches and thus ensuring easy positioning of the sphere within the sound beam. The unwanted signals of highly abundant fish during calibration exercise allowed training but no proper calibration of the echosounder.

The second training was carried out in a drifting mode in the lee of the island St. Helena at water depths around 600 to 1,000 m. In drifting mode, the ship sails in the wind, and drifts with the current of the ocean. During calibration, the relative motion of the ship and the underwater winches deployed at 25 m depth has to be minimized by manoeuvring of the ship. The second training includes a proper calibration of the 38 kHz transducer of the Simrad EK60. A theoretical training on use of the calibration system and calibration itself was carried out during port lay time in Cape Town for scientist participating in the cruise PS89, planning to calibrate the echosounder in Antarctic waters.

Results

The training was successful, thanks to the team consisting of the deck's crew, nautical officers, ships command and electronic engineers. The training offered the potential of some refining ideas, which might further improve the handling during system set-up.

Data management

No data were recorded for scientific purposes.

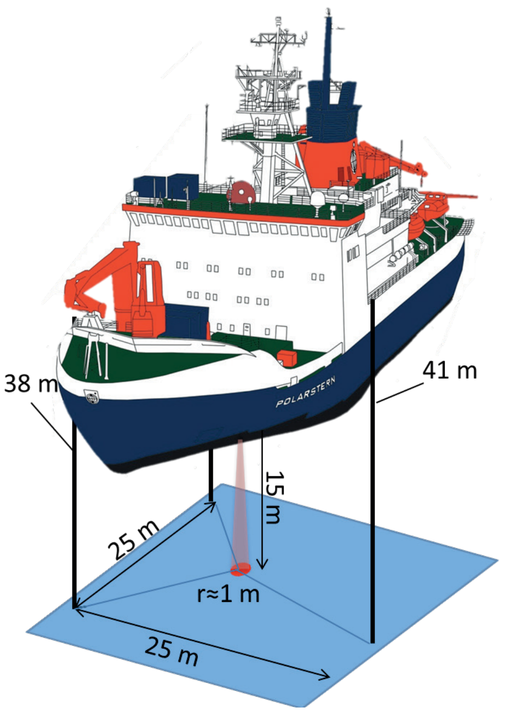

Fig. 7.1: Calibration set-up. Location of the three underwater winches (black vertical lines) and resulting plain of calibration (blue area). Blue thin lines represent the lines connected to the calibration sphere. The red circle marks the sound beam area (radius ca. 1 m) at 15 m depth below the ship's hull.

8. CALIBRATION OF NEW ANTENNA FOR UNDERWATER POSITIONING (POSIDONIA)

Ralf Krocker[1], Werner Dimmler[2],
not on board: Johannes Rogenhagen[2],
Saad El Naggar[2]

[1]AWI
[2]RFL

Objectives

In spring 2014 a new deployable antenna as part of underwater positioning system POSIDONIA 6000 from IXBLUE was purchased as back-up for existing flush array. As the new antenna had not been calibrated, this task was executed during this cruise. Both antennas are lowered through the moonpool to the ship's keel, where its position is fixed by hydraulic stamps. As the finally mounting angles roll, pitch and yaw do not exactly coincides to the axis defined by inertial system, these offsets are subject of determination. Additionally the calibration process measures the inner geometry of the antenna and adjusts these parameters during calculation.

Work at sea

The calibration was executed on 10 November 2014 at location 006°02.1'N, 023°13'W at seafloor depth of 2,220 meter. This position is listed as PS88/022-1 in station book. To achieve best calibration results and to avoid uncertainties due to signal refractions a CTD cast was executed prior to the profiling. CTD profile was taken by scientist of GEOMAR making oceanography during the cruise. The CTD was lowered nearly to the seafloor until depth of 2,200 meter.

The mooring for calibration consists of a rail wheel of 300 kg, ten meter robe, the double releaser, another ten meter rope and finally five meter rope bending four benthos spheres for uplift. The double releaser consists of IXBLUE releaser of type RT861, S/N 202 and IXBLUE releaser of type OCEANO RT2500 with S/N 604. The calibration profile was planned to sail two circles with a diameter of 1,700 meter with ship's speed of three to four knots. The touching point of the two circles is located directly above the transponder as shown in Fig. 8.1. The tracked transponder positions are displayed as green dots.

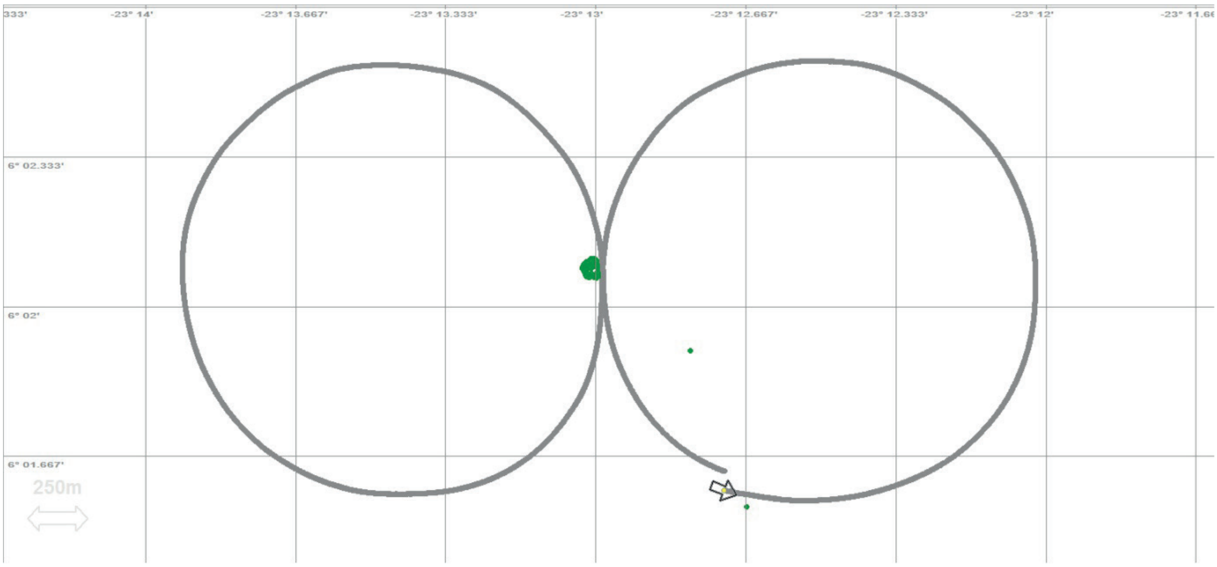

Fig. 8.1: Calibration profile consists of two circles with diameter of ~1,700 meter

Results

During data tracking very few outliers have been detected. After first completion of the two calibration circles the calculation was executed using software application “USBL Cal 3.0.5” with following results:

Offsets (°):	**CALIBRATION VALUES**		
	Heading	**Roll**	**Pitch**
	-0.69	**+0.16**	**+0.57**
Standard dev (m):			
	X	**Y**	**Z**
	3.56	**3.79**	**3.62**
Accuracy:	**0.26**		
Hi Hj (mm)	**H1 H2**	**H2 H3**	**H3 H4**
x	**-499.94**	**246.94**	**6.06**
y	**6.04**	**-253.00**	**499.96**
z	**4.95**	**-3.16**	**1.37**

Fig. 8.2: List of calibration parameters as calculated by “USBL cal”

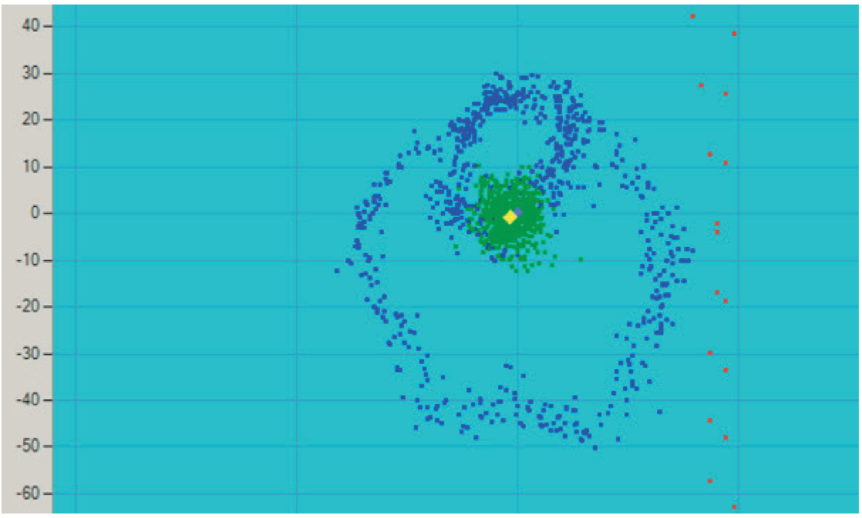

Fig 8.3: Blue dots show detections of transponder position with uncalibrated system. Green dots are representing same transponder positions after calculation and appliance of calibration parameters.

After adopting the 12 calibration parameters (highlighted in red in Fig. 8.2) into web interface of USBL-Box the calibration profile was sailed again to confirm the new settings. The calibration calculation was repeated but no significant further improvements could be achieved.

Data management

Transponder positions provided by USBL-Box were archived online by ships data management system DShip. They will be available with no restrictions for public use (http://dship.awi.de).

9. SYSTEM TEST OF THE KONGSBERG SYNCHRONIZATION UNIT

Sören Krägefsky[1], Boris Dorschel[1], Werner Dimmler[2], Catalina Gebhardt[1], Ralf Krocker[1], Gerhard Kuhn[1], Frank Niessen[1]
not on board: Saad El Naggar[2], Johannes Rogenhagen[2]

[1]AWI
[2]RFL

Objectives

On board RV *Polarstern* different echosounders potentially cover the total water column, the bottom area and the sub-bottom region with measurements. They allow to survey the oceanic flow field (Teledyne/RDI ADCP), the distribution and abundance of marine organism in the water column (Simrad EK60), the bathymetry (Atlas Hydrosweep DS3) and sub-bottom structure (Atlas Parasound). A set of echosounders allows depth measurements.

A parallel survey with different echosounders might gain useful information. However, simultaneous use of the different echosounders can cause strong interferences, masking measured signals by noise. Repeated measurements with different echosounders along identical survey tracks are very time consuming. Moreover, such measurement set up is only appropriate if the measured variables can be considered as time-independent within the survey timeframe.

Synchronisation of the different echosounders can avoid interferences by triggering successive measurements of interfering echosounders, and thus can allow a parallel survey. However, synchronisation causes reduction in survey resolution. Moreover, most surveys, e.g. on the abundance of krill and fish, the flow field, or complex bottom structure, demands a certain resolution in time and space. A proper synchronization, thus, can demand a complex measuring sequence of the different echosounders.

Objective of our work during the cruise was to test the Synchronisation Unit Kongsberg KSync, whether it can assure a stable triggering and measuring performance of the echosounders and whether the offered features will meet our measuring requirements.

Work at sea

The KSync Unit was installed prior to the cruise in the dock in Bremerhaven. The echosounders intergrated in triggering process are the Teledyne ADCP, the single beam echosounder Simrad EA500 “DWS”, Atlas Hydrosweep DS3, Atlas Parasound P70 and Simrad EK60, running as two instances serving for depth measurements (18 kHz) and water column survey (38, 70, 120 and 200 kHz).

During the cruise, different combination of echosounders and synchronisation sequences were tested. The different tests lasted for several hours an up to several days. Of particular interest was the stability of the triggering process and the spatial and temporal survey resolution reached during synchronisation, and whether this resolution was sufficient for the survey task.

Preliminary results

The KSync Unit shows stable signal processing and triggering of the different echosounders. The KSync Unit software allows definition of quite complex synchronisation sequences. However, the software needs few adaptations to increase definition abilities to fully meet requirements. A logging file should automatically be created listing start and stop times as well as scheme of current trigger sequence.

Parasound: For external triggering of Parasound the options under Hydromap Control, Transmission Sequence were set to "Transmission on Request", and Trigger to "Externally Triggered 1". In addition under Sounder Environment "Blanking Output" has to be activated, and under External Signal 1 and 2 "Delay" has to be 0 and "Prolongation" 5.000 ms. In this mode the transmission options "single pulse", "pulse train" and "quasi equi-distant" cannot be used. The result is a significant reduction of lateral resolution of the data. For example, compared to the commonly used "Quasi-Equidistant Operation", the lateral resolution is reduced from 100 % to about 20 %. However, even in deep water (> 3,000 m) and at a vessel speed of 10 kn, a meaningful survey is still possible under external trigger control, in case the geometry of the sea floor is relatively flat and the sub-bottom structures are relatively constant over larger distances. Fig. 9.1 exhibits a Parasound profile of pelagic sediments recorded under K-Sync triggered operation mode. In this example, the lateral resolution is still sufficient to interpret the sedimentary environment and to select coring locations.

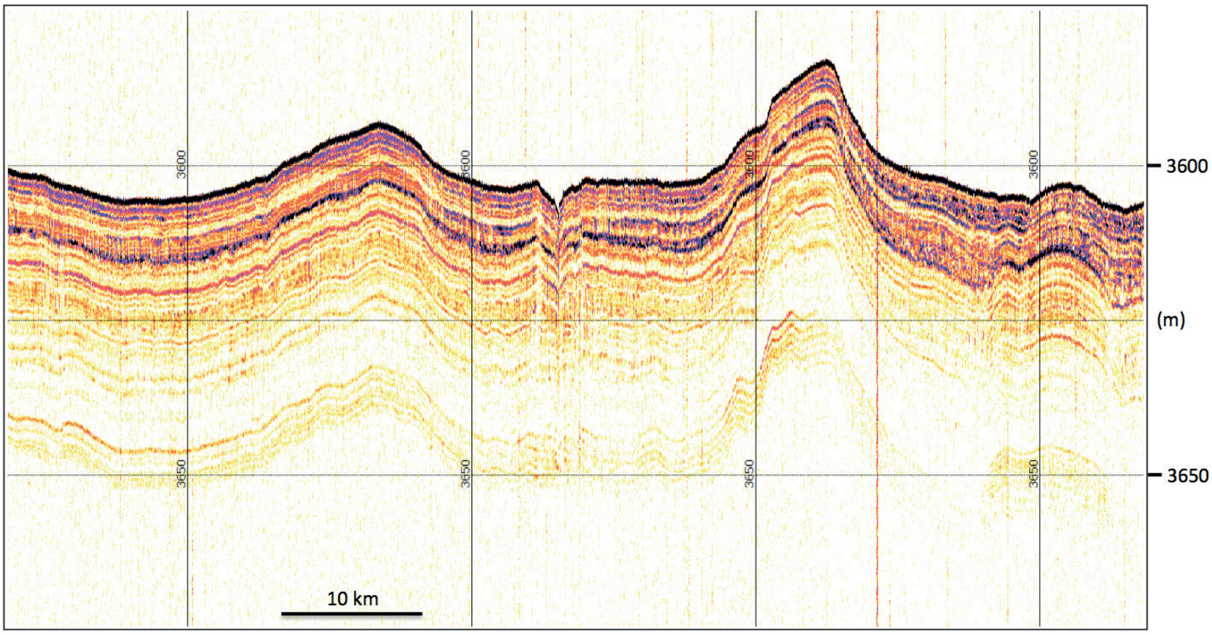

Fig. 9.1: Example of a Parasound record triggered by K-Syc recorded between 5.11.14, 22:00 UTC, and 6.11.14, 02:00 UTC north of the Cape Verde Island

Hydrosweep: The synchronisation capability of the swath sonar system can be switched on selecting “Transmission on request” in AHC basic settings for “Transmission sequence” and “Externally triggered – line 2” for “Trigger”. In trigger mode Hydrosweep runs as stable as usual. During epochs other sonar systems are triggered, Hydrosweep and Parastore are waiting for data and show timeout messages. When the next trigger was sent and a ping was shot, the panels change from red to green again. This seems not to have any effect on data quality and stability of the system but it continuously forces the operator to investigate the messages and to separate other and more harmful error messages.

Hydrosweep is not able to send “RTT” (Ready To Transmit) signal but “Transmit” signal only. So, the time point Hydrosweep has finished processing last ping and is ready to receive next trigger signal must be calculated. But as the slant ranges of outer beams vary due to changing swath angles, the setting for this calculation must be adjusted by the operator manually.

Teledyne ADCP: In the software “VmDas” operating the ADCP there is no button, checkbox or other selection possibility to switch on or off the trigger mode. To do so, the setting must be made by manually changing and loading command file. Two versions of this command file have been created to load recommended one.

ADCP is able to send RTT signal but unfortunately the system is not ready at that moment. As consequence the RTT signal is not used and hardware settings have been made to calculate the duration due to water depth applying a time offset of 1.3 seconds additionally.

Deep water sounder: The single beam deep sea echo sounder could robustly be triggered without problems. The sonar is not able to send “Transmit” or “RTT” signal.

EK60: The frequencies of Simrad EK60 sounder have been organized in two parts: 18 kHz transducer is linked to a KSync module, 38,70,120 and 200 kHz transducers are linked parallel to another module. 18 kHz transducer is sending “RTT” signal. As the signals of the other frequencies arrive at different times and would consequently be ready at different times, the “RTT” signal would lead to confusion. For that reason these transducers do not sent “Transmit” or “RTT” signal.

DShip: Depths measured by the sonar systems are archived in ships data management system DShip (nadir depths only but not all swath information). In DShip the sounders are ordered by priority and topmost running system is providing “system depth”. Due to triggering by synchronisation unit, the time intervals sending data is lowered and DShip is detecting a timeout. As the trigger sequences are adjusted due to changing scientific purpose, the intervals of incoming data vary as well. Until DShip is adjusted to avoid this problem, the continuous provision of system depth must be supervised by the IT system administrator.

The following example shows a trigger sequence of Hydrosweep, Parasound and EK60 where Hydrosweep and Parasound had been assigned a higher priority as can be seen in the table representing the synchronization sequence:

Tab. 9.1: Example of trigger sequence emphasizing seabed imaging

Echo sounder	Trigger group 1	Trigger group 2	Trigger group 3
Hydrosweep	X		X
Parasound	X		X
EK60 (18 kHz)		X	
(generic Z1)		X	

The Fig. 9.2 shows the resulting bathymetry profile, gridded with cell size of 40 meter. The gaps show the influence of interrupts for triggering the EK60 sounder.

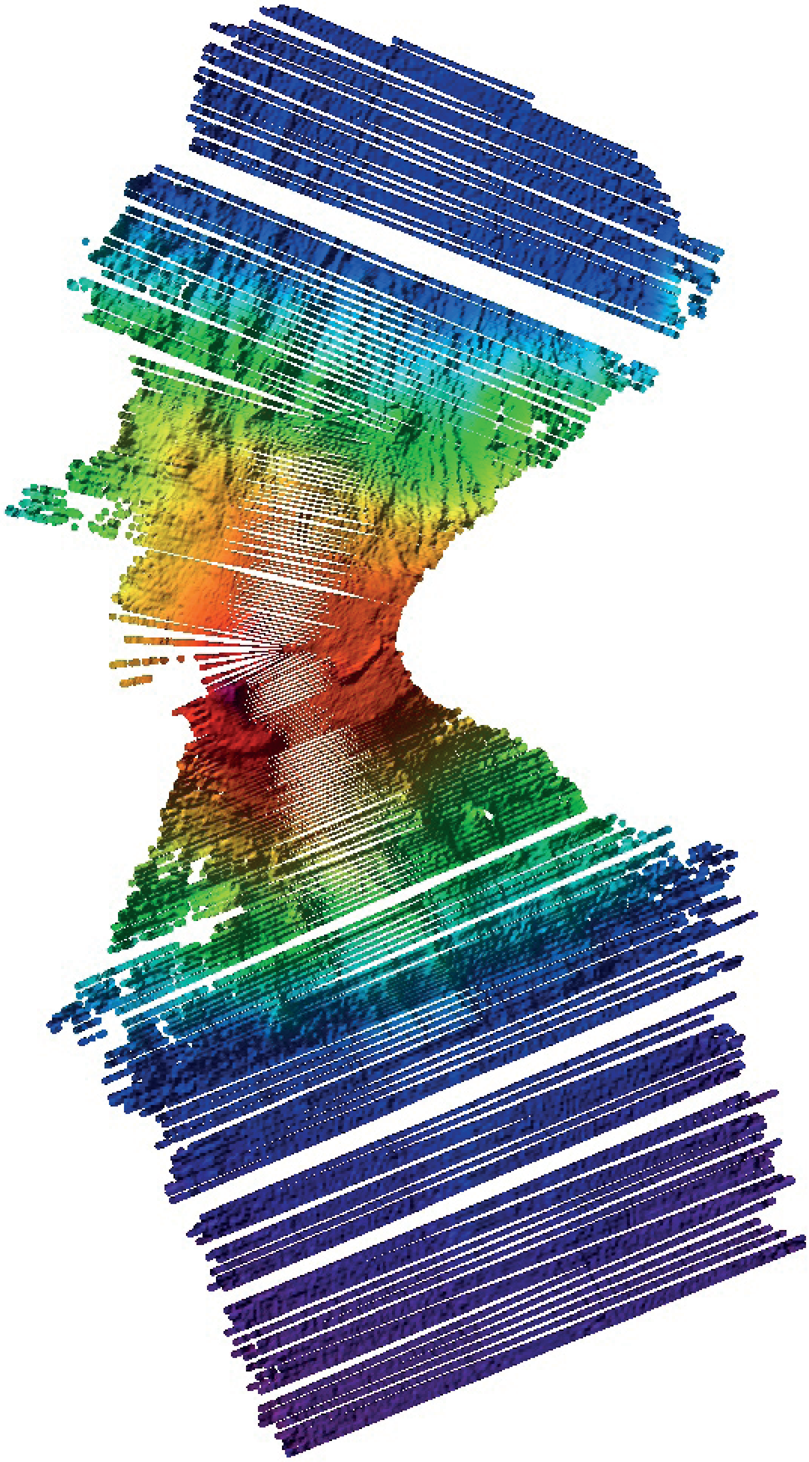

Fig. 9.2: Swath sonar profile across a seamount, while the sonar was triggered by synchronization unit.

Data management

No data for scientific purpose were recorded.

A.1 BETEILIGTE INSTITUTE / PARTICIPATING INSTITUTES

	Adresse /Address
AWI	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung Am Alten Hafen 26 27568 Bremerhaven Germany
CAU	Christian-Albrechts-Universität zu Kiel 24098 Kiel Germany
DESY	Deutsches Elektronen-Synchrotron DESY Zeuthen Platanenallee 6 15738 Zeuthen Germany
DWD	Deutscher Wetterdienst Bernhard-Nocht-Str. 76 20359 Hamburg Germany
ETH	ETH Zürich Rämistrasse 101 8092 Zürich Schweiz
GEOMAR	Helmholtz-Zentrum für Ozeanforschung Kiel Wischhofstraße 1 – 3 24148 Kiel Germany
KONGSBERG	Kongsberg Maritime Kirkegårdsveien 45 3616 Kongsberg Norway
NWP	Nort-West University Potchefstroom South Africa

	Adresse /Address
MPI-M	MPI-Meteorology Bundesstraße 53 20146 Hamburg Germany
RFL	Reederei F. Laeisz GmbH Brückenstr. 25 2752 Bremerhaven Germany
UNI-HB	Universität BremenW Bibliothekstraße 1 28359 Bremen Germany
WU	Wageningen University Droevendaalsesteeg 4 6708 PB Wageningen The Netherlands

A.2 FAHRTTEILNEHMER / CRUISE PARTICIPANTS

PS88.1 + PS88.2 Bremerhaven - Cape Town

No.	Name	Given Name	Institute	Profession	Discipline
1	Becker	Tobias	MPI-M	scientist	meteorology
2	Hempelt	Juliane	DWD	technician	meteorology
3	Krocker	Ralf	AWI	engineer	geo sciences
4	Miller	Max	DWD	scientist	meteorology
5	Stößl	Achim	Desy Zeuthen	scientist	physics

PS88.1 Bremerhaven - Las Palmas

No.	Name	Given Name	Institute	Profession	Discipline
6	Albers	Elmar	Uni-HB	student	geo sciences
7	Biller Teixeira	Tiago José	Uni-HB	student	geo sciences
8	Biskaborn	Boris	AWI	scientist	geo sciences
9	Blaise Ngundam	Ngwana	Uni-HB	student	geo sciences
10	Brückner	Nils	Uni-HB	student	geo sciences
11	da Silva	Mariucha	Uni-HB	scientist	geo sciences
12	Dorschel	Boris	AWI	scientist	geo sciences
13	Ehmen	Tobias	Uni-HB	student	geo sciences
14	Gatti	Susanne	AWI	scientist	bio sciences
15	Gebhard	Catalina	AWI	scientist	geo sciences
16	Hanfland	Claudia	AWI	scientist	geo sciences
17	Heinecke	Liv	AWI	PhD student	geo sciences
18	Heredia Barión	Pablo	AWI	PhD student	geo sciences
19	Klages	Johann Philipp	AWI	scientist	geo sciences
20	Klimm	Frederic	Uni-HB	student	geo sciences
21	Knust	Rainer	AWI	chief scientist	bio sciences
22	Kuhn	Gerhard	AWI	scientist	geo sciences
23	Lautenschläger	Olaf	KONGSBERG	engineer	electronics
24	Meyer	Vera Dorothee	AWI	PhD student	geo sciences
25	Monkenbusch	Johannes	Uni-HB	student	geo sciences
26	Radosavljevic	Boris	AWI	PhD student	geo sciences
27	Reusch	Anna-Lena	ETH	PhD student	geo sciences
28	Rippert	Nadine	AWI	PhD student	geo sciences
29	Ronge	Thomas	AWI	PhD student	geo sciences
30	Rösner	Alexander	Uni-HB	student	geo sciences
31	Schlegel	Rebecca	Uni-HB	student	geo sciences
32	Tanski	George	AWI	PhD student	geo sciences
33	Waßmuth	Saskia	Uni-HB	student	geo sciences
34	Wengler	Marc	AWI	PhD student	geo sciences

PS88.2 Las Palmas - Cape Town

No.	Name	Given Name	Institute	Profession	Discipline
6	Deppenmeier	Anna-Lena	WU	PhD student	meteorology
7	Fu	Yao	Geomar	PhD student	phy. oceanography
8	Hahn	Johannes	Geomar	scientist	phy. oceanography
9	Hahn	Tobias	Geomar	student	chemistry
10	Hanisch-Niessen	Sabine	AWI	scientist	geo sciences
11	Hauschildt	Jaard-Okke	Geomar	student	phy. oceanography
12	Kisjeloff	Boris	Geomar	technician	phy. oceanography
13	Klenz	Thilo	Geomar	student	phy. oceanography
14	Kopte	Robert	Geomar	PhD student	phy. oceanography
15	Krägefsky	Sören	AWI	scientist	bio sciences
16	Müller	Mario	Geomar	engineer	phy. oceanography
17	Niessen	Frank	AWI	chief scientist	geo sciences
18	Tuchen	Franz Philip	Geomar	student	phy. oceanography

A.3 SCHIFFSBESATZUNG / SHIP'S CREW

No.	Name	Rank
01.	Wunderlich, Thomas	Master
02.	Spielke, Steffen	1.Offc.
03.	Ziemann, Olaf	Ch.Eng.
04.	Lauber, Felix	2.Offc.
05.	Kentges, Felix	2.Offc.
06.	Hering, Igor	2.Offc.
07.	Spilok, Norbert	Doctor
08.	Hofmann, Jörg	Comm.Offc.German
09.	Schnürch, Helmut	2.Eng.
10.	Westphal, Henning	2.Eng.
11.	Rusch, Torben	2.Eng.
12.	Brehme, Andreas	Elec.Tech.
13.	Ganter, Armin	Electron.
14.	Dimmler, Werner	Electron.
15.	Winter, Andreas	Electron.
16.	Feiertag, Thomas	Electron.
17.	Schröter, Rene	Boatsw.
18.	Neisner,Winfried	Carpenter
19.	Clasen, Nils	A.B.
20.	Burzan, Gerd-Ekkehard	A.B.
21.	Schröder, Norbert	A.B.
22.	Moser, Siegfried	A.B.
23.	Hartwig-L., Andreas	A.B.
24.	Kretzschmar, Uwe	A.B.
25.	Müller, Steffen	A.B.
26.	Gladow, Lothar	A.B.
27.	Sedlak, Andreas	A.B.
28.	Beth, Detlef	Storekeep.
29.	Plehn, Markus	Mot-man
30.	Fritz, Günter	Mot-man
31.	Krösche, Eckard	Mot-man
32.	Dinse, Horst	Mot-man
33	Watzel, Bernhard	Mot-man

No.	Name	Rank
34.	Meißner, Jörg	Cook
35.	Tupy,Mario	Cooksmate
36.	Völske, Thomas	Cooksmate
37.	Luoto, Eija	1.Stwd.
38.	Westphal, Kerstin	Stwdss/KS
39.	Mack, Ulrich	2.Steward
40.	Hischke, Peggy	2.Stwdess
41.	Wartenberg, Irina	2.Stwdess
42.	Hu, Guo Yong	2.Steward
43	Chen, Quan Lun	2.Steward
44.	Ruan, Hui Guang	Laundrym.

A.4 STATIONSLISTE / STATION LIST PS88

Station	Date	Time	Gear	Action	Position Latitude	Position Longitude	Depth [m]
PS88/0001-1	28.10.2014	16:14:00	SVP	on ground/ max depth	46° 48,64' N	007° 24,66' W	4499
PS88/0002-1	04.11.2014	15:05:00	CTD/RO	on ground/ max depth	21° 12,63' N	021° 07,18' W	4221
PS88/0003-1	05.11.2014	08:55:00	GLD	on ground/ max depth	18° 59,68' N	022° 00,26' W	3447
PS88/0003-2	05.11.2014	11:11:00	CTD/RO	on ground/ max depth	18° 59,44' N	022° 00,40' W	3445
PS88/0004-1	06.11.2014	06:12:00	CTD/RO	on ground/ max depth	17° 35,05' N	024° 17,11' W	3597
PS88/0005-1	06.11.2014	09:04:59	MOR	on ground/ max depth	17° 36,20' N	024° 15,00' W	3597
PS88/0006-1	07.11.2014	07:23:00	CTD/RO	on ground/ max depth	13° 59,98' N	023° 02,01' W	4327
PS88/0007-1	07.11.2014	11:43:00	CTD/RO	on ground/ max depth	13° 30,02' N	023° 01,98' W	4526
PS88/0008-1	07.11.2014	15:51:00	CTD/RO	on ground/ max depth	13° 00,00' N	023° 02,02' W	4713
PS88/0009-1	07.11.2014	20:05:00	CTD/RO	on ground/ max depth	12° 30,08' N	023° 02,07' W	4897
PS88/0010-1	08.11.2014	00:27:00	CTD/RO	on ground/ max depth	11° 60,00' N	023° 01,84' W	5021
PS88/0011-1	08.11.2014	04:31:00	CTD/RO	on ground/ max depth	11° 29,96' N	023° 02,00' W	5088
PS88/0012-1	08.11.2014	08:55:00	CTD/RO	on ground/ max depth	11° 00,01' N	023° 02,02' W	5124
PS88/0012-2	08.11.2014	10:02:59	FLOAT	on ground/ max depth	11° 00,30' N	023° 01,89' W	5119
PS88/0013-1	08.11.2014	13:53:00	CTD/RO	on ground/ max depth	10° 30,00' N	023° 01,98' W	5153
PS88/0014-1	08.11.2014	19:21:00	CTD/RO	on ground/ max depth	10° 00,07' N	023° 02,05' W	5040
PS88/0015-1	08.11.2014	23:35:00	CTD/RO	on ground/ max depth	09° 30,10' N	023° 01,99' W	4463
PS88/0016-1	09.11.2014	03:50:00	CTD/RO	on ground/ max depth	08° 59,96' N	023° 01,77' W	4874
PS88/0017-1	09.11.2014	08:07:00	CTD/RO	on ground/ max depth	08° 30,10' N	023° 01,92' W	4757
PS88/0018-1	09.11.2014	12:32:00	CTD/RO	on ground/ max depth	08° 00,20' N	023° 01,85' W	4406
PS88/0019-1	09.11.2014	16:53:00	CTD/RO	on ground/ max depth	07° 30,01' N	023° 02,00' W	4386
PS88/0020-1	09.11.2014	21:07:00	CTD/RO	on ground/ max depth	06° 59,83' N	023° 02,04' W	2044
PS88/0021-1	10.11.2014	01:22:00	CTD/RO	on ground/ max depth	06° 30,04' N	023° 01,99' W	3205
PS88/0022-1	10.11.2014	04:12:00	HS_PS	profile start	06° 09,00' N	023° 10,40' W	3868
PS88/0022-1	10.11.2014	04:55:59	HS_PS	profile end	06° 02,06' N	023° 13,09' W	2224

Station	Date	Time	Gear	Action	Position Latitude	Position Longitude	Depth [m]
PS88/0023-1	10.11.2014	06:00:00	CTD/RO	on ground/ max depth	06° 02,10' N	023° 12,99' W	2274
PS88/0023-2	10.11.2014	07:13:00	CAL POS	in the water	06° 02,11' N	023° 23,00' W	2278
PS88/0023-2	10.11.2014	14:19:59	CAL POS	on deck	06° 02,00' N	023° 13,00' W	2282
PS88/0024-1	10.11.2014	15:19:00	HS_PS	profile start	06° 02,54' N	023° 12,97' W	2603
PS88/0024-1	10.11.2014	16:43:59	HS_PS	profile end	05° 49,39' N	023° 09,76' W	4201
PS88/0025-1	10.11.2014	19:26:00	CTD/RO	on ground/ max depth	05° 30,02' N	023° 01,99' W	4224
PS88/0026-1	11.11.2014	00:35:00	CTD/RO	on ground/ max depth	04° 59,99' N	023° 01,96' W	4216
PS88/0026-1	11.11.2014	00:36:00	CTD/RO	hoisting	04° 59,99' N	023° 01,96' W	4216
PS88/0026-1	11.11.2014	02:02:59	CTD/RO	on deck	05° 00,04' N	023° 01,95' W	4216
PS88/0027-1	11.11.2014	05:13:00	CTD/RO	in the water	04° 29,98' N	023° 00,03' W	4112
PS88/0027-1	11.11.2014	06:37:00	CTD/RO	on ground/ max depth	04° 30,03' N	022° 60,00' W	4111
PS88/0028-1	11.11.2014	12:34:00	CTD/RO	on ground/ max depth	04° 00,01' N	023° 01,99' W	4183
PS88/0028-2	11.11.2014	14:08:59	FLOAT	on ground/ max depth	03° 59,93' N	023° 01,94' W	4181
PS88/0029-1	11.11.2014	18:43:00	CTD/RO	on ground/ max depth	03° 30,01' N	022° 59,99' W	4373
PS88/0030-1	12.11.2014	00:59:00	CTD/RO	on ground/ max depth	03° 00,01' N	023° 00,02' W	4627
PS88/0031-1	12.11.2014	07:13:00	CTD/RO	on ground/ max depth	02° 30,00' N	022° 59,98' W	4624
PS88/0032-1	12.11.2014	13:21:00	CTD/RO	on ground/ max depth	01° 59,98' N	023° 00,03' W	4322
PS88/0033-1	12.11.2014	18:19:00	CTD/RO	on ground/ max depth	01° 40,01' N	023° 00,05' W	4113
PS88/0034-1	12.11.2014	23:23:00	CTD/RO	on ground/ max depth	01° 20,01' N	023° 00,02' W	4699
PS88/0035-1	13.11.2014	04:12:00	CTD/RO	on ground/ max depth	00° 59,98' N	022° 60,00' W	3228
PS88/0036-1	13.11.2014	08:45:00	CTD/RO	on ground/ max depth	00° 40,02' N	023° 00,01' W	3897
PS88/0036-2	13.11.2014	10:14:59	FLOAT	on ground/ max depth	00° 39,80' N	023° 00,04' W	
PS88/0037-1	13.11.2014	13:44:00	CTD/RO	on ground/ max depth	00° 20,02' N	023° 00,01' W	3915
PS88/0038-1	13.11.2014	18:31:00	CTD/RO	on ground/ max depth	00° 00,02' N	023° 01,99' W	3948
PS88/0039-1	13.11.2014	23:43:00	CTD/RO	on ground/ max depth	00° 19,98' S	023° 00,03' W	4601
PS88/0040-1	14.11.2014	04:50:00	CTD/RO	on ground/ max depth	00° 39,99' S	023° 00,01' W	3570
PS88/0041-1	14.11.2014	09:41:00	CTD/RO	on ground/ max depth	00° 59,99' S	023° 00,03' W	4106

Station	Date	Time	Gear	Action	Position Latitude	Position Longitude	Depth [m]
PS88/0042-1	14.11.2014	14:59:00	CTD/RO	on ground/ max depth	01° 20,00' S	022° 59,98' W	4821
PS88/0043-1	14.11.2014	20:35:00	CTD/RO	on ground/ max depth	01° 39,96' S	023° 00,00' W	4896
PS88/0044-1	15.11.2014	02:08:00	CTD/RO	on ground/ max depth	01° 59,96' S	022° 60,00' W	5193
PS88/0045-1	17.11.2014	16:22:00	CAL EK60	in the water	07° 54,58' S	014° 25,23' W	35
PS88/0045-1	18.11.2014	00:45:59	CAL EK60	on deck	07° 54,58' S	014° 25,22' W	34
PS88/0046-1	19.11.2014	11:04:59	FLOAT	on ground/ max depth	12° 03,84' S	010° 00,38' W	3933
PS88/0047-1	20.11.2014	18:09:00	CAL EK60	in the water	15° 54,56' S	005° 45,34' W	926
PS88/0047-1	21.11.2014	00:18:59	CAL EK60	on deck	15° 52,63' S	005° 44,55' W	802
PS88/0048-1	22.11.2014	13:57:59	FLOAT	on ground/ max depth	18° 29,94' S	000° 04,03' E	5537
PS88/0049-1	24.11.2014	07:28:00	MOR	action	20° 58,30' S	005° 59,11' E	4236
PS88/0049-1	24.11.2014	11:35:59	MOR	on deck	20° 57,68' S	005° 57,20' E	4247
PS88/0050-1	25.11.2014	10:15:59	FLOAT	on ground/ max depth	23° 59,96' S	007° 59,96' E	4675
PS88/0051-1	27.11.2014	07:14:59	FLOAT	on ground/ max depth	30° 42,75' S	013° 13,24' E	3180

Die **Berichte zur Polar- und Meeresforschung** (ISSN 1866-3192) werden beginnend mit dem Band 569 (2008) als Open-Access-Publikation herausgegeben. Ein Verzeichnis aller Bände einschließlich der Druckausgaben (ISSN 1618-3193, Band 377-568, von 2000 bis 2008) sowie der früheren **Berichte zur Polarforschung** (ISSN 0176-5027, Band 1-376, von 1981 bis 2000) befindet sich im electronic Publication Information Center **(ePIC)** des Alfred-Wegener-Instituts, Helmholtz-Zentrum für Polar- und Meeresforschung (AWI); see http://epic.awi.de. Durch Auswahl "Reports on Polar- and Marine Research" (via "browse"/"type") wird eine Liste der Publikationen, sortiert nach Bandnummer, innerhalb der absteigenden chronologischen Reihenfolge der Jahrgänge mit Verweis auf das jeweilige pdf-Symbol zum Herunterladen angezeigt.

The **Reports on Polar and Marine Research** (ISSN 1866-3192) are available as open access publications since 2008. A table of all volumes including the printed issues (ISSN 1618-3193, Vol. 377-568, from 2000 until 2008), as well as the earlier **Reports on Polar Research** (ISSN 0176-5027, Vol. 1-376, from 1981 until 2000) is provided by the electronic Publication Information Center **(ePIC)** of the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI); see URL http://epic.awi.de. To generate a list of all Reports, use the URL http://epic.awi.de and select "browse"/ "type" to browse "Reports on Polar and Marine Research". A chronological list in declining order will be presented, and pdf-icons displayed for downloading.

Zuletzt erschienene Ausgaben:

Recently published issues:

696 (2016) The Expedition PS88 of the Research Vessel POLARSTERN to the Atlantic Ocean in 2014, edited by Rainer Knust and Frank Niessen

695 (2016) The Expedition PS93.1 of the Research Vessel POLARSTERN to the Greenland Sea and the Fran Strait in 2015, edited by Ruediger Stein

694 (2016) The Expedition PS92 of the Research Vessel POLARSTERN to the Arctic Ocean in 2015, edited by Ilka Peeken

693 (2015) The Expedition PS93.2 of the Research Vessel POLARSTERN to the Fram Strait in 2015, edited by Thomas Soltwedel

692 (2015) Antarctic Specific Features of the Greenhouse Effect: A Radiative Analysis Using Measurements and Models by Holger Schmithüsen

691 (2015) Krill in the Arctic and the Atlantic Climatic Variability and Adaptive Capacity by Lara Kim Hünerlage

690 (2015) High latitudes and high mountains: driver of or driven by global change? 26th Intern. Congress on Polar Research, 6 – 11 September 2015, Munich, Germany, German Society for Polar Research, edited by Eva-Maria Pfeiffer, Heidemarie Kassens, Christoph Mayer, Mirko Scheinert, Ralf Tiedemann and Members of the DGP Advisory Board

689 (2015) The Expedition PS89 of the Research Vessel POLARSTERN to the Weddell Sea in 2014/2015, edited by Olaf Boebel

688 (2015) The Expedition PS87 of the Research Vessel POLARSTERN to the Arctic Ocean in 2014, edited by Rüdiger Stein

687 (2015) The Expedition PS85 of the Research Vessel POLARSTERN to the Fram Strait in 2014, edited by Ingo Schewe

686 (2015) Russian-German Cooperation CARBOPERM: Field campaigns to Bol'shoy Lyakhovsky Island in 2014, edited by Georg Schwamborn and Sebastian Wetterich

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG

BREMERHAVEN

Am Handelshafen 12
27570 Bremerhaven
Telefon 0471 4831-0
Telefax 0471 4831-1149
www.awi.de

HELMHOLTZ
GEMEINSCHAFT