Berichte
zur Polar-
und Meeresforschung

646
2012

Reports
on Polar and Marine Research

The Expedition of the Research Vessel "Polarstern" to the Antarctic in 2011/12 (ANT-XXVIII/2)

Edited by
Gerhard Kattner
with contributions of the participants

HELMHOLTZ
GEMEINSCHAFT

ALFRED-WEGENER-INSTITUT FÜR
POLAR- UND MEERESFORSCHUNG
in der Helmholtz-Gemeinschaft
D-27570 BREMERHAVEN
Bundesrepublik Deutschland

ISSN 1866-3192

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* Anschrift / Address
Alfred-Wegener-Institut
für Polar- und Meeresforschung
D-27570 Bremerhaven
Germany
www.awi.de

Editor:
Dr. Horst Bornemann

Assistant editor:
Birgit Chiaventone

Die "Berichte zur Polar- und Meeresforschung" (ISSN 1866-3192) werden ab 2008 als Open-Access-Publikation herausgegeben (URL: http://epic.awi.de).

Since 2008 the "Reports on Polar and Marine Research" (ISSN 1866-3192) are available as open-access publications (URL: http://epic.awi.de)

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Please cite or link this publication using the identifier
hdl:10013/epic. 39675 or http://hdl.handle.net/10013/epic.39675

ISSN 1866-3192

ANT-XXVIII/2

3 December 2011 – 5 January 2012

Cape Town - Cape Town

Chief scientist
Gerhard Kattner

Coordination
Eberhard Fahrbach

Contents

1. ZUSAMMENFASSUNG UND FAHRTVERLAUF

Gerhard Kattner
Alfred-Wegener-Institut

Der Fahrtabschnitt ANT-XXVIII/2 begann am 3. Dezember 2011 in Kapstadt (Südafrika) und endete am 5. Januar 2012 wieder in Kapstadt (Abb. 1.1). 24 CTD-Stationen mit Wasserprobenahmen wurden überwiegend entlang des Greenwich-Meridians auf der Fahrt zur Neumayer-Station III und zurück durchgeführt. Die ozeanographischen Arbeiten ergänzen langfristige Datensätze zur Untersuchung der antarktischen Wassermassen. Am 5. und 7. Dezember wurden zwei Verankerungen (PIES, Pressure Inverted Echosounder), die für die Untersuchung des Strömungssystems des Antarktischen Zirkumpolarstroms am Meeresboden Messungen durchführen, ausgebracht bzw. aufgenommen. Die Aufnahme eines weiteren PIES am 8. Dezember war leider erfolglos. Die PIES messen alle 30 Minuten mit hoher Genauigkeit den Wasserdruck sowie die Laufzeit eines Schallsignals vom Boden bis zur Oberfläche und zurück. Aus den Druckunterschieden zwischen mehreren PIES an verschiedenen Positionen werden die Änderungen der Strömungsgeschwindigkeit berechnet. Die Schalllaufzeit ist abhängig von der Schallgeschwindigkeit, die wiederum von der Wassertemperatur beeinflusst wird. So kann man Aussagen zur Temperatur in der gesamten Wassersäule machen. Der Transport und die Temperatur im Antarktischen Zirkumpolarstrom (ACC) sind von besonderem Interesse, da der ACC als größte Meeresströmung weltweit alle Ozeane verbindet. Der ACC spielt für die Ausbreitung von Tiefenwasser und den Wärmetransport aus niederen Breiten in die Antarktis eine entscheidende Rolle.

Am 12. Dezember nachmittags hatten wir uns dem Eisrandgebiet genähert bei Wasser- und Lufttemperaturen von unter minus einem Grad. Am 13. Dezember waren wir dann richtig im Eis, das jedoch noch sehr dünn und von großen offenen Wasserflächen unterbrochen war. Die MARU-Verankerung (Marine Autonomous Recording Unit), die akustische Signale, Geräusche von Tieren (Wale, Robben) und Eisbergen aufzeichnet, sollte am 14. Dezember geborgen werden. Die Aufnahme wurde aber wegen zu starker Eisbedeckung vorschoben. Eine Aufnahme war dann auf der Rückfahrt nach Kapstadt am 26. Dezember ebenfalls nicht möglich, da die Verankerung auf die Auslösesignale nicht reagierte.

Die Neumayer-Station III auf dem antarktischen Schelfeis wurde vom 17. bis 22. Dezember versorgt. Kurz vor der Versorgung kam es bei einem Flug zur Erborung von Eiskernen in der Atkabucht zu einem Hubschrauberunfall. Beim Rückflug zur *Polarstern* hatten sich die Wetterbedingungen so verschlechtert, dass bei einem „Whiteout" beide Hubschrauber Bodenberührung hatten und verunglückten. Glücklicherweise gab es nur Leichtverletzte, aber beide Hubschrauber waren danach nicht mehr einsatzfähig. Wegen des weiterhin schlechten Wetters mit Windstärken um die 8 Bft und Schneeschauern blieben alle zunächst auf der Station, wurden dort hervorragend und professionell versorgt und dann am 19. Dezember zurück zur *Polarstern* gebracht. Währenddessen musste *Polarstern* zunächst einen ca.

200 m breiten Meereisstreifen vor der Schelfeiskante wegbrechen, bevor sie dort anlegen konnte. Nach dem Anlegen begannen sofort die Versorgungsarbeiten. Container wurden auf die Schelfeiskante gestellt, Tankcontainer befüllt und mit den Pistenbullys zur Station gefahren oder auch von dort zum Schiff gebracht.

Am 22. Dezember waren alle Versorgungsarbeiten beendet. Danach ging es wieder Richtung Norden zurück zum Greenwich-Meridian. Am 24. Dezember wurden die Arbeiten für die gemeinsame Weihnachtsfeier unterbrochen. Am 27. Dezember fuhren wir noch die ganze Zeit durch lang gezogene Eisfelder und vervollständigten unser Stationsprogramm Richtung Norden. Die letzte CTD-Station fand am 30. Dezember statt, und danach wurde noch ein Continuous Plankton Recorder bis zum 4. Januar geschleppt.

Südlich von 53°S wurden parallel zu den CTD Stationen regelmäßig an ca. 16 Positionen die Hand- und Multinetze für das Sammeln von Phyto- und Zooplanktonproben eingesetzt. Die Zooplanktonarbeiten befassten sich überwiegend mit den Überwinterungsstrategien von Copepoden, die während des Frühjahrs und Sommers aus der Tiefe, in der sie in einer Art Diapause überwintern, in die oberen Wasserschichten aufsteigen. Die Copepoden, winzige Zooplankter von 1 bis 10 mm Länge, sind sehr wichtige Glieder des Nahrungsnetzes und können 80 % der Zooplanktonbiomasse ausmachen. Die beiden dominanten antarktischen Copepodenarten, *Calanus propinquus* and *Calanoides acutus*, ernähren sich hauptsächlich vom Phytoplankton. Sie müssen daher mit dem Nahrungsmangel während der langen und dunklen Jahreszeit in der Antarktis zurechtkommen, wenn Algen nicht wachsen können. Sie haben sich in ihren Lebensstrategien in sehr unterschiedlicher Weise angepasst. *Calanoides acutus* wandert im Herbst in große Tiefen von über 1000 m und überdauert den Winter in einem extrem energiesparenden Ruhestadium, genannt Diapause. Im Gegensatz dazu bleibt *Calanus propinquus* während des Winters oberhalb von 500 m aktiv und wechselt von Algennahrung im Sommer zu einer vielfältigeren Nahrung im Winter. Beide Arten speichern große Fettreserven (Energiespeicher), die sich jedoch in der Zusammensetzung deutlich unterscheiden. Ein weiteres Ziel war die Untersuchungen der Mechanismen, die die Diapause kontrollieren und den Auftrieb der Copepoden regulieren.

Die Phytoplanktonarbeiten konzentrierten sich auf das Auftreten von Diatomeen in der Wassersäule und im Meereis, um deren geographische Verbreitung zu untersuchen sowie die Hustedt Diatomeen Sammlung zu ergänzen. Dafür wurden an den CTD-Stationen Proben mit Planktonnetzen und den Niskinschöpfern genommen. Es werden RNA und DNA Untersuchungen durchgeführt und mit begleitenden Bestimmungen wie Chlorophyllgehalt, Temperatur und Salzgehalt korreliert. Das Sammeln von Meereisproben war jedoch wegen der bereits stark angetauten Eisschollen und der häufig schlechten Wetterbedingungen kaum möglich.

Wasserproben wurden auch regelmäßig für die mikrobiologisch-chemischen Projekte genommen, die sich mit dem Bakterioplankton befassten, insbesondere dem *Roseobacter* Stamm, der eine wichtige Rolle in der globalen Verteilung der marinen Bakterien spielt. Die Verbreitung, Häufigkeit und Aktivität von Bakterien der *Roseobacter*-Gruppe soll in den verschiedenen Wassermassen von den Subtropen bis zum Antarktischen Küstenstrom zu erfasst werden. *Roseobacter*-Arten wurden aus den unterschiedlichen Wassermassen isoliert und kultiviert, um ihre Wachstumsbedingungen zu charakterisieren. Da Bakterien in diesen sehr kalten Gebieten nur sehr langsam wachsen, müssen die Versuche bei den Originaltemperaturen über mehrere Monate durchgeführt werden, und werden daher auf den weiteren Fahrtabschnitten fortgesetzt. Ebenfalls an Bord wurden die Anzahl der Bakterien sowie die bakterielle Produktion gemessen. Anhand konservierter Proben werden die *Roseobacter*-Bakterien später im heimischen Labor weiter untersucht.

Bestimmte Bakterien dieser Gruppe spielen wahrscheinlich eine wichtige Rolle beim Umsatz des gelösten organischen Materials und haben somit eine globale Bedeutung für marine Stoffkreisläufe. Daher wurden gleichzeitig Proben für die Bestimmung der chemischen Zusammensetzung des gelösten organischen Materials (DOM) genommen und das DOM angereichert. Mittels ultra-hochauflösender Massenspektrometrie wird das DOM chemisch charakterisiert und mit der Bakteriengemeinschaft, insbesondere mit den Bakterien der *Roseobacter*-Gruppe, korreliert. Durch die Kombination dieser unterschiedlichen Untersuchungsmethoden soll bestimmt werden, warum die *Roseobacter*-Bakterien eine so wichtige Rolle im Ozean spielen.

Walbeobachtungen und -zählungen wurden vom Schiff und Hubschrauber aus durchgeführt, wenn immer die Wetterbedingungen es zuließen. Während der gesamten Fahrtstrecke wurden auch von der Brücke aus Vögel, Wale und Robben bestimmt und gezählt. Die Daten sollen dazu dienen, Maßnahmen zum Schutz der Wale zu unterstützen. Diese Arbeiten standen in engem Zusammenhang mit dem MAPS-Projekt, in dem kontinuierlich thermographische Bilder aufgenommen werden. Mit diesen Daten sollen Mustererkennungsalgorithmen zur automatischen Detektion von Walen entwickelt werden. Während der gesamten Fahrt wurden Anzahl und Verteilung der Wale vom Krähennest aus bestimmt, mit dem Hubschrauber leider nur bis zur Neumayer-Station III, da danach die Hubschrauber wegen des Unfalls nicht mehr einsatzfähig waren. Verschiedene Bartenwalarten, wie der Buckel-, Finn- und Antarktischer Zwergwal sowie Delfine und seltene Schnabelwale wurden beobachtet. Eine ganz besonders interessante Sichtung war eine Gruppe von Südlichen Entenwalen, die sehr tief im Packeis vom Helikopter aus beobachtet wurde.

Neben den Walbeobachtungen wurden auch die Vögel systematisch erfasst. Von Kapstadt bis zur Neumayer-Station III und zurück wurden ca. 52 Vogelarten beobachtet und insgesamt 9072 Vögel gezählt. Unter den Robben waren erwartungsgemäß die Krabbenfresserrobben am häufigsten vertreten. Seeleoparden wurden nur dreimal gesehen.

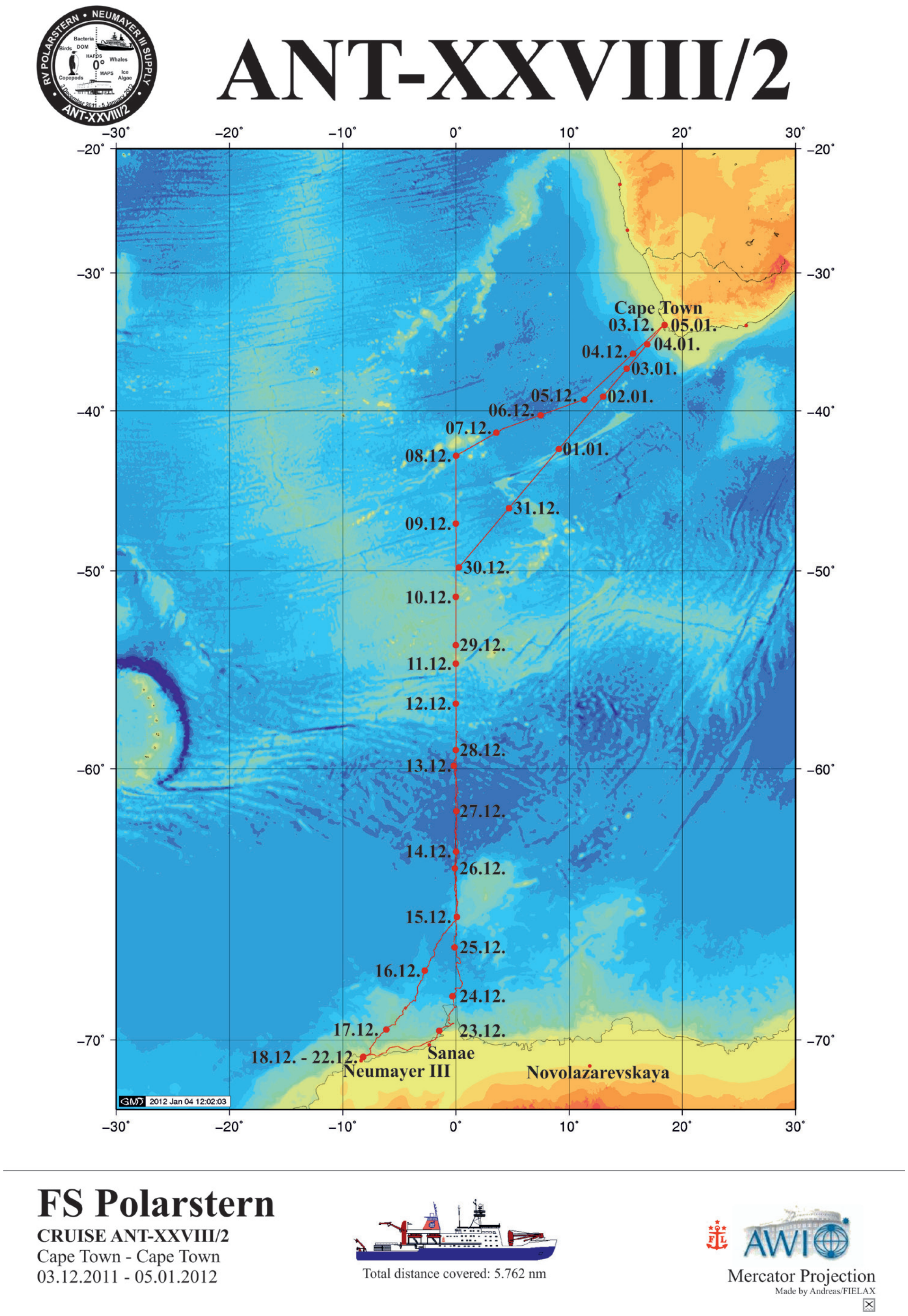

Abb. 1.1: Kurskarte der Polarstern Reise ANT-XXVIII/2
Fig. 1.1: Cruise track of RV Polarstern during the expedition ANT-XXVIII/2

SUMMARY AND ITINERARY

The cruise leg ANT-XXVIII/2 started in Cape Town (South Africa) on 3 December 2011 and ended on 5 January 2012 again in Cape Town (Fig. 1.1). 24 CTD and water sampling stations were performed mostly along the Greenwich meridian from Cape Town to the Neumayer Station III and back. The oceanographic program prolonged the time series of regular hydrographic surveys studying the Antarctic water masses. Two moorings (PIES, Pressure Inverted Echosounder), which are located at the sea floor to determine the properties of the Antarctic Circumpolar Current (ACC), were deployed and recovered on 5 and 7 December, respectively. The recovery of another PIES on 8 December failed unfortunately. The PIES measure the water pressure with high accuracy every 30 minutes, as well as the travel time of an acoustic signal from the PIES to the sea surface and back. From pressure differences between two PIES at different locations, one can calculate changes of the current velocity. Furthermore, the acoustic travel time depends on sound speed, which is influenced by the water temperature. Hence it is possible to assess the water temperature of the entire water column with a single instrument at the seafloor. The ACC is the largest oceanic current worldwide and connects all three oceans. Therefore the transport and temperature of the ACC are of particular interest. The dynamics of the ACC plays a critical role for the spreading of deep water masses and for the meridional heat transport from lower latitudes to Antarctica.

On 12 December we swiftly approached the marginal ice zone at water and air temperatures below -1°C. On 13 December we were surrounded by ice, but it was still very thin and often interrupted by large open leads. The MARU mooring (Marine Autonomous Recording Unit), which recorded acoustic signals, sounds of animals (whales, seals) and icebergs, should be recovered on 14 December. However, the recovery of the MARU had to be postponed because large ice floes covered the spot. The second attempt on 26 December also failed because the mooring did not respond to the release signal.

The German Neumayer Station III on the Antarctic ice shelf was supplied from 17 to 22 December. Just before the Neumayer supply started a helicopter accident happened during a flight to collect ice cores in the Atka Bay. During the return to *Polarstern* the weather became extremely bad and in a whiteout situation both helicopters touched the bottom and were damaged. Fortunately, the passengers were only slightly injured but both helicopters were not anymore operational. Due to the continuously bad weather with wind forces around 8 Bft and snow showers, all passengers stayed at the station until 19 December, when we were transported back to *Polarstern*. During this time *Polarstern* had to break a ca. 200 m wide area covered with ice in front of the shelf ice before she could dock at the ice shelf edge. The Neumayer supply started immediately. Containers were lifted on the ice, tank containers were filled and everything was transported to the station or back from the station to the ship.

On 22 December we had finished the supply work and started to continue the scientific program northward back to the Greenwich meridian. On 24 December the work was interrupted to celebrate the Christmas Eve. On 27 December we still passed extensive ice fields and completed our station program towards the North. The last CTD station was performed on 30 December, and thereafter we towed a continuous plankton recorder until 4 January.

South of 53°S zooplankton and phytoplankton were regularly collected with multinets and handnets at about 16 stations. The zooplankton studies focused on overwintering strategies of copepods. During spring and early summer copepods ascent to the surface layer from depth where they overwinter in a diapause. Copepods, tiny crustaceans between 1 and 10 mm length, are very important members of the food web comprising up to 80 % of the zooplankton biomass. The two dominant Antarctic, algae-eating copepod species, *Calanus propinquus* and *Calanoides acutus*, have to cope with extended periods of food shortage during the long and dark winter season, when phytoplankton algae cannot grow. However, their life-cycle strategies and adaptations differ substantially. *Calanoides acutus* descends to great depths of more than 1000 m in autumn and survives the winter time in an inactive state called diapause. In contrast, *Calanus propinquus* remains active during winter and switches from its algae-based summer diet to a wider food spectrum in winter. Both species accumulate large fat reserves, although of different chemical compositions. Another topic was to study the buoyancy regulation of copepods.

The phytoplankton studies addressed the abundance of diatoms in the water column and in sea ice to improve the biogeographic records and the culture collection of the Hustedt Diatom Study Centre. Therefore, samples were collected at the CTD stations with plankton nets and from Niskin bottles. RNA and DNA studies will be performed for the molecular ecological characterization accompanied by physical-biological meta-data (temperature, salinity, pH and chlorophyll profiles). The collection of sea ice samples was however almost impossible because the ice floes were thin and rotten due to increasing summer melting.

Water samples were regularly taken at the CTD stations for the microbiological and chemical projects to study bacterioplankton focused on the *Roseobacter* clade which plays an important role in the global distribution of marine bacteria. The distribution, abundance and activity were studied as well as its influence on the dissolved organic matter (DOM). In the home lab DOM will be chemically characterized to detect relations between bacterioplankton and DOM. The *Roseobacter* clade will be studied in the different water masses from the subtropics to the Antarctic Coastal Current. Efforts were made to isolate and culture bacteria of this clade to specify their growth conditions. In general, bacteria grow very slowly at low temperatures. Therefore, the samples were kept at *in-situ* temperatures in the cold room on board *Polarstern* for several months, and the work will be continued during the next legs. In addition, total bacterial abundance and turnover rates were measured on board. Upon arrival at the home labs preserved samples of the *Roseobacter* clade will be studied in more detail.

Bacteria within this clade may occur in high densities in marine surface waters of polar and temperate regions and thus may play an important role in the turnover of DOM and the global cycling of carbon and nutrients in the oceans. Samples were taken in parallel to determine the composition of DOM. With ultra-high resolution mass spectrometry DOM will be characterized and compared to the bacterioplankton community composition. Using such a multiple approach, we hope to better understand, why the *Roseobacter* bacteria are so successful in their environment.

Whale observations and counting of sightings were performed from the ship and by helicopters whenever the weather situation allowed. During the entire cruise birds and mammals were identified and counted from the ship's bridge. The data are important to support the protection of whales. These studies were in close connection with the MAPS project, an automatic whale detection system on the basis of thermographic images. The goal is to develop algorithms for this detection of whales. During the entire cruise whales were determined from the crow's nest; by helicopters, however, only until Neumayer because of the helicopter accident. Various baleen whales, like humpback, fin or Antarctic Minke whales, could be observed, and also dolphins and rare beaked whales. The observation of a group of Southern beaked whales, sighted from the helicopter far inside the pack ice, was particularly interesting.

Parallel to whale observations, birds were systematically monitored. During the entire cruise about 52 species were determined with a total of 9,072 birds. Apart from the birds, seals were also counted. As expected, crabeater seals were most abundant, whereas leopard seals were only seen three times.

2. WEATHER CONDITIONS

Max Miller, Hartmut Sonnabend
Deutscher Wetterdienst

At the beginning of December a subtropical high was the dominating feature in Cape Town. Additionally, a small low over the western part of South Africa caused strong south-easterly wind, the well known “Cape Doctor”. On Saturday evening, 3 December 2011, RV *Polarstern* left Cape Town at 8 to 9 Bft from southeast. Travelling only a short distance the wind abated to 4 Bft caused by a mountain effect. A short time later the wind increased just as fast up to 9 to 10 Bft again. Additionally, we observed a swell of 4 m. As expected, wind and swell decreased as we departed from the continent.

RV *Polarstern* first approached the subtropical high and the wind abated more and more. But the high weakened and the frontal zone spread to north a bit. On 6 Dec., the approaching warm front of a low at 67°S 25°W caused increasing south-westerly wind up to 8 Bft. Until 8 Dec., wind from southwest to west remained at 7 to 8 Bft but the swell did not exceed 4 m. Meanwhile we had reached the Greenwich meridian on which we headed south.

After a short period of high pressure influence a new front crossed our area on 12 Dec. Wind from west to northwest increased up to 8 Bft for a short while. We almost reached the edge of sea ice (at 58°S) and therefore, the swell was clearly dampened. The next days on our way south we mostly operated in the central area of a widespread low. Temporarily we measured only light and variable wind.

On 17 Dec. we approached the Antarctic continent and helicopter flights to destination “Neumayer” became possible. In the morning both helicopters started for a first flight. But from the east a new low approached and deterioration in the weather was forecasted for late afternoon. The second flight of both helicopters finally ended with an incident.

On 18 Dec. we observed easterly wind at 7 Bft and RV *Polarstern* broke the ice in front of the shelf ice to get a suitable berth. As forecasted the weather improved on 19 Dec. Until 22 Dec. the unloading for “Neumayer” could be done at light winds and partly sunny skies.

In the evening of 22 Dec. RV *Polarstern* left the ice shelf and headed for the Greenwich meridian along the Antarctic coast. At first only light and variable wind was observed, but stormy weather was forecasted for Christmas. A strong low with a central pressure of less than 950 hPa at 61°S 21°W slowly moved southeast. On Christmas Eve wind from east to northeast increased and reached its maximum on Christmas Day at 8 Bft.

During the night to 26 Dec. we crossed the above mentioned storm on our way north. The wind from southeast abated temporarily to 4 Bft and increased again in the morning of Boxing Day up to 7 Bft while veering west to northwest.

Until 28 Dec. we still operated at the northern edge of the weakening storm located at the Greenwich meridian and 68°S. Small secondary lows caused a variation of the north-westerly wind between 5 and 7 Bft. In addition, we slowly left the sea ice and noticeable swell started.

During the return journey to Cape Town we had to cross the west wind zone. By starting with a relative high speed RV *Polarstern* could avoid the centre of a strong storm. Only for short times we measured Bft 9 and the swell did not exceed 6 m. On Thursday morning, 5 Jan 2012 we reached Cape Town on schedule at moderate wind around south.

Details on the distribution of wind forces, directions, wave heights and ceiling are presented below in Fig. 2.1 to 2.4.

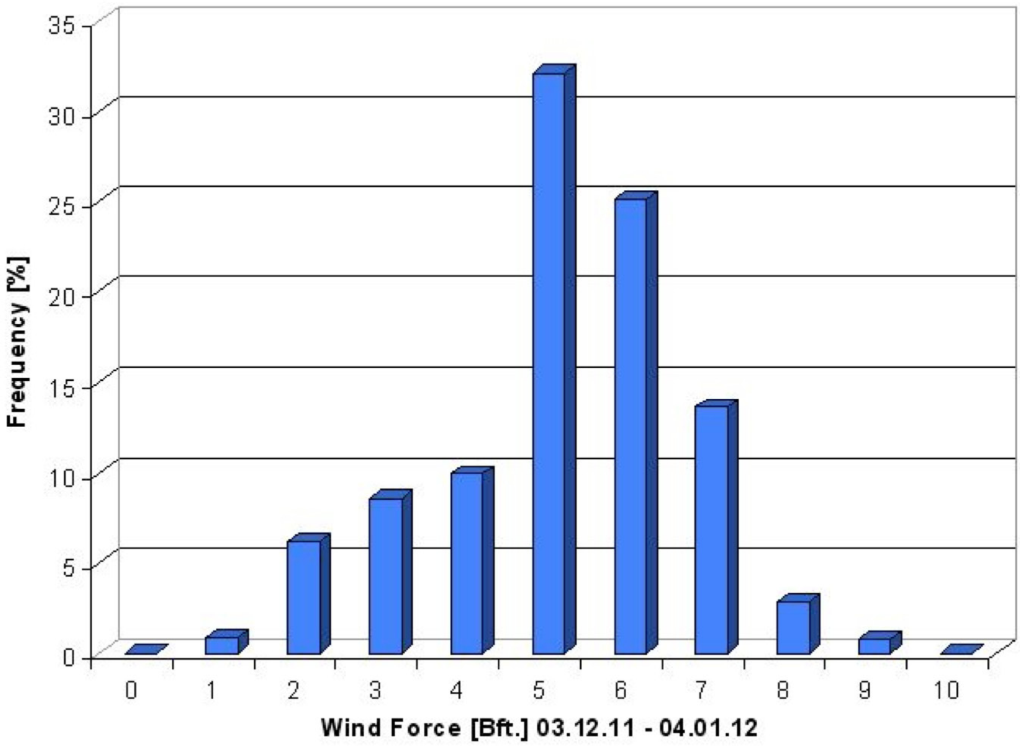

Fig. 2.1: Distribution of wind force

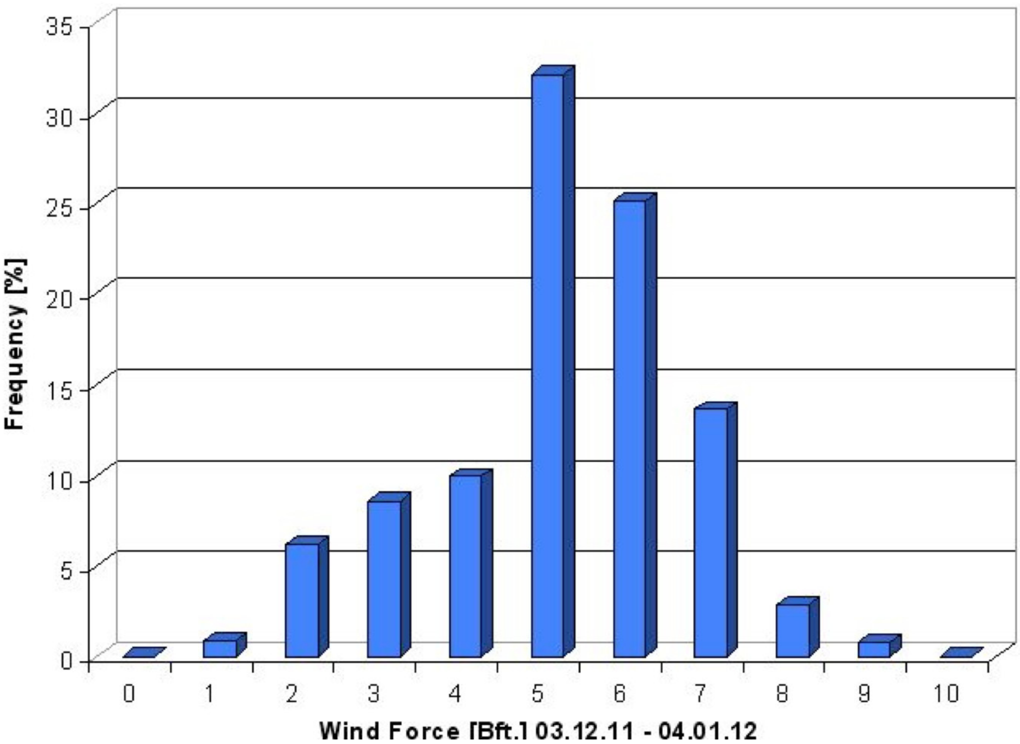

Fig. 2.2. Distribution of wind direction

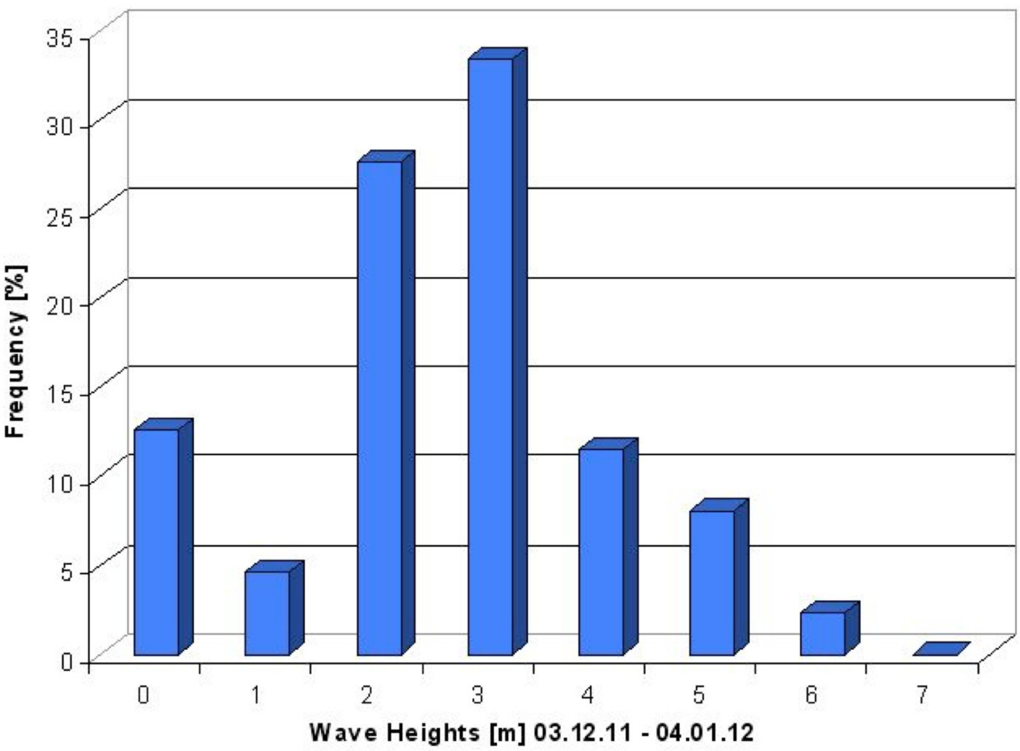

Fig. 2.3: Distribution of wave heights

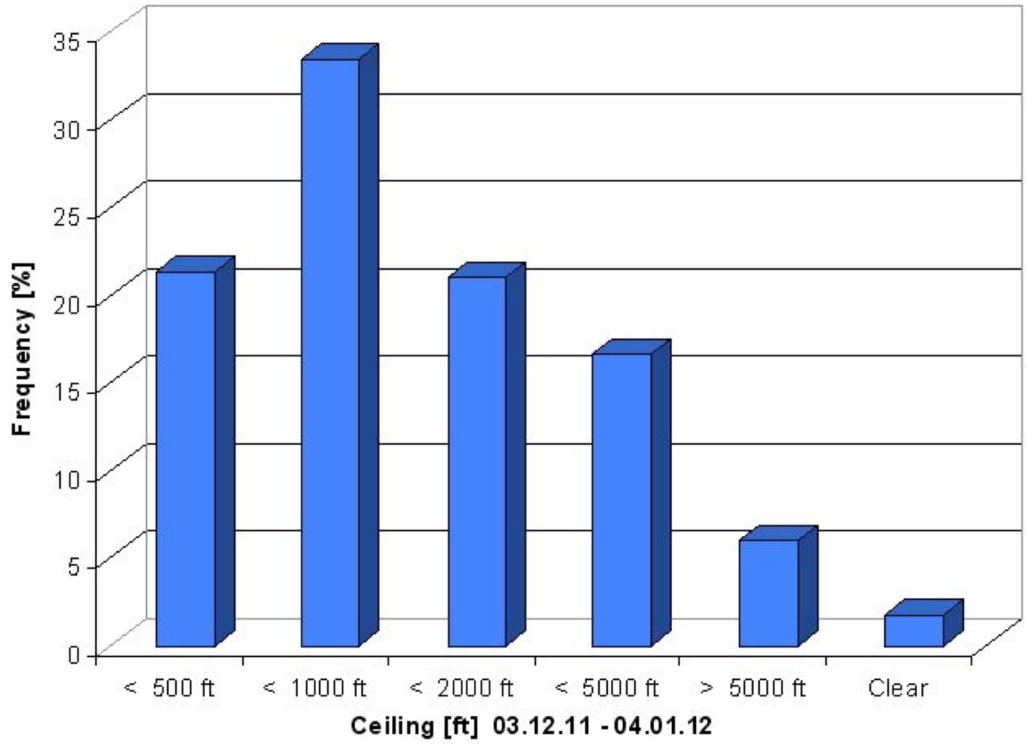

Fig. 2.4: Distribution of ceiling

3. OCEANOGRAPHY: CLIMATE OF THE ANTARCTIC AND THE SOUTHERN OCEAN

Hendrik Kienert[2], Andreas Macrander[1,4], Siri Rackebrandt[3], Krissy Reeve[1], Thomas Remke[3], Hiroshi Yoshinari[1], Xu Zhang[1]

[1] Alfred-Wegener-Institut für Polar- und Meeresforschung (AWI)
[2] Potsdam-Institut für Klimafolgenforschung (PIK)
[3] Institut für Chemie und Biologie des Meeres (ICBM)
[4] now at Hafrannsóknastofnunin, Reykjavík

Objectives

The densest bottom waters of the global oceans originate in the Southern Ocean. Production and export of these dense waters constitute a vital component of the global climate system. The influence of Southern Ocean waters can be traced far into the northern hemisphere. As deep and bottom waters, they represent the deepest layer of the global overturning circulation. The conditions in the Southern Ocean are largely controlled by the Antarctic Circumpolar Current (ACC), the world´s most powerful current system, which transports about 140 Sv (10^6 m^3 s^{-1}) of water at all depths. It connects the three ocean basins and forms an isolating water ring around the Antarctic continent.

Within the subpolar region south of the ACC, warm and salty water masses are carried in the subpolar gyres to the continental margins of Antarctica. Water sinking near the continental margins spreads to the adjacent ocean basins. These dense waters are produced at several sites near the continental margins of Antarctica. Quantitatively the most important region for dense water formation may well be the Weddell Sea, however, other areas provide significant contributions as well. The properties and volume of newly formed bottom water varies significantly on a wide range of time scales, which are only poorly explored due to the large efforts needed to obtain measurements in ice covered ocean areas. Furthermore, the inflow of warmer Circumpolar Deep Water into the Weddell Gyre varies markedly depending on atmospheric circulation, affecting the heat budget of the Warm Deep Water and the subsequent formation of dense water masses.

The *Polarstern* cruise ANT-XXVIII/2 extended the time series of hydrographic observations along the Greenwich meridian in the eastern part of the Weddell gyre. Additionally, the deployment of one PIES (Pressure Inverted Echo Sounder) closed the last gap in a PIES array across the ACC which monitors both barotropic and baroclinic transport variations.

The cruise was part of the *Hybrid Antarctic/Arctic Float Observing System* (HAFOS) which aims to establish a contribution to the *Southern Ocean Observing System* (SOOS) in international cooperation in the context of the PACES programme of the Helmholtz Association of German Research Centres (HGF). The observations occur jointly with the IBONUS-GOODHOPE project which covers the northern part of the Atlantic sector of the Southern Ocean. The PIES array is part of the SAMOC programme (*South Atlantic Meridional Overturning Circulation*).

Work at sea

The focus of *Polarstern* ANT-XXVIII/2 was the Greenwich meridian section, where the decades-long time series of regular hydrographic surveys has been prolonged. Additionally to CTD/Rosette casts, underway observations by means of vmADCP, Thermosalinograph and Ferrybox were made. Four moorings were served.

3.1 Conductivity – Temperature – Depth (CTD)

During ANT-XXVIII/2, 18 full depth CTD stations and 2 shallow stations were carried out. Additionally, 2 shallow repeat CTD casts were made to collecting water for biological experiments on board (Fig. 3.1). The stations covered the entire ACC and Weddell Gyre from 39° S to the Antarctic Coast. Most stations were located on repeat positions on the Greenwich meridian section for unbiased comparison with previous cruises. Several stations also served as calibration casts for moored PIES (Pressure Inverted Echo Sounder) at these positions, allowing for comparison with the acoustic travel time data of the PIES with a known T/S and sound speed profile. Station 45 near Neumayer was also used for calibration of the sub-shelf ice CTD at the PALAOA observatory.

During the cruise, the Sea-Bird SBE 911 plus CTD system of the observational oceanography section at AWI was used. It was equipped with two pairs of pumped conductivity cells and temperature sensors, and a single pressure sensor. Additionally, the CTD was equipped with sensors for oxygen, fluorescence, transmission, a rotation counter monitoring possible twisting of the single-conductor wire, and an altimeter for secure detection of the sea floor. The sensor configuration and approximate accuracies are given in Table 3.1. All data shown in this report are preliminary, as the final data may change after the sensors have been factory-calibrated after the 3rd cruise leg.

The CTD system was mounted in a Sea-Bird SBE32 rosette water sampler with 24 Niskin bottles each with a volume of 12 litres, closed by inside stainless steel springs. The rosette bottles were closed during the upcast for collecting water samples for the different working groups on board *Polarstern*. Until station 46, the singleconductor winch EL 31 was used. At all later stations, the winch EL32.1 was used.

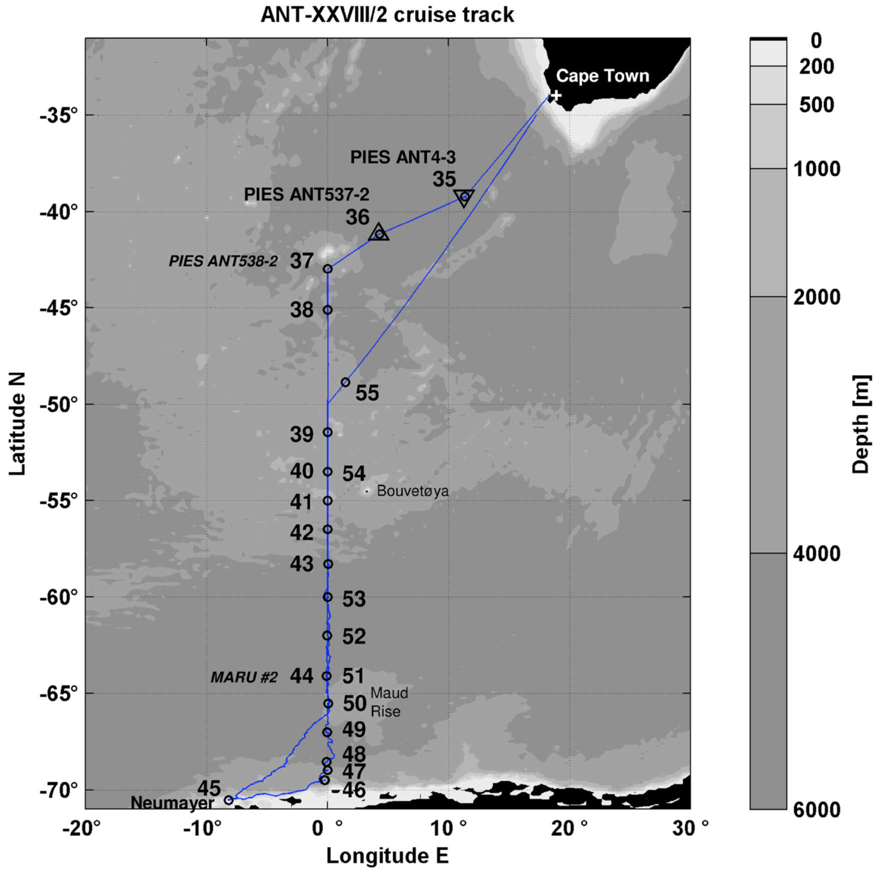

Fig. 3.1: Cruise track of ANT-XXVIII/2 with CTD stations and moorings. Stations are marked by black circles and the corresponding PS79/0xx station number. Mooring deployment is marked with ▽, recovery with △. Unsuccessful mooring recoveries are marked by mooring name only.

Table 3.1: CTD sensors during ANT-XXVIII/2, and expected accuracies

Quantity	**Sensor type**	**Serial Number** **Last calibration**	**Remarks**
Conductivity 1	SBE 4c	1199 21-Oct-2010	acc. uncalibr. 0.04 mS/cm *) acc. calibr. 0.003 mS/cm resolution 0.0004 mS/cm
Temperature 1	SBE 3plus	5027 18-Mar-2011	acc. uncalibr. 0.002°C acc. calibr. 0.001°C resolution 0.0002°C
Conductivity 2	SBE 4c	1198 29-Oct-2010	acc. uncalibr. 0.04 mS/cm *) acc. calibr. 0.003 mS/cm resolution 0.0004 mS/cm
Temperature 2	SBE 3plus	1338 18-Mar-2011	acc. uncalibr. 0.002°C acc. calibr. 0.001°C resolution 0.0002°C
Pressure	Paroscientific Digiquartz (0 – 6800 m)	0937 26-Mar-2009	acc. uncalibr. 3.7 dbar acc. calibr. 1 dbar resolution 0.068 dbar

Quantity	Sensor type	Serial Number Last calibration	Remarks
Oxygen	SBE 43	743 (St. 36+37) 09-Nov-2010	ca. 5 % of saturation data noisy, sensor exchanged
Oxygen	SBE 43	1605 (St. 38-55) 06-Nov-2010	ca. 5 % of saturation qualitative data only
Fluorescence	Wetlab ECO-FL	FLRTD-1870 26-May-2010	sensitivity 0.2 mg/m³ qualitative data only, units equivalent to mg/m³
Transmission	Wetlab CStar (25 cm)	CST-1198DR 23-Mar-2009	long-term stability 0.02 %
Rotation counter	Optimare SUMO	002 25-Oct-2011	Full rotation counts
Altimeter	Benthos PSA 900D	1229 N/A	Acc. +/- 0.1 m Nominal range 0.75 – 100.0 m

*Notes: Acc. uncalibr.: Absolute accuracy before post-cruise calibration. Acc. calibr.: expected absolute accuracy after post-cruise calibration. All values obtained from manufacturer specifications, i.e. Sea-Bird (2011, 2010), WET Labs (2011 a,b), Teledyne Benthos (2011). *) Effect on calculated salinity ca. +/- 0.05.*

Temperature

Both temperature sensors agreed within +/- 1 mK. A significant pressure effect had been observed in all stations, with T_1 decreasing by ca. 1 mK relative to T_2 at 5000 dbar (Fig. 3.2). Furthermore, there were obvious oscillations in $\Delta T = T_1 - T_2$ with an amplitude of ca. 0.5 mK and a vertical length scale of 50 to 100 m (i.e. a period of > 1 minute) (Fig. 3.2). These were not a reason for concern, being smaller than the sensor accuracy (Table 3.1).

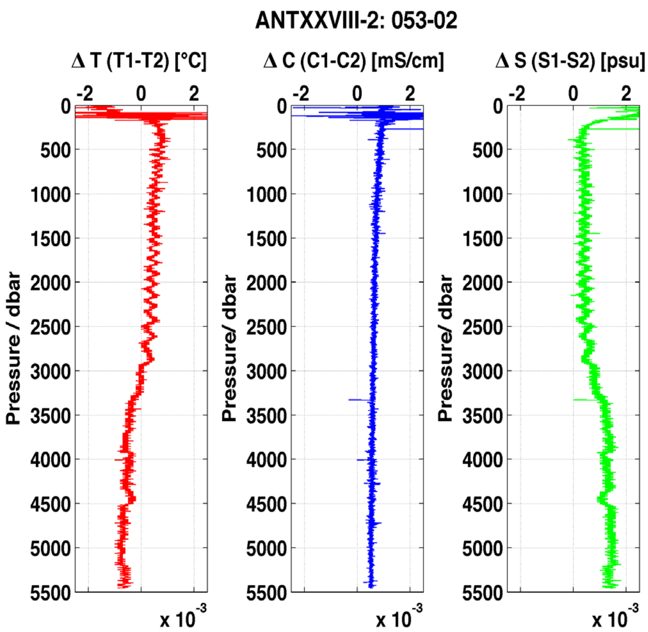

Fig. 3.2: Sensor differences $\Delta T = T_1 - T_2$, $\Delta C = C_1 - C_2$ and the difference between salinities derived from each sensor pair at station 53-2. Oscillations correlated with rosette rotations show up most pronounced in the 1500 to 2,500 m depth range.

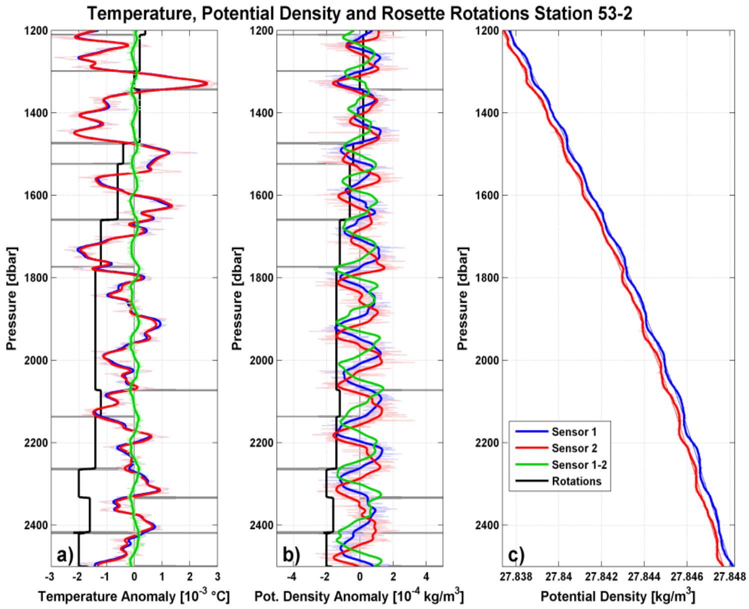

*Fig. 3.3: Temperature (a), and Potential Density (b) anomalies. Blue: Sensor 1, red: Sensor 2, green: Difference Sensor 1 – 2. Black: Rosette rotations *0.2. Heavy lines: Band-passed anomalies showing only variability with length scales between 25 dbar and 250 dbar. Light lines: 1 dbar data.*
(c) Profiles of absolute Potential Density, with rotation-related wiggles clearly visible.

A closer analysis revealed that both sensors showed such oscillations. However, in the individual temperature profiles they were obscured by larger natural short-scale variability (Fig. 3.3a). Nevertheless, the "real" variability canceled in the temperature difference ΔT, whereas the sinusoidal oscillations remained, as there was a constant phase lag of ca. 60° between the oscillations of the individual sensors (T_1 was leading during downcast). The natural variability in temperature (typically +/- 2.5 mK at length scales of 25 to 250 m, Fig. 3.3a) was largely compensated by variations in conductivity, since density always increased monotonically with depth. Hence the oscillations of the individual temperature sensors were clearly evident in profiles of potential density σ_Θ (Fig. 3.3b,c). The oscillations were not correlated with the natural temperature variability, but they appeared to be correlated with rosette rotations; full turns of the rosette always occurred in the same phase of the sinusoidal oscillations (though there appeared to occur partial rotations too, which were not counted by the SUMO). Although the amplitude was smaller than the nominal accuracy of the temperature sensors, the oscillations had a visible effect on the otherwise rather homogeneous salinity and density profiles in deep and abyssal regions (Figs. 3.3c, 3.4). Similar artefacts had also been found in ANT-XXVII/2 profiles. Further analysis and tests are required to determine the reason of these oscillations and the phase-lag between the two temperature sensors, and whether the problem is caused within the electronics due to e.g. presence of the SUMO rotation counter (to be compared with data from CTD casts without

SUMO), other instruments, or due to e.g. electromagnetic induction effects from the geomagnetic field of the earth.

Conductivity, Salinity

The data of the two conductivity cells were almost identical, with no differential pressure effect on C_1-C_2 (Fig. 3.2). Hence salinity mostly reflected the pressure dependence of the temperature sensors. A comparison of S_2 with profiles from 2010 shows a rather constant offset of -0.003 over the entire water column, whereas S_1 exhibited a reduced offset at 5000 dbar due to the pressure effect on T_1 (Fig. 3.4).

Based on this comparison, S_2 appeared to be more realistic, except for the constant offset, which was unlikely to be a natural signal, but rather an instrument offset. In fact, natural interannual changes in salinity were smaller than the accuracy of the uncalibrated data (+/- 0.05), and can only be discussed when the offset has been corrected by accurate salinometer measurements (better than +/- 0.001) and post-cruise calibration of the sensors. This will improve the absolute accuracy of the salinity data from about 0.05 (conservative estimate, Table 3.1) to ca. 0.001.

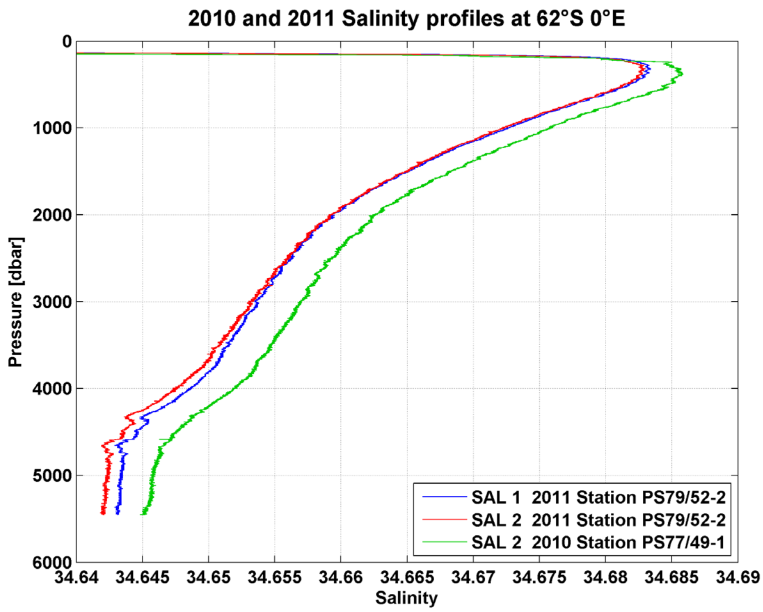

Fig. 3.4: Salinity profiles at 62°S 0°E. 2011 profiles shown in blue (Salinity 1) and red (Salinity 2). The 2010 profile (green) is Salinity 2, which better agreed with the salinometer calibration in 2010. Note the reduced offset of SAL2(2011) to SAL2(2010) in the deep part of the profile. The small wiggles around 1200 m to 2500 m depth can be attributed to the rotation-related temperature oscillations.

Pressure

Pressure is used together with integrated density data to obtain depth in metres. Normally, the geographic latitude of the GPS NMEA signal is automatically read by the CTD data acquisition software to correctly calculate the local acceleration of gravity. On some stations, though, this did not work, and standard bottle closing depths were about 1 % shallower than intended. During manual data post-processing on board, this error had been corrected for; hence all data have now correct depths, although some of the standard bottle depths are at "odd" values like e.g. 1992 m.

Oxygen

Oxygen values should be treated as qualitative data only, as no Winkler sampling was done on this cruise. The SBE43 oxygen sensor SN 743 showed large noise in larger depths. It was exchanged for a new sensor after the first two stations. Furthermore, O_2 data showed spikes whenever the altimeter caught an echo (positive spike) or lost an echo (negative spike). Both the noise on the first two stations and the altimeter-inferred spikes will be removed in the on-shore post-processing of the data to obtain realistic (qualitative) profiles.

Fluorescence

Fluorescence has to be calibrated with actual Chlorophyll-a measurements which were regularly made from bottle samples (see chapter 4). The values of the uncalibrated data are roughly equivalent to Chl-a concentrations in mg/m^3. In the deeper layers below the euphotic zone, a rather constant value of ~0.465 was retrieved by the fluorometer, which may be considered to represent zero Chl-a.

Transmission

Transmission was measured as the beam transmission in 650 nm over a path length of 25 cm. In the surface layers, reduced transmission was strongly anticorrelated with fluorescence, indicating phytoplankton abundance. In abyssal waters, transmission revealed the turbid near-bottom layer.

Rotation counter

A SUMO (SUbmersible Motion Observer) rotation counter monitored the (slow) rotations of the rosette. Especially new singleconductor wires sometimes build up significant twist, which may cause hazards when the rosette is lifted by waves at the surface. During deep stations, up to 20 rotations were observed, but the rosette turned back during the upcast; there was no critical situation encountered during this cruise. Temperature data exhibited a small rotation effect, which might be caused by the rotations themselves, or by electronic interference with the SUMO (see above).

Altimeter

On all deep stations, the altimeter reliably detected the sea floor from a distance of 50 to 30 m. Using the altimeter readings, the CTD was lowered to ca. 10 m above the sea floor. The altimeter was essential for safe operation of the CTD system, as water depth estimates from the ship's DWS or fish echo sounder are potentially unreliable due to the unknown sound speed profile. Furthermore, the DWS failed during the later part of the cruise (broken power supply), and the fishsounder was unavailable either on some stations, or did not reliably capture the bottom echo. The altimeter caused spikes in the oxygen data (see above), although it was not attached to a common Y-cable with the SBE43.

Salinometer

For calibration purposes, salinity samples had been taken at all deep stations, mostly in the abyssal layers and at 3000 m and 1000 m (often as double samples), where vertical small-scale temperature and salinity gradients are smaller than 1 mK/m and 0.001/m, respectively. Some samples were measured on board with the Optimare Precision Salinometers (OPS) S/N 007 and 006. Due to their temperature-stabilized baths, they have a nominal accuracy of a few ten-thousands of a practical salinity unit. However, due to unresolved technical problems, we were unable to obtain stable measurements: Standardization with IAPSO Standard Sea Water (Batch P149, K_{15} = 0.99984, 05-Oct-2007) yielded salinity differences exceeding 0.01 between different measurements of standard water. Long-time test measurements with old samples (recycling the water into the sampling bottle) showed decreasing salinity and sudden shifts for the first 5 to 8 hours before finally turning into a smooth curve. All samples were appropriately equilibrated to room temperature, homogenized and de-gassed. We suspect problems like contamination with bath water through possible leaks in the tubing system or dirt. During the 3rd leg, an Optimare technician will take care of the two OPSs, and measure the remaining larger part of the ANT-XXVIII/2 samples. This is critical to correct any sensor offsets in the CTD data (see above).

Data

The data of the CTD profiles and the bottle files will be transferred to the PANGAEA database after final post-processing on shore.

Preliminary results

The cruise track from Cape Town to the Neumayer Station III crossed the entire Antarctic Circumpolar Current (ACC) and the eastern part of the Weddell Gyre. The CTD section revealed the typical distribution of the water masses along this section (Figs. 3.5, 3.6, 3.7; c.f. Orsi et al., 1995; Tomczak and Godfrey, 2003; Whitworth and Nowlin, 1987). In the north, warm and saline subtropical waters with T>15°C and S>35.5 were found at the surface. Below this, Subantarctic Mode Water (SAMW, T≈10°C) originating from winter cooling at the Subtropical Front was found, and, at ca. 1000 m, cold (T≈2.5°C) and fresh (S≈34.2) Antarctic Intermediate Water (AAIW) subducted at the Polar Front. Deeper was the Circumpolar Deep Water (CDW), which ultimately stems from the southward-flowing North Atlantic Deep Water and is marked by somewhat higher salinity (S>34.7). Below the salinity and temperature maximum of the lower CDW, both salinity and temperature gradually decreased towards the bottom due to some influence of Antarctic Bottom Water (AABW), although the Cape Basin north-east of the shallow Mid Atlantic Ridge was not in the direct pathway of AABW. Isotherms, isohalines and consequently isopycnals were shoaling towards the south, indicating the baroclinic current shear of the ACC, with the strongest eastward flow at the surface and lower velocities in the deeper levels.

South of the circumpolar regime of the ACC, the cruise track encountered the cyclonic circulation of the Weddell Gyre, which extends between 56°30′ S and the Antarctic Coast. The upper ~100 m were occupied by cold Antarctic Surface Water (AASW) which was fresh due to ice melt, particularly farther north (Behrendt et al., 2011). A little seasonal warming was already found at the northern stations, whereas both the lower part of the AASW layer and closer to Antarctica, where sea-ice cover was still 100 %, the entire surface layer still represented winter water from the last winter season. Below the AASW, Warm Deep Water (WDW) (T>1°C) extended as a warm and saline layer, with its core around 500 to 1000 m. WDW is fed into the Weddell Gyre from the ACC, but the amount varies significantly on interannual timescales, presumably depending on atmospheric circulation patterns (Fahrbach et al., 2011). Below the WDW, Weddell Sea Deep Water (WSDW) and Weddell Sea Bottom Water (WSBW) were found. WSBW is supplied by cooling and convection in coastal polynyas, mainly along the western Weddell Sea. Its very high density prevents it from directly leaving the Weddell Sea Basin. In contrast, WSDW, which is produced by mixing / entrainment of WDW into WSBW, eventually leaves the deep Weddell Basin through some passages farther west to become Antarctic Bottom Water spreading northward in the abyssal oceans.

The domed structure of the isopycnals in the Weddell Sea is indicative of the cyclonic circulation, with eastward flow north of 61°S, and westward flow south of this latitude, particularly concentrated in the Antarctic Coastal Current between 68°30′ S and the coast at 69°30′ S. On a smaller scale, doming isopycnals suggest some cyclonic circulation around Maud Rise at 65°30′ S, although this was poorly resolved by the coarse station spacing during ANT-XXVIII/2.

Oxygen showed the well-ventilated surface layer of about 100 m in stable-stratified parts of the Weddell Sea, and >200 m in the subduction regions north of the Polar Front, and in the vertically homogeneous profiles at the Antarctic Coast. Oxygen minima were found in the upper CDW, and in parts of the WDW, where residence times are long.

Fluorescence showed enhanced phytoplankton concentrations in the upper 100 m, particularly in parts of the ACC, and in the marginal ice zone in the Weddell Sea.

Transmission was mostly anticorrelated with fluorescence; additionally slightly lower transmission was measured in the turbid layer close to the sea floor.

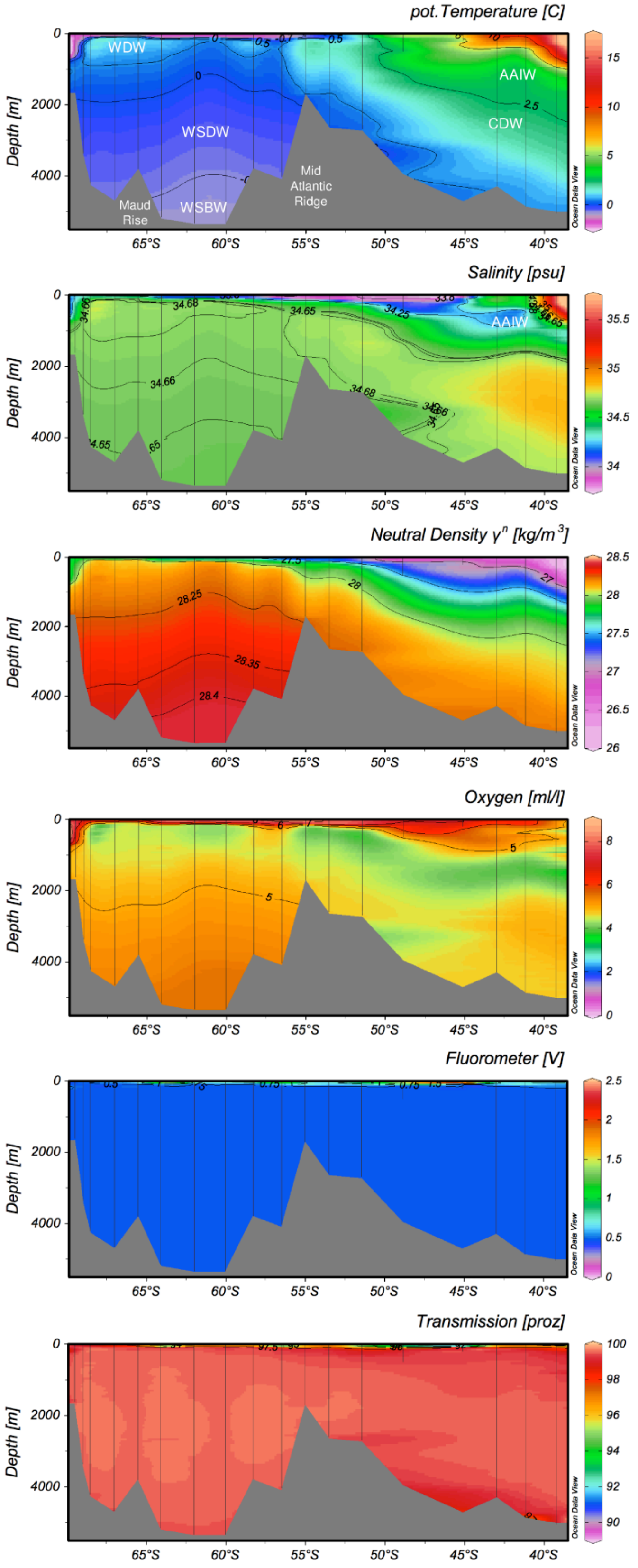

Fig. 3.5: CTD section, full depth range. Black lines denote location of CTD profiles. AAIW Antarctic Intermediate Water, CDW Circumpolar Deep Water, WDW Warm Deep Water, WSDW Weddell Sea Deep Water, WSBW Weddell Sea Bottom Water.

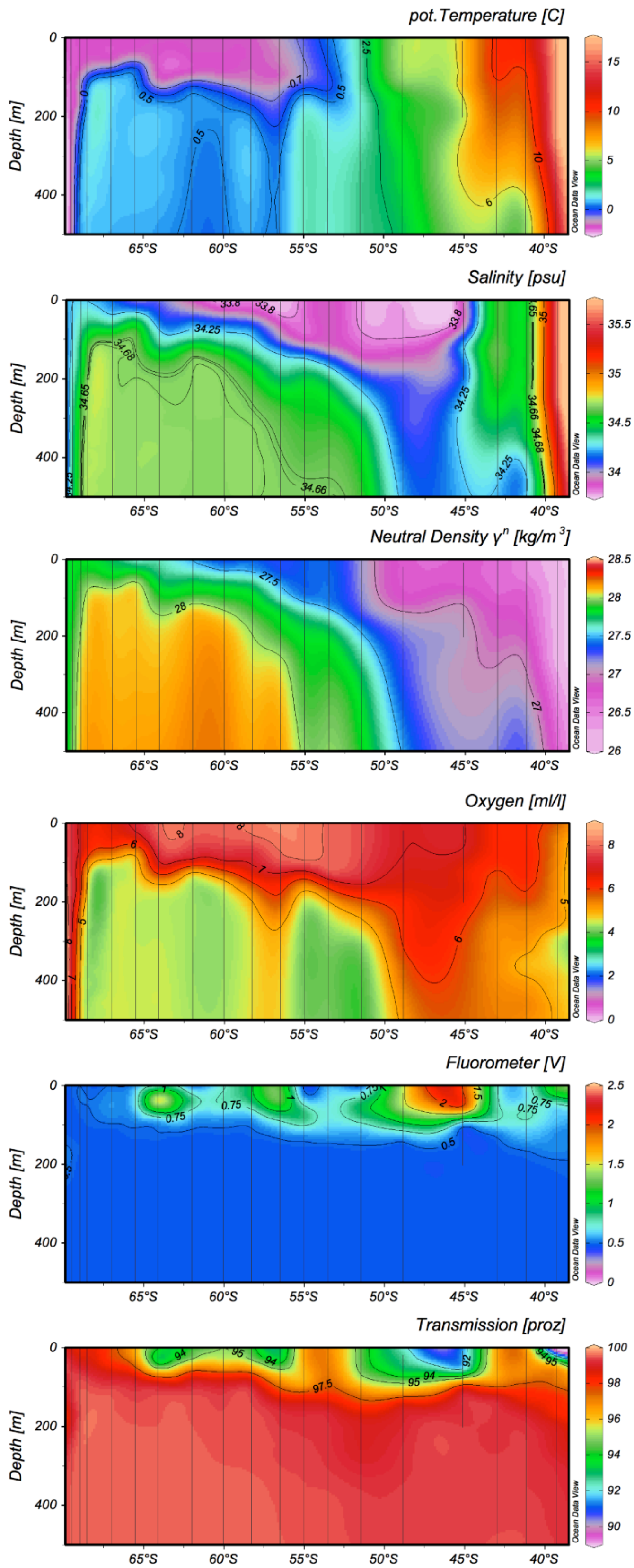

Fig. 3.6: CTD section, upper 500 m. Same latitude and colour axis scaling as in Fig. 3.4.

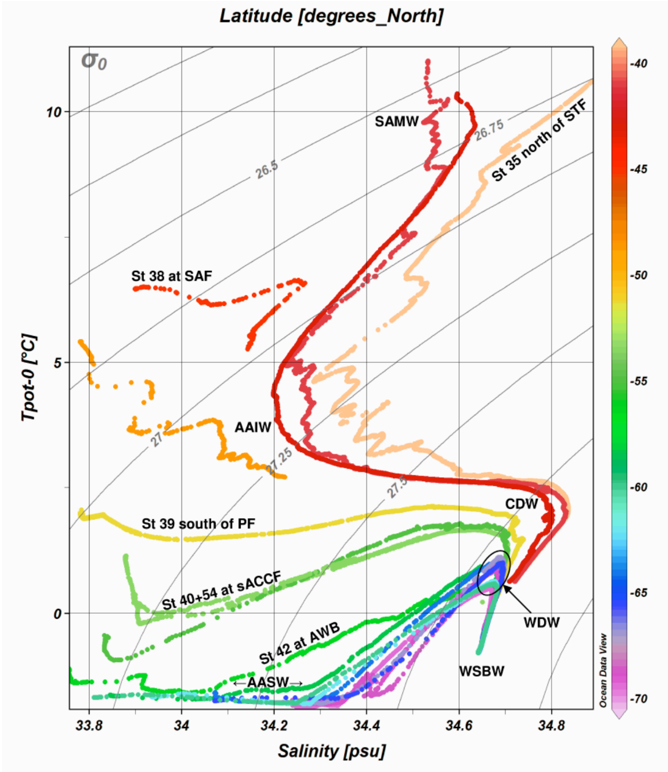

Fig. 3.7: Theta/S diagram indicating the different water masses sampled. Please note that the subtropical surface water at station 35 (Θ= 16.82°C, S = 35.58) is outside the figure axes. Abbreviations: STF Subtropical Front, SAF Subantarctic Front, PF Polar Front, sACCF southern ACC Front, AWB Antarctic Weddell Gyre Boundary. Selected water masses within the ACC: SAMW Subantarctic Mode Water, AAIW Antarctic Intermediate Water, CDW Circumpolar Deep Water. Selected water masses within the Weddell Gyre: AASW Antarctic Surface Water, WDW Warm Deep Water, WSBW Weddell Sea Bottom Water.

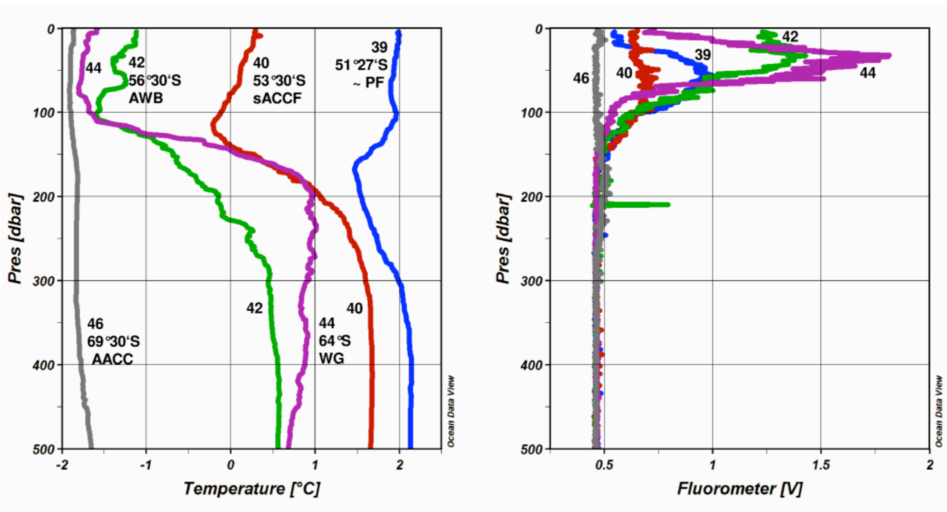

Fig. 3.8: Selected profiles of Temperature, and Fluorescence. Station 39 lies within the southern ACC region, south of the Polar Front. Station 40 is at the southern ACC Front, station 42 at the Antarctic Weddell Gyre Boundary. Station 44 is at 64° S in the Weddell Sea (with beginning ice melt), station 46 in the Antarctic Coastal Current (AACC) with heavy sea ice coverage.

Selected CTD profiles from the southern ACC and the Weddell Sea (Fig. 3.8) reveal that some seasonal warming had already occurred except in the southern part which was still completely ice covered (Station 46 at 69°31′ S, and partly Station 44 at 64°S). Fluorescence exhibits the highest values where the sea ice is just melting, with a subsurface maximum at around 40 m to 80 m. The stable stratification of the surface layer is favourable for plankton staying within the euphotic zone.

Due to the comparatively short duration of ANT-XXVIII/2, CTD stations had to be focused on obtaining samples representative for the different regions and water masses found between and in the fronts of the ACC. The Weddell Gyre was sampled with a resolution of 1.5° to 2° latitude (90 to 120 nm) between stations, with enhanced resolution close to oceanic fronts (e.g. the Antarctic Weddell Gyre Boundary), and within the Antarctic Coastal Current. The Theta-S diagram (Fig. 3.7) confirms that all major water masses have been sampled. A qualitative comparison with data from previous cruises which had a 30 nm station spacing south of 55°S ensured that water mass volume and property estimates are as least biased as possible despite the lower spatial resolution on this cruise. Further analysis will be done on-shore to analyse long-term changes, particularly of the deeper water masses in the Weddell Sea. The uncalibrated raw data suggest an ongoing freshening of WSBW and WSDW, compared with 2010, and possibly cooling in the WSDW. However, post-cruise calibration is required to finally resolve interannual and decadal variability of these water masses, as such changes are close to the measurement accuracy of the CTD system.

3.2 Underway measurements: Thermosalinograph, Ferrybox and vmADPC

Thermosalinograph

During the entire cruise, surface water temperature and salinity were measured by the ship’s Thermosalinograph (TSG). The intakes are located at the bow thruster tunnel in 5 m depth (switched off in the ice due to clogging with sea ice), and in the box keel in 11 m depth (only switched off for servicing at Neumayer). Absolute accuracy is expected to be 0.01°C and 0.001 mS/cm, respectively (Sea-Bird specifications).

Salinity samples were taken in regular intervals by the ship’s electronic engineer, and measured by salinometer (though, see salinometer accuracy issues above). During the cruise, the TSG data were fully available in DShip. The final post-processing takes place in Bremerhaven by Fielax, and a few weeks after the cruise TSG data can be downloaded from the PANGAEA database.

Ferrybox

Fluorescence, pH and other parameters have been measured by the Ferrybox. Except for a failure of the FSI CTD (which is anyhow less accurate than the Thermosalinograph, due to its location far away from the intake) and a few temporary data gaps in e.g. fluorescence, the Ferrybox was operational during the entire cruise. However, navigational data were not always transferred, and Ferrybox data not always into DShip. Thus, the complete data set was stored only locally, and required later manual assignment of position data, using the synchronized time stamps of Ferrybox and DShip navigation data.

Vessel-mounted Acoustic Doppler Current Profiler (vmADCP)

Upper-ocean current velocities between 20 and 340 m depth were continuously measured by *Polarstern*'s RDI Teledyne Ocean Surveyor vmADCP. The vmADCP was operational almost continuously. For this report, 20 minutes averages as provided by the vmDAS software are used. Tidal currents were not removed. The vmADCP data can be linked with geostrophic current anomalies derived from CTD profiles thus full-depth current estimates can be obtained.

Preliminary results

Whereas the CTD casts resolved the full-depth structure of the water column with a spatial resolution of 90 to 120 nm, near-surface properties were measured continuously by the Thermosalinograph, Ferrybox and vessel-mounted Acoustic Doppler Current Profiler (vmADCP). Thus, the underway measurements resolved particularly well the typical banded structure of the Antarctic Circumpolar Current (ACC), where large changes in temperature and salinity are concentrated in narrow zonal fronts (c.f. Swart et al., 2008). Within the fronts, current velocities were highest, and typically, primary production is enhanced (Fig. 3.9).

In the northernmost part of the cruise track, still within the subtropical regime, *Polarstern* crossed anticyclonic Agulhas Rings, which carry warm water from the Indian Ocean into the Atlantic. These were evident by high current velocities (up to 1.50 m/s), which turned counter clockwise about the centre. *Polarstern* crossed rings at least around 36°30'S (southward leg), and 39°S (northward leg) (c.f. Fig. 3.9 top panel). The location of the rings is to be validated by elevated Sea Surface Height in satellite altimetry data.

The Subtropical Front (STF) was found at 39°30'S; here, Sea-Surface Temperature (SST) dropped below 15°C, and Sea-Surface Salinity (SSS) decreased from 35.5 to 34.6. The STF marks the northern boundary of the ACC.

The Subantarctic Front (SAF) was encountered at 45°S, with SST < 6.5°C, and SSS decreasing to 34.1. Both STF and SAF have pronounced maxima in fluorescence (i.e. phytoplankton), and eastward current velocities of > 0.4 m/s.

Further south, at 50°S, *Polarstern* crossed the Polar Front (PF), which marks the northernmost extent of Antarctic Surface Water. Over a distance of 20 nm, SST fell from >4°C to <2.5°C, while the eastward current velocity exceeded 0.50 m/s.

The southern ACC Front (sACCF) was crossed somewhat north of 53°30'S. While the sACCF was rather poorly defined in current speed, SST, SSS and chlorophyll, it was evident in the subsurface winter water temperature minimum falling below 0°C at station 40.

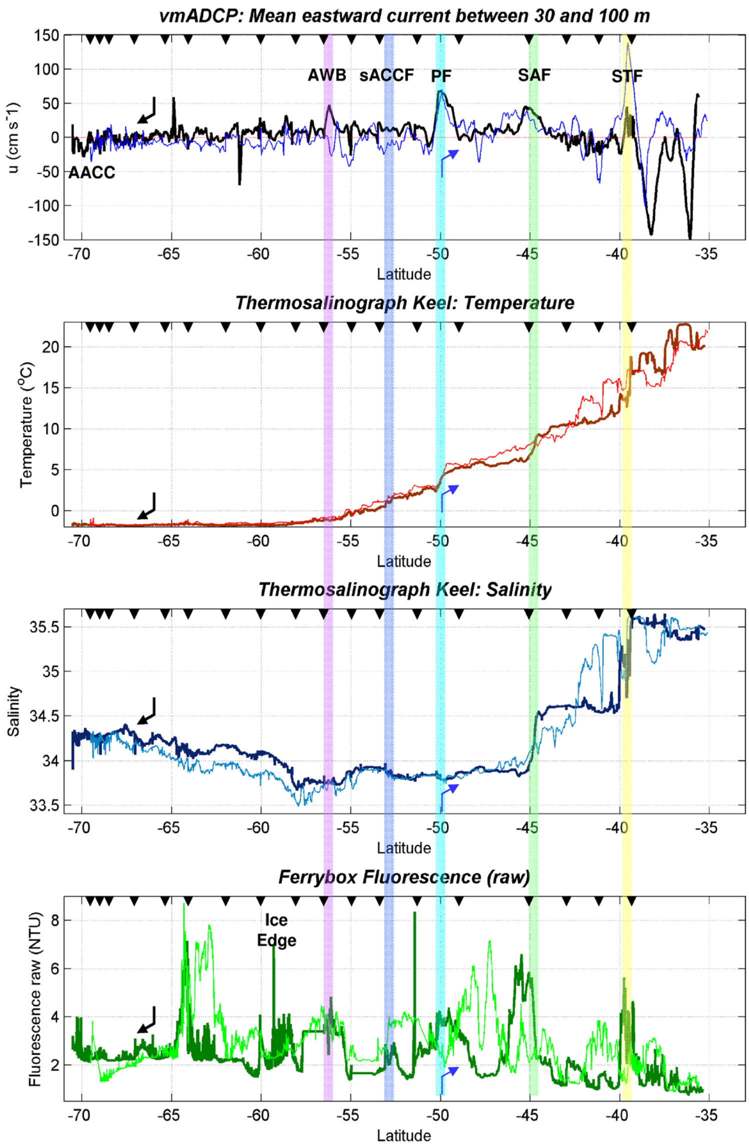

Fig. 3.9: Underway measurements during ANT-XXVIII/2. Heavy lines: Southward course from Cape Town to Neumayer, light lines: course back from Station 46 (69°30' S 0° W) to Cape Town.
Note that north of 55°S and south of 66°S (marked by bent arrows), the cruise tracks are not identical. CTD stations marked with black triangles. ACC fronts marked by shaded bands: STF Subtropical Front, SAF Subantarctic Front, PF Polar Front, sACCF southern ACC Front, AWB Antarctic Weddell Gyre Boundary. From top to bottom: vmADCP eastward current velocity (positive: current to the east). Thermosalinograph keel temperature. Thermosalinograph keel salinity. Ferrybox Chlorophyll-a (raw).

Finally, the Antarctic Weddell Gyre Boundary (AWB) at ~56°S marked the southern boundary of the ACC. At the AWB, a significantly increased current velocity was observed.

The Weddell Gyre showed mainly eastward-flowing waters in the northern part, (returning from the western Weddell Sea), and westward movement in the southern part, although current speeds were generally smaller than in the ACC. The Antarctic Coastal Current (AACC) showed up in the southernmost part of the section, with current velocities of up to 0.2 m/s. SSS gradually increased further south due to less sea ice melt and more sea ice formation. On the southward track in mid-December, plankton blooms were found at the sea ice edge around 59°S, while a localized bloom occurred at 64°S, which is close to the opening Maud Rise polynya. On the way back in late December, sea ice between 64°S and 62°S was disintegrating rapidly, and a plankton bloom was starting to form. North of the sea-ice, fluorescence was lower than within the ice zone, but still higher than in mid-December during the southward cruise track of *Polarstern*.

3.3 Moorings

Three Pressure Inverted Echo Sounders (PIES) and one acoustic recorder (MARU) were served during ANT-XXVIII/2.

PIES deployment
With the deployment of ANT4-3 (Table 3.2), the last gap was closed in the GoodHope/Greenwich section array of PIES, which spans the entire Antarctic Circumpolar Current (ACC).

Table 3.2: Pressure inverted echo sounder (PIES) deployed during ANT-XXVIII/2

Mooring ID Station book (deploym.)	**Deployment date/time [UTC]**	**Deployment position (GPS) Depth (DWS)**	**Final position (best estimate from Posidonia)**	**PIES SN DCS SN Posidonia SN**	**PIES Auto-release date, REL code**	**Remarks**
ANT4-3 PS79/035-2	05.12.2011 12:07	39° 13.07' S 11° 20.04' E 5122 m	39°13.34' S 11°19.98' E 5072 m @ 13:12	C-PIES #184 DCS #752 ET861 #726	20-Apr-2017 12:00 UTC REL: 56	Posidonia good no PopUps

The mooring consisted of a Posidonia ET 861 transponder (for underwater location, and providing extra buoyancy), an Aanderaa Doppler Current Sensor (DCS, measuring local current speed), connected by 50 m of 4 mm-Dyneema line and cable, and the PIES itself which was firmly attached to a steel stand to ensure an absolutely fixed position on the sea floor. The mooring was lifted over the starboard side by the large “Schiebebalken” and deployed free-falling. The descent was monitored with Posidonia; the descent speed of 1.31 m/s was well in the range expected for this mooring configuration with a net negative buoyancy of -57 kg (stand+weight -80 kg, PIES+ET+DCS+cable +23 kg). In contrast to the deployments in 2010, a thinner wire (4 mm Dyneema instead of 9 mm Kevlar) was chosen, and the additional 17” float omitted. This reduces drag and the danger of the mooring tipping over in strong currents. Due to the heavier stand weight, this configuration is even safer than the URI C-PIES (Current meter + PIES) standard configuration, with a critical tip-over current speed of clearly > 1.50 m/s (c.f. Annex A.6 in Fahrbach, 2011). As the PIES was attached directly to the stand, the release is not over-stressed even if the mooring hit the bottom with a rather high descent speed.

Two PopUp buoys manufactured by Optimare were scheduled for deployment with this mooring. PopUps receive daily averaged data from the PIES via an infrared link. They release automatically after e.g. 1 or 2 years, and transmit the data to the AWI via an Iridium satellite connection. All four PopUps on board comprised completely new designed electronics; however, in final testing on board it turned out that the burn-wire releases had wrong polarity, hence the wire which holds the release bolt would not have been burnt during release. As time did not permit lengthy hardware modification and testing on board, the PopUps were not deployed.

PIES recovery

Two PIES, which had been deployed in 2008 north-west of the main GoodHope section for validation of large-scale ocean bottom variability detected by the GRACE satellite mission, were scheduled for final recovery during ANT-XXVIII/2 (Table 3.3). No re-deployment was done as these positions are seldom served by *Polarstern*.

PIES #005 at ANT537-2 was released by an EG&G deck unit and a hydrophone lowered over the side of *Polarstern*. The PIES was not equipped with a Posidonia transponder, hence, underwater location of the mooring was not possible. Although no acoustic reply was received due to the noise of *Polarstern*, the PIES surfaced after 75 minutes (ascent speed 1.23 m/s, assuming 10 minutes releaser burn time). After surfacing, the PIES's VHF transmitter was immediately detected by the ship's VHF direction finder, and the PIES was located and recovered without problems.

Table 3.3: Pressure inverted echo sounder (PIES) recovered during ANT-XXVIII/2.

Mooring ID cruise/station (deployment)	Deployment date/time [UTC]	Deployment position (GPS) Depth (DWS)	PIES SN DCS SN Posidonia SN	Station book Date/time rel./surface	Recovery position (GPS) Depth (DWS)	Remarks
ANT537-2 G.O.Sars N/A	09.02.2008 21:50	41° 10.85' S 004° 15.51' E ~4867 m	PIES #005 no DCS no Posidonia	PS79/036-3 07.12.2011 06:33 / 07:48	41° 10.15' S * 4° 15.00' E * 4827 m @ 08:12	* Mooring on deck +one 17" float. PIES: TT 6% ok, P good
ANT538-2 G.O.Sars N/A	08.02.2008 23:55	42° 58.8000' S 000° 00.080' E ~4359 m	PIES #012 no DCS no Posidonia	PS79/037-3 08.12.2011 08:36 / never	42° 58.75' S 0° 0.14' E DWS off@08:36	no additional floats no contact recovery failed

The recovery of PIES #012 at ANT538-2 failed despite repeated release commands transmitted every minute over 30 min to re-start the release process in case of e.g. low-battery resets in the PIES. Within 4 hours after the first release command, the PIES was not detected at the surface, neither visually nor by VHF direction finder. Finally, a 45 min helicopter search flight was conducted without results. The search covered the area between the deployment/release position and the farthest possible position 4 nm away, where the PIES might have drifted due to wind and surface current.

Based on the experiences with PIES deployments in 2010, it appears likely that at this PIES, the release already broke the moment the mooring landed on the bottom. As in such a case the relocation module is not activated, the re-surfacing of the PIES would remain unnoticed unless monitored by Posidonia. However, this PIES had no Posidonia transponder, and no additional 17" floatation. During the deployment cruise with *G.O. Sars* in 2008, it was planned to recycle the transponders of two previous recoveries – one of which failed, and in the other, the Posidonia ET was missing. Nevertheless, the anchor weight remained unchanged, thus the net buoyancy was -80 kg (stand+weight) +10 kg (PIES), i.e. a total net buoyancy -70 kg. The expected descent speed would have been 1.40 m/s. As an anchor weight of 40 kg had been attached free-hanging under the PIES release, the release might have been over-stressed when the mooring hit the seafloor with this speed – in 2010, the PIES at ANT4-2 failed at a descent speed of 1.25 m/s. The present modified mooring design, where the PIES is attached directly to a crossbar welded into the stand avoids over-stressing of the releaser, hence, this type of mooring failure has been avoided after the ANT4-2 deployment in 2010.

MARU (Marine Autonomous Recording Unit)

Long-term acoustic recordings are an important tool to gain insights into the movement and distribution patterns of marine mammals, which are poorly known so far. The deployment of two passive underwater acoustic recorders (MARU) from Cornell University along the Greenwich meridian during ANT-XXV/2 in 2008 aimed at obtaining acoustic recordings of vocalizations of marine mammals, including large baleen whales, unbiased by the presence of a vessel. For recording more than 1 year, both instruments were upgraded with an external battery pack. MARU#1 was recovered in December 2010 during ANT-XXVII/2; the recovery of MARU#2 was cancelled due to dense sea ice coverage.

Table 3.4: Mooring to be recovered on Greenwich meridian

Mooring ID cruise/station (deployment)	**Deployment date/time [UTC]**	**Deployment position (GPS) Depth (DWS)**	**MARU SN Release SN**	**Station book Date/time rel./surface**	**Recovery position (GPS) Depth (DWS)**	**Remarks**
MARU #2 XXV/2 PS73/069-1	14.12.2008 08:54	64° 04.97' S** 00° 04.76' W**	MARU #2 RT 861 #220	PS79/044-xx 14.12.2011 not released	64° 05.07' S* 00° 05.47' W* 5188 m @ 16:41	* Posidonia recovery cancelled due to ice coverage
		64° 05.03' S*** 00° 05.40' W*** 5188 m***		PS79/051-2 26.12.2011 13:38 / never	64° 05.02' S* 00° 05.53' W* 5188 m @ 13:38	*Posidonia; released depth unchanged recovery failed

*** Polarstern GPS position on 14-12-2008 08:55. Correct deployment position 64° 04.17' S 0° 04.72' W 5196 m. The deployment position in the ANT-XXV/2 cruise report (64°50.20' S 00°49.30' W 5194 m; Boebel, 2009) is wrong. *** Posidonia estimate ANT-XXVII/2 PS77/054-1 15.12.2010 17:15 (c.f. Annex A.5 in Fahrbach, 2011).*

The MARU#2 position was reached twice (Table 3.4). On 14 Dec. 2011, the mooring was localized by Posidonia within 100 m of the position found in 2010. On this day the area was covered by large sea-ice floes. The ice drift was monitored by GPS tracking of individual echoes on the ship's radar, however, the few open patches in between the floes were at unsuitable positions. During the 5 hours *Polarstern* was on site the mooring was beneath closed sea-ice; based on the observed ice-drift, it was clear that also during the following hours, no open patch drifted across the mooring position, which would have allowed a safe recovery, considering the ice drift, mooring position uncertainty, and the expected ascent time of about 53 min (5188 m depth / 1.62 m/s ascent speed, based on the MARU#1 recovery in 2010).

On the way back from Neumayer, *Polarstern* reached the MARU#2 position again on 26 Dec. 2011. Except for an isolated patch of broken floes directly above the mooring, the sea was now ice-free. After the ice patch had drifted away with about 1 kn to the SE, the releaser was localized with Posidonia, and released several times, beginning at 13:38. As the mooring depth did not change over 20 min, the mooring was released from 14:09 by a TT301 deck unit and hydrophone lowered over the ship's side. At 14:25, Posidonia detected a still unchanged position of the mooring. After further release attempts with a TT801 deckunit after 14:35, Posidonia could not establish any acoustic contact, possibly due to the releaser's batteries being exhausted. The mooring had still not been sighted at the surface 5 hours later, when *Polarstern* left the site.

In contrast to the Posidonia device, the TT301 and TT801 are capable of processing the acknowledge signal from the RT861 releaser once it has released mechanically. No reply was detected, which is typical under the high-noise conditions caused by *Polarstern*. Two possible reasons appear most likely to explain the recovery failure: During previous recoveries of moorings equipped with the same type of RT861 release it was observed that remains of the protective zinc anodes went into the slit between moving and fixed parts of the hook, thus blocking the hook, even when the holding pin has been freed upon release execution. The MARU#2 mooring had only a single RT861 releaser – if this one is blocked, no second release is available. Furthermore, the Vitrovex floatation spheres implode occasionally, particularly in larger depths, even though they are rated for 6000 dbar. In the MARU#2 mooring, there was a single package of four 17" spheres just 10 m above the MARU, i.e. at 5168 m depth. If one float implodes, the resulting shockwave often damages neighbouring floats. If all four floats fail, the remaining buoyancy of the MARU is not sufficient to lift the entire mooring. Dredging would be difficult, too, as the entire mooring is just 20 m in length. In December 2012, *Polarstern* ANT-XXIX/2 may be able to try a recovery again.

During all acoustic operations of the Posidonia device and hydrophones lowered over the side of *Polarstern*, watch-out was on duty on both sides of the vessel to detect the possible presence of any whales or other marine mammals in the vicinity of the ship. As a precautionary measure to avoid marine mammals potentially being harmed when they are directly exposed to Posidonia or hydrophone signals, all operations would have been stopped as long as whales or other mammals were within 40 m of the ship. However, no whales were sighted around *Polarstern* during the MARU recovery attempts, or during the PIES mooring operations farther north, regardless of distance.

Preliminary results

One Pressure Inverted Echo Sounder (PIES) was recovered at ANT537-2. Deployed in February 2008, the instrument delivered a time series of almost 4 years (Fig. 3.10).

The pressure data were rather stable, with a long-term drift of the pressure sensor of <0.5 dbar. Spring and neap tides showed up with a peak-to-peak amplitude of 1.5 and 0.5 dbar, respectively. More relevant for monitoring the variability of the ACC, and for comparison with the GRACE satellite mission (Macrander et al., 2010) are, however, ocean-bottom pressure changes on time scales of weeks to months. In this time range, variability was about 0.05 dbar, which is typical for the highly energetic Southern Ocean. Temperature was around 0.30 to 0.38°C, with smaller variability and lower temperatures in 2011; possible changes in abyssal circulation require further analysis.

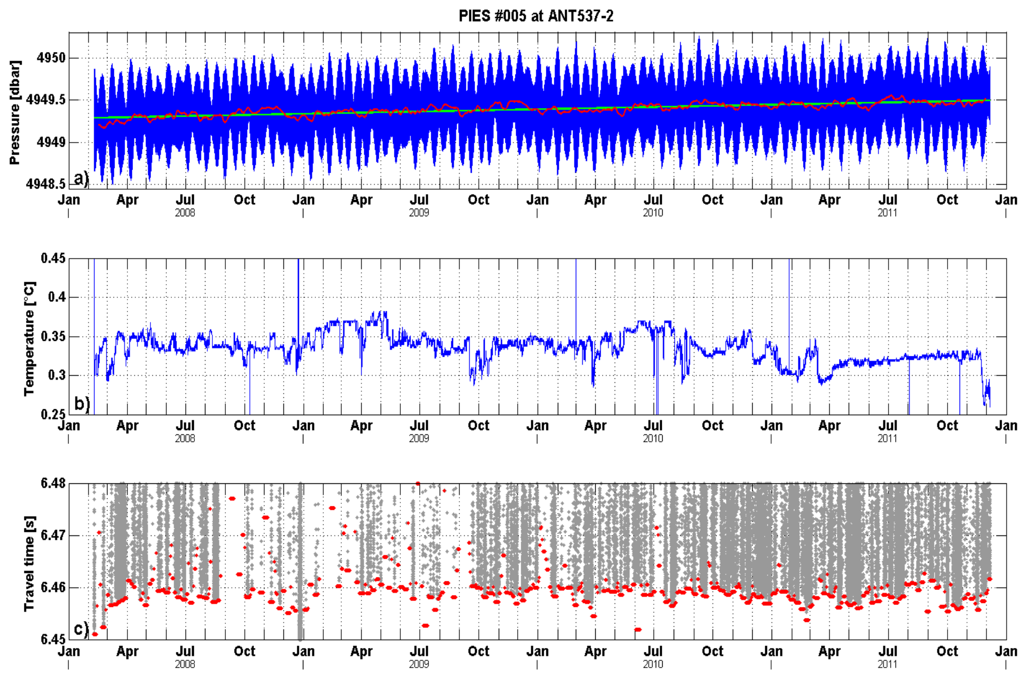

Fig. 3.10: PIES ANT538-2 time series. Figure shows uncorrected raw data. a) Pressure, hourly data (blue), 7 day low passed values (red), linear trend (green line). b) Near-bottom temperature. c) Acoustic travel time (grey dots). The travel times shown represent 6 % of all pings only; in 94 % of all pings no echo was detected. Minimum travel times in 7 days intervals shown in red.

The PIES mostly failed to detect a surface echo, only 6 % of all pings returned valid travel time data. The hardware of the PIES will be checked to find out the reason for the poor travel time data. As the valid travel times are widely scattered toward excessively long travel times, weekly minimum travel times may be assumed as a reasonable approximation; these vary by about 5 ms, which corresponds to vertical shifts of the thermocline of ca. 200 m.

Changes in acoustic travel time are mostly related to temperature. By calibration with known T/S and sound speed profiles from nearby CTD casts, all travel time and pressure data can be assigned to specific T/S profiles by a method called Gravest Empirical Mode (Meinen and Watts, 1998). Hence, dynamic height and baroclinic transport of the ACC can be assessed by using a single bottom-mounted instrument. Additionally, the pressure data of this and other PIES in the ACC array are used to calculate barotropic transport variations, which is important to better understand the dynamics of the Antarctic Circumpolar Current.

After on-shore post-processing, the PIES data will become available in the PANGAEA database within one year.

3.4 Profiling floats

In the framework of the Argo programme, 8+1 profiling NEMO floats (Navigating European Marine Observer) were planned for deployment in the Weddell Sea. The NEMO floats are specifically adapted to ice-covered waters by aborting the ascent when the near-surface water temperature is close to the freezing point. Data are stored internally until the float finds open water in the next summer. Furthermore, the floats are able to receive signals from different sound sources moored in the Weddell Sea, allowing RAFOS location of the sub-ice profiles.

However, the floats were not deployed and will be returned to the manufacturer for technical modification. Excessively long data transmission times of some recently deployed NEMO floats suggest that the air bladder is not sufficiently inflated to lift the satellite antenna clearly free above the sea surface. After modification the floats may be deployed during ANT-XXIX/2 in austral summer 2012/13.

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4. THE *ROSEOBACTER* CLADE AND THE DISSOLVED ORGANIC MATTER (DOM) COMPOSITION IN THE ATLANTIC SECTOR OF THE SOUTHERN OCEAN DOM

Christine Beardsley[1], Helge Giebel[1], Birgit Kürzel[1], Helena Osterholz[1], Siri Rackebrandt[1], Thomas Remke[1], Maren Seibt[1], Matthias Wietz[1], Mascha Wurst[1], Martin Engelhaupt[2], John Vollmers[2], Rolf Daniel[2] (not on board), Thorsten Dittmar[1], (not on board), Meinhard Simon[1](not on board)

[1] Institute for Chemistry and Biology of the Marine Environment (ICBM), University of Oldenburg
[2] University of Göttingen, Institute of Microbiology and Genetics

Objectives

The goal of this project is a comprehensive assessment of the *Roseobacter* clade and its major bacterioplankton subclusters in the Atlantic sector of the Southern Ocean. This project is part of a key work package of the Transregional Collaborative Research Center Ecology, Physiology and Molecular Biology of the *Roseobacter* clade: Towards a Systems Biology Understanding of a Globally Important Clade of Marine Bacteria (TRR 51). The work on this cruise includes investigations of the biogeography, diversity, growth and population dynamics, the genomic potential and the impact on the DOM decomposition and cycling by the *Roseobacter* clade.

Work at sea

Therefore, water samples of 17 CTD stations were collected from different water masses and frontal systems along a transect from the subtropics to the Antarctic Coastal Current at different depth (0-1,000 m, some deeper). Additionally, ice samples (pack ice, ice cores) were collected to assess the biodiversity and significance of the *Roseobacter* clade in sea ice microbial communities. Samples were processed for chemical and molecular biological analyses, which were conducted partly on board (indicated) but mostly stored at suited temperature for later measurements in the home lab.

The following parameters were/are going to be analyzed:

- Dissolved organic matter concentration and composition (by FT-ICR MS)
- Particulate organic carbon (POC) & nitrogen (PON)
- Amino acid and carbohydrate concentrations (by HPLC)
- Chlorophyll concentration (on board)
- Phytoplankton composition and abundance
- Total bacterial abundance (by flow cytometry; on board),
- Bacterial biomass production (by leucine incorporation; on board)

- Subtrate turnover rate (using amino acids, carbohydrates; on board)
- Abundance of photoheterotrophic bacteria (by IR-microscopy)
- Phylogenetic diversity and abundance (by DGGE, CARD-FISH, 16S DNA sequencing)
- Functional diversity (by MAR-FISH, 16S RNA sequencing, expression of functional genes by qPCR, metagenomics, metatranscriptomics, metaproteomics)

At station PS79/46 (69°36.6’S 0°) mesocosm experiments were set up with manipulated substrate conditions to examine how the *Roseobacter* clade will respond to a changed substrate environment as it may be encountered during a phytoplankton bloom or decease or during sea ice melting.
Seawater from 20 m depth was incubated in 2 L and 20 L bottles at 0°C in the dark or in a 12 h light-dark rhythm and manipulated by adding

a) concentrated exudates of axenic algal cultures
b) laminarin or laminarin and laminarase
c) controls without any additions.

Added substrates are expected to trigger changes in bacterial abundance and community composition, bacterial production, turnover rates and metabolic activities.

Another important task was to isolate new strains of the *Roseobacter* clade (e.g. RCA and other important subclusters). Therefore, enrichments and dilution cultures from four stations were amended with various substrates and incubated at ambient temperature (4°C, 0°C). In the home lab they will be transferred into new media until strains of interest are in pure culture.

In addition to the work focusing on the *Roseobacter* clade, further experiments were carried out within the DFG-funded postdoc project "Biogeography and functional diversity of *Bacteroidetes* in Antarctic marine habitats". The phylum *Bacteroidetes* is abundant in the Southern Ocean and involved in the degradation of polymeric organic matter, such as polysaccharides.

Preliminary results

The bacterial abundance were stained with SybrGreenI and analysed within one to two hours of sampling by flow cytometry (= live counts). Preliminary evaluation of the data indicated that bacterial abundance in the surface water decreased from ~$8*10^8$ cells L^{-1} at lower latitudes to <$2*10^8$ cells L^{-1} at higher latitudes (paralleled with increasing ice cover and lower phototrophic production) as well as with depth (to ~$1*10^7$ cells L^{-1}). Bacterial production accounted for approximately 1-$10*10^6$ cells L^{-1} h^{-1} (~1-2 % of the standing stock) in the surface layer and continuously decreased with depth (e.g., ~$1*10^4$ cells L^{-1} h^{-1} at 4,000 m). Measurements of the turnover of amino acids and carbohydrates are still under evaluation. Photoautotrophic organisms were distinguished due to their characteristic autofluorescence and enumerated according to their size as pico-, nano-, and microplankton (<40 µm). These raw data will be further processed after returning to the home lab. Phytoplankton abundances measured by flow cytometry will be compared to fluorometrically measured chlorophyll concentrations from the same stations and depths.

In addition, bacterial degradation of polymers was studied by incubating bacterial communities from Antarctic seawater and sea ice with the polymeric nutrients agarose, alginate (algal polysaccharides) and chitin (a major structural polysaccharide of zooplankton such as copepods). Subsequent molecular analyses will focus on bacterial population dynamics upon stimulation with polymeric nutrients to show whether *Bacteroidetes* (or other bacterial groups) respond to availability of polymeric organic matter. In combination with molecular community fingerprinting of bacterioplankton from filtered water samples, this will illustrate the biogeography and specific biogeochemical role of *Bacteroidetes* in the Southern Ocean and improve the understanding of microbial nutrient cycling in the marine Antarctic.

5. PELAGIC DIATOM BIOGEOGRAPHY, SEA ICE MOLECULAR ECOLOGY AND BIOGEOCHEMISTRY

Anique Stecher, Christiane Uhlig, Yubin Hu, Bánk Beszteri, Gerhard Dieckmann (not on board), Klaus Valentin (not on board), Stephan Frickenhaus (not on board)

Alfred-Wegener-Institut für Polar- und Meeresforschung

Objectives

Diatoms are the dominant group of primary producers both in the pelagic Southern Ocean and in sea ice communities. Besides fuelling food webs of the area, they also play a substantial role in biogeochemical cycling of elements (Si, C), in climate regulation on a global scale, and in shaping the microbial habitats within sea ice. These facts are the major motivation behind our projects which are aimed at better understanding the interactions between diatom distribution and activities and physico-chemical environment in the Southern Ocean and in sea ice. To achieve this, we use methods ranging from classical biogeographic inventories through species distribution modeling to environmental marker gene sequencing and meta-transcriptomics.

Sampling phytoplankton (like most other sets of parameters) with a broad geographic coverage and even a limited temporal resolution (e.g. seasonal) in the vast and difficult-to-reach areas of the Southern Ocean is still not feasible. Thus, public archival and availability of taxon observation data obtained, aggregation and synthesis of such data from diverse projects, and application of methods linking biodiversity information with oceanographic contextual information are crucial for extending our understanding of taxon distribution patterns to wide geographic ranges. Our ongoing DFG funded project entitled "Integrating biodiversity and oceanographic information for modeling and predicting Southern Ocean diatom biogeography" aims at probing and improving the possibilities of such work at the interfaces between the currently existing global biodiversity information network, global physical oceanographic data collections, previously obtained taxon observation records from AWI studies, and material available at the diatom collection of the Hustedt Diatom Study Centre. For this project, as important as extending sampling to previously less represented areas and seasons, is the aspect of repeated sampling of a well characterized region which allows to test distribution models calculated using previously available data.

Eukaryotic microorganisms inhabiting the brine system within sea ice display a range of specialized adaptation mechanisms which enable them to survive and build up dense communities among the extreme conditions of this habitat type. These communities have been the target of molecular ecological investigations during numerous AWI and externally funded projects during the last years. The aim of these projects is to characterize the diversity, activity and functional properties of sea ice communities with molecular methods using ribosomal DNA, ribosomal RNA and whole transcriptome sequencing, respectively, and to gain insights into patterns of variation in molecular diversity and gene expression activities in the context of physical-chemical parameters of the respective habitats. The current DFG project "Comparative functional biodiversity of Antarctic and Arctic sea ice communities" is extending to comparisons between Antarctic and Arctic sea ice communities, but in parallel, establishment of a seminal data set for Antarctic sea ice communities is still ongoing. Our activities at this cruise are contributing to this aim.

The presence of a calcium carbonate form called ikaite was recently reported from sea ice for the first time. Clarification of the interactions of ikaite formation and dissolution with the physics and chemistry of sea ice and the atmosphere is still ongoing. Our *in-situ* investigations of the carbonate system of brine solution were planned to complement ongoing laboratory studies aimed at a quantitative description of physico-chemical controls of formation of ikaite.

Our three major aims for this cruise were accordingly to

1) collect pelagic diatom samples using plankton nets and Niskin-bottles for extending the biogeographic record and culture collection of the Hustedt Diatom Study Centre;
2) collect sea ice samples for molecular ecological characterization (filtered biomass for RNA and DNA extraction), accompanied by physical-biological meta-data (temperature, salinity, pH and chlorophyll profiles); and
3) characterize ice cores and their brine content physico-chemically to better understand *in-situ* formation of ikaite in sea ice and its physico-chemical controls.

Work at Sea

Plankton samples were collected in Niskin bottles mounted on a rosette sampler and using multinet tows at discrete depths from the surface 200 m, as well as using hand nets and the sea water supply system from the surface at 20 stations of the cruise. Living diatoms from different surface water masses were documented by micrographs obtained from fresh material with a ZEISS AXIOCam camera mounted on an AXIOVert inverted microscope. Quantitative phytoplankton samples from Niskin bottles, as well as subsamples from net tows were fixed and will be delivered to the home lab for further light and scanning electron microscopic analyses. Enrichment cultures of several diatom species have been established by micropipette isolation and will also be further processed in the home lab. Live samples (subsamples from net tows as well as from the sea water supply) were furthermore inoculated into culture medium and will be transferred to the home lab for the isolation of further cultures. The cultures isolated will be characterized using light and electron microscopy, as well as using molecular methods, contributing towards the goal of establishing a reference data set which will enable linking taxon observations obtained by classical (microscopic) and modern molecular methods (environmental marker sequencing studies).

Possibilities for sea ice coring were strongly limited by ice and weather conditions in the first, southward half of the cruise (soft, thin and flooded ice floes; bad flight conditions during our crossing of the ice). Accordingly, we could drill ice cores on only two occasions: once during the first MARU recovery trial at 64°S, and once in the Atka Bay,near the Neumayer Station. Even from these, only the cores taken at the first station could be used fully for the molecular ecology project. Biomass was filtered onto 1.2 µm membrane filters directly after melting and was immediately frozen at -80°C, these samples will be transported back to the home lab for molecular ecological investigations of the eukaryotic communities (18S rRNA / rDNA amplification, cDNA synthesis and sequencing). Samples from the second station were completely lost for molecular biology, since they had to be left outside for too long under undefined conditions due the helicopter accident and bad weather. However, two complete ice cores could be used for determining the vertical profile of the carbonate system and its relationship with biomass accumulation. One complete ice core was cut into 10 cm sections which were then centrifuged to extract the brine for pH and salinity measurement. Brine samples for DIC and alkalinity measurement were filtered through 0.22 µm membrane filters by a syringe and will be transported back in the home lab in a cooled box. The other complete ice core was also cut into 10 cm sections, melted at 4°C, and used for obtaining bulk salinity and chlorophyll profiles.

During the second half of our cruise leg (return from Neumayer), no ice coring work could be performed at all. In this period, we obtained further ice samples by collecting chunks of ice broken up by *Polarstern* using a crane from the working deck during station work (“ice fishing”). Unfortunately these samples are not ideally suited for most of our purposes, because these pieces of ice were flooded by sea water after ice breaking and the exact physico-chemical conditions they had been subjected to previously to sampling cannot be characterized accurately. In spite of these drawbacks, the samples collected will be useful for testing and optimizing nucleic acid extraction methods specifically for sea ice communities, an often rather challenging step in molecular ecological studies of eukaryotic communities from this habitat. Samples for microscopic investigation of the eukaryotic communities were also obtained and fixed from all ice samples (including ice cores and “ice fishing” samples), and raw and enrichment cultures were established.

Expected results

Most of our analyses will only be performed in the home lab, so detailed results will only be available later on. Diatom samples from the water column as well from the ice samples obtained will be archived in the diatom collection of the Hustedt Diatom Study Centre at the AWI. Taxon observations to be obtained from these samples will be used in our ongoing biogeographic studies. Cultures both from the water column and from sea ice will be characterized using a combination of classical morphological and molecular methods and will be part of our reference data set for linking classical and molecular biodiversity survey results. Filtered and frozen sea ice biomass will be used for optimizing nucleic acid extraction methods, and, as far as availability of meta-data allow, for molecular characterization of these communities. The carbonate system parameters (pH, DIC and TA) together with chlorophyll profiles will be analysed to learn more about their interrelationships.

6. LIFE CYCLE STRATEGIES OF CALANOID COPEPODS

Holger Auel[1], Wilhelm Hagen[1], Carolin Hauer[1], Sabine Schründer[1], Franz Josef Sartoris[2], Sigrid Schiel[2], Richard Steinmetz[2], Hans M. Verheye[3], Jenny Huggett[3], Keshnee Pillay[3]

[1] BreMarE - Marine Zoologie, Universität Bremen
[2] Alfred-Wegener-Institut für Polar- und Meeresforschung
[3] Department of Environmental Affairs, Oceans & Coasts Research

Objectives

Studies on the life-cycle strategies of dominant copepod species have been carried out in the Weddell Sea since the 1980s. One of the most interesting aspects is how the dominant herbivorous species are adapted to the distinct seasonality in light, ice cover and, hence, to primary production. It has been shown that copepods have developed specific adaptations to utilize short-term food pulses and to endure long periods of food scarcity in the water column. Ontogenetic and seasonal vertical migrations associated with a diapause are known as an adaptation to escape temporarily from unfavourable conditions and food scarcity during the unproductive winter season. These diapausing copepod species migrate mainly as late copepodite stages to greater depths, where they reside for several months in diapause characterized by low swimming activity, cessation of feeding, arrested development and reduced metabolic rates. They accumulate large amounts of depot lipids during spring and summer, often exclusively composed of wax esters, to fuel diapause and reproduction in the following spring partly independent of food intake.

However, in contrast to the Arctic Ocean, only one calanid copepod in the Southern Ocean, *Calanoides acutus*, has adopted this strategy for sure, *Rhincalanus gigas* is an uncertain ontogenetic migrant. Most Antarctic copepods apparently do not have a resting stage. They remain active during winter and adjust their feeding behaviour.

Two main questions concerning diapause in calanoid copepods are still unanswered: (i) what controls the beginning and the end of diapause and (ii) how diapausing copepods with a reduced swimming activity regulate their buoyancy to remain at a certain depth over a long period of time.

Our preliminary studies on ion composition and concentration during *Polarstern* cruise ANT-XXIII/7 in September-October 2006 showed high concentrations of ammonia/ammonium (NH_3/NH_4^+) in the haemolymph of the two pelagic species, *Calanoides acutus* and *Rhincalanus gigas*. All other species investigated did not show elevated ammonium concentrations in their haemolymph. The finding that high levels of ammonia are only found in species, which undergo vertical ontogenetic migration is evidence that ontogenetic migration is related to and/or relies on ammonia-aided buoyancy. Dependent on the pH, ammonia exists in solutions as both, NH_3 and NH_4^+. NH_3 is more toxic than NH_4^+ and in contrast to NH_4^+ it easily penetrates cell membranes. Due to the toxicity and the higher diffusibility of NH_3, we predict a low haemolymph pH in diapausing copepods to favour the formation of ammonium (NH_4^+).

Our studies during ANT-XXVIII/2 aim to test the hypotheses on the role of ammonia for triggering metabolic depression and regulating buoyancy during the diapause of polar calanoid copepods during the transition from the spring to the summer state.

The key aim and question of our studies were:
To test the hypotheses on the role of ammonia for triggering metabolic depression and regulating buoyancy during the diapause of polar calanoid copepods during the transition from the spring to the summer state.
How do resting and non-resting species differ in their biochemical and physiological status as well as lipid biochemistry?

Work at sea

For the experimental work, live specimens were caught with the bongo net and the multinet from different depth layers to study the metabolic activities in animals living in upper and deeper water depths.

The feeding activity of *C. acutus* was studied in grazing experiments on a plankton wheel. Samples from the experiments will be analyzed by the fluorescence method, which measures chlorophyll a and derived pigments in the guts of the animals.

For the respiration experiments, copepods were transferred to filtered seawater. The experiments were run at 0.4°C for approx. 12 hours. A total of 288 respiration measurements were conducted by optode respirometry (PreSens Regensburg, Germany) mainly with the target species *C. acutus*, *C. propinquus* and *R. gigas*, but also with other copepods such as *Paraeuchaeta antarctica*, *Gaetanus* spp., *Pseudochirella* spp. and *Euaugaptilus antarcticus*. After termination of the incubations, the copepods were removed and frozen at -80°C for later determination of dry mass.

Excretion measurements were run for 24 hours. Thereafter, the water from the incubation bottles was frozen at –80°C for the determination of ammonium, urea, DON, nitrate and phosphate in the home lab.

In addition to the experimental work, individuals of *C. acutus, C. propinquus* and *R. gigas* were preserved for analyses of lipids, fatty acids, proteins, stable isotopes ($\delta\ ^{13}C$, $\delta^{15}N$), C/N ratio and digestive enzyme activity. The animals were starved and then frozen at -80°C.

Ion regulation

Live individuals of *C. acutus*, C. *propinquus* and *R. gigas* were caught with the multinet from different depth layers to determine the ion concentration and pH of the heamolymph. Haemolymph was extracted for determination of ion concentration. pH was measured directly after the extraction with a fluorometric approach.

Egg production

Because of their sheer abundance and rather complicated life-history features, copepods are very suitable for estimating zooplankton production. Knowledge of their production is essential to understand nutrient and carbon fluxes in the marine environment, especially because copepods are the dominant trophic link between primary producers (phytoplankton) and higher food web levels, including fish, seabirds and whales.

Calculation of copepod production requires data on biomass (obtained from net tows) and knowledge of their growth rate. The latter comprises somatic growth (weight gain) of the larvae (= 6 nauplius stages: N1-N6) and the juveniles (= 5 copepodite stages: C1-C5) plus reproductive growth (fecundity, or egg production) of adult females (C6), with the contribution by adult males considered negligible.

Secondary production is defined as the conversion by heterotrophs of photosynthetically assimilated energy derived from primary producers into body tissue, or the amount of tissue (= biomass) accumulated by zooplankton (as well as zoobenthos) per unit time and per unit area, regardless of its fate. It also includes production lost to predators and other loss sources, in addition to reproductive products (i.e. eggs). There are two types of egg production strategies in copepods: (i) broadcast-spawners, which release numerous eggs in batches freely in the surrounding water where they are subject to heavy predation, and (ii) egg-sac spawners, which deposit fewer eggs in a 'brood pouch' that remains attached to the female until hatching.

One of the focus areas of zooplankton research conducted during the *Polarstern* cruise ANT-XXVIII/2 was the measurement of daily egg production rate of dominant broadcast-spawning planktonic calanoid copepods in different hydrographic regions of the Southern Ocean. At every station we collected zooplankton samples in the upper 10 m of the water column using a hand-operated, 300-µm driftnet fitted with a large-volume cod-end bucket. Unlike other plankton nets, which are towed through the water column exerting stress on the plankton, the driftnet traps plankton organisms as they drift with the natural flow of the water currents through the net's meshes. This is a gentle collection method, which yields animals in a pristine condition. Adult females of one or more of four calanoid copepod species that are dominant in the study area were present in our surface driftnet collections, viz. *Calanus propinquus*, *Calanoides acutus*, *Calanus similimus*, and *Rhincalanus gigas* (Fig. 6.1).

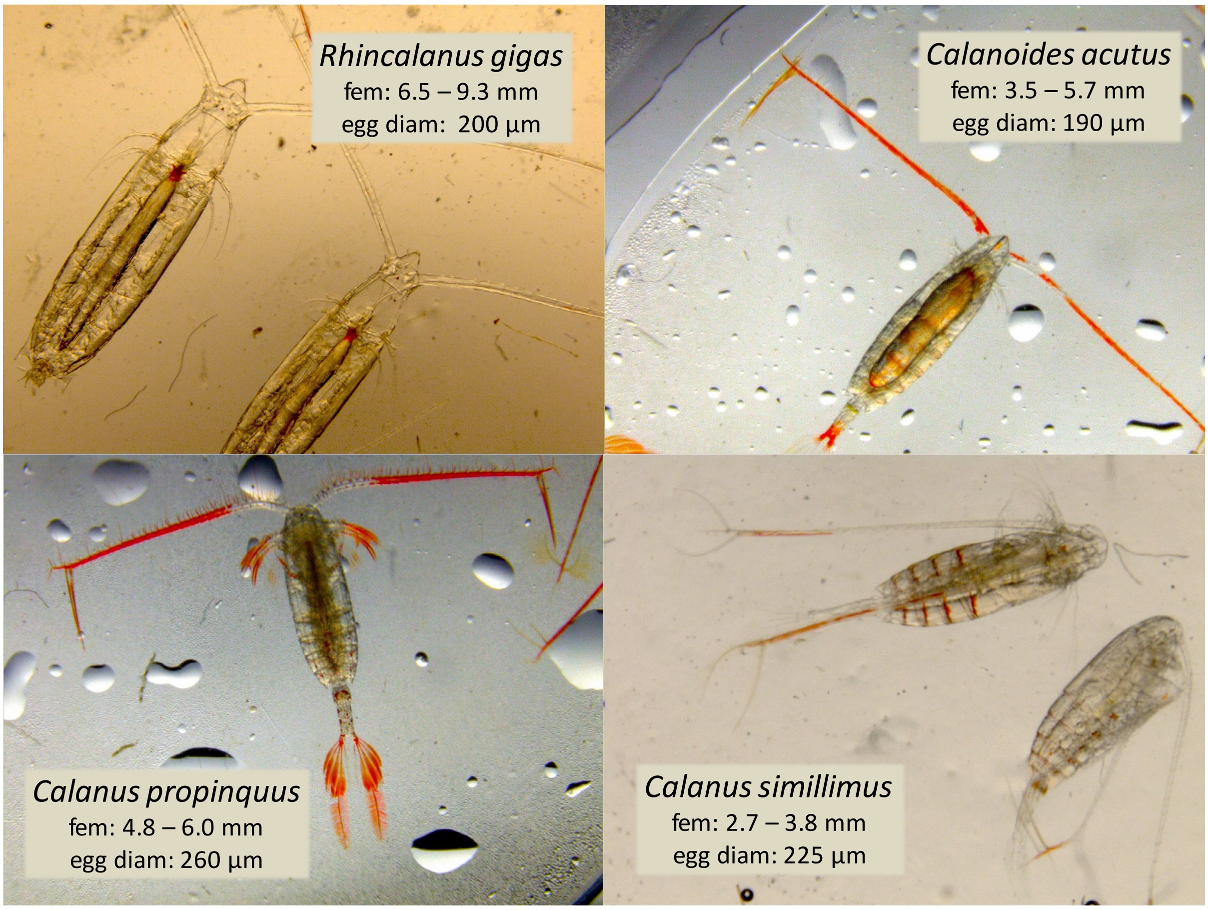

Fig. 6.1: Photographs of the four most commonly found calanoid copepods during the cruise, with size range of the females and egg diameters.

Immediately after collecting the zooplankton, lively, undamaged specimens of mature adult female copepods were sorted from the driftnet catches under a microscope in a temperature-controlled laboratory (2°C) onboard the ship. This ensures that the animals are not being exposed to thermal shock and remain in a pristine condition for experimental work.

Daily egg production rates (EPRs) of copepods were measured using a simple technique, called the 'bottle incubation method'. Typically, single specimens of adult female copepods were carefully placed into opaque, 1-L plastic incubation bottles. These were filled with ambient sea surface water that contains natural phytoplankton assemblages, but we filtered the water through a 63-µm mesh to avoid possible contamination with eggs that might already be present in the water. All bottles were maintained in an incubator in the laboratory at ~0°C, thus simulating the ambient sea surface temperature conditions at the time of collection. After 24 hours, the incubations were terminated, the condition of the females in each bottle was assessed and the eggs that were spawned during the incubation period were counted under a microscope on board. The number of eggs per female produced during a 24-h period is a measure of fecundity or daily EPR. Experiments where females were found dead or moribund were not considered in the data analysis.

EPRs are often a reflection of recent feeding history and are therefore usually related to the amount of food (chlorophyll *a*) ingested, which together with other environmental conditions (e.g. temperature) vary both seasonally and spatially. While we have not yet performed such relational analyses rigorously, we needed to test for the effect of presence *versus* absence of food on egg production rate, to enable a meaningful comparison of our measurements (i.e. with food present) with those previously made (i.e. without food) by other researchers. Therefore, at stations where sufficient females of *C. acutus* and *C. propinquus* were collected, we incubated two batches of individual females, with one batch in 63-µm filtered, natural seawater (i.e. with food) and the other in <1 µm-filtered seawater (FSW, i.e. without food).

Preliminary results

The experiments that were conducted to compare EPR for females incubated in <1 µm-filtered seawater (FSW) as opposed to 63-µm filtered seawater for *C. acutus* (n = 21 and 24 respectively) and *C. propinquus* (n = 11 and 15 respectively) demonstrated that EPR was not significantly different for the two incubation media (ANOVA; $p>0.05$ for both experiments). We therefore combined our EPR results obtained under these different experimental food conditions in further data analyses and they can also be compared with data from previous studies in the Southern Ocean during the same time of year.

The results of our measurements of copepod egg production rate (EPR) conducted for each species, as well as corresponding maximum EPRs values obtained from the literature, are summarized in Table 6.1. It is apparent that our EPR measurements for *C. acutus* and *C. propinquus* are higher than those previously reported in the literature (albeit for other parts of the Southern Ocean), while our data for *C. simillimus* and *R. gigas* are too limited to allow a meaningful comparison. It was evident that *C. acutus* had already terminated its overwintering and started feeding at the time of sampling, with multiple faecal pellets present in most incubations and individual females producing on average 37 eggs per day, up to a maximum of 130 eggs per day. Likewise, *C. propinquus* also proved to be actively feeding on microalgae, and produced also many faecal pellets as well as numerous eggs, on average 51 eggs per day and with a maximum of 265 per female per day, more than twice the known maximum daily EPR of 157 eggs per female per day for that copepod in the Southern Ocean.

Table 6.1: Summary of the number of copepod egg production rate incubations conducted, mean egg production rates (EPR, eggs female^{-1} day^{-1}) per species, as well as maximum EPR compared with EPR values obtained from the literature for the Antarctic region (S. Schiel, pers. comm.)

Species	No. Expts	Avg no. eggs	Max no. eggs	Literature max
Calanus propinquus	122	50.6	265	157
Calanoides acutus	98	37.1	130	118
Calanus simillimus	17	15.5	44	50
Rhincalanus gigas	5	5.4	27	94
Grand total	**242**			

Egg production rates varied with latitude (Table 6.2), generally showing an increasing trend in a north-south direction for *C. acutus* (except in the vicinity and north of the southern Antarctic Circumpolar Front) whilst declining for *C. propinquus* (Fig. 6.2). Interestingly, peaks in daily egg production of the two species often appeared to be more or less associated with peak chlorophyll concentrations, measured en route as fluorescence of the surface waters (Fig. 6.2).

Table 6.2: Means (and range) of daily egg production rates (eggs female^{-1} day^{-1}) by female copepods *Calanoides acutus*, *Calanus propinquus*, *Calanus simillimus* and *Rhincalanus gigas* collected mainly by driftnet from near-surface depths at 14 stations (39-54).

Latitude	Station	*C. acutus*	*C. propinquus*	*C. simillimus*	*R. gigas*
51°27′	PS 79/39	14 (0-29)*	0 (n=1)	20 (9-44)	5 (0-27)*
53°30′	PS 79/40		2 (0-3)	8 (1-14)	
55°	PS 79/41		139 (48-256)	11 (7-14)	
56°30′	PS 79/42	39 (0-109)	40 (0-265)		
58°17′	PS 79/43		109 (0-212)		
64°06′	PS 79/44	50 (0-99)	73 (0-174)		
70°31′	PS 79/45	53 (0-130)	2 (0-6)		
69°30′	PS 79/46	36 (0-109)	0 (n=1)		
68°59′	PS 79/47		27 (0-119)		
67°	PS 79/49		11 (0-54)		
64°05′	PS 79/51	26 (0-81)			
61°59′	PS 79/52	7 (0-59)			
60°01′	PS 79/53		31 (0-93)		
53°28′	PS 79/54			17 (16-19)	

Females collected from Tucker Trawl, not driftnet

It should be stressed that the results reported here are only preliminary because more rigorous analysis of the data remains to be done, and therefore they should be treated with caution. In addition, length, weight and gonad state of the females used in the experiments will be measured and the mass of eggs spawned need to be determined to calculate mass-specific growth rates of each species. Furthermore, a more detailed analysis of these growth rates in relation to environmental conditions (e.g. temperature, chlorophyll concentration and phytoplankton species composition), that characterize the surface layer (and the incubation medium) of the different water masses encountered during the cruise, remains be performed.

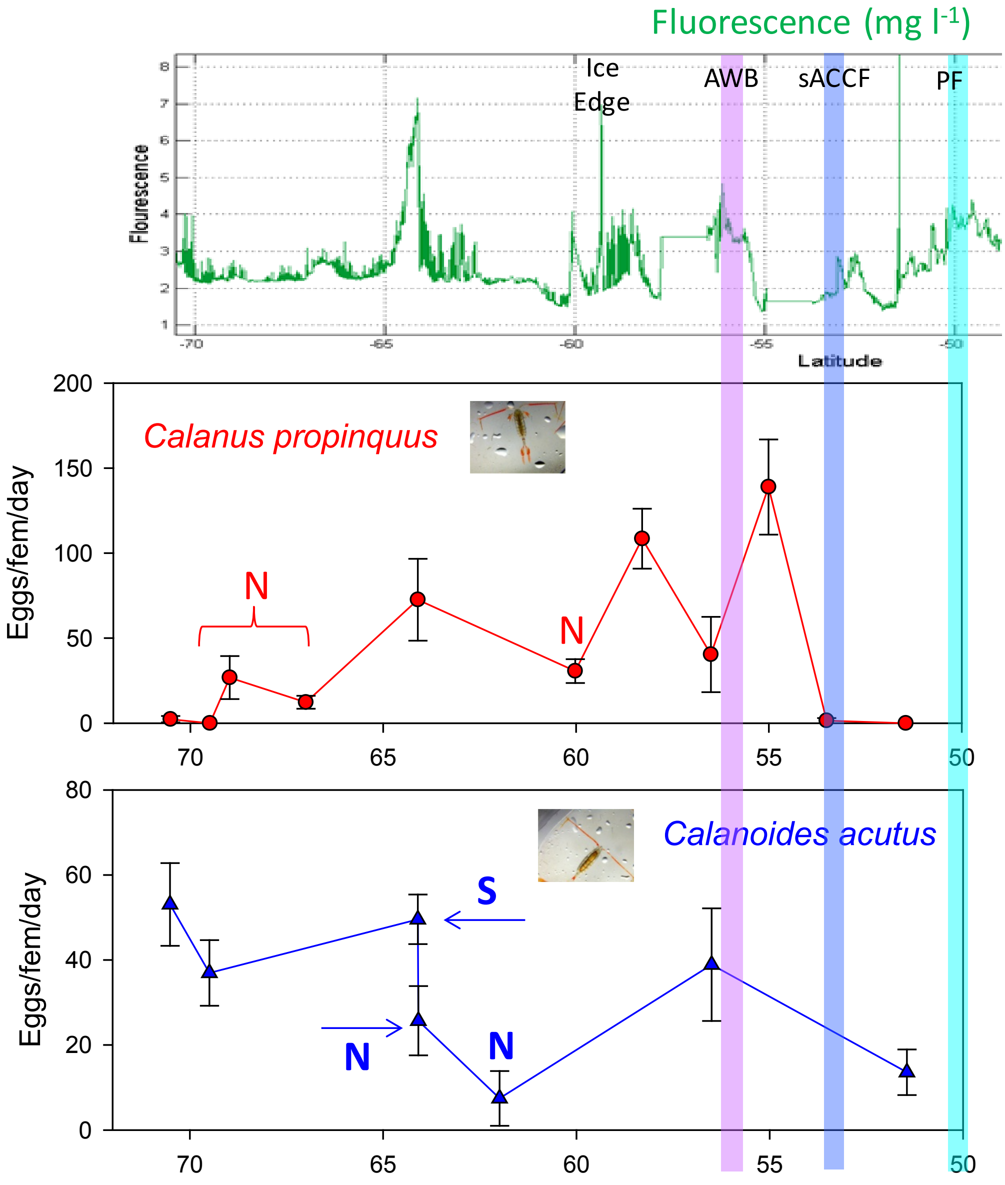

Fig. 6.2: Mean egg production rate (eggs female^{-1} day^{-1}) of Calanus propinquus and Calanoides acutus in relation to latitude (°S) and underway fluorescence values (mg l^{-1}). The approximate locations of the ice-edge, Antarctic Weddell Gyre Boundary, southern Antarctic Circumpolar Front (sACCF) and Polar Front (PF) are also shown. S and N indicate whether experiments were done on the southward (S) or northward (N) legs of the voyage (default is southward).

7. INVESTIGATING FEEDING INTERACTIONS AND PREDATOR-PREY RELATIONSHIPS BY STABLE ISOTOPE ANALYSIS

Keshnee Pillay
Department of Environmental Affairs, Oceans & Coasts Research

Objectives

Certain elements in nature exist in different atomic forms or isotopes. These isotopes are based on variations in atomic weight, specifically the number of neutrons in the nucleus of the atom. Isotopes of an element can be used in many studies to answer ecological questions and new disciplines of science have emerged, one of which is stable isotope ecology.

The difference in atomic weight (number of neutrons) does not affect the physical or chemical properties of a reaction in which such an element is used. However, lighter isotopes require less energy in reactions and are therefore favoured leaving the reaction substrate with a higher abundance of the heavier isotope than the lighter isotope. This allows for patterns to be traced using stable isotope ecology.

The most commonly used elements are carbon, nitrogen, hydrogen, oxygen and sulphur. Identification of the stable isotope ratio of heavy isotope to light isotope is done by isotope ratio mass spectrometry (IRMS). This ratio is similar to that of a fingerprint and can be traced to reveal patterns in nature. The stable isotope ratios of carbon ($^{13}C/^{12}C$ also annotated as $\delta^{13}C$) and nitrogen ($^{15}N/^{14}N$ also annotated as $\delta^{15}N$) are the most commonly used isotopes to trace feeding interactions and predator-prey relationships. This is because predator tissues are directly related to that of prey items and are transferred in a fairly predictable manner through the foodweb via a process called fractionation. For $\delta^{13}C$ and $\delta^{15}N$ there is respectively a 0-1 ‰ and 3-5 ‰ enrichment (increase) relative to diet per trophic level.

Work at sea

One of the focus areas of zooplankton research conducted during *Polarstern* cruise ANT-XXVIII/2 was to investigate feeding interactions and predator-prey relationships in different hydrographic regions of the Southern Ocean using $\delta^{13}C$ and $\delta^{15}N$. At every station five litres of water was collected from the surface, using a hand-operated bucket (Pütz), and from the depth of maximum fluorescence (F_{max}) using the CTD/Rosette water sampler. Surface water was not collected from the CTD as the sea and ice conditions made it difficult to sample true surface water. In addition, samples of sea-ice algae were also collected through ice-coring and ice-fishing. These were allowed to slowly melt at 4ºC to ensure the algae cells did not burst. All water samples were filtered onto pre-combusted glass fibre filters immediately to extract particulate organic matter (POM). The $^{13}\delta C_{\text{(POM \& Sea Ice)}}$ and $\delta^{15}N_{\text{(POM \& Sea Ice)}}$ signatures form the basis of the web and are used as 'tracers' up the food web.

Zooplankton samples were collected in the upper 10 m of the water column using a hand-operated, 300 µm driftnet and in the upper 300 m using a 500 µm bongo net or a 1000 µm Tucker trawl (Table 7.1). Some zooplankton samples were opportunistically collected from the 100 µm multinet that was deployed to 2000 m to primarily assess zooplankton species diversity, vertical distribution and abundance. All zooplankton samples were size-fractionated in the following size classes: 200 – 300 µm, 300 – 500 µm, 500 – 1000 µm, 1000 – 2000 µm, 2000 – 3000 µm and >3000 µm. Each size-fraction was sorted separately under a dissecting microscope, zooplankton species were identified, removed and frozen for subsequent analysis of $\delta^{13}C$ and $\delta^{15}N$ in the home laboratory. Though the mesh size-fractions do not correspond to the mesh size of the nets used all samples were still sieved through all six mesh sizes to possibly retain any smaller animals trapped in the nets and more importantly collect any masses of phytoplankton that might occur. Pure phytoplankton samples would add to acquiring a better base for the foodweb.

Table 7.1: Samples taken for stable isotope analysis

Station number	**Samples taken (including preliminary identification)**
39	POM (surface and F_{max}), *The pyramidata pyramidata misto gaudichaudi*, chaetognatha, *Limacina* sp., *Euphausia* sp., *Rhincalanus gigas*, *Clione limacina antarctica, Tomopteris* sp., *Sagitta maxima, Sagitta gazellae*, radiolarian and phytoplankton mixed sample.
40	POM (surface and F_{max}), siphonophore, *Clione limacina antarctica, Salpa thompsoni, Salpa fusiformis, Salpa* sp. (aggregate), *Themisto gaudichaudi, Hyperiella* sp., *Thysanoessa* sp., *Euphausia* sp.
41	POM (surface and F_{max}), *Calanus propinquus, Themisto gaudichaudi,* chaetognatha, *Rhincalanus gigas*, *Salpa thompsoni* (various sizes to test for size- related feeding patterns)
42	POM (surface and F_{max}), *Salpa thompsoni* (various sizes to test for size-related feeding patterns), chaetognatha, *Themisto gaudichaudi, Thysanoessa* sp.
43	POM (surface and F_{max}), *Euphausia superba, Thysanoessa macrura, Clio pyramidata* forma *sulcata, Limacina helicina antarctica, Euphausia* sp., *Calanus propinquus, Calanus similimus, Calanoides acutus,* phytoplankton
44	POM (surface, F_{max} and sea-ice), *Thysanoessa* sp., *Calanus propinquus, Calanoides acutus, Rhincalanus gigas*, *Clione limacina antarctica,* amphipod (to be identified), chaetognatha, Jellyfish (to be identified)
45	POM (surface and F_{max}), *Calanus propinquus, Calanoides acutus, Rhincalanus gigas*
46	POM (surface and F_{max}), *Calanus propinquus, Calanoides acutus, Rhincalanus gigas,* chaetognatha, *Clione limacina antarctica*
47	POM (surface, F_{max} and sea-ice), *Calanus propinquus, Calanoides acutus*
49	POM (surface and F_{max}), *Calanus propinquus, Thysanoessa* sp., *Euphausia* sp.
50	POM (surface and F_{max}), *Calanus propinquus, Calanoides acutus,* starfish larvae, *Euphausia* sp., *Rhincalanus gigas*, chaetognatha, *Clio pyramidata* forma *sulcata*
52	POM (surface and F_{max}), *Thysanoessa* sp., *Calanus propinquus, Calanoides acutus, Rhincalanus gigas*, *Clione limacina antarctica,* amphipod (to be identified), chaetognatha, *Euphausia* sp., *Diphyes antarctica, Beroe* sp.
53	POM (surface and F_{max}), *Salpa thompsoni* (various sizes to test for size-related feeding patterns)

8. DISTANCE SAMPLING SURVEYS FOR CETACEANS IN ANTARCTIC WATERS

Linn Sophia Lehnert[1], Steve Geelhoed[3], Ian Gray[1], Kristina Lehnert[2], Stephanie Plön[1], Kornelia Schmidt[1], Hans Verdaat[3], Anita Gilles[1] (not on board), Helena Herr[1] (not on board), Ursula Siebert[1] (not on board)

[1] Institut für Terrestrische und aquatische Wildtierforschung, Stiftung Tierärztliche Hochschule Hannover
[2] HZG Helmholtz-Zentrum Geesthacht
[3] IMARES Wageningen UR

Objectives

Knowledge on distribution, density and abundance of cetaceans in the Southern Ocean is rather limited. Especially in pack-ice regions, little research has been conducted as only few vessels can penetrate into the ice. In previous studies (Kock et al., 2009; Scheidat et al., 2011) we confirmed earlier investigations (Plötz et al., 1991; van Franeker, 1992) and showed that in the Southern Ocean ship-based helicopters provide a useful platform to survey marine mammals not only in open water but also in pack-ice. By means of a dedicated aerial and shipboard cetacean sighting survey following standard line-transect distance sampling methodology, our project aimed to contribute to solid base-line data on cetacean occurrence and abundance, needed by decision makers for management and conservation plans. In addition, behavioural observations were to investigate potential responsive behaviour of cetaceans towards vessels in Antarctic waters.

Work at sea

Aerial surveys

Aerial surveys following standard line-transect distance sampling methodology (Buckland et al., 2001) were conducted with the two helicopters (BO 105) of RV *Polarstern*. The duration of survey flights ranged from 15 minutes to 2 hours with an average duration of 1 ½ hours. Surveys were planned in an "ad-hoc" way, depending on the position and the track of RV *Polarstern* as well as the actual weather conditions.

Survey flights were conducted at 600 feet with a speed of 80-90 nm per hour. Two observers were positioned in the back of the helicopter and were observing the area to the right and to the left side of the helicopter, respectively. The third observer was seated in the port front seat of the helicopter observing the area to the front, focusing on the transect line. The observer in the right back seat of the helicopter used the VOR software, designed by Lex Hiby and Phil Lovell and described in Hammond et al. (1995), to continuously store GPS data, data on environmental conditions (sea state, cloud cover, glare, ice coverage, overall sighting conditions) and sighting data.

For each sighting of a marine mammal in the water the following data were collected: species, distance to transect (via declination angle), group size, group composition, behavior, cue, swimming direction and potential reaction to the helicopter. Inclinometers were used to measure the declination angle to each sighting when abeam the helicopter. With the known survey altitude, this angle will be used to calculate the distance of the sighting to the transect line. Using the software *Distance* (Thomas et al., 2010) the effectively searched strip widths for the different cetacean species can be estimated post-survey. Furthermore, swimming penguins, vessels, and floating debris were recorded.

If a sighting occurred and species or group size could not be identified, the survey was interrupted to approach the sighting for closer inspection. After identification the helicopter returned to the transect line and the survey was continued (closing mode). Digital photography was used for species identification.

Shipboard survey

A ship based survey following line-transect distance sampling methodology was conducted from the crow's nest platform with two observers scanning the area in front of the vessel. The two observers were situated in wooden observer boxes located on the left and right side of the platform. The scanning was done naked eye but binoculars were used to identify species and group sizes. An additional team member was situated inside the crow's nest operating as data recorder. During shipboard observations the same information on environmental and sighting conditions as for the aerial surveys was collected. Surveys were generally conducted if *RV Polarstern* had a speed of at least 7 knots. Some observations were done in lower speed while breaking through ice.

Tracking

To investigate potential responsive behaviour of whales towards the survey vessel, high powered binoculars (Big Eyes) were used to follow the track of detected animals as long as possible, while the ship passed by the sightings. These behavioural studies were conducted from the crow's nest. "Tracking", however, is only possible under perfect weather conditions with winds of less than 3 Bft, good visibility (clear horizon), a low swell and no ice breaking activity of the ship. These conditions were not given during this cruise and hence, tracking could not be performed.

Preliminary results

Aerial surveys were conducted from 6 to 16 December 2011. During this time, a total of 11 flights were conducted, adding up to 15½ hours of survey, covering 2030 km. During these surveys 6 cetacean sightings with a total of 9 animals were made. Overall, 5 different species were identified. Table 8.1 gives an overview of the number of sightings and animals for all cetacean species encountered.

During the shipboard survey a total of 70 hours was surveyed on effort, covering about 700 nm (estimate based on total hours of effort and assuming average speed of 10 knots). 9 cetacean sightings, totaling 10 animals, were recorded (Table 8.1). All cetacean sightings made from the crow's nest occurred south of the ice edge and consisted either of Antarctic minke whales (*Balaenoptera bonaerensis*) or unidentified baleen whales.

On the southbound leg of the cruise, from Cape Town to Neumayer Station III, bad weather with high sea states and low clouds repeatedly hampered our survey work. Between 40°S and 55°S four helicopter flights and 17 ½ hours of observations from the crow's nest were conducted. One fin whale (*Balaenoptera physalus*), one humpback whale (*Megaptera novaeangliae*), one southern bottlenose whale (*Hyperoodon planifrons*), one unidentified large whale and a group of hourglass dolphins (*Lagenorhynchus cruciger*) were recorded in this area. In the vicinity of the ice edge, bad weather conditions with fog and high sea states made systematic observations impossible.

The vessel entered the pack-ice at 58°S. Sea ice coverage was very high during the whole passage from the ice edge to the shelf ice edge. Only two species were seen in waters covered by sea ice; these were the Antarctic minke whale and a group of southern bottlenose whales, which was encountered at 68°S in an area of 70 % sea ice coverage.

Due to the accident of the board helicopters on the way to the Neumayer Station III on 17 December, helicopter surveys could neither be conducted in the coastal polynya and adjacent areas close to the Neumayer Station III, nor for the rest of the cruise.

When *Polarstern* left Neumayer Station III on 22 December, the distance-sampling surveys from the crow's nest where continued, recording further sightings of Antarctic minke whales and one sighting of an unidentified baleen whale. Strong winds and fog where the steady companions of RV *Polarstern* on her way north, often making systematic counts of cetaceans impossible. Fig. 8.1 gives an overview of the positions of all cetacean sightings and the survey effort from the aerial survey and shipboard observations combined.

Publication in scientific journals in the fields of marine biology and zoology and presentation on scientific conferences will make the data available for science and public.

Acknowledgements

We would like to thank Captain Wunderlich and the whole crew of *Polarstern* for their friendly assistance throughout the whole trip. These surveys would not have been successful without the helicopter crew, Burkhard Zepik, Lars Vaupel, Jens Brauer and Carsten Möllendorf. We would like to thank the pilots and technicians for the good cooperation and kind assistance. We are indebted to Max Miller and Hartmut Sonnabend from the meteorological office whose weather predictions made it possible to conduct these surveys in an extremely variable environment. This project was financed by the German Federal Ministry of Food, Agriculture and Consumer Protection within the project: „Modellierungen zu Populationsgrößen und räumlicher Verteilung von Zwergwalen im antarktischen Packeis auf der Grundlage von See- und luftgestützten Tiersichtungen.“ (Förderkennzeichen 2811HS002).

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Table 8.1: Cetacean sightings by species from the aerial and shipboard surveys during ANT-XXVIII/2

Species	**Number of groups**	**Number of individuals**
Antarctic minke whale (*Balaenoptera bonaerensis*)	5	6
Humpback whale (*Megaptera novaeangliae*)	1	1
Fin whale (*Balaenoptera physalus*)	1	1
Southern bottlenose whale (*Hyperoodon planifrons*)	2	3
Hourglass dolphin (*Lagenorhynchus cruciger*)	1	3
Unidentified baleen whale	5	5
Total	**15**	**19**

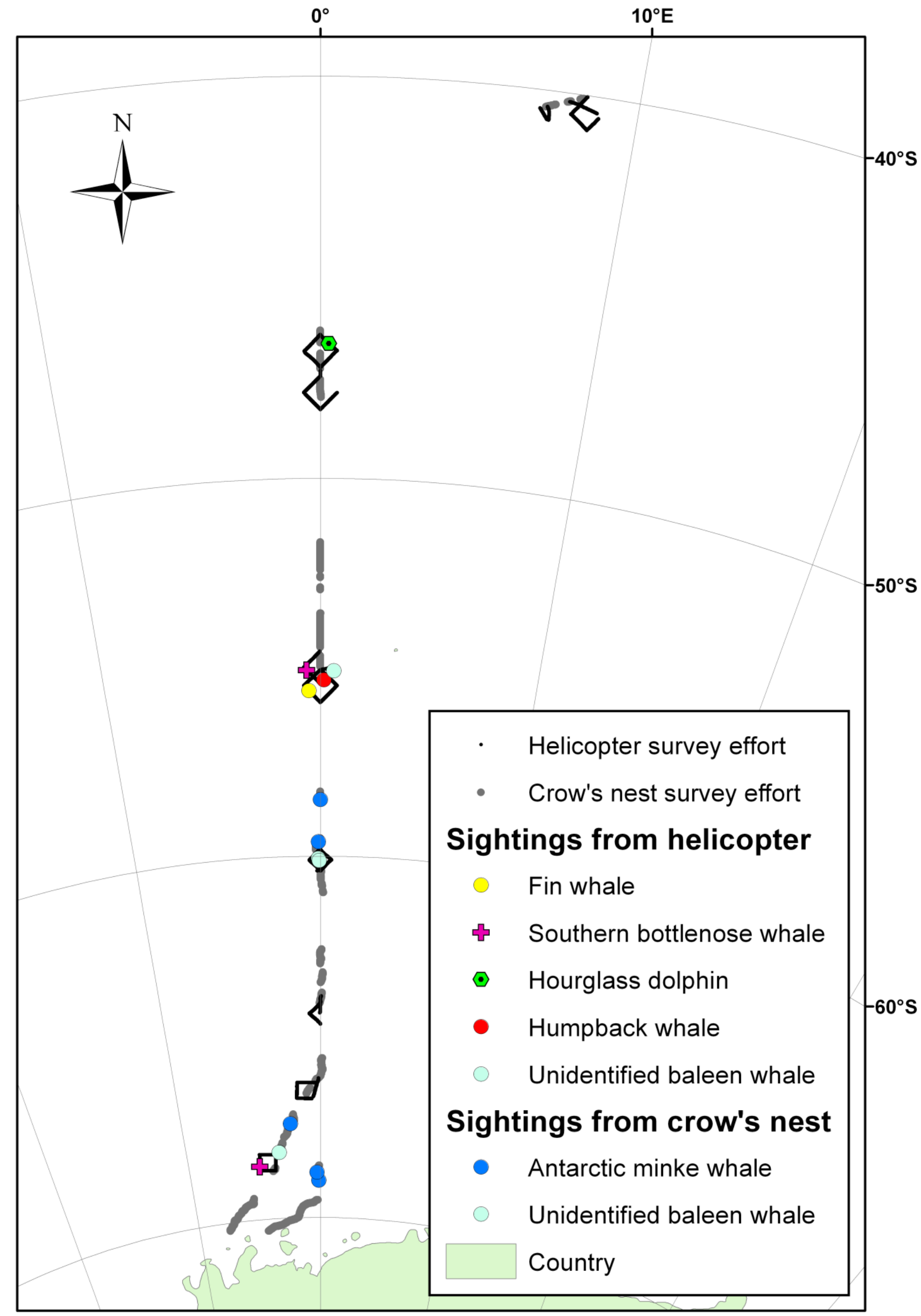

Fig. 8.1: Survey effort and distribution of cetacean sightings along the cruise track

9. MAPS: MARINE MAMMAL PERIMETER SURVEILLANCE

Sebastian Richter[1,2], Mirjam Müller[3], Olaf Boebel[1] (not on board), Lars Kindermann[1] (not on board), Daniel P. Zitterbart[1,2] (not on board)

[1] Alfred-Wegener-Institut für Polar- und Meeresforschung
[2] Universität Erlangen-Nürnberg
[3] Umweltbundesamt

Objectives

Monitoring for marine mammals in the vicinity of ships, to either collect data for cetacean research or to mitigate contingent detrimental effects of hydroacoustic surveys is a strenuous, time and personnel intensive task. Addressing these challenges, the MAPS project aims at making maximum use of ship-time through systematic logging of opportunistic whale sightings by the ship's nautical officers and by developing an automatic whale detection system, based on thermal imaging.

Whales are detectable in polar regions by means of the thermal anomaly generated by the whale's blow which contrasts the cold environment. 360° thermal images of the ships vicinity are provided by a high resolution infrared scanner (FIRST-Navy) at 5 frames per second. On the basis of this video stream, an automatic whale blow detection software (Tashtego) was developed and tested during past cruises (ANT-XXVII/1 & ANT-XXVII/2), showing promising first results.

This cruise's main goal was to collect and save as much IR as possible (i.e. throughout the entire cruise) in conjunction with concurrent visual sighting data to allow retrospective double blind studies along with further development and efficiency testing of the algorithm. To obtain to-the-second logs of blowing whales for development and testing, a dedicated observer was logging individual whale blows from the ship's bridge. Information of such accuracy is indispensible to be able to manually search for a whale's blow in the thermal images during retrospective analysis and to unequivocally identify false positive (missed) autodetections. Additional concurrent visual observations (line transect) were to be obtained in an independent project (Lehnert et al., this report), who conducted distance sampling from the crow's nest.

Finally, both hard- and software components of the autodetections system were to be operated continuously to test their stability and performance under working conditions. Additional technical developments, including data processing and storage, stabilization and control of camera features, were to be implemented on the PiP (picture in picture) system, which collects supplemental visual video footage of IR-based autodetections.

Work at sea

The FIRST Navy sensor was operated continuously throughout the entire cruise. The only downtimes (of order minutes) occurred during the first two days of operation, when three restarts of the system were necessary to apply and verify the effect of different firmware configurations of the FIRST Navy. The operation period of the FIRST-navy thermal sensor head (unit no. 1) was from 4 Dec 2011, 11 o'clock, to 4 Jan 2012, 18 o'clock, with in total 751 operational hours.

Infrared data recorded

A continuous IR-video data stream, covering almost the entire cruise was recorded, covering 735 hours and 123 TB of data on 41 3-TByte hard disk drives (Table 9.1).

T**able 9.1:** Log of the recorded data sets

Type	Hard disk Nr.	Start yyyymmdd-hhmmss	End yyyymmdd-hhmmss	Duration hh:mm
First RAW	1	20111204-105924	20111205-035156	16:52
	2	20111205-035157	20111205-222422	18:32
	3	20111205-092823	20111206-041104	18:42
	4	20111206-041104	20111206-225855	18:47
	5	20111206-225855	20111207-174015	18:41
	6	20111207-174015	20111208-122012	18:39
	7	20111208-122017	20111209-070020	18:40
	8	20111209-070020	20111210-014024	18:40
	9	20111210-014024	20111210-202027	18:40
	10	20111210-202027	20111211-150030	18:40
	11	20111211-150030	20111212-094033	18:40
	12	20111212-094033	20111213-042406	18:43
	13	20111213-042406	20111213-230409	18:40
	14	20111213-230409	20111214-174412	18:40
	15	20111214-174412	20111215-122419	18:40
	16	20111215-122419	20111216-070422	18:40
	17	20111216-070422	20111217-014425	18:40
	18	20111217-014426	20111217-202428	18:40
	19	20111217-202429	20111218-150431	18:40
	20	20111218-150432	20111219-094434	18:40
	21	20111219-094434	20111220-042437	18:40
	22	20111220-042437	20111220-230440	18:40

Type	Hard disk Nr.	Start yyyymmdd-hhmmss	End yyyymmdd-hhmmss	Duration hh:mm
	23	20111220-230440	20111220-174443	18:40
	24	20111221-174443	20111222-122445	18:40
	25	20111222-122446	20111223-070448	18:40
	26	20111223-070448	20111224-014451	18:40
	27	20111224-014451	20111224-202454	18:40
	28	20111224-204554	20111225-150457	18:19
	29	20111225-150457	20111226-094500	18:40
	30	20111226-094500	20111227-042502	18:40
	31	20111227-042503	20111227-234515	19:20
	32	20111227-234515	20111228-182638	18:41
	33	20111228-182638	20111229-130641	18:40
	34	20111229-130641	20111230-074644	18:40
	35	20111230-074644	20111231-022647	18:40
	36	20111231-022647	20111231-210650	18:40
	37	20111231-210650	20120101-154653	18:40
	38	20120101-154653	20120102-102656	18:40
	39	20120102-102656	20120103-050659	18:40
	40	20120103-050659	20120103-234702	18:40
	41	20120103-234702	20120104-134432	13:57
	Sum			**735:20**
				30 days 15:19h

In addition, time-lapse data, containing one image every 10 seconds were recorded for the entire cruise on a single additional hard drive.

Focus reset

The focus had to be reset five times, mostly due to significant changes in environmental conditions, presumably air temperatures, which affect the focal distance of the thermal optics (Table 9.2).

Table 9.2: Focus reset of the FIRST thermal imager

Date Time	Reason
04.12.2011	Cooling down after start
08.12.2011	Significant correction necessary, due to rise in Air temperature of ~5°C in 24h 7.12.2011 12:00 T(air) = 6.8 °C 8.12.2011 12:00 T(air) = 10.5 °C
02.01.2012 10:00	Significant correction necessary, due to rise in Air temperature of ~5°C in 24h 1.1.2012 10:00 T(air) = 10.1 °C 2.1.2012 10:00 T(air) = 15.5 °C
02.01.2012 18:00	Minor correction
02.01.2012 12:00	Minor correction

Cue counting

To further develop and test the performance of the infrared imager and the automatic detection algorithm, individual whale blows were logged to the second by a dedicated observer, supplemented by time stamped photos, if possible. For this task the observer was equipped with a tablet computer and customized software (BLOWLOG) which logs a blow by a single tap on the touch sensitive screen, recording time, direction and direction accuracy. In total 184 blows were recorded in 62 h of effort (Table 9.3). To ensure correct time, the tablet computer was synchronized by the ships NTP time service at least once daily.

Table 9.3: Visual observations effort

Date	on effort [hh:mm:ss]	off effort [hh:mm:ss]	Duration [hh:mm:ss]	# blows sighted
07.12.2011	08:08:38	08:08:43	00:00:05	0
07.12.2011	08:08:45	08:09:25	00:00:40	0
07.12.2011	08:26:53	08:26:53	00:00:00	0
07.12.2011	08:26:55	09:08:18	00:41:23	0
08.12.2011	14:05:23	14:11:03	00:05:40	0
08.12.2011	18:45:50	19:00:55	00:15:05	0
09.12.2011	08:40:00	12:09:14	03:29:14	10
09.12.2011	16:10:32	18:00:24	01:49:52	0
10.12.2011	13:28:19	15:31:11	02:02:52	0
12.12.2011	09:04:01	11:44:05	02:40:04	16
12.12.2011	12:34:03	17:32:41	04:58:38	59
12.12.2011	18:34:37	19:48:19	01:13:42	0

Date	on effort [hh:mm:ss]	off effort [hh:mm:ss]	Duration [hh:mm:ss]	# blows sighted
13.12.2011	13:59:33	16:30:00	02:30:27	0
13.12.2011	18:10:00	19:00:00	00:50:00	0
14.12.2011	06:15:00	07:50:00	01:35:00	0
14.12.2011	09:30:00	11:20:42	01:50:42	0
14.12.2011	12:24:05	15:13:24	02:49:19	0
14.12.2011	16:53:27	16:56:59	00:03:32	0
15.12.2011	09:24:23	11:49:16	02:24:53	0
16.12.2011	15:00:00	17:30:55	02:30:55	0
16.12.2011	18:16:55	19:25:51	01:08:56	0
17.12.2011	06:13:15	07:55:06	01:41:51	0
17.12.2011	10:41:54	11:38:54	00:57:00	0
17.12.2011	13:14:13	15:40:15	02:26:02	0
17.12.2011	16:13:24	17:46:55	01:33:31	0
23.12.2011	09:44:28	11:18:05	01:33:37	0
23.12.2011	13:29:29	14:20:55	00:51:26	0
23.12.2011	14:23:34	15:00:00	00:36:26	0
24.12.2011	09:36:42	12:49:11	03:12:29	1
24.12.2011	12:59:03	12:59:17	00:00:14	0
26.12.2011	08:45:08	11:59:00	03:13:52	0
28.12.2011	07:02:03	11:30:32	04:28:29	0
28.12.2011	13:54:03	17:20:01	03:25:58	54
29.12.2011	10:53:34	11:37:46	00:44:12	44
30.12.2011	13:51:34	16:45:46	02:54:12	0
31.12.2011	16:10:03	17:55:46	01:45:43	0
		Total	**62:26:01**	**184**

Technical development of Tashtego and PiP Software:

To avoid possible software performance problems as encountered during previous cruises, the Tashtego and Pip-System were modified to be operated on two individual computers. Four versions of the support vector machine (SVM) based automatic whale detection algorithm were tested and evaluated concerning their stability and false positive rate. The majority of false positives were caused by birds (up to 200) circling the ship, leading to a dedicated classification layer in the SVM which separates whale blows from passing birds.

Finally, several improvements to the PiP whale verification system were implemented:

The different mounting positions of the IR and PiP systems cause a static offset between the IR video and the visual images. This offset is now being compensated by means of a look-up table integrated into the PiP pan and tilt unit control software. An automatic regulation for the aperture of the PiP color camera system, based on the exposure times of the camera, was implemented.
As an autofocus cannot be used due to diffusivity of a whales blow, a look-up table based approach has been implemented to ensure the correct focus settings.

Automatic whale detection

During the cruise, the autodetection system was operated for the first time during darkness. The automatic whale detection algorithm captured several whale blows during night. Two examples are provided below (Fig. 9.1a,b), giving first direct prove that a thermal imaging camera can be used to automatically detect whales at night, allowing nocturnal marine mammal mitigation. Unfortunately species identification is not available for these recordings, as naturally no concurrent visual sighting was made.

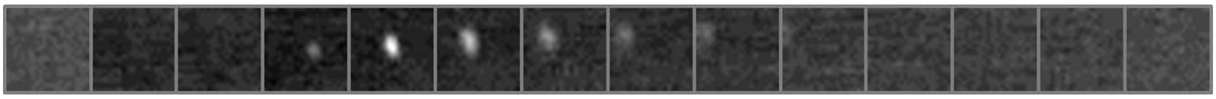

Fig. 9.1a: Sequence of video snippets (0.2 s resolution) of a whale detected automatically at night. Date: 29.12.2011 01:06, Distance: 1116 m, latitude: -56.49 longitude: 0.00, water temperature: -0.8°C, air temperature: -0.5°C

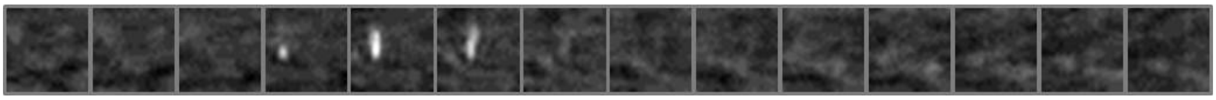

Fig. 9.1b: Sequence of video snippets (0.2 s resolution) of a whale detected automatically at night. Date: 01.01.2012 02:38, Distance: 879 m, latitude: -43.96 longitude: 7.44, water temperature: 8.8°C, air temperature: 8.7°C

The distributed (dual computer based) FIRST-PIP system was tested, automatically acquiring several ship-whale encounters. An example is presented in Fig. 9.2 with the species being clearly distinguishable as minke whale.

Fig. 9.2: Top: Sequence of video snippets (0.2 s resolution) of a whale; bottom: visual photo automatically generated by the PiP System. Date: 28.12.2011 14:41, Distance: 1072 m, latitude: -58.65 longitude: 0.02, water temperature: -1.5°C, air temperature: -0.6°C

Data description and metadata will be accessible through the PANGAEA database, however as IR and visual image data occupy more than 123 Terabytes, they will not be available online. PI: Olaf Boebel.

10. AT-SEA DISTRIBUTION OF HIGHER TROPHIC LEVELS: SEABIRDS ACROSS THE SOUTHERN OCEAN (ATLANTIC SECTOR)

Dominique Verbelen, Jan Haelters
Laboratory for Polar Ecology

Objectives

Seabirds are well studied worldwide, mainly at the breeding colonies. The at-sea distribution of oceanic seabirds is less well known, as most of the feeding grounds are extensive, remote and difficult to access for systematic surveys. This is even more so the case for polar regions, as very few ships venture into the pack-ice. Hence, RV *Polarstern* offers a unique opportunity to study the distribution of seabirds at sea between Cape Town and Neumayer Station III. Since the distributional information of many species is rather scarce south of 60°S, all data collected provide a valuable contribution to this, while combined with oceanographic data they could help us to learn about the reasons behind distributional patterns, and thus in contributing in modeling their distribution over larger areas.

Work at sea

During daylight hours and during favorable observation conditions (no fog, snow, rain) birds were observed, identified and counted from the ship's bridge. Depending on the conditions (eg. spray, glare) observers were at the starboard or port side, or observed birds from a central position. If the sea state caused extensive spray and thus a bad visibility from the bridge, the observer would stand outside on the starboard or port side.

The birds that could be seen with the naked eye were further investigated with high quality binoculars (Swarovision 10 x 42) and if necessary a Leica spotting scope (magnification of 30 x) to identify them to species level. As the identification of some birds is not always straightforward, the most recent literature was always at hand (eg Onley & Scofield, 2008; Shirihai, 2008). In a number of cases a photo camera was used to take pictures to validate identifications (DSLR camera, cropped sensor, zoom lens 100-400 mm).

All bird counts lasted half an hour, after which the observations were introduced into a database, which also introduces, together with each count, the D-Ship data. The analysis of data will include the occurrence of seabird species between Cape Town and Neumayer, including the distribution vs. the parameters collected on board the ship: water temperature, chlorophyll content (with fluorescence as a proxy – taken from the Ferrybox data), salinity, etc. Next to seabirds, also observations of marine mammals were recorded (species, number).

Preliminary results and conclusions

Between Cape Town and Neumayer (southward journey), in total 337 half hour counts were made of seabirds. Between Neumayer and Cape Town, with a track partly different than the southward journey, 247 half hour counts were made. Weather and observation conditions were worse during the northward journey. From Cape Town to Neumayer 42 bird species were observed, totaling 4,560 birds. Some genera (especially the prions) pose major identification problems at sea, and even when clear photographs were available some could not be identified to the species level. A list of bird species observed and their numbers from 4 December 2011 until 3 January 2012 (south- and northward journey, except for the last day of the expedition) are presented in Table 10.1.

The data collected during the transect from Cape Town to Neumayer largely confirm the present knowledge on the distribution of seabirds in this area. However, some data, such as those on observations of Indian and Atlantic Yellow-nosed Albatrosses, do fill gaps in our current knowledge. Indian and Atlantic Yellow-nosed Albatrosses have recently been recognized as separate species on the basis of differences in breeding ecology, vocalizations, genetics and morphology. The knowledge about the at sea distribution of both species is currently rather scant.

The provisional data collected illustrate how so-called twin-species hardly overlap, hence avoiding competition for food. Fig. 10.1 presents the observations of Northern Giant Petrel and Southern Giant Petrel during the southward journey, expressed vs. the latitude at which they were observed – this simplification can be made, given that the ship kept an approximate southward heading, and that frontal systems, possibly having an influence of seabird distribution, lie perpendicular to this heading.

All data will be further examined and correlated with some determining oceanographic parameters, collected by Dship and the Ferrybox on board of *Polarstern*, as the water masses and especially the different convergences determine to a large extent the boundaries of the distribution of various species. In addition to seabirds, records of pinnipeds were documented. As was expected, Crabeater Seal was the most common species encountered. Leopard Seal was only seen on four occasions. Being a top predator in the Antarctic region, it is not surprising that its densities are mostly low. The observations of Ross Seals were interesting, in that little is known about this pinniped and data on the presence in the Weddell Sea and the Lazarev Sea are rather scarce.

Both during the southward and northward journey, a region was crossed, approximately near the edge of the sea-ice (between 58°S and 59°S), with particularly high densities of seabirds, especially Antarctic Petrel (Fig. 10.2) and Chinstrap Penguin, and frequent observations of marine mammals (notably Crabeater Seal and baleen whale species). During the southward journey this was also the location where fully-grown krill was present in plankton samples (Wilhelm Hagen, personal communication). Though not the prime target of the survey, the number and species of marine mammals encountered were also noted (Table 10.2). Since the *Polarstern* followed partly the same transect on the way from Neumayer to Cape Town (northward journey), the data obtained during Cape Town - Neumayer and Neumayer - Cape Town will be juxtaposed to identify any seasonal shifts, especially in the northern part of the region investigated. Data collected during this survey will be added to data collected during previous surveys of *Polarstern* and other vessels in this area.

Acknowledgements

We would like to acknowledge the excellent cooperation with, and services provided by the crew of the RV *Polarstern*. We thank AWI for offering the chance to participate in this expedition, and Prof. Dr. Claude Joiris for offering us to participate in this project. We are grateful for the continued support of other scientists on board, and especially of Steve Geelhoed and Hans Verdaat (IMARES).

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Shirihai, H., 2008. The complete guide to Antarctic wildlife. Second edition. Princeton University Press, Princeton and Oxford.

Table 10.1: Overview of the observations of seabirds during the southward and northward journey, total number of individuals per species and total effort (preliminary data).

ENGLISH SPECIES NAME	SCIENTIFIC SPECIES NAME	RED-LIST CATEGORY	SOUTH	NORTH	TOTAL
Emperor Penguin	*Aptenodytes forsteri*		68	46	**114**
Adélie Penguin	*Pygoscelis adeliae*		256	50	**306**
Chinstrap Penguin	*Pygoscelis antarctica*		546	364	**910**
Macaroni Penguin	*Eudyptes chrysolophus*	vulnerable	6	0	**6**
Wandering Albatross	*Diomedea exulans*	vulnerable	11	122	**133**
Black-browed Albatross	*Thalassarche melanophrys*	near-threat.	31	11	**42**
Shy Albatross	*Thalassarche cauta*		2	1	**3**
Grey-headed Albatross	*Thalassarche chrysomata*	vulnerable	1	7	**8**
Atlantic Yellow-nosed Albatross	*Thalassarche chlorohynchos*	near-threat.	2	10	**12**
Indian Yellow-nosed Albatross	*Thalassarche carteri*	vulnerable	2	0	**2**
Dark-mantled Sooty Albatross	*Phoebetria fusca*	vulnerable	33	14	**47**
Light-mantled Sooty Albatross	*Phoebetria palpebrata*	near-threat.	24	25	**49**
Southern Giant Petrel	*Marconectes giganteus*	vulnerable	36	12	**48**

ENGLISH SPECIES NAME	SCIENTIFIC SPECIES NAME	RED-LIST CATEGORY	SOUTH	NORTH	TOTAL
Northern Giant Petrel	*Macronectes halli*	near-threat.	11	6	**17**
Southern Fulmar	*Fulmaris glacialoides*		97	60	**157**
Antarctic Petrel	*Thalassoica antarctica*		1053	1491	**2544**
Cape Petrel	*Daption capense*		163	22	**185**
Snow Petrel	*Pagodroma nivea*		226	216	**442**
Great-winged Petrel	*Pterodroma macroptera*		160	144	**304**
White-headed Petrel	*Pterodroma lessonni*		15	15	**30**
Atlantic Petrel	*Pterodroma incerta*	vulnerable	26		**26**
Kerguelen Petrel	*Pterodroma brevirostris*		103	107	**210**
Soft-plumaged Petrel	*Pterodroma mollis*		350	344	**694**
Blue Petrel	*Halobaena caerulea*		703	45	**748**
White-chinned Petrel	*Procellaria aequinoctialis*	vulnerable	55	40	**95**
Spectacled Petrel	*Procellaria conspicillata*	vulnerable	0	27	**27**
Grey Petrel	*Procellaria cinerea*	near-threat.	3	0	**3**
Cory's Shearwater	*Calonectris diomedea*		62	132	**194**
Great Shearwater	*Puffinus gravis*		23	93	**116**
Sooty Shearwater	*Puffinus griseus*		19	4	**23**
Subantarctic Little Shearwater	*Puffinus assimillis*		22	3	**25**
Wilson's Storm-petrel	*Oceanites oceanicus*		15	6	**21**
Black-bellied Storm-petrel	*Fregatta tropica*		62	120	**182**
White-bellied Storm-petrel	*Fregatta grallaria*		2	7	**9**
Leach's Storm Petrel	*Oceanodroma leucorhoa*		0	2	**2**
Grey Phalarope	*Phalaropus fulicarius*		46	3	**49**
Subantarctic Skua	*Catharacta antarctica*		3	5	**8**
South Polar Skua	*Catharacta maccormicki*		1	3	**4**
Pomarine Jaeger	*Stercorarius pomarinus*		2	1	**3**
Arctic Jaeger	*Stercorarius parasiticus*		0	1	**1**
Long-tailed Jaeger	*Stercorarius longicaudus*		2	0	**2**

ENGLISH SPECIES NAME	SCIENTIFIC SPECIES NAME	RED-LIST CATEGORY	SOUTH	NORTH	TOTAL
Sabine's Gull	*Xema sabinii*		0	91	**91**
Kelp Gull	*Larus vetula*		0	34	**34**
Arctic Tern	*Sterna paradisaea*		70	33	**103**
Swift Tern	*Sterna bergii*		0	54	**54**
Sandwich Tern	*Sterna sandvicensis*		0	58	**58**
Cape Cormorant	*Phalacrocorax capensis*		0	14	**14**
Storm petrel sp.			4	5	**9**
Giant petrel sp.	*Marconectes giganteus/halli*		6	2	**8**
Yellow-nosed albatross sp.	*Thalassarche chlorohynchos/carteri*		5	1	**6**
Diving petrel sp.	*Pelecanoides urinatrix/ georgicus*		14	22	**36**
Prion sp.	*Pachyptila sp.*		348	510	**858**
TOTAL NUMBER OF BIRDS			**4689**	**4383**	**9072**
NUMBER OF COUNTS			**335**	**261**	**596**
HOURS ON EFFORT			**167.5**	**130.5**	**298**

Table 10.2: Overview of the observations of marine mammals during the southward and northward journey, total number of individuals per species and total effort (preliminary data).

ENGLISH SPECIES NAME	*SCIENTIFIC SPECIES NAME*	RED-LIST CATEGORY	SOUTH	NORTH	TOTAL
Subantarctic Fur Seal	*Arctocepahlus tropicalis*		1	4	**5**
Cape Fur Seal			0	4	**4**
Leopard Seal	*Hydrurga leptonyx*		3	2	**5**
Weddell Seal	*Leptonychotes weddellii*		2	4	**6**
Crabeater Seal	*Lobodon carcinophaga*		135	70	**205**
Ross Seal	*Ommatophoca rossii*		3	0	**3**
Antarctic Minke Whale	*Balaenoptera bonaerensis*		5	6	**11**
Southern Blue Whale	*Balaenoptera intermedia*	endangered	0	2	**2**
Fin Whale	*Balaenoptera physalus*	endangered	5	11	**16**

ENGLISH SPECIES NAME	*SCIENTIFIC SPECIES NAME*	RED-LIST CATEGORY	SOUTH	NORTH	TOTAL
Humpback Whale	*Megaptera novaeangliae*	vulnerable	14	3	**17**
Fur seal sp.	*Arctocepahlus sp.*		4	2	**6**
Seal sp.			12	1	**13**
Large whale sp.			9	5	**14**
TOTAL			**193**	**114**	**307**
NUMBER OF COUNTS			**335**	**247**	**582**
HOURS ON EFFORT			**167.5**	**123.5**	**291**

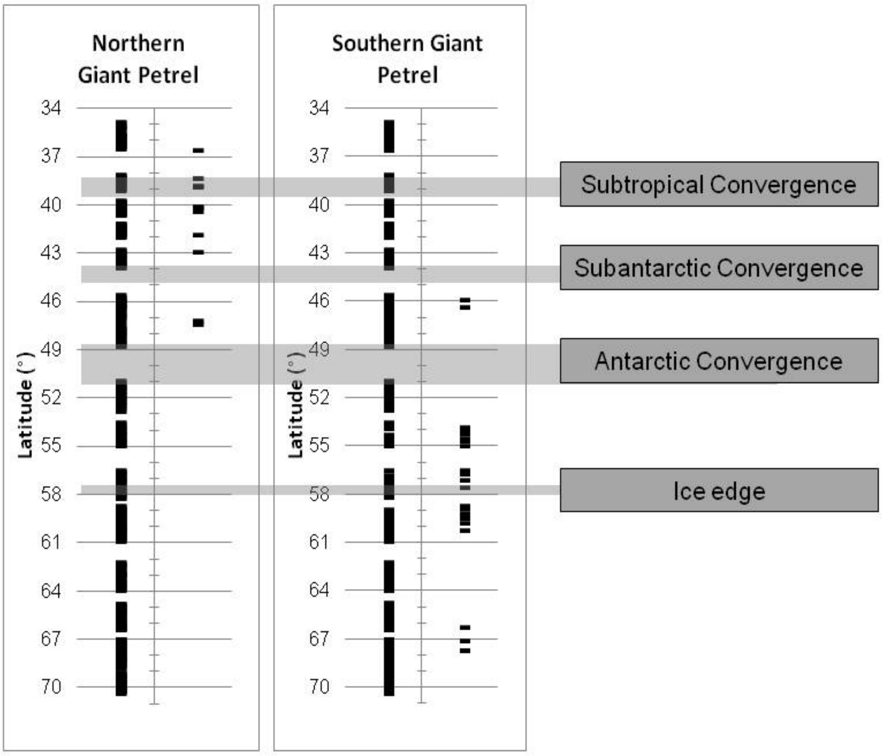

Fig. 10.1: Example of recorded observations of giant petrels identified to the species level during the southward part of the expedition. Northern Giant Petrel (left) and Southern Giant Petrel (right), with for each species on the left hand side, indicated vs. the latitude, negative counts (black) and on the right hand side counts during which the species was observed. Blank areas indicate where no counts were made. The convergence zones, according to water temperature (DShip data) and ice coverage, are indicated.

Fig. 10.2: During a short section of the transit, very high numbers of Antarctic Petrel were observed (near the ice-edge at approx. 58°S; image taken during the northward journey). These observations, as all other, will be correlated with oceanographic parameters (DShip and Ferrybox data) to elucidate possible links.

11. PHOTO- AND VIDEO FOOTAGE

Stefan Lehmann[1], Martin Varga[1], Thomas Steuer[2]

[1] Video: real tv group
[2] Fotodesign

The Communication and Media Department of AWI has contracted real tv group and Thomas Steuer to shoot video footage and still images of scientific work and life on board RV *Polarstern* for their media database. Systematically organized and labeled raw film sequences and pictures enable easy access for internal and public use in media relations.

Professional footage of the AWI infrastructure and its application in the field is needed for a convincing presentation to the outside world. Pictures and videos on specialized topics can only be provided by an expert team with experience in remote outdoor settings. Images are needed for a variety of occasions, e.g. the 30th anniversary ceremony of RV *Polarstern* and will be also used for print media, posters, public relations and lectures. AWI employers are encouraged to access the media database and illustrate their work and applications with the help of visual impressions.

From 22 December 2011 until 5 January 2012 we were on board RV *Polarstern* on the leg ANT-XXVIII/2 traveling from the Neumayer Station III at Atka Bay to Cape Town. The cooperation with scientists and crew was excellent, and we could complete most of our job. We managed to get footage of the supply to Neumayer, departure from Neumayer, scientific work on deck, the various laboratories as well as the work of the crew and everyday life on board RV *Polarstern*. Aerial footage of RV *Polarstern* at the shelf ice edge, in sea ice and in open water was not possible due to special circumstances.

We would like to thank all participants of ANT-XXVIII/2 for their patience and kind assistance. To obtain access to the images please contact the Communication and Media Department of AWI which reserves all footage rights.

12. COOLE KLASSEN

Monika Kallfelz
Pfalzmuseum für Naturkunde – POLLICHIA-Museum,

Objectives

Polar topics are underrepresented in lessons as well as in curricula of German schools, and also in the public awareness, in relation to the importance of these topics for climate and climate change.

The objective of the project „Antarctica – a pole in lesson" as part of the "Coole Klassen" program (Fig. 12.1) is to transfer polar topics in lessons in an interesting and exciting manner also including the public. The project is incorporated in the activities at the Pfalzmuseum für Naturkunde in Bad Dürkheim, which displays various items, books, exhibits and an audio-guide to polar topics.

Fig. 12.1: The logo of "Coole Klassen"

A group of 37 schools – 33 originate from Rhineland Palatinate - gathered in preparation for this expedition. They are all interested in the topics and the authentical situation of this expedition. Most of the participants became aware of this project by a teacher training, which was offered in cooperation of the Pfalzmuseums für Naturkunde – POLLICHIA-Museum in Bad Dürkheim and the Pädagogisches Landesinstitut in Speyer in September 2011. Other teachers joined the group either in response to direct invitation, through a message from the ministry of education addressed to all schools in the state, or press publications.

All participants received information and materials, and teachers and pupils were invited to hand in questions and tasks. The intensity of the work with the students is determined by the teacher himself or the school. The scope varies from a number of lessons in individual classes to the participation of the entire school.

Most of the pupils are 10 to 12 years old, i.e. 5th and 6th graders. However, elementary classes and upper grades were also participating. Some of the classes already visited the Pfalzmuseum and ran through the "Polar Program", listening to the audio-guide and conducting the experiments. The project was also directly presented in 2 schools. Other classes will visit the museum in the spring.

The interests of all ages are mainly focused on everyday issues on the vessel like accommodation, food (Do they give you something to eat or do you have to hunt?), weather (How cold is it? How do you protect yourself against the coldness?) equipment of the vessel (Do you have W-Lan?), supply and removal and what will you find in Antarctica (Do they have houses there? What kind of animals will be there?) and, last but not least on the research projects (What do you actually explore there?).

There had been a big media interest before the start of the expedition. The "Rheinpfalz" (27 Oct. and 1 Dec., 2011), the "Allgemeine Zeitung Mainz" (end of November) and the "Rheinzeitung" (30 Nov., .2011) published a long article in their supra-regional issue, SWR 1 (radio) broadcast a recorded telephone interview in their „Guten Morgen Rheinland-Pfalz" (2 Dec., 2011) and „SWR 1 am Sonntagnachmittag" (27 Nov., 2011) and in the SWR 3 (television) „Wetternachrichten" (2 Dec., 2011) I could explain the design model of the hydraulic pillars of the Neumayer station.

Work at sea

Firstly, I had to get to know the ship, the life on board and how to report about these experiences. In addition, the animals, the weather and the experiences with sea ice, icebergs and shelf-ice were important. Where possible I tried to talk to the scientists to gain more information about their research than offered in the research booklet and to observe the research directly and document it with pictures. In some cases I was allowed to assist, e.g. to microscope or to collect water samples.

I wrote a daily report of 1-2 pages including 1-2 pictures about various aspects in a blog for the whole duration of the trip. In these reports I also answered the questions which I received from the students before I started the trip. The blog was looked after by the online editorial staff of the newspaper „Rheinpfalz".

Some examples of topics covered in the blog:

Pfalzmuseum unterwegs- in die Antarktis!
Wie spät ist es denn nun wirklich?
Bekommt ihr Essen geliefert oder geht ihr jagen?
Wasserproben aus der Tiefe
Mein Tag an Bord
Wo ist der Eisrand?
Kunstformen der Natur – Kieselalgen
Angekommen – an der Neumayer Station III
Einen Wetterballon starten
Maschinenführung mit Ole

Beyond the blog I called and informed 11 school classes as well as the Pfalzmuseum from the ship. The pupils had additional questions and seemed to be extremely interested. Despite the sometimes technically poor connection it was important for the teachers to have this direct contact to the vessel. On one occasion the television broadcasting team was present while I called the class during their lesson.

On 8 Dec., 2011 I presented the project „Coole Klassen", the connection to the „Pfalzmuseum in Bad Dürkheim", my project and my work on board in a presentation

in the evening to inform the scientists and to invite them to cooperate.
Of course, I also attended the presentations of the scientists and consider them as very helpful for my work.

A special highlight was the visit of the Neumayer Station III on 19 Dec. There I could personally hand over the wine box to the head of the Station, Dr. Jölund Asseng, which has been ceremonially shipped at the Pfalzmuseum in August. In addition, the chief scientist of the expedition, Prof. Gerhard Kattner and the cook of the station acting on behalf of all the persons overwintering in the coming season were also present.

First results

The feedback I received while being on board was consistently positive, as well as the response to my blog and the telephone calls. The newspaper articles, the television broadcast and the radio interviews were received very positively, too. I have received some information about the activities of some schools while still being on the expedition.

Here is a small collection of the feedback:

...heute morgen habe ich dich wieder einmal zufällig in Radio gehört. Welch schöner Tagesauftakt - Danke!!! Das klang alles wahnsinnig spannend - Buckelwale, Finnwale und dann noch Robben und Hunderte von fernen Vögeln. Gerne würde ich dir über die Schulter schauen!....
….. Voller Stolz haben wir auch Deinen Fernsehauftritt vor der Abfahrt verfolgt und fanden Dich großartig…
..... Übrigens konnte ich dank Ihrer Erklärungen meinem Sohn stichhaltig erklären, wie Eisberge entstehen. Gut, er ist 5 Jahre und hat es noch nicht ganz verstanden mit dem Schelfeis ect. Aber er fragte, ob Sie Fotos von Eisbergen haben.
..... Wir haben Ihre täglichen Berichte ausgedruckt und an eine Stellwand (4 Stellwände zum Thema Südpol) gehängt. Auch die Fahrtroute wird jeden Tag ergänzt. Am Tag der offenen Schule gab es Vorträge zum Südpol. Meine Abgesandten fragen täglich mehrmals nach den Berichten...
…. Deine Berichte sind wie das Öffnen von Adventskalendertürchen, wir freuen uns jedes Mal. Weiter so !
….. Ihre Berichte sind wirklich toll und ich habe schon überall tüchtig Werbung dafür gemacht und bin jeden Tag auf Ihre Neuigkeiten gespannt.

To date, I received first materials from some scientists which can be used in lessons. I also can imagine to adjust some research projects for educational purposes. This will be quite difficult as this requires a relatively intensive support by the scientists especially concerning the materials. On the other hand, this is a chance for the scientists to communicate their projects to the schools.

By the end of January I expect a short collation of the activities of all participating schools, showing the contents, subjects, used materials, ages of the participating pupils and the number of lessons. In addition, activities apart from the lessons, like open house presentation, movable walls (posters) or project days. Quite a few schools expressed their wish to visit them. On 21 May, 2012 I have scheduled a course at the Pfalzmuseum for the participating teachers, where the teachers also will report about their activities.

The media have also been very interested during the tour. A telephone interview at the SWR 4 was broadcast on 29 Dec. The three big newspapers "Rheinpfalz", "Allgemeine Zeitung Mainz" and "Rheinzeitung" issued an article on Christmas, the one from the "Allgemeine Zeitung Mainz" covering the whole front page.

Further media interests were already announced before the tour started. A team working for the SWR-environmental magazine „Im Grünen" wants to broadcast a contribution for the show, which will be broadcast on 17 Jan., 2012. I am invited as a studio guest in the show „SWR Landesschau" and the Schroedel-Verlag would like to have an article from me in their magazine "360°"

In summary I can say that the plan to involve schools was very successful, and that these schools got involved more or less intensively, and always positively with Antarctica and the research projects. In addition, the varied and intensive media coverage aided in a broad exposure of the public to the expedition.

13. ACKNOWLEDGEMENTS

The *Polarstern* expedition was a great success due to the harmonic and professional cooperation of all participants although it was unfortunately overshadowed by the helicopter accident. We are especially grateful to the overwintering and logistic team of the Neumayer station III for their excellent and professional help and care during and after this accident. We were able to collect a huge amount of samples and important and interesting data. This was only possible due to the excellent support and friendly assistance of Captain Wunderlich and the entire *Polarstern* crew. Sincere thanks to all who contributed to the success of this cruise.

APPENDIX

A.1 PARTICIPATING INSTITUTIONS

A.2 CRUISE PARTICIPANTS

A.3 SHIP'S CREW

A.4 STATION LIST

A.1 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTIONS

	Address
AWI	Stiftung Alfred-Wegener-Institut für Polar- und Meeresforschung in der Helmholtz-Gemeinschaft Postfach 120161 27515 Bremerhaven Germany
DEA	Department of Environmental Affairs, Oceans and Coasts Research P.O. Box 52126, Victoria & Alfred Waterfront Cape Town/ South Africa
DWD	Deutscher Wetterdienst Geschäftsbereich Wettervorhersage Seeschifffahrtsberatung Bernhard Nocht Str. 76 20359 Hamburg Germany
HeliService	HeliService International GmbH, Deutschland Am Luneort 15 27572 Bremerhaven Germany
HZG	Helmholtz Zentrum Geesthacht, Institut für Küstenforschung Werftstraße 6 25761 Büsum Germany
ITAW	Institut für Terrestrische und Aquatische Wildtierforschung Stiftung Tierärztliche Hochschule Hannover Werftstraße 6 25761 Büsum Germany
ICBM	Institute for Chemistry and Biology of the Marine Environment University of Oldenburg 26131 Oldenburg Germany
IMARES	IMARES Wageningen UR 1790 AD Den Burg (Texel) The Netherlands

	Address
Laeisz	Reederei F. Laeisz (Bremerhaven) GmbH Brückenstraße 25 27568 Bremerhaven Germany
MarZoo	Marine Zoologie Universität Bremen P.O. Box 330 440 28334 Bremen Germany
Pfalzmuseum	Pfalzmuseum für Naturkunde – POLLICHIA-Museum, Kaiserslauterer Straße 111 67098 Bad Dürkheim Germany
PIK	Potsdam-Institut für Klimafolgenforschung Telegraphenberg A 31 14473 Potsdam Germany
PolE	Laboratory for Ecotoxicology and Polar Ecology Free University of Brussels Pleinlaan 2 B-1050 Brussels Belgium
Fotodesign	Thomas Steuer Fotodesign info@thomassteuer.com Germany
real tv group	real TV group GmbH & Co. KG Holtenauer Strasse 96 24105 Kiel Germany
UBA	Umweltbundesamt Wörlitzer Platz 1 06844 Dessau-Roßlau Germany
Uni GÖ	Institute of Microbiology and Genetics Georg-August-Universität Göttingen Grisebachstr. 8 37077 Göttingen Germany

A.2 FAHRTTEILNEHMER / CRUISE PARTICIPANTS

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession
Auel	Holger	MarZoo	Biologist
Beardsley	Christine	ICBM	Microbiologist
Beszteri	Bánk	AWI	Biologist
Brauer	Jens	HeliService	Technician/Pilot
Engelhaupt	Martin	Uni GÖ	Student, biology
Geelhoed	Steve	IMARES	Biologist
Giebel	Helge-Ansgar	ICBM	Microbiologist
Gray	Ian	ITAW	Biologist
Haelters	Jan	PolE	Biologist
Hagen	Wilhelm	MarZoo	Biologist
Hauer	Carolin	MarZoo	Student, biology
Hirsekorn	Marius	AWI	Logistic (to Neumayer)
Hu	Yubin	AWI	PhD student, chemistry
Huggett	Jenny	DEA	Biologist
Kallfelz	Monika	Coole Klassen	Teacher
Kattner	Gerhard	AWI	Chemist
Kienert	Hendrik	PIK	PhD Student, oceanography
Kürzel	Birgit	ICBM	Technician
Lehmann	Stefan	real tv group	Producer (from Neumayer)
Lehnert	Kristina	HZG	Biologist
Lehnert	Linn Sophia	ITAW	Biologist
Macrander	Andreas	AWI	Oceanographer
Miller	Max	DWD	Meteorologist
Möllendorf	Carsten	HeliService	Technician
Müller	Mirjam	UBA	Biologist
Osterholz	Helena	ICBM	PhD student, geochemistry
Pillay	Keshnee	DEA	PhD student, biology
Plön	Stephanie	ITAW	Biologist

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession
Pluder	Andreas	Laeisz	Logistic (to Neumayer)
Rackebrandt	Siri	ICBM	PhD student, marine sciences
Reeve	Krissy	AWI	PhD student, oceanography
Remke	Thomas	ICBM	Student, marine sciences
Richter	Sebastian	AWI	Physicist
Sartoris	Franz-Josef	AWI	Biologist
Schiel	Sigrid	AWI	Biologist
Schmidt	Kornelia	ITAW	Technician
Schründer	Sabine	MarZoo	PhD student, biology
Seibt	Maren	ICBM	PhD student, geochemistry
Sonnabend	Hartmut	DWD	Technician
Stecher	Anique	AWI	PhD student, biology
Steuer	Thomas	Fotodesign	Photographer (from Neumayer)
Steinmetz	Richard	AWI	Technician
Uhlig	Christiane	AWI	Biologist
Varga	Martin	real tv group	Producer (from Neumayer)
Vaupel	Lars	HeliService	Pilot
Verbelen	Dominique	PolE	Biologist
Verdaat	Hans	IMARES	Biologist
Verheye	Hans	DEA	Biologist
Vollmers	John	UniGÖ	PhD student, microbiology
Wietz	Matthias	ICBM	PhD student, microbiology
Wurst	Mascha	ICBM	PhD student, microbiology
Yoshinari	Hiroshi	AWI	Oceanographer
Zepick	Burkhard	HeliService	Pilot
Zhang	Xu	AWI	PhD student, oceanography

A.3 SCHIFFSBESATZUNG / SHIP'S CREW

Name	Rank
Wunderlich, Thomas	Master
Spielke, Steffen	1. Offc.
Ziemann, Olaf	Ch. Eng.
Hering, Igor	2. Offc.
Peine, Lutz	2. Offc.
Lauber, Felix	2. Offc.
Lambrecht, Wolfgang	Doctor
Koch, Georg	R. Offc.
Kotnik, Herbert	2. Eng.
Schnürch, Helmut	2. Eng.
Westphal, Henning	2. Eng.
Brehme, Andreas	Elec. Eng.
Dimmler, Werner	ELO
Feiertag, Thomas	ELO
Fröb, Martin	ELO
Winter, Andreas	ELO
Clasen, Burkhard	Boatsw.
Neisner, Winfried	Carpenter
Burzan, Gerd-Ekkehard	A.B.
Hartwig-Lab., Andreas	A.B.
Kreis, Reinhard	A.B.
Kretzschmar, Uwe	A.B.
Moser, Siegfried	A.B.
Schröder, Norbert	A.B.
Schröter, René	A.B.
Schultz, Ottomar	A.B.
Beth, Detlef	Storek.
Becker, Holger	Mot-man
Dinse, Horst	Mot-man
Fritz, Günter	Mot-man
Krösche, Eckard	Mot-man
Watzel, Bernhard	Mot-man
Fischer, Matthias	Cook
Tupy, Mario	Cooksmate
Völske, Thomas	Cooksmate
Dinse, Petra	1. Stwdess
Henning, Christina	Stwdess/N.
Chen, Quan Lun	2. Stwdess

Name	Rank
Hischke, Peggy	2. Steward
Hu, Guo Yong	2. Stwdess
Streit, Christina	2. Steward
Wartenberg, Irina	2. Stwdess
Ruan. Hui Guang	Laundrym.
Seibel, Sebastian	Apprent.
Strauß, Erik	Apprent.

A.4 STATIONSLISTE / STATION LIST PS 79

Station PS79	Date	Time [UTC]	Position (Lat.)	Position (Lon.)	Depth [m]	Gear	Action
PS79/ 035-1	05.12.2011	11:57	39° 12.88' S	11° 20.19' E	5109	BUOY	in the water
PS79/ 035-2	05.12.2011	12:07	39° 13.07' S	11° 20.04' E	5122	PIES	slipped
PS79/ 035-3	05.12.2011	12:56	39° 13.68' S	11° 21.55' E	4912	CTD/RO	in the water
PS79/ 035-4	05.12.2011	13:05	39° 13.79' S	11° 21.71' E	4907	HN	in the water
PS79/ 035-2	05.12.2011	13:15	39° 13.93' S	11° 21.85' E	4919	PIES	on ground
PS79/ 035-4	05.12.2011	13:24	39° 14.05' S	11° 21.97' E	4951	HN	on deck
PS79/ 035-3	05.12.2011	14:39	39° 14.97' S	11° 22.29' E	5012	CTD/RO	on ground
PS79/ 035-3	05.12.2011	16:06	39° 15.77' S	11° 22.57' E	5111	CTD/RO	on deck
PS79/ 035-1	05.12.2011	16:53	39° 17.85' S	11° 27.31' E	5051	BUOY	on deck
PS79/ 036-1	07.12.2011	03:28	41° 10.90' S	4° 15.95' E	4861	CTD/RO	in the water
PS79/ 036-1	07.12.2011	04:58	41° 10.58' S	4° 16.13' E	4866	CTD/RO	on ground
PS79/ 036-2	07.12.2011	05:18	41° 10.55' S	4° 16.12' E	4864	HN	in the water
PS79/ 036-2	07.12.2011	05:24	41° 10.55' S	4° 16.13' E	4865	HN	on deck
PS79/ 036-1	07.12.2011	06:14	41° 10.45' S	4° 16.18' E	4865	CTD/RO	on deck
PS79/ 036-3	07.12.2011	06:33	41° 10.85' S	4° 15.46' E	4839	PIES	released
PS79/ 036-3	07.12.2011	07:48	41° 10.39' S	4° 15.43' E	4844	PIES	at surface
PS79/ 036-3	07.12.2011	08:12	41° 10.15' S	4° 15.00' E	4827	PIES	on deck
PS79/ 037-1	08.12.2011	05:53	42° 58.56' S	0° 0.48' E	4298	CTD/RO	in the water
PS79/ 037-1	08.12.2011	07:16	42° 58.59' S	0° 0.52' E	4300	CTD/RO	on ground
PS79/ 037-2	08.12.2011	07:26	42° 58.55' S	0° 0.54' E	4300	HN	in the water
PS79/ 037-2	08.12.2011	07:30	42° 58.55' S	0° 0.56' E	4301	HN	on deck
PS79/ 037-1	08.12.2011	08:22	42° 58.61' S	0° 0.43' E	4299	CTD/RO	on deck
PS79/ 037-3	08.12.2011	08:36	42° 58.75' S	0° 0.14' E	-	PIES	released

Station PS79	Date	Time [UTC]	Position (Lat.)	Position (Lon.)	Depth [m]	Gear	Action
PS79/ 037-3	08.12.2011	09:09	42° 58.80' S	0° 0.24' E	-	PIES	released
PS79/ 037-3	08.12.2011	11:45	42° 58.64' S	0° 0.32' E	-	PIES	start heli search
PS79/ 037-3	08.12.2011	12:27	42° 58.50' S	0° 0.55' E	4300	PIES	end heli search
PS79/ 038-1	09.12.2011	00:56	45° 6.49' S	0° 0.26' E	4709	HN	in the water
PS79/ 038-2	09.12.2011	00:58	45° 6.51' S	0° 0.33' E	4710	CTD/RO	in the water
PS79/ 038-1	09.12.2011	01:06	45° 6.58' S	0° 0.55' E	4712	HN	on deck
PS79/ 038-2	09.12.2011	01:07	45° 6.59' S	0° 0.58' E	4713	CTD/RO	on ground
PS79/ 038-2	09.12.2011	01:20	45° 6.66' S	0° 0.89' E	4714	CTD/RO	on deck
PS79/ 039-1	10.12.2011	05:51	51° 25.99' S	0° 0.01' W	2714	BUOY	in the water
PS79/ 039-2	10.12.2011	06:03	51° 27.13' S	0° 0.14' E	2732	MN-PP	in the water
PS79/ 039-2	10.12.2011	06:13	51° 27.14' S	0° 0.15' E	2732	MN-PP	on ground
PS79/ 039-2	10.12.2011	06:28	51° 27.14' S	0° 0.17' E	2733	MN-PP	on deck
PS79/ 039-3	10.12.2011	06:36	51° 27.14' S	0° 0.18' E	2732	CTD/RO	in the water
PS79/ 039-3	10.12.2011	07:01	51° 27.11' S	0° 0.15' E	2732	CTD/RO	on ground
PS79/ 039-3	10.12.2011	07:12	51° 27.09' S	0° 0.15' E	2732	CTD/RO	on deck
PS79/ 039-4	10.12.2011	07:18	51° 27.09' S	0° 0.16' E	2733	MN	in the water
PS79/ 039-4	10.12.2011	08:23	51° 26.99' S	0° 0.09' E	2731	MN	on ground
PS79/ 039-5	10.12.2011	08:38	51° 27.01' S	0° 0.08' E	2730	HN	in the water
PS79/ 039-4	10.12.2011	09:48	51° 27.03' S	0° 0.21' E	2734	MN	on deck
PS79/ 039-5	10.12.2011	09:57	51° 27.04' S	0° 0.16' E	2732	HN	on deck
PS79/ 039-6	10.12.2011	09:58	51° 27.04' S	0° 0.16' E	2732	CTD/RO	in the water
PS79/ 039-6	10.12.2011	10:57	51° 27.09' S	0° 0.27' E	2736	CTD/RO	on ground
PS79/ 039-6	10.12.2011	11:45	51° 27.03' S	0° 0.01' W	2729	CTD/RO	on deck
PS79/ 039-7	10.12.2011	11:52	51° 26.84' S	0° 0.27' W	2720	TT	in the water

Station PS79	**Date**	**Time** [UTC]	**Position** (Lat.)	**Position** (Lon.)	**Depth** [m]	**Gear**	**Action**
PS79/ 039-7	10.12.2011	12:06	51° 27.02' S	0° 0.50' W	2717	TT	profile start
PS79/ 039-7	10.12.2011	12:28	51° 27.44' S	0° 0.97' W	2704	TT	profile end
PS79/ 039-7	10.12.2011	12:28	51° 27.44' S	0° 0.97' W	2704	TT	on deck
PS79/ 039-1	10.12.2011	13:13	51° 24.83' S	0° 4.80' E	2536	BUOY	on deck
PS79/ 040-1	10.12.2011	22:20	53° 29.98' S	0° 0.20' W	2642	MN-PP	in the water
PS79/ 040-1	10.12.2011	22:27	53° 30.02' S	0° 0.19' W	2649	MN-PP	on ground
PS79/ 040-1	10.12.2011	22:40	53° 30.09' S	0° 0.16' W	2656	MN-PP	on deck
PS79/ 040-2	10.12.2011	22:51	53° 30.13' S	0° 0.15' W	2653	CTD/RO	in the water
PS79/ 040-3	10.12.2011	23:09	53° 30.16' S	0° 0.17' W	2651	HN	in the water
PS79/ 040-3	10.12.2011	23:18	53° 30.18' S	0° 0.17' W	2650	HN	on ground
PS79/ 040-3	10.12.2011	23:18	53° 30.18' S	0° 0.17' W	2650	HN	on deck
PS79/ 040-2	10.12.2011	23:45	53° 30.20' S	0° 0.18' W	2649	CTD/RO	on ground
PS79/ 040-2	11.12.2011	00:31	53° 30.17' S	0° 0.43' W	2649	CTD/RO	on deck
PS79/ 040-4	11.12.2011	00:41	53° 30.17' S	0° 0.38' W	2647	MN	in the water
PS79/ 040-5	11.12.2011	00:51	53° 30.16' S	0° 0.34' W	2648	HN	in the water
PS79/ 040-4	11.12.2011	01:44	53° 30.14' S	0° 0.18' W	2652	MN	on ground
PS79/ 040-5	11.12.2011	02:59	53° 30.24' S	0° 0.01' W	2651	HN	on deck
PS79/ 040-4	11.12.2011	03:04	53° 30.25' S	0° 0.02' W	2651	MN	on deck
PS79/ 040-6	11.12.2011	03:25	53° 30.32' S	0° 0.06' W	2644	BONGO	in the water
PS79/ 040-6	11.12.2011	03:38	53° 30.37' S	0° 0.15' W	2638	BONGO	on ground
PS79/ 040-6	11.12.2011	03:56	53° 30.41' S	0° 0.23' W	2634	BONGO	on deck
PS79/ 041-1	11.12.2011	12:02	54° 59.93' S	0° 0.18' E	1706	BUOY	in the water
PS79/ 041-2	11.12.2011	12:14	55° 0.13' S	0° 0.03' W	1741	MN-PP	in the water
PS79/ 041-2	11.12.2011	12:26	55° 0.20' S	0° 0.05' W	1743	MN-PP	on ground

Station PS79	**Date**	**Time** [UTC]	**Position** (Lat.)	**Position** (Lon.)	**Depth** [m]	**Gear**	**Action**
PS79/ 041-2	11.12.2011	12:38	55° 0.25' S	0° 0.03' W	1739	MN-PP	on deck
PS79/ 041-3	11.12.2011	12:45	55° 0.27' S	0° 0.00' W	1735	CTD/RO	in the water
PS79/ 041-4	11.12.2011	12:50	55° 0.29' S	0° 0.00' E	1745	HN	in the water
PS79/ 041-4	11.12.2011	13:02	55° 0.35' S	0° 0.02' W	1744	HN	on deck
PS79/ 041-3	11.12.2011	13:25	55° 0.48' S	0° 0.04' W	1715	CTD/RO	on ground
PS79/ 041-3	11.12.2011	14:00	55° 0.46' S	0° 0.04' E	1702	CTD/RO	on deck
PS79/ 041-5	11.12.2011	14:32	55° 0.44' S	0° 0.02' W	1750	MN	in the water
PS79/ 041-6	11.12.2011	14:36	55° 0.44' S	0° 0.04' W	1753	HN	in the water
PS79/ 041-5	11.12.2011	15:17	55° 0.36' S	0° 0.14' W	1765	MN	on ground
PS79/ 041-6	11.12.2011	15:44	55° 0.28' S	0° 0.16' W	1748	HN	on deck
PS79/ 041-5	11.12.2011	16:09	55° 0.32' S	0° 0.31' W	1746	MN	on deck
PS79/ 041-7	11.12.2011	16:14	55° 0.34' S	0° 0.35' W	1759	MN	in the water
PS79/ 041-7	11.12.2011	16:34	55° 0.39' S	0° 0.41' W	1743	MN	on ground
PS79/ 041-7	11.12.2011	16:39	55° 0.40' S	0° 0.44' W	1765	MN	on deck
PS79/ 041-8	11.12.2011	16:47	55° 0.44' S	0° 0.48' W	1764	TT	in the water
PS79/ 041-8	11.12.2011	17:09	55° 1.03' S	0° 1.50' W	1861	TT	profile start
PS79/ 041-8	11.12.2011	17:24	55° 1.40' S	0° 2.25' W	2081	TT	profile end
PS79/ 041-8	11.12.2011	17:29	55° 1.48' S	0° 2.49' W	2119	TT	on deck
PS79/ 041-1	11.12.2011	18:13	54° 58.19' S	0° 1.61' E	1717	BUOY	on deck
PS79/ 042-1	12.12.2011	02:37	56° 30.08' S	0° 0.22' W	2602	MN-PP	in the water
PS79/ 042-1	12.12.2011	02:45	56° 30.06' S	0° 0.28' W	2376	MN-PP	on ground
PS79/ 042-1	12.12.2011	03:05	56° 30.05' S	0° 0.22' W	-	MN-PP	on deck
PS79/ 042-2	12.12.2011	03:15	56° 30.06' S	0° 0.12' W	4096	CTD/RO	in the water
PS79/ 042-3	12.12.2011	03:16	56° 30.06' S	0° 0.11' W	2323	HN	in the water

Station PS79	**Date**	**Time** [UTC]	**Position** (Lat.)	**Position** (Lon.)	**Depth** [m]	**Gear**	**Action**
PS79/ 042-3	12.12.2011	03:29	56° 30.07' S	0° 0.01' W	2239	HN	on deck
PS79/ 042-2	12.12.2011	04:37	56° 30.03' S	0° 0.03' W	4100	CTD/RO	on ground
PS79/ 042-2	12.12.2011	05:47	56° 30.03' S	0° 0.07' W	2350	CTD/RO	on deck
PS79/ 042-4	12.12.2011	06:00	56° 30.03' S	0° 0.10' W	4101	MN	in the water
PS79/ 042-5	12.12.2011	06:08	56° 30.03' S	0° 0.14' W	4101	HN	in the water
PS79/ 042-5	12.12.2011	06:13	56° 30.03' S	0° 0.15' W	4100	HN	on deck
PS79/ 042-4	12.12.2011	07:06	56° 30.03' S	0° 0.21' W	4100	MN	on ground
PS79/ 042-4	12.12.2011	08:19	56° 29.99' S	0° 0.13' W	4100	MN	on deck
PS79/ 042-6	12.12.2011	08:31	56° 30.00' S	0° 0.11' W	4100	BONGO	in the water
PS79/ 042-6	12.12.2011	08:49	56° 30.00' S	0° 0.15' W	4095	BONGO	on ground
PS79/ 042-6	12.12.2011	09:07	56° 29.98' S	0° 0.27' W	4100	BONGO	on deck
PS79/ 042-7	12.12.2011	09:12	56° 29.97' S	0° 0.30' W	4103	BONGO	in the water
PS79/ 042-7	12.12.2011	09:16	56° 29.97' S	0° 0.31' W	4103	BONGO	on ground
PS79/ 042-7	12.12.2011	09:20	56° 29.97' S	0° 0.31' W	4103	BONGO	on deck
PS79/ 043-1	12.12.2011	19:30	58° 17.16' S	0° 3.24' E	3869	MN	in the water
PS79/ 043-1	12.12.2011	19:37	58° 17.15' S	0° 3.21' E	3807	MN	on ground
PS79/ 043-1	12.12.2011	19:51	58° 17.14' S	0° 3.16' E	3817	MN	on deck
PS79/ 043-2	12.12.2011	19:57	58° 17.14' S	0° 3.17' E	3833	CTD/RO	in the water
PS79/ 043-3	12.12.2011	20:05	58° 17.15' S	0° 3.18' E	3841	HN	in the water
PS79/ 043-3	12.12.2011	20:14	58° 17.16' S	0° 3.20' E	3854	HN	on deck
PS79/ 043-4	12.12.2011	20:17	58° 17.16' S	0° 3.21' E	3829	BUCKET	in the water
PS79/ 043-4	12.12.2011	20:20	58° 17.17' S	0° 3.21' E	3823	BUCKET	on deck
PS79/ 043-2	12.12.2011	21:12	58° 17.22' S	0° 3.47' E	3795	CTD/RO	on ground
PS79/ 043-2	12.12.2011	22:19	58° 17.40' S	0° 4.34' E	3841	CTD/RO	on deck

Station PS79	**Date**	**Time** [UTC]	**Position** (Lat.)	**Position** (Lon.)	**Depth** [m]	**Gear**	**Action**
PS79/ 043-5	12.12.2011	22:27	58° 17.43' S	0° 4.45' E	3879	MN	in the water
PS79/ 043-5	12.12.2011	23:36	58° 17.75' S	0° 5.63' E	3595	MN	on ground
PS79/ 043-5	13.12.2011	00:49	58° 18.22' S	0° 7.66' E	3448	MN	on deck
PS79/ 043-6	13.12.2011	01:00	58° 18.31' S	0° 8.04' E	3458	BONGO	in the water
PS79/ 043-6	13.12.2011	01:20	58° 18.48' S	0° 8.55' E	3517	BONGO	on ground
PS79/ 043-6	13.12.2011	01:42	58° 18.72' S	0° 9.21' E	3713	BONGO	on deck
PS79/ 044-1	14.12.2011	17:04	64° 5.02' S	0° 5.46' W	5193	CTD/RO	in the water
PS79/ 044-1	14.12.2011	18:37	64° 5.35' S	0° 7.02' W	5198	CTD/RO	on ground
PS79/ 044-1	14.12.2011	19:58	64° 5.84' S	0° 8.32' W	5182	CTD/RO	on deck
PS79/ 044-2	14.12.2011	20:02	64° 5.86' S	0° 8.38' W	5123	BONGO	in the water
PS79/ 044-2	14.12.2011	20:14	64° 5.90' S	0° 8.60' W	5123	BONGO	on ground
PS79/ 044-2	14.12.2011	20:17	64° 5.91' S	0° 8.65' W	5123	BONGO	on deck
PS79/ 044-3	14.12.2011	20:20	64° 5.93' S	0° 8.70' W	5123	BONGO	in the water
PS79/ 044-3	14.12.2011	20:37	64° 6.07' S	0° 8.87' W	5181	BONGO	on ground
PS79/ 044-4	14.12.2011	20:46	64° 6.10' S	0° 9.02' W	5181	HN	in the water
PS79/ 044-3	14.12.2011	20:51	64° 6.15' S	0° 9.07' W	5181	BONGO	on deck
PS79/ 044-4	14.12.2011	20:52	64° 6.15' S	0° 9.08' W	5181	HN	on deck
PS79/ 044-5	14.12.2011	20:54	64° 6.17' S	0° 9.10' W	5174	BONGO	in the water
PS79/ 044-5	14.12.2011	21:00	64° 6.24' S	0° 9.14' W	5174	BONGO	on ground
PS79/ 044-5	14.12.2011	21:04	64° 6.28' S	0° 9.17' W	5174	BONGO	on deck
PS79/ 044-6	14.12.2011	21:37	64° 5.42' S	0° 5.45' W	5174	EF	in the water
PS79/ 044-6	14.12.2011	21:42	64° 5.46' S	0° 5.49' W	5174	EF	on deck
NaN	15.12.2011	14:50	66° 3.58' S	0° 1.49' W	3609	NaN	information
NaN	19.12.2011	11:10	70° 30.76' S	8° 11.75' W	248	NaN	shelf ice edge
PS79/ 045-1	22.12.2011	10:14	70° 30.64' S	8° 11.60' W	248	CTD/RO	in the water

Station PS79	**Date**	**Time** [UTC]	**Position** (Lat.)	**Position** (Lon.)	**Depth** [m]	**Gear**	**Action**
PS79/ 045-3	22.12.2011	10:14	70° 30.64' S	8° 11.60' W	248	HN	in the water
PS79/ 045-1	22.12.2011	10:26	70° 30.56' S	8° 11.71' W	245	CTD/RO	on ground
PS79/ 045-1	22.12.2011	10:39	70° 30.54' S	8° 11.82' W	245	CTD/RO	on deck
PS79/ 045-2	22.12.2011	10:44	70° 30.54' S	8° 11.86' W	244	MN	in the water
PS79/ 045-2	22.12.2011	10:53	70° 30.54' S	8° 11.92' W	244	MN	on ground
PS79/ 045-2	22.12.2011	11:06	70° 30.54' S	8° 12.00' W	244	MN	on deck
PS79/ 045-4	22.12.2011	11:17	70° 30.56' S	8° 12.05' W	245	BONGO	in the water
PS79/ 045-4	22.12.2011	11:30	70° 30.48' S	8° 12.18' W	247	BONGO	on ground
PS79/ 045-4	22.12.2011	11:40	70° 30.43' S	8° 12.25' W	250	BONGO	on deck
PS79/ 045-3	22.12.2011	11:41	70° 30.43' S	8° 12.25' W	250	HN	on deck
PS79/ 045-5	22.12.2011	11:51	70° 30.48' S	8° 12.44' W	248	BONGO	in the water
PS79/ 045-5	22.12.2011	12:06	70° 30.44' S	8° 12.50' W	249	BONGO	on ground
PS79/ 045-5	22.12.2011	12:20	70° 30.38' S	8° 12.43' W	252	BONGO	on deck
NaN	22.12.2011	21:15	70° 30.76' S	8° 11.74' W	248	NaN	shelf ice edge
PS79/ 046-1	23.12.2011	15:39	69° 29.38' S	0° 13.14' W	1636	CTD/RO	in the water
PS79/ 046-1	23.12.2011	15:51	69° 29.39' S	0° 13.52' W	1642	CTD/RO	on ground
PS79/ 046-1	23.12.2011	16:00	69° 29.39' S	0° 13.85' W	1641	CTD/RO	on deck
PS79/ 046-2	23.12.2011	16:06	69° 29.37' S	0° 13.95' W	1652	EF	in the water
PS79/ 046-2	23.12.2011	16:27	69° 29.43' S	0° 13.78' W	1645	EF	on deck
PS79/ 046-3	23.12.2011	16:41	69° 29.59' S	0° 14.49' W	1657	CTD/RO	in the water
PS79/ 046-4	23.12.2011	17:06	69° 29.60' S	0° 14.91' W	1663	HN	in the water
PS79/ 046-4	23.12.2011	17:18	69° 29.58' S	0° 15.23' W	1670	HN	on deck
PS79/ 046-3	23.12.2011	17:19	69° 29.57' S	0° 15.26' W	1671	CTD/RO	on ground
PS79/ 046-3	23.12.2011	17:55	69° 29.59' S	0° 15.81' W	1682	CTD/RO	on deck
PS79/ 046-5	23.12.2011	18:27	69° 31.24' S	0° 22.14' W	1787	TT	in the water

Station PS79	**Date**	**Time** [UTC]	**Position** (Lat.)	**Position** (Lon.)	**Depth** [m]	**Gear**	**Action**
PS79/ 046-5	23.12.2011	18:53	69° 31.16' S	0° 24.94' W	1869	TT	profile start
PS79/ 046-5	23.12.2011	19:13	69° 31.09' S	0° 27.25' W	1919	TT	profile end
PS79/ 046-5	23.12.2011	19:18	69° 31.07' S	0° 27.80' W	1927	TT	on deck
PS79/ 047-1	24.12.2011	01:46	68° 58.49' S	0° 1.30' E	3381	MN-PP	in the water
PS79/ 047-1	24.12.2011	01:56	68° 58.49' S	0° 1.13' E	3382	MN-PP	on ground
PS79/ 047-1	24.12.2011	02:10	68° 58.48' S	0° 0.89' E	3385	MN-PP	on deck
PS79/ 047-2	24.12.2011	02:21	68° 58.73' S	0° 0.83' E	3400	CTD/RO	in the water
PS79/ 047-3	24.12.2011	02:22	68° 58.73' S	0° 0.83' E	3400	BUCKET	in the water
PS79/ 047-3	24.12.2011	02:23	68° 58.74' S	0° 0.82' E	3399	BUCKET	on deck
PS79/ 047-4	24.12.2011	02:26	68° 58.74' S	0° 0.78' E	3402	HN	in the water
PS79/ 047-4	24.12.2011	02:44	68° 58.76' S	0° 0.57' E	3404	HN	on deck
PS79/ 047-2	24.12.2011	03:27	68° 58.79' S	0° 0.35' W	3427	CTD/RO	on ground
PS79/ 047-2	24.12.2011	04:21	68° 58.89' S	0° 1.72' W	3451	CTD/RO	on deck
PS79/ 047-5	24.12.2011	04:31	68° 58.92' S	0° 2.44' W	3426	MN	in the water
PS79/ 047-5	24.12.2011	05:39	68° 59.13' S	0° 4.25' W	3401	MN	on ground
PS79/ 047-5	24.12.2011	06:53	68° 59.39' S	0° 5.86' W	3383	MN	on deck
PS79/ 047-6	24.12.2011	07:03	68° 59.44' S	0° 6.05' W	3382	BONGO	in the water
PS79/ 047-6	24.12.2011	07:21	68° 59.54' S	0° 6.43' W	3380	BONGO	on ground
PS79/ 047-6	24.12.2011	07:35	68° 59.59' S	0° 6.64' W	3374	BONGO	on deck
PS79/ 047-7	24.12.2011	07:38	68° 59.61' S	0° 6.73' W	3371	BONGO	in the water
PS79/ 047-7	24.12.2011	07:57	68° 59.66' S	0° 6.87' W	3364	BONGO	on ground
PS79/ 047-7	24.12.2011	08:14	68° 59.70' S	0° 7.08' W	3361	BONGO	on deck
PS79/ 048-1	24.12.2011	13:01	68° 31.66' S	0° 5.23' W	4253	CTD/RO	in the water
PS79/ 048-1	24.12.2011	14:28	68° 31.78' S	0° 6.12' W	4261	CTD/RO	on ground

Station PS79	Date	Time [UTC]	Position (Lat.)	Position (Lon.)	Depth [m]	Gear	Action
PS79/ 048-1	24.12.2011	15:46	68° 31.90' S	0° 7.25' W	4281	CTD/RO	on deck
PS79/ 049-1	25.12.2011	07:58	67° 0.08' S	0° 1.13' W	4700	MN-PP	in the water
PS79/ 049-1	25.12.2011	08:04	67° 0.09' S	0° 1.11' W	4700	MN-PP	on ground
PS79/ 049-1	25.12.2011	08:17	67° 0.13' S	0° 1.28' W	-	MN-PP	on deck
PS79/ 049-2	25.12.2011	08:25	67° 0.19' S	0° 1.72' W	4700	CTD/RO	in the water
PS79/ 049-3	25.12.2011	08:31	67° 0.23' S	0° 1.93' W	4700	HN	in the water
PS79/ 049-3	25.12.2011	08:42	67° 0.24' S	0° 2.08' W	-	HN	on deck
PS79/ 049-2	25.12.2011	10:07	67° 0.36' S	0° 3.66' W	4700	CTD/RO	on ground
PS79/ 049-2	25.12.2011	11:38	67° 0.16' S	0° 5.66' W	4700	CTD/RO	on deck
PS79/ 049-4	25.12.2011	11:44	67° 0.19' S	0° 5.81' W	4700	MN	in the water
PS79/ 049-4	25.12.2011	12:54	67° 0.04' S	0° 7.28' W	4700	MN	on ground
PS79/ 049-4	25.12.2011	14:12	66° 59.93' S	0° 9.70' W	4700	MN	on deck
PS79/ 049-5	25.12.2011	14:27	67° 0.31' S	0° 9.98' W	4700	BONGO	in the water
PS79/ 049-5	25.12.2011	14:46	67° 0.16' S	0° 10.70' W	4700	BONGO	on ground
PS79/ 049-5	25.12.2011	15:03	67° 0.05' S	0° 11.22' W	4700	BONGO	on deck
PS79/ 049-6	25.12.2011	15:13	67° 0.29' S	0° 10.89' W	-	EF	in the water
PS79/ 049-6	25.12.2011	15:48	67° 0.12' S	0° 12.40' W	-	EF	on deck
PS79/ 050-1	26.12.2011	00:52	65° 30.60' S	0° 1.27' E	3916	MN-PP	in the water
PS79/ 050-1	26.12.2011	00:58	65° 30.62' S	0° 1.31' E	3916	MN-PP	on ground
PS79/ 050-1	26.12.2011	01:10	65° 30.65' S	0° 1.45' E	3916	MN-PP	on deck
PS79/ 050-2	26.12.2011	01:19	65° 30.72' S	0° 1.89' E	3888	CTD/RO	in the water
PS79/ 050-3	26.12.2011	01:28	65° 30.74' S	0° 1.92' E	3887	HN	in the water
PS79/ 050-3	26.12.2011	01:38	65° 30.79' S	0° 2.12' E	3882	HN	on deck
PS79/ 050-2	26.12.2011	02:42	65° 31.01' S	0° 3.29' E	3800	CTD/RO	on ground

Station PS79	Date	Time [UTC]	Position (Lat.)	Position (Lon.)	Depth [m]	Gear	Action
PS79/ 050-2	26.12.2011	03:53	65° 31.32' S	0° 4.77' E	3727	CTD/RO	on deck
PS79/ 050-4	26.12.2011	04:03	65° 31.35' S	0° 5.29' E	3668	EF	in the water
PS79/ 050-4	26.12.2011	04:20	65° 31.26' S	0° 5.89' E	3666	EF	on deck
PS79/ 051-1	26.12.2011	12:34	64° 4.48' S	0° 6.75' W	5203	MN	in the water
PS79/ 051-1	26.12.2011	12:42	64° 4.50' S	0° 6.64' W	5189	MN	on ground
PS79/ 051-1	26.12.2011	12:54	64° 4.53' S	0° 6.61' W	5189	MN	on deck
PS79/ 051-2	26.12.2011	13:38	64° 5.01' S	0° 5.36' W	5181	MOOR	released
PS79/ 051-2	26.12.2011	13:58	64° 5.05' S	0° 5.48' W	5181	MOOR	on ground
PS79/ 051-2	26.12.2011	14:09	64° 5.05' S	0° 5.48' W	5181	MOOR	released
PS79/ 051-2	26.12.2011	14:35	64° 5.04' S	0° 5.44' W	5181	MOOR	released
PS79/ 051-2	26.12.2011	15:06	64° 5.18' S	0° 5.02' W	5181	MOOR	on ground
PS79/ 051-3	26.12.2011	15:06	64° 5.18' S	0° 5.02' W	5181	MN	in the water
PS79/ 051-3	26.12.2011	16:15	64° 5.35' S	0° 5.20' W	5182	MN	on ground
PS79/ 051-3	26.12.2011	17:24	64° 5.45' S	0° 5.25' W	5182	MN	on deck
PS79/ 051-4	26.12.2011	17:28	64° 5.46' S	0° 5.27' W	5182	MN-Midi	in the water
PS79/ 051-4	26.12.2011	17:36	64° 5.48' S	0° 5.29' W	5182	MN-Midi	on ground
PS79/ 051-4	26.12.2011	17:46	64° 5.51' S	0° 5.34' W	5182	MN-Midi	on deck
PS79/ 051-5	26.12.2011	17:52	64° 5.53' S	0° 5.34' W	5189	BONGO	in the water
PS79/ 051-5	26.12.2011	18:15	64° 5.64' S	0° 5.35' W	5189	BONGO	on ground
PS79/ 051-5	26.12.2011	18:31	64° 5.73' S	0° 5.31' W	5189	BONGO	on deck
PS79/ 051-2	26.12.2011	19:01	64° 5.13' S	0° 4.88' W	5181	MOOR	recovery failed
PS79/ 052-1	27.12.2011	06:55	61° 59.21' S	0° 1.34' W	5367	MN-PP	in the water
PS79/ 052-1	27.12.2011	07:05	61° 59.22' S	0° 1.34' W	5366	MN-PP	on ground
PS79/ 052-1	27.12.2011	07:15	61° 59.20' S	0° 1.42' W	5365	MN-PP	on deck

Station PS79	**Date**	**Time** [UTC]	**Position** (Lat.)	**Position** (Lon.)	**Depth** [m]	**Gear**	**Action**
PS79/ 052-2	27.12.2011	07:20	61° 59.19' S	0° 1.45' W	5359	CTD/RO	in the water
PS79/ 052-3	27.12.2011	07:30	61° 59.21' S	0° 1.47' W	5360	HN	in the water
PS79/ 052-3	27.12.2011	07:42	61° 59.21' S	0° 1.43' W	5360	HN	on deck
PS79/ 052-2	27.12.2011	09:14	61° 59.36' S	0° 1.58' W	5359	CTD/RO	on ground
PS79/ 052-2	27.12.2011	10:50	61° 59.76' S	0° 0.09' W	5360	CTD/RO	on deck
PS79/ 053-1	27.12.2011	22:03	60° 0.67' S	0° 0.63' W	5340	MN	in the water
PS79/ 053-2	27.12.2011	22:09	60° 0.73' S	0° 0.70' W	5340	HN	in the water
PS79/ 053-1	27.12.2011	22:10	60° 0.74' S	0° 0.70' W	5340	MN	on ground
PS79/ 053-1	27.12.2011	22:26	60° 0.88' S	0° 0.78' W	5340	MN	on deck
PS79/ 053-3	27.12.2011	22:37	60° 1.12' S	0° 0.67' W	5340	CTD/RO	in the water
PS79/ 053-2	27.12.2011	23:48	60° 1.76' S	0° 0.77' W	5340	HN	on deck
PS79/ 053-3	28.12.2011	00:31	60° 2.24' S	0° 0.78' W	5355	CTD/RO	on ground
PS79/ 053-3	28.12.2011	02:23	60° 2.92' S	0° 0.57' E	5355	CTD/RO	on deck
PS79/ 053-4	28.12.2011	02:32	60° 3.10' S	0° 0.85' E	5359	MN	in the water
PS79/ 053-4	28.12.2011	03:36	60° 3.35' S	0° 1.48' E	5374	MN	on ground
PS79/ 053-4	28.12.2011	04:50	60° 3.41' S	0° 1.91' E	5396	MN	on deck
PS79/ 053-5	28.12.2011	05:00	60° 3.33' S	0° 2.03' E	5365	BONGO	in the water
PS79/ 053-5	28.12.2011	05:21	60° 3.22' S	0° 2.14' E	5366	BONGO	on ground
PS79/ 053-5	28.12.2011	05:34	60° 3.14' S	0° 2.08' E	5367	BONGO	on deck
PS79/ 053-6	28.12.2011	05:37	60° 3.11' S	0° 2.07' E	5367	BONGO	in the water
PS79/ 053-6	28.12.2011	05:51	60° 3.02' S	0° 1.99' E	5367	BONGO	on ground
PS79/ 053-6	28.12.2011	06:00	60° 2.97' S	0° 1.96' E	5367	BONGO	on deck
PS79/ 053-7	28.12.2011	06:27	60° 2.85' S	0° 2.07' E	5374	TT	in the water
PS79/ 053-7	28.12.2011	06:46	60° 2.87' S	0° 3.20' E	5374	TT	profile start

Station PS79	**Date**	**Time** [UTC]	**Position** (Lat.)	**Position** (Lon.)	**Depth** [m]	**Gear**	**Action**
PS79/ 053-7	28.12.2011	07:02	60° 2.92' S	0° 4.22' E	5374	TT	profile end
PS79/ 053-7	28.12.2011	07:03	60° 2.93' S	0° 4.29' E	5375	TT	on deck
PS79/ 054-1	29.12.2011	14:28	53° 29.89' S	0° 0.12' E	2653	MN-PP	in the water
PS79/ 054-1	29.12.2011	14:31	53° 29.88' S	0° 0.16' E	2655	MN-PP	on ground
PS79/ 054-1	29.12.2011	14:34	53° 29.87' S	0° 0.18' E	2652	MN-PP	at surface
PS79/ 054-2	29.12.2011	14:34	53° 29.87' S	0° 0.18' E	2652	BUCKET	in the water
PS79/ 054-2	29.12.2011	14:34	53° 29.87' S	0° 0.18' E	2652	BUCKET	on deck
PS79/ 054-1	29.12.2011	14:37	53° 29.86' S	0° 0.20' E	2652	MN	in the water
PS79/ 054-1	29.12.2011	14:45	53° 29.82' S	0° 0.28' E	2654	MN	on ground
PS79/ 054-1	29.12.2011	14:55	53° 29.77' S	0° 0.33' E	2650	MN	on deck
PS79/ 054-3	29.12.2011	15:02	53° 29.73' S	0° 0.37' E	2647	CTD/RO	in the water
PS79/ 054-3	29.12.2011	15:15	53° 29.68' S	0° 0.44' E	2649	CTD/RO	on ground
PS79/ 054-3	29.12.2011	15:29	53° 29.65' S	0° 0.58' E	2655	CTD/RO	on deck
PS79/ 054-4	29.12.2011	15:36	53° 29.68' S	0° 0.65' E	2660	MN	in the water
PS79/ 054-4	29.12.2011	16:45	53° 29.58' S	0° 0.81' E	2668	MN	on ground
PS79/ 054-4	29.12.2011	17:56	53° 29.68' S	0° 0.76' E	2663	MN	on deck
PS79/ 054-5	29.12.2011	18:01	53° 29.69' S	0° 0.72' E	2662	MN	in the water
PS79/ 054-5	29.12.2011	18:10	53° 29.71' S	0° 0.68' E	2662	MN	on ground
PS79/ 054-5	29.12.2011	18:18	53° 29.73' S	0° 0.68' E	2663	MN	on deck
PS79/ 054-6	29.12.2011	18:28	53° 29.75' S	0° 0.67' E	2665	BONGO	in the water
PS79/ 054-6	29.12.2011	18:42	53° 29.74' S	0° 0.64' E	2661	BONGO	on ground
PS79/ 054-6	29.12.2011	18:56	53° 29.77' S	0° 0.62' E	2661	BONGO	on deck
PS79/ 054-7	29.12.2011	18:58	53° 29.76' S	0° 0.61' E	2661	BONGO	in the water
PS79/ 054-7	29.12.2011	19:12	53° 29.74' S	0° 0.47' E	2656	BONGO	on ground

Station PS79	**Date**	**Time** [UTC]	**Position** (Lat.)	**Position** (Lon.)	**Depth** [m]	**Gear**	**Action**
PS79/ 054-7	29.12.2011	19:24	53° 29.80' S	0° 0.50' E	2661	BONGO	on deck
PS79/ 054-8	29.12.2011	19:32	53° 29.54' S	0° 0.27' E	2637	CPR	in the water
PS79/ 054-8	30.12.2011	10:52	50° 0.25' S	0° 0.01' E	3601	CPR	information
PS79/ 054-8	30.12.2011	17:50	48° 51.32' S	1° 28.65' E	3965	CPR	on deck
PS79/ 055-1	30.12.2011	17:58	48° 51.22' S	1° 28.66' E	3965	CTD/RO	in the water
PS79/ 055-1	30.12.2011	18:12	48° 51.18' S	1° 28.75' E	3963	CTD/RO	on ground
PS79/ 055-1	30.12.2011	18:31	48° 51.11' S	1° 28.74' E	-	CTD/RO	on deck
PS79/ 054-8	30.12.2011	18:38	48° 50.87' S	1° 28.81' E	3962	CPR	in the water
PS79/ 054-8	31.12.2011	10:07	46° 33.80' S	4° 20.79' E	4973	CPR	on deck
PS79/ 054-8	31.12.2011	10:22	46° 31.74' S	4° 23.31' E	4946	CPR	in the water
PS79/ 054-8	02.01.2012	04:54	40° 5.11' S	11° 50.87' E	4725	CPR	on deck
PS79/ 054-8	02.01.2012	05:00	40° 4.40' S	11° 51.67' E	4745	CPR	in the water
PS79/ 054-8	04.01.2012	14:55	35° 7.86' S	17° 6.71' E	2965	CPR	on deck

Gear abbreviations

BONGO	Bongo net
BUOY	Wave rider buoy
BUCKET	Bucket for surface water sampling
CPR	Continuous Plankton Recorder
CTD/RO	Conductivity-Temperature-Depth/Rosette water sampler
EF	“Eisfischen”
HN	Handnet for phytoplankton sampling
MN	Multinet large
MN-Midi	Multinet small
MN-PP	Multinet for phytoplankton sampling
MOOR	Mooring
NaN	Logistics Neumayer
PIES	Pressure Inverted Echo Sounder
TT	Tucker Trawl

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