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The Expedition PS82 of the Research Vessel POLARSTERN to the southern Weddell Sea in 2013/2014

Edited by
Rainer Knust and Michael Schröder
with contributions of the participants

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GEMEINSCHAFT

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Herausgeber
Dr. Horst Bornemann

Redaktionelle Bearbeitung und Layout
Birgit Chiaventone

Editor
Dr. Horst Bornemann

Editorial editing and layout
Birgit Chiaventone

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

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

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

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Titel: FS Polarstern an der Eiskante des Drescher-Inlets mit Kaiserpinguinen im Vordergrund
(Foto: Horst Bornemann, AWI)
Cover: RV Polarstern at the ice edge of the Drescher Inlet with emperor penguins in the foreground
(Photo: Horst Bornemann, AWI)

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PS82

(ANT-XXIX/9)

19 December 2013 – 5 March 2014

Cape Town – Cape Town

Chief scientist
Rainer Knust

Coordinator
Rainer Knust

Contents

1. ZUSAMMENFASSUNG UND FAHRTVERLAUF

Rainer Knust, Michael Schröder AWI

Polarstern startete mit halbtägiger Verspätung am 20.12.2013 zur 82. Expedition (ANT-XXIX/9) (Filchner Outflow System, FOS). An Bord befanden sich 53 Wissenschaftlerinnen und Wissenschaftler unterschiedlicher Disziplinen, vertreten waren die Eisphysik, physikalische Ozeanographie und Tracerphysik, Geologie und Sedimentologie. Die Biologie war mit den Fachrichtungen Eisbiologie, Primär- und Sekundärproduktion im Pelagial, Benthosökologie, Fischbiologie und Ökophysiologie, Genetik und Robbenbiologie vertreten. Beteiligt an der Expedition waren insgesamt 28 Institute aus 13 Ländern. Das Hauptuntersuchungsgebiet war das Meeresgebiet vor dem Filchner–Ronne–Schelfeis, im südlichsten Teil des Weddellmeeres; ein Gebiet, das aufgrund der sehr schwierigen Eisverhältnisse bisher nur selten untersucht wurde. Die wenigen Daten und Beobachtungen aus diesem Gebiet lassen allerdings die Vermutung zu, dass es sich hier um ein Gebiet mit besonderer Bedeutung hinsichtlich ozeanographischer Verhältnisse und hinsichtlich einer erhöhten biologischen Produktion handelt. Die Hauptfragestellungen der Expedition waren daher:

- Was sind die physikalischen Eigenschaften, die das Filchner-Trog-Ein/Ausflusssystem kontrollieren und welche zeitliche und räumliche Variabilität zeigen diese physikalischen Eigenschaften?
- Ist das Seegebiet vor dem Filchner-Schelfeis im Vergleich zu anderen Gebieten im Weddellmeer ein biologischer Hotspot?
- Welche steuernden Einflüsse haben das ozeanographische System und die Meereisverhältnisse auf die biologische Produktion und die räumliche und zeitliche Verteilung von Arten in diesem Seegebiet, und welche Konsequenzen werden zukünftige klimabedingte Veränderungen auf die Biologie in diesem Gebiet haben?

Neben dem wissenschaftlichen Hauptprogramm wurde im Gebiet Austasen, südwestlich der Atka-Bucht das BENDEX-Gebiet aufgesucht, in dem 2003/2004 ein Benthos-Störungsexperiment durchgeführt worden war. Nach einer Expedition im Jahre 2011 war dies die zweite Überprüfung des Gebietes um die Wiederbesiedelung nach zehn Jahren zu untersuchen. Weiter südlich wurden als Teil des internationalen ARGO-Experiments zwei hydroakustische Verankerungen ausgebracht, die zur Navigation der RAFOS-Bojen im südlichen Weddellmeer dienen.

Das verspätete Auslaufen aus Kapstadt war den Starkwinden, dem sogenannten Capedoctor, geschuldet, so dass der Hafen für fast einen Tag geschlossen war. Die recht ruhige Überfahrt Richtung *Neumayer-Station III* wurde nicht nur zum Einrichten der Labore und dem Aufbau der Geräte genutzt, sondern auch schon zu *en route* Messungen der Bathymetrie und der Ozeanographen.

Die Eissituation vor *Neumayer* stellte kein großes Problem dar, so dass *Polarstern* am 30.12.2013 die Atka-Bucht erreichte. Das Ladegeschäft zur *Neumayer-Station III*- Versorgung war ausgezeichnet vorbereitet und konnte am 31.12. abgeschlossen werden. Bereits beim Ablaufen aus der Atka-Bucht war durch einen Helikopter-Erkundungsflug klar, dass wir wie geplant unsere Arbeiten in Austasen aufgrund der Eislage nicht durchführen konnten. Die erneute Beprobung des BENDEX-Gebietes musste daher an das Ende der Expedition verschoben werden.

Dank einer recht offenen Küsten-Polynia kam *Polarstern* Richtung Filchner gut voran, so dass am 2. Januar 2014 das Hauptprogramm am nordöstlichen Teil des Filchner-Ausstromsystems beginnen konnte. Der gesamte Kursplot ist in Abb. 1.1 dargestellt. Um die Schiffszeit möglichst effizient nutzen und möglichst synoptische Datenerhebung durchführen zu können, wurden zumeist nachts CTD-Profile gefahren, die am Tage von biologischen Probenahmen ergänzt wurden. Da Anfang Januar eine gut befahrbare Küsten-Polynia im östlichen Teil angetroffen wurde, folgten wir dieser "Straße" zunächst und bargen Verankerungen und brachten neue aus. In nächtlichen CTD-Profilen versuchten wir ausgehend von der Polynia immer wieder Vorstöße in Richtung Westen in das Gebiet des eigentlichen Filchner-Trogs. Die Vorstöße wurden allerdings immer wieder durch die schlechten Eisverhältnisse begrenzt und oft waren die folgenden biologischen Arbeiten mit geschleppten Geräten nur schwer möglich. Am 16.01.2014 erreichte *Polarstern* den südlichsten Punkt der Expedition unmittelbar vor dem Filchner-Schelfeis. Ein weiterer Vorstoß Richtung Westen wurde durch die Wetterprognose am 17.01.2014 beendet. Die Änderung der Windrichtung würde sehr schnell die noch offenen Wege durch das sehr hohe mehrjährige Meereis schließen. Durch die noch offene Polynia erreichte *Polarstern* am 19. Januar wieder das Gebiet bei *Halley VI*. Die Eiskarten zeigten, dass auch noch am 3. Februar das südliche Gebiet, wie erwartet, komplett "zugeweht" war (Abb. 1.2). Wir versuchten daher weiter im Norden Richtung Westen voranzukommen und erstmalig auf dieser Expedition gelang es uns, den Filchner-Trog zu überqueren und Messungen auf der Westseite durchzuführen. Arbeiten mit geschleppten Geräten, oder das Ausbringen des ROVs, waren aber nur sehr begrenzt möglich, da zuvor erkundete freie Wasserflächen immer wieder durch Winddrift oder Gezeitenstrom mit Eisschollen geschlossen wurden. Auch die Eisphysiker, Eisbiologen und Robbenforscher hatten mit den Wetterverhältnissen zu kämpfen. Diese Gruppen waren auf Helikopterflüge zum Ausbringen von Messgeräten auf den Eisschollen, oder zum Erfassen der Robbenbestände auf dem Eis angewiesen. Oft ließen die Wetterverhältnisse Flugoperationen aber nicht zu, so dass ergänzend Operationen direkt vom Schiff aus nötig wurden. Trotz dieser widrigen Eisverhältnisse und Wetterverhältnisse waren wir in der Lage, unser Hauptprogramm erfolgreich abzuarbeiten, auch wenn einige Gebiete im westlichen Teil des Untersuchungsgebietes nicht erreichbar waren und einige Zählflüge nicht stattfinden konnten. Am 13. Februar wurden die Arbeiten im Filchner-Gebiet abgeschlossen. Auf der Rückfahrt wurden im Drescher-Inlet noch weitere Robben besendert, die ergänzend zu den besenderten Robben im Filchner-Gebiet die Daten zu Wassertemperatur und Salinität an das AWI senden, und dies aus Gebieten, die mit dem Schiff nicht erreichbar sind. Am 16. und 17. Februar wurde die Probennahme im Bendex Gebiet erfolgreich nachgeholt. Nach einem kurzen Anlauf an *Neumayer-Station III* erfolgte die Rückreise am 20. Februar, die lediglich durch eine kurze Plankton-Station unterbrochen wurde. Am 5. März erreichte *Polarstern* den Hafen von Kapstadt und beendete die Expedition PS82.

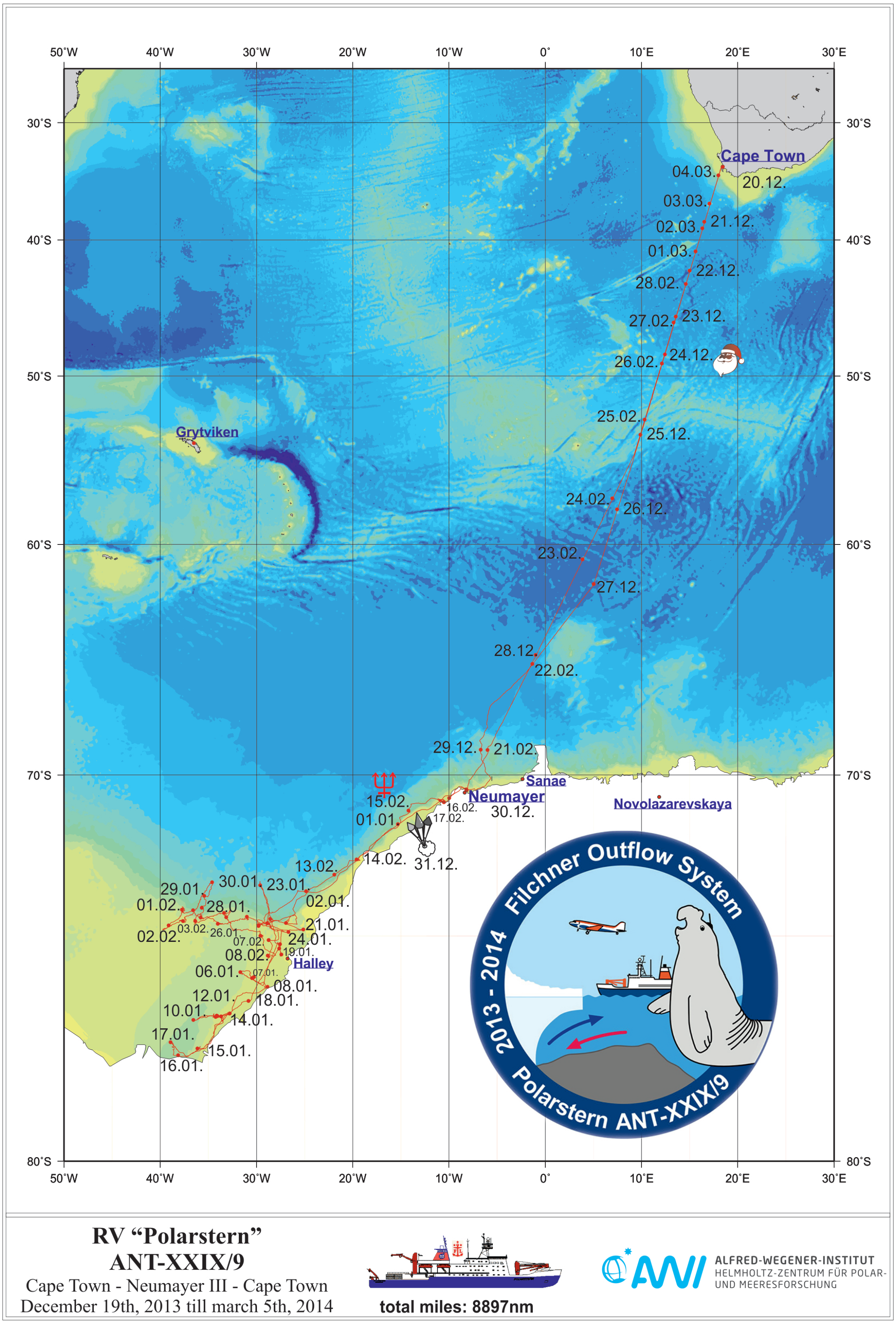

Abb. 1.1: Kursplot PS82 (ANT-XXIX/9 FOS); see http://doi.pangaea.de/10.1594/PANGAEA.832168

Fig. 1.1: Course plot PS82 (ANT-XXIX/9 FOS); see http://doi.pangaea.de/10.1594/PANGAEA.832168

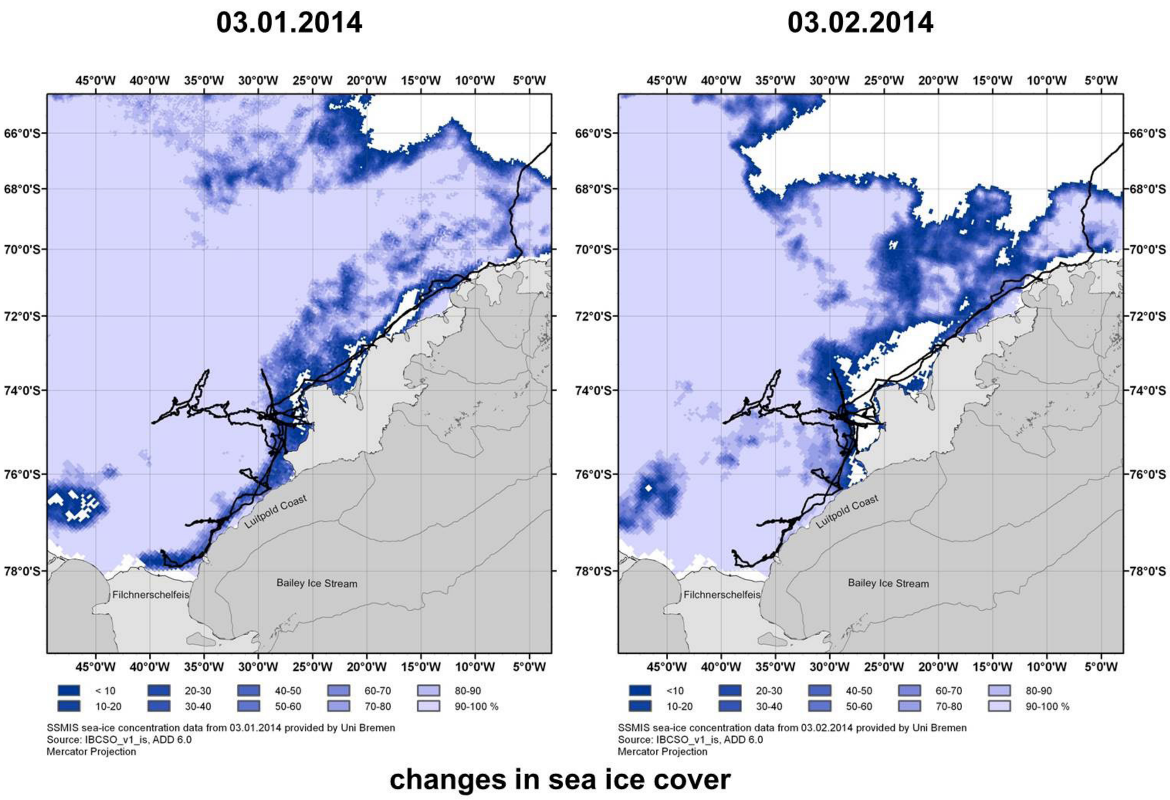

Abb. 1.2: Die Eissituation im Filchner-Gebiet

Fig. 1.2: The ice situation in the Filchner area

SUMMARY AND ITINERARY

Polarstern started the 82[nd] Expedition (ANT-XXIX/9; Filchner Outflow System, FOS) with half a day of delay.

The delayed departure in Cape Town was caused by strong winds, the so called "Cape Doctor" – the reason why the harbor was closed for almost a whole day.

Fifty-three scientists from various disciplines were on board, representing ice physics, physical oceanography and tracer physics, geology and sedimentology. The biologists represented the following disciplines: sea ice biology, primary and secondary production in the pelagic zone, benthos ecology, fish biology, ecophysiology, genetics and seal biology. Twenty-eight institutes from 13 different countries took part in the expedition. The main research area was the area in front of the Filchner Ronne Ice Shelf in the southernmost part of the Weddell Sea; a region, which is only poorly investigated due to the challenging sea ice conditions. The small amount of data and the few observations from this area, however, lead to the assumption that it is an area of special relevance with regard to oceanographic conditions and to increased biological production. The main questions of this expedition were:

- What are the physical parameters controlling the Filchner Outflow System and what are the temporal and spatial variabilities of these physical properties?
- Is the area in front of the Filchner Ice Shelf a biological hotspot compared to other areas of the Weddell Sea?
- What are the relevant controlling mechanisms of the oceanographic system and the sea-ice cover on the biological production and the spatial and temporal distribution of species and what will be the consequences of future climate-induced changes on the biology in this area?

Additionally to the main questions we re-visited the BENDEX-zone at Austasen, an area southwest of the Atka Bay where we carried out an artificial benthos disturbance experiment in 2003/2004. After 2011 this was the second visit to investigate the re-colonization process after 10 years. Further south, as part of the international ARGO experiment, we deployed two sound source moorings, which provide navigation data of the RAFOS floats in the southern Weddell Sea.

During the relative calm crossing to *Neumayer Station III* the time was not only used to install the labs and to set up the instruments, but also to carry out bathymetric and oceanographic *en route* measurements.

The ice conditions at *Neumayer* were fine and, thus, *Polarstern* arrived at the Atka Bay on December 30, 2013. The unloading of the supplies for the *Neumayer Station*

III had been thoroughly prepared and lasted only until December 31, 2013. Already when leaving the Atka Bay, by means of helicopter survey, it became obvious that we would not be able to conduct the work at Austasen as planned. The re-sampling at the BENDEX area had to be postponed until the end of the expedition.

Due to a relatively open coastal polynia *Polarstern* proceeded well towards Filchner and on January 2, 2014 we could start the main programme in the northeastern part of the Filchner Outflow System. The entire cruise track is shown in Fig. 1.1. To use the ship time as efficiently as possible and aiming for synoptic data collection, we carried out most of the CTD profiles during night time which were complemented by biological sampling during day time. At the beginning of January we found a well navigable Polynia in the eastern part and followed this "road", thus, being able to recover moorings and to deploy new ones. During nighttime profiles in the Polynia we tried to advance towards west into the area of the Filchner Trough. These approaches were, however, hindered by heavy ice conditions and, thus, biological work with towed devices was hardly possible. On January 16, 2014, *Polarstern* reached the southernmost point of the expedition – directly in front of the Filchner Ice Shelf. Another approach towards West was stopped by the weather forecast on January 17, 2014. The changing wind to northeast direction would quickly close the open water with thick multi-year ice. Therefore *Polarstern* headed northward and reached the area at *Halley VI* through the remaining polynia on January 19, 2014. On February 3, the ice charts showed that the southern area, as expected, had completely been shut by the drifting sea ice (Fig. 1.2).

Now, further north we tried to approach to the west, and for the first time during this expedition we succeeded in crossing the Filchner Trough and were able to carry out measurements on the west side. Work with towed instruments or the operation with the ROV was rarely possible as areas of open water turned out to be closed quickly- either through drift or tidal currents - by ice floes although the ice cover was monitored by helicopter reconnaissance flights. Also the ice physicists, ice biologists and the seal biologists struggled with the weather conditions. These groups were dependent of helicopter flights for deployment of instruments or for counting seals on ice floes. Often helicopter flights were impossible due to bad weather conditions and additional operations from the ship became necessary. In spite of the heavy ice and weather conditions we were able to conduct our main programme successfully – even though some areas in the western part remained inaccessible and some of the flights for counting seals could not take place. On February 13, the scientific work in the Filchner area had to be finished. On the way back some seals were equipped with transmitters in the Drescher Inlet. These seals will – additionally to the ones equipped with tags in the Filchner area – send data as water temperature and salinity to AWI from areas not accessible by ships. On February 16 and 17, we succeeded in sampling the area of BENDEX. After a short stop at *Neumayer Station III* we started our return journey - only interrupted by a short plankton station - on February 20. On March 5th, 2014 *Polarstern* arrived at the harbor of Cape Town and the expedition PS82 ended.

2. WEATHER CONDITIONS DURING PS82

Klaus Bähnke, Hartmut Sonnabend DWD

With a delay of almost 12 hrs *Polarstern* left Cape Town early on 20th December, 2013. The weather situation was influenced by a flat low pressure system (1007 hPa) over southern Africa and a flat ridge of high pressure which stretched out from the nearly stationary subtropical high north of Gough Island. Both pressure systems caused the "Cape Doctor"-Strong-Wind in the near coastal area and the harbour of Cape Town. On 18th December this local wind reached gusts of Bft 11 and interrupted all work and ship landing activities in the port of Cape Town. After departure at around 08:00 local time the southeastern wind was rather weak but increased later rapidly to Bft 6-7, in gusts 8.

On our south to southwest cruise track the weather was influenced by the above mentioned flat ridge of high pressure. Weather charts forecasted that *Polarstern* would come closer to the strong gradient field of a large storm low (<950 hPa) south of 60th latitude while maintaining the course. This storm low was nearly stationary and weakened very slowly. While coming closer to the low pressure system the wind increased to Bft 6-7, in gusts 8 and the windsea increased to 2-3 m plus a swell of 3 m. At the same time a short wave of low pressure developed at a trough on 22nd December, which propagated east and crossed the course of the vessel with its cold front and rain showers in the afternoon; the strong wind maintained with gale forces from the west.

On 26th December *Polarstern* left the turbulent latitudes with the rapidly moving lows between the 40th and 50th latitudes, where wave heights of 3 to 5, temporary 6 m occurred. The water temperature had dropped to -0.6°C, air temperature to -0.7°C.

On 28th December *Polarstern* reached at 67.1° S and 4.9° W the ice edge. In the night from 29th to 30th December the vessel arrived at the landing point in Atka Bay. The weather situation was influenced by the large and stable high pressure system over the Antarctic continent and the strong lows propagating eastwards in the westwind drift south of the 50th latitude. At the ice edge a weak wind situation prevailed under anticyclonic weather condition, partly with dense cloud patches moving over the area with strong impact on flight conditions.

In the early afternoon of 31st December *Polarstern* departed from *Neumayer* and sailed on 1st and 2nd January 2014 in a wide Polynia on a southwesterly course along the ice edge to the Filchner Region. While sailing the weather situation was influenced by a weak pressure gradient at the edge of the large pressure system along the shelf of the Antarctic continent. Large cloud patches with southwesterly wind over the Polynia and low cloud ceilings and temporary snowfall, locally with freezing drizzle, made helicopter flights rather difficult.

From 4th to 12th January *Polarstern* operated in the pack ice around 75th latitude S. In a steady northeasterly flow large patches of dense clouds propagated constantly over the operation area and made weather conditions for helicopter flights extremely difficult or impossible. During this time, a low with its centre north of the ship's position was moving in a westerly direction. The resulting northeasterly wind became temporary weaker but increased after 11th January to Bft 4-5 again. As simulated in weather model runs 4 days before a field of strong southerly wind with Bft 5-6, in gusts 7, occurred further west of the 40th longitude with negative effects on the ice situation in the operation area.

On 13th January an area of high pressure built up over the Weddell Sea with a centre north of *Polarstern*´s position. Prevailing northeasterly winds were weakening, the dense clouds disappeared in the early morning helicopter operations again were possible.

Despite a high pressure system over the Weddell Sea, thick and dense clouds with temporary snowfall caused low ceiling and whiteout-conditions on 14th January. Only in the evening and during the night the clouds cleared up as it had be the case during earlier days as well. This weather situation with dense layered clouds also sustained on 15th and 16th January *en route* to the Filchner Ice Shelf. Nevertheless daily late evening reconnaissance flights and a longer seal counting flight were possible on 16th January.

In the early morning of 17th January again a layer of thick and dense clouds lay over the operational area. But the satellite pictures showed that it could get cleared up by a sky clear area over the continent, which moved into the vessels area.

On 20th January an announced northeasterly storm situation nearly parallel to the axis of the open Polynia carried the risk that thick ice floes could be pushed into the open Polynia by the storm. All planned scientific operations of that day were accomplished and *Polarstern* returned back to the area of *Halley VI*. After the sky had cleared off several helicopter flights for seal counting and ice reconnaissance were performed.

From 18th to 21st January the vessel cruised in the Polynia off *Halley VI*. The weather situation was dominated by dense and thick clouds in connection with low ceiling and snowfall, which propagated at the northeastern edge of a developing low over Berkner Island into the operational area. This situation prevented the helicopters from flying. On 22nd January *Polarstern* left the Polynia and sailed into the ice field to the west. During the night there had been longer snow fall in connection with a cold front. Dense clouds with very low ceiling and snowfall prevented flying activities till midday, but in the early afternoon the cold front had passed over the vessel, weather condition became better and seal counting flights were possible.

On 23rd January *Polarstern* operated in the ice field around 74° S and 29° W at the northeastern edge of the still over the Berkner Island lying central low with its frontal cloud patches and snow fall areas. These conditions prevented the "seal group" from flight activities until 24th January. On 25th January cloud ceiling and visibility in the operational area at 74.5° S 30.9° W for flying were better and allowed after midday an three hour seal counting flight and in the evening two additional ice reconnaissance flights.

During 26th to 28th January a low pressure gradient situation with mostly overcast sky did not allow any flight activities. On 29th January in the early morning, *Polarstern* laid beside an ice floe at position 73.9° S and 35.4° W. The weather situation was dominated by a low pressure gradient with partly cloudy sky but allowed several helicopter flights for dropping five buoys on the ice floes.

On 30th January the wind had shifted to northwest and it was overcast with low clouds, snowfall, poor contrast and horizon visibility in the morning. At midday weather conditions improved and a longer seal counting flight could be performed. At similar weather condition on 31st January, short early morning and evening ice reconnaissance flights were performed.

On 1st and 2nd February, weather conditions allowed several seal counting flights. In the afternoon of 2nd February the weather situation rapidly deteriorated and dense clouds and snowfall as well as poor horizon contrast prevented further helicopter activities.

On 3rd February the wind shifted to southeast and increased. However larger cloud patches with snowfall were steered by the upper air northwesterly flow. Because of poor horizon and contrast only one short ice reconnaissance flight in the morning was possible.

On 4th February the wind flow shifted to south, drier and colder air came into the area and the ceiling of partly clouds had lifted and many helicopter flights could be made. Since the day before air temperature dropped remarkably to approx. minus 14°C, with windchill to minus 32°C.

On 5th February the wind flow shifted to westerly directions and dense clouds propagated over the operational area. Apart from short ice reconnaissance flights in the morning and in the early evening no longer flight activities were possible.

On 6th February the wind flow shifted further north to northeast. Until the evening dense clouds with low ceiling and snowfall came up caused by a developing strong low (950 hPa) over the northern Weddell Sea. Helicopter flights were performed till late afternoon. The strong northeast- to north wind (Bft 6-7, gusts 8) with long lasting snowfall maintained until the 7th February. The influence of the low with low clouds, snow showers and freezing drizzle maintained on 8th February. The northerly wind decreased but the weather did not allow any helicopter flights.

On 9th February there was a weak wind situation during the day in the operational area. In the afternoon a longer seal counting flight was performed. This weather situation with sunny sky under weak high pressure influence maintained onto 11th February with only temporary cloud patches over the area.

On 12th February *Polarstern*'s operational area was under the influence of a small low with low clouds. A helicopter flight to the ice edge for seal tagging had to be cancelled because of white-out-conditions at the arrival point.

On 13th February *Polarstern* sailed to the Drescher Inlet under calm weather conditions during the transit, allowing an evening reconnaissance flight to the inlet

Antarctic smoke developed along the ice edge due to -10°C cold air moving from the ice to the open water making scientific activities on the ice during night time impossible. On 14th February, a forecasted strong wind field with easterly winds Bft 8 for the area around Austasen led to the captain´s and chief scientist´s decision to finish work at Drescher Inlet in the evening and sail to Austasen immediately in order to commence the scientific work there before the storm begins.

On 15th February *Polarstern* sailed to Austasen. On 17th February near Austasen the wind increased strongly (Bft 8-10, in gusts 10-11) in front of the announced storm low with a forecasted pressure of 963 hPa. The stormy easterly wind maintained until the early morning of the 18th February and decreased rapidly thereafter.

On 19th to 20th February the air flow in the Austasen region shifted to a southerly direction coming from the continent and the cloud layer cleared up. *Polarstern* set sail from *Neumayer Station III* heading north towards Cape Town in the early evening. In the night and the following day (21st February) the vessel cruised through weak fast ice in front of Atka Bay; in the early evening of 21st February *Polarstern* left the ice field and reached open water.

The weather forecast models for the following days along the planned cruise track to Cape Town indicated the development of a very strong low (924 hPa) between the 60th to 40th latitude with its centre moving south of our route. Wave forecasts resulted in 6 m waves for a 10 kts and 8 m waves for an 8 kts cruising speed. For Wednesday 26th February there were signals for waves of even 8-13 m on the vessels route and the captain decided to sail with the higher speed to avoid this field of very strong waves and wind. On 25th February the westerly wind with Bft 7-8 shifted to northwest 9-10 with waves 4-5 m, later 6 m height. This weather situation maintained on 26th February. The American forecast model simulated a centre pressure of 919 hPa for the storm low. On 27th February we reached the northern edge of the storm low and the wind decreased rapidly, only the swell maintained with around 5 m.

On 1st March *Polarstern* cruised in an area of high pressure with a weak southwesterly wind at first. However, a strong low approached from the west. This very intensive low moved in a southeasterly direction with its centre (980 hPa) over *Polarstern*'s position on 2nd March. This low with showers and lightning and later with a westerly wind Bft 8-10, in gusts 10-11, temporarily 12, built up waves of 6-7 m height.

On the back side of the storm low a flat ridge of high pressure developed off the coast of the Western Cape from 3rd February on. *Polarstern* cruised at first in a weak southwesterly, later fresh to strong southeasterly winds towards Cape Town.

Figs. 2.1-2.4 summarize the weather and sea conditions during the scientific activities between *Neumayer* and *Neumayer*, i.e. 30th December 2013 to 21st February 2014. They characterise the wind direction (Fig. 2.1), and the particular weather situation with long lasting low wind speeds (Fig. 2.2), high percentage of low cloud ceiling (Fig. 2.3) and cloud coverage (Fig. 2.4) during that period.

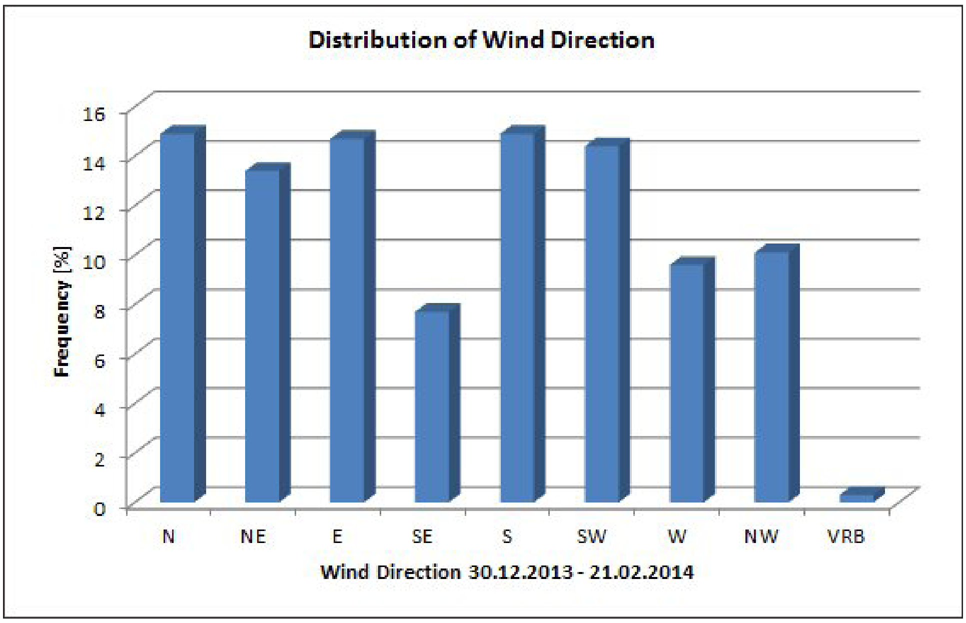

Fig. 2.1: Wind direction during the scientific activities between Neumayer and Neumayer, i.e. 30 December and 21 February

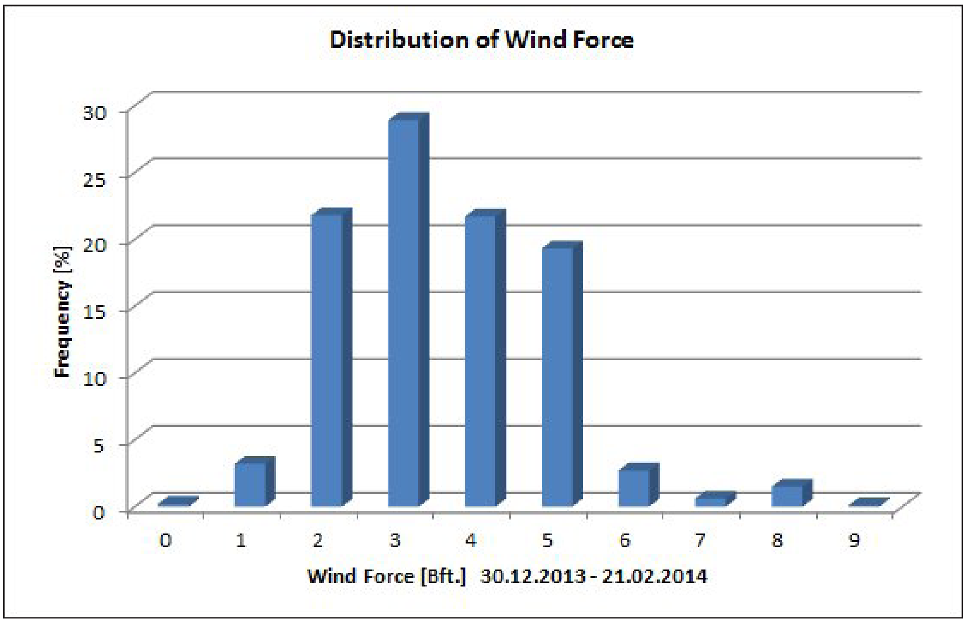

Fig. 2.2: Long lasting wind forces during the scientific activities between Neumayer and Neumayer, i.e. 30 December and 21 February

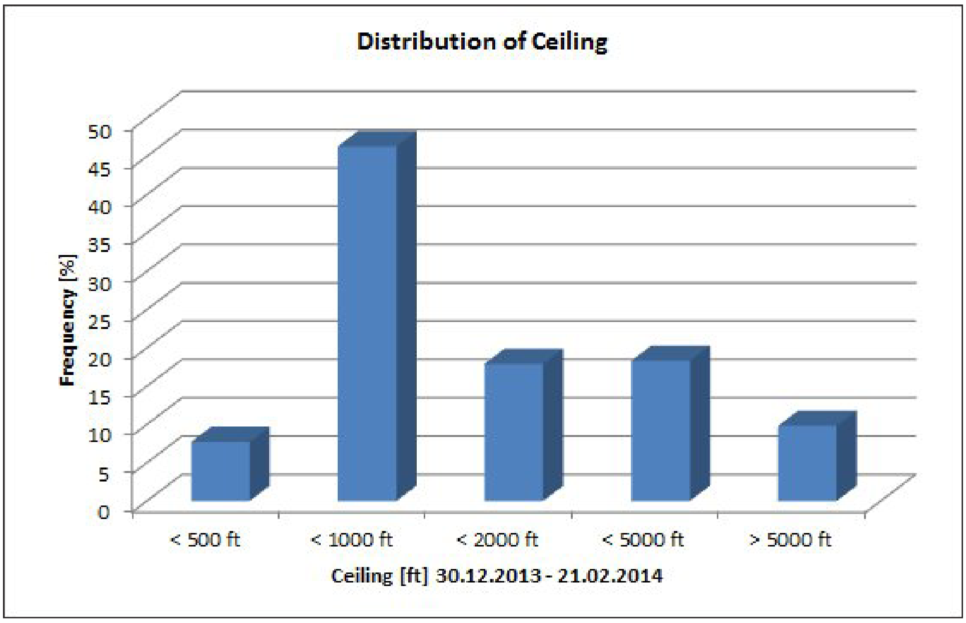

Fig. 2.3: Distribution of cloud ceiling during the scientific activities between Neumayer and Neumayer, i.e. 30 December and 21 February

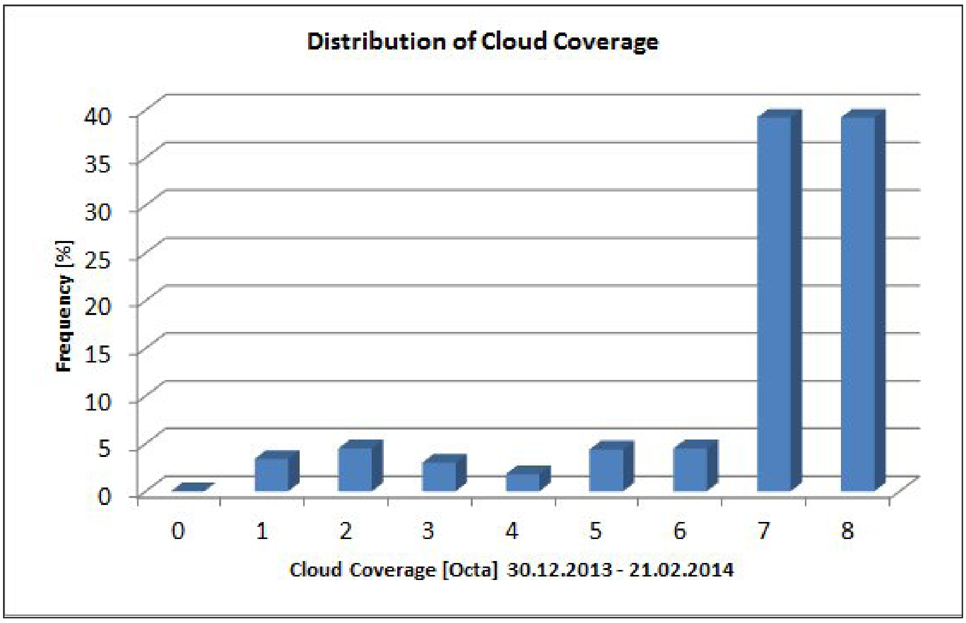

Fig. 2.4: Distribution of cloud coverage during the scientific activities between Neumayer and Neumayer, i.e. 30 December and 2 February

3. SCIENTIFIC PROGRAMMES

3.1 BATHYMETRY AT THE FILCHNER OUTFLOW SYSTEM (BATFOS)

Daniel Frederik Damaske[1], Hannes Sardemann[1], Leander Wachsmuth[1]
Not on board: Boris Dorschel[1]

[1]AWI

Grant No: AWI_PS82_01

Objectives

Accurate knowledge of the seafloor topography, hence high resolution bathymetry data is essential information necessary to understand many marine processes in a spatial context. Bathymetry and bathymetry-derived products furthermore represents basic parameters for the study, understanding and interpretation of many marine processes.

From the Filchner Trough and the surrounding shelf area, accurate depth information collected with echo sounders is limited. Up to now, the International Bathymetric Chart of the Southern Ocean (IBCSO) (Arndt et al. 2013) is the most comprehensive bathymetric dataset from this area. The IBCSO has however uncertainties in areas where no bathymetric soundings exist. For these areas of the Filchner Trough, only bathymetry derived from satellite based radar altimeter data (Smith & Sandwell 1997) exists. During previous expeditions to other Antarctic shelf areas, discrepancies of tens up to hundreds of meters were observed between the IBCSO dataset and echosounder measurements. Since large parts of the Filchner Trough are so-far uncharted by echosounders, the IBCSO dataset can only provide an approximate representation of the seafloor topography in this area. Also the resolution of IBCSO (as a Pan-Antarctic map) is limited to 500m x 500m. For some scientific approaches, like for example habitat studies, higher resolutions are necessary down to sometimes meter scales. Improving the bathymetric charts of the Filchner Trough area can therefore support a variety of biological, geophysical and geological studies by resolving geomorphological features on the shelf as small as approximately 10 meters.

On *Polarstern*, bathymetric data were recorded with multibeam echosounder. The Atlas Hydrosweep DS3 multibeam echosounder permanently installed on *Polarstern* measured the seafloor across a fan perpendicular to the ships heading. For each measurement, up to a maximum of 960 soundings were recorded covering a strip of up to five times the water depth.

The single beam echosounders on board *Polarstern* were mainly used for navigation purposes and were therefore, other than the multibeam data, not corrected for changes of the sound velocity in the water column. These measurements contained uncertainties of a few up to tens of meters in the shelf area and even up to hundreds of meters in the deep sea and were therefore not included in the bathymetric products of this expedition.

For further analysis and interpretation of the bathymetry, the BATFOS group collected high resolution sub-bottom profiler data with the shipboard parametric sediment echosounder Atlas Parasound P70. The sedimentary layering of the top tens of meters below the seabed was recorded and used for analysing geo-morphological seabed features. The visualization of the sedimentary architecture and surface sediment conditions assisted colleagues during station planning and sampling site selection

The bathymetric data that has been collected during the expedition will be provided to regional mapping projects and included in regional data compilations like IBCSO and GEBCO (General Bathymetric Chart of the Ocean).

Work at sea

Technical settings

During PS82, multibeam data were recorded with the Atlas Hydrographic Hydrosweep DS3 multibeam echosounder system, permanently installed on *Polarstern*. The Hydrosweep DS3 was operated using the Atlas control software Hydromap Control (AHC) version 2.6.6.0. The following relevant parameter settings were applied: Swath width portside "300 %", swath width starboard "300 %", beam spacing "equal footprint", desired number of beams "345", C-Keel source "System C-keel", and the transmission sequence "single pulse".

Sub-bottom data were recorded with the shipboard Atlas Parasound P70 parametric sediment echosounder. The system was operated with AHC version 2.2.8.0. The applied C-Mean value was 1,500 m/s. The desired bottom penetration was set between 80 m and 200 m. The Parasound P70 was externally triggered by the Hydrosweep DS3 to minimize interferences between both systems.

Operations

Multibeam and sub-bottom data was acquired from 21st of December 2013 at 11:21 UTC until the 3rd of March 2014 at 10:00 UTC outside of the exclusive economic zone of South Africa. During station work both echosounders were switched of. This was furthermore done to avoid unnecessary duplication of data coverage and during whale encounter. On longer transits under ice-free conditions, the ship track was planned to collect bathymetric data from so far un-surveyed seabed areas.

Multibeam raw-data were recorded with the Atlas Parastore software version 3.3.17.0 in *.asd-format (PHF and PHS) and with the Hypack software package version 13.0.0.6 in *.hsx-format. The raw-data were stored in 30 min blocks. Water column data were not recorded. Sub-bottom profiler data were recorded with Atlas Parastore software version 3.3.13.0 in *.asd-format (PHF and SLF) also in 30 min blocks. For almost the entire cruise, the full profile was recorded.

For bathymetric data processing, the *.hsx-files were imported in CARIS HIPS and SIPS 7.1 and cleaned for erroneous soundings and artefacts. For the sound velocity corrections, CTD-measurements of the hydrographic-group were used. The sound velocities were calculated after the formula by Chen and Millero (1977) and applied in AHC and Hypack. Sound velocity corrections were furthermore applied in CARIS

HIPS and SIPS 7.1 during data processing. In total 134 sound velocity profiles were used for sound velocity corrections. In the transit area between Cape Town and the Antarctic *Neumayer Station III*, no CTD cast were performed. Therefore 3 sound velocity profiles were taken from previous cruises contained in the *World Ocean Database* (www.nodc.noaa.gov) in order to minimize the sound velocity related errors in the bathymetric data.

For data access, station planning and further use, the multibeam data were included in an ArcGIS Project. ArcGIS based maps were provided by the BATFOS group to assist cruise planning and site selection during PS82.

The hydroacoustic systems were operated by three operators in a 24/7 shift mode. The recorded data is stored in the PANGAEA Data Publisher for Earth & Environmental Science and can be made available by the Bathymetry working group at the AWI.

Preliminary (expected) results

In total, an area of almost 25,020 km² was surveyed during PS82 south of *Neumayer Station III* (70 °S). During the cruise, data were acquired on 67 separate days. Fig. 3.1.1 shows the mapped area in the Filchner Trough area in comparison to the Source ID-Grid of the IBCSO dataset. During PS82 new uncharted areas were mapped. In some areas which were already in parts charted on previous expeditions the data density and quality was improved.

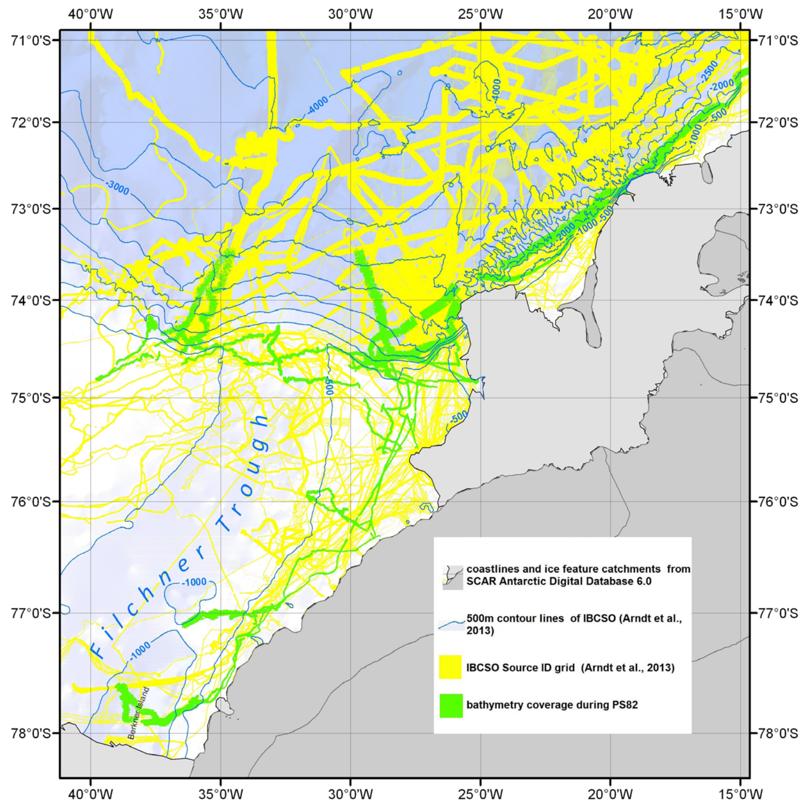

Fig 3.1.1: MBES data coverage during Polarstern Expedition PS82. The source ID grid of the IBCSO shows the multibeam data used for bathymetric data interpolation.

In most cases simultaneously to the bathymetric measurements, Parasound P70 was switched on. During the parallel operation of Hydrosweep DS3 and Parasound P70, a systematic error occurred in the multibeam data (Fig. 3.1.2) due to interferences of the hydroacoustic systems. In the multibeam data, these errors were removed during data post-processing with CARIS HIPS AND SIPS 7.1. In order to avoid additional interferences, the single beam *Deep Water Sounder* was always switched off during Hydrosweep DS3 and Parasound P70 operations.

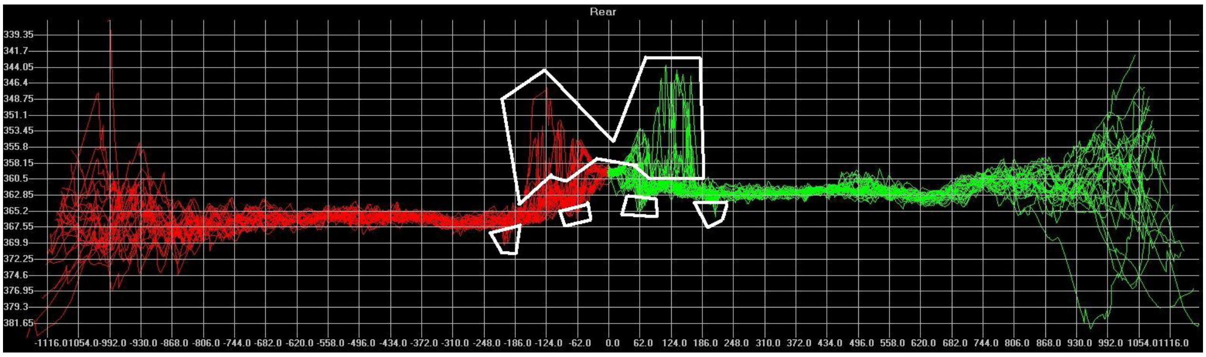

Fig. 3.1.2: Systematic errors in the central swath of the multibeam caused by interferences with the Parasound P70 (errors surrounded in white boxes) during parallel operation

Based on the bathymetric data acquired during the cruise, several geomorphic features were identified. In the eastern section of the east-west transect just north of 78°S, drumlins were discovered. To the west of these drumlins, in the centre of the Filchner Trough, bedrock lineations covered the seafloor. The area close to the shelf edge (section mid trough) was covered with iceberg scours. The scours occurred down to 600 m water depth. In the east of this transect, east-west striking gullies were identified on the continental slope. In the east of the transect at 77° S, a roche moutonnée was identified.

Data management

All multibeam data and sound velocity profiles recorded during *Polarstern* expedition PS82 will be stored by the AWI bathymetry group for post-processing. The processed data will be stored in the PANGAEA Data Publisher for Earth & Environmental Science and made available on request by the Bathymetry working group at the AWI.

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3.2 OCEANOGRAPHY AND TRACER MEASUREMENTS

Michael Schröder[1], Andreas Wisotzki[1], Svenja Ryan[2], Wilma Huneke[2], Stefanie Semper[2], Svein Osterhus[3], Sandra Schwegmann[1], Giulia Castellani[1], Oliver Huhn[4], Malte Krieger[4], Angela Scharfbillig[4]

[1]AWI
[2]UNI Kiel
[3]UIB
[4]UHB-IUP

Grant No: AWI_PS82_02

The region around the sill of the Filchner Trough Outflow is considered a "hotspot", both in terms of biology and physical oceanography. The factors contributing to this oceanic area of enhanced food availability and its relation to physical processes are not yet understood, and shall undergo a multidisciplinary in-depth investigation in tandem with the biological disciplines on board. Based on the fact that polar regions are especially sensitive to climate warming, it can be expected that biological hotspots may undergo substantial transformations linked to environmental changes. The culmination of upper and intermediate trophic level interactions at a hotspot offers the opportunity for paradigm studies to elucidate how climate changes in Antarctica may determine changes elsewhere in the ocean. The combination of CTD casts from aboard *Polarstern* together with animal born satellite telemetry to collect behavioural data in tandem with hydrographic data aims to describe the physical environments passed by the seals during their foraging migrations at sea, and their behavior and responses to the oceanographic features they experience for up to one year tracking time, and thus covering the winter season.

Tracer observations will help substantially to investigate the interaction of basal glacial melting (stable noble gas isotopes [^{3}He, ^{4}He, Ne] to quantify basal glacial melt water), basal melt rates and WSBW formation (transient trace gases [CFCs] to determine transit time scales [TTDs], formation rates, and anthropogenic carbon storage) and their variability.

3.2.1 Observations of the hydrographic conditions and water mass compositions at the Filchner Sill and in the Filchner Trough

Michael Schröder[1], Andreas Wisotzki[1], Svenja Ryan[2], Wilma Huneke[2], Stefanie Semper[2], Svein Osterhus[3], Sandra Schwegmann[1], Giulia Castellani[1]

[1]AWI
[2]UNI Kiel
[3]UIB

Grant No: AWI_PS82_02

Objectives

The region around the sill of the Filchner Trough Outflow is also considered as a “hotspot” in physical oceanography because here a major portion of the deep and bottom waters of the Weddell Sea abyss is formed. According to recent IPCC-scenario simulations (Hellmer et al. 2012) the southeastern Weddell Sea is also extremely sensitive to climate warming, causing substantial transformations in sea ice conditions and ocean circulation with severe consequences for the Filchner Ronne Ice Shelf and the ice streams draining the Antarctic ice sheet. The combination of CTD casts from aboard *Polarstern* together with long-term moorings aims to describe the present physical environment, and monitor its variability and the changes which might occur.

General objectives

- Which physical properties are the basis to convert the Filchner Outflow region into a hotspot in terms of food availability and as foraging ground for southern elephant seals and likely other seal species?
- Why is this area so unique compared to other places?
- What are the physical properties which control the Filchner Trough in and outflow?
- How can we specify the temporal and spatial variability of the physical properties?
- Is it possible to provide a comprehensive dataset for numerical model validation and initialization of coupled ocean ice shelf - ice sheet models?

Specific objectives

- How much ISW / (basal) glacial melt water is formed from the Filchner Ice Shelf and how much leaves the Filchner Trough or is available for WSBW formation west of the Filchner Sill?
- How much AABW (WSBW and subsequently WSDW) is generated?
- How can we determine the course of the coastal current in the southeastern Weddell Sea and MWDW flowing towards the Filchner Ice Shelf Front?
- Are we able to specify the path of HSSW from the Berkner Shelf into the Filchner Trough?
- What are the basal melt rates underneath Filchner Ronne Ice Shelf?
- How do these numbers differ by comparing actual and historic observations / data i.e. assess temporal variability, and can that variability be linked to decadal variation or climate change?
- What are the dominant oceanographic features under the sea ice particularly in wintertime when no other data are available due to ship based observations?

As a key area for the formation of Weddell Sea Deep and Bottom Water, the Filchner Outflow on the southern Weddell Sea shelf is of major importance for the global ocean circulation. Even though it is probably the only permanent source supplying ice shelf water for the conversion of surface water into bottom water, the long term variation and production rates of the outflow are unknown.

More recent results from IPCC-scenario simulations with the regional coupled ice-ocean model BRIOS reveal a pronounced sensitivity of the southeastern Weddell Sea to projected atmospheric changes due to climate warming. The complex interplay between different polar processes causes the coastal current to depart from its present course along the continental shelf break and flow into the Filchner Trough. Depending on the strength of the pulses, Warm Deep Water is transported southward to the deep grounding lines of the Filchner Ronne Ice Shelf. The drastic warming of the ice shelf cavern causes enhanced melting at the ice shelf base with possible consequences (subject to ongoing research) for the dynamics of the ice streams draining the West/East Antarctic Ice Sheets and thus for the evolution of global sea level rise. The few hydrographic observations from the southeastern Weddell Sea show, that already today Modified Warm Deep Water reaches sometimes the front of the Filchner Ice Shelf. However, due to the sparse resolution in time it remains speculative whether this is a permanent feature with constant characteristics (T, S) or a quite variable one.

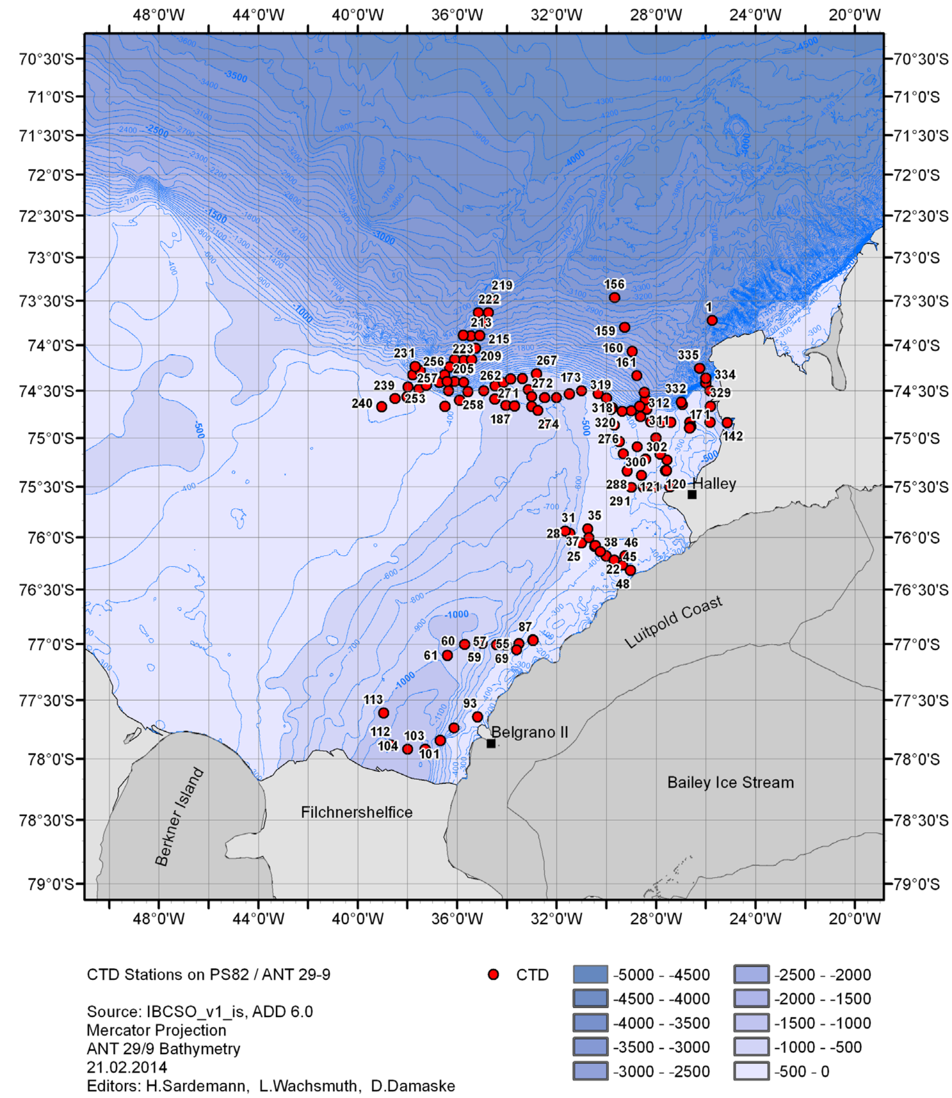

Fig. 3.2.1.1a: CTD stations with station number

Enhanced basal melting directly influences the shelf water density on the southern and western Weddell Sea continental shelf, including Ice Shelf Water (ISW). The processes at the sill of the Filchner Trough and along the western continental shelf break are important for deep and bottom water formation and thus for the ventilation of the world ocean abyss (Foldvik et al. 2004). However, the long-term water mass formation rate, its variability as well as its sensitivity to changes in the environmental conditions, including sea ice, remains unclear.

Own hydrographic measurements along the Filchner Ice Shelf front, carried out with RV *Polarstern* in 1995, show significant changes in the water mass characteristics and flow patterns in the Filchner Trough in comparison to measurements from the early 1980s (Grosfeld et al. 2001). Changes in the trough will affect the flow over the sill to the deep Weddell Abyssal Plain.

This expedition and the upcoming cruise in 2015/2016 (PS96) should give us a detailed state of the art picture of the hydrographic conditions in the Filchner area before dramatic changes will happen as forecasted by some models. Figs. 3.2.1.a and 3.2.1b show CTD stations and oceanographic transects.

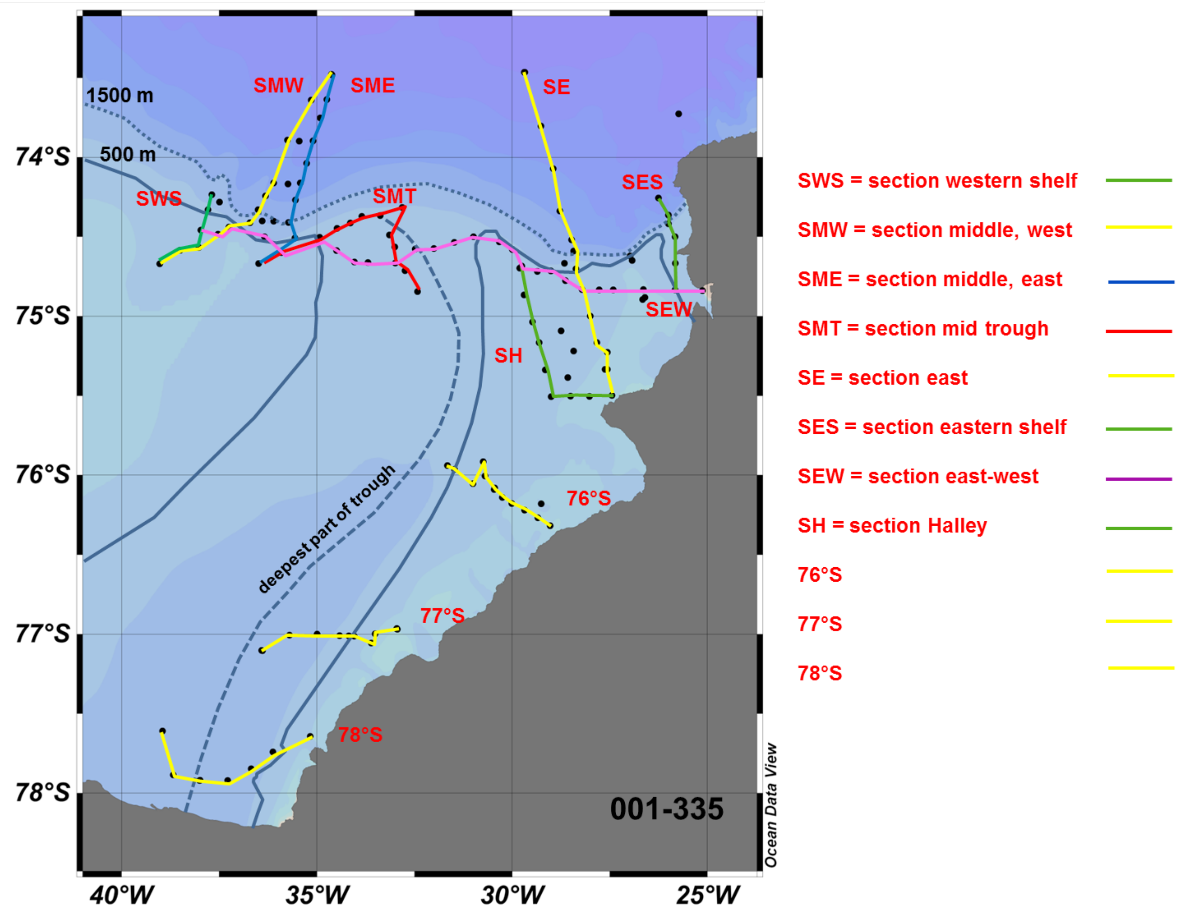

Fig. 3.2.1.1b: CTD stations and oceanographic transects with their annotations used in the text

Work at sea

The programme consisted of measurements from the ship using a Seabird 911+ CTD (SN 321) connected to a caroussel (SBE 32, SN 657) with 24-(12-l) water bottles. This instrument system contains two sensor pairs of conductivity (SBE 4, SN 2446, SN 2078) and temperature (SBE 3, SN 2685, SN 2423), a high precision pressure sensor Digiquartz 410K-105 (SN 53962), one oxygen sensor (SBE 43, SN 1834), a transmissiometer (Wetlab CST, SN (814DR), a fluorometer (Wetlabs FLRTD, SN 1670) and an altimeter (Benthos Model PSA-916, SN1228).

The conductivity and temperature sensor calibration were performed before the cruise at Seabird Electronics. The accuracy of the temperature sensors can be given to 2 mK. The readings for the pressure sensors are better than 1 dbar. The conductivity was corrected using salinity measurements from water samples. IAPSO Standard Seawater from the P-series P154 (K15 = 0.99990, practical salinity 34.996) was used. A total of 202 water samples from 93 CTD stations were measured using two Optimare Precision Salinometer (OPS SN 006. SN 007). On the basis of the water sample correction, salinity is measured to an accuracy of 0.002 (see also Fig. 3.2.1.2). The salinity still has to be corrected at home after recalibration of the sensors at the factory.

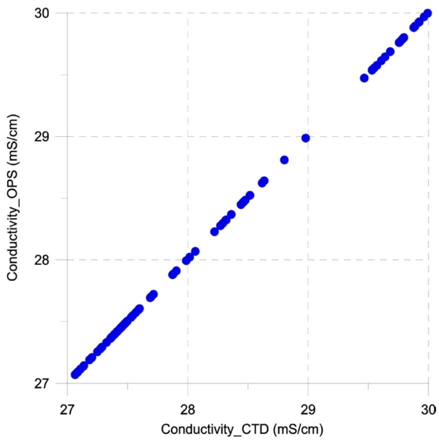

Fig. 3.2.1.2: Conductivity in mS/cm of water samples measured with OPS compared to the CTD primary conductivity sensor in mS/cm

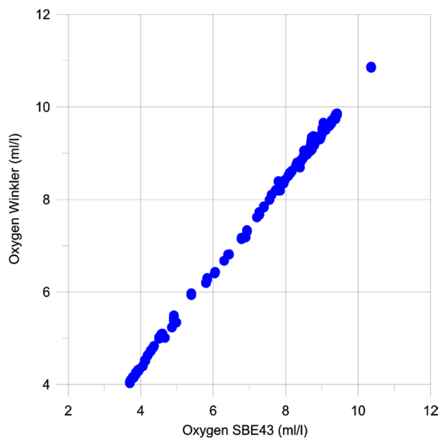

Fig. 3.2.1.3: Oxygen in ml/l of water samples measured by Winkler method compared to the CTD oxygen sensor (SBE43) values in ml/l

The oxygen was corrected from water samples by using the Winkler method with a Dissolved Oxygen Analyser (DOA, SIS-Kiel type). 328 water samples were measured from 39 stations (Fig. 3.2.1.3). The dissolved oxygen is measured to an accuracy of 0.02 ml/l.

In total 142 CTD profiles were measured on this cruise including 4 short profiles into the surface for a need of large water volumes for the biologists (Tab. 3.2.1.4).

The distribution over depth is as follows:

3 profiles in water depths of more than 3,000 m, 35 between 1,000 m and 3,000 m, 41 in the range of 500 m to 1,000 m, and 63 in water depths of less than 500 m. The deepest profile was at 3,245 m, the shallowest profile at 21 m.

The whole system will be calibrated using the pre and post calibration values from Seabird. The accuracy for temperature will be better than 2 mK, for salinity it will be better than 0.002, and the pressure sensor measured with an accuracy better than 1 dbar.

To supply the ship with surface temperature and salinity values the ships SBE 21/ SBE 38 thermosalinograph was used in 11 m depth in the keel. The instrument was controlled by taking water samples which are measured on board with the same salinometer type as for the CTD.

Preliminary (expected) results

The experiment represents a synoptic oceanographic data set of the eastern shelf of the Filchner Trough including the eastern part of the Filchner depression south of 75° S. North of 75° S, at the Filchner sill, a closely spaced station grid could be performed from which an interpretation of the highly variable hydrography will be possible. In addition two short hydrographic sections at the Drescher Inlet and in the Bendex area near Austasen were done, to give background information of physical properties to the biological groups.

Surface measurements with the ships thermosalinograph between Cape Town and Neumayer

By using the information of the ships thermosalinograph the changes in temperature and salinity near the surface are visible. It gives an overview over the zonation of the Antarctic Circumpolar Current (ACC) (Fig. 3.2.1.4). Some of the fronts coincide with drastic temperature and

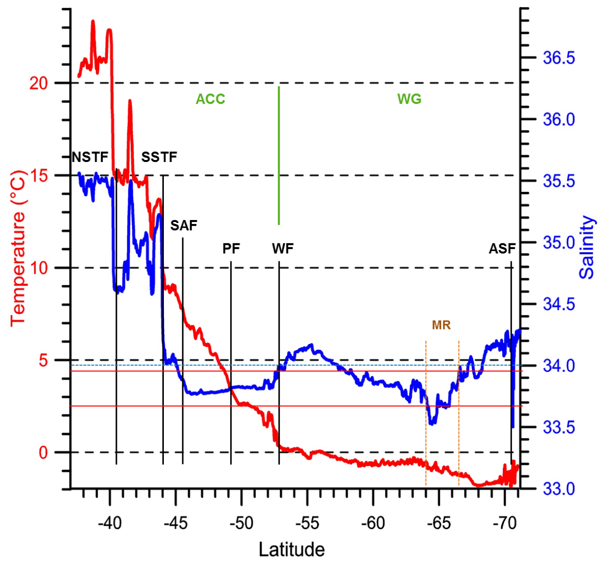

Fig. 3.2.1.4: Surface (11m) temperature and salinity when crossing the Southern Ocean between Cape Town and Neumayer Station III over latitude. The position of fronts in the Antarctic Circumpolar Current (ACC) are shown. NSTF, SSTF – northern, southern Subtropical front, SAF – Subantarctic front, PF – Polar front, WF – Weddell Front, ASF – Antarctic Slope Front, ACC - Antarctic Circumpolar Current, WG – Weddell Gyre regime, MR – Maud Rise.

salinity changes esp. the Subtropical Fronts (NSTF, SSTF) and the Subantarctic Front (SAF) whereas others show only small surface variations as at the Polar Front (PF) and at the Weddell Front (WF). Remarkable is the northern extent of the Weddell Gyre (WG) near 53° S which is more than 2° latitude north of the normal position. The minimum in salinity around Maud Rise (MR) is due to the melting of sea ice, which starts in this region at the beginning of summer.

Surface measurements with the ships thermosalinograph in the Filchner area

The surface values of temperature and salinity reflect the history of sea ice melt and/or sea ice concentration. In the polynia in front of Halley (75° S to 76°30’ S) the warmer temperatures and higher salinity values dominate due to the influence of the sun and the mixture of the freshwater layer with the underlying waters of higher salt content by the wind. In regions of maximum ice cover freezing point temperatures and increased salinity values were measured which reflect still winter conditions. The lowest salinities were found in a band at 28° W (pink colours) where the melting of sea ice just started, producing a thin freshwater layer which is not really warmed up by the sun or mixed down by the wind. Figs. 3.2.1.5a and b show surface temperature and salinity south of *Neumayer Station III* and and in the Filchner area.

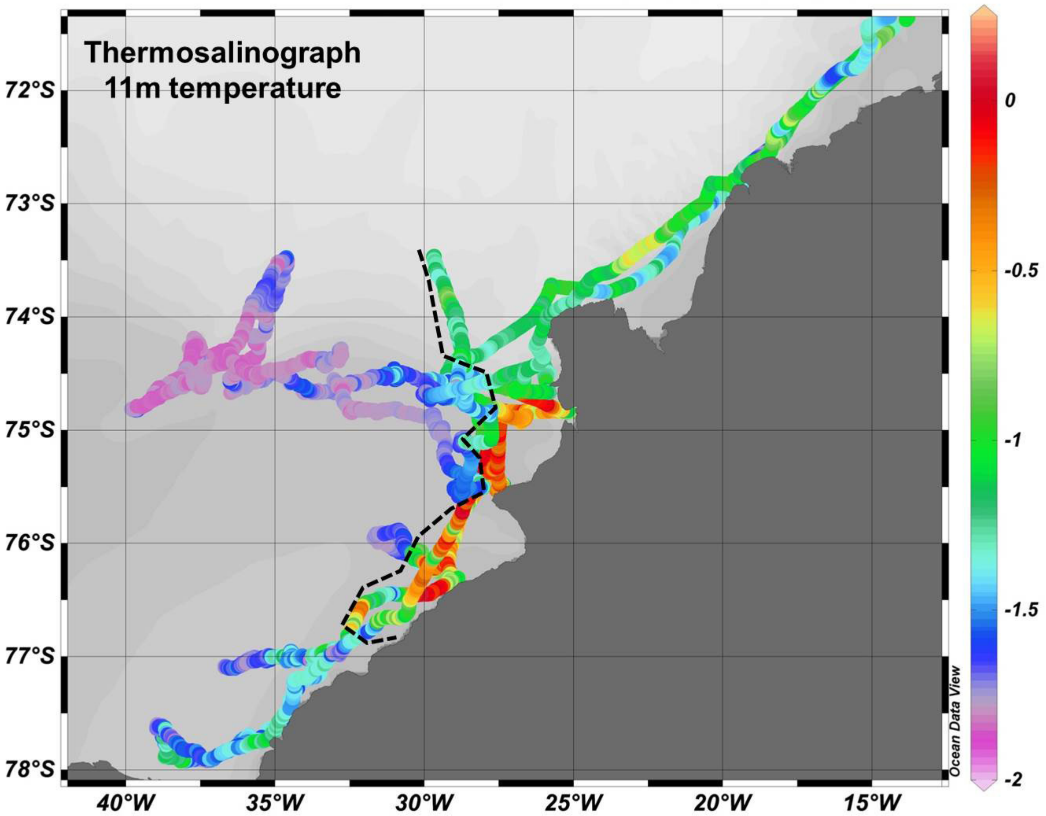

Fig. 3.2.1.5a: Surface (11m) temperature south of Neumayer Station III and in the Filchner area

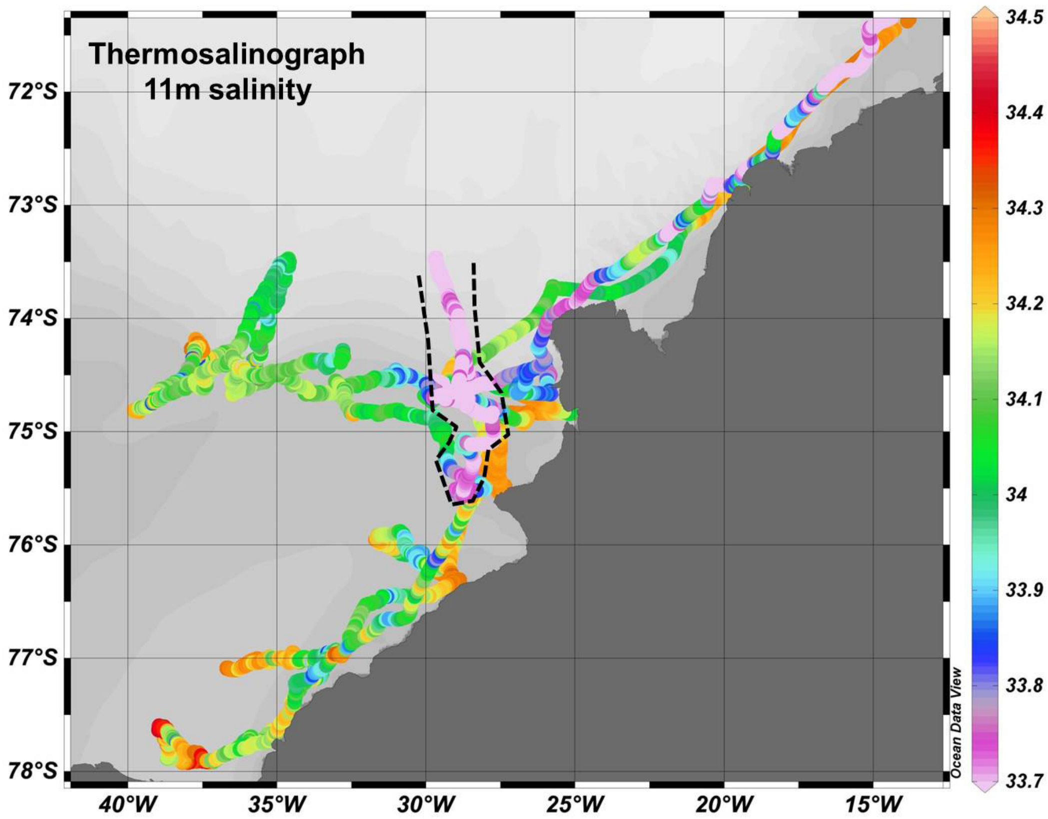

Fig. 3.2.1.5b: Surface (11m) salinity south of Neumayer Station III and in the Filchner area

Physical properties of stations on the eastern flank of the Filchner Trough showing the dominant water masses.

The oceanographic collection shown in Fig. 3.2.1.6 illustrates the differences of physical parameter as temperature, salinity, oxygen, and light transmission over the upper 500 m depth for the background region at the shelf break (brown), the eastern sill (grey), and three stations in the Filchner Trough at 76° S (pink, green, and red).

The main water masses for this region could be detected. The warm pool of the Weddell basin, the Warm Deep Water (WDW), is uplifted at the shelf break and visible at the bottom of the grey station (400 m) by an increase in temperature of more than half a degree Celsius. This temperature increase is also detectable at the green station further south as a remnant of this Modified Warm Deep Water (MWDW) with higher temperatures at the same depth of 0.25°C. The nearby stations (pink and red) do not show these effect, because they are more influenced by the overall presence of Ice Shelf Water (ISW). The MWDW also shows a distinct minimum in the dissolved oxygen content (circle at the bottom of the grey station). The decreased values in the light transmission of the green and red station at the bottom are due to topographic effects at the eastern slope of the Filchner Trough.

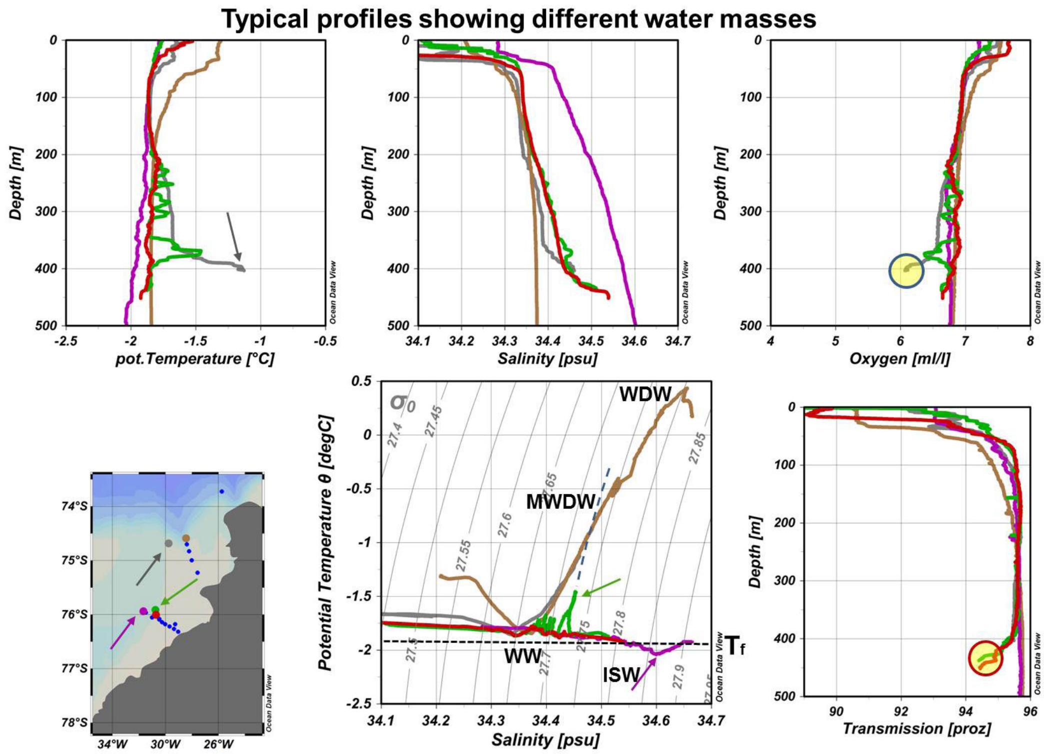

Fig. 3.2.1.6: 5 CTD stations representing the different water masses of the eastern Filchner Trough between 74°30' S and 76° S. Profiles of temperature, salinity, dissolved oxygen, transmission are shown together with the TS-diagram and a map for the location. WDW – Warm Deep Water, MWDW – Modified Warm Deep Water, WW – Winter Water, ISW- Ice Shelf Water, T_f - Surface freezing temperature

Physical properties along the middle part of section SEW (see also Fig. 3.2.1.1b) representing the conditions across the Filchner sill.

The Filchner sill can be described as the outflow region of cold ISW formed in the south below the Filchner Ice Shelf into the deep Weddell basin in the north. The sill depth of slightly more than 600 m allows only the upper part of ISW to overflow this barrier northward. Due to its higher density compared to the adjacent water masses, the ISW plume is able to reach the deepest parts of the Weddell Sea. On its way downslope it is trapped by submarine ridges and canyons and altered in its physical properties by turbulent mixing with the Warm Deep Water (WDW) of the Weddell Gyre. In contrast Modified Warm Deep Water (MWDW) enters the sill from the north at the eastern side and flows in opposite direction to the ISW to the south. MWDW is a mixture of WDW with the overlaying Winter Water(WW) or the Eastern Shelf Water (ESW). This is shown in Fig. 3.2.1.7a and 7c for the potential temperature and the dissolved oxygen. The core of MWDW is at the bottom of station 180 with pot. temperatures of >-0.8°C and a very low oxygen content of less than 5.55 ml/l. The core of ISW at station 181 and west of station 274 has pot. temperatures of less than -1.9°C with its minimum at station 193 with -2.02°C at a depth of 460 m. The dissolved oxygen content in this temperature minimum is larger than 6.75 ml/l. The salinity distribution shown in Fig. 3.2.1.7b has its maximum salinities just below the ISW cores at the bottom. These values are slightly higher than in the MWDW core although the WDW core outside has almost the same salinity values as the ISW.

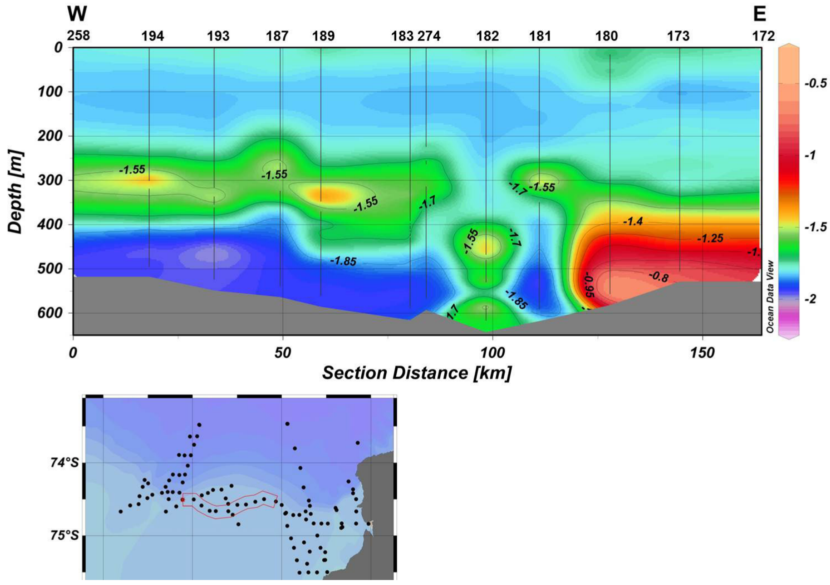

Fig. 3.2.1.7a: Potential temperature on the hydrographic section SEW (stat. 172 – 258) across the Filchner sill. Station numbers are shown on top of the plot together with the geographical orientation. The inset marks the position of the section as part of section SEW (see also Fig. 3.2.1.1b).

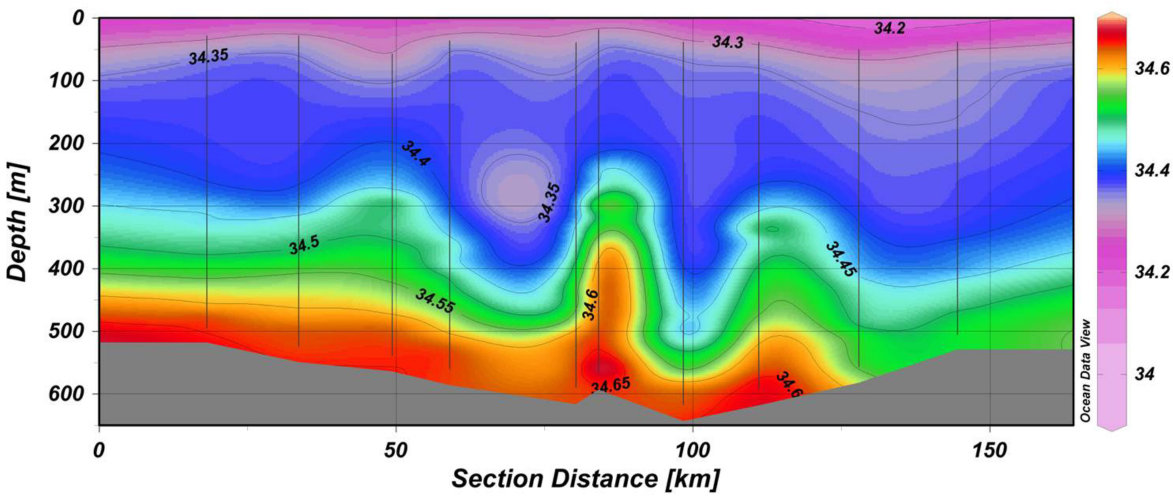

Fig. 3.2.1.7b: Salinity on the hydrographic section SEW. For more information see Fig. 3.2.1.7a.

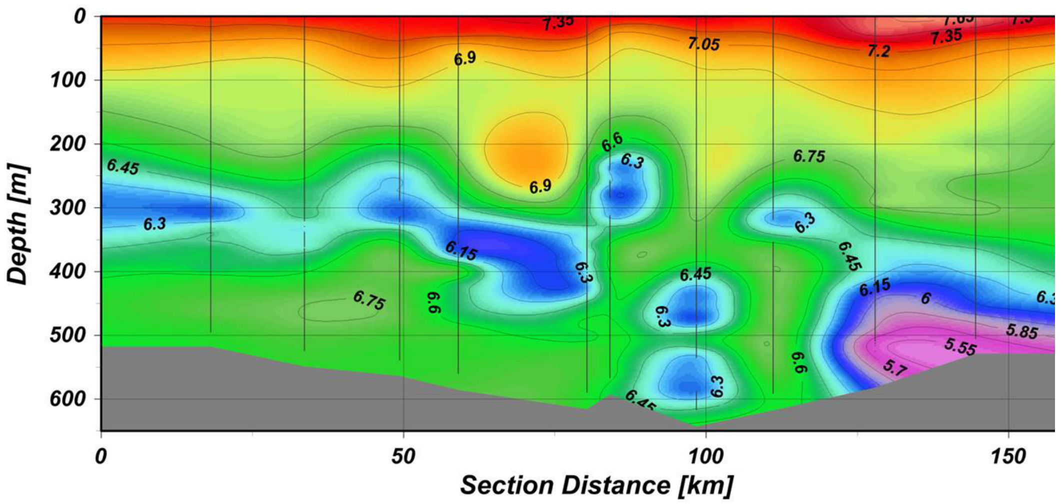

Fig. 3.2.1.7c: Dissolved oxygen in ml/l on the hydrographic section SEW. For more information see Fig. 3.2.1.7a.

Measurements with the fluorometer attached to the CTD

The depth of the fluorescence maximum measured by the un-calibrated sensor at the CTD shows a highly heterogeneous picture. Two types of profiles can be identified, the pink and blue dots, showing the maximum at the surface or slightly below (up to 25 m) and the green and orange dots with a deep maximum of 50 m to 80 m (Fig. 3.2.1.8). These two different types can exist in a very near distance, which is a sign of specific local conditions, as sea ice cover and thickness or local melting processes.

The measurements can be taken as a first hint for the depth of the chlorophyll-*a* maximum in the water column.

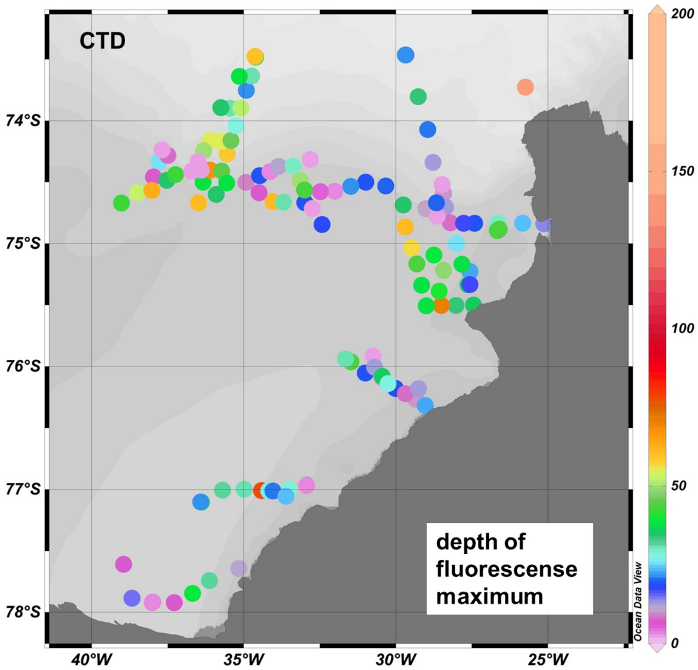

Fig. 3.2.1.8: Depth of the fluorescence maximum measured in uncalibrated digits

Bottom temperature and salinity measured by the CTD

When combining the measured bottom temperatures and the bottom salinities in a regional map (Fig. 3.2.1.9a and 9b), the water mass regime in the lowest water layer is visible. In the east, on the shallower part, the dominant water mass is the low salinity Eastern Shelf Water (ESW), which is detectable on the whole eastern Weddell shelf and extents nearly to the Ice Shelf Front.

In the north the southward leaking tongue of Modified Warm Deep Water (MWDW) is dominant in the bottom boundary layer, displayed by the green and yellow colours in Fig. 3.2.1.9a. The whole Filchner depression and the middle part of the Filchner sill is covered by pure Ice Shelf Water (ISW) with the coldest temperatures in the south. The measured salinity distribution is not as clear as the temperature field but it shows an almost equal salinity range for the ISW as for the Weddell Sea Deep Water, which stays outside the southern shelf in the deep basin of the Weddell Sea.

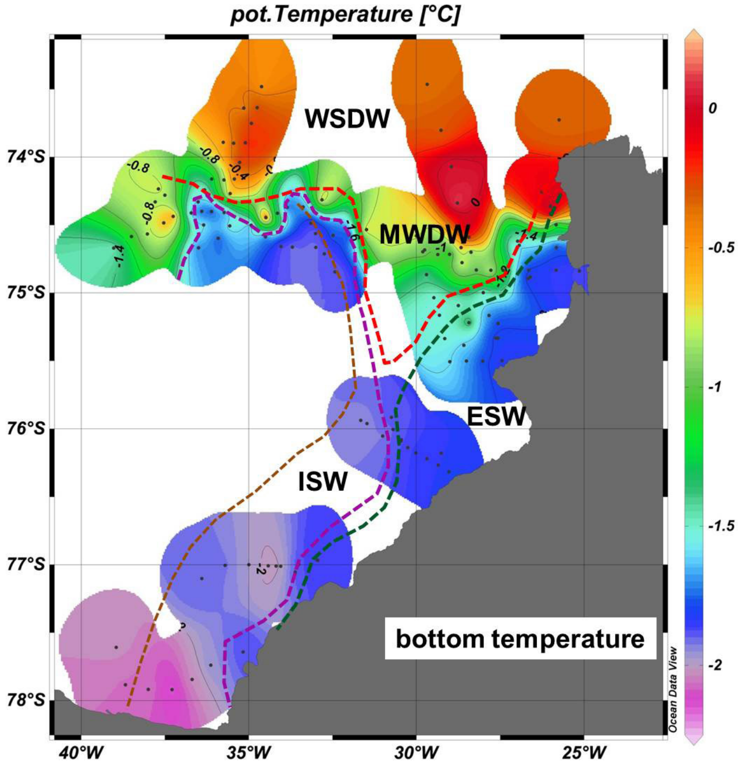

Fig. 3.2.1.9a: Bottom temperature in the Filchner area. WSDW – Weddell Sea Deep Water, MWDW – Modified Warm Deep Water, ESW – Eastern Shelf Water, ISW – Ice Shelf Water. The broken lines denote the approximate border of: green – ESW, red – MWDW, pink – ISW. The brown broken line shows the deepest part of the Filchner Trough.

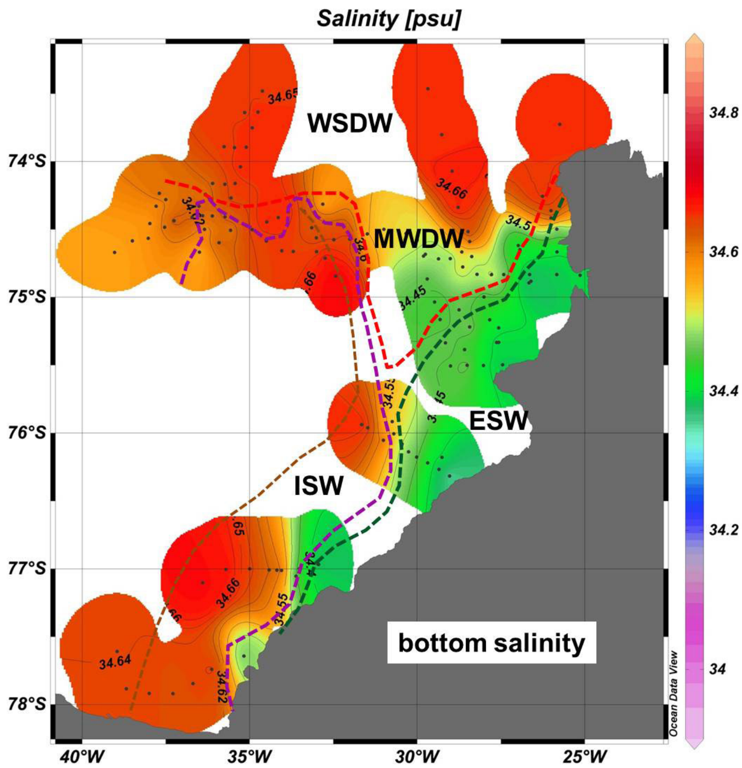

Fig. 3.2.1.9b: Bottom salinity in the Filchner area. WSDW – Weddell Sea Deep Water, MWDW – Modified Warm Deep Water, ESW – Eastern Shelf Water, ISW – Ice Shelf Water. The broken lines denote the approximate border of: green – ESW, red – MWDW, pink – ISW. The brown broken line shows the deepest part of the Filchner Trough.

3.2.1.1 Mooring work during this expedition

Michael Schröder[1], Andreas Wisotzki[1], Svenja Ryan[2], Wilma Huneke[2], Stefanie Semper[2], Svein Osterhus[3]

[1]AWI
[2]UNI-Kiel
[3]UIB

Grant No: AWI_PS82_02

Work at sea

The mooring work was carried out for three institutions; AWI, Uni Kiel, and University of Bergen. Altogether 4 moorings were recovered and 7 moorings deployed (Fig. 3.2.1.10 and Tab. 3.2.1.1).

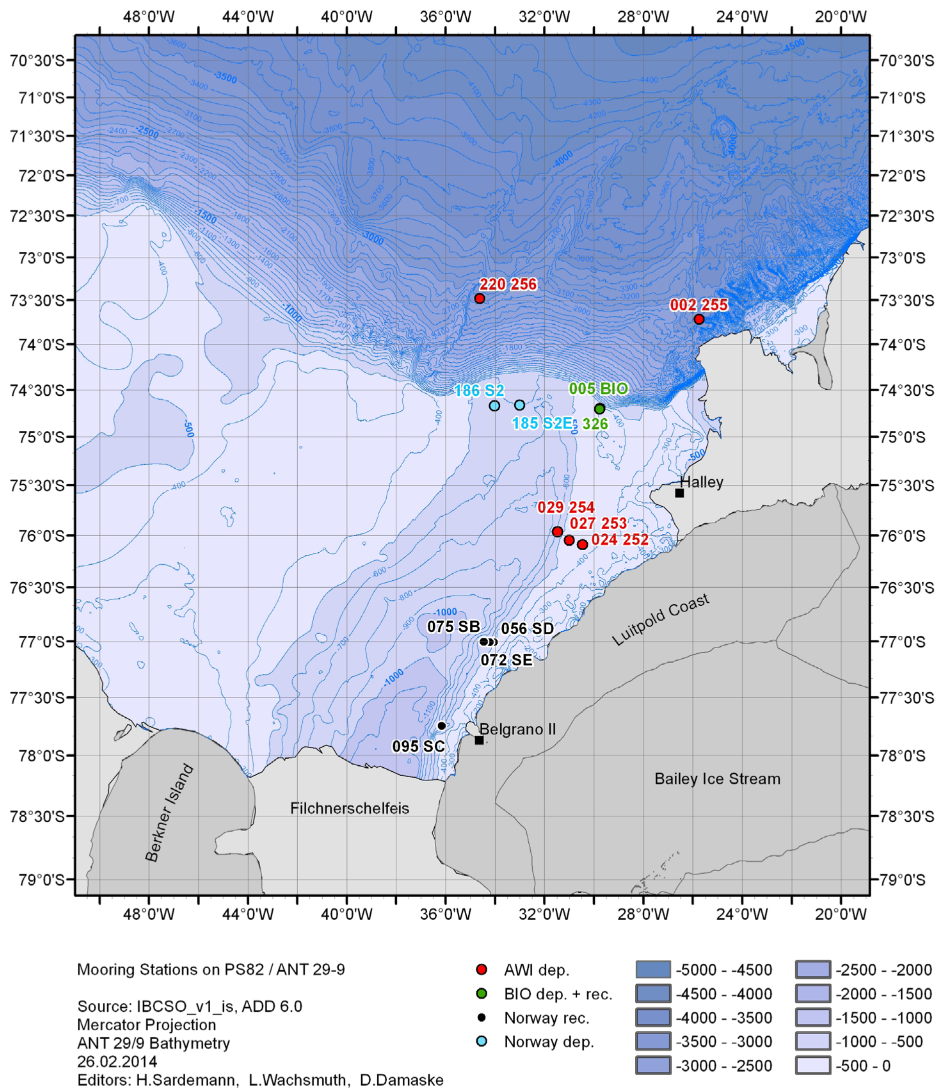

Fig. 3.2.1.10: Map showing bathymetry (IBSCO) and the location of the moorings. The first 3 digits denote the station number of the CTD at that position, the last 3 digits are the mooring number.

Funded by the Research Council of Norway (RCN), Norwegian Antarctic Research (NARE), a project entitled "WEDDELL" was started in 2011, with an objective to investigate the dynamics of Ice Shelf Water (ISW) outflow from the Filchner Ice Shelf. To meet this objective five moorings were deployed in January 2013 during RRS *Ernest Shackleton* cruise ES060. Four of these moorings were recovered during ANT-XXIX/9. Another objective for the same project is to extend the long-term observations of the ISW overflow at the Filchner sill. Two new moorings, S2 and S2E, were deployed to continue this time series. The S2 observatory was established in 1977 and continues to deliver the longest existing marine time series from Antarctica.

Observations at the Filchner sill also show a seasonal inflow of relatively warm water that is able to reach Filchner Ice Shelf. New model results indicate that this flow of water might increase in the future. As a part of an AWI funded project three instrumented moorings (AWI 252, AWI 253, AWI 254) were deployed in the Filchner Depression to estimate the heat flux towards the ice shelf.

As part of the ARGO float project and to complete the grid of sound sources for positioning of floats while drifting at depth two acoustic moorings (AWI 255 and AWI 256) were deployed in the southern part of the Weddell basin.

Tab. 3.2.1.1: Mooring positions and depths

Mooring	**Latitude**	**Longitude**	**Depth [m]**	
UIB SB	77° 00.36' S	034° 27.59' W	705 m	Recovered
UIB SC	77° 45.04' S	036° 09.02' W	728 m	Recovered
UIB SD	77° 00.48' S	034° 03.05' W	505 m	Recovered
UIB SE	77° 00.61' S	034° 14.24' W	612 m	Recovered
AWI 252-1	76° 05.49 'S	030° 28.24' W	469 m	Deployed
AWI 253-1	76° 02.76' S	030° 59.72' W	473 m	Deployed
AWI 254-1	75° 57.78' S	031° 29.13' W	604 m	Deployed
AWI 255-1	73° 43.00' S	025° 44.51' W	3262 m	Deployed
AWI 256-1	73° 28.78' S	034° 37.21' W	3110 m	Deployed
UNI S2-2014	74° 40.14' S	034° 01.54' W	570 m	Deployed
UNI S2E-2014	74° 39.78' S	032° 59.96' W	618 m	Deployed

Mooring details

All recovered moorings consist of 8 mm Dynema line, glass and foam spheres for floatation. The moorings were equipped with instruments from Aanderaa, Aqualog, RDI and Seabird, see Table 3.2.1.2 for details.

The acoustic release failed for two of the moorings and they had to be dragged. The EK60 fish echo sounder was used to localize the moorings, Fig. 3.2.1.11. Knowing the exact position the mooring was dragged using a rubber boat and a U-shape dragging line. The mooring line on mooring SC broke during dragging due to the heavy anchor load and an inline mounted instrument making an unfortunate twist on the mooring line.

All recovered instruments except for one temperature logger (Aqualog s.n. 367 on mooring SD) have been working and extensive year-long data sets are obtained.

Tab. 3.2.1.2: Configuration for the UIB moorings SB, SC, SD and SE. The parameters T, C, P, V stand for temperature, conductivity, pressure and velocity (in x,y,z), respectively.

SB

Height (m.a.b.)	Instrument	Serial Number	Parameters
400	RDI 75kHz down (ADCP)	18447	T, P, V
400	Aqualog	400	T, P
375	SBE-56	1948	T
350	SBE-37	4446	T, C
225	SBE-37	7224	T, C, P

SC

Height (m.a.b.)	Instrument	Serial Number	Parameters
325*	SBE-37	8972	T, C, P
300*	SBE-39	3566	T
275*	SBE-39	3571	T
250*	SBE-56	1953	T
225*	SBE-39	6149	T, P
225*	RDI 150kHz down (ADCP)	18595	T, P, V
200*	SBE-39	3572	T
150*	SBE-37	7223	T, C, P
125*	Aqualog	362	T
100	SBE-39	3574	T
75	SBE-39	3746	T
50	SBE-39	3573	T
25	SBE-37	5251	T, C

* exact depth uncertain

SD

Height (m.a.b.)	Instrument	Serial Number	Parameters
175	Aqualog	375	T, P
125	Aqualog	403	T, P
125	RDI 300kHz down (ADCP)	8026	T, P, V
100	SBE-37	5252	T, C
50	Aqualog	1192	T, P
25	SBE-37	5409	T, C

SE Height (m.a.b.)	Instrument	Serial Number	Parameters
300	SBE-56	1962	T
250	Aqualog	377	T, P
200	SBE-56	1965	T
150	RCM-9	1238	T, C, V
150	SBE-39	6143	T, P
125	SBE-56	1955	T
75	SBE-56	1954	T
25	SBE-56	1951	T

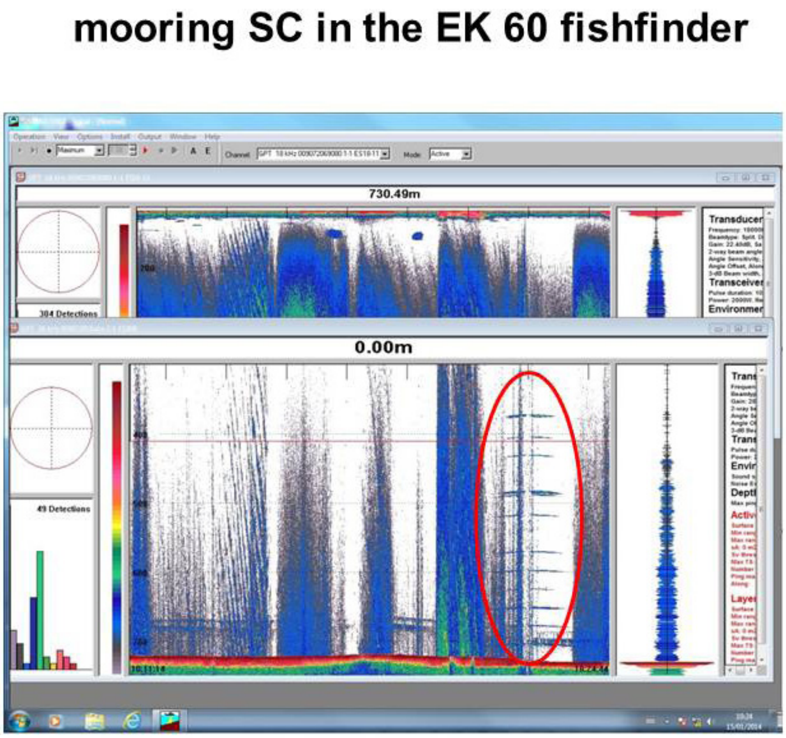

Fig. 3.2.1.11: Echo sounder signature from the UIB SC mooring

The three AWI moorings (252, 253 and 254) deployed on the eastern slope of the Filchner depression are designed to measure the southward flux of relatively warm water towards the Filchner Ice Shelf. The moorings are equipped with Aanderaa RCM 11 current meters and SeaBird SBE-37 (CTD). The mooring AWI 254-1 was in addition equipped with Develogic SonoVault for sound recording. For more mooring details see Table 3.2.1.3.

Tab. 3.2.1.3: Configuration for the AWI moorings 252, 253 and 254

Mooring	**Latitude Longitude**	**Water Depth [m]**	**Date Time**	**Type**	**Serial Number**	**Depth [m]**
AWI 252-1	76° 5.49'S 30°28.24'W	469	05.01.2014 12:21	SBE37-CTP SBE37-CTP RCM11-AVTP	10931 10948 569	356 445 451
AWI 253-1	76° 2.76'S 30° 59.72'W	473	05.01.2014 16:24	SBE37-CTP SBE37-CTP RCM11-AVTP	10929 10930 568	340 449 455
AWI 254-1	75° 57.78'S 31° 29.13'W	604	05.01.2014 20:45	SBE37-CTP SonoVault SBE37-CTP RCM11-AVTP	10928 1001 10947 500	404 504 580 586

The S2 observatory at the Filchner sill is a part of the global net of monitoring sites under CLIVAR Southern Ocean Observing System (SOOS), OceanSITES and the FP7 project FixO3. The UNI S2 mooring was deployed in the core of the ISW overflow. S2 is equipped with Aanderaa current meters, and temperature, conductivity and oxygen (Optode) sensors, see Fig. 3.2.1.12. The S2E mooring is placed east of S2 to improve the ISW transport estimates. S2E is equipped with and Aanderaa RDCP-600 and three SeaBird SBE-37, Fig. 3.2.1.12.

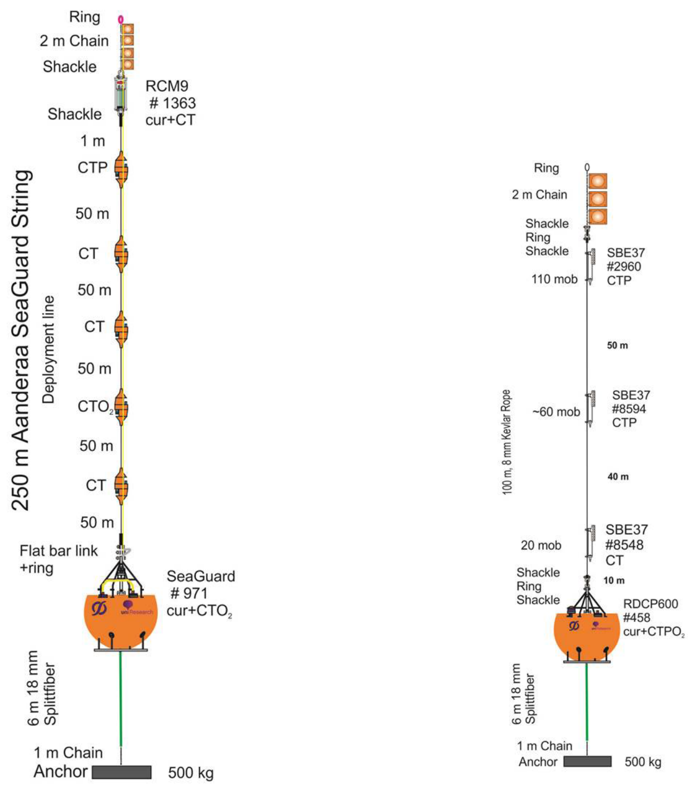

Fig. 3.2.1.12: Configuration for the UNI S2 and S2E moorings

Data management

All oceanographic data sets will be calibrated on board or after return of the sensors from the manufacturer at the institute, quality controlled, published in a peer reviewed journal, and will then be stored in the PANGAEA Data Publisher for Earth & Environmental Science for public use.

Tab. 3.2.1.4: All CTD stations of ANT-XXIX/9

Station	Date	Time/ UTC	Latitude	Longitude	Water depth [m]	Pressure max. [dbar]
1	02-Jan-2014	14:51	73°43.560′ S	25°44.592′ W	3224	3226
4	03-Jan-2014	08:14	74°41.040′ S	29°45.288′ W	425	408
12	03-Jan-2014	23:11	74°35.430′ S	28°25.752′ W	1415	1387
13	04-Jan-2014	01:17	74°42.042′ S	28°22.332′ W	530	513
14	04-Jan-2014	03:01	74°49.878′ S	28°12.630′ W	530	512
16	04-Jan-2014	05:56	74°59.862′ S	28° 0.438′ W	460	441
17	04-Jan-2014	08:49	75°13.548′ S	27°33.810′ W	385	370
21	05-Jan-2014	07:27	76°16.020′ S	29°20.682′ W	365	354
22	05-Jan-2014	09:16	76°10.668′ S	30° 0.702′ W	408	392
23	05-Jan-2014	11:12	76° 5.412′ S	30°27.918′ W	469	450
25	05-Jan-2014	14:14	76° 3.180′ S	31° 0.408′ W	473	456
28	05-Jan-2014	19:42	75°57.732′ S	31°28.590′ W	597	578
31	06-Jan-2014	09:20	75°56.292′ S	31°39.570′ W	688	666
35	06-Jan-2014	19:39	75°54.930′ S	30°44.808′ W	431	443
37	06-Jan-2014	22:15	76° 0.312′ S	30°41.952′ W	479	457
38	07-Jan-2014	06:11	76° 4.800′ S	30°26.862′ W	463	444
44	07-Jan-2014	20:20	76° 8.352′ S	30°15.348′ W	447	429
45	07-Jan-2014	21:54	76°13.182′ S	29°41.190′ W	377	364
46	07-Jan-2014	23:08	76°10.728′ S	29°15.570′ W	428	414
48	08-Jan-2014	01:33	76°19.050′ S	29° 2.052′ W	246	235
54	09-Jan-2014	02:31	76°57.828′ S	32°57.300′ W	282	268
55	09-Jan-2014	04:01	76°59.898′ S	33°30.708′ W	397	383
57	09-Jan-2014	16:23	77° 0.570′ S	34°25.122′ W	653	631
59	09-Jan-2014	19:40	76°59.970′ S	34°59.712′ W	958	931
60	09-Jan-2014	23:17	77° 0.348′ S	35°42.300′ W	1048	1018
61	10-Jan-2014	03:35	77° 6.180′ S	36°23.928′ W	1133	1101
63	10-Jan-2014	06:03	77° 6.132′ S	36°25.158′ W	1114	21
69	11-Jan-2014	03:19	77° 0.612′ S	34°10.998′ W	575	554
70	11-Jan-2014	04:11	77° 0.708′ S	34° 2.742′ W	500	482
80	12-Jan-2014	18:55	77° 3.312′ S	33°36.750′ W	378	364
85	13-Jan-2014	17:22	76°57.978′ S	32°57.690′ W	259	260
87	14-Jan-2014	06:13	76°58.062′ S	32°56.538′ W	273	261
93	15-Jan-2014	06:14	77°38.592′ S	35°10.260′ W	399	382

Station	Date	Time/ UTC	Latitude	Longitude	Water depth [m]	Pressure max. [dbar]
96	15-Jan-2014	13	77°44.418′ S	36° 7.812′ W	704	684
101	15-Jan-2014	22:47	77°50.748′ S	36°41.190′ W	936	904
103	16-Jan-2014	02:15	77°55.188′ S	37°17.370′ W	1114	1083
104	16-Jan-2014	04:29	77°55.098′ S	37°59.688′ W	1194	1159
106	16-Jan-2014	06:53	77°55.188′ S	38° 0.522′ W	1193	39
112	16-Jan-2014	18:55	77°53.052′ S	38°40.782′ W	1195	1165
113	17-Jan-2014	00:51	77°36.510′ S	38°57.252′ W	1063	1035
119	18-Jan-2014	23:34	75° 9.978′ S	27°49.932′ W	464	445
120	19-Jan-2014	01:21	75°20.010′ S	27°37.590′ W	350	350
121	19-Jan-2014	03:07	75°29.898′ S	27°26.988′ W	288	274
137	20-Jan-2014	22:08	75°19.968′ S	27°34.080′ W	352	336
138	21-Jan-2014	02:12	74°49.962′ S	27°24.948′ W	476	459
139	21-Jan-2014	04:19	74°49.938′ S	26°38.550′ W	358	343
140	21-Jan-2014	06:19	74°49.992′ S	25°49.890′ W	521	500
142	21-Jan-2014	09:29	74°50.250′ S	25° 8.112′ W	702	680
149	22-Jan-2014	06:37	74°31.062′ S	28°28.950′ W	1771	1739
156	23-Jan-2014	07:05	73°27.900′ S	29°40.572′ W	3250	3245
158	23-Jan-2014	10:58	73°27.888′ S	29°41.412′ W	3251	21
159	23-Jan-2014	14:47	73°48.168′ S	29°15.912′ W	2739	2721
160	23-Jan-2014	19:01	74° 4.260′ S	28°57.192′ W	2285	2258
161	23-Jan-2014	22:49	74°20.298′ S	28°46.770′ W	1911	1885
162	24-Jan-2014	02:27	74°42.930′ S	29° 0.792′ W	531	512
167	24-Jan-2014	15:01	74°52.932′ S	26°36.222′ W	309	294
171	24-Jan-2014	22:18	74°53.628′ S	26°39.900′ W	295	282
172	25-Jan-2014	07:08	74°31.872′ S	30°19.980′ W	481	464
173	25-Jan-2014	09:12	74°29.970′ S	30°59.508′ W	529	511
180	25-Jan-2014	21:51	74°32.058′ S	31°29.232′ W	582	563
181	26-Jan-2014	00:11	74°34.392′ S	32° 0.618′ W	618	598
182	26-Jan-2014	02:53	74°34.608′ S	32°29.100′ W	643	624
183	26-Jan-2014	05:57	74°39.888′ S	32°59.880′ W	616	596
187	26-Jan-2014	12:59	74°39.492′ S	34° 2.550′ W	564	545
189	26-Jan-2014	17:46	74°39.750′ S	33°41.772′ W	586	566
193	27-Jan-2014	00:50	74°35.172′ S	34°30.048′ W	549	530
194	27-Jan-2014	03:24	74°30.132′ S	34°55.800′ W	518	501
196	27-Jan-2014	07:02	74°35.922′ S	35°54.702′ W	446	430
197	27-Jan-2014	09:12	74°40.050′ S	36°29.682′ W	401	385
203	27-Jan-2014	21:57	74°29.952′ S	36°20.568′ W	911	885
204	28-Jan-2014	01:56	74°24.060′ S	36° 6.678′ W	1327	1296
205	28-Jan-2014	04:09	74°24.522′ S	35°43.902′ W	1260	1233
207	28-Jan-2014	10:15	74°16.158′ S	35°33.192′ W	1797	1767

Station	Date	Time/ UTC	Latitude	Longitude	Water depth [m]	Pressure max. [dbar]
208	28-Jan-2014	13:39	74°10.098′ S	35°44.412′ W	2003	1977
209	28-Jan-2014	17:37	74° 9.648′ S	35°25.638′ W	2039	2015
212	29-Jan-2014	01:03	74° 2.310′ S	35°16.068′ W	2288	2264
213	29-Jan-2014	05:08	73°53.910′ S	35°27.168′ W	2288	2263
215	29-Jan-2014	20:21	73°53.730′ S	35° 6.018′ W	2536	2518
216	30-Jan-2014	00:08	73°45.108′ S	34°55.110′ W	2762	2744
217	30-Jan-2014	03:48	73°38.172′ S	34°44.700′ W	2929	2915
219	30-Jan-2014	11:26	73°28.860′ S	34°36.888′ W	3109	3103
221	30-Jan-2014	14:30	73°28.602′ S	34°37.878′ W	3111	73
222	30-Jan-2014	18:28	73°38.352′ S	35° 8.892′ W	2840	2834
223	30-Jan-2014	23:35	73°53.502′ S	35°45.432′ W	2207	2189
224	31-Jan-2014	04:54	74° 9.678′ S	36° 6.348′ W	1942	1920
225	31-Jan-2014	07:28	74°14.490′ S	36°19.032′ W	1828	1816
228	31-Jan-2014	23:03	74°19.812′ S	37°47.502′ W	554	535
230	01-Feb-2014	03:17	74°16.872′ S	37°29.808′ W	1073	1041
231	01-Feb-2014	05:03	74°14.100′ S	37°41.472′ W	781	756
238	02-Feb-2014	02:02	74°27.450′ S	37°58.338′ W	481	466
239	02-Feb-2014	04:49	74°35.112′ S	38°30.072′ W	455	441
240	02-Feb-2014	06:58	74°40.158′ S	39° 1.698′ W	440	425
245	03-Feb-2014	06:14	74°34.002′ S	38° 1.392′ W	461	445
252	03-Feb-2014	20:07	74°29.058′ S	37°32.130′ W	389	374
253	03-Feb-2014	21:41	74°26.250′ S	37°15.132′ W	479	462
254	04-Feb-2014	01:38	74°24.678′ S	36°43.008′ W	939	911
256	04-Feb-2014	05:31	74°19.830′ S	36°30.552′ W	1274	1245
257	04-Feb-2014	07:42	74°23.988′ S	36°24.000′ W	1275	1247
258	04-Feb-2014	17:39	74°30.450′ S	35°33.900′ W	584	562
260	05-Feb-2014	02:36	74°26.730′ S	34°29.058′ W	549	532
261	05-Feb-2014	04:04	74°24.780′ S	34° 8.628′ W	578	559
262	05-Feb-2014	07:41	74°22.242′ S	33°51.288′ W	627	604
263	05-Feb-2014	11:47	74°22.032′ S	33°22.800′ W	654	633
267	05-Feb-2014	22:49	74°18.900′ S	32°48.960′ W	705	680
271	06-Feb-2014	12:02	74°29.250′ S	33° 8.562′ W	657	636
272	06-Feb-2014	13:44	74°33.792′ S	33° 0.372′ W	663	647
274	06-Feb-2014	19:20	74°42.768′ S	32°44.922′ W	593	573
275	06-Feb-2014	21:56	74°50.652′ S	32°25.692′ W	608	589
276	07-Feb-2014	06:16	74°51.900′ S	29°41.712′ W	416	395
285	07-Feb-2014	19:59	75° 2.112′ S	29°28.902′ W	412	394
287	07-Feb-2014	23:06	75° 9.882′ S	29°18.780′ W	419	402
288	08-Feb-2014	01:28	75°20.220′ S	29° 9.348′ W	421	405
289	08-Feb-2014	04:43	75°30.180′ S	28° 1.368′ W	303	289

Station	Date	Time/ UTC	Latitude	Longitude	Water depth [m]	Pressure max. [dbar]
290	08-Feb-2014	06:17	75°30.090′ S	28°30.630′ W	402	386
291	08-Feb-2014	07:58	75°30.360′ S	29° 0.240′ W	453	435
300	08-Feb-2014	23:34	75°23.082′ S	28°34.860′ W	450	432
301	09-Feb-2014	01:41	75°13.098′ S	28°25.872′ W	459	441
302	09-Feb-2014	07:15	75° 5.550′ S	28°45.132′ W	423	407
310	10-Feb-2014	00:57	74°49.992′ S	27°46.530′ W	488	471
311	10-Feb-2014	03:28	74°46.572′ S	28°38.298′ W	540	522
312	10-Feb-2014	05:06	74°40.038′ S	28°39.948′ W	678	662
318	10-Feb-2014	18:27	74°43.038′ S	29°21.648′ W	448	430
319	10-Feb-2014	21:20	74°34.740′ S	30° 0.078′ W	517	499
320	10-Feb-2014	23:09	74°41.832′ S	29°48.510′ W	426	410
327	11-Feb-2014	22:09	74°25.008′ S	26° 0.222′ W	946	930
328	11-Feb-2014	23:33	74°29.928′ S	25°49.998′ W	539	516
329	12-Feb-2014	01:47	74°39.948′ S	25°49.398′ W	575	556
330	12-Feb-2014	04:43	74°38.958′ S	26°55.908′ W	433	416
332	12-Feb-2014	10:56	74°37.128′ S	26°58.932′ W	782	764
334	12-Feb-2014	21:08	74°21.780′ S	26° 0.060′ W	1926	1905
335	12-Feb-2014	23:41	74°15.378′ S	26°15.462′ W	2504	2491
336	13-Feb-2014	18:51	72°49.632′ S	19°45.408′ W	1963	1953
337	13-Feb-2014	20:55	72°48.372′ S	19°36.222′ W	1207	1171
338	13-Feb-2014	22:13	72°48.240′ S	19°20.328′ W	504	486
339	13-Feb-2014	23:05	72°48.978′ S	19°18.120′ W	457	440
354	17-Feb-2014	04:03	70°56.640′ S	10°32.052′ W	305	294
355	17-Feb-2014	04:50	70°57.972′ S	10°27.510′ W	217	208
356	17-Feb-2014	05:50	70°54.912′ S	10°40.080′ W	344	331
361	17-Feb-2014	15:31	70°52.962′ S	10°59.988′ W	491	300
362	17-Feb-2014	16:57	70°49.098′ S	11°10.218′ W	1069	1045
363	20-Feb-2014	20:11	70°16.140′ S	7° 58.158′ W	1578	1554
364	20-Feb-2014	22:19	70°10.512′ S	7° 57.648′ W	2200	2157

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Grosfeld K, Schröder M, Fahrbach E, Gerdes R, Mackensen A (2001). How iceberg calving and grounding change the circulation and hydrography in the Filchner Ice Shelf-Ocean System. Journal of Geophysical Research, Vol. 106, C5, 9039-9055.

Hellmer HH, Kauker F, Timmermann R, Determann J, Rae J (2012) 21st-century warming of a large Antarctic ice shelf cavity by a redirected coastal current, Nature, 485 (7397), pp. 225-228, doi:10.1038/nature11064.

3.2.2 Observation of stable noble gas isotopes (^{3}He, ^{4}He, Ne) and transient tracers (CFCs)

Oliver Huhn[1], Malte Krieger[1], Angela Scharfbillig[1]

[1]UHB-IUP

Grant No: AWI_PS82_02

Objectives

Our approach aims to quantify the basal shelf ice melting in the southern Weddell Sea and to investigate the related Weddell Sea Bottom Water (WSBW) composition, its formation rate and export northward, into the deeper Weddell Basin. It aims to enhance our understanding how basal shelf ice melting and WSBW composition, formation, and export interact under changing climate conditions.

Observations and model studies emphasize the complex and unique interaction of the Antarctic Ocean climate components (atmosphere – sea ice – shelf ice – ocean) and their sensitivity to changing environmental conditions and response to climate change. The WSBW formation and composition is known to be strongly related to the dynamics of the ice shelf in the southern Weddell Sea (Filchner Ice Shelf). Recent observations show distinct variability or even trends in the WSBW properties (warming, freshening, water mass age increase, reduced ventilation and anthropogenic carbon uptake). However, the actual state of basal ice shelf melting, its variability and possible future trends due to changing climate conditions and its impact on the WSBW composition and formation and its variability is not yet fully understood.

Hence, investigating and quantifying basal glacial melting and WSBW formation as close as possible to its sources (Filchner Ice Shelf and Filchner Trench as its outflow area) will help to increase our understanding of the interaction of these unique Antarctic Ocean climate components under changing climate conditions.

The aims of our tracer observation based approach are the following:

- To produce an improved actual estimate of basal glacial melt water inventories and basal melting rates for the ice shelf in the southern Weddell Sea (Filchner Ice Shelf) to be able to address temporal trends in the future
- To trace the pathways of the basal melt water, how it contributes to local Antarctic Bottom Water formation, and to quantify the related actual Antarctic Bottom Water formation rates.
- To investigate, if there is evidence for local shifts or temporal trends in glacial melting processes and related Antarctic Bottom Water formation. Possible changes could be related to changing properties or circulation of ambient water masses.
- To assess, how local processes and their variability are related to basin wide or global scales (e.g. observed basin wide Antarctic Bottom Water property changes, warming, freshening, age increase and declining ventilation, slow down anthropogenic carbon uptake, declining volumes, trends).

To reach these aims, new and spatially high resolved synoptic tracer measurements are required. We will use the stable noble gas measurements (^{3}He, ^{4}He, Ne) to quantify glacial melt water fractions and volumes and quantify the composition of newly formed WSBW at their sources. We will use the transient tracer (chlorofluorocarbon, CFC) measurements to determine the time scales of residence and circulation to quantify the formation rates of glacial melt water (basal melting rates) and of WSBW formation rates. We will use CFC data to estimate the anthropogenic carbon content and uptake in the recently formed WSBW. We will also incorporate available historic tracer data to assess possible temporal variability of glacial melting, WSBW composition, formation, and anthropogenic carbon uptake.

Approach and methods

The oceanic measurement of the low-solubility and **stable noble gases** helium (^3He, ^4He) and neon (Ne) provide a useful tool to identify and to quantify basal glacial melt water. Atmospheric air with a constant composition of these noble gases is trapped in the ice matrix during formation of the meteoric ice. Due to the enhanced hydrostatic pressure at the base of the shelf ice, these gases are completely dissolved in the water, when the ice is melting from below. This leads to an excess of Δ^4He = 1060% and ΔNe = 770% in pure glacial melt water (the Δ stands for the noble gas excess over the air-water solubility equilibrium). Frontal or surface melt water would equilibrate quickly and not lead to any noble gas excess in the ocean water. With an accuracy of <0.5% for He measurements performed at the IUP Bremen, basal glacial melt water fractions of <0.05% are detectable. The $^3He/^4He$ isotope ratio provides additional information. In Antarctic shelf water the ratio is low in comparison to ratios in WDW (the WDW has a maximum in $^3He/^4He$) and provide complementary information of the composition of WSBW. Finally, primordial helium (mantle helium with a far higher $^3He/^4He$ ratio, $\delta^3He \approx 800\%$) enters the ocean from spreading regions of submarine ridge systems or other hydrothermal active sites like hydrothermal vents or submarine volcanoes.

The anthropogenic transient trace gases **chlorofluorocarbons** (CFC-11 and CFC-12) allow estimating the time scales of the renewal and ventilation of inner oceanic water mass transport. They enter the ocean by gas exchange with the atmosphere. Since the evolution of these transient tracers in the ocean interior is determined on first order by their temporal increase in the atmosphere and subsequently by advection in the ocean interior, they allow quantifying the time scales of deep and bottom water transport and formation. In a higher order approach, using the so called Transit Time Distribution (TTD) method (or water mass age spectra), they allow determining the integrated advection and mixing time scale of a water mass. These CFC and TTD method based time scales of ventilated water masses integrate residence, circulation, and transport and on the shelf, slope, and deep basin and allow determining water mass ventilation and formation rates. Combined CFC based time scales with noble gas and OMP based melt water inventories allow calculating basal glacial melting rates and the basal glacial melting induced WSBW formation rates.

Additionally, the CFCs and TTD method can be used to estimate the anthropogenic carbon content in WSBW by applying the CFC based TTDs to the well known atmospheric anthropogenic carbon history. That method is very reliable particularly in deep and bottom water and it is fully independent of carbon measurements and back calculating methods, which require additional geochemical observations or linear regression methods (which need carbon measurements from at least two different times of observations at the same location and which are not available in the area of our investigation).

Work at sea

We took 540 water samples for stable noble gas isotopes (^3He, ^4He, Ne) in copper tubes from 68 stations (profiles usually from bottom to surface; see black circles in Fig. 3.2.1.1b). For the transient tracers (chlorofluorocarbons, CFC-11, CFC-12), we took 1,080 samples on 94 stations (all full bottom-surface-profiles; see red dots in Fig. 3.2.2.1).

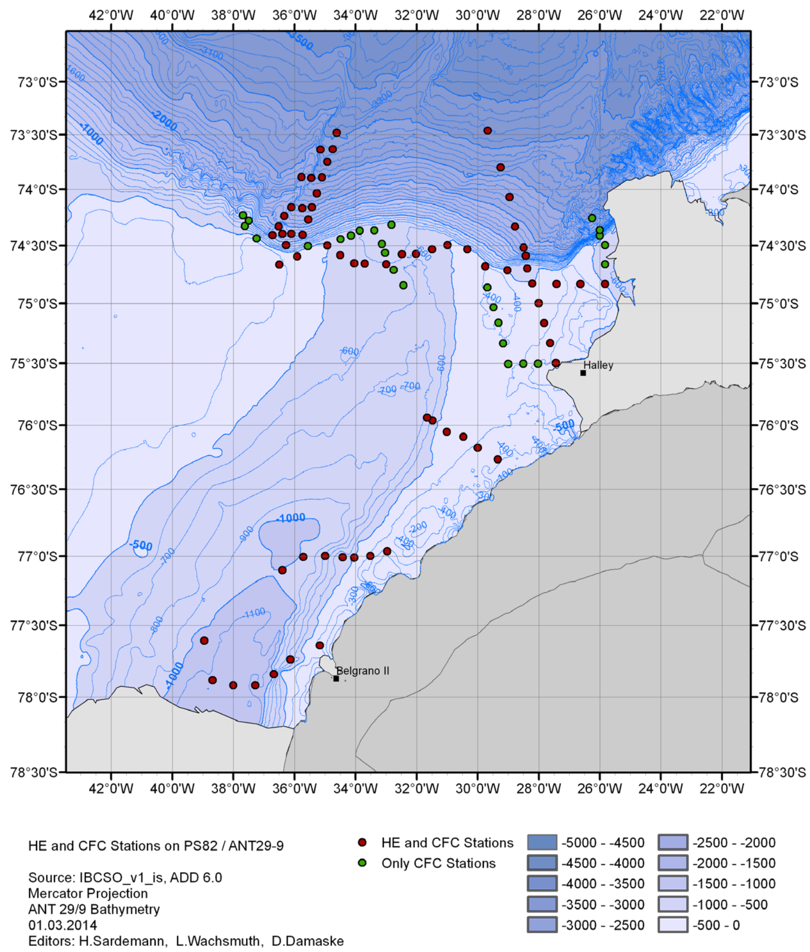

Fig. 3.2.2.1: Map of the Filchner Trough with noble gas and CFC stations during Polarstern PS82 (ANT-XXIX/9). Red dots are positions of combined noble gas and CFC stations, green dots are positions of only CFC stations.

Oceanic water samples for helium isotopes and neon were stored from the CTD/water bottle system into gas tight copper tubes, which are clamped of at both sides. The noble gas samples are analyzed later in the IUP Bremen noble gas mass spectrometry lab. The copper tube water samples are processed in a first step with an ultra high vacuum gas extraction system. Sample gases are transferred via water vapour into a glass ampoule kept at liquid nitrogen temperature. For analysis of the noble gas isotopes the glass ampoules are connected to a fully automated ultra high vacuum mass spectrometric system equipped with a two-stage cryogenic trap system. The system is regularly calibrated with atmospheric air standards (reproducibility better ±0.2%). Also measurement of blanks and linearity are done.

For the transient tracers (CFC) water samples from the CTD/water bottle system were collected into 100 ml glass ampoules and are flame sealed after a CFC free headspace of pure nitrogen had been applied. The CFC samples are later analysed in the CFC-laboratory at the IUP Bremen. The determination of CFC concentration will be accomplished by purge and trap sample pre-treatment followed by gas chromatographic (GC) separation on a capillary column and electron capture detection (ECD). The amount of CFC degassing into the headspace will be accounted for during the measurement procedure in the lab. The system will be calibrated by analyzing several different volumes of a known standard gas. Additionally the blank of the system will be analyzed regularly.

All samples will be shipped home after the expedition and will be analysed in the UHB-IUP noble gas and CFC laboratories. The measurements are expected to be completed one year after arrival in our home lab in Bremen. A careful data quality check will be carried out then.

Expected results

The 3-dimensional spatial coverage with CFC and noble gas samples in the Filchner Trench region is higher than from previous expedition. If this spatially dense and almost synoptic station distribution is sufficient to estimate realistic basal melt rates from the Filchner Ice Shelf, i.e. if we have covered the total dense water that was formed at Filchner to integrate the total glacial melt water volume, can be judged only, when the final noble gas and CFC data, together with the final hydrographic data, are available. However, we expect that we have covered sufficiently the area, where recently formed WSBW is transferred on the shelf northward and down the slope into the deeper Weddell Basin and also possibly westward. This will allow us to estimate the glacial melt water fraction and its inventory in WSBW and to assess the formation and export rates of WSBW.

Data management

All our data will be made public on the PANGAEA Data Publisher for Earth & Environmental Science as soon as we have them available (approx. one year after the cruise), carefully quality controlled, and published in a peer reviewed journal. Our cooperation partners will receive the data as soon as the final data set is available.

3.2.3 Sea ice physics

Sandra Schwegmann[1], Giulia Castellani[1], Not on board: Marcel Nicolaus[1]

[1]AWI

Grant No: AWI_PS82_02

Outline

The mass- and energy balance of sea ice and its snow cover are key elements for a better understanding of the interaction between atmosphere, sea ice, and ocean of the Southern Ocean. Although satellite observations allow for observing sea-ice extent around Antarctica on a daily basis, it is not yet understood what the main drivers for the large regional differences are. The trend of the mean annual sea ice extend differs strongly in strength and direction for different regions. For the Weddell Sea, a positive, but not significant trend towards larger extends has been derived over the last decades. Therefore, it is of particular interest to gather in-situ observations covering the spatial variability and seasonal evolution of the physical properties of snow and sea ice. The sea-ice physics work done during ANT-XXIX/9 is of special value as it serves data from the rarely observed Filchner Outflow region. Therefore it resulted in unique data from the central and eastern Weddell Sea. In addition, the data set extends work performed during the winter experiments (ANT-XXIX/6 & 7). So, all these data cover different seasons and regions of the Weddell Sea.

The gathered data sets will also serve as a valuable tool for the validation of satellite-based (e.g. CryoSat-2, SMOS) and simulated sea-ice thickness distributions. Buoy data will also contribute to the International Program on Antarctic Buoys.

3.2.3.1 Visual observation of sea-ice conditions from the ship's bridge

Sandra Schwegmann[1], Giulia Castellani[1], Stefanie Semper[2], Wilma Huneke[2], Svenja Ryan[2]

[1]AWI
[2]CAU-MarSci

Grant No: AWI_PS82_02

Objectives

Over the last three decades, ship-based visual observations of the state of the sea ice and its snow cover have been performed over all seasons and serve the best-available observational data set of Antarctic sea ice. The recordings follow the Antarctic Sea Ice Processes and Climate (ASPeCt) protocol and include information on sea-ice concentration, sea-ice thickness and snow depth as well as sea-ice type, surface topography and floe size. Those data are combined with information about meteorological conditions like air temperature, wind speed and cloud coverage. This protocol is a useful method to obtain a broad range of characterization and documentation of different sea-ice states and specific features during the cruise.

Work at sea

Every full hour during daylight conditions the sea-ice observation was carried out by five trained scientists. The observations follow the ASPeCt protocol (Worby 1999), with the standard software being provided on a notebook on the ship's bridge. For every observation, pictures were taken in three different directions (Fig. 3.2.3.1.1.a-c).

Date, time and position of the observation were obtained from the DSHIP system, along with standard meteorological data (current sea temperature, air temperature, true wind speed, true wind direction, visibility). The characterisation of the ice conditions were then estimated by taking the average between observations to port side, ahead and to starboard side. Ice thicknesses of tilted floes were estimated by observing a stick attached to the ships starboard side.

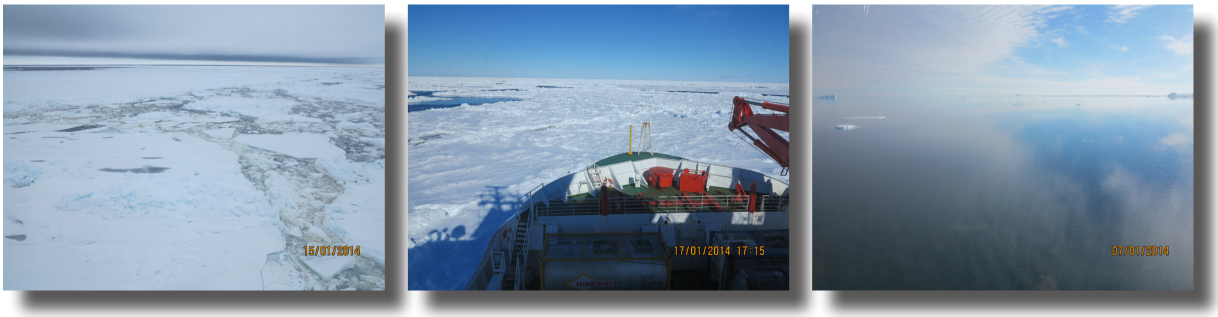

Fig. 3.2.3.1.1a-c: Example for pictures made to the portside, ahead and starboard showing different sea ice and weather conditions

Preliminary results

We performed hourly sea-ice observations as soon as we passed the first sea ice on 28 December 2013 at -66° 42.0′ S and -3° 45.0′ W. The ship left the sea-ice zone on 21 February 2014 at -68° 19′ S and -4° 55′ W. Over the 56 days, 458 individual observations were recorded. Sea-ice observations were skipped when the ship was stopped, for example at CTD and ice stations or when trapped in heavy sea ice. The mean sea-ice concentration was calculated as 39.49%, from which 34.19% were covered by snow (Fig. 3.2.3.1.2).

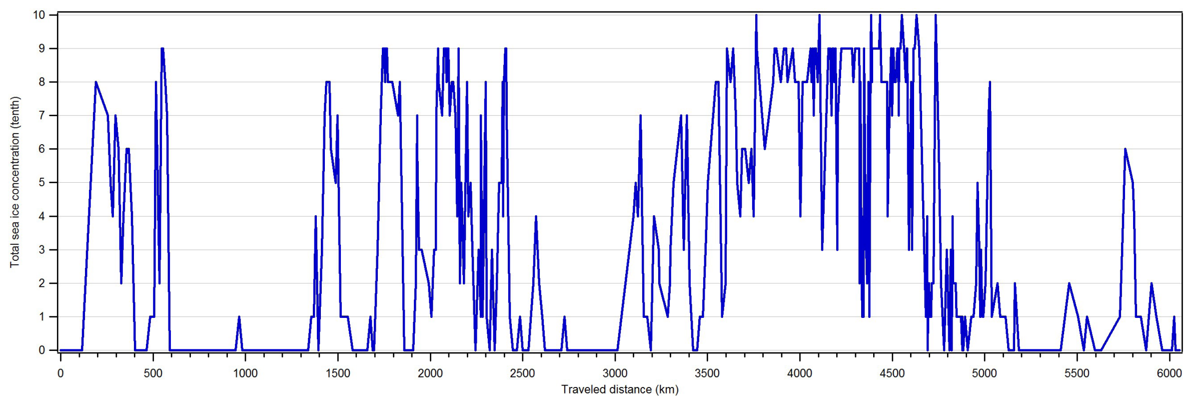

Fig. 3.2.3.1.2: Sea-ice concentration out of ASPeCt observations over travelled distance

Data management

The visual sea-ice observations will be post-processed after the cruise and will be published together with the taken pictures in PANGAEA Data Publisher for Earth & Environmental Science within two months after the cruise.

3.2.3.2 Autonomous buoys

Sandra Schwegmann[1], Giulia Castellani[1]
Benjamin Lange[1], Marcel Nicolaus[1]
Not on board: Hauke Flores[1], Petra Heil[2],
Jenny Hutchings[3], Ignatius Rigor[4]

[1]AWI
[2]AAD
[3]Uni-Alaska
[4]Uni-Washington

Grant No: AWI_PS82_02

Objectives

The investigation of physical sea-ice and snow parameters like sea-ice thickness, snow depth and sea-ice drift is possible also beyond the cruise by deploying autonomous buoys. Those buoys record the afore mentioned parameters mostly along with the meteorological variables like air temperature and sea level pressure and yield valuable information about the evolution of the investigated sea-ice floe and the surrounding area. During ANT-XXIX/9 it was planned to deploy

- 9 Surface Velocity Profiler (SVP) buoys along the ship's course to monitor the large-scale, long-term ice motion throughout the Weddell Sea
- 2 ABiPSO systems
- 4 sets of the newly developed snow depth buoys in combination with ice mass balance buoys (IMB) or an ABiPSO system
- 6 marker buoys in order to build up a buoy array around a centre station, which includes one ABiPSO system and a snow depth buoy. This array is supposed to provide information on the dynamical processes on scales within 100 km, while the centre station provides information on the thermodynamical growth history of sea ice, the snow accumulation and the meteorological conditions of the area.

Work at sea

SVP buoys: In total, 7 SVP buoys were deployed, two using the ship's mummy chair, and five by helicopter. Prior to deployment, all buoys were tested, with two malfunctioning buoys found. At the deployment sites, snow depth and sea ice thickness was measured and general ice and weather conditions were noticed. The buoys were deployed in the eastern to central Weddell Sea, each at least ~ 100 km apart from the former deployment site (see Fig. 3.2.3.2.1, Tab. 3.2.3.2.1).

ABiPSO System: The Autonomous Bio-Physical Sea Ice Observation (ABiPSO) station consisted of 4 independent systems that transmit data daily via Iridium satellite connection: 1) ice mass balance buoy (IMB) measuring ice thickness and temperature, as well as the water temperature to a depth of 25 m; 2) MetOcean CTD buoy for under-ice water salinity and temperature; 3) ADCP buoy for water current velocity and direction, and for the estimation of zooplankton vertical distribution from backscatter data; and 4) a radiation station that measures the incoming irradiance and the light transmission through the sea ice. However, the radiation station didn't transmit data during the testing phase and was therefore not deployed. The systems were deployed in the centre of the drift buoy array on an ice floe with a high probability of surviving the rest of the melt season based on *in situ* inspection and projected drift trajectories for the region (see Tab. 3.2.3.2.2).

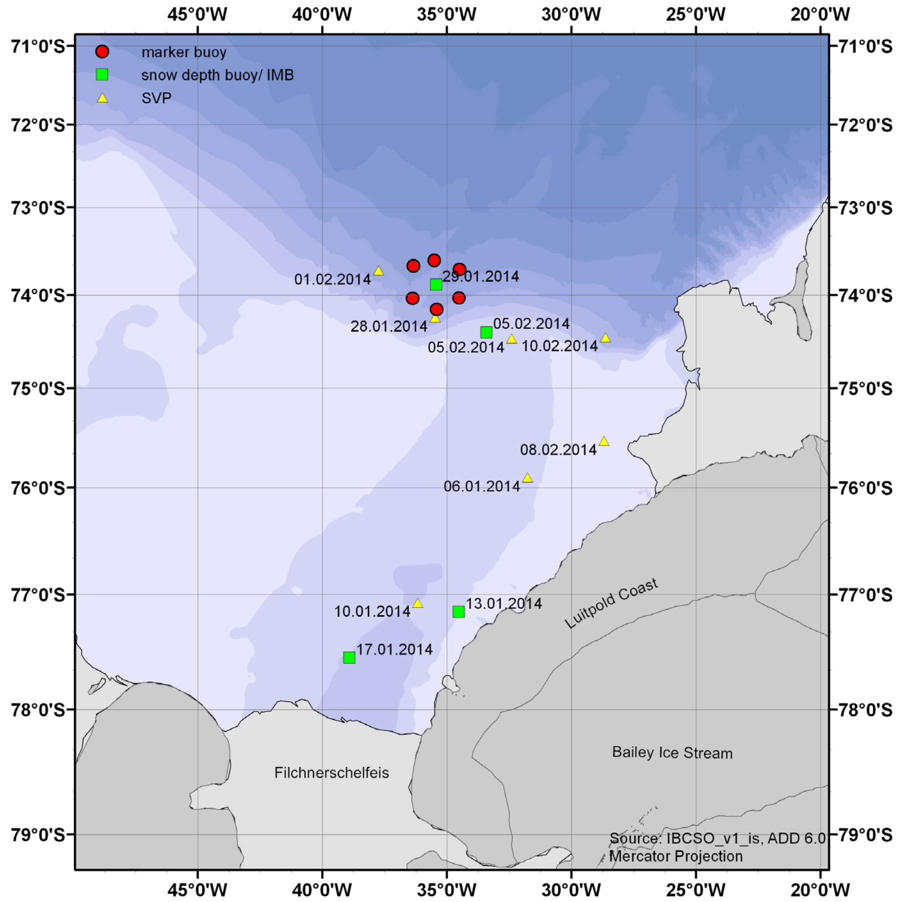

Fig. 3.2.3.2.1: Map of buoy deployment sites

A smaller version of ABiPSO was planned to be deployed together with a snow depth buoy, consisting only of an IMB and one radiation station. However, as both radiation stations didn't work, only the IMB was deployed together with a snow depth buoy.

Tab. 3.2.3.2.1: List and initial positions of all SVP buoys

Event	Latitude	Longitude	Label	Device	Date	Comments
PS82/H01	-75.90514	-31.76542	PS82/H01_SVP	SVP buoy	06/01/2014	Drift velocity
PS82/068-01	-77.07833	-36.17833	PS82/068-01_SVP	SVP buoy	10/01/2014	Drift velocity
PS82/H04	-74.25063	-35.48287	PS82/H04_SVP	SVP buoy	28/01/2014	Drift velocity
PS82/H06	-73.72987	-37.75644	PS82/H06_SVP	SVP buoy	01/02/2014	Drift velocity
PS82/H07	-74.4311	-32.96937	PS82/H07_SVP	SVP buoy	06/02/2014	Drift velocity
PS82/299-01	-75.5417	-28.6978	PS82/299-01_SVP	SVP buoy	08/02/2014	Drift velocity
PS82/H08	-74.4647	-28.6431	PS82/H08_SVP	SVP buoy	10/02/2014	Drift velocity

Fig. 3.2.3.2.2: a) Snow depth buoy combined with an IMB (yellow Pelicase), b) SVP buoy, c) marker buoy for outer buoy array, and d) central station with ABiPSO and snow depth buoy

Snow depth buoys/ ice mass balance buoys: Four snow depth buoys were deployed during the cruise, two during ice stations, and two by helicopter (Tab. 3.2.3.2.3). The snow depth buoys were always combined with an IMB, from which two were part of the ABiPSO system. One of them went into the centre of the buoy array. All buoys were tested prior to deployment and except for one IMB, all of them still transmit data at the end of the cruise.

Deformation array: A small buoy array was deployed close to the continental shelf edge in the central Weddell Sea, with the array centred around 73° 53' S and 35° 27' W. It consists of 6 marker buoys as the outer array and a combination of the main ABiPSO system and a snow depth buoy in the centre of the outer array. The centre station and the first marker buoy were build up during an ice station with the ship attached to the floe, while the remaining 5 marker buoys where deployed via helicopter transportation in a radius of roughly 30 km around the centre station. Fig. 3.2.3.2.2 shows the different types of buoys and the centre station of the buoy array. Table 3.2.3.2.4 lists the initial positions of the deployed marker buoys for the buoy array during ANT-XXIX/9.

Preliminary (expected) results

SVP buoys: The SVP buoys will serve information on the sea-ice drift velocity and its seasonal behaviour. Data will be transmitted as long as batteries will work, which is supposed to be several months. Measurement time series will only be generated after the cruise. In case the sea ice doesn't survive the summer season, the SVPs will pass over to the sea and will measure ocean currents, as they are able to swim. A data example is given in Fig. 3.2.3.2.3, where SVP drift velocities from 07.02. to 08.02.14 are compared with the sea ice drift of the marker buoys.

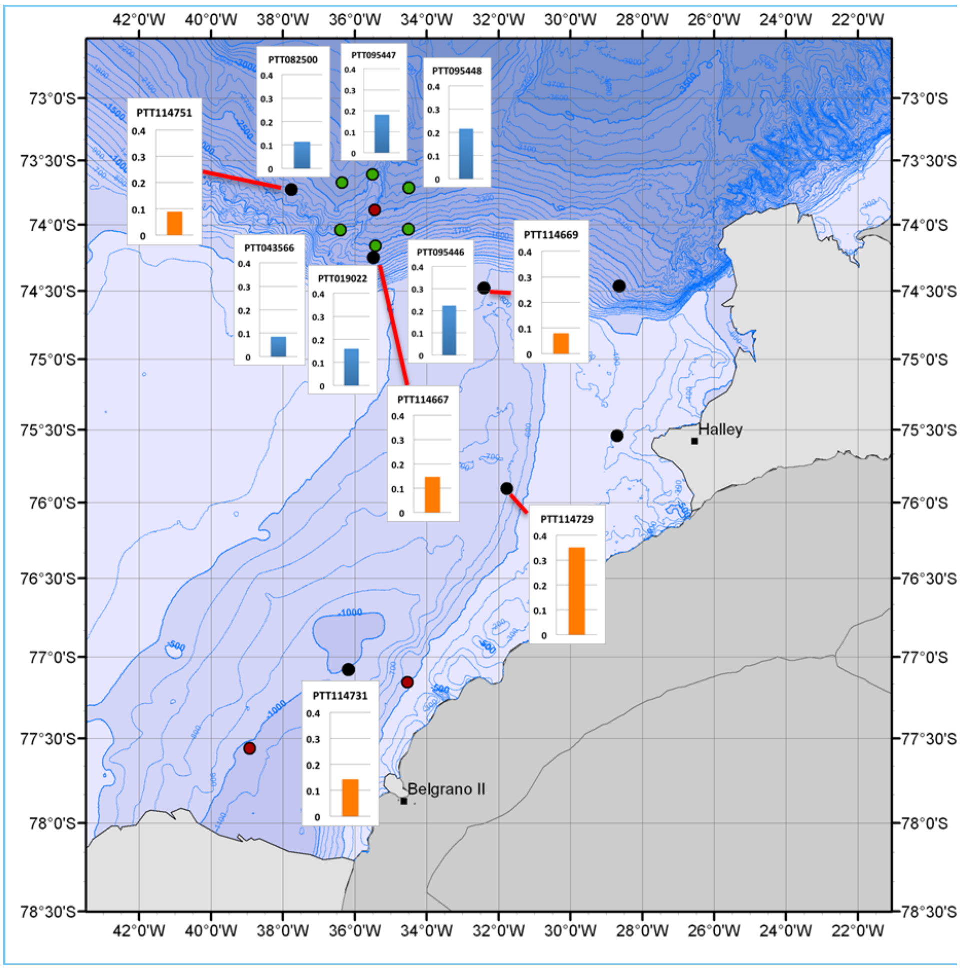

Fig. 3.2.3.2.3: Drift velocities of SVP and marker buoys from 07.02.-08.02.14. The figure demonstrates the spatial variability of drift velocities.

ABIPSO System: The station is supposed to provide a unique data set that combines information on the snow and ice conditions together with a set of meteorological and oceanographic information.

As of this writing, the ABiPSO system is still working except for the IMB placed in the centre station of the buoy array. Snow accumulation was quite high at this position and might be responsible for this loss, as too high snow coverage on top of the IMB would cut the data connection.

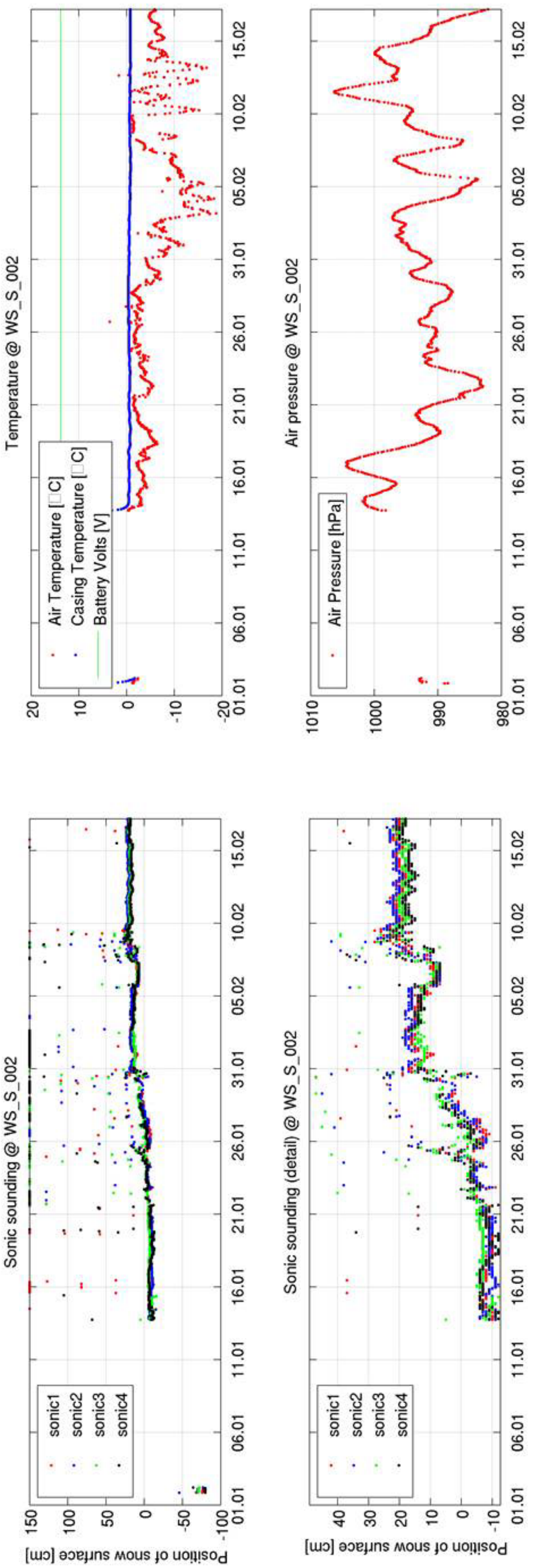

Fig. 3.2.3.2.4: Snow depth evolution (left) for snow depth buoy WS_S_002, deployed at the 13.01.2014 combined with information on meteorological conditions (right)

Tab. 3.2.3.2.2: List and initial positions of the deployed ABiPSO systems

Event	Latitude	Longitude	Label	Device	Date	Comments
PS82/H02	-77.15826	-34.53315	PS82/H02_IMB	IMB	13/01/2014	Ice mass balance buoy, radiation station broken
PS82/214-01	-73.88646	-35.4423	PS82/214-01_IMB	IMB	29/01/2014	Ice mass balance buoy, radiation station broken
PS82/214-01	-73.88646	-35.4423	PS82/214-01_MO	MO-CTD	29/01/2014	MetOcean CTD buoy
PS82/214-01	-73.88646	-35.4423	PS82/214-01_ ADCP	ADCP	29/01/2014	Acoustic Doupler Current Profiler

Snow depth buoys: The snow depth buoys measure the snow accumulation at four spots by sonar sensors. Together with the IMBs, information on the snow depth changes, sea-ice growth and eventually estimates of flooding processes can be expected from the data. Sea ice growth data will be processed after the cruise, and all the buoys will provide data up to one year beyond the cruise. Fig. 3.2.3.2.4 shows an example for snow accumulation for the period 13.01. to 17.02.2014. Data will be combined with findings of former deployments during ANT-XXIX/6 and will help to understand the temporal and spatial variability of snow accumulation, ice thickness growth and eventually help to better understand flooding of Antarctic sea ice.

Tab. 3.1.3.2.3: List and initial positions of snow depth buoys

Event	Latitude	Longitude	Label	Device	Date	Comments
PS82/H02	-77.15826	-34.53315	PS82/H02_ SDB	Snow depth buoy	13/01/2014	Snow depth buoy
PS82/H03	-77.5595	-38.91932	PS82/H03_ SDB	Snow depth buoy	17/01/2014	Snow depth buoy
PS82/H03	-77.5595	-38.91932	PS82/H03_ IMB	IMB	17/01/2014	Ice mass balance buoy
PS82/214-01	-73.88646	-35.4423	PS82/214-01_SDB	Snow depth buoy	29/01/2014	Snow depth buoy
PS82/265-01	-74.408167	-33.41317	PS82/265-01_SDB	Snow depth buoy	05/02/2014	Snow depth buoy
PS82/265-01	-74.408167	-33.41317	PS82/265-01_IMB	IMB	05/02/2014	Ice mass balance buoy

Deformation Array: For the deformation array, it was not possible to access buoy data from the ship. However, since one of the snow depth buoys was deployed within the array, it is assumed that the deformation array has followed the approximate path of that buoys. In Fig. 3.2.3.2.3, drift velocities of the marker buoys are compared to the drift of the SVP buoys for one day, exemplarily. The Figure shows the high spatial variability of daily drift velocities, even within smaller scales. However, measurement time series have not yet been generated and therefore, a more detailed comparison is missing here.

Tab. 3.2.3.2.4: List and initial positions of the deployed marker buoys

Event	Latitude	Longitude	Label	Device	Date	Comments
PS82/211-01	-74.16188	-35.42158	PS82/211-01_MO	METOCEAN	28/01/2014	drift velocitiy
PS82/H05	-74.03961	-36.39291	PS82/H05_CW43566	CLEARWATER	29/01/2014	drift velocitiy
PS82/H05	-73.67435	-36.34879	PS82/H05_CW82500	CLEARWATER	29/01/2014	drift velocitiy
PS82/H05	-74.03373	-34.51236	PS82/H05_CW95446	CLEARWATER	29/01/2014	drift velocitiy
PS82/H05	-73.71564	-34.50078	PS82/H05_CW95448	CLEARWATER	29/01/2014	drift velocitiy
PS82/H05	-73.6113	-35.50364	PS82/H05_CW95447	CLEARWATER	29/01/2014	drift velocitiy

Data management

All data from autonomous drift buoys will be available through different project home pages. Buoy positions and atmospheric parameters will also be accessible through the website of the International Program for Antarctic buoys within two years after data collection. Furthermore, we are currently integrating buoy data into the AWI-based sea-ice portal www.meereisportal.de.

3.2.3.3 Ship- and buoy-tracking by TerraSAR-X images

Sandra Schwegmann[1], Wolfgang Dierking[1]
Not on board: Thomas Krumpen[1],
Thomas Busche[2], Christine Wesche[1]

[1]AWI
[2]DLR

Grant No: AWI_PS82_02

Objectives

Monitoring of sea-ice drift and deformation is important for the estimation of the sea-ice transport through key regions in the Arctic and Antarctic, for studying the atmosphere-sea ice-ocean interactions, and also for tactical ship navigation and offshore operations. Sea-ice drift and deformation are mainly influenced by wind and ocean currents, but also the presence of obstacles such as islands and coastlines and the thickness and strength of the sea-ice play an important role. Satellite-borne imaging sensors, operating in the optical and in the microwave range of the electromagnetic spectrum, are used for continuous monitoring of sea-ice covered regions. SAR imaging modes with different spatial coverage and resolution make it possible to investigate drift patterns at different scales. However, time gaps between single SAR images can be relatively large (on the order of a few hours to a few days), and even too large for studying short-term variations of sea-ice movement due to, e. g., tidal effects or highly variable wind conditions. Therefore, drifting buoys are an extremely useful complement since they resolve ice movement at temporal resolutions of minutes. In addition they serve as data source for the validation of drift retrieval algorithms developed for sequences of SAR images.

The order of TerraSAR-X satellite imagery aims to support the spatial (and temporal) expansion of the buoy array data. Therefore, a drift and deformation retrieval algorithm developed at AWI will be applied to the images and will be validated by the available buoy data.

This special provision of images also helps DLR to develop and improve its near-real time Ship Detection service in the realm of marine security, which will be of increasing importance in the future, and which is becoming a major driver for recent and future space-borne SAR developments.

Work at sea

Ship Detection: At least 17 hours before ordering a scene, information of the ships position and planned cruise track for the next 17 hours was provided to colleagues at AWI. Ordering and first processing was done in the home office.

Navigation issues: Images were sporadically ordered in order to get an overview on the ice conditions and to decide about possible buoy deployments in a special area.

Buoy array: The largest amount of satellite images was and will be ordered for the detection of sea-ice drift (e.g. Fig. 3.2.3.3.1). In order to cover the same region with buoy data and satellite images, actual positions of the buoy array and a weather forecast for the next 24 hours of that region were provided to the colleagues who place the orders.

Preliminary (expected) results

For the ship detection algorithm used by DLR, 10 orders were placed. Those images were not only taken above *Polarstern* but also over the MV *Akademik Shokalski*, which got trapped in heavy sea ice in the East Antarctic. Especially those images helped to get an impression on the ice conditions in the surrounding of the ship and help to plan further navigation. However, the main purpose was to validate the ship's detection algorithm, which will be done by DLR.

Further images were ordered to allow for the spatial (and temporal) expansion of the buoy array data. A drift and deformation retrieval algorithm developed at AWI will be applied to the satellite images. The goal is to take advantage of the combination of spatially dense drift field retrievals from satellite images and high-resolution time series of drifting sea-ice buoys. In addition, buoy data will be used to validate the drift and deformation algorithm. However, the majority of data will be processed in the home office and therefore, no results can be presented here.

Data management

Satellite images are property of DLR and will not be published by AWI. However, data products like satellite drift velocities will be published within two years after the cruise.

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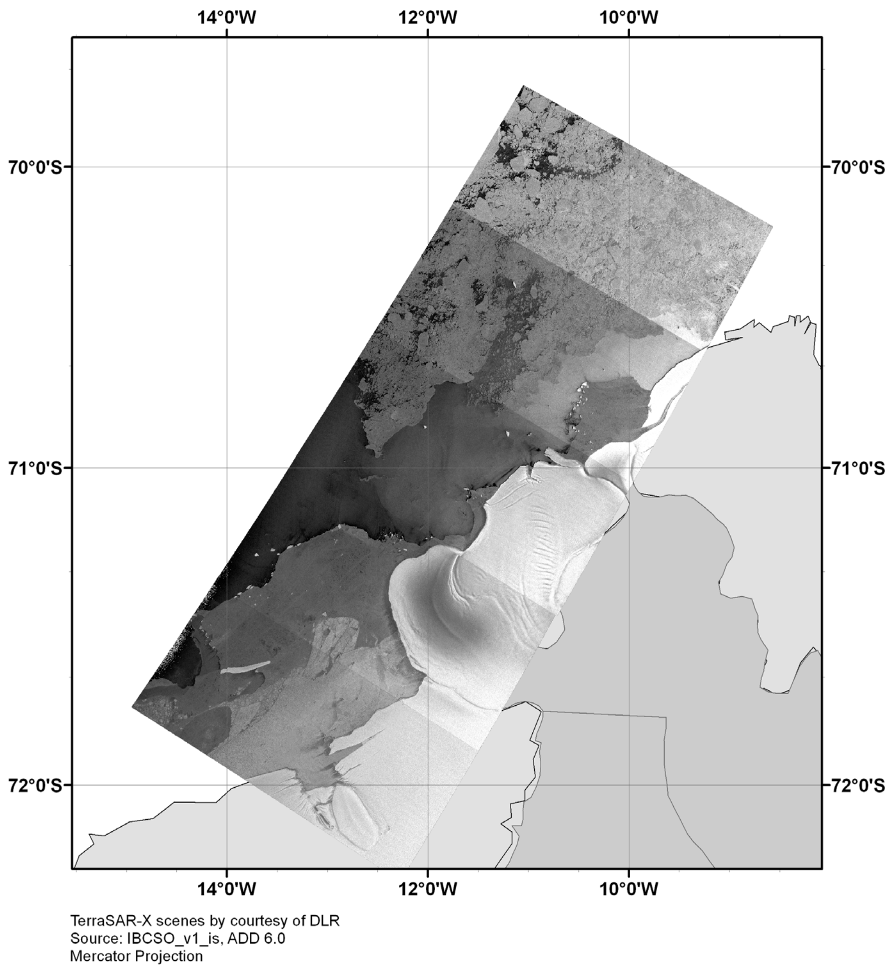

Fig. 3.2.3.3.1: TerraSAR-X scenes from 31.12.13. At the right edge the ice shelf is visible while the left part shows pack ice (top), open water (~middle) and fast ice (bottom).

3.3 BIOLOGICAL PROGRAMMES

3.3.1 Biological and biogeochemical processes in sea ice and the pelagic realm

Holger Auel[1], Julia Dürschlag[1], Dieter Janssen[2], Kerstin Ksionzek[2], Dorein Kohlbach[2,3], Benjamin Lange[2,3], Martina Vortkamp[2]
Not on board: Hauke Flores[2,3], Martin Graeve[2], Boris Koch[2]

[1]BreMarE, Uni HB
[2]AWI
[3]Uni HH

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Objectives

The region of the Filchner Trough is characterized by the outflow of Ice Shelf Water (ISW) from the Filchner-Ronne Ice Shelf, which interacts with Warm Deep Water of the Weddell Gyre circulation. As a key area for the formation of Weddell Sea Deep and Bottom Water, the Filchner Outflow is of major importance for the global ocean circulation. It is probably the only permanent source supplying ISW for deep convection, but the long term variation and production rates of the outflow are unknown.

Bottom water formation in the Weddell Sea is also an important potential mechanism transporting sea-ice algae-derived dissolved organic matter (DOM) from the euphotic zone into the deep sea. This mechanism might contribute substantially to the organic carbon flux in the ocean and the transport of organic material. The molecular composition of organic matter is a key to estimate bioavailability. It can also provide a chemical fingerprint for a specific source or process. Despite recent substantial progress in the field of molecular characterization by Fourier Transform Ion Cyclotron Resonance Mass Spectrometry (FT-ICR-MS, Koch et al. 2005), the chemical nature of dissolved organic sulfur (DOS) remains largely unknown. To improve our understanding of the role of heteroatomic organic matter in cryo-pelagic and bentho-pelagic processes (e.g. nutrient cycling, methanogenesis), bottom water and sediment pore water were sampled for analyses by high performance liquid chromatography (HPLC) hyphenated to inductively coupled plasma mass spectrometry (ICP-MS, Lechtenfeld et al. 2011).

A high spatial resolution, particularly in surface and bottom water of the southern Weddell Sea, is essential to improve our mechanistic understanding of the biogeochemistry of DOM. Specific research objectives of the biogeochemical studies were (i) to identify and characterize specific molecular biogeochemical provinces based on organic matter quantity and quality and inorganic nutrient availability (Koch et al. 2011) and (ii) to detect and trace molecular fingerprints of sea ice-derived organic matter in bottom water of the southern Weddell Sea.

Biological studies on pelagic processes in the Filchner Outflow System comprise one component of an integrative food-web analysis, supplementing and extending corresponding research on benthic communities and fish fauna. The major objectives were (i) to quantify and trace the relative contributions of ice algal- *vs*. phytoplankton-derived primary production throughout the marine food web and (ii) to analyse and describe zooplankton community composition in the Filchner Outflow System in comparison to adjacent regions.

In sea ice-covered polar regions, primary production is based on both, sea ice algae and phytoplankton. For the majority of the growing season, sea ice algae are likely the most abundant food source due to the large spatial coverage of sea ice throughout the year. However, at the ice edge and in polynyas, phytoplankton dominates production with important implications for food web interactions. Many zooplankton species, such as copepods and krill, rely on both, sea ice algae and phytoplankton, as food sources. These organisms are in turn an important source of lipids and, therefore, an important linkage between primary producers and higher trophic levels. The meso- and macrozooplankton community of the Filchner Trough consists of at least 110 species including larval stages of benthic and nektonic species (Boysen-Ennen 1987, Piatkowski 1987, Boysen-Ennen and Piatkowski 1988). In terms of biomass, however, it was poorer than the zooplankton community north of 74° S along the eastern Weddell Sea shelf. Typical representatives include the copepods *Calanus propinquus*, *Calanoides acutus*, *Metridia gerlachei*, *Paraeuchaeta antarctica*, and the herbivorous pteropod *Limacina* sp.

Biochemical and isotopic biomarkers will allow tracing sea ice- and phytoplankton-derived carbon throughout the pelagic food web and quantifying the proportional contributions of ice algae-produced carbon versus phytoplankton production to the nutrition of different zooplankton species. To this end, a combined approach of two established methods, fatty acid analysis and stable isotope analysis will be applied. Different taxonomic groups of microalgae can be distinguished by fatty acid trophic markers (FATM). A fatty acid composition can thus be regarded as a trophic fingerprint of primary producers, since many fatty acids are not bio-transformed by consumers and therefore originally traceable along marine food chains. Stable isotope ratios of nitrogen and carbon provide information on the trophic level and on the origin of organic matter, respectively. The specific stable isotope signature of a consumer reflects the diet composition, since the contribution of carbon as well as nitrogen isotopes in the body tissue is directly related to the isotopic composition of prey items. Via mixing models, the relative contribution of biomarker fatty acids originating from ice algae versus phytoplankton in the tissue of zooplankton species can be determined. This enables quantifying trophic interactions among the investigated organisms. Biomarker analysis is complemented by information on the physical properties of sea ice in addition to the vertical distribution and community structure of pelagic communities within the research area.

Work at sea

As part of the biogeochemical studies, about 470 water samples were taken for solid phase DOM extraction at a total of 40 CTD stations with a special focus on the uppermost and lowermost water column. At 14 multicorer (MUC) stations, sediment pore water and the overlying water column were sampled. The pore water was extracted using rhizon samplers (Rhizosphere). All water samples were filtered through pre-combusted GF/F filters and preserved for subsequent analysis of inorganic nutrients and dissolved organic carbon and nitrogen back in the AWI laboratory. Filtered water samples were acidified with hydrochloric acid (suprapur, Merck) to pH 2. DOM extraction was performed with 200 mg solid-phase extraction cartridges (PPL, Agilent) according to Dittmar et al. (2008). A volume of 500 ml was extracted. After drying with nitrogen gas, DOM was eluted with 1 mL methanol (LiChrosolv, Merck) in pre-combusted GC vials and stored at -20° C. Quantification of dissolved organic sulphur and dissolved organic phosphorus by HPLC-ICP-MS and the analysis of the chemical composition of DOM by FT-ICR-MS will also be performed back in the AWI laboratory.

In addition, at some selected stations 20 L water samples from three different depths (surface, chlorophyll maximum and bottom) were collected for liquid-liquid DOM extraction. After filtration through pre-combusted GF/F-filters, liquid-liquid extraction of DOM was performed with 500 ml cyclohexane. The extract was then concentrated to 1 ml for storage at -20 °C and subsequent lipid analysis in our lab. Water extracts will be analysed with several methods. First, a lipid class analysis will be performed on an HPLC system and on an liquid chromatography-mass spectrometry (LC-MS) system. After derivatization of a sample aliquote, the fatty acid composition will be analyzed by gas chromatography (GC) and if necessary by GC-MS.

Phytoplankton samples were collected with the rosette water sampler attached to the CTD sensor. Usually 3 L of seawater from the surface layer and from the chlorophyll maximum were filtered on GF/F filters for analyses of pigment content, fatty acid and stable isotope composition at Bremen University. Additionally, Utermöhl samples were taken from the chlorophyll maximum and preserved in 4 % formalin.

For mesozooplankton studies, samples were collected by Multinet Midi equipped with 150 µm mesh size usually down to the seafloor or to a maximum sampling depth of 2,000 m. The Multinet was deployed at 36 stations to obtain zooplankton samples; 34 stations were located within the Filchner Outflow System, while two additional casts were conducted north of the Atka Bay and north of the Polar Front. Sampling intervals were selected based on the hydrographic regime. Zooplankton samples were sorted immediately after the catch and deep-frozen at -80 °C for lipid and stable isotope analyses at Bremen University. To establish zooplankton secondary production, the egg production rates of *Calanoides acutus* and *Calanus propinquus* were measured at nine stations, where females occurred in the surface layer. Females from the upper 100 m were put in separate dishes and the production of eggs and fecal pellets monitored after 24 h and 48 h. The remains of the Multinet samples were preserved in 4 % formalin or ethanol for later analysis of species compositon and abundance.

Macrozooplankton was sampled with a Multiple opening Rectangular Midwater Trawl (M-RMT) at 28 stations. M-RMT sampling was complemented with profiles of *Polarstern*'s EK60 echosounder during steaming. On the shelf, depth-stratified M-RMT hauls were conducted from near-bottom to the surface, sampling at three different depth intervals. Over deep waters, the maximum sampling depth was 700 m. Hauls were distributed over a station grid covering the areal extent of other fishing and zooplankton sampling within the Filchner Outflow System. Large organisms were sorted for biomarker analysis and the remaining samples were either preserved in formaldehyde (4 %) for detailed analysis at AWI or frozen at -20 °C.

For biomarker analysis, individuals of abundant species, e.g. euphausiids, amphipods and fish, obtained from M-RMT catches and other sampling gears (multi-corer, bottom trawl and Agassiz Trawl) were sorted by species and developmental stage, and subsequently preserved at -80° C. In order to estimate the trophic baseline signal from primary producers, samples of particulate organic matter from sea ice (collected with an ice corer) and the water column (collected with the CTD rosette) were filtered on pre-weighted and pre-combusted GF/F filters and frozen at -80° C . In the home laboratory, coupled gas chromatography and mass spectrometry will be used to determine the lipid, fatty acid and stable isotope composition of the material, as well as the stable isotope fractionation of microalgal marker fatty acids.

Sea-ice work was conducted in close collaboration with AWI sea ice physics (S. Schwegmann) and consisted of ice coring, bio-optical measurements, and the deployment of buoys (refer to section 3.2.3.2 Autonomous Buoys for a description of buoy deployments). Ice cores were collected from eight ice stations and bio-optical measurements were conducted at three ice stations. Sea-ice cores were collected for biomarker analysis, chlorophyll *a* content, genomics, salinity, temperature, and ice texture. At three ice stations, bio-optical measurements required the deployment of an L-arm under the ice with a mounted spectral radiometer to acquire the spectral light properties of the sea ice and the under-ice environment. At L-arm survey sites, ice cores were extracted and processed for chlorophyll *a* content in order to determine the relationship of ice algal biomass with the under-ice spectral light properties.

Preliminary (expected) results

About 230 phytoplankton samples were collected on GF/F filters for the analysis of pigment composition, fatty acid composition and stable isotope signature. In addition, 20 seston samples from algal blooms were deep-frozen from Multinet catches. 29 Utermöhl samples were preserved in formalin for the analysis of phytoplankton composition.

As a preliminary proxy of chlorophyll *a* concentration, the fluorescence signal of the CTD sensor was integrated over the upper 200 m of the water column. Chorophyll *a* content was correlated to sea surface temperature and dependent on sea-ice coverage. Highest chl *a* content occurred in the polynya on the eastern Weddell Sea shelf, which had been ice-free for a longer period of time. By contrast, chl *a* was low in ice-covered regions over the Filchner Trough and further west. Higher chl *a* contents only occurred in conjunction with low ice coverage of less than 20 % and higher SST.

The Multinet deployment delivered approx. 660 frozen zooplankton samples and 150 samples preserved in formaldehyde, ethanol or RNA later. At most stations, zooplankton was still in a very early stage of seasonal succession probably because of the dense sea-ice cover. Only few copepods of the herbivorous species *Calanoides acutus* and *Calanus propinquus* occurred in the surface layer. Many *C. acutus* females had not started feeding yet, as evident in the lack of fecal pellet production. Only one copepod female in an experimental series covering nine stations actually produced eggs.

Higher zooplankton concentrations only occurred in the open Weddell Sea, whereas zooplankton biomass was very poor in the Filchner Trough. Many stations in the Filchner Outflow System and in the polynya on the southeastern shelf of the Weddell

Sea had very low zooplankton concentrations in the upper 100 m, even though dense phytoplankton blooms occurred at some polynya stations. At station 82-210 in the open Weddell Sea, by contrast, more copepods were found in the upper 100 m, as typical of a summer situation.

With the M-RMT net in total 28 hauls were completed, including 22 depth-stratified stations (near-bottom or 700 to 200 m, 200 to 50 m and 50 to 0 m), and 6 stations without using the multi-opening function. This allows for the upper two strata to be compared with the standard CCAMLR RMT hauls conducted from 200 m to the surface. RMT 1 m^2 catches were dominated by various copepod species, e.g. *Calanus propinquus*, *Paraeuchaeta antarctica*. Within the RMT 8 m^2 catches, approximately 60 different taxa could be identified from a total of more than 600 sorted samples.

From RMT catches, the krill species *Euphausia crystallorophias*, *Euphausia superba*, and *Thysanoessa macrura* were classified by sex and developmental stage, before length measurement. The northern part of the research area along the continental shelf break showed the highest abundances for both *E. superba* and *E. crystallorophias* (Fig. 3.3.1.1-A and -B). In the southern part of the study region, *E. crystallorophias*, represented the most abundant euphausiid taxa (Fig. 3.3.1.1-B). Highest abundances of fish larvae, consisting primarily of *Pleuragramma antarcticum*, were found in the south near the edge of the Filchner Ice Shelf (Fig. 3.3.1.1-C). In krill-rich hauls, euphausiid abundance was highest in the uppermost 200 m. Differences in vertical distribution related to developmental stages and lengths were observed in *E. superba*. All developmental stages were found in the uppermost 50 m. At 200 to 50 m depth, however, only older developmental stages were present. Accordingly, a higher proportion of larger krill individuals occurred in the 200 to 50 m depth interval than in the uppermost 50 m.

For the biomarker analysis, approximately 700 pelagic samples were collected from the RMT hauls and immediately frozen at -80 °C. Euphausiids were also sexed, staged and measured and subsequently frozen. For lipid and stable isotope analysis of benthic material, approximately 30 sediment samples and 25 benthic samples from the bottom trawl, Agassiz trawl and Multi-Corer were collected. For determination of the trophic baseline signal of primary producers, phytoplankton samples were collected with a CTD rosette at two (surface and chlorophyll max) or three (including bottom water) depths from nearly 40 stations close to the RMT stations resulting in over 130 phytoplankton samples. Samples of sea ice particulate organic matter were collected by taking ice cores at seven ice stations for a total of 30 sea-ice algae samples.

Ice coring was conducted at eight ice stations. Biomarker, texture, genetic, HPLC and taxonomic composition analyses of the cores will be performed back at AWI. Fluorometric chlorophyll *a* analysis was conducted on board for six cores from five different ice stations with a vertical resolution of 10 cm. Chl *a* concentrations were highly variable, ranging from 3 to 56 mg m^{-2} (Fig. 3.3.1.1-D). Highest chl *a* concentrations occurred in the bottom layers for five cores. However, in one core from station 82-146 chl *a* concentration was highest at the surface, which was likely due to flooding.

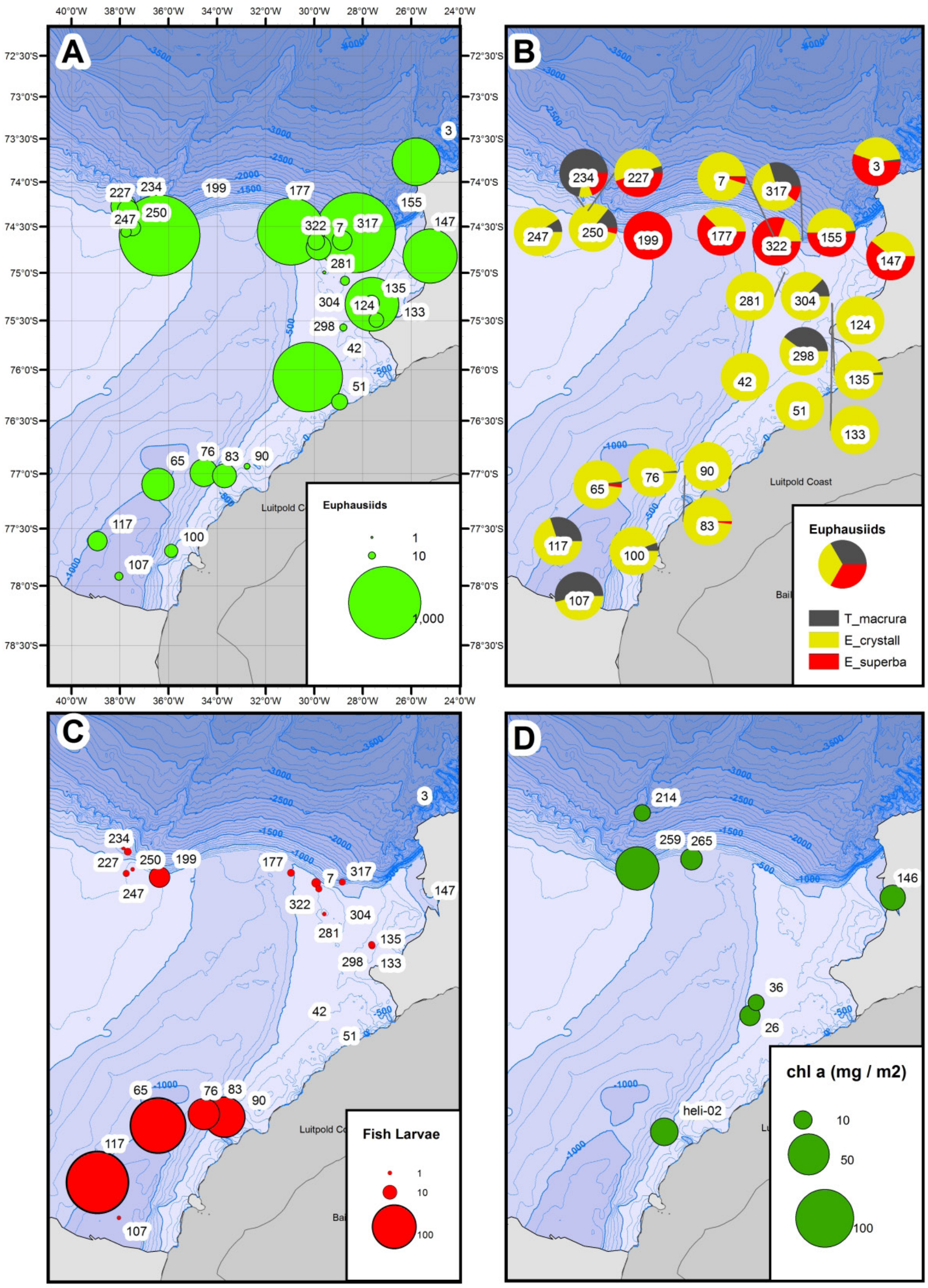

Fig. 3.3.1.1: Maps of the Filchner Outflow region showing: A) the total number of euphausiids per catch represented by symbol size for each RMT haul (Euphausia superba, Euphausia crystallorophias and Thysanoessa macrura combined); B) relative contribution of E. superba, E. crystallorophias and T. macrura for each RMT haul; C) the total number of fish larvae per catch (ca. 90 % Pleurogramma antarcticum) for each RMT haul; and D) integrated chl a concentrations (mg m^{-2}) for each ice station. Bathymetric data acquired from IBCSO (Arndt et al. 2013).

Data management

Data obtained in this project will form part of three Ph.D. and one M.Sc. theses. It is expected that all essential data will be published and made available via the

PANGAEA Data Publisher for Earth & Environmental Science (http://www.pangaea.de) within two or three years after the expedition. Depending on the speed of the different analyses, certain data sets will be available earlier, soon after the publication of the respective scientific articles.

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3.3.2. Bentho-pelagic coupling

Enrique Isla[1], Dieter Gerdes[2], Harald Biebow[3], Ariadna Purroy[1]

[1]ICM-CSIC
[2]AWI
[3]ISITEC

Grant No: AWI_PS82_03

Outline

The marine vicinities of the Filchner Ice Shelf have been identified as one of the principal areas of deep and bottom water formation in the southern Weddell Sea, where the outflow of cold and fresh water from below the shelf ice mixes with the oceanic Weddell Sea Gyre waters. The resulting physical fronts presumably convert the region in a biological hotspot. This study area is of great interest for a multidisciplinary scientific research given the fact that Polar Regions are especially sensitive to the ongoing global warming and climate change. Thus, it is easy to imagine that these biological hotspots may be undergoing rapid transformations linked to environmental changes. On this basis, analyzing how the productive processes in the pelagic zone couple with the benthic realm offers the possibility to investigate how the actual environmental conditions are reflected in the status of the local benthic communities and the chemical characteristics of the sediment providing a baseline for a region where this information is scarce. We expect to identify how the region reacts to environmental changes and the effect of these reactions on the local biogeochemical cycles, especially those of the carbon and silicon, and the Antarctic biota. We will enrich the expected results of the present project with a comparison with other areas of the Weddell Sea where climate change produced dramatic changes and others where its effects are less evident. The scenario offers unique opportunities to examine to which extent the effects of climate change in Antarctica may determine changes elsewhere in the ocean, specially, on how the influence of ice shelves determines the intensity of biological production in polar areas.

The aim of the present study is to identify the characteristics of the pelagic-benthic coupling in the marine vicinities of the Filchner Ice Shelf through, the analysis of currents, composition and fluxes of particles, abundance and distribution of benthic communities, function of selected species in carbon and silicon fluxes and biochemical characteristics of the sediment. We want to answer questions relative to the transfer of organic matter from the euphotic zone to the benthic realm and how the environmental variables may set conditions for primary production to develop.

Specific questions are:

- Is the Filchner outflow area a benthic-pelagic hotspot, i.e. a local enrichment in plankton and benthos relative to surrounding areas? What is the actual status of the diversity, abundance and biomass of the local benthic communities?
- To what extent is the biological enrichment related to particular bathymetric (ridge, canyon) and hydrographic features (vertical currents)?
- Which is the magnitude and composition of organic matter and mineral fluxes between the shelf and oceanic, surface and deep areas?
- What is the quality and quantity of the organic matter incorporated into the sediment?

- Which are the main species enhancing pelagic-benthic coupling in the area?

Objectives

Within the benthic-pelagic coupling group the particular objectives of this section are:

- To analyze the distribution of the particulate silicon and organic matter in the sediment column through the analyses of several variables (e.g., proteins, lipids, carbohydrates, phytopigments, amino acids, fatty acids and ^{14}C, ^{210}Pb)
- To identify local characteristics of particle fluxes, currents and organic matter distribution in the sediment column in a short-scale (km) spatial distribution in a presumably highly productive polar setting.

Work at sea

Sediment

A total of 16 multicorer (10 cm diameter) stations were developed in the Filchner Outflow System and its vicinities. Due to sea ice conditions most of them were located on the continental shelf on the eastern flank of the Filchner Trough, whereas four stations were carried out along the axis of the Trough and three on the continental slope. Two stations on the continental shelf off Austasen were carried out as part of the BENDEX follow-up. The complete set of sediment cores represents 18 stations. Sediment cores were subsampled on board in slices 0.5 cm (the uppermost 10 cm), 1 cm (from cm 10 to 20) and 2 cm (from cm 20 to 30) thick to a maximum core length of 30 cm. Four stations failed recovering sediment due to the nature of the substrate, either with hard sediment or covered by benthos in shallow areas close to the ice shelf edge.

Mooring

A set of two conical SMT 234 sediment traps was moored on a station at 423 m depth on the continental shelf at the eastern flank of the Filchner Trough. One trap was located 28 m above the seabed (mas) coupled to a current meter Aanderaa RCM9 located 8 mas and the second one at 233 mas. Operating time of these instruments started on January 4, 2014 and finished February 11, 2014 with sampling intervals of three days for the sediment traps and 10 min for the current meter.

Preliminary results

Sediment cores

Sediment core lengths varied between 6 and 30 cm. First observations showed that the sediment was mainly constituted by mud and sandy mud. The stations at the continental shelf showed a sandy and even gravely mud layer in the upper 8 cm; below this layer the sediment was muddy. The color varied from dark green and brownish in the upper 10 cm to grey towards the base of the cores. The continental slope stations and those in the axis of the Filchner Trough presented only greenish to grey mud. The two stations off Austasen had a 5 cm upper layer mainly constituted by sponge spicules and many infauna specimens and fine sediment.

Mooring

The sediment traps collected 13 samples, which represent a 40 days sampling period. Eye inspection of the samples revealed the presence of amphipods, faecal pellets and occasionally a jelly fish. At first sight the upper trap collected more material than the deeper one.

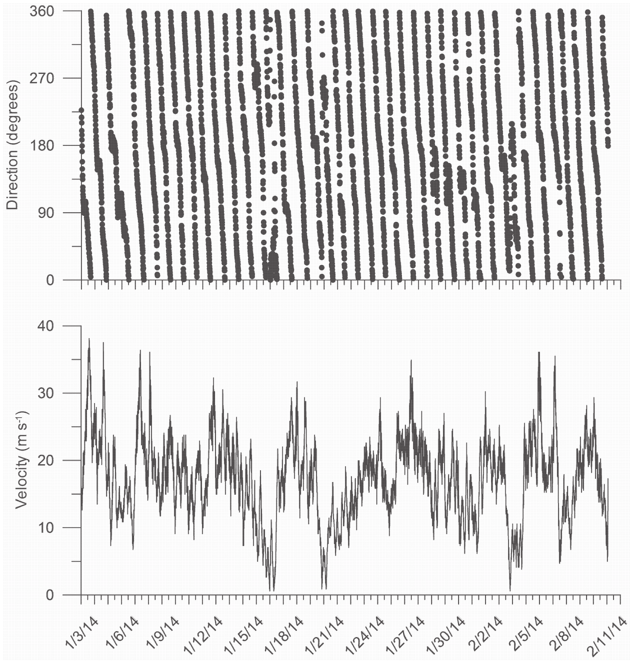

Fig. 3.3.2.1: Current velocity and direction 8 meters above the seabed at 427 m depth on the eastern flank of the Filchner Trough

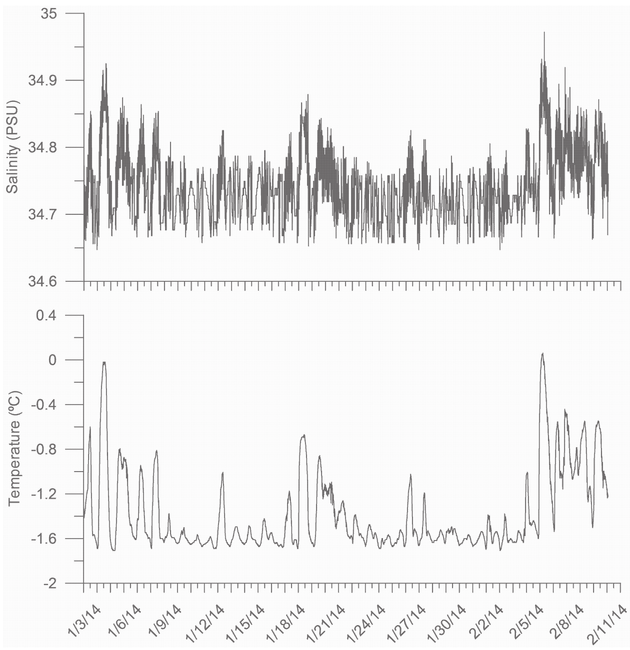

Fig. 3.3.2.2: Temperature and salinity variation 8 meters above the seabed at 427 m depth on the eastern flank of the Filchner Trough

Current meter data showed that the average current velocity for the study period was 17 cm s^{-1} with peaks of 39 cm s^{-1}. Current velocity and direction showed a variation periodicity of ca. 24 h describing an eddy like pattern where the diurnal tidal pattern showed influence (Fig. 3.3.2.1). The velocity profile showed the typical 14-day spring tide pattern. There were three distinct events when relatively warmer and saline water occurred at the mooring site, these events made the temperature and salinity gradients to vary throughout the sampling period as much as 1.6º C and 0.3 PSU, respectively (Fig. 3.3.2.2). The characteristics of these water types suggest that this variation represents warm deep water replacing low salinity shelf water. However, data are presented without post-processing; therefore, figures show absolute salinity values not true values.

Data management

All the data generated from this expedition will be included either in PANGAEA Data Publisher for Earth & Environmental Science or in the Spanish Polar Database located in the Spanish Polar Committee's National Polar Data Center, http://hielo.igme.es/index.php/en/.

3.3.3 Benthos communities

Stefano Ambroso[3], Pilar Casado de Amezúa[1,4], Kerstin Beyer[1], Harald Biebow[2], Astrid Böhmer[2], Luisa Federwisch[1], Dieter Gerdes[1], Charlotte Havermans[1,4], Nils Owsianowski[1], Santjago Pineda[1], Chester J. Sands[5], Rebecca Zapata[3]
Not on board: Christoph Held[1], M. Eléaume[6], Josep-Maria Gili[3], Claudio Richter[1]

[1]AWI
[2]ISITEC
[3]AICM-CSIC
[4]IRSNB
[5]BAS
[6]MNHN

Grant No: AWI_PS82_03

3.3.3.1 Benthos communities and production

Harald Biebow[1], Aastrid Böhmer[2], Dieter Gerdes[2], Santjago Pineda[2]

[1]ISITEC
[2]AWI

Grant No: AWI_PS82_03

Objectives

Heavy ice conditions year round make the southern Weddell Sea and particularly the Filchner Trench to a rarely visited and poorly sampled high Antarctic region. Valuable data from the Filchner Trench date back to the early studies of Voss (1988), who described the shelf fauna between Atka Bay in the northeast to the base of the Peninsula in the southwest, based on Agassiz Trawl and bottom trawl catches. According to this study a ´Southern Trench Community´ is living on the soft bottoms with scattered erratic boulders and stones in the Filchner Trench. This community type seems to differ distinctly from the biomass rich and diverse, suspension feeder dominated, shelf community on the eastern Weddell Sea Shelf. Up to now just 2 stations were sampled in the Filchner Trench with quantitative corers, positioned directly at the southernmost edge of the Filchner shelf ice, i.e. the Filchner Trench up to now appears as a gap between our benthic studies that focussed more on the northeastern Weddell Sea shelf and the Peninsula region.

The planned work aims to get quantitative samples from the Filchner Trench in order to analyse the composition, organism densities and biomass as well as production of benthic stocks in this rarely studied part of the Weddell Sea.

Work at sea

To tackle the principal objectives the multibox corer equipped with an UW camera system was deployed at 28 stations in the Filchner Outflow System (Fig. 3.3.3.1.1, Tab. 3.3.3.1.1) covering water depths from 254 to 1,216 m. Due to the heavy ice situation in the western parts of the Filchner region the bulk of stations concentrated on the northern and eastern margin of the trench; sampling on the western flank of the trench was possible only in the north. Altogether we collected on the 28 stations 143 sediment cores and 1,189 high quality UW-pictures for the description of the fauna. The cores were sieved on board over 500 µm mesh size and preserved in a 5 % seawater formaldehyde solution buffered with hexamethylentetramine prior to sorting, counting and weighing in the home laboratories.

Additional 3 cores and 165 UW pictures were obtained in the Drescher Inlet and in the BENDEX site 40 corer samples and 194 UW pictures were obtained from 5 stations inside the disturbed area (Tab. 3.3.3.5.1; *cf*. Chapter 3.3.3.5).

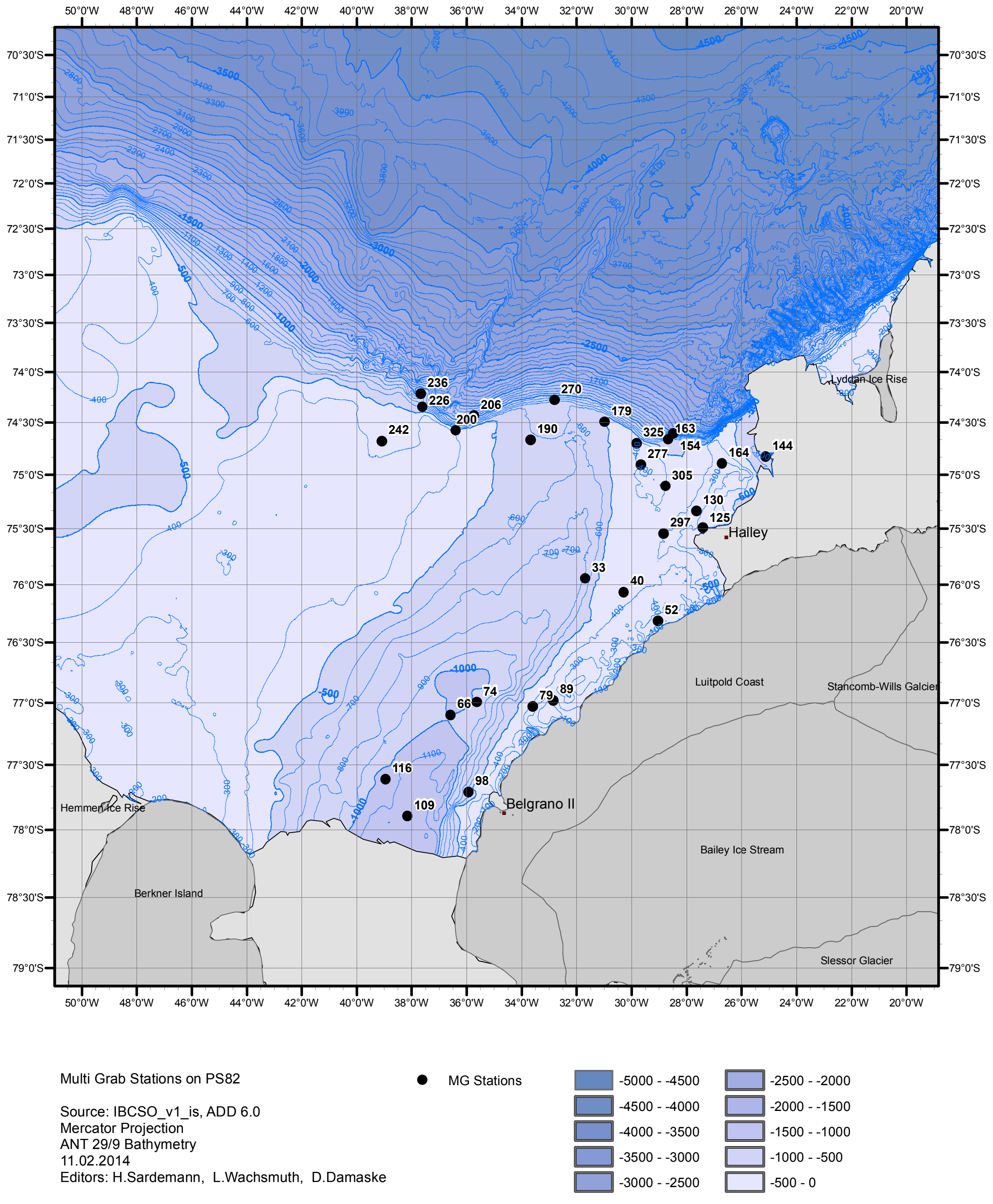

Fig. 3.3.3.1.1: Multibox corer stations in FOS

Tab.: 3.3.3.1.1: Locations of multibox corer deployments in the FOS

St. No.	Lat/Long	Date	No. of samples	Depth (m)	No.of pics	
33	75°56,83; 31°40,57	06.01.14	9	684	37	
40	76°03,96; 30°16,83	07.01.14	8	472	24	
52	76°19,06; 29°02,21	08.01.14	0	243	36	
66	77°06,09; 36°34,39	10.01.14	7	1111	34	
74	76°59,89; 34°97,71	11.01.14	8	571	59	
79	77°01,92; 33°35,19	12.01.14	8	390	32	
89	76°59,02; 32°51,05	14.01.14	(7)	254	45	qualitative
98	77° 42,76; 35° 55,73	15.01.14	7	585	58	fish
109	77° 53,92; 38° 08,49	16.01.14	1	1216	38	
116	77° 36,77; 38° 56,70	17.01.14	7	1060	23	
125	75° 29,48; 27° 24,60	19.01.14	4	286	35	
130	75° 20,28; 27° 38,48	20.10.14	3	361	69	
144	74° 49,80; 25° 07,44	21.01.14	8	702	16	inner slope
154	74°36,53; 28° 28,72	22.01.14	7	1217	81	
163	74°39,94; 28°40,16	24.01.14	8	696	49	outer slope
164	74°53,67; 26°42,48	24.01.14	8	290	45	
179	74°29,86; 30°59,01	25.02.14	8	530	83	
190	74°40,21; 33°40,27	26.01.14	8	591	103	NW Filchn.
200	74°34,73; 36°23,70	27.01.14	8	426	46	barnacles
206	74°26,09; 35° 43,48	28.01.14	8(7)	1140	51	barnacles
226	74°21,12; 37°36,14	31.01.14	1	554	47	
236	74° 13,23; 37° 39,67	01.02.14	4	798	71	
242	74°40,84; 39°04,43	02.02.14	4	436	61	
270	74°17,05; 32°47,81	06.02.14	4	835	46	
277	74°54,42; 29°39,80	07.02.14	0	406	146	no sampling
297	75°32,61; 28°49,88	08.02.14	0	412	116	no sampling
305	75°06,53; 28°45,83	09.02.14	0	413	120	no sampling
325	74°42,28; 29°48,41	11.02.14	5	427	85	
344	72°48,38; 19°18,13	14.02.14	3	485	165	Drescher Inl
346	70°56,67; 10°32,07	16.02.14	8	308	39	BEND.289
348	70°56,64; 10°32,02	16.02.14	8	304	32	BEND.280
350	70°56,55; 10°31,85	16.02.14	8	297	48	BEND 288
359	70°56,63; 10°32,19	17.02.14	8	322	29	BEND.285
360	70°56,50; 10°31,64	17.02.14	8	283	46	BEND.202

Preliminary results

Based on first visual checks of UW-pictures the benthic macrofauna of the Filchner region appears rather heterogeneous and in some areas extremely patchily distributed. At a first glance we can distinguish between 5 different community types, although, due to extreme sea ice conditions we could not properly sample the central and western regions of the Filchner region – especially south of 76° S.

The deep basins of the southern trough are inhabited by the ´Southern Trench Community´ *sensu* Voss (1988), in which suspension feeders are almost absent and migrating deposit feeders are numerous. On fine sand with gravel and small stones on top lives an impoverished fauna, which is dominated by the elasipod holothurian *Protelpidia murrayi*. Most of the specimens, which occurred with up to 30 individuals in the pictures were juveniles. Dropstones were occasionally covered by small sponges. At St. No. 116 the echinoid *Sterechinus neumayeri* was frequent, and actinarians attached to small stones were sometimes visible. Ophiuroids and polychaetes occurred only seldom, as well as crustaceans. At the more northern trough station 33, the fauna appeared a bit more diverse. The echinoid *Sterchinus neumayeri* occurred often, tube building polychaetes, ophiuroids and echinoids (*Sterechinus neumayeri*) are common, crustaceans (*Notocrangon*; *Serolis*, a mysid), small sponges attached to stones and holothurians (species different as compared to the south) were rare (Fig. 3.3.3.1.2).

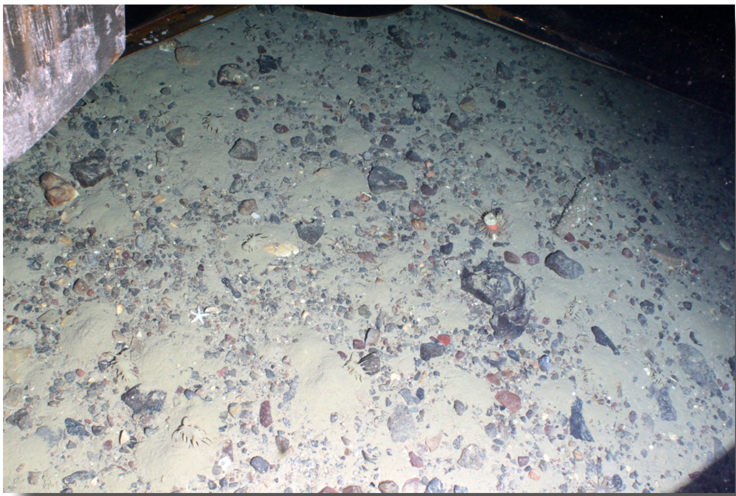

Fig. 3.3.3.1.2: The Southern Trench Community

The ´Eastern Shelf Community´ *sensu* Voss (1988) lived on the north-eastern shelf in water depths down to 400 m. In or study the southern border of this community is defined by St. No 52 at 76° 19´; the exact border, however, remains unclear because of our in-complete station grid in the south. This community is dominated by suspension feeding sponges, bryozoans, ascidians and ophiuroids building up a biomass rich three-dimensional

Fig. 3.3.3.1.3: The Eastern Shelf Community

community type with a diverse associated fauna, living in and on these habitat structuring species, thus having better access to the by currents transported food items (Fig 3.3.3.1.3).

The 3rd traditional community type already defined by Voss (1988) is the ´Southern Shelf Community´. In our study this community was found at St. No. 89 in 254 m water depth. This community is characterized by the dominance of suspension feeding bryozoans (Fig. 3.3.3.1.4), ascidians and sedentary polychaetes occurred frequently, whereas ophiuroids (*Ophioplinthus gelida),* sponges, pennatularians and crustaceans were rare.

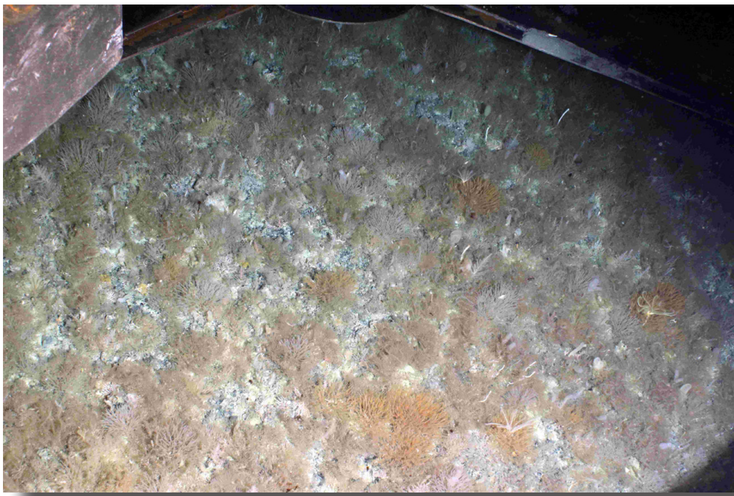

Fig. 3.3.3.1.4: The Southern Shelf Community

Faunistically interesting appears the northern part of the Filchner region. The northern slope of the area (water depths between 700 and 1,200 m) towards the deep Weddell Sea basin is inhabited by a ´Northern Slope Community´ living on sediments, which are covered by gravel and small and medium sized stones, occasionally also by bigger stones (Fig. 3.3.3.1.5). This community type is dominated by a diverse ophiuroid fauna with *Ophiacantha antarctica, Ophiocantha pentactis, Ophiocamax gigas, Ophiocten megalopax, Ophioleuce regulare,* and *Ophionotus victoriae* contributing especially to this dominance. Also very abundant at all stations are sedentary polychaetes, at St. 206 also serpulids (*Serpula narconensis*). At the two eastern slope stations small specimens of the hydrocoral *Errina laterorifa* are very abundant attached to stones of different sizes, whereas especially at the western slope St. 206, but also at St. 163, small sponges are very abundant. Also other taxa contribute to a high diversity in this community, however, they all seem to be rare. At St. 206, which is situated directly in the outflow of the super-cooled ice shelf water (ISW), these small sponges reached densities of up to 35 specimens per picture. Lots of barnacle shell debris covering the entire sediment surface in all pictures are another special feature of this station and also of the adjacent St. 200, which, however, is a western shelf station with 400 m water depth.

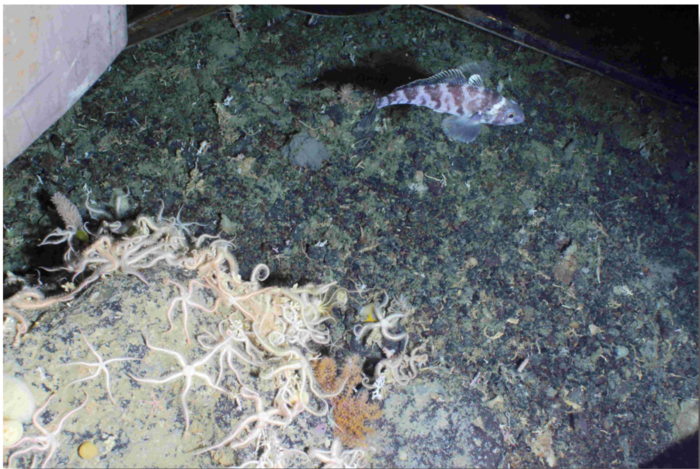

Fig. 3.3.3.1.5: The Northern Slope Community

A ´Western Shelf Community` is represented by two stations (Nos. 200 and 226) on the northwestern shelf of the Filchner Trench in water depths from 426 to 530 m. The benthos appears rather impoverished with a diverse but not abundant echinoderm fauna, mainly asteroids and echinoids, crinoids, ohiuroids and holothurians were rather rare. The hydrocoral *Errina laterorifa* was quite abundant at St. 226, mostly with young specimens but also some aggregations of bigger ones, and the same holds true for sponges, which, however, seem to be rare in this community as also are bryozoans and especially polychaetes (Fig. 3.3.3.1.6).

Fig. 3.3.3.1.6: The Western Shelf Community

This preliminary classification of benthic communities in the Filchner Region bases on the analysis of few UW-pictures per station taken with the UW-camera attached to the multibox corer. The future analysis of the entire pictures will provide much more valuable information for better recognition of the different community types in this part of the Weddell Sea. This additional information has to be combined with the data obtained from the numerous corer samples thus completing a nice data set that will allow detailed insight into the Filchner Outflow System (FOS) with its different benthic communities. In a next step these results have to be related to environmental parameters, e.g. to different water masses and the complex current regimes, which we believe shape the distribution patterns of communities considerably.

Beside the community analyses the UW-pictures also provide insights into behavior and biology on single species level. An example for this is the finding of fish nests at two stations on the eastern trench slope: St. 98 in 585 m and further north St. 277 in 406 m water depths. At St. 98 we found dense nest aggregations of the Jonah glassfish *Neopagetopsis ionah,* we counted on 58 UW pictures 82 nests. 19 nests were empty, 5 nests had eggs and were not guarded and in 7 nests we found carcasses of dead specimens. The nests were digged some centimeters into the sediment and had a diameter of appr. 50 to 60 cm. In the center the fish accumulated gravel and small stones, on which the eggs were attached (Fig. 3.3.3.1.7). We estimated after first counts > 1,000 eggs per nest.

Fig. 3.3.3.1.7: The Ionah glassfish Neopagetopsis ionah

Fig. 3.3.3.1.8: The spiny ice fish Chaenodraco wilsoni Regan 1914

At St. 277 we found in 6 UW-pictures stones to which the spiny ice fish *Chaenodraco wilsoni* Regan 1914 had attached his eggs (Fig. 3.3.3.1.8). We counted from 4 stones the egg numbers and came up with a mean number of 530 eggs per stone. At both stations the quite abundant holothurian *Elasipodida* sp. was obvious, which was obviously feeding on the fish eggs.

We will combine our data with those of the fish group onboard (*cf.* Chapter 3.3.4.4) who sampled the same stations with AGTs and/or bottom trawls thus completing their studies on fish fecundity based on caught fish specimens.

Data management

All data generated from this expedition will be published in the AWI data base PANGAEA (http://www.pangaea.de).

References

Voss J (1988) Zoogeographie und Gemeinschaftsanalyse des Makrozoobenthos des Weddellmeeres (Antarktis). Ber. Polarforsch., 45.

3.3.3.2 Understanding the persistence and maintenance of Weddell Sea macrobenthos using molecular techniques

Chester J. Sands[5], Charlotte Havermans[1,4], Kerstin Beyer[1], Pilar Casado de Amezúa[1], Rebecca Zapata[3], Stefano Ambroso[3], Astrid Böhmer[1]
Not on board: Claudio Richter[1]

[1]AWI
[2]ISITEC
[3]ICM-CSIC
[4]IRSNB
[5]BAS

Grant No: AWI_PS82_03

Objectives

The long-term isolation of the benthic fauna on the Antarctic continental shelf and slope, from that of neighbouring shelf regions, has produced a unique assemblage that is rich and diverse (Clark & Johnston 2003). Understanding how such an assemblage is maintained over evolutionary and ecological time scales is possible by testing specific sets of hypotheses using modern molecular laboratory techniques and statistical tools. The Filchner Outflow System as a sampling location provides an excellent opportunity to test molecular ecological hypotheses regarding the movement or connectivity of populations across different depths, different sediment types, different current regimes and different water masses. Our objectives on this expedition were to collect statistically meaningful numbers of selected taxa from as many varying locations as possible across the Filchner area of continental shelf, and by collaboration, work up a detailed picture of the physical environment of each station. The taxa we focused on were crustaceans, glass sponges, gorgonians and ophiuroids. A further objective was to collect samples suitable for stable isotope analysis to strengthen existing models of trophic interactions around the Antarctic.

Work at sea

The specimens for ecological and evolutionary genetic work were collected using Agassiz trawl (AGT), bottom trawl (BT) and Rauschert dredge (RD). The RD was deployed mid-ships. The frame was lowered at 0.4 ms^{-1} until the cable length was 50 m longer than the depth. The trawl began at 0.5 kn for 10 min, after which the trawl was recovered at 0.3 ms^{-1} until the frame was clear of the sea floor, then increased to 0.5 ms^{-1}.

Specimens were sorted, labelled and photographed to obtain information about the colour patterns of the different species while still alive. Ophiuroids and crustaceans were fixed whole in 96 % ethanol. For gorgonians and poriferans, a tissue sample, were fixed in 100 % ethanol, a second gorgonian fragment was fixed in 70 % ethanol for further identification at the stereomicroscope on board. Gorgonian colonies and some poriferan tissue samples were frozen at -20 ºC for DNA studies. For some gorgonian specimens, tissue was buffered in 50mM Tris-HCl pH 8.0 for DNA storage in FTA cards. Moreover, some tissue of selected gorgonian and crustacean specimens were fixed in RNA latter and stored at -20 ºC for RNA analysis. Cnidarians (other than gorgonians) were fixed for morphological studies (histology, anatomy, etc.) in buffered 4 - 8 % formaldehyde, fragments of each morphospecies were also fixed in 100 % ethanol for further molecular analysis. Once in the laboratory, all specimens will be preserved in 70 % ethanol.

For stable isotope analysis, invertebrates and fishes were collected from bottom trawls, Agassiz trawls, dredges and baited traps. Small organisms were sampled completely, while from macro- and megafaunal specimens’ body wall pieces or muscle tissue samples were taken for analysis. All samples were rinsed with distilled water and frozen at -20 °C until further analysis of stable isotope ratios (N, C) at home. For later validation of the taxonomy reference animals were preserved in 70 % ethanol.

Preliminary (expected) results

The RD was deployed at 10 stations. Positions and depth are provided in Table 3.3.3.2.1. Details of the AGT and BT can be found in sections 3.3.3.3 and 3.3.4.1, respectively.

Tab. 3.3.3.2.1: Station details for each RD deployment

Station	Date	Time	Latitude	Longitude	Depth [m]
PS82/127-1	19/01/2014	15:05	75° 28.78 S	27° 21.66 W	275.5
PS82/134-1	20/01/2014	13:28	75° 19.52 S	27° 35.93 W	364.5
PS82/148-1	21/01/2014	20:08	74° 49.58 S	25° 10.51 W	691.7
PS82/169-1	24/01/2014	16:58	74° 52.32 S	26° 35.77 W	319.7

Station	Date	Time	Latitude	Longitude	Depth [m]
PS82/176-1	25/01/2014	14:05	74° 32.05 S	30° 56.50 W	528.7
PS82/251-1	02/03/2014	19:15	74° 29.58 S	37° 29.96 W	385.5
PS82/283-1	02/07/2014	17:16	74° 58.63 S	29° 23.79 W	408.2
PS82/295-1	02/08/2014	12:17	75° 31.34 S	28° 49.66 W	420.5
PS82/307-1	02/09/2014	14:47	75° 5.38 S	28° 39.95 W	445.5
PS82/351-1	16/02/2014	17:28	70° 56.41 S	10° 32.58 W	314.5

- *Crustaceans*

The Southern Ocean is considered as a hotspot for biodiversity and endemism for several orders of peracarid crustaceans (e.g. isopods, amphipods) that have undergone spectacular adaptive radiations. Of these, amphipods are the most speciose animal group in Antarctic coastal and shelf regions. Although extensively sampled and studied in several regions of the Southern Ocean (e.g. Antarctic Peninsula and Scotia Sea), recent studies show that most species are inadequately described or composed of several genetically heterogeneous species complexes, with allopatric or sympatric distributions. Hence, the underexplored Filchner area could provide a number of species new to science for several crustecean groups and information regarding the connectivity between these shelf areas, surrounding regions and abyssal basins.

Species numbers and abundances per station are summarized for several crustacean taxa (Amphipoda, Decapoda, Cumacea, Cirripedia, Euphausiacea, Mysidacea, Tanaidacea) in Tab. 3.3.3.2.2 a and b, Tab. 3.3.3.2.3 and Tab. 3.3.3.2.4 for the three different gears used. Finally, sampling by means of amphipod traps attached to the fish trap lander system at station PS82/118 provided thousands of scavenging lysianassoid amphipod species, which can be used for population genetic studies.

- *Decapoda*

Only three species of decapods were recovered. The two species *Notocrangon antarcticus* and *Chorismus antarcticus* were found together in all shelf depth trawls except for the shelf station at Austasen. In the AGT station at the eastern shelf break/slope around 1,750 m depth and the northern bottom trawl stations PS82/331 (760 m) and PS82/341 (740 m), these species were replaced by *Nematocarcinus longirostris*, present in high numbers (300, 205 and 45 specimens respectively).

- *Amphipoda*

The AGT recovered the highest abundance (> 1,100 specimens) and species richness (80 different species) at the easternmost station on the southern shelf (PS82/91; 290 m). Most species belonged to the family Iphimediidae, as associated fauna to the large quantities of bryozoans that characterized this catch. The stations at the Filchner Trench (i.e. PS82/67, PS82/111, PS82/115) were characterized by a low abundance and species richness of amphipods, and crustaceans in general. BT catches were characterized by a high diversity and abundance of epimeriid and iphimediid species. The station with the highest species richness and abundance was situated at the NE shelf (PS82/11; 300 m). The two northernmost stations sampled using the RD were characterized by the highest abundance and species richness (+/- 50 species) of amphipods.

Tab. 3.3.3.2.2.a: see electronic supplement

Tab. 3.3.3.2.2.b: Species numbers and abundances for crustacean taxa

Taxa / Stations	296-1		306-1		316-1		331-1		341-1		357-1	
	Sp	N	Sp	N	Sp	N	Sp	N	Sp	N	Sp	N
Amphipoda												
Ampeliscidae	0	0	0	0	0	0	0	0	0	0	0	0
Epimeriidae	1	1	0	0	2	4	3	4	1	2	1	1
Eusiroidea	2	3	1	1	0	0	0	0	0	0	0	0
Iphimediidae	3	4	1	1	1	1	1	1	0	0	0	0
Leucothoidea	0	0	0	0	0	0	0	0	0	0	0	0
Lysianassoidea	0	0	0	0	0	0	1	1	0	0	0	0
Melitidae	0	0	0	0	0	0	0	0	0	0	0	0
Oedicerotidae	0	0	0	0	0	0	0	0	0	0	1	1
Stenothoidae	0	0	0	0	0	0	0	0	0	0	0	0
Stilipedidae	0	0	0	0	0	0	0	0	0	0	0	0
Indet	0	0	0	0	0	0	0	0	0	0	0	0
Decapoda												
Notocrangon antarcticus	1	18	1	14	0	0	0	0	0	0	0	0
Nematocarcinus longirostris	0	0	0	0	1	2	1	205	1	45	0	0
Chorismus antarcticus	0	0	1	1	0	0	0	0	0	0	1	4
Euphausiacea	0	0	0	0	0	0	0	0	0	0	0	0
Isopoda												
Flabellifera – Serolidae	1	1	1	1	0	0	0	0	0	0	0	0
Flabellifera – Gnathiidae	0	0	0	0	0	0	0	0	0	0	0	0
Flabellifera – *Natatolana*	0	0	0	0	0	0	0	0	0	0	0	0
Valvifera – Arcturidae	0	0	1	1	0	0	0	0	0	0	0	0
Valvifera – *Glyptonotus*	1	1	0	0	0	0	0	0	0	0	0	0
Indet	0	0	0	0	0	0	0	0	0	0	0	0
Mysidacea	1	18	1	1	1	2	1	2	1	3	0	0
Tanaidacea	0	0	0	0	0	0	0	0	0	0	0	0
Total species number	10		7		5		7		3		3	
Total abundance	46		20		9		**213**		50		6	

Tab. 3.3.3.2.3: see electronic supplement

Tab. 3.3.3.2.4: Species numbers and abundances per station are summarized for several crustacean taxa

Stations	127-1		134-1		148-1		169-1		176-1		251-1		283-1		295-1		307-1		351-1	
Taxa	Sp	N	Sp	N	Sp	N	Sp	N	Sp	N	Sp	N	Sp	N	Sp	N	Sp	N	Sp	N
Amphipoda																				
Amathillopsidae	0	0	0	0	0	0	1	12	3	16	1	3	0	0	0	0	0	0	0	0
Ampeliscidae	1	2	1	1	0	0	1	35	1	6	2	8	1	2	2	28	1	3	2	2
Calliopidae	0	0	0	0	0	0	0	0	0	0	1	111	0	0	0	0	1	2	1	3
Caprellidea	0	0	0	0	0	0	0	0	5	5	0	0	0	0	3	8	0	0	0	0
Corophioidea	0	0	0	0	0	0	1	2	3	6	5	7	3	3	0	0	0	0	0	0
Epimeriidae	1	3	2	2	0	0	4	5	3	3	3	10	1	1	1	1	0	0	0	0
Eusiroidea	2	5	2	6	0	0	3	11	3	35	6	31	3	6	1	2	0	0	2	2
Iphimediidae	4	5	6	7	0	0	4	5	2	6	0	0	0	0	0	0	1	3	0	0
Isaeidae	1	2	1	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
Ischyroceridae	0	0	0	0	0	0	0	0	2	4	1	5	0	0	0	0	0	0	0	0
Lepechinellidae	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0
Leucothoidea	0	0	1	1	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0
Liljeborgiidae	1	3	1	1	0	0	0	0	0	0	3	4	1	1	1	1	0	0	0	0
Lysianassoidea	2	6	1	1	0	0	1	1	7	10	8	166	6	9	3	3	2	3	3	3
Melphidippidae	0	0	1	1	0	0	0	0	2	44	1	7	2	7	1	4	0	0	1	1
Oedicerotidae	0	0	0	0	0	0	2	12	3	51	1	1	1	1	1	2	1	1	0	0
Phoxocephalidae	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	2	1	1	0	0
Podoceridae	1	1	0	0	0	0	0	0	2	22	1	2	0	0	1	3	1	1	0	0
Stegocephalidae	0	0	0	0	0	0	0	0	2	10	2	9	0	0	2	3	1	1	0	0
Stenothoidae	0	0	0	0	0	0	0	0	0	0	1	27	0	0	0	0	1	1	0	0
Stilipedidae	0	0	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0
Synopidae	0	0	0	0	0	0	1	6	0	0	1	8	1	6	1	7	0	0	0	0
Indet	10	>50	11	46	3	4	11	71	10	129	10	112	10	15	13	31	7	8	1	1
Cumacea	5	>50	2	16	2	8	8	44	7	67	3	3	7	91	12	85	8	13	4	5

Taxa / Stations	127-1		134-1		148-1		169-1		176-1		251-1		283-1		295-1		307-1		351-1	
	Sp	N	Sp	N	Sp	N	Sp	N	Sp	N	Sp	N	Sp	N	Sp	N	Sp	N	Sp	N
Decapoda																				
Notocrangon antarcticus	0	0	1	2	0	0	1	4	0	0	1	5	1	1	1	1	0	0	0	0
indet	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Euphausiacea	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Isopoda																				
Asellota	0	0	0	0	1	1	1	3	4	17	5	13	1	1	2	2	1	1	2	2
Flabellifera –Serolidae	0	0	0	0	0	0	0	0	2	7	1	1	0	0	0	0	0	0	0	0
Flabellifera – Gnathiidae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
Flabellifera –*Natatolana*	0	0	0	0	0	0	0	0	1	1	1	124	0	0	1	1	0	0	0	0
Valvifera – Arcturidae	1	1	0	0	0	0	1	6	4	15	1	6	2	4	1	4	2	2	1	1
Valvifera – *Glyptonotus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Indet	1	1	1	1	0	0	0	0	1	5	0	0	1	1	0	0	0	0	1	2
Mysidacea	1	2	1	2	3	7	4	22	4	55	5	31	1	1	3	12	4	4	3	3
Tanaidacea	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	0	0	0	0
Total species number	32		31		9		**44**		**75**		**66**		43		54		32		21	
Total abundance	> 134		88		20		**239**		**520**		**697**		151		202		44		25	

In the amphipod traps, a total of 8 amphipod species and 1 isopod species (*Natatolana* sp.) were found. The lysianassoid species *Orchomenella* (*O.*) *pinguides*, *Uristes* sp. and *Waldeckia* spp. were the most abundant. Other amphipod species included the lysianassoid species of the genera *Hirondellea* and *Pseudorchomene*, an unidentified lysianassoid species and *Eusirus* sp.

- *Isopoda*

Serolid species were most abundant at the AGT stations PS82/43 and PS82/73 on the outer shelf at +/- 470 m and the southern shelf at +/- 570 m depth, respectively, as well as at the bottom trawl stations PS82/11 (300 m) and PS/249 (370 m). Other most abundant species recovered in BT and AGT were *Natatolana* spp. and *Glyptonotus antarcticus*.

- *Cumacea*

Cumaceans were more dominant than amphipods in the RD samples characterised by gravel and fine sediment, in contrast to dredge samples dominated by sponge spicules or bryozoans. The most diverse catch was that at station PS82/295 (420 m), with 12 different species and a number of 85 specimens. Station PS82/283 (408 m) was characterized by the highest abundance (91 specimens, belonging to 7 different species). The AGT deployed at station PS82/151 (1,750 m) contained the highest number of specimens (33) for all trawls, indicating that the relative abundance of cumaceans increases with depth.

Upon return in the home laboratory, DNA extractions will be carried out on several taxa of interest for molecular studies. For amphipods, these taxa include the families Lysianassoidea, Epimeriidae and Iphimediidae, for which an extensive DNA barcode (COI) library has been established so far. Lysianassoid samples will be used to complement on-going phylogenetic and phylogeographic studies (see Havermans et al. 2010, 2011; Havermans *in press*) by means of sequencing of mitochondrial (COI, 16S rDNA) and nuclear (28S rDNA, 18S rDNA) gene fragments. Population genetic studies will be initiated using abundant amphipod taxa such as *Orchomenella* (*O.*) *pinguides*, *Waldeckia obesa*, *Eusirus* spp. and iphimediid species by developing microsatellite or SNP markers based on Next-Generation Sequencing data. Ongoing or past population genetic studies on decapods (*N. antarcticus*, *C. antarcticus*) and isopods (serolids, *Glyptonotus antarcticus*) can be complemented by the numerous samples obtained during this expedition.

- *Ophiuroids*

There are 219 species of ophiuroids to be found in Antarctic waters of which 126 are endemic (Marin-Ledo & López-González 2013). The majority of species are small and morphologically cryptic. However, the more common, large ophiuroids are possible for a non-expert taxonomist to identify. Ophiuroids were collected from all stations and tentative identifications are given in Tab. 3.3.3.2.5. The most common species was *Ophiacantha antarctica*, present at most stations. Other common species include *Ophionotus victoriae*, *Ophioplinthus gelida*, *Ophiocten dubium*, *Ophioceres incipiens* and *Ophioperla koehleri*. *Ophioperla koehleri* was only found in shallower regions, (max depth found 570 m).

Based on non-expert morphotype sorting some biogeographical patterns were apparent suggesting distinct assemblages for the eastern shelf region, the trough and western shelf region, the shelf break, and the Filchner Trench in the south. The Filchner Trench itself was impoverished with only *O. victoriae* collected from the two southernmost stations. This contrasts with the eastern shelf fauna (i.e., shallower regions close to the continent) that even at the southernmost shelf station was considerably more diverse. This may be related to depth, substrate and current regimes. There was no obvious difference between the ophiuroid assemblages from the north or south of the eastern shelf. Typical species that defined this inner shelf assemblage include *Astrotoma agassizi*, *Ophiosteira* sp. and, at shallower stations, *Ophiura caranifera*. The shelf break was another clearly definable assemblage. *Ophiacantha pentactis* was collected exclusively and in large numbers from these stations (PS82/233, western shelf break at 830 m; PS82/266, mid trough shelf break at 720 m; PS82/314 eastern shelf break at 710 m), but not from deeper slope station (e.g. PS82/151 eastern slope 1,750 m) nor from stations of similar depth but clearly on the shelf itself (e.g. PS82/264 mid trough close to shelf break at 650 m). *Astrochlamys sol* was also collected only from shelf break stations. The stations south of the shelf break, both in the trough itself and to the shallower regions to the west of the trough, had similar assemblages consisting mostly of the common species *Ophiacantha antarctica*, *Ophioplinthus gelida* and *Ophionotus victoriae*.

On return samples will be identified by a taxonomist specializing in Antarctic ophiuroids, DNA will be extracted from all individuals and the Cytochrome c Oxidase subunit one gene amplified for molecular identification and initial phylogenetic analyses. Specific hypotheses will be tested using double digested restriction associated DNA sequencing (ddRAD). Species presence data will be submitted to the SCAR MarBIN database. DNA sequences will be submitted to GENBANK.

- *Poriferans*

Poriferans are a regionally important element in some Antarctic benthic communities. They can be considered as ecosystem engineers as they provide structure to the sea-floor positively influencing the diversity and composition of Antarctic benthic communities, facilitating recruitment of other sessile organisms, and serve as refuge various species including juvenile stages of fish (Kaiser et al. 2013). *Rossella racovitzae* and *Anoxycalyx joubini* are two dominant species that form these extensive assemblages, and are suspected to reproduce actively by asexual reproduction (Teixidó et al. 2006). However the extent of asexual reproduction and the balance sexual/asexual reproduction that contributes to the assemblage structure is unknown. The major aim of this study was to investigate the population structure of both species at a microscale (within sampling sites) and regional scale (between sampling sites) using population genetic techniques to better understand species dispersal capacities and genetic variability within and among the different localities.

Ten to 30 samples of *R. racovitzae* and 7 to 27 samples of *A. joubini* were collected using AGT and BT from 5 stations (Tab. 3.3.3.2.6).

Tab. 3.3.3.2.5: Identified ophiuroids collected at stations using AGT and BT

AGT	Amphiura sp	Astrochlamys bruneus	Astrochlamys sol	Astrotoma agassizi	Ophiacantha antarctica	Ophiacantha pentactis	Ophiacantha sp	Ophiolimna antarctica	Ophiosparta gigas	Ophiocten dubium	Ophiocten sp	Ophioleuce regulare	Ophioceres incipiens	Ophiosteira sp	Ophioperla koehleri	Ophioplinthus gelida	Ophioplinthus sp	Ophiura carinifera	Ophiura sp	Ophiomastus sp	Ophiomusium sp	Ophionotus victoriae	UNKNOWN	ASSORTED SMALL UNKNOWN
PS82/43	X			X	X		X			X	X			X	X	X						X	X	
PS82/50																X	X	X					X	X
PS82/67									X	X													X	
PS82/73				X	X					X				X	X		X					X	X	
PS82/91				X												X		X				X		X
PS82/97				X											X		X	X				X		
PS82/112																						X		
PS82/115																						X		
PS82/151					X																	X	X	
PS82/233					X	X		X				X					X						X	
PS82/264	X									X			X				X							
PS82/266			X		X	X											X							
PS82/284	X				X					X					X	X								
PS82/293	X				X			X		X						X				X		X	X	
PS82/308	X				X					X					X							X	X	
PS82/314			X		X	X							X											
PS82/349													X	X		X	X	X						
BT																								
PS82/11					X			X		X	X				X	X	X				X	X		
PS82/18	X				X					X	X		X		X	X	X					X		X
PS82/39					X			X		X	X				X									
PS82/53	X			X						X				X		X		X				X	X	X
PS82/78					X		X				X			X									X	X
PS82/84	X			X	X			X		X	X				X	X	X					X		
PS82/88	X			X	X					X	X			X		X	X						X	X
PS82/126					X																	X		X
PS82/129																								
PS82/166	X				X					X					X	X	X					X		X
PS82/175					X										X		X					X		
PS82/201					X																			
PS82/244															X	X	X							
PS82/248	X				X										X		X						X	
PS82/249					X								X										X	X
PS82/282	X	X			X					X					X							X		
PS82/296	X			X	X					X													X	X
PS82/306				X	X					X					X							X	X	
PS82/316					X	X				X		X	X											
PS82/331					X	X		X				X	X		X			X		X			X	
PS82/341				X	X	X				X			X				X							
PS82/357					X	X		X					X		X	X	X					X		

Tab. 3.3.3.2.6: Sampling sites and number of individuals per sponge species collected at each station

Station	**Gear**	**Depth [m]**	***Rosella racovitzae***	***Anoxycalys joubini***
PS82/011	BT	406	10	9
PS82/053	BT	261	18	10
PS82/088	BT	265	28	27
PS82/166	BT	306	10	7
PS82/349	AGT	225	30	14

Four stations were located in the Filchner area and one was in Austasen. Samples from both areas were collected on a depth range 220-410 m. Presence of propagules was recorded and, where present, these were sampled and preserved for further analysis. Two different preservation treatments were used, -20 ºC storage temperature and 100 % ethanol and storage in cool chambers, in order to ensure a suitable preservation for further DNA isolation. The genetic analyses will be done at the home laboratory. For the molecular genetics analysis, RAD-Seq (restriction site associated DNA sequencing) will be used. This genetic approach is exceedingly sensitive and is able to provide information on the maintenance and/or extinction of local populations, the recovery after disturbance, and the colonization of new areas.

Gorgonians

The cnidarian material collected during PS82 was obtained from 21 Bottom Trawls, 14 Agassiz Trawls, 2 Multicorers, 2 Multigrabs and one Rauschert Dredge. More than 1,200 individuals/colonies have been preliminarily identified on board, although most are awaiting further morphological studies in the laboratory (e.g. histology, SEM). The specimens belong to 95 morphospecies, of which 14 belong to Hydrozoans, 5 to jellyfishes and 76 to Anthozoans. This last group includes 44 species belonging to Octocorallia and 32 to the Hexacorallia. The hexacoral species consisted of 22 actiniarians, 7 scleractinians and 3 zoanthideans. While the octocoral material collected consisted of 3 species of pennatulaceans, 3 bamboo corals, 4 soft corals and 34 primnoid species.

Preliminary results on the primnoids composition showed that shallow stations from the east flank of the Filchner Trough are more diverse than deeper ones (>1,000m), and than stations from the west flank. Data from the shelf break stations suggests they are less diverse than the eastern shelf. In the northern stations (up 76º) gorgonian communities are dominated by *Dasystenella acanthina*, while in the southern stations *Thouarella* species seem to be the dominant (Fig. 3.3.3.2.1).

For the present study on the gorgonian population structure and connectivity genomic DNA will be extracted from seven primnoid species. For each species we collected a minimum of 5 specimens at each station, but not all species have been found in the same stations (Tab. 3.3.3.2.7).

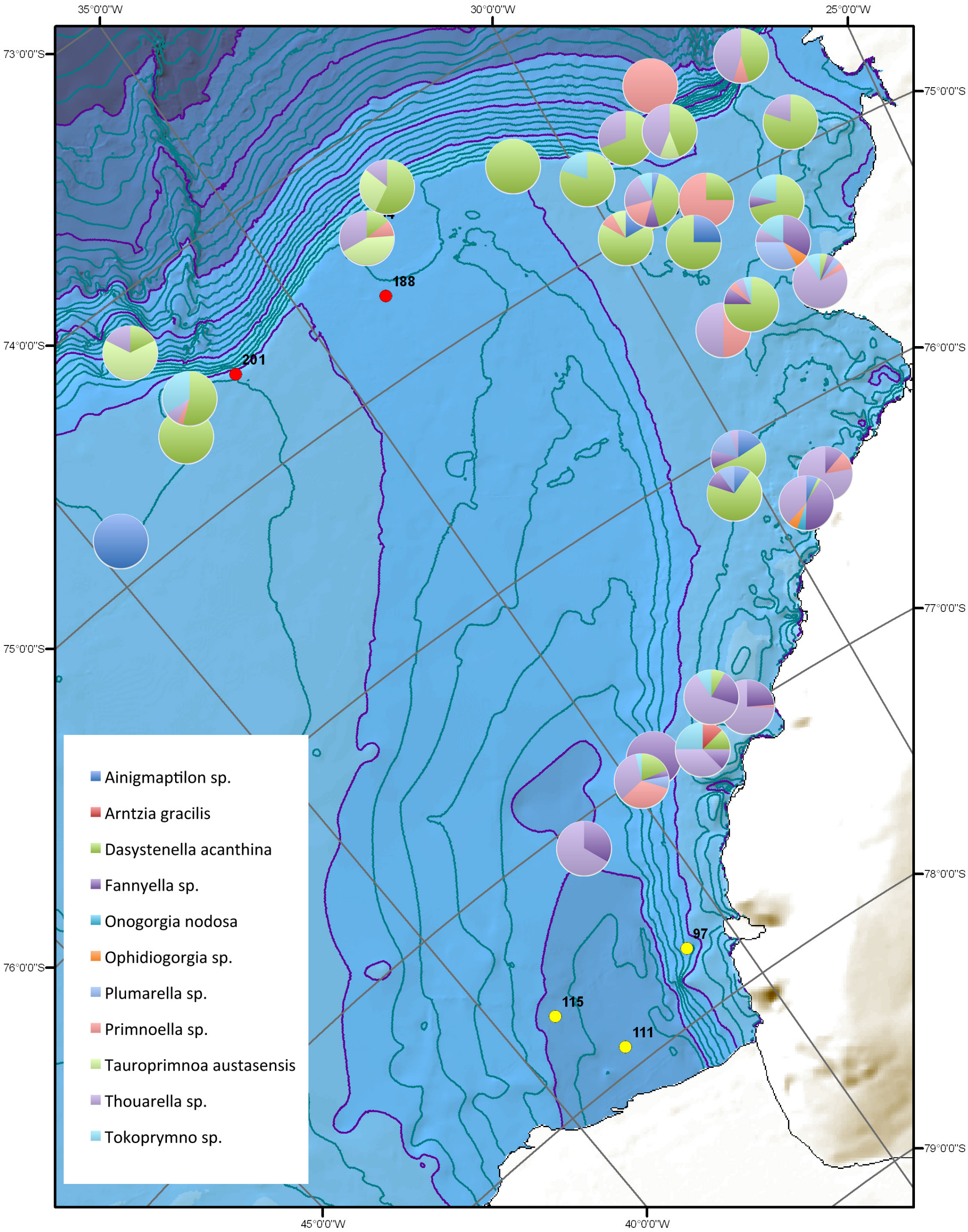

Fig. 3.3.3.2.1: Composition of Antarctic primnoids in the Filchner Outflow System

Tab. 3.3.3.2.7: Number of primnoid specimens collected for population genetic analyses

	PS82																					
Taxa	**11**	**18**	**39**	**43**	**50**	**53**	**73**	**88**	**91**	**126**	**166**	**175**	**249**	**264**	**282**	**284**	**296**	**314**	**316**	**331**	**341**	**349**
Ainigmaptilon sp.						7																18
Dasystenella acanthina	68	10	7	10			5	6			8	9	14		8	10	15	11	19	5	11	
Fannyella rossii						42		16	15													
Thouarella sp1						16		22	21													
Thouarella sp2					5	9			13													
Thouarella sp4						7		17	10	11												
Tokoprymno sp.	17							7					9									

Populations from the seven Antarctic gorgonians will be compared; five of them found at shallow depths (~250 m) will be compared in a latitudinal gradient. One species has been found at 77° transect at two different depths allowing the comparison in depth of two populations. Moreover, two species have been found at both sides of the Filchner Trench at depths around 400 m, and the primnoid *Dasystenella acanthina,* which seems to have a wider distribution in this area, will be used for detailed studies of the connectivity among the different populations in the Filchner area (Fig. 3.3.3.2.2).

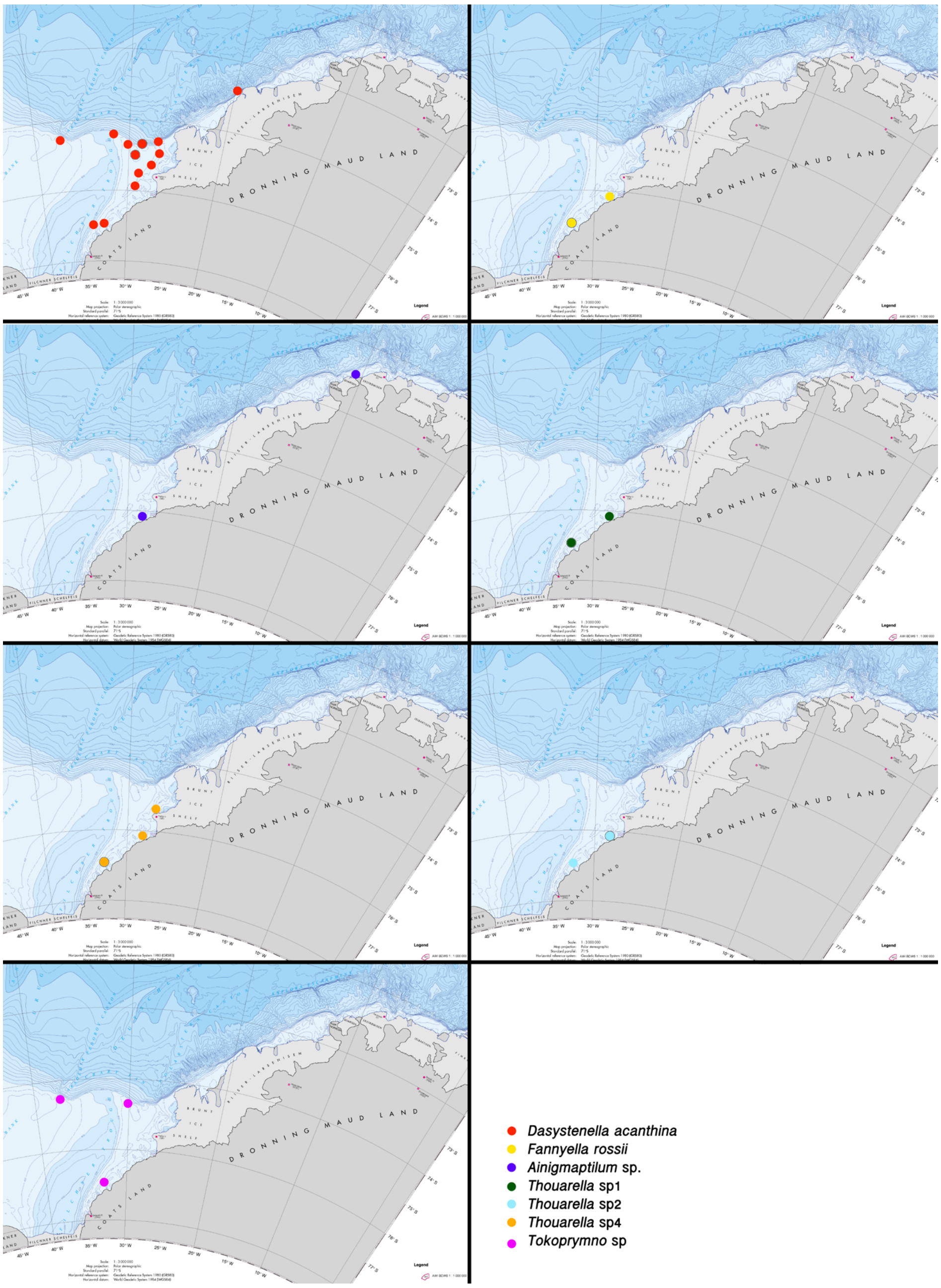

Fig. 3.3.3.2.2: Localities of primnoid species for population comparisons

Stable isotopes

The stable isotopes $\delta^{15}N$ and $\delta^{13}C$ are proxies of trophic relationships, with $\delta^{15}N$ reflecting the trophic position of a consumer and $\delta^{13}C$ reflecting the basic food sources of the whole community. These isotope signatures are used to identify the trophic position of major components of the Filchner Outflow System. Regarding the high-Antarctic Weddell Sea, previous stable isotope ratio studies on the trophic position of pelagic organisms, benthic invertebrates and vertebrate top predators identified trophic relations within limited sub- systems of the whole network.

In total we collected 620 stable isotope samples from invertebrate organisms belonging to 13 Taxa groups and 199 samples from fishes referring to 20 species (Tab. 3.3.3.2.8).

Tab. 3.3.3.2.8: Major taxa sampled for stable isotope analysis

Major Taxon	[n]	Major Taxon	[n]
Foraminifera	3	Annelida	66
Porifera	31	Chelicerata	16
Cnidaria	34	Crustacea	72
Bryozoa	8	Hemichordata	23
Nemertini	4	Echinodermata	221
Mollusca	90	Tunicata	45
Sipunculida	7	Pisces	199

Data management

Once specimens are identified either by morphotaxonomy or by molecular DNA "Barcoding", occurrence data for species at each station will be submitted to SCAR MarBIN. DNA sequence data and population genetic matrices will be submitted to NCBI GENBANK.

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3.3.3.3 Biomass estimations from AGT and bottom trawls

Chester J. Sands[2], Astrid Böhmer[1], Kerstin Beyer[1]

[1]AWI
[2]BAS

Grant No: AWI_PS82_03

Objectives

It has long been recognised that there is spatial heterogeneity among the distribution of Antarctic benthic communities, with assemblages affected by depth, food availability (primary production), currents regimes, sediment type, ice scour and annual ice cover duration (Hedgepeth 1969). Here we use subsamples from Agassiz and bottom trawls to assess abundance and biomass at stations across the Filchner shelf region in an attempt to generalise patterns of diversity and abundance on the scale of 10s to 100s of kilometres.

Work at sea

The AGT was deployed from the stern A-frame gantry. The trawl was lowered at 1 ms^{-1} with the ship running at 2.3 kn. The position and depth was logged as the trawl frame hit the seafloor, which could be determined by the sudden decrease in wire tension. The cable was further released until there was twice the depth worth of cable length. At this time the ship speed was reduced to 1 kn for trawling with a trawl time of 10 min. Once trawl time elapsed the ship was stopped and hauling began at 0.5 ms^{-1} until the frame was free of the bottom, then hauling speed was increased to 0.7 ms^{-1}.

Bottom trawls were deployed as detailed in section 3.3.4.1.

Specimens were collected by hand from the trawl material, washed free of sediment, and sorted to phylum or lower taxonomic level where possible. A subsample of material was collected from the AGT and BT for abundance and biomass estimation. The subsample (one 20 L bucket as a proportion of N buckets estimated from the catch) was reserved and sorted separately into phylum and morphotype. Individual morphotypes were photographed and weighed. s species identifications were generally not possible, abundance and wet weights were pooled for lowest confident clade identification.

Preliminary (expected) results

Over the duration of the expedition we conducted 16 AGTs in the Filchner region and one at Austasen outside of the BENDEX area. The locations and depth of each station is given in Tab. 3.3.3.3.1.

Tab. 3.3.3.3.1: Station details for each AGT deployment

Station	Date	Time	Latitude	Longitude	Depth [m]
PS82/043-1	01/07/2014	18:15	76° 4.22 S	30° 8.700 W	473
PS82/050-1	01/08/2014	07:09	76° 19.32 S	29° 0.170 W	228.5
PS82/067-1	01/10/2014	14:46	77° 6.08 S	36° 32.76 W	1101
PS82/073-1	01/11/2014	09:13	77° 0.28 S	34° 9.34 0 W	570
PS82/091-1	14/01/2014	14:52	76° 58.07 S	32° 51.48 W	293.7
PS82/097-1	15/01/2014	13:59	77° 43.45 S	35° 58.84 W	572.5
PS82/111-1	16/01/2014	15:50	77° 54.31 S	38° 12.45 W	1209
PS82/115-1	17/01/2014	06:56	77° 36.68 S	38° 56.33 W	1058.2
PS82/151-1	22/01/2014	10:25	74 ° 32.26 S	28° 31.50 W	1749.5
PS82/233-1	02/01/2014	07:21	74° 14.65 S	37° 42.35 W	833.5
PS82/264-1	02/05/2014	12:32	74° 22.41 S	33° 23.03 W	649
PS82/266-1	02/05/2014	20:37	74° 18.39 S	32° 50.05 W	718.2
PS82/283-2	02/07/2014	18:19	74° 59.87 S	29° 22.90 W	409.2
PS82/293-1	02/08/2014	09:34	75° 31.50 S	28° 59.08 W	462.2
PS82/308-1	02/09/2014	15:39	75° 5.32 S	28° 38.92 W	452.7
PS82/314-1	02/10/2014	08:27	74° 39.93 S	28° 41.89 W	712.2
PS82/349-1	16/02/2014	12:38	70° 55.57 S	10° 28.22 W	213.5

Estimates of Abundance and Biomass

From the sub sample we estimated relative abundance and biomass of the clades collected from counts and wet weights of individuals given in Table 3.3.3.3.2. The results can be visualized in Fig. 3.3.3.3.1, where we plotted the location of each sample, specifically marking the four BTs, and scaled the pie chart to indicate total wet biomass per m^2 taken from each location, and the individual abundance of the different clades as slices of the pie. Due to extreme values we transformed the data using square root of the biomass per m^2 in order for low biomass points to be visible and high biomass points not to swamp the figure. It is clear that the shallower stations on the eastern shelf had the highest biomass (wet weight). Bryozoans were a large, often dominant, component, particularly at the southern shelf station. The northernmost station was dominated numerically by the decapod *Nematocarcinus longirostris,* but the high biomass for this station was due primarily to echinoderms, particularly echinoids, holothurians and asteroids. At the most southern shelf station PS82/97 no subsample was taken as the catch consisted almost entirely of the fish species *Neopagetopsis ionah* (see section 3.3.3.1). In the Filchner trough, and the southern trench in particular, biomass was generally low with holothurians the most abundant group. AGTs clearly collect more benthos per m^2 compared with BTs.

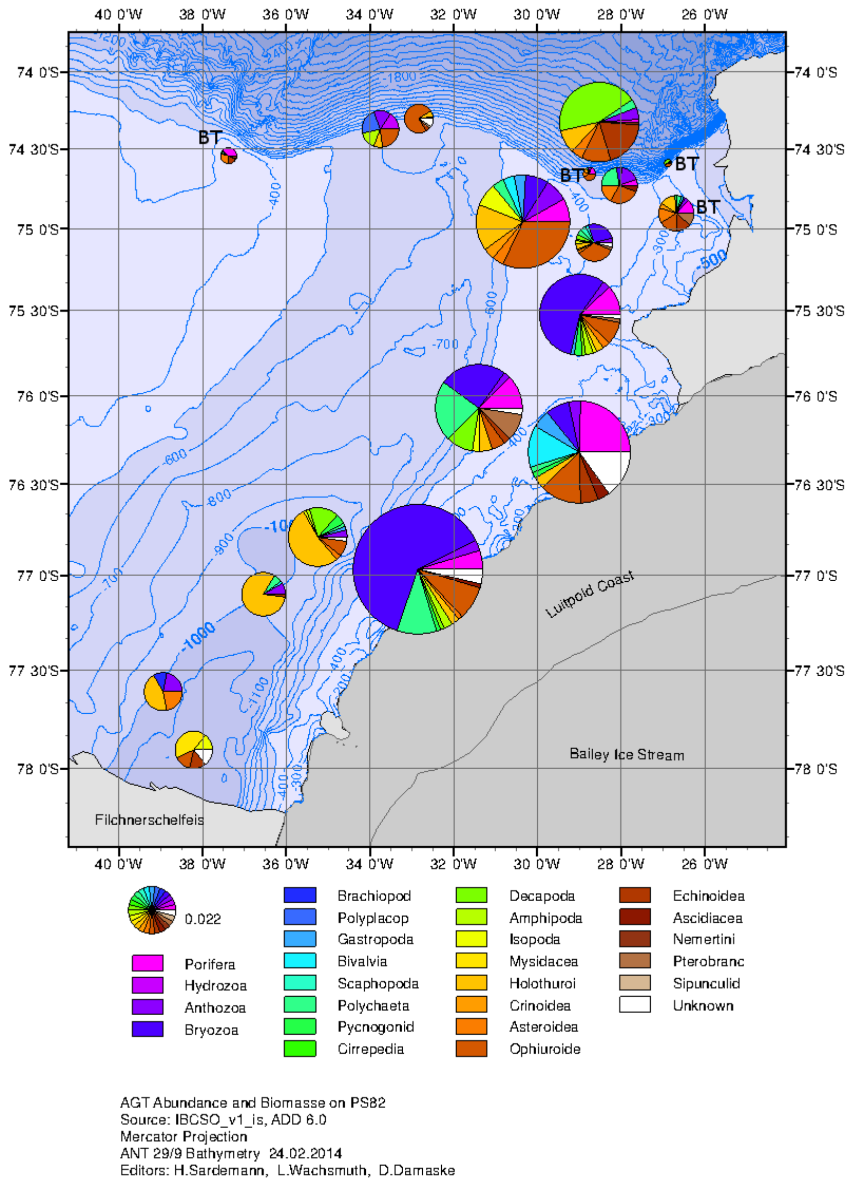

Fig. 3.3.3.3.1 Locations of sub samples taken from AGTs and BTs with square root transform of biomass per m^2 indicated by size of the pie charts and abundance of clade given relative size of pie slices.

Tab. 3.3.3.3.2: Raw data collected from AGT and BT sub samples

Station no.	PS82/43	PS82/50	PS82/67	PS82/73	PS82/91	PS82/111	PS82/115	PS82/151	PS82/264	PS82/266	PS82/283	PS82/293	PS82/308	PS82/314	PS82/349	PS82/166	PS82/249	PS82/316	PS82/331	PS82/341	PS82/357
	AGT	AGT	AGT	AGT	AGT	AGT	AGT	AGT	AGT	AGT	AGT	AGT	AGT	AGT	AGT	BT	BT	BT	BT	BT	BT
Porifera	5	13			9			1		1	2	8		1	8	19	20	25	1	3	3
Hydrozoa									2												
Anthozoa	1	2	4	8	5		2	4	2		2	2	3	3	11	6	1	10	2	11	3
Bryozoa	10	4			120						2	37	20	1	200	2				11	3
Brachiopoda							1														
Polyplacophora									3						6						
Aplacophora																					
Gastropoda		3		4	1						1	1						3		4	1
Bivalvia		7	1	2							1		2			3					
Scaphopoda													4								
Polychaeta	9	1	3	4	19			3			1		4	4		7	2	4	1	3	2
Pycnogonida		1		11	2							2			2	2					1
Cirripedia																	1			1	
Decapoda	4			33	2			37				1	3		3				17	5	
Amphipoda				4	4				2			2	1		20						
Isopoda	1			3	1	1					2	1	2								
Mysidacea						3															
Holothuroidea	2	2	40	107	4		4	8	1	3	4	2	4		6	21				9	14
Crinoidea					1						1		1		1	7		14		16	14
Asteroidea				6	2		2	4			1	2	2	3	2	21	15	18	2	9	4
Ophiuroidea	2	7		17	16	1		10	3	32	8	6	26	5	11	25		52	11	7	5
Echinoidea	1	3	1			1		16		2					4	19	9		2	6	1
Ascidiacea		2			2									1	6		1				11
Nemertini								1									3			1	
Pterobranchia	4											1	2		6	17		1			6
Sipunculida										1											
Indet.	1	8		5	7	1				4		1	3		2						
total Biomass	51480	64700	5840	9175	130800	2940	3850	116970	3400	1350	51360	39540	2280	2460	700200	296590	11408	5334	774	2520	52440

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Data management

All data generated from this expedition will be published in the AWI data base PANGAEA (http://www.pangaea.de).

3.3.3.4 Distribution, community composition and ecology of suspension feeders

Stefano Ambroso[1], Pilar Casado de Amezúa[2,3], Luisa Federwisch[2], Enrique Isla[1], Anna Kluibenschedl[2], Nils Owsianowski[2], Rebecca Zapata[1]
Not on board: Josep-Maria Gili[1], Claudio Richter[2]

[1]ICM-CSIC
[2]AWI
[3]UAH

Grant No: AWI_PS82_03

Objectives

The marine vicinities of the Filchner Trench have been identified as one of the principal areas of deep and bottom water formation in the southern Weddell Sea, where the outflow of cold and fresh water from below the shelf ice mixes with the oceanic Weddell Sea Gyre waters. The resulting physical fronts presumably convert the region into a biological hotspot. This study area is of great interest given the fact that the polar regions are especially sensitive to the ongoing climate change. Thus, it is easy to imagine that these biological hotspots may be undergoing rapid transformations linked to environmental changes.

The aim of this work was therefore to investigate how the current environmental conditions are reflected in the status of the local benthic communities of suspension feeders, in particular hexactinellid sponges and cnidarians (anthozoans, gorgonians), providing a baseline for a region where this information is scarce.

The main objectives were:

- To investigate the distribution, abundance and biomass of glass sponges along environmental gradients (bathymetry, current regimes)
- To relate the findings to particular environmental parameters, such as temperature, salinity, pH, oxygen concentrations or concentrations of dissolved silicate
- To estimate the retention of (pico-)plankton and dissolved silicate by glass sponge communities
- To study the spatial distribution patterns of the gorgonians *Dasystenella acanthina*, *Thouarella variabilis* and *Fannyella rossi* in the eastern Weddell Sea
- To study the spatial distribution of the different benthic communities over a large geographical and bathymetrical extent

Work at sea

In order to map the distribution and composition of the benthos in water depths up to 500 m, a modern inspection-class ROV (Remotely Operated Vehicle V8 Sii, Ocean Modules) was deployed at 10 stations in the area of the Filchner Trench and at one station in the BENDEX area in Austasen (Table 3.3.3.4.1).

Tab. 3.3.3.4.1: Overview of ROV stations during ANT-XXIX/9

Station No.	Latitude Start	Longitude Start	Depth Start	Latitude End	Longitude End	Depth End	Notes
PS82/020	75° 12.83'	27° 34.41'	397 m	75° 12.56'	27° 34.08'	394 m	
PS82/049	76° 19.15'	29° 01.94'	255 m	76° 19.29'	29° 00.91'	250 m	
PS82/081	77° 04.82'	33° 39.02'	368 m	77° 05.16'	33° 39.23'	357 m	transect >600 m
PS82/086	76° 57.41'	32° 59.11'	293 m	76° 57.95'	32° 57.23'	276 m	transect crossed scour, >1300 m
PS82/128	75° 29.99'	27° 27.17'	289 m	75° 29.43'	27° 28.00'	297 m	transect >1000 m
PS82/136	75° 19.99'	27° 32.40'	347 m	75° 20.00'	27° 34.58'	354 m	transect >1000 m
PS82/170	74° 53.89'	26° 38.10'	296 m	74° 53.55'	26° 39.98'	296 m	transect >1100 m
PS82/202	74° 34.41'	36° 27.64'	425 m	74° 34.36'	36° 27.93'	424 m	aborted after 50 min, currents too strong
PS82/309	75° 05.81'	28° 38.24'	461 m	75° 06.02'	28° 37.33'	465 m	transect >600 m
PS82/333	74° 39.08'	26° 55.86'	421 m	74° 39.50'	26° 57.75'	422 m	Repeat transect PS12/333; >1000 m
PS82/352	70° 56.05'	10° 32.39'	301 m	70° 56.74'	10° 31.23'	281 m	Repeat transect PS77/264; >1600 m
PS82/353	70° 56.73'	10° 31.03'	279 m	70° 56.50'	10° 31.69'	287 m	Sipper sampling

The V8 Sii is a comparatively small, but modular system with a size of ca. 60x80x80 cm owned by AWI's Bentho-Pelagic Processes section. It is equipped with two High Definition (HD) video cameras (Kongsberg oe14-502) in front and one wide-angle camera (Bowtech L3C-550) for umbilical surveillance in the back. Both HD cameras were equipped with two parallel red lasers providing reference scales of 4 and 6 cm on the videos. The lighting is ensured by four LED lights (Bowtech LED-2400 aluminium) in the front and one in the back. Furthermore, the ROV has a compass, an orientation sensor, an altimeter (Tritech Micron Echo Sounder) and an obstacle avoidance sonar (Tritech Micron). During the video transects, a sledge bearing a CTD (SeaBird SBE19 plus), as well as sensors for pH, oxygen, light, fluorescence, and a Doppler Velocity Logger (RDI EXP600-FAM5SC/EXPCP) for bottom tracking and current measurements was attached to the ROV.

For its operation from on board *Polarstern*, a new winch (CORMAC 5) was installed. At the end of the winch cable, a depressor weight was attached in order to pull the cable vertically down and keep it close to the ship to avoid contact with drifting ice floes. The ROV was connected to the winch cable by an additional tether cable of 50 m length, providing a free movement radius of 50 m around the weight. The whole system was successfully run for the first time on board of *Polarstern* during this expedition.

The exact underwater position of the ROV was determined via an Ultra Short Baseline (USBL) system linked to the GPS system of *Polarstern*. The USBL data were imported into the ROV data processing software OFOP (short for "Ocean Floor Observation Protocol") which was used for real-time display and recording of the ROV position. On two occasions, ROV transects of former *Polarstern* expeditions

(PS12/333 in 1988 and PS77/264 in 2011) were repeated by importing a map with the old ROV track into OFOP and following that track as closely as possible. During all of the transects, one of the cameras was directed perpendicularly towards the ground, whereas the other one was looking forward in an angle of 40-45°. A distance of 1-2 m was kept to the ground, mainly to avoid sediment resuspension caused by the ROV's thrusters.

For ground-truthing and taxonomic identification, glass sponges and gorgonians were collected from bottom trawls and Agassiz trawls at stations located close to the ROV transects. Intact glass sponges of various species and a large size range were collected from the trawls for biomass estimation and to establish size-biomass relationships which are later to be applied to the ROV transect data. The sponges were cleaned, photographed, measured and weighed, and then dried at a warm, well-aerated place for at least ten days. Dried sponges were packed into sealed plastic bags for further analysis at AWI.

To characterize the environmental conditions at each station, water samples were collected from the CTD/rosette sampler in 5-7 depths at every ROV station and some additional stations in most areas. Samples for dissolved organic carbon (DOC) from the bottom water and 20-50 m above the bottom were filtered with syringes through pre-combusted GF/F filters into acid-washed glass vials, acidified with hydrochloric acid (HCl) to pH 2, and stored tightly sealed at 4 °C. Samples for dissolved and particulate silicate, as well as for picoplankton cell numbers, were taken from all of the sampled depths. For dissolved silicate (dSi), water was hand-filtered with syringes through cellulose acetate filters and stored at 4 °C until later analysis on board. The samples were analysed photometrically according to Koroleff (1999). For particulate silicate (pSi), 400-1,000 ml of water were filtered through cellulose acetate filters with a vacuum pump at max. 500 mbar. The filters were folded into aluminium foil and frozen at -20 °C. Picoplankton samples were directly filled into CryoVials, fixed with glutaraldehyde and frozen at -20 °C.

To analyse the composition of silicon and oxygen isotopes in glass sponges and compare it to the isotopic composition of the surrounding seawater, 2 L of bottom water were sampled at every ROV station. The water was filtered through polycarbonate filters with a vacuum pump at 200 mbar. The filtrate was stored at 4 °C in the dark in acid-washed PE bottles and the filters were frozen at -20 °C. Dried sponge material from the trawls will be used for analysis of the isotopic composition of the glass sponges themselves.

Subsequently to the ROV transect in the BENDEX area, the ROV was deployed once more with a novel Sipper system instead of the CTD and sensor sledge. The Sipper is a revolver system of spring-loaded syringes which allows the collection of up to twenty water samples of 20 ml. Each syringe can be released individually at a specific location and time. The sampling process is recorded on one of the ROV's HD cameras, allowing a precisely controlled collection of samples. After several unsuccessful tests at other stations, it was possible to collect 13 water samples before the releaser of the syringes failed. The first 10 samples were collected just outside of the BENDEX area, five of them directly above a sponge bed and the other five in a height of 2 m above the sponges. The ROV was then flown into the central BENDEX area to collect samples at a location devoid of glass sponges. The last three samples were taken directly above the empty ocean floor as a comparison to the glass sponge-rich area.

Preliminary results

Ten successful ROV transects with lengths of 600-1,600 m were conducted during the expedition. Nine of the stations were located on the shelf east of the Filchner Trench in depths of 250-465 m and one was located in Austasen, crossing the BENDEX area in 280-300 m depth (Fig. 3.3.3.4.1). Another deployment of the ROV west of the Filchner Trench (station PS82/202, 425 m depth) had to be aborted after ~50 min due to too strong currents that made maneuvering extremely difficult and put too much tension on the ROV cable leading to optical blackouts. As it turned out, the optimal way to fly the ROV most stably and get the clearest images was to have the ship traverse sideways with the wind and currents at a speed of ~0.2 knots pulling the ROV along on the starboard side. Overall, approximately 30 hours of video material have been recorded on the ground.

The ROV transects revealed large regional differences in the benthic communities. Up to five different morphotypes of glass sponges could be distinguished at first sight while conducting the transects. They corresponded to the species *Rosella nuda/Anoxycalyx joubini*, *Rosella villosa*, *Rosella racovitzae*, *Rosella fibulata* and *Rosella antarctica*. This first identification was mainly based on photos and descriptions given by Janussen and Göcke (2011) and Brueggeman (1998). *R. villosa* was generally the most abundant species and occurred, together with *R. racovitzae* and *R. nuda/Anoxycalyx joubini*, at all stations where glass sponges were found. *R. fibulata* was very rare; only single individuals were found at some of the stations. *R. antarctica* occurred only at some of the stations north of *Halley VI*, but could reach high abundances there.

In general, glass sponges and gorgonians in the Filchner area were more abundant at the southern stations PS82/081 and PS82/086 than at the stations north of *Halley VI*. In all of these stations, however, both sponges and gorgonians were mostly distributed in small patches. Station PS82/309 at the eastern slope of Berkner Bank was completely devoid of glass sponges. In contrast to this, a surprisingly rich and diverse sponge community was encountered at station PS82/333 at the continental slope of the eastern shelf. This observation corresponds with the video material from 1988, when the station was first visited by Julian Gutt. Interestingly, there were also many sea stars and possibly some nudibranchs preying on glass sponges at this station.

Only at station PS82/086 clear evidence of iceberg scouring was visible as a sudden change from recurring megabenthic assemblages to almost bare ground. Different stages of recolonization could be observed with some parts being dominated by hydrozoans, whereas in other parts mainly bryozoans were encountered. Furthermore, at the northern stations PS82/136 and PS82/170 high numbers of fish nests have been recorded. Whereas there were only empty depressions on transect PS82/170, some nests with eggs guarded by *Chaenodraco wilsoni* and generally many fishes have been observed at station PS82/136.

On the western side of Filchner Trench, at station PS82/202, no glass sponges were found during the short time on ground. Instead, the soft bottom was covered by large numbers of goose barnacle shells. However, gorgonians occurred at this station, as well as at station PS82/309. In general, gorgonians were found at all of the investigated stations, but species composition and abundances varied greatly. The most abundant genus in the Filchner area was *Thouarella*, present in ~80 % of all transects. The second most abundant genera were *Dasystenella* and *Fannyella*, both with a presence of ~60 % of all transects.

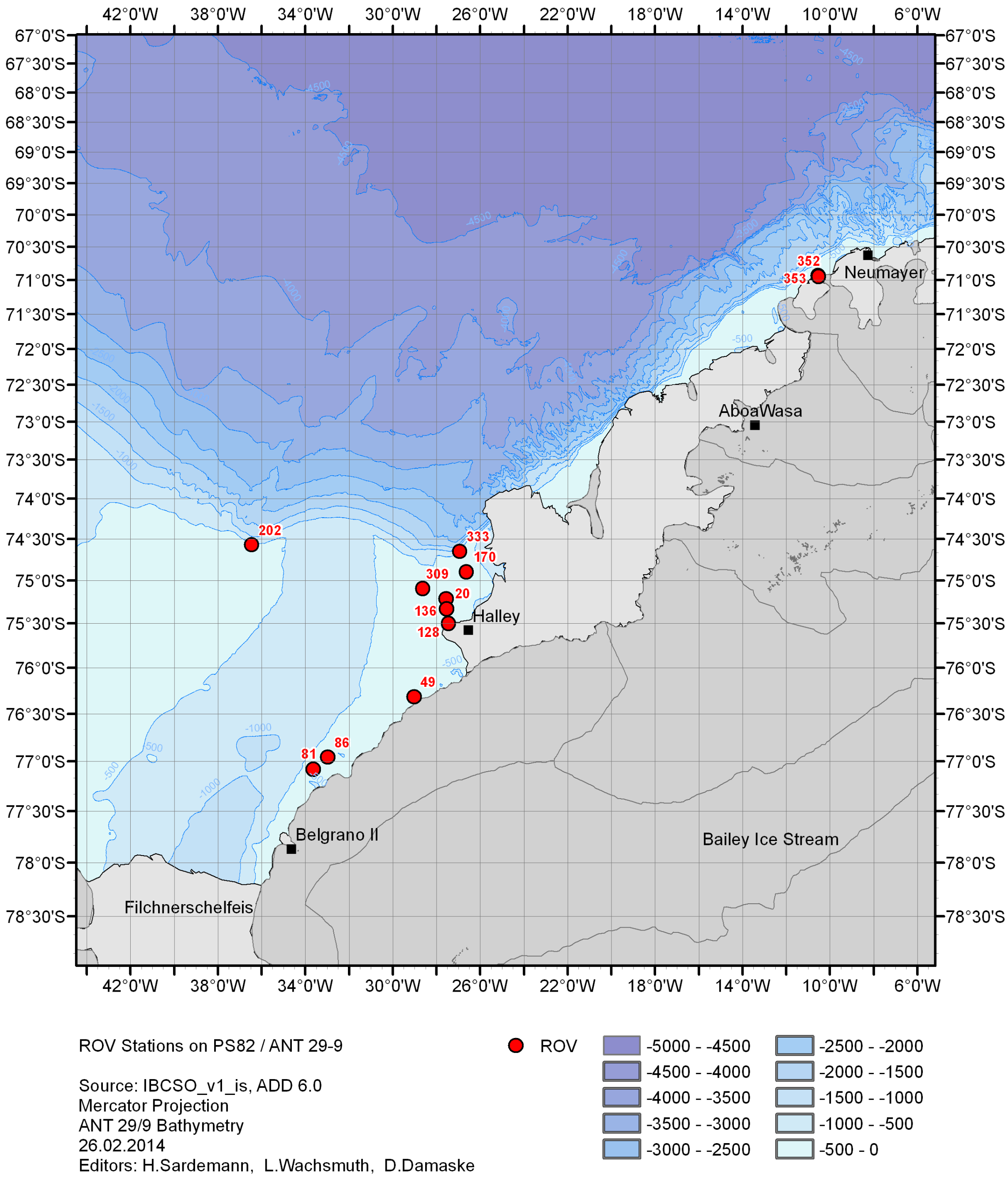

Fig. 3.3.3.4.1: ROV stations during ANT-XXIX/9

In Austasen (station PS82/352) an ROV transect of 2011 was repeated, starting well outside of the artificially disturbed BENDEX area and crossing this area to reach undisturbed ground on the other side. Outside of the BENDEX area, abundant and diverse glass sponge communities, as well as gorgonian assemblages (Primnoidae) were found. Towards the central BENDEX area, sessile epifauna got scarcer. Scours of the trawling gear from 2003 were still visible, but mostly filled up with sediment. However at first glance, glass sponges seem to have increased both in numbers and in size within the disturbed area compared to 2011. Although there were still wide, deserted areas, several groups of quite large glass sponges of different species were encountered. Some glass sponges were growing directly on the filled-up trawling scours. Between the sponges, many ascidians were found, representing an early stage of recolonization, whereas glass sponges are generally thought to belong to a later succession stage.

Comparing all the stations, there seems to be no obvious correlation between glass sponge abundance and depth. The regional differences might rather be due to bathymetric or hydrographic features or the influence of different water masses. This remains to be checked when all data are analysed.

For detailed taxonomic identification and biomass estimation of glass sponges, 96 individuals have been collected at 16 stations from bottom and Agassiz trawls. They represent the same species that were seen during the ROV transects, with the addition of *Rosella levis* and *Rosella vanhoeffeni*. Both species could not be distinguished at first sight on the ROV videos, but might be found there as well with detailed analysis.

Of the water samples taken from the CTD/rosette sampler and the ROV's Sipper system, only the samples for dissolved silicate have been analysed directly on board. The uncorrected raw data suggest that in the upper water column (0-100 m depth) the concentrations of dSi are in the same range at all stations. However, in the bottom water (2-50 m above ground) the dSi concentrations were considerably higher at the two stations without glass sponges than at all other stations. This may hint to a measurable effect of glass sponges on local silicate concentrations. The raw data of the samples from the Sipper showed no obvious differences in the concentrations of dSi. However, a final assessment can only be given after the data have been processed and corrected.

Data management

All the data generated from this expedition will be included in Pangaea and in the Spanish Polar Database located in the Spanish Polar Committee's National Polar Data Center, http://hielo.igme.es/index.php/en/.

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Janussen D, Göcke C (2011) Short Guide to some important / characteristic sponges of the Antarctic shelf. Senckenberg.

Koroleff F (1999) Determination of dissolved inorganic silicate. In: Grasshoff K, Ehrhardt M, Kremling K (1999) Methods of Seawater Analysis. 3rd, completely revised and extended Edition, Wiley-VCH, Weinheim, p. 193 ff.

3.3.3.5 The bendex experiment: follow-up 2

Harald Biebow[2], Dieter Gerdes[1], Enrique Isla[3], Rainer Knust[1], Santjago Pineda[1], Chester Sands[4]

[1]AWI
[2]ICM-CSIC
[3]BAS

Grant No: AWI_PS82_03

Objectives

Iceberg scours inflict substantial damage on established communities of endo- and epifauna. In the course of recovery it is possible to distinguish different successional stages of recolonization although these never could be placed yet in an absolute temporal sequence. As iceberg scouring destroys older and major community stages, it creates space for ´pioneer species´ which initiate recolonization. Various hypotheses in the literature have attempted to describe the effects of such processes on biodiversity. As a general result appears an enhancement of diversity on larger scales due to the co-existence of a variety of recolonization stages with different species inventories. Beside this effect on biodiversity, the time scale of recovery after disturbance is considered as an important question, because in comparison with community recovery in lower latitudes it illustrates the vulnerability and resilience capacity of polar systems.

To set a time stamp for recolonization an artificial mechanical disturbance experiment was started in 2003 to simulate the impact of grounding icebergs on benthic and demersal fish communities. As a result benthic biomass was drastically reduced by a factor of 10. In 2011 we revisited the BENDEX site to follow the recolonization and succession in the disturbed area. The multibox corer was deployed at 8 stations in the BENDEX site and 4 stations adjacent to this area. At that time the BENDEX area still showed hardly any signs of recolonization. Eight years after the disturbance inside the BENDEX area clear trials of the fishing gear were visible, whereas epifauna was rare or totally absent. In between the gear spurs the trawl activities had accumulated locally benthic material, on which living specimens of sponges, ascidians and especially motile taxa such as ophiuroids, crinoids, and asteroids. Just at 2 marginal stations in the experimental site (St. Nos. 289 and 293) the MG collected 1-3 cm juvenile, max. three years old specimens of the demosponge *Tethyopsis multispinosa,* which were assumed to be the first pioneer species inside the BENDEX area. On this cruise we continue these studies in order to get a proper data base which finally allows us for the first time to quantify recolonization and succession processes in high Antarctic benthos after disturbance.

Work at sea

The multibox corer with the attached UW-camera was deployed on 5 stations inside the BENDEX-core area (*cf*. Tab. 3.3.3.1.1, section 3.3.3.1). The positions of these stations were identical with station positions of the two former BENDEX campaigns (*cf*. Tab.3.3.3.5.1.). From these five stations 40 quantitative corer samples were obtained and at each station high resolution photos were done along transects, resulting in a total of 194 pictures (Fig. 3.3.3.5.1 A-E). The samples were sieved over 500µm mesh size and preserved in a 4 % seawater formaldehyde solution buffered with hexamethylentetramine prior to sorting in the home laboratory.

Preliminary results

All quantitative samples obtained at the 5 stations with the multibox-corer will be analysed in Bremerhaven, i.e. these preliminary impressions of the actual situation in the study site rely on first onboard analyses of our photographic material from the stations. These photos suggest that the benthos in the BENDEX site is a highly complex system with distinct local peculiarities among stations. Based on what we have checked so far no homogeneous patterns in the recolonization process are recognizable. Eleven years after the disturbance was set some taxa/species obviously have recolonized the area. To these taxa belong tube building sedentary polychaetes and ascidians, which clearly are more abundant as compared to the 2011 situation. Further pioneer species are e.g. the sponge *Tethyopsis multispinosa*, which was already in the 2011 survey identified as a pioneer species at St. 289 on the eastern border of the BENDEX site. Other species such as *Umbellula sp*. or *Molgula pedunculata* and gorgonians (the latter often as juveniles) also were found in disturbed locations. Obviously many juveniles of echinoids, holothurians, asteroids, ophiuroids, and pygnogonids were to be seen on the pictures. From 2003 to 2011 we already found a threefold increase in macrozoobenthos biomass in the disturbed areas, and we have the impression that this trend is going on. Better data to falsify/verify this impression will be available after the analysis of the corer samples.

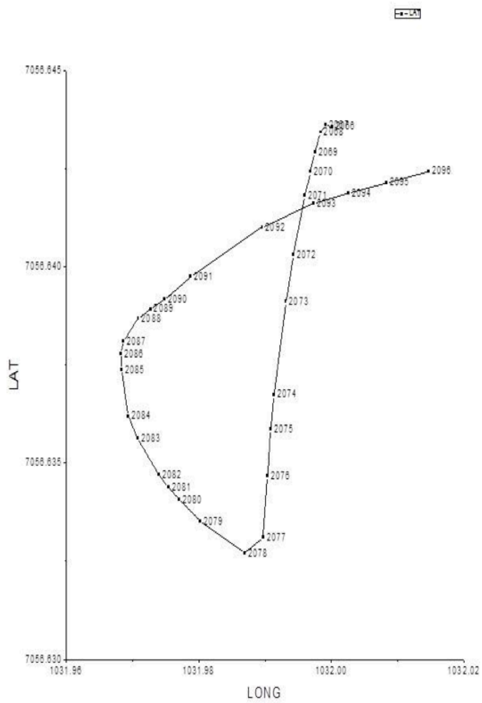
Data management

Most data (see Preliminary results) will be obtained through laboratory analyses after the cruise. As soon as they are available, processed data will be uploaded to the open-access database PANGAEA.

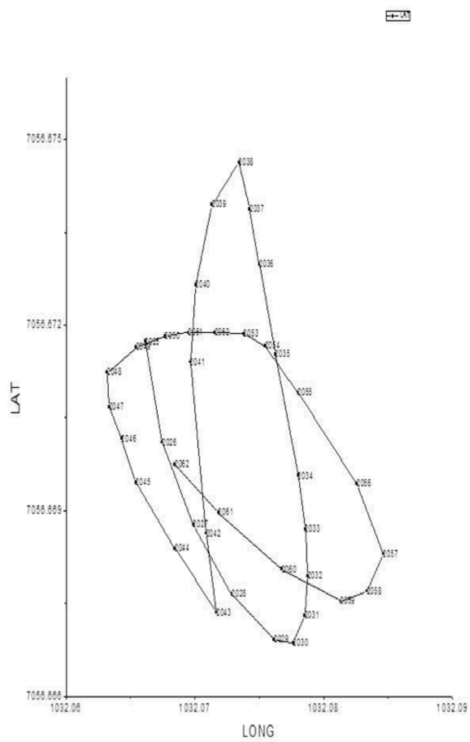
Tab.3.3.3.5.1: Multibox-corer stations worked up during the 3 BENDEX campaigns in 2003, 2011 and 2014

BENDEX 2003	BENDEX 2011	BENDEX 2014
183	288	350
187	280	348
199	289	346
202		360
	285	359

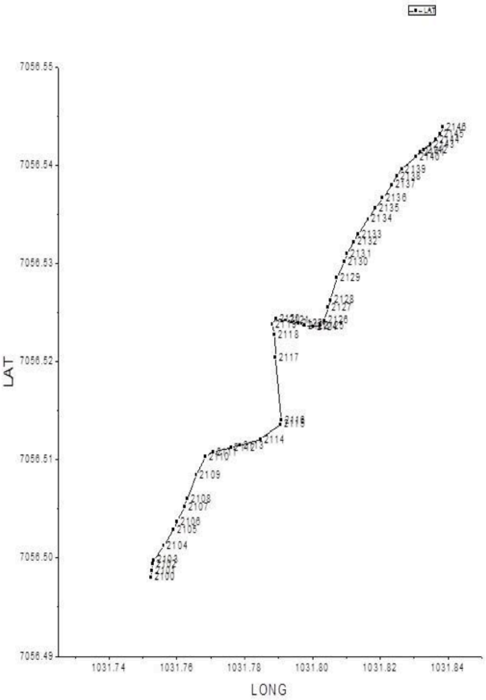
A)



B)



C)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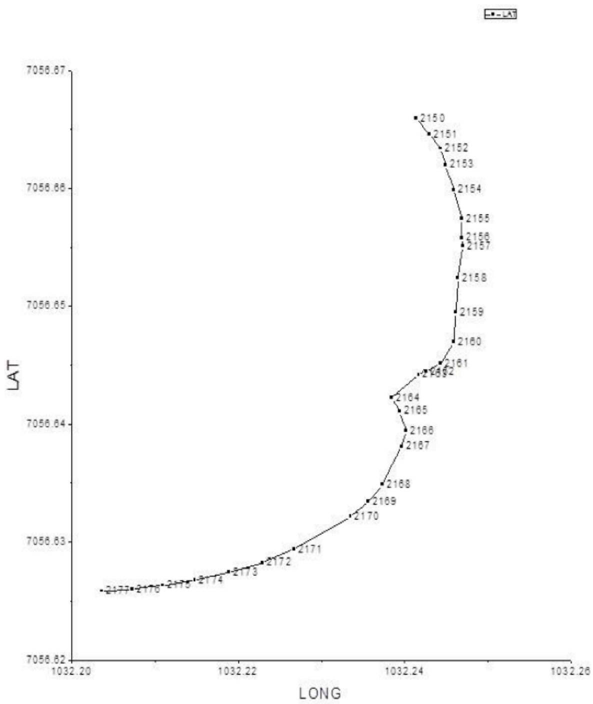
1031.82
1031.84

D)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1032.26

E)

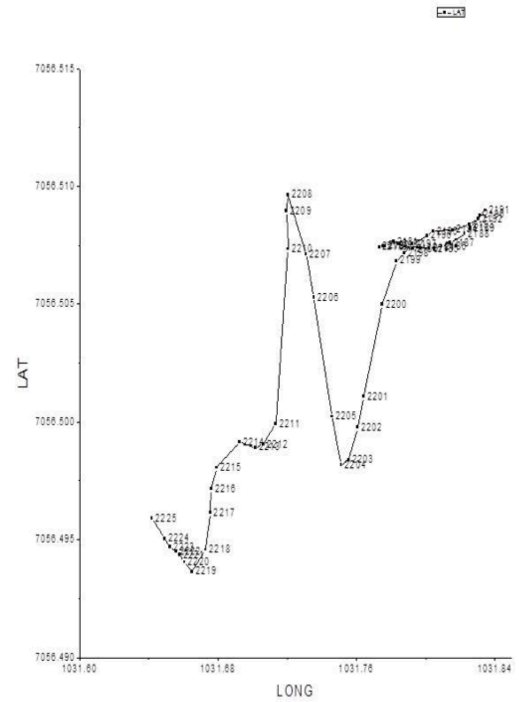

Fig. 3.3.3.5.1: Photo transects made on 5 stations in the BENDEX area

A)	*Station 348*
B)	*Station 346*
C)	*Station 350*
D)	*Station 359*
E)	*Station 360*

3.3.4 Antarctic fishes

3.3.4.1 Fish communities, distribution and production

Maj Wetjen[1], Kai Wätjen[1], Chiara Papetti[1,2], Masimiliano Babbucci[2], Emilio Riginella[2], Nils Koschnick[1], Rainer Knust[1]
not on board: Tina Sandersfeld[1]

[1]AWI
[2]Uni-Padova

Grant No: AWI_PS82_03

Objectives

The fish fauna of the Antarctic waters is, with respect to other marine systems of lower latitudes, predominantly populated by demersal organisms while the pelagic zone is only sparsely inhabited. The Antarctic fish fauna is dominated by a single perciform suborder, the Notothenioidei. Over 90 % of the species of this suborder are endemic in the Southern Ocean and mainly represented by 5 families which account for more than 50 % of the species and more than 90 % of the fish biomass on the Antarctic shelf. The Notothenioidei, comprising more than 100 closely related species, include a wide range of ecotypes from sluggish demersal benthos feeders to herring-like pelagic shoaling species and large piscivorous predators. Despite the low diversity on higher taxonomic levels, the diversity of species within demersal communities on the high Antarctic shelf is extraordinarily high. On the eastern Weddell Sea shelf, the fish fauna is closely associated to the benthic sponge communities and adapted to the year-round cold water temperature of about -1,8 °C. On the deeper slope (>600 m) in warmer waters deep sea species like eelpouts (e.g. *Pachycara brachycephalum*) and snailfishes (Liparidae) occur and species diversity is much lower. From the southern Weddell Sea and Filchner area only a few data on fish distribution are available from expeditions in the early 1980s. Based on the results of these expeditions, the differences between the fish fauna of southern Weddell Sea in comparison to the eastern Weddell Sea seems to be minor in terms of species number and species composition (Schwarzbach 1988), but seems to be most evident in respect of fish biomass and production (Hubold 1992). Biomass of demersal fish species on the southern shelf is low and the estimated production is only one-fourths of the production on the eastern shelf. Pelagic fish biomass, in contrast, is distinctly higher on the southern shelf. The main objectives of this project were to investigate the spatial distribution, species composition, biomass and production of demersal and pelagic fish fauna in the Filchner area. These data will form the basis for further analysis of the relationship between abiotic parameters, such as Water temperature, ice cover and the spatial and temporal development of biodiversity in the Filchner area.

Work at sea

Species composition, biomass and size distribution of the demersal and pelagic fish fauna were determined from both, bottom trawl and Agassiz trawl catches on all study sites. Trawling took place at water depths between 213.5 m and 1,749.5 m. Fish were sorted by species, and the total length (TL) and standard length (SL) measurements were rounded down to the nearest whole centimeter. Fish weights were recorded to within an accuracy of 1 g. During weighing, a distinction was made between the total weight and the gutted weight of the fish. In addition, individuals were sexed and the gonad weight was taken. In juveniles, it was not possible to sex every individual. In this case, individuals were only documented as juveniles (J). Trawling distance was computed via the GPS positions of each trawl. The trawling area was calculated over the distance and the width of the trawl. All biomass and abundance data were converted to an area of 1,000 m², which allows a direct comparison of the data from each haul of the single stations. The aim was, despite to get an idea of the biomass, abundance and distribution of Antarctic fish in the Filchner area, to take different samples needed for the single integrated projects within our working group. The main objectives were to catch some alive fish, to get environmental samples of different specimens (e.g. gonads, otoliths, stomachs) and also muscle or fin tissues for population genetics and phylogenetics. During the cruise PS82, an aquarium container system and a backup system container were installed to host alive fish. Sampling of alive fish was mainly done by bottom trawls. With the baited fish trap, which was only used once, four individuals of the genus *Trematomus* could be collected additionally to the bottom trawl catches. Only alive fish in a good condition were taken out of the catches and were immediately taken into an antibiotic bath, where they were kept for a few hours to maintain their health. Afterwards, fish were conveyed into the aquarium container where they are kept at 0 °C water temperature.

Preliminary (expected) results

In total 23 bottom trawls and 17 Agassiz trawls could be realized at different study sites during the cruise PS82 (Fig. 3.3.4.1.1). Dead fish from the trawls were directly

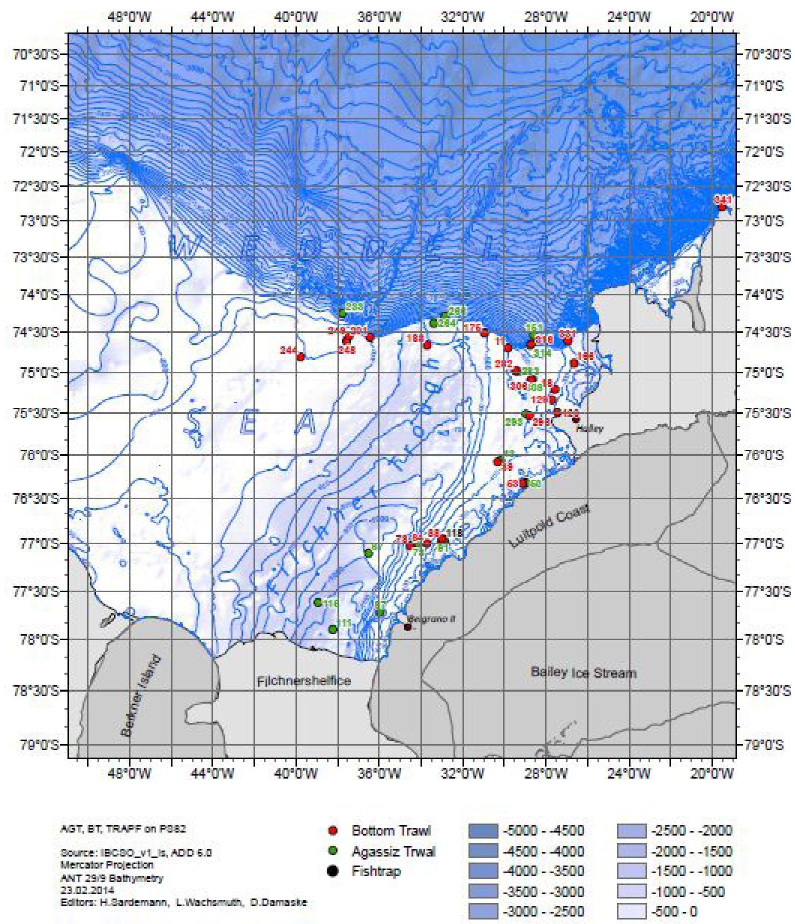

Fig. 3.3.4.1.1: Overview of all bottom trawls and Agassiz trawls realised during the cruise PS82

processed after the trawl. All individuals were identified, measured (total length and standard length), weighted (total weight and gutted weight), and sexed.
Over 2,000 samples were taken from different Antarctic fish species, hence building a sufficient basis for further ecological, physiological, molecular, and genetic analyses. These data will provide information about the growth, reproduction, and population genetics of fish in the Filchner area. So far, the biomass (Fig. 3.3.4.1.2) and abundance (Fig. 3.3.4.1.3) of all species from the bottom trawls could be calculated for the different stations. Besides *Pleuragramma antarcticum*, species from the genus *Chionodraco* and *Trematomus* constitute a relatively great portion of the total biomass observed at the single investigated stations. Comparing the single investigated stations, total biomass per haul was obviously lower in the southern trench (*PS82/078-1, PS82/084-1, PS82/088-1*). Highest mean biomass could be observed in the eastern shelf areas. This is also true for the abundance; highest number of individuals could be detected at station *PS82/306-1* whereas the lowest were found at station *PS82/088-1.*

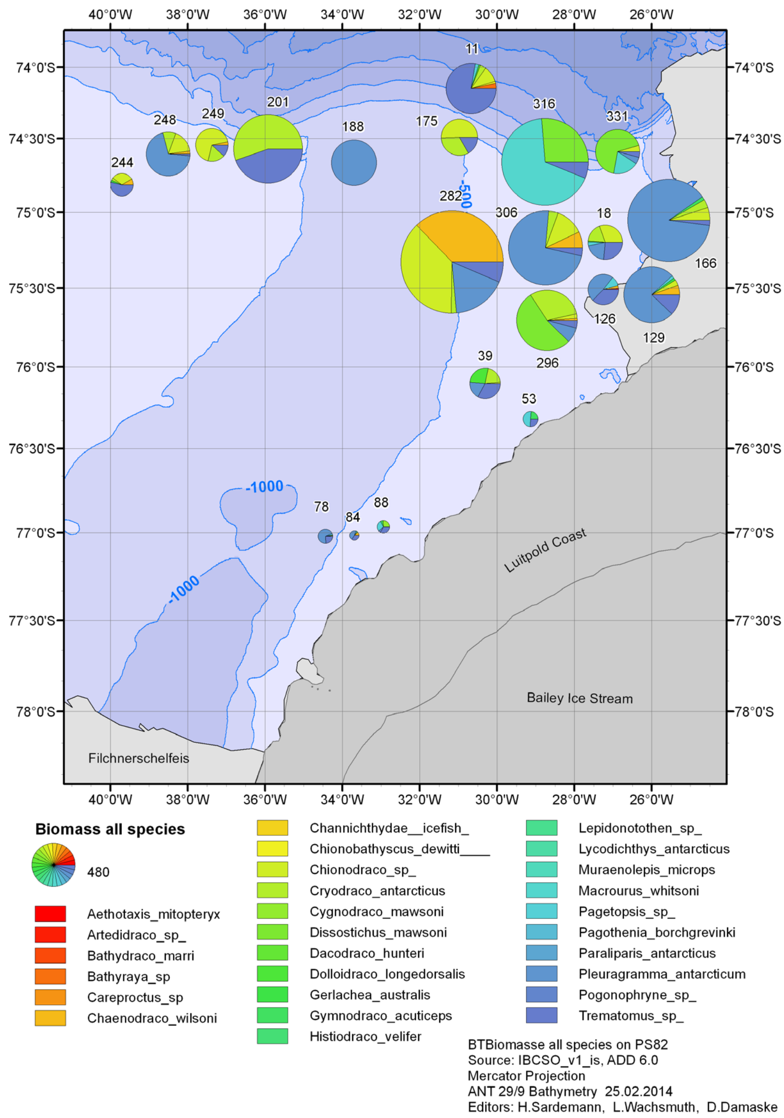

Fig. 3.3.4.1.2: Biomass (g/1,000 m²) of the single species or genus caught by bottom trawls during the cruise PS82

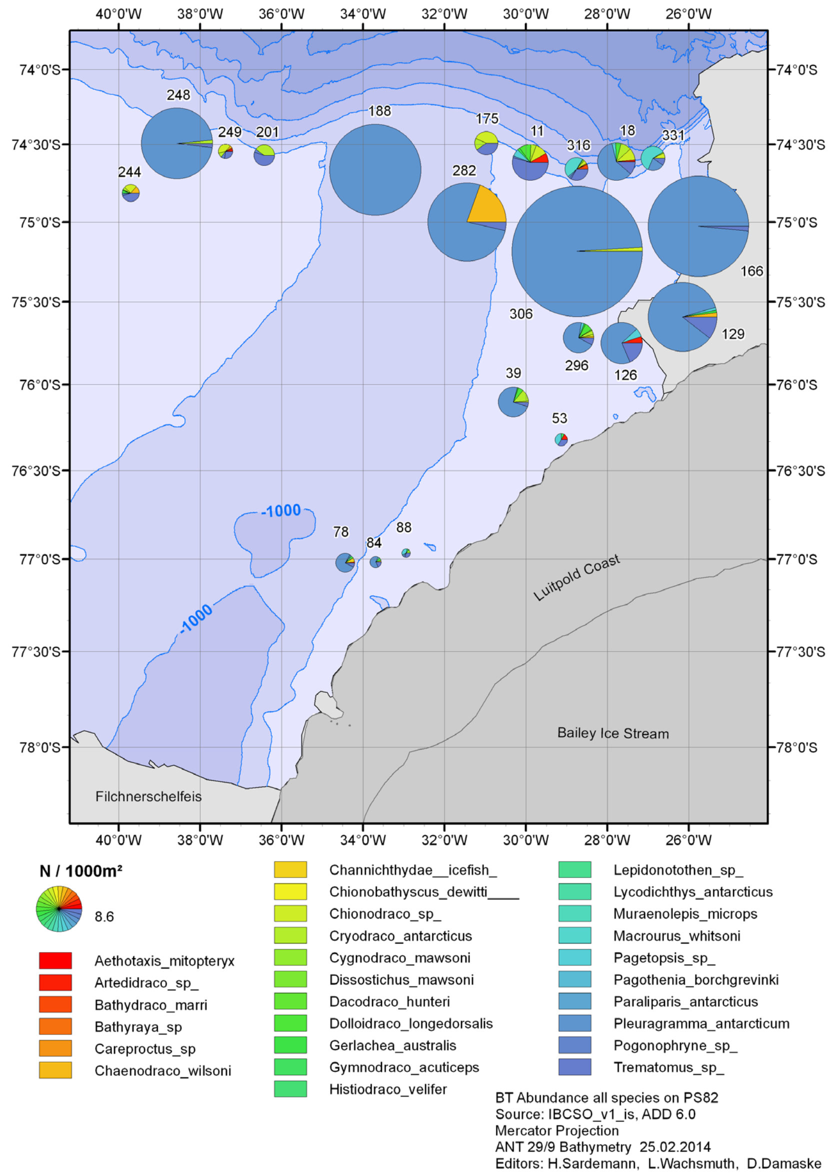

Fig. 3.3.4.1.3: Abundance (N/1,000 m²) of the single species or genus caught by bottom trawls during the cruise PS82

Data management

All samples taken during this expedition will be analysed in the laboratories at the AWI in Bremerhaven and the University Padova in Italy. Tissue samples will be analysed for stable isotopes and population genetics, stomach contents will be investigated to get a better insight in the prey taxa, gonads will be inspected for the reproductive status and otoliths will be analysed to determine the age and growth of Antarctic fish in the Filchner area. After data analyses, all results generated from this expedition will be published in the AWI data base PANGAEA Data Publisher for Earth & Environmental Science (http://www.pangaea.de/).

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3.3.4.2 The role of the Antarctic silverfish *Pleuragramma antarcticum* in the Antarctic waters

Maj Wetjen[1], Kai Wätjen[1], Rainer Knust[1] [1]AWI

Grant No: AWI_PS82_03

Objectives

Studies have shown that the Antarctic fish communities differ between the north-eastern Weddell Sea shelf areas and the southern shelf of the Filchner area (Hubold 1992). The pelagic fish biomass and production is quite high in the southern Weddell Sea (1.3 g/m²) compared to the north-eastern shelf (0.10 g/m², Hubold 1992) and is mostly borne by one single species, the Antarctic silverfish *Pleuragramma antarcticum* (Hubold 1992, Hubold & Ekau 1987). This zooplankton-feeding species inhabits both, the ice-free and the pack ice waters over the Antarctic continental shelf and distinctly dominates the fish communities on the eastern Weddell Sea shelf. Therefore, it is the most important food source for upper consumers (e.g. seals, pinguins) (Hubold 1992, Plötz et al. 2001) and contributes to the bentho-pelagic coupling by vertical feeding migrations (Knust et al. 2012) from the seafloor towards upper water layers (Fulman et al. 2002, Plötz et al. 2001). Recent studies have shown that besides high abundances of adult *Pleuragramma* specimen, high densities of larvae and postlarvae could be observed off the Filchner Ice Shelf in the upper water layers over the Filchner Trough (Ekau & Hubold 1985, Keller 1983, Boysen et al. 1983, Hubold 1984). Therefore, the Filchner area might probably not only be a feeding ground for adults, but also a nursery ground and retention area for larval *P. antarcticum* (Hubold 1984). Moreover, in the eastern part of the Weddell Sea, foraging behavior of Weddell seals is known to be linked to the occurrence of *P. antarcticum* (Plötz et al. 2001). It is an important food source, not only for Weddell seals, but also for southern elephant seals from King George Island (Daneri & Carlini 2002) and other high-level predators in the Antarctic waters. The dense stock of *P. antarcticum* in the southern Weddell Sea may also explain the tendency of male southern elephant seals to migrate from King George Island to the Filchner area for feeding. The dominant role of *P. antarcticum* in the high-Antarctic shelf areas evinces that this key species represents a central and essential position in the Antarctic food webs.

Work at sea

Biomass, abundance and size distribution of *P. antarcticum* was determined from bottom trawl catches as it could not be caught via Agassiz trawls or baited traps. The bentho-pelagic trawl could not be operated due to the very difficult ice situation. *Pleuragramma* specimens were selected from the trawl catches in order to collect morphological and biological data of each individual. Directly after the haul *Pleuragramma* specimens were measured, weighed and dissected in order to obtain the following information: total and standard lengths (TL and SL); total and gutted weights (TW and EW); and sex. Moreover, from around 20 – 40 specimens per station tissue samples (stable isotope analysis), stomachs (food web analysis), and otoliths (age determination) were extracted. After proceeding, tissue samples were labeled and directly frozen at -20 °C. Additionally to the sampling activities, several *Pleuragramma* specimens were also labeled and frozen at -20 °C for later investigation in our home laboratories at the AWI in Bremerhaven.

Preliminary (expected) results

Overall around 450 specimens of *P. antarcticum* could be processed directly on board to extract the otoliths, stomachs and tissue samples, whereas further individuals were frozen to be processed and analysed in the laboratories of the AWI. Biomass and abundance data of *P. antarcticum* were converted to an area of 1,000 m² to allow a direct comparison of the different investigated stations. In most investigated areas *P. antarcticum* takes in a great portion of the whole biomass and abundance determined. At the stations *PS82/129-1*, *PS82/166-1*, and *PS82/306-1* it`s biomass accounts for more than 70 % and at station PS82/188-1 even 100 % of the entire biomass determined. Abundance was also quite high at the stations *PS82/166-1*, *PS82/248-1*, *PS82/282-1*, and *PS82/306-1*. At these stations the abundance was greater than 90 % of the total catches. Besides the stations where no *Pleuragramma* specimens could be obtained (*PS82/011-1, PS82/053-1, PS82/088-1, PS82/175-1, PS82/201-1, PS82/244-1, PS82/249-1*), abundance was relatively low at the stations *PS82/316-1* and *PS82/341-1* with less than 1 individual per 1,000 m². In 12 out of 23 bottom trawls *P. antarcticum* showed an abundance > 50 % of the total individuals caught.

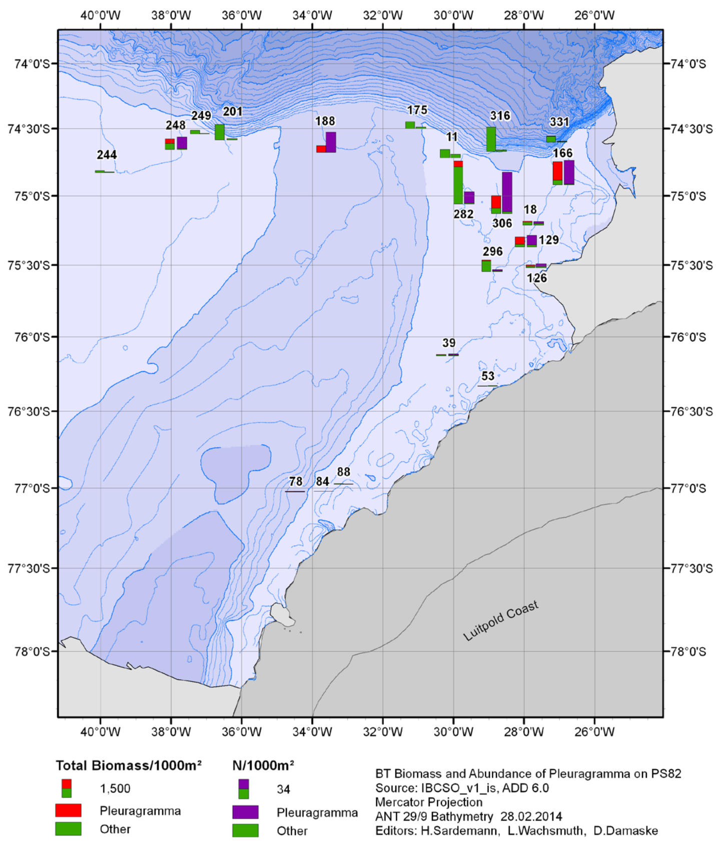

Fig. 3.3.4.2.1.: Abundance (N/1,000 m²) and biomass (g/1,000 m²) of P. antarcticum in comparison to the total abundance and biomass of the investigated stations (only bottom trawls) during the cruise PS82

Data management

All samples taken during this expedition will be analyzed in the laboratories at the AWI in Bremerhaven. Tissue samples will be analyzed for stable isotopes, stomach contents will be investigated to get a better insight in the prey taxa and food webs, and otoliths will be examined to determine the age and growth of *P. antarcticum* in the Filchner area. After data analyses, all results generated from this expedition will be published in the AWI data base PANGAEA Data Publisher for Earth & Environmental Science (http://www.pangaea.de/). In collaboration with the colleges from the University of Padova, data of *P. antarcticum* are likely to be joined together to get a full overview and a better understanding of the ecological role of this key species in the Antarctic waters.

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3.3.4.3 Reproductive traits in Antarctic fish: a comparative analysis of notothenioidei

Emilio Riginella[1 2]
not on board: Carlotta Mazzoldi[1], Maria B. Rasotto[1] and Mario La Mesa[2]

[1]Uni-Padova
[2]ISMAR-CNR

Grant No: AWI_PS82_03

Objectives

Teleost fish present large variability in reproductive traits. Individual investment in gonads varies at inter- and intra-specific levels, in relation to reproductive modalities and strategies. On the female side, investment in gonads and the trade-off between egg size and egg number are more variable.

For what is known about their reproductive strategies, Antarctic and non-Antarctic notothenioids show generally high reproductive investment, documented by high gonadosomatic indices, large egg sizes, prolonged gametogenesis and, in some cases, long male parental care. However, comparing species within the notothenioids, a wide variability in the above mentioned reproductive traits has been observed. The comparative study of male and female reproductive apparatus, including morphology, gametogenesis and investment in gametes, is particularly interesting from an evolutionary biology point of view. Notothenioids are well known for their adaptations to the Antarctic environment, however, within the Southern Ocean they inhabit different environments, characterized by differences in abiotic factors.

This study is aimed to comparatively analyse male and female reproductive traits of notothenioid fish, in relation to their ecological characteristics and environmental factors, and, taking into account the available information on phylogenetic relationships, to apply comparative methods such as independent contrasts. This study will also contribute to the conservation policies of this suborder, since the knowledge of reproductive characteristics of exploited species is recognized crucial for their management.

This study started with the collection of samples during the ANT-XXVII/3 (2011) and ANT-XXVIII/4 (2012) expedition cruises on board of *Polarstern*, in which gonad samples of 14 species (about 1,500 specimens) of Nototheniidae and one Zoarcidae were collected, together with otoliths, along the Scotia Arc (Antarctic Peninsula, Elephant Island, South Orkney, South Georgia, South Shetland Islands) and Burdwood Bank. The availability of samples taken from different sites will allow intra-specific comparison of life history traits along environmental gradients and highlight potential isolation of populations. The present cruise represented a unique and important opportunity to collect samples of high Antarctic species from Filchner Trench, a rarely accessible part of the Weddell Sea, therefore a key sampling site for comparative analyses. Samples collected during PS82 will be compared not only to those from the western Antarctic Peninsula, but also to specimens from the Ross Sea thanks to the collaboration with the research group of R. Knust (AWI) and T. Sandersfeld (AWI, not on board). In addition, differences in the life history parameters of different populations of the same species, including reproduction, spawning and maturity, as well as age and growth, will be integrated to provide a more precise tool for fish-stocks identification. Estimates of these parameters, indeed, are considered representative of individual fish within a putative stock, and can be used to distinguish among discrete stocks because they are phenotypic expression of the interaction between genotypic and environmental influences. Consequently, differences in life history parameters are assumed to mirror geographically and/or reproductively isolated fish populations and therefore considered as discrete stock units for management purposes.

Work at sea

A total of 40 hauls were conducted only during daylight hours, the catches were located in water depths between 261 and 769 m (bottom trawls, 23 stations), and between 213 and 1,749 m (Agassiz trawl, 17 stations). Sorting and species identification were performed once the catch was on board. Date and site of collection together with a set of standard measurements (total and standard length, total weight and gonad weight) were recorded. Sex and maturity were macroscopically determined and assigned to each fish (Kock & Kellermann 1991). Gonads or, in few cases, the whole fish or trunks of males and females were removed and fixed in either Dietrich solution for histological analysis or 10 % buffered seawater formaldehyde solutions for fecundity estimation and stored at room temperature. To estimate age, growth rate and age at first sexual maturity, otoliths were removed and dry-stored. This work was performed in collaboration with C. Papetti, M. Babbucci (Uni-Padova), N. Koschnick, K. Waetjen, M. Wetjen and R. Knust (AWI), see also specific contribution for more details. Further analyses will be carried out in the lab in Italy, at the University of Padova (reproductive biology) and at the Institute of Marine Science of Ancona (age and growth rate).

Preliminary (expected) results

Overall, more than 1,900 specimens were collected from 40 notothenioid species and 3 other taxa (Liparidae, Macrouridae and Muraenolepidae). In particular, for the reproductive study and age and growth rate assessment, samples from both female and male were collected for different species in this study (Table 3.3.4.3.1).

Although few specimens were obtained for rare species, they were anyway preserved for future exchange with international scientific institutions or for Museum exposition, taking into account their rarity. For all species, otolith and gonads samples were obtained from the whole size range of fish collected. The size range of the most abundant species, measured as total length, was as follows: *Chaenodraco wilsoni* (20.5 – 32.3 cm), *Chionodraco hamatus* (14.5 – 49 cm), *Chionodraco myersi* (7.5 – 38 cm), *Chionodraco rastrospinosus* (6.1 – 48 cm), *Cryodraco antarcticus* (15.5 - 60 cm), *Dolloidraco longedorsalis* (7 – 14 cm), *Gerlachea australis* (11.5 - 28), *Macrourus whitsoni* (10.4 – 89 cm), *Neopagetopsis ionah* (43 – 55 cm), *Pagetopsis maculatus* (12 – 23 cm), *Pleuragramma antarcticum* (7.8 – 25.8), *Trematomus eulepidotus* (11 – 35 cm), *Trematomus loennbergi* (14 – 30 cm), *Trematomus scotti* (6.5 – 16.2 cm).

Important observations about fish reproduction and parental care (*Neopagetopsis ionah* and *Chaenodraco wilsoni*, nests guarding) were recorded thanks to the collaboration with all scientific groups focused in collecting benthos images and video data (H. Biebow et al., AWI, and S. Ambroso et al., ICM-CSIS respectively, see specific contributions, chapters 3.3.3.1 and 3.3.3.3).

Moreover, digitally recorded images of gonad and otolith samples together with the whole specimen, taken during the sampling activity, will be used for additional comparative analysis (e.g. sexual dimorphisms assessment).

Tab. 3.3.4.3.1: List of samples collected with more than 5 specimens for reproductive traits study

	Female		Male		Total N.
Species	**Stage 1-2**	**Stage 3-4-5**	**Stage 1-2**	**Stage 3-4-5**	
Artedidraco skottsbergi	11	7	5	3	26
Bathydraco macrolepis	1	2	5	-	8
Bathydraco marri	2	3	1	3	9
Chaenodraco wilsoni	13	59	39	20	131
Chionodraco hamatus	32	30	41	14	117
Chionodraco myersi	37	20	30	3	90
Chionodraco rastrospinosus	20	13	24	2	59
Cryodraco antarcticus	58	6	66	9	139
Cygnodraco mawsoni	1	1	6	-	8
Dissostichus mawsoni	4	1	1	1	7
Dolloidraco longedorsalis	33	21	24	2	80
Gerlachea australis	10	16	13	6	45
Macrourus whitsoni	53	23	27	1	104
Neopagetopsis ionah	-	56	-	26	82
Pagetopsis macropterus	3	3	7	-	13
Pagetopsis maculatus	24	14	39	-	77
Pleuragramma antarctica	76	65	82	34	257
Pogonophryne phyllopogon	2	1	3	-	6
Prionodraco evansii	3	1	3	-	7
Racovitzia glacialis	4	2	1	-	7

	Female		Male		Total N.
Species	**Stage 1-2**	**Stage 3-4-5**	**Stage 1-2**	**Stage 3-4-5**	
Trematomus eulepidotus	58	95	33	66	252
Trematomus hansoni	1	3	2	-	6
Trematomus lepidorhinus	12	1	13	-	26
Trematomus loennbergii	40	4	27	-	71
Trematomus scotti	45	40	69	3	157

Data management

All data collected during this cruise will be provided upon request. All gonads samples will be stored and analysed at the Hydrobiological Station "Umberto D'Ancona" in Chioggia (Venice, Italy, detached facility of Biology Department, Padova University), in collaboration with C. Mazzoldi and M.B. Rasotto. Otoliths reading will be perform at ISMAR-CNR of Ancona (Italy) in collaboration with M. La Mesa. All data resulting from samples analyses collected during this cruise will be available through publications or reports.

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3.3.4.4 Molecular physiology and genetic profiling of Antarctic fish

Chiara Papetti[1,2], Nils Koschnick[1], Massimiliano Babbucci[2],
not on board: Magnus Lucassen[1], Lorenzo Zane[2], Tomaso Patarnello[2]

[1]AWI
[2]UniPadova

Grant No: AWI_PS82_03

Objectives

Thermal adaptation and phenotypic plasticity, which define the thermal niche and the kind of response to fluctuating environmental factors, are ultimately set by the genetic interior of an organism. Adaptations to the extreme cold appear to have evolved at the expense of high thermal sensitivity. Thus, the molecular physiology group at the AWI combines holistic expression profiling and the investigation of key functional traits for an in-depth understanding of climate sensitivity in Antarctic fish (Windisch et al. 2011, 2012). The molecular data are being interpreted in the context of physiologically and ecologically relevant parameters for meaningful conclusions. Example studies on fish mitochondria, resembling such a key functional trait, suggest that mitochondrial functioning and organisation underwent significant adaptations upon evolution to extreme cold (Mark et al. 2006, 2012; Windisch et al. 2011; Papetti et al. 2007). For Antarctic eelpout we identified a sensitively responding molecular network, which may explain higher performance including large rearrangements of the energy metabolism beyond the realized ecological niche (Windisch et al. 2011). Gene profiling by means of microarrays indicate a reciprocal relation between growth performance and the expression of the temperature-responsive genes of the transcriptome (Windisch et al. 2014). The principles and general applicability of these studies from Antarctic eelpout needs to be validated in other (highly cold-adapted) Antarctic fish phyla, which may differ in sensitivity to thermal challenges. The selectivity of identified genetic traits has to be judged against information about population structure and diversity provided by neutral genetic markers. In this regards, the Biology Department at the University of Padova has a long tradition in studying the population genetics of Antarctic fish, in particular along the western Antarctic Peninsula. Ongoing projects on Antarctic fish in that area include studies of the molecular phylogeny of Notothenioids and population genetics of *Chionodraco rastrospinosus*, *Chaenocephalus aceratus* and *Pleuragramma antarcticum* (Papetti et al. 2011, 2012; Marino et al. 2011). Monitoring the genetic differentiation of some of these and further species in the Weddell Sea will allow comparing differentiation pattern of the southern Weddell Sea and the Antarctic Peninsula and verify possible connectivity patterns. under the idea that water circulation at small spatiotemporal scales may be modified by global warming leading to the possible reduction of suitable habitats and strongly impacting the inter-annual recruitment and growth variability of both pelagic and benthic organisms. The ongoing collaboration of both groups and the application of new approaches in conservation genomics including gene expression profiling on the background of physiological and ecological performance parameters, may give a major boost to the understanding of the evolution and population genetic structuring of Antarctic marine organisms, especially in response to global climate change. The PS82 cruise provided a unique opportunity to expand molecular genetic sampling programme of species from the Filchner and the area of Austasen in the south-eastern Weddell Sea, i.e. the cold edge of the Antarctic ecosystem, which is essential for a comprehensive understanding of climate-driven evolution and sensitivity of highly cold-adapted species.

Work at sea

Specific activities on board were aimed to catch Antarctic fishes, namely Notothenioids, eelpouts but also other abundant species, along the cruise plot.

In particular, for the aims of the project, three different samples categories were needed:

- alive specimens;
- environmental samples from individual specimens (different body tissues);
- ethanol preserved muscle or fin tissues for population genetics and phylogenetics.

Our work at sea was integrated within the sampling programme of other biology groups. In particular, all sampling activities, fish species identification, parameters recording, tissue collection and storage were conducted together with two groups working on other aspects of Antarctic fish research, (M. Wetjen, K. Wätjen, R. Knust from the AWI and E. Riginella (UniPadova), see also specific contributions, chapters 3.3.4.1, 3.3.4.2, and 3.3.4.3.

All specimens were collected by means of either bottom trawls or Agassiz trawls.

During the cruise PS82, an aquarium container system (AWI024) and a backup system in a cool container were installed to host alive fish.

Alive fish were mainly taken from short bottom and, most rarely, Agassiz trawls (10-15 min on ground). In these cases, to minimize the handling stress, only fish netted alive and without macroscopically visible damage are being kept in the aquarium container on board *Polarstern* at environmental temperature and light conditions, and will be transported alive to the AWI during PS83 (ANT-XXIX/10).

Some alive fish from bottom trawls were processed directly or after recovery for short time in the aquarium container (AWI024). Individual fish were anesthetized and killed before tissue sampling following international rules for animal care. Tissues were dissected immediately to avoid RNA degradation. Organs sampled for RNA extraction were blood and serum, spleen, brain, liver, gills, kidney, pronephros, red muscle, muscle, otoliths and gonads. They were collected under clean conditions, frozen instantaneously in liquid nitrogen and stored at -80 °C.

During past cruises, a reasonable number of tissue samples from a broad set of alive fish species were already collected within other Antarctic study areas, mainly the western Antarctic Peninsula. These samples will be used for future comparisons. The modern molecular analyses tools (high-throughput sequencing) represent a quantum leap in analysing environmental samples from individual specimens. The continuous sampling of these samples will allow for holistic analyses of active genomes in a changing environment over time.

Dead fish from bottom trawls and Agassiz trawls of all fishing areas were processed directly after the haul. In particular, these samples are of great interest for population genetics analyses. Regarding this, the work at sea targeted the expansion of UniPadova geographical sampling series of frozen and ethanol preserved muscle/ fin tissues of notothenioid fish. The working plan for population genetics sampling was aimed to collect adult and juvenile specimens, together with information about total length, wet weight, gutted weight, sex, gonad index/maturity state information, and otoliths. In particular, as during past *Polarstern* cruises (e.g. ANT-XXVIII/4), a unique individual identifier was assigned to each fish collected, thus allowing to record these pieces of ancillary information for each fish for further use in following genetic analyses. As previously mentioned, this information was recorded thanks to the collaboration with all scientific groups focused in collecting fish data (M. Wetjen, K. Wätjen, R. Knust from the AWI and E. Riginella from UniPadova) who will provide upon request the data related to otoliths collection, sex determination, biomass assessment and stomach content analyses of some target species. Several single fishes of different sex and species have been digitally recorded in collaboration with E. Riginella (Uni Padova) and pictures associated to the corresponding identification number for late re-analyses. Muscle tissue or a piece of the caudal fin for DNA extraction was dissected from each individual and preserved in ethanol 99 % at +4 °C. All the remaining experimental protocols concerning the objectives described in this report will be carried out once back in the laboratories at the AWI or at Padova University.

Preliminary (expected) results

The cruise provided access to a large number of fresh tissue samples from most of the Antarctic notothenioid fish families, and thus representing an excellent basis for comparative tissue and cellular analyses. This cruise sampling activity has definitively allowed the AWI and Uni Padova to widely extend their sample sets of Antarctic fishes especially by high-Antarctic species from the Filchner and Austasen areas. Once analysed at the respective home institutions they will provide a comprehensive picture of the genetic basis of climate-driven evolution and sensitivity of highly adapted species.

The joint sampling, fish processing and rearing efforts in aquaria of all scientists on board, involved in fish sampling projects on board, allowed to increase the reciprocal sampling size to more than 1,900 individuals.

Catching alive fish

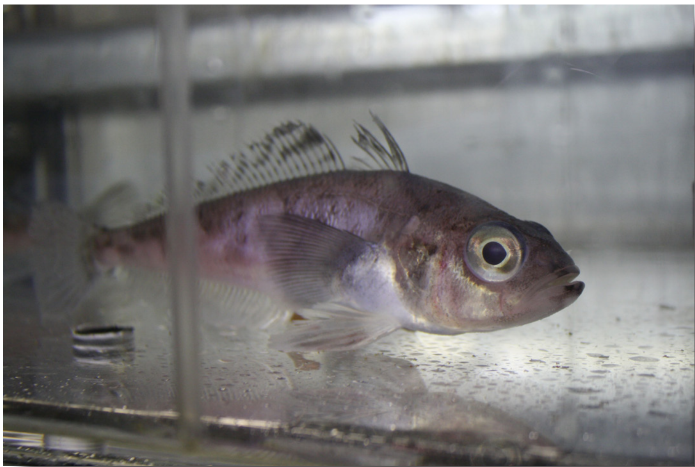

Fig.3.3.4.4.1: Trematomus eulepidotus (Notothenioidei) in the Polarstern cold aquarium facility (Photo: courtesy of M. Babbucci, UniPadova)

As anticipated sampling of alive animals was mainly done from the bottom trawls. More than 150 individuals from 13 different fish species (mainly *Trematomus eulepidotus*, Fig. 3.3.4.4.1 and Artedidraco sp.) were finally collected for transportation to the AWI, Bremerhaven. Depending on sufficient specimen numbers, some of these fish will be used for physiology, growth rate and transcriptomic experiments upon acclimation to specific conditions in collaboration with R. Knust (AWI). This approach will contribute to characterise fish performance-limiting processes at different organismic levels facing environmental challenges by physiological and molecular tools.

Sampling of tissues

For molecular and physiological studies at home institutes, samples were instantaneously isolated after the haul from selected species (Table 3.3.4.4.1). These samples, taken from a number of red-blooded Notothenioids and several icefish will allow the projected comparative analyses at the home institutes.

Tab. 3.3.4.4.1: List of samples collected on board *Polarstern* for molecular and physiological studies. In the table, for every species, the number of individuals and their sex are provided.

Species	N	Males	Females
*Chaenodraco wilsoni**	3	2	1
*Chinodraco hamatus**	1	1	-
*Chionodraco myersi**	2	1	1
*Chionodraco rastrospinosus**	7	3	4
*Cryodraco antarcticus**	7	3	4
Gerlachea australis	3	-	3
Gymnodraco acuticeps	5	3	2
*Pagetopsis macropterus**	4	1	3
*Pagetopsis maculatus**	4	1	3
Pleuragramma antarctica	4	2	2
Racovitzia glacialis	1	-	1
Trematomus bernacchii	2	-	2
Trematomus eulepidotus	14	4	10
Trematomus hansoni	4	1	3
Trematomus scotti	6	1	5

* icefish species

Population genetics

All dead fish obtained from standard bottom trawl and Agassiz trawl catches were sampled for population genetics. The catches were located in water depths between 261 and 769 m (bottom trawls, 23 stations), and between 213 and 1,749 m (Agassiz trawl, 17 stations). Fish species were determined and individuals processed following a common protocol conceived by all fish groups (see contribution chapters 3.3.4.1, 3.3.4.2, 3.3.4.3, 3.3.4.4). In particular for all of them, information on individual length, weight, sex and gonad size and maturity were recorded. One to ten grams of muscle tissue or caudal fin were collected from each individual. Each sample has been stored in 99 % ethanol (at +4 °C) to maximize the chance of obtaining high quality DNA from it. DNA extraction and genetic analysis will be carried out in the laboratory in Italy. In total, tissue samples for DNA extraction were collected from more than 1900 individual fish during PS82.

Several abundant species yielded particularly useful large samples (>30 ind.), namely: *Trematomus eulepidotus, Pleuragramma antarcticum, Chaenodraco wilsoni, Chionodraco hamatus, Chionodraco myersi, Chionodraco rastrospinosus, Cryodraco antarcticus, Dolloidraco longedorsalis, Gerlachea australis, Neopagetopsis ionah, Pagetopsis maculatus*. These species were collected in different areas of the Weddell Sea and will complement samples already stored at the AWI and Padova University. The availability of different size classes, and the possibility of working on the same individuals aged by E. Riginella (Uni Padova; see also specific contribution) and analysed by fish ecologists (M. Wetjen, K. Wätjen, R. Knust, AWI, see also specific contribution) may enable genetic analysis of different cohorts and sex to be conducted for meaningful conclusions. The selectivity of identified genetic traits, indeed, has to be judged against field information about the ecology and population structure/diversity provided by neutral genetic markers. In particular, a successfully large sample has been obtained for the pelagic species *P. antarcticum* although the bottom trawl nature of the fishery technique usually does not allow reaching this kind of species. This sample will promote the ongoing studies on this key species of the pelagic food web in the Southern ocean.

Other species collected

On occasion alive cephalopod specimens of good quality were sampled from the bottom trawls for further experimentations at the AWI (population genetics and expression profiling) and for a comparison to other Antarctic regions (in particular western Antarctic Peninsula). These specimens will be transferred to the AWI aquaria together with fish.

Data management

All data collected during this cruise will be provided upon request. All samples will be stored at the AWI and transported in case of need to the Biology Department of Padova University and may also be available to scientists from other institutions. All data resulting from the molecular analysis of the samples collected during this cruise will be available through publications or reports, and the corresponding project will be identified as Grant number PS82_03. Moreover, all samples obtained from the fishes after further experimentation at the AWI will be stored at the AWI and may, as well, become available to scientists from other institutions on request.

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3.3.5 Seal research at the Filchner Outflow System (SEAFOS)

Horst Bornemann[1], W. Christiaan Oosthuizen[2], Marthán N. Bester[2]

[1]AWI
[2]MRI

Grant No: AWI_PS82_03

Outline

Seal research at the Filchner Outflow System (SEAFOS) is one of the key elements within the investigations of the Filchner Outflow System onboard RV *Polarstern*, and closely related to parallel investigations in bathymetry, oceanography, and biology. By including biotic components from phytoplankton via fishes to seals and abiotic parameters such as bottom topography, sediment structure, and hydrographic features, these projects comprehensively aim to investigate the Filchner Trough Outflow System. Here the outflow of ice shelf water of the Filchner Ronne Ice Shelf interacts with warm deep water of the Weddell Gyre circulation. This interaction is supposed to be the primary cause that converts this area into a biological "hotspot" where upper and intermediate trophic level interactions are maximised. Physical, biogeochemical and ecological studies in the target area shall characterize this hotspot in detail.

Our earlier studies on migration behaviour of male southern elephant seals, satellite tagged in April and May 2000 on King George Island / Isla 25 de Mayo, showed that some individuals travelled into the dense winter pack ice of the southern Weddell Sea until they reached the region of the Filchner Trough outflow, covering a distance of more than 2,000 nautical miles (Tosh et al. 2009). The tagged seals remained in a localized shelf-slope area at the outflow of the Filchner Trough (~74.5° S ; 30-40° W) for several months. Area restricted movements within this locality during the study period indicate active foraging in a locally attractive feeding spot. The factors contributing to this hotspot of enhanced food availability are largely unexplored. The tendency of southern elephant seals to forage on the Antarctic continental shelf within the pack ice was illustrated also for seals from Bouvetøya (Biuw et al. 2010), Iles Kerguelen (Bailleul et al. 2007) and Macquarie Island (Bradshaw et al. 2003). Weddell seal foraging behaviour in the Weddell Sea has been linked to the presence of the Antarctic silverfish *Pleuragramma antarcticum* (Plötz et al. 2001). The presence of this dominant pelagic fish species (Hubold 1985), likely influences the movement patterns of female elephant seals from King George Island as well (Bornemann et al. 2000) and forms an important part of the pelagic fish diet of southern elephant seals from King George Island (Daneri & Carlini 2002). Our data on southern elephant seals (Tosh et al. 2009) and those derived from recent tagging studies of Weddell seals (Nicholls et al. 2008; Årthun et al. 2012) represent the only and still preliminary behavioural investigations of foraging behaviour and habitat use of seals in the south-eastern Weddell Sea. It is assumed that other marine endotherms such as emperor penguins from the breeding colonies at Gould Bay (77.71° S - 47.68° W), Luitpold Coast (77.07° S – 33.06° W) and Halley (75.54° S – 27.43° W), with estimated populations of about 8,000, 6,000, and 22,000 birds (Woehler 1993; Fretwel et al. 2012), could also forage towards the same region. However, reports on top predator abundances in this region are extremely scarce. Recent aerial seal surveys by the AWI *Polar 2* aircraft along the eastern coast of the Weddell Sea (Plötz et al. 2011a-e) did not go far beyond the Drescher Inlet at 19°W (Southwell et al. 2012), and helicopter surveys from aboard RV *Polarstern* in the Weddell Sea in 2004 / 2005 (ANT-XXII/2) concentrated north of 69°S (Flores et al. 2008). Just one flight transect was flown in 1998 with a fixed wing aircraft by a British team in the area of the Berkner and Belgrano Banks west of the Filchner Trough (Forcada & Trathan 2008; Forcada et al. 2012; Southwell et al. 2012). However, this transect did not reveal regional abundances of pack ice seals in the area of the Filchner Trough, since the analyses applied to the whole sector between 90° W and 30° W and 60° S to 80° S (Forcada & Trathan 2008; Forcada et al. 2012; Southwell et al. 2012). A completed APIS survey, based on helicopter flights from aboard RV *Polarstern* in 1998 (ANT-XV/3), covered the area from 7° W to 45° W with only 15 transects, concentrating on the east coast of the Weddell Sea between 7° W and 26° W (12 transects), rather than on the area around the Filchner Trough, where only two transects were flown far north from the outflow system (Bester & Odendaal 1999; Bester & Odendaal 2000) and the results did not inform on local abundances of seals. Early cruise reports of RV *Polarstern* and other research vessels contain few data on seal sampling in this area but recorded opportunistic sightings of southern elephant seals (Cline et al. 1970; Kohnen 1982). Cruise reports reflected the impression of enhanced occurrences of seals and other marine endotherms during voyages towards the former *Filchner* Station at the Filchner-Ronne Ice Shelf. As a result, we hypothesized that the area constitutes a biological hotspot.

3.3.5.1 Abundance and distribution of seals

Marthán N. Bester[2], W. Christiaan Oosthuizen[2], Daniel Steinhage[1] (not on board), Horst Bornemann[1]

[1]AWI
[2]MRI

Grant No: AWI_PS82_03

Objectives

This approach concentrates on an aerial seal survey over ice covered sea in order to get data on potential density gradients and density estimates for seals towards and within the area of the Filchner Trough. Historically, methods for seal surveys varied considerably, which restricts the comparability of data taken with different methodological approaches. In order to ensure that findings can be compared with those from earlier surveys, and thus contribute to testing the working hypothesis, we used the exact same methods applied in the only recent data set that is available for the Weddell Sea. This data set was generated by Bester and Odendaal (1999, 2000) from aboard RV *Polarstern* in 1998 during the multinational circumpolar Antarctic Pack Ice Seal (APIS) Programme of SCAR. The analyses of APIS were recently completed (Southwell et al. 2012), and are comparable in their methods with seal surveys that were carried out more easterly in the Weddell Sea by Bester et al. (1995; *cf*. Erickson et al. 1993).

Work at sea

A survey with the AWI fixed wing research aircraft *Polar 6* in November 2013 from *Halley VI* Research Station (UK) preceded the helicopter survey from aboard RV *Polarstern*.

Fixed wing aircraft survey with research aircraft Polar 6

RA *Polar 6* on its transfer flight between *Rothera* Research Station (UK) and *Novolazarewskaja* Air Base (RUS) made a stopover at *Halley VI* for two days. Based at *Halley VI, Polar 6* conducted a systematic digital photographic aerial survey of the area of the Filchner Outflow System during two survey flights of

3,000 km each on 15 (eastern section) and 16 (western section) November 2013. Due to a low cloud ceiling on 15 November, the first flight operation was terminated prematurely and thus the westernmost track could not be flown. This track was flown on 16 November, and the total number of tracks numbered 11 instead of 12 as had been planned originally.

The aircraft was equipped with nadir mounted vertically built in Canon Mark III 1Ds photo (sensor-ID 724) and a video camera (710) with recording unit (B835) for still pictures and video footage respectively. The camera has a 24 x 36 mm full-frame sensor with 3888 x 2592 pixel resolution, and was equipped with a 14 mm wide angle f 2.8 lens (81° vertical and 104° horizontal angle of view). In addition, the aircraft's zenith video camera (710), the laser scanner RIEGL VG580 (B832), the laser altimeter RIEGL LD90 (705), and the infrared radiation thermometer KT19 (B839) and the hygrometer CR2 (722) were successfully operated. During the flights, a total of 7,213 nadir camera images (stored as .jpg and as Canon specific raw .CR2 formats) and 13 files of parallel video footage (stored as .mpg) were taken and archived on an external hard drive. The hard drive was deposited at *Neumayer Station III* via *Novolazarewskaya* Air Base, retrieved by the authors during the supply operations on 30 December 2013, and the stored images were analysed thereafter on board RV *Polarstern*. The total data set is complemented by report files that contain GMT scripts for documenting the flight tracks relative to bathymetry, and GPS files containing the coordinates of the flight tracks in relation to time stamps (UTC) and altitude flown (WGS84). Approaches to the tracks were flown at 660 m (2,000 ft), and the tracks at 200 m (600 ft) altitude.

The survey design comprised 11 parallel transects with 37 km (20 nm) separation between successive transects (Fig. 3.3.5.1). Transects were placed perpendicular to the 1,000 m bathymetric contour to effectively sample the pack-ice habitat along a bathymetric gradient. Images were continuously recorded and successive photographs taken along the trackline overlapped to cover the entire length of the transect. Digital video footage recorded in parallel was not analysed, as still images were of superior resolution.

Seal density was estimated using strip transect sampling. Strip-width (the width of the observation area perpendicular to flight direction) was derived using simple trigonometry, using the flight altitude and field of view angle of the lens. Because the mean flight altitude varied somewhat between transects (194 to 221 m asl), strip-width was calculated separately for each transect (331 m to 378 m). Transect length summed to a total distance of 1,148.44 km. The total area covered by images taken at ~200 m asl, including the area surveyed when flying between two transects (lines connecting two transects; total distance 367.51 km), was 656.62 km^2.

Strip transect sampling assumes that all objects in the covered strip are detected (in our case, always detecting a seal when present in an image). In theory, detectability does not fall away with distance from the trackline for digital aerial surveys; though our personal experience was that objects near the edge of an image required more searching and may have a greater probability of non-detection. To control for incomplete detection, three trained observers independently examined all images on high definition LCD screens and annotated the presence or absence of seals in each image. All seals in an image were counted and the coordinates of the image tagged in a GIS layer.

All images with detections were validated after selection to ensure the correct identification of seals and removal of any images considered to be false positive identifications (e.g., shadows, cracks in ice, melt pools). Detected seals could, however, not be classified to species level. To estimate detection probability detections were split into those found by one, two or three observers. We assume that all seals located in each strip were counted when individual observer data was collated.

We additionally searched for seals on images taken during flights to and from the transect grid and *Halley VI*. Approach and return flights were flown up to a height of 660 m asl, allowing us to assess how detection probability falls away with altitude and if detections were still reliable at higher altitudes. If detection remained reliable at higher altitudes, such altitudes have the advantage of having a wider strip-width, increasing the covered area.

Helicopter survey from aboard RV Polarstern

Visual surveys of pack ice seals using helicopters were conducted from 4 January to 9 February 2014 from aboard RV *Polarstern*. For all seal related operations (including deployments of satellite transmitters and reconnaissance flights) a total of 30:13 hours during 20 flights were flown (MIN 0:11; MAX 3:13). Three reconnaissance flights over fast ice were done to detect potential locations to deploy satellite transmitters on Weddell seals (see below). For the survey flights, we used line transect sampling, an extension of strip transect sampling in which not all individuals in the strip need to be detected (Buckland et al. 2001, 2012; Thomas et al. 2010), to estimate the density and abundance of pack ice seals.

Our planned survey design included multiple, regularly spaced line transects with random starting points to provide uniform coverage of the entire region of interest (Thomas et al. 2010; Southwell et al. 2012). Such systematic designs often yield better precision than simple random designs, especially in the presence of density gradients through the survey region (Buckland et al. 2010). While aspiring to a systematic survey, logistical constraints such as ship position (as determined by various research programmes and pack ice conditions), helicopter range limits and inclement weather prevented exact implementation of the planned survey design. Nonetheless, our methods comply with the basic principles of survey design, which are randomization with regard to habitat, and replication. Ultimately, the survey region was sampled by flying systematically spaced line transects (parallel lines approximately 10 nm apart) whenever ship position and weather conditions allowed, without clustering transects in areas of easier access. When a full transect length could not be flown on a day, we attempted to complete (extend) the particular transect on a following day.

We considered two sampling regions, allowing comparisons to be drawn between these areas. First, we surveyed pack ice along the east coast of the Weddell Sea (Coats Land), from the Brunt Ice Shelf (76° section) along the Luitpold Coast (77° section) southwards to the Filchner Ice Shelf (78° section) as outlined in the station chart (see Fig. 3.2.1.1b). We subsequently refer to this area as the Filchner Trough region. Second, we surveyed pack ice to the west of the Brunt Ice Shelf along the outflow of the Filchner Trough between the section 'eastern' and the section 'western' shelf. We only surveyed pack ice as potential seal habitat. Counting seals on fast ice was disregarded as it would have been biased towards Weddell seals and not representative of the species composition of pack ice seals.

Transects in the Filchner Trough region were placed perpendicular to the coast across the bathymetric gradient, starting at the 400 m contour (Fig. 3.3.5.1). Six transects, totalling 425.54 km, were flown in this region. Transects in the Filchner outflow region were superimposed on the transect grid surveyed with *Polar 6*, though with less latitudinal extent and a doubling of the longitudinal density of transects to increase sampling intensity (transects were 18.52 km, i.e. 10 nm apart). Again, transects were placed perpendicular to the 1,000 m bathymetric contour, and extended if possible up to the 400 and 2,000 m bathymetric contours. Twenty-five transects, totalling 1,367.61 km, were flown in this region.

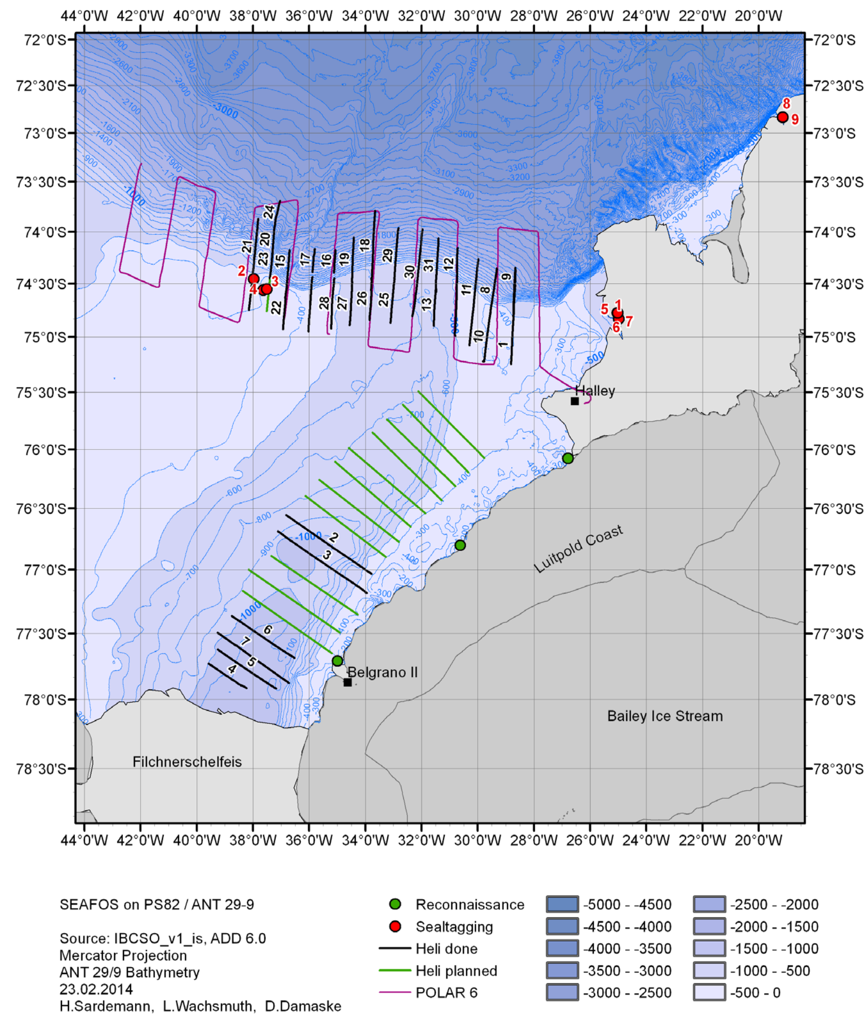

Fig. 3.3.5.1: Transects flown in the FOS by the AWI research aircraft Polar 6 (purple trackline), and the RV Polarstern onboard helicopter (black transects). Numbers in black denote the corresponding transect installations. Green transects were projected according to the corresponding ship's positions, but could not be flown due to unfavourable weather conditions. Green dots identify potential locations for deployments of satellite transmitters on Weddell seals following reconnaissance flights. Red dots mark locations where transmitters were deployed on fully or partly moulted adult Weddell seals. Numbers in red correspond with the seal IDs as given in Table 3.3.5.2.

Aerial surveys were flown with a Bölkow Blohm twin engined helicopter at a height of approximately 60 m (200 ft) and at a velocity of ~110 km h^{-1} (60 knots). Three observers (two on portside, one on starboard) independently searched for seals hauled out on ice, and identified seals sighted to species level. Each observer counted seals through sighting bars (aligned markers on the windows of the helicopter) allowing observations to be grouped into non-overlapping distance intervals (or "bins") based on the perpendicular distance from the trackline (Fig. 3.3.5.2, Table 3.3.5.1). Sighting bar distance intervals were calibrated to each observer by flying over flagged marker poles laid out on the shelf ice in proximity to the *Neumayer Station III* prior to the start of the survey. These perpendicular distances were used to estimate the detection function - the probability that a seal is detected, as a function of distance from the trackline. All individuals present 'on the trackline' are assumed to be detected for conventional distance sampling analyses; this assumption could be tested for the two portside observers using mark-recapture distance sampling methodology. Because the area directly below the helicopter was obscured for observers sitting in the rear of the helicopter, the visible trackline (g0) was offset by 35.2 m to each side of the helicopter.

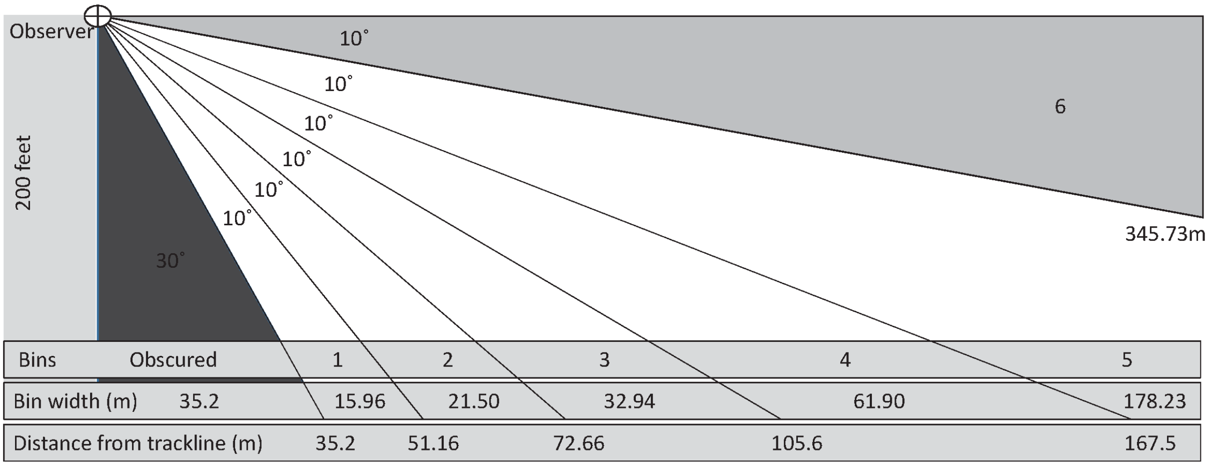

Fig. 3.3.5.2: Grouping of non-overlapping distance intervals ("bins") based on the observers' angle of view and resulting in the respective perpendicular distance from the trackline

Tab. 3.3.5.1: "Binned" observations based on perpendicular trackline distance

Bin	Bin width [m]	Distance from helicopter [m]*	Mean detection distance [m]	Comment
0	35.2	0	-	Observations truncated
1	15.96	35.2	43.18	g(0)
2	21.5	51.16	61.91	
3	32.94	72.66	89.13	
4	61.9	105.6	136.55	
5	178.23	167.5	256.615	
6	-	345.73	-	Observations truncated

*Distance to the start of the bin. Bin 6 stretched to the horizon

Counts were made in conjunction with the date, time and GPS location (continuous logging of GPS positions) of each observation. Observers used digital voice recorders to log count data and maximize search effort. Seals within two-body lengths of each other were assumed to occur as a group. One observer visually assessed sea ice concentration, size of ice floes and their surface nature during flights; in addition, photographs of sea ice were taken at 3 min intervals as reference material. To correct on-ice abundance estimates for seals unavailable for detection (seals in water), all flights were flown between 11:00 (starting) and 16:00 (ending) approximate local apparent time (LAT), corresponding to the midday haulout maxima of seals on the ice (Southwell et al. 2005). Since the Filchner Trough is located ca. -3h relative to UTC, flights were scheduled between 13:00 and 17:00 UTC, under consideration of the Filchner Trough area circumscribed (coverage) by Median Latitude: -74.50 * Median Longitude: -34.00 * South-bound Latitude: - 75.50 * West-bound Longitude: -43.00 * North-bound Latitude: -73. 00 * East-bound Longitude: -26.00.

Preliminary estimates of seal density and abundance was obtained using Program Distance 6.0 (release 2) (Thomas et al. 2009). A half-normal key function with cosine adjustments was used to model the detection function which was truncated to the range 35.2 – 256.5 m. Density estimates were stratified by region (Filchner Trough and Outflow respectively) and in the Filchner outflow region by transect to assess density gradients.

Preliminary (expected) results

Fixed wing aircraft survey

A total of 3,511 photos amounting to 42 GB storage volume together with 11 GB video footage was recorded on 15 November, and another 3,702 photos (46 GB) and video footage (12,5 GB) on 16 November 2013. In total, 389 seals were counted on 272 images across the entire flight profile, including transit flights to and from the transect grid. Detection probability varied by observer, decreasing and becoming more variable with increasing altitude (Fig. 3.3.5.3). Observer specific detection probability on transect lines was 0.69, 0.87 and 0.96 respectively. Combining unique records from all observers tallied to 265 seals sighted on transect lines, corresponding to a mean density of 0.40 seals km^{-2}. Linear regression of density across longitude suggested a significant longitudinal density gradient (β = -0.034 ± 0.007 SE (standard error); adjusted R^2 = 0.51, $p < 0.001$), from 0.04 seals km^{-2} in the east to 0.94 seals km^{-2} in the west (Fig. 3.3.5.4a). Latitude were weakly correlated with density (β = 0.15 ± 0.11 SE; adjusted R^2 = 0.05, p = 0.18), possibly because we surveyed a relatively small latitudinal gradient (Fig. 3.3.5.4b). Assuming that the proportion of seals available for detection (hauled out on ice) was 0.8 (Southwell et al. 2005), our density estimates scale upward to 0.50 seals km^{-2} (range 0.05 – 1.17 seals km^{-2}).

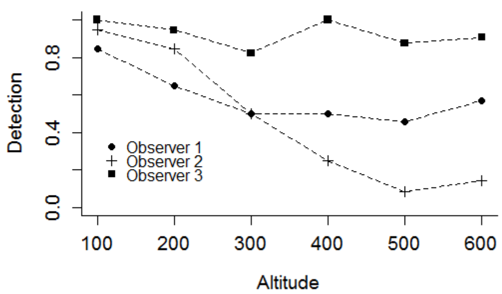

Fig. 3.3.5.3: Observer specific probability of detection at varying survey altitude

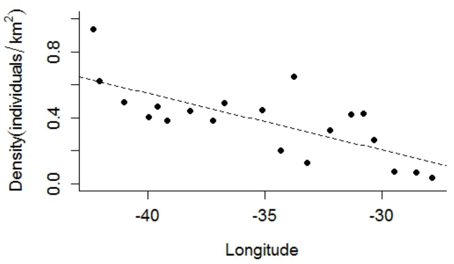

Fig. 3.3.5.4a: Density estimates (seals km^{-2}) for each transect in relation to longitude

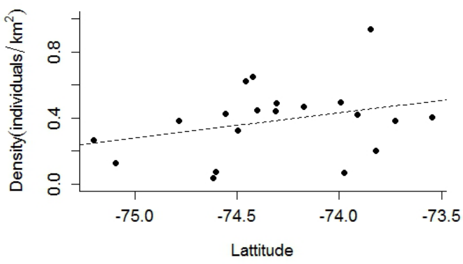

Fig. 3.3.5.4b: Density estimates (seals km^{-2}) for each transect in relation to latitude

Helicopter survey - species composition

Only two seal species, crabeater seals (*Lobodon carcinophaga*) and Weddell seals (*Leptonychotes weddellii*), were observed. No sightings of other true Antarctic seal species, leopard seals (*Hydrurga leptonyx*) and Ross seals (*Ommotophoca rossii*), or southern elephant seals (*Mirounga leonina*), were made. This was not entirely unexpected; leopard seals typically utilize sea-ice at the outer edge of the pack (Bester et al. 1995), Ross seals generally occur to the east of the sampling area (Siniff et al. 1970; Condy 1977) and southern elephant seals rarely haul out during foraging migrations (Bornemann et al. 2000).

Crabeater seals comprised 68% (n = 754) of all sightings made within 256.5 m from the trackline (bins 1 to 5). Weddell seals (20%, n = 217) occurred in comparatively low numbers on the sea ice. However, our surveys did not include areas of fast ice adjacent to the continental shelf, a favoured haulout habitat for Weddell seals. Indeed, aggregations of Weddell seals along tidal cracks were found during reconnaissance helicopter flights over areas of fast ice (Fig. 3.3.5.1) with about ten seals in the area of the 76° section, 70 in the area of the 77° section, and about 200 each in the 78° section and in the Drescher Inlet. The fast ice area north of *Halley VI* was not overflown, and hence the number of seals could not be estimated. One hundred seals, mostly within the outermost bins, were not identified to species. Censuses coincided with a period that corresponds to the moult in crabeater (Southwell et al. 2005) and Weddell seals (*cf.* van Opzeeland et al. 2010).

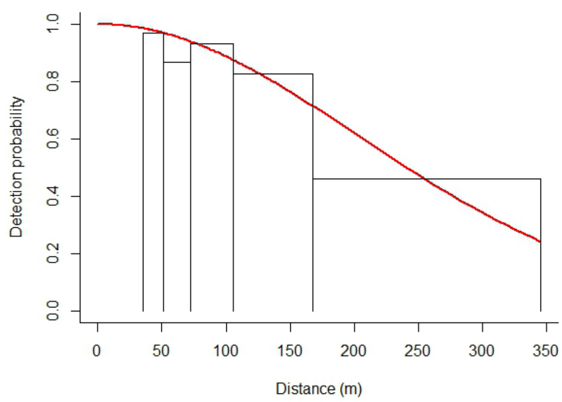

Fig. 3.3.5.5: Detection probability function (red line), superimposed on histograms showing the frequency of counts of seals in each distance interval

Detection and density

The detection probability, estimated for all species (including unidentified seals) and all observers, was less than one, validating a distance sampling approach (Fig. 3.3.5.5). Density of seals differed strongly between the two survey regions (Figs. 3.3.5.6 and 3.5.5.7). A single crabeater seal was encountered in the Filchner Trough region (0.0078 seals km^{-2} [95% confidence interval 0.001-0.060]). The mean density for Weddell seals in this region was 0.14 seals km^{-2} (0.04-0.58). Seal density estimates in the Filcher Outflow region were higher: 1.32 seals km^{-2} (1.09-1.61) for crabeater seals and 0.38 seals km^{-2} (0.21-0.68) for Weddell seals.

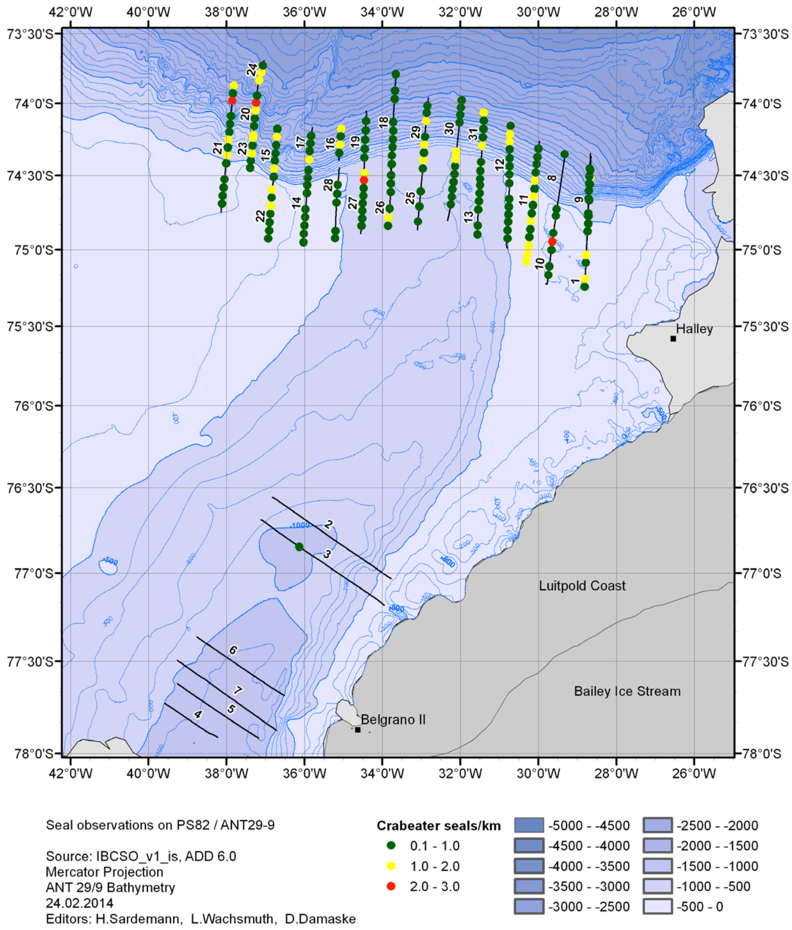

Fig. 3.3.5.6: Density of crabeater seals (seals km) along the helicopter transects derived from counts within three-minute time frames

In the Filchner outflow region, crabeater seal density increased from east to west (linear regression; β = -0.11 ± 0.04 SE, adjusted R^2 = 0.21, p = 0.01) (Fig. 3.3.5.8). In contrast, Weddell seal density was generally higher on our eastern- and westernmost transects and lower on transects located near the centre of the Filchner Trough (31° W - 35° W) (generalised additive model; adjusted R^2 = 0.21, p = 0.09 [approximate significance of longitude as smooth term]). Crabeater seal density tended to be somewhat higher on transects with a more northerly mean latitude (β = 0.94 ± 0.46 SE, adjusted R^2 = 0.11, p = 0.05) whereas no relationship existed between density and latitude inside the Filchner Outflow region for Weddell seals.

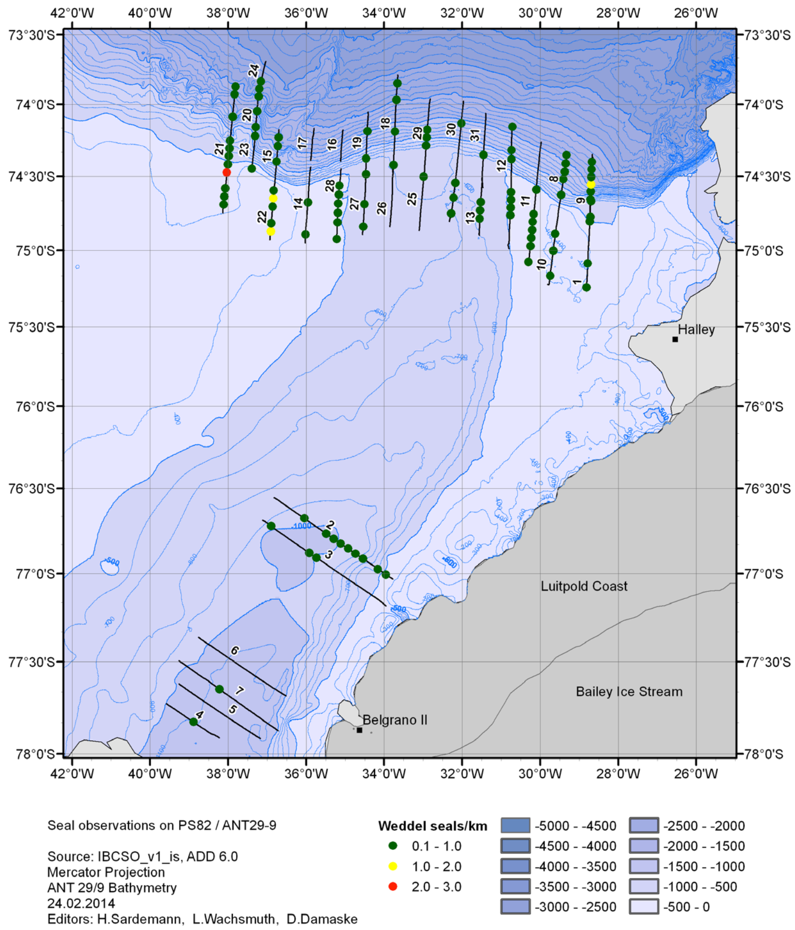

Fig. 3.3.5.7: Density of Weddell seals per (seals km) along the helicopter transects derived from counts within three-minute time frames

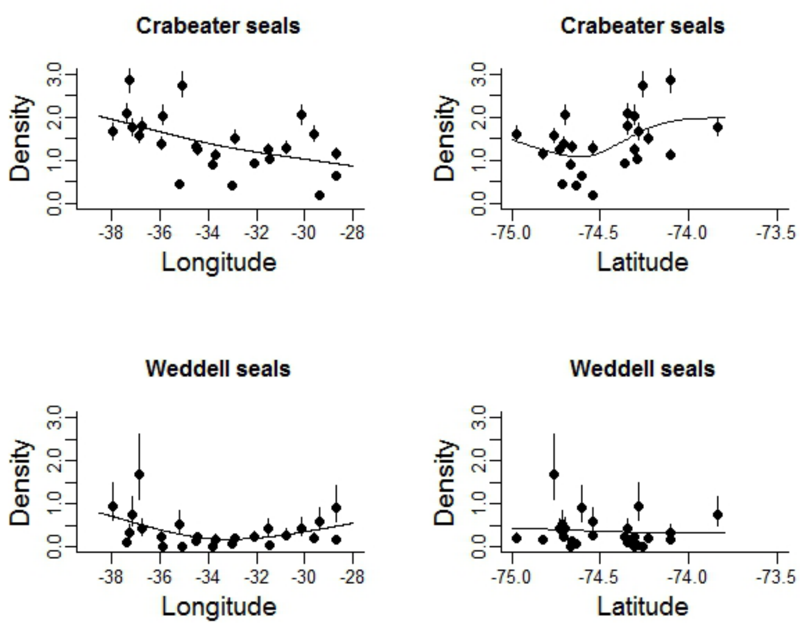

Fig. 3.3.5.8: Density estimates (seals km^{-2}) per transect for crabeater and Weddell seals respectively in relation to longitude and latitude

Comparisons with old data

To assess changes in abundance of pack ice seals across regions of different size is difficult, but comparisons of density can be made. Our density estimates for the Filchner Outflow region for crabeater seals (1.32 km^{-2}) are very low compared to those reported for 1998 in the eastern Weddell Sea (8.01 km^{-2}, Bester and Odendaal 2000). However, that was an anomalous year (El Niño) with virtual absence of pack ice, leading to high concentrations of seals where pack ice did occur. Despite this, the densities of Weddell seals were higher in the present study (0.38 km^{-2}), which had the highest ice concentrations in the Weddell Sea in three decades, compared to those (0.19 km^{-2}) in 1998 (Bester & Odendaal 2000). Densities for crabeater seals counted more easterly (0 – 4° W) in 1992 were similar to our counts (1.18 km^{-2}), whereas those of Weddell seals were again much lower (0.006 km^{-2}) (*cf*. Bester et al. 1995).

Further analysis

A model-based approach may improve extrapolation from our surveys to the entire region of interest. The density surface modelling (DSM) engine of program Distance can be used to model variation in seal density in relation to predictive environmental covariates, such as sea ice cover and composition derived from remote sensing or bathymetry. Continuous recording of the flight track via GPS allow transects to be divided into smaller segments; each segment then comprise an analytical unit with the number of seals as the response variable and environmental covariates specific to the block as predictors of seal abundance.

Data management

All data and related meta-information will be made available in open access via the Data Publisher for Earth & Environmental Science PANGAEA (www.pangaea.de), and will be attributed to a consistent project label denoted "Marine Mammal Tracking" http://www.pangaea.de/search?q=project:label:mmt.

3.3.5.2 Foraging behavioor of seals and oceanography

Horst Bornemann[1], Marthán N. Bester[2], W. Christiaan Oosthuizen[2], Michael Schröder[1]
not on board: Maria E.I. Márquez[3], Jorge A. Mennucci[3], Gustavo A. Daneri[4], Tracey Rogers[5], R. Eisert[6], Boris Dorschel[1], Hartmut Hellmer[1]

[1]AWI
[2]MRI
[3]IAA
[4]MBR
[5]UNSW
[6]UC

Grant No: AWI_PS82_03

Objectives

This approach concentrates on deployment of satellite transmitters on seals on the sea ice in order to get data on the seals' foraging behaviour and concurrent hydrographic data towards and within the area of the Filchner Trough. Only three recent publications provide evidence for extended residence times of satellite tracked southern elephant seals (Tosh et al. 2009) and Weddell seals (Nicholls et al. 2008; Årthun et al. 2012) in the area of the Filchner Trough. Long-distance tracking of marine mammals in the Southern Ocean by satellite relies on the ARGOS system. ARGOS satellite transmitters for marine mammal applications are designed to provide the animals' at-sea locations and transmit data to the satellites when the seals surface. CTD-combined ARGOS satellite-relayed dive loggers

(CTD-SRDLs) have the capabilities to record also *in situ* water temperature and conductivity for the entire migrations of tracked seals. Such data are of suitable quality to characterise the oceanographic settings utilised by seals (e.g. Nicholls et al. 2008; Boehme et al. 2009; Meredith et al. 2011), and are complementary to the oceanographic investigations as described in 3.2. During the annual moult the units will be shed, and thus tracks and concurrent behavioural and hydrographic data can be collected over a maximum period of one year. The reconciliation of data on the seals' diving behaviour and the hydrographic features with information on the occurrence and biomass of the seals' prey aims to describe the upper trophic level interactions at the Filchner Trough. The intention was to target adult Weddell seal males (*L. weddellii*) for instrumentation with CTD-SRDLs, since they can be expected to remain over the investigation area throughout the year due to their "maritorial" behaviour. Weddell seals, furthermore, dive to depths of up to 900 m (Årthun et al. 2012), and their foraging dives can yield information on both potential pelagic and demersal or benthic prey in the investigation area.

Work at sea

Deployments of CTD-SRDLs on post-breeding southern elephant seal males (*Mirounga leonina*; n = 19) of the colony located within the Antarctic Specially Protected Area (ASPA) 132 at King George Island / Isla 25 de Mayo in October / November 2013 preceded the deployments of transmitters on Weddell seals from aboard RV *Polarstern* in the area of the Filchner Trough (see Fig. 3.3.5.1). The CTD-SRDLs were deployed on Weddell seals (n = 9) during their moult and all individuals selected had at least completed the moult on the head, the site of deployment.

Before instrumentation, the seals were anaesthetized following the methods described in Bornemann & Plötz (1993), Bornemann et al. (1998), and Bornemann et al. (2013). Drugs were initially administered intramuscularly by remote injection using blow-pipe darts. Follow-up doses were usually given intramuscularly by direct manual injection or in the case of doxapram (see below) intravenously. The dose regime involved the drugs as listed below and dosages or respectively dose ranges varied depending on initial or follow-up injections. Southern elephant seals (n = 19) were drugged with a combination of tiletamine and zolazepam, Weddell seals (n = 9) with a combination of ketamine and xylazine. Depending on the course of the immobilisation, dosages needed to be individually adjusted and were occasionally complemented by the same drugs to maintain or extend the immobilisation period on demand. The benzodiazepine diazepam was used occasionally in Weddell seals to attenuate muscle tremors. Atipamezol was used to reverse the xylazine component in the xylazine / ketamine immobilisation. Flumazenil was available as antidote for the unlikely situation of an overdose of benzodiazepines. Doxapram was used to stimulate breathing during extended periods of apnoea, in the absence of mechanical obstructions of the upper airways.

The length and girth of each seal was measured. The actual dosages will be determined in a *post hoc* calculation of the mass of each seal through photogrammetry performed at the time (de Bruyn et al. 2009). The transmitters were glued to the hair of seals on the head using quick setting epoxy resin (see Figs. 3.3.5.9 and 3.3.5.10). In addition to instrumentation, a blood sample of 30 ml (southern elephant seals n = 19, Weddell seals n = 5) was taken together with hair and whisker samples. Blood samples were centrifuged, separated in red blood cells and serum and both deep frozen at -80° C. All immobilisation, sampling and tagging procedures are summarized in Table 3.3.5.2

Fig. 3.3.5.9: Southern elephant seal male with satellite transmitter

Fig. 3.3.5.10: Weddell seal male with satellite transmitter

Preliminary (expected) results

Sampling of blood, whisker, and hair will provide information on the seals' prey range. Within the serum fraction we aim to analyse for prey specific biomarker proteins that allow for reconciliation with the seals' prey range (e.g. octopine in octopods, specific amines in fishes, homarines and dimethylsulfoniopropionate in molluscs and crustaceans) in the laboratory (*cf*. Hochachka et al. 1977; Ito et al. 1994; Eisert et al. 2005; Eder et al. 2010). These data can suggest which prey type was taken within a couple of days prior to blood sampling using both serum and blood cell fractions. The hair and whisker samples will be used to get retrospective information on the prey base on intermediate time scales up to a couple of months by means of isotope analyses (*cf*. Lewis et al. 2006; Newsome et al. 2010; Hückstädt et al. 2012a, 2012b).

Satellite-tagging at King George Island / Isla 25 de Mayo

Deployments of ARGOS satellite transmitters on 19 post-breeding adult southern elephant seal males at King George Island / Isla 25 de Mayo in November 2013 represent a follow-up study of earlier projects on post-moulting adult males satellite tagged in 2000 and 2010. These previous deployments were constrained by the fact that only a small fraction of the satellite tagged seals could be unequivocally attributed to the local breeding population of the Antarctic Specially Protected Area (ASPA) 132 on King George Island / Isla 25 de Mayo owing to earlier permanent marking procedures. As a result, a number of the previous tracks ended at South Georgia towards the breeding season, implying that the tagged seals originated from that breeding colony. The recent tracks represent the first deployments on post-breeding males at the ASPA 132 and they include about 50 % of the population of adult males that were present during the breeding period either as harem bulls (n = 3), challengers (n = 7), or isolated males (n = 9) between October and December 2013. Of the 19 transmitters, two failed within the first two weeks after deployment and were disregarded for further analyses. The post-breeding long-distance foraging tracks of the remaining 17 males were primarily oriented along the continental shelf margin towards the Bellingshausen and even Amundsen Seas (n = 12), and shorter tracks along the Bransfield Strait / Mar de la Flota to the North (n = 4) and around the tip of the Antarctic Peninsula (n = 1). This suggests far more south-westerly oriented foraging movements of mature males of the ASPA 132 elephant seal colony than previously assumed. In contrast to our expectation, no elephant seals moved towards the Filchner Outflow System. This also coincides with movements of (sub)adult males satellite tagged at Elephant Island post-breeding (2008, 2009) and post-moulting (2007, 2008, 2009, 2010) by Muelbert et al. (2013), implying that the earlier results (2000, 2001) of Tosh et al. (2009) are exceptional. This may be a result of the increasing ice conditions in the eastern Antarctic Peninsula region of the Weddell Sea during the past decade (Schwegmann 2012) and in the aforementioned years during April / May and October / November (Schwegmann pers. com.) making the Weddell Sea a less attractive destination for southern elephant seals. Moreover, during our campaign, the Weddell Sea reached its highest sea ice concentration in 30 years. All the elephant seal males showed extended residence times at specific circumscribed at-sea locations, which were widely distributed within the aforementioned marine areas and coincided with bathymetric features, such as slopes, bays and troughs. Seals are expected to return to the ASPA 132 in March 2014 to complete their annual moult. During the moult the seals will shed off the transmitters, which will then by retrieved by the overwintering personnel of our Argentinean collaborators at the *Dallmann* Laboratory and *Carlini* Station.

Satellite-tagging at the Filchner Outflow System

Deployment of ARGOS satellite transmitters on 9 post-moulting adult Weddell seals (2 males; 7 females) at the Filchner Outflow System (n = 7) and at the Drescher Inlet (n = 2) in January / February 2014 (see Fig. 3.3.5.1) augments earlier projects on post-breeding adult males and females satellite tagged within the Filchner area (Nicholls et al. 2008; Årthun et al. 2012) and in Atka Bay (McIntyre et al. 2012). Within the first few weeks after deployment the seals remained near the area where they were tagged. During this period dives were most often to depths up to 400 m with a few deeper dives up to 700 m. We expect to receive about 4 CTD profiles per seal per day, almost in real time, which will allow us to study how changes in the underwater environment alter prey distribution beneath the ice as indicated by the seals' individual diving and foraging behaviour. We furthermore anticipate that these key physical oceanographic variables collected from hitherto under-sampled coastal shelf regions may assist the refinement of computer models of the Southern Ocean circulation. The seals are expected to shed their satellite tags in February 2015 at the latest during their annual moult.

Data management

All data and related meta-information will be made available in open access via the Data Publisher for Earth & Environmental Science PANGAEA (www.pangaea.de), and will be attributed to a consistent project label denoted "Marine Mammal Tracking" http://www.pangaea.de/search?q=project:label:mmt.

Tab. 3.3.5.2: Summary of immobilisation, sampling and tagging procedures

Event label	Lat	Lon	Date	Time	Length	Girth	Sampling			PTT
	[deg]	*[deg]*	*yyyy-mm-dd*	*hh:mm*	*[mm]*	*[mm]*	*Blood*	*Whisker*	*Hair*	*ID*
CAR2013_sel_a_m_01	-62,255	-58,635	2013-09-23	16:56	4130	3795	x	x		
CAR2013_sel_a_m_02	-62,255	-58,635	2013-09-24	18:46	4230	4080	x	x		
CAR2013_sel_a_m_03	-62,261	-58,598	2013-09-26	16:04	4430	4250	x	x		
CAR2013_sel_a_m_03	-62,252	-58,634	2013-11-09	18:54						130072
CAR2013_sel_a_m_04	-62,255	-58,635	2013-09-26	20:02	4680	4690	x	x		
CAR2013_sel_a_m_05	-62,261	-58,598	2013-09-27	18:55	4280	3840	x	x		
	-62,254	-58,653	2013-11-11	19:37						102365
CAR2013_sel_a_m_06	-62,255	-58,635	2013-09-30	19:16	4720	4060	x	x		
CAR2013_sel_a_m_07	-62,255	-58,635	2013-10-01	17:53	4240	3890	x	x		
CAR2013_sel_a_m_08	-62,261	-58,598	2013-10-02	20:38	4180	3830	x	x		
	-62,256	-58,636	2013-11-09	22:28						130073
CAR2013_sel_a_m_09	-62,255	-58,635	2013-11-05	21:29	4200	3480	x	x		130069
CAR2013_sel_a_m_10	-62,261	-58,598	2013-11-07	20:23	3890	3350	x	x		130070
CAR2013_sel_a_m_11	-62,261	-58,598	2013-11-07	21:21	4190	3945	x	x		
	-62,256	-58,611	2013-11-19	18:23						97963
CAR2013_sel_a_m_12	-62,258	-58,659	2013-11-09	17:23	4060	3340	x	x		130071
CAR2013_sel_a_m_13	-62,256	-58,632	2013-11-11	16:12	4020	2940	x	x		112848
CAR2013_sel_a_m_14	-62,256	-58,625	2013-11-11	20:41	4290	3570	x	x		7075
CAR2013_sel_a_m_15	-62,294	-58,664	2013-11-15	16:48	3780	2950	x	x		24656
CAR2013_sel_a_m_16	-62,271	-58,634	2013-11-15	18:03	4390	3250	x	x		97960
	-62,271	-58,634	2013-11-23	20:32						
CAR2013_sel_a_m_17	-62,263	-58,612	2013-11-15	19:39	4560	3620	x	x		97964
CAR2013_sel_a_m_18	-62,263	-58,612	2013-11-05	19:51	4370	3430	x	x		

Event label	Lat	Lon	Date	Time	Length	Girth	Sampling			PTT
	[deg]	*[deg]*	*yyyy-mm-dd*	*hh:mm*	*[mm]*	*[mm]*	*Blood*	*Whisker*	*Hair*	*ID*
	-62,266	-58,593	2013-11-15	20:38						97962
CAR2013_sel_a_m_19	-62,254	-58,642	2013-11-18	16:22	4200	3320	x	x		97965
CAR2013_sel_a_m_20	-62,258	-58,662	2013-11-18	20:00	4360	3270		x		97961
CAR2013_sel_a_m_21	-62,256	-58,645	2013-11-19	20:40	3920	3120	x	x		97966
CAR2013_sel_a_m_22	-62,250	-58,683	2013-11-22	17:10	4320	3390	x			97967
CAR2013_sel_a_m_23	-62,254	-58,621	2013-11-22	20:03	4050	3120		x		97968
	-62,263	-58,612	2013-11-23	19:31			x			
CAR2013_sel_a_m_24	-62,256	-58,640	2013-11-22	21:18	4690	3900	x	x		85662
FIL2014_wed_a_f_01	-74,833	-24,990	2014-01-21	12:22	2530	2040		x	x	130059
FIL2014_wed_a_f_02	-74,458	-37,971	2014-02-02	00:05	2520	1890		x	x	130060
FIL2014_wed_a_f_03	-74,562	-37,640	2014-02-02	11:55	2310	1780		x	x	130061
FIL2014_wed_a_f_04	-74,552	-37,514	2014-02-02	14:12	2340	1840		x	x	130062
FIL2014_wed_a_f_05	-74,777	-25,031	2014-02-11	11:24	2540	2030	x	x	x	130063
FIL2014_wed_a_f_06	-74,777	-25,029	2014-02-11	13:24	2430	1710	x	x	x	130065
FIL2014_wed_a_f_07	-74,777	-25,029	2014-02-11	15:10	2740	1970	x	x	x	130066
FIL2014_wed_a_f_08	-72,838	-19,150	2014-02-14	09:20	2560	1940	x	x	x	130067
FIL2014_wed_a_f_09	-72,837	-19,153	2014-02-14	12:05	2730	1800	x	x	x	130068

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APPENDIX

A.1 Teilnehmende Institute / Participating Institutions

A.2 Fahrtteilnehmer / Cruise Participants

A.3 Schiffsbesatzung / Ship's Crew

A.4 Station List PS82

A.1 TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTIONS

	Address
AAD	Australian Antarctic Division Channel Highway Kingston Tasmania 7050 Australia
AWI	Alfred-Wegener-Institut Helmholtz - Zentrum für Polar- und Meeresforschung Postfach 120161 27515 Bremerhaven Germany
BAS	British Antarctic Survey Natural Environment Research Council High Cross, Madingley Road Cambridge CB3 0ET United Kingdom
CAU-MarSci	Fachbereich: Marine Science Christian-Albrechts-Universität zu Kiel Ludewig-Meyn-Str. 10, 24118 Kiel, Germany
DLR	Deutsches Zentrum für Luft- und Raumfahrt Institut für Hochfrequenztechnik und Radarsysteme Münchner Str. 20 82234 Weßling Germany
DWD	Deutscher Wetterdienst Geschäftsbereich Wettervorhersage Seeschifffahrtsberatung Bernhard-Nocht-Str. 76 20359 Hamburg Germany
HELISERVICE	HeliService international GmbH Am Luneort 15 27572 Bremerhaven Germany
IAA	Instituto Antártico Argentino Dirección Nacional del Antártico Buenos Aires Argentina

	Address
ICM-CISIC	Institut de Ciencies del Mar-CSIC Passeig Maritim de la Barceloneta 37-49 08003 Barcelona Spain
IRSNB	Institut Royal des Sciences naturelles de Belgique 29, rue Vautier 1000 Bruxelles Belgium
ISITEC	iSiTEC GmbH Bussestr. 27 27570 Bremerhaven Germany
ISMAR-CNR	Istituto di Scienze Marine Consiglio Nazionale delle Ricerche Viale Romolo Gasi 2 34123 Trieste Italy
LAEISZ	Reederei F. Laeisz GmbH Brückenstr. 25 27568 Bremerhaven Germany
MBR	Museo Argentino de Ciencias Naturales “Bernardino Rivadavia”, Buenos Aires Argentina
MNHN	Museum national d‘Histoire naturelle Departement Milieux et Peuplements Aquatiques CP 26 43, Rue Cuvier 75005 Paris France
MRI	Mammal Research Institute Department of Zoology and Entomology University of Pretoria Private Bag X20 Hatfield 0028 Pretoria South Africa
TU-Dresden	Technische Universität Dresden 01062 Dresden Germany

	Address
UAH	Iniversidad de Alcalá EU-US Marine Biodiveristy Research Group Life Sciences Department 28871, Alcalá de Henares, Madrid Spain
UC	University of Canterbury Private Bag 4800 Christchurch 8140 New Zealand
UHB-IUP	Universität Bremen Institut für Umweltphysik Otto-Hahn-Alle 1 28359 Bremen Germany
UHB-MarZoo	Universität Bremen Fachbereich 2: Biologie / Chemie Marine Zoologie Leobener Straße 28359 Bremen Germany
UiB-BCCR	Universitetet i Bergen Berknes Centre for Climate Research and Geophysical Institute Postboks 7800 5020 Bergen Norway
UMAG	Universidad de Magallanes Instituto de la Patagonia Av. Bulnes #01855 Punta Arenas Chile
Uni-Alaska	University of Alaska International Arctic Research Center PO Box 757340 Fairbanks Alaska 99775-7340 USA
Uni-Kiel	Christian-Albrechts-Universität zu Kiel Christian-Albrechts-Platz 4 24118 Kiel Germany
Uni-Padova	Università degli Studi di Padova Via 8 Febbraio 2 35122 Padova Italy

	Address
Uni-Washington	University of Washington Polar Science Center, Applied Physics Laboratory University of Washington 1013 NE 40th, Seattle WA 98105 USA
UNSW	University of New South Wales, Evolution & Ecology Research Centre, School of Biological, Earth and Environmental Science, Sydney Australia
VNIRO	Russian Federal Research Institut of Fisheries and Oceanography Verkhnaya Krasnoselskaya str. 12 Moscow 107140 Russia

A.2 FAHRTTEILNEHMER / CRUISE PARTICIPANTS

No	Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession
1	Ambroso	Stefano	ICM-CSIC	Scientist, biology
2	Auel	Holger	UHB-MarZool	Scientist, biology
3	Bähnke	Klaus	DWD	Scientist, meteorology
4	Babbuci	Masimiliano	Uni-Padova	Scientist, biology
5	Bester	Marthán	MRI	Scientist, biology
6	Beyer	Kerstin	AWI	Technician, biology
7	Biebow	Harald	ISITEC	Engineer, electronics
8	Bizikow	Viachestlav	VNIRO	Scientist, biology (to Neumayer)
9	Böhmer	Astrid	AWI	Scientist, biology
10	Bornemann	Horst	AWI	Scientist, veterinary medicine
11	Brauer	Jens	Heliservice	Technician, helicopter service
12	Casado de Amezúa	Maria del Pilar	AWI	Scientist, biology
13	Castellani	Giulia	AWI	PhD student, sea ice physics
14	Damaske	Daniel	AWI	Student, geosciences
15	Dürschlag	Julia	UHB-MarZool	Student, biology
16	Federwisch	Luisa	AWI	PhD student, biology
17	Gall	Fabian	Heliservice	Technician, helicopter service
18	Gerdes	Dieter	AWI	Scientist, biology
19	Gischler	Michael	Heliservice	Pilot, helicopter service
20	Havermanns	Charlotte	RBINS	Scientist, biology
21	Huhn	Oliver	UHB-IUP	Scientist, physics
22	Huneke	Wilma	Uni-Kiel	Student, oceanography
23	Isla	Enrique	ICM-CSIC	Scientist, geo sciences
24	Janssen	Dieter	AWI	Technician, chemistry
25	Kluibenschedl	Anna	AWI	Student, biology
26	Knust	Rainer	AWI	Scientist, biology, chief scientist
27	Kohlbach	Dorein	AWI	PhD student, biology
28	Koschnick	Nils	AWI	Engineer, biology
29	Krieger	Malte	UHB-IUP	Student, physics
30	Ksionzek	Kerstin	AWI	PhD student, chemistry
31	Lange	Benjamin	AWI	PhD student, biology
32	Oosthuizen	W. Christiaan	MRI	Scientist, biology
33	Osterhus	Svein	UoB-BCCR	Scientist, oceanography
34	Owsianowski	Nils	AWI	Engineer, ROV
35	Papetti	Chiara	UniPadova	Scientist, biology
36	Pineda	Santjago	UNI-HB	Student, biology
37	Purroy	Ariadna	ICM-CSIC	Scientist, biology
38	Riginella	Emilio	Uni-Padova	Scientist, biology

No	Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession
39	Ryan	Svenja	Uni-Kiel	Student, oceanography
40	Sands	Chester	BAS	Scientist, biology
41	Sardemann	Hannes	TU-Dresden	Student, geodesy
42	Scharfbillig	Angela	UHB-IUP	Student, physics
43	Schröder	Michael	AWI	Scientist, oceanography
44	Schwegmann	Sandra	AWI	Scientist, sea ice physics
45	Semper	Stefanie	CAU-MarSci	Student, oceanography
46	Sonnabend	Hartmut	DWD	Technician, meteorology
47	Vaupel	Lars	Heliservice	Pilot, helicopter service
48	Vortkamp	Martina	AWI	Technician, biology
49	Wachsmuth	Leander	AWI	Student, geodesy
50	Wätjen	Kai	AWI	Scientist, biology
51	Wetjen	Maj	AWI	Scientist, biology
52	Wisotzski	Andreas	AWI	Scientist, oceanography
53	Zapata	Rebecca	ICM-CSIC	Scientist, biology

A.3 SCHIFFSBESATZUNG / SHIP'S CREW

No	Name	Rank
1	Schwarze, Stefan	Master
2	Grundmann, Uwe	1.Offc.
3	Farysch, Bernd	Ch. Eng.
4	Fallei, Holger	2. Offc.
5	Langhinrichs, Moritz	2.Offc.
6	Peine, Lutz	3.Offc.
7	Pohl, Claus	Doctor
8	Koch, Georg	R.Offc.
9	Grafe, Jens	2.Eng.
10	Minzlaff, Hans-Ulrich	2.Eng.
11	Holst, Wolfgang	3. Eng.
12	Scholz, Manfred	Elec.Tech.
13	Fröb, Martin	Electron.
14	Himmel, Frank	Electron.
15	Hüttebräucker, Olaf	Electron.
16	Nasis, Ilias	Electron.
17	Loidl, Reiner	Boatsw.
18	Reise, Lutz	Carpenter
19	Bäcker, Andreas	A.B.
20	Brickmann, Peter	A.B.
21	Brück, Sebastian	A.B.
22	Guse, Hartmut	A.B.
23	Hagemann, Manfred	A.B.
24	Kaiser, Ralf	A.B.
25	Scheel, Sebastian	A.B.
26	Schmidt, Uwe	A.B.
27	Winkler, Michael	A.B.
28	Preußner, Jörg	Storek.
29	Elsner, Klaus	Mot-man
30	Pinske, Lutz	Mot-man
31	Schütt, Norbert	Mot-man
32	Teichert, Uwe	Mot-man
33	Voy, Bernd	Mot-man
34	Müller-Homburg, Ralf-Dieter	Cook
35	Martens, Michael	Cooksmate
36	Silinski, Frank	Cooksmate
37	Czyborra, Bärbel	1.Stwdess
38	Wöckener, Martina	Stwdss/KS
39	Arendt, Rene	2.Steward
40	Gaude, Hans-Jürgen	2.Steward

No	Name	Rank
41	Möller, Wolfgang	2.Steward
42	Silinski, Carmen	2.Stwdess
43	Sun, Yong Shen	2.Steward
44	Yu, Kwok Yuen	Laundrym.

A.4 STATIONSLISTE / STATION LIST PS82

All stations operated by *Polarstern* are listed in the table. Station on ice and transects for seal counting operated by helicopter are listed in the text above.

Station	Date	Time	Position Lat	Position Lon	Depth [m]	Wind force [m/s]	Course [°]	Gear ID
PS82/001-1	2014-01-02	14:51	73° 43,56‘ S	25° 44,59‘ W	3224,2	SSE 4	151,0	CTD/RO
PS82/002-1	2014-01-02	17:33	73° 43,00‘ S	25° 44,51‘ W	3262,0	SSW 6	110,2	MOR
PS82/003-1	2014-01-02	18:52	73° 44,80‘ S	25° 46,20‘ W	3189,0	WSW 6	192,0	RMT
PS82/003-1	2014-01-02	19:34	73° 46,04‘ S	25° 48,02‘ W	3160,5	WSW 7	209,9	RMT
PS82/004-1	2014-01-03	8:14	74° 41,04‘ S	29° 45,29‘ W	425,0	N 4	195,0	CTD/RO
PS82/005-1	2014-01-03	10:09	74° 41,88‘ S	29° 45,52‘ W	426,5	NNE 4	166,6	MOR
PS82/006-1	2014-01-03	10:49	74° 42,20‘ S	29° 44,97‘ W	415,0	NNE 2	188,7	MN
PS82/007-1	2014-01-03	12:11	74° 43,67‘ S	29° 48,53‘ W	399,2	NW 3	330,3	RMT
PS82/008-1	2014-01-03	13:30	74° 43,11‘ S	29° 48,38‘ W	387,1	NW 2	106,5	MUC
PS82/009-1	2014-01-03	14:58	74° 43,03‘ S	29° 47,16‘ W	401,2	N 5	146,9	MUC
PS82/010-1	2014-01-03	15:32	74° 42,99‘ S	29° 46,66‘ W	394,0	N 3	104,9	MUC
PS82/011-1	2014-01-03	17:55	74° 42,30‘ S	29° 53,99‘ W	406,2	ENE 2	99,1	BT
PS82/012-1	2014-01-03	23:11	74° 35,43‘ S	28° 25,75‘ W	1415,0	N 6	70,1	CTD/RO
PS82/013-1	2014-01-04	1:17	74° 42,04‘ S	28° 22,33‘ W	529,7	NNE 8	278,3	CTD/RO
PS82/014-1	2014-01-04	3:01	74° 49,88‘ S	28° 12,63‘ W	529,7	N 7	265,8	CTD/RO
PS82/015-1	2014-01-04	3:55	74° 49,87‘ S	28° 13,65‘ W	529,2	NE 7	228,1	MN
PS82/016-1	2014-01-04	5:56	74° 59,86‘ S	28° 0,44‘ W	459,5	NE 8	299,4	CTD/RO
PS82/017-1	2014-01-04	8:49	75° 13,55‘ S	27° 33,81‘ W	385,2	ENE 6	186,4	CTD/RO
PS82/018-1	2014-01-04	10:12	75° 12,03‘ S	27° 32,56‘ W	391,2	NE 5	192,6	BT
PS82/019-1	2014-01-04	18:42	75° 12,93‘ S	27° 35,81‘ W	396,2	NE 6	248,7	ROV
PS82/020-1	2014-01-04	20:32	75° 12,84‘ S	27° 34,41‘ W	396,0	ENE 6	10,5	ROV
PS82/021-1	2014-01-05	7:27	76° 16,02‘ S	29° 20,68‘ W	364,7	S 6	249,8	CTD/RO
PS82/022-1	2014-01-05	9:16	76° 10,67‘ S	30° 0,70‘ W	407,5	S 6	210,6	CTD/RO
PS82/023-1	2014-01-05	11:12	76° 5,41‘ S	30° 27,92‘ W	469,2	S 4	221,8	CTD/RO
PS82/024-1	2014-01-05	12:21	76° 5,49‘ S	30° 28,24‘ W	468,7	SW 3	4,7	MOR
PS82/025-1	2014-01-05	14:14	76° 3,18‘ S	31° 0,41‘ W	473,2	SSW 5	209,7	CTD/RO
PS82/026-1	2014-01-05	14:56	76° 3,13‘ S	31° 0,54‘ W	472,7	SSW 5	24,7	ICE
PS82/027-1	2014-01-05	16:24	76° 2,76‘ S	30° 59,72‘ W	472,5	S 4	24,0	MOR
PS82/028-1	2014-01-05	19:42	75° 57,73‘ S	31° 28,59‘ W	597,2	S 4	163,7	CTD/RO
PS82/029-1	2014-01-05	20:45	75° 57,78‘ S	31° 29,13‘ W	603,7	S 3	242,9	MOR
PS82/030-1	2014-01-05	21:49	75° 58,65‘ S	31° 29,92‘ W	598,5	S 4	164,4	MN
PS82/031-1	2014-01-06	9:20	75° 56,29‘ S	31° 39,57‘ W	687,5	ENE 2	136,9	CTD/RO
PS82/032-1	2014-01-06	10:30	75° 56,50‘ S	31° 40,17‘ W	688,2	NE 3	208,6	MN

Station	Date	Time	Position Lat	Position Lon	Depth [m]	Wind force [m/s]	Course [°]	Gear ID
PS82/033-1	2014-01-06	12:04	75° 56,83‘ S	31° 40,57‘ W	696,2	ENE 4	253,3	MG
PS82/034-1	2014-01-06	14:03	75° 57,08‘ S	31° 40,60‘ W	691,2	ENE 3	77,4	MUC
PS82/035-1	2014-01-06	19:39	75° 54,93‘ S	30° 44,81‘ W	430,5	E 5	110,3	CTD/RO
PS82/036-1	2014-01-06	20:06	75° 55,23‘ S	30° 44,91‘ W	461,0	ENE 6	155,8	ICE
PS82/037-1	2014-01-06	22:15	76° 0,31‘ S	30° 41,95‘ W	478,5	E 4	230,6	CTD/RO
PS82/038-1	2014-01-07	6:11	76° 4,80‘ S	30° 26,86‘ W	463,0	ESE 2	15,0	CTD/RO
PS82/039-1	2014-01-07	9:14	76° 6,16‘ S	30° 18,80‘ W	453,0	E 3	358,8	BT
PS82/040-1	2014-01-07	11:31	76° 3,95‘ S	30° 16,78‘ W	471,2	ENE 4	78,9	MG
PS82/041-1	2014-01-07	13:12	76° 4,23‘ S	30° 18,40‘ W	470,0	NE 5	221,4	MUC
PS82/042-1	2014-01-07	16:05	76° 4,38‘ S	30° 15,98‘ W	444,5	NE 3	81,8	RMT
PS82/043-1	2014-01-07	18:15	76° 4,22‘ S	30° 8,70‘ W	473,0	E 3	295,4	AGT
PS82/044-1	2014-01-07	20:20	76° 8,35‘ S	30° 15,35‘ W	447,2	ENE 2	79,0	CTD/RO
PS82/045-1	2014-01-07	21:54	76° 13,18‘ S	29° 41,19‘ W	376,5	SE 1	185,4	CTD/RO
PS82/046-1	2014-01-07	23:08	76° 10,73‘ S	29° 15,57‘ W	427,7	SW 2	27,8	CTD/RO
PS82/047-1	2014-01-07	23:48	76° 10,72‘ S	29° 15,49‘ W	416,2	SW 1	350,0	MN
PS82/048-1	2014-01-08	1:33	76° 19,05‘ S	29° 2,05‘ W	245,7	E 4	72,7	CTD/RO
PS82/049-1	2014-01-08	3:35	76° 19,15‘ S	29° 1,94‘ W	254,7	E 7	108,0	ROV
PS82/050-1	2014-01-08	7:09	76° 19,32‘ S	29° 0,17‘ W	228,5	E 8	91,2	AGT
PS82/051-1	2014-01-08	10:46	76° 19,03‘ S	28° 56,98‘ W	254,7	ENE 5	58,0	RMT
PS82/052-1	2014-01-08	13:01	76° 19,10‘ S	29° 2,12‘ W	244,2	ENE 5	127,4	MG
PS82/053-1	2014-01-08	14:39	76° 19,33‘ S	29° 8,44‘ W	261,0	ESE 4	142,0	BT
PS82/054-1	2014-01-09	2:31	76° 57,83‘ S	32° 57,30‘ W	282,2	ENE 4	12,3	CTD/RO
PS82/055-1	2014-01-09	4:01	76° 59,90‘ S	33° 30,71‘ W	397,0	E 4	99,5	CTD/RO
PS82/056-1	2014-01-09	6:26	77° 0,49‘ S	34° 3,28‘ W	512,5	E 6	278,2	MOR
PS82/057-1	2014-01-09	16:23	77° 0,57‘ S	34° 25,12‘ W	652,7	E 4	195,6	CTD/RO
PS82/058-1	2014-01-09	17:28	77° 0,72‘ S	34° 25,59‘ W	662,2	E 5	81,6	MN
PS82/059-1	2014-01-09	19:40	76° 59,97‘ S	34° 59,71‘ W	957,5	E 6	256,4	CTD/RO
PS82/060-1	2014-01-09	23:17	77° 0,35‘ S	35° 42,30‘ W	1047,7	E 4	137,9	CTD/RO
PS82/061-1	2014-01-10	3:35	77° 6,18‘ S	36° 23,93‘ W	1133,0	ENE 2	76,8	CTD/RO
PS82/062-1	2014-01-10	5:15	77° 6,14‘ S	36° 24,23‘ W	1126,5	ESE 1	76,8	MN
PS82/063-1	2014-01-10	6:03	77° 6,13‘ S	36° 25,16‘ W	1113,5	NE 2	263,1	CTD/RO
PS82/064-1	2014-01-10	7:34	77° 6,11‘ S	36° 25,51‘ W	1115,2	NE 2	68,3	MUC
PS82/065-1	2014-01-10	9:48	77° 5,95‘ S	36° 25,78‘ W	1121,5	ESE 1	258,9	RMT
PS82/066-1	2014-01-10	12:21	77° 6,09‘ S	36° 34,39‘ W	1111,7	E 1	83,4	MG
PS82/067-1	2014-01-10	14:46	77° 6,08‘ S	36° 32,76‘ W	1101,0	N 4	102,3	AGT
PS82/068-1	2014-01-10	19:42	77° 4,92‘ S	36° 10,97‘ W	1126,2	N 3	200,1	ICE
PS82/069-1	2014-01-11	3:19	77° 0,61‘ S	34° 11,00‘ W	575,0	NE 5	279,6	CTD/RO

Station	Date	Time	Position Lat	Position Lon	Depth [m]	Wind force [m/s]	Course [°]	Gear ID
PS82/070-1	2014-01-11	4:11	77° 0,71‘ S	34° 2,74‘ W	499,7	ENE 5	241,6	CTD/RO
PS82/071-1	2014-01-11	5:08	77° 0,74‘ S	34° 3,28‘ W	503,0	NNE 5	240,8	MN
PS82/072-1	2014-01-11	6:25	77° 0,59‘ S	34° 14,22‘ W	614,0	NE 2	326,6	MOR
PS82/073-1	2014-01-11	9:13	77° 0,28‘ S	34° 9,34‘ W	570,0	NNE 1	168,4	AGT
PS82/074-1	2014-01-11	11:58	76° 59,90‘ S	34° 7,80‘ W	570,7	N 6	180,8	MG
PS82/075-1	2014-01-11	14:52	77° 0,37‘ S	34° 27,60‘ W		ENE 7	194,3	MOORY
PS82/076-1	2014-01-11	18:20	76° 59,52‘ S	34° 32,72‘ W	822,2	NE 9	18,6	RMT
PS82/077-1	2014-01-12	6:37	77° 0,57‘ S	34° 29,08‘ W	758,7	NE 8	85,5	MOR
PS82/078-1	2014-01-12	12:57	77° 1,25‘ S	34° 26,47‘ W	699,5	NE 8	273,0	BT
PS82/079-1	2014-01-12	17:18	77° 1,89‘ S	33° 35,21‘ W	389,7	NE 5	140,1	MG
PS82/080-1	2014-01-12	18:55	77° 3,31‘ S	33° 36,75‘ W	378,2	NE 6	227,4	CTD
PS82/081-1	2014-01-12	21:14	77° 4,81‘ S	33° 39,02‘ W	368,5	NE 3	198,8	ROV
PS82/082-1	13.01.2014	01:39	77° 5,29‘ S	33° 38,31‘ W	337,2	S 3	16,6	ROV
PS82/083-1	2014-01-13	12:02	77° 1,19‘ S	33° 41,25‘ W	427,2	WSW 3	342,6	RMT
PS82/084-1	2014-01-13	14:07	77° 0,93‘ S	33° 41,71‘ W	435,2	NW 3	344,5	BT
PS82/085-1	2014-01-13	17:22	76° 57,98‘ S	32° 57,69‘ W	258,7	WSW 2	26,5	CTD/RO
PS82/086-1	2014-01-13	20:18	76° 57,41‘ S	32° 59,11‘ W	293,2	WSW 3	139,1	ROV
PS82/087-1	2014-01-14	6:13	76° 58,06‘ S	32° 56,54‘ W	273,0	SW 6	248,2	CTD/RO
PS82/088-1	2014-01-14	8:27	76° 57,98‘ S	32° 56,67‘ W	265,2	WSW 9	303,6	BT
PS82/089-1	2014-01-14	11:01	76° 59,02‘ S	32° 51,10‘ W	254,5	WSW 6	222,7	MG
PS82/090-1	2014-01-14	12:53	76° 55,85‘ S	32° 45,53‘ W	336,0	WSW 10	252,6	RMT
PS82/091-1	2014-01-14	14:52	76° 58,07‘ S	32° 51,48‘ W	293,7	WSW 8	296,4	AGT
PS82/092-1	2014-01-14	16:08	76° 58,07‘ S	32° 55,83‘ W	274,5	SW 5	0,2	TRAPF
PS82/093-1	2014-01-15	6:14	77° 38,59‘ S	35° 10,26‘ W	399,0	SW 7	188,1	CTD/RO
PS82/094-1	2014-01-15	7:00	77° 38,61‘ S	35° 10,26‘ W	397,7	S 7	187,4	MN
PS82/095-1	2014-01-15	9:46	77° 44,89‘ S	36° 9,03‘ W		SW 6	27,5	MOR
PS82/096-1	2014-01-15	13:00	77° 44,42‘ S	36° 7,81‘ W	704,0	SSW 6	21,8	CTD/RO
PS82/097-1	2014-01-15	13:59	77° 43,45‘ S	35° 58,84‘ W	572,5	SSW 7	89,9	AGT
PS82/098-1	2014-01-15	16:22	77° 42,79‘ S	35° 55,82‘ W	587,5	SW 7	149,5	MG
PS82/099-1	2014-01-15	18:25	77° 42,91‘ S	35° 55,00‘ W	583,2	SSW 4	202,1	MUC
PS82/100-1	2014-01-15	19:58	77° 41,86‘ S	35° 53,39‘ W	588,2	S 3	213,1	RMT
PS82/101-1	2014-01-15	22:47	77° 50,75‘ S	36° 41,19‘ W	935,5	WNW 2	273,2	CTD/RO
PS82/102-1	2014-01-16	0:09	77° 50,82‘ S	36° 43,42‘ W	1011,0	NW 3	187,5	MN
PS82/103-1	2014-01-16	2:15	77° 55,19‘ S	37° 17,37‘ W	1114,0	NW 2	191,3	CTD/RO
PS82/104-1	2014-01-16	4:29	77° 55,10‘ S	37° 59,69‘ W	1194,0	NNW 3	54,3	CTD/RO
PS82/105-1	2014-01-16	5:57	77° 55,04‘ S	38° 0,29‘ W	1195,2	NW 3	323,6	MN
PS82/106-1	2014-01-16	6:53	77° 55,19‘ S	38° 0,52‘ W	1192,5	NNW 1	315,2	CTD/RO

Station	Date	Time	Position Lat	Position Lon	Depth [m]	Wind force [m/s]	Course [°]	Gear ID
PS82/107-1	2014-01-16	8:00	77° 55,08‘ S	38° 2,81‘ W	1204,0	N 4	293,6	RMT
PS82/108-1	2014-01-16	9:36	77° 54,17‘ S	38° 9,99‘ W	1215,5	NNE 4	29,6	MUC
PS82/109-1	2014-01-16	11:35	77° 53,92‘ S	38° 8,49‘ W	1215,7	N 4	24,9	MG
PS82/110-1	2014-01-16	13:25	77° 53,87‘ S	38° 8,70‘ W	1212,5	NE 2	27,0	MG
PS82/111-1	2014-01-16	15:50	77° 54,31‘ S	38° 12,45‘ W	1209,0	ENE 3	330,5	AGT
PS82/112-1	2014-01-16	18:55	77° 53,05‘ S	38° 40,78‘ W	1194,5	ENE 2	86,4	CTD/RO
PS82/113-1	2014-01-17	0:51	77° 36,51‘ S	38° 57,25‘ W	1063,0	ENE 2	217,6	CTD/RO
PS82/114-1	2014-01-17	2:14	77° 36,64‘ S	38° 57,41‘ W	1064,7	ESE 2	267,1	MN
PS82/115-1	2014-01-17	6:56	77° 36,68‘ S	38° 56,33‘ W	1058,2	SSE 5	166,2	AGT
PS82/116-1	2014-01-17	11:06	77° 36,76‘ S	38° 56,66‘ W	1061,0	S 7	190,2	MG
PS82/117-1	2014-01-17	13:45	77° 36,67‘ S	38° 55,53‘ W	1056,2	SSW 7	212,1	RMT
PS82/118-1	2014-01-18	7:02	76° 58,06‘ S	32° 56,17‘ W	274,2	SW 4	86,8	TRAPF
PS82/119-1	2014-01-18	23:34	75° 9,98‘ S	27° 49,93‘ W	463,7	SW 3	234,2	CTD/RO
PS82/120-1	2014-01-19	1:21	75° 20,01‘ S	27° 37,59‘ W	350,3	SW 5	193,9	CTD/RO
PS82/121-1	2014-01-19	3:07	75° 29,90‘ S	27° 26,99‘ W	288,2	W 4	250,6	CTD/RO
PS82/122-1	2014-01-19	3:40	75° 29,91‘ S	27° 27,03‘ W	288,5	WSW 3	46,4	MN
PS82/123-1	2014-01-19	8:18	75° 30,00‘ S	27° 26,99‘ W	285,5	ENE 6	66,0	MUC
PS82/124-1	2014-01-19	9:34	75° 29,83‘ S	27° 25,92‘ W	286,5	ENE 6	45,8	RMT
PS82/125-1	2014-01-19	11:05	75° 29,46‘ S	27° 24,70‘ W	286,0	ENE 6	56,8	MG
PS82/126-1	2014-01-19	13:36	75° 30,44‘ S	27° 29,14‘ W	281,5	NE 6	50,5	BT
PS82/127-1	2014-01-19	15:05	75° 28,78‘ S	27° 21,66‘ W	275,5	ENE 6	357,1	RD
PS82/128-1	2014-01-19	17:39	75° 29,99‘ S	27° 27,17‘ W	288,7	ENE 6	70,5	ROV
PS82/129-1	2014-01-20	6:56	75° 21,47‘ S	27° 44,57‘ W	371,7	NE 11	52,1	BT
PS82/130-1	2014-01-20	9:20	75° 20,27‘ S	27° 38,51‘ W	362,7	NE 9	14,5	MG
PS82/131-1	2014-01-20	10:47	75° 20,28‘ S	27° 38,38‘ W	362,0	ENE 9	54,5	MUC
PS82/132-1	2014-01-20	11:13	75° 20,27‘ S	27° 38,44‘ W	360,7	ENE 9	54,6	MUC
PS82/133-1	2014-01-20	12:25	75° 19,98‘ S	27° 37,22‘ W	364,5	ENE 8	54,2	RMT
PS82/134-1	2014-01-20	13:28	75° 19,52‘ S	27° 35,93‘ W	364,5	ENE 8	298,7	RD
PS82/135-1	2014-01-20	14:29	75° 19,14‘ S	27° 36,79‘ W	369,2	N 5	58,9	RMT
PS82/136-1	2014-01-20	18:01	75° 19,99‘ S	27° 32,40‘ W	346,5	NNE 7	83,5	ROV
PS82/137-1	2014-01-20	22:08	75° 19,97‘ S	27° 34,08‘ W	352,2	NNE 8	184,4	CTD/RO
PS82/138-1	2014-01-21	2:12	74° 49,96‘ S	27° 24,95‘ W	475,7	NW 6	66,7	CTD/RO
PS82/139-1	2014-01-21	4:19	74° 49,94‘ S	26° 38,55‘ W	357,5	WNW 7	42,3	CTD/RO
PS82/140-1	2014-01-21	6:19	74° 49,99‘ S	25° 49,89‘ W	520,7	NW 6	199,5	CTD/RO
PS82/141-1	2014-01-21	7:15	74° 50,08‘ S	25° 50,37‘ W	517,0	NW 6	249,6	MN
PS82/142-1	2014-01-21	9:29	74° 50,25‘ S	25° 8,11‘ W	702,2	NW 4	237,5	CTD/RO
PS82/143-1	2014-01-21	11:12	74° 49,80‘ S	25° 7,43‘ W	702,7	NNW 4	58,3	ICE

Station	Date	Time	Position Lat	Position Lon	Depth [m]	Wind force [m/s]	Course [°]	Gear ID
PS82/144-1	2014-01-21	12:12	74° 49,80‘ S	25° 7,43‘ W	702,7	NNW 5	58,3	MG
PS82/145-1	2014-01-21	14:03	74° 49,80‘ S	25° 7,44‘ W	702,0	N 5	58,3	MUC
PS82/146-1	2014-01-21	14:04	74° 49,80‘ S	25° 7,44‘ W	702,0	N 5	58,3	ICE
PS82/147-1	2014-01-21	18:05	74° 49,32‘ S	25° 12,80‘ W	682,2	NW 7	297,6	RMT
PS82/148-1	2014-01-21	20:08	74° 49,58‘ S	25° 10,51‘ W	691,7	NNW 6	201,6	RD
PS82/149-1	2014-01-22	6:37	74° 31,06‘ S	28° 28,95‘ W	1771,0	W 9	108,9	CTD/RO
PS82/150-1	2014-01-22	8:33	74° 31,49‘ S	28° 28,98‘ W	1783,2	W 6	214,3	MN
PS82/151-1	2014-01-22	10:25	74° 32,26‘ S	28° 31,50‘ W	1749,5	WNW 5	268,3	AGT
PS82/152-1	2014-01-22	14:15	74° 37,01‘ S	28° 31,83‘ W	1151,5	NW 6	0,7	MUC
PS82/153-1	2014-01-22	15:25	74° 36,85‘ S	28° 30,57‘ W	1176,0	NNW 6	47,4	MUC
PS82/154-1	2014-01-22	17:51	74° 36,53‘ S	28° 28,72‘ W	1219,5	NNW 5	359,0	MG
PS82/155-1	2014-01-22	21:06	74° 33,98‘ S	28° 18,05‘ W	1655,5	NW 5	336,5	RMT
PS82/156-1	2014-01-23	7:05	73° 27,90‘ S	29° 40,57‘ W	3250,0	NNW 5	339,8	CTD/RO
PS82/157-1	2014-01-23	9:41	73° 27,96‘ S	29° 41,19‘ W	3249,7	WNW 3	339,8	MN
PS82/158-1	2014-01-23	10:58	73° 27,89‘ S	29° 41,41‘ W	3251,2	WNW 1	339,8	CTD/RO
PS82/159-1	2014-01-23	14:47	73° 48,17‘ S	29° 15,91‘ W	2738,5	SE 3	222,5	CTD/RO
PS82/160-1	2014-01-23	19:01	74° 4,26‘ S	28° 57,19‘ W	2284,7	SE 4	68,8	CTD/RO
PS82/161-1	2014-01-23	22:49	74° 20,30‘ S	28° 46,77‘ W	1911,0	NNE 7	225,8	CTD/RO
PS82/162-1	2014-01-24	2:27	74° 42,93‘ S	29° 0,79‘ W	530,5	NNE 6	199,7	CTD/RO
PS82/163-1	2014-01-24	5:40	74° 39,92‘ S	28° 40,05‘ W	700,0	NNE 8	33,2	MG
PS82/164-1	2014-01-24	10:36	74° 53,66‘ S	26° 42,47‘ W	290,5	NNE 12	358,9	MG
PS82/165-1	2014-01-24	12:01	74° 53,69‘ S	26° 41,75‘ W	295,5	N 10	213,2	MUC
PS82/166-1	2014-01-24	13:44	74° 54,43‘ S	26° 41,30‘ W	306,0	NNE 11	46,3	BT
PS82/167-1	2014-01-24	15:01	74° 52,93‘ S	26° 36,22‘ W	309,2	NNE 9	13,2	CTD/RO
PS82/168-1	2014-01-24	15:34	74° 52,90‘ S	26° 36,28‘ W	310,2	NNE 8	346,2	MN
PS82/169-1	2014-01-24	16:58	74° 52,32‘ S	26° 35,77‘ W	319,7	NNE 7	262,1	RD
PS82/170-1	2014-01-24	18:37	74° 53,89‘ S	26° 38,10‘ W	298,5	NE 6	264,0	ROV
PS82/171-1	2014-01-24	22:18	74° 53,63‘ S	26° 39,90‘ W	295,2	NNE 8	30,2	CTD/RO
PS82/172-1	2014-01-25	7:08	74° 31,87‘ S	30° 19,98‘ W	481,0	N 5	177,5	CTD/RO
PS82/173-1	2014-01-25	9:12	74° 29,97‘ S	30° 59,51‘ W	529,2	N 6	259,8	CTD/RO
PS82/174-1	2014-01-25	10:06	74° 30,26‘ S	31° 0,11‘ W	529,7	NNE 5	194,9	MN
PS82/175-1	2014-01-25	12:16	74° 29,46‘ S	30° 58,61‘ W	530,5	NNE 4	159,1	BT
PS82/176-1	2014-01-25	14:05	74° 32,05‘ S	30° 56,50‘ W	528,7	NNE 4	198,4	RD
PS82/177-1	2014-01-25	15:35	74° 33,11‘ S	30° 57,06‘ W	528,5	NNE 4	77,2	RMT
PS82/178-1	2014-01-25	17:17	74° 29,96‘ S	30° 59,75‘ W	530,0	N 4	93,3	MUC
PS82/179-1	2014-01-25	18:38	74° 29,85‘ S	30° 59,23‘ W	530,5	NNW 2	102,2	MG
PS82/180-1	2014-01-25	21:51	74° 32,06‘ S	31° 29,23‘ W	582,0	NE 2	92,9	CTD/RO

Station	Date	Time	Position Lat	Position Lon	Depth [m]	Wind force [m/s]	Course [°]	Gear ID
PS82/181-1	2014-01-26	0:11	74° 34,39‘ S	32° 0,62‘ W	617,7	NE 1	87,2	CTD/RO
PS82/182-1	2014-01-26	2:53	74° 34,61‘ S	32° 29,10‘ W	643,0	N 3	27,3	CTD/RO
PS82/183-1	2014-01-26	5:57	74° 39,89‘ S	32° 59,88‘ W	616,2	N 4	359,0	CTD/RO
PS82/184-1	2014-01-26	6:58	74° 39,32‘ S	32° 59,94‘ W	634,7	N 3	347,3	MN
PS82/185-1	2014-01-26	8:25	74° 39,78‘ S	32° 59,96‘ W	618,2	NNE 3	343,2	MOR
PS82/186-1	2014-01-26	12:20	74° 40,14‘ S	34° 1,54‘ W	569,5	N 4	193,9	MOR
PS82/187-1	2014-01-26	12:59	74° 39,49‘ S	34° 2,55‘ W	564,2	N 4	176,7	CTD/RO
PS82/188-1	2014-01-26	16:33	74° 39,39‘ S	33° 45,70‘ W	592,2	NNW 4	152,8	BT
PS82/189-1	2014-01-26	17:46	74° 39,75‘ S	33° 41,77‘ W	585,5	NNW 4	156,7	CTD/RO
PS82/190-1	2014-01-26	19:20	74° 40,20‘ S	33° 40,73‘ W	591,0	NNW 3	130,5	MG
PS82/191-1	2014-01-26	21:27	74° 39,56‘ S	33° 43,59‘ W	591,7	NNW 4	246,9	MUC
PS82/192-1	2014-01-26	22:07	74° 39,62‘ S	33° 43,47‘ W	585,5	NNW 4	79,8	MUC
PS82/193-1	2014-01-27	0:50	74° 35,17‘ S	34° 30,05‘ W	549,2	NNW 4	222,2	CTD/RO
PS82/194-1	2014-01-27	3:24	74° 30,13‘ S	34° 55,80‘ W	518,2	NNW 5	251,3	CTD/RO
PS82/195-1	2014-01-27	4:14	74° 30,05‘ S	34° 56,99‘ W	521,7	NNW 5	262,4	MN
PS82/196-1	2014-01-27	7:02	74° 35,92‘ S	35° 54,70‘ W	445,7	N 4	320,4	CTD/RO
PS82/197-1	2014-01-27	9:12	74° 40,05‘ S	36° 29,68‘ W	400,5	N 5	104,2	CTD/RO
PS82/198-1	2014-01-27	10:47	74° 36,21‘ S	36° 21,31‘ W	421,7	N 5	22,4	MUC
PS82/199-1	2014-01-27	12:00	74° 35,83‘ S	36° 21,65‘ W	425,2	NNW 5	330,3	RMT
PS82/200-1	2014-01-27	13:58	74° 34,77‘ S	36° 23,77‘ W	426,0	NW 4	80,8	MG
PS82/201-1	2014-01-27	16:04	74° 34,23‘ S	36° 25,70‘ W	427,7	NNW 5	178,1	BT
PS82/202-1	2014-01-27	17:56	74° 34,41‘ S	36° 27,51‘ W	424,7	NW 6	264,2	ROV
PS82/203-1	2014-01-27	21:57	74° 29,95‘ S	36° 20,57‘ W	911,2	NNW 4	313,0	CTD/RO
PS82/204-1	2014-01-28	1:56	74° 24,06‘ S	36° 6,68‘ W	1327,2	NNW 4	276,2	CTD/RO
PS82/205-1	2014-01-28	4:09	74° 24,52‘ S	35° 43,90‘ W	1259,5	NNW 5	135,2	CTD/RO
PS82/206-1	2014-01-28	5:46	74° 26,07‘ S	35° 43,44‘ W	1141,7	NW 4	143,4	MG
PS82/207-1	2014-01-28	10:15	74° 16,16‘ S	35° 33,19‘ W	1796,7	NW 4	346,6	CTD/RO
PS82/208-1	2014-01-28	13:39	74° 10,10‘ S	35° 44,41‘ W	2002,7	WSW 4	0,6	CTD/RO
PS82/209-1	2014-01-28	17:37	74° 9,65‘ S	35° 25,64‘ W	2039,2	SW 4	36,8	CTD/RO
PS82/210-1	2014-01-28	19:41	74° 9,59‘ S	35° 25,33‘ W	2042,5	WSW 3	102,0	MN
PS82/211-1	2014-01-28	21:12	74° 9,67‘ S	35° 25,16‘ W	2040,5	W 3	117,9	ICE
PS82/212-1	2014-01-29	1:03	74° 2,31‘ S	35° 16,07‘ W	2288,0	SSE 2	194,9	CTD/RO
PS82/213-1	2014-01-29	5:08	73° 53,91‘ S	35° 27,17‘ W	2287,5	SSW 2	80,9	CTD/RO
PS82/214-1	2014-01-29	17:37	73° 53,35‘ S	35° 26,47‘ W		WSW 2	174,8	ICE
PS82/215-1	2014-01-29	20:21	73° 53,73‘ S	35° 6,02‘ W	2536,2	NNW 2	202,0	CTD
PS82/216-1	2014-01-30	0:08	73° 45,11‘ S	34° 55,11‘ W	2762,0	N 4	17,3	CTD/RO
PS82/217-1	2014-01-30	3:48	73° 38,17‘ S	34° 44,70‘ W	2929,0	NE 4	206,7	CTD/RO

Station	Date	Time	Position Lat	Position Lon	Depth [m]	Wind force [m/s]	Course [°]	Gear ID
PS82/218-1	2014-01-30	8:47	73° 28,51‘ S	34° 37,80‘ W	3116,2	NNW 5	240,1	MN
PS82/219-1	2014-01-30	11:26	73° 28,86‘ S	34° 36,89‘ W	3109,0	NNW 6	126,1	CTD/RO
PS82/220-1	2014-01-30	14:12	73° 28,78‘ S	34° 37,21‘ W	3110,5	NW 8	133,6	MOR
PS82/221-1	2014-01-30	14:30	73° 28,60‘ S	34° 37,88‘ W	3111,0	NW 8	296,0	CTD/RO
PS82/222-1	2014-01-30	18:28	73° 38,35‘ S	35° 8,89‘ W	2840,2	NNW 4	291,8	CTD/RO
PS82/223-1	2014-01-30	23:35	73° 53,50‘ S	35° 45,43‘ W	2206,7	WNW 4	197,6	CTD/RO
PS82/224-1	2014-01-31	4:54	74° 9,68‘ S	36° 6,35‘ W	1942,2	NW 5	254,4	CTD/RO
PS82/225-1	2014-01-31	7:28	74° 14,49‘ S	36° 19,03‘ W	1828,2	WNW 5	149,1	CTD/RO
PS82/226-1	2014-01-31	16:46	74° 21,45‘ S	37° 34,66‘ W	548,2	WNW 4	306,4	MG
PS82/227-1	2014-01-31	19:28	74° 19,09‘ S	37° 40,83‘ W	840,7	NW 3	234,4	RMT
PS82/228-1	2014-01-31	23:03	74° 19,81‘ S	37° 47,50‘ W	553,5	WNW 4	304,0	CTD/RO
PS82/229-1	2014-01-31	23:50	74° 19,68‘ S	37° 48,17‘ W	553,0	W 4	306,6	MN
PS82/230-1	2014-02-01	3:17	74° 16,87‘ S	37° 29,81‘ W	1073,0	W 2	275,6	CTD/RO
PS82/231-1	2014-02-01	5:03	74° 14,10‘ S	37° 41,47‘ W	780,5	NNW 4	258,9	CTD/RO
PS82/232-1	2014-02-01	6:06	74° 14,23‘ S	37° 44,48‘ W	700,2	N 4	247,5	MN
PS82/233-1	2014-02-01	7:21	74° 14,65‘ S	37° 42,35‘ W	833,5	NNW 4	245,6	AGT
PS82/234-1	2014-02-01	10:56	74° 16,53‘ S	37° 51,46‘ W	884,5	NNW 3	91,2	RMT
PS82/235-1	2014-02-01	14:15	74° 11,62‘ S	37° 44,00‘ W	805,7	NNW 2	323,9	MUC
PS82/236-1	2014-02-01	16:05	74° 13,22‘ S	37° 39,51‘ W	796,2	W 3	225,3	MG
PS82/237-1	2014-02-01	23:50	74° 27,75‘ S	37° 56,97‘ W	461,4	W 2	272,3	ICE
PS82/238-1	2014-02-02	2:02	74° 27,45‘ S	37° 58,34‘ W	481,2	WSW 2	339,7	CTD/RO
PS82/239-1	2014-02-02	4:49	74° 35,11‘ S	38° 30,07‘ W	455,2	SSW 2	273,5	CTD/RO
PS82/240-1	2014-02-02	6:58	74° 40,16‘ S	39° 1,70‘ W	440,0	SW 2	277,0	CTD/RO
PS82/241-1	2014-02-02	7:44	74° 40,25‘ S	39° 2,84‘ W	434,7	SSW 3	238,6	MN
PS82/242-1	2014-02-02	9:06	74° 40,65‘ S	39° 4,17‘ W	437,2	SSW 2	205,8	MG
PS82/243-1	2014-02-02	10:48	74° 41,31‘ S	39° 4,53‘ W	435,0	S 3	170,4	MUC
PS82/244-1	2014-02-02	15:33	74° 48,94‘ S	39° 42,21‘ W	415,5	SE 6	280,4	BT
PS82/245-1	2014-02-03	6:14	74° 34,00‘ S	38° 1,39‘ W	460,7	SSE 6	275,2	CTD/RO
PS82/246-1	2014-02-03	7:00	74° 34,16‘ S	38° 2,50‘ W	462,5	SSE 7	200,1	MN
PS82/247-1	2014-02-03	10:10	74° 33,48‘ S	37° 44,95‘ W	414,7	SE 9	156,9	RMT
PS82/248-1	2014-02-03	12:09	74° 36,34‘ S	37° 36,87‘ W	391,0	SSE 7	130,3	BT
PS82/249-1	2014-02-03	15:56	74° 32,64‘ S	37° 22,72‘ W	377,5	SSE 10	219,1	BT
PS82/250-1	2014-02-03	18:04	74° 30,73‘ S	37° 28,38‘ W	380,2	S 9	55,7	RMT
PS82/251-1	2014-02-03	19:15	74° 29,58‘ S	37° 29,96‘ W	385,5	SSE 8	343,4	RD
PS82/252-1	2014-02-03	20:07	74° 29,06‘ S	37° 32,13‘ W	389,0	S 10	312,2	CTD/RO
PS82/253-1	2014-02-03	21:41	74° 26,25‘ S	37° 15,13‘ W	478,5	S 8	293,8	CTD/RO
PS82/254-1	2014-02-04	1:38	74° 24,68‘ S	36° 43,01‘ W	938,5	S 9	185,0	CTD/RO

Station	Date	Time	Position Lat	Position Lon	Depth [m]	Wind force [m/s]	Course [°]	Gear ID
PS82/255-1	2014-02-04	2:59	74° 24,81‘ S	36° 43,74‘ W	928,2	S 8	322,9	MN
PS82/256-1	2014-02-04	5:31	74° 19,83‘ S	36° 30,55‘ W	1273,7	SSW 8	296,9	CTD/RO
PS82/257-1	2014-02-04	7:42	74° 23,99‘ S	36° 24,00‘ W	1275,2	SSW 8	24,6	CTD/RO
PS82/258-1	2014-02-04	17:39	74° 30,45‘ S	35° 33,90‘ W	583,7	SW 7	358,8	CTD/RO
PS82/259-1	2014-02-04	21:20	74° 30,64‘ S	35° 38,99‘ W	619,7	W 7	225,6	ICE
PS82/260-1	2014-02-05	2:36	74° 26,73‘ S	34° 29,06‘ W	549,2	WSW 8	97,0	CTD/RO
PS82/261-1	2014-02-05	4:04	74° 24,78‘ S	34° 8,63‘ W	577,5	WSW 6	18,0	CTD/RO
PS82/262-1	2014-02-05	7:41	74° 22,24‘ S	33° 51,29‘ W	627,0	WNW 5	341,4	CTD/RO
PS82/263-1	2014-02-05	11:47	74° 22,03‘ S	33° 22,80‘ W	653,5	WNW 6	171,1	CTD/RO
PS82/264-1	2014-02-05	12:32	74° 22,41‘ S	33° 23,03‘ W	649,0	WNW 5	197,8	AGT
PS82/265-1	2014-02-05	15:05	74° 24,40‘ S	33° 24,86‘ W	648,0	WNW 6	170,3	ICE
PS82/266-1	2014-02-05	20:37	74° 18,39‘ S	32° 50,05‘ W	718,2	WNW 5	333,7	AGT
PS82/267-1	2014-02-05	22:49	74° 18,90‘ S	32° 48,96‘ W	704,5	NW 4	18,2	CTD/RO
PS82/268-1	2014-02-05	23:44	74° 18,47‘ S	32° 48,02‘ W	708,5	NNW 4	18,6	MN
PS82/269-1	2014-02-06	1:01	74° 18,05‘ S	32° 47,56‘ W	747,7	NNW 6	19,0	MUC
PS82/270-1	2014-02-06	2:53	74° 17,17‘ S	32° 47,79‘ W	830,5	NW 2	356,6	MG
PS82/271-1	2014-02-06	12:02	74° 29,25‘ S	33° 8,56‘ W	657,0	NNW 2	248,6	CTD/RO
PS82/272-1	2014-02-06	13:44	74° 33,79‘ S	33° 0,37‘ W	663,2	NNE 3	319,4	CTD/RO
PS82/273-1	2014-02-06	14:48	74° 33,53‘ S	33° 2,20‘ W	664,7	ESE 2	10,3	MN
PS82/274-1	2014-02-06	19:20	74° 42,77‘ S	32° 44,92‘ W	593,0	E 8	18,4	CTD/RO
PS82/275-1	2014-02-06	21:56	74° 50,65‘ S	32° 25,69‘ W	608,0	E 7	331,4	CTD/RO
PS82/276-1	2014-02-07	6:16	74° 51,90‘ S	29° 41,71‘ W	415,5	NE 15	202,2	CTD/RO
PS82/277-1	2014-02-07	7:44	74° 54,31‘ S	29° 40,10‘ W	408,0	NE 15	54,7	MG
PS82/278-1	2014-02-07	9:59	74° 56,33‘ S	29° 41,04‘ W	413,0	NE 14	60,8	MUC
PS82/279-1	2014-02-07	10:28	74° 56,44‘ S	29° 40,75‘ W	408,2	NNE 13	148,0	MUC
PS82/280-1	2014-02-07	11:00	74° 56,57‘ S	29° 40,26‘ W	413,2	NNE 15	174,3	MUC
PS82/281-1	07.02.2014	13:26	74° 59,80‘ S	29° 34,78‘ W	414,5	NNE 12	53,3	RMT
PS82/282-1	2014-02-07	15:36	74° 59,99‘ S	29° 29,62‘ W	411,2	NNE 11	46,8	BT
PS82/283-1	2014-02-07	17:16	74° 58,63‘ S	29° 23,79‘ W	408,2	N 11	21,9	RD
PS82/283-2	2014-02-07	18:19	74° 59,87‘ S	29° 22,90‘ W	409,2	N 10	349,8	AGT
PS82/284-1	= PS82/283-2							
PS82/285-1	2014-02-07	19:59	75° 2,11‘ S	29° 28,90‘ W	411,5	N 11	55,8	CTD/RO
PS82/286-1	2014-02-07	20:40	75° 2,08‘ S	29° 28,69‘ W	410,0	N 11	130,1	MN
PS82/287-1	2014-02-07	23:06	75° 9,88‘ S	29° 18,78‘ W	418,5	N 10	174,9	CTD/RO
PS82/288-1	2014-02-08	1:28	75° 20,22‘ S	29° 9,35‘ W	420,7	N 9	150,0	CTD/RO
PS82/289-1	2014-02-08	4:43	75° 30,18‘ S	28° 1,37‘ W	302,7	NNE 10	341,4	CTD/RO
PS82/290-1	2014-02-08	6:17	75° 30,09‘ S	28° 30,63‘ W	401,7	NNE 10	241,4	CTD/RO

Station	Date	Time	Position Lat	Position Lon	Depth [m]	Wind force [m/s]	Course [°]	Gear ID
PS82/291-1	2014-02-08	7:58	75° 30,36‘ S	29° 0,24‘ W	452,5	NNE 10	198,7	CTD/RO
PS82/292-1	2014-02-08	8:39	75° 30,60‘ S	29° 0,44‘ W	454,0	N 9	17,4	MUC
PS82/293-1	2014-02-08	9:34	75° 31,50‘ S	28° 59,08‘ W	462,2	NNE 9	35,8	AGT
PS82/294-1	2014-02-08	11:27	75° 31,30‘ S	28° 49,55‘ W	419,0	NNE 7	83,0	MN
PS82/295-1	2014-02-08	12:17	75° 31,34‘ S	28° 49,66‘ W	420,5	NNE 8	246,2	RD
PS82/296-1	2014-02-08	14:00	75° 32,06‘ S	28° 42,84‘ W	396,0	NNE 8	279,6	BT
PS82/297-1	2014-02-08	16:20	75° 32,55‘ S	28° 50,23‘ W	411,7	NNE 9	175,6	MG
PS82/298-1	2014-02-08	18:54	75° 34,44‘ S	28° 47,66‘ W	407,2	NNE 9	47,2	RMT
PS82/299-1	2014-02-08	21:20	75° 32,33‘ S	28° 41,87‘ W	389,0	NNE 8	184,1	ICE
PS82/300-1	2014-02-08	23:34	75° 23,08‘ S	28° 34,86‘ W	450,2	NNE 8	171,3	CTD/RO
PS82/301-1	2014-02-09	1:41	75° 13,10‘ S	28° 25,87‘ W	458,5	NNE 5	139,9	CTD/RO
PS82/302-1	2014-02-09	7:15	75° 5,55‘ S	28° 45,13‘ W	422,7	NNE 4	31,0	CTD/RO
PS82/303-1	2014-02-09	8:00	75° 5,54‘ S	28° 45,28‘ W	418,0	NNE 3	31,6	MN
PS82/304-1	2014-02-09	8:58	75° 5,05‘ S	28° 44,03‘ W	418,2	NNE 3	31,3	RMT
PS82/305-1	2014-02-09	10:47	75° 6,47‘ S	28° 46,15‘ W	415,0	NNW 3	155,1	MG
PS82/306-1	2014-02-09	13:00	75° 6,95‘ S	28° 45,01‘ W	421,7	NW 1	42,9	BT
PS82/307-1	2014-02-09	14:47	75° 5,38‘ S	28° 39,95‘ W	445,5	NNE 2	4,5	RD
PS82/308-1	2014-02-09	15:39	75° 5,32‘ S	28° 38,92‘ W	452,7	SSW 2	144,5	AGT
PS82/309-1	2014-02-09	18:01	75° 5,81‘ S	28° 38,24‘ W	460,7	SSW 2	135,8	ROV
PS82/310-1	2014-02-10	0:57	74° 49,99‘ S	27° 46,53‘ W	488,0	SSW 8	59,1	CTD/RO
PS82/311-1	2014-02-10	3:28	74° 46,57‘ S	28° 38,30‘ W	540,2	SSW 6	303,9	CTD/RO
PS82/312-1	2014-02-10	5:06	74° 40,04‘ S	28° 39,95‘ W	678,0	S 6	133,2	CTD/RO
PS82/313-1	2014-02-10	7:27	74° 40,06‘ S	28° 39,77‘ W	672,2	SSW 9	153,5	MUC
PS82/314-1	2014-02-10	8:27	74° 39,93‘ S	28° 41,89‘ W	712,2	S 9	266,6	AGT
PS82/315-1	2014-02-10	10:34	74° 39,36‘ S	28° 47,30‘ W	800,2	S 10	356,7	MN
PS82/316-1	2014-02-10	12:29	74° 39,57‘ S	28° 45,77‘ W	769,0	SE 8	82,9	BT
PS82/317-1	2014-02-10	15:27	74° 39,14‘ S	28° 50,71‘ W	868,2	NE 7	83,6	RMT
PS82/318-1	2014-02-10	18:27	74° 43,04‘ S	29° 21,65‘ W	448,2	NE 12	267,2	CTD/RO
PS82/319-1	2014-02-10	21:20	74° 34,74‘ S	30° 0,08‘ W	517,2	NE 9	188,2	CTD/RO
PS82/320-1	2014-02-10	23:09	74° 41,83‘ S	29° 48,51‘ W	425,5	NE 10	52,6	CTD/RO
PS82/321-1	2014-02-10	23:46	74° 41,89‘ S	29° 48,37‘ W	425,2	NNE 8	36,9	MN
PS82/322-1	2014-02-11	6:39	74° 39,67‘ S	29° 55,08‘ W	430,5	E 8	128,4	RMT
PS82/323-1	2014-02-11	8:30	74° 41,61‘ S	29° 49,39‘ W	424,7	E 7	250,2	MUC
PS82/324-1	2014-02-11	9:04	74° 41,61‘ S	29° 48,29‘ W	426,0	E 8	259,8	MUC
PS82/325-1	2014-02-11	10:37	74° 42,19‘ S	29° 48,59‘ W	428,0	E 7	215,4	MG
PS82/326-1	2014-02-11	12:06	74° 42,45‘ S	29° 45,99‘ W	421,7	ESE 6	42,2	MOR_D
PS82/327-1	2014-02-11	22:09	74° 25,01‘ S	26° 0,22‘ W	945,7	SW 8	196,2	CTD/RO

Station	Date	Time	Position Lat	Position Lon	Depth [m]	Wind force [m/s]	Course [°]	Gear ID
PS82/328-1	2014-02-11	23:33	74° 29,93‘ S	25° 50,00‘ W	539,2	SW 9	207,4	CTD/RO
PS82/329-1	2014-02-12	1:47	74° 39,95‘ S	25° 49,40‘ W	574,5	WSW 10	89,9	CTD/RO
PS82/330-1	2014-02-12	4:43	74° 38,96‘ S	26° 55,91‘ W	433,2	WSW 12	274,1	CTD/RO
PS82/331-1	2014-02-12	9:14	74° 35,41‘ S	26° 53,21‘ W	762,7	SW 10	217,8	BT
PS82/332-1	2014-02-12	10:56	74° 37,13‘ S	26° 58,93‘ W	782,2	SW 8	274,2	CTD/RO
PS82/333-1	2014-02-12	12:49	74° 39,08‘ S	26° 55,86‘ W	421,2	WSW 6	204,1	ROV
PS82/334-1	2014-02-12	21:08	74° 21,78‘ S	26° 0,06‘ W	1925,7	WSW 2	343,6	CTD/RO
PS82/335-1	2014-02-12	23:41	74° 15,38‘ S	26° 15,46‘ W	2503,7	S 3	316,5	CTD/RO
PS82/336-1	2014-02-13	18:51	72° 49,63‘ S	19° 45,41‘ W	1963,2	S 3	236,8	CTD/RO
PS82/337-1	2014-02-13	20:55	72° 48,37‘ S	19° 36,22‘ W	1206,5	SE 2	255,9	CTD/RO
PS82/338-1	2014-02-13	22:13	72° 48,24‘ S	19° 20,33‘ W	504,2	ENE 1	175,4	CTD/RO
PS82/339-1	2014-02-13	23:05	72° 48,98‘ S	19° 18,12‘ W	457,0	SSE 2	282,7	CTD/RO
PS82/340-1	2014-02-14	7:12	72° 48,89‘ S	19° 17,63‘ W	456,2	WNW 6	28,3	ICE
PS82/341-1	2014-02-14	9:15	72° 47,93‘ S	19° 29,71‘ W	739,7	WNW 8	233,5	BT
PS82/342-1	2014-02-14	13:18	72° 48,39‘ S	19° 18,13‘ W	483,5	W 8	270,4	MUC
PS82/343-1	2014-02-14	13:48	72° 48,40‘ S	19° 18,01‘ W	480,5	WSW 6	237,4	MUC
PS82/344-1	2014-02-14	15:58	72° 48,38‘ S	19° 18,13‘ W	485,0	SW 9	244,5	MG
PS82/345-1	2014-02-14	16:42	72° 48,40‘ S	19° 17,75‘ W	477,5	SW 7	325,1	ICE
PS82/346-1	2014-02-16	8:45	70° 56,67‘ S	10° 32,07‘ W	308,7	SSW 8	353,5	MG
PS82/347-1	2014-02-16	10:23	70° 56,63‘ S	10° 32,09‘ W	308,5	SSW 9	217,8	MUC
PS82/348-1	2014-02-16	11:30	70° 56,64‘ S	10° 32,00‘ W	326,5	SSW 7	344,0	MG
PS82/349-1	2014-02-16	12:38	70° 55,57‘ S	10° 28,22‘ W	213,5	SW 11	225,9	AGT
PS82/350-1	2014-02-16	16:25	70° 56,50‘ S	10° 31,75‘ W	291,0	SSW 9	211,9	MG
PS82/351-1	2014-02-16	17:28	70° 56,41‘ S	10° 32,58‘ W	314,5	S 9	153,9	RD
PS82/352-1	2014-02-16	18:52	70° 56,05‘ S	10° 32,39‘ W	300,5	S 8	134,3	ROV
PS82/353-1	2014-02-17	1:56	70° 56,73‘ S	10° 31,03‘ W	279,0	SSE 4	202,1	ROV
PS82/354-1	2014-02-17	4:03	70° 56,64‘ S	10° 32,05‘ W	305,2	ENE 3	242,6	CTD/RO
PS82/355-1	2014-02-17	4:50	70° 57,97‘ S	10° 27,51‘ W	217,2	ENE 5	56,2	CTD/RO
PS82/356-1	2014-02-17	5:50	70° 54,91‘ S	10° 40,08‘ W	344,0	ENE 8	17,7	CTD/RO
PS82/357-1	2014-02-17	7:28	70° 54,83‘ S	10° 44,64‘ W	357,2	N 0	107,1	BT 1)
PS82/358-1	2014-02-17	9:45	70° 54,49‘ S	10° 45,93‘ W	346,0	E 16	306,7	MUC
PS82/359-1	2014-02-17	11:11	70° 56,67‘ S	10° 32,23‘ W	319,0	ENE 17	304,2	MG
PS82/360-1	2014-02-17	12:43	70° 56,51‘ S	10° 31,77‘ W	291,5	ENE 19	269,9	MG
PS82/361-1	2014-02-17	15:31	70° 52,96‘ S	10° 59,99‘ W	490,5	E 20	180,7	CTD/RO
PS82/362-1	2014-02-17	16:57	70° 49,10‘ S	11° 10,22‘ W	1068,5	E 20	140,0	CTD/RO
PS82/363-1	2014-02-20	20:11	70° 16,14‘ S	7° 58,16‘ W	1578,2	SSE 4	137,4	CTD/RO
PS82/364-1	2014-02-20	22:19	70° 10,51‘ S	7° 57,65‘ W	2099,7	SSW 4	232,2	CTD/RO

Station	Date	Time	Position Lat	Position Lon	Depth [m]	Wind force [m/s]	Course [°]	Gear ID
PS82/365-1	2014-02-21	0:23	70° 10,63‘ S	7° 57,28‘ W	2095,2	SW 2	76,7	MN
PS82/366-1	2014-02-27	8:56	46° 22,96‘ S	13° 21,59‘ E	3763,2	W 10	329,3	MN

All posiitions at „Gear on ground“ or „start profile“

1) No information about position „on ground“ Position = end profile

Gear ID	Gear
AGT	Agassiz trawl
BT	Bottom trawl
CTD	CTD
CTD/RO	CTD/rosette water sampler
RD	Dredge, Rauschert
ICE	Ice station
MOR	Mooring
MUC	Multi corer
MG	Multi grab
MN	Multiple net
RMT	Rectangular midwater trawl
ROV	Remote operated vehicle
TRAPF	Trap, fish

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HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG

BREMERHAVEN

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

HELMHOLTZ
GEMEINSCHAFT