EXPEDITION PROGRAMME No. 91

RV POLARSTERN

ANT-XXIX/4
22 March 2013 - 16 April 2013
Punta Arenas – Port Stanley

ANT-XXIX/5
18 April 2013 - 29 May 2013
Port Stanley - Cape Town

ANT-XXIX/6
8 June 2013 - 12 August 2013
Cape Town - Punta Arenas

ANT-XXIX/7
14 August 2013 - 16 October 2013
Punta Arenas - Cape Town

Coordinator
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INHALT / CONTENTS

ANT-XXIX/4

22 March - 16 April 2013

Punta Arenas – Port Stanley
Scotia Sea

Chief Scientist
Gerhard Bohrmann

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CONTENTS

1. ÜBERBLICK UND FAHRTVERLAUF

G. Bohrmann (MARUM)

Der vierte Fahrtabschnitt der 29. *Polarstern* Expedition in die Antarktis wird am 22. März 2013 starten. Das Schiff wird von Punta Arenas (Chile) nach Osten durch die Magellanstraße in den Südatlantik aufbrechen. Südlich der Falkland-Inseln planen wir eine erste Kernstation am Rande des Falkland-Plateaus. Bisherige Beprobungen des British Antarctic Surveys konnten den letzten glazialen Zyklus kernen und im Bereich einer kondensierten Abfolge soll versucht werden, auch frühere Glazial-Interglazial-Zyklen mit dem Kolbenlot zu beproben. Nach 2 Tagen Transit wird *Polarstern* Südgeorgien erreichen, wo in der westlichen Cumberland-Bucht ein internationales Team von 6 Sedimentologen und Geomorphologen von Bord geht, um während der kommenden zweieinhalb Wochen amphibische Sedimentkernbeprobungen in Lagunen und tiefliegenden Seen der Bucht durchzuführen. *Polarstern* wird die Ablagerungen der zentralen Bucht beproben und auf dem Weg zu den Sandwich-Inseln ein glaziales Rinnensystem im Südosten von Südgeorgien untersuchen. Neben sedimentechographischen Aufzeichnungen wird die Bathymetrie vermessen, sowie 1 bis 2 Sedimentkernstationen beprobt.

Sodann wird *Polarstern* das Hauptuntersuchungsgebiet der Sandwich-Inseln aufsuchen. Ziel der Arbeiten dort ist die multidisziplinäre Untersuchung von hydrothermalen und kalten Quellen mithilfe geophysikalischer und geologischer Methoden sowie visueller Meeresbodenbeobachtungen und Probennahme. Neu zu entdeckende Austritte von Gas und Fluiden sollen geologisch und geochemisch charakterisiert werden. Bisher gibt es nur sehr wenige Hinweise auf Seeps und Vents entlang der Sandwich-Mikroplatte. Neu zu entdeckende Seeps und Vents sind von besonderem Interesse, da die Sandwich-Mikroplatte ein wichtiges Verbindungsglied zwischen dem Weltozean und der Antarktis darstellt, und damit gerade auch im Hinblick auf die Biogeographie von chemosynthetischen Lebensgemeinschaften eine Schlüsselstellung einnimmt. Zudem nimmt die Sandwich Mikroplatte eine besondere geologisch-geochemische Stellung ein, wegen ihrer Lage unterhalb der Polarfronten innerhalb des Opalgürtels einerseits und ihrer Tektonik mit einer Konvergenzzone zwischen zwei ozeanischen Platten andererseits. Bislang gibt es hydrothermale Quellen an den Segmenten E2 und E9 des östlichen Scotia Rückens, wohingegen kalte Quellen im Bereich des Fore-Arcs bisher nicht bekannt sind. In Analogie zu anderen konvergenten Plattengrenzen sind hier Fluidaustritte zu erwarten.

Wir planen einen Großteil des Fore-Arc-Bereiches zwischen den Sandwich-Inseln und dem bis zu 8.000 m tiefen Tiefseegraben mit dem Fächerecholot sowie mit dem Sedimentecholot zu kartieren. Dabei steht die Suche nach kalten Quellen im Mittelpunkt, wobei vorwiegend nach geeigneten Topographien und Gasaustrittsstellen am Meeresboden exploriert wird. Sedimentbeprobungen mit Kolben- und Schwereloten, sowie Multicorer und Dredge werden zur Beprobung von Seeps und paläozeanographische und sedimentgeologische Studien im Opalgürtel durchgeführt. Untersuchungen der Wassersäule mittels CTD und Wasserschöpfern für mikrobiologische Fragestellungen und zur Detektion von Gasemissionen ergänzen das Programm, genauso wie Beprobungen des kieseligen Phyto- und Zooplanktons der Wassersäule im südlichen Antarktischen Zirkumpolarstrom.

Im Bereich des vulkanischen Sandwich-Bogens werden submarine Vulkane auf hydrothermale Aktivitäten exploriert und wenn möglich auch beprobt. Weitere Hydrothermalsysteme werden am Backarc-Spreading-Zentrum des Ost-Scotia-Rückens untersucht. Visuelle Direktbeobachtungen von heißen und kalten Quellen werden mit dem Tiefseefotoschlitten des AWI entlang von überstreichenden Bodenprofilen durchgeführt. Eine kontinuierliche Beobachtung von Walen und Seevögeln ist während der Expedition geplant.

In der letzten Woche wird die Expedition wiederum Südgeorgien anlaufen, um das zu Beginn der Expedition abgesetzte Landteam aufzunehmen und ergänzende Sedimentbeprobungen zur glazialen und postglazialen Geschichte der Insel durchzuführen. Von Südgeogien aus ist der Falklandinselkomplex in 2 Tagen zu erreichen, wo das Einlaufen von *Polarstern* am Dienstag den 16. April in Port Stanley geplant ist.

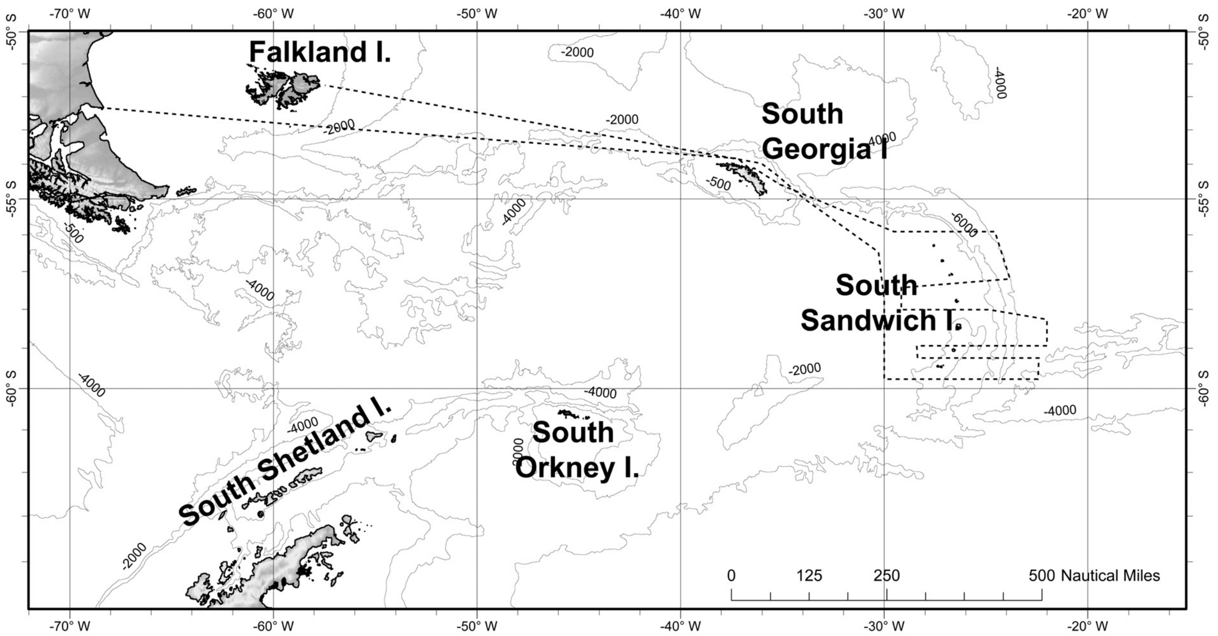

Abb. 1.1: Geplante Fahrtroute der Polarstern-Expedition ANT-XXIX/4
Fig. 1.1: Planned cruise track during R/V Polarstern expedition ANT-XXIX/4

SUMMARY AND ITINERARY

Leg of of *Polarstern* cruise 29 to Antarctica will start on 22 March 2013. The vessel will steam eastwards from Punta Arenas (Chile), across the Magellan Strait heading to the South Atlantic. South of the Falkland Islands we plan a first core station, on the edge of the Falkland Plateau. Earlier samplings of the British Antarctic Survey could core the last glacial cycle, and we will try to also sample earlier glacial-interglacial cycles deeper in the sediments using our piston corer in an area, where a more condensed sequence is deposited. After a two days transit *Polarstern* will reach South Georgia where, in its western Cumberland Bay, an international team of six sedimentologists and geo-morphologists will disembark, in order to perform amphibian sediment sampling in lagoons and abyssal lakes of the bay for the next two weeks. *Polarstern* will sample sediments from the central bay, and on the way to the Sandwich Islands we will examine a glacial channel system southeast of South Georgia.

Besides sediment echo sounding also multi-beam bathymetry will be performed, and 1-2 sediment core stations will be sampled.

Afterwards *Polarstern* will transit to the Sandwich Islands, the main research area of our cruise. Main objective of our work is a multidisciplinary examination of hydrothermal and cold seeps by geophysical and geological methods, as well as visual seafloor monitoring and sampling. Discovery of new gas and fluid emission sites shall be characterized geologically and geochemically. Up to now there are only few indications of seeps and vents along the Sandwich micro-plate. Consequently a discovery of new seeps and vents are of special interest, as the Sandwich micro-plate represents an important link between the World Ocean and Antarctica, and in this connection the Sandwich plate also has a key position regarding the biogeography of chemosynthetic communities. Furthermore the Sandwich micro-plate takes a special geological-geochemical position because of its situation below the polar front within the Antarctic silica belt on one hand, and its tectonic situation with a convergence zone between two oceanic plates on the other hand. Up to now there are hydrothermal sources on the segments E2 and E9 on eastern Scotia Ridge, whereas cold seeps in the area of the fore-arc are unknown so far. By analogy with other convergent plate boundaries, fluid emission can be expected here.

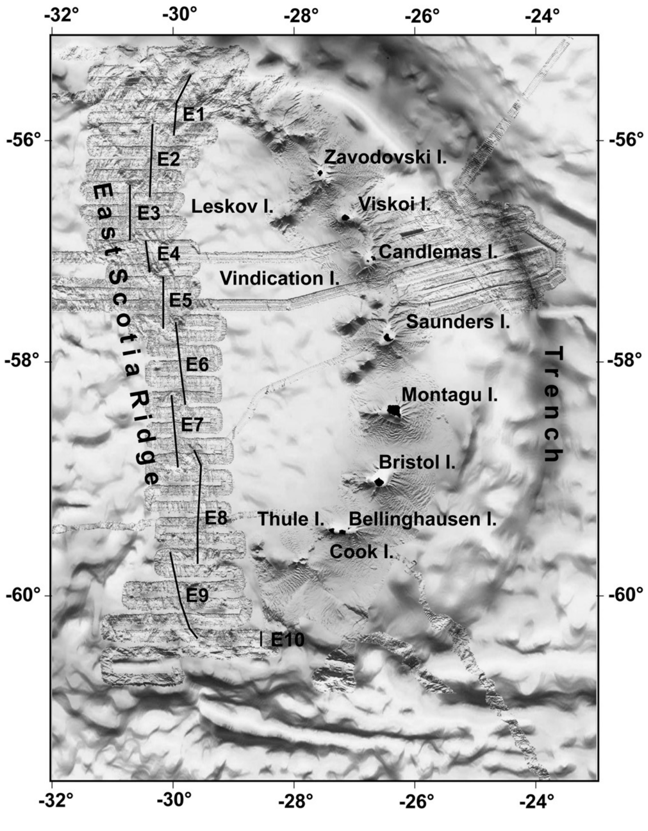

Fig. 1.2: The Sandwich plate is confined from the South Sandwich Trench in the east to the backarc spreading zone of the East Scotia Ridge. Two segments E2 and E9 which reveal higher heat flux will be investigated in detail. Multi-beam data from several cruises were merged: JR09-1995, Hawaii MR1; JR 168-2007 EM120; JR224-2009 EM120; JR206-2010; PS ANT-XV/2 1997 HD)

Multi-beam mapping is planned, as well as sediment echo-sounding of the majority of the fore-arc area between Sandwich Islands and the up to 8,000 m deep deep-sea trench. In the center of interest is the search for cold seeps, exploring mainly for suitable topographies and gas emission locations at the seafloor. Sediment sampling with piston and gravity corer, as well as multi-corer and dredge will be operated for sampling of seeps and paleoceanographic and sedimentological studies in the Antarctic biogenic silica belt. Investigation of the water column by CTD and water samplers with respect to microbiological questions and for detection of gas emission will complete the program, same as sampling of siliceous phyto- and zoo-plankton in the water column of the southern Antarctic Circumpolar Current.

In the area of the volcanic Sandwich arc we will explore submarine volcanoes for hydrothermal activity, and if possible we will also take samples. Further hydrothermal systems will be investigated on the back-arc spreading center of East Scotia Ridge. By means of the AWI deep-sea photo sled we will have direct visual seabed sight at hot vents and cold seeps by towing the deep sea sled along the sea floor along track lines. Continuous watching of wales and seabirds is planned during the entire cruise.

In the last week the expedition again will arrive at South Georgia, in order to pick up the land team that had been left there at the beginning of the cruise. Further sampling of fjord sediments to investigate glacial and interglacial history of the island is planned. From South Georgia the Falkland Islands can be reached within 2 days, where *Polarstern* is supposed to arrive on Tuesday, 16 April in Port Stanley.

2. EXPLORATION OF COLD SEEPS AND HOT VENTS OF THE SANDWICH PLATE

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Objectives

The oceanic lithosphere comprises a large aquifer system, containing as much fluid as that stored in ice caps and glaciers. Water circulation through that reservoir of the oceans links sub-seafloor hydrologic, mechanical, chemical, and biological systems. The fluid cycling transports energy and matter that is modified and used by a variety of biota in, at, and above the seafloor. The geofuel not only sustains chemotrophic life but also leads to precipitation of authigenic minerals, which is a process again influenced by microbial activity. Thus, the topic of fluid flow through the oceanic lithosphere has been identified as fundamental for understanding processes in the solid Earth, oceans and the biosphere (e. g. IODP: International Ocean Discovery Program 2013 - 2023). Fluid flow is either induced by hydrothermal circulations related to seafloor spreading or by dewatering processes at convergent plate margin settings. While fluid flow is a widely observed and well documented phenomenon around the world, many details are yet unstudied, which includes the driving forces of fluid flow, the fluid sources, pathways, and sinks as well as the transfer efficiency of energy and matter between the fluid and the biota.

We have identified the fore-arc and back-arc off the South Sandwich Islands as a key area to study processes related to fluid circulation for several reasons: (1) Studies of cold and hot venting can be studied in relatively close proximity to each other at the Sandwich micro-plate. (2) The classical interoceanic subduction zone is located in the biogenic opal belt of the Southern Ocean, which has an impact on geochemical processes within the subduction zone and has potentially also influence on the chemical composition of the fluids circulating in the sediments and vents at the seafloor. This is in contrast to most other convergent continental margins which receive mainly terrigenous or calcareous sediments. (3) The interoceanic convergent margin is characterised by subduction erosion. It can be hypothesised that the tectonic control of fluid flow at this interoceanic plate margin is comparable to other well studied continental margins that are also characterized by subduction erosion, which is a major objective of this proposal. (4) The remoteness of the Sandwich micro-plate on the one hand and its location that links the Pacific and the Atlantic Ocean on the other hand makes the region a key area to study the biogeography of chemosynthetic communities.

The Sandwich Arc and the Scotia Sea have been identified by the ChEss (Chemosynthetic Ecosystem Science), which is the field project of the Census of Marine Life Program (CoML), as a key area understanding biogeographic aspects of chemosynthetic communities (see Science on http://www.noc.soton.ac.uk/chess). At a global scale, differences between vent biogeographic provinces largely reflect their degree of separation along the ridge system (Tunnicliffe & Fowler, 1996). At present the only ridge-crest connection between the Atlantic and Pacific is via the Indian Ocean along the South-West, Central, and South-East Indian Ridge. However, the Sandwich arc could possibly provide a short-cut between the Pacific and Atlantic for larvae that drift for a long time in the water column. The Sandwich arc together with the South-West Indian Ridge are therefore target areas for present and proposed research cruises to hydrothermal vents.

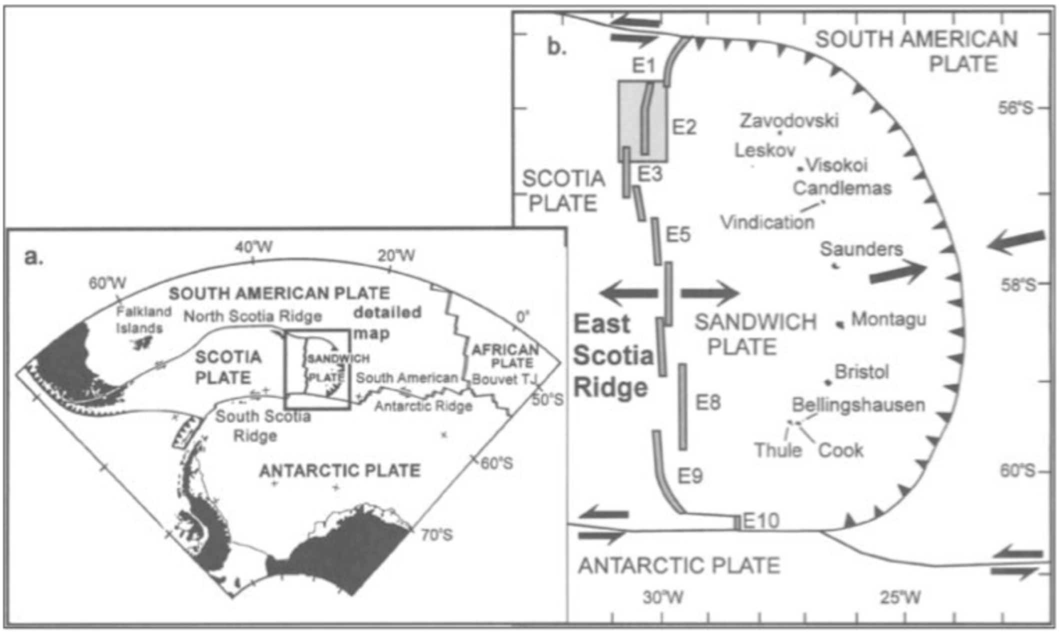

Fig. 2.1: (a) Tectonic setting of the Sandwich Plate surrounded by the South American Plate, Antarctic Plate and Scotia Plate. (b) Map of the Sandwich Plate from the east Scotia Ridge (Segments E1-E10), the volcanic arc and the trench (from Harrison et al. 2003).

The overarching goal of the cruise is to increase our knowledge of fluid flow and its related processes in the area of the South Sandwich fore-arc and back-arc. The cruise will concentrate on exploratory work at hydrothermal vents and cold seeps using existing seismic data, multi-beam and Parasound echosounder, hydrocasts as well as TV-guided observations and sampling at the seafloor. The objective is to find and characterize sites at the seafloor influenced by fluid flow. A follow-up cruise Sandwich II with *Polarstern* is planned to investigate in detail the hydrothermal and cold vent sites using an autonomous underwater vehicle (AUV) and remotely operated vehicle (ROV).

One specific goal of the cruise is to understand the role of fluid seepage in the South Sandwich fore-arc area, which is a classic intra-oceanic convergence zone characterised by subduction erosion (Vanneste and Larter, 2002a). We will test the hypothesis that the location of fluid flow at the seafloor is controlled by thermally-induced mineral dewatering processes at the plate boundary as has been observed at other convergent margins characterised by subduction erosion. Analogous to other settings, the fluids that are released at the plate boundary may be channelled through extensional faults in the upper plate and eventually reach the seafloor. Consequently, the exploration in the South Sandwich fore-arc will initially concentrate on the so-called “trench slope break” at about 4,500 m water depth, where normal faulting has been documented with deep-penetration multi-channel seismics. A combination of various mapping techniques will be used to systematically find fluid-flow influenced areas at the seafloor including multibeam, Parasound echosounder, and towed TV-sled.

A further goal of the initial cruise is to investigate fluid circulation patterns in the area of known hydrothermal vent sites at the East Scotia Ridge in the back-arc basin off the Sandwich Islands. Following the finding of hydrothermal vents at the segments E2 and E9 by our British colleagues from NOCS and BAS (Rogers et al. 2012, Marsh et al. 2012) and others, currently preparing a publication, the geophysical investigations intend to complement their work. A further objective is to obtain a detailed insight into the composition of the chemosynthetic community as well as any occurring precipitates. Sampling of precipitates and the related pore water environment will allow characterizing the geochemical environment of seepage. Precipitates will be used as archives of seepage. These investigations will allow defining specific targets for ROV and AUV dives which are planned during a future cruise.

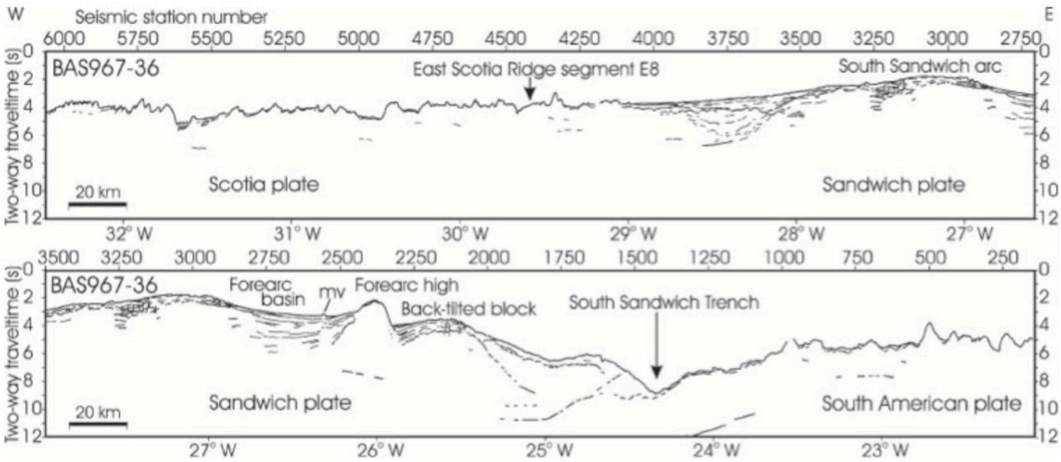

Fig. 2.2: Interpreted line drawing of the line BAS967-36 showing reflections identified on both migrated stack; mv is a mud volcano. Vertical exaggeration at the seafloor is 6:1 (from Vanneste et al. 2002b).

The **East Scotia Ridge** is located ca. 100 - 150 km west of the South Sandwich arc which consists of 11 volcanic islands forming a 500 - km-long distinctly curved island arc (Leat et al. 2003a). Most of the islands show evidence of recent volcanic activity and are entirely volcanic in origin. Although the location of rift segments of the East Scotia Ridge was documented by the magnetic anomalies and seismic profiles the entire ridge was mapped in 1995 using the Hawaii-MR1 swath sonar, from which detailed bathymetry and backscatter information was performed (Livermore et al. 1997). The data clearly showed 9 ridge segments, separated by non-transform offsets. Based on these findings the WNW-ESE-trending gravity anomalies in the west of the back-arc ridge are interpreted to represent the loci of migrating ridge offsets or pseudo-faults. Spreading rates of 60 - 70 mm/year place the East Scotia Ridge in the intermediate range of seafloor spreading centres, which is attributed to upwelling of the mantle cooled by the subducted slab. However, the morphology of the active centre varies from segment to segment and is transitional between a fast spreading centre with an axial high and slow ridge with a median valley.

Water column investigations have revealed the first evidence of hydrothermal activity along some segments of the back-arc ridge. Using a combination of *in-situ* optical light-scattering sensor data and the dissolved manganese concentrations, hydrothermal plumes were detected in Segments E2 and E9 (German et al. 2000). Hydrothermal anomalies in the overlying water column are consistent with the presence of hydrothermal fields located close to the ridge axis. Hydrothermal anomalies in the overlying water column are consistent with the presence of hydrothermal fields located close to the ridge axis. Both segments are characterised by a smooth volcanic high (Fig. 2.2). The apical dome of Segment E2 is associated with a seismic axial magma chamber reflection from a depth of approximately 3 km beneath the seafloor (Livermore et al. 1997). Recent investigations during research cruise JR224 (January - February 2009, JC42 (January - February 2010), and JC55 (January - February 2011) within the NERC program CHESSO (Chemosynthetically-driven Ecosystems South of the Polar Front Consortium) revealed more evidence for hydrothermal activities in Segments E2 and E9 (Rogers et al. 2012; Marsh et al. 2012).

Along the **South Sandwich Trench** the South American Plate is subducting beneath the Sandwich Plate at a rate of 70 - 85 mm/year (Fig. 2.1). Earthquake data indicate that the subducting plate is dipping by an angle of 45 - 55° from east to west. The slab is probably steepening in the southern part of the subduction zone. The sedimentary cover of the oceanic crust consists of 200 - 400 m siliceous ooze of the Antarctic silica belt which is a unique sediment type composed of more than 95 % of pure biogenic opal. The age of the southern part of the subducting crust is 28 - 35 Ma, whereas the crust subducting in the northern arc is much older (50 - 60 Ma). Multichannel seismic reflection lines that cross the South Sandwich trench (Fig. 2.2) and the Island arc to the West were conducted in 1997 during the Sandwich Lithospheric and Crustal Experiment (SLICE; Larter et al. 1998). Those data together with detailed bathymetry and side-scan imagery gave first insights how the crust is modified by the subduction processes and the tectonic fabric and sedimentary features in the area of plate convergence (Vanneste et al. 2002a; Vanneste and Larter 2002b). The interpretation of the data together with the marine magnetic record of the seafloor spreading since 15 Ma has enabled quantitative estimation of sediment subduction and subduction erosion rates.

Any accretionary wedge present is constrained to be very small, extending less than 6 km from the trench (Fig. 2.2). More than 95 % of the sediment which has entered since 15 Ma has been subducted and the Island arc migrated ca. 70 km to the west. The average rate of fore-arc retreat during that time interval is inferred to be 3.1 - 4.7 mm/year. At the present convergence rate of 74 mm/year this erosion rate requires a 420 - 635 m thick layer of subducting material derived from the fore-arc crust (Vanneste and Larter 2002b). Since the frontal erosion can only account for less than 40 % of the total subduction erosion, the basal erosion must significantly exceed the frontal erosion. The new data also provide insight into the fore-arc strain regime and the fore-arc basin evolution (Fig. 2.3). Extensional faulting near the trench slope break was observed and is interpreted to be caused by gravitational instability of the lower slope. The seismic profiles over the fore-arc basin suggest that the balance between sediment deposition and erosion is sensitive to change in the elevation of the trench slope break. It was postulated by Vanneste and Larter (2002a) that the basin is a dynamic feature which goes through repeated cycles of growth and destruction controlled by cyclic uplift and collapse of the trench slope break. Recently collected multibeam data of the northern arc islands largely confirm the concept of subduction erosion and a westward migration of arc volcanism relative to the underlaying plate (Leat et al., 2010). This westward migration leads to asymmetry in the morphology of volcanoes being steep with abundant recent volcanism on their western flanks and gently sloping with extinct, eroded volcanic sequences to their east. The multi-beam data by Leat et al. (2010) considerably enlarge the available multibeam coverage in the South Sandwich fore-arc.

Fig. 2.3: Interpreted line drawing of mosaic of side-scan sonar data from HAWAII-MR1 survey of part of the South Sandwich forearc. Small subcircular, high-backscatter features on the fore-arc bench, interpreted as slide blocks, are shown as solid areas (from Vanneste and Larter 2002b).

Work at sea

In general, we follow the approach to conduct exploratory work during the cruise in order to identify and characterize seeps and vents at the seafloor of the East Scotia Ridge and seeps in the fore-arc area off the South Sandwich Islands, respectively. The two already discovered hydrothermal vents are located at the segments E2 and E9 (Rogers et al. 2012; Marsh et al. 2012). Methane seepage might be expected in two areas of the fore-arc. The first area is a potential mud volcano that has been identified in seismic data, the second area is the normally faulted "slope trench break". At present, we plan to visit all four areas but ongoing work by our British colleagues during recent James Cook cruise (JC 80) may require adjustment of the plans.

The following methods and tools will be employed during the cruise:

A *CTD with Niskin bottle rosette* equipped with oxygen and turbidity sensors will be used for hydrocasts and water column profiling. The system is employed in order to detect hydrothermal plumes as well as to study the methane concentration in the water column at methane seeps.

A *TV-sled* operated on the fiber-optic cable is used for visual observation of the seafloor. The TV-sled is towed by the ship at speeds around 0.5 to 1 knot. It transmits video images online to the ship. In seep and vent areas we will perform detailed profiles with underwater navigation of the sled.

Alternatively, a *TV-MUC* for TV-guided coring of fluid-influenced sediments will be deployed using the video-data telemetry if the TV-sled.

A conventional *gravity corer* (GC) and *piston corer* are used in order to conduct exploratory sampling of fluid seeps.

The ship-mounted ATLAS *PARASOUND* deep-sea single beam echo-sounder system will be used for water column imaging and sub-bottom profiling. The PARASOUND system is particularly useful for localizing gas flares while operating in the deep-sea environment.

Hydrosweep multi-beam echo-sounder will be used for swath bathymetry mapping. In addition, the backscatter amplitudes will be extracted giving important information of the seafloor properties.

The following outlined work program is planned for segments E2 of the East Scotia Ridge and potential submarine active volcanoes where hydrothermal venting has already been detected. In order to confirm the ongoing activity of high-temperature hydrothermal venting a program with CTD for hydrothermal plume detection and TV-sled video observations of the seafloor is planned. The second half of the cruise will be used to search for seeps in the South Sandwich fore-arc. There are presently two target areas with high potential for active fluid seepage, the mud volcano-like feature in the fore-arc basin ESE of Saunders Island, and the “trench slope break” marked by “TSB” in Figure 2.4. In both areas Parasound echo-sounder surveys will be conducted that are used for sub-surface sediment imagery as well as for the search of gas bubble-induced hydro-acoustic anomalies in the water column. In order to gain a detailed insight into the shallow subsurface structure, it is planned to conduct two overview profiles along and across slope as well as about five shorter surveys that cross perpendicular the 25 nm wide area of the trench slope break. At least three TV-sled deployments should be conducted to search at the seafloor for evidence of fluid flow where seismic data indicate the presence of gas. In addition, gravity corer and piston corer deployments to reveal the presence or absence of gas- or gas hydrate-rich sediments will complement the work. A similar work schedule with comparable time requirements is requested for the potential mud volcano-like feature in the fore-arc basin.

Data management

The following measures are taken to promote scientific exchange and guarantee long-term data storage: During the cruise all data are made available for all scientists, either as raw or analysed data. A comprehensive cruise report will be written for thorough description of the acquired data and their preliminary interpretation. After the cruise, data analyses and interpretation should lead to scientific publications to present the findings to the scientific community. Several raw data will be made available to the public along with the publication either directly as, e.g. electronic appendix or indirectly by submitting the original data to Pangaea world data center.

The proponents are currently involved in the discussion of long term data storage of heterogeneous as well as large-sized data sets. While it is good practice already to submit raw multibeam data to the Bundesamt für Seeschifffahrt und Hydrographie (BSH) there is no platform to provide processed multi-beam data so far. A solution for this is in discussion. Original data of Parasound echo-sounder will be preliminary stored as data bundle in Pangaea. As soon as the current discussion of how to standardize the submission of these echo-sounder data has come to an agreement, we will convert the data accordingly and re-submit it to Pangaea. At present, there is no platform how to archive videos from, e.g. TV-guided tool for long term data storage. The data is archived in house and available for everyone upon request. However, a discussion of how to archive these data is currently taking place.

References

German, C. R., R. A. Livermore, et al. (2000). Hydrothermal plumes above the East Scotia Ridge: an isolated high-latitude back-arc spreading centre. Earth and Planetary Science Letters 184: 241-250.
Harrison, D., P. T. Leat, et al. (2003). Resolving mantle components in oceanic lavas from segment E2 of the East Scotia back-arc ridge, South Sandwich Islands. Geological Society, London, Special Publications 219: 333-344.
Larter, R. D., E. C. King, et al. (1998). South Sandwich Slices reveal much about arc structure, geodynamics, and composition. EOS 79(24): 2
Livermore, R. A., A. Cunningham, et al. (1997). Subduction influence on magma supply at the East Scotia Ridge. Earth and Planetary Science Letters 150: 261-275.
Leat, P. T. and R. D. Larter (2003a). "Intra-oceanic subduction systems: introduction." Geological Society, London, Special Publications 219: 1-17.
Leat, P. T., A. J. Tate, et al. (2010). Growth and mass wasting of volcanic centers in the northern South Sandwich arc, South Atlantic, revealed by new multibeam mapping. Marine Geology 275(1-4): 110-126.
Livermore, R. A. (2003). "Back-arc spreading and mantle flow in the East Scotia Sea." Geological Society, London, Special Publications 219: 315-331.
Marsh L, Colpley J, Huevennne VAL, Linse K, Reid WDK, Rogers AD, Sweeting CJ, Tyler PA (2012) Microditribution of faunal assemblages at deep-sea hydrothermal vents in the Southern Ocean. PLOS, volume 7 (10) e48348
Rogers AD, Tyler PA, Connelly DP, Copley JT, James R, et al. (2012) The discovery of new deep-sea hydrothermal vent communities in the southern ocean and implications for biogeography. PLoS Biology 10: e1001234.
Tunnicliffe, V. and C. M. R. Fowler (1996). "Influence of sea-floor spreading on the global hydrothermal vent fauna." Nature 379: 531-533.
Vanneste, L. E., R. D. Larter, et al. (2002a). Slice of intraoceanic arc: Insights from the first multichannel seismic reflection profile across the South Sandwich island arc. Geology 30(9): 819-822.
Vanneste, L. E. and R. D. Larter (2002b). Sediment subduction, subduction erosion and strain regime in the northern South Sandwich forearc. Journal of Geophysical Research 107(B7): 2149.

3. SEDIMENT GEOCHEMISTRY AND BIOGEOCHEMISTRY

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Objectives

The sediments of the Scotia Sea/South Sandwich Plate are characterized by high opal contents that also go along with elevated contents of Ba in the sedimentary solid phase (e.g., Nürnberg, et al., 1997). We suggest that the fluids evolving both from porewater/rock interactions at hydrothermal vents and compressional forces at cold seep systems in the area display a distinct and unique composition. We aim at using the chemical and isotopic composition of interstitial fluids in “normal” hemipelagic deposits as well as in hydrothermal and cold-seep environments in the study area to trace the sources and the migration patterns and pathways of the fluids. Furthermore, we seek to investigate the impact that the particular composition and transport mechanisms of the fluids have on geochemical and bio-geochemical processes operating throughout the sediment column and which diagenetic signals these processes leave behind in the solid phase. Understanding and quantifying these complex interactions in the different depositional systems will enhance our understanding of subsurface biosphere processes and improve the quality of paleo-environmental and paleoceanographic reconstructions from sedimentary archives.

Recent studies by Bodeï et al. (2008) and Ziebis et al. (2012) have shown that both active discharge of hydrothermal fluids at and recharge of seawater into seamounts can have a profound impact on biogeochemical and diagenetic processes in the overlying sediments. We therefore intend to measure concentration/depth profiles of oxygen and other pore water constituents in sediments draping the flanks of selected seamounts in the study area. In this way we seek to elucidate whether and in which way upward advection of fluids or diffusion of ions from "cold" seawater circulating within the fractured seamount basalts might control biogeochemical processes in the overlying sediments and whether these processes may be of a broader significance than previously thought.

Work at sea

We plan to work on surface sediments sampled by means of a multiple corer (MUC) and will also process long piston cores (PC) taken from "normal" hemipelagic sites as well as locations affected by hydrothermal activity and seepage of cold methane-rich fluids. After arrival of the cores on deck of the *Polarstern*, samples will be transferred into a cooling container and ex situ oxygen measurements using amperometric microelectrodes will be performed according to the technique described by Ziebis et al. (2012). Subsequently, pore water will be retrieved by means of rhizons (Seeberg-Elverfeldt et al., 2005) followed by on-board analyses of various pore water constituents – including alkalinity, iron, nitrate, nitrite, ammonium, phosphate, and silica. Redox potential and pH will be determined using punch-in electrodes. Furthermore, subsamples of the pore water will be taken and adequately conserved and stored for the shore-based analyses of sulfate, chloride, hydrogen sulfide, total inorganic carbon, major cations, trace metals, methane and other hydrocarbons as well as the stable isotopic composition of several of these constituents. In addition, sediments will be taken from the MUC and piston cores and adequately stored under both oxic and anoxic conditions depending on the particular redox conditions of the sampled sediments.

Data management

All geochemical data collected on board will be implemented into the PANGAEA data base to ensure long-term storage and will be made available for the scientific community after a moratorium of 3 years after the end of the cruise. Data obtained and collected during subsequent analyses at the AWI, the MARUM/University of Bremen and at Oregon State University will be submitted to PANGAEA and made publicly available after acceptance of the respective manuscripts.

References

Bodeï, S., Buatier, M., Steinmann, M., Adatte, T., Wheat, C.G. (2008) Characterization of metalliferous sediment from a low-temperature hydrothermal environment on the Eastern Flank of the East Pacific Rise. Mar. Geol., 250: 128-141.

Nürnberg, C.C., Bohrmann, G. and Schlüter, M. (1997) Barium accumulation in the Atlantic sector of the Southern Ocean: Results from 190,000-year records. Paleoceanography, 12, 594-603.

Seeberg-Elverfeldt, J., Schlüter, M., Feseker, T., Kölling, M. (2005) Rhizon sampling of porewaters near the sediment-water interface of aquatic systems. Limnol. Oceanogr. Methods, 3: 361-371.

Ziebis, W., McManus, J., Ferdelman, T., Schmidt-Schierhorn, F., Bach, W., Muratli, J., Edwards, K.J., and Villinger, H. (2012). Interstitial fluid chemistry of sediments underlying the North Atlantic gyre and the influence of subsurface fluid flow. *Earth Planet. Sci. Lett.* 323-324: 79-91.

4. BIOGEOCHEMISTRY OF THE WATER COLUMN

S. Mau (AWI), P. Gepraegs, E. Kopiske (MARUM), J. Rethemeyer (Uni Koeln), I. Morgunova (VNIIOkeangeologia)

Objectives

Work during the cruise will focus on the methane cycle in the water column. Methane is a potent greenhouse gas: per unit mass, methane has a global warming potential that is 23 times higher than that of CO_2 over a 100-year timescale (Ramaswamy, Boucher et al. 2001). Methane is produced in ocean sediment as well as in the water column. Despite of these methane sources only little of the gas actually escapes to the atmosphere. Only 4 – 15 Tg yr^{-1} CH_4 is emitted to the atmosphere from the ocean (Solomon, Qin et al. 2007) contributing only 0.7 – 2.5% to the ~600 Tg CH_4 from all natural and anthropogenic sources. The low nanomolar concentration in the bulk of the ocean is thought to be maintained by microbial activity (Reeburgh 2007).

This effective methane biofilter includes both anaerobic and aerobic microbial methane consumption in sediments and the water column. However, anaerobic oxidation of methane (AOM) only takes place at methane concentrations >0.5 – 5 μmol L^{-1} (Valentine 2011). Below this concentration and in the oxic water column, aerobic methanotrophy controls methane emissions to the atmosphere. The high variability of aerobic methane oxidation rates in the water column, from 0.0001 to 100 nM d^{-1}, indicates that physical, chemical, and biological factor and their interactions modulate aerobic microbial methane oxidation.

In order to understand and predict this process in the future, it is essential to explore methanotrophy in the ocean. A combination of field work and laboratory experiments is planned to investigate the following questions:

1. Is methane oxidation limited in the upper water column by light or increased wind speed? Methane oxidizing bacteria may be light sensitive or their substrate (methane) may be removed too fast by gas-transfer to the atmosphere, especially at high wind speed.
2. Does suspended material in the water enhance microbial methane oxidation?
3. Does microbial methane oxidation depend on the origin of the water mass?
4. How fast can methane-oxidizing bacteria increase their activity and/or abundance to significantly reduce methane plumes? Methanotrophs are a very diverse group and although cultured bacteria of the low affinity methanotrophs are available, in situ community maximum uptake rates and half saturation constants are hardly known.

Work at sea

In order to answer the above questions, work at sea will include collecting different data sets, kinetic and inhibition experiments. Samples for methane concentrations, methane oxidation rates, and carbon isotopic ratios will be collected throughout the water column in the working area using the rosette sampler. Salinity, temperature, and oxygen concentrations will be measured using sensors of the CTD-unit. Furthermore, wind and current data, which are commonly recorded on board, will be available for data correlation. Freshly sampled microbial communities will be used to derive maximum uptake rates and half saturation constants. For this, methane-oxidizing communities will be incubated with different tracer concentrations and their methane oxidation rate will be measured. Furthermore, water samples will be incubated with light, without light, and with light-dark cycle as well as with and without sediment (which will be collected nearby) to investigate if these two factors significantly alter methane oxidation rates. After each experiment methane concentration and methane oxidation rates will be measured.

Methane concentration analyses will be performed with a gas chromatograph (GC) equipped with a flame ionization detector. These measurements will be performed at sea by collecting water samples immediately taken from the Niskin bottles and extracting the dissolved gas from the water by sampling with a pre-evacuated 1600 ml sample bottle. This method is a modification (Rehder, Keir et al. 1999) of the vacuum degassing method described by Lammers and Suess (1994). This method requires knowledge of dissolved O_2 concentration, which will be determined by an O_2 sensor attached to the CTD-unit. After GC analyses the remainder of the gas will be transferred into evacuated glass containers for analysis of the carbon isotopic signature on shore. Methane concentrations after experiments need to be quantified differently by introducing a 10 ml headspace consisting of ultra-high purity N_2 into the 160 ml sample. After vigorously shaking and equilibration for at least 24 h, the headspace can be analyzed by GC.

Methane oxidation rate measurements using radiotracers will be performed as described in Valentine et al. (2001) and Treude et al. (2003). $[^{14}C]$-CH_4 or $[^{3}H]$-CH_4 is added to the sample bottles by syringe whereupon displaced water can pass off through an additional needle. The bottles are shaken to equilibrate the tracer with the liquid phase. Then, the sample bottles are incubated for several hours in the dark near *in-situ* temperatures. At the end of an incubation period, the uptake of CH_4 is either stopped by addition of an inhibitor or, in case of the $[^{3}H]$-CH_4 tracer, the residual $[^{3}H]$-CH_4 can be removed by purging with N_2-gas. This leaves the oxidation product ($[^{3}H]$-H_2O) behind. The $[^{14}C]$-CO_2 produced is trapped by addition of NaOH and can be recovered by acidifying the sample. Label incorporated into cell carbon can be extracted by filtering the acidified sample. The recovered oxidation products are combined with a scintillation cocktail. The light that is produced from the excitation of the cocktail by the radioactivity of the sample is detected and converted to amplified electrical pulses by a photomultiplier tube. The Liquid Scintillation Counter (LSC) necessary to measure the radioactivity is on board.

Data management

The acquired data will be published in peer-reviewed publications. Long-term archiving of the data will be assured through Pangaea database at WDC Mare.

References

Lammers, S. and E. Suess (1994). "An improved head-space analysis method for methane in seawater." Mar. Chem. 47: 115-125.

Ramaswamy, V., O. Boucher, et al. (2001). Radiative Forcing of Climate Change. Climate Change 2001: The Scientific Basis, Third Assessment Report of the Intergovernmental Panel on Climate Change. J. Houghton, T. , Y. Ding, D. Griggs, J. et al. Cambridge, Cambridge University Press: 349-416.

Reeburgh, W. S. (2007). "Oceanic Methane Biogeochemistry." Chem. Rev. 107: 486-513.

Rehder, G., R. S. Keir, et al. (1999). "Methane in the Northern Atlantic controlled by microbial oxidation and atmospheric history." Geophys. Res. Lett. 26(5): 587-590.

Solomon, S., D. Qin, et al. (2007). IPCC Fourth Assessment Report (AR4) Climate Change 2007: The physical Science Basis. Cambridge, United Kingtom, Cambridge University Press.

Treude, T., A. Boetius, et al. (2003). "Anaerobic oxidation of methane above gas hydrates at Hydrate Ridge, NE Pacific Ocean." Mar. Ecol-Prog. Ser. 264: 1-14.
Valentine, D. L. (2011). "Emerging topics in marine methane biogeochemistry." Annu. Rev. Mar. Sci., doi: 10.1146/annurev-marine-120709-142734.
Valentine, D. L., D. C. Blanton, et al. (2001). "Water column methane oxidation adjacent to an area of active hydrate dissociation, Eel River Basin." Geochim. Cosmochim. Ac. 65(16): 2633-2640.

5. SCOTIA SEA SEDIMENT SAMPLING

G. Kuhn, T. Ronge, B. Luedke, S. Wiers, O. Meisel, N. Lensch, B. Glueckselig (AWI), A. Graham, W. Dickens, J. Roberts (BAS)

Objectives

Glacial and interglacial changes in the extent of Antarctic ice sheets, their sensitivity to melting by warm ocean currents, their impact on sea level variations and their influence on Antarctic Bottom Water (AABW) formation are at the forefront of marine geoscientific investigations. Marine sediments in the Southern Ocean provide natural archives, documenting glacial/interglacial paleoenvironmental changes.

The flow of the Antarctic Circumpolar Current (ACC), related oceanographic frontal systems and bathymetrically controlled outflow regions of AABW make the Scotia Sea an area of particular interest for surface and bottom water paleoceanographic reconstructions. Near shore on the continental shelf the extent of inland ice caps and glacial-marinesediments deposited after the deglaciation can be mapped by multibeam swath and sub-bottom echo-sounding and high sediment accumulation in some fjords and channels superbly archive more recent glacier behaviour and climate changes.

During cruises ANT-X/5 (Gersonde, 1993), ANT-XI/2 (Gersonde, 1995), ANT-XXII/4 (Schenke & Zenk, 2005) with *Polarstern* in 1992, 1993/94, and 2005, and cruises JR224, JR244 and JR257 with RRS James Clark Ross in 2009, 2011, and 2012, respectively, AWI and BAS collected marine geological and geophysical data sets from the Falkland Plateau, Scotia Sea, and from the South Georgia shelf. Extensive paleo-ice sheet drainage on this shelf was highlighted in a bathymetric compilation by Graham et al. (2008). During this cruise we will complete partially mapped areas and collect additional sediment cores and sediment surface samples for sedimentological, geochemical and micropaleontological work. This work will focus on previously selected sites on the Falkland Plateau, in the Scotia Sea, on the South Georgia shelf, bays and on sites selected from underway survey during the cruise. Our investigations on South Georgia shelf will address glacial changes and the climatic history of the island from the marine perspective, expanding upon the lake and shallow bay (not accessible with *Polarstern*) investigations planned by Martin Melles (s. Chapter 6).

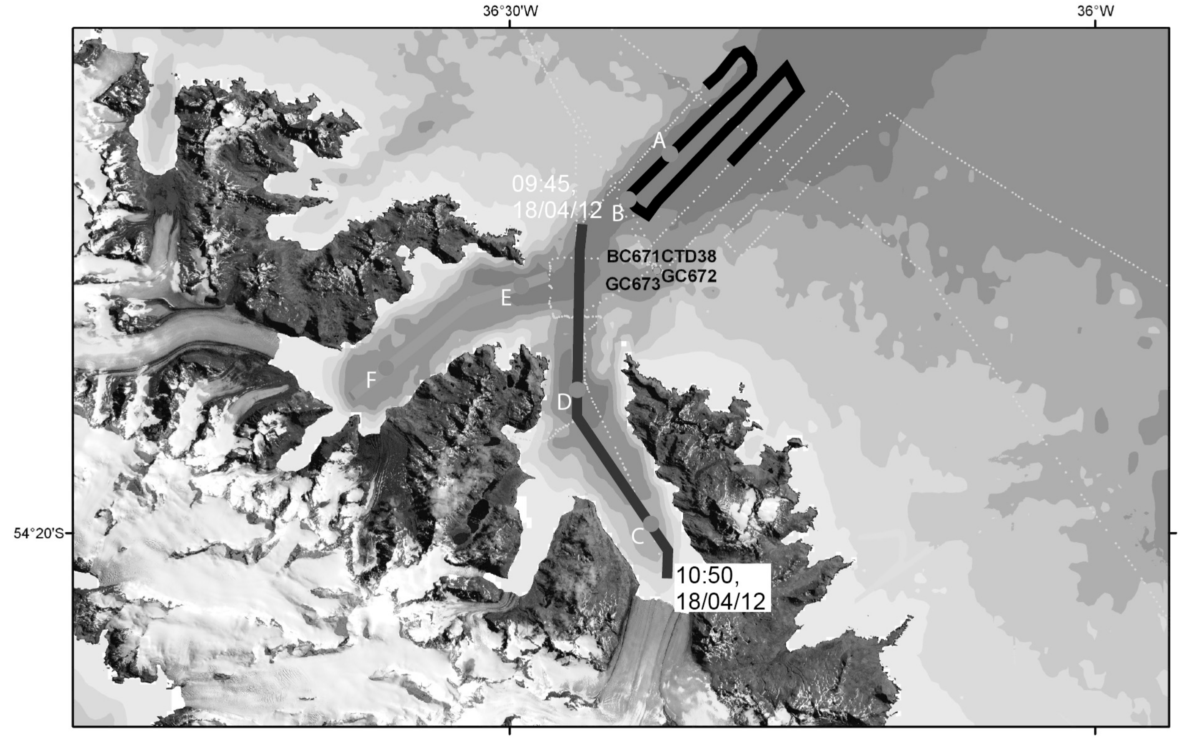

Fig. 5.1: Proposed core location A - F for glacier front sequence: Partly based on the geophysical data taken during Cruises JR244 and JR257 in 2011 and 2012 and partly after the sediments have been investigated by Parasound during the cruise.

Work at sea

The marine geoscience work will concentrate on four targets:

1. the Hydrosweep swath echosounder and Parasound sediment echosounder will add new bathymetric data and sub-bottom profiles for seafloor characterization and site selection,
2. sediment coring on the shelf and bays in South Georgia on pre-selected (see Fig. 5.1) and opportunistic sites (mainly in troughs as indicated in Fig. 5.2 including stations near to and away from glacier fronts to investigate patterns of past glacier change (A. Graham, G. Kuhn and others, with a small grant funded by the UK QRA).
3. sediment coring close to cold seeps and hot vents on the Sandwich Plate to discover temporal variations in activity and sedimentation processes,
4. resampling coring sites to get longer cores or more material for new investigations. Two sites: first on the Falkland Plateau (GC642 53°00.120'S, 58°02.786'W, 585 m water depth, Fig. 5.3, close to Site PS2319) and second East of S-Sandwich Trench (at Site PS2283-7 59°50,5´S, 23°23,0´W, 4813 m water depth).

Sediment surface samples will be taken in addition to longer sediment cores by means of a giant box corer (GKG) and with a multiple corer (MUC), depending on sediment composition and hardness. Within these samples the recent signal transfer between environmental parameter and sedimentary record will be studied. In this respect, analyses on trace metal (Mg/Ca, U/Ca, B/Ca) ratios recorded in tests of foraminifers to estimate calcification temperatures, salinity variations, carbonate ion saturation, pH and alkalinity became common methods and will be a study aspect of J. Wollenburg (AWI). However, for the Southern

Ocean deep-sea benthic foraminifera calibration curves constrained by culture experiments are lacking. During this expedition we will retrieve 2 - 3 MUCs from 1,500 m water depth and transfer the retrieved sediments cores into a cold laboratory running at a site-alike bottom water temperature during the cruise. During the final day onboard the sediments and overlying water will be transferred into transfer-cores and storage systems. These storage systems will be transferred into special cold boxes ensuring a site-alike temperature during the flight to Bremerhaven. In Bremerhaven the sediments willbe transferred immediately into the respective aquaria and connected to respective supportive sea-water systems. These aquaria will in different experimental set-ups be used to cultivate our most trusted paleodeep-water recorders at different temperatures and in waters with different carbonate chemistries to establish species-specific trace metal calibration curves for the Antarctic Ocean.

Two of the MUC cores will be sampled in 1 cm steps and frozen for silicon isotope studies on the biogenic silica components and as paleoceanographic reference material. Water column samples by CTD-rosette water samplers and plankton samples by a multiple plankton net will be taken on a south-north depth profile for silicon isotope ratios in the water and plankton profiles (A. Abelmann, AWI).

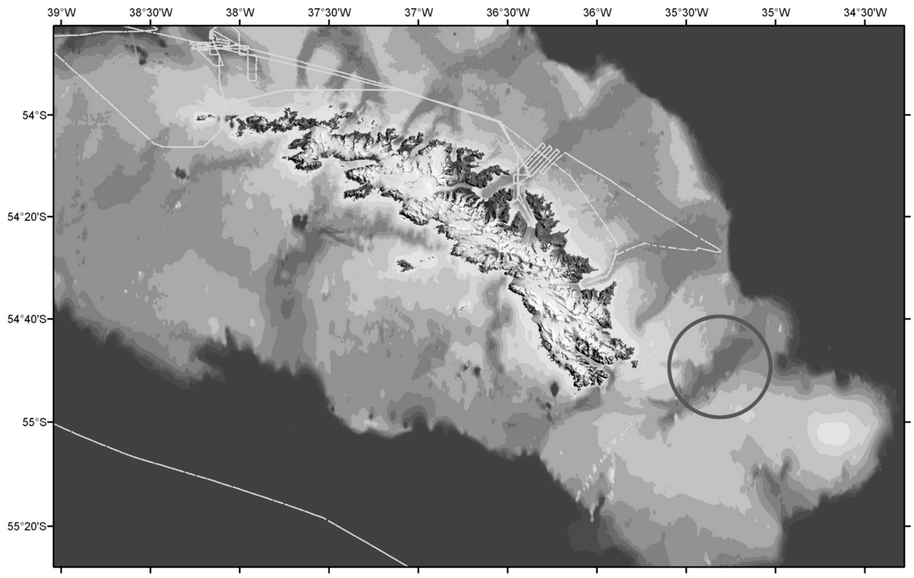

Fig. 5.2: Track lines from Cruises JR 244 and JR 257 in 2011 and 2012. During the Polarstern cruise the area of circle is a potential area for 2 - 4 sediment cores after the sediments have been investigated by sediment echo-soundings.

Data management

Meta-Data from all stations, and data from bathymetric and sub-bottom echo-sounding profiles will be stored in digital form and after the cruise transferred to the Pangaea data base.

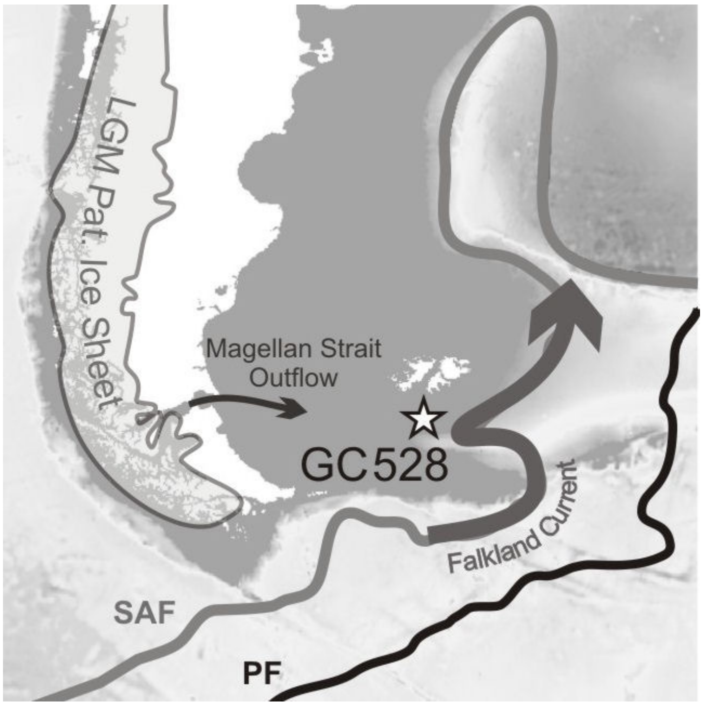

Fig. 5.3: Coring station on the southern Falkland Plateau

References

Gersonde, R. (1993). Die Expedition ANTARKTIS X/5 mit FS "Polarstern" 1992 = The expedition ANTARKTIS X/5 of RV "Polarstern" in 1992, Berichte zur Polarforschung (Reports on Polar Research), Bremerhaven, Alfred Wegener Institute for Polar and Marine Research, 131, 167 p. hdl:10013/epic.10132

Gersonde, R. (1995). Die Expedition ANTARKTIS-XI/2 mit FS "Polarstern" 1993/94 = The expedition ANTARKTIS-XI/2 of RV "Polarstern" 1993/94, Berichte zur Polarforschung (Reports on Polar Research), Bremerhaven, Alfred Wegener Institute for Polar and Marine Research, 163 , 133 p. hdl:10013/epic.10164

Graham, A. G. C., P. T. Fretwell, et al. (2008). "A new bathymetric compilation highlighting extensive paleo-ice sheet drainage on the continental shelf, South Georgia, sub-Antarctica." Geochem. Geophys. Geosyst. 9(7): Q07011, 21 pages, doi:10.1029/2008GC001993.

Schenke, H. W. and Zenk, W. (2006). The Expeditions ANTARKTIS-XXII/4 and ANTARKTIS-XXII/5 of the Research Vessel "Polarstern" in 2005, Berichte zur Polar- und Meeresforschung (Reports on Polar and Marine Research), Bremerhaven, Alfred Wegener Institute for Polar and Marine Research, 537 , 133 p. hdl:10013/epic.10542

6. HOLOCENE AND PLEISTOCENE ENVIRONMENTAL HISTORY OF SOUTH GEORGIA

M. Melles, F. Viehberg, B. Ritter (Uni Köln), O. Bennike (GEUS), M. Leng (BGS), D. White (Uni Canberra), M. Leng (BGS)

Objectives

Because of its location in the Southern Ocean, the island of South Georgia is superbly situated to study the climatic connections between temperate and polar environments in the Southern Hemisphere (Rosqvist et al. 1999). Lake sediments from different locations on South Georgia provided valuable information on the local environmental history back to the late Pleistocene. The radiocarbon dates from the existing sediment records suggest that some parts of the island were ice-free over the last ca. 10 ka BP (Birnie 1990, Rosqvist &

Schuber 2003), and probably even longer (Rosqvist et al., 1999). This is supported by radiocarbon dating on peat sequences (Van der Putten et al., 2004, 2009; Van der Putten & Verbruggen 2005). Although there exist already a number of records, which provide valuable information on climatic and environmental changes, the overall picture of deglaciation and of Holocene environmental change is not consistent (see QSR correspondence 2007, Quaternary Science Reviews 26, 2684-2691). The inconsistent picture could be due to local effects, but also due to dating uncertainties, or different dating methods, such as cosmogenic nuclide dating (Bentley et al. 2007).

A better understanding of the deglaciation and environmental history of South Georgia and a distinction of local and regional signals would be needed to improve the understanding of teleconnections between the Antarctic continent and South America and link this information to marine geological information from the Southern Ocean (e.g. Hodell et al. 2000). For this purpose, we plan to conduct fieldwork on South Georgia, which combines marine and lacustrine sedimentological work with geomorphological studies and sampling for cosmogenic dating. New methods, focusing on stable isotopes (e.g. Berg et al. in press) will help to better interpret sedimentological and geochemical datasets obtained from the studies of the sediment sequences to be recovered. Sampling for cosmogenic dating shall be carried out along altitudinal transects, as also the lakes to be investigated will be located at different altitudes. The combination of all information will allow a better understanding of the deglaciation history, of regional environmental changes and of the relative sea-level history.

The proposed project is part of an international collaboration with the GEUS (Denmark), the BGS and NERC (UK), and the University of Canberra (Australia), and is closely related to the marine geological investigation by Kuhn et al. (Chapter 5).

Field work

The planned field work shall concentrate on north-eastern South Georgia, in the vicinity of the Cumberland East Bay, where the King Edward Point Research Station (British Antarctic Survey, BAS) is located (Fig. 6.1).

The field work shall be carried out by a team of 4 sediment drillers and 2 geomorphologists and comprises ca. 14-16 days. This will allow paleolimnological and geomorphological work simultaneously and carrying relatively heavy equipment parts from site to site. We plan to establish a base camp at the shore of Little Jason Lagoon in Cumberland West Bay (Fig. 6.1). Little Jason Lagoon offers a small natural harbour at its eastern side for a rubber boat and a floating platform, which will be used for embarkment and disembarkment to and from RV "*Polarstern*". The field work will start with a bathymetric survey of the ca. 40 m deep Little Jason Lagoon. Based on the results of this survey, sediment sequences of up to 20 m length will be recovered from 1-2 selected sites in this basin using UWITEC coring technology. Simultaneously to the field work at the Little Jason Lagoon, 2 team members will carry out work onshore based on day trips from the base camp. The onshore work includes sampling of macrofossils from marine terraces and beaches and sampling for cosmogenic dating, as well as a pre-site survey of lakes at different altitudes on the peninsula north of Little Jason Lagoon. Based on the results of those pre-site surveys, 4-5 lakes will be selected for lake sediment coring. These lakes will be cored using a small transportable platform and a Russian peat corer, allowing recovery of up to 8 m long sediment sequences from up to 15 m deep basins. The geomorphological work will continue during this period.

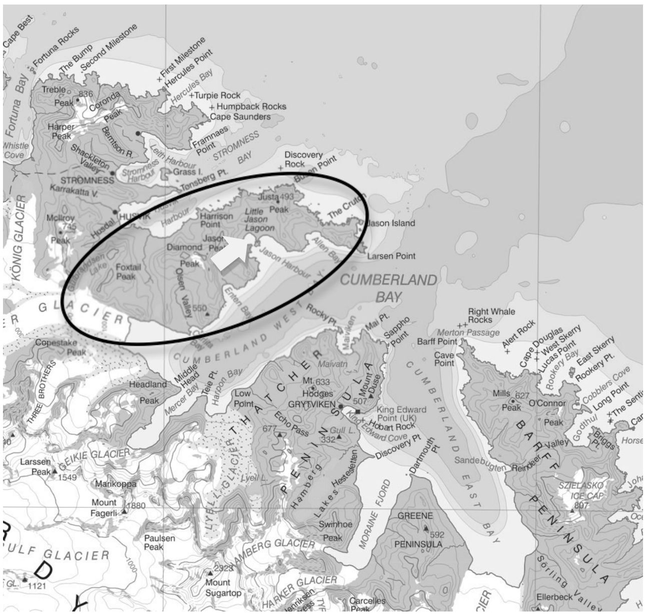

Fig. 6.1: Map of Cumberland Bay, South Georgia (modified from British Antarctic Survey 2004). The King Edward Point Station (BAS) is located in Cumberland East Bay. The preferred site for field work concentrates on Little Jason Lagoon (arrow) and the peninsula to the north of this lagoon (circle). The length of the circle is ca. 15 km and indicates the range of day trips from the base camp at Jason Lagoon.

Data management

All data related to sampling locations and to the scientific outcome of the studies on the sediment sequences and from cosmogenic and macrofossil dating will be provided to the PANGAEA database.

References

Bentley, M.J., Evans, D.J.A., Fogwill, C.J., Hansom, J.D., Sugden, D.E., Kubik, P.W. (2007) Glacial geomorphology and chronology of deglaciation, South Georgia, sub-Antarctic. Quaternary Science Reviews 26, 644–677.

Berg, S., Leng, M., Kendrick, C.P., Cremer, H., Wagner, B. (in press): Bulk sediment and diatom silica carbon isotope composition from coastal marine sediments off East Antarctica. Silicon.

Birnie, J. (1990) Holocne environmental change in South Georgia: evidence from lake sediments. Journal of Quaternary Science 5, 171-187.

Hodell, D.A., Shemesh, A., Kanfoush, S., Crosta, X., Charles, C.D., Guilderson, T. (2000) Abrupt cooling of Antarctic surface waters and sea ice expansion in the South Atlantic sector of the Southern Ocean at 5000 cal yr BP. Quatern. Res., 56, 191–198.

Rosqvist, G.C., Schuber, P. (2003) Millenial-scale climate changes on South Georgia, Southern Ocean. Quaternary Research 59, 470–475.

Rosqvist, G.C., Rietti-Shati, M., Shemesh, A. (1999) Lateglacial to middle Holocene climatic record of lacustrine biogenic silica oxygen isotopes from a Southern Ocean Island. Geology 27 (11), 967–970.

Van der Putten, N., Verbruggen, C. (2005) The onset of deglaciation of Cumberland Bay and Stromness Bay, South Georgia. Antarctic Science 17 (1), 29–32.

Van der Putten, N., Stieperaere, H., Verbruggen, C., Ochyra, R. (2004) Holocene palaeoecology and climate history of South Georgia (sub-Antarctic) based on a macrofossil record of bryophytes and seeds. The Holocene 14 (3), 382–392.

Van der Putten, N., Verbruggen, C., Ochyra, R., de Beaulieu, J.-L., De Dapper, M., Hus, J., Thouveny, N. (2009) Peat bank growth, Holocene palaeoecology and climate history of South Georgia (sub-Antarctica), based on a botanical macrofossil record. Quaternary Science Reviews 28, 65-79.

7. HIGHER TROPHIC LEVELS: AT-SEA DISTRIBUTION OF SEABIRDS AND MARINE MAMMALS

R.-M. Lafontaine, R. Beudels, G. Driessens, G. Nijs, H. Robert (PolE), not on board: C.L. Joiris

Background and objectives

In the frame of our long-term study of the quantitative distribution at sea of seabirds and marine mammals in polar marine ecosystems, the main aims are, on the one hand, to deepen the mechanisms influencing their distribution (water masses, fronts, pack ice, ice edge and eddies) and on the other hand to try and detect spatial and temporal evolutions with special attention to possible consequences of global climatic changes. As upper trophic levels their distribution reflects prey abundance: zooplankton, krill, nekton, and small fish and thus integrates the ecology and the biological production of the whole water column. They constitute thus the best approach to identify and localize areas of high biological production, and to detect temporal changes.

In the Antarctic, biological studies mainly concern the Weddell Sea and the Ross Sea, and to a lesser extent Amundsen and Bellingshausen seas. So that the area covered by this *Polarstern* expedition, a poorly studied one for the upper trophic levels, deserves special attention. Particularly taking into account the presence of a major feeding ground for fin whales, southern fulmars and grey-headed albatrosses around the South Shetland Islands.

Work at sea

Birds and mammals will be recorded by transect counts from the bridge, without width limitation. Animals are detected with the naked eye, observations being confirmed and detailed with binocular and/ or telescope. Each count lasts 30 minutes - an adaptation to poor ecosystems – with a 90° angle in front of *Polarstern*. Counting will be continuous during all movements (transects) of the ship, visibility conditions allowing. Complementary simultaneous counts will be realized when possible from the crow's nest and helicopter flights following the same route, in order to allow comparison between data obtained from different observation platforms.

Data management

The main topic in the utilization of results will concern water masses, fronts and eddies; when possible, prey abundance will be evaluated from echo-sounder figures.
Results will be included in our PolE data base, made accessible to any colleague interested in collaboration (crjoiris@gmail.com), and published within one year after the expedition in an international journal.

References

Joiris C.R. and Dochy O. (submitted) A major feeding ground for fin whales, southern fulmars and grey-headed albatrosses arount the South Shetland Islands, Antarctica. *Polar Biol.*

Joiris C.R. (2000) Summer at-sea distribution of seabirds and marine mammals in polar ecosystems: a comparison between the European Arctic seas and the Weddell Sea, Antarctica. *J. Mar. Syst.* 27: 267-276.

Joiris, C.R., (1991) Spring distribution and ecological role of seabirds and marine mammals in the Weddell Sea, Antarctica. *Polar Biol.* 11:415–424.

8. TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTIONS

Institut/Institute	Adresse / Address
AWI	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung Postfach 120161 27515 Bremerhaven / Germany
BAS/NERC	British Antarctic Survey Natural Environmental Research Council Madingley Road, High Cross Cambridge Cambridgeshire CB3 0ET / United Kingdom
BGS/NERC	British Geological Survey Natural Environmental Research Council Nicker Hill Keyworth Nottingham, NG12 5GG / United Kingdom
DWD	Deutscher Wetterdienst Geschäftsbereich Wettervorhersage Seeschifffahrtsberatung Bernhard-Nocht-Str. 76 20359 Hamburg / Germany
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MARUM	Zentrum für marine Umweltwissenschaften Universität Bremen Leobener Str., MARUM 28334 Bremen / Germany
OSU	Ocean Ecology and Biogeochemistry Oregon State University 104 CEOAS Administration Building Corvallis, OR 97331-5503 / USA

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Visual Drugstore	Visual Drugstore GmbH Gysslingstr. 72 80805 München / Germany
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9. FAHRTTEILNEHMER / CRUISE PARTICIPANTS

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Bennike	Ole	GEUS	Fieldwork, South Georgia
Beudels	Roseline	PolE	Biologist
Bohrmann	Gerhard	MARUM	Chief Scientist
Dickens	William	BAS, NERC	Geologist
Driessens	Gerald	PolE	Biologist
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Ferreira	Christian	MARUM	Technician, bathymetry
Fischer	David	AWI	Geochemist
Freksa	Christian	Uni Bremen	Computer scientist
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Gepraegs	Patrizia	MARUM	PhD Student, chemistry
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Kasten	Sabine	AWI	Geochemist
Kern	Markos	Visual Drugstore	Media/NG, Web-Log
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Lindner	Roland	Heliservice Intl.	Pilot
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Little	Crispin	Uni Leeds	Biologist
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Neuhoff	Holger, von	IMMH	Media/NG, Web-Log
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Roberts	Jenny	BAS	Biologist
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Ronge	Thomas	AWI	Geologist
Sonnabend	Hartmut	DWD	Meteorologist
Stoltmann	Tim	MARUM	Student, geosciences
Torres	Marta	OSU	Geochemist
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Wei	Jiangong	MARUM	Geologist

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession
White	Duanne	Uni Canberra	Fieldwork South Georgia
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Wintersteller	Paul	MARUM	Geologist
Wu	Tingting	MARUM	Geophysicist

10. SCHIFFSBESATZUNG / SHIP'S CREW

Name	Rank
Schwarze, Stefan	Master
Grundmann, Uwe	1.0ffc.
Farysch, Bernd	Ch. Eng.
Fallei, Holger	2. Offc.
Langhinrichs, Moritz	2.0ffc.
Peine, Lutz	3.0ffc.
Pohl, Claus	Doctor
Hecht, Andreas	R.Offc.
Grafe, Jens	2.Eng.
Minzlaff, Hans-Ulrich	2.Eng
Holst, Wolfgang	3.Eng
Scholz, Manfred	Elec.Tech.
Riess, Felix	Electron.
Hüttebräucker, Olaf	Electron.
Nasis, Ilias	Electron.
Himmel, Frank	Electron.
Loidl, Reiner	Boatsw.
Reise, Lutz	Carpenter
Scheel, Sebastian	A.B
Brickmann, Peter	A.B
Winkler, Michael	A.B
Hagemann, Manfred	A.B
Schmidt, Uwe	A.B
NN	A.B
Wende, Uwe	A.B
Bäcker, Andreas	A.B
Preußner, Jörg	Storek.
Teichert, Uwe	Mot-man
Schütt, Norbert	Mot-man
Eisner, Klaus	Mot-man
Voy, Bernd	Mot-man
Pinske,- Lutz	Mot-man
Müller-Homburg, Ralf-Dieter	Cook
Silinski, Frank	Cooksmate
Martens, Michael	Cooksmate
Czyborra, Bärbel	1.Stwdess
Wöckener, Martina	Stwdss/KS
Gaude, Hans-Jürgen	2.Steward
Silinski, Carmen	2.Steward
Arendt, Rene	2.Steward
Möller, Wolfgang	2.Steward
Sun, Yong Shen	2.Steward
Yu, Kwok Yuen	Laundrym.

ANT-XXIX/5

18 April - 29 May 2013

Port Stanley - Cape Town

Chief scientist
Wilfried Jokat

Coordinator
Rainer Knust

CONTENTS

1. ÜBERBLICK UND FAHRTVERLAUF

Wilfried Jokat (AWI)

Die *Polarstern* Expedition ANT-XXIX/5 wird am 18. April 2013 in Port Stanley (Falkland Inseln) beginnen und am 29. Mai 2013 in Kapstadt enden. Die wissenschaftlichen Programme zielen darauf, neue geophysikalische Kenntnisse über die geologische Entwicklung des Falkland Plateaus zu gewinnen. Das geophysikalische Programm konzentriert sich auf die Erhebung eines tiefenseismischen Profils, das an der Ostküste der Falkland Inseln beginnt und auf der Maurice Ewing Bank endet. Die Gesamtlänge des Profils beträgt mehr als 1500 km. Insgesamt sollen an 80 Positionen Ozeanbodenseismometer aufgestellt werden, um die Luftpulser Signale aufzuzeichnen, die auf *Polarstern* generiert werden. Zusätzlich sollen Schweredaten sowie mit den beiden Bordhelikopter Magnetikdaten entlang des tiefenseismischen Profils erhoben werden. Biologische Multinetzstationen, die darauf abzielen die oberen 300 m der Wassersäule zu beproben, werden sowohl entlang dieses Profils aber auch auf dem Transit nach Kapstadt durchgeführt. Diese beiden Projekte werden durch ein atmosphärisch/astrophysikalisches Projekt mit fest installierten Beobachtungsgeräten auf *Polarstern* sowie durch ein Vogel/Walbeobachtungsprogramm vervollständigt.

SUMMARY AND ITINERARY

The *Polarstern* expedition ANT-XXIX/5 will start at April 18th, 2013 in Port Stanley (Falkland Islands), and terminates on May 29th, 2013 in Cape Town (Rep. South Africa). The scientific programmes aim to retrieve new geophysical information on the geological evolution of the Falkland Plateau. The activities concentrate on the acquisition of a deep seismic profile starting close to the coast of the Falkland islands and terminating east of the Maurice Ewing Bank. The line has a length of more than 1,500 km, and we will use up to 80 oceanbottom seismometers to record the airgun shots generated on *Polarstern*. In addition, we will try to gather detailed aeromagnetic data with the two available helicopters as well as gravity data. Along this geophysical transect several biological multinet stations investigating the upper 300 m of the water column as well as using hand nets and the on board seawater supply system will try to retrieve information about diatom species in the research area. Few biological stations are planned along the final transit to Cape Town. These two programmes are supplemented by an atmospheric/astrophysical project with fixed installed instrument and a bird/mammal watching project.

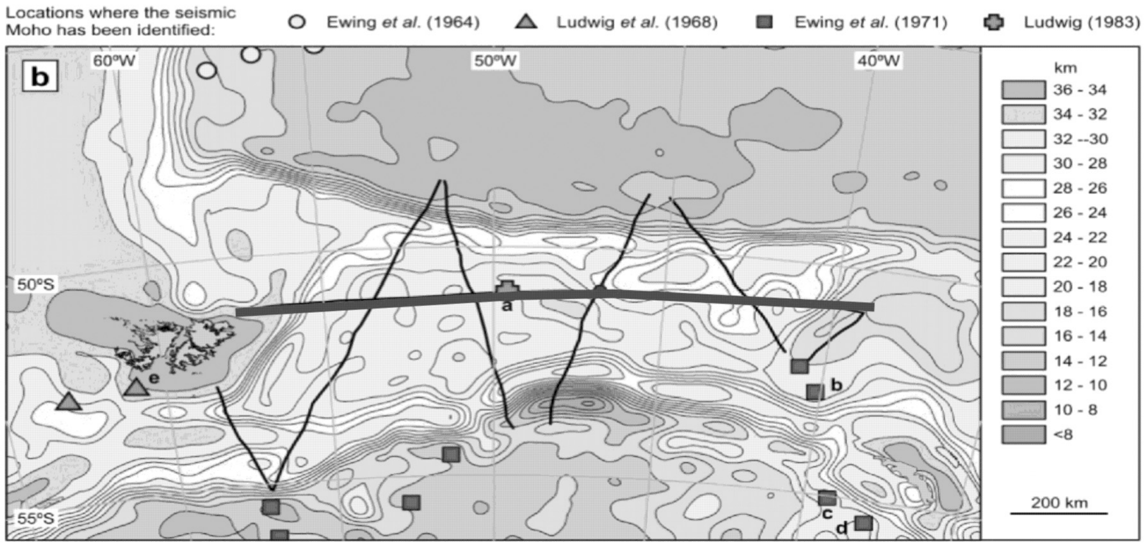

Fig. 1.1: Shows the research area. The black lines represent existing seismic profiles, the colored rectangles/triangles indicate the locations, where sonobuoy measurements are available to provide constraints on the crustal thickness in the area. The red line is the planned crustal thickness along which up to 80 oceanbottom seismometers will be deployed. The background colors indicate the crustal thickness of the research region as estimated from gravity modeling.

2. CRUSTAL STRUCTURE OF THE FALKLAND PLATEAU

W. Jokat (AWI), T. Altenbernd, J. Catellino, B. Dorschel, M. Fink (GEOMAR), S. Franke (AWI), T. Fromm, L. Gassner, A. Hegewald, H. Kirk, N. Lensch, G. Lüttschwager, D. Penshorn, A. Schlömer, B. Schmitz, P. Slabon, E. Wiles (AWI)

Objectives

The Falkland Plateau is today more than 1,500 km long, and stretches from the Falkland Islands eastwards to the Georgia Basin. Some 170 Ma as part of the Gondwana supercontinent the plateau had a different shape according to geodynamic models. The E-W extension was smaller, and the islands were located off eastern Africa. From the current geoscientific data base only rough estimates can be made about the amount of stretching, which the Falkland Plateau underwent during the rifting and break-up of Gondwana. One of the most important parameter for any enhanced geodynamic model is the crustal thickness and structure along the entire plateau. Thus, we intend to gather a more than 1,500 km long seismic refraction line by using 40 ocean-bottom seismometers, which will be deployed twice. Helicopter borne magnetic data will be gathered along the line to identify especially in the Georgia Basin marine seafloor spreading anomalies in greater detail. We like to use ocean bottom seismometers twice and airguns to conduct this active experiment, and, thus, test the existing models. The following results are expected:

- What is the nature of the crust between the Falkland Islands and the Maurice Ewing Band (MEB)?
- If the crust in between is oceanic, how does the continent-ocean transition look like?

- Are there any evidences for a HVLB underneath the plateau? This would indicate the presence of much more volcanic material in the region than previously known.
- How does the transition from the MEB to the oceanic Georgia Basin look like? Is the MEB a volcanic structure or extended continental crust?
- What kind of ß factor (stretching) can be calculated to constrain the maximum extension of the plateau?
- Are the seafloor spreading anomalies symmetric to the conjugate Natal Basin? Which age model is supported by the new magnetic investigations?

The new data will provide a reliable crustal model for the Falkland Plateau, and will put strong constraints on any future geodynamic interpretation in this area.

Work at sea

The proposal intends to investigate the crustal structure of the Falkland Plateau and parts of the Georgia Basin with an active seismic experiment. To achieve the scientific objectives the following experiments are planned:

- Seismic refraction investigations along a 1,500 km long line in the strike of the Falkland Plateau. In total 40 ocean bottom seismometers will be used deployed two times. The seismic source will be a middle sized airgun array (8) of 64 l total volume. The shooting interval will be 60 - 90 s depending on the water depths. Landstations onshore the Falkland Islands are planned to record the seismic signals at greater distances.

- Detailed magnetic investigation along the seismic transect with the onboard helicopters and the Helimag system.
- Gravimeter measurements with the onboard KSS31 system

3. MOLECULAR TAXONOMY AND BIOGEOGRAPHY OF SOUTHERN OCEAN PLANKTONIC DIATOMS

B. Beszteri, S. Pinkernell, F. Hinz (AWI)

Objectives

Diatoms are the dominant group of primary producers in the Southern Ocean, playing a substantial role in sustaining pelagic food webs, in exporting organic material from the surface layers to the sediments and in regulating the deep sea-atmosphere CO_2 exchange. We are studying the geographic distribution of individual diatom species and its expected changes caused by climate change using classical (microscopic) taxon observations as well as molecular surveys combined with species distribution modeling. In order to be able to combine information from microscopic and molecular surveys, the availability of reference information, linking morphology to molecular marker sequences, is essential. A main aim of our project is to isolate clonal cultures of a wide range of Antarctic and Subantarctic diatom species for such an integrative taxonomic characterization. The data collected will be part of a publicly available taxonomic information system on Southern Ocean diatoms which we are currently constructing based on the EDIT Platform for Cybertaxonomy. A second aim of our project is to isolate cultures of *Fragilariopsis kerguelensis*, the dominant diatom species of the Antarctic-Subantarctic region, and its congeners, for an in-depth characterization of the amount and patterns of genetic variation harbored by these species. This is an important determinant of the short term evolutionary potential of a species, and thus a parameter of high relevance for assessing potential consequences of environmental change.

Work at sea

Samples will be collected using multinet tows at discrete depths in the upper 300 m of the water column, as well as using hand nets and the on board seawater supply system. Fresh samples will be observed and diatom species occurring in them documented using microphotography with a ZEISS AxioVert 40 microscope and an AxioCam digital camera. Single diatom cells / colonies will be isolated using Pasteur pipettes and a mouthpiece and with small volume automatic pipettes, washed, and transferred into sterile F/2 growth medium. Cultures will be observed for growth and transferred to the home laboratory for further characterization.

4. INSTALLATION AND DATA ACQUISITION OF A COMBINED NEUTRON MONITOR AND MUON TELESCOPE ON BOARD OF *POLARSTERN* AND *NEUMAYER* STATION

NN, M. Walter (DESY, not on board), B. Heber, (CAU, not on board)

Objectives

Galactic cosmic rays are high-energy charged particles, mainly protons, doubly ionized helium, and other fully ionized nuclei originating in the galaxy and bombarding the Earth from all directions. They are a direct sample of material from far beyond the solar system. Measurements by various particle detectors have shown that the intensity varies on different time scales, caused by the Sun's activity and geomagnetic variation. The role of Interplanetary Coronal Mass Ejections (ICMEs) in causing Forbush decreases, and Corotating Interaction Regions causing recurrent decreases in the GCR intensity observed at Earth, has been well established since the last twenty years. However, these interplanetary disturbances cause space weather effects, which warrant a more detailed study. Most of the research on GCR intensity variations is based on the analysis of ground-based neutron monitors and muon telescopes. Their measurements as explained in what follows depend on the geomagnetic position, and the processes in the Earth's atmosphere. Beside the modulation of cosmic rays in the heliosphere there are two possible lines of defense: while the atmosphere shields life against cosmic radiation uniformly, the Earth magnetosphere acts as a rigidity filter. Before the primary particles can enter the atmosphere they are subject to the deviations in the magnetic field in the vicinity of the Earth, and as a consequence the intensity of charged particles on top of the atmosphere is reduced with respect to interplanetary space. To estimate this shielding effect of the magnetic field it is helpful to characterize particles by their magnetic rigidity R rather than their energy as the impact of the Lorentz force on a charged particle is related to the former quantity. In order to get a better understanding of atmospheric and the geomagnetic filter over the solar cycle, the Christian-Albrechts-Universität (Kiel), Desy (Zeuthen), and the North-West University in Potchefstroom (South Africa) agree on a regular monitoring of the GCR intensity as a function of latitude, by developing a portable device, which is planned to be installed on a research ship. The vessel of choice is the German research vessel the *Polarstern*, because it covers extensive geomagnetic latitudes (i.e. goes from the Arctic to the Antarctic) at least one per year and is thus ideally suited for the research campaign.

Work at sea

Data will be acquired with a mobile, lightweight Neutron Monitor on *Polarstern*, which will be able to continue to measure the cosmic-ray yield function in the atmosphere. This is unique chance for galactic cosmic ray investigation since the University of Delaware experiment has been stopped. The reason for this is the decommissioning of the US Coast Guard fleet. Furthermore, a Muon telescope installed on the Polarstern will gather continuously data. This would allow comparing both measurement results for cross calibrations and would give a higher confidence of the results.

5. HIGHER TROPHIC LEVELS: AT-SEA DISTRIBUTION OF SEABIRDS AND MARINE MAMMALS

R.-M. Lafontaine, R. Beudels, G. Driessens, G. Nijs, H. Robert (PolE), not on board: C.L. Joiris

Background and objectives

In the frame of our long-term study of the quantitative distribution at sea of seabirds and marine mammals in polar marine ecosystems, the main aims are, on the one hand, to deepen the mechanisms influencing their distribution (water masses, fronts, pack ice, ice edge and eddies) and on the other hand to try and detect spatial and temporal evolutions with special attention to possible consequences of global climatic changes. As upper trophic levels their distribution reflects prey abundance: zooplankton, krill, nekton, and small fish and thus integrates the ecology and the biological production of the whole water column. They constitute thus the best approach to identify and localize areas of high biological production, and to detect temporal changes.

In the Antarctic, biological studies mainly concern the Weddell Sea and the Ross Sea, and to a lesser extent Amundsen and Bellingshausen seas. So that the area covered by this *Polarstern* expedition, a poorly studied one for the upper trophic levels, deserves special attention. Particularly taking into account the presence of a major feeding ground for fin whales, southern fulmars and grey-headed albatrosses around the South Shetland Islands.

Work at sea

Birds and mammals will be recorded by transect counts from the bridge, without width limitation. Animals are detected with the naked eye, observations being confirmed and detailed with binocular and/ or telescope. Each count lasts 30 minutes - an adaptation to poor ecosystems – with a 90° angle in front of *Polarstern*. Counting will be continuous during all movements (transects) of the ship, visibility conditions allowing. Complementary simultaneous counts will be realized when possible from the crow’s nest and helicopter flights following the same route, in order to allow comparison between data obtained from different observation platforms.

Data management

The main topic in the utilization of results will concern water masses, fronts and eddies; when possible, prey abundance will be evaluated from echo-sounder figures.
Results will be included in our PolE data base, made accessible to any colleague interested in collaboration (crjoiris@gmail.com), and published within one year after the expedition in an international journal.

References

Joiris C.R. and Dochy O. (submitted) A major feeding ground for fin whales, southern fulmars and grey-headed albatrosses arount the South Shetland Islands, Antarctica. *Polar Biol.*

Joiris C.R. (2000) Summer at-sea distribution of seabirds and marine mammals in polar ecosystems: a comparison between the European Arctic seas and the Weddell Sea, Antarctica. *J. Mar. Syst.* 27: 267-276.

Joiris, C.R., (1991) Spring distribution and ecological role of seabirds and marine mammals in the Weddell Sea, Antarctica. *Polar Biol.* 11:415–424.

5. TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTIONS

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6. FAHRTTEILNEHMER / CRUISE PARTICIPANTS

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Castelino	Jude	AWI	Geophysicist
Dorschel	Boris	AWI	Geologist
Fink	Markus	Geomar	Geophysicist
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Fromm	Tanja	AWI	Geophysicist
Gall	Fabian	Heliservice Int.	Technician
Gassner	Laura	AWI	Student, geophys
Hegewald	Anne	AWI	Geophysicist
Hempelt	Juliane	DWD	Technician
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Wiles	Errol	AWI	Student, geophys
Zepick	Burkhard	Heliservice	Pilot
NN			Bird/Mammal Observer
NN			Bird/Mammal Observer
NN			Bird/Mammal Observer

7. SCHIFFSBESATZUNG / SHIP'S CREW

Name	Rank
Schwarze, Stefan	Master
Grundmann, Uwe	1.Offc.
Farysch, Bernd	Ch. Eng.
Fallei, Holger	2. Offc.
Langhinrichs, Moritz	2.Offc.
Peine, Lutz	3.Offc.
Pohl, Claus	Doctor
Hecht, Andreas	R.Offc.
Grafe, Jens	2.Eng.
Minzlaff, Hans-Ulrich	2.Eng
Holst, Wolfgang	3.Eng
Scholz, Manfred	Elec.Tech.
Riess, Felix	Electron.
Hüttebräucker, Olaf	Electron.
Nasis, Ilias	Electron.
Himmel, Frank	Electron.
Loidl, Reiner	Boatsw.
Reise, Lutz	Carpenter
Scheel, Sebastian	A.B
Brickmann, Peter	A.B
Winkler, Michael	A.B
Hagemann, Manfred	A.B
Schmidt, Uwe	A.B
NN	A.B
Wende, Uwe	A.B
Bäcker, Andreas	A.B
Preußner, Jörg	Storek.
Teichert, Uwe	Mot-man
Schütt, Norbert	Mot-man
Eisner, Klaus	Mot-man
Voy, Bernd	Mot-man
Pinske,- Lutz	Mot-man
Müller-Homburg, Ralf-Dieter	Cook
Silinski, Frank	Cooksmate
Martens, Michael	Cooksmate
Czyborra, Bärbel	1.Stwdess
Wöckener, Martina	Stwdss/KS
Gaude, Hans-Jürgen	2.Steward
Silinski, Carmen	2.Steward
Arendt, Rene	2.Steward
Möller, Wolfgang	2.Steward
Sun, Yong Shen	2.Steward
Yu, Kwok Yuen	Laundrym.

ANT-XXIX/6

8 June 2013 - 12 August 2013

Cape Town – Punta Arenas

Chief Scientist
Peter Lemke

Coordinator
Rainer Knust

Contents

1. ÜBERBLICK UND FAHRTVERLAUF

Peter Lemke (AWI)

Polarstern wird am 8. Juni 2013 in Kapstadt (Südafrika) auslaufen. Auf der interdisziplinär angelegten Forschungsfahrt stehen im winterlichen Weddellmeer (Fig. 1) atmosphärische, ozeanographische, meereisphysikalische, biogeochemische, biologische, luftchemische und akustisch-ökologische Untersuchungen im Mittelpunkt.

Ziel der Expedition: Ein interdisziplinäres Forschungsprogramm in Atmosphäre, Meereis, Ozean und Ökosystem im antarktischen Winter, um die physikalischen und biogeochemischen Eigenschaften und Prozesse während der Meereiswachstumsphase besser zu verstehen. Es ist die erste antarktische Winterexpedition seit 2006, und der geplante Kurs wird das erste Mal seit 1992 wieder im antarktischen Winter gefahren.

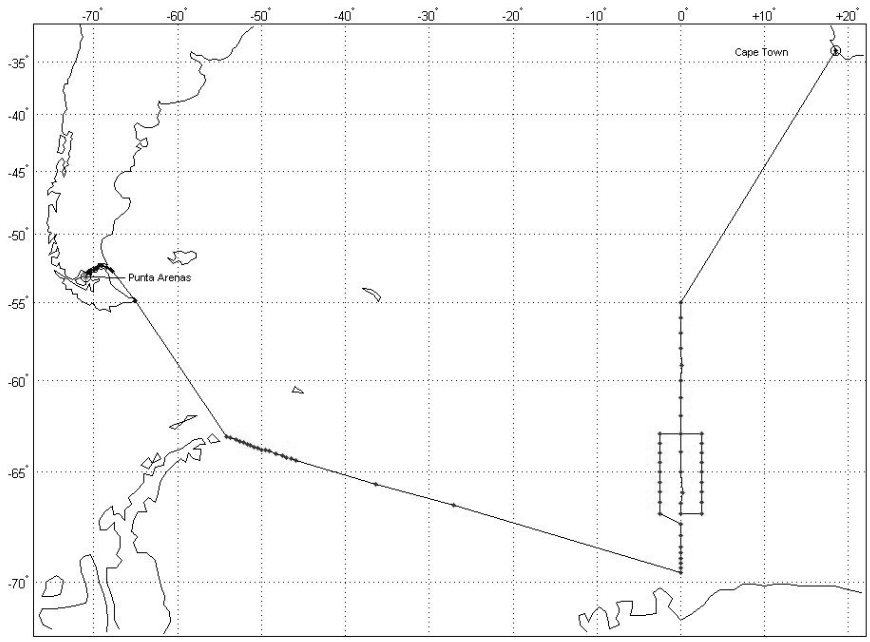

Abb. 1: Geplante Fahrtroute der Polarstern-Expedition ANT-XXIX/6.
Die Punkte zeigen einen Teil der Messstationen.
Fig. 1: Planned cruise track for the Polarstern-Expedition ANT-XXIX/6.
Dots indicate a subset of the stations to be taken.

Während der letzten Winterexpedition konnte festgestellt werden, dass im September und Oktober – also mitten im antarktischen Winter – die Biologie im Meer und im Eis bereits auf Hochtouren läuft und es stellte sich die Frage, was genau den Start des Ökosystems in die neue Saison bedingt. Deswegen startet diese Expedition bereits im Juni, damit die Dunkelheit der Polarnacht ausgenutzt werden kann, um dann von Süden nach Norden dem wieder zunehmenden Sonnenlicht entgegenzufahren und zu untersuchen, wie das Ökosystem den neuen Jahresgang beginnt.

So sollen auf der Fahrt zwei grundlegende Forschungsfragen untersucht werden: Welche Mechanismen lassen das Ökosystem des Südpolarmeeres nach dem langen, kalten und äußerst dunklen Winter wieder zum Leben erwachen? Und: Aus welchen Gründen nimmt die Ausbreitung des antarktischen Meereises leicht zu, während die Meereisbedeckung in der Arktis stetig zurückgeht?

Die Forschungsthemen enthalten die Physik des Meereises und seine Rolle als Reaktionsoberfläche für wichtige chemische Umwandlungsprozesse und als Quelle bzw. Senke für Treibhausgase. Zusätzlich werden Untersuchungen durchgeführt zu Prozessen in der atmosphärischen Grenzschicht, zu biogeochemischen Prozessen im Meereis und zu Änderungen des Ökosystems im Meereis und im Ozean. Schließlich werden Eigenschaften der verschiedenen Wassermassen und ihre Änderungen untersucht und Messungen zur akustischen Ökologie durchgeführt.

Im Gegensatz zum starken Rückgang des arktischen Meereises nimmt das antarktische Meereis im Winter leicht zu. Als Ursachen werden verschiedene Gründe angegeben, die von Änderungen der atmosphärischen Antriebe bis zu physikalischen Prozessen reichen, die die Eismassenbilanz bestimmen, wie z.B. Prozesse in der Schneeauflage. Es werden zusätzliche Informationen über die Dicke und andere Eigenschaften des Meereises benötigt, um diese Frage zu klären. Daher beschäftigt sich das meereisphysikalische Messprogramm mit der Bestimmung von Meereis- und Schneedicken unter Verwendung verschiedener Messmethoden. Gleichzeitig wird der existierende Datensatz zur Dickenverteilung des Meereises erweitert, um klimatologische Änderungen besser bewerten zu können. Die physikalischen Eigenschaften des Meereises und Schnees werden ebenfalls untersucht, da sie eine wichtige Rolle in der Wechselwirkung mit Prozessen in der Atmosphäre und im Ozean spielen, und gleichzeitig die Randbedingungen für das Ökosystem im Meereis und im Ozean bestimmen.

Die meteorologischen Arbeiten konzentrieren sich auf die Struktur der atmosphärischen Grenzschicht über der inhomogenen Meereisbedeckung unter Winterbedingungen. Das Projekt basiert auf der Nutzung von ferngesteuerten Kleinflugzeugen, die die horizontale und vertikale Struktur der Windkomponenten und der Temperatur messen, aus denen der turbulente Austausch zwischen Meereisoberfläche und der Atmosphäre bestimmt werden kann. Die gewonnen Daten werden eine wichtige Grundlage für das Verständnis der Grenzschichtphysik sein und zur Verbesserung von Klimamodellen genutzt werden.

Untersuchungen zur Atmosphärenchemie umfassen Messungen von Aerosolen, Ozon, Halogenkohlenwasserstoffe und Quecksilber und seinen Verbindungen in der atmosphärischen Grenzschicht. Außerdem wird die chemische Zusammensetzung in Schnee, Meereis und Ozean bestimmt. Ziel der Untersuchungen ist ein besseres Verständnis der Rolle des Weddelmeeres als Quelle für Meersalz-Aerosole und Halogenverbindungen in der Atmosphäre.

Die Arbeiten zur Biogeochemie im Meereis konzentrieren sich auf die Frage, wie die physikalischen Umweltbedingungen im antarktischen Packeis im Winter die biogeochemischen Kreisläufe beeinflussen. Physikalische Messungen unterstützen dabei spezielle biogeochemische und ökologische Prozessstudien.

Das Weddellmeer gehört zu den wichtigsten Gebieten, in denen ozeanisches Tiefen- und Bodenwasser erzeugt wird. Über die Wassermassenbildung im Winter ist bisher nur wenig bekannt. Daher liegt der Schwerpunkt der ozeanographischen Arbeiten auf zwei hydrographischen Schnitten entlang des Greenwich Meridians und quer durch den Weddellwirbel, die zum letzten Mal im Winter des Jahres 1992 durchmessen wurden. Dadurch wird eine bessere Einschätzung der Daten möglich, die auf diesen Schnitten bisher überwiegend im Sommer erhoben wurden. Damit ergibt sich auch eine stabilere Basis für das Verständnis der Anregung der ozeanischen Tiefenzirkulation.

An das Meereis ist ein komplexes Ökosystem im Eis und im darunter liegenden Ozean angepasst. Die Arbeiten zur marinen Biologie befassen sich mit der Überwinterungsstrategie dominanter antarktischer Kopepoden (Ruderfußkrebse) und ihrer vertikalen Migration. Insbesondere soll die Rolle des Ammoniums in der Hämolymphe untersucht werden, das den Auftrieb und die Diapause reguliert.

Ziel der Arbeiten zur akustischen Ökologie ist die Untersuchung, ob das im Südlichen Ozean sehr häufig vorkommende akustische „bioduck“-Signal von den Minkewalen stammt. Dies wird vermutet, konnte aber bisher noch nicht bewiesen werden. Deswegen werden akustische Aufnahmen von Bojen mit kontinuierlich laufenden thermischen Aufnahmen zur Detektion von Wal-Blasen verknüpft.

Die Fahrtroute folgt zunächst dem Greenwich Meridian bis zum antarktischen Kontinent und führt dann nach Nordwesten quer durch den Weddellwirbel. Nach Beendigung der Arbeiten an der Spitze der Antarktischen Halbinsel wird *Polarstern* in Richtung Punta Arenas (Chile) dampfen und dort am 12. August 2013 einlaufen.

SUMMARY AND ITINERARY

Polarstern will leave port in Cape Town (South Africa) on 8 June 2013 to perform atmospheric, oceanographic, sea ice, biological, air chemistry and acoustical ecology investigations in the Weddell Sea (Fig.1).

The aim of the cruise is to carry out an interdisciplinary research programme on atmosphere, sea ice, ocean and ecosystem during winter to obtain an understanding of physical and biogeochemical properties and processes during the sea ice growth season. This is the first Antarctic winter expedition since 2006, and on the planned cruise track it is the first since 1992. The investigations include the physics of sea ice and its role as a reaction surface for important chemical conversion processes, and as a source or sink for greenhouse gases. In addition atmospheric boundary layer processes, biogeochemical processes in the sea ice, and ecosystem changes in sea ice and ocean will be studied. Finally, investigations concerning ocean water mass properties and their changes and acoustical ecology will be performed.

In contrast to the strongly decaying Arctic sea ice, the Southern Ocean sea ice extent has slightly increased during the past decades. The causes for this increase are unclear. Possible explanations range from changes in the atmospheric forcing to the role of physical processes affecting the sea ice mass balance, such as snow processes. Additional information on sea ice thickness and other properties during wintertime is required to distinguish between the different processes and to better understand the state of Antarctic sea ice. Therefore, the sea ice physics programme deals with the determination of the sea ice and snow thickness distribution using various methods. Simultaneously, data aim at extending the existing sea ice thickness time series and to evaluate possible changes. Physical sea ice conditions of sea ice and snow will also studied since they have a strong impact on chemical processes occurring at the sea ice – atmosphere interface, on the sea ice – ocean ecosystem, and on the ocean water mass properties.

The meteorological activities are focussed on the atmospheric boundary layer structure over the heterogeneous sea ice cover under winter conditions. The core of the project is based on the operation of unmanned aircraft to measure the horizontal and vertical structure of the wind components and temperature so that turbulent fluxes can be derived, which are important for the understanding of the boundary layer physics and to provide a basis for improvement of climate models.

Atmospheric chemistry investigations are concerned with measurements of aerosols, ozone, halocarbons, mercury and mercury compounds in the atmospheric boundary layer. In addition, the chemical composition of all different components of the ocean and cryosphere like snow, sea ice, and sea water will be determined. The objective of the project is to better quantify the role of the Weddell Sea as a source of sea salt or halogenated compounds and the chemical processing of sea salt generating reactive halogens.

The biogeochemistry work aims at contributing to the understanding of how the Antarctic sea ice physical environment affects the seasonal and regional dynamics of biogeochemical cycles. The physical measurements will support a suite of biogeochemical and ecological process studies that focus on the major physical and biogeochemical drivers controlling gas exchange in the sea ice zone.

The oceanographic investigations include a hydrographic section along the Greenwich Meridian and a crossing of the Weddell Gyre with a high resolution section at the continental slope near the tip of the Antarctic Peninsula. Both sections will be taken in winter for the first time since 1992, providing a strongly needed comparison to the same sections typically taken in summer. The main goal is the study of water mass production and modification to understand the thermohaline forcing of the deep and bottom water circulation in the world's oceans.

The marine biology activities will concentrate on overwintering strategies in polar copepods. Of interest are the physiological regulation mechanisms of seasonal vertical migrations in dominant Antarctic copepod species. The winter cruise will allow a further completion of the seasonal comparison of field data, ecophysiological measurements and biochemical analyses based on the hypothesis that the ammonium concentration in the haemolymph of overwintering copepods regulates buoyancy during deep-water phase and at the same time triggers the induction of diapause by metabolic depression.

The purpose of the acoustic ecology studies are to verify whether the so-called "bioduck" sound in the Southern Ocean is associated with the minke whales or not. To accomplish this, passive acoustic recorders (sonobouys) are used together with a thermal imager in the crow´s nest of *Polarstern*, which operates continuously to automatically detect the blow of whales.

The cruise track will initially follow the Greenwich Meridian towards the Antarctic continent and then cross the Weddell Sea in north-westerly direction. After the conclusion of the work programme near the tip of the Antarctic Peninsula *Polarstern* will steam towards Punta Arenas (Chile) and reach port on 12 August 2013.

2. METEOROLOGY

P. Tisler, M. Jonassen (FMI), B. Altstädter, A. Scholtz (TU-BS), C. Lüpkes (AWI, not on board), T. Vihma (FMI, not on board)

Objectives

This project aims filling the gap of knowledge about the structure of the atmospheric boundary layer (ABL) over the sea ice covered Weddell Sea during winter. Observations will be carried out to obtain a better understanding of the interaction between atmosphere, sea ice and ocean.

The project includes both an observational part during the cruise and the following data analysis. It consists of joint work by groups from the Technical University of Braunschweig (TU-BS), from the Finnish Meteorological Institute in Helsinki (FMI), and from the Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (AWI). Observations of wind, temperature, and humidity will be carried out by several unmanned aerial systems (UAS). The core of the project is based on the operation of an unmanned aircraft (M^2AV) by TU-BS, of the unmanned aircraft SUMO (Fig. 2), and a small quadrocopter run by FMI. The data from these airborne instruments will be supplemented by the routine meteorological observations at *Polarstern*, by *Polarstern* soundings, and by meteorological observations from a mast on the sea ice, which will be installed by FMI during stations.

The M^2AV aircraft enables highly resolved measurements of the wind components and temperature so that turbulent fluxes can be derived by application of the eddy covariance method. Based on the profiles of mean and turbulent quantities, which will be obtained by all UAVs together, the structure of the atmospheric boundary layer will be characterized along the cruise track in different ice morphology regimes, where so far only very limited data is available for this time of the year. A focus is on the (turbulent) processes over regions with large ice cover and regions with leads, so that the data set can be used after the cruise for a test and further development of existing parameterizations of atmospheric turbulence over various ice regimes.

Fig. 2: Unmanned aircraft SUMO (left) of FMI and M^2AV (right) of TU-BS.

Work at sea

Work at sea is restricted to the operation of the different UAVs during ice stations because take-off and landing is not possible from *Polarstern*. The coordinated flight patterns will depend on both meteorological conditions and on the sea ice situation. For large sea ice cover without leads, the focus is on profiling. Thereby, the actual flight levels will depend on the ABL depth, which will be estimated roughly prior to the flights from the last available *Polarstern* sounding. Vertical profiles of turbulent fluxes require 3 km horizontal flight sections flown in different heights while profiles of wind, temperature, and humidity will be obtained during ascend and descend. Both aircraft will be operated below 3,000 m height, quadrocopter flights will be below 100 m.

A specific flight pattern will be carried out in the presence of leads which will consist of lead parallel and lead orthogonal horizontal sections and profile flights.

The flight operations will be supplemented by the meteorological observations from the small tower, which needs to be built up on the upstream side of the ship to avoid a flow distortion by the ship.

Expected results

We expect to obtain a unique and high-quality dataset about the vertical structure of the ABL over the Antarctic sea ice covered Weddell Sea during winter. This dataset allows increasing our knowledge on the Antarctic climate system, validating operational weather prediction systems, and improving boundary layer parameterizations for models of different scales from the micro-scale to the scale of climate models.

Due to the special focus on the impact of leads on the ice atmosphere interaction, the measurements will be used to extend an existing parameterization of micro-scale atmospheric turbulence over leads, developed at AWI, so that it can be applied to a wider range of ice and atmospheric forcing parameters.

Data policy

The data obtained during the cruise will be included in data bank systems such as PANGAEA.

3. ATMOSPHERIC CHEMISTRY

K. Abrahamsson, A. Granfors, M. Ahnoff (GU), B. Jourdain (LGGE), K. Gardfeldt,
M. Nerentorp (Chalmers), P. Anderson (SAMS), M. Frey (BAS), G. Méjean (LIPhy),
J. Buxmann (UHD), H.-W. Jacobi (LGGE, not on board)

Objectives

We will participate in the two cruises ANT-XXIX/6 and ANT-XXIX/7 with an atmospheric/snow/sea ice project based on international collaboration involving six different groups from four different countries including Laboratoire de Glaciologie et Géophysiqe de l'Environnement LGGE and Laboratoire Interdisciplinaire de Physique LIPhy (both CNRS / University Joseph Fourier – Grenoble 1), British Antarctic Survey, Chalmers University of Technology Gothenburg, University of Gothenburg, and University of Heidelberg. The different groups will perform continuous atmospheric measurements of aerosols, ozone, halocarbons, mercury and mercury compounds in the atmospheric boundary layer. We will further perform for the first time in situ measurements of reactive halogens over sea ice-covered areas using a laser-based instrument from LIPhy Grenoble and a cavity enhanced DOAS instrument from the University of Heidelberg. Moreover, the chemical composition of all different components of the ocean and cryosphere like snow, sea ice, and sea water will be determined to study the role of these different compartments on the release of sea salt aerosols and reactive halogen and mercury compounds to the atmosphere. The objective of the project is to better quantify the role of the Weddell Sea as a source of sea salt or halogenated compounds and the chemical processing of sea salt generating reactive halogens. Mercury will further be studied as an example of the impact of the halogens on the cycling of pollutants in the sea ice region. The analysis of all measurements will help to elucidate the role of the halogens in the depletion of ozone and mercury in this region and the contribution of the Weddell Sea to the sea salt burden in Antarctica.

Work at sea

Two major types of measurements will be performed: (1) continuous atmospheric and surface sea water measurements and (2) sampling of snow, sea ice, and sea water during stations with either direct access to sea ice floes from the ship or using helicopters.
Continuous atmospheric measurements will be performed with laser cavity ring down instruments and cavity-enhanced DOAS spectrometer suitable for *in situ* measurements of concentrations of BrO, IO and NO_2. Furthermore, ozone, halocarbons, total gaseous mercury (TGM) and further mercury species will continuously be observed using commercial detectors and techniques. The halocarbons will include a full range of chlorine, bromine, and iodine containing compounds. In situ BrO, IO, OClO, ozone and NO_2 as well as BrO and IO vertical profiles will further be detected using active and passive DOAS instruments. All detectors will be mounted on one of the uppermost decks of the ship in front of the smoke stack to reduce periods with potential contamination. In addition, aerosols will be collected on filters to determine the bulk and size-segregated chemistry and potentially N and O isotopes of particulate nitrate. Further measurements include the size spectrum of aerosol and blowing snow, as well as the salinity and chemistry of blowing snow. Mercury and halocarbon measurements in sea water will further be performed continuously during the trips using the direct sea water supply of the ship or in samples collected with the CTD system. The instruments will be installed during ANT-XXIX/6 and many will continue during the following cruise ANT-XXIX/7.

Snow, sea ice, and sea water samples will be taken at stations throughout the cruises. Snow samples will include surface snow as well as snow pits. Theses samples will be analysed for salinity and after return for a more detailed analysis of major and minor sea salt components using ion chromatography. Moreover, further snow and sea ice samples will be analysed regarding dissolved gaseous mercury, total mercury, methyl mercury, and halocarbons. The sampling of snow and sea ice will be performed in close collaboration with the sea ice physics group.

Expected results

The research proposed here addresses three specific questions/science areas that are critical to extending our understanding of the Antarctic sea ice/atmosphere/ocean system:

1. What role does sea ice play in the generation of sea salt aerosol and reactive halogens? What are the consequences on atmospheric chemistry?

To address these questions we will define the physical and chemical characteristics of snow, sea ice, and sea water by determining physical properties and by measuring salinity and chemical profiles in the snow/upper sea ice, and sea water. We will further study how easily snow can be mobilized by wind by defining criteria for and characteristics of blowing snow and by defining wind speeds at which snow is lofted to different altitudes. We will further examine the salinity as well as detailed chemical signatures of blowing snow and sea salt aerosols. Finally, the conditions for the formation of reactive halogen species (BrO, IO) will be assessed using the continuous on-board measurement and measurements close to the snow surface.

2. What role does sea ice play in emissions of volatile halocarbons and on the atmospheric behaviour of these compounds with respect to halogens?

The measurements of sea ice and sea water concentrations of halocarbons will be studied to highlight the poorly known relationship between sea ice and sea water concentrations and emissions of halogenated compounds to the atmosphere. The continuous atmospheric sampling and analysis of halocarbons will help to determine their role as a source of reactive halogens.

3. What processes govern mercury (Hg) cycling between the air/sea-ice/ocean system, and can we quantify the associated fluxes? How does the lack of sunlight influence concentrations of dissolved gaseous mercury in sea ice and water?

We will use the continuous measurements of gaseous elemental mercury and further mercury species in the atmosphere to investigate concentrations of airborne mercury species during dark conditions in the marine polar atmosphere. The measurements in the snow, sea ice, and sea water in the Antarctic sea ice zone will be used to document air/sea ice/ocean fluxes of Hg and to derive sources of methyl mercury and the influence of oceanic waters on the atmospheric cycle of mercury. Using measurements in the sea water below sea ice, air-water exchanges following winter accumulation of mercury underneath sea-ice will be studied.

Data policy

Quality-controlled data of the continuous atmospheric and sea water measurements will be made available in public data bases (e.g. PANGEA) in the form of time series with the maximum available temporal resolution after publication in peer-review literature. Similarly, published results regarding the analysis of snow, sea ice, and sea water will also be made available.

4. SEA ICE PHYSICS

S. Schwegmann, S. Hendricks, T. Krumpen, M. Hoppmann, S. Arndt (AWI),), K. Leonard (EPFL, CIRES), S. Paul (UTR), S. White (UNAVCO)), NN (WHOI); M. Nicolaus (AWI, not on board), P. Heil (AAD, not on board), T. Maksym (WHOI, not on board)

Objectives

The annual mean sea ice extent in the Southern Ocean shows a slight increase over the last three decades, but regional trends vary strongly in strength and direction. The Amundsen-Bellingshausen Sea, e.g., shows a strong decrease, while there is a positive but not significant trend in the Weddell Sea. Neither the underlying causes for these differences nor the relation to the sea-ice- and snow-thickness distribution are well understood. In particular trends for the sea ice thickness and snow depth distribution are not well known, since we have little information on their interannual variability. Therefore, we will investigate the state and interaction between various sea ice parameters in the Weddell Sea during ANT-XXIX/6 in order to better understand sea ice thickness distribution, the processes that control it, and hence, determine potential causes and impacts of the increase in extent in this sector.

Sea ice thickness distribution will be observed on different scales from few meters to several kilometres by various methods. These data sets will identify the actual state of the sea ice cover and will also serve a valuable tool for the validation of satellite-based and simulated sea ice thickness distributions. Since a snow cover on sea ice strongly influences the sea ice mass balance, and in particular the observational methods to quantify sea ice thickness, and information on snow is sparse in the Southern Ocean, extensive measurements on the regional-scale snow thickness distribution and stratigraphy will be conducted using a variety of methods. Snow measurements will also be performed in order to identify the partitioning of falling snow into level-ice accumulation and blowing snow loss and to quantify the role of blowing snow in controlling the snow depth distribution. Properties of drifting/blowing snow on sea ice will be analysed and evaluated as a function of meteorological and snow conditions. The sea ice and snow thickness data sets will be complemented by visual shipboard underway observations of the state of the sea ice and snow cover. These data will contribute to the data base of the Antarctic Sea Ice Processes and Climate (ASPeCt) program.

Sea ice physical properties are also of great importance. The salinity, temperature, and density, in particular determine the sea ice conditions and characteristics derived from remote sensing data. In order to investigate these properties, and to identify interactions between ice shelves and sea ice through the occurrence of platelet ice at the sea ice bottom, ice cores will be taken and analysed on-board. Sea ice density and platelet ice occurrence are particularly poorly known parameters for the Antarctic sea ice zone and these new data will help to improve numerical models as well as the determination of sea ice thicknesses by remote sensing data.

Another aim of this cruise is to investigate the effect of dynamical processes on the sea ice. Deployments of autonomous observatories in the framework of the International Program on Antarctic Buoys (IPAB) will help to study the meso-scale sea ice kinematics including effects of internal ice stress. This is important for the investigation of ice-ocean and ice-atmosphere interactions and changes, and will be used for the quantification of any scale-dependency of austral winter dynamic sea ice processes. Additionally, these observatories will enable us to extrapolate the findings of the ice station work through time series data from the same floes. These data will help to validate large-scale satellite observations and will help to improve sea-ice parameterization in numerical (climate) models.

Work at sea

Sea ice thickness distributions will be measured along the cruise track by means of helicopter surveys carrying an EM-Bird. Additionally, information on the surface roughness will be obtained by airborne laser altimetry, and a nadir-looking aerial camera will document the general surface conditions. These measurements will be performed as often as possible in order to obtain a dense grid of measurements and will last about 2 hours per flight. Continuous visual observations of the sea ice cover and meteorological conditions will be made on an hourly basis from the ships bridge by trained observers. To support these observations, a camera system will be installed and maintained during the cruise. Those data will contribute to the ASPeCt data base. Shipboard measurements of snowfall (in coordination with Atmosphere-Ice-Chemistry group) will additionally provide information on precipitation frequency and intensity.

The physical properties of the sea ice and snow cover will be assessed during all ice stations. For a multi-day sea ice station these measurements will include:

- Sea ice coring for in-situ measurements of temperature, salinity, and texture. Quantifying the fraction of platelet ice in the ice cores will be of particular interest.
- Ground-based EM-measurements, which produce high resolution ice thickness data.
- Manual thickness measurements through drilling to obtain ratios of sea-ice freeboard, draft, and thickness.
- A variety of methods (depth soundings with probes, laser scanning, infrared photography) will be applied to obtain floe-scale snow depth and surface-roughness

distributions. Measurements will be partially repeated if snowfall/blowing snow occur during ice stations.

- Snow stratigraphy and physical snow properties will be obtained from snow pits.
- Blowing snow weather station(s) will be installed and size distribution of blowing snow and precipitation will be analysed through formvar and microphotography.
- Spectral radiation measurements (320 to 950nm, 3.3 nm resolution) will be performed over and under sea ice. From these data spectral (and total) albedo and transmittance will be derived.
- Two fixed GPS stations will be installed in order to correct surveying data.
- Stationary ADCP deployment will be performed in combination with CTD measurements using an ice-floe mounted microcat.
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Sea-ice mass balance buoys (IMB), snow depth buoys, and GPS buoys will be deployed on the ice, some paired with automatic weather stations (AWS). These buoys will measure and transmit various snow and sea-ice properties also beyond the cruise and contribute to the IPAB. This program needs re-deployment tests and calibrations, ship-based or helicopter-based buoy deployments, and additional analyses (in -20°C freezer lab) of ice cores from buoy sites between ice stations.

Expected results

The measurement program will result in data that allow us to identify the state of the regional sea ice thickness and snow depth distribution as well as drift conditions during austral winter. Furthermore, data aim to identify the partitioning of falling snow into level-ice accumulation and blowing snow loss and to quantify the role of blowing snow in controlling the snow depth distribution. The buoy program will provide time series data of various sea ice and snow parameters beyond the cruise and serve data for the quantification of any scale-dependency of austral winter dynamic sea ice processes. Physical properties of sea ice and the determination of the ice shelf-sea ice-interaction will be investigated and will be used to improve the parameterization in numerical models.

Data policy

Sea-ice-thickness and snow depth data, aerial photos from helicopter surveys, physical properties of snow and sea ice (ice cores and snow pits), spectral radiation data, and sea-ice observations will be post-processed and delivered to PANGAEA within two years after the cruise. Sea-ice-thickness data from the EM measurements will be additionally submitted to the Sea Ice Thickness Climate Data Record. All autonomous data from drifting 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. In addition, we are working on including the buoy data into the new sea ice portal (www.meereisportal.de). Archive cores from all ice stations will be archived in the cold storage facilities of the Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung.

5. SEA ICE BIOLOGY AND BIOGEOCHEMISTRY

G. Dieckmann (AWI), D. Nomura (HU), N. Gussone (WWU), A.-M. Lutanen, J.-M. Rintala (UH), J.-L. Tison, J. De Jong, J. Zhou (ULB), B. Delille (ULG), C. Uhlig (AWI)

Objectives

The aim of the Biogeochemistry group is to contribute to the understanding of how the Antarctic sea ice physical environment affects the seasonal and regional dynamics of biogeochemical cycles.

We propose a multi-disciplinary sea ice science program to determine the variability of sea ice and snow properties on small-regional scales using a multiple platform approach that includes ice coring surveys and instrument deployment on sea ice. The data collected will be available for the validation and calibration of process studies on sea ice biogeochemistry and the improved parameterization of sea ice processes in climate and ecosystem models. The physical measurements will support a suite of biogeochemical and ecological process studies that focus on the major physical and biogeochemical drivers controlling gas exchange in the sea ice zone. This work also entails the investigation of functional relationships between the physical and biogeochemical properties of sea ice and sea ice microbes ranging from viruses to protozoans.

Work at sea

Sea ice in situ measurements and ice coring surveys: Measurements will include sea ice and snow thickness, porosity, snow properties, and ice core analyses. Ice crystal structure will be measured by thin-section analysis to determine sea ice growth conditions in close collaboration with the sea ice physics group. Melted ice core segments will be used to measure a multitude of properties ranging from salinity to stable isotopic composition. Ice core samples will also be used for trace gas analysis (DMSP), methane, CO_2) using gas chromatography. Further biogeochemical ice core analyses include determination of $CaCO_3$/ikaite concentrations, macro-nutrients and ice algal pigment concentrations and collection of foraminifera for isotopic analyses. Ice cores will also be used for analyses of microbe species identification and cell abundances, and melted core sections will be filtered for DNA community analyses. Bacteria will be isolated for virus screening and virus induced bacterial mortality studies. Sackholes will be drilled to do various analyses on brine. These include direct pCO_2 measurements to compare the pCO_2 deduced from the chemical measurements. Complementary measurements of total gas content will be made in ice/brine and water fractions and gas composition (O_2, N_2, CO_2 dry extraction) and measured on board using gas chromatography. Chambers will be deployed on the sea ice to measure air-ice CO_2, methane and DMS fluxes.

Expected results

We expect:

- Improved measurements to assess coupled physical-biogeochemical processes and changes in the sea ice zone.

- Information on atmosphere – sea ice – ocean interactions to assess the role of ice dynamics in a changing climate and to improve the implementation of biogeochemical dynamics in climate models.
- Identification and quantification of physical-biological processes affecting microbial metabolism, growth, survival and productivity in the sea ice zone.
- A mechanistic understanding of the impact of sea ice variability on Southern Ocean ecosystem dynamics.
- An assessment of the relationships between the physical, chemical and biological properties of sea ice for improved parameterisation of sea ice primary production in numerical ecosystem models.

Data policy

Data collected and processed during the expedition will be available immediately to cruise participants. Alternatively, data on ice core analyses including biogeochemical properties and chamber studies will be post-processed subsequent to the cruise and delivered to PANGAEA within two years after the cruise. Archive cores from all ice stations will be stored in the cold storage facilities of the Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung.

6. OCEANOGRAPHY

H. Sander (Optimare), J. Sutter, F. Richter, M. Krüger (AWI), G. Rohardt (AWI; not on board),

Modification of water masses

Objectives

The densest bottom waters of the global oceans originate in the Southern Ocean. Production and export of these dense waters constitute an important component of the global climate system. The formation of dense water in polar areas is controlled by the balance between supply of fresh water through precipitation, and melt of continental and sea ice and the extraction of freshwater by sea ice formation and evaporation. As deep and bottom waters, they represent the deepest layer of the global overturning circulation. The influence of Southern Ocean waters can be traced into the Northern Hemisphere, far north of the Antarctic Circumpolar Current (ACC). The ACC is the world´s most powerful current system, transporting about 140 Sv (10^6 m^3 s^{-1}) of water at all depths. It connects the Pacific, Atlantic and Indian Ocean and forms a ring around the Antarctic continent. South of the ACC, in the subpolar region, warm and salty water masses are carried in the subpolar gyres to the continental margins of Antarctica. The most prominent are the Weddell and Ross Gyres. In the subpolar gyres, water mass modification occurs through ocean-ice-atmosphere interactions and mixing with adjacent water masses. The ACC is dynamically linked to meridional circulation cells, formed by southward ascending flow at intermediate depth and feeding into northward flow above and below. In the deep cell, water sinking near the continent spreads to the adjacent ocean basins, whereas in the shallow cell, the northward flow occurs in the surface layers. Dense waters are produced at several sites near the continental margins of Antarctica. Quantitatively the most important region for dense water formation may well be the Weddell Sea; however other areas provide significant contributions as well.

The basic mechanism of dense water generation involves upwelling of Circumpolar Deep Water, which is relatively warm and salty, into the surface layer where it comes into contact with the atmosphere and sea ice. The newly formed bottom water is significantly colder and slightly fresher than the initial Circumpolar Deep Water, which indicates heat loss and the addition of freshwater. Since freshwater input in the upper oceanic layers would impede sinking due to increasing stratification of the water column, it has to be compensated by salt gain through fresh water extraction. The upwelled water is freshened by precipitation and melting of glacial and sea ice. Freshwater of glacial origin is supplied from the ice shelves or melting icebergs. Ice shelves melt at their fronts and bases in response to the oceanic circulation in the cavity. Iceberg melting depends highly on the iceberg drift and can supply freshwater to areas distant from the shelves as the Antarctic frontal system. Due to the spatial separation of major sea-ice freezing and melting areas, cooling and salt release during sea-ice formation also help compensating the freshwater gain. Significant parts of salt accumulation occur on the Antarctic shelves in coastal polynyas. With extreme heat losses occurring only over ice free water areas, the polynyas are areas of intense sea ice formation. Offshore winds compress the newly formed sea ice and keep an open sea surface in the polynyas.

The cold and saline water accumulated on the shelves can descend the continental slope and mix with water masses near the shelf edge or it circulates under the vast ice shelves, where it is cooled further, below the surface freezing point, and freshened by melt water from the ice shelf. The resulting Ice Shelf Water spills over the continental slope and mixes with ambient waters to form deep and bottom water. For both mechanisms, relatively small scale processes at the shelf front, topographic features and the nonlinearity of the equation of state of sea water at low temperatures is of particular importance to induce and maintain the sinking motion. The various processes, topographic settings and the atmospheric forcing conditions lead to variable spatial characteristics of the resulting deep and bottom water masses which then spread along a variety of pathways to feed into the global oceanic circulation. Climate models suggest that dense water formation is sensitive to climate change. However, since the relatively small scale formation processes are poorly represented in the models, further improvement is needed.

The properties and volume of the newly formed bottom water underlies significant variability on a wide range of time scales, which are only scarcely explored due to the large efforts needed to obtain measurements in ice covered ocean areas. Seasonal variations of the upper ocean layers are only partially known and normally exceed other scales of variability in intensity. Impacts of longer term variations of the atmosphere-ice-ocean system, such as the Southern Hemispheric Annular Mode and the Antarctic Dipole, are only poorly observed and understood. Their influence on or interaction with oceanic conditions are merely guessed on the basis of models which are only superficially validated due to lack of appropriate measurements.

The extreme regional and temporal variability represents a large source of uncertainty when data sets of different origin are combined. Therefore circumpolar data sets of sufficient spatial and temporal coverage are needed. At present, such data sets can only be acquired by satellite remote sensing. However, to penetrate into the ocean interior and to validate the remotely sensed data, an ocean observing system is required, which combines remotely sensed data of sea ice and surface properties with *in-situ* measurements of atmospheric, sea ice and the ocean interior.

Significant progress towards this goal already occurred in the development of appropriate technology and logistics. The *Hybrid Antarctic Float Observing System* (HAFOS), which was installed during the expedition ANT-XXIX/2, aims to capitalize on these advances to investigate the ocean interior in the Atlantic Sector of the Southern Ocean. Around 50 NEMO floats have been deployed during that cruise extending the international *Argo* programme into the Weddell Sea and making an important step towards a *Southern Ocean Observing System* (SOOS). HAFOS is the extension of the frequently measured CTD-transect along the Greenwich Meridian from 50°S towards 69.5°S. Between 1992 and 2012 nine sections were obtained and long-term modifications of water masses could be studied. Seasonal sea ice formation and melt increased respectively decreased the salinity in the surface water on top of the Warm Deep Water (WDW). Because CTD-sections were obtained in different seasons it is necessary to apply a seasonal correction to get a long-term record of the surface salinity as shown in Fig. 3.

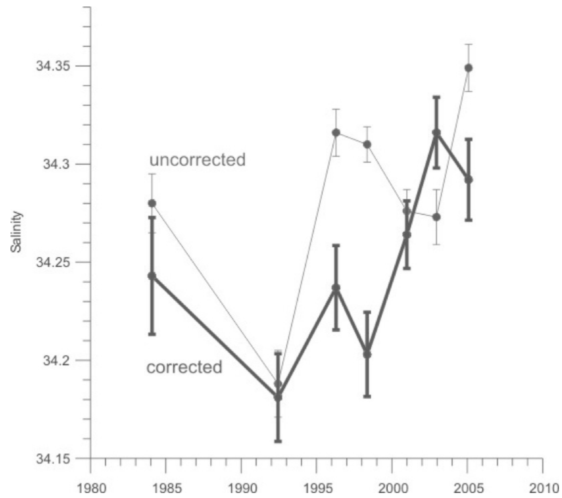

Fig. 3: Average salinity of the Winter Water calculated for a period from 1984 until 2005 from CTD profiles along Greenwich Meridian from 56°S towards 69.5°S. The data were obtained in different months of the year and included seasonal variations (thin line). The applied corrections adjusted the salinity to winter conditions (thick line). 1992 was a winter cruise.

Up to now one section was obtained during a winter cruise only (ANT-X/4; 1992), which can be taken to verify the correction method. A winter section is needed to get an additional comparison between the measured and adjusted surface salinity. Due to the sea ice the floats can measure a fraction of the winter surface layer only.
Another CTD section was frequently obtained at the tip of the Antarctic Peninsula, where a relatively thin layer of Weddell Sea Bottom Water (WSBW) flows northward. Its core with minimum potential temperature leaned against the continental slope in a depth of 2400 m. A series of ten sections between 1989 and 2012 showed a slightly decreasing temperature. Moored CTD-recorders provide time series of seasonal variations in the WSBW layer. Theses moorings were recovered and re-deployed during ANT-XXIX/2. But the spatial distribution of the WSBW core was based on the CTD-section measured in summer or spring but not in winter (see Figure 4). Therefore a section direct after the summer section obtained during ANT-XXIX/2 should be repeated to investigate seasonal effects in more detail.

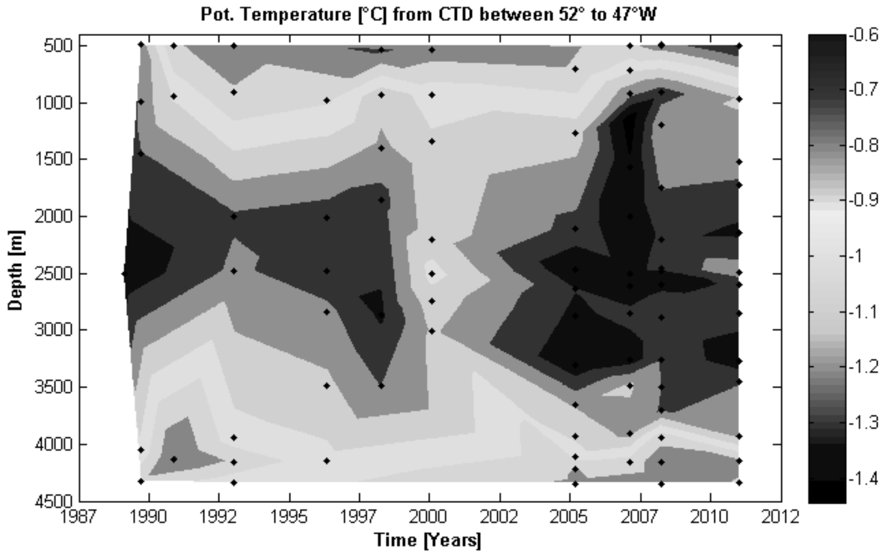

Fig. 4: Contour plot of the potential temperature at the bottom from CTD profiles at the continental slope at the tip of the Antarctic Peninsular obtained during ten cruises in the period 1989 to 2011. All cruises took place in summer or spring.

Work at sea

The oceanographic studies during *Polarstern* cruise ANT-XXIX/6 will concentrate on two major areas, the Greenwich Meridian and the north-western Weddell Sea, continuing past CTD observations in the Atlantic sector of the Southern Ocean.

The CTD/water sampler consists of a SBE911plus CTD system in combination with a carousel water sampler SBE32 with 24 12-l bottles. To determine the distance to the bottom an altimeter from Benthos is mounted. A transmissiometer from Wetlabs, a SBE43 oxygen sensor from Seabird Electronics and a fluorometer will be incorporated in the sensor package.

Along the ship’s route underway measurements will be recorded from the thermosalinograph (TSG) and vessel mounted ADCP. The ADCP is a 150 kHz Ocean Surveyor from RD-Instruments, which provides current velocity profiles up to 600 m depth. Two TSG’s are installed with water intakes at the bow thrusters (5 m deep) and at the box keel (11 m deep) to measure the surface temperature and salinity. Both instruments are from Seabird Electronics, type SBE21 with external temperature sensor SBE38.

Expected results

We expect to obtain data from CTD during winter season combined with the underway measurements from vessel mounted ADCP (Acoustic Doppler Current Profiler) and TSG (thermosalinograph; surface temperature and salinity).

Data policy

Metadata of recorded data will be made available through the cruise report. CTD, ADCP and TSG data will be made available after validation through the PANGAEA database. Results will be published in international journals.

7. MARINE BIOLOGY

H. Auel, S. Schründer (UHB), F.-J. Sartoris, S. Schiel (AWI)

Overwintering strategies of Antarctic copepods: Physiological mechanisms and buoyancy regulation by ammonium

Objectives

Within the framework of the DFG project “Overwintering strategies in polar copepods: Physiological mechanisms and buoyancy regulation by ammonium” (Auel, Sartoris, Schiel, Schründer), the physiological regulation mechanisms of seasonal vertical migrations in dominant Antarctic copepod species are studied. The research cruise ANT-XXIX/6 in austral winter will allow us to further complete a seasonal comparison of field data, ecophysiological measurements and biochemical analyses based on the hypothesis that the ammonium concentration in the haemolymph of overwintering copepods regulates buoyancy during deep-water phase and at the same time triggers the induction of diapause by metabolic depression.

The mesozooplankton community in the Southern Ocean is strongly dominated by only a few endemic copepod species. Within the calanoids, the epipelagic species Calanoides acutus and Calanus propinquus contribute substantially to the total mesozooplankton biomass (10 - 52 %). Their ecological and evolutionary success is based inter alia on their ability to cope with the pronounced seasonality of primary production in the Southern Ocean. The C. propinquus population remains active during winter in the upper and mid water layers and switches to a more omnivorous diet, whereas C. acutus is known to conduct extensive seasonal vertical migrations associated with a resting stage (diapause) at greater depths (≥ 500 m). This diapause is marked by severely reduced metabolic and swimming activities and requires complex changes at biochemical and physiological levels.

Previous studies dealing with life cycle strategies of Antarctic copepods have generally focused on the copepod population structure, the abundance, distribution and stage composition and its variety between seasons and regions. Only recent approaches concentrated on buoyancy regulation mechanisms of vertical migrations and on the termination of overwintering. Two main questions are still unanswered: (i) how do diapausing copepods with a reduced swimming activity regulate their buoyancy to remain at a certain depth over a long period of time and (ii) what controls the beginning and the end of the diapause.

Our preliminary studies on *Polarstern* cruises ANT-XXIII/7 (September – October 2006), ANT-XXVII/3 (February – April 2011) and ANT-XXVIII/2 (December 2011 – January 2012) showed that only copepod species known to enter diapause contain highly elevated concentrations of ammonia (NH4+) in their haemolymph. Such concentrations were not apparent in any of the other investigated copepod species, leading to the assumption that there is a functional link between the ammonium accumulation and diapause. Ammonia accumulation and the reduction of fluid density by the replacement of heavier ions to achieve neutral buoyancy is known from cranchiid squids and pelagic deep-sea crustacean but has never been studied for copepods before. Compared to the extra cost of swimming or the accumulation of low-density organic compounds such as lipids, the energetic costs involved in the production of ammonia is low, since it is a waste product of protein/nitrogen metabolism. Nevertheless, ammonia (i.e. the total of NH_3 and NH_4^+) is usually highly toxic in most animals and ammonia concentration in the body fluids is typically low. In aqueous solution, ammonia exists as either ammonium ions (NH_4^+) or molecular ammonia (NH_3). Since NH_3 is uncharged, lipid soluble and therefore easily diffusible across phospholipid membranes, it is regarded as the form of ammonia that is toxic to fish and aquatic crustaceans. The relative proportions of NH_3 and NH_4^+ are strongly dependent upon the pH and to a lesser extent upon temperature and salinity of the solution. At a physiological pH of 7.8, 0°C temperature and 32 - 40‰ salinity (pK≈10.16), 99.6% of total ammonia exists in the ionic form NH_4^+, whereas only 0.4% is present as un-ionized NH_3.

Therefore, we predicted a low extracellular haemolymph pH in copepods with elevated ammonia concentrations to favor the formation of NH_4^+. Our recent study revealed that the extracellular pH values in the haemolymph of diapausing copepods with high levels of ammonia were sufficiently acidic (about pH 6.0). It is of interest to determine the potential effects of low pH values on the required metabolic depression during diapause, knowing that low pH values are a relevant factor depressing metabolic rate during dormancy. If our hypothesis is applicable, we would also expect a seasonality of ammonia-regulated buoyancy with a lower pH in the winter than in the summer time or transition zones. Therefore the cruise will fill an important gap in the seasonal comparison with rather rare winter data of copepods being in diapause.

Work at sea

Stratified depth samples of diapausing copepod species will be sampled from a maximum depth of ,2000 m to the surface using multiple/opening closing nets (Multinet Maxi, mouth opening 0.5 m²; Multinet Midi, mouth opening 0.25 m²; equipped with 9 and 5 nets, respectively, and 100 µm mesh size for both). Copepods will eventually be sorted on board the ship from the different depth layers by species, sex and developmental stage. Deep-frozen (-80°C) samples of the different copepod species will be collected for biochemical analyses in the home lab, whereas live intact specimens will be kept in jars with filtered seawater in temperature-controlled refrigerators at in situ temperatures for haemolymph extraction and experiments. The remaining zooplankton from each sample will be fixed in 4% borax-buffered formaldehyde seawater solution for post-cruise studies on abundance, population structure, and vertical distribution.

- Haemolymph extraction and analysis

Under a dissecting microscope, haemolymph will be extracted manually using borosilicate glass capillaries. Each haemolymph sample will be diluted in deionized water and kept in a deep-freezer at -80°C. The cation composition such as NH_4^+, Na^+, Mg^{++}, K^+, and Ca^+ will be analyzed by ion chromatography with a DIONEX ICS 2000.

- pHe-measurements

At least 500 nL of each hemolymph sample will be used to measure pH directly onboard using a NanoDrop 3300 fluorometer (Thermo Fischer) and HPTS (8-Hydroxypyrene-1,3,6-trisulfonic acid trisodium salt) as a pH indicator. To avoid inaccuracies due to temperature induced changes, pH measurements will be carried out in temperature-controlled laboratories at in situ temperatures.

- Respiration

Respiration rates will be determined under simulated in situ conditions in temperature-controlled laboraties onboard the ship as a measure of metabolic activity. Depending on the size, several individuals will be incubated in gas-tight bottles filled with filtered and oxygenated seawater for several hours. The decrease in oxygen concentration will be monitored in comparison to animal-free controls by oxygen micro-optodes using a 10-Channel Fiber-Optic Oxygen Meter (OXY-10, PreSens, Precision Sensing GmbH). At the end of the experiments, individuals will be kept in the deep-freezer at -80°C for post-cruise measurements of dry weight and respiration rates.

- Experimental manipulations of the pH to provoke activity

Incubations with a variation of seawater pH will be conducted to increase pHe in the haemolymph of diapausing copepods in order to provoke behavioral changes. Changes in extracellular pH and ammonium content will be recorded as well as the effect on the activity level. Activity will be determined by respiration measurements and/or observations of swimming and sag performances in measuring cylinders (for those copepods might need to be anaesthetized). To examine the extent of density reduction via ion replacement, relative buoyancies will be determined based on the ammonium, lipid content and other biochemical composition.

Expected results

Ammonium content and pHe levels in the haemolymph of several copepod species with different overwintering-strategies will be determined and compared with the results from previous expeditions during other seasons. We expect a seasonal variation in the amount of ammonium in the haemolymph of diapausing copepods with highest contents in the course of diapause in winter. We hypothesize that ammonium accumulation contributes to buoyancy regulation and is functionally linked to a decrease of extracellular pH that acts as a trigger for the requested metabolic depression throughout diapause duration. Therefore, we expect lowest metabolic rates in copepods with low haemolymph pHe and an increase of metabolic rates and swimming activities in animals with manipulative increased pHe values.

Data policy

Parts of the collected data will be published within the framework of a PhD thesis (in progress, Sabine Schründer 2011 - 2013) within the prescribed frame. If georeferenced data will be collected, they will be freely available in the PANGAEA Open Access library within the next two years.

8. ACOUSTIC ECOLOGY

L. Kindermann (AWI)

Objectives

Throughout the southern ocean a unique rhythmic underwater sound with a frequency range of 100 Hz to 20 kHz has been recorded repeatedly by many researchers and navy sonar officers. The first published evidence of its existence dates back to 1964 where it appeared in an audio recording as an "unidentified signal in the background". The crew of an Australian submarine designated the sound "the bioduck" because of is auditory impression. However, the source of this signal remains yet a mystery. The PALAOA observatory, located north of Neumayer Station and several moored audio recorders throughout the Weddell Sea pick up this sound regularly - but strictly during austral winter only, which explains much of the difficulty in its investigation. From end of April to begin of November it is continuously audible and most of that time it even constitutes the most intense sound source in the southern ocean. The most accepted theory at the moment says, it might be vocalizations of the

Antarctic minke whale (Balaenoptera bonaerensis), as this is the last mysticete species with yet unknown vocal repertoire and it is known to stay in ice covered areas far south even during wintertime when most other whales migrate to the north. However, no empirical evidence exists for this assumption hitherto. Despite being the most abundant whale species in the southern ocean, there is still a great lack of knowledge regarding this species. Official population estimates issued by the International Whaling Commission show a very large uncertainty: 720.000 animals (510.000 - 1.010.000 at 95% confidence level) derived from 1985 - 91 data and 515.000 (360.000 - 730.000) from 1992 - 2004 data. One of the reasons is the difficulty to perform standard line transect surveys for counting animals in ice covered areas. On the other hand, passive acoustic monitoring using autonomous, long term underwater recorders - which are not affected by the harsh conditions at the surface - has proven to be a reliable tool for accessing animal presence for many species already. Giving the Minkes a voice thus would make them much easier accessible.

Work at sea

The FirstNavy 360° thermal imager in the crow´s nest will operate continuously to automatically detect the blow of whales, even during darkness. Once the detection is verified and the whale is identified, at least two military sonobuoys will be dropped behind the ship to record the underwater acoustics while the vessel can continue its cruise. The sensors allow localizing sound sources remotely via a radio link up to a distance of 30 km, mostly clear from the ships noise then. Aim is to check for the coincidence of visual and acoustic localization. In another attempt, during ice stations a long baseline hydrophone array will be deployed on an ice floe to find and localize acoustic "bioduck" signals and a helicopter will check at that exact position for the presence of whales.

Expected results

If we can be prove that the "bioduck" is indeed produced by minke whales, a wealth of acoustic data will immediately be open for interpretation. More than 25.000 hours of audio containing "bioduck" signatures have been recorded by AWI alone so far, using the PALAOA observatory and an array of moored recorders spanning throughout the Weddell Sea and covering more than 7 years. This would allow studying minke whale winter abundance, distribution, migration and behaviour and possibly fill some of the gaps necessary to establish reliable population and development estimates. However, in the not completely unlikely case, that we fail, we will at least obtain winter minke counts from the thermal imager. And it would be even more spectacular, if the "bioduck" turned out not to be a minke at all.

Data policy

All collected data, i.e. geo referenced acoustic recordings and thermal images will be published and made accessible under an open access policy in the PANGAEA repository within one year after the cruise.

9. TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTIONS

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Chalmers	Chalmers University of Technology SE-412 96 Gothenburg / Sweden
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DWD	Deutscher Wetterdienst Geschäftsbereich Wettervorhersage Seeschifffahrtsberatung Bernhard Nocht Str. 76 20359 Hamburg / Germany
EPFL	École polytechnique fédérale de Lausanne EPFL ENAC IIE CRYOS GR B0 420 (Bâtiment GR) Station 2 CH-1015 Lausanne / Switzerland
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	Adresse / Address
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UTR	Universität Trier D-54286 Trier / Germany
WHOI	Woods Hole Oceanographic Institution 266 Woods Hole Road Woods Hole, MA 02543-1050 / U.S.A.
WWU	Westfälische Wilhelms-Universität Schlossplatz 2 D-48149 Münster / Germany

10. FAHRTTEILNEHMER / CRUISE PARTICIPANTS

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession
Abrahamsson	Katarina	GU	Chemist
Ahnoff	Martin	GU	Chemist
Altstädter	Barbara	UB-BS	Meteorologist
Anderson	Phil	SAMS	Atmospheric physicist
Arndt	Stefanie	AWI	Student, Meteorology
Auel	Holger	UHB	Biologist
Buxmann	Joelle	UHD	Physicist
De Jong	Jeroen	ULB	Engineer
Delille	Bruno	ULG	Biogeochemist
Dieckmann	Gerhard	AWI	Biologist
Frey	Markus	BAS	Atmospheric chemist
Gardfeldt	Katarina	Chalmers	Chemist
Granfors	Anna	GU	Chemist
Gussone	Nikolaus	WWU	Mineralogist
Hendricks	Stefan	AWI	Physicist
Hoppmann	Mario	AWI	PhD-Student, Physics
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Sander	Hendrik	Optimare	Physicist
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Schiel	Sigrid	AWI	Biologist
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Schwegmann	Sandra	AWI	Physicist
Sutter	Johannes	AWI	PhD-Student, Physics
Tisler	Priit	FMI	Meteorologist
Tison	Jean-Louis	ULB	Biogeochemist/Glaciologist
Uhlig	Christiane	AWI	Biologist

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession
von Neuhoff	Stephanie	AWI	Journalist
White	Seth	UNAVCO	Engineer
Zhou	Jiayun	ULB	PhD-Student,
Rentsch	Harald	DWD	Meteorologist
Sonnabend	Hartmut	DWD	Met. Technician
NN		HeliService	Pilot
NN		HeliService	Pilot
NN		HeliService	Heli. Technician
NN		HeliService	Heli. Technician

11. SCHIFFSBESATZUNG / SHIP'S CREW

Name	Rank
Pahl, Uwe	Master
Spielke, Steffen	1.Offc.
Ziemann, Olaf	Ch.Eng
Lauber, Felix	2.0ffc
Rackete, Carola	3.0ffc.
Hering, Igor	2.0ffc.
Spilok, Norbert	Doctor
Koch, Georg	R.Offc.
Kotnik, Herbert	2.Eng.
Schnürch, Helmut	2.Eng.
Westphal, Henning	2.Eng.
Brehme, Andreas	Elec.Tech.
Fröb, Martin	Electron.
Dimmler, Werner	Electron.
Winter, Andreas	Electron.
Feiertag, Thomas	Electron.
Schröter, Rene	Boatsw.
Neisner,Winfried	Carpenter
Clasen, Nils	A.B.
Burzan, Gerd-Ekkehard	A.B.
Schröder, Norbert	A.B.
Moser, Siegfried	A.B.
Hartwig-L., Andreas	A.B.
Kretzschmar, Uwe	A.B.
Kreis, Reinhard	A.B.
Seibel, Sebastian	A.B.
Beth, Detlef	Storekeep.
Plehn, Markus	Mot-man
Fritz, Günter	Mot-man
Krösche, Eckard	Mot-man
Dinse, Horst	Mot-man
Watzel, Bernhard	Mot-man
Fischer, Matthias	Cook
Tupy,Mario	Cooksmate
Völske, Thomas	Cooksmate
Dinse, Petra	1.Stwdess
Hennig, Christina	Stwdss/KS'
Streit, Christina	2. Steward
Hischke, Peggy	2.Stwdess
Wartenberg, Irina	2.Stwdess
Hu, Guo Yong	2. Steward
Chen, Quan Lun	2. Steward
Ruan, Hui Guang	Laundrym.

ANT-XXIX/7

14 August - 16 October 2013

Punta Arenas – Cape Town

Chief scientist
Bettina Meyer

Coordinator
Rainer Knust

CONTENTS

1. ÜBERBLICK UND FAHRTVERLAUF

B. Meyer (AWI), Auerswald (DAAF), Teschke (AWI)

Der Fahrtabschnitt ANT-XXIX/7 WISKY (**WI**nter **S**ea Ice Study on **Key** Species) wird am 14. August 2013 in Punta Arenas (Chile) beginnen und am 16. Oktober 2013 in Kapstadt enden. Der Hauptschwerpunkt der Fahrt befasst sich mit den Untersuchungen zur Kondition von antarktischem Krill, *Euphausia superba* (im Folgenden Krill), in Relation zu biologischen und physikalischen Gegebenheiten im offenen Wasser sowie in Regionen mit unterschiedlich intensiver Meereisbedeckung. Die Untersuchungen werden in der Schottischen See sowie dem nördlichen Weddell Meer durchgeführt, während der Übergansphase vom antarktischen Winter zum Frühjahr (Abb.1).

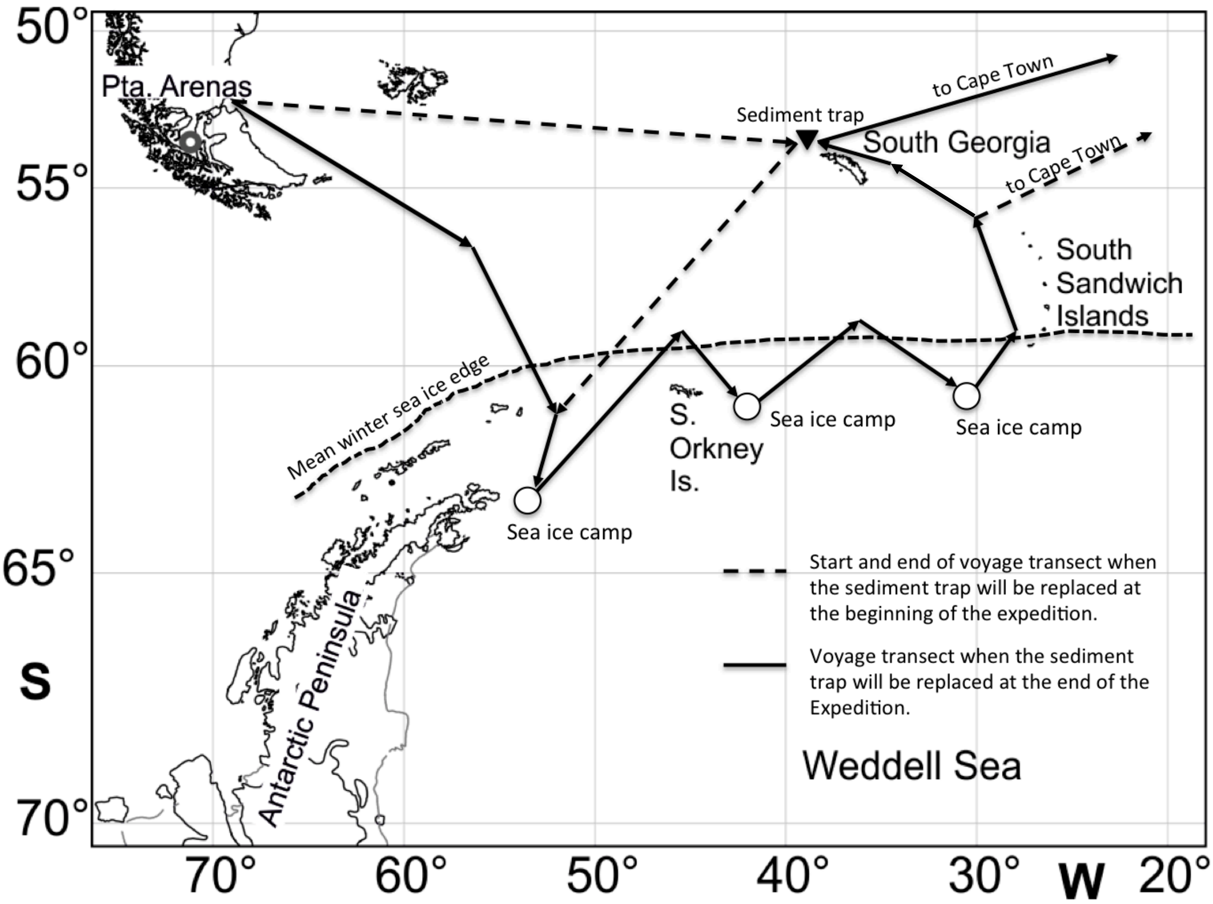

Abb. 1: Geplante Fahrtroute der Expedition Polarstern ANT-XXIX/7. Zur Zeit ist noch nicht geklärt ob die Sedimentfalle zu Beginn der Expedition oder am Ende der Expedition geborgen wird.
Fig. 1: Planned cruise track and working areas of Polarstern expedition ANT-XXIX/7. It is not clear yet if the sediment trap will be deployed at the beginning or at the end of the cruise.

Krill strukturiert das marine Ökosystem im Südozean aufgrund seiner zentralen Position im Nahrungsnetz, in dem er sowohl Beuteorganismus von Top-Prädatoren wie Pinguinen, Robben und Walen ist, sowie auch als effizienter Konsument von ausgeprägten Phytoplankton Blüten auftritt (Diatomeen). Die Schottische See ist zusammen mit der

Meeresregion westlich der antarktischen Halbinsel (WAP) das Meeresgebiet das den Großteil der Krillpopulation im Südozean beheimatet (bis zu 70 %). Langzeitdatensätze zur Krilldichte gibt es aus den Sommermonaten der Schottischen See seit den 1920er Jahren. Diese Meeresregion, höchster Krilldichte, zeichnet sich durch hohe Variabilität in der interanuellen sowie regionalen Meereisbedeckung und Nahrungskonzentration aus. Weiterhin ist in der Region ein Rückgang des Meereises in den letzten 20 Jahren zu beobachten.
Im Gegensatz zu Untersuchungen aus den Sommermonaten fanden Krill Studien im Winter, wie *Polarstern* Expedition ANT-XXIII/6 in die Lazarev See, sowie Untersuchungen in der Überganspahse vom antarktischen Winter zum Frühjahr (wie diese geplante Expedition),aufgrund der widrigen Eisbedingungen bisher nur sehr selten statt. Neuere Untersuchungen haben jedoch gezeigt, dass diese beiden Jahreszeiten eine kritische Phase für den Rekrutierungs- aber auch den Laicherfolg von Krill darstellen. Zwei Parameter, die maßgeblich für die Populationsdichte vom Krill verantwortlich sind:

Rekrutierungserfolg
Langzeitdatensätze zur Krilldichte, die in der WAP-Region und in der Schottischen See erhoben wurden, zeigen eine erhebliche Abnahme des Krillbestandes seit Mitte der 1970er Jahre, die mit einem Rückgang der winterlichen Meereisbedeckung assoziiert ist. Die Larvenstadien des Krills entwickeln sich über den Sommer und Winter zum juvenilen Tier im folgenden Frühjahr. Neuere Untersuchungen zur Krillüberwinterung haben gezeigt, dass die Larvenstadien kontinuierlich Nahrung aufnehmen müssen, um ihren Energiebedarf für ihre Entwicklung und ihren Zuwachs zu decken, da sie nur über geringe Lipidreserven verfügen. In den Wintermonaten, wenn kaum Nahrung in der Wassersäule vorhanden ist, spielt das Meereis als Nahrungsquelle für die Larven eine essentielle Rolle. Es ist zurzeit jedoch unklar welche biologischen und physikalischen Meereisbedingungen die Entwicklung und das Wachstum der Larven im Winter fördern.

Laicherfolg
Im Gegensatz zu den Larven haben die erwachsenen Tiere spezifische Überwinterungsmechanismen entwickelt (z. B. Reduktion des Stoffwechsels, der Fressaktivität, des Wachstums, Nutzung von Körperlipiden). Die Reduktion der Soffwechselaktivität während der Wintermonate ist ein sehr effizienter Mechanismus um den Bedarf von Körperenergie in dieser Nahrungsarmen Jahreszeit zu reduzieren. Ein opportunistisches Fressverhalten, geringe Fressaktivität und die Nutzung von Lipidreserven in Kombination mit einer reduzierten Stoffwechselaktivität ermöglichen, dass die Tiere nur langsam ihre Körper–reserven während der nahrungsarmen Wintermonate aufbrauchen. Aufgrund dieser Anpassungsmechanismen scheint das Meereis in den Wintermonaten für den adulten Krill nicht die essenzielle Rolle als Nahrungsquelle zu spielen, wie es bei den Larvenstadien der Fall ist. Am Ende des Winters oder zum Beginn des Frühjahrs, wenn die Lipidreserven gering sind, steigt der Energiebedarf aufgrund der einsetzenden Reproduktionsphase wieder an. In dieser Jahreszeit scheint die autotrophe und heterotrophe mikrobielle Meereisgemeinschaft eine wichtige Nahrungsquelle auch für die adulten Tiere zu sein, um ihren hohen Energiebedarf zu decken.

Erste Ergebnisse haben gezeigt, dass der Verlauf der Stoffwechselaktivität des Krills über das Jahr durch ein endogenes Zeitmesssystem, eine sogenannte „innere Uhr“, kontrolliert zu werden scheint. Diese innere Uhr wird durch die Tageslichtlänge (Photoperiode) als *Zeitgeber* mit der Außenwelt synchronisiert und kann wiederum physiologische und molekulare Funktionen im adulten Krill steuern. Der genaue Zusammenhang zwischen Photoperiode, innerer Uhr und funktioneller Umsetzungen im Krill ist jedoch noch nicht verstanden. Das heißt, es ist bisher z. B. unklar bei welcher Photoperiode, in der Übergangsphase zwischen Winter und Frühjahr wenn der Energiebedarf ansteigt, eine

Zunahme der Stoffwechselaktivität im Krill ausgelöst wird und wie die innere Uhr in der Lage ist die Veränderung der Photoperiode zu registrieren und wiederum physiologische und molekulare Funktionen zu steuern.

Vor diesem Hintergrund sollen auf der Expedition folgende Hypothesen getestet werden:

(1) Eine frühe Meereisbildung im Jahr bedingt eine gut entwickelte autotrophe und heterotrophe mikrobielle Meereisgemeinschaft während des Winters, die als Nahrungsquelle eine erfolgreiche Larvalentwicklung und hohe Wachstumsraten ermöglicht.
(2) Ab einer Photoperiode von ca. 12 Stunden erhöht sich die Stoffwechselaktivität der adulten Tiere.
(3) Die Photoperiode fungiert nicht als Zeitgeber für physiologische und molekulare Funktionen in den Larvenstadien.

Zusätzlich zu den intensiven Untersuchungen an der Schlüsselart Krill werden wir auch die Biologie anderer dominanter Organsimen, die mit dem Meereis assoziiert sind, studieren. Zu ihnen gehören die calanoiden Copepoden, die Rippenquallen, die Salpen sowie das Protozooplankton (z.B. Tintinnen) und das Mikrophytoplankton. Ein intensives biologisches und physikalisches Meereisprogramm sowie die Untersuchungen der proto–zooplanktologischen und phytoplanktologischen Wintergemeinschaft in der Wasser–säule runden das Forschungsprogramm auf der Expedition ab.

Das übergeordnete Ziel der Expedition ist es, die mechanistische Beziehung zwischen der winterlichen Meereisbedeckung und der Kondition des Krill (speziell seiner Larvenstadien), und anderer dominanter Organismen, die mit dem Meereis assoziiert sind, zu untersuchen. Die sich daraus ergebenden Resultate geben Aufschluss darüber, welche Folgen ein klimatisch bedingter Rückgang der Meereisbedeckung im Winter auf die Populationsdynamik des Krill und anderer Zielorganismen hat und welche Auswirkungen Populations–veränderungen auf das pelagische Ökosystem mit sich bringen würden.

Um die gesteckten Ziele umzusetzen, erfolgt die Probennahme auf verschiedenen Transekten vom offenen Wasser bis hin zum Packeis. (siehe Abb.1). Anhand dieser Probennahmestrategie kann die Kondition und Abundanz der Zielorganismen zwischen Regionen mit und ohne Meereisbedeckung und den biologischen und physikalischen Gegebenheiten in den jeweiligen Habitaten verglichen werden. Der Zickzack-Transekt von der antarktischen Halbinsel bis zu den südlichen Sandwichinseln gibt Aufschluss darüber inwieweit Meereisgebiete unterschiedlicher biologischer und physikalischer Ausprägung die Kondition der Zielorganismen beeinflussen. Entlang der Transekte werden verschiedene Netzsysteme eingesetzt (Retangular Midwater Trawl-net, Surface Under Ice-Trawl-net, Bongo-net, Multi-net), um die zu untersuchenden Organismen für experimentelle und/oder analytische Zwecke in verschiedenen Bereichen der Wassersäule zu fangen. In Regionen mit Meereisbedeckung werden Forschungstaucher die Probennahme der Zielorganismen unter dem Eis vornehmen. Dies erfolgt zum einen während mehrtägiger Eisstationen von jeweils 7-10 Tagen, von denen drei geplant sind, sowie während Stationsarbeit auf dem Zickzack-Transekt vom Schlauchboot aus. Die Abundanz, Verteilung sowie das Verhalten der Organismen unter dem Eis wird mit Kamerasystemen, die von den Forschungstauchern bedient werden sowie auf einem ROV montiert sind, dokumentiert.

SUMMARY AND ITINERARY

Cruise leg ANT-XXIX/7 of *Polarstern* will commence on 14 August 2013 in Punta Arenas (Chile) and end on 16 October 2013 in Cape Town (South Africa). The main aim of the voyage will be the study of the condition of Antarctic krill, *Euphausia superba* (hereafter krill), in relation to specific biological and physical sea ice and open water conditions during the transitional phase between austral winter and spring in the Scotia Sea and Northern Weddell Sea (Fig. 1).

Krill shape the structure of the marine Antarctic ecosystem due to their central position within the Southern Ocean food web as prey of a wide range of higher trophic predators such as birds, penguins, seals and wales and as effective grazers on large phytoplankton blooms (Diatoms). The Scotia Sea and the adjacent West Antarctic Peninsula (WAP) are the main population centres of krill in the Southern Ocean and long term krill abundance records, starting in 1920, are available from regions in the Scotia Sea where regularly krill surveys take place during summer (South Georgia, South Orkneys and Elephant Island). In addition, this region is characterised by a decline in sea ice cover during the last 20 years as well as a high degree of inter-annual and regional variability in ice cover and food concentrations. On the other hand, investigations during winter (i.e. ANT-XXIII/6 into the Lazarev Sea) and the transition phase between winter and spring (i.e. the forthcoming voyage) are rare. However, recent investigations provide evidence that both seasons (winter and transition phase) represent a bottle-neck for krill's recruitment and spawning success, and suggest importance of understanding the process in krill during this period.

Recruitment success
Long-term data on krill abundance in the WAP and the Scotia Sea have documented a major reduction in krill density since the mid-1970s, and this decline is associated with reductions in sea ice in this region. Larval krill develop over summer and winter to juveniles until the forthcoming spring. Recent investigations on krill overwintering demonstrated that the larvae have to feed during winter to meet their energy demand for development and growth, because of their low lipid reserves. In the winter months, when the food concentration in the water column is near zero, sea ice plays a vital role as food source for larval krill. In this respect, it is unclear, which biological and physical sea ice conditions promote larval krill development and growth during winter.

Spawning success
In contrast to larvae, adult krill evolved specific overwintering mechanisms such as reduced metabolic -, feeding - and growth activity as well as body lipid utilisation. The metabolic depression during winter is an important and very efficient energy saving mechanism in adults. Opportunistic feeding, low feeding rates and combustion of body stores in combination with a reduced metabolic activity ensure that the animals lose condition only slowly during the winter season. Because of these inherent adaptations, sea ice appears to play only a minor role for adults as food source during winter. However, at the end of winter or beginning of spring, adult krill switch to a high energy mode to fulfil their reproduction process but lipid levels are low from winter depletion. At this period of the year, sea ice appears to become an important feeding ground for adult krill to accumulate lipids and to produce gametes for successful spawning.

First results have indicated that the course of metabolic activity of krill throughout the year is governed by an endogenous timing system, a so called endogenous clock. The internal clock is synchronised with the outside world by the day length (photoperiod) as an environmental *Zeitgeber* and can in turn govern physiological and molecular functions in krill.

However, the exact interconnection between photoperiod, endogenous timing system and specific output functions in krill is still not understood. This means, for example, that it is currently still unclear at which photoperiod, in the transition phase between winter and spring when the energy demand of krill is increasing, krill enter their high-energy mode. It is also unclear by which mechanisms the internal clock is measuring changes in photoperiod and consequently is triggering physiological and molecular functions.

Against this background, we will test the following hypotheses:

1) Early sea ice formation results in favourable feeding conditions for larval krill development and growth.
2) A 12h photoperiod accelerates physiological and molecular function of adult krill.
3) Photoperiod does not act as *Zeitgeber* for physiological and molecular functions in larval krill.
4)

In addition to the intense investigation of the key species krill, we will investigate the biology of other dominant organisms associated with sea ice, such as calanoid copepods, ctenophores and salps, as well as the protozooplankton and mircophytoplankton. An intense biological and physical sea ice program as well as the investigations on the protozooplankton and phytoplankton winter community in the water column will top our investigations off.

The overall aim of the expedition is the investigation of the mechanistic relationship between specific biological and physical sea ice conditions and the condition of krill, especially the larvae stages, and other dominant organisms associated with sea ice. The resulting information will enable the prediction of likely effects of environmental change (e.g. decrease of sea ice) on the organisms under study and the response of the pelagic ecosystem to a shift in species composition.

To meet the goals of our cruise, we will perform sampling from the open water to the ice edge and marginal ice zone (MIZ) into the pack ice and *vice versa* (see MAP 1). Using this sampling approach, we will study the condition and abundance of larval and adult krill as well as other target organism in open water and ice covered regions in relation to the biological and physical conditions of these habitats. The zigzag transect from the tip of the Antarctic Peninsula to the South Sandwich Islands will be performed to sample organisms and to analyse their condition in regions with different intensity of sea ice coverage and different biological and physical environmental conditions. Along transects, we will catch krill and other dominant organisms for experimental purposes employing various net types (Rectangular Midwater Trawl-net, Surface Under Ice-Trawl-net, Bongo-net, Multi-net) from near the sea floor to the surface. Imaging methods will be used to observe krill foraging at the sea floor. A team of scientific Scuba divers will sample our target organisms under sea ice in the MIZ and during ice camp work. Three ice camps of seven to ten days each are planned. Camera systems mounted to a remotely operated vehicle (ROV) as well as camera systems used by the Scuba divers will document the abundance, distribution and the behaviour of krill and other target organisms under sea ice during ice camp work but also in the MIZ. An intense biological and physical sea ice program will set the environmental parameters in relation to the condition of organisms under study.

2. ANTARCTIC KRILL ECOPHYSIOLOGY AND BIOLOGY

2.1 Physiological condition of krill, with emphasis on the larval stages, in relation to biological and physical open water and sea ice conditions

B. Meyer (AWI), L. Auerswald (DAFF), S. Moorthi (UOL), V. Fuentes (ICM-CSIC), S. Kerwath (DAFF), A. Götz (SAEON), M. Teschke (AWI), S. Spahic (AWI), Ulrich Freier (AWI)

Objectives

Former winter studies showed that krill larvae collected from under sea ice are in better condition than individuals caught in open water regions. So far, it is unclear however, which sea ice conditions promote larval krill development to juveniles in the forthcoming spring. Based on these findings, our main objectives are to study the condition of larval krill in relation to different biological and physical conditions in the open water and regions covered by sea ice.

The basic aim of our sampling program is to obtain a detailed description and overview of the dynamics of the physical (e.g. currents, under ice topography, sea ice texture) and biological environment (quantity and quality of food sources in the water column, sea ice-water interface, and in the sea ice) along the transects from the open water into the pack ice and *vice versa*. In combination with the data on abundance, distribution and condition of krill along transects, we will be able to characterise preferred regimes for larval krill development during winter and to identify trophic links between larvae and their potential food sources. In addition, we will be able to quantify which particular ice environments are required for successful development of krill larvae.

These investigations will be carried out in close cooperation with the Biological and Physical sea ice group of Meiners and Nicolaus, respectively, as well as the Kawaguchi, Fuentes and Flores groups.

Work at sea

Parameterization of the biological environment

These physical characteristics of sea ice environment and open water will be related to the quantity and quality (Chl*a* concentration, nitrogen and carbon contents and protein-carbohydrate-lipid levels in the seston) of food available to krill, with emphasis on micro-environments within sea ice (e.g. giving shelter from currents and predators) and whether the food is locked into the ice or available to krill. In order to identify trophic links between larval krill and the available food sources, trophic biomarkers (fatty acids), microscopic - and molecular techniques will be used.

Parameterization of larval krill distribution, abundance and condition

In addition to the parameterization of the physical and biological environment, we will examine the distribution and abundance of krill within sea ice and open water. In open water the sampling program will be based on different net systems (RMT- and Bongo nets). In ice covered regions, krill distribution and abundance under sea ice will be determined via video technique on defined transects by divers and ROV. A multi-level approach was chosen for a detailed investigation of physiological condition of krill larvae in freshly caught animals and onboard experiments (see below). Under sea ice the larvae will be sampled by scuba divers, using the MASMA (MAnguera SubMArina), a motor pump system that worked successfully during our previous winter expedition (AN-XXIII/6) in the Lazareav Sea.

Freshly caught animals will be investigated to determine their condition in terms of:

- Morphometrics (length, dry mass),
- Elemental and biochemical composition (e. g. C, N, protein-carbohydrate-lipid balance, lipid classes and fatty and amino acid contents)
- Metabolic activity (oxygen uptake rates and metabolic enzyme activity)
- Growth rate (instantaneous growth rate method: IGR)
- Feeding activity (digestive gland size and coloration, stomach content analyses by molecular and microscopic techniques).
- Food preferences (microscopic and molecular techniques, fatty acid markers)

The work will be carried out in close cooperation with the Sea ice biology/ROV group, the sea ice physic group (Nicolaus et al.) and the other krill groups on board (Kawaguchi et al., Flores et al.).

Maximum activities of representative enzymes from different catabolic pathways will be determined and put in ratio with each other to estimate the significance of each pathway and to detect shifts between the use of carbohydrates, proteins and lipids from ingested food and body reserves, respectively. A shift from one reserve to another is usually accompanied by an adjustment of the activities of enzymes of the involved catabolic pathways, reducing the capacity of one while increasing that of the other. We selected the following enzymes regarding their position in specific pathways GAPDH (carbohydrate catabolism), HOAD (lipid catabolism) and GluDH, AlaAT, AspAT (protein catabolism).

Expected results

The overall aim is to describe the mechanistic relationship between sea and krill with emphasis on the larva stages to enable the prediction of likely effects of environmental change (e.g. decrease of sea ice).

Data management

See 2.2 .

2.2 Mechanisms of temporal synchronization of Antarctic krill with their environment: Endogenous clocks and biological rhythms at the daily and annual scale

M. Teschke (AWI), B. Meyer (AWI)

Objectives

Krill has evolved rhythmic physiological and behavioral functions, which are synchronized with the cyclic changes of the Southern Ocean ecosystem. These occur over a daily cycle, such as diel vertical migration (DVM), which is believed to allow krill to maximize food intake in the upper water column during the night and minimize predator risk in the deep during the day. In addition, krill exhibits seasonal cycles of metabolic regulation and maturity which are synchronized with the extreme seasonal cycles in environmental factors such as day length, sea ice extent and food availability.

Investigations on adults, field based and in the laboratory, indicate that synchronization between krill and its environment depend upon an endogenous timing system, which facilitates synchronization of its physiology and behaviour to daily environmental cycles but may also play a role for the control of seasonal events during its annual life cycle. The seasonal course of photoperiod in the environment seems to act as an essential *Zeitgeber* that links the endogenous clock with the outside world.

However, in general, our understanding of how circadian clocks of high latitude organisms, such as krill, might have adapted to the strong variability in annual day length (at the extreme ranging from constant darkness in winter to constant light in summer) is limited.
In this sense, three main questions will be the primary objectives during the upcoming expedition:

Do adult krill have a functional rhythmic circadian clock during short day conditions?
Do adult krill carry out DVM during short day conditions and is a functional clock involved?
Do larval krill possess a functional circadian clock?

Work at sea

To address the first two objectives, samples of freshly caught adult krill will be taken at regular intervals (e.g. 3 h) over certain 24 h sampling campaigns and shock frozen for molecular analyses at the AWI. In parallel, by using Multi-Plankton nets, the vertical distribution of krill around the clock will be investigated at discrete depth ranges during these campaigns. Overall, we are planning to perform different 24 h sampling series along a latitudinal gradient (e.g. 65°/60°/55° S) around mid-September to compare different geographical locations at a similar photoperiod ($\Delta \sim 1$h), and along a temporal gradient (beginning *vs.* end of September) to compare different photoperiods at a given latitude.

To test for the existence of a functional circadian clock in larval krill, freshly caught larvae will be maintained in cooling containers under different light-dark cycles and samples will be taken at regular intervals over a 24 h cycle and shock frozen for molecular analyses at the AWI (see above).

The sampling of adult krill will be based on different sampling gears. A multi rectangular midwater trawl type RMT 8+1 harnessed with 4x 4.5 and 0.3mm mesh nets will be used to sample adult krill in open water areas in four discrete depth ranges per time series interval. A Plankton Maxi-MultiNet will be used to perform station-based vertical collections of adult krill at up to 8 different depth ranges per interval. In addition, larval krill will be sampled with a 200µm mesh Bongo net with a 5 litre closed cod end attached. Under sea ice sampling of larval krill will be performed with a zooplankton pump operated by divers.

Expected results

Samples of adult and larval krill around the clock during the polar twilight will be used to identify expression levels of clock and clock controlled physiological target genes by quantitative Polymerase Chain Reaction (qPCR). Comparisons of molecular data from different geographical locations and under different photoperiodic scenarios together with the vertical distribution data of adult krill will foster our insights into the mechanisms of temporal synchronisation of this key species. This is crucial to predict the response of krill to the ongoing environmental changes and, due to its central position, to predict alterations in biodiversity composition and productivity in the Southern Ocean ecosystem.

Data handling of 2.1 and 2.2

Most data will be obtained through laboratory analyses after the cruise. Processed data will be uploaded to the database PANGAEA. Three years after the cruise it is expected that all samples will be analysed and the data entered into PANGAEA. Data will be available to cruise participants directly after analysis.

2.3 Adult krill growth and benthic feeding

S. Kawaguchi (AAD), S. Jarman (AAD), Roland Proud (UTAS)

Objectives

Antarctic krill's life history and annual physiological cycles are evolutionally finely tuned to synchronize the dramatic Antarctic environment. These environments are also known to be spatially and temporary dynamic and these patterns further vary along with climate change. At the same time krill, especially in their post-larval stages, are known for their plasticity of their growth and life style, which is suggested to be the important strategy for the population survival.

Krill growth is one of the most important parameters required for ecosystem management under the Commission for Conservation of Antarctic Marine Living Resources (CCAMLR) regime, and emerging priority agenda for the future CCAMLR management is the potential effects of climate change. Data on distribution and condition of krill in Eastern Scotia Sea is still scarce during the winter period.

By improving our understanding on how environmental conditions, such as quantity and quality of the food as well as photoperiod and temperature, affect krill growth and their condition, we will be able to better model krill growth according to their habitat condition. We especially lack data on the details of feeding and growth from winter/early spring as well as krill from sea floor. The latter was recently suggested to be one of the common habitats for krill.

Detailed objectives are:

- to describe krill demography and large-scale distribution patterns of size groups and maturity stages.
- to collect information on krill growth and condition and relate that to habitat environment, especially quality and quantity of food from open sea, MIZ, ice area, and sea floor.
- to describe the diet of krill from analysis of DNA in stomach contents. Dietary information generated from samples collected on WISKY will be compared to samples collected in other locations and at different times of year.
- to compare gene allele frequencies of krill from the Weddell sea with allele frequencies of krill collected in a variety of other locations.

Work at sea

Krill samples from RMT 1+8 net across the study area will be collected and will be processed for demographic measurement on board (maturity staging and sex, digestive gland size).

We will also use deep-sea krill light trap with camera (capable of 4,000 m depth) at CTD stations to film and collect krill from benthic habitats. Whenever reasonable numbers of live krill in good condition are caught, we will conduct instantaneous growth rate (IGR) experiments. Freshly caught animals will be kept in individual jars and checked regularly for moults for up to 5 d following capture within a flow-through seawater system, and if an animal had moulted, the animal and its moult will be collected and frozen in liquid nitrogen for later analysis. Krill will be preserved for DNA analysis of stomach contents and for population genetics analyses. Echosounder EK60 will be operated throughout the cruise. Echosounder calibration will also be undertaken twice at sea.
The work will be carried out in close cooperation with the Krill group at AWI (Meyer et al.)

Expected results

It is expected that a set of samples for growth rate analysis be obtained from across a range of habitat. These samples are planned to be analysed back ashore. The obtained growth rates will then be analysed in relation to various habitat parameters and observations through ROV during the cruise. We also expect to obtain distribution patterns of krill across the survey area including the sea floor. Krill diet and population genetics will be compared with samples from East Antarctica and from other locations in West Antarctica to generate a broad-scale picture of krill diet. Population genetics analyses will also be expanded by inclusion of these samples to answer the ongoing question of whether different 'stocks' of krill exist.

Data management

Most data will be obtained through laboratory analyses after the cruise. Processed data will be registered and will be available through the Australian Antarctic Data Centre.
pelagic food webs

3. PELAGIC FOOD WEBS

3.1 Sea ice-associated macro-fauna and mega-fauna (*Iceflux* / IMARES)

H. Flores (AWI), Jan Andries van Franeker (IMARES), Carmen David (AWI), N.N. (IMARES), M. van Dorssen (van Dorssen Metaalbewerking)

Objectives

Pelagic food webs in the Antarctic sea ice zone can depend significantly on carbon produced by ice-associated microalgae. Future changes in Antarctic sea ice habitats will affect sea ice primary production and habitat structure, with unknown consequences for Antarctic ecosystems. Antarctic krill *Euphausia superba* and other species feeding in the ice-water interface layer may play a key role in transferring carbon from sea ice into the pelagic food web, up to the trophic level of birds and mammals. To better understand potential impacts of changing sea ice habitats for Antarctic ecosystems, the HGF Young Investigators Group *Iceflux* aims to quantify the trophic carbon flux from sea ice into the under-ice community. This will be achieved by 1) quantitative sampling of the under-ice community and environmental parameters; 2) using molecular and isotopic biomarkers to trace sea ice-derived carbon in pelagic food webs; and 3) applying sea ice-ocean models to project the flux of sea ice-derived carbon into the under-ice community in space and time. ANT-XXIX/7 will provide the first Antarctic bio-environmental dataset for the modelling incentive of *Iceflux*, as well as biological samples for the biomarker approach.

Investigations on the association of krill and other key species with under-ice habitats will be complemented by systematic top predator censuses in order to develop robust statements on the impact of sea ice decline on polar marine resources and conservation objectives.

Work at sea

SUIT sampling

A Surface and Under-Ice Trawl (SUIT) will be used to sample the pelagic fauna down to 2 m under the ice and in open surface waters. During SUIT tows, data from the physical environment will be recorded, e.g. water temperature, salinity, ice thickness, and multi-spectral light transmission. SUIT deployments will be conducted along transects from open water into the closed pack-ice and back. At the planned ice stations / dive camps, SUIT hauls will be conducted on arrival and/or departure to obtain the maximum possible comparability of under-ice species composition and abundance and under-ice sensor data with data collected during the ice stations. Here and elsewhere in areas of high zooplankton abundance, SUIT may be towed for short time periods to sample organisms for experiments and physiological analyses.

Pelagic sampling
In collaboration with the AWI krill group, the group of E. Pakhomov (UBC) and others, we aim to also investigate deeper-dwelling key species of the pelagic food web, such as euphausiids, amphipods, and myctophids. Work will concentrate on a collaborative study of the diel vertical distribution of these organisms using a Multiple opening Rectangular Midwater Trawl (M-RMT) in parallel with SUIT, as well as multinets during ice stations, and *Polarstern's* EK60 echosounder during steaming. In addition, a new type of dip-net will be tested, to sample zooplankton surface swarms from a helicopter, should those be encountered.

Stationary sea ice research
For comparative sampling of physico-chemical and biological properties of the sea ice environment, the *Iceflux* team cooperates in the following activities:
- Sampling of under-ice habitat properties with an ROV (Meiners, Nicolaus et al.)
- Ice-coring, including sea ice POC for biomarker analysis, biomass and production estimates, and biogeochemistry (Meiners & Meyer et. al.)

For later biomarker analysis, samples of phytoplankton, zooplankton, and sea ice biota collected with the CTD rosette, SUIT, other nets and ice corers will be frozen at -80°C on board.

Top predator censuses
During steaming, surveys of top predator densities will be conducted mainly from observation posts installed on the Peildeck. Standard band transect methods are used, with snapshot methodology for birds in flight, and line-transect methods for marine mammals. At stations, top predator surveys will be conducted from a helicopter following rigid grid patterns. In relation to diver safety, any such heli-survey will be combined with closer inspection of the surroundings of the station checking for the presence of Leopards seals.

Data management

Almost all sample processing will be carried out in the home laboratories at AWI and IMARES. This may take up to three years depending on the parameter as well as analysis methods (chemical measurements and species identifications and quantifications). As soon as the data are available they will be accessible to other cruise participants and research partners on request. Depending on the finalization of PhD theses and publications, data will be submitted to PANGAEA and SCAR-MarBIN, and will be open for external use.

3.2 Meso-, macrozooplankton and micronekton ecology

E. A. Pakhomov (UBC), B.P.V. Hunt (UBC)

Objectives

Meso- and macrozooplankton as well as micronekton are important plankton functional groups covering the size range from 0.2 mm to 20 cm, and are responsible for the energy transfer from phytoplankton to top predators. In addition, these functional groups are critical in attenuating vertical, both passive and active, carbon flux acting as major components of the biological pump. Despite their importance and long history of research conducted, there are still major gaps in the understanding of their life cycles, feeding ecology, vertical daily and seasonal migrations, importance of variable carbon sources in their diets and their responses to environmental changes. Such information is particularly scarce in the ice covered regions of the Southern Ocean and even more so for the winter or early spring seasons. Some of these species have already been shown to be sensitive to climate change, particularly warming and acidification. Knowledge gaps in the life cycles and feeding ecophysiology of metazoan plankton can limit our ability to predict their adaptive responses to the changing environment. Indeed some groups, such as pteropods, salps and krill, are recognized to be critical ecosystem indicators of the whole Antarctic pelagic ecosystem functioning. Previous observations have shown that during winter many zooplankton species stay active, creating a situation when their activity exceeds carbon sources available in the water column. It raises the important question of where the energy is coming from and how important the sea ice community is in sustaining pelagic metazoan fauna. Based on these questions above, we would like to carry out an extensive zooplankton and micronekton sampling in the marginal ice zone, within the sea ice and at the APF regions with following main objectives. To:

- characterize meso-, macrozooplankton and micronekton community structure within the marginal ice zone (MIZ), in the sea ice covered region as well as at the Antarctic Polar Front (APF) during the late winter-early spring season;
- study the dynamics of the biomass spectra (vertical, spatial, temporal) of plankton from microplankton through to micronekton in the epipelagic and mesopelagic layers;
- investigate the population biology of major species (including *Salpa thompsoni, Ihlea racovitzai, Euphausia superba, Themisto gaudichaudii* etc.) during late winter-early spring;
- collect information on the winter diet composition of the main zooplankton/micronekton groups (stomach contents, fecal pellets for genetics, stable isotopes);
- estimate *in situ* feeding rates of main herbivorous species;
- measure the metabolic rates of the most numerous zooplankton groups (in collaboration with the Meyer and Fuentes groups);
- study zooplankton vertical migrations during late winter – early spring;
- collect winter APF-MIZ size fractionated particulate organic matter samples for subsequent stable isotope analyses.

Work at sea

Towed sampling gears (multi RMT) will be deployed at the APF region near South Georgia and on the way to Cape Town. Within the MIZ, it will be attempted to deploy the SUIT and multi RMT at the same station (in collaboration with Flores group). Vertical nets will be deployed at all multi-RMT stations and during the ice stations to obtain time series information as well as to collect animals for experiments.

Animals for gut fluorescence will be collected from the top 200 m at every station possible, using any gear type available. Their length will be measured, the pigment content will be extracted in 90 % acetone for 24 - 36 hours and measured fluorometrically. Healthy animals will be used for gut evacuation as well as for fecal pellet production experiments. Freshly produced fecal pellets will be collected in eppendorf tubes and frozen at -80°C for subsequent C/N and pigment content as well as for genetic analyses. Salps, *Themisto* and krill will be counted, sexed, measured and developmental stage identified.

For the biomass spectra, surface and subsurface POM will be size fractionated into 0.7-2, 2-20 and 20 - 64 µm through the serial filtration unit. Bongo (64 and 150 µm) and RMT 1 or large multinet (320 µm) sub-samples will be size fractionated into 64 - 125, 125 - 250, 250 - 500, 500 - 1,000, 1,000 - 2,000 and 2,000 - 4,000 µm size intervals. RMT-8 samples will be analysed entirely and all organisms will be measured.

Vertical migrations will be studied during the ice stations by conducting depth stratified vertical sampling down to 1,500 m using multinets (small and large) every 4 hours throughout a 24 h cycle.

Zooplankton and micronekton taxa will be collected on an ad-hoc basis from all gears for the stable isotope and stomach content analyses.

Samples for zooplankton community structure analysis will be collected from all nets and preserved at sea using formalin for microscopic analysis after the voyage.

Data management

Most data will be obtained through laboratory analyses after the cruise. Processed data will be uploaded to the databases PANGAEA and/or SCAR-MarBIN.

3.3 Process studies on gelatinous organisms

V. Fuentes (ICM-CSIC), S. Piraino (UNI-SAL not onboard), N. Yilmaz (UNI-IST), A. Olariaga (ICM-CSIC), B. Meyer (AWI)

Objectives

Recent investigations have demonstrated that gelatinous mesozooplankton (planktonic cnidarians and ctenophores) represent an important component of the under-ice winter community. However, our knowledge of the biology of Antarctic gelatinous plankton, their overwintering and their role in the Southern Ocean food web remain sparse, due to the difficulties in sampling and handling of these fragile animals. Therefore our main aim on the expedition is to study the species composition as well as the abundance, distribution and condition of gelatinous organisms in relation to their biological and physical environment. Moreover, recent investigations in the Arctic showed the first record of sympagic hydroids (Hydrozoa, Cnidaria) in Arctic coastal fast ice. The cnidarian fauna within Antarctic sea ice is not explored yet and will be a specific focus on the upcoming expedition.

Work at sea

For studying the condition of gelatinous organisms in relation to biological and physical open water and sea ice condition we will use a similar sampling and analytical approach as described for larval krill (see above). In the open water, to collect gelatinous organism in good physiological condition we will use a 1m ring net with a 20l closed cod, whereas in ice covered regions, the sampling will be performed by scuba divers. Sampling of the sympagic community in sea ice will be carried out by using ice cores.

This work will be performed in close cooperation with the Pakhomov group.

Data management

Data will be forwarded to open-access data repositories: PANGAEA and faunistic data to *ANTABif* (Antarctic Biodiversity Information Facility; former SCAR-MarBIN).

4. SEA ICE STUDIES

4.1 Floe-scale ice algal distribution and under-ice krill observations using an instrumented Remotely Operated Vehicle (ROV)

K. Meiners (AAD), S. Kawaguchi (AAD), S. Jarman (AAD), ROV technicians (AAD)

Objectives

Sea ice is an important factor in determining the structure of the Southern Ocean and plays a pivotal role in the biogeochemical cycles of Antarctic marine ecosystems. The sea ice cover greatly affects the exchange of energy and material between the ocean and the atmosphere, and provides a vast habitat for a diverse assemblage of organisms. Sea ice algae production is considered to contribute significantly to ecosystem primary production, accounting for up to 25 % of overall primary production in ice-covered waters. Sea ice algal distribution is highly patchy and classical sampling methods, e.g. ice coring, are insufficient to properly quantify ice algal on the sea ice floe-scale. Sea ice communities provide an important food source for pelagic herbivores during winter and early spring, when food supply in the water column is very low. There is a close relationship between the extent of winter sea ice and the subsequent recruitment and abundance of Antarctic krill (*Euphausia superba*) in certain areas of the Southern Ocean. The mechanism proposed for this relationship hinges on the reliance by krill, particularly krill larvae and juveniles, on the algal communities, which grow at the subsurface of ice. Krill have been observed feeding on sea ice microbial communities, particularly in late winter, but whether this community is a major food source over the entire range of krill and throughout the winter is uncertain. To study the relationships between sea ice physical properties, ice algae and krill, our research project addresses the following objectives:

1) Estimate floe-scale sea ice algal biomass distribution from under-ice irradiance measurements using an instrumented Remotely Operated Vehicle (ROV),
2) observe and analyse under-ice topography and krill distribution with ROV mounted sonar, and video- and stills camera systems,
3) measure physical, biogeochemical and biological sea ice parameters using ice coring surveys to ground-truth ROV observations.

Work at sea

We will carry out under-ice observations by deploying a ROV instrumented with up-ward-looking altimeter, video cameras and radiometer. The ROV will provide video footage of under-ice fauna and will also collect transmitted under-ice irradiance spectra, which will be used to estimate ice algal biomass. Positioning of the ROV will be carried out using a Long Base line transponder array deployed from, and marked at, the surface of the ice floe. This allows for merging of the ROV data with surface data sets into the same relative floe-scale spatial grid, facilitating ground-truthing of ROV data as well as cross-disciplinary analysis. Planned surface measurements include determination of snow thickness and point measurements (ice coring) for physical and biological sea ice properties.

This work will be performed in close cooperation with the Meyer group.

Data management

Most data will be analysed after the cruise. Processed data will be registered and will be publicly available through the Australian Antarctic Data Centre.

4.2 Sea ice physics

M. Nicolaus (AWI, not on board), S. Hendricks (AWI, not on board), R. Ricker (AWI), P. Hunkeler (AWI), M. Schiller (AWI), S. Schwegmann (AWI, not on board)

Objectives

The annual mean sea-ice extent in the Southern Ocean shows a slight increase over the last three decades, but interannual changes in the five individual sectors are quite different. The Amundsen-Bellingshausen Sea is the only sector with a strong decrease while there is no significant trend in the Weddell Sea. The causes for this different and partially contrary behaviour are related to atmosphere and ocean interaction, but are not well understood yet and need more profound investigations. During ANT-XXIX/7 we will continue measurements from earlier expeditions to the Weddell Sea, in particular those from the previous leg ANT-XXIX/6, where we investigate the state and interactions between various sea-ice parameters in the Weddell Sea.

Hence, our measurements contribute to investigate seasonal and interannual variability as well as changes of the sea ice mass balance on regional scales. To fulfil this goal, the sea-ice-thickness distribution will be observed on different scales from few meters to several kilometres by different methods. This data set will identify the actual state of the sea ice and will also serve a valuable tool for the validation of satellite-based and simulated sea-ice thickness distributions.

Snow on sea ice strongly influences sea-ice mass balance and in particular also the observational methods to quantify sea-ice thickness. At the same time information on snow is sparse in the Southern Ocean. Therefore, extensive measurements of snow depth, physical properties, and stratigraphy will be conducted.

General information on the state of the sea ice and snow cover will also be recorded by visual observations of key sea-ice parameters in combination with meteorological conditions. These data will contribute to the data base of the Antarctic Sea Ice Processes and Climate (ASPeCt) program.

Work at sea

Sea-ice thickness distributions will be measured along the cruise track by means of helicopter surveys carrying an EM-Bird. Additionally, information on the surface roughness will be obtained by laser altimetry. A nadir-looking aerial camera will indicate the general surface conditions. These measurements will be performed as often as possible in order to obtain a dense grid of measurements and will last about 2 hours per flight.

Continuous visual observations of the sea ice and meteorological conditions will be made on an hourly basis from the ships bridge by trained observers. A camera system will be used to additionally document sea ice conditions during the cruise to support these observations. Those data will contribute to the ASPeCt data base.

The physical properties of the sea ice and snow cover will be assessed during all ice stations. These measurements will include:

- Ground-based EM-measurements for high resolution ice-thickness data.
- Manual thickness measurements through drilling to obtain ratios of sea-ice freeboard, draft, and thickness.
- Snow stratigraphy and physical snow properties will be obtained from snow pits.

Data management

Sea-ice thickness and snow-depth data, aerial photos from helicopter surveys, physical properties of snow and sea ice as well as sea-ice observations will be post-processed and delivered to PANGAEA within one year after the cruise. Sea-ice thickness data from the EM measurements will be additionally submitted to the Sea Ice Thickness Climate Data Record.

4.3 DMSP (dimethylsulfoniopropionate) degradation and DMS (dimethylsulfide) production under sea ice during zooplankton grazing

E. Damm (AWI), J. Ciomber (AWI, not on bard)

Objectives

Air - sea ice - ocean interactions in the Polar Regions have a substantial impact on the oceanographic regime, natural biogeochemical cycles and global climate. However, our understanding of the fundamentals of the associated surface chemical, physical, and biological exchange processes that occur at relevant interfaces, particularly those associated with sea ice, is very limited. Changes in brine salinity and salt precipitation/dissolution cycles affect the solubility of gases (minor direct relationships for most gases, but quite dramatic, indirect relationships for carbon and sulphur dioxides) and organic solutes. These relationships dictate the physical controls on mass, gas and energy fluxes operating within the ocean-sea ice-atmosphere system and hence play an important role in chemical exchange across the sea ice interface.

DMSP is an abundant methylated substrate in the surface ocean and large amounts are produced annually by marine phytoplankton and in sea ice by ice algae, respectively. Hence, the DMSP turnover plays a significant role in carbon and sulphur cycling in the surface ocean and in sea ice. Especially, an understanding of the role of these methylated substrates in sea ice is still lacking. Demethylation dominates dissolved DMSP consumption and leads to formation of MMPA (3-mercaptopropionate) and subsequently methanethiol (MT). Cleavage of DMSP can be carried out by bacteria or by phytoplankton, and leads to formation of DMS (dimethylsulfide). DMS partly escapes to the atmosphere where it is oxidized to sulphuric acid and methanesulfonic acid. These sulfur-containing aerosols serve as cloud condensation nuclei altering the global radiation budget. Thus, DMS may exert a cooling (negative) effect on earth’s climate. The cycling of DMS and DMSP in the marine environment is controlled by bacterial activities and phytoplanktonic enzymes but also by zooplankton grazing. Under ice zooplankton grazing may also act as a sink for DMSP produced in sea ice. Experiments with grazing krill are planned to test the DMS/P acquiring from their phytoplanktonic food. As DMSP cleavage produces also acrylic acid, a broad spectrum antibiotic, its potential concentrating in their cells as a means to photo-protect delicate cells will be tested just as DMS that may act as an antioxidant neutralising oxygen radicals and therefore may also contribute to protect cells.

Work at sea

DMS and DMSP, particulate and dissolved, will be measured in seawater, sea ice and in compartments of zooplankton with emphasis on krill. Water samples will be collected in Niskin bottles mounted to a rosette sampler at discrete depths throughout the water column up to 200 m water depth on several stations along transects. Ice cores and brine will be collected at one-year and multi-year sea ice, respectively. Sea ice cores will be returned to the vessel where they will be sectioned and melted at 4°C. In addition, DMSP will be analysed on compartments of zooplankton. DMS analyses will be carried out directly on board by gas chromatography equipped with a pulsed flame photometer (PFPD) and a purge and trap system. DMSP total will be measured after alkaline cleavage as DMS. DMSP dissolved will be filtered before cleavage. DMSP particulate results from the difference of total and dissolved DMSP.

The DMS and DMSP work focus on different zooplankton organisms will be performed in cooperation with the Meyer group.

Expected results

The investigations proposed here focus on assessing sinks of DMS and DMSP in the Southern Ocean and on the processes controlling the cycling of DMS in the polar marine environment.

Data management

Most data will be obtained through laboratory analyses during the cruise. Processed data will be uploaded to the database PANGAEA.

4.4 Biogeochemistry of calcium carbonates from sea ice

G. Nehrke (AWI), J. Göttlicher, (KIT) G. Dieckmann (AWI, not onboard), N. Gussone (IMM)

Objectives

The aim of the Biogeochemistry group is to contribute to the understanding on how the geochemical signatures of the calcium carbonate mineral ikaite and the calcium carbonate test of the foraminifera pachyderma are related to their physicochemical environment, the brine within Antarctic sea ice.

We propose a science program to determine the distribution of ikaite, especially the areal distribution under the sea ice. The latter will allow investigating the possibility of ikaite entering the underlying water column. The comparison with data obtained from sea ice cores will allow to determine the spatial distribution of ikaite in sea ice, which will enable quantifying the effect of ikaite formation and dissolution on the carbon cycle. Concurrently, the geochemistry of the pachyderma will be analysed to determine to what extend their intermittent presence in the brine channels effects their shell geochemistry. The shell geochemistry of pachyderma represents an important proxy archive for paleo climate reconstruction in the Antarctic realm.

Work at sea

Ice core sampling will be used to obtain ikaite and foraminifera samples from the Sea ice. The cores will be processed onboard to extract the crystals and shells. Furthermore, ice core segments will be centrifuged to obtain samples for later geochemical analysis. The geochemical parameters which will be measured on these samples are salinity, DIC, pH, alkalinity, and element concentrations for Mg and Sr. The ikaite crystals and shells will later be analysed for their Mg and Sr content, too.

For the first time scratch samples from under the ice will be taken by scuba diving to investigate the areal distribution of ikaite under the ice. Crystals present under the sea ice are probably lost by the classical sampling methods (ice coring).

Expected results

- To identify the distribution of ikaite at the sea ice- water interface, to determine if the
- "escape" of crystals from the sea ice is a realistic scenario in the ongoing investigate of its role in Polar sea ice.
- Determining the element fractionation (Mg and Sr) between brine and ikaite to identify if this data can provide information on the conditions of formation.

Data management

Data on ice core analyses including biogeochemical properties will be post-processed and delivered to PANGAEA within two years after the cruise. Before, this data will be available to cruise participants. Archive cores from all ice stations will be archived in the cold storage facilities of the Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research.

5. PHYTOPLANKTON AND PROTOZOOPLANKTON STUDIES

5.1 Winter plankton and particulate matter stocks and composition

C. Klaas (AWI), D. Wolf-Gladrow (AWI), S. Moorthi (ICBM-UOL), 2NN

Objectives

The Atlantic sector of the Southern Ocean encompasses several key open ocean areas sustaining, among others, a large proportion of the krill stocks found around the Antarctic continent. However, only a handful of studies, in restricted areas of the Atlantic sector (mainly marginal ice zone in the Weddell-Scotia confluence and Weddell-Sea) have investigated conditions at the start of the growth season. Our purpose is, therefore, to extend the spatial coverage on bacteria and protist (phyto and protozooplankton) biomass distribution and composition to key open-ocean areas in the Atlantic sector of the Southern Ocean at the beginning of the growth season. Basic data on bacteria and protist distribution will be complemented by the study of phytoplankton (diatoms) *in situ* growth rates, nanoplankton (heterotrophic and mixotrophic) grazing rates and particulate matter biomass and composition in order to better understand seasonal dynamics and biogeochemical impacts of phytoplankton production in the Southern Ocean.

Further, as part of a biogeochemical study in the Georgia Basin, moored sediment traps deployed in 2012 (AWI-K01) at 52°15.27'S and 40°29,95'W will be recovered and replaced.

Work at sea

Discrete 200 ml water samples for microscopic analyses of protist assemblage composition and biomass will be obtained from Niskin bottles attached to a Conductivity Temperature Depth (CTD) rosette from 8 discrete depths between 10 and 200 m depth at each station. One set of samples will be preserved with hexamine-buffered formalin solution and one with acidic Lugol's iodine at a final concentration of 2 % and 10 %, respectively. Species-specific growth rates of diatoms will be estimated from 24 hours on-deck incubation of undisturbed surface (10 m depth) water samples collected from the Niskin bottles attached to the CTD rosette after staining with the fluorochrome PDMPO that binds to the newly deposited silica during cell division. The difference between *in situ* growth rates determined with the PDMPO technique and the actual accumulation rates of individual species populations during the cruise will allow a quantitative estimate of the loss rates acting on individual species populations.

Water samples for flow cytometry, Chlorophyll *a* (Chl*a*), biogenic silica (BSi), particulate and dissolved organic carbon and nitrogen (POC, PON, DOC and DON) determination will be obtained from the same bottle and depth as for microscopic analysis. Flow-cytometry samples (5ml) will be preserved at 1 % with formaldehyde and stored at -20°C until analysis of bacteria, and photo- and heterotrophic pico- and nanoplankton abundances. Chl*a* samples (1 - 2 L) will be filtered onto 25 mm diameter GF/F filters and stored at –80°C for analysis in the home laboratory.

1 to 2 litres seawater samples for BSi will be filtered onto 25 mm diameter polycarbonate filters and stored in plastic (PE) petri dishes. Similar samples will be filtered onto pre-combusted GFF filters and stored in pre-combusted glass petri dishes for POC and PON analysis. After filtration all filters will be dried overnight at 50°C and stored frozen (-20°C) for further analysis on land.

About 60 ml samples for DOC and DON analysis will be filtered onto 25 mm diameter pre-combusted GFF filters using a HCL-cleaned glass filtration unit. The procedure is repeated 3 times in order to rinse the vials and the filtration unit, keeping the last filtrate for analysis. The final filtrate will be collected directly into HCL-rinsed plastic (HDPE) bottles and frozen (-20°C) for further analysis on land.

Furthermore, triplicate 2 L water samples will be taken from the same depths to conduct uptake grazing experiments using fluorescent tracers to determine consumption rates of heterotrophic and mixotrophic protistan consumers. Fluorescent tracers will be incubated with the natural plankton communities and 100ml subsamples taken after 10 min, 30 min, 1 h, 2 h and 4 h, which will be fixed at 1% with Glutaraldehyde. Samples will be filtered on 2 µm polycarbonate membrane filters and will be mounted on slides for the analysis of heterotrophic and mixotrophic consumers with ingested fluorescent prey via epifluorescence microscopy.

Data management

Data will be delivered to PANGAEA after analysis and processing (within three years and depending on analysis). Data will be available to cruise participants directly after analysis.

6. CHEMISTRY

6.1 Atmospheric chemistry

H.-W. Jacobi (LGGE), M. Nerentorp (Chalmers), J. Zielcke (UHD), J. Nasse (UHD)

Objectives

We will participate in the two cruises ANT-XXIX/6 and 7 with an atmospheric/snow/sea ice project based on international collaboration involving six different groups from four different countries including Laboratoire de Glaciologie et Géophysiqe de l'Environnement LGGE and Laboratoire Interdisciplinaire de Physique LIPhy (both CNRS / University Joseph Fourier – Grenoble 1), British Antarctic Survey, Chalmers University of Technology Gothenburg, University of Gothenburg, and University of Heidelberg. The different groups will perform continuous atmospheric measurements of aerosols, ozone, halocarbons, mercury and mercury compounds in the atmospheric boundary layer. We will further perform for the first time *in situ* measurements of reactive halogens over sea ice-covered areas using a laser-based instrument from LiPhy Grenoble and a cavity enhanced DOAS instrument from the University of Heidelberg. Moreover, the chemical composition of all different components of the ocean and cryosphere like snow, sea ice, and sea water will be determined to study the role of these different compartments on the release of sea salt aerosols and reactive halogen and mercury compounds to the atmosphere. The objective of the project is to better quantify the role of the Weddell Sea as a source of sea salt or halogenated compounds and the chemical processing of sea salt generating reactive halogens. Mercury will further be studied as an example of the impact of the halogens on the cycling of pollutants in the sea ice region. The analysis of all measurements will help to elucidate the role of the halogens in the depletion of ozone and mercury in this region and the contribution of the Weddell Sea to the sea salt burden in Antarctica.

Work at sea

Two major types of measurements will be performed: (1) continuous atmospheric and surface sea water measurements and (2) sampling of snow, sea ice, and sea water during stations with either direct access to sea ice floes from the ship or using helicopters.

Continuous atmospheric measurements will be performed with laser cavity ring down instruments and cavity-enhanced DOAS spectrometer suitable for *in situ* measurements of concentrations of BrO, IO and NO_2. Furthermore, ozone, halocarbons, total gaseous mercury (TGM) and further mercury species will continuously be observed using commercial detectors and techniques. The halocarbons will include a full range of chlorine, bromine, and iodine containing compounds. *In-situ* BrO, IO, OClO, ozone and NO_2 as well as BrO and IO vertical profiles will be further detected using active and passive DOAS instruments. All detectors will be mounted to one of the uppermost decks of the ship in front of the smoke stack to reduce periods with potential contamination. In addition, aerosols will be collected on filters to determine the bulk and size-segregated chemistry and potentially N and O isotopes of particulate nitrate. Further measurements include the size spectrum of aerosol and blowing snow, as well as the salinity and chemistry of blowing snow. Mercury and halocarbon measurements in seawater will further be performed continuously during the trips using the direct sea water supply of the ship or in samples collected with the CTD system. The instruments will be installed during ANT-XXIX/6 and many will continue during the following cruise ANT-XXIX/7.

Snow, sea ice, and sea water samples will be taken at stations throughout the cruises. Snow samples will include surface snow as well as snow pits. Theses samples will be analyzed for salinity and after return for a more detailed analysis of major and minor sea salt components using ion chromatography. Moreover, further snow and sea ice samples will be analyzed regarding dissolved gaseous mercury, total mercury, methyl mercury, and halocarbons. The sampling of snow and sea ice will be performed in close collaboration with the sea ice physics group.

Expected results

- Determination of spatial and temporal variability of trace gases like BrO, NO2, ozone, and gaseous elemental mercury
- Better characterization of the source of reactive halogen species and relationship of the formation of halogen compounds with meteorological and sea ice processes
- Chemical characterization of different snow and sea ice types
- Improved understanding of the mercury cycling in the atmosphere/sea-ice/ocean system

Data management

Quality-controlled data of the continuous atmospheric and seawater measurements will be made available in public data bases (e.g. PANGAEA) in the form of time series with the maximum available temporal resolution after publication in peer-review literature. Similarly, published results regarding the analysis of snow, sea ice, and seawater will also be made available.

7. TEILNEHMENDE INSTITUTE / PARTICIPATING INSTITUTIONS

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AAD	Australian Antarctic Division 203 Channel Hwy, Kingston, Tasmania 7050 / Australia
AWI	Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung Postfach 120161 27515 Bremerhaven / Germany
Chalmers	Chalmers University of Technology SE-412 96 Gothenburg / Sweden
DAFF	Department of Agriculture, Forestry and Fisheries Branch: Fisheries Management Private Bag X2 Rogge Bay 8012 (Cape Town) / South Africa
DOX	DOX PRODUCTIONS, 84 ADDISON GARDENS W14 0DR, LONDON / Great Britain
DWD	Deutscher Wetterdienst Geschäftsbereich Wettervorhersage Seeschifffahrtsberatung Bernhard Nocht Str. 76 20359 Hamburg / Germany
FIELAX	FIELAX Gesellschaft für wissenschaftliche Datenverarbeitung mbH Schleusenstraße 14, 27568 Bremerhaven / Germany
HELISERVICE	HeliService international GmbH SERVICE Am Luneort 15 27572 Bremerhaven / Germany
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	Adresse / Address
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IUPH	Institut für Umweltphysik Heidelberg Im Neuenheimer Feld 229 D-69120 Heidelberg / Germany
KIT	Karlsruher Institut für Technologie (KIT) Institut für Synchrotronstrahlung (ISS) Geb. 329 Hermann-von-Helmholtz-Platz 1 D-76344 Eggenstein-Leopoldshafen / Germany
LGGE	Laboratoire de Glaciologie et Géophysique de l'Environnemer 54 rue Molière 38402 - Saint Martin d'Hères cedex / France
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SAEON	South African Environmental Observation Network Elwandle Node 18 Somerset Street Private Bag 1015 Grahamstown 6140 / South Africa
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UHD	Universität Heidelberg Grabengasse 1 69117 Heidelberg / Germany
UNI-IST	Istanbul University, Institute of Marine Sciences and Management Muskule Sok, No:1, Vefa, 34116 Istanbul / Turkey
UTAS	University of Tasmania Private Bag 49 Hobart TAS 7001 / Australiea

8. FAHRTTEILNEHMER / CRUISE PARTICIPANTS

Name/ Last name	Vorname/ First name	Institut/ Institute	Beruf/ Profession
Albrecht	Götz	SAEON	Biologist
Bose	Aneesh	AWI	Student
Auerswald	Luz	DAFF	Biologist
Damm	Ellen	AWI	Geo-Chemist
David	Carmen	AWI	Biologist
Dorssen		IMARES	Technican
Franeker van	Jan Andries	IMARES	Biologist
Freier	Ulrich	SC	Biologist
Fuentes	Veronica	ICM-CSIC	Biologist
Göttlicher	Jörg	KIT	Mineralogist
Hempelt	Juliane	DWD	Technician
Hölscher	Jana	AWI	Technician
Hunt	Brian	UBC	Biologist
Jacobi	Hans-Werner	LGGE	Chemist
Jarman	Simon	AAD	Biologist
Kawaguchi	So	AAD	Biologist
Kerwath	Sven	DAFF	Biologist
Klaas	Christine	AWI	Biologist
Krieger	Malte	UOL	Student
Krumpen	Thomas	AWI	Physicist
Lamb	Simon	DOX	Cameraman
Mattfeldt	Tobias	AWI	PhD student, Biology
Meiners	Klaus	AAD	Biologist
Meyer	Bettina	AWI	Biologist
Miller	Max	DWD	Meteorologist
Milnes	Mark	AAD	Technician
Moorthi	Stephani	ICBM-UOL	Biologist
Nasse	Jan-Marcus	IUPH	Physicist
Nehrke	Gernot	AWI	Mineralogist
Nerentorp	Michelle	Chalmers	PhD student, Chemistry
Olariaga	Alejandro	ICM-CSIC	Engineer
Pakhomov	Evgeny	UBC	Biologist
Proud	Roland	UTS	PhD student Physic
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Teschke	Mathias	AWI	Biologist
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Wolf-Gladrow	Dieter	AWI	Physicist
Yilmaz	Noyan	UNI-IST	Biologist
Zielcke	Johannes	IUPH	Physicist
NN		AWI	PhD student, Biology
NN		AWI	Student, Biology
NN		AWI	Student, Geo-Chemistry
NN		AAD	Technician
NN		OPTIMARE	

NN	IMARES	PhD student, Biology
NN	SC	Technician

9. SCHIFFSBESATZUNG / SHIP'S CREW

Name	Rank
Schwarze, Stefan	Master
Grundmann, Uwe	1.Offc.
Farysch, Bernd	Ch.Eng
Fallei, Holger	2.0ffc
Langhinrichs, Moritz	2.0ffc.
Peine, Lutz	3.0ffc.
Pohl, Claus	Doctor
Hecht, Andreas	R.Offc.
Grafe, Jens	2.Eng.
Minzlaff, Hans-Ulrich	2.Eng.
Holst, Wolfgang	3.Eng.
Scholz, Manfred	Elec.Tech.
Riess, Felix	Electron.
Hu ttebräucker, Olaf	Electron.
Nasis, Ilias	Electron.
Himmel, Frank	Electron.
Loidl, Reiner	Boatsw.
Reise, Lutz	Carpenter
Scheel, Sebastian	A.B.
Brickmann, Peter	A.B.
Winkler, Michael	A.B.
Hagemann, Manfred	A.B.
Schmidt, Uwe	A.B.
NN	A.B.
Wende, Uwe	A.B.
Bäcker, Andreas	A.B.
Preußner, Jörg	Storekeep.
Teichert, Uwe	Mot-man
Schü tt, Norbert	Mot-man
Eisner, Klaus	Mot-man
Voy, Bernd	Mot-man
Pinske, Lutz	Mot-man
Müller-Homburg, Ralf-Dieter	Cook
Silinski, Frank	Cooksmate
Martens, Michael	Cooksmate
Czyborra, Bärbel	1.Stwdess
Wöckener, Martina	Stwdss/KS'
Gaude, Hans-Jü rgen	2. Steward
Silinski, Carmen	2.Stwdess
Arendt, Rene	2.Stwdess
Möller, Wolfgang	2. Steward
Sun, Yong Shen	2. Steward
Yu, Kwok Yuen	Laundrym.