Expeditionsprogramm Nr. 76

FS POLARSTERN

ANT-XXIII/6

ANT-XXIII/7

Koordinator:
Dr. E. Fahrbach

Fahrtleiter:

ANT-XXIII/6
Prof. Dr. U. Bathmann

ANT-XXIII/7
Prof. Dr. P. Lemke

NG ALFRED-WEGENER-INSTITUT FÜR POLAR-
UND MEERESFORSCHUNG
DER HERMANN VON HELMHOLTZ-GEMEINSCHAFT
DEUTSCHER FORSCHUNGSZENTREN E.V. (HGF)

BREMERHAVEN, JUNE 2006

EXPEDITIONSPROGRAMME No. 76

RV POLARSTERN

ANT-XXIII/6

17 June 2006 - 21 August 2006
Cape Town - Cape Town

ANT-XXIII/7

24 August 2006 - 29 October 2006
Cape Town - Cape Town

Coordinator:
Dr. E. Fahrbach

Chief Scientists:

ANT-XXIII/6: Prof. Dr. U. Bathmann
ANT-XXIII/7: Prof. Dr. P. Lemke

INHALT / CONTENTS

ANT-XXIII/6

17 June 2006 - 21 August 2006
Cape Town - Cape Town

Chief Scientist:
Ulrich Bathmann

CONTENTS

1. ÜBERBLICK UND FAHRTVERLAUF

U. Bathmann (AWI)

Am 17. Juni 2006 wird FS *Polarstern* von Kapstadt aus zum sechsten Fahrtabschnitt ihrer 23. Antarktis-Expedition auslaufen. Während des Fahrtabschnittes wird sie als Basis für die Durchführung eines umfangreichen marinen Forschungsprogramms während des antarktischen Winters dienen. Enden wird der Fahrtabschnitt am 21. August 2006 in Kapstadt.

Um das Arbeitsgebiet in der eisbedeckten Lazarew-See so früh wie möglich zu erreichen, wird FS *Polarstern* nach Auslaufen von Kapstadt direkten Kurs zur ersten Position bei 52°S 3°E nehmen. Nur einige Forschungsarbeiten, die während der Fahrt durchgeführt werden können, werden schon nach Ablaufen aus Kapstadt beginnen.

Bei den Arbeiten während der Fahrt handelt es sich um Beobachtungen mariner Wirbeltiere (Seevögel, Robben, Wale). Ein holländisches Team wird Beobachtungen von Seevögeln einschließlich Pinguinen vom Peildeck des Schiffes aus 2 Beobachtungskojen heraus bei Tageslicht vornehmen. Zählungen von Walen und Robben werden von einem von der Internationalen Walfang-Kommission (International Whaling Commission, IWC) gestellten Beobachter vorgenommen werden. Der IWC-Beobachter wird zudem diverse Parameter zur Charakterisierung der Meereisbedeckung aufzeichnen. Parallel zu den visuellen Beobachtungen mariner Säuger werden auf der Anreise zwei verschiedenartige automatisierte Überwachungssysteme eingesetzt. Das eine System basiert auf speziellen passiven Hydrophon-Ketten, die vom Schiff geschleppt werden. Das andere nutzt Infrarot-Kameras, die im Krähennest montiert mit einer Bildverarbeitungs-Software betrieben werden und es erlauben, den warmen Wal-Blas auch bei Dunkelheit und schlechten Sichtverhältnissen zu erkennen.

Nur nördlich der Ausbreitungsgrenze von Meereis ist der Einsatz eines sammelnden Schleppsystems, dem Continous Plankton Recorders (CPR) möglich. Der CPR fängt oberflächennahes Zooplankton mittels eines hinter dem Schiff geschleppten Systems.

Das marine Hauptmessprogramm beginnt an der nördlichsten Station eines aus 4 Transekten bestehenden Messgitters. Die vom BMBF geförderte Lazarew-See KRIII Studie (LAKRIS), einem deutschen Beitrag zu SO-GLOBEC, bildet den Kern dieses Programms.

SO-GLOBEC (Southern Ocean Global Ocean Ecosystems Dynamics) ist ein internationales und multi-disziplinäres Wissenschaftsprogramm, das ein besseres Verständnis der physikalischen und biologischen Faktoren, die Wachstum und Reproduktion und den Überwinterungserfolg von antarktischem Krill (*Euphausia superba*) beeinflussen, anstrebt. LAKRIS zielt darauf ab, Prozesse der saisonalen Populationsdynamik und die physiologische Kondition von Krill in einem interdisziplinären Ansatz zu quantifizieren, und zwar in einer Region, die bisher nur wenig beprobt und hinsichtlich ihrer Bedeutung für die Krillbestände fast unbekannt ist.

Im Wesentlichen stammt unser Wissen über den antarktischen Krill aus nur wenigen Gebieten, insbesondere dem um die Antarktischen Halbinsel. Es verdichten sich aber die Hinweise, dass die saisonalen Überlebensmechanismen variabel sind, dass weder die lokalen Umweltfaktoren noch die Reaktion von Krill darauf auf ein größeres umgebendes Gebiet extrapoliert werden dürfen. Mit dem LAKRIS-Projekt sollen Messungen, die im Rahmen von SO-GLOBEC und von CCAMLR (Convention for the Conservation of Antarctic

Marine Living Resources) auf der Westseite der Antarktischen Halbinsel, im Südantillenmeer und im Indischen Sektor des Südpolarmeeres vorgesehen sind, durch detaillierte Untersuchungen in der Lazarew-See ergänzt werden.

Innerhalb des Wasserringes um die Antarktis gibt es unter anderem zwischen der Antarktischen Halbinsel und dem Nullgrad-Meridian, bzw. der Lazarew-See, ein Gebiet mit anscheinend erhöhten Konzentrationen von Krill. Ob diese offenbare Krillansammlung einem einzigen Krillbestand oder mehreren verschiedenen Beständen zuzuordnen ist, ist unklar. Strittig debattiert wird gegenwärtig auch, wie und ob dieser Bestand bzw. diese Bestände mit denen in anderen Abschnitten des Südpolarmeeres in Verbindung stehen. Untersuchungen in der Lazarew-See sollen zur Klärung dieser Fragen entscheidend beitragen.

Wenn Krill mit Meeresströmungen in das Weddellmeer eingetragen wird, dann am wahrscheinlichsten im Bereich der Lazarew-See, wo, zusammenfallend mit der Ostflanke des Weddell-Wirbels, südwärtige Strömungen angetroffen werden. Entlang des Nullgrad-Meridians kommt Krill zwischen dem 50. südlichen Breitengrad und der antarktischen Küste bei 70°S vor. Dies stellt die weiteste Nord-Süd-Verteilung von Krill im gesamten zirkumpolaren Südpolarmeer dar. Nördlich von 60°S ist Krill dem ostwärts versetzenden Zirkumpolarstrom unterworfen; Krill, der hier angetroffen wird, befindet sich also stromab der bekanntermaßen großen Bestände des Südantillenmeeres. Aus dem Bereich weiter südlich in Nähe des Kontinents, wo in der Lazarew-See westwärtige Strömungen vorherrschen, gibt es kaum Informationen über das Vorkommen von Krill-Larven. Diese müssten hier aber vorkommen, wenn eine Rezirkulation von Krill mit dem Weddell-Wirbel in das Südantillenmeeres postuliert wird.

Das im Rahmen von LAKRIS vorgesehene Messprogramm verteilt sich auf drei Forschungsfahrten zu verschiedenen Jahreszeiten, von denen diese hier die zweite ist - abgesehen von einer Pilotstudie, die bereits mit der FS *Polarstern*-Reise ANT-XXI/4 erfolgreich absolviert wurde. Die jetzige Reise ANT-XXIII/6 ist die erste Winterreise des Projektes. Thematisch gliedert sich LAKRIS in fünf Teilprojekte:

SAISONALE UND ZWISCHENJÄHRLICHE VARIABILITÄT IN DER DEMOGRAPHISCHEN STRUKTUR DER KRILL-BESTÄNDE IN DER LAZAREW-SEE. Ein standardisiertes Beprobungsprogramm mit RMT (Rectangular Midwater Trawl)-Netzhols wird im Rahmen von LAKRIS durchgeführt, um biologische Daten über die Krill-Population in der Lazarew-See zu gewinnen. Das Hauptaugenmerk wird auf die Schätzung der mittleren Bestandsstärke und die Stärke der Jahresklassen in Relation zu Umweltvariablen gerichtet. Der Reproduktionserfolg des Laicherbestandes wird ebenso untersucht wie die Larvenverteilung und die Überlebensrate während des Winters.

HORIZONTALE UND VERTIKALE VERTEILUNG VON KRILL UND ZOOPLANKTON. Die täglichen vertikalen Wanderungsbewegungen und geographischen Verteilungen von Schlüsselorganismen wie Krill (*Euphausia superba, E. crystallorophias*), Copepoden (*Calanus propinquus, Rhincalanus gigas, Oithona* spp.) und anderem Zooplankton (Salpen, Pteropoden, Chaetognathen, Amphipoden) sowie Fischen (Myctophiden) sollen mittels eines Mehrfrequenz-Echolotes (38, 72, 120, 200 kHz) aufgezeichnet werden. Anhand der aufgezeichneten Verteilungen sollen vor allem folgende Fragen bearbeitet werden: Wandern die Organismen täglich in Relation zum Lichtfeld, zu den Nahrungsbedingungen und/oder zu den Fressfeinden?

Trennen sich Populationen unterschiedlicher Arten und/oder unterschiedlicher Entwicklungsstadien der gleichen Art unter bestimmten Umweltbedingungen oder zu bestimmten Jahreszeiten? Ist die geographische Verteilung bestimmter Arten Schwankungen unterworfen und was sind gegebenenfalls die Ursachen dafür?

AUSWIRKUNGEN DER WASSERMASSENZIRKULATION UND DER SAISONALEN MEEREISBEDECKUNG AUF DAS ZOOPLANKTON. Das Projekt ist ausgerichtet auf die Identifikation von Beziehungen zwischen dem physikalischen Umfeld und dem Vorkommen von Zooplankton in der Lazarew-See. Besonderes Gewicht wird auf die mögliche Rolle des Weddell-Wirbels für die Schließung des Lebenszyklus' von Krill gelegt. Die Datenbasis für diese Untersuchung wird geschaffen durch Aufzeichnung multi-disziplinärer Zeitreihen mit verankerten Instrumenten und durch schiffsgestützte räumliche Messaufnahmen.

SAISONALE DYNAMIK DER PHYSIOLOGISCHEN KONDITION VON KRILL MIT SCHWERPUNKT AUF DEN LARVENSTADIEN. Es sollen verschiedene Fitness-Indikatoren, die eine Vorhersage des Rekrutierungserfolges und der Überlebensrate der Nachfolge-Generation erlauben, quantifiziert werden. Die Arbeiten mit Krilllarven konzentrieren sich darauf, welche Fähigkeit sie entwickelt haben, um im nahrungsarmen Winter, trotz hoher metabolischer Aktivität, zu überleben.

SAISONALE LIPID-DYNAMIK UND ENERGETISCHE ANPASSUNGEN VON *EUPHAUSIA SUPERBA* UNTER BESONDERER BERÜCKSICHTIGUNG DER JUGEND- UND ERWACHSENEN-STADIEN. Die Untersuchungen konzentrieren sich auf die saisonale Dynamik der Lipid-Anreicherung und deren Nutzung. Der Energiebedarf bei verschiedenen Überwinterungsstrategien und für die Reproduktion soll durch Laborexperimente und mittels Feldmessungen festgestellt werden.

Die Ernährungsbedingungen von Seevögeln durch Nahrungsnetze in der saisonal eisbedeckten Lazarew-See wird die dominierende Rolle von Krill als Nahrungsorganismus der Meereiszone hinterfragen.

Die umfassenden, dem Krill gewidmeten Forschungsarbeiten werden ergänzt durch zusätzliche Projekte, die andere Zooplankton-Gruppen wie pelagische Tunicate (Salpen), Quallen (Medusen) und Flohkrebse (Amphipoden). Die Untersuchung von Fischlarven ergänzt das Programm. Zentrale Frage bei all diesen Untersuchungen ist, welchen Fraßdruck diese verschiedenen Zooplankton-Gruppen ausüben und welchen Fluss von Materie und Energie durch das Nahrungsnetz und durch die vertikale Wassersäule sie bewirken. Hierbei sollen auch Zooplankter der tieferen Wasserschichten untersucht werden.

Die Reise wird fotografisch begleitet, um in Bildmaterial die Forschungstätigkeit unter winterlichen Bedingungen zu dokumentieren.

ITINERARY AND SUMMARY

On 17th June 2006 RV *Polarstern* will leave from Cape Town for the 6th leg of her 23rd Antarctic Expedition. During this cruise that will end 21st August 2006 in Cape Town, RV *Polarstern* will support an extensive marine research programme during the austral winter.

In order to access the working area in the Lazarev Sea as soon as possible, RV *Polarstern* will head almost straight towards its first scientific position at 52°S 3°E. On the way to the Antarctic only scientific activities will be carried out requiring no extra ship time.

The projects planned on the way south will focus on observations of marine vertebrates and zooplankton. A Dutch team will visually observe penguins and seabirds from the upper bridge out of two wooden cabins. One observer sent by the International Whaling Commission (IWC) to participate in the cruise will contribute cetacean sightings and records of other wildlife such as seals. The IWC observer will also record a comprehensive suite of sea ice data. In addition to the visual observations of marine mammals, two different automated monitoring systems will be tested during transit. The one is a passive acoustic system consisting of towed hydrophone streamers that are custom-tailored to the detection of marine mammals. The other system is based on two infrared cameras, which are mounted at the crow's nest and are operated with image processing software that will continuously monitor the regions next to the ship for infrared signatures of whale spouts even at night and poor visibility.

On the southward route from Cape Town another project scheduled and not requiring any ship time is the sampling of the near-surface zooplankton by use of the so-called Continuous Plankton Recorder (CPR).

The major marine research programme of this cruise is devoted to the BMBF-funded LAzarev Sea KRIII Study (LAKRIS), a German contribution to SO-GLOBEC. The ongoing cruise is the first winter cruise within the framework of this project.

The Southern Ocean Global Ocean Ecosystems Dynamics (SO-GLOBEC) programme is an international, multidisciplinary effort to understand the physical and biological factors that influence the growth, reproduction, recruitment, and survival of Antarctic krill (*Euphausia superba*) with special emphasis on its overwintering mechanisms. As part of SO-GLOBEC, LAKRIS aims to quantify seasonal population dynamics and physiological condition of krill in an interdisciplinary approach and in a region of the Antarctic that is poorly sampled and understood, especially during winter.

Much of our knowledge of Antarctic krill originates from a few regions, such as the much-studied Antarctic Peninsula. But it is becoming increasingly clear that the seasonal survival mechanisms of krill are variable, so neither the local environment, (e.g. those along the Antarctic Peninsula) nor the response of krill to it can be easily extrapolated to a wider area. The LAKRIS project will complement the existing international research activities within SO-GLOBEC and CCAMLR (Convention for the Conservation of Antarctic Marine Living resources) along the west Antarctic Peninsula, Scotia Sea and in the Southwest Indian Ocean Sector.

Within the great current systems encircling Antarctica, there is a hotspot of krill density within a sector defined roughly by the Greenwich Meridian (i.e. the Lazarev Sea) and the west of the Antarctic Peninsula. Whether this hotspot itself contains one or several "stocks" of krill and whether these are connected with those in the rest of the Southern Ocean are currently topics of intense debate. Understanding krill survival at the seldom-studied eastern extremity of this hotspot may provide some clues in this puzzle.

The Lazarev Sea has been suggested to be the gateway through which the krill population enters the Weddell Gyre. At the 0° meridian krill distribution ranges from approximately 50°S to the Antarctic continent at 70°S - the widest latitudinal range throughout their entire circumpolar distribution. North of 60°S, krill are under the influence of the eastward-flowing Antarctic Circumpolar Current. Thus, they are downstream of the extensive Scotia Sea populations and reflect spawning success there. But south of 60°S, within the westwards flowing counter currents of the Lazarev Sea, there is little information on krill spawning and larval occurrence. If, however, the Weddell Gyre is the source of high krill densities in the Scotia Sea, then the westward moving water masses of the Lazarev Sea should seed substantial amounts of krill larvae into the system to sustain the large population observed at the northern outflow of the Weddell Gyre.

Field work for LAKRIS will be distributed over three cruises in different seasons, of which this is the second, apart of a pilot study already conducted during RV *Polarstern* cruise ANT-XXI/4. The LAKRIS-project is divided in 5 subprojects with the following topics:

SEASONAL AND INTERANNUAL VARIABILITY IN KRILL DEMOGRAPHY OF HIGH LATITUDE KRILL STOCKS IN THE LAZAREV SEA. A standardized RMT (Rectangular Midwater Trawl) net sampling programme will be carried out during the LAKRIS study to collect biological data on the krill population in the southern Lazarev Sea. The main focus will be the estimation of average spatial krill density and the determination of year-class strength in relation to key environmental variables. Reproductive success of the spawning stock will be studied as well as larval distribution and survival during the winter period.

HORIZONTAL AND VERTICAL DISTRIBUTION OF KRILL AND ZOOPLANKTON. Diel vertical migration and geographical distribution of target organisms like krill (*Euphausia superba, E. crystallorophias*), copepods (*Calanus propinquus, Rhincalanus gigas, Oithona* spp.), other zooplankter (salps, medusae, pteropods, chaetognaths, amphipods) and fish (Myctophiden) will be detected by means of a four-split beam acoustic array (38, 72, 120, 200 kHz). Some major questions are: Do organisms migrate daily in relation to the light field, feeding conditions and/or to the predator field? Do populations of different species and/or different developmental stages of one species segregate in certain environmental conditions or different times of the year? Is the geographical distribution of species subject to change and if so, what are the possible causes?

EFFECTS OF WATER MASS CIRCULATION AND SEA ICE ON THE ABUNDANCE OF ZOOPLANKTON. The project is aimed at identifying relationships between the physical environment and the abundance of zooplankton in the Lazarev Sea. Special emphasis will be put on the possible role of the Weddell Gyre circulation in closing the life cycle of krill. The data base for this study will be collected by moored instruments

to reveal temporal variations, by shipboard observations to map spatial distributions, and will also encompass the analysis of historical ADCP (Acoustical Doppler Current Profiler) data from the region.

SEASONAL DYNAMICS OF PHYSIOLOGICAL CONDITION OF KRILL WITH EMPHASIS ON THE LARVAE STAGES. The subproject will quantify various fitness indicators, which will permit the prediction of recruitment success and mortality rates of the following generation and how these factors will be influenced. The work on larval krill will focus on their mechanisms that have evolved to survive the nutrient poor winter conditions despite high larval metabolism.

SEASONAL LIPID DYNAMICS AND ENERGETIC ADAPTATIONS OF *EUPHAUSIA SUPERBA*, WITH EMPHASIS ON JUVENILE AND ADULT STAGES. The subproject will focus on seasonal dynamics of lipid accumulation and utilization of juvenile and adult stages of krill. Energetic requirements with regard to overwintering strategies and reproductive effort will be quantified using experiments and field data.

A study about "Seabird food chains in the Antarctic sea-ice zone" will investigate the diatary requirements of the ex top predators, especially by closely examining the under-ice fauna. The role of krill as main food source for such surface feeding populations is challenged. Our extensive study of krill will be complemented by further projects, which focus on other zooplankton genera such as pelagic tunicates (salps) and jellyfish (medusae), and on fish and fish larvae. The central question addressed by these projects is the grazing impact exerted and the flow of biogenic matter through the food chain and water column accomplished by those groups of zooplankton.

A photographer will accompany the cruise in order to collect material to document the research work taking place under winter conditions for presentation to the general public. Special emphasis will be given on the hard working conditions and the results obtained during the Antarctic winter.

Fahrtroute

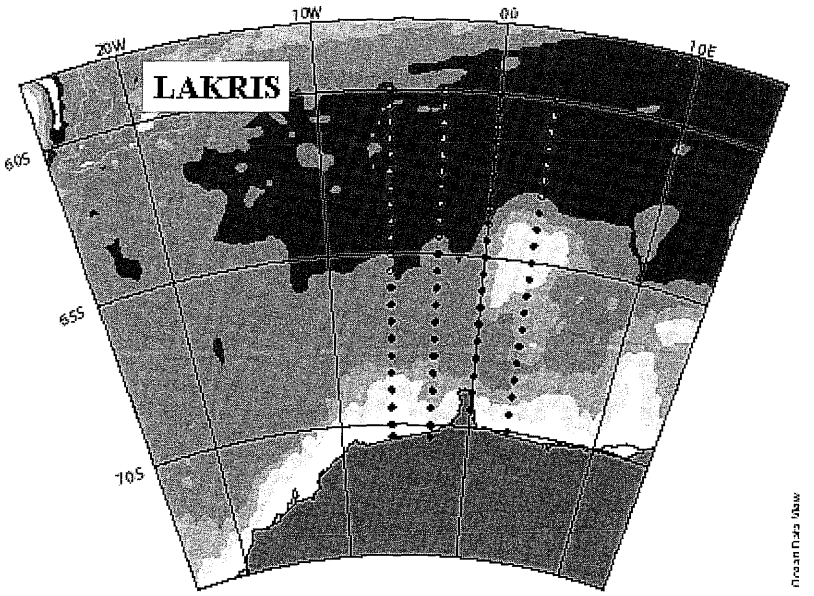

Abb.1: Übersichtskarte des Untersuchungsgebietes und der geplanten Fahrroute der FS Polarstern-Reise ANT-XXIII/6. Die Reise wird am 17. Juni 2006 in Kapstadt beginnen und am 21. August 2006 in Kapstadt enden.

Fig.1: Map of the area of observations and of the planned cruise track of RV Polarstern expedition ANT-XXIII/6. The cruise will begin on the 17th June 2006 in Cape Town and will end 21th of August 2006 in Cape Town.

2. RMT SAMPLING OF KRILL AND ZOOPLANKTON

M. Haraldsson, M. Vortkamp, L. Würzberg (BFA Fisch)

Objectives

Krill data that contribute to the long-term monitoring of the stocks in the Antarctic Peninsula were collected between 1978 to 2004 by German surveys or by international cooperations in the Antarctic Peninsula region. Data were collected on an annual basis and allow the study of interannual aspects in krill demography and population dynamics. The planned RV *Polarstern* cruise is a continuation of this activity in a more remote and far less studied region of Antarctica, the Lazarev Sea, and the studies will focus on seasonal aspects of Antarctic krill demography.

The main topics that will be covered by the net sampling programme are:

Seasonal aspects of krill distribution,
Seasonal variability in krill abundance,
Demography,
Development of larval stages,
Recruitment indices,
Seasonal vertical distribution,
Distribution and abundance of other Euphausiacea species, salps and Myctophid fish.

The overall objective is the establishment of management procedures to allow a sustainable development of the Antarctic krill stocks as a key element of the entire ecosystem.
Several topics will certainly overlap with other subgroups (e.g. physical oceanography, krill ecophysiology) and will foster multidisciplinarity of the study. Support is given for the comprehensive cooperation among groups by the:

Joint national project LAKRIS, International cooperation under the SO-GLOBEC umbrella.

Concerning the krill part of the ecosystem we intend to study the following questions:

- What biological and environmental key factors affect the successful reproduction of krill?
- How does breeding season relate to successful spawning or larval survival?
- Which physical key factors influence krill larval survival and subsequently recruitment?
- Can we detect natural variation in reproduction and recruitment success between years?
- Are there geographical variations in krill distribution, abundance or growth and mortality rates in relation to within-season or between-season?
- How does breeding and recruitment success relate to krill stock size?
- Are there long-term trends in krill abundance/biomass and if so, are they related to long-term trends in the environment?

These questions are of complex nature and require a large amount of data collected in a standardised way to allow direct comparisons between data sets. The German krill data have been collected over the years with standard gear and standard methods for net sampling procedures as well as for sample handling and measuring and staging krill. These allow interannual and inter-season comparison of quantitative aspects of krill demography and population dynamics.

In the recent past indices for krill density, spawning timing and recruitment success have been developed and standardised. Further data available include standardised length frequency distributions, which are essential for estimation of growth and mortality rates .

From this basic parameters and indices the above listed questions can be addressed subsequently. After the seasonal variability of distribution and abundance and succession of maturity stages has been described, it will be necessary to estimate the range of within-season variability of population parameters. From the knowledge of seasonal variability of krill parameters the next step will be the identification of possible relationships between the biological and environmental parameters like temperature, sea surface temperature, sea ice, etc.

Work at sea
The planned investigations will be carried out in the Lazarev Sea during austral winter 2006, a potential nursery area for Antarctic krill larvae. About 80 established standard stations will be covered along meridional transects during the survey period of late June to early August.

The multiple RMT1+8 plankton net will be used as standard gear to collect krill samples from the upper 400 m surface layer. In its multiple version the RMT net will be used to sample depth strata from 400 – 300 m, 300 – 200 m, and 200 to 0 m. This will allow comparisons with summer data collected in the upper 200 m depth layer, but also study the possible deep occurrence of krill in winter. Biological parameters such as sex ratio, age composition and maturity stage development will be determined from each sample following the international classifications. Studies on the spawning success, survival rates and recruitment success are essential to develop prediction models for the development of the krill stocks. Data will be analysed as part of the CCAMLR (Convention for the Conservation of Antarctic Marine Living Resources) related research activities. Results will be submitted to the CCAMLR working group meetings to support the monitoring of the krill stocks in the Atlantic sector and the management of the krill fishery.

3. DISTRIBUTION AND BIOMASS OF KRILL AND ZOOPLANKTON: ACOUSTIC SURVEY

U. Bathmann, S. Herrmann, B. Wendts, K. Schreiber (AWI), V. Balhara (IITD)

Objectives
Since the early assessments by the DISCOVERY expeditions between 1930 and 1960 we know about the spacious distribution of substantial stocks of *Euphausia superba*. Commencing with the BIOMASS programme, the determination of krill catch quota by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) is based on acoustic stock assessments.

Compared with, for example, the Antarctic Peninsula area, only little information exists on the development in krill stock in the Antarctic waters of the Eastern Weddell Sea and the Lazarev Sea during the last decades.

Work at sea
To survey the spatial distribution of *Euphausia surperba* and the zooplankton, including possible prey organism of krill, multifrequency acoustic measurements will be made by a Simrad EK60 scientific echosounder with the frequencies 38, 70, 120 and 200 kHz. Sampling and processing of acoustic data will be carried out in accordance to the CCMLAR standard procedures. By using different scattering models and discrimination methods for example, additional data analysis will be performed to account for current difficulties in interpretation of acoustic measurements. The echosounder has to be physically calibrated.

For comparison with and biological calibration of the acoustic survey data net samples of zooplankton will be taken with the multinet. Roughly 30 vertical net hols in the upper few hundred meters of the water column are planned using mesh sizes of 55 and 300 mm.

In addition, the Bongo net will be employed to also catch larger zooplankton animals, such as amphipods, which are able to swim fast enough to escape the multinet. Once on board, the net samples of zooplankton will be preserved using a 4 % solution of formol in sea water and then stored in Nalgene bottles. Gelatinous plankton like jelly fish will be sorted out before, with their biomass determined separately.

Beyond the purpose of calibration of the acoustic survey data the zooplankton net samples will be used for an investigation of the spatial distribution of different developmental stages of the various species.

4. EFFECTS OF WATER MASS CIRCULATION AND SEA ICE ON THE ABUNDANCE OF ZOOPLANKTON

B. Cisewski, I. Nunez-Riboni, D. Ewe, J. Hager, A. Lenderink, C. Sahlmann (AWI),
T. Witte (Optimare);

Objectives
The project is aimed at identifying relationships between the physical environment and the abundance of zooplankton in the Lazarev Sea. The overarching goal is to reveal whether or not the Weddell Gyre circulation acts as a mechanism that supports krill by closing its life cycle. In particular we seek answers to the following questions:

- Does the distribution pattern of zooplankton, and especially of krill, correlate with the distribution of water masses?
- Are horizontal differences in the demographic structure of the krill population explicable by advection?
- What is the role of sea ice in shaping the horizontal and vertical zooplankton distribution patterns?

Work at sea
During ANT-XXIII/6 the data base for this study will be extended by winter data of temperature, salinity and density, chlorophyll fluorescence and light transmissivity, ocean currents and zooplankton backscatter.

Vertical profiles of temperature, salinity, density, chlorophyll fluorescence and light transmissivity will be recorded by lowering a CTD(Conductivity Temperature Depth)-sonde at hydrographic stations, which will be organized in a regular grid across the Lazarev Sea. The carousel water sampler attached to the CTD will be the main device used to provide water samples for the analysis of a variety of variables by other working groups aboard.

Measurements of ocean currents will be made with an acoustic Doppler current profiler (ADCP), which is installed in the keel of the ship. From the very same instrument the recorded echo intensity, or backscatter signal, will be analyzed in order to provide an estimate of zooplankton abundance. This estimate will be compared with the zooplankton abundance indicated by the dedicated Simrad EK60 zooplankton-echosounder, and abundance data derived from net catches.

It is expected that, by combining the physical oceanographic measurements made at a regular grid, which is fine enough to reveal mesoscale variations but large enough to cover the gyre-scale features, with multi-annual Eulerian time series records taken with moored instruments already deployed in the survey area, we will succeed to describe the circulation pattern of the eastern margin of the Weddell gyre more accurately than at present and accurately enough for a reliable study of advection of zooplankton.

5. SEASONAL DYNAMICS OF PHYSIOLOGICAL CONDITION OF ANTARCTIC KRILL EUPHAUSIA SUPERBA WITH SPECIAL EMPHASIS OF ITS LARVAL STAGES

B. Meyer, V. Fuentes, A. Olariaga, C. Pape, S. Spahic (AWI)

Objectives

The Antarctic krill *Euphausia superba* plays a key role in the ecosystem of the Southern Ocean and occupies a central place in commercially valuable resources. Several studies have shown that larval and adult krill have fundamentally different overwintering mechanisms. Adults survive over 200 days without food by using their lipid reserves and reducing their metabolic rates and it is assumed that they shrink during long starvation periods. Larval krill have low lipid reserves and thus might not be able to tolerate long starvation periods. Further, adults may switch to benthopelagic or carnivorous feeding, whereas larval krill have to feed on ice algae to survive.

In adults, the reduction in metabolic rate is regarded as one of the most important energy-saving mechanisms during winter (Quetin and Ross 1991). Meyer et al. (2002) found a significant reduction in the metabolic key enzyme citrate synthase activity compared to summer values. Metabolic rate measurements and feeding experiments during a SW Lazarev Sea autumn study have shown that juveniles and adults have threefold reduced oxygen uptake rates compared to rates measured during summer. They also failed to respond with increased rates even after exposure to high food concentration for 11 days (Atkinson et al. 2002). These findings favour the theory of an adaptive seasonal strategy for juveniles and adults. The mechanisms that cause these reductions in metabolic rates are still unknown but very significant for our understanding of how krill survives the winter season

and how this relates to their population development and recruitment success. Based on our previous findings we believe that physiological functions of krill may be triggered or controlled by the annual course of the photoperiod. We hypothesised that melatonin, a substance primarily known as a vertebrate hormone, may act as a chemical transducer of photoperiodical information in krill. Furthermore, the biochemically closely related indoleamine serotonin reveals a similar function in several crustacean species. Serotonin is known to influence glucose level in the haemolymph and to alter heart beat frequency and intensity. As its concentration in crustaceans depends on the photoperiod it represents another candidate molecule for communicating the light signal within the organism controlling its metabolic state. For a better understanding of the different overwintering mechanisms major krill functions have to be studied with the same experimental set up in different seasons and with different developmental stages. This includes filtration, feeding, respiration, and excretion rates, as well as krill growth.

In larval krill we have only little information how they survive the winter season because it is assumed that they have no overwintering strategies like adults. However, data on growth, feeding, food sources and metabolic rates during winter are essential to understand their development and hence recruitment success of *E. superba*, a key species in the Southern Ocean.

Work at sea

As an outcome of this cruise we are aiming to characterise the physiological condition of larval and adult krill during winter by analysing their length, dry mass, elemental (carbon, nitrogen), and biochemical composition (protein, lipid, carbohydrates), as well as their metabolic rates (respiration, excretion, activity of metabolic enzymes) and growth. Experiments with larval krill feeding on different food sources (ice biota, specific zooplankton organisms) should give us information of the importance of zooplankton as a food source during winter when phytoplankton concentration in the water column is low. Growth experiments with larval krill and adults will demonstrate if the animals grow or even shrink during this time of the year when food is scarce. For the feeding experiment enriched with zooplankton we will capture prey organisms from nighttime 0-150 m hauls by use of the Bongo net and from 0-50 m catches with a hand-hauled Apstein net. The ice algae used in the feeding experiments will be obtained by scooping up brown discoloured chunks of sea ice with the ships's crane, slowly thawing lumps in seawater at 2° C, and sieving out large particles through 100 µm gauze.

Application experiments are planned to study the effects of melatonin and serotonin on krill physiology. The substances will be injected to the animals or given to the seawater to study their possible effect on respiration, feeding and metabolic key enzymes. In addition, animals subjected to different photoperiods will be sampled for melatonin and serotonin determinations with commercial ELISA-Kits during the cruise and for further investigations at the AWI.

The planned investigations will be carried out in the Lazarev Sea as part of the LAKRIS-Project (Lazarev Sea Krill Study, subproject 4). The plankton net RMT 1+8 will be used as standard gear to collect krill samples, especially adult krill, from the upper 200 m surface layer at several LAKRIS grid stations. Part of the freshly caught krill will be frozen in liquid nitrogen and stored at -80° C for later analyses in the laboratory (length, dry mass, elemental- and biochemical composition, indoleamine concentration, activity of metabolic enzymes). The remaining krill will be kept alive to measure their metabolic rates and to analyse their feeding activity. Larval krill will be collected by divers under the ice to get the

animals alive and in good condition to realize the growth experiments planed. In addition, the sampling by divers shows in an ideal way the location of larval krill under the ice. We will be able to estimate the physiological condition of larvae in relation to their immediate habitat and can study the under ice biota, the putative food source of the animals.

Atkinson A, Meyer B, Bathmann U, Stübing D, Hagen W, Schmidt K (2002) Feeding and energy budget of Antarctic krill *Euphausia superba* at the onset of winter. II. Juveniles and adults. Limnol Oceanogr 47: 953-966

Meyer B, Saborowski R, Atkinson A, Buchholz F, Bathmann U (2002) Seasonal differences in citrate synthase and digestive activity in larval and postlarval Antarctic krill, *Euphausia superba*. Mar Biol 141: 855-862

Quetin, L. B., and R. M. Ross. 1991. Behavioural and physiological characteristics of the Antarctic krill, *Euphausia superba*. Amer. Zool. 31: 49-63.

6. LIPID BIOCHEMISTRY OF ANTARCTIC EUPHAUSIIDS

D. Stübing, A. Schukat (University Bremen)

Objectives

This sub-project of the "Lazarev Sea Krill Study" aims at characterising the physiological condition and feeding behaviour of *Euphausia superba* and other Antarctic krill species during the critical winter period when food is scarce for these mainly herbivorous animals. From previous studies we know that *E. superba* accumulates large lipid reserves during the productive season that will be catabolised for energy production during the winter. Unlike the other Antarctic euphausiids, *E. superba* does not rely on internal reserves for fuelling gonad maturation and reproduction but is dependent on external resources making use of the spring/summer phytoplankton bloom. Hence, their lipid stores are exclusively available for overwintering.

Lipid content and lipid class composition indicate the amount and type of energy reserves and will be measured separately for each maturity stage available. The fatty acid composition reflects the animals' feeding histories integrated over several weeks and is thus an important supplement to the classical gut content analyses providing short-term trophic information. Sampling will be carried out in parallel to the demographic studies of V. Siegel. The data may provide ecological information that help understand the observed distribution patterns. Furthermore, in comparison with the lipid data from previous spring/summer and autumn expeditions a potential interannual and geographic variability of nutritive status and general fitness of the different development stages in the investigation area can be detected.

Winter data are extremely scarce, and thus this expedition will help to fill an important gap in the seasonal cycle of lipid accumulation and depletion. The possibility to assign divers during the long-term stations gives us the unique opportunity to observe krill behaviour in its natural environment and to sample the animals simultaneously to other parameters from its actual habitat (e.g. the under ice with attached and enclosed organisms) and hence to directly relate condition, physiological activity and biochemical composition to the immediate feeding situation of the animals caught. All these invaluable information can normally not be obtained when sampling open water krill with trawled nets.

Another central topic is the accumulation of lecithin, which may attain exceptionally high levels in polar euphausiids. The physiological significance of this unusual phenomen is still unknown. The identification of the position of the lecithin stores in the krill body (i.e. proximity to certain organs) and their ultrastructure, as well as a potential selective utilisation or conservation of this reserve under controlled feeding or starvation conditions may provide information on the ecophysiological role of this membrane lipid. Accordingly, lipid-rich juvenile and adult krill specimens are to be specifically prepared for various histological analyses (cryo-sections, transmission electron microscopy).

Work at sea
The sampling will be performed in coordination with the LAKRIS zooplankton and krill groups by means of the various plankton nets on board. Most species will be either frozen (–80°C) or chemically preserved. Additional experiments to determine food selection will be performed in temperature controlled container on board.

7. POTENTIAL KRILL ALLERGENS

L. Auerswald (UCT), B. Meyer (AWI)

Objectives
Currently, the main commercial use of krill is as feed for aquaculture. Only a small proportion is used for human consumption. In future, however, krill will most likely be caught for high quality chemical, pharmaceutical and health products but also as a protein source for human consumption. Due to its close proximity to the catching grounds of krill and its fishing interests, South Africa has an excellent position to benefit most from this rich natural source. Krill carries the risk, however, of containing proteins allergenic to humans as it is well known from other crustacean species. Allergy to crustaceans is one of the most common food allergies. So far, no research has been conducted in this regard on krill, although exposure to crustaceans can cause life-threatening reactions in allergic individuals. No crustacean species investigated so far has been found free of allergens.

The aim of our study is to investigate the allergic potential of krill in comparison with other crustacean species. To achieve these aims, it is planned 1) to extract, purify and elucidate the molecular structure of potential allergens from Antarctic krill during different seasons and physiological conditions and 2) to propose the right policies for public and occupational health to avoid problems currently experienced, for example in the lobster industry.

Work at sea
During the winter cruise, samples of krill material (whole animals and body parts) will be collected to study the role of tropomyosin, the muscle protein responsible for allergenicity in other crustacean species. In addition, haemolymph samples will be collected from stressed krill (freshly caught, starved) to investigate stress proteins as a potential cause of allergy.

8. NEAR-SURFACE ZOOPLANKTON SAMPLING BY USE OF THE CONTINUOUS PLANKTON RECORDER, CPR

U. Bathmann (AWI), E. Pakhomov (UBC)

Objectives

The survey is using the sensitivity of plankton to environmental change as early warning indicators of the health of Southern Ocean, as well as serving as a reference on the general status of the Southern Ocean for other monitoring programmes. The SO-CPR Survey is an independent project but together with CPR surveys in the northern hemisphere, it is a major survey and monitoring tool able to support GOOS. The SO-CPR Survey is not officially recognised as part of SO-GLOBEC, but contributes to GLOBEC internationally. The SO-CPR Survey is associated with the CPR Survey based at the Sir Alister Hardy Foundatiion for Ocean Science, Plymouth. Data acquired by partners in the SO-CPR Survey are shared between partners.

The specific objectives are:

- Map the biodiversity and distribution of zooplankton, including euphausiid (krill) life stages, in the Southern Ocean.
- Assess the seasonal, annual and long term variability in abundance, species composition and distribution patterns of the Southern Ocean zooplankton communities.
- Similarly, assess the variability of abundance and development of krill larvae produced each year.

Work at sea

The CPR can be towed from any vessel at speeds up to 23 knots and in conditions up to Force 12. They can be deployed and retrieved at normal ship's speed, although we often slow the ship to 3-5 knots for the final few metres of retrieval to prevent the CPR hit the stern. The CPR is towed 100 m aft of the ship, within the ship's wash, using wire of at least 12 mm diameter, and can be deployed from an A-frame, gantry, davit or similar. The unit cannot be towed in ice. The recorders can be towed continuously with no interruption to shipping schedules for 450 n miles before retrieval. They are purely mechanical, as they are driven by water passing over a propeller, and have no electronic components or power supplies that can fail. The mesh is advanced at a fixed rate of 1 cm per 1 nautical mile, regardless of ship's speed.

No dedicated ship time is required. CPR can be deployed and retrieved at normal ship speed, although brief swing to 3-5 kn is advisable for the final few metres of retrieval. No deviation is required from the scheduled cruise track. For the ANT-XXIII/6 cruise, tows will be conducted on the route south from Cape Town, commencing at 45°S and finishing at the krill survey area. Further tows are expected to be conducted on the return route to Cape Town commencing on departure from the krill survey area and finishing at 45°S.

9. FEEDING RATES OF COMMON COPEPOD SPECIES AND FAECAL PELLET FLUX IN THE LAZAREV SEA IN AUSTRAL WINTER

D. Martynova (University St. Petersburg)

Objectives
The project is aimed to estimate the role of common copepod species (both *Calanidae* and *Cyclopidae*) to vertical organic matter flux in the Lazarev Sea in the period of austral winter (i.e. July – August).

Since a lot of observations were held in the Antarctic waters and were devoted to evaluate the grazing and faecal pellet production rates of zooplankton species, most of them were performed in spring and summertime. Overwintering strategies of zooplankton species are partly studied but mostly in biochemical view. There is the lack of investigations describing life cycle strategies related to food conditions. Winter studies of zooplankton abundance and especially grazing rates were not so numerous and were held in the other Antarctic seas: Weddell Sea and Scotia Sea. Pellet investigations were also held in the other Antarctic seas dominantly in summertime and showed relations between occurrence of cyclopoid copepods and faecal material.

The major purposes of the present investigation are:

- to estimate feeding rates of dominant species;
- to estimate pellet production rates of dominant species;
- to evaluate role of cyclopids in pellet disbanding.

Work at Sea:
The sampling will be performed in coordination with the AWI zooplankton group by means of the various plankton nets on board. Main copepods will be selected from the samples and being used in experiments in temperature controlled container on board. Grazing, excretion, reproduction will be measured under various food conditions and with several species to determine the winter performance of the organismns. Frozen samples will be taken to AWI to measure biochemical parameters.

10. ECOLOGY AND PHYSIOLOGY OF CALANOID COPEPODS

J. Michels, R. Alheit (AWI)

Objectives
The life cycles of dominant calanoid copepods are all well-timed to the annual periodicity in ice cover and primary production, although the different species exhibit varying strategies to utilize short-term food pulses and to endure periods of food scarcity in the pelagial. However, our knowledge of the winter situation is not yet fully understood as studies during the dark season are extremely rare. Hence, studies carried out during this leg should enable detailed

descriptions of the life strategies of the dominant pelagic copepod species and to characterize the zooplankton community in the Lazarev Sea during winter. Our research will focus on the following issues: species diversity, abundance, horizontal and vertical distribution, population structure, maturity of gonads and feeding activity as well as molecular genetic analysis. Additionally studies on physiological and biochemical parameters of dominant calanoid copepod species include experimental work on feeding, defecation, reproduction and respiration as well as metabolic indicators such as C:N and O:N ratios, stable isotopes, lipid and protein contents.

The zooplankton campaign is part of CMarZ (Census of Marine Zooplankton), which is part of CoML (Census of Marine Life).

Work at sea
The major gear employed for the distributional studies of mesozooplankton will be the multiple opening and closing net (multinet, 0.25 m^2 mouth opening) equipped with five nets of 100 µm each. The multinet will be towed vertically, sampling the standard layers between 1000m and the surface. The samples were preserved in 4 % buffered formalin. For molecular genetic purpose, additional samples will be preserved in absolute ethanol and stored at 0° C.

All organisms sampled quantitatively with the multinet will be sorted and quantified to major taxa level at the AWI (Bremerhaven, Germany). The sorted material except calanoid copepods will be made available to other research groups for systematic and biogeographical analyses.

For the study of stable isotopes, lipid content and CN analyses different zooplankton species will be sorted out immediately after sampling from different depth layers and will be deep frozen at –80° C for later analyses.

For the experimental and biochemical work, live specimens will be caught by means of a Bongo net (100 µm mesh size).

11. PELAGIC TUNICATE (SALPA THOMPSONI AND IHLEA RACOVITZAI) ABUNDANCE, DISTRIBUTION, DEVELOPMENTAL AND ELEMENTAL COMPOSITION AS WELL AS FEEDING INTENSITY AND GRAZING IMPACT IN THE LAZAREV SEA

E. Pakhomov (UBC)

Objectives
This project is a continuation of the salp biology project currently run at the AWI. The fall cruise ANT-XXI/4 has been successful in obtaining novel information of the salp distribution patterns, their densities and feeding activity in the Lazarev Sea. One of the unexpected findings during this cruise was the presence of high concentrations of *S. thompsoni* in the near costal region, suggesting that this species could have been advected into the region recently or may have established viable population in the south most parts of the Lazarev Sea. The origin of this population is unknown. Since salps may insert dramatic grazing

impact, it would be extremely valuable to obtain year round observations on salp biology as their complete life cycle in the high Antarctic under severe environmental conditions is still unknown. This in term would help to predict behaviour of this "warmer" water species in the region south of the Antarctic Polar Front under changing climatic conditions. During the present cruise, we will follow the salp population structure and distribution in the field as well as growth of salps *Euphausia superba*. Furthermore, we will carry out *Euphausia superba* feeding experiments to estimate their grazing impact in the different areas. In addition, the gut content of salps of different regions will be analyzed to determine their in situ food ingestion and digestion over different depths.

Work at sea
Salps will be collected from RMT-8 samples according to the stations of the krill grid and will be counted, sexed, measured and developmental stage identified.

Bongo net samples in the top 200 m will be needed to sample animals for experiments. Essentially, three types of experiments will be carried out: a) grazing *Euphausia superba* (just salps and in combination with krill); (b) salp fecal pellet production rate experiments as short incubations just after sampling providing close to *in situ* ingestion rates; (c) growth rate experiments will involve keeping salps in large containers for 1-2 days and measure their growth over this short period of time.

To obtain an indication of salp feeding activity in the different regions, representative samples of salp guts will be collected with Bongo nets (~100 m), frozen and kept at –80° C for subsequent gut fluorescence measurements and HPLC analysis in the laboratory at home. Additionally, samples from different depths caught with the multinet (eventually in combination with sampling of mesopelagic micronekton by Svenja Kruse) at representative stations will allow to determine effects of digestion on the pigment composition. Water samples from according depths for later analysis of the Chl a concentration and pigment composition in the field will be taken.

Salps caught in nets for other use („bycatch") will be sampled whenever possible, frozen and kept at –80° C for further biometric analysis at home.

12. CARNIVOROUS ZOOPLANKTON IN THE MESOPELAGIC FOOD WEB OF THE SOUTHERN OCEAN

S. Kruse, U. Bathmann (AWI)

Objectives
In the Southern Ocean, carnivorous zooplankton taxa contribute to a great extent to marine zooplankton biomass and are therefore believed to have a significant predation impact on the zooplankton community. Consequently, carnivores may also contribute significantly to the downward carbon flux due to marked diel vertical migrations and due to production of fast-sinking faecal pellets. Pronounced variations in the food web dynamics of plankton communities, depending highly on factors like season, climate and location, can be expected. In order to understand the role of carnivorous zooplankton taxa like chaetognaths, amphipods and medusae, comprehensive seasonal and geographical studies on such little

known mesopelagic taxa are required. During this cruise, the composition of the zooplankton community, distribution and abundance of deep-living carnivores, their feeding habits and predation impact as well as their role in the carbon cycle will be investigated in the Lazarev Sea. The results of these investigations are extremely important, e.g. with regard to the degree mesopelagic carnivores feed on over-wintering zooplankton originating from epipelagic layers.

Work at sea
Investigations on board RV *Polarstern* will be made by a combination of sampling and experimental approaches. For gut content analysis samples will be taken from down to 1000 m with a Multinet. Additional stratified sampling from 2000 m to the surface is intended to cover deeper layers of the water column. The samples will be concentrated on gauze (100 µ) and will be stored at -80° C for later analysis. Additional specimens will be picked for fatty acid analysis, shock-frozen and quickly stored at -80° C for further analysis in Germany.

Animals for the feeding experiments will be sampled with a newly developed plankton net equipped with a 15 l closed cod-end bucket. In this bucket, the animals not only remain in the natural seawater during the net haul, but are also saved from being compressed during the vertical net tow. Actively swimming species with prey items in their gut will be placed in special containers with seawater and will be allowed to defecate. After a starvation period of two days feeding experiments will be conducted by offering different prey to the chosen carnivores. To determine digestion time the containers will be checked continuously until defecation. The digestion time is necessary to calculate the daily feeding rate and to draw conclusions about the predation impact.

The faecal pellets produced under different diets will be used to estimate the role of the zooplankton in the carbon flux. Therefore, measurements of the sinking velocities will be conducted in a Plexiglas cylinder (1 m) filled with filtrated seawater at an ambient temperature. Moreover, we will investigate the size and content as well as the C/N-ratio of additional pellets.

13. MARINE TOP PREDATORS AND THEIR PREY - A TOP DOWN APPROACH TO ANTARCTIC FOODWEBS

J.v. Franeker, H. Flores, R. Fijn , A. Meijboom, M. v. Dorssen, (ALTERRA)

Objectives
The winter LAKRIS expedition of *Polarstern* (ANT-XXIII/6, Jun-Aug 2006) is the third cruise in which Alterra participates with the project "Seabird food chains in the Antarctic seasonal sea-ice zone: challenging the dominant role of krill". Earlier expeditions were the SO-GLOBEC autumn study (ANT-XXI/4, Lazarev Sea, Mar-May'04) and the ISPOL study (ANT-XXII/2, interior Weddell Sea, Nov'05-Jan'06).

This is a 4-year project funded by the Netherlands AntArctic Program (NAAP proj nr 851.20.011). The central theme of the project is that we aim for simultaneous studies of:

- quantitative distributions of top-predators in relation to environmental conditions
- dietary studies of top-predators (stomach-flushing live birds; scat collection of mammals)
- distribution and abundance of surface prey (fish and larger zooplankton)
- energetic value and stomach contents analysis of fish and zooplankton

We focus this work on the foodwebs associated with the Antarctic seasonal sea-ice zone. The combined study elements result in a 'top down" approach to unravel and quantify the importance of biological production in the Antarctic sea-ice zone. High productivity of sea-ice may be evidenced by large top predator populations, but is poorly understood, let alone quantified (van Franeker et al. 1997, Deep-Sea Research II 44(1/2): 435-455). Simultaneous study of prey-abundance and utilization by top-predators explores the alleged simplicity in structure of Antarctic foodchains. Improved modelling of the sea-ice related foodweb is needed in questions concerning animal abundance and biodiversity, management of living-resources and impacts of climate change.

Work at sea

Distribution and abundance of top predators is determined by international standard census methods, using band-transect methods for birds, supplemented with line-transect elements for marine mammals. Outdoor observation posts will be installed on top of the bridge of RV *Polarstern*. Low light conditions during this winter cruise will complicate regular observations. We will explore possibilities for partial surveys in ice lights, in combination with the infrared sensing cameras operated by other teams on board. In addition to ship based surveys, helicopter will be used to maximize survey areas during short daylight periods.

Seabird diets can be studied without harm to animals by stomach flushing. For this we will use birds accidentally landed on the ship. If conditions allow, we will experiment with actively capturing birds by e.g. nets during station work. On an opportunistic basis, we will sample faeces from seals or other marine mammals. Prey remains from predator stomachs will be used to reconstruct original mass and energy consumption of different types of prey.

A considerable part of the effort in this project is directed towards the construction of a special net to sample fish and zooplankton residing directly under sea-ice. A special heavy-framed but floating net that can 'roll' along the under surface of sea-ice has been developed by Alterra (SUIT-net = Surface-Under-Ice-Trawl). The net can be operated from the rear gangway of RV *Polarstern* and shears sidewards to starboard away from the ship's trackline.

Because of the heavy steel frame, floaters and wheels, the construction weighs ± 1000 kg which, together with the rough operation in sea ice, has led to the nickname 'der Kampfwagen' ('Charriot') among the ship's crew. The netframe-opening is square with sides of about 2.4 m and has a 'slide-out' system for heavy lumps of ice. The net is made of a shrimp-net type (7 mm mesh) and about 13 m long. The rear two meters of the net are lined with 0.3 mm mesh. Based on experiences with the first SUIT-net in autumn 2004 expedition, various aspects of the frame and net have been modified. The escape hatch for ice has been enlarged by inserting floating panels in the sides of the frame. This has improved shearing performance (Fig.2) and has reduced water turbulence in front of the net (Fig.3) Also, in combination with adaptations to RV *Polarstern*, measures are being prepared that will keep net-cables better under the ice, even at close range to the ship. The midwinter sea-ice conditions will be a severe test for intended future SUIT operation in milder seasons in the Antarctic and Arctic sea-ice areas.

Net catches will, as much as possible, be immediately identified, measured and processed while fresh during the cruise itself. Subsamples will be stored in various ways suitable for the later analyses of e.g. energy-density and contents of stomachs/guts, both needed to make stepwise additions to foodweb analysis and productivity estimates. Subsamples will also be taken for a large planned IPY project on contaminant levels and pathways in polar ecosystems.

The Alterra study will closely co-operate with, and benefit from other research conducted during the interdisciplinary LAKRIS expedition such as dedicated IWC whale censuses, the infra-red seal imageing and a range of krill, other zooplankton and fish studies. The predator-prey project will be staffed by principal-investigator Jan van Franeker (Alterra), PhD Hauke Flores (Alterra & University of Groningen), Masters Student Ruben Fijn (VU/Alterra), assistant researcher André Meijboom (Alterra) and net-operator Michiel van Dorssen.

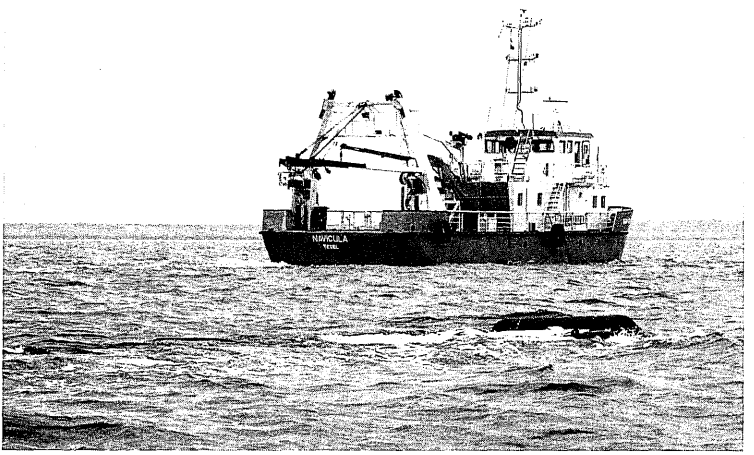

Fig. 2: Testing the shearing properties of the second generation SUIT net in the Wadden Sea, summer 2005

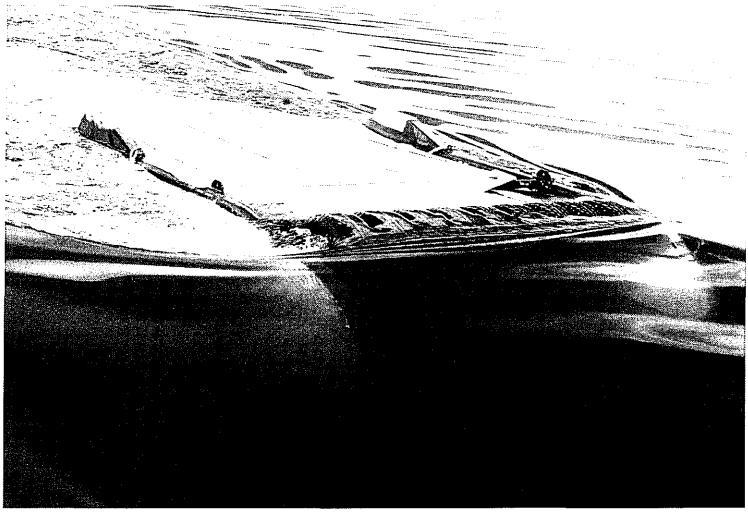

Fig. 3: The second generation SUIT has a modified design of floaters (partly incorporated in side panels: closed row of wheels) strongly reducing water turbulence in front of the net

14. DISTRIBUTION, COMPOSITION AND FOOD WEB STRUCTURE OF MESOPELAGIC MICRONEKTON IN THE LAZAREV SEA DURING WINTER 2006

A. van de Putte (LAE), H. Flores (ALTERRA), E. Pakhomov (UBC), S. Risch (LAE)

Objectives

This multi-lateral project focuses on the importance of mesopelagic fish in the food web of the Lazarev Sea. Mesopelagic fish are gaining more and more attention, especially since the exclusive role of krill as a key energy transmitter between lower and higher trophic levels has been increasingly questioned over the past decades.

Special attention is paid to lanternfishes (Myctophidae) which represent the bulk of the fish in the mesopelagic realm of the Southern Ocean, both in numbers and biomass. Myctophids have high energy content, and some species such as *Electrona antarctica* are widely distributed and abundant. They contribute substantially to the diet of many species of seabirds, penguins, seals and whales.

Being mostly consumers of zooplankton and often prey of top predators, mesopelagic fish are found at a key position in the Antarctic marine food web. As consumers, their potential impact on larval and adult Antarctic krill (*Euphausia superba*) populations deserves a closer look.

The LAKRIS winter-expedition of 2006 forms the last step in the framework of a multi-year sampling programme in the Lazarev Sea. Comparative data analysis of three different seasons will among others address the following objectives:

- To determine the distribution of Antarctic pelagic key species in relation to biotic and abiotic factors of the environment,
- to improve the understanding of interactions between species and populations and their role in the Southern Ocean Ecosystem,
- to improve a conceptual model and numerical ecohydrodynamical model of the Austral Ocean pelagic ecosystem,
- to investigate the importance of surface-migrating mesopelagic species as energy transmitters to higher trophic levels.

Work at sea
The proposed research will focus on sampling mesopelagic backscattering layers in order to quantify mesopelagic micronekton density, to identify their species composition and to collect specimens for future gut content, stable isotope, elemental composition and growth analyses. A substantial fish collection has already been initiated during the fall cruise 2004 (ANT-XXI/4) and summer 2005/2006 cruise (ANT-XXIII/2). As a standard, the entire fish by-catch of the LAKRIS krill sampling programme will be analyzed. The RMT-1*8 will be used for micronekton collection. Species identification and length measurements will be done on board as far as possible. For further treatment in the home laboratories, we will take frozen, ethanol and formalin samples. Additionally, larval and adult fish samples will be taken for genetic analysis. Genetic data will later be used for population genetics and molecular species discrimination.

15. WHALES

M. Garcia (IWC)

Objectives
IWC SOC observers will participate in this German SO GLOBEC multidisciplinary survey of the Lazarev Sea, Weddell Sea during the Antarctic winter in 2006. IWC SOC observers are experienced in Antarctic cetacean surveys and sea ice classification. This survey will provide the opportunity to conduct cetacean survey work in the Lazarev Sea study area for the third time, thus providing repeat data across a range of seasonal conditions (summer, winter, autumn) from one site. Thus providing a unique time series to investigate seasonal variability in cetacean distribution and sea ice. Our aim, in working with a range of international SO GLOBEC and other multidisciplinary programmes (Germany, UK, USA, Australia) is to collect data in each of the Antarctic regions (Weddell Sea, Scotia Sea, Western Antarctic Peninsula, Amundsen-Bellingshausen Sea, Ross Sea and East Antarctica) over a range of seasonal conditions to investigate connections between variability in cetacean distribution and other physical and biological processes for input to local, regional and circumpolar scale models.

Multidisciplinary programmes, particularly those conducted under the auspices of SO GLOBEC, provide access to data across disciplines (hydrography, krill distribution, primary productivity) for collaborative analysis and modelling

Work at sea
The observers will conduct visual survey along track in daylight hours throughout the cruise, dependent upon weather conditions. They will record cetacean sightings and records of other wildlife, using a methodology we have developed for use on SO GLOBEC multidisciplinary surveys. These data will provide distribution data for cetaceans and a biodiversity index for other marine wildlife (seals, penguins, seabirds). The IWC observers will record a comprehensive suite of sea ice data at 10-minute intervals during daylight hours. Digital images and the ASPeCt sea ice classification method will be used for all sea ice observations. Cetacean, marine wildlife and sea ice data will be entered on a laptop on the bridge (connected to live gps feed from the vessel) using the 'Logger' programme that allows real time entry of visual survey, sea ice and other related data fields.

16. MARINE MAMMAL AUTOMATED PERIMETER SURVEILLANCE (MAPS)

H. Klinck, E. Burkhardt (AWI)

Scientific Background
Ship-based detection of marine mammals has a broad range of applications. On the one hand, population ecologists with focus on whale distributions and migratory patterns are interested in effective methods for conducting a census of marine mammals. On the other hand, users of hydroacoustic instruments are interested to most effectively implement reliable mitigation methods if adverse reactions of marine mammals to the ship's presence may be apprehended.

Objectives
Several methods for the detection, identification and localization of marine mammals will be evaluated. Because whales and seals spend considerable periods of time both at the surface as well as submerged, multiple methods need to be simoultaneously employed to ensure detection regardless of their location. Underwater, vocalizing mammals can be detected by passive sonar. Its usefulness, however, is currently compromised by intrinsic vessels' noise, which will mask particularly low- to mid-frequency vocalizations of the mammals. We will attempt to develop modern signal processing methods to optimally separate the sounds and provide the optimal sensitivity for the bioacoustic signals. Near the surface, whales might be recognized by their warm blow, which stands out against the cold Antarctic environment. Here, research will focus on establishing pattern recognition software, to automatically and reliably detect whale blows under varying environmental conditions.

Work at sea
A passive acoustic system, especially designed for the detection of marine mammals will be deployed while cruising and recovered during stations. It consists of three streamer segments, each containing five broad band hydrophones on a portable winch with 700 m tow cable and a signal processing unit.

In addition two infrared cameras mounted at the crow's nest with image processing software will continuously monitor the regions next to the ship for infrared signatures of whale spouts even at night and poor visibility. The acoustic and infrared systems were tried out for the first time on the ANT-XXII/3 expedition (January – April 2005). Based on the results of this expedition several adjustments were done. During the ANT-XXIII/2 expedition (polar summer) and the ANT-XXIII/6 expedition (polar winter) the modified systems will be tested in detail.

Both at the summer and the winter expedition visual surveys will be done by a group of experienced scientist. The number of visual whale sightings can be compared with the automated detections of the MAPS System. Thus the efficiency of the system can be verified. The results of both expeditions are important for improving the automated detection of marine mammals in the vicinity of *RV Polarstern* using MAPS in future.

17. DEPLOYMENT OF IPAB METEOROLOGICAL SEA ICE DRIFTING BUOYS

C. Haas (AWI)

Objectives
In the framework of the WCRP/SCAR International Program for Antarctic Buoys (IPAB) AWI is committed to deploy drifting buoys on the sea ice to measure sea level pressure, air temperature, and ice drift. The data are transmitted via the Argos satellite system into the global weather data network GTS, and to AWI.

Work at sea
During ANT-XXIII/6, three buoys will be deployed on stable ice floes between 68-70°S und 0-10°E, either by helicopter or directly from the ship. The actual region will be decided based on the actual cruise track and prevailing ice conditions as observed by satellites. Ideally, buoys will be deployed at the corners of a triangle with legs of 100-300 km width.

18. SCIENTIFIC DIVING UNDER ANTARCTIC WINTER CONDITIONS

U. Freier, S. Yasseri, S. Spahic, C. Pape (AWI), H. Flores (ALTERRA)

Objectives
Due to winter conditions we expect extensive and stable sea-ice cover with ice-thickness ranging between 80 and 150 cm, depending on the origin of the sea ice . The ice cover may be interspersed by leads or small polynyas. In these cases diving can be carried out from the edges of the ice.

Scuba diving will be carried out during this cruise to collect adult and larval krill (*Euphausia superba*) and different planctonic- as well as sea ice biota. The intention is to obtain live

material in the best possible physical condition for subsequent physiological experiments. Sampling will be done with modified hand nets/sampling-bottles. Diving will mostly be practiced directly under the ice-surface where krill and ice-algae are expected to be found. Diving will be limited to a maximum depth of 10 m. Low temperatures, strong winds (ice-movement//wind-chill) and darkness will be the highest risk factors for scuba-diving. The occurrence of large predators like the leopard seal may interfere with the diving at the given diving station. When leopard seals are encountered the diving procedure will follow the AWI guidelines for diving in the presence of leopard seals.

Work at sea
In correspondence to weather and cruise conditions diving is planned to take two time blocks of about 60 hours each for ice station work and/or diving in open water polynyas.

Diving in polynyas
If larger open water areas occur, a motorised Zodiac rubber boat will serve as diving platform. From the boat, divers will line-guided to go underneath the ice edge to do their job. Video- /photo-work and sampling will be carried out under the ice at a maximum distance of 25-30 m from the ice edge/boat.

Diving at ice stations
Helicopters, skidoo and RV *Polarstern* logistics will be used to establish the ice stations. A base station with two heated plastic igloos and a modified "Scott tent" will protect against outside conditions. Two 5 kW generators will provide 24 h electricity. One or, depending on the time schedule, two holes of approximately 2 m^2 will be cut through the sea ice using chain sawas and coring equipment adjacent to the ice camp.

Helicopter flights, laptop-based 24 h video-scan of the ice hole, permanent under-water-noise detection and observation from RV *Polarstern* bridge will provide us information on the presence of leopard seals and other mammalian activity.

Diving through the ice hole will be performed as line-guided diving in a radius of about 30 m under the ice. If there is enough time to cut a second security hole, both ice holes will be connected by a security line running under the ice.

Diving organisation
A diving group will consist of 5 persons. The sampling diver (1) will always be accompanied by a second "security-and reconnaissance" diver (2) to look out for leopard seals.

The divers will always be connected to the "On-Ice-Signalman" (3) by a combined line- and telephone-system, which allows vocal communication. The fourth person is the standby-"Rescue-Diver"(4), who is positioned directly next to the ice hole. Other persons will be requested to assist if required. A normal diving will have a maximum of 30 minutes time under water, the diving depth is strictly limited to 10 m water column depth to avoid decompression-syndromes.

Safety and Diving Regulations
RV *Polarstern*-hospital will be in charge for any type of accident. Oxygen and first aid will be readily available at the diving station. Fast rescue transportation from the ice station to RV *Polarstern* will be organised.

Scuba diving will at all times be carried out according to the German Diving Regulations BGR 225/ZH 540 for German Scientific Divers from the "Fachausschuss Tiefbau der deutschen Berufsgenossenschaften (BGZ)" as well as the AWI internal guidelines for diving in the presence of leopard seals.

19. PHOTOGRAPHIC ART PROJECT

L. Tadday

During my first cruise with RV *Polarstern* during the Antarctic autumn (April/May 2001), I was under the spell of displaying the ice scenery. During the forthcoming winter cruise (June – August 2006) I will focus on completely different dimensions. I intend to show the work of crew and scientists on board under the influence of Antarctic winter (permanent darkness, extreme coldness, thick ice covers).

A focus of this project will be to sharpen the view of the observer for the work under extreme conditions. Touching the soul by the eye and establish a bridge between scientific measurements of natural phenomena and the creative art of reflecting nature.

20. FAHRTTEILNEHMER / PARTICIPANTS

Fahrtleiter/Chief Scientist: Ulrich Bathmann
Cape Town – Cape Town

Name	Vorname/ First Name	Institut/ Institute	Beruf/ Profession
Alheit	Ruth	AWI	Technician
Auerswald	Lutz	UCT	Biologist
Balhara	Vikas	IITD	Technician
Bathmann	Ulrich	AWI	Biologist
Buldt	Klaus	DWD	Technician
Burkhardt	Elke	AWI	Biologist
Cisewski	Boris	AWI	Oceanographer
Dorssen	Michiel van	ALTERRA	Biologist
Ewe	Daniela	University Bremen	Student, physics
Fijn	Rin	ALTERRA	Biologist
Flores	Hauke	ALTERRA	Biologist
Franeker	Jan van	ALTERRA	Biologist
Freier	Ulrich	AWI	Diver
Fuentes	Veronica	AWI	Biologist
Garcia	Maria	IWC	Biologist
Hager	Julia	University Bremen	Student, physics
Haraldsson	Matilda	BFA Fisch	Student, biology
Herrmann	Sarah	AWI	Student, biology
Klinck	Holger	AWI	Physicist
Kruse	Svenja	AWI	Biologist
Lenderink	Andrea	University Bremen	Student, physics
Rudolf	Anton	HeliTransair	Pilot
NN	-	HeliTransair	Pilot
Stimac	Mihail	HeliTransair	Technician
Fuhs	Elisabeth	HeliTransair	Technician
Martynova	Daria	Univers.St. Petersb.	Biologist
Meijboom	Andre	ALTERRA	Biologist
Meyer	Bettina	AWI	Biologist

Name	Vorname/ First Name	Institut/ Institute	Beruf/ Profession
Michels	Jan	AWI	Biologist
Miller	Max	DWD	Meteorologist
Nunez-Riboni	Ismael	AWI	Student, physics
Olariaga	Alejandro	AWI	Student, technique
Pakhomov	Evgeny	UBC	Biologist
Pape	Carsten	AWI	Biologist
Risch	Sarah	LAE	Biologist
Sahlmann	Christian	University Bremen	Student, physics
Schreiber	Karolin	AWI	Technician
Schukat	Anna	University Bremen	Student, biology
Spahic	Susanne	AWI	Technician
Stübing	Dorothea	University Bremen	Biologist
Tadday	Lilo		Photographer
Van de Putte	Anton	LAE	Biologist
Vortkamp	Martina	BFA Fisch	Technician
Wendts	Britta	AWI	Biologist
Witte	Timo	OPTIMARE	Technician
Würzberg	Laura	BFA Fisch	Biologist
Yasseri	Michael S.	AWI	Diver

21. BETEILIGTE INSTITUTE / PARTICIPATING INSTITUTES

	Adresse /Address
ALTERRA	ALTERRA Marine and Coastal Zone Research PO Box 167 1790 AD Den Burg (Texel) The Netherlands
AWI	Alfred-Wegener-Institut für Polar- und Meeresforschung in der Helmholtz-Gemeinschaft Postfach 12 01 61 27515 Bremerhaven
BFA Fisch	Bundesforschungsanstalt für Fischerei Institut für Seefischerei Palmaille 9, D-22767 Hamburg
DWD	Deutscher Wetterdienst Bernhard-Nocht Str. 76 20359 Hamburg / Germany
HeliTransair	Heli Transair GmbH Flugplatz 63329 Egelsbach
IITD	ITT Dehli Department of Biotechnology Hauz Khas New Delhi – 110 016 / India
IWC	Whale Ecology Group- Southern Ocean, School of Ecology and Environment Deakin University P.O. Box 423 Warrnambool/ Australia
LAEISZ	Reederei F. Laeisz GmbH Brückenstr. 25 27568 Bremerhaven

	Adresse /Address
LAE	Laboratory of Aquatic Ecologie Deberiotstraat 32 3000 Leuven / Belgium
OPTIMARE	Optimare Sensorsyteme AG Am Luneort 15A 27572 Bremerhaven
University St. Petersburg	The White Sea Biological Station Zoological Institute Russian Academy of Sciences Universitetskaya nab., 1 St.Petersburg, 199034, Russia
University Bremen	Marine Zoologie Universität Bremen Postfach 33 04 40 28334 Bremen
UCT	Zoology Department University of Cape Town Rondebosch 7701 South Africa
UBC	University of British Columbia Department of Earth and Ocean Science 6339 Stores Road Vancouver, B.C. Canada V6T 1Z4
VUB	Vrije Universiteit Brussel Department of Analytical and Environmental Chemistry Pleinlaan 2 1050 Brussels / Belgium

22. SCHIFFSBESATZUNG / SHIP'S CREW

Name of Ship : POLARSTERN
Nationality : GERMAN
Cape Town - Cape Town

No.	Name	Rank
1	Schwarze, Stefan	Master
2	Spielke, Steffen	1.Offc.
3	Ziemann, Olaf	Ch.Eng.
4	Bratz, Herbert	2. Offc.
5	Birnbaum, Tilo	2.Offc.
6	Hering, Igor	2.Offc.
7	Kleyheeg, Jörg	Doctor
8	Koch, Georg	R.Offc.
9	Simon, Wolfgang	2.Eng.
10	Schnürch, Helmut	3.Eng.
11	Westphal, Henning	3.Eng.
12	Holtz, Hartmut	ElecTech.
13	Dimmler, Werner	ELO
14	Riess, Felix	ELO
15	Fröb, Martin	ELO
16	Feiertag, Thomas	ELO
17	Clasen, Burkhard	Boatsw.
18	Neisner, Winfried	Carpenter
19	Kreis, Reinhard	A.B.
20	Schultz, Ottomar	A.B.
21	Burzan, G.-Ekkehard	A.B.
22	Schröder, Norbert	A.B.
23	Moser, Siegried	A.B.
24	Pousada, Martinez	A.B.
25	Hartwig-L., Andreas	A.B.
26	Schmidt, Uwe	A.B.
27	Beth, Detlef	Storek.
28	Hoppe, Kurt	Mot-man
29	Fritz, Günter	Mot-man
30	Krösche, Eckard	Mot-man
31	Dinse, Horst	Mot-man
32	Watzel, Berhard	MotMan
33	Fischer, Matthias	Cook
34	Tupy, Mario	Cooksmate
35	Martens, Michael	Cooksmate
36	Dinse, Petra	1.Stwdess
37	Tillmann, Barbara	Stwdss/Kr
38	Streit, Christina	2.Stwdess
39	Schmidt, Maria	2.Stwrdess
40	Deuß, Stefanie	2.Stwdess
41	Wu, Chi Lung	2.Steward
42	Sun, Yong Sheng	2.Steward
43	Yu, Chung Leung	Laundrym.

ANT-XXIII/7

24 August 2006 - 29 October 2006
Cape Town - Cape Town

Chief Scientist:
Peter Lemke

CONTENTS

1. ÜBERBLICK UND FAHRTVERLAUF

RV *Polarstern* wird am 24. August 2006 in Kapstadt (Südafrika) auslaufen mit dem Ziel, im nordwestlichen Weddellmeer südlich der South Orkney Islands (Fig. 1) ozeanographische, meereisphysikalische, biologische, luftchemische und bathymetrische Untersuchungen durchzuführen.

Die ozeanographischen Arbeiten konzentrieren sich auf die Erfassung der winterlichen Bedingungen in der Hauptausstromregion für neu gebildetes Tiefenwasser des Weddellmeeres. Damit werden die im Rahmen internationaler Projekte seit mehr als einem Jahrzehnt durchgeführten Messungen entlang des Süd-Scotia Rückens fortgesetzt. Ein dichtes Stationsnetz über der Orkney Passage (41°W, 61°S) und der Philip Passage (49°W, 61°S) sowie ein zonaler und zwei meridionale Schnitte im tiefen Weddellmeer sind geplant, um die Ausbreitungspfade und die Exportrate des für die Ventilation der globalen Tiefsee wichtigen Tiefenwassers zu erfassen. Da ebenfalls die Hauptzugbahn der im Weddellmeer gekalbten Eisberge mehrmals gekreuzt wird, werden im Rahmen des AWI-Monitoring Programms Eisberge kleiner bis mittlerer Größe mit Satelliten gestützten Driftbojen bestückt.

Die hydrographischen Untersuchungen werden durch Messungen von Edelgasen (Heliumisotope ^{3}He und ^{4}He sowie Neon) und Fluorchlorkohlenwasserstoffen (FCKWs) unterstützt und erweitert. Durch die wiederholten Messungen sollen eventuelle Veränderungen der Tiefen- und Bodenwasserverteilung, deren Ausbreitung und ihre Zusammensetzung aus unterschiedlichen Quellwassermassen untersucht werden, insbesondere in Hinblick auf den Abbruch von Teilen des Larsen Eisschelfs. Edelgase liefern Aufschluss über unterschiedliche Bildungsprozesse von Weddellmeer Bodenwasser, etwa über Beiträge von glazialem Schmelzwasser, in dem sie deutlich überhöht sind. FCKWs ermöglichen aufgrund ihres zeitlichen Anstiegs Abschätzungen der Zeitskalen der Tiefen- und Bodenwasserausbreitung.

Zusätzlich werden CO_2-Messungen durchgeführt, um die Hypothese zu testen, dass das Weddellmeer ein wesentliches Gebiet für die Kohlenstoffbilanz des durch den Menschen gestörten Kohlenstoffkreislaufs ist. Gesamt CO_2 und Alkalinität werden während der Fahrt gemessen und mit anderen Daten genutzt, um das anthropogene CO_2-Signal in den Wassermassen des Weddellmeeres zu bestimmen. Ziel ist es, die gesamte über einen Jahresgang integrierte CO_2-Aufnahme im Weddellmeer abzuschätzen.

Beobachtungen des Ozeanbodendrucks liefern ein integrales Maß für Veränderungen des ozeanischen Massenfeldes durch Variabilität geostrophischer Strömungen, des Meeresspiegels und der Verteilung unterschiedlicher Wassermassen. Dafür werden 6 Drucksensoren (PIES, Pressure Sensors / Inverted Echo Sounder) zur Messung des Ozeanbodendrucks im Antarktischen Zirkumpolarstrom verankert. Zusammen mit bereits ausliegenden PIES ermöglichen diese Geräte eine großräumige 2-dimensionale Erfassung von Drucksignalen in der Region 5 °W – 15°E / 36 °S – 51°S. Damit sind die Bodendruck-Zeitreihen im Rahmen des BMBF-Verbundprojekts "Qualitätsverbesserte GRACE Level-1 und Level-2 Produkte und deren Validation gegen Ozeanbodendruck" ein wichtiger Beitrag zur Validation der von der GRACE Satelliten-Mission gemessenen Variabilität des Schwerefeldes über den Ozeanen. In Kombination mit der von den PIES ebenfalls gemessenen Schalllaufzeit vom Boden zur Meeresoberfläche sowie der Satelliten-Altimetrie werden Variabilität von Strömung, Massentransport und Wärmeinhalt im Antarktischen Zirkumpolarstrom integral erfasst.

In den Polargebieten spielt Meereis bezüglich der Wechselwirkung zwischen Atmosphäre und Ozean eine wichtige Rolle und bestimmt damit das Klima nicht nur regional sondern auch auf der globalen Skala. Die Meereiseigenschafen im Weddellmeer im Winter sind nur ungenügend bekannt und sollen daher im Detail untersucht werden; insbesondere steht die regionale und zeitliche Variabilität der Dicke von Schnee und Meereis im Zentrum der physikalischen Aktivitäten, die vom Hubschrauber, vom Schiff und vom Meereis aus durchgeführt werden. Zusätzlich werden Satellitenbeobachtungen genutzt bzw. validiert. Insbesondere sollen die Eigenschaften von ein- und zweijährigem Meereis, untersucht und das Schicksal des Meereisökosystems im zweiten Winter nach der sommerlichen Schmelzphase beleuchtet werden. Diese Untersuchungen vervollständigen den Datensatz, der während ISPOL (ANT-XXII/2, Dezember/Januar 2005/6) gewonnen wurde.

Jüngere Forschungsergebnisse weisen darauf hin, dass salzhaltige Frostblumen, die auf neu gebildetem Meereis entstehen, die lang gesuchte Quelle der reaktiven troposphärischen Bromverbindungen in den Polargebieten darstellen. Diese *Polarstern*-Expedition bietet die einmalige Gelegenheit neue Feldmessungen in einer der Schlüsselregionen durchzuführen, in denen häufig explosionsartig ansteigende atmosphärische Bromkonzentrationen beobachtet werden. Die geplanten Aktivitäten umfassen Messungen von reaktiven Spurenstoffen über dem Meereis, die Sammlung von Frostblumenproben und die Analyse der Ergebnisse in Beziehung zu den Meereiseigenschaften, die durch Daten von Bord und von Satelliten charakterisiert werden können. Das Ziel ist die Identifizierung der potentiellen Brom-Quelle und wenn möglich die Quantifizierung und Parametrisierung der Brom-Flüsse in die Atmosphäre.

Hauptziel der Untersuchungen zur Meereisbiogeochemie und Biodiversität ist die umfassende Charakterisierung der physikalischen, chemischen und biologischen Wechselwirkung im winterlichen Meereis des Weddellmeeres, um ein besseres Verständnis der Biomasse-Entwicklung im Spätwinter zu erhalten.

Unter anderem sollen die photosynthetischen Eigenschaften der Meereisalgen mittels PAM Fluorometrie untersucht werden. Diese Daten werden mit physikalischen sowie biogeochemischen Parametern des Meereises verglichen, um deren Wirkung auf die Primärproduktion im Meereis zu bestimmen.

Aufgrund der enormen Ausdehnung der Meereisdecke und ihrer Funktion als mehr oder weniger durchlässige Barriere für Stoff- und Energieflüsse, kommt dem Meereis eine Schlüsselrolle im System des polaren Ozeans zu. Zu den Stoff- und Energieflüssen tragen die mit dem Meereis assoziierten Organismen entscheidend bei. Um diese Prozesse zu klären werden die ökologische Bedeutung und Verteilung von Organismen im Eis und direkt unter dem Eis untersucht und so deren Beiträge zu diesen Flüssen charakterisiert. Außerdem werden die Charakteristiken des Habitats Meereis bestimmt und Anpassungsstrategien der Organismen an niedrige Temperaturen und variable Salzgehalte, die im Habitat vorkommen können, untersucht.

Ein weiterer Schwerpunkt der biologischen Arbeiten soll neben der zoogeographischen Verbreitung der Meereis-Copepoden auf Untersuchungen zur Stoffwechselphysiologie gelegt werden. Diese sollen zeigen, dass Unterschiede zwischen Meereis-Copepoden (*Stephos longipes, Drescheriella glacialis*) im Vergleich zu rein pelagischen Copepodenarten (*Oithona similis, Ctenocalanus citer, Oncaea curvata*) bezüglich Temperatur und Salinität auf spezielle biochemische Adaptationen beruhen. Parallele Experimente ermöglichen eine Aussage über

den Einfluss der Ernährung von Eisalgen auf Reproduktion, Wachstum und Überlebensrate verschiedener Copepodenarten. Folgende Fragen sollen dabei geklärt werden:

- Welche physiologischen Faktoren begrenzen die Anzahl der Arten, die im Eis bzw. in der Eis/Wasser-Grenzschicht leben?
- Welche Mechanismen sind verantwortlich für die Toleranz der Eisorganismen an hohe Salzgehalte und niedrige Temperaturen?
- Welche Unterschiede bestehen zwischen den Arten (Meereis - Pelagial)?

Zusätzlich sind Untersuchungen zu den Lebensstrategien inklusive der Nahrungsaufnahme, Respiration, Exkretion und Reproduktion der dominanten pelagischen Copepodenarten geplant. Die geplanten Zooplanktonuntersuchungen werden im Rahmen der internationalen marinen Biodiversitätsinitiative "Census of Marine Zooplankton" (CMarZ) durchgeführt.

Ein weiteres Thema betrifft die Produktion von Dimethylsulfid (DMS) durch biophysikalische Prozesse im Oberflächenwasser und im Meereis. DMS wird in die Atmosphäre eingetragen und spielt als Aerosol eine wichtige Rolle bei der Bildung von Nebel und Wolken und beeinflusst damit den Niederschlag und die Strahlungseigenschaften und daher die Energieabsorption in der Atmosphäre. DMS und seine Oxidationsprodukte werden auch über den Schnee in den Eisschilden eingelagert und dienen neuerdings als Indikator für die Meereisausdehnung in vergangenen Zeiten. Die geplanten Untersuchungen sollen die Basis für das Prozessverständnis erweitern und zur Verbesserung von Parametrisierungen in den Klimamodellen und der Eiskernanalyse beitragen.

Den Polarmeeren kommt eine zentrale Rolle im globalen Kohlenstoffkreislauf zu. Die Bildung von Tiefen- bzw. Bodenwasser in diesen Gebieten führt dazu, dass den aktiven Kreisläufen große Mengen gelösten organischen Materials (DOM) über Jahrtausende entzogen wird. Die chemische Identität des DOM ist hierbei von entscheidender Bedeutung, da nur biogeochemisch stabile, refraktäre Substanzen den Transport in das Tiefenwasser überdauern. Über Bildungsprozesse und Struktur dieses DOM ist wenig bekannt. Im Mittelpunkt des geplanten Projekts steht die Frage: „Beeinflusst das Südpolarmeer globale Kreisläufe, indem Kohlenstoff in Form stabiler, organischer Substanzen gespeichert und in die Tiefsee verfrachtet wird?" DOM im Bereich der antarktischen Bodenwasserbildung soll mit modernen, analytischen Methoden auf molekularer Ebene charakterisiert werden. Prozesse, die im polaren Ozean zur Ausbildung stabiler organischer Strukturen führen, sollen identifiziert und die "DOM-Pumpe" des Südpolarmeeres quantifiziert werden. Mit diesen Informationen können Modelle zum globalen Kohlenstoffkreislauf verbessert werden.

Die Vermessung der Meeresbodentopographie liefert die Geodatenbasis für die räumliche Zuordnung meereskundlicher Beobachtungen und dient darüber hinaus zur Interpretation physikalischer, chemischer und biologischer Prozesse am Meeresboden und in der Wassersäule. Das bathymetrische Programm umfasst vier Arbeitsschwerpunkte.

Während der gesamten Fahrt werden außerhalb der nationalen Wirtschaftszonen Fächerlotmessungen mit dem Hydrosweep durchgeführt, um die globale bathymetrische Datenbasis zu erweitern und diese zur Überarbeitung der vorhandenen bathymetrischen Kartenwerke (GEBCO, IBCSO) und für die internationale Seekartenherstellung bereitzustellen. Im Übergangsgebiet zwischen dem Weddellmeer und dem Scotiameer ist es geplant, die bisher morphologisch unbekannten Transportwege des Weddell Sea Deep Water östlich (Orkney Passage) und westlich (Philip Passage) des South Orkney Plateaus bathymetrisch zu vermessen. Die Topographie des Meeresbodens in der unmittelbaren

Umgebung der Ozeanographie-Messstationen wird durch zusätzliche kurze Fächerlotprofile erfasst und kartiert, um die vorhandenen lokalen Strukturen zur Beurteilung der Messungen zu nutzen. Ein mehrtägiges Vermessungsprogramm ist im Gebiet eines Erdbebens nördlich der South Orkney Inseln vorgesehen. Die bisher in diesem Gebiet gemessenen Fächerlotprofile sollen zu einer flächenhaften Überdeckung des South Orkney Grabens ergänzt werden. Ziel ist es, durch Vergleiche mit älteren Messungen Rückschlüsse auf Massenverlagerungen, eventuell ausgelöst durch das Erdbeben, zu ziehen.

Nach Beendigung der Arbeiten wird RV *Polarstern* in Richtung Kapstadt dampfen und dort am 29. Oktober 2006 einlaufen.

ITINERARY AND SUMMARY

RV *Polarstern* will leave port in Cape Town (South Africa) on 24 August 2006 to perform oceanographic, sea ice, biological, air chemistry and bathymetric investigations in the north-western Weddell Sea southward of the South Orkney Islands (Fig.1).

The oceanographic work is dedicated to investigate the winter conditions in the dominant regions of deep and bottom water production and export to the world's oceans. Dense sections across the main passages east and west of the South Orkney Islands and a U-shaped section to the south comprise the main hydrographic activities, which are aimed at the understanding of the formation, the distribution, the pathways and the export of the deep water masses. The hydrographic work is complemented by tracer measurements (Helium isotopes ^{3}He and ^{4}He, Neon and CFCs), which are also used to characterise water mass formation and transport, and by iceberg marking to provide a better estimate on their drift trajectories and the freshwater input to the Weddell Sea due to iceberg melting. In addition, total CO_2 and total alkalinity will be measured during the cruise which, in combination with auxiliary data, will allow deriving the anthropogenic CO_2 signal in Weddell Sea waters. It is expected that these data will provide an estimate of the total annual anthropogenic CO_2 uptake by the Weddell Sea water masses.

Furthermore, six bottom pressure sensors will be deployed on the sea floor in the area of the Antarctic Circumpolar Current (ACC) to acquire multi-year time-series of ocean bottom pressure and acoustic travel time to the surface for the validation of gravity field variability measurements by the GRACE satellite mission, for estimates of the variability of ocean currents, transport, heat content and mass in the South Atlantic part of the ACC.

Sea ice plays a major role in determining the exchange between ocean and atmosphere in polar regions and affects the climate system also on the global scale. The sea ice characteristics in winter in the Weddell Sea are poorly known and will be investigated in detail, especially concerning the regional and temporal variability of snow and sea ice thickness, which will be determined from the helicopter-borne thickness sensor, from the ship's sea ice monitoring system and from in-situ measurements on the ice. The main emphasis lies on the characteristics of first-year and second-year ice, and especially on the modification of the ecosystem after survival of the summer melt conditions.

Increasing evidence supports the hypothesis that salty frost flowers on newly formed sea ice represent the long-sought major source of polar tropospheric bromine. In order to shed light on this it is planned to perform trace gas measurements over the sea ice surface, to collect samples of frost flowers, and to analyze the results using surface information from both ship observations and from satellite. The aim is to verify the potential bromine sources and to possibly quantify and parameterize the bromine fluxes.

The main focus of the sea ice – biogeochemistry and biodiversity work is on the characterization of the physical, chemical and biological interactions in the Weddell Sea during winter, in order to understand the evolution of the biomass production in this part of the seasonal cycle. As part of these activities photosynthetic parameters and bio-optical properties of sea ice will be determined to understand the influence and forcing factors on sea ice primary production.

The distribution of organisms in and below the sea ice will be investigated with respect to species composition, vertical distribution, abundance, biomass, as well as their living conditions, physiological performance and adaptation strategies. Of special importance are sea ice copepodes and their pelagic counterparts. Investigation will be performed in order to understand the respective physiological and biochemical adaptation, energy requirements and life strategies to utilize short-term food-pulses and to endure periods of food scarcity.

Another topic is the production of dimethyl sulfide (DMS) through biophysical processes in the sea ice and the surface ocean layer. DMS is transported into the atmosphere as aerosol and plays a major role in the development of fog and clouds, with effects on precipitation, on radiative properties and energy absorption in the atmosphere. The investigations will provide an extended basis for process understanding, climate model parameterizations, and interpretation of ice cores.

The polar oceans play a central role in the global carbon cycle. The formation of deep and bottom water in these regions removes high amounts of dissolved organic matter (DOM) from the active carbon cycles for thousands of years. The knowledge of the chemical structure of DOM is of major importance because only biogeochemical stable, refractory substances survive the transport to the deep ocean. DOM in the area of Antarctic bottom water formation will be analyzed on a molecular level by modern analytical techniques. Transformation processes of DOM resulting in refractory organic substances will be identified for the quantification of the so called "DOM-pump". This knowledge will help to improve models for the global carbon cycle.

During the entire cruise bathymetric investigations will collect multi-beam data to enlarge the data bases for different ocean mapping programs and to improve Nautical Charts in the Antarctic INT Scheme. The hydrographic work will be supported through surveys around oceanographic sampling sites, especially in the regions of ocean passages. A special survey will be performed in the vicinity of an earth quake epicenter to detect a possible change in bottom topography.

After the conclusion of the work programme RV *Polarstern* will steam towards Cape Town and reach port on 29 October 2006.

2. PHYSICAL AND CHEMICAL OCEANOGRAPHY

2.1 WATER MASS VARIABILITY IN THE NORTHWESTERN WEDDELL SEA: A CONTINUATION OF THE DOVETAIL PROJECT

H.H. Hellmer, D. Olbers, L. Sellmann (AWI); M. Rücker van Caspel, V. Da Silva Duarte, M. Mata, R. Kerr Duarte Perreira (FURG); O. Huhn (IUP), N. Nunez (UEA)

Objectives

The physical oceanographic programme during ANT-XXIII/7 has three main objectives:

- Acquisition of wintertime hydrographic conditions in a key region for the composition and export of newly formed water masses to reduce the summer bias in any temporal interpretation.

- Continuation of the long-term observations in the northwestern Weddell Sea as part of the international DOVETAIL (Deep Ocean VEntilation Through Antarctic Intermediate Layers) project to monitor deep and bottom water variability and outflow.

- Monitoring iceberg drift in a key area for Weddell iceberg export as part of the freshwater balance studies.

Work at sea

The hydrographic work is focused on CTD and (L)ADCP measurements combined with water sampling for tracer and biogeochemical studies. We expect approx. 60 stations with a spacing of 5-30 nm depending on the steepness of topography and, certainly, local sea ice conditions. If latter conditions turn out to become severe, the mobile helicopter CTD will be used to sample relevant sites within a range of 50 nm. Helicopters will also be used to deploy markers on icebergs of small to medium size either grounded on the shallow South Orkney Plateau or drifting within the western Weddell Sea pack.

Hydrographic measurements will start and end with a dense station grid across Orkney Passage (41°W, 61°S) and Philip Passage (49°W, 61°S), respectively (Fig.1). In between, two N-S transects will be conducted across the NW Weddell Sea along ~42°W (southward - A) and ~50°W (northward across Powell Basin - C), from the ice edge (at ~60°S) to 65°S depending on sea ice conditions. Both meridional transects will be connected by a line following AWI's "traditional" Kapp Norvegia – Joinville Island section (B). All transects allow for a re-occupation of earlier CTD stations or mooring sites and cross several topographic features (Orkney Passage, Endurance Ridge, Weddell Abyss - Joinville Ridge, Powell Basin, Philip Passage) either located close to water mass formation sites or known to have significant influence on the spreading of newly formed water masses. If time allows and sea ice conditions are favourable, a section across the northwestern continental shelf into the Larsen polynya will be added.

Expected results

The South Scotia Ridge (SSR) separating the Weddell Sea from the Scotia Sea (Fig.1) represents a natural topographic barrier for deep and bottom waters to directly escape from the Weddell Sea. The rough topography on its southern flank guides ventilated Weddell Sea

Deep Water (WSDW) from the western Weddell Sea to a few gaps with maximum sill depths of ~3000 m (e.g. Orkney Passage), which allow for the passage into the Scotia Sea and beyond. Intensive field work during the past decade, e.g., as part of the international DOVETAIL project revealed that flow and characteristics of the deep and bottom waters in the northwestern Weddell Sea are subject to seasonal and interannual variability. The investigation area is located downstream of Larsen Ice Shelf which, as the Ice Station RV *Polarstern* (ISPOL) experiment 2004/05 showed, influences the continental shelf/slope by its melt. The recent loss of northern portions of the ice shelf might have caused significant changes to the shelf waters and, consequently, to the mixing products at the continental slope. An experiment in austral winter 2006 near the South Orkney Plateau allows to encounter the same water masses observed ~1.5 years before in the western Weddell Sea during ISPOL. The northwestern Weddell Sea also acts as a switch for icebergs travelling with the Weddell gyre. For reasons still unknown, certain bergs leave the Weddell Sea on a northerly route into the Scotia Sea while others continue eastward with the northern limb of the gyre.

This field study represents an important contribution to the long-term monitoring of deep water characteristics and export in the northern branch of the Weddell gyre, continuously conducted by colleagues in the USA (LDEO) and Brazil (FURG). It also contributes to AWI's long-term iceberg monitoring programme in the Weddell Sea and provides additional data for the validation of the coupled ice-(Southern) ocean finite element model (FESOM) developed by AWI's special research initiative "Community Model".

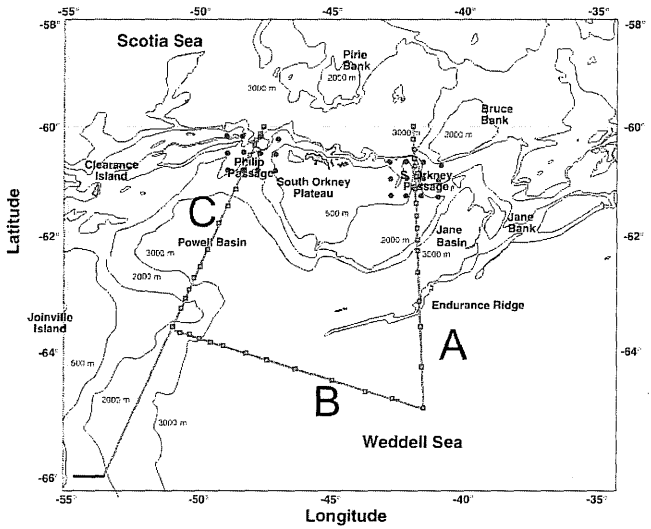

Fig. 1:
Map of hydrographic stations proposed for the winter cruise ANT-XXIII/7 to the north-western Weddell Sea. Grey solid line in the lower left points to the former position of Larsen B Ice Shelf .

2.2 WATER MASS VARIABILITY IN THE NORTHWESTERN WEDDELL SEA: TRACER MEASUREMENTS: HELIM ISOTOPES, NEON, CFCS

O. Huhn (IUP)
Not on board: M. Rhein (IUP)

Objectives

The measurement of noble gases (helium isotopes ^{4}He and ^{3}He and neon) and chlorofluorocarbons (CFCs) will complement the hydrographical programme. These tracers provide additional and independent information to identify and to compute fractions of contributing source water masses to the formation of deep and bottom water and the time scales of their spreading. Tracer measurements in the relevant area exist from previous cruises (e.g. from the same subsections occupied in 1998, and from ISPOL close to the Larsen Ice Shelf in 2004/2005).

Main objectives of the repeated tracer measurements are to

- extend the tracer time series, particularly after large parts of the northern Larsen Ice Shelf have disintegrated
- assess changes in deep and bottom water distribution in the area of exiting the Weddell Basin
- quantify the deep and bottom water composition, i.e. changes in contributing shelf water types, particularly Ice Shelf Water or glacial melt water, respectively

Work at sea

During the cruise a sampling of helium isotopes and neon on every second of the planned CTD profiles shall lead to 250 helium samples. Additionally, samples will be taken from the helicopter-deployed CTD stations in the bottom layer. The helium samples are stored in clamped off copper tubes, and they are analysed later in the Bremen mass spectrometer lab.

There are also 600 samples for CFC from the ship-deployed CTD profiles planned. The CFC samples will be stored in glass ampoules and sealed off after a CFC free headspace of nitrogen has been applied. The CFC samples are analysed later in the Bremen gas chromatography lab.

Tracer methods and expected results

Atmospheric helium and neon is trapped in air bubbles during formation of glacial ice. They are completely dissolved into the water by melting at the underside of the ice due to enhanced hydrostatic pressure. Thus, pure glacial melt water is supersaturated by roughly 1060 % in helium and 770 % in neon. Noble gas observations allow calculating even small fractions of glacial melt water (or Ice Shelf Water, respectively) contributing to the formation of deep and bottom water. Furthermore, the lighter isotope ^{3}He is considerably enriched in water masses from the deep Pacific, where they had been in contact with submarine ridge systems before they are advected into the Weddell Sea.

The CFCs enter the ocean by air-sea gas exchange. The concentrations in the atmosphere had been increasing steadily until the mid 90th of the last century. Thus, CFCs provide information about the time elapsed (or a transit time, respectively) since the last contact of the water mass with the ocean surface.

Major aims of the repeated tracer measurements are to compare the contemporary distribution, the composition and the time scales of spreading of deep and bottom water leaving the Weddell Basin with tracer measurements from previous cruises. Since large parts of the Larsen Ice Shelf had collapsed in 2002, changes in these boundary conditions are expected to modify in the deep and bottom water formation and its distribution and spreading, particularly concerning possible changes in the contributing fractions of different shelf water types, i.e. Ice Shelf Water or glacial melt water, respectively.

2.3 OCEANIC MASS VARIABILITY IN THE ANTARCTIC CIRCUMPOLAR CURRENT OBSERVED BY BOTTOM PRESSURE SENSORS AND GRACE SATELLITES

A. Macrander (AWI)
Not on board: O. Boebel (AWI)

Objectives
Six PIES (Pressure sensors / Inverted Echo Sounder) will be deployed on the sea floor in the area of the Antarctic Circumpolar Current (ACC; Fig.2). The objectives are:

- Acquisition of multi-year timeseries of Ocean Bottom Pressure (OBP) and acoustic travel time bottom to surface in a 2-dimensional array in the region 5 °W – 15°E / 36 °S – 51°S (Fig.2), where a high signal-to-noise ratio is expected.

- Validation of gravity field variability observed by the GRACE satellite mission.

- Integrating observations of current, transport, heat content and mass variability of the ACC.

- Validation of Finite Elements Sea-Ice – Ocean Model (FESOM).

Work at sea
During the cruise, 6 PIES (manufactured by University of Rhode Island) will be deployed by RV *Polarstern*. Preliminary positions are shown in Fig.2; the final deployment positions depend on the investigation of spatial coherence patterns of OBP variability in the FESOM model and GRACE data, and the actual cruise schedule of RV *Polarstern*. Recovery of the instruments is planned for 2010 to obtain continuous multi-year OBP timeseries.

Each mooring consists of a Posidonia transmitter for relocation purposes, floatation, 50 m of line, and the actual PIES located in a 1.5 m diameter steel stand that ensures a stable position of the PIES at the ocean bottom. All moorings reach the sea floor freely falling. To enable start of data analysis before 2010, three of the PIES include an additional pop-up buoy module for intermediate data retrieval via an Iridium satellite link.

Hydrographic CTD casts are planned for calibration and referencing of the acoustic travel time and OBP timeseries.

Expected results
The GRACE satellite mission provides monthly time series of the gravity field of the Earth with unprecedented accuracy. Over the oceans, short-term fluctuations of the gravity field are

associated with changes of sea surface height (SSH) or the density structure of the water column.

The Ocean Bottom Pressure observations obtained by the PIES array will be employed as a ground-truth site to validate GRACE OBP estimates. Since in the ACC, large OBP variability and hence a higher signal-to-noise ratio than in other regions is expected, GRACE may well perform to observe oceanic mass variability associated with geostrophic current and mass variations. First results from two PIES deployed from 2002-2005 suggest, that GRACE in fact captures the dominant modes of OBP variability in the ACC (Fig. 3). The extended 2-dimensional array, operating from 2005/2006 to 2010 (Fig. 2), is expected to improve the detection of large-scale coherent OBP signals and is thus an important contribution to the global ground-truth validation of GRACE in the framework of the BMBF-Geotechnologien project "Improved GRACE level-1 and level-2 products and their validation against ocean bottom pressure".

All PIES are deployed on Topex/Jason altimeter ground tracks, allowing to combine in-situ observations of acoustic travel time and OBP, Topex/Jason Sea Surface Height and GRACE gravity measurements. This dataset will be assessed to determine the variability of geostrophic current velocities both at the surface and in abyssal depths, transport and heat content of the ACC.

Moreover, the multi-year OBP time series will be used for validation of the German community Finite Elements Sea-Ice Model (FESOM) operated by the group of Jens Schröter at AWI.

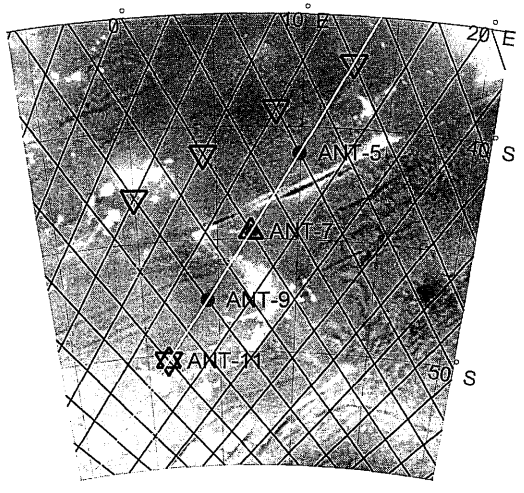

Fig. 2: Intended PIES deployment positions during ANT-XXIII/7. Black lines represent TOPEX/Poseidon altimetry ground tracks. Transect and track 133 highlighted with white line. Labels denote mooring sites already occupied since 2002/2005. ▽ : PIES deployed 2002, recovered in 2005 during ANT-XXII/3. Grey dots: PIES deployed during ANT-XXII/3 (Jan 2005). ▽: Intended deployment positions on ANT-XXIII/7 (August – October 2006), extending the array to a 2-dimensional coverage. Position of the 6th PIES to be decided later.

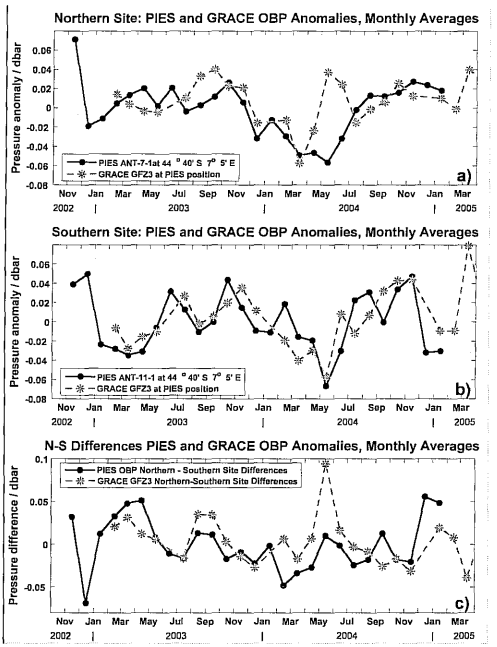

Fig.3: First comparison of in-situ OBP observations by PIES and GRACE satellite data. a,b: Monthly OBP anomalies measured by PIES (black solid lines) and the GRACE satellite mission (grey dashed lines) at the two mooring sites ANT7 and ANT11 in the northern part of the ACC. For locations, see Fig. 2. The GRACE observations are significantly correlated with the PIES observations (r=0.45 at ANT7, r=0.69 at ANT11). c: OBP differences between both sites, which correspond to geostrophic current anomalies.

2.4 UPTAKE OF ANTHROPOGENIC CO_2 BY THE WEDDELL SEA

H. J. Zemmelink, S. van Heuven (NIOZ)
Not on board: M. Hoppema (AWI)

Objectives

The Southern Ocean plays a prominent role in the redistribution of CO_2 between atmospheric and oceanic reservoirs. There are suggestions now that Antarctic waters play an important role in the sequestration of the anthropogenic CO_2 taken up by the Southern Ocean. We want to validate the hypothesis that the Weddell Sea area constitutes a major actor in the anthropogenically perturbed carbon cycle. The anthropogenic CO_2 signal in Weddell Sea waters will be derived from several recently proposed concepts for resolving anthropogenic

CO_2 from contemporary CO_2 and auxiliary data, like oxygen, salinity, nutrients, and transient tracers. This technique calculates the fossil fuel CO_2 component of total dissolved CO_2 (TCO_2) of a water sample by correcting for the biological and physical changes in TCO_2 incurred since the time the water was last at the surface. Rigorous comparison of these different concepts (proposed by e.g. Goyet et al., 1999; McNeil et al., 2001; and Thomas et al., 2001) should lead to improved application of them, while applying different concepts constitutes a further constraint for the anthropogenic CO_2 inventory. We expect to provide an estimate of the total annual anthropogenic CO_2 uptake by Weddell Sea waters.

From the differences between calculated inventories for different years the change of anthropogenic CO_2 inventory of Weddell Sea waters can be calculated, which gives insight into the dynamic development of anthropogenic CO_2 uptake. Using the computational methods mentioned above to determine fossil fuel CO_2 then provides a double-check and will be used to further improve the overall assessment.

Work at sea

TCO_2 will be measured on samples from all over the water column with a bias toward the surface. Measurements are performed by means of the state of the art coulometric method, where accuracy will be set by using certified reference material to be obtained from Prof. A. Dickson (Scripps Institution of Oceanography). As previous data from this region have also been standardized against this widely applied reference material, all available data sets are compatible for most accurate interpretation. Total alkalinity must be measured in order to be able to correct for the occurrence of organisms that produce calcite shells. This will be done with an automated potentiometric titration. The accuracy is again set by certified reference material to be obtained from Prof. Dickson.

The partial pressure of CO_2 (pCO_2) will be measured continuously in water from the ship's pumping system and in the air above the ship. The measuring system is based on a Li-cor infrared analyzer and runs autonomously. Automatic calibration is done with reference gases that are traceable against most accurate NOAA standards. Since auxiliary data will be needed for interpretation of the results, including temperature, salinity, oxygen and nutrients we rely on other cruise participants, mainly from the Alfred Wegener Institute. Already several high-quality data sets have been collected by our groups and by those of our German partners during successive RV *Polarstern* sections in the years 1992, 1996, 1998, 2002 and 2005 with data of excellent quality .

Expected results

As stated above we will apply several methods for deriving anthropogenic CO_2 inventories from contemporary TCO_2 data. These methods have been available for some years, but they are not perfect. By the combined application of these different methods, we expect to improve the overall application of the methods, especially for the Antarctic and Subantarctic regions as the sensitivity of the methods is also regionally dependent. In addition, we expect to provide an estimate of the total annual anthropogenic CO_2 uptake by Weddell Sea waters.

2.5 DISSOLVED ORGANIC CARBON SEQUESTRATION IN THE DEEP WEDDELL SEA

I. Vogel (AWI); A. C. Friedrich (FSU)
Not on board: G. Kattner, T. Dittmar, B. Koch (AWI)

Objectives

Source, diagenesis and preservation mechanisms of dissolved organic matter (DOM) remain elemental questions in contemporary marine sciences and represent a missing link in models of global elemental cycles. The polar oceans are probably a primary source of DOM to the deep ocean because these regions are the only places where surface waters efficiently convect down to the oceans' bottom. Deep-water formation is directly linked to sea ice formation, when salt is rejected and dense brine-enriched waters penetrate the deep ocean. Sea ice is one of the most productive marine environments, and DOM concentrations in the brine are among the highest measured in marine waters. The biogeochemistry of sea ice is widely unknown, and it is not clear whether sea ice DOM is persistent enough to survive downward convection. Broad significance is expected by answering the question: "Do ice-covered oceans act as a DOM pump to the abyssal ocean and so sequester carbon from active cycles?". By combining several molecular tracer techniques we will be able to quantify the concentration of ice-algal derived DOM in the different water masses and along diagenetic pathways on a large scale in the Weddell Sea.

Work at sea

CTD profiles and large-volume water samples for the extraction of DOM will be taken along transects from the shelf through the slope into the central Weddell Sea. Large volume sampling will focus on Warm Deep Water (WDW) in order to obtain a suite of samples along a diagenetic sequence of DOM, from less (on the shelf) to highly degraded (central Weddell Sea). Furthermore, the prime source of DOM will be sampled from sea ice and brine. This sampling scheme is a continuation of our activities during the ISPOL experiment, where sampling was restricted to mainly one position. All samples will be analysed on land for dissolved organic carbon and nitrogen (DOC, DON) and on molecular constituents with advanced analytical techniques.

Expected or preliminary results

First indications for the existence of a "DOM-pump" in the Weddell Sea were obtained during the ISPOL experiment. WDW is characterised by the highest temperatures (~0.5° C, ~600 m) and represents the oldest water mass being transported southwards from the Antarctic Circumpolar Current. The mineralization of sinking organic particles in the history of this water mass causes nutrient accumulation and oxygen depletion in WDW. The nutrient maximum (~1200 m) is significantly deeper than the temperature maximum of the WDW (~600 m). Hence mixing of WDW with surface and bottom water alone cannot explain the nutrient profiles in the water column. The nutrient increase was rather caused by mineralization of sinking particles. The increasing silicate/nitrate-ratio with water depth reflects the slower mineralization rates of silicate compared to nitrate. Bottom water was the densest water with lowest temperatures (-1.7° C) and the highest salinity (34.6). Contrary to WDW it was characterised by low nutrient content, high oxygen concentration, and, most importantly in the context of our study, increased DOC concentrations. These profiles indicate the formation of fresh bottom water from biologically active surface water within

relatively short periods of time. This is a first indication for DOM being transported from surface into bottom waters.

3. SEA ICE PHYSICS AND CHEMISTRY

3.1 REGIONAL VARIABILITY OF SEA ICE PROPERTIES AND THICKNESS IN THE NORTHWESTERN WEDDELL SEA OBTAINED BY IN-SITU AND SATELLITE MEASUREMENTS

C. Haas, M. Nicolaus (AWI); T. Toyota (ILTS); Z. Li (LCOE); A. Paffling (PG); A. Friedrich (Uni Trier);

Objectives

1. Quantification of the regional variability of first- and second-year sea ice thickness in the north-western Weddell Sea. The measurements will continue earlier observations performed by other scientists to ensure a longer period of observations of temporal thickness trends, which will also continue during IPY 2007 and later. In particular ANT-XXIII/7 will continue with observations performed during ISPOL (ANT-XXII/2) in December 2005. We will particularly include extensive mapping of snow thickness into our observations.

2. Validation of satellite measurements of ice type and surface elevation. We will receive real-time Envisat-&ERS-SAR, NOAA-AVHRR and DMSP-SSM/I data on board, and will relate their spatial and temporal variability to the presence of different ice regimes and ice types. This will result in a better understanding of sea ice microwave signatures. We will also try to obtain measurements along ground tracks of ICESat to validate its retrievals of surface elevation.

3. Investigation of physical and biological ice properties and processes and the fate of perennial ice after surviving one summer melt season. From earlier RV *Polarstern* cruises including ISPOL it is clear that the ice undergoes significant changes during the summer season. ANT-XXIII/7 offers the opportunity to study the fate of this ice during the following winter. In particular we will focus on the properties of metamorphous snow, superimposed ice, and the refrozen gap layer.

Work at sea

We will perform measurements on the ice, from the ship, and by helicopter. These will include:

Helicopter measurements:
- EM (electromagnetic) ice thickness, DGPS and laser profiling (ridge distribution, surface elevation), possibly GPR (ground penetrating radar) snow thickness.

Ship-based measurements:
- EM ice thickness using the ship-based sea ice monitoring system SIMS, possibly GPR snow thickness, Aspect sea ice conditions, reception of satellite imagery.

On-ice measurements:
- EM and drill-hole snow and ice thickness and freeboard, possibly GPR snow thickness, ice coring (T, S, texture), snow-pit measurements of snow properties.

3.2 WEDDELL SEA AIR-ICE CHEMISTRY INTERACTION STUDY

H.-W. Jacobi (AWI); K. Aspmo (GKSS); H. Kirk (IUP)
Not on board: R. Ebinghaus, C. Temme (GKSS); C. Ferrari (Polytech Grenoble - Université Joseph Fourier, Saint Martin d' Hères, France); L. Kaleschke, A. Richter (IUP)

Objectives

Halogen radicals are involved in important tropospheric processes because they can oxidize several substances, generate organo-halogen compounds, and catalytically destroy tropospheric ozone. The discovery of ozone depletion events (ODEs) in the lower Arctic atmosphere triggered much research into their origin. Subsequently, it became evident that the processes are related to halogen chemistry, and widespread plumes of enhanced boundary layer BrO have been observed in the Arctic and Antarctic in spring both on the ground and from space. It is now fairly well understood that reactive bromine and chlorine can be liberated from a slightly acidic sea salt solution. The so-called bromine explosion mechanism explains the autocatalytic release of bromine from the condensed phase to the gas phase.

Although the chemical reaction mechanism responsible for the halogen activation has been identified, knowledge about the exact kind of the surface, where the halogen activation takes place, is still limited. Several potential candidates (e.g. open ocean, airborne sea salt aerosols, sea salt aerosols deposited on surface snow, upward migration of brine in the snow) have been suggested. Recently, it was recognized that the surface of newly formed sea ice can be a major source of sea salt aerosol and it has been hypothesized that salty frost flowers (FF), which grow on newly formed sea ice, might be the source of atmospheric bromine. It is assumed that FF enhances the mobilization of sea salt into the atmosphere. Although no direct observation of aerosol formation from FF has been reported, aerosols generated by FF can be distinguished from aerosols generated from seawater. Due to the precipitation of mirabilite ($Na_2SO_4 \cdot \delta\delta 10\ H_2O$) at –8° C, FF can exhibit lower sulfate-to-sodium ratios compared to standard seawater. Such low sulfate-to-sodium ratios are also commonly observed in aerosols collected at coastal stations in Antarctica. Therefore, it was proposed that this is a strong indication of FF as the aerosols source. In contrast to the recent strong scientific interest in FF, the database concerning the chemical characterization of FF remains extremely limited. Although the chemical composition (e.g. high Br-concentration for the bromine activation, low sulfate-to-sodium ratio as a key for the aerosol identification) is a crucial parameter for the impact of FF, the analysis of the ionic components has been reported for only few samples.

Due to the long atmospheric lifetime of about one year elemental gaseous mercury (GEM) is normally present in the atmosphere at rather constant levels. GEM can be transformed to more reactive and toxic compounds and bio-accumulated in the fragile polar biosphere. Mercury depletion events (MDEs) accompanied by ODEs occur in the Antarctic after polar sunrise and suddenly end by the end of November. Kinetic data and modelling studies show that Br and BrO are the most effective halogens responsible for the mercury oxidation. In that case GEM is transformed into oxidized and more reactive gaseous mercury (RGM) compounds. Due to the higher solubility of RGM, it is quickly deposited or transferred to aerosols, where it can be detected as particulate mercury (PM). Simultaneous measurements of all three forms of mercury in the atmosphere (GEM, RGM, and PM)

provide information about the stage of the ODE, since the ratios between the three forms are expected to change drastically before, during, and after the O_3 decay. For example, GEM levels are expected to drop during the O_3 destruction leading to higher RGM levels. Subsequently, GEM levels will recover and RGM will drop, while PM is supposed to reach higher levels. Therefore, such a 'mercury-clock' can be used to distinguish if low O_3 concentrations are caused in-situ by chemical processes or by the long-range transport of air with low O_3 concentrations. Recent measurements of enhanced mercury bio-accumulation in Antarctic ecosystems facing the Terra Nova Bay coastal polynya support the hypothesis of frost flowers as the bromine source.

Work at sea

We will collect samples of naturally grown frost flowers. Sampling will be performed from adjacent sea ice (either during regular station time or after transfer by helicopter) or directly from the ship. In these experiments, a physical and chemical characterization of frost flowers, the slush layer, and the underlying sea ice will be performed. Height, densities, and covered areas will be measured using a high resolution IR camera. Due to the strong temperature gradients between the sea ice surface and the FF extending into the colder air, the FF can easily be detected using the IR technique. The data obtained with an IR camera allows the determination of the height and the covered areas without disturbing the environment of the frost flowers. Therefore, it can also be used to quantify the undisturbed growth of selected FF. Furthermore, FF samples will be recovered and shipped back to Bremerhaven, where they will be analyzed regarding the concentration of sea salt ions. Additional FF samples will be collected to analyze mercury compounds. To obtain reliable statistical information about the frost flowers, it is intended to sample as many different frost flower fields as possible. If possible, selected frost flower fields will also be sampled multiple times to investigate the temporal development of the physical and chemical properties. In addition, surface snow samples will be collected to better assess the impact of halogen chemistry onto mercury species deposition.

To identify the effect of frost flowers on the chemical composition of the atmosphere, we will perform continuous trace gas measurement during the entire cruise. We will determine concentrations of compounds, which are affected during ODE. These measurements include gas phase concentrations of compounds like O_3, BrO, Hg, reactive Hg compounds, and formaldehyde, which will be carried out on board. The detectors will be installed in a laboratory container on the upper level deck. Further measurements are planned adjacent to FF fields. For that purpose we intend to install several detectors on ice floes in close vicinity to selected FF fields. The data acquired by comparing the local measurements with the measurements made on board will be utilized to identify the activation of reactive halogen compounds by FF. Under stable meteorological conditions horizontal and vertical concentration gradients of the affected species can be expected if the FF are the source of the reactive halogen compounds. For BrO, MAXDOAS measurements both from RV *Polarstern* and from the ice are planned. By pointing the instruments at different directions, horizontal gradients will be determined which in combination with wind measurements can provide information on source strengths. Vertical information can be derived from the inversion of the measurements and comparisons of data from the ice and from the ship. Target areas for the local measurements will be identified by the online analysis of satellite remote sensing data of ice coverage and BrO and previous surveillance flights with helicopters.

Expected results
The collected data will be used to contribute to the following topics:

- To extend the existing database regarding the chemical composition of frost flowers.
- To determine the range and variability of the concentrations of major sea salt ions in FF (Cl^-, Br^-, SO_4^{2-}, CO_3^{2-}, Na^+, Ca^{2+}).
- To investigate the FF formation and decay at selected locations in the field.
- To determine the area coverage of newly formed sea ice with FF.
- To investigate the temporal development of FF coverage.
- To study the spatial and temporal development of concentrations of trace gases, which are affected during ODE, in the vicinity of FF fields (O3, BrO, Hg, reactive gaseous Hg compounds, particulate Hg compounds, HCHO).
- To analyze ODEs regarding the most likely source of reactive halogen.
- To use the Hg-clock to distinguish between local processing and long-range transport during ODEs.
- To validate satellite measurements of BrO and frost flower coverage.

4. BIOLOGY

4.1 SEA ICE BIOGEOCHEMISTRY AND BIODIVERSITY

G. Dieckmann, E. Allhusen, C. Uhlig (AWI); L. Norman,
S. Papadimitriou, D. Thomas (UWB); F. Dai, Z. Wang (CLE)

Objectives
The aim of our proposed work (in collaboration with other groups) is to make a detailed characterisation of the physical, biological and chemical environment of late winter sea ice, with an emphasis on sites supporting growing biological assemblages. Currently, one of the main limitations of our sea ice studies is the paucity of data related to either the temporal variability and/or evolution of temporal changes in the environmental conditions in which these communities develop. This cruise gives us the rare opportunity to make such studies, and the characterisation of sea ice processes on the turn from winter to spring conditions will be central to the suite of biogeochemical studies to be carried out.

Our specific objectives are:

- To make an extensive characterisation of the spatial variability in the physio-chemical environment (salinity, temperature, $\delta^{18}O_{H2O}$, oxygen, pH, alkalinity, NO_3^-, NH_4^+, $Si(OH)_4$, PO_4^{3-}, $\delta^{13}C_{DIC}$, DOC, DON, POC, PON, $\delta^{15}N_{PON}$, $\delta^{13}C_{POC}$).
- To determine the respective scale and rate of temporal variation and evolution in the environmental conditions at sites displaying high standing stocks and active growth of microbial assemblages.
- To relate rates of DOM accumulation or utilisation to primary and bacterial production as well as environmental conditions.

- To improve our understanding of the factors limiting algal and bacterial growth and those forcing community structure within sea ice on a transition form winter to spring conditions.
- To investigate the habitat range of the foraminifera *Neogloboquadrina pachyderma* using its stable isotopic composition for environmental reconstruction.
- To collect samples for sea ice species diversity investigations using molecular biological approaches

Work at sea

The field work allows for the temporal fluctuations and development of the biogeochemical parameters to be quantified. We will employ standard ice coring techniques to sample the solid ice, and have the skills to sample surface gap layer and melt ponds along transects from the outside to interior of ice floes. Particulate (chlorophyll, POC/PON/, $\delta^{13}C_{POC}$, $\delta^{15}N_{PON}$, $\delta^{13}C_{foram}$ and $\delta^{18}O_{foram}$) and some of the dissolved parameters (nutrients, salinity) will be collected by tried and tested sampling and processing of retrieved ice cores. No differentiation between live and dead foraminfera will be made. Cytoplasm, that provides the staining material, is likely to decompose at slow rates at the temperature of the sea ice and so many foraminifers may be designated live, when dead). For analytes that could be compromised by this sampling procedure (in-situ temperature, DOM, $\delta^{13}C_{DIC}$, $\delta^{18}O_{H2O}$, alkalinity, pH, O_2 & CO_2) we will also sample the brines at a range of depths using 'sackhole' sampling and/or brine drainage. Centrifugation of ice brines will also be employed for the non-gaseous components. For comparison of ice samples we will take routine samples for all parameters we are measuring from the water samples at various depths down to 200 m.

4.2 PHOTOSYNTHETIC PARAMETERS OF SEA-ICE ALGAE AND OPTICAL PROPERTIES OF SEA ICE

K. Meiners (ACE)

Introduction

Sea ice is a structuring component of the Southern Ocean and plays a pivotal role in the biogeochemical cycles of Antarctic marine ecosystems. The sea ice cover greatly affects energy and material fluxes between the ocean and the atmosphere, and provides a habitat for diverse microbial communities which, in terms of biomass, are generally dominated by algae. Sea ice primary production contributes significantly to overall ecosystem primary production and provides an important food source for pelagic herbivores during winter and early spring, when food supply in the water column is low.

Only recently, modern techniques like pulse amplitude modulated (PAM) fluorometry have been introduced to sea ice ecological research. These studies primarily focused on small scales and were mainly carried out on land fast-ice. Information on the large scale distribution of pack ice algae and their photosynthetic parameters as well as on the influence of physico-chemical factors on these parameters is still scarce.

Objectives

1.) The aim of our work is the determination of photosynthetic parameters of pack ice algae using PAM fluorometry. These measurements will be related to an extensive set of physical and biogeochemical parameters to understand the influence and forcing of abiotic factors on sea ice primary production.

2.) The second aim of the project is to measure bio-optical properties of sea ice and to determine the influence of sea ice algae on the spectral composition of the irradiance transmitted through Antarctic pack ice. These measurements will be used to explore the potential to use under-ice light spectra to estimate sea ice algae distribution with non-invasive optical sensors from beneath the sea ice.

Work at sea
In collaboration with the sea ice group of the Alfred-Wegener Institute, on each ice station physical parameters (snow cover, ice thickness, freeboard, temperature, salinity, ice crystal structure, irradiance and under-ice irradiance, chemical parameters (stable oxygen isotopic composition ($^{18}0$), inorganic nutrients, dissolved organic carbon/nitrogen) and biological parameters (chlorophyll a, particulate organic carbon/nitrogen, stable isotopic composition (^{13}C) of particulate matter, species composition, biomass of ice algae) will be determined.

The contribution of the ACE CRC is the measurement of ice algal physiological parameters with a pulse amplitude modulated fluorometer and measurements of the sub-ice hyperspectral irradiance distribution. On the ice, sampling will be performed on transects to explore the small- to medium scale (0,1-1000 m) spatial variability of the parameters. Data collected during the ice stations will give information on the spatial distribution of physical and biological sea ice parameters and the influence of physico-chemical parameters on sea ice primary production.

Methods
Photosynthetic parameters (effective quantum yield, maximum quantum yield and electron transfer rate of Photosystem II) will be measured from centrifugated ice samples and ice algal scrapings transferred to cuvettes using a conventional PAM fluorometer in the ships drylab. A TriOS Ramses ARC underwater spectroradiometer will be used for the measurements of under-ice transmitted light spectra. The spectra will be compared to the horizontal sea ice chlorophyll a distribution along transects across the sea ice floes. Optical properties of the sea ice particulate material will be measured using filter-pad absorption techniques.

4.3 DISTRIBUTION OF SULPHUR COMPOUNDS IN SEA ICE DURING EARLY SPRING

J. Stefels, D. den Oss (RUG)

Objectives
Dimethyl sulphide (DMS) is a volatile compound from biological origin that is intensively studied because its oxidation products are involved in the formation of condensation nuclei and clouds. As a consequence, it affects the albedo of skies and clouds and is thus highly relevant for "global change" discussions and models. Antarctic waters are estimated to contribute 10-30 % to the global DMS flux, with the ice edge as major source area. Considering these large amounts of DMS transferred to the atmosphere, it is conceivable that the oceanic productivity affects climate over a large area of the Antarctic continent and possibly over a much larger area of the Southern Hemisphere. In addition, the amount of oxidation products from DMS that are deposited in continental ice has been proposed to be a proxy for sea ice extent during ancient times (Curran et al. Science 2003), although this has been debated by others (Wolff et al. Nature 2006). Biophysical processes in the Antarctic

coastal waters and ice edges are therefore very relevant in the context of global climate studies.

The estimations on Antarctic DMS production are based on a very limited number of data. A unique data set collected during the ISPOL cruise (ANT-XXII/2) in the summer season of 2004/5 showed extremely high concentrations of DMS and dimethylsulphoniopropionate (DMSP; the algal precursor of DMS) in vertical profiles of ice cores. Surface-, bottom, as well as internal communities with high concentrations could be identified. Also high turnover rates of various sulphur compounds were measured in incubations with surface ice communities collected from slush samples. To measure these rates, a new technique was developed and successfully used for the first time on board of RV *Polarstern*.

Given the potential physiological roles of DMS, DMSP and DMSO (cryoprotectant, osmoticum, oxygen-radical scavengers), it is hypothesised that organisms trapped in brine pockets, need these compounds to survive the extreme conditions in winter sea ice. Therefore, even higher concentrations are expected to be found during ANT-XXIII/7.
In short, the objectives of this project are:

1. To investigate the spatial heterogeneity of DMS, DMSP and DMSO of sea ice in relation to a variety of biological and chemical parameters.

2. To study the conversion of these compounds upon ice melt in incubation experiments.

Work at sea
During ANT-XXIII/7, the spatial variability of DMS, DMSP and its oxidation product DMSO will be investigated in ice cores that are taken at regular intervals during the cruise track; if possible every other day. Cores will be sectioned in 5 to 10 cm intervals, thawed in hypersaline water and filtered and analysed on board, using a Proton Transfer Reaction Mass Spectrometer (PTR-MS). From the same sections, samples will be taken for algal-pigment analyses, which can give us an indication of the abundance of different phytoplankton groups in the samples. After filtration, pigment samples will be stored at -80° C and analysed at home by HPLC. Other biochemical parameters will be taken in collaboration with Drs Dieckmann and Thomas and co-workers.

The conversion of sulphur compounds during ice melt will be studied by using a new tracer technique in combination with the PTR-MS. In on-board incubations of sea ice communities, stable isotope tracers of DMS and DMSP will be added. By comparing the natural abundances of sulphur compounds with the change in added tracers, effects of different salinities and light on the conversion processes of DMS and DMSP during melting can be followed.

Expected results
The acquired knowledge will improve our understanding of how ice, oceans and atmosphere are linked via the flux of climatically important gases. It will provide essential and basic information on the influence of biological production on DMS emission to the atmosphere around Antarctica and improve scenarios of climate forcing by ice-ocean-atmosphere interactions and the significance of the Antarctic.

It is also expected to provide fundamental information on the requirements of organisms to survive the extreme sea ice habitats during winter. During ANT-XXIII/7, we hope to see the transition between winter and spring and how sea ice communities use sulphur compounds to cope with shifts in the abiotic environment (increase in temperature, melting of ice, shifts in salinity, etc.).

4.4 SEA ICE MEIOFAUNA – ECOLOGY AND ENVIRONMENTAL PHYSIOLOGY

R. Kiko, M. Kramer, A. Scheltz (IPÖ)

Antarctic sea ice communities in winter

Objectives

The sea ice of polar regions represents one of the largest ecosystems on earth with a specially adapted fauna and flora. In the Southern Ocean alone, up to 20 million km^2 are covered by sea ice in winter, an area as big as North America and Canada combined. Sea ice is not a solid block, but an ice crystal matrix permeated by brine channels and pores which are colonized by a unique fauna and flora. The size of the brine channels - varying from a few micrometer to millimetres - and the salinity of the brine are controlled by the ambient temperature and are considered to be the main factors controlling the distribution of sympagic (ice-associated) organisms. Virtually nothing is known about biotic and abiotic factors controlling the survival and development of sympagic meiofauna (metazoans >20 µm) communities and their structure in Antarctic pack ice during winter. This cruise will give us the opportunity to study these topics over a large area, from the marginal ice zone to central regions of the Weddell Sea in winter.

Work at sea

Different habitats are associated with Antarctic sea ice: the under-ice layer, the bottom layer and the infiltration or freeboard layer on top of the ice. We will characterize meiofauna communities in these habitats with respect to species composition, vertical distribution, abundance and biomass, as well as their living conditions (temperature, salinity and chl a concentrations). Furthermore we will determine grazing rates of dominant meiofauna species in-situ and in the laboratory and will perform gut content analysis in order to characterize their feeding strategies.

The under-ice layer (approx. down to 5 m below the ice) is characterized by special abiotic (temperature, salinity) and biotic (e.g. food resources) factors differing from those in the brine channels as well as from those in the deeper water column and varying with region and season. The use of an under-ice pump will allow us to qualify and quantify small meiofauna organisms living directly under the ice in a vertical resolution of metres from the underside of the ice down to 5 m depth. Also temperature and salinity, as well as chl a concentrations will be determined at these depth. The use of an under-ice video system will allow us to quantify larger organisms living attached to or in close association with the ice like e.g. the krill (*Euphausia superba*), which is known to feed at the ice-underside during winter. Using baited traps deployed from ice floes we will catch under-ice amphipods for the determination of ingestion and respiration rates. To study the distribution of organisms in the ice, we will drill ice-cores and determine the above mentioned biotic and abiotic factors and the meiofauna community structure in relation to their location in the ice column. A special emphasis will be put on the identification of colonisation processes of the infiltration layer by sympagic species.

Expected results
Our studies will accomplish measurements already performed during a previous summer cruise (ANT-XXII/2), allow an assumption of biological productivity and foodweb dynamics of the sea ice system during winter and the identification of life-cycle based overwintering strategies of sympagic species.

Environmental physiology of sympagic organisms

Objectives
Salinity and temperature are the main abiotic factors governing the survival and development of sympagic organisms. Salinity in the brine channels is coupled to the environmental temperature and rises when temperatures drop below the freezing point, as only water and not the contained solutes crystallize. The brine salinity can vary between approx. S = 220 at –22° C ice temperature and S = 2-3 during meltwater flushing in summer near 0° C. We have started ecophysiological and molecular-biological studies on temperature and salinity tolerance with the sympagic copepod species *Drescheriella glacialis* and *Stephos longipes* in order to identify mechanisms these organisms have developed to survive in their unique habitat.

Work at sea
During this cruise, we will determine the supercooling points of whole animals and the thermal hysteresis and osmolarity of their hemolymph after different temperature and salinity incubations. This will show, if these organisms are isoosmotic to their habitat and whether they use antifreeze agents to avoid intracellular ice formation. Furthermore we will determine tolerated temperature extremes for these species. Establishing laboratory cultures for molecular-biological studies will be another aspect of our work. We will use these cultures to perform gene expression analysis and other molecular-biological techniques after different temperature and salinity incubations. Genes to be analysed will be identified using a "Suppression subtractive hybridization" approach, a technique with which differentially expressed genes, due to e.g. elevated salinities can be identified.

Expected results
Our work should result in the establishment of one of the above mentioned copepod species as a model system for research on cold acclimation and adaptation of sea ice inhabiting meiofauna organisms and in a better understanding of mechanisms allowing their survival at low temperatures.

4.5 ECOLOGY AND PHYSIOLOGY OF SYMPAGIC AND PELAGIC COPEPODS

S. Schiel, A. Cornils, F. J. Sartoris, (AWI); K. Nachtigall (IFM-GEOMAR)

Objectives
Studies on the copepod fauna in and underneath the sea ice in the eastern Weddell Sea as well as in the Bellingshausen and Amundsen Seas have indicated that only a few species are adapted to this extreme environment. However, results obtained during ISPOL (ANT-

XXII/2) in spring (November 2004 - January 2005) showed that more species than previously known lived in close association to the sea ice in the western Weddell Sea. Hence, studies carried out during ANT-XXIII/7 should enable detailed descriptions of the occurrence, distribution pattern and population structure of the sympagic copepods in winter as well as their physiological and biochemical adaptation, their energy budget and requirements.

Additional studies will be carried out with dominant pelagic copepod species to deepen our knowledge of their life strategies which are well-timed to the annual periodicity in ice cover and primary production, although the different species exhibit varying strategies to utilize short-term food pulses and to endure periods of food scarcity in the pelagial. However, our knowledge of the winter situation is not yet complete as studies during the dark season are extremely rare.

The zooplankton campaign is part of CMarZ (Census of Marine Zooplankton), which is part of CoML (Census of Marine Life).

Work at sea

Quantitative sampling of sympagic and pelagic copepods

The sampling of the sea ice copepods will be carried out with ice corers and the sub-ice fauna with pumps (in close cooperation with the sea ice research group).

As standard devices for the quantitative collection of the pelagic copepods two multiple opening and closing nets (multinet, 0.25 m^2 and 0,5 m^2 mouth opening) equipped with 5 and 9 nets, respectively, of 100 µm will be used. The multinets will be towed vertically, sampling the standard layers between 2000-1000m and the surface. The samples will be preserved in 4 % buffered formalin. For molecular genetic purposes, additional samples will be preserved in absolute ethanol and stored at 0° C.

Species composition, abundances and biomass, vertical distribution patterns and population structure of the sea ice and pelagic copepod species will be analysed from these samples.

Experimental studies with sympagic and pelagic copepods

Live pelagic specimens will be caught with a Bongo net and a multinet from different depth layers to study the metabolic activities in animals living in upper and deeper water depths. Sympagic copepods will be obtained from ice cores and slush ice samples.

Studies on physiological and biochemical parameters will include experimental work on feeding, defecation, excretion, respiration and reproduction as well as metabolic indicators such as C:N and O:N ratios, stable isotopes, lipid and protein contents. The hypothesis that sloppy feeding of the sea ice copepods produces a high DOC/ DON pool in sea ice and ammonium excretion is responsible for high NH_4 levels in sea ice will also be tested in the experiments.

The experimental work will be conducted on board in a cooled container (0°C). Specimens for the analysis of metabolic activities will be sorted on board and stored at -80° C.

Physiological and biochemical adaptions of sympagic copepods

All organisms inhabiting the sea ice have adapted to the highly variable environmental conditions of the ice habitat and must cope physiologically with both low temperatures and extremely high salinities. In contrast to intensive work on distribution patterns within the sea

ice, our knowledge of physiological and biochemical adaptation of sympagic organisms to the sea ice micro-environments is very scarce.

The questions adressed in this study are:

- What limits the number of species in sea ice and the ice/water interface?
- Which mechanisms are responsible for the limits of tolerance to temperature and salinity?
- What are the differences between species (sympagic versus pelagic)?

The study of the specific adaptations of sea ice copepods to low temperature and variable salinities includes physiological rate responses and mechanisms and scope of osmotic regulation. The study includes the determination of osmolality as well as analyses of the levels of osmotically active substances such as inorganic ions (Na^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, SO_4^{2}), and amino acids (glycine, proline, taurine) in whole animal extracts. Furthermore, activities of sodium potassium ATPase will be analysed in whole animal extracts for a determination of adaptive changes in enzyme capacity as well as enzyme functional properties. Physiological rates response to stress includes experimental work on the effect of low temperatures and high salinities on ingestion, excretion, respiration and reproduction.

All experiments on the physiological and biochemical adaptations will be carried out in a wide range of temperatures and salinities on board.

5. BATHYMETRY

Sea Floor Morphology and Topography of the Northern Weddell Sea
E P. Dubinin (GEOKHI); A. Rieck, J. Schneider (AWI)

Objectives
Digital bathymetric charts, derived from multibeam surveys, supply high resolution geodata which are indispensable for the scientific interpretation of marine research data and for subsequent explanation of physical, chemical and biological processes at the seafloor and in the water column. The bathymetric work programme includes continuous data recording along transits, and in selected investigation areas systematic multibeam (MB) surveys by deploying parallel tracklines.

The South Scotia Ridge, including the South Orkney Plateau (SOP) and the submarine continental blocks like the Bruce, Discovery and Herdman Rises in the north-eastern Weddell Sea represent a distinct morphological margin between the Weddell Sea and the Scotia Sea. The SOP, a crustal block with an extension of approx. 200 km by 300 km, showing on the top of the plateau water depths less than 500 m, play an important role in controlling the transport mechanisms and routes of the Weddell Sea Deep Water (WSDW), bottom water and the drift routes of icebergs. The northern and north-eastern flanks of the block are marked by more than 5000 m deep trenches which recently have been seismically active areas. Several earth quakes occurred during the last few years, one of the strongest one took place at the northern slope of the SOP on 4 August 2003 (7.5 Mag., epicentre at 60°30'S and 43°24'W).

The large scale seafloor topography of the SOP is rather unknown. While the region south of the South Orkney Islands is relatively shallow (<500 m) and thus probably subject to enormous iceberg groundings, the eastern and western areas of the SOP are of special interest for the transport passages of the WSDW. East of the SOP the regions between Bruce, Discovery and Herdman Rises can be considered as possible water outflows from the Weddell Sea into the Scotia Sea. The passage through the Orkney Deep between Bruce Rise and SOP, connecting the Jane Basin and the Scotia Sea by a more than 6000 m deep passage seem to be a main WSDW transport route, compared to the shallower Bruce (2500 m), Herdman (3000 m) and Discovery (3000 m) passages.

West of the SOP parts of the continental block of the Antarctic Peninsula form with maximum water depth of 2000 m a kind of barrier for bottom water exchange between the Powell Basin and the Scotia Sea. However, it will be of great interest to study possible connections between the Powell Basin and the Hesperides Trough and the South Scotia Trench.

Work at sea
The bathymetric research programme during this cruise concentrates on multibeam (MB) surveys:

- along the transits between operation areas

- in the regions of possible passages of WSDW

- in the vicinity of oceanographic stations

- in the earth quake area north of the South Orkney Islands (Fig. 4).

During the entire cruise multibeam data will be measured and recorded along with navigation data in order to extend and enlarge the bathymetric data base for different ocean mapping programmes. The slant beam correction of the multibeam data required sound velocity profiles which will be derived from CTD measurements. MB data will be utilized to support the global and regional ocean mapping programmes, such as the International Bathymetric Chart of the Southern Ocean (IBCSO), and will be used to improve the quality of Nautical Charts in the Antarctic INT Scheme. After scientific use all data will be supplied to the international IHO Data Centre for Digital Bathymetry (DCDB).

On the basis of all existing bathymetric information extracted from the GEBCO Digital Atlas, the predicted bathymetry ETOPO2 (Smith and Sandwell) and from all other existing multibeam and single beam data, the passage routes of the WSDW eastern and western of the SOP will be studied in detail in cooperation with the physical oceanography and especially in the gaps at the Orkney and the Phillip Passages surveyed with MB. Where required, systematic surveys can be performed in order to receive complete topographic information of the passage areas.

The station programme of the physical oceanography will be supported by performing small MB surveys around oceanographic sampling sites in order to spatially allocate and collocate the observations. The size of the local survey depend on the available ship time, on the water depth and will finally be cleared based upon the requirements from the oceanographic working groups.

A systematic survey will be performed in the vicinity of the earth quake epicentre (Fig.4). The profiles of this survey will be planned according to existing data in this region gathered by RV *Polarstern*, especially during the legs ANT-XIX/5 and ANT-XXII/4, and from other research vessels. Data from previous RV *Polarstern* cruises are stored on RV *Polarstern* and can be utilized for in-situ seafloor mapping. This survey will focus on the region around the epicentre and investigate areas of a possible change in the topography after the earth quake. Data from single beam surveys performed by the UK Hydrographic Office are available for these studies.

Expected results

All measured multibeam data including the ship's positions will be processed during the cruise. Quick look bathymetric plots will be prepared for selected study areas such as the Philip and Orkney/Bruce Passages, as those can be used for on board interpretation of oceanographic measurements.

Data from the systematic survey in the epicentre vicinity will also be processed. Products from these surveys (contour line map and DTM) will be used for first analyses and comparison to previous surveys in order to depict slumping areas probably caused by the earth quake.

At the end of the expedition, major parts of the multibeam surveys will be post-processed, preliminary bathymetric maps can be made available and included in the cruise report.

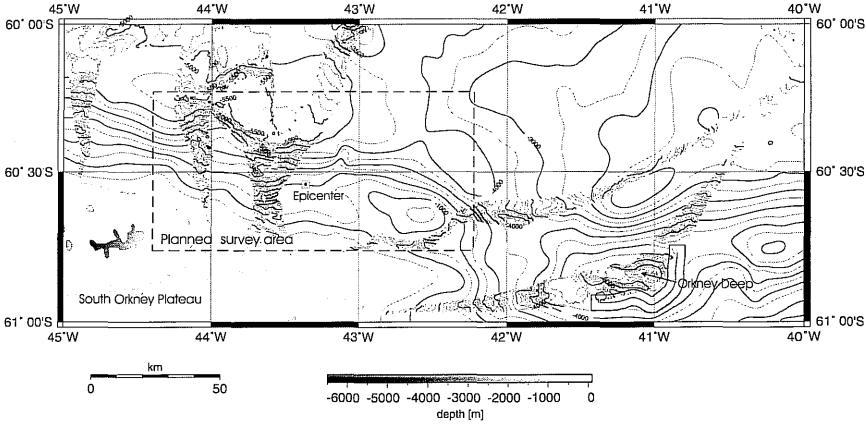

Fig. 4: Earth quake area north of the South Orkney Islands

6. BETEILIGTE INSTITUTE / PARTICIPATING INSTITUTES

	Adresse Address
ACE	Antarctic Climate & Ecosystems Cooperative Research Centre (ACE CRC) Private Bag 80 Hobart, Tas 7001 /Australia
AWI	Alfred-Wegener-Institut für Polar- und Meeresforschung in der Helmholtz-Gemeinschaft Postfach 120161 27515 Bremerhaven
CLE	College of Life & Environment Zhejiang Wanli University Ningbo, 315100 / China
DWD	Deutscher Wetterdienst Geschäftsfeld Seeschifffahrt Bernhard-Nocht-Str. 76 20359 Hamburg
FSU	Department of Oceanography Florida State University 0102 OSB, West Call Street Tallahassee, Florida 32306-4320 / USA
FURG	Fundação Universidade Federal do Rio Grande Rua Eng. Alfredo Huch, 475 - Centro CEP: 96201-900 - Rio Grande/RS / Brasil
GEOKHI	Vernadsky Institute of Geochemistry and Analytical Chemistry Russian Academy of Sciences 19, Kosygin Street Moscow / 119991 Russia
GKSS	GKSS-Forschungszentrum Geesthacht GmbH Max-Planck-Straße 1 21502 Geesthacht

	Adresse /Address
IFM-GEOMAR	Leibniz-Institut für Meereswissenschaften IFM-GEOMAR Düsternbrooker Weg 20 24105 Kiel
ILTS	Institute of Low Temperature Science Hokkaido University Nishi-8, Kita-19 Sapporo 060-0819 / Japan
IPÖ	Institut für Polarökologie Universität Kiel Wischhofstr. 1-3, Geb. 12 24148 Kiel
IUP	Institut für Umweltphysik Universität Bremen Otto-Hahn-Allee 1 28359 Bremen
LCOE	State Key Laboratory of Coastal and Offshore Engineering Dalian University of Technology 116024 Dalian / China
NIOZ	Royal Netherlands Institute for Sea Research P.O.Box 59 NL-1790 AB Den Burg (Texel) The Netherlands
PG	Pfaffling Geophysics Eilbeker Weg 36 22089 Hamburg
RUG	Rijksuniversiteit Groningen Oude Boteringestraat 44 9712 GL Groningen The Netherlands
UEA	University of East Anglia Norwich NRW 7TJ United Kingdom

	Adresse /Address
UWB	School of Ocean Sciences University of Wales, Bangor Menai Bridge Anglesey, LL59 5AB United Kingdom

7. FAHRTTEILNEHMER / PARTICIPANTS

Fahrtleiter/Chief Scientist: Peter Lemke
Cape Town – Cape Town

Name	Vorname/ First Name	Institut/ Institute	Beruf / Profession
Allhusen	Erika	AWI	Technician
Aspmo	Katrine	GKSS	Chemist
Cornils	Astrid	AWI	Biologist
Da Silva Duarte	Vagner	FURG	Oceanographer
Dai	Fangfang	CLE	Biologist
Dieckmann	Gerhard	AWI	Biologist
Dubinin	Evgeny P.	GEOKHI	Geophysicist
Franz	Karl	Helitransair	Pilot
Friedrich	Anica	Uni Trier	Student, Life sciences
Friedrich	Ana Claudia	FSU	Chemist
Haas	Christian	AWI	Geophysicist
Hartig	Rüdiger	DWD	Meteorologist
Hellmer	Hartmut	AWI	Oceanographer
Heuven	Steven van	NIOZ	Oceanographer
Huhn	Oliver	IUP	Physicist
Jacobi	Hans-Werner	AWI	Chemist
Kerr Duarte Perreira	Rodrigo	FURG	Oceanographer
Kiko	Rainer	IPÖ	Biologist
Kirk	Henning	IUP	Physicist
Kramer	Maike	UO	Student, Marine sc.
Lemke	Peter	AWI	Physicist, Chief Scientist
Li	Zijun	LCOE	Oceanographer
Macrander	Andreas	AWI	Oceanographer
Mata	Mauricio	FURG	Oceanographer
Meiners	Klaus	ACE	Biologist
Nachtigall	Kerstin	IFM-GEOMAR	Technician
Nicolaus	Marcel	AWI	Geophysicist
Norman	Louiza	UWB	Biologist/Chemist
Nunez	Nuno	UEA	Student, Cartography

Name	Vorname/ First Name	Institut/ Institute	Beruf / Profession
Olbers	Dirk	AWI	Physicist
Oss	Desiree den	RUG	Biologist
Papadimitriou	Stathys	UWB	Chemist
Pfaffling	Andreas	PG	Geophysicist
Rieck	Anja	AWI	Student, geodesy
Rücker van Caspel	Mathias	FURG	Oceanographer
Sartoris	Franz-Josef	AWI	Biologist
Scheltz	Annette	IPÖ	Technician
Schiel	Sigrid	AWI	Biologist
Schneider	Jana	AWI	Student, cartography
Sellmann	Lutz	AWI	Physicist
Sonnabend	Hartmut	DWD	Technician
Stefels	Jacqueline	RUG	Biologist
Thomas	David	UWB	Biologist
Toyota	Takenobu	ILTS	Geophysicist
Uhlig	Christiane	AWI	Student, biology
Vogel	Ines	AWI	Technician
Wang	Zipan	CLE	Biologist
Wassmuth	Jürgen		Photographer
Zemmelink	Henk	NIOZ	Oceanographer
NN		Helitransair	Technician
NN		Helitransair	Technician
NN		Helitransair	Pilot

8. SCHIFFSBESATZUNG / SHIP'S CREW

Name of Ship : POLARSTERN
Nationality : GERMAN
Cape Town - Cape Town

No.	Name	Rank
1	Pahl, Uwe	Master
2	Grundmann, Uwe	1.Offc.
3	Farysch, Bernd	Ch.Eng
4	Fallei, Holger	2.Offc.
5	Peine, Lutz	2.Offc.
6	Niehusen, Frank	2.Offc.
7	Ignatzy, Klaus	Doctor
8	Hecht, Andreas	R.Offc.
9	Minzlaff, Hans-Ulrich	2.Eng.
10	Wanke, Steffen	3.Eng.
11	Somnicht, Stefan	3.Eng.
12	Scholz, Manfred	ElecTech.
13	Nasis, Ilias	ELO
14	Verhoeven, Roger	ELO
15	Muhle, Helmut	ELO
16	Himmel, Frank	ELO
17	Loidl, Reiner	Boatsw.
18	Reise, Lutz	Carpenter
19	NN	A.B.
20	NN	A.B.
21	Winkler, Michael	A.B.
22	NN	A.B.
23	Hagemann, Manfred	A.B.
24	Schmidt, Uwe	A.B.
25	Bäcker, Andreas	A.B.
26	Wende, Uwe	A.B.
27	Preußner, Jörg	Storek.
28	Ipsen, Miachel	Mot-man
29	Voy, Bernd	Mot-man
30	Elsner, Klaus	Mot-man
31	Hartmann, Ernst-Uwe	Mot-man
32	Grafe, Jens	MotMan
33	Müller-Homburg, Ralf-Dieter	Cook
34	Silinski, Frank	Cooksmate
35	Völkse, Thomas	Cooksmate
36	Jürgens, Monika	1.Stwdess
37	Wöckener, Martina	Stwdss/Kr
38	Czyborra, Bärbel	2.Stwdess
39	Silinski, Carmen	2.Stwrdess
40	Gaude, Hans-Jürgen	2.Steward
41	Müller, Wolfgang	2.Steward
42	Huang, Wu-Mei	2.Steward
43	Yu, Kwok Yuen	Laundrym.